A Few Words First

Courtesy – Please mute your phone (*6 toggle).

Upcoming Meetings:

- **Mar 14: Systems Engineering Transformation**
  Troy Peterson, System Strategy, VP; Director INCOSE's Transformation Initiative
- **Apr 11: Is Systems Engineering Really Engineering? LUNCH MEET 11:45-13:00**
  Dr. Steve Jenkins, JPL, Chief Engineer of Integrated Model-Centric Engineering
- **May 09: Creating Decision Guidance for Applying Agile System Engineering**
  Ron Lyells, Retired Honeywell, Co-Chair INCOSE Agile Systems & SE WG
- **May 10-11: Tutorial – Model Based Systems Engineering**
  Mathew Hause, PTC, Engineering Fellow; Chair OMG SysML V2 submission team
- **Sep 20-22: Western States Regional Conference, Ogden, Utah**
  Website: https://incose-wsrc.eventbrite.com, Presentation call open all of March

CSEP Courses by *Certification Training International:*
Course details | Course brochure
Upcoming Course Schedule (close by, but many more locations and dates):
2018 Feb 26-Mar 02 | Las Vegas, NV
2018 Apr 02-Apr 06 | Denver, CO
2018 May 21-May 25 | Austin, TX
2018 Oct 15-Oct 19 | Albuquerque, NM

Chapter SEP mentors: Ann Hodges alhodge@sandia.gov, Heidi Hahn hahn@lanl.gov

First slide, not recorded but retained in pdf presentation.

And Now - Introductions

Enchantment Chapter Monthly Meeting

14 February 2018 – 4:45-6:00 pm:

MBSE Implementation Across Diverse Domains

Dr. Ron Carson, Seattle Pacific University, ronald.s.carson@gmail.com

Abstract: This presentation discusses some necessary considerations in selecting MBSE strategy, processes, and tools. These considerations include the variety of organizational products and services, size and complexity of products and services, phases of the life cycle, and organizational knowledge and culture regarding systems engineering, modeling, and complex, data-based-driven tools. Therefore diversity itself is a multi-dimensional function of organizational history and future plans for products, services, and organizational skills. This situation is made more complicated by a desire not to compromise near-term business performance while introducing new organizational capability.

Download slides today-only from GlobalMeetSeven file library or anytime from the Library at www.incose.org/enchantment

NOTE: This meeting will be recorded

Today's Presentation

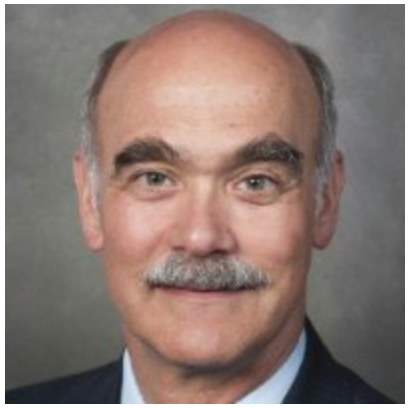
Things to Think About

How can this be applied in your work environment?

What did you hear that will influence your thinking?

What is your take away from this presentation?

Speaker Bio



Dr. Ron Carson is an Adjunct Professor of Engineering at Seattle Pacific University, an Affiliate Assistant Professor in Industrial and Systems Engineering at the University of Washington, a Fellow of the International Council on Systems Engineering and a certified Expert Systems Engineering Professional (ESEP®).

He retired in 2015 as a Technical Fellow in Systems Engineering after 27 years at The Boeing Company.

He is the author of numerous articles regarding requirements analysis and systems engineering measurement, and is the developer of numerous industry systems engineering training courses.

He has been issued six US patents in satellite communications, and two patents regarding “Structured Requirements Generation and Assessment.”

His current interests are in quantitatively incorporating sustainability considerations in systems engineering methodologies and education.

Dr. Carson has a PhD from the University of Washington in Nuclear Engineering (Experimental Plasma Physics), and a BS from the California Institute of Technology in Applied Physics.

MBSE Implementation Across Diverse Domains at The Boeing Company

INCOSE MBSE Working Group
25-26 January 2014

Barbara Sheeley, Robert Malone, John Palmer, Ron Carson (ronald.s.carson@gmail.com)

Topics

- Boeing diverse product lines
- Boeing approach to MBSE
- Boeing MBSE challenges
- Boeing MBSE needs from industry

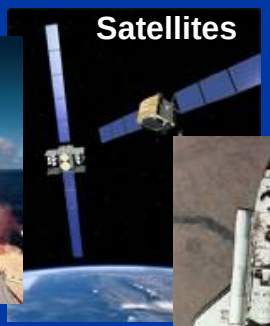
Boeing at a Glance

The Boeing Company

- **Customers and customer support in 150 countries**
  - Total revenue in 2012: $81.7 billion
  - 70 percent of commercial airplane revenue from customers outside the United States
- **Manufacturing, service & technology partnerships with companies around the world**
  - Contracts with 22,000 suppliers and partners globally
- **Research, design & technology-development centers & programs in multiple countries**
- **More than 170,000 Boeing employees in 50 states and 70 countries**

A Sample of Diverse Boeing Products

The Boeing Company



FUTURE PROGRAMS

Diverse Boeing Product Domains

- Commercial Airplanes and Aviation Services
- Defense, Space & Security includes:
  - Boeing Military Aircraft
  - Network & Space Systems
  - Global Services & Support
  - Phantom Works
- Components to systems-of-systems
- Highly networked and high-integrity performance demands

Product and Organizational Diversity Yields MBSE Challenges and a Need for Diversity of MBSE Solutions

Topics

- Boeing diverse product lines
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- Boeing MBSE challenges
- Boeing MBSE needs from industry

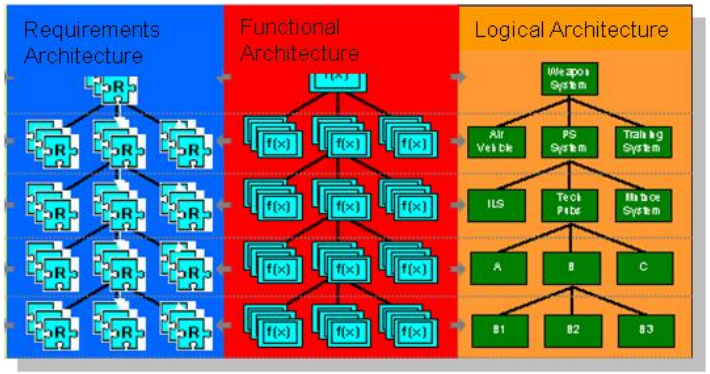
Boeing Enterprise Approach to MBSE Implementation

- **Education on the topic of MBSE**
  - Reestablishment of basic SE beyond requirements management
  - Importance of functional models (Carson & Sheeley, INCOSE 2013)
- **Development of MBSE capability for programs to use**
- **Development of guidance for how to use the MBSE developed capability**
- **A core group that provides support to all programs**
- **Means to capture and share successes and lessons learned**

Boeing Approach to MBSE Capability Development

- **A unified enterprise approach**
  - Common process
  - Common set of tools

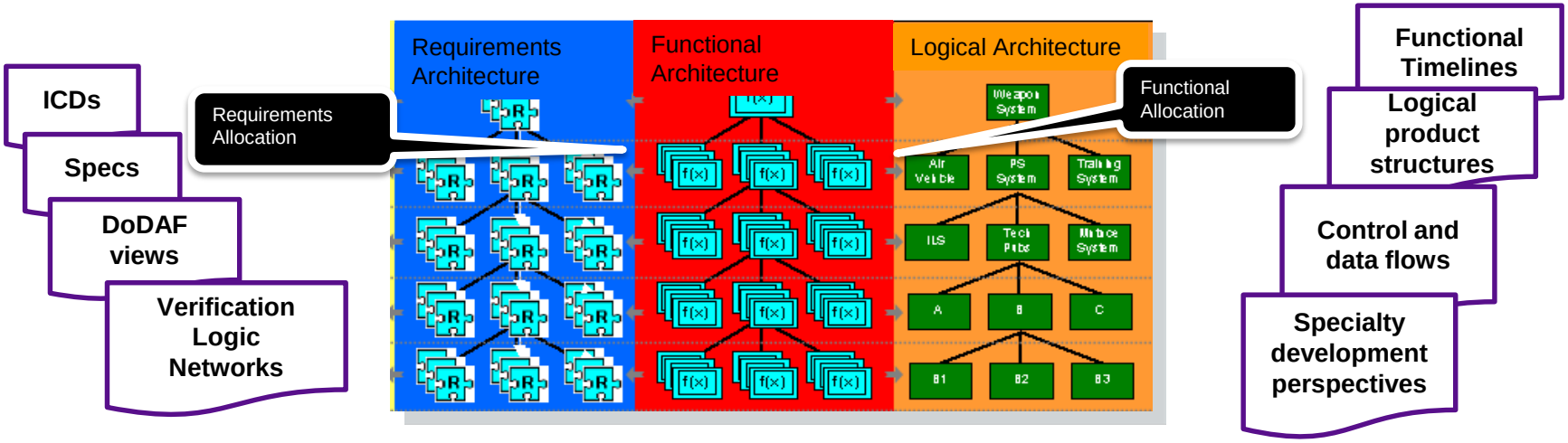
- **MBSE will be accomplished thru capturing information in an integrated architecting environment, in 3 major architecture pieces**
  - Functions and interfaces
  - Requirements
  - Logical elements and interfaces



- **Architecture data extended / used to perform integration, verification and validation efforts**

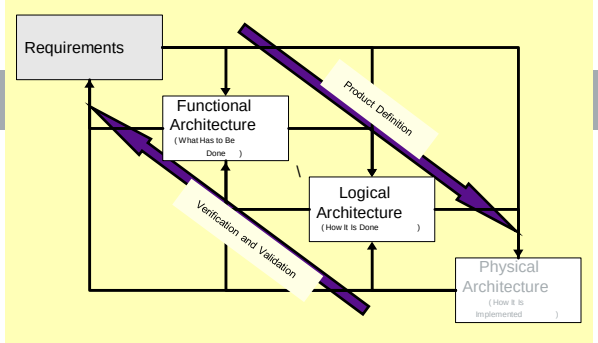
Integrated Product Architectures at The Boeing Company

- IPA is a enterprise effort to develop and deploy a common capability to enable Boeing engineers to integrate requirements, architectures, and analyses
- IPA uses a model based systems engineering (MBSE) approach in an integrated data environment
- The integrated architecture environment enables consistent, seamless generation of SE artifacts and enables more effective system trades

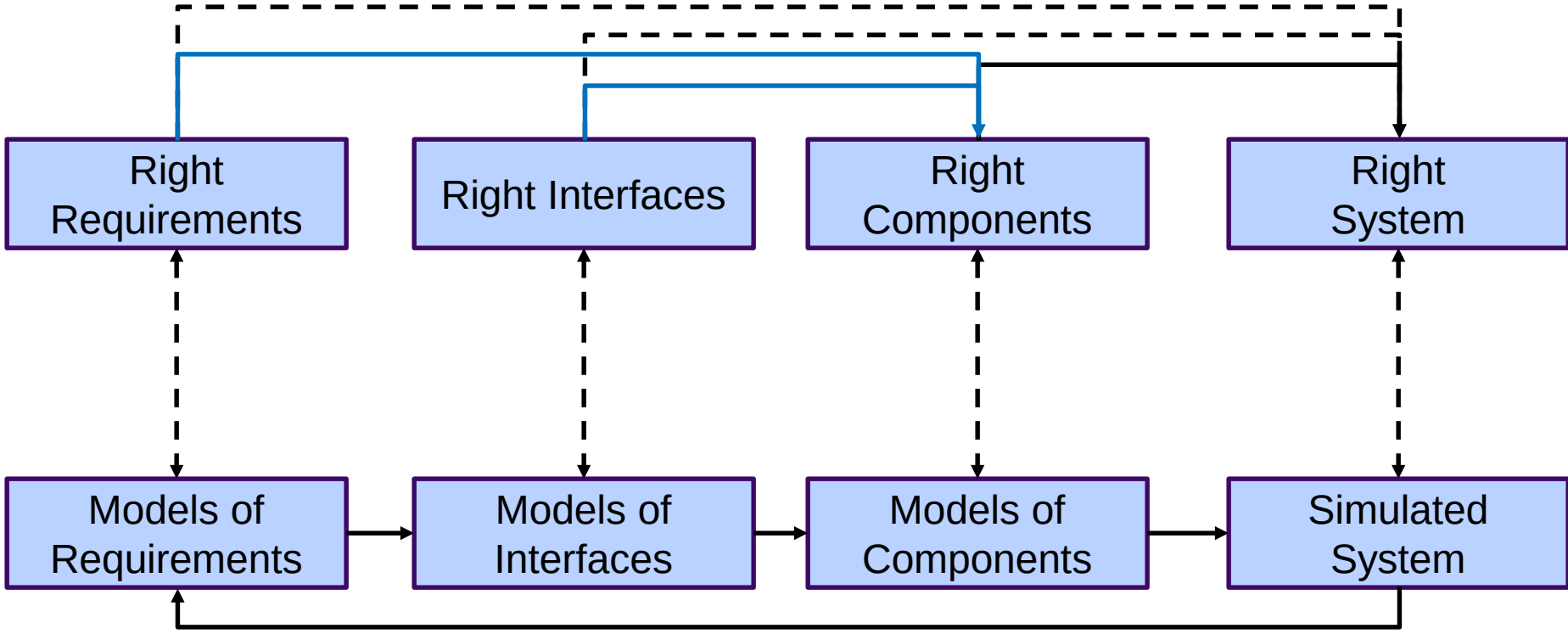


Architecture Data Captured and Managed in a Single Data Environment Ensures Product Quality and Enables Affordability

Getting it Right



- **MBSE can improve probability of "getting it right" the first time**



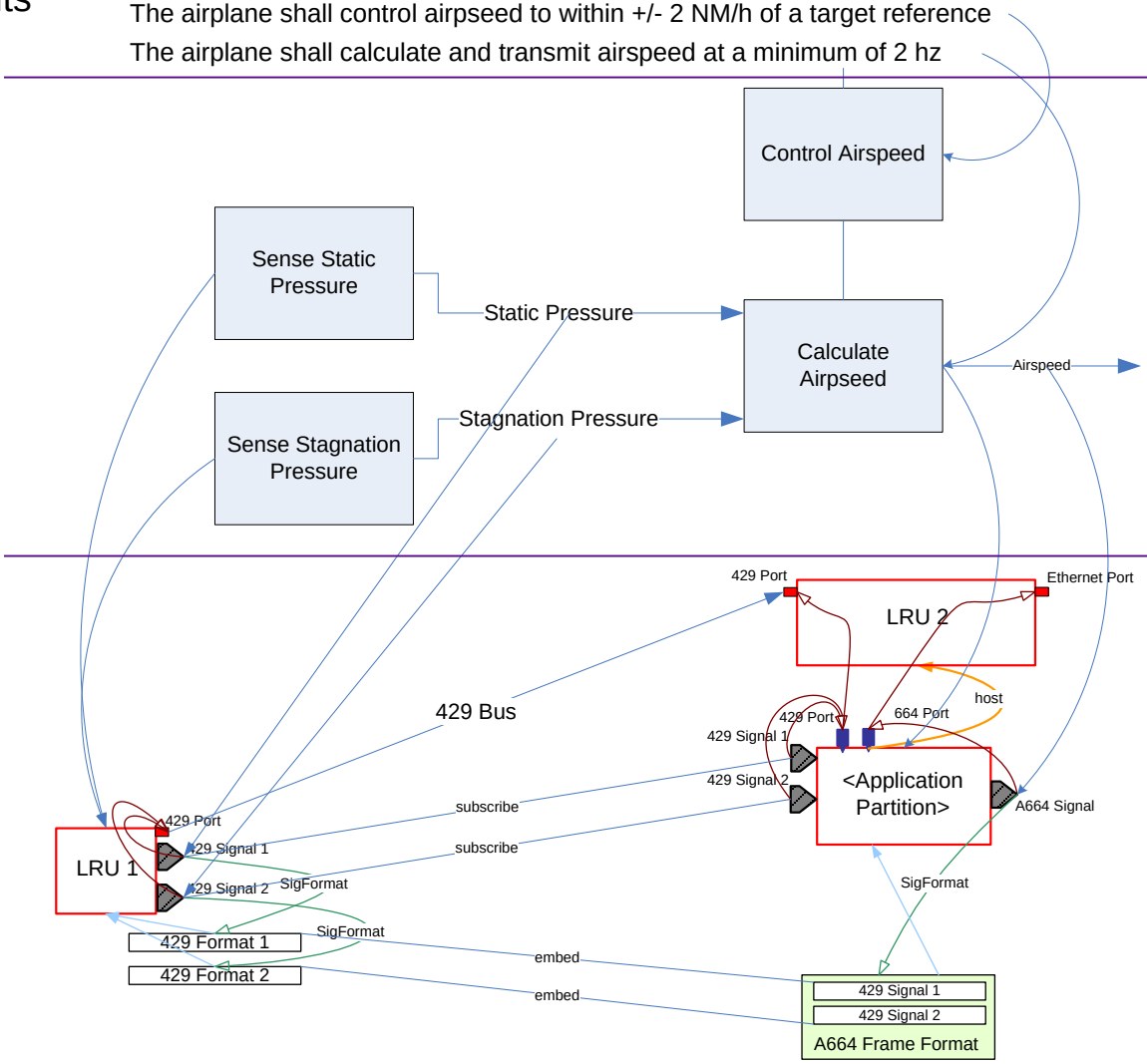
All Information is Connected in a Single Data Model

Getting the Specifications Right

Requirements Architecture

Functional Architecture

Logical Architecture



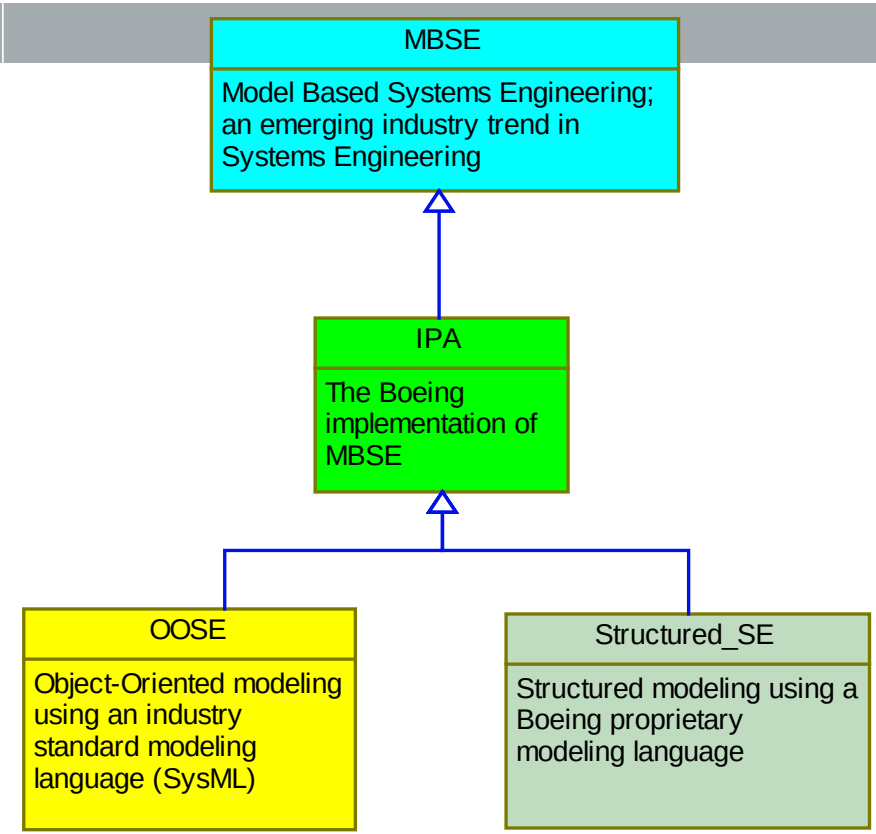
Do the functions and requirements included in the specification completely and accurately specify the logical architecture model?

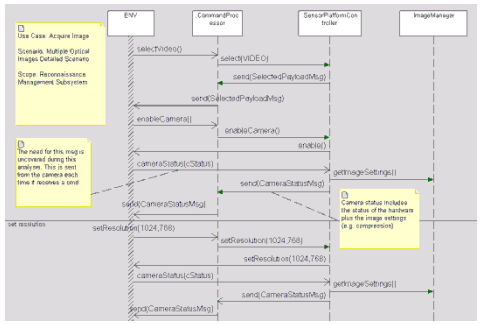
Are the individual specifications, especially regarding interfaces, consistent with each other?

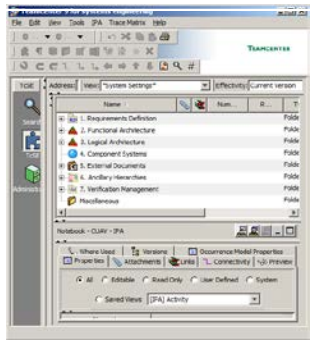
Boeing Approach to MBSE Tools

- **Structured MBSE approach**
  - Siemens® Teamcenter® for SE → Teamcenter® Unified

- **Object-oriented MBSE approach using SysML™**
  - IBM® Rational® Rhapsody®







Boeing Approach to MBSE Deployment

- **Legacy programs**
  - **Apply MBSE to the increment or change (Herzog et al., INCOSE 2010)**
  - **“Come along side” to train new approach, tools**
    - **“Tell, show, do, apply”**
- **New programs**
  - **Gain adoption during program definition phase**
  - **Provide training, support, expertise, assistance, tools, help, troubleshooting, tailoring – “service-ready solution”**
- **Ensure persistence – embed the new ways of thinking in the organizational culture**

Topics

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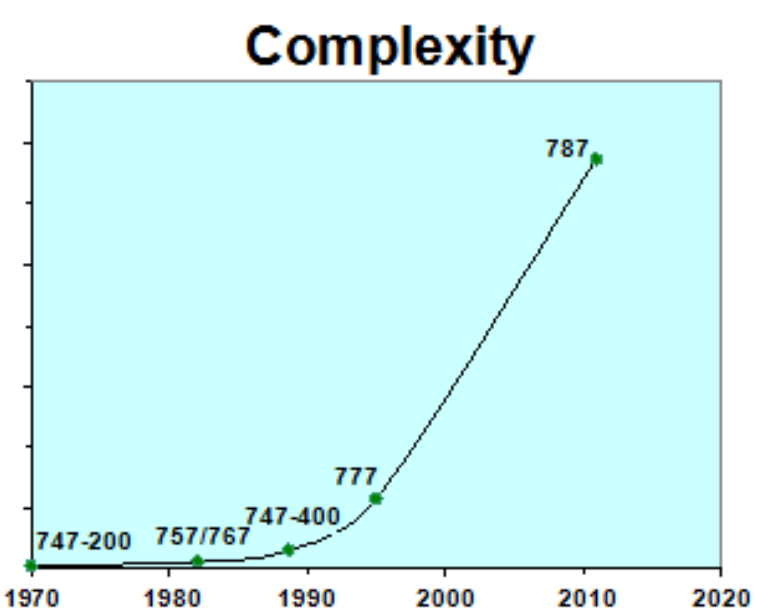
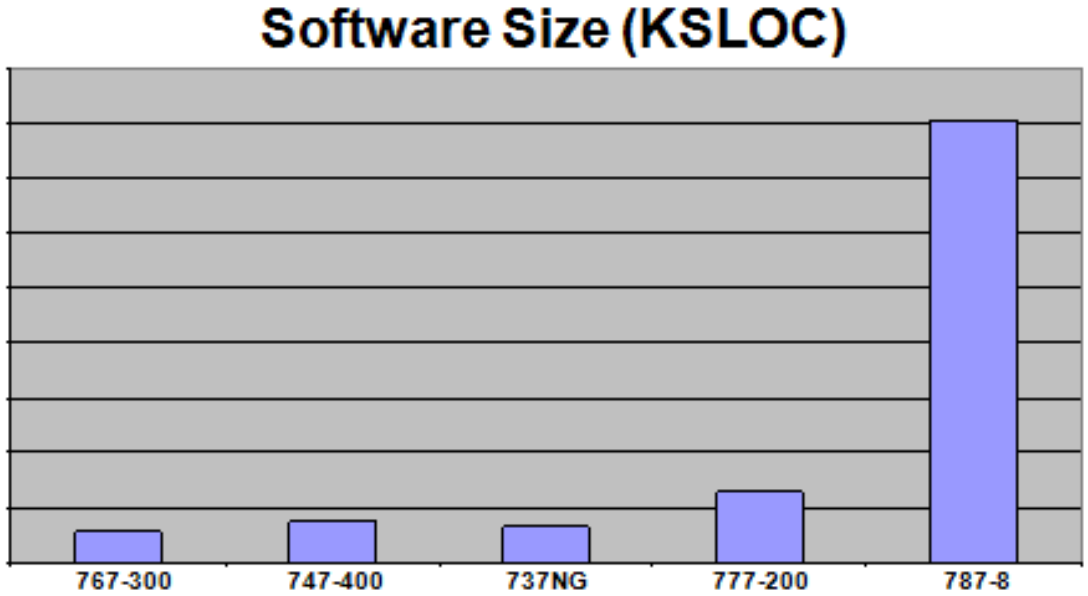
Challenges

- **Legacy and new products**
- **Process definition/adoption**
- **Transition to downstream phases and tools**
  - Integration, Verification, Manufacturing, PLM, Support
- **Product complexity**
- **Quantity of engineering data**
- **Process/tool training and skills**
- **Use of diagramming**

Size/Complexity Challenges





Number of signals versus introduction date of the commercial transport aircraft.

Lines of Software code versus commercial transport aircraft.

Increased Systems Complexity/Integration Drives Need for MBSE

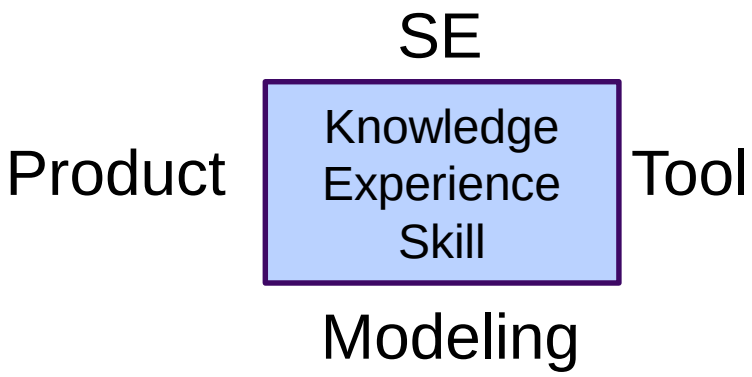
Quantity of Engineering Data

- **Example Boeing Commercial Airplane System Architecture Model Volume (~14 GB)**
  - **~2,300 functions**
  - **~10,000 data flows**
  - **~5266 equipment installations with data interfaces**
  - **~1,000,000 data parameters**
  - **~9490 electrical connections**
  - **~ 60,000,000 objects in data base (~ 3 relationships (links) per object)**

~1300 users are required to produce this dataset

Training & Skill Challenges

- **Programs need a combination of 4 skill sets:**
  - SE knowledge and experience
  - Product domain knowledge
  - Tool user skills
  - Modeling skills

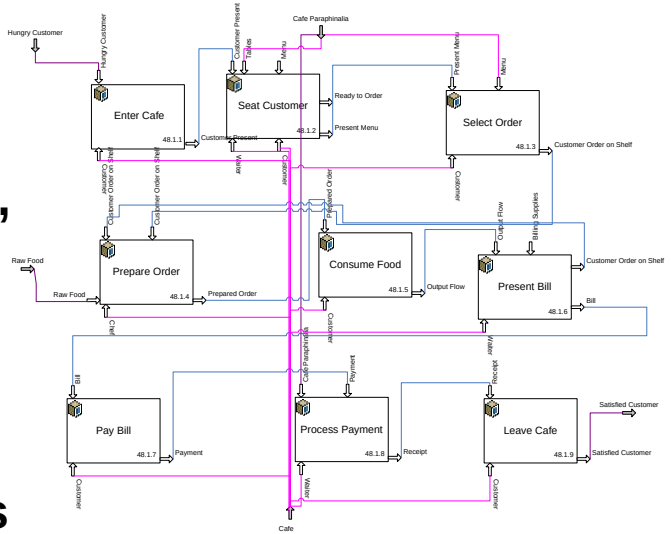


- **Acquiring modeling skills is the most difficult to achieve**
  - Knowing what to model at what level of detail based on the questions to be answered
  - Knowing what modeled data to analyze & how to analyze it

Diagramming Challenges

The Boeing Company

- **Diagramming is a starting point for stakeholder discussions and model review**
- **A diagramming interface is inadequate for creating millions of objects and relationships**
  - **Also use bulk import utilities, spreadsheets, documents, and database objects**
- **A diagramming interface is impractical for analyzing millions of objects and relationships for integrity**
  - **Also need query and presentation of results in a report format**



A diagramming interface is a necessary component of an MBSE environment to allow human comprehension of the model, but is not sufficient, in itself, to define and analyze the model

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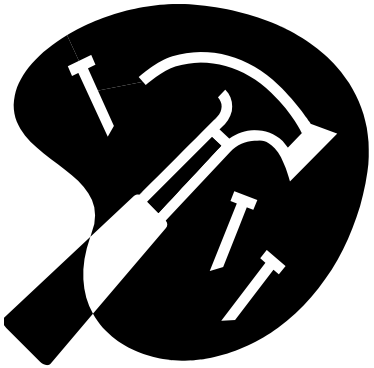
MBSE Process Needs

- **Success stories – to help promote the benefits**
- **Methods to measure impact of MBSE**
- **Training to develop good “modelers”**
- **Methods to ensure persistence of MBSE after the advocates move on**

MBSE Tool Needs

- Lower user ‘entry barriers’ – more intuitive user interfaces
- Support for hundreds of globally distributed users
- Size scaling – consistent performance when managing large quantities of data and users
- Each diagram object is a database object
- Exchange and synchronization of federated engineering data (different databases)
  - Other Engineering disciplines (SWE, EE, etc.)
  - Transition to Manufacturing and PLM
  - Tool vendors working together!
- Support for data reference libraries and data reuse
- Configuration and version control of all objects
- Bulk import / export / update capability



Summary

- **Boeing diverse product lines, customer bases, and legacy programs require a balanced effort to implement MBSE**
- **Success has been seen on a variety of programs**
- **Boeing is committed to moving forward with MBSE**
- **Help needed with integrating data among different tools**

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Please

The link for the online survey for this meeting is

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www.surveymonkey.com/r/2018_02_MeetingEval

Look in GlobalMeet chat box for cut & paste link.

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The library page at: www.incose.org/enchantment.

Recording will be there in the library tomorrow.