Toray’s Business Strategy for Carbon Fiber Composite Materials

September 21, 2012
Toray Industries, Inc.
Senior Vice President
Moriyuki Onishi

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Business Categories and Strategies

**Foundation Businesses**
- Fibers & Textiles
- Plastics & Chemicals
  - Expand businesses in growth business fields and regions and steadily increase revenues and profits
  - Improve products and business models to expand earnings and allocate management resources to growth business fields

  Steadily drive business expansion and profit growth of the Group

**Strategically Expanding Businesses**
- IT-related Products
- Carbon Fiber Composite Materials
  - Focus on growth business fields including information-telecommunication, automobiles and aircraft, and energy saving and new energy
  - Allocate management resources with priority
  - Implement measures including M&A and business alliance

  Drive revenue and profit growth over the medium- and long-term and achieve strategic and aggressive business expansion

**Intensively Developing and Expanding Businesses**
- Environment & Engineering
- Life Science
  - Allocate management resources with priority
  - Develop and expand businesses by measures including M&A and business alliance

  Develop as the next driver for revenue and profit growth to follow IT-related products and carbon fiber composite materials
Three themes in AP-G 2013 that would work more effectively when practiced on a group basis are implemented as a group-wide project.

**Green Innovation Business Expansion (GR) Project**
Toray Group will use its strength in chemistry to develop “Green Innovation Businesses” on a global scale to provide solutions to the environmental issues and energy and resource issues, towards the independence from petroleum resources and the realization of a low-carbon society.

**Asia and Emerging Country Business Expansion (AE) Project**
Toray Group will seek to aggressively develop and expand businesses in Asia and emerging countries in other regions that are expected to realize major economic growth.

**Total Cost Reduction (TC-II) Project**
Toray Group will continue cost reduction initiatives to reinforce the robust business footing required to achieve its objective of becoming a corporate group that continually increases revenues and profits.
Position of Carbon Fiber Composite Materials Business under GR Project

Aim for substantial expansion as a core business of Green Innovation

**Energy Saving**
- Weight saving
  - Boeing
  - Airbus
  - Daimler AG

**New Energy**
- Alternative fuel
  - Natural gas tank (© Lincoln Composites)
  - Hydrogen gas tank (© Toyota Motor)
- Battery-charging flywheel
  - Electric cable core
  - Large wind-power blade

**Efficiency enhancement**
- ©Areva Wind
- ©Beacon Power
- ©CTC
- ©Hexagon
- ©Luxfer
- ©Lincoln Composites

© Daimler AG
© Airbus
© Boeing
© Airbus
© Boeing
© Airbus
© Boeing
© Airbus
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© Boeing
© Airbus
<Effect of CO₂ Reduction by Toray>
Year 2007 16 million tons/year  Around Year 2020 200 million tons/year
Usage of carbon fiber will contribute substantially to the reduction of CO₂ emissions over the total life cycle.

**Automobile**

- **CFRP for 17% of auto weight**
- Lightens auto weight by 30%
- **Conventional model**: 1,380 kg
- **CFRP model**: 970 kg
- **Volume of CO₂ emissions from the production of CFRP**: ▲ 20 tons
- **Life cycle CO₂ reduction**: * 50 tons
- **Light weight**: ↓ Improvement of fuel efficiency

**Aircraft**

- **CFRP for 50% of total structural elements**
- Lightens 20% by weight of structural elements
- **B767 conventional aircraft**: 60 tons
- **B767 CFRP Aircraft**: 48 tons
- **Volume of CO₂ emissions from the production of CFRP**: ▲ 1,400 tons
- **Life cycle CO₂ reduction**: * 1,400 tons

Usage of carbon fiber will contribute substantially to the reduction of CO₂ emissions over the total life cycle.

- **Consolidated Net Sales**
  - FY 2011 Actual
  - FY 2013 Target
  - Around FY 2015 Image

- **Consolidated Operating Income**
  - FY 2011 Actual
  - FY 2013 Target
  - Around FY 2015 Image
Business Environment and Market Structure
Carbon Fiber Market Revolution

(Ktons/year)

150
100
50
0


Industrial Application
Aerospace Application
Sporting Goods Application

Start of Manufacture of Torayca
Artificial Satellite
Tennis Racket and Carbon Golf Shaft Boom
Selected for primary structure of Airbus A320
Selected for primary structure of Boeing 777
Full-scale expansion in Industrial application
Full-scale expansion in Aerospace application
Full-scale expansion in a automobile application

© JAXA
© Airbus © Boeing © Luxfer © Daimler AG © Airbus © Boeing © Areva Wind/Jan Oelker © CTC
Global Demand Forecast

- **Total Market**: 16%
  - **Industrial**: 18%
  - **Sporting Goods**: 7%
  - **Aerospace**: 12%

Yearly forecast from 2007 to 2020:

- 2007: 32 Ktons/year
- 2008: 31 Ktons/year
- 2009: 24 Ktons/year
- 2010: 33 Ktons/year
- 2011: 37 Ktons/year
- 2012: 41 Ktons/year
- 2013: 48 Ktons/year
- 2015: 70 Ktons/year
- 2020: 140 Ktons/year
Carbon Fiber Demand by Application & Area

Total Global Demand 37Ktons/year

(in 2011: estimated by Toray)

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Examples of Application -Aerospace-

**Boeing 777**
Primary / Secondary structure
CFRP usage: Approx. 10 ton

**Boeing 787**
Primary / Secondary structure
CFRP usage: Approx. 35 ton

**Satellite**

**Airbus A320**
Primary / Secondary structure
CFRP usage: Approx. 2 ton

**Airbus A380**
Primary / Secondary structure
CFRP usage: Approx. 35 ton

**Rocket**

© Boeing
© JAXA
© Airbus
© JAXA
Examples of Application
-Environment and Energy-related -

Wind power blade
Tube trailer tank
Battery-charging flywheel

Tidal power blade
Electric cable core

Fuel cell
Examples of Application
- Automobile -

- Hood
- Toray concept EV TEEWAVE® AR1
- Roof
- Compressed natural gas tank
- CFRP body panel for bus
- Propeller shaft
Examples of Application
- Industrial Use -

- X-ray top panel
  © Toshiba Medical Systems

- Body for high-speed train
  © Hankuk Fiber

- Robot hand for liquid crystal panel
  © Yaskawa Electric

- PC housing
  © Sony

- Bridge pier reinforcement
Example of Application
- Sporting Goods -

- Fishing rod
- Bicycle
- Hockey stick

- Racket
- Golf shaft
- Softball bat

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Current Status of Toray
Progress of the Basic Strategies set up at the Last IR Seminar (April, 2008)

Maintain and strengthen overwhelming competitive advantages in aircraft application

- Started production lines for Boeing 787
  - US: precursor / carbon fiber / prepreg one line each
  - Japan: precursor / carbon fiber one line each

- Signed a long-term basic supply agreement with Airbus (May, 2010)

- Started production of the tail wing parts of MRJ (Mitsubishi Regional Jet)

Develop advanced technologies for automotive market expansion

- Expanded the A&A Center in Nagoya
  - Opened the Automotive Center (AMC) (June, 2008)
  - Opened the Advanced Composite Center (ACC) (April 2009)

- Acquired 21% shares of ACE Advanced Composite Engineering (ACE) in Germany (December, 2008)

- Established a joint venture Euro Advanced Carbon Fiber Composites GmbH (EACC) with Daimler AG in Germany to produce and sell CFRP automotive parts (June, 2011)
Progress of the Basic Strategies set up at the Last IR Seminar (April, 2008)

Improve competitiveness in quality and cost through enhancement of technical capabilities

- Developed A-VaRTM (Advanced-Vacuum assisted Resin Transfer Molding) technology and adopted it to mass production - Tail wing Parts for MRJ
- Developed High-cycle RTM (Resin Transfer Molding) technology and adopted it to mass production - Established EACC
- Expanded technical centers worldwide
  - enhanced technical centers in Europe and the US
  - established Advanced Composite Materials Technical Center at Toray Advanced Materials Korea in the Republic of Korea
  - set up development and technical service function related to composites at Toray Advanced Materials Research Laboratories (China)

Continuously expand production capacity worldwide

Enhance competitiveness and business scale in industrial market

- Commence full-scale production of carbon fibers in the Republic of Korea (scheduled in January 2013 / 2,200 tons)
- Increase worldwide production capacity at four production bases (Japan, US, France and the Republic of Korea)
  - Japan: precursor / carbon fiber one line each
  - USA & Republic of Korea: carbon fiber one line each
  - France: precursor one line
Worldwide Carbon Fiber Production Capacity Increase at 4 Production Bases

Released on Mar.9, 2012

- At Ehime Plant, build an integrated production facility of precursor and high-performance fine carbon fiber, mainly used in aircrafts and luxury automobiles
- At three overseas bases, bolster production facilities for high strength and standard modulus fiber, which has become the de-facto standard for industrial and sporting goods applications, to ensure stable supply to those markets / Establish the first precursor production line in Europe
Carbon Fiber Production Capacity (Sep. 2012 → Mar. 2015) (tons)

<table>
<thead>
<tr>
<th>Toray Carbon Fibers Europe (CFE) (France)</th>
<th>Toray Advanced Materials Korea (TAK) (Republic of Korea)</th>
<th>Toray Carbon Fibers America (CFA) (USA)</th>
<th>Group Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>5,200</td>
<td>7,300 9,300</td>
<td>5,400 7,900</td>
<td>17,900 27,100</td>
</tr>
</tbody>
</table>
Business Strategy
Strength of Toray’s Carbon Fiber Composite Materials Business

Vertically-integrated business model from precursor to composites materials
- Maximize product competitiveness by technological capabilities of precursor and carbonization
- Comprehend market evolution and customer demand

“Global operation” among 4 production bases to efficiently enhance business competitiveness
- Tight relationship with customers
- Strong Business structure, less effected by exchange rate fluctuation

Strong capability of market creation supported by integrated technological advantages
- Technical capability to satisfy advanced technical requirement from aircraft manufacturers
- Development of high quality and competitive intermediate materials
- Development of competitive molding process technology

Commitment to market with continuous investment to R&D and production capacity increase
- Investment of capital resource based on long perspective
Basic strategy of Carbon Fiber Composite Materials Business

Promote business expansion by **globally strengthening production, marketing, technical services and R&D**

Maintain and strengthen **overwhelming world’s No.1 position in aerospace application and high-performance industrial and sporting goods applications** by **high quality** of Torayca carbon fiber.

Expand middle / down stream business by strengthening R&D forces and establishing supply chain through proactive alliance in intermediate products such as prepreg / fabric and in advanced composite processing field.

Accelerate developing new application / market by **further increasing production capacity of cost competitive carbon fiber for commodity industrial applications.**
Basic strategy of Carbon Fiber Composite Materials Business

1. Business strategy by application
   (1) Maintain and strengthen overwhelming competitive advantages in aerospace application
   (2) Expand business in strategically selected industrial applications
   (3) Promote technical development and market exploitation in automotive industry
   (4) Stably expand business in high-performance sporting goods application

2. Expand advanced composites business

3. Enhance stable supply-ability by continuous capital investment to increase production capacity

4. Enhance global R&D forces

5. Develop market in emerging countries

6. Establish carbon fiber recycling system
Strategy of Carbon Fiber Composite Materials Business

Aerospace Application

✔ Maintain and strengthen overwhelming competitive advantages in aerospace application

;line: Aggressively sign in to programs of two major aircraft manufacturers and expand supply to them

✈ Boeing

- Secure stable supply to increasing build rate of Boeing 787
- Secure stable supply to increasing build rate of existing models such as Boeing 777 and 737
- Develop and supply new materials for next generation model

✈ Airbus

- Realize supply of prepreg based on Long-term Basic Supply Agreement concluded May 2010
  - Develop and get qualified new high performance prepreg
  - Establish production base of prepreg in Europe (integrated supply chain in Europe)
- Secure stable supply to existing models such as A320, A380, A330
Strategy of Carbon Fiber Composite Materials Business
Aerospace Application

- Develop new market and new application
  - Regional & Business Jet
    - Supply tail wing parts for MRJ
    - Enter the programs of small-mid size aircraft in emerging countries
  - Engine parts
    - Proceed with development of engine made of CFRP with major engine manufactures (CFRP Carbon Fiber Reinforced Plastics)

- Maintain overwhelming top share in space application
  - Space industry
    - Continuously expand production capacity of high-performance grades such as high modulus carbon fiber
History of Aircraft Materials

Early 1900s
- Ornithopter (Leonardo da Vinci)
  Wood/Canvas
- Wright Flyer 1
  Wood/Steel/Canvas

1930s
- Boeing 247
  1st aluminum structure

1950s
- Comet
  1st aluminum jetliner

1980 to 1990s
- Boeing 777, Airbus A320
  CFRP Primary structure

The present
- Boeing 787
  "CFRP" Aircraft

(CFRP  Carbon Fiber Reinforced Plastics)
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Agreement of long-term Supply of Carbon Fiber Composite Materials for Boeing 787

Concluded a comprehensive agreement with Boeing Co. to supply carbon fiber composite materials for Boeing 787 medium-sized aircraft over a long-term period of 16 years (including 5 years available option).

Toray supplies carbon fiber Uni-Directional Prepreg* used for the main wing and tail wing of Boeing 787 as well as carbon fiber cloth prepreg used for the fuselage.

*1 Uni-Directional Prepreg; Disposition carbon fiber in one direction and combine with epoxy resin to foam sheet

Max. 80% of fastener reduction by one piece molding of carbon fiber cloth prepreg for fuselage

20 to 30% of weight reduction for large sized main wing
Advantages of CFRP applied to Aircrafts

- Weight Reduction - Improved Fuel Efficiency
- High Durability - Maintenance Cost Reduction
- High Strength - Higher Cabin Pressure
- High Strength - Larger Window
- Corrosion Resistant - More Cabin Humidity
CFRP Applications on Boeing 787

<table>
<thead>
<tr>
<th>Part</th>
<th>Boeing 767</th>
<th>Boeing 787</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fuselage</td>
<td>Aluminum</td>
<td>Composite</td>
</tr>
<tr>
<td>Main Wing</td>
<td>Aluminum</td>
<td>Composite</td>
</tr>
<tr>
<td>Tail Wing</td>
<td>Aluminum</td>
<td>Composite</td>
</tr>
<tr>
<td>Flap</td>
<td>Composite</td>
<td>Composite</td>
</tr>
</tbody>
</table>

Boeing 787

- Composite 50%
- Aluminum 20%
- Titanium 15%
- Steel 10%
- Other 5%

Boeing 767

- Composite 3%
- Aluminum 77%
- Titanium 6%
- Steel 10%

© Boeing
Development of Empennage Material for MRJ

- **Full-scale vertical stabilizer parts for MRJ**
  (co-development with Mitsubishi Heavy Industries)

- **A-VaRTM molding**
  - Low-cost, energy-saving molding technology
  - Realization of complex-shapes including multilayer difference
  - Dimension accuracy equivalent to prepreg
  - Stable control of Vf (fiber content)

- **Spar**
- **Stringer/co-bond panel**
- **Rib**
Strategy of Carbon Fiber Composite Materials Business
Industrial Application

✓ Expand business in strategically selected industrial applications

Establish overwhelming advantages in environment/energy-related applications requiring high-performance

Pressure Vessel ➞ Maintain world No.1 share

- Respond to the demand associated with the use of shale gas in US
- Enter natural gas programs in emerging countries collaborating with leading manufacturers of pressure vessels
- Develop high-performance carbon fiber for compressed hydrogen gas tanks installed in fuel-cell vehicles

liner (aluminum or plastic)

CFRP reinforced section

deflection control
burst protection
high modulus
high strength

Weight of Hydrogen gas tank

Designed pressure: 160MPa
Working pressure: 70MPa

- Toray newly developed product
- Regular carbon fiber
- Glass fiber

20% light-weight
55% light-weight

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### Strategy of Carbon Fiber Composite Materials Business

#### Industrial Application

##### Electrical Cable Core

- Make Torayca de facto standard
  - Secure power transmission demand from wind-power / photovoltaic stations located in remote areas
  - Approach infrastructure construction projects in China and emerging countries

  ![Cable core (aluminum)](image)

- Steel core
- CFRP core

- Low thermal expansion coefficients
- High strength

- Suspensory control
- Increase of distance between towers
- Improvement of electric transmission efficiency
- Increase of electric transmission capacity

##### Nuclear Power Generation (Uranium Centrifuge)

- Stably supply of high-performance products

- Capture uranium enrichment plant programs in Europe and US

##### Offshore Oilfield Drilling

- Pioneer of the development

- Promote joint development programs with major oil companies
Strategy of Carbon Fiber Composite Materials Business

Industrial Application

✓ Expand business in strategically selected industrial application

Strategically expand commodity industrial application through the establishment of a competitive supply chain

Wind Power Blade

⇒ Selectively enter programs, focusing on profitability

⇒ Selectively capture programs under the strategy to maximize added-value through supply chain

Civil Engineering ⇒ Expand sales in overseas market

⇒ Expand sales corresponding to the demand increase in infrastructure construction projects in China and emerging countries

⇒ Further strengthen cost competitiveness through local production of fabric

Plastics Compounds

⇒ Expand sales utilizing Group collective strength

⇒ Expand sales of compound products by Plastics Division / reserve added value within Toray Group
Strategy of Carbon Fiber Composite Materials Business

Automotive Application

✓ Proceed technical development and market exploitation in automotive industry

Realize further adoption in automotive parts

Automotive Outer Panel / Structural parts

- Reinforce High-cycle RTM technology (further cycle time reduction)
- Develop and promote thermoplastic intermediate materials having better recycling property
- Develop competitive CFRP automotive parts through industry-government-academia collaboration

Fuel-Cell Vehicles

- Co-develop fuel-cell electrode substrate (carbon paper / GDL)
- Develop and promote Toray carbon fiber as de facto standard for compressed hydrogen gas tanks (GDL Gas Diffusion Layer)

Proactively promote business alliances

- Enhance R&D capabilities, especially automotive parts designing
- Secure sales channel and establish robust supply chain
- Proactively promote “Molding technology license / Material supply” business model
# Increase in Adaption of Carbon Fiber for Automobiles

<table>
<thead>
<tr>
<th>Decade</th>
<th>Examples</th>
</tr>
</thead>
<tbody>
<tr>
<td>1980's</td>
<td>F1 machine parts</td>
</tr>
<tr>
<td>1990's</td>
<td>Mitsubishi PAJERO: Propeller shaft, Nissan SKYLINE GT-R: Engine hood</td>
</tr>
<tr>
<td>2000's</td>
<td>Nissan SKYLINE: Radiator core support</td>
</tr>
<tr>
<td>2010's</td>
<td>LEXUS LFA: Chassis, roof, other parts, Subaru WRX STI: Roof, Mercedes-Benz SL AMG: Trunk lid</td>
</tr>
</tbody>
</table>

## CFRP Effectiveness

- Weight reduction (fuel efficiency improvement)
- Crash safety improvement
- Assembly man-hours reduction through modularization

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Establishment of a Join Venture with Daimler AG in Germany

Realized mass production of CFRP automotive parts utilizing High-cycle RTM technology

1. Company Name: Euro Advanced Carbon Fiber Composites GmbH
2. Location: Esslingen, Germany
3. Investment ratio:
   - Toray 50.1%
   - Daimler 44.9%
   - ACE Advanced Composite Engineering 5.0%
4. Establishment: June, 2011
5. Start operation: October, 2012 (scheduled)
**TEEWAVE® AR1** 
Next-Generation Concept EV

**TEEWAVE® AR1** is the flagship vehicle that embodies Toray Group's green innovation strategy in the automotive field, offering concepts tailored for the automotive industry, the users and the environment.

<table>
<thead>
<tr>
<th>Item</th>
<th>TEEWAVE® AR1 (two-seater open car)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Body size (mm)</td>
<td>3,977 x 1,766 x 1,154</td>
</tr>
<tr>
<td>Weight (kg)</td>
<td>846</td>
</tr>
<tr>
<td>(of which the weight of battery)</td>
<td>(220)</td>
</tr>
<tr>
<td>Number of passengers</td>
<td>2</td>
</tr>
<tr>
<td>Maximum power (kW/rpm)</td>
<td>47/3,000 to 6,000</td>
</tr>
<tr>
<td>Maximum torque (Nm/rpm)</td>
<td>180/0 to 2,000</td>
</tr>
<tr>
<td>Electricity consumption rate (km/kWh)</td>
<td>11.6</td>
</tr>
<tr>
<td>Range (Japan 10-15 mode cycle, km)</td>
<td>185</td>
</tr>
<tr>
<td>Maximum speed (km/h)</td>
<td>147</td>
</tr>
<tr>
<td>Acceleration 0-100km/h (sec)</td>
<td>11.0</td>
</tr>
</tbody>
</table>

Toray used Gordon Murray Design Ltd. of the U.K. (CEO: Gordon Murray, former F1 designer) for the vehicle's body and structural design as well as manufacture.
Forecast of World’s Automobile Production and Carbon Fiber Market

World’s production around 2020:
Approx. 100 million units

Mass production car
Approx. 95 million units

Luxury model
5 million units

Super-luxury model
500,000 units

Supercar
5,000 units

World’s production around 2020:
Approx. 100 million units

Thermosetting plastics CFRP
Thermoplastics CFRP

Stampable Sheet
UD tape
Market Forecast of Fuel-Cell Vehicles

- Toward “first year on the market of fuel-cell vehicles” in 2015, automobile manufacturers worldwide are accelerating their development of Fuel-Cell Vehicles.
- National governments have announced support for infrastructure construction toward the spread of Fuel-Cell Vehicles. For example, the Japanese government has decided to support the private sector with such plans as to install 100 hydrogen gas stations mainly in the 4 metropolitan areas by 2015 in association with the revision in the High Pressure Gas Control Act and the Fire Service Act.

Forecast of Fuel-Cell Vehicle Production

(Source: Pike Research)
Maintain overwhelming competitive advantages in the market required high-performance through continuous development of new products

Further expand sales to bicycle application which has become the mainstay of sporting goods application

Proceed the co-design and co-development with leading brand name manufacturers of golf shaft and fishing rods

Expand sales to new applications such as hockey sticks and softball bats

Strengthen cost competitiveness of commodity products

Establish competitive supply chain through collaboration with leading intermediate material manufacturers
Sales Expansion in Sporting Goods Application with Branding Strategy

Appeal high-performance and high-value added advantage to end-consumers through combination of product brand and technology brand

Product brand

Technology brand

A specific technology that realizes alloy structure of a number of polymers on a nanometer order. Toray holds the basic patent as well as major patent for production and application.

This is a technology that offers high-performance and high-functional properties to polymer materials which could not have been realized with general micron order alloy.

Balance between Rigidity and Flexibility

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Target and Role of Advanced Composites Business

Market Creation

Development of composite products business
- IT-related devices
  - PC housing
  - Smartphone housing
- Medical devices
  - CT cradle, etc.
  - X-ray cassette

Development of carbon fiber / intermediate material market
- Automobile / Aircraft parts
  - Toray composite products business
  - Capital participation
  - Technology Licensing

Development of innovative materials and molding technologies complying with market requirements

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Expansion of Advanced Composites Business

Develop and market composite products through the combination between quality competitiveness of carbon fibers / intermediate materials and outstanding molding technology

- Hybrid molding ➔ IT device housing
- High-cycle RTM ➔ Automotive outer panel / structural parts
- A-VaRTM ➔ Complex-shaped aircraft structural parts

Hybrid molding

CFRP molded panel

CFRTP(*1) or GFRTP (*2) outsert injection molding

*1 CFRTP Carbon Fiber Reinforced Thermoplastics
*2 GFRTP Glass Fiber Reinforced Thermoplastics

![Graph showing specific gravity and modulus comparison]

Lightweight ➔ High rigidity

Specific gravity

plode (GPa)
Establish competitive production supply chain in low cost countries.

- Respond to the relocation of IT/medical devices production base to China and Southeast Asia.
- Expand production bases (subcontractors).

Establish integrated supply chain just in front of the market.

- Collaborate with end-customers including parts designing.

Collaborate with end-customers including parts designing.
Toray’s Global Management Principle

- Conduct cutting-edge research and development and develop advanced materials and innovative processes at mother factories in Japan
- Leverage global production sites (in and outside Japan) to maximize business expansion and manufacture in optimal locations
- Reinvest profits in further research and development (in Japan: advanced materials / outside Japan: development of product applications)

Sustainable growth

Further bolster business expansion and cost competitiveness

Base sites outside Japan
- Development of product applications to meet local needs
- Localize production to manufacture products close to source of demand and enhance cost competitiveness

Reinvestment in research and development

Mother factories in Japan
- Development of advanced materials
- Creation of high value-added products
- Development of innovative processes
- Thorough cost reductions
Expand Supply Capacity by Continuing Capital Investment

Increase capacity at world four production bases toward 2015

- Expand capacity of high-performance carbon fiber (Production start-up in 2015)
  - Expand production of high value added products as the global mother factory

- Expand capacity of standard grade carbon fiber for industrial applications (Production start-up in 2014)
  - Respond to expanding demand of environment and energy-related applications in USA

- Install first precursor production line in France (Production start-up in 2014)
  - Establish integrated structure of production from precursor to carbon fiber

- Install production facility of standard grade carbon fiber for industrial applications (2 lines) (Production start-up in 2013 and 2015)
  - Establish production site having cost competitiveness
# Grade Line-up by Production Base

<table>
<thead>
<tr>
<th>Line-up</th>
<th>Major Application</th>
<th>TORAY</th>
<th>CFA</th>
<th>CFE</th>
<th>TAK</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>High modulus fiber</strong></td>
<td>Satellite, Rocket, High-end sporting goods</td>
<td>◯</td>
<td></td>
<td>◯</td>
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<tr>
<td></td>
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</tr>
<tr>
<td><strong>Intermediate modulus fiber</strong></td>
<td>Aircraft primary structure, High-end sporting goods</td>
<td>◯</td>
<td>◯</td>
<td>◯</td>
<td>◯</td>
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<tr>
<td></td>
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</tr>
<tr>
<td><strong>Standard modulus fiber</strong></td>
<td>Aircraft secondary structure, Luxury car, Fuel cell parts</td>
<td>◯</td>
<td></td>
<td></td>
<td>◯</td>
</tr>
<tr>
<td>(fine fiber)</td>
<td></td>
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<td></td>
<td></td>
</tr>
<tr>
<td><strong>Standard modulus fiber</strong></td>
<td>General industry, Sporting goods</td>
<td>◯</td>
<td>◯</td>
<td>◯</td>
<td>◯</td>
</tr>
</tbody>
</table>

- Integrated production of precursor line and carbonization line
- Carbonization line only
Future Expansion Plan

Prepreg for Airbus

Standard grade carbon fiber for industrial applications

Ishikawa Plant
Prepreg

High-performance fine fiber

Ehime Plant

For Boeing’s new program

Standard grade carbon fiber for industrial application

Carbon Fiber Production Capacity

Prepreg Production Capacity

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R&D Strategy

Strength of Toray advanced composite materials technology

- Overwhelming development capabilities of carbon fibers and resins
- Integrated process engineering capability from polymers to composite products
- Global integration of R&D forces (close collaboration with Boeing, Airbus, Daimler, etc.)

R&D basic strategies

- Pursuit of ultimate performance of carbon fiber
- Improvement of performance of composite resins
- Development of innovative molding technology and proposal of solution
- Further reinforcement of Global R&D

![Diagram showing Toray's Strength in material, product, and process design with feedback to materials and processes.](image)

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Development of High Performance Carbon Fibers

- Achievement of compatibility between high strength and high modulus through innovative technology, which was not able to be realized with conventional technologies, by i) defect control, ii) improvement of fracture toughness, and iii) optimization of interface.

Strength improvement of carbon fibers

- Target Area
- Existing products
- T300
- T700
- T800
- MJ series

Defect size
- Nano
- Submicron
- Micron

Fiber defect control in nano-scale

Strength improvement of carbon fibers

- Tension
- Compression

Existing products

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Technology Development for improvement of composite performance

- Respond to market needs for high performance
  - NANOALLOY® resin
    - Compatibility between toughness and rigidity
    - Extension of applications
  - Functional particles
    - Improvement of damping characteristics
      - Vibration absorption for bike
      - Improvement on impact feeling of golf shaft
    - Improvement of conductivity
      - Improvement of lightning resistance
  - Resin modulus (rigidity)
  - Viscosity control
  - Conductive particle
    - High conductivity and impact resistance
  - Toughening particle
  - High conductivity and impact resistance

Target Area

- Conventional resins

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© PINARELLO
© Airbus

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Deepening of composite molding technology

- **Realize compatibility between high productivity and high performance**
  - High cycle molding technology with thermoset plastics
  - Realization of high modulus with thermoplastics
  - Technology verification by concept car TEEWAVE®AR1

Key performances of TEEWAVE®AR1 (comparison with the steel body)

- Vehicle weight: 846 kg (about 40% decrease)
- Mileage (1 charge): 185 km (about 30% improvement)
- Number of structural parts: 231 (about 40% decrease)

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**<CFRP (thermoset)>**

- Monocoque frame, Crash box, etc.
- High cycle RTM (10 minutes)

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**<CFRTP (thermoplastics)>**

- Roof, Hatch, etc.
- PP resin, Stamping molding (1 minute)

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RTM: Resin Transfer Molding

SMC: Sheet Molding Compound

Autoclave

Press molding

Injection molding [SMC, etc.]

Areas to aim at

Molding cycle (minute)
Global R&D Enhancement

- **Enhance world five R&D bases**
  - Mother R&D base of Toray group
    - (Technical Dept., Research Lab., A&A Center and E&E Center)
  - Product development and technical service base for North American market
    - (TCA Technical Center & Research Lab. / CFA Technical Center)
  - Product development and technical service base for European market
    - (Pan European Technical Center / ACE Advanced Composite Engineering)
  - Technical service base for Korean industrial markets
    - (TAK Advanced Composite Materials Technical Center)
  - Composite product development and technical service base for Chinese market
    - (TARC : Toray Advanced Materials Research Laboratories (China) Co., Ltd.)

- **Strengthen R&D forces for automotive application**
  - Enhance parts designing technology through alliance including M&A
  - Accelerate development by further enhancement of pilot plants
Global R&D Network

- **Design and development of CFRP automotive parts**
  - ACE

- **Development of industrial applications for Korean domestic market**
  - TAK

- **R&D of prepreg and resin system for aircraft application**
  - TCA

- **Cultivation of US industrial market and development carbon fibers suitable for industrial applications**
  - CFA

- **Development of industrial applications in Europe**
  - CFE

- **Development of composite products for Chinese domestic market**
  - TARC

- **Mother R&D base of Toray group**
  - Development of basic technologies
  - Development of advanced materials and value-added products
  - Development of advanced composite technologies
  - TORAY
R&D bases in Japan
(A&A Center & E&E Center)

A&A Center
(Automotive & Aircraft Center)

Plastics Application Technology Engineering Center (1989)

Automotive Center
(June, 2008)

Advanced Composite Center (April, 2009)

E&E Center
(Regarding & Energy Center)

Environment & Energy Development Center

Two Wings Driving Green Innovation

A&A Center

Automotive & Aircraft
- structural materials
- Panel / Interior
- Car electronics

Common fields

E&E Center

Environment & Energy

Environment & Energy Development Center

Li battery
Fuel Cell
Photovoltaic
Wind power
Biomass materials
Approach to Carbon Fiber Recycling

✔ Establish carbon fiber recycling system

■ Develop basic recycling technologies

  “Verification research of carbon fiber recycling technology”
  ➢ Establish basic technology to produce recycled fiber
    (chopped fiber and milled fiber)

■ Issues to establish recycling system

☒ Develop mass production technology
  (scrap materials separation and cost reduction)

☒ Cultivate recycled product markets / applications

Chopped fiber  Milled fiber

Recycling pilot plant (Omuta City, Fukuoka)
Business Plan
Business strategies (summary)

**Europe**
- Establish integrated supply structure from precursor, carbon fiber to prepreg
- Establish in-house supply chain to Airbus programs
- Strengthen business competitiveness in Europe
- Expand Pan European Technical Center
- Reinforce R&D facility for automotive application (ACE and Branch Lab. of Pan Europe Technical Center)

**Japan/Asia**
- Strengthen R&D forces of fundamental technologies and advanced materials, and expand production capacities of value-added products as the mother factory of Group
- Create domestic market of automotive application by industry, government, and academia collaboration
- Expand as core production base of standard grade carbon fiber for industrial and sporting goods applications
- Establish supply chain of intermediate materials and composite products

**Americas**
- Strengthen integrated supply structure for Boeing programs
- Enhance supply structure for environment and energy-related applications
- Develop supply chain of intermediate materials and composite products for automotive application

Central & Eastern Europe, Russia and MENA market development
India and ASEAN market development
Latin American market development
Future Business Scale (Vision)

**Net sales by product type**

- **Composites**
- **Intermediate Materials**
- **Carbon Fiber**

**Net Sales by application**

- **Industrial**
- **Sporting Goods**
- **Aerospace**

Unit: Billion ¥
Descriptions of predicted business results, projections and business plans contained in this material are based on assumptions and forecasts regarding the future business environment, made at the present time.

The material in this presentation is not a guarantee of the Company’s future business performance.
End of presentation

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