

Advanced 3D Factory Design integrated with Throughput Simulation PLM World 2006

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UGS Enterprise PLM





Plant design & optimization



Create factory models faster
& ensure they operate at
peak efficiency before
production ramp-up

- ▶ Factory design and analysis
- ▶ Material handling & costing
- ▶ Throughput simulation
- ▶ Order sequencing optimization
- ▶ Digital layout and design

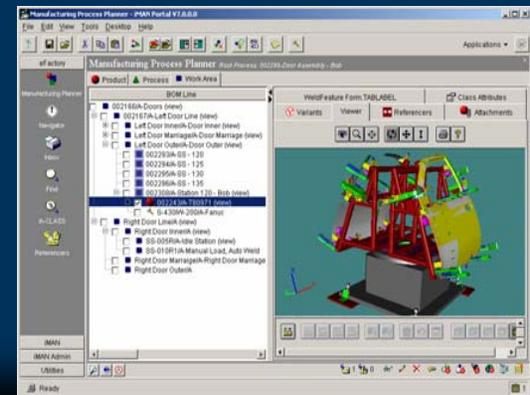
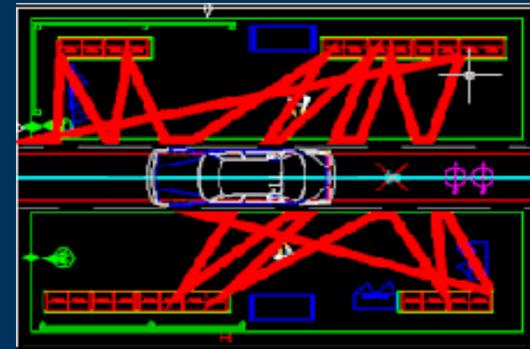
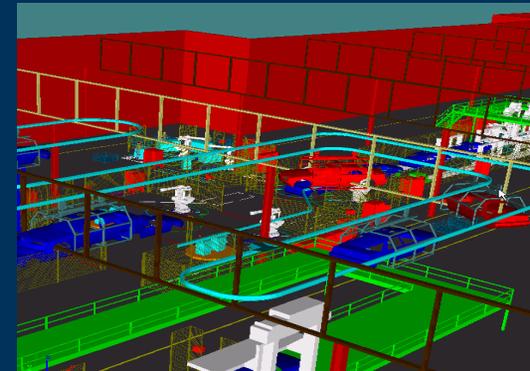


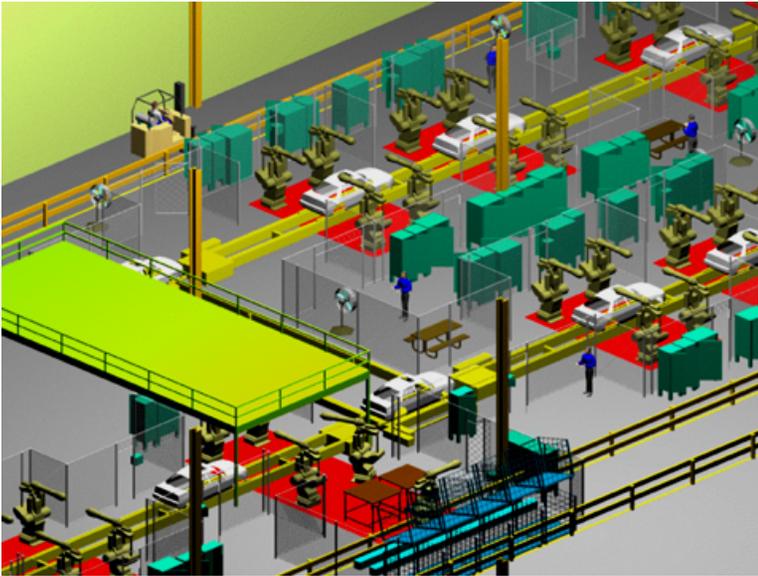


Factory Design & Optimization



- ▶ **FactoryCAD:** easiest method of authoring intelligent 3D models of facilities – facilitates quicker, more cost effective manufacturing launch
- ▶ **FactoryFLOW:** material handling tool to reduce non-value added work, minimizes indirect labor costs, and helps realize lean manufacturing objectives
- ▶ **Plant Simulation:** Discrete Event Simulation tool for statistical modeling of facilities where throughput, machine capacity constraints, queuing constraints, etc are important
- ▶ **Plant Simulation FactoryCAD / SDX:** discrete event simulation on top of 3D FactoryCAD factory models
- ▶ **eM-Designer Logistics:** Toolset to plan and design supply chains
- ▶ **eM-Sequencer:** constraint based decisions tool to optimize production sequences
- ▶ **Factory Mockup:** share, walk through, evaluate and animate models of 3D virtual factory
- ▶ **ICE:** In Context Editor – Managing factory layout designs in Teamcenter
- ▶ **FIRM:** FactoryCAD Integrated Resource Management – Managing FactoryCAD equipment objects in Teamcenter RM





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*Transforming the
process of innovation*



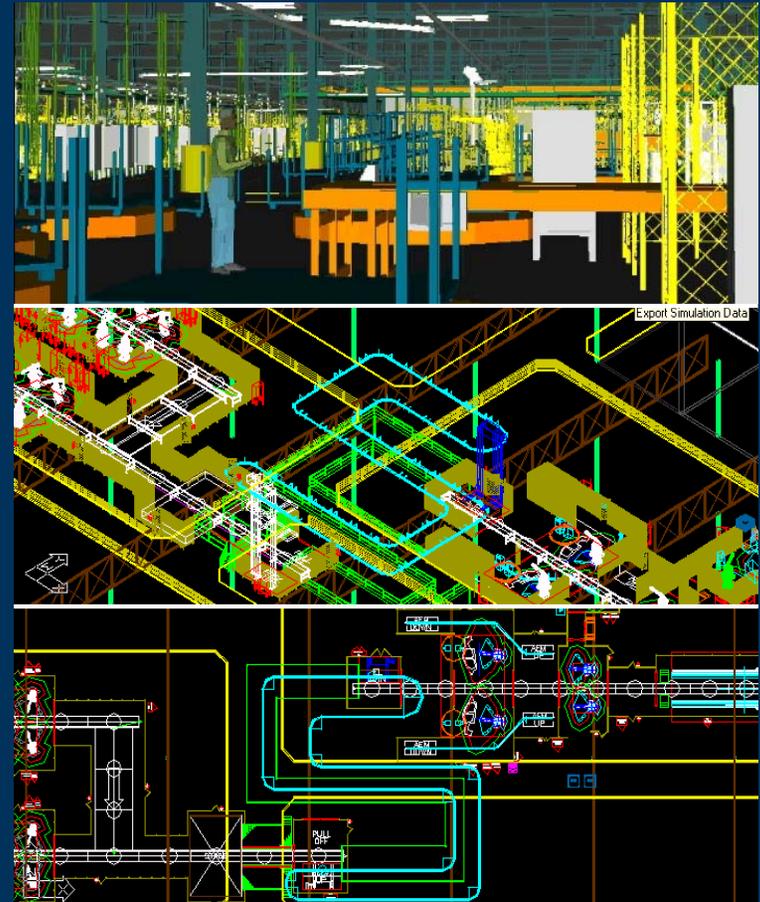
Introducing FactoryCAD



FactoryCAD overview



- ▶ Turn AutoCAD into a factory design tool
- ▶ Work with parametric models of factory equipment
- ▶ Create custom objects to model unique equipment
- ▶ Import/export data to bring product, tooling & plant data together
- ▶ Complete a 3D factory model quickly and easily





FactoryCAD savings



- ▶ Reduce tooling and equipment change costs by 15% or more
- ▶ Reduce layout creation costs by 30%
- ▶ Save time - 90% reduction in 3D models, 30% reduction in 2D drawings; complete layout designs in weeks instead of months

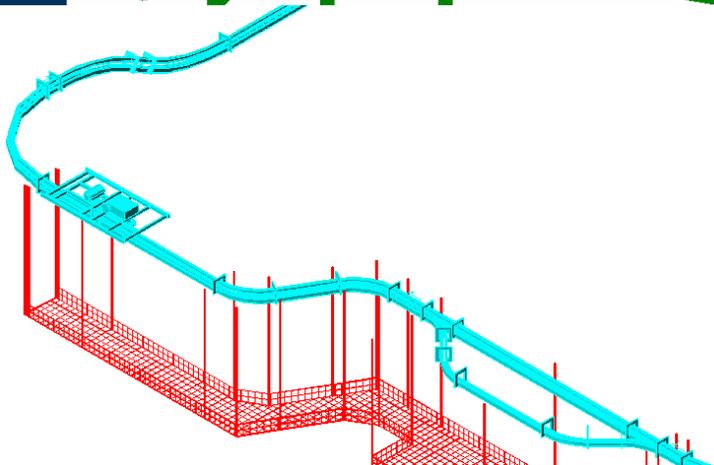
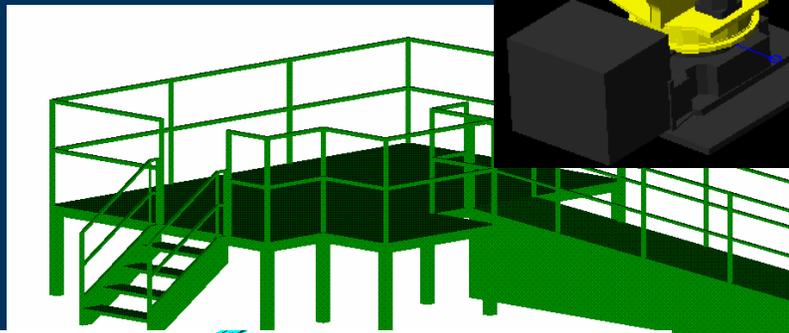
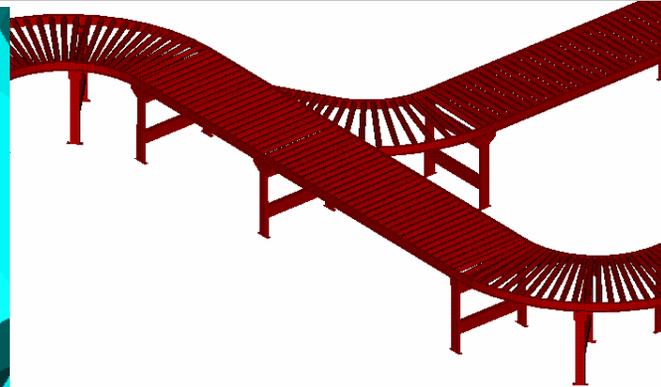
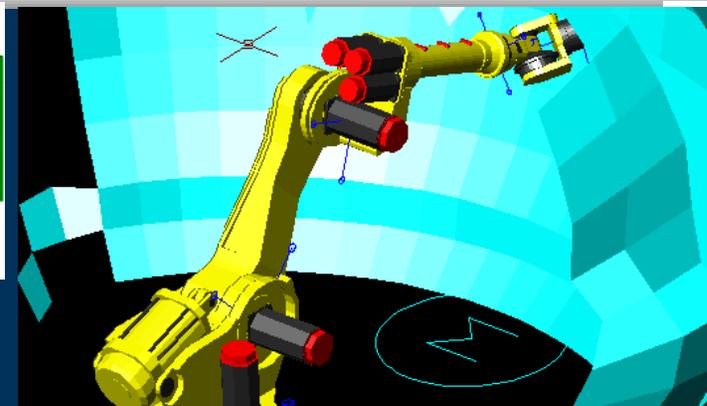
<u>Method</u>	<u>Time</u>
Solid models	3 + months
Plain AutoCAD	1 - 3 months
FactoryCAD	1 - 3 weeks





- ▶ Drop, drag, stretch and connect together
- ▶ Fast and easy to add and position
- ▶ Objects contain built-in intelligence
- ▶ Very small file sizes compared to other solutions
- ▶ Hundreds of equipment configurations





Object Toolkit
File Edit Add

- Leg Width
- Leg Steel Thickness
- Outer Leg Height
- Inner Leg Height
- Left Side Drive
- Side Mount Motor
- Motor Location
- Motor Diameter
- Motor Length
- Angle
- Head Connector
- Tail Connector
- Rollers
 - Roller Adjustment
 - Rollers Repeat
 - Single roller
- Leg Assembly
 - Leg Adjustments
 - Single Leg
- Drive Box
 - driveGeomext
- Rails
 - driveSiderail
 - siderail

Cylinder
Name: Single roller

Top Radius < 1.2500"

Bottom Radius < 1.2500"

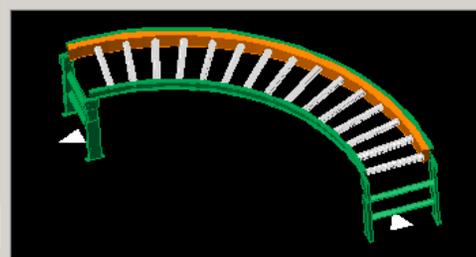
Height < 1'-11.5000"

Location < 13'-8.0000" 10'-1.7500" 2'-10.7500"

Axis < 0.0000" 1.0000" 0.0000"

Number of Faces: 18

Color... 0 Transparency: 0



Undo Redo OK Cancel Apply Help

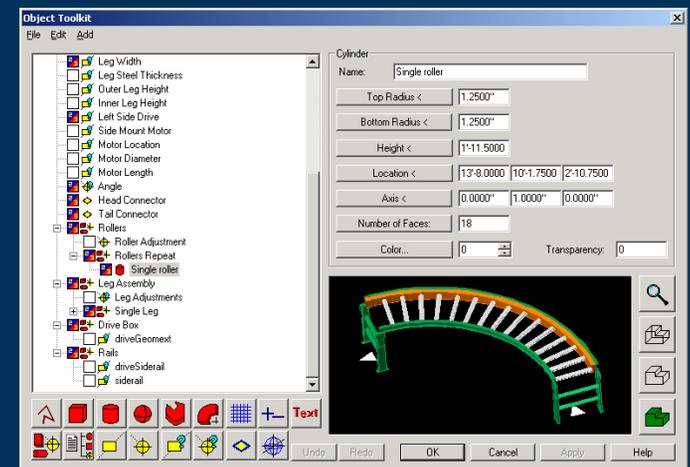
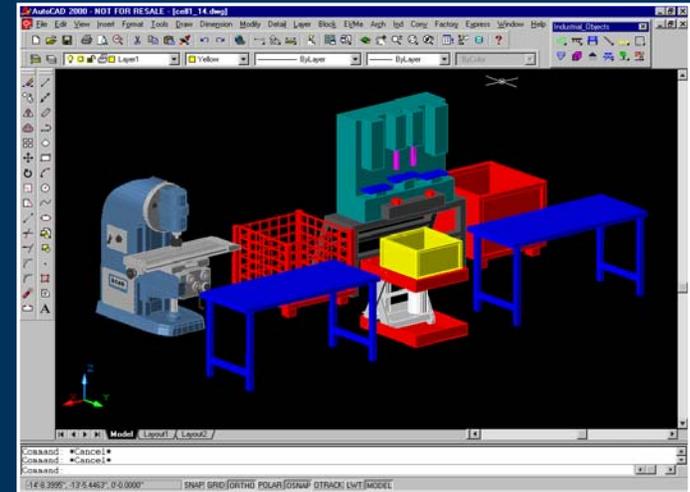
User defined custom objects



Create your own custom objects



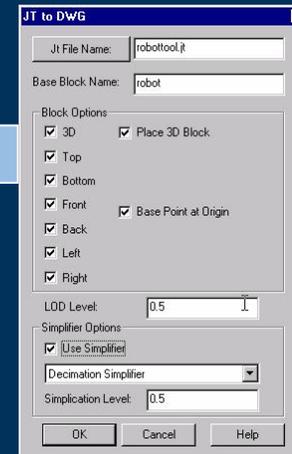
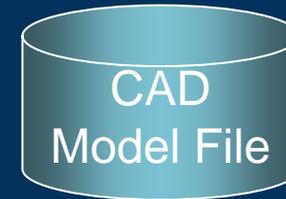
- ▶ Parametric object and system toolkit built into FactoryCAD
 - ▶ Create your own simple parametric objects in XML
 - ▶ Build in intelligence using design rules and customize object-to-object interaction
 - ▶ XML objects can be combined to form complex systems





Leverage existing tooling and product data

- ▶ Start with 3D CAD model
- ▶ Convert to JT or Parasolid OR
- ▶ Use NX or Solid Edge in native format
- ▶ Read product data into FactoryCAD
 - ▶ Lightweight
 - ▶ 2D/3D views
 - ▶ Add simulation and cost data



Custom
Tooling
Objects



Extending the value of FactoryCAD



- ▶ Teamcenter connectivity
- ▶ Cost Estimating
- ▶ Collision detection
- ▶ Simulation Data Exchange (SDX)
 - ▶ FactoryCAD objects store data that can be exported to simulation programs
 - ▶ Create part routing information with built-in SDX editor

Cost Estimation Report

Plant: _____
Program: Job Number 500033435
Date (Time): Mar 13, 1999 (03:01 PM)
Estimator: Albert Einstein
Drawing File Name: Ladder1.dwg
Economic Factor: _____
Unit of Measure: units for length/width/height/de

UNIT	# OF UNITS (FIXED)	LENGTH
NONE	320	8.000
NONE	96	10.000
NONE	200	8.000

7
8 FACTORY_SUPPORT=C:\CimfSupport
9 DRAWING=C:\WINNT\Profiles\aaaron\Desktop\Drawing1.dwg
10 CIMFX_METENG=English
11 UNIT_OF_MEASURE=units for length/width/height/depth, area and volume are in., square in. and cubic in.
12 RESERVED FOR FUTURE USE
13

Unit Number	Fixed Units	Object Description	Status	Length	Width	Height/Depth	AutoCAD Entity Handle
101	4	Rack-Shelf	As-Built	96	48	1	E5
200	6	Rack-Support	As-Built	48	1.5	3	E5
343	8	Rack-Beam	As-Built	96	3	3	E5
187	4	Rack-Post	As-Built	96	3	1.5	E5

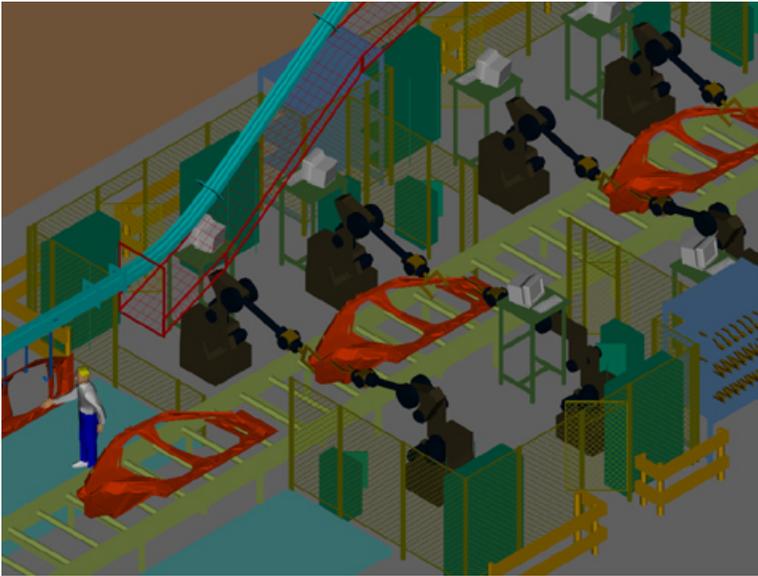
Library Manager

Folder System Object Block Command Add selected item to drawing

Name: |RH PDC|
Parameter Set Filename: _____
Parameter Set Name: |NONE|
Appearance Scheme: |NONE|
Layer: |CURRENT|
Object Type: Segment Component
Jig Type: Keyword Straight Turn
Jig Control: _____
Jig Keyword: |Rhpc|
Company: |EDS|
Division: |eFactory|
Manufacturer: |EDS|
Type: |Track Conveyor|
Model: |Power n Free Right Hand Power on Curve|
Version: |1|
Description: |RH PDC|

Bypass Dialog and Use Specified Parameter Set

Close Help



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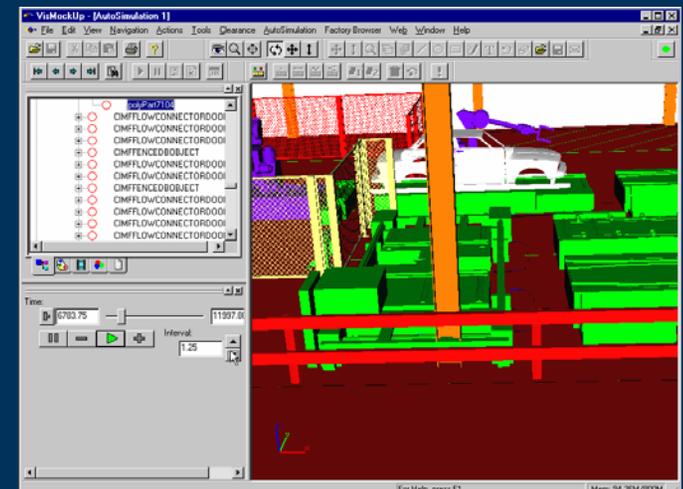
Introducing Factory Mockup



Factory Mockup



- ▶ Improves factory design communication by providing a CAD neutral environment for collaboration
- ▶ Identify collision and clearance problems before ordering and installing equipment
- ▶ Reduces time required to validate factory model





Factory Mockup features



- ▶ Collaboration-friendly design review environment
- ▶ Interactive viewing, walk, and fly-through modes
- ▶ Measure, mark-up, object manipulation
- ▶ Image and movie capture tools
- ▶ Animation scripting
- ▶ Dynamic collision and clearance violation detection



Tecnomatix **eMPlant** Manufacturing Process Management

www.tecnomatix.com

Version 6.0

eM-Plant

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Plant Simulation



- ▶ eM-Plant allows for creating a **dynamic** computer model of a **complex system** (e.g. production) to explore its characteristics and **optimize the performance** of the system.
- ▶ The computer model enables user to run experiments and what-if **scenarios** without disturbing an existing production or – used in the planning process – long before the real system is installed.

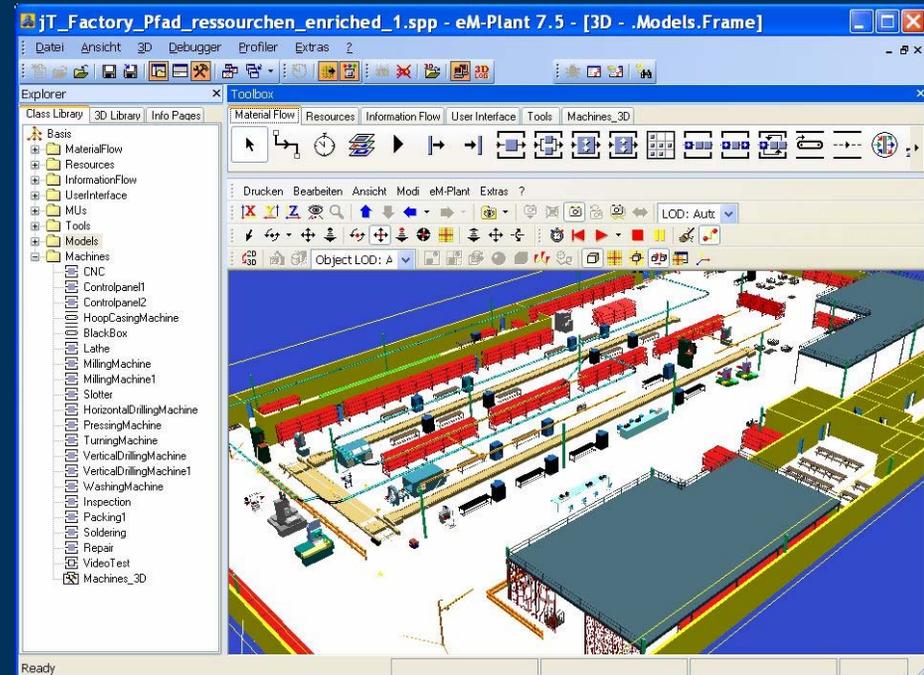




Benefits of simulation



- ▶ Detect and **eliminate problems** that otherwise would have required cost and time consuming correction measures during the production ramp-up
- ▶ **Minimize the invest cost** for production lines without jeopardizing the required output
- ▶ **Optimize the performance of complex production systems** with many variants





Real System / Plan

Simulation-Model

Simulation result



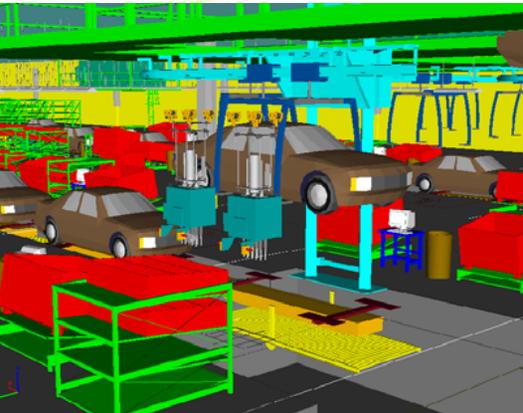
- ▶ Transparent analysis of complex systems
- ▶ Calculation and comparison of real numbers
- ▶ Computer supported investment decisions



- ▶ **3 - 6 % savings on investment**
(VDI, Association of German Engineers)
- ▶ **Cost / benefit ratio > 1: 12**
(eM-Plant customer questionnaire)
- ▶ **15 - 20 % productivity increase** of existing systems
- ▶ **5 - 20 % reduced cost** of new systems
- ▶ **20 - 60 % decreased throughput time** and inventory
Average savings found in European market survey



Quick recap



Features

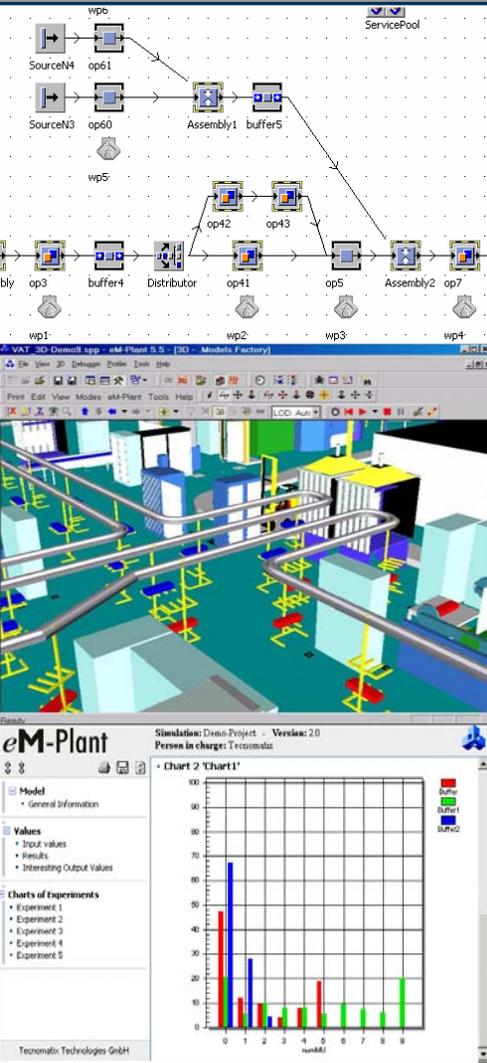
- ▶ *A 3D factory modeling and layout tool*
- ▶ Provides over 150 types of smart objects of factory equipment such as racks, cranes, conveyors, guardrails, paint booths.
- ▶ The models holds cost, performance and process information, which can be used by other applications
- ▶ Based on the Autodesk AutoCAD software
- ▶ Provides 3D output in JT format
- ▶ Reads in UG, Parasolid, JT data
- ▶ Allows user to create custom equipment objects
- ▶ Bill of Materials and Costing capability
- ▶ SDX (Simulation Data eXchange) enabled to link to DES systems

Benefits

- ▶ Allows the user to create layouts very quickly
- ▶ Creates a whole 3D factory model that is smaller in file size than a 2D model
- ▶ Integrated with Teamcenter Manufacturing
- ▶ Brings Product data, Tooling data & Plant data together

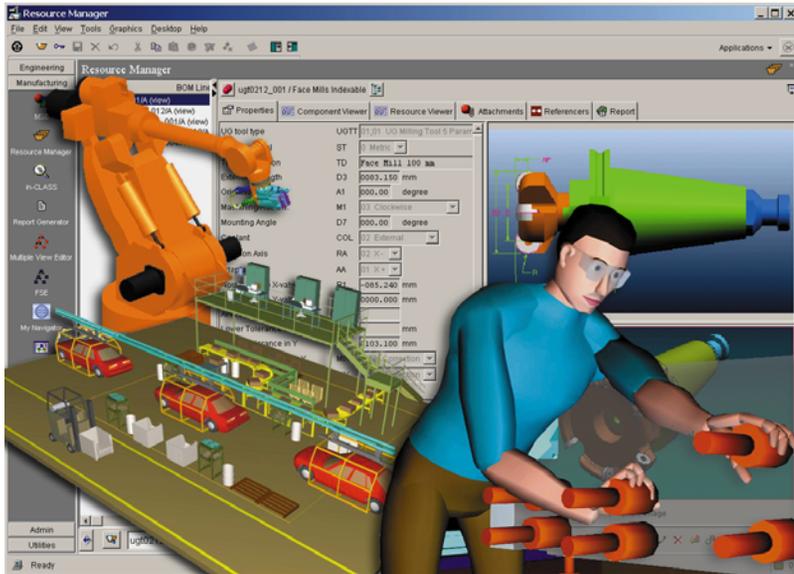


Plant Simulation (eM-Plant)



Highlights

- ▶ *Discrete Event Simulation system*
- ▶ Allows for creating a computer model of a system (e.g. production) to explore its dynamic behavior
- ▶ Optimize the performance (throughput) of the system and minimizes investment costs
- ▶ Enables user to run stochastic experiments
- ▶ Conduct what-if scenarios without disturbing an existing production
- ▶ Use in the planning process – long before the real system is installed
- ▶ Completely integrated with FactoryCAD – Single click simulations from FactoryCAD
- ▶ Ability to read in JT of the facility to run simulations on



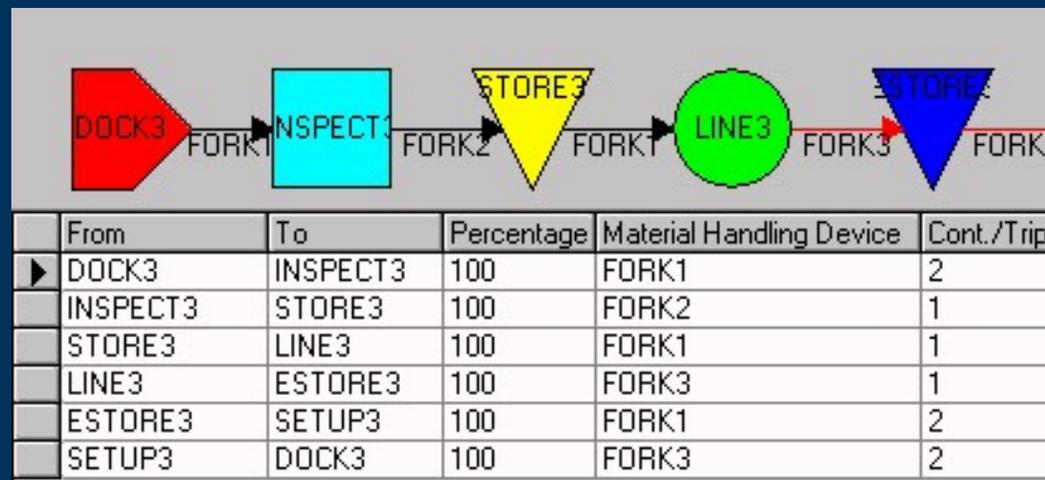
Integrating 3D Plant Layout to Throughput Simulation with Simulation Data eXchange (SDX)



- ▶ Plant Design
 - ▶ Static Simulation
 - ▶ FactoryFLOW
 - ▶ Discrete Event Simulation
 - ▶ Spreadsheet
 - ▶ Iconic 2-D
 - ▶ Physical 3-D
- ▶ SDX – Simulation Data Exchange
 - ▶ Need to channel data sources to DES
 - ▶ History of SDX
- ▶ SDX – Simulation Data Exchange
 - ▶ Brief overview
 - ▶ FactoryCAD functionality supporting SDX



- ▶ Static Simulation – Inputs
 - ▶ Assembly tree
 - ▶ Individual part routings
 - ▶ Containerization information
 - ▶ Material Handling equipment definition
 - ▶ Other miscellaneous details like load pickup and drop off....

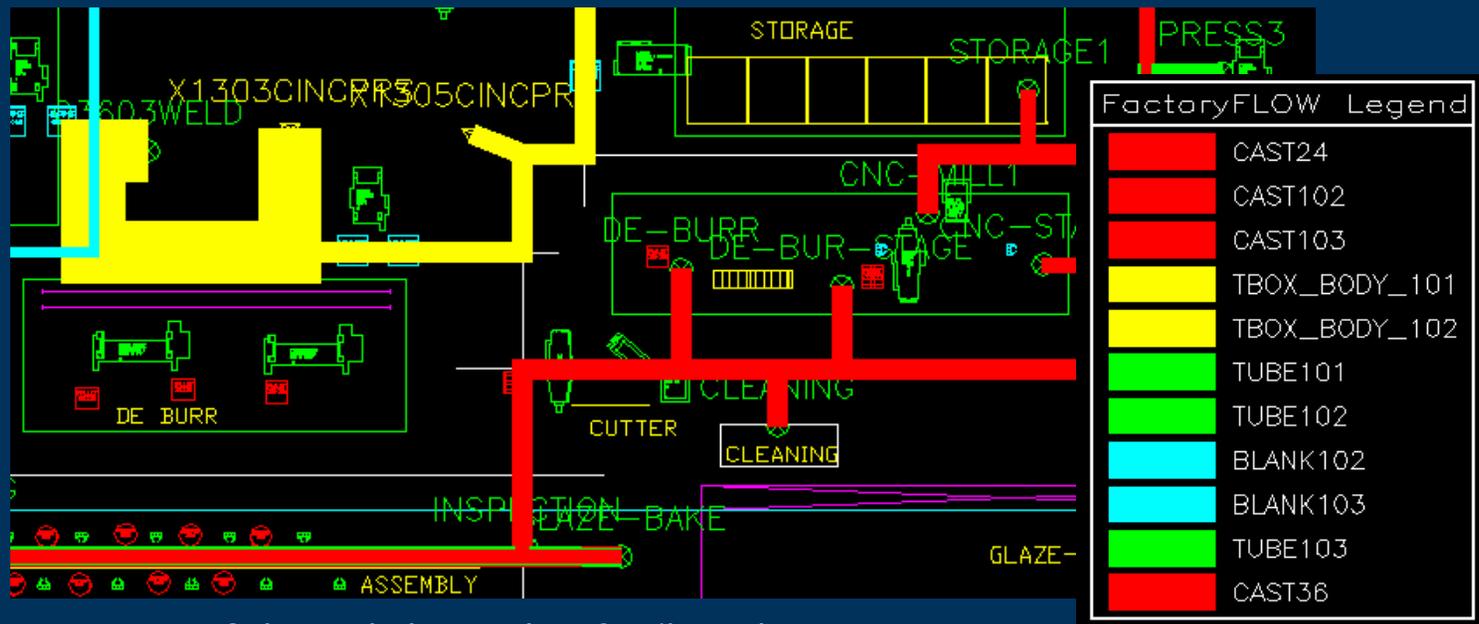


Process charts are used to specify material flow routings



▶ Static Simulation – Outputs

- ▶ Shortest travel path algorithms determine travel time
- ▶ Analyses are usually over a time period – day, shift, etc.
- ▶ Color coded material travel – showing intensity of travel
- ▶ Material handling utilization over a time period.



Color-code by product family and
thickness represents flow intensity



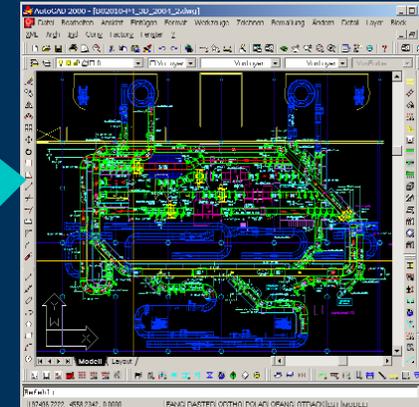
Problem statement discussion



Real-world system



Modeling,
Concept

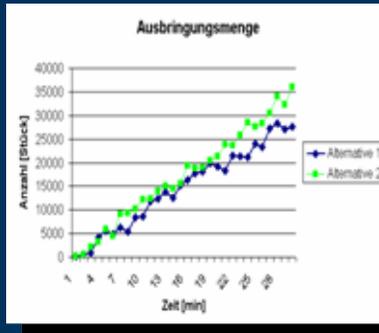


CAD
Layout

Result-
Transfer

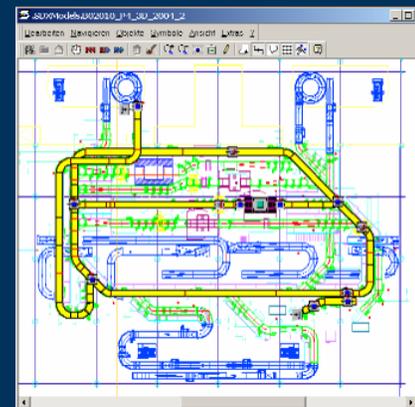
Iteration

Experiments



Quantified results

Analysis,
Interpretation



Simulation
model



- ▶ The layout is the hub of all change
- ▶ There is a need to connect the layout community with the throughput simulation team
- ▶ Need for shorter simulation / validation turn-around times in iterative layout design process
- ▶ Need to focus throughput simulation experts' efforts in modeling instead of spending most of their time on creating the model
- ▶ Enable knowledge capture and reuse – Cut down duplication and repetitive tasks
- ▶ Allow more engineers to harness the power of throughput simulation



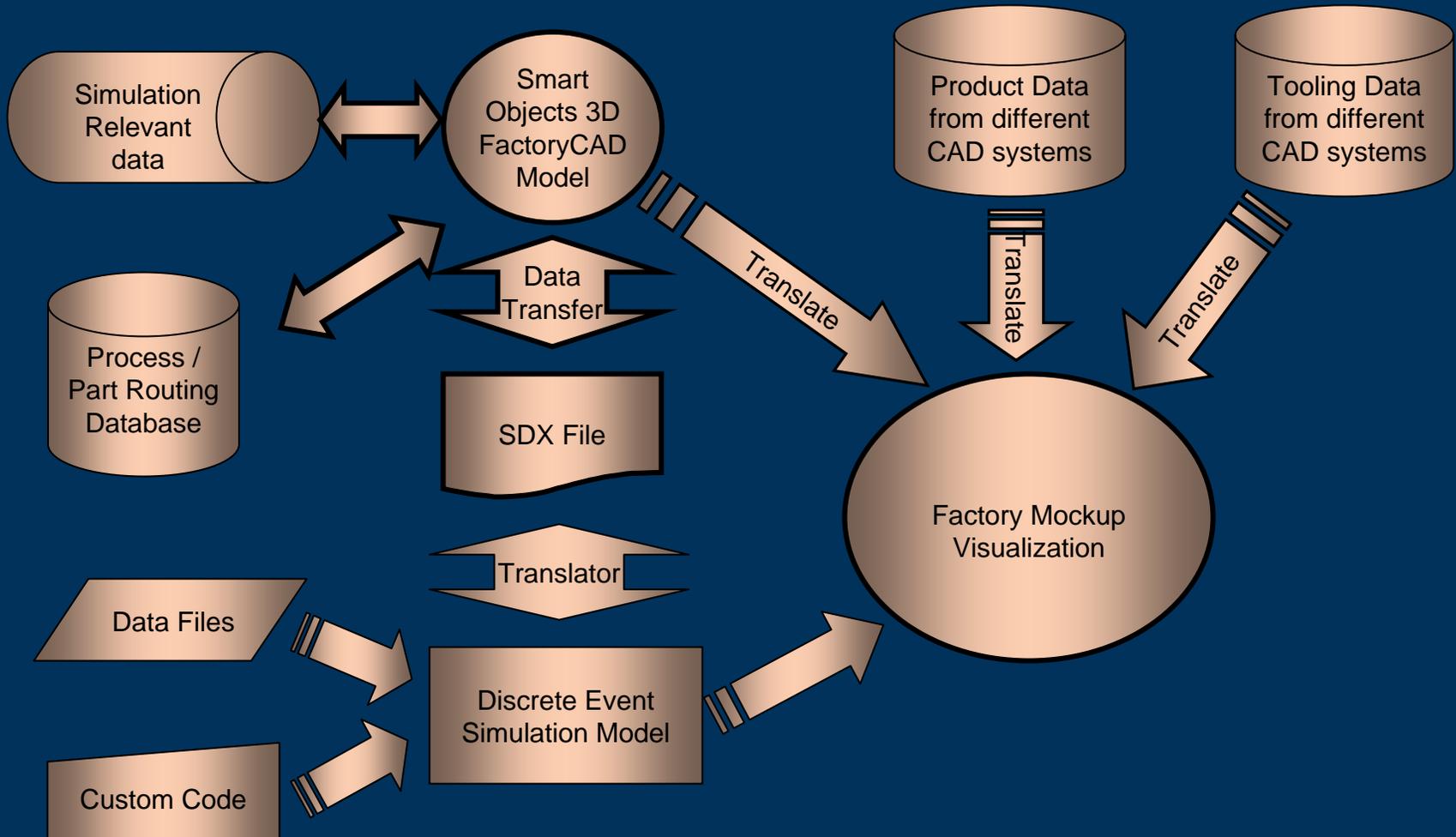
The answer – SDX



- ▶ The SDX concept provides the data protocol and fundamental connectivity between layout design and throughput simulation
- ▶ Model Construction Functionality
 - ▶ Utilize Smart Objects to quickly and easily create DES systems
 - ▶ Define base movement system attributes in FactoryCAD
 - ▶ Easy system design maintenance with one location (application) for physical layout – no longer maintained in simulation and CAD
 - ▶ No more redrawing system layout in the throughput simulation tool

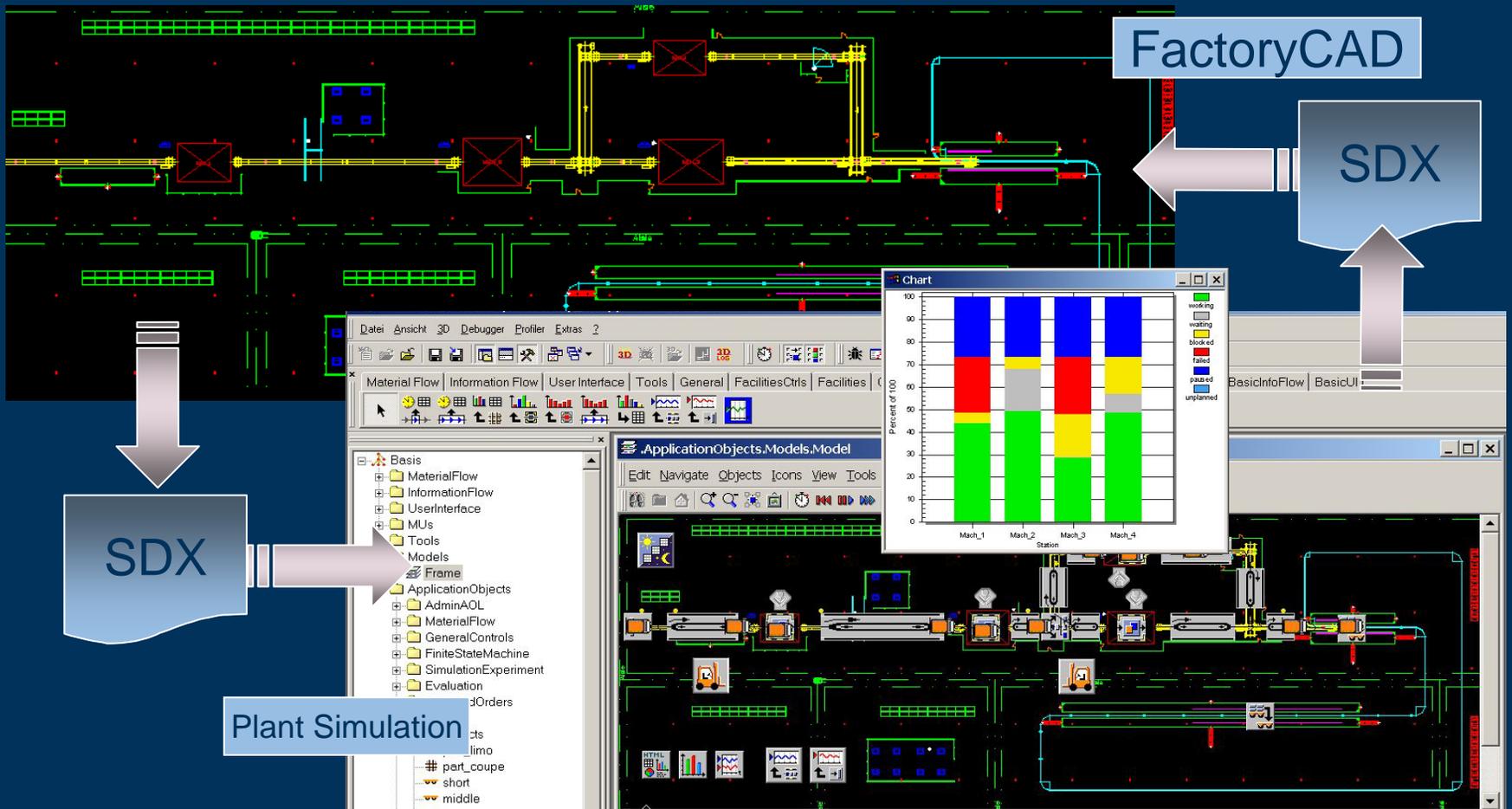


SDX – Generic Architecture





► How FactoryCAD data can be leveraged in Plant Simulation





SDX Objects



- ▶ Loads or Parts
- ▶ Conveyors - Floor and Overhead
- ▶ Vertical Lift Systems
- ▶ Pivots & Cross Transfers
- ▶ Aisles and Aisle Networks
- ▶ Buffer
- ▶ Runtime
- ▶ Route
- ▶ Process
- ▶ Dock
- ▶ Station Area
- ▶ Shifts
- ▶ Regular Monorail Systems
- ▶ Transporters (Vehicles)
- ▶ Carriers
- ▶ Machines
- ▶ Connection
- ▶ Workcenter
- ▶ Statistics
- ▶ Labor
- ▶ Robot
- ▶ Gantry
- ▶ All industrial objects

27 classes and growing...



▶ Machines

- ▶ Name, Type and Internal Type
- ▶ Breakdowns - multiple (w.r.t. Time or Number of Operations)
- ▶ Setups - multiple (w.r.t. Part Change, Time, Number of Operations)
- ▶ Shift patterns
- ▶ Linked Objects
- ▶ Cost Information

▶ Conveyors - Floor & Overhead

- ▶ Name, Type and Internal Type
- ▶ Breakdowns - multiple (w.r.t. Time or Number of Operations)
- ▶ Speed
- ▶ Spaces (distance between parts)
- ▶ Shift patterns
- ▶ Cost Information



▶ Transporters

- ▶ Name, Internal Type, and Image File
- ▶ Breakdowns - multiple (w.r.t. Time or Number of Operations)
- ▶ Capacity
- ▶ Quantity
- ▶ Load / Unload times
- ▶ Speeds - Load / Unload / Acceleration / Deceleration
- ▶ Size
- ▶ Shifts
- ▶ Linked Objects
- ▶ Cost Information



Sample of SDX properties



▶ Carriers

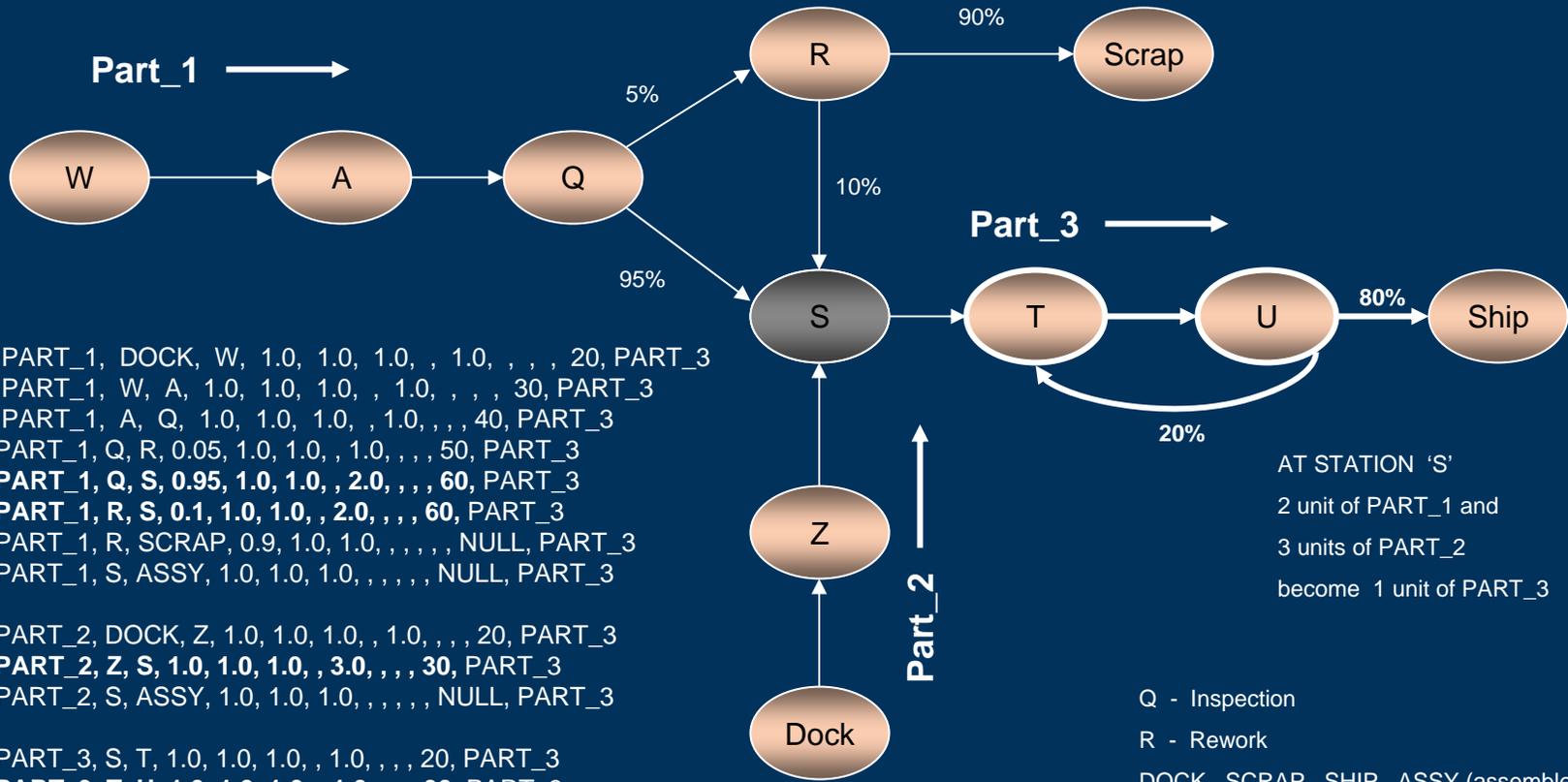
- ▶ Name, Internal Type, and Image File
- ▶ Capacity
- ▶ Quantity
- ▶ Load / Unload times
- ▶ Size
- ▶ Linked Objects
- ▶ Cost Information

▶ Buffers

- ▶ Name, Internal Type
- ▶ Minimum and Maximum Dwell time
- ▶ Minimum and Maximum number of loads
- ▶ Image file



SDX Route Handling



10, PART_1, DOCK, W, 1.0, 1.0, 1.0, , 1.0, , , 20, PART_3
 20, PART_1, W, A, 1.0, 1.0, 1.0, , 1.0, , , 30, PART_3
 30, PART_1, A, Q, 1.0, 1.0, 1.0, , 1.0, , , 40, PART_3
 40, PART_1, Q, R, 0.05, 1.0, 1.0, , 1.0, , , 50, PART_3
 40, PART_1, Q, S, 0.95, 1.0, 1.0, , 2.0, , , 60, PART_3
 50, PART_1, R, S, 0.1, 1.0, 1.0, , 2.0, , , 60, PART_3
 50, PART_1, R, SCRAP, 0.9, 1.0, 1.0, , , , NULL, PART_3
 60, PART_1, S, ASSY, 1.0, 1.0, 1.0, , , , NULL, PART_3

10, PART_2, DOCK, Z, 1.0, 1.0, 1.0, , 1.0, , , 20, PART_3
 20, PART_2, Z, S, 1.0, 1.0, 1.0, , 3.0, , , 30, PART_3
 30, PART_2, S, ASSY, 1.0, 1.0, 1.0, , , , NULL, PART_3

10, PART_3, S, T, 1.0, 1.0, 1.0, , 1.0, , , 20, PART_3
 20, PART_3, T, U, 1.0, 1.0, 1.0, , 1.0, , , 30, PART_3
 30, PART_3, U, T, 0.2, 1.0, 1.0, , 1.0, , , 20, PART_3
 30, PART_3, U, SHIP, 0.8, 1.0, 1.0, , , , NULL, PART_3

AT STATION 'S'
 2 unit of PART_1 and
 3 units of PART_2
 become 1 unit of PART_3

Q - Inspection
 R - Rework
 DOCK, SCRAP, SHIP, ASSY (assemble),
 are all reserved words

<Seq_Num> , <Load_Name> , <From> , <To> , <Percent_Rule> , <Transfer_Qty> , <Output_Qty> , <Part_Cycle_Time> ,
 <Qty_Per_Prod> , <Scrap_Rate> , <Mh_Equip> , <Load_Setup_Time> , <Next_Seq> , <Assembly_Name>



- ▶ All objects are written out in SDX
- ▶ Labor object - with labor pools...
- ▶ Labor can be connected to different machines and conveyor stations.
- ▶ Conveyor stations can be linked to machines
- ▶ Resources (machines) can be linked to resources
- ▶ Click and change SDX type for certain objects
- ▶ ***SDX Route Editor***
 - ▶ Single database used for ALL material flow studies (i.e. static and discrete event)



SDX implementation



- ▶ 95% of companies in the US use AutoCAD for plant layouts
- ▶ Layout drives changes - ultimate model
- ▶ It's simple
- ▶ ***It works !!***



HLA - High Level Architecture



- ▶ IMS - MISSION consortium
- ▶ Methodology to communicate between models at run-time.
- ▶ Eg: Models created in different DES packages interacting in run-time
- ▶ *Very “cutting-edge”, very “cool”*
- ▶ Contact N.I.S.T., Gaithersburg, MD for more details.
- ▶ National Institute for Standards & Technology
- ▶ Or visit their website at <http://www.mel.nist.gov/msid/>



- ▶ Save time validating your concept in an early planning phase
- ▶ Save money reducing stock and investment for equipment and inventory
- ▶ Increase revenues by increasing system throughput
- ▶ Present animated results to upper management
- ▶ Provide proof of concept = added value for your work
- ▶ Minimize risk & make reliable decisions, thus increasing your decision competence



Imagine this for the future....



- ▶ A single visualization environment
- ▶ Distributed simulation systems
 - ▶ Different simulations from different sources interact
- ▶ Fly through facility and run simulation on demand
- ▶ Collaborating with various simulations simultaneously
 - ▶ Discrete Event Simulation
 - ▶ Robotic / equipment simulation
 - ▶ Human simulation
 - ▶ Machine simulation
- ▶ Retrieve data across the web to run simulations online
- ▶ Query and data-mine through the virtual environment
- ▶ Studying effects of changes (eg: process) in real time
- ▶ ***All from your PC***



Contact and training information



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