



How to Fail at MBSE

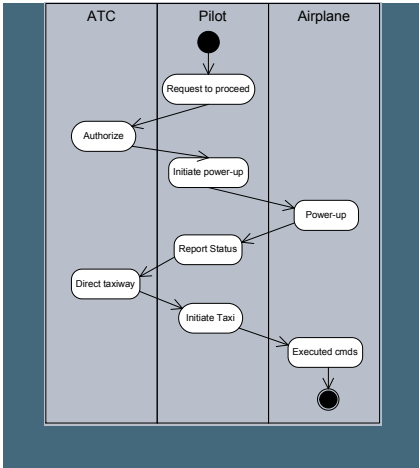
Matthew Hause - Atego

Changes in Systems Engineering Practice

Change from Document centric to Model centric



Requirement Specifications
Interface Definitions
System Architecture
System Functionality
Trade-off Analysis
Test Specifications
Etc.



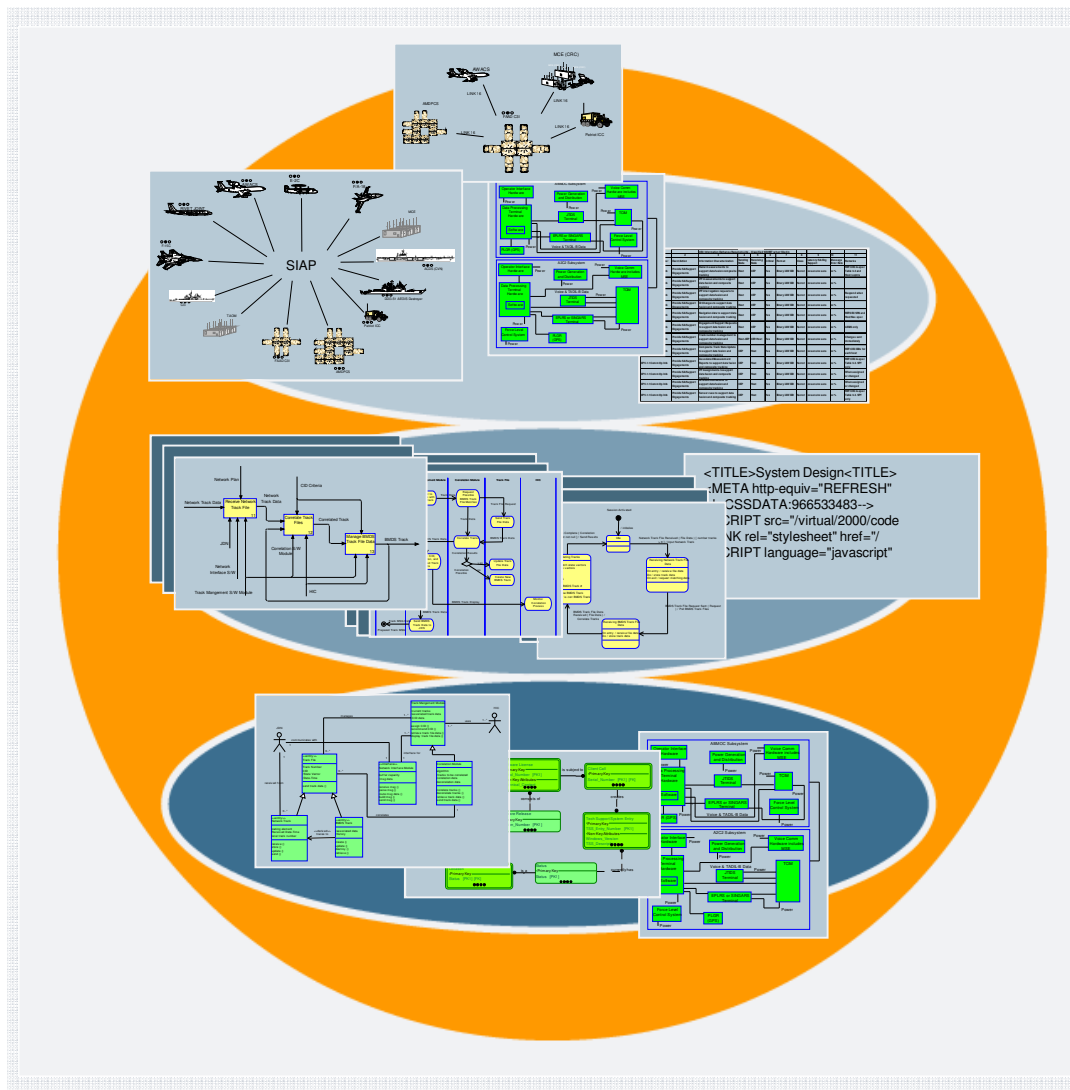
Old Approach

New Approach

Model-Based Engineering

- Model-based Systems Engineering (MBSE) is the formalized application of modeling to support system requirements, design, analysis, verification, and validation activities beginning in the conceptual design phase and continuing through-out development and later lifecycle phases.” (INCOSE, 2007).
- Modeling is at the heart of all aspects of the development effort
 - Covers the complete product and project lifecycle
 - Has a direct effect on any generated artifacts
 - MBE encompasses architecture, systems and software development

Modeling at Multiple Levels of the System

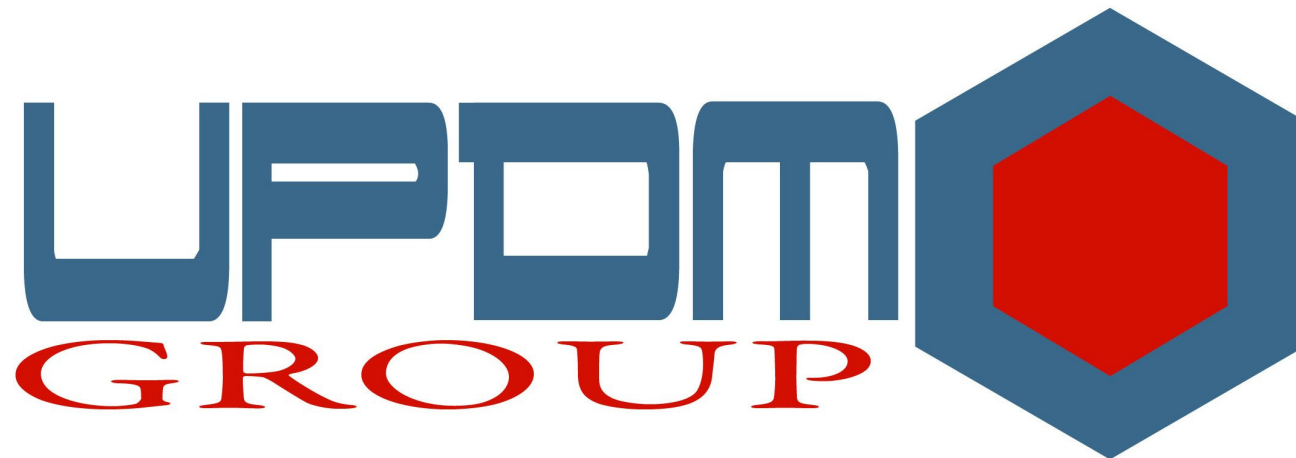


Architecture Models

Systems Models

Component Models

Modeling Language for these Multiple Levels of the System



"Testing Solutions through SysML/UML" Hause, M. Richards, D. Stuart, A., INCOSE IS 2009, June, 2009

- Used on a Safety Critical Rail Project
- Adopted an approach to MBSE for testing
- Leveraged a substantial body of UML/SysML models
- **Decreased validation costs by 75%!**
- Eliminates manual work
 - Excel files created automatically, which are used as evidence
- Reduces human errors
 - Originally the files were hand-coded
- Decreases the number of files used
- Enforces design standards
- Automatically produces documentation

Raytheon Findings on MBSE

- Presented at the Boston CTO Club meeting 30th May, 2012
 - Chief Software Engineer, Engineering Fellow, Integrated Defense Systems, Colorado
 - Engineering Fellow, Integrated Defense Systems Massachusetts
- They reported productivity increases from 150% to 700%, and defect rates of 10% to 50% of the same team's rates on previous projects.

Adopting MBSE can be hard

- Often there are a few ways to do something correctly
 - However, there are an infinite number of ways to do things wrong
- Used correctly, tools can help build systems more efficiently
 - Using the wrong end of a hammer to pound in a nail does not make the hammer a bad tool; it makes you a bad carpenter.
 - A fool with a tool is still a fool
- The following guidelines will help to guide managers with implementing an MBSE initiative



Things NOT to do when adopting MBSE

- Avoid Training and Mentoring
- Discourage Collaboration
- Avoid Professional and Standards Organizations
- Adopt an External Process Wholesale
- Duplicate your Work
- Avoid Configuration Management
- Stay Ignorant of Best Practice
- Ignore Metrics
- Conduct Paper-Based Reviews
- Abuse Lean and Agile Development
- Avoid Optimizing Your Process
- Model Too Much, Too Early
- Delay Building Documentation and Code Templates
- Use Incompatible Modeling Tools
- Adopt a Custom Notation
- Duplicate Paper-based Processes With Tools
- Buy a Tool First (Any tool)

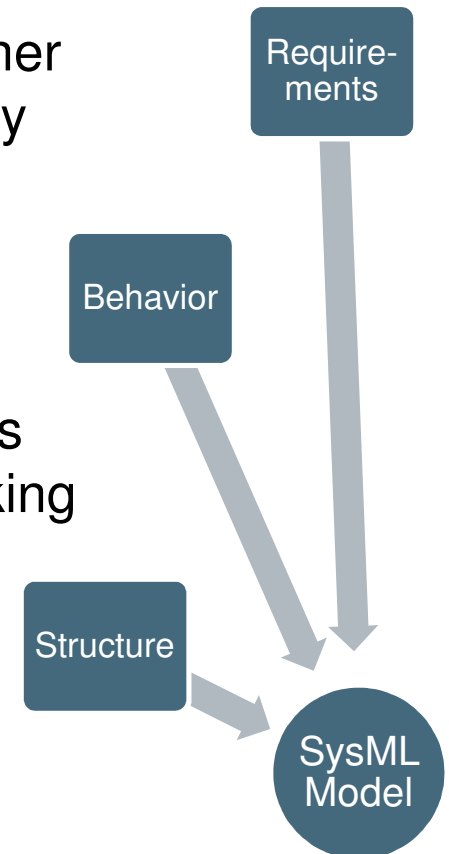
Don't Neglect Training and Mentoring

- The Problem: Modeling is an actively acquired skill
 - You can't learn to swim by reading a book
 - A FORTRAN programmer can do FORTRAN in any language
- The Solution: Adopting MBSE requires learning to solve problems differently
 - The same engineering techniques are used
 - You just do them using standardized models rather than just words
- Comprehensive training gets you started
 - Available from Atego and others
 - Books are essential, but not enough
 - You cannot ask a book a question
- Mentoring ensures that your techniques and processes are sound
 - “Course correction”
 - Model review
 - Process review

Encourage Collaboration



- **The Problem:** Project communication is difficult
 - It is common practice that software, hardware, and systems engineers only communicate with each other at the end of the project to blame each other for why they are late.
- **The Solution:** Models provide a force-multiplier for engineering work.
 - Models are developed using the different viewpoints
 - Each group develops it's portion of the model, working towards a whole
 - Traceability can be added between the views to create a coherent whole
 - The model can then be examined for coherence, correctness, compliance, etc.
 - The model is used to communicate between disciplines



Engage with Professional and Standards Organizations



- The Problem: Sharing best practice is seen as “Giving information to the enemy”
 - IP is to be protected at all costs
 - Publishing papers only helps our competitors
- The Solution: Mankind has progressed over time through the ability to communicate and share information
 - Professional and standards bodies are a means to achieve this
- The International Council On Systems Engineering (INCOSE)
 - “Our mission is to share, promote and advance the best of systems engineering from across the globe for the benefit of humanity and the planet.”
- The Object Management Group (OMG)
 - “OMG’s mission is to develop, with our worldwide membership, enterprise integration standards that provide real-world value. OMG is also dedicated to bringing together end-users, government agencies, universities and research institutions in our communities of practice to share experiences in transitioning to new management and technology approaches”.

Don't Adopt an External Process Wholesale

- The Problem: Wholesale process adoption
 - Confuses engineers
 - Causes resentment
 - Delays projects
- The Solution: All processes MUST be customized
 - Additional steps
 - Redundant steps
- Normal Process Improvement is:
 - Start with your existing process
 - Figure out where you would like to be
 - Determine how you are going to arrive at your destination incrementally whilst ensuring that improvement can be measured
 - Start first with most effective ROI (Largest problem)
 - Correct the process as required

Don't Adopt an External Process Wholesale

- It is imperative that a well defined process be specified elaborating how quality checks fit into the overall process
 - Suggested vs. mandatory, and
 - How updates, modifications, variations, dispensations, etc. will be handled.
- Allow easy access to the process
 - Wiki/Intranet as opposed to paper or electronic documents
- Object Oriented Systems Engineering Methodology (OOSEM).
 - A good starting point for defining a process or integrating these concepts into an existing process
 - Successfully adopted by several major companies
 - More information is available at the OOSEM website <http://syseng.omg.org>

Don't Look at MBSE as Duplicate Work

- The Problem: MBSE is often considered “Extra Work”
 - Visio/PowerPoint diagrams added to tick boxes
 - Models not integrated into the process
- The Solution: MBSE needs to be integrated into existing processes
 - Redundant tasks and I/O need to be identified early
- Modeling needs to be at the center of the development effort
 - Covers the complete product and project lifecycle
 - The model contains the requirements, the strategy to meet the requirements, and the implementation of the requirements
 - Has a direct effect on any generated artifacts.
 - What goes in, should go out
- Adopt an “Agile” modeling approach for concept development
 - Avoids the need for “PowerPoint models”

Integrate MBSE with Configuration Management

- The Problem: Projects often view model CM like document CM
 - File based MBSE can easily lead to version skew
- The Solution: MBSE Configuration Management requires special attention
 - Model Versions
 - Model Variants
 - Component Versions
 - Component Variants
 - Error traceability and reporting across projects, models, and components
- Most companies have rigorous configuration management over code, documentation, artwork, architecture, versions, etc.
- Models are aggregations of interconnected data
 - The only solution is a whole model approach



Stay Informed of Best Practice

- The Problem: Companies become reliant on existing processes and tools
 - Projects stagnate due to lack of innovation
 - “We’ve always done it this way before.”
- The Solution: We need to adapt processes, tools, technology, etc. to keep pace with our competitors or risk falling behind
- New problems require a different approach
 - “We can't solve problems by using the same kind of thinking we used when we created them.” Einstein
- The technology landscape is changing at an alarming rate
 - Technology
 - Engineering
 - Tools
 - Processes
 - Etc.
- Best practice from 5 years ago is now archaic



Integrate Metrics into Your Process

- The Problem: Collecting metrics is seen as a time-consuming, unnecessary, overhead
 - Often metrics that are collected are never analyzed
- The Solution: Metrics are an essential indicator as to whether or not your MBSE initiative is working
 - Integrate automated collection of metrics into your process
- “If you can measure it, you can manage it”
 - Consequently, if you aren’t measuring your process, productivity, error rates, defect rates, etc., how can they be managed?
 - Similar to a control loop with no feedback
- Prior to starting any process improvement initiative, start a metrics initiative
 - Process Improvement tells you how to get from A to B in your process
 - Metrics tell you if you are going in the right direction
 - “If you don’t know where you are, a map won’t help.”

Don't Conduct Paper-Based Reviews

- The Problem: When project documents were all words, all we reviewed were the words
 - Often devolved into spelling and grammar checking
 - Usually missed substantial issues
 - Tedious and disheartening
 - Lowering motivation and morale
- The Solution: Model-based reviews provide substance
 - Can include model execution, trade-off analysis, etc.
 - Issues can be entered into the tool, traced and acted upon
 - Automated checks can review the model for:
 - Correctness
 - Compliance to industry and company standards
 - Traceability
 - Completeness
 - Etc.
 - Reduces tedium and busywork

Don't Abuse Lean and Agile Development

- The Problem: Agile development can be used to bypass process
 - It becomes a “License to Hack”
 - Loose requirements, traceability, and a lack of criteria against which to determine if the system is “correct”
- The Solution: Agile development needs to be integrated into a process in an effective way
 - Concept development
 - Bid management
 - Investigation of alternatives
 - Prototyping
 - Etc.
- Agile development can be a powerful tool providing a fast and efficient way to build systems
- Always develop your systems, processes and models to the “Right” level of quality

Optimize Your Process

- The Problem: We are often tempted to continue with existing broken processes
 - “If it ain’t broke don’t fix it”
- The Solution: Regular and Periodic Process Review
 - Learning from our mistakes improves the way we do things
 - Error correction needs to be built into our processes
 - One definition of madness is doing the same thing over and over again and expecting a different result
- Perform a process review at the start of the process to determine what is and is not required
- Meet with other teams during the project to identify common problems
- Perform a post-mortem after the project
 - Document what did and didn’t work
 - Capture and document reusable assets
 - Publicize success stories
 - Update the process to improve things the next time

Don't Model Too Much, Too Early

- The Problem: Modeling without a clear structure and plan
 - Adopting a “Mongolian Hoard” approach towards modeling creates a large amount of data that will be impossible to sort out.
- The Solution: Establish a model structure early
 - This should support the Work Breakdown Structure as well as the process
 - Separate areas for specialist areas, project teams, project phases
- Start by modeling the requirements
 - Helps establish a foundation on which to build the model
 - Add traceability from the requirements to the requirements model
- Do investigative modeling in a separate area
 - Prototypes of designs, products, alternatives, processes, etc.
- The best modeling tool is a whiteboard
 - Use the whiteboard to solve problems, make decisions
 - Use the tool to document those decisions

Build Documentation and Code Templates Early



- The Problem: A lack of standardized templates can be disastrous
 - Severely impacts project deadlines
 - Reduces standards compliance
 - Causes duplication of effort

- The Solution: Prototype the process prior to project start
 - Documentation generation
 - Code generation
 - Modeling standards
 - Model and project reviews
 - Configuration management
 - Etc.

- Have the tools available when people need them
 - Achieves “Just in Time” project documentation

- A model with no output capability is useless
 - What goes in, must come out

Don't Use Incompatible Modeling Tools

- The Problem: Use of project tools evolves over time
 - One tool for architecture (DoDAF), another for systems engineering, and a third for software engineering
 - Often the tools use different methodologies (IDEF-0/State/OO)
 - Traceability and interchange done through documents/RM Tools
 - Extremely difficult to manage and communicate between stages
- The Solution: UML tools now cover the complete project lifecycle
 - DoDAF (UPDM)
 - Systems Engineering (SysML)
 - Software (UML)
 - Model Traceability across project phases
 - Direct impact analysis and traceability
- Requirements integrated into the model
 - Direct connection to model elements

Don't Adopt a Custom Notation

- The Problem: A non-standard notation locks you into a single vendor, limits resources, reduces communication, and increases risk
- The Solution: Adopt International Proven Standards
 - The Systems Engineering Modeling Language (SysML) was started in 2001 to provide a standardized means of communicating between systems engineers, stakeholders, and other project personnel.
- Resources are now plentiful
 - Multiple tools on the market
 - Several books have been published
 - E.g. Holt, Friedenthal, Weilkiens
 - Training course from several sources
 - Taught at university
 - In wide use in industry
 - Documented project success
 - Etc.

Don't Duplicate Paper-Based Processes with Tools

- The Problem: Companies buy tools first and then use them in the same way as the existing paper-based process
 - This gets the least out of tools, not the most
- The Solution: Paper-based and model-based processes are different
 - The inventors of the car did not start by inventing an electric horse
 - Work practices need to adapt to the paradigm shift
 - Processes need to adapt to make better use of tools
- Project documents
 - Originally large paper documents, then electronic documents
 - Next, electronic documents with cut and paste diagrams
 - Need to shift to automated document generation
- Requirements traceability
 - Originally large sheets of graph paper, then spreadsheets
 - Next, Requirements Management (RM) tools
 - Then, traceability links between RM tools and models
 - Need to shift toward models integrated with reqts.

Don't Start by Buying a Tool (Any Tool)

- The Problem: Projects often buy the cheapest tool to minimize costs
 - Models then expand to the point where converting to a different tool is too expensive
 - Projects have no choice but to carry on
 - Buying cheap can be very expensive
- The Solution: People – Process – Tools
- Tools must be fit for purpose
 - As always, start with requirements
 - What will the tool be used for?
 - How does it fit into existing processes?
 - Can it manage a complex, concurrent development environment?
 - Will the tool scale to meet your needs?
- Evaluate tools as you are going to use them on projects
 - Tools are *Usually* evaluated by individuals
 - *Always* used by groups

Conclusion and Summary

- Model-Based Systems Engineering can be a project enabler for success
- There are many ways to do integrate MBSE into an organization
 - Some are helpful, others are not
 - Without metrics, it is difficult to know if things are improving
- Investigate and adopt best practice
 - Professional bodies are a good place to start
 - What is best practice today, may not be tomorrow
- Perform a post-mortem after every project
 - Determine what was and wasn't helpful
 - Update the process accordingly
 - Publicize MBSE success stories

Questions and Answers



Thanks for your attention!



Speaker