

TOSHIBA

Leading Innovation >>>

Toshiba's Technology Strategy

The Driver of Renewed Growth

Dr. Naoto Nishida

**Executive Officer and
Corporate Executive Vice President
Toshiba Corporation**

October 18, 2016

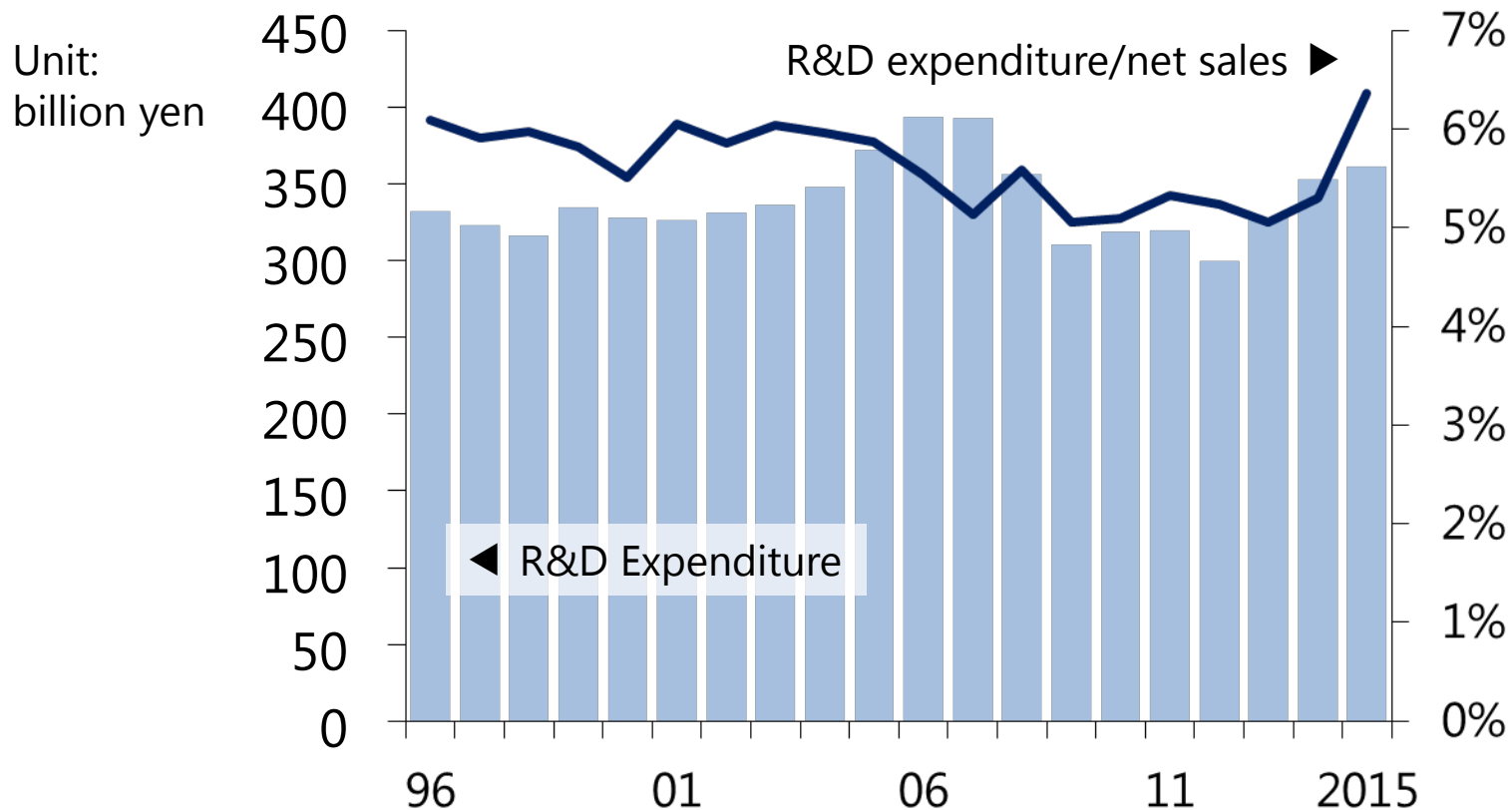
-
- 1. Today's Realities and Toshiba's Basic Technology Policy**
 - 2. Technology Development: Organization, System and Roles**
 - 3. Responding to Pressing Social Issues with Innovation**

-
- 1. Today's Realities and Toshiba's Basic Technology Policy**
 2. Technology Development: Organization, System and Roles
 3. Responding to Pressing Social Issues with Innovation

The Current Situation in Technology Development: Trend in Research and Development Expenditures over 20 years

In the midst of management change, a consistent focus on technology

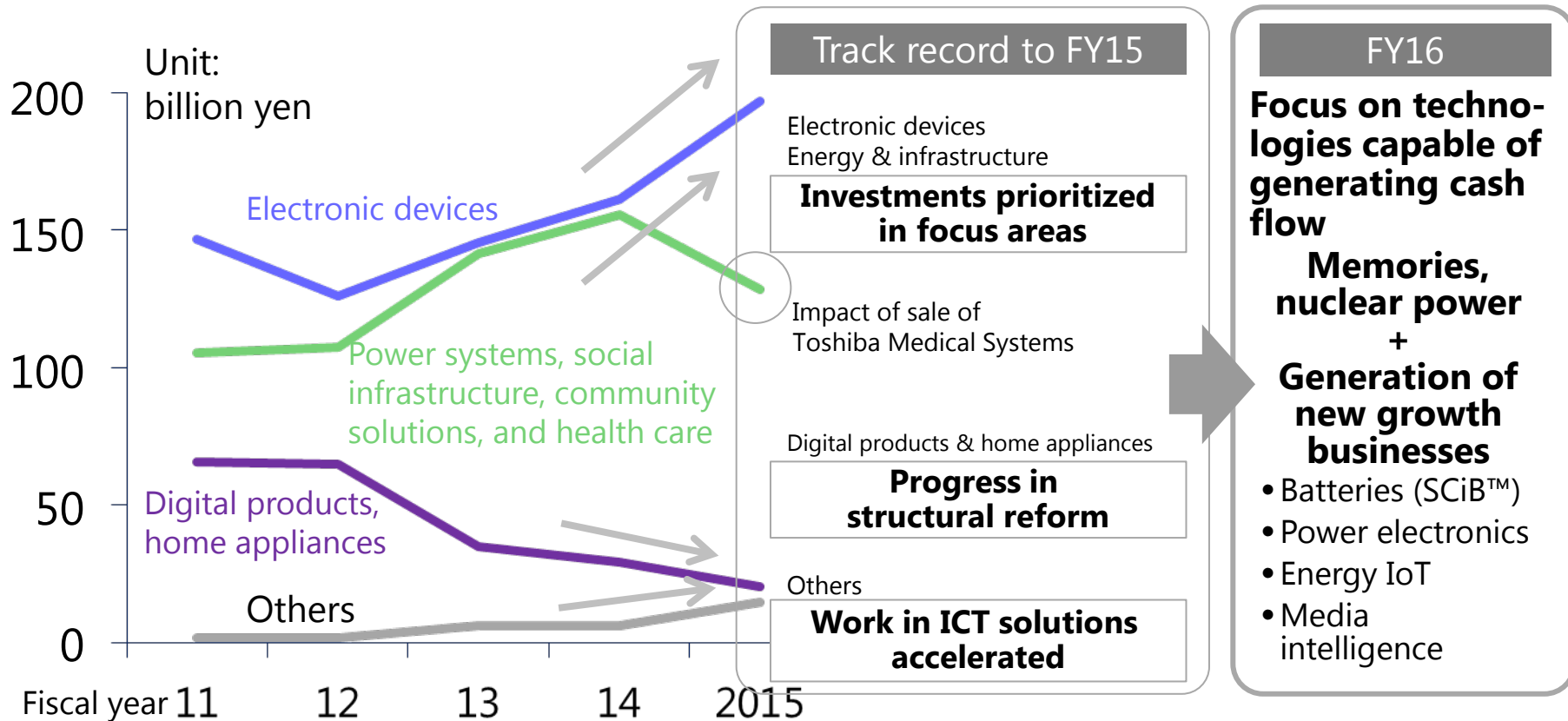
A 20-year average research and development expenditure ratio of 5.6%
Also expected to be about 6% in FY16



The Current Situation in Technology Development: Research and Development Expenditures by Business

Continuing balanced, up-front investments in focus businesses

Raise R&D expenditures for power systems, infrastructure and electronic devices over 5 years from 72% to 90%



Basic Policy on Technology Development

Substantial Solutions that solve social issues

Fully utilize Toshiba's product strengths and existing connections with customers through its products.

■ Examples of contact with customers through products

Power generation turbines^{*1}

4,344 units
shipped worldwide

Commercial air-conditioning

370,000 units a year
shipped worldwide

POS cash registers

370,000
shipped worldwide

NAND-type flash memory

90 billion gigabytes
shipped worldwide

Smart meters

6.56 million units a year
shipped worldwide^{*2}

MFP

320,000 units
shipped worldwide

Industrial PV panels

6.7 million panels
shipped worldwide

Rechargeable batteries

approx. **20 million** cells
shipped worldwide

Strategy for Policy Implementation

Solve social issues with substantial solutions

1 Use innovative technologies to create substantial products offering high level functionality, quality and cost competitiveness

▼ AP1000™ ▼ SCiB™ ▼ BiCS FLASH™ ▼ Apply AI to improve semiconductor processes, and more

2 Technologies that turn unique, substantial products into solutions

▼ Weather and disaster prevention solutions ▼ Hydrogen solutions ▼ Low-carbon energy solutions
▼ Energy management solutions ▼ Store solutions with robot, and more

3 Information technologies that convert data from substantial products into customer value

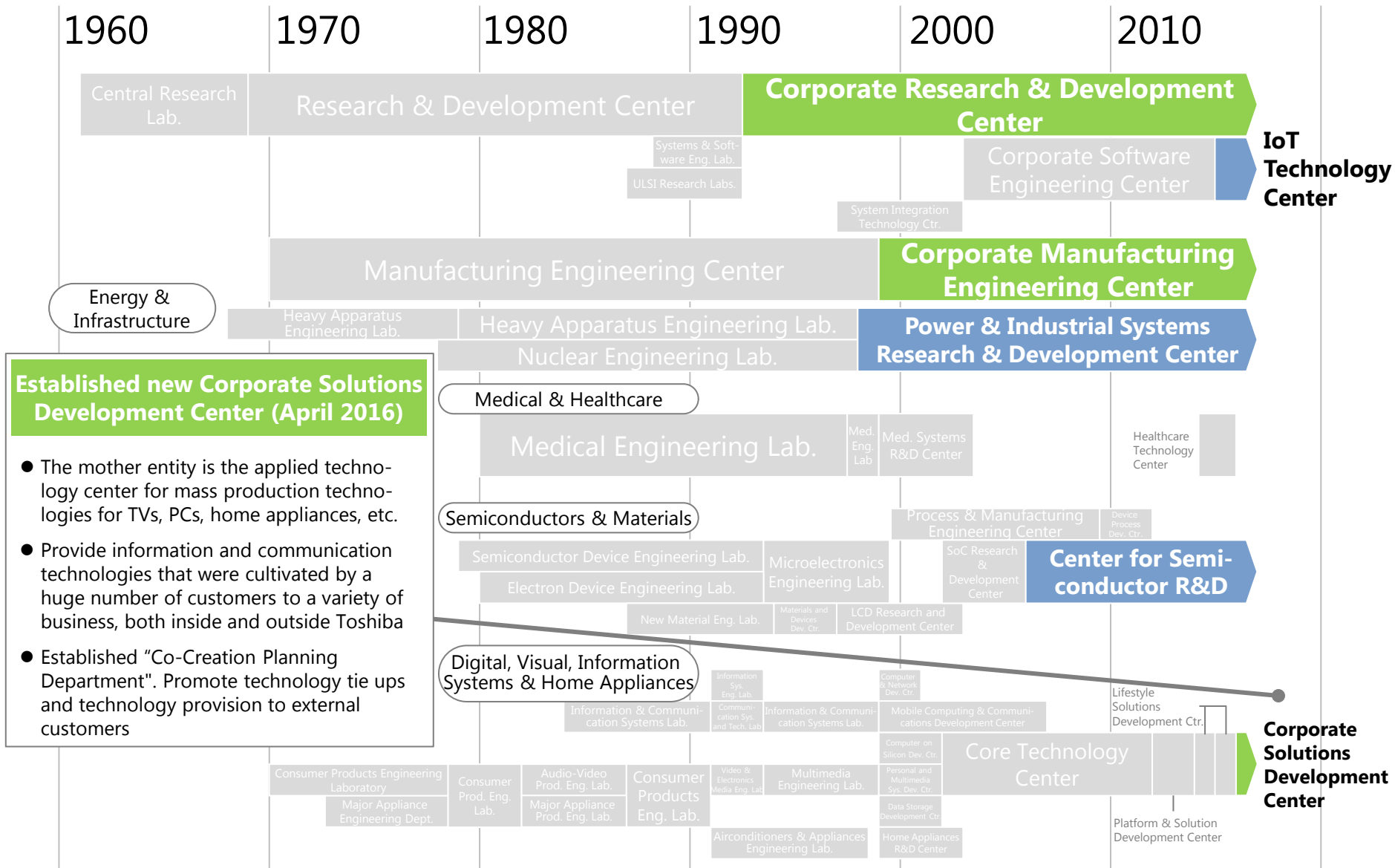
▼ Image recognition processor ▼ High-speed retrieval technology for large-scale data
▼ RECAIUS™, and more

4 Technologies that fully utilize synergies from multiple businesses and bring core competences to multi-faceted development

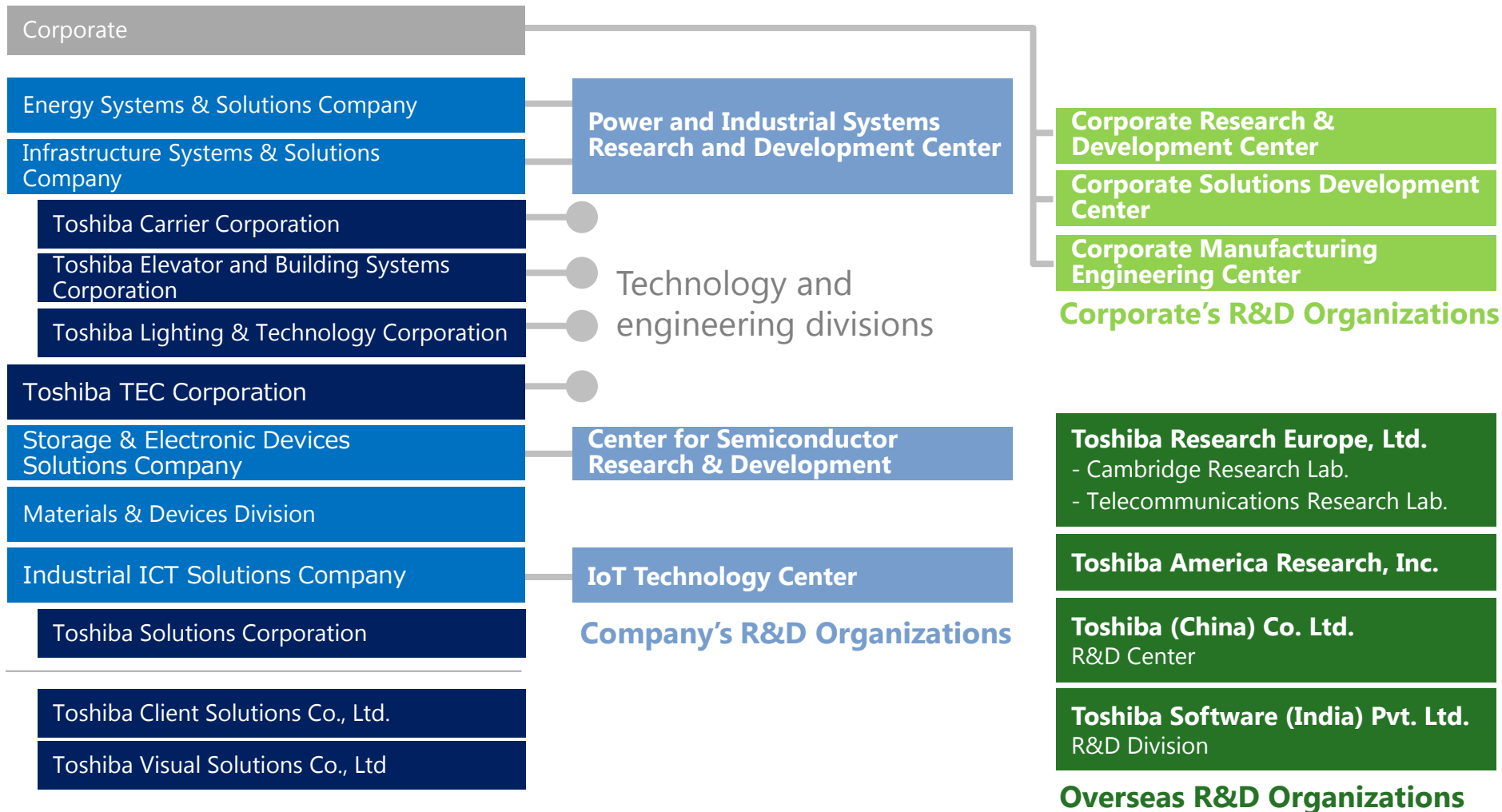
▼ Heavy-ion radiotherapy systems, and more

-
1. Today's Realities and Toshiba's Basic Technology Policy
 - 2. Technology Development: Organization, System and Roles**
 3. Responding to Pressing Social Issues with Innovation

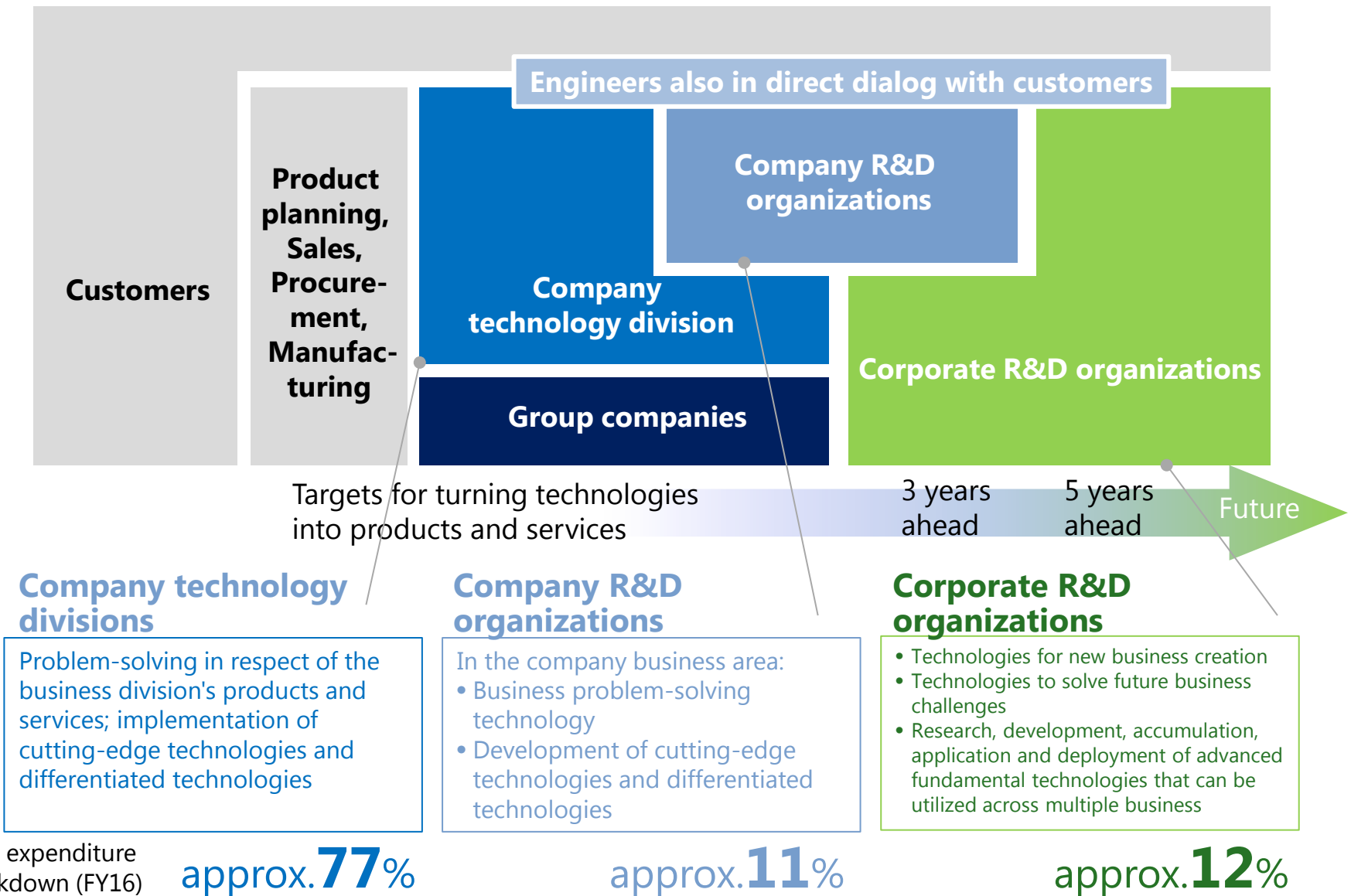
Changes in Research and Development Organization



Research & Development Organizations



Research and Organizations: Roles and Resource Allocations



1. Today's Realities and Toshiba's Basic Technology Policy
2. Technology Development: Organization, System and Roles
3. **Responding to Pressing Social Issues with Innovation**
 - The information explosion
 - The increase in greenhouse gases
 - An aging society and decreasing workforce
 - Intensifying extreme weather and natural disasters

A World of Complex Problems and Challenges

Respond to globally diversifying challenges and aim to develop together with society

Insights into Social Foundations

Information explosion

- Amount of data generated worldwide — approx. **4.4 zettabytes** (2013) approx. **44 zettabytes** (2020)
- Increase in cyber attack victims worldwide (2013) — approx. **380 million** per year, over 1 million a day, approx. 12 in every second

Global warming

- Global CO₂ emissions — approx. **31.6 billion tons** (2012) approx. **34.2 billion tons** (2020)
- Global increase in energy consumption — approx. **9.3 billion tons** (2000) approx. **19.3 billion tons** (2040)

Aging

- Global life expectancy at birth — approx. **71 years** (2010-15) approx. **77 years** (2045-50)
- Number in elderly people in the world — surpasses **1 billion** (2030)

Insights into Life

Decrease in the labor force

- Working-age population per elderly person in Japan — **3.6** (2000) → **1.2** (2050)
- In 2030, there will be labor shortages in **nine of the 11 G7+BRICs countries**

Traffic congestion

- Deaths from road traffic injuries worldwide — approx. **1.4 million** a year
- Time lost due to congestion in Japan — the time caught up in traffic jams is approx. **40%** of total drive time

Aging of social capital

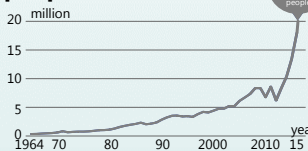
- Maintenance and upgrade costs of infrastructure inspection in Japan — approx. **5.1 trillion yen** (2023) in maximum
- Aging of Japan's waterworks facilities — 2031-2035 upgrade costs **over 1.4 trillion yen / year**

Extreme weather and natural disasters

- Landslide disasters in Japan — approx. **10,500 cases** in 10 years
- Cost of crop damage from natural disasters in Japan — **23 billion yen** (2014)

Expanding inbound

- Number of foreign tourists visiting Japan in recent years — toward **20 million people**



Logistics

- Global number of letter-post items per year — approx. **330 billion items** (2014)
- Increase in courier and mailing service in Japan — approx. **9.1 billion items** (2014, 2x 10 years ago)

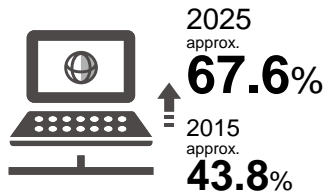
Increase in health care costs

- Global medical equipment market — approx. **363.8 billion dollars** (2013) → approx. **513.5 billion dollars** (2020)

Social Issues Worthy of Particular Attention

Responding to the information explosion

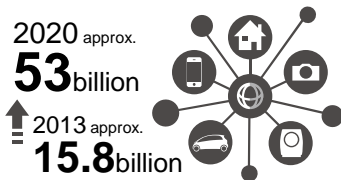
Internet penetration rate in global population



Amount of data generated worldwide

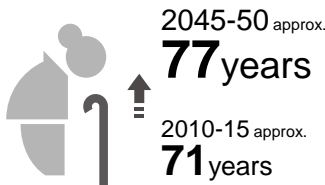


Number of IoT devices connected to the internet worldwide



Responding to an aging society and decreasing workforce

Life expectancy at birth, globally

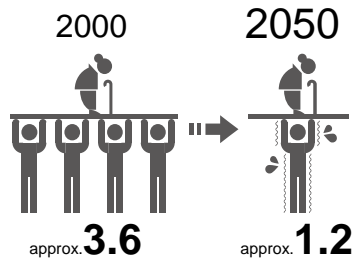


Global aging



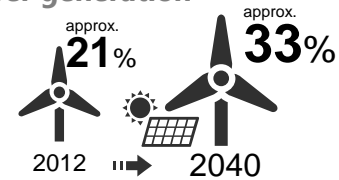
Number in elderly people in the world surpasses **1 billion** (2030)

Number of people bearing burden of social security for the aging (Japan)

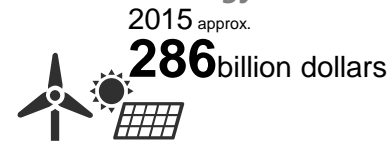


Responding to the increase in greenhouse gases

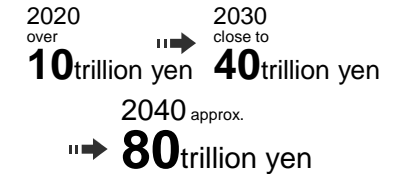
Global renewable share in power generation



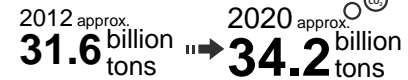
Global investments in renewable energy



Global hydrogen infrastructure market



Global CO₂ emissions



Global warming will push over **100 million** people back into poverty by 2030

Responding to intensifying extreme weather and natural disasters

Instances of heavy rain of 50mm/h and over (Japan)

average **229** instances (2005-2014)

Number of landslides (Japan)

approx. **10,500** instances (in 10 years)

Cost of flood damage (Japan)

more than **5** trillion yen (in 10 years)

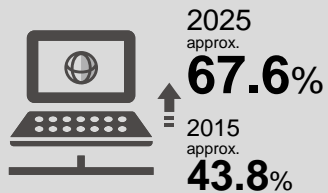
Crop damage due to natural disasters (Japan)

approx. **23.0** billion yen (2014)



Responding to the information explosion

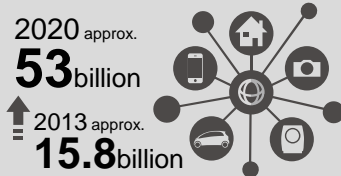
Internet penetration rate in global population



Amount of data generated worldwide



Number of IoT devices connected to the internet worldwide



Value to provide

- Highly integrated and highly reliable storage systems
- Improved productivity that applies big data and AI
- In-vehicle high-speed processing for safe transportation
- Application of AI to realize services that understand human intent
- High-speed data retrieval that can handle ever-increasing data volume

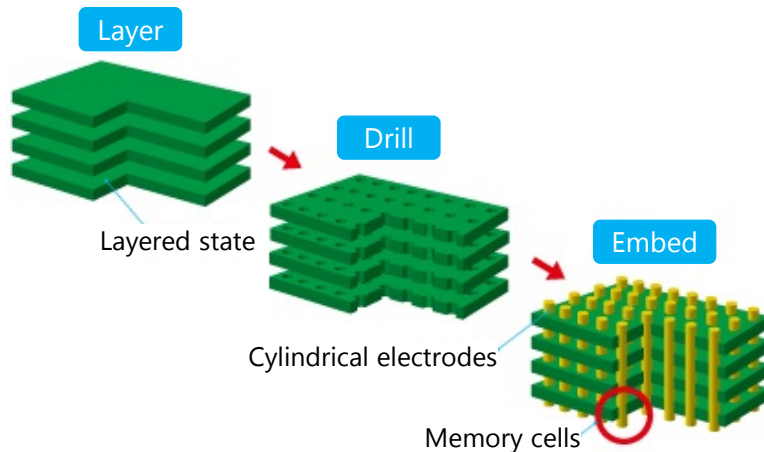
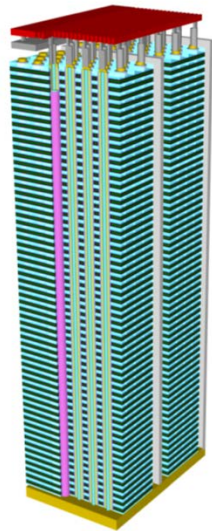
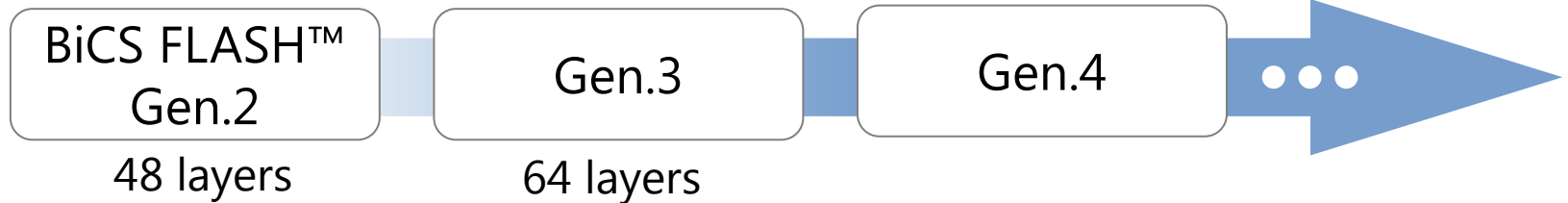
Solution technologies

- ▶ **BiCS FLASH™**
- ▶ **Semiconductor manufacturing process improvements through AI** **Exhibit**
- ▶ **High-performance sensing processor** **Exhibit**
- ▶ **RECAIUS™, Cloud AI services capable to handle audio and visual data** **Exhibit**
- ▶ **Large-scale high-speed data retrieval technology** **Exhibit**

BiCS FLASH™

Steadily establish the technology line-up that realizes the memory structure necessary for the era

Provide highly integrated storage devices



- ▶ Mass production of 48-layer products
- ▶ A 64-layer device that will be first in the world to start sample shipments*
- ▶ Improve integration density per unit area through multi-layering
- ▶ Technologies to improve manufacturing yields and for further multi-layering are under development

Toshiba's technology strategy
which realizes "Substantial Solutions"

Strategy 1. Innovative technologies to create superior products

Applying Artificial Intelligence to Improve Semiconductor Manufacturing Processes

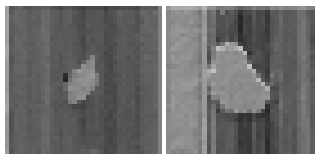
Exhibit

Take advantage of artificial intelligence and analyse information using big data from Yokkaichi Operations

Support business growth by improving yields and reliability



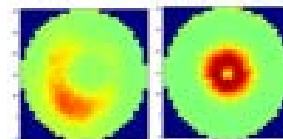
Every day, more than 1.6 billion data points, output by approximately 4,000 units of manufacturing and inspection equipment, are collected in real time



Inspection image analysis

Automatic classification of data on 100 kinds of failure from 300 thousand SEM* images a day.

Deep Learning has boosted the automatic classification rate from 49% to 83%



Product yield monitoring

Automatic classification of 200 thousand wafer images per month.

Amount of average time required to estimate the cause of a defect **reduced from 6 hours to 2 hours**

Toshiba's technology strategy
which realizes "Substantial Solutions"

Strategy 1. Innovative technologies to create superior products

Strategy 3. Information technologies that convert data into customer value


Image Processing Technologies

A 50-year history and a strong track record of application in a variety of products and fields

■ Currently active



**Product recognition
POS cash registers**



**High-performance
sensing processor**




**Automated
mail-processing
systems**



**Semiconductor
defect image
analysis**



RECAIUS™



**1967
Demonstration of
post code automatic
reading and sorting
machine**

■ Application outcome



**Big data
high-speed
retrieval**



**Image
translation**

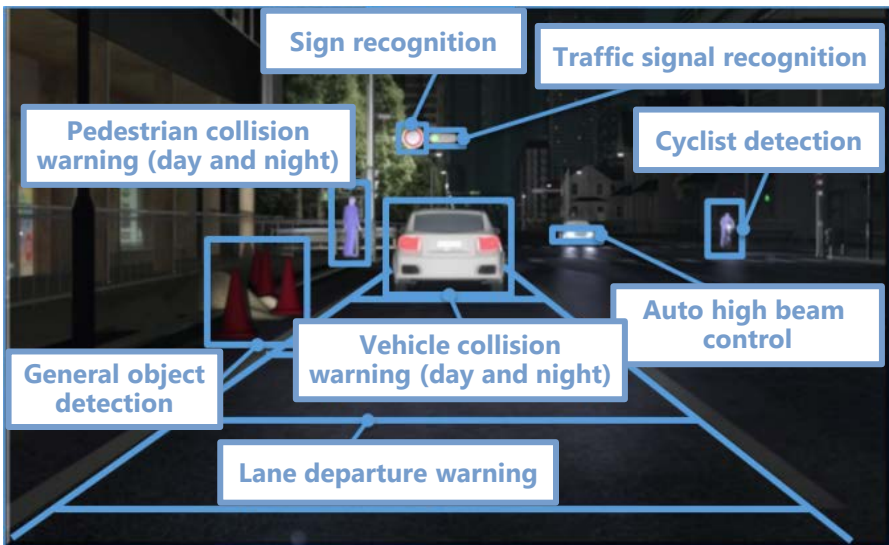
High-Performance Sensing Processor

Expertise in the development and implementation of accumulated image recognition technologies

Towards active safety and advanced autonomous driving

Need for active safety to suppress rise in traffic accidents. Growing market for autonomous driving.

- ▶ Unique image features and recognition algorithm improve nighttime performance.
- ▶ Application of deep learning and artificial intelligence to developing advanced recognition will realize autonomous driving in collaboration with Denso Corporation.
- ▶ Solutions combined with infrastructure are also planned.



Toshiba IT & Control Systems has commercialized an image analysis box built around the processor. It offers the functions of **intrusion detection, retention analysis, and people counting while reducing the communication load on the camera network.**



Toshiba's technology strategy which realizes "Substantial Solutions"

- Strategy 2. Technologies that create unique product solutions
- Strategy 3. Information technologies that convert data into customer value

Responding to the increase in greenhouse gases

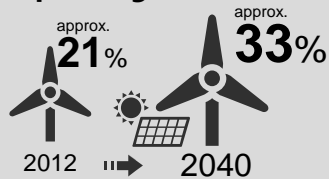
Value to provide

- Stable energy supply
- Realize a low-carbon society
- Expand use of renewable energy

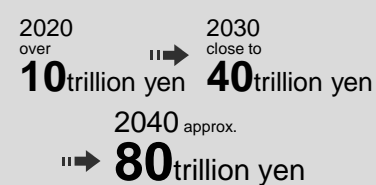
Solution technologies

- ▶ **Hydrogen solutions**
- ▶ **Energy management solutions**
- ▶ **Low-carbon energy solutions**

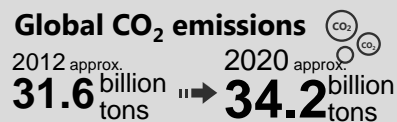
Global renewable share in power generation



Global hydrogen infrastructure market



Global investments in renewable energy



Global warming will push over **100 million** people back into poverty by 2030

Exhibit

Separate speech

Responding to an aging society and decreasing workforce

Life expectancy at birth, globally

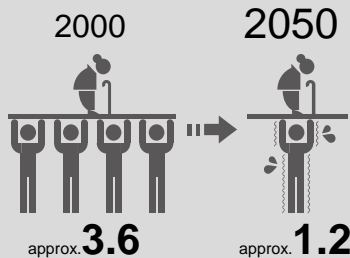


Global aging



Number in elderly people in the world surpasses **1 billion** (2030)

Number people bearing social security burdens from aging (Japan)



Value to provide

- Active safety by advanced driving assistance
- Provision of treatment measures that maintain QOL
- Solutions for workforce shortages in stores and warehouse

Solution technologies

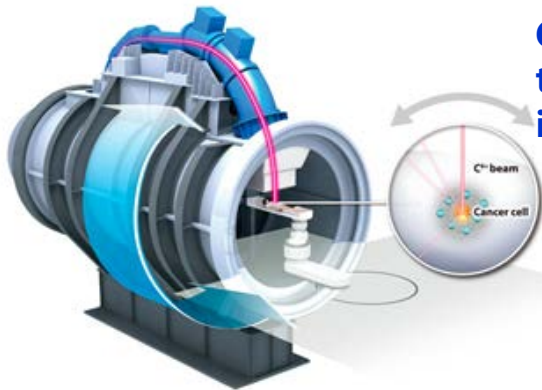
- ▶ **High-performance sensing processor** [Exhibit](#)
- ▶ **Heavy-ion radiotherapy systems** [Exhibit](#) [Separate speech](#)
- ▶ **Store solutions with robots** [Exhibit](#)

Heavy-ion Radiotherapy Systems

Cancer treatment solutions that reduce burdens on patients Provide treatment opportunities for many patients

Lightweight and compact, with rotating gantry

- First in the world to use a **superconducting magnet** (Delivered to National Institute of Radiological Sciences in 2015*1; order received from Yamagata University Hospital)



Can irradiate through 360° in all directions

High-speed 3D scanning irradiation

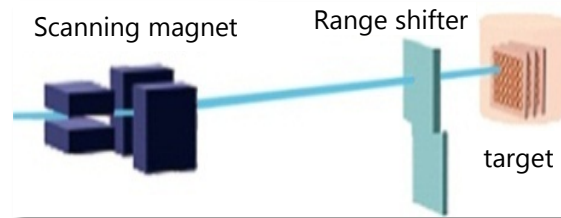
- Pinpoint irradiation** according to the shape of the tumor (track record*2 of application on more than 1,000 patients at National Institute of Radiological Sciences)

Respiratory synchronization

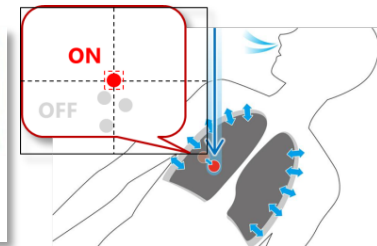
- Irradiation is controlled by tracking the movement of the tumor from breathing
Achieves irradiation with reduced damage to normal tissue

Marker-less tumour tracking (in cooperation with QST*1)

- Developed a technology that learns a position of the tumor in advance and tracks it in real time **without surgically implanted body markers**



High-speed 3D scanning irradiation



Respiratory synchronization

Toshiba's technology strategy which realizes "Substantial Solutions"

Strategy 1. Innovative technologies to create superior products

Strategy 4. Technologies for multifaceted deployment of core competencies

*1 National Institutes for Quantum and Radiological Science and Technology, National Institute of Radiological Sciences

*2 National Institute of Radiological Sciences Handbook (April 11, 2016)

Responding to intensifying extreme weather and natural disasters

Instances of heavy rain of 50mm/h and over (Japan)
average **229** instances (2005-2014)

Number of landslides (Japan)
approx. **10,500** instances (in 10 years)



Cost of flood damage (Japan)
more than **5** trillion yen (in 10 years)

Crop damage due to natural disasters (Japan)
approx. **23.0** billion yen (2014)



Value to provide

- Predict increasingly frequent, sudden, localized rain downpours
- Issue pinpoint accurate advisories

Solution technologies

- ▶ **Weather and disaster prevention solutions**

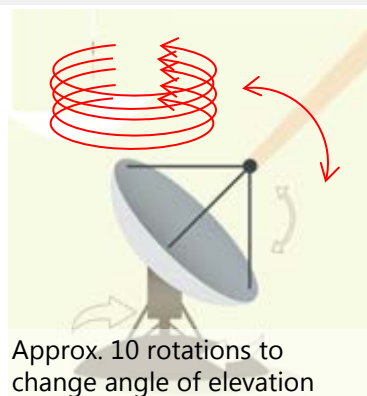
Exhibit

Weather and Disaster Prevention Solutions

Exhibit

Cooperate with social infrastructure to provide a solutions base for disaster prevention

Aim to reduce disasters caused by sudden torrential rain, etc.

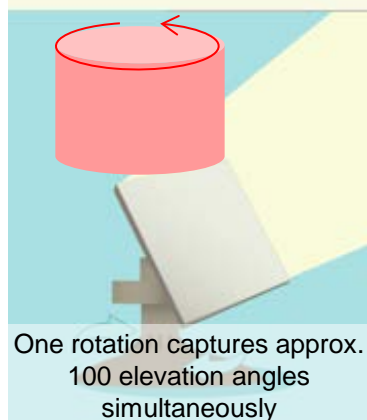


Conventional

Parabolic type weather radar

5 minutes needed for a simple observation

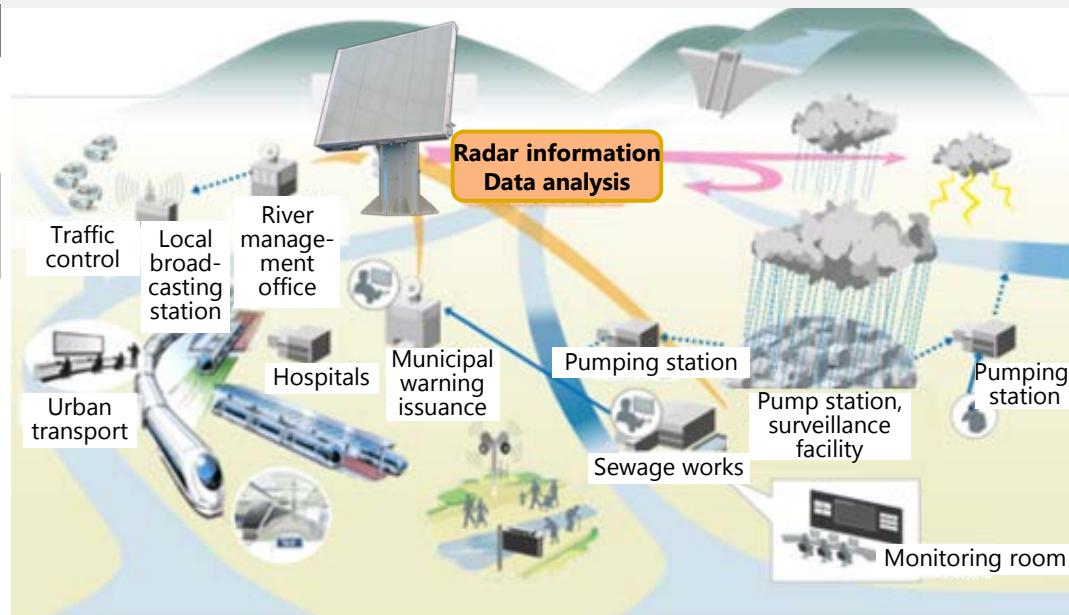
Large spatial and temporal gap
Difficult to predict localized heavy rain



Toshiba's cutting-edge technology

Phased array weather radar

High-density observation possible in just 30 seconds



Possible to observe growth of raindrops in the clouds
Predicts local heavy rain in the near future (10s of minutes)

Supports issues of warnings, Protects lives and property

Toshiba's technology strategy

which realizes "Substantial Solutions"

Strategy 1. Innovative technologies to create superior products

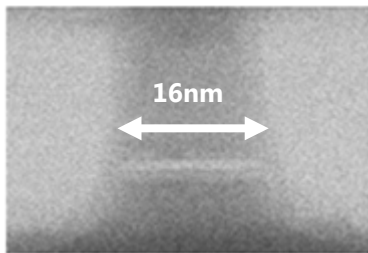
Strategy 2. Technologies that create unique product solutions

Cutting-edge technologies that solve emerging social issues

- ▶ **Magnetoresistive Random Access Memory (MRAM)**
- ▶ **Quantum cryptography communication (UK)**
- ▶ **Self-amplifying reporter DNA**
- ▶ **Knowledge base construction "DeepDive" (US)**

A Commitment to Developing Advanced Technologies

Magnetoresistive Random Access Memory (MRAM)



Memory that has the high speed performance of SRAM and the non-volatility of NAND-type Flash Memory.

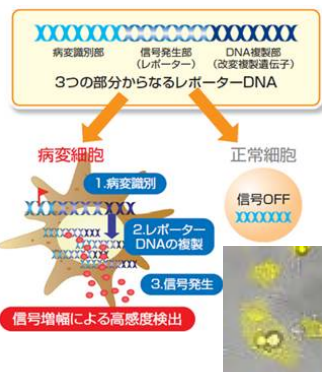
Demonstrates high speed and low power operation in 1Xnm size elements*1.

Cross-section view of MTJ (Transmission electron microscope photograph)

Achieve low power consumption computing

MTJ: Magnetic Tunnel Junction

Self-amplifying reporter DNA



Joint research with the Nara Institute of Science and Technology on development of an agent that identifies changes in genomic information.

First realization of highly sensitive reading of genome information changes in live cells.

Instantaneous discovery of diseased cells at very early stage

Quantum cryptography communication (UK)

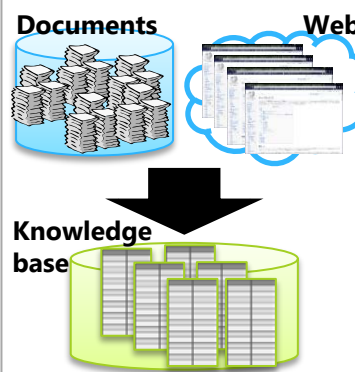


Research at Toshiba's Cambridge Research Laboratory has achieved the world's highest performance and is being developed towards practical use*2.

Toshiba has begun to show future applications in the banking industry, in collaboration with the UK's BT Group plc.

Robust protection of personal information and transaction information, etc.

Knowledge base construction "DeepDive" (US)



Joint research with Stanford University.

Automatic extraction of relationships between words in text through machine-based learning from rough examples. Reduce the cost of constructing knowledge bases.

Discover "awareness" hidden in large amounts of text

Conclusion

Toshiba's Technology

**Solves diversifying social issues
by providing substantial solutions
and
aims to grow and develop along with society.**

TOSHIBA

Leading Innovation >>>