



# MBSE through the Project Lifecycle

Systems Engineering

NASA and NESC SE Technical Discipline Team

An MBSE Overview

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# Systems Engineering TDT NESC Mission

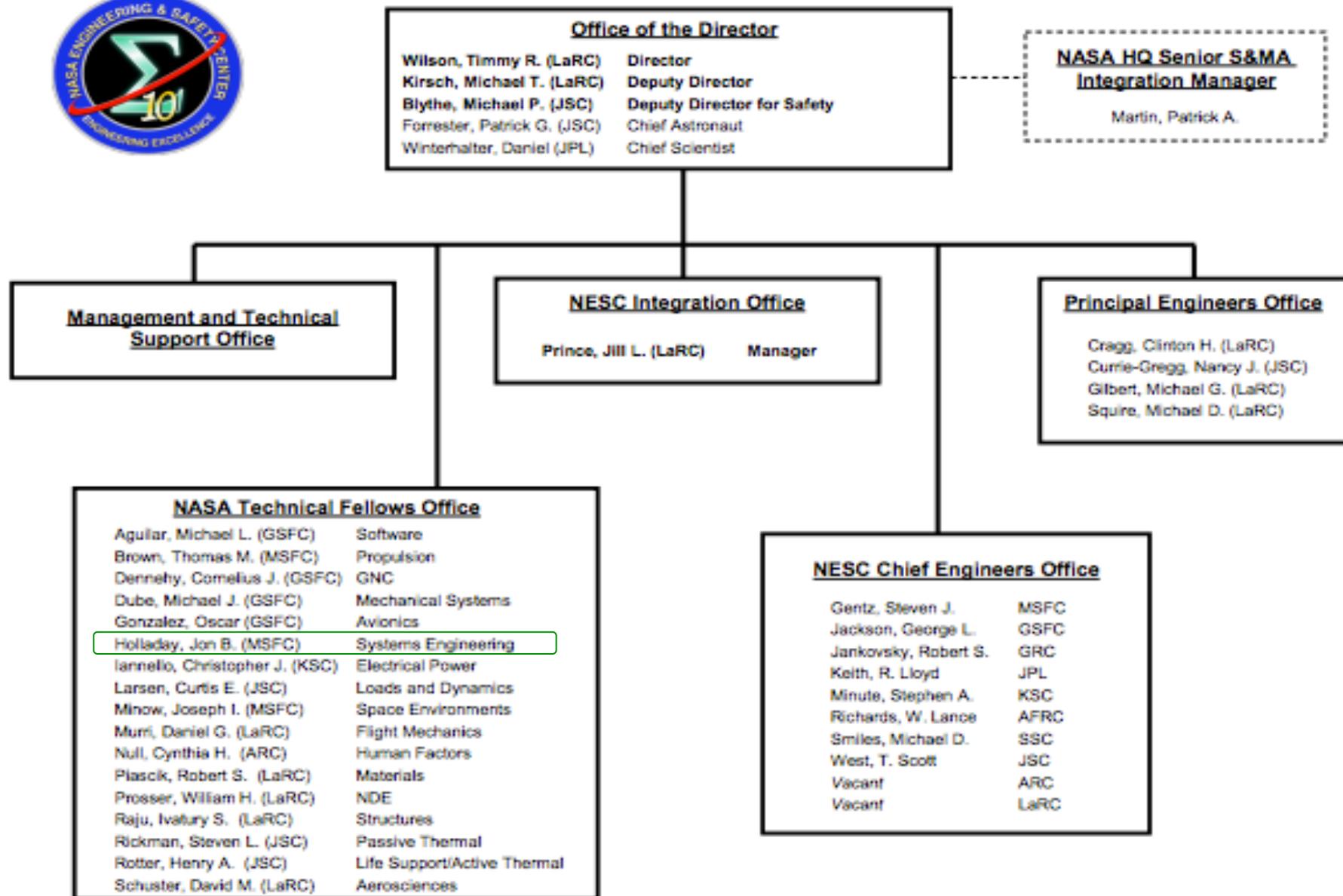


**“The NASA Engineering and Safety Center's (NESC) mission is to perform value-added independent testing, analysis, and assessments of NASA's high-risk projects to ensure safety and mission success. The NESC engages proactively to help NASA avoid future problems.”**

**“The NESC is an established knowledge base of technical specialists pulled from the ten NASA Centers and from a group of partner and organizations external to the Agency. It’s organized into 17 disciplines areas called Technical Discipline Teams (TDTs). By drawing on the minds of leading engineers across the country, the NESC consistently optimizes its processes, deepens its knowledge base, strengthens its technical capabilities, and broadens its perspectives, thereby further executing its commitment to engineering excellence.”**

**<http://www.nasa.gov/offices/nesc/home/index.html>**

# \*NESC Leadership Team



\*Also NESC Review Board (NRB) Members



# Systems Engineering TDT Standup Philosophy



- **One cohesive Intra-Agency Team**
  - Communicate and Integrate
  - Flexible and able to grow as needed
- **Develop an aligned response**
  - Understand issues and opportunities
  - Infuse best practices
- **Respond**
  - Results focused
  - Short and long term strategy

**Focus is on communication and lean alignment of Agency resources toward current and future Mission**



# Systems Engineering TDT Organizational Construct



**SE TDT**  
 Lead: Jon Holladay, MSFC / GSFC  
 Deputy TDT: Vicki Regenie<sup>1</sup>, AFRC  
 Deputy CLT: Todd MacLeod, MSFC  
 SELDP: Roger Forsgren<sup>5</sup>, HQ/APPEL

In addition to Center Senior Advisory Representatives, 9 of the 10 Centers (all civil servants) are now involved in a leadership role for the SE TDT implementation, representing a diversity of flight and research centers and tie-back to all four Mission Directorates. JPL direct support is considered civil servant.

**SE Center Reps for CLT**

Center Representatives for Capability Leadership Team

**NASA SE Advancement**  
 Dan Yuchnovicz<sup>1</sup>, LaRC / Britt Walters<sup>6</sup>, JSC

Integrate and implement tactical / strategic investment

**SE Capability Focus Efforts FY16**

- MBSE Pathfinder; Karen Weiland<sup>2, 6</sup>, GRC
- NASA SE Consortium; Dr. Mike Watson<sup>2</sup>, MSFC
- Complex Systems/IAWG; Dr. Anna-Maria McGowan<sup>5</sup>, LARC
- SE Handbook; Steven Hirshorn<sup>5</sup>, HQ / Jana Killebrew<sup>2</sup>, ARC

**MBSE Concentration Areas**

Primarily NESC assessment focused, but also provide expertise in evaluation and implementation of NASA SE Advancement planning

Cross-cutting discipline representative

**GN&C TDT**  
 N. Dennehy<sup>3</sup>

**Software TDT**  
 M. Aguilar<sup>3</sup>

**Human Factors TDT**  
 C. Dischinger<sup>3</sup>

**S&MA (NASA Safety Center)**  
 Mike Blythe<sup>4</sup> / Don Hull<sup>1</sup>

**Subject Matter Experts**

**Validation & Verification Team**  
 Tim Brady<sup>1</sup>, JSC / Kim Simpson, JPL

**Systems Analysis Team**  
 Tim Barth<sup>1</sup>, KSC

**Engineering Statistics Team**  
 Ken Johnson<sup>1</sup>, MSFC

**Data Mining & Trending Team**  
 Bob Beil<sup>1</sup>, KSC

**Matrix Support**

- 1 – NESC, Systems Engineering Office
- 2 – NASA HQ Office of Chief Engineer, Detail
- 3 – NESC, Other Technical Discipline Team
- 4 – NASA Safety Center
- 5 – Center Funded
- 6 – Rotating Position

**SE Capability Leadership Team**

AFRC: John Saltzman. Alternate - Cynthia (CJ) Bixby  
 ARC: Mark Turner. Alternate - Drew Demo  
 GRC: Derrick Cheston  
 GSFC: Tupper Hyde. Alternate - Steve Schmidt and Karen Stewart  
 JPL: Bill Berch. Alternate - Mike Jones  
 JSC: Randall Adams  
 KSC: Josephine Banno Santiago-Bond. Alternate - Curtis Coleman Dugger  
 LaRC: Jim Price. Alternate Chuck Leonard  
 MSFC: Renee Cox  
 SSC: Christine Powell



# Systems Engineering TDT MBSE within NASA/NESC for V&V



- **TI-12-00775 (April, 2012): Modeling and Simulation of System Behavior at the SLS, MPCV, and GSDO Interfaces**

The modeling was to initially focus on and execute abort scenarios to benefit both the requirements and design phases, but evolved to directly supporting SLS and GSDO programs with the definition of their interfaces in support of upcoming PDRs.
- **TI-13-00870 (May, 2013): Modeling and Simulation of System Behavior at GSDO Interfaces**

Systems architecture analysis for NASA's Exploration GSDO Program at Kennedy Space Center (KSC) to ensure the Communications, Command and Control and Range (C3R) design meets vehicle ground processing/ pre-launch requirements..
- **TI-14-00938 (Feb 2013): Review of GSDO Tools for Verifying Command and Control Software**

Assessment of GSDOs plan for pulling together models and emulators to create a tool(s) for verifying their command and control software.
- **TI-15-01025 (Jun 2015): Exploration System Development (ESD) Integrated Avionics and Software Verification (IAS) and Validation (V&V) Plan Assessment**

Assessment of the Exploration Systems Development's (ESD's) integrated avionics and software (IAS) verification and validation (V&V) plan.
- **TI-15-01070 (Aug 2015): Review of the Orion-European Space Agency (ESA) Interfaces**

Assessment of the Orion ESA interfaces – including the government-furnished equipment embedded in the European Service Module (ESM) to ensure there are no gaps or miscommunications regarding exchanges across the interface.
- **TI-15-01045 (Jun 2015): Exploration Systems Development (ESD) Verification and Validation (V&V) Plan**

The NESC is requested to implement a phased approach to assess each program's V&V during their upcoming Critical Design Review (CDR) prior to the Exploration Systems Integration (ESI) Build-to Sync (BTS).
- **TI-15-01089 (Dec 2015): Commercial Crew Program (CCP) Verification and Validation (V&V) Integration and Mapping**

Assessment of CCP and partner V&V flow-down and response to look for gaps and weaknesses and provide recommendations for improvement, as appropriate.



# Systems Engineering TDT

## NASA MBSE Pathfinder



### 1. Architectures and Mission Campaigns

Demonstrate system modeling for mission architecture use and reuse for a campaign of missions. The campaign of Lunar Prospector, Lunar Sample Return, Human Lunar, Mars Sample Return, and Human Mars are being considered. The system modeling would be done at the mission and system levels. Show model re-use, requirement reuse, sensitivity analysis, consistency, change evaluation, technology evaluation, etc.

### 2. Additive Manufacturing and Re-Tooling Engineering

Demonstrate how the use of system models and additive manufacturing can lead to design and manufacturing improvements. Examine ways for schedule reductions on the design and reduced changes during manufacturing for a part or assembly. Manufacturing of an engine or light-weight structure are being considered.

### 3. Hardware/Design Commonality

Demonstrate system modeling of a mission element, such as a lander or in-space stage, for interactions among the System Model and other engineering disciplines (CAD, physics-based models, etc.). Modeling would be done at a system and subsystem level. Look for areas that are common across all campaign elements. Demonstrate interactions between the System Model and CAD model, requirements, and physics-based models. Capture external interfaces between payload and launch vehicle.

### 4. Mission Flow Shadowing

Evaluate actual mission processing flow for sounding rockets via MBSE to understand how, and how much improvement can be made over multiple flight iterations. DoD is also a possible partner on this effort.



# Systems Engineering TDT

## Why a NASA MBSE Pathfinder



- **NASA SE Summit with all of the Centers in September 22-23, 2015**
- **Critical need identified to advance Agency's application of MBSE**
- **More effectively utilize 21st Century technology, tools and methods across its diverse portfolio of programs, projects, and technological innovations**
- **The SE Technical Discipline Team established the MBSE Pathfinder**
  - NASA Integrated Modeling Architecture, follow-on
  - Addresses current NASA issues
  - Better align MBSE across Centers
  - Develop a user and practitioner community
  - Capture issues and opportunities for evaluating next steps
  - Engage the future technical capability of NASA Systems Engineering



# Systems Engineering TDT

## Sampling of MBSE Across NASA



- **ARC**

- ✓ Resource Prospector (RP) Mission
- ✓ EuCROPIS Project
- ✓ Intelligent Systems Division (Code TI)

- **GRC**

- ✓ ARRMS/SEP (in conjunction with JPL)
- ✓ Spacecraft Fire Safety Demonstration Project
- ✓ SLS Mission and Fault Management
- ✓ Space Communications and Navigation Program
- ✓ AOSP SMART-NAS
- ✓ AES Hab Comm Architecture (in conjunction with JSC)

- **GSFC**

- ✓ JPSS
- ✓ SCan
- ✓ ARRMS
- ✓ Project
- ✓ OSIRIS-Rex
- ✓ SN – TDDF
- ✓ SGSS
- ✓ Sounding rockets
- ✓ Project
- ✓ TIRS II
- ✓ CATTENS
- ✓ S&MA MBE

- **JPL**

- ✓ Europa Mission
- ✓ Mars 2020
- ✓ ARRMS
- ✓ Ni-SAR
- ✓ SWOT
- ✓ Mars Helicopter
- ✓ RefBus, ELF
- ✓ MSFC SLS and Europa Mission

- **JSC**

- ✓ AES Hab Comm Architecture

- **LaRC**

- ✓ Materials on ISS Experiment – X (MISSE-X)
- ✓ On-orbit Autonomous Assembly of Nanosatellites (OAN)
- ✓ Engineering Design Studio (EDS)
- ✓ Radiation Budget Instrument (RBI)

- **MSFC**

- SLS**
- ✓ Vehicle Integration
- ✓ Payload Interface
- ✓ Requirements Management
- ✓ Advanced Concepts Trade Studies
- ✓ Flight Software Development



# Systems Engineering TDT

## SE Related (Non-Assessment) Activities



- ✧ Refreshing the SE Website on NASA Engineering Network (**On-going**)
- ✧ Detailed Focus/Response on Select SE Issues/Opportunities (**On-going**)
- ✧ SE Consortium Principles/Practitioner Handbooks Released (**Spring**)
- ✧ Conference on Systems Engineering Research (**Spring**)
- ✧ SE Technical Discipline Team (TDT) Face-to-Face (**Spring**)
- ✧ SE Handbook (NASA-SP-6105) Released (**Summer**)
- ✧ NASA Systems Engineering Capability Assessment (**On-going**)
- ✧ NASA SE Leadership Development Program Re-Start (**On-going**)
- ✧ Model Based Systems Engineering (MBSE) Pathfinder, Part 1 Complete (**Fall**)
- ✧ NASA SE Vision (Initial Draft) (**Fall**)
- ✧ NASA SE Summit (Capability Leadership Team) (**Fall**)
- ✧ SE TDT FY 17 Operating Plan Finalized/Approved (**Fall**)
- ✧ Inter-Agency Working Group (**On-going**)
- ✧ PDES Inc. (**On-going**)