Logistics Management Institute

Operational Baseline of the MCRD-San Diego 3-D Scanner Implementation

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Introduction

PROBLEM STATEMENT

The Defense Logistics Agency (DLA) asked LMI to conduct an operational and economic analysis of a proposed three-dimensional (3-D) body scanner at the Marine Corps Recruit Depot in San Diego (MCRD-SD). The proposed scanner would replace hand measurement in determining which sizes of dress uniforms to issue to recruits. The key questions in this study are as follows:

- How is dress clothing issued to recruits?

- How fast is the scanner?

- How accurate is the scanner?

- Do the speed and accuracy of the scanner lead to operational benefits for the Marines that will offset the cost of purchasing and maintaining the scanner?

Our findings are presented in three reports. This report, which is the first of the three, addresses the first three key questions. It presents an operational baseline of the recruit dress clothing issuance process with and without the proposed 3-D body scanner at MCRD-SD. The second report updates the scanner processing times and accuracy rates, and the third report presents our economic and operational feasibility analysis.

BACKGROUND

The military distributes clothing to new recruits through a multi-echelon supply chain. Private-sector manufacturers sell clothing to the DLA. The DLA operates a series of wholesale warehouses (although some items are delivered directly to retail from the manufacturer). The military services—in this case the Marines—operate retail warehouses at recruit training centers. Recruits come to receive their clothing at issue lines associated with these retail warehouses.[1]

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[1] See Eric L. Gentsch and Jack J. Vandenberghe, *Metrics for the Apparel Research Network* (2 volumes), Logistics Management Institute, Reports DL701T1 and DL702T2, August 1997. "Volume 1: The Defense Apparel Business" provides overall measures of cost, quality, and lead-time.

The Marines operate one recruit training center at Parris Island, South Carolina (MCRD-PI), and another at San Diego, California (MCRD-SD). Each center receives approximately 20,000 recruits per year. Parris Island handles male and female recruits; San Diego handles male recruits only. Each recruit receives about 30 different items of clothing, with a total value of about $1,000.

For several years, the Marines and the DLA have been working on a series of projects to improve the flow of clothing through the supply chain, reduce inventory, and reduce the number of stockouts and back-orders that occur at the recruit centers. One of these projects, funded by the DLA, has been the development of a 3-D body scanner to replace hand measurement. With the 3-D scanner ready for prove-out, MCRD-SD agreed to use the scanner on a trial basis.

The 3-D scanner uses lasers to form a computer image of the subject's body, complete with outside dimensions. With these dimensions, software algorithms predict the sizes necessary for fitting garments (e.g., crown, neck, sleeve, chest, waist, and inseam measurements). Traditionally, these measurements have been taken manually with a measuring tape by a civilian Marine employee and written on paper.

During initial use, the Marines found the 3-D scanner to be more accurate but slower than hand measurement. Because of the recruits' tight training schedule, the Marines' requirement is that the total issue process using the scanner must take no longer than the process using hand measurement. Indeed, if the scanner process could be made faster than the hand measurement process, the clothing operation could "give back" time to the overall schedule, making the recruits' training more productive.

Because the scanner was believed to be slower but more accurate, its overall impact was uncertain. Inaccurate measurements mean that recruits must repeatedly change into and out of the garments they are issued until they find the right size. Thus, although scanning a recruit takes longer than measuring by hand, the fact that scanned recruits spend less time changing than hand-measured recruits implies that the scanner's overall impact on total issue time could be beneficial.

We made three visits to MCRD-SD between December 1999 and February 2000. With the cooperation of the Marines and Cyberware (the scanner vendor), we interviewed issue line personnel, observed the measurement and clothing issue processes, and collected data on hand measurement and 3-D scanner processes.

The remainder of this report presents our operational baseline of dress clothing issuance with and without the 3-D scanner. The baseline operational analysis section describes the layout, flow, and key processing and throughput times of the current issue process, using hand measurement.[2] The alterations process description section details the tailoring process and related throughput times and accuracy rates. Finally, the 3-D scanner operational analysis section examines the impact of the scanner as currently implemented.

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[2] For an excellent qualitative description of MCRD-SD's clothing issue process, see Addleman, *Automating Information Extraction from Three-Dimensional Scan Data, Garment Issue As-Is Report.*

Chapter 2
Baseline Operational Analysis

To effectively estimate the potential benefits of 3-D scanning implementation, one must first understand the current clothing issue process. On several visits to MCRD-SD, we were able to observe this process first-hand and collect statistics on process times and accuracy. By assembling these data, we were able to characterize the process and establish a baseline from which the impact of process changes enabled by the 3-D scanner could be measured.
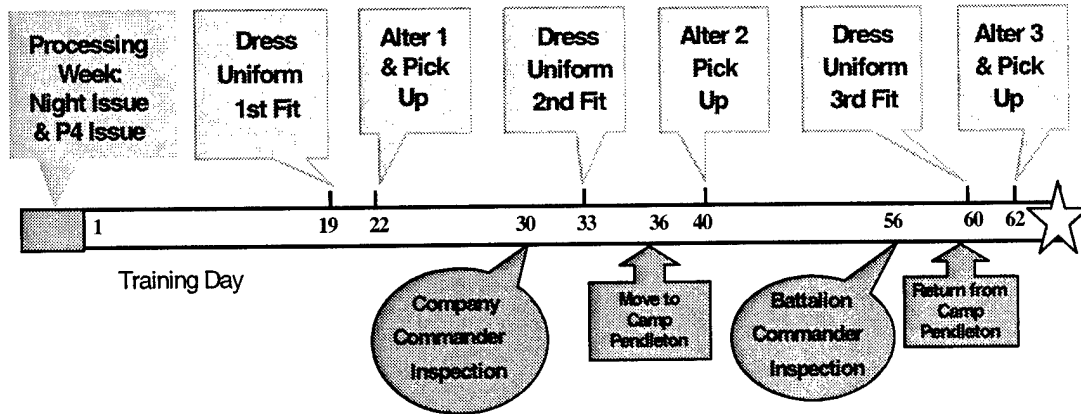
RECRUIT TRAINING SCHEDULE

The first week that Marine recruits arrive at MCRD-SD is "processing week," when new recruits arrive and are processed into the Marine Corps. (Processing week is the week prior to the beginning of formal training.) During processing week, recruits are issued the minimal amount of clothing required for the first three weeks of training. Clothing issue during this week occurs during two events—Night Issue and P4 Issue. No recruit measurements (except for shoe size, if necessary) are taken at these times.

The formal training process takes 13 weeks. At MCRD-SD, new recruits start formal training almost every week of the year. The number of recruits in training is seasonal; the peak load is in the summer months, and the lightest load is around the winter holidays.

Issuance of individual dress clothing and first alteration occurs in the third week of training—on training day 19 or 20 (T19/20). For this first issue and fit, recruits are measured individually for clothing size estimates, receive clothing, and see a tailor for alteration mark-up. Subsequent to T19/20, two additional dress uniform fitting and alteration cycles occur during the remainder of the training cycle; these fittings occur on T33 and T60. Figure 2-1 depicts a timeline of the 13-week training schedule, with recruit clothing events highlighted.

Figure 2-1. Clothing Events During Marine Recruit Training

WEEKLY CLOTHING OPERATIONS

Clothing organization operations at MCRD-SD typically follow a consistent weekly schedule as new recruit platoons are formed and begin formal training. T19/20 clothing issue and fit is scheduled for Tuesday and Wednesday of each week. Other MCRD-SD clothing operation activities include processing week issues (Night Issue and P4 Issue), second and third dress fit and alterations, clothing turn-in and pick-up for alterations, inventory restocking, and various other duties. Figure 2-2 shows the weekly issue schedule, by day—including how many boardmen and fitters are involved in each operation (100 percent represents one person). Note that considerable time blocks are not formally allocated to issue operations but that boardmen and fitters spend part of these periods stocking and counting inventory, cleaning, and doing paperwork.

Figure 2-2. MCRD-SD Clothing Operations Weekly Schedule

Figure 2-2. MCRD-SD Clothing Operations Weekly Schedule
(continued)

MCRD Weekly Issue Schedule

ID	Task Name	6	7	8	9	10	11	12	1	2	3	4	5	6	7	8	9
16	Thursday																
17	Unallocated																
18	P4: Training Uniform										Fitters[400%]					
19	T33: 2nd Fit									Board Men[300%]						
20	Friday																
21	T22: Pickup & Go, 1st Fit				Board Men[300%]											
22	Unallocated																
23	T34: 2nd Fit							Board Men[300%]								
24	T40: Pickup of 2nd Fit by Bn S-																
25	Unallocated																
26	Other Duties																
27	Re-stock Inventory																
28	Count Inventory																
29	Cleanup																
30	Misc. Paperwork																
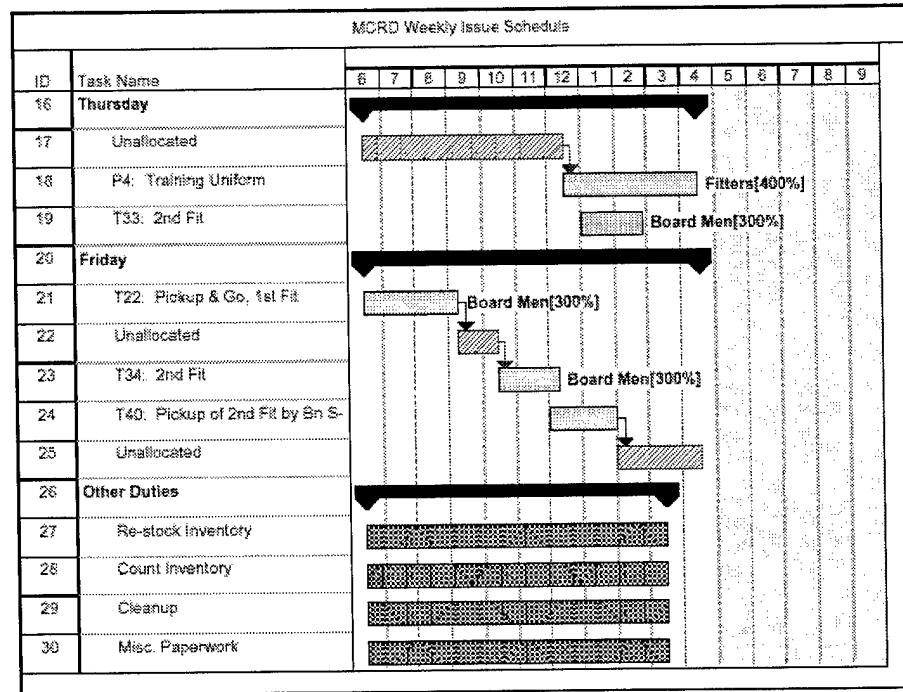
T19/20 CLOTHING ISSUE AND FIT

Three major activities make up T19/20 uniform issue and fit: measurement/sizing, clothing issue, and alterations/tailoring. The training regiment at MCRD-SD has allocated the clothing operations organization 5 hours, 50 minutes—from 0630 to 1220—to complete these activities. This time allotment corresponds to approximately one recruit processed per minute during the peak summer load, when clothing is issued to approximately 350 recruits per day.

◆ *Measurement/sizing.* Individual recruits are hand-measured for clothing size estimates. The Marine Corps is considering replacing this measurement, which is performed by clothing operation personnel, with measurement by the 3-D scanner. This activity also includes a period of time for orientation and instructions.

◆ *Clothing issue to recruit.* Recruits are issued clothing according to size estimates generated by the measurement/sizing activity.

◆ *Alterations/tailoring.* A tailor assesses the fit of three dress garments that have been issued to the recruit—the dress coat, green dress trouser, and blue dress trouser. The tailor sees each recruit wearing each garment and makes alteration markings according to his judgment of proper garment fit. The garment is then collected and sent off-base for alterations.

HAND MEASUREMENT AND SIZING PROCESS DESCRIPTION

On day T19/20, recruits arrive by platoon at approximately 0630 at Alterations Building 220, where the measurement and alterations processes take place (a layout of Building 220 appears in Figure 2-3). The first platoon to arrive is assigned as the work platoon for that day. The work platoon is sent to Clothing Issue Building 221, where its recruits are dispersed among the issuing process stations and issue line inventory locations. The work platoon assists in clothing issue, restocking, guiding recruits through the building, cleanup, and various other duties as needed by the clothing operation personnel. Platoons that arrive after the work platoon assemble in one of the four alterations bays in Building 220. One of the MCRD-SD clothing operations personnel is assigned to each bay as the "boardman." Upon arrival at the alterations bay, each platoon is released by its drill instructor to the boardman, who will guide the platoon through the measurement and alterations processes.

Figure 2-3. Alterations Building 220

Approx. 9000 sqft.

▨ = Tailor Platform   ▬▬▬ = Station Tables   ▢ = Boardman Station
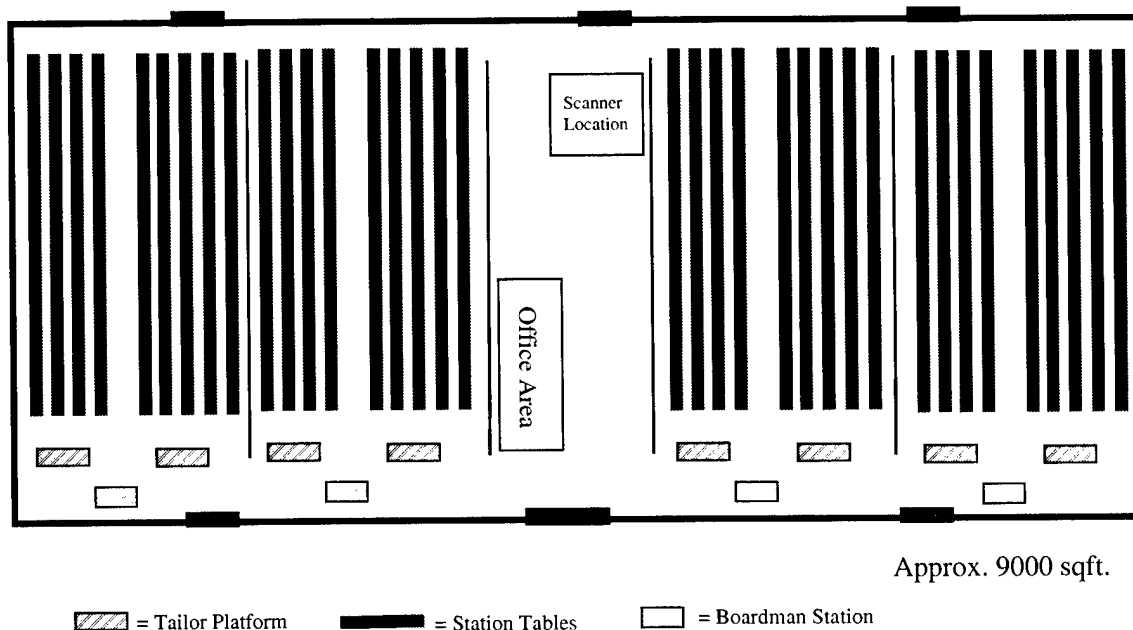
The boardman begins by addressing the platoon(s) assembled in his bay and providing instructions on the clothing issue process and the preparation of required paperwork. After the instructions are given, the recruits line up for measurement at tailoring stands in the front of the alterations bay. Each recruit steps up onto the tailoring stand, and the boadman measures the recruit's crown, neck, sleeve, chest, and waist with a standard tape measure. Each of these measurements is called out by the boardman to a platoon scribe, who writes down the recruit's

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measurements on a "chit" sheet. The chit is then handed to the recruit, who will use it later for size selection on the clothing garment issue line. Recruits wait in the bay until each member of the platoon has been hand-measured; hence, we refer to this as a batch process. The platoon is then released to receive their garments in Building 221.

HAND MEASUREMENT DATA COLLECTED

We divided the hand measurement process into three subtasks: boardman instruction, measurement, and platoon re-assembly. By observing the activities associated with each subtask, we determined the average duration of each.

◆ *Boardman instruction.* The elapsed time from scheduled clothing issue start (0630) until the platoon lines up for hand measurement.

◆ *Measurement.* The elapsed time from when a recruit steps on the tailoring platform to have his measurement taken until the recruit steps off the platform. Adding these times and then dividing by the number of recruits gives an average time to measure an individual recruit.

◆ *Platoon re-assembly.* The elapsed time from when the last recruit in the platoon steps off the tailoring platform until the whole platoon is released to the clothing issue activity in Building 221.

The following table summarizes the data that we collected for each of the subtasks in the hand measurement activity.

Table 2-1. Hand Measurement Activities Data

| Activity	Observations	Average	Std. dev.
Boardman instruction	4 platoons	18:14 min.	6:57 min
Individual measurement	81 recruits	0:24 min.	8 sec.
Re-assemble	1 platoon	8:00 min.	

CLOTHING ISSUE PROCESS DESCRIPTION

After the measurement activity is complete, the platoon walks over to the Clothing Issue Building 221. In this building, each recruit is issued a specified quantity of the following items:

◆ Dress shoes

◆ Dress shirt (long sleeve and short sleeve)

◆ Dress trousers (green and blue)

◆ Pull-over sweater

◆ Battle dress uniform (BDU) coat and trousers

◆ All-weather dress coat

◆ Cap, cover, and frame

◆ Gloves

◆ Insignias.

Figure 2-4 illustrates the layout of Building 221 and the relative location of the issue line inventory. As the recruit enters the building, he is issued dress shoes, based on the size of the sneakers he was issued during processing week. A fitter checks the fit of the shoe at the shoe fitting station. If the fitter judges the shoe to be adequate, the recruit proceeds down the issue line. If the fit is inadequate, the recruit returns to the dress shoe issue area and exchanges the pair in hand for a different size. This process is repeated until the recruit receives a pair of dress shoes that are judged to fit properly.

Figure 2-4. Clothing Issue Building 221
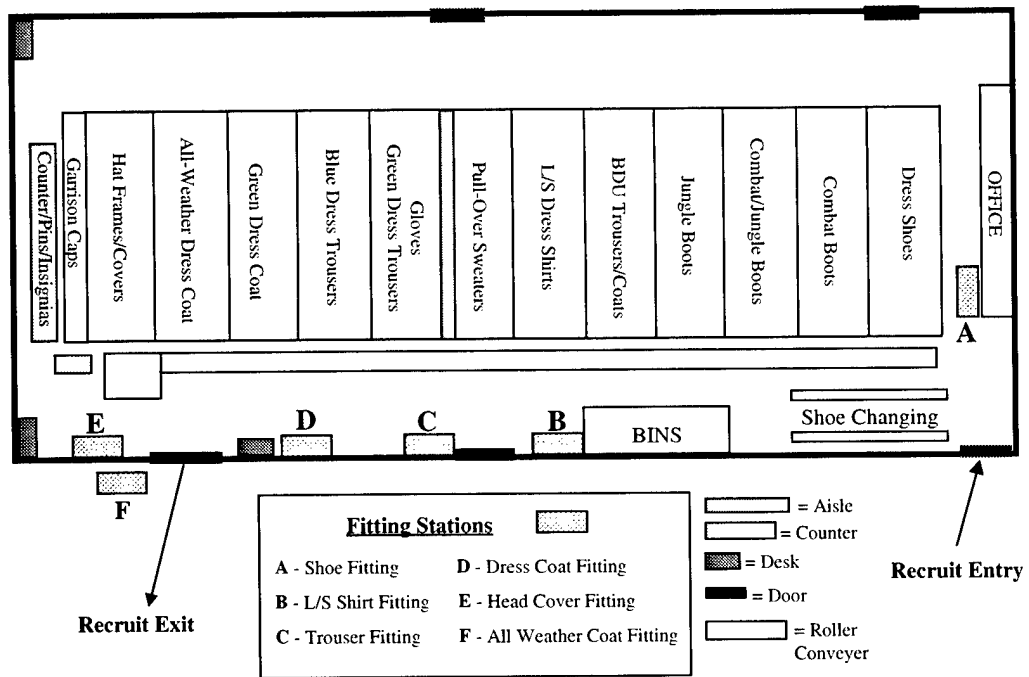
After the recruit receives his dress shoes, he is given a gray bin to collect and carry the garments he is issued. These bins are rolled down the issue line along the roller conveyor as the recruit proceeds through the issue process. There are six fitting stations (similar to the dress shoe fitting station) along the issue line, where selected garments are assessed for proper fit by a fitter. The garments are issued

to recruits in the order of the inventory location on the issue line (as depicted in Figure 2-3), from entry point to exit point.

CLOTHING ISSUE PROCESS DATA

We collected statistics on each fitting station to estimate the accuracy of data taken from the hand-measurement process in predicting correct garment size and the average time required to issue garments to individual recruits on the issue line. To estimate hand measurement accuracy, we counted "go" and "no-go" decisions by the fitter(s) at the issue stations. A "go" is defined as follows: The fitter assesses the recruit's garment as having a proper fit and instructs the recruit to proceed to the next issue station. A "no-go" is defined as follows: A fitter assesses the garment as having an improper fit and instructs the recruit to return to the garment issue station to exchange it for a different-sized garment. The number of "go" decisions as a percentage of the overall number of fitter assessments ("go" + "no-go") provides an indication of the accuracy of the initial measurement.

We also observed and estimated the average "loop time" associated with each fitting station. Loop time is defined as the time required for the recruit to step off the fitting station platform after a "no-go" decision, return to the issue station for garment exchange, and return to the platform for re-assessment by the fitter.

Tables 2-2 through 2-9 present the data we collected for accuracy and loop time at the six fitting stations.

Table 2-2. Shirt Station—Accuracy

Activity	Observations	Go	No-go	Percentage
Shirt fitting	244 fittings	122	122	50%

Table 2-3. Shirt Station—Loop Time

Activity	Observations	Average time	Std. dev.
Shirt return loop	55 returns	2:01 min.	1:01 min

Table 2-4. Trouser Station—Accuracy

Activity	Observations	Go	No-go	Percentage
Trouser fitting	243 fittings	155	88	64%

Table 2-5. Trouser Station—Loop Time

Activity	Observations	Average time	Std. dev.
Trouser return loop	20 returns	2:12 min.	1:09 min

Table 2-6. Dress Coat Station—Accuracy

Activity	Observations	Go	No-go	Percentage
Dress coat fitting	180 fittings	100	80	56%

Table 2-7. Dress Coat Station–Loop Time

Activity	Observations	Average time	Std. dev.
Dress coat return loop	79 returns	1:41 min.	0:45 min

Table 2-8. Other Stations—Accuracy

Activity	Observations	Go	No-go	Percentage
Shoe fitting	112 fittings	100	12	89%
AW coat fitting	17 fittings	12	5	71%
Frame/cover fitting	34 fittings	19	15	56%

Table 2-9. Other Stations—Loop Time

Activity	Observations	Average time	Std. dev.
Shoe return loop	24	5:50 min.	1:52 min.
AW coat return loop	5	2:01 min.	0:45 min.
Frame/cover return loop	15	0:06 min.	0:03 min.

TOTAL RECRUIT ISSUE LINE PROCESS TIME

We collected data to estimate the average time required for a recruit to complete the issue line process. This estimate captures the time required for a recruit to enter Building 221; proceed down the issue line, collecting required items; be assessed at each fitting station; and exit the building. Table 2-10 presents the results.

Table 2-10. Average Recruit Issue Process Time

Activity	Observations	Average time	Std. dev.
Individual issue process time	25 recruits	47:44 min.	5:27 min.

Chapter 3
Alterations Process Description

After clothing issue, each recruit returns to the original bay in the alterations building. The recruit is carrying his gray bin and wearing a long-sleeve dress shirt, green dress trousers, and dress coat in preparation for seeing the tailor. The alteration process for a platoon does not start until all of the recruits from that platoon are re-assembled in the alterations bay. Once they are assembled, the boardman gives instructions to the platoon(s) on the tailoring process and the proper tagging of garments for alterations. After the instructions are given, the recruits line up at the tailoring stand for assessment by the tailor and mark-up of the garment.

The alterations process consists of three tailoring cycles—one cycle each for the dress coat, the dress green trousers, and the dress blue trousers. The dress coat is tailored first. Recruits step on the tailor platform, where the tailor marks up the coat for alterations. The recruit then steps off the platform, removes the dress coat, and proceeds to the boardman for alteration recording. The boardman creates a written record of the alterations required for each garment. The recruit then turns the coat in and returns to the end of the tailoring line for dress trouser tailoring.

Essentially, the same mark-up and turn-in process is repeated for the dress green and dress blue trousers. The dress shirt is also altered if the fitter indicated to the recruit that the top button or sleeve length needs adjustment; we did not observe any recruits who needed alterations to their dress shirt. In addition to the dress clothing alterations, recruits tag and turn in the BDUs that they have just been issued so the tailors can attach their nameplates. After all garments to be tailored are turned in, the recruits put on their original BDUs, pack their sea bag with items that were not turned in for alterations, and receive final instructions from the boardman. The platoons are then returned to their drill instructors.

The alterations process can be broken down into the following four subtasks:

- ◆ Boardman initial instruction

- ◆ Alteration mark-up

- ◆ Garment turn-in

- ◆ Final instruction/release to drill instructor.

We observed activities associated with these subtasks to estimate the time required for each. Table 3-1 summarizes the results of these observations.

Table 3-1. Alterations Process Time Data

Activity	Observations	Average time	Std. dev.
Alt. boardman instructions	4 platoons	13:48 min.	6:49 min.
Dress coat alteration	8 platoons	19:05 min.	4:23 min
Green trouser alteration	8 platoons	7:46 min.	4:37 min
Blue trouser alteration	8 platoons	8:51 min.	3:34 min.
Finish garment turn-in	6 platoons	11:17 min.	6:13 min
Final instruction	6 platoons	23:13 min.	16:04 min
Total		1 hr. 24 min.	

The average time shown in Table 3-1 is an estimate of the average time required for a platoon to complete that garment alteration cycle. These cycles include the time the recruit stands in line waiting for the tailor. In the case of the blue trousers, it also includes the time required for the recruit to put on the blue trousers.

In addition to the time for each alteration process, we collected data to estimate the accuracy of fitters on the issue line. If a tailor judges that a different-sized garment would provide a better fit, the recruit is sent back to the clothing issue building to exchange the garment. The number of times recruits are sent back for a different-sized garment provides an indication of the accuracy of the issue line fitter. Table 3-2 presents the results of our observations on fitter accuracy.

Table 3-2. Fitter Accuracy

Garment	Observations	Returns	Accuracy
Dress coat	283 recruits	75	74%
Green trouser	283 recruits	3	99%
Blue trouser	283 recruits	8	97%

MCRD-SD provided additional statistics regarding the annual number of alterations and relative annual costs associated with each of the three scheduled fittings (Table 3-3).

Table 3-3. Annual Alterations Costs

Fitting	Annual # of alterations	Percentage of alterations budget
First	194,000	83%
Second	22,000	5%
Third	34,000	11%

Chapter 4
3-D Scanning Measurement Process

We next observed the T19/20 clothing issue process with the 3-D scanner predicting garment sizes in lieu of the hand measurement activity. Few physical changes were made to the clothing issue process to accommodate the 3-D scanner. We did observe one major difference, however: The measurement process had changed from a batch process to a serial process. That is, after boardman instruction, the recruits lined up at the scanner, were scanned, and proceeded to the clothing issue building. Recruits did not wait for the rest of their platoon to be scanned and assembled before proceeding to the clothing issue building. Other than this change, the rest of the clothing issue activity was physically similar to the process associated with hand measurement.

3-D SCANNER DATA

We estimated 3-D scanner measurement accuracy by comparing the size prediction of the 3-D scanner with the actual garment size that was finally issued to the recruit. We accomplished this comparison by collecting scanner-generated chits after the clothing issue and alterations processes were completed. Prior to turning in the chits, recruits were instructed to note any garment for which the size they were issued differed from the scanner-predicted size for the garment on their chit sheets.

We collected accuracy data by comparing the number of garment sizes that the scanner correctly predicted with the total number of garment predictions. Table 4-1 shows scanner accuracy in predicting sizes for five of the garments. (The scanner does not predict shoe size.)

Table 4-1. Scanner Accuracy Rates

Garment	Observations	Errors	Accuracy
Dress shirt	157	57	64%
Dress trouser	157	35	78%
Dress coat	157	71	55%
Cap/frame	157	38	76%
All-weather coat	157	23	85%

The chits also provided time stamps indicating when they were printed and issued to the recruit before he proceeded to the clothing issue line. This time stamp allowed us to collect two other statistics:

◆ The time required to successfully scan an individual recruit

◆ The total time for an individual, scanned recruit to pass through the clothing issue line (when the time an individual recruit leaves the clothing issue process is recorded).

We observed that the average time for the scanner to scan the recruit and print out a chit with size predictions was 48 seconds. Table 4-2 presents data regarding the average time for a scanned recruit to pass through the clothing issue process.

Table 4-2. Scanned Recruit Issue Process Time

Activity	Observations	Average time	Std. dev.
Scanned recruit issue time	82	29:29 min	12:10 min.

SUMMARY

Table 4-3 summarizes the data we collected for comparison of the hand measurement and 3-D scanner measurement processes.

Table 4-3. Comparison of Time and Accuracy Data

Activity	As-is	Scanner
Individual measurement time	24 sec.	48 sec.
Accuracy		
Shoes	89%	89%
Shirt	50%	64%
Trousers	64%	78%
Dress coat	56%	55%
Cap/frame	56%	76%
All-weather coat	71%	85%
Issue process entry	Batch	Serial
Individual time for issue	47:44 min.	29:29 min.

Note: At the time of our observations, the scanner did not predict shoe size.

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REPORT DOCUMENTATION PAGE

Public reporting burden for this collection of information is estimated to average 1 hour per response, including the time for reviewing instructions, searching existing data sources gathering, and maintaining the data needed, and reviewing the collection of information. Send comments regarding this burden estimate or any other aspect of this collection of information, including suggestions for reducing this burden, to Washington Headquarters Services, Directorate for Information Operations and Reports, 1215 Jefferson Davis Highway, Suite 1204, Arlington, VA 22202-4302, and to the Office of Information and Regulatory Affairs, Office of Management and Budget, Washington, DC 20503.

1. AGENCY USE ONLY *(Leave Blank)*	2. REPORT DATE May 00	3. REPORT TYPE AND DATES COVERED Final

4. TITLE AND SUBTITLE

Operational Baseline of the MCRD-San Diego 3-D Scanner Implementation

5. FUNDING NUMBERS

C DASWO1 99 F3309

PE 0902198D

6. AUTHOR(S)

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7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES)

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8. PERFORMING ORGANIZATION REPORT NUMBER

LMI– DL007T1

9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES)

Mr. Donald O' Brien, Chief, Technical Enterprise Team
Defense Logistics Agency
725 John Kingman Road, Room 3135
Fort Belvoir, VA 22060-6221

10. SPONSORING/MONITORING AGENCY REPORT NUMBER

11. SUPPLEMENTARY NOTES

12a. DISTRIBUTION/AVAILABILITY STATEMENT

A: Approved for public release; distribution unlimited

12b. DISTRIBUTION CODE

13. ABSTRACT *(Maximum 200 words)*

The Marines and the DLA have been working on a series of projects to improve the flow of clothing through the supply chain, reduce inventory, and reduce the number of stockouts and back-orders that occur at the recruit centers. One of these projects, funded by the DLA, has been the development of a 3-D body scanner to replace hand measurement. With the 3-D scanner ready for prove-out, MCRD-SD agreed to use the scanner on a trial basis.

The DLA asked LMI to conduct an operational and economic analysis of the proposed 3-D body scanner at the MCRD-SD. This report, which is the first of three, presents an operational baseline of the recruit dress clothing issuance process with and without the proposed 3-D body scanner. We describe the recruit dress clothing issuance process and provide data on the speed and accuracy of the process with and without the scanner.

14. SUBJECT TERMS
apparel research, Marine Corps clothing, 3-D scanner

15. NUMBER OF PAGES
24

16. PRICE CODE

17. SECURITY CLASSIFICATION OF REPORT	18. SECURITY CLASSIFICATION OF THIS PAGE	19. SECURITY CLASSIFICATION OF ABSTRACT	20. LIMITATION OF ABSTRACT
Unclassified	Unclassified	Unclassified	UL