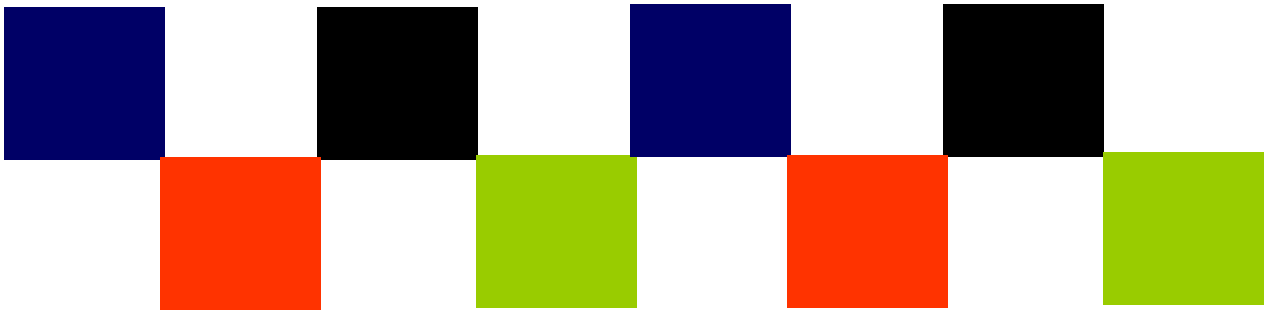
Toray's Strategy for Carbon Fiber Composite Materials

'TORAY'
Innovation by Chemistry

TORAYCA

April 11, 2008
Toray Industries, Inc.
Senior Vice President
Masayoshi Kamiura

Long-term Corporate Vision and Positioning of Carbon Fiber Composite Materials Business



Project Innovation TORAY 2010 (IT-2010)

Road map to IT-2010 and Targets in IT-2010

After achieved NT reforms, Toray Group launched Project "Innovation TORAY 2010 (IT-2010)" in October 2006 in order to challenge for further growth through Innovation.

April 2002 **April 2006**

Long-term Vision

AP-New TORAY 21 | **AP-Innovation TORAY 21**

Mid-term Business Strategies

NT21

「Corporate Structure Reinforcement defensive management postures」

- Breakaway from Crisis -

NT-Ⅱ

「Offensive management postures」

- Establish foundation for further growth -

Achievement of ¥100 billion in Operating Income

IT-2010

「Management based on Innovation」

- Challenges for further growth -

Toward a Global Top Company of Advanced Materials

Goals in and around 2010

Net sales ¥1,800 billion

Operating income ¥150 billion

Operating income to net sales ratio 8.3%

ROA:8%

ROE:11%

2002 April **2004 April** **2006 October** **Around 2010**

Basic Strategies (by Business Category)

Fibers & Textiles, Plastics / Chemicals

Foundation Businesses

① Developing global operations
② Promoting "New Value Creator"
③ Developing downstream and processing business
④ Expanding advanced materials (automobiles, environment/energy, etc.)

→ Establish stable profit base

→ Promote advancement of foundation businesses

IT-related Products, Carbon Fiber Composite Materials

Strategically Expanding Businesses

① Focusing on growing markets (IT, automobiles, aircrafts)
② Prioritizing allocation of managerial resources

→ Positive expansion as profit driving businesses

Life Science, Environment (water treatment)

Strategically Developing Businesses

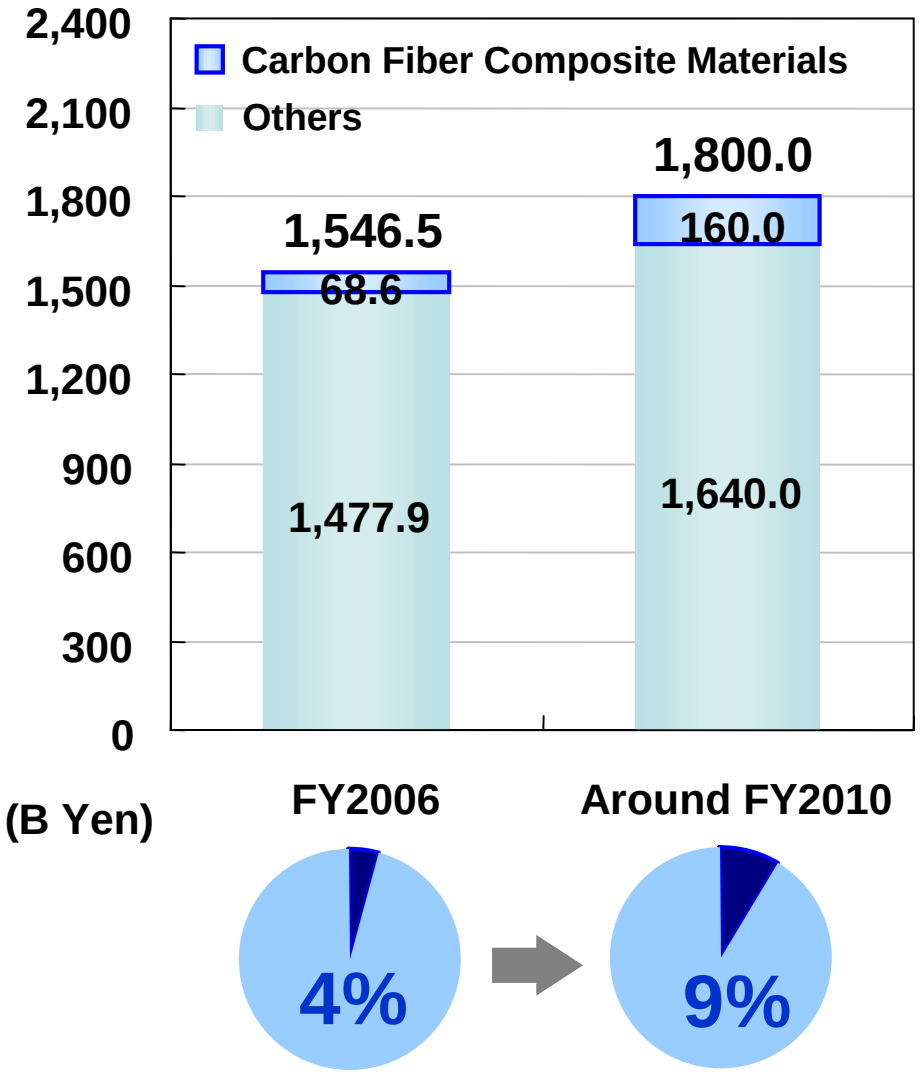
Nurturing the next profit base beyond 2010
① Intensive allocation of managerial resources
② M&A and strategic alliances with external parties

→ Strategically developing and expanding

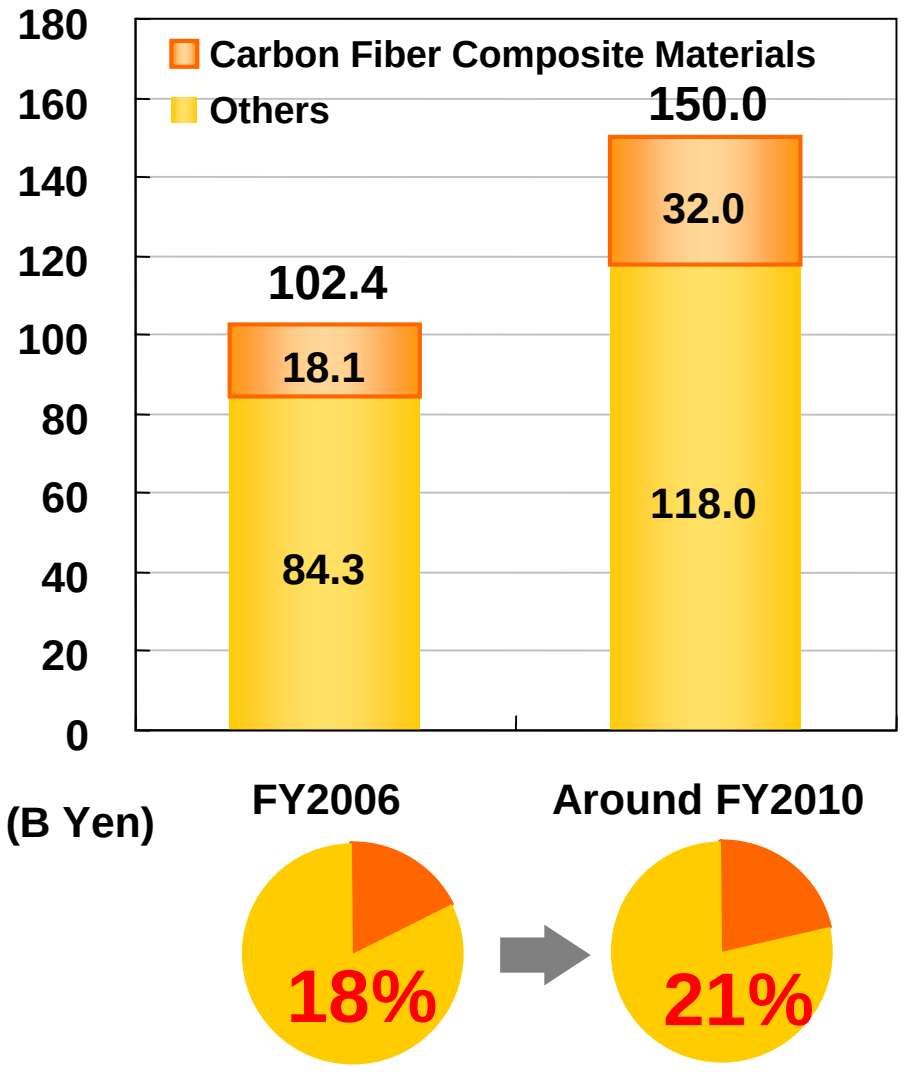
Sustainable Growth

Positioning of Carbon Fiber Composite Materials Business in IT-2010

Consolidated Net Sales

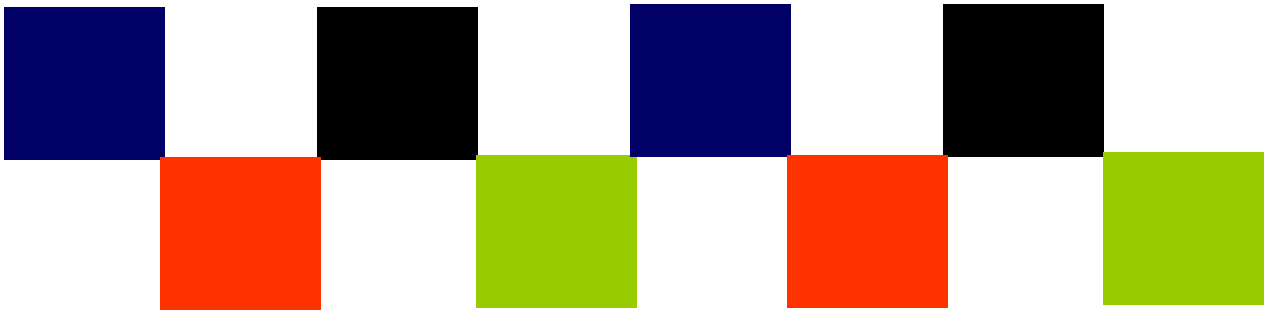


Consolidated Operating Income



Strategy for

Carbon Fiber Composite Materials



(1) Business environment and market structure

Business environment of Carbon Fibers

Global Warming

Strict exhaust gas regulations
high consciousness of energy saving

Inflation of oil prices

Improvement of fuel efficiency
Shift to alternative energy

Needs for High-performance Materials

Clean Energy

Energy Saving

Diversification of energy

Corrosion-resistance
High Modulus
Radiolucency
Electromagnetic Shielding, etc.

Wind Power

Natural Gas

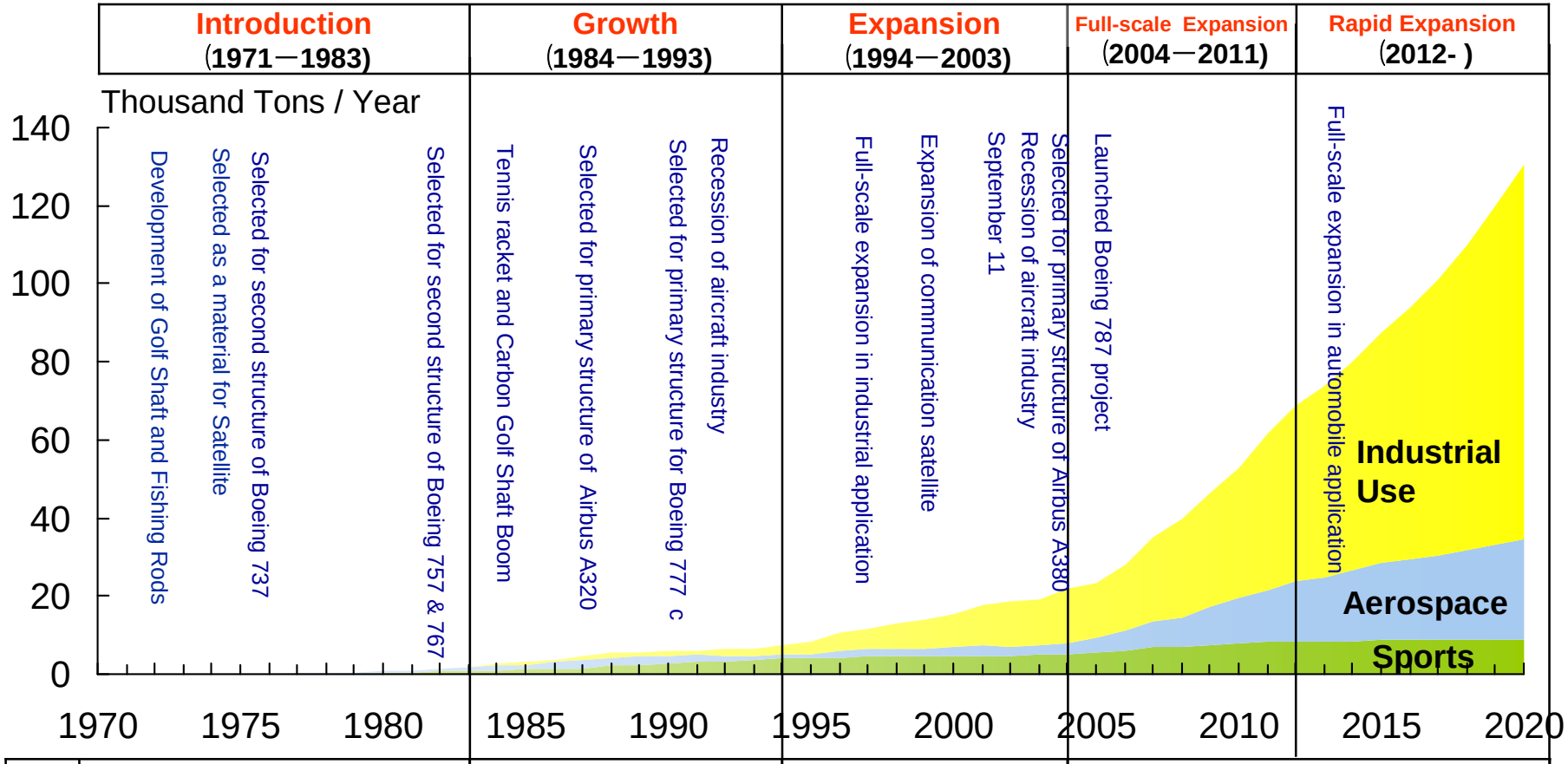
Weight saving
(Aircraft, Automobile)

Deep water oil mine

Medical Equipment

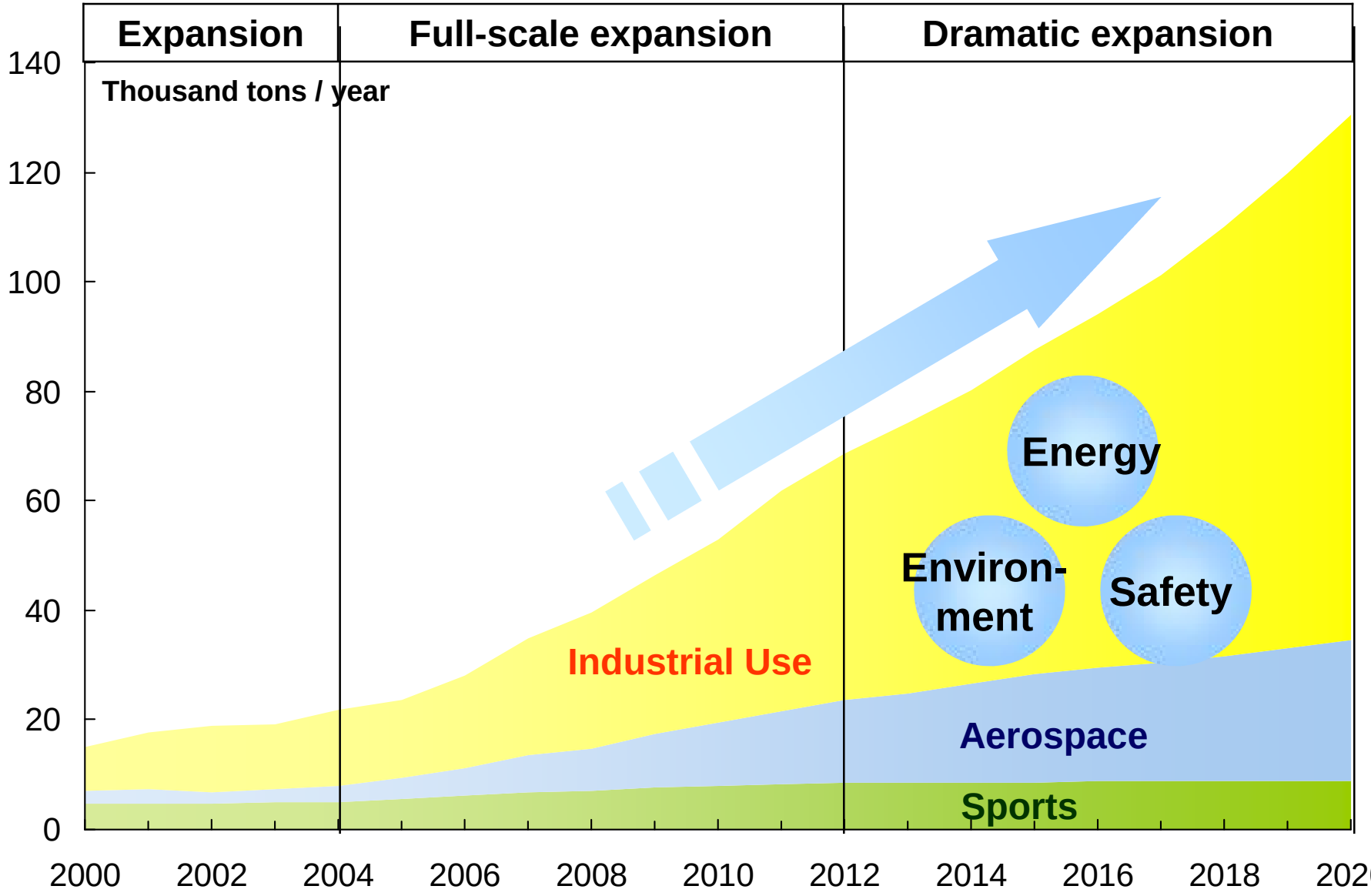
PC Casing

Carbon Fiber Market transition

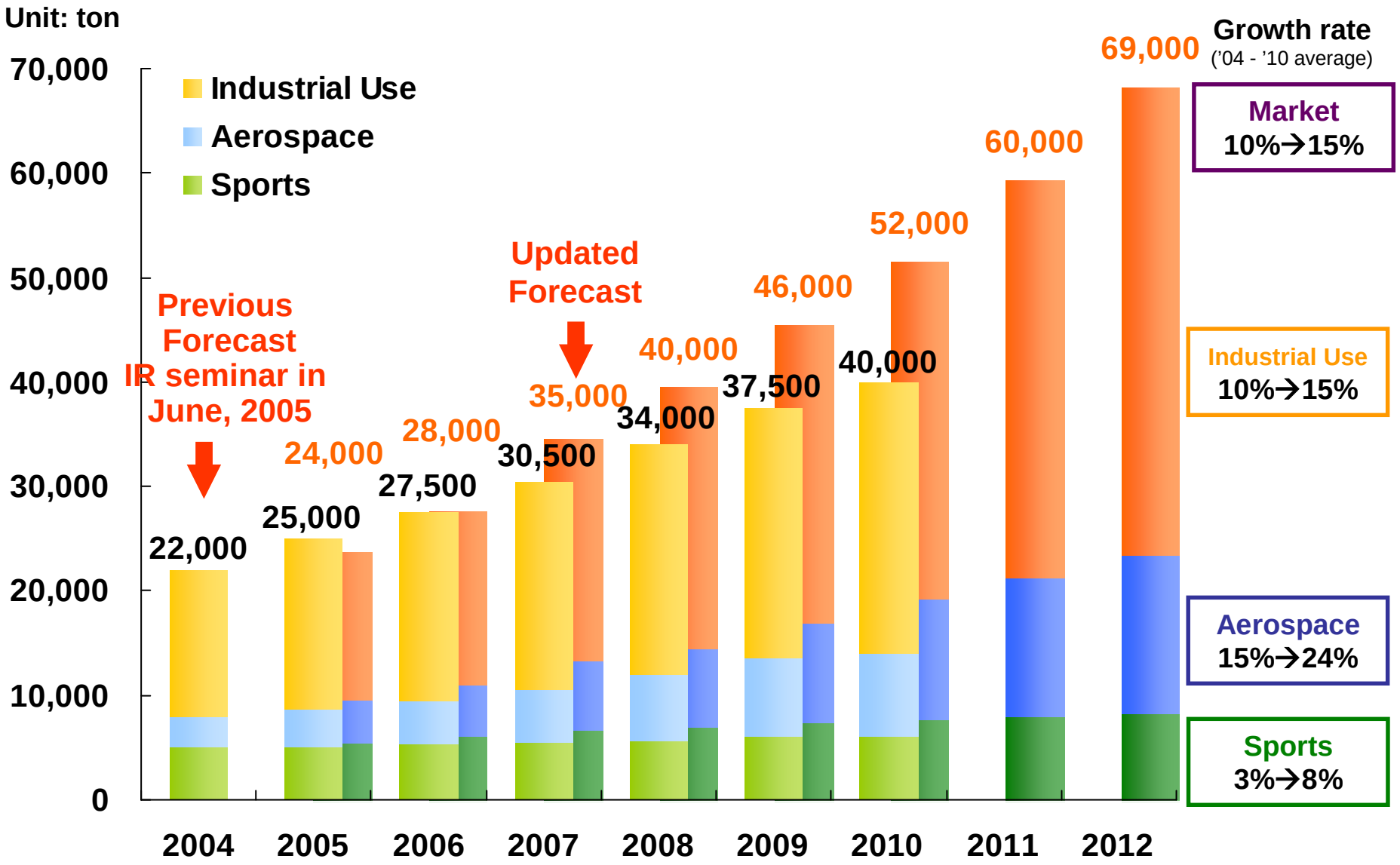


	Introduction (1971－1983)	Growth (1984－1993)	Expansion (1994－2003)	Full-scale Expansion (2004－2011) / Rapid Expansion (2012-)
Main Application	**Limited Field** Fishing rods Aircraft secondary structure	**Increase in application** Tennis rackets Golf Shafts Aircraft primary structure	**Increase in Industrial Use** Pressure vessel Machine parts Engineering, Marine	**Full-scale increase in Aircraft and Automobile** Large aircraft program Wind blade Automobile, Oil mine
Remarks	High Quality	Increase of product type Progress in molding technology	Cost reduction Large scale structure	Variety in molding method Recycle of Carbon Fibers

Carbon Fiber Market transition

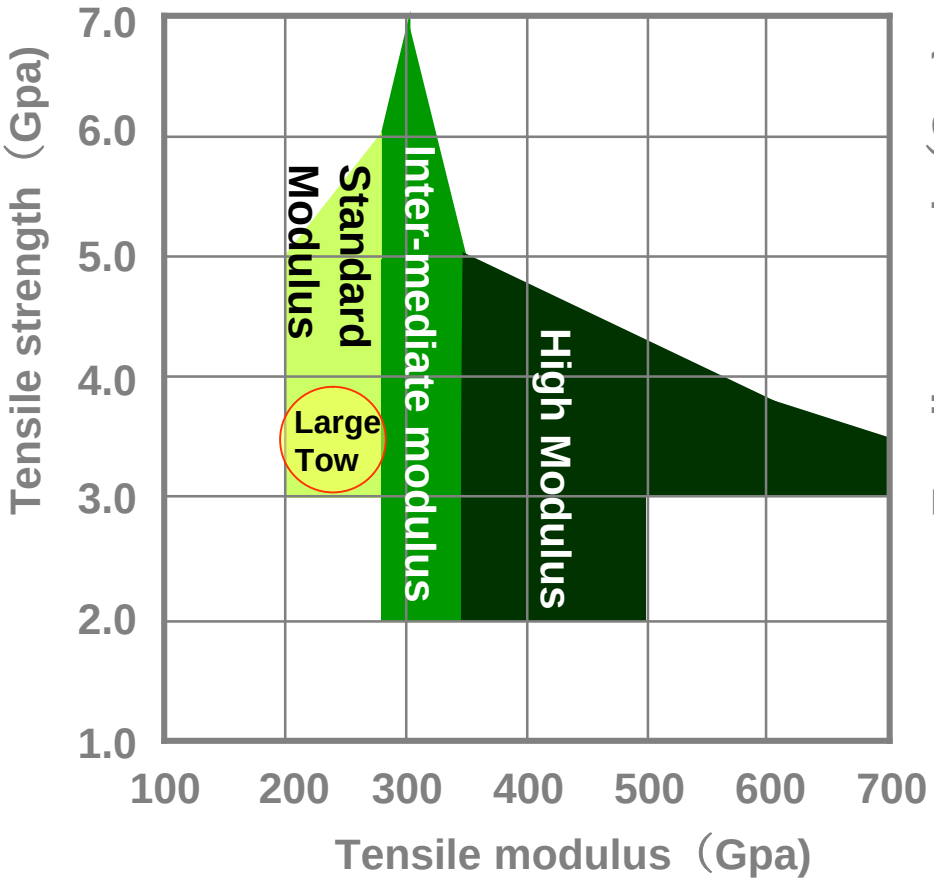


Forecast of Carbon Fiber demand

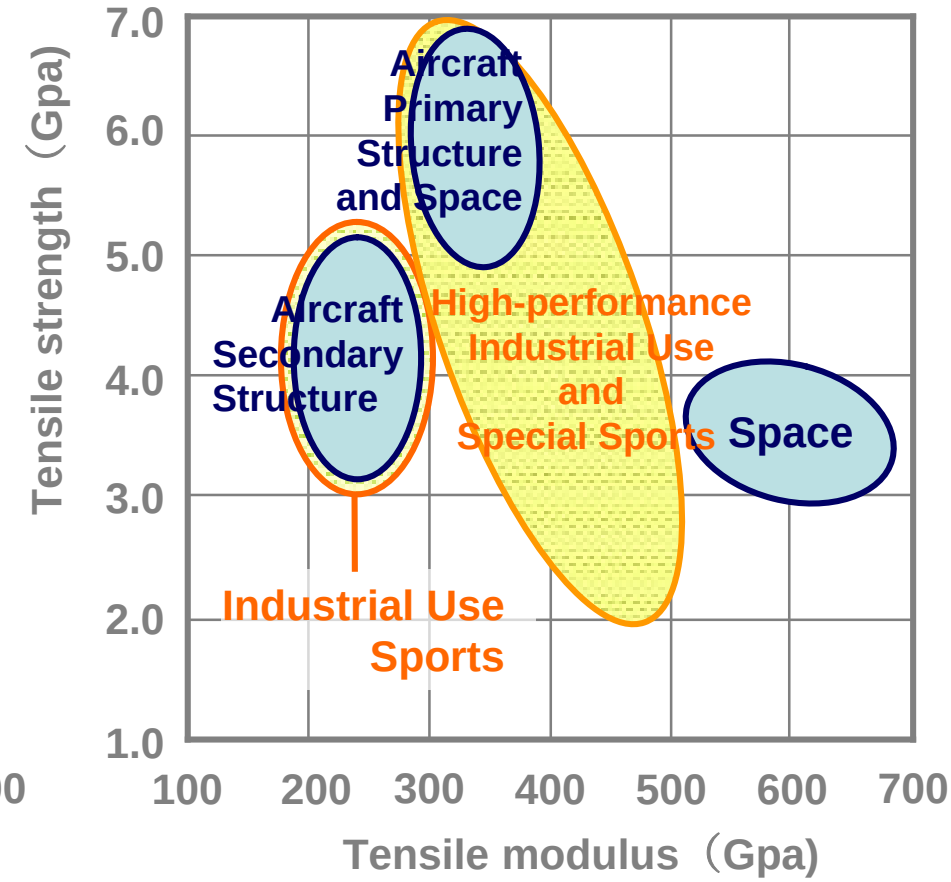


Market classification of PAN-based Carbon Fibers 1

Classification by Mechanical characteristic 1

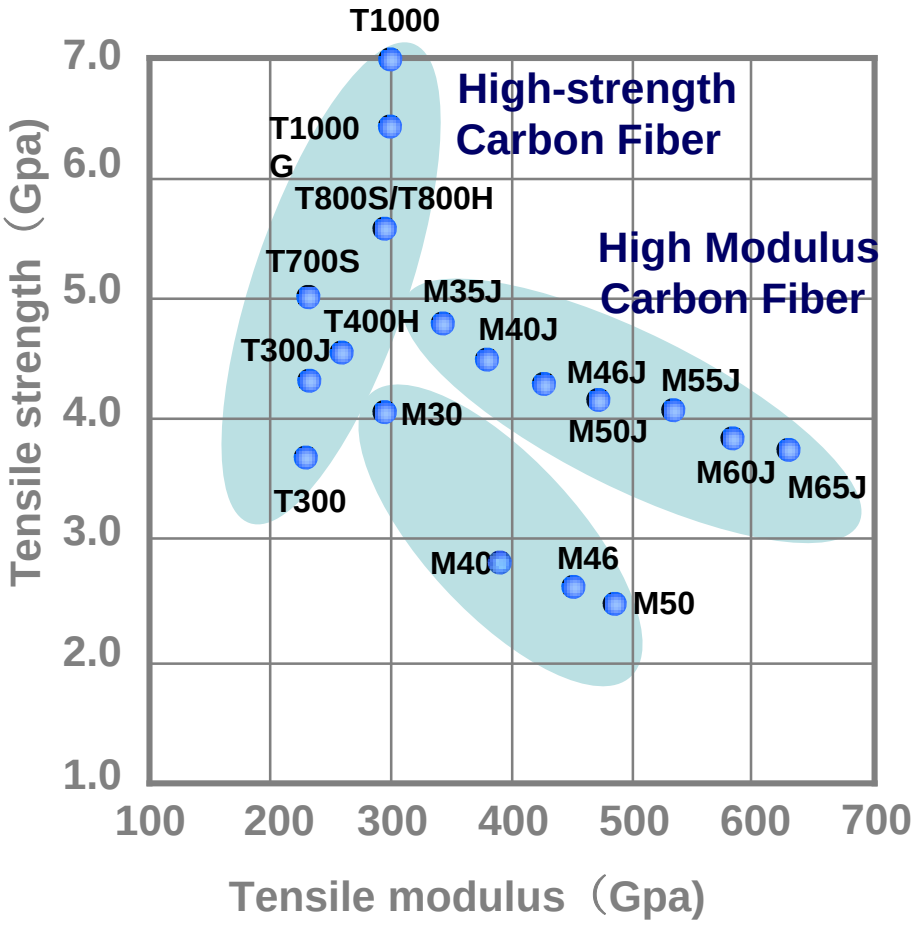


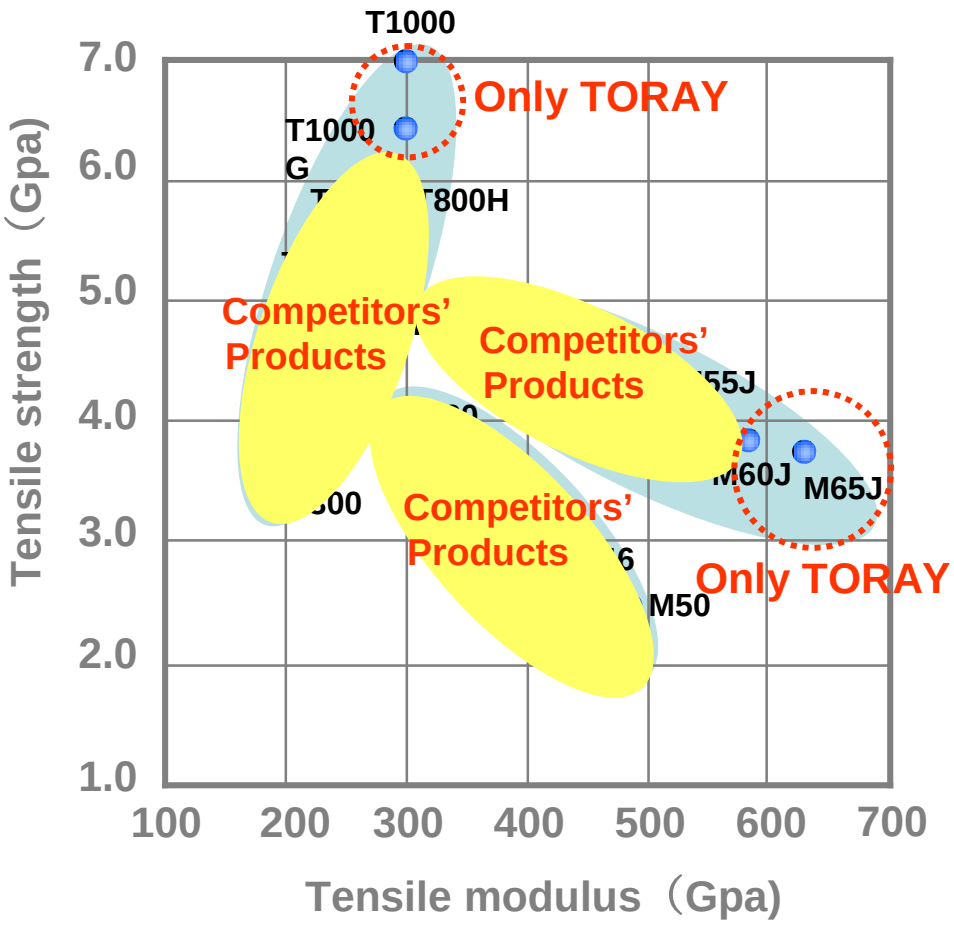
Classification by Mechanical characteristic 2



Market classification of PAN-based Carbon Fibers 2

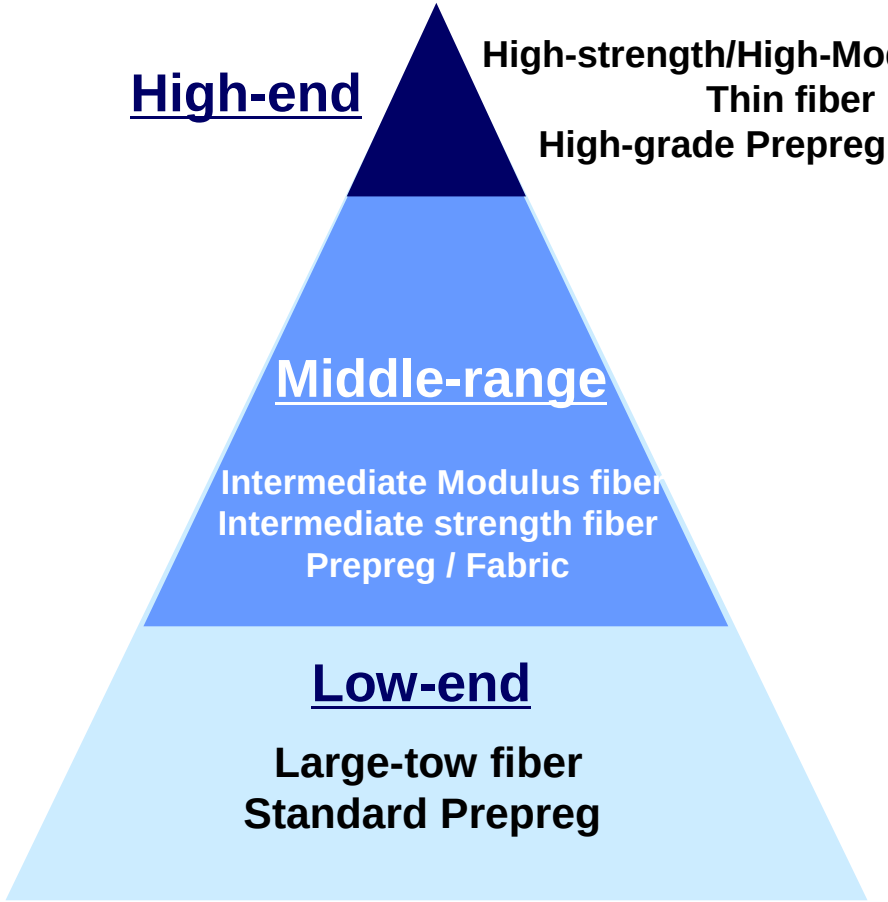
Carbon Fiber TORAYCA® series



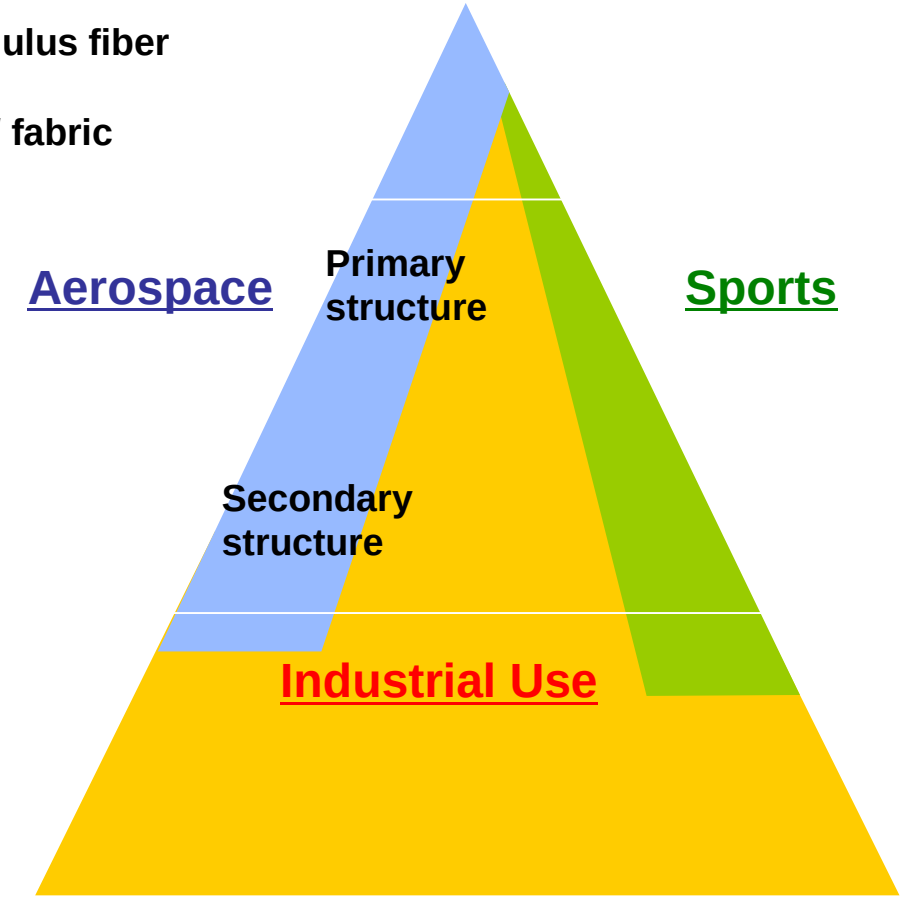


Market structure of PAN-based Carbon Fibers 1

Market structure by grade



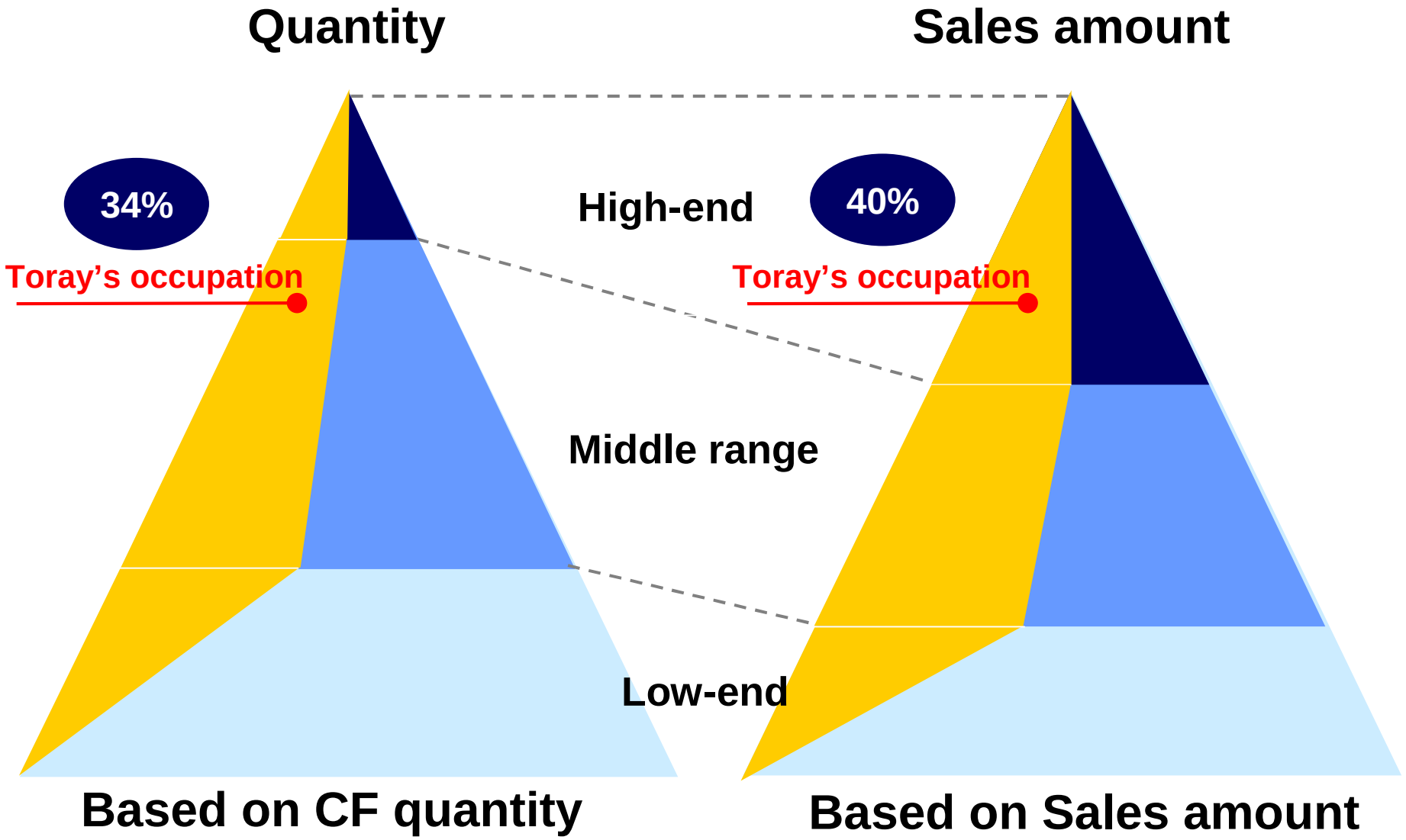
Market structure by application



Market size: 35,000 tons

***As of 2007, Toray's estimation**

Market structure of PAN-based Carbon Fibers 2



*As of 2007, Toray's estimation

Examples of application -Aerospace-

Boeing 777

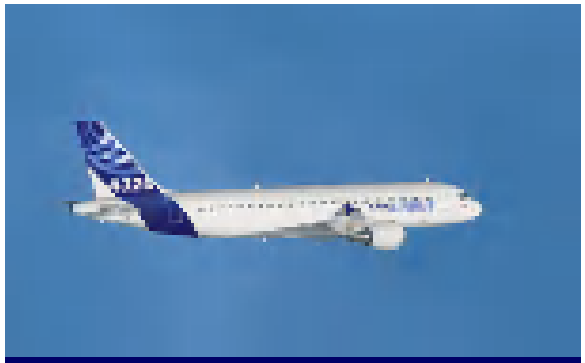
Primary/Secondary structure
CFRP usage : Approx. 10t

Boeing 787

Primary/Secondary structure
CFRP usage: Approx. 35t

Satellite

Airbus A320



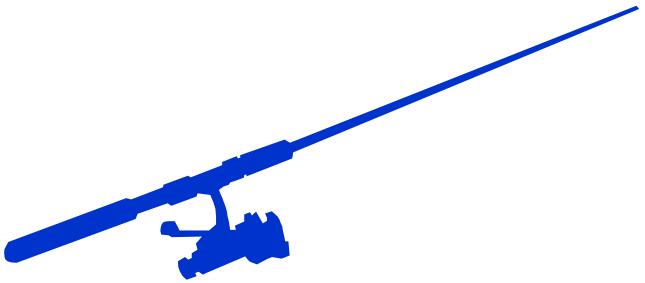
Primary/Secondary structure
CFRP usage: Approx. 2t

Airbus A380

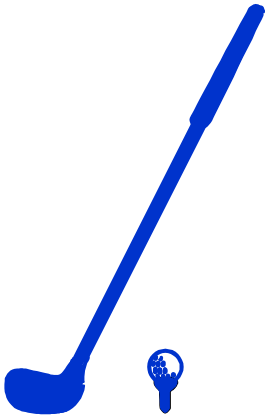
Primary/Secondary structure
CFRP usage: Approx. 35t

Rocket

Examples of application -3 major sports-



Fishing rod

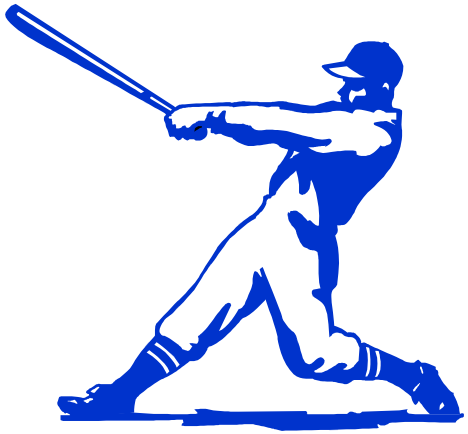


Golf Shaft

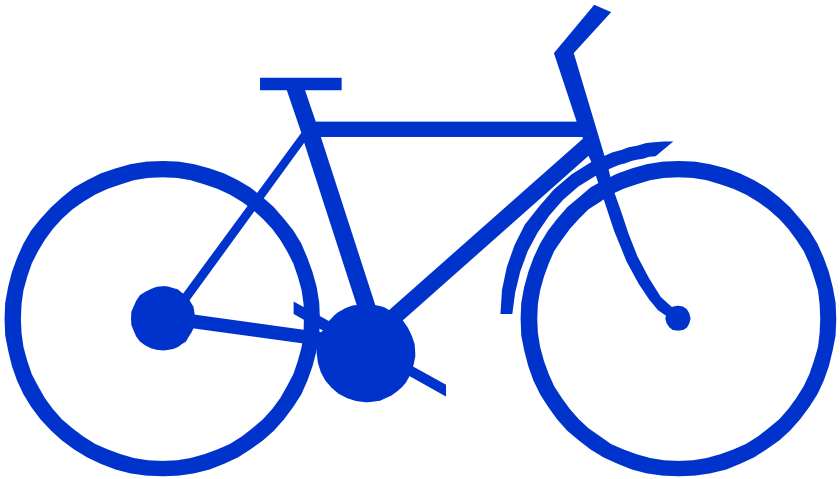
Tennis racket

Examples of application -New sports-

Hockey stick



Softball bat



Bicycle

Examples of application -Industrial use-

Energy-related

Wind power blade

Fuel cell

Oil-related

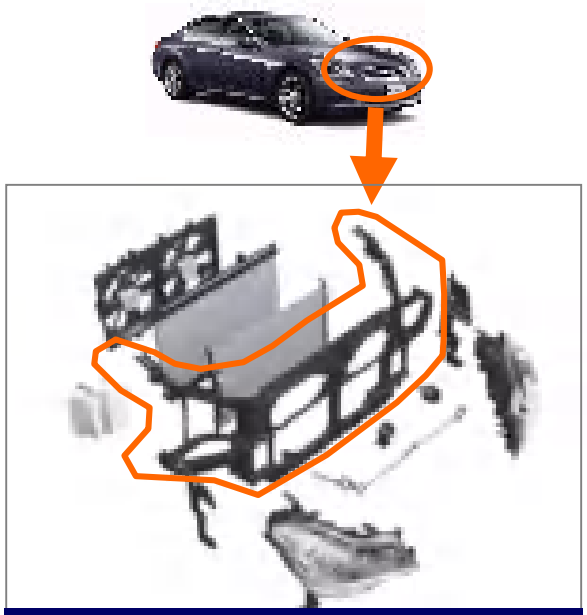
Examples of application -Industrial use-

Automobile-related

Hood

Spoiler

Propeller shaft



Radiator core support

F1 machine parts

Body panel

Examples of application -Industrial use-

Civil engineering, Repair and Reinforcement

Bridge pier reinforcement

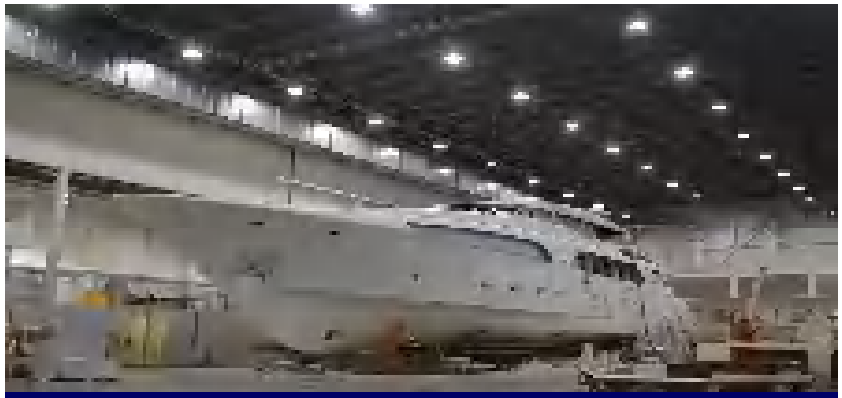
Deck reinforcement

Bridge railing

Pillar reinforcement

Examples of application -Industrial use-

Ships and Boats



Boat

Sailboat

Examples of application -Industrial use-

Pressure vessel

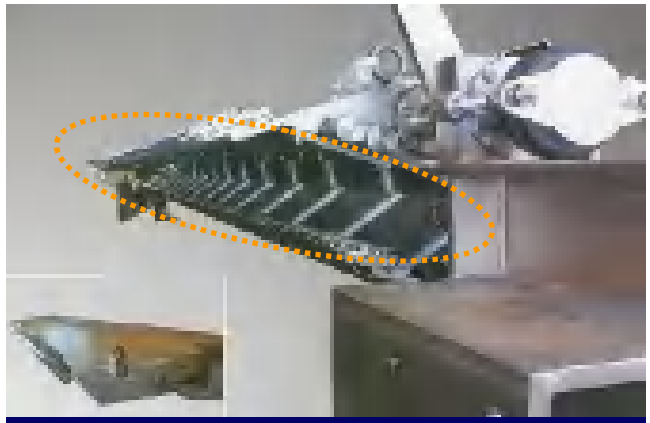
SCBA (self-contained-compressed air breathing apparatus)

CHG (Hydrogen) tank

CNG (Compressed Natural Gas) tank

Examples of application -Industrial use-

Machine parts, Medical equipment and IT-related products



Doctor blade

Robot hand
for LC panel

Roller / Pipe

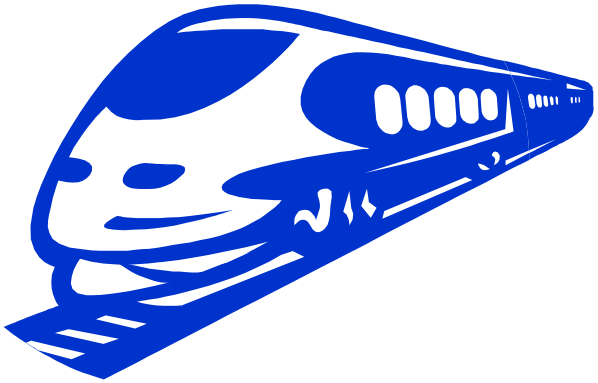
PC casing (Compound)

X-ray top panel

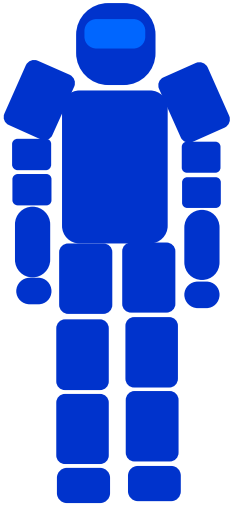
Examples of application -Industrial use-

New applications

Electric cable core



Body panel for train

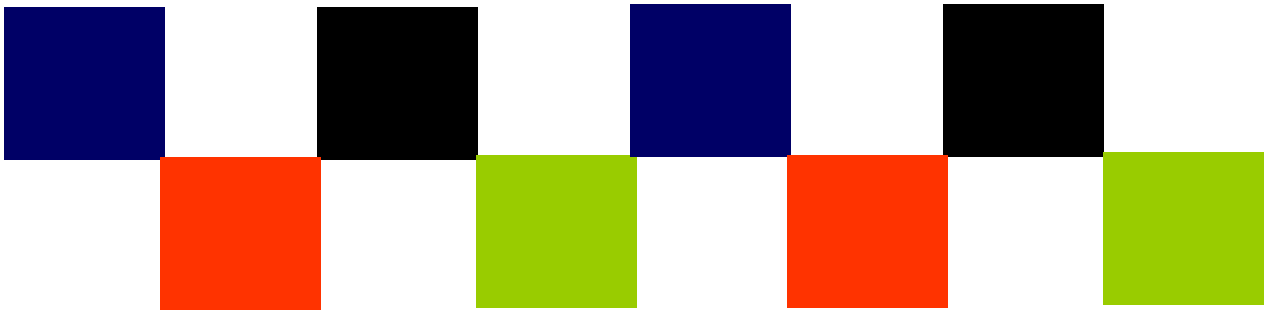


Robot parts

Tube trailer tank (length 12 m)

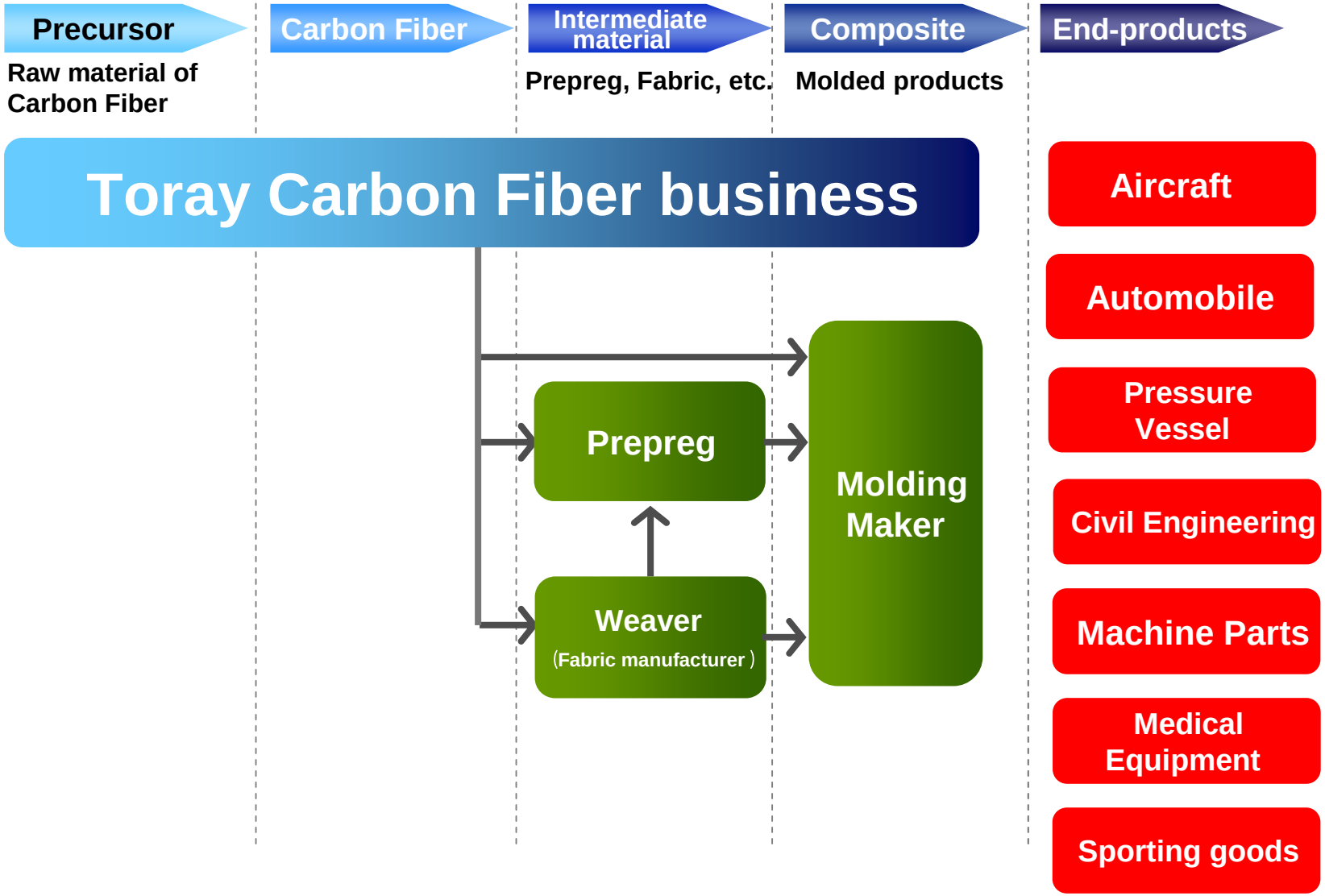
Strategy for

Carbon Fiber Composite Materials

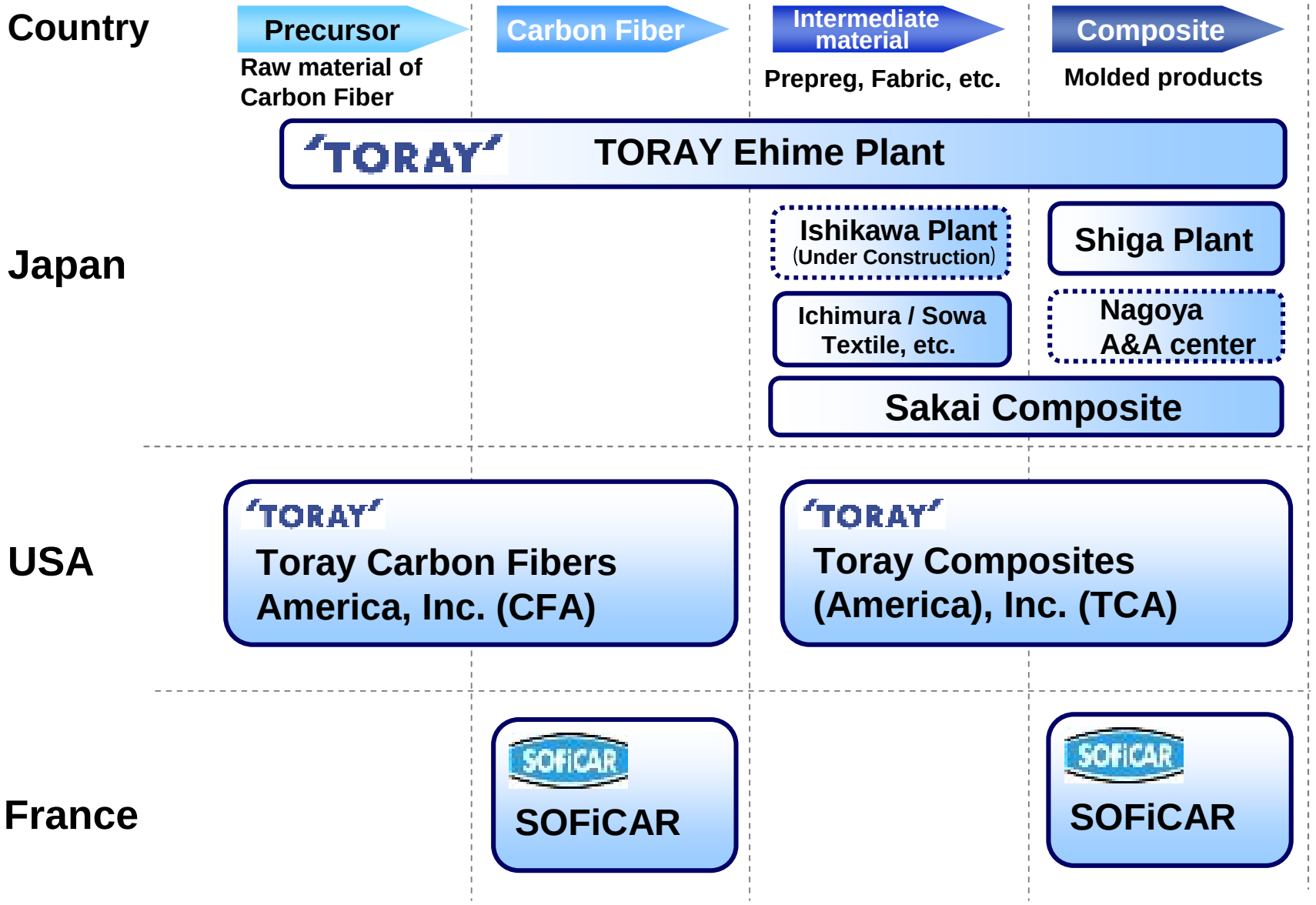


(2) Current status

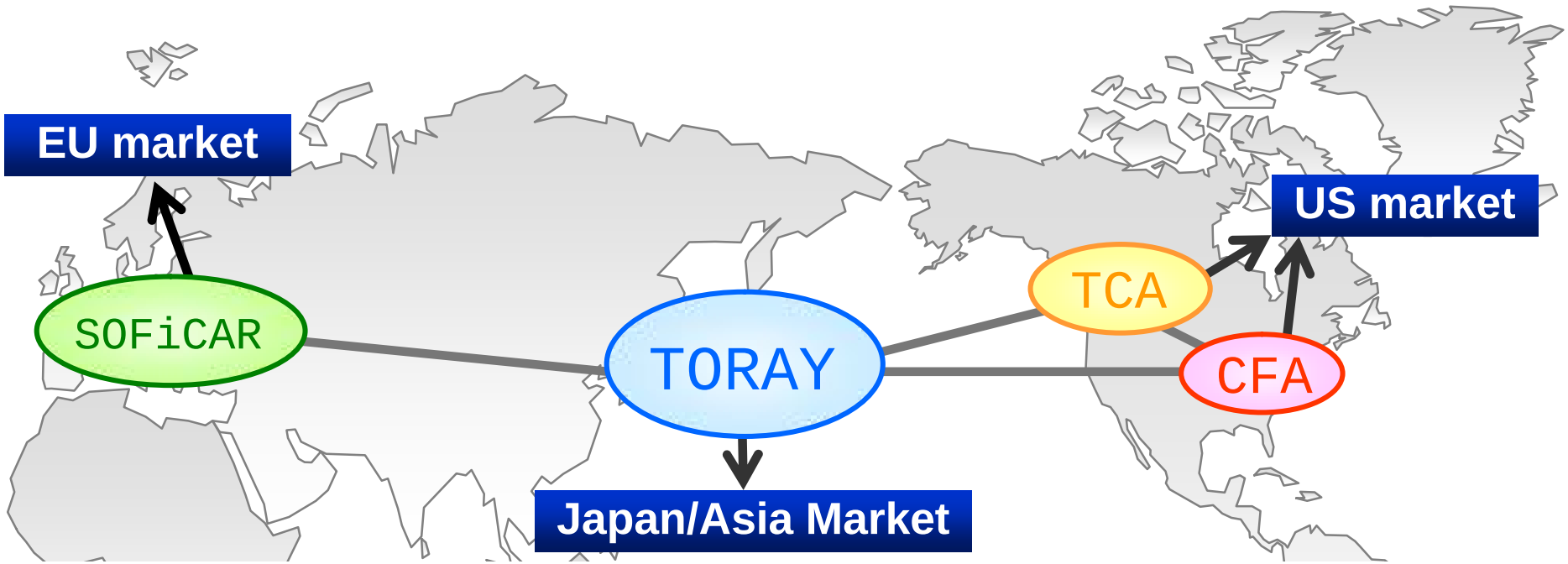
Supply-chain of Carbon Fiber business



Our Production base



Our Global Operation



Production capacity of each production base

	Societe des Fibres de Carbone S.A. (SOFICAR) (FRA)	TORAY (Ehime/Ishikawa) (JPN)	Toray Composites (America) (TCA) (USA)	Toray Carbon Fibers America (CFA) (USA)
Carbon Fiber (t)	3,400 → 5,200 (Jan, 2008) (Dec,2008)	7,300 → 8,300 (Jan, 2008) (Jul, 2009)		3,600 → 5,400 (Jan,2008) (Dec,2008)
Prepreg ('000㎡)		10,800 → 16,600 (Jan, 2008) (Jan, 2009)	11,400 → 17,200 (Jan, 2008) (Jul, 2008)	

*1: Lines under construction are inclusive. *2: Composites are manufactured at Toray Shiga plant, SOFiCAR and TCA.

Our advantage

- **Worldwide vertically-integrated operations, from Precursor to Composite materials**
- **37-year long top supplier of high-performance carbon fibers**
- **27-year experience in production of aircraft Prepreg**
- **Proactive R&D investment and technical development from Carbon Fibers to molding process**
- **Strong and reliable partnerships with customers from development stage**

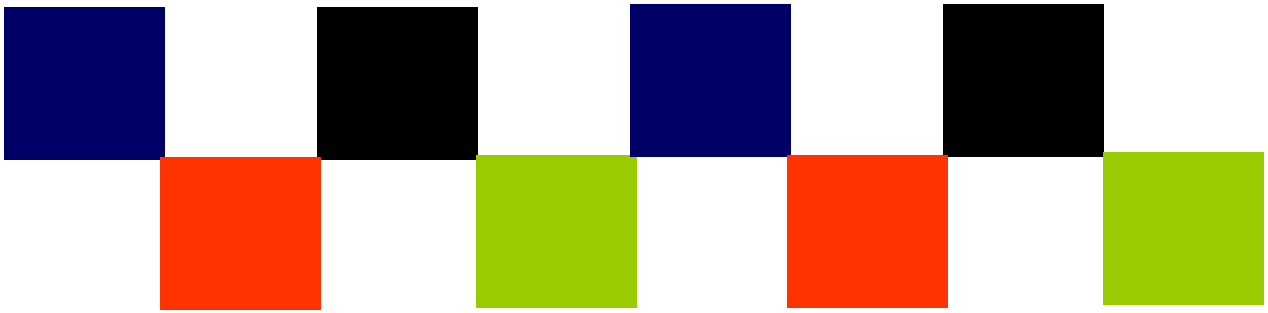
  (Aircraft, PC casing, Automobile, Sporting goods, Machine parts, etc)

Our Characteristics

	TORAY	Regular tow competitors	Large tow competitors
Quality / R&D ability	Excellent	Fair – Good	Poor – Good
Global marketing system	Excellent	Good	Poor – Fair
Performance in the Qualified business	Excellent	Fair – Good	Poor
Sales price (High = Excellent)	Excellent	Good	Fair
Supply capacity	HP*1: Excellent GP*2: Good (Excellent for future)	HP: Good GP: Good	GP : Excellent
Intermediate products, Composites	Excellent	Good	Poor
Main application	Aerospace HP industrial use High-grade sports	Sports Industrial use A part of Aerospace	Industrial use (Wind power blade, Compound, etc) A part of sports

Strategy of

Carbon Fiber Composite Materials



(3) Strategy

Business expansion policy

- **Promote business expansion in each market through global production, marketing and technical services as the world's largest Carbon Fiber manufacturer**

	Net Sales	Operating profit ratio
Around 2010:	160 billion ¥	~ 20%
Around 2015:	300 billion ¥	
Around 2020:	500 billion ¥	

- **Maintain firmly largest share by differentiation of TORAYCA's high-quality and high-performance**
- **Try to expand supply of Carbon Fiber with cost competitiveness into industrial use market**
- **Differentiate in intermediate and composite materials and promote business expansion with high profitability**

Basic Strategies

1. Business strategies by applications

(1) Maintain and expand overwhelming advantages in aircraft application

(2) Develop market and technologies as a pioneer in automobile applications

(3) Enhance competitiveness in high-performance industrial market and establish overwhelming cost competitiveness in general-purpose market

(4) Maintain high market share and increase revenue in high-grade sports application

2. Improve competitiveness in quality and cost through enhancement of technical capabilities

3. Expand supply capability by continuing proactive capital investment

4. Give consideration to recycle and global environment

Basic strategy 1-(1)

Maintain and expand overwhelming advantages in aircraft application

Boeing

- Establish production lines for 787
- Develop and propose new materials for next generation aircraft

→ Strengthen our sole-supplier position

Airbus

- Secure stable supply for existing models
- Promote qualification test of our materials for A350XWB

→ Become main supplier

Regional

- MRJ: Develop materials and molding technology
- Regional jet: Expand sales based at TCA

→ Exploit new aircraft Market

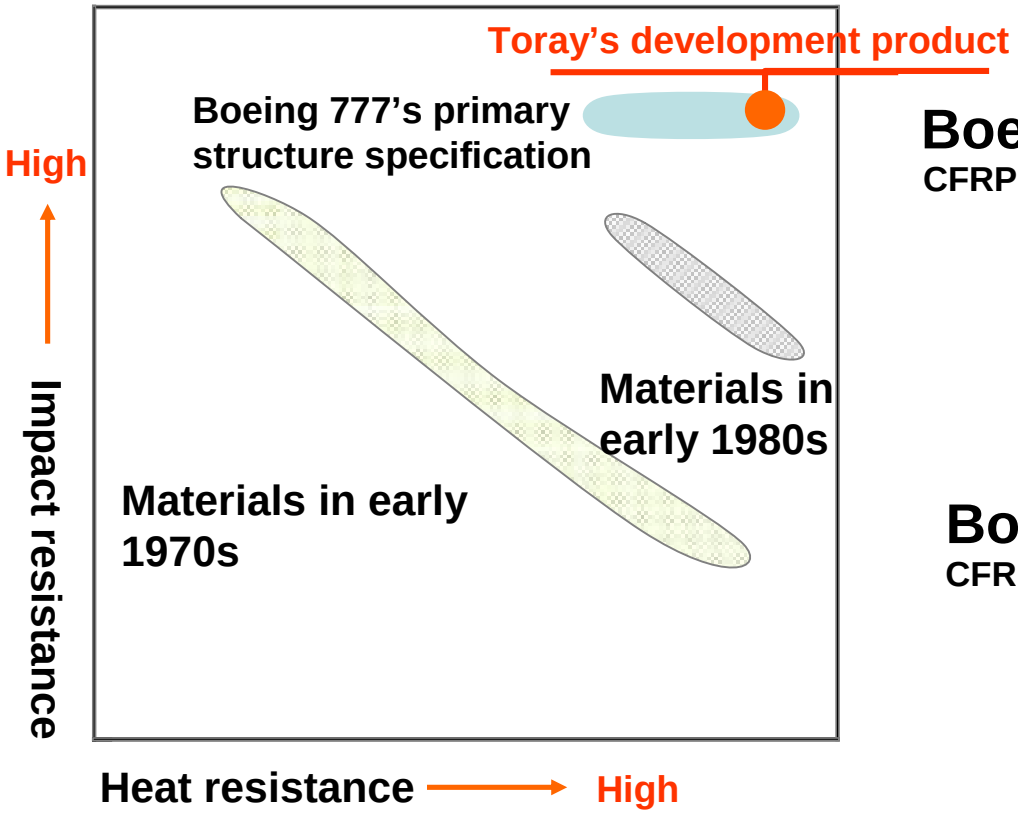
Overwhelming advantages in aircraft application

History of aircraft business in Toray

1971/1972	**Started commercial production of Carbon fiber/Prepreg**
1975	**Selected as CF for secondary structure of Boeing 737**
1981	**Selected as Prepreg for secondary structure of 757 & 767**
1982	**Established SOFiCAR : Started CF production in Europe**
1983	**Selected as CF for secondary structure of Airbus A300**
1987	**Selected as CF for primary structure of Airbus A320**
1989	**Qualified as Prepreg for primary structure of Boeing 777**
1992	**Established TCA : Started Prepreg production in USA**
1997	**Established CFA : Started CF production in USA**
2002	**Selected as CF for primary structure of Airbus A380**
2003	**Started Co-development of materials for 787 with Boeing**
2004	**Signed MOU with Boeing on contract for supply to 787**
2006	**Singed comprehensive long-term agreement with Boeing**

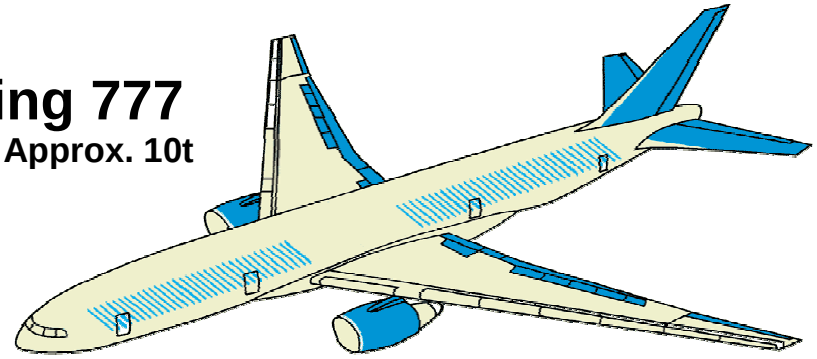
Overwhelming advantages in aircraft application

Heat resistance and Impact resistance

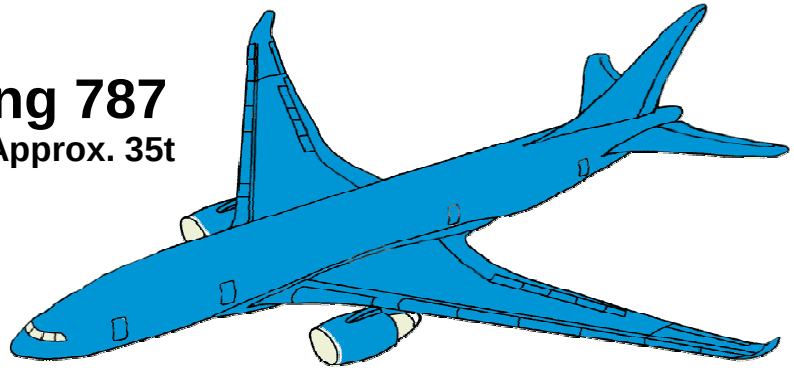


CFRP used for primary structures

Boeing 777
CFRP: Approx. 10t



Boeing 787
CFRP: Approx. 35t



Used CFRP at 50% out of all structure

Only Toray's Carbon fiber and Prepreg are qualified as materials for primary structure of Boeing aircrafts

Overwhelming advantages in aircraft application

Now co-developing new molding technology (A-VaRTM) for Mitsubishi Regional Jet (MRJ) with Mitsubishi Heavy Industries, Ltd.

◇**Points of technology (Compared with existing Prepreg laminated composite)**

1. **Excellent mold ability: Easy to mold complicated shapes by using dry fabric (no need for chilled storage)**
2. **Excellent mechanical characteristic: Achieve the same characteristic as using chilled Prepreg**
3. **Cost competitiveness: No need for autoclave → Small capital investment**

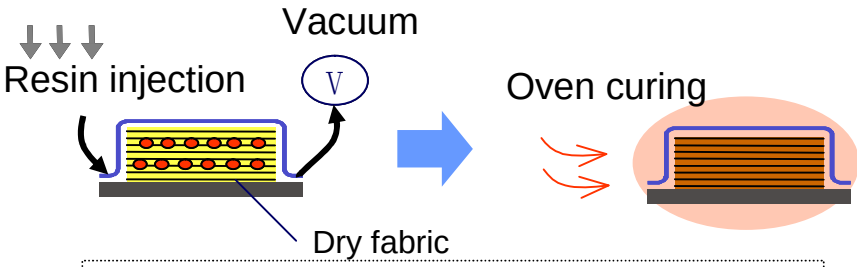
Real-size vertical tail wing (Prototype)

Skin / Stringer panel

Spar

Rib

A-VaRTM method



A-VaRTM method
Advanced-Vacuum assisted Resin Transfer Molding

Overwhelming advantages in aircraft application

Carbon Fiber Demand for commercial aircraft and our market share forecast

Basic strategy 1-(2)

Develop market and technologies as a pioneer in automobile application

Respond to environmental regulation and needs for weight saving

- Comprehend trends in automobile industry
- Study effect of weight saving by CFRP
- Propose solutions to automobile manufacturers

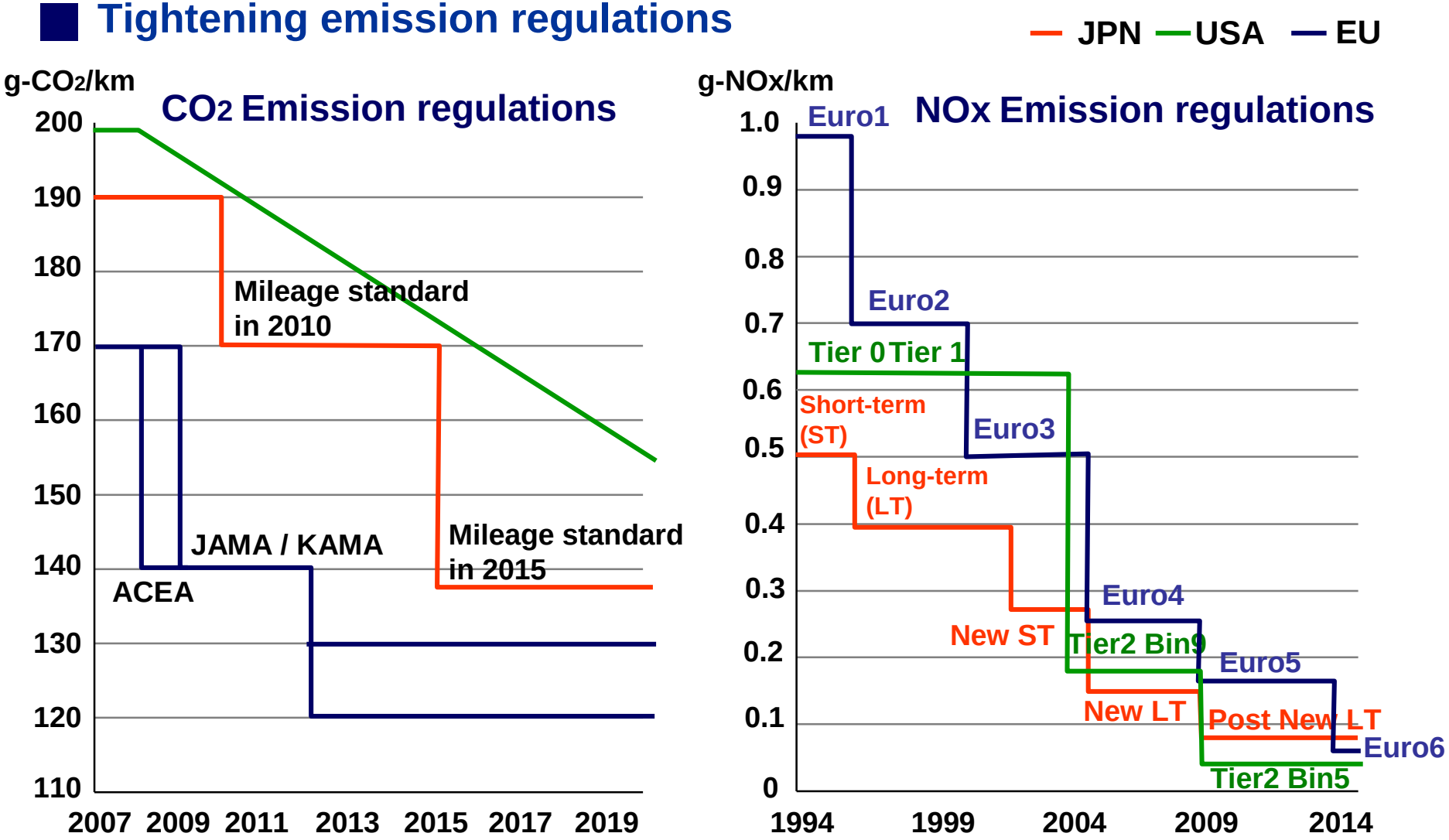
→ Create CFRP demand for automobile

Enhance R&D for automobile

- Integration of company-wide technologies
- Develop low-cost material and mass production molding technology
- Co-develop with customers

→ Cross-organizational development
Go into automobile field drastically

Tightening emission regulations



•US standard is based on the draft passed by Senate recently , in which CO_2 limit is set to 35mpg(156g-CO_2/km) by 2020, reduced by 4% annually after 2020. Due to uncertainness of CO_2 limit on each year, we estimate decrease in linear manner from current limit (2008).

Business environment and issues in automobile industry

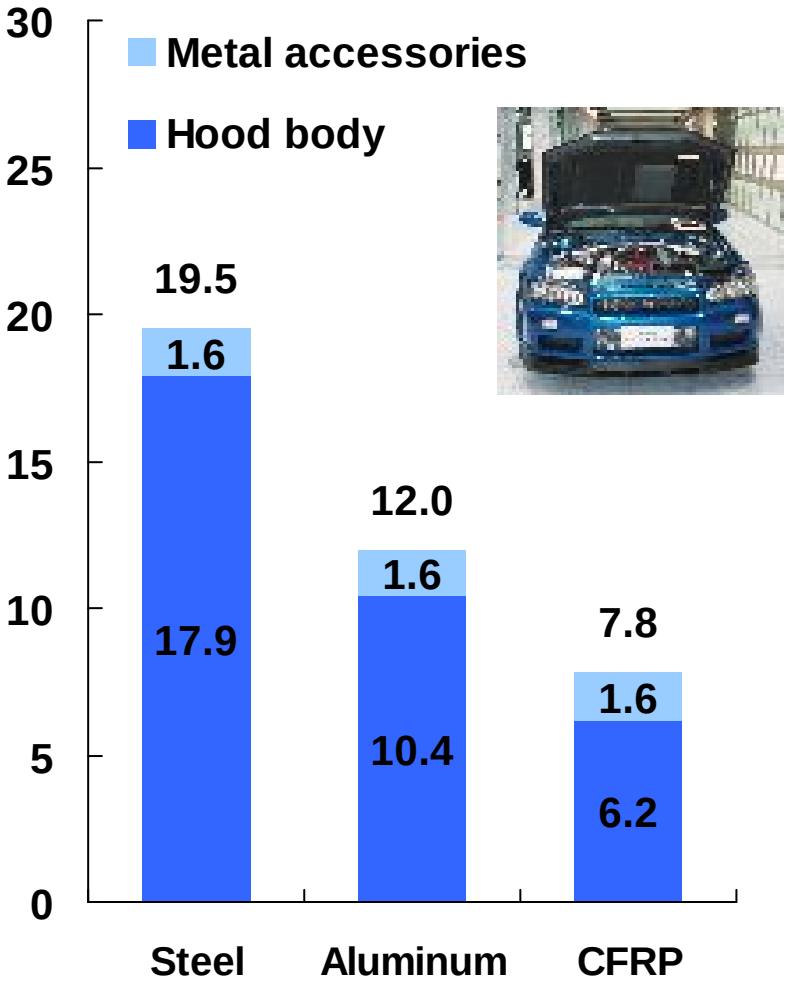
Trends in automobile industry

Weigh saving project on main automobile manufacturer

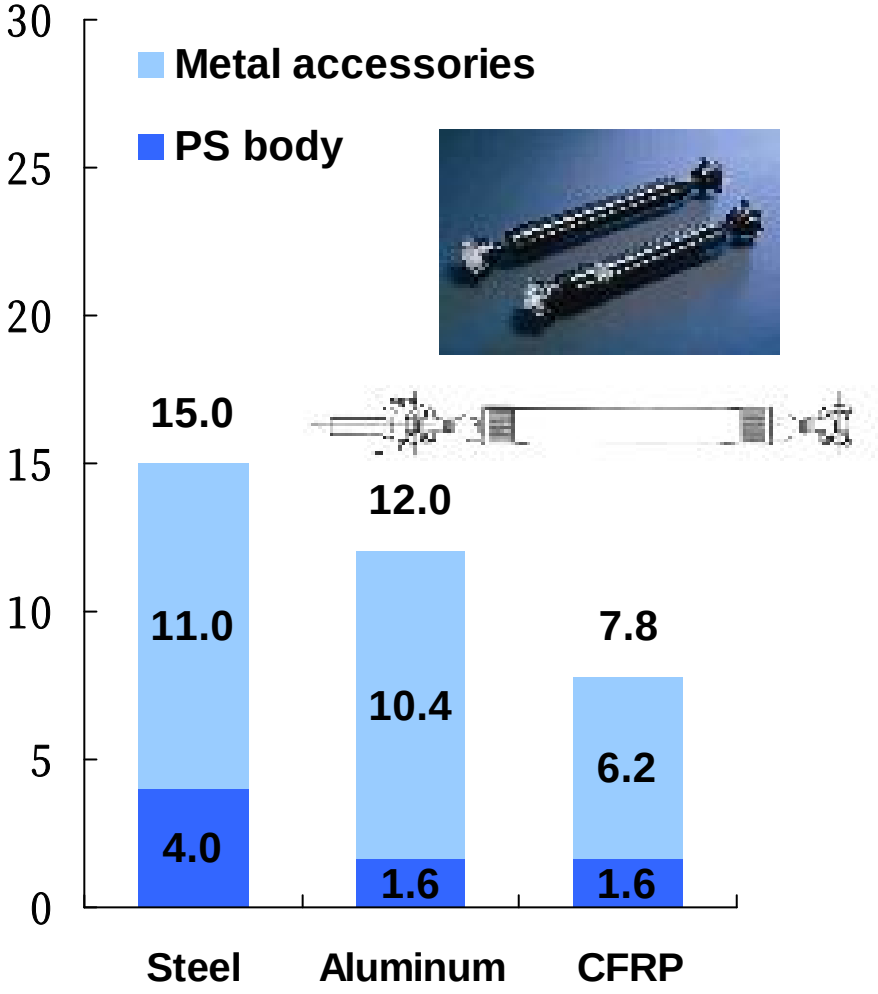
	Project	Target	Outline
TOYOTA	Mass Innovation	10% weight saving by 2011 (Midsize sedan)	・Position CFRP as one of the method ・Reduce component ・Resinification
Honda	*Vary by model	10% CO_2 reduction by 2010	・CO_2 reduction by LCA (include production) ・Ahead in using Aluminum
NISSAN	Vision 2015	15% weight saving by 2015 (Average)	・Position CFRP as one of the method ・40% CO_2 reduction by 2015 (vs 2005) ・Completed main method for 10% mileage improvement
Mitsubishi	CLW30 (Challenge for Light Weight)	30% weight saving by 2010 (2010 model car)	・Start accepting supplier's proposal for the development for next model

Business environment and issues in automobile industry

Hood weight comparison (Unit: kg)



Propeller shaft weight comparison (Unit: kg)



Basic strategies 1-(2)

Achievement of Toray's CFRP propeller shaft

1996 1998 2000 2002 2004 ～2007 Reason for adoption

Total 900,000 units!

Development →  5,000 Units → Light weight

Nissan GTR 2007

Development →  10,000 Units → Light weight

Aston MartinV8-Vantage 2005

Development →  10,000 Unites → Light weight

Aston Martin DB9 2004

Development →  130,000 Unites → Light weight

MAZDA RX-8 2003

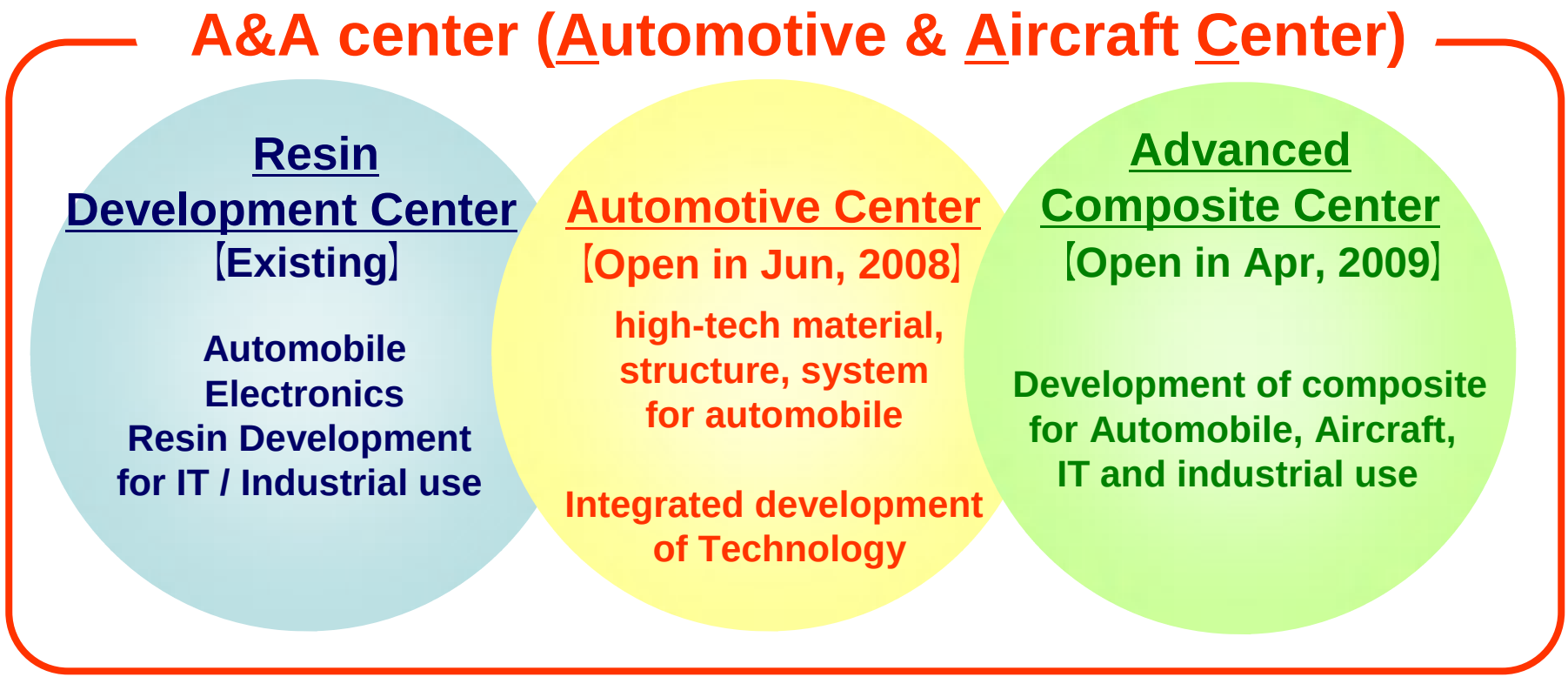
Development →  250,000 Unites → Light weight

Nissan FairladyZ 2002

Development →  500,000 Unites →  → Crash safety

MMC Pajero 1999 New Pajero 2006

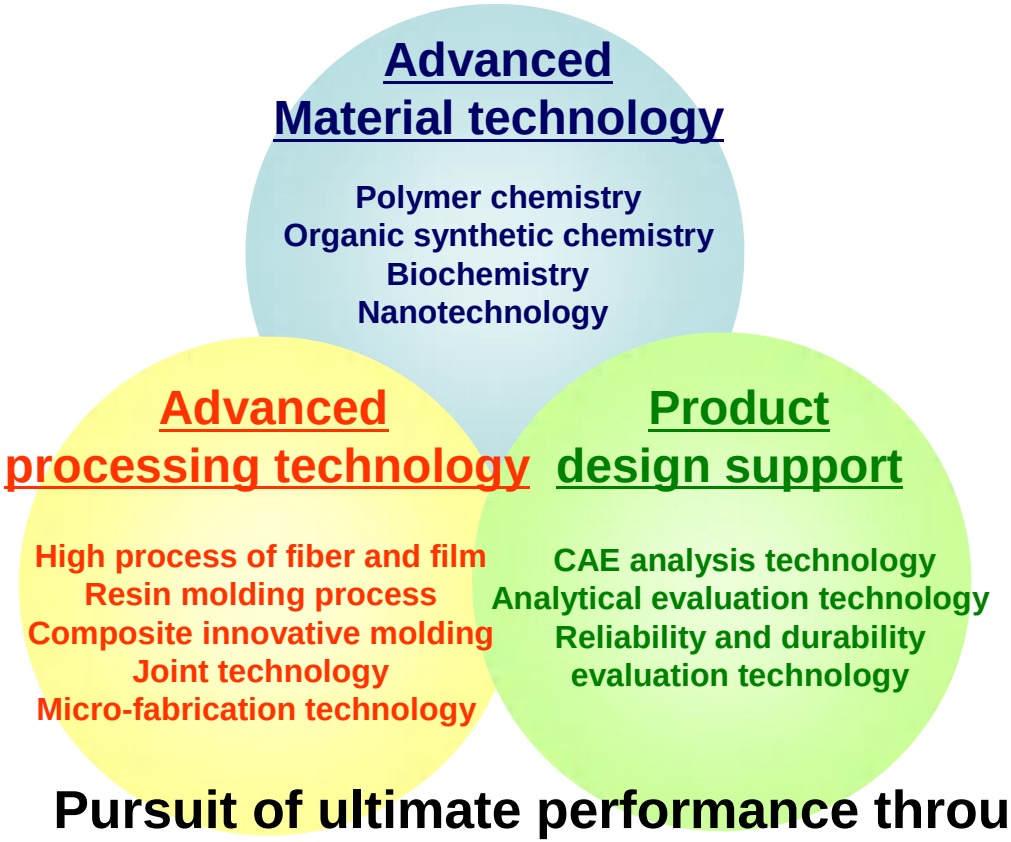
General R&D center for Automobile and Aircraft



Fundamental reinforcement of development capability for automobile application

Integration of Toray Group technology

Establish Automotive Center as cross-organizational base



Automotive center (AMC)

Pursuit of ultimate performance through integration of material and technology

Proposal of innovative solution by integrated technology

Enhancement of composite development function

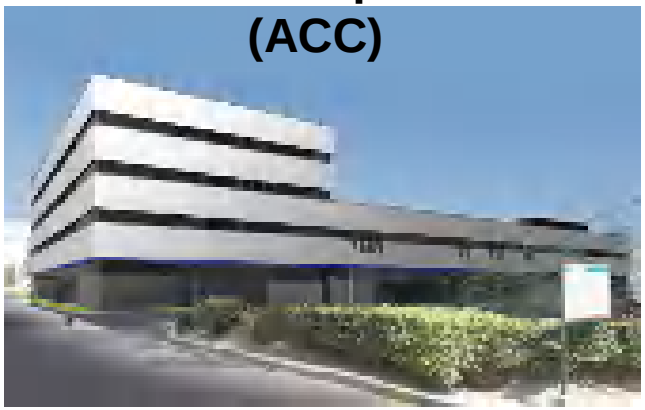
Transfer composite development bases to Nagoya ▶ **Promote development innovation**

Ehime plant
Advanced Composites Development Center
Advanced Composites Technical Dept.

Shiga plant
Advanced Composite Technical Dept.

Transfer to Nagoya plant

Advanced Composites Center (ACC)



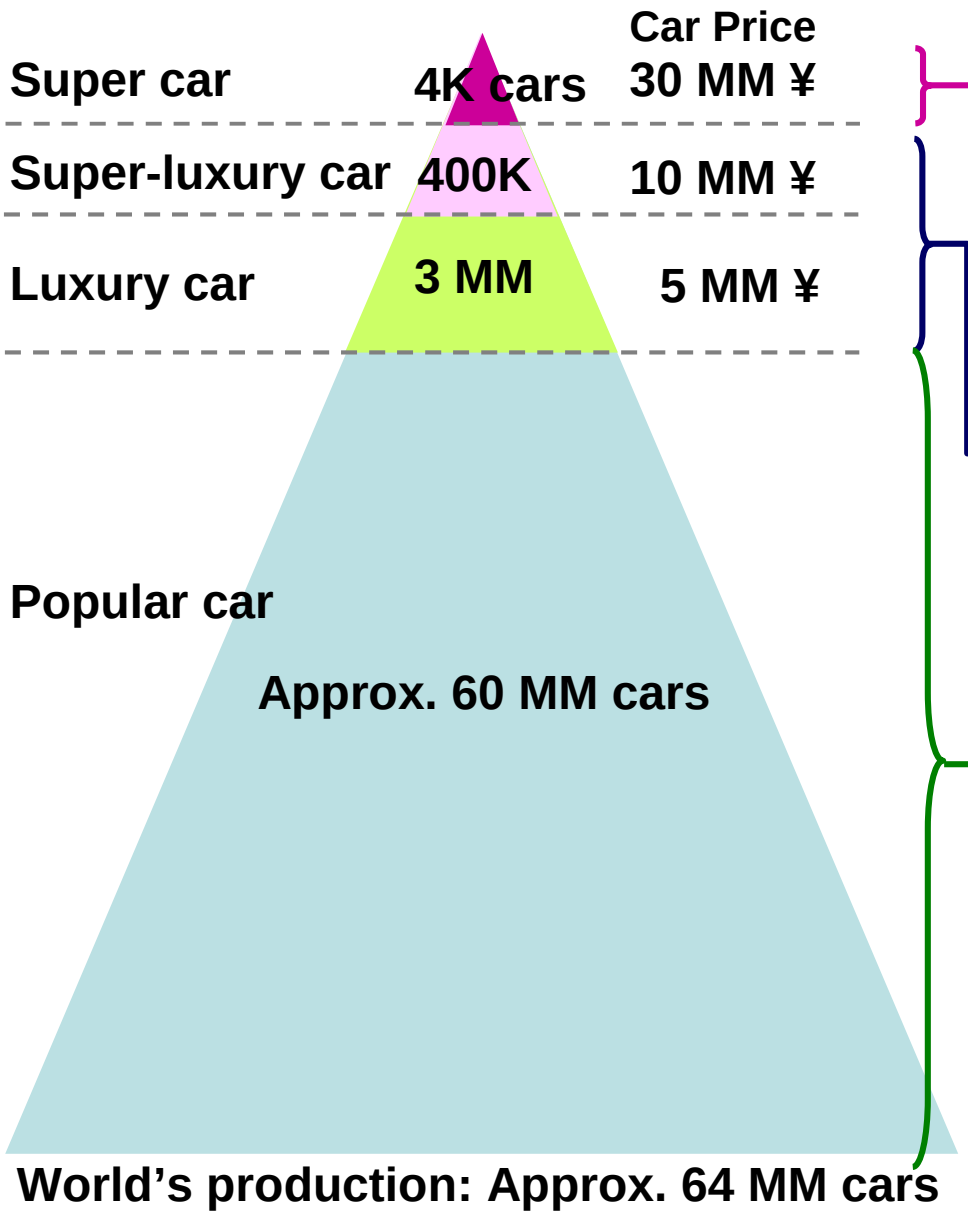
Image【Open in Apr, 2009】

- Design of composite products
- Deepening molding process technology
- Development of next generation composite products
- Integration of resin and chemical technology
- Collaborative development for automobile application
- Co-development system with customers
- Speed-up of development
- Collaborative development with AMC

Promote drastic expansion of composite products, especially in automobile and aircraft application

Basic strategies 1-(2)

Breakdown of world's automobile production and CF demand



Use Carbon fiber (CF) in all body (100kg / car)
CF demand : 400 tons

Use CFRP in parts
CF 100kg / car X 500K cars
CF demand: 50,000 tons

Huge potential market
CF 100 kg / car X 6MM cars
CF demand: 600,000 tons

[CFRP effects]

Weight saving
Good Mileage → Ecology

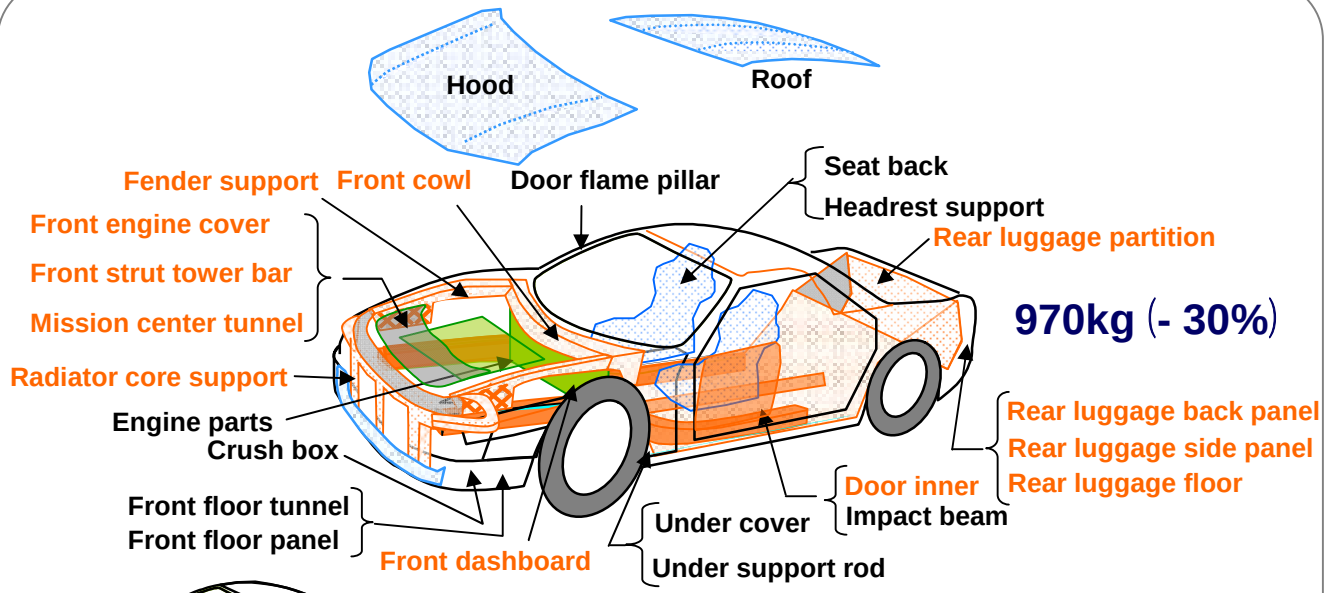
Better crash safety
Energy-absorbing

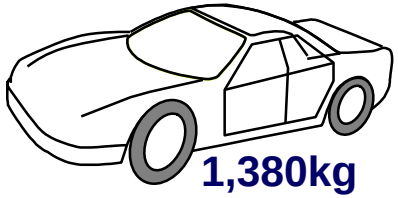
Lower assembly man-hour / expense
Modularized by unification

Better driving performance
Better vibration damping
Natural vibration UP

Safety improvement
Improvement of material fatigue

Possible to reduce 400kg by CFRP





CFRP化

Average weight car model
(Gasoline car, 4 door, FF)

Thermal cure CFRP:
Panel, Reinforced member RTM method, 30% the weight of steel
Thermoplastic CFRP:
Press molding material
50 the weight of steel

For more CFRP application…

■Issues

- Total cost down
- Improvement of molding flexibility

■Countermeasures

-Integration and systematization of material

Combination with thermoplastic materials and joint technology, etc.

Solving issues, even as aiming for proposing new concepts by integration of CF characteristics (electromagnetic shielding, etc.) and those of other materials such as resin or IT-related materials.

Basic strategy 1-(3)

Enhance competitiveness and expand business scale in industrial application

Enhance cost competitiveness in general-purpose CF by growing in machine size

- Install world's largest line (4000tons/yaer)
- Develop low-cost molding method

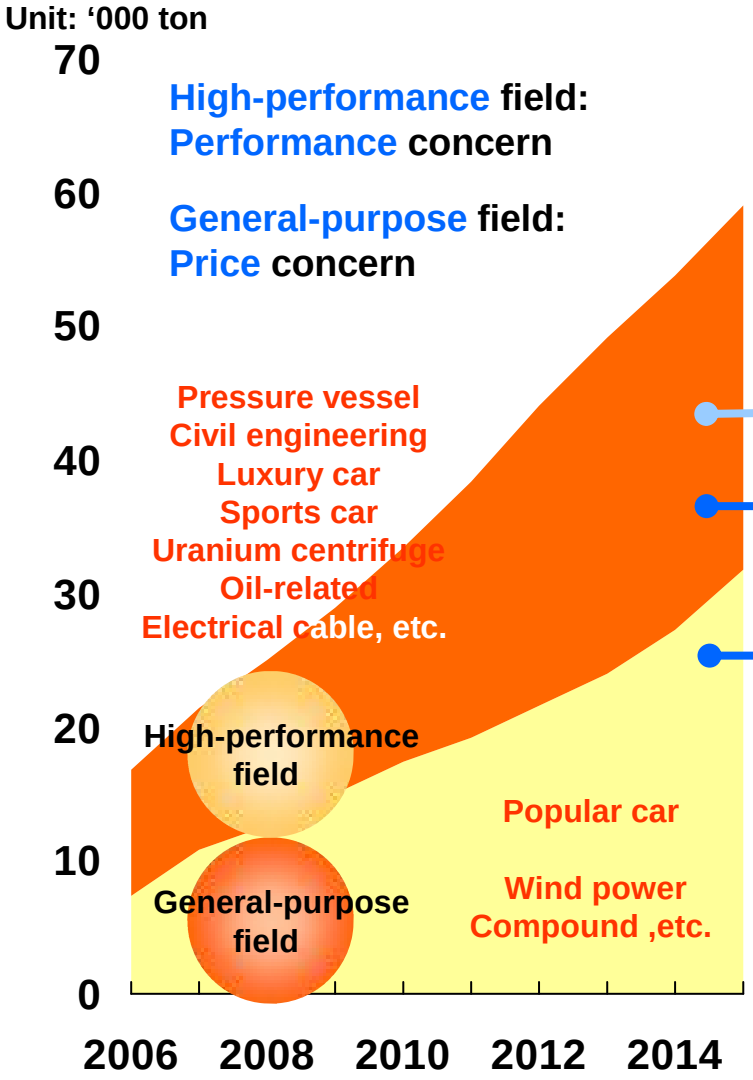
→ Promote cost down
Maintain quality advantage in 24K fiber

Develop new application by technical marketing

- Enhance function of technical center in US and Europe
- Promote cooperation among government, industry and academia

→ Develop new application
Expand in high-performance field

Demand forecast in industrial application by business field



1st Step Until 2012

A. Increase outlets in high-performance field (High-price field), especially in high-strength fiber (T700S-12K) and thin fiber (T300)

B. Enhance cost competitiveness by large line

C. Develop low-cost molding method

2nd Step After 2012

A. Increase sales in automobile application with cost competitiveness

B. Expand composite business with low-cost molding technology

Create demand by switching from other materials

Further expansion of CF demand

Expansion into high-performance field

Top panel for X-ray CT scanner

Taking advantage of high modulus materials with high radiolucent ratio

Electrical cable core

Weight saving → Long-span, fewer power pylon
Increase carrying capacity
(larger aluminum cross-sectional area)

Taking advantage of high-strength

Robot hand for LC glass substrate (Fork)

Taking advantage of vibration dumping by high modulus

Basic strategy 1-(4)

Enhance high-end sporting goods and maintain high market share

Maintain high profitability through expansion of high-value added products

- Respond to production shift to Asia as a top supplier for leading brand manufacturers in Japan and US
- Design and develop best suitable materials for sporting use

Expansion in high-value added products

Create new market and application

- Survey Vietnam and India market which can become production base of sporting goods following China
- Increase sales into new application such as bicycle, hockey stick, softball bat, etc.

Increase share by acquiring new demand

Basic strategy 2

Improve competitiveness in quality and cost Through Enhancement of technical capabilities

Develop high-performance CF

- Increase tensile strength
- Increase tensile modulus

Develop resin enhancing CFRP property

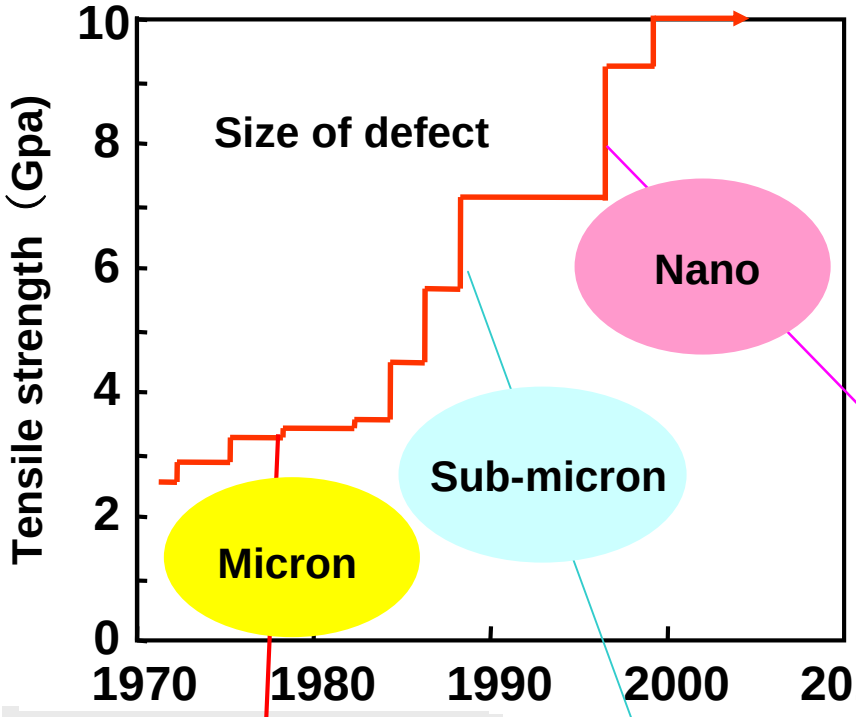
- Develop nano-matrix resin

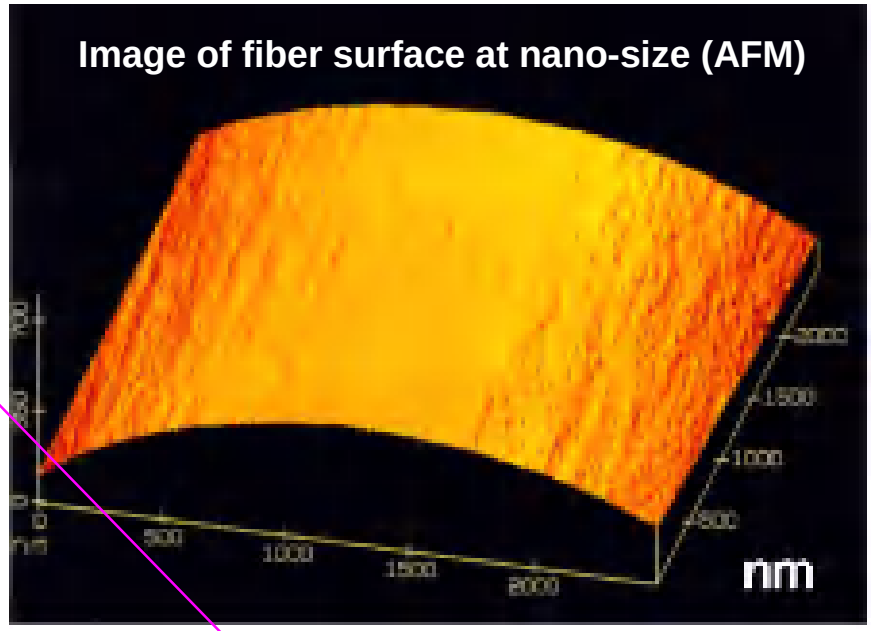
Reduce composite molding time

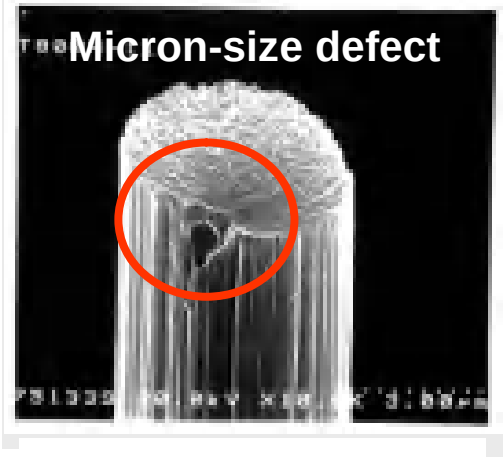
Expand technical center

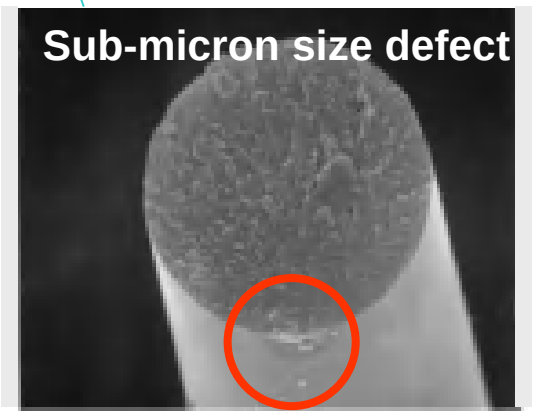
Pursuit of ultimate strength

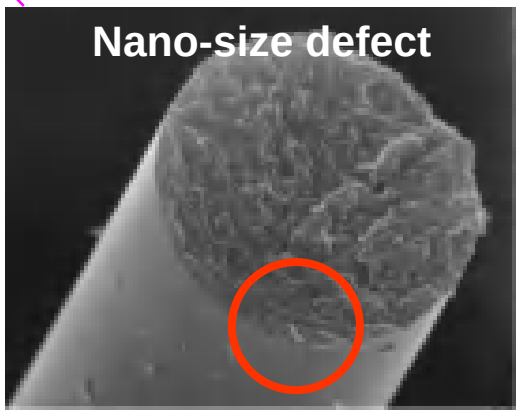
Control of surface defect at nano-level



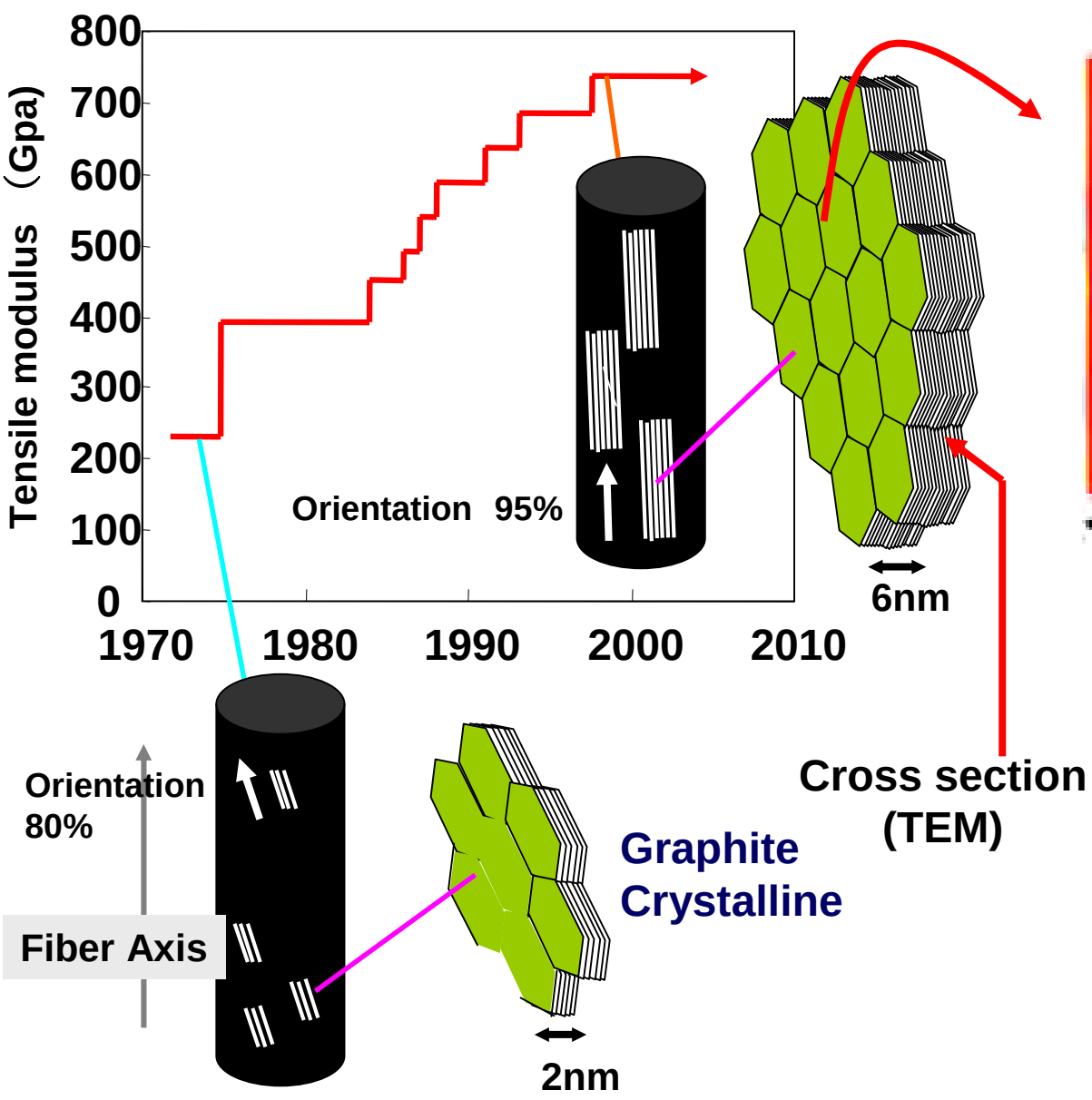


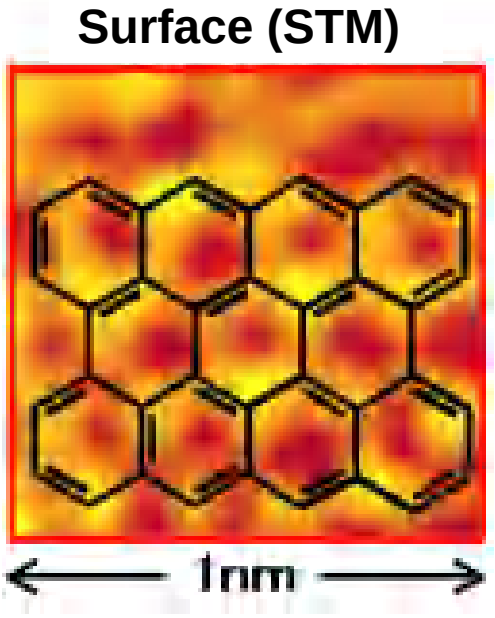


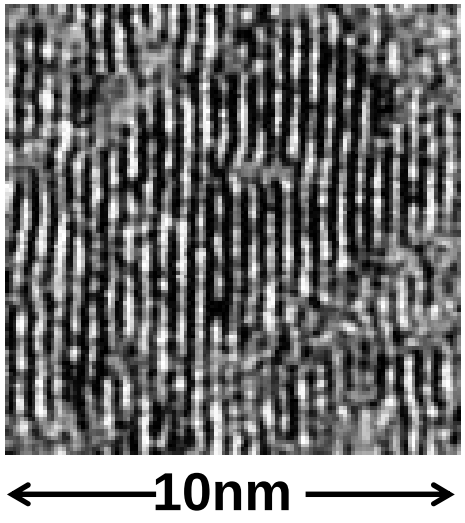




Pursuit of ultimate modulus



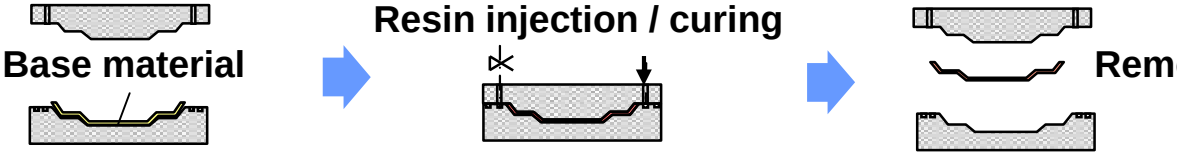


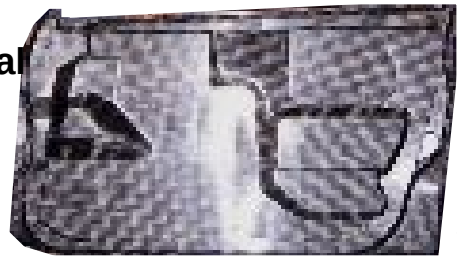


Reduction of composite molding time

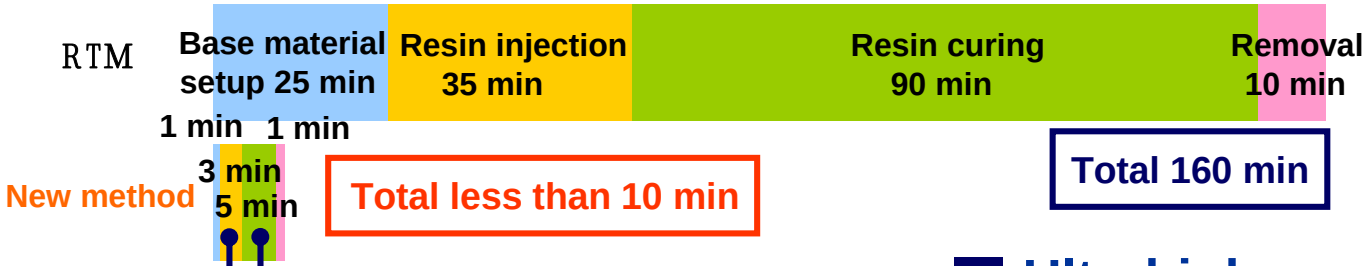
Reduced composite molding time by developing ultrahigh-speed curing resin and high-speed resin injection technology in national project led by NEDO

Achieved less than 10 minutes of molding by new method

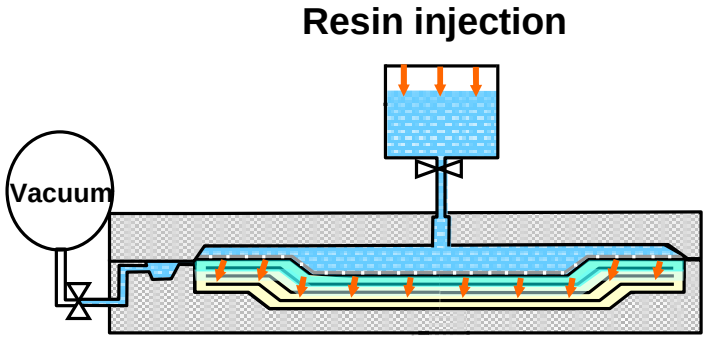




Demonstration of 10 minutes molding in inner door panel

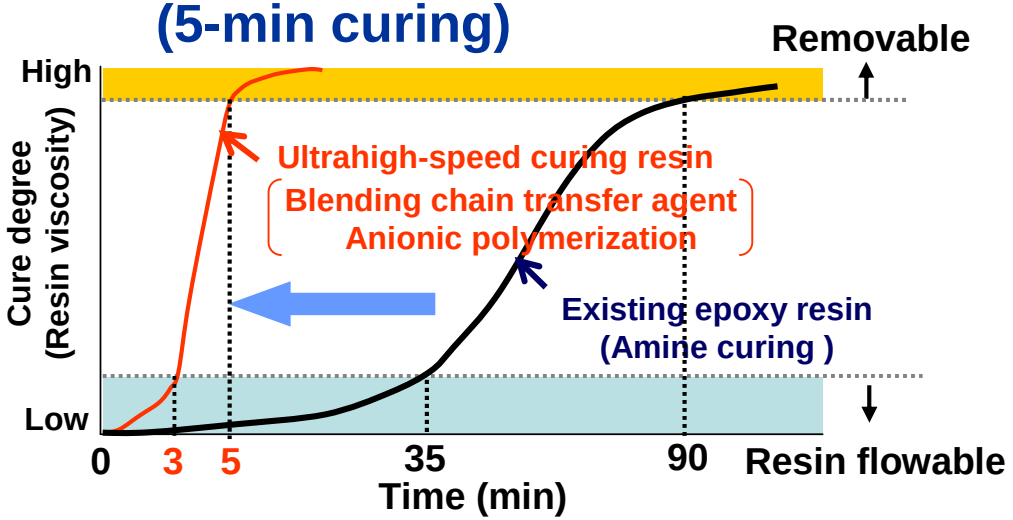


High-speed resin injection technology (3-min injection)



It takes 3 min by multipoint injection

Ultrahigh-speed curing resin (5-min curing)



*Based on isothermal condition

4 worldwide R&D sites [R&D workforce: Approx. 350 workers]

Site	Name of unit	Main function
TORAY	Technical Dept. / Research institution, A&A center	- Basic and general R&D center - Headquarter of R&D
TCA	Technical center / Research institution	- R&D for aircraft Prepreg & resin
CFA	Technical center	- Develop industrial application in US - R&D for Carbon fiber
SOFiCAR	Composite center	- Develop industrial application in EU - Develop molding method

- TORAY : General R&D center from yarn to composite material
- Overseas site: Develop new application with market-based development function

Enhancement of Technical support / Solution, Cooperation among government, industry and academia, Discover potential needs

Expand business in high-performance field and composite business in which we can take advantage of our strength

Core business: Commercial aircraft, Pressure vessel, Civil engineering, sports, etc.

Long-term Growing business: Automobile, Electrical cable, Robot, Uranium centrifuge, etc.

Basic strategy 3

Expand supply capability by continuing proactive capital investment

Continue capital investment in worldwide

In Japan : 1 line precursor / 1 line CF / 1 line Prepreg – under construction
In USA : 1 line precursor / 1 line CF / 1 line Prepreg – under construction
In EU : 1 line CF – under construction

Plan to start local production of Precursor and Prepreg in Europe

Establish first production line of precursor and Prepreg in Europe

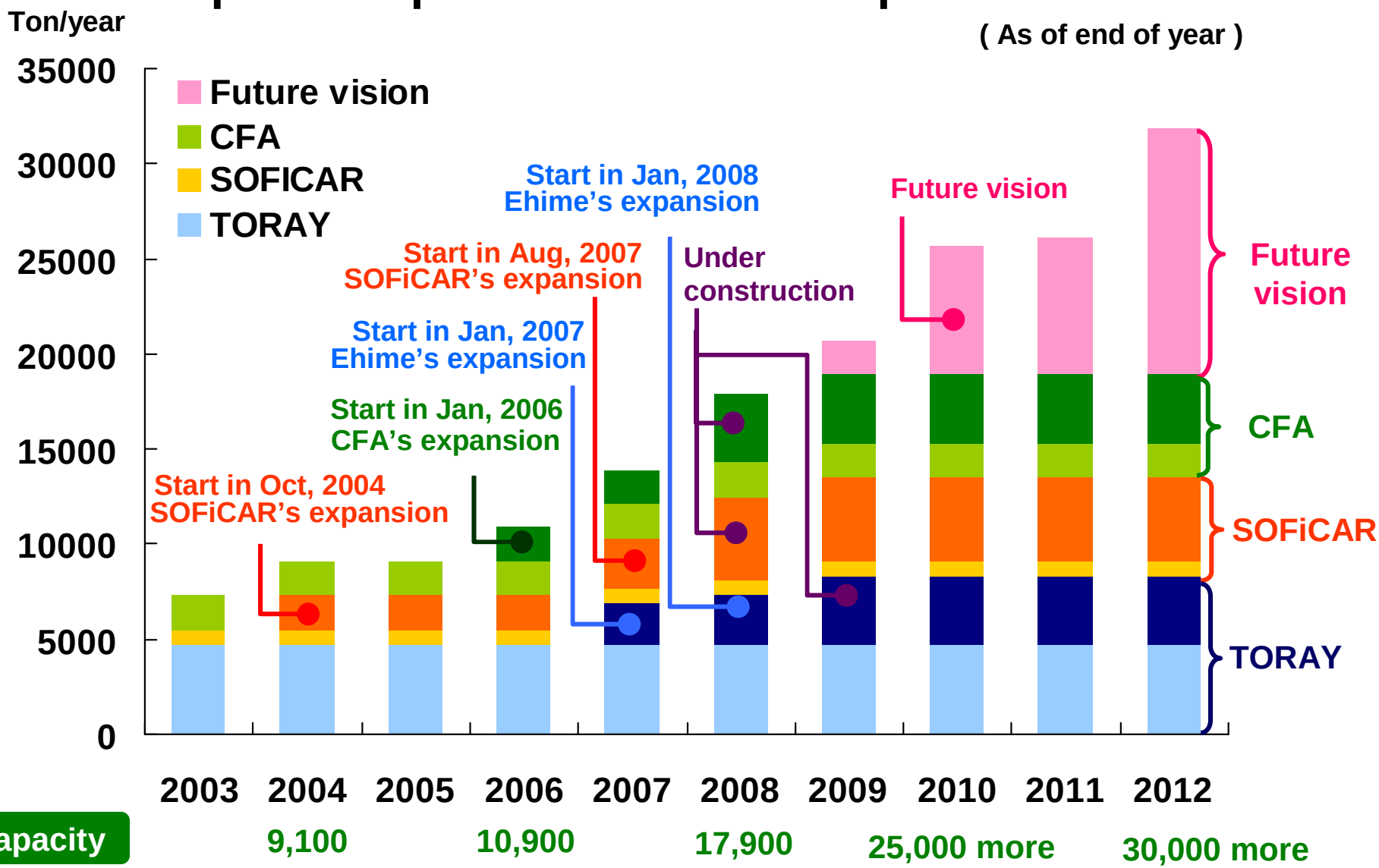
→ Integrated production system from precursor to Prepreg
Reduction of transport cost

Install dedicated large machine for industrial application

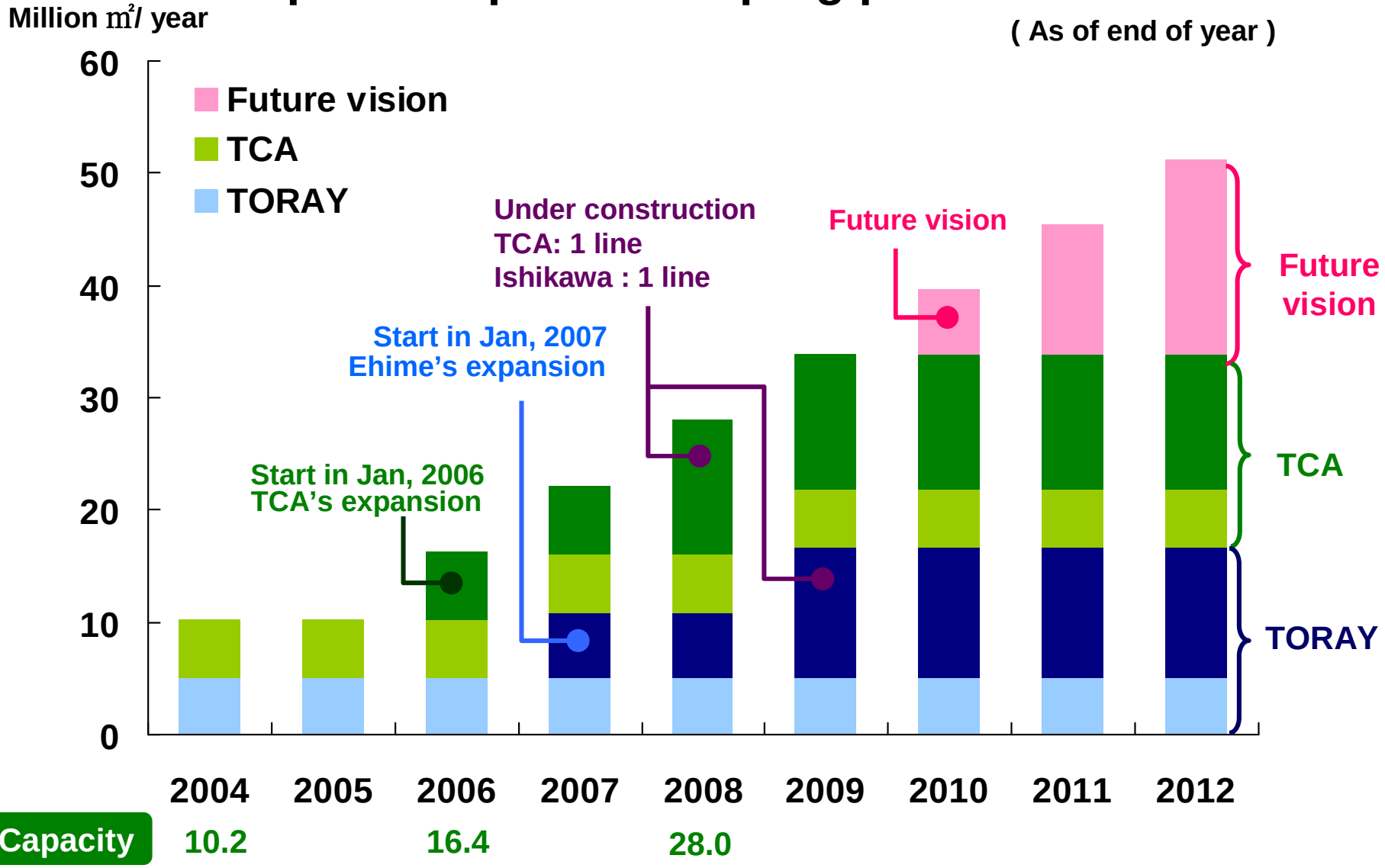
World's largest dedicated machine with 4000ton production capacity

→ Cost-down by high energy efficiency and scale merit
Secure suitable supply

Expansion plan of carbon fiber production lines



Expansion plan of Prepreg production lines



Give consideration to recycle and global environment

Establish CF recycle technology

- Establish Collecting system
- Demonstrate recycle technology
- Verify business potential

Survey CF's effect on global environment

- Survey CF's LCA
- Analyze production energy of CF and reduce its energy

Consideration to global environment

JCMA started establishing CF recycle system and studying its business

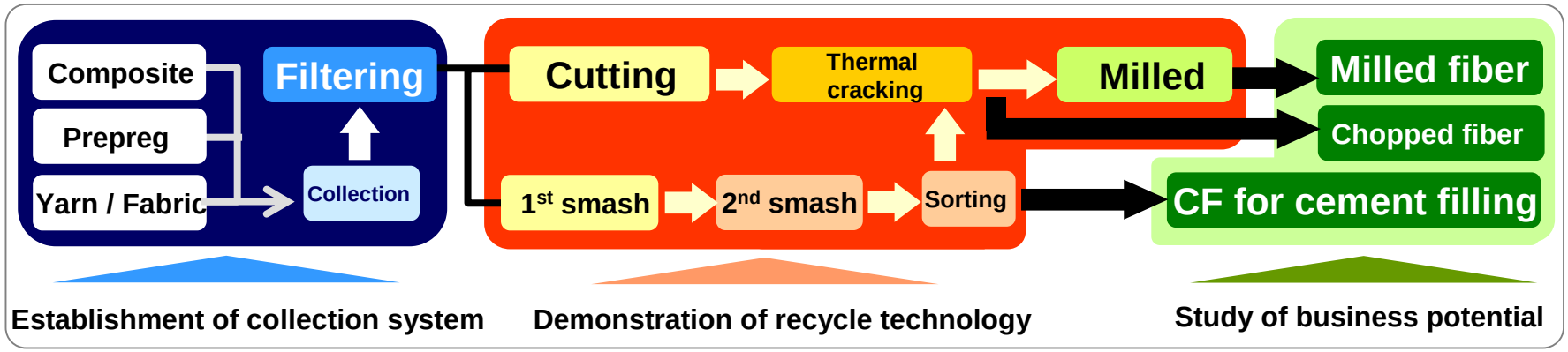
◆Granted project of METI

Theme: The energy reduction at carbon fiber manufacturing process

* JCMA promotes “Proof research and development of carbon fiber recycling technology”

◆Twentieth production energy compared with producing CF from raw materials (Estimation)

◆CF recycle flow



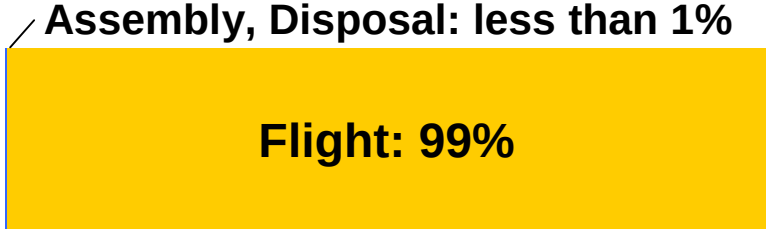
◆Schedule

Apr, 2008	Start-up of a pilot plant
Apr, 2008 – Mar, 2009	Demonstrated operation of recycle process and evaluation
Summer, 2008	Start of user’s evaluation

LCA of aircraft and automobile ("TORAY model")

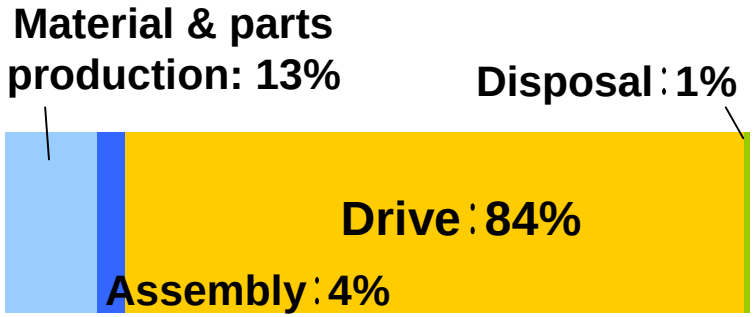
LCA (Life Cycle Assessment): the assessment of the environmental impact of a given product or service throughout its lifespan

Aircraft CO_2 emission



(Based on 10-year operation)

Automobile CO_2 emission



(Based on 10-year driving)

Most part of CO_2 is emitted during operation and driving

Improvement of mileage by weight saving with using Carbon Fiber is a key to reduce CO_2 emission.

Give consideration to global environment

LCA of aircraft and automobile ("TORAY model")

Aircraft CO_2 emission

CFRP in use at 50% → 20% weight saving

Annual 2,700 tons CO2 reduction / aircraft

Automobile CO_2 emission

CFRP in use at 20% → 30% weight saving

Annual 0.5 tons CO2 reduction / car

Amount of CO_2 emission reduction in Japan (CFRP in use)

Japan 430aircrafts (more than 100 seats) 2,700t/(unit -year) : Approx. 1 MM t CO_2/year

Japan 42MM cars (except mini cars), 0.5t/(unit-year) : Approx. 20 MM t CO_2/year

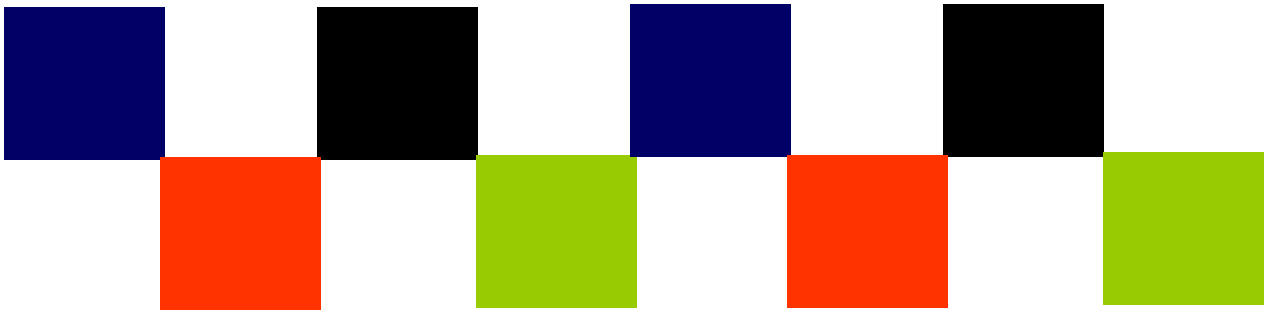
Total Approx. 21 MM t CO2/year

Contribution to reduction of Japanese CO_2 emission (CFRP in use)

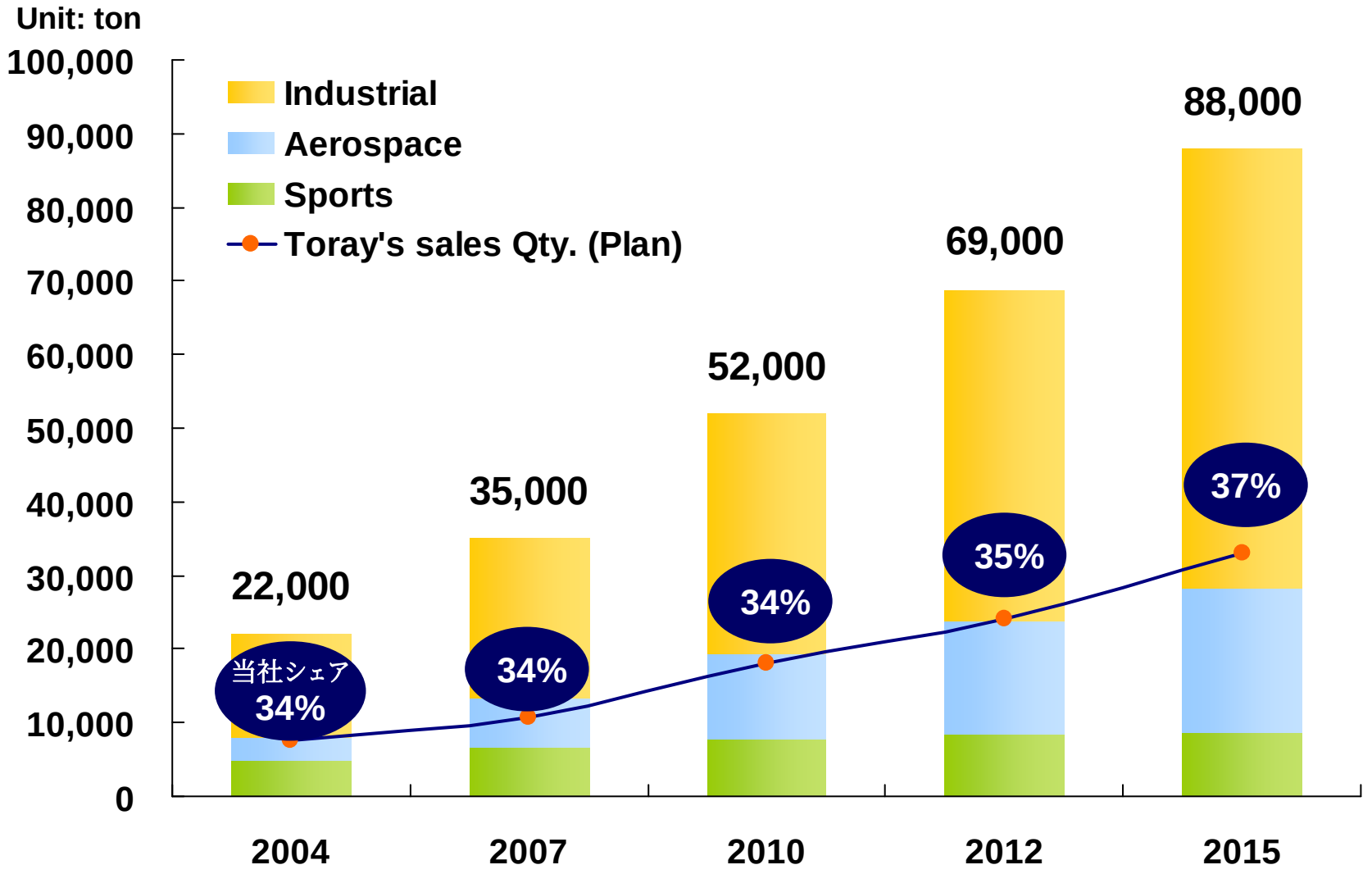
Equal to 1.5% of Japanese gross CO_2 emission – 1.3 billion ton CO_2/year)

(Equal to 8% of Japanese transportation dept. CO2 emission – 0.25 billion ton CO2/year)

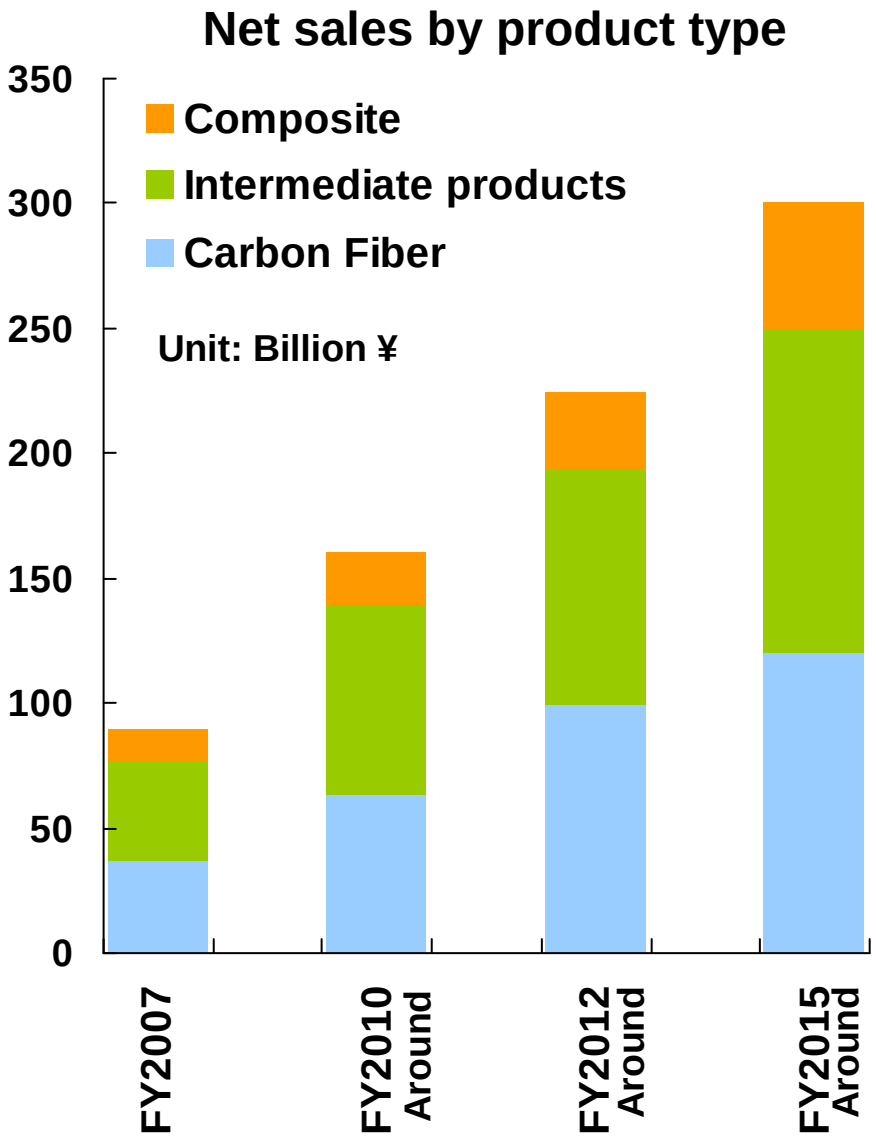
Business Plan

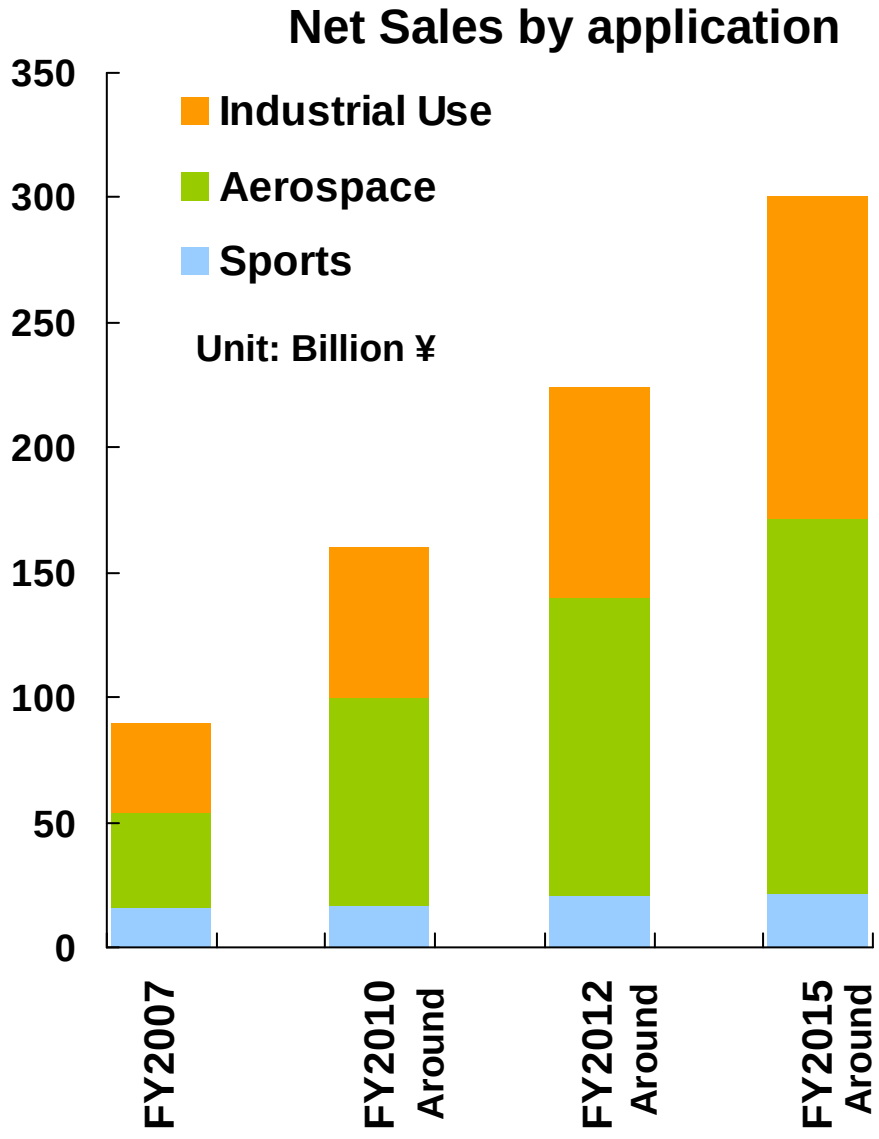


Market share by application



Future business scale (Vision)





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