스마트제조 NIST 표준동향 및 실증사례

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National Institute of Standards & Technology (NIST)

- DOC (Dept of Commerce) 산하 표준과학기술 연구 기관
  - ~ 2,900 employees
  - ~ 2600 associates and facilities users
  - ~ 1,600 field staff in partner organizations
  - ~ 400 staff serving on 1,000 national and international standards committees
- NIST/EL/SID과 지속적 공동연구
  - 1992, FMS 개발
  - 2001-2002, Shop Floor Control 시뮬레이션 개발
  - 2008-2009, B2B 상호운용성 테스트베드 개발
  - 2015- , 스마트생산시스템을 위한 정보표준화, 인증 연구개발
    - 스마트 팩토리 대신에 스마트생산시스템 (SMS: Smart Manufacturing System) 용어 사용

PCAST AMP 2.0 보고서 (2014년10월)

- PCAST: President's Council of Advisors on Science and Technology
- AMP: Advanced Manufacturing Partnership
- 세 가지 미래혁신 생산기술 언급
  - Advanced Sensing, Control, and Platforms for Manufacturing (ASCPM) → 스마트생산시스템 도입 필요성
  - Visualization, Informatics and Digital Manufacturing Technologies (VIDM) → 빅데이터 등의 데이터 활용 필요성
  - Advanced Materials Manufacturing (AMM)
- 표준의 중요성도 언급
  - 신기술, 신제품, 제조방식의 도입 리스크 최소화
  - 서로 다른 표준이나 프로토콜 사이의 상호운용성 확보 가능

Smart Manufacturing System 정의

- 기능적 정의: Adaptive systems with differing levels of autonomy
  - Self-aware and predictive systems with the ability of diagnosis, prognosis, and optimal performance with incomplete information
- 필요 기술: Synthesis of advanced manufacturing capabilities (예, 3d printing) and digital technologies (예, IoT, Cloud computing)
- 동기
  - Product Lifecycle 측면: End-to-end development and delivery of highly customizable products faster, cheaper, better, and greener
  - Production System Lifecycle 측면: Reconfigurable, flexible, agile corresponding to demand
  - Business Cycle 측면: ERP, Scheduling, SCM 등의 autonomous synchronization
  - Enterprise/Control System Integration 측면: Integration of business systems with manufacturing systems

Smart Manufacturing Ecosystem

저작권 보호 관계로 발표 슬라이드 미제공

Product Lifecycle 표준

저작권 보호 관계로 발표 슬라이드 미제공

Production System Lifecycle 표준

저작권 보호 관계로 발표 슬라이드 미제공

Business Cycle 표준

저작권 보호 관계로 발표 슬라이드 미제공

Enterprise/Control System Integration 표준

저작권 보호 관계로 발표 슬라이드 미제공

NIST의 진행 중 Project List

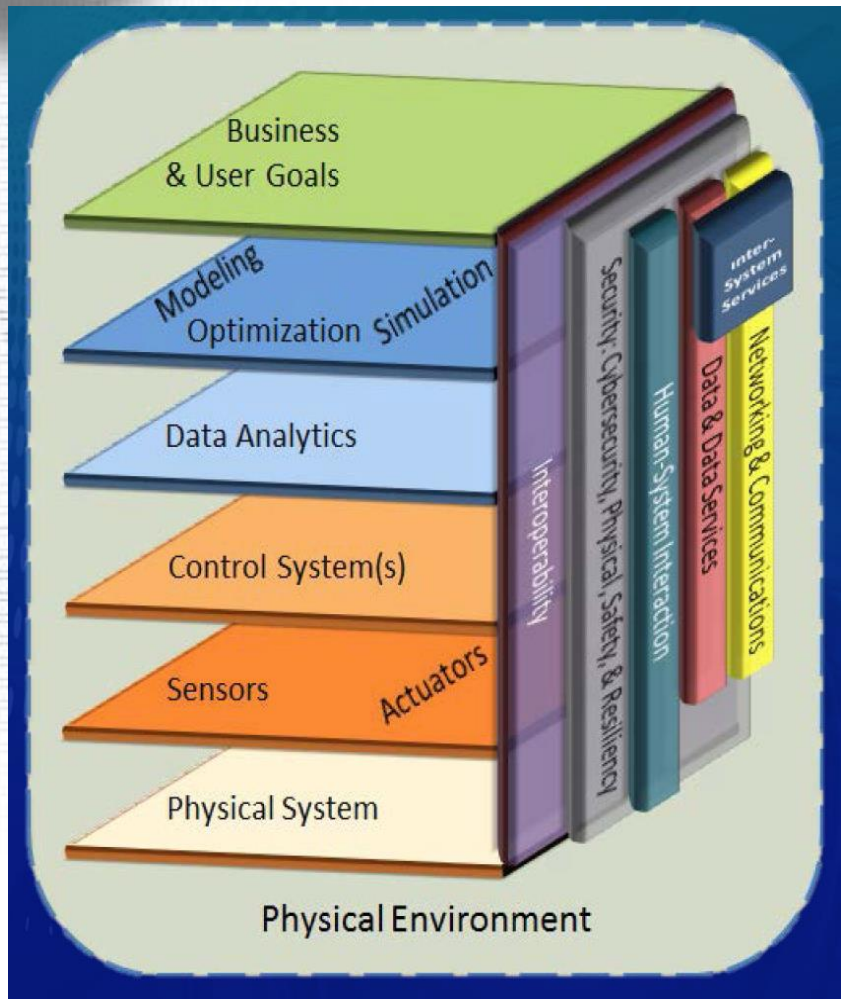
- Reference Architecture
  - A common vocabulary and taxonomy, a common (architectural) vision, and modularization and the complementary context
- Predictive Analytics
  - Diagnosis, prognosis, and optimal performance with incomplete information
- Performance Assurance
  - Performance metrics, including tools for verification and validation.
- Modeling Methodology
  - Conceptual modeling, information modeling, and behavior modeling

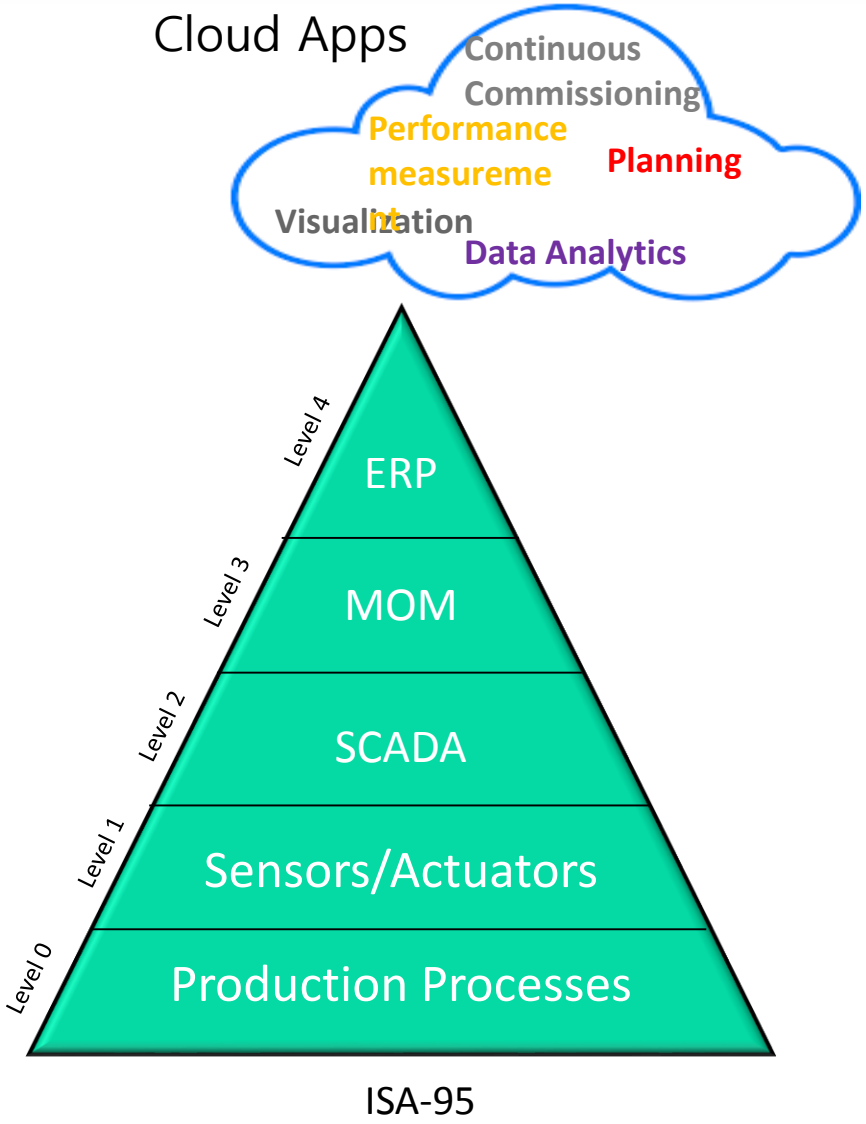
- Yearly budget
  - 2014 – 2018, 연간 약 290억원

Reference Architecture

- Objectives
  - Model-based architecture to guide the development, management, and use of composable, cloud- and on premise-based manufacturing services
  - To be used within a manufacturing services marketplace
- Standards
  - OAGi: Smart Mfg., Sem. Refinement, Virtual BOD, & Quality WGs
  - MESA: Smart Mfg, & Recipe Transformation WGs
  - ISA: 95, 88, 106 Committees
  - OPC Foundation: Unified Architecture WG, ISA WG
- Industry Interactions
  - Industry Groups: SMLC
  - OEMs: Land O' Lakes, General Mills, Boeing
  - Vendors: Oracle, iBASEt, E2open, ADP, AgGateway, Savigent Software

CPS Architecture 활용 방안

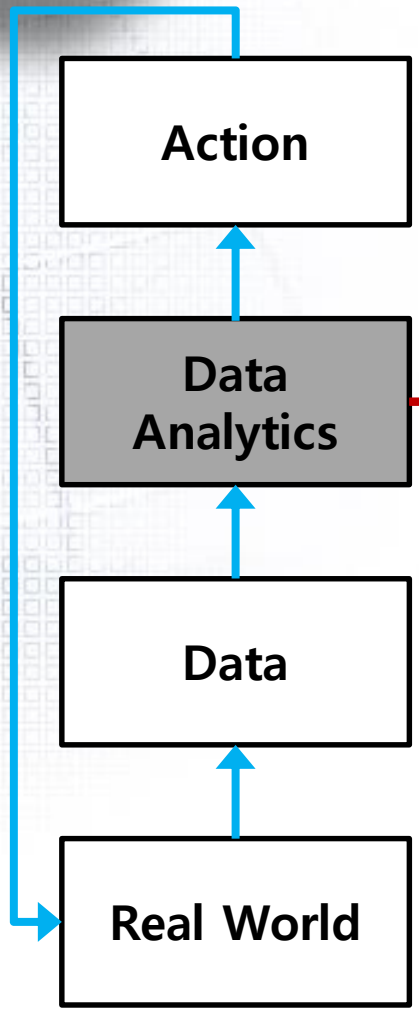




개발 일정

2014	Reference Architecture 평가 프레임워크 개발
2015	Reference Architecture 개발
2016	Reference Architecture 도입 가이드라인 개발
2017	Reference Architecture 적합성 평가방법 개발
2018	Reference Architecture 적용 및 검증

Real-time Data Analytics



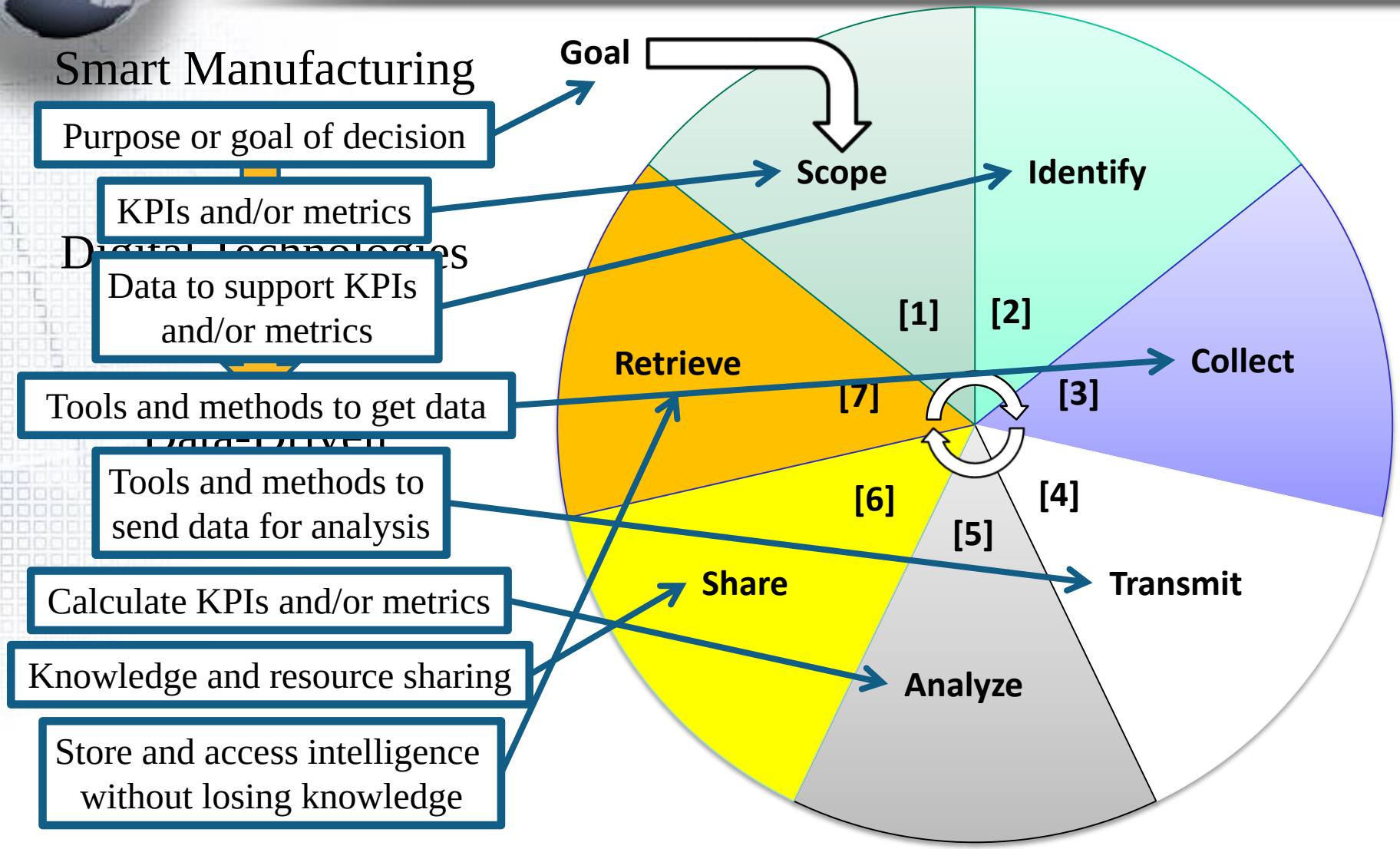
Diagnostics

What happened?
Why did it happen?
How can we solve it?

Prognostics

What will happen?
Why it will happen?
How can we make it happen?

Data-Driven Decision Making

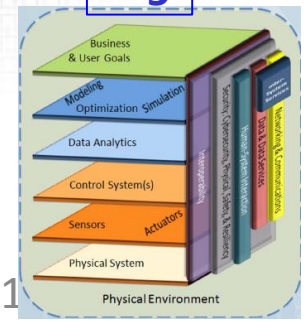


RA에 부응하는 데이터 축약

Data

Small

Big



Decision

Business and User Goals

Business Intelligence (web, desktop, mobile apps), Dynamic production system, Operations

Protocols/standards

Integration

Rules Engine, Distributed and real-time computing, Apps, APIs, Web Services

Protocols/standards

Analytics

Predictive Models, Algorithms, Analytics engine, Model composition, Uncertainty quantification

Protocols/standards

Data

Structured, multi-structured, Streaming, DAQ, Data pre-processing, Descriptive analytics

MES, MOM
SCADA, PLC, HMI, DCS

Time

Slow

Fast

개발 일정과 표준화 활동

2014	데이터 수집 및 분석 요구사항 개발
2015	Open standards and protocols 시제품 개발
2016	대표적인 표준 및 프로토콜 구현 및 검증
2017	공개 솔루션 저장소 개발
2018	적용 가능한 소프트웨어 구현

STANDARDS AND INDUSTRY INTERACTIONS
- ASME – New committee on V&V?
- DMG – Contributing Member/PMML for Manufacturing
- SISO – CMSD Standard Support Group/Chair

INDUSTRY INTERACTIONS
- Ford, Boeing, GE
- Industry partners of DMG (e.g., IBM, Zementis, and Open Data Group)

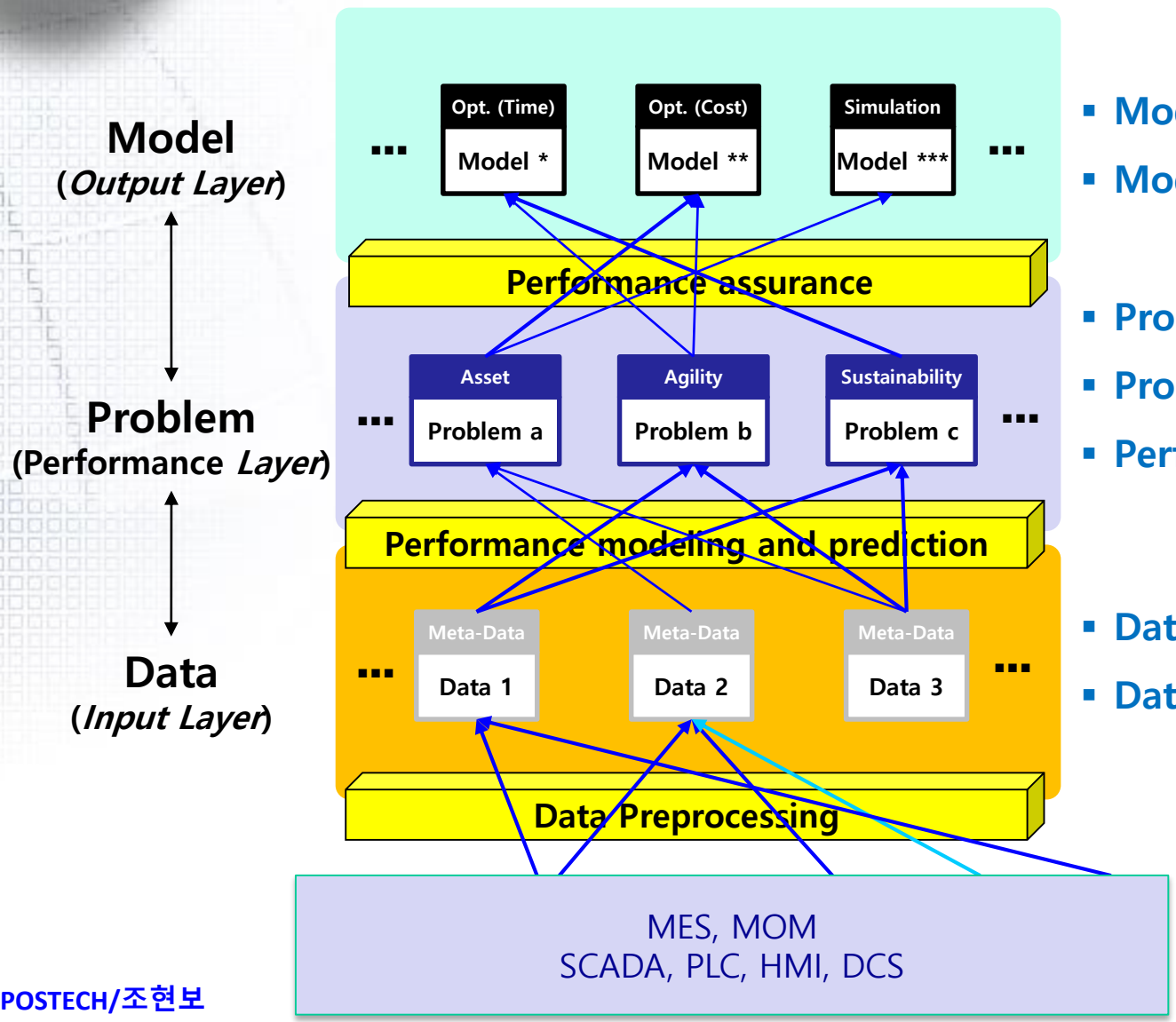
표준화 활동 계획

Explore… Cloud-based Analytics Standards?

Explore… OMG – Domain Specific Modeling?

FY		2015			2016			
Quarter		Q2	Q3	Q4	Q1	Q2	Q3	Q4
Data Mining Group	PMML	GPR Proposal Developed	Proposal submitted	Proposal reviewed	Draft version done			
	PMML			Bayesian Networks Proposal Developed	Proposal submitted	Proposal reviewed	Draft version done	
	PFA (Portable Format for Analytics)			PFA evaluated for Predictive Analytics				
ASME			V&V Sub-committee kickoff meeting held	Sub-committee established	Work with committe e for draft proposal		Proposal reviewed	First draft done

Performance Assurance



표준 항목

- Model Classification
- Model Tuning and validation
- Problem Classification
- Problem Commonalities
- Performance metrics
- Data Classification
- Data of Data (meta-data)

개발 일정과 표준화 활동

2014 Performance Failure Mode 분류

2015 Performance 측정 기준점 정의

2016 단일 시스템 Pilot 구현

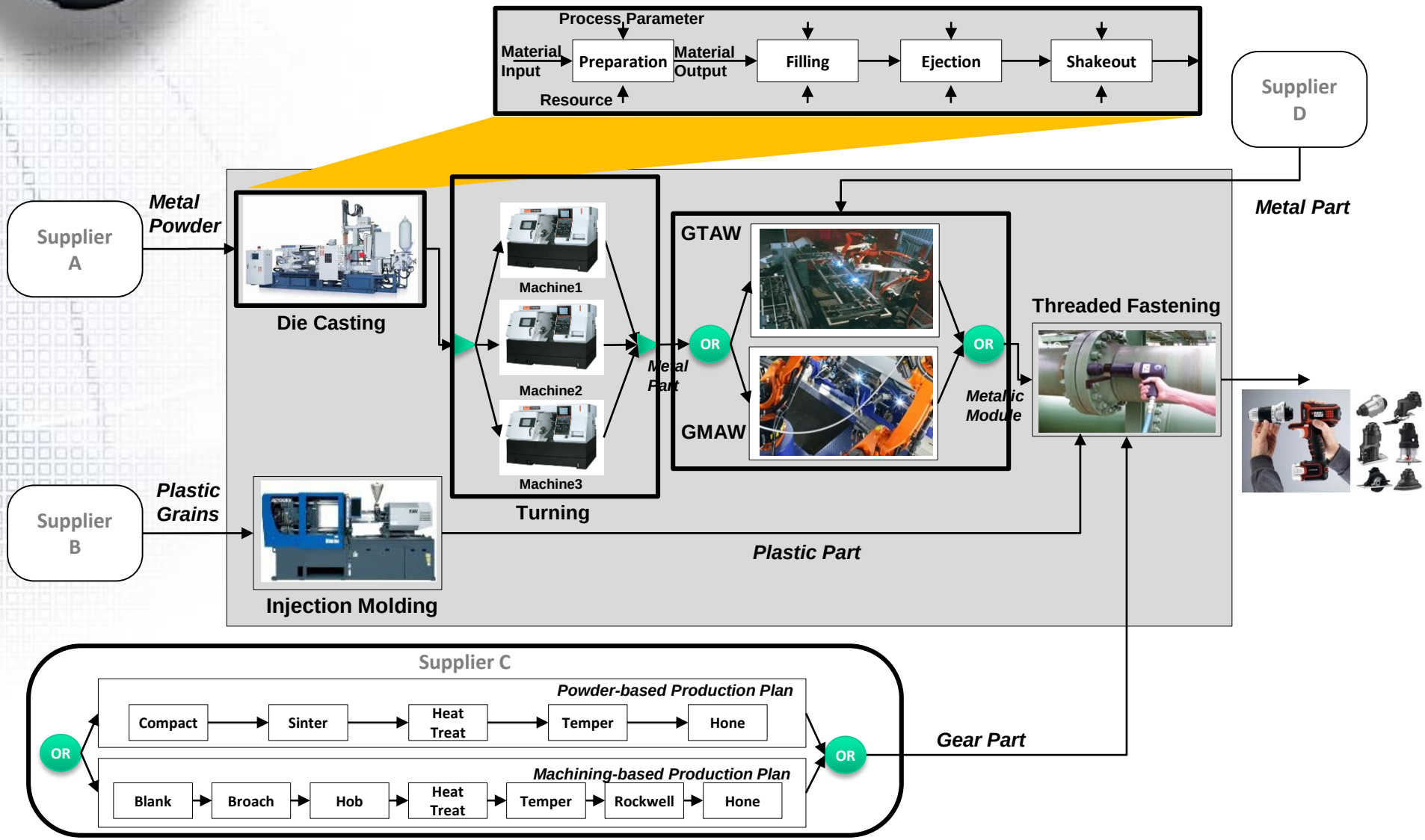
2017 복합 시스템 Pilot 구현

2018 Reference 구현

STANDARDS INTERACTIONS
- ASTM E60.13
- MTConnect
- ISO 22400
- SCOR, MESA

INDUSTRY INTERACTIONS
- Industry Groups: SMLC, DMDII
- Manufacturers: Boeing, Philips, SMEs
- Vendors: Planned through upcoming workshops

실증 시나리오


Process Parameter
Material Input
Preparation
Material Output
Filling
Ejection
Shakeout
Resource
Supplier D
Metal Part
Supplier A
Metal Powder
Die Casting
Machine1
Machine2
Machine3
Turning
Metal Part
GTAW
GMAW
OR
OR
Metallic Module
Threaded Fastening
Supplier B
Plastic Grains
Injection Molding
Plastic Part
Supplier C
Powder-based Production Plan
Compact
Sinter
Heat Treat
Temper
Hone
OR
Machining-based Production Plan
Blank
Broach
Hob
Heat Treat
Temper
Rockwell
Hone
OR
Gear Part

결론 및 시사점

- PCAST AMP 2.0의 제안에 따라 Smart Manufacturing System 개발에 5년 동안 매년 290억원의 예산으로 Reference Architecture, Data Analytics, Performance Assurance, Modeling Methodology의 네 가지 주요 프로젝트 수행 중
- 산업체와 개발업체의 요구사항을 국제표준 제정에 적극적으로 반영
- 국내 Smart Factory의 성공적인 실현을 위해서는 수요자 기반의 요구사항을 파악하여 견고한 인프라 연구개발과 국제 표준 활동이 필요해 보임
- 또한 국내 중소/중견기업의 현실을 반영한 Smart Factory Readiness Level 지표를 개발하여 점진적 도입을 위한 Transformation 전략 수립이 필요해 보임
- 보이기 식 도입이 아니라, Cost, Time, Quality, Customization, Agility, Sustainability 등의 KPI 개선 효과가 반드시 보장되어야 함