PHM FOR SMART MANUFACTURING SYSTEMS

CASE STUDIES & LESSONS LEARNED

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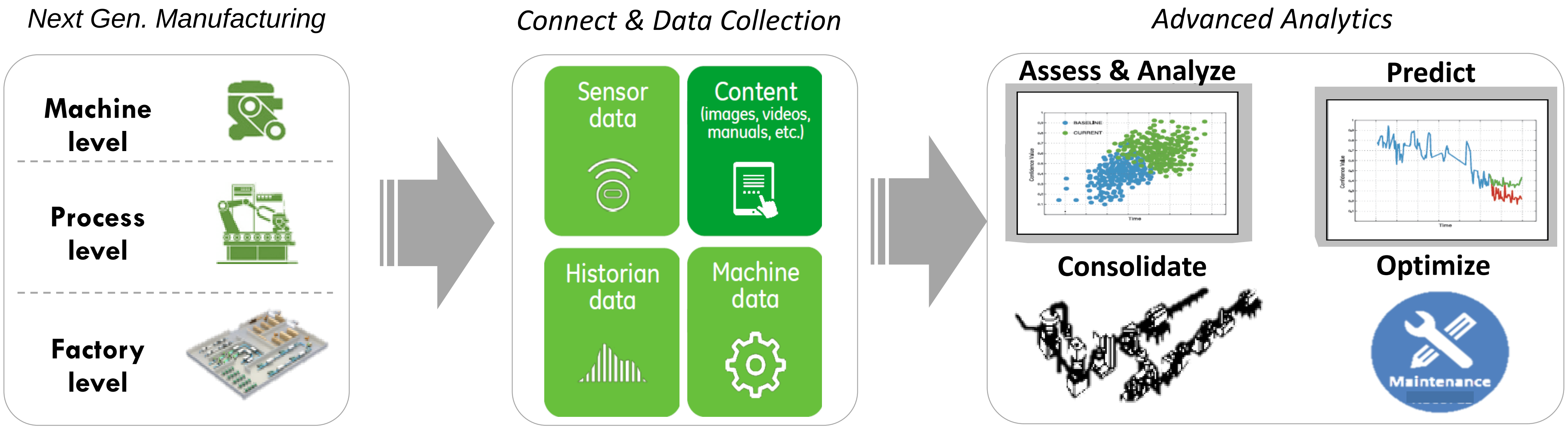
COMPELLING NEEDS OF NEXT GENERATION MANUFACTURING

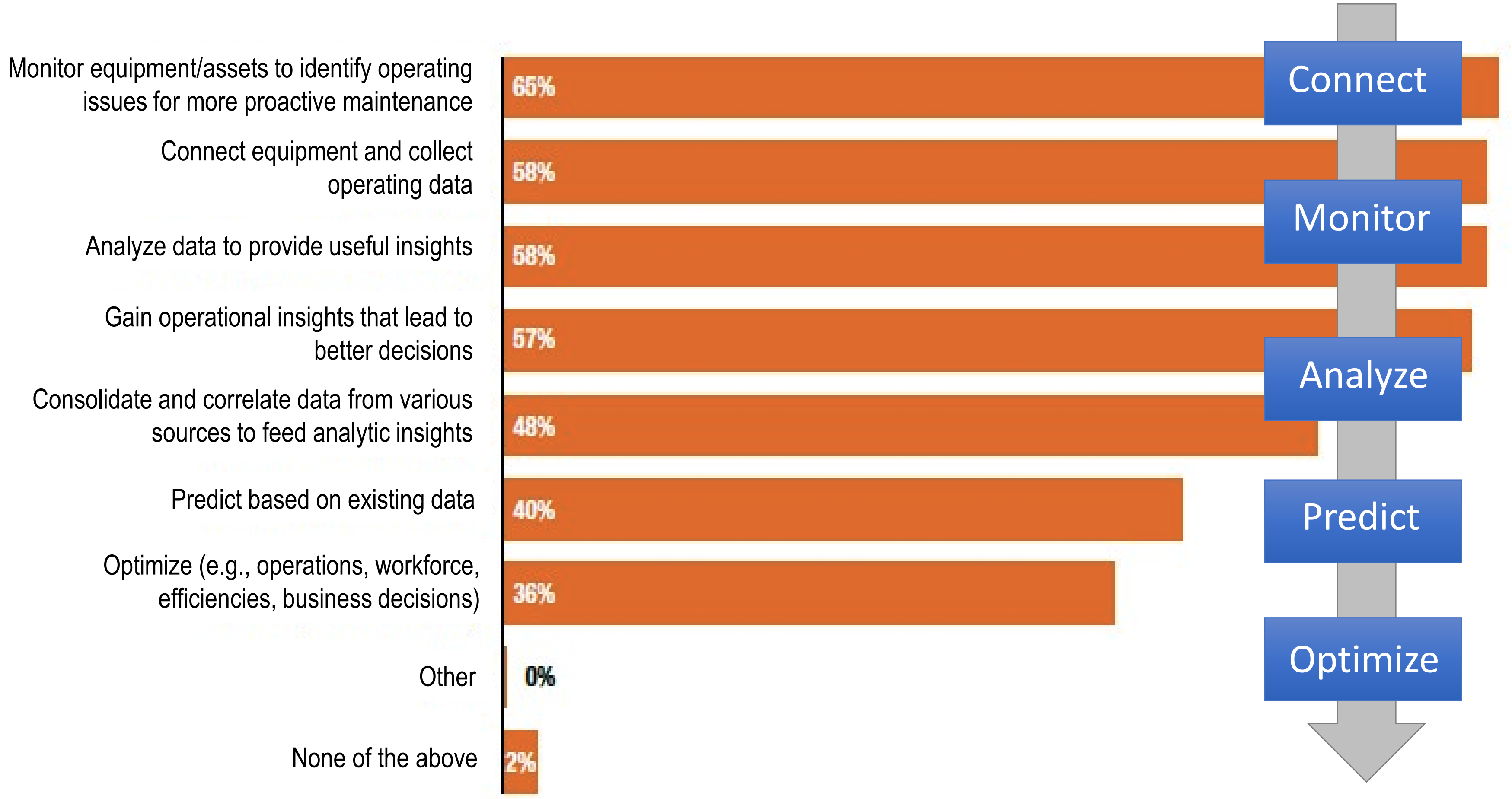


- Self-aware and predictive of equipment condition
- Resilient to uncertainties and disruptions
- Near-zero defect and downtime factory performance

- Massive and complex data
- Imperfect/missing data
- Multi-stream/multi-source data

- Greater asset reliability
- Lower operating costs
- Increased factory visibility
- Worry-free production

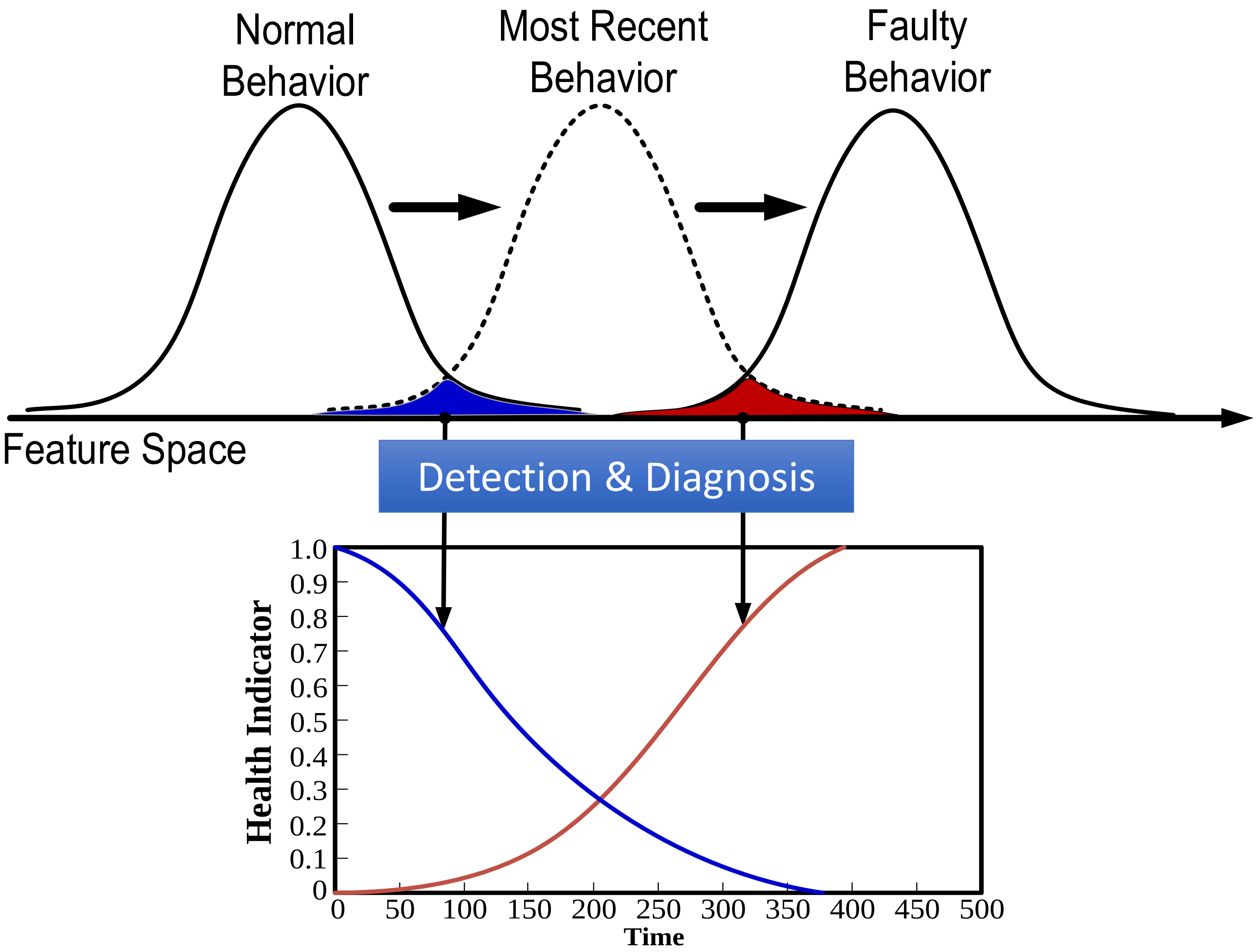
INDUSTRIAL BIG DATA ANALYTICS CAPABILITIES

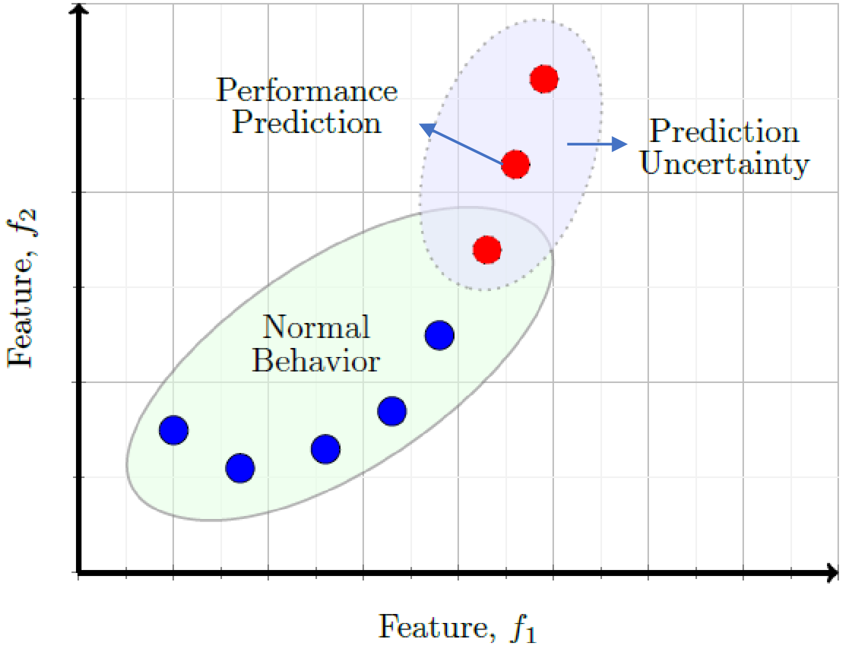


Current Data Analytics capabilities are stronger in the areas of monitoring and connecting equipment than in predicting issues and optimizing operations.

Source: GE & Accenture report (2015)

UNOBSERVABLE PERFORMANCE DEGRADATION



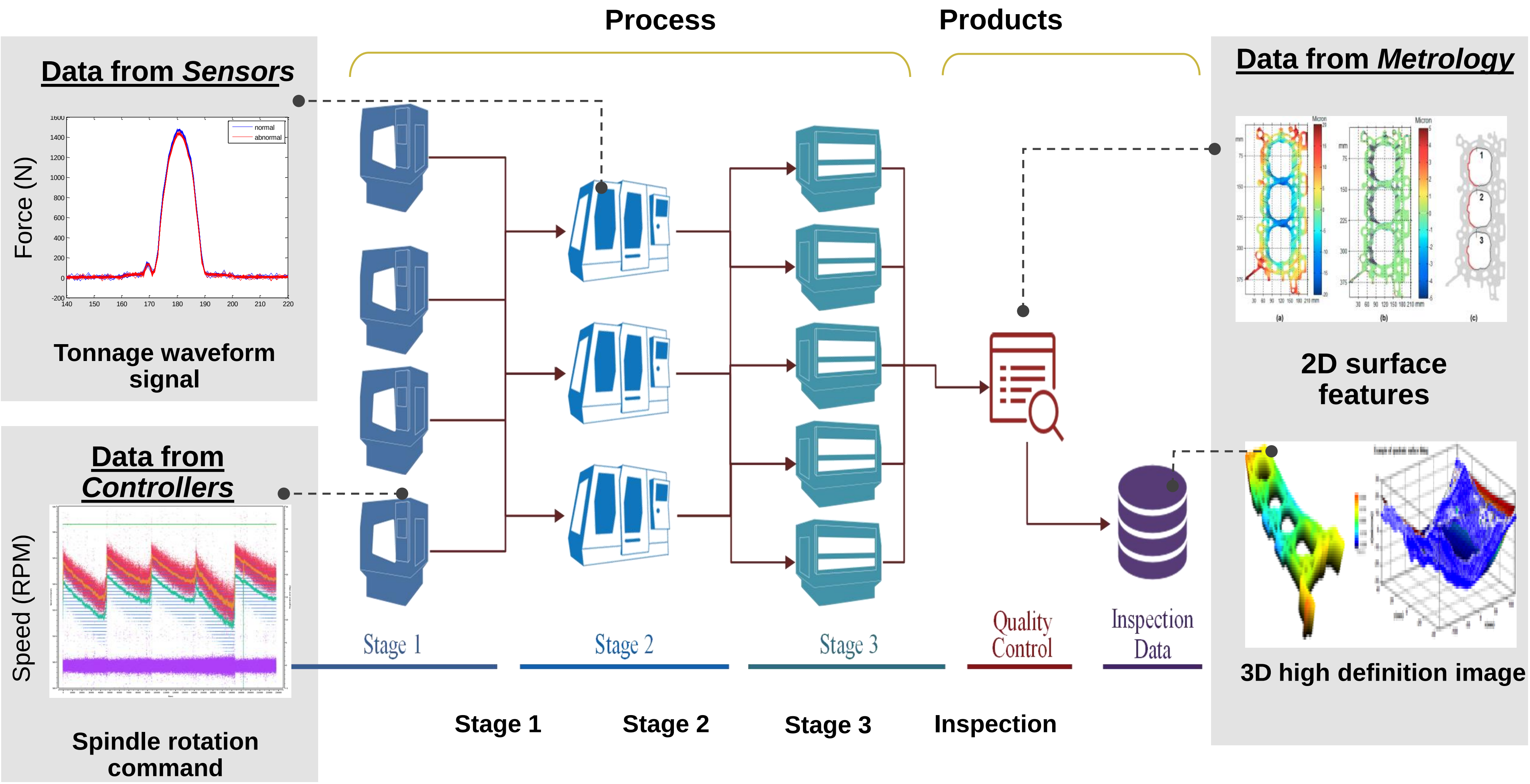


- **Model-based methods**
  - Physics-based, empirical
- **Data-driven methods**
  - Statistical, AI
- **Hybrid methods**
  - Various fusion interface

CHALLENGES & OPPORTUNITIES

- Rich Data / Sparse Data environment
- Sensor selection & allocation
- Lack of understanding degradation mechanism
- Sampling Strategy (static, dynamic, event-driven)
- Nominal condition (baseline) identification
- Variability & uncertainty quantification & control
- Physics-based or Data-driven methods fusion and interface design
- Applications: (1) discrete manufacturing (2) continuous manufacturing

MULTISTAGE DISCRETE MANUFACTURING SYSTEMS

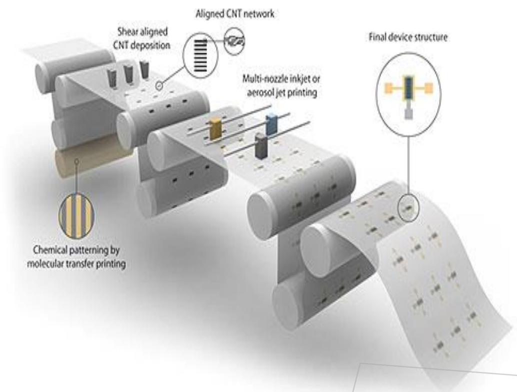


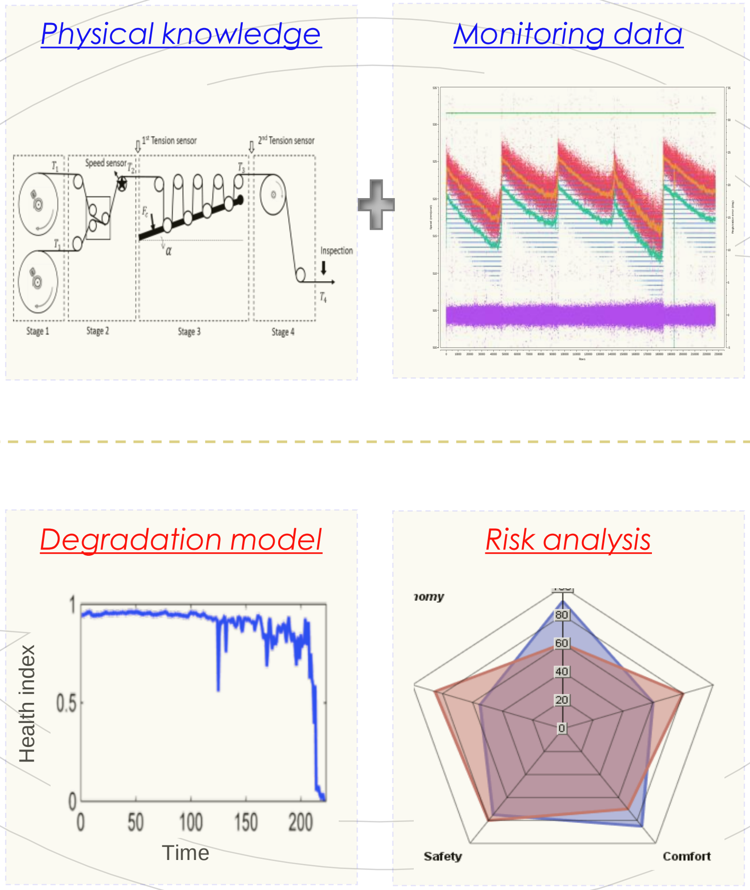
Source: X. Gu, ***X. Jin***, J. Ni, 2014, ASME Manufacturing Science and Engineering

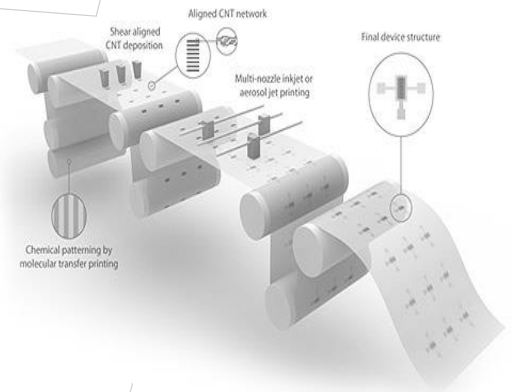
CYBER-MANUFACTURING SYSTEMS

Physical World

Cyber Space





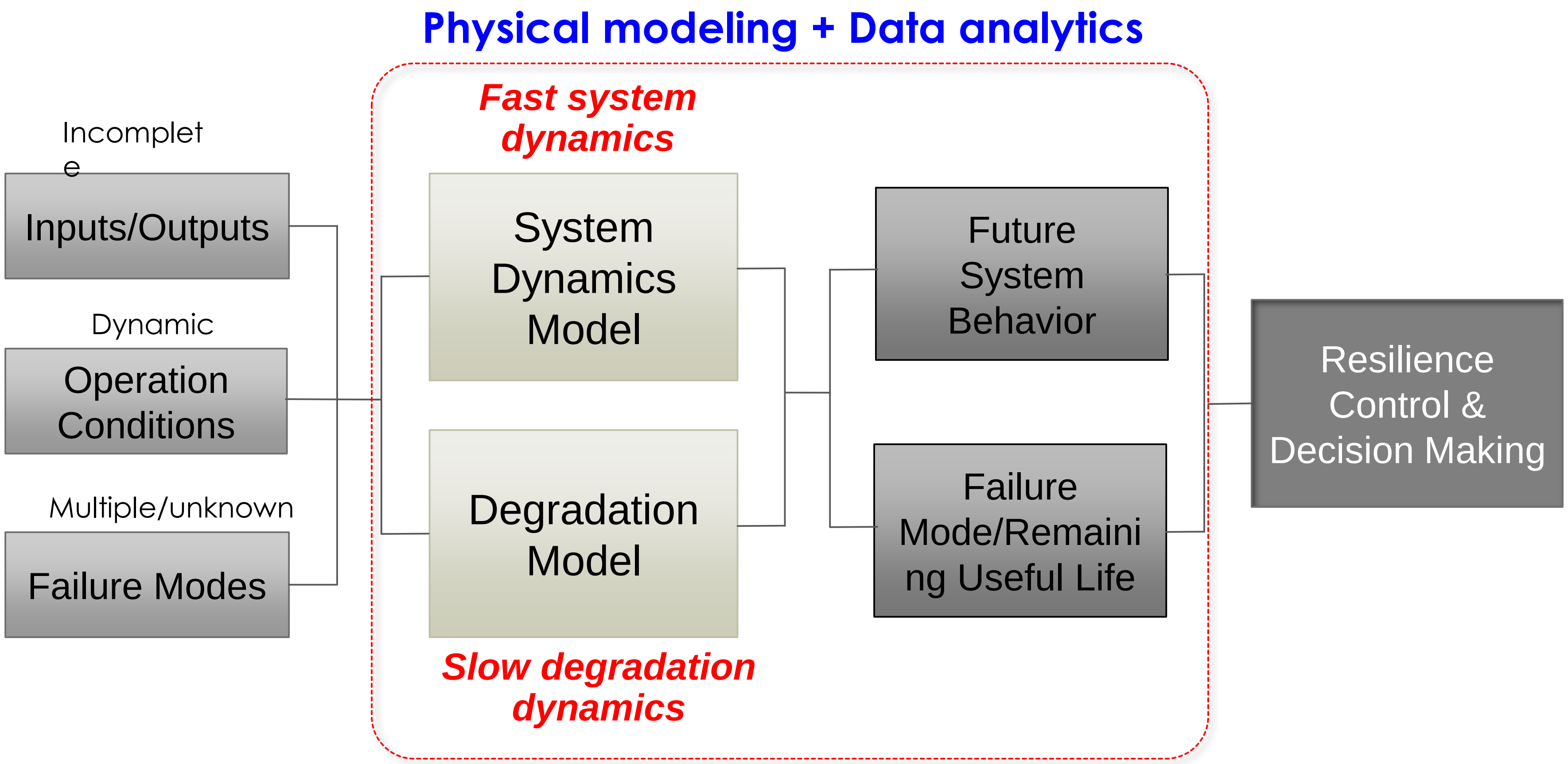


- Real implementation
  - Real component
  - Real machine
  - Real system
  - Real ……

- Virtual synthesis
  - Virtual component
  - Virtual machine
  - Virtual system
  - Virtual ……

FUSION OF PHYSICAL MODELS AND DATA ANALYTICS

- AN INTEGRATED PHYSICS-BASED AND DATA-DRIVEN PROGNOSTICS FOR DEGRADATION MODELING OF VEHICLE SUB-SYSTEMS UNDER DIFFERENT ENVIRONMENTS, EACH DYNAMIC.



PHM FOR SMART CONNECTED SYSTEMS

- ❑ Networked machines
- ❑ Connected IoT devices
- ❑ Remote monitoring
- ❑ Fleet Health management of connected assets
- ❑ …