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SIMULATION OF DEFENSE DISTRIBUTION  
REGION WEST (DDRW) REGIONAL FREIGHT  
CONSOLIDATION CENTER (RFCC)

February 1992

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REGION WEST (DDRW) REGIONAL FREIGHT  
CONSOLIDATION CENTER (RFCC)**

**February 1992**

**Capt David Bertrand, USAF**

**DEPARTMENT OF DEFENSE  
DEFENSE LOGISTICS AGENCY  
OPERATIONS RESEARCH AND ECONOMIC ANALYSIS OFFICE  
CAMERON STATION  
ALEXANDRIA, VA 22304-6100**



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FOREWORD

This report presents the results of a simulation analysis of the proposed mechanization design of the Regional Freight Consolidation Center (RFCC) at the San Joaquin site of the Defense Logistics Agency (DLA) Defense Distribution Region West (DDRW). An increase in expected workload at that site due to depot consolidation, along with the addition of Consolidation and Containerization Point (CCP) functions to the RFCC, have caused extensive changes to the design. The purpose of this analysis was to evaluate the mechanization design, identify any design problems, and recommend solutions or possible improvements.

Three major areas of concern were identified in the analysis. First, expected value analysis showed two automated guided vehicles (AGVs) could not handle the workload from the palletization stations. The AGV path was redesigned to allow four vehicles. The second problem was inadequate throughput capacity at parcel data collection. Expected value and simulation analysis of this area indicated the number of workstations should be increased from six to nine. The third area of concern involved the assignment of lines to customers on the main carton sorter. The simulation demonstrated this assignment was critical to the efficient operation of the sortation system. Therefore, the person making these assignments must be well trained, and decision aids should be developed to support this critical task.

  
 ROGER C. ROY  
 Assistant Director  
 Office of Policy and Plans



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sufficient for the workload. Two recommendations were made to solve this problem. First, a ninth station should be added to further spread the workload. Second, the control mechanism directing cartons to the stations should have the ability to recognize when a queue is full and stop directing cartons to that station until the queue is reduced.

In addition to data collection, another area of concern was the assignment of customers to sortlines. On one simulated workday, the system became overloaded because a single customer received a very large amount of material. No change was required to the mechanization system because the problem could be solved by allocating an additional sort line to that customer. This points out the extreme importance of properly allocating the lines on the carton sorter. It is critical that the person making these allocations be well trained, have accurate information on the day's workload, and have well designed decision aides to assist in this task. Development of such decision aids should be given a high priority.

In summary, the system is generally well designed. Incorporating the recommendations from the expected value and simulation analyses should ensure the DDRW RFCC can process the expected workload. Assignment of sortlines is an important factor which should be given considerable attention both before and during system implementation.

## EXECUTIVE SUMMARY

This analysis evaluates the mechanization design of the Regional Freight Consolidation Center (RFCC) at the San Joaquin site of Defense Logistics Agency (DLA) Defense Distribution Region West (DDRW). It is an update and extension of an earlier study, "Enhanced DLA Distribution System (EDDS) Freight Terminal Simulation Analysis," DLA-90-P90094, completed in January 1990, which simulated the terminal design at each of six DLA depots. These EDDS terminals, now called RFCCs, will act as the hubs of a hub-and-spoke distribution system. Recently, a significant increase in expected workload at the San Joaquin site due to depot consolidation, as well as the addition of Consolidation and Containerization Point (CCP) functions, have caused an extensive redesign of the RFCC at that site. The purpose of this analysis was to evaluate the mechanization design using the best workload estimates available, identify bottlenecks or other design problems, and recommend solutions or possible improvements.

The first step in evaluating the design was to perform an expected value analysis based on the estimated workload. Workload estimates for the various types of material entering the system were developed by the Depot Operations Support Office (DOSO) in coordination with the DLA Depot Consolidation Office. They were based in part on the results of the EDDS study cited above. This workload was used to determine how many times per day specific processes in the system needed to be performed. When multiplied by the time required to perform the action, and compared to a 7.5 hour workday, this indicated where the system had insufficient capacity. Based on this preliminary analysis, three changes were made: carton data collection was increased from 6 to 8 stations, the number of automated guided vehicles (AGVs) was increased from 2 to 4, and the number of lines at the Air Lines of Communication (ALOC) sorter was increased from 10 to 15.

Before the simulation could be done, the estimated workload needed to be linked to specific customer destinations. However, there was not sufficient data available to identify the customer mix for the consolidated San Joaquin site, so data from the EDDS study was used. Although this would provide sufficient accuracy for testing the mechanization system, the specific customer names taken from the EDDS study may not correspond to the customers that will be served by the consolidated site. For this reason, names of customers identified in this study should be considered notional. Once the workload by customer was developed, the simulation model of the mechanization system was built, debugged, and validated by matching to the estimated workload. The model was then run for three replications of ten simulated workdays each. Statistics were collected from each run and analyzed to develop the simulation results.

Simulation results identified a significant problem at the carton data collection stations. Due to the large variance in the service times of different types of material being processed, queues at these stations would occasionally exceed the available space even though overall capacity was

**DDRW  
REGIONAL FREIGHT  
CONSOLIDATION CENTER**

**SIMULATION ANALYSIS**

**CAPT DAVE BERTRAND  
DLA-DORO**

PROJECT BACKGROUND

- HQ DLA-OT AND -OW REQUESTED ANALYSIS OF PROPOSED RFCC AT SAN JOAQUIN
  - EARLIER PROJECT ANALYZED EDDS (NOW RFCC) DESIGNS AT THE 6 DLA DEPOTS
  - SYSTEM AT THE SAN JOAQUIN (FORMERLY DDTC) SITE COMPLETELY REDESIGNED
    - CONSOLIDATION OF BAY AREA DEPOTS HAS SIGNIFICANTLY INCREASED WORKLOAD
    - CCP OPERATIONS WILL BE COMBINED WITH THE RFCC, USING THE SAME FACILITY
- PURPOSE OF THE ANALYSIS: EVALUATE THE MECHANIZATION DESIGN OF THE DDRW RFCC
  - DEVELOP WORKLOAD DATA FOR THE RFCC AND CCP OPERATIONS
  - CREATE A SIMULATION MODEL OF THE DDRW RFCC MECHANIZATION SYSTEM
  - IDENTIFY PROBLEMS OR POSSIBLE IMPROVEMENTS BASED ON SIMULATION RESULTS
  - RECOMMEND DESIGN CHANGES WHERE APPROPRIATE

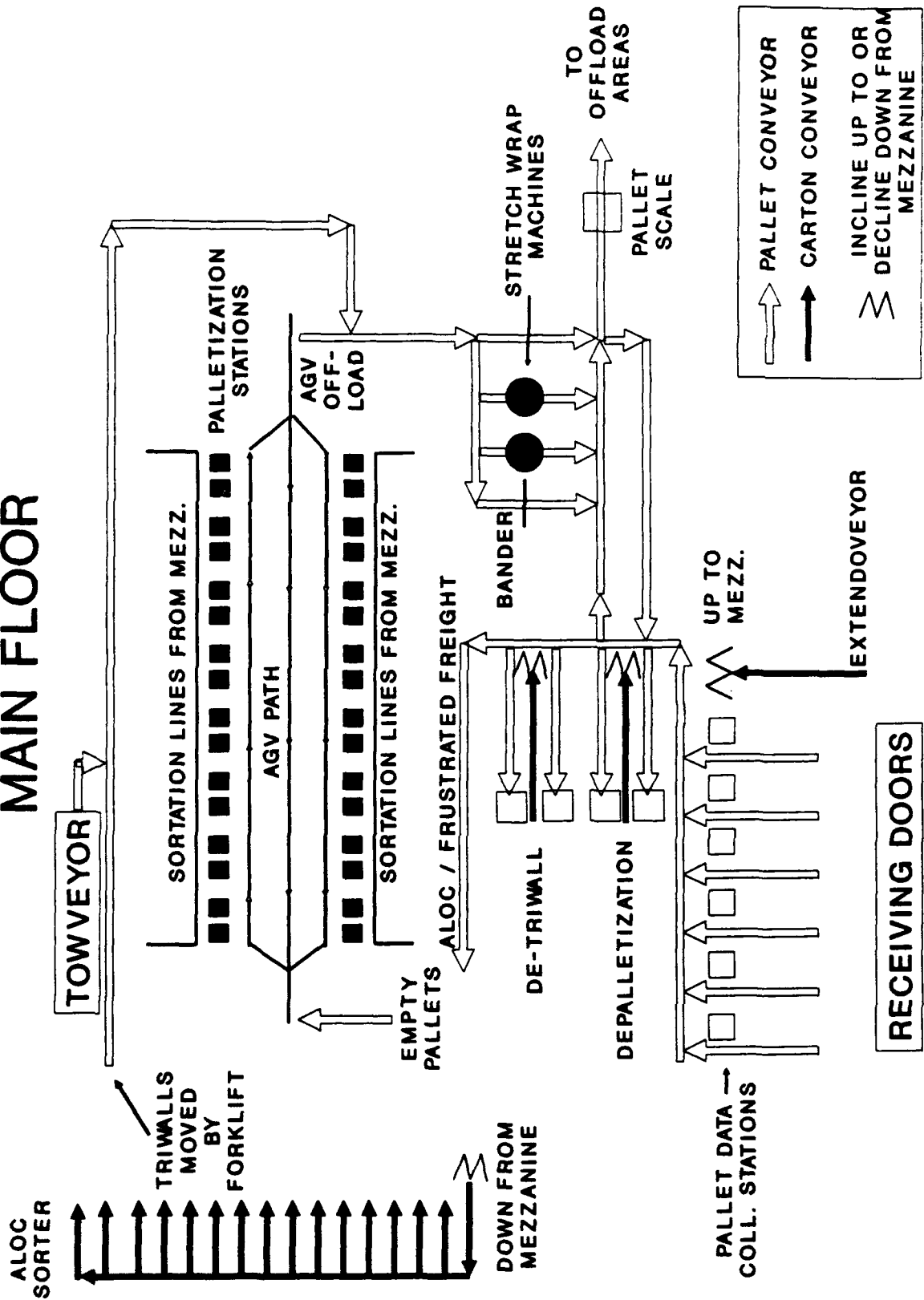
# OVERVIEW

- **DDRW RFCC/CCP SYSTEM DESIGN**
- **SCOPE & ASSUMPTIONS**
- **METHODOLOGY**
- **MODEL PARAMETERS**
- **RESULTS**
- **CONCLUSIONS & RECOMMENDATIONS**



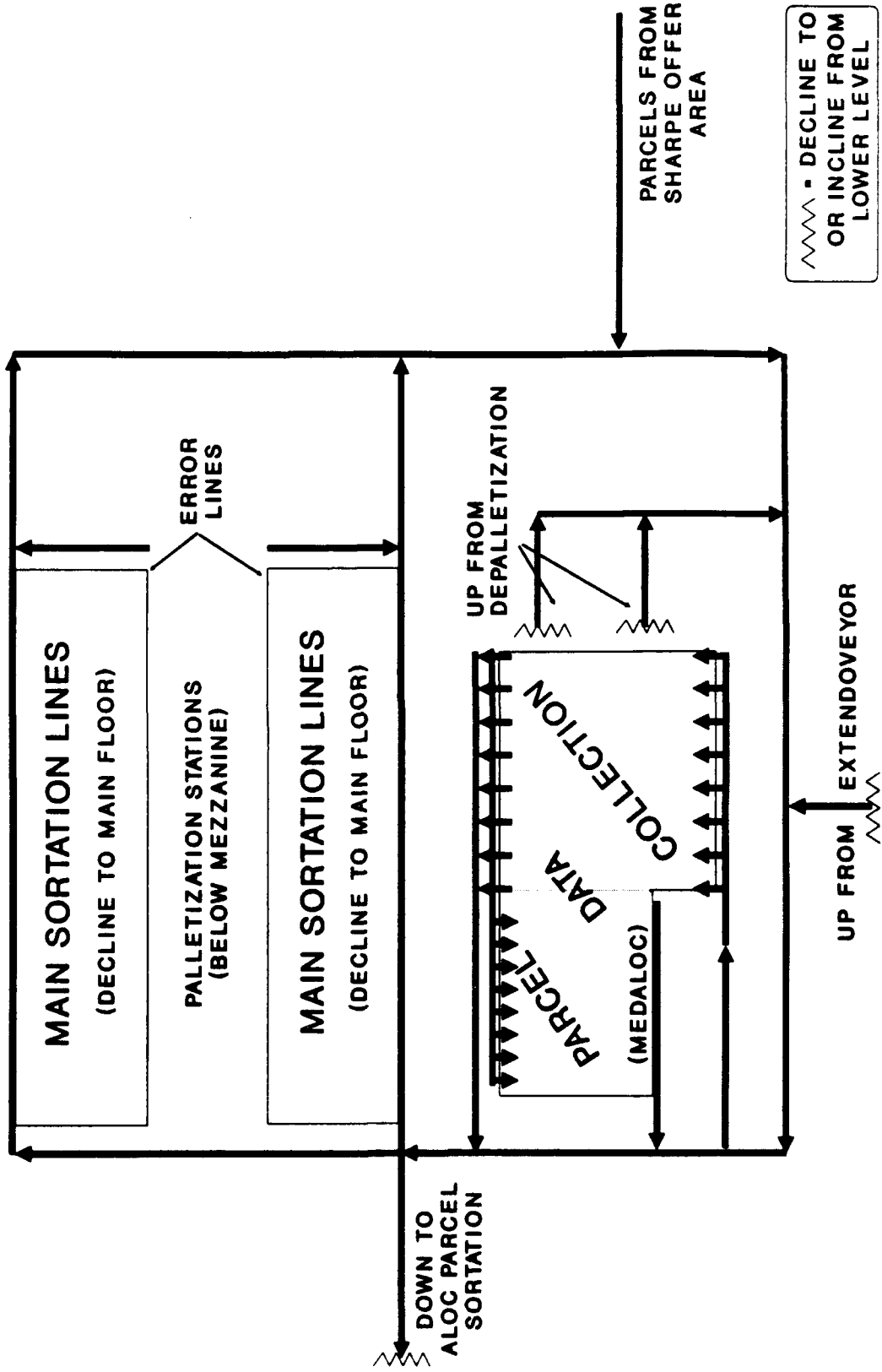
# DDRW RFCC TERMINAL DESIGN

## MAIN FLOOR



# DDRW RFCC TERMINAL DESIGN

## MEZZANINE



DDRW RFCC/CCP SYSTEM DESIGN

- DRAWINGS OF THE DDRW RFCC/CCP WERE PROVIDED BY DOSO
- MATERIAL ENTERS THE SYSTEM AS PALLETS/TRIWALLS (PLT/TWS) OR CARTONS
  - PLT/TWS ENTER FROM TRUCKS THROUGH RECEIVING DOORS, OR BY TOWVEYOR
  - DATA COLLECTED ON VENDOR AND CCP PLT/TWS THAT WILL NOT BE DEPALLETIZED
  - SINGLE CUSTOMER PLT/TWS NOT DEPALLETIZED, FLOW TO OFFLOAD CONVEYORS
  - MULTI-CUSTOMER PLT/TWS GO TO DEPALLETIZATION STATIONS
- CARTONS ENTER VIA EXTENDOVEYOR (FROM SMALL PARCEL CARRIERS) OR PACKAGE CONVEYOR (FROM SHARPE OFFER AREA), GO TO MEZZANINE
  - JOINED BY CARTONS FROM DEPALLETIZATION, MOVE TO CARTON DATA COLLECTION
  - DATA COLLECTED ON VENDOR, MEDALOC, AND SOME CCP CARTONS
  - MEDALOC PASSED TO A SEPARATE MEDALOC DATA COLLECTION AREA
  - OTHER CARTONS BYPASS DATA COLLECTION AREA; ALL THEN MOVE TO SORTATION

DDRW RFCC/CCP SYSTEM DESIGN  
(CONTINUED)

- CARTON SORTATION CONSISTS OF A MAIN SORTER AND AN ALOC SORTER
- MAIN SORTER USED FOR ALL RFCC CUSTOMERS AND HIGH VOLUME SURFACE CCP
  - CONTAINS 76 30-FT SORT LINES + 2 ERROR LINES
  - PLT/TWS BUILT AT 16 PALLETIZATION STATIONS WITH 2 TABLES EACH
  - AGV SYSTEM TAKES AWAY FULL PLT/TWS, BRINGS EMPTY PALLETS
  - TWO-PLACE VEHICLES SO CAN DO BOTH IN ONE STOP AT TABLE
- ALOC SORTER USED FOR ALOC AND SMALL VOLUME SURFACE CCP CUSTOMERS
  - OPEN WORK AREA: MORE THAN ONE CUSTOMER CAN BE FILLED FROM EACH LINE
  - SURFACE CCP PLT/TWS FORK-LIFTED TO CONVEYOR, JOIN THOSE FROM MAIN SORTER
- PLT/TWS ARE STRETCH WRAPPED OR BANDED, THEN WEIGHED BEFORE MOVING TO OFFLOAD AREA
  - PALLETS GO TO ONE OF TWO AUTOMATIC STRETCH WRAP MACHINES
  - TRIWALLS GO TO A BANDING MACHINE
  - BOTH THEN MOVE TO AN IN-LINE SCALE FOR WEIGHING
  - PLT/TW THEN MOVES TO AN ACCUMULATION CONVEYOR OR FLOOR STAGING, AS APPROPRIATE

## SCOPE

- INCLUDES RFCC AND CCP OPERATIONS
- WORKLOAD VOLUME INCREASED TO REFLECT DEPOT CONSOLIDATION
- EFFECT OF FORCE REDUCTION AND DEPOT CONSOLIDATION ON THE CUSTOMER MIX IS UNCERTAIN. THEREFORE, SPECIFIC NAMES OF DESTINATIONS SHOULD BE CONSIDERED "NOTIONAL"
- IMPACT OF FORCE REDUCTION ON FUTURE WORKLOAD LEVELS WAS NOT CONSIDERED
- MECHANICAL FAILURE WAS NOT MODELED

PROJECT SCOPE

- BOTH RFCC AND CCP FUNCTIONS WILL BE PERFORMED BY THE SYSTEM, SO BOTH WERE INCLUDED IN THE MODEL
- DOSO WORKLOAD ESTIMATES TOOK DEPOT CONSOLIDATION INTO ACCOUNT
  - GENERALLY DOUBLED WORKLOAD FROM DDTC EDDS SIMULATION
  - DEPOT CONSOLIDATION OFFICE RECOMMENDED ADDING AN ADDITIONAL 10%
  - CCP, MEDALOC WORKLOAD DEVELOPED FROM OTHER SOURCES
- ASSIGNMENT OF WORKLOAD TO CUSTOMER DESTINATIONS BASED ON DDTC EDDS SIMULATION
  - EFFECTS OF FORCE REDUCTION AND DEPOT CONSOLIDATION COULD NOT BE DETERMINED
  - CUSTOMERS SERVED BY DDTC EDDS MAY NOT BE SAME AS FOR THE CONSOLIDATED SITE
    - ADEQUATE FOR TESTING MECHANIZATION DESIGN
    - NAMES OF CUSTOMERS USED IN ANALYSIS SHOULD BE CONSIDERED "NOTIONAL"
- ESTIMATED WORKLOAD IS BASED ON CURRENT LEVELS
  - DID NOT ATTEMPT TO PROJECT FUTURE TRENDS BASED ON FORCE REDUCTION
  - WORKLOAD LIKELY TO DECREASE, SO ANALYSIS PROBABLY USES "WORST CASE"
- DID NOT EXPLICITLY MODEL BREAKDOWN OF SYSTEM COMPONENTS
  - EFFECTS OF MECHANICAL FAILURE CAN BE INFERRED FROM SIMULATION RESULTS
  - BREAKDOWNS COULD BE EXPLICITLY MODELED AS A FOLLOW-ON EFFORT

## ASSUMPTIONS

- 7.5 HOUR WORKDAY
- DROP/ARRIVAL PATTERNS FROM DDTC  
EDDS SIMULATIONS ARE REASONABLE  
APPROXIMATIONS FOR DDRW RFCC
- TRANSSHIPMENT VOLUME INTO DDRW  
SAME AS USED IN DDTC SIMULATION
- STEADY ARRIVAL OF PIECES/PALLETS
- SORT LINE CAPACITY = 30 PIECES

ASSUMPTIONS

- SIMULATED WORKDAY IS 7 1/2 HOURS LONG, ONE SHIFT PER DAY
- ADDITIONAL SHIFTS WOULD BE RESERVED FOR MOBILIZATION/CONTINGENCIES
- DISTRIBUTIONS OF DAILY WORKLOAD PER CUSTOMER TAKEN FROM DDTC EDDS SIMULATION
  - TOTAL WORKLOAD THEN FACTORED UP TO THE RFCC ESTIMATE
  - SHOULD REPRESENT RFCC CUSTOMERS CLOSE ENOUGH TO TEST SYSTEM DESIGN
- VOLUME OF MROS TRANSSHIPPED FROM OTHER DEPOTS NOT INCREASED FROM DDTC EDDS
  - INCLUSION OF FORMER SERVICE DEPOTS WOULD SEEM TO INCREASE TRANSSHIPMENTS
  - CONSOLIDATION AT PRIMARY DISTRIBUTION SITES MEANS MORE FULL TRUCKLOADS, LESS THROUGH THE RFCCS
- NET EFFECT ASSUMED TO BE EVEN
- CARTONS AND PLT/TWS MODELED ARRIVING STEADILY THROUGHOUT WORKDAY
  - NO PEAK ARRIVAL RATE AT CERTAIN TIMES OF THE DAY
  - INTERARRIVAL TIME VARIED RANDOMLY AROUND A CONSTANT RATE EACH DAY



# ASSUMPTIONS

(CONTINUED)

- 12 CARTONS PER PALLET/TRIWALL
- PALLETS FROM TRACY  
ARE NOT STRETCH WRAPPED
- 25% OF SAN JOAQUIN MRO PALLETS  
ARRIVE ON TOWVEYOR
- MATERIAL ARRIVES AND DEPARTS  
60% ON PALLETS, 40% TRIWALLS
- 40% OF CCP MATERIAL DOES NOT  
REQUIRE DATA COLLECTION

ASSUMPTIONS  
(CONTINUED)

- EVERY PLT/TW ENTERING AND LEAVING SYSTEM CONTAINS 12 CARTONS
- PALLETS TRANSPORTED FROM TRACY SITE WILL NOT BE STRETCH WRAPPED
  - LEFT LOOSE ON PALLET FOR TRIP FROM TRACY TO SHARPE SITE
  - IF STRETCH WRAPPED, WOULD CAUSE QUEUING AT DEPALLETTIZATION STATIONS
    - REMOVING STRETCH WRAP IS OVER 75% OF DEPALLETTIZATION TIME
- 25% OF SAN JOAQUIN STOCK ARRIVING ON PLT/TWS WILL BE BROUGHT BY TOWVEYOR
  - EQUATES TO APPROX. 60% OF STOCK FROM SHARPE SITE
  - REDUCES WORKLOAD AT RECEIVING DOORS, PALLET DATA COLLECTION
- RATIO OF PALLETS TO TRIWALLS IS 60% / 40%
  - APPLIES TO BOTH INCOMING AND OUTGOING MATERIAL
  - IMPACTS DEPALLETTIZATION STATIONS, STRETCH WRAP MACHINES, AND BANDER
- 40% OF INCOMING CCP CARTONS DO NOT REQUIRE DATA COLLECTION
  - ALL REQUIRED INFORMATION ON THESE CARTONS ASSUMED TO BE IN DATA SYSTEM
  - IMPACTS CARTON DATA COLLECTION STATIONS

# METHODOLOGY

## DETERMINING VOLUME BY DESTINATION

- WORKLOAD VOLUME BASED ON DOSO ESTIMATES
- DISTRIBUTIONS DEVELOPED FOR DAILY VOLUME TO EACH CUSTOMER
- SORTER LINES ASSIGNED TO CUSTOMERS BASED ON AVERAGE VOLUME
- SAMPLE TAKEN EACH DAY FROM EACH DISTRIBUTION
- TRACY/SHARPE MROS ADJUSTED TO REDUCE VARIATION

METHODOLOGY  
DETERMINING WORKLOAD VOLUME BY DESTINATION

- TOTAL VOLUME TO ALL CUSTOMERS BASED ON DOSO ESTIMATES DISCUSSED EARLIER
- PROBABILITY DISTRIBUTION DEVELOPED TO REFLECT DAILY AMOUNTS TO EACH DESTINATION
  - DISTRIBUTIONS FOR RFCC WORKLOAD TAKEN FROM DDTC EDDS
  - DISTRIBUTIONS FOR CCP BASED ON DATA FROM "TERMS" DATA FILE
    - FILE OF OVERSEAS SHIPMENTS, COLLECTED BY MILITARY TRANS MGT COMMAND (MTMC)
    - OVERSEAS DROP POINTS IDENTIFIED BY DODAAC BASED ON INPUT FROM DDRW
- CUSTOMERS ASSIGNED LINES ON MAIN SORTER BASED ON AVERAGE DAILY VOLUME
  - VERY LARGE CUSTOMERS GIVEN MULTIPLE LINES TO EVEN WORKLOAD, AVOID BACKUPS
  - HEAVY-USE LINES SCATTERED ACROSS SORTER TO EVEN WORKLOAD AMONG WORKSTATIONS
- PROBABILITY DISTRIBUTIONS CODED INTO FORTRAN PROGRAM, RUN AT START OF EACH WORKDAY
  - SAMPLE TAKEN FROM EACH DISTRIBUTION, GIVES VOLUME TO EACH CUSTOMER THAT DAY
    - SUM TO GET TOTAL VOLUME
    - DIVIDE CUSTOMER VOLUME BY TOTAL TO GET PERCENT TO EACH CUSTOMER
  - TOTAL VOLUME FACTORED UP SO AVERAGE WOULD EQUAL ESTIMATED RFCC WORKLOAD
  - PERCENT TO EACH CUSTOMER USED TO ASSIGN CUSTOMERS TO INCOMING CARTONS BASED ON RANDOM DRAW

METHODOLOGY  
DETERMINING WORKLOAD VOLUME BY DESTINATION  
(CONTINUED)

- TEST OF PROGRAM FOUND VOLUME FROM SAN JOAQUIN STOCK VARIED WIDELY
  - IN PROGRAM, VOLUME "DROPPED" TO EACH CUSTOMER IS INDEPENDENT OF OTHERS
  - IN "REAL LIFE", DROPS ARE MANAGED TO EVEN OUT DAILY WORKLOADS
  - AFTER CONSULTING WITH CLIENT, PROGRAM OUTPUT DAMPENED TO REDUCE WORKLOAD
  - REDUCED DIFFERENCE BETWEEN DAILY VOLUME AND MEAN VALUE BY HALF
  - FORMULA USED:  $NEWVOLUME = MEAN + ((MEAN-OLDVOLUME) / 2)$
- WHERE NEWVOLUME IS THE ADJUSTED WORKLOAD VOLUME WITH REDUCED VARIATION
- OLDVOLUME IS THE WORKLOAD GENERATED BY THE PROGRAM BEFORE ADJUSTMENT
- MEAN IS THE AVERAGE EXPECTED VOLUME BASED ON THE DOSO ESTIMATES

# MODEL PARAMETERS

## WORKLOAD VOLUME

### DOSO ESTIMATE      SIMULATION

<b>VENDOR:</b>	1 PLT	1 PLT
	365 CTNS	349 CTNS
<b>MROs from SAN JOAQUIN:</b>	80 PLTS	65 PLTS
	4210 CTNS	4174 CTNS
<b>MROs from OTHER DEPOTS:</b>	624 CTNS	564 CTNS
<b>CCP (Incl ALOC):</b>	375 PLTS	378 PLTS
	2732 CTNS	2606 CTNS

MODEL PARAMETERS  
WORKLOAD VOLUME

- CHART COMPARES THE EXPECTED WORKLOAD VOLUME WITH THE SIMULATION OUTPUT
- "DOSO ESTIMATE" REFLECTS VOLUME ESTIMATED BY DOSO AS DESCRIBED EARLIER
- "SIMULATION" SHOWS AVERAGE DAILY VOLUME OVER A 10-DAY SIMULATION RUN
  
- SIMULATION OUTPUT GENERALLY WITHIN 10% OF DOSO ESTIMATE

# MODEL PARAMETERS

## TRAVEL / SERVICE TIMES

- PACKAGE CONVEYOR: 120 FT / MIN
- PALLET CONVEYOR: 60 FT / MIN
- AUTOMATED GUIDED VEHICLE: 160 FT / MIN
- DATA COLLECTION:
- PALLETS: VENDOR: 10 MIN PER PALLET  
            CCP: 5 MIN PER PALLET
- CARTONS: VENDOR: 50 SEC PER PIECE  
            MEDALOC: 180 SEC PER PIECE  
            CCP: 50% at 30 SEC PER PIECE  
                50% at 240 SEC PER PIECE



# MODEL PARAMETERS

## TRAVEL/SERVICE TIMES (Cont)

- PALLET UNLOADING: 156 SEC PER PALLET
- TRIWALL UNLOADING: 96 SEC PER TRIWALL
- ERROR RESOLUTION: 10 MIN PER PIECE
- PALLET/TRIWALL LOADING: 32 SEC PER PIECE
- TRIWALL ASSEMBLY: 48 SEC PER PIECE
- STRETCH WRAP: 120 SEC PER PALLET
- BANDER: 50 SEC PER TRIWALL
- PALLET WEIGHING: 20 SEC PER PALLET/TW

**MODEL PARAMETERS**  
**TRAVEL / SERVICE TIMES**

- TRAVEL AND SERVICE TIMES PROVIDED BY DOS<sup>1</sup> OR TAKEN FROM DDTC EDDS SIMULATION
- TIME FOR CCP CARTON DATA COLLECTION REFLECTS TWO POSSIBILITIES
  - HALF THE CCP CARTONS WILL HAVE "SOME" DATA IN THE DATA SYSTEM, ALLOWING THE SHORTER SERVICE TIME
  - OTHER HALF WILL HAVE NO DATA, REQUIRING THE LONGER SERVICE TIME
  - ONLY APPLIES TO THE 60% OF CCP CARTONS THAT REQUIRE DATA COLLECTION; THE REST BYPASS THE DATA COLLECTION AREA ENTIRELY
- PALLET UNLOADING INCLUDES 120 SEC TO REMOVE STRETCH WRAP + 3 SEC PER CARTON
- TRIWALL UNLOADING INCLUDES 60 SEC TO OPEN TRIWALL + 3 SEC PER CARTON
- PALLET WEIGHING IS ONLY FOR THOSE PALLETS/TRIWALLS BUILT AT THE SORTERS; THOSE THAT ENTERED AS PLT/TWS WILL NOT REQUIRE RE-WEIGHING

## PRE-SIMULATION DESIGN CHANGES

- EXPECTED VALUE ANALYSIS USED TO ASSESS ADEQUACY OF INDIV. PARTS OF THE SYSTEM
- RESULTS:
  - ADDED 2 DATA COLLECTION STATIONS
  - CHANGED AGV PATH AND INCREASED NUMBER OF VEHICLES FROM 2 TO 4
  - INCREASED NUMBER OF LINES ON "ALOC SORTER"

PRE-SIMULATION DESIGN CHANGES

- EXPECTED VALUE ANALYSIS CHECKS SYSTEM CAPACITY AGAINST AVERAGE EXPECTED WORKLOAD
- AVG WORKLOAD USED TO DETERMINE NO. OF TIMES PER DAY PROCESSES NEEDED TO BE DONE
- MULTIPLIED BY TIME TO DO PROCESS, GIVES TOTAL AVG TIME PROCESS IS DONE PER DAY
- DIVIDE BY 7.5 HRS, GIVES NUMBER OF STATIONS (PEOPLE) REQUIRED
  
- SHOWED THREE CHANGES REQUIRED TO DESIGN
- INCREASED NUMBER OF DATA COLLECTION STATIONS FROM 6 TO 8
- INCREASED NUMBER OF AGVS FROM 2 TO 4
- CHANGED PATH TO ADD A CENTER RETURN PATH
- INCREASED NUMBER OF ALOC SORTER LINES FROM 10 TO 15

# RESULTS

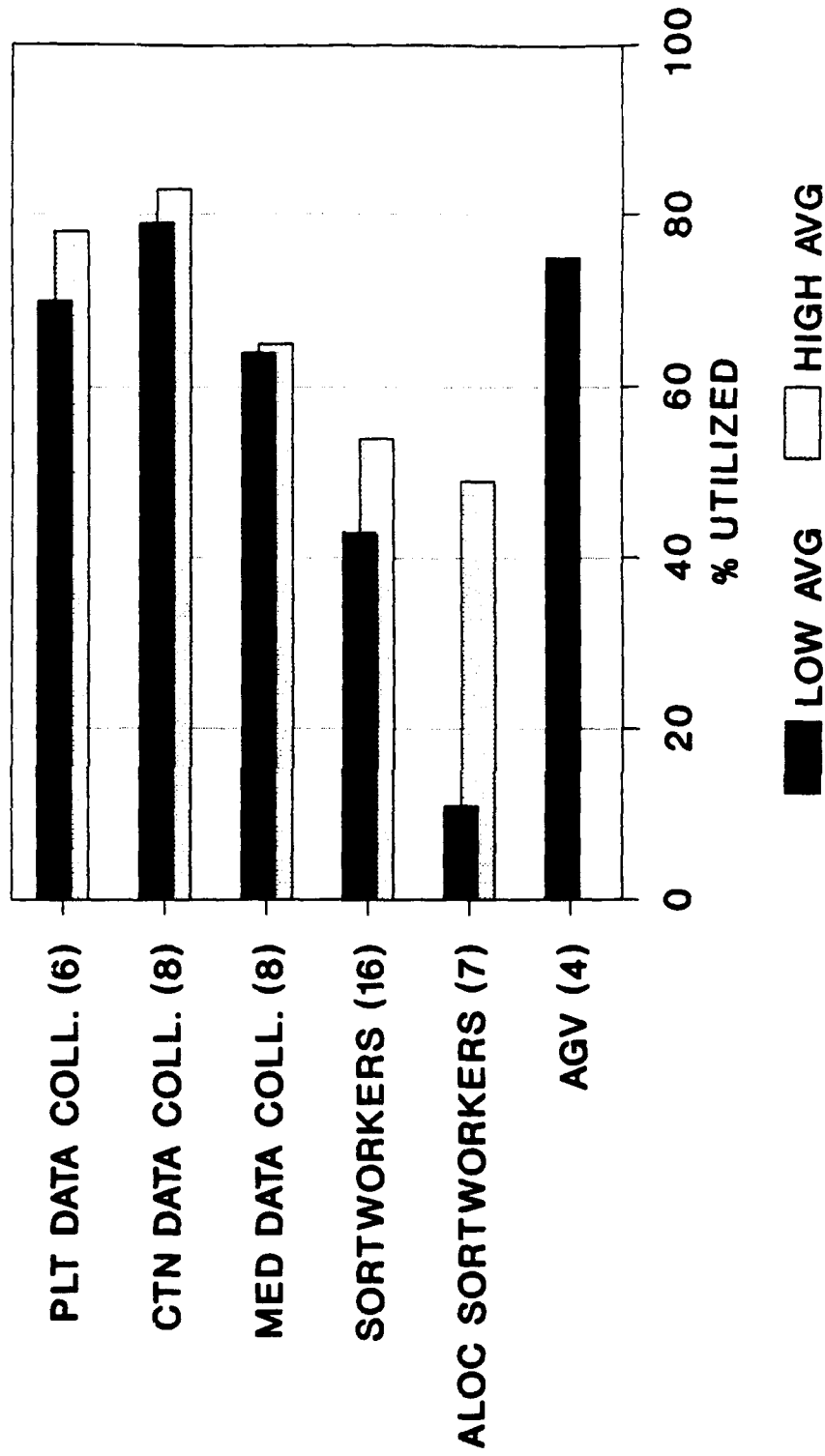
## 10 DAY SIMULATION RUN

- AVERAGE THROUGHPUT PER DAY:
  - 6173 PIECES ENTER SORTER
  - 514 PALLETS BUILT AT SORTER
  - 836 PALLETS TO OFFLOAD AREA
  - 246 PALLETS TO ALOC AREA
  
- NO SIGNIFICANT "LOOPING" OF PIECES
  
- OBSERVATIONS:
  - BUILDUP OF LARGE QUEUES AT DATA COLL.
  - 14 SORTER LINES BUILD < 1 PLT PER DAY AVG
  - IMPORTANT TO SPREAD WORK AMONG LINES

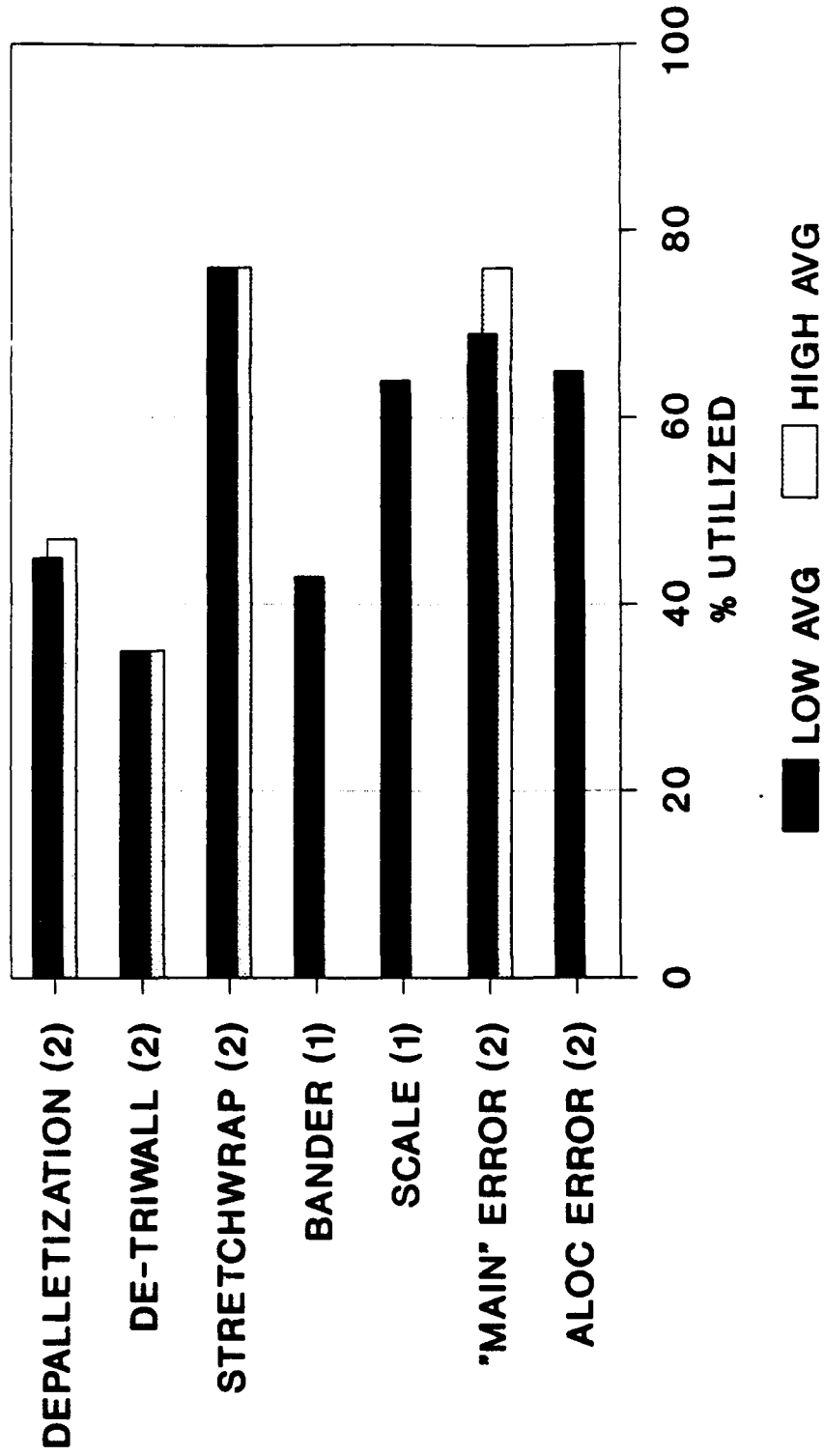
RESULTS  
10 DAY SIMULATION RUN

- RESULTS SHOWN ARE FOR ONE 10-WORKDAY SIMULATION RUN
  - FIRST OF THREE REPLICATIONS
  - OF THE OTHER TWO RUNS, ONE AVERAGED HIGHER, ONE LOWER WORKLOAD VOLUME
- "LOOPING" REFERS TO CARTONS THAT RECYCLE THROUGH THE SORTER DUE TO A FULL SORTLINE
  - TOTAL OF 4 CARTONS "LOOPED" DURING THE 10 DAY SIMULATION
  - ONLY 2 OF THE 76 SORT LINES EVER BECAME FULL DURING THIS REPLICATION
  - THE SECOND REPLICATION DID HAVE EXTENSIVE LOOPING
  - ONE CUSTOMER HAD VERY HEAVY VOLUME
  - ASSIGNING ANOTHER LINE TO THAT CUSTOMER REDUCED LOOPING TO 17 CARTONS TOTAL
- CARTON DATA COLLECTION OCCASIONALLY HAD QUEUES LARGER THAN AVAILABLE WAITING AREA
  - EFFECT OF LARGE VARIATION IN SERVICE TIMES FOR DIFFERENT TYPES OF MATERIAL
  - IF SAME STATION GOT SEVERAL CARTONS WITH LONG SERVICE TIME, WOULD CAUSE BACKUP
- 14 OF THE SORTER LINES AVERAGED LESS THAN ONE PLT/TW BUILT PER DAY
  - INDICATES SORTLINES UNDERUTILIZED, COULD BE ELIMINATED IF NECESSARY
  - BETTER OPTION: SPREAD LARGE CUSTOMERS AMONG MORE LINES, EVEN WORKLOAD
  - OVERLOADED LINES IN SECOND REPLICATION SHOWS IMPORTANCE OF SPREADING WORKLOAD

# AVERAGE UTILIZATION OVER 10 SIMULATED WORKDAYS



# AVERAGE UTILIZATION OVER 10 SIMULATED WORKDAYS

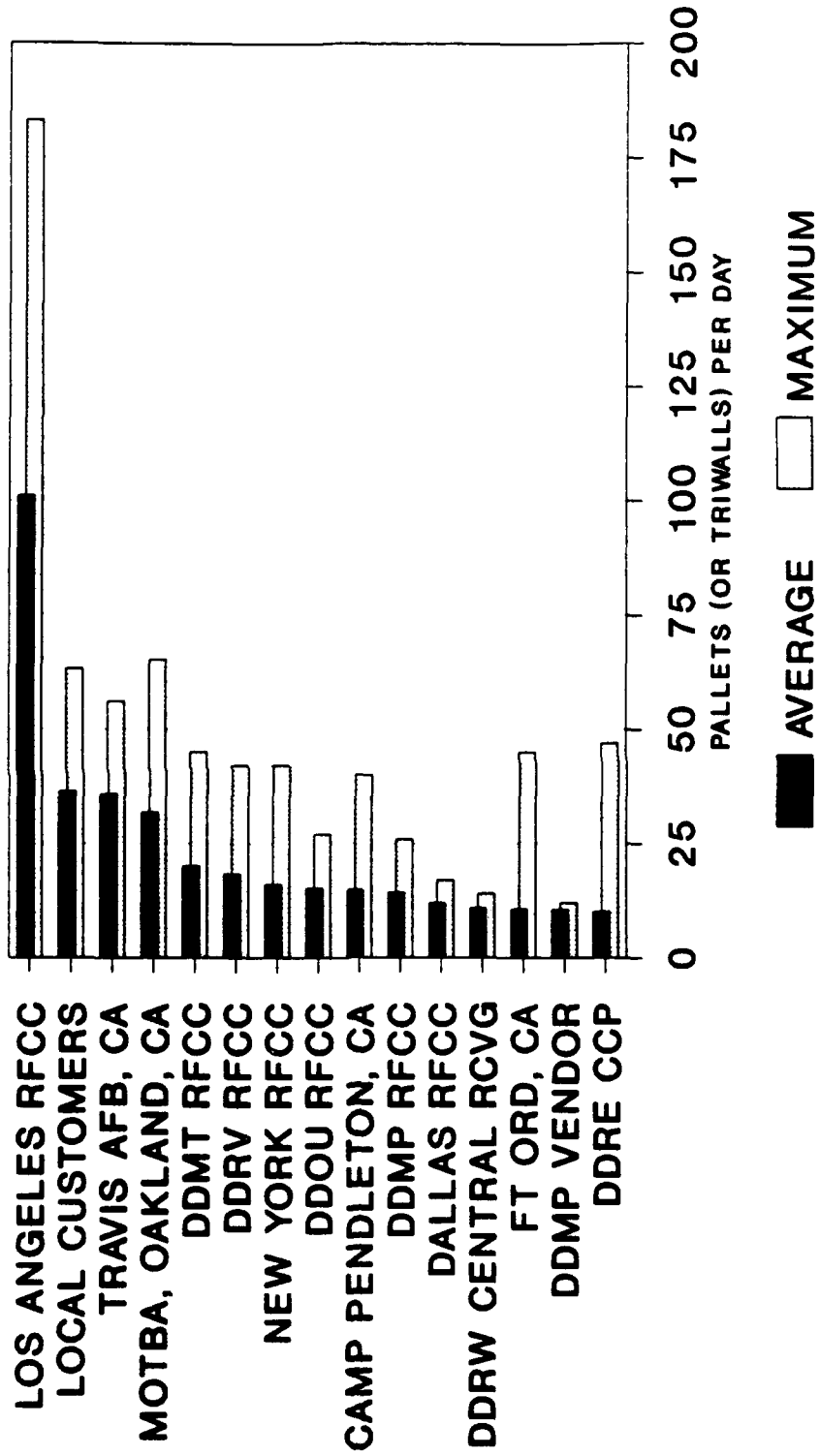




AVERAGE UTILIZATION  
OVER 10 SIMULATED WORKDAYS

- CHART SHOWS AVG % OF TIME EACH STATION/MACHINE/ETC. WAS BUSY OVER THE 10 DAY RUN
- FOR A GROUP OF STATIONS, DARK BAR SHOWS AVG FOR LEAST BUSY STATION
- LIGHT BAR SHOWS AVERAGE FOR BUSIEST STATION
- CARTON DATA COLLECTION AREA IS BUSIEST GROUP
- UTILIZATION ABOUT 80% ON AVERAGE
- WITH LARGE QUEUING MENTIONED EARLIER, INDICATES ADDING ANOTHER STATION MAY BE ADVISABLE
- MOST OTHER UTILIZATIONS 75% OR LESS
- LARGE VARIATION IN ALOC SORTWORKER UTILIZATION DUE TO ASSIGNMENT OF SORTLINES
- STATIONS PROCESSING ALOC/MEDALOC HAVE ABOUT 50% UTILIZATION
- STATIONS PROCESSING LOW-VOLUME SURFACE CCP HAVE 10-15% UTILIZATION
- INDICATES NEED FEWER THAN ONE WORKER PER LINE FOR THE SURFACE CCP LINES

# PALLETS TO EACH DESTINATION DESTINATIONS AVERAGING 10+ PLTS/DAY



SURFACE CCP: 349 PLTS/DAY AVG (373 MAX)

**PALLETS TO EACH DESTINATION**  
**DESTINATIONS AVERAGING 10+ PALLETS PER DAY**

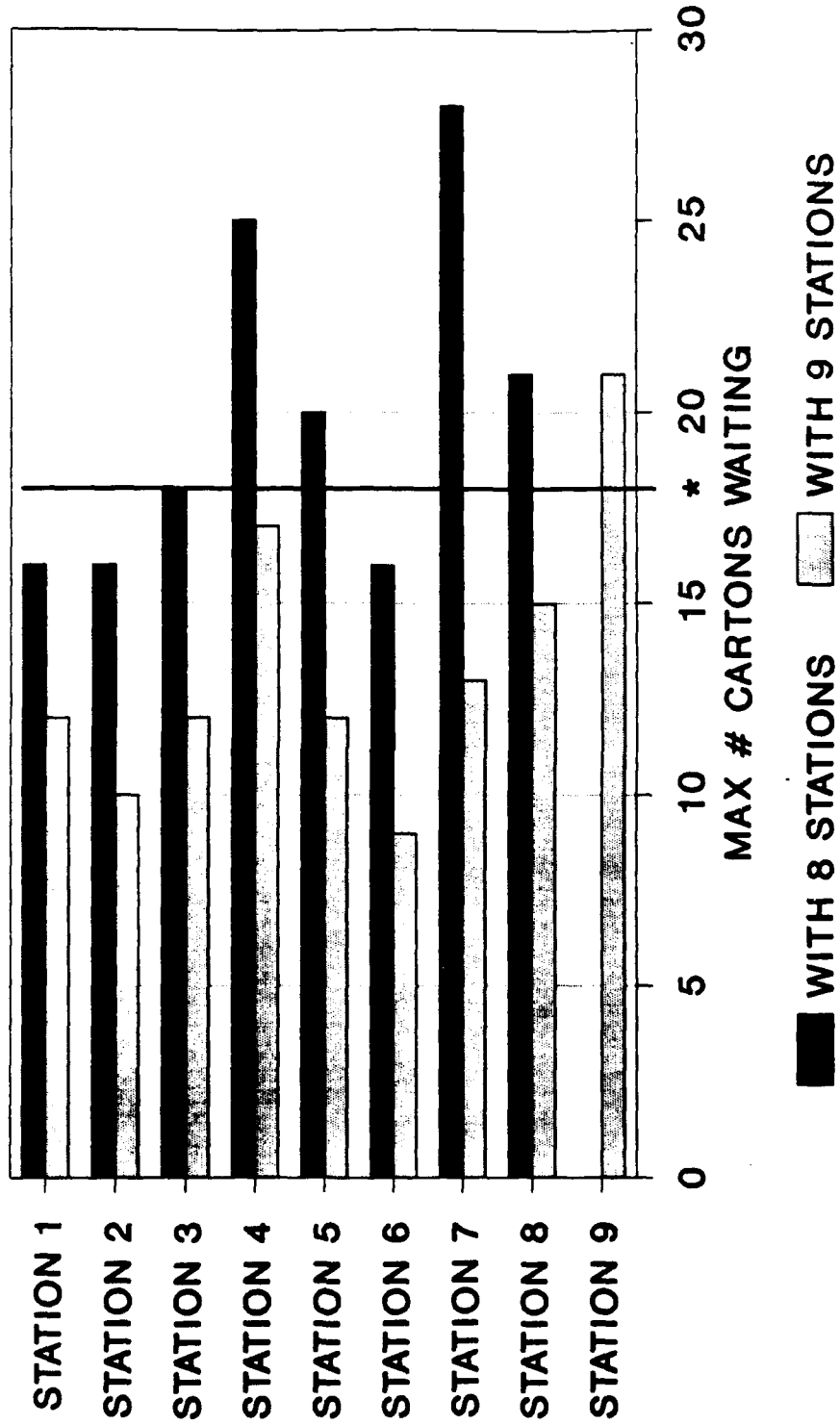
- CHART SHOWS NUMBER OF PLT/TWS PER DAY TO CUSTOMERS AVERAGING 10 OR MORE
  - DARK BAR SHOWS AVERAGE OVER THE 10 DAY SIMULATION
  - LIGHT SHADED BAR SHOWS MAXIMUM PALLETS TO THAT CUSTOMER ON ANY ONE WORKDAY
- SURFACE CCP NOT GRAPHED BECAUSE SCALE WOULD BE TOO LARGE
- REMEMBER, CUSTOMER NAMES ARE "NOTIONAL" IN MOST CASES
- IDENTIFICATION OF LA RFCC AS BIGGEST CONUS CUSTOMER PROBABLY ACCURATE
- LIST ON NEXT PAGE BREAKS OUT ALL CUSTOMERS
  - CCP BROKEN OUT BY OVERSEAS BREAK BULK POINT
  - NOTE: MOST CCP PLT/TWS NOT DEPALLETIZED
  - SIMULATION DID NOT IDENTIFY SPECIFIC BREAK BULK POINT FOR THIS MATERIAL
  - FOR LIST, DISTRIBUTED THESE PLT/TWS BASED ON PROPORTION OF THOSE BUILT ON THE SORTER THAT WERE SENT TO EACH BREAK BULK POINT

**PALLETS TO OUTBOUND DESTINATIONS**

<b>RANK</b>	<b>DESTINATION NAME</b>	<b>AVG PLTS/DAY</b>	<b>MAX PLTS/DAY</b>
1	RFCC - LOS ANGELES	101.1	183
2	CCP - OTHER (2nd Sorter)	56.5	79
3	CCP - TAEGU (AF)	55.8	72
4	CCP - KADENA (AF)	47.2	52
5	"VARIABLE"	44.7	53
6	CCP - OSAN (AF)	40.4	50
7	LOCAL	36.4	63
8	TRAVIS AFB, CA	35.9	56
9	MOTBA, OAKLAND, CA	31.9	65
10	CCP - HAWAII (AF)	25.7	37
11	CCP - YOKOTA (AF)	25.7	33
12	CCP - GUAM (AF)	23.4	28
13	CCP - KUNSAN (AF)	21.2	27
14	RFCC - DDMT	20.1	45
15	RFCC - DDRV	18.3	42
16	RFCC - NEW YORK	16.1	42
17	CCP - MISAWA (AF)	16.0	29
18	RFCC - DDOU	15.2	27
19	CAMP PENDLETON, CA	14.9	40
- 20	RFCC - DDMP	14.3	26
21	RFCC - DALLAS	12.0	17
22	DDRW CENTRAL RECEIVING	10.9	14
23	FT ORD, CA	10.7	45
24	DDMP VENDOR	10.5	12
25	DDRE CCP	10.1	47
26	FT LEWIS, WA	9.3	30
27	RFCC - DDCO	8.7	12
28	RFCC - JACKSONVILLE	8.5	25
29	CCP - KOREA (A-3)	8.3	12
30	SACRAMENTO AD, CA	8.0	30
31	NATIONAL CITY ANNEX, CA	7.9	27
32	CCP - TONGDUCHON (D-1)	7.4	10
33	RFCC - CHICAGO	6.8	18
34	CCP - SEOUL (C-3)	6.4	10
35	DDMT VENDOR	5.9	7
36	CCP - PYONGTAEK (B-1)	5.8	8
37	MTMC, SEATTLE, WA	4.9	21
38	MATHER AFB, CA	4.9	14
39	CCP - PUSAN (A-1)	4.8	7
40	CCP - JAPAN (WT5JZ9)	4.2	5
41	PRESIDIO OF SAN FRAN., C A	3.4	13
42	NSC PUGET SOUND, WA	3.1	19
43	HILL AFB, UT	2.9	15
44	BEALE	2.9	11
45	NSC SAN DIEGO, CA	2.5	12
46	MCCLELLAN AFB, CA	2.1	10
47	DDRV VENDOR	1.0	1
48	DDOU VENDOR	0.9	1
49	DDCO VENDOR	0.5	1

# RESULTS OF ADDING 9TH DATA COLLECTOR

## MAX QUEUE SIZES AT DATA COLL. STATIONS



\* QUEUE SPACE AVAILABLE: 18 CARTONS

RESULTS OF ADDING NINTH DATA COLLECTOR  
MAX QUEUE SIZES AT DATA COLLECTION STATIONS

- CHART SHOWS MAX IN EACH QUEUE AT ANY POINT OF 10 DAY SIMULATION
  - DARK BAR SHOWS MAX QUEUES WITH 8 STATIONS
  - LIGHT SHADED BAR SHOWS MAX QUEUES WITH 9 STATIONS
  - VERTICAL LINE SHOWS QUEUE CAPACITY: 18 CARTONS AT EACH STATION
- WITH 8 STATIONS, 4 OF THE 8 EXCEED QUEUE CAPACITY AT SOME TIME DURING THE 10 DAYS
  - ONE OTHER STATION REACHES, BUT DOES NOT EXCEED, CAPACITY
  - OTHER 3 LINES ALL GET WITHIN 2 CARTONS OF FILLING THEIR QUEUES
- WITH 9 STATIONS, ONLY ONE STATION EVER EXCEEDS QUEUE CAPACITY
  - ONE OTHER LINE GETS WITHIN 1 CARTON OF FILLING QUEUE
  - REST OF STATIONS MAX OUT AT 15 OR LESS
- ADDING 9TH STATION GREATLY REDUCES, BUT DOES NOT ELIMINATE, THE PROBLEM
  - CONTROL MECHANISM NEEDS ABILITY TO SKIP FULL QUEUES WHEN DIRECTING CARTONS
  - THIS ABILITY, IN ADDITION TO 9TH STATION, SHOULD ELIMINATE THE PROBLEM

# CONCLUSIONS & RECOMMENDATIONS

- CONCLUSIONS:
  - RFCC DESIGN CANNOT HANDLE EST. WORKLOAD
    - DATA COLL. QUEUES CAN CLOG SYSTEM
  - PROPER ALLOCATION OF SORTER LINES *CRITICAL*
- RECOMMENDATIONS:
  - ADD 9TH DATA COLLECTION STATION
  - CONTROL SOFTWARE SHOULD ATTEMPT TO EQUALIZE QUEUE SIZES AT DATA COLL.
  - DEVELOP TRAINING PROGRAM AND DECISION AIDS TO SUPPORT SORTER LINE ALLOCATION

CONCLUSIONS AND RECOMMENDATIONS

- MAJOR CONCLUSIONS OF THE STUDY:
  - BUILD-UP OF QUEUES AT DATA COLLECTION ONLY PROBLEM AREA IN MECHANIZATION DESIGN
  - GIVEN CHANGES INDICATED BY EXPECTED VALUE ANALYSIS ALREADY INCORPORATED
  - HOW SORTER LINES ARE ASSIGNED TO CUSTOMERS IS CRITICAL TO OPERATION
  - PROPER ASSIGNMENT SPREADS OUT WORKLOAD, USES WORKERS EFFICIENTLY
  - IMPROPER ASSIGNMENT CAUSES INEFFICIENCIES, CAN CLOG THE SORTER
  
- RECOMMENDATIONS:
  - CHANGES INDICATED BY EXPECTED VALUE ANALYSIS MUST BE IMPLEMENTED
  - 8 CARTON DATA COLLECTORS, 4 AGVS, 15 ALOC SORT LINES
  - AGREED TO BY DOSO BEFORE SIMULATION BEGUN
  
  - TWO CHANGES TO ELIMINATE LARGE QUEUES AT CARTON DATA COLLECTION
  - ADD NINTH CARTON DATA COLLECTION STATION
  - ENSURE CONTROL MECHANISM WILL SKIP FULL QUEUES WHEN DIRECTING CARTONS
  
  - ENSURE PERSON MAKING LINE ASSIGNMENTS IS EQUIPPED TO DO IT RIGHT
  - EXTENSIVE TRAINING WILL BE A MUST
  - DEVELOPMENT OF DECISION AIDS SHOULD BE GIVEN A HIGH PRIORITY



STATUS OF RECOMMENDATIONS

- RECOMMENDED CHANGES TO MECHANIZATION DESIGN ACCEPTED BY CLIENT
  - DOSO WILL INCLUDE IN SPECIFICATIONS FOR CONTRACT
- RECOMMENDATION ON DECISION AIDS IS BEING FURTHER EXPLORED
  - DORO AND DLA-OT WILL EVALUATE AND SCOPE THE EFFORT REQUIRED

# REPORT DOCUMENTATION PAGE

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<b>13. ABSTRACT (Maximum 200 words)</b>  This is a simulation analysis of the proposed mechanization design of the Regional Freight Consolidation Center (RFCC) at the San Joaquin site of the Defense Logistics Agency (DLA) Defense Distribution Region West (DDRW). An increase in expected workload at that site due to depot consolidation, along with the addition of Consolidation and Containerization Point (CCP) functions to the RFCC, has caused extensive changes to the design. The purpose of this analysis was to evaluate the mechanization design, identify any design problems, and recommend solutions or possible improvements.  Three major areas of concern were identified in the analysis. First, expected value analysis showed two automated guided vehicles (AGVs) could not handle the workload from the palletization stations. The AGV path was redesigned to allow four vehicles. The second problem was inadequate throughput capacity at parcel data collection. Expected value and simulation analysis of this area indicated the number of workstations should be increased from six to nine. The third area of concern involved the assignment of lines to customers on the main carton sorter. The simulation demonstrated that how this assignment was made was critical to the efficient operation of the sortation system. Therefore, the person making these assignments must be well trained, and decision aids should be developed to support this critical task.				
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