Advanced 3D Factory Design integrated with Throughput Simulation
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UGS Enterprise PLM

NX
Transforming product development

Tecnomatix
Transforming manufacturing & production

Solid Edge
Evolving to 3D for competitive advantage

PLM Components
Open solutions for standardization & interoperability

Teamcenter
Capturing & sharing product knowledge

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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
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

<table>
<thead>
<tr>
<th>Method</th>
<th>Time</th>
</tr>
</thead>
<tbody>
<tr>
<td>Solid models</td>
<td>3 + months</td>
</tr>
<tr>
<td>Plain AutoCAD</td>
<td>1 - 3 months</td>
</tr>
<tr>
<td>FactoryCAD</td>
<td>1 - 3 weeks</td>
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FactoryCAD – Smart Factory Objects

- 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
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
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
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
eM-Plant

- 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
Tecnomatix Plant Simulation

- 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
FactoryCAD (3D plant modeling)

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 hold 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)
Agenda

- 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.
Real-world system

Modeling, Concept

Iteration

Experiments

CAD Layout

Simulation model

Result-Transfer

Analysis, Interpretation

Quantified results

Problem statement discussion
The needs

- 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

- Simulation Relevant data
- Smart Objects 3D FactoryCAD Model
- Process / Part Routing Database
- SDX File
- Data Transfer
- Translator
- Discrete Event Simulation Model
- Product Data from different CAD systems
- Tooling Data from different CAD systems
- Factory Mockup Visualization

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FactoryCAD to simulation

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...
Sample of SDX properties

- **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
Sample of SDX properties

- **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
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>
SDX Features

- 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/
Benefits

- 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

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