SysML Parametrics Research for Modeling & Simulation Interoperability

- DNA Signatures (Panorama plugin)
- STK/LVC Interoperability (AeroMagic plugin)
- Virtual Rover/STK (prototype)

Development Team
- Selcuk Cimtalay (testing and feedback ideas)
- Russell Peak (objectives, requirements, and concepts)
- Andy Scott (Panorama & AeroMagic s/w development)
- Miyako Wilson (SysML parametrics s/w development)
- Collaboration with InterCAX and other vendors
System/SoS M&S Examples in STK

Geo-positioning Model

Missile Launcher Model

Communications Link Simulation between Satellite and Ground Station

(a) Link with ground station at t=t1

(b) Link with ground station at t=t2 (several orbits after t1)

(c) Link broken with ground station at t=t3 (~10 minutes after t2)

Based on original models by AGI.
Two-way interoperability SysML-STK (throughout simulation run-time)

- Changeable inputs (SysML to STK): satellite and ground station properties
- Results (STK to SysML): duration of each link session with each ground station

STK satellite comm. link sim (a constructive simulation)

comm. link w/ stationBlue at t=t1

comm. link w/ stationGreen at t=t2 (and so on)
Initial prototype: STK & SysML parametrics (for req. verification, ...)

Active connection between SysML and LVC-type simulations.

Impact: Can use SysML to effectively V&V such sims.
“DNA Signature” Nomenclature

Interacting with equation graph structure via Panorama tool

DNA signature of instance ft330 (flattened equation structure auto-generated from SysML)
Exercise 0: Automobile Fuel Capacity & Mileage

Modular, Reusable Building Blocks
Exercise 0: Automobile Fuel Capacity & Mileage

Solved Instance and DNA Signature

state 1.1 (after solving)
Examples of Executable SysML Parametrics

- Road scanning system using unmanned aerial vehicle (UAVs)
- UAV-based missile interceptor system trade study
- Space systems (tutorials): orbit planning; mass/cost roll-ups
- Space systems (studies/pilots): FireSat (INCOSE SSWG), ...
- Space systems (actuals): science merit function, ...
- Environmentally-conscious energy systems / smart grid
- Manufacturing “green-ness” / sustainability assessments
- Regional water management systems (e.g. South Florida)
  ...
- Mechanical part design and analysis (FEA)
  ...
- Wind turbine supply chain management
- Insurance claims processing and website capacity model
- Financial model for small businesses
- Banking service levels model

Next-Generation Spreadsheet Technology++
(object-oriented, multi-dimensional, ...)
Test: Match the actual model titles (below) to their “DNA signatures” with imagined titles (left).

____ 1. South Florida water mgt. (hydrology) model
____ 2. 2-spring physics model
____ 3. 3-year company financial model
____ 4. UAV road scanning system model
____ 5. Car gas mileage model
____ 6. Airframe mechanical part model
____ 7. Design verification model (automated test for two Item 6. designs)

a. Snowman
b. Mini Snowman
c. Snowflake
d. Mouse
e. Cactus
f. ?
g. Robot
g. Springy Snowflakes
Recent Models: ~Medium Complexity

2010-10
Model size = $O(100s)$ equations, $O(1000+)$ variables

- Supply chain metrics
- Mfg. sustainability: airframe wing
- Electronics recycling network

- "Galaxy with Black Hole"
- "Turtle" (mfg. sustainability: automotive transmissions)
- "Tumbleweed"

2010-12:
~20k variables
~15k equations

WIP:
100K, 1M, ...
Recent Models: ~Medium Complexity

F-86 Cast Wing Assembly [adapted from Bras, Romaniw, et al.] – p2/3
### F-86 Wing Section Test Case in SysML Parametrics

**Comparing Sustainability Metrics for Design Alternatives**

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#### Parameter Values and Changes

<table>
<thead>
<tr>
<th>Value</th>
<th>Description</th>
<th>Change Aluminum to Steel</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total Carbon Dioxide</td>
<td>Total CO2 For Life of Part (up to this stage)</td>
<td>-25.3 kg</td>
</tr>
<tr>
<td>Total Energy</td>
<td>Total Energy for Life of Part (up to this stage)</td>
<td>-105.4 MJ = -29.3 kWh</td>
</tr>
<tr>
<td>Invested Carbon Dioxide</td>
<td>CO2 in Harvesting/Refining Raw Materials</td>
<td>-25.3 kg</td>
</tr>
<tr>
<td>Operation Carbon Dioxide</td>
<td>Manufacturing/Fabrication CO2</td>
<td>+0.02 kg</td>
</tr>
<tr>
<td>Operation Energy</td>
<td>Manufacturing/Fabrication Energy</td>
<td>+502.2 kJ = +1.4 kWh</td>
</tr>
<tr>
<td>Final Mass</td>
<td>Final Part Mass</td>
<td>+3.4 kg</td>
</tr>
<tr>
<td>Waste Mass</td>
<td>Total Manufacturing Waste Mass</td>
<td>+0.1 kg</td>
</tr>
</tbody>
</table>

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*Source: Bras, Romaniw, et al. 10/2009 [www.sdm.gatech.edu]*

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**“Object-Oriented Multi-Dimensional Spreadsheet++”**
electronics recycling network materials recovery facility with 11 processes

“Pinwheel”

DNA signature auto-generated from SysML parametrics structure

Based on model by Culler, Bras, et al.

user-controlled model navigation (on/off, pan, zoom)
Snowflake Composition

Five composition levels: primitive equation to system-of-systems

Snowflake de Spring
alternative layout style (and scalability testing)