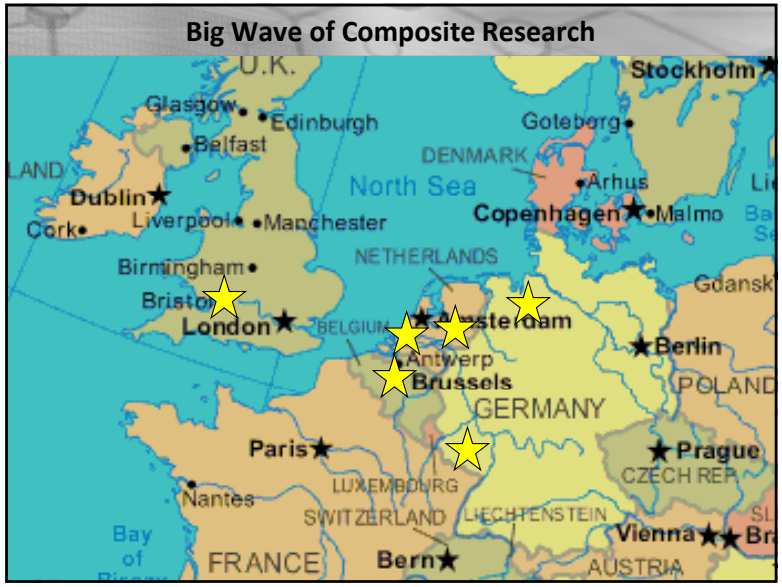
13th Japan International SAMPE Symposium & Exhibition (JISSE-13)
11-13 November 2013
Nagoya, Japan

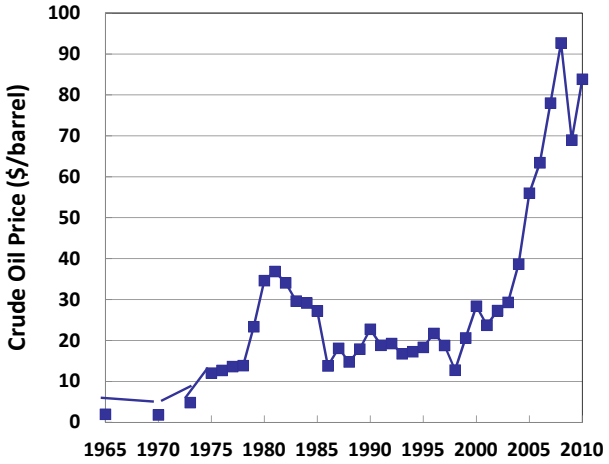
Current Japanese Activity in CFRTP for Mass Production Automotive Application

Jun Takahashi
The University of Tokyo, Japan
and
Takashi Ishikawa
Nagoya University, Japan

Big Wave of Composite Research



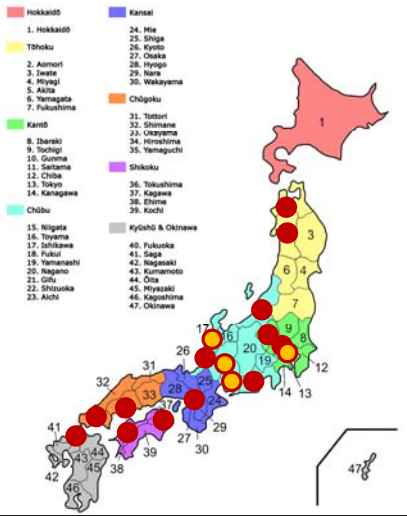
Long Term Trend in Crude Oil Price



Big Wave of Composite Research

Global Boom of Composite Materials

Japanese Regions and Prefectures Promoting CFRP



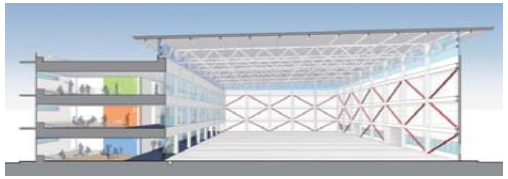
17/47

- ◆ Tohou
  - 2 Aomori
  - 5 Akita
- ◆ Kanto
  - 10 Gunma
  - 11 Saitama
  - 13 Tokyo ... LCIC
- ◆ Chubu
  - 15 Niigata
  - 17 Ishikawa ... ICC
  - 18 Fukui
  - 21 Gifu ... GCC
  - 22 Shizuoka
  - 23 Aichi ... NCC
- ◆ Kinki (Kansai)
- ◆ Chugoku
  - 34 Hiroshima
  - 35 Yamaguchi
- ◆ Shikoku
  - 36 Tokushima
  - 38 Ehime
- ◆ Kyushu
  - 40 Fukuoka

Recent Established Japanese Composite Research Centers

Since	Name	Full name	Location	Key persons	
2009 July	LCIC	Low Carbon Engineering Innovation Center	The University of Tokyo	Kazuro Kageyama Jun Takahashi	 
2012 April	NCC	National Composite Center	Nagoya University	Takashi Ishikawa	
2012 April	GCC	Gifu University Composite Materials Center	Gifu University	Takushi Miyake Asami Nakai	 
2012 August	ICC	Ishikawa Carbon Fiber Cluster	Kanazawa Institute of Technology	Isao Kimpara Kiyoshi Uzawa	 

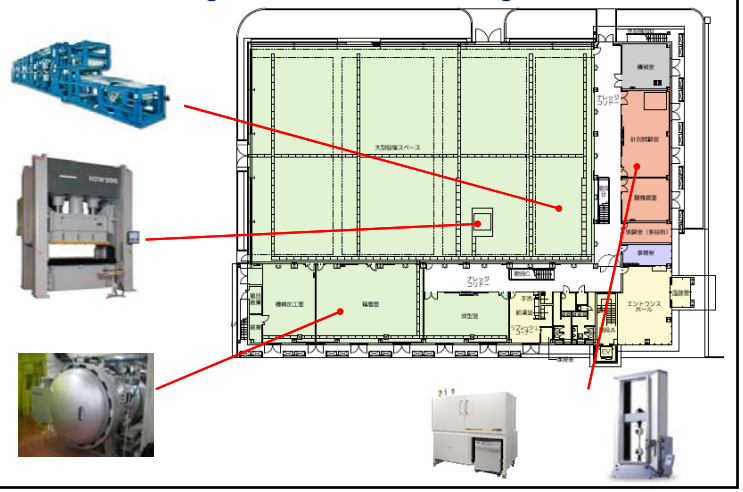
Ishikawa Innovative Composite materials research & development Center



4,400m² Total
2,500m² Working Area

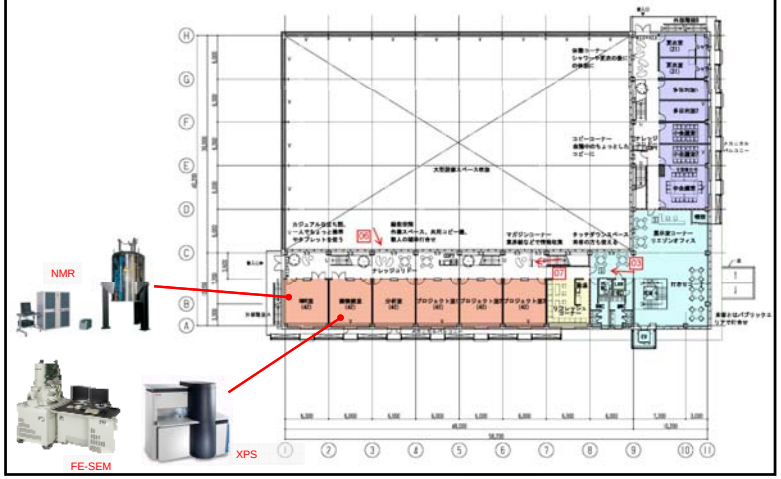
Ishikawa Innovative Composite materials research & development Center

1F Manufacturing and Mechanical Testing Facilities



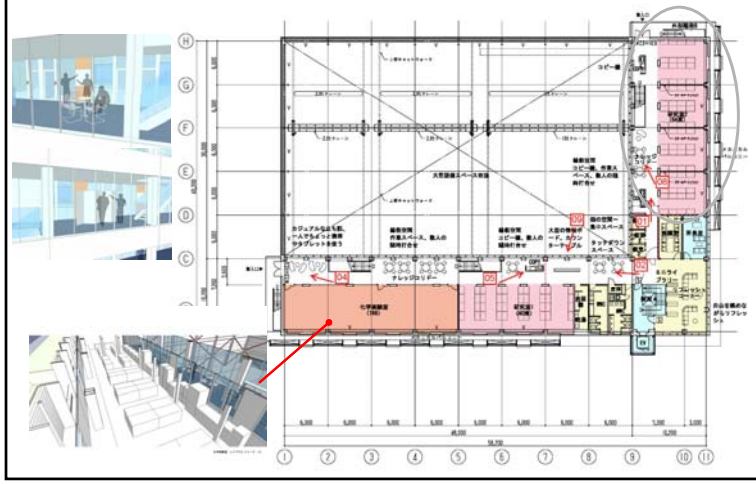
Ishikawa Innovative Composite materials research & development Center

2F Analytical Facilities and Laboratories

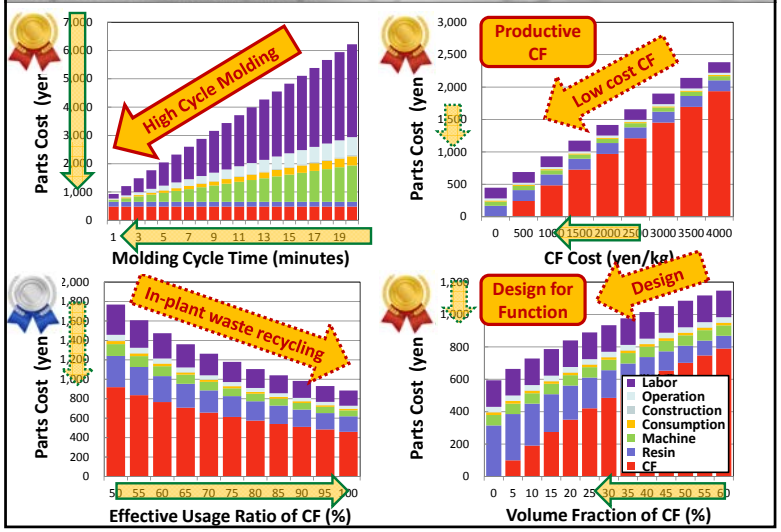


Ishikawa Innovative Composite materials research & development Center

3F Chemical Facilities and Laboratories



Effective Cost Reduction Methods of CF/PP Parts



World Carbon Fiber Potential Demand by Application

	unit	passenger automobile	truck	wind turbine blade	commercial airplane (L)
world stock	10^3	700,000@2010 1,000,000@2030	260,000@2010 380,000@2030	120@2010 1,000@2030	15@2010 30@2030
world annual production					
CF demand per product	ton	0.	0.4	4	25
world annual CF demand	10^3 tons per year	5,300@2010 7,500@2030 10,000@2050	8,000@2010 12,000@2030 16,000@2050	100@2010 200@2030 240@2050	15@2010 30@2030 45@2050
production volume per plant	per year	200,000	50,000	5,000	300
	per day	800	200	20	1.2
	per hour	50	13	1.25	0.075
number of plants (Assuming an ideal production plant)		65@2010	400@2010	5@2010	2@2010
CF demand per plant					

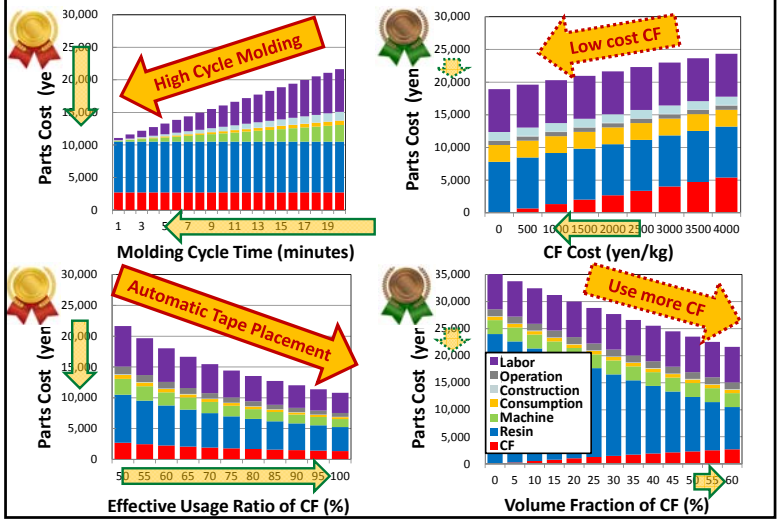
Drastic increase of carbon fiber production capacity is necessary

Japanese National Project 2011-2017

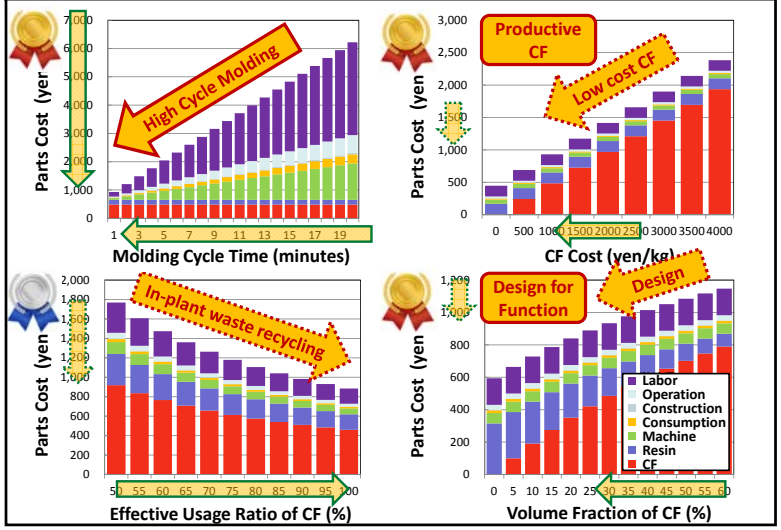
Drastic high cycle manufacturing technology of CFRP is necessary

Japanese National Project 2008-2022

Effective Cost Reduction Methods of CF/PEEK Parts



Effective Cost Reduction Methods of CF/PP Parts



Expectations for CFRTP

		Airplane	Automobile
Motivation		High oil price → tight national budget (including military budget) → low-cost CFRP (<50$/kg) and maintenance	High oil price and CO2 measures → weight lightening & early spread of EV (by battery reduction) → low-cost CFRP (<10$/kg) and recycling
Direction of technology development	Material & Preform	Low-cost engineering plastics	Low-cost & productive CF Low-cost general-purpose resin Low-cost impregnation
	Molding	Low-cost manufacturing → from hours to minutes → thermoforming/welding	Low-cost manufacturing → less than one minute → thermoforming/welding
		Yield improvement → automatic tape placement	Yield improvement → recycling of in-plant waste
		Measures for labor cost and intellectual property → automation	Measures for labor cost and intellectual property → automation
	Operation	Reparability Impact resistance Simplification of NDI	Reparability Recyclability of market waste New design for dynamic social demand

Japanese National Projects For Mass Production CFRP Automobile

2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020

CFRTP (material) Project *40M$*

- Parts replacement
- High cycle molding
- In-plant waste recycling

METI, NEDO, +5 (+5)
PL: Prof. Takahashi (LCIC)

LCIC, Mitsubishi Rayon, Toray, Toyobo, Takagi Seiko
(Kyoto Institute of Tech., Shizuoka Uni., Tohoku Uni., Toyama Uni., Yamagata Uni.)

CFRTP (structure) Project (2013-2022) *120M$*

- Composite design
- High cycle manufacturing
- Market waste recycling

METI, +25 (+9)
PL: Prof. Takahashi (LCIC), Prof. Ishikawa (N

LCIC, NCC, ICC, Tokyo Institute of Tech., Fukui Pre, NIMS, Mitsubishi Rayon, Toho Tenax, Toray, Toyo, Shimadzu, Aisin Seiki, Fukui Fibertech, KADO Corporation, Komatsu, Kyowa, Takagi Seiko, IHI, SHI, Honda, Mitsubishi Motors, Nissan, Suzuki, Toyota (GCC, Tohoku Uni., Yamagata Uni., AIST, JAXA, DOME, Taiseiplas, Toray Engineering)

2020 Tokyo

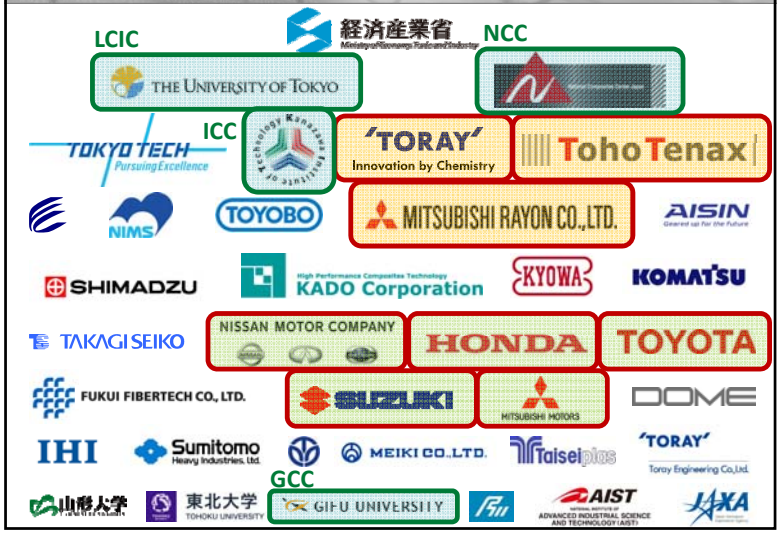
Innovative CF Project

- Productive & low cost

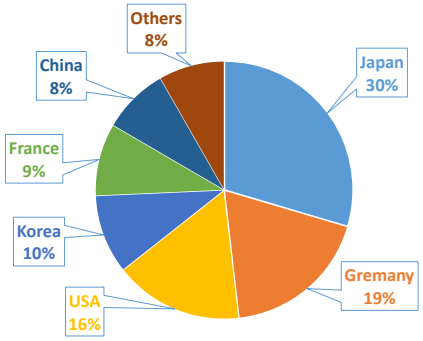
METI, +5
GM: Prof. Kageyama, PL: Prof. Hatori (LCIC)

LCIC, AIST, Mitsubishi Rayon, Teijin, Toray

Consortium Members (34) of CFRTP Project

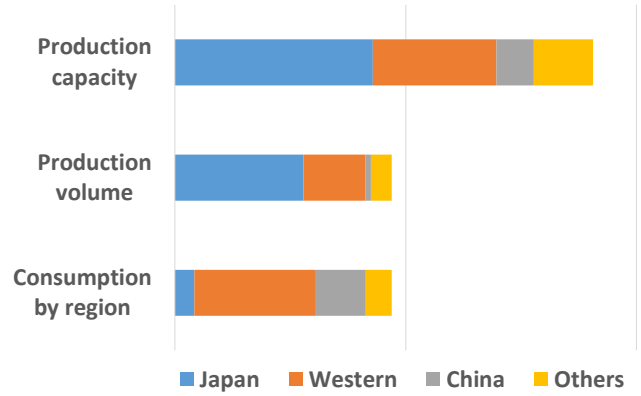


World Passenger Automobile Production Share (2011)

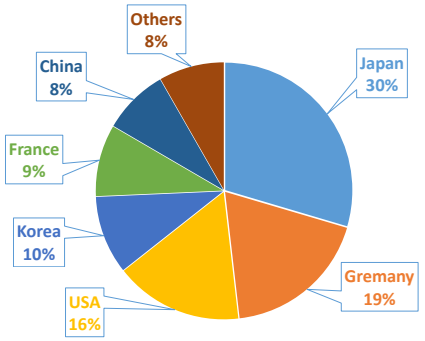


World production share	
Toyota	11%
Nissan	6%
Honda	5%
Suzuki	4%
Mazda	2%
Mitsubishi	2%
Subaru	1%

World Carbon Fiber Share (2012)



World Passenger Automobile Production Share (2011)



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CFRTP (material) Project
- Parts replacement
- High cycle molding
- In-plant waste recycling

METI, NEDO, +5 (+5)
PL: Prof. Takahashi (LCIC)

LCIC, Mitsubishi Rayon, Toray, Toyobo, Takagi Seiko (Kyoto Institute of Tech., Shizuoka Uni., Tohoku Uni., Toyama Uni., Yamagata Uni.)

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PL: Prof. Takahashi (LCIC), Prof. Ishikawa (NCC)

LCIC, NCC, ICC, Tokyo Institute of Tech., Fukui Pref., JFCC, NIMS, Mitsubishi Rayon, Toho Tenax, Toray, Toyobo, Shimadzu, Aisin Seiki, Fukui Fibertech, KADO Corporation, Komatsu, Kyowa, Takagi Seiko, IHI, SHI, Honda, Mitsubishi Motors, Nissan, Suzuki, Toyota (GCC, Tohoku Uni., Yamagata Uni., AIST, JAXA, DOME, Taiseiplas, Toray Engineering)

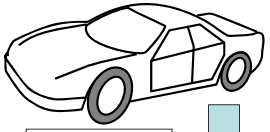
Innovative CF Project
- Productive & low cost

METI, +5
GM: Prof. Kageyama, PL: Prof. Hatori (LCIC)

LCIC, AIST, Mitsubishi Rayon, Teijin, Toray

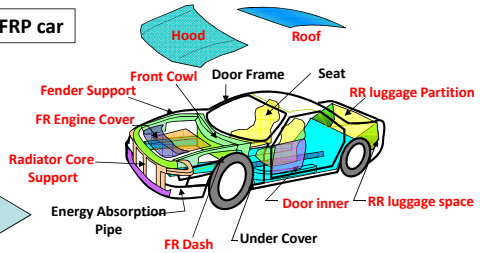
Weight Reduction Concept by using CFRTP

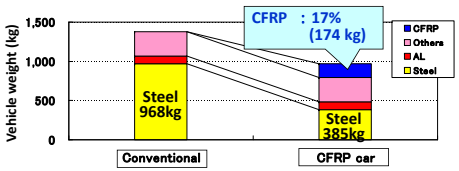
◆ Conventional car and CFRP car



Standard sedan

CFRP





Continuous CFRTP
:Structural member such as frame
Discontinuous isotropic CFRTP
: Panels, complex parts

Body weight 1380→970kg（▲30%）

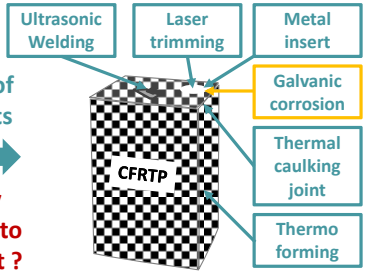
Body weight can be reduced by 30% with CFRTP application

How to make Oil Can by CFRTP ?

Rectangular Steel Oil Can

Replacement of individual parts

Is this really the right way to reduce weight ?



Design by composites

More Flexible !

More Functional !

More Cute !

Japanese National Projects For Mass Production CFRP Automobile

2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020

CFRTP (material) Project

- Parts replacement
- High cycle molding
- In-plant waste recycling

METI, NEDO, +5 (+5)
PL: Prof. Takahashi (LCIC)

LCIC, Mitsubishi Rayon, Toray, Toyobo, Takagi Seiko (Kyoto Institute of Tech., Shizuoka Uni., Tohoku Uni., Toyama Uni., Yamagata Uni.)

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- Composite design
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Innovative CF Project

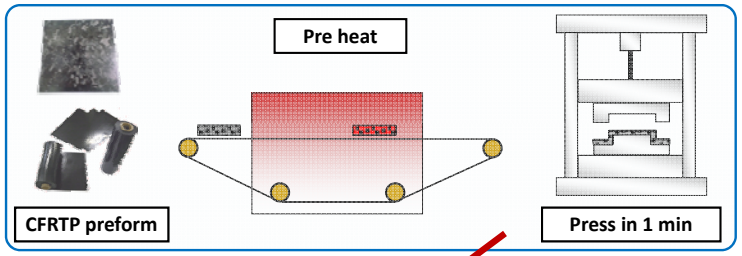
- Productive & low cost

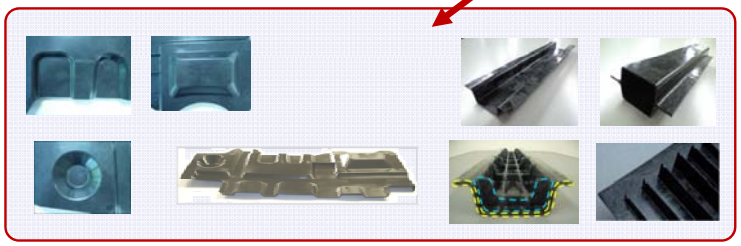
METI, +5
GM: Prof. Kageyama, PL: Prof. Hatori (LCIC)

LCIC, AIST, Mitsubishi Rayon, Teijin, Toray

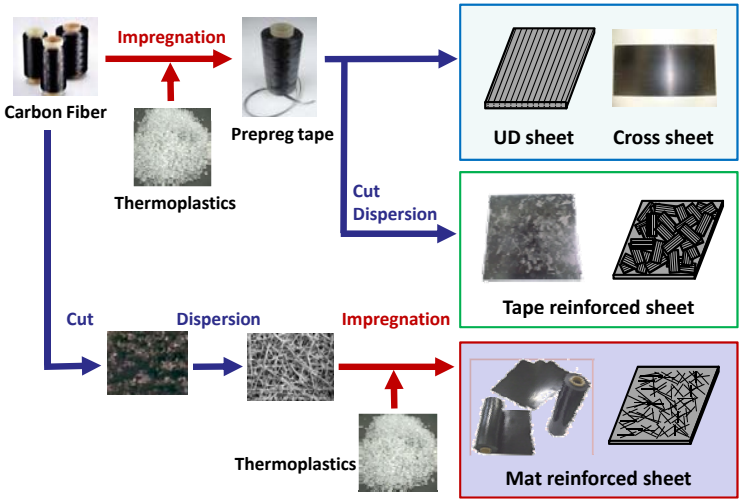
Heat and Cool Molding is not bad, however…

Continuous Compression Molding for Mass Production

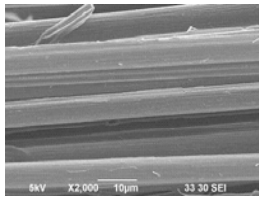




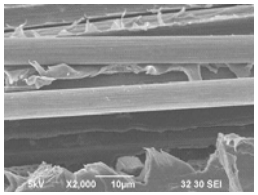
Thermoplastic Preforms for Complex Parts



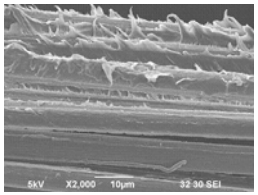
Modification of both CF and PP to Improve Adhesion



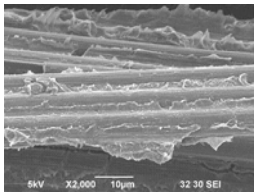
Normal CF
+ PP without modification



Special treated CF
+ PP without modification

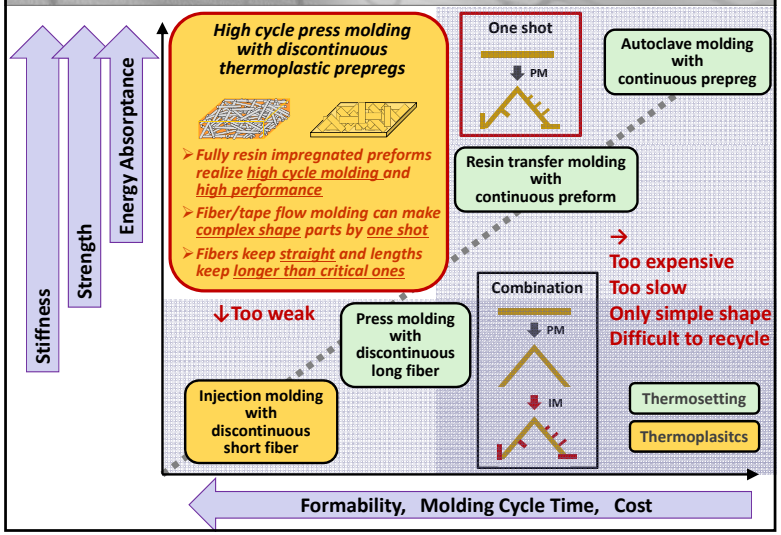


Normal CF
+ PP with modification

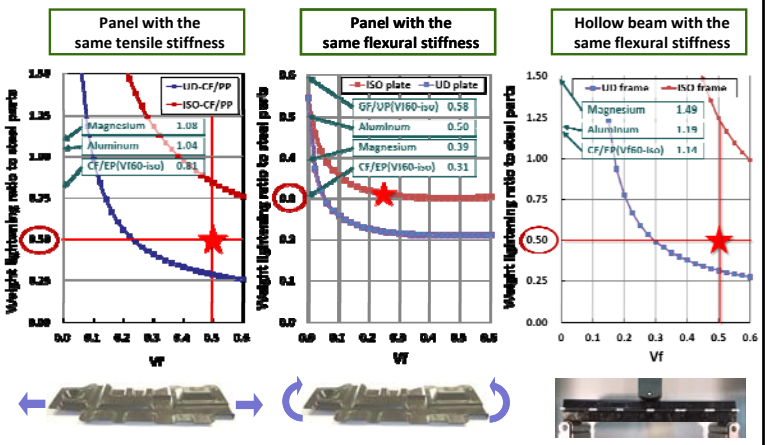


Special treated CF
+ PP with modification

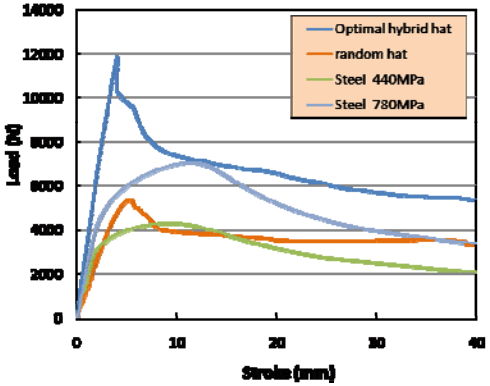
Developing Direction of CFRTP for Mass Production



Comparison of Weight Lightening Ratio between CF/PP and Steel Parts



Comparison between CFRTP and Steel Hollow Beam



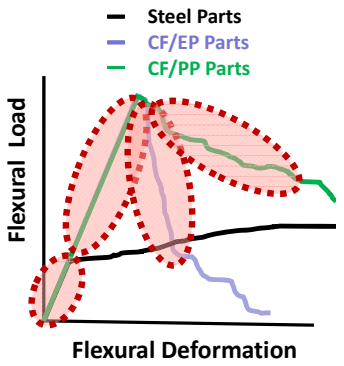
- Weight is 50%
- Energy absorption capacity is
  2.0 times of 440MPa grade steel
  1.5 times of 780MPa grade steel

Comparison of Fracture Process

CF/EP

CF/PP

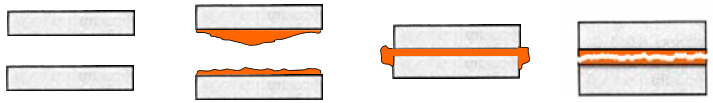
Comparison of Steel, CF/EP, and CF/PP Parts



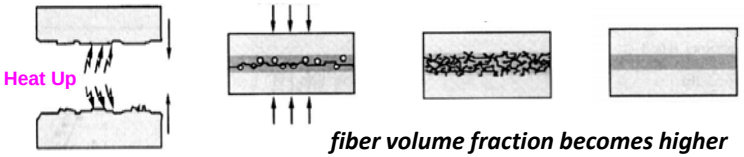
1. Compared to steel parts, the weight of CFRP parts is from 1/3 (plate) to 1/2 (beam).
2. Elastic strain range of CFRP is larger, hence less likely to dent.
3. CF/EP shows sudden load fall due to the delamination, hence is weak in hole, notch and corner.
4. CF/PP not only shows high energy absorption capacity but is stronger in hole, notch and corner.
5. Additionally, CF/PP can easily bond, repair and recycling by using thermoplasticity.
6. By using these features of CF/PP, new structures and manufacturing methods can be developed.

Difference in Adhesion between CFRTS and CFRTP

CFRTS: Bolted or adhesive joint --- weaker than base material

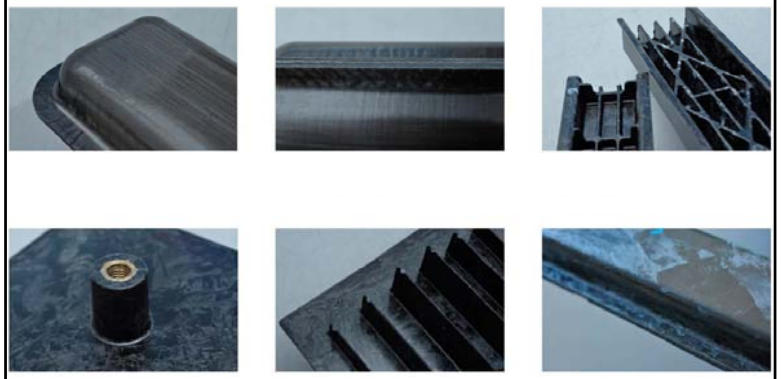


CFRTP: Welding joint --- the same or stronger than base material

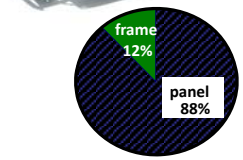


fiber volume fraction becomes higher and fiber tangles at the welded section !

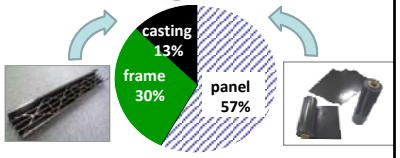
Sample Parts by using Discontinuous CF Preforms



Automotive Materials and Structures



< Monocoque body >
Better structure for lightweight

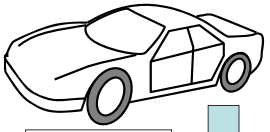


< Frame monocoque hybrid body >
Better for safety and recyclability

- Automobile parts are mostly composed of plates.
- Flexural properties are dominant in the case of automotive materials and structures.

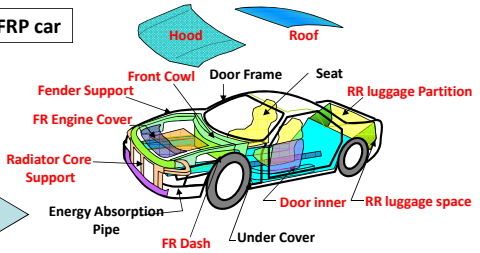
Weight Reduction Concept by using CFRTP

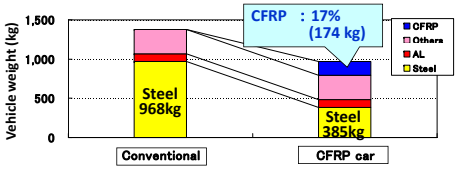
◆ Conventional car and CFRP car



Standard sedan

CFRP





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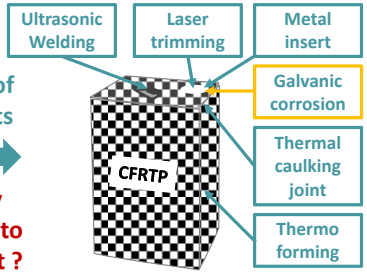
Replacement of individual parts

Is this really the right way to reduce weight ?



Design by composites

More Flexible !

More Functional !

More Cute !

Japanese National Projects For Mass Production CFRP Automobile

2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020

CFRTP (material) Project

- Parts replacement
- High cycle molding
- In-plant waste recycling

METI, NEDO, +5 (+5)
PL: Prof. Takahashi (LCIC)

LCIC, Mitsubishi Rayon, Toray, Toyobo, Takagi Seiko (Kyoto Institute of Tech., Shizuoka Uni., Tohoku Uni., Toyama Uni., Yamagata Uni.)

CFRTP (structure) Project (2013-2022)

- Composite design
- High cycle manufacturing
- Market waste recycling

METI, +25 (+9)
PL: Prof. Takahashi (LCIC), Prof. Ishikawa (NCC)

LCIC, NCC, ICC, Tokyo Institute of Tech., Fukui Pref., JFCC, NIMS, Mitsubishi Rayon, Toho Tenax, Toray, Toyobo, Shimadzu, Aisin Seiki, Fukui Fibertech, KADO Corporation, Komatsu, Kyowa, Takagi Seiko, IHI, SHI, Honda, Mitsubishi Motors, Nissan, Suzuki, Toyota (GCC, Tohoku Uni., Yamagata Uni., AIST, JAXA, DOME, Taiseiplas, Toray Engineering)

Innovative CF Project

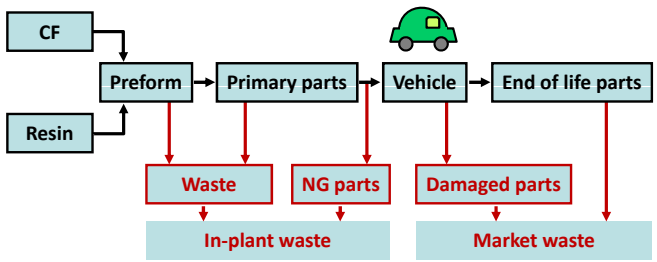
- Productive & low cost

METI, +5
GM: Prof. Kageyama, PL: Prof. Hatori (LCIC)

LCIC, AIST, Mitsubishi Rayon, Teijin, Toray

How to Reduce or Reuse the In-plant Waste of CFRP ?

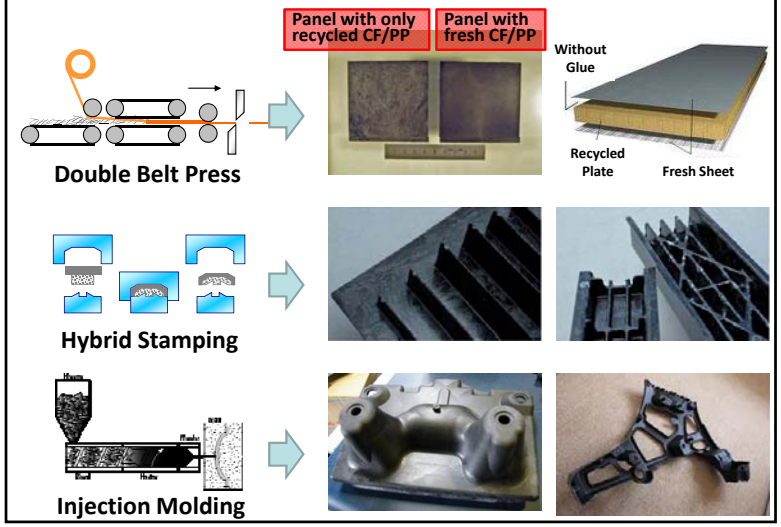
"in-plant waste" and "market waste"



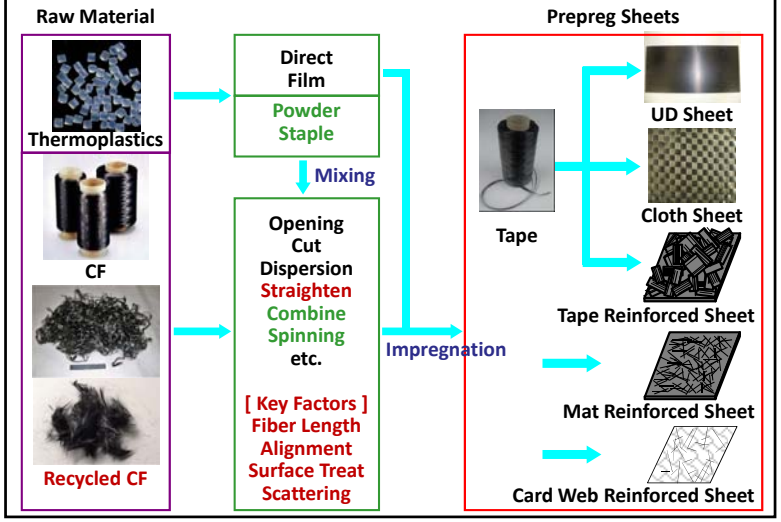
"in-plant waste" : identity of the material is clear
no environmental degradation ⇨ high quality recycled materials

"market waste" : identity of the material is not clear
with environmental degradation

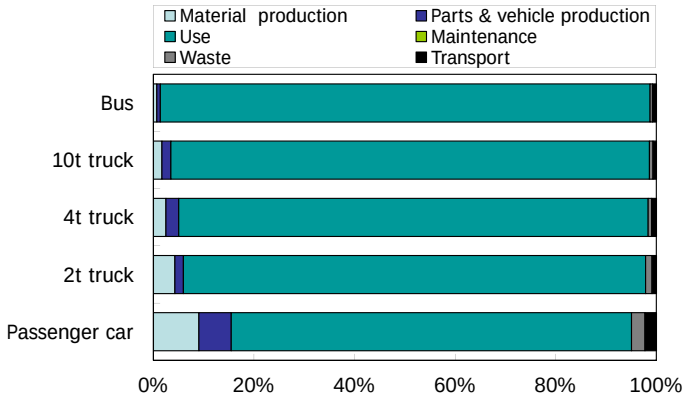
Recycling of In-Plant CFRTP Waste



Thermoplastic Prepreg Sheets by Waste CFRP



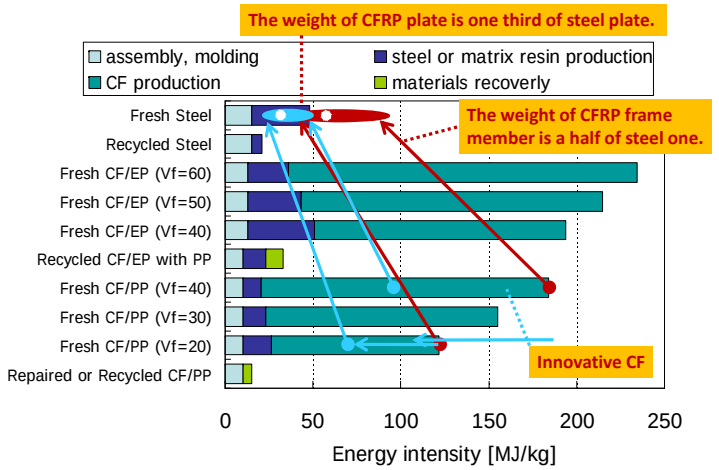
Life cycle energy consumption of various types of vehicles



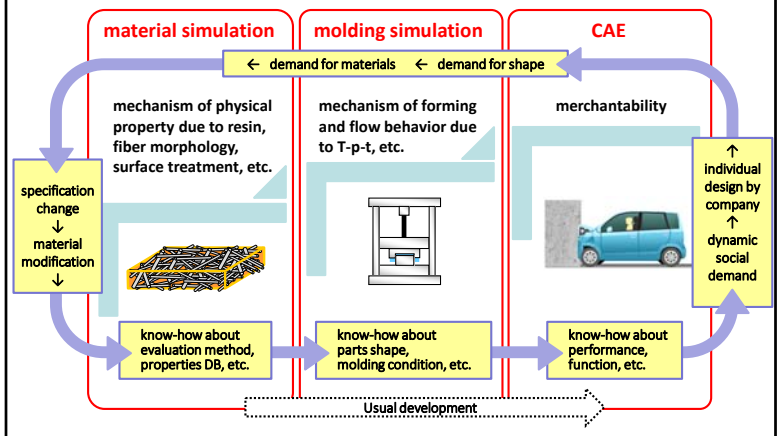
Source: J. Kasai, The Int. J. of Life Cycle Assessment, Vol.5, No.5, p.316 (2000)

Energy Consumption for Parts Production

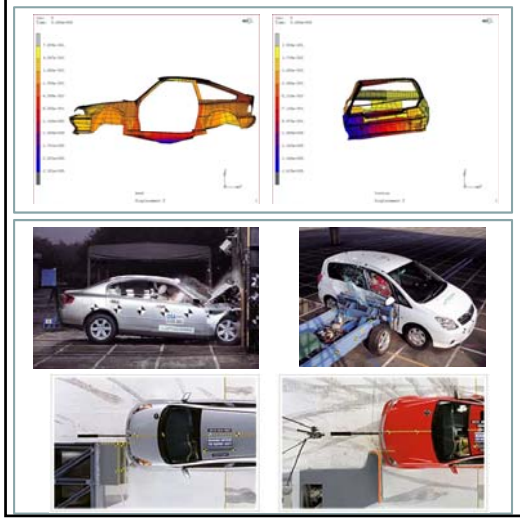
Energy Consumption [MJ/parts] ≠ Energy Intensity [MJ/kg]



Systematic R&D of CFRTP Technologies



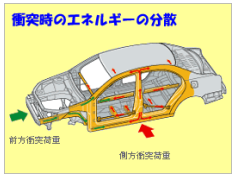
Solve the New Requests for Automobile !



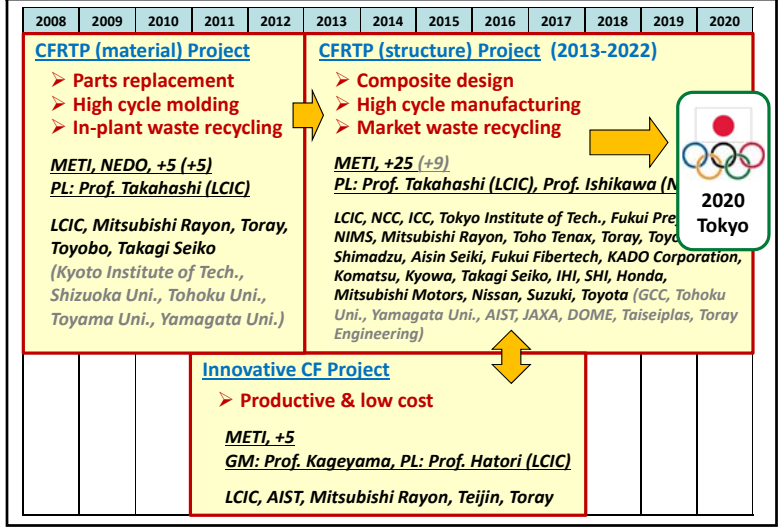
Stiffness

For driving performance
↑
Panel parts solve them

Energy Absorption
↑
Frame parts solve them



Japanese National Projects For Mass Production CFRP Automobile



Thank you for your kind attention.

INNOVATION

THE UNIVERSITY OF TOKYO