TOSHIBA

Toshiba's Technology Strategy

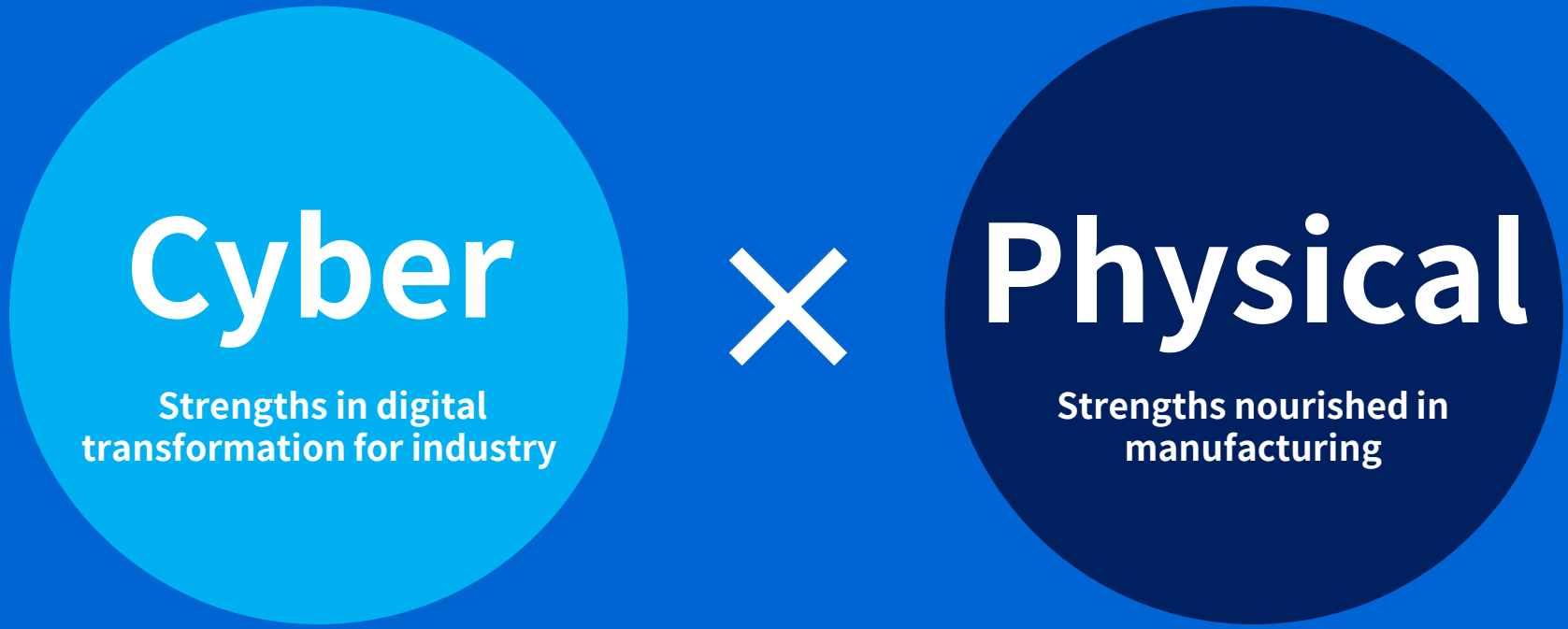
Dr. Shiro Saito

CTO

Corporate Executive Vice President

Toshiba Corporation

November 28, 2019



We turn on the promise of a new day

Agenda

1 Toshiba Group’s Vision

2 Technology Development to Become a CPS Technology Company

3 Activities for new business creation

4 In Closing

1

Toshiba Group’s Vision

- Process towards Growth
- CPS Technology Company Image Realized by Technology
- R&D Structure
- R&D Investment

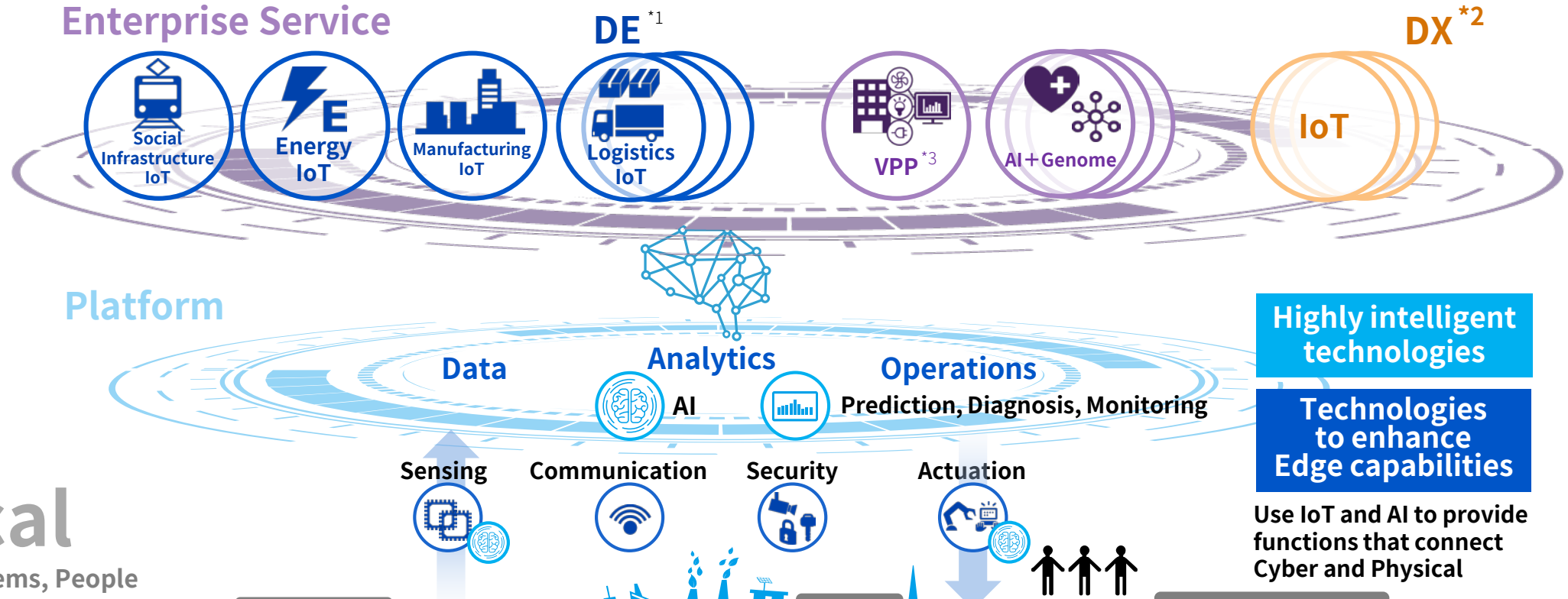
Process towards Growth

Nov. 13
Toshiba Next Plan
Progress Report

Completed recovery of financial base; shifting towards growth phase 2

CPS Technology Company Image Realized by Technology

Through R&D and open innovation, bring Edge capabilities to key components for existing businesses; use Toshiba's IoT architecture to create new enterprise services



Highly intelligent technologies

Technologies to enhance Edge capabilities

Use IoT and AI to provide functions that connect Cyber and Physical

*1 Digital Evolution
*2 Digital Transformation
*3 Virtual Power Plant

R&D Structure

Promotion of digital services, new businesses and IoT architecture deployment; three new organizations established* to strengthen security-related technologies

*Cyber-Physical System Promotion Division, Digital Innovation Technology Center and Cyber Security Technology Center

Toshiba Corporation

- **Research & Development Division**
  - Cyber-Physical System Promotion Division
    - New Business Development Office
  - Digital Innovation Technology Center
- **Corporate Research & Development Center**
  - Cyber Security Technology Center
- **Corporate Software Engineering & Technology Center**
- **Corporate Manufacturing Engineering Center**

Key group companies R&D organization

Toshiba Energy Systems & Solutions Corporation	Energy Systems Research & Development Center
Toshiba Infrastructure Systems & Solutions Corporation	Infrastructure Systems Research & Development Center
Toshiba Electronic Devices & Storage Corporation	Electronic Devices & Storage Research & Development Center
Toshiba Digital Solutions Corporation	Software & AI Technology Center
Toshiba Tec Corporation	Research & Development Center

Overseas R&D Organization

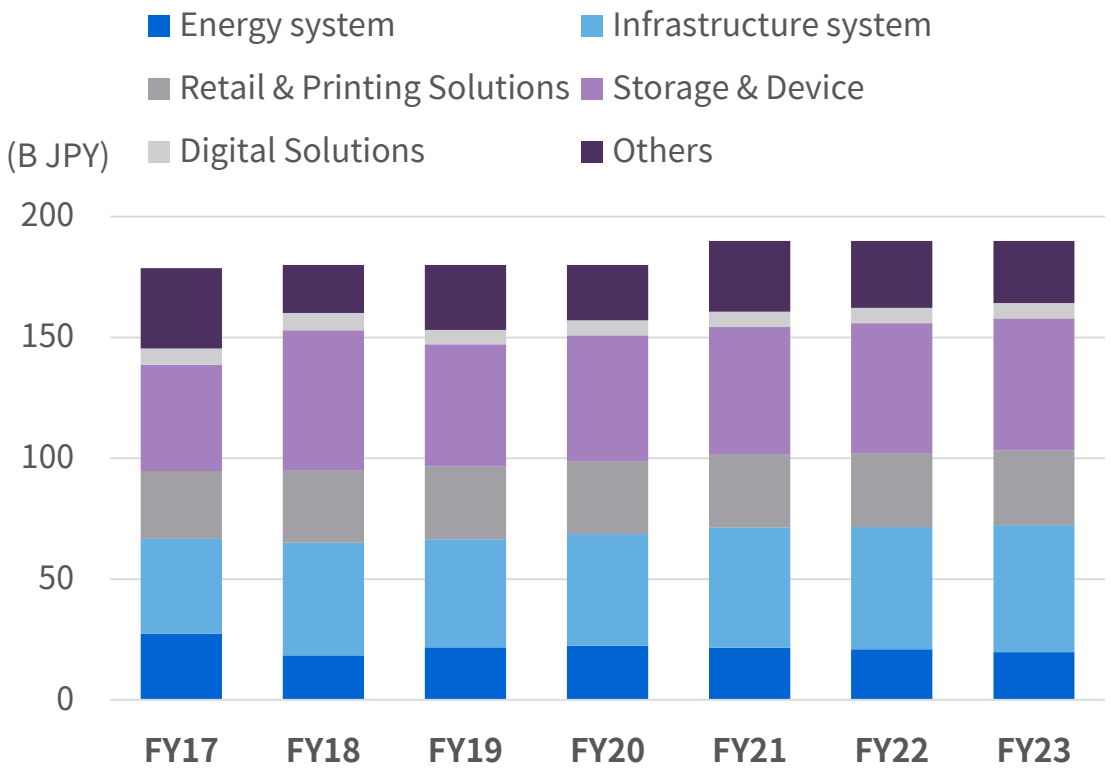
- **Toshiba Research Europe Limited**
  - Cambridge Research Laboratory
  - Bristol Research and Innovation Laboratory
- **Toshiba America Research, Inc.**
- **Toshiba (China) Co., Ltd.**
  - R&D Center
- **Toshiba Software (India) Private Limited**
- **Toshiba Software Development (Vietnam) Co., Ltd.**

R&D Investment

Accelerate investments to support profit and medium- to long-term profit

R&D investment*1

Total investment plan: JPY 930B (FY19-23)



*1 Before segment reclassification in April 2019
*2 Virtual Power Plant

Major R&D projects

Energy systems
Focus on growth fields such as clean energy (renewable energy, VPP*2, supercritical CO_2 turbine, etc.), and asset management.

Infrastructure systems
Focus on fields that support growth, including SCiB™ application, robotics, highly efficient motors, power supply systems, etc.

Electronic devices and storage
Focus investment on the development of power devices (Si, SiC), automotive semiconductors, and HDD for data centers.

Digital solutions
Focus on development for business model transformation such as *RECAIUS™*, and *SATLYS™*

Building solutions
Continue investments to develop products that create new value and that align with target customers.

2

Technology Development to Become a CPS Technology Company

Technology Development Policy

Differentiate competitive components and enhance their capabilities for the Edge

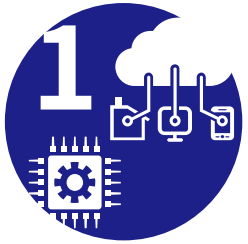
Reinforce AI-based digital technologies

Deploy IoT reference architecture and services

Technology Development Policy

Create original CPS with competitive components and AI & IoT technologies
Resolve social issues and maximize enterprise value through technology

In FY2019, focus on realizing DE and DX deployment



Differentiate competitive components and enhance their capabilities for the Edge

Reinforce AI-based digital technologies

Deploy IoT reference architecture and services

Differentiate competitive components and enhance their capabilities for the Edge

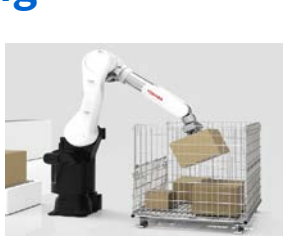
Increase and reinforce Edge capabilities of components

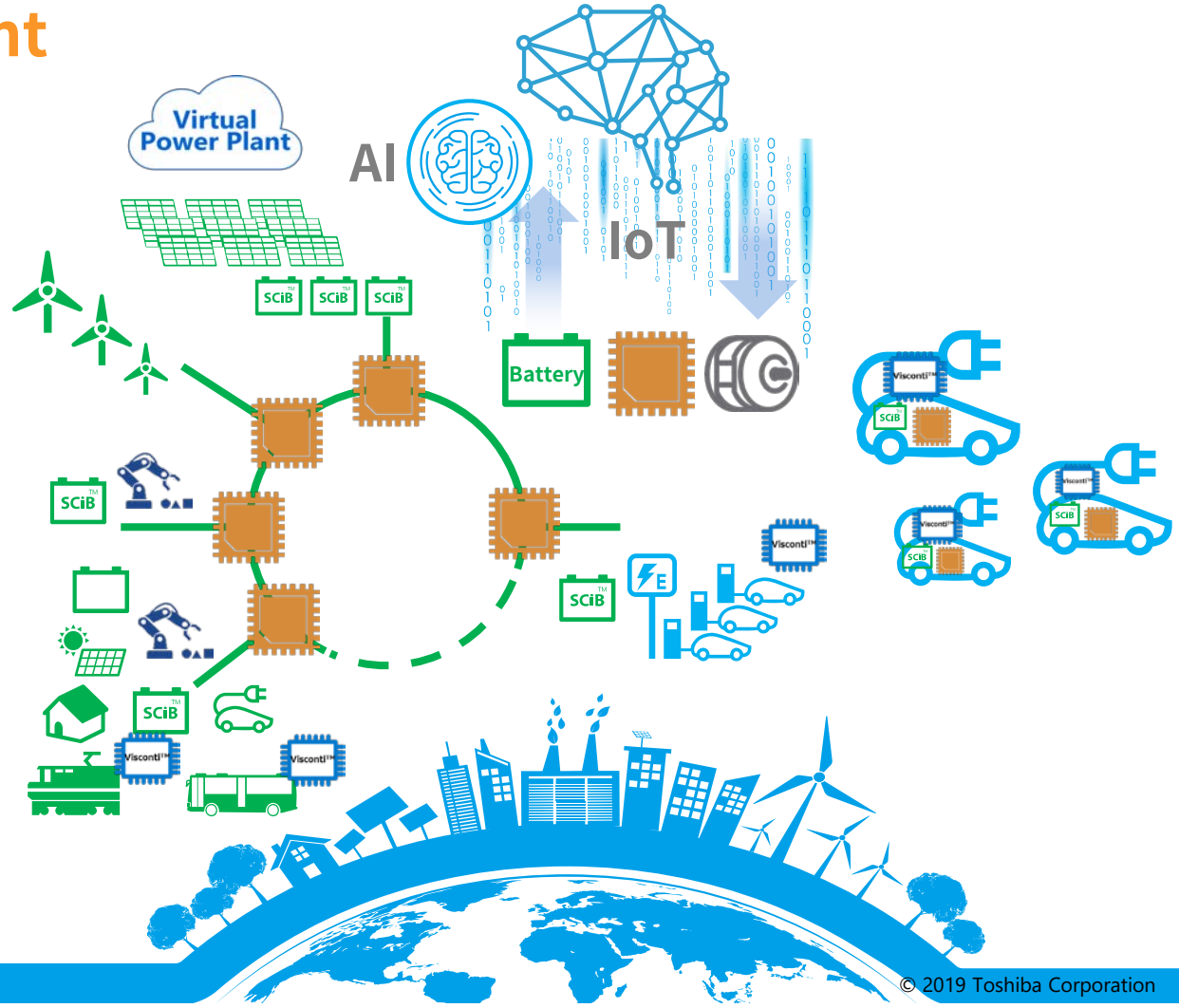
Realize CPS for social infrastructure and energy
by making full use of Toshiba's customer base, technology and products

Toshiba's Edge Capability Enhancement

Components x AI & IoT technology
create competitive edge components
that support CPS

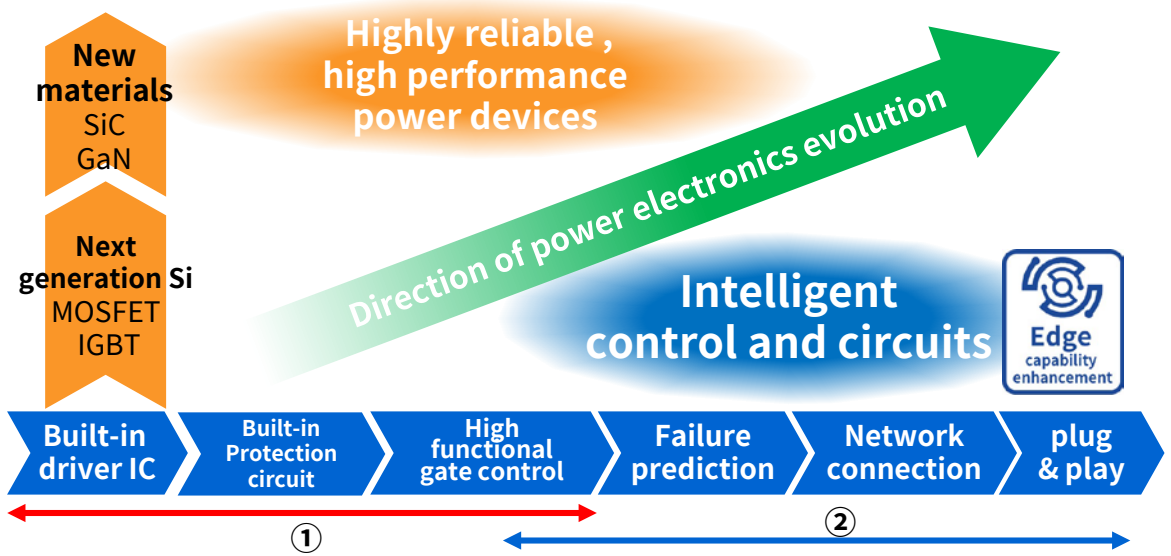
- Safe and highly reliable
- Power saving, low power consumption
- High-speed response
  and autonomous control
- Sensing and status monitoring
- Automation and labor saving





Edge Capability Enhancement Strategy: Power Electronics

Pursuit of device performance x Intelligent control and circuits
Promote development of edge devices that support social infrastructure and energy CPS



Development of next generation Si power devices

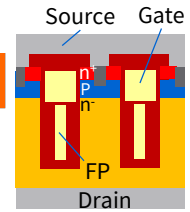
Low voltage power MOSFETs for automobiles

- Toshiba's original trench structure and process for UMOS-X
- Industry's top class device performance

Development completed

➡ Low on-resistance 25% reduction

(Compared with the 100V-class U-MOS VIII process, according to our research , as of March 2019)



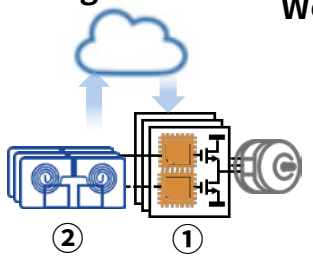
Enhancement of 8-inch process capability
at Kaga Toshiba Electronics Corporation
FY17→FY20 x1.5

Intelligent control and circuit technology

Enhanced collaboration with Cyber

①Gate control: High-efficiency gate drive IC with high-speed switching[*1]
20-25% power reduction in normal operation and noise suppression

②Device monitoring and protection:
High-speed, multiple transmission isolator IC[*2]
World's highest level multiplexing (3ch) & highest-speed[*3] (35MHz) transmission of isolated signals



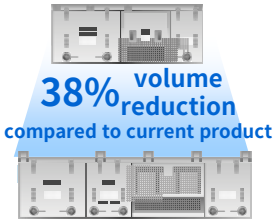
Expanded application: SiC power devices

- Supplied propulsion systems using All-SiC inverter to new railway vehicles[*4]
- Introduced the world's first propulsion system using All-SiC inverter, Totally Enclosed PMSM[*5], and SCiB ™[*6]

World's first

West Japan Railway Company

Tokyo Metro Co., Ltd. Marunouchi Line



In operation from February 2019

*1 http://www.toshiba.co.jp/rdc/detail/1902_01.htm
*2 IEEE international conference "ISSCC 2020"(San Francisco, Feb., 2020)
*3 As an isolation amplifier
*4 https://www.toshiba.co.jp/infrastructure/en/news/20190314.htm
*5 Permanent Magnet Synchronous Motor
*6 https://www.toshiba.co.jp/cs/topics/back-number/20181011.htm

Edge Capability Enhancement Strategy : Image Recognition Processor Visconti™5

Application of DNN*1-hardware IP realizes high speed, low-power and high accuracy recognition Contributes to driving that secures safety of vehicle surroundings, driver and passenger

In mass-production

Visconti™4

Strong recognition technology, even at night

Enhanced driving support

「Visconti™4」
Toyota Motor Corporation vehicles equipped with Visconti™
Winner of Grand Prix, **"2018 Japan New Car Assessment Program (JNCAP)" Award**

- Recognition of drivable area
- Simultaneous recognition of multiple objects

Processing speed*3
Approx. x10

Power efficiency*3
Approx. x4

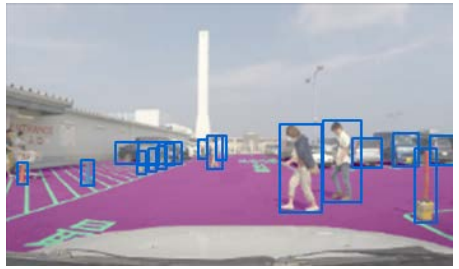
Deployment/application
Automobiles, surveillance camera, digital signage, AGV/drones, etc.

Sample Shipment*2

Visconti™5

Algorithm that supports DNN

Front monitoring, automatic parking



DNN image recognition + 3D technology

Concept

Future

Expand application of DNN and AI application

Limited autonomous driving

Prediction + Decisions using AI

「Visconti™5」DNN accelerater

*4

① **Lower power consumption during DRAM access**
Place temporal data retention SRAM close to executing unit

②**Parallelization of multiply-accumulate units operation process**
4 processors, each with 256 multiply-accumulate units

③ **Lower power consumption during SRAM access**
Allowing a series of DNN calculations to be executed by one SRAM access

*1 DNN is a machine model using artificial deep neural networks inspired by human brain function.
*2 shipping of sample product from September, 2019
*3 Compared with previous Toshiba's SoC (presented at International conference "ISSCC 2015").
*4 https://toshiba.semicon-storage.com/ap-en/product/automotive/image-recognition.html

History of Rechargeable Battery Development - Toshiba's Contributions

1976 — 1980 — 1985 — 1991 — 2004 — 2008 — Present day

S. Whittingham
2019 Nobel Prize for Chemistry
Li/TiS2 battery proposal (electrode reaction basics)

Akira Yoshino
2019 Nobel Prize for Chemistry
Established basic concepts of lithium-ion battery

Lithium-ion battery Commercialization
(Sony Corporation)

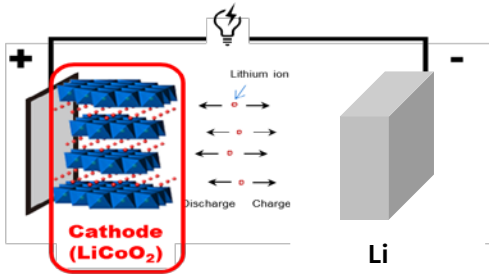
Start of SCiB™ mass prod.

Kashiwazaki Works Manufacturing Base

Widely used in automotive and industrial fields

Discovery of lithium cobalt oxide cathode material

Widely used as the positive electrode material In lithium-ion batteries used in mobile devices



Main uses

Cell phones

Laptop PCs

Smart phones

Toshiba Executive Fellow

Koichi Mizushima

J.B. Goodenough, 2 others

2016 NIMS Award

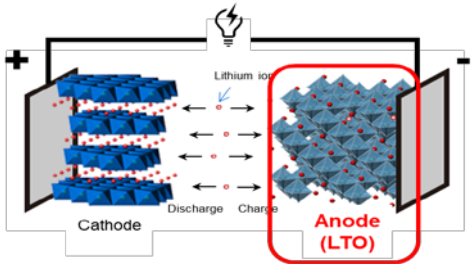
K. Mizushima, P.C. Jones, P.J. Wiseman, J.B. Goodenough: *Mat. Res. Bull.* 15, 783 (1980)

University of Tokyo President's Special Award

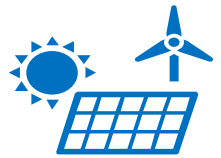
Toshiba Special Award

Development of rechargeable battery with lithium titanium oxide negative electrode

Realization of a highly-safe, long-life, rapid charging rechargeable battery that contributes to solving environmental and energy problems



Main uses



Power storage systems for stationary use

EV•PHEV

Norio Takami, Hiroki Inagaki
"Prime Minister Award"
National Commendation for Invention 2019

"Large long-life rechargeable battery with excellent charge-discharge performance"

Edge Capability Enhancement Strategy : SCiB™

Higher capacity & higher output x Battery service
Respond to potential markets and needs by leveraging SCiB™ strengths

New material
•
New structure

NTO anode

LTO anode

Higher capacity and higher output

Automotive (HEV, commercial vehicles)
industrial (railways, AGV, etc.)

Potential growth market / needs

Car sharing, EV buses, railways, power system

Battery as a Service

Battery diagnosis and controls
Charging curve analysis (CCA)

Battery system monitoring

O&M

Cycle characteristics
more than 20,000 times

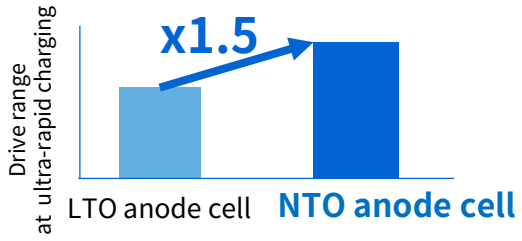
Shipped 39M cells
Zero accidents

Edge capability enhancement

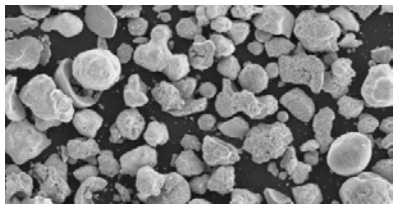
SCiB™ high capacity technology

Next generation anode material

NTO*1 anode achieves capacity 1.5 times during ultra-rapid charging

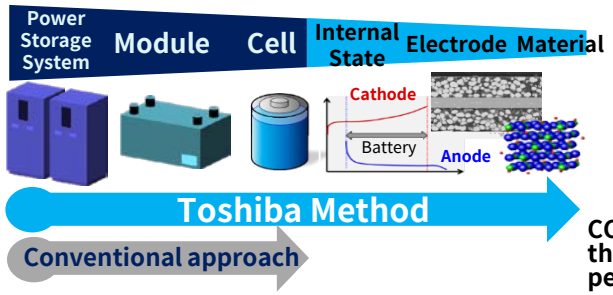


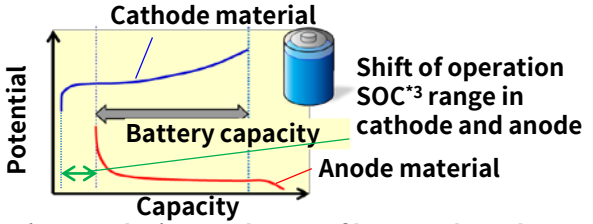
Joint development of battery grade niobium material with CBMM in Brazil*2



Battery life diagnostic technology

- Accurate battery life estimation by diagnosis of degradation at material level
- Applicable to a Li-ion battery using a variety of cathode and anode material





CCA estimates the internal state of battery, based on the curves of the cathode and the anode material, by performing fitting to the charging data.

*1 Titanium Niobium oxide

*2 https://www.toshiba.co.jp/cs/en/topics/back-number/20180619.htm

*3 SOC：State of Charge

Edge Capability Enhancement Strategy : SCiB™

**As advances in mobility realize the start of MaaS and other changes,
Technologies that enhance edge capabilities will promote SCiB™ service businesses providing safe, secure battery systems**

SCiB™ Technology and product capabilities

- Long life
- Rapid charging

Edge capability enhancement

Battery life diagnosis and AI technology

Digitization of value

- Highly accurate diagnosis
- Long life and safe operation with charge control

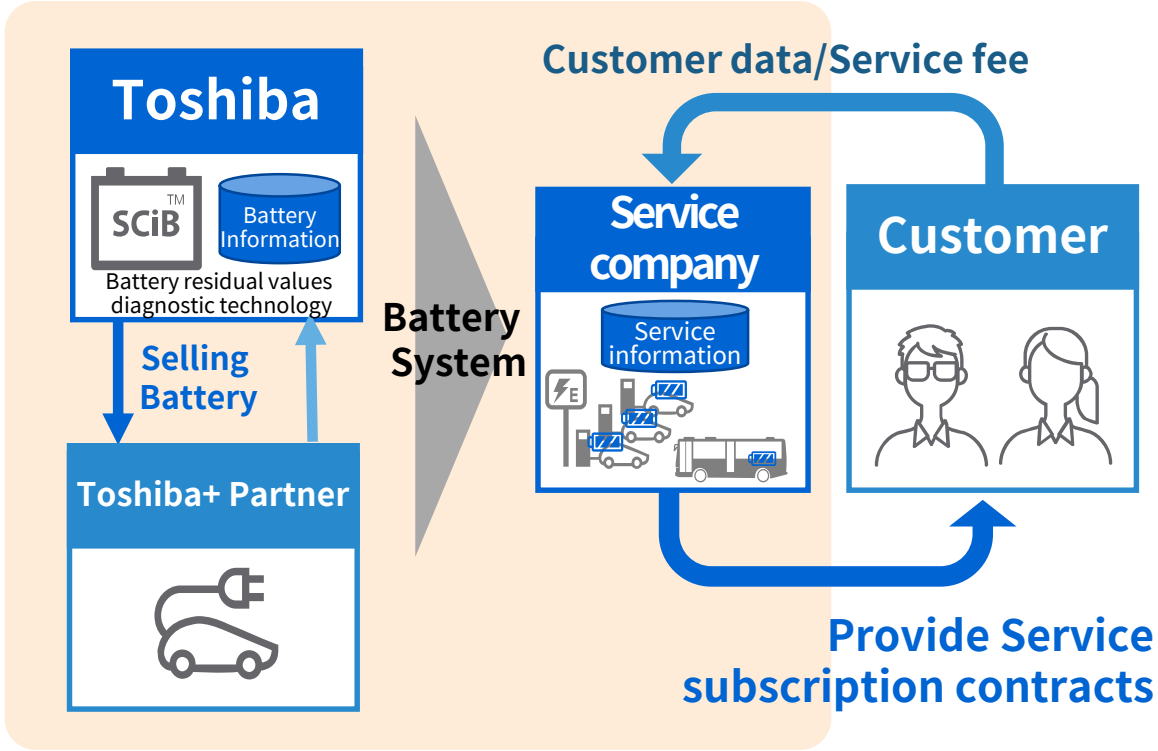
Customers

Customer base built through co-creation

- Diverse operating achievements in automotive, railways, power system and AGV

Value supply as a total Watt hour per price(ΣWh)

Switch from sell out to service business



Realize market expansion and sustained, stable profit

Edge Capability Enhancement Strategy :
Automation and Labor Savings with Intelligent Robots

Bring intelligence to clumsy robots capable only of pre-set tasks

Achieve unsupervised automation of non-routine work in logistics, manufacturing, and retail

Strengths of Toshiba Robots

Automation system integration technology
Recognition and sensing technology

1967 ~
Postal sorting machines

World first handwritten post code reader

1970s ~
Various manufacturing facilities

Electrolyte injection sealing device for SCiB™

Advanced AI technology

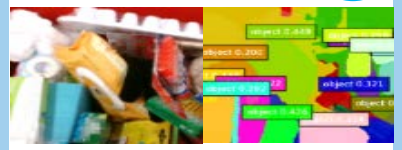
Over 50 years
AI technology research

Accumulated data, domain knowledge

Core technologies for intelligent robots

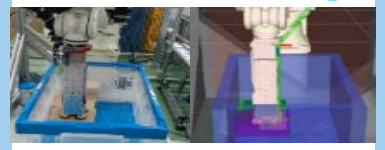
Technology for situation appropriate autonomous movement

Recognition technology



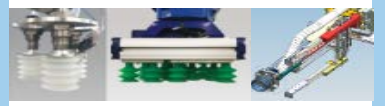
- High precision object region segmentation
- High-speed object posture estimation

Planning technology

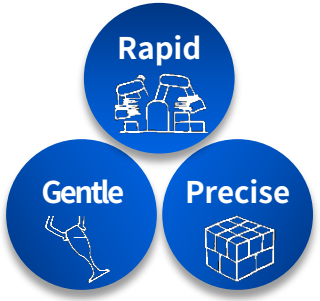


- Motion planning to avoid collisions
- Optimum packing and loading

Mechanism control technology



- Firm grip on heavy objects
- Exerted force feedback control



Toshiba Intelligent Robots

Providing solutions for labor shortages and increased workloads, etc.

Holding heavy loads carefully
De-palletizer

19/3 Delivered the first machine

Skilfully gripping and packing without gaps
Piece-picking Robot

19/12 Scheduled to deliver the exhibition machine

High-speed automatic adjustment of probe angle
Weld Inspection robot

20/1 Scheduled to start PoC at customer

Efficient transfers by AGV with arm
Mobile palletizer

20/1 Scheduled to deliver the first machine

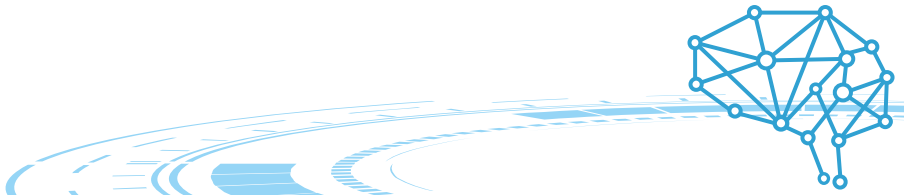
Unsupervised autonomous transportation
Cart-transporting robot

19/8 Implemented PoC at customer

Automatic in-store check of price tags
Shelf-monitoring robot

18/5 Implemented PoC at customer

Reinforce AI-based digital technologies



The Strengths of Toshiba AI Technology

AI technologies and data Toshiba has accumulated enable deeper analysis of customer data, and realize solutions for customer issues in the CPS domain, such as manufacturing and maintenance

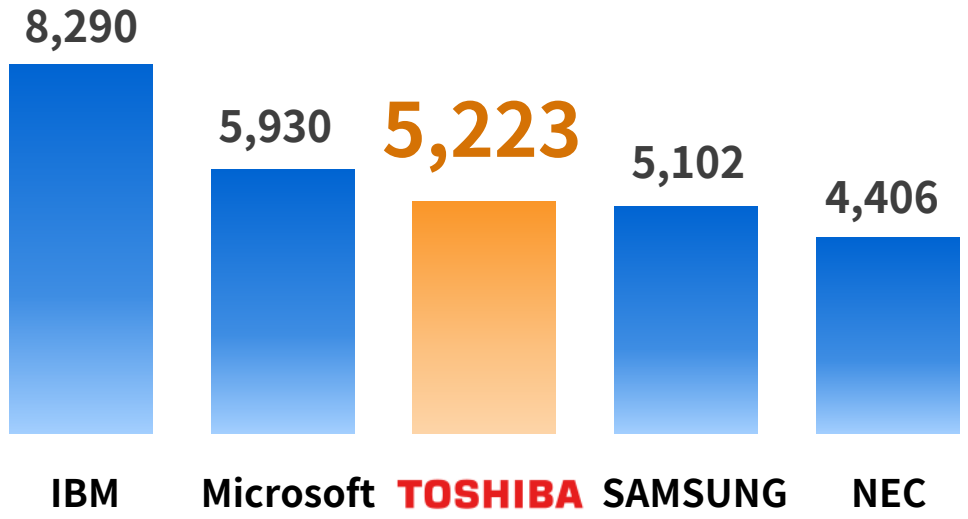
Point 1

Many years of AI technology development

1956 1970 1980 1995 2010 2015 2019

- **1st AI boom** — Search and inference
- **2nd AI boom** — Knowledge expression
- **3rd AI boom** — Machine learning/ deep learning

Over 50 years of history in spoken language, image processing and analytics
⇒ Cumulative total of AI-related patents: **No. 3 in the world, No. 1 in Japan***



Modified from Technical Trend Report published by the World Intellectual Property Organization (WIPO)

Point 2

Toshiba's manufacturing and maintenance has accumulated master data and provided a place to put it into practice

	Analysis	Prediction	Optimal planning
A "site" full of data	・Product defect analysis ・Infrastructure degradation analysis	・Equipment failure prediction ・Power demand prediction	・Plant operation plan ・Railway operation plan ・Infrastructure maintenance plan

	Recognition	Judgment and control	Interaction
A "site" where people are involved	・In-vehicle image recognition ・Object recognition for logistics ・People tracking for crime prevention etc.	・Robot motion planning ・Path planning for autonomous driving	・Spoken dialogue system

AI tech. DB (180 items)

AI technologies are ready to use within Toshiba group

Enhancement of AI Technology

From AI with manual intervention to AI that learns from limited data
Ultimately advance to self-learning AI

Field
Accumulated data, domain knowledge

AI

Co-creation
Deep cultivation of cutting-edge AI technology

RIKEN AIP

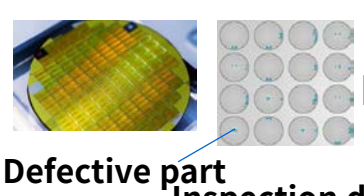
Research Organization of Information and Systems
The Institute of Statistical Mathematics

"Enhancement at business fields with large amount of data"

"Enhancement at cutting-edge research laboratories"

Technology development close to on-site issues

Apply deep-learning to automated classification of defects in semiconductors



Defective part

Inspection data

Combining limited supervised learning with transfer learning achieves highly accurate automatic defect classification with less teaching

Used in-house semiconductor factory

Winner of ISSM2018 Best Paper Award (FY2018)

Deep cultivation through open innovation

HMLasso*1 identifies failure factors from data with many missing values

Joint research with the Institute of Statistical Mathematics*2

- High-speed, high-accuracy identification of causes of quality and yield deterioration
- Reduction in estimation error of approximately 41% against the cutting-edge algorithm

Presentation at International Joint Conference on Artificial Intelligence (IJCAI), one of the most important international conferences in the AI field (FY2019)

AI with manual intervention

Supervised learning
weakly supervised learning
Unsupervised learning
Semi-supervised learning
Transfer learning
Full information learning
Incomplete information learning

AI that learns from limited data

Structured learning
Automatic knowledge acquisition
Explainable AI

Self-learning AI

*1 HMLasso (Least Absolute Shrinkage and Selection Operation with High Missing rate)
*2 http://www.toshiba.co.jp/rdc/rd/detail_e/e1908_01.html *3 CoCoLasso (Convex Conditional Lasso) Ref. : Datta, A., & Zou, H. (2017). CoCoLasso for high-dimensional error-in-variables

Examples of AI Technology Development

Toshiba AI technology generated from co-creation and field capabilities

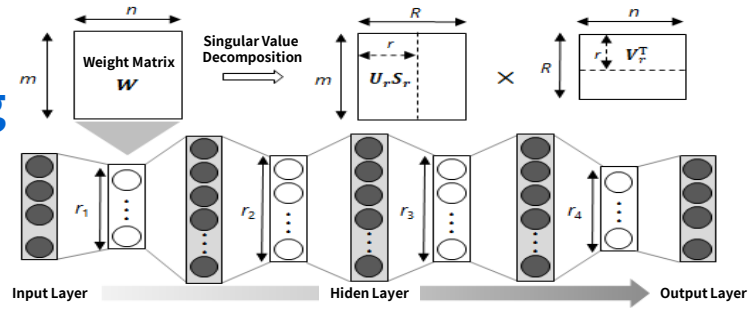
Strengthen Deep Learning tech. through open innovation

World-class performance that achieves with joint research by RIKEN AIP

- **Scalable DNN that adjusts computation level after learning**
- **Parallel distributed learning that reduces learning time**

Joint research by RIKEN AIP*1 and Toshiba Collaboration Center*1

https://www.toshiba.co.jp/about/press/2018_12/pr1702.htm



PV Power Generation Prediction

Grand Prix Winner in "PV in HOKKAIDO" PV Power Generation Prediction Contest*2
TEPCO Holdings, Inc.
Hokkaido Electric Power Co., Inc.

*2 https://www.toshiba.co.jp/rdc/detail/1907_02.htm

Adoption of coestation as "virtual operator" *3

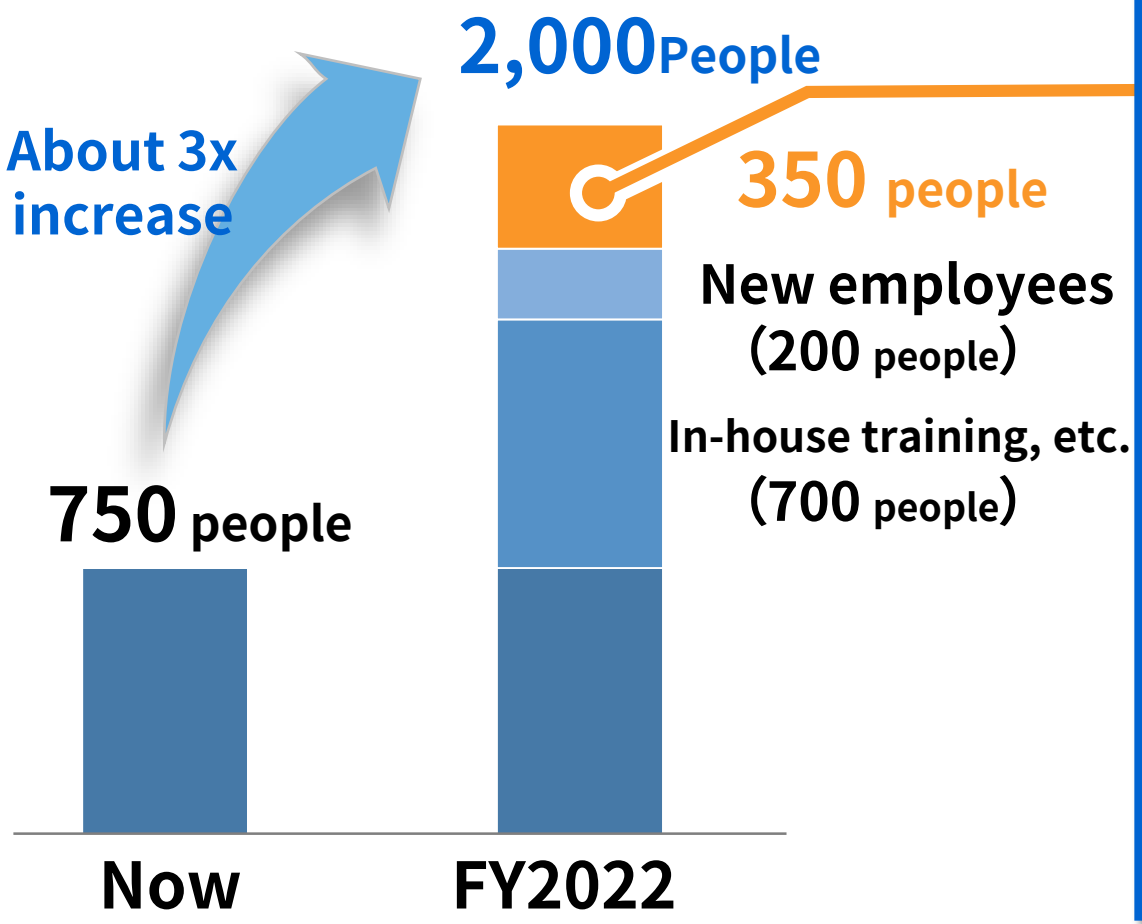
RECAIUS™

Agreement on train timetable planning project with Greater Anglia, a train operator in the U.K.*4

*3 https://www.toshiba-sol.co.jp/news/detail/20190327.htm
*4 https://www.toshiba-sol.co.jp/en/news/detail/20190910.htm

AI Human Resources Development

Reinforce AI human resources that support CPS by introducing practical education using actual data



AI engineer training program developed with the University of Tokyo*1 Train AI engineers at a scale of 100 per year

10 sessions in total (a 1.5-hour lecture and 2 hours of exercises for each)

- A wide range of study, from classic machine learning to the latest deep learning
- Focus on exercises for practical use

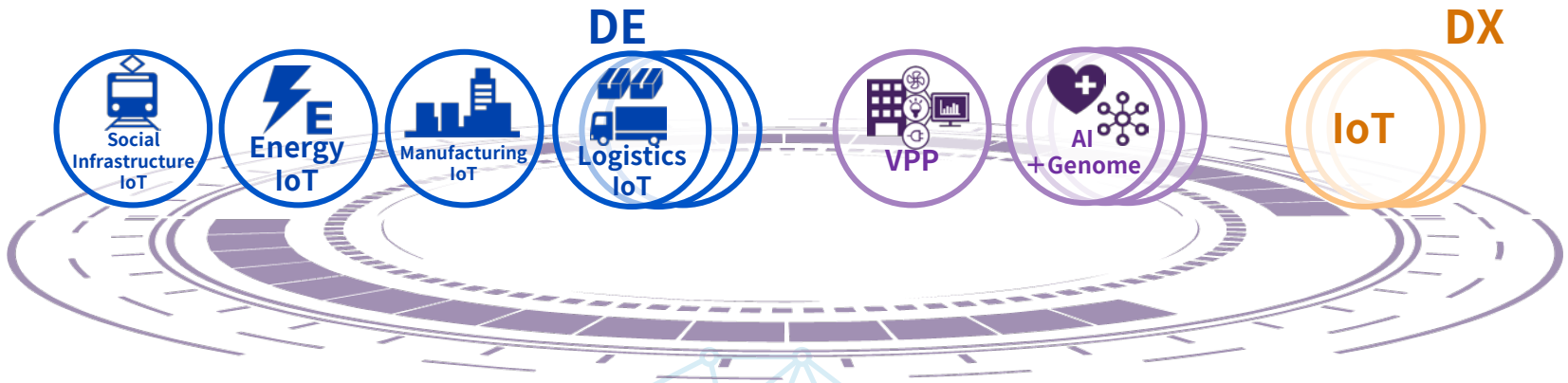
Final assignment problem period of about 1 month

Examine and implement assignments*2 using real big data owned by the company, etc.

Presentations on final assignments in poster format

- Utilize knowledge and programming experience gained in lectures and exercises to present results of final assignment
- Develop problem-solving skills through implementation

*1: Graduate School of Information Science and Technology - University of Tokyo
*2: Workplace challenges can be used



Deploy IoT reference architecture and services

Services Scheduled for this Fiscal Year

Energy	Dashboards
	Real-time plant efficiency monitoring
	Failure prediction
	Optimal power generation planning service
	Design and maintenance data linkage between documents
Social Infrastructure	Remote Monitoring Service for Railway Vehicles
	Remote management and maintenance service for chillers
	Building wellness service
Manufacturing	Meister Cloud™ Series for manufacturing IoT
	Distributed & coupled simulation platform for in-vehicle control model
	AI image inspection service
Logistics	Logistics IoT cloud service




IoT Service Development in Social Infrastructure Business

Railways Building Water Radio waves Roads

Accelerate the development of attractive systems and their application to IoT services, by taking advantage of domain knowledge and components in social infrastructure

Expand "As a Service" (Railways)

DE/DX

Step2:
Develop platform business

Step1:
Develop individually customized digital service

Physical

- Components
- Systems
- Domain knowledge

Platform business

Customer asset management service

Maintenance service

Transit Scheduling ICT Solution
TrueLine®

Business service for making things visible

Remote monitoring service

12 Service

Business services utilizing collected data

Failure analysis support service

Life cycle assessment service

Railway vehicle system

Propulsion, Power supply, Air-conditioning, Train information

Information system

Train traffic control, Transportation planning

Power supply system

SCADA for power supply system, Transmission, Power feeding

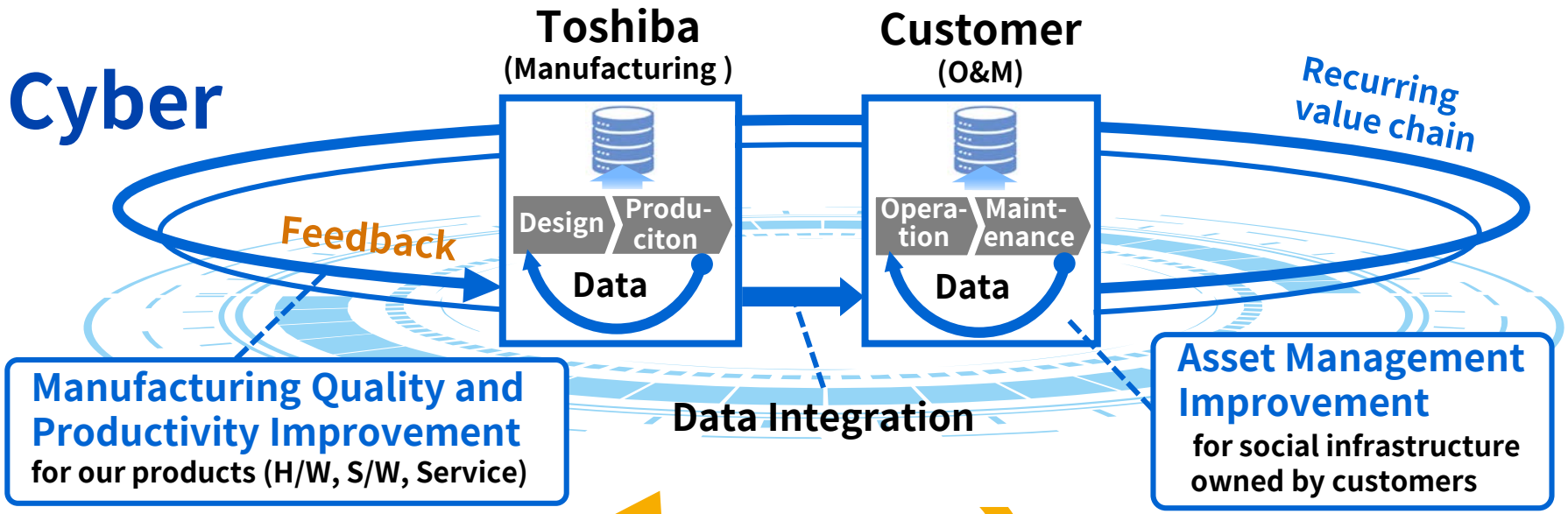
Fare collection system

Automated ticket gates, Fare collection management

IoT Service Development in Social Infrastructure Business

Railways Building Water Radio waves Roads

Contribute to our customers' business by CPS-loop connecting cyber & physical world



Adoption of remote monitoring service for railway vehicles

Improvement of stable transportation,
Failure prediction,
Improvement of operational efficiency

Risk reduction for public sewerage system

Optimization of pump control with prediction of rainwater inflow

IoT Service Development in Energy Business

With Toshiba's deep expertise in power plants, Provide IoT solutions that meet customer needs

Expand "As a Service"

DE/DX

Step2:
Develop platform business

Step1:
Develop individually customized digital service

Use prediction and optimization technologies to realize and provide

- Total value chain optimization service
- Collaboration with other companies through open API technology

Extend proven in-house plant technology to external power plants

- Dashboard service
- Performance monitoring to provide performance evaluation and abnormality prediction service
- Design and maintenance data linkage between documents
- Failure prediction using operation data

Physical

- Components
- Systems
- Domain knowledge

Steam turbine

No.1 share in North America

※On an installed capacity basis. Source: Toshiba (2004~2018 Cumulative Actual))

Central load-dispatching office system

No.1 share in Japan

Adjustable-speed pumped-storage hydropower system

No.1

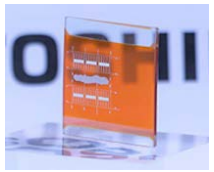
Global share

※Plant number base

AND

Develop businesses in response to diverse potential needs

Turbine and combustor for supercritical CO_2 cycle power plant



Tandem solar cell development

Autonomous hydrogen energy supply system "H2One™"

Expansion of business domain

IoT Service Development in Energy Business

Customer

Operation data / work data

+

Toshiba

Engineering data / Know-how

Abundant experience in existing business

+

Proactively expand into focus business areas

- De-carbonization
- Diversification of electric power supply
- Effective use of energy

, etc

Component

Digital Transformation

IoT

Physical

CPS Loop

Cyber

High added value realized through co-creation

Feedback to Physical

+

Improve operability of customer energy assets

Data access using information models

By using engineering data and know-how, data can be handled in a structured form

Detecting signs of equipment anomalies contributes to improving thermal efficiency and increased power plant availability

Start of demonstration experiment at

Saltillo Thermal Power Station, Mexico

owned by Mitsui & Co. and NMF Consulting Holdings (invested in by Mitsui)

Press announcement released on November 1, 2019

Use of Manufacturing IoT & Service Development, with examples

Using technologies and know-how in manufacturing X cutting-edge digital technology, Implementing innovation in manufacturing and construction of digital base inside and outside of company

Expand "As a Service"

DE/DX

Step2:
Develop platform business

Step1:
Develop individually customized digital service

Physical

- Master data
- Domain knowledge
- Field capabilities

Manufacturing IoT solutions

Toshiba's AI technology

- Utilize — Data utilization, Advanced analysis
- Storage — Integrated data base

Manufacturing and O&M data modelling

- Collect — IoT data collection

Precisely reproduce sites of manufacturing and usage of products in digital space
Digital twin

External application

Internal deployment

Function, data model, utilization know-how enshrined at site

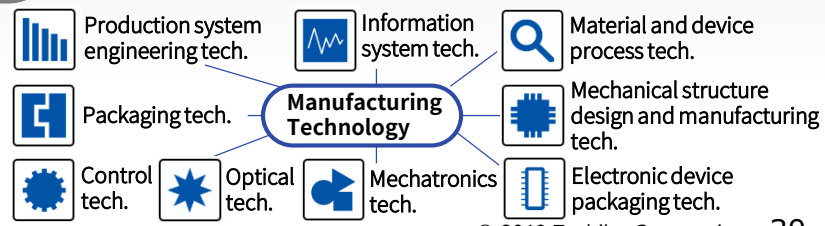
Corporate Manufacturing Engineering Center

Innovative consulting for manufacturing based on abundant experience

Technology and know-how in Manufacturing site

that Toshiba Group have cultivated

Contribute to enhancement of business strength using knowledge and experience nourished at manufacturing sites



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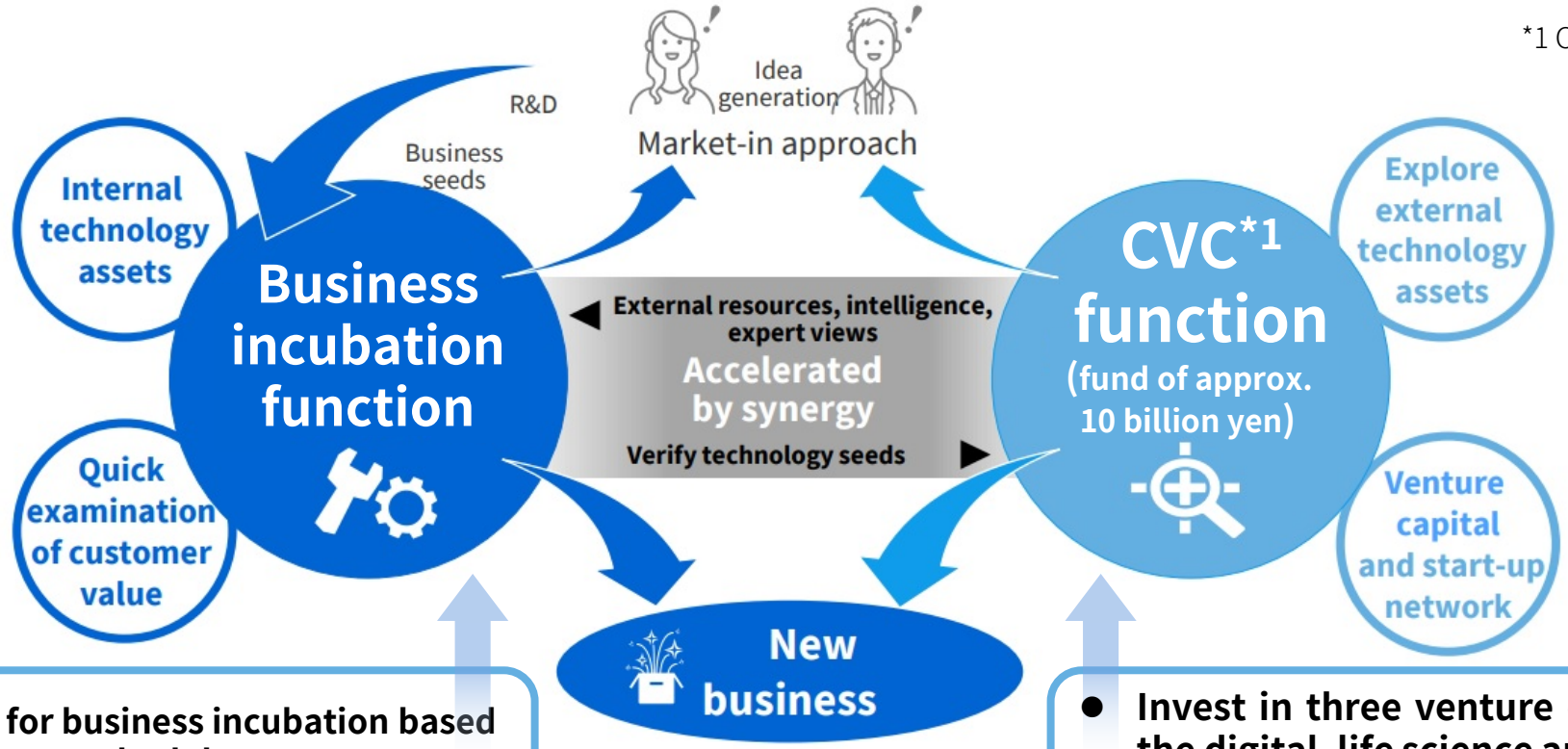
Activities for new business creation

Toshiba's Efforts to Resolve Social Issues – New Business Creation

New Business Development Office established in January 2019
Accelerate business incubation and open innovation

*1 CVC: Corporate Venture Capital



- **Build a platform for business incubation based on the lean startup methodology**
- **Working toward commercialization of quantum key distribution system with two companies*2, one in the US and one in Europe**

*2 Quantum Xchange, Inc., British Telecommunications plc

- **Invest in three venture capital companies in the digital, life science and energy fields**

global brain　Beyond Next Ventures　Energy Environment Investment

- **Build a platform to create synergies between VB networks and existing business units**

Cutting-edge Technologies to Resolve Social Issues

Precision medicine

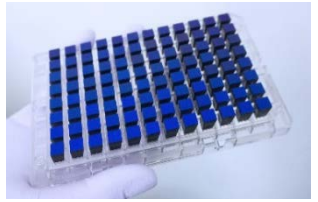
Disease prediction / prevention AI

Random survival forest
× Learning model optimization

Diabetes severity analysis
× Medical knowledge*1

*1 Collaboration with Kanazawa University

Japonica array*2

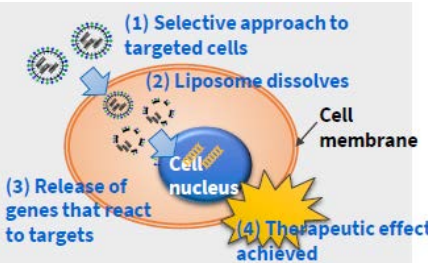


*2 Collaboration with Tohoku University

Micro RNA*3

*3 Collaboration with National Cancer Center Japan/ Tokyo medical University

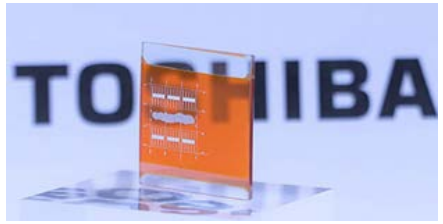
Biodegradable liposome*4



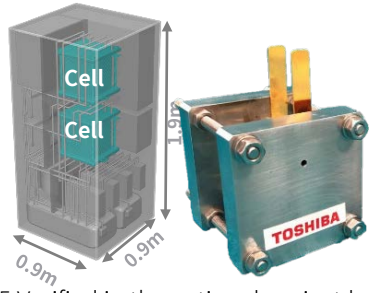
*4 Collaboration with Shinsyu University

Energy

Tandem solar cells



Power to Chemicals*5

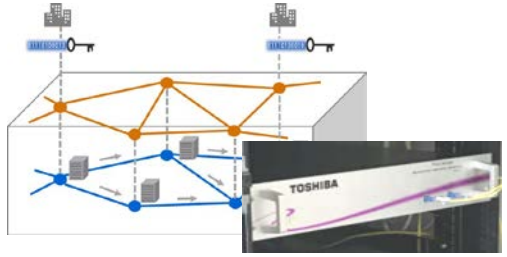


*5 Verified in the national project by Ministry of the Environment (FY18-22)

Turbine and Combustor for Supercritical CO_2 cycle power plant

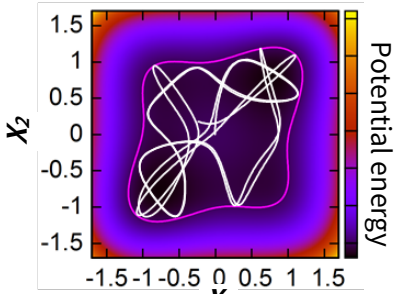
Quantum applications

Quantum cryptographic communication*6

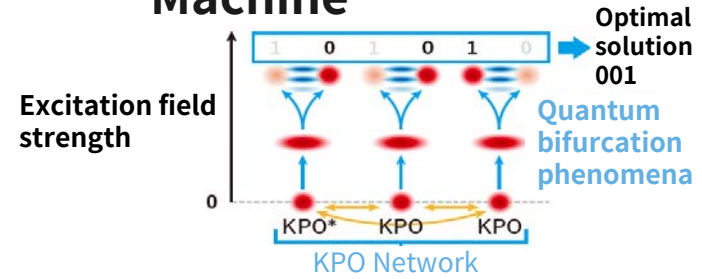


*6 Cross-ministerial Strategic Innovation Promotion Program (SIP)

Simulated bifurcation machine



Quantum bifurcation Machine*7



*7 The Exploratory Research for Advanced Technology (ERATO), MEXT - Quantum Leap Flagship Program(MEXT Q-LEAP)

Cutting-edge Technology - Precision Medicine

Diseases Prediction AI ＋ Prevention of Diabetic Nephropathy

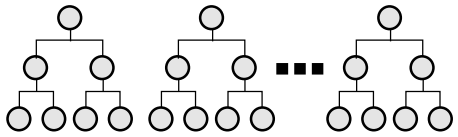
【Disease Prevention】

Achieved **world's top level prediction accuracy*1 of 96%** in prediction of risk of diabetes.

*1: Risk prediction accuracy for diabetes in three years

＜Highly accurate AI utilizing high quality data of several years＞

Random survival forest × **Learning model optimization technology**



Average results of several decision trees

1 Medical verification is possible

Possible to extract the impact of individual input item against prediction

2 High robustness

Realized high accuracy using data set provided by Tokyo Midtown Clinic

【Prevent worsening】 **Prevent** worsening of diabetic nephropathy in patients **(dialysis)**

Started joint research

Kanazawa University
Long-term clinical information/ Pathological information Medical knowledge

×

Toshiba
Data analysis AI

Stratify patients to suggest optimized treatment

Cancer detection technology using Micro RNA

High sensitivity Micro RNA chip

Space-saving inspection device

Ultra-early detection of cancer using health check blood tests

Can detect cancer in 13 organs

1 drop of blood, in only 2 hours

Identify about **99%** of cancer patients

Collaborating on implementation with the National Cancer Center and Tokyo Medical University

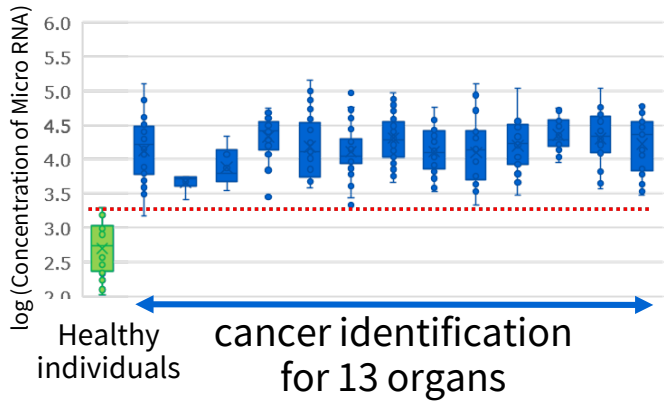
＜Cancer detection technology using Micro RNA＞

1 Cancers in 13 organs

Identify cancers in 13 organs (e.g. breast, stomach)

2 At stage 0

Identify cancers at stage 0



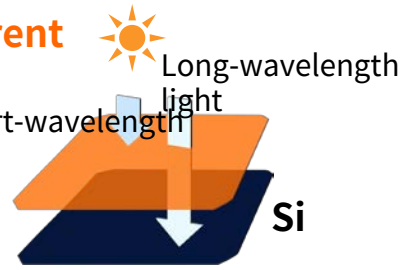
Cutting-edge Technology - Energy

Tandem solar cells

Semi-permanent **drive** for electronic mobility **without charging**
High-power supply with a **small footprint** at **low cost**

Transparent Cu_2O Solar Cell

Cu_2O+Si Tandem solar cell



＜Low cost tandem solar cell stacking Cu_2O and Si＞

1 Transparent Cu_2O solar cell

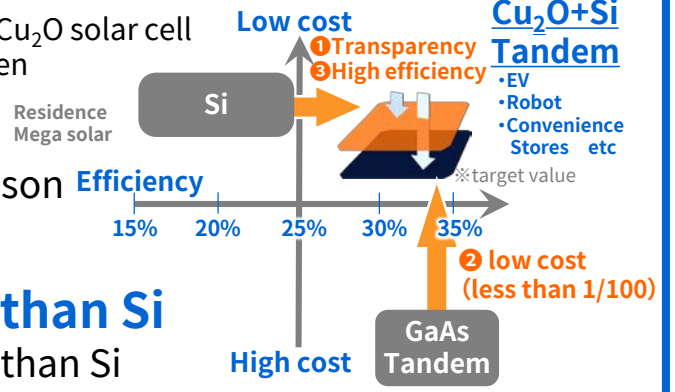
Succeeded in creating transparent Cu_2O solar cell by controlling the presence of oxygen

2 Low cost

Less than 1/100 in comparison with one of GaAs tandem

3 Higher efficiency than Si

Achieved higher efficiency than Si by combining Cu_2O and Si in tandem



Power to Chemicals (P2C)

Achieved **high** ton-per-year **throughput** and **saved space**
Available to **adjacent to the CO_2 emission facility**

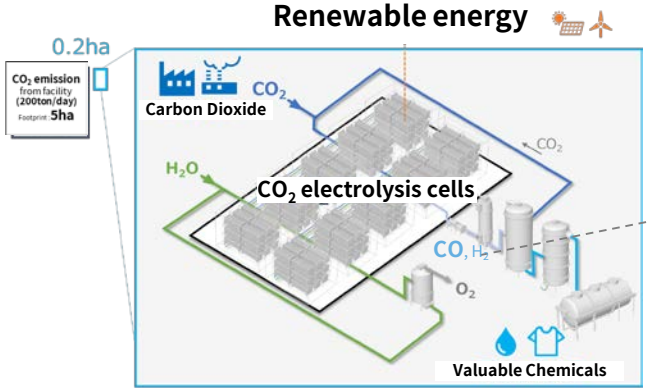
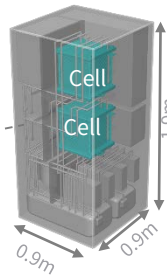


Image of P2C plant

P2C device
(image of verification device)



CO_2 throughput 10.6 ton/y (Max)

Verified in the national project by Ministry of the Environment (FY18-22

＜CO_2 electrolysis that realizes high ton per year throughput＞

1 World's fastest CO_2 conversion rate

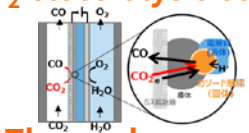
CO_2 conversion rate of 645mA/cm^2

2 Cell structure that directly uses CO_2

Direct CO_2 gas reaction by three-phase boundary control technology

3 Porous catalyst electrode with superior CO_2 diffusion

CO_2 electrolysis cell



Three-phase boundary control

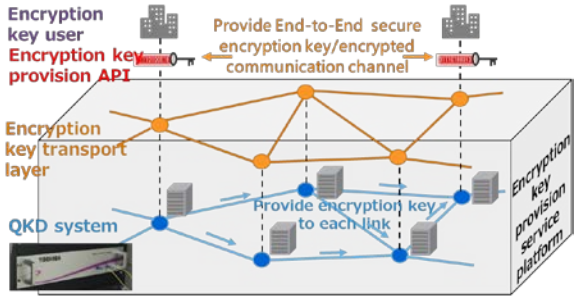
Catalyst electrode

Cutting-edge Technology - Quantum Applications

Quantum cryptographic communication

Development and standardization of platform technology for service business

Secure communication platform safe from risk of decryption attack by quantum computers



Coexistence with existing optical fiber networks; promote as a platform through interface and network configuration standardization

＜**Platformization** of **Toshiba's original quantum cryptographic communication technology**＞

1 Unique wavelength application technology

- Coexistence with data multiplexing transmission and quantum cryptography communication at O-band (1.3μm light wavelength band)
- Achieved the world's fastest quantum key distribution speed and proposed design for world's longest distance communication on C-band (1.55μm light wavelength band)

2 A platform that provides cryptographic keys

- A platform that provides encryption keys for various applications with standardized encryption key provision interface

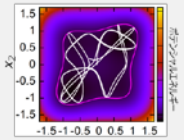
Simulated bifurcation machine

Resolving combinational optimization problems on the world's fastest and largest scale

Simulated bifurcation algorithm

$$\frac{dx_i}{dt} = \frac{\partial H}{\partial y_i} = Dy_i$$

$$\frac{dy_i}{dt} = -\frac{\partial H}{\partial x_i} = -\left(D - p + x_i^2\right)x_i - c\alpha h_i + c\sum_{j=1}^{N} J_{i,j}x_j$$



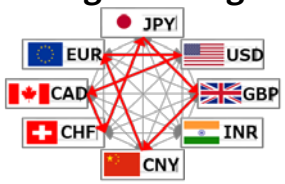
Taking full advantage of a **high-speed algorithm** in the **world's fastest automated financial transaction system**

A arbitrage trading machine with this algorithm can issue trade orders in 30 μs (microsecond)

Collaborate with partners to solve problems in areas other than finance, such as genetic analysis

＜**FPGA implementation** of Arbitrage trading machine＞

Arbitrage trading loop

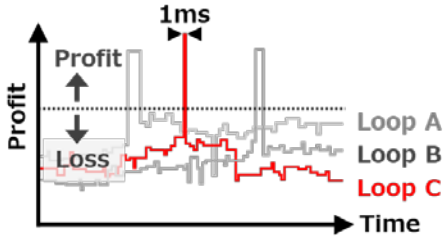


1 High-speed response and solution accuracy

- Even with a 30μs response, best solution accuracy is 91%. Captures 1ms arbitrage trading opportunities.

2 Easy to install

- Can be installed on a commercially available FPGA. No need for installation on large-scale equipment.



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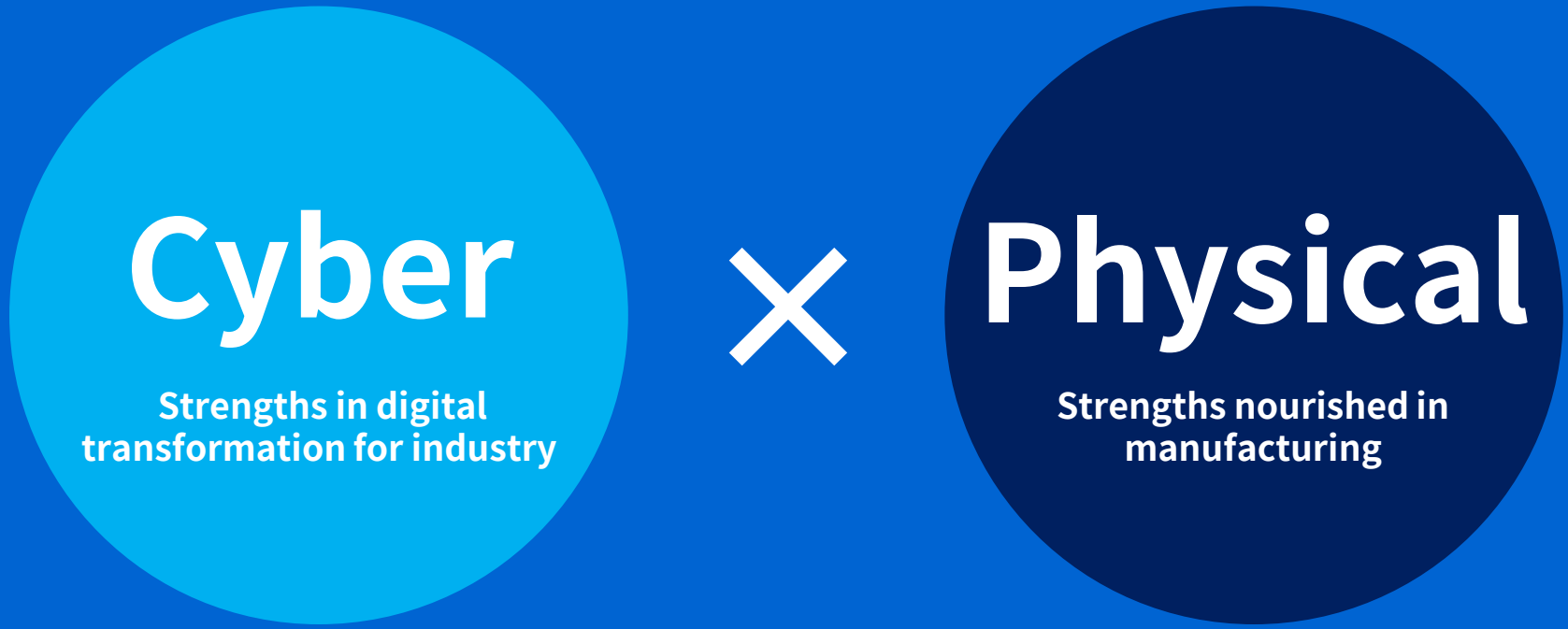
In Closing



We turn on the promise of a new day

Committed to People,
Committed to the Future.