

# Further Improvement of R&D Capability and Challenge to Speed

Motoo Nishihara,  
Executive Vice President, Member of the Board, and CTO

# Table of Contents

## ■ Establishment of R&D Unit

Further Improvement of R&D Capability

## ■ “Technological Genealogy and the Technology Value Chain,” Leading to NEC's Technological Prowess

Further Improvement of R&D Capability

## ■ Record of Co-creation & Further Activity Expansion

## ■ Challenges to Speed

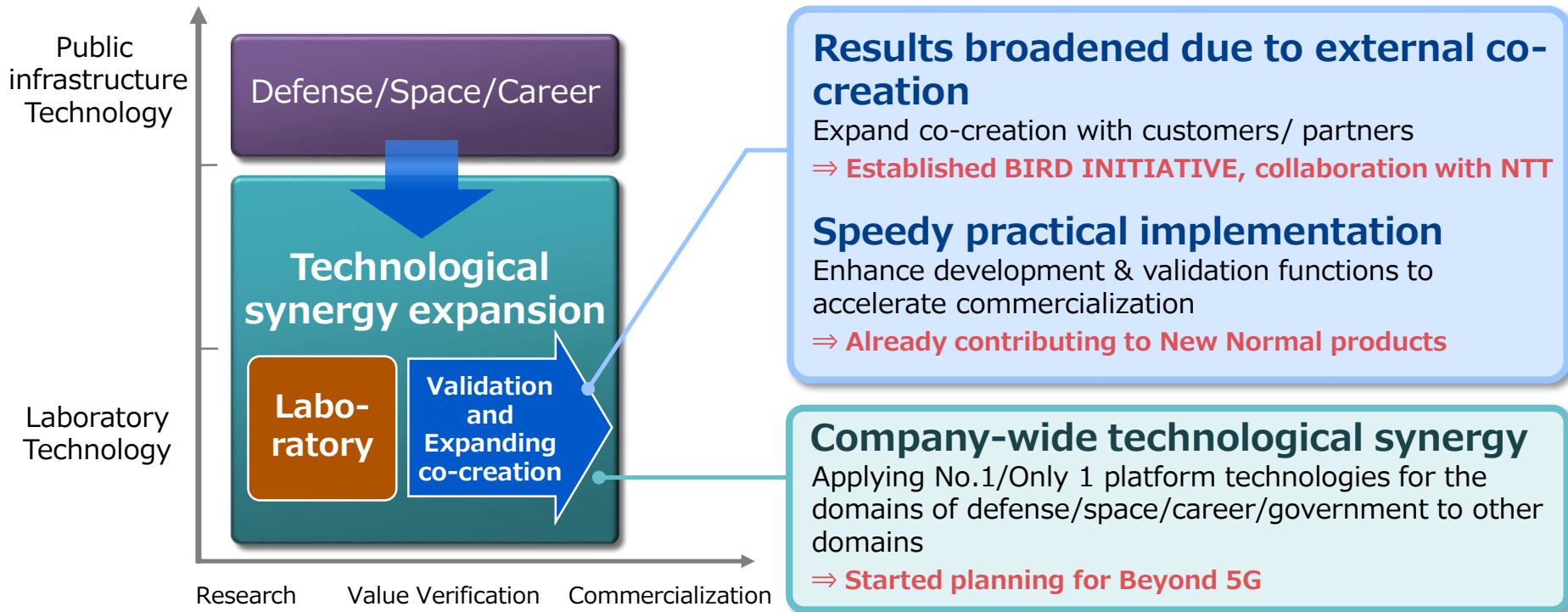
## ■ No. 1 Cutting-edge Technology to Support Future Business

## ■ Summary

# Establishment of R&D Unit

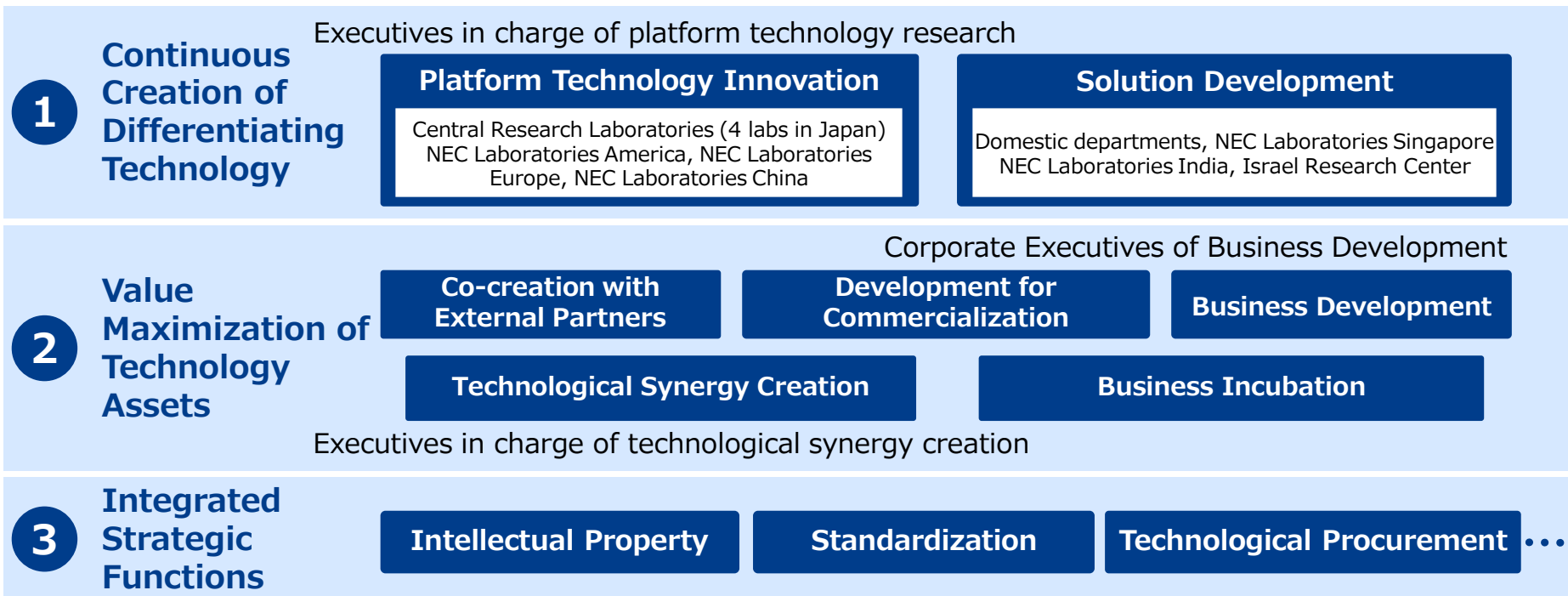
# Purpose of Re-organization (April 2020)

**Enhanced output through co-creation, accelerating commercialization, company-wide technological synergy**



# Integrate All R&D Functions

Organized all R&D functions which had been scattered between Central Research Laboratories and Corporate, aggregating them into a new unit. Assign company executives to relevant functions.



Further Improvement of R&D Capability

# **“Technological Genealogy and the Technology Value Chain,” Leading to NEC's Technological Prowess**

# NEC Research Competitiveness

## Maintain global competitiveness in the fields of AI, security, and network



AI

- **Ranked 6th** in terms of # of accepted papers at **top-quality international academic conferences on machine learning<sup>\*1</sup>**; ranked **solidly 2nd after IBM** among B2B enterprises (since 2000, internal survey)
- **A number of Papers accepted at top conferences also in other AI fields<sup>\*2</sup>**

<sup>\*1</sup> NeurIPS, ICML, KDD, ECML-PKDD, ICDM

<sup>\*2</sup> AI General: IJCAI, AAAI, image recognition systems: ICCV, ECCV, CVPR etc.



Security

- **A number of papers accepted at top-quality academic conferences on cyber security (CRYPTO, ACM CCS etc.)**
  - Awarded CRYPTO 2019 best paper award



Network

- **A number of papers accepted continuously at top-quality academic conferences on optical communication (OFC, ECOC etc.) for over 30 consecutive years**



Patent

- **Ranked 5th in the world in terms of # of AI-related patent applications (2019)**  
Source: WIPO / WIPO Technology Trends 2019 - AI  
[https://www.wipo.int/edocs/pubdocs/en/wipo\\_pub\\_1055.pdf](https://www.wipo.int/edocs/pubdocs/en/wipo_pub_1055.pdf)
- **The very best in terms of domestic patent capability in facial authentication (2019)**  
Source: Patent Result Press Release (2019)  
<https://www.patentresult.co.jp/news/2019/01/faceauth.html>

### No. of Accepted Papers at Top-quality Int'l Conferences (machine learning)

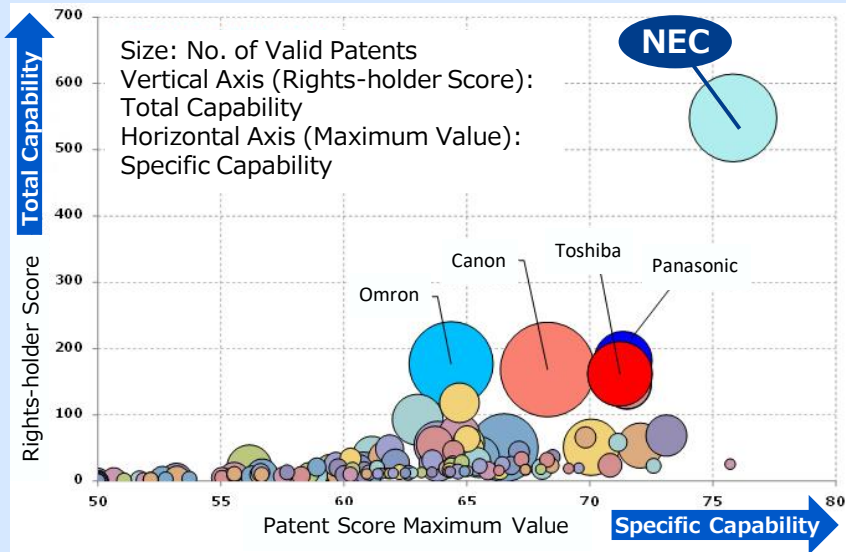
1	Microsoft	816
2	IBM	732
3	Google	570
4	Yahoo	320
5	DeepMind	194
6	NEC	168
7	Facebook	122
8	Siemens	93
9	Tencent	77
10	Baidu	76

Company Ranking (internal survey 2000-2018)

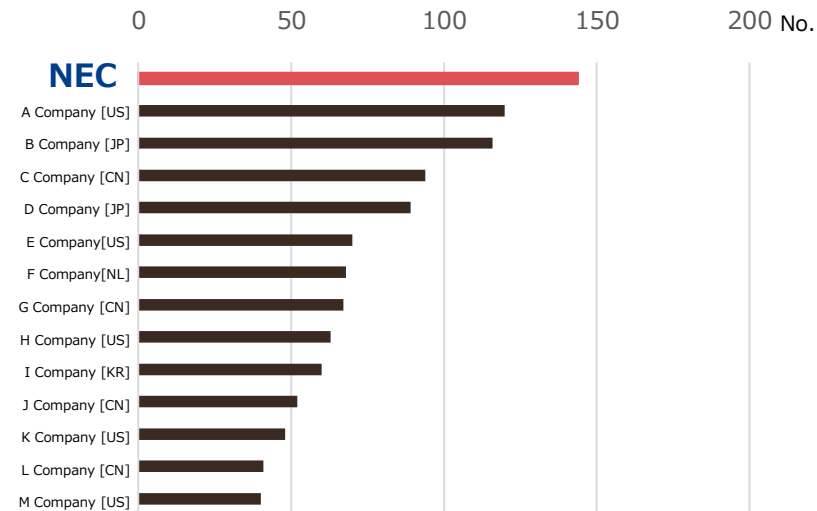
# Technology Patent Portfolio of Facial Authentication

**Our patent portfolio of facial authentication** is the best in terms of total patent capability (Japan) and the number of international patent applications (global)

## Evaluation of Total Patent Capability (Japanese)



## No. of International Patent Applications (Global)



Source: Patent Result Press Release (2019)  
<https://www.patentresult.co.jp/news/2019/01/faceauth.html>

(Internal survey, accumulated no. of applications since 2001)



# R&D Results – Cases (1/2)



## AI-powered Drug Discovery (graph-based relational learning)

Began trials of a cancer vaccine developed using AI with Transgene



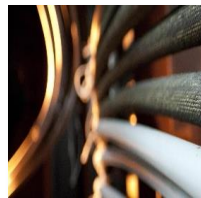
## Integration of Simulation and Machine Learning

Conducted R&D together with AIST. Structured digital twins of factories and production sites to prove optimization and streamlining



## Insight Marketing

Launched service business together with MACROMILL, utilizing recognition AI and analytical AI



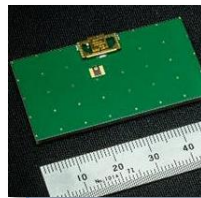
## Optical Fiber Sensing

Began trials with Verizon. Successfully obtained traffic data using existing optical fiber networks as sensors



## Newborn Children Fingerprint Identification

Recognized newborn fingerprints 2 hours after birth with 99.7% accuracy. Verified it in the Republic of Kenya together with Nagasaki University.



## Antennae using Metamaterial

Brought the world's smallest class of high-functioning antennae into service by combining JAE's precision engineering technology

# R&D Results – Cases (2/2)



## Invariant Analysis, etc.

Analyzed variety of data from satellites etc. with AI under partnership with Lockheed Martin Space in the satellite/outer space field.



## Secure 5G

Began co-operation with Cisco. Aiming to provide a secure network platform with blockchain technology in the core



## High Bandwidth Optical Transport Systems

Developed technology of transport bandwidth expansion of optical submarine cable system. In average, 25% of bandwidth expansion was verified in 10,000km



## Digital Healthcare (Gait analysis)

Collaborated with FiNC to accelerate commercialization using cloud funding. Received international design awards etc.



## Quantum Computing

Launched "Quantum Computing Application Service" in June. Collaborating with D-Wave to accelerate development.



## Next-Gen. Heat management

Proved 50% reduction in air conditioning power consumption at a data center using a new coolant. Worked together with NTT Communications.

# Genealogy of NEC's Strengths

Technological strength is born from "the bonds between human talent".  
Why was facial authentication invented?

■ The bonds between human talent surpass time and location, creating strong technology

■ Key players in AI history form the genealogy of NEC Laboratory's AI Research

Yann LeCun

Vladimir Vapnik

Leon Bottou

Hitoshi Imaoka

■ Our story is also introduced in an article on R&D talent in the field of AI

## Received ACM Turing Award (2018)

"The Three AI Giants"



"The Godfather of AI"  
Geoffrey Hinton



Yoshua Bengio

## LeCun School



**Yann LeCun**

AT&T Bell Lab  
→NEC Labs America  
→Facebook AI Lab Director

@NEC  
Labs  
America

## Central Research Labs



**Hitoshi Imaoka**

World No.1 in  
Facial Authentication



**Keiji Yamada**

Introduced machine learning  
to pattern recognition



**Atsushi Sato**

Discovered and utilized  
generalized learning  
vector quantization

**Pioneers in  
Pattern Recognition**

Advising  
Research  
Direction



**Vladimir Vapnik**

Joint Inventor of Support Vector Machine  
Received C&C Award (2013)



**Leon Bottou**

Won Test of Time Award\* for works  
during his tenure at NEC (ICML 2018)



**Ronan Collobert**

**&  
Jason Weston**

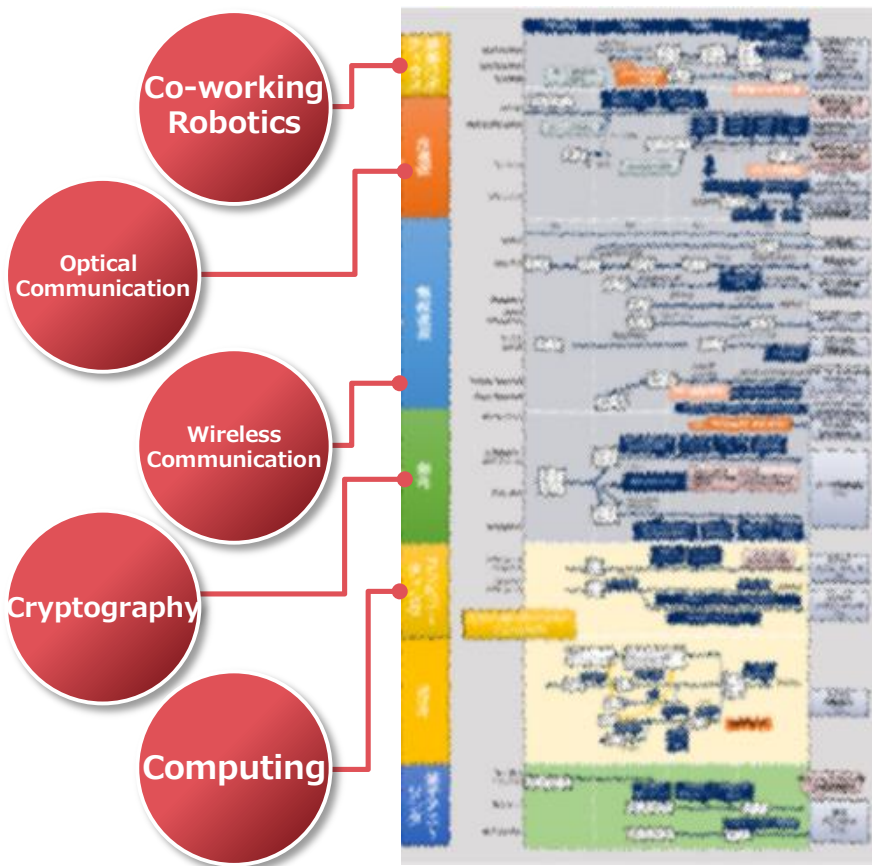
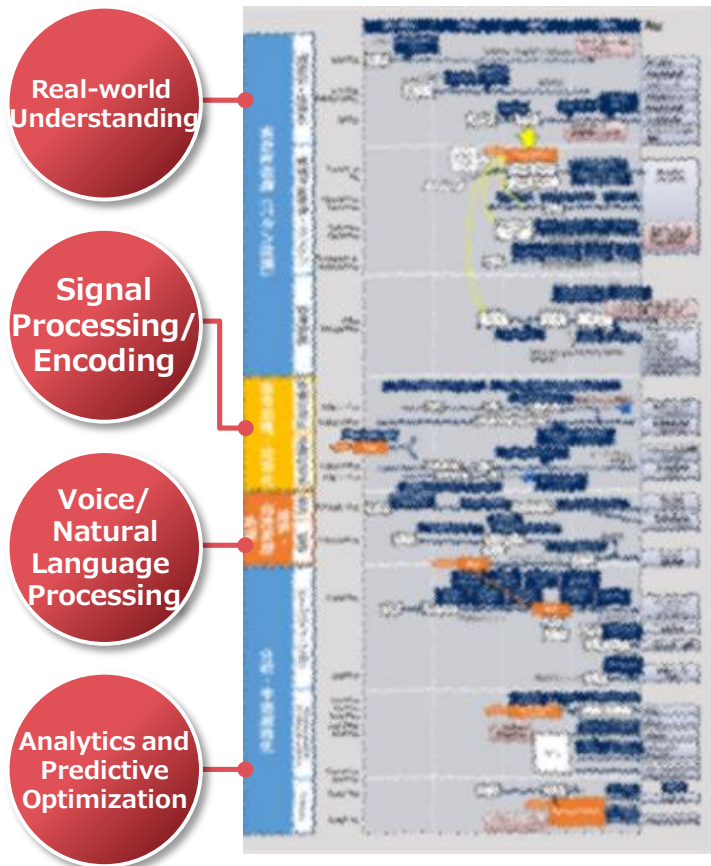
Awarded the Test of Time Award\*  
for works during his tenure at NEC  
(NeurIPS 2018)

\*Test of Time Award:

An award for the most important papers which have  
pioneered new paradigms in the last decade

Photograph of Yann LeCun by [Jérémy Barande "Yann LeCun \(41208595340\)"](#), photographs of Geoff Hinton & Yoshua Bengio by [Steve Jurvetson "Deep Thinkers on Deep Learning"](#), licenses for all three photographs are based on [CC BY 2.0](#)

# Genealogy of NEC's Technology over 30 Years

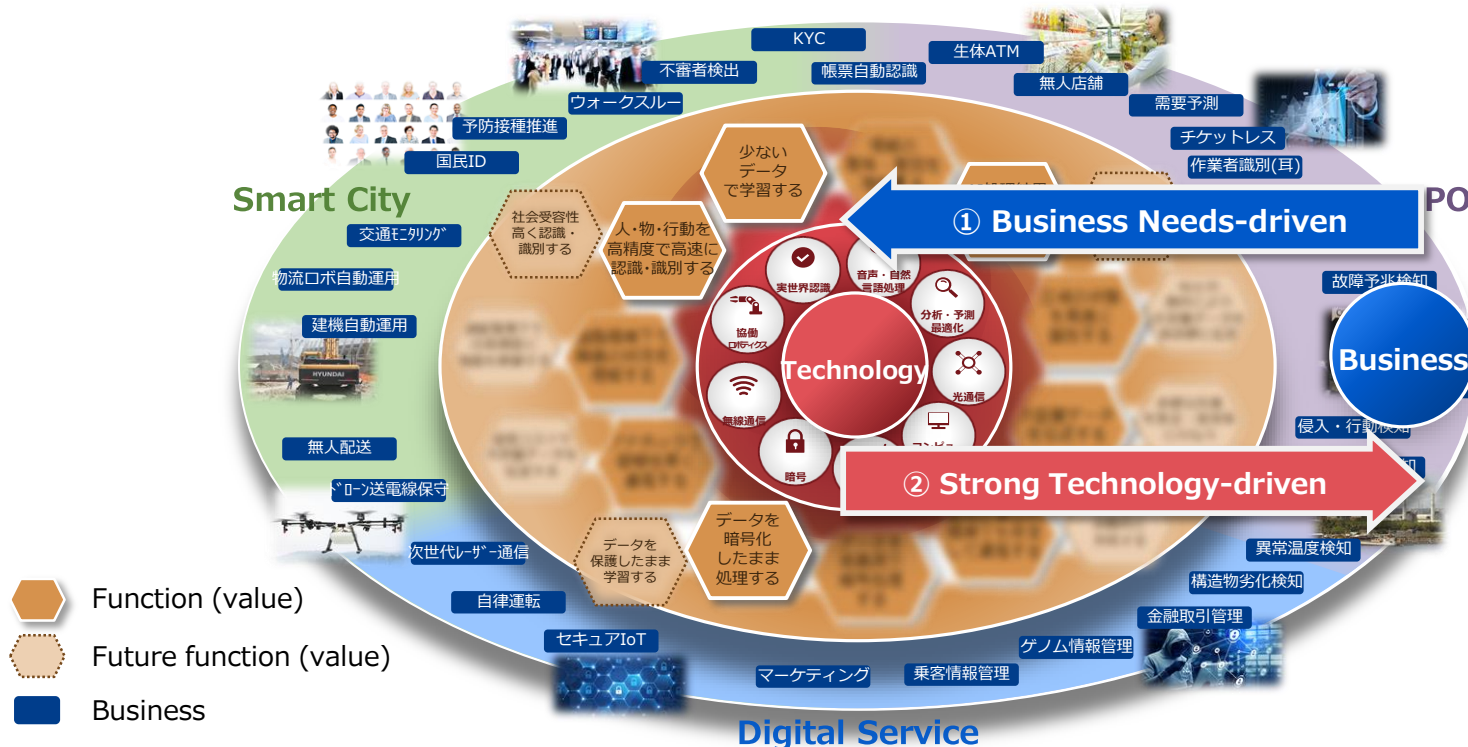




# Development of Technology Value Chain

～Finding Strong Technology and Pioneering Business Opportunities～

Launching company-wide movements to create new business opportunities by finding strong core technology from our technological genealogy, and by generating value from it



## Continuously invest in our human talent via fair evaluations, creation of an environment where everyone strives for their best, etc.

### **In 2019, we introduced the "Selective Compensation Program for Professional Researchers" for top young researchers**

- Considering the market value of researchers, we did not cap their remuneration
- The program began in 2019 with 9 researchers in Japan.  
During recruitment activities in the US, **we gave an offer to new graduates applicable to the program**

### **Continuously strengthening our acquisition of excellent talent from overseas, such as India**

- We have been engaging in recruitment activities at India's prestigious institute, IIT, for the last 8 years, and have recruited 38 researchers
- 8.5% of research staff at our Japanese labs have foreign background, and we continue to strengthen our global excellent talent acquisition

Young researchers using the program



Masafumi Oyamada



Riki Eto

Researchers from IIT



Kanishka Khandelwal



Chaki Prakash

# "Source of New Strength" through Company-wide Technological Synergy

NEC is executing various public infrastructure businesses over the long-term, and has plenty of No.1/Only 1 technologies that are unique to NEC. The technologies will be utilized as company-wide strength for other businesses

## NEC

We have refined and accumulated our technology over many years

Social Value-oriented  
Technological  
Demands



Completely unique  
No.1/Only 1  
technologies

## Specific Clients

Space/satellite



Network Careers



Defense System



Government Offices



Strong public infrastructure technologies to be cultivated into NEC's shared strengths and launch on other markets

⇒ Promoted in newly established **"Technology Synergy Creation Division"**

Further Improvement of R&D Capability

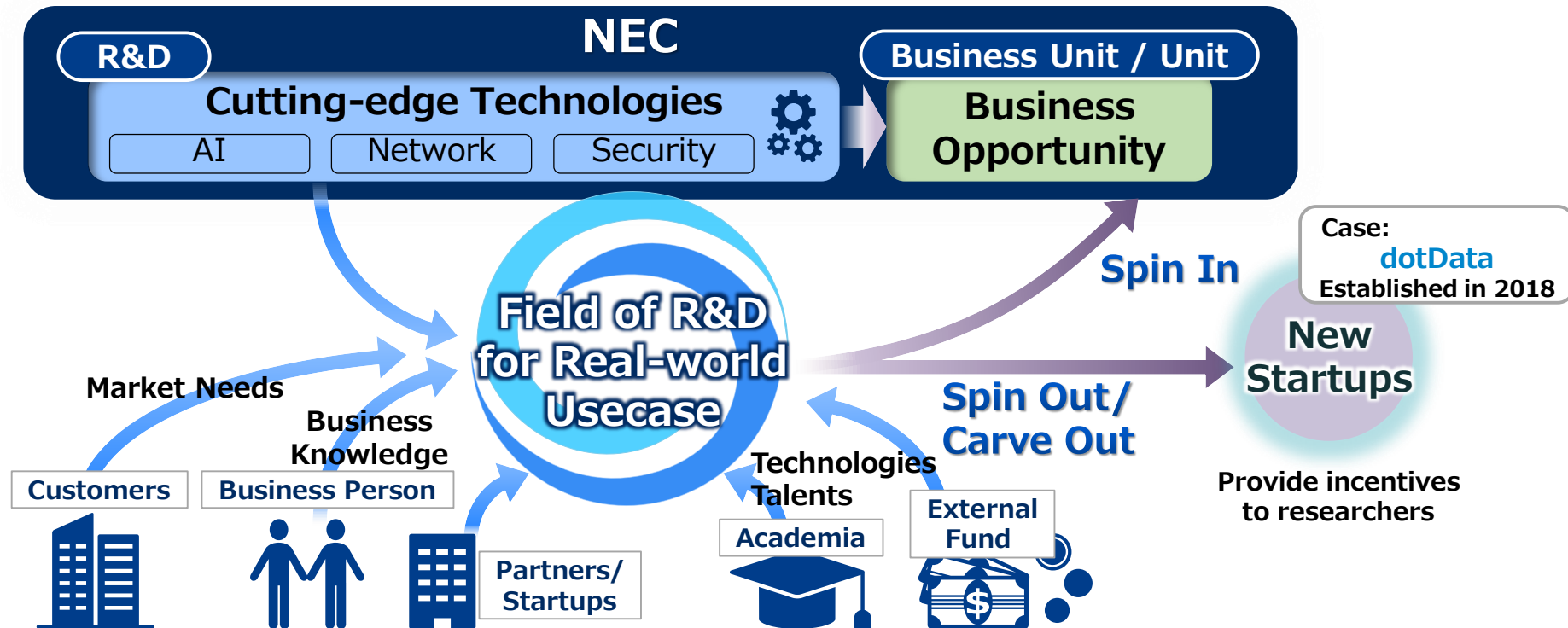
# **Record of Co-creation & Further Activity Expansion**



# Promotion of Eco-system Type R&D (from Previous Year's IR Day Materials)

Provide NEC's technologies externally at an early phase to involve external partners and speed up R&D.

Open innovation of an Inbound/Outbound integration.



# Outcome of Eco-system Type R&D (with Business Innovation Unit)

## Created new business that exceeds the existing framework, with NEC's technology at the core

### Business Expansion of dotData

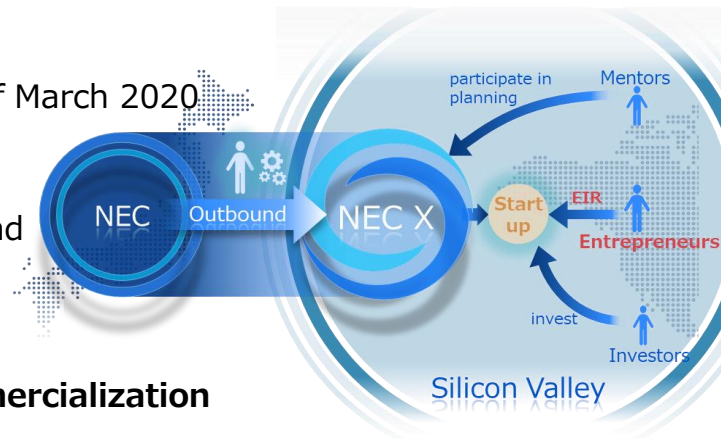
- Completed the large financing round of \$23m for dotData
- Acknowledged as a 'Leader' enterprise in machine learning automation SL market in a US market research report
  - Forrester New Wave Report (The Forrester New Wave™: Automation-Focused Machine Learning (AutoML) Solutions, Q2 2019)
- Providing commercial services to over 50 customers as of the end of March 2020

### Creating new business with NEC X

- Established an organization together with local venture capitalists and accelerators in Silicon Valley
- Since its establishment in 2018, it has examined over 30 advanced technology projects.  
**Approx. 10 projects of which have been moving towards commercialization**

### Earnest participation in advanced AI-powered drug discovery

Began trials for a cancer vaccine in January 2020



**Mutually driving medium-to-long term R&D as well as development of O-RAN and compact optical IC (DSP). Launching business globally with Japanese revolutionary technologies and products**



## Overview of Medium-to-Long Term Joint R&D

- Joint development of revolutionary optical/wireless devices needed for the IOWN
- Transforming the submarine cable system to a high bandwidth, high function, and low-cost system
- Transforming space communications to a high bandwidth, low delay, automated/autonomous system
- Enhancing technologies to ensure the security of infrastructure networks

## 6 companies from different industries launch an unprecedented research and development business from Japan

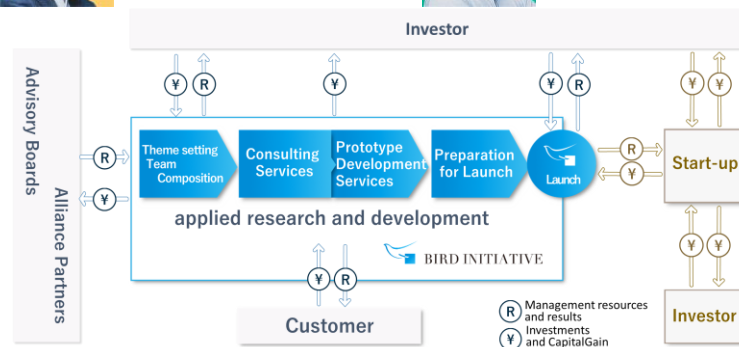
- Technology: Advanced AI technologies (Intelligent Simulation and Automation) from NEC-AIST AI Cooperative Research Laboratory
- Business: Provides consulting and prototype development to realize customer DX
- Success: Create 6 new businesses by 2025 through carve-outs.



Masamitsu Kitase,  
CEO at BIRD



Satoshi Morinaga,  
CDO at BIRD



# Challenges to Speed

# Increasing Development Speed for Faster Commercialization

## Improving development speed driven by newly established Technology Value Creation Division.

We are already accomplishing a number of results.

### Organization for Practical Development

#### Technology Value Creation Division

→ NEC Laboratories Singapore

→ Israel Research Center

→ NEC Laboratories India

#### ■ Infection control solution platform [NEC Laboratories Singapore]

- Expand the image analysis platform for safety, building a prototype in a very short time  
⇒ Technology Value Creation Division is working together with the Sales division to achieve commercialization **within 3 months** (Announcements on July 2<sup>nd</sup> and 17<sup>th</sup>)

#### ■ Visualization of Social Distancing [Biometrics Lab]

- Development & testing were completed very quickly based on underlying image analysis technologies developed over many years. Reached to the usable level **in 2 months**

#### ■ Advanced facial authentication for people wearing face-masks [Biometrics Lab]

- Achieved enhanced face mask compatibility immediately, precision was improved and verified **in 2 months**

#### ■ Contributions to development of vaccines against COVID-19 [NEC Laboratories Europe]

- Researchers of AI-powered drug for cancer proposed to contributing to the vaccine architecture. Working together with Oncolmunity, which we acquired, and our AI Drug Development Division, we completed a genetic analysis of COVID-19 and published the results **within 1 month**

# Cases of Speedy Practical Implementation

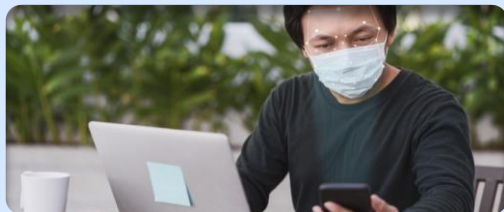
Since March, development of visualization technology of social distancing and facial authentication for people wearing face-masks was completed, and supported the commercialization of infection control solutions.

## Social Distancing for Infection Control



Automatically detects the distance between people using camera imaging and displays the risk level

## Facial Authentication for People Wearing Masks



Highly precise facial authentication using only the parts not covered by the mask

## Vaccine Development Support for COVID-19



### Graph-based Relational Learning

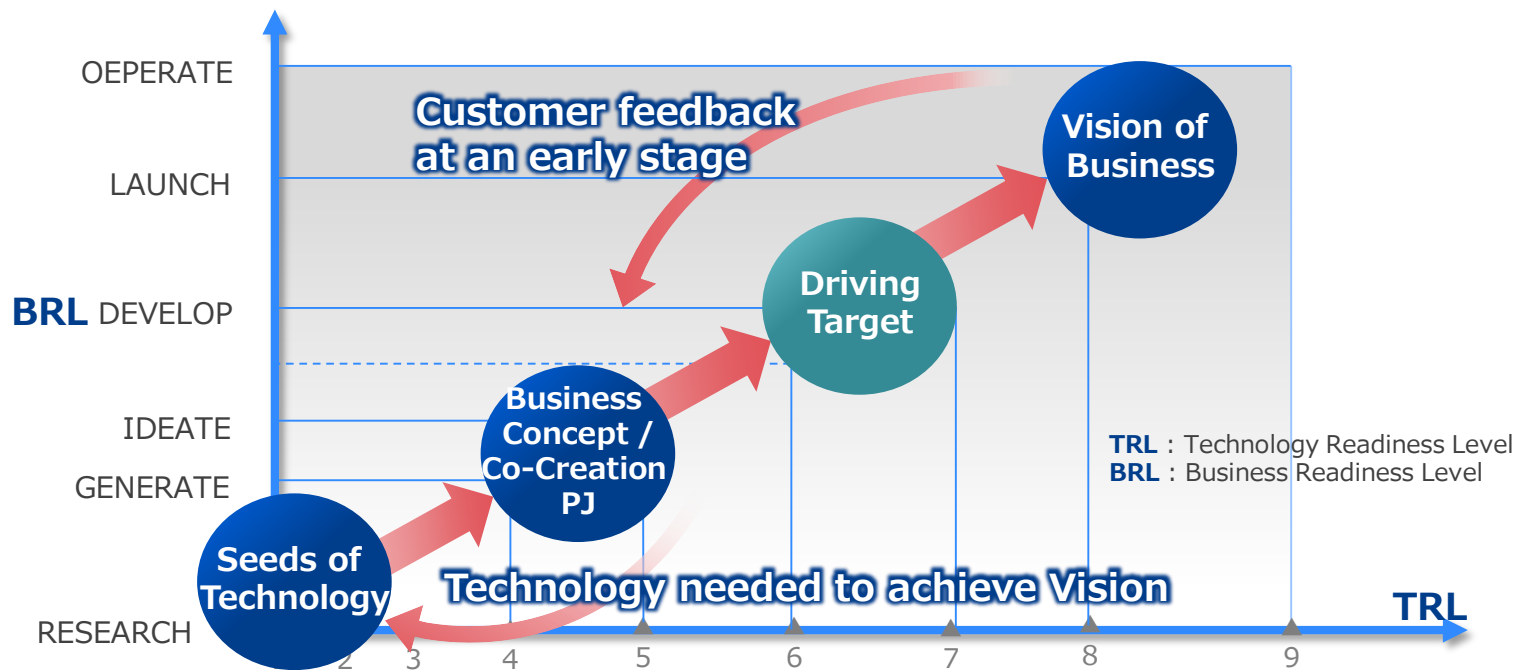
Published COVID-19 genetic analysis results within approx. 1 month after using AI-powered drug discovery methods

▲ **Contributing to New Normal Products** ▲



# Research Activity Management and Accelerating Commercialization using TRL/BRL

Accelerate establishment of a technology needed for the vision of business by presenting the technology at an early stage to communicate with the market. Improve the speed for commercialization through bilateral approaches from technology seeds and by business development





# Promoting Business Incubation Activities

Promoting and accelerating incubation of business with an advanced technology

## Quantum Computing Promotion Office (since January 2020)

Accelerating application development, technology development and market creation using co-creation, in addition to chip development

Understand market needs  
Develop the market

Accelerate development  
of software/application

Accelerate service provision  
(Verification, Education etc.)

Collaboration with D-Wave

Accelerate the market  
creation with industry-  
leading companies

Development of quantum  
annealing simulation

Expand applied areas  
Respond to unprecedented  
large-scale issues with practical speed

Launch of co-creation service

Develop quantum technology  
applications with customers

Comprehensive support for  
commercial use  
(Service launched on June 30, 2020)

# No. 1 Cutting-edge Technology to Support Future Business

An abstract graphic consisting of several thin, flowing orange lines that originate from the top right and curve downwards and to the left, crossing each other in a dynamic, organic pattern.

# No. 1 Cutting-edge Technology to Support Future Business

**DX Business**

**Data Business**

**Network Business**

## Acquire higher-level insight

- From efficiency to business sustainability, from stable operations to handling of unknown issues
- Constantly renewing and growing system with instant adaptation to environmental changes

**Support High-level Human Judgements**

**High-level Real-world Recognition**

## Common Data Platform

- Secure Data Use & Management
- Acquire insights through inter-industry data sharing and utilization

**Secure Data Management**

**Data Collection Platform**

## ICT Platform

- Technological differentiation
- Harmony with eco-systems

**Revolutionary Network Technology**

**Sensor/Computing Technology**

# Support High-level Human Judgements

## Acquire higher-level insight

- From efficiency to business sustainability, from stable operations to handling of unknown issues
- Constantly renewing and growing system with instant adaptation to environmental changes

## Support High-level Human Judgements

High-level Real-world Recognition

## Common Data Platform

- Secure Data Use & Management
- Acquire insights through inter-industry data sharing and utilization

Secure Data Management

Data Collection Platform

## ICT Platform

- Technological differentiation
- Harmony with eco-systems

Revolutionary Network Technology

Sensor/Computing Technology

# AI Supporting Complex and High-level Judgments with Human

**Provide analytical results of complex issues of realworld that human can understand and trust**

Can communicate with human and understanding each other



Accountability and transparency that anyone can accept

Can make high-level judgments for public infrastructure operation etc.



Analysis in complex and large-scale environments



Graph-based Relational Learning



Retrieval based time series analysis

Logical thinking AI



Discovery of rare critical events

⋮

**Working together with human to solve diverse and complex issues**



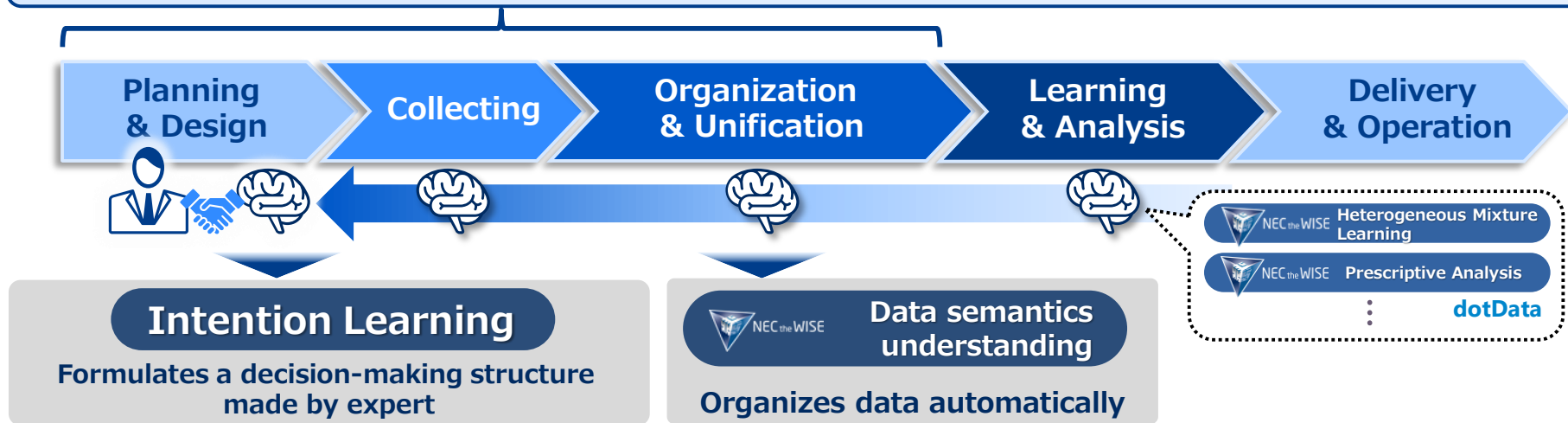
# Automation of Data Scientists' Work

## Targets for AI automation are advancing from analytical processes to upstream processes

As a result of development of new learning & analysis technology...

**More than 80%\*** of total man-power are spent for data preparation and design planning

\* The New York Times (Aug. 17, 2014) <https://www.nytimes.com/2014/08/18/technology/for-big-data-scientists-hurdle-to-insights-is-janitor-work.html>



**Expand automation scope and quickly provide analysis of indisputable value**

# High-level Real-world Recognition

## Acquire higher-level insight

- From efficiency to business sustainability, from stable operations to handling of unknown issues
- Constantly renewing and growing system with instant adaptation to environmental changes

Support High-level Human Judgements

**High-level Real-world Recognition**

## Common Data Platform

- Secure Data Use & Management
- Acquire insights through inter-industry data sharing and utilization

Secure Data Management

Data Collection Platform

## ICT Platform

- Technological differentiation
- Harmony with eco-systems

Revolutionary Network Technology

Sensor/Computing Technology

# Strengthen Real-world Understanding based on Strong Biometrics



**Facial**  
Authentication



**Iris**  
Authentication

**Facial** Authentication **x** **Iris** Authentication



## Maintain No.1 in Biometric Authentication

Continual improvement of precision of person authentication using multimodal recognition



**Understanding the relationship  
between people and things**



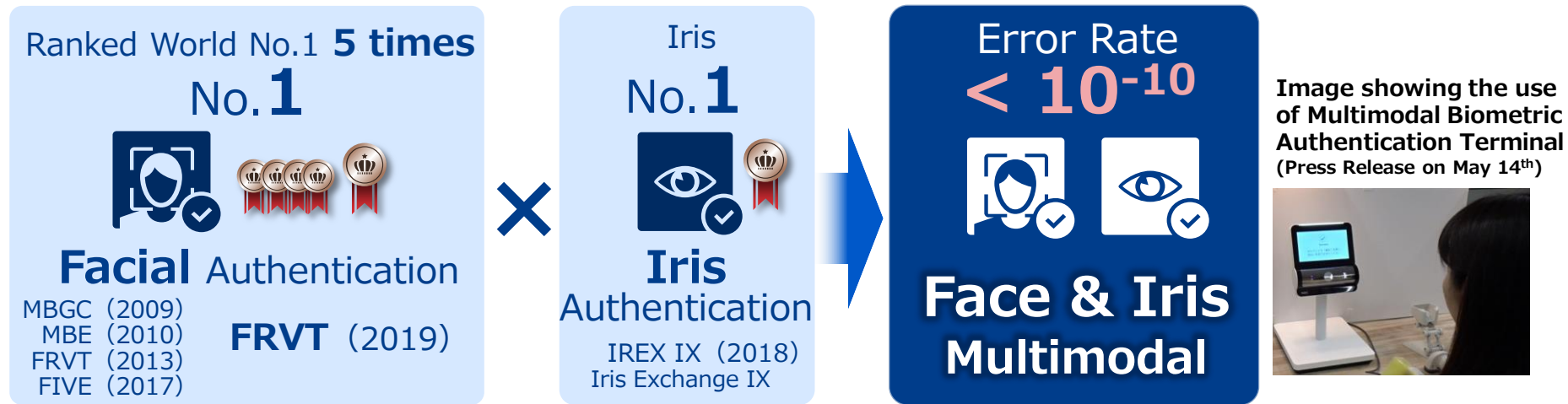
## Expand strength to real-world understanding

Correct understanding of the on-site situation is becoming critical requirement



# Authentication Technology with High Precision and Safety

Covered the world population with an error rate of less than 1 in 10 thousand million (theoretical figure)

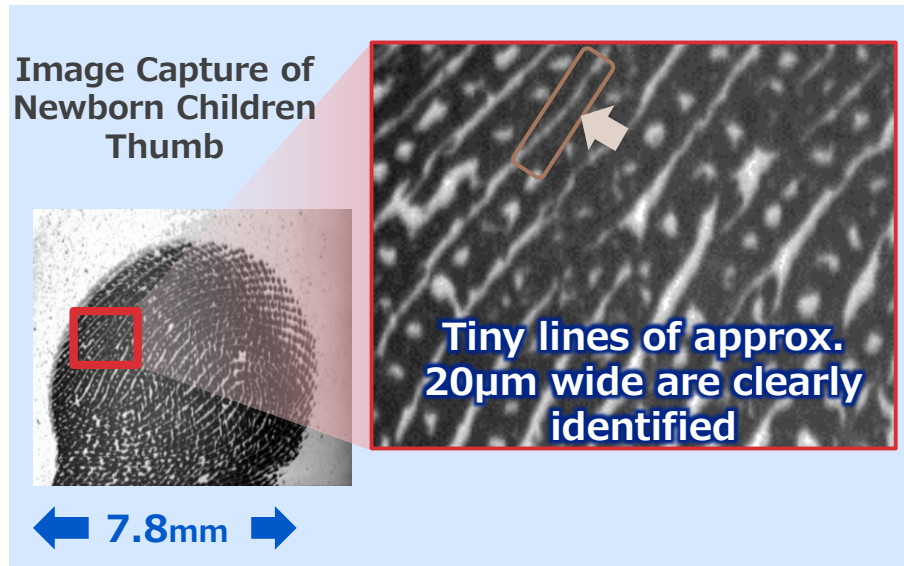


**1 / 10,000,000,000 = World Population Coverage**

**Expanding the use of this technology for ATM user identification and payment which requires strict identification**

※ NIST contest results have been obtained for the recognition of Face&Iris ([https://jpn.nec.com/press/201910/20191003\\_01.html](https://jpn.nec.com/press/201910/20191003_01.html)) ([https://jpn.nec.com/press/201804/20180427\\_02.html](https://jpn.nec.com/press/201804/20180427_02.html))  
※ Results proposed by NIST does not imply the recommendation of specific system, service, or company by US government

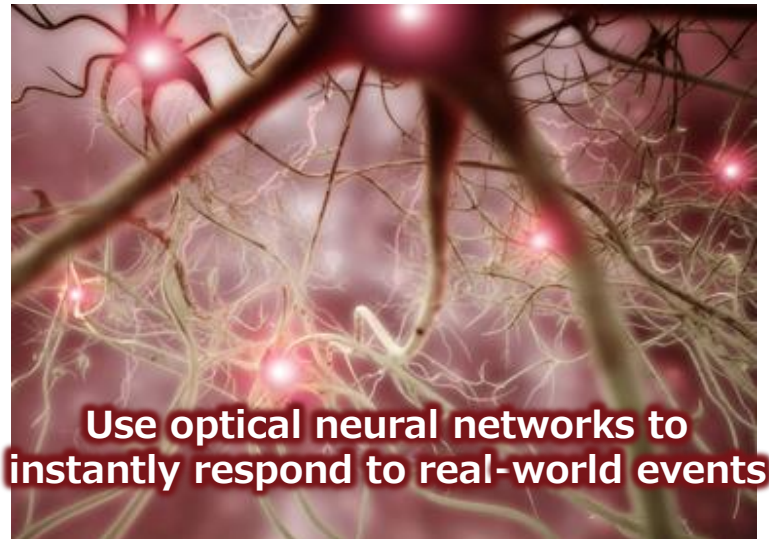
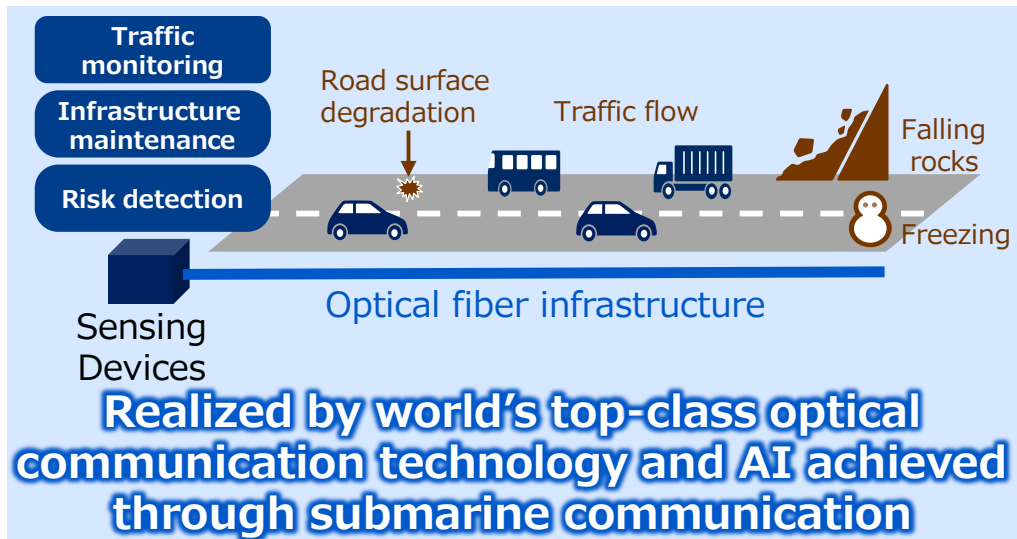
## Recognized fingerprints of newborn children 2 hours after birth with 99.7% accuracy for the first time in the world



Can be used to issue a proof of birth, a personal verification, or a vaccine record after birth, even in places where mothers and babies are left from hospitals mere hours after birth

# Optical Fiber Sensing Technology

Use existing wide-spectrum optical fiber infrastructure to automate traffic monitoring, the maintenance of communication/road network, and the risk detection of falling rocks/freeze



Successfully verified the technology with existing fiber in Dallas, US with Verizon. Currently co-operating towards commercialization

# Secure Data Management / Data Collection Platform

## Acquire higher-level insight

- From efficiency to business sustainability, from stable operations to handling of unknown issues
- Constantly renewing and growing system with instant adaptation to environmental changes

Support High-level Human Judgements

High-level Real-world Recognition

## Common Data Platform

- Secure Data Use & Management
- Acquire insights through inter-industry data sharing and utilization

Secure Data Management

Data Collection Platform

## ICT Platform

- Technological differentiation
- Harmony with eco-systems

Revolutionary Network Technology

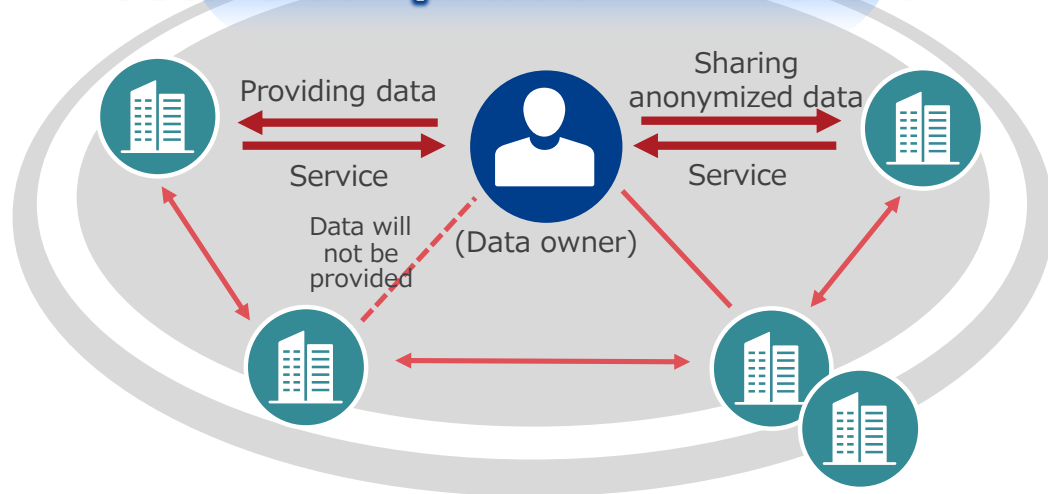
Sensor/Computing Technology

# Enabling "Protecting Data x Collecting Data"

Sharing valuable data  
in which individuals  
cannot be identified



## Secure Computation + Blockchain



Person Authentication **No.1** (incl. product/system performance)

Secure Computation **No.1** (Academic, POC performance)

Blockchain **No.1** (Academic, POC performance)

Secure Storage **Partially commercialized**

FIWARE **Leading the OSS community**

AI Security **New security in the AI era**

**NEC owns the top technology needed for the major functions of data management & collection platform. The new unit will accelerate commercialization from now on.**

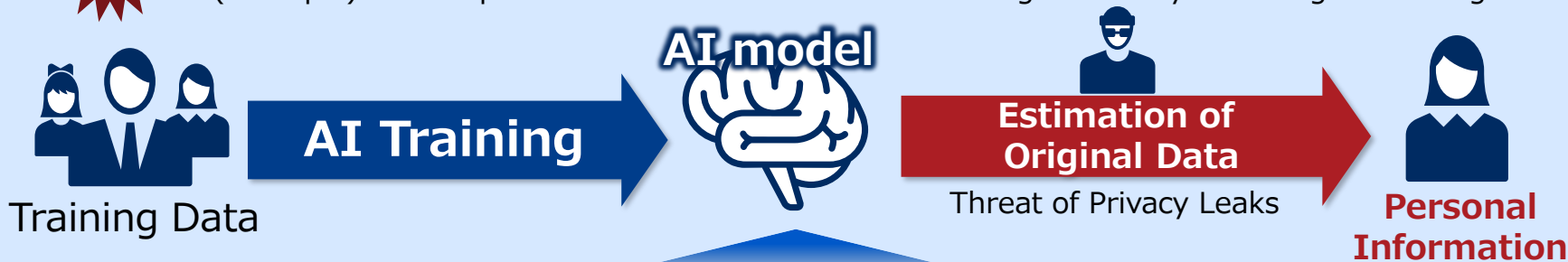
# AI Security

Along with the popularization of AI, vulnerability of AI learning models and threats of information leaks by exploiting it are exposed. We will focus on security technologies to minimize privacy leaks.



## Threats in the AI Era: Estimating training data from the AI model

(Example) Leak of personal information such as face images used by AI during its training



## AI Security Technology to protect personal information from the threat of leaks



- Technology which extracts only the data necessary for training and input it to AI
- AI training technology which makes it difficult to estimate the original data from the AI model

# Revolutionary Network Technology

## Acquire higher-level insight

- From efficiency to business sustainability, from stable operations to handling of unknown issues
- Constantly renewing and growing system with instant adaptation to environmental changes

Support High-level Human Judgements

High-level Real-world Recognition

## Common Data Platform

- Secure Data Use & Management
- Acquire insights through inter-industry data sharing and utilization

Secure Data Management

Data Collection Platform

## ICT Platform

- Technological differentiation
- Harmony with eco-systems

Revolutionary Network Technology

Sensor/Computing Technology



# Boundless Social Value from 5G to Beyond 5G

Expand from the value for individual, to the value for company/city, and to the value for the entire Earth. We are co-creating with NTT on 5G to develop revolutionary O-RAN & security technology

## NEC 5G Strength

### O-RAN

- Reducing size and power consumption by using optical and wireless technology
- Communications × AI × Computing
- Optimal operation in a multi-vendor environment

### Security

- Security as infrastructure

**Safety, Security, Equality, Efficiency**

**Circular Economy**

**Value for the entire Earth**

Use global-scale coverage to optimize for the entire Earth and respond to resource depletion and environmental issues

**Beyond 5G**

**Beyond 5G Challenges**

**Company DX & City DX**

**Value for Company/City**

**5G**

Users will spread from human to things by high-bandwidth, low-latency and massive connectivity

**Smartphone & SNS**

**Value for Individual**

**LTE/4G**



# Leading Earth-level Infrastructure through Synergy of Technologies (Beyond 5G)

High-bandwidth & Low-latency 5G Technology

Standardization



Network Service BU  
Technology



Public Infrastructure BU  
Space & Wireless Technology

Research Labs Technology



Public Infrastructure BU  
Technology

Using "mobile communication technology" with Earth-wide coverage,  
we will accelerate DX of the entire Earth



Current

5G

Local 5G

Public Wireless / Satellite Communication

Future

**Beyond 5G**

**Beyond 5G  
Solutions**

**User  
Management**

Ultra Large Number  
of Connections

E2E Connections

**High-speed  
Wireless  
Communication**

Ultra High  
Bandwidth

>100Gbps

**Mission  
Critical**

Ultra High  
Reliability

High security

**Wide Area  
Communication**

Coverage expansion

National Area  
Coverage

**Networking  
Control**

Ultra low latency /  
Traffic optimization

Unmanned &  
Labor-saving  
advancements

**High-speed  
Optical  
Communication**

Low-cost

Anywhere and  
everywhere  
Gbps

# Summary

# Summary

**Integrate functions needed to improve R&D capability and accelerate commercialization by establishing R&D unit as a company-wide technological organization**

## Further improvement of R&D capability

- Acquire & develop excellent human talent for continuous development of our technological genealogy **Human talent**
- Promote ecosystem-type R&D via large-scale co-creation with external partners **Co-creation**
- Business division technology (public infrastructure, etc.) as the source of new strengths for the whole company **Synergy**

## Challenges to accelerate commercialization

- Largely shorten the time for commercialization of a core technology by creating an engineering division

**Commercialization**

**Lead NEC's growth via continuous creation of differentiating technologies and accelerating their commercialization**

# [Reference] R&D Unit – New Structure

## R&D Unit

**Biometrics  
Research Laboratories**

**Data Science  
Research Laboratories**

**Security  
Research Laboratories**

**System Platform  
Research Laboratories**

**NEC Laboratories America**

**NEC Laboratories Europe**

**NEC Laboratories China**

**Continuous creation of  
differentiating technology**

**Technology Value Creation  
Division**

**NEC Laboratories  
Singapore**

**Israel Research Center**

**NEC Laboratories India**

**Technology Synergy  
Creation Division**

**Value maximization  
of technological assets**

**Corporate Technology  
Strategy Division**

**Intellectual Property  
Division**

**Integration of strategic  
functions**

 **Orchestrating** a brighter world

**NEC**