

# **Systems Engineering Reboot**

## **A Lockheed Martin Space Initiative**

*Re-architecting the Systems Engineering Enterprise at Lockheed Martin Space  
to Meet the Challenges of DoD Mission Needs*

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**Calvin Craig**

**Systems Engineering Director – LM Space**

# Systems Engineering Reboot



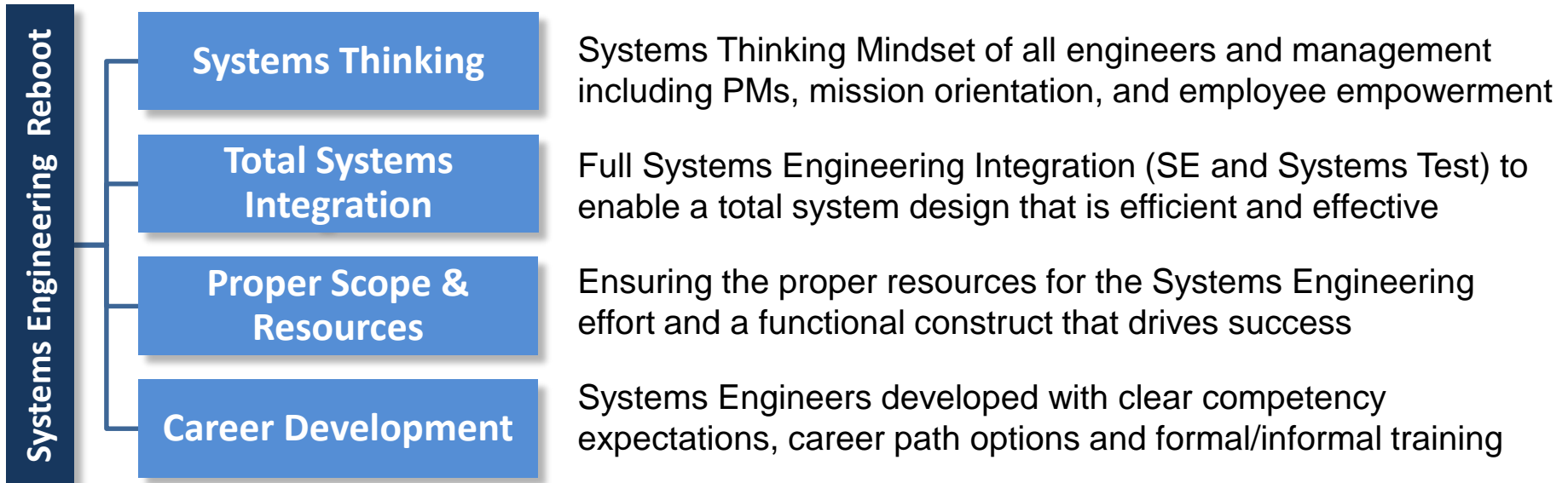
## Why?

- **Customers' Needs and Expectations are Changing (Agility ↑ and Complexity ↑)**
- **Design Escapes are often rooted early in the Development Life Cycle**
  - Systems Engineering is crucial to avoiding them
  - Using heritage designs does not mean ignoring SE
- **Evolving New Approaches to DoD Challenges**
  - Digital Engineering
  - Mission Engineering
  - Systems of Systems development/ integration
- **Develop the Next Generation of Systems Engineers**
  - Demographic profile of SEs: heavy in the late and early career
  - Need to invigorate SE development to replace pending retirees

## SE Reboot Initiative Goals/ Benefits

- Improve consistency of Systems Engineering across the Enterprise
- 100% Systems Thinking Mindset (this is for Everyone, not just SEs)
- Improve performance and efficiency; reduce design escapes
- Increase empowerment and accountability across the full life cycle

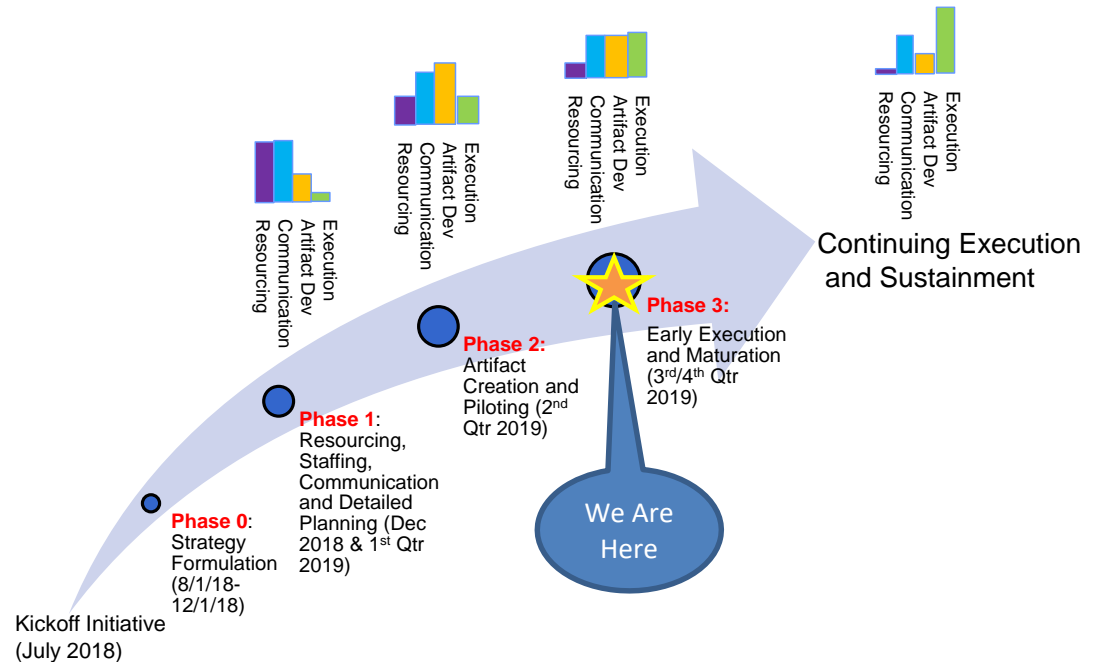
# Systems Engineering Reboot Summary



**Jan – Jun 2019:**  
Staffing, Planning, Developing

**Jul – Dec 2019:**  
Training, Engaging, Executing

**2020:**  
Implement Process Improvements



# SE Reboot Tenets (1 of 2)



## Systems Thinking

## Total System Integration

### What

- Takes a big picture view of all activities in the proposal, design, delivery, and sustainment of our products. Special focus on boundaries, inter-connections, and optimization at the Mission/Enterprise level
- Ensures we consider how decisions impact the broader system.

- Strengthening End-to-End Systems Integration across the Program Life Cycle (Requirements, Design, Production, Test, Operations)

### Actions

- Initiative Leadership Team in place
- Systems Thinking Workforce Survey
- Communications Campaign
- Training Program

- Added SMEs to drive integration excellence (Electrical, Mechanical, HW/ SW)
- Created System of Systems (SoS) Eng'g Dept
- Testbed & Simulators Lab Survey
- Clean-Sheet Test Approach Study
- Bi-Monthly Integration Technical Forums
- Training Campaign for Integration expertise

### Benefits

- Customers: Well thought-out Mission Solutions; Close Partnership for life cycle mission success
- Executive Mgmt: Better linked IRADs & new business ventures; Fewer point solutions
- Program Mgmt: Systematic solutions architected to work from the start
- Engineering Employees: More commonality/ familiarity in SE execution across LM Space

- Customers: Well-managed interfaces across mission segments
- Executive Mgmt: Increased commonality
- Program Mgmt: Fewer design escapes
- Engineering Employees: Expertise is sought after

## Proper SE Scope

## Career Development

### What

- Provide SEs with guidance, artifacts and support to ensure they have what they need for programs to be successful
- Important for budget alignment and capture phase execution to help achieve consistent mission success on programs

- Provides tools and resources, in concert with increased training, to help Systems Engineers chart and follow their personal development path

### Actions

- Standard/Common SE requisition tool
- Standard SE Scope Matrix Chart/Spreadsheet
- SE Cost Targets model developed based on extensive program history data
- More than 50 Systems Engineering Proposal Artifacts developed to drive consistency and reduce cycle time

- Established SE Competency Model aligned with LM Space priorities & industry standards
- Providing career guidance & planning tools
- Enhanced training; increased number of instructor-led and on-demand offerings
- Enhanced Architect Development & Qualification Program (ADQP)

### Benefits

- Customers: Better predictability in schedule and budget performance
- Executive Mgmt: Fewer Red programs Program Mgmt: More agile and efficient performance
- Engineering Employees: More predictable path to the full solution

- Customers: Close partnership with all team members for mission success
- Executive Mgmt: More “mobile” workforce
- Program Mgmt: Engineers that understand better how to balance all program resources
- Engineering Employees: Career path development, Increased training

# SE Reboot 2019 Plan



Jan Feb Mar Apr May Jun Jul Aug Sep Oct Nov Dec 2020>>

## Systems Thinking (ST) Mindset

- Funding
- Skip Levels
- Brief LOB Executive Staff
- Staffed SOS Sr. Mgr.
- Draft Sys Think Video
- ST Video Completed
- Held 1<sup>st</sup> ST Pilot Course
- Released ST Video
- Released ST WordPress Site
- Hold ST Courses for Eng'g Org
- *Inside LM* Article
- ST Newsletter
- Hold ST Courses for Eng'g Org
- Hold ST Courses for Eng'g Org
- Release 1<sup>st</sup> Habit Web Vignette
- Hold ST Courses for Eng'g Org
- Hold ST Courses for Eng'g Org
- ST Survey
- ST Awards
- Hold ST Courses for Eng'g Org
- Develop ST Tool Kit

## Total Systems Integration

- Move System Test to SE
- Start Testbed Surveys
- Mech Integ. Forum
- Test Lab Surveys
- Draft Clean Sheet Test Plan
- HW/SW Integ. Forum
- Elec Integ. Forum
- Test Lab Evals
- Publish Test Lab Guidance
- Sys Test Forum
- Complete Integ. Tools Assessment
- Implement Test Architect Role
- Start Updates to Integ. Discipline Training
- Stand-up Payload Integ. Process

## Proper Resources

- Create Standard Chief SE Req
- Begin Cost Data Analysis
- Begin Standard Req Generation
- Pre-ATP "Gift" List generated
- Establish SE Cost Model
- Common SE Req Template Release
- Scope and Cost Leadership Forum
- Release Pre-ATP Aides
- Develop SRR "Gifts"
- Release SRR "Gifts"

## Career Development

- Establish Training Lead
- Develop list of 19 Webinars for early career SEs
- Certify Architects
- Hold 1<sup>st</sup> SE Boot Camp
- Finalize Technical Knowledge Mgmt Skills List
- Release SE Career Guidebook
- Begin Architect Mentoring
- Spacecraft Design Lecture Series Starts
- Knowledge Transfer for Senior Architects
- Complete Pipeline Gaps Assessments
- SE Career Journey Webinar

## Systems Engineering Reboot Tenets are Key to Our Future Success

- Increased agility requires more integration throughout the lifecycle
- Ensuring proper resources for Systems Engineering is crucial
- Rapid development of employees is essential to backfill retirees

## Foundational Culture Change Initiative Requires Sustainable Approaches

- Support of the workforce is key
- 2019 focus areas were deemed high payoff areas
  - New focus areas will get added as current ones enter sustainment mode
  - Feedback will help shape the next round of focus areas
- Refreshed focus areas will help keep the culture change momentum going

## Improvement Needed Across the Industry

- Need to emphasize that Systems Engineering is more than just requirements and coordination

**Enhancing Systems Engineering Through New Perspectives  
and Training For More Agile and Accurate Execution**



# Q&A





# Backup



# About the Presenter



**Calvin Craig**  
Systems Engineering Director  
Lockheed Martin Space

Calvin Craig is the director of Systems Engineering with Lockheed Martin Space and is located in Waterton CO. He began his current position in August 2017. His roles and responsibilities in this role include leading a collaborative consortium of over 2,500 integrators, requirements verification, mission operations engineers, and system architects focused on designing, developing, integrating and delivering flight spacecraft and missile systems across LM Space. As part of this, Calvin is charged with pioneering the development of a world-class Systems Engineering organization.

Calvin brings over 20 years of Engineering development, leadership, and program management experience to this role. Calvin most recently served as the GOES-R Chief Systems Engineer, where he successfully led the organization responsible for the satellite requirements, architecture, and verification. Prior to that, Calvin served key roles on multiple NASA programs such as Orion, the Mars Reconnaissance Orbiter, Mars Odyssey, and the Stardust programs. Calvin also helped drive the strategy for the Raptor Avionics, which will serve as the common avionics platforms for multiple LM spacecraft.

Calvin holds a Bachelor of Science degree in Electrical Engineering from the University of Central Florida.

# Common Breakdowns in Systems Thinking **NDIA**

## Incompatible Interfaces



- Often Characterized by focus on lower level requirements
- Lack of a “Mission Orientation” is sometimes at play

## Solving Your Problem at the Expense of Others



- Behavior exhibited by those valuing solutions to their issues above Enterprise or System Optimization
- Often happens in “over-constrained” or “over-taxed” organizations

## Solving a Piece vs. the Whole



- Sometimes follows a pattern of making a good thing the ultimate thing
- Can be driven by a focus on the “Initiative du Jour”

# Systems Engineering Scope Matrix



**SE Functional Org Chart**

- Functions/Org Structure depends on program size/content/life cycle
- See SE Scope Matrix for More Detail and Product List

## Chief Systems Engineer

### 1 SE Mgmt Functions

- Mgmt & Leadership
- Program Planning
- Sys Engr CAM
- Customer I/F
- IPT/Subcontract I/F
- Risk & Opp
- Tech Process
- Standards & Mngt
- Peer Review Process
- Metrics

### 2 Technical Baseline

- Required Technical document plan/schedule
- Baseline control approach
- ERB Coordination
- Major Review Coord.
- IRB Interface
- Action Item Mngt
- EIDP/System Cert

### 3 System Architecture

- System Definition
- Trade Studies
- Conops / DRM
- Sys Perform & TPMs
- System Model (MBSE)
- Fault Management
- *Mission Planning (orbit, trajectory)\**

### 4 System Reqts Verif & Valid

- Reqmts & Reqmt DB
- Spec Peer Reviews
- Verification planning/reports
- Validation
- Planning/reports
- Environments Doc
- Waivers & Deviations

### 5 Multi-Segment Integration & Test

- External ICD/Interfaces (including CFE/CFI)
- Seg-Seg ICDs/Interfaces
- Sys Cmd/Telm/Parameter Database
- Intersegment Test & validation plan and support

### 6 System Design Integration

- PHSL/MEL
- HW/SW Reuse, Qual and Env Test Matrix
- DFX, Tech Insertion, Design Standards
- Compatibility analyses, I/F risk reduction
- System Power Budget
- Multi-functional (Mech-Elec.-x) Integration
- Mechanical Integr. (FOV, Align)
- Electrical Integr. (Channelization, Pin-Pin)
- HW/SW Integration
- Payload Integration into system
- Launch Segment Integration

### 7 System/Vehicle Test

- Test Requirements
- Test Plan Approval
- TLYF Exceptions
- Test Review Support
- Test Predictions
- Test Execution Support
- Test Flag review/ Support
- Failure Review Board
- Consent to Break of Config
- HW/SW Integ. lab support

### 8 Specialty Engineering

- Special Disciplines
- Reliability, Maintain, Avail
  - Mass Prop Anal & Budgets
  - Surv, & Radiation
  - E3 (EMI/EMC/ESD)
  - Human Interface Engr
  - Nuclear Surety
- Other Specialty Engr\*\**
- *Parts and Materials*
  - *Logistics/Sparing*
  - *Contamination*
  - *Cyber Security and Info Assur.*

### 9 Mission Operations

- Mission Ops Planning
- Ops Procedures
- Ops Doc and Training
- Ops Reviews
- Ops Rehearsals
- Initial Ops Checkout
- Customer Acceptance
- Operations & Maint.

### 10 Config and Data Mgmt

- ERB & CCB Admin
- Doc/Drw Release and Change Mngt through EPDM
- CDRL delivery/tracking
- FCA/PCA
- CMDM Plan

• *Item typically managed by non-SE Org*  
 \*\* *Item typical in program SE but not part of central SE*  
 5-31-2019