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

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Agenda

Introduction

Digital Transformation

Topic 1 – Enterprise Architecture

Topic 2 – Equipment Integration

Topic 3 – Technology Deployment

Digital Call to Action
# Introduction

## Michael Cody

### 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

B.S. Chemical Engineering – Cornell University  
M.S. Engineering Management – Tufts University  
TOGAF 9.1 Certified
NECI: Empowering our Customers to Advance the World

Outcome Based Industry Solutions

Managed Services & Support

- 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

**Virtualization**
- Cloud based applications
- Digital Twin

**Augmented / Virtual Reality**
- Augmented Operator Experience
- Virtual Training
- Remote Assist

**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
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

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

Clean Steam | WFI | RO | Process Air | Nitrogen
---|---|---|---|---
Media | Seed Train | Bioreactor | Harvest | Buffer / Downstream
CIP | Drain | Temperature Control | 
HVAC | Electrical / Power | NaOH / Chemical | Waste / Neut

**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

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?

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

**Application**

- ERP: Process Order
- MES: Electronic Batch Record
- PCS: Equipment Integration
- Equipment: Process Method

**Technology**

- SAP
- Syncade
- DeltaV / Kepware
- OEM Controller

**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: R200A, Description: <200L Buffer Tank Equipment Class>, Type: Buffer Tank

- **Bill of Materials – Sent from ERP**
  - ID: M0004, Description: Sodium Chloride USP, Target: 400 g
  - ID: M0005, Description: Disodium Hydrogen Phosphate, Target: 70 g

- **Bill of Parameters – Master Data in MES**
  - ID: OEM_method, Description: OEM Method Name, Target: Buffer_Type_A
  - ID: Buffer_mix_speed, Description: Mixing Speed, Target: 25 rpm
  - ID: Buffer_mix_duration, Description: Mix Time, Target: 30 s

**Syncade eBR Workflow**

- Equipment Selection Operation
- Material Charge Operation
- Start Equipment Operation

**Syncade Configuration Screenshot**

![Syncade Configuration Screenshot](image-url)
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

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**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
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.
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 occurring 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?
## 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

Process Mapping → Storyboard → eBR Build → Sprint 1 → Sprint 2 → Deploy

Requirements Gathering
- Process Definition
- Business Flows
- CPPS
- Data Sources
- Data Context

Initial Build
- Executable Object
- User Test
- Punchlist
- Resolve

Iterative User Acceptance Tests
- 50% Complete
- 90% Complete
- 100% Complete

Final Test
- Release for Use

Agile Process
- Expect Change
- Contain Scope

10% Complete
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

- 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