

LEAN SIMULATION MODELS

Demonstration



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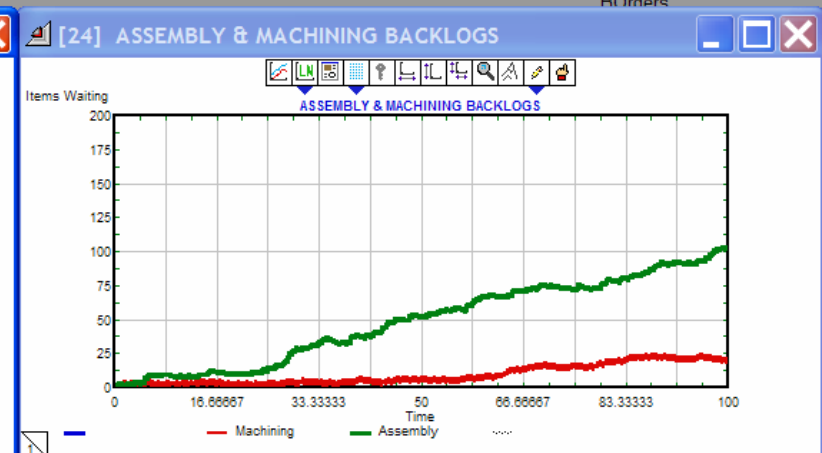
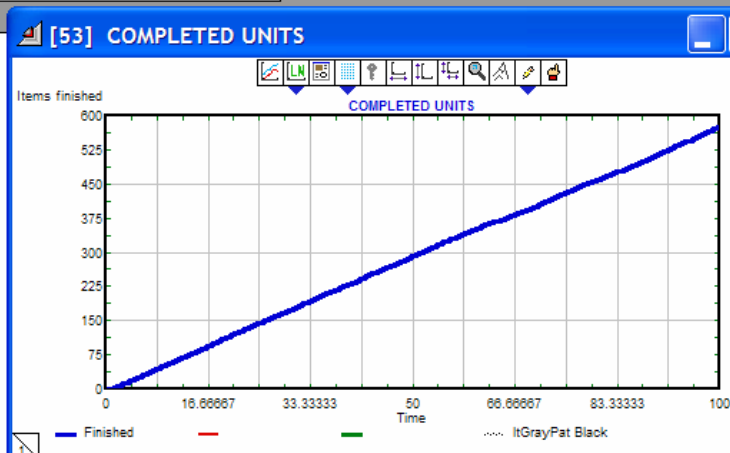
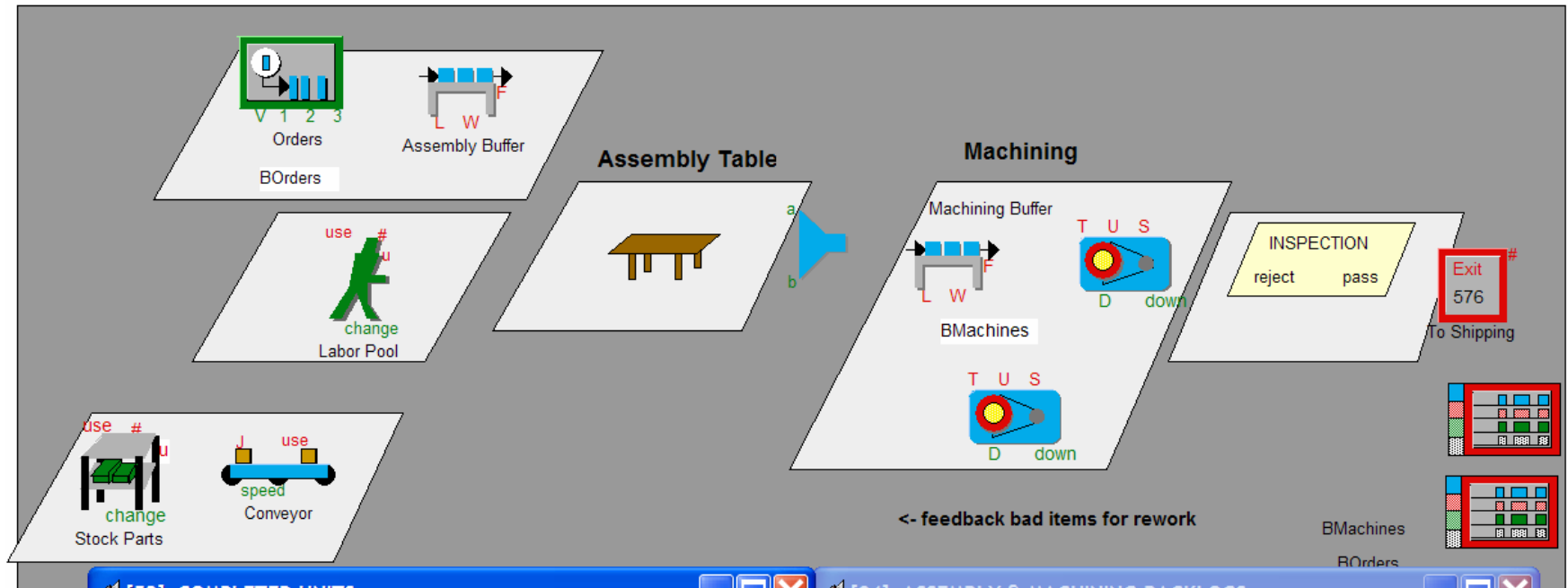
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- **Demonstration of Lean Models**
 - **Mini case study: MRP to Pull in a flow shop**
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 - **Inventory replenishment model**

Extend™ from Imagine That Inc.

Production Line



Simulation Models Are Essential Tools for Lean Programs To Test Alternative Solutions Before Implementing Them

- To analyze *plant capacity* – to trade-off volume & mix (variety) of products
- To analyze *service levels* – to balance demand and supply
 - Make-to-Stock inventory
 - Make-to-Order lead times

Models are adaptable to either flow shops or job shops.

Multiple sites across a supply chain may be analyzed.

Simulation takes variability (in processing, setups and downtime) into account.

Some Real Benefits – beyond traditional lean tools such as value-stream mapping

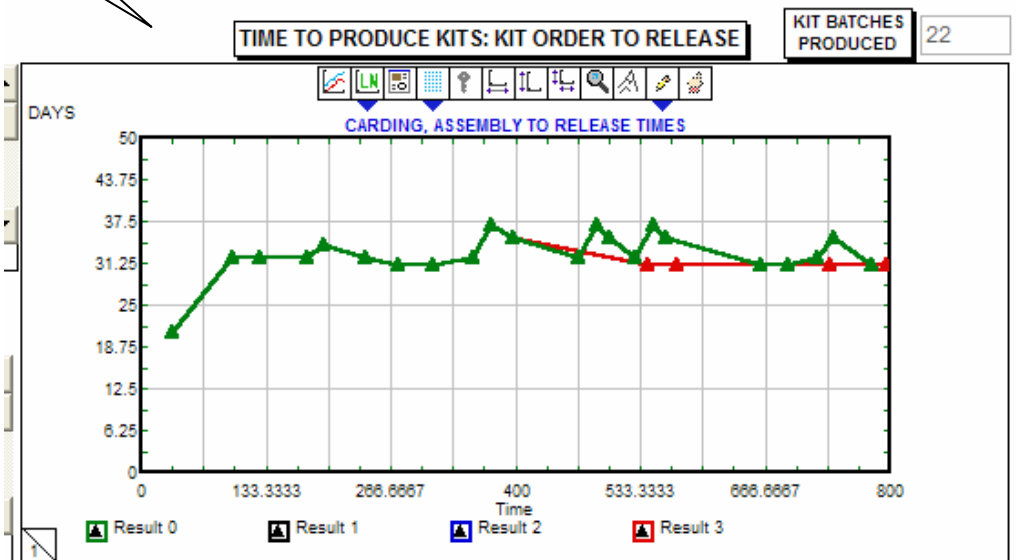
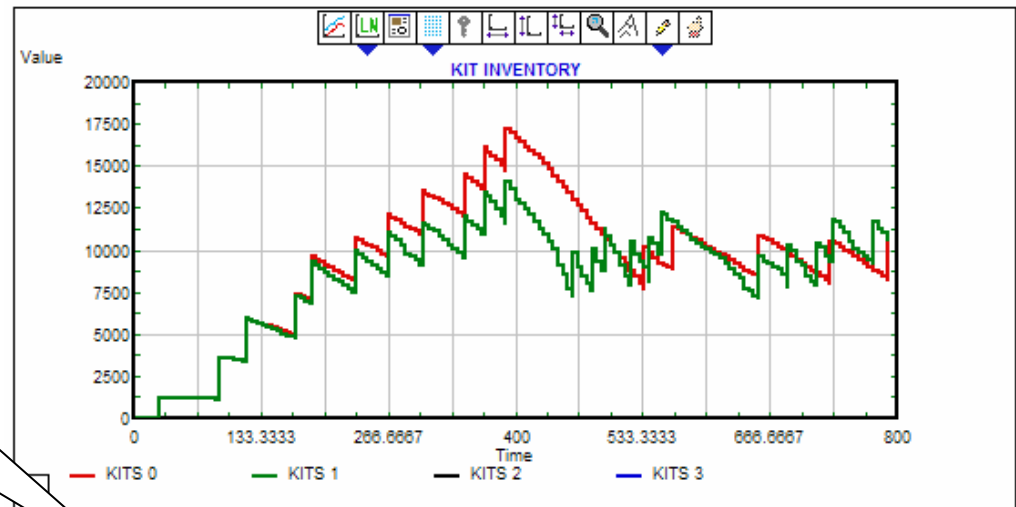
- **Postponement** of final packaging results in 30% inventory reduction; with substantial service improvement to 97+%
- **Synchronized operation** reduces cycle time from 18 to 13 weeks
- **Shift/work center change** allows schedule change from 7 to 6 days/week
- **PLUS** actually test & measure impacts of:
 - **Late materials** starving downstream operations
 - **Schedules & kanbans** on throughput, service level & utilization
 - **Variability & mix** on capacity investments

Lean Analysis & Improvement Techniques Included in Lean Simulation Model

- Kanbans
- Schedules
- EPE (every-part-every ...) interval
- Batch & campaign sizes vs. one piece flow
- Setup reduction
- Routing changes
- Shared resources
- Postponement
- Variability impacts
- Downtime impacts
- Yield & scrap
- Material lead times
- Metrics
 - Takt times/rates
 - Overall Equipment Effectiveness
 - End to end cycle times

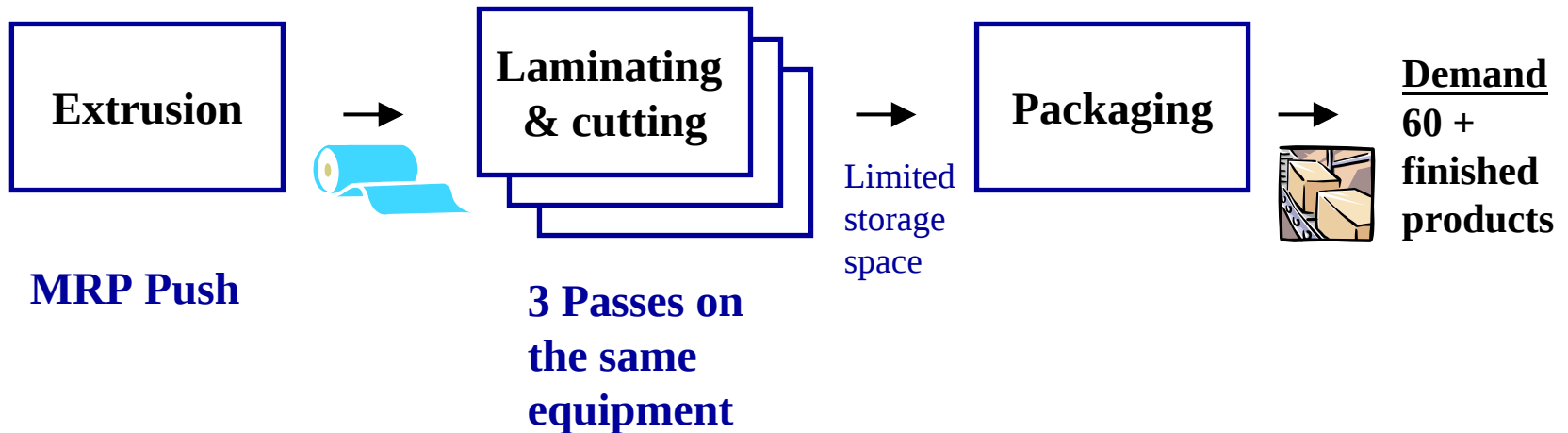
Key Metrics Can Be Compared For Multiple Scenarios

Results of Multiple Simulations are Compared on the Same Graph



Example: Lean Simulation Model Set Up to Test a Pull Process in a Flow Shop

Before Model: Laminated Plastic Manufacturing



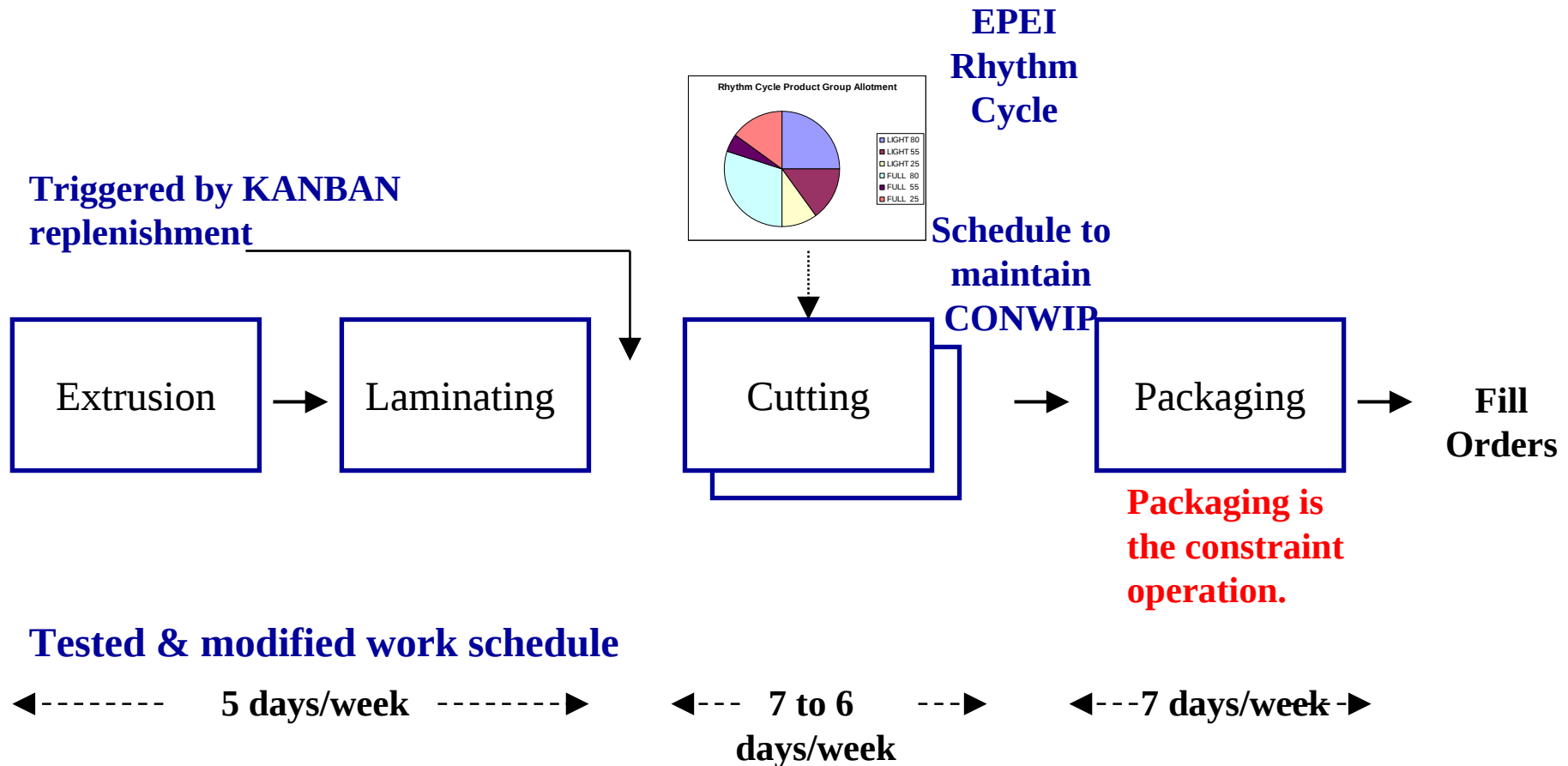
Each work center operates on a different work schedule.

◀---5 days/week---▶

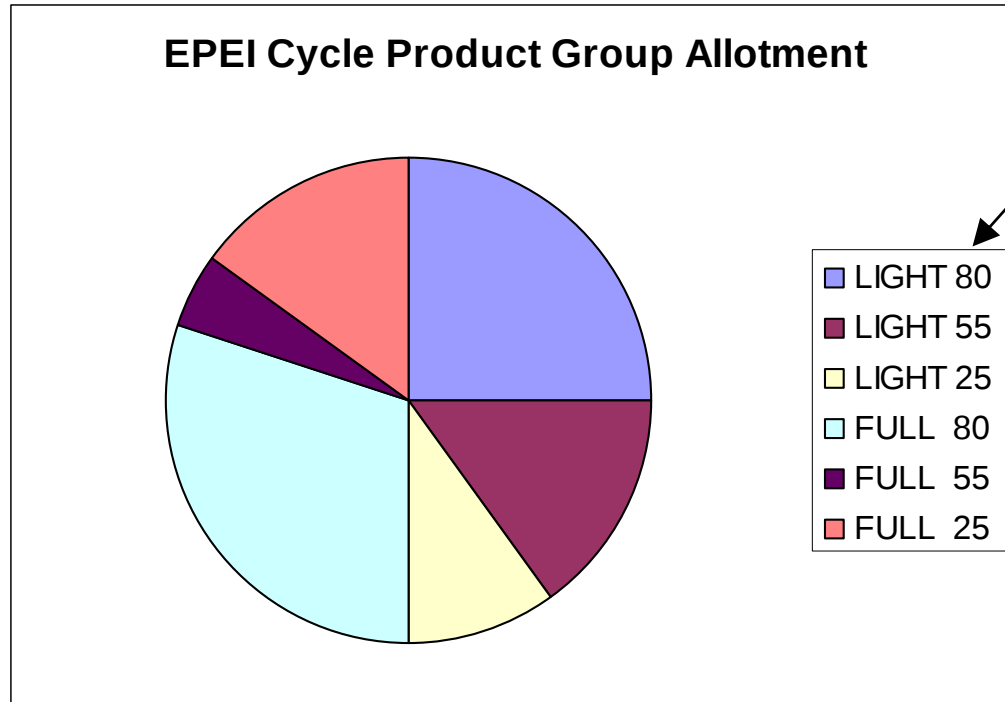
◀---7 days/week---▶

◀---7 days/week---▶

Pull Process Scheduling/Replenishment Rules Development



EPEI: Every Product Every Interval Testing aka Rhythm Cycle



~60 total products;
in 6 product groups

As demand arrives
for each product,
the production
order is assigned to
the next available
cycle spot

Fairly complex
setup rules between
product groups

Before: throughput/service problem

END TO END PROCESSING OF LOTS

MEAN CYCLE TIME (days): MTL
AVAILABLE TO FULFILLMENT 4.19

STND DEV OF CYCLE TIME (days) 1.79

MAX CYCLE TIME (days) 14

MIN CYCLE TIME (days) 1

Not meeting demand

THROUGHPUT

LOTS PRODUCED 298

LOTS RELEASED 298

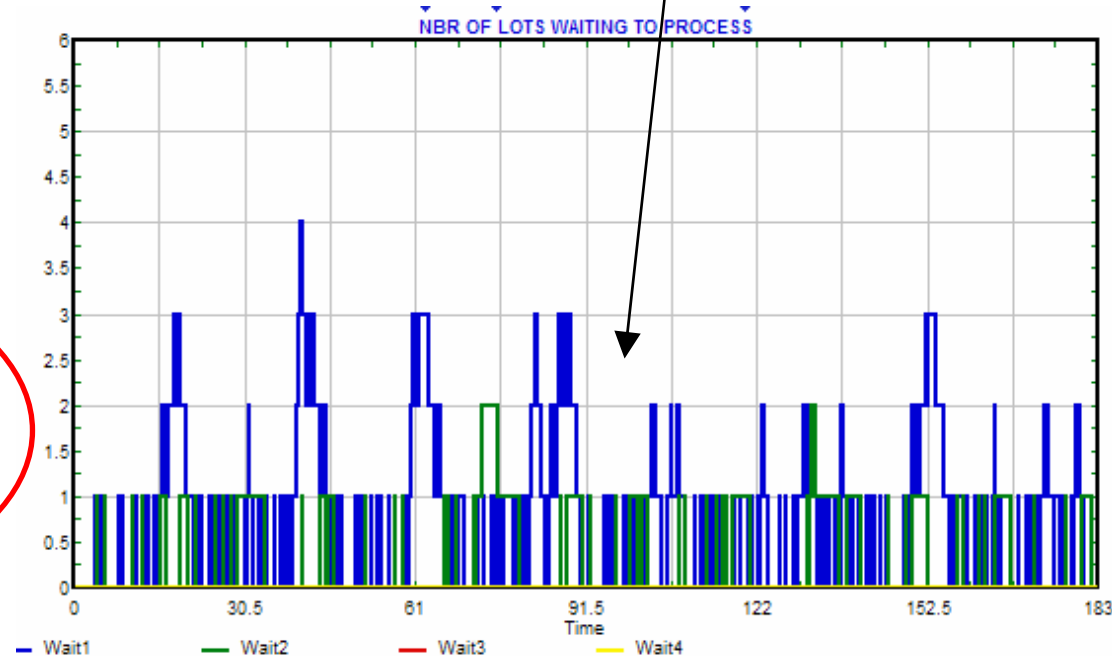
DEMAND & FULFILLMENT

TOTAL LOTS ORDERED 338

FULFILLED 256

BACKORDERED 82

Packaging operation is sometimes starved



After: Increased throughput/consistent flow

END TO END PROCESSING OF LOTS

MEAN CYCLE TIME (days): MTL AVAILABLE TO FULFILLMENT	3.8
STND DEV OF CYCLE TIME (days)	2.14
MAX CYCLE TIME (days)	18
MIN CYCLE TIME (days)	1

Better Demand fulfillment

THROUGHPUT

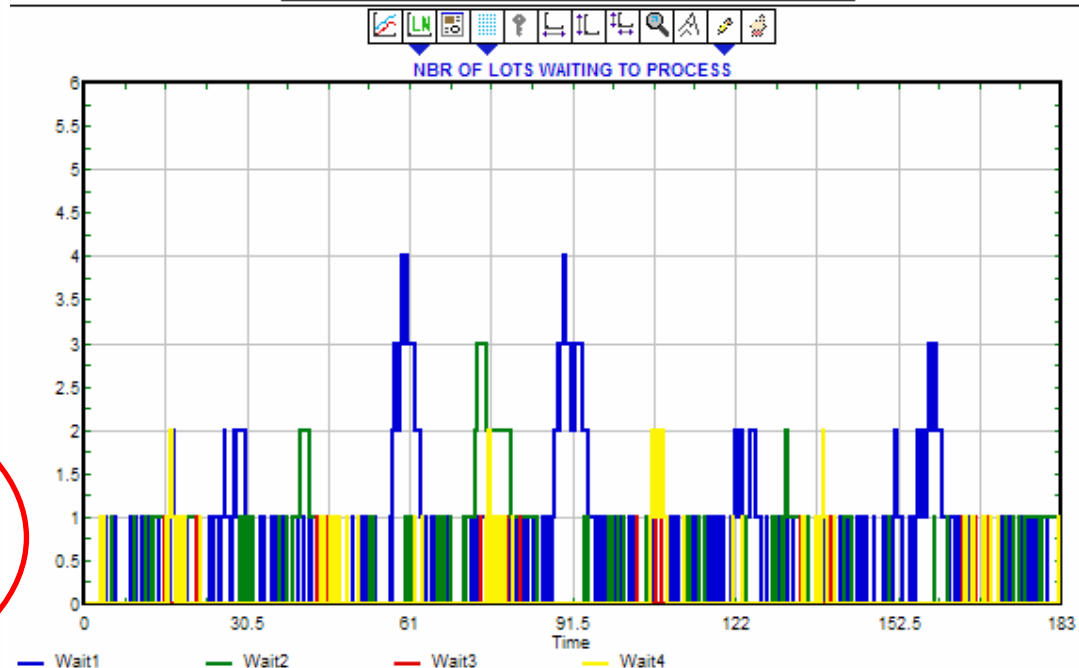
LOTS PRODUCED	339
LOTS RELEASED	339

DEMAND & FULFILLMENT

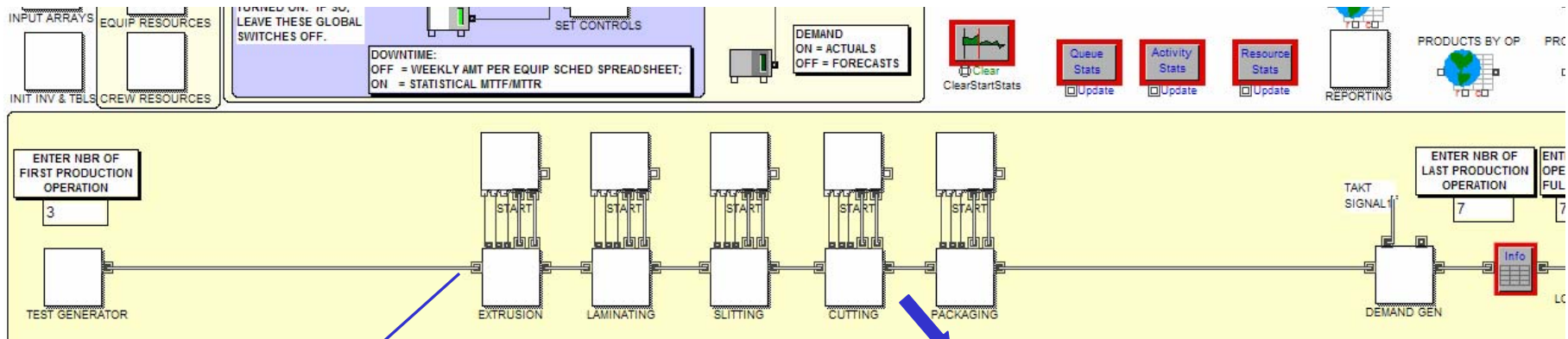
TOTAL LOTS ORDERED	338
FULFILLED	318
BACKORDERED	22

Improvement in Packager utilization

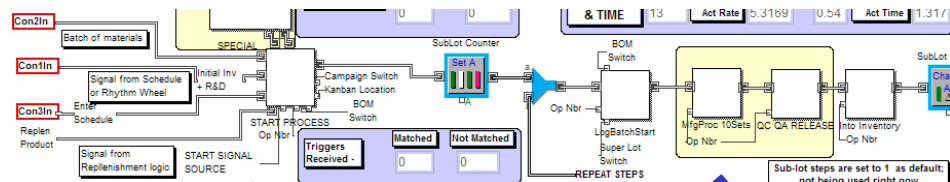
LOTS WAITING FOR EQUIPMENT PATHS 1- 4



Hierarchical Model Building

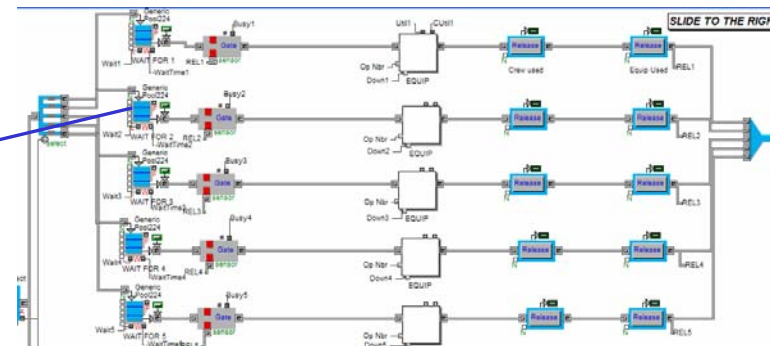


Hierarchical blocks for each plant or workcenter



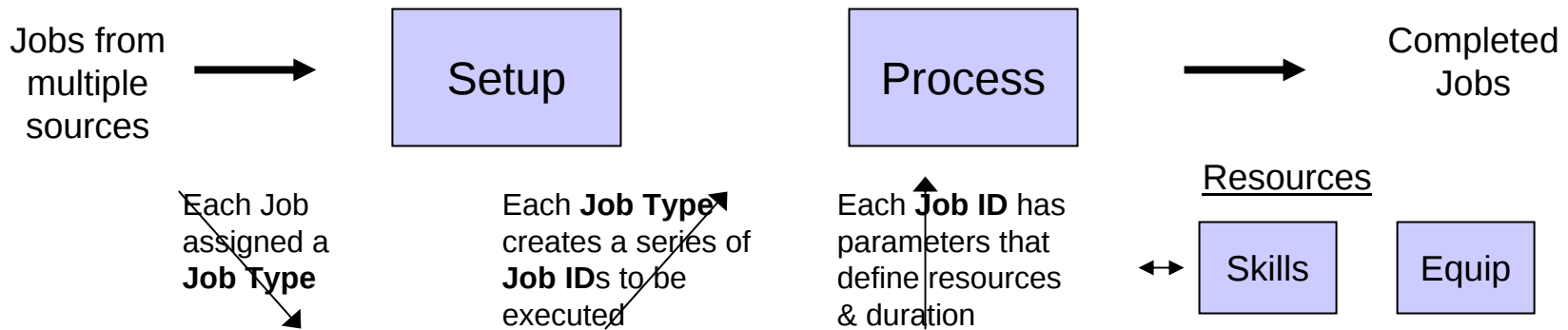
Each workcenter has flow logic for material, and schedule input

Each line has logic for each equipment set



Job Shop Model Overview

Equipment & Job Profiles



Job Type	Job Sequence	Job IDs in the Sequence		
Code	Nbr of Ops	1	2	3
2	3	10	20	30
3	2	20	30	
4	1	40		
5	3	20	10	40

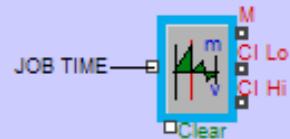
Test ID	Resource Requirements			
	Skill	Equipment	Time	Hold Time
10	3	101	4 hrs	24 hrs
20	2	102	8 hrs	0
30	4	206	.5 hrs	6 hrs
40	4	210	3 hrs	1 week

Job Shop Statistical Outputs

EXAMPLE OUTPUT METRICS

JOB TIMES (days)

EACH JOB COMPLETED



	Arrival(days)	Priority	Job ID	Test Type	Nbr of Tests
0	0.8225	1	1	3	2
1	1.86256048141	1	2	3	2
2	3.12489703492	1	3	2	3
3	4.8125	1	6	3	2
4	5.08802910815	1	5	2	3
5	7.50537137167	1	7	2	3

Confidence intervals
for results, e.g.,
end-to-end time
& utilization



[37] Resource Stats

Statistics

Export

Comments

Records statistics on all resource-type blocks in the model.

Update Now

	Block	Block Name	Available	Utilization
0	E1 DRILL	Resource Pool	±	0.6573±0.1001
1	E2 MACHINING	Resource Pool	±	0.8268±0.06749
2	E3 LATHE	Resource Pool	±	0.5637±0.1542
3	E4 JIG PRESS	Resource Pool	±	0.4156±0.2081
4	SKILL1	Resource Pool	±	0.09041±0.08971
5	SKILL2	Resource Pool	±	0.3062±0.1186
6	SKILL3	Resource Pool	±	0.2214±0.03744
7	SKILL4	Resource Pool	±	0.002095±0.0008

Demo Inventory Model Available From OpStat & Imagine That Websites



The Green Arrow on the toolbar above runs the model

These 3 toolbar buttons above turn animation on/off & faster/slower

This replenishment model will simulate the resupply requirements for a product, based on the demand (orders), lead times, and the replenishment rules specified.

It is set up to run for 365 days - that may be changed by entering a different period in Run - Simulation Setup above.

OpStat

INITIAL INV Arrays Statistics

MODEL INPUTS

DEMAND SETUP

To enter demand, set the Demand Switch, then double-click the ENTER DEMAND box to set values

Green light
Off=actual
On=statistical



Order Amount
Fulfilled



DIST WAREHOUSE

ENTER DEMAND

Are BACKORDERS allowed?
yes=0; no =1

1

If Backorders are Allowed:
SERVICE LEVEL STND (in days)

1



CUSTOMERS

REPLENISHMENT RULES SETUP

REVIEW PERIOD:
how often is inventory
checked? In Days

1

REORDER QUANTITY
amount to replenish
when triggered

120

REORDER TRIGGER LEVEL:
replenish when inventory +
on order amounts will fall
below this (over the lead
time)

100

REORDER TARGET LEVEL:
when reordering, ensure
inventory + on order +
reorder quantity is >
target

300

LT
ReOrder
Amount



REORDERING

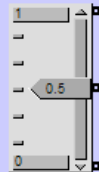
INITIALINVENTORY

400

EXPECTED STANDARD
LEAD TIME (days)

15

MAX LEAD TIME
VARIABILITY
(as % of standard)



LT

MODEL RESULTS

Ordered Quantity 3022
Fulfilled Quantity 2608
Average Inventory Qty 228
Ending Inventory Qty 192

Total Orders 180

SERVICE LEVEL

Fulfilled > Std
if backorders are allowed, these
are orders over the service level standard

0

% Amount Fulfilled
this is the line fill - % of items fulfilled
1 = 100%

0.863

