Firsthand Reports on the INCOSE 2014 International Workshop

February 18, 2014

IW2014 Attendees

INCOSE
International Council on Systems Engineering

IW2014

- January 25-28, 2014
- Torrance Marriott South Bay, Torrance, CA
- Learn, Network, and Engage
- Eight C-NO Members in attendance
  - Chuck Alexander, Sean Beckman, Cody Farinacci, Marton Forkosh, Edith Parrott, Dennis Rohn, Ron Toll, Katie Trase
- IW2015 in LA

INCOSE
International Council on Systems Engineering

Opening Plenary

- 388 Participants – largest IW ever
- Administrative Report (as of 12/31/13)
  - 9422 Members, 67 chapters
  - 74 CAB members (5 new)
  - 21 Academic Council Members
- Why Use Social Media
  - 61% of engineers use social media for work related activities
- WG Awards
- President's Farewell
- Installation of New Officers
- Service Awards
- President's Remarks
- Technical Operations Report
- IT Realignment
- Certification Update

MBSE WORKSHOP
(AND RELATED MEETINGS)

Presentations available on the MBSE Wiki:
http://www.omgwiki.org/MBSE/doku.php?id=mbse:incose_mbse_iw_2014

Workshop Theme: Infusing MBSE Across Domains
   6 challenge teams, 7 activity teams, 2 related WGs

MBSE Workshop Agenda

- Keynote
- MBSE Implementation Across Diverse Domains at The Boeing Company
- How MBSE is used in Rail
- Integrating Descriptive Models with an Analytical Model Culture : Lessons Learned at Ford
- Applying Model-Based Patterns At Procter & Gamble
- Application of MBSE at JPL Through the Life Cycle
- MBSE in Government - Leveraging the 'M' for DoD Acquisition
- MBCD Working Group - 2013 Activity Report
- Future Directions for MBSE Research and Education: What to Focus on and Why?
- Breakout Session Reports
- Selected Takeaways and Closing Statements

MBSE Workshop Keynote

MBSE–the missing Link in the digital Enterprise Strategy

- Google Earth metaphor for future MBSE modeling environments
  - Continuous, layered, 2-way vertical zoom and horizontal connections
  - Need improved visualizations of SysML models for efficient and effective use
- MBSE Benefits (Europa Orbiter team)
  - More efficient and accurate communication of technical information
  - Greater re-use and evolution of system designs
  - More consistent, controllable generation of system metrics and normalization of risk assessment
  - More efficient generation of project documentation
  - A better bridge from college education to project best practices
  - More complete capture of expert knowledge, lessons learned, principles

INCOSE
International Council on Systems Engineering

MBSE Workshop Keynote (cont.)

MBSE–the missing Link in the digital Enterprise Strategy

- "MBSE translates physics, functional, economic, and social (product) data into a digital, integrated model"
- Beware:
  - The product of an arithmetical computation is the answer to an equation; it is not the solution to a problem
  - Confusing the model with reality is like sitting in a restaurant and proceeding to eat the menu
- MBSE has grown in popularity as a way to deal with the limitations of document-based approaches, but is still in an early stage of maturity
- A thorny path with incremental steps for years to come
- MBSE is on an acceleration path and will become the norm for System Engineers in "complex product" enterprises by the turn of the decade
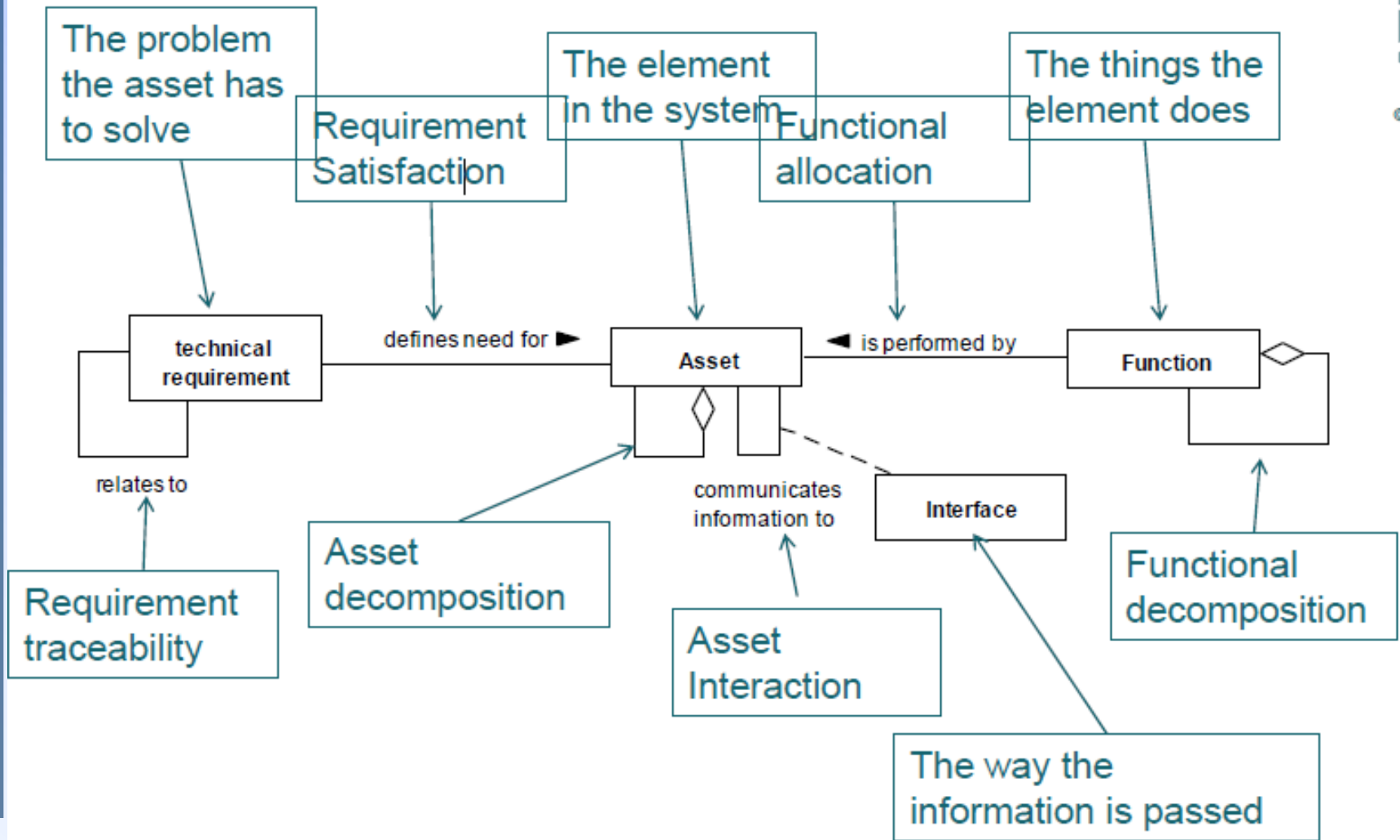
Industry Experiences: Boeing Corp.

- "A diagramming interface is impractical for analyzing millions of objects and relationships for integrity"

- Training offered on 2 sides:
  - Processes and architectures
  - Tool-specific implementation of those processes

- Skills: SE experience, product domain knowledge, tool use, modeling skills
  - "Knowing what to model, at what level of detail, to answer which questions"

- Core group provides modeling support to all programs

INCOSE
International Council on Systems Engineering

Dr. Brownsword:
How MBSE is used in Rail

<u>Before starting</u>

- Identifying the right process

- Understand the information and activities to be delivered

- Don't focus on documents but on the activities

What is the Information

The problem the asset has to solve

Requirement Satisfaction

The element in the system

Functional allocation

The things the element does

technical requirement —— defines need for ▶ —— Asset —— ◀ is performed by —— Function

relates to

Requirement traceability

Asset decomposition

communicates information to

Interface

Asset Interaction

Functional decomposition

The way the information is passed

INCOSE
International Council on Systems Engineering
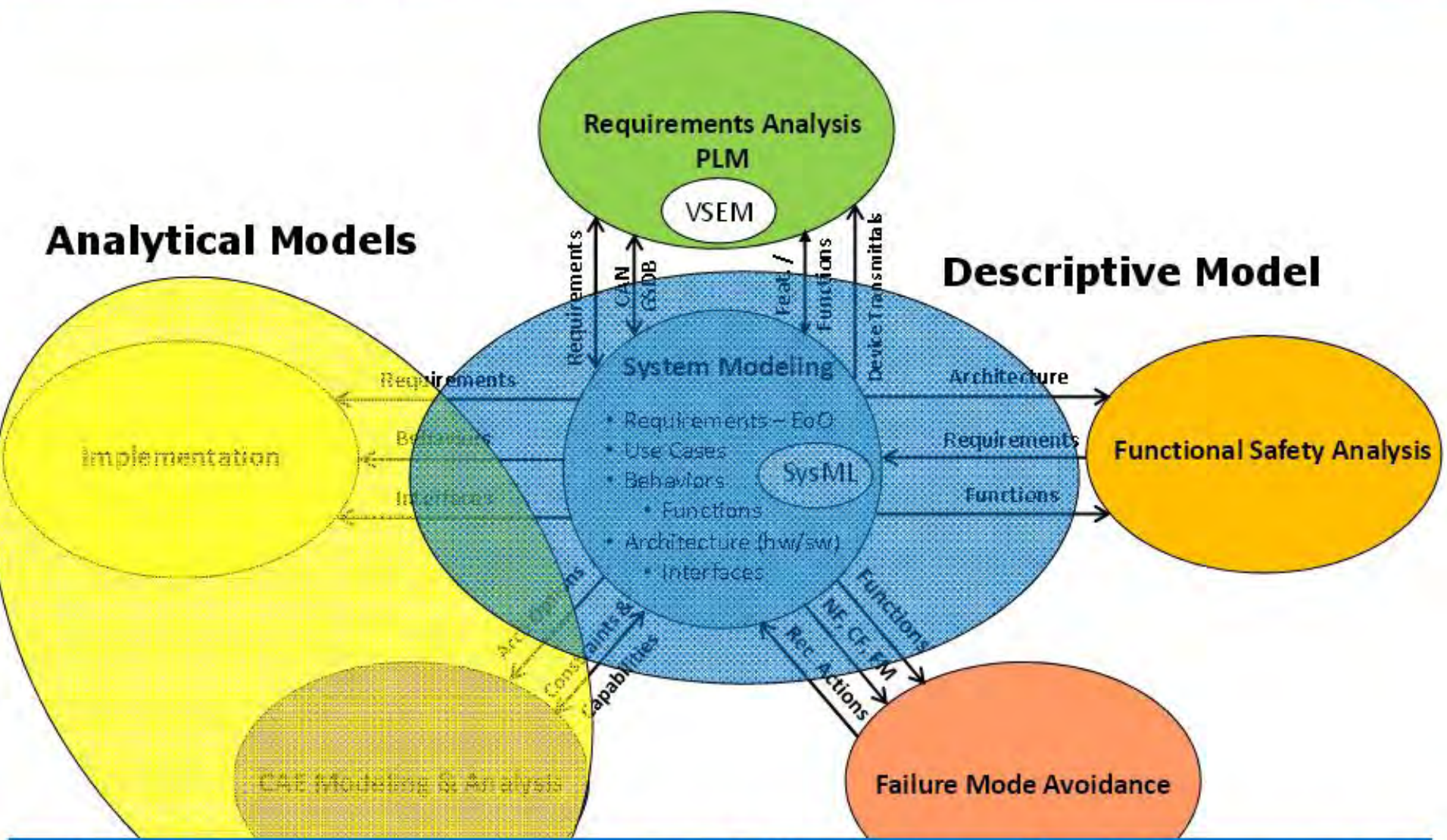
Industry Experiences: Ford Motor Co.

- Found more constructive feedback provided on a model vs. a document

- Extensive planning on model development, integration, V&V during system development

- Management currently acting out of goodwill (based on previous good work)- still have not seen ROI yet to incentivize

> In one case a proposed project, which was originally not kicked off due to questions on the ability to meet timing, was approved on the spot after creating a SysML model and walking the decision makers through the diagrams. None of the decision makers involved had ever heard or seen SysML before the meeting.

- Brought on InterCAX (contractor) to help set up

- Excited about generating, populating FMEAs

INCOSE
International Council on Systems Engineering

Descriptive / Analytical Model Breakdown

Analytical Models

Descriptive Model

Requirements Analysis
PLM

VSEM

System Modeling

- Requirements – EoO
- Use Cases
- Behaviors
  - Functions
- Architecture (hw/sw)
- Interfaces

SysML

Implementation

Requirements

Behaviors

Interfaces

CAE Modeling & Analysis

Architecture

Requirements

Functions

Functional Safety Analysis

Failure Mode Avoidance

Distinguishing the purpose and value of different types of models in an overall MBSE strategy helped alleviate concerns that SysML was yet another modeling language to compete with existing analytical modeling languages.

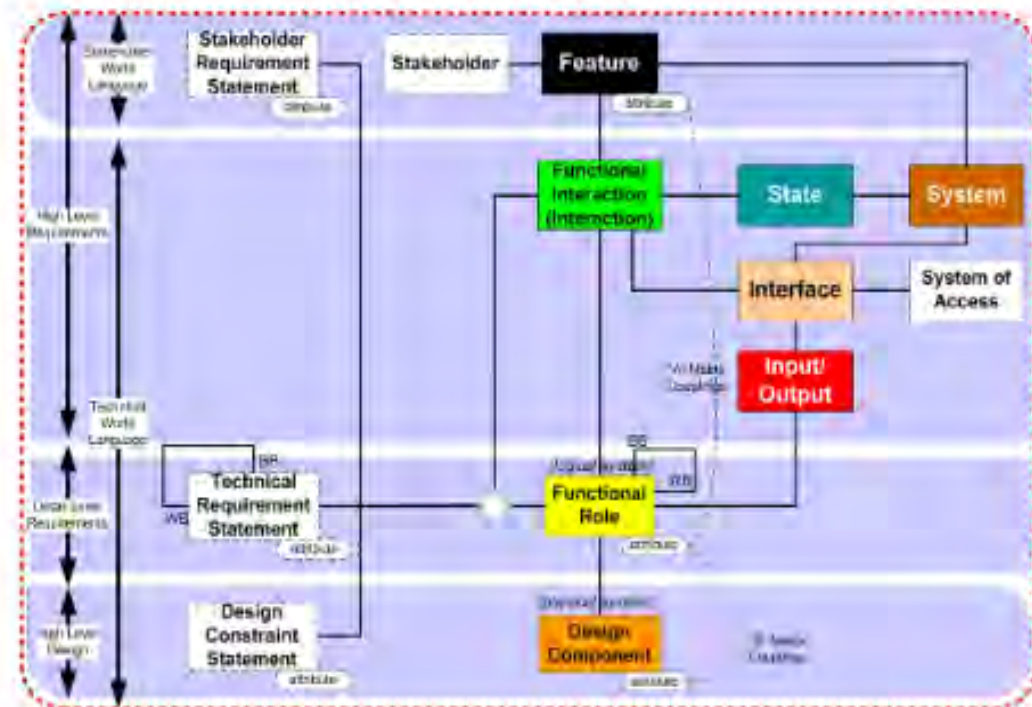# Industry Experiences: Procter and Gamble Co.

- No budget/overhead for typical SE
  - Must prove value with no increase in headcount
  - Add SE to reduce inefficiencies
  - Had to find SEs from other engineering disciplines
- Uses "Pattern-Based" SE that uses, but does not require, SysML
- Reusable, configurable model "patterns" moves implementation challenge from learning "how to model" to learning the "company's models"

INCOSE
International Council on Systems Engineering
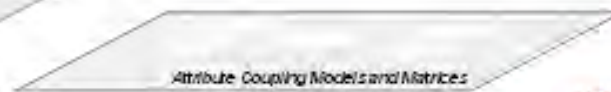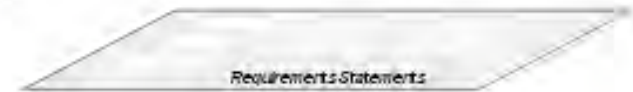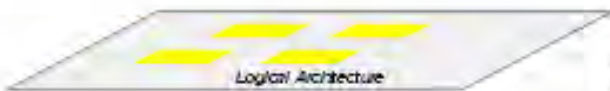
Systematica™ framework for MBSE

- ## Systematica (S*) Metamodel

  - A succinct model than can describe virtually any system, and that is independent of SE tools or languages used

MBSE provides a powerful paradigm for discovering all the Interactions, and therefore all the system Functional and Non-Functional Requirements
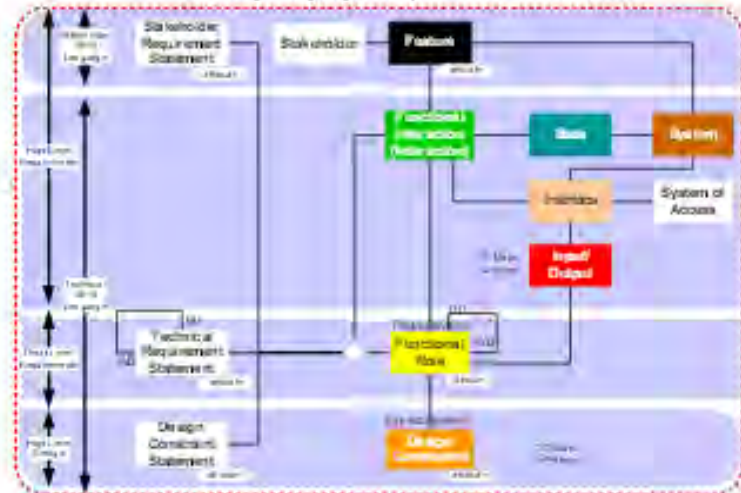
S* Metamodel

Systematica™ Views

Stakeholders, Features

Interactions

State Model

Domain Model

Logical Architecture

Detail Interaction Model
Detail Interaction Model
Detail Interaction Model

Requirements Statements

Physical Architecture

Attribute Coupling Models and Matrices

Modeling Language Independent S*Metamodel

Generic Views

SysML Specific Views

SysML Diagram

Behavior Diagram

Requirement Diagram

Structure Diagram

Activity Diagram

Sequence Diagram

State Machine Diagram

Use Case Diagram

Block Definition Diagram

Internal Block Diagram

Package Diagram

Parametric Diagram

Procter and Gamble Co.

Conclusion

- MBSE and PBSE make Systems Engineering an attainable goal for CPG
  - We are re-inventing lost organizational capability
  - New capability is superior, pervasive and persistent compared to requirements management before SE
  - Fully integrated solution can initially be supported by contract Systems Engineers
  - Demonstrated value will allow us to add dedicated Systems Engineers to our own organization
  - S* Methodology independent of SE Tools, we have ported it to DOORS, TcUA and soon: Enovia

JPL: MBSE Life Cycle

Motivation:
- Early validation of system design
- More engineering analysis time with less paper
- Improved communication
- Reduces # of products and mission defects work more complex projects
- Increased productivity which reduces cost

Benefits realized:
- Re-use of system design elements
- Improved control over the evolution of the system design
  - Less time to do mission studies
- Consistent and rapid generation of technical margin
- Consistency of documentation
  - Ensuring consistency by drawing from same system model

JPL: MBSE Life Cycle
Issues discovered

- **Need to modify the SE approach**
  - Keep SE products updated with the ongoing design/developments/tests
  - Sharing information across a diverse team avoiding information "silos"
  - Improving the flow and traceability of design decisions and tests
  - Managing cross-cutting complexity and understanding of scope
  - Pre-empting the V&V "armageddon" at the end of the project – 3 test beds running 7 days a week!
  - Improving parameter tracking and test correspondence (and visibility by others on this)

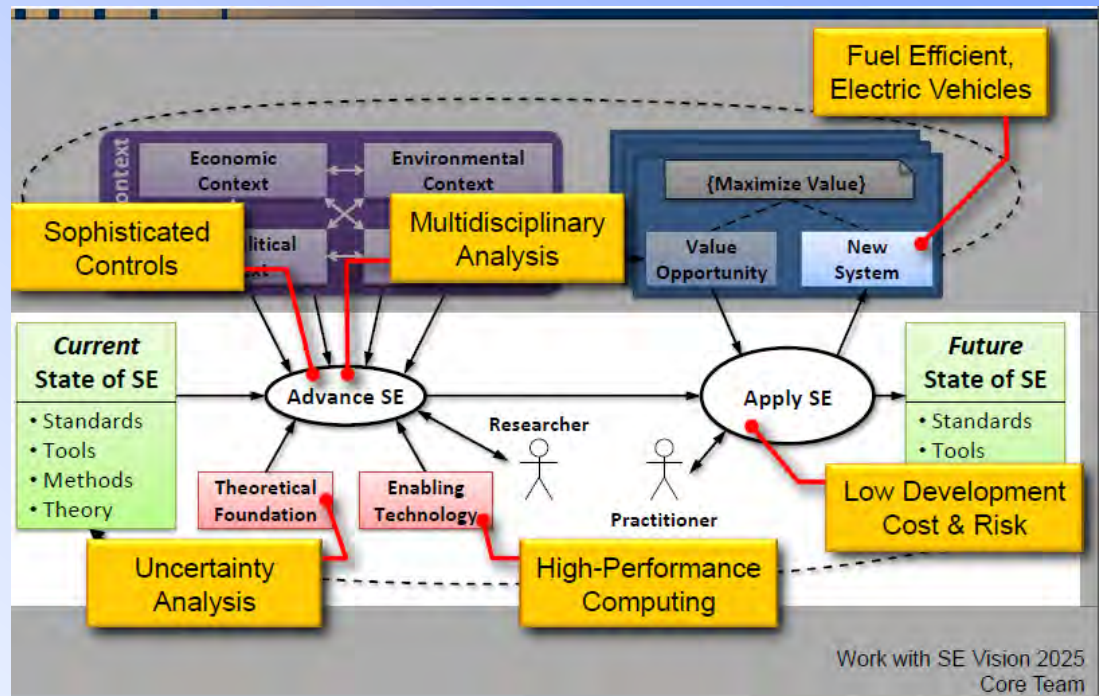# JPL: MBSE Life Cycle
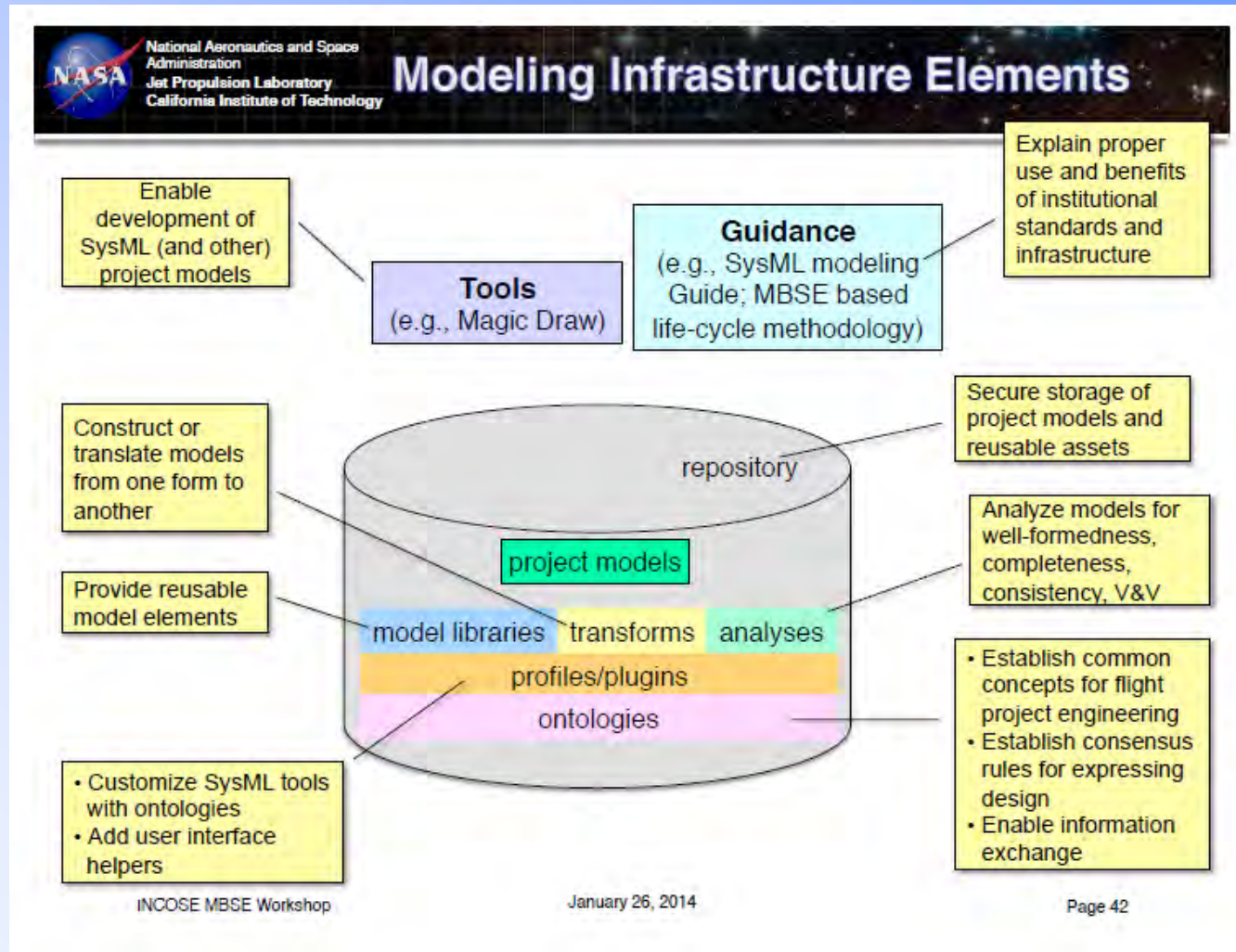
JPL: MBSE Life Cycle
SE Team Composition
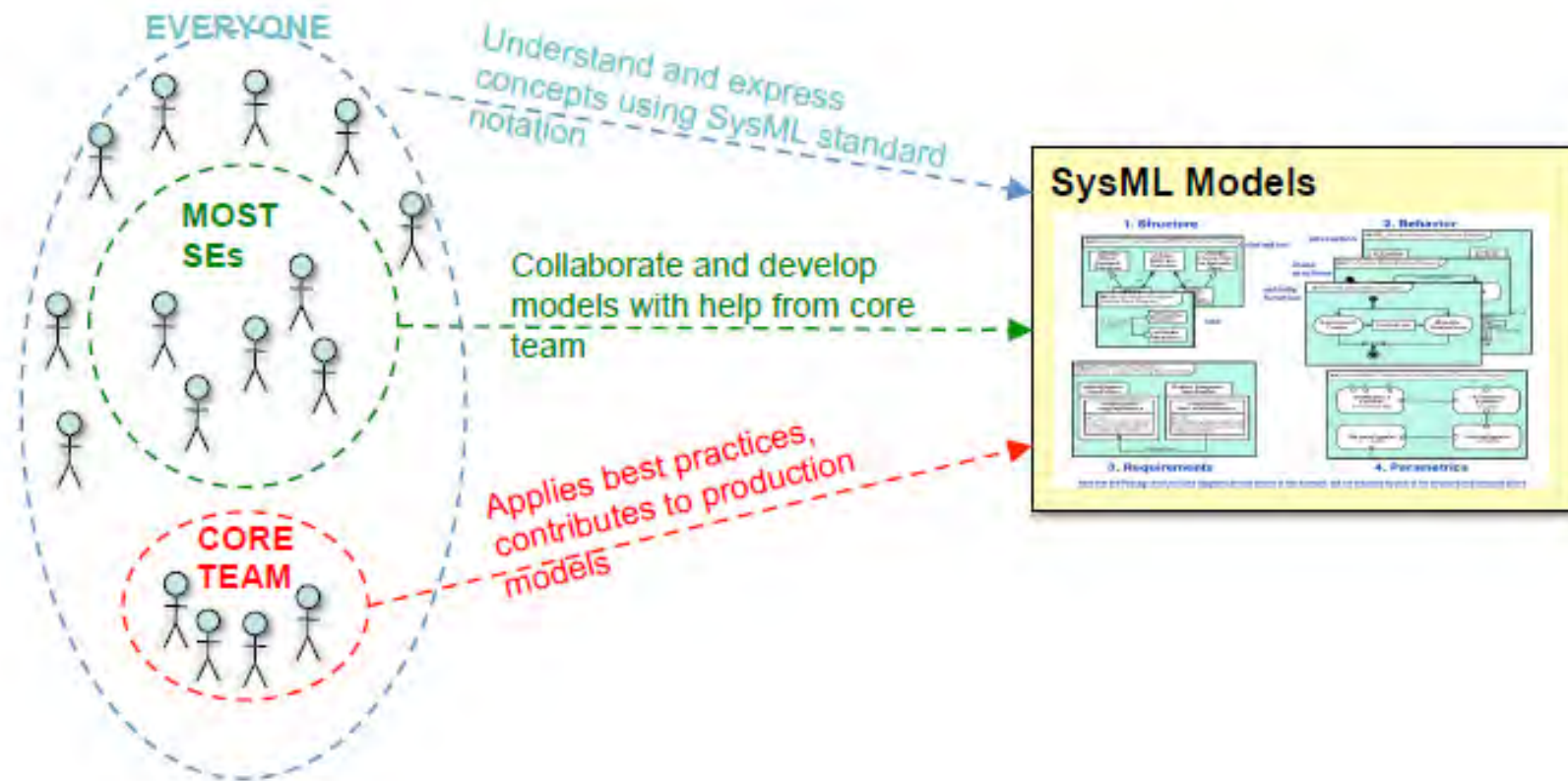
Chris Paredis:
What to Focus on and Why

- Maximizing Value and how SE can drive advances

Chris Paredis:
What to Focus on and Why

- Advances in SE for Enabling Technology

  - Ways to Collect, Store, Express, Share, Manage, Process, Access, and interpret information

  - Accomplished by better decision in methods and tool development

- Advances in SE for Theoretical Foundation

  - Gap between SE practices and Theorectical practices

  - Accomplished by how to formulate and solve SE decisions

INCOSE
International Council on Systems Engineering

Chris Paredis:
What to Focus on and Why

Summary

- As the global context changes, SE must adapt…

  …by operationalizing the theoretical foundation for each specific context

- Increasing complexity
- Shorter lifecycle times
- Decentralization
- Miniaturization
- Mass-customization
- Human-centered

- Systems of Systems
- The Internet of Things
- Dynamic, Data-Driven Application Systems
- Sustainable Systems

INCOSE
International Council on Systems Engineering

Industry Experiences

- DOD Models, Simulations, and Analysis

  – SEs must plan for Models and Sims as part of design development process

- MBSE Research and Education

  – Models (formal languages) bring down the "cost of communication"

  - No one must sit and explain a concept ('just read the model')

  - Increased communication effectiveness will lead to further distribution of the organization

    – Crowd-sourcing system problems?

INCOSE
International Council on Systems Engineering

Industry Experiences

- John Deere
  - Doesn't have a formal SE presence currently, but planning to foster SE
  - "When it SE is deployed, it will be model-based. We wouldn't even think of doing it any other way"
  - "Commercial sector hasn't historically used SE, but MBSE will allow quick integration of SE"

INCOSE
International Council on Systems Engineering

Industry Experiences

- Raytheon
  - Investing in MBSE and MBE
  - Scalability (team size), access control, IP still challenges
  - Use pilot approach to break "business as usual" mindset

- Skygazer Consulting
  - http://blog.ricksteiner.net/?tag=sysml
  - Top SysML Stumbling Blocks

MBSE Breakout – Infusing MBSE into an Organization

- Objective
  - Main objective of this break-out session is to identify effective approaches for infusion of MBSE into practice
    - Survey different infusion MBSE approaches into organizations
    - Identify enables and barriers
- Pre-defined questions
  - How do you measure infusion progress?
  - What is the nature of the organization for which your are infusing MBSE
    - E.g. size, function, discipline, product
  - What enablers and barriers in your environment
  - What primary MBSE value do you communicate to for your stakeholders to obtain their involvement/commitment. Do you try to measure this value?

MBSE Breakout – Infusing MBSE into an Organization – Enablers

- Corporate/Institutional Support:
  - Top-level leadership support, strong management support
  - Seed funding from corporate and BA and BU
  - Corporate cross-BU collaboration and vendor relationship
  - Having authority to change corporate processes and tools (Ford SE Council)
  - Organizational commitment to follow-through
  - Strategically embed MBSE-enabled engineers in projects, Forge close relationships with projects

- Success Stories:
  - Culture and heritage of success
  - Conduct pilots, small success stories, "build a little, deploy a little"
  - Bite-sized but steady and pragmatic deployment … don't forget still being able to do the basics

- Tools:
  - Develop and deploy tooling for ease of usability
  - Shared model repositories

- People:
  - Passionate practitioners
  - Interested people (managers, engineers)
  - New employees
  - Customer excitement
  - Team up young engineers with senior engineers; recruit early-career engineers
  - User community / tech clubs for informal support

- Training:
  - Tool-neutral and tool-specific process training
  - Well-defined processes to address "now what do I do?"
  - Codify know-how into formal repeatable methodologies
  - Readily available and consistent training

INCOSE
International Council on Systems Engineering

MBSE Breakout – Infusing MBSE into an Organization – Barriers

- Barriers:
  - "Not the way we do business", "Show me the ROI"
  - Conservative engineering philosophy
  - Early negative experiences with immature tool sets
  - Difficulty integrating with long-running legacy programs
  - Need for "up front" funding with value realized late in the program
  - *Not invented here* syndrome
  - *Scape goat* syndrome (if something goes wrong, blame MBSE)

- Tools:
  - Maturity of tools and their integration
  - Tool interoperability and data exchange gaps
  - Internal policies governing new tools
  - Learning curve

INCOSE
International Council on Systems Engineering

MBSE Breakout – Infusing MBSE into an Organization - Main value communicated to stakeholders?

- Reduced rework, earlier visibility into risk and issues

- Reduced cycle time, reduce development cost, cost avoidance

- Better communication and more effective analysis

- Potential for increased re-use (product line reusability: engineering done once, reuse elsewhere)

- Ability to generate and regenerate current reports and work products

- Knowledge management (long-term and short-term)

- Single source of truth

- Competitiveness (our partners and competitors are doing it)

- Think about how much of an engineer's time is spent on data management rather than critical thinking (Change that ratio! Shift the *nature* of my hours)

MBSE Breakout – Model Management

- Review current practices and challenges in model management

- Versioning

- CM

- Granularity

- Vendor Representation: Siemens, PTC, IBM, NoMagic, InterCAX, Phoenix Integration
  - Product Line Engineering
  - The "Ws" of model management
  - Use of model in SE is not necessarily MBSE

- JPL use of Alfresco

INCOSE
International Council on Systems Engineering

MBSE Breakout – MBSE 101

- FAQ Format
  - What is MBSE?
  - What SE problems does MBSE address?
  - What is SysML?
  - What is a system model?
  - What are typical purposes of modeling?
  - What are the different types of models
  - How are the different types of models integrated?
  - How can models help a SE effort?
  - What does MBSE mean for projects?
  - How does MBSE Compare to Traditional SE?
  - How good is a model?
  - What is an ontology?
  - Why are ontologies relevant?
- Lessons Learned
  - JPL Perspective

MBSE Breakout – MBSE and Education/Research

- SE curricula based on GRCSE (Graduate Research Curriculum for SE)
- Discussion on MBSE vs. SE curricula
  - Knowledge, Skills and Abilities needed for MBSE
    - What are specific KSAs desired for MBSE?
    - Abstraction v. approximation
    - Which level of abstraction / approximation?
    - Object-oriented thinking
    - Modeling patterns
    - Modeling in teams
    - Meta-modeling
    - Modeling not diagramming…
- Recap of Research Opportunities in SE in general
- Discussion on MBSE-specific research opportunities and challenges

INCOSE
International Council on Systems Engineering

MBSE Breakout – MBSE and Government

- Challenges (difficulties and roadblocks) in implementing MBSE in government

- Possible approaches for implementing MBSE in government

- 'Good practice' examples of MBSE implementation in government

INCOSE
International Council on Systems Engineering

MBSE Workshop Takeaways

- Context for SE and MBSE
  - Digital engineering and digital enterprise and smart systems (smart factory, smart vehicle)
    - Everything digitized, everything connected (internet of things)
  - Google earth analogy for MBSE to seamlessly zoom in and out
    - Integrate vertically and horizontally
    - Leverage IT technologies (visualization, connectivity, processing, ..)
  - MBSE is in state similar to early stage of CAD

- Diversity of applications
  - <u>Systems:</u> Diapers/Automobiles/Spacecraft
  - <u>Production lots:</u> millions per day/millions per year/few per year
  - <u>Unit</u> cost: 0.25/25K/2.5B

INCOSE
International Council on Systems Engineering

MBSE Workshop Takeaways

- All kinds of models
  - descriptive models including data & process
  - analytical models
  - CAD models
- Use of models
  - Organize technical data
  - Answer specific questions
- System model
  - Describe system
  - Integrate discipline specific models
    - (e.g., integrated vehicle analysis)

- System Model Benefits
  - Communicate system information among stakeholders
    - domain engrs and disciplines (subsystems, ilities, mfg, …)
  - Reuse of modeling information
  - Finding req'ts & design gaps/inconsistencies
  - Increased trade space exploration
  - Improved testing
  - …

INCOSE
International Council on Systems Engineering

MBSE Workshop Takeaways

- Importance of MBSE methodology (e.g., systematic approach)

  – Reqt's, functions, interfaces, features, components, analysis, verification

  – Analysis of behavior, performance, other attributes, failures

  – Use of patterns/product lines

  – Use of models across life cycle

- Challenges

  – Tool integration

  – Visualization of models

  – …

INCOSE
International Council on Systems Engineering

MBSE Model Management - Monday

- Review of White Paper on Model Management
- OSLC4MBSE (Open Services for Lifecycle Management)
  - A method for tools to talk to one another
  - Use of "URLs"5

Subject	Predicate	Object
Object ID	Info Type	Values
Req't ABC	Name	Req't ABC
Req't ABC	Type	requirement

- Model Management and CM
  - Addressed primarily from a s/w perspective
- Tool Vendor Demos

INCOSE
International Council on Systems Engineering

MBSE Usability – Monday

- To identify how systems engineering languages such as SysML, processes, and supporting tools can be made easier to learn and use and to promote usability improvements.

- Recent focus has been on the creation and use of libraries – capturing of patterns.

- Need a "style guide" on how to diagram the model.

  - E.g. how are interfaces represented

WORKING GROUPS

Pattern-Based SE Working Group - Monday

- S*metamodel: smallest set of ideas needed to model a system for engineering or science

  - Resulting S*models may be expressed in SysML or other languages

- Platform: like a family of products that have slight variations to meet a certain usecase

  - The pattern underlies the platform

- S*compliant: do you have enough information to make/complete the part of the task (e.g., develop requirements?)

- Strongest patterns are configurable- just have to populate classes, set attribute values, but NO specialization

- Fast generation of draft FMEA tables

- Pattern ~ Framework ~ Reference Architecture

Power and Energy Systems Working Group - Tuesday

- EnergyTech 14: July 28 – 30, 2014
  - Abstracts due February 28th; Papers due March 30th
- Future of Energy presentation by Alex Pavlak/ Chesapeake Bay Chapter
- Ohio State Steckler Grant update from Al Juhasz
- MOU with AIAA, IECEC, IEEE collaboration by Chuck Alexander
- Introduction of MBSE for Energy by Katie Trase
  - Looking for help with modeling!
- Google Hangouts planned to continue refining MBSE concept and discuss updates to Alex's Energy Initiative
  - Use INCOSE website to share information, resources, references

INCOSE
International Council on Systems Engineering