



# Smart Manufacturing: The Practice of Real Time Data and Manufacturing Intelligence

## **May 2017**

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# Smart Manufacturing Simply Stated

The Operational Business and Technology Practice of radically increasing the application of real-time data throughout the manufacturing enterprise and changing the operational structure

The right data in the right form, the right people with the right knowledge, the right technology and the right operations, whenever and wherever needed throughout the manufacturing 'enterprise'



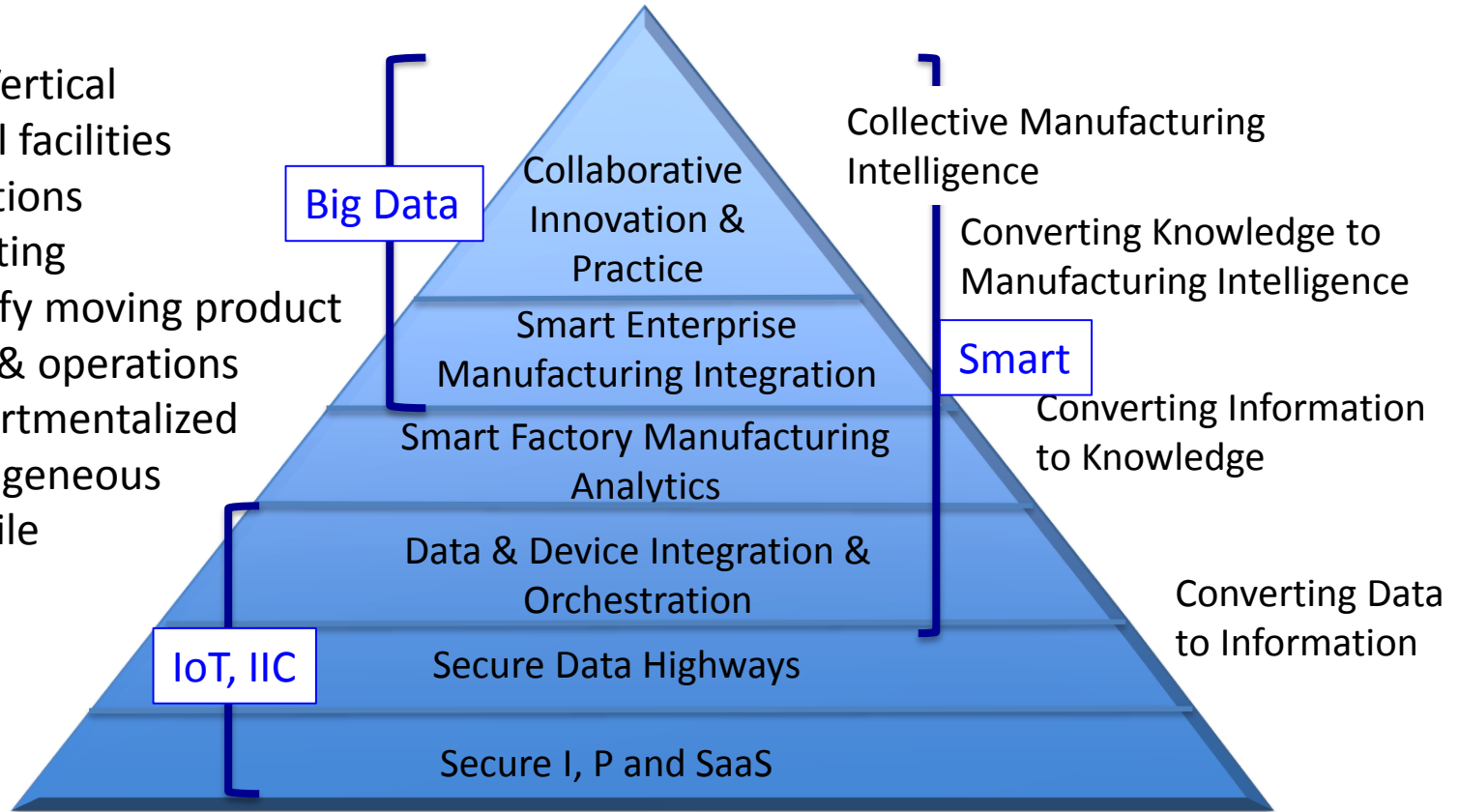
# Smart Manufacturing

## A Term of Practice

- Enterprise integration to realize untapped market , productivity and performance opportunities
- Real-time Data and Modeling to qualify materials, parts, properties, assemblies and drive real-time precision
- Operational Practices (A Vocabulary of Practices: intensification, virtualization, modularization, qualification and optimization) to achieve value in an an increasingly customized product space with accelerated demand dynamics

## Manufacturing Vertical

- Static physical facilities
- Legacy operations
- Always operating
- Need to qualify moving product
- IP in product & operations
- Highly compartmentalized
- Highly Heterogeneous
- High risk profile



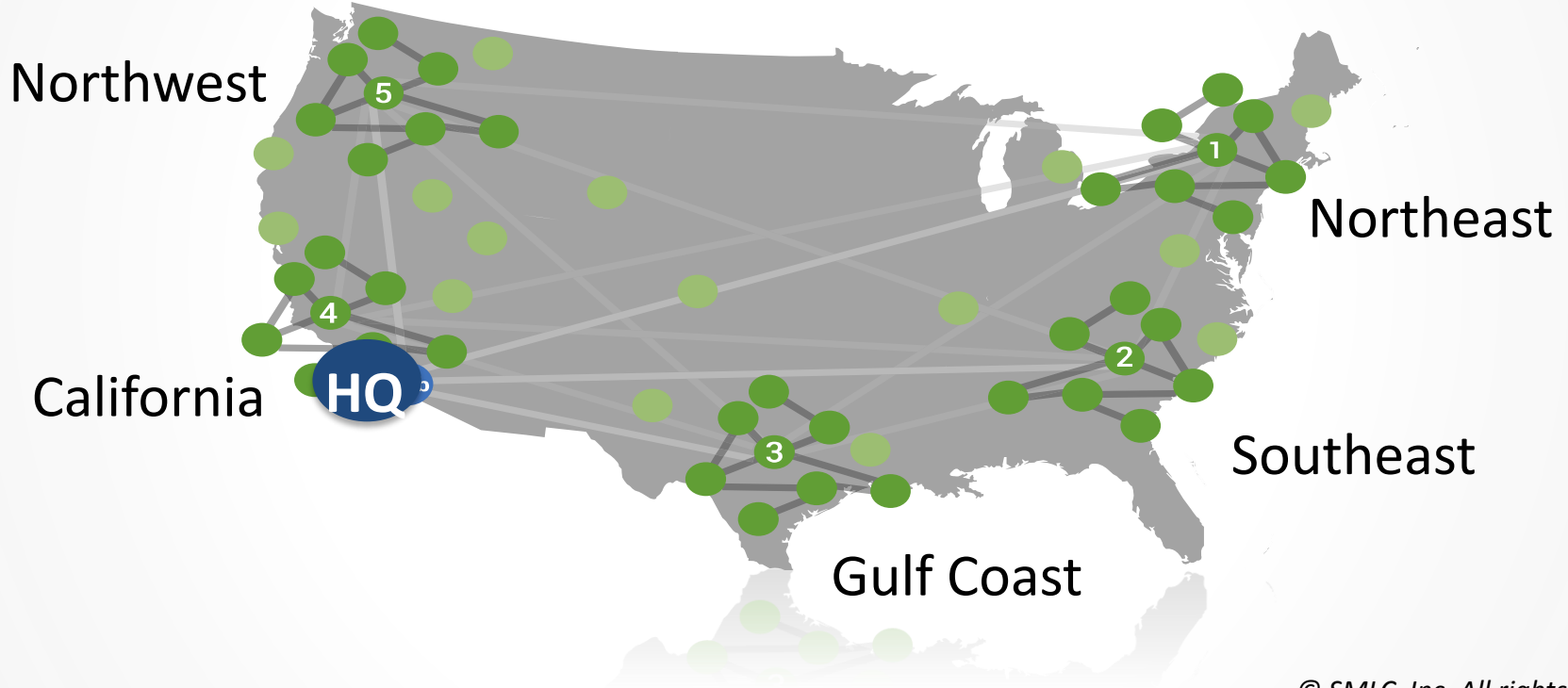


## What is the CESMII?



Fullen View, a leader in boiler

A National Network of Capability  
Headquartered in LA



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Precision, Productivity,  
Product Space  
Energy a Material Cost

**REVENUE,  
GROWTH &  
REINVESTMENT**

### **CESMII's goals:**

- Double energy productivity in US manufacturing every 10 years
- Halve the cost of deploying SM systems relative to state of the art in 5 years
- Increase the SM workforce in US multi-fold in 10 years
- Double the SM technology supply chain rate of increase in value and participation
- Reduce U.S. energy use in 10 years while increasing manufacturing competitiveness



# Enterprise Thinking and Practice

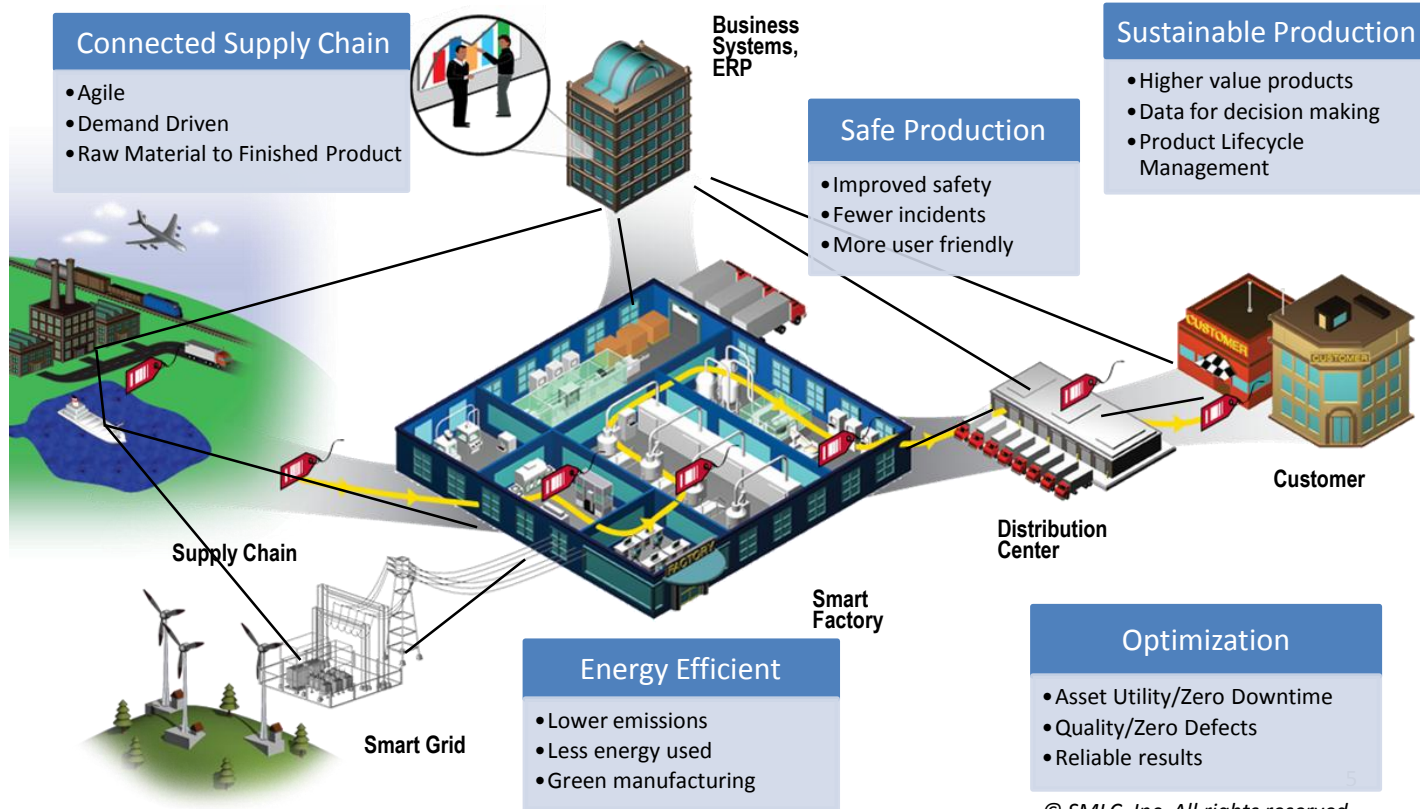
## Let's Consider Some Examples





# “Field to Fork”

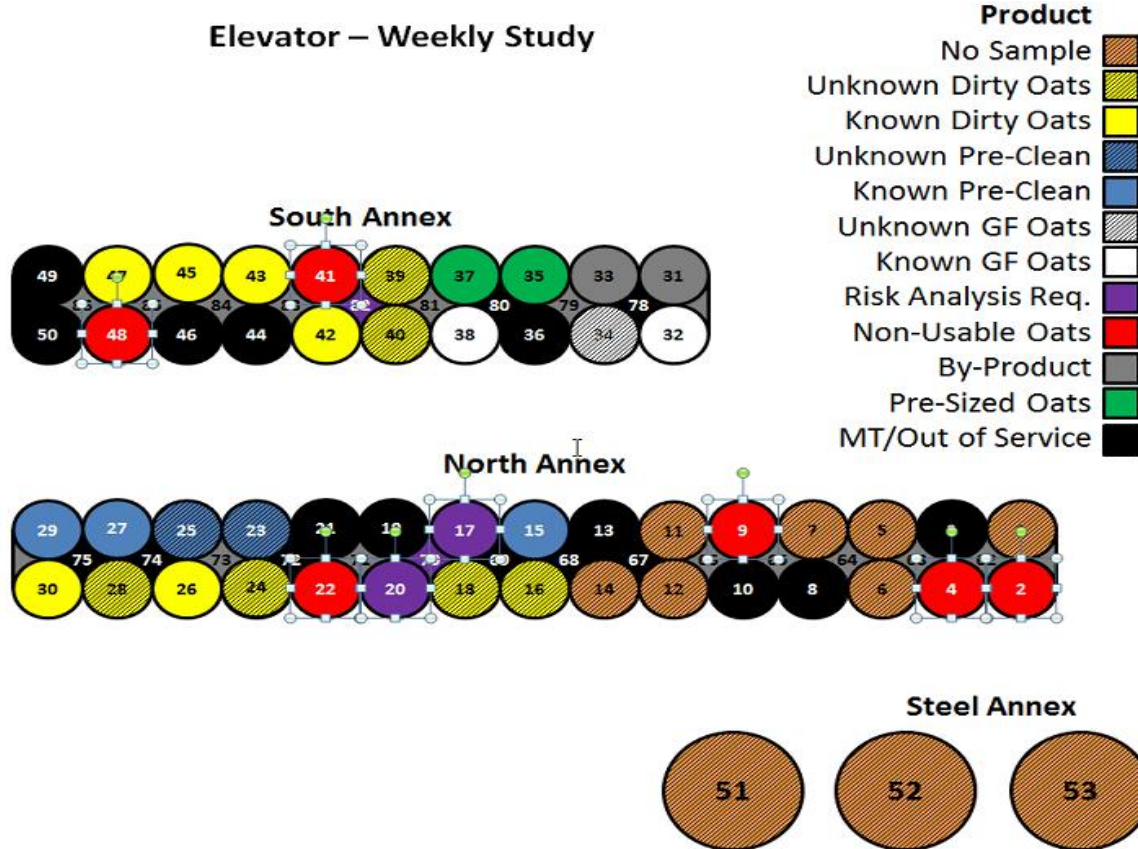






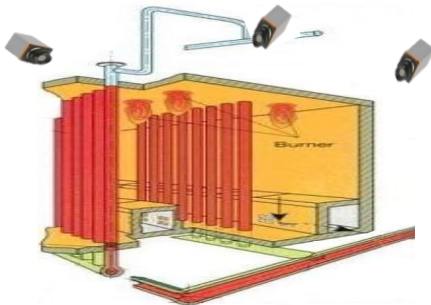
# Supply Side Management Chain of Custody

## Elevator – Weekly Study

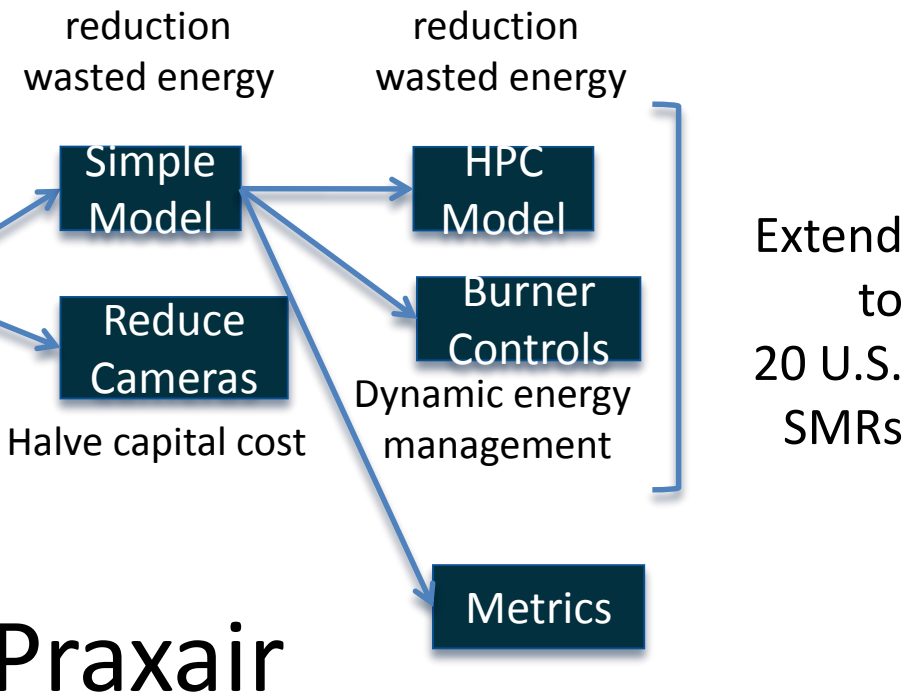


# Intensification through Measurement & Operational Integration

## First Steam Methane Reformer Furnace Port Arthur, TX



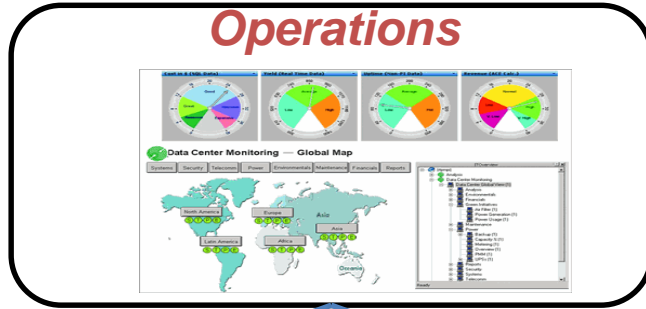
- Already efficient
- Distributed sensing
- Distributed actuation (96 burners)
- High fidelity model & reduced order models



# Business Virtual Enterprise & Distributed Asset Modularization

Enterprise thinking: virtual enterprise model that incorporates physical assets as components to execute production

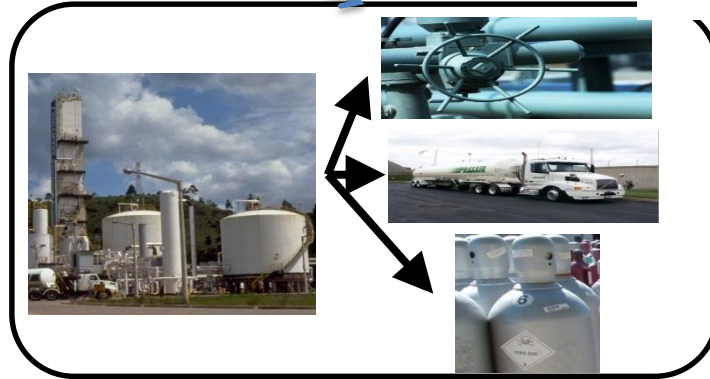
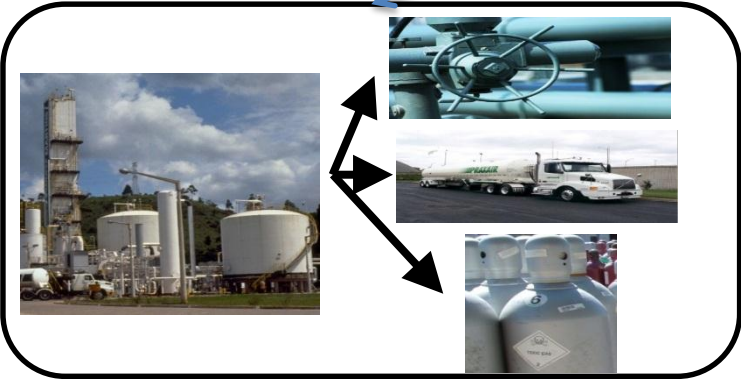
## Customers



Port Arthur TX

2<sup>nd</sup> Location

Production on Demand



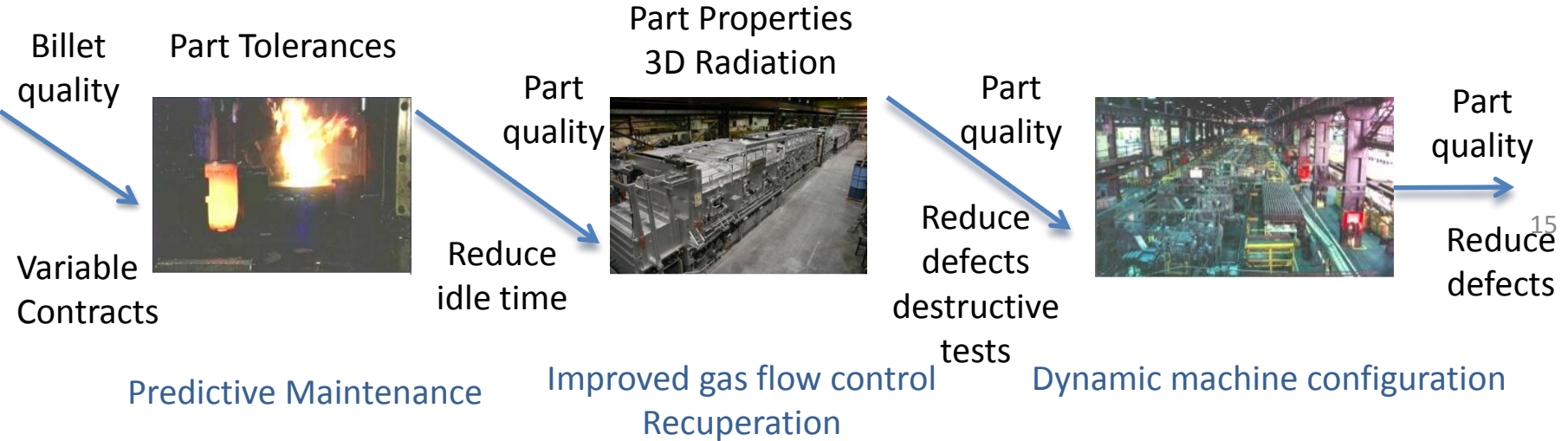
**Production and Delivery**

**Production and Delivery**

-  Steel
-  Energy
-  Bio/Pharma
-  Electronics
-  Healthcare

**General Dynamics**  
**Scranton, PA**

Integrated line management of part precision, materials/metallurgical properties, dynamic part movement, defect reduction, energy management →



Corning – modularize (integrate) upstream supplier

LA & Orange County – small metals, food & apparel utility demand-response/  
renewables

Pfizer – micro reactors for product customization qualification

Alcoa – real-time optimization of sheet & plate manufacturing  
flow paths

Over 90% manufacturing in SME's

## **PATTERNS OF APPLICATION**

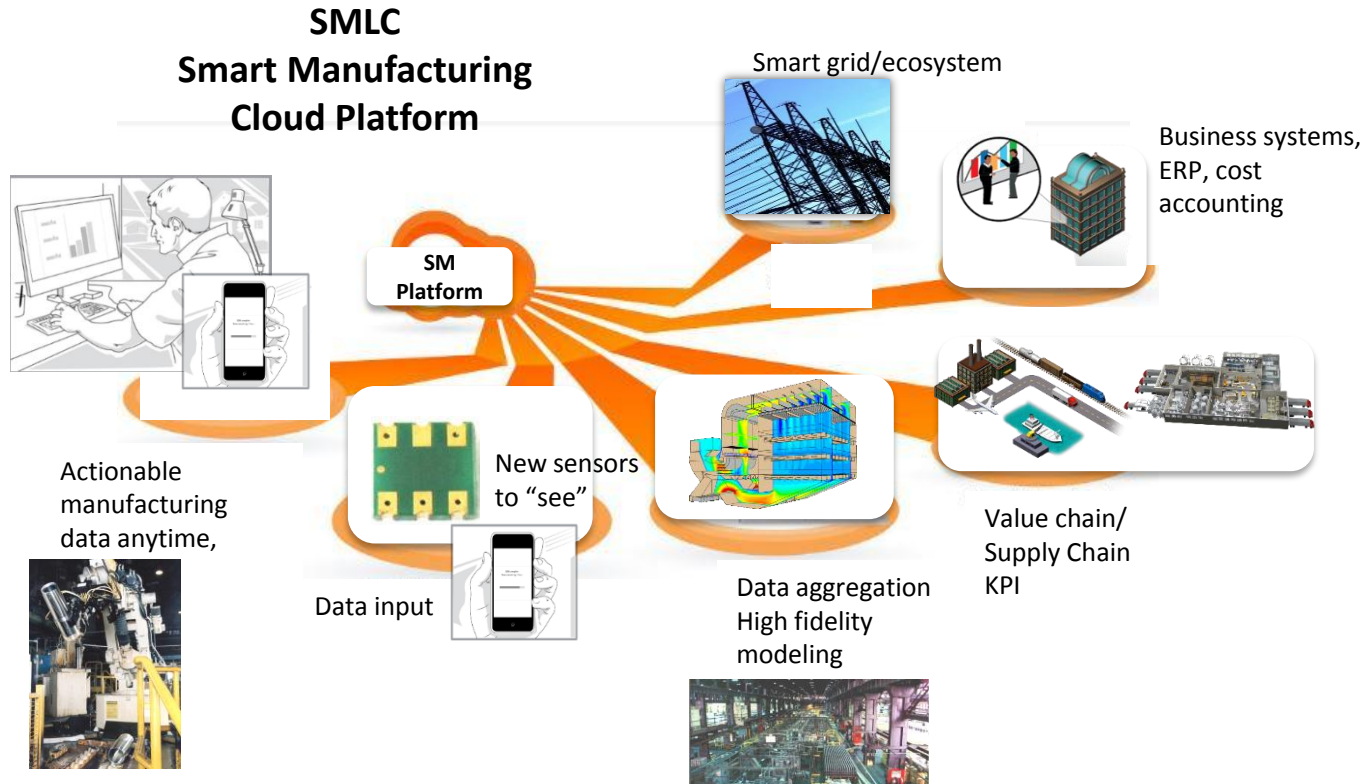


## *Modularization, Intensification Virtualization & Optimization with Sensors, Controls, Platforms & Modeling*

### SM Value propositions

- Intensification
- Production on demand
- Customization and value add in the trade space
- Supply side management and chain of custody
- Portable continuous miniaturization
- Distributed modularization & ecosystems
- Business virtualization & asset modularization
- Modularization and scaling flexibility

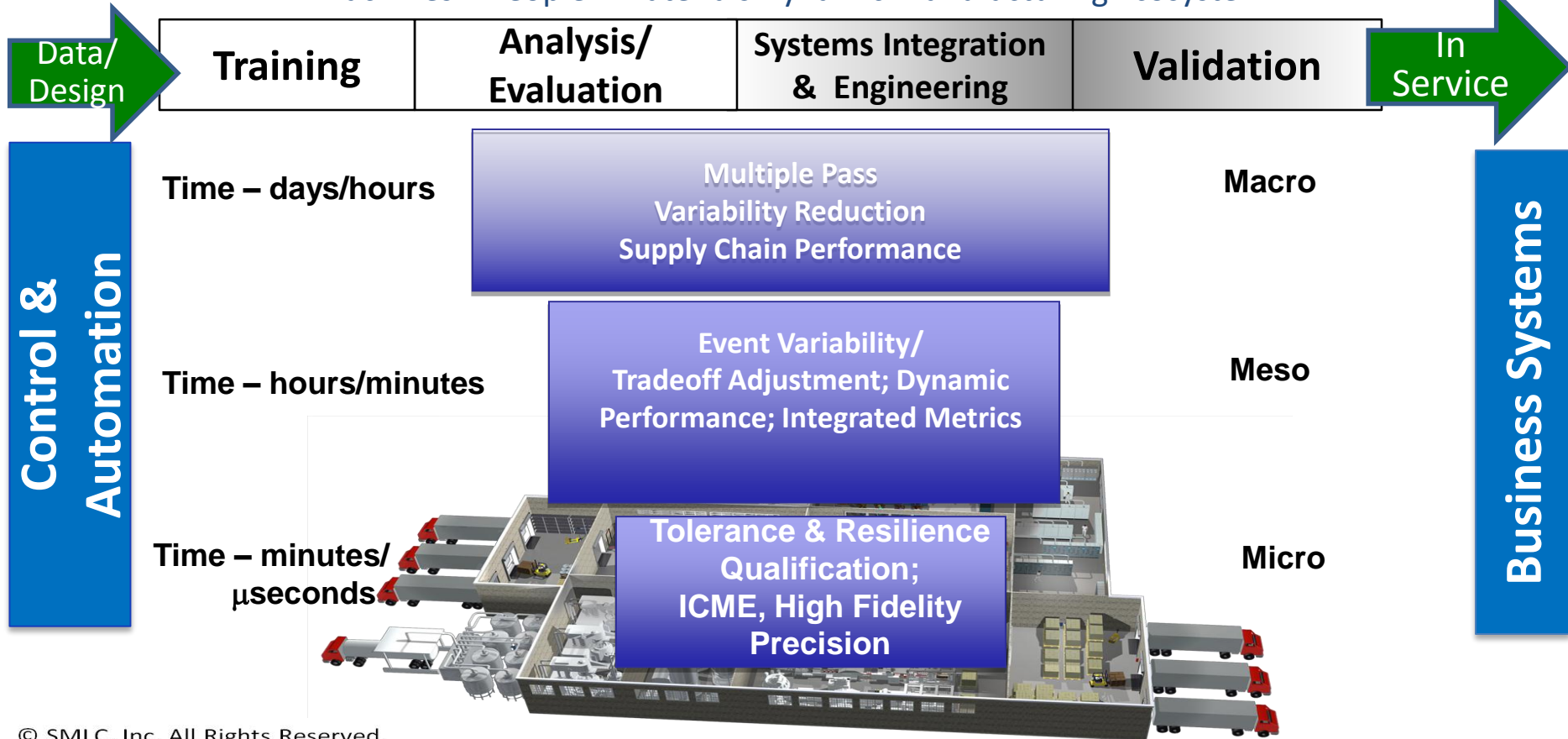
# The Analogy with Health Care



# Operational Space of Seams, Time, Data & Action

## Sweet Spot for Operational Modularization & Intensification

Machines – People - Materials Dynamic Manufacturing Ecosystem





# Smart Manufacturing Practice and Reusability

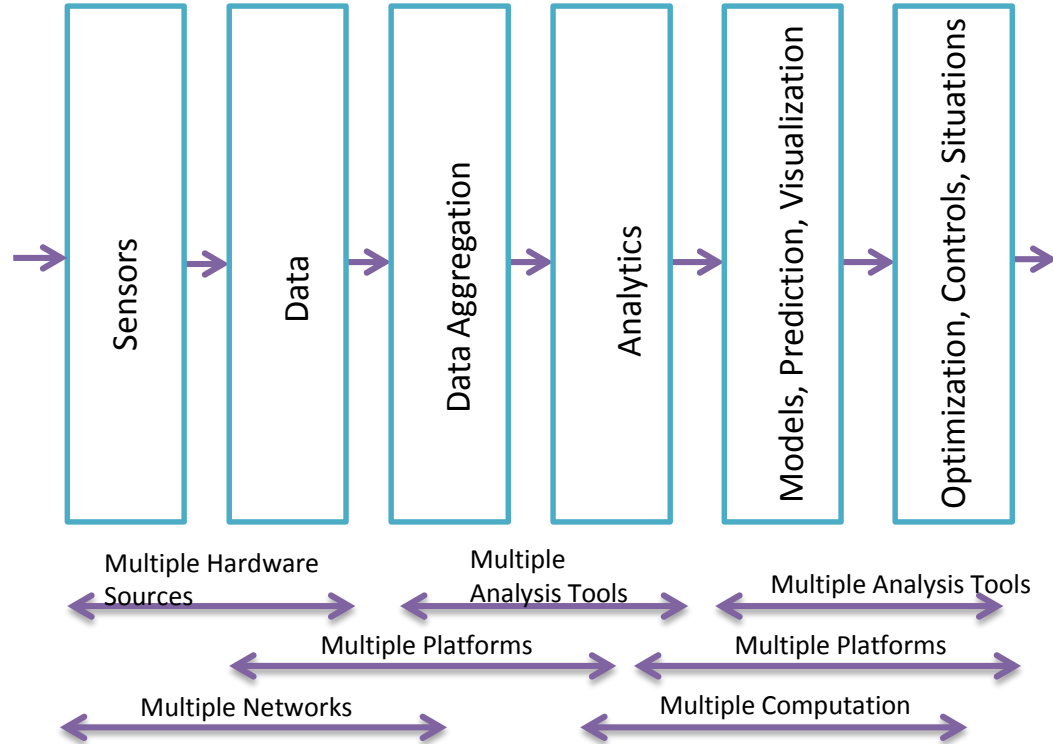


Fullen View Leadership Footer

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# End-to-End Systems

## Advanced Sensing Controls Platforms & Modeling (ASCPM)



# What Got Us Here Won't Get US There

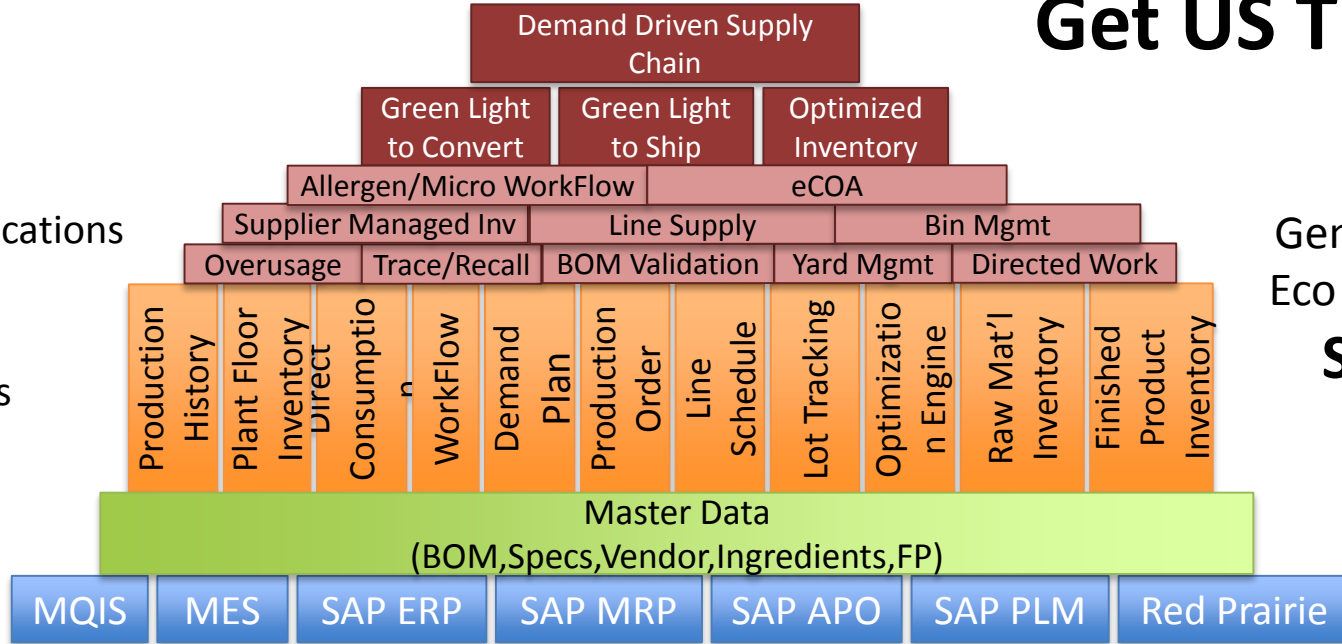
Value Creation

Business Applications

Core Functions

Core Systems

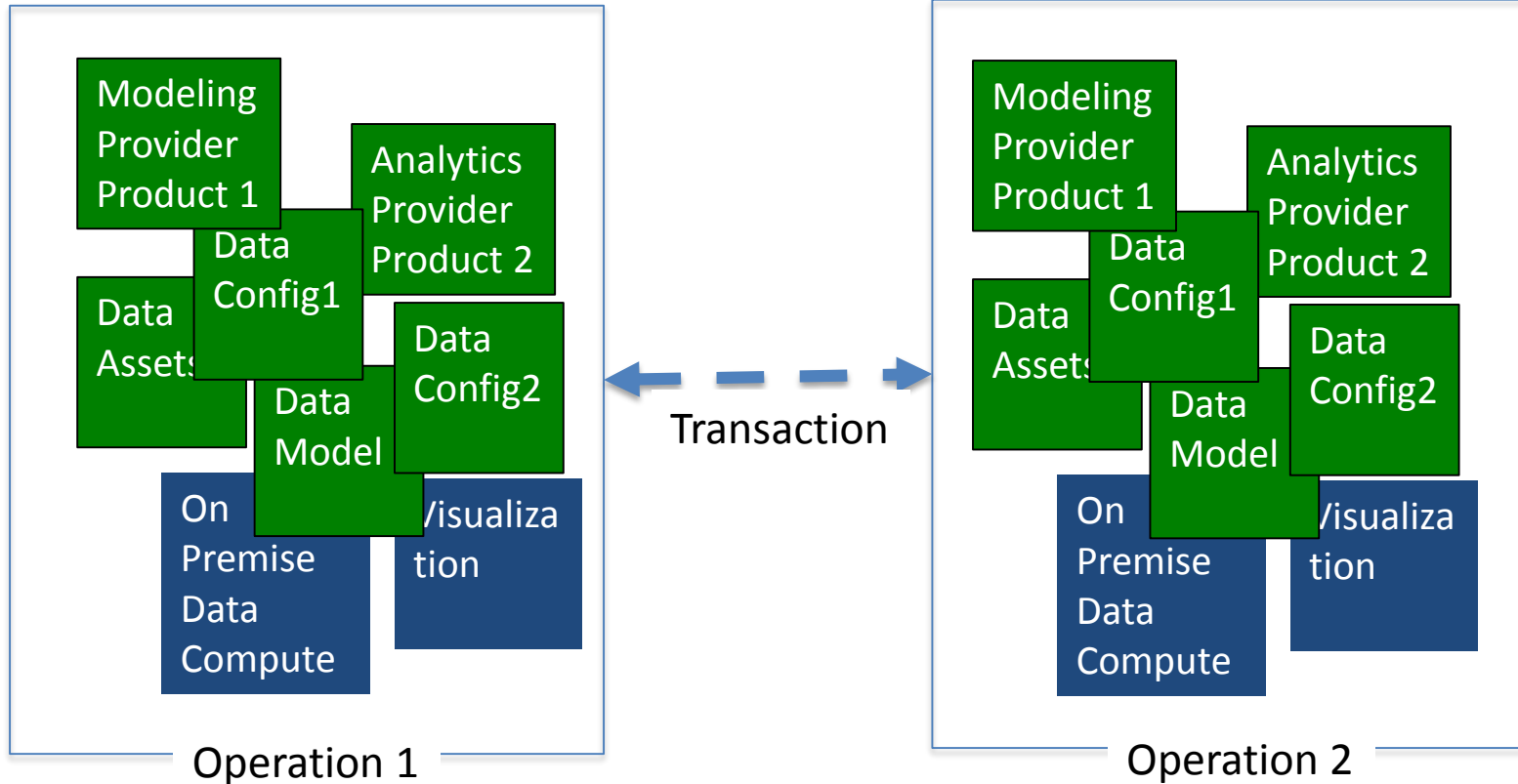
Data Input



General Mills  
 Eco System of  
**STUFF**



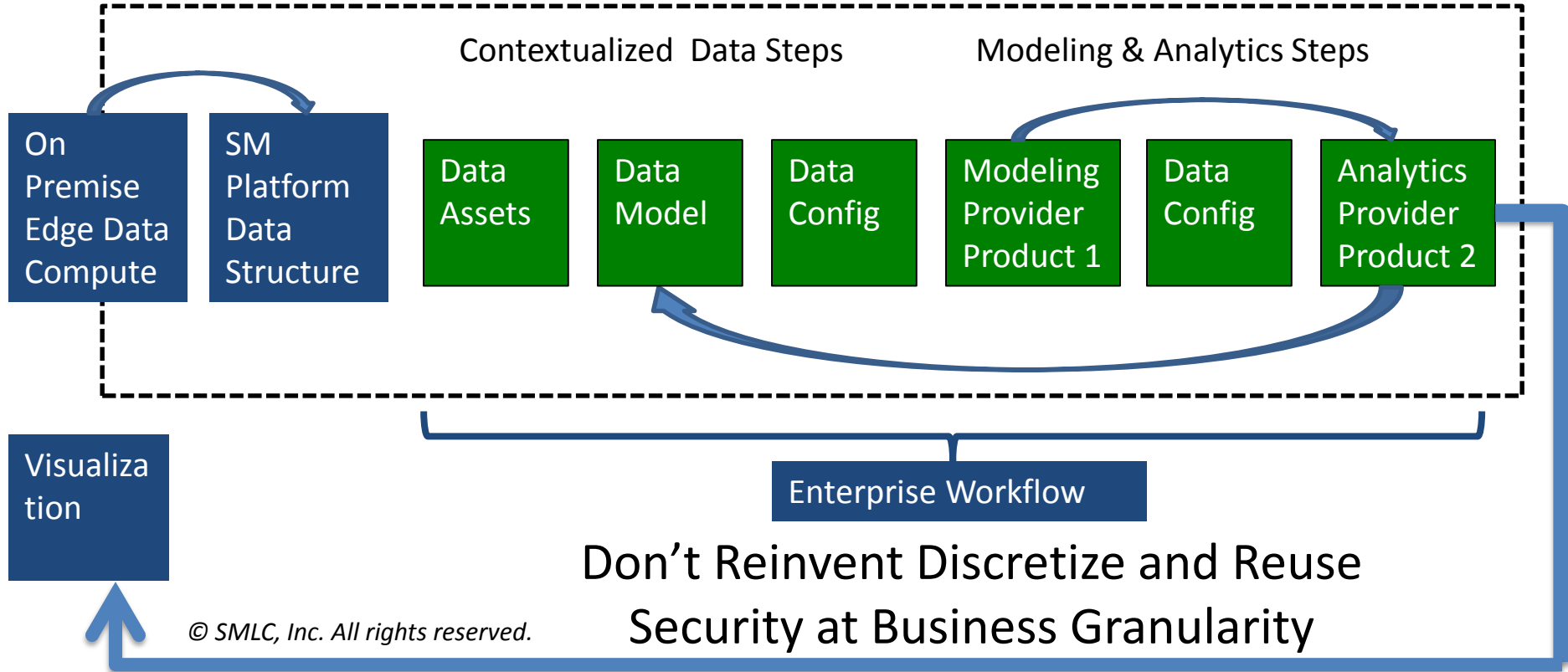
# One-off, Proprietary, On Premise Will not Get Us There This is not secure



# Span Heterogeneous Environment

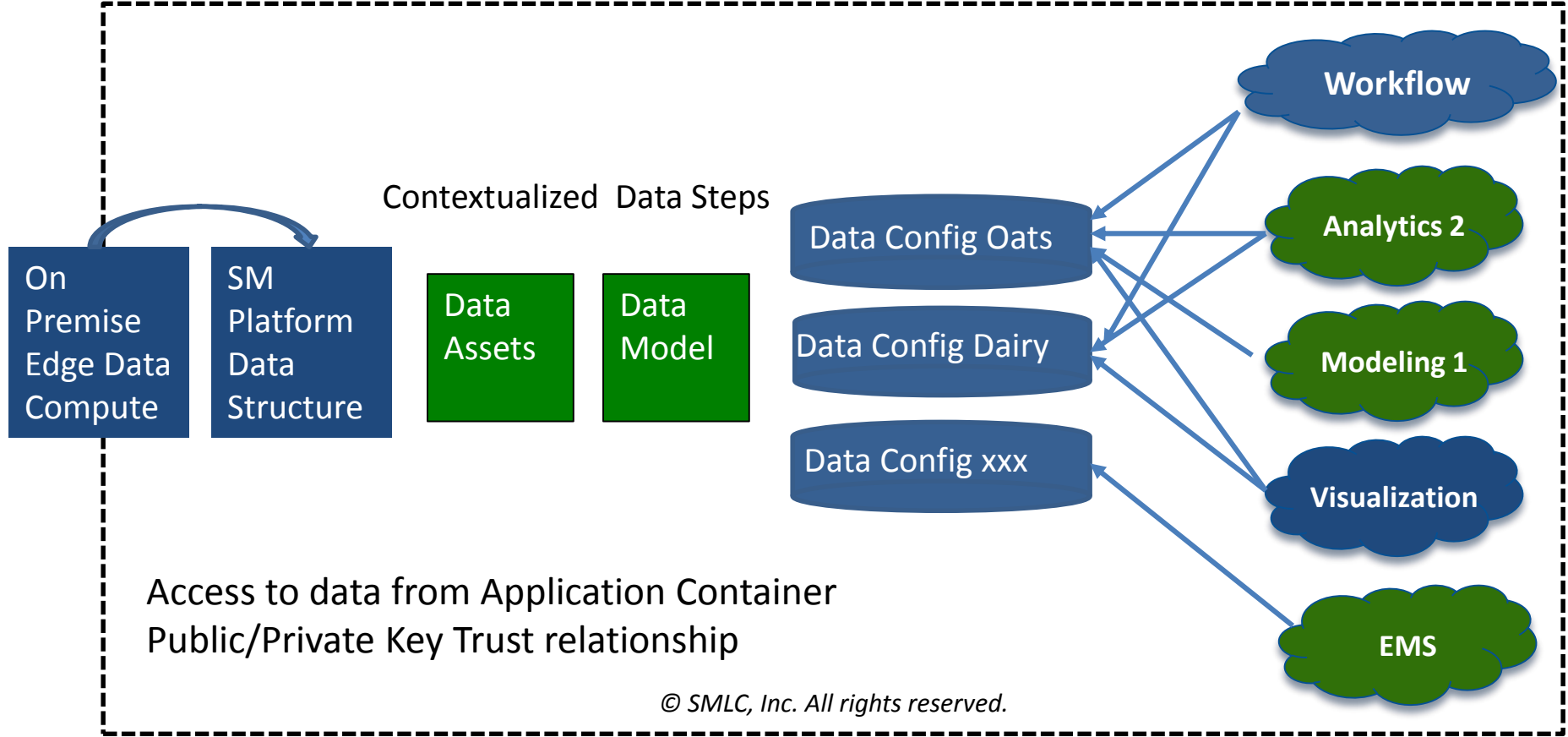
On-premise – Off Premise – On Premise

## Maintain State





# Spin Up Multiple Projects Reuse Data & Application Configurations



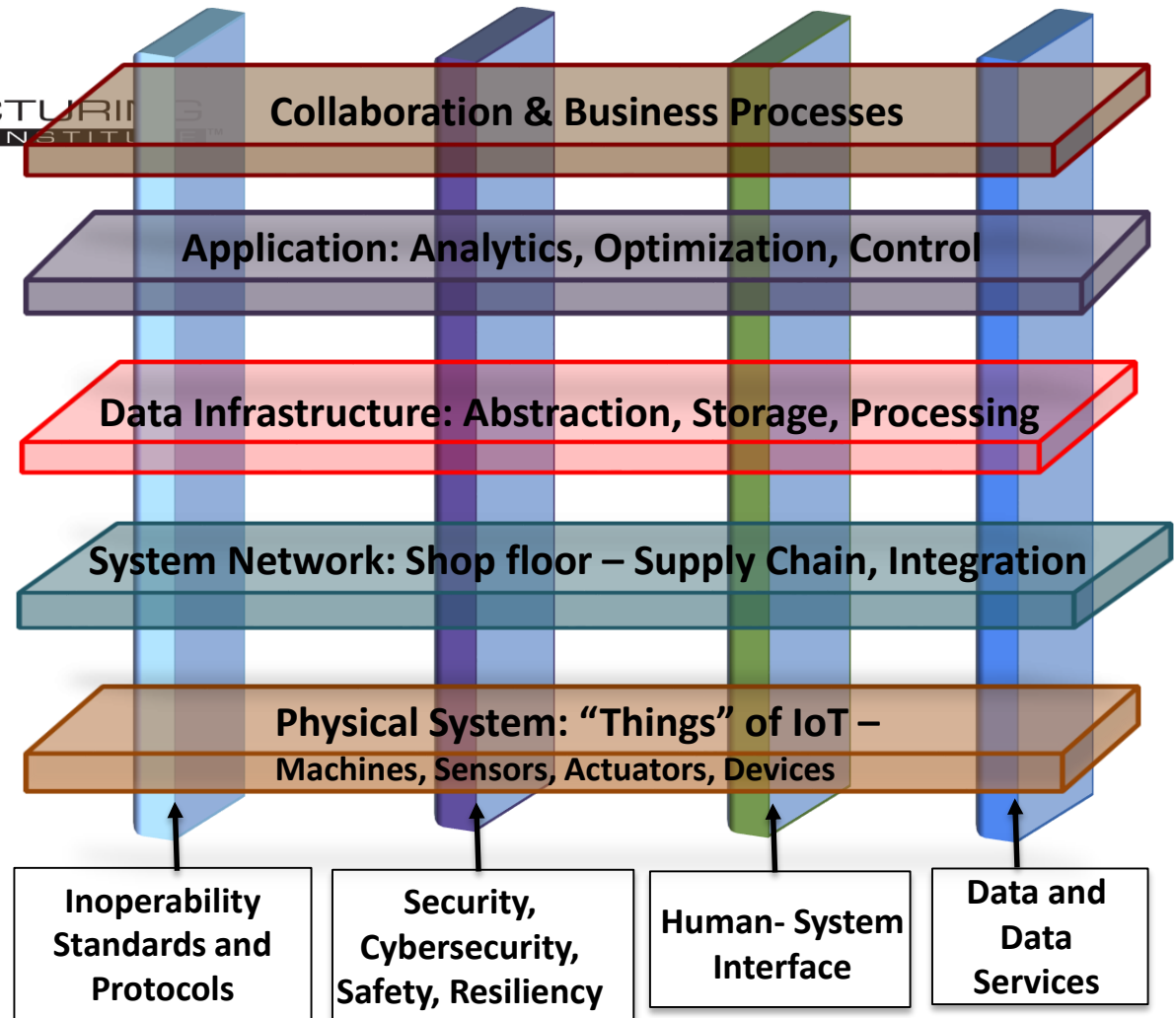


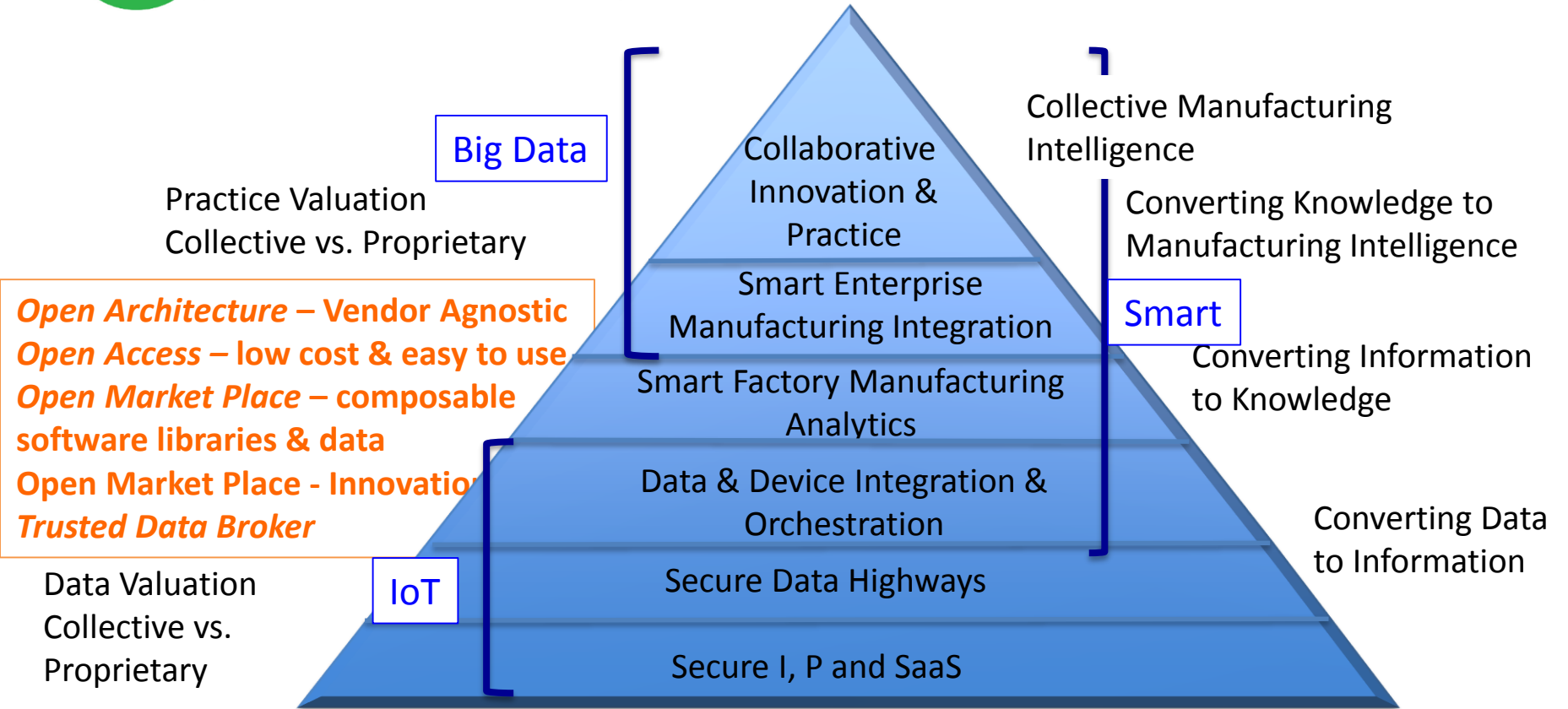
# Systems Infrastructure for Smart Manufacturing Practice



Reference  
Architecture &  
Practice  
Thinking

Sudarsan  
Rachuri

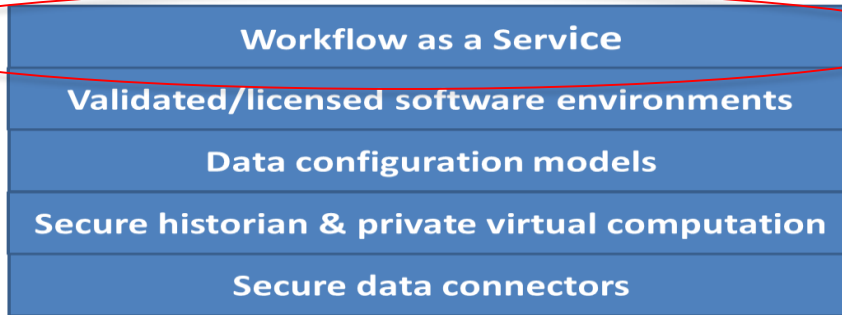




# Build a Rich Marketplace

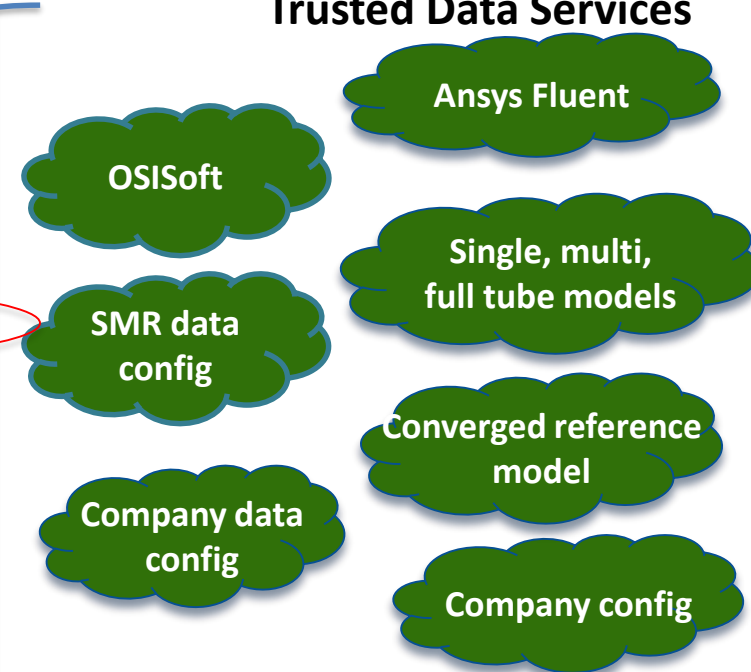
Reusable Configurations  
 Core Deployment Services  
 Trusted Data Services

## WfaaS - OT/IT Construct



## Cloud Integration Services

Security; Machine & Human Interfaces;  
 Virtual Compartments; Interoperability; Standards

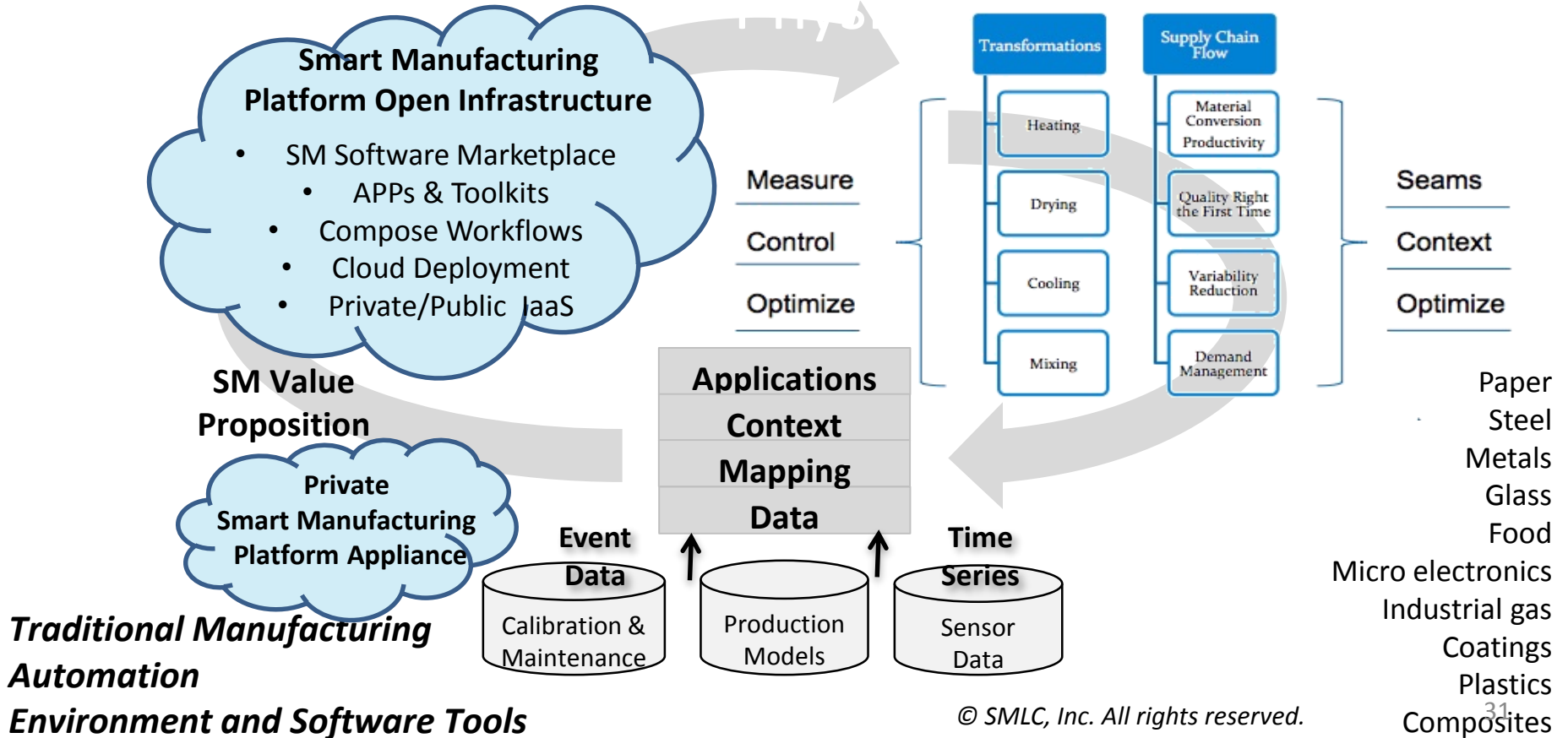


Industry Marketplace  
 Reusable Configurations

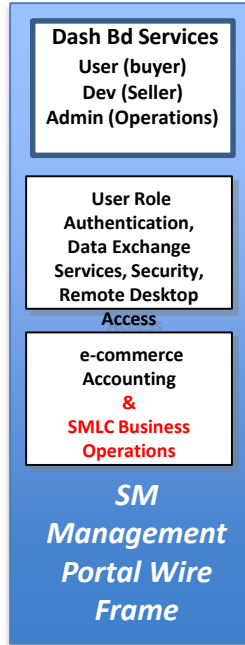
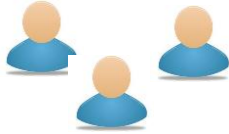
# *Example of Reusability and Configurations aaS*

High-Fidelity Model for a rectangular furnace with flowing materials in vertical tubes with interspersed burners

<b>Reference model</b>	<b>Configuration</b>	<b>Mesh hexagonal polygon</b>	<b>Compute time/platform</b>	<b>First-of-kind development time</b>	<b>Reuse time for similar operation</b>
Single Tube	Tube side heat transfer & kinetics	50 thousand	Minutes/ desktop	6 months	Validate kinetics/heat transfer Days
Small Furnace	4 tubes/3 burners	2 million	Hours/ 4 core	6 months	Confirm convergence validate results Days
Fall Furnace	336 tubes/96 burners	30 million	Days/ 48 core	6 months	Converge full model Days



# SMLC Smart Manufacturing Platform Ecosystem



## SM Commercial Marketplace

<b>APPS</b>	<b>Analysis Applications</b>	<b>Turn Key Solutions (WFs of WFs)</b>
<b>Eternal Connector Services</b>	<b>Visualization &amp; Domain GUIs</b>	<b>Solution Provider Services</b>

SM Open Marketplace Wire Frame Services

*User Selected or Defined Testbed Dashboards, Process  
Functions, Visualization and Metrics Works Spaces*

SM Open Cloud Orchestration Wire Frame

Scalable Cloud Computing Service Provider(s)  
Public & Private

Business and Capability Oversight Provided by SMLC SM Platform Board  
Feature Enhancements Contributed by SMLC Members (SMLC Rights)  
SM Platform Specification and Its Management by Nimbis Services



# SM Platform Infrastructure

## SMART MANUFACTURING PLATFORM MARKETPLACE

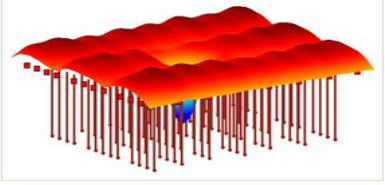
Logged in as: User 1 [Log out](#)

App Store My Apps My Workflows

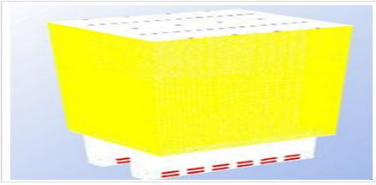
Available Apps

Build Workflow

Upload App




EC-SMR Furnace Model



Furnace CFD Model

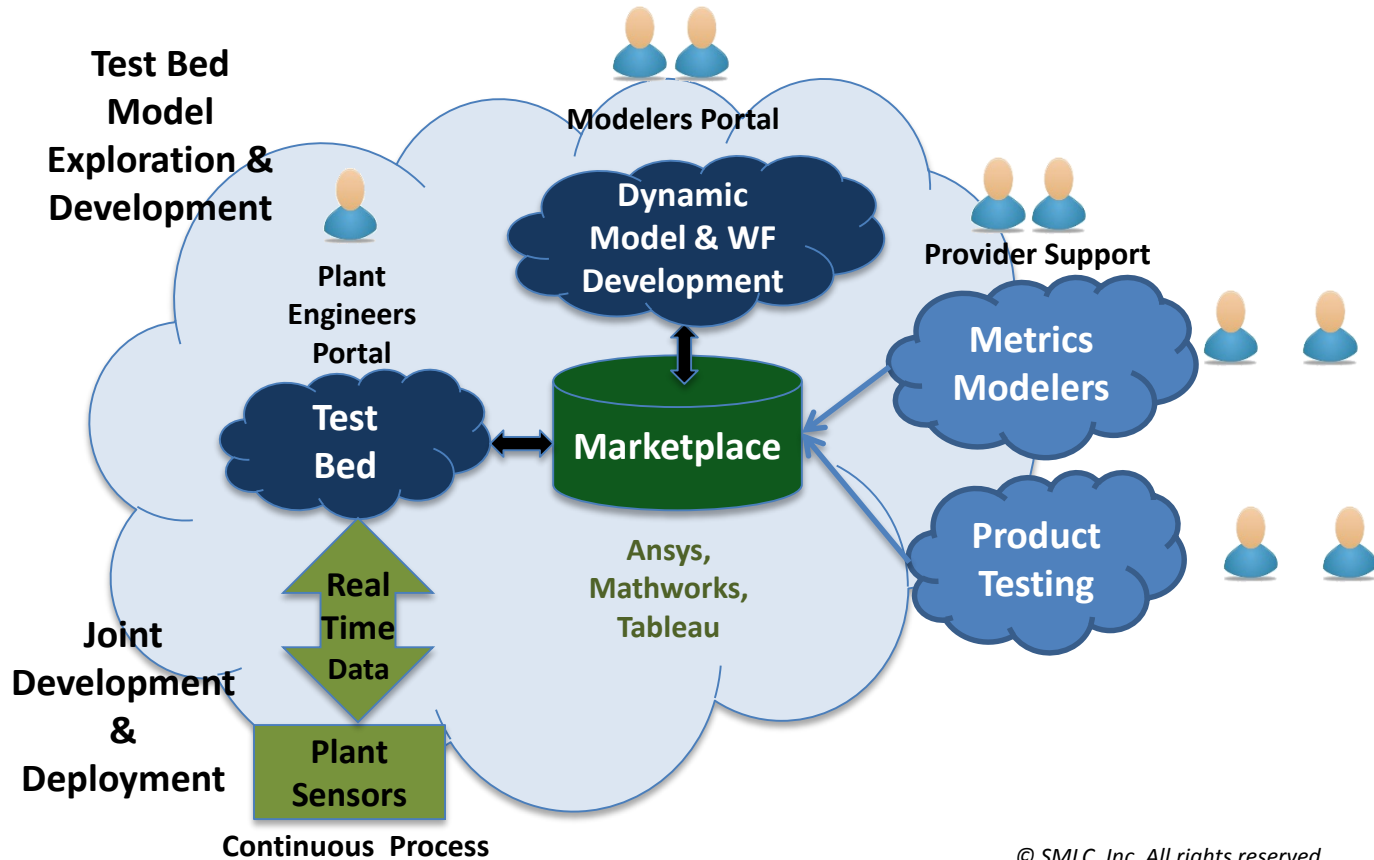
Properties  
Customize  
User Manual



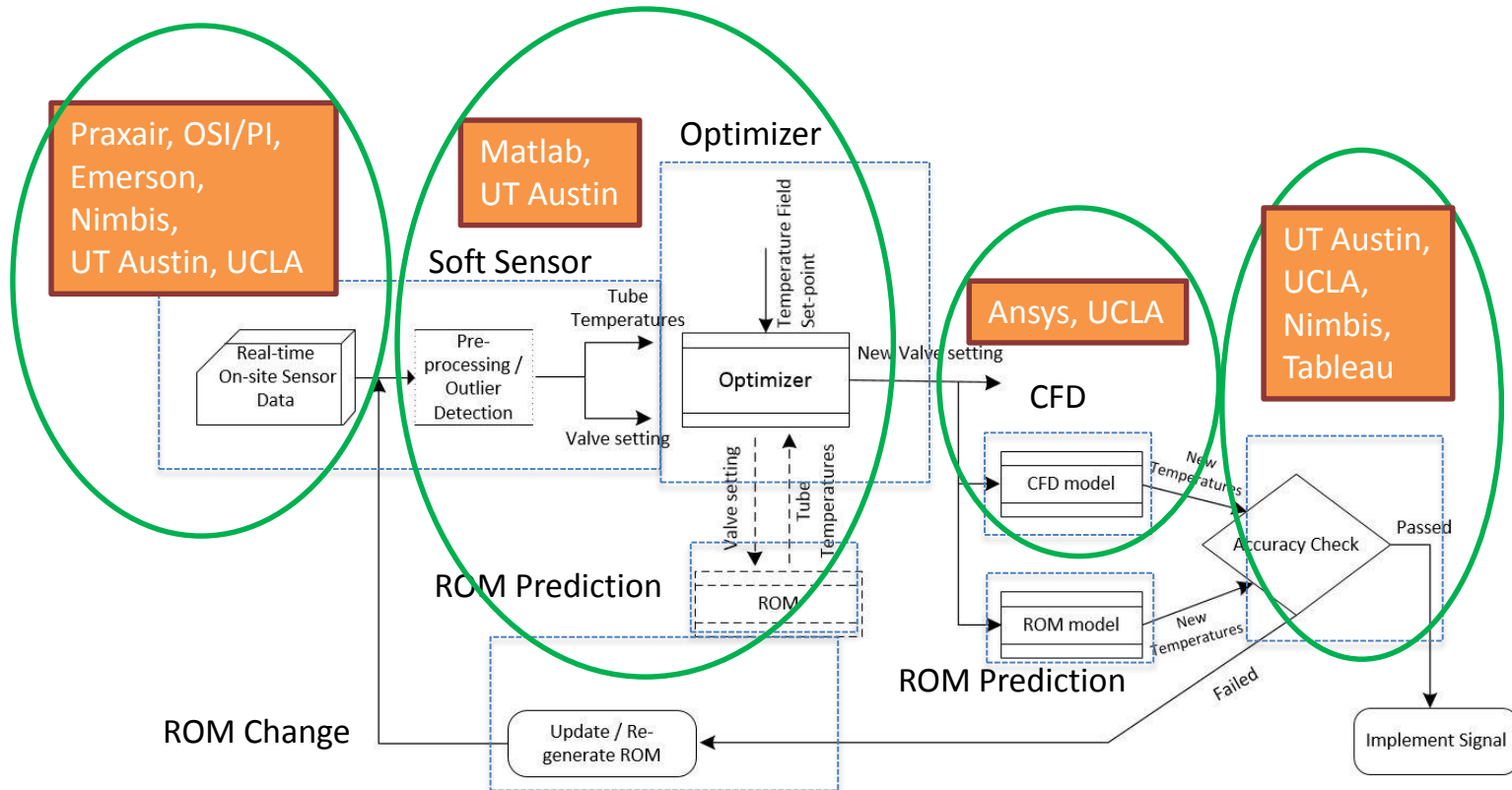
Furnace Balancing Solution

- Certified app 'configurations'
- Search Engine
- Compose and reuse
- IoS for manufacturing
- DevOps for manufacturing
- Data to Applications
- Trusted Data, Marketplace, End-to-end State Services

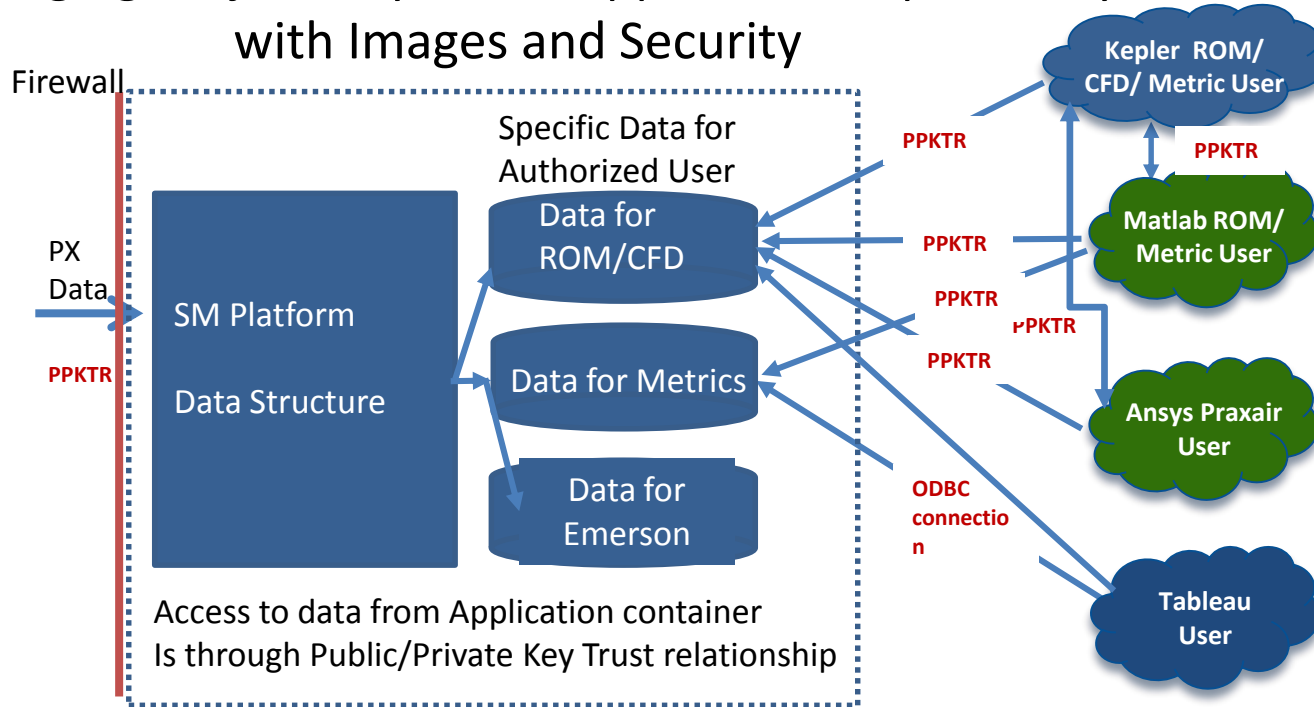
# SM Platform Collaborative development



# SM Platform for Systems Engineering



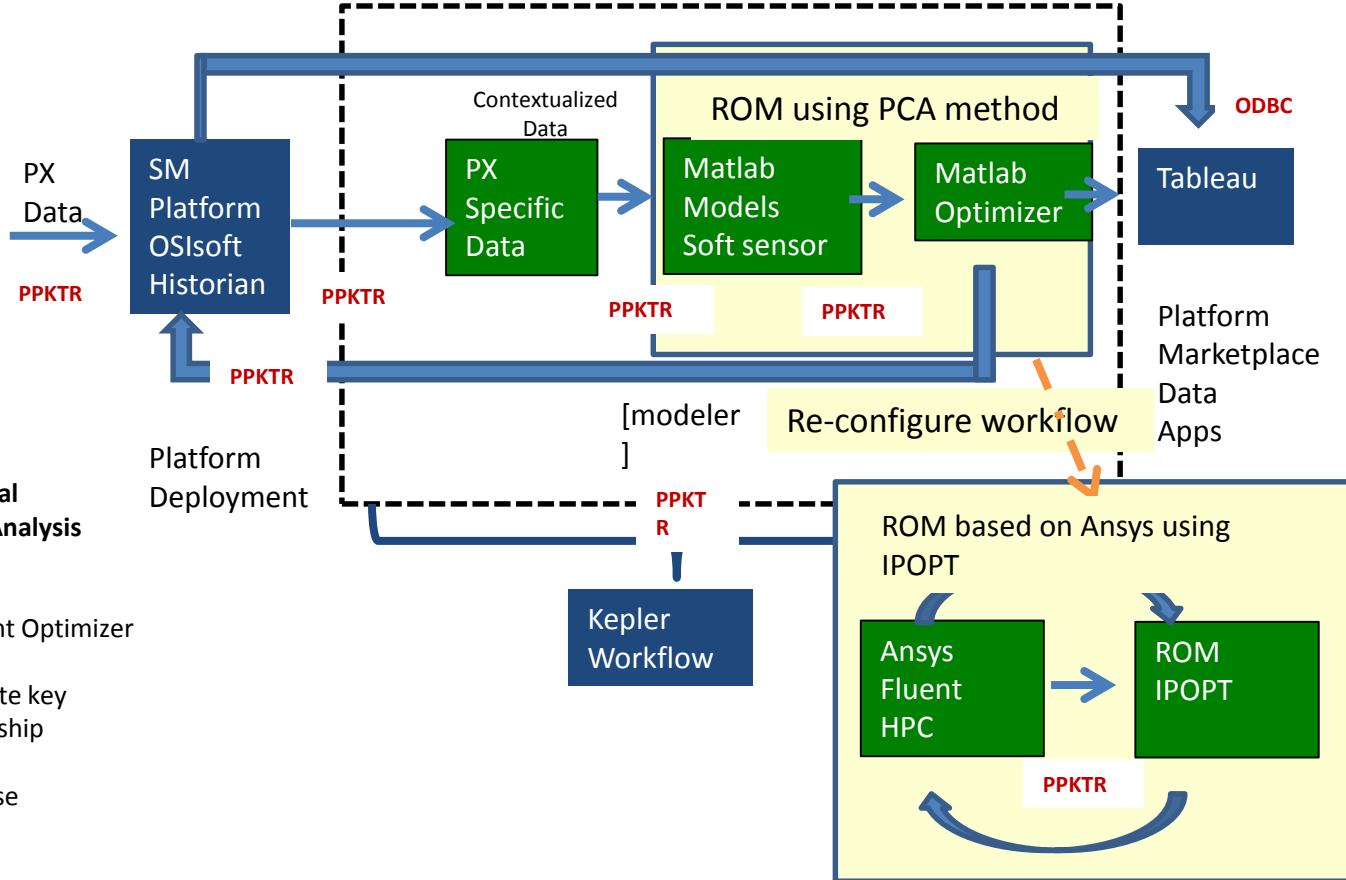
# Managing Projects, Systems, Apps and Composability with Images and Security



**PPKTR**  
= Public-private key  
Trust relationship

**ODBC**  
= Open Database  
Connectivity

# Systems Engineering, Development & Execution as DevOps



**PCA = Principal Component Analysis (statistical)**

**IPOPT**

= Interior Point Optimizer

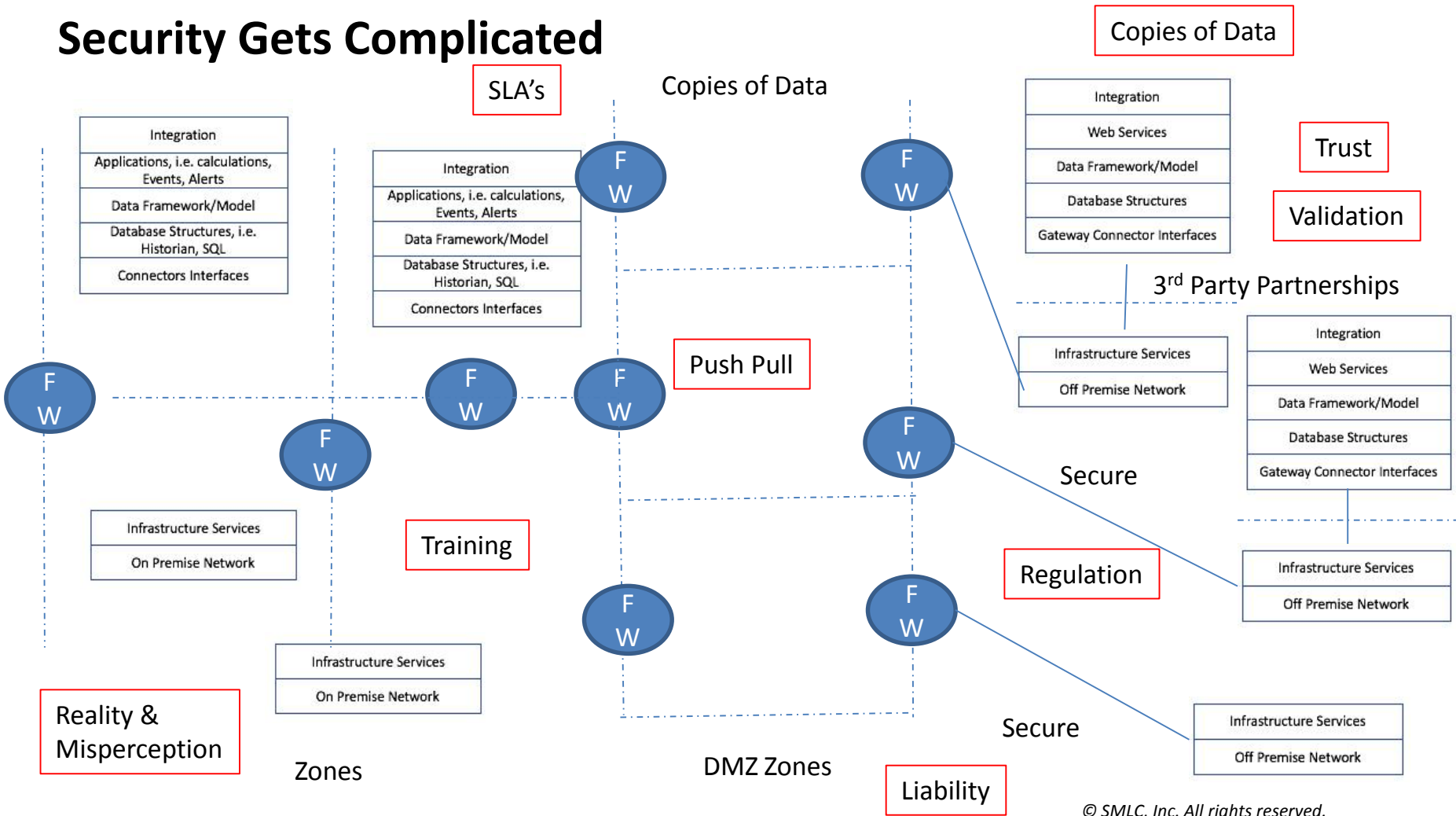
**PPKTR**

= Public-private key Trust relationship

**ODBC**

Open Database Connectivity

# Security Gets Complicated



# Wire Frame Economics

	Year 1	Year 2	Year 3	Year 4	Year 5
Decrease First of Kind System	25%	30%	35%	40%	50%
Accelerated outcomes	2 years to 1 year	+5% faster	+10% faster	+15% faster	+20% faster
Decrease Replication cost/risk		60% first replication	65% multiple replications		



# Putting My University Hat On?



Fullen View Leadership Footer

May 23, 2017



- UCLA interests
  - Research funding reallocated to institutes like this one
  - Public private partnership
  - Value of data and algorithms
  - Tech transfer
    - Test, evaluate and productize University IP
    - Commercial data with which to develop university IP
    - New pathways to productization
  - Researcher/capabilities discovery and cross linking
  - Integrated infrastructure
  - Training, education and STEM in data, analytics, and data sciences
  - Integration of research universities, CSUs and CCCs
  - Public mission around economic development, energy productivity and environmental sustainability

- Academic Interests
  - Not a Grant; Industry Driven
  - The value of real data
  - Requires inverse thinking
    - Connecting TRL 1 – 3 to TRL 4 - 7
    - Expertise on problems and data
    - Training and education in data analytics and sciences
    - Platform for training
    - Spin off research and development projects
  - Implementing new academic infrastructure
    - Faculty and students participating in projects
    - Avenue for tech transfer
    - Avenue for great student and faculty involvement
    - Access to real world problems

# Smart Manufacturing Reinvestment Potential

## A Comprehensive Approach to Manufacturing

### At the Intersection

- Workforce Productivity
- Business & Product Agility
- Supply Chain Agility & Optimization
- Asset Management and Risk
- Product Lifecycle
- Energy & Material Productivity
- Environment, Sustainability & Safety

## Next Generation IT for Next Generation Manufacturing

- Make Data a Key Asset
- Advanced Real-Time Sensing, Controls, Platform and Modeling

