Digital Twin + Industrial Internet

for Smart Manufacturing

A Case Study in the Process Industry (*Steel)*

Dr. Shi-Wan Lin, CTO   **Mr. Kebin Li, Co-CEO**
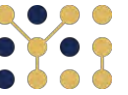
Yo-i Information Technology

Co-Chair, Technology WG & Architecture, Digital Twin Interoperablity TG, IIC (Current)

Co-Chair, Joint Task Group, Plattform Industrie 4.0 & IIC (Current)
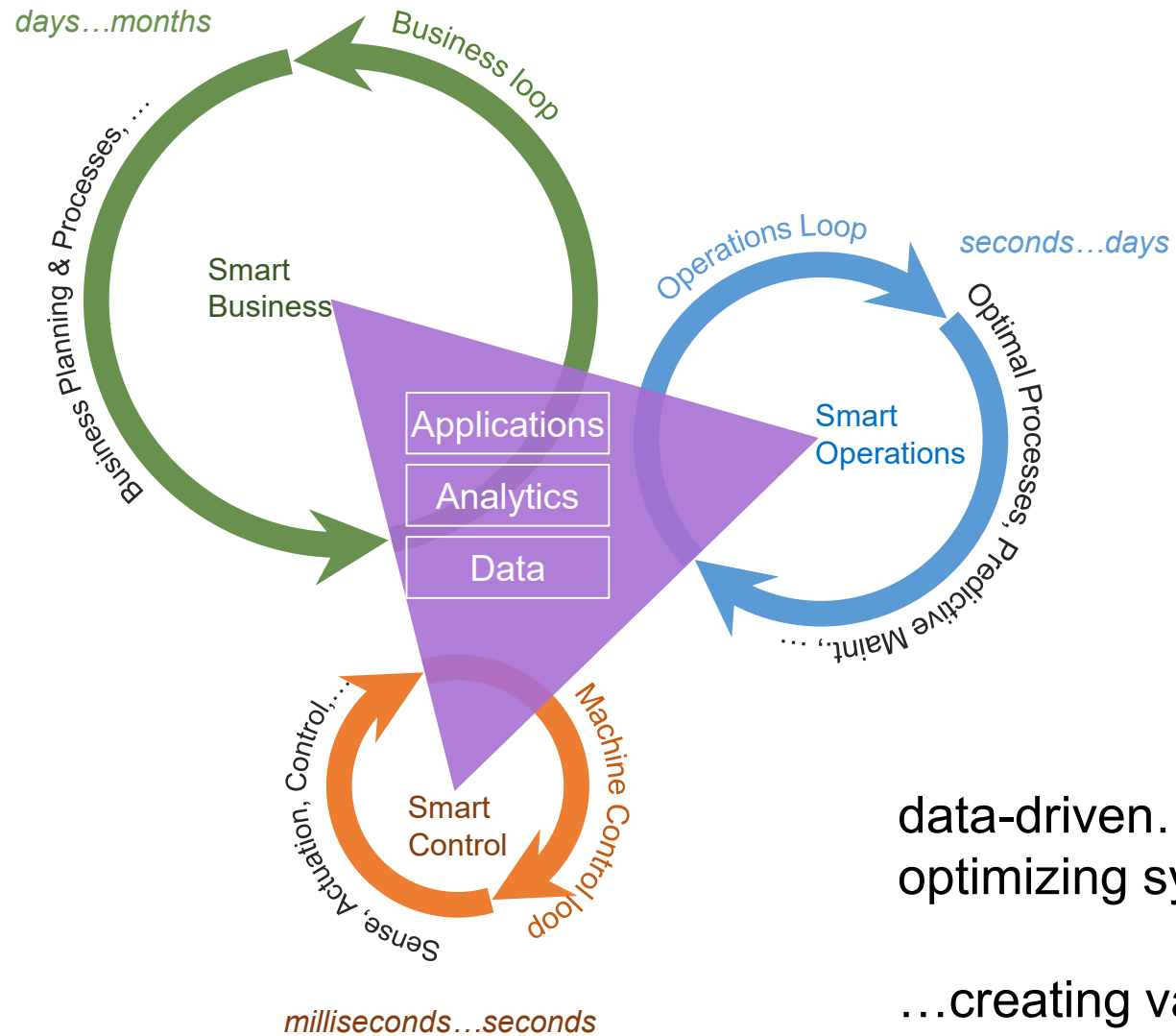
Vice-Chair, IEEE Digital Representation Working Group (Current)

Co-Chair, Vocabulary and Reference Architecture, NIST CPS Public Working Group (Past)
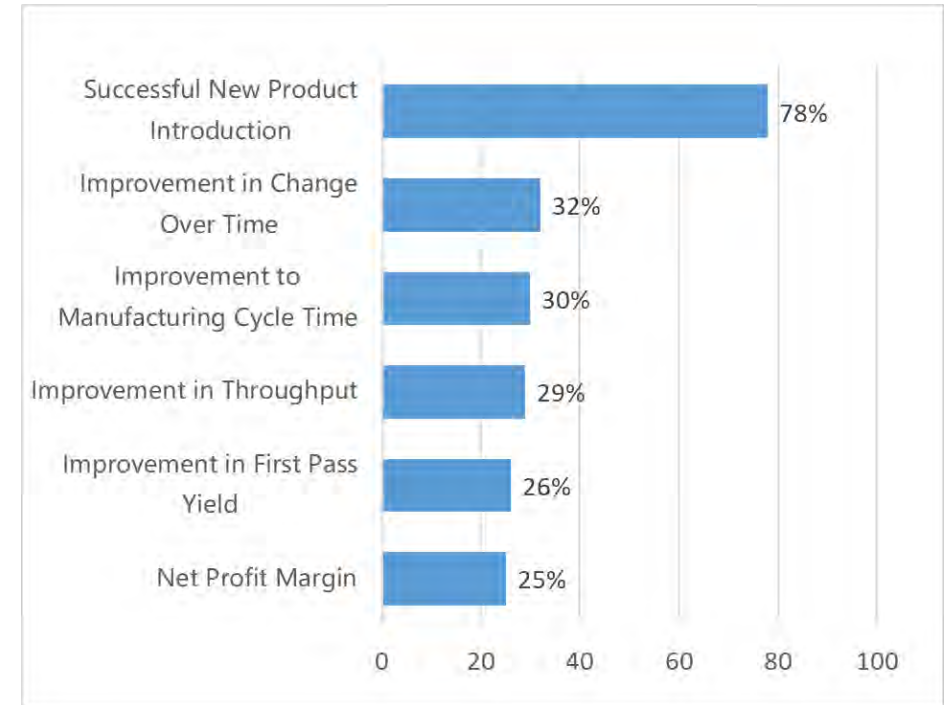
Digital Transformation

Technology Development

Digital Transformation

New Services

New Business Models

New Economic Systems

Enterprise Total Performance

AI

5G

Big Data

Industrial Internet

Cloud Computing

Smart Manufacturing

Sensor Technology

OT & IT Convergence

High Efficiency

Agility

Flexibility

Environment

时间

Industrial Internet

an enabling technology for the digitalization …

days…months

Business loop

Smart Business

Business Planning & Processes, …

Operations Loop

seconds…days

Smart Operations

Optimal Processes, Predictive Maint., …

Applications

Analytics

Data

Machine Control loop

Sense, Actuation, Control,…

Smart Control

milliseconds…seconds

Improvements from IIoT platforms, analytics and digital tools

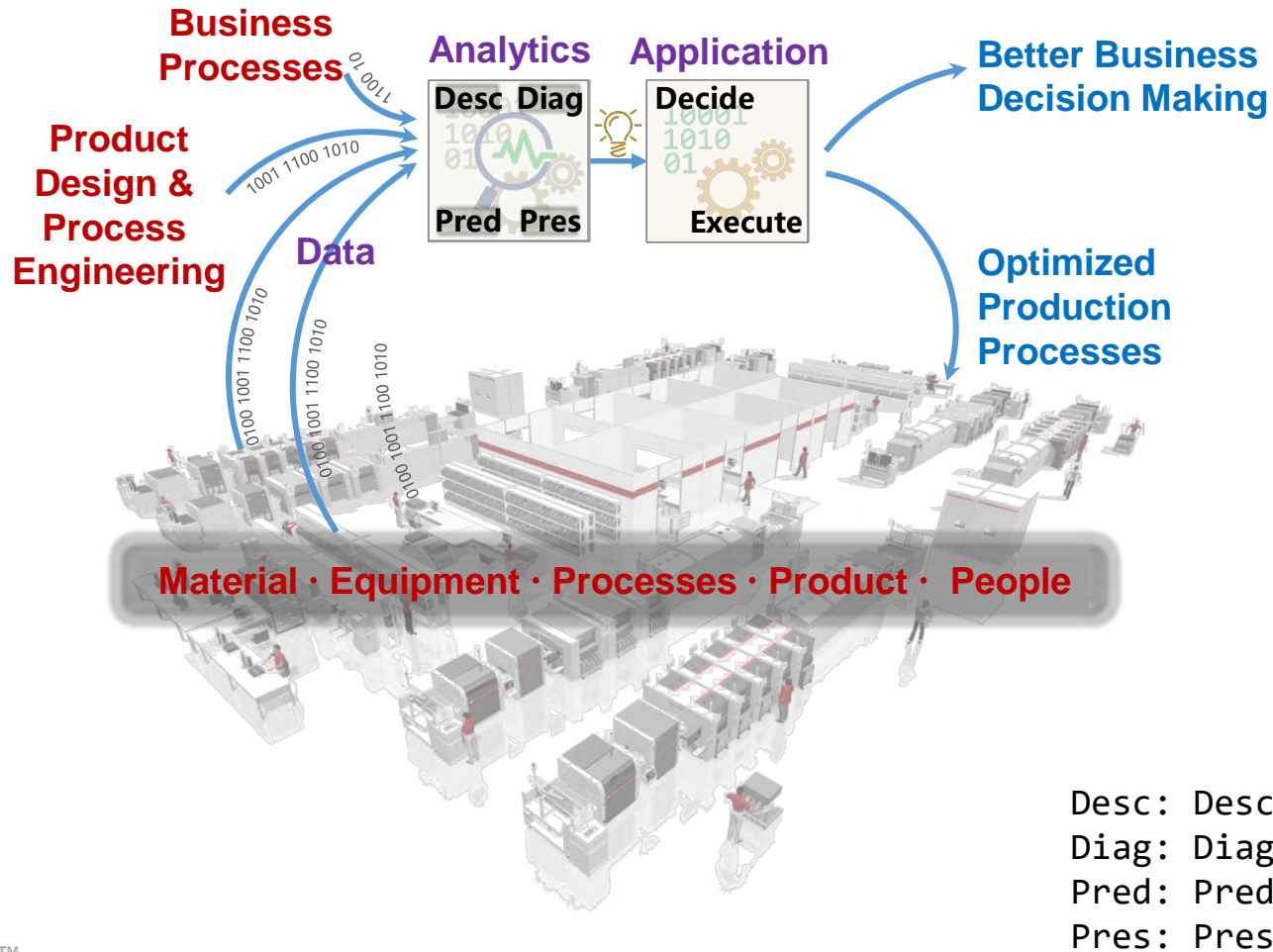|	
Successful New Product Introduction	78%
Improvement in Change Over Time	32%
Improvement to Manufacturing Cycle Time	30%
Improvement in Throughput	29%
Improvement in First Pass Yield	26%
Net Profit Margin	25%

LNS Research, 2018

data-driven…
optimizing systems & processes, informing business strategy

…creating values, transforming businesses…

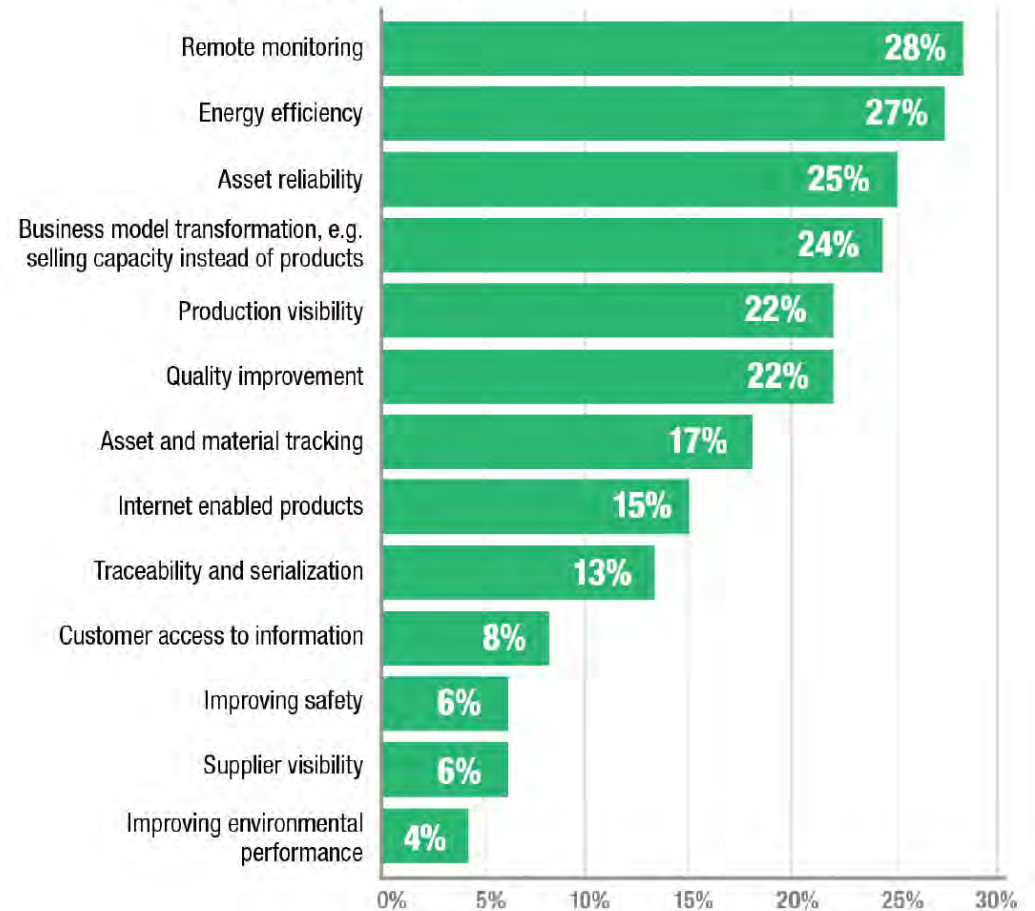# Industrial Internet in Manufacturing
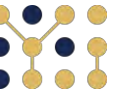
Digitalization of industrial technologies & know-hows through analytic models & software
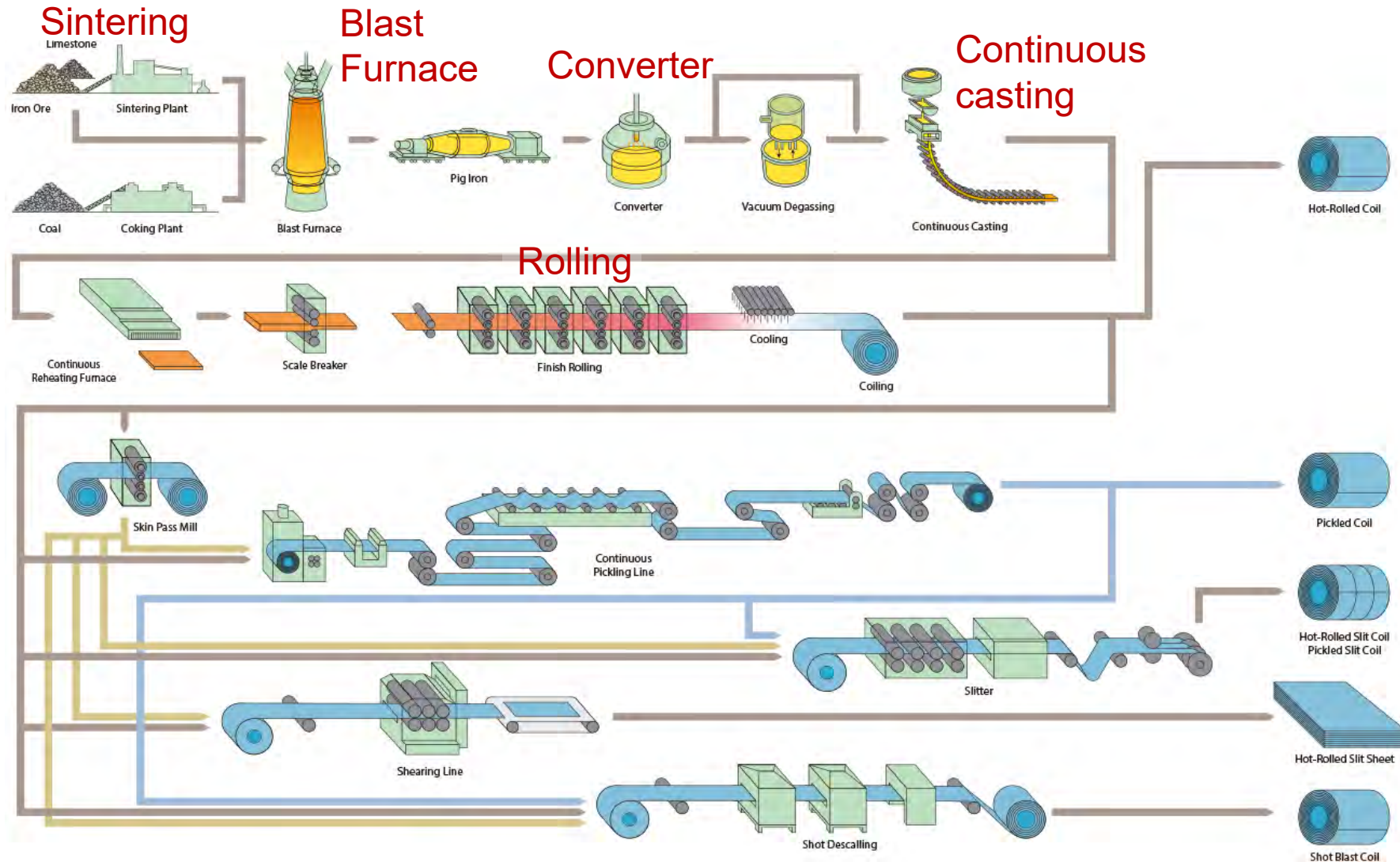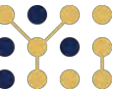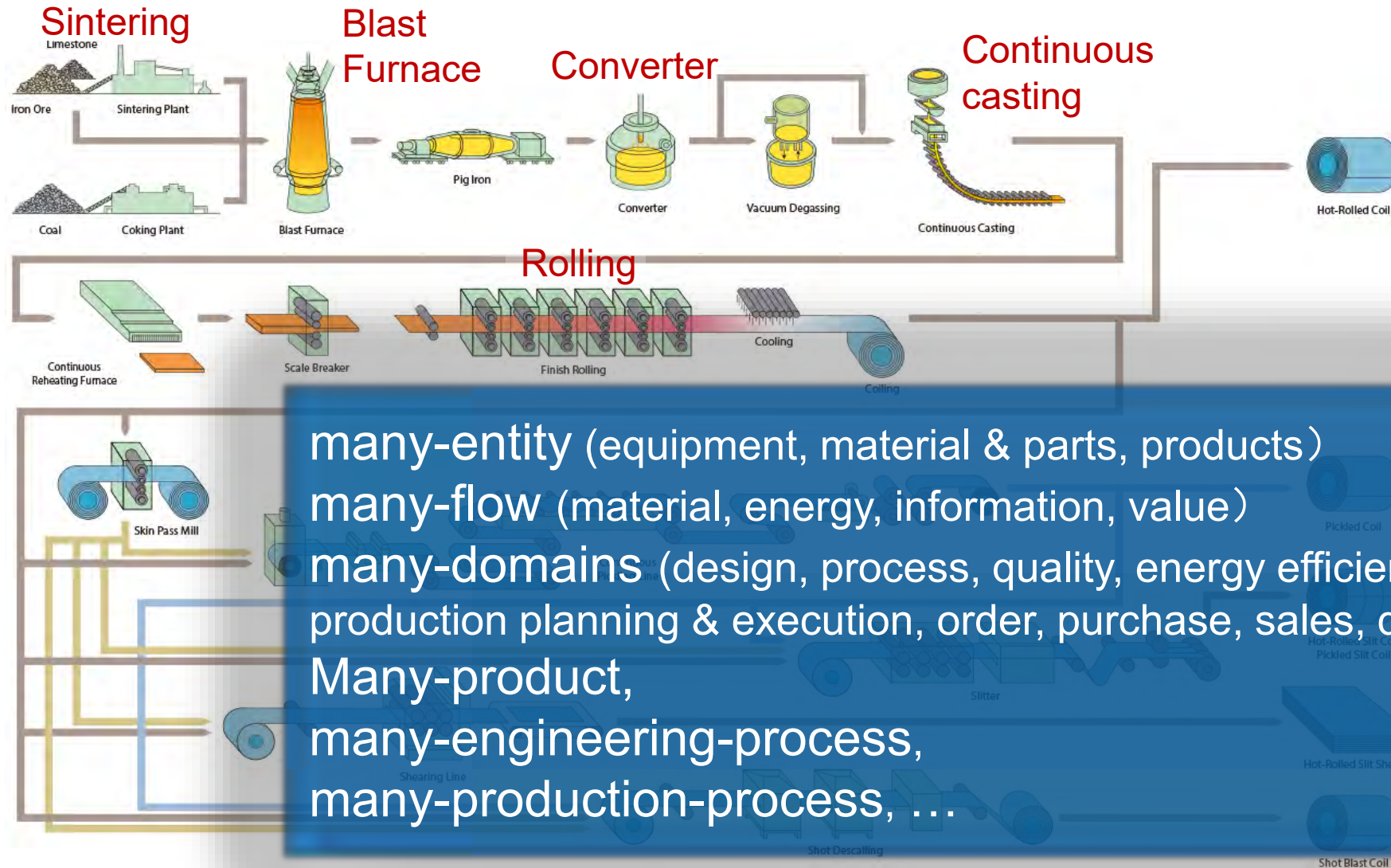
Business Processes
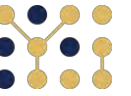
Product Design & Process Engineering

Data

Analytics

Desc	Diag
Pred	Pres

Application

Decide

Execute

Better Business Decision Making

Optimized Production Processes

Material · Equipment · Processes · Product · People

Desc: Describe
Diag: Diagnose
Pred: Predict
Pres: Prescribe

Top IIoT Use Cases

Use Case	Percentage
Remote monitoring	28%
Energy efficiency	27%
Asset reliability	25%
Business model transformation, e.g. selling capacity instead of products	24%
Production visibility	22%
Quality improvement	22%
Asset and material tracking	17%
Internet enabled products	15%
Traceability and serialization	13%
Customer access to information	8%
Improving safety	6%
Supplier visibility	6%
Improving environmental performance	4%

Production Process – Complex Processes

Production Systems - Complex Systems
Production Process – Complex Processes

Sintering — Limestone, Iron Ore, Sintering Plant, Coal, Coking Plant

Blast Furnace — Blast Furnace, Pig Iron

Converter — Converter, Vacuum Degassing

Continuous casting — Continuous Casting

Hot-Rolled Coil

Rolling — Continuous Reheating Furnace, Scale Breaker, Finish Rolling, Cooling, Coiling

Skin Pass Mill, Pickled Coil, Hot-Rolled Slit Coil, Pickled Slit Coil, Slitter, Hot-Rolled Slit Sheet, Shearing Line, Shot Descaling, Shot Blast Coil

many-entity (equipment, material & parts, products）
many-flow (material, energy, information, value）
many-domains (design, process, quality, energy efficiency, maintenance, production planning & execution, order, purchase, sales, delivery, service, …)
Many-product,
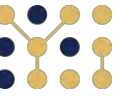many-engineering-process,
many-production-process, …

Manufacturing Information System Architecture Evolution
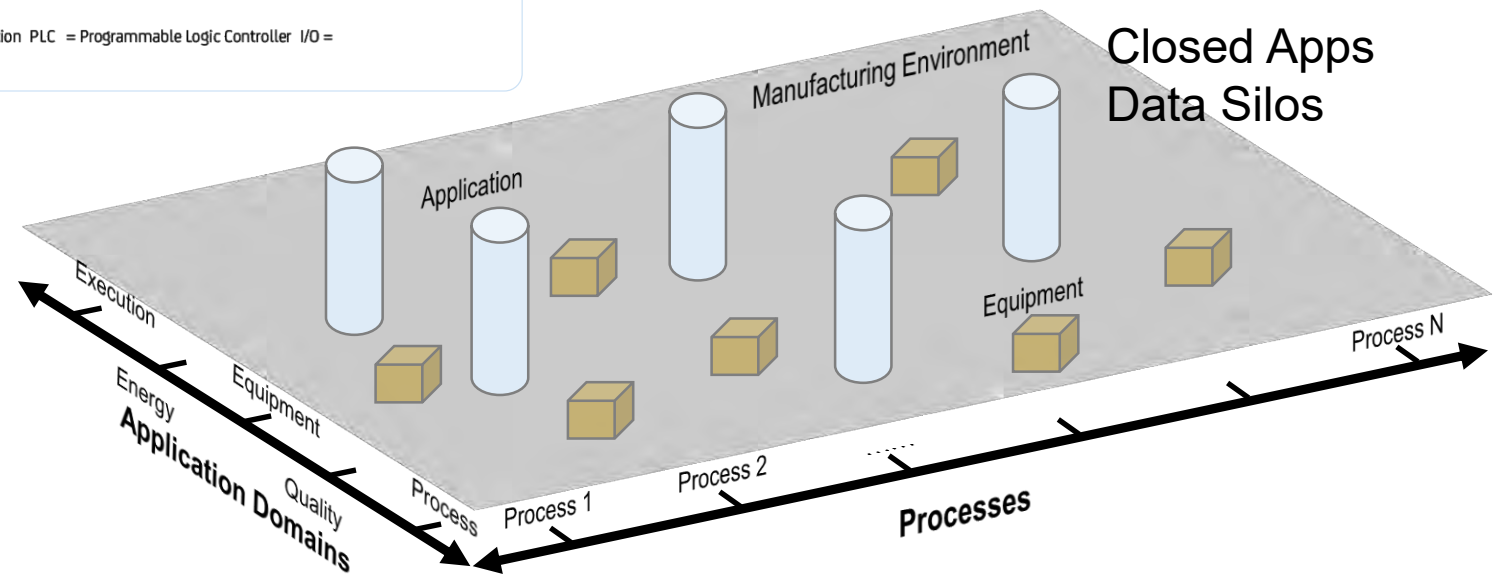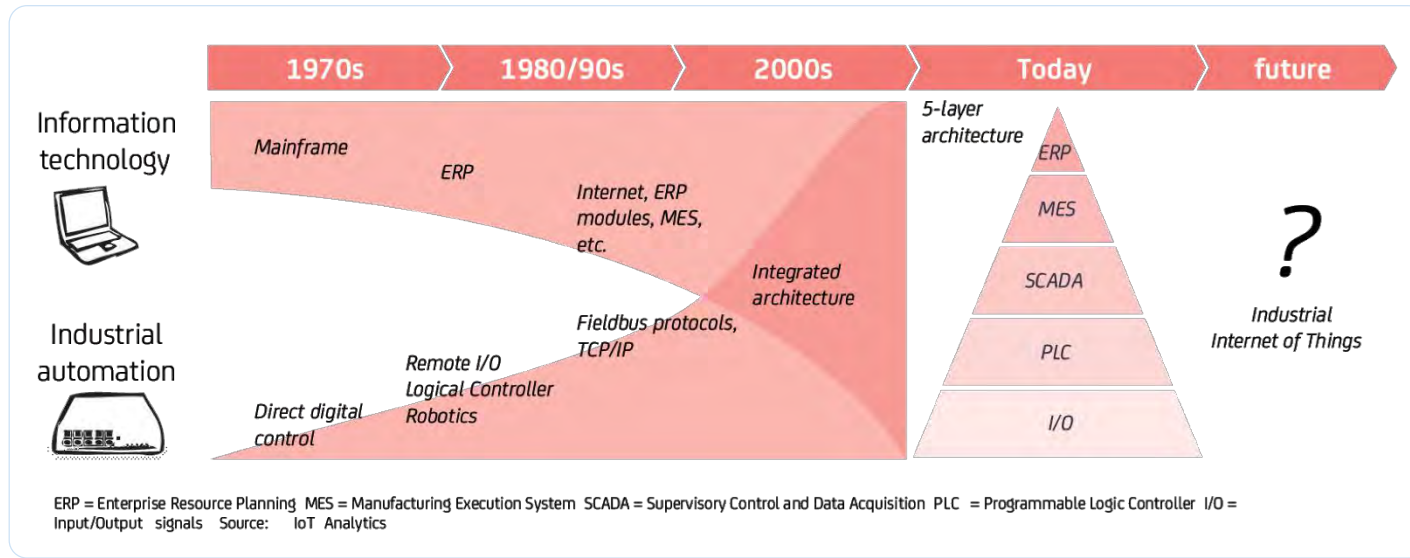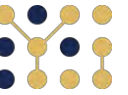
- Hierarchical layered structure,

- large, monolith, complex integrated multi-functional applications
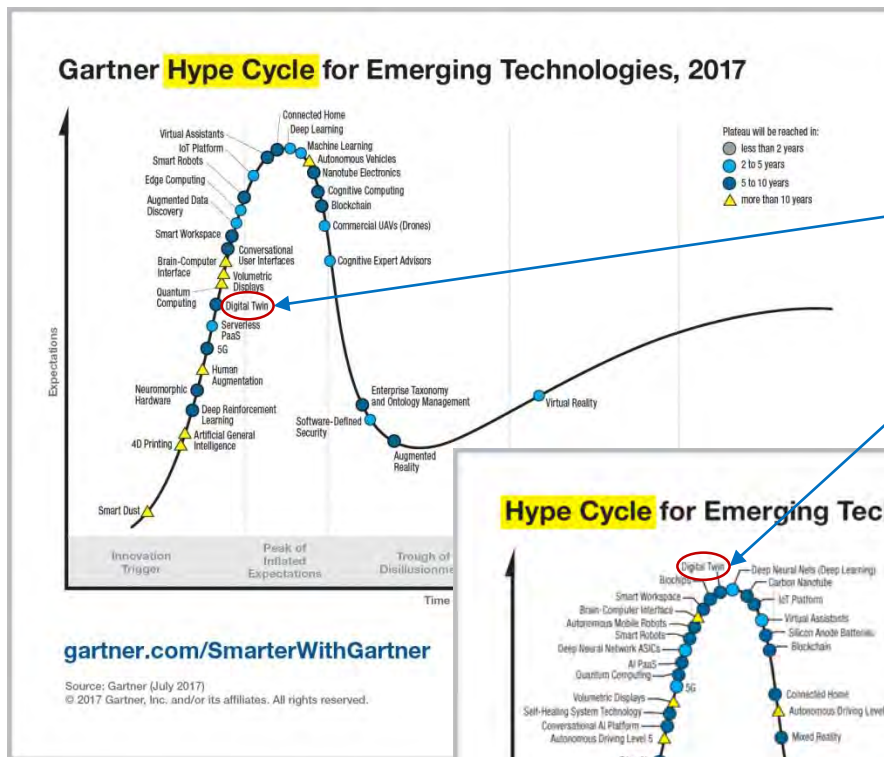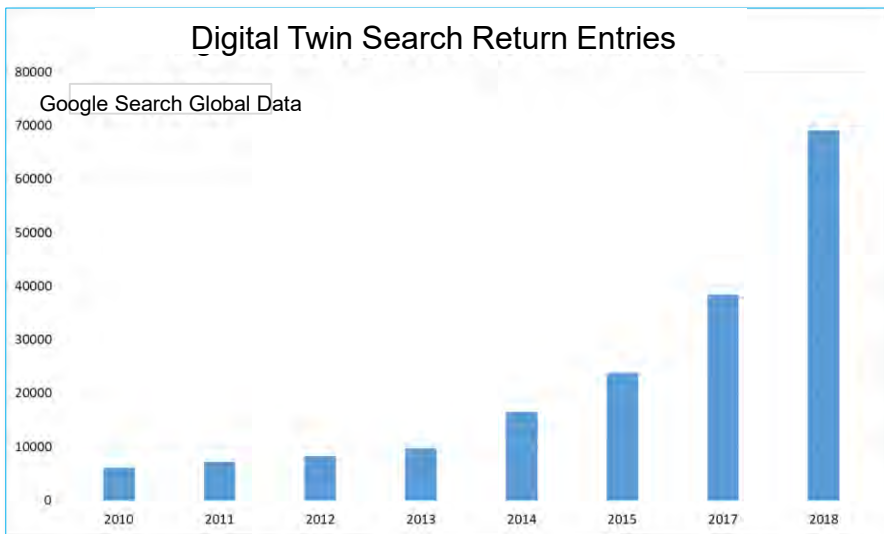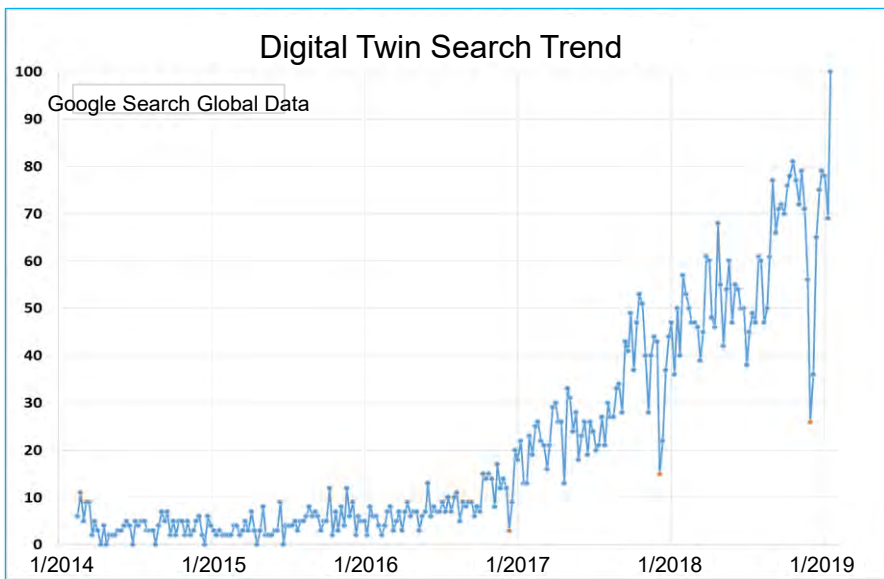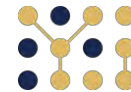
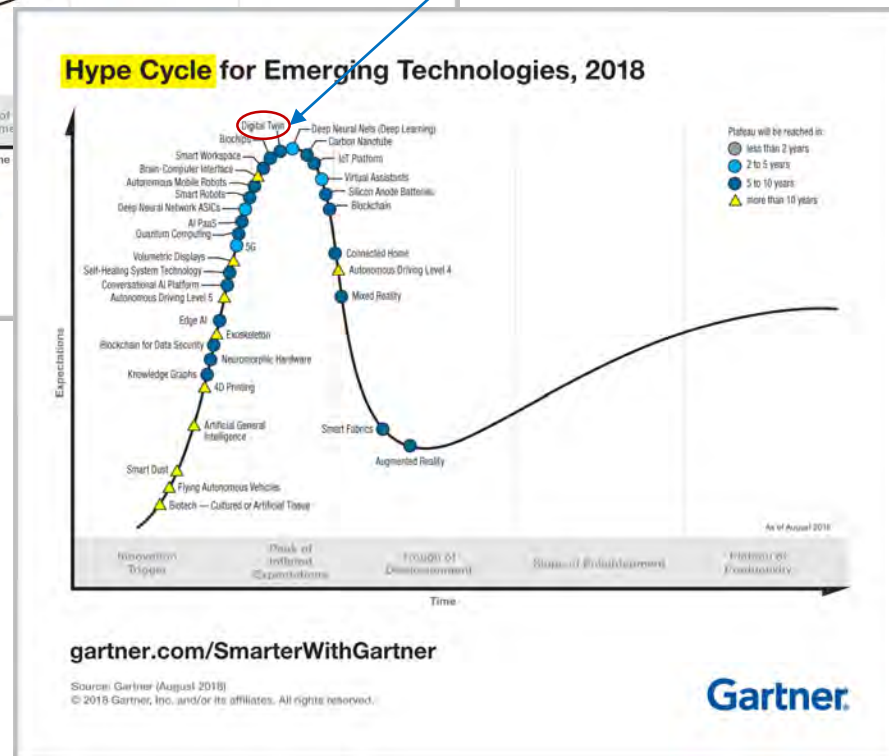- Hard to interoperate & extend, barrier to innovation

Industrial Internet – Increasing Model Complexity

Depth of Analytics

Prescriptive

Predictive

Diagnostic

Descriptive

Model Complexity

Breath of Analytics

Equip   Prod. Line   Workshop   Factory   Enterprise

Maintenance   Production Process   Business Process
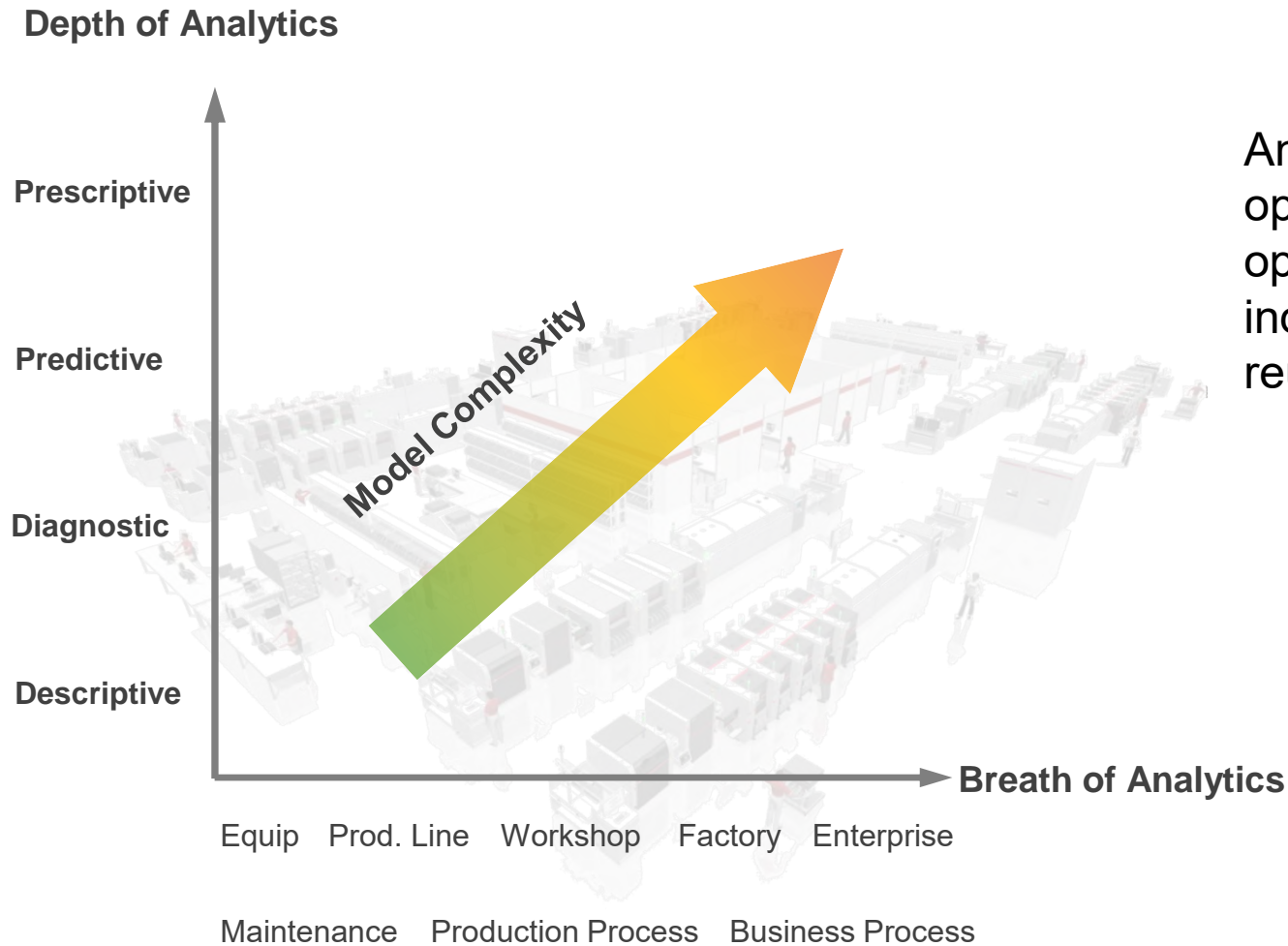
Analytic model is at the core of optimization capturing operational technologies and industrial know-hows, & enabling reuse.
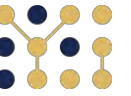
Calling for a new & systematic approach…

TM
优也 Yo-i

The Hype about Digital Twin

Digital Twin Search Trend

Google Search Global Data

Digital Twin Search Return Entries

Google Search Global Data

Gartner **Hype Cycle** for Emerging Technologies, 2017

Digital Twin

gartner.com/SmarterWithGartner

Source: Gartner (July 2017)
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Hype Cycle for Emerging Technologies, 2018

gartner.com/SmarterWithGartner

Source: Gartner (August 2018)
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Gartner

Digital Twin - Characteristics

The digital & real-world twins born, grow together…

Digital Twin

What is it：A full lifecycle dynamic digital replica of a physical or logical object in the real world.

What does it do：Describe, simulate and predict the state and behavior of its real world twin based on analytics on historical and real time data.

What is it for：deep understand, correct deduction and precise operation of its real-world twin.

Engines, navigation systems, landing gear, aircraft, runways, weather, flight control systems...

Valves, machine tools, production lines, workshops, factories...

Production process, organization, logistics process, management process...

Real World

Sensing

Data

Dynamic, Real time, Bi-Directional Connection

Commands

Real Twin

Computation

Digital World
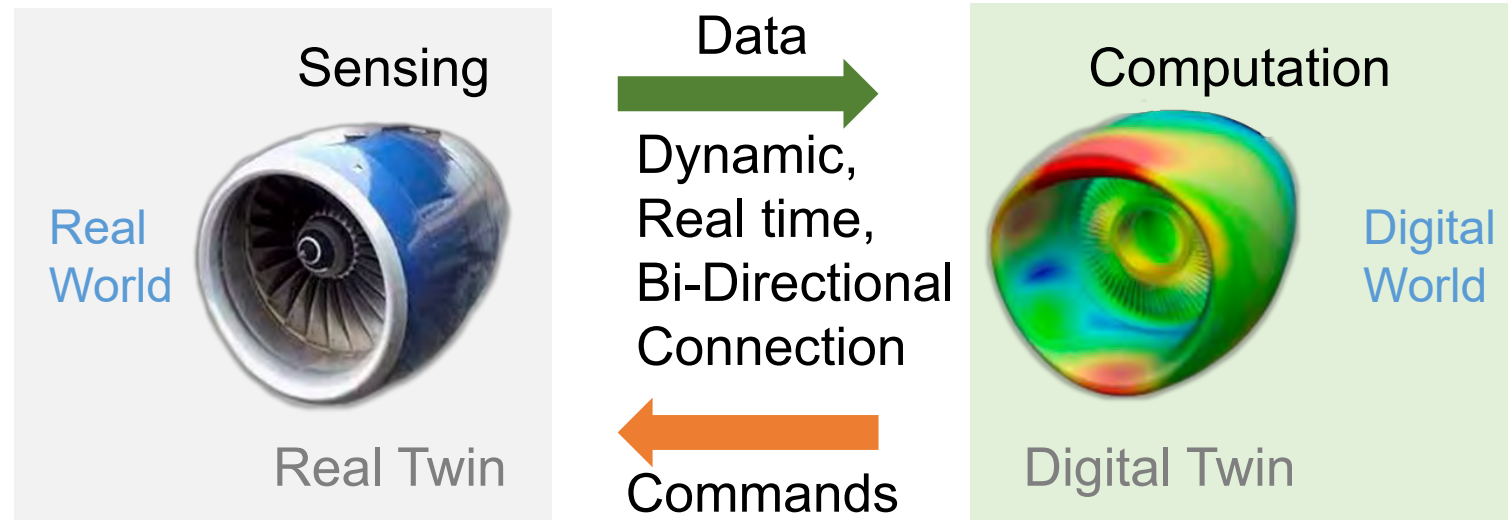
Digital Twin

A systematic way for building the digital world ground-up
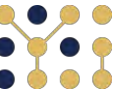
Digital Twin – Core Elements

Descriptive	Diagnostic	Predictive	Prescriptive	Visualization	AR

Design
Specifications, models, process and engineering data

Production
Human, machine, material, method, quality data

Operation
Real-time & historical status & configuration data, maintenance records

Business
Transaction records

Data

Service

Model

1st Principle
Physics, Chemistry, Engineering, Simulation...

Data
Statistical, Machine learning/Artificial Intelligence…

Visualization
3D Models…

AR
Augmented Reality

Digital Twin

A systematic approach to represent complex real world systems in the digital space

Service API

int invoke(x1,x2,…)

Data

1001 1100
1011 1010

T_H Q_H Q_C T_C
W

Models
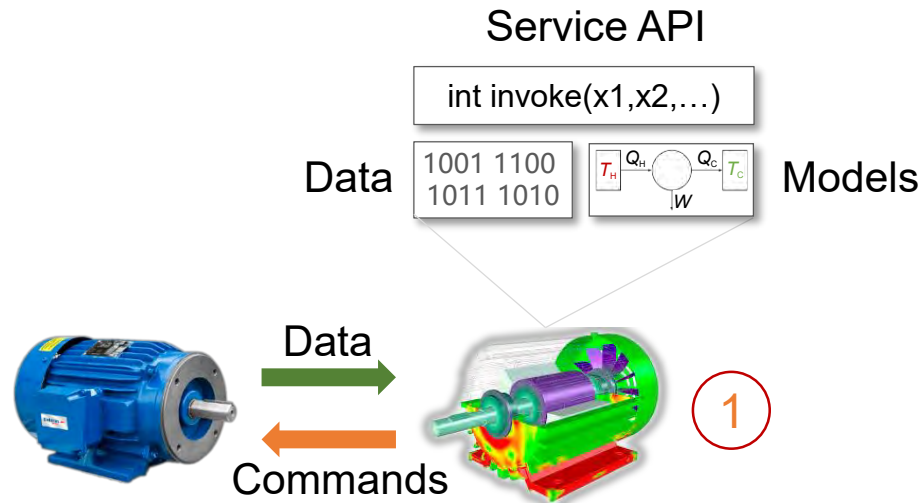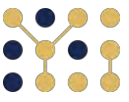
Common internal construct & interaction interface

②

Data →

← Commands

①

Component → Equipment →
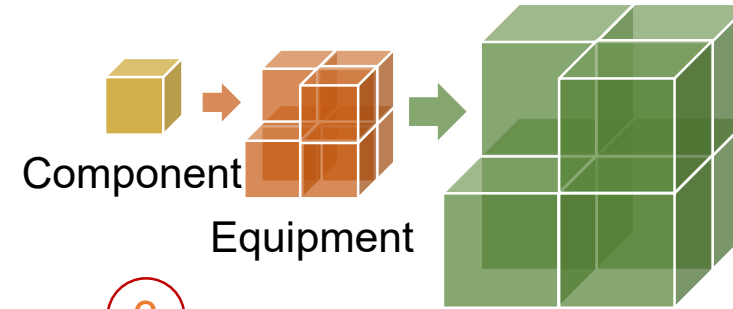
③

Line, Workshop, Factory, Enterprise, …, World

Real Twin

Digital Twin

Commands ←

Data →

Smart
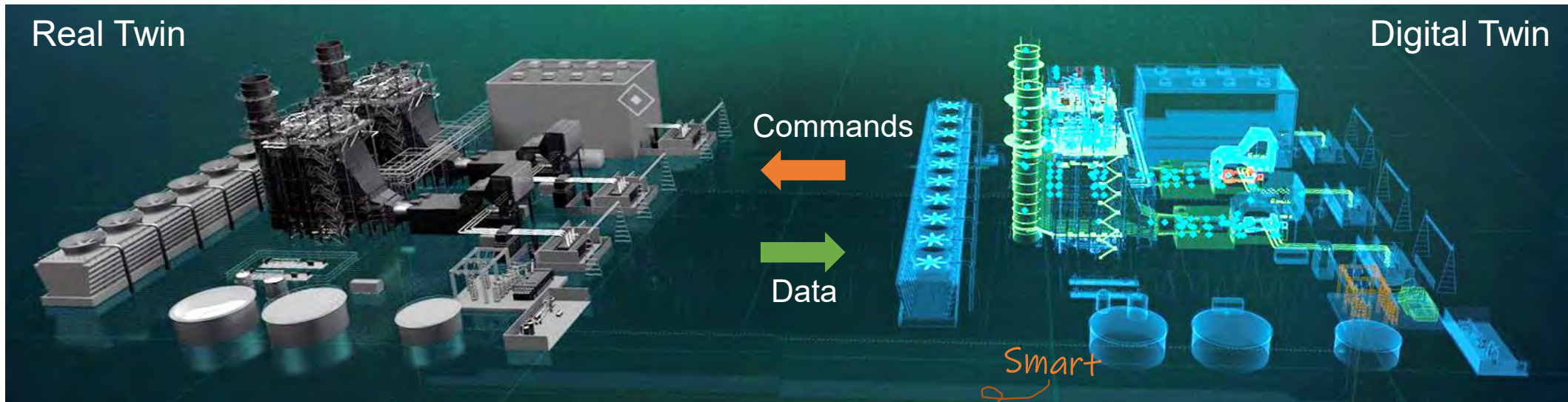
A multi-level digital twin system forms the basis for intelligent operations of the physical world.

Industrial Data OS (iDOS) – Refactored, Horizontalized, Decoupled Architecture

- based on Industrial Internet

Vertical App

Platform + APP

Functional Decoupling

Abstract Common Functions

Platform-ized Reuse

APP
Digital Twin
Model
Data
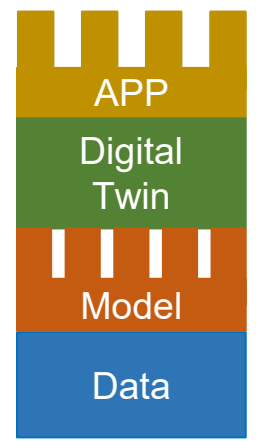
Runs many Apps

Describe complex systems

Run many models

Collect all the Data

Yo-I Thingswise iDOS
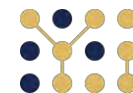
APP

Unified App DevOp Framework

Unified Digital Twin Framework

Unified Model Framework

Unified Data Framework

Asset, Process, Business Data

PLC、SCADA、DCS、PCS、MES、ERP、……

Business Logic

System Logic

Natural Logic

Data Logic
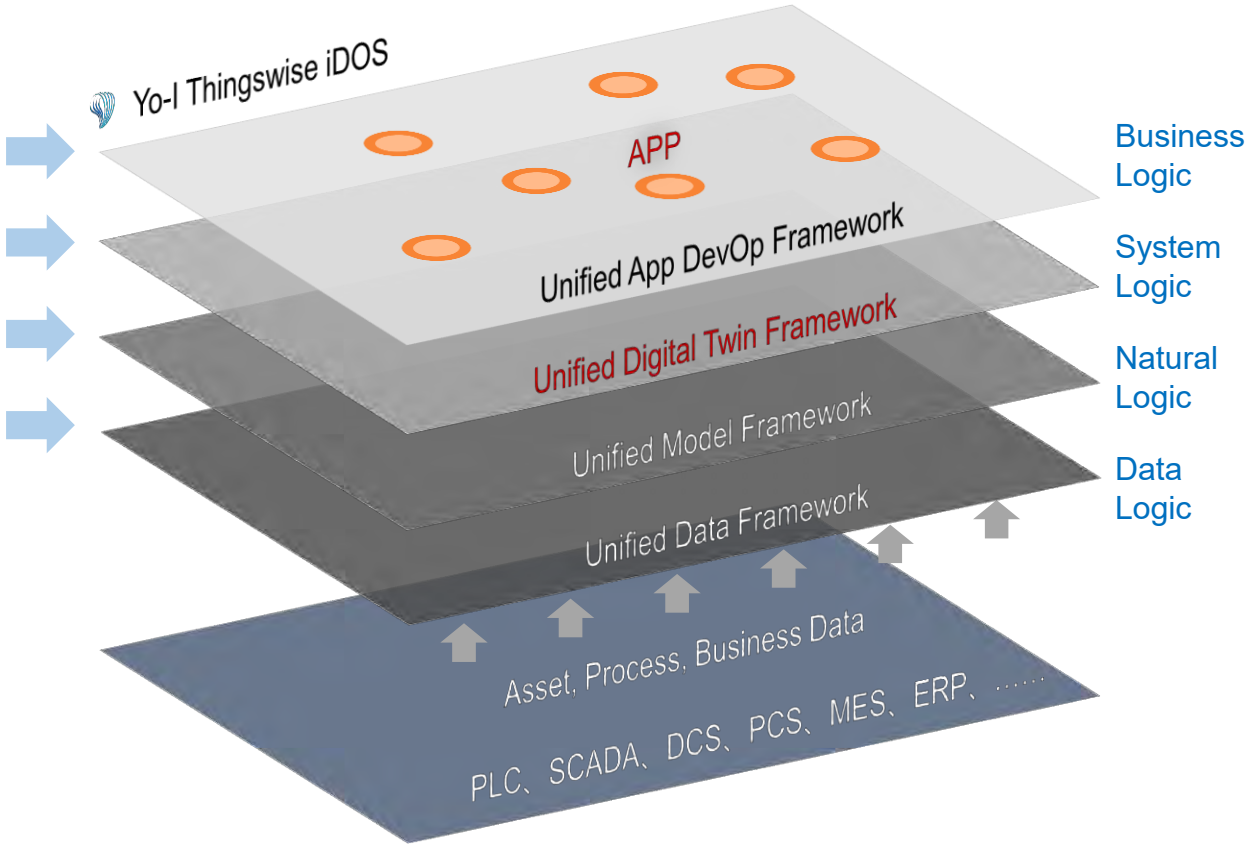
Methodology：Abstraction and Simplification – Systematically solving complex problems

Bring cloud computing, machine learning & big data technologies to the production environment
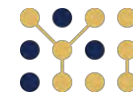
™

优也 Yo-i

Digital Twin Framework –
Symmetrically Represent the Real World in the Digital Space

Based on biz requirements
Asset Characteristics

Define Digital Twin Classes

abstract

reuse

concrete

Based real deployment
environment Configuration

Instantiate the Digit Twin Classes

call — App
Digital Twin
contain → Model
organize → Data ← use

优也Thingswise iDOS

APP

Unified App DevOp Framework

Unified Digital Twin Framework

Unified Model Framework

Unified Data Framework

Asset, Process, Business Data

PLC、SCADA、DCS、PCS、MES、ERP、......

Business Logic

System Logic

Natural Logic

Data Logic

After solving the structural complexity problem,
the models are still the core capability

Most valuable for complex systems，large systems, large number of assets, lots of data & app, in-deep analytics

Digital Twin – App Development

Develop APP

Software

App

Define Digital Twin Classes：
- **Define data structures**
- **Built models**
- **Define relationship**

System

Data Scientist

Industrial Domain Expert

System

Instantiate Digital Twins

Collect

Data Collection
（automation）

Connect

Insight

Digital Twin

Data

Asset

Yoi-I Thingswise iDOS

APP

Unified App DevOp Framework

Unified Digital Twin Framework

Unified Model Framework

Unified Data Framework

Asset, Process, Business Data

PLC、SCADA、DCS、PCS、MES、ERP、……

Business Logic

System Logic

Natural Logic

Data Logic

Digital Twin Configurator

Support Both Multi-level Hierarchical Digital Twin Construction & Associational Relationships
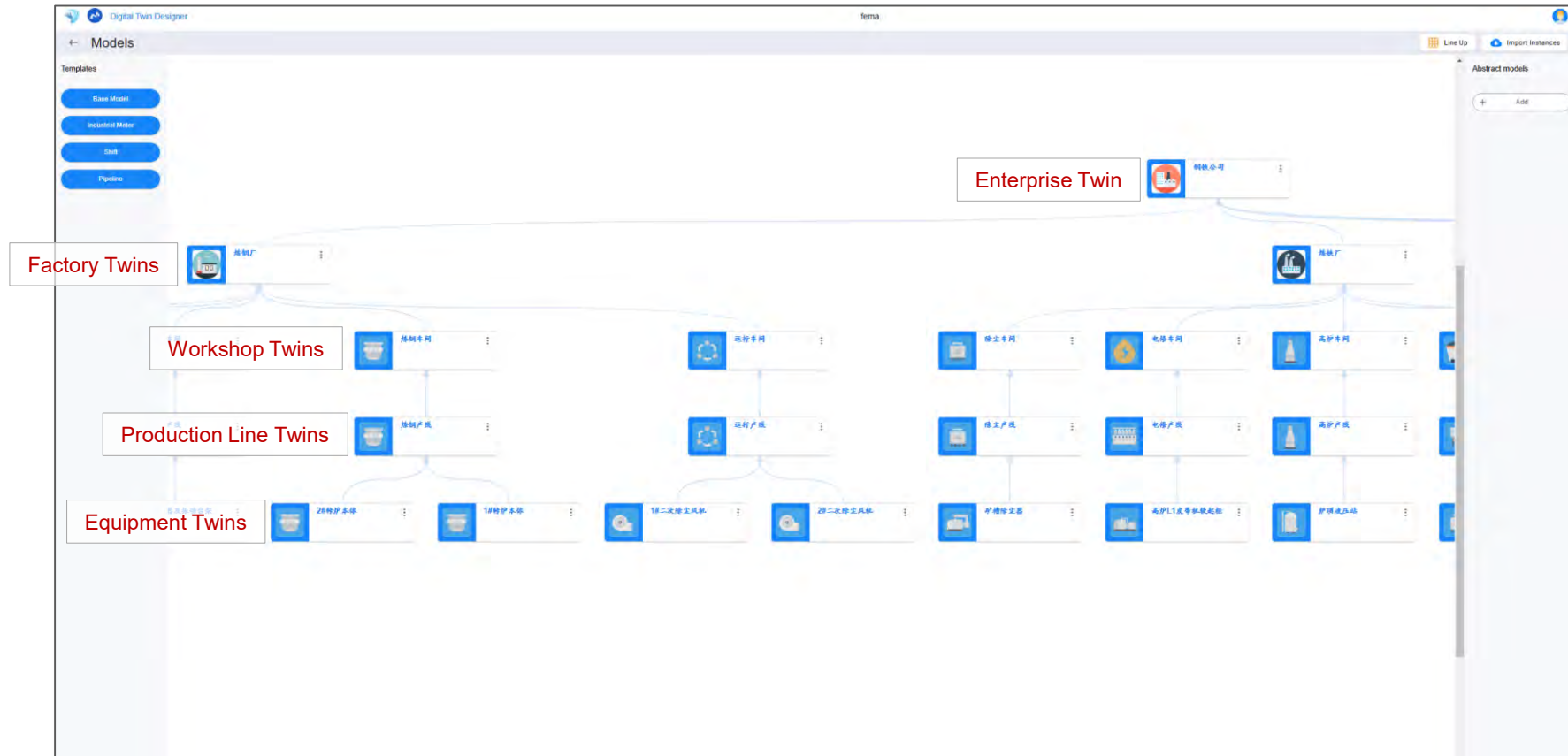
GUI-based Designing Tools

Digital Twin Designer

API Mgmt

App Designer

Data Visualization

Yo-I Thingswise iDOS

APP

Unified App DevOp Framework

Unified Digital Twin Framework

Unified Model Framework

Unified Data Framework

Data Flow Designer

Model Designer (off-line)
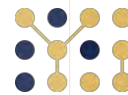
A New Architecture for Smart Industrial Apps
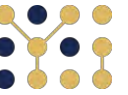
An **architectural upgrade, building a solid technical foundation for continuing digital transformation...**

Yo-i Thingswise iDOS

APP

Unified App DevOp Framework

Unified Digital Twin Framework

Unified Model Framework

Unified Data Framework

Business logic- & data-driven smart feedback loop

Supported by cloud computing, machine learning & big data technologies

One platform collect & manage all the data across production processes & application domains
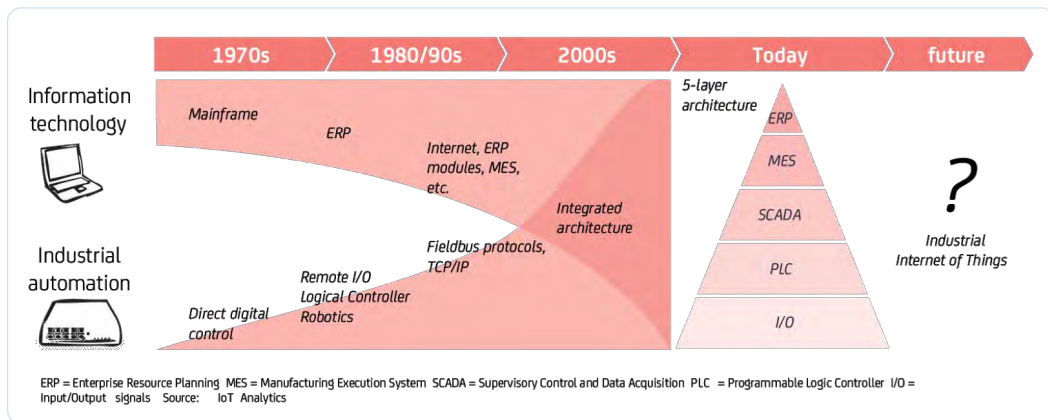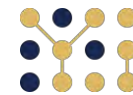
Deployable on-premise & in the cloud

An Architectural Refactoring?

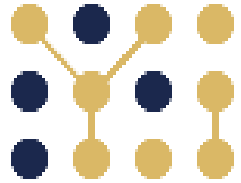vertically layered architecture ➜ horizontalized flatten app architecture
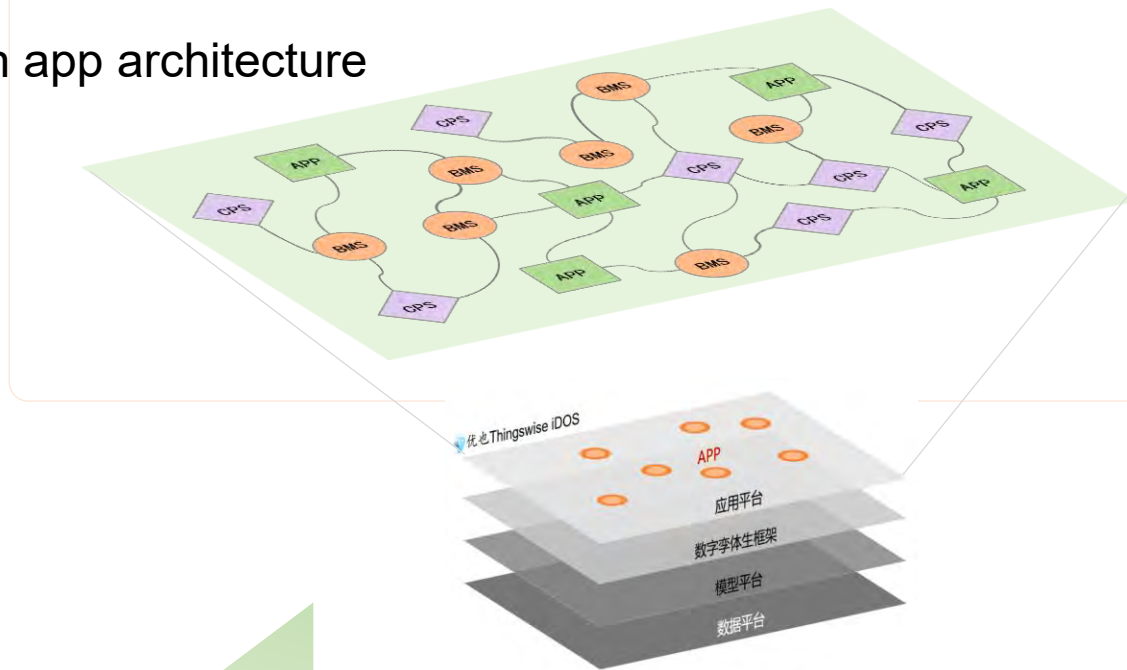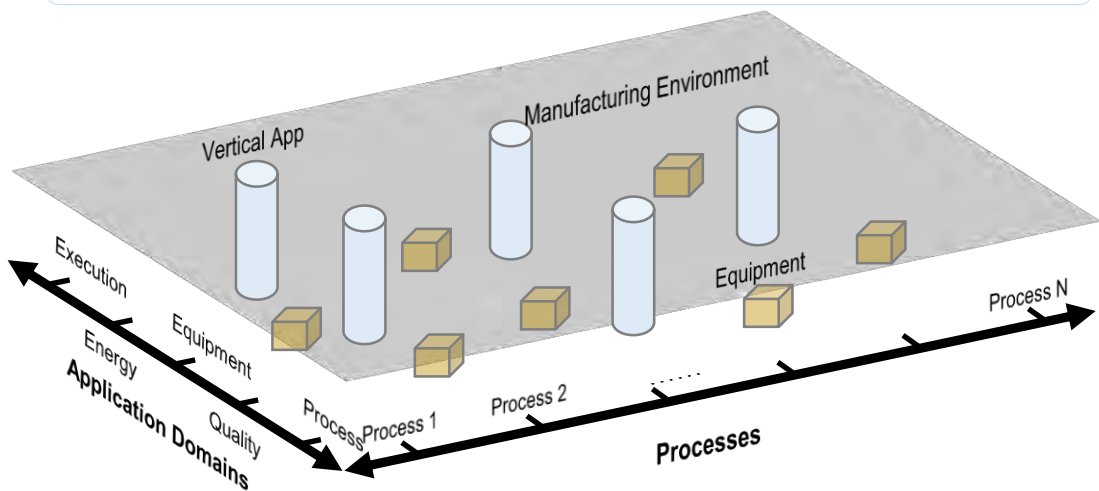
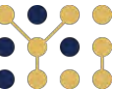# Smart Apps for the Steel Industry

Our Company – The New Yo-i

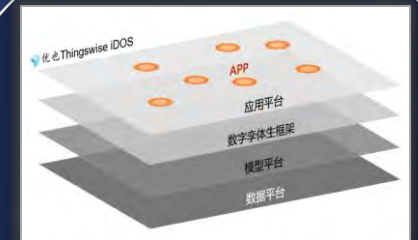A startup based in Shanghai with deep industrial operational (OT) expertise

Recently merged with Thingswise, LLC with deep industrial internet (IT) expertise

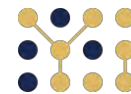**Industrial Operational Consultation**

Smart Industrial Apps Digital Twin Models

Thingswise Industrial Internet Platform

Our Business Approaches

Industrial Internet Platform
Powered by Thingswise

**Thingswise
Industrial Data OS
Digital Twin + Models**

- Unified Data, Model & App runtime
- Scalable & Reliable
- Deployable on-prem & in the clouds
- Support physical modeling & Machine Learning

Open · Enabling · Cooperative

Across Industries

Continuous Process Industry Smart Apps
Advanced by Yoi-Wise's Apps

**★-wise Smart Industrial Apps

Smart App Suites**

- Based on & solving real world problems
- Role-based operational recommendation delivery
- Extendable for solving simple to complex problems
- Built-on an unified platform expending apps across application domains

Focused · In-depth · Effective

Steel · Power Generation · Chemical · Nonferrous · Cement

Consultation, Planning & Solutions
Enabled by Yo-i Insight

**Diagnosis, Consultation & Planning
Industrial Talent Training
Total Solution Integration**

- Full process diagnostic zooming in enhancement potential & digital transformation planning
- Improve energy efficiency, asset, site, raw material, supply chain mgmt, etc.
- Organizational improvement & personnel capability training

Insight, Implement, cultivation

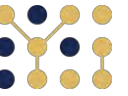**Steel · Power Generation · Chemical · Nonferrous · Cement**

Smart Apps for the Steel Industry – A Case Study

Customer: A Steel Manufacturer in Shandong, China,

- with production capacity of 3 million ton of steel
- eager to employ industrial internet technologies to increase operational efficiency
- invested in installing Thingswise iDOS Platform and data collections from large amount of assets.
- installed a number of smart apps to optimize production processes

Smart Apps for the Steel Industry

Yo-i Smart Apps for the Steel Industry

Sintering Machine Terminal Temperature Prediction & Operation Recommendation

烧结终点温度预测系统

高炉炉况分析系统

转炉吹炼导航系统

热送热装智慧监控

库存经营分析系统

能效管理驾驶舱

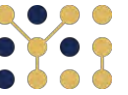**Furnace Heat Efficiency Optimization**
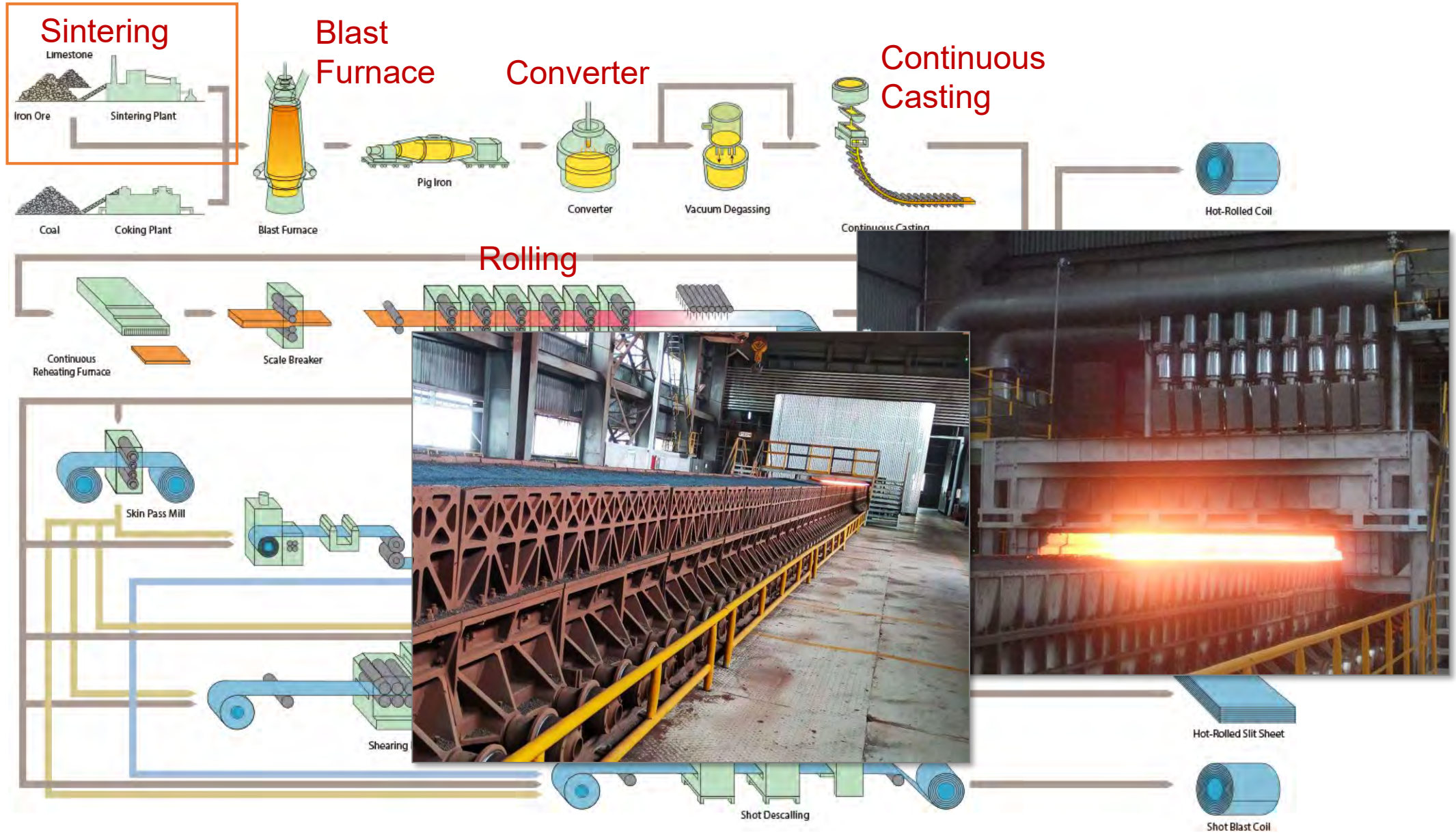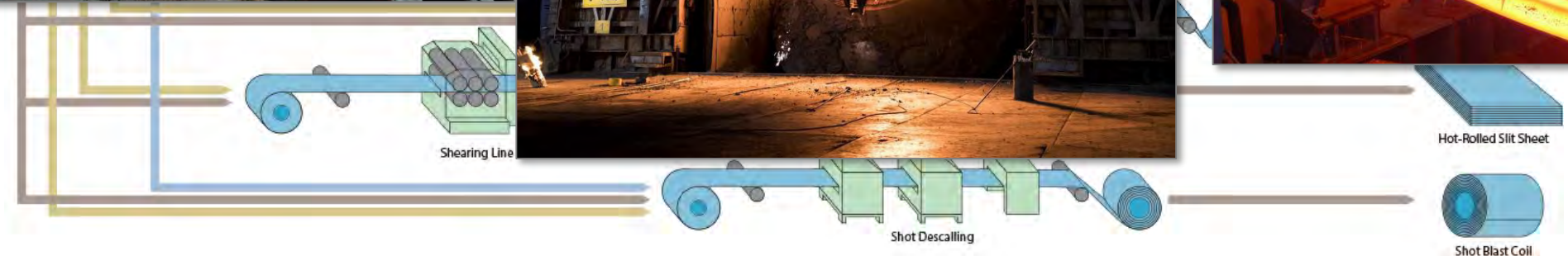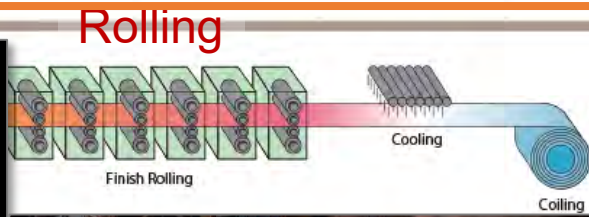
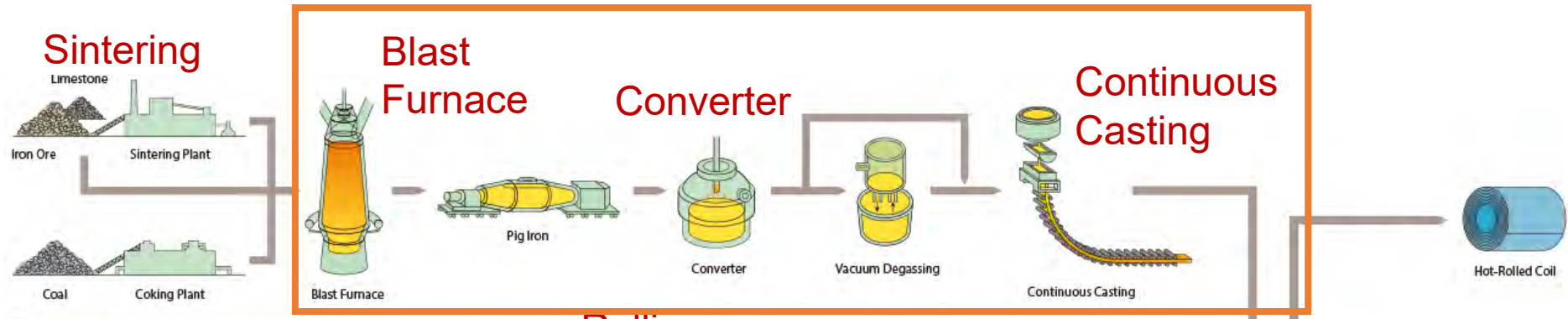锅炉热效率实时仿真平台

煤气智能平衡系统

Oxygen Pipeline Optimization

氧气智能调度系统

更多...

Sintering Process Optimization

Sintering

Blast Furnace

Converter

Continuous Casting

Rolling

Limestone
Iron Ore
Sintering Plant
Coal
Coking Plant
Blast Furnace
Pig Iron
Converter
Vacuum Degassing
Continuous Casting
Hot-Rolled Coil
Continuous Reheating Furnace
Scale Breaker
Skin Pass Mill
Shearing
Shot Descalling
Hot-Rolled Slit Sheet
Shot Blast Coil

Oxygen Supply and Demand Balancing Optimization

Sintering

Blast Furnace

Converter

Continuous Casting

Rolling

Limestone

Iron Ore

Sintering Plant

Coal

Coking Plant

Pig Iron

Blast Furnace

Converter

Vacuum Degassing

Continuous Casting

Hot-Rolled Coil

Finish Rolling

Cooling

Coiling

1° 转炉

Shearing Line

Shot Descalling

Hot-Rolled Slit Sheet

Shot Blast Coil

Furnace Heat Efficiency Optimization

Online Demos
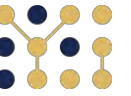
Sintering Process Optimization
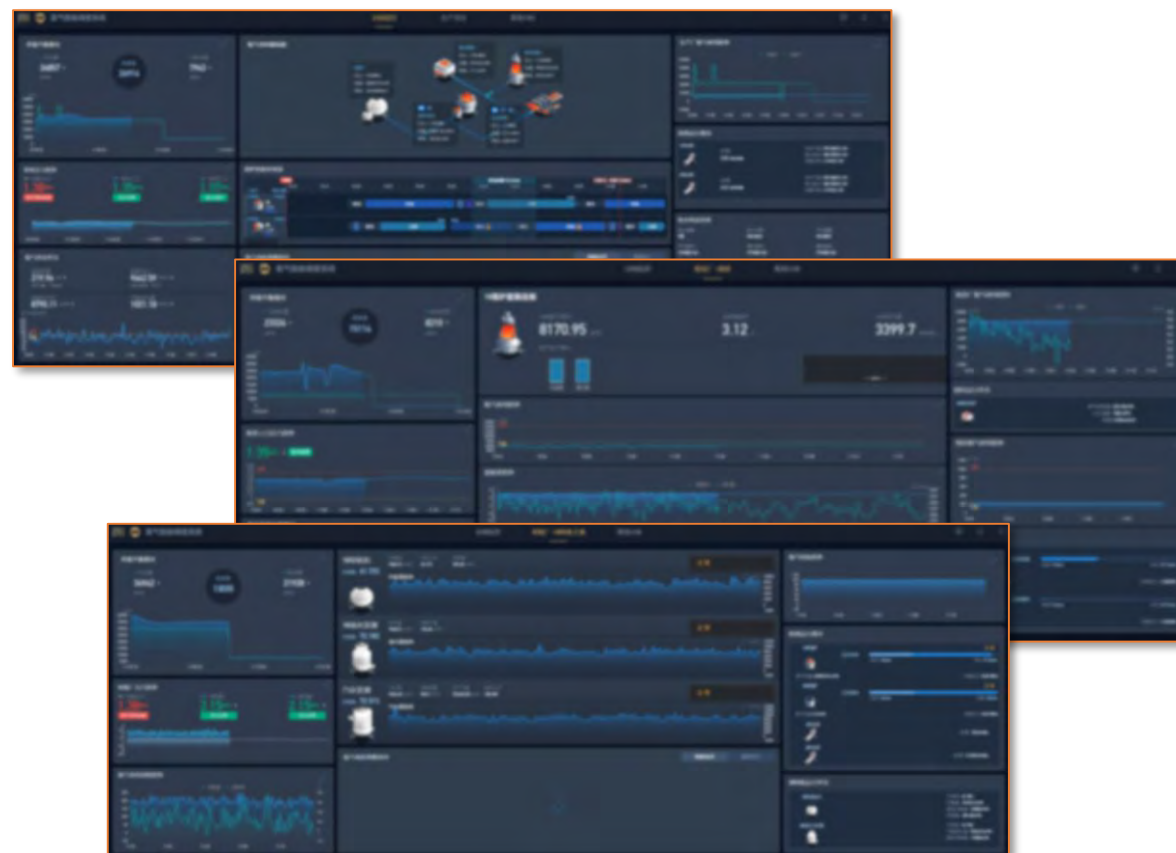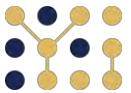
Oxygen Supply and Demand Balancing Optimization

Furnace Heat Efficiency Optimization

Learnings

- Need deep knowledge about operational/production processes to understand what the customers' needs (pain-points) are and where optimizations are most valuable and feasible (low-hanging fruits)

- Need committed customers – not only in financing the projects but also a strong willingness to adapt the workflows to the new tools and to train the operators to use them.

- After the initial installation of the solutions, it needs continuing effort to collaborate with the customers to improve them and gather new requirements.

- OT & IT convergence is not only in the customer environment but also in house– OT experts, data analytic experts and app developers (IT) need to collaborate seamlessly in order to deliver quality products

- Collecting and validating data from the large number of equipment, meters, sensors and other systems are still the most daunting tasks in the implementation

- The Industrial Internet Platform + Digital Twin Frame do greatly simplify the implementation of the solutions and provides a solid foundation for adding new solutions.

Thank You!

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