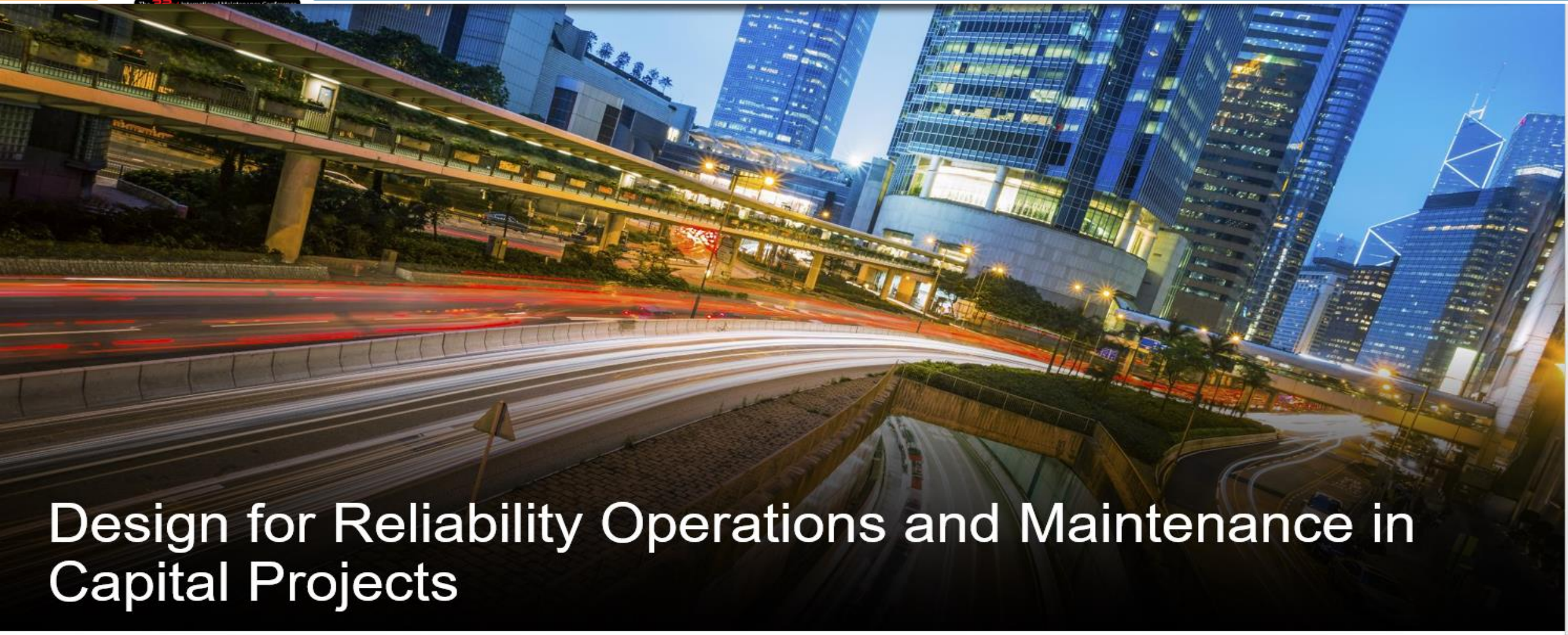


Design for Reliability Operations and Maintenance in Capital Projects

December 2017

MIMOSA

JACOBS

ARMS RELIABILITY

EMPOWER | EDUCATE | EQUIP

Bentley Advancing Infrastructure

Standards-based Interoperability

- **MIMOSA Vision** - Interoperable Components, Systems, Systems of Systems and Networks of Networks composed into adaptable, scalable, secure and sustainable Digital Business Ecosystems

Industry Path Forward:

- Simplify
- Standardize
- Digitalize
- Interoperate

Alan Johnston: MIMOSA President, ISO TC 184/WG 6 Convener

- 35 years of expertise designing reliability into industrial IT/IM/IS systems supporting asset, reliability and condition management.

The Open Industrial Interoperability Ecosystem

The Standards-based Digital Business Ecosystem for Reliability Centered Design

International Maintenance Conference

Dec 12, 2017

Bonita Springs, FL

What Is MIMOSA?

- A non-profit industry standards organization organized as a 501 (c) 6 Mutual Benefit Association
- Funded and managed by members for mutual benefit
  - Owner/Operators (Dow, BP, Southern Company, US Army/DoD)
  - OEMs
  - Major Software Suppliers
  - EPCs
  - Academia
- Builds, publishes and maintains supplier-neutral, open standards addressing Life-cycle Asset Management
- Manages the definition, validation and evolution of the Open Industrial Interoperability Ecosystem (OIIE) and the associated interoperability testbed.

Analytical Framework

- **What** are the key IT/IM/IS related problems impacting reliability?
  - Many inherently complex processes and systems, which are constantly evolving
  - Many people, processes and systems exist in silos
  - IT Security is an increasing threat to all aspects of Critical Infrastructure
  - **Industrial IT/IM/IS solutions still follow an artisan model, rather than the industrial model**
- **Why** do they matter?
  - Industries must gain efficiencies, while improving risk management and sustainability
  - Custom systems integration increases costs and risks, while decreasing adaptability and sustainability
- **How** do we address them?
  - Standards Based Interoperability Framework
  - Standard asset information models incorporating Reliability, Condition and Maintenance Management
  - Standard Use Cases and Scenarios covering complete Asset Life-cycle
  - Digital Business Ecosystems
  - **The Open Industrial Interoperability Ecosystem (OIIE)**

Standards-based Interoperability

- **MIMOSA Vision** - Interoperable Components, Systems, Systems of Systems and Networks of Networks composed into adaptable, scalable, secure and sustainable Digital Business Ecosystems

Path Forward:

- Simplify
- Standardize
- Digitalize
- Interoperate

Ecosystems and Interoperability-Concept

- Supplier-specific Interoperability
  - **Lego**
  - Enterprise Resource Planning (ERP)
  - Apple Ecosystem
- Open Source
  - Linux
  - Android
- Standards-based Interoperability
  - **Intermodal Transport**
  - Internet
  - Industrial Internet of Things (IIOT)

➢**Open Industrial Interoperability Ecosystem (OIIE) – Embraces COTS & Open Source**

An IEEE Interoperability Definition

- IEEE: The capability…
  - of two or more systems or elements to exchange information and to use the information that has been exchanged.
  - for units of equipment to work together to do useful functions.
  - that enables heterogeneous equipment, generally built by various vendors, to work together in a network environment.
  - of two or more systems or components to exchange information in a heterogeneous network and use that information.

Critical Infrastructure: Key Sectors

Critical Infrastructure Definition

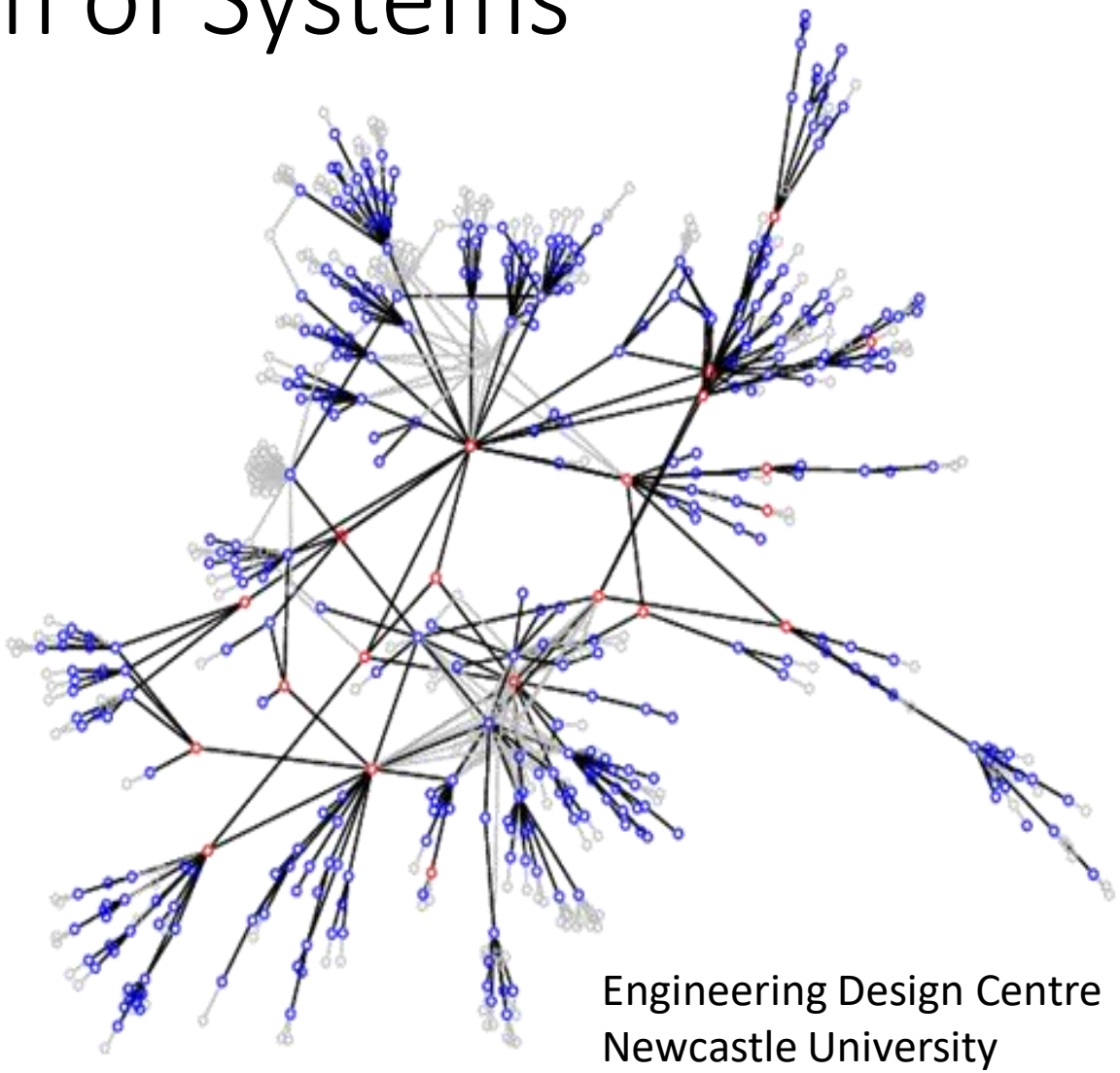
What Is Critical Infrastructure?

Critical infrastructure is a term used by governments to describe assets that are essential for the functioning of a society and economy. - Wikipedia

Critical infrastructure are the assets, systems, and networks, whether physical or virtual, so vital to the United States that their incapacitation or destruction would have a debilitating effect on security, national economic security, national public health or safety, or any combination thereof.

Last Published Date: November 1, 2013
US Department of Homeland Security

A “simple” System of Systems



Engineering Design Centre
Newcastle University

System of Systems

- **A System of Systems** (SoS) is a collection of task-oriented or dedicated systems that pool their resources and capabilities together to create a new, more complex system which offers more functionality and performance than simply the sum of the constituent systems. – Wikipedia

  - SoS has been developed and is widely used in the aerospace and defense community, but it is now being adopted by many other industry groups
  - SoS terminology is linked to the systems engineering community and the International Council on Systems Engineering (INCOSE).

- Interoperability is considered to be an intrinsic part of SoS

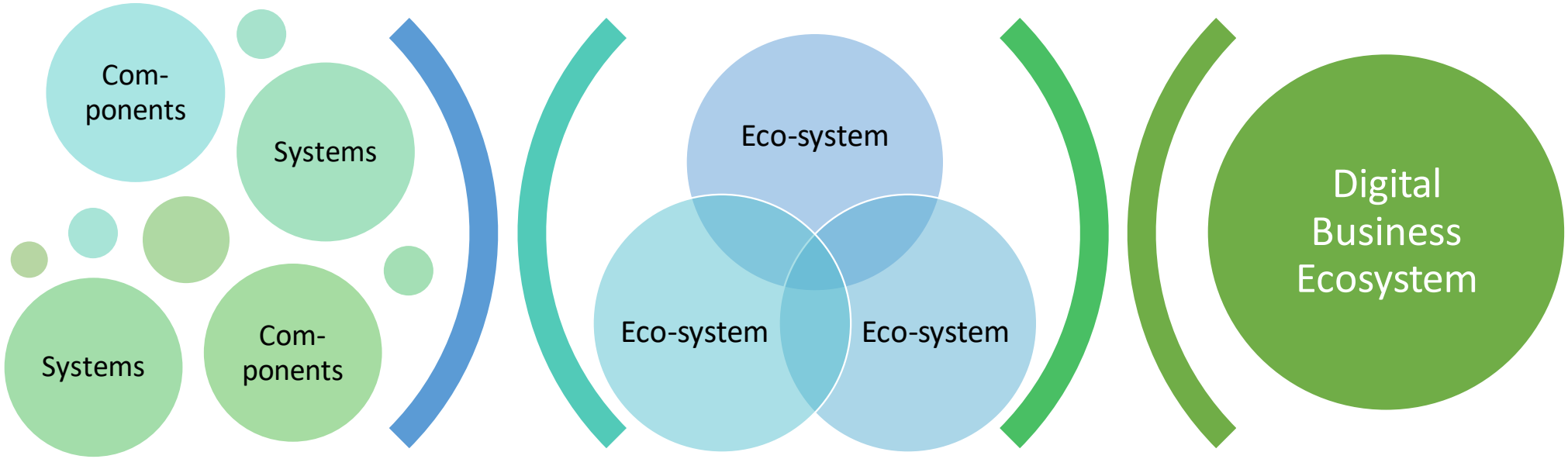
  - Proprietary Interoperability Schemes usually fail as no single company knows everything about everything.

  ❖Standards-based Interoperability now provides a rational alternative to the status quo

Industrial Interoperability and Digitalization
Potential Paths

- Single Supplier/Single Platform
  - Supplier/Product-centric Design
  - Single supplier or cartel of suppliers impose their own product “standards” on industry
  - Problems:
    - No single supplier or cartel controls a critical mass of the entire market
    - No single supplier or cartel understands every important aspect of the entire market
- Open, Supplier-Neutral Specifications
  - Industrial Solutions Architecture Centric Design
  - Follow broadly accepted industrial IT Solutions Architecture (TOGAF)
  - Interoperability Specifications informed by Industrial Use Cases and Scenarios
  - Incorporate multiple, existing standards
  - Standardized Enterprise Solutions Architecture which is cloneable, rather than custom built

Systems of Systems and Individual Enterprise Ecosystems Must Interoperate In Digital Business Ecosystems



Nodes

Network of Enterprise Eco-systems

The Big Picture

The Open Industrial Interoperability Ecosystem (OIIE) defines the basis for Supplier Neutral Digital Business Ecosystems composed of Enterprise Ecosystems which share the required standards.

Digital Ecosystem

Wikipedia:

- A digital ecosystem is a distributed, adaptive, open socio-technical system with properties of self-organisation, scalability and sustainability inspired from natural ecosystems.
- Digital ecosystem models are informed by knowledge of natural ecosystems, especially for aspects related to competition and collaboration among diverse entities.
- The term is used in the computer industry, the entertainment industry, and the World Economic Forum.

Major IT/IS firms (Apple, Google, Microsoft, SAP and many others) have all been developing and promoting their own proprietary digital ecosystems for over 10 years.

Digital Business Ecosystem-Why?

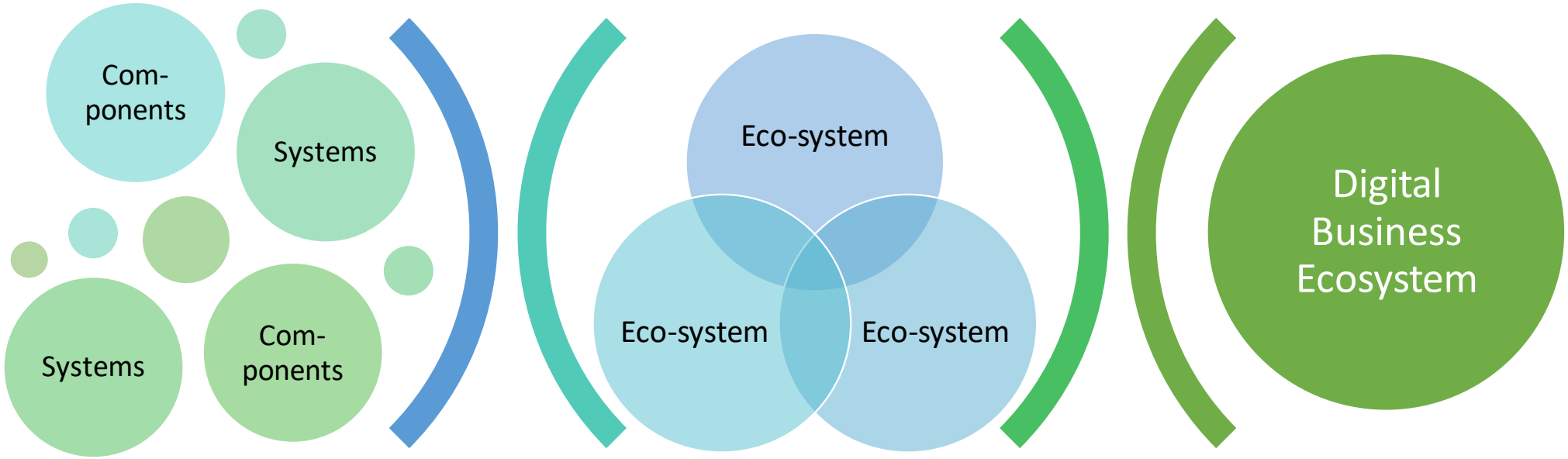
Wikipedia:

- The concept of Digital Business Ecosystem was put forward in 2002 by a group of European researchers and practitioners, including Francesco Nachira, Paolo Dini and Andrea Nicolai, who applied the general notion of digital ecosystems to model the process of adoption and development of ICT-based products and services in competitive, highly fragmented markets like the European one.

Digital Business Ecosystem-Status

- The challenge is to find pragmatic ways of implementing Digital Business Ecosystems which are supplier neutral and adaptive enough to sustainably span the industrial sectors included in for Critical Infrastructure.
- The OIIE provides such an approach where:
  - OIIE provides a standardized intra and inter-enterprise Solutions Architecture fully composed of published, supplier-neutral standards
  - OIIE Instances are Cloanable

Systems of Systems and Individual Enterprise Ecosystems Must Interoperate In Digital Business Ecosystems



Nodes

Network of Enterprise Eco-systems

The Big Picture

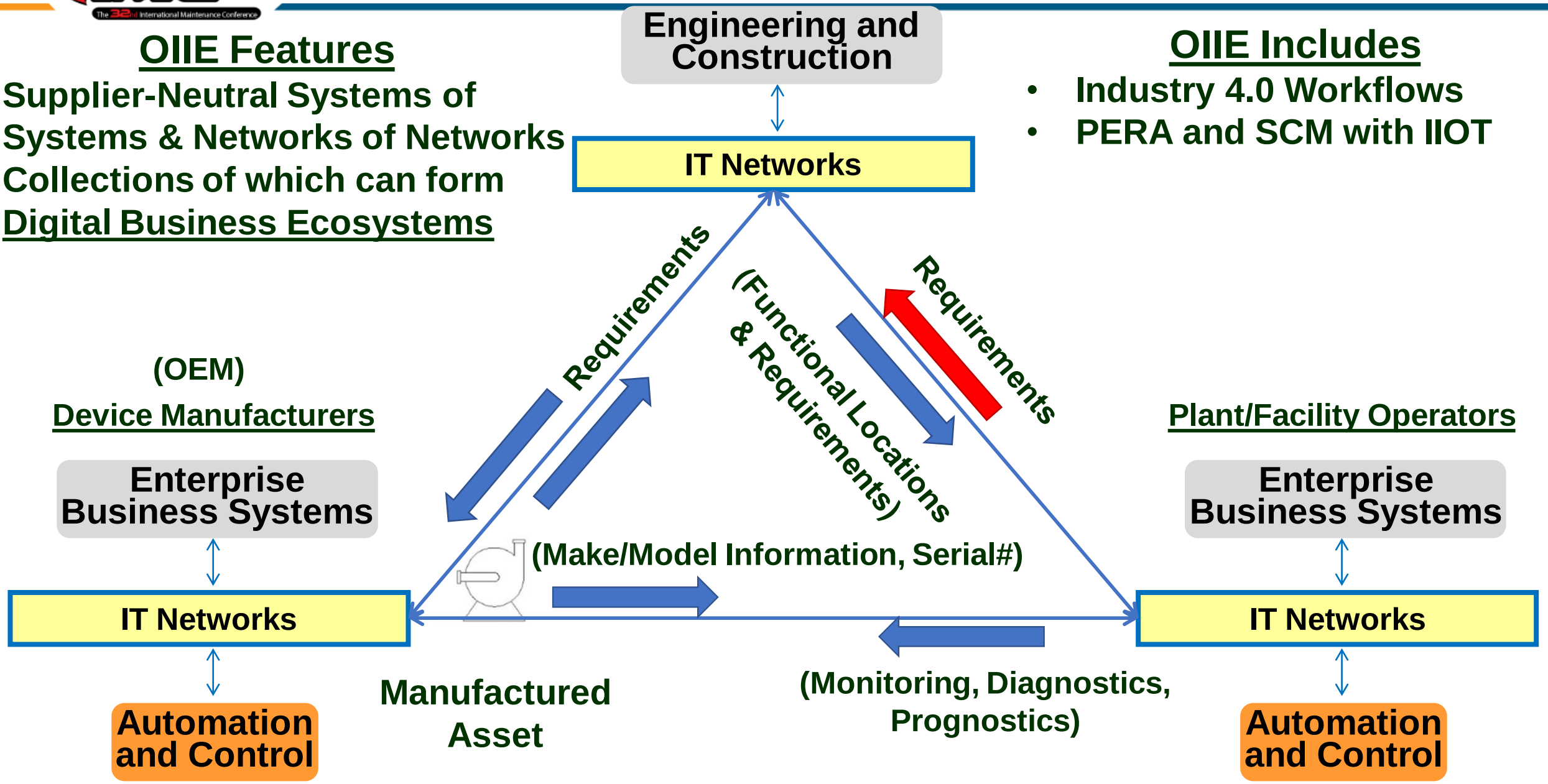
The Open Industrial Interoperability Ecosystem (OIIE) defines the basis for Supplier Neutral Digital Business Ecosystems composed of Enterprise Ecosystems which share the required standards.

OIIE Features

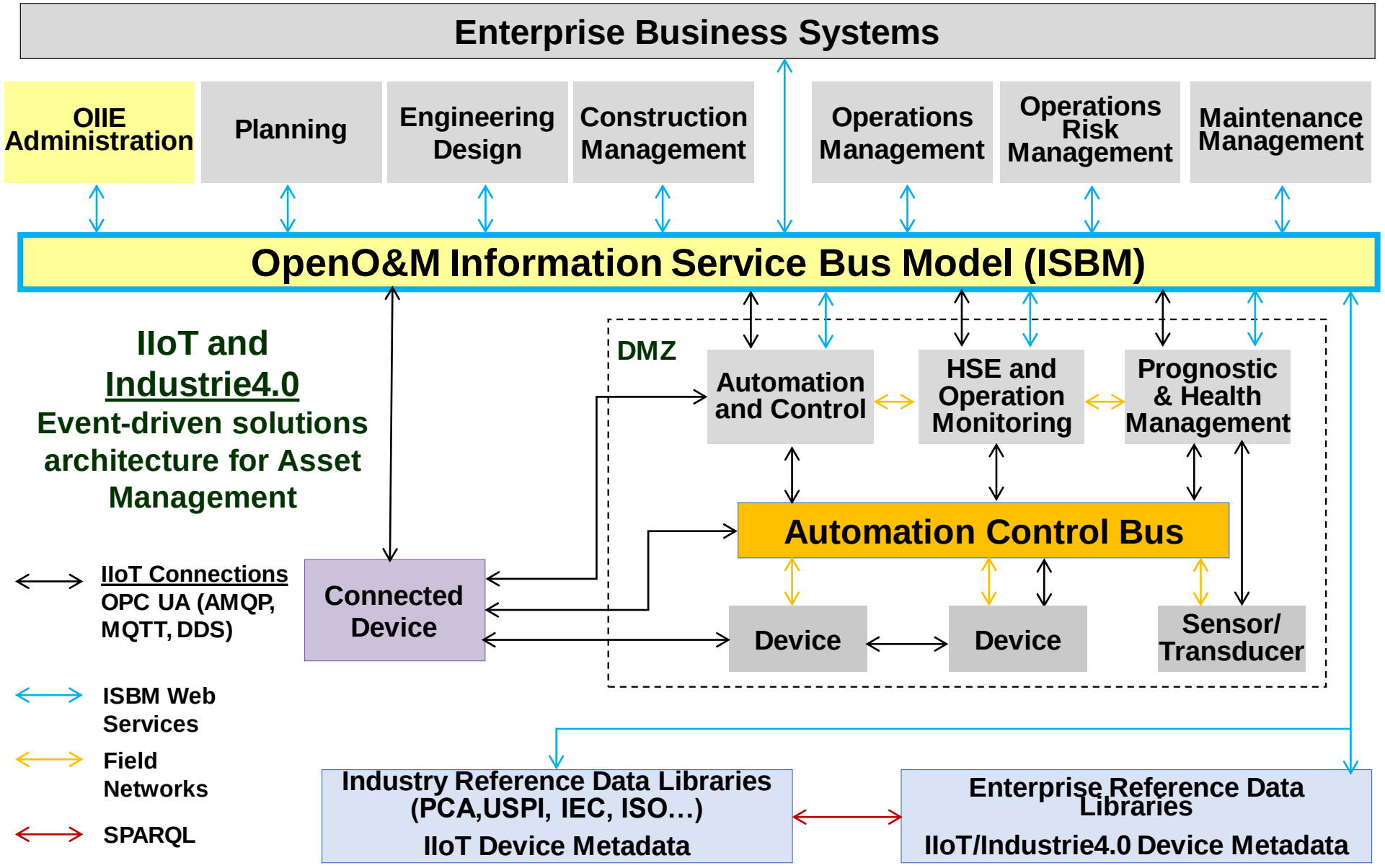
- Supplier-Neutral Systems of Systems & Networks of Networks
- Collections of which can form Digital Business Ecosystems

OIIE Includes

- Industry 4.0 Workflows
- PERA and SCM with IIOT



OIIE Simplified Systems Connectivity and Services Architecture



Enterprise Capital Project Data Management Standards

OIIE Pilot Business Use Cases Roadmap - Part 1

Plan Program Contract	Engineer Simulate Design	Procure	Fabricate Construct	Complete Commission Startup	Operate Maintain	Decommission Dispose

Continuous Handover (Structured Digital Assets, Tags, Docs)
Establishing an Environment for Lifecycle System of Systems Interoperability

Sustained Lifecycle Digital Asset Management

- **OIIE Use Case 1: Capital project handovers to O&M**
- **OIIE Use Case 4: Enterprise Product Data Library Management**
- **OIIE Use Case 10: Automated provisioning of O&M systems**
- **OIIE Use Case 11: Enterprise Reference Data Library (RDL) Management**

OIIE Pilot Business Use Cases Roadmap - Part 2

Enterprise Capital Project Data Management Standards

Plan Program Contract	Engineer Simulate Design	Procure	Fabricate Construct	Complete Commission Startup	Operate Maintain	Decommission Dispose

Continuous Handover of Structured Digital Assets

Sustained Lifecycle Digital Asset Management

Sustaining the Interoperable O&M Environment

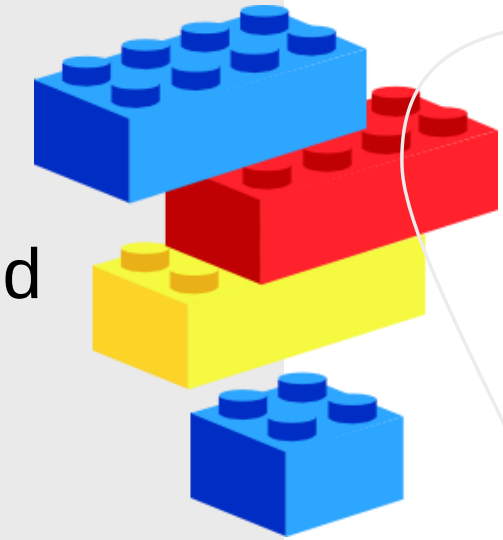
- **OIIE Use Case 2: Recurring Engineering Updates to O&M**
- **OIIE Use Case 3: Field Changes to Plant/Facility Engineering**
- **OIIE Use Case 4: Enterprise Product Data Library Management**
- **OIIE Use Case 5: Asset Installation/Removal Updates**
- **OIIE Use Case 6: Preventive Maintenance Triggering**
- **OIIE Use Case 7: Condition-Based Maintenance Triggering**
- **OIIE Use Case 8: Early Warning Notifications**
- **OIIE Use Case 9: Incident Management/Accountability**
- **OIIE Use Case 10: Provisioning of O&M systems**

OIIE Standardized Use Case Architecture

Standardized Methodology to Define and Re-use OIIE Components

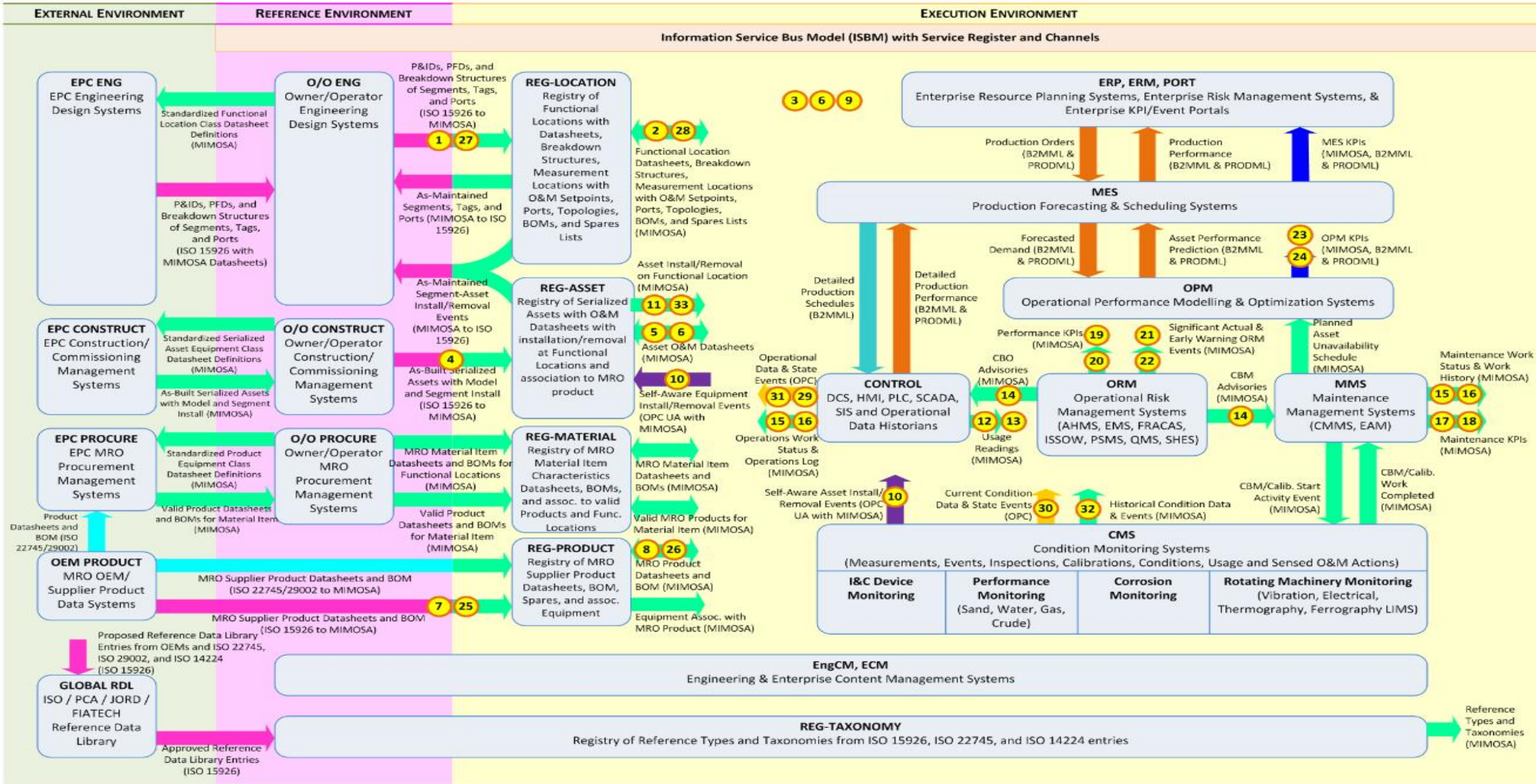
Use Case = 11+4

- Background
- Scope
- Preconditions
- Successful End Condition
- Actors
- Triggers
- Process Workflow
- Scenarios



Scenario (OIIE Event/Micro Service Definition for Adaptors)= 32

- Actors
- Data Content
- Data Formats
- Reference Data
- Information Service Bus Configuration


EXTERNAL ENVIRONMENT
REFERENCE ENVIRONMENT
EXECUTION ENVIRONMENT
Information Service Bus Model (ISBM) with Service Register and Channels
EPC ENG
EPC Engineering Design Systems
O/O ENG
Owner/Operator Engineering Design Systems
Standardized Functional Location Class Datasheet Definitions (MIMOSA)
P&IDs, PFDs, and Breakdown Structures of Segments, Tags, and Ports (ISO 15926 with MIMOSA Datasheets)
P&IDs, PFDs, and Breakdown Structures of Segments, Tags, and Ports (ISO 15926 to MIMOSA)
1
27
As-Maintained Segments, Tags, and Ports (MIMOSA to ISO 15926)
As-Maintained Segment-Asset Install/Removal Events (MIMOSA to ISO 15926)
REG-LOCATION
Registry of Functional Locations with Datasheets, Breakdown Structures, Measurement Locations with O&M Setpoints, Ports, Topologies, BOMs, and Spares Lists
2
28
Functional Location Datasheets, Breakdown Structures, Measurement Locations with O&M Setpoints, Ports, Topologies, BOMs, and Spares Lists (MIMOSA)
3
6
9
ERP, ERM, PORT
Enterprise Resource Planning Systems, Enterprise Risk Management Systems, & Enterprise KPI/Event Portals
Production Orders (B2MML & PRODML)
Production Performance (B2MML & PRODML)
MES KPIs (MIMOSA, B2MML & PRODML)
MES
Production Forecasting & Scheduling Systems
Forecasted Demand (B2MML & PRODML)
Asset Performance Prediction (B2MML & PRODML)
23
24
OPM KPIs (MIMOSA, B2MML & PRODML)
Detailed Production Schedules (B2MML)
Detailed Production Performance (B2MML & PRODML)
OPM
Operational Performance Modelling & Optimization Systems
EPC CONSTRUCT
EPC Construction/ Commissioning Management Systems
O/O CONSTRUCT
Owner/Operator Construction/ Commissioning Management Systems
Standardized Serialized Asset Equipment Class Datasheet Definitions (MIMOSA)
As-Built Serialized Assets with Model and Segment Install (MIMOSA)
4
As-Built Serialized Assets with Model and Segment Install (ISO 15926 to MIMOSA)
REG-ASSET
Registry of Serialized Assets with O&M Datasheets with installation/removal at Functional Locations and association to MRO product
Asset Install/Removal on Functional Location (MIMOSA)
11
33
5
6
Asset O&M Datasheets (MIMOSA)
10
Self-Aware Equipment Install/Removal Events (OPC UA with MIMOSA)
Operational Data & State Events (OPC)
31
29
15
16
Operations Work Status & Operations Log (MIMOSA)
Performance KPIs (MIMOSA)
19
20
21
22
Significant Actual & Early Warning ORM Events (MIMOSA)
Planned Asset Unavailability Schedule (MIMOSA)
CBO Advisories (MIMOSA)
14
12
13
Usage Readings (MIMOSA)
CONTROL
DCS, HMI, PLC, SCADA, SIS and Operational Data Historians
ORM
Operational Risk Management Systems (AHMS, EMS, FRACAS, ISSOW, PSMS, QMS, SHES)
CBM Advisories (MIMOSA)
14
MMS
Maintenance Management Systems (CMMS, EAM)
Maintenance Work Status & Work History (MIMOSA)
15
16
17
18
Maintenance KPIs (MIMOSA)
EPC PROCURE
EPC MRO Procurement Management Systems
O/O PROCURE
Owner/Operator MRO Procurement Management Systems
Standardized Product Equipment Class Datasheet Definitions (MIMOSA)
Valid Product Datasheets and BOMs for Material Item (MIMOSA)
MRO Material Item Datasheets and BOMs for Functional Locations (MIMOSA)
Valid Product Datasheets and BOMs for Material Item (MIMOSA)
REG-MATERIAL
Registry of MRO Material Item Characteristics Datasheets, BOMs, and assoc. to valid Products and Func. Locations
MRO Material Item Datasheets and BOMs (MIMOSA)
Valid MRO Products for Material Item (MIMOSA)
Product Datasheets and BOM (ISO 22745/29002)
Self-Aware Asset Install/ Removal Events (OPC UA with MIMOSA)
10
Current Condition Data & State Events (OPC)
30
32
Historical Condition Data & Events (MIMOSA)
CBM/Calib. Start Activity Event (MIMOSA)
CBM/Calib. Work Completed (MIMOSA)
CMS
Condition Monitoring Systems
(Measurements, Events, Inspections, Calibrations, Conditions, Usage and Sensed O&M Actions)
I&C Device Monitoring
Performance Monitoring (Sand, Water, Gas, Crude)
Corrosion Monitoring
Rotating Machinery Monitoring (Vibration, Electrical, Thermography, Ferrography LIMS)
OEM PRODUCT
MRO OEM/ Supplier Product Data Systems
MRO Supplier Product Datasheets and BOM (ISO 22745/29002 to MIMOSA)
7
25
MRO Supplier Product Datasheets and BOM (ISO 15926 to MIMOSA)
REG-PRODUCT
Registry of MRO Supplier Product Datasheets, BOM, Spares, and assoc. Equipment
8
26
MRO Product Datasheets and BOM (MIMOSA)
Equipment Assoc. with MRO Product (MIMOSA)
Proposed Reference Data Library Entries from OEMs and ISO 22745, ISO 29002, and ISO 14224 (ISO 15926)
EngCM, ECM
Engineering & Enterprise Content Management Systems
GLOBAL RDL
ISO / PCA / JORD / FIATECH Reference Data Library
Approved Reference Data Library Entries (ISO 15926)
REG-TAXONOMY
Registry of Reference Types and Taxonomies from ISO 15926, ISO 22745, and ISO 14224 entries
Reference Types and Taxonomies (MIMOSA)

ISDD Project Build and Use Processes

ISDD BUILD

Discipline Engineers

Information Engineers

SUBJECT MATTER EXPERTS

EXISTING INDUSTRY STANDARD DATA SHEETS (ISD)

API

ASME

ISA

PIP

BUILD Process

INDUSTRY STANDARD DATA SHEET DEFINITIONS (ISDD) (Version Managed)

XML CCOM

CCOM

CCOM

Standard Mappings

15926 RDL2 CFIHOS ECCMA EOTD

INDUSTRY REFERENCE DATA LIBRARIES

ISDD USE

An Industry Rosetta Stone

Custom Mappings which enable normalization for property sets "on the wire" in M2M exchanges

Version Managed ISDDs

XML CCOM

Map Elements

EPCs

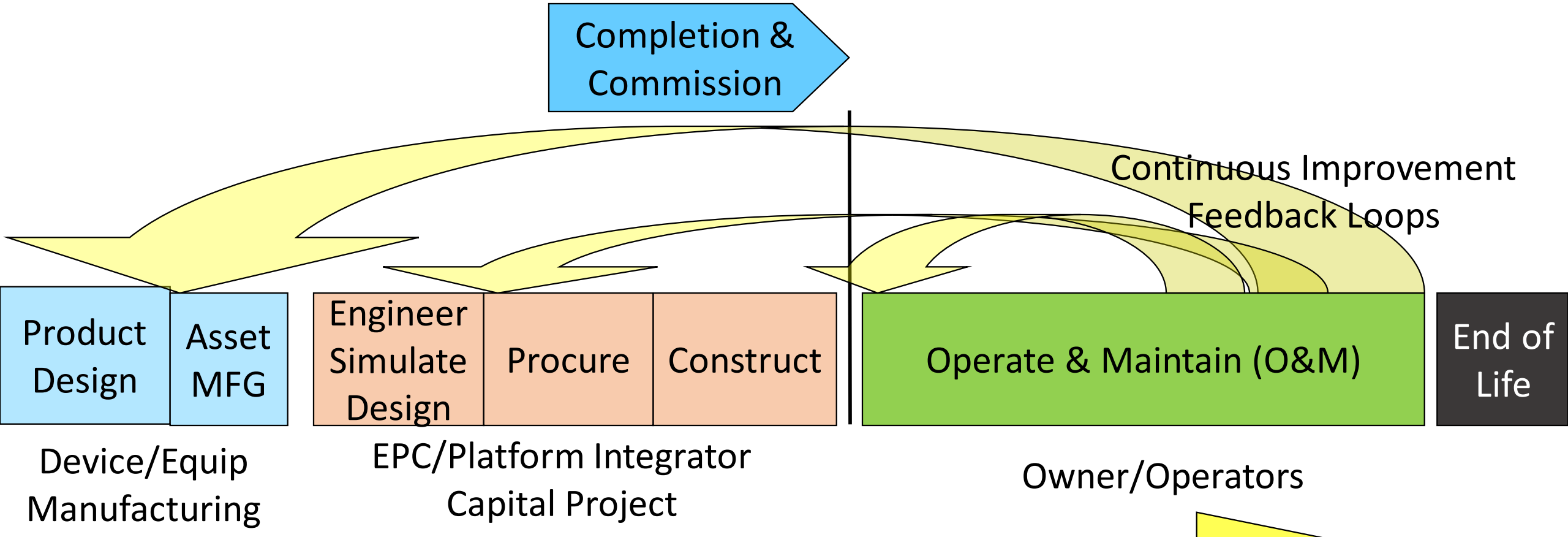
Owner/ Operators

Map Elements

Map Elements

Capital Equipment Suppliers

Full Asset Life-cycle Management



Derived from ISO TC 184
Manufacturing Asset Management Integration Task Force Final Report

MIMOSA CCOM Information Domains

Configuration Management

Work Management

Resource Management

Reliability Management

Operation and Condition Management

Reference Data and Meta Data Management

MIMOSA CCOM Information Domains

Configuration Management

- Assets
- Asset Tracking
- Functional Locations
- Manufacturers Models
- Specifications Datasheets
- Organizations Sites
- Hierarchies
- Mesh Networks
- Geospatial Tracking
- Documents

Reliability Management

- Model Info
- Engineering Studies
- FMECA
- Failure History
- Work History

Recent Activities

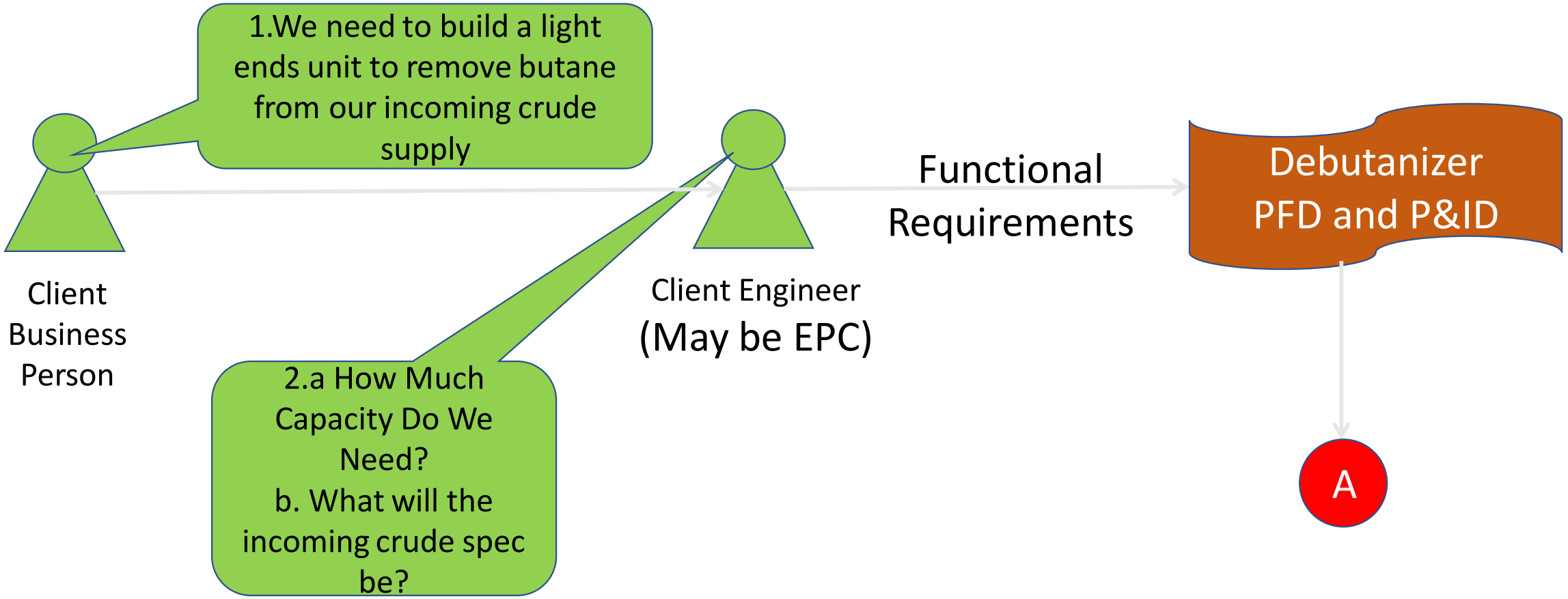
- ISO TC 184/WG 6 Meetings
  - Nov 13-15, 2017- BP, Houston, TX
- MIMOSA Industry Digitalization Meetings
  - Nov 16, 2017-SAP America, Houston, TX
  - PCA – OIIE ILAP Pilot
  - Fiatech/MIMOSA JWG for Interoperability – Barbara Migl (Dow), Co-chair
  - Deb McNeil (Dow) – MIMOSA Board Chair
  - Ted Weitzman (Southern Company) – Joining Board
  - Jim Colson (US Army) – Joining Board
- Projects/Workstreams
  - ISDDs
  - RESTful Services
  - OPC UA
  - ECCMA
  - OIIE/OGI Pilot – Open Industrial Digital Business Ecosystem

OIIE Pilot Phase 3

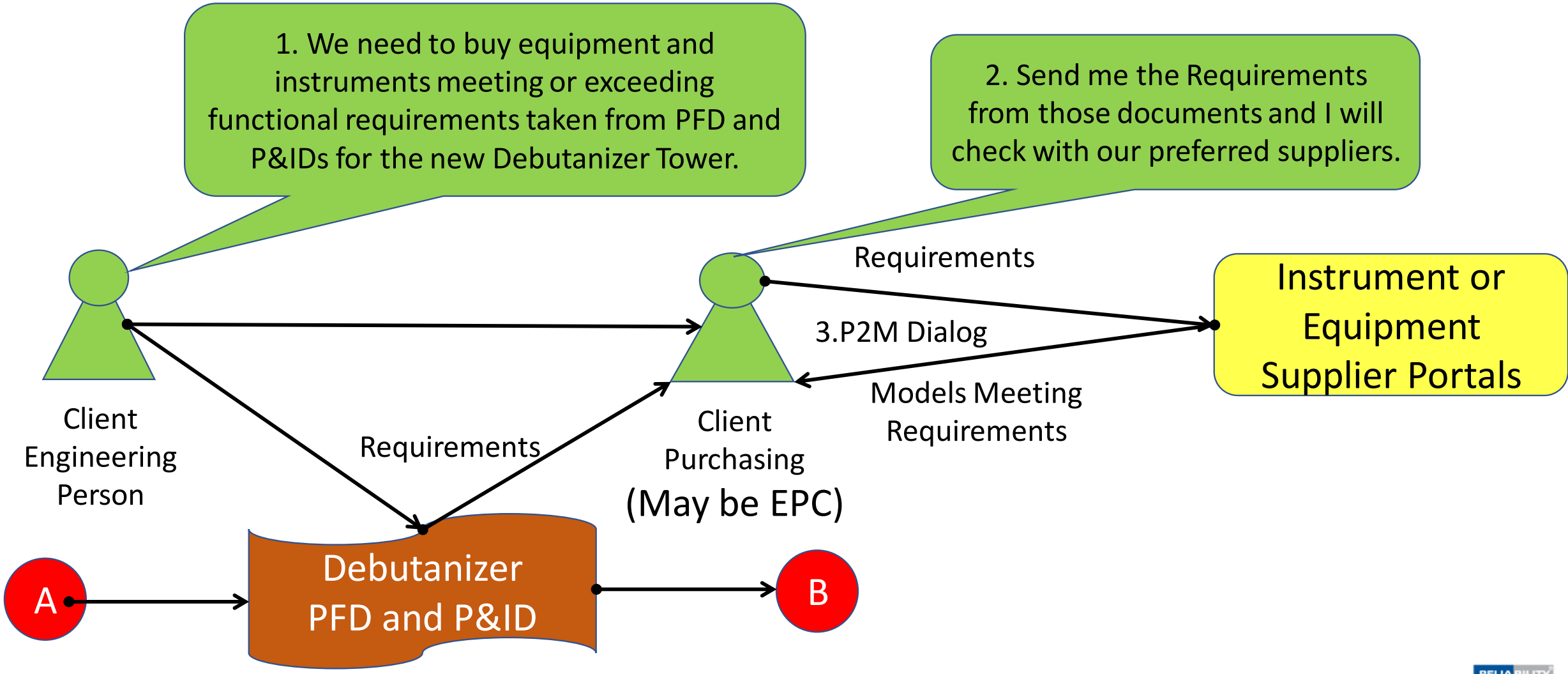
- Covers entire asset life-cycle
- Builds on OIIE/OGI Pilot Phase 2 Engineering and Design Models
  - Debutanizer Tower
  - Adds More details to simulate a real project
- Adds major new participating members
  - OEMs
  - EPCs
  - Procurement Suppliers
  - Materials and Asset Management Suppliers
- Adds ISDDs and Updated OpenO&M ISBM Specification
- In cooperation with CII/Fiatech, ECCMA, PCA, USPI and OPC Foundation

➢ **Kicks off in January- Join and participate or sponsor**

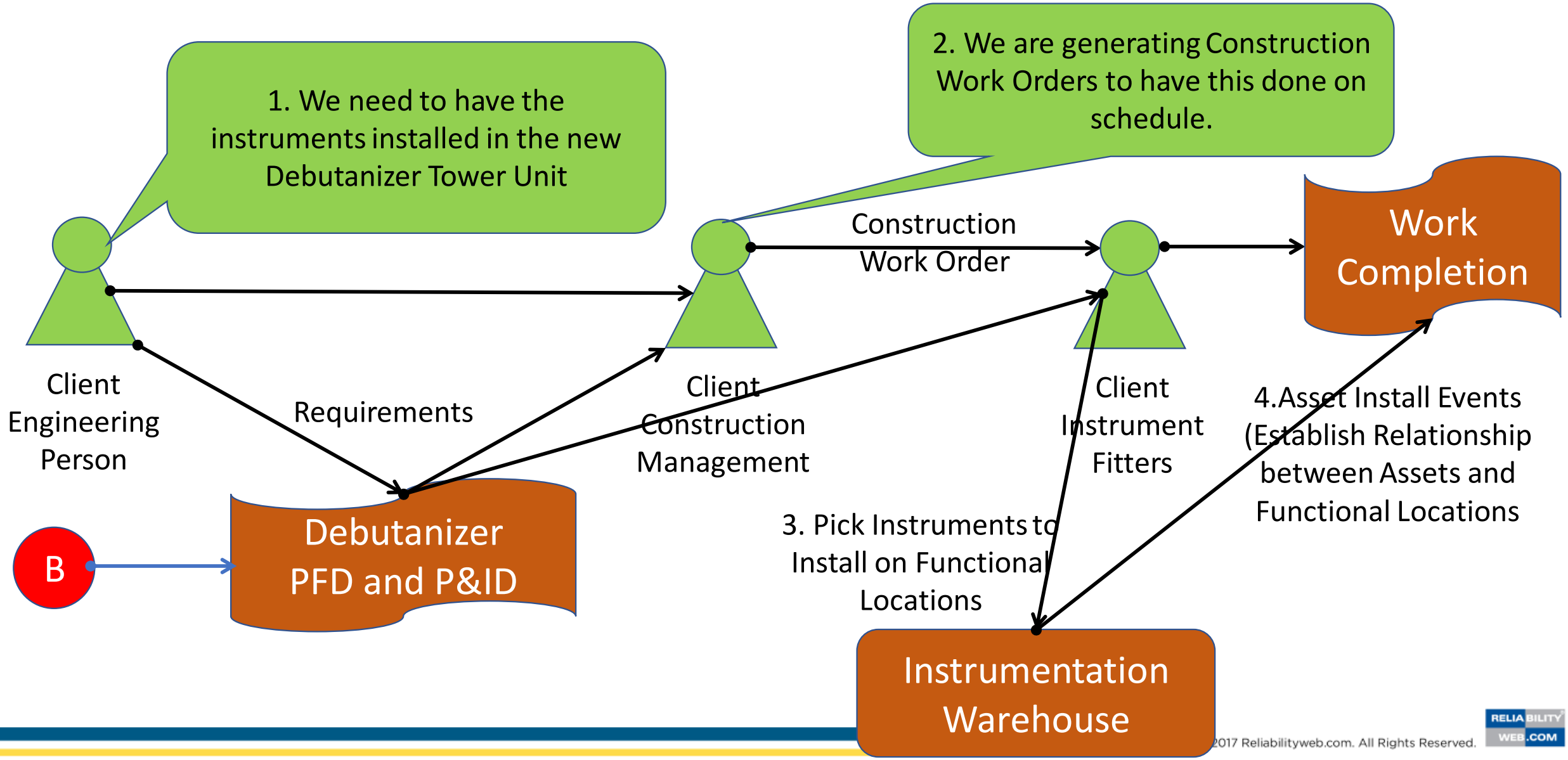
OIIE Pilot Story M100: Start Unit Functional Requirements



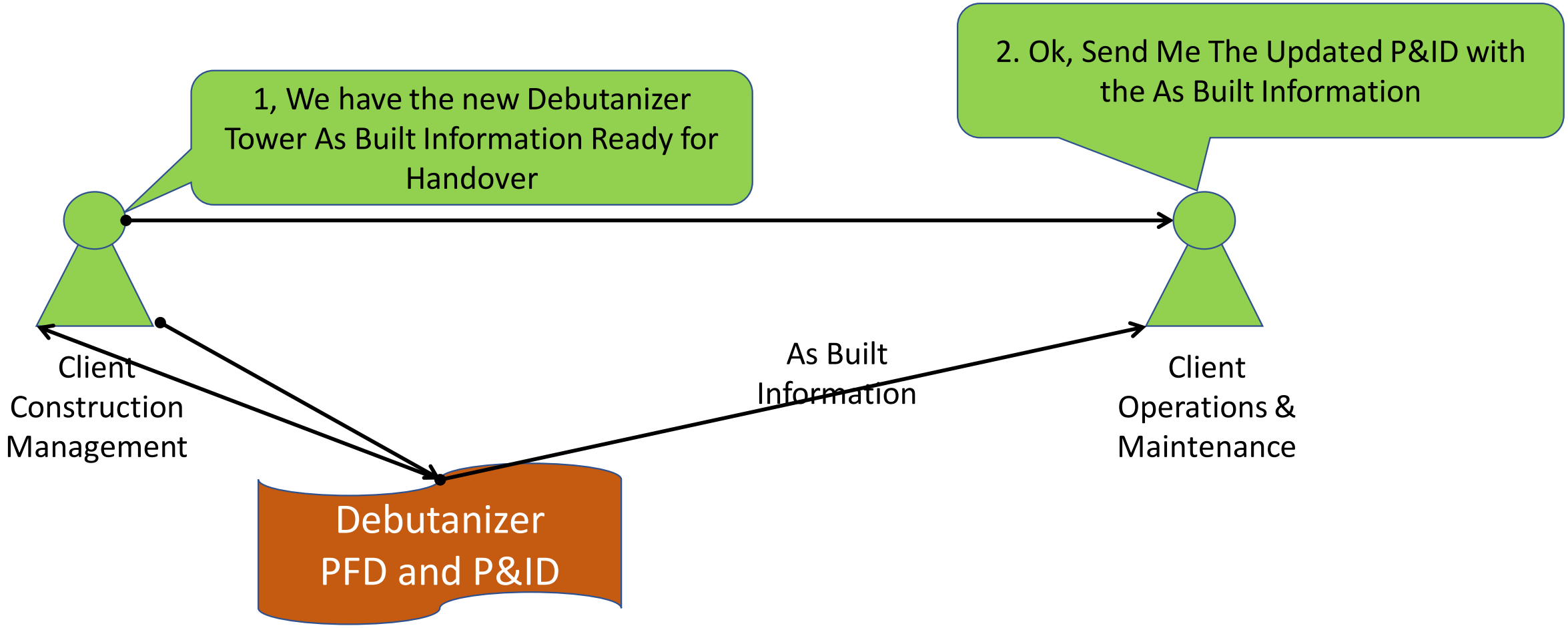
OIIE Pilot Story M101: Model Selection



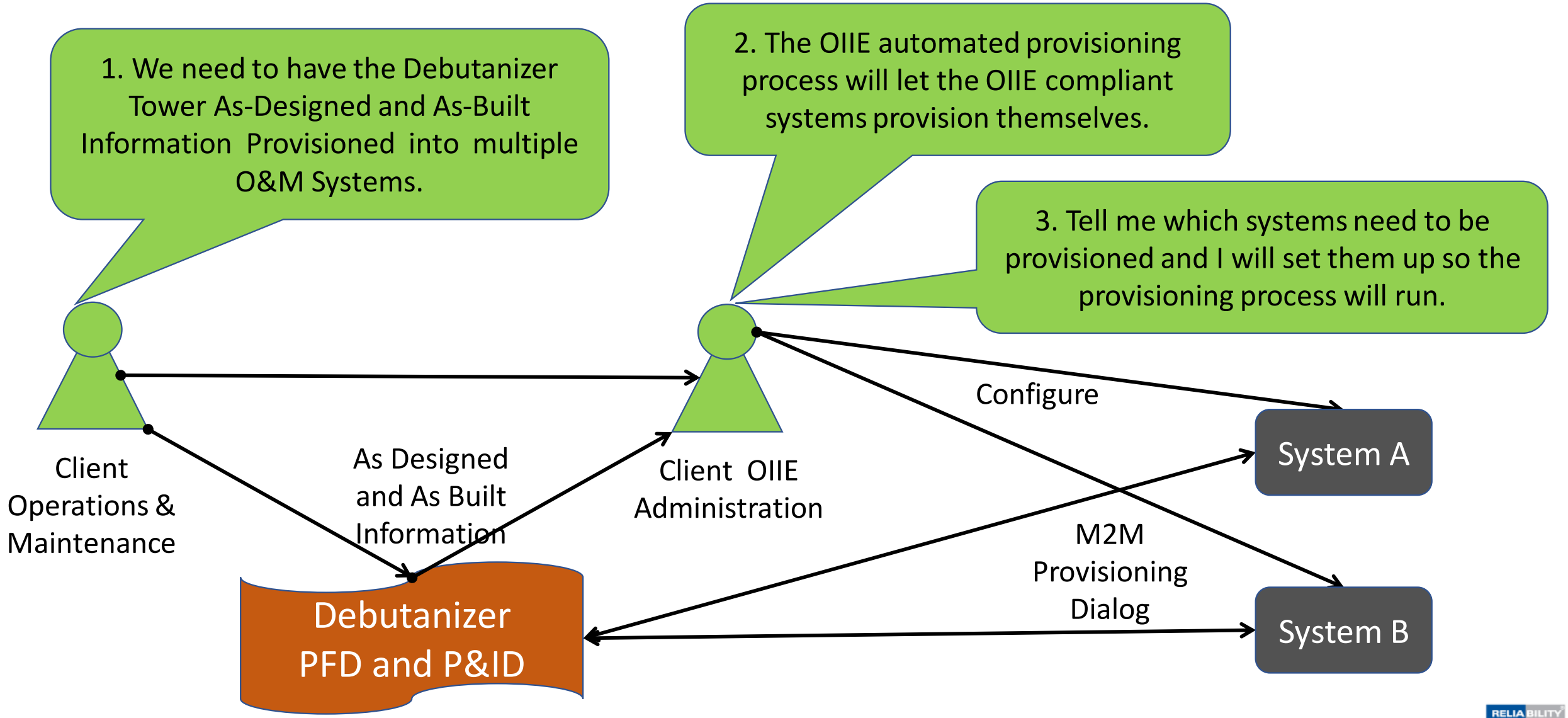
OIIE Story M102: Install Equipment and Instruments



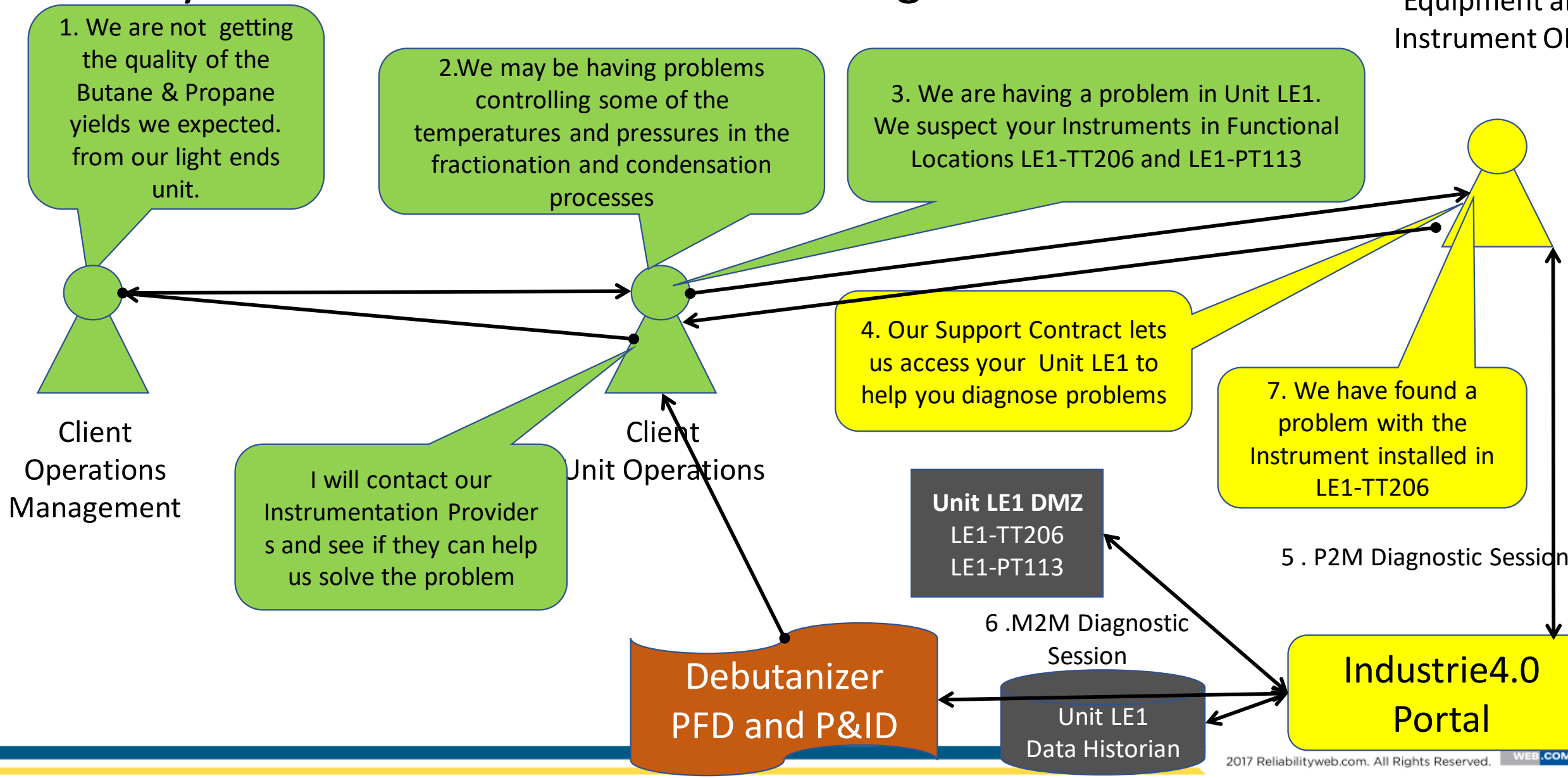
OIIE Story M103: Handover Unit with As Built Information



OIIE Story M104:Provision Client O&M Systems



OIIE Story M105: Unit Performance Management and CBM



OIIE Story-M106: Remove and Replace