Integrating Mode-Based Systems Engineering into SE Training Program

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Jet Propulsion Laboratory
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Topics

- Systems Engineering Competency Framework
- Basic Elements
- Model-Based Systems Engineering Practices
- Implementation and Execution
- Closing Remarks

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Systems Engineering Competency Framework

Personal Behavior & Critical Thinking

- Leadership Skills
- Attitudes and Attributes
- Problem Solving & System Thinking

Processes

- Systems Engineering Practices
- Discipline-Specific Procedures

Body Of Knowledge

- General knowledge on SE
- Discipline Systems Engineering Know How
- Model-Based Systems Engineering

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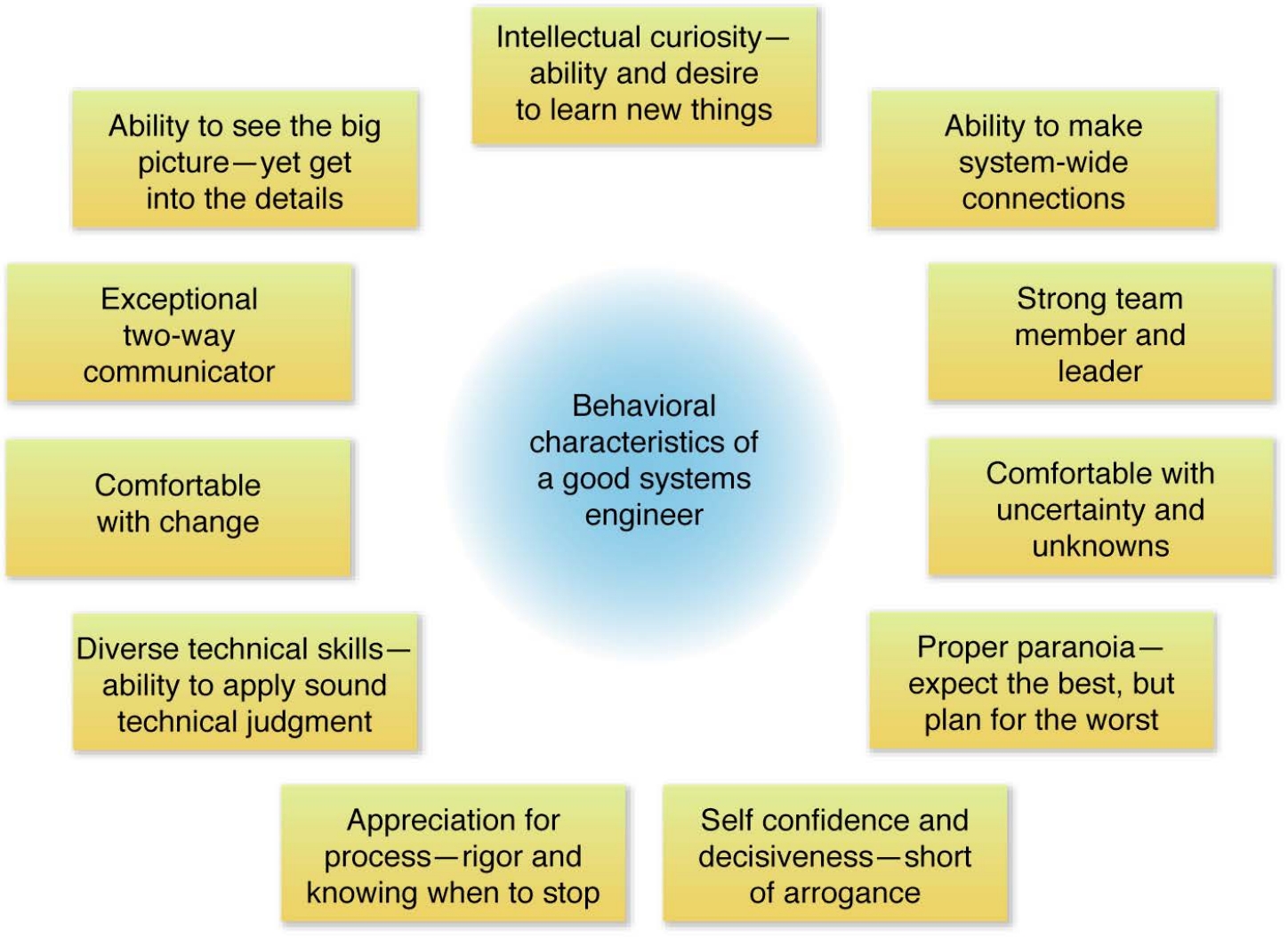
Personal Behavior & Critical Thinking



Source: Quote from Dr. Michael Ryschkewitsch and Gentry Lee

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The SE Critical Thinking Training Program

SE Workshop Agenda

Time	Subject	Presenters
DAY 1 - Tuesday October 20		
7:00 - 8:15	**BREAKFAST**	
8:15 - 8:30	**Introduction / Logistics**	Mark Brown, Paul Gowler
8:30 - 9:30	**Special Topic #1:** INCOSE Presentation / Video	David Long INCOSE Video "Building for Tomorrow" Mark Brown, Cece Guiar, Chi Lin
9:30 - 10:30	**Case Study #1:** MSL Entry, Descent and Landing	Facilitator: Adam Steltzner SME: Allen Chen
10:30 - 10:45	**BREAK**	
10:45 - 12:00	**Case Study #1:** MSL Entry, Descent and Landing (continued)	Facilitator: Adam Steltzner SME: Allen Chen
12:00 - 1:00	**LUNCH**	
1:00 - 2:00	**Panel #1:** Career Paths for becoming a System Engineer	Moderator: Cece Guiar Panel: Wayne Lee, Peter Kahn, Alex Jimenez, Matt Bennett, 1 TBD
2:00 - 3:00	**Case Study 2#:** Orbiting Carbon Observatory	Facilitator: Peter Kahn SME: P. J. Guske
3:00 - 3:15	**BREAK**	
3:15 - 4:15	**Case Study 2#:** Orbiting Carbon Observatory (continued)	Facilitator: Peter Kahn SME: P. J. Guske
4:15 - 5:15	**Special Topic #2:** Planning for Cassini's Titan Flybys	David Seal
6:30 - 7:15	**DINNER**	
7:15 - 7:45	Networking	All
DAY 2 - Wednesday October 21		
7:00 - 8:00	**BREAKFAST**	
8:00 - 9:45	**Case Study #3**: Cassini Instrument Mounting Tradeoff	Facilitator: Jennifer Trosper SME: Julie Webster
9:45 - 10:00	**BREAK**	
10:00-10:45	**Case Study #3**: Cassini Instrument Mounting Tradeoff (con't)	Facilitator: Jennifer Trosper SME: Julie Webster
10:45 -12:00	**Special Topic #3:** Mars Human Mission Study	Hoppy Price
12:00 - 1:00	**LUNCH**	
1:00 - 2:30	**Panel #2:** Cubesat, Class C/D, and Instrument Missions	Moderator: Peter Kahn; Panel: Stacy Boland, Tom Randolph, Dave Durham, Matt Bennett, Perry Danesh
2:30 - 2:45	**BREAK**	
2:45 - 5:15	**Case Study #4:** MSL Curiosity Sol 200 Anomaly	Facilitator: Magdy Bareh SME: Rajeev Joshi
6:30 - 7:15	**DINNER**	
7:15 - 8:15	**Evening Lecture:** Topic: A Short History of Avionics and Flight Software at JPL	Rob Manning
DAY 3 - Thursday October 22		
7:00 - 8:00	**BREAKFAST**	
8:00 - 8:45	**Special Topic #4:** Advancing the Practice of Systems Engineering	Steve Jenkins
8:45 - 9:45	**Special Topic #5:** MBSE Application	Elyse Fosse
9:45 - 10:00	**BREAK**	
10:00 - 11:00	**Special Topic #6:** SE and Risks Across the Project Lifecycle	Mark Brown
11:00 - 12:00	**Case Study #5:** Aquarius (International Environment)	Facilitator: Dave Durham SME: Amit Sen
12:00 - 1:00	**LUNCH**	
1:00 - 2:30	**Case Study #5:** Aquarius (International Environment)(con't)	Facilitator: Dave Durham SME: Amit Sen
2:30 - 2:45	**BREAK**	
2:45 - 4:00	**Special Topic #7:** TBD	Gentry Lee
4:00 - 4:30	**Summary**	Mark Brown, Bill Bertch

Objective: Promote critical thinking, collaboration and networking

Format: Case Study driven, panel discussions

Participants: Up and coming SEs from discipline organizations; invitation only, nominated by management

Location: Off-site

Length: 3 days

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Systems Engineering Practices - The Ten Functions

- Architecting
- Requirements
- Analyze and Characterize the Design
- Technical Resource and Performance
- Interfaces
- Verification and Validation
- Reviews
- Risk Management
- Manage and Control the Requirements and Design
- Systems Engineering Task Management

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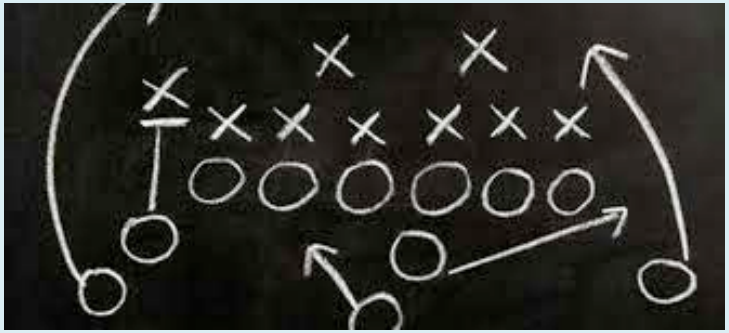
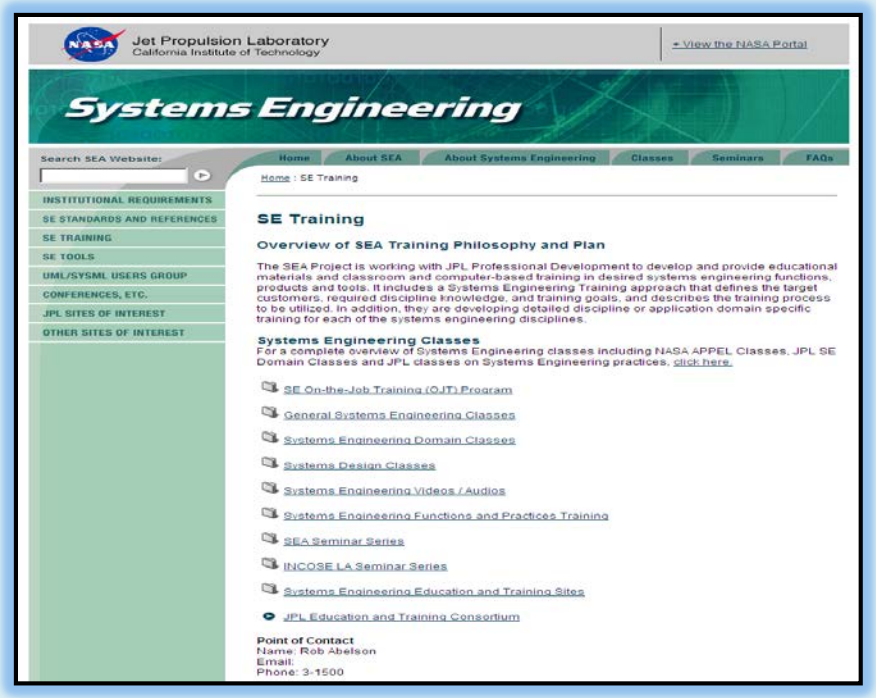
Systems Engineering Practices Training Programs

Class Room



Function Master



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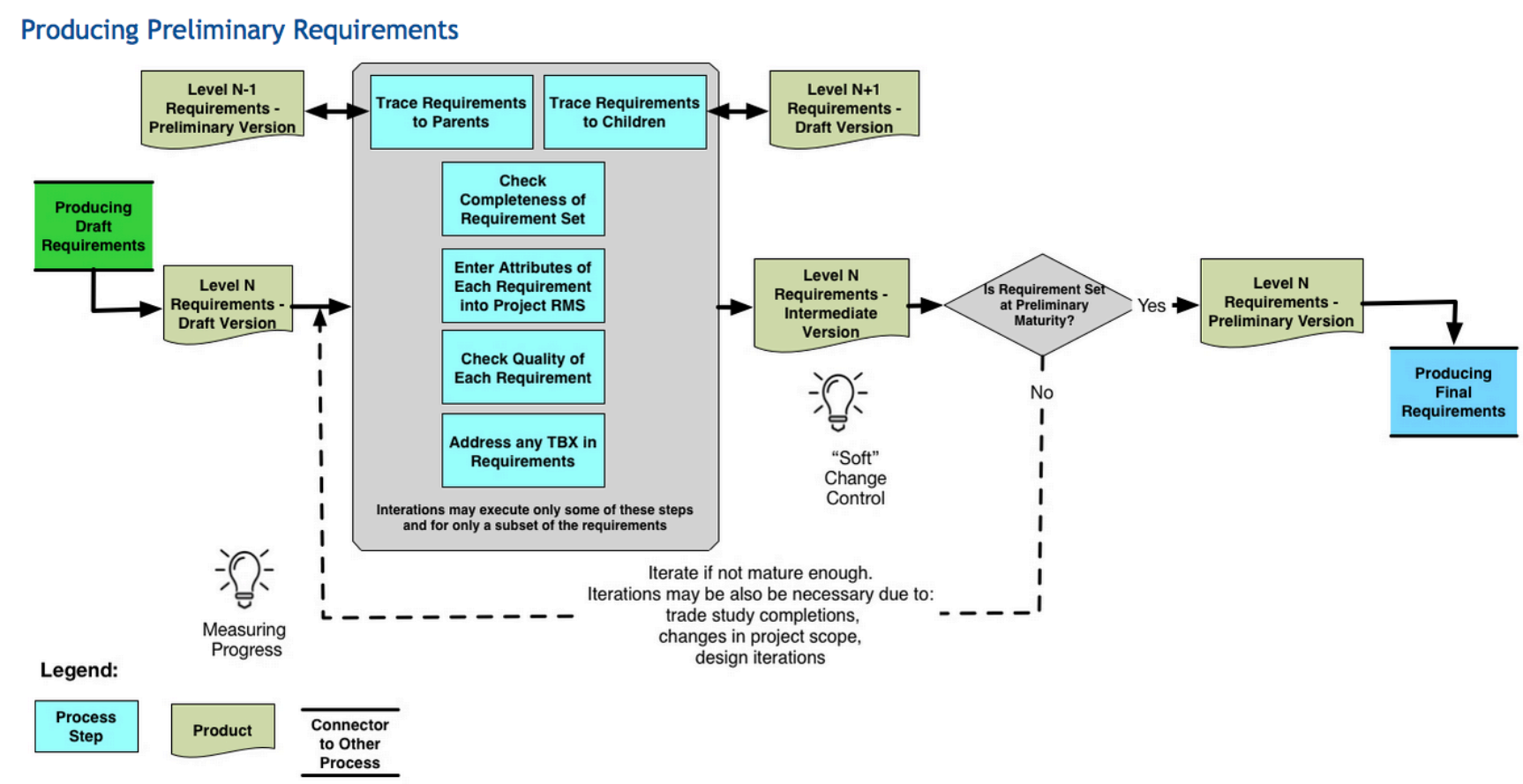
Example of Systems Engineering Process: The Requirements Process Wiki



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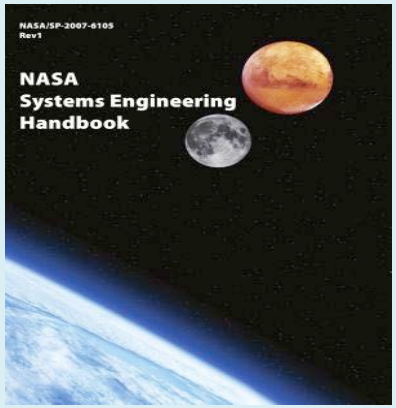
Body of Knowledge

- Introduction to Project Systems Engineering
- Mission Architecture Workshop
- Introduction to Flight Systems

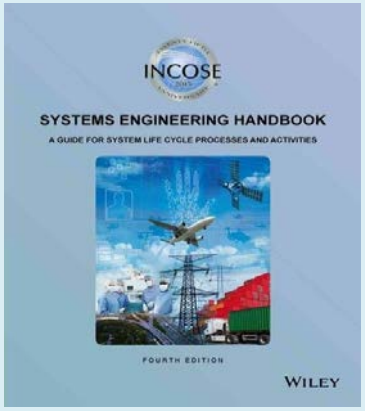
- Web based Systems Engineering Field Guides
- Web based Fault Management Handbook

JPL Wired!

NASA Systems Engineering Handbook



INCOSE SEBoK



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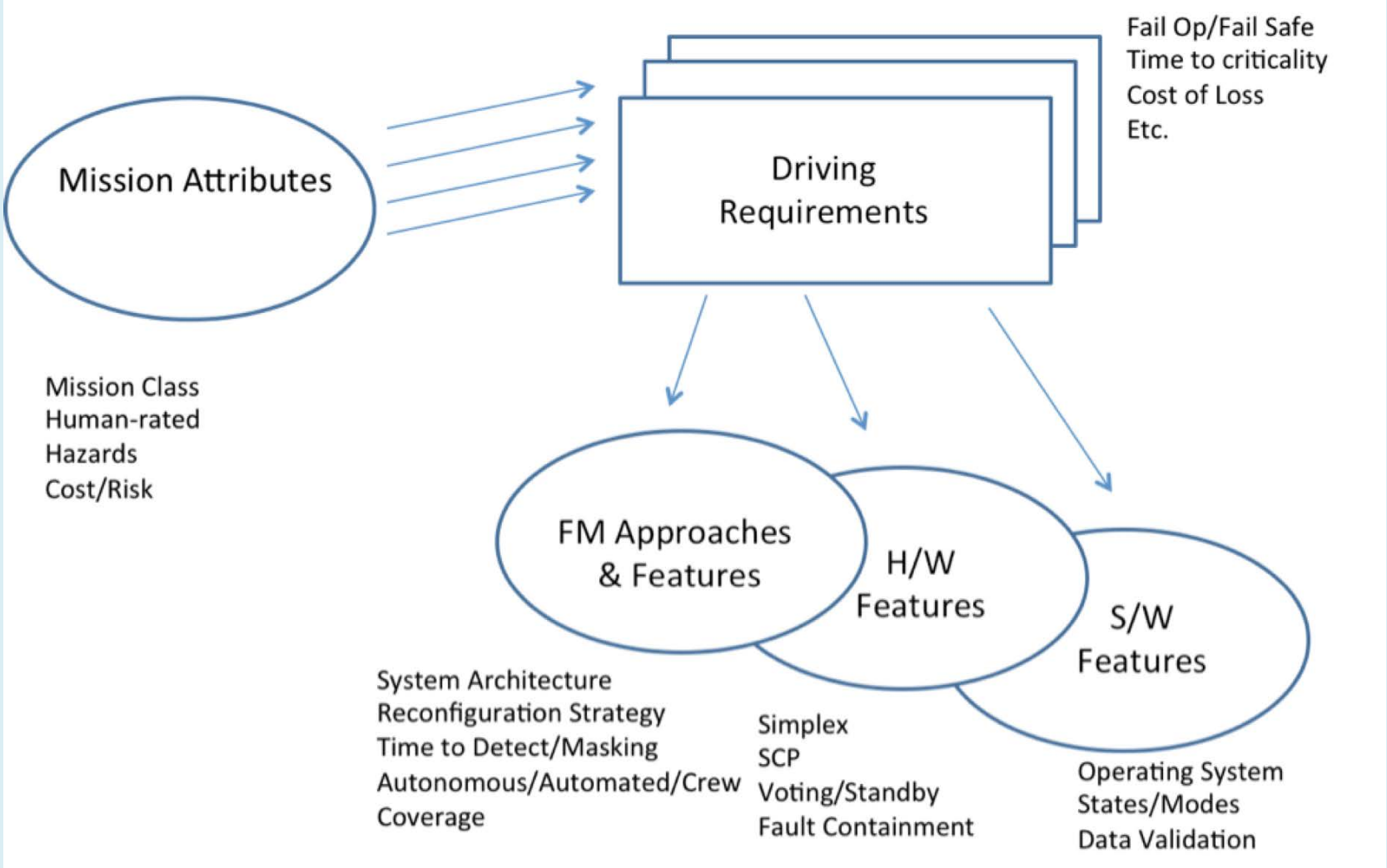
Example Body Of Knowledge: Fault Management Handbook



Mission Requirements and FM Design

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Model-Based Systems Engineering

An Emerging SE Practice

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Integrated Model-Centric Engineering

- JPL established a Model-Based Centric Engineering program to help the institution **advance and modernize systems engineering practices** by developing and deploying MBSE assets to practitioners and projects. It also helps **nurture** the MBSE environment

- Assets are categorized
  - Methodology and Guidance
  - Software Assets
  - ✓ Training and Community Engagement

- Together these assets form the foundation for transformation

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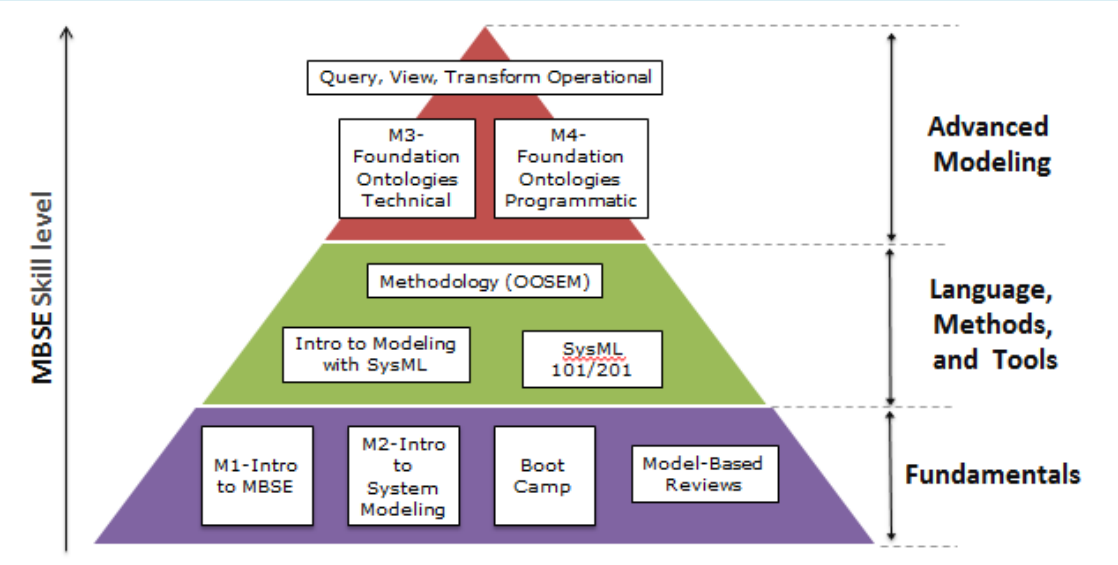
Structured Training For MBSE



Objective

Provides educational resources enabling systems engineers (and managers) to become proficient in applying MBSE to perform their engineering tasks.

	Course Name	Target Audience				
		Reviewers	Project/Task Managers	Line Managers	Engineers/ Practitioners	Core Modelers
Fundamentals	Model-Based Reviews	1	2	1	3	3
	Boot Camp		2		2	
	M1: Intro to MBSE (online)		1	1	1	1
	M2: Intro to System Modeling (online)		1	1	1	1
Implementation Techniques	Introduction to Modeling using SysML			2	1	1
	SysML 101/201			3	1	1
	Methodology (OOSEM)		3	3	3	1
Advanced Modeling	M3: Foundation ontologies / technical		3	2	1	1
	M4: Foundation ontologies / programmatic		3	2	2	1
	Query, View, Transform Operational				3	3

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MBSE Community Engagement

NASA/JPL Symposium & Workshop on Model-Based Systems Engineering

PST	Wednesday - Jan. 28 (321 Auditorium)			
7:45	Coffee, Tea, Pastries			
8:15	**Introductions, Purpose, Goals** - Chi Lin **Welcome** - JPL Executive **Agenda and Logistics** - Dan Dvorak			
9:00	**MBSE: Harnessing Technology to Revolutionize NASA's Engineering Practice** David Miller, NASA Chief Technologist			
9:45	**Break (outside Auditorium)**			
10:00	**MBSE on Europa Clipper** Brian Cooke Project Systems Engineer, Europa Clipper, JPL			
10:45	**Panel 1** **How MBSE affects the work of systems engineers** Moderator: Mark Brown Panel: T. Bayer, S. Mitchell, G. Walley, M. Watson			
11:45	Lunch in 303 Café			
12:45	Pick one breakout:			
12:45	**Breakout 1** Early Lifecycle MBSE: Collaborative and Concurrent Engineering John Ziemer 321-B20A	**Breakout 2** Reference architectures & system modeling platforms R.Karban, C.Delp 321-B20B	**Breakout 3** MBSE Value and Progress: The Metrics Conundrum Todd Bayer 321-127/128	**Breakout 4** Mission Assurance in the MBSE Future Steve Cornford, Martin Feather 321-129
2:30	Break (321-B20 Lobby)			
2:45	**Breakout 5** Early Lifecycle MBSE: Mission Formulation & Development John Day 321-B20A	**Breakout 6** Advancing the State-of-Art in Model Analysis B. Cole, J. Gross, M. McKelvin 321-127/128	**Breakout 7** Visualization of Model Content and Engineering Process Scott Davidoff 321-B20B	**Breakout 8** Enterprise Strategies for MBSE Capability Development Steve Jenkins 321-129
4:30	Reassemble in Auditorium			
4:40	**Outbriefs** Breakouts 1-8 Auditorium			
5:30	**Adjourn**			

PST	Thursday - Jan. 29 (321 Auditorium)			
8:00	Daily Announcements + Coffee, Tea, Pastries			
8:15	**Building for Tomorrow: 21st Century Systems Engineering** David Long President, International Council on Systems Engineering			
9:00	**Panel 2** **MBSE in the Next Decade** Moderator: Heinz Stoewer Panel: R. Fradet, K. Hjortnaes, C. Paredis, R. Poel, B. Tobey			
10:00	**Break (outside Auditorium)**			
10:15	**Report on MBSE sessions from INCOSE IW** Chris Schreiber / Sandy Friedenthal Lockheed Martin Space Systems / INCOSE MBSE Chair			
11:00	**Top 3 Research Directions That Could Accelerate the Impact of MBSE** Daniel DeLaurentis, Purdue University			
11:45	Lunch in 303 Café			
12:45	**Tour of JPL** Tour site 1: Mission Control (SFOC) Tour site 2: Curiosity full-scale (180) Tour site 3: LDSD (High Bay #2) Annie Richardson, Dave Seidel, Todd Barber Randii Wessen (backup)			**Study Hall** Free time for those not taking tour 321-B20B
2:15	Break (321-B20 Lobby)			
2:30	**Breakout 9** What is the Skill Set of Modern Systems Engineers? M.Sarrel, C.Salvo 321-B20B	**Breakout 10** Model Mgmt Challenges & Approaches Seung Chung, David Coren 321-B20A	**Breakout 11** MBSE Infusion into Fault Management Magdy Bareh, JF Castet, L. Fesq 321-415/416	**Breakout 12** MBSE Infusion Strategies Alex Jimenez, S. Friedenthal 321-128/317
4:10				
4:15	**Model Visualization Showcase** Examples of Visualization at Work Emcee: Scott Davidoff (Auditorium)			
5:00	**Outbriefs** Breakouts 9-12 (Auditorium)			
5:30	**Adjourn**			

PST	Friday - Jan. 30 (321-B20)			
8:00	Daily Announcements + Coffee, Tea, Pastries			
8:15	**Culture Change Driven by LM's Digital Tapestry Implementation** Brynn Watson, VP, Engineering Operations Lockheed Martin Space Systems			
9:00	**Incremental Deployment of MBSE: Managing a Big Change in Small Steps** Harald Eisenmann, Airbus Defence and Space			
9:45	Break			
10:00	**Model-Aided Systems Engineering of Complex Cross-Program Architectures** Kim Simpson, NESC Software Tech. Discipline - Deputy, JPL			
10:45	**Panel 3** **Academic Curricula for SE/MBSE** Moderator: David Nichols Panel: E. Atkins, M. Chodas, B. Cooke, L. McGinnis			
11:45	Lunch in 303 Café			
12:45	**Breakout 13** Moving NASA Forward Vicki Regenie 321-B20	**Breakout 14** Bringing Model Checking into Practice Jessica Samuels 321-128/129	**Breakout 15** Challenges for Practitioners Kerzhner, Jackson 321-415/416	**Breakout 16** JWST model-based software engineering Michael Aguilar 321-317/418
1:55				
2:00	**Outbriefs:** Breakouts 13-16 (321-B20)			
2:15	Break (321-B20 Lobby)			
2:30	**Wrap-up 1: Highlights and Take-Aways** David Nichols (321-B20)			
3:00	**Wrap-up 2: Open Microphone and Actions** Audience participation 321-B20			
4:00	**Adjourn**			

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Community Engagement: MBSE CoP

MBSE Community of Practice

Home | Quick Start! | Asset Views | Resources | Training | Tools | Practices & Patterns | Software Hub | Calendar | About | MEA Wiki

Dashboard > Welcome to MBSE CoP

Resources

The CoP provides access to

- SMEs who can help you with your modeling tasks.
- FAQs, Presentations,Lessons Learned and a list of Papers, Books and Links contributed by CoP members.

View more...

Hot Topics

NEW MagicDraw Package Released!

This new release makes available No Magic's MagicDraw version 18.0, including patches up to SP2. Download at MagicDraw with Model Development Kit (MDK)

MagicDraw: Project Usage Integrity Checker: Nicolas Rouquette

> more...

View All Update Details...

Recently Updated

- Scenario Pattern updated 6 minutes ago
- image2016-6-21 9:9:49.png attached about 5 hours ago
- image2016-6-21 9:8:37.png attached about 5 hours ago
- Subject Matter Experts -

Welcome to MBSE CoP

Welcome to the Integrated Model Centric Engineering **MBSE CoP** where JPL MBSE practitioners can

- **Access** MBSE knowledge
- **Interact** with MBSE subject-matter experts and other practitioners
- **Find & Contibute** MBSE tools, resources, training and upcoming meetings and events

Contribute to Our Community of Practice!

Happening This Week....

This weeks Focus Topic meeting:

No meeting this week, check out the QuickStart guide!

Tools

The modeling tool environment includes the tools and services required to develop and control the system engineering models. It is provided through the collaborative efforts of the **SECAE** tool service and **IMCE**.

Go To the CAE-EMS to download current MBSE tools. The Modeling Environment Quick Start! is currently under development and will be available soon!

Contact the **MBSE Tool Manager** Chris Delp if you have any questions or need more information.

View more...

Training

IMCE, SECAE & Professional Development are working together to provide various training opportunities to meet your interests and learning styles. These training opportunities include:

- Traditional classroom courses
- Training Library
- Workshops

View more...

Hot Events & Training

Missed Nerijus Jankevicius', MBSE product manager of NoMagic, overview of new features for 18.3 release of MagicDraw and associated plugins and preview of future releases and features?

Get it here

IMCE FY 16 Implementation Plan Available

Get it here

Missed the MEA Presentation: Traceability Beyond Source Code and Applications by Dr. Lionel Briand?

Get it here.

Missed the NASA/JPL Symposium & Workshop on MBSE - Jan 28-30, 2015?

Get all the presentations here.

MEA Presentation: SysML Conceptual Stumbling Blocks

Missed Rick Steiner's presentation? Get it here.

MEA Presentation: What is the Smallest Model of a System?

Missed Bill Schindel's presentation? Get it here.

Sec 312 Seminar Series: An agile approach to architecture trade studies using MBSE

Missed Peter Shames's presentation? Get it here.

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Implementation and Execution

- Training Profile created for SE practitioners utilizing institutionally established educational programs.
- Training Profiles used as a coaching tool to guide practitioners to acquire needed knowledge and skills, and help establish career paths.

Learning Activity Category	Learning Objective	Specific Learning Activity/Method of Acquisition	System Integration and Test	Verification & Validation	Engineer	System Architect	Flight System SE	Payload Accommodation	Electrical Flight System SE	Entry, Descent, and Landing SE	Fault Protection SE
Division	General understanding of the Division's work. An introduction that includes what we do, strategic objectives, values, etc.	Division Video	R	R	R	R	R	R	R	R	R
	General understanding of JPL's expectation with respect to project implementation and design practices.	Read DP's and FPP's	R	R	R	R	R	R	R	R	R
	Understanding of MBSE Concepts	Links on the MBSE CoP	S	S	S	S	S	S	S	S	S
	Understanding of SE as practiced at JPL and the ten SE Functions	See the SEA webset	S	S	S	S	S	S	S	S	S
	Know the environment in which we operate by understanding a typical project organization and the project lifecycle	TBD	S	S	S	S	S	S	S	S	S
	Develop soft skills that will improve the abilities to both lead and work in a team.	How to Handle Difficult People	C	C	C	C	C	C	C	C	C
		Negotiation Skills	C	C	C	C	C	C	C	C	C
		Presentation Skills	C	C	C	C	C	C	C	C	C
		Problem Solving and Conflict Resolution	C	C	C	C	C	C	C	C	C
Basic System Engineering (Section Mandatory)	Introduction to Section 313 - Introduce new section employees to the Section's charter, each group's focus, typical products, and, at a high level, how the groups interact/interface.	Become familiar with Section 313 Charter/Operating Plan	R	R	R	R	R	R	R	R	R
	Understand FPPs and how they apply to the work that we perform.	Read Design, Verification/Validation & Operations Principles for Flight Systems	R	R	R	R	R	R	R	R	R
	Understand DPs and how they apply to the work that we perform.	Read Flight Project Practices	R	R	R	R	R	R	R	R	R
	Understand the 10 functions and related practices and how they apply to the work that we perform.	Utilize the current videos on the SEA website. Supplement with pointers to the SE Practices on Rules. Use SEFG as reference material.	R	R	R	R	R	R	R	R	R
	Learn how the line and the projects should interact.	Read Implementing Projects in a Matrix Organization	R	R	R	R	R	R	R	R	R
	As work evolves using MBSE techniques, it will be important that all employees have a basic understanding of the important concepts.	Take MBSE 101	R	R	R	R	R	R	R	R	R
Project Orientation	What is a Project? - Describe how JPL projects are funded. Describe differences between a "directed" and "competed" project. Describe key positions within a project. Describe typical project organizations pre- and post-launch. Describe the JPL/NASA Project Lifecycle.	Discuss with your group supervisor	S	S	S	S	S	S	S	S	S
	What is a WBS and which ones are own by 313? - Describe the JPL standard WBS. Describe the relevant 313 parts of it.	Read JPL Standard Flight Project Work Breakdown Structure (WBS) and Dictionary	S	S	S	S	S	S	S	S	S
	What is a WA? - Describe a WA and elements of a well-written one. What is the BOE?	Discuss with your group supervisor	S	S	S	S	S	S	S	S	S
Discipline Related Internal	What you need to know about "inside 313 work" (e.g., I&T, FSE, FP, V&V, EDL, etc...)	Discuss with your group supervisor	S	S	S	S	S	S	S	S	S
	What you need to know about "inside 313 products" (e.g., PFRs, PEL, MEL, circuit data sheets, function lists, "waivers", critical sequences, etc....)	Discuss with your group supervisor	S	S	S	S	S	S	S	S	S
	What is your role in "operations"	Discuss with your group supervisor	S	S	S	S	S	S	S	S	S
Discipline Related External	What you need to know about "outside 313 Stuff" (e.g., telecom, avionics, power, thermal, instruments etc.)	Take specific classes	S	S	S	S	S	S	S	S	S
	What you need to know about "operations"	Discuss with your group supervisor	S	S	S	S	S	S	S	S	S
Genrating New Busisness	What does it mean to "generate a task plan"?	Discuss with your group supervisor	S	S	S	S	S	S	S	S	S
	Tips for writing a successful proposal	Take a proposal class	S	S	S	S	S	S	S	S	S
	Partnering on proposals inside or outside JPL	Take a proposal class	S	S	S	S	S	S	S	S	S
	What is Team-X (312)? And your role	Discuss with your group supervisor	S	S	S	S	S	S	S	S	S
	What is "reimbursable work" and how do I get involved?	Discuss with your group supervisor	S	S	S	S	S	S	S	S	S
	What are the functions of the Program Offices?	Discuss with your group supervisor	S	S	S	S	S	S	S	S	S
Soft Skills	How to Handle Difficult People	Take class	C	C	C	C	C	C	C	C	C
	Presentation Skills	Take class	C	C	C	C	C	C	C	C	C
	Time Management and Organizational Skills	Take class	C	C	C	C	C	C	C	C	C
	Problem Solving and Conflict Resolution	Take class	C	C	C	C	C	C	C	C	C
Certifications	Understand proper mate/demate of connectors	Take Connector Mate & Demate class	R								
	Understand ESD and implications to hardware	Take Electrostatic Discharge - ESD Control class	R								

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Closing Remarks

- Systems engineering is a critical core competency for successful NASA missions (see source)
- The systems engineer is like the maestro, who knows what the music should Sound like (the look and function of a design) an has the skills to lead a team in achieving the desired sound (meeting the system requirements) (See source)

  Source: The Art and Science of Systems Engineering by Dr. Michael Ryschkewitsch

- Training the SE state-of-practice complimented with the state-of-art (MBSE) helps raise engineers competency level and stay current with evolving SE practices
- Training requires continuous investment and commitment in execution
- Measuring training effectiveness is a challenge

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