2016 R&D Strategy
To become “An Innovation Partner for the IoT Era”

28 June 2016
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Chief Technology Officer
General Manager, Research & Development Group
Hitachi, Ltd.
Contents

1. Basic directions for 2018 Mid-term Management Plan
2. Creating service business by accelerating collaborative creation
3. Building-up technology platforms for business growth
4. Challenging future societal issues
5. Summary
Contents

1. Basic directions for 2018 Mid-term Management Plan
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2015 Mid-term Management Plan
- Achieve growth & Hitachi’s transformation -

Hitachi Gr. business policy: increase business income

From “product-out” to “market-in”
Shift to “customer-driven”

Realign R&D organization, enhance innovation strength

1. Assign researchers close to customers to expand collaborative creation
2. Create innovative technology that satisfy market needs
1-2 Events worldwide

- **Hitachi Social Innovation Forum**
  - London ['15/6]
  - Munich ['15/10]

- **Hitachi Social Innovation Forum**
  - Las Vegas ['15/4]
  - CSI-North America New facility
  - Santa Clara ['16/1]

- **Hitachi Technology Forum**
  - Beijing ['15/12]

- **CSI-North America**
  - Tokyo ['15/10]
  - Technology Community
  - Tokyo ['15/11]

- **CSI-Europe**
  - CSI-China

**Strengthening engagement with customers by holding events worldwide**
1-3 Collaborative creation with customers

**Number of cases discussed**

<table>
<thead>
<tr>
<th>FY 2014</th>
<th>FY 2015</th>
</tr>
</thead>
<tbody>
<tr>
<td>81</td>
<td>179</td>
</tr>
</tbody>
</table>

**Number of co-created PoC with prototype**

<table>
<thead>
<tr>
<th>FY 2014</th>
<th>FY 2015</th>
</tr>
</thead>
<tbody>
<tr>
<td>27</td>
<td>74</td>
</tr>
</tbody>
</table>
An Innovation Partner for the IoT Era

Accelerate collaborative creation with customers through advanced Social Innovation Business

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**Driver of overall growth**

Digitalized Social Innovation Business = Digital solution

IoT platform “Lumada”

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EPC: Engineering, Procurement, Construction

Source: 18 May 2016 Hitachi Mid-term Management Plan

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2018 Mid-Term Management Plan: What Hitachi hopes to become

An Innovation Partner for the IoT Era

Accelerate collaborative creation with customers through advanced Social Innovation Business

Basic directives for the R&D Group

Create business innovation amidst uncertainty

- Create service business by accelerating collaborative creation
- Build-up technology platforms for Service & Product business growth
- Challenge future society issues through open innovation

Section 2

Section 3

Section 4
1-6 Research supporting the Front

Driving R&D close to customer sites

**Business structure from FY2016**

- **Customers**
  - Regional bases
  - Customers’ segments (12 BUs)

- **Front**
  - Regional bases

- **Platform**
  - Core of Social Innovation

- **Products**
  - Industrial products, Automotive parts, Materials, etc.

---

**[R&D structure from FY2015]**

- **Global Center for Social Innovation (CSI)**
  - Developing services in keeping with the needs of customers in each region
  - North America 100
  - Europe 70
  - China 115
  - Asia 65
  - Japan 200
  - [Total: 550]

- **Center for Technology Innovation (CTI)**
  - Establishing Global No. 1 technologies (Platforms, Products)
  - [Japan: 2,050]

- **Center for Exploratory Research (CER)**
  - Resolving future societal issues
  - [Japan: 100]
  - [Total: 2,700] (+100 from FY2015)

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Source: 18 May 2016 Hitachi Mid-term Management Plan

BU: Business Unit

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New research building @Kokubunji site to facilitate co-creation

Cutting-edge research equipment for rapid prototyping in accordance with customer needs, will be installed to promote collaborative research with customers worldwide.

Construction to be completed in March 2019

- **Jinsō-tō**: Rapid prototyping for materializing ideas
- **Kyōsō-tō**: Environment to hold discussions with customers worldwide (Convention center & Collaboration space)
- **Odaira Memorial Building**: Entrance to welcome visitors
1-8 Global Research: Collaboration between sites

- **CSI-Europe** [70]
  - Industrie 4.0
  - Railway business

- **CSI-China** [115]
  - Made in China 2025
  - '16/4
  - New Guangzhou site

- **CSI-APAC** [65]

- **CSI-Tokyo** [200]

- **CTI** [2,050]

- **CSI-NA** [100]
  - Industrial Internet
  - IoT platform business

- **CER** [100]

Globally coordinated

- Society 5.0
  - '19/3
  - New collaboration space

- '16/1: Opened new office
- '16/4: Est. Financial Innovation Lab.
Approx. 4% of revenues is invested in Hitachi Group R&D

- **R&D expenditure (billion JPY)**
- **R&D expenditure/revenues (%)**

<table>
<thead>
<tr>
<th>Fiscal year</th>
<th>R&amp;D expenditure (billion JPY)</th>
<th>R&amp;D expenditure/revenues (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>'03</td>
<td>500</td>
<td>5</td>
</tr>
<tr>
<td>'04</td>
<td>450</td>
<td>4.5</td>
</tr>
<tr>
<td>'05</td>
<td>420</td>
<td>4.2</td>
</tr>
<tr>
<td>'06</td>
<td>400</td>
<td>4</td>
</tr>
<tr>
<td>'07</td>
<td>380</td>
<td>3.8</td>
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<tr>
<td>'08</td>
<td>360</td>
<td>3.6</td>
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<tr>
<td>'09</td>
<td>340</td>
<td>3.4</td>
</tr>
<tr>
<td>'10</td>
<td>320</td>
<td>3.2</td>
</tr>
<tr>
<td>'11</td>
<td>300</td>
<td>3</td>
</tr>
<tr>
<td>'12</td>
<td>280</td>
<td>2.8</td>
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<tr>
<td>'13</td>
<td>260</td>
<td>2.6</td>
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<tr>
<td>'14</td>
<td>240</td>
<td>2.4</td>
</tr>
<tr>
<td>'15</td>
<td>220</td>
<td>2.2</td>
</tr>
<tr>
<td>'16</td>
<td>200</td>
<td>2.0</td>
</tr>
</tbody>
</table>

(Forecast)
Frontier & Platform Research: Strengthening digital solutions research

Research target

- **Sponsored research**
  - <BU funding>
- **Adv. sponsored research**
  - <BU funding>

Business roadmap [Led by BU]

- Current business
- Next gen. business

Technology roadmap [Led by R&D Group]

- Co-creation/ Technology platform enhancement/ New business creation

Portfolio

- Frontier & Platform Research
  - Sponsored research
  - Advanced sponsored research

% Change in digital solutions related research

- FY2015: 24%
- FY2016: 64%

*1: Roughly 20% of total Hitachi Gr. R&D expenditure
Contents

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5. Summary
2-1 Generating service business through co-creation

Co-creating digital solutions using IoT/Big Data/AI

Power/Energy
- Microgrid
- Wide-area grid stabilization
- Decision support system
- Wind turbine gen. system

Industry/Distribution/Water
- Value chain optimization
- Demand forecasting
- Predictive diagnostics
- Smart manufacturing/Logistics

Urban
- Physical security
- Human behavior/flow analysis
- Train management system
- Video surveillance

Finance/Public/Healthcare
- Digital network payment
- Hospital mgmt. reforms
- Integrated community care

JP: Japan  NA: Americas  EU: Europe  CN: China  AP: Asia-Pacific

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Derive business opportunities from *Kizashi* through joint workshops & validate with prototype

**Vision design**
- Analyze customer issues
- Discover business opportunities
- Create service ideas

**Monozukuri-related Kizashi**
- Increased *Monozukuri* close to market (locally produced & consumed *Monozukuri*)
- Increased quality from non-experts due to work support
- Change in supply chain structure due to design data circulation and 3D printer manufacturing
- Increased automation of supporting tasks due to AI
- Increased security risks

**Service prototyping**
- Work analysis/support by IoT
  - [Flow analysis]
  - [Movement analysis]

PoC with several customers
2-3 Smart logistics

Improve warehouse efficiency by automated guided vehicle & AI-based demand prediction

Automated guided vehicle | OT
---|---
Challenge: Decreasing availability of workers

Automated guided vehicle (AGV)

Racrew

AGV conveys shelf

Workers only pick items

Picking station

3x more efficient than only manual labor

AI-based demand prediction | IT
---|---
Challenge: Dynamic demand-based work orders

Warehouse cart allocation system

AI (Lumada)

Picking order

AI predicts demand, optimizes the order of carts & issues work orders

Item picking based on the issued orders

8% efficiency increase due to AI

OT: Operational Technology

* Hitachi AI Technology/H

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2-4 Next evolution in Industry & Distribution

Optimization across the total value chain

"Connecting" to create new value
Contents

1. Basic directions for 2018 Mid-term Management Plan
2. Creating service business by accelerating collaborative creation
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5. Summary
3-1 Challenges in the 4 Social Innovation Business areas

Contribute to Social Innovation Business by resolving challenges

- Large-scale projects (EPC business)
  - Raise total value
- System integration (SI business)
  - Raise profitability by rapid delivery of high quality systems
- Digitalized Social Innovation Business = Digital solution
  - Scalability by platforming
  - Expand share & profitability by IoT

- Base business
- Collaborative creation (Open)

- Driver of overall growth
- Driver business

- Independent (Closed)
- General (Scalable)

- Base business

EPC: Engineering, Procurement, Construction

Source: 18 May 2016 Hitachi Mid-term Management Plan
3-2 Technology platforms for business growth

(2) Large-scale projects (EPC business)
- Train/Maintenance/Traffic Management
- Proton beam therapy equip.
- System modernization

(3) System integration (SI business)

(4) Products (Products/Materials business)
- Lumada-based solutions
- Sensing
- Security
- Robotics
- Symbiotic-ADS
- IoT industrial products
  - ADAS
  - Wind turbine generation systems
  - High efficiency converters

EPC: Engineering, Procurement, Construction  ADAS: Advanced Driver Assistance System
3-3-1 (1) Digital solutions: Examples

Build-up multiple digital solutions on Lumada

- **Air-conditioning**
  - Predictive maintenance

- **Mining**
  - Event-based failure prediction

- **Power**
  - Smart grid controls

- **Healthcare**
  - Efficient hospital operation

IoT platform “Lumada”

- Solution core (Solution blueprint)
- Data analysis
- Security
- AI*

Core technology

- Customer OT system
- Customer IT system

- Data lake

OSS community

Partner’s IoT platforms

IT/OT partners

*Hitachi AI Technology/H

OSS: Open source software

OT: Operational Technology

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### 3-3-2 (1) Digital solutions: Core technology

**Strengthen technology forming the revenue stream in IoT**

<table>
<thead>
<tr>
<th>Sensing</th>
<th>Security</th>
</tr>
</thead>
<tbody>
<tr>
<td>Environmentally-powered sensing system</td>
<td>Control ramification of threats from the open market</td>
</tr>
<tr>
<td>Field test @ internal factory ['16/6]</td>
<td>Joint research with Keio University ['16/4]</td>
</tr>
</tbody>
</table>

**AI**

- Making current systems intelligent by connecting to AI
- Monitoring → Control

<table>
<thead>
<tr>
<th>IT/Facility</th>
<th>Hitachi AI Technology/H</th>
</tr>
</thead>
<tbody>
<tr>
<td>Data Mgmt./Tasks/ Human behavior</td>
<td>Generate hypothesis → Select indices</td>
</tr>
</tbody>
</table>

**Robotics**

- New human-symbiotic service robot EMIEW3
- Press conference, Collaborative creation activity ['16/4]
Raise total value of railways by transforming rolling stock, maintenance & operations

### Rolling stock / Maintenance

- **New orders received for**
  - U.K. Rolling stock/Maintenance for Abellio
  - U.K. Rolling stock/Maintenance for First Great Western
  - U.K. Rolling stock/Maintenance for TransPennine Express

- **Trains for First Great Western**
- **Trains for Abellio**
- **Trains for TransPennine Express**
- **Scalable carriage design**
- **Reliability-centered maintenance (RCM)**
  - Using IoT
  - Monitoring standard condition
  - Optimizing maintenance
  - Raising efficiency by RCM

### Traffic Management

- **New order received for UK ThamesLink TMS**
- **TMS for ThamesLink**
- **On-board signaling equip.**
- **Depot**
- **Energy efficient driving**
- **Efficient cars & crew operations**
- **Coordinated cooperation with the field through TMS**

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**RCM:** Reliability centered maintenance  
**TMS:** Traffic management system  
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3-5 (3) SI business: System modernization

Recover business spec from legacy system, enabling rapid delivery of new systems

**Before**

- Conventional system transfer
  - Specification document
  - Spec changes over time → Difficult to grasp actual spec

**Development**

- Incorrect spec
  - Missing necessary functions
  - Remaining unused functions
  - Rework (many hours)

**After**

- System transfer with this technology
  - Operation data
    - Operation log
    - Database
    - Program
  - Automatic spec recovery
    - Log structure analysis
    - Program analysis
    - Data expression clustering
    - → 60% reduction in spec survey hours
  - Correct spec
  - Reduced development time

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3-6-1 (4) Product business: IoT compatible industrial products

Visualization of operation status & optimization of maintenance by IoT of facility equipment

System configuration

Customer

Internet

Hitachi private cloud

Dedicated line

Mobile VPN

Operation status alarm

Operation data

Wireless carrier terminal

<table>
<thead>
<tr>
<th>Exterior</th>
<th>Product</th>
<th>Comm.</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Ubicube-GW</td>
<td>3G</td>
</tr>
<tr>
<td></td>
<td>CPTTrans series</td>
<td>LTE</td>
</tr>
</tbody>
</table>

Product example

Controller integrated permanent magnet motor
Use case in Hitachi HE pump*

Sensor embedded IoT compatible products

VPN: Virtual private network

*Fresh water on the ground construction pump (Hitachi Industrial Equipment Systems Co., Ltd.)

In field-trial ['15/11~ ]
### 3-6-2 (4) Product business: ADAS

Automated driving by integration with infrastructure, environmental sensing and vehicular control

#### 360 degrees sensing technology
- 4 monocular cameras
- Stereo camera
- 4 radars

#### ADAS
- **Integration with infrastructure**
- **Environment sensing**
- **Vehicle control**

Automated driving on highways/urban roads

**Recognition**

<table>
<thead>
<tr>
<th>Highway</th>
<th>Road</th>
</tr>
</thead>
<tbody>
<tr>
<td>Signs</td>
<td>Lights</td>
</tr>
<tr>
<td>Vehicles</td>
<td>Bicycles</td>
</tr>
<tr>
<td>Lanes</td>
<td>Pedestrians</td>
</tr>
</tbody>
</table>

**Decision**

<table>
<thead>
<tr>
<th>Highway</th>
<th>Road</th>
</tr>
</thead>
<tbody>
<tr>
<td>Integrate information</td>
<td>Prediction</td>
</tr>
</tbody>
</table>

**Operation**

<table>
<thead>
<tr>
<th>Highway</th>
<th>Road</th>
</tr>
</thead>
<tbody>
<tr>
<td>Safe driving</td>
<td>Safe + Practical driving</td>
</tr>
</tbody>
</table>

Begin public road tests ['16/2]

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ADAS: Advanced Driver Assistance System

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Contents

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2. Creating service business by accelerating collaborative creation
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5. Summary
4-1 Challenging future societal issues

Cabinet Office of Japan
5th Science and Technology Basic Plan

Super Smart Society
Society 5.0

Incubating for a Super Smart Society

<table>
<thead>
<tr>
<th>Information sciences</th>
<th>Physical sciences</th>
<th>Life sciences</th>
<th>Frontier</th>
</tr>
</thead>
<tbody>
<tr>
<td>Advanced road traffic systems</td>
<td>Energy value chains</td>
<td>New manufacturing systems</td>
<td>Integrated community care system</td>
</tr>
<tr>
<td>Smart food chain systems</td>
<td>Smart production systems</td>
<td>Integrated materials development system</td>
<td>Infrastructure maintenance &amp; renewal</td>
</tr>
<tr>
<td>Global environment information platform</td>
<td>Hospitality systems</td>
<td>Resilience against natural disasters</td>
<td></td>
</tr>
</tbody>
</table>

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# 4-2 Research topics

## Build-up collaboration networks for rapid incubation

<table>
<thead>
<tr>
<th>Life sciences</th>
<th>Regenerative medicine</th>
<th>Info. sciences</th>
<th>New-paradigm computing</th>
</tr>
</thead>
<tbody>
<tr>
<td>Low-cost cell production for proliferation of regenerative medicine(^*1)</td>
<td>Automated cell culturing</td>
<td>Quality check</td>
<td>Optimization of complex society systems</td>
</tr>
<tr>
<td>iPS cell</td>
<td></td>
<td></td>
<td>Solving combinatorial optimization problems in real-time with lower power (1/1000)</td>
</tr>
<tr>
<td>Partner: Kyoto University, Sumitomo Dainippon Pharma</td>
<td></td>
<td></td>
<td>Optimization of society systems</td>
</tr>
</tbody>
</table>

## Life sciences | Breath-alcohol detection | Info. sciences | Logical dialogue AI |
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Portable prototype for vehicle smart key</td>
<td></td>
<td></td>
<td>AI to support management decisions</td>
</tr>
<tr>
<td>• Reacts only to human breath; tamper resistant</td>
<td></td>
<td></td>
<td>Decision-supporting AI</td>
</tr>
<tr>
<td>• Ignition interlock to prevent drink-driving</td>
<td></td>
<td></td>
<td>Logical dialogue</td>
</tr>
<tr>
<td>Partner: Honda R&amp;D Co.</td>
<td></td>
<td></td>
<td>Text big data</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>World affairs/ Industry news…</td>
</tr>
</tbody>
</table>

*1: This research is partially supported by the Japan Agency for Medical Research and Development, AMED.
An comprehensive approach beyond the confines of industry-academia-govt., country or region will become indispensable.

- Intelligence
- Academia
- Cutting-edge technology development
- Fostering of human resources
- Fusion of Arts & Science
- Systemization of knowledge
- Regulatory reform
- Forums for discussion

Industry-Academia-Govt. collaboration to share a vision or ideal for society.
Joint research sites @ 3 universities in Japan to realize a Super Smart Society (Society 5.0)

**Hitachi The University of Tokyo Lab ['16/6]**
Drafting national vision
Create a vision for government policy based on accumulated knowledge from government & society, propose policy/conduct joint research

**Hitachi Hokkaido University Lab ['16/6]**
Solution for emerging regional challenges
Leverage regional attribute of scale representation of Japan to explore society issues and lead solution PoCs

**Hitachi Kyoto University Lab ['16/6]**
Explore future society issues
Explore future society issues up to 2050 on the basis of regional tradition and culture amassed through a history over 1,000 years

13th Commendations for persons of distinguished achievement in Industry-Academia-Government collaborations - Connecting Innovation Grand Prize – Prize of the Minister of Education, Culture, Sports, Science and Technology
For the development and proliferation of “4D tumor tracking proton beam therapy system” (Joint research with Hokkaido University)
4-4-2 Open Innovation: Outside Japan

- **Basic research**
  - University of Cambridge (UK)

- **Railway**
  - University of Birmingham (UK)

- **Healthcare**
  - Bispebjerg and Frederiksberg Univ. Hospital (Denmark)

- **Industry**
  - acatech (Germany)

- **Automotive**
  - Stanford University (USA)

- **Resources**
  - EERC (USA)

- **Telecomm.**
  - Indian Institute of Technology (India)
  - Universiti Teknologi Petronas (Malaysia)

- **Energy**
  - Universiti Teknologi Petronas (Malaysia)
  - Shanghai Jiao Tong University (China)

- **Materials**
  - Shanghai Jiao Tong University (China)

- **IT**
  - Tsinghua University (China)

- **Automotive**
  - University of Michigan MTC (USA)

- **New markets**
  - University of Campinas (Brazil)

EERC: Energy and Environment Research Center  
MTC: Mobility Transformation Center
Contents

1. Basic directions for 2018 Mid-term Management Plan
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To become “An Innovation Partner for the IoT Era”

- Create service business by accelerating collaborative creation
- Build-up technology platforms for Service & Product business growth
- Challenge future social issues through open innovation
THE FUTURE IS OPEN TO SUGGESTIONS

Hitachi Social Innovation

Delivering new value to society through collaborative creation with our customers and partners
2016 R&D Strategy
To become “An Innovation Partner for the IoT Era”

2016/6/28

Norihiro Suzuki, Ph.D.
Vice President & Executive Officer
Chief Technology Officer
General Manager, R&D Group, Hitachi, Ltd.
HITACHI
Inspire the Next