DIGITAL THREAD AND LOGISTICS: RUGBY IN A BROOKS BROTHERS SUIT?

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The Summit's purpose is to identify challenges, research, implementation issues, and lessons learned in manufacturing and quality assurance where a digital three-dimensional (3D) model of the product serves as the authoritative information source for all activities in the product's lifecycle.

How far we have come!
The Context

It’s all about **LEVERAGE**

A Continuum of Authoritative Digital Surrogate Representations
Leveraged Over the Entire Life Cycle

Dr. Ed Kraft, Technical Adviser, Arnold Engineering Development Center

What makes all this possible?

A reference model in systems, enterprise, and software engineering is an abstract framework or domain-specific ontology consisting of an interlinked set of clearly defined concepts produced by an expert or body of experts in order to encourage clear communication. Reference model - Wikipedia

No “universal” reference model, but at least in each domain of interest, an agreement on the semantics; necessary for a robust marketplace of solutions.
Are we missing an opportunity?

There is a LOT more going on than the connection between the product model and the individual manufacturing processes.
“Logistics” inside the factory

Global logistics

Each new supply chain was a step to win customers via capacity increase – example from the qualification flexible mobile phone business

Logistics network issues

Network Visualizations: % Sales + Financial Health

Supplier XYZ
Poor Financial Health

Op Col Fin Str

Partner
LM Aero
Supplier
Star Supplier

Tie Strength:
Based on Supplier’s % Sales going towards GDS

Global Supply Network Health Levels
Weak/ Vulnerable
Average
Good
Strong/ Optimal
Logistics Decision Making

_What production technologies?_
- How is production allocated?

_Who are the suppliers?_
- Where are they located?

_What about inventories?_
- What are our factories?
- What do our factories produce?
- How do we transport?

_Planning_

_Accept a job?_
- Which resources to assign?

_How to sequence tasks?_
- When to change resources?

_Where does job go next?_

_Operations Management_

_Behavior_

*G00* - Positioning at rapid speed; Mill and Lathe
*G01* - Linear interpolation (machining a straight line); Mill and Lathe
*G02* - Circular interpolation
*G03* - Circular interpolation
*G04* - Mill and Lathe, Dw
*G09* - Mill and Lathe, Exa
*G10* - Setjaw effects in it

*M00* - Program stop; Mill and Lathe
*M01* - Optional program stop; Lathe and Mill
*M02* - Program end; Lathe and Mill
*M03* - Spindle on clockwise; Lathe and Mill
*M04* - Spindle on counterclockwise; Lathe and Mill
*M05* - Spindle off; Lathe and Mill
*M06* - Toolchange; Mill
What About...?
What About...?
In this domain, our “wetware” does not have the same level of technical support for decision making that is common in the systems design domain.
The Elegant Design Intention Meets the Rough and Tumble of the Global Production System
Why Should You Care?

The quality of all this (logistics-related) decision-making has a huge impact on cycle time, cost, reliability, and risk.

You can’t settle for historical performance!
Leverage the lessons learned from MBE, MBSE, CAx, CAxI/F, etc to improve production system decision making!

Integrate production system knowledge into the system design process! DFL...
First, Identify The Domain

- Manufacturing systems are systems:
  - through which materials (product, tasks) flow
  - and are transformed by processes (make, move, store, measure)
  - executed using resources (people, equipment, inventory)
  - organized in some way (facility or network)

- Product/Process/Resource/Facility

- **Discrete Event Logistics Systems, or DELS**
WHAT DO WE NEED TO SUPPORT DELS PLANNING AND OPERATIONS MANAGEMENT DECISIONS?
Basic Framework from CAx

Tools for capturing system models

Transform Engine

Vocabulary
Semantics
Ontology

Mapping

Theories
Models
Solvers

Standard analyses for answering common questions
What Is Available Today For DELS?

- UML
- IDEF
- BPMN
- SysML
- VSM
- CMSD
- STEP

Tools for capturing system models

Transform Engine

Mapping

Vocabulary Semantics Ontology

Standard analyses for answering common questions

?
What We Do Have

www.omgsysm.org

http://www.uml-diagrams.org/uml-meta-models.html

Industrial Partnerships!
One Example From Keck VFL

- Fast, cheap, good analysis models
- Layered abstraction
- Transformation technology
- Decision support
A Use case: SC design

- Many locations where loads originate or terminate
- Many possibilities for distribution center locations
- Many possibilities for fleet configuration at each DC
- Want to guarantee delivery lead time
- Uncertain pickup/drop rates at each customer

If you care about both cost and service level, how many DCs should you have, where should they be, how should you configure each DC’s vehicle fleet, and how should you dispatch vehicles?

- Not just an optimization problem, because of control and uncertainty.
- Not just a simulation problem, because of facility and fleet configuration decisions.
Network meta model

An example of a “meta-model” defining the semantics for creating an instance model of a particular (abstract) network.
Using the meta-model concepts (e.g., <<Flow Network>>, <<Flow Edge>>, etc.) to develop a “domain specific language”, with semantics that are easily understood by the domain experts and stakeholders.
Transport channel behavior

For this to work, we have to be precise—the system instance model cannot be ambiguous, because that will prevent reliable transformation to analysis models.
SC “class” Reference model

- Includes slots for source-sink flow network
- Includes slots for transportation network
- Includes slots for depots, fleets, and vehicle dispatch control

- Create an “instance” of the supply chain “class” which contains all the information you have for a particular supply chain design.
- Or, alternatively, create an data schema and a database with a record for every “instance” of the supply chain “class”; now you have all the information you need to describe a particular supply chain instance.
Hierarchical DESIGN analysis

Each analysis “conforms” to the supply chain reference model, thus works for any “instance” of the supply chain object.
Structure: Depot Selection via MCFN

- Aggregate and approximate the flows and costs
- Solve MCFN using a COTS solver (CPLEX)
- Apply a “leave one out” strategy to generating several feasible candidate network structures.
- In this case, generate 5 candidates

**Goal:** Reduce the computational requirements of optimizing the distribution network structure.

**Strategy:** Formulate and solve a corresponding multi-commodity flow network and facility location problem.
Behavior: Resource Selection

**Goal**: Capture and evaluate the behavioral aspects of the system using discrete event simulation.

**Strategy**: Generate a DES that simulates a probabilistic flow of commodities through the system.

- For each candidate supply chain network structure, generate a portfolio of solutions to the fleet sizing problem
- Trade-off cycle time/service level and resource investment cost
Control: Resource Assignment

**Goal:** Select and design a detailed specification of the control policies for assigning trucks to pickup/dropoff tasks at customers.

**Strategy:** Generate a high-fidelity simulation that is detailed enough to fine-tune resource and control behavior.

Generate a Pareto set of solutions that trade-off Service Level, Capital Costs, and Travel Distance
Kinds of results

- These are Pareto optimal designs
- Decision makers make trade-offs
- Hundreds, perhaps thousands of simulation runs, with varying depot location decisions, varying fleet configurations, varying control policies—all generated algorithmically
Are We There Yet?

http://www.imdb.com/title/tt0368578/mediaviewer/rm3959165184
Current Status

- Large demonstration project on high volume central fill pharmacies (Keck VFL)
- Start up company focused on adding decision support to value stream maps (ModGeno)
- Creating a challenge team within INCOSE MBSE Initiative (NIST + Keck VFL + ?)
MAKE A DIFFERENCE