Undergrad Research Opportunities in ASDL MBSE Branch

MBSE = Model-Based Systems Engineering

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MBSE Branch

Advanced Methods Division

ASDL

Apr 2023

Follow instructions on slide #10 if you are interested

Georgia Tech | Aerospace Systems Design Laboratory

- Example projects & external collaborators:
  - Lockheed MBSE - CubeSat testbed
  - NASA MBSE Pathfinder initiative *(see Project 1 below)*
  - US Navy (NAVAIR) Model-Centric Engineering (MCE) – UAV testbed *(see Project 2 below)*
  - NASA JPL: model-based systems engineering (MBSE); model-based wikis; embedded s/w; …
  - Boeing: MBSE model complexity & health management
  - Other emerging projects and sponsors
  - Most of our projects (but not all) require US Persons (US citizens or permanent residents)
  - Multiple potential position types (depending on interests) – see next slide
- *Example results for students for MBSE/SysML-related jobs:*
  - Summer internships at Aerojet Rocketdyne, Boeing, GTRI, Harris Corp, various NASA centers (ARC, GRC, JPL, JSC, LARC), No Magic Inc, Orbital ATK, Sandia, ...
  - Full-time hires (after graduation) at Boeing, various NASA centers (JPL, LARC), Lockheed Space Systems, Sandia, US Navy contractors, ...

NOTE: Our normal policy is that (a) first-semester 1st-year students and (b) new last-semester seniors are *not* eligible for these positions.

IMPORTANT: *See also GPA requirement on slide #10.*

ASDL

SysML = The Systems Modeling Language
www.omgsysml.org

Normal Timeline

URA Semester1
- Learn SysML basics
- Apply in team project

URA Semester2 (and beyond)
- Increase SysML skills
- Apply in Sponsor projects

After URA Semester1
- Optional: Seek internships related to MBSE/SysML

URA = undergrad research assistant

- **Position Type1** desired skills (System Modeling Using SysML):
  - Strong interests in learning and applying SysML (see overview below)
  - A key requirement is an interest in SysML (no prior SysML experience required) and a willingness to learn and explore

- **Position Type2** desired skills (SysML & OOP Interfacing):
  - Strong interests in programming, especially object-oriented programming (OOP)
  - Experience with object-oriented languages (Java, python)
  - A key requirement is an interest in SysML (no prior SysML experience required) and a willingness to learn and explore

- **Position Type3** desired skills (Parametric CAD/CAE and Computing):
  - NOTE: We typically require that Type3 be combined with an interest in Type1 or Type2 per above.
  - Strong interests in parametric CAD/CAE and engineering computing in general
  - Experience with CAD parametric modeling, and/or CAE/analysis/simulation, etc.
  - Mostly we use the NX CAD tool by Siemens PLM Corp. Prior NX experience is helpful but not required (as long as you have a willingness to learn and explore). That said, at least some type of CAD experience is required (ideally including some parametric CAD experience, but not essential).

- **Position Type4** = combinations of two or more positions above

SysML Curriculum History & Formats

Statistics as of Dec 2022

Georgia Tech Academic Courses

- ◆ Undergrad & graduate courses
  - Fall 2007 originated by Profs. Leon McGinnis (IE) & Chris Paredis (ME)
  - Today ~24 courses across campus with MBSE/SysML content (~10 courses in AE) and ~790 course participants per year (academic degree students)
- ◆ Ex: Professional Masters in Applied Systems Engineering
  - *www.pmase.gatech.edu* (initiated 2009)
    - » Blended distance learning & in-person format; ~12 courses with MBSE/SysML
    - » Two-year program (~25-35 students per cohort)
  - ASE 6005: SysML-based MBSE course: each Spring/Summer
    - » Content = SysML 101/201, SysML 621 & 631, plus more homework etc.
  - ASE 6006: Systems Engineering Lab: each Fall
    - » SysML-based system design project: SMAD/FireSAT++ (satellite mission)
  - ASE 6xxx: [*many PMASE courses thereafter utilize SysML*]

Professional Masters in Applied Systems Engineering
ASE 6005 – Systems Modeling Using SysML
Lead Instructor: Russell.Peak @gatech.edu

Team Advanced Projects (TAPs)

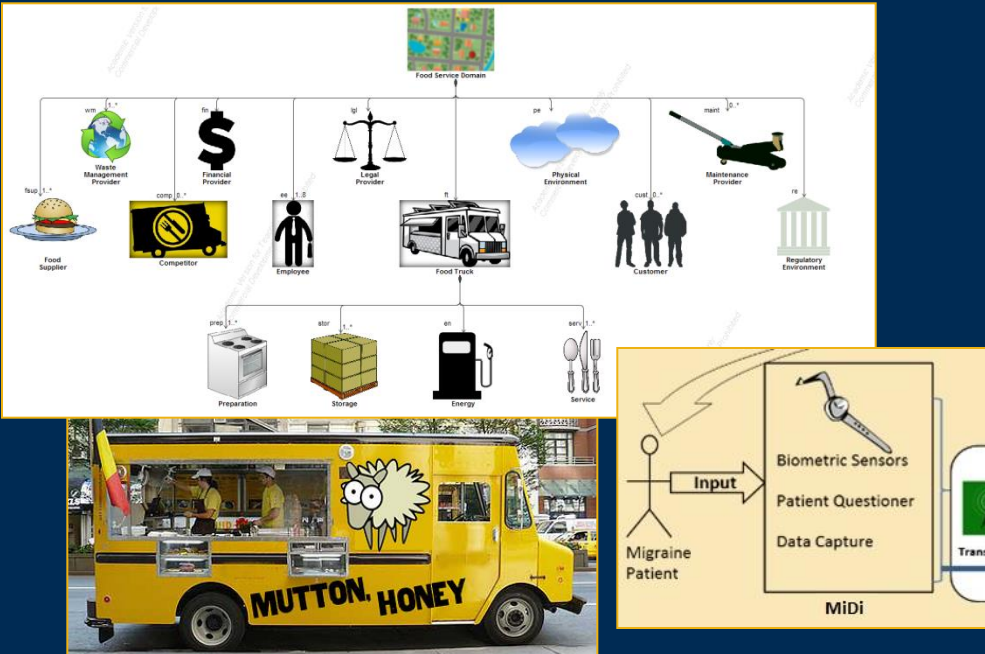| Team	Short Name	System-of-Interest (SOI) — May-Jun 2013
S1	GT60	GT60 Commercial Microturbine CHP (power generation equipment - gas turbine; CHP=combined heat power)
S2	SGS	Smart Grocery System Product Line 2013 (smart grocery system)
S3	SPlane	Solar Plane (small manned solar plane)
S4	DropX	DropX.1, Site-To-Store-To-You (unmanned aircraft system delivering site-to-store orders to customers)
S5	Hybrid Boat	Eco Power Boat Product Line 2013 (plug-in hybrid leisure boat)
S6	GMM	Green Mean Machine To Go (off-grid renewable energy system)

Team	Short Name	System-of-Interest (SOI) — Mar-Apr 2014
S1	Fit-Er	Fit-Er Product Line 2014 (wearable computing device: fitness tracking monitor)
S2	Jurassic Park	SmartGen's Jurassic Park (material & supplies logistics system - food/water/etc. for dinosaurs & humans)
S3	WFAP	Wildfire Firefighter Assistant and Protector (UAV-based monitoring & communications system)
S4	HEMS	Home Energy Management System (residential alternative energy mgt. system - monitoring & cost optimization)
S5	TacCOM	Tactical Cellular Communication Network (mobile battlefield communications system)
S6	E-Pedigree	Ollie's E-Pedigree System (pharmaceutical serialization, authentication, and tracking system)

SysML & MBSE/MBX Quick-Start Course (SMQS)

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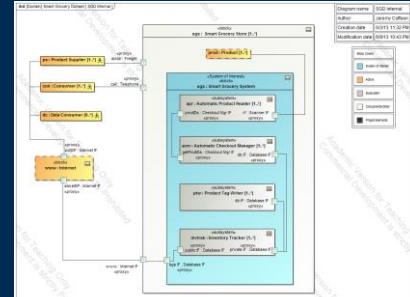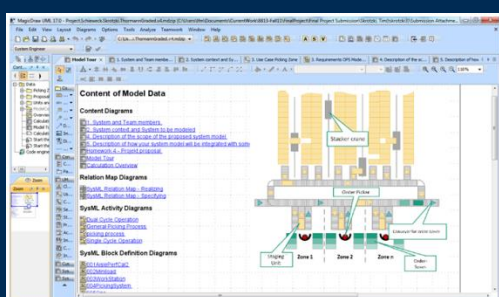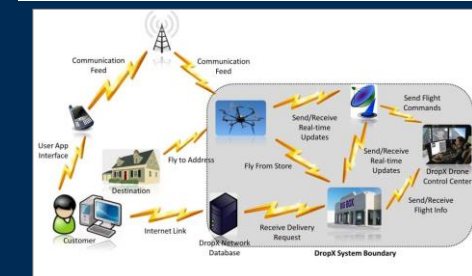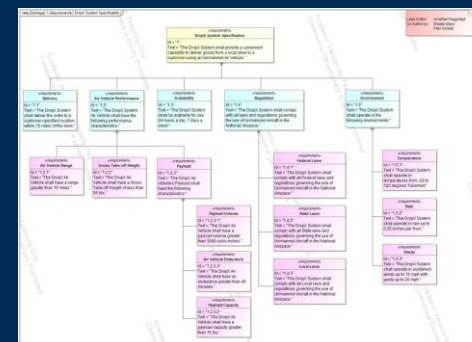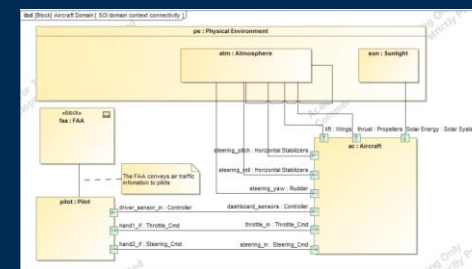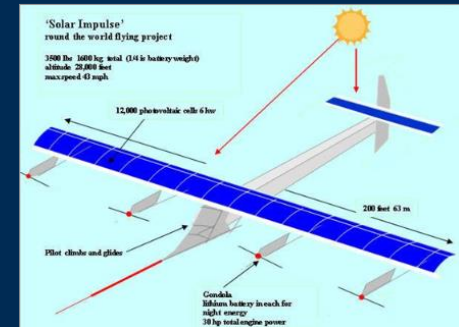
Position Type1: System Modeling w/ SysML
Creating SysML models for examples similar to below (pg 2/2)

| Team	Short Name	Project Title & System-of-Interest (SOI)
S1	NDV	Next-Gen Delivery Vehicle (hybrid commercial vehicle for the local home/business delivery industry – e.g., UPS)
S2	MiDi	Migraine Diary (wearable biometric device for migraine mgt.; interfaces with remote medical professionals)
S3	EATS	Evaluating Aspects of Traveling Sustenance (food truck industry – mobile food service operations and financial model)
S4	DeathStar	DeathStar: The Other 364 Days (space station materials & supplies logistics system - food/water/meds/etc.)
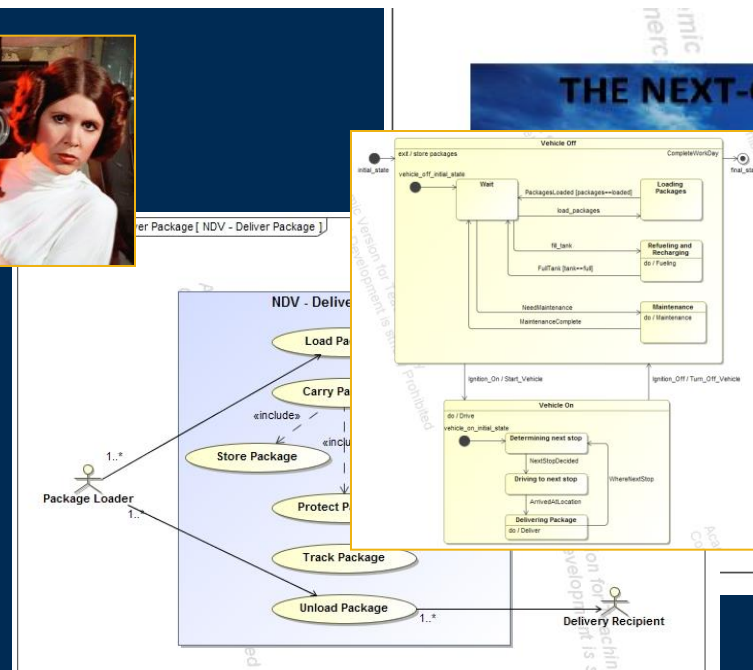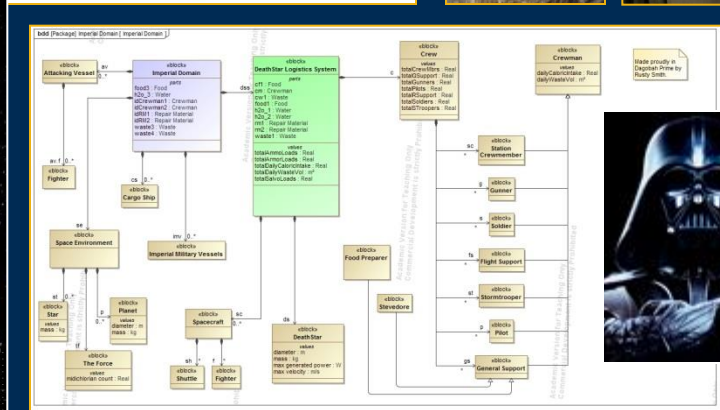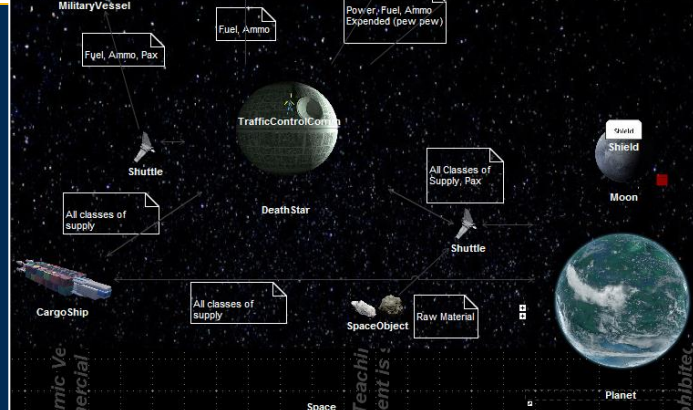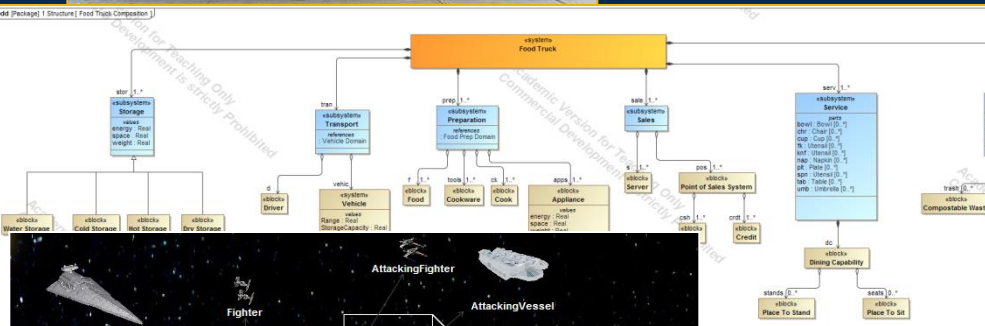
Position Type1/2: SysML & OOP Interfacing
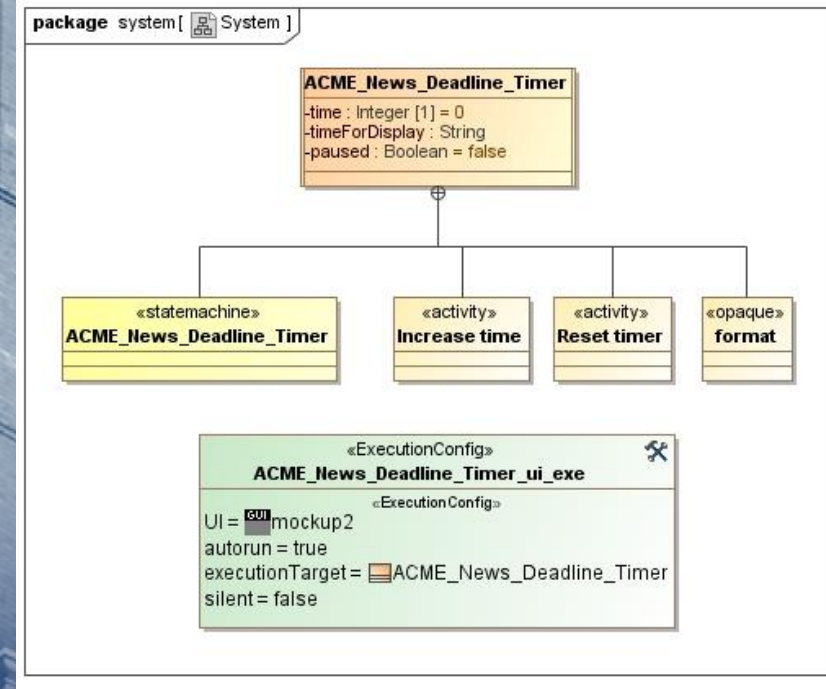## Primary Associated Project/Stakeholder: NASA JPL

Utilizing Cameo Simulation Toolkit
(state machines, executable activities, ...)

Interfacing with Simulations
(Unity, Ergo/Jack, STK, ...)

SysML = The Systems Modeling Language
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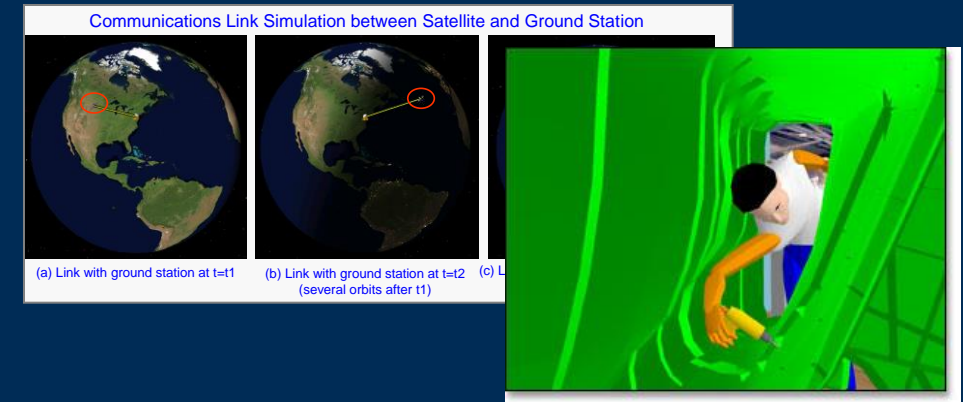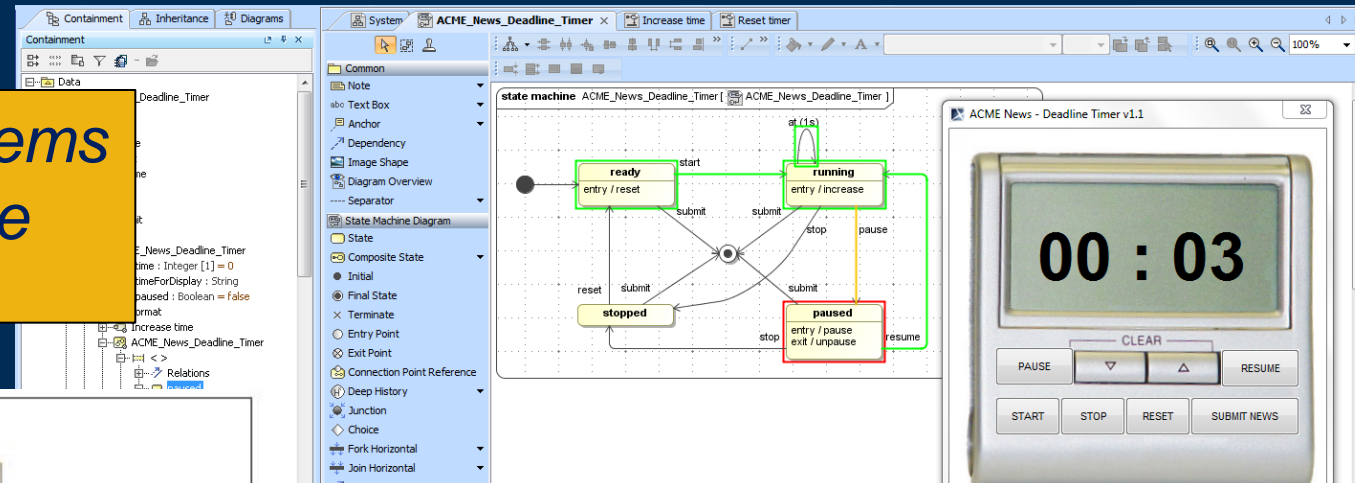
Interfacing with Physical Systems
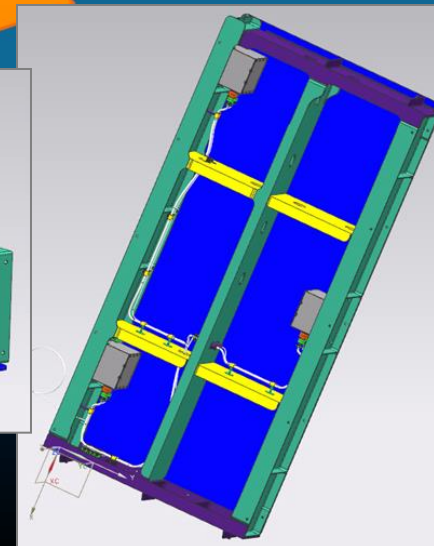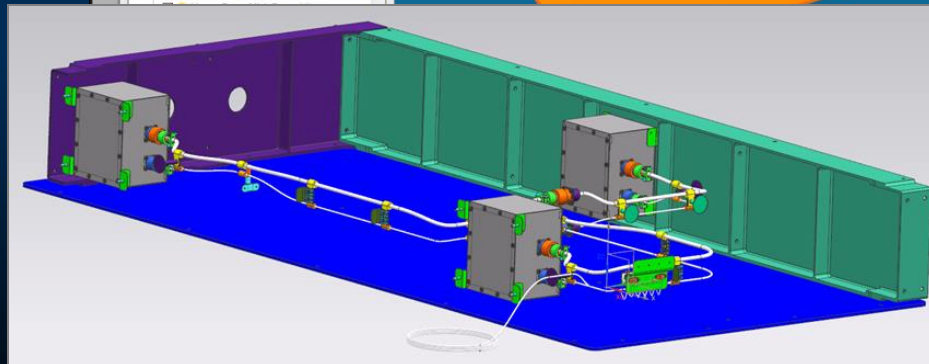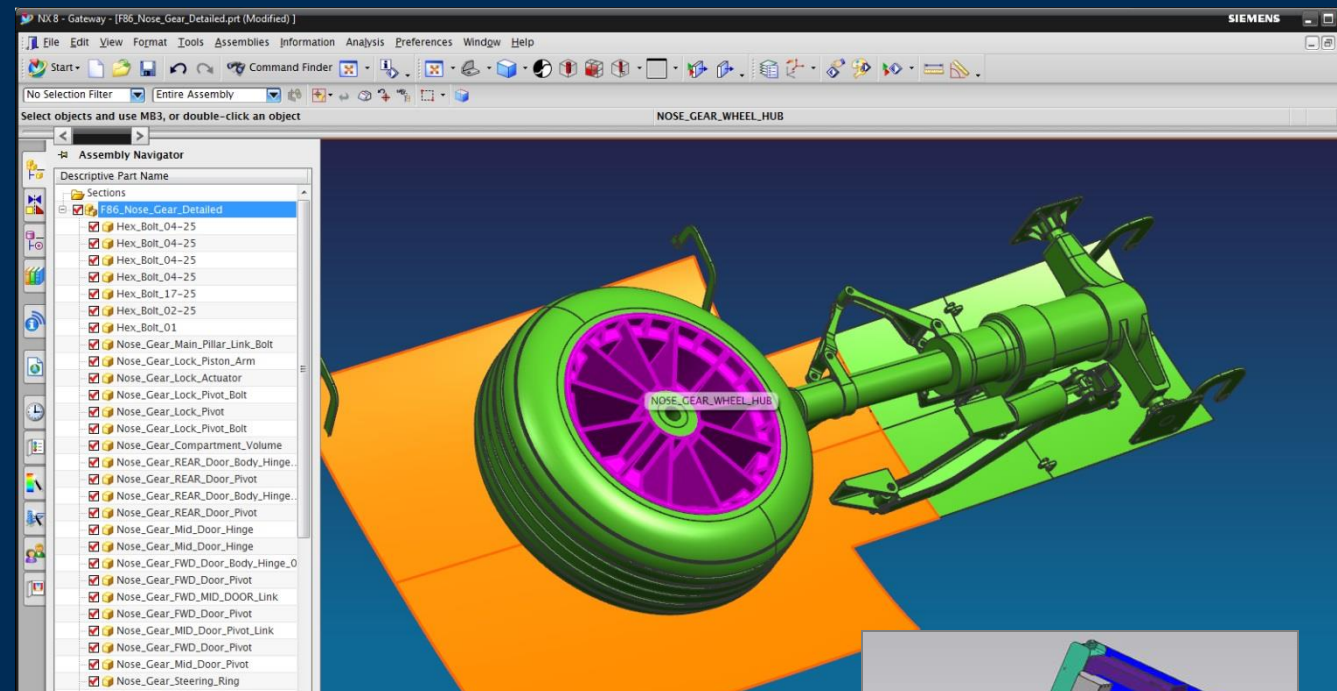
http://en.wikipedia.org/wiki/Raspberry_Pi

Position Type3: Parametric CAD/Simulation
Primary Associated Project/Stakeholder: Boeing

Creating New CAD Models, and
Parameterizing Existing Models (for Design/Analysis ...)

Building Models for CAE and SysML
(Matlab/Simulink, ModelCenter, Jack, FEA, …

NOTE: Type3 normally needs to be combined with interests in Positions Type1 or 2
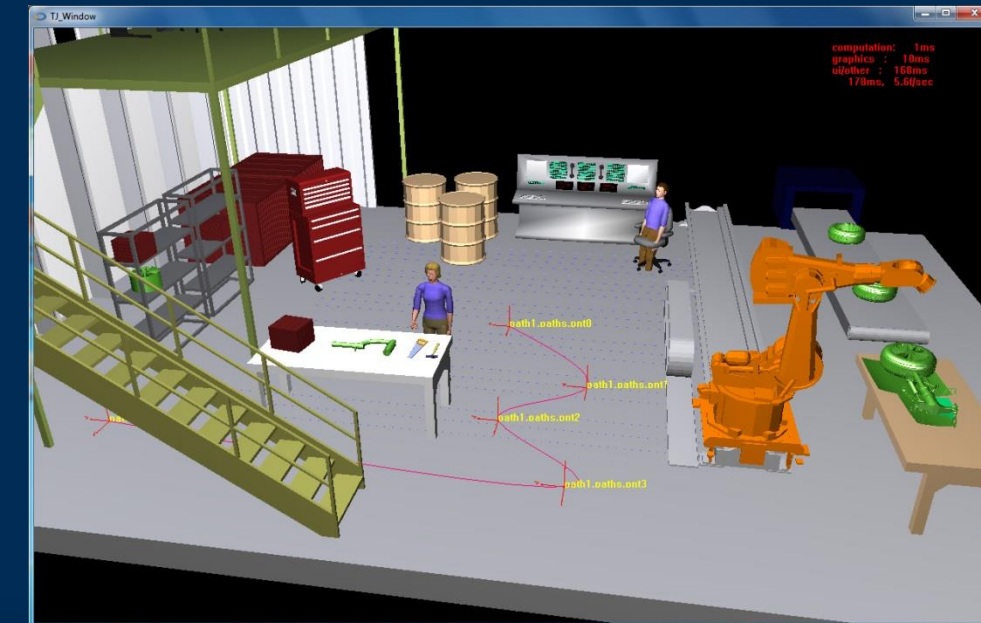
Jack (Environment for Ergonomics Simulation)

Ex. Project: NASA MBSE Pathfinder

Students worked on Team Nx with NASA engineers & fellow students (Nx = N1, N2, N3, N4 and N5)

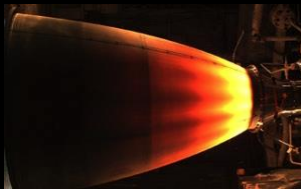### MBSE Pathfinder Focus Areas

Team N1:
Mars Colony ISRU

- Begin with the End, ISRU Colony
- LEO : Surface, 20 : 1 gear ratio
- Architecture/System/Campaign

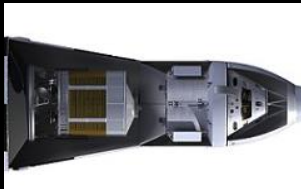*ISRU = in-situ resource utilization*

Team N2:
Space Habitat

- Integral Element, Space Habitat
- Generic Element Extensibility
- System/Sub-System

Team N3:
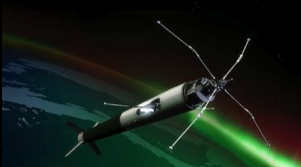*LOX/Methane Rocket Engine*

- Element/Sub-System, AM Engine
- In-Space, Lander, Ascent Applicability
- System/Design, Re-Tooling SE

Team N4:
Launch Vehicle Payload Attach Fitting & Mfg

- Mission Integration, SLS Payload Attach Fitting
- Extensible to numerous missions
- Functional and Physical Integration

Team N5:
Mission Lifecycle Sounding Rocket

- Mission Integration, Sounding Rocket
- Extensible to any LV
- Mission Design Life Cycle

MBSE Pathfinder Product/Work Activities

Team N1:
Mars Colony ISRU

- Lox and/or Methane Farm Development Trades
- Characterization of Components
- Concept of Operations

Team N2:
Space Habitat

- Space System Requirements Decomposition
- Systems level optimization trades

**Team N3:**
LOX/Methane Rocket Engine

- Engine Requirements to include Analysis (ROCETS) & Test V&V
- Configuration Management of Design (CAD)
- Flow from CAD to Additive Manufacture (CAM)
- Testing and Additive Manufacturing (LSM)

Team N4:
Launch Vehicle Payload Attach Fitting & Mfg

- PAF Requirements to include Analysis (CLA) & IDD Generation
- Configuration Management of Design (CAD)
- Flow from CAD to Composite Manufacture (CAM)
- Testing and Composite Manufacture

Team N5:
Mission Lifecycle Sounding Rocket
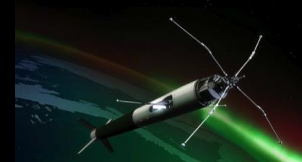
- Addition of discipline analysis to existing MBSE mission models
- Includes both programmatic and technical (DoD partnering)
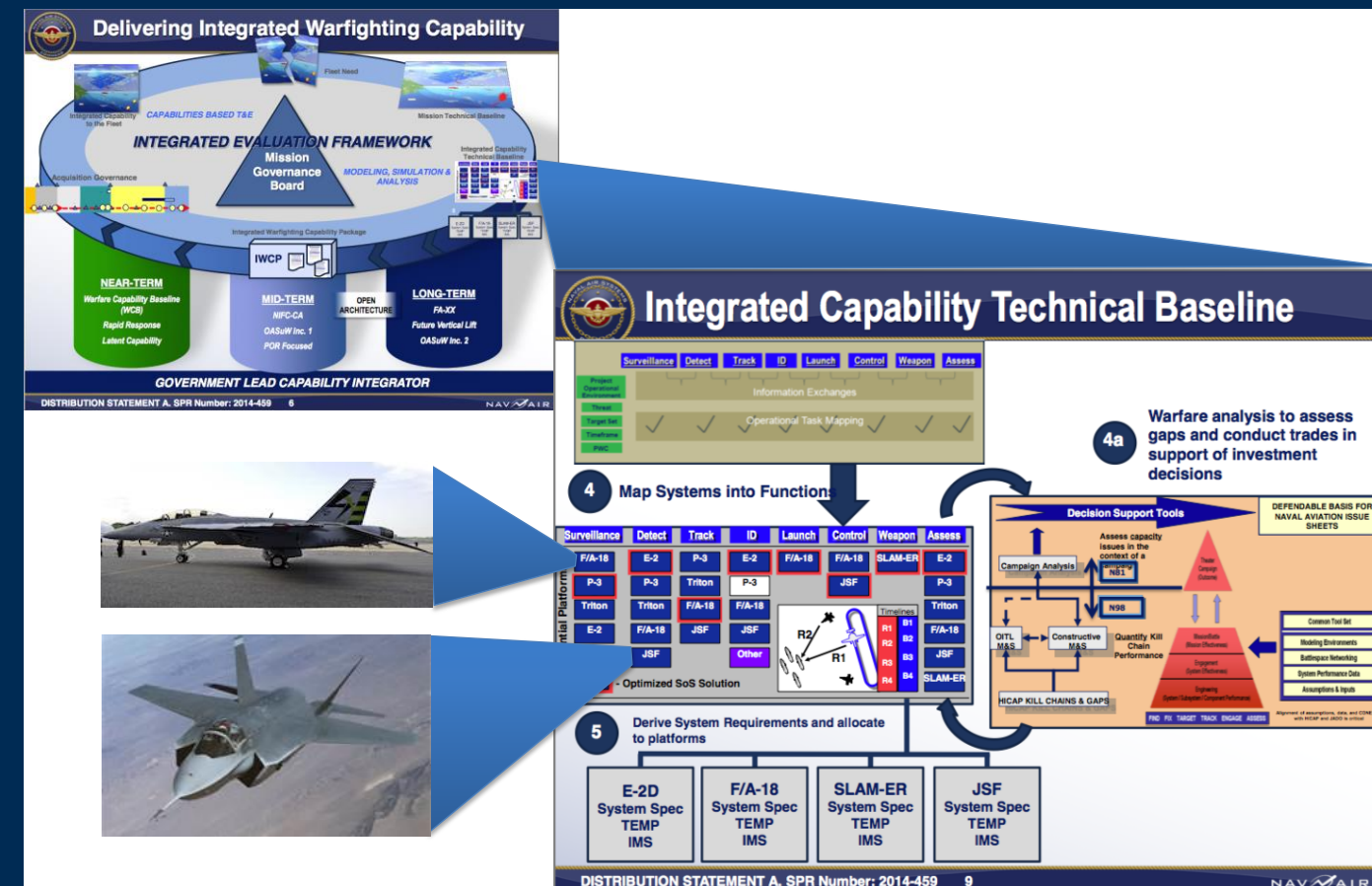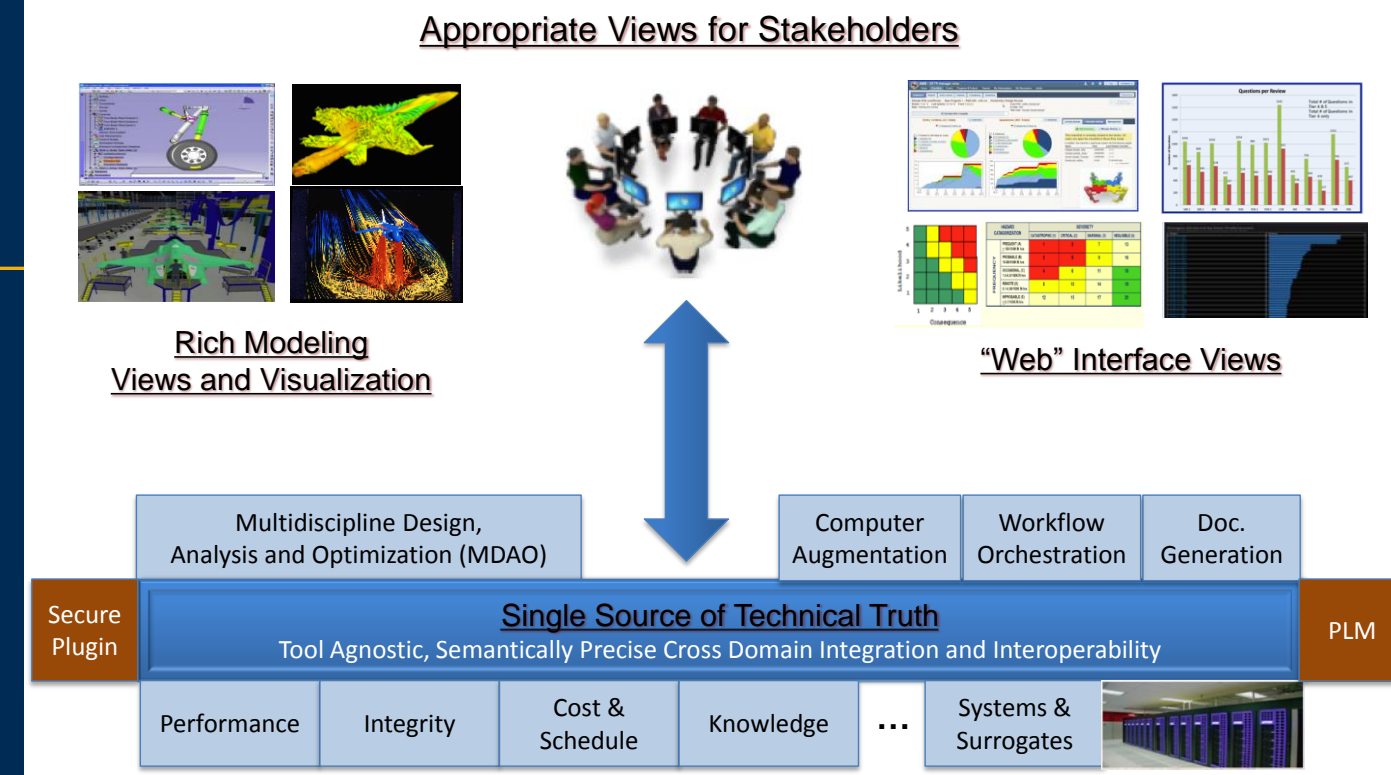- 20+ Flights per year for shadowing and validation

Ex. Project: NAVAIR MCE / UAV Testbed

- *Overall objective:*
  Develop and demonstrate next-gen MCE capabilities
  (MCE = model-centric engineering)

- *Sponsor:*
  NAVAIR (Pax River, Maryland) – US Navy

- *Collaborators:*
  SERC (DoD-sponsored systems engineering research
  consortium = ~20 universities), specifically
  Stevens Institute of Technology and U. of Maryland

- *Approach:*
  Extend/apply model-based techniques
  (ala ASDL JPL E2E project, etc.)

- *Testbed:*
  UAV design and advanced trade studies

Appropriate Views for Stakeholders

Rich Modeling Views and Visualization

"Web" Interface Views

If you are interested … do this asap:

Follow these instructions carefully (as attention to detail is important for all positions):

- Sending from your gatech email address, email your resume'
  to *cimtalay@gatech.edu* using

  - Email Subject: ASDL MBSE URA interest - *last name, first name*
  - Include citizenship info & GPA (see Note 2 below)
  - Include expected graduation date & level (1st year, 2nd year, etc.)
  - Indicate which position type(s) you are interested in
    (including priority, if you have multiple interests):
    - *Position Types 1, 2, 3, 4 (per above slides)*

- After that, we will contact the best-fit candidates:
  - *Determine if this is a good mutual fit*
  - *Finalize setup before the class registration deadline*

URA = undergrad research assistant

- Note1: Our normal policy is that (a) first-semester 1st-year students and (b) new last-semester seniors are *not* eligible for these positions. And we give priority to students interested in a multi-semester URA position.
- Note2: Our normal policy is we prioritize for a GPA of at least 3.5 (and absolute minimum GPA = 3.2). Normally we have so many applications that the cut-off GPA is 3.5 or above.
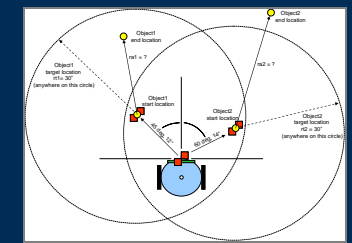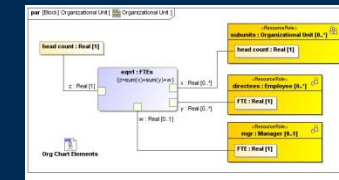
MBSE Branch Overview

Russell S. Peak, PhD

Russell.Peak@gatech.edu

Georgia Tech | Aerospace Systems Design Laboratory

MBSE Branch Overview

Branch Chief: Russell.Peak@gatech.edu

MBSE: Model-Based Systems Engineering

SysML: The Systems Modeling Language

- SysML – graphical language for system structure, behavior, requirements, ...
- Unified, complete, consistent, verifiable
- Enables MBSE vs. "doc/ppt-engineering"
- Rapidly growing usage in diverse fields

Academic & Professional Education

- Academic & professional masters courses
- MBSE/SysML short course series
- Delivered over 187+ hands-on courses for 3320+ professionals to date
- Public offerings & onsite contract courses
- Ex. Industry, NASA (*ARC, GRC, JSC, JPL ...*) DoD (*ARDEC, DISA, MDA, NSWC ...*), Sandia

1. Structure
2. Behavior
3. Requirements
4. Parametrics
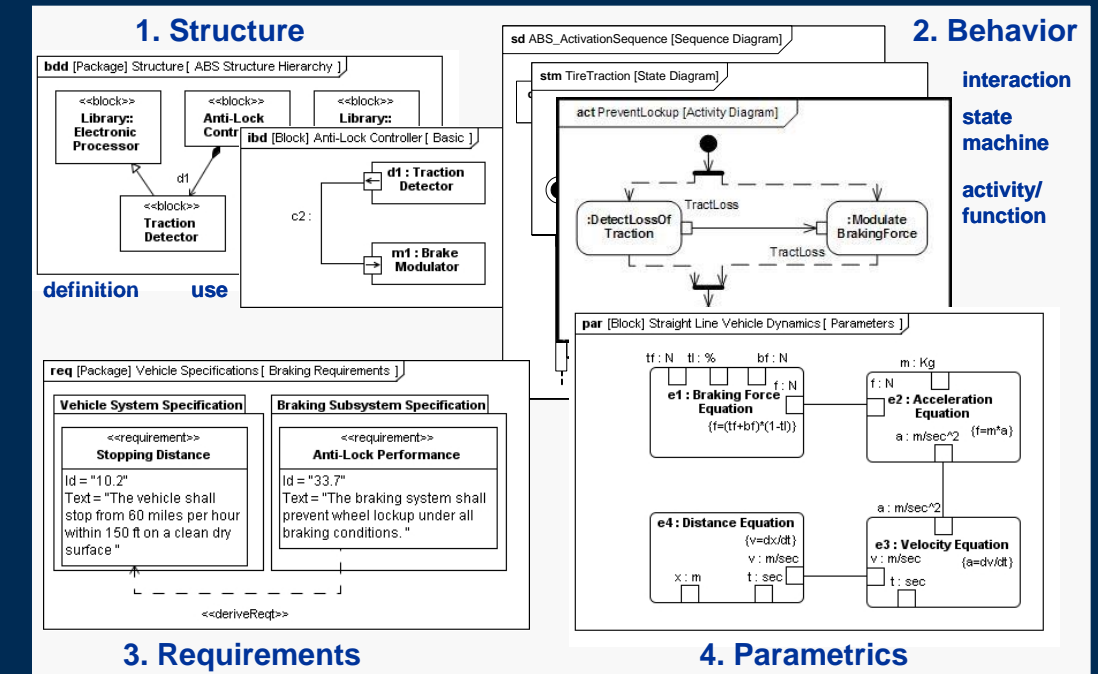
MBSE/SysML Research

- Next-gen spreadsheets++
- Traceability graphs / impact analysis
- DoDAF/UPDM interfaces
- V&V patterns and automation
- Simulation interoperability
- Execution & interfacing with things
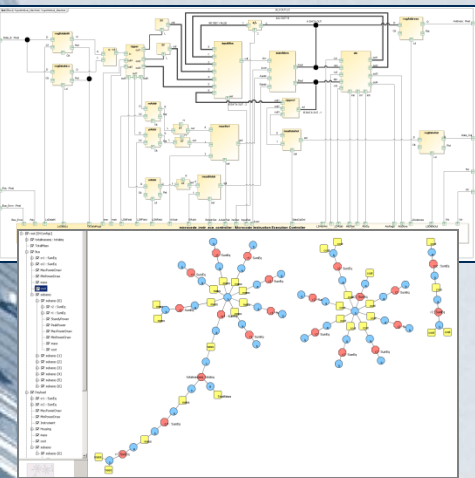
Are Spreadsheets Sabotaging Your Profits?

Summary
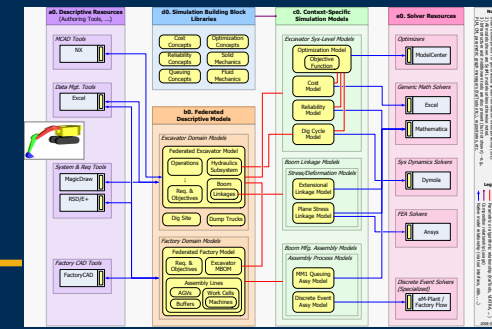
- MBSE & SysML are critical and growing trends
  – Quantified benefits: cost estimates, error reductions, ...
  – Broad usage across many industries & applications
  – Defining the present and the future
- Guiding your organization's destiny
  – Kick start & enhance your MBSE effort
  – Develop MBSE/SysML adoption roadmap
  – Define & manage your tool ecosystem
  – Provide short courses for your organization
  – Engage consulting & project support
  – Foster research & advanced studies

Representing System Models
With SysML: Unified, Connected, Consistent, Explicit