A SysML-Based Semantic Reference Model for Design-to-Production Translation

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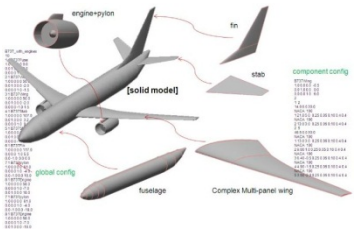
Context & Vision

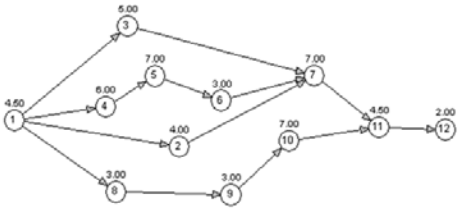


Concept to Detail

D2P

D2P Translation:
early, often, integrated

D2P

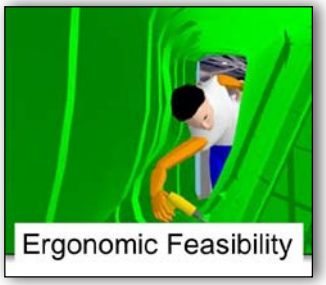


Concept to Detail

777 production line (Gail Hanusa/Boeing)

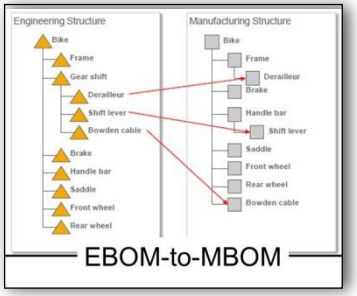
Fundamental Questions

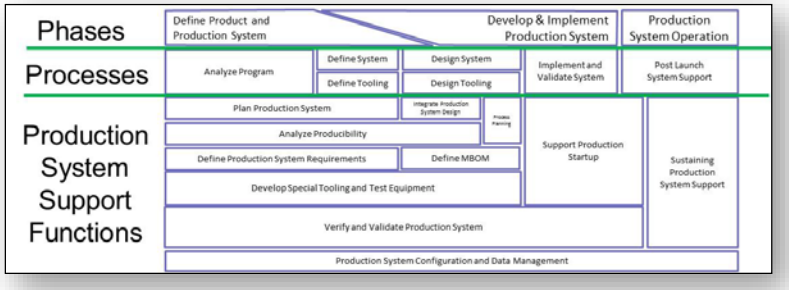

Technical Feasibility


Ergonomic Feasibility

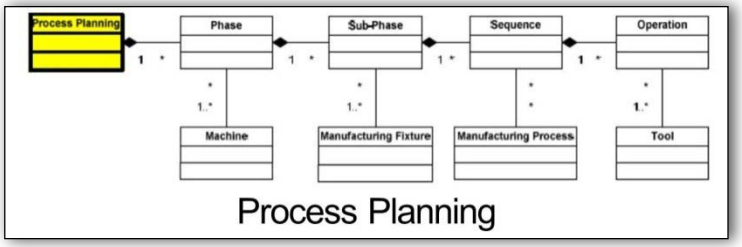

Constraints?


Global Sourcing






Investment




Factory Configuration

Design-To-Production involves taking a product design and creating its production system. Fundamental questions include:

- (*MBOM Structure*) Given an EBOM, how should the MBOM (manufacturing bill of materials) be structured?
- (*Production Feasibility*) For each part and assembly in the MBOM, is production technically feasible with respect to materials and processes? Are there constraints on capability or capacity which preclude in-house production?
- (*Ergonomic Feasibility*) For each part and assembly in the MBOM, is production ergonomically feasible? If so, do ergonomic considerations create constraints on production?
- (*Sourcing*) How should each part and assembly in the MBOM be sourced (in-house or out-sourced) to maximize the program's value?
- (*Process Requirements*) For parts and assemblies in the MBOM produced in-house, what new process technologies are required?
- (*Facility Configuration*) For parts and assemblies in the MBOM produced in-house, how should production facilities be configured?
- (*Process Plans*) For parts and assemblies in the MBOM produced in-house, what are the process plans and individual operation work instructions?

What Makes Design-To-Production Difficult?

- Requires integration across many knowledge domains.
- For any substantial product, the scale of knowledge is formidable.
- Strong dependence on tacit knowledge.
- Transient nature of some knowledge, due to economic and technological changes.

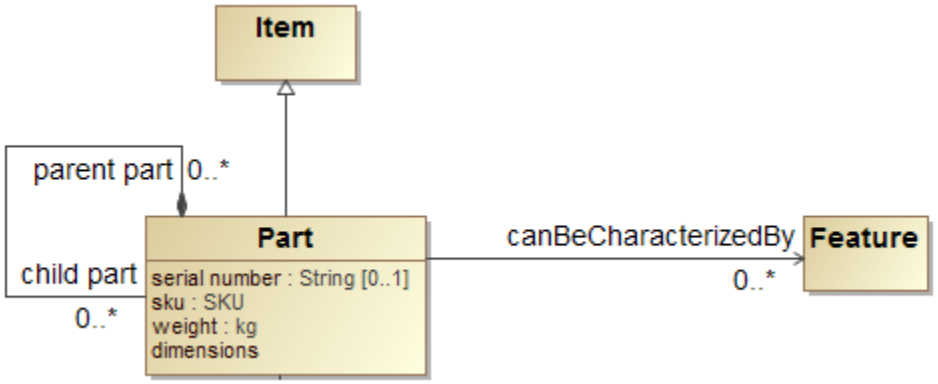
Premise: Design-To-Production Requires Reference Models

- A *reference model* is an attempt to formalize the semantics of a domain.
- The intent is to make design-to-production decision-making better, faster, cheaper, and more reliable. To do this, a goal is to formally capture design-to-production knowledge, an investment which enables seamless access to analysis models.
- What design-to-production knowledge must be captured?
- Product
- Process
- Resource
- Facility (make) and Supply Chain (buy)

Notes

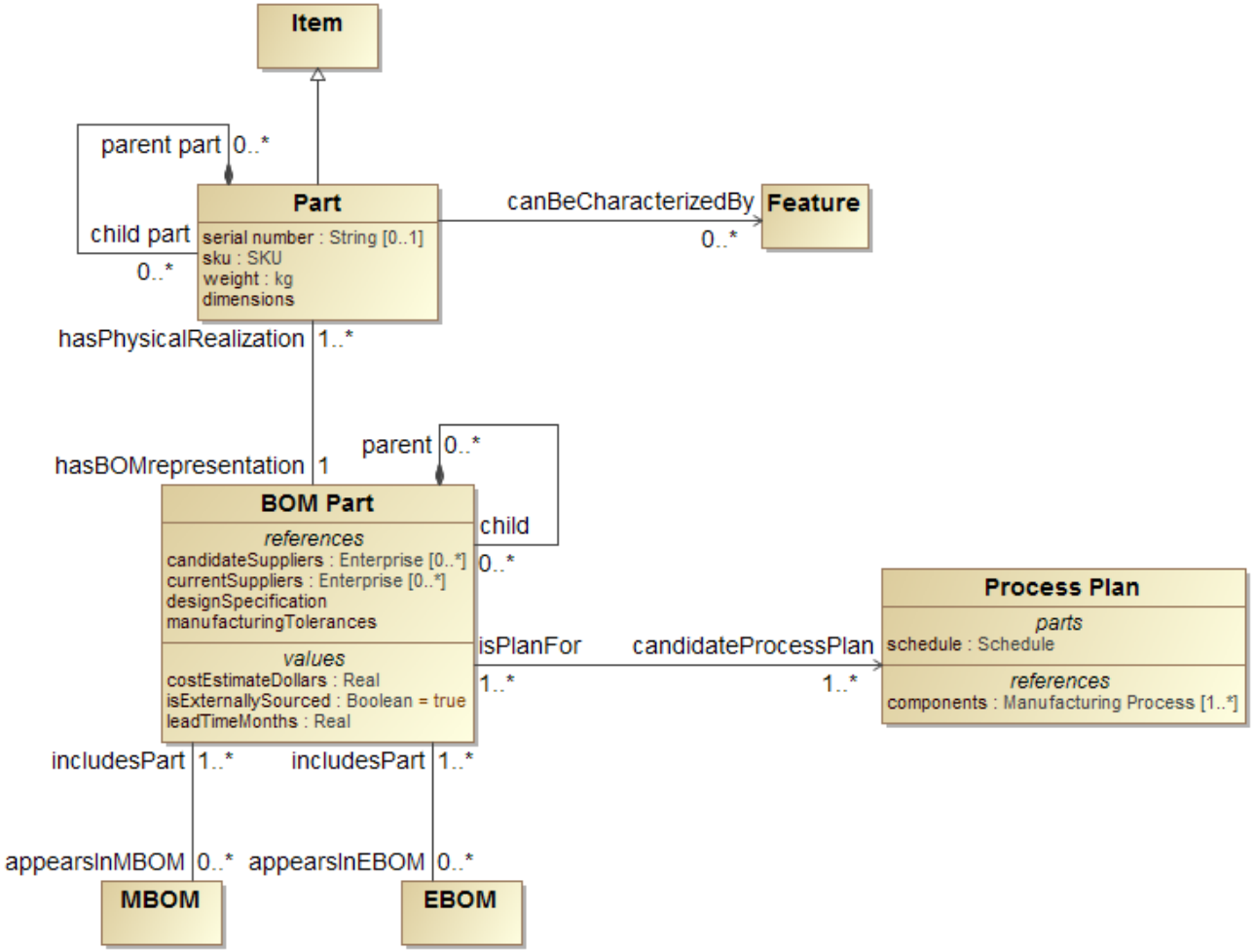
- Whenever possible, to create a reference model we begin from an existing standard:
- OASIS PP&S: http://docs.oasis-open.org/pps/v1.0/pps-core-elements-1.0.pdf
- OAGIS for defining enterprise-wide business functions such as ERP, e-commerce, CRM, and finance: http://www.oagi.org/oagi/downloads/ResourceDownloads/2009_OAGIS_STEP_Final.pdf
- SCOR: http://en.wikipedia.org/wiki/Supply-Chain_Operations_Reference
- Our chosen language for creating formal reference models is SysML: http://www.omg.org/spec/SysML/

PRODUCT



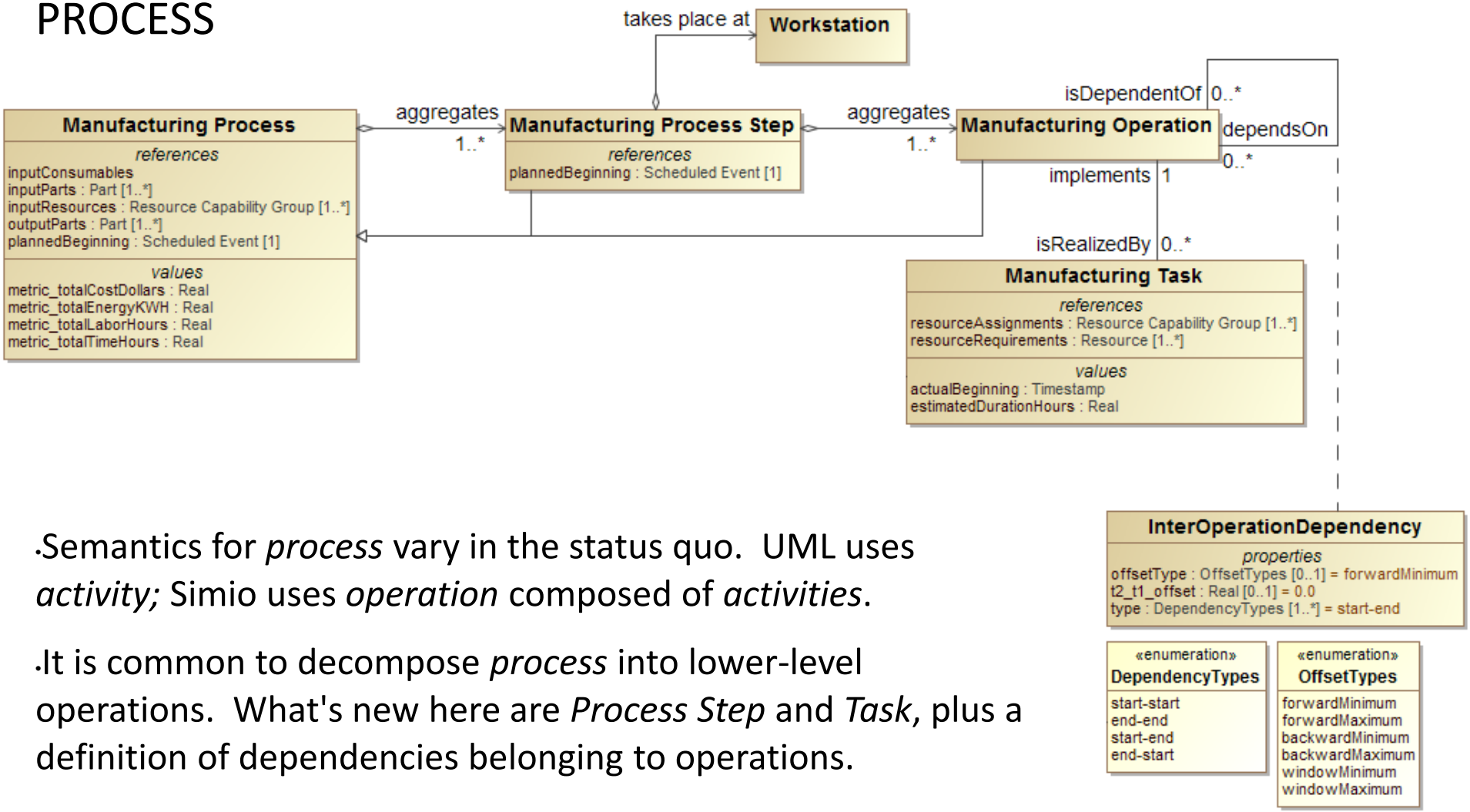
- The semantic **Item** comes from the *OASIS PP&S* standard. **Part** is customary in manufacturing, yet implies something physical and subordinate to a whole.
- Needed are links to a part's **Process Plan** and **Bill Of Materials**.

PRODUCT



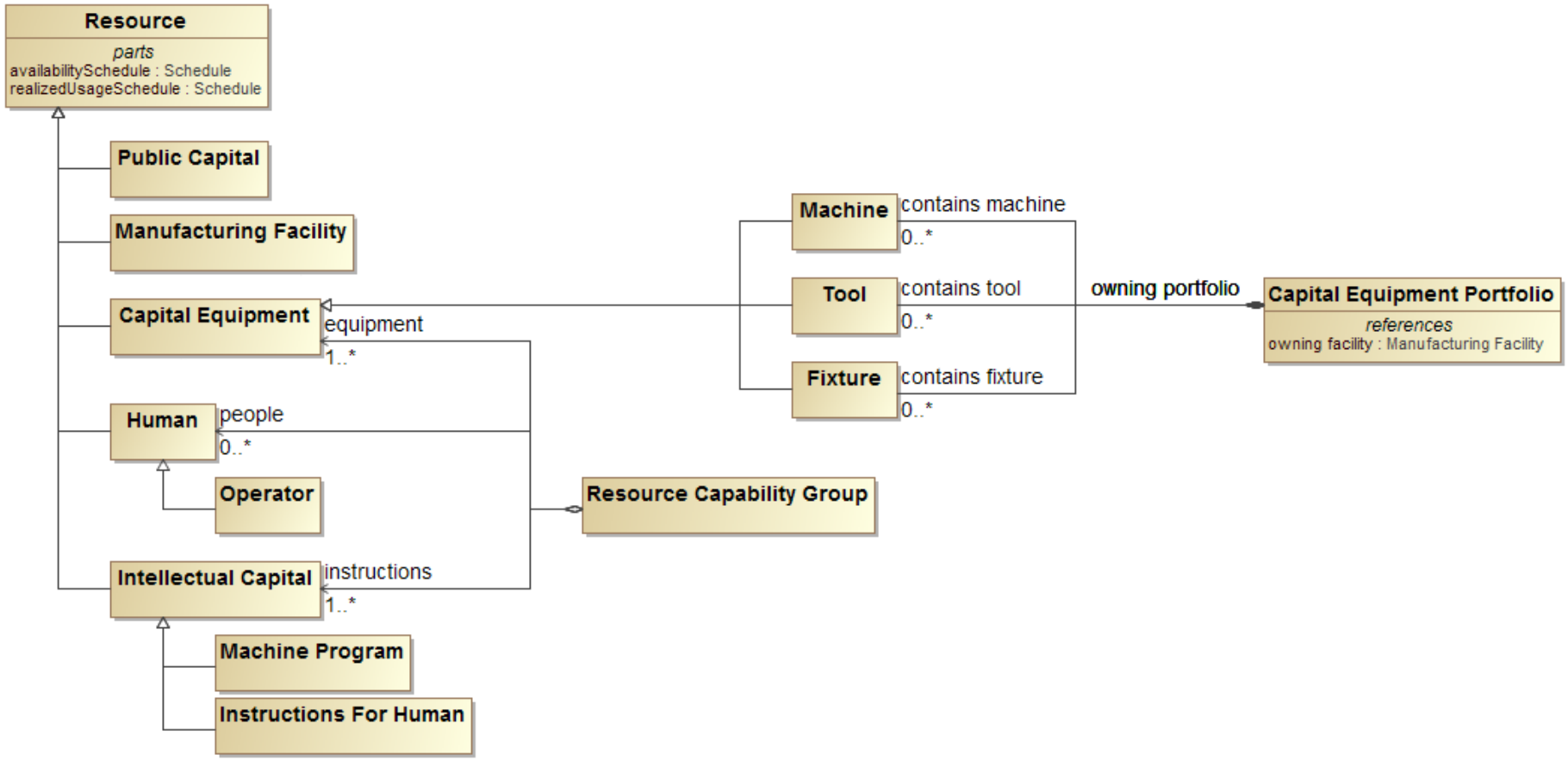
- What is a **BOM Part**? It's a planning semantic with attributes including supplier information, lead time, design specification, manufacturing tolerances, estimated cost, and more.
- Why both **Part** and **BOM Part**? We prefer not to burden **Part** with planning attributes when it already contains a large set of execution attributes.
- Note that **EBOM** is the extent of design semantics here.

PROCESS



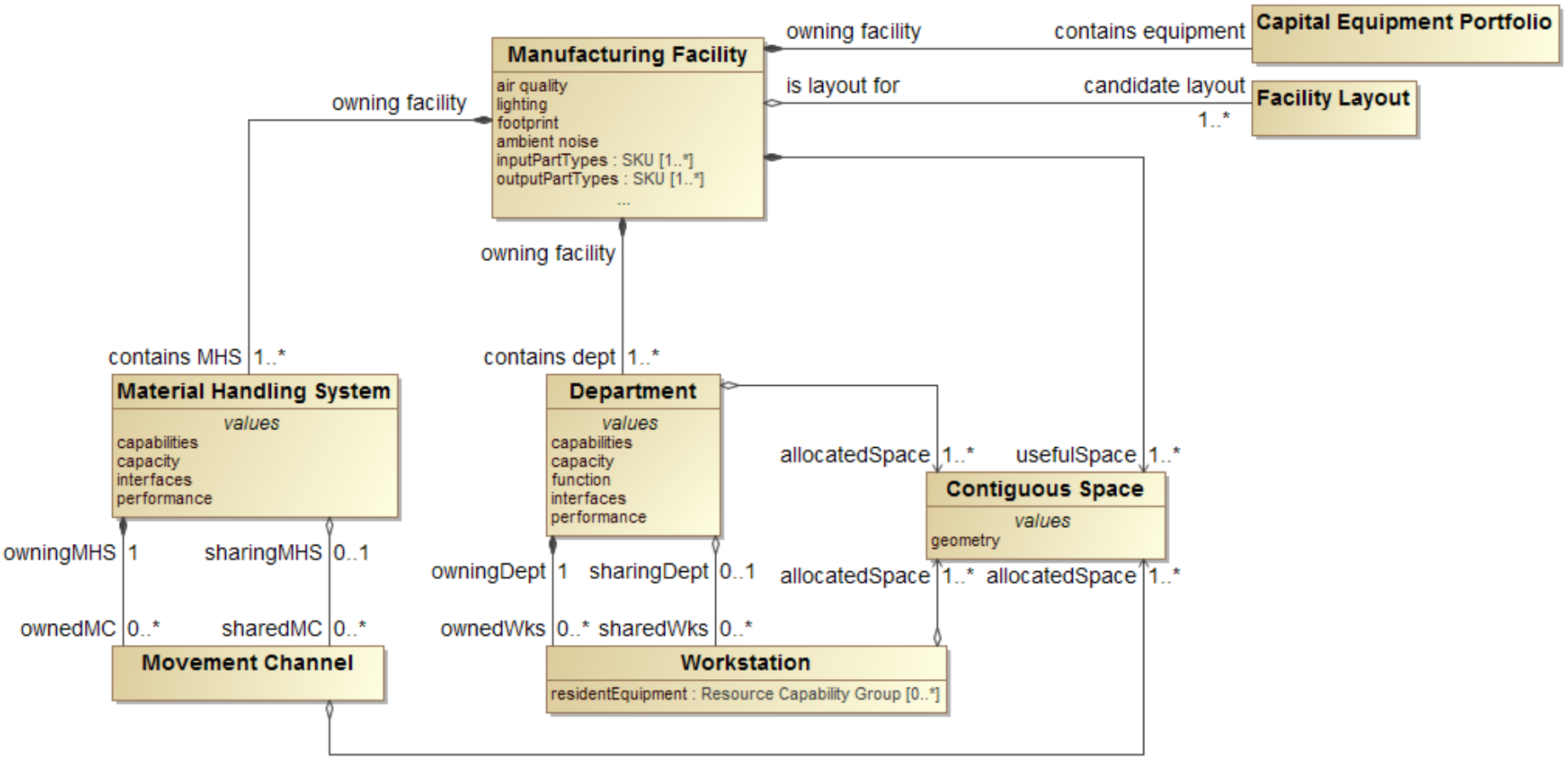
- Semantics for *process* vary in the status quo. UML uses *activity;* Simio uses *operation* composed of *activities*.
- It is common to decompose *process* into lower-level operations. What's new here are *Process Step* and *Task*, plus a definition of dependencies belonging to operations.

RESOURCE



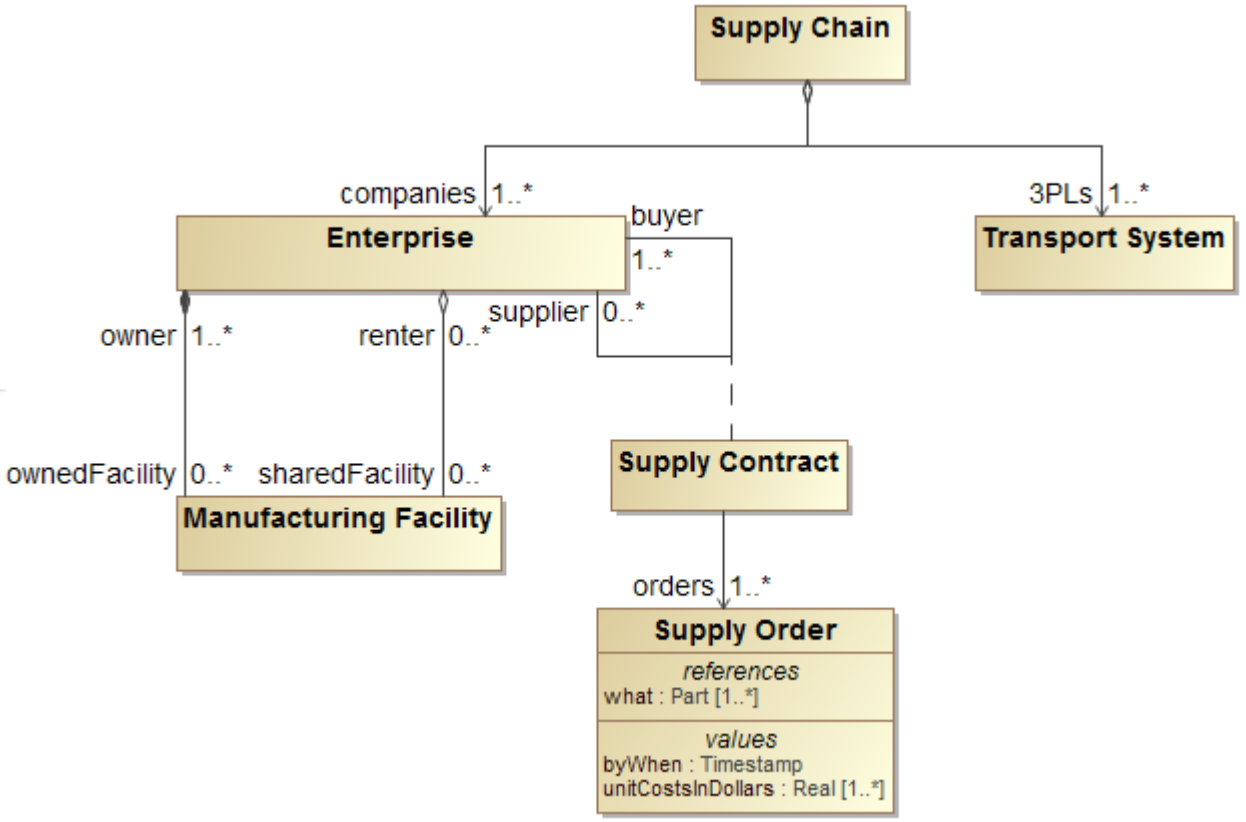
- A *Resource* is any asset usable in a state-conversion process.
- *Capital Equipment Portfolio* exists for querying any facility's equipment. Future work might add semantics for querying other resource types, such as human employees.
- *Resource Capability Group* identifies common bundles of resources.

FACILITY (make)



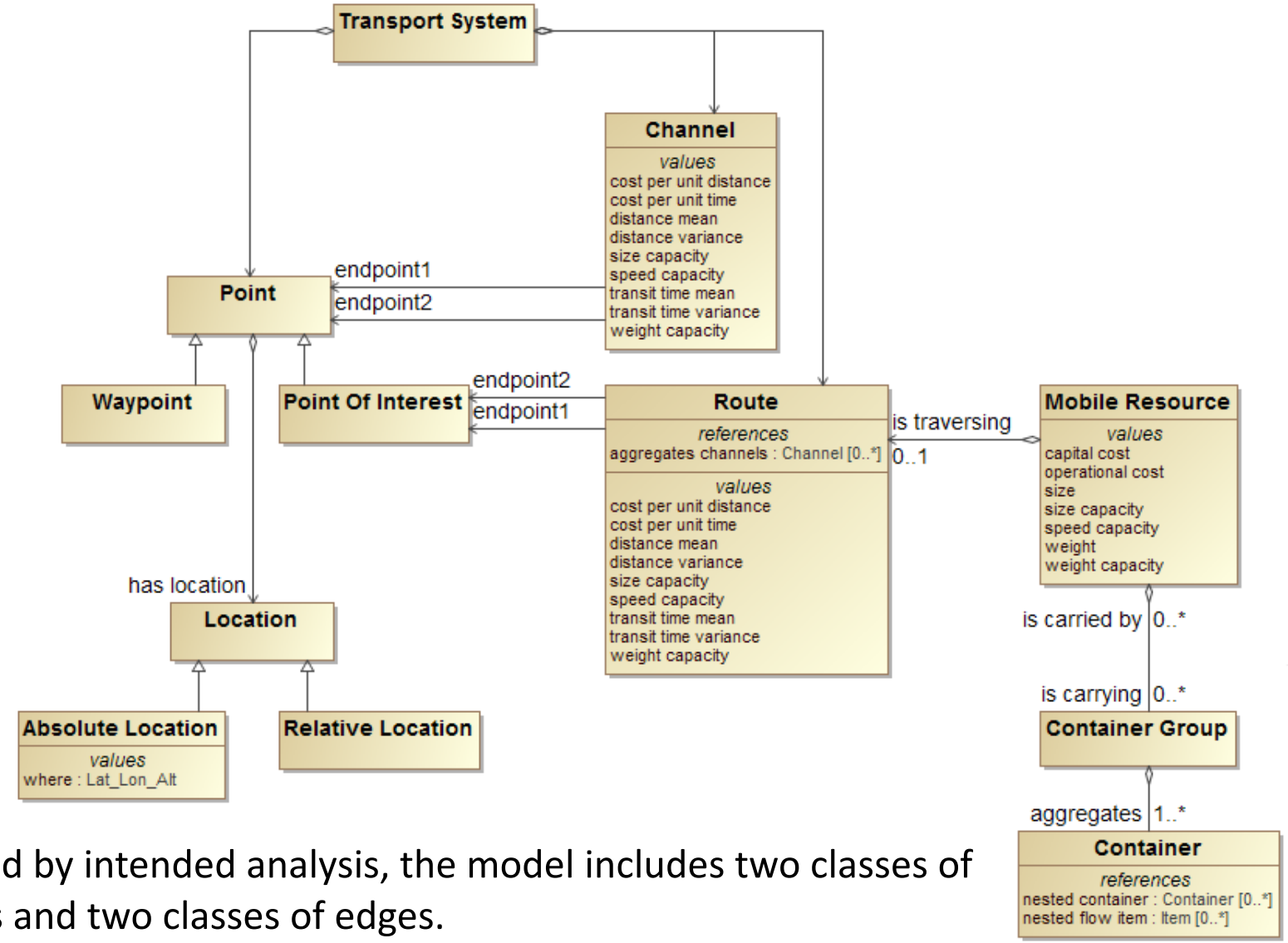
- A *Facility* is composed of *Departments*, each composed of *Workstations*.
- So far is modeled "nodes" and material movement between them. The original intent was designing a facility layout, hence a strong overlap with *network* semantics.

SUPPLY CHAIN (buy)



- A first-person of "my" supply chain view would include semantics like *supplier base*; this is a third-person view.
- Future work includes semantics for *control*. What is captured here suffices for simple analysis like network optimization, but operational analysis via simulation requires making control explicit and formal.

TRANSPORT SYSTEM



- Biased by intended analysis, the model includes two classes of nodes and two classes of edges.
- The semantics may be correct, but the syntax is not useful.

SUMMARY

- A reference model is a “single source of truth” of domain knowledge, helping to address design-to-production questions including:
- MBOM Structure
- Production Feasibility
- Ergonomic Feasibility
- Sourcing
- Process Requirements
- Facility Configuration
- Process Plans
- Answering these questions can require sophisticated analysis. Reference models are essential infrastructure to automate the formulation of analysis models. *Automation requires an investment in making implicit knowledge explicit.*