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# Entities, Agents, and Manufacturing Systems

Simio User Forum  
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### Outline

- Introduction and background
- Entities as "first class" objects
- Entities and elements as data structures and control
- Populations as experiment control
- Conclusion



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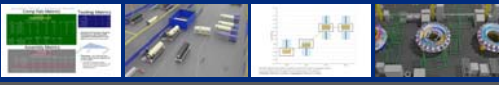
### Introduction and background

**Boeing Research and Technology**

- Systems, Aeromechanics, Materials and Standards, Manufacturing, and...
- Support and Analytics

**Production Analytics has been using Simio for ~7 years**

- Object oriented nature supports complex modeling projects
- API enables integration and workflow efficiencies



Where are my highest risk calls and what can I do to reduce the risk?

What are the minimum tooling requirements?

Is the cost of engineering worth the impact to production?

Is this process capable?

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### Large-scale manufacturing presents specific challenges

**Highly variable statement of work per production item**  
**Thousands (and thousands) of objects of interest**

- Parts, jobs, mechanics, tools, etc.

**Production system is schedule-driven based on delivery commitments**

- Centralized scheduling, de-centralized operations management

**Quality and availability of data varies**


- Existing versus proposed production systems

**Production systems are unique**

**Example: May 2016 student competition**

- <https://www.simio.com/academics/StudentCompetition/May2016/contest-overview.php>

Solution? Intelligent objects help address these complexities



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**Entities as "first class" objects**

Enables agent-based approaches within DES framework

- Base class "agent" is an abstract class, but entities are a subclass

Entity object definition can include:

- Processes – logic/behavior
- Definitions– elements, states, properties, etc.
- Data
- Entities can be "resource objects"

Dynamic run-time objects

- Can be created and destroyed during run-time!
- Have "physical" attributes such as speed, acceleration, orientation
- But! Entities don't *have* to move

```

graph TD
    IO[Intelligent Object] --> Agent
    IO --> Entity
    IO --> Transporter
    Entity --> Freight
    Entity --> Link
    Entity --> Node
    
```

**Entity vocabulary**

**Entity definitions**

Entity properties→

- Set at the entity instance
- Is the same value for all entity population members of that instance

Entity states→

- Set at the entity population member level

**Examples:**

Posted by Asagan <http://www.simio.com/forums/viewtopic.php?t=16&t=1446>

<http://www.simio.com/forums/viewtopic.php?r=36&t=1067>

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### Entities and elements as data structures and control

Now that we have entities with behavior, logic, and data, what can we do?  
 Elements and process steps add functionality to manage populations of entities at the parent model level

- Stations and Storage
  - Station is a physical home for an entity
  - Storage is a logical home, meaning we can have multiple references on multiple storage elements representing the same "physical" entity
- Search/Insert/Remove/Transfer are "control" logic to find, move, or generate reference to a set of entities
- Monitors, Events, Wait and Fire are useful for message exchange/communication

**These can all be used to manage entities, or on the entities themselves!**

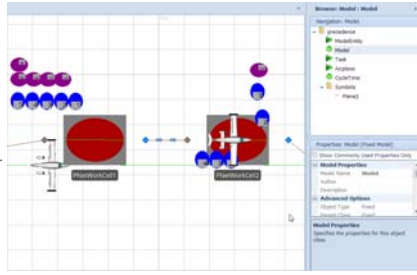
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### Example: job processing on assembly

**Challenge:**

- Tasks (jobs) may span servers—tasks are associated with entity, not server
- Tasks have relationships—precedence, start-at location, resource requirements
- Approach: use entities for tasks, storage queues for data management. Sub-classed server provides task processing and management



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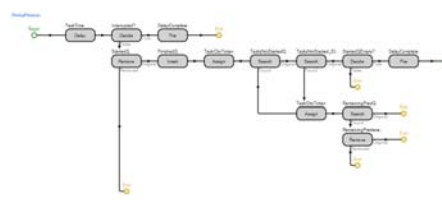
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### Example details

**Airplane entity definitions:**

- Monitor Elements
  - WorkQueueMonitor
  - Storage Elements
    - TravelTask
    - WorkQueue
    - TaskStarted
    - TaskFinished
    - TaskStarted\_Eligible

**Task management on server:**



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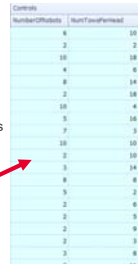
### Populations as experiment control

The dynamic nature of entities leads to experimentation opportunities

- Properties can be used to generate populations of specific quantities
- Offers a different kind of flexibility than using fixed objects

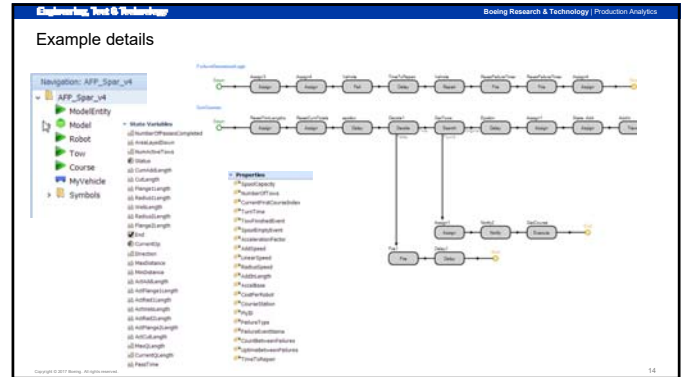
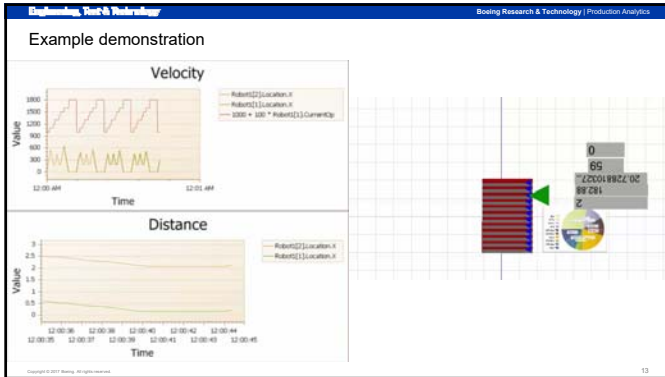
**Example:**

- Manufacturing assessments for using robotic process on large-scale airplane structures
- Goal: determine cell configuration to minimize cost subject to rate requirements
  - Need to experiment with the number of robots and number of heads per robot
- Approach:
  - Robots and robot heads modeled as entities
  - Number of robots and robot heads are experiment properties; population is dynamically created at each simulation run
  - Each entity type has processes, properties, and states defined to support the overall behavior of the system



Number of Robots	Number of Heads	Build Time/Period
4	4	10
2	2	5
10	10	10
4	4	4
8	8	14
2	2	10
10	10	10
3	3	14
7	7	7
10	10	10
3	3	14
4	4	4
3	3	14
2	2	10
2	2	10
2	2	10
3	3	14
4	4	4

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**Additional examples**

Crane Library  
 • <http://www.simio.com/forums/viewtopic.php?f=36&t=1026>

Vehicle with driver  
 • <http://www.simio.com/forums/viewtopic.php?f=36&t=2334>

• Additional application: assembly must use a tool for movement, and tool needs AGV to move  
 Standard library objects Vehicle and Worker are subclassed entities!

**Summary**

Entities are fully “intelligent objects” that can have broad use  
 Agent-based/DES hybrid models  
 Dynamic populations with complex logic  
 Experimentation benefits

**Commentary:**

- Usually need instantiation logic (at parent-model level)
- Often requires multiple object definitions to capture behavior and interactions
  - Design objects with these interfaces in mind
- Good object-oriented design principles reduce frustration and increase flexibility

