DIGITAL TRANSFORMATION FROM INSTRUMENT TO BUSINESS VALUE

Industry 4.0 Implementation Strategies, Best Practices, and Lessons Learned from a Fully Digital Clinical Manufacturing Deployment Project

ISPE Product Show – Boston Area Chapter - 18SEP2019

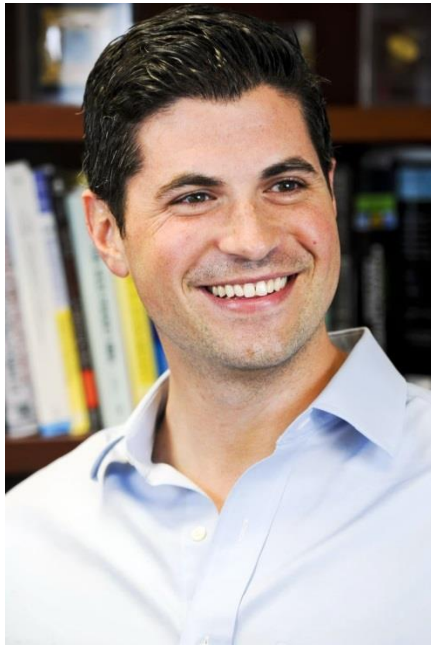
Michael Cody

Agenda

- Introduction
- Digital Transformation
- Topic 1 – Enterprise Architecture
- Topic 2 – Equipment Integration
- Topic 3 – Technology Deployment
- Digital Call to Action

Introduction

Michael Cody



B.S. Chemical Engineering – Cornell University
M.S. Engineering Management – Tufts University
TOGAF 9.1 Certified

Current Role

Senior Solution Architect – Life Sciences - NECI

Solution Designer

Technology Driver

Deployment Leader

Customer Ambassador

Past Experience

Multi-role Engineer

CQV/Startup Automation Engineer

DCS System Owner

Capital Programs Process Engineer

Contractor & End User

NECI: Empowering our Customers to Advance the World

Outcome Based Industry Solutions

Managed Services & Support

- **Mechanical Portfolio**
  - Isolation Valve Services
  - Instrumentation Services
- **I&C Portfolio**
  - Reliability
  - Instruments, Valves, Regulators
  - Calibration
  - Panels
  - PLCs
- **Systems Portfolio**
  - Virtual & Cloud Infrastructure
  - DeltaV
  - Syncade
  - OSI PI
  - Data
  - Analytics

- 35 years providing Life Science Solutions
- 180+ employees in 4 locations in MA, NH CT, ME
- Emerson Impact Partner
  - Locations supported locally & globally

DIGITAL TRANSFORMATION

WHAT IS DIGITAL TRANSFORMATION?

INDUSTRY 4.0 VISION

WHERE ARE WE NOW

What is Digital Transformation?

What is Digital Transformation?

Big Data

Visualizations

Statistical Analysis

Process Analytical

Technology

Machine Learning

IIoT

Augmented / Virtual Reality

Augmented Operator

Experience

Virtual Training

Remote Assist

Virtualization

Cloud based applications

Digital Twin

Digital Lot Release

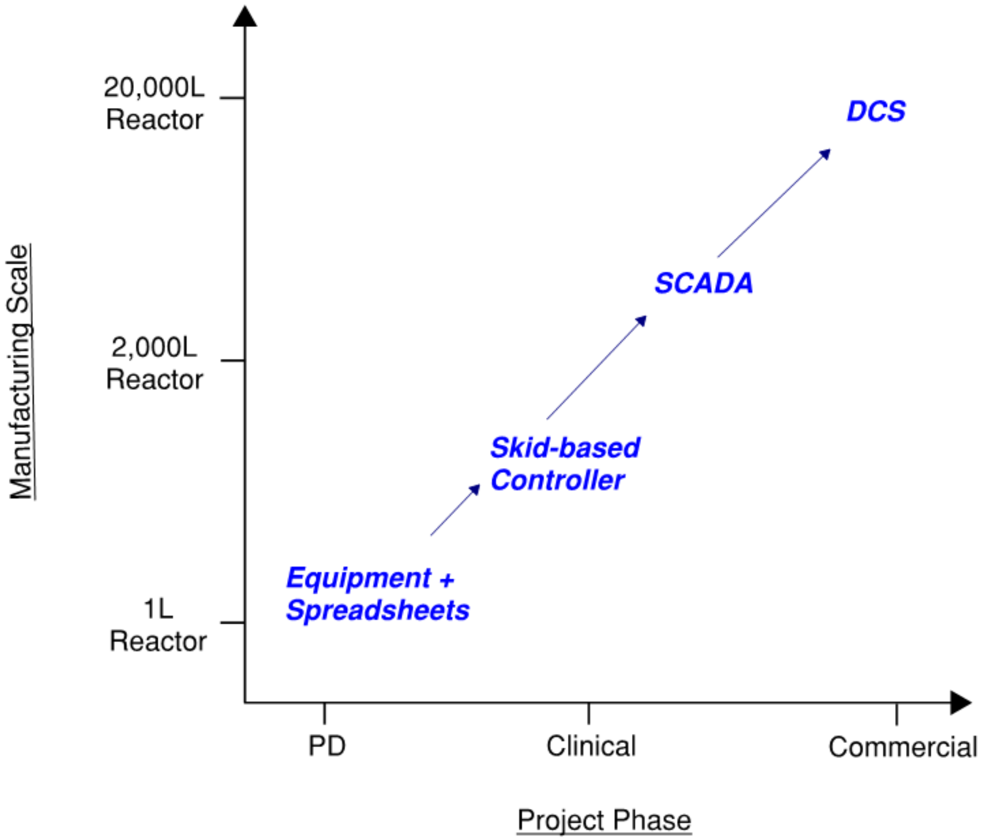
Real Time Exception

Handling

Real Time Quality

Review

Life Science Technology Selection – Traditional "Rules of Thumb"



Manufacturing Scale Continuum

Digital system selected based on **ROI of deployment**

Clinical Stage Continuum

Minimize "digitization" in the development stage to allow for changes

Life Science Industry Trends

Manufacturing Scale is *Shrinking*…

- Higher Titers / "n-1" Bioreactor Stage Process Design
- Continuous Processes
- Smaller Patient Populations / Personalized Medicine

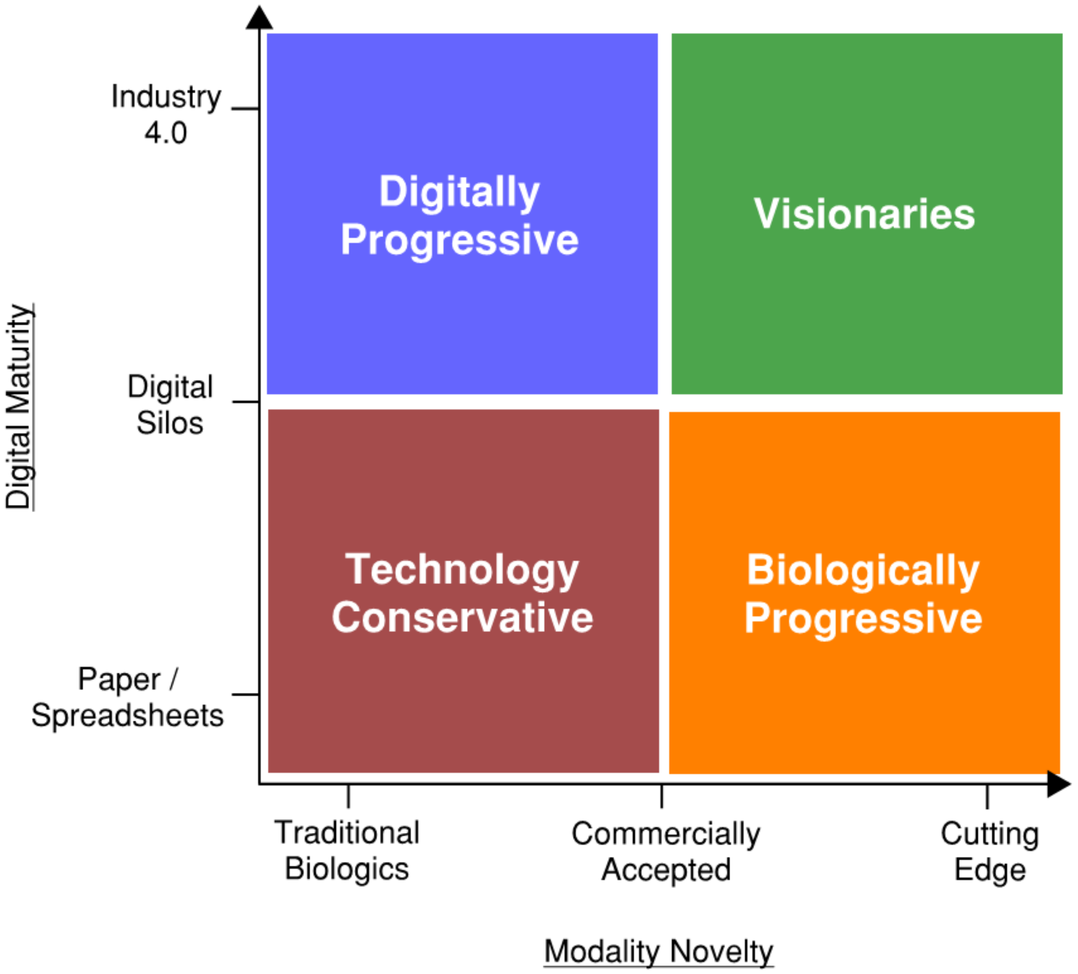
New Product Development is *Accelerating*….

- New modalities
  - Cell and Gene Therapies
  - mRNA
- Speed to IND
  - *Funding*
- Speed to NDA
  - *Market Share*
- Speed to Commercial
  - *Revenue*

Digital Requirements are *Expanding*…

- Process Analytical Technologies
- Chain of Identity
- Review by Exception

Life Science Digital Future



Digital Maturity – Modality Novelty Integrated Model

The design process of what was done in the past, will not get a company where it needs to go in the digital future.

Digital Transformation requires:

- ***Change in Process***
- ***Change in Technology***
- ***Change in Culture***

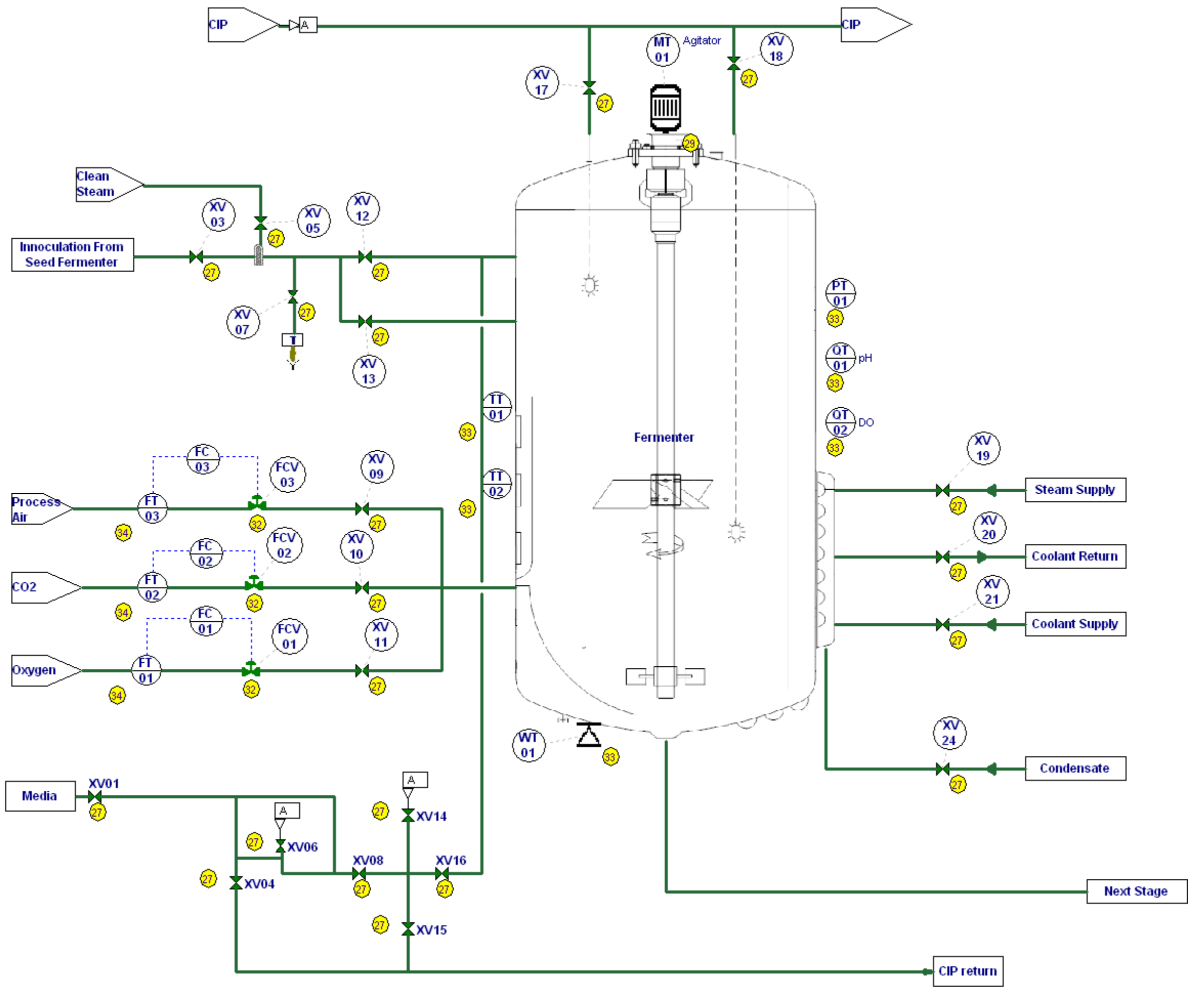
TOPIC 1 – ENTERPRISE ARCHITECTURE

“BUILD A BIOREACTOR” THOUGHT EXERCISE

CASE STUDY

LESSONS LEARNED

Thought Exercise #1 – Build a 20kL Production Bioreactor

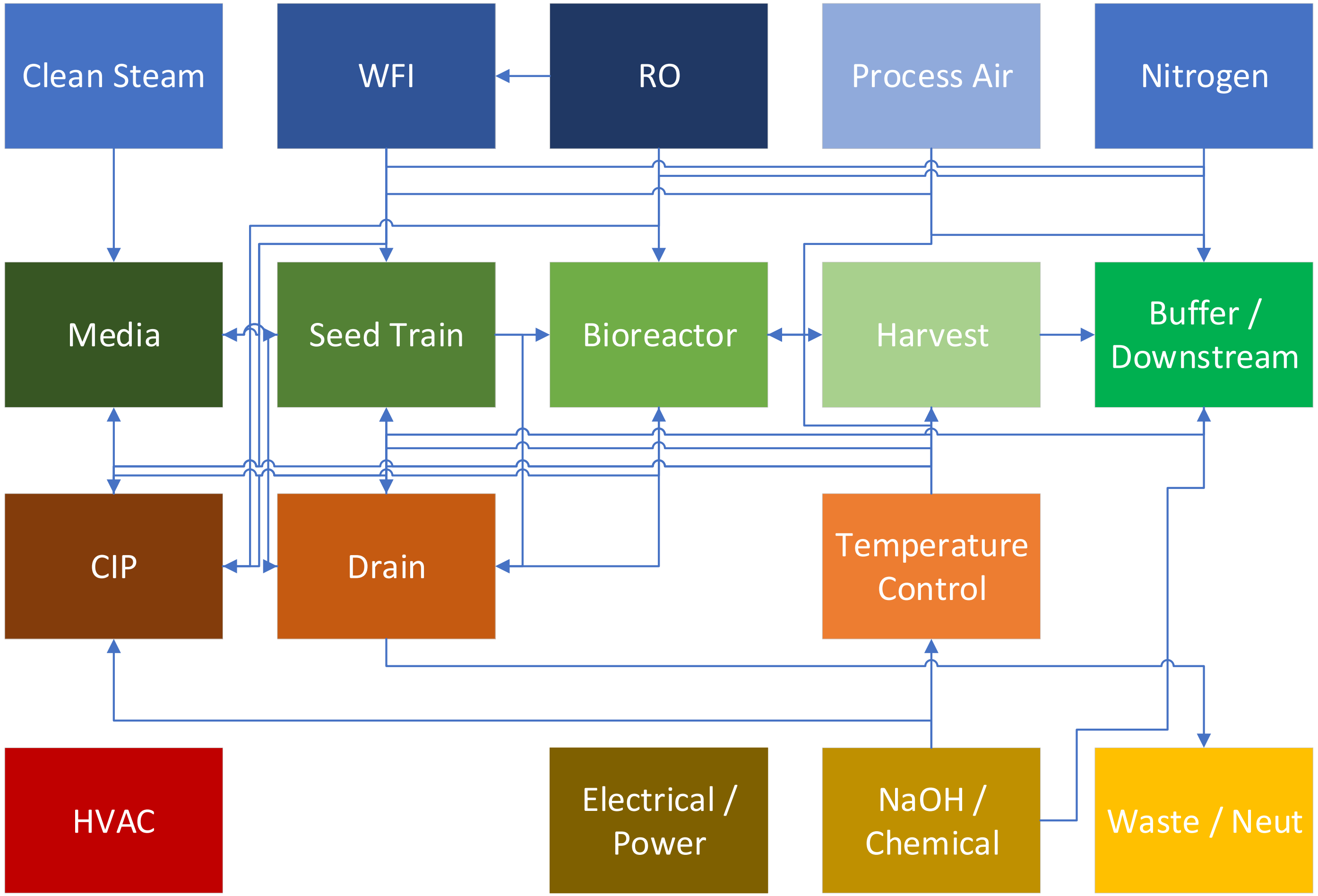


http://s88control.blogspot.com/2011/09/example-of-controldraw-p-for.html

Bioreactor Plant Services

- Inoculation Path
- Harvest Path
- Media Path
- Process Air
- CO2
- Oxygen
- N2
- Clean Steam
- CIP Supply
- CIP Return
- Temperature Control
- Process Drain
- Vents

Bioprocess Architecture



High Level Process Systems Design

Business Requirements

Output / Scale

Process Time

Flexibility

System Boundaries

System Functions

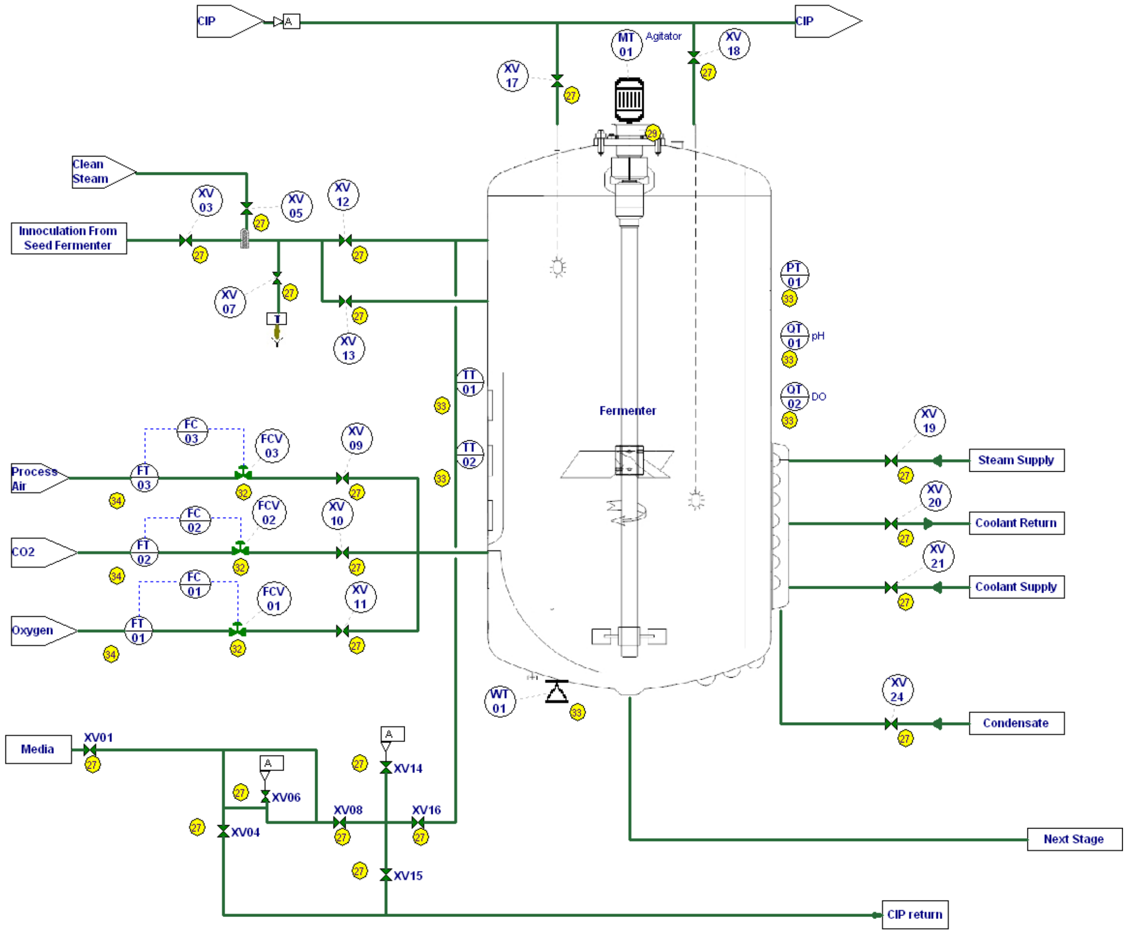
Service Demand

Process Technology

Biologic Technology

Single Use Technology

Thought Exercise #2 – Build a "Digitally Transformed" Bioreactor



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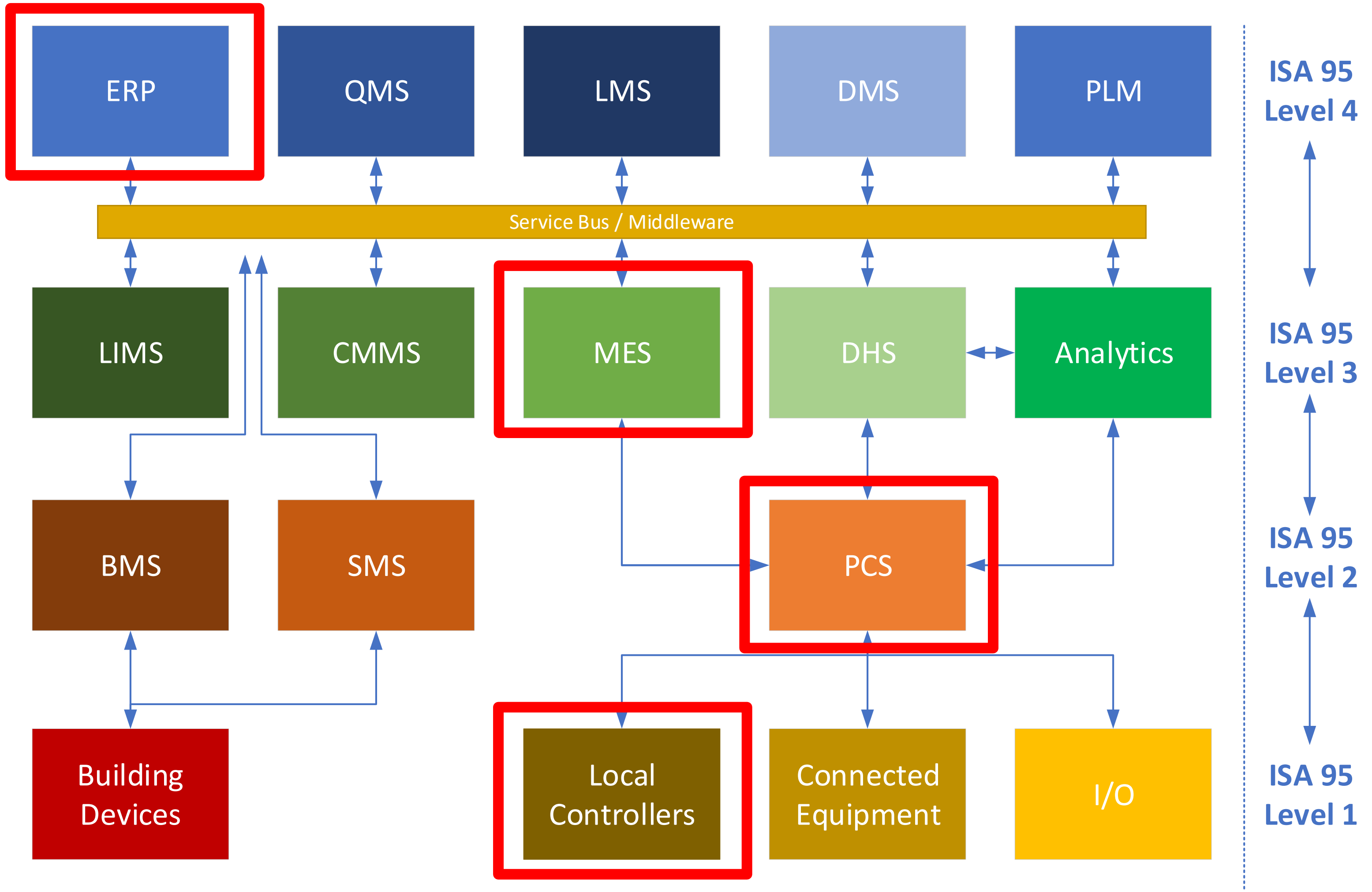
Digital Plant Services

- Instrumentation / I/O
- PLCs
- Equipment Control (Agitation, pH, Temp)
- Batch Control
- Process Historian

"Digital Transformation" Plant Services

- In-Process Sampling
- Batch Records / Work Instructions
- Material Genealogy
- Process Analytics
- Operator Training
- Business and Financial Tracking

Digital Enterprise Architecture



High Level Digital Systems Design

Business Requirements

Financial KPIs

Regulatory Demands

System Boundaries

Application Functions

Application Capabilities

***Data* Technology**

Digital Platform Selections

Deployment Approach

Case Study in Enterprise Architecture

Design Background

ERP Driven Process Order

MES Batch Records

“Lean” Distributed Control System Layer

Original Equipment Manufacturer Skids / Local Controllers

Problem Statement

How do I verify that the process order was executed on the digital equipment correctly?

§211.68 Automatic, mechanical, and electronic equipment.

(a) Automatic, mechanical, or electronic equipment or other types of equipment, including computers, or related systems that will perform a function satisfactorily, may be used in the manufacture, processing, packing, and holding of a drug product. If such equipment is so used, it shall be routinely calibrated, inspected, or checked according to a written program designed to assure proper performance. Written records of those calibration checks and inspections shall be maintained.

(b) Appropriate controls shall be exercised over computer or related systems to assure that changes in master production and control records or other records are instituted only by authorized personnel. Input to and output from the computer or related system of formulas or other records or data shall be checked for accuracy. The degree and frequency of input/output verification shall be based on the complexity and reliability of the computer or related system. A backup file of data entered into the computer or related system shall be maintained except where certain data, such as calculations performed in connection with laboratory analysis, are eliminated by computerization or other automated processes. In such instances a written record of the program shall be maintained along with appropriate validation data. Hard copy or alternative systems, such as duplicates, tapes, or microfilm, designed to assure that backup data are exact and complete and that it is secure from alteration, inadvertent erasures, or loss shall be maintained.

(c) Such automated equipment used for performance of operations addressed by §§211.101(c) or (d), 211.103, 211.182, or 211.188(b)(11) can satisfy the requirements included in those sections relating to the performance of an operation by one person and checking by another person if such equipment is used in conformity with this section, and one person checks that the equipment properly performed the operation.

[43 FR 45077, Sept. 29, 1978, as amended at 60 FR 4091, Jan. 20, 1995; 73 FR 51932, Sept. 8, 2008]

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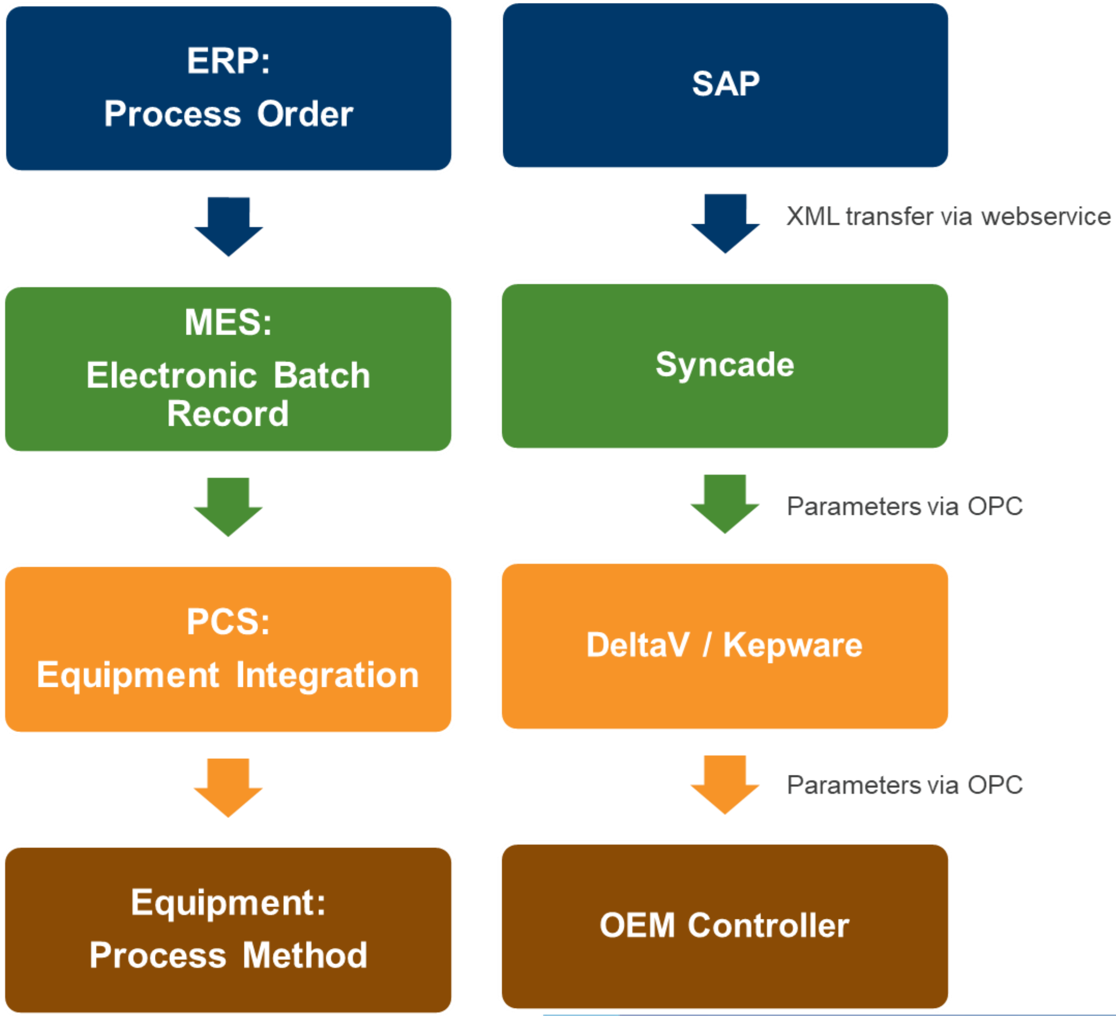
https://www.ecfr.gov/cgi-bin/retrieveECFR?gp=&SID=761ab6af9e1ae85001cc626c5bb8ebab&mc=true&r=PART&n=pt21.4.211

Process Order – Data Flow Strategy

Application | Technology | Functionality



Functionality

- Process Order
- Bill of Material

- Electronic Batch Record
- Procedural Model / Order of Operations
- Parameter Master Data

- Data Transfer / Coordinator (Starts, Holds, Restarts, Aborts)
- Data Translation

- Vendor supplied functionality
- Process Control

Data Flow Integrated into the Electronic Batch Record

Master Data Sources

Equipment – Selected at Runtime

ID	Description	Type
R200A	<200L Buffer Tank Equipment Class>	Buffer Tank

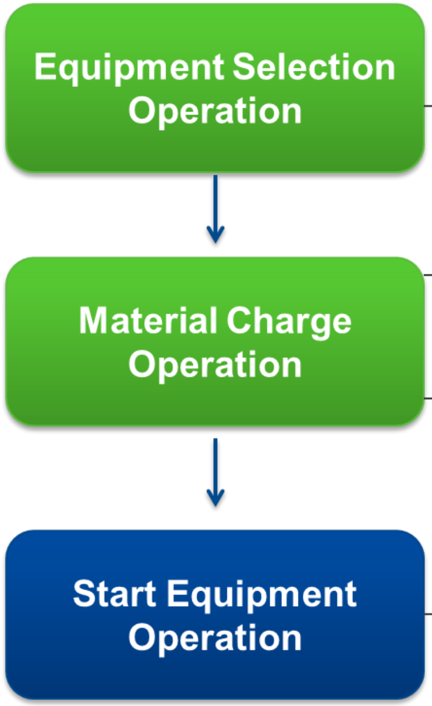
Bill of Materials – Sent from ERP

ID	Description	Target
M0004	Sodium Chloride USP	400 g
M0005	Disodium Hydrogen Phosphate	70 g

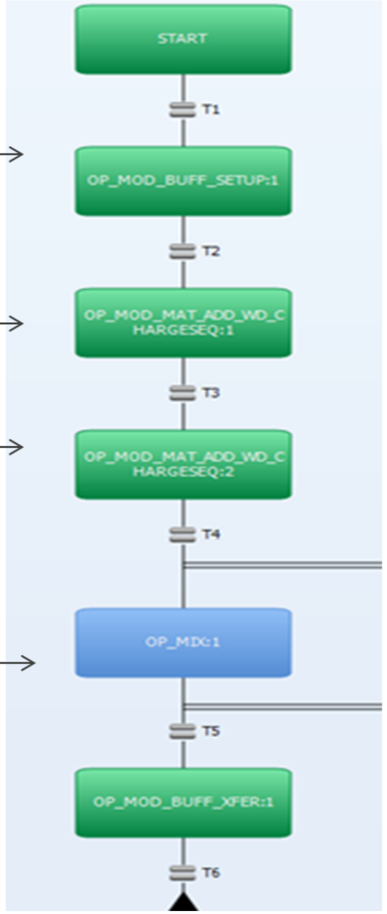
Bill of Parameters – Master Data in MES

ID	Description	Target
OEM_method	OEM Method Name	Buffer_Type_A
Buffer_mix_speed	Mixing Speed	25 rpm
Buffer_mix_duration	Mix Time	50 s

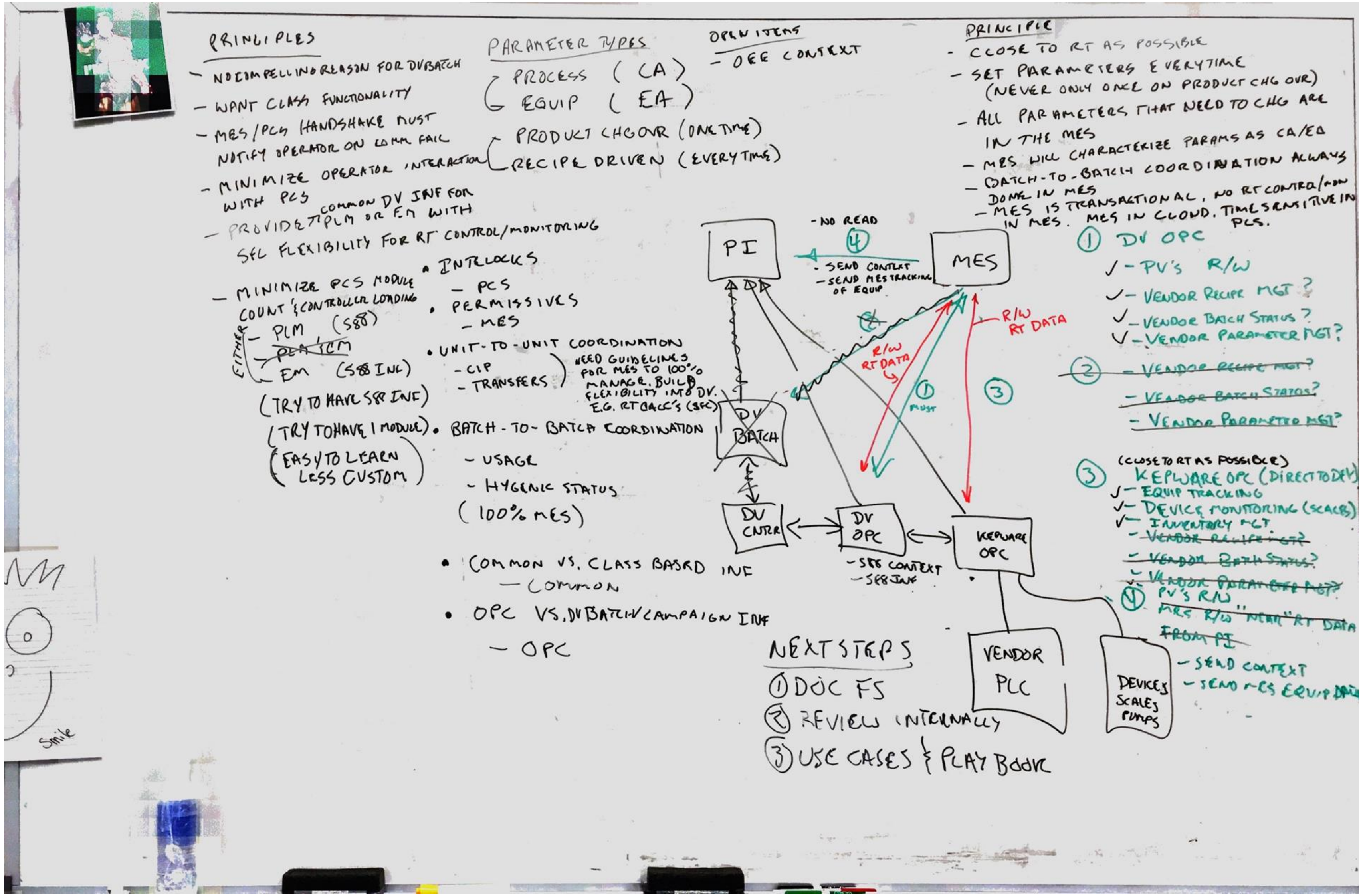
Syncade eBR Workflow



Syncade Configuration Screenshot



Design Reality…



Lessons Learned

Successes

- Site wide leadership
  - Digital Mindset at the Top
- Data Integrity from ERP to Equipment
- Dedicated Digital Team

Areas for Improvement

- IT Deployment
  - Security Requirements
  - Domain Requirements
  - Cloud v. On-Prem
- No Integrated Testing Environment
  - Shakedown runs generated a long digital punch list

Best Practice Recommendations

- Digital Leadership
  - Digital Vision from the Top Down
- Define the Enterprise Architecture
- Integrated Test Strategy / Schedule

Key Takeaway

Establish Enterprise IT Architecture and Governance

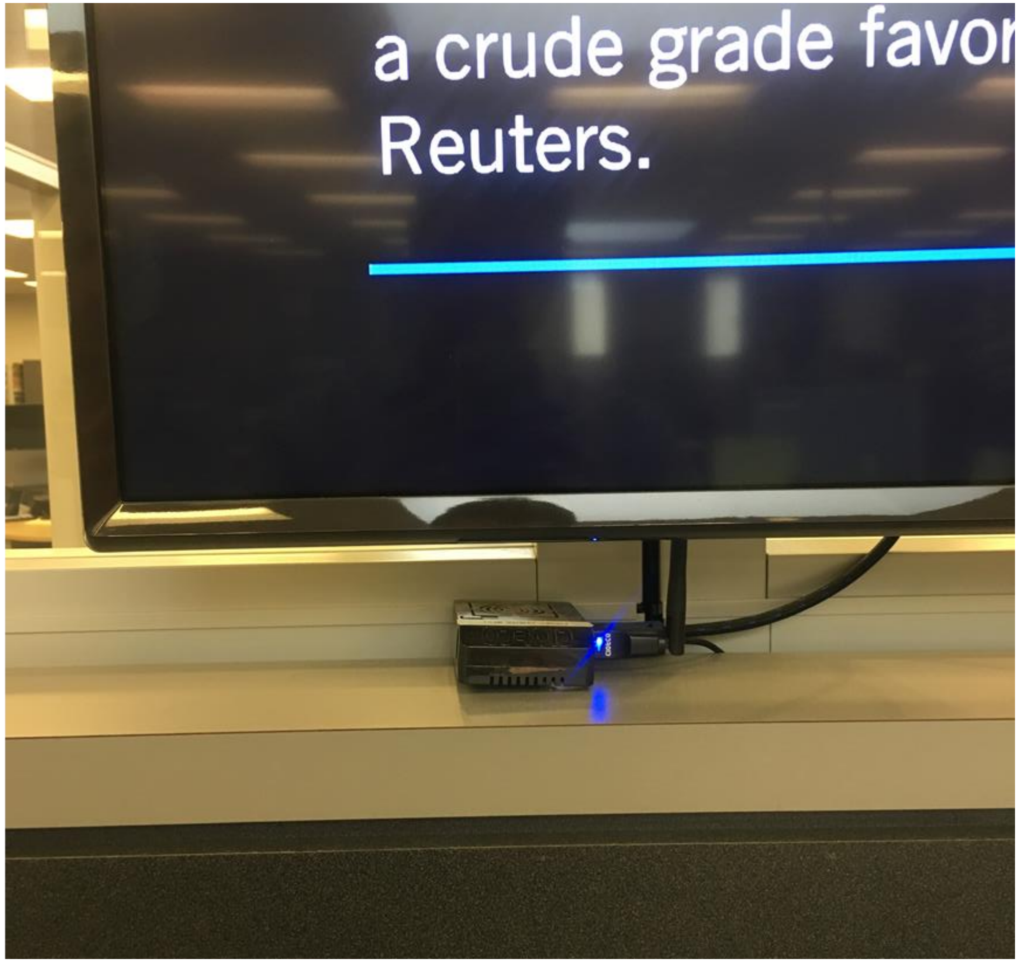
TOPIC 2 –
EQUIPMENT INTEGRATION

INDUSTRIAL INTERNET OF THINGS

CASE STUDY

LESSONS LEARNED

Industrial Internet of Things



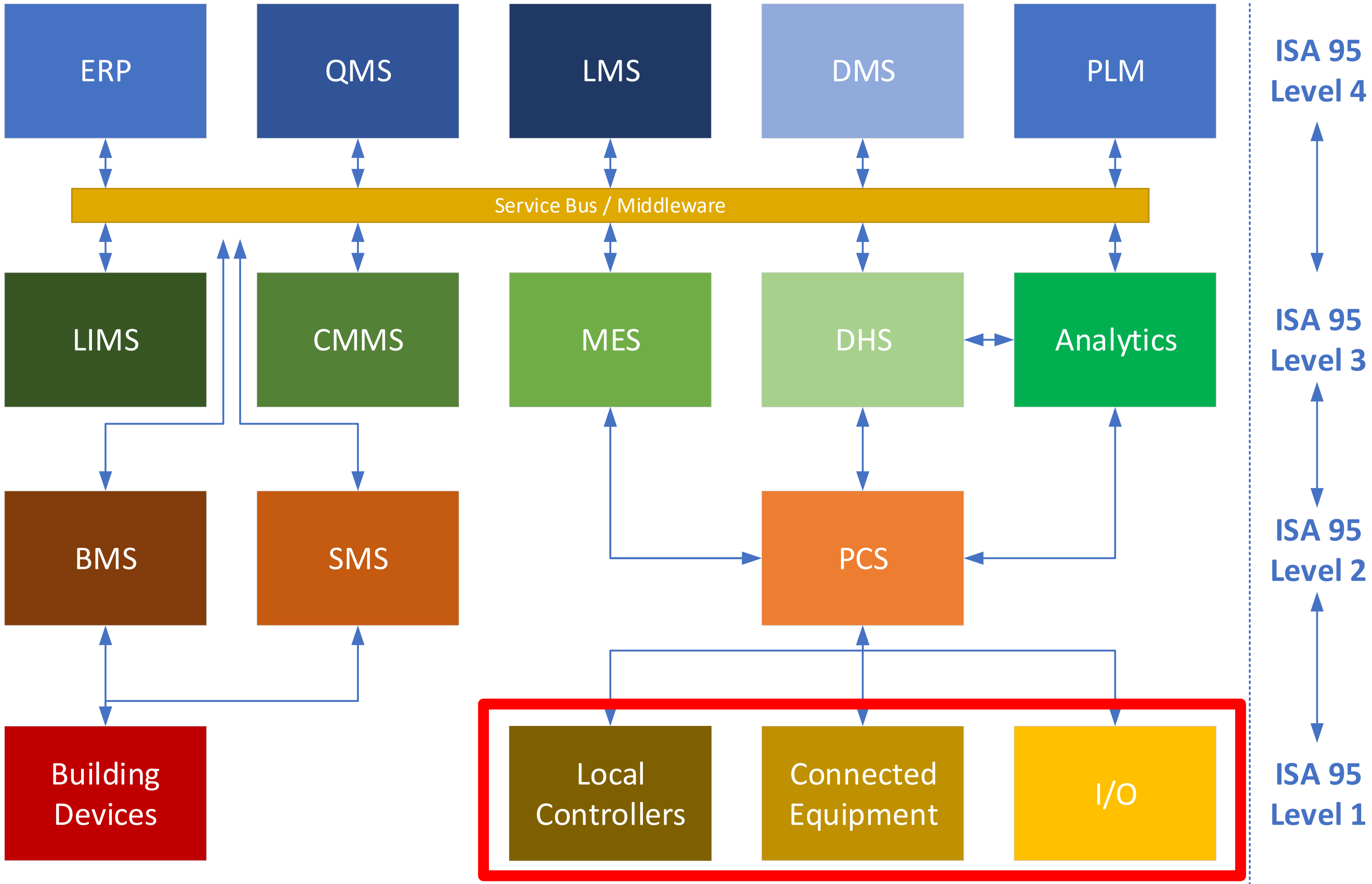
IIoT Vision

- Smart Devices
- Easy to Integrate
- Quick to Deploy
- Cheap to Purchase

IIoT Reality

- Not ready for "industrial" use
- Difficult to integrate into architecture
- Difficult to innovate in a regulated industry

Digital Enterprise Architecture – IIoT Perspective



How do we integrate all the "things"?

Traditional I/O

Wired to a controller on PCS

Connected Equipment

OPC / Ethernet IP / Serial / etc.

OEM Skids

Local Controllers on Equipment

Local Historians / Databases / HMIs

Case Study in Equipment Integration

Design Background

Large equipment list

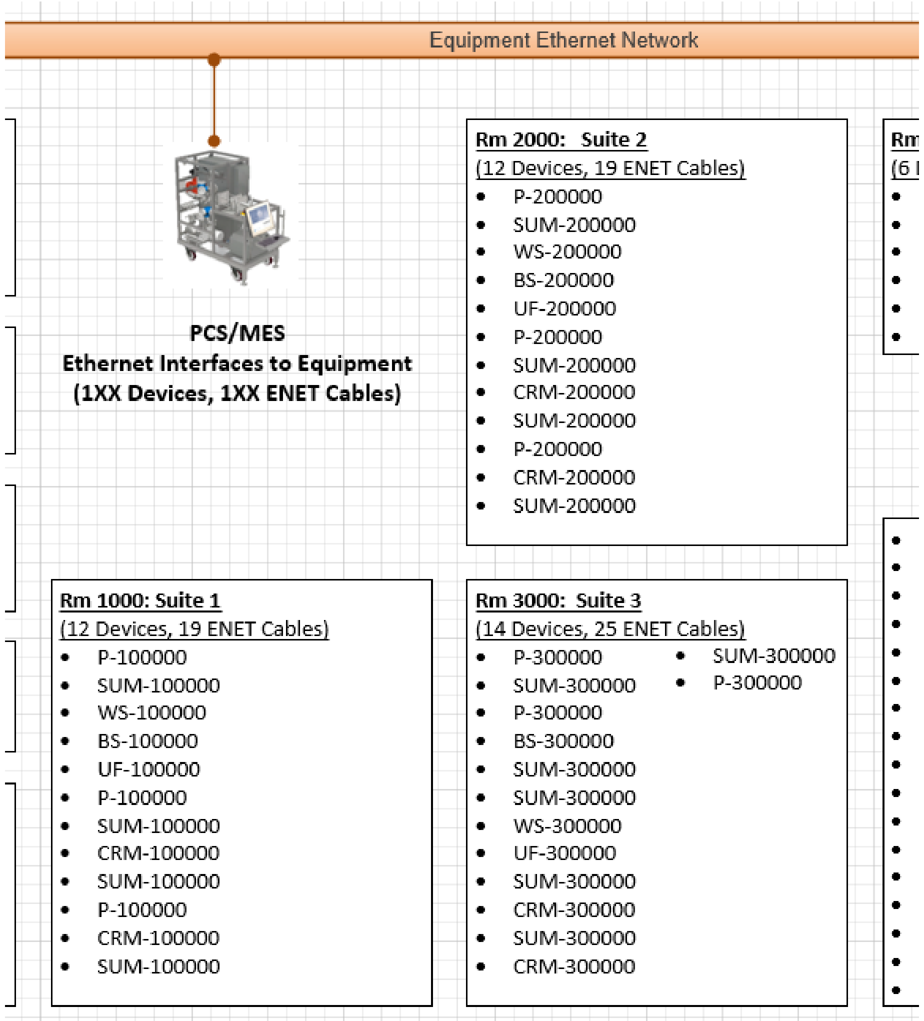
Clinical scale

Blend of different OEMs

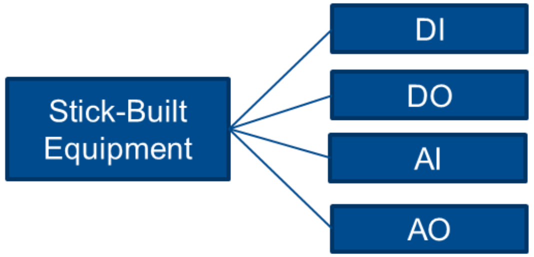
Stick built WFI system

Problem Statement

How do I send and receive critical process data to all of my digital devices?

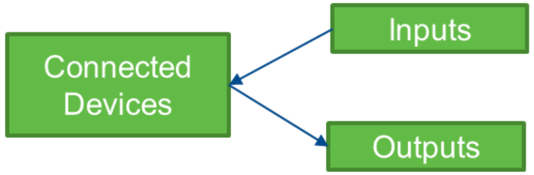


Case Study in Equipment Integration – 3 Classifications



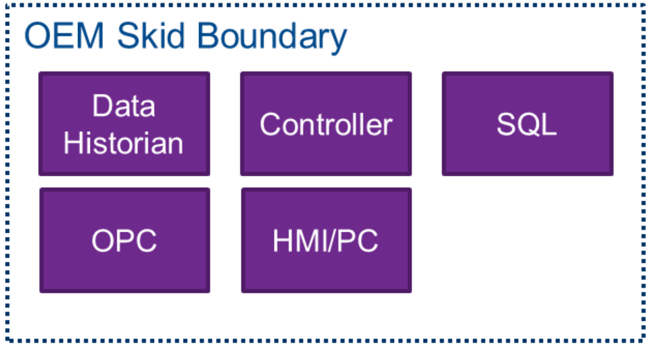
Wired devices

- Discrete Inputs / Outputs
- Analog Inputs / Outputs



Connected Simple Devices

- Equipment with device drivers (scales/printers)
- Equipment with data output files (FITs)
- Equipment with COTS Connectivity (pH Meter with Ethernet)



OEM "Smart" Skid

- Controller – Control Logic
- SQL – Batch Data, Control Configuration, Audit Trail
- OPC – External Communication
- HMI/PC – Operator Screen
- Data Historian – On unit time-based data cache

Case Study in Equipment Integration – Success Factors

Platform & Architecture

- Local Controller Firmware
- Communication Protocol
- Internal Data Structure
- “Locked” or “Unlocked” Code
- Data Flow and Contextualization

Supervisory Control

- Heartbeat
- Control Sequences / S88 State Model
- Data Interface to Control Sequences
- Modes of Operation
- Time-Based Data History / Cache

Security

- Active Directory Requirements
- User Roles Definition

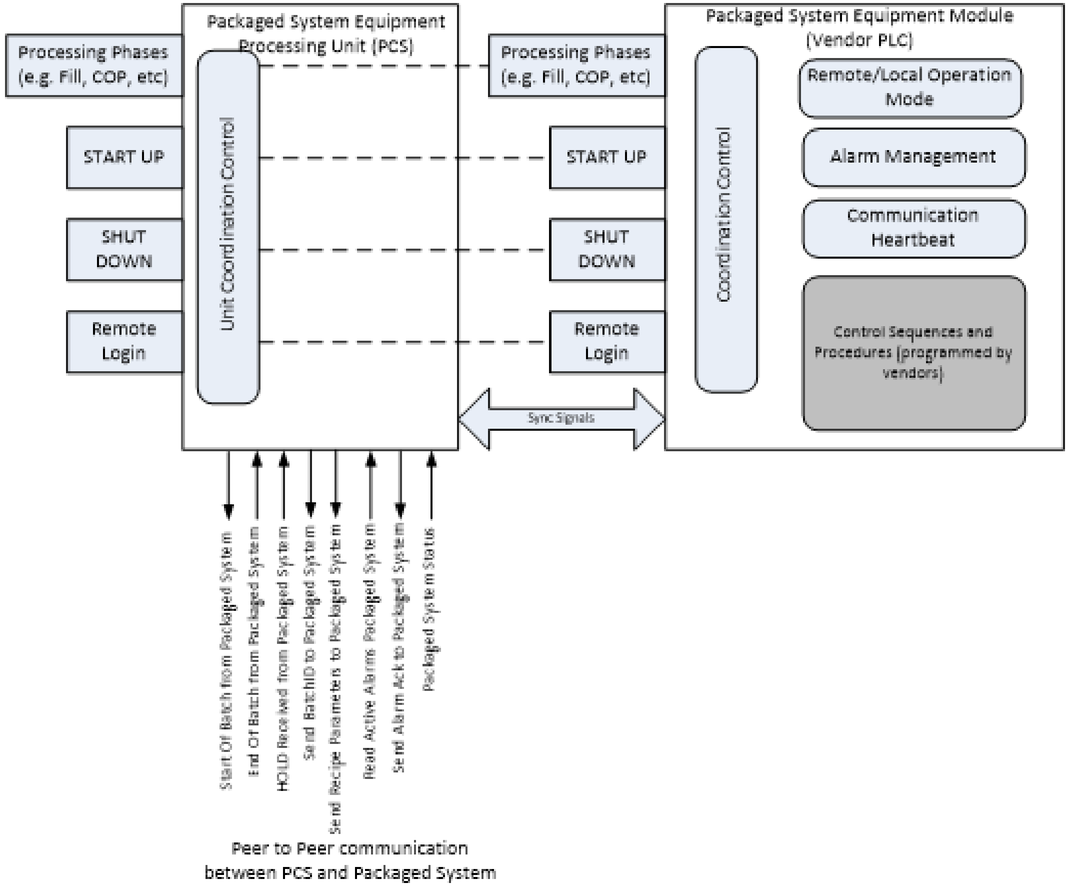
Alarm Management

- Local/Remote Acknowledgment
- Alarm Priorities
- Alarm Enabling / Suppression

Part 11 Compliance

- Audit Trail
- Batch Event History
- Data Integrity

Case Study in Equipment Integration – Detailed Example



Wrapper Phases

- Interact with PCS
- Provides synchronization
  - Start
  - End
  - Hold
  - Alarming
- Non-intrusive

Lessons Learned

Successes

- Method Coordination through MES→DCS→OEM interfaces
- Standard integration strategies defined
- Dedicated equipment integration team

Areas for Improvement

- Every OEM Vendor is different
- Difficult to be 100% "Connected" based on project timelines

Best Practice Recommendations

- Classify and Categorize Equipment
- Specify connectivity requirements and work with OEM Vendor during the bid process.

Key Takeaway

If a "THING" cannot meet a functional requirement, that function must be handled elsewhere

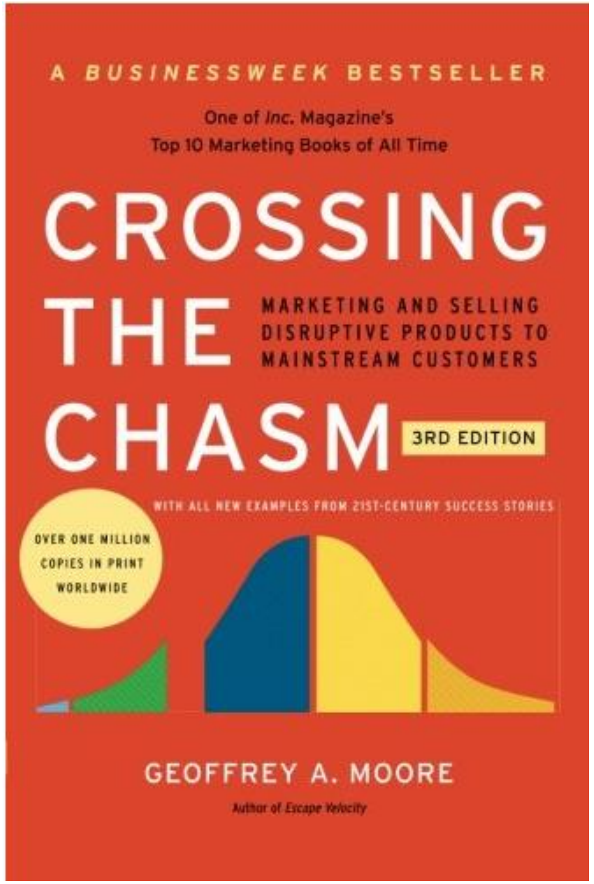
TOPIC 3 –
TECHNOLOGY DEPLOYMENT

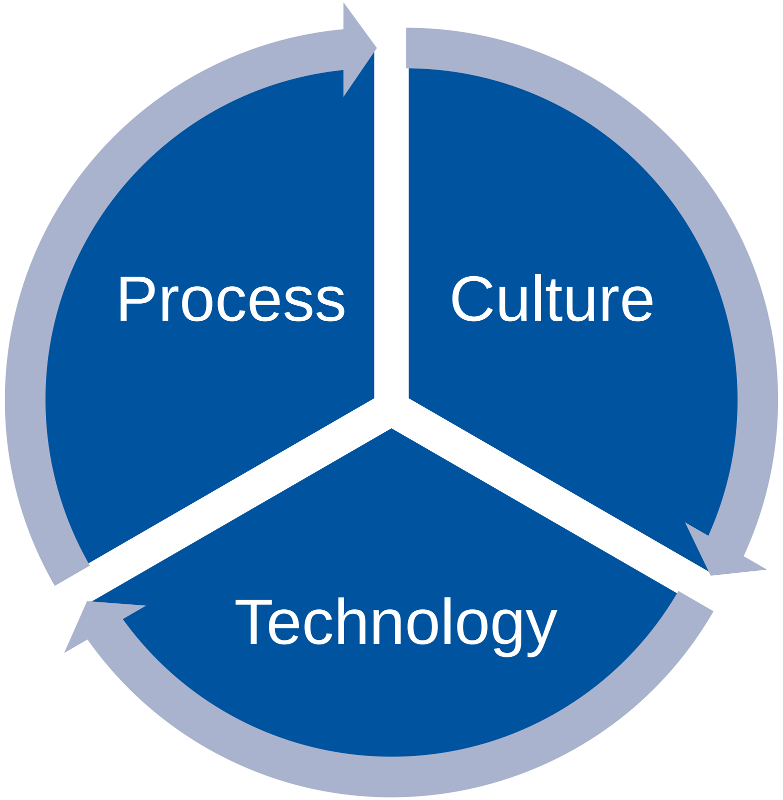
PROCESS – CULTURE – TECHNOLOGY REDEFINED

CASE STUDY

LESSONS LEARNED

Technology Deployment – Adoption Success





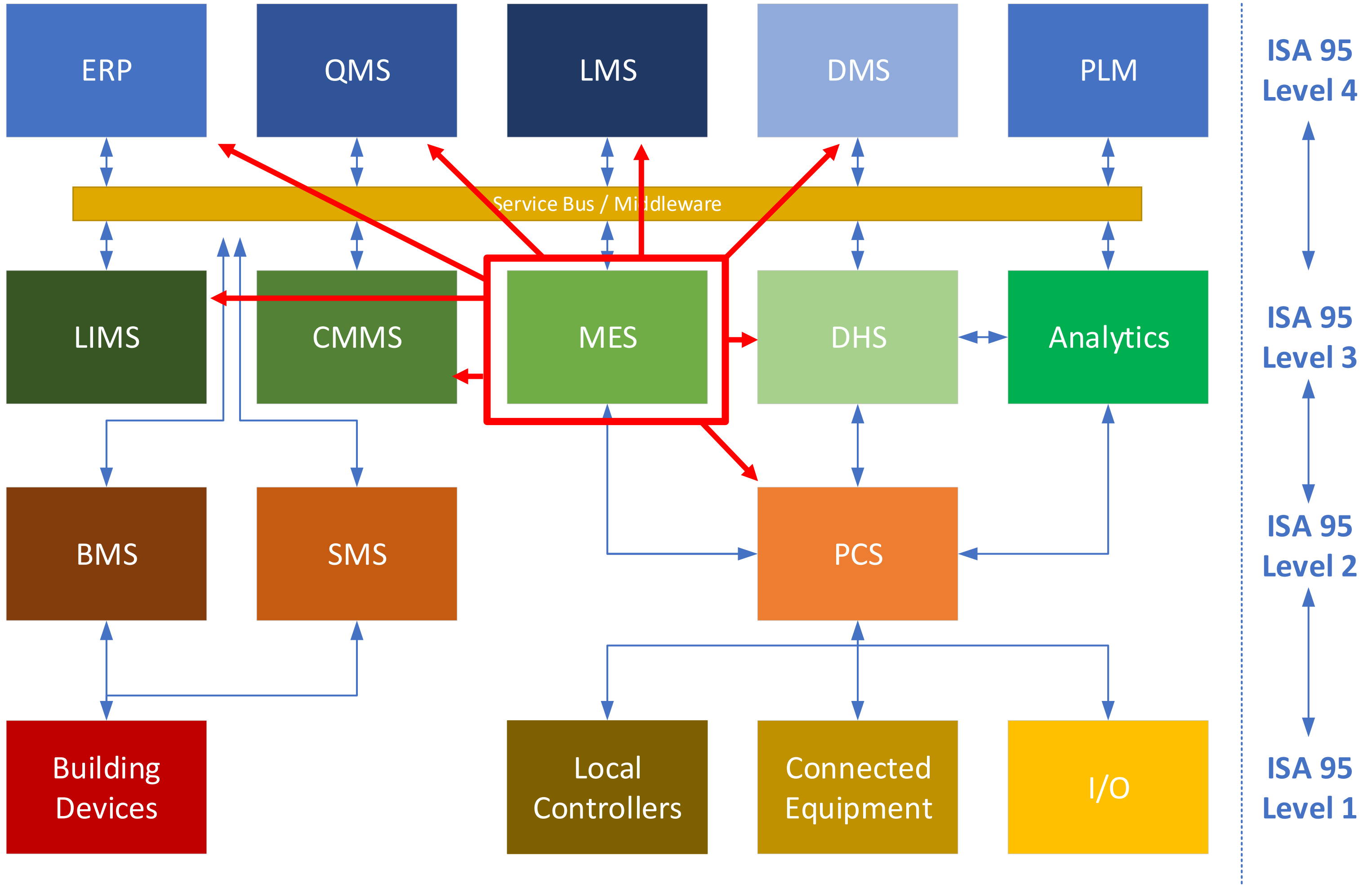
Technology Adoption

Life Sciences Enterprise IT Architecture is not a fully adopted strategy.

Culture Change

How work is done to design, deploy, and maintain manufacturing IT technology is different from the traditional approach.

Digital Enterprise Architecture – Deployment Success



How to ensure technology adoption?

Process Definition is remains the same.

Process ***Implementation*** has to change!

How is a Batch Record defined?

On Paper?

Electronically?

Case Study in Technology Deployment

Design Background

Clinical Process

Still in development with the PD team

Current process was occuring at a different location

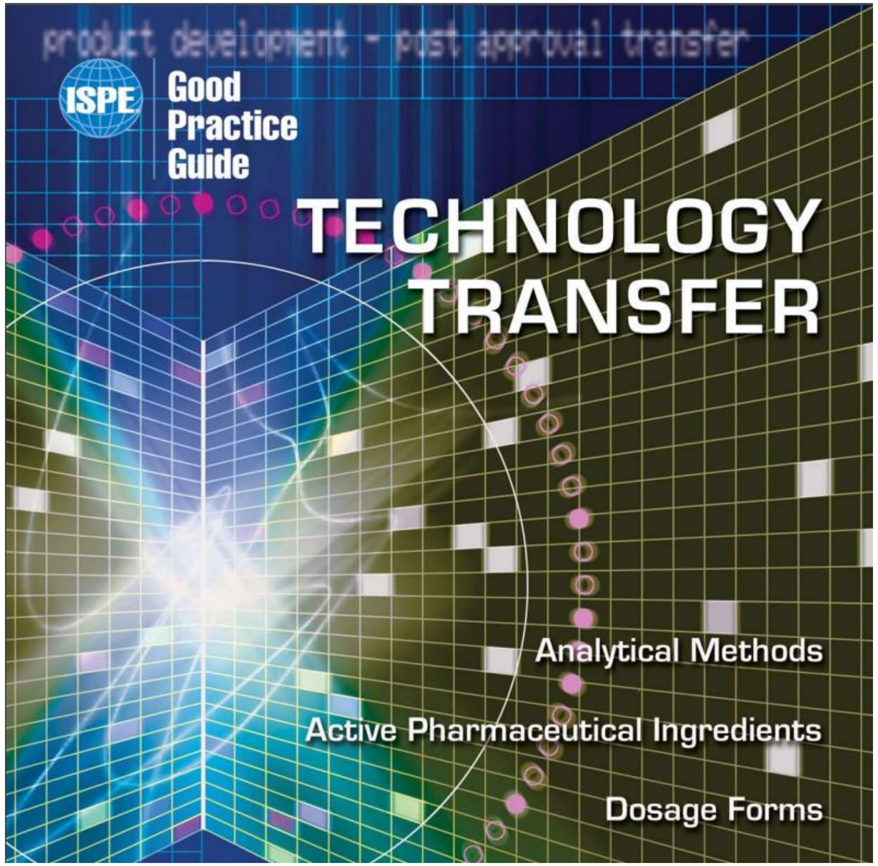
Multi Product Facility

Multi Scale Facility

Platform Process

Problem Statement

How do I develop and deploy electronic batch records agilely in a clinical environment?



Case Study in Technology Deployment – Culture Change

Technology Transfer

- Define the "digital" technology transfer process
- Each Application requires 2 roles:
  - Business Owner
  - IT Application Owner

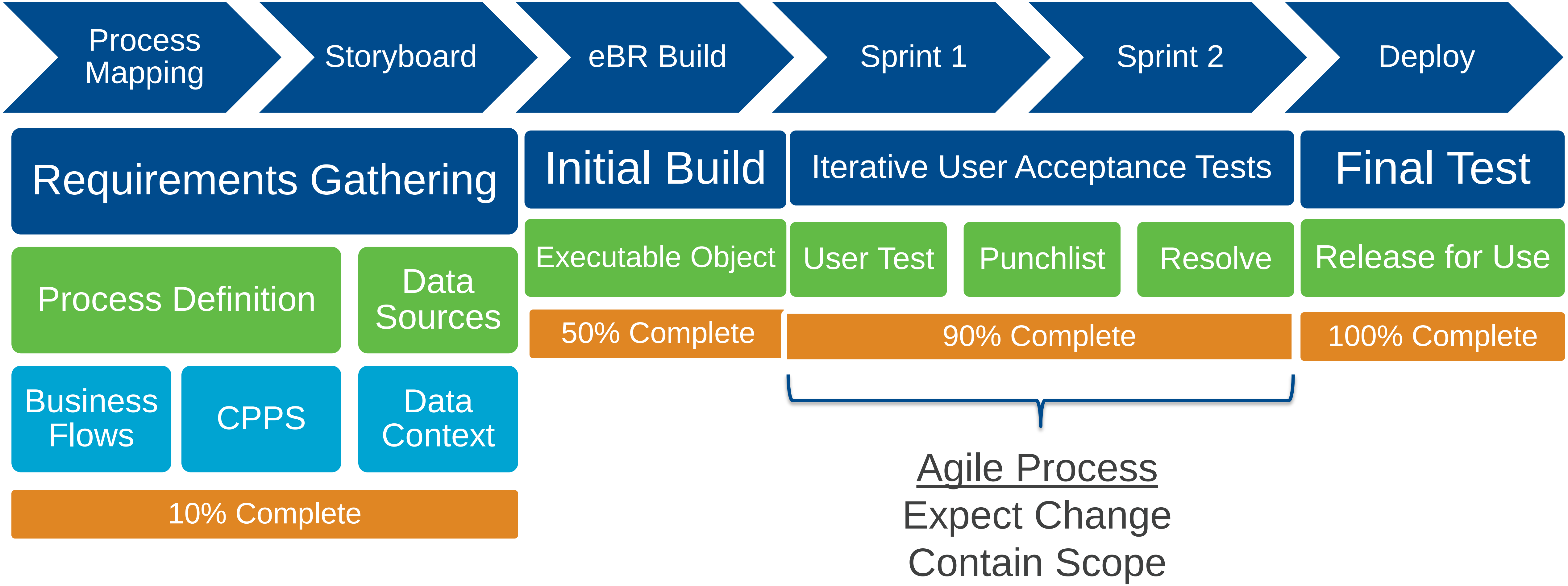
Operational Readiness

- Business owners own "digital" readiness
  - SOP design
  - Electronic batch Record design
  - System/equipment maintenance design
- Design reviews are interactive and iterative

Configuration Strategy

- Enterprise IT is a team member, not a service provider.
- Emphasis "change management velocity" vs. "flexibility"
- Quality-by-Design agile approach when automating business processes

NECI Engagement Approach



Lesson’s Learned

Successes

- Major digital efficiencies
- Rapid Design Lifecycle
  - 5 Weeks – 17 electronic batch records

Areas for Improvement

- Too much time designing in a conference room
- Definition of the Procedural Model

Best Practice Recommendations

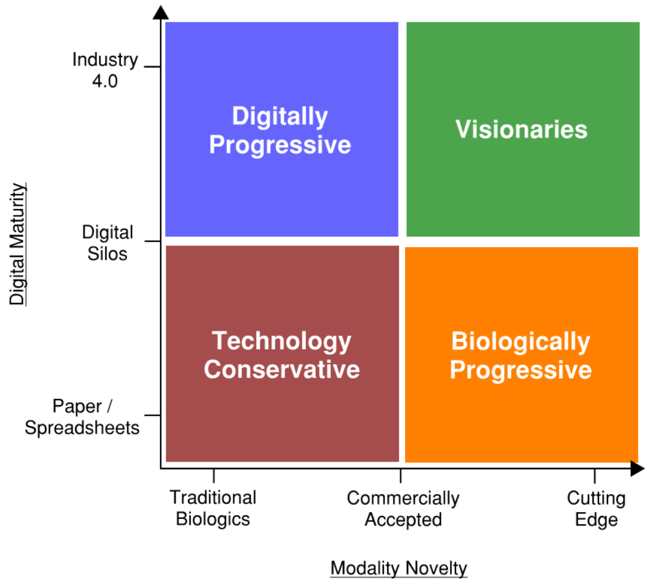
- Define the “digitally integrated” business process
  - Tech Transfer
  - Operational Readiness
- Plan for Change Management
  - Iterative Processes
  - Quick Implementation

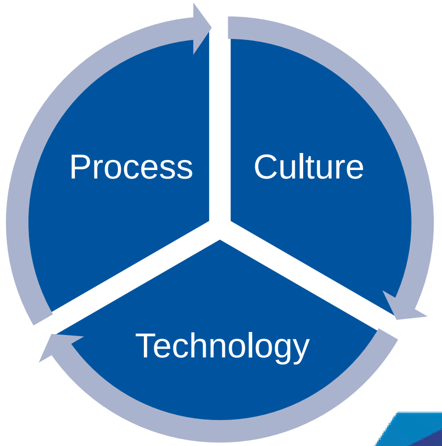
Key Takeaway

Develop new business practices for defining and deploying electronic systems

DIGITAL CALL TO ACTION

What was done in the past…
Will not get you to where you need to be in the future





Paper Site → Digital Site

- 35% reduction in manufacturing FTE
- Cycle time decrease from 12 days to 6 Days
- 40% reduction in process variability
- ZERO manual deviations 3 months after go-live
- Batch review reduced from 3 days to 3 hours