SIMSCRIPT II.5 TUTORIAL

EDWARD C. RUSSELL

CSCI
12011 San Vicente Boulevard
Los Angeles, California 90049

ABSTRACT

This tutorial will present the highlights of the SIMSCRIPT II.5 approach to building discrete event simulation models. The approach will be to construct a small example problem, implement the program in SIMSCRIPT II.5, and then to display the modularity which is possible with SIMSCRIPT II.5 by adding several "real-world" complexities to the model.

1. BACKGROUND

Simulation languages are (or should be) more than extensions of general-purpose programming languages designed to ease the burden of programming simulation problems. The influence of a good simulation language should be felt during the specification and model design stages of simulation as well as during computer implementation. If the "world-view" of the simulation language is well understood, and if the world-view is appropriate for a given problem, the language should aid immeasurably in reducing the effort (and consequently elapsed time) in transforming model from concept to realization.

2. SIMSCRIPT II.5 WORLD-VIEW

SIMSCRIPT is a discrete-event language (Figure 1.) Actions are modelled in terms of events. Sequences of events describing actions of a single object (or entity) are modelled as processes. Many important relationships are described dynamically in terms of entities-attributes-sets. This very powerful data structuring is one of the unique features of the language. The implementation in SIMSCRIPT of the classical simulation problems, such as small queueing models or job-shop simulations, have been described elsewhere (see References).

3. SIMSCRIPT II.5 IMPLEMENTATIONS

SIMSCRIPT II.5 has been implemented on seven different manufacturer's computers including IBM, Honeywell, CDC, Univac, VAX, NCR, PRIME and most recently the IBM PC/XT. Development is underway for VAX/UNIX and Gould. A major emphasis is to achieve portability of models from one machine to another since the type of models typically written in SIMSCRIPT have a fairly long lifetime and are often shared among a community of users with different computers.

4. SIMSCRIPT II.5 AVAILABILITY

SIMSCRIPT II.5 is the proprietary product of CACI and is available from them for lease or purchase. SIMSCRIPT is also available on Boeing Computer Services, Control Data-Cybernet, D & B Computing Services, Service Bureau Corporation, and United Computing Services.

Figure 1: The Timing Routine

A university program is supported by CACI in which SIMSCRIPT is supplied to educational institutions for the cost of distribution.

5. THE TUTORIAL EXAMPLE

The tutorial is built around a simple queuing problem first presented in (SCHRIER) and later revised in (FISHER 1978). An African Port consists of three docks serviced by a single tug (Figure 2). Ships which arrive to be loaded must use the tug to enter and leave the docks. The ships arrive according to an exponential distribution of inter-arrival times with a mean of
eleven hours. The ships are of three sizes distributed as follows:

25% have a mean loading time of 18 hours
55% have a mean loading time of 24 hours
20% have a mean loading time of 36 hours

Finally, in order to verify the correct execution of the model, the SIMSCRIPT tools for debugging will be added to the model.

The tutorial shall be comprised of a detailed walkthrough of the original model and a discussion of the evolution to the completed model in the following steps:

1) original simple model with only old tankers (Figure 3);
2) additions for statistical output (Figure 4);
3) additions for the new tankers; (Figure 5);
4) additions for storms and smog; (Figure 6);
5) additions for debug (Figure 7).

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SIMSCRIPT IIE TUTORIAL MODEL
"AN AFRICAN PORT STUDY"

PREAMBLE
PROCESSES INCLUDE GENERATOR AND SHIP
RESOURCES INCLUDE DOCK AND TUG
THE SYSTEM HAS A LOADING TIME RANDOM STEP VARIABLE
DEFINE LOADING TIME AS A REAL VARIABLE
DEFINE END OF SIMULATION TO MEAN TIME, Y >= 365.
END "PREAMBLE"

MAIN
READ LOADING TIME
CREATE EVENT DOCK(0)
LET U(0)(D) = 1
CREATE EVERY TUG(1)
LET U(1)(T) = 1
ACTIVATE A GENERATOR NOW
START SIMULATION
END "MAIN"

INPUT DATA:
0.25 0.18 0.55 0.24 0.2 0.36

PROCESS GENERATOR
UNTIL END OF SIMULATION,
  ACTIVATE A SHIP NOW
  WAIT EXPONENTIAL,F(11,9), 2 HOURS
  LOOP
END "PROCESS GENERATOR"

PROCESS SHIP
REQUEST 1 DOCK(1)
WAIT TUG(1)
WAIT EXPONENTIAL,F(1,0.3), HOURS
REFUELISH 1 TUG(1)
WORK EXPONENTIAL,F(L,0,5), 4 HOURS
REQUEST 1 TUG(1)
WAIT EXPONENTIAL,F(1,0.5), HOURS
REFUELISH 1 DOCK(1)
END "PROCESS SHIP"
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Figure 2: Example Program

The times are all exponentially distributed about these means. The time for moving a ship into or out of a dock is also exponentially distributed with a mean of one hour. Ships queue for the tug and/or the dock on a first-come-first-served basis.

The first task is to model this existing situation and measure the utilization factors for the tug and the dock. In addition, the congestion in the harbor (queueing statistics for the tug and dock) are to be measured. Finally, statistics on the import time for the ships should be collected.

After this simple model is developed, the next phase is to superimpose a new category of tanker. These new tankers belong to a fixed size fleet. They have a mean loading time of 21 hours and require the same tug and dock services as the other tankers. When they leave the port, they make a round-trip to their destination in a mean time of ten days (again exponentially distributed). The same statistics should be reported as above in order to determine the impact of the new tankers on the port.

The next complication to be added to the model is the effect of external interruptions such as storms and smog. A storm serves to delay the arrival of ships and to detain them when ready to depart. Smog alerts cause the unloading of ships to be interrupted until the smog alert is lifted. Since storms and smog are fairly rare occurrences, these phenomena are to be represented as they actually occurred over some historical period.
SIMSCRIPT II.5 TUTORIAL MODEL
AN AFRICAN PORT STUDY

PREAMBLE

PROCESSES INCLUDE GENERATOR AND SHIP
RESOURCES INCLUDE DOCK AND TUZ
THE SYSTEM HAS A LOADING TIME RANDOM STEP VARIABLE
DEFINE THE LOADING TIME AS A REAL VARIABLE
ACUMULATE AVG.DOCK.QUEUE AS THE AVERAGE OF N.DOCK
ACUMULATE DOCK.USE AS THE AVERAGE OF N.DOCK
ACUMULATE N.DOCK.QUEUE AS THE AVERAGE OF N.DOCK
ACUMULATE N.TUZ.QUEUE AS THE AVERAGE OF N.TUZ
ACUMULATE AVG.TUZ.QUEUE AS THE AVERAGE OF N.TUZ
TALLY AVG.IN.PORT.TIME AS THE AVERAGE
AND MAX.IN.PORT.TIME AS THE MAXIMUM OF IN.PORT.TIME
DEFINE IN.PORT.TIME AS A REAL VARIABLE
DEFINE END.OF.SIMULATION TO MEAN TIME.Y >= 365.
END "PREAMBLE

MAIN

READ TYPE.DISTRIBUTION
PRINT 1 LINE TIME
"AFRICAN PORT TANKER STUDY"
SKIP 1 LINE
CREATE EVERY DOCK(1)
LET U.DOCK(1) = 0
LET U.TUZ(1) = 1
ACTIVATE A GENERATOR NOW
START SIMULATION
END "MAIN

PROCESS GENERATOR

UNTIL END.OF.SIMULATION.
DO
ACTIVATE A SHIP NOW
WAIT EXPONENTIAL(0.4)-2.0 HOURS
LET T.UZ.TUZ = 1
END "PROCESS GENERATOR

PROCESS SHIP

DEFINE ARRIVAL TIME AS A REAL VARIABLE
LET ARRIVAL TIME = TIME.V
REQUEST 1 DOCK(1)
WAIT EXPONENTIAL(0.1)-0.3 HOURS
RELINQUISH 1 TUZ(1)
WORK EXPONENTIAL(0.1)-0.4 HOURS
RELINQUISH 1 DOCK(1)
WAIT EXPONENTIAL(0.1)-0.2 HOURS
RELINQUISH 1 DOCK(1)
LET IN.PORT.TIME = (TIME.V - ARRIVAL TIME) * HOURS.V
END "PROCESS SHIP

AFRICAN PORT TANKER STUDY
AFTER 206.02 DAYS
803 SHIPS HAVE BEEN LOADED;
THE AVERAGE INPORT TIME FOR A SHIP WAS 40.54 HOURS.
THE MAXIMUM INPORT TIME FOR A SHIP WAS 205.58 HOURS.
THE DOCK UTILIZATION WAS .77 (.100 %)
THE AVERAGE QUEUE FOR THE DOCK WAS .92 SHIPS
THE TUG UTILIZATION WAS .20 (.100 %)
THE AVERAGE QUEUE FOR THE TUG WAS .3 SHIPS

Figure 4

Figure 5
**SIMSCRIPT II.5 TUTORIAL MODEL**

**AN AFRICAN PORT STUDY**

**PREMISE**

**PROCEDURES** INCLUDE **GENERATOR AND SHIP**

**EVERY SHIP HAS A TYPE**

**PRIORITY**, WHICH BELONGS TO THE **FLEET**

**DEFINITE TYPE IS AN ALPHA VARIABLE**

**DEFINE SHIP.TYPE AS AN ALPHA VARIABLE**

**EXTERNAL PROCESSES ARE SMOKE AND STORM**

**EXTERNAL EVENT UNIT IS 7**

**RESOURCES INCLUDE DOCK AND TUG**

**AND PERMIT**

**DEFINE NO.NEW.SHIRPS AS AN INTEGER VARIABLE**

**THE SYSTEM HAS A LOADING.TIME RANDOM STEP VARIABLE**

**AND OWNS THE FLEET**

**DEFINE LOADING.TIME AS A REAL VARIABLE**

**ACCUMULATE AVG.DOCK.QUEUE AS THE AVERAGE OF N.DOCK**

**ACCUMULATE DOCK.UTILIZATION AS THE AVERAGE OF N.DOCK**

**ACCUMULATE TUG.QUEUE AS THE AVERAGE OF N.TUG**

**ACCUMULATE TUG.UTILIZATION AS THE AVERAGE OF W.TUG**

**TALLY AVG.IN.PORT.TIME AS THE AVERAGE**

**AND MAX.IN.PORT.TIME AS THE MAXIMUM OF IN.PORT.TIME**

**DEFINE IN.PORT.TIME AS A REAL VARIABLE**

**DEFINE DEPART TO MEAN 1**

**DEFINE UNLOAD TO MEAN 2**

**DEFINE END.OF.SIMULATION TO MEAN TIME.V >= 300.**

**END "PREMISE"**

**MAIN**

CALL ORIGIN(P.1,1,5)

READ LOADING.TIME

PRINT 1 LINE THRU

1 LINE

AFRICAN PORT TANKER STUDY

SKIP 1 LINE

READ NO.NEW.SHIRPS

PRINT 1 LINE WITH NO.NEW.SHIRPS THUS

NO. OF NEWS SHIPS IS *.

SKIP 1 LINE

CREATE EVERY DOCK(1)

LET TUG(0) = 0

CREATE EVERY TUG(1)

LET U.PERMIT(UNLOAD) = 1

LET U.PERMIT(DEPART) = 1

ACTIVATE A GENERATOR NOW START SIMULATION

**END "MAIN"**

**INPUT DATA:**

\[0.25\quad 0.25\quad 0.25\quad 0.25\quad 0.25\]

**PROCESS GENERATOR**

**DEFINE AS AN INTEGER VARIABLE**

**FOR I = 1 TO NO.NEW.SHIRPS, DO**

**ACTIVATE A SHIP IN * 1 DAYS**

**LET TYPE(I) = "NEW"**

**LET SHIP.STATUS(I) = "AT SEA"**

**FILESHIP IN FLEET**

**LOOP**

**UNTIL END.OF.SIMULATION, DO**

**ACTIVATE A SHIP NOW**

**LET TYPE(I) = "OLD"**

**LET SHIP.STATUS(I) = "AT SEA"**

**FILESHIP IN FLEET**

**WAIT EXPONENTIAL(11.0, 0) HOURS**

**SKIP 2 LINES**

PRINT 1 LINE WITH TIME.V, NO.OF SHIPS.SERVED, AVERAGE PORT TIME, MAX IN PORT TIME, DOCK.UTILIZATION, AVG.DOCK.QUEUE, TUG.UTILIZATION AND AVG.TUG.QUEUE THUS AFTER **1000** DAYS

**" SHIPS HAVE BEEN LOADED.**

**" THIS AVERAGE IN PORT TIME FOR A SHIP WAS **1.00** HOURS.**

**" THE MAXIMUM IN PORT TIME FOR A SHIP WAS **5.00** HOURS.**

**" THE DOCK UTILIZATION WAS **.50**.**

**" THE AVERAGE QUEUE FOR THE DOCK WAS **.92** SHIPS**

**" THE AVERAGE QUEUE FOR THE TUG WAS **.54** SHIPS**

**STOP**

**END "PROCESS GENERATOR"**

**PROCESS SHIP**

**DEFINE ARRIVAL.TIME AS A REAL VARIABLE**

**DEFINE MEAN.LOAD.TIME AS A REAL VARIABLE**

**IF TYPE(I) = "OLD"**

**LET MEAN.LOAD.TIME = LOADING.TIME**

**ELSE**

**LET MEAN.LOAD.TIME = 21**

**ALWAYS**

**UNTIL END.OF.SIMULATION, DO**

**LET ARRIVAL.TIME = TIME.V**

**LET SHIP.STATUS(I) = "IN.HARBOR"**

**REQUEST 1 DOCK(I)**

**WAIT EXPONENTIAL(11.0, 0) HOURS**

**REQUEST 1 PERMIT(UNLOAD)**

**WAIT EXPONENTIAL(11.0, 0) HOURS**

**LET SHIP.STATUS(I) = "UNLOADING"**

**REQUEST 1 DOCK(I)**

**WAIT EXPONENTIAL(11.0, 0) HOURS**

**REQUEST 1 PERMIT(DEPART)**

**LET SHIP STATUS(I) = TIME.V - ARRIVAL.TIME - 10 HOURS**

**IF I REMOVE THIS SHIP FROM FLEET**

**SAVE**

**FILE**

**LET SHIP.STATUS(I) = "AT SEA"**

**WAIT EXPONENTIAL(11.0, 0) HOURS**

**LOOP**

**END "PROCESS SHIP"**

**PROCESS STORM**

**DEFINE DURATION AS A REAL VARIABLE**

**READ DURATION**

**REQUEST 1 PERMIT(DEPART) WITH PRIORITY 1**

**FOR EACH SHIP IN FLEET, WITH SHIP.STATUS(I) = "AT SEA"**

**INTERCEPT SHIP**

**WAIT DURATION DAYS**

**REQUEST 1 PERMIT(UNLOAD)**

**FOR EACH SHIP IN FLEET, WITH SHIP.STATUS(I) = "UNLOADING"**

**RESUME SHIP**

**END "STORM"**

**PROCESS SMOG**

**DEFINE DURATION AS A REAL VARIABLE**

**READ DURATION**

**REQUEST 1 PERMIT(UNLOAD)**

**FOR EACH SHIP IN FLEET, WITH SHIP.STATUS(I) = "UNLOADING"**

**INTERCEPT SHIP**

**WAIT DURATION DAYS**

**REQUEST 1 PERMIT(DEPART)**

**FOR EACH SHIP IN FLEET, WITH SHIP.STATUS(I) = "AT SEA"**

**RESUME SHIP**

**END "SMOG"**

AFRICAN PORT TANKER STUDY

NO. OF NEW SHIPS IS 5.

AFTER 365.02 DAYS

928 SHIPS HAVE BEEN LOADED.

THE AVERAGE IN PORT TIME FOR A SHIP WAS 112.49 HOURS.

THE MAXIMUM IN PORT TIME FOR A SHIP WAS 481.69 HOURS.

THE DOCK UTILIZATION WAS **.50** (90.0 %)

THE AVERAGE QUEUE FOR THE DOCK WAS **9.12** SHIPS

THE TUG UTILIZATION WAS **.50** (90.0 %)

THE AVERAGE QUEUE FOR THE TUG WAS **5.4** SHIPS

STOP

**END "PROCESS GENERATOR"**

Figure 6
SIMSCRIPT II.5 Tutorial

.. Simscript II.5 Tutorial Model

**PREAMBLE**

PROCESS INCLUDE GENERATOR AND SHIP
EVERY SHIP HAS A TYPE AND A SHIP ID AND A SHIP'S STATUS AND A SHIP’S LOCATION AND BELONGS TO THE FLEET
DEFINE TYPE AS A STRONG VARIABLE
DEFINE SHIP'S STATUS AS AN ALPHABETIC VARIABLE
DEFINE SHIP'S LOCATION AS AN INTEGER VARIABLE
EXTERNAL PROCESSES ARE SMOKES AND STORMS
EXTERNAL EVENT UNIT IS 10 MINUTES
RESOURCES INCLUDE DOCK AND TUG
AND PERMIT
DEFINE NO.NEWSHIPS AS AN INTEGER VARIABLE
THE SYSTEM HAS A LOADING TIME (RANDOM) AND THE FREIGHT
DEFINE LOADING TIME AS A REAL VARIABLE
ACCUMULATE AVG.DOCK;QUEUE AS THE AVERAGE OF N.DOCK
ACCUMULATE DOCK;STATIONIZATION AS THE AVERAGE OF N.DOCK
ACCUMULATE AVG.N.TUG;DOCK;QUEUE AS THE AVERAGE OF N.TUG
ACCUMULATE AVG.N.TUG;STATIONIZATION AS THE AVERAGE OF N.TUG
DEFINE AVG.PORT;TIME AS THE AVERAGE
AND NO. OF SHIPS SERVED AS THE NUMBER
AND MAX.PORT;TIME AS THE MAXIMUM OF IN.PORT;TIME
DEFINE IN.PORT;TIME AS A REAL VARIABLE
DEFINE DEPART TO MEAN 1
DEFINE UNLOAD TO MEAN 2
DEFINE END;SIMULATION TO MEAN TIME, Y = 300
END **PREAMBLE**

MAIN

LET BETWEEN.V = "DETIAL"
CALL ORIGIN.RL, LIST
READ TYPE DISTRIBUTION
PRINT 1 LINE THIS
AFRICAN PORT TANKER STUDY
SKIP 1 LINE
READ NO.NEWSHIPS
PRINT 1 LINE WITH NO.NEWSHIPS
NO. OF NEWSHIPS IS "+".
SKIP 1 LINE
CREATE EVERY DOCK;1
LET DOCK;COUNT = 3
CREATE EVERY TUG;1
LET TUG;COUNT = 1
CREATE EVERY PERMIT;1
LET PERMIT;COUNT = 1
LET PERMIT;COUNT;1 = 1
CREATE A GENERATOR NOW
START SIMULATION
END **MAIN**

INPUT DATA:

G

.25 18 0.55 24 0.2 35 *

PROCESS GENERATOR

DEFINE AS AN INTEGER VARIABLE
DEFINE SHIP;COUNT AS AN INTEGER, SAVED VARIABLE
FOR I = 1 TO NO.NEWSHIPS
DO
ACTIVATE A SHIP IN 2 TO 7 DAYS
LET TRIP;DISTANCE = "HLP"
LET SHIP;STATUS;1 = "AT.SEA"
ADD TO SHIP;COUNT
LET SHIP;ENDING = SHIP;COUNT
FILE SHIP; IN FLEET
LOOP
UNTIL END;SIMULATION
PRT 1 LINE
ACTIVATE A SHIP NOW
LET TRIP;DISTANCE = "HLP"
LET SHIP;STATUS;1 = "AT.SEA"
ADD TO SHIP;COUNT
LET SHIP;ENDING = SHIP;COUNT
FILE SHIP; IN FLEET
PRINT EXPONENTIAL (110, 4) HOURS
LOOP
PRINT 1 LINE WITH TIME, V, NO. DOCK;1, N.O.TUG;1, N.X.DOCK;1, N.X.TUG;1, (J.O.DOCK;1), (J.O.TUG;1), (J.I.N.TUG)
AT TIME " + "
PRINT 1 LINE WITH SHIP;ID, SHIP; TYPE, SHIP; IN.FLEET
PRINT EXPONENTIAL (110, 4) HOURS
STOP
RETURN
END **SMOKE**

ROUTINE DETAIL

DEFINE LINE;COUNT AS AN INTEGER, SAVED VARIABLE
ADD TO LINE;COUNT
IF LINE;COUNT = 25
LET BETWEEN.V = 0
ALWAYS
IF EVENT.V = 1
PRINT 1 LINE WITH TIME, V, NO. DOCK;1, N.O.TUG;1, N.X.DOCK;1, N.X.TUG;1, (J.O.DOCK;1), (J.O.TUG;1), (J.I.N.TUG) " + FREE DOCKS"
PRINT 1 LINE WITH SHIP;ID, SHIP; TYPE, SHIP; IN.FLEET
SHIP " + "
RETURN
OTHERWISE
IF EVENT.V = SIMU01
PRINT 1 LINE WITH LINE;PERIOD AND TIME;V LET SIMU;PERIOD = 1000000000
SIMU;PERIOD = 1000000000
RETURN
OTHERWISE
END **ROUTINE DETAIL**

Figure 7
ROUTINE FOR SNAPR
START NEW PAGE
PRINT 1 LINE THUS
GLOBAL CONDITIONS AT SNAPR
SKIP 2 LINES
FOR EACH SHIP IN THE FLEET,
PRINT 1 LINE WITH SHIP(PSHIP) AND TYPE(SHIP) AND LINEN(PSHIP) THUS
SHIP ---- (TYPE " * " ) IS AWAITING EXECUTION OF LINE
SKIP 2 LINES
PRINT 3 LINES WITH U.DOCK(I), N.DOCK(I) AND N.DOCK(I) THUS
THERE ARE I FREE DOCKS
THERE ARE I DOCKS IN USE
AND I SHIPS IN THE DOCK QUEUE.
END "SNAPR"

AFRICAN PORT TANKER STUDY
NO. OF NEW SHIPS IS 5

AT TIME 0, N.DOCK = 0, N.TUG = 0, N.DOCK = 0 FREE DOCKS 3
SHIPS 3
AT TIME 2, N.DOCK = 0, N.TUG = 0, N.DOCK = 0 FREE DOCKS 2
SHIPS 2
STORM PROCESS RESUMING ON LINE 1 AT TIME 5.

AT TIME 10, N.DOCK = 0, N.TUG = 0, N.DOCK = 0 FREE DOCKS 1
SHIPS 1
STORM PROCESS RESUMING ON LINE 2 AT TIME 10.

AT TIME 10, N.DOCK = 0, N.TUG = 0, N.DOCK = 0 FREE DOCKS 1
SHIPS 1
STORM PROCESS RESUMING ON LINE 3 AT TIME 10.

AT TIME 10, N.DOCK = 0, N.TUG = 0, N.DOCK = 0 FREE DOCKS 1
SHIPS 1
STORM PROCESS RESUMING ON LINE 4 AT TIME 10.

AT TIME 10, N.DOCK = 0, N.TUG = 0, N.DOCK = 0 FREE DOCKS 1
SHIPS 1
STORM PROCESS RESUMING ON LINE 5 AT TIME 10.

AT TIME 10, N.DOCK = 0, N.TUG = 0, N.DOCK = 0 FREE DOCKS 1
SHIPS 1
STORM PROCESS RESUMING ON LINE 6 AT TIME 10.

AT TIME 10, N.DOCK = 0, N.TUG = 0, N.DOCK = 0 FREE DOCKS 1
SHIPS 1
STORM PROCESS RESUMING ON LINE 7 AT TIME 10.

AT TIME 10, N.DOCK = 0, N.TUG = 0, N.DOCK = 0 FREE DOCKS 1
SHIPS 1
STORM PROCESS RESUMING ON LINE 8 AT TIME 10.

AT TIME 10, N.DOCK = 0, N.TUG = 0, N.DOCK = 0 FREE DOCKS 1
SHIPS 1
STORM PROCESS RESUMING ON LINE 9 AT TIME 10.

AT TIME 10, N.DOCK = 0, N.TUG = 0, N.DOCK = 0 FREE DOCKS 1
SHIPS 1
STORM PROCESS RESUMING ON LINE 10 AT TIME 10.

AT TIME 10, N.DOCK = 0, N.TUG = 0, N.DOCK = 0 FREE DOCKS 1
SHIPS 1
STORM PROCESS RESUMING ON LINE 11 AT TIME 10.

AT TIME 10, N.DOCK = 0, N.TUG = 0, N.DOCK = 0 FREE DOCKS 1
SHIPS 1
STORM PROCESS RESUMING ON LINE 12 AT TIME 10.

AT TIME 10, N.DOCK = 0, N.TUG = 0, N.DOCK = 0 FREE DOCKS 1
SHIPS 1
STORM PROCESS RESUMING ON LINE 13 AT TIME 10.

AT TIME 10, N.DOCK = 0, N.TUG = 0, N.DOCK = 0 FREE DOCKS 1
SHIPS 1
STORM PROCESS RESUMING ON LINE 14 AT TIME 10.

AT TIME 10, N.DOCK = 0, N.TUG = 0, N.DOCK = 0 FREE DOCKS 1
SHIPS 1
STORM PROCESS RESUMING ON LINE 15 AT TIME 10.

AT TIME 10, N.DOCK = 0, N.TUG = 0, N.DOCK = 0 FREE DOCKS 1
SHIPS 1
STORM PROCESS RESUMING ON LINE 16 AT TIME 10.

AT TIME 10, N.DOCK = 0, N.TUG = 0, N.DOCK = 0 FREE DOCKS 1
SHIPS 1
STORM PROCESS RESUMING ON LINE 17 AT TIME 10.

AT TIME 10, N.DOCK = 0, N.TUG = 0, N.DOCK = 0 FREE DOCKS 1
SHIPS 1
STORM PROCESS RESUMING ON LINE 18 AT TIME 10.

AT TIME 10, N.DOCK = 0, N.TUG = 0, N.DOCK = 0 FREE DOCKS 1
SHIPS 1
STORM PROCESS RESUMING ON LINE 19 AT TIME 10.

AT TIME 10, N.DOCK = 0, N.TUG = 0, N.DOCK = 0 FREE DOCKS 1
SHIPS 1
STORM PROCESS RESUMING ON LINE 20 AT TIME 10.

AT TIME 10, N.DOCK = 0, N.TUG = 0, N.DOCK = 0 FREE DOCKS 1
SHIPS 1
STORM PROCESS RESUMING ON LINE 21 AT TIME 10.

AT TIME 10, N.DOCK = 0, N.TUG = 0, N.DOCK = 0 FREE DOCKS 1
SHIPS 1
STORM PROCESS RESUMING ON LINE 22 AT TIME 10.

AT TIME 10, N.DOCK = 0, N.TUG = 0, N.DOCK = 0 FREE DOCKS 1
SHIPS 1
STORM PROCESS RESUMING ON LINE 23 AT TIME 10.

AT TIME 10, N.DOCK = 0, N.TUG = 0, N.DOCK = 0 FREE DOCKS 1
SHIPS 1
STORM PROCESS RESUMING ON LINE 24 AT TIME 10.

AT TIME 10, N.DOCK = 0, N.TUG = 0, N.DOCK = 0 FREE DOCKS 1
SHIPS 1
STORM PROCESS RESUMING ON LINE 25 AT TIME 10.

AT TIME 10, N.DOCK = 0, N.TUG = 0, N.DOCK = 0 FREE DOCKS 1
SHIPS 1
STORM PROCESS RESUMING ON LINE 26 AT TIME 10.

AT TIME 10, N.DOCK = 0, N.TUG = 0, N.DOCK = 0 FREE DOCKS 1
SHIPS 1
STORM PROCESS RESUMING ON LINE 27 AT TIME 10.

AFTER 365.02 DAYS
200 SHIPS HAVE BEEN LOADED.
THE AVERAGE IMPORT TIME FOR A SHIP WAS 115.49 HOURS.
THE MAXIMUM IMPORT TIME FOR A SHIP WAS 481.59 HOURS.
THE DOCK UTILIZATION WAS 55.0 (100%).
THE AVERAGE QUEUE FOR THE DOCK WAS 9.32 SHIPS.
THE TUG UTILIZATION WAS .23 (100%)
THE AVERAGE QUEUE FOR THE TUG WAS 24 SHIPS.

Figure 7 continued

REFERENCES


