Model-Based Design Reviews with Innoslate

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MAE CubeSat Project…
…to UCF Program?

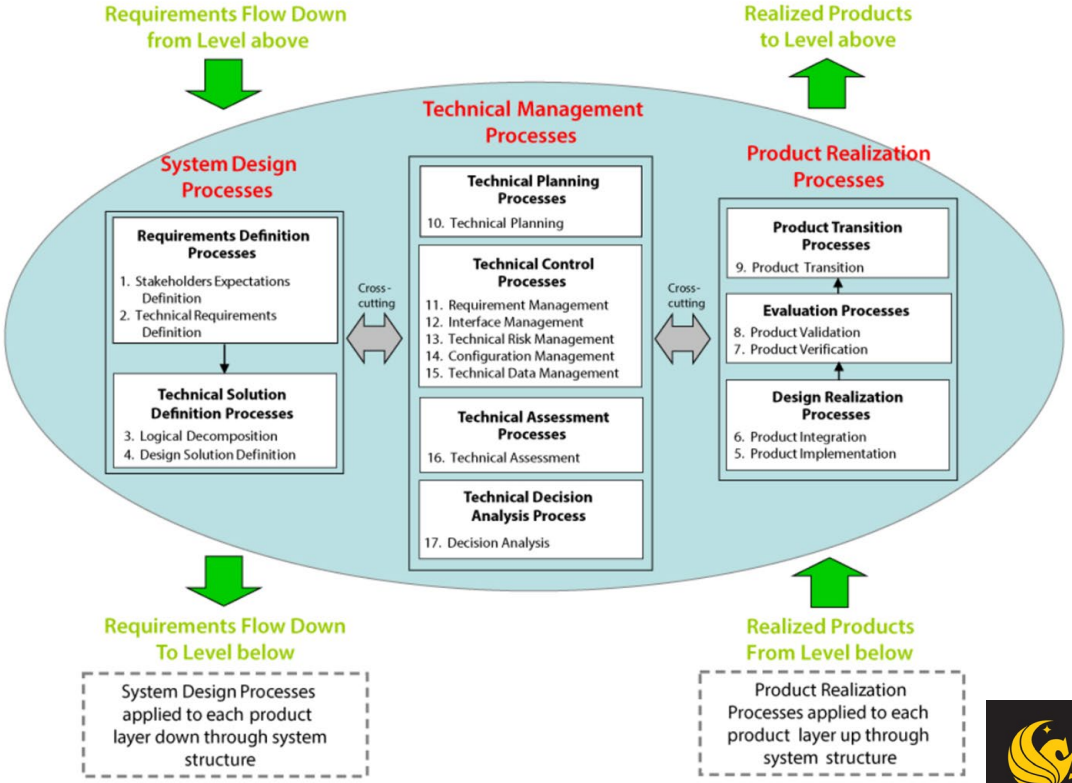
- Mechanical and Aerospace Engineering students
  - Beginning to involve Electrical and Computer Engineering students
- Designing and building in the context of two-semester Senior Design
  - Mission: To grow plants in the more hostile environment of lunar orbit
  - Currently, two integrated bus and payload teams
  - Each student is responsible for a particular subsystem, e.g., CDH, EPS, etc.
  - Challenges with ABET requirements and only two semesters to design and build
  - Offset with the Collegiate Space Foundation (student onramp and Senior Design support)
- Plan is to develop a CubeSat program
  - *Small Satellite Program Guide* (Qedar, Alonzoperez, & Larson)

Systems Engineering

- Each academic year, new students are taught Systems Engineering with material compiled from the following sources:
  - *NASA Systems Engineering Handbook* (NASA SP-2016-6105 Rev2)
  - *Applied Space Systems Engineering* (Larson, Kirkpatrick, Sellers, Thomas, & Verma)
  - *Real MBSE* (Dam)
- …and supplemental material (especially exercises) for subsystems (e.g., link margin) from:
  - *Understanding Space* (Sellers)

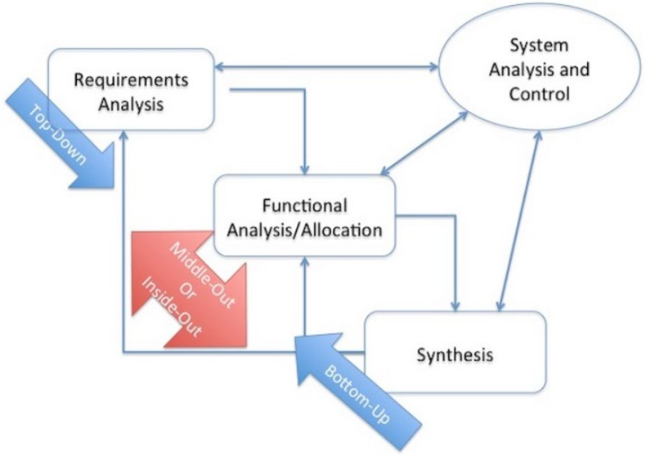
Systems Engineering

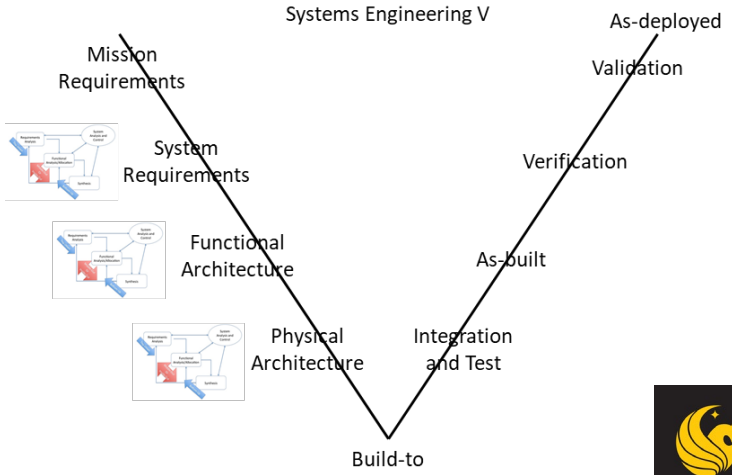
- The 17 SE processes are taught no matter where they are in the “V”
- This is part of adhering to ABET requirements
- Not all the processes are rigorously followed for our relatively small project, but students are taught them in case they work on a JWST



Systems Engineering

- Because there are new students every academic year, the agile (*Real MBSE*) approach is amenable to our overall process
- New students iterate on each portion of the systems engineering “V”
- Advantages
  - Build-a-little, test-a-little
  - Stakeholder engagement and user feedback
  - Fail fast, fail often
  - Lessons learned (from prior teams)





Three-Year Status of the Project

- Year one – Mostly a pathfinding effort (and learning for me too)
  - *Stakeholder Expectation Definition* and *Technical Requirements Definition* processes; MCR and an initial SRR
- Year two – Iteration/refinement of processes
  - Introduction of *Innoslate* to enable *Real MBSE*
    - Configuration Control: Requirements, ConOps, other artifacts (System Design Study Report)
  - *Logical Decomposition* and *Design Solution Definition;* SRR, SDR, and an initial PDR
- Year three – Iteration/refinement of processes
  - Began with a PDR using *Innoslate* for a model-based review
  - Current students tasked with Functional Analysis (derivation of the functional behavior and creation of an action diagram in *Innoslate*)
  - *Product Implementation* and *Product Integration* resulting in an initial CDR?

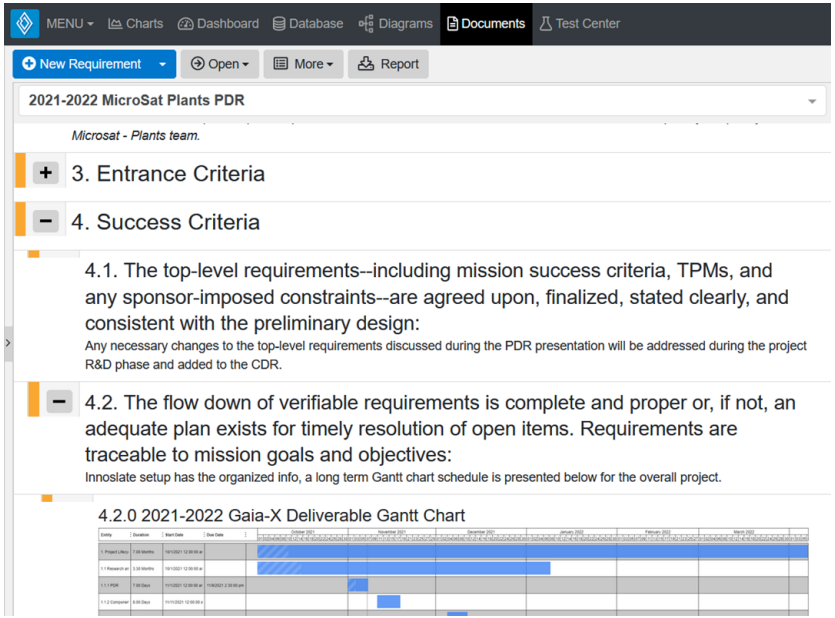
Model-Based Reviews

- PDR entrance/success criteria
- Prior to the review, students checked-off entrance criteria and after the review, students performed the work required to check-off the exit criteria
- NASA Systems Engineering NPR-71323.1B.pdf, e.g., Table G-6 – PDR Entrance and Success Criteria

Preliminary Design Review	
Entrance Criteria	**Success Criteria**
1. The Project has successfully completed the previous planned milestone reviews, and responses have been made to all RFAs and RIDs, or a timely closure plan exists for those remaining open. 2. A preliminary PDR agenda, success criteria, and instructions to the review board have been agreed to by the technical team, project manager, and review chair prior to the PDR. 3. All planned lower level PDRs and peer reviews have been successfully conducted and RID/RFA/Action Items have been addressed with the concurrence of the originators. 4. Programmatic products are ready for review at the maturity levels stated in the governing program/project management NPR. 5. The following primary products are ready for review: a. **A preliminary design that can be shown to meet requirements and key technical performance measures. b. Updated trending information on the mass margins (for projects involving hardware), power margins (for projects that are powered), and closure of review actions (RFA, RID, and/or Action Items). 6. Other PDR technical products (as applicable) for hardware, software, and human system elements have been made available to the cognizant participants prior to the review: a. Subsystem design specifications (hardware and software), with supporting trade-off analyses and data, as required, that are ready to be baselined after review comments are incorporated. b. *Updated technology readiness assessment. c. *Updated Technology Development Plan. d. *Updated risk assessment and mitigation. e. *Life-Cycle Cost and Integrated Master Schedule (IMS) that are ready to be baselined after review comments are incorporated. When required, the Joint Confidence Level (JCL) analysis. f. *Baseline ILSP.	1. The top-level requirements—including mission success criteria, TPMs, and any sponsor-imposed constraints—are agreed upon, finalized, stated clearly, and consistent with the preliminary design. 2. The flow down of verifiable requirements is complete and proper or, if not, an adequate plan exists for timely resolution of open items. Requirements are traceable to mission goals and objectives. 3. The program cost, schedule, and JCL analysis (when required) are credible and within program constraints and ready for NASA commitment. 4. The preliminary design is expected to meet the requirements at an acceptable level of risk. 5. Definition of the technical interfaces (both external entities and between internal elements) is consistent with the overall technical maturity and provides an acceptable level of risk. 6. Any required new technology has been developed to an adequate state of readiness, or backup options exist and are supported to make them viable alternatives. 7. The project risks are understood and have been credibly assessed, and plans, a process, and resources exist to effectively manage them. 8. Safety and mission assurance (e.g., safety, reliability, maintainability, quality, and Electrical, Electronic, and Electromechanical (EEE) parts) have been adequately addressed in preliminary designs and any applicable S&MA products (e.g., PRA, system safety analysis, and failure modes and effects analysis) meet requirements, are at the appropriate maturity level for this phase of the program's life cycle, and indicate that the program safety/reliability residual risks will be at an acceptable level. 9. Adequate technical and programmatic margins (e.g., mass, power, memory) and resources exist to complete the development within budget, schedule, and known risks. 10. The operational concept is technically sound, includes (where appropriate) human systems, and includes the flow down of requirements for its

Model-Based Reviews

- The entrance and success criteria were captured from the NASA/NPR documented which served as the agenda for the review
- If questions required more support, the SRD is in Innoslate
- Full support for this review approach from our NASA KSC PI



Student Benefits

- Diversity
  - UCF/IE is heavily focused on SysML, *Innoslate* exposes the students to an alternative approach based on LML*
- Interaction with subject matter experts
  - Principal investigators associated with the payload scientific (bio) experiment
  - Professional system engineers involved with the successful launch and deployment of spacecraft
- New graduates entering workforce with…
  - Space systems engineering and project management experience
  - Knowledge of state-of-the-art “agile” processes (Real MBSE)
  - Hands-on experience with enabling platforms (Innoslate, STK, etc.)
  - Formal written & oral communication skills and team-building

*Benefit to SPEC Innovations – Students take this knowledge into the workplace (the MATLAB marketing model)

Acknowledgements

- SPEC Innovations for their Innoslate support
- Dr. Jerry Sellers and Dr. Steven Dam for their personal support
- Dr. Jose Nunez (NASA KSC) who has supported us since we began

Questions?

UCF