

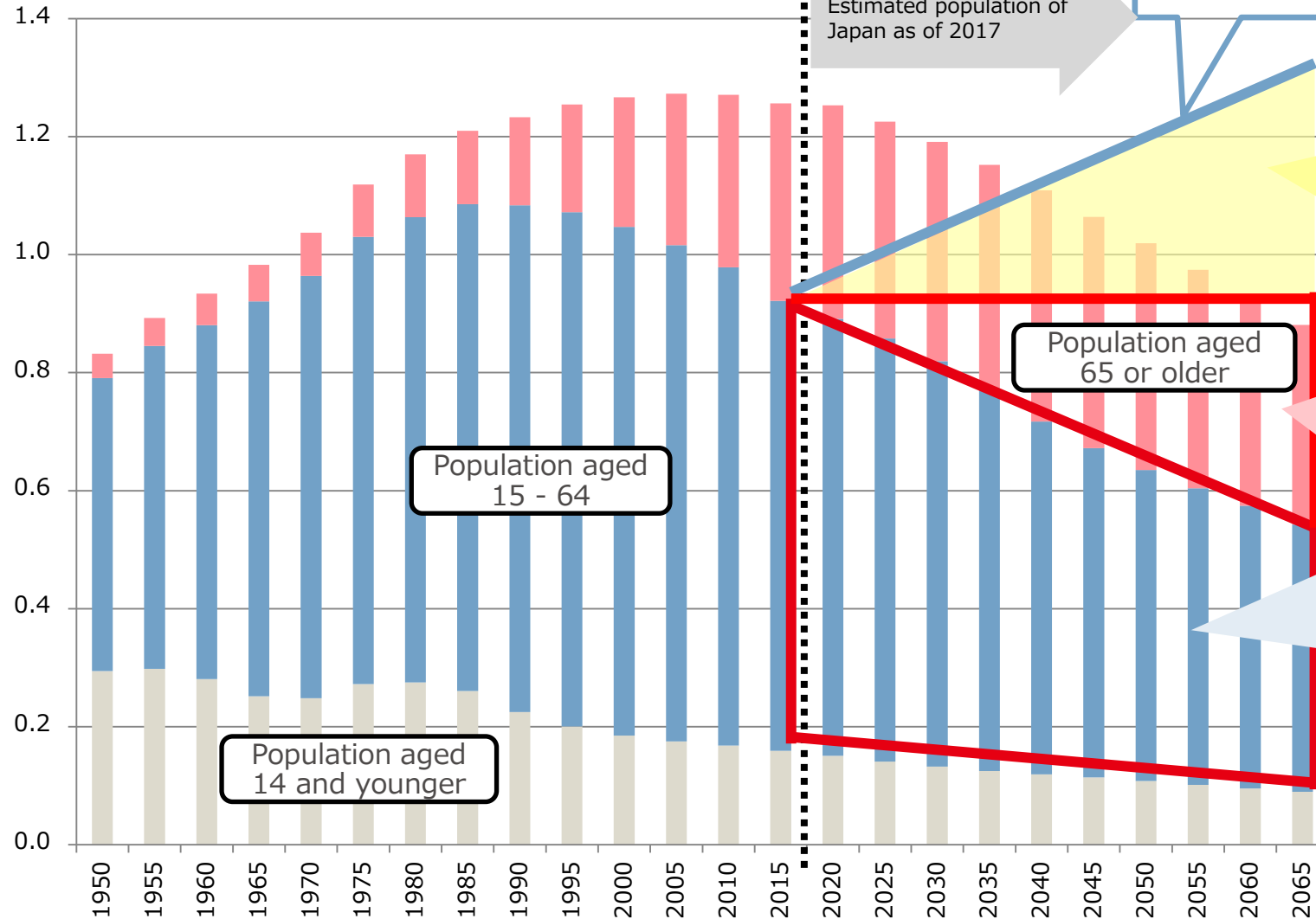
# **Launch of “Successor”, a New Robot System that Reproduces the Movements of Expert Engineers Through Remote Collaboration**

- A new solution for fields where robotization has been difficult to achieve -**

# Issue of working population decrease in Japan

\*Source: National Institute of Population and Social Security Research  
*Future estimated population of Japan (2017 estimate)*

Unit: million people



Estimated population of Japan as of 2017

GDP curve

Necessary working population estimated from the GDP curve (Target of robotization)

The issues of skill transfer and labor shortage can be solved by robotization

Population aged 65 or older

Population aged 15 - 64

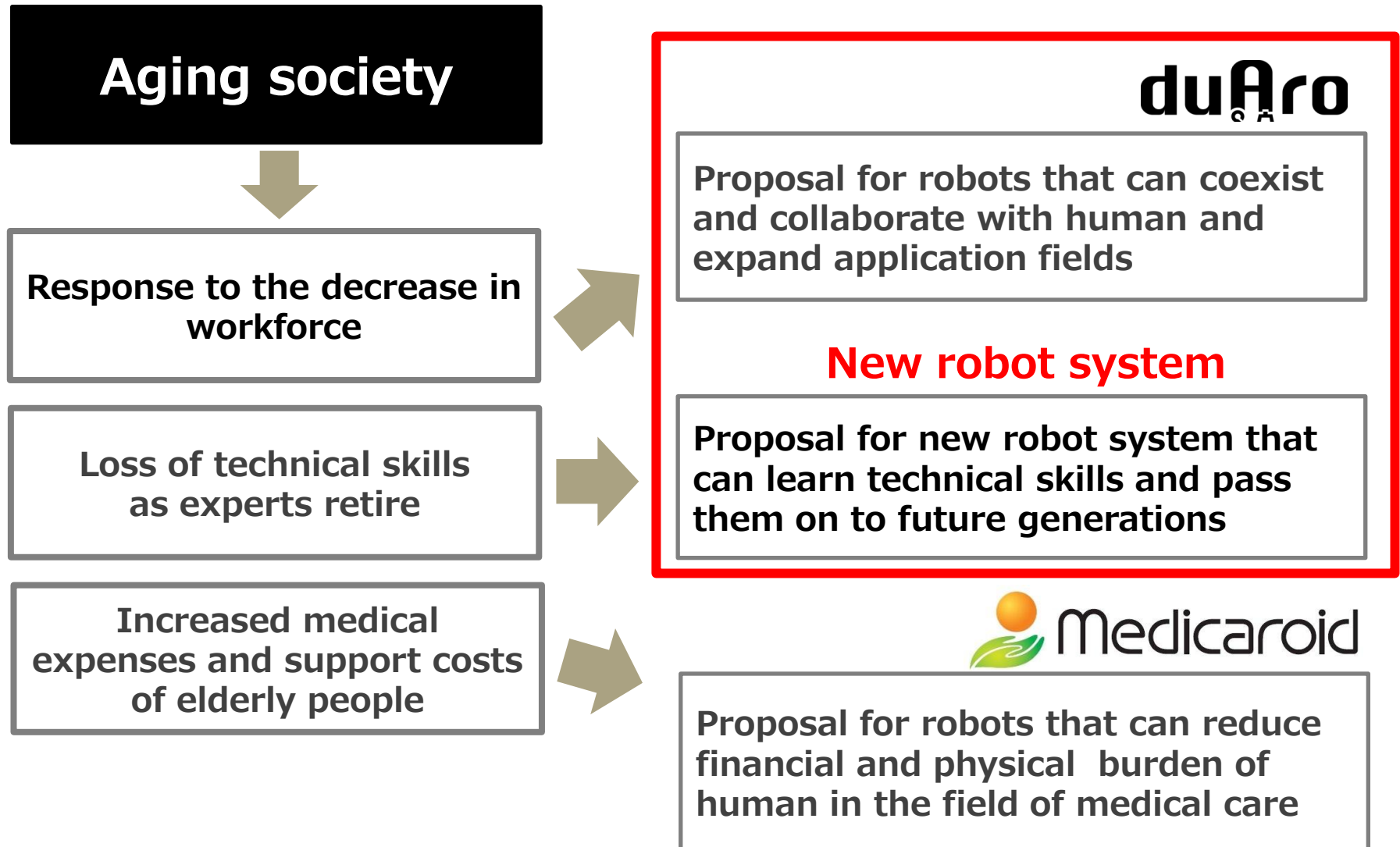
Population aged 14 and younger

Steady decrease of working population

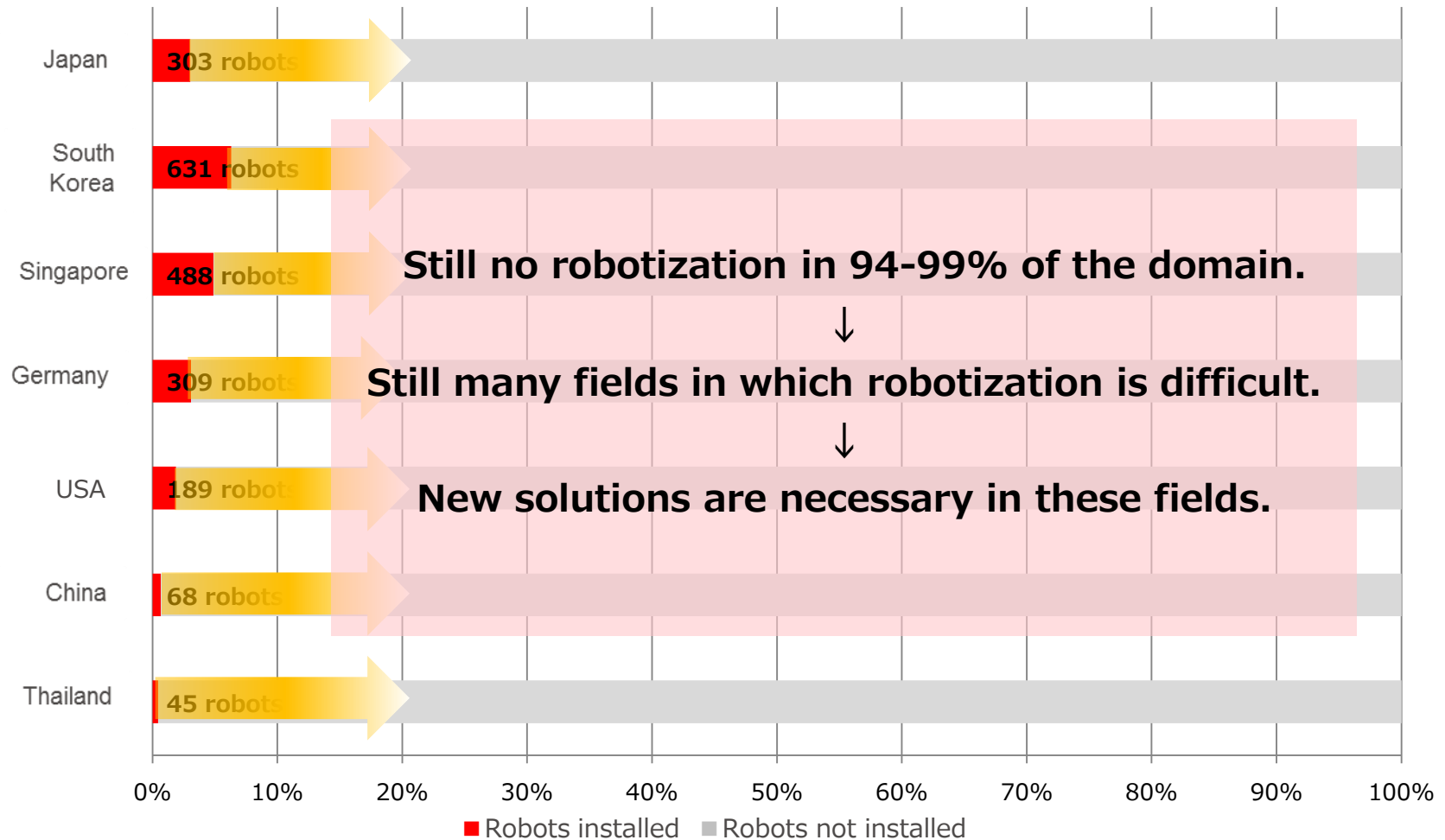
**2015** 77.28 mil.  
**2040** 59.78 mil.  
**2065** 45.29 mil.

Decrease of **640,000 people** per year on average

# Aging society as a global issue and Kawasaki's proposal

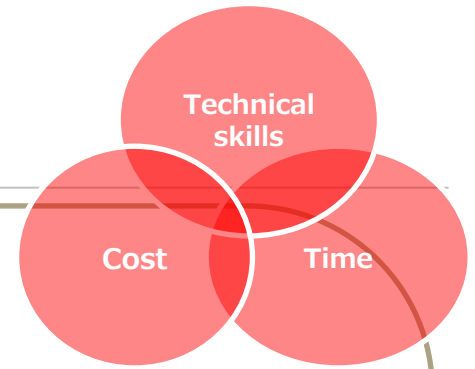


# Number of industrial robots used per 10,000 employees in the manufacturing industry (2016)



\*Source: IFR Statistical Department, *World Robotics 2017*

# Fields in which robotization is difficult:



## ● Fields requiring technical skills

Processes in which humans use their **senses** to carry out work (assembling, polishing etc.)

Large **dispersion** of parts accuracy (casting, pressed items etc.)

## ● Fields requiring disproportionate amounts of cost/time

Applications that are not achievable without the use of many **sensors**

Applications that require **modifications** of the production line or the whole factory

Processes and work for which **programming** and other preparatory work take too much time



### ex) Small-volume production

**Made-to-order products** and items with **custom-made parts**

Parts for products that are **frequently changed**, such as ones that are manufactured at small- and medium-sized enterprises

# New robot system

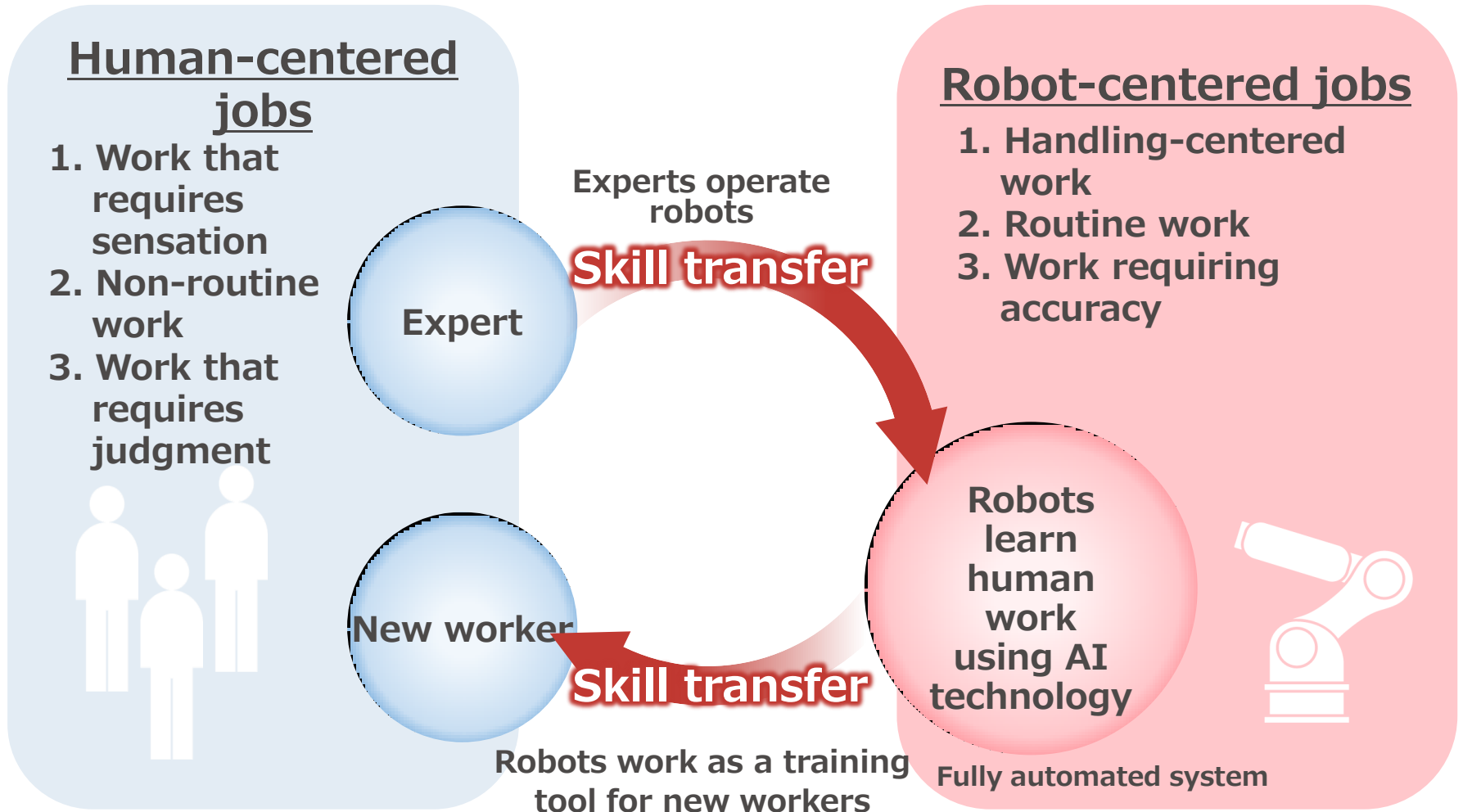
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A robot system proposing  
a new concept for robots, including **skill  
transfer through remote collaboration:**

**Successor**

# Challenges to the fields that are difficult to robotize

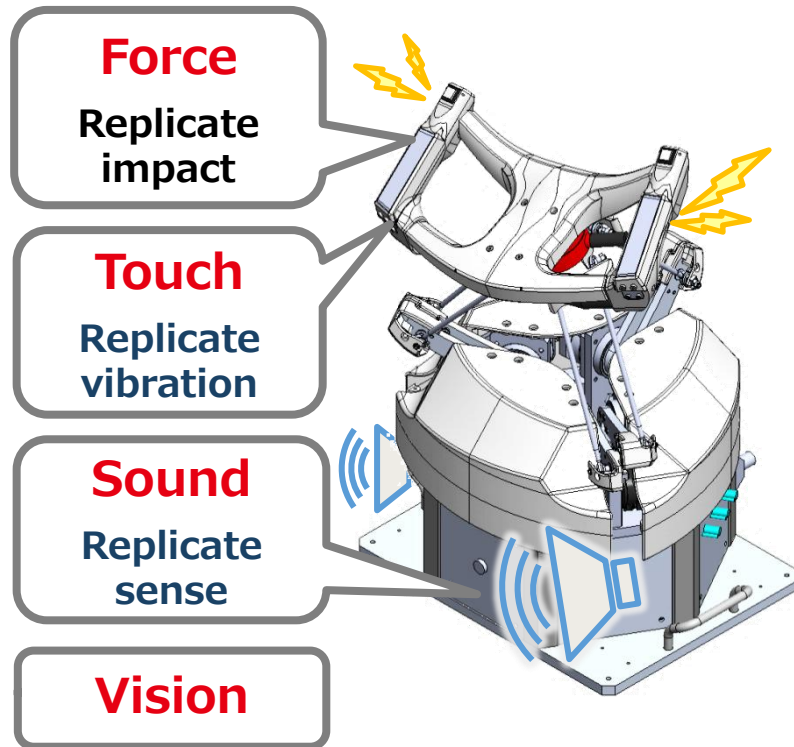
## How can robots transfer skills?



# Control unit that realizes skill transfer to/by robots

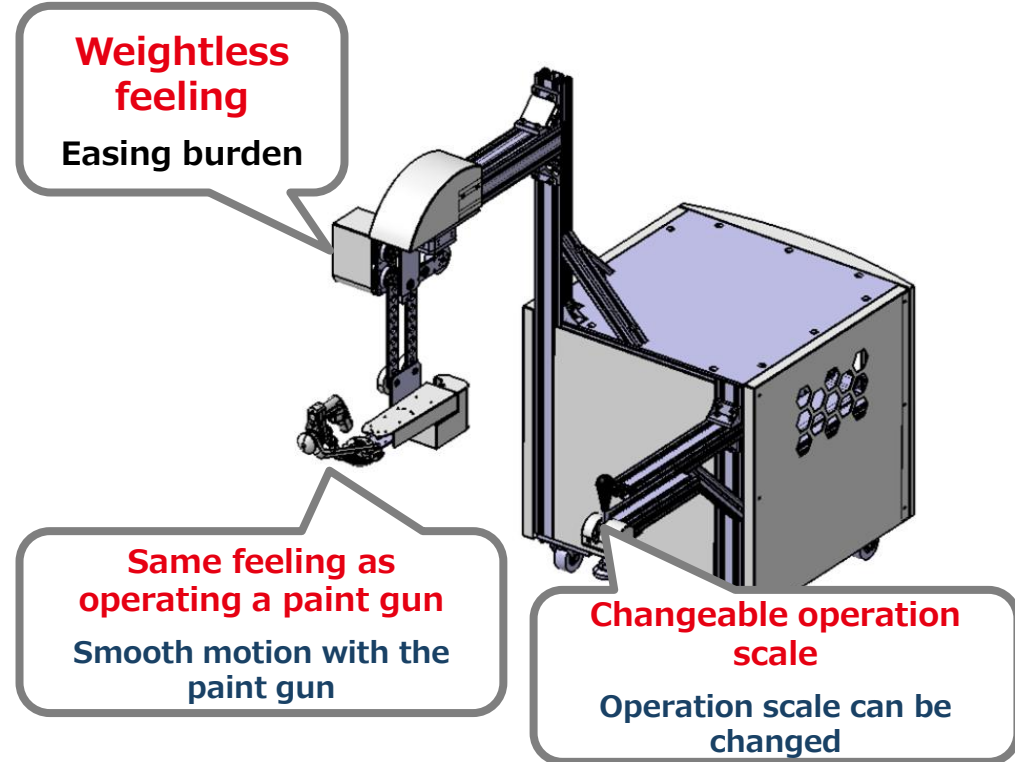
## Communicator for assembling

Replicate feelings with IoT technology



## Communicator for painting

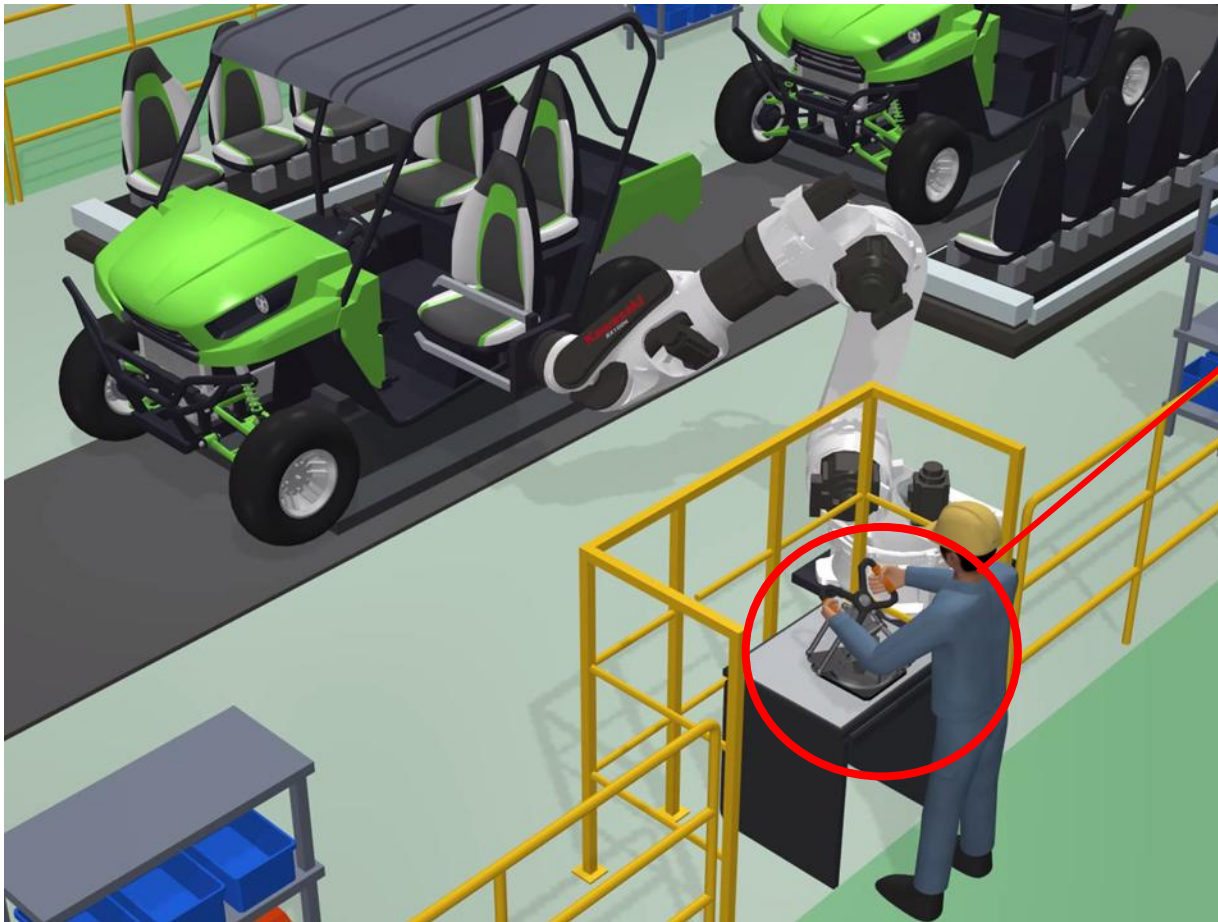
Natural maneuvering feeling by human dynamics



The *Communicator* helps intuitive operations and therefore the workers can feel as if s/he is in the real work environment.



# Features of *Successor*: Remote collaboration system



## Remote collaboration system

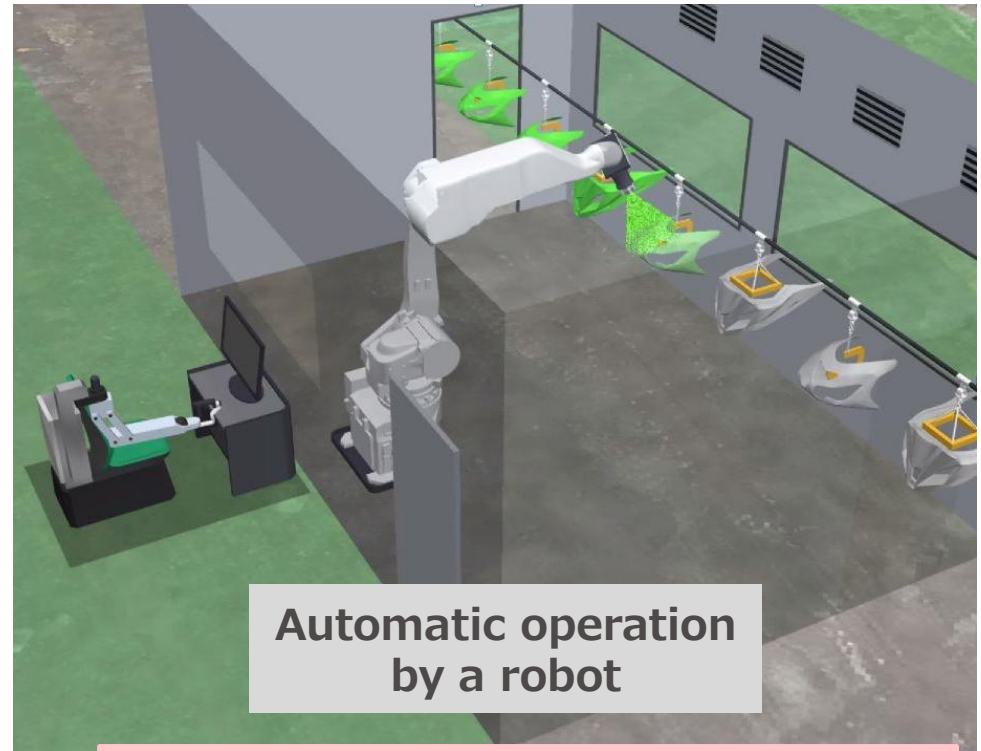
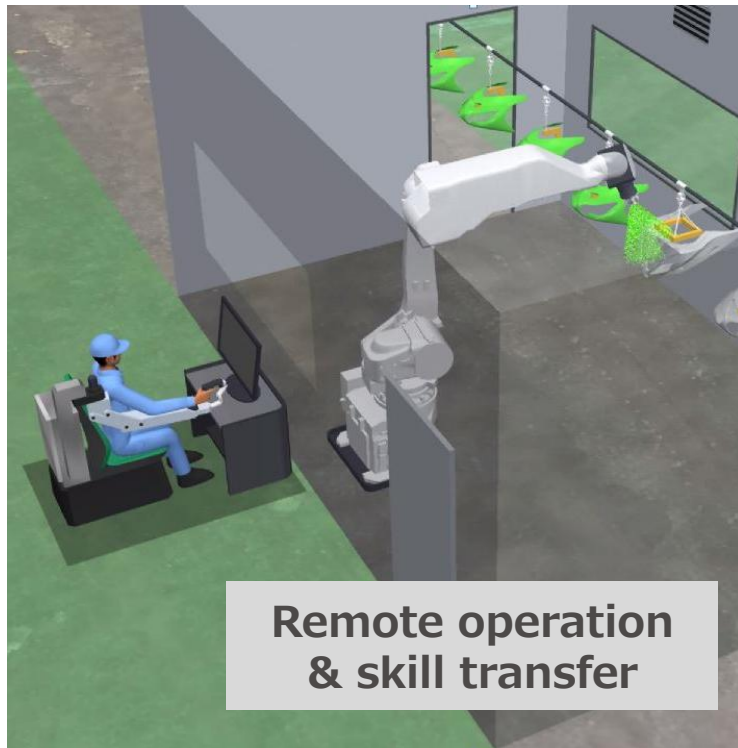
Equipped with a system in which physical senses (e.g. sight, force, touch, sound) during the operation are fed back, giving the remote operator the sense of being at the place where the work is performed.

Workers can operate outside the working range of the robot, ensuring intrinsic safety



Enables collaborative work with large robots

# Function of *Successor*: 1. Conversion function (learns human operations and converts them into automated operations)



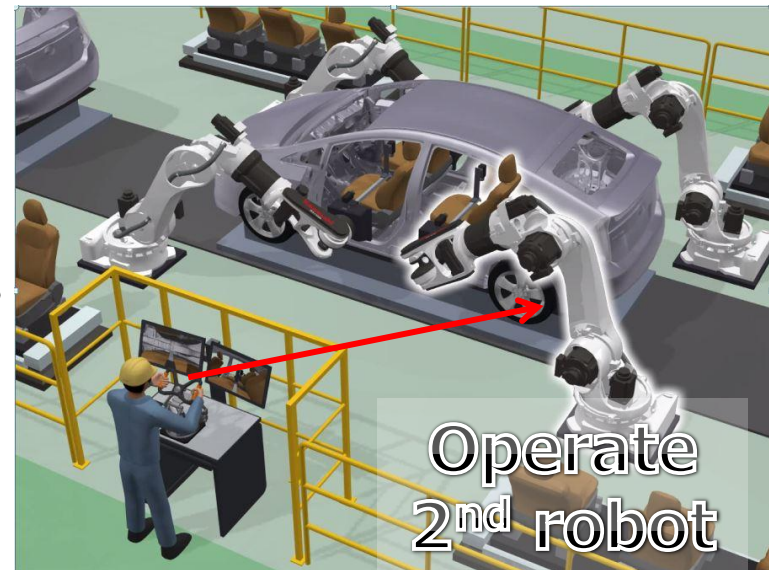
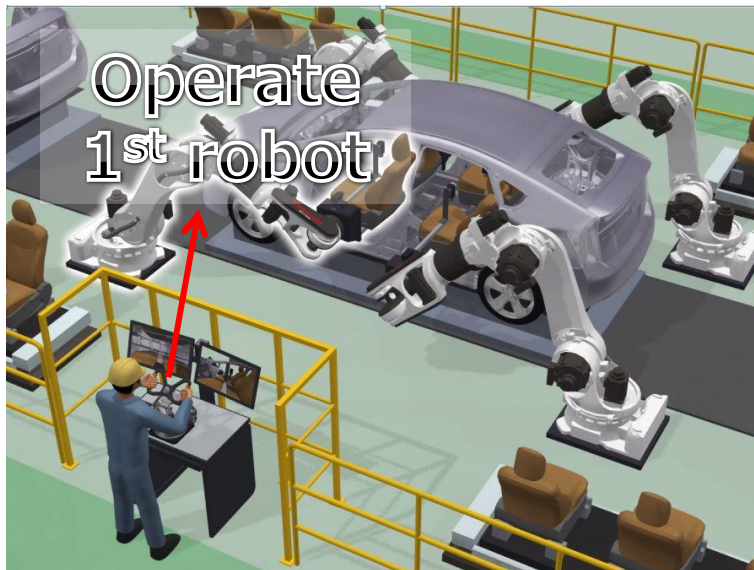
OJL : On the Job Learning  
(learning human skills on the job)

Step 1: Operation Teaching → Step 2: Trial/Correction Training through repetition → Step 3: Automation Mastery

**Skill transfer to robots** can be realized online

## Function of *Successor*: 2. Hybrid function of automatic/remote operations & 3. Multi-control function (one *Communicator* operates multiple robots)

Both remote operation with the *Communicator* and automatic operation by robots can be switched easily



One *Communicator* can operate multiple robots

## Function of *Successor*: 4. AI function (Robots learn to optimize movement with dispersion with AI technology and to convert it to automated operations. )



OJL : On the Job Learning  
(learning human skills on the job)

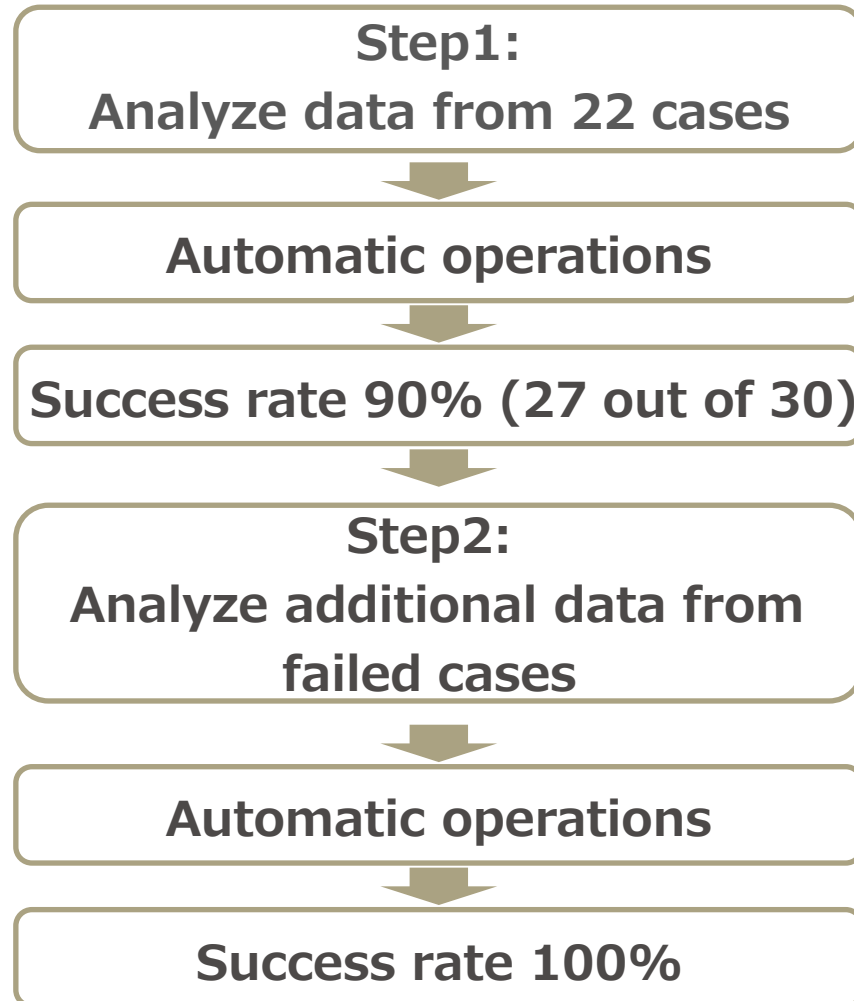
AI technology



Step 1: Operation → Step 2: Trial/Correction → Step 3: Automation  
Teaching                      Training through repetition                      Mastery  
**Skill transfer to robots** can be realized online

# Function of *Successor*: 4. AI function (Robots learn to optimize movement with dispersion with AI technology and to convert it to automated operations. )

## Validation of the AI function by case testing

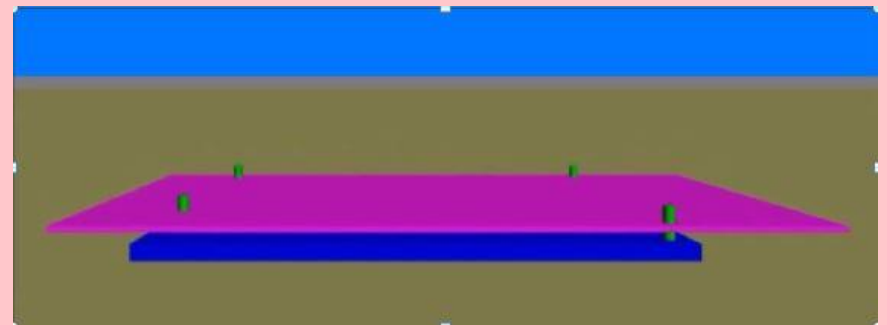


### Failed cases



When it tries to insert it here, this side touches first  
•Unexpected events for robots which knows Step1 data only

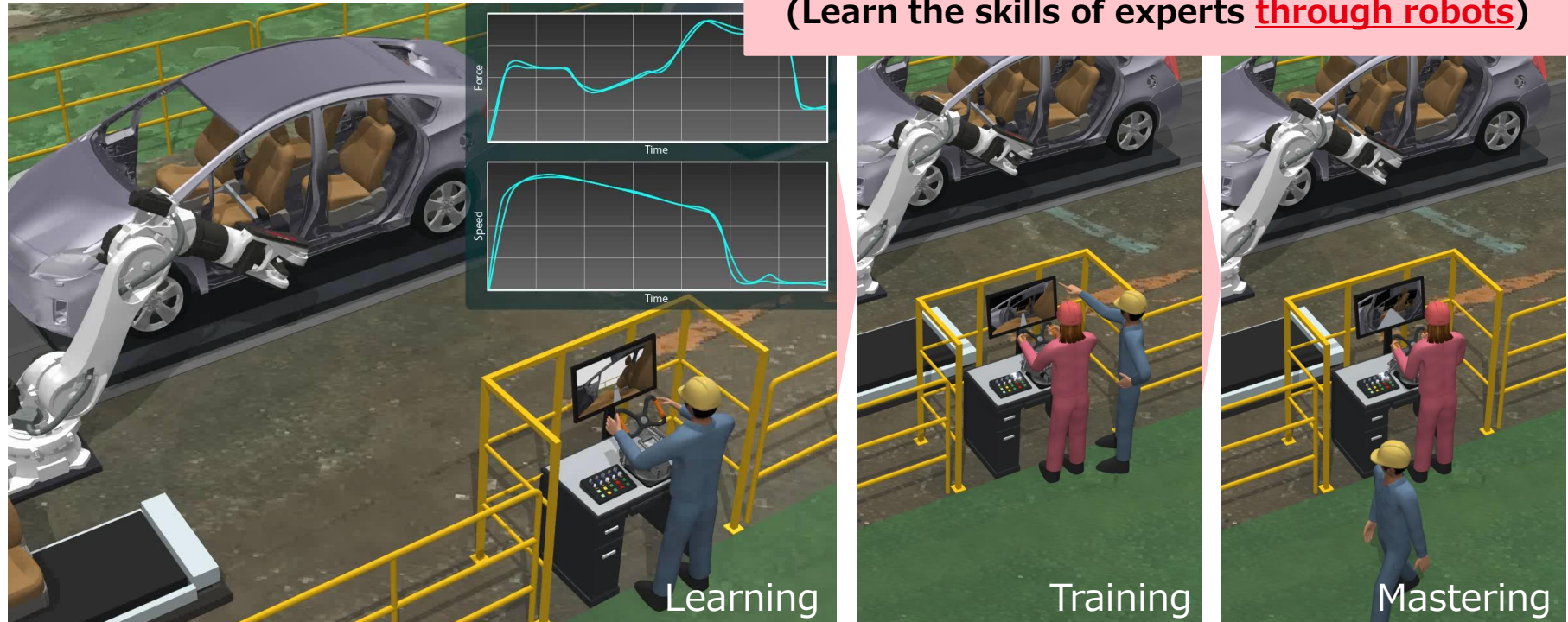
### Success cases



Work by automatic operation was successful after learning with AI function

# Function of *Successor*: 5. Training function (newcomers learn operations taught to robots by experts)

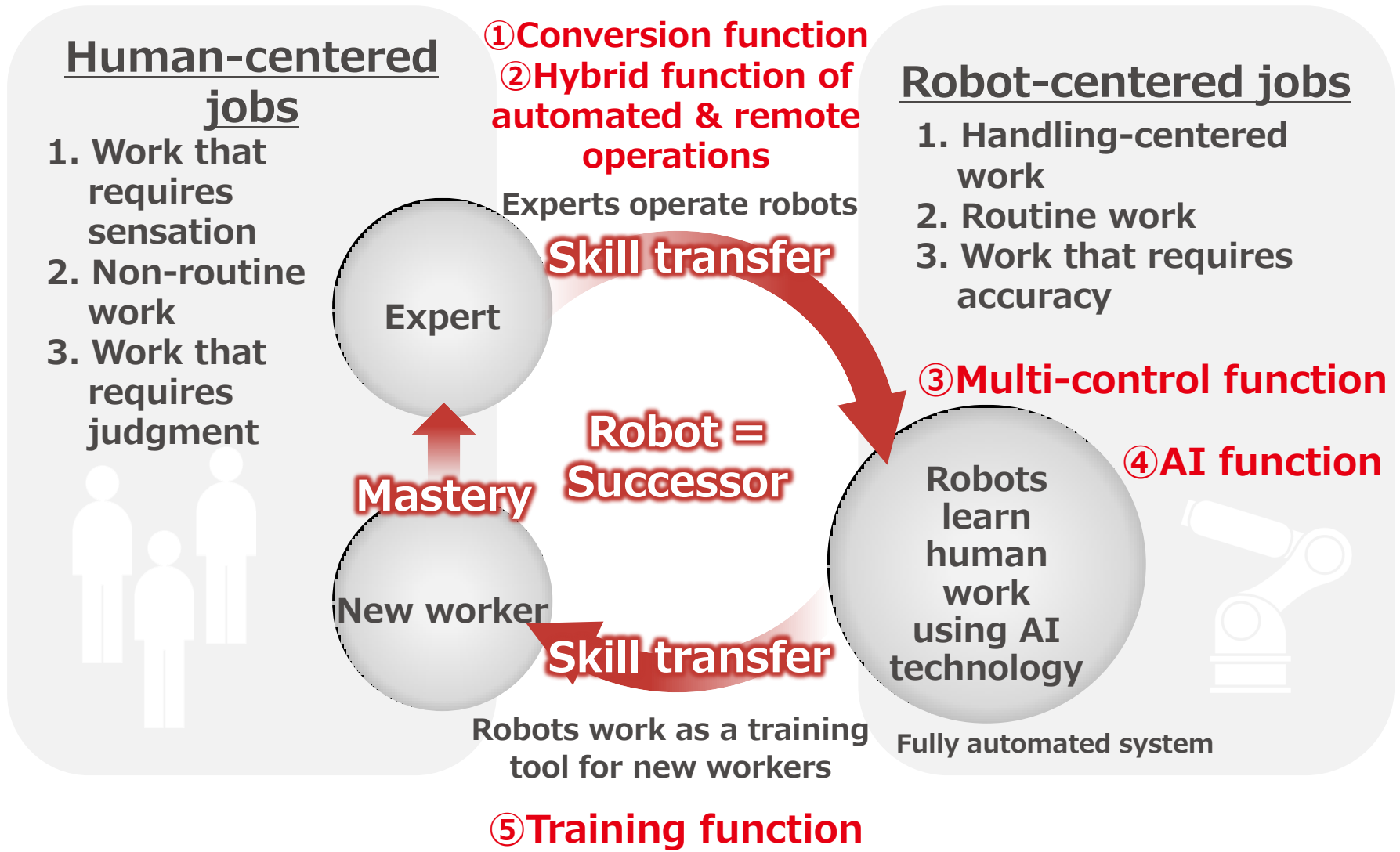
OJL: On-the-Job Learning  
(Learn the skills of experts **through robots**)



Step 1: Operation → Step 2: Trial/Correction → Step 3: Automation  
Teaching                      Training through repetition                      Mastering

**Skill transfer to robots** can be realized online

# Summary of *Successor's* functions in the fields that are difficult to robotize



# Successor is:

## A robot system that can be used with any robot



Robot that fits to applications+  
The remote controlling unit, *Communicator*



Painting



Rigging



Processing



Handling



Assembling



# What *Successor* can realize:

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Simplify the  
Implementation  
of robots

- **Anyone can program robots** without professional knowledge on robots
- Implementation **cost and time for robots can be reduced**
- Application fields are widened

Increase  
productivity

- Workers can be **released from harsh working conditions**
- **Physical burden of labor is relieved** from the elder

Secure  
workforce and  
nurture next  
generation

- **Experts' skill can be transferred by robots**

# Targeted fields for *Successor*

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- **Made-to-order manufacturing**

E.g. Kawasaki Heavy Industries, etc. (welding, painting, finish processing, heavy load handling)

- **Fields of assembly and outfitting in mass-production industries**

E.g. Automobile outfitting processes, etc.

- **Foundry industry**

- **Logistics industry, logistics processes**

- **Outdoor work fields** (construction / civil engineering / transportation / plants)

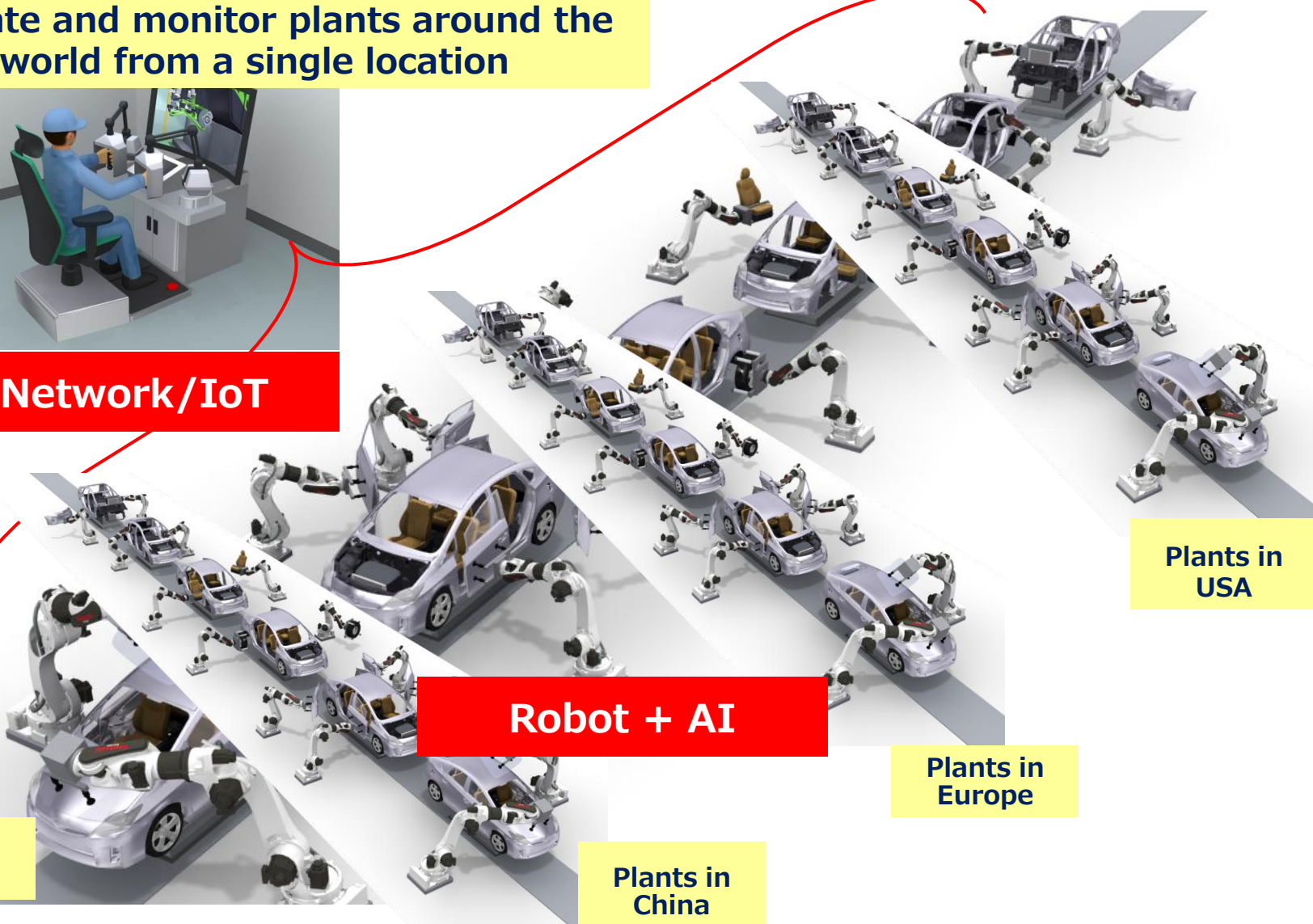
- **Small- to medium-sized enterprises**

# Future vision of *Successor's* development

Operate and monitor plants around the world from a single location



Network/IoT



Robot + AI

Plants in USA

Plants in Europe

Plants in Japan

Plants in China

Kawasaki. working as one for the good of the planet

**“Global Kawasaki”**