MBSE Workshop
Opening Plenary

Find a seat and strap in…
MBSE: Failing Faster Earlier Once

Mark Sampson
MBSE Initiative Chair, INCOSE
Doing the math…

Nodes = 5
Potential Links = 10
Networks = $2^{10} \times 1024$

Nodes = 30, potential links = 435, unique configurations = $2^{435}$
Number of atoms in the universe est. between $2^{158}$ and $2^{246}$

Murphy happens at the interfaces
Integrated MBSE Vision
What does the integrated digital thread look like…

Minimum Turn Radius: 24 ft.
Automatic Dry Pavement Braking
Distance at 60 MPH: 110 ft, 90 ft

Hydraulic Fluid: SAE 1340 not-compliant
Recent Headlines from other industries...

**Boeing Says Charges Tied to 737 Max Grounding to Reach $8 Billion**

*The New York Times*

Boeing 737 Max planes are parked at the municipal airport in Renton, Wash. The Max planes have been grounded after two were involved in fatal accidents.

By David Gelles

July 16, 2019

The financial fallout from the troubled 737 Max jetliner continues to swell for Boeing, which on Thursday announced $7.3 billion in costs that will hit its bottom line.

**Walmart sues Tesla over solar panel fires at seven stores**

*CNBC*

Walmart is suing Tesla for breach of contract after Tesla solar panels ignited atop seven of its stores.

Walmart has also pre-ordered at least 45 Tesla electric semi-trucks to add to its vehicle fleet.

Tesla Solar Panels... Defective connectors/grounding Amazon joins the suit as well

08/20/19
Do you see the problem?
Case Study: Fuel Pump Control Module

Fuel pump control module bad placement...

- Resulting in Bi-Metal Corrosion, failed ECU
- 86,000 vehicles recalled.. $8.6M direct costs
How about now?
Even when you were evaluating places to put it

Bi-metal contact, corrosion risk

What about purchasing?
Supply chain?
Imagine this working across an entire supply chain!
Model Based Design Chain (MBDC)

Hydraulic Fluid: SAE 1340 not-compliant

Minimum Turn Radius: 24 ft.
Automatic Dry Pavement Braking Distance at 60 MPH: 110 ft. 90 ft
MBSE Process…
Shift left…

- **Product Definition**
  - Concept Design
  - Derived System Requirements
  - Derived mechanical Requirements
  - Derived EE Requirements
  - Derived Software Requirements
  - Derived By Parts Requirements

- **System Design**
  - Mecanical Design
  - Components (virtual)
  - EE Design
  - Components (virtual)
  - Software Design
  - Components (binary)
  - Purchase
  - Buy Parts

- **Component**
  - Mechatronic BOM
  - Manufacturing BOM
  - Maintained BOM

- **Product Implementation**
  - eBOM
  - mBOM

- **Product Build**

**Use Cases & Demands**

**Selected Product Requirements**

**Solution (wished by Customer)**

**SoS**

- Scope
- Constraints
- Interactions
How do we learn the lessons from the threads? How to store/recall from somewhere so we don’t repeat them

Problem resurface metric: how long does a problem once solved take to come back

- Auto: ~3 years
- High Tech ~6 mo.
- Aero ~15 years

Cross-Domain problems result from:
- Siloed/Disconnected Decisions
- Form follows function, Problems follow functions
- Everyone involved, including purchasing
- Disconnected requirements
- Uncommunicated change
- Happen at domain/organizational boundaries
- Migrate with people (overt or covert)
- Missing/disconnected product architecture

“Water on the knee”
Where are we?  
Our Murphy-risk profile?

<table>
<thead>
<tr>
<th>Capability Assessment:</th>
<th>Basic</th>
<th>Low</th>
<th>Medium</th>
<th>High</th>
<th>Advanced</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>MBSE Process Maturity Level 4</strong></td>
<td></td>
<td></td>
<td></td>
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</tr>
<tr>
<td>System Modeling/Architecture</td>
<td>PPT in docs</td>
<td>Disconnected bliss</td>
<td>Sys Models with Simulations</td>
<td>Multiple model exchange/optimization</td>
<td>Integrated architecture models for cross-domain sim/optimization</td>
</tr>
<tr>
<td>PLE/Configuration (variation)</td>
<td>None</td>
<td>Variation documents, spreadsheets</td>
<td>Disconnected variation rules</td>
<td>Integrated variation rules</td>
<td>PL variation definition built into architecture decisions</td>
</tr>
</tbody>
</table>

| **MBSE Process Maturity Level 3** | | | | | |
| Interface Management | ICD in docs | Managed interfaces | Standard-based Interface library | Reused interfaces | Functions/logical allocation drives interface definitions |
| Logical Modeling | Logical description documents | Logical hierarchy | Isolated logical behavior models | Integrated logical behavior models | Logical architecture with allocation with traceability |
| Parameter Management | Unmanaged spreadsheets | Managed spreadsheets | Parameter library | Integrated with functions | Reusable parameter library with traceability |

| **MBSE Process Maturity Level 2** | | | | | |
| Feature/Functional Modeling | Functional description docs | Function hierarchy | Isolated functional behavior models | Integrated functional modeling | Functional arch with allocations & Traceability |
| Characteristic/Target Mgmt | None | Uncontrolled Excel/Docs | Controlled targets | Distributed targets/constraints | Integrated targets, budgets, with compliance reports |
| Change Management | Document-based change process | Isolated models included in change | Impact analysis & suspicion mgmt | Metrics with History for improvement | Project level reuse, starting point for next project |

| **MBSE Process Maturity Level 1** | | | | | |
| Requirement Management | Uncontrolled spreadsheets & docs | Managed Docs | Standalone solutions (disconnected) | RM/traceability exchange | Connected, configured, cross-domain traceability with reuse |
| Model Management | Uncontrolled, rules-of-thumb, hierarchies | Uncontrolled, behavior models | Shared model repository | Integrated, component library | Model reuse with controlled parameters |
| Verification & Validation | Minimum to no planning | Manually testing everything | Isolated validation simulations | Integrated simulation (HIL, SIL) | Focused testing, reuse results, swap out models |
| Design Management | Unmanaged CAX/SW models | Locally Managed CAX/SW | Enterprise repositories | Integrated models (MIL, SIL, etc.) | Cross-domain design/optimization |
Where are we?

Best Aero (best case)

Best Auto (best case)
...by industry
### Integrated MBDC Journey

Example: OEM electronics mfg & Semiconductor supplier

- Power of shared Product Architecture
- Identify supply chain disconnects
- Shift to right together
- Slash system integration effort

…realize total value of Product Architecture driving supply chain
Dishonesty/Meta-Dishonesty

“Semmelweis Reflex”
“…to dismiss/reject out of hand any information, automatically, without thought, inspection, or experiment”

Fore-ordained answers
…will the answer provided by SE tools be accepted

Don’t waste your time on the wrong answers, unless…


Dr. Ignaz Semmelweis
(1818-1865)

Early Germ Theory

Wash Your Damn Hands
Organization SDB’s (Self-Defeating Behaviors)…

- No process for the tools to work within
- No time/money to use tools
- No backing for resources
- No training on tools
- Expecting tools to run themselves
- Thinking tools are static
- Not convincing the customer of the tool benefits
- No mechanism for using tool results
- Applying the tool to everything
- Funneling everything through a gate keeper
- Expecting “paper” results from tools
- “where’s the hardware?”
- Rewarding fire-fighters vs. fire-preventers
- Blockading support organizations (…they cost too much, etc.)

...next year you will have a 90% probability of this failure…but you will do nothing about it!

Dr. Stephen Wheelwright
(Harvard Business School)

[Covey 1995, Sampson 2000]
Organizational SDB’s continued…

How prepared is your organization?

Culture change vs. getting lucky…

Buckminster Fuller’s Magic Log
Thank you