

**All Service Maternity
Battle Dress Uniform – Coat & Slacks
Year 3 - Final Technical Report**

Date: September 7, 1999

Apparel Technology and Research Center
California State Polytechnic University, Pomona

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Foreword

The Apparel Technology and Research Center (Cal Poly Demo) was funded by the Defense Logistics Agency (DLA) Apparel Research Network (ARN) to establish a demonstration and research manufacturing activity. As part of the ARN program, the work of the Cal Poly Demo supports the DLA and the Defense Supply Center, Philadelphia (DSCP) by:

1. Conducting studies on costs and problems associated with the manufacturing of military garments;
2. Manufacturing military garments the DSCP had difficulty placing with commercial businesses;
3. Recruiting new businesses to become military contractors through an incubator production program; and
4. Transferring the lessons learned in the demonstration factory to industry through an industry advisory committee, a newsletter, a Home Page and other events and activities.

During the first three years the following military items were produced and studied by the demonstration factory:

- a. Marine men's short sleeve dress shirt
- b. Marine maternity dress uniform - tunic, skirt, and slack
- c. All Service Maternity Battle Dress Uniform - coat and slacks

The purpose has been to identify and establish measurements and costs at each manufacturing function level as a basis for implementing continuous improvement to lower production costs, decrease lead times and maintain/increase quality levels.

Individual reports will be completed for each of the items above.

This report is for the All Service Maternity Battle Dress Uniform the Cal Poly Demo produced through an incubator program in support of the DSCP's requirement for difficult to procure items.

Executive Summary

All Service Maternity Battle Dress Uniform – Coat and Slacks

Background, Objectives and Scope

As stated in the Foreword, the Cal Poly Demo was established as part of the Apparel Research Network (ARN) to be a demonstration and research manufacturing activity to support the Defense Logistics Agency (DLA) and the Defense Supply Center, Philadelphia (DSCP). The DSCP is responsible for the placement of military apparel contracts with commercial apparel manufacturers. The All Service Maternity Battle Dress Uniform (BDU) contract, composed of two items - a coat and slacks, is a contract that the DSCP had experienced difficulty in placing. The Cal Poly Demo assisted the DSCP with production of these items after no commercial producer could be identified.

With the Maternity Battle Dress Uniform (BDU) – coat and slacks contract the Demo's objectives were two-fold:

1. Assist the DSCP with a long term solution for the production of the maternity BDU items through establishment of an incubator program with a West Coast manufacturer; and
2. Document all labor hours, costs and occurrences experienced in the manufacturing of the BDU coat and slacks.

For the first objective, the Demo was successful in the recruiting of a West Coast contractor for establishment of an incubator program. The company will be referenced as Company X in this report for confidentiality. The goal of the relationship was for the Demo to guide Company X into becoming capable of bidding and winning a military apparel contract. Prior to the start of the BDU contract, Company X offered only sewing and finishing services which are not sufficient to support a military contract. Through the relationship with the Demo and participation in the BDU contract in Year 3, Company X was exposed to the preparation, paperwork and quality levels required for bidding a military contract. In September 1998 Company X took a large step toward developing a full package capability by adding an automated cutting system.

Manufacturing Cost Summary

To meet the second objective, this report (sections 3.0 and 4.1 through 4.7) documents all labor hours, costs and issues experienced in the manufacturing of the BDU coat and slacks. In section 4.8, the total labor hours and costs, excluding material costs, are summarized for each factory level and pay grade. The total manufacturing costs for the BDU garments are as follows:

	Cal Poly Demo	Company X
Slacks	\$4.04	\$3.27
Coat	\$9.83	\$7.78
<ul style="list-style-type: none"> - Cal Poly Demo costs are based on the Demo's labor rates. - Demo\Company X costs are derived from using Company X's pay rates for the cut and sew hierarchy levels, sections 4.4 and 4.5, and the Demo's rates for all other levels. 		

Over 97% of the production costs are attributed to the following three factory hierarchy levels and pre-production:

Hierarchy Level	Slacks				Coat			
	Cost		%		Cost		%	
Sew, Finish & Inspect*	\$3.43	\$2.67	84.90%	81.65%	\$9.16	\$7.12	94.14%	91.52%
Ship & Invoice **	\$0.33	\$0.33	8.17%	10.09%	\$0.33	\$0.33	3.39%	4.24%
Pre-Production **	\$0.10	\$0.10	2.47%	3.06%	\$0.10	\$0.10	1.02%	1.29%
Spread, Cut & Bundle*	\$0.08	\$0.07	1.98%	2.14%	\$0.12	\$0.11	1.22%	1.41%

* Company X activity

**Demo activity

The following labor grades contribute the highest number of hours to the manufacturing of the slacks and coat. The chart below shows the total labor per category for each item.

Labor Grade	Slacks		Coat	
	Labor Hours	% of Total Hours	Labor Hours	% of Total Hours
Sew Operator	0.3815	87.06%	1.0175	94.14%
Production Manager's Assistant	0.0504	9.14%	0.0528	3.91%
Cutting Operator	0.0090	2.28%	0.0132	1.34%

In Section 4.5, it is shown how the accumulation of problems experienced in the factory at factory levels preceding the Sew, Finish and Inspect level resulted in low sew efficiencies and proportionately higher unit costs. The sew efficiencies for the BDU garments are calculated to be as follows:

Slacks	79.71%
Coat	67.91%

For a dedicated production line these efficiencies are especially low and should be at or near 100%.

Based on the results noted, the Cal Poly Demo and Company X should focus on the resolution of the below problems:

1. Receipt of the government furnished material in ample time for inspection and reorder if found to be damaged;
2. Implementation of an inventory control procedure for all trim materials.

By resolving these two main issues the avoidance of a costly production line shutdown due to lack of raw materials will be greatly reduced. In addition, sewing efficiency can be improved by:

1. Inspecting incoming materials before acceptance;
2. A change in timing of exact tasks (i.e. delivery of government furnished material); and
3. Analyzing batch sizes of units produced.
4. Establishing a multiple commercial vendor resource list for supply of military approved trim materials.

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1.0 Introduction

This report is for the All Service Maternity Battle Dress Uniform – Coat and Slacks contract.

1.1 Background and Objectives

The Apparel Technology and Research Center (Cal Poly Demo) was funded by the Defense Logistics Agency (DLA) to establish a demonstration and research manufacturing activity to support the DLA and the Defense Supply Center, Philadelphia (DSCP). One area the DSCP requires support in is the placement of military contracts with commercial apparel manufacturers. The All Service Maternity Battle Dress Uniform (BDU) contract, composed of two items a coat and slacks, is a contract the DSCP has experienced difficulty in placing.

Within the West Coast industrial base, a possible placement source for military contracts is with one of the many small- to medium-sized apparel manufacturers and/or contractors. However, many smaller apparel contractors are unable to support a military contract because the company can only perform sew and finish services. To be a military contractor the company must have full package capability. Full package capability relates to a company having the additional production systems and processes and financial depth to successfully bid for and support a military contract. The additional systems and processes include:

1. Preparation of Garment Specifications for Commercial Manufacturing
2. Pattern Making
3. Producing of Samples
4. 1st Article Approval
5. Establishment of Vendor Relationships for Trim Material (Labels, Elastic, etc.)
6. Cutting
7. Sew & Finish
8. Package & Ship
9. Completion of Military Paperwork for Contract Start-up, Shipping and Invoicing.

For the BDU contract, the Demo helped the DSCP to locate a West Coast contractor with the potential of becoming a full package contractor. The subcontractor selected for the project is referenced as Company X in this report.

The objectives of this project are:

1. To establish an incubator program between Cal Poly Demo and Company X using the BDU contract.
2. To document, quantitatively and qualitatively by demonstrable samples, all times, procedures, issues and costs encountered in the production of the BDU coat and slacks.

1.2 Scope

The study scope includes:

1. The documentation of the incubator program progress.
2. The documentation of the direct labor hours, labor costs and issues experienced by the Cal Poly Demo and Company X in the production of the All Service Maternity Battle Dress Uniform.

The time period covered is from November 1997 – August 1999.

1.3 Methodology

The report results are presented in the below sections:

- 2.0 Incubator Program**
- 3.0 Pre-Production Costs and Issues**
- 4.0 Production Costs and Issues**

All information documented is based on interviews with the Cal Poly Demo's director, production manager, and assistant and one of the co-owners of Company X. The labor hours reported are based on estimates provided by the Demo's and Company X's personnel, the cutting operator's log book and the actual labor hours reported for each production run of the BDU items. For productivity measurement of the sew, finish and inspect hierarchy levels, standard allowed minutes are provided by Company X.

For comparison purposes labor costs are shown using both Cal Poly Demo and Company X pay rates. The actual cost per item is based on Company X pay rates for cut and sew operators and Cal Poly Demo pay rates for all other labor categories. All rates are included in Table 1.

Table 1: Hourly Labor Wage & Experience Level				
Position	Cal Poly Demo's \$/Hour with Benefits	Experience Level	Company X \$/Hour without Benefits	Experience Level
Manufacturing Manager	\$40.00	15+ years	N/A	N/A
Production Manager	\$23.81	10 years	N/A	N/A
Production Assistant	\$22.23	20 years	N/A	N/A
Sew Operator	\$9.00	Varies	\$7.00	Varies
Cutting Operator	\$10.16	8 years	\$9.25	Varies
Production Manager Assistant	\$7.12	1 year	N/A	N/A
Machine Technician	\$23.57	27 years	N/A	N/A

2.0 Incubator Program

In the spring of 1996, Bernie Johns, DSCP Branch Chief identified the need for the Cal Poly Demo to assist with the difficult to procure maternity BDU items. During the planning of the contract for production of these items, the DLA, DSCP and Cal Poly Demo personnel involved determined it was not feasible for the Demo factory to do the actual production. It was decided that there was an opportunity for the Demo to place these products with a commercial contractor under an incubator arrangement. The goal was to prepare the incubator company to compete directly for the garment award at a later date.

The Demo already had a company on its' Coalition (industry advisory committee) that was an excellent candidate for this program. Company X had tried several times in the past to bid on military contract work but had been unsuccessful in obtaining an award. Company X indicated to Demo staff they were still interested in pursuing military contract work but knew they would need direction and assistance to be successful in pursuit of a contract.

The contract was awarded to the Cal Poly Demo and Company X in January 1998. At start-up of the contract, the Demo provided all systems and processes for the BDU contract, excluding Sewing, Finishing and Inspecting. (Reference Section 1.1 for listing of required systems and processes.)

Company X beginning at start-up and for the following nine months, until September 1998, performed only the sewing, finishing and inspecting processes. Then, in September Company X acquired an automated cutting system and took over the process of cutting for the Battle Dress Uniform contract. In the Demo's coming Year 4, the goal of the incubator program is for Company X to be completely independent from the Cal Poly Demo and be fully awarded the BDU contract in the late Fall of 1999.

3.0 Pre-Production Costs

At start-up of all military contracts an apparel manufacturer incurs the following pre-production expenses:

1. Preparation of Specifications
2. Pattern Making
3. Producing of Samples
4. 1st Article Approval
5. Establishment of Vendor Relationships for Trim Material

These expenses are not included under the factory's hierarchy levels defined in sections 4.1 through 4.7 but, are to be added to the cost of the garments in the contract's first year. For this report no direct documentation of hours were recorded for the start up of the BDU contract.

To establish pre-production costs, the labor tasks and labor standards provided in the Cal Poly Demo's report titled Indirect Labor Activity Cost Study for a Sample Military Apparel Contract, submitted September 21, 1996, are used as a foundation for cost derivation. As shown in the following tables some of the pay rates are changed to reflect the activity performed directly by the ATRC staff.

Table 2 shows the recalculation of the pre-production costs based on the production volume for this BDU contract. The following cost detail tables are taken from the 1996 report and show how the costs were originally derived.

Table 2: Pre-production Costs BDU Maternity Slacks and Coat			
Pre-production Costs Summary			
	Activity	Level of Expertise	Cost
1	Preparation of Specifications	Very Experienced	\$233.50
2	Pattern Making	Experienced	\$105.50
3	Production Coordination	Very Experienced	\$1,260.00
4	Cutting Material	Experienced	\$176.90
5	Production of Samples	Inexperienced	\$1724.48
		Total Cost	\$3,500.38
		Year 3 Total Ordered Units	34,080
		Pre-Production Cost per Unit	\$ 0.10

Pre-production Costs Detail			
1. Preparation of Specifications			
Step	Cost Element	Calculation	Cost

1	Preparation of Specifications - 14 hours/ 3 garments = 4.67 hrs/garment	(4.67 hrs/garment * 2 BDU garments * \$25/hr) =	\$233.50
		Total Cost	\$233.50
		Year 3 Total Units Ordered	25,777
		Unit Cost	\$ 0.01

2. Pattern Making			
Step	Cost Element	Calculation	Cost
1	Slacks Pattern	\$50	\$ 50.00
2	Coat Pattern	\$55	\$ 55.00
		Total Cost	\$105.50
		Year 3 Total Units Ordered	25,777
		Unit Cost	\$ 0.00

3. Production Coordination			
Step	Cost Element	Calculation	Cost
1	Review Patterns, fabric, trims, etc. necessary to produce samples and coordinate pattern work.	4 hrs * \$60 /hr	\$240.00
2	Review construction methods with team leader to assemble samples	2 hrs * \$60 /hr	\$120.00
3	Review samples	2.5 hrs * \$60 /hr	\$150.00
4	Send samples	0.5 hrs * \$60 /hr	\$30.00
5	Contract related activities	12 hrs * \$60 /hr	\$720.00
		Total Cost	\$1260.00
		Year 3 Total Units Ordered	25,777
		Unit Cost	\$ 0.05

4. Cutting Material			
Step	Cost Element	Calculation	Cost
1	Pre-Production	1.5 hrs * \$10.16 /hr	\$15.24
2	Spreading	0.75 hrs * \$10.16 /hr	\$7.62
3	Cutting	1.0 hrs * \$10.16 /hr	\$10.16
4	Bundling	0.5 hrs * \$10.16 /hr	\$5.08
5	Marker	1.5 hrs * \$10.16 /hr	\$15.24
6	Office	0.5 hrs * \$7.12 /hr	\$3.56
7	Management Labor	3.0 hrs * \$40 /hr	\$120.00
		Total Cost	\$176.90
		Year 3 Total Units Ordered	25,777
		Unit Cost	\$ 0.01

5. Production of Samples			
Step	Cost Element	Calculation	Cost
1	Planning Meeting	6.0 hrs * \$40 /hr	\$240.00
2	Source Fabric & Patterns	2.0 hrs * \$40 /hr	\$80.00

3	Implementation Meeting	1.45 hrs * \$40 /hr	\$58.00
4	Pre-samples/Method Development - 12 hrs/garment	12 hrs/garment * 2 garments * \$9.25 /hr	\$222.00
5	Source Trims	1.1 hrs * \$22.23 /hr	\$24.45
6	Sample Production - 53.45 hrs/garment	53.45 hrs/garment * 2 garments * \$9.25 /hr	\$988.83
7	Present Samples & Review	0.45 hrs * \$40/hr	\$18.00
8	Operations Garment Analysis	1.83 hrs * \$40 /hr	\$73.20
9	Review Data	0.5 hrs * \$40 /hr	\$20.00
		Total Cost	\$1724.48
		Year 3 Total Units Ordered	25,777
		Unit Cost	\$ 0.07

4.0 Production Costs and Issues

Production costs and issues are presented based on the Cal Poly Demo's factory hierarchy. The factory's structure is represented by the seven function levels illustrated in the following diagram:

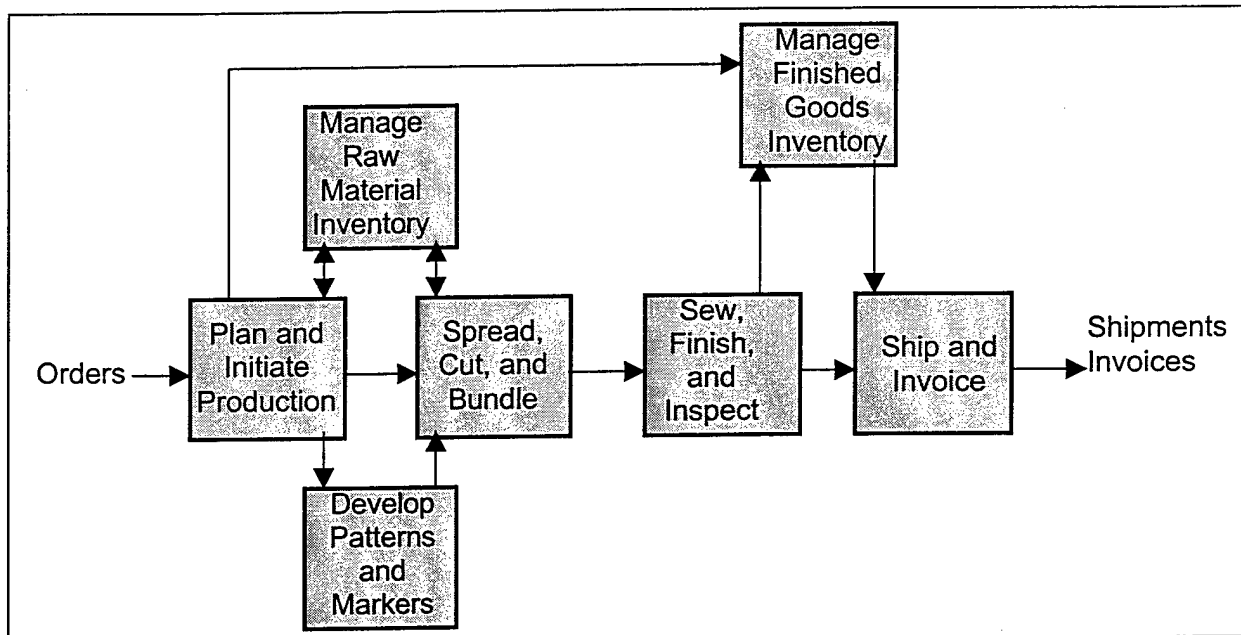


Figure 1: Factory Hierarchy Levels

For each of the above functional levels the below items are documented:

- A. Labor Hours & Cost per military garment
- B. Problems \ Solutions \ Comments

To derive a cost per unit, production quantities for the BDU slacks and coat need to be established. For the first six months of the BDU contract, the Demo and Company X were to manufacture 300 units of each garment per week or 4800 per Delivery Order. This quantity was increased in July 1998 to 500 per week or 8000 per Delivery Order for each garment. For the labor hour and cost per unit calculations, the final quantities agreed upon with the Defense Supply Center, Philadelphia (DSCP) are used and restated in the table below.

Table 3: Order/Production Quantity	
Time Period	Quantity Produced per Garment
1 Week	500
1 Month	2000
Delivery Order (4 Months)	8000

4.1 Plan & Initiate Production

Upon the receipt of a delivery order for either the slacks or coat, the six steps below are followed in the Plan & Initiate Production phase:

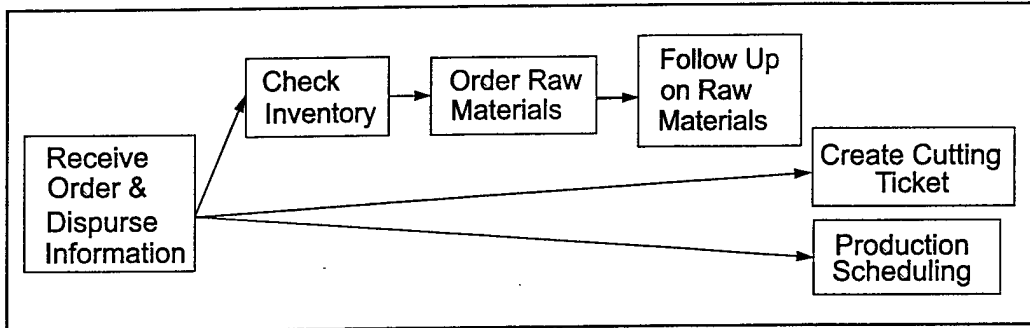


Figure 2: Plan & Initiate Production

Each of the above steps represents a production cost element and is documented in further detail, as shown below.

1. Receive Initial Order & Disburse Information - The production assistant receives the order via facsimile, and then makes two copies and distributes the requirements to the production manager and the student assistant.
2. Check Finished Goods Inventory - The student assistant checks the finished goods inventory for fulfillment of the order and reports the results to the production manager.
3. Check Raw Materials Inventory - The production manager reports the required pieces to the cutting operator. The cutting operator checks the raw material inventory for the needed quantities. The operator reports checked results back to the production manager.

To calculate costs for ordering, handling and holding raw materials the slacks and coat are composed of 8 and 6 items, respectively, as illustrated in the following table:

Table 4: Materials Listing	
Slacks	
Number	Item
1	Self (Basic Material)
2	Rib
3	Thread
4	Elastic

5	Buttons
6	Identification/Instruction Label
7	Size Label
8	Bar Code
Coat	
Number	Item
1	Self (Basic Material)
2	Thread
3	Buttons
4	Identification/Instruction Label
5	Size Label
6	Bar Code

4. Order Raw Materials - Based on the inventory information from the production manager and the cutting operator, the production assistant places an order(s) for the needed material(s).
5. Create Cutting Ticket – The Demo’s production manager reports the number of pieces to be cut and the total yards required to the Demo’s production assistant. The production assistant completes a cutting ticket and sends the cutting information to the subcontractor, Company X.

For a cost calculation, the Year 3 reported cutting data for the slacks and coat are used as reported in the table below:

Table 5: Year 3 Cut Data			
Item	# of Cuts	Total Units Cut	Average Quantity Cut
Slacks	14	17934	1281
Coat	13	17979	1383

6. Schedule Production – Company X’s production manager calculates the sewing hours required by consulting the master production schedule.

Based on these six cost elements, the labor hours per unit and the costs per unit are derived for the Plan and Initiate Production hierarchy level, as illustrated in the table below:

**Table 6:
Plan & Initiate Production
"Slacks"**

Step	Cost Element	Calculation	Labor Hours per Unit	Labor Rate per Hour	Cost per Unit
1	Receive Order & Disburse Information	0.08 hrs/order / 8000 units per order	0.0000	\$22.23	\$0.0000
2	Check Finished Goods Inventory	0.33 hrs/order / 8000	0.0000	\$22.23	\$0.0000
3	Check Raw Materials Inventory - 8 Items/Slacks	0.08 hrs/item * 8 items / 8000	0.0001	\$22.23	\$0.0022
4	Order Raw Materials - 8 Items/Slacks	0.08 hrs/item * 8 items / 8000	0.0001	\$22.23	\$0.0022
5	Create Cutting Ticket - 1281 Slacks per cut	0.33 hrs/cut / 1281 slacks/cut	0.0003	\$22.23	\$0.0067
6	Schedule Production - 1281 Slacks per cut	0.25 hrs/cut / 1281	0.0002	\$23.81	\$0.0048
		"Slacks" Totals:	0.0005 0.0002	\$22.23 \$23.81	\$ 0.02

**Plan & Initiate Production
"Coat"**

Step	Cost Element	Calculation	Labor Hours per Unit	Labor Rate per Hour	Cost per Unit
1	Receive Order & Disburse Information	0.08 hrs/order / 8000 units per order	0.0000	\$22.23	\$0.0000
2	Check Finished Goods Inventory	0.33 hrs/order / 8000	0.0000	\$22.23	\$0.0000
3	Check Raw Materials Inventory - 6 Items/Coat	0.08 hrs/item * 6 items / 8000	0.0001	\$22.23	\$0.0022
4	Order Raw Materials - 6 Items/Coat	0.08 hrs/item * 6 items / 8000	0.0001	\$22.23	\$0.0022
5	Create Cutting Ticket - 1383 Coats per cut	0.33 hrs/cut / 1383 coats/cut	0.0002	\$22.23	\$0.0053
6	Schedule Production - 1383 Coats per cut	0.25 hrs/cut / 1383	0.0002	\$23.81	\$0.0048
		"Coat" Totals:	0.0004 0.0002	\$22.23 \$23.81	\$ 0.01

Note: The Labor Hours used above are estimates provided by the Demo's production manager and assistant. The Labor Rates are based on the Cal Poly Demo's pay grades.

The issues experienced by the Plan and Initiate Production hierarchy level are documented as follows:

1. Delivery Orders – 1st Four Months Payment Problems – With the execution of many military contracts a delivery order is issued to the manufacturer. A government delivery order specifies the quantities per size to send to a specified location, reference Appendix A6 for a sample delivery order. In the case of the BDU contract, the Delivery Orders 0254 for the

coat and 0255 for the slack were not available prior to production. Based on a verbal agreement with the Defense Supply Center, Philadelphia (DSCP), the Demo/Company X were to produce 300 units of each garment per week. Also, that the Demo could use its discretion for the sizes manufactured as long as the quantities were within the projections contained within the government contract (Project Number BAA93-01) due to expire September 1998. This verbal agreement was to be applicable until the delivery orders were available.

However, complications occurred once the delivery order paperwork became available to the Demo. The complications resulted because the order's requested quantities per size did not match what had already been shipped by the Demo. The difference caused payment issues because the Demo's governing financial Foundation could only bill according to the Delivery Order's requested quantities per size. As result, the Demo could not initially receive payment for the finished goods produced.

The problem was resolved in June 1998 when the delivery orders for the BDU garments arrived in advance of production. However, the payment issue for the first four months of production was not rectified until the 1st quarter of Year 4.

2. Late Release of Delivery Orders – From the start of the BDU contract, the Demo experienced problems with receiving delivery orders in time to order GFM (government furnished material). Per the contract, the GFM order lead-time is 25 days. As reported by the production manager, 33% of the time the delivery orders did not arrive in advance of the GFM order lead-time. Thus, the Demo was not able to fully supply the sewing subcontractor, Company X, with GFM in a timely manner. The situation worsened in July 1998 when the DSCP manager increased the production amount of each garment from 300 to 500 units per week.

Without the needed supply of GFM, Company X initially slowed the BDU production line by shortening the operators' workday and eventually had to shut down the line for three weeks. This resulted in the departure of some operators because they needed full time work. Company X then had to hire new operators. The new operators required training on how to sew military apparel which subsequently impacted Company X's overall productivity, quality and cost.

To resolve this issue, the DSCP needs to release delivery orders a minimum of 30 days in advance of the end the previous delivery order to allow adequate time for GFM to be ordered and avoid production disruption.

3. Rib Material Lack of Supply – Beginning in May 1998, the rib material supplier for the BDU slacks failed to deliver needed rib material. The orders, delivery dates and quantities received are noted in the following table:

Table 7: Rib Material Order & Delivery Dates			
Order Date	27-May	Order Date	29-Sep
Quantity	1000 Yards	Quantity	1500 Yards
Delivery Date	# of Yards Received	Delivery Date	# of Yards Received
6-Jun	33	30-Oct	594
18-Jun	462		
1-Jul	187		
Total	682	Total	594

As a result of the lack of rib material, Company X stopped and started production of the slacks at the rib sew operation. This disruption in process caused additional material handling and lower sewing efficiencies. Additionally, operators became frustrated with the lack of continuity in garment completion.

To resolve the rib supply problem, the Demo requested an alternate vendor from the DSCP item manager. The new vendor reference was not received by the Demo until October 1998. However, by October, the original vendor had hired a new manager and assured the Demo that future deliveries would arrive in the stated lead-time. The Demo remained with the original vendor but should establish a multiple commercial vendor resource list to avoid any future problems.

A summary of the Plan & Initiate Production issues are presented in the following table:

Table 8: Plan & Initiate Production - Problems \ Solutions		
	Problem	Solution
1	Delivery Orders – 1 st Four Months Payment Problems	Receiving Delivery Order Schedule prior to production.
2	Late Release of Delivery Orders	Release Delivery Orders a minimum of 30 days prior to production
3	Rib Material Lack of Supply	Resolved. Vendor hired new manager and is meeting stated lead times. Recommend developing a multiple vendor resource list.

4.2 Manage Raw Material Inventory

For the BDU contract, the Demo orders, receives and inventories all raw materials. Once the order is placed in the Plan and Initiate Production hierarchy level, the Demo performs the following procedure:

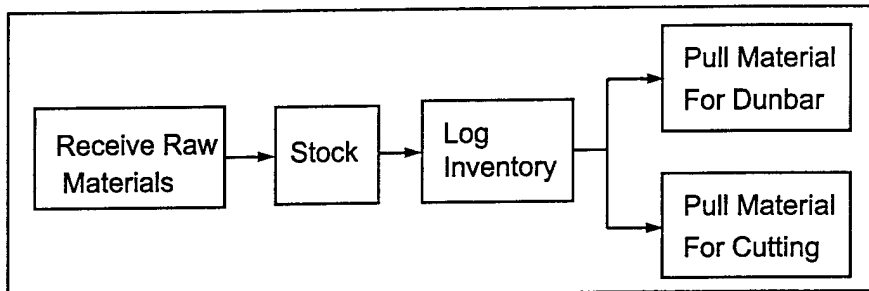


Figure 3: Manage Raw Material Inventory

Each of the steps represent a production cost element for the Manage Raw Material Inventory hierarchy level and is defined below:

1. **Receive Raw Materials** - A production manager's assistant receives the raw materials (including government furnished material) from the shipper, verifying that the item and the quantity received matches the packing list. No other inspection is performed. Raw materials are received for an entire delivery order of 8000 units per garment type.
2. **Stock Raw Materials** - All raw materials and GFM are moved into storage containers by the production manager's assistant.
3. **Inventory Log** - Only GFM is logged into inventory. The roll number and quantity received is entered into the inventory log book.
4. **Pull Material for Cutting/Company X** - For the first six months of the contract, the Demo performed the cutting operation for the BDU contract. In September 1998 Company X added cutting capability to their operations and took over the cutting operation for the BDU slacks and coat. Since Company X will cut for the remainder of the contract, the labor hours and costs per unit are based on the Demo pulling all raw material (GFM and trims) to send to Company X.

The labor to prepare the material for shipment is performed by the production manager's assistant. The assistant identifies and loads for Company X's truck with the raw materials for 2000 units per garment type which is approximately one month of production.

For each of the above cost elements, the labor hours and costs per unit are calculated in the following table:

**Table 9:
Manage Raw Materials
"Slacks"**

Step	Cost Element	Calculation	Labor Hours per Unit	Labor Rate per Hour	Cost per Unit
1	Receive Raw Materials - Slacks 7 items - Plus, GFM rolls: 8000 units * 1.2405 yards per slacks = 100 rolls	$[(0.08 \text{ hrs/item} * 7 \text{ items}) + (0.17 \text{ hrs/roll} * 100 \text{ rolls/order})] / 8000 \text{ units per order}$	0.0022	\$7.12	\$0.0156
2	Stock	$[(0.08 \text{ hrs/item} * 7 \text{ items}) + (0.08 \text{ hrs/roll} * 100 \text{ rolls/order})] / 8000 \text{ units per order}$	0.0011	\$7.12	\$0.0076
3	Inventory Log - GFM only	$0.08 \text{ hrs/rolls} * 100 \text{ rolls} / 8000$	0.0010	\$7.12	\$0.0071
4	Pull Raw Materials for Company X - 1 month, 2000 units	$2.5 \text{ hours} / 2000 \text{ units/month}$	0.0013	\$7.12	\$0.0093
		"Slacks" Totals:	0.0056	\$7.12	\$ 0.04

**Manage Raw Materials
"Coat"**

Step	Cost Element	Calculation	Labor Hours per Unit	Labor Rate per Hour	Cost per Unit
1	Receive Raw Materials - Coat 5 items - Plus, GFM rolls: 8000 units * 1.8135 yards per slacks = 146 rolls	$[(0.08 \text{ hrs/item} * 5 \text{ items}) + (0.17 \text{ hrs/roll} * 146 \text{ rolls/order})] / 8000 \text{ units per order}$	0.0032	\$7.12	\$0.0224
2	Stock	$[(0.08 \text{ hrs/item} * 5 \text{ items}) + (0.08 \text{ hrs/roll} * 146 \text{ rolls/order})] / 8000 \text{ units per order}$	0.0015	\$7.12	\$0.0108
3	Inventory Log - GFM only	$0.08 \text{ hrs/rolls} * 146 \text{ rolls} / 8000$	0.0015	\$7.12	\$0.0104
4	Pull Raw Materials for Company X - 1 month, 2000 units	$3.75 \text{ hours} / 2000 \text{ units/month}$	0.0019	\$7.12	\$0.0134
		"Coat" Totals:	0.0080	\$7.12	\$ 0.06

Note: The above Labor Hours are estimates by the Demo's production manager.

The problems experienced in the Manage Raw Materials hierarchy level follows:

1. Storage Problem – The BDU slacks and coat require a total of 12 additional trim materials, excluding government furnished material, for construction. Reference section 4.1 for the

material listing of each garment. For two of the trim materials, the size and bar code labels, 27 types of labels were ordered to account for the 27 different garment sizes. All trim materials were ordered for the entire delivery order, 8000 units per garment or 16,000 total units. The Demo experienced difficulty in the inventory process due to the large variety and quantity of trim materials. No formal inventory accounting system was in place at the Demo.

A direct result of the Demo's difficulty was in the loss of 1459 bar code labels that had to be reordered. Due to the lack of an inventory accounting system, it was unclear whether the labels were lost at the Demo or at Company X's facility. The delay in receiving the new labels contributed to a three-week shutdown of the sewing production line and lower sewing efficiencies.

To resolve the inventory problem the Demo needs to develop a procedure for the garments' trim materials. The procedure is to include steps for:

- Initially logging the items and quantities received from a vendor.
- Storing the items in individual containers.
- Recording the items and quantities shipped to Company X with confirmation.

The above problem is summarized in the following table.

Table 10: Manage Raw Materials - Problems \ Solutions		
	Problem	Solution
1	Storage Problem for Trim Materials	Develop an inventory procedure for logging in and out trim materials for each garment, with confirmation.

4.3 Develop Patterns and Markers

In section 3.0 – Pre-Production Costs, the expense of developing patterns and markers for the BDU slacks and coat is calculated. Within this section, the continual labor costs for the printing of markers per production cut are calculated. From the Demo's Year 3 production data, the number of markers per unit is derived for each garment in the below table.

	Units Cut	# of Markers Used	# of Markers per Unit
Slacks	17888	121	0.006764
Coat	21229	117	0.005511

The figures above are used for the labor and cost allocation for the Develop Patterns and Markers hierarchy level. The labor and costs per unit are illustrated in the table below:

Table 11: Develop Patterns and Markers					
"Slacks"					
Step	Cost Element	Calculation	Labor Hours per Unit	Labor Rate per Hour	Cost per Unit
1	Print Markers	0.20 hrs/marker * 0.006764 markers/unit	0.0014	\$10.16	\$0.0137
"Slacks" Totals:			0.0014	\$10.16	\$ 0.01
"Coat"					
Step	Cost Element	Calculation	Labor Hours per Unit	Labor Rate per Hour	Cost per Unit
1	Print Markers	0.20 hrs/marker * 0.005511 markers/unit	0.0011	\$10.16	\$0.0112
"Coat" Totals:			0.0011	\$10.16	\$ 0.01
Note: The above labor hours are based on the production manager's estimation.					

The problems experienced with the Develop Patterns and Markers hierarchy level are reported below:

1. Incorrect Armhole Size – The armhole size for the coat's pattern sizes 6 and 8 (short, regular, long) is incorrect. The sleeve is too large for the armhole. This results in excessive time spent by the sewing operator in attaching the sleeve to the body.

In August 1999, a new pattern was received by the Demo. The Demo's CAD operator will correct the top and bottom of the sleeves for marker sizes 6 through 22. The jacket comes in 3 lengths, short, regular, and long. This translates into 27 sizes. The operator estimates she will spend 5 hours to complete this task.

2. Incorrect GFM Width - The Demo in Year 3 received GFM (government furnished material) in incorrect widths. This resulted in the extra expense of creating a new marker, approximately two labor hours using a computer aided drawing system. The solution is for a procedure to check fabric roll characteristics when the material is initially received from the vendor or a review of the parameters of the contract required from the DSCP manager.

The issues experienced in this hierarchy are summarized in the below table.

Table 12: Develop Patterns and Markers – Problems/Solutions		
	Problem	Solution
1	Incorrect Armhole Size	Pattern Correction received by Demo in August 1999.
2	Incorrect GFM Width	Procedure to check fabric roll characteristics when initially received from the vendor.

4.4 Spread, Cut and Bundle

For each cut, one or more sizes may be included with each size requiring a different marker. The three stages of the cutting process are defined below:

1. Spread - The marker length is 6 yards and 34 inches with 5 sets of cut parts. The cutter spreads an average of 15 plies per roll.
2. Cut - The Cal Poly Demo uses an automated cutter.
3. Bundle - The cutting operator prints bundle tickets and places them with each bundle. The bundles are placed in boxes for storage.

The labor rate for spreading, cutting and bundling is derived from the actual hours reported by the cutting operator and are as follows:

Table 13: Spread, Cut and Bundle Labor Rate		
Slacks		
Hours	Units	Hours/Unit
33.75	4446	0.0076 Slacks
Coat		
Hours	Units	Hours/Unit
69.12	5736	0.0121 Coat

Using the labor rates shown above the following costs are derived:

Table 14: Spread, Cut and Bundle "Slacks"					
Step	Cost Element	Calculation	Labor Hours per Unit	Labor Rate per Hour [Demo/Company X]	Cost per Unit [Demo/Company X]
1	Spread, Cut & Bundle	0.0076 hrs/unit	0.0076	\$10.16/\$9.25	\$0.0772/\$0.0703
		"Slacks" Totals:	0.0076	\$10.16/\$9.25	\$ 0.08/\$0.07
"Coat"					
Step	Cost Element	Calculation	Labor Hours per Unit	Labor Rate per Hour [Demo/Company X]	Cost per Unit [Demo/Company X]
1	Spread, Cut & Bundle	0.0121 hrs/unit	0.0121	\$10.16/\$9.25	\$0.1229/\$0.1119
		"Coat" Totals:	0.0121	\$10.16/\$9.25	\$ 0.12/\$0.11

The problems encountered in the Spread, Cut and Bundle hierarchy level are discussed below:

1. Small Lot Manufacturing – Due to the small lot size of each of the garments’ multiple sizes, the time spent cutting and bundling becomes proportionately higher. The only way to reduce the cutting cost is to cut more of each size per marker. However, this could result in a high inventory of cut parts.
2. Excessive Fabric Flaws – The Demo and Company X experienced fabric flaws with the BDU government furnished material (GFM). A four month study found of 13,843 yards, 581 yards or 4.2% were unusable, reference Appendix A7 for more detailed results. The material flaws include:
 - Design not completely printed
 - Design smeared
 - Lumps in fabric
 - Needle dropped thread

The flaws impact sewing production because the damages are hidden by the camouflaged print and are found during a sew operation. The result is excessive time spent recutting parts to remove the damage and additional material handling to place the part(s) back into production.

A solution is for the implementation of an inspection procedure when the fabric is initially received from the vendor. The DSCP procedure requires return of the entire roll if any damage is found. Conversations with Bernie Johns and Jim Kane, DSCP, revealed the GFM was all made by one vendor who was no longer making this particular fabric on contract. The number of rolls of fabric that was damaged was excessively high (77% - see A7). Part of the installation of the procedure requires analysis of returning damaged material to the vendor and hopefully, receiving replacement material within the contract’s shipment lead-time.

While return of the fabric was not an option in this situation the Cal Poly Demo extensively documented the fabric quality problem. The results are shown in Appendix A7.

The above two problems are summarized in the following table:

Table 15: Spread, Cut and Bundle – Problems/Solutions		
	Problem	Solution
1	Small Lot Size	Possibly increase quantity cut per marker.
2	Excessive Fabric Flaws	Procedure to inspect fabric when initially received from the vendor to insure quality level.

4.5 Sew, Finish and Inspect

The subcontractor, Company X, performs the sew, finish and inspect operations for the BDU contract. Within Company X's facility a continuous production line is dedicated for the manufacturing of the BDU slacks and coat. On the production line operators perform two to three sewing operations, including finishing and inspecting. In the following table the efficiency percent to standard for each garment is calculated.

Table 16: Production Summary Actual versus Standard Allowed Hour, SAHS Per Unit			
	SAHS	Actual Average Hours	% Efficiency to Standard
Slacks	0.3041	0.3815	79.71%
Coat	0.6909	1.0175	67.91%
<ul style="list-style-type: none"> - Reference Appendix A.3 – Labor Standards Tables for SAMs per operation and Appendix A.4 – Actual Hours Reported for reported hours per month. - Note: The SAHS reported above were derived by Company X using the Time Study technique. 			

The lower percent efficiencies shown above are a result of the problems documented in the previous sections and summarized below:

Table 17: Problems Impacting Production Summary		
Section	Problem	Impact on Production
4.1 Plan & Initiate Production	Lack of Rib Material Supply	Stopped slacks production at the attach rib to front sew operation which caused an increase in material handling and a loss of sewing efficiency.
	Late Release of Delivery Orders, Lack of GFM Supply	Stopped slacks and coat production, resulting in a three-week layoff of operators, an extremely high cost in loss of sewing efficiency.
4.2 Manage Raw Materials	Storage Problem for Trim Materials, Re-order of Bar Code Labels	Stopped production, causing an increase in material handling and a loss of sewing efficiency.
4.3 Develop Patterns & Markers	Incorrect Arm Hole Size	Sew efficiency is lost due to the operators having to correct the problem with unnecessary material handling at the attach sleeve operation.
4.4 Spread, Cut & Bundle	Small Lot Size	Labor efficiency cannot be maximized on the continuous production line with small lots.

Excessive Fabric Flaws (GFM)	Stops slacks and coat production at multiple sew operations, causing an increase in material handling and a loss of sewing efficiency.
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Company X kept no records on the time spent on rework or on actual production time lost for each of the problems in Table 17. To increase production efficiency each of the problems needs to be addressed. For possible solutions to the problems, reference the identified sections in this report.

For the Sew, Finish and Inspect hierarchy cost calculation, the labor rate is based on the actual reported hours and units produced in Year 3, reference Appendix A4 – Actual Hours Reported for further documentation. The labor and costs per unit are shown in the following table.

Table 18: Sew, Finish and Inspect "Slacks"					
Step	Cost Element	Calculation	Labor Hours per Unit	Labor Rate per Hour [Demo/Company X]	Cost per Unit [Demo/Company X]
1	Sew, Finish and Inspect	0.3815 hrs/unit	0.3815	\$9.00/\$7.00	\$3.4335/2.6705
		"Slacks" Totals:	0.3815	\$9.00/\$7.00	\$ 3.43/\$2.67
"Coat"					
Step	Cost Element	Calculation	Labor Hours per Unit	Labor Rate per Hour	Cost per Unit
1	Sew, Finish and Inspect	1.0175 hrs/unit	1.0175	\$9.00/\$7.00	\$9.1575/\$7.1225
		"Coat" Totals:	1.0175	\$9.00/\$7.00	\$ 9.16/\$7.12

4.6 Manage Finished Goods Inventory

For the BDU contract, the Demo maintained an inventory for the slacks and coat. The average monthly inventory levels are reported below:

Monthly Inventory Level	
	Average Quantity per Month
Slacks	1355
Coat	1446

The cost element of the Manage Finished Goods Inventory level is attributed to the stocking and logging of the garments in inventory. The labor rate used is for the Demo's production manager's assistant to transport finished goods from Company X's truck into the Demo's storage containers and log the inventory level. The labor and cost per unit are illustrated in the following table.

Table 19: Finished Goods Inventory Slacks and Coat					
Step	Cost Element	Calculation	Labor Hours per Unit	Labor Rate per Hour	Cost per Unit
1	Stock Finished Goods	0.0048 hours/unit	0.0048	\$7.12	\$0.0342
		Slacks or Coat Totals:	0.0048	\$7.12	\$ 0.03

Note: The Labor Hours used above are based on an estimate provided by the Demo's production manager.

In Year 3, the Demo experienced no problems within the Finished Goods Inventory hierarchy level.

Table 20: Finished Goods Inventory – Problems/Solutions		
	Problem	Solution
1	No Problems Reported.	

4.7 Ship and Invoice

For the BDU contract, the Demo completes the final packing of goods and all shipping paperwork. The steps shown in the below figure are followed.

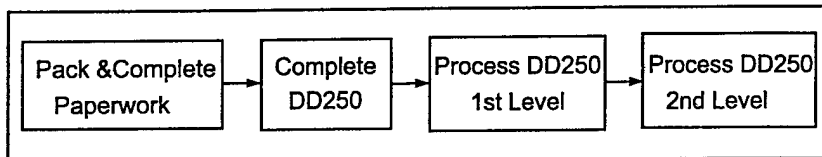


Figure 4: Ship and Invoice

Each of the steps above represents a cost element in the Ship and Invoice hierarchy level and are defined in further detail below:

1. Pack & Complete Shipper Paperwork - The production manager's assistant packs the final shipment boxes, secures the boxes with tape and completes shipping paperwork. The following guidelines are adhered to for the packing of each garment type:

- Slacks, 40 units per box
- Coat, 35 units per box

An exception to the number of units per box as shown above is made when the Delivery Order calls for quantities that are not multiplies of either 40 or 35 for the slacks and coat,

respectively.

Also, for the labor and cost per unit calculations, the Demo ships an average of 500 units per garment type weekly. This quantity is based on the verbal agreement with the DSCP.

2. Complete DD250 - The production assistant completes all fields on the DD250 form.
3. Process DD250, 1st Level - The Cal Poly Demo military accounts administrator reviews the DD250, signs off on the production batch sheet, logs the order into a spreadsheet, posts the order to the Demo's internal financial ledger, copies the DD250 for filing and sends the original DD250 to Foundation for billing.
4. Process DD250, 2nd Level - The Cal Poly Demo Director reviews and signs off the DD250.

The following table illustrates the labor hours and costs per unit for each of the defined cost elements for the Ship and Invoice hierarchy level.

Table 21: Ship & Invoice Slack & Coat					
Step	Cost Element	Calculation	Labor Hours per Unit	Labor Rate per Hour	Cost per Unit
1	Pack & Complete Shipper Paperwork	0.04 hrs/unit	0.0400	\$7.12	\$0.2848
2	Complete DD250	0.32 hrs/shipment / 500 units/shipment	0.0006	\$23.81	\$0.0152
3	Process DD250, 1 st Level	0.33 hrs/shipment / 500	0.0007	\$19.67	\$0.0130
4	Process DD250, 2 nd Level	0.08 hrs/shipment / 500	0.0002	\$78.69	\$0.0126
		Totals:	0.0400	\$7.12	\$ 0.33
			0.0006	\$23.81	
			0.0007	\$19.67	
			0.0002	\$78.69	

Note: The Labor Hours used above are estimations provided by the Demo's production manager and assistant.

During Year 3 the Demo and Company X experienced the following two problems within the Ship and Invoice hierarchy.

1. Delivery Orders – 1st Four Months Payment Problems – Reference section 4.1 – Plan & Initiate Production for documentation of this problem.
2. Short Ship Notices – The Demo has received short-ship notices for the BDU slacks from the depot. A short-ship notice is issued when the quantity received by the depot is less than the quantity called for on the Delivery Order. The problem occurred with two Delivery Orders with a balance due of 369 pair for Order #255 and 48 pair for Order #288.

To try and correct this problem the Demo instituted a double checking procedure for counting the shipment. However, even with the procedure in place the Demo continued to receive short-ship notices. The Demo's production manager believes the notices are possibly the exceptions noted on containers in supposed non-conformance. As previously discussed the Demo ships boxes with less than the contract required units per box when the Delivery Order does not call for quantities in multiples of 35 and 40. To resolve this issue the Demo worked with the DSCP manager to correct the problem.

The problems experienced in this hierarchy are summarized in the table below:

Table 22: Ship & Invoice - Problems \ Solutions		
	Problem	Solution
1	Delivery Orders -- 1 st Four Months Payment Problems	Receiving Delivery Order Schedule prior to production.
2	Short Ship Notices	Worked with the DSCP manager to investigate problem and correct it.

4.8 Labor & Cost Summary

Based on the previous sections 3.0 and 4.1 through 4.7, the below Labor Hours and Costs Summary table compiles the direct labor hours per labor grade for each hierarchy level and calculates the labor cost per unit for both the BDU slacks and coat.

Table 23: Labor Hours and Costs Summary BDU "Slacks"					
Section	Cost Element	Total Hours per Unit (per Labor Grade)	Demo Labor Rate (per Labor Grade) [Demo/Co. X]	Cost per Unit (per Labor Grade) [Demo/Co. X]	Total Cost per Unit (per Hierarchy Level) [Demo/Co. X]
3.0	Pre-Production	-----	-----	\$0.10	\$0.10
4.1	Plan & Initiate Production	0.0005	\$22.23	\$0.0111	\$0.02
		0.0002	\$23.81	\$0.0048	
4.2	Manage Raw Material Inventory	0.0056	\$7.12	\$0.0399	\$0.04

4.3	Develop Patterns & Markers	0.0014	\$10.16	\$0.0142	\$0.01
4.4	Spread, Cut and Bundle	0.0076	\$10.16/\$9.25	\$0.0772/\$0.0703	\$0.08/\$0.07
4.5	Sew, Finish and Inspect	0.3815	\$9.00/\$7.00	\$3.4335/\$2.6705	\$3.43/\$2.67
4.6	Manage Finished Goods Inventory	0.0048	\$7.12	\$0.0342	\$0.03
4.7	Ship and Invoice	0.0400	\$7.12	\$0.2848	\$0.33
		0.0006	\$23.81	\$0.0143	
		0.0007	\$19.67	\$0.0138	
		0.0002	\$78.69	\$0.0157	
	"Slacks" Total	0.4437	---	\$4.0434/3.2735	\$4.04/\$3.27

BDU "Coat"

Section	Cost Element	Total Hours per Unit (per Labor Grade)	Demo Labor Rate (per Labor Grade) [Demo/Co. X]	Cost per Unit (per Labor Grade) [Demo/Co. X]	Total Cost per Unit (per Hierarchy Level) [Demo/Co. X]
3.0	Pre-Production	----	----	\$0.10	\$0.10
4.1	Plan & Initiate Production	0.0004 0.0002	\$22.23 \$23.81	\$0.0089 \$0.0048	\$0.01
4.2	Manage Raw Material Inventory	0.0080	\$7.12	\$0.0570	\$0.06
4.3	Develop Patterns & Markers	0.0011	\$10.16	\$0.0112	\$0.01
4.4	Spread, Cut and Bundle	0.0121	\$10.16/\$9.25	\$0.1229/\$0.1119	\$0.12/\$0.11
4.5	Sew, Finish and Inspect	1.0175	\$9.00/\$7.00	\$9.1575/\$7.1225	\$9.16/\$7.12
4.6	Manage Finished Goods Inventory	0.0048	\$7.12	\$0.0342	\$0.03
4.7	Ship and Invoice	0.0400	\$7.12	\$0.2848	\$0.33
		0.0006	\$23.81	\$0.0143	
		0.0007	\$19.67	\$0.0138	
		0.0002	\$78.69	\$0.0157	
	"Coat" Total	1.0856	---	\$9.8251/\$7.7791	\$9.83/\$7.78

Note: In the Spread, Cut and Bundle and the Sew, Finish and Inspect hierarchy levels both Cal Poly Demo's and Company X's labor rates are used for cost comparison.

The next table, Cost Distribution by Hierarchy Level, illustrates the percent contribution for each hierarchy to the garment's total cost.

Table 24: Cost Distribution By Hierarchy Level BDU "Slacks"
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Section	Hierarchy Level	Demo Cost per Unit	Demo % of Total Cost	Company X Cost per Unit	Company X % of Total Cost
3.0	Pre-Production	\$0.10	2.47%	\$0.10	3.06%
4.1	Plan & Initiate Production	\$0.02	0.50%	\$0.02	0.61%
4.2	Manage Raw Materials Inventory	\$0.04	1.00%	\$0.04	1.22%
4.3	Develop Patterns & Markers	\$0.01	0.25%	\$0.01	0.31%
4.4	Spread, Cut & Bundle	\$0.08	1.98%	\$0.07	2.14%
4.5	Sew, Finish & Inspect	\$3.43	84.90%	\$2.67	81.65%
4.6	Manage Finished Goods Inventory	\$0.03	0.74%	\$0.03	0.92%
4.7	Ship & Invoice	\$0.33	8.17%	\$0.33	10.09%
	Total	\$4.04	100.00%	\$3.27	100.00%

BDU "Coat"

Section	Hierarchy Level	Demo Cost per Unit	Demo % of Total Cost	Company X Cost per Unit	Company X % of Total Cost
3.0	Pre-Production	\$0.10	1.02%	\$0.10	1.29%
4.1	Plan & Initiate Production	\$0.01	0.10%	\$0.01	0.13%
4.2	Manage Raw Materials Inventory	\$0.06	0.61%	\$0.06	0.77%
4.3	Develop Patterns & Markers	\$0.01	0.10%	\$0.01	0.13%
4.4	Spread, Cut & Bundle	\$0.12	1.22%	\$0.11	1.41%
4.5	Sew, Finish & Inspect	\$9.16	93.18%	\$7.12	91.52%
4.6	Manage Finished Goods Inventory	\$0.03	0.31%	\$0.03	0.39%
4.7	Ship & Invoice	\$0.33	3.34%	\$0.33	4.24%
	Total	\$9.83	100.00%	\$7.78	100.00%

- Demo costs are based on the Demo's labor rates.
- Company X costs are derived from using Company X's pay rates for the cut and sew hierarchy levels, sections 4.4 and 4.5, and the Demo's rates for all other levels.

The final table, Labor & Cost Distribution by Pay Grade, summarizes the labor hours spent by each pay grade in the manufacturing of the BDU garments. Also, calculated is the percent contribution of each pay grade to the garment's cost, excluding the pre-production cost of \$0.10 per garment.

**Table 25:
Labor & Cost Distribution
By Pay Grade**

BDU "Slacks"								
Position	Cal Poly Demo			Company X				
	Labor Hours per Unit	% of Total Labor Hours	Hourly Labor Rate	Total Cost per Unit	% of Total Cost	Hourly Labor Rate	Total Cost per Unit	% of Total Cost
Cal Poly Demo Director	0.0002	0.05%	\$78.69	\$0.02	0.51%	\$78.69	\$0.02	0.63%
Production Manager	0.0008	0.18%	\$23.81	\$0.02	0.51%	\$23.81	\$0.02	0.63%
Production Assistant	0.0005	0.11%	\$22.23	\$0.01	0.25%	\$22.23	\$0.01	0.32%

Accounts Administrator	0.0007	0.16%	\$19.67	\$0.01	0.25%	\$19.67	\$0.01	0.32%
Cutting Operator	0.0090	2.03%	\$10.16	\$0.09	2.28%	\$9.25	\$0.07	2.21%
Sew Operator	0.3815	86.10%	\$9.00	\$3.43	87.06%	\$7.00	\$2.67	84.23%
Production Manager's Assistant	0.0504	11.37%	\$7.12	\$0.36	9.14%	\$7.12	\$0.36	11.36%
Total	0.4431	100.00%	---	\$ 3.94	100.00%	---	\$3.17	100.00%

BDU "Coat"

Position	Labor Hours per Unit	% of Total Labor Hours	Cal Poly Demo			Company X		
			Hourly Labor Rate	Total Cost per Unit	% of Total Cost	Hourly Labor Rate	Total Cost per Unit	% of Total Cost
Cal Poly Demo Director	0.0002	0.02%	\$78.69	\$0.02	0.21%	\$78.69	\$0.02	0.26%
Production Manager	0.0008	0.07%	\$23.81	\$0.02	0.21%	\$23.81	\$0.02	0.26%
Production Assistant	0.0004	0.04%	\$22.23	\$0.01	0.10%	\$22.23	\$0.01	0.13%
Accounts Administrator	0.0007	0.06%	\$19.67	\$0.01	0.10%	\$19.67	\$0.01	0.13%
Cutting Operator	0.0132	1.22%	\$10.16	\$0.13	1.34%	\$9.25	\$0.11	1.43%
Sew Operator	1.0175	93.73%	\$9.00	\$9.16	94.14%	\$7.00	\$7.12	92.71%
Production Manager's Assistant	0.0528	4.86%	\$7.12	\$0.38	3.91%	\$7.12	\$0.38	4.95%
Total	1.0856	100.00%	---	\$ 9.73	100.01%	---	\$7.68	100.01%

- Cal Poly Demo costs are based on the Demo's labor rates.
- Company X costs are derived from using Company X's pay rates for the cut and sew hierarchy levels, sections 4.4 and 4.5, and the Demo's rates for all other levels.

5.0 Conclusions

With the All Service Maternity Battle Dress Uniform (BDU) – coat and slacks contract the Demo's objectives were two-fold:

1. Establish an initial incubator program with a West Coast manufacturer and/or contractor.
2. Document all labor hours, costs and occurrences experienced in the manufacturing of the BDU slacks and coat.

For the first objective, the Demo was successful in the recruiting of a West Coast contractor, Company X, for establishment of an incubator program. The goal of the relationship is for the Demo to guide Company X into becoming capable of bidding and winning a military apparel contract. Prior to the start of the BDU contract Company X offered only sewing and finishing services which is not sufficient to support a military contract. Because of the relationship with the Demo and the BDU contract in Year 3, Company X was exposed to the preparation, paperwork and quality level required for bidding a military contract. In September 1998 Company X took a large step to developing a full package capability by adding an automated cutting system.

For the second objective, the report in sections 3.0 and 4.1 through 4.7 documented all labor hours, costs and issues experienced in the manufacturing of the BDU slacks and coat. In section 4.8, the total labor hours and costs, excluding material costs, are summarized for each factory level and pay grade. The total manufacturing costs for the BDU garments are as follows:

	Cal Poly Demo	Company X
Slacks	\$4.04	\$3.27
Coat	\$9.83	\$7.78
<ul style="list-style-type: none"> - Cal Poly Demo costs are based on the Demo's labor rates. - Demo\Company X costs are derived from using Company X's pay rates for the cut and sew hierarchy levels, sections 4.4 and 4.5, and the Demo's rates for all other levels. 		

The majority of costs for the production of the garments are attributed to the following three factory hierarchy levels and pre-production:

Hierarchy Level	Slacks				Coat			
	Cost		%		Cost		%	
Sew, Finish & Inspect *	\$3.43	\$2.67	84.90%	81.65%	\$9.16	\$7.12	94.14%	91.52%
Ship & Invoice **	\$0.33	\$0.33	8.17%	10.09%	\$0.33	\$0.33	3.39%	4.24%
Pre-Production **	\$0.10	\$0.10	2.47%	3.06%	\$0.10	\$0.10	1.02%	1.29%
Spread, Cut & Bundle *	\$0.08	\$0.07	1.98%	2.14%	\$0.12	\$0.11	1.22%	1.41%

* Company X activity

** Demo activity

The below labor grades contribute the highest number of hours to the manufacturing of the slacks and coat.

Labor Grade	Slack		Coat	
	Labor Hours	% of Total Hours	Labor Hours	% of Total Hours
Sew Operator	0.3815	87.06%	1.0175	94.14%
Production Manager's Assistant	0.0504	9.14%	0.0528	3.91%
Cutting Operator	0.0090	2.28%	0.0132	1.34%

In Section 4.5, it is shown how the accumulation of problems experienced in the factory hierarchy levels preceding the Sew, Finish and Inspect level resulted in low sew efficiencies and proportionately higher unit costs. The sew efficiencies for the BDU garments are calculated to be as follows:

Slacks	79.71%
Coat	67.91%

For a dedicated production line these efficiencies are especially low and should be at or near 100%.

Based on the results noted, the Cal Poly Demo and Company X should focus on the resolution of the below problems:

1. Coordination of the GFM manufacturer who furnished material to be released by the user to provide ample time for inspection and reorder if found to be damaged.
2. Implementing an inventory control procedure for all trim materials.

By resolving these two main issues the avoidance of a costly production line shutdown due to lack of raw materials will be greatly reduced. In addition, sewing efficiency can be improved by:

1. Inspecting incoming materials before acceptance
2. A change in timing exact tasks (i.e. Delivery of government furnished material)
3. Analyzing batch sizes of units produced.
4. Establishing a multiple commercial vendor resource list for supply of military approved trim materials.

Appendix A

A1 Monthly Orders, Shipments and Production

In Year 3, BDU production began in March 1998 with the first delivery order due in April. The following tables show the Quartile Orders and Actual Shipment Statistics for the period of January – October 1998, Year 3. The Delivery Order Quantities are based on the Demo's Production Report (Master Production Schedule) for the BDU contract.

Slacks, Maternity BDU			
Delivery Order	Quantity	# of Shipments	Average Shipment Quantity
#255	4345	14	310
#288	4307	8	538
#309	4265	8	533
Total	11092	30	
Average	4306		370

Coat, Maternity BDU			
Delivery Order	Quantity	# of Shipments	Average Shipment Quantity
#254	4987	19	263
#287	4410	10	441
#306	5288	6	881
Total	14685	35	
Average	5667		420

Delivery Orders Filled Jan. – Oct. 1998	
Slack	11092
Coat	14685
Total	25777

Slacks, Maternity BDU								
Monthly Orders						Monthly Production		
	Delivery Order #255	Delivery Order #288	Delivery Order #309	Total Orders	Maximum Monthly Order Limit	Difference (minus,-, = less than limit: positive = over the limit)	Sewing, Units Produced	Surplus, Production minus Orders
Mar	0	0		0		n/a	1200	1200
Apr	1712			1712	1440	272	1989	277
May	175			175	1440	-1265	438	263
Jun	1806			1806	1440	366	1916	110
Jul	340	1110		1450	1440	10	2795	1345
Aug	307	3162		3469	1440	2029	2982	-487
Sep			3076	3076	1440	1636	2133	-943
Oct	5	35	1189	1229	1440	-211	2180	951
Totals	4345	4307	4265	11092		2837	15633	2716

Coat, Maternity BDU								
Monthly Orders						Monthly Production		
	Delivery Order #254	Delivery Order #287	Delivery Order #306	Total	Maximum Monthly Order Limit	Difference (minus,-, = less than limit: positive = over the limit)	Sewing, Units Produced	Surplus, Production minus Orders
Mar	0	0	0	0	N/A	N/A	130	130
Apr	210			210	1500	-1290	500	290
May	1733			1733	1500	233	1801	68
Jun	2221			2221	1500	721	1963	-258
Jul	794	899		1693	1500	193	2232	539
Aug	13	3348		3361	1500	1861	3649	288
Oct	16	163	3096	3275	1500	1775	1651	-1624
Sep			2192	2192	1500	692	3337	1145
Totals	4987	4410	5288	14685			15263	578

A2 Sewing Labor Standards

The Standard Allowed Minutes, SAMs, for the BDU coat and slack were created by Company X. The SAMs per operation were established using Time Study and are shown in the following tables:

Coat, Labor Standards						
Coat, Preparation for Production						
Step	Operation Description	Normal Minutes	PF&D, 25%	Standard Minutes	Cost/Min	Cost
1	S/N HEM POCKETS (2)	0.948	1.25	1.185	\$0.11	\$0.13
2	S/N JOIN POCKET FLAPS (2)	0.695	1.25	0.869	\$0.11	\$0.10
3	TURN POCKET FLAPS (2) & TRIM	0.279	1.25	0.349	\$0.11	\$0.04
4	S/N TOPSTITCH POCKET FLAPS 1/4"	0.582	1.25	0.728	\$0.11	\$0.08
5	SET BUTTON HOLES ON POCKET FLAPS (2)	0.274	1.25	0.343	\$0.11	\$0.04
6	S/N JOIN SLEEVE TABS (2)	0.582	1.25	0.728	\$0.11	\$0.08
7	TURN SLEEVE TABS (2)	0.278	1.25	0.348	\$0.11	\$0.04
8	S/N TOPSTITCH SLEEVE TABS 1/4"	0.441	1.25	0.551	\$0.11	\$0.06
9	SET 1 BUTTON HOLE ON SLEEVE TABS (2)	0.300	1.25	0.375	\$0.11	\$0.04
10	S/N JOIN WAIST TABS (2)	0.881	1.25	1.101	\$0.11	\$0.12
11	TURN WAIST TABS (2) & TRIM	0.526	1.25	0.658	\$0.11	\$0.07
12	S/N TOPSITITCH WAIST TABS 1/16" (2)	0.745	1.25	0.931	\$0.11	\$0.10
13	SET 2 BUTTONHOLES ON WAIST TABS (2)	0.549	1.25	0.686	\$0.11	\$0.08
14	S/N JOIN FRONT LAPEL FLAP (1)	0.256	1.25	0.320	\$0.11	\$0.04
15	TURN LAPEL FLAP (1)	0.165	1.25	0.206	\$0.11	\$0.02
16	S/N TOPSTITCH LAPEL FLAP 1/4"	0.254	1.25	0.318	\$0.11	\$0.03
17	SET 4 BUTTONHOLES ON LAPEL FLAP (1)	0.551	1.25	0.689	\$0.11	\$0.08
18	S/N JOIN & MAKE COLLAR	0.601	1.25	0.751	\$0.11	\$0.08
19	TURN COLLAR	0.184	1.25	0.230	\$0.11	\$0.03
20	BUNDLE - SEPARATE FOR FLOOR & PRODUCTION	1.030	1.25	1.288	\$0.11	\$0.14
Totals		10.121	1.25	12.651	\$0.11	\$1.39

Coat, Production						
Step	Operation Description	Normal Minutes	PF&D, 25%	Standard Minutes	Cost/Min	Cost
1	S/N TOPSTITCH LAPEL 2", OVERLOCK FRONTS	2.560	1.25	3.200	\$0.11	\$0.35
2	BUTTON HOLE (1) KEYHOLE	0.300	1.25	0.375	\$0.11	\$0.04
3	S/N SET POCKETS (2) & SET LABELS	2.267	1.25	2.834	\$0.11	\$0.31
4	FEED OFF ARM 2 PARTS UNDER SLEEVES (2)	1.170	1.25	1.463	\$0.11	\$0.16
5	S/N HEM SLEEVES	0.970	1.25	1.213	\$0.11	\$0.13
6	S/N SET FRONT INSERT FLAP, SET FLAPS & POCKETS (2) & TOPSTITCH	1.230	1.25	1.538	\$0.11	\$0.17
7	FEED OFF ARM SHOULDERS & CLOSE SLEEVES (2)	3.000	1.25	3.750	\$0.11	\$0.41

8	FEED OFF ARM SIDESEAMS	1.407	1.25	1.759	\$0.11	\$0.19
9	S/N MAKE PLEATS (8)	2.290	1.25	2.863	\$0.11	\$0.31
10	S/N BOTTOM HEM JACKET	0.933	1.25	1.166	\$0.11	\$0.13
11	S/N SET COLLAR & TOPSTITCH COMPLETE	2.660	1.25	3.325	\$0.11	\$0.37
12	MARK BUTTON (1) BARTACK COAT (9)	1.320	1.25	1.650	\$0.11	\$0.18
13	SET BUTTONS (15) ON COAT	1.330	1.25	1.663	\$0.11	\$0.18
14	UNLOAD, TRIM & INSPECT	1.502	1.25	1.878	\$0.11	\$0.21
	Totals	22.939	1.25	28.674	\$0.11	\$3.15

Coat, Preparation for Shipping						
Step	Operation Description	Normal Minutes	PF&D, 25%	Standard Minutes	Cost/Min	Cost
1	PREPARE BOX, FOLD GARMENT, TAG, CLOSE BOX & SHIP TO DEMO	0.105	1.25	0.131	\$0.11	\$0.01
	Totals	0.105	1.25	0.131	\$0.11	\$0.01

Coat, Labor Standard Summary						
		Normal Minutes	PF&D, 25%	Standard Minutes	Cost/Min	Cost
1	Preparation for Production	10.121	1.25	12.651	0.11	1.39
2	Production	22.939	1.25	28.674	0.11	3.15
3	Preparation for Shipping	0.105	1.25	0.131	0.11	0.01
	Totals	33.165	1.25	41.456	0.11	4.56
	<i>Total: Standard Hours per Unit</i>	<i>0.553</i>		<i>0.691</i>		

Slacks, Labor Standards						
Slacks, Preparation for Sewing Operations						
Step	Operation Description	Normal Minutes	PF&D, 25%	Standard Minutes	Cost/Min	Cost
1	BUNDLE - SEPARATE FLOOR PREP & LINE PRODUCTION	0.740	1.25	0.925	\$0.11	\$0.10
	Totals	0.740	1.25	0.925	\$0.11	\$0.10

Slacks, Preparation for Production						
Step	Operation Description	Normal Minutes	PF&D, 25%	Standard Minutes	Cost/Min	Cost
1	SINGLE OVERLOCK LYCRA & S/N TACK SIDE SEAMS AT LYCRA	0.850	1.25	1.063	\$0.11	\$0.12
2	FEED OFF ARM SIDESEAM	1.530	1.25	1.913	\$0.11	\$0.21
3	S/N SET PODCTES, SET FLAPS & TOPSTITCH	2.604	1.25	3.255	\$0.11	\$0.36
4	FEED OFF ARM BACK RISE & INSEAM	1.695	1.25	2.119	\$0.11	\$0.23
5	S/N SET ELEASTIC AND LABELS	2.171	1.25	2.714	\$0.11	\$0.30
6	BARTACK POSCETS (4) MARK BUTTON HOLES (12) & SET BUTTONS	0.760	1.25	0.950	\$0.11	\$0.10
7	OVER LOCK BOTTOM LEGS	0.300	1.25	0.375	\$0.11	\$0.04
8	UNLOAD FROM GERBER TRIM & INSPECT	1.030	1.25	1.288	\$0.11	\$0.14

	Totals	10.94	1.25	13.675	\$0.11	\$1.50
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Slacks, Production						
Step	Operation Description	Normal Minutes	PF&D, 25%	Standard Minutes	Cost/Min	Cost
1	S/N HEM POCKETS (2)	0.370	1.25	0.463	\$0.11	\$0.05
2	S/N JOIN FLAPS (2)	0.455	1.25	0.569	\$0.11	\$0.06
3	TURN FLAPS (2) & TRIM	0.375	1.25	0.469	\$0.11	\$0.05
4	S/N TOPSTITCH FLAPS 1/4" (2)	0.583	1.25	0.729	\$0.11	\$0.08
5	BUTTON HOLES (2) ON POCKET FLAPS (2)	0.273	1.25	0.341	\$0.11	\$0.04
6	CUT & TACK ELASTIC	0.200	1.25	0.250	\$0.11	\$0.03
	Totals	2.256	1.25	2.820	\$0.11	\$0.31

Slacks, Preparation for Shipping						
Step	Operation Description	Normal Minutes	PF&D, 25%	Standard Minutes	Cost/Min	Cost
1	PREPARE BOX, FOLD GARMENT, TAG, CLOSE BOX & SHIP TO DEMO	0.660	1.25	0.825	\$0.11	\$0.09
	Totals	0.660	1.25	0.825	\$0.11	\$0.09

Slacks, Labor Standard Summary						
		Normal Minutes	PF&D, 25%	Standard Minutes	Cost/Min	Cost
1	Preparation for Sew Operations	0.740	1.25	0.925	0.11	\$0.14
2	Preparation for Production	10.940	1.25	13.675	0.11	\$1.50
3	Production	2.256	1.25	2.820	0.11	\$0.31
4	Preparation for Shipping	0.660	1.25	0.825	0.11	\$0.09
	Totals	14.596	1.25	18.245	0.11	\$2.01
	<i>Total: Standard Hours per Unit</i>	<i>0.243</i>		<i>0.304</i>		

A3 Actual Hours Reported

Actual Hours Reported Slacks 1998			
	Hours	Units	Actual Hrs/Unit
Mar	1148	1200	
Apr	610	1989	
May	144	438	
Jun	820	1916	
Jul	1096	2795	
Aug	679	2982	
Sep	982	2133	
Oct	813	2180	
Nov	704	2703	
Totals	6996	18336	0.3815

Actual Hours Reported Coat 1998			
	Hours	Units	Actual Hrs/Unit
Mar	280	130	
Apr	1319	500	
May	2802	1801	
Jun	2906	1963	
Jul	2855	2232	
Aug	1272	3649	
Sep	1572	1651	
Oct	3407	3337	
Nov	1410	2254	
Totals	17823	17517	1.0175

A4 Finished Goods Inventory

Finished Goods Inventory Slacks	
	Quantity
Mar	1200
Apr	0
May	485
Jun	1310
Jul	2655
Aug	2168
Sep	1225
Oct	1211
Nov	1940
Totals	12194
Monthly Average	1355

Finished Goods Inventory Coat	
	Hours
Mar	130
Apr	340
May	815
Jun	444
Jul	983
Aug	1179
Sep	388
Oct	3536
Nov	5197
Totals	13012
Monthly Average	1446

A6 Delivery Schedule Example

COURT, MATERNITY, WOODLAND CAMPHILAGE
 8P0100-95-D1012/0287

NSN	SIZE	DRBY	CLIN	TOTAL	14AUC98	13SEP98	13OCT98	12NOV98
8410-01-170-7526	SR	SW3200	0001AA	400		200		200
8410-01-170-7528	309	SW3200	0002AA	100	100			
8410-01-170-7529	30R	SW3200	0003AA	900	300		300	300
8410-01-170-7531	12E	SW3200	0004AA	300		200		
8410-01-170-7532	12R	SW3200	0005AA	400		200		200
8410-01-170-7533	13L	SW3200	0006AA	300	200			
8410-01-170-7535	14R	SW3200	0007AA	200			100	200
8410-01-170-7536	14L	SW3200	0008AA	150	150			
8410-01-170-7537	16S	SW3200	0009AA	250	50	200		
8410-01-170-7538	16R	SW3200	0010AA	700	100	300	275	125
8410-01-170-7539	16L	SW3200	0011AA	50	50			
8410-01-170-7540	18S	SW3200	0012AA	50	50			
8410-01-170-7541	18R	SW3200	0013AA	350			350	
8410-01-170-7542	18L	SW3200	0014AA	200	125	75		
8410-01-201-4203	20R	SW3200	0015AA	50	50			
8410-01-201-4206	20L	SW3200	0016AA	50			50	
8410-01-201-4307	22S	SW3200	0017AA	50				50
8410-01-201-4308	22R	SW3200	0018AA	50			50	
8410-01-201-4209	22L	SW3200	0019AA	50				50
TOTALS				4500	1175	3125	1125	1325

DESTINATION: SW3200- DEFENSE DISTRIBUTION REGION WEST
 DEFENSE DISTRIBUTION DEPOT SAN JOAQUIN
 TRACY, CA 95376-5000

A7 Fabric Quality Summary

The following information was compiled by the Demo's industrial engineer:

Below is a 4-month quality summary of "First Quality" fabric received for the manufacturing of BDU Coat and Slacks.

Garment Type	Cut Date	Ticket Yards	Total Yards Damaged	% of Yards Damaged	# of Yards Short	Unusable yards %	# of Rolls	# of Rolls w/ Damage	% of Rolls w/ Damage	Avg # of unusable Yards per roll
Coat	2/26/99	1255	36	2.9%	10	3.7%	12	12	100%	3.00
	3/12/99	1681	71	4.2%	13	5.0%	15	11	73%	4.73
	3/25/99	1465	53	3.6%	13	4.5%	16	12	75%	3.31
	5/26/99	381	8	2.1%	0	2.1%	3	3	100%	2.67
	6/3/99	789	27	3.4%	0	3.4%	6	5	83%	4.50
	6/7/99	2493	107	4.3%	30	5.5%	20	19	95%	5.35
subtotals:		8064	302	3.7%	66	4.6%	72	62	86%	4.19

Pants	2/25/99	683	13	1.9%	7	2.9%	7	3	43%	1.86
	3/8/99	709	18	2.5%	0	2.5%	7	7	100%	2.57
	3/15/99	1431	37	2.6%	12	3.4%	12	8	67%	3.08
	5/11/99	1263	57	4.5%	13	5.5%	16	11	69%	3.56
	5/16/99	1693	38	2.2%	15	3.1%	15	8	53%	2.53
	subtotals:		5779	163	2.8%	47	3.6%	57	37	65%

	Ticket Yards	Total Yards Damaged	% of Yards Damaged	# of Yards Short	Unusable yards %	# of Rolls	# of Rolls W/ Damage	% of Rolls W/ Damage	Avg # of unusable Yards per roll
Summary Totals:	13843	465	3.4%	113	4.2%	129	99	77%	3.60

Though the manufacturer does not incur direct costs for unusable quantities of fabric, there are additional inherent costs to the manufacturer:

1. Damaged fabric results in fabric shortages. The manufacturer may be unable to cut the required pieces per the contract for a given pattern and quantity of fabric. This may cause delays and impact scheduling, driving increases in cost to the garment manufacturer.
2. Fabric must be cut around damaged areas causing delays in the cutting process.
3. If the garment manufacturer returns the damaged rolls per previous instructions, there would only be a minimum amount of rolls left to work with, causing significant manufacturing delays (and associated costs) and potential shortages of ready-for-issue military garments.

8/24/99