National Aeronautics and Space Administration

Adopting Digital Representations for Use in Systems Engineering

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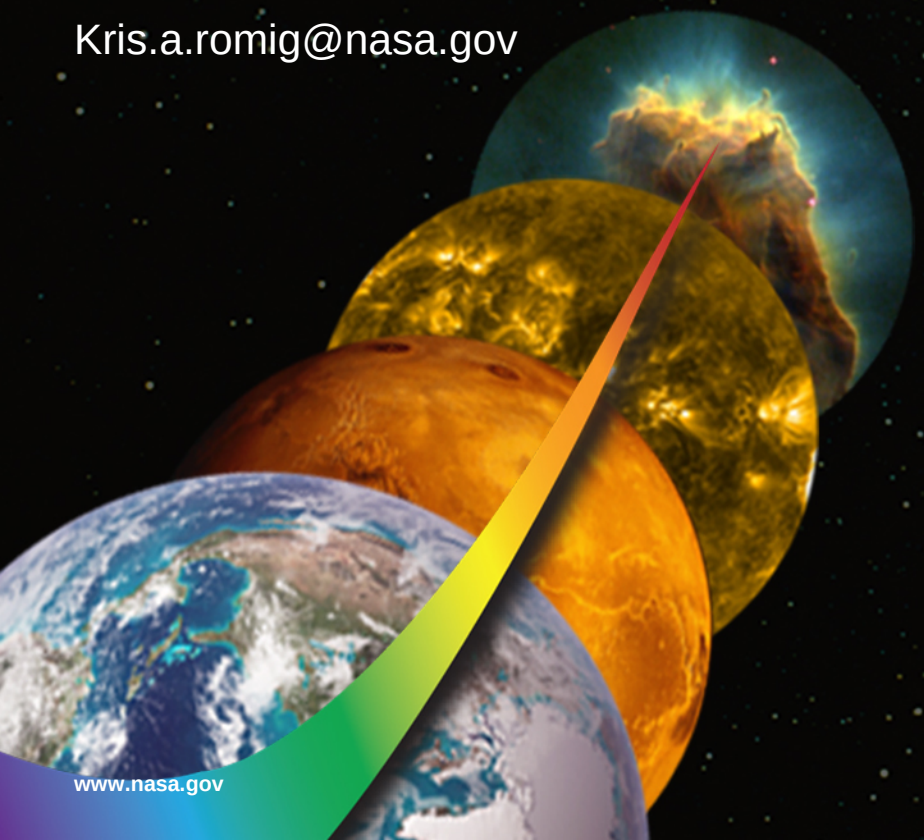

Goddard Space Flight Center
Instrument & Payload
Systems Engineering Branch

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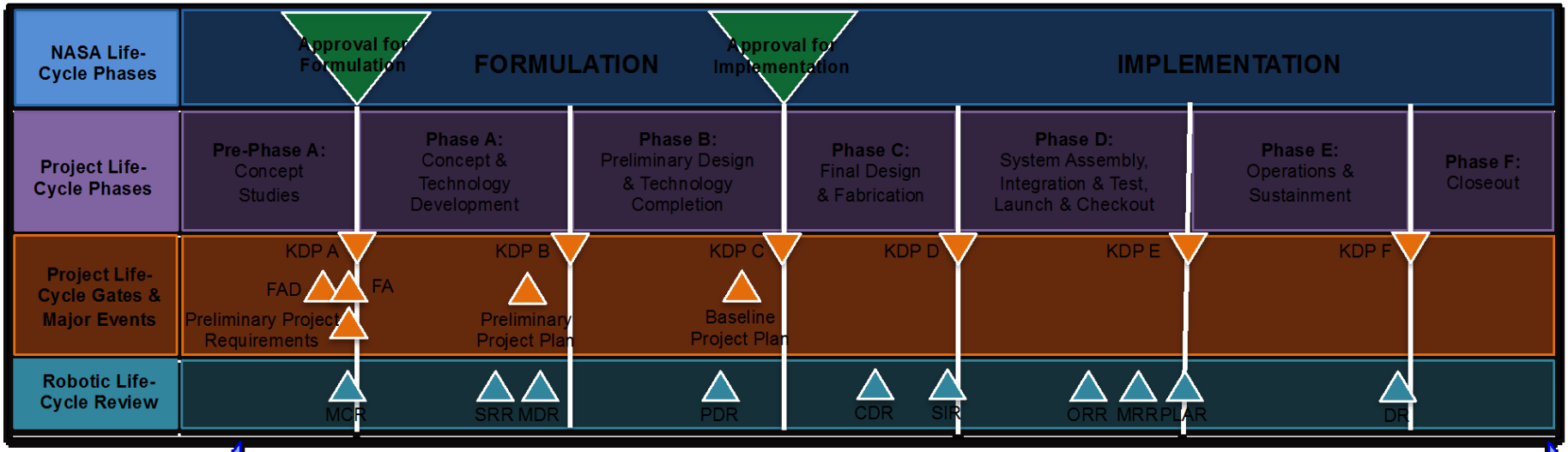
Systems Engineering at GSFC

- Two SE organizations
  - Missions Systems Engineering
  - Instrument & Payload Systems Engineering
- Follow Agency level procedural requirements (NPR 7123.1B)
- Follow GSFC level procedural requirements (GSFC 7123.1B, GSFC STD 7000A and, GSFC STD 1000F, etc)
- Both organizations perform SE functions cradle to grave (in-house developments and out of house acquisitions)
- GSFC SE's typically provide 3 main functions:
  - Follow the required processes and produce SE artifacts ie, requirements development and decomposition, V&V of those requirements, con ops, SEMPs, etc
  - Technical managers
  - Chief Engineers

What We Do



Instrument and Payload Systems Engineers

1) Aircraft, Sub-orbital, and Space Missions, Studies, Proposals, IRADs; 2) Instrument Design Lab; 3) Advanced Concepts; 4) Technology Developments

Specialized Engineers

1) Orbital Debris Analysis; 2) End of Mission Planning; 3) On-Orbit Anomaly Analysis and Resolution; 4) Integrated Modelers

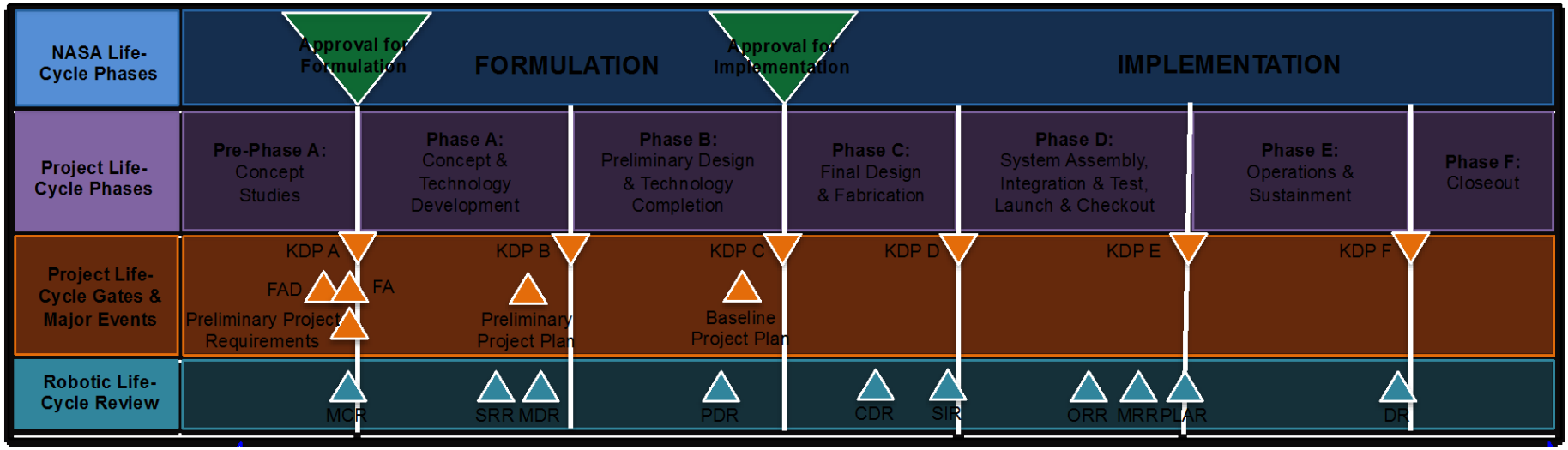
SE Tools, Capabilities, Standards, & Procedures

1) Model-centric Engineering; 2) Integrated Modeling; 3) Concurrent Engineering Tools; 4) Model Based Systems Engineering; 5) Systems Engineering NPR/GPR, MBSE Standard, etc.

Technical Training & Development Programs

Systems Engineering Education Development (SEED), Product Development Lead (PDL) Training Program, Systems Engineering Leadership Development Program (SELDP), Technical Managers Training (TMT), Science and Engineering Collaboration Program (SECP)

Application of Model Centrism to SE Process



Develop CONOPS

Technical Trade Studies

Interface Control Documents

Verification & Validation Plans

V&V traceability matrices

On-orbit checkout and commissioning

Lessons learned

GSFC's Goals for Implementation

- Investigate and assess the applicability and process for deploying model centric tools and methodologies to GSFC instrument and spacecraft development.
- Generate real world data within GSFC business model for answering tough but fair questions regarding the value of these methods
  - How much will it cost?
  - How much will it save in cost and schedule?
  - How does it help program/project risk posture?
- Create informed process and guidelines for model centric approaches to traditional GSFC programs/projects.
- Ensure a trained and capable workforce for implementation

Challenges

- Adoption and implementation of model centrism isn't anyone's full time job
  - Part time, grass roots, disconnected efforts
  - Inconsistent engagement within GSFC and the wider community
- Workforce
  - Because GSFC SEs must function as technical managers and Chief Engineers only seasoned employees are targeted for open SE positions
  - Very few internships or hiring opportunities for junior individuals who have had exposure and training to modern/emerging SE tools and methods
- Training & Tools
  - Access to training opportunities are frequently limited by insufficient resources
  - Access to COTS tools has been an issue, but is improving
- Process/Guidelines
  - A process for deployment that is in alignment with Agency and GSFC level procedural requirements and standards has not yet been established

Adoption/Maturation Strategy

- Increase awareness and education at all levels
  - Classroom and on the job training for SEs
  - Awareness and real world data for leadership
- Form an active CoP
- Provide access to tools
- Identify and secure project opportunities for implementation
- Establish process/guidelines for implementation at GSFC
- Consistently engage the wider community to share best practices, leverage unique experiences and form partnerships

Current Activities

- Raising general awareness through guest speakers, colloquia, and vendor workshops
- Working with GSFC training office to coordinate and fund training opportunities for employees in both tools and methods
- Procuring additional licenses to COTS tools as resources become available
- A few early adopters have begun to work “behind the scenes” to produce their SE deliverables
  - Providing informal mentoring to other SEs
- Several high profile flight projects have adopted model centrism as part of their ground systems development efforts
- Developing implementation strategies that fits within the GSFC culture and business model
- Continuing collaboration with OSD Systems Engineering

Resources at GSFC

- **Principal Software used:**
  - MagicDraw
  - ViTech CORE
  - Enterprise Architect
  - Maple and MapleSIM
  - Mathlab and Simulink
  - Phoenix Integration products (via SBIR)
  - Integrated Modeling….
- **Examples of use:**
  - Space Network – USS-CR
    - Vitech CORE software
  - OSIRIS Rex Ground System
    - Vitech CORE software
  - JPSS Ground System
    - MagicDraw software

Small Flight Project Opportunities

- Full life cycle flight projects with higher risk postures and short total project times (12-18 months)
- Shadow or directly engage the project activity with model centric tools and methods
- Current options within GSFC:
  - Cubesats/Small Sats
    - Leverage the model centric work of others in this area (partnerships/model exchange)
    - Recently received support for model centric deployment
    - Planning activities are underway
  - Sounding rockets/High altitude balloons
    - Thousands of launches and decades of flight experience with document centric methods from Wallops Flight Facility provide great opportunity for historical comparison against model centric methods

Concurrent Engineering Opportunities

- GSFC has 3 concurrent engineering facilities
- Typically used to mature science instrument and mission concepts early in the lifecycle of a program/project
- By definition a highly integrated multidisciplinary design environment
- These CE environments can see many dozens of projects per year. Thus a large opportunity to impact future GSFC instrument and mission development activities by infusing model centrism from the start.
- Goal is to develop a suite of tools/models that can become the backbone of a project
  - Something that will grow and evolve as the project matures through the various phases of the lifecycle

Next Steps

- Evaluate the products and process of Systems Engineering as defined by Agency and GSFC procedural requirements with a focus on model centrism (internal development and external acquisitions)
  - Already started by Agency level team (NIMA)
  - Need to focus on applicability to GSFC business model
- Establish a process / guidelines for how to perform traditional SE functions via model centric approaches
  - Use small scale, short duration, pilot projects to inform process and guidelines
  - Identify metrics for determining quality of model centric methods during pilot activities
- Identify opportunities to change how we train and hire up and coming SEs at GSFC
  - Create positions on staff to allow for individuals with less overall career experience but with greater Model Centric Engineering experience (typically through academia)
    - Place them in a mentoring relationship with seasoned SEs
- Refine and mature partnership opportunities and agreements with the larger community
  - OGAs (OSD Systems Engineering, NIST, etc)
  - Other NASA Centers
  - Academia
  - Vendors

Conclusion

- Adoption of model centrism within GSFC remains slow but momentum is growing
- The early adopters are building a community of practice and getting organized to begin tackling challenges more directly
- Near term focus is on expanding our experience base and skill sets through mentorship, training, and real world project activities
- There is great potential for full life cycle pilot activities via small scale flight projects at GSFC.
- Actively looking for strategic partners to collaborate