Undergrad Research Opportunities in ASDL MBSE Branch

MBSE = Model-Based Systems Engineering

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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

- 2013-2019 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 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 Type 4** = combinations of two or more positions above

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SysML = The Systems Modeling Language
www.omgsysml.org

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
Commercial Microturbine CHP

Georgia Tech professional masters degree courses
000.01
ISYE / ME 8813 & 4803: Since Fall 2007
Primary instructors: Profs. Leon McGinnis and Chris Paredis

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em)
monitoring & cost optimization

Traditional grad/undergrad courses (full-semester)
– ISYE / ME 8813 & 4803: Since Fall 2007 (~40-60 students per year)
– Primary instructors: Profs. Leon McGinnis and Chris Paredis

Georgia Tech professional masters degree courses
– Professional Masters in Applied Systems Engineering
  www.pmase.gatech.edu (initiated 2009)
  » Blended distance learning and face-to-face format
  » Two-year program (~30 students per cohort)
– ASE 6005: SysML-based MBSE course: each Spring (Peak, et al.)
  » Content = SysML 101/201 & 891/892, plus more homework etc.
– ASE 6006: Systems Engineering Lab: each Fall
  » SysML-based system design project:
    SMAD/FireSAT++/EyasSAT (satellite mission)
– ASE 6xxx: [most PMASE courses thereafter utilize SysML]
Position Type1: 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>
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<tr>
<td></td>
<td></td>
<td>(wearable biometric device for migraine mgt.; interfaces with remote medical professionals)</td>
</tr>
<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>
</tr>
</tbody>
</table>
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, ...)

Interfacing with Physical Systems

Communications Link Simulation between Satellite and Ground Station
(a) Link with ground station at $t=t_1$
(b) Link with ground station at $t=t_2$
(several orbits after $t_1$)
(c) Link broken with ground station at $t=t_3$
(~10 minutes after $t_2$)

SysML = The Systems Modeling Language
www.omg.sysml.org

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=1, 2, 3, 4 or 5)

**MBSE Pathfinder Focus Areas**

- **Team N1: Mars Colony ISRU**
  - Begin with the End, ISRU Colony
  - LEO : Surface, 20 : 1 gear ratio
  - Architecture/System/Campaign

- **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
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 Russell.Peak@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

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2015-04a
MBSE Branch Overview
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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