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
Example Projects

- 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.*
Undergrad Research Opportunities (p2/2)

Position Types & Timeline

- **Position Type 1** 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 Type 2** 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 Type 3** desired skills (Parametric CAD/CAE and Computing):
  - NOTE: We typically require that Type 3 be combined with an interest in Type 1 or Type 2 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 Type 4** = combinations of two or more positions above

Normal Timeline

URA Semester 1
- Learn SysML basics
- Apply in team project

URA Semester 2 (and beyond)
- Increase SysML skills
- Apply in Sponsor projects

After URA Semester 1
- Optional: Seek internships related to MBSE/SysML

URA = undergrad research assistant

SysML = The Systems Modeling Language
www.omgsysml.org
Position Type1: System Modeling w/ SysML
Creating SysML models for examples similar to below (pg 1/2)

SysML Curriculum History & Formats

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]

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

<table>
<thead>
<tr>
<th>Team</th>
<th>Short Name</th>
<th>System-of-Interest (SOI)</th>
<th>Mar-Apr 2014</th>
</tr>
</thead>
<tbody>
<tr>
<td>S1</td>
<td>Fit-Er</td>
<td>Fit-Er Product Line 2014 (wearable computing device: fitness tracking monitor)</td>
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<tr>
<td>S2</td>
<td>Jurassic Park</td>
<td>SmartGen’s Jurassic Park (material &amp; supplies logistics system - food/water/etc. for dinosaurs &amp; humans)</td>
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<tr>
<td>S3</td>
<td>WFAP</td>
<td>Wildfire Firefighter Assistant and Protector (UAV-based monitoring &amp; communications system)</td>
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<tr>
<td>S4</td>
<td>HEMS</td>
<td>Home Energy Management System (residential alternative energy mgmt. system - monitoring &amp; cost optimization)</td>
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<tr>
<td>S5</td>
<td>TacCOM</td>
<td>Tactical Cellular Communication Network (mobile battlefield communications system)</td>
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</tr>
<tr>
<td>S6</td>
<td>E-Pedigree</td>
<td>Ollie’s E-Pedigree System (pharmaceutical serialisation, authentication, and tracking system)</td>
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</tbody>
</table>
Position Type 1: System Modeling w/ SysML
Creating SysML models for examples similar to below (pg 2/2)

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

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

Interfacing with Physical Systems

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)

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

SysML = The Systems Modeling Language
www.omgsysml.org

Position Type3: Parametric CAD/Simulation

Primary Associated Project/Stakeholder: Boeing

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

NOTE: Type3 normally needs to be combined with interests in Positions Type1 or 2

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

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**
- **Team N2: Space Habitat**
- **Team N3: LOX/Methane Rocket Engine**
- **Team N4: Launch Vehicle Payload Attach Fitting & Mfg**
- **Team N5: Mission Lifecycle Sounding Rocket**

**MBSE Pathfinder Product/Work Activities**

- **Team N1: Mars Colony ISRU**
- **Team N2: Space Habitat**
- **Team N3: LOX/Methane Rocket Engine**
- **Team N4: Launch Vehicle Payload Attach Fitting & Mfg**
- **Team N5: Mission Lifecycle Sounding Rocket**

**MBSE Pathfinder Focus Areas**

- Begin with the End, ISRU Colony
- ISRU = in-situ resource utilization
- LEO : Surface, 20 : 1 gear ratio
- Architecture/System/Campaign
- Integral Element, Space Habitat
- Generic Element Extensibility
- System/Sub-System
- Element/Sub-System, AM Engine
- In-Space, Lander, Ascent Applicability
- System/Design, Re-Tooling SE
- Mission Integration, SLS Payload Attach Fitting
- Extensible to numerous missions
- Functional and Physical Integration
- Mission Integration, Sounding Rocket
- Extensible to any LV
- Mission Design Life Cycle
- Lox and/or Methane Farm Development Trades
- Characterization of Components
- Concept of Operations
- Space System Requirements Decomposition
- Systems level optimization trades
- 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)
- PAF Requirements to include Analysis (CLA) & IDD Generation
- Configuration Management of Design (CAD)
- Flow from CAD to Composite Manufacture (CAM)
- Testing and Composite Manufacture
- Addition of discipline analysis to existing MBSE mission models
- Includes both programmatic and technical (DoD partnering)
- 20+ Flights per year for shadowing and validation
**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
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

- 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
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

MBSE/SysML Research

• Next-gen spreadsheets++
• Traceability graphs / impact analysis
• DoDAF/UPDM interfaces
• V&V patterns and automation
• Simulation interoperability
• Execution & interfacing with things
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