Exploring Model-Based System Engineering (MBSE) /Model-Based Development (MBD) in the Life-Cycle Development for Civil Aircrafts

John Zhang, Ph.D., MBA
Technical Director of the Computation & Simulation Lab (CSL)
BASTRI of COMAC
June 27, 2017 Beijing China
Disclaimer & Acknowledgment

- This presentation is for education purpose ONLY. The presenter is NOT responsible for any liabilities of any means for any reason.

- All original authors’ ideas and concepts are formally acknowledged here. Individual trademarks and IPs belong to each author or corresponding companies.
TABLE OF CONTENTS

1 Background & Motivation
2 Benchmarking
3 COMAC Approaches to MBSE/MBD
4 Needs/Challenges
Challenges for Commercial Aircraft Development
MBSE v.s. MBD

- MBE – Model Based Engineering
- MCE – Model Centric Engineering
- MBSE – Model Based System Engineering
- MBD – Model Based Development
- MBT – Model Based Test
- MBR – Model Based Reliability
- MBM – Model Based Manufacturing
Background

- **MBSE Definition:** The formalized application of modeling to support system requirements, design, analysis, verification and validation activities beginning in the conceptual design phase and continuing throughout development and later life cycle phases”

- **3 Key Characteristics of Commercial Aircraft**
  - High Complexity
  - High Risk
  - High Cost

**Virtual System Integration Is Very Critical in Early Stage**
Motivation

- **MBSE/MBD** is a cultural change, and a new disruptive development process

- **Key SE Characteristics Requirements**
  - Open Minds
  - Independent Critical Thinking
  - Life-long learning

- **Overcome Psychological Inertia**
  - Understand how sub-conscious mind works
  - Be aware of mind-mistakes
  - Engage with active listening like an infant
Motivation – Paradigm Shift

In order to implement MBSE successfully, a mindset change is needed and required.

**From**
- Evolving design requirements
- Extensive design rework
- Product performance assessed by "build and test"
- Performance and producibility problems fixed after product in use
- Quality "tested in"

**To**
- Disciplined CTC flowdown
- Controlled design parameters
- Product performance modeled and simulated
- Designed for robust performance and producibility
- Quality "designed in"
TABLE OF CONTENTS

1 Background & Motivation
2 Benchmarking
3 COMAC Approaches to MBSE/MBD
4 Needs/Challenges
Benchmarking – Lockheed Martin 1

Complex Model Ecosystem – Combined a fully integrated digital system model enables programs to pull a digital thread to analyze performance and change impacts faster and with more accuracy.
Benchmarking – Lockheed Martin 2

Model-Centric Engineering – Model is an essential part of product data baseline.

- A well defined System Architecture Model (SAM) is a key enabler for integrating and linking our engineering enterprise
- The SAM helps link requirements to logical and behavioral design
- Requirements can be fed into increasingly detailed levels of domain specific modeling
- Integration between Systems Engineering and the PDM/PLM backbone opens up a new frontier for integrated model-centric engineering

Key Points:
① System Architecture Model;
② SAM Links Reqs & Design;
③ Mission Analysis & Cost Model;
④ PDM/PLM Backbone;
⑤ Model-centric.
Benchmarking – Raytheon

Complex Model Ecosystem – Combined A fully integrated digital system model enables programs to pull a digital thread to analyze performance and change impacts faster and with more accuracy.

Matlab/Simulink
Benchmarking – Boeing Company

Integrated Product Architectures at The Boeing Company

Paradigm Shift/Change:
① Model is requirement;
② Model is technical baseline;
③ Model is component of product data;
④ Model is useful even it is not fully validated!

Key Points:
① Requirement Architecture;
② Single Data Environment;
③ Effective System Trades;
④ Quality & Affordability.

IPA is an 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 environment architectures enables consistent, seamless generation of SE artifacts and enables more effective system trades.
Benchmarking – Airbus Group

4 Layers: Workflow → Methods → Platform → Tools

Our Vision
## TABLE OF CONTENTS

1. **Background & Motivation**
2. **Benchmarking**
3. **COMAC Approaches to MBSE/MBD**
4. **COMAC MBSE Needs/Challenges**
**Vision**
- To be the industry leader in the area of MBSE

**Mission**
- To promote & Implement MBSE

**Values**
- Integrity, Innovation, Customer-Oriented, Continuous Improvement

**Slogan**
- We are OneTeam!
COMAC Approach to MBSE Implementation

- **Education on the topic of MBSE**
  - Grass-rooting 2 session of enterprise-wise formal SE training
  - Rotation within different organizations within COMAC for students
  - Re-establishment of basic SE beyond requirements management only
  - Importance of requirement & functional models

- **Development of MBSE key capability for programs to use through pilot projects**

- **Development of guidance for how to use the MBSE developed capability**

- **A core group (COMAC MBSE DreamWorks) that provides support to all programs**

- **Means to capture and share successes and lessons learned within the enterprise**
COMAC Approach to MBSE Tools & Methodologies

- Different tools & methodologies at different stages
  - Tools: Rhapsody, EA, Canpella, Matlab/Simulink, AMESim/SysDM/Synthesis
  - Methodologies: OOSEM(Incose Object-Oriented SE Method), RUP-SE
Use a small aircraft as a pilot project to demonstrate the MBSE implementation process
COMAC MBSE Implementation – Pilot Project

Use a small aircraft as a pilot project to demonstrate the MBSE implementation process – Using Simulink as a common simulation platform
COMAC MBSE Implementation – Next Steps

Using MathWorks Certification Toolkit for Automatic Certification Compliance
TABLE OF CONTENTS

1 MBSE Background & Motivation

2 MBSE Benchmarking

3 COMAC Approaches to MBSE

4 Needs/Challenges
COMAC MBSE Needs

- COMAC Cultural Change Needs

- COMAC Process Needs
  - Process methods to measure the impact of MBSE/MBD (Tangible values)
  - Training good modelers using levels I, II, and III
  - Process method to make sure the persistence of MBSE/MBD
  - Modeling guidelines and standards

- COMAC MBSE Tools Needs – With Tool Vendors Together
  - Tool support for distributed users across all enterprise
  - Tool support for reference model and model/data reuse
  - Configuration and version control tool for all objects
  - Exchange and synchronization of federated engineering data
  - Tool support for managing large quantity of model users
COMAC MBSE Challenges

- **COMAC Cultural and Traditional Resistance (Need top leader)**
  - Communication and understanding of motivation of MBSE

- **COMAC MBSE Implementation Challenges**
  - Legacy and new product development methods conflicts
  - New MBSE process definition and adoption
  - MBSE V-shape whole life-cycle tool support
  - Product complexity and quantity of large engineering data
  - Diagramming (SysML) limitation

- **Training and Skill Challenges**
  - 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
  - Need to have combination of 4 skills:
    1) SE knowledge and experience
    2) Product domain knowledge
    3) Tool use skills and modeling skills
Summary

- COMAC requires a balanced effort to implement MBSE/MBD due to the complex nature of commercial aircraft and cultural challenges.

- Success has been seen on a variety of pilot programs.

- COMAC will be committed to moving forward with MBSE/MBD.

- COMAC needs help with integrating model/data among different tools for strengthening virtual system integration capability.
Thank You for Your Attention

COMAC MBSE Approaches

OneVision, OneVoice, OneTeam, OneBrand