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2017 R&D Strategy

Global R&D driving further growth in Social Innovation Business

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General Manager of Research & Development Group

Hitachi, Ltd.

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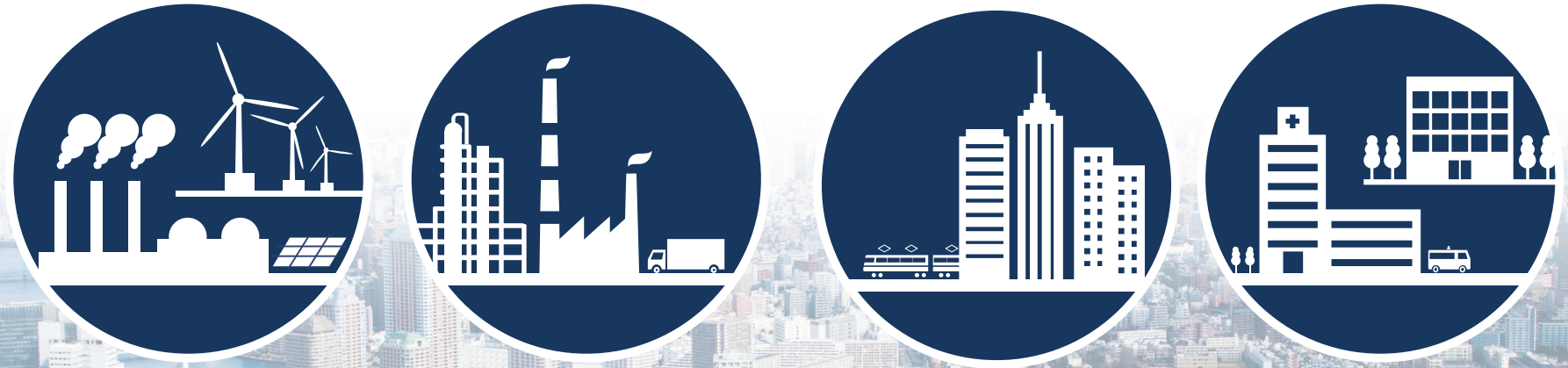
An Innovation Partner for the IoT Era

Accelerate collaborative creation with customers through Advanced Social Innovation Business

Four Focus Business Domains



Power・Energy

Industry・Distribution・Water

Urban

Finance・Public・Healthcare

IoT: Internet-of-Things

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FY2018 MMP: R&D Group operational directives

Generate business innovation in an era of uncertainty

1. Focusing on four business domains — Section 2
2. Enhancing Lumada supporting the expansion of Social Innovation Business — Section 3
3. Challenging future societal issues — Section 4

MMP: Mid-term Management Plan

1.3 Major achievements in FY2016

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Main products, services & contribution to Lumada in the four focus business domains

Power · Energy

5MW wind turbine generator system

15% larger rotor swept area for light-wind regions with annual avg. wind speeds below 7.5m/sec

Industry·Distribution·Water

Optimization solution for manufacturing site

Detects signs of anomaly in workers' actions and equipment malfunctions

Urban

Ultra-high speed elevator for Guangzhou CTF Finance Centre

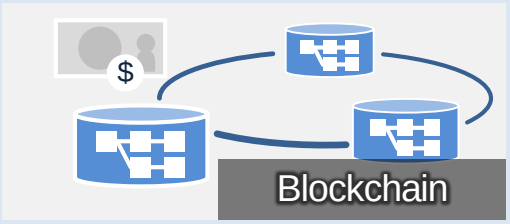
Maximum speed
1,260m/min.
[World's fastest]

(Normal operation
1,200m/min.)

Finance · Public · Healthcare

Blockchain technology for check digitalization PoC

PoC in Singapore to test issue and settlement of digital checks*



Diagnostic ultrasound platform ALOKA ARIETTA 850

CMUT silicon wafer transducer realizing wide bandwidth and high sensitivity

Lumada

Contribution to customer cases

43/203

- Predictive maintenance for equipment
- People flow analysis for public space
- Identifying cause of over stocking
- Production plan optimization
- Activation of organization (using wearable sensors)

*Executed together with The Bank of Tokyo-Mitsubishi UFJ, Ltd.
CMUT: Capacitive Micro-machined Ultrasonic Transducers, PoC: Proof of Concept

1.4 FY2017 R&D Group organization

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Global R&D driving further growth in Social Innovation Business

R&D Group structure

Global Center for Social Innovation (CSI)

Accelerate collaborative creation with customers to generate service business

NA	Europe	China	APAC	Japan
100	70	115	65	200

[550]

Center for Technology Innovation (CTI)

Enhance technology platforms to promote growth in service & product business

[Japan:2,050]

AI Lab.	OSS Technology Lab.	Reliability Informatics Lab.	Intelligent Systems Control Lab.

Center for Exploratory Research (CER)

Challenge future societal issues through open innovation

[Japan:100]

Total 2,700

Business structure

Customer

Front

Front BU
- Power・Energy
- Industry・Distribution・Water
- Urban
- Finance・Public・Healthcare

Global Front
- Americas
- EMEA/CIS
- APAC
- China
- Japan

Platform

Product

APAC: Asia Pacific, BU: Business Unit,
EMEA/CIS: Europe, the Middle East and Africa, Commonwealth of Independent States,
NA: North America, OSS: Open Source Software

1.5 Hitachi Group total R&D expenditure

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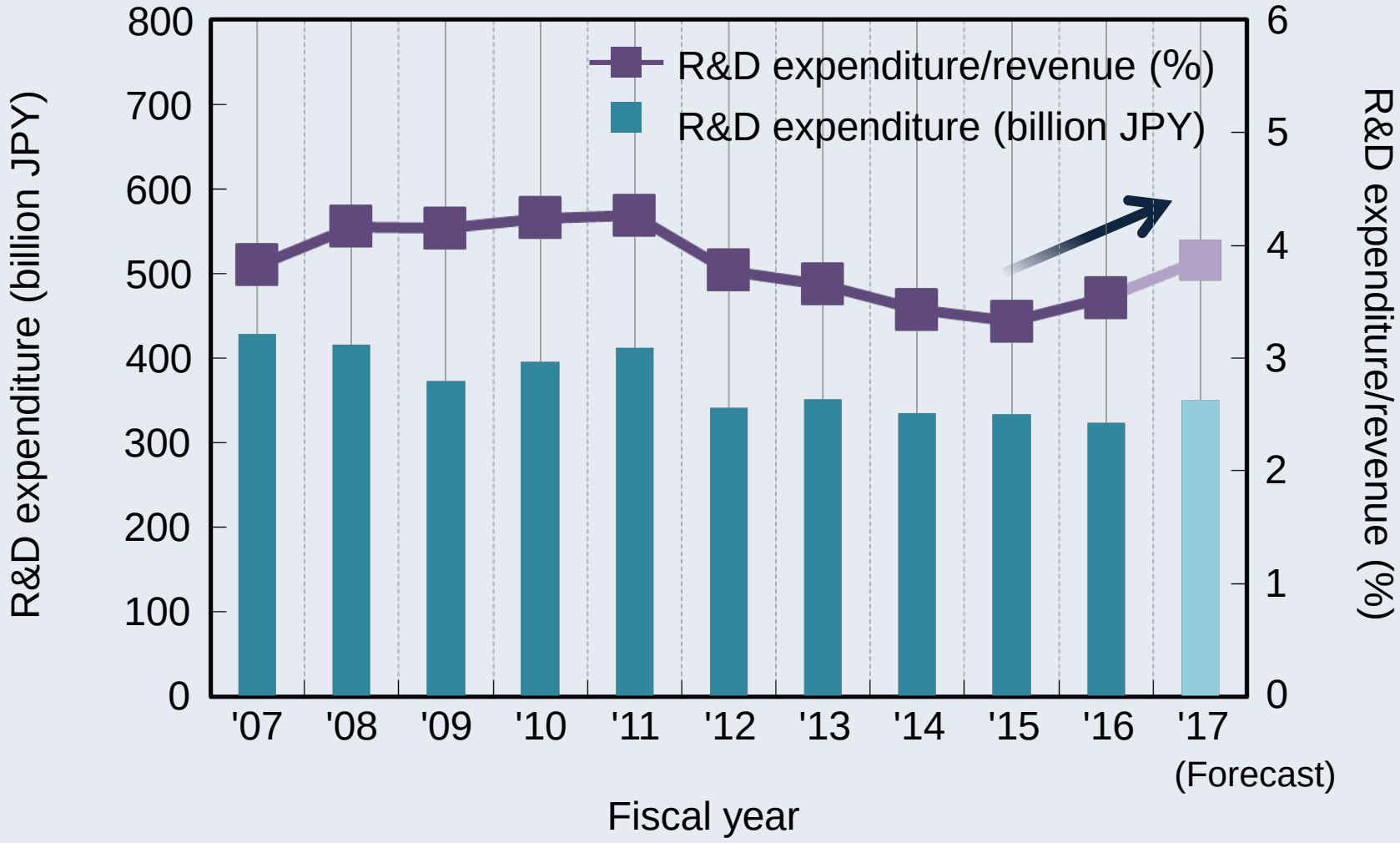
Investing approx. 4% of revenue in Hitachi Group R&D



1.6 Allocation of R&D Group funds

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Focusing resources in the four business domains & Lumada

■Research target

Sponsored research
<Business unit funding>

Advanced sponsored research
<Business unit funding>

Frontier & Platform
<Corporate funding>

Business roadmap [Led by Business unit]

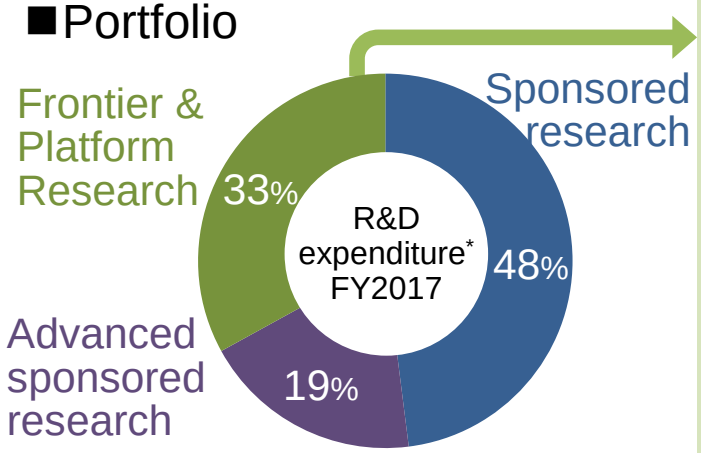
Current business

Next gen. business

Technology roadmap [Led by R&D Group]

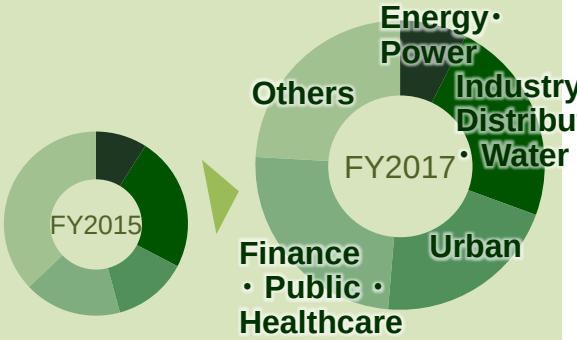
Co-creation/Technology PF enhancement/New business creation/Open innovation

■Portfolio



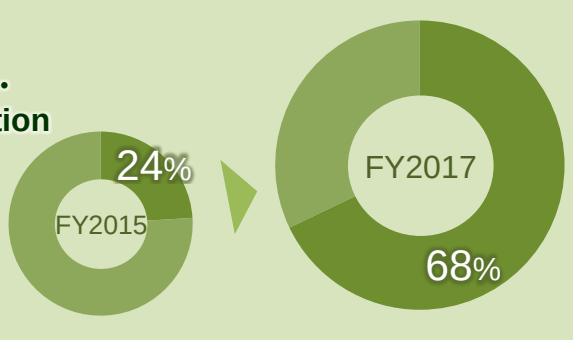
%Change in focus domains

63% (FY'15) → 76% (FY'17)



%Change in digital solutions

24% (FY'15) → 68% (FY'17)



* Roughly 20% of total Hitachi Group R&D expenditure

PF: Platform

1.7 External awards & recognitions

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Open innovation with Hokkaido University
Joint award National Commendation for Invention Imperial Invention Prize

Particle beam therapy system*

National Commendation for Invention

Award	Theme
JIII Imperial Invention Prize	**Real-time tumor-tracking particle therapy system**
Minister of Internal Affairs and Communications: Encouragement Prize for Cybersecurity	Promotion of Nippon CSIRT Association and contributions to raising domestic cybersecurity
The Energy Conservation Center: Energy Conservation Award	“Stainless clean Shirokuma-kun” air conditioner
Nikkan Kogyo Shimbun: Best Ten New Products Award: Nippon Brand Prize	Walk-through-type explosives detection system
“Cho Monodzukuri” Innovative Parts and Components Award: Nippon Brand Prize	Video processing module for low irradiation X-ray diagnostic systems
iF DESIGN AWARD 2017	Next-generation elevator “HF-1”

JIII: Japan Institute for Promoting Invention and Innovation

* A part of this research was jointly conducted with Hokkaido University under the funding program for world-leading innovative R&D on science and technology by Cabinet Office of Japan

**Awards received between July 2016 – June 2017, CSIRT: Computer Security Incident Response Team

Total 142**

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2.1 Strategic investment & research in the four focus business domains

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Expand Social Innovation Business & enhance supporting products and services through collaborative creation

Business domain	Power・Energy	Industry・Distribution・Water	Urban	Finance・Public・Healthcare
				
Strategy & investment	• Electric power reforms (Japan) • Distributed Power / Renewable Energy	• Plant optimization using digital technologies • Rebuilding supply chains by digital technologies	• QoL enhancement (Urban / Mobility / Home digitalization) • Further growth of product business	• Growth in keeping with changes in technologies and markets (financial) • Support for “My-Number”
Research strategy	• Create a T&D solution that will accelerate the use of renewables • Differentiate on down-wind wind farms, develop O&M service menus	• Co-create smart manufacturing & logistics solutions • IoT for industrial equipment & develop digital services	• Make elevators & escalators, rail cars /electric & automotive products No. 1 global products • Enhance digital solutions around railway O&M	• Co-create FinTech business solutions • Develop new applications using “My-Number” system

FinTech: Financial technology, IoT: Internet of Things, O&M: Operation & Maintenance,
QoL: Quality of Life, T&D: Transmission & Distribution

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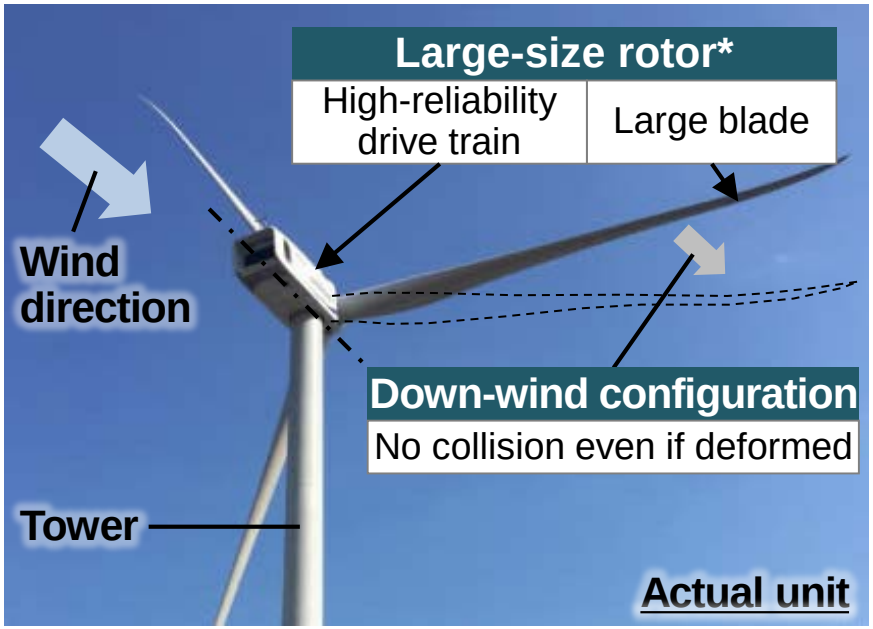
Enhance development for deployment outside Japan & to increase profitability of O&M services

5MW Downwind-type wind turbine

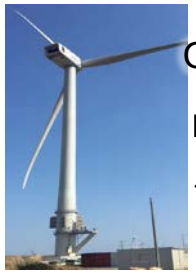
- Enlarged blade surface area by 15%
- Down-wind blade configuration suitable for typhoon regions



Deploy outside Japan focusing on southeast Asia

IoT-based O&M services

- IoT platform increasing power generation & optimizing maintenance
- Physical simulation to assess equipment status



Operational data

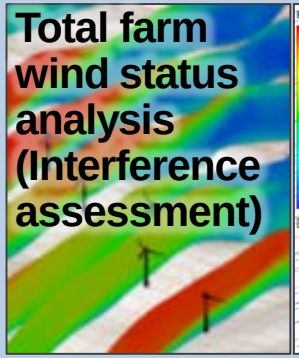
Control

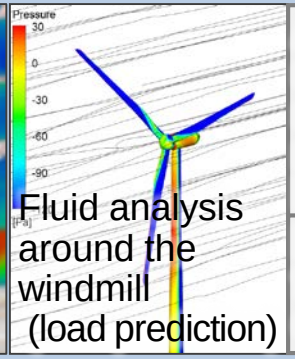
IoT analytics platform

Optimal operation・maint-enance

Assess status

Physical simulation





Analyze structural strength・Predict remaining useful life

Detect sign of failure in electrical parts

*A part of the large-size rotor development was conducted in a project supported by the New Energy Development Organization, Japan (NEDO), IoT: Internet of Things, MW: Megawatt, O&M: Operation and Maintenance

2.3.1 Industry·Distribution·Water: Smart manufacturing

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Realize digitalized & smart production sites using sensors & AI

Smart production sites

- Work progress monitored with 80,000 RFID
- Early identification & response to bottlenecks

Omika Works

Monitor with RFID

Work progress

Factory simulator
Resource allocation
Modular design
Reflect design
Support *kaizen*
Visualization・Countermeasures

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Transfer know-how from in-house operations to external partners

Digitalizing factory-floor know-how

- Anomaly work detection by video analysis
- Analytics of gaze and arm motion

Video analytics of action & movement

- Detect movement anomaly
- Trace origin of defects

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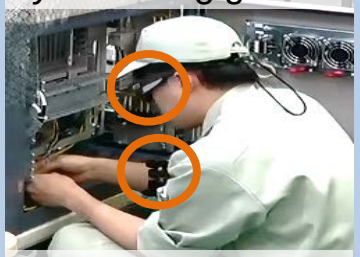
Co-creation with Daicel

AI analytics of gaze & arm movement

- Determine end of task
- Technical transfer of intuition and knack

(Joint research with DFKI)
(Exhibited at CeBIT2017)

Eye-tracking glasses



Arm band sensor

Lateral deployment of co-creation

AI: Artificial Intelligence, DFKI: Das Deutsche Forschungszentrum für Künstliche Intelligenz GmbH (The German Research Center for Artificial Intelligence), RFID: Radio Frequency Identification

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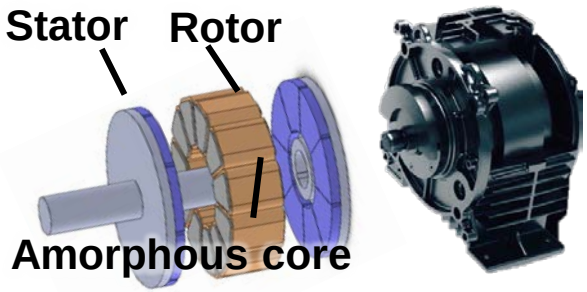
Global deployment of digital solutions through innovative products and IoT

Amorphous motor integrated scroll air compressor

- World's first amorphous core flat motor
- Compact integrated structure

Flat motor

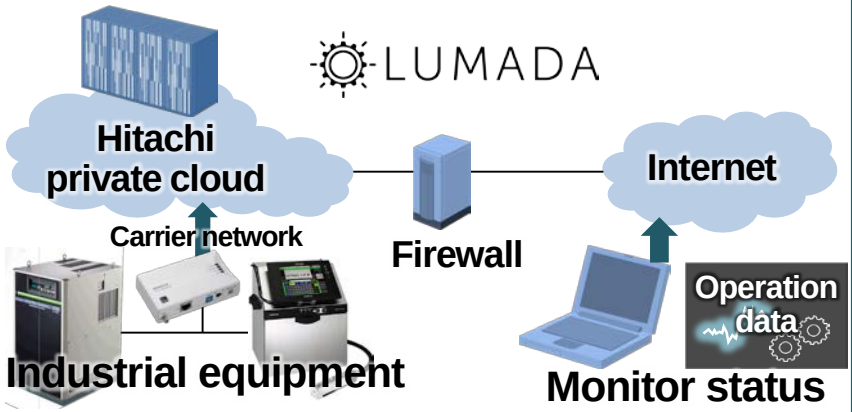


Compact integrated structure

Advanced AI-based maintenance service

- Optimal operation by anomaly detection & analytics
- Tie-up with Sullair for global deployment

Cloud-based monitoring service (FitLive)



Predictive maintenance technology

A part of the motor development was conducted in a project supported by the New Energy Development Organization, Japan (NEDO), AI: Artificial Intelligence, IoT: Internet of Things, OT: Operational Technology

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Realize total O&M solutions around Global No. 1 products

Elevators

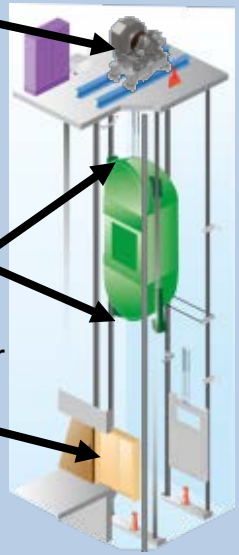
- Apply railway technology to overcome noise & vibrations issues which accompany higher speeds, to realize world's fastest elevator

World's fastest elevator (1,260m/min*)

Drive・Control
- New high strength twisted wire rope (1.3x previous rope)
- Large diameter permanent magnet motor

Comfort
- Active guide (vibration control)
- Capsule structure for low-noise car

Safety
- ETSD to realize smaller size & less inspection components



Maintenance service
- Mechanize the functional check conducted by engineers

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Railway

- Improve KPIs in the rail business by connecting the on-board systems, signaling and operation systems

Railway system total solution

Optimal maintenance plan
- Remote monitoring to predict car breakdowns
- Rail car allocation, depot maintenance, plan optimization

Energy-efficient driving
- Energy efficient driving based on big data analytics and AI
- Driving advisor

Passenger management
- Optimal operation using people flow analysis

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*2017/6/2 News release, AI: Artificial Intelligence, ETSD: Emergency terminal speed-limiting device, KPI: Key Performance Indicator, O&M: Operation and Maintenance

2.4.2 Urban: Automotive components

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Increase competitiveness of motorization and autonomous driving by enhancing system integration

Electro-mechanical systems

Battery ✖ **Inverter** ✖ **Motor**

- Battery control technology enhancing driving range・Lifespan
- Double-sided cooling high power inverter

Li-ion battery control technology

Degradation model developed for each internal component using material simulation

↓

Smart battery control

Inverter

World's highest power density

Motor

Compact high power (rectangular wire roll)

Autonomous driving systems

Recognition ✖ **Control** ✖ **Connectivity**

- High speed computation
- Security in connections with infrastructure

Highly reliable high-speed ECU

Fusion with sensor ・Stereo camera ・Radars	Autonomous driving ECU	Central gateway
Exterior recognition	Vehicle control	Connect with infrastructure

DB high-speed processing

High security

Field tests

M-city
U. Michigan MTC
USA

DB: Data Base, ECU: Engine Control Unit, Li: Lithium, MTC: Mobility Transformation Center

2.5 Finance・Public・Healthcare: Blockchain

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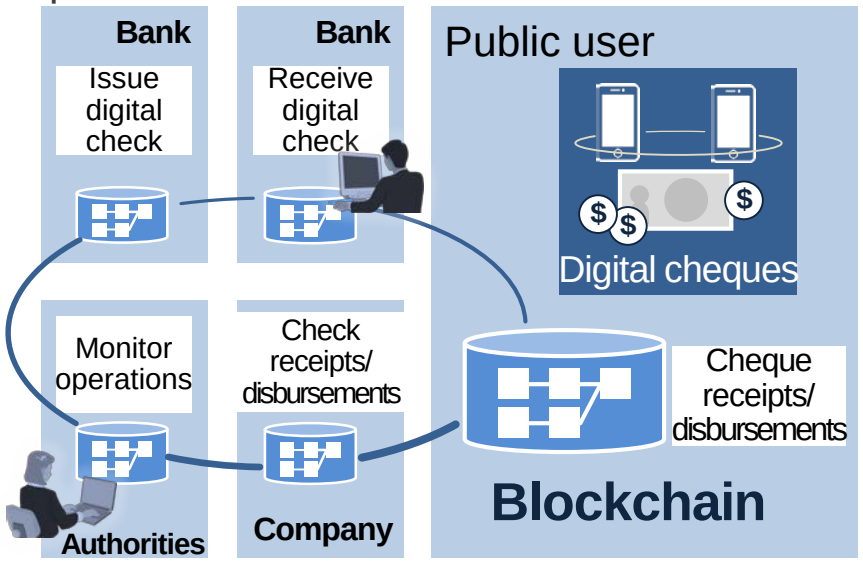
Financial Innovation Laboratory (US) leading activity to create new services using blockchain

FinTech Service

- Increase reliability & quality by building on repeated PoC

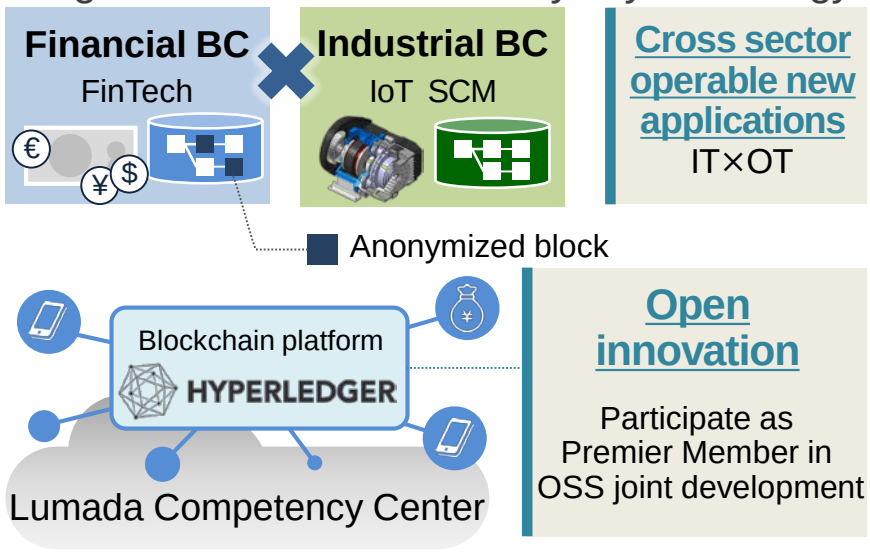


Est. FinTech research team in US ['16/3]
Financial Innovation Laboratory

Initiated PoC in Singapore ['16/8]
Digital check service using blockchain

Blockchain platform cloud

- Successive creation of new applications using a ready-to-test development environment
- Hyperledger implementation technology & know-how
- Original blockchain data anonymity technology



Start cloud service* ['17 1H]**
Initiate a service to provide a blockchain environment

BC: Blockchain, OSS: Open Source Software, SCM: Supply Chain Management, **1H: Apr.-Sep.
*Service will be available 1 month after the release of the official version of Hyperledger Fabric v1.0

2.6 Contributing to global deployment

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Power・Energy

Industry・Distribution・Water

Urban

Finance・Public・Healthcare

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Europe

- Railway
- Nuclear energy
- Energy

China

- Elevators/ Escalators
- Healthcare
- Construction machinery

Asia

- Finance (FinTech)
- Industrial products

NA

- Automotive components
- Industrial products
- Urban mobility

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3.1 Enhancing Lumada

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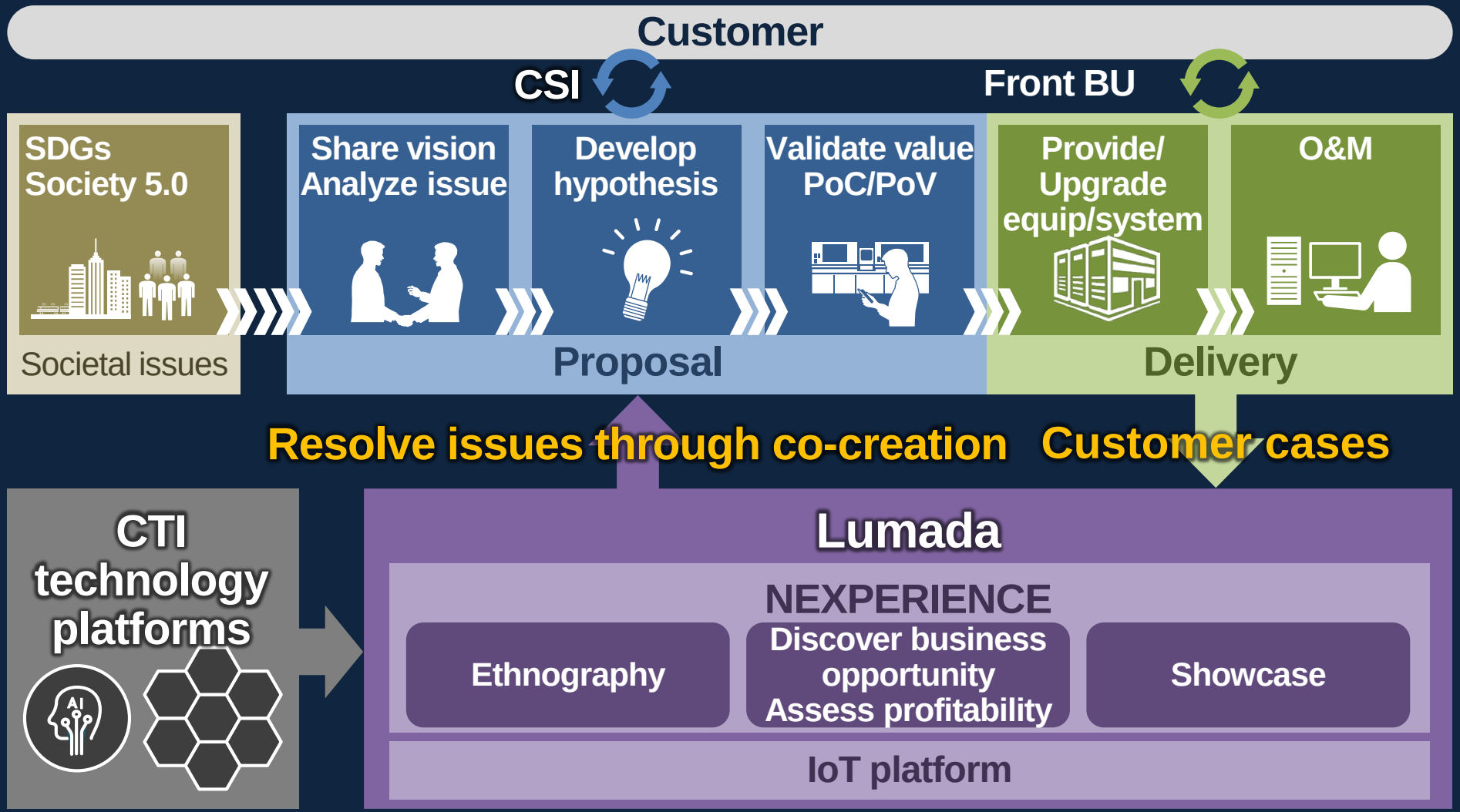
Aggressively promote collaborative creation with customers by incorporating Hitachi's original methodology NEXPERIENCE into Lumada



BU: Business Unit, CSI: Global Center for Social Innovation, CTI: Center for Technology Innovation, PoV: Proof-of-value SDGs: UNDP Sustainable Development-Goals, Society 5.0: CSTI, Cabinet Office, Govt. of Japan 5th Science and Technology Basic Plan (2016/1)

3.2 Global scaling customer cases of Lumada

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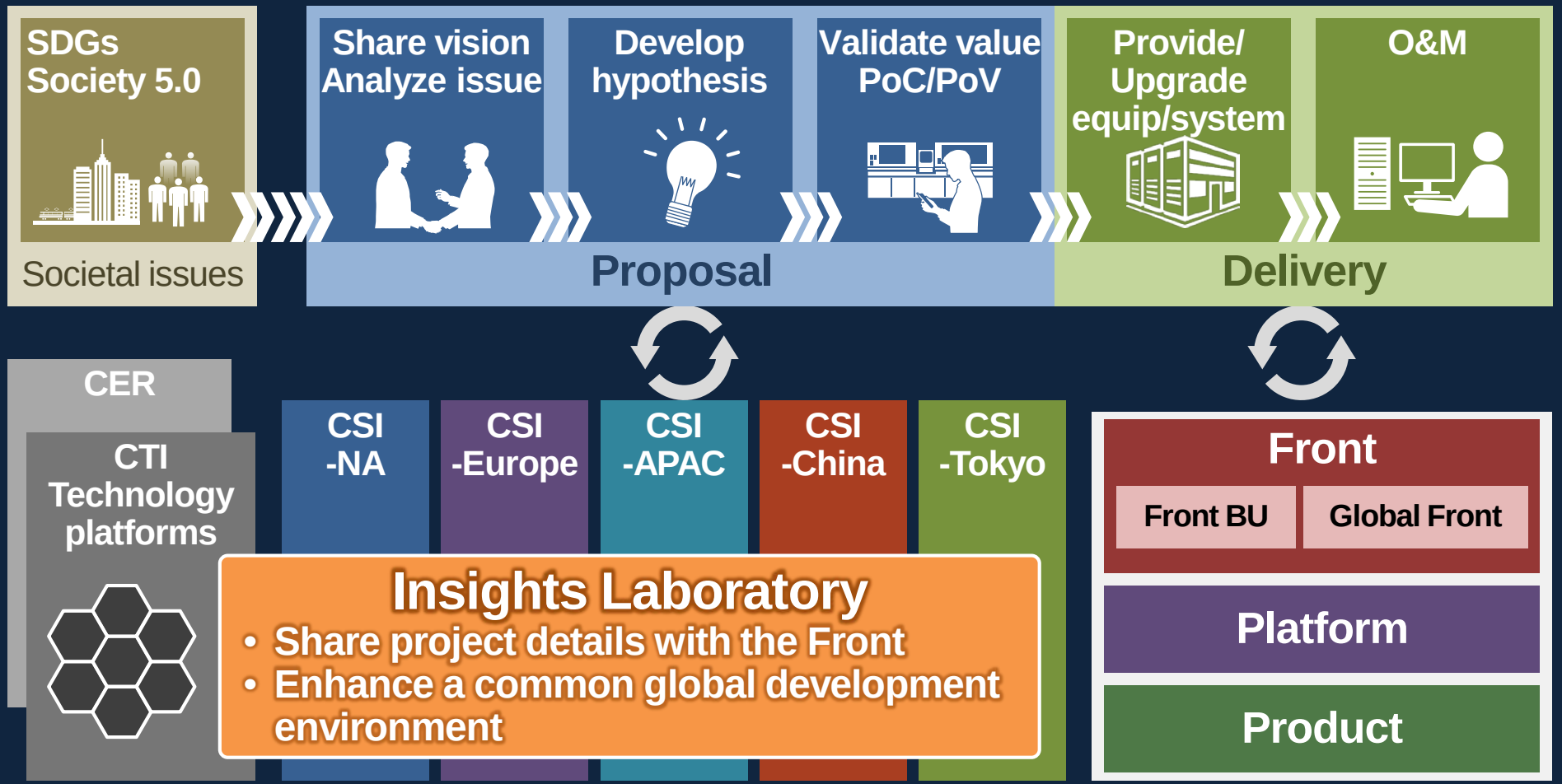
Set-up Insights Laboratory for pipe-line management of customer cases with the Global Front



BU: Business Unit, CSI: Global Center for Social Innovation, CTI: Center for Technology Innovation, CER: Center for Exploratory Research, NA: North America, SDGs: Sustainable Development Goals

3.3 Increasing customer cases of Lumada

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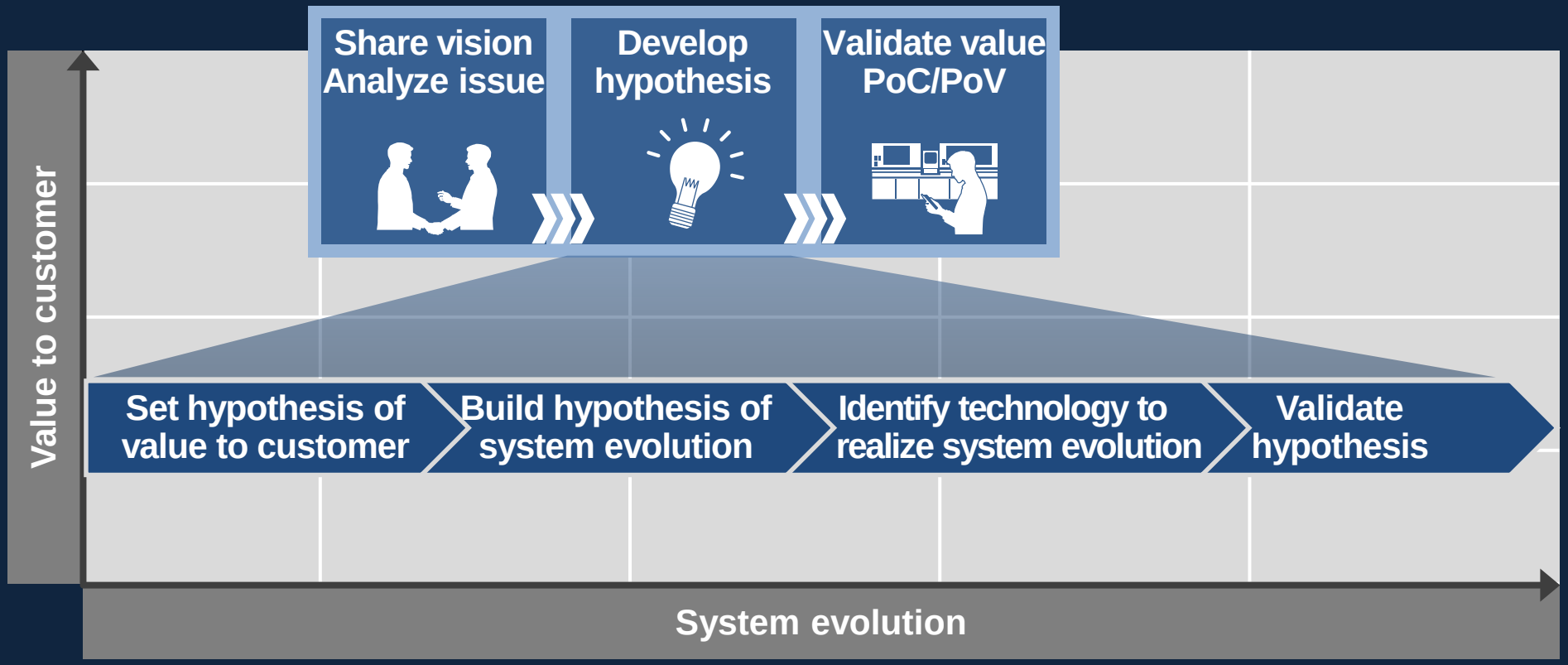
Accelerate validation of customer cases developed from value-to-customer perspective that include system evolution



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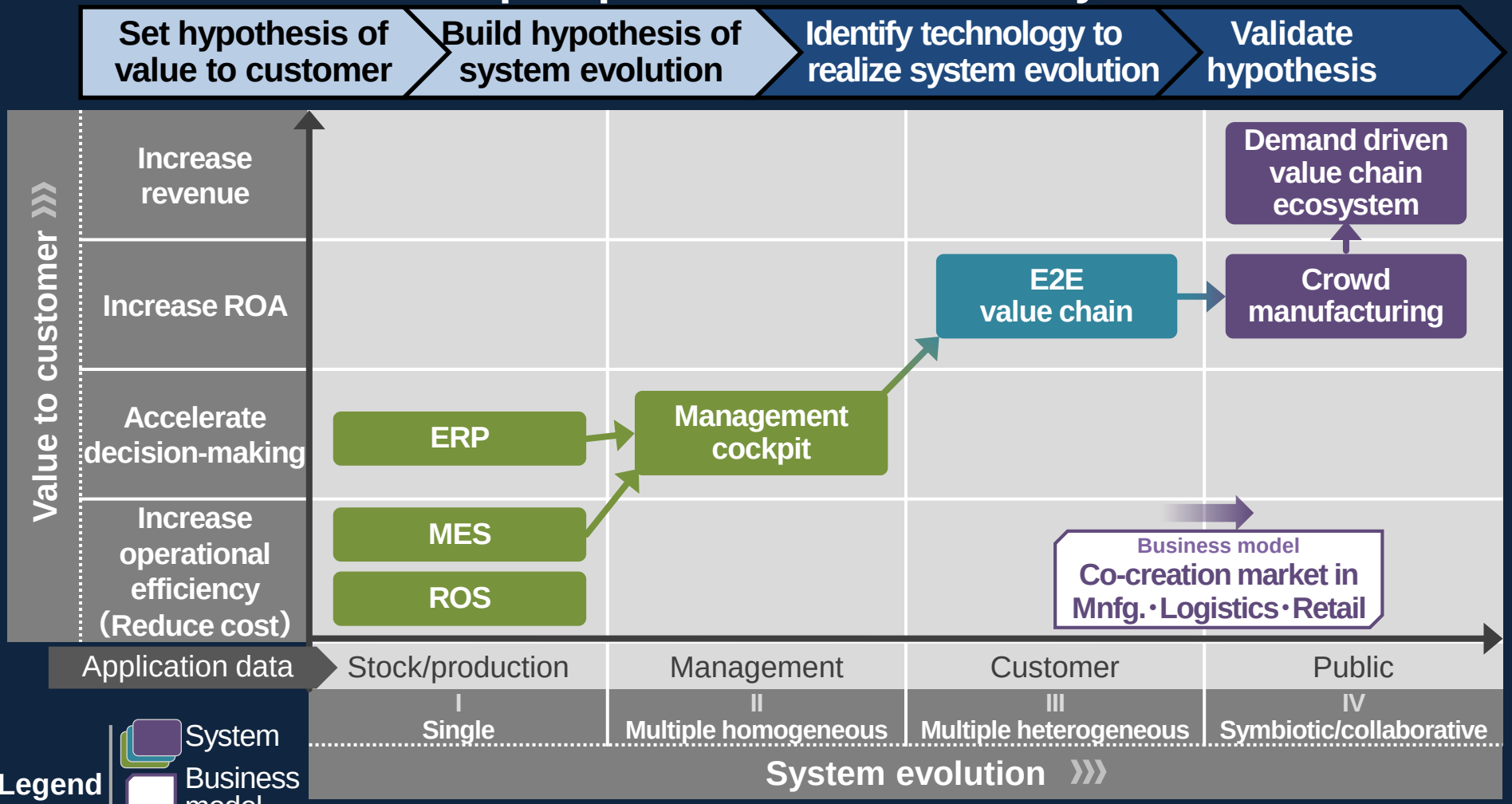
Accelerate validation of customer cases developed from value-to-customer perspective that include system evolution



E2E: End-to-End, ERP: Enterprise Resource Planning, MES: Manufacturing Execution System, ROA: Return-on-Assets, ROS: Robot Operating System

3.3 Increasing customer cases of Lumada

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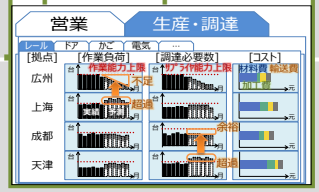
Accelerate validation of customer cases developed from value-to-customer perspective that include system evolution

Set hypothesis of value to customer → Build hypothesis of system evolution → Identify technology to realize system evolution → Validate hypothesis

Value to customer

- Increase revenue
- Increase ROA
- Accelerate decision-making
- Increase operational efficiency (Reduce cost)

AT/H Optimized production



ERP

MES

ROS

Management cockpit

E2E value chain

Dynamic scheduling

Demand driven value chain ecosystem

Crowd manufacturing

Matching AI

Business model
Co-creation market in Manufacturing・Logistics・Retail

Application data

Stock/production	Management	Customer	Public
I Single	II Multiple homogeneous	III Multiple heterogeneous	IV Symbiotic/collaborative

System evolution

Legend: System / Business model / Technology

AI: Artificial Intelligence, AT/H: AI Technology/H, E2E: End-to-End, ERP: Enterprise Resource Planning
MES: Manufacturing Execution System, ROA: Return-on-Assets, ROS: Robot Operating System

3.4.1 Innovating the functionality of Lumada

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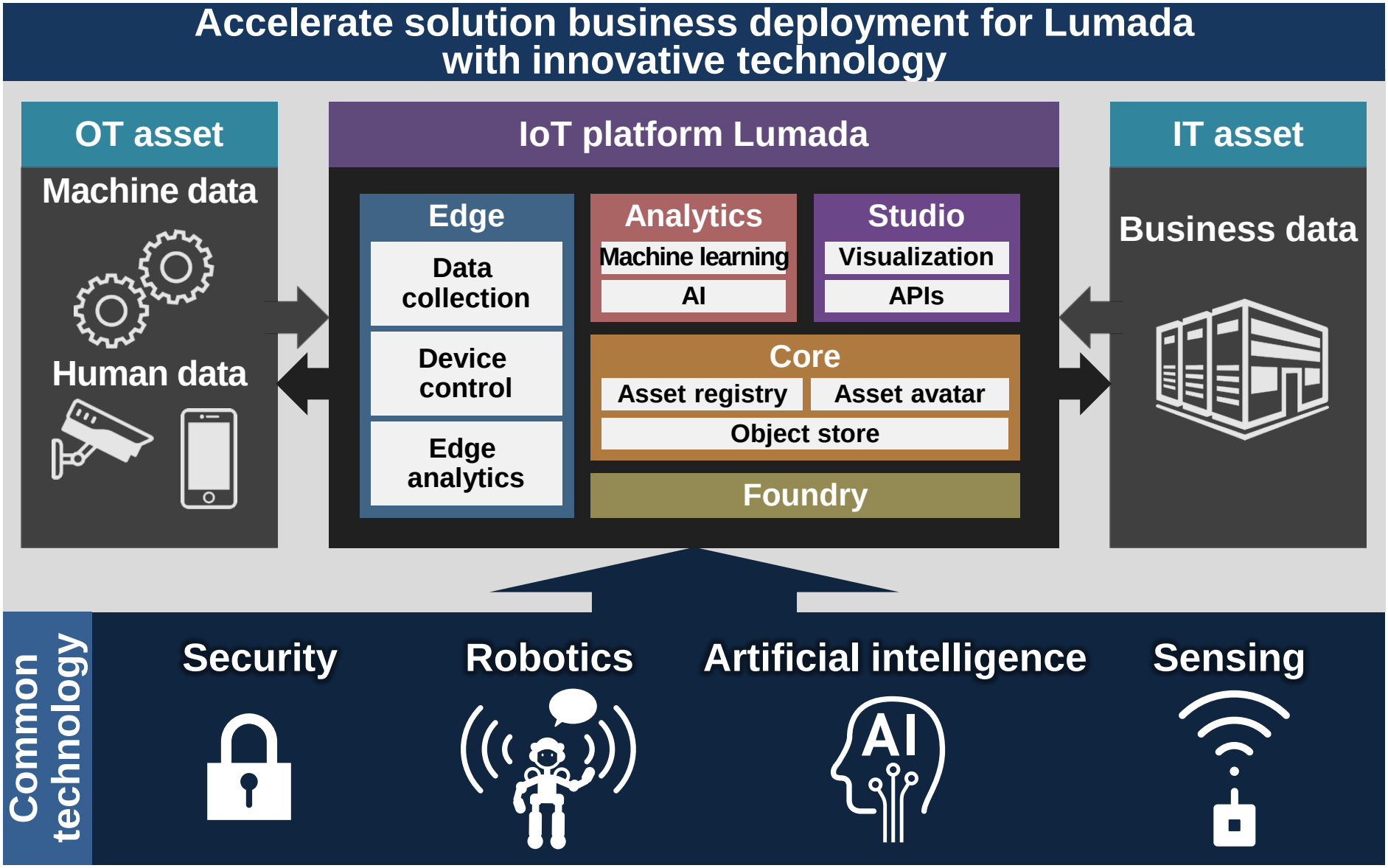
Accelerate solution business deployment for Lumada with innovative technology



AI: Artificial Intelligence, APIs: Application Programming Interfaces, IoT: Internet of Things, IT: Information Technology, OT: Operational Technology

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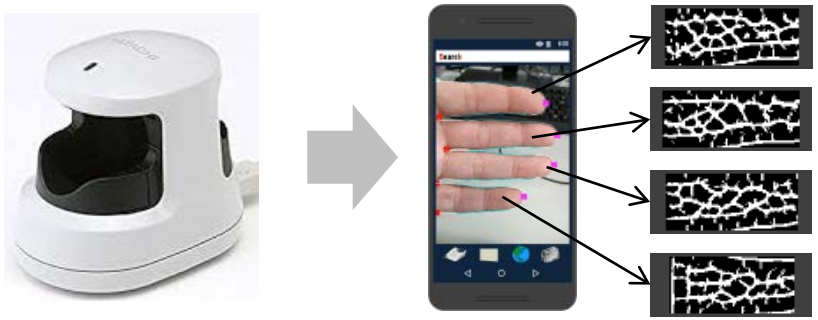
Transferring common core technology for an IoT platform to real cases

Security

Realized token-less and password-less public key authentication based on PBI technology

Expand finger vein authentication repertoire



Dedicated terminal **Smartphone**

Realized “hands free” ATM transaction

Robotics

Verifying various support services using a robot equipped with various recognition AI

Field tests at various locations in Japan

Tokyo Int’l Airport
(Facility guide)

DiverCity Tokyo Plaza
(Visitor guide)

JR Tokyo Station
(Tourist guidance)

Nojima Corporation
(Shop front･Product guidance)

AI: Artificial Intelligence, ATM: Automated Teller Machine, IoT: Internet of Things, PBI: Public Biometric Infrastructure

3.4.3 Activities in artificial intelligence

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Formed new global AI team to accelerate AI technology development and application

Global AI team

Global AI team

Insights Laboratory
- Open community activity
- Integrate cutting-edge technology

AI Lab. (CTI-wide lab.)
- Accelerate modelling based on industry sector applications

Hitachi Insight Group
- Accelerate expansion of AI applied business

Accelerate solution development through open innovation

Stanford University
DeepDive
(SDSI: Stanford Data Science Initiative)

industrial internet CONSORTIUM
OpenFog
HYPERLEDGER PROJECT

AI deployment status

Increase task efficiency by using RPA

Applied to in-house smart transformation

Certificate → Receipts/Disbursements (Read/Reconcile/Authorize) → Authorize **70%**, Reconfirm

Apply RPA

Confirmed 70% of certificates can be automated, applying technology to customer solutions

Workstyle transformation

In-house test of happiness-raising advice with 600 sales & marketing staff

- Organizational activity level increased with AI work advice
- 11% avg. increase in order rates in groups where activity level rose

- Confirmed correlation between organizational activity level & order rates
- Next step: Link with customer and production systems to support productivity

AI: Artificial Intelligence, CTI: Center for Technology Innovation, RPA: Robotics Process Automation

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Regional co-creation hubs contributing to global scaling

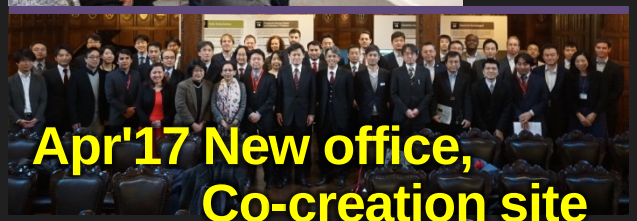
CSI-Europe

CSI-China

CSI-Tokyo, CTI

CSI-NA

CSI-APAC



APAC: Asia Pacific, CSI: Global Center for Social Innovation, CTI: Center for Technology Innovation, NA: North America

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4.1 Challenging future societal issues

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Realize sustainable growth through research for SDGs & Society5.0

SDGs

Goals for sustainable development

Society 5.0

Human centric Super Smart Society

CER

Info. sciences	Life sciences
New paradigm computing AI	Cancer screening Human empowerment
Physical sciences	**Frontier**
Thermo-electric conversion material Holography EM	Breath-alcohol detection Area energy design

Joint research sites

Hitachi Tokyo Univ. Lab.	Hitachi Kyoto Univ. Lab.
Generate Society 5.0 vision	Ideal image of universities and companies in 2050 AI/system learned from living organisms
Hitachi Hokkaido Univ. Lab.	**Hitachi Kobe Lab.**
Self-healthcare Digital fisheries industry	Regenerative medicine

Vision sharing

Vision Design PJ

School education
Public safety
Ageing support
Meal experience

AI: Artificial Intelligence, CER: Center for Exploratory Research, EM: Electron Microscope

4.2 Thermo-electric conversion material

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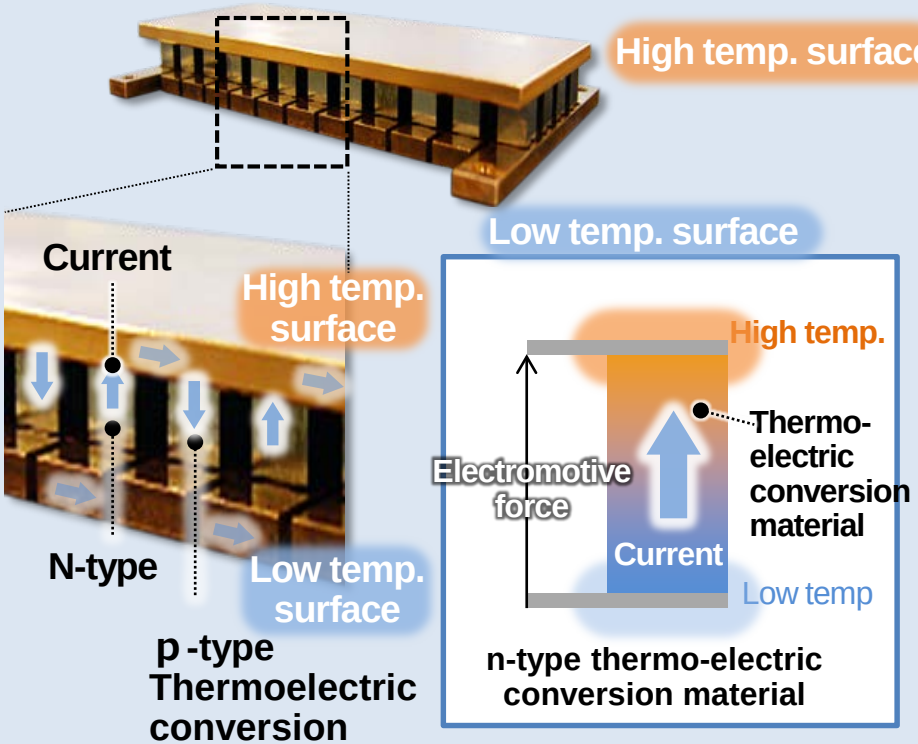
Improve energy efficiency & reduce CO2 emission by collecting & using unused thermal energy

Thermo-electric conversion module

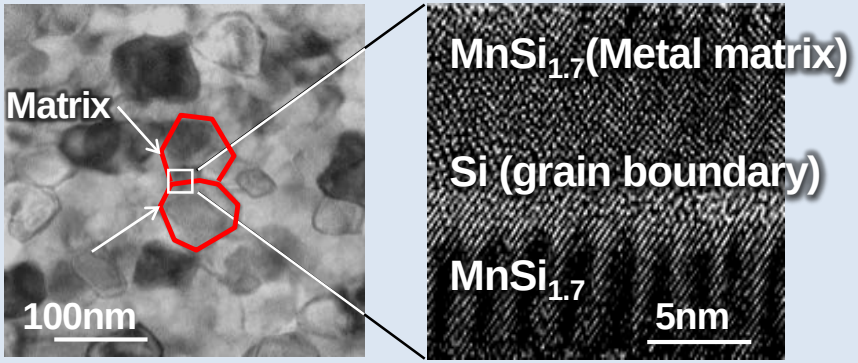
- Generate electricity by using the temperature difference between the electrodes across thermoelectric conversion material



Silicon nano composite material

- Non-toxic & inexpensive silicon-based material
- High electric conductivity and low thermal conductivity due to nano structure

Achieved world top low thermal conductivity in Si thermo-electric material



Silicide ($MnSi_{1.7}$/Si) nano composite

Application

- Turbine-less solar thermal power generation, geothermal power generation
- Automobile waste heat recovery

Partners TherMAT, Osaka U., Tohoku U., U. Tokyo, SPring-8, KEK

This work was supported by Future Pioneering Program "Research and Development of Thermal Management and Technology" commissioned by New Energy and Industrial Technology Development Organization (NEDO) and TherMAT.

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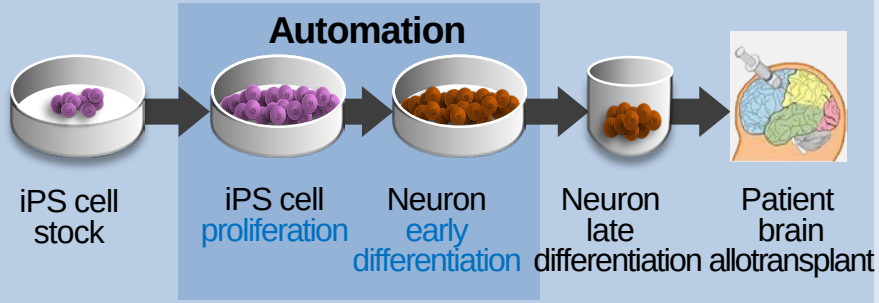
Paradigm shift from palliative to curative treatment through increased access to regenerative medicine

Large-scale automated cell culture

Sterile closed system for allografts

iPS-derived neuron cell process for Parkinson's disease



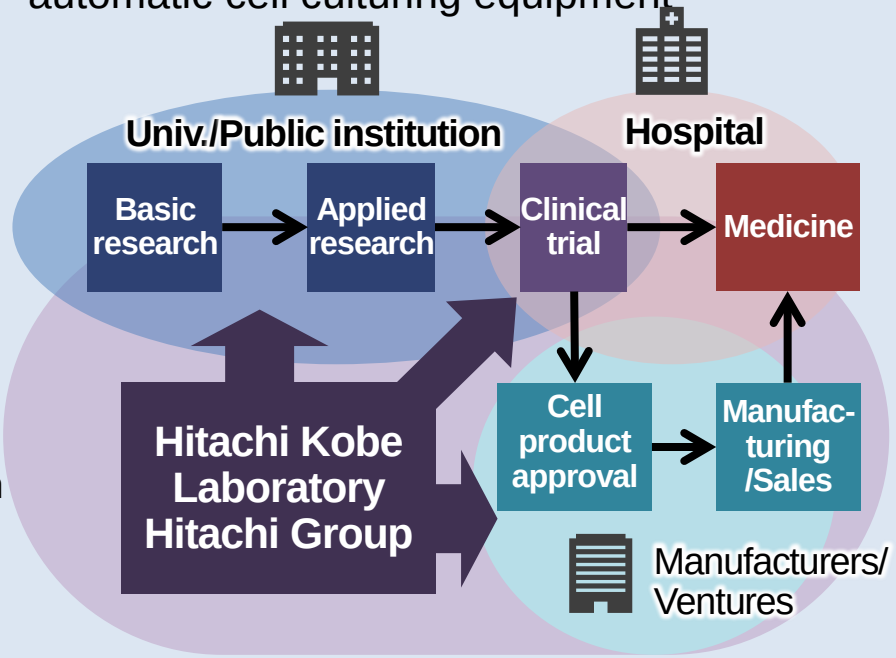
Automated cell culturing equipment iACE1

- Realized culturing in a completely closed system
- Automatic culturing of 1 billion cells
- Automation of iPS cell proliferation & early cell differentiation

Lowering cell culturing cost
1/100

Joint industry/academia research site

- Joint research site within KOBE Biomedical Innovation Cluster (KBIC)
- Form ecosystem around the automatic cell culturing equipment



Industry/Academia regenerative medicine ecosystem

Partners Kyoto Univ., Sumitomo Dainippon Pharma Co., Ltd., KBIC

News release: 3 & 10 Apr '17

A part of this research was conducted in a project supported by the Japan Agency for Medical Research and Development (AMED). iPS: induced Pluripotent Stem

4.4 Sharing our vision for Society 5.0

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Draw a vision of the future by identifying challenges from the perspective of future citizen

How do we become happier by using things we share and no longer own?

How will learning change when everything can be found on the Internet?

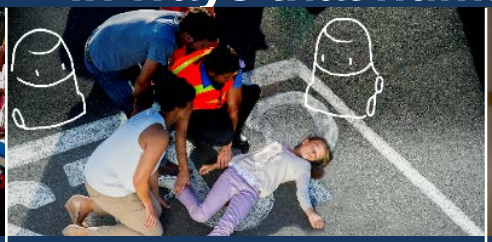
Can we protect people from anxieties that cannot be removed?

How will the shape of families and homes change as lifestyle choices diversify?

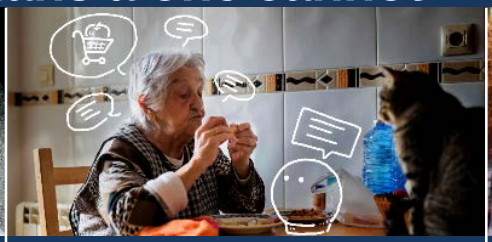
Does a connected world free us or control us?

Identify unique ways that technology can support people in ways that humans alone cannot

School Education
Support a multi-cultural teaching environment for students with diverse needs and backgrounds



Public Safety
Not only protect citizens but make this security visible



Ageing Support
Ease the anxiety of ageing by identifying and supporting cognitive decline

Meal Experience
Not only improve food safety for individuals but create fun meal experiences

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Contents

1. R&D direction & Progress
2. Focusing on four business domains
3. Enhancing Lumada supporting the expansion of Social Innovation Business
4. Challenging future societal issues
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Generate business innovation in an era of uncertainty

- Focusing on four business domains
- Enhancing Lumada supporting the expansion of Social Innovation Business
- Challenging future societal issues

THE FUTURE IS OPEN TO SUGGESTIONS

Hitachi Social Innovation

Delivering new value to society through collaborative creation with our customers and partners

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END

2017 R&D Strategy
Global R&D driving further growth in Social Innovation Business

June 28, 2017

Norihiro Suzuki, Ph.D.

Vice President & Executive Officer
Chief Technology Officer
General Manager, Research & Development Group

Hitachi, Ltd.

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