



Delivering IoT technology for a cleaner and efficient operation of a Coal Fired Power Plant

TOSHIBA

TOSHIBA Energy Systems & Solutions Corporation

DX Business Design Project Team

Nov. 2019

Contents

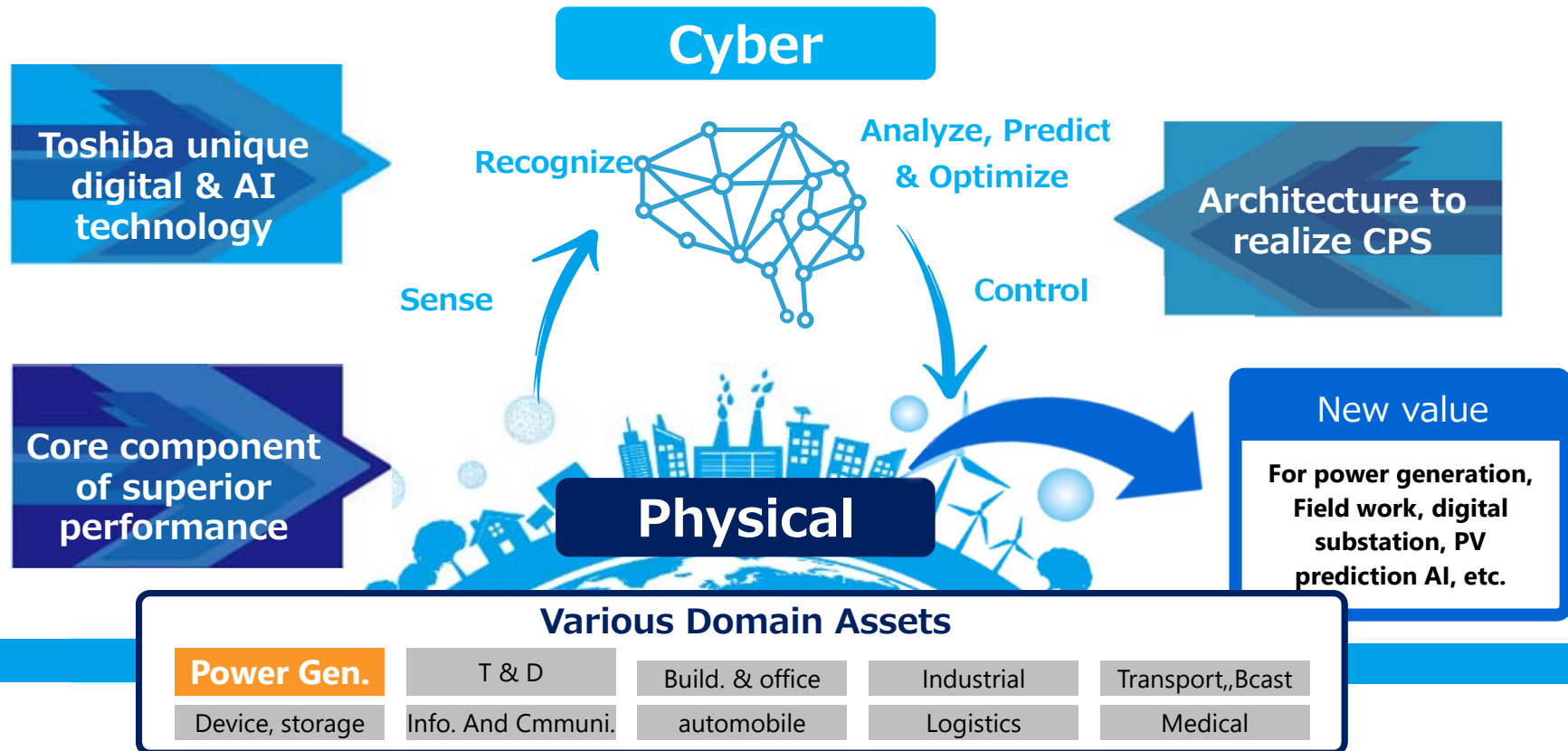
- 01 Toshiba IOT (CPS) Technology Enterprise
- 02 Example of Digital Solutions

01

Toshiba IOT (CPS) Technology Enterprise

Toshiba IOT (CPS) Technology Enterprise

Collect data from physical world and analyze by digital technology in cyber world,
then feedback to physical world to create new values



Toshiba IOT (CPS) Technology Enterprise Toshiba IoT Reference Architecture (1/3)

Based on industry's IoT & CPS reference model



Power · Water

Building · Facility

**Control Technology · IoT
working in the Domains,
Practical Solutions**

Manufacturing · Logistics

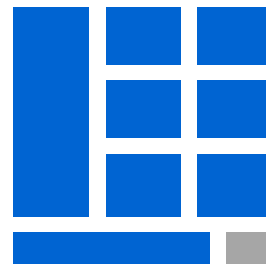
Transportation · Road

R&D Technology



- Continuous study on AI & application
- Sensor data processing
 - Voice recognition
 - Image processing
 - Statistical processing

Integration into Logical Architecture



Toshiba IoT Reference Architecture



Int'l Standard

Open Toshiba's DX technology globally

As a Service

Toshiba Enterprise IoT Service



Digital Energy



Digital Infrastructure



Digital Logistics

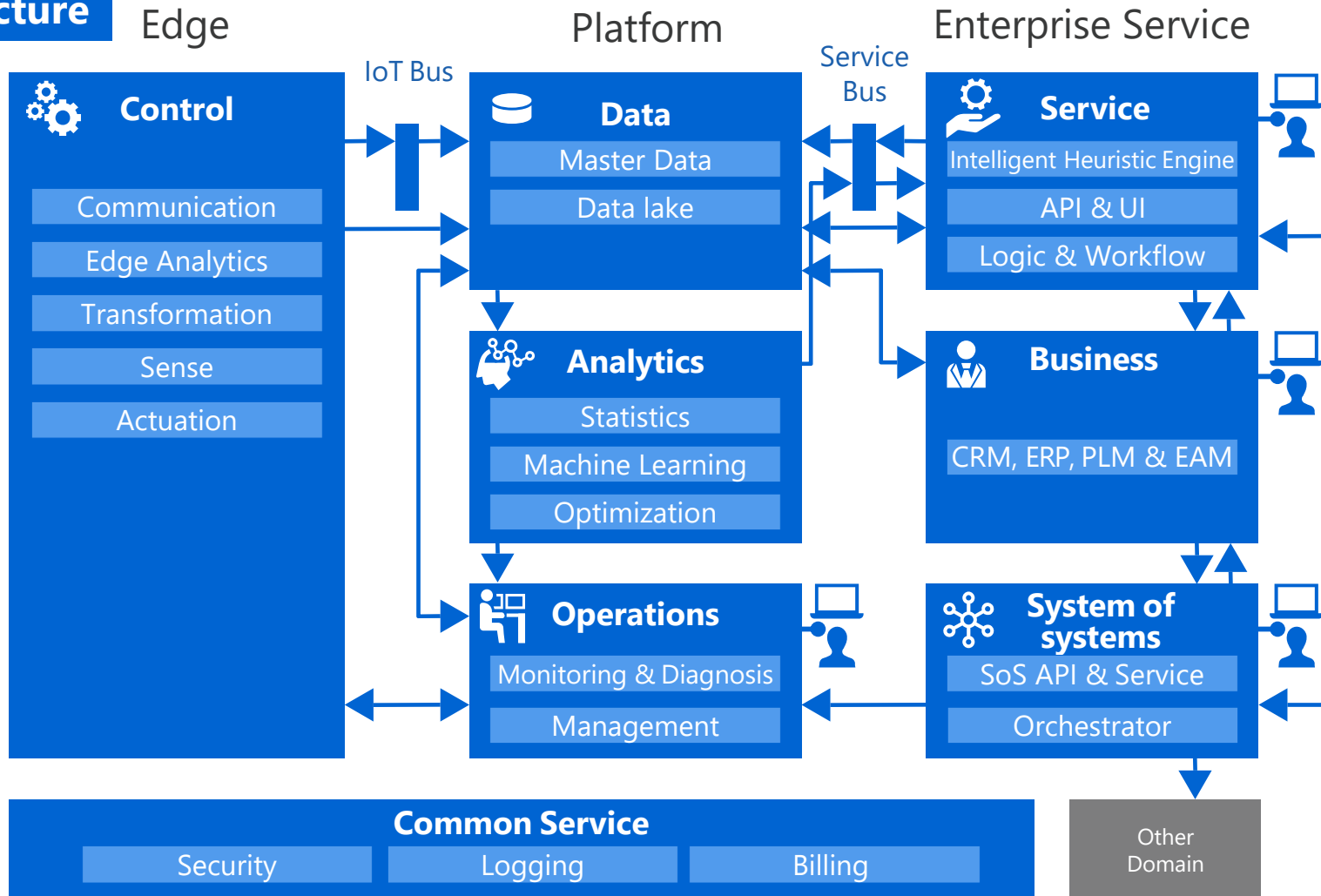


Digital Manufacturing

Toshiba IOT (CPS) Technology Enterprise

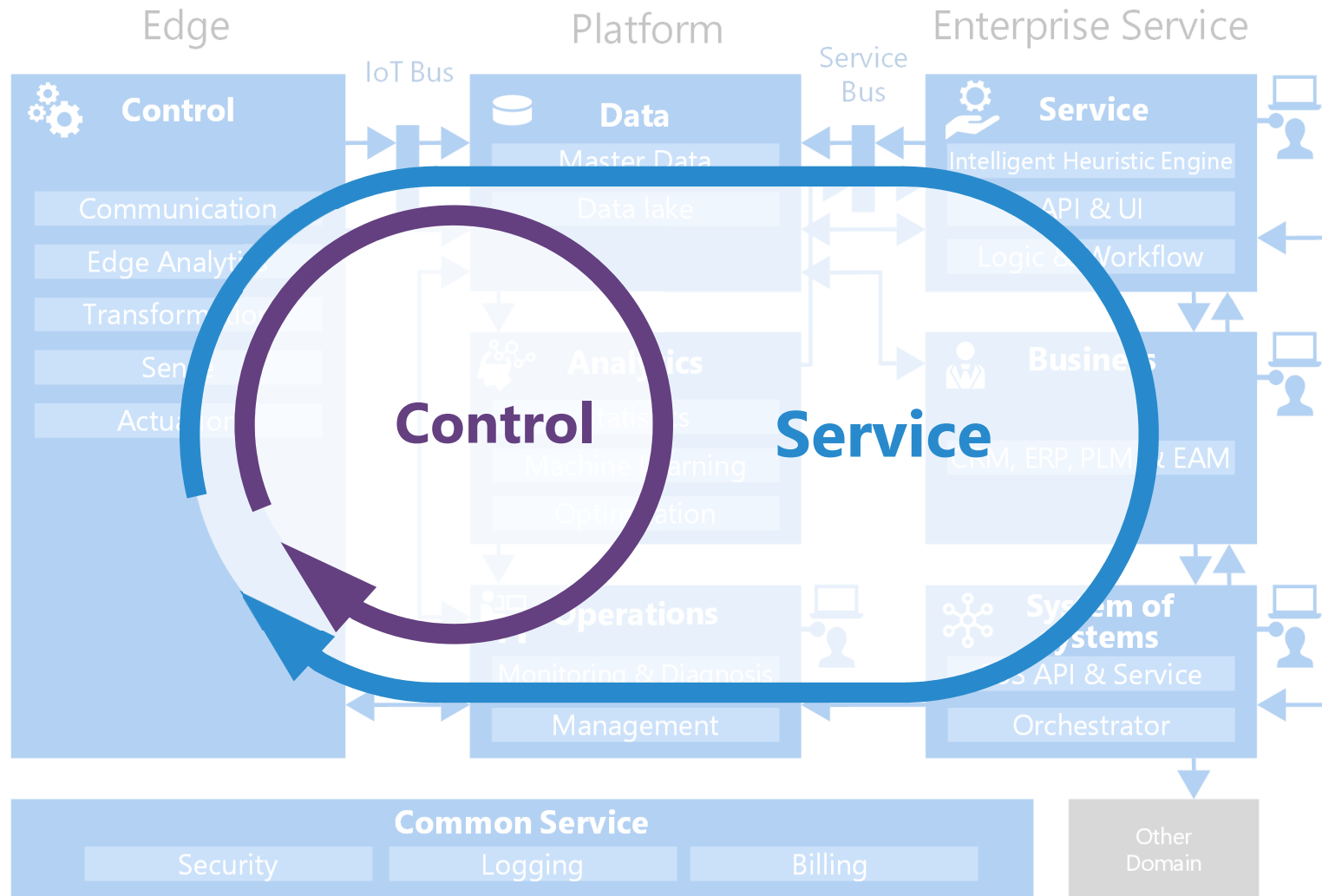
Toshiba IoT Reference Architecture (2/3)

3 Tier Architecture



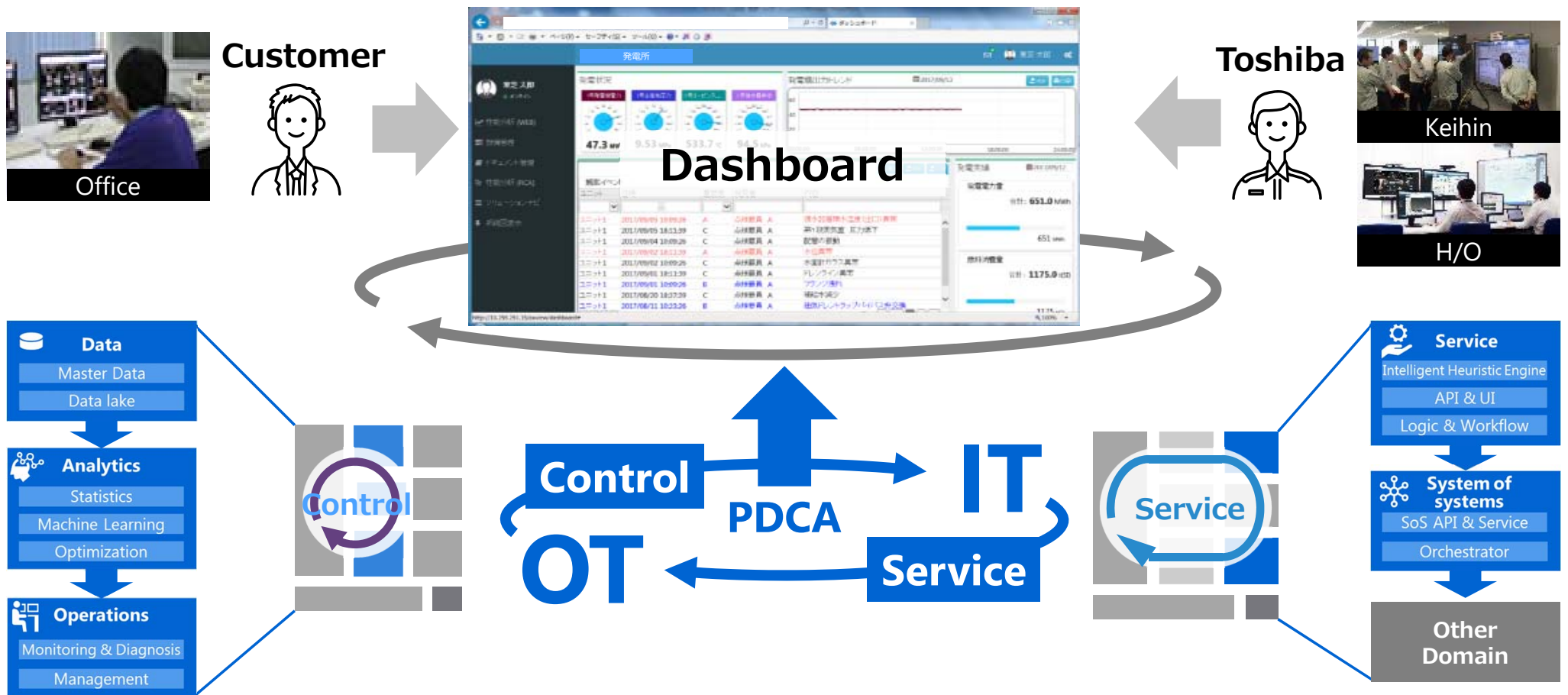
Toshiba IOT (CPS) Technology Enterprise

Toshiba IoT Reference Architecture (3/3)

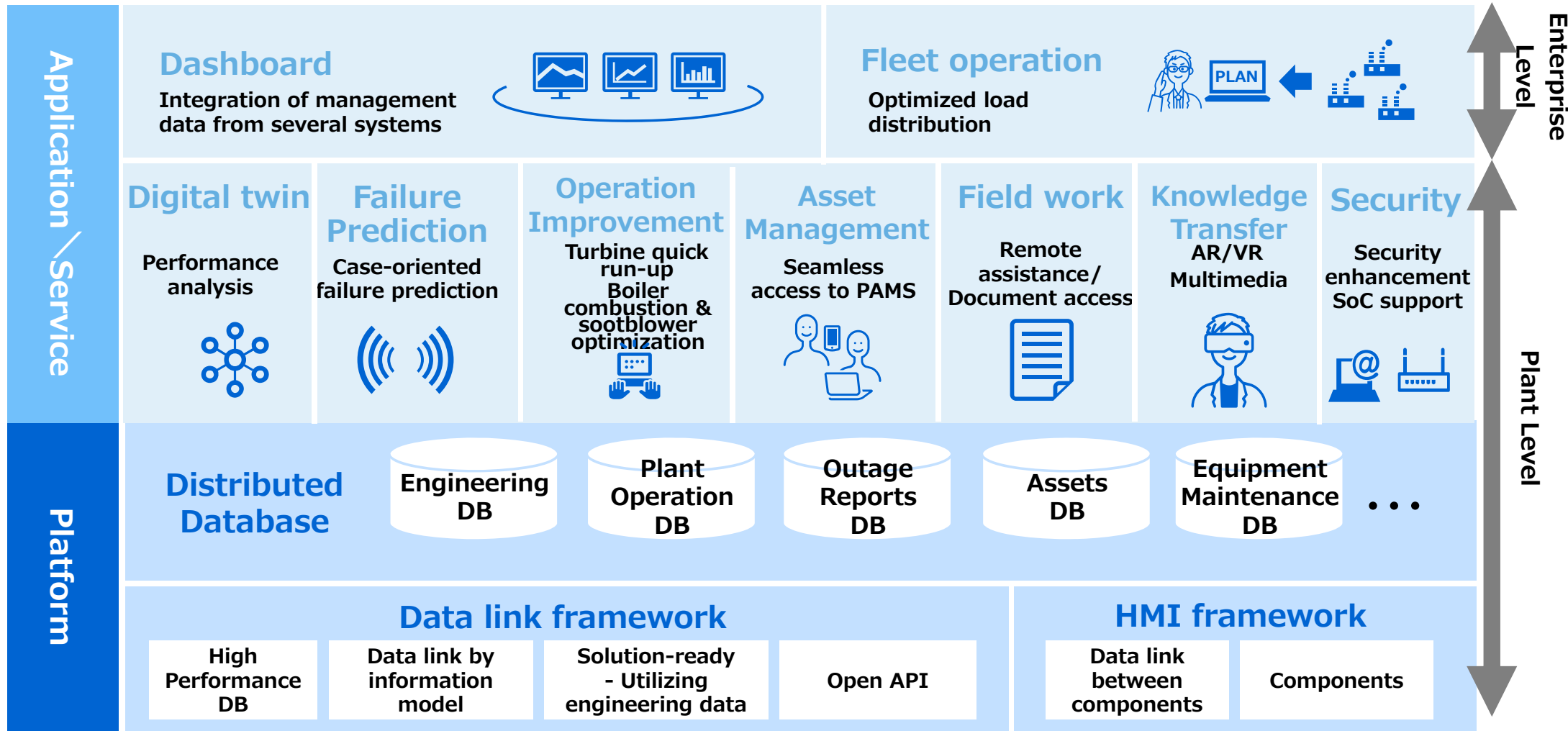


Toshiba IOT (CPS) Technology Enterprise Power Industry IoT Solution (1/6)

By combining OT & IT, solutions are displayed in single Dashboard

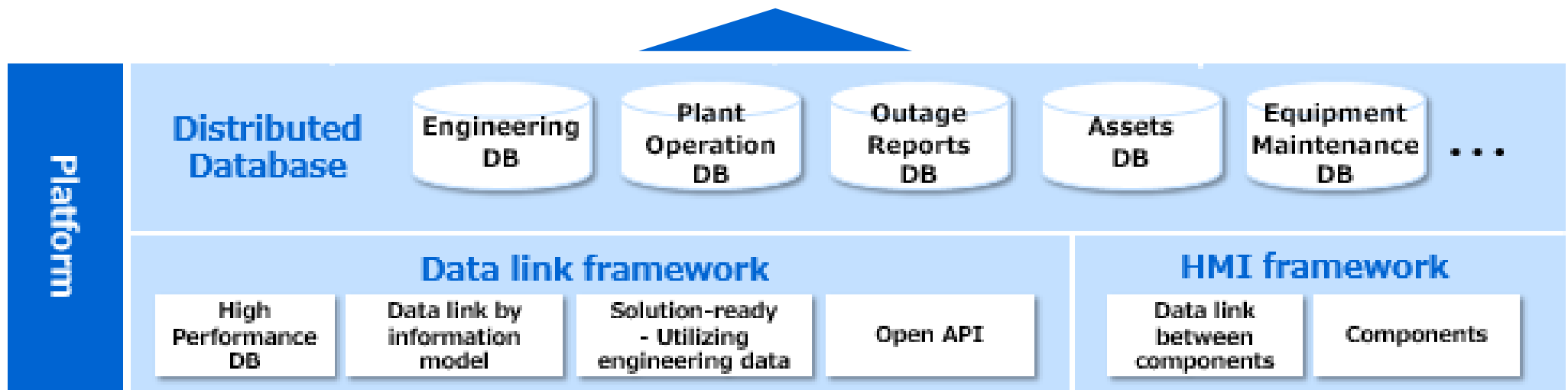


Toshiba IOT (CPS) Technology Enterprise Power Industry IoT Solution (2/6)



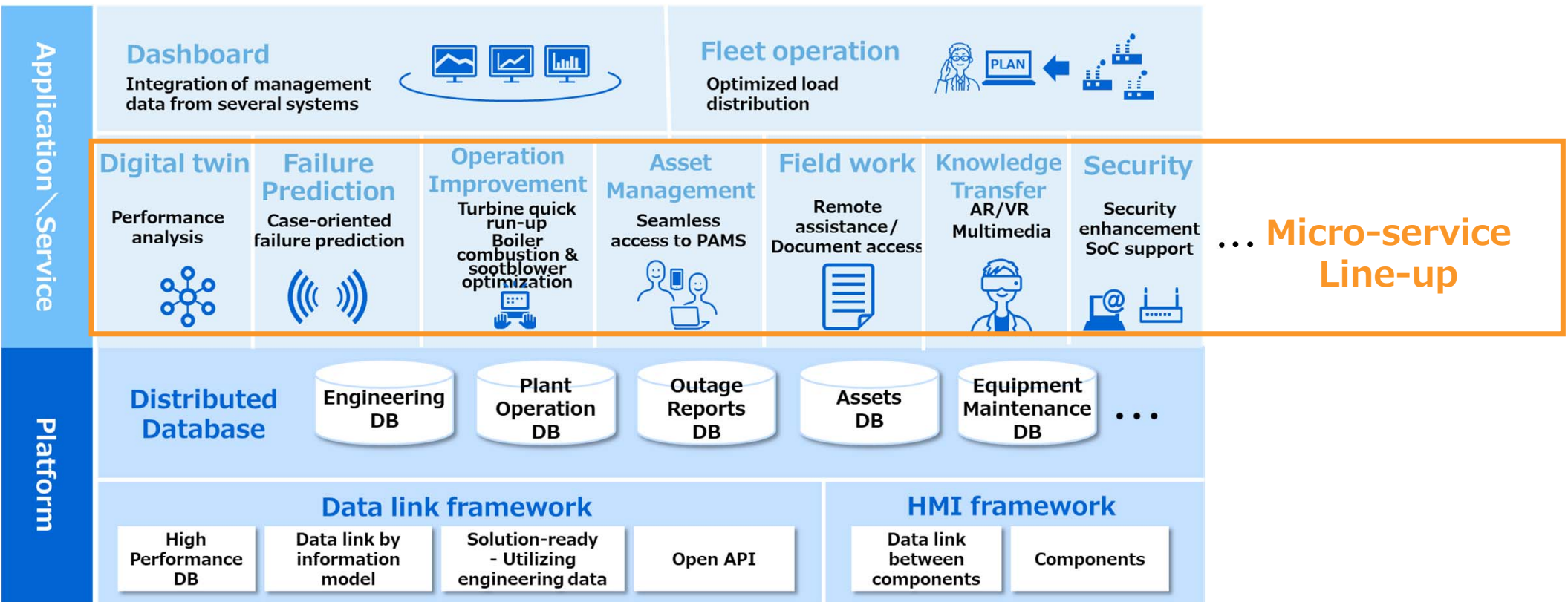
Platform Features

1. Micro-service (Service Oriented Architecture)
2. Hybrid configuration
3. Distributed database
4. Data link by information model (Ontology)
5. Open API for system link (System of Systems)



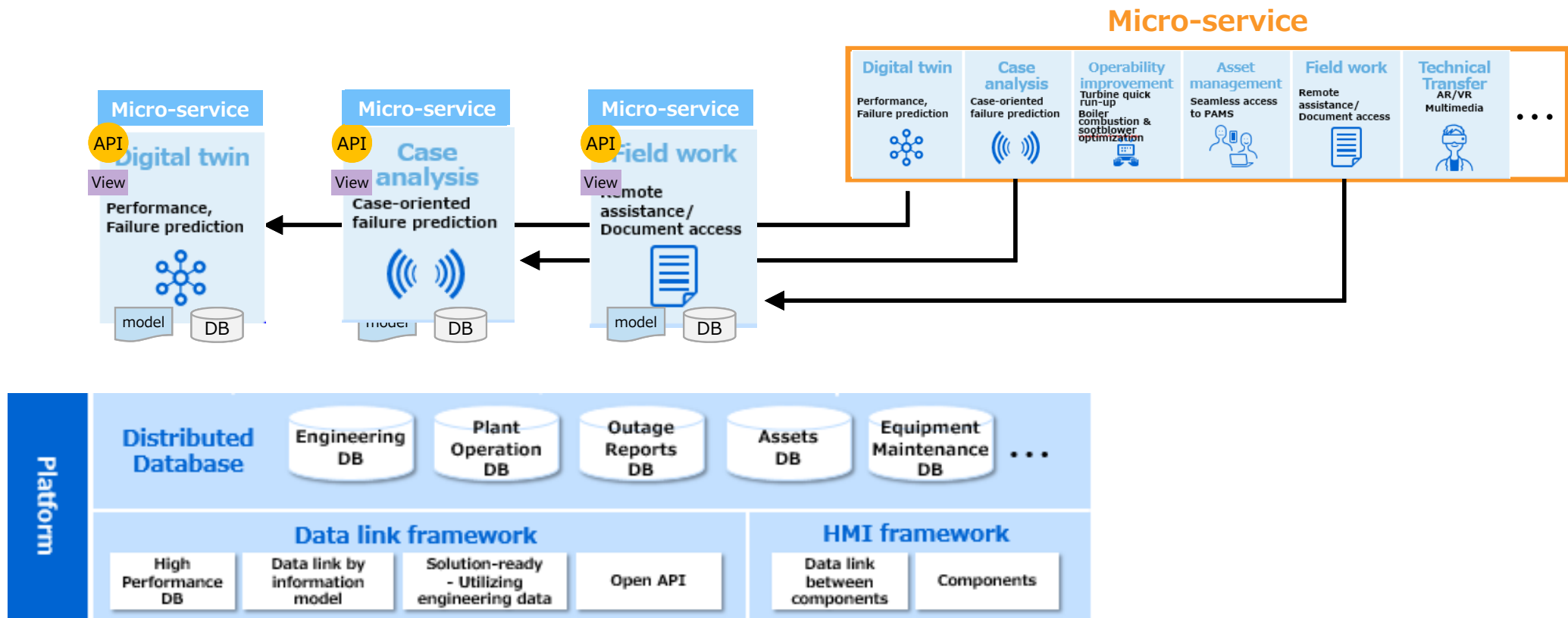
Toshiba IOT (CPS) Technology Enterprise Power Industry IoT Solution (4/6)

Platform feature - ① Selectable micro-services to match Customer needs (Service Oriented Architecture)



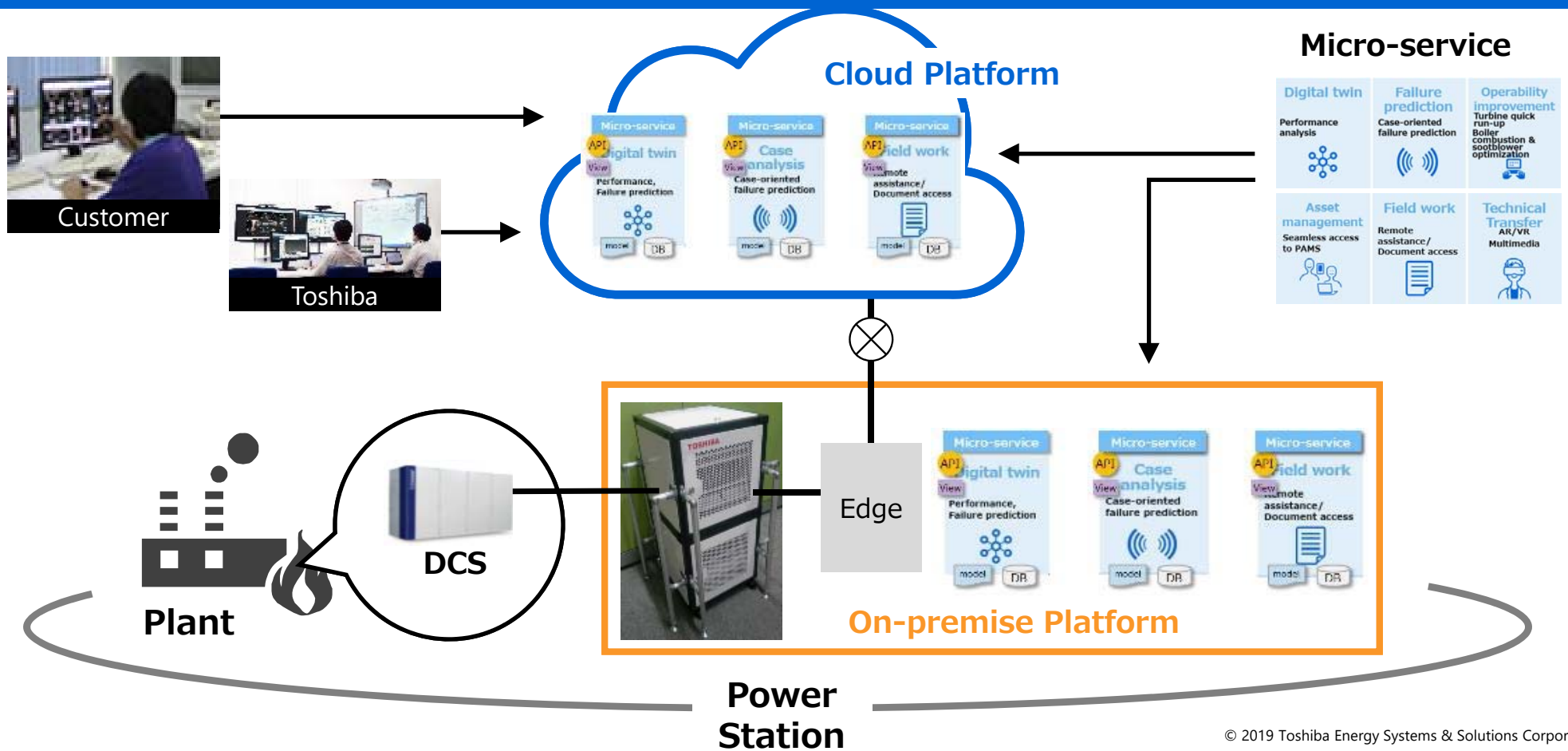
Toshiba IOT (CPS) Technology Enterprise Power Industry IoT Solution (5/6)

Platform feature - ① Selectable micro-services to match Customer needs (Service Oriented Architecture)



Toshiba IOT (CPS) Technology Enterprise Power Industry IoT Solution (6/6)

Platform Feature-② - Hybrid Configuration (Configure functional distribution freely On-premise and/or Cloud platform)

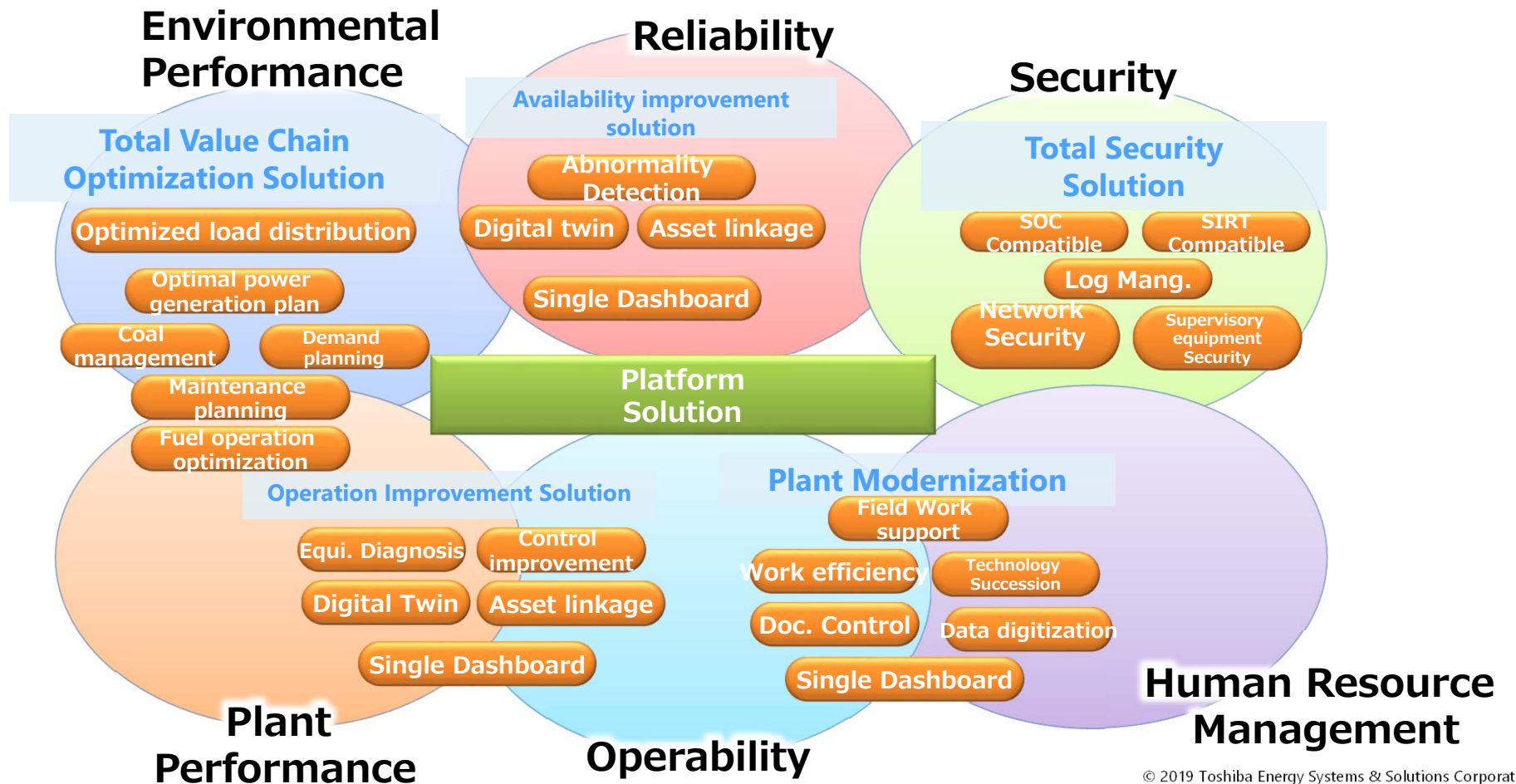


02

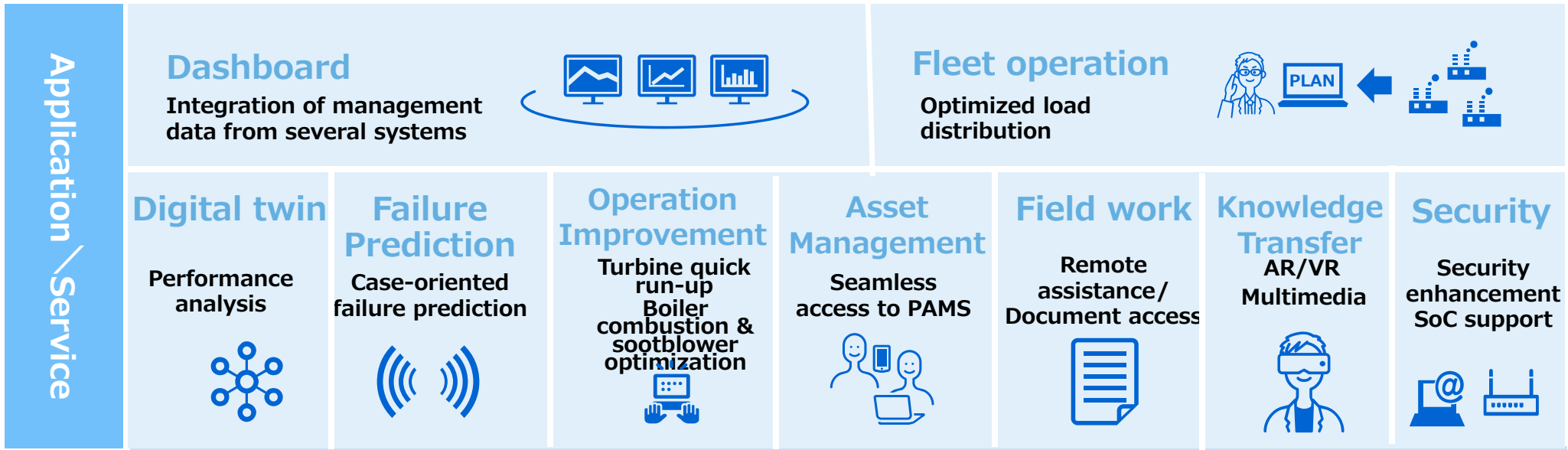
Example of Solutions

Solutions for Power Industry (1/2)

Providing solutions from a broad perspective in the power generation business



Solutions for Power Industry (2/2)



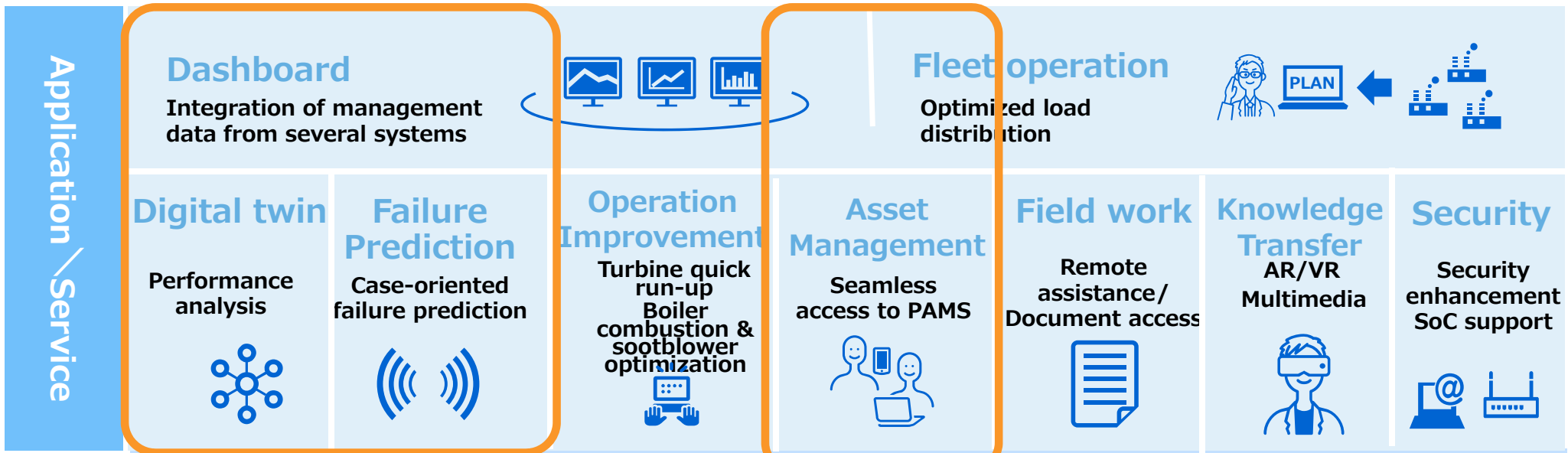
Total Life Cycle Solutions

1. Plant Availability Improvement Solutions
2. Plant Operation Improvement Solutions
3. Plant Modernization Solutions
4. Total Value Chain Optimization Solutions



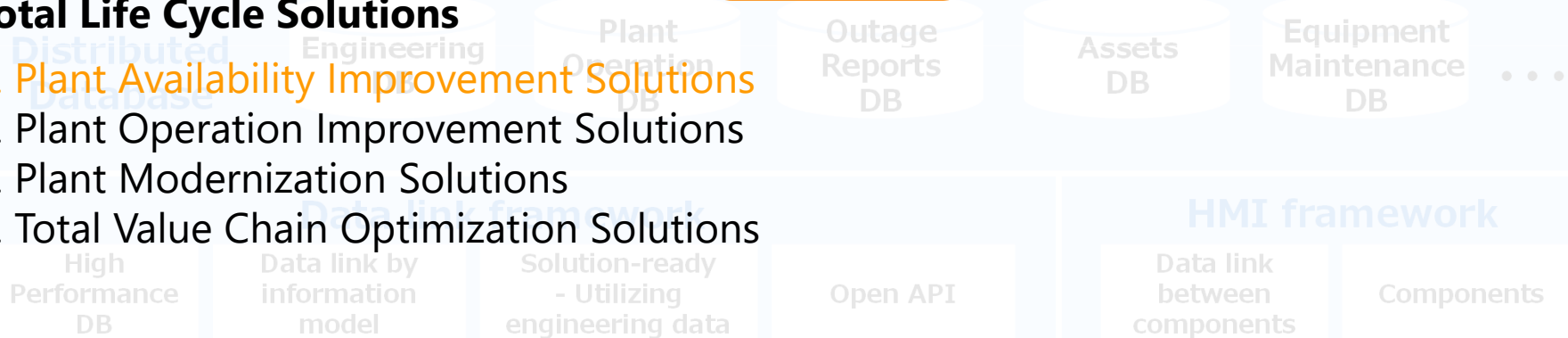
1. Plant Availability Improvement Solutions (1/6)

Total Support from abnormality detection to recovery, contributing to availability improvement



Total Life Cycle Solutions

1. Plant Availability Improvement Solutions
2. Plant Operation Improvement Solutions
3. Plant Modernization Solutions
4. Total Value Chain Optimization Solutions



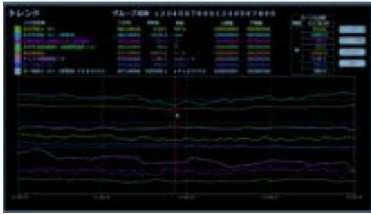
1. Plant Availability Improvement Solutions (2/6)

Total Support from abnormality detection to recovery, contributing to availability improvement

Operation Data



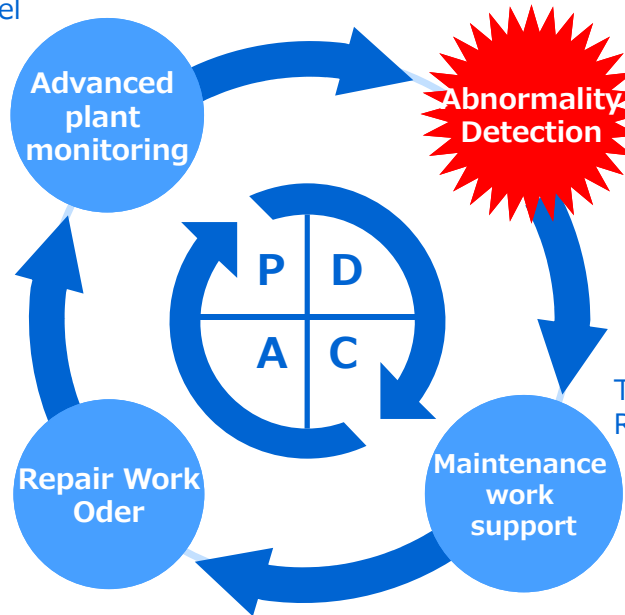
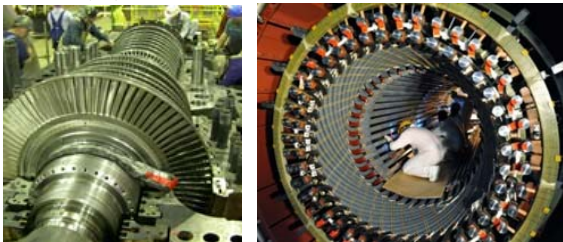
Discover signs of failure from the model



Dashboard



Work Repair

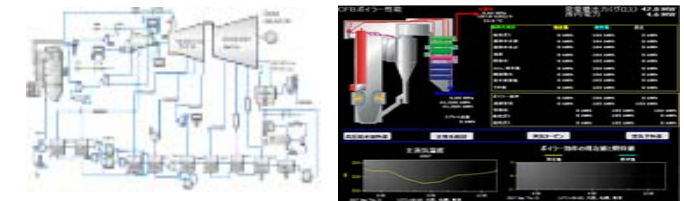


Individual Abnormality Detection

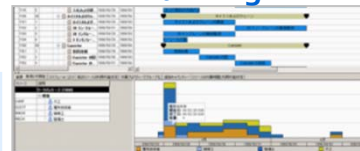


Total support after detection, issue RCA and maintenance support

Digital Twins



Optimized Maintenance Planning



Integration of Several Power Plant

Asset Management Linkage

1. Plant Availability Improvement Solutions (3/6) :

Performance Monitoring - Build thermal efficiency model and monitor performance online

ENGデータ



- Heat balance chart
- GT Curve
- Turbine
- Condenser
- etc

Creation

Plant Model



Plant model

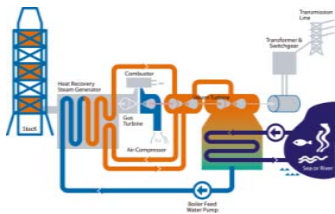
Model-based performance data

Compare

Actual performance data

Operation Data

Thermal power plant



Online Performance Monitoring

Monitoring Screen

※This sample only
Values are different from Mikawa Power Plant



現在値	期待値	期待値との差
215.0 MW	220.9 MW	-5.9 MW
10,694.0 kJ/kWh	10,308.9 kJ/kWh	427.1 kJ/kWh
2,260.4 t(SI)/h	2,232.0 t(SI)/h	28.4 t(SI)/h
623.1 °C	610.6 °C	12.5 °C

Actual Data

Model Results
(Expected value)

Deviation

1. Plant Availability Improvement Solutions (4/6)

Abnormality Detection using Big data Analysis - Build a monitoring model based on historical data, detect abnormalities before reaching a fatal failure

Select monitoring targets

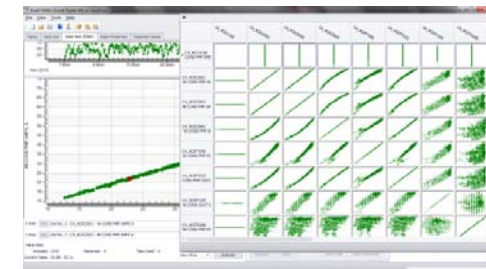


- Generator output
- Main steam pressure
- Exhaust gas temperature
- IGV opening degree
- Condenser vacuum degree
- Bearing temperature

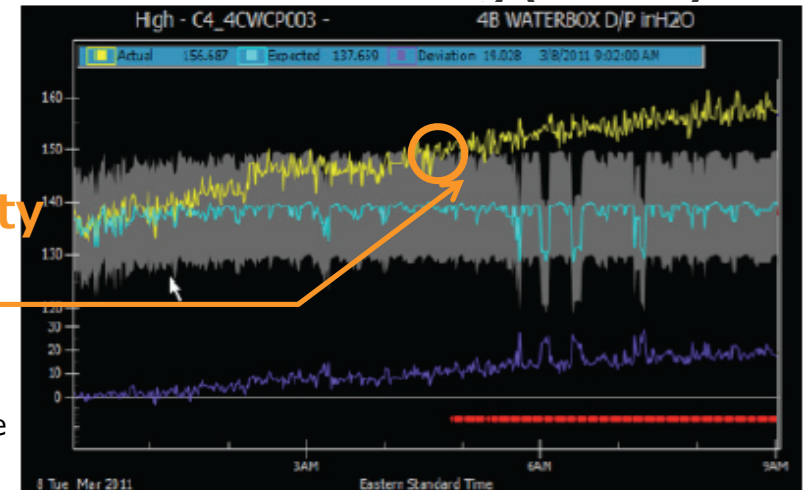
Upload healthy condition historical data



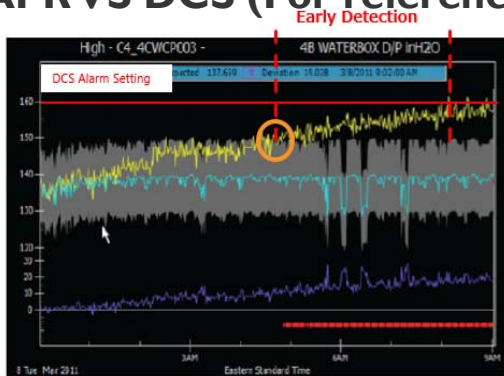
Define monitoring model from correlation



Real Time Monitoring (Online)



APR VS DCS (For reference only)



DCS has fixed value.

APR builds the model from historical data (Normally 1 year data) and change accordingly to operation change. The model combines different scenario of operation (Example full load, partial load), then detect deviation at early stage.

Abnormality Detection

— : Current Value
— : Ideal Value

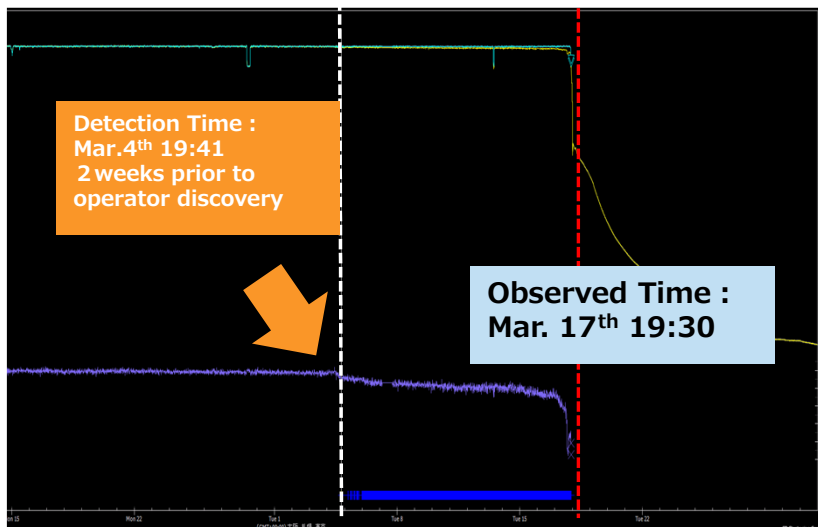
— : Current Value — : Ideal Value

1. Plant Availability Improvement Solutions (5/6)

Abnormality detection cases through Joint research with Tohoku Electric Power Co Inc
Analysis shows that model can detect abnormality before plant operator can detect

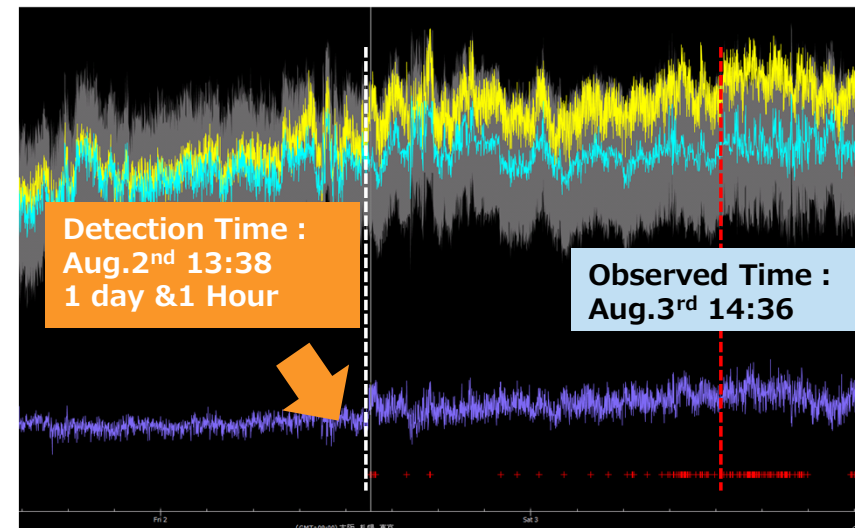
- ◆ further improvement to power plants thermal efficiency
- ◆ Verifications are underway to introduce cutting-edge digital technologies

Example 1: High-pressure feed water heater leakage



Reduce the feed water temperature at the inlet of the next stage high-pressure feed water heater
Detected about **2 weeks before** operator discovery

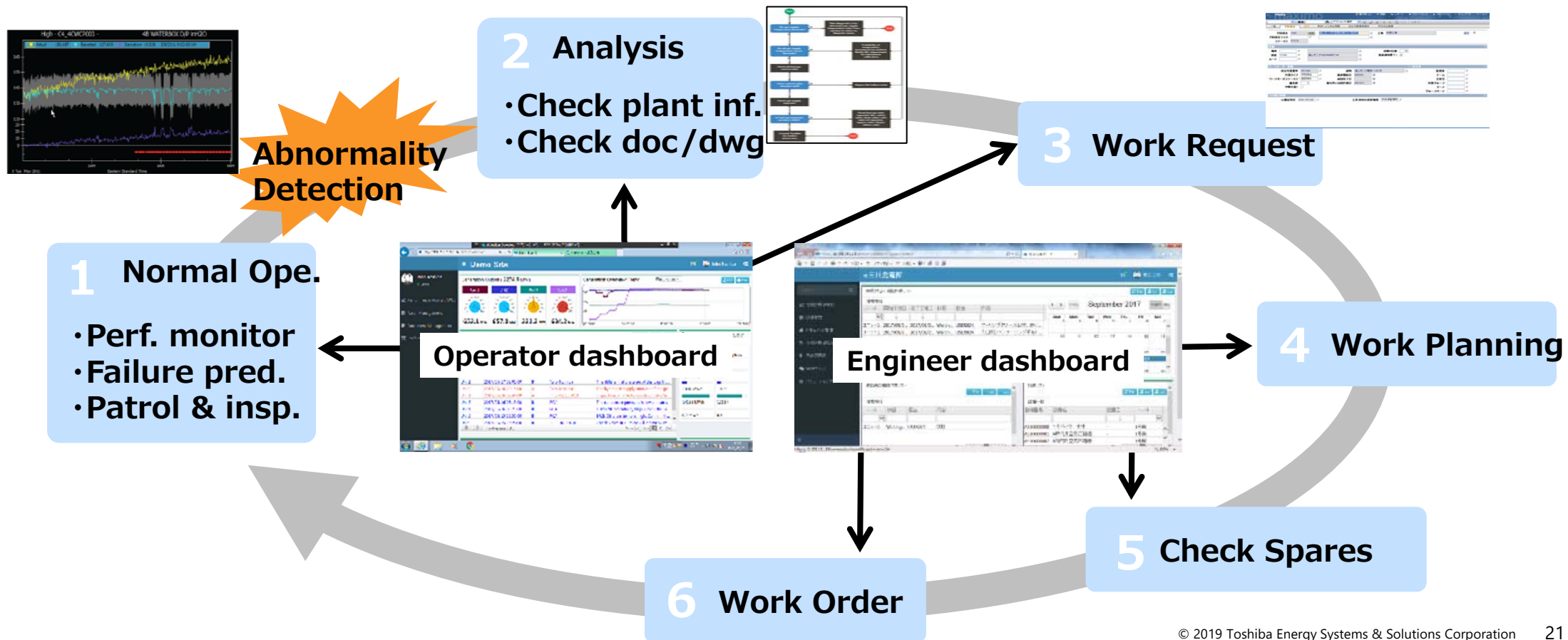
Example 2: Air preheater differential pressure rise



Air preheater secondary air differential pressure deviates from threshold lower limit
Detected **1 day & 1 hour** before operator discovery

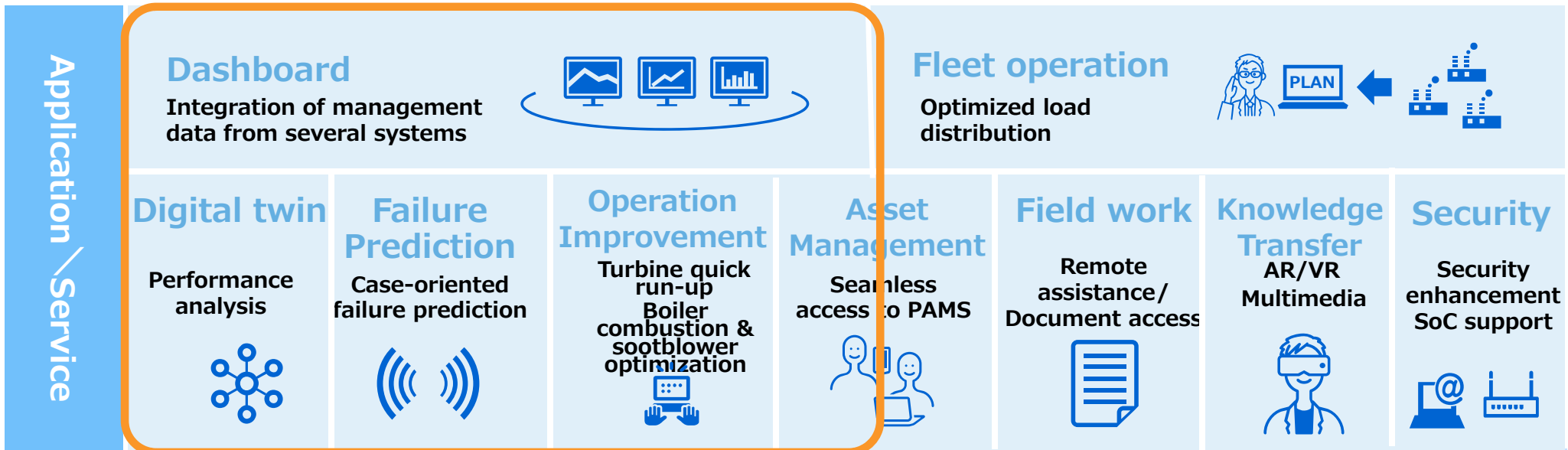
1. Plant Availability Improvement Solutions (6/6)

Plant Life cycle support -
Seamless data linkage of plant operations from abnormality detection to maintenance



2. Plant Operation Improvement Solutions (1/4)

Analyzing operation data , providing solutions with the technical capabilities



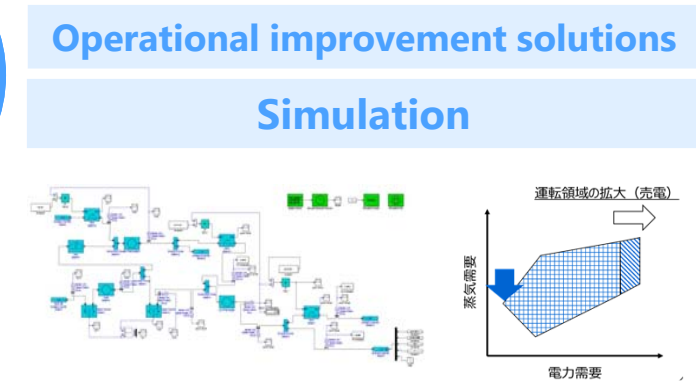
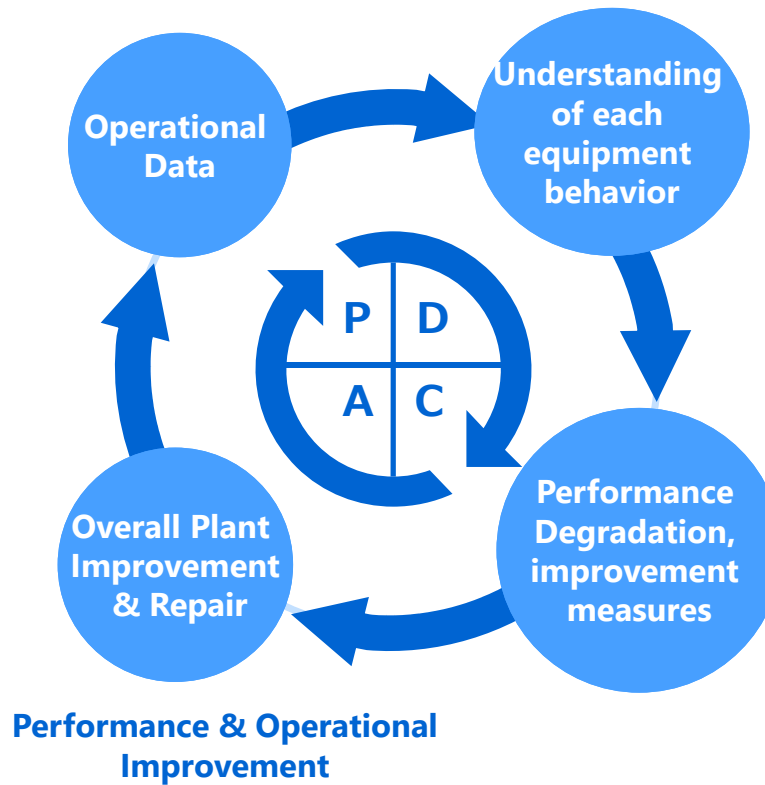
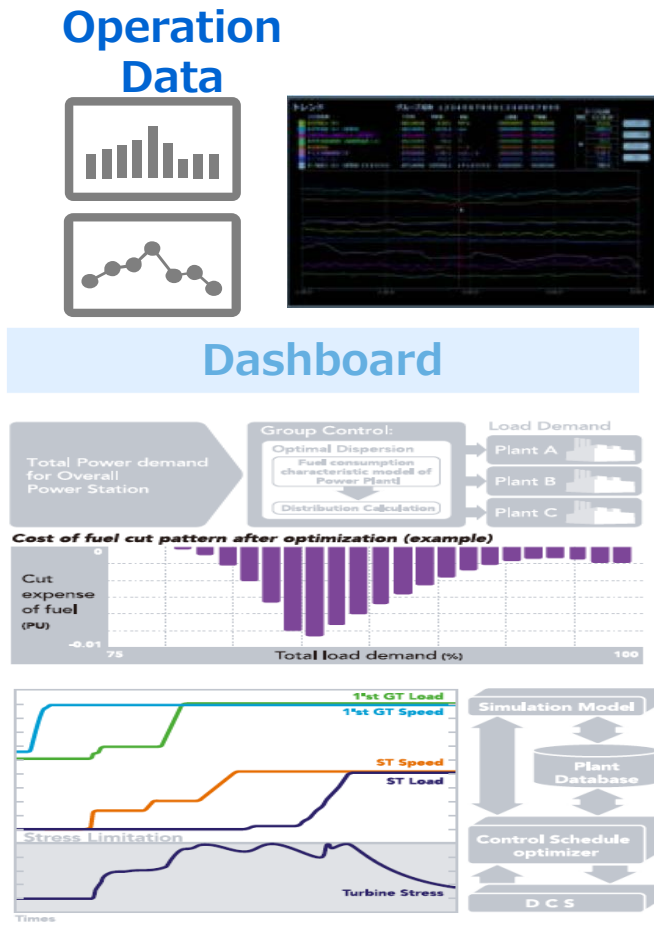
Total Life Cycle Solutions

1. Plant Availability Improvement Solutions
2. Plant Operation Improvement Solutions
3. Plant Modernization Solutions
4. Total Value Chain Optimization Solutions



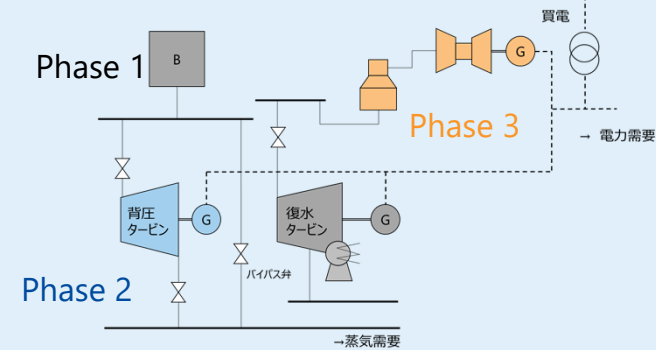
2. Plant Operation Improvement Solutions (2/4)

Improve power plant value through operational data analysis

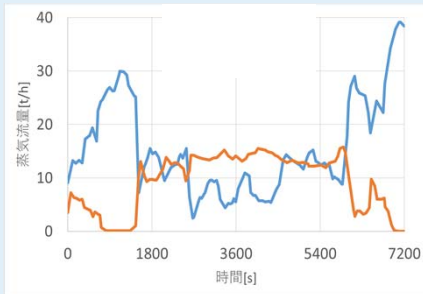


2. Plant Operation Improvement Solutions (3/4)

Redesign the heat balance of the ageing plant to improve efficiency and maximize output

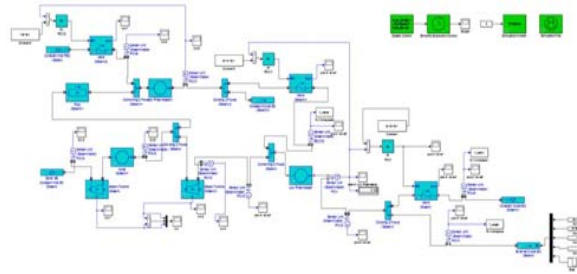


Renewed Plant

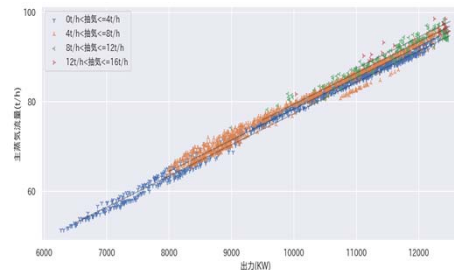


Demand Fluctuation

Simulate plant optimization based on actual plant operation



Dynamic Simulation



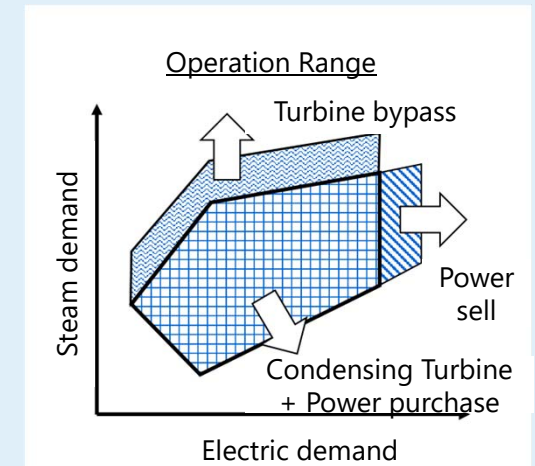
Generate & Understand Trends

Redesign heat balance cycle for plant optimization

Operation Change

Optimized heat balance
Fuel cost reduction

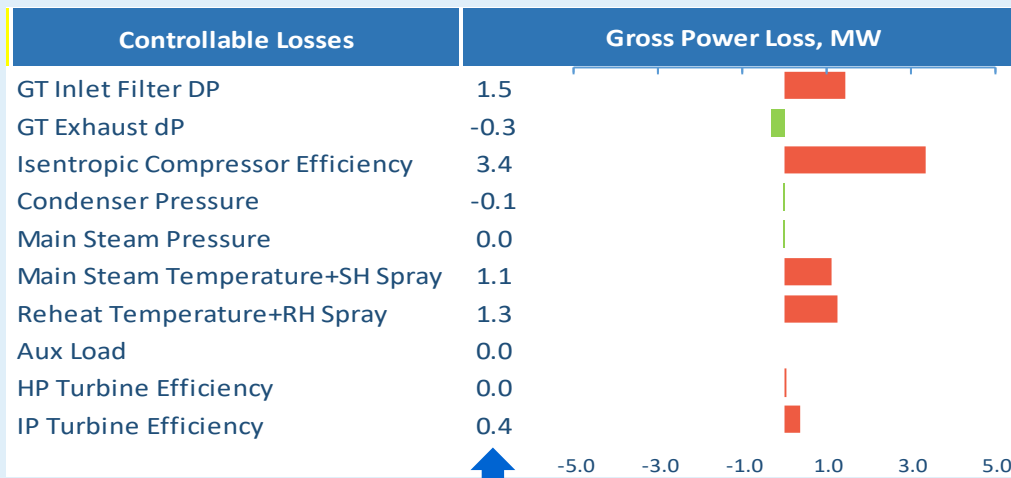
Effective use of waste heat



2. Plant Operation Improvement Solutions (4/4)

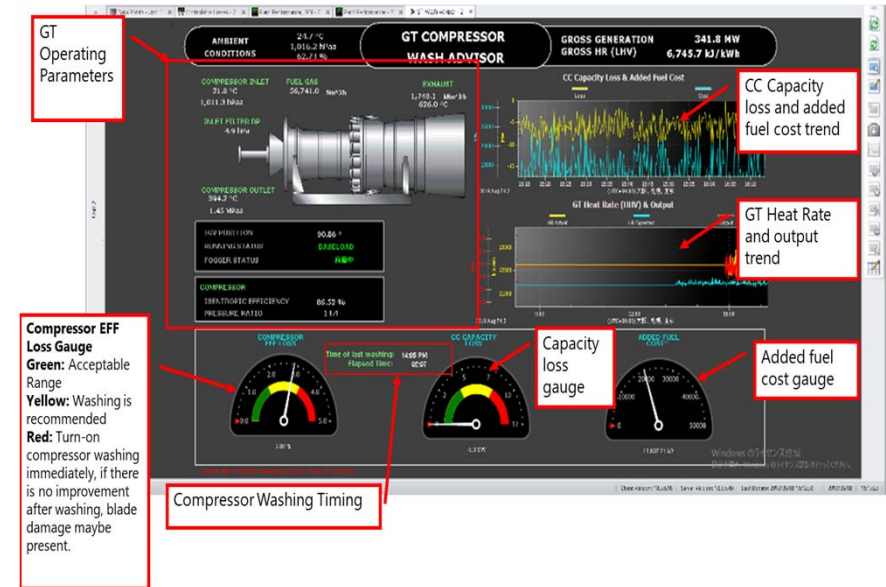
Case study - Examples of improving plant efficiency through offline data analysis

- Uses offline data model to analyze plant performance, such as compressor efficiency, steam leak, etc.
- Confirm potential improvement before actual implementation



6.78 MW Potential Improvement

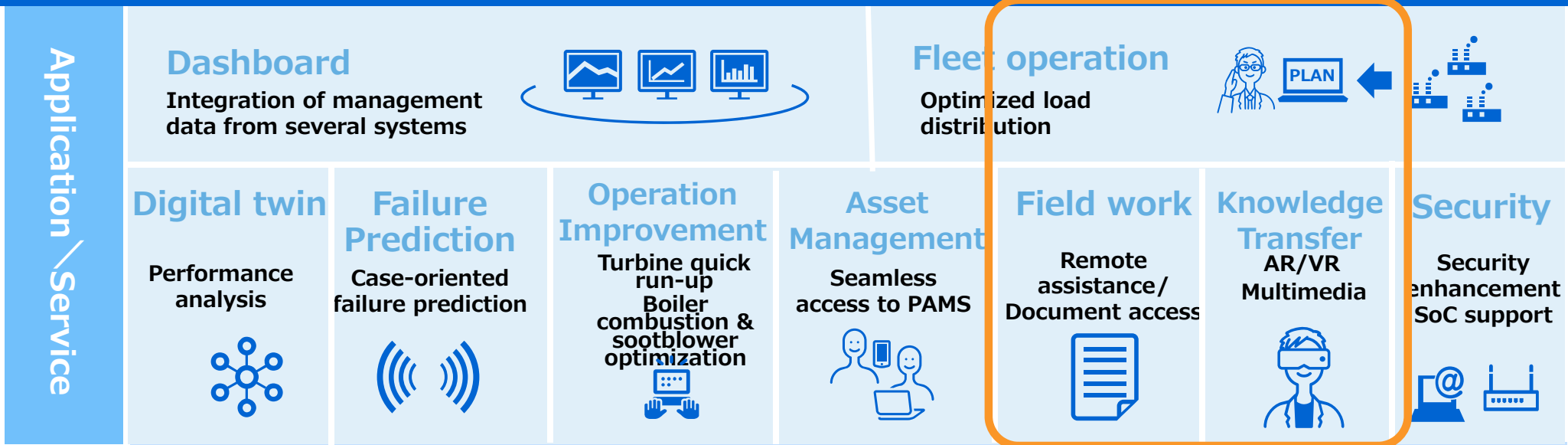
- Propose solution to each potential improvement



Compressor performance improvement (Online Washing Advisor)

3. Plant Modernization Solutions (1/5)

Renew power plant through digital technology



Total Life Cycle Solutions

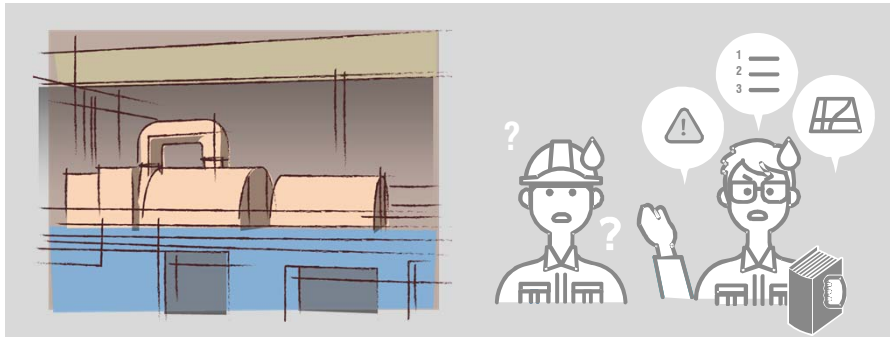
1. Plant Availability Improvement Solutions
2. Plant Operation Improvement Solutions
3. Plant Modernization Solutions
4. Total Value Chain Optimization Solutions



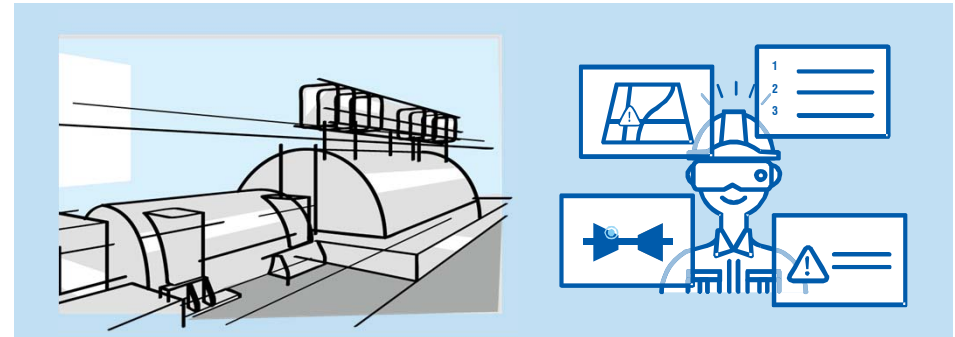
3. Plant Modernization Solutions (2/5)

Renew power plant through digital technology

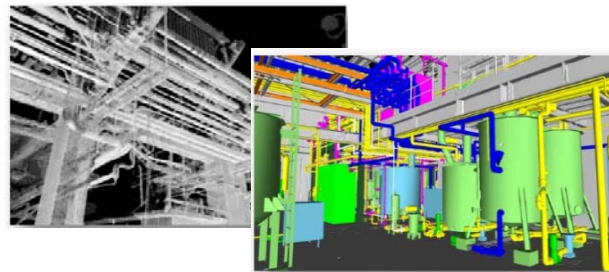
Aging power plants



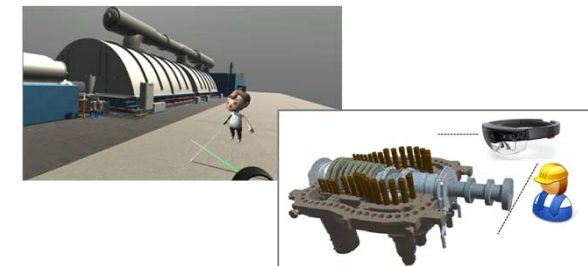
Digital power plants



① Advance inspection



② 3D Data

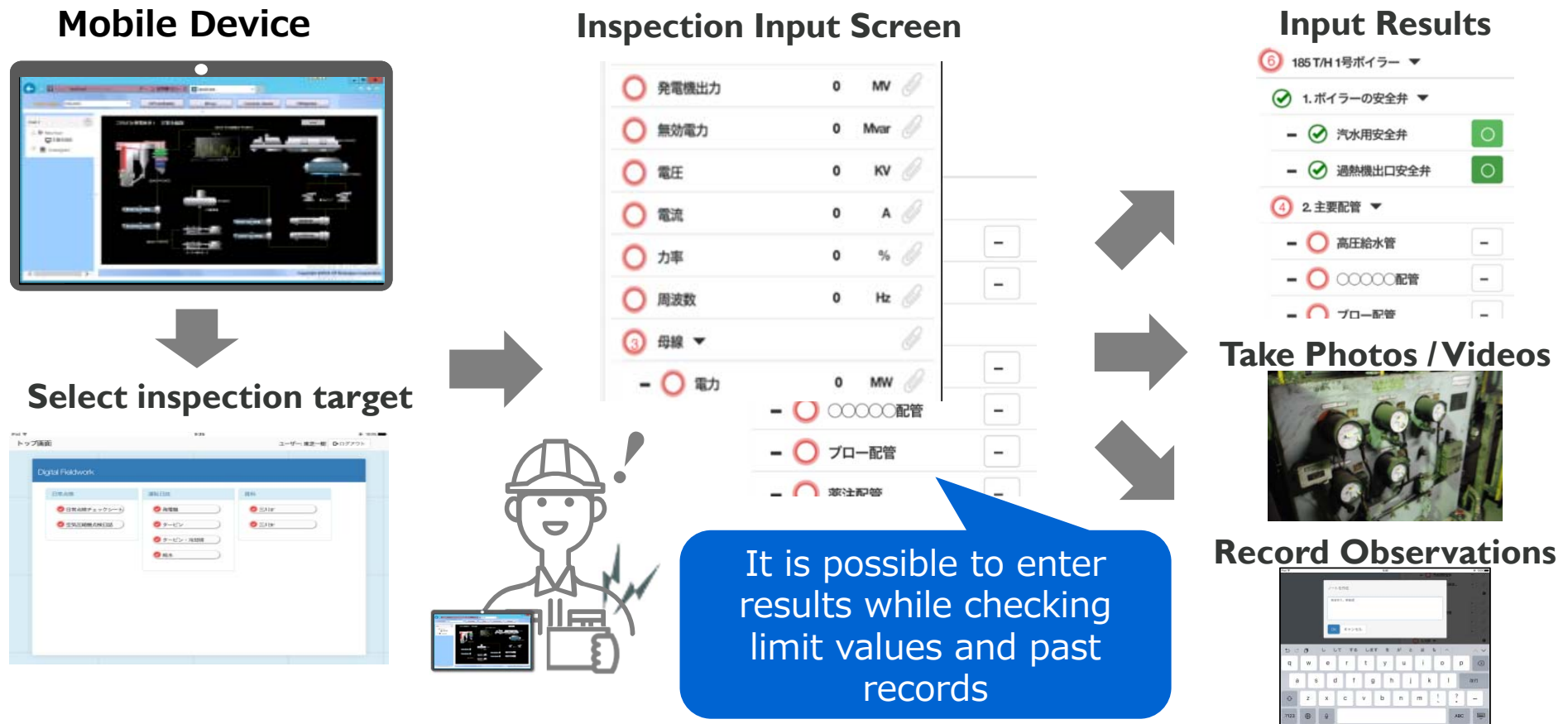


③ Field support & knowledge transfer

3. Plant Modernization Solutions (3/5)

① : Mikawa Power Plant- Patrol Inspection, instrument reading

Daily inspections are recorded on mobile devices and uploaded as digital data



3. Plant Modernization Solutions (4/5)

② : Drone Utilization

Simple package from 3D laser capture to whole digitalized image

Basic Flow

3 D Laser



Drone Route



Drone shooting



Display

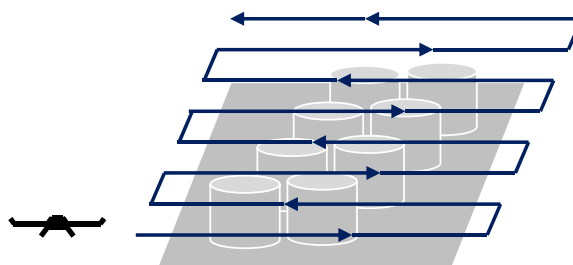


Generate flight routes, perform actual flight, and visualize by 3D model

Characteristic

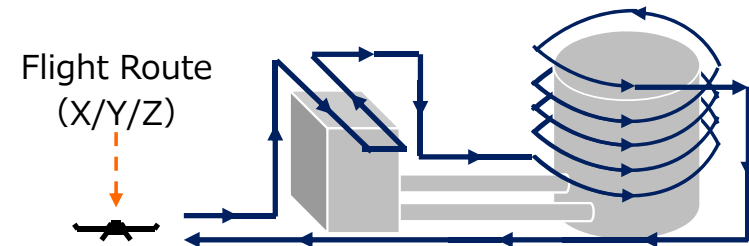
< General drone flight >

Simple pattern flight (landscape)



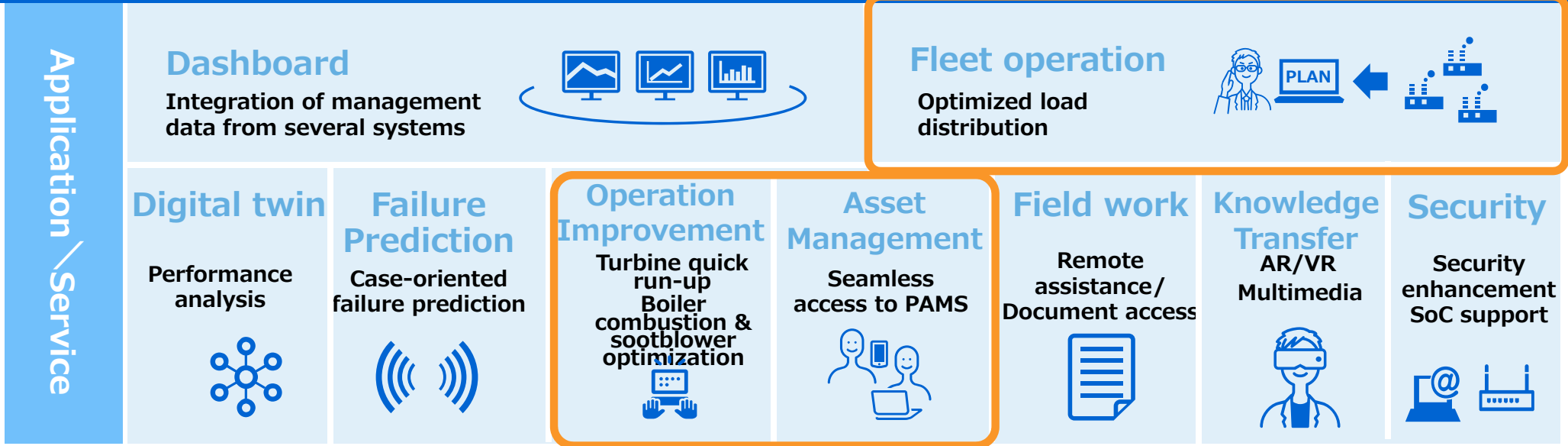
< Developed drone flight >

Close flight and shooting along the object



4. Total Value Chain Optimization Solutions (1/7)

Support various decision constrain with prediction & optimization



Total Life Cycle Solutions

1. Plant Availability Improvement Solutions
2. Plant Operation Improvement Solutions
3. Plant Modernization Solutions
4. Total Value Chain Optimization Solutions

High Performance DB

Data link by information model

Solution-ready - Utilizing engineering data

Open API

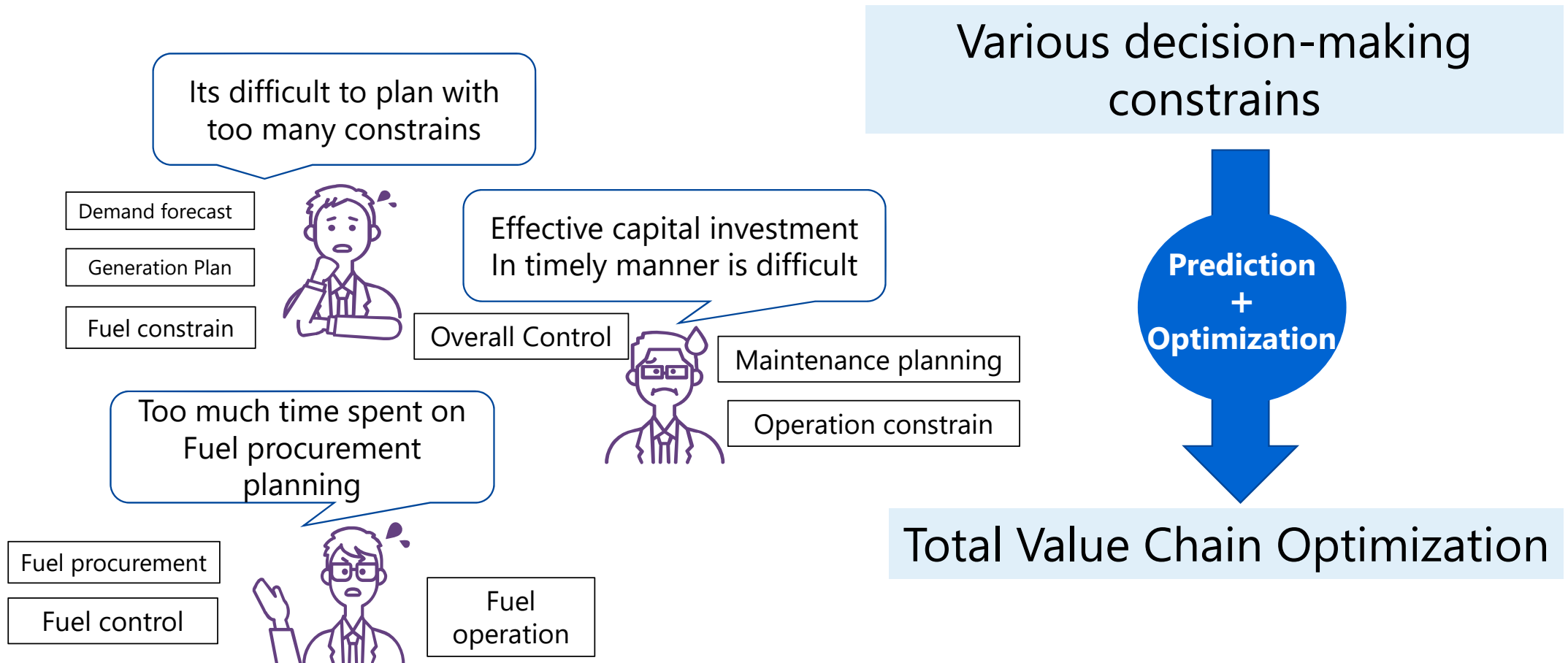
Data link between components

Components

HMI framework

4. Total Value Chain Optimization Solutions (2/7)

Support various decision constrain with prediction & optimization

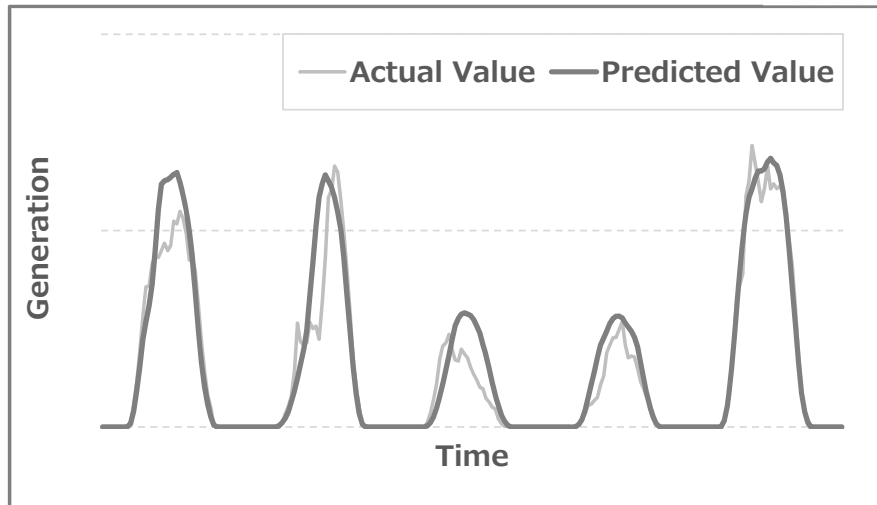


4. Total Value Chain Optimization Solution (3/7)

Prediction technology - Combining weather forecast and AI, predict PV output precisely

Awarded Grand Prix Prize in Technical Competition
for PV output prediction 『PV in HOKKAIDO』
(Cosponsored by Tokyo Electric Power Co. and Hokkaido Electric Power Co.)

Grand Prix Award 



Predicting the amount of power generation
at each PV site

『"Electricity demand forecast contest"』
(Tokyo Electric Power Company Holdings, Inc.)

Winning the highest award 

Point
1

Unique Weather forecasting technology
To generate highly accurate forecasting data
Utilizing various physical data obtained from
Toshiba's unique weather forecasting system

Point
2

Utilizing multi-point weather forecast data
Sparse modeling technology
Prediction technology for PV condition with AI has
been developed

Point
3

Deep learning predictions
Ensemble learning technology

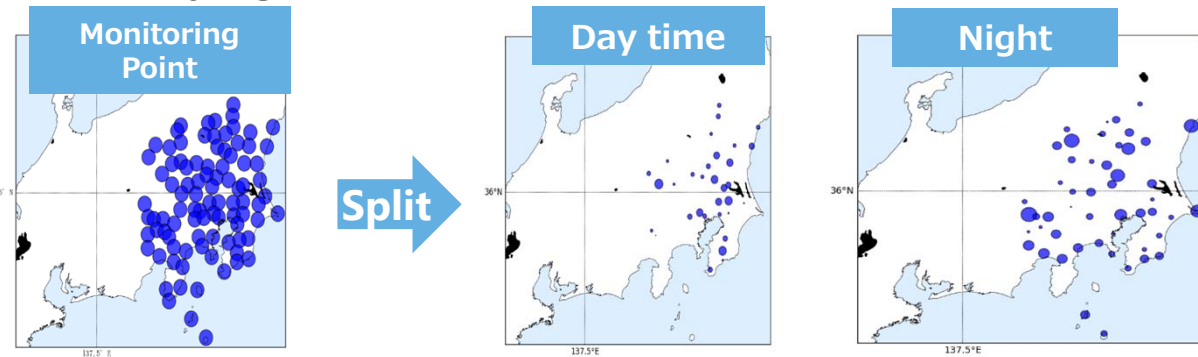
4. Total Value Chain Optimization Solutions (4/7)



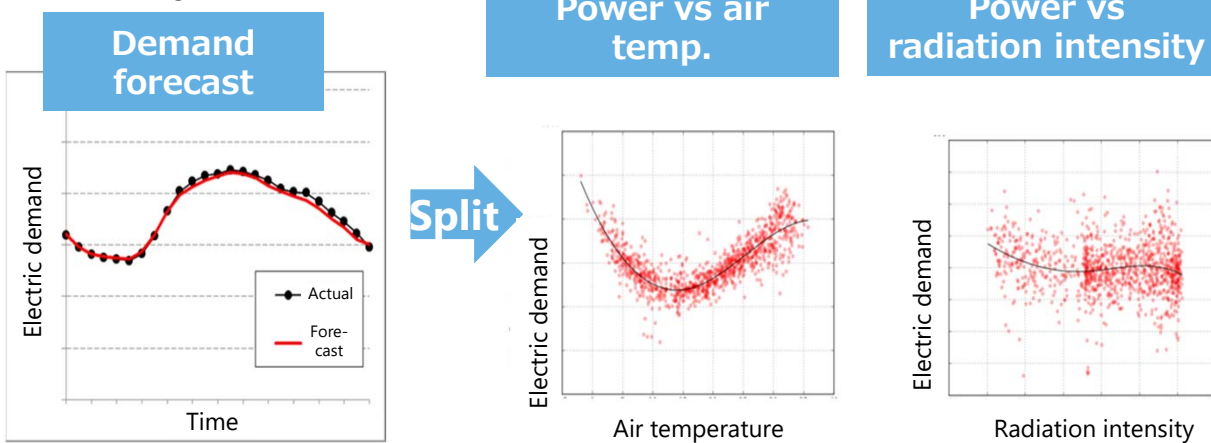
Prediction Technologies - Use Sparse modeling, Ensemble learning for Weather and Demand forecasting



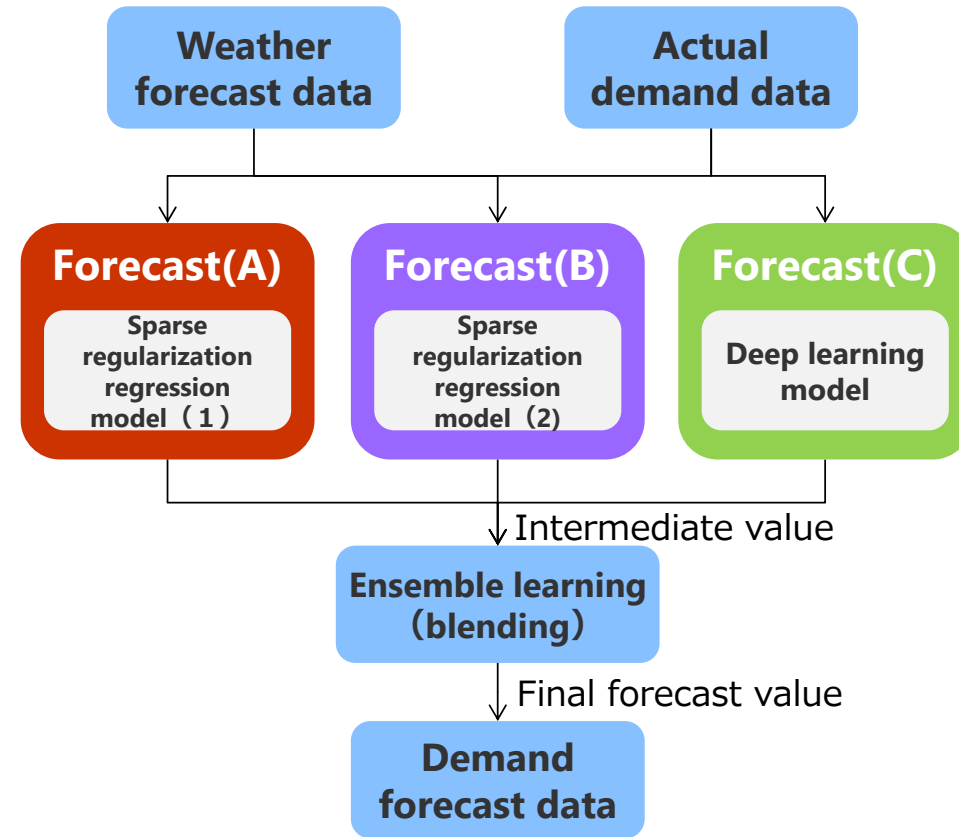
Classify significant areas



Classify Demand



Improve forecast accuracy by blending results of models

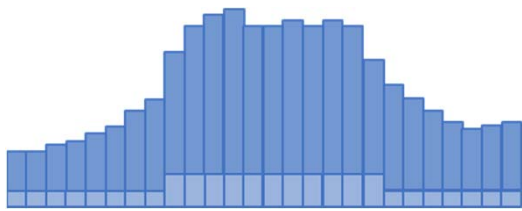


4. Total Value Chain Optimization Solution (5/7)

Optimization algorithm is applied for solution

Ex. : Optimized load distribution for hundreds of thermal units

Demand forecast



Constraints

Fuel storage



Statistic/dynamic characteristics

Generating units



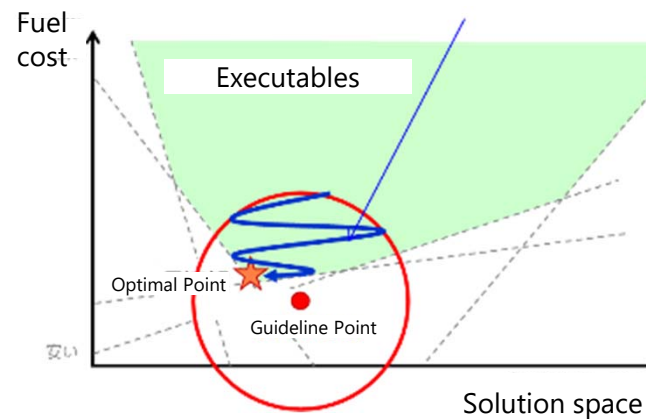
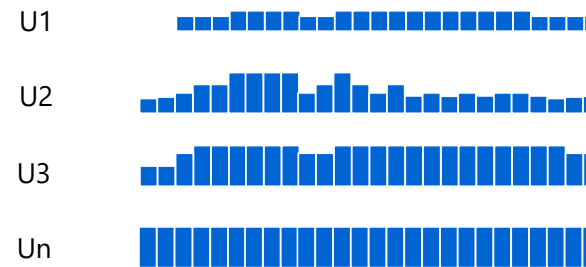
Outage, MW restriction, Reserve capacity

Delivery ship



Electric market

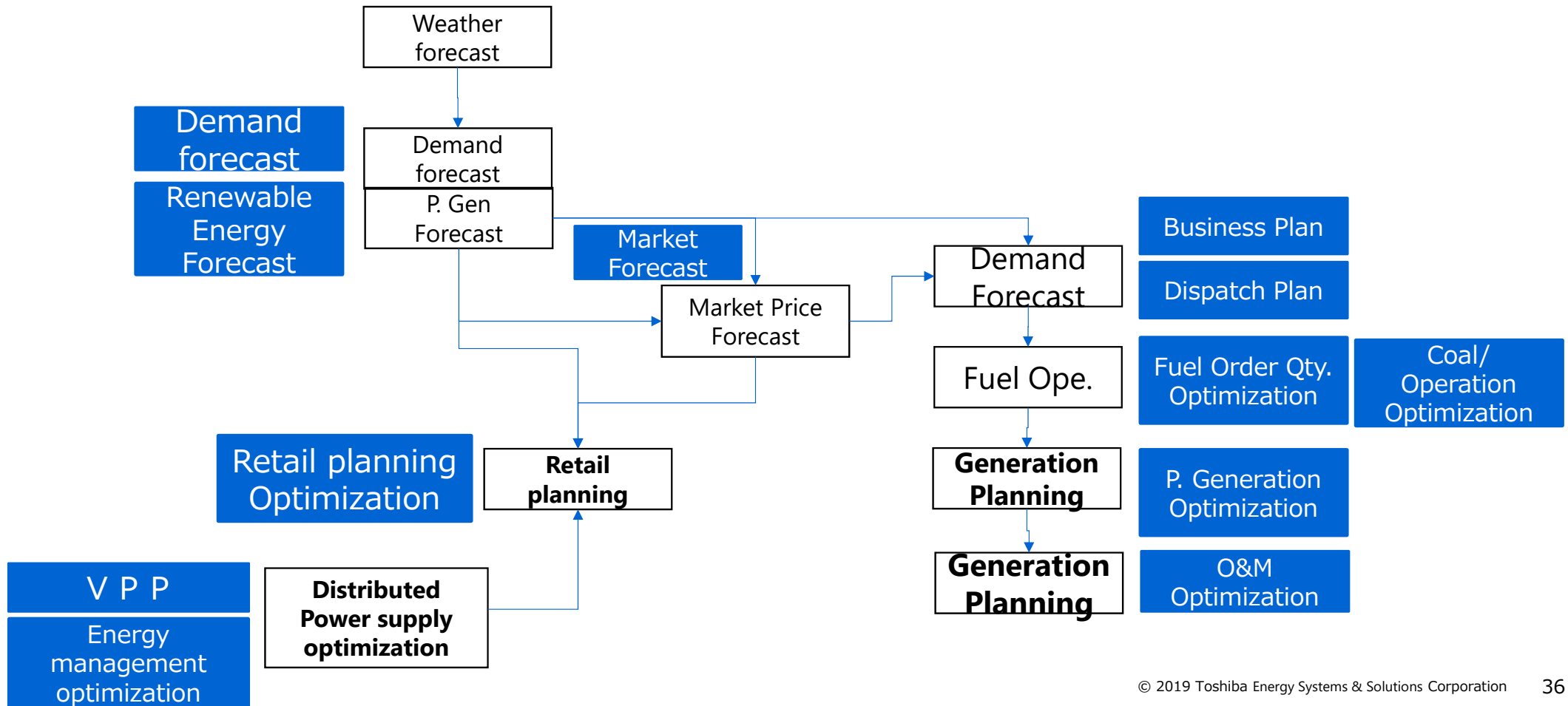
Load Distribution



An algorithm was developed to solve large scale optimization calculation within the practical time, without it even super-computer requires huge amount of time.

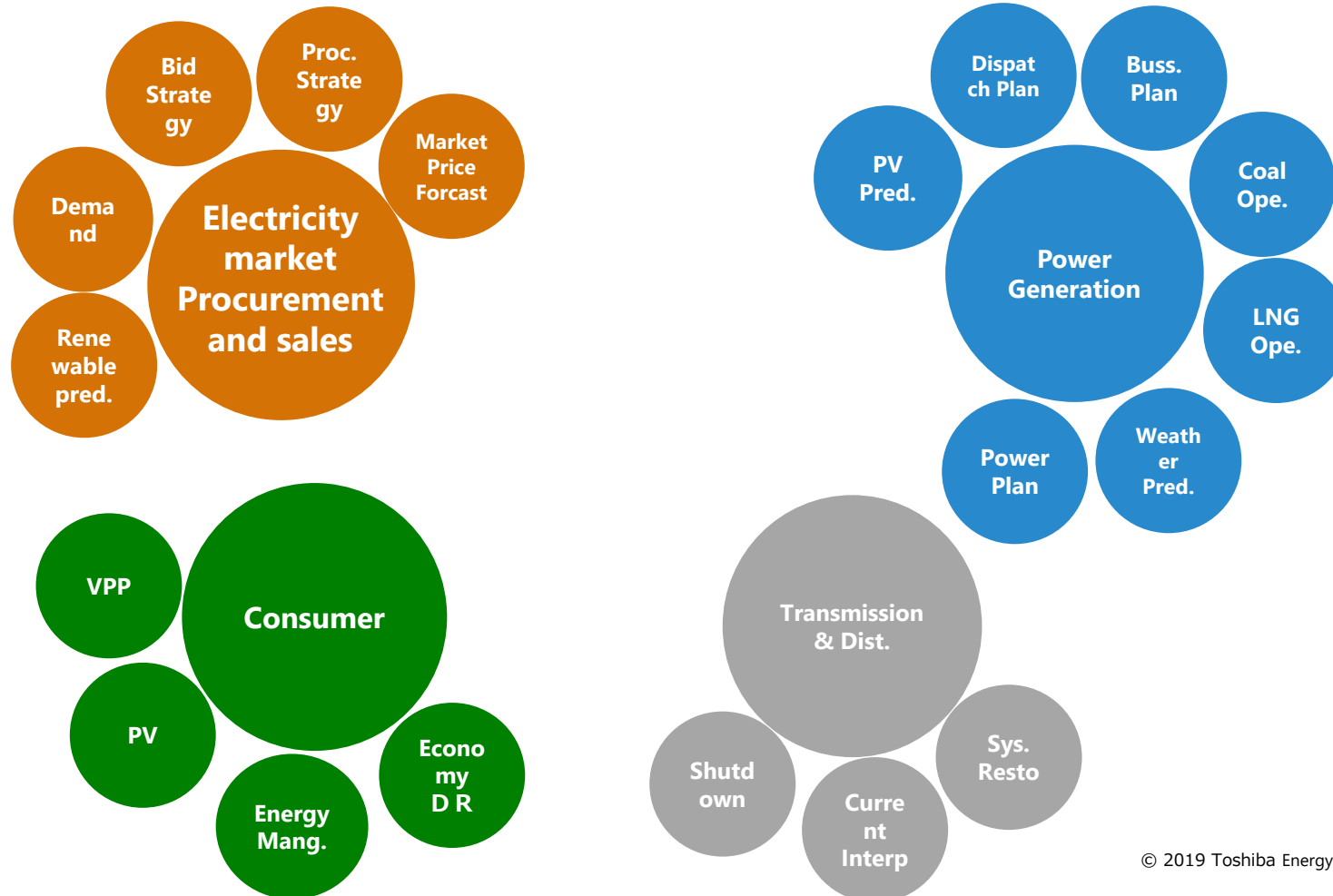
4. Total Value Chain Optimization Solutions (6/7)

Total Value Chain Optimization through optimized forecasting and advance technologies



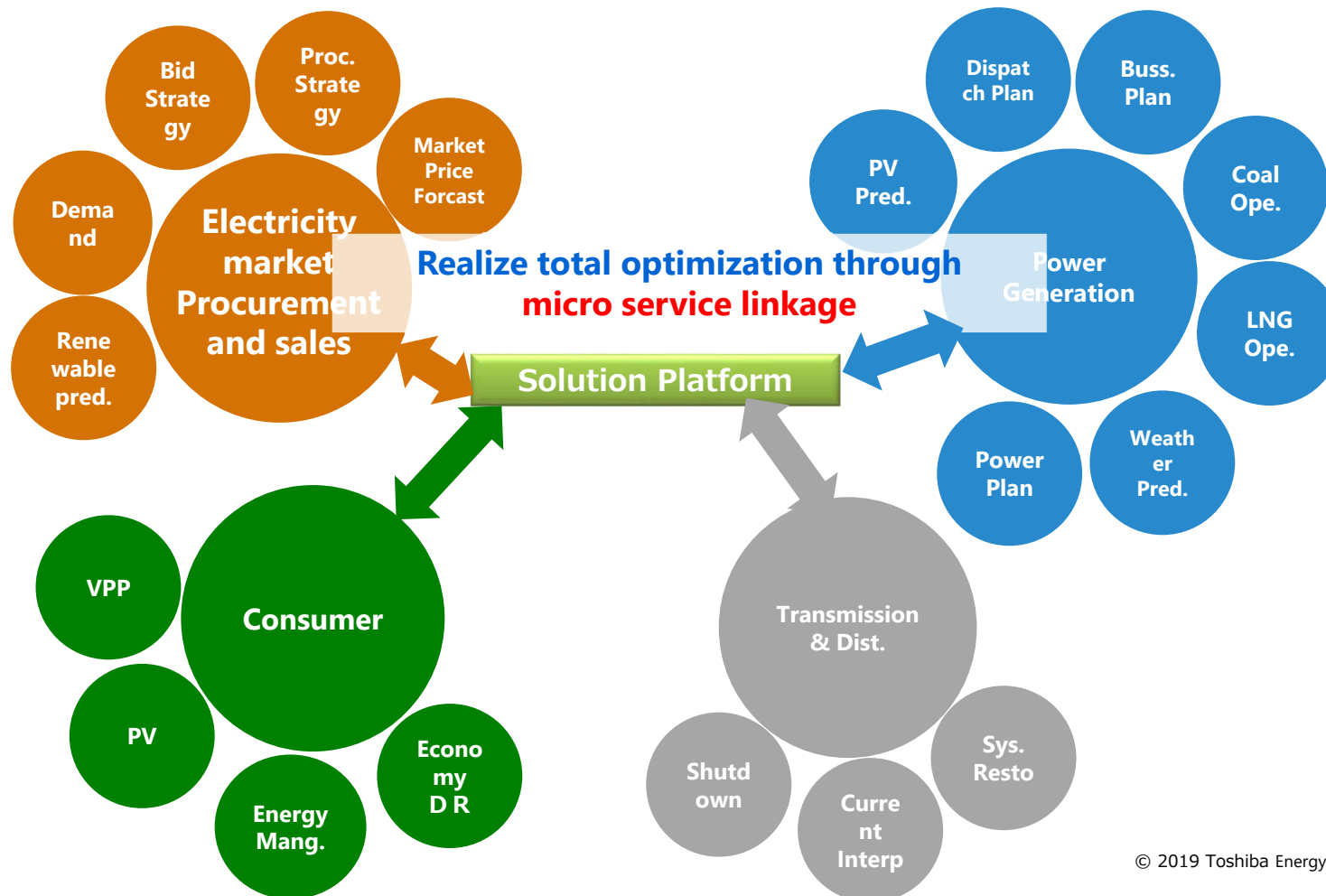
4. Total Value Chain Optimization Solutions (7/7)

Total Value Chain Optimization through optimized forecasting and advance technologies



4. Total Value Chain Optimization Solutions (7/7)

Total Value Chain Optimization through optimized forecasting and advance technologies



TOSHIBA

Thanks for your attention

