Standards-based Interoperability for Systems and Asset Management

Serm Kulvatunyou (with Nenad Ivezic and Yan Lu)

Systems Integration Division (SID)

Engineering Laboratory

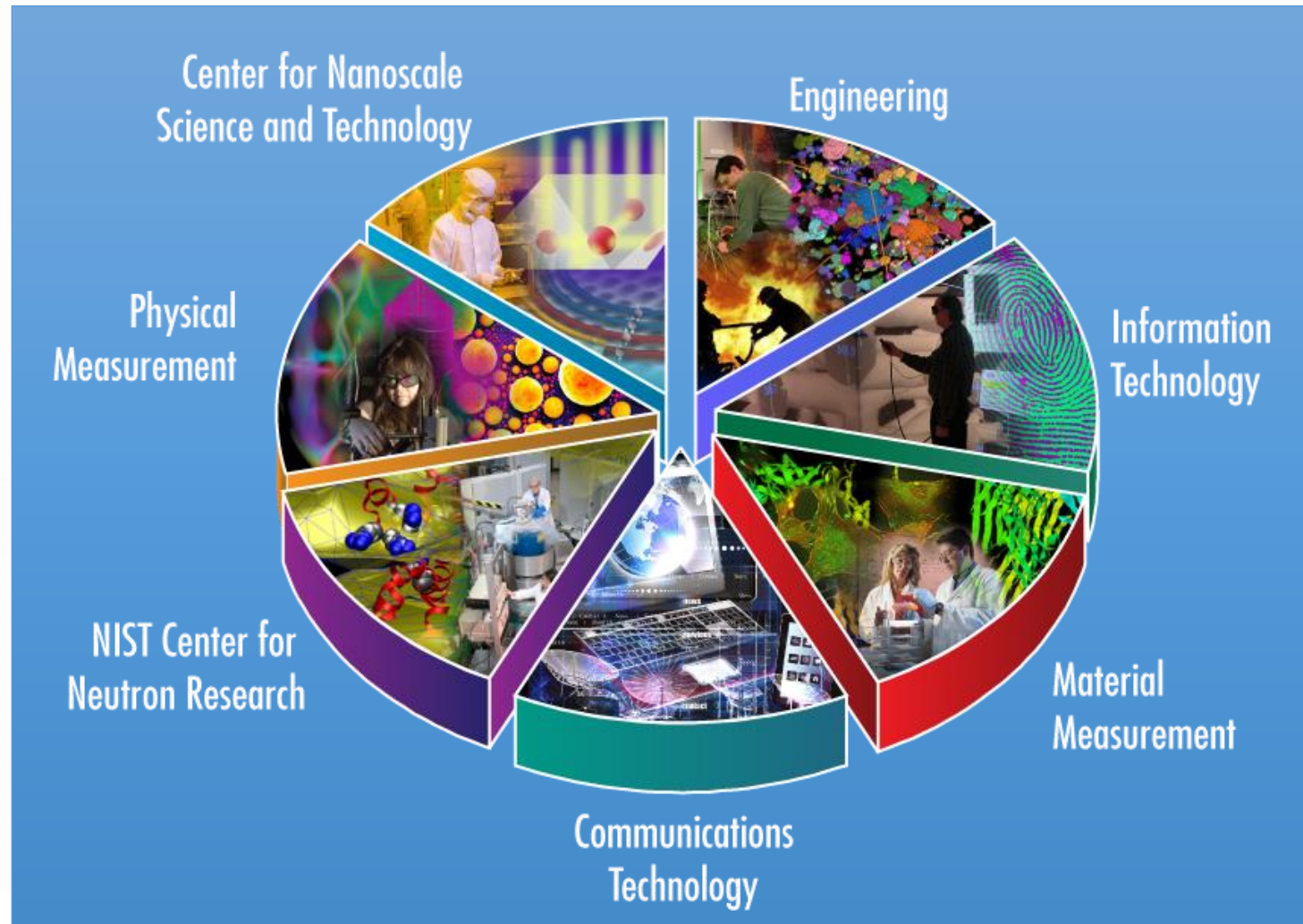**National Institute of Standards and Technology (NIST)**

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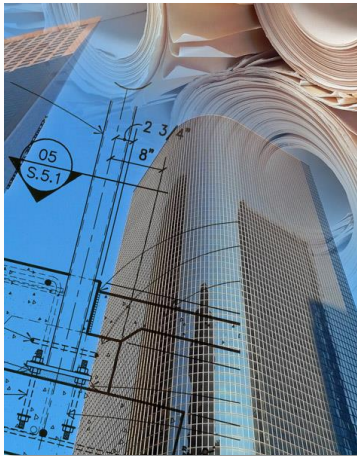
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NIST SID, Who We Are?

NIST Mission:
Promoting U.S. Innovation and Industrial Competitiveness by advancing **measurement science, standards, and technology** in ways that enhance economic security and improve our quality of life.

NIST Laboratories

NIST

Systems Integration Division (SID)

- We develop models, methods, and tools to help industry develop, implement, and validate standards for integrating manufacturing related systems
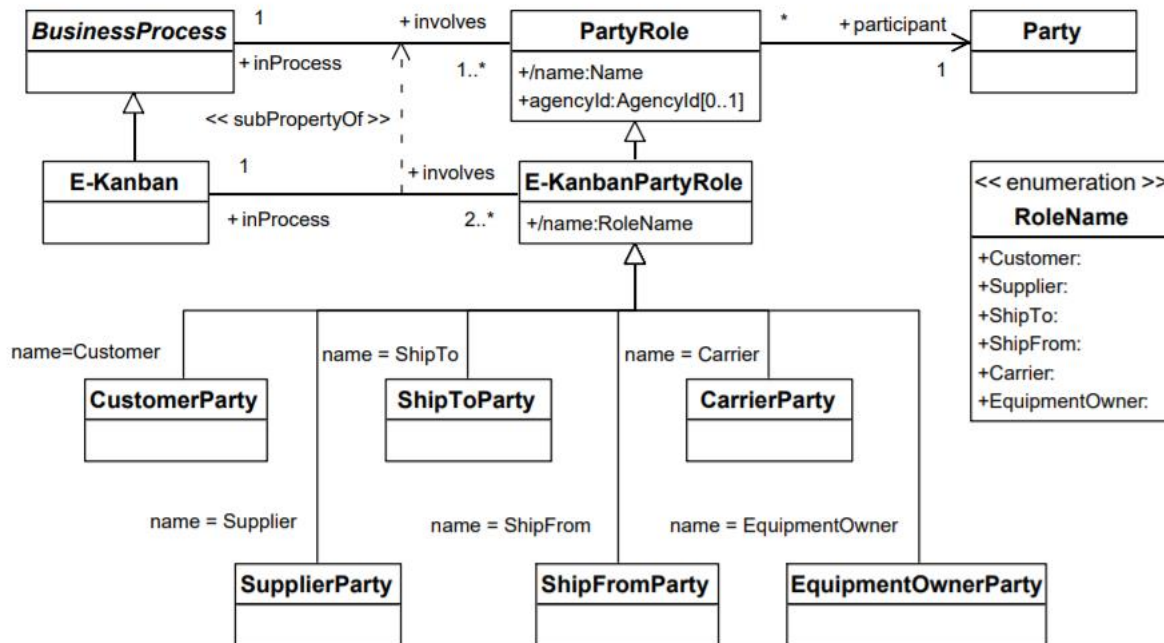
Figure 3   E-Kanban Process and Roles

Smart Manufacturing Goal

Model-based Manufacturing Services: Service Oriented for Data and IT
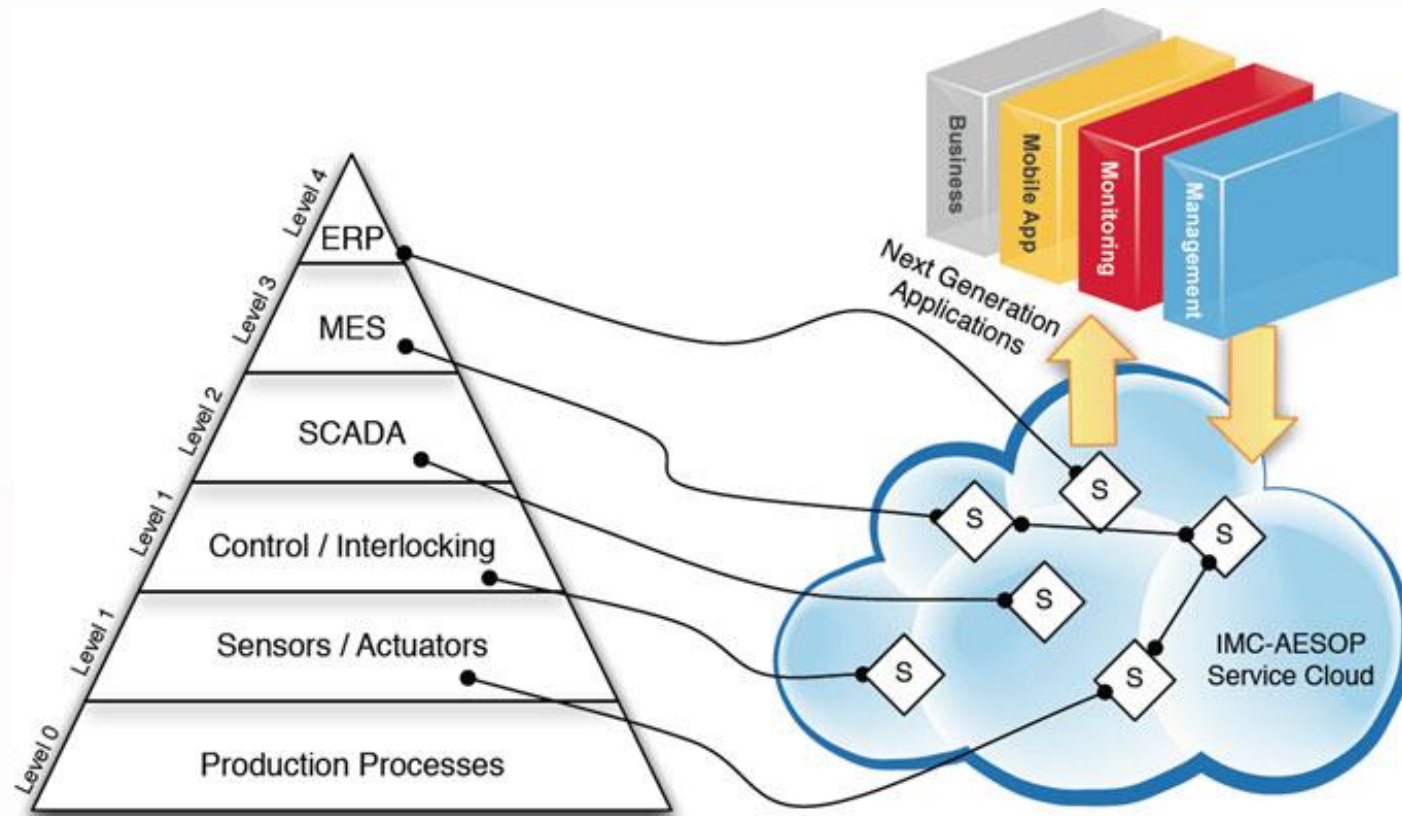
Source: Karnouskos et al. 2012. A SOA-based architecture for empowering future collaborative cloud-based industrial automation. EU FP7 Project IMC-AESOP

Standards for Data and IT

Product Lifecycle Data Management:
- ISO 10303 – 239
- LOTAR
- PLMXML

Modeling Practice
- ASME Y14.41, Y 14.36, Y14.5
- ISO 16792, 7083
- ISO 1101, 5459
- ISO 14405, 2692
- ISO 1302, 5458
- ISO 8062, 17863
- IEC 81724

Product Model & Data Exchange
- ISO 10303 - 203/214/210/242
- ISO 14306(JT)
- ISO 14739 (PRC)
- IGES, DXF
- ISO/ASTM 52915 (AMF), STL

Manufacturing model data
- ISO6983 (G-Code)
- ISO 14649
- ISO 10303 - 207
- ISO 10303 - 224
- ISO 10303- 238 (STEP-NC)
- QIF Part 1

Product Catalog Data:
- ISO 13584
- ISO 15926-4 (RDL)
- ISO 22745 eOTD

Production System Model Data & Practice
- ISO 10303 – 214, 221, 225, 227, ISO 16739 (IFC), ISO 18629 (PSL),
- IEC 62832 (Digital factory), IEC 62794, IEC 62237
- IEC 62424 (CAEX), ISO 17506 (COLLADA), PLC Open XML

Production System Engineering
- SysML, Modelica
- IEC 61011, 61499, 61804 -2, 62337
- IEC 61508, 61511 , ISO 13849
- IEC 62714 (AutomationML)
- IEC 62453 (FDT), IEC 61804 (EDDL)

Production System Maintenance
- MIMOSA OSA-EAI, CBM
- GEIA 927
- ISO 13374, ASME B5.59-2

Production Lifecycle Data Management
- ISO 10303 – 239,
- ISO 15926, ISO 16739
- IEC 62890, IEC 61987

Enterprise Level
- ISO 19439 Enterprise integration
- ISO 19440 Enterprise integration
- ISO 20140 Automation systems and integration
- OAGIS
- BPMN, DMN, PMML

ERP

MOM Level
- B2MML
- IEC 62541, IEC 62837
- IEC 62264 (ISA 95)
- ISO 22400
- OAGIS
- PMML
- DMIS, QIF

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SCADA Level
- IEC 62541 (OPC UA)
- IEC 61512 (ISA 88)
- Modbus
- BatchML, PACKML

HMI/DCS

Device Level
- IEC 62541 (OPC UA)
- MT Connect
- IEC 61158 (EtherCAT, PROFINET)
- IEC 61784
- Modbus/Profibus
- PROFIenergy
- IEC 62591/ HART
- IEC 62541 (FDI)

Field Device

- **OMG** – BPML, BPMN, BPDM
- **OASIS** – ebXML, BPEL, WS-BRSP
- **W3C** – WSDL, SOAP, WS-CDL
- **WfMC** – XPDL
- **OAGI** – OAGIS
- **APICS** – SCOR
- **MESA** - B2MML

Business Process Protocol

Data Exchange Protocol

Messaging Protocol

Transfer Protocol

Networking Protocol

Security Protocol
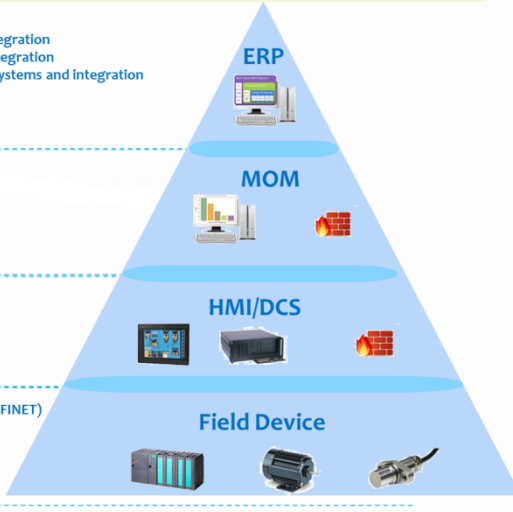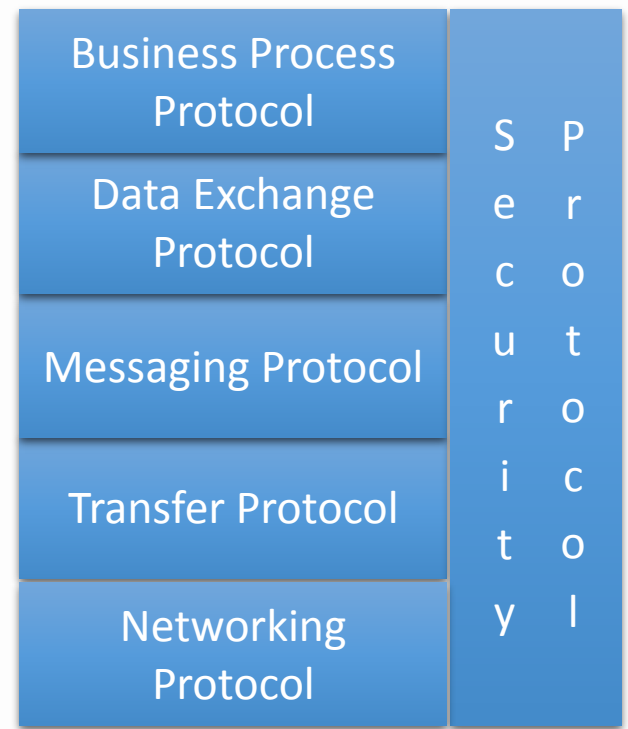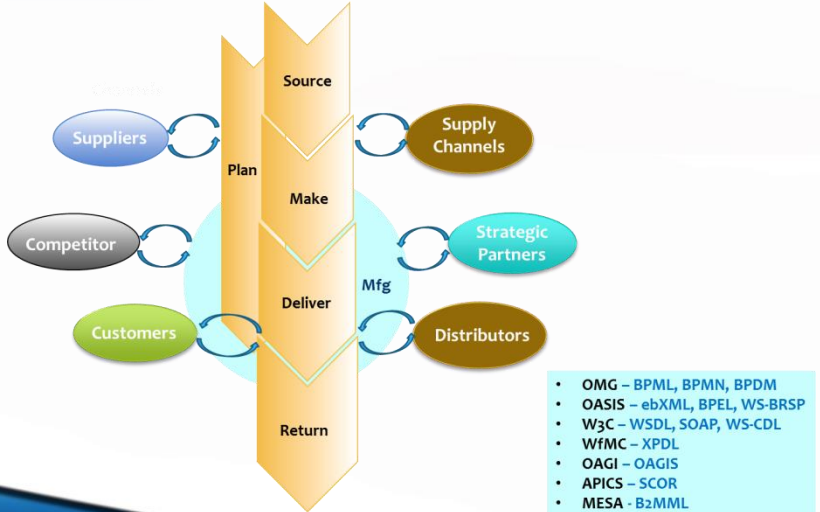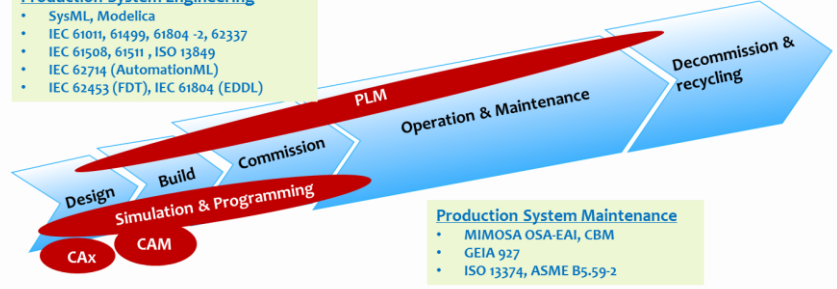
Source: Lu, et al., Standards Landscape for Smart Manufacturing Systems

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Some of the Past and Present collaborators

- Past
  - Open Applications Group Inc. (OAGi) standards for enterprise applications and supply chain interoperability
  - Automotive Industry Action Groups standard for automotive manufacturing supply chains
  - FIATECH AEX cfiXML standard for exchanging engineered equipment
  - ISO TC 184 SC4, SC5
    - ISO 10303 – Standards for geometric data exchange
- Present and Future
  - Open Applications Group Inc. (OAGi) standards – Smart Manufacturing WG, JSON Mobile WG, SME WG
  - ISO TC 184 SC4, SC5
    - ISO 10303 – Standards for product manufacturing information data exchange
    - ISO 18101 – Interoperability and Digitalization for Oil and Gas and Process Industries
  - MIMOSA CCOM and ISBM standards enabling digitalization and interoperability for life-cycle asset management, manages OGI Pilot
  - MTConnect standard for machine tool data

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Model-based Manufacturing Services

- Our project has been building these set of capabilities

Component & Systems Integration Modelling

NIST & OAGi Smart Manufacturing Systems Integration Modelling Capability @ Enterprise Level

Business Process Modelling, Classification & Cataloging

Collaborative Interface Modelling

Core Component + Business Information Modelling

Core Component Model Management

Expression Generation (XML Schema, JSON Schema)

BPCCS Tool

Score Tool and REST-based Web Services Specs

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Process Industry Smart Manufacturing
Agile Integration and Standards Based Interoperability

Cross-layer Operation Management Processes

P E R A

Analytics can be performed in all levels using the Models to Contextualize the Sensor-based Information. Other significant events are also captured for analysis, including those resulting in Configuration Changes resulting in Model Changes.

Analytical Models

Trusted S forystems

IIConsors

Supply Chain Integration

ERP Process Models

L4

OAGi Collaboration

Condition-based Maintenance and Operation

L3

Industrial Process Models

System Models

MIMOSA Collaboration

Equipment Models

Components Models

L2

Device Models

Sensor Models

Systems Integration Management

L1

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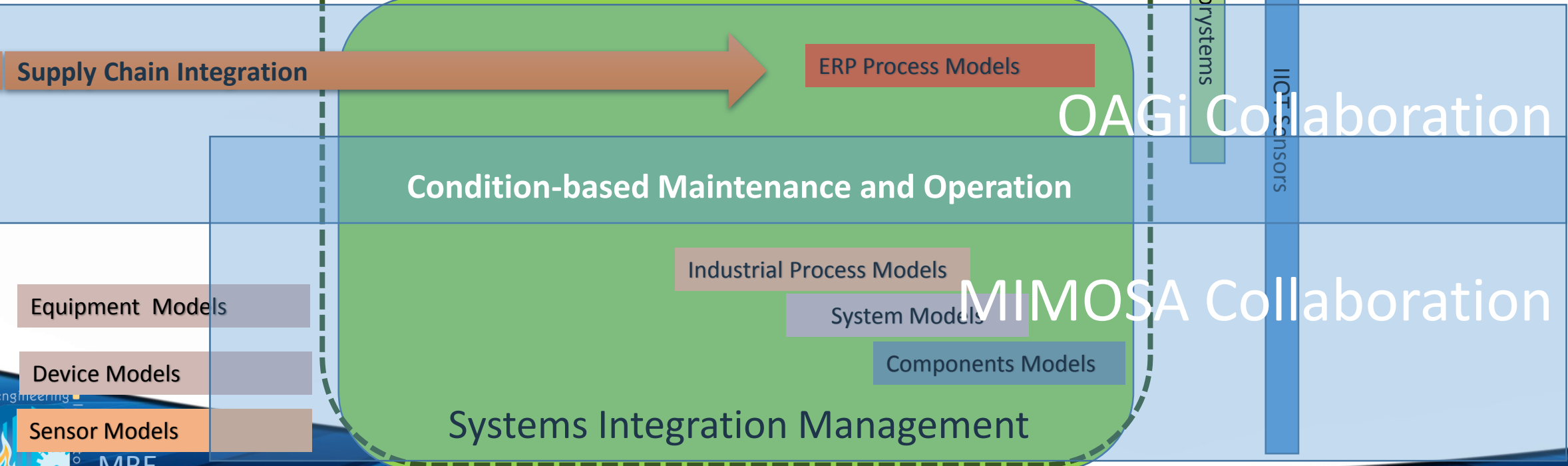
Land O'Lakes CBM/CBO and IIOT Collaboration Scenario

Source: Scott Nieman, Enterprise Architect, Land O'Lakes

Cross-Sectored Smart Manufacturing
with Critical Infrastructure Management (CIM)

Critical Infrastructure Management Process

Analytics can be performed in all levels using the Models to Contextualize the Sensor-based Information. Other significant events are also captured for analysis, including those resulting in Configuration Changes resulting in Model Changes.

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Risk Models

Trusted S forystems
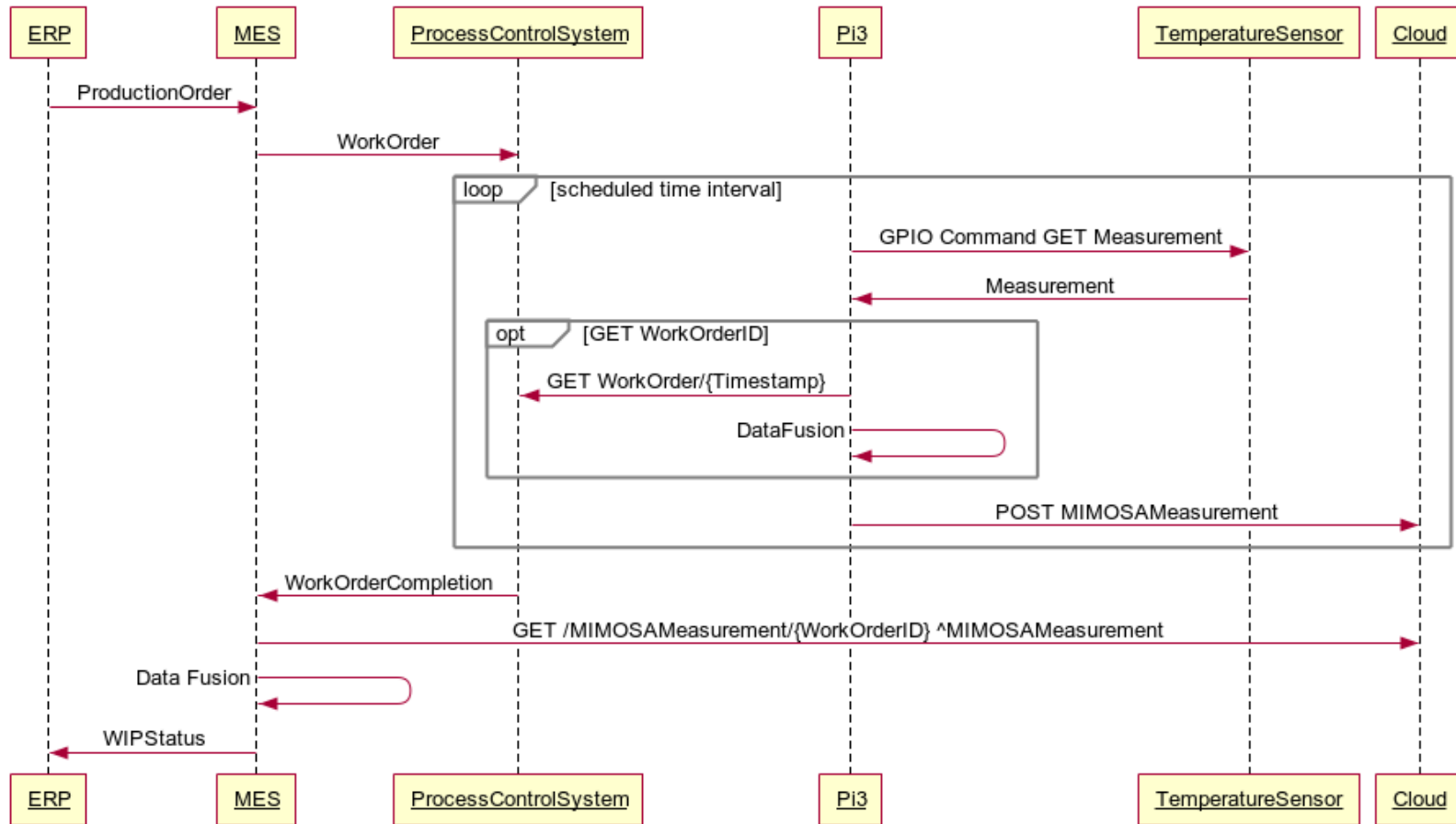
IoT Sensors

P
E
R
A

Supply Chain Integration

ERP Process Models

OAGi Collaboration

L4

MOM Joint Collaboration
OpenO&M, ISA, OPC, IEC, ISO

Industrial Process Models

System Models

L3

Equipment Models

Component Models

MIMOSA Collaboration

L2

Device Models

Sensor Models

Systems Integration Management

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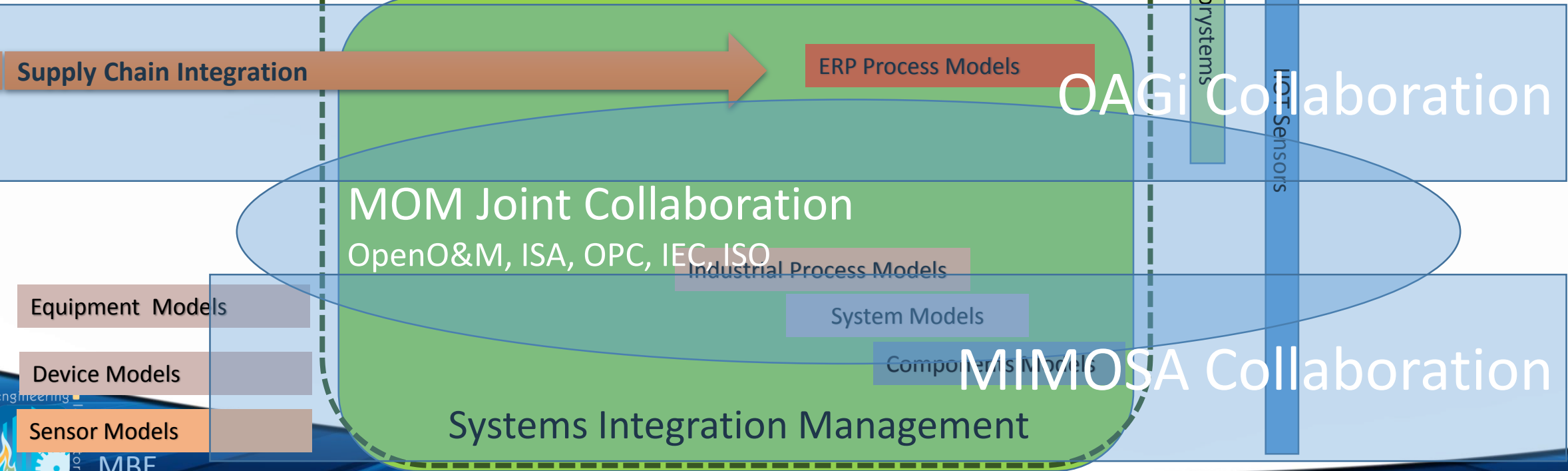
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White Paper Series with MIMOSA

- Use cases
  - Discrete and Process Industry IIOT/CBM/CBO/CIM use cases
- Existing IoT message standards: OMF, O-DF/O-MI, MQTT, MTConnect, QIF
- Architecture of IIOT message integration into OAGi and other relevant manufacturing operation standards
  - Standards-based interoperability approach
  - Integrate CCOM Measurement Type into OAGi message
  - Contextualization of CCOM message using the Score tool
- Proof of concept with Land O'Lakes, Lockheed, and other upcoming use cases
- Generalization of the architecture for cross-sectored critical infrastructure management

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Conclusion & Remark

- NIST works with manufacturing industry across sectors

- NIST's smart manufacturing goal is to deliver standards-based solutions to improve the performances of manufacturing industry, particularly the agility

- Critical infrastructure reliability and resilience are interdependent with manufacturing agility

- Reliability and resilience of critical processes, systems and components supports manufacturing agility

- NIST SID Model-based Manufacturing Services project uses a model-based approach to support standards development and implementation to enable smart manufacturing

- The model-based approach along with additional SOA standards have proven values in level 3 & 4 use cases. We will be working with MIMOSA and OAGi to pilot it in the level 2-4 CBM/CBO use cases

- From this experience, we would like to expand our collaboration with other SDOs to apply the CBM/CBO capability for cross-sectored CIM use cases

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Thank you

Question?