Building a Brave New World: From Industrial AI to Systems Intelligence

Chetan Gupta, Ph.D.

Head, Industrial AI Lab
Hitachi America, Ltd. R&D

Email: First.Last@hal.hitachi.com

Agenda

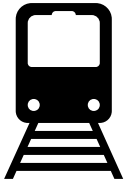
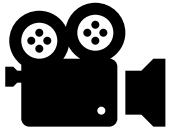
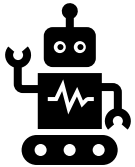
HITACHI
Inspire the Next

- **Part I: Introduction to Industrial AI**
- **Part II: Point Use Cases**
- **Part III: Putting Things Together**

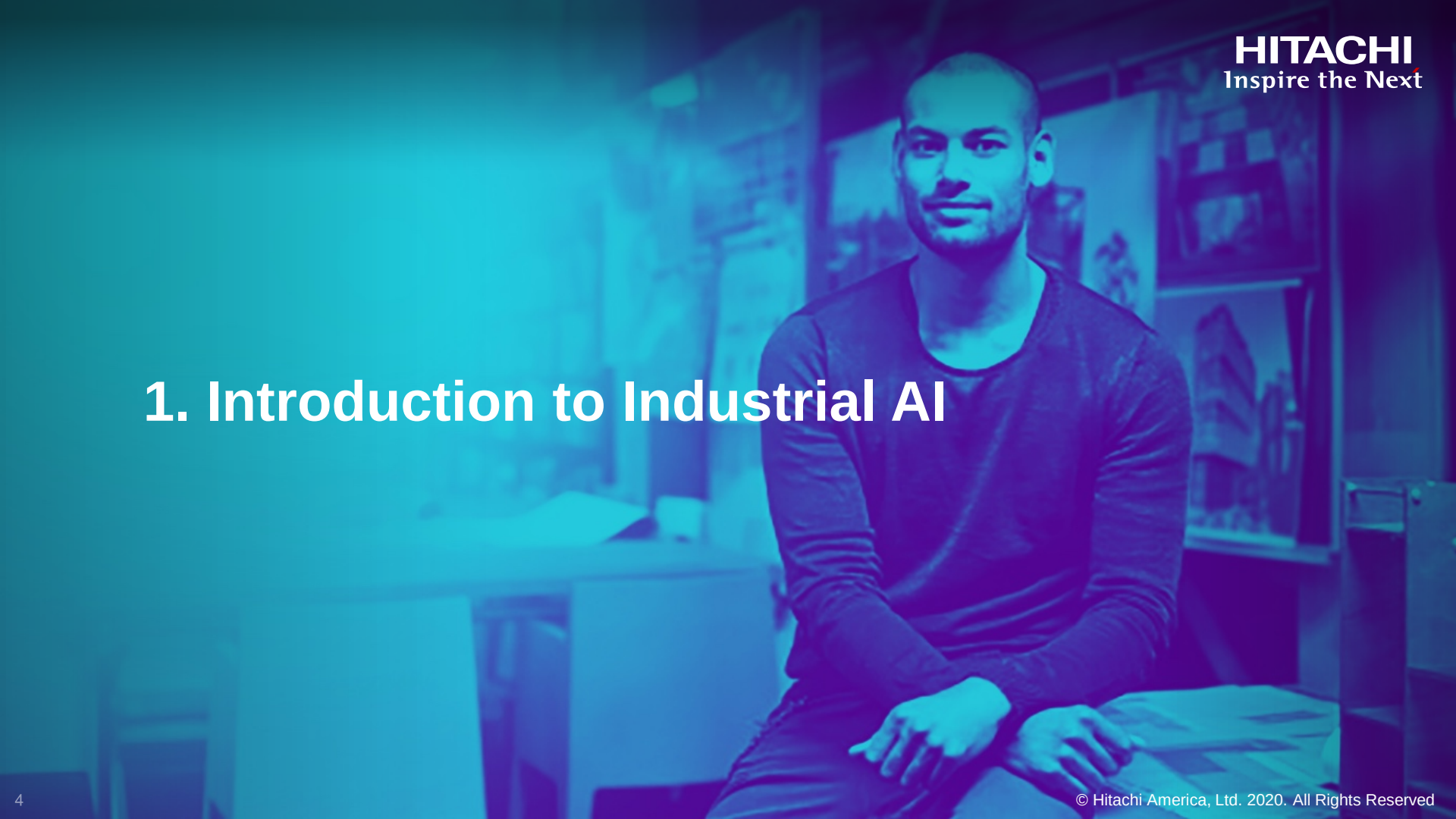
Quiz – What's Common to All of These?

HITACHI
Inspire the Next





1. Introduction to Industrial AI

What is Industrial AI?

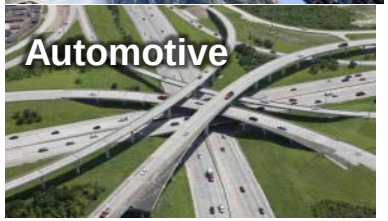
HITACHI
Inspire the Next

Application of artificial intelligence, machine learning and related technologies towards addressing real world challenges in industrial and societal domains

Major Functional Areas:

- Maintenance and repair
- Operations optimization
- Quality assurance
- Safety management
- Supply chain management
- Automation and control

Ultimate Goal: End-to-end optimization



Motivating Example – Open Pit Mine

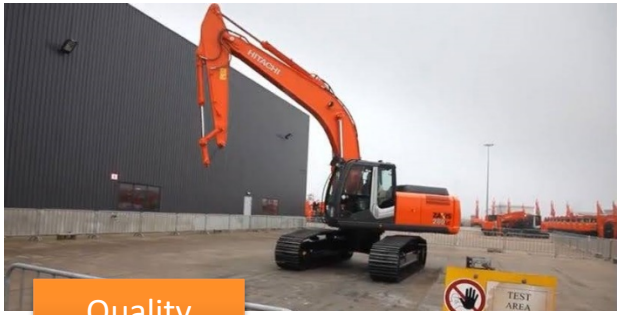
HITACHI
Inspire the Next

Kalgoorlie Super Pit
Worlds Largest Open Pit Gold Mine Western Australia

Motivating Example – Manufacturing

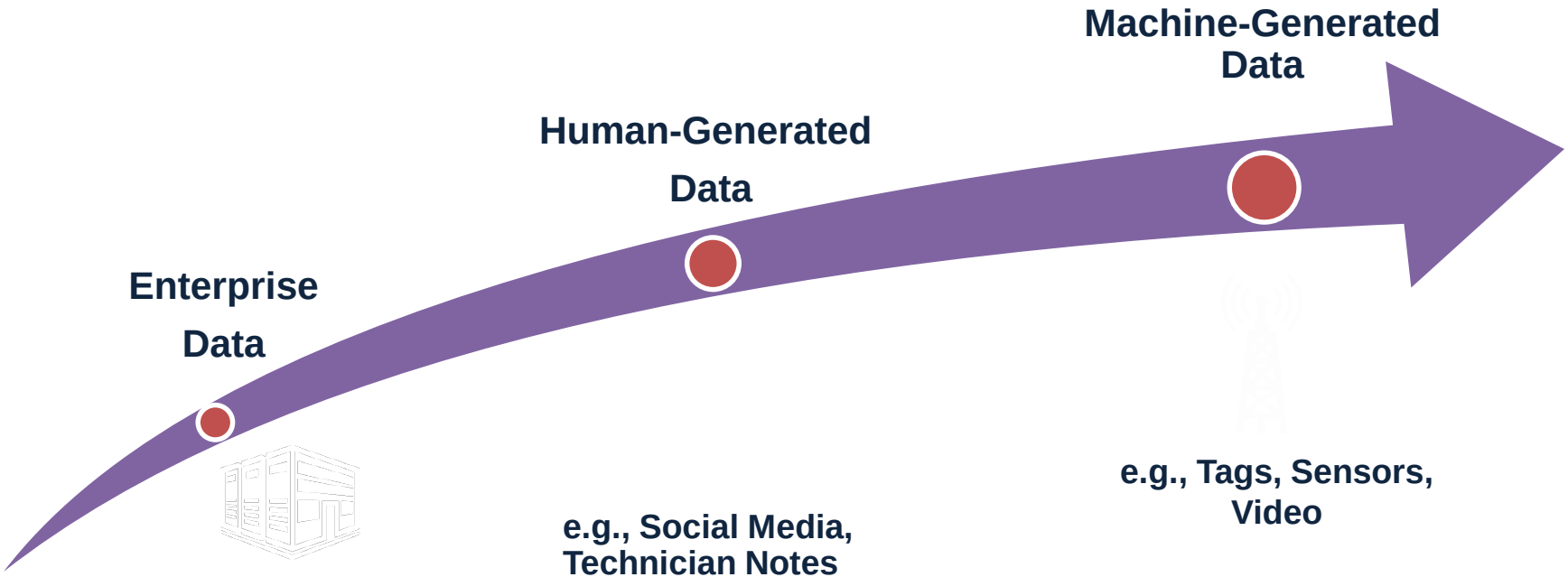
HITACHI
Inspire the Next

Demand Forecasting



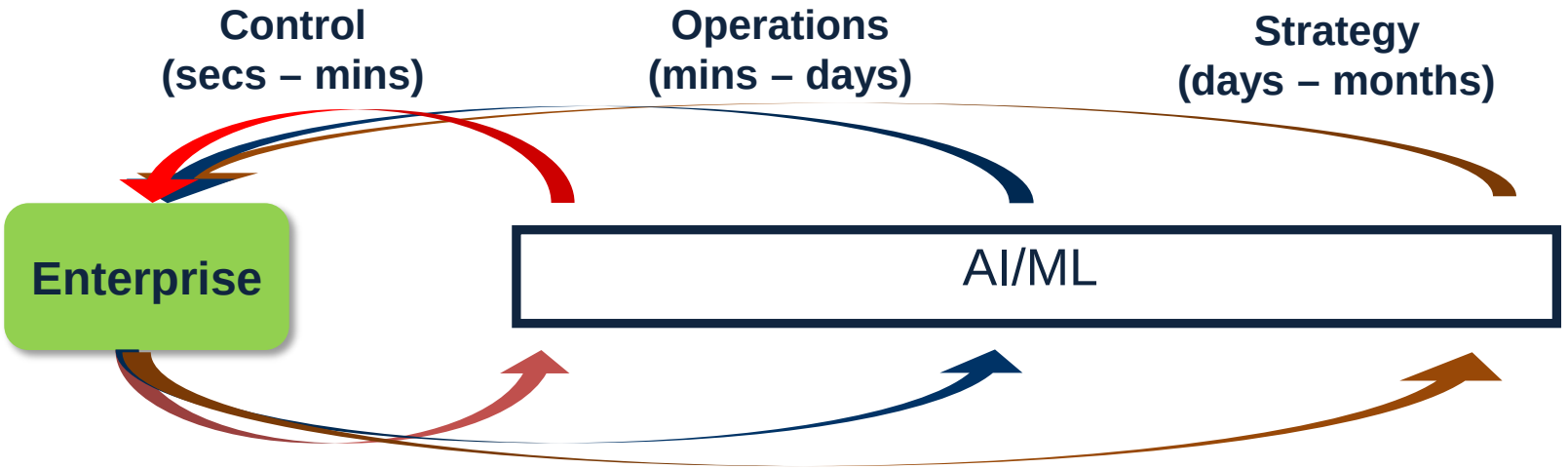
Data Sources

HITACHI
Inspire the Next



Complexity of Automation

HITACHI
Inspire the Next



Key Challenges

HITACHI
Inspire the Next

Data

- Historical data collection processes
- Often incomplete, missing and noisy data
- Data collected in different operational modes
- No benchmark data sets

Modeling

- Analytics over heterogenous data
- Models that work with “small data” and few positive examples
- Explanatory models are often required
- Modeling system of systems working in complex environment
- Incorporating domain knowledge

Operationalization

- Cost tradeoffs are very important
- Decision making under uncertainty
- Humans in the loop
- Real world is analog

2. Use Cases

2a. Maintenance

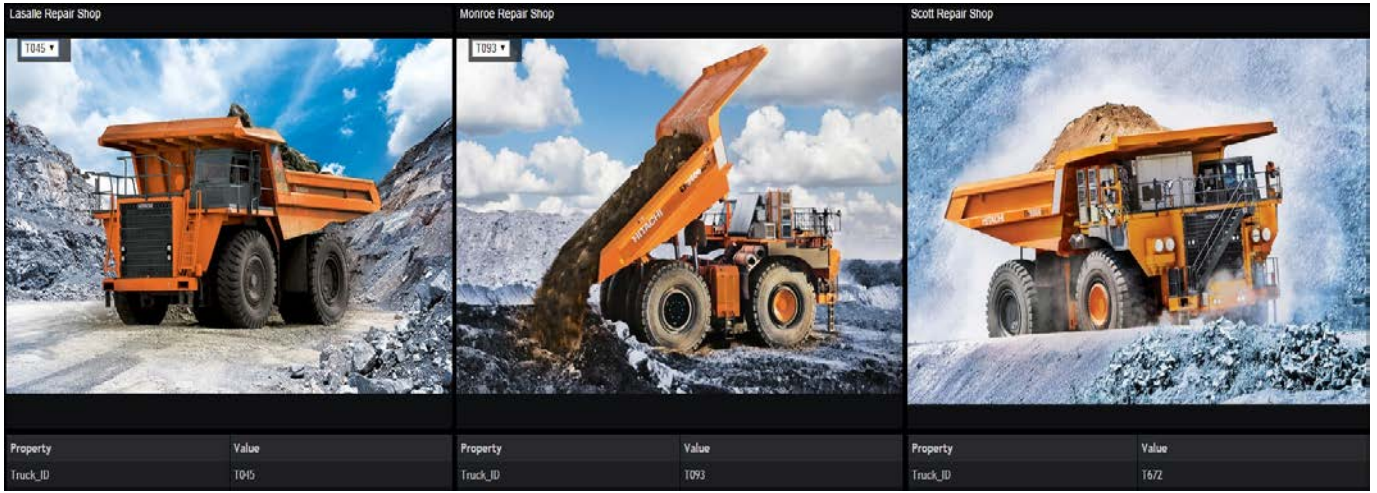
Sample Use Case: Damage Detection

HITACHI
Inspire the Next

- **Problem:** Diagnosis of surface damages using visual data
- Traditional CV approaches (e.g., feature extractors, 3D construction) do not generalize well to detect surface damages across multiple conditions, sizes, and viewpoints
- Deep learning have been successfully proven to generalize fine-grained features of objects, and style categories in other domains
- **Difference from typical tasks**: Not only need to learn representation of object, shape and texture, but also irregular regions and changes that denote damages

Surface damages across a variety of conditions, sizes and viewpoints.

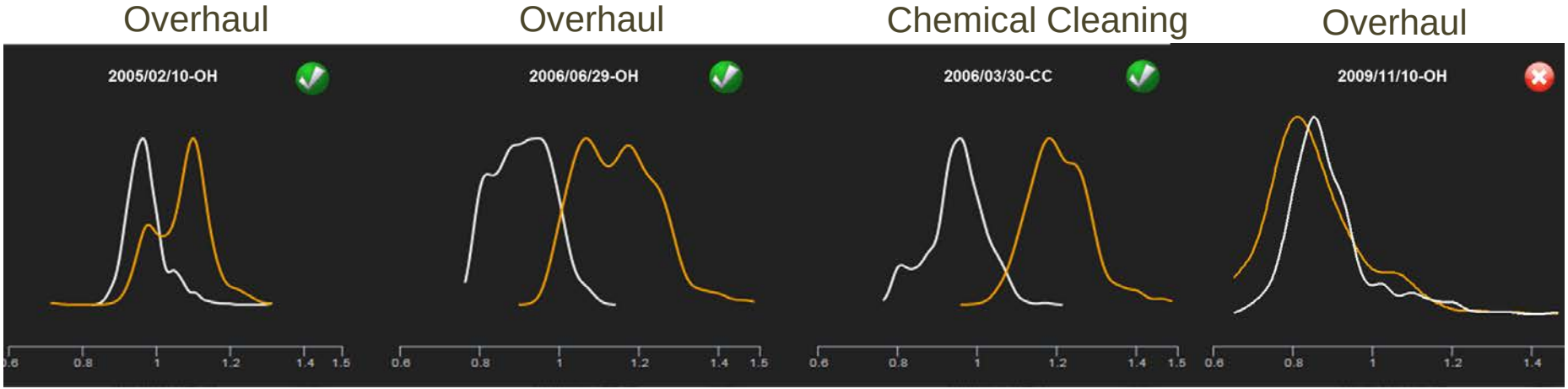
Repair Recommendation



Example – Maintenance Effectiveness Estimation

HITACHI
Inspire the Next

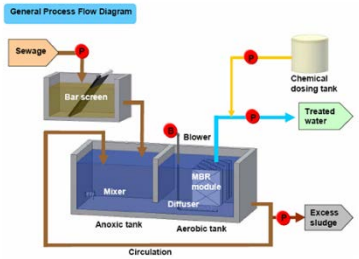
Determine the effectiveness of each maintenance activity, vendor, practice, etc. to improve maintenance operations



From Equipment to Industrial Networks

HITACHI
Inspire the Next

- **How to detect and isolate faults in industrial networks?**
- Examples:
  - leaking tanks in a water supply network, congested roads in a transportation network, failed transformers in a power grid.
- Challenges:
  - Existing methods detect failures independently on individual equipment and do not capture dependency between interconnected components
- Key Idea:
  - Use network structure (relationship between components) and sensor data together to achieve maximum accuracy

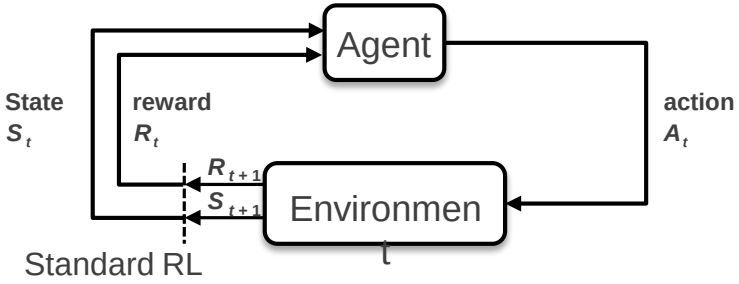


2b. Operations

Operations: Production Dispatching using RL

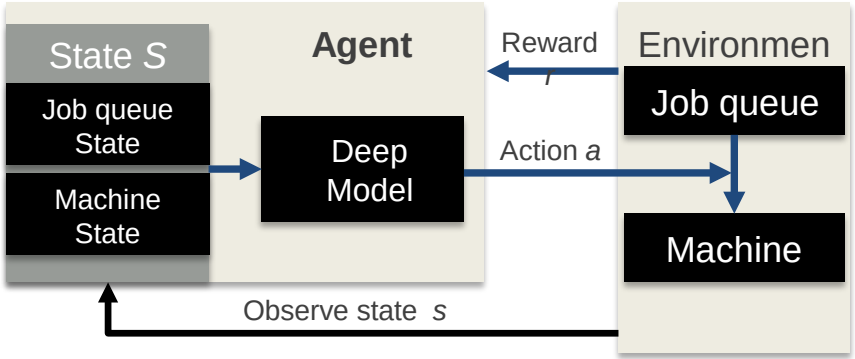
HITACHI
Inspire the Next

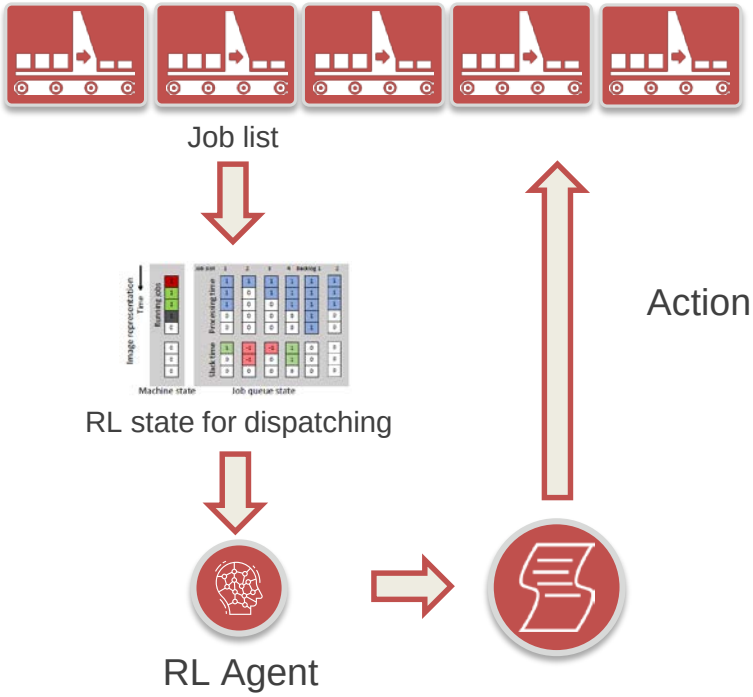
Using Reinforcement Learning (RL) for manufacturing dispatching



Standard RL

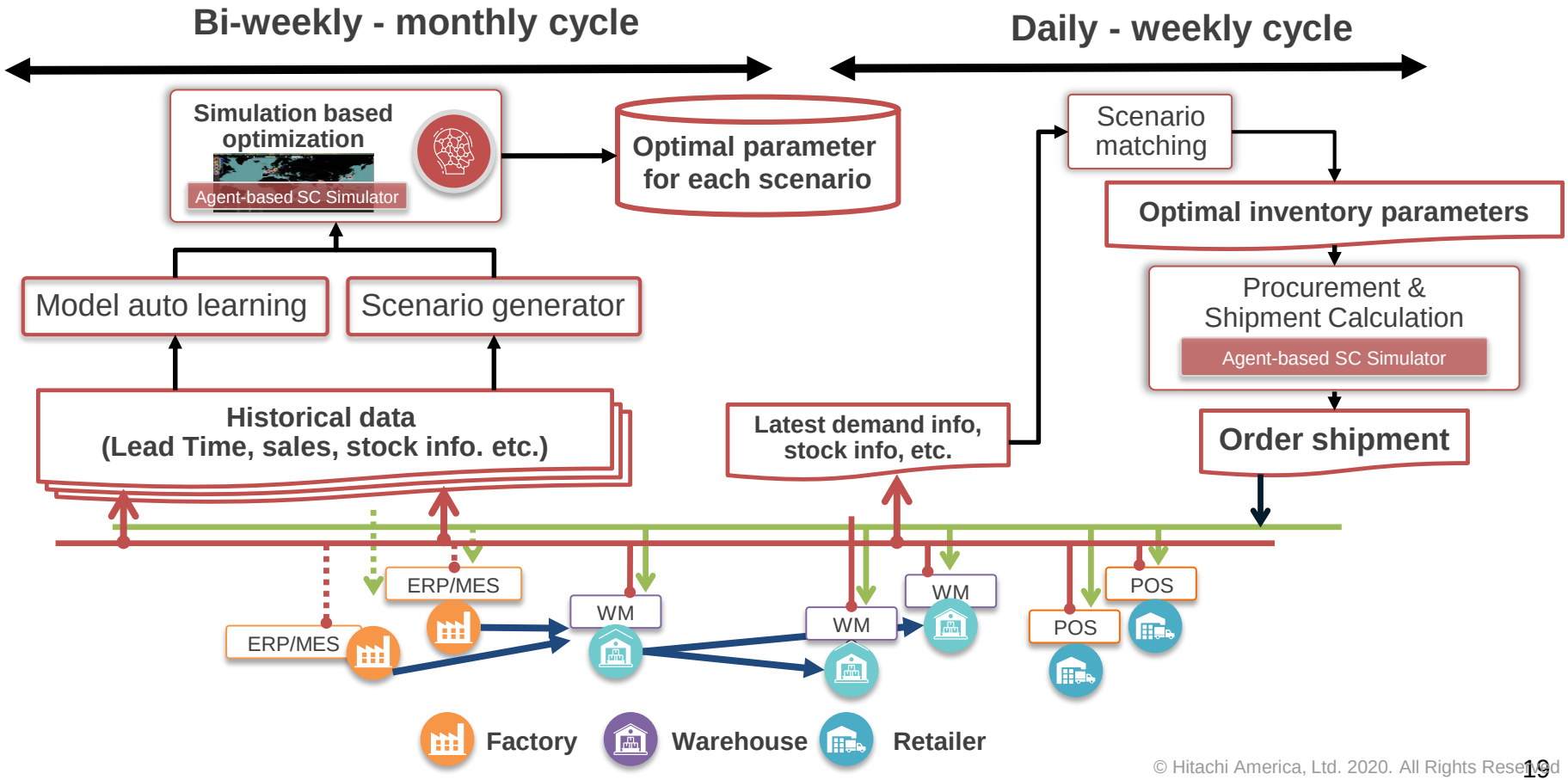
RL for dispatching





Supply Chain: Robust Multi-echelon Inventory Management

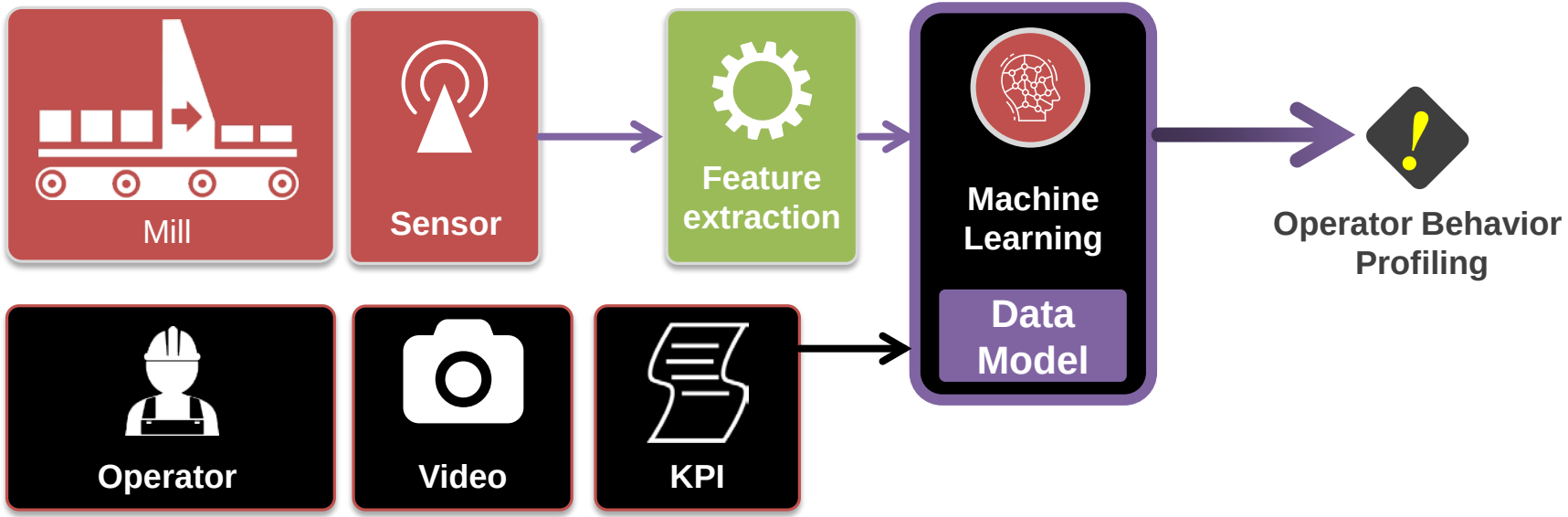
HITACHI
Inspire the Next



Skilled Labor: Improving Operator Performance

HITACHI
Inspire the Next

Characterize the efficiency, safety of operator behavior to improve operations

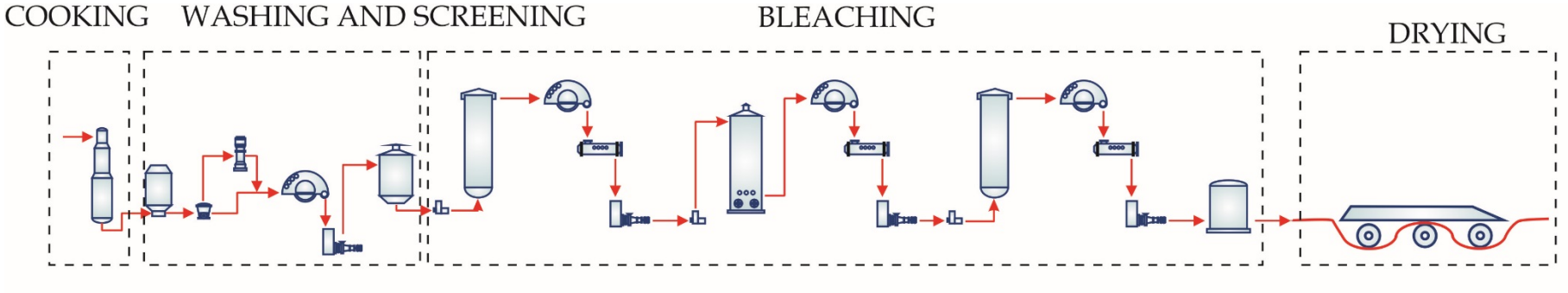


2c. Quality, Safety, Automation

Example – Quality Test Failure Prediction

HITACHI
Inspire the Next

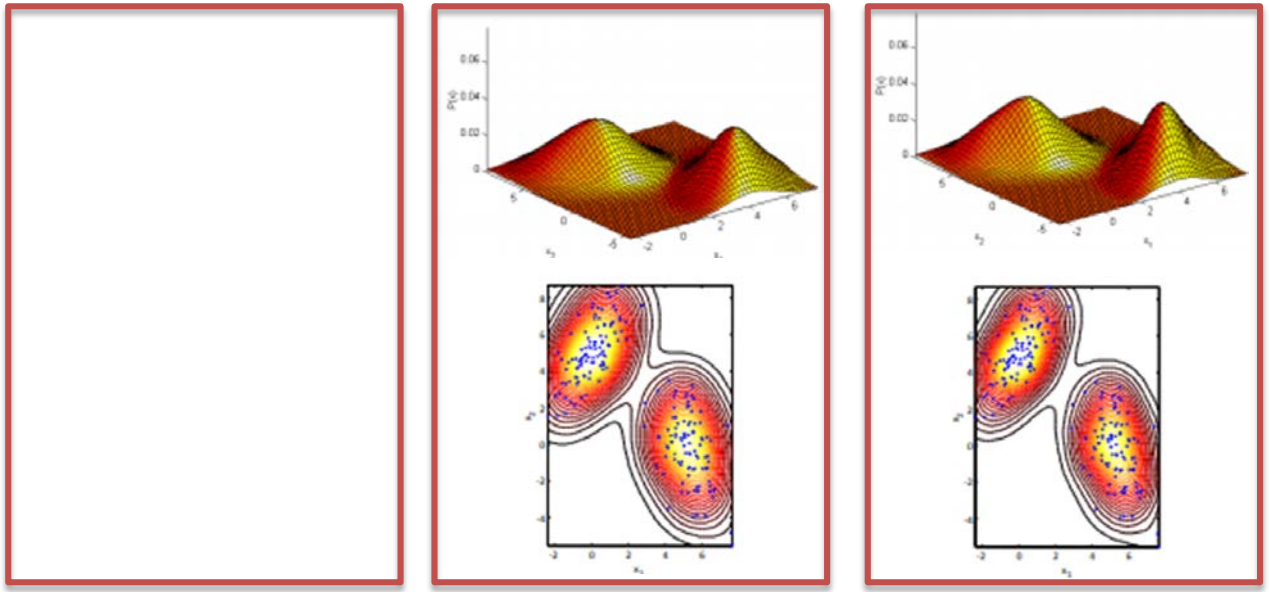
Predict failures earlier in process



Operating Envelope

HITACHI
Inspire the Next

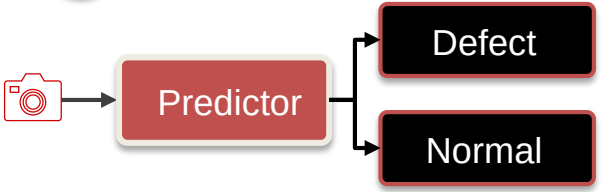
- **This example shows the product KDE of a bivariate bimodal Gaussian**
  - **100 data** point were drawn from the distribution
  - **The figures** show the true density (left) and the estimates using $h = 1.06\,\sigma N^{-1/5}$ (middle) and $h = 0.9AN^{-1/5}$ (right)



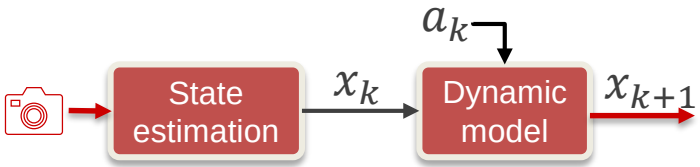
Robotics And Automation: Defect Prevention

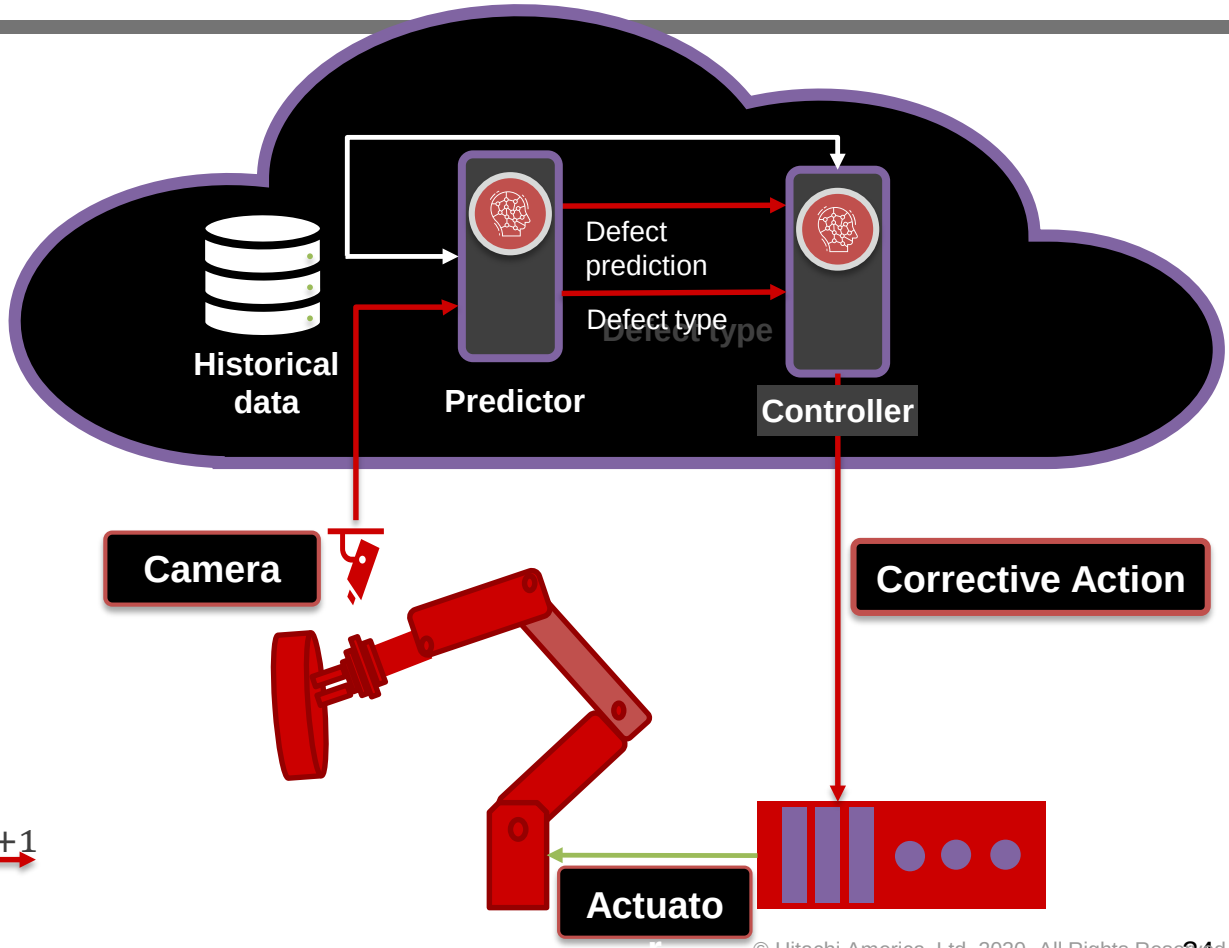
HITACHI
Inspire the Next

- Defect prediction
  - Supervised learning



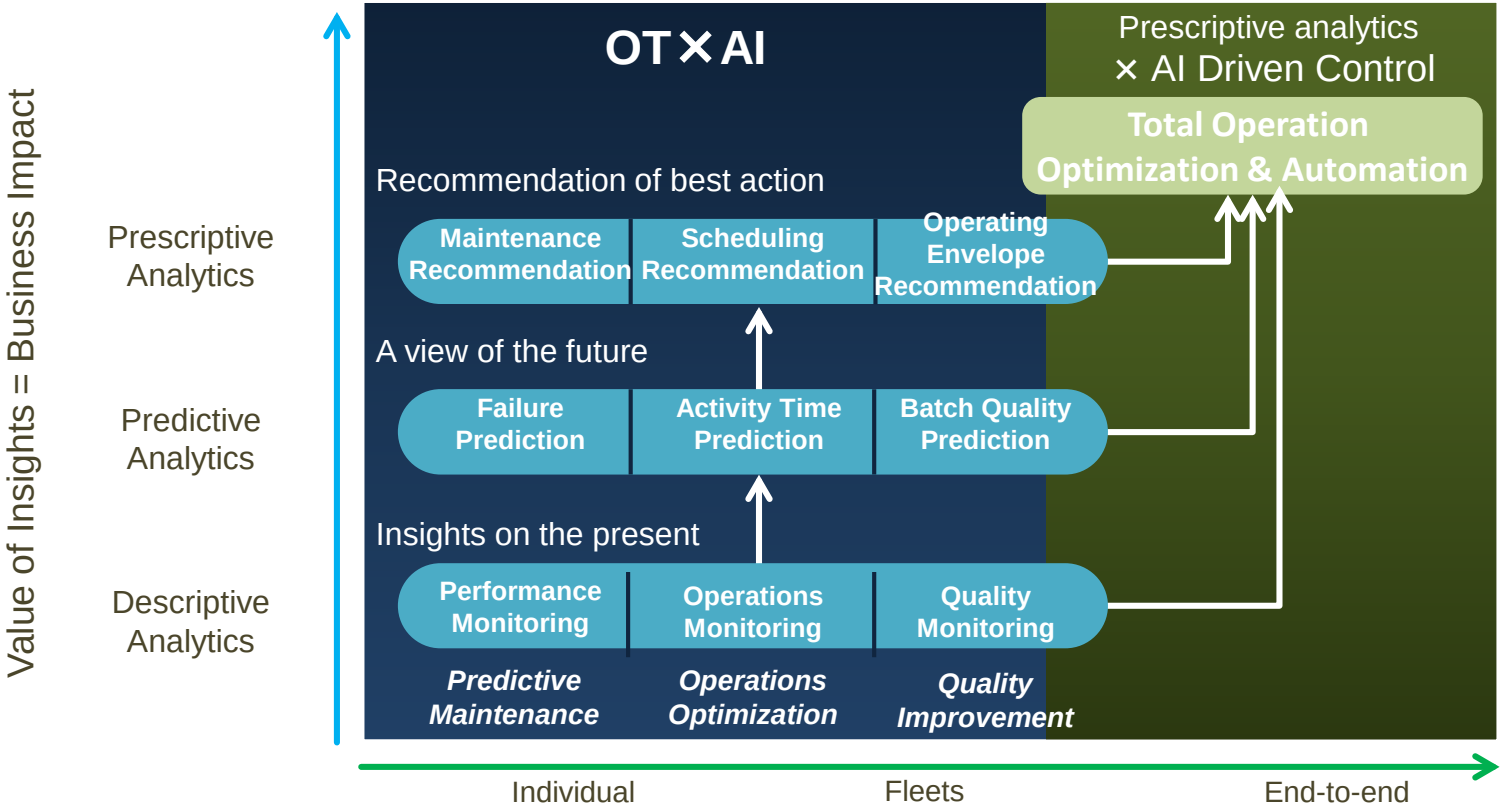
- Corrective action:
  - Learn state estimation & dynamic models
  - Generate action, a_k ,to prevent the predicted defect



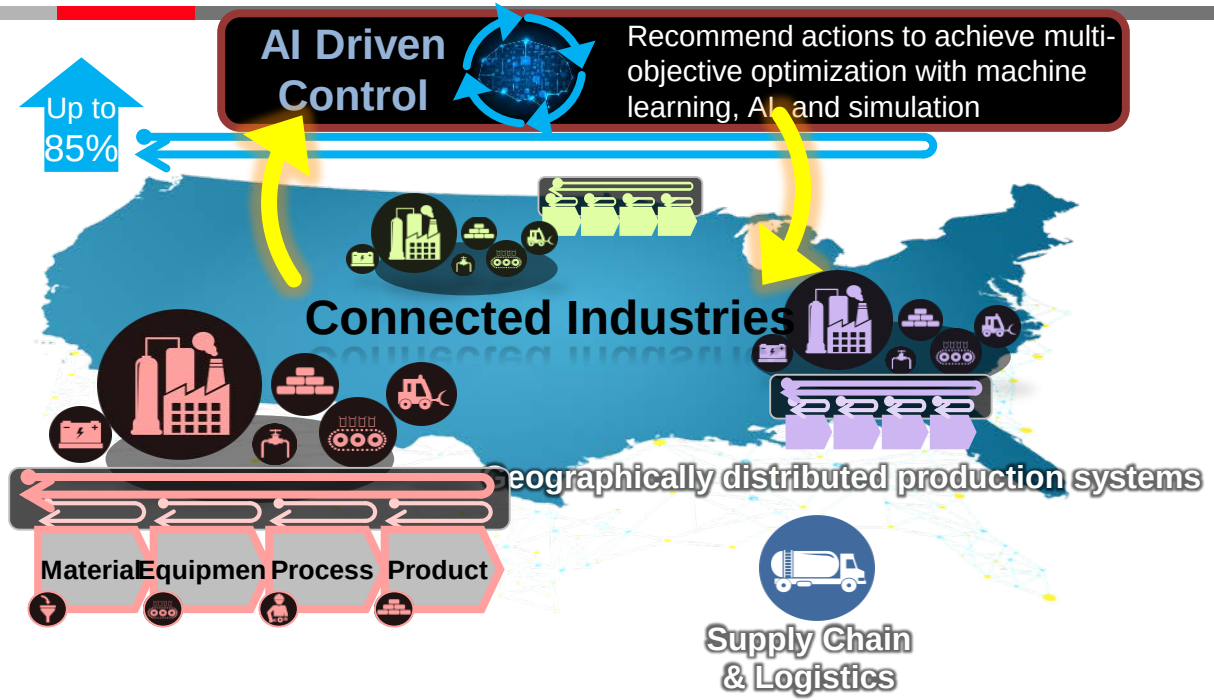


Part 3: Putting Things Together

Composing AI



System Wide Optimization



- Automated Control & Optimization of the Electrical Grid
- Decision Making for Enabling Circularity through Remanufacturing
- Enabling multimodal mobility and delivery networks

Last Thoughts

HITACHI
Inspire the Next

- Industrial AI augments human intelligence rather than trying to supplant it
- It is foundational and transformative
- We are still in early stages
- Several open technical challenges in different domains
- Need to think about new business and financial models

What else would you rather work on?

Thank you!

Hitachi Industrial AI Blog

https://www.hitachi.com/rd/special/aiblog/index.html

Discussion and Q&A