NOTICE: When government or other drawings, specifications or other data are used for any purpose other than in connection with a definitely related government procurement operation, the U. S. Government thereby incurs no responsibility, nor any obligation whatsoever; and the fact that the Government may have formulated, furnished, or in any way supplied the said drawings, specifications, or other data is not to be regarded by implication or otherwise as in any manner licensing the holder or any other person or corporation, or conveying any rights or permission to manufacture, use or sell any patented invention that may in any way be related thereto.
EVALUATION OF NAVY INVENTORY DECISION RULES UTILIZING THE IBM INVENTORY MANAGEMENT SIMULATOR

FINAL REPORT
CONTRACT NONR 3742(00)

Flow Charts

IBM
FEDERAL SYSTEMS DIVISION
ROCKVILLE, MARYLAND
Evaluation of Navy Inventory Decision Rules
Utilizing the IBM Inventory Management Simulator

FINAL REPORT
CONTRACT NONR 3742(00)

29 June 1962

Submitted to
DEPARTMENT OF THE NAVY
Bureau of Supplies and Accounts
Advanced Logistics Research Division
Washington 25, D. C.

Flow Charts
CALL SUBROUTINE START

CALL SUBROUTINE IRUN. THIS ROUTINE READS SYSTEM PARAMETERS AND INITIATES RUN

CALL SUBROUTINE I ITEM. THIS ROUTINE READS ITEM INFORMATION AND INITIATES ITEM PARAMETERS

CALL SUBROUTINE DEMAND. THIS ROUTINE READS A BLOCK OF DEMANDS, IF NEEDED, AND EXAMINES THE NEXT DEMAND, SO THAT IT CAN SET THE PROGRAM SWITCHES IN THE PROPER CONDITION

END OF THE WEEK

IS THIS THE BEGINNING OF THE WEEK

CALL SUBROUTINE RECEPT. ROUTINE SIMULATES RECEIPT OF AN ORDER

CALL SUBROUTINE BVOH. ROUTINE FILLS BACK ORDERS FROM ON HAND

CALL SUBROUTINE ISSUE. ROUTINE ISSUES FROM ON HAND TO FILL DEMAND.

CALL SUBROUTINE FORECAST. ROUTINE COMPUTES EOQ AND MAKES NEXT FORECAST.

CALL SUBROUTINE RULE. ROUTINE SELECTS THE RULE (SR1 OR PR1) AND COMPUTES EOQ AND ORDER POINT
CALL SUBROUTINE REVIEW. ROUTINE CHECKS THE ORDER LEVEL AND PLACES ORDER, IF NEEDED

CALL SUBROUTINE RUN REP. ROUTINE PRODUCES A LINE OF OUTPUT FOR THE RUNNING REPORT

NO

NO

NO

NO

HAS THIS ITEM BEEN COMpletely PROCESSED

CALL SUBROUTINE EVITEM. ROUTINE EVALUATES ITEM AND PRINTS RESULTS

PRINT OUT

PRINT OUT

PRINT OUT

3

YES

YES

YES

IS THIS THE END OF PARAMETER RUN.

CALL SUBROUTINE EVRUN. ROUTINE PRINTS THE SYSTEM SUMMARY
SUBROUTINE START

READ ITEM RECORD INFORMATION FROM INPUT TAPE

WRITE TO TAPE IN BINARY CODE

ARE ALL THE ITEM READ IN

YES CALL D TAPE TO PREPARE DEMAND TAPE

EXIT

NO
SUBROUTINE D_TAPE
(PREPARE DEMAND TAPE)

READ HEADER CARD

READ A CARD

IS THIS A DEMAND CARD?

YES

CONVERT THE VARIOUS FIELDS INTO DEMAND AMOUNT TRANSACTION CODE TIME FRAME ITEM NUMBER

NO

INTERPRET AS A SEPARATOR CARD

PLACE IN OUTPUT BLOCK

TAKE THE DEMANDS FOR 1ST 22 WEEKS AND ADD TO PREVIOUS 82 WEEKS, TO MAKE 104 WEEKS OF DEMANDS

IS THIS THE LAST ITEM?

NO

YES

PREPARE DEMAND TAPE BY WRITING FROM THE OUTPUT BLOCK. RECORDS OF 30 DEMANDS

EXIT
SUBROUTINE I RUN
(INITIATE RUN (SYSTEM) PARAMETERS)

CLEAR OUTPUT FROM PREVIOUS RUNS

WHAT IS CONDITION OF SENSE SWITCH 1

DOWN
READ SYSTEM PARAMETERS FROM CARDS

UP
READ SYSTEM PARAMETERS FROM SYSTEM TAPE

IS RUN NUMBER NEGATIVE

YES ➔ STOP

NO

SET FORECAST INTERVAL TO 13 WEEKS

TURN OFF SENSE LIGHTS

TURN SENSE LIGHT 2 ON IF THIS IS A S.R.1. RUN

SET REVIEW INTERVAL TO 2 WEEKS IF CONTINUOUS REVIEW, SET REVIEW INTERVAL TO 13 WEEKS IF DISCRETE REVIEW

REWIND INPUT TAPE

EXIT
SUBROUTINE ITEM

RESET TO ZERO ALL COLLECTOR'S OF ITEM SUMMARY RESULTS

READ A NEW ITEM FROM TAPE

INITIATE ON HAND, ON ORDER QUEUES

INITIATE FORECAST PARAMETERS
FORECAST OVERLEAD TIME = \( \text{MEAN ANNUAL DEMAND} \) (LEAD TIME IN YEARS)
STANDARD DEVIATION = \( \sqrt{\text{FORECAST L.T. YEARS}} \)
MEAN ABSOLUTE DEVIATION = 0.8 \( \sqrt{\text{MEAN ANNUAL DEMAND}} \)

CALL SUBROUTINE RULE TO INITIATE ORDER QUANTITY AND ORDER POINT

EXIT
SUBROUTINE DEMAND

SET SWITCH B=OLD T WHERE (B) IS BEGINNING OF A WEEK AND (T) IS END OF A WEEK

IS THIS THE FIRST DEMAND OF RUN

YES

NO

IS THIS OF THE START OF A NEW ITEM

YES

NO

MOVE POINTER TO NEXT DEMAND IN BLOCK OF DEMAND

HAVE ALL THE DEMANDS BEEN USED IN THE BLOCK

YES

NO

READ A NEW BLOCK OF THIRTY DEMANDS

SET POINTER TO FIRST DEMAND OF BLOCK

TRANSFER THIS DEMAND TO TEMPORARY AREA (A)

IS DEMAND IN AREA (A) MORE THAN 1 WEEK IN THE FUTURE

YES

NO

MOVE DEMAND FROM AREA (A) TO ACTUAL DEMAND AREA (B)

4

5
SUBROUTINE DEMAND

4

MOVE POINTER TO NEXT DEMAND OF BLOCK

5

INCREASE WEEK INDICATOR BY 1

YES

ARE THERE MORE DEMANDS IN BLOCK

NO

READ A BLOCK OF 30 DEMANDS

SET POINTER TO 1ST DEMAND

TRANSFER THIS DEMAND TO TEMPORARY AREA (A)

EMIT ZERO DEMAND TO ACTUAL DEMAND AREA (B)

WHAT TYPE TRANSACTION CODE

A, S, Y,

ADD DEMAND TO SUM OF FORECAST DEMAND

WHAT TYPE TRANSACTION CODE

A, H,

S, Y,

B, T, Z

A, H,

S, Y,

B, T, Z

6

7

8
REDUCE THE FOLLOWING BY THE DEMAND AMOUNT:
1. SUM OF REPORTABLE DEMANDS
2. SUM OF FORECAST DEMANDS
3. SUM OF ISSUES

WHAT TYPE TRANSACTION CODE

T,Z
ADD AMOUNT TO ON HAND BALANCE

7
SET DEMAND AMOUNT TO ZERO FOR LATER USE

6
DOES DEMAND IN AREA (A) REQUIRE TRANSACTION THIS WEEK

YES
SET SWITCH T TO INDICATE NOT END OF WEEK

NO

6

SET DEMAND AMOUNT TO ZERO FOR LATER USE

6
DOES DEMAND IN AREA (A) REQUIRE TRANSACTION THIS WEEK

YES
SET SWITCH T TO INDICATE NOT END OF WEEK

NO

NUMBER OF WEEKS SINCE LAST FORECAST

< 13
ADJUST COUNTER

> 13
SET FORECAST SWITCH

RESET COUNTER

NUMBER OF WEEKS SINCE LAST REVIEW

< N
10

< N
9

> N
10
SUBROUTINE DEMAND

9

ADJUST COUNTER

10

SET REVIEW SWITCH

RESET COUNTER

11

IS THE DEMAND IN AREA (A) A SEPARATOR DEMAND?

YES

EXAMINE PRESENT TIME, IS THE TIME EQUAL TO 104 WEEKS?

YES

SET END OF ITEM SWITCH

CLEAR END OF ITEM SWITCH

NO

IS THIS LAST ITEM?

YES

CLEAR END OF RUN SWITCH

NO

SET END OF RUN SWITCH

REWIND INPUT TAPES

EXIT
SUBROUTINE RECPT

IS

ANYTHING
ON ORDER

YES

NO

IS AN
ORDER DUE IN
THIS WEEK

YES

UPDATE
ON HAND
BY AMOUNT
RECEIVED

NO

RECEIVED

REDUCE
ON ORDER
BY AMOUNT
RECEIVED

EXIT
SUBROUTINE BOVOH

(BACK ORDERS VS ON HAND)
1 of 2

13

IS THERE STOCK ON HAND

ARE THERE BACK ORDERS

CAN ALL BACK ORDERS BE FILLED?

YES

NO

YES

NO

YES

EXIT

EXIT

SUBTRACT BACK ORDER TOTAL FROM ON HAND AMOUNT

NO

12

13

QUEUE THE REMAINING ON HAND

ADD TO NUMBER OF BACK ORDERS FILLED

ADD TO NUMBER OF ITEMS ISSUED FROM BACK ORDER

ADD (NUMBER ITEMS IN BACK ORDER) (TIME IN BACK ORDER) TO SUM OF BACK ORDER WEEKS

RESET BACK ORDER QUEUE TO ZERO

SET BACK ORDER TOTAL TO ZERO
SUBROUTINE MOVE

SHIFT ENTRIES OF QUEUES FORWARD DISCARDING FIRST ENTRY

EXIT
**SUBROUTINE ISSUE**

1. **IS THIS DEMAND NON ZERO**
   - **YES**
   - **IS ON HAND EQUAL TO 0**
     - **YES**
     - **IS THERE ENOUGH ON HAND TO COMPLETELY FILL DEMAND**
       - **YES**
         - INCREASE OUT OF STOCK Times TOTAL ADD DEMAND TO BACK ORDERS PLACE IN BACK ORDER QUEUE
       - **NO**
         - PLACE UNFILLED PORTION OF DEMAND IN BACK ORDER QUEUE
     - **NO**
2. **ISSUE GOODS:**
   1. DECREASE ON HAND BY AMOUNT FILLED
   2. INCREASE SUM OF ISSUES FIGURE
   3. READJUST QUEUES
3. ADD 1 TO NUMBER OF ISSUES
4. **EXIT**
SUBROUTINE FORCST

FORECAST ERROR = PREV. QTR. FORECAST - ACTUAL DEMAND

ADD FORECAST ERROR TO SUM OF FORECAST ERRORS

COMPUTE ABSOLUTE DEVIATION (AD)
AD = α(FORECAST ERROR) + (1-α)(OLD AD)

COMPUTE STANDARD DEVIATION α OVER QUARTER
α = 1.25 × AD

COMPUTE STANDARD DEV. OVER LEAD TIME σD
σD = (σ)√LEAD TIME IN YEARS

FORECAST FOR QUARTER = α(ACTUAL DEMAND) + (1-α)(OLD FORECAST)

FORECAST FOR YEAR = (FORECAST FOR QTRS) (4)

FORECAST OVER LEAD TIME = (FORECAST FOR QTR) (LEAD TIME IN QTRS)

EXIT
SUBROUTINE RULE

CALL SRI ROUTINE

IS THIS A PRC RUN

CALL PRC ROUTINE

EXIT
SUBROUTINE PRC

Page 2 of 2

CALL NORMAL SUBROUTINE FOR COMPUTING ORDER POINT

IS YEARLY DEMAND LESS THAN 100

YES

IS VARIANCE TO MEAN RATIO GREATER THAN 1

YES

CALL NEG BIN NEGATIVE BINOMIAL SUBROUTINE

EXIT WITH ORDER QUANT. ORDER POINT COMPUTED

CALL NORMAL SUBROUTINE FOR COMPUTING ORDER POINT

NO

NO
SUBROUTINE PRC

PAGE 1 OF 2

COMPUTE ORDER QUANTITY

\[ Q_Q = \sqrt{\frac{\text{VARIABLE ORDER COST} \times \text{ANNUAL DEMAND}}{\text{HOLDING RATE} \times \text{UNIT COST}}} \]

- **YES**
  - ORDER QUANTITY LESS THAN 6 WEEKS SUPPLY
  - **NO**
    - ORDER QUANTITY MORE THAN 2 YEARS SUPPLY
    - **YES**
      - ORDER QUANTITY EQUAL TO 6 WEEKS SUPPLY
      - **NO**
        - ORDER QUANTITY EQUAL TO 2 YEARS SUPPLY
        - **SET ORDER QUANTITY EQUAL TO NEXT HIGHER INTEGER IF IT IS A FRACTION**

COMPUTE RISK RATIO

\[ \text{RISK} = \frac{\text{HOLDING RATE} \times \text{UNIT COST} \times Q_Q}{\text{ANNUAL DEMAND} \times \text{SHORTAGE COST}} \]

- **YES**
  - IS RISK LESS THAN .01
- **NO**
  - IS RISK GREATER THAN .01
    - **YES**
      - SET RISK = .5
      - **NO**
        - SET RISK = .5

VAR \[ \sigma^2 \]

- **YES**
  - IS YEARLY DEMAND GREATER THAN 2
  - **NO**
    - CALL POISSON SUBROUTINE FOR COUNTING ORDER POINT

14 15
SUBROUTINE NORMAL

IS RISK RATIO \leq 0.14

YES

T = -644R^3 + 247.7R^2 - 33.26R + 2.713

NO

T = 1.59R^2 - 3.893R + 1.553

N = \Phi_1 + (T)(SD)

EXIT
SUBROUTINE FISSON

COMPUTE THE PROBABILITY OF ZERO DEMANDS, \( p(0) \)
CUM = 1 - \( p(0) \)
SET \( I = 0 \)

IS RISK RATIO \( \geq \) CUM

YES
SET ORDER POINT \( N = 1 \)
EXIT

NO

INCREASE \( I \) BY \( 1 \)

COMPUTE THE PROBABILITY OF \( I \) DEMANDS, \( p(I) \)

SET CUM = OLD CUM - \( p(I) \)

22
SUBROUTINE NEG BIN

COMPUTE PROBABILITY OF ZERO DEMANDS, $p(0)$
COMPUTE $CUM = 1 - p(0)$
SET $I = 0$

IS $\text{RISK RATIO} \geq CUM$

YES
SET ORDER POINT, $N = 1$

NO
INCREASE $I$ BY 1

EXIT

COMPUTE THE PROBABILITY OF $I$ DEMANDS, $p(I)$

SET $CUM = \text{OLD CUM} - p(I)$
SHORTAGE COST
FUNCTION SHC(I)

\[ \text{SHORTAGE COST} = \text{SHORTAGE \ COST EQUALS} \]
\[ \$50 + \text{UNIT COST} \]

\[ \text{SHORTAGE COST} = \text{SHORTAGE \ COST \ EQUA} \]
\[ \text{L} \]

\[ \text{SHORTAGE COST} = \text{SHORTAGE \ COST \ EQUA} \]
\[ \text{LES} \]

\[ \text{SHORTAGE COST} = \text{SHORTAGE \ COST \ EQUA} \]
\[ \text{LES} \]

\[ \text{EXIT} \]

\[ \text{WHAT} \]

\[ \text{MOD} \]

\[ \text{IF} \]

\[ \text{SHORTAGE} \]

\[ \text{FUT FORMULA} \]

\[ \text{IF} \]

\[ \text{R} \]

\[ \text{FIN} \]
SET UP CONSTANTS

Z = 0 FOR CONTINUOUS RULE
Z = \( \frac{1}{N} \) YEARS DEMAND FOR DISCRETE RULE

\[ Q_w = \sqrt{\frac{3PD}{CN}} \]

\[ V_D = \left( \frac{\sigma_D}{D} \right)^2 \]
\[ V_L = \left( \frac{\sigma_L \text{ WEEKS}}{\text{MEAN LEAD TIME}} \right)^2 \]

\[ k = \sqrt{\frac{(1 + V_L)(1 + 2V_L + 3V_D + V_D)^2}{3(1 + V_L + V_D)}} \]

\[ K = \frac{D_L (1 + V_L + V_D L)}{2K} \]

\[ F = kL \]

\[ P_o = \frac{HCF}{(HCF + \lambda S)} \]

\[ Q^* = 1.85(FDQ_w^2)^{1/2} \]
\[ Q^* = FD + Q_w \]

IS THIS CONTINUOUS REVIEW

\[ Q_w \geq 225 FD^2 \]

16 \hspace{1cm} 17
ORDER QUANTITY IS MAXIMUM OF
Q*+D(2D+VD) AND
1+ DV 2 + 8

RESTRICT ORDER QUANTITY (Q) TO BETWEEN 6 WEEKS AND 5 YEARS SUPPLY

COMPUTE
X* = FD log [K/(1-1) FD] + 2(W-D)

ORDER POINT (X) IS
X = MAX[D, DL+Z, X*]
HALF ADJUST

EXIT
SUBROUTINE REVIEW

IS AVAILABLE ≤ X

NO ORDER PLACED

EXIT

PLACE AN ORDER FOR X + Q - AVAILABLE

ADD $25 TO TOTAL ORDER COST

SET LEAD TIME TO FIRST UNUSED VARIABLE LEAD TIME ON ITEM RECORD

PLACE ORDER IN DUE-IN QUEUE IN PROPER SEQUENCE

EXIT
SUBROUTINE RUNREP
(PRODUCE RUNNING REPORT)

THE FOLLOWING ARE ACCUMULATED WEEKLY FOR USE IN THE ITEM SUMMARY REPORT:
COST OF MATERIAL PROCURED = (UNIT COST) (ORDER QUANTITY)
ON HAND AMOUNT
ORDER POINT
FORECAST OVER LEAD TIME

IS THIS THE FIRST TIME FRAME

WRITE A SYSTEM HEADING, ITEM INITIALIZATION HEADING, AND COLUMN HEADING FOR RUNNING REPORT

COMPUTE AVAILABLE = ON HAND + DUE IN - BACK ORDER TOTAL

HAS FORECAST OR BACKORDER OR ORDER OCCURRED

WRITE A LINE OF THE RUNNING REPORT

EXIT
SUBROUTINE EVITEM

COMPUTE FOR INDIVIDUAL ITEM OUTPUT AND SUM FOR SYSTEM OUTPUT

**AVERAGE VALUE OF ON HAND STOCKS**
(UNIT COST)
(INVENTORY LEVEL SUMMARIZED WEEKLY)
(NUMBER OF WEEKS)

**NUMBER OF ITEMS PLACED INTO BACKORDER**
(DOLLAR BASE)
($1.00) (NUMBER OF ITEMS PLACED IN B/O)

**DOLLAR VELOCITY OF ANNUAL DEMAND**
(SUM OF DEMANDS) (UNIT COST)
(NUMBER OF YEARS)

**SHORTAGE COST (DOLLAR BASE)**
(UNIT COST)
($1.00) (NUMBER OF ITEMS PLACED IN B/O)

**AVERAGE VALUE OF LEAD TIME STOCK**
(LEAD TIME STOCK SUMMED WEEKLY) (UNIT COST)
(NUMBER OF WEEKS)

**SHORTAGE COST (UNIT COST BASE)**
(UNIT COST)
(NUMBER OF ITEMS PLACED IN B/O)

**AVERAGE VALUE OF ORDER POINT STOCK**
(ORDER POINT SUMMED WEEKLY) (UNIT COST)
(NUMBER OF WEEKS)

**TOTAL COST (DOLLAR BASE)**
ORDER COST + HOLDING COST + SHORTAGE COST (DOLLAR BASE)

**TOTAL COST (UNIT COST BASE)**
ORDER COST + HOLDING COST + SHORTAGE COST (UNIT COST BASE)

**HOLDING COST**
15% OF AVERAGE VALUE OF ON HAND STOCK
SUBROUTINE EVITEM

SERVICE PERCENTAGE =
100% IF THERE ARE NO DEMANDS OR
(100) [ISSUES IMMEDIATELY]
(DEMANDS)

BACK ORDER SERVICE =
(100) [BACK ORDER ISSUE]
(DEMANDS)

AVERAGE BACK ORDER AGE =
BACK ORDER WEEKS (OF ITEMS ISSUED FROM B/O)
BACK ORDER ISSUES

PRINT ITEM SUMMARY RESULTS

EXIT
SUBROUTINE EVRUN

WRITE RUN
PARAMETER
HEADING

COMPUTE FOR THIS RUN
PERCENT SERVICE = 100
(SUM OF ISSUES FOR ALL ITEMS)
(SUM OF DEMANDS FOR ALL ITEMS)

COMPUTE FOR THIS RUN
PERCENT BACK ORDER SERVICE =
100
(SUM OF BACK ORDER ISSUES)
(SUM OF DEMANDS)

WRITE OUT
SYSTEM SUMMARY
REPORT

EXIT