New Manufacturing Division Committee:
Advanced Manufacturing Engineering Capabilities (AMEC)
Kick-Off

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Brench Boden, AFRL (Vice-Chairman)
NDIA Manufacturing Division
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JCSEM M&S Report Key Findings

• Producibility is neglected “ility” due to lack of analysis capability
  – Producibility issues are difficult to predict and drive “hidden” costs
  – Manufacturing VOC needs to be included in requirements definition
  – SE trade studies need to incorporate producibility considerations

• Producibility M&S is a critical research area that has been missing
  – M&S tools required to drive manufacturing to left in acquisition
  – Product, process, & supply chain centric analyses are needed
  – Requires focused research attention and investments to mature

• Producibility evaluations must be integrated into SE trade studies
  – Producibility figure of merit developed as “goodness” measure
  – Current QFD-based methods can be extended to address producibility
  – More research is needed to develop and mature VDD-based approaches

Final Report Documents Investment Recommendations
Why is Producibility Important?

• Performance and affordability requirements often conflicting
  – Modeling & Simulation (M&S) tools provide a means to balance trades
  – Mature M&S tools exist for evaluating performance feasibility and risk
  – Comparable affordability M&S tools are far less mature and/or lacking

• Producibility is a design characteristic linked to affordability
  – “Ease and economy of manufacturing items in production quantities”
  – Includes “hidden costs” due to excessive cycle time and yield fallout
  – Should cost is one element that goes into a producibility evaluation

• Most producibility problems not uncovered until units are built
  – Difficult to quantify due to the lack of validated analytical tools
  – Unanticipated yield fallout drives excessive scrap and rework levels
  – Excessive quality controls implemented to tighten process capabilities

Key to Controlling Cost and Risk is Predicting Producibility
Current State of Producibility M&S

- Many producibility issues driven by early SE & design decisions
  - Producibility forgotten requirement
  - Producibility hard to quantify early
  - Producibility M&S tools immature

- Most producibility analyses are CAD-based rule checkers
  - Require nearly final design layout
  - Occur too late to influence design
  - Only as good as rules loaded in

- Need quantitative low & high-fidelity tools for trade studies
  - Balance performance/producibility
  - Guide analysis-based decisions
  - Shape design vs. verify problems

Void Exists in Current Producibility M&S Capabilities
Producibility Impact on LCC

- Product Cost = Should Cost + Hidden Costs + Risk Costs
  - Factory inefficiencies impact should costs due to producibility issues driving higher overhead rates, conversion costs, and additional capital
  - Yield fallout due to producibility issues drive hidden costs due to extra quality controls and in process rework required to achieve tolerances
  - Producibility issues also drive risk costs such as increased safety stock and lead time buffers to compensate for yield fallout and meet deliveries

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<tr>
<th>System Producibility Elements</th>
<th>Key Factory Metrics</th>
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<td>Producibility Score: $Y=f(x_1, x_2, \ldots, x_n)$</td>
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<td>$x_1$ Unit Product Cost (Material &amp; Conversion)</td>
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<td>$x_2$ Manufacturing Capital Investment Cost &amp; Risk</td>
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<td>$x_8$ Item Long Term Sustainability Risks</td>
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Legend:
- Manufacturing Cost Currently Considered
- Manufacturing Cost not Currently Considered
- Hidden Factory Cost not Currently Considered

Producibility Impacts Multiple Aspects of Life Cycle Cost
**Product & Process Centric Tool Matrix**

**Matrix focus areas:**
- Should cost analyses
- Yield prediction models
- DFX analyses
- Manuf process modeling
- Production line modeling
- Physics based analyses (casting, solder flow, etc.)
- System integration, assembly, & test modeling
- Operator assembly & test modeling, e.g., ergonomics
- Obsolescence modeling

**M&S Analysis Output for each Design Phase Identified**
Analysis focus areas:

- Distribution aspects
  - Infrastructure complexity
  - Business strategy alignment
  - Logistics/queuing delays
  - Environmental events

- Technical aspects
  - Product complexity
  - Material availability/maturity
  - Process learning curves
  - Technology maturity
  - Work force maturity
  - Sustainability impact
  - Contract/policy constraints
  - Trend analysis & diagnostics

System Modeling Approach for Industrial Base Design
**Product, Process, and Supply Chain Enterprise M&S Linkage**

**Producibility Figure of Merit Integrates M&S Tool Output into a Single “Goodness” Measure for Trade Evaluations**

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Program Planning & Risk Management Tools & Approaches Apply Here

**Legend**

- Manufacturing Cost Currently Considered
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*Weight factors would be assigned to each element of the figure of merit based on relative cost impact and risk for critical systems, sub-systems, & components*
Mission:
Promote the development and use of advanced manufacturing “engineering” capabilities for the DoD and Defense Industrial Base community that enhance the affordability of weapons system development, production, and sustainment.

Charter:
• Promote collaboration between government, industry, universities, associations and consortia to develop and cultivate advanced manufacturing “engineering” tools, methodologies, and skills.
• Actively support the development and use of modeling and simulation (M&S) tools and approaches to optimize producibility and manufacturing processes during product design and development.
• Advocate the integration of advanced manufacturing “engineering” methodologies into early product design activities that drive a “systems engineering” mindset into the manufacturing sector.
• Drive a manufacturing and production capability mindset into the System Engineering process where preliminary and detailed design trades and decisions and being made.
• Communicate trends and needs for advanced manufacturing “engineering” M&S tools, methodologies, and core competencies for inclusion in strategic plans and roadmaps.
2010 Objective & Approach

2010 Objective:
Stand-up the Committee and initiate activities that support the Mission and Charter

Approach:
1. Form the committee by establishing the leadership and participating members
2. Develop a taxonomy of subjects to be addressed by the Committee, working with the other existing Manufacturing Division Committees
3. Develop and implement an action plan to communicate and promote the recommendations contained in the “Modeling & Simulation Investment Needs for Producible Designs and Affordable Manufacturing” White Paper created by the JCSEM M&S Working Group
4. Establish a collaborative working relationship with other NDIA Divisions and Committees that are engaged in Modeling & Simulation activities in their areas of interest
5. Identify Objectives and Action plans for 2011
• Establish close relationship with new JDMTP AME sub-panel to collaborate on tech challenges and coordinate investment plans

• IIM Imperative #2 focus areas (builds upon JCSEM M&S Report)
  – System integration assembly and test modeling
  – Supply chain modeling and analysis
  – Hybrid QFD-VDD trade study approaches
  – Yield modeling (mechanical, electrical, assembly)
  – Quantitative DFX analyses
  – Should cost analyses

• AMEC committee to develop **M&S roadmaps** for IIM Imperative #2
  – Define detailed capability requirements criteria for each focus area
  – Validate and document gaps in current analysis tool capabilities
  – Identify key institutions performing research in areas to close gaps
  – Establish ROM timelines and investment requirements to close gaps
AMEC Interfaces

Competencies & Skills

Manufacturing Workforce Committee
Manufacturing Supply Chain Committee

AMEC

NDIA Systems Engineering Division

Manufacturing Technology Committee

Universities, Associations, & Consortiums

Decision Methodologies

Advanced M&S Tools
Other Potential AMEC Subjects

• What is the role and core competencies of an “advanced manufacturing engineer” – build upon JCSEM workforce findings
• How can we accelerate “scar tissue” accumulation in a virtual environment to better prepare the workforce of tomorrow
• How can we integrate advanced supply chain design and analysis tools into the supply chain management discipline
• How can simulation based approaches help enable Service Oriented Manufacturing (SOA) approaches by reducing risk
Back-Up
DOD/NASA IIM Imperative 2 Focus Areas for Roadmap Development

1. System integration assembly and test modeling
   - Which requirements drive specialized assembly and test capabilities?
   - How can we understand integration complexity early in the process?

2. Supply chain modeling and analysis
   - More than logistics – how do we model process & quality “loss mechanisms”?
   - How can we model and manage risk across multiple enterprise dimensions?

3. Hybrid QFD-VDD trade study approaches
   - How can we drive requirements traceability AND early producibility evaluations?
   - How can we identify, define, allocate, and flow down critical industrial reqmts?

4. Yield modeling (mechanical, electrical, assembly)
   - How can we predict yield early in the design process before hardware is built?
   - How can we extend proven electrical/semiconductor yield models to other areas?

5. Quantitative DFX analyses
   - More than rules - how can we predict DFM violation impact on producibility?
   - How do we balance and optimize assembly versus component DFM criteria?

6. Should cost analyses
   - How do we set and flow down realistic cost targets for fluid conceptual designs?
   - How can we assign uncertainty bounds to cost estimates based on rqmt stability?
It all Starts with Requirements…. 

Need to De-Fragment the Systems Engineering “V” Diagram