

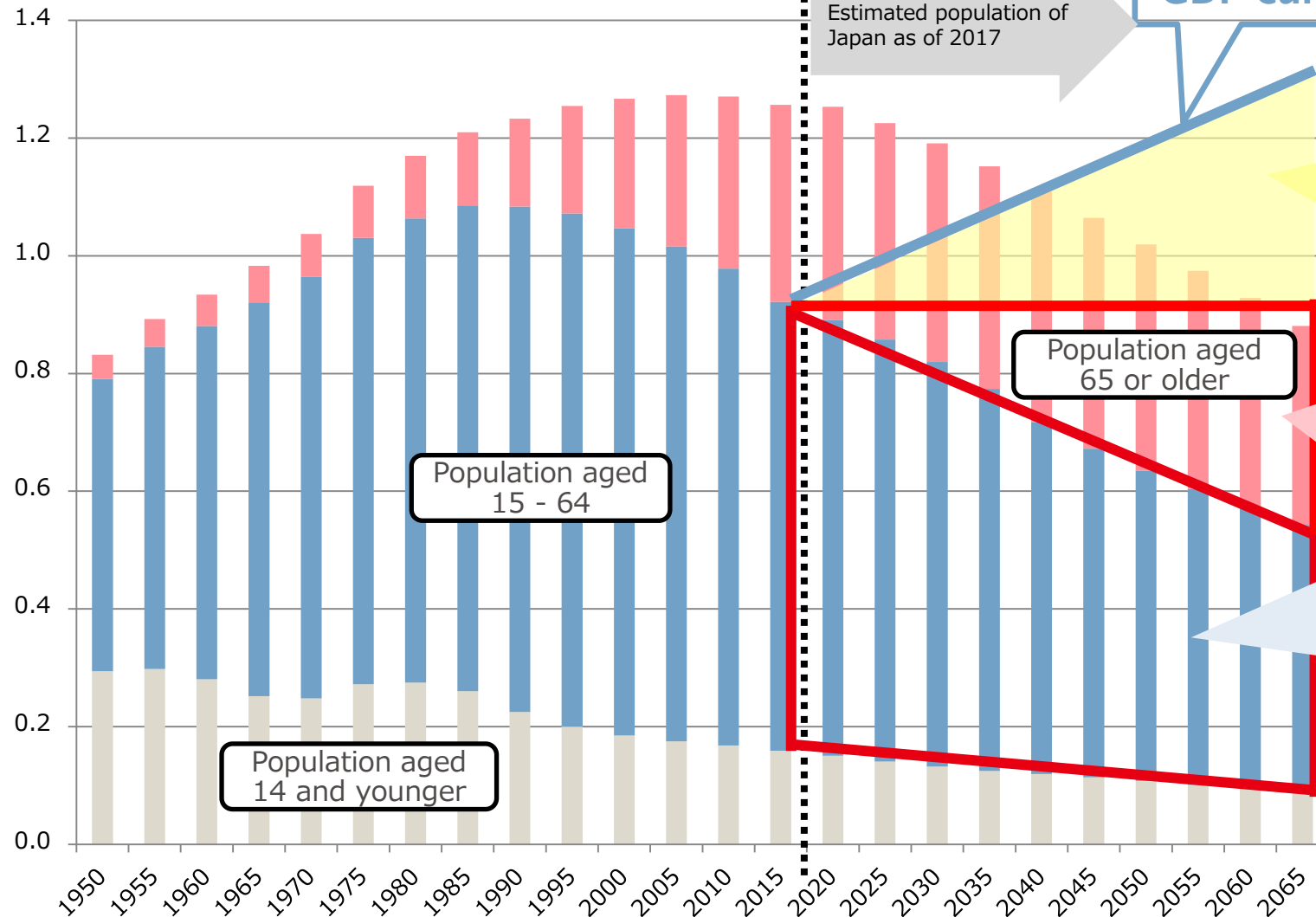
Launch of “Successor”, a New Robot System that Reproduces the Movements of Expert Engineers Through Remote Collaboration

- 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



GDP curve

Estimated population of Japan as of 2017

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

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

Steady decrease of working population

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

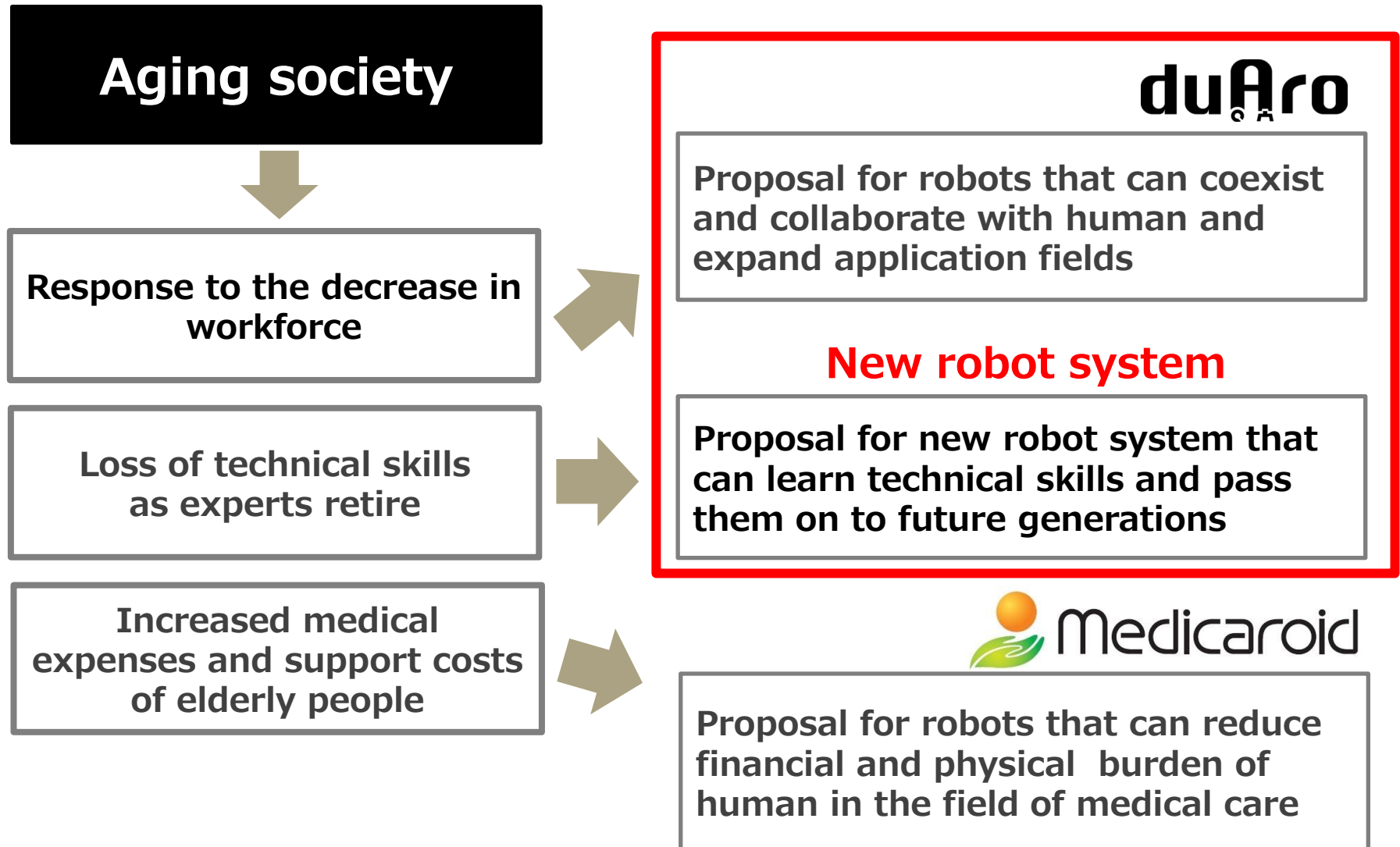
Decrease of **640,000 people** per year on average

Population aged 15 - 64

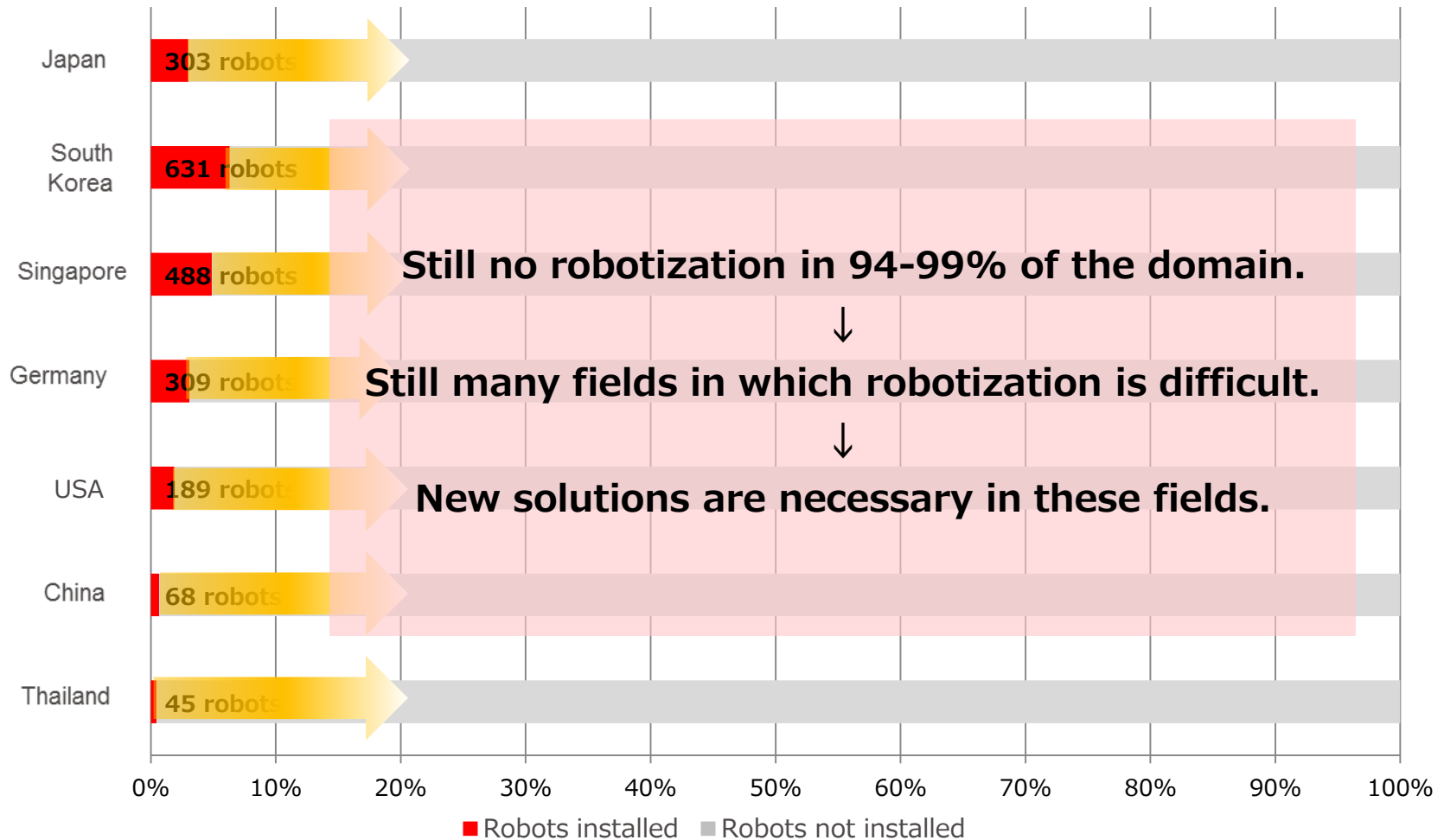
Population aged 14 and younger

Population aged 65 or older

Aging society as a global issue and Kawasaki's proposal

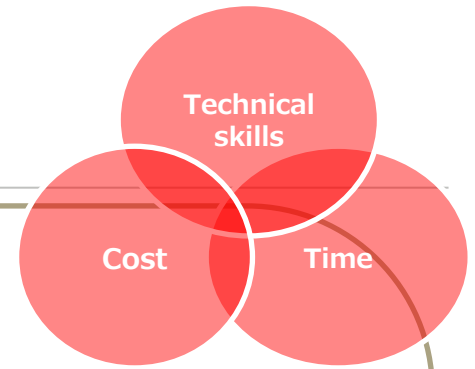


Number of industrial robots used per 10,000 employees in the manufacturing industry (2016)



*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

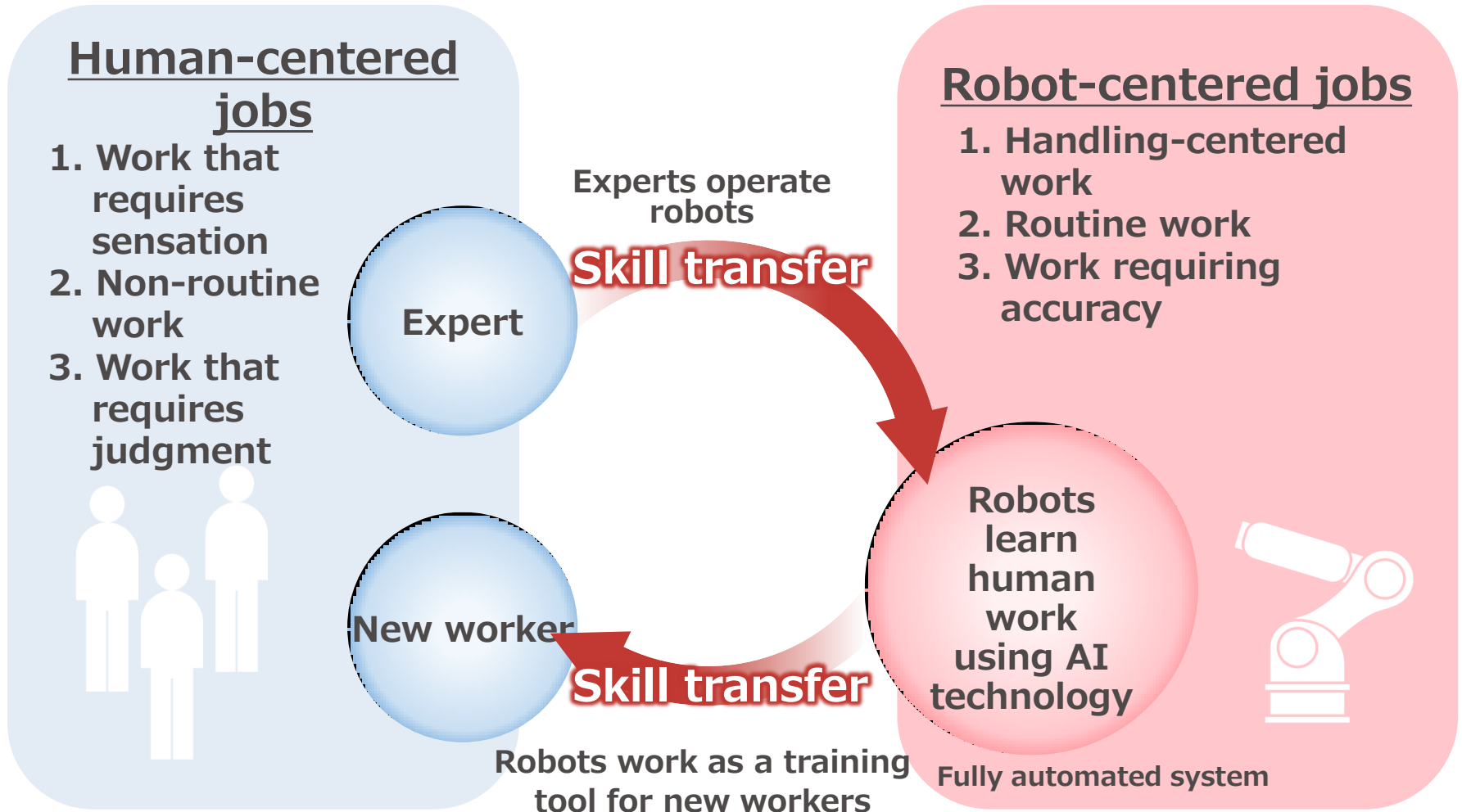
New robot system

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

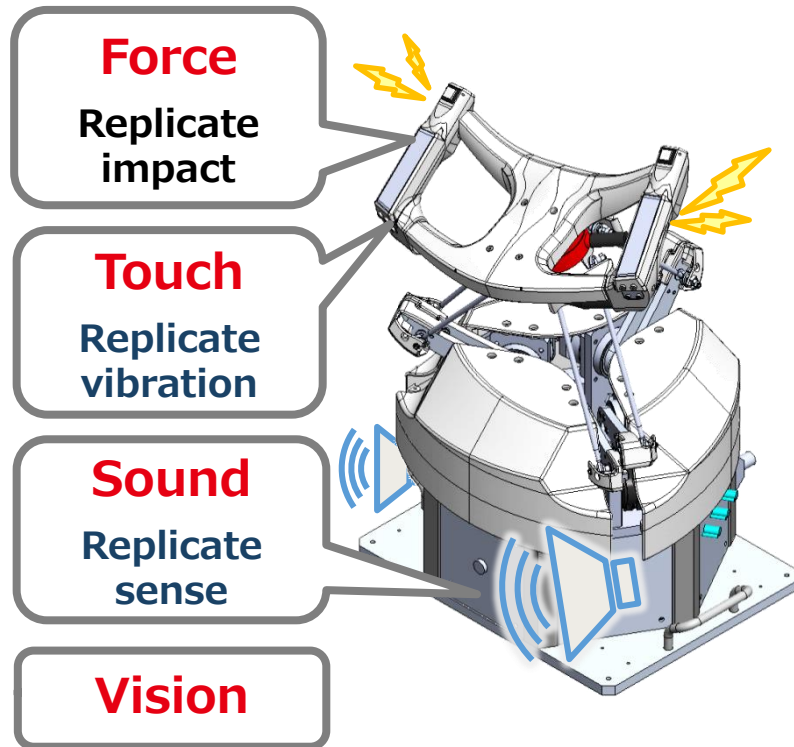
How can robots transfer skills?



Control unit that realizes skill transfer to/by robots

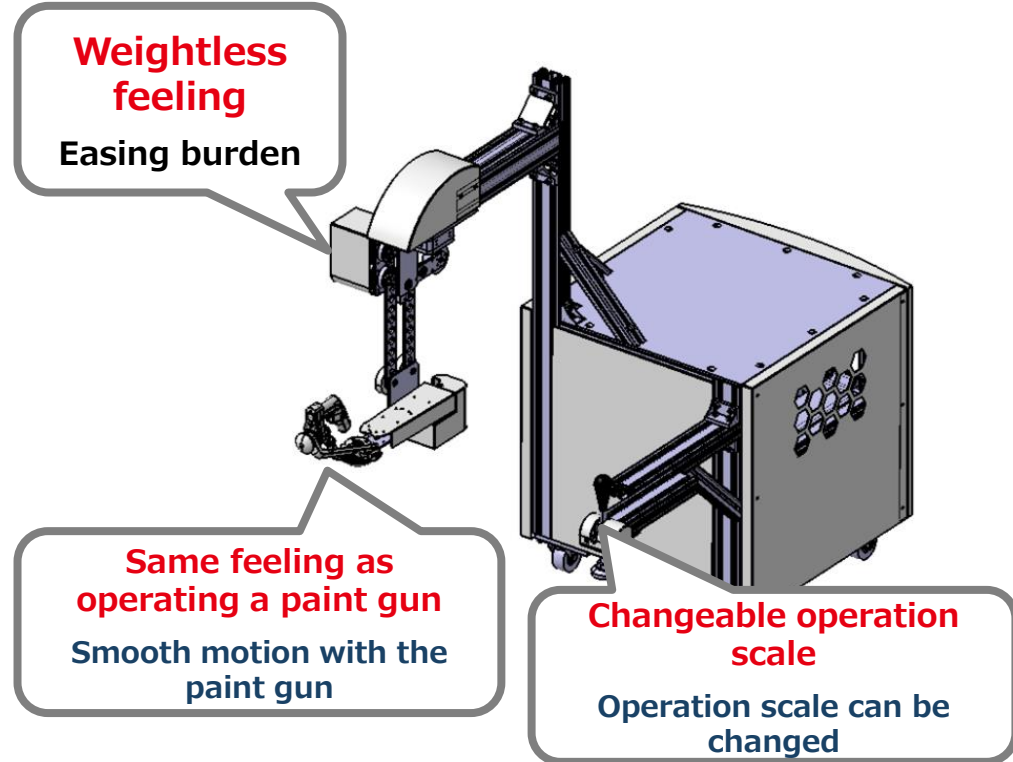
Communicator for assembling

Replicate feelings with IoT technology



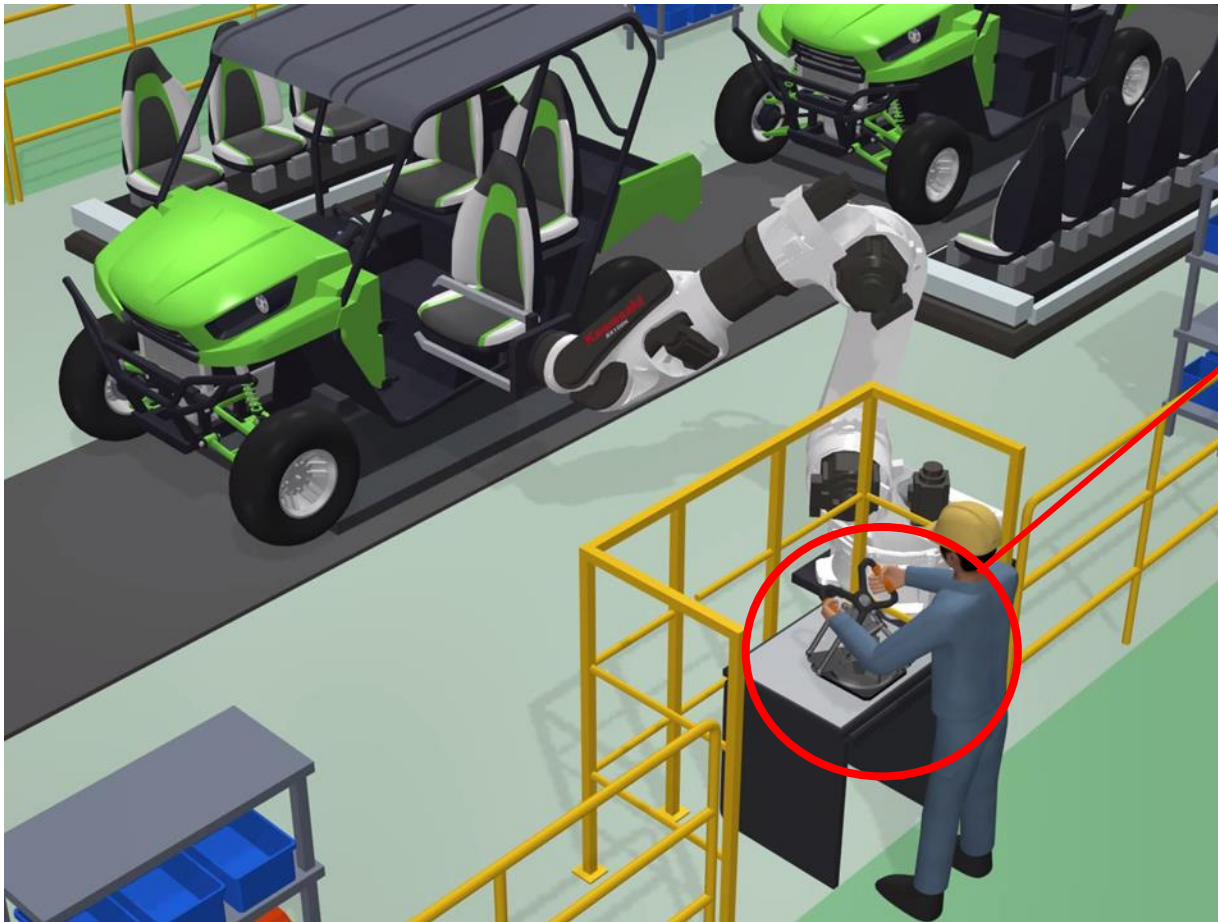
Communicator for painting

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

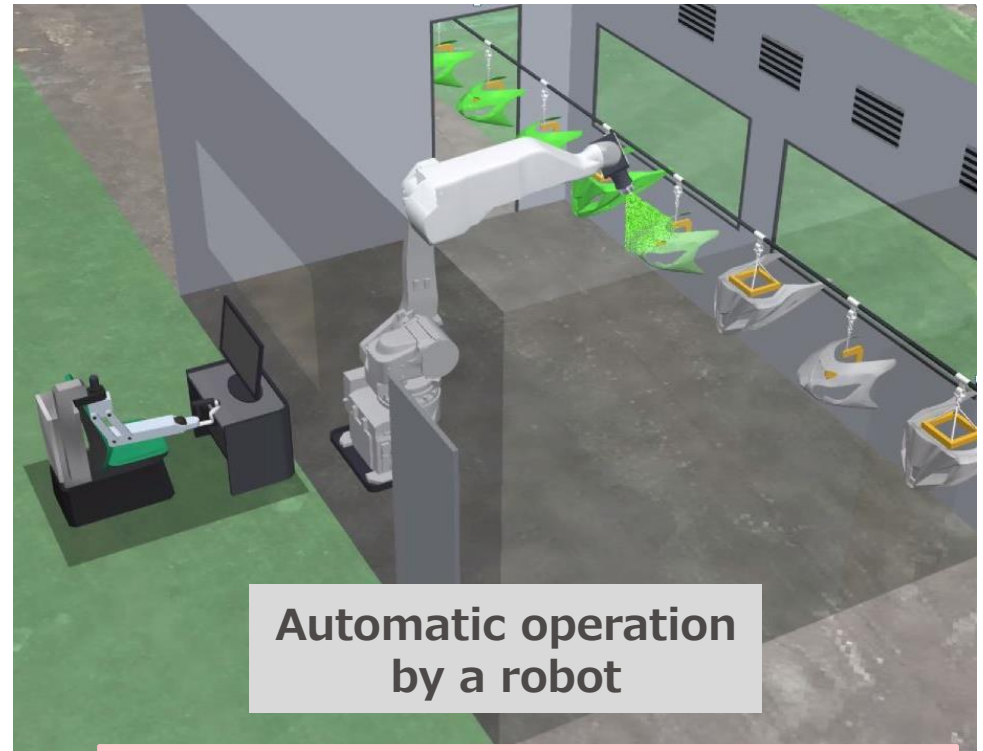
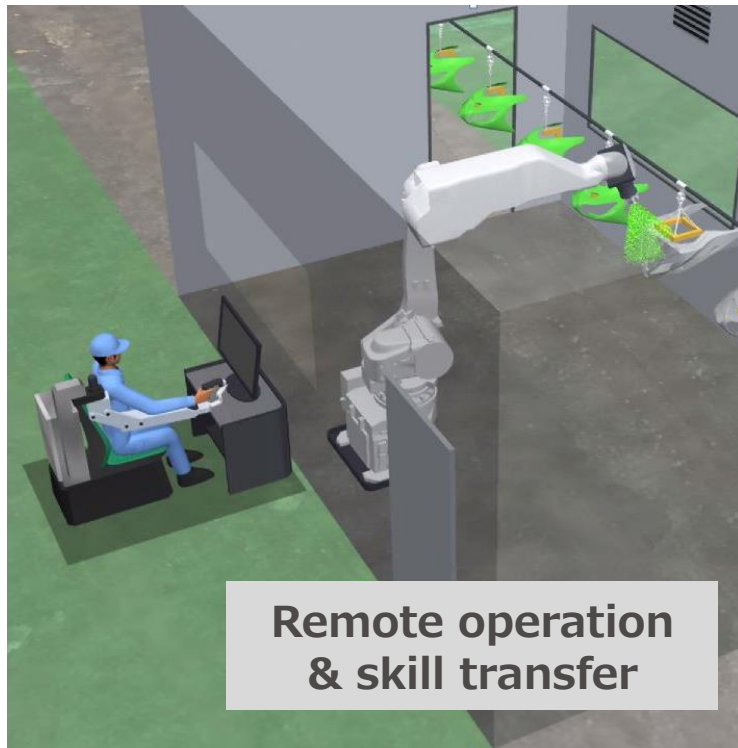
Equipped with a system in which physical senses (e.g. sight, force, touch, sound) during the operation are fed back, giving the remote operator the sense of being at the place where the work is performed.

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)



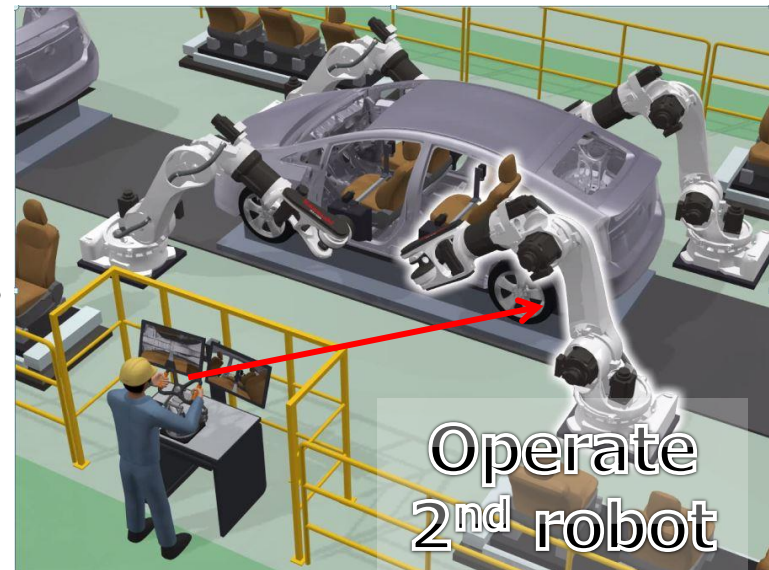
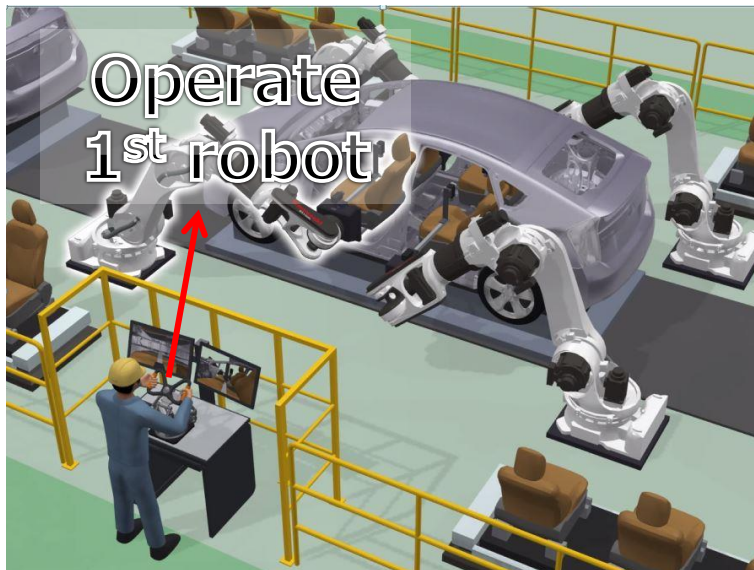
OJL : On the Job Learning
(learning human skills on the job)

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)

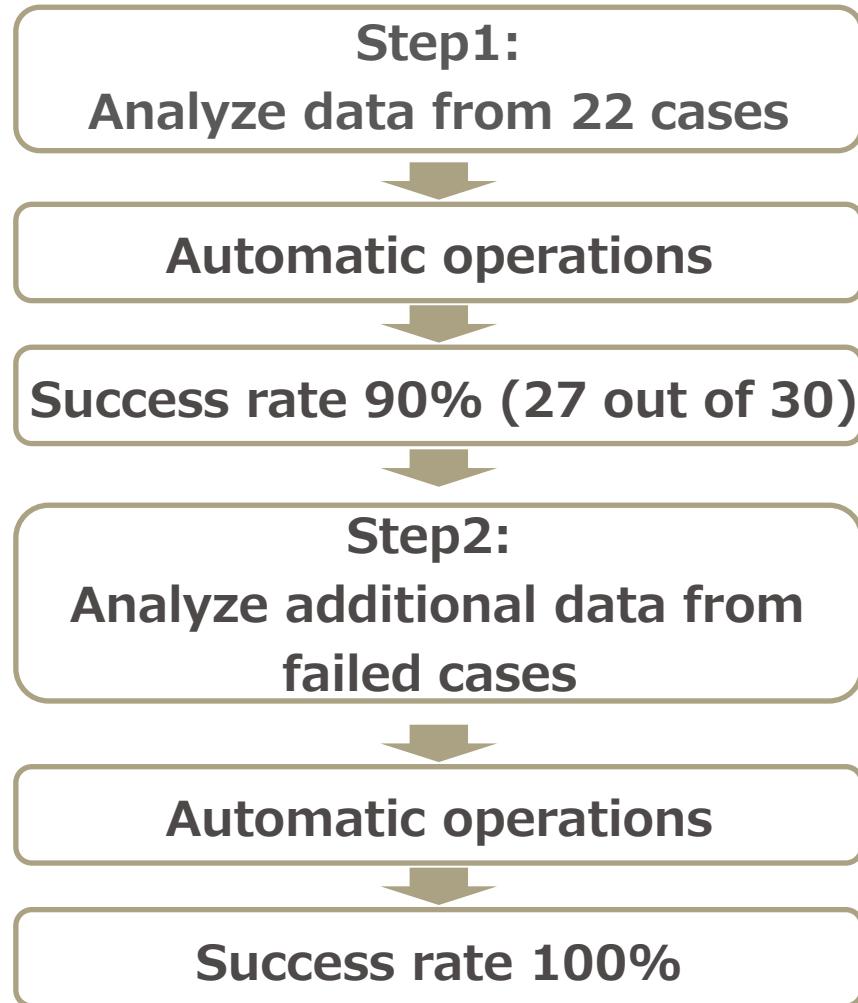
AI technology



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

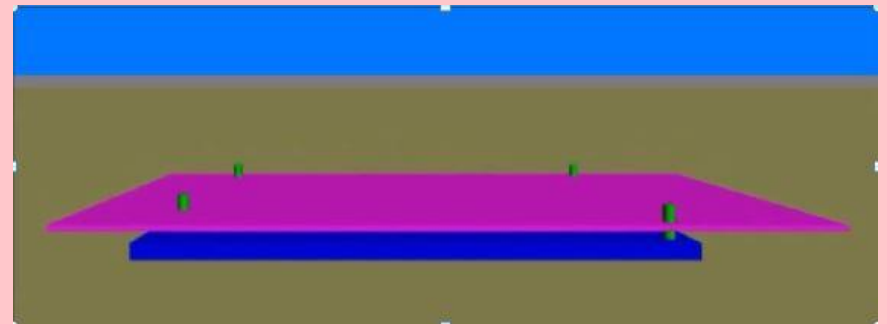


Failed cases



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

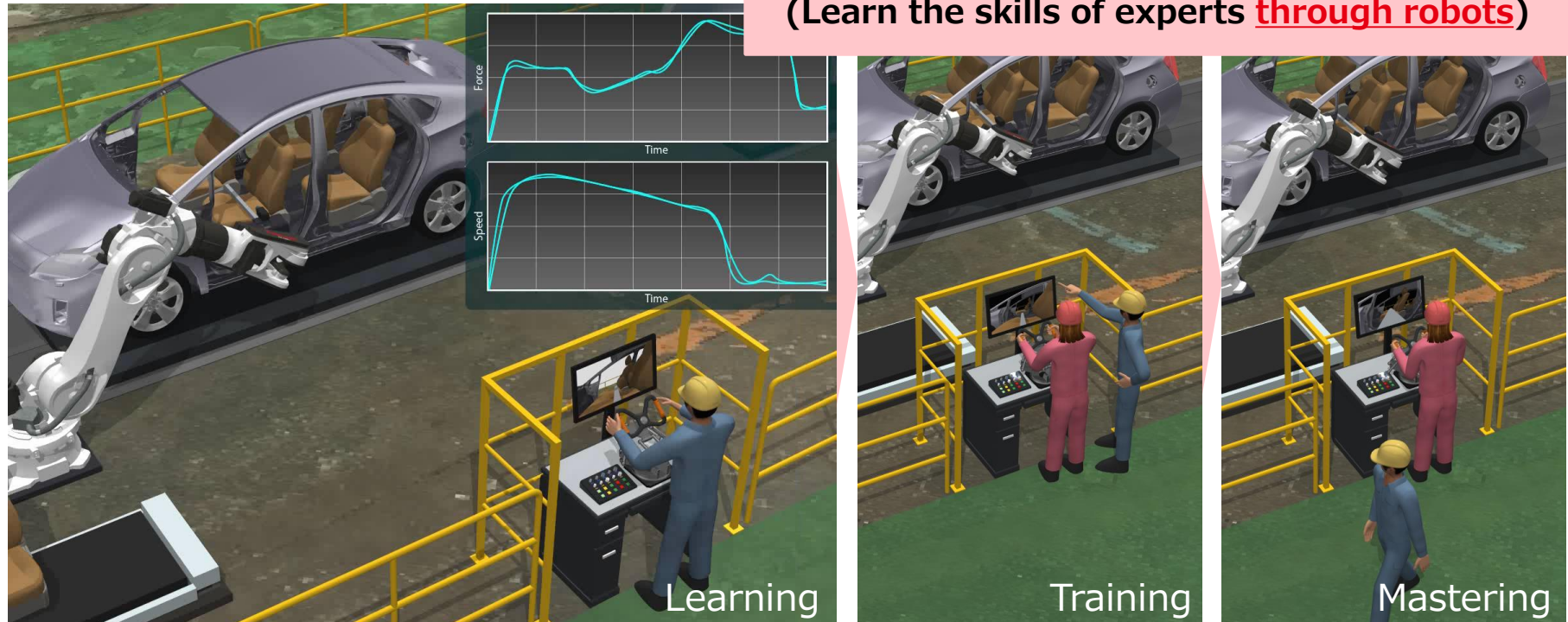
Success cases



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)

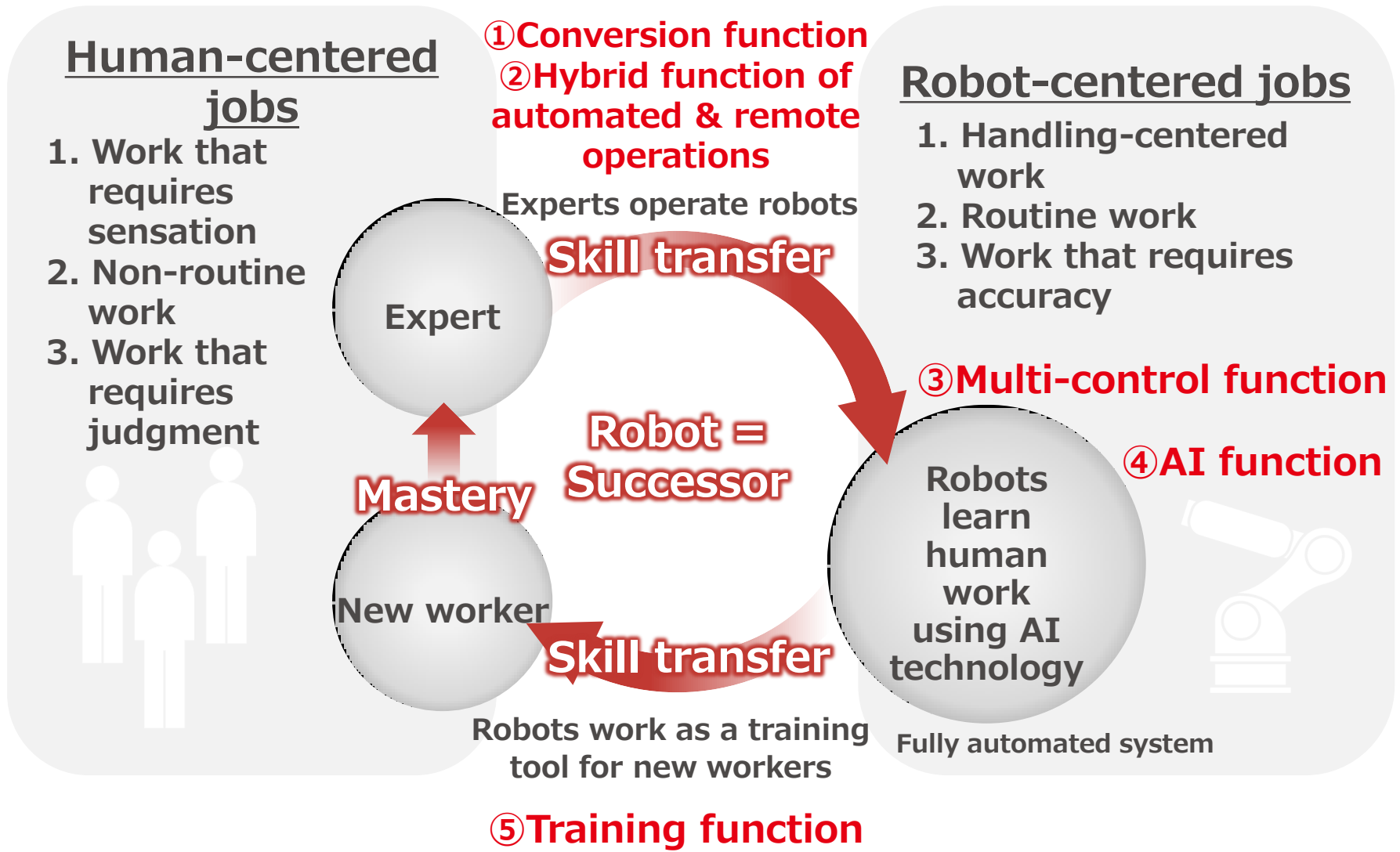
OJL: On-the-Job Learning
(Learn the skills of experts **through robots**)



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:

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*

- **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)

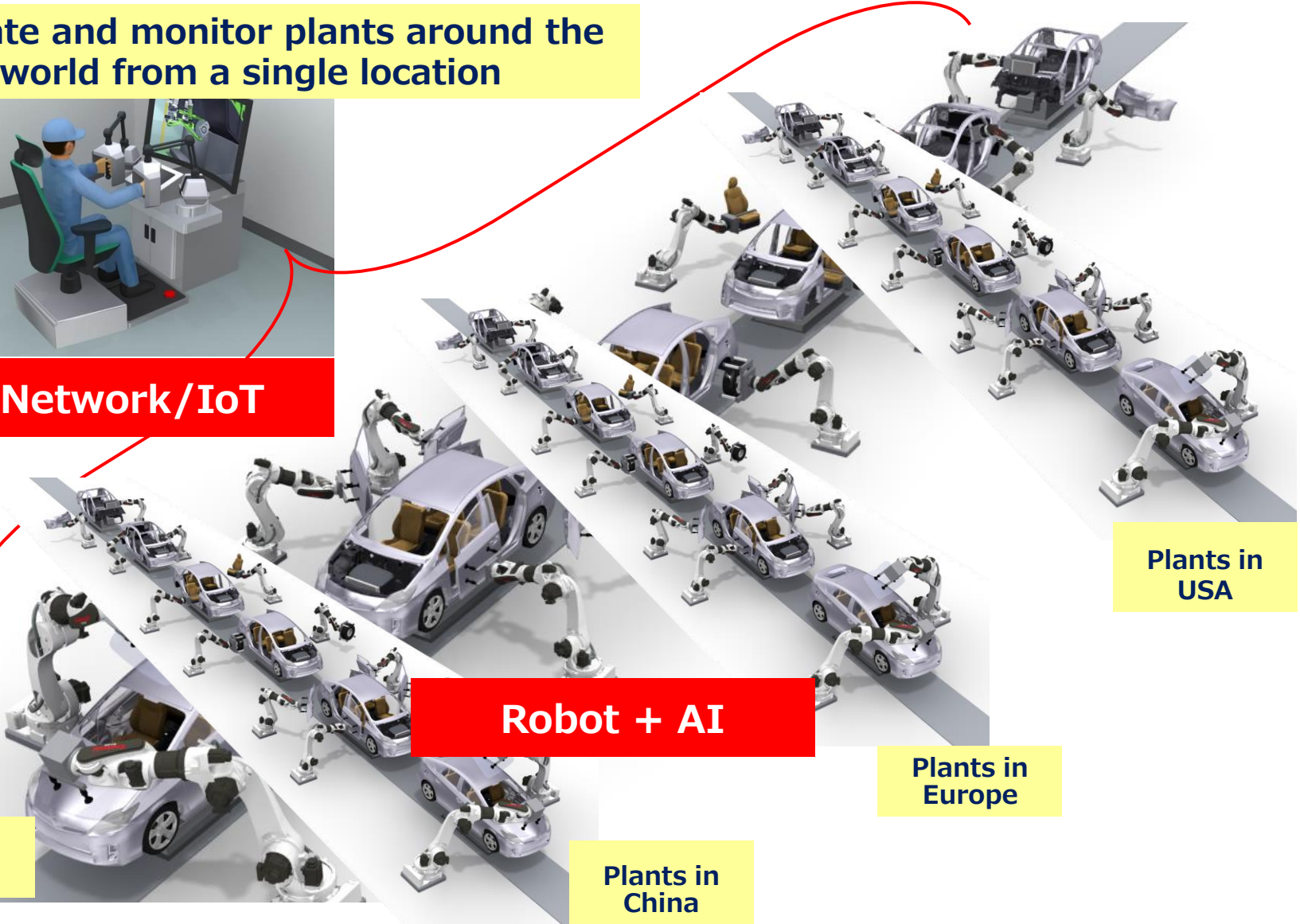
- **Small- to medium-sized enterprises**

Future vision of *Successor's* development

Operate and monitor plants around the world from a single location



Network/IoT



Robot + AI

Plants in Japan

Plants in China

Plants in Europe

Plants in USA

Kawasaki. working as one for the good of the planet

“Global Kawasaki”