SIMULATION MODELING OF SUPPLY CHAINS

Presented by:

RICKI G. INGALLS

OKLAHOMA STATE UNIVERSITY

DIAMOND HEAD ASSOCIATES, INC.

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COLLEGE-INDUSTRY COUNCIL ON MATERIAL HANDLING EDUCATION

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Presenter Background
Ricki Ingalls

- Current Position
  - Associate Professor, Oklahoma State University, School of Industrial Engineering and Management
  - Founding Principal, Diamond Head Associates Inc.
  - Former Site Director, Center for Engineering Logistics and Distribution (CELDi)
  - Former Member, College-Industry Council on Material Handling Education (CICMHE)
- Education
  - Ph.D. – Management Science – Texas (1999)
  - M.S. – Industrial Engineering – Texas A&M (1984)
  - B.S. – Mathematics – East Texas Baptist (1982)
- Work Experience
  - 30 Years, including 16 years in industry and 14 years consulting after joining OSU.

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Thinking about today

- The Supply Chain is big and unwieldy idea. It encompasses everything you see at MODEX plus a myriad of other equipment, software and processes.
- Like all models, a simulation model for a supply chain (or a piece of a supply chain) must suite the purpose of the analysis.
  - For example, you would not include PLC logic for a controller in one warehouse if you were trying to model the effect of supplier reliability on your supply chain.
  - Another example, you wouldn't be modeling your suppliers if you were worried about how a single ASRS would perform under high-transaction conditions.
- So, today we take a broad definition of the supply chain – from the global supply chain down to PLC controllers – and look at the use of simulation across that spectrum.

The three swear words: Modeling, Optimization, and Simulation

- There are two words I never use in mixed company (academics and industry people) - Optimization and Simulation. I will use the word "Model," but I have to be careful.
- Let's say that you have a very dynamic supply chain that you want to analyze. What does the VP think when you tell him...
  - "I am going to model your supply chain."
  - "I am going to optimize your supply chain."
  - "I am going to simulate your supply chain."

What these words mean

	The VP	The Academic
Model	MRP and/or Excel	Any mathematical or logical formulation
Optimize	***An efficient system in spite of real world problems***	The best alternative of all mathematical formulations
Simulate	An MRP simulation	***A detailed computer model that mimics the real system***

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Top 5 Supply Chain Issues

- 1. Continue to ***reduce costs*** while simultaneously ***improving customer service*** and supporting ***expansion in new markets and product lines***
  - 68% of respondents say that operating cost reduction is “very important” as a supply chain contribution to business strategy – up from 64% in 2012.
  - 83% believe that supply chain excellence contributes high or very high value in terms of enhancing customer service and loyalty; while almost three-quarters say the same about business expansion and new product introduction.

Results from The Chief Supply Chain Officer Report 2013, SCM World, September 2013 as reported by Supply Chain Management Review, SCM World Survey Finds Supply Chain Managers Still Under Pressure To Deliver by Patrick Burnson, October 1, 2013.

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Top 5 Supply Chain Issues

- 2. Manage the ***complexity of omnichannel selling*** and ***customer fulfillment***
  - 55% report that the demands of e-commerce and mobile-enabled consumers are increasing the number of SKUs they have to support.
  - 54% are building new distribution centres (of both the larger, more centralised and smaller, more local variety); and 48% are building direct-to-customer fulfillment capabilities.

Results from The Chief Supply Chain Officer Report 2013, SCM World, September 2013 as reported by Supply Chain Management Review, SCM World Survey Finds Supply Chain Managers Still Under Pressure To Deliver by Patrick Burnson, October 1, 2013.

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Top 5 Supply Chain Issues

- 3. ***Deliver*** top- and bottom-line ***value***, not just compliance, ***from sustainability initiatives***
  - 47% say their boards expect lower costs and greater efficiency – up from 43% in 2012 and just 32% in 2011.
  - 24% say higher sales revenue is a business driver – up from 17% last year.

Results from The Chief Supply Chain Officer Report 2013, SCM World, September 2013 as reported by Supply Chain Management Review, SCM World Survey Finds Supply Chain Managers Still Under Pressure To Deliver by Patrick Burnson, October 1, 2013.

Top 5 Supply Chain Issues

- 4. ***Mitigate the risk of product integrity issues*** – and do so across all supply tiers
  - In the wake of the horsemeat scandal in Europe, safety and quality incidents top the risk index – 37% are “very concerned” about this for 2013-14 and 35% are “concerned.”
  - Just 13% say they have visibility of potential risks at the third tier of their supply base (their supplier’s supplier’s supplier); while 41% are limited to the tier-one level.

Results from The Chief Supply Chain Officer Report 2013, SCM World, September 2013 as reported by Supply Chain Management Review, SCM World Survey Finds Supply Chain Managers Still Under Pressure To Deliver by Patrick Burnson, October 1, 2013.

Top 5 Supply Chain Issues

- 5. Facilitate ***career progression***, ***new product introduction skills*** and ***demonstrate ROI***
  - 76% report that providing compelling career options for talented supply chain staff is challenging – up from 66% in each of the previous two years.
  - 53% believe that new product introduction and launch capabilities are now “essential” for supply chain – up from just 18% in 2011.
  - 53% of respondents overall – and 31% of those spending 5% or more of their fully loaded personnel costs on training and development – say they don’t track return on investment.

Results from The Chief Supply Chain Officer Report 2013, SCM World, September 2013 as reported by Supply Chain Management Review, SCM World Survey Finds Supply Chain Managers Still Under Pressure To Deliver by Patrick Burnson, October 1, 2013.

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In Summary

- Reduce Costs
- Improve Customer Service
- Expansion In New Markets
- Expansion In Product Lines
- Complexity Of Omnichannel Selling And Customer Fulfillment
- Deliver Top- And Bottom-Line Value From Sustainability Initiatives
- Mitigate The Risk Of Product Integrity Issues
- New Product Introduction Skills
- Demonstrate ROI

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You can think of simulation of supply chains in 4 broad areas

	Design	Operations
Supply Chains/Logistics/Transportation	The design (or re-design) of the supply chain based on markets, locations of warehouses, manufacturing locations and suppliers.	The planning/scheduling of the supply chain. Are the supply chain resources adequate to execute the expected demand.
Warehouse and Manufacturing Sites	The design (or re-design) of a DC, warehouse, or manufacturing site for an expected product mix and volume.	The scheduling of the DC, warehouse or manufacturing site based on the known (and/or expected) orders.

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Supply Chain/Logistics/Transportation

	Design or Design Changes	**Operations Execution**
Reduce Costs	Better planned used of resources	Better actual use of resources
Improve Customer Service	Measure on time-delivery system wide	Measure on-time delivery of each order
Expansion In New Markets	Change the supply chain to deliver to new markets	Schedule the delivery into new markets
Expansion in Product Lines	Design and plan the addition of new product lines	Schedule the delivery of new product lines
Complexity of Omnichannel	Design the delivery system for Omnichannel complexity	Schedule the warehouse and transportation resources for delivery

Supply Chain/Logistics/Transportation

	Design or Design Changes	**Operations Execution**
Sustainability Value	Design for low-carbon emissions	Schedule for low-carbon emissions
Product Integrity Issues	Measure the effect of supplier quality/evaluate new suppliers	Determine scheduling algorithms that mitigate product integrity issues
New Product Introduction	Product Ramp capabilities and time to profitability	Scheduling the new product ramp
Demonstrate ROI	Evaluate ROI on every investment	Track ROI

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Key Modeling Constructs of the Supply Chain

- Customers
  - Demand (and/or Orders), including line items, quantity, due dates
  - Location
- DCs
  - Incoming orders from multiple customers
  - Modeling of key resource constraints (flow rates, dock doors, warehouse space, workers)
  - Modeling of on-hand inventory (quantities and/or locations)
  - WMS control logic as it pertains to picking orders
  - Replenishment order logic

Key Modeling Constructs of the Supply Chain

- Manufacturing
  - Incoming replenishment orders from DCs
  - Modeling of key resources (lines, workers, etc.)
  - Modeling of raw material availability
  - Raw material order logic
- Suppliers
  - Incoming replenishment orders from manufacturing
  - Usually lead-time based (can be random lead-times based on history)
- Transportation – DC to Customer, Manufacturing to DC, Suppliers to Manufacturing
  - Private Fleet – can model individual trucks and their availability
  - OTR Carriers – model rates and expected delivery times

Supply Chain Example

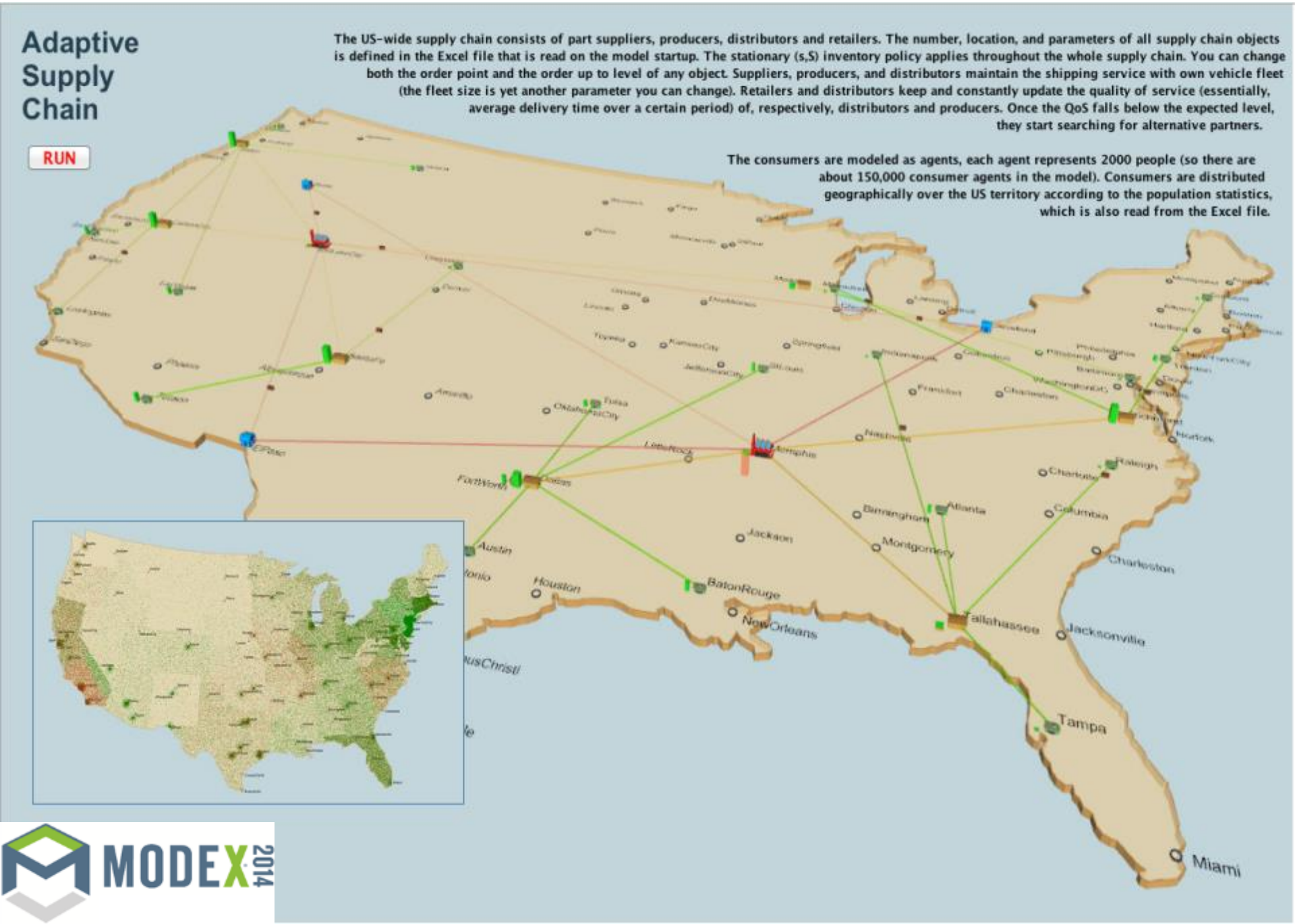
- The US-wide supply chain consists of part suppliers, producers, distributors and retailers.
- The stationary (s,S) inventory policy applies throughout the supply chain.
- Suppliers, producers and distributors maintain the shipping service with their own vehicle fleet (you can change the fleet size).
- Retailers and distributors keep and constantly update the quality of service (average delivery time). Once the quality of service falls below a certain level, they start searching for alternative partners.
- The consumers are modeled as agents, each agent represents 2000 people (there are 150,000 customer agents in the model). Consumers are distributed geographically according to population.

Adaptive Supply Chain

RUN

The US-wide supply chain consists of part suppliers, producers, distributors and retailers. The number, location, and parameters of all supply chain objects is defined in the Excel file that is read on the model startup. The stationary (s,S) inventory policy applies throughout the whole supply chain. You can change both the order point and the order up to level of any object. Suppliers, producers, and distributors maintain the shipping service with own vehicle fleet (the fleet size is yet another parameter you can change). Retailers and distributors keep and constantly update the quality of service (essentially, average delivery time over a certain period) of, respectively, distributors and producers. Once the QoS falls below the expected level, they start searching for alternative partners.

The consumers are modeled as agents, each agent represents 2000 people (so there are about 150,000 consumer agents in the model). Consumers are distributed geographically over the US territory according to the population statistics, which is also read from the Excel file.



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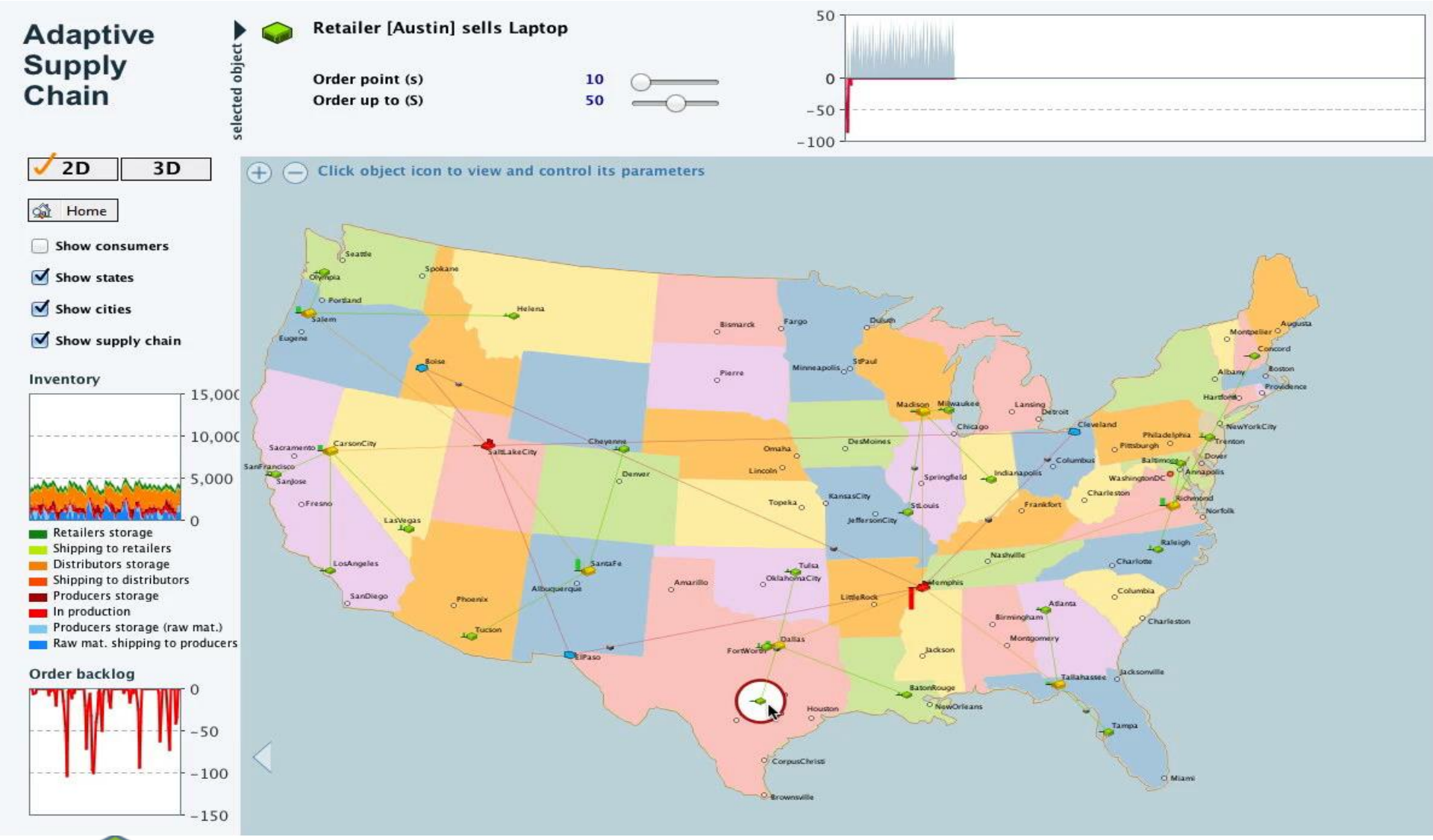
Adaptive Supply Chain
selected object
Retailer [Austin] sells Laptop
Order point (s) 10
Order up to (S) 50
50
0
-50
-100
2D
3D
Home
Show consumers
Show states
Show cities
Show supply chain
Click object icon to view and control its parameters
Inventory
15,000
10,000
5,000
0
Retailers storage
Shipping to retailers
Distributors storage
Shipping to distributors
Producers storage
In production
Producers storage (raw mat.)
Raw mat. shipping to producers
Order backlog
0
-50
-100
-150
Seattle
Olympia
Spokane
Portland
Salem
Eugene
Helena
Boise
Bismarck
Fargo
Duluth
Pierre
Minneapolis
StPaul
Madison
Milwaukee
Chicago
Lansing
Detroit
Cleveland
Montpelier
Augusta
Concord
Boston
Albany
Providence
Hartford
NewYorkCity
Trenton
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Pittsburgh
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Annapolis
WashingtonDC
Richmond
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Sacramento
CarsonCity
SanFrancisco
SanJose
Fresno
SaltLakeCity
Cheyenne
Denver
Omaha
Lincoln
DesMoines
Columbus
Indianapolis
Springfield
Charleston
Frankfort
KansasCity
Topeka
JeffersonCity
StLouis
LasVegas
LosAngeles
SanDiego
Phoenix
Tucson
SantaFe
Albuquerque
Amarillo
Tulsa
OklahomaCity
LittleRock
Memphis
Nashville
Raleigh
Charlotte
Columbia
Atlanta
Birmingham
Montgomery
Charleston
Jackson
Dallas
FortWorth
ElPaso
BatonRouge
NewOrleans
Tallahassee
Jacksonville
Tampa
Miami
Houston
CorpusChristi
Brownsville

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Warehouse/Manufacturing Sites

	Design or Design Changes	Operations Execution
Reduce Costs	Design for efficiency	Schedule for efficiency
Improve Customer Service	WMS Changes, Warehouse Design Changes	Schedule each order for on-time delivery
Expansion In New Markets	Setting up new DCs or Manufacturing in New Markets, Transportation into New Markets	Scheduling the ramp and on-going operations in the new markets
Expansion in Product Lines	Expansion of existing warehouse/mfg to handle new products	Scheduling the new products
Complexity of Omnichannel	WMS Changes, Warehouse Design Changes	Scheduling the warehouse based on WMS changes

Warehouse/Manufacturing Sites

	Design or Design Changes	**Operations Execution**
Sustainability Value	Design the implementation of low-carbon alternatives	Track the impact of low-carbon alternatives
Product Integrity Issues	Effect of late/bad material in existing site	Schedule based on availability of material
New Product Introduction	Space/Resource Planning for new product ramp	Scheduling of new product ramp
Demonstrate ROI	Complete financial plan	Financials based on schedule

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Key Modeling Constructs of Warehouses/Manufacturing Sites

- DCs
  - Incoming orders from multiple customers
  - Modeling of the DC in detail – conveyors, racks, forktrucks, workers, swim lanes, truck loading, etc.
  - Modeling of on-hand inventory in detail – what is on a pallet and how the pallet and pieces on the pallet move.
  - WMS control logic – to the detail necessary to control the conveyors, racks, forktrucks, etc.
  - Incoming material – either according to a schedule or a replenishment plan

Key Modeling Constructs of Warehouses/Manufacturing Sites

- Manufacturing
  - Incoming replenishment orders from DCs
  - Modeling of the factory in detail – machines, conveyors, raw material movement, assembly operations, packing operations, all workers, etc.
  - Modeling of raw material in detail – where is it stored, how is it moved to the line, how is it consumed.
  - Manufacturing control logic
  - Incoming raw material – either according to a schedule or a replenishment plan.

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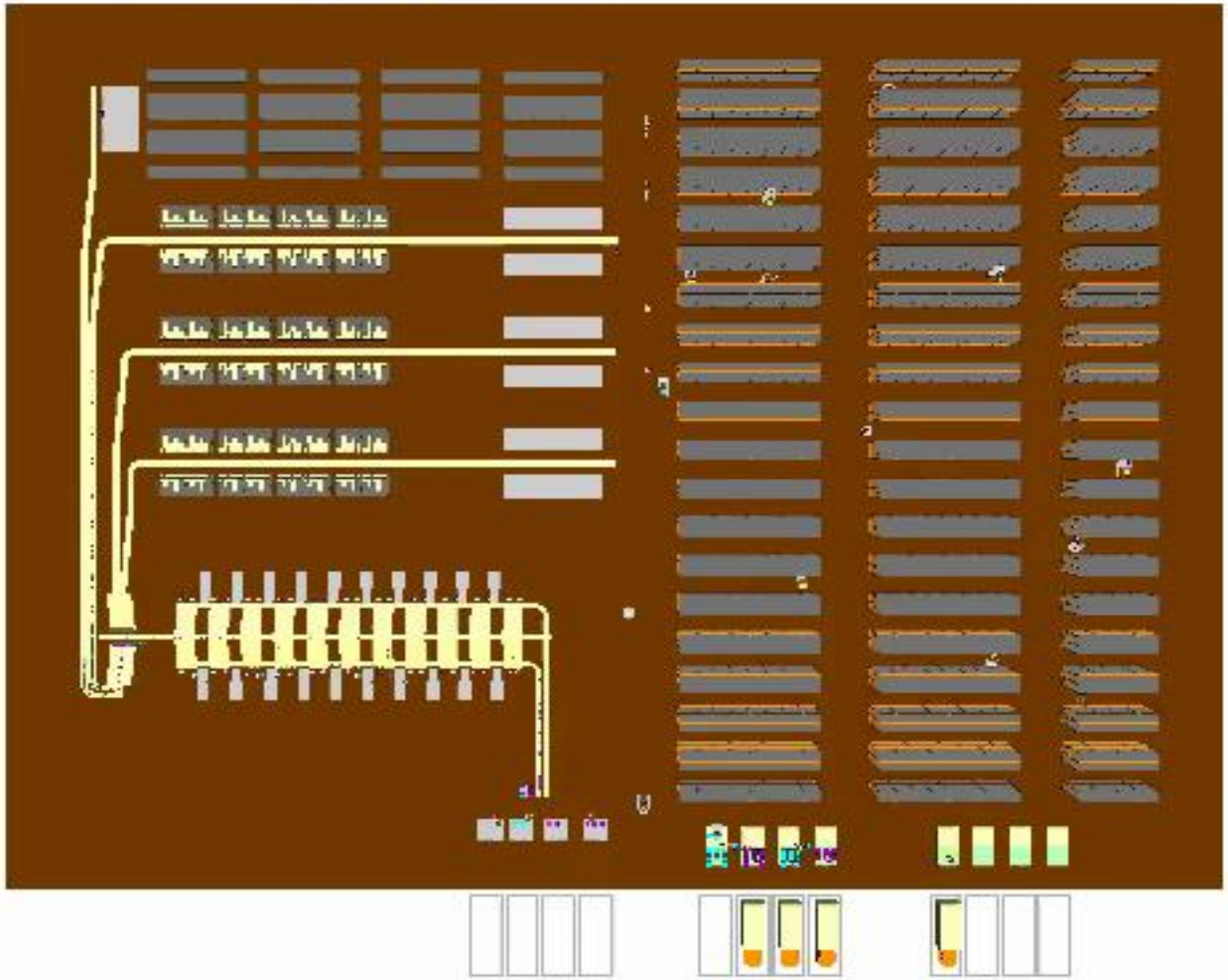
Warehouse Example

- Simulation of a warehouse design
- Incoming trucks arrive according to a schedule.
- Outgoing trucks are filled based on customer orders.
- All warehouse operations are included in the model.

Ryder Integrated Logistics

Simulation Template Model



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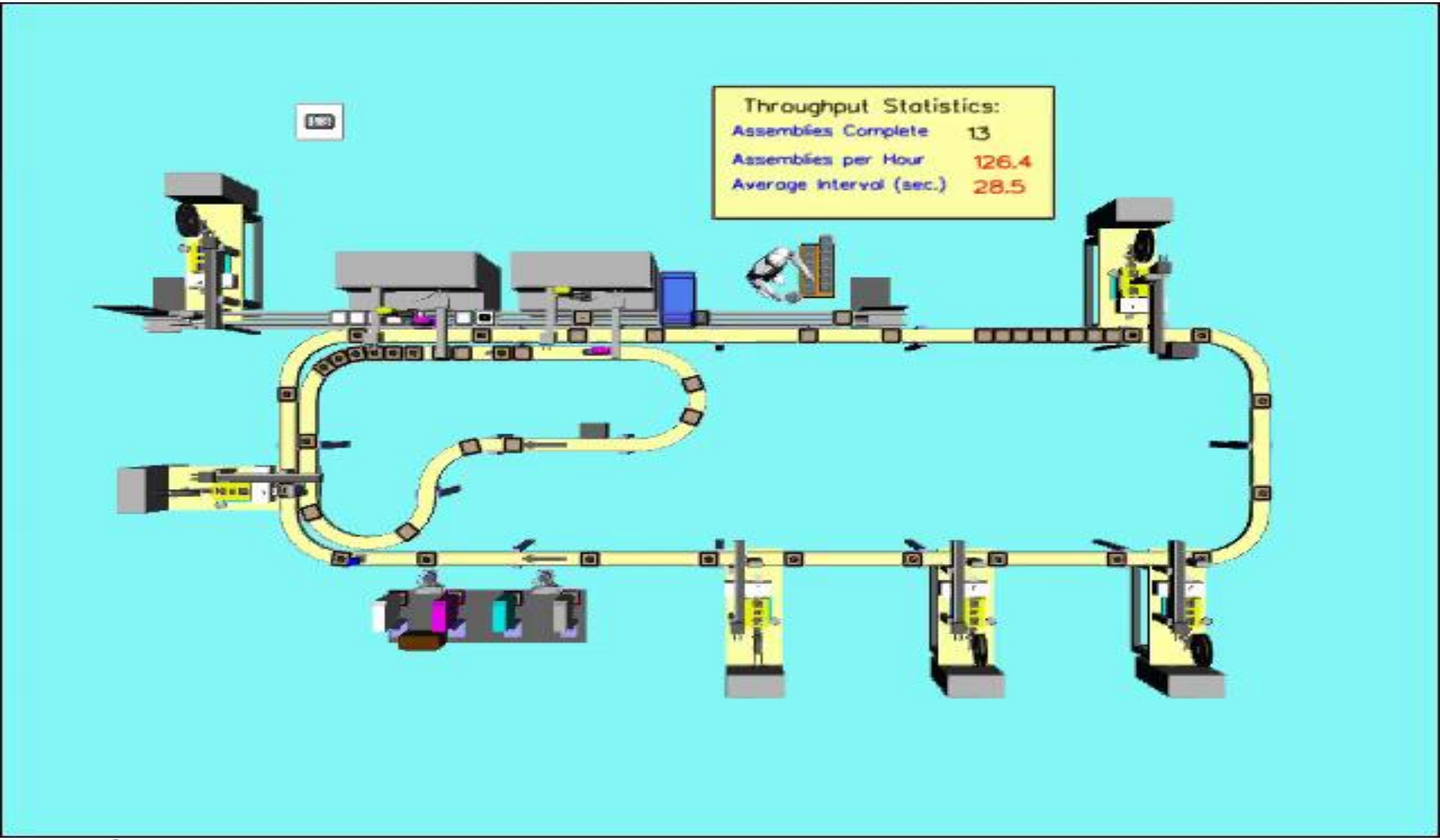
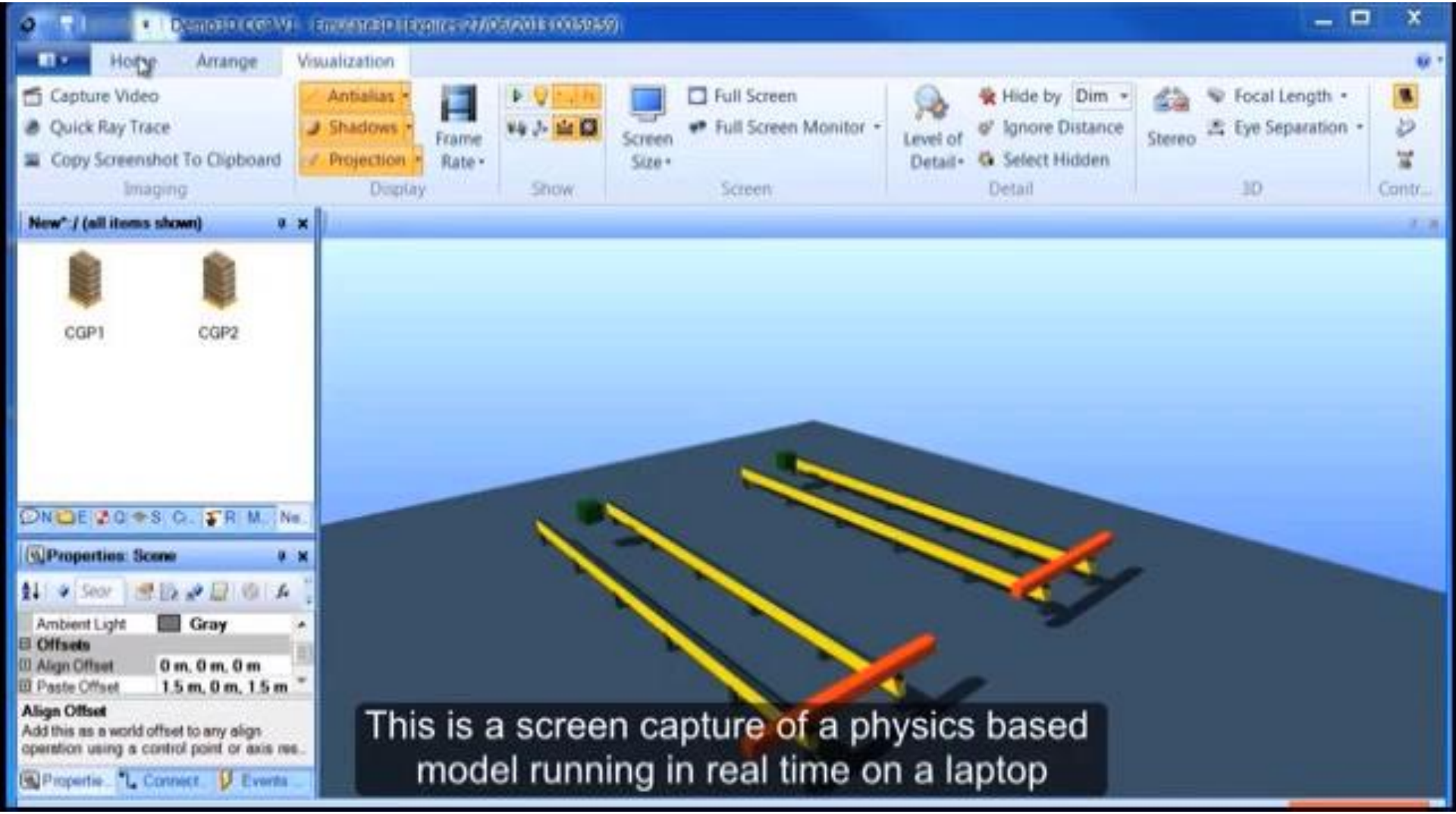
Manufacturing Example

- Electronics assembly line
- The system is “closed”, meaning that pallets never leave the system.
- System consists of:
  - 4 robotic assembly stations
  - 4 testers that are fed with robots.
  - Another robot that handles a subassembly.
  - 2 final assembly robots.
  - 1 manual packing station.


Throughput Statistics:
Assemblies Complete 13
Assemblies per Hour 126.4
Average Interval (sec.) 28.5

Package Stability Example

- This short example to determine the stability of a pallet configuration.
- It compares a pallet stacked with dividers vs. a pallet stacked without dividers


Home
Arrange
Visualization
Capture Video
Quick Ray Trace
Copy Screenshot To Clipboard
Imaging
Antialias
Shadows
Projection
Display
Frame Rate
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Screen Size
Full Screen
Full Screen Monitor
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Select Hidden
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Stereo
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Eye Separation
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Properties: Scene
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Offsets
Align Offset
0 m, 0 m, 0 m
Paste Offset
1.5 m, 0 m, 1.5 m
Align Offset
Add this as a world offset to any align operation using a control point or axis res...
This is a screen capture of a physics based model running in real time on a laptop

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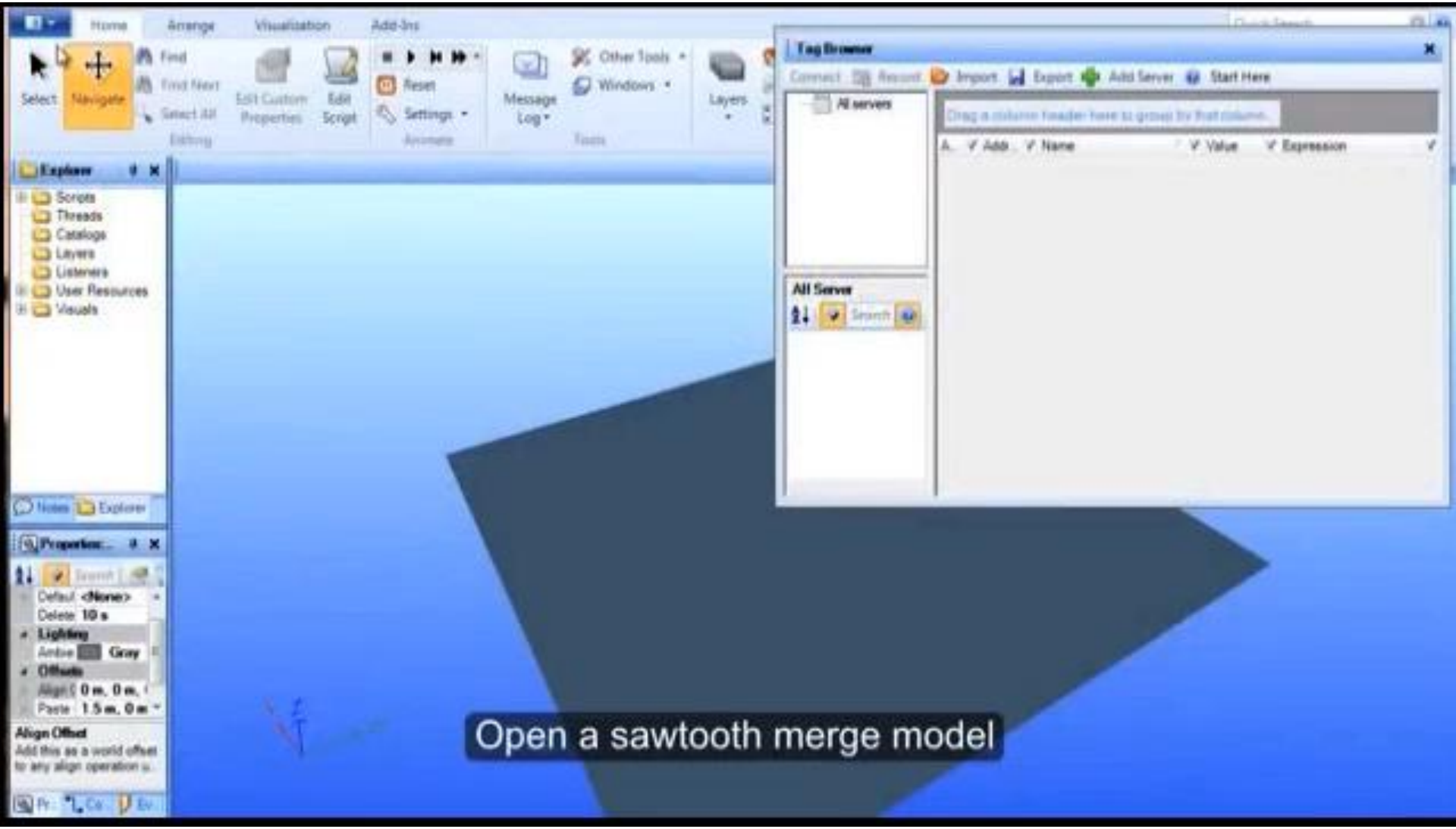
PLC Simulation Example

- This example shows how the simulation can be used to test PLC logic as part of an overall system.


Home
Arrange
Visualization
Add-Ins
Select
Navigate
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Find Next
Select All
Edit Custom Properties
Edit Script
Reset
Settings
Message Log
Other Tools
Windows
Layers
Tag Browser
Connect
Recent
Import
Export
Add Server
Start Here
All servers
All Server
Search
Drag a column header here to group by that column.
Add
Name
Value
Expression
Explorer
Scripts
Threads
Catalogs
Layers
Listeners
User Resources
Visuals
Notes
Explorer
Properties
Default
Delete
Lighting
Ambient
Gray
Offsets
Paste
Align Offset
Add this as a world offset to any align operation
Open a sawtooth merge model

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Simulation is like a test drive – drive it before you own it.

For More Information:

Ricki Ingalls
ricki.ingalls@okstate.edu
ricki.ingalls@diamond-head-associates.com

Carmen Murphy, MHI Education Coordinator
cmurphy@mhi.org
http://www.mhi.org/cicmhe