Realizing the Industrial Automation Revolution by i³-Mechatronics

June 6, 2024

YASKAWA ELECTRIC CORPORATION

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YASKAWA

1. Materializing i³-Mechatronics

i³-Mechatronics Concept

Solutions to Materialize i³-Mechatronics

1. Materializing i³-Mechatronics   - i³-Mechatronics Concept -

The smart factory where i³-Mechatronics is realized

i³-Mechatronics
アイキューブ メカトロニクス

② intelligent
Analyzing and learning (AI) using data from production sites

③ innovative
Improving productivity through technological innovation

ERP/SCM
Enterprise resource planning
Supply chain management

Data Center /Cloud

Feedback

MES
Manufacturing Execution System

Cloud / FOG

Data Analysis Area

Utilization and analysis using "big data"

Model generation and learning

Accumulation of knowhow

①-3 integrated
Cooperation between FA and IT

data delivery

model delivery

Feedback

Data area

Real-time data collection & real-time execution

Digital data management

+

Production automation

System management and control master

Converted into physical motion

①-2 integrated
Connecting production sites with data

Cell System (Assembly, Processing, etc.)

Parts supply

Shipping

①-1 integrated
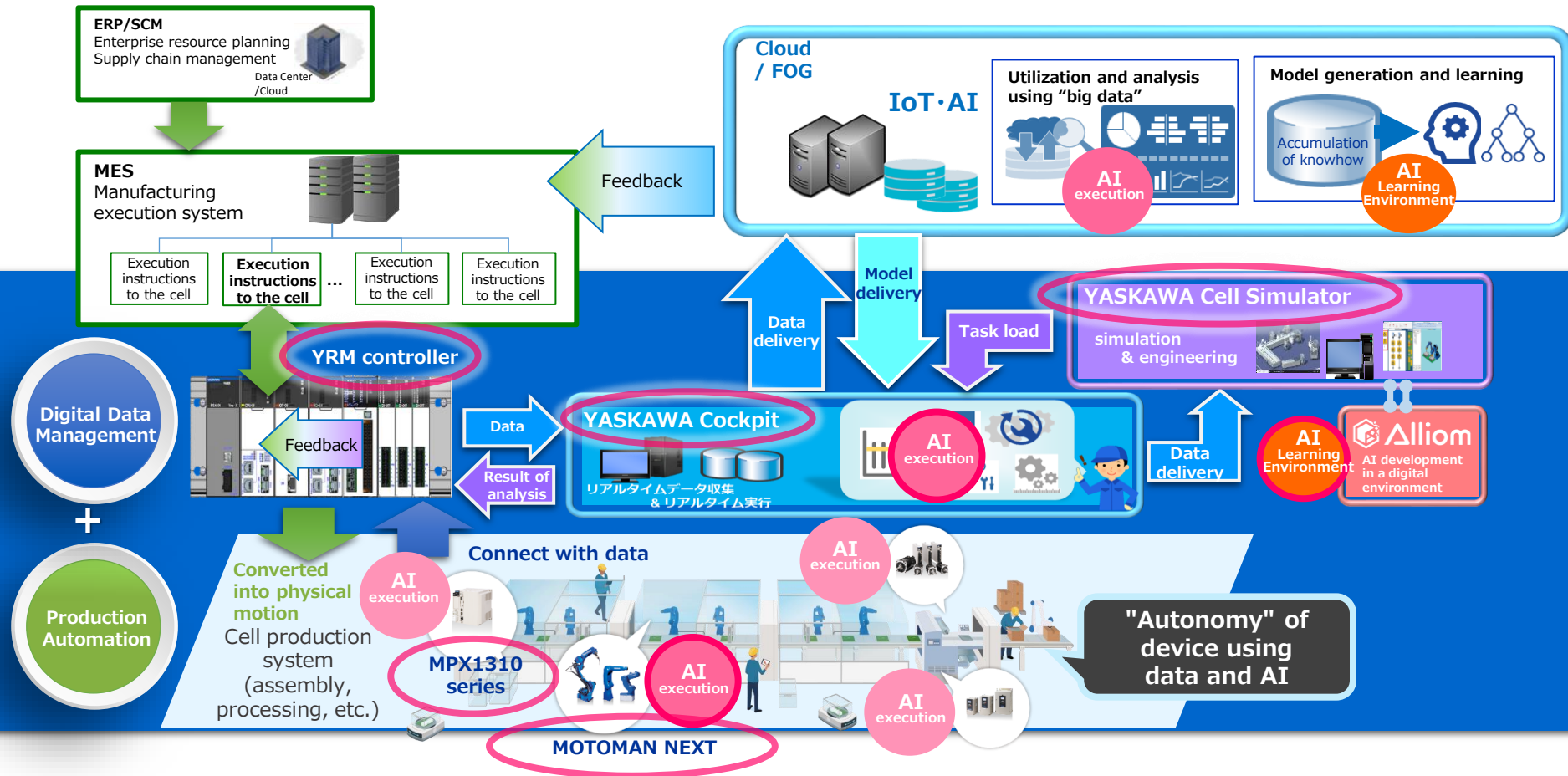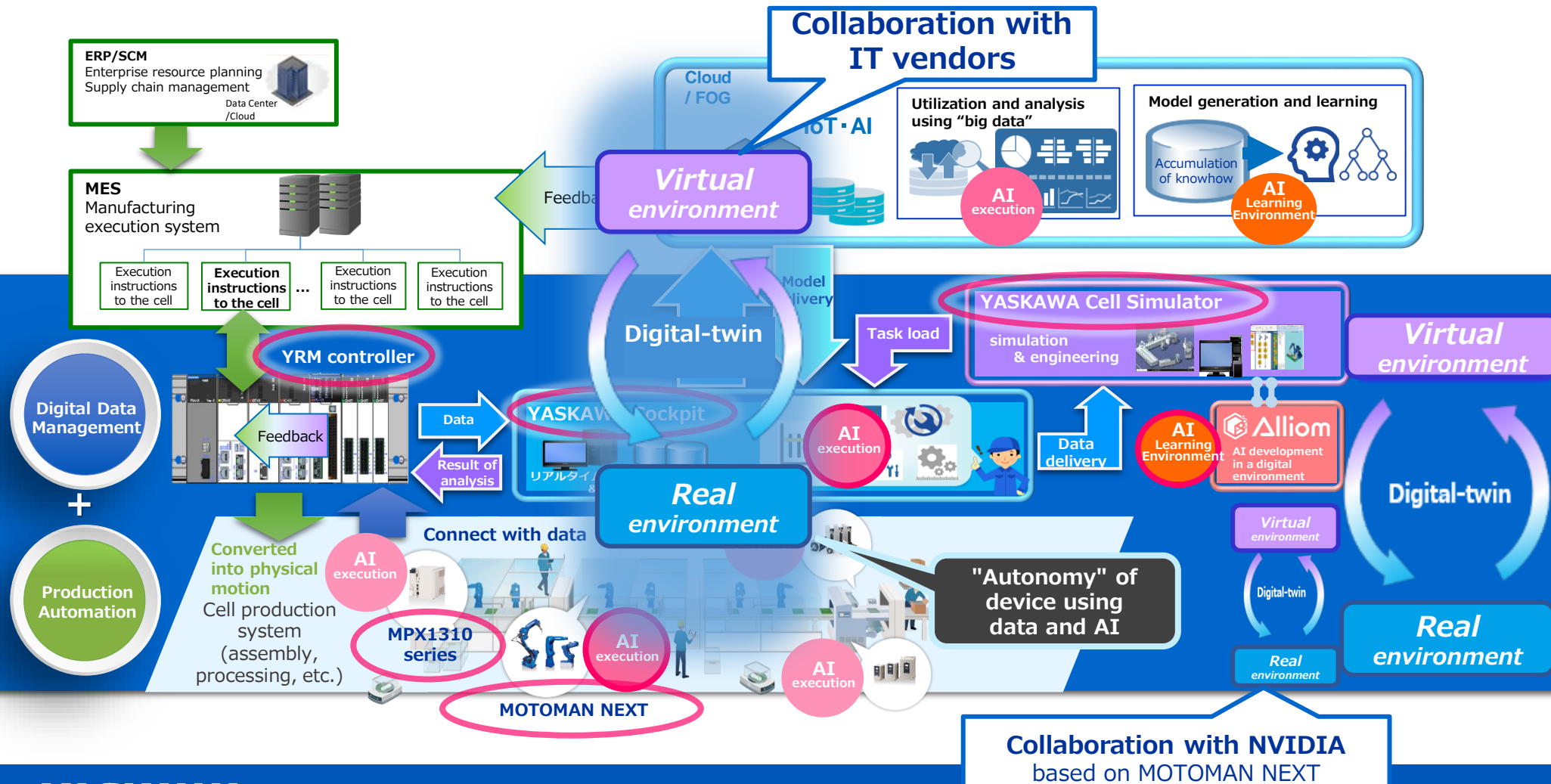Integrating components and processes at production sites

1. Materializing i³-Mechatronics - Solution to materialize i³-Mechatronics -

Products to realize i³-Mechatronics ➡ key solution

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Products to realize i³-Mechatronics ➡ key solution

ERP/SCM
Enterprise resource planning
Supply chain management
Data Center /Cloud

MES
Manufacturing execution system

Execution instructions to the cell | **Execution instructions to the cell** | ... | Execution instructions to the cell | Execution instructions to the cell

YRM controller

Digital Data Management

+

Production Automation

Feedback

Converted into physical motion
Cell production system (assembly, processing, etc.)

AI execution

MPX1310 series

MOTOMAN NEXT

AI execution

Connect with data

Data

Result of analysis

YASKAWA Cockpit
リアルタイム

Real environment

AI execution

Collaboration with IT vendors

Cloud / FOG

IoT・AI

Virtual environment

Feedback

Utilization and analysis using "big data"

AI execution

Model generation and learning

Accumulation of knowhow

AI Learning Environment

Model Delivery

Digital-twin

Task load

YASKAWA Cell Simulator
simulation & engineering

Data delivery

AI Learning Environment

Alliom
AI development in a digital environment

"Autonomy" of device using data and AI

Virtual environment

Real environment

Virtual environment
Digital-twin
Real environment

Digital-twin

Virtual environment

Real environment

Collaboration with NVIDIA
based on MOTOMAN NEXT

2. Realizing i³-Mechatronics

Expanding the Field of Automation by Using AI -*i*ntegrated-

« Example of factory automation » Initiatives with Suntory

Suntory News Release   Excerpt and summarized (Nov. 30, 2023)

Began full-scale technical verification with the aim of automating raw material handling operations at factories

-Reduce the burden on workers, shift to higher-value-added operations,
and improve the quality of our products and services -

· Started verification of technology for handling raw materials of various sizes and packaging forms in a single device using AI with Yaskawa Electric

· Digitalizing the human senses and judgment when handling raw materials, and AI identifies the size and packaging form of raw materials in real time, and judge the grasping position and unpacking method

· Largely promotes automation by accurately handling raw materials in various forms of packing using a single device

> Through the use of technology that combines data, robots and AI, we will work on fundamental work style reforms at manufacturing sites and aim to create additional value.

Mr. Atsushi Yoshioka,
Executive Officer, Division COO, D&P Planning & Development Department
Engineering Department
Suntory Holdings Limited

2. Practice of i³-Mechatronics
- Expanding the Field of Automation by Using AI –*i*ntegrated -

« Example of automation of manual work » Removing transparent cups
AI recognition enables automation

The work of supplying cups to a printing machine and boxing the printed cups

[In the past]
Manual work for putting cups into equipment and packing them in boxes

To realize automation, it is necessary to "remove till the last cup"

AI is essential to recognize deformed (bent) cups ➡ enables automation

Robot that uses AI to take out cups stacked in cardboard boxes

AI

Recognize by AI

Can be grasped because of AI recognition

Devices + Human ➡ Devices + Robots = Generating data in the field

Promoting i³-Mechatronics

2. Practice of i³-Mechatronics
- Expanding the Field of Automation by Using AI –*i*ntegrated -

« Example of automation of manual work » Picking of foodstuffs (indefinite objects)

AI recognition enables automation

Removing only one Oden ingredient from the bulk loading condition

[In the past]
Since knotted kelp is easy to tear, it was picked by human

To realize automation, it is necessary to adsorb "knot" of knotted kelp

AI is required to accurately determine only the specific location of an amorphous object ➡ enables automation

Robot that uses AI to accurately pick "knot" of knotted kelp

Kelp

Identified with AI
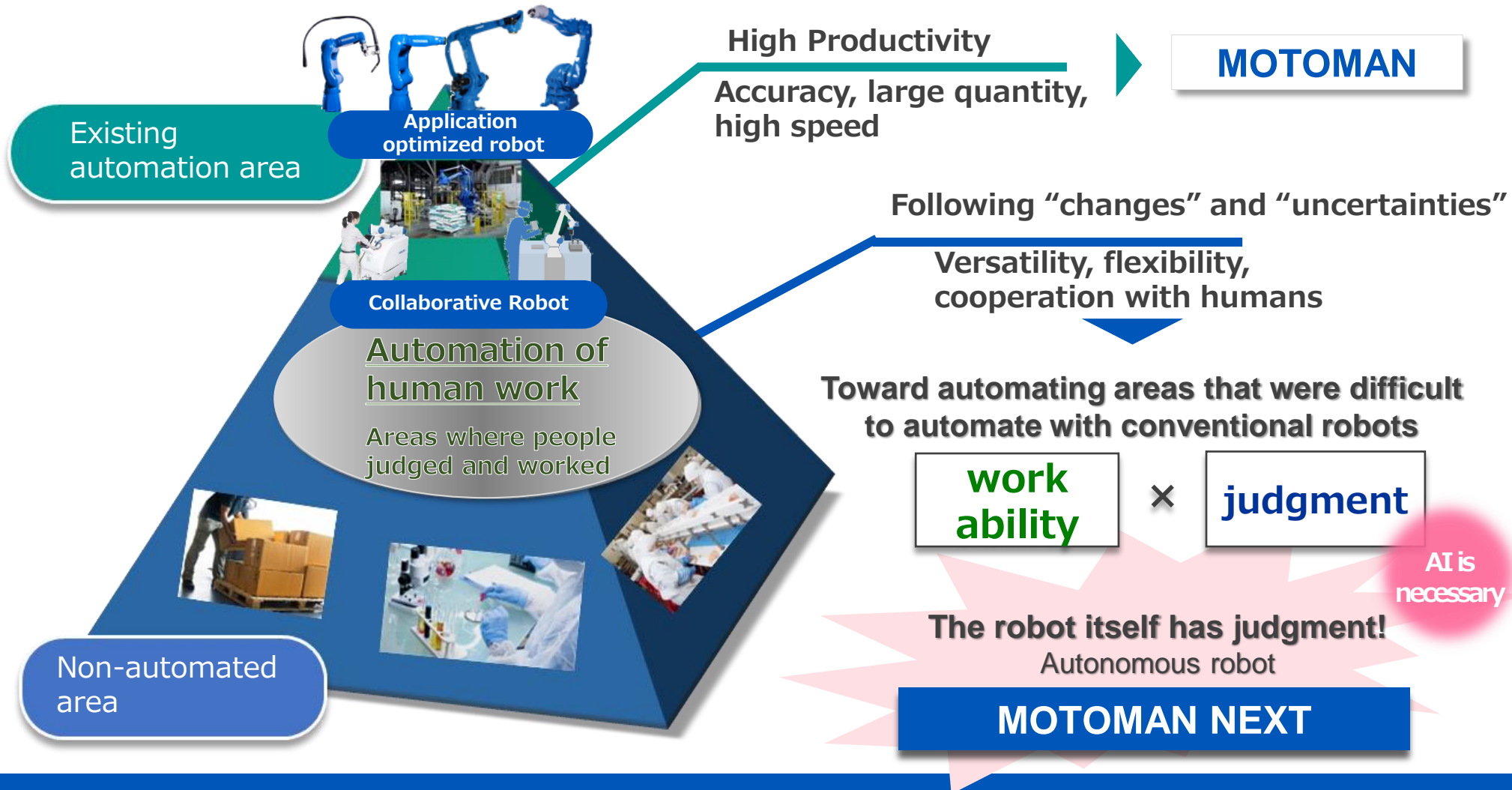
Total automation = connecting data in the field

Promoting i³-Mechatronics

3. Inevitability of Leveraging AI for i³-Mechatronics Expansion

Application to MOTOMAN NEXT

3. Inevitability of Leveraging AI for i³-Mechatronics Expansion - Application to MOTOMAN NEXT -

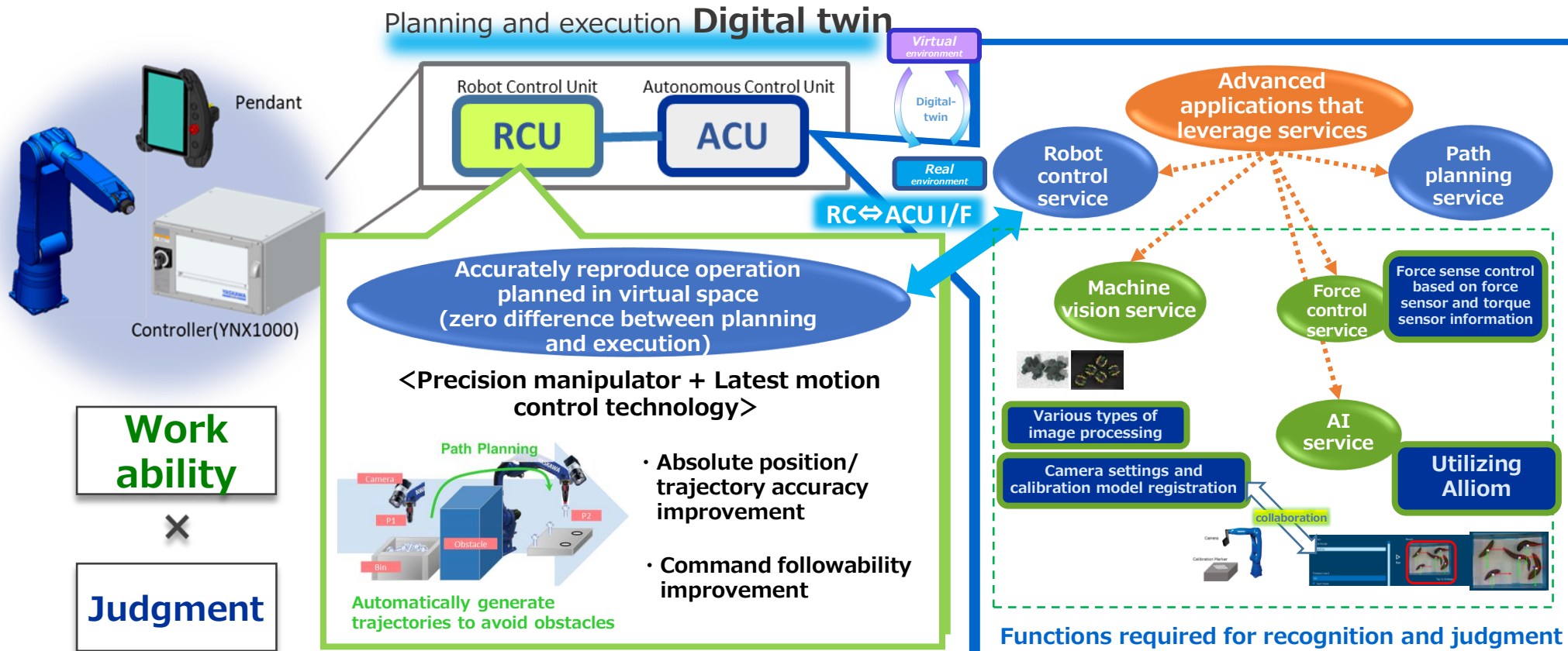**"MOTOMAN NEXT series" are released to expand the automation area!**

High Productivity

Accuracy, large quantity, high speed

MOTOMAN

Existing automation area

Application optimized robot

Following "changes" and "uncertainties"

Versatility, flexibility, cooperation with humans

Collaborative Robot

Automation of human work

Areas where people judged and worked

Toward automating areas that were difficult to automate with conventional robots

work ability × **judgment**

AI is necessary

The robot itself has judgment!
Autonomous robot

MOTOMAN NEXT

Non-automated area

3. Inevitability of Leveraging AI for i³-Mechatronics Expansion
- Application to MOTOMAN NEXT -

Functions required for recognition and judgment are included as standard services in ACU

Functions required for recognition and judgment are standard in ACU as a service

Enable development of user applications utilizing these functions and execute generated autonomous operations with high accuracy

Planning and execution **Digital twin**

Pendant

Controller(YNX1000)

Work ability

×

Judgment

Robot Control Unit — Autonomous Control Unit

RCU — **ACU**

Virtual environment

Digital-twin

Real environment

RC⇔ACU I/F

Accurately reproduce operation planned in virtual space (zero difference between planning and execution)

<Precision manipulator + Latest motion control technology>

Path Planning

Camera
P1
Obstacle
P2
Bin

Automatically generate trajectories to avoid obstacles

· Absolute position/ trajectory accuracy improvement

· Command followability improvement

Advanced applications that leverage services

Robot control service

Path planning service

Machine vision service

Force control service

Force sense control based on force sensor and torque sensor information

Various types of image processing

Camera settings and calibration model registration

AI service

Utilizing Alliom

collaboration

Functions required for recognition and judgment

3. Inevitability of Leveraging AI for i³-Mechatronics Expansion
- Application to MOTOMAN NEXT -

Functions required for recognition and judgment are included as standard services in ACU

Cooperation with AI
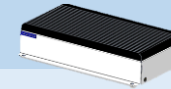Open Innovation

Planning and Execution **Digital Twin**

Controller(YNX1000)

AI

**System Integrator
IT vender
AI venture
Academia**

MOTOMAN NEXT breaks barriers to feasibility

ACU / Linux / Jetson Orin NVIDIA.

Open environment

Wind River Linux WNDRVR

User Application

| Machine Vision Service | Force Control Service | AI Service |

| Path Planning Service | Robot Control Service | ※Included as standard services |

RCU

Motion Control Core

3. Inevitability of Leveraging AI for i³-Mechatronics Expansion
- Application to MOTOMAN NEXT -

Next development using MOTOMAN NEXT as a platform

Cooperation with AI
Open Innovation

Planning and Execution **Digital Twin**

Collaboration with Virtual
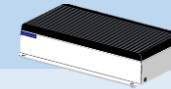Environments
Open Innovation

Controller(YNX1000)

AI

**System
Integrator
IT vender
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User Application

Machine Vision Service	Force Control Service	AI Service
Path Planning Service	Robot Control Service	

※Included as standard services

RCU

Motion Control Core

**Collaboration
with virtual
environments**

Simulation
Technology

AI Technology

Planning technology
·
·
·

**NVIDIA
Isaac Platform** NVIDIA.

·
·

Working with NVIDIA Virtual Environments
Planning and Execution **Digital Twin**

4. Next Generation Manufacturing for i³-Mechatronics Expansion

Motion Generation Using AI

4. Next Generation Manufacturing for i³-Mechatronics Expansion
- Motion Generation Using AI -

Production that matches the things to be made or their completed form

Use AI to generate actions to accomplish tasks based on task goals (= completed form)

« Example » **Task: Removing objects from cardboard boxes**

Open the cardboard Lid
***Even the deformed cardboard**

Open the plastic bag inside the cardboard

Take out the stuff in the plastic bag

MOTOMAN NEXT

Can be automated
Vision + AI + Robot

Cannot be automated
Start/end status is uncertain
The work object is uncertain

Challenging

Can be automated
Vision + AI + Robot

It's not just more processes that can be automated,
it **also secures continuity of data that was previously disconnected.**
Promoting i³-Mechatronics

4. Next Generation Manufacturing for i³-Mechatronics Expansion
- Motion Generation Using AI -

Using AI technology to digitize ambiguous human decisions to expand the automation field
Next, use AI technology to generate motion to complete tasks (= breakthrough in autonomy)

Past to Present

Mass production ➡ Production of goods with stable (forecast of) demand on the variety and quantity

- Production system in which equipment is fixed according to what is made
- Robot motion by teaching and playback
- Quality assurance/motion assurance by repetition accuracy and positioning accuracy

Present to Future

Evolution of production

Digital Twin
Completion of tasks and quality assurance/operation assurance by adding analysis, confirmation, and judgment to data in operation

Autonomous distribution Edge device evolution
A production system in which facilities are "flexibly" adapted to what is made

Transformation of production

Now …
Motion generation by teaching tasks

Next …
Evolution to automatic machines that perform tasks based on task goals (= completed form) rather than task teaching

Motion generation
Leveraging AI

Realization of Unmanned Factory

Unmanned Factory:
A term coined by Yaskawa meaning a **human-centered automation factory** while moving away from manpower dependence. We differentiate it **from "no-man,"** which marginalizes human intervention.