Making Smart Manufacturing Work: The Stakeholder-driven Requirements Development Process

Smart Manufacturing Pavilion
Meet the Experts Theatre

Alan Weber, July 11, 2018

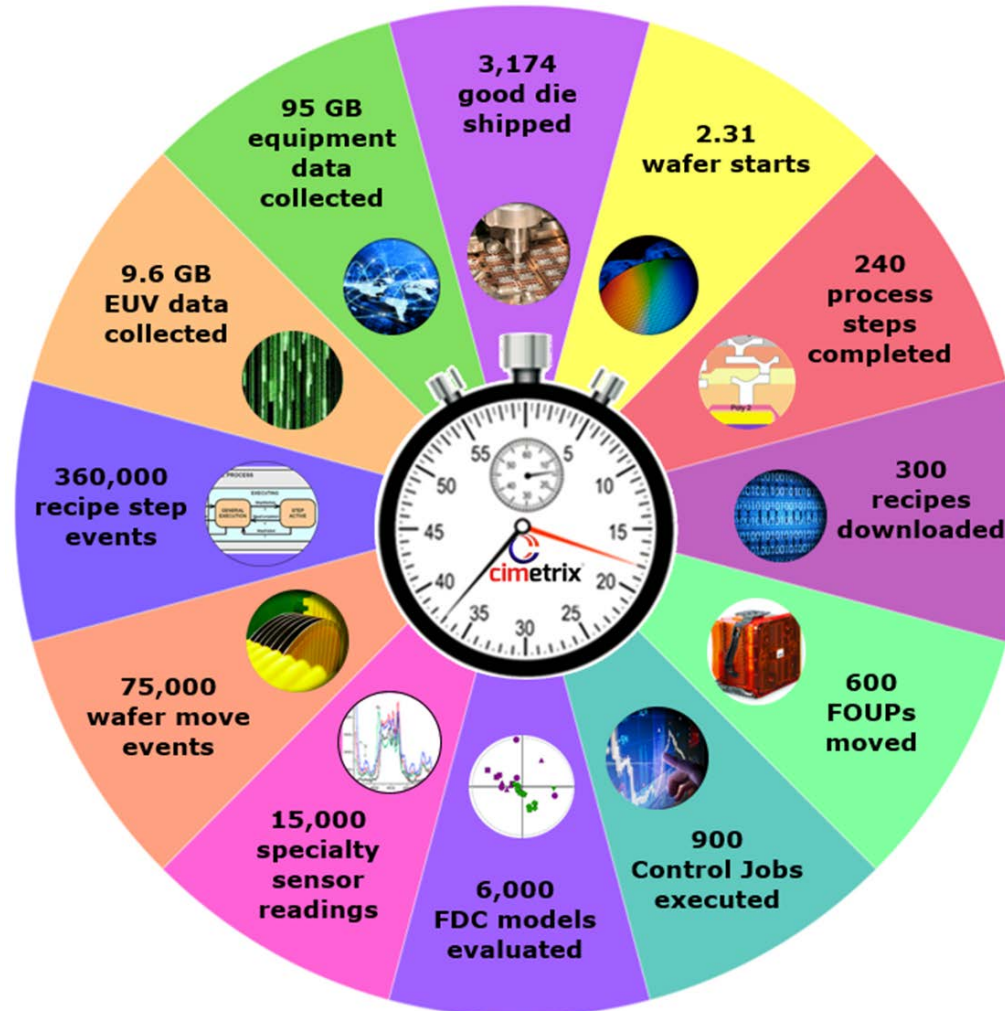**SEMICON WEST**
BEYOND SMART

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Outline

- Gigafab context
- Key messages
- Importance of the equipment model
- Smart Factory stakeholders
- Requirements development process
- Call to action

Gigafab context
In every minute of every day…

EDA services collect millions of parameters…

GEM messages coordinate hundreds of transactions…

GEM300 events track thousands of activities…

- 3,174 good die shipped
- 2.31 wafer starts
- 240 process steps completed
- 300 recipes downloaded
- 600 FOUPs moved
- 900 Control Jobs executed
- 6,000 FDC models evaluated
- 15,000 specialty sensor readings
- 75,000 wafer move events
- 360,000 recipe step events
- 9.6 GB EUV data collected
- 95 GB equipment data collected

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Key messages

- We understand what data fabs want to collect … and *why*
  - Fabs collect data to solve specific problems… *not* to make life difficult for their equipment suppliers
- Purchase specifications should be based on real requirements from a broad set of smart manufacturing stakeholders
  - Operational *and* strategic company objectives
  - System infrastructure goals and limitations
- We have defined a rigorous process for translating stakeholder requirements into interface purchase specs
  - And applied it successfully in multiple instances

Current EDA* purchase specifications…
…*Cover a broad spectrum*

Our target

15-20 pages, complete, unambiguous expectations for standards versions, model content, performance and reliability, functional priorities, testing requirements, and expected response format

10 pages of redundant or out-of-date material copied from old versions of the standards mixed in with real requirements; difficult for OEMs to interpret and respond
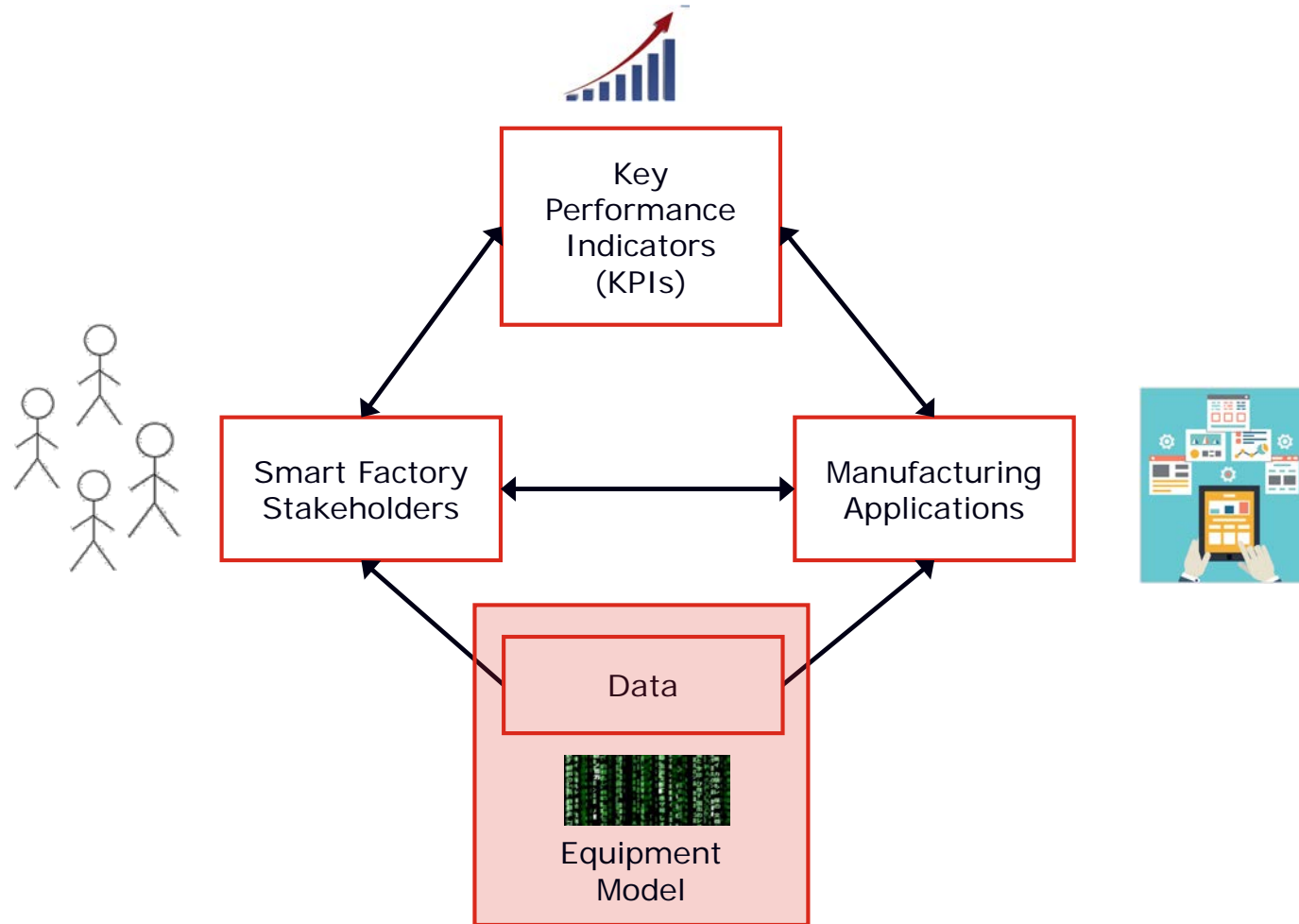

3 pages,
Simple, incomplete list of standards with no additional guidance

Good information scattered across multiple documents and spreadsheets that mix requirements, priorities, and expected response formats
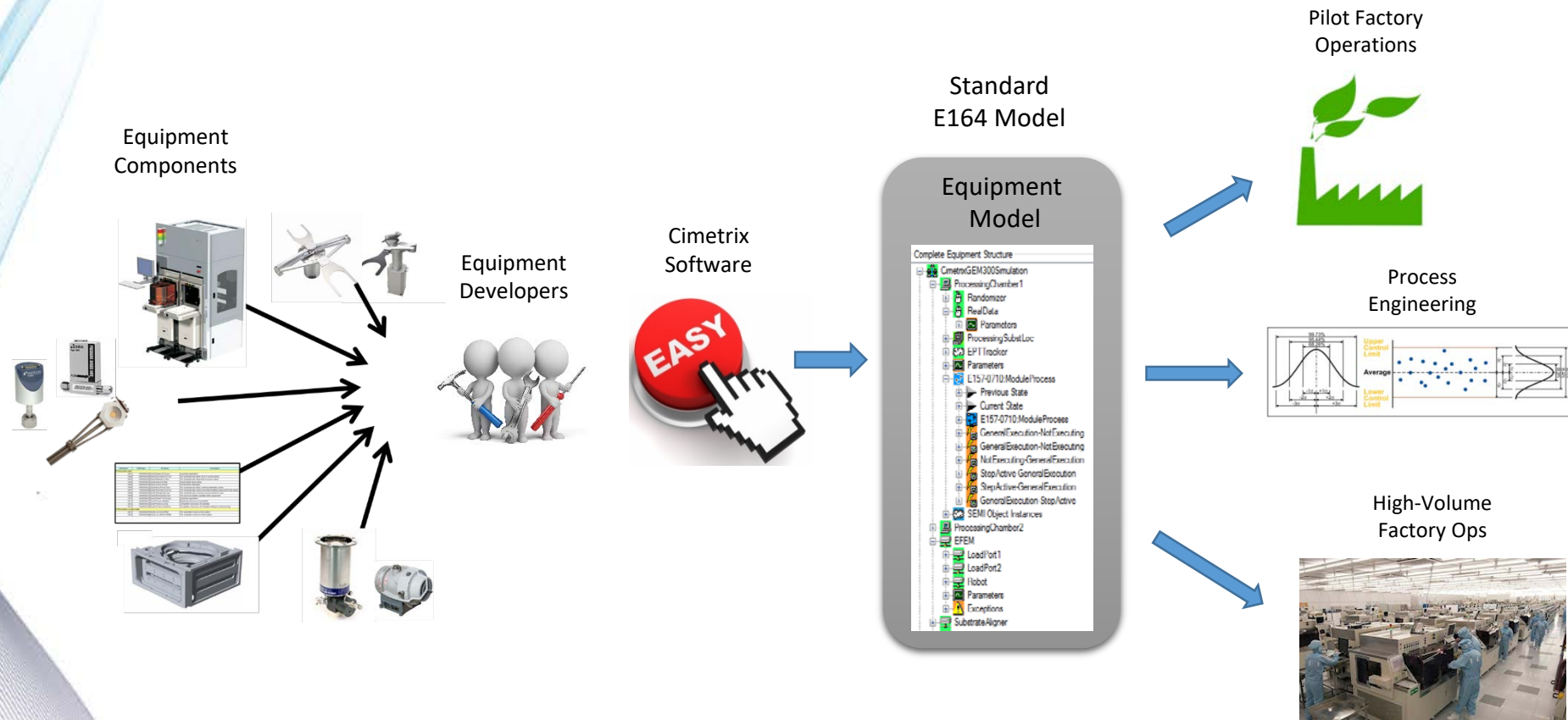
* EDA = SEMI's Equipment Data Acquisition standards suite

KPIs, stakeholders, applications, …
Importance of the equipment model

The equipment model value chain

Equipment
Components

Equipment
Developers

Cimetrix
Software

EASY

Standard
E164 Model

Equipment
Model

Complete Equipment Structure
- CimetrixGEM300Simulation
  - ProcessingChamber1
    - Randomizer
    - RealData
      - Parameters
    - ProcessingSubstLoc
    - EPTTracker
    - Parameters
    - E157-0710:ModuleProcess
      - Previous State
      - Current State
      - E157-0710:ModuleProcess
      - GeneralExecution-NotExecuting
      - GeneralExecution-NotExecuting
      - NotExecuting-GeneralExecution
      - StepActive GeneralExecution
      - StepActive-GeneralExecution
      - GeneralExecution StepActive
    - SEMI Object Instances
  - ProcessingChamber2
  - EFEM
    - LoadPort1
    - LoadPort2
    - Robot
    - Parameters
    - Exceptions
  - SubstrateAligner

Pilot Factory
Operations

Process
Engineering

High-Volume
Factory Ops

KPIs (metrics)

- Time to money
- Yield
- Productivity
- Throughput
- Cycle time
- Capacity
- Scrap rate
- EHS

Smart Factory stakeholders
and their priorities (engineering)

- Process engineers
  - Develop and maintain robust manufacturing processes that achieve device operational specifications (speed, power, size)
- Equipment engineers
  - Fleet matching and management to minimize or eliminate the need to dedicate certain equipment sets for critical process steps and thereby simplify the overall factory scheduling process
- Maintenance engineers
  - Minimize equipment downtime, MTTR (mean time to repair), and test wafer usage required to bring equipment back to production-ready state
- Industrial engineers
  - Monitor equipment and factory throughput in real-time, identify opportunities to eliminate wait time waste in individual equipment types as well as the overall factory, and address bottlenecks as they shift and emerge
- Facilities engineers
  - Collect and integrate sub-fab data from pumps, chillers, exhaust systems, and other complex subsystems into the production data management infrastructure for use by a growing range of analysis applications

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Smart Factory stakeholders
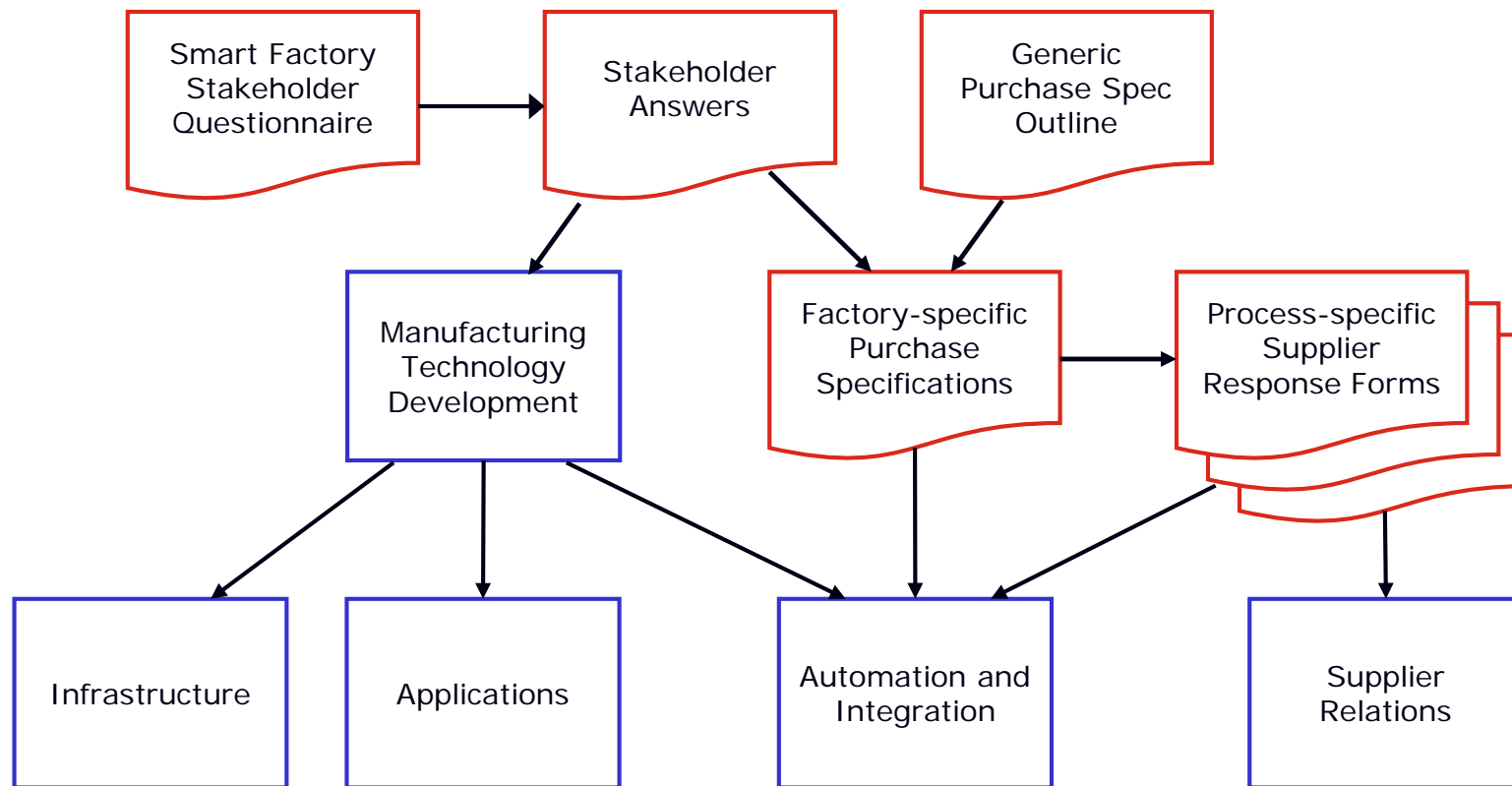## *and their priorities (operations, other)*
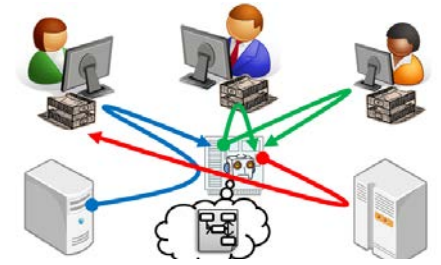
- Production control staff
  - Determine the material release schedule and manage the factory scheduling/dispatching systems to accommodate changes in customer orders and/or factory status;

- Application and infrastructure developers
  - Define overall factory system design and implementation roadmap to achieve and maintain competitive advantage, and provide applications that achieve productivity, quality, and reliability objectives of the industrial, process, and equipment engineers

- Automation and integration specialists
  - Connect equipment to factory system infrastructure and related applications and verify compliance to automation purchase specifications

- Procurement/Supplier Relations
  - Manage the overall purchasing process to support factory customers while achieving capital budget targets

- Factory management
  - Responsible to executive management for competitive manufacturing results

Requirements development
Process and results

Document

Organization

Smart Factory Stakeholder Questionnaire → Stakeholder Answers

Generic Purchase Spec Outline

Manufacturing Technology Development

Factory-specific Purchase Specifications → Process-specific Supplier Response Forms

Infrastructure

Applications

Automation and Integration

Supplier Relations

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Stakeholder questionnaire
Sample questions (1)

- **Manufacturing Automation/Technology Development**
  - Are you familiar with SEMI E157 (Module Process Tracking)? Is it implemented on any of your current tools, and if so, do you monitor those events?
  - Do you require that all state machines, states, state transition events, and attributes of the objects defined in the referenced 300mm SEMI Standards be implemented? If not, why not?
  - Do you currently use information from sub-fab systems in any of your on-line production applications, like FDC, PHM, R2R control, or others? If so, what range of equipment is supported, and how (pumps, chillers, abatement systems …)?
  - How do you express performance expectations for process variable reporting, such as sampling frequency, # parameters per chamber, report sizes, total bandwidth of all data reported, maximum latency of event generation, etc.?

Stakeholder questionnaire
Sample questions (2)

- **Production Operations and Engineering Support**
  - How do you schedule carrier pick-up and delivery from/to equipment, respectively? Is this done using algorithms in the AMHS/MCS/OHT system components, or do you get real-time updates from the equipment about pending lot completion and tool availability?
  - Do you need to have remote access capability for checking basic tool status outside the fab?
  - Do you require your suppliers to provide built-in data collection schemes (pre-defined reports, macros, etc.) to support common monitoring, maintenance, or diagnostic processes?
  - Do you have a list of parameters/events that must be collectable to support your production application portfolio?
  - Do you monitor any of the low-level actuator/sensor signals in the various mechanisms that make up a manufacturing tool?

Stakeholder questionnaire
Sample questions (3)

- **Procurement and Supplier Relations**
  - What compliance tests/reports do you require of the equipment suppliers before they ship equipment to your factories? Do you ever/sometimes/always visit the supplier's site to observe this process? What about *after* delivery?
  - Do you have a standard supplier response sheet or checklist for your automation requirements? If so, are you satisfied with its clarity, completeness, and ease of use for evaluating responses?
  - At what point in the equipment purchasing cycle do you review the capabilities of the interface software (event/parameter lists, model structure/content, projected performance, etc.)? When are these capabilities validated?
  - Do you assign a monetary value (say, some % of the equipment purchase price) to the interface software?

Sample purchase specification
Major sections

Purchase Spec
- Standards
- Platform
- E120, E125, …
- Process info
- Performance
- Testing
- Life cycle

- References to standards required (SEMI, other)
- Platform and system architecture
- Standard-specific items (E120, E125, E134, E164…)
- Model content (by process, use case)
- Performance and data quality
- Acceptance testing (pre-/post-delivery)
- Life cycle interactions

…and

- Consistently formatted Supplier Response Checklist

Valid Entries:
Comply
Comply by (Date)
Partially Comply (Notes)
Do no comply
N/A

Why is E164* so important?

Common metadata results in...

- Consistent implementations of GEM300

- Commonality across equipment types

- Automation of many data collection processes

- Less work to interpret collected data

- Enables true "plug and play" applications

- Major increases in fab engineering efficiency

> *E164 is to EDA what GEM was to SECS-II*

*EDA Common Metadata standard

Call to action

- Identify your key Smart Manufacturing stakeholders
- Craft a process to capture their requirements
- Assess the impact to your manufacturing systems
- Pick a champion and a high-priority opportunity
- Leverage SEMI Standards frameworks in solution design
- Turn 'em loose... but call if you need help!

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