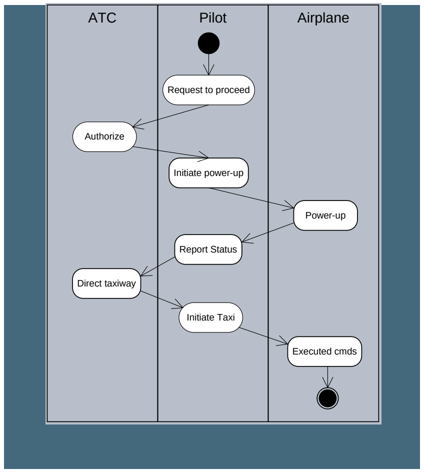
How to Fail at MBSE

Matthew Hause – Atego Chief Consulting Engineer

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.



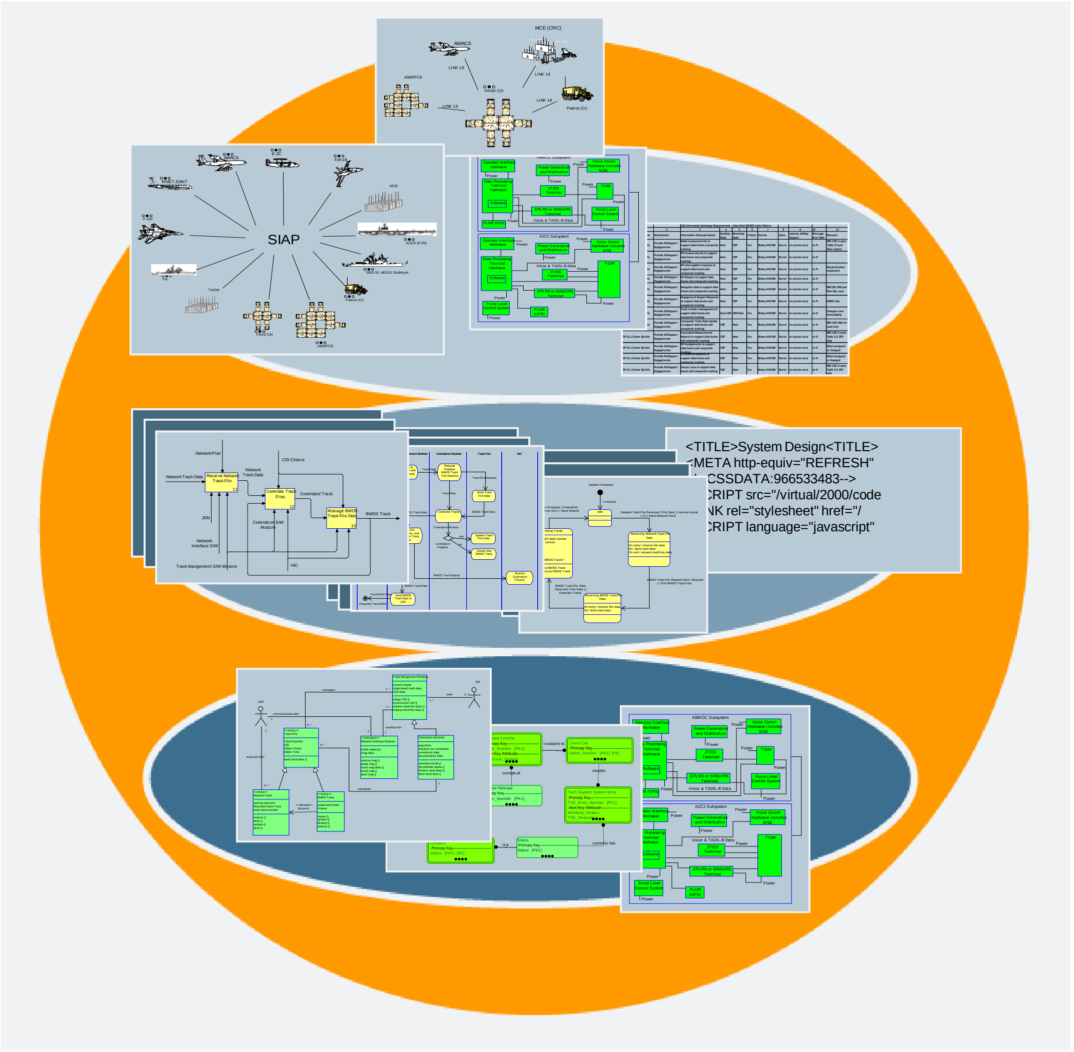
Old Approach

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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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 engineers with implementing an MBSE initiative
- The order of adoption should be:
  - – People
  - – Process and finally
  - – Tools

Things NOT to do when adopting MBSE

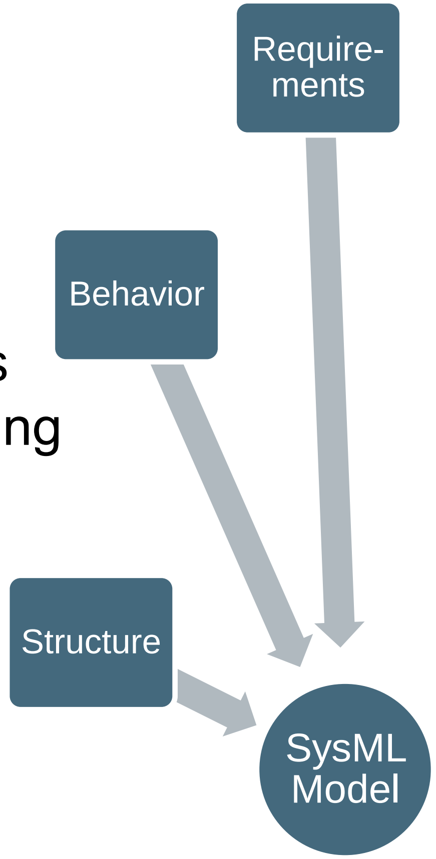
- Avoid Training and Mentoring
- Discourage Collaboration
- Avoid Professional and Standards Organizations
- Adopt an External Process Wholesale
- Duplicate your Work
- Avoid Configuration Management
- Stay Ignorant of Best Practice
- Ignore Metrics
- Conduct Paper-Based Reviews
- Abuse Lean and Agile 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
- Start by Buying a Tool (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 good FORTRAN programmer can do FORTRAN in any language
- The Solution: Adopting MBSE requires learning to solve problems differently
  - The same engineering techniques are used
  - Uses standardized models instead of just words
- Comprehensive training gets you started
  - Available from Atego
  - Books are useful, 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
  - Software, hardware, and systems engineers often 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
  - Adding steps when needed
  - Removing 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 (2)

- A well defined process MUST 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 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: Adapt processes, tools, technology, etc. to keep pace with 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
- Before starting on process improvement, 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 unusable data.
- 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, Delligatti
  - Training courses from Atego
  - Taught at universities
  - 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 requirements.

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

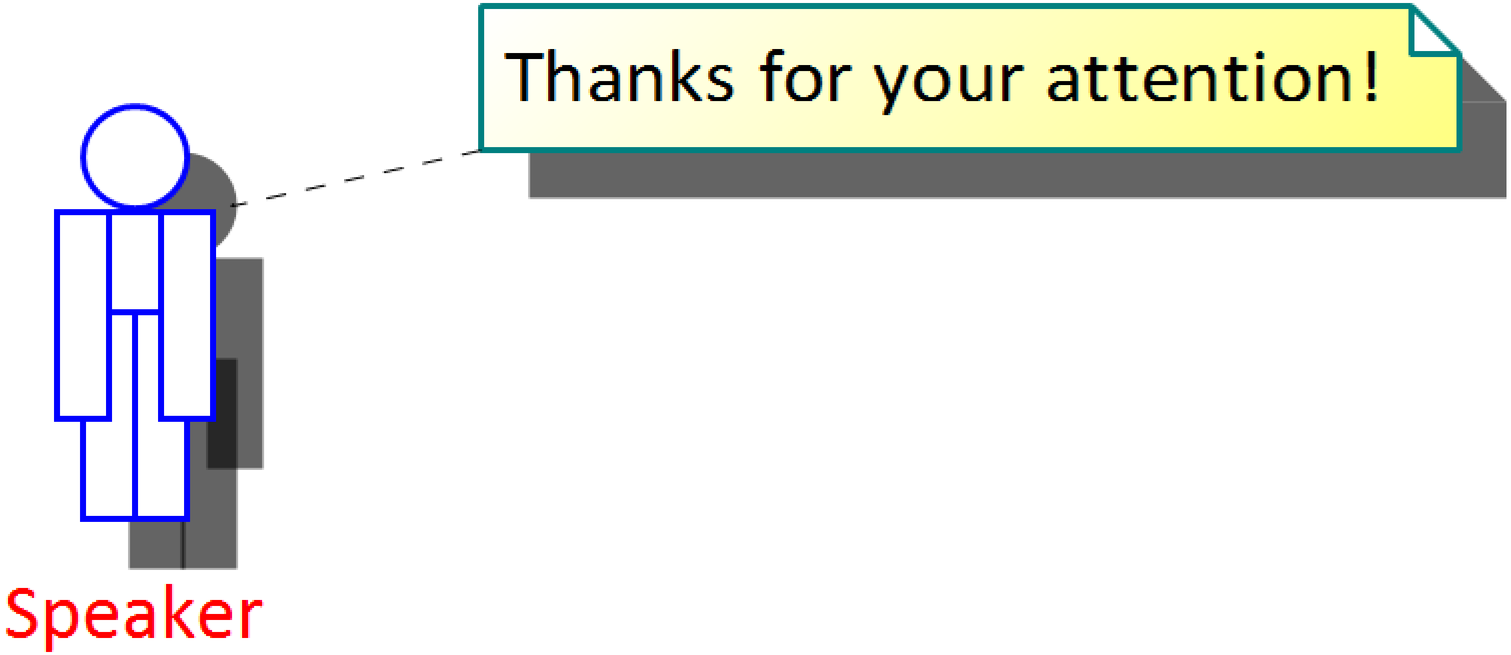
- Model-Based Systems Engineering can be a project enabler for success

- 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!

Contact Details

- Matthew Hause
  Atego Systems
  Chief Consulting Engineer
  +1 917 514 7581
  Matthew.Hause@Atego.com