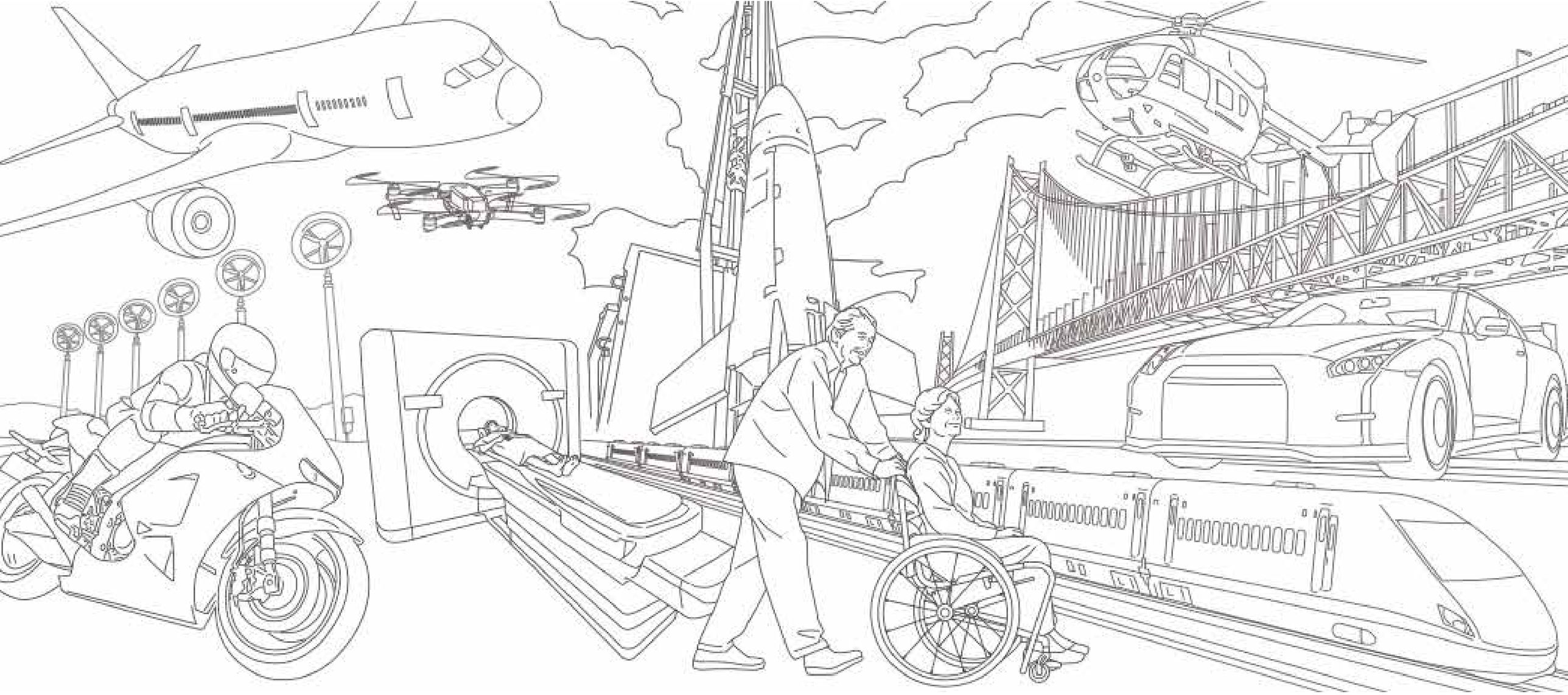


Development Case Studies

Aerospace, Drone, Automobile, Motorcycle, Racing, Sports, Consumer

"TORAY" Toray Carbon Magic

ORBITAL LAUNCH VEHICLE

Interstellar Technologies Inc.

Supported the development of CFRP for important parts such as satellite fairings, contributing to weight reduction and quality assurance.

"ZERO" is a liquid-fuel rocket currently under development by Interstellar Technologies, which will provide a space transportation service exclusively for small satellites. We have been involved in the project since the prototype stage, and have adopted CFRP for key components such as the satellite fairing, satellite payload, and fuselage. We have developed a parts manufacturing method based on analysis, contributing to weight reduction. We have also made the most of our in-house facilities, contributing to quality assurance.

Rocket fuselage

Satellite fairing

Scope of support

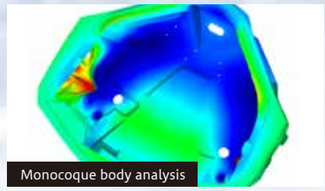
Development Part	Satellite fairing / satellite payload / fuselage
Required Characteristics	Lightweight / Rigidity / Impact resistance
Development Scope	Design / Structural analysis / Evaluation testing / Prototype / Manufacturing
Development Period	Approximately 3 years (development ongoing)
Molding Method	Autoclave
Size	Aircraft specifications: Length 32m, diameter 2.3m
Weight	71t

'TORAY' Toray Carbon Magic

YMR-08

YAMAHA
Yamaha Motor Co., Ltd.

Monocoque body



Monocoque body analysis

Propeller arm

By Making Aircraft Body A CFRP Monocoque (stressed-skin structure), Integration of Many Parts Has Been Achieved, Contributing to Cost Reduction

The industrial multi-rotor YMR-08 employs a CFRP monocoque body and CFRP movable propeller arms that have achieved design and ultimate lightweighting in order to achieve a maximum takeoff weight of 25 kg or less. Our company has been involved from the development stage, and has combined our unique design and analysis know-how with Yamaha's technology to complete the current part. In addition, the monocoque construction has achieved the integration of many parts, contributing to price reduction. The monocoque body is manufactured using the autoclave molding method, achieving a shape that would be difficult to mold using other methods. The propeller arm is manufactured using the sheet winding molding method. The production with use of our own materials and equipment has contributed to quality assurance and a price reduction.

Scope of support

Development Part	Monocoque Body / Propeller Arm / Boom
Required Characteristics	Lightweight / Rigidity / Design
Development Scope	Structural Analysis / Design / Material Selection / Evaluation Testing / Prototyping / Molding MethodSelection / Manufacturing / Production Technology / Mass Production
Development Period	Approx. 3 years
Molding Method	Autoclave (monocoque body) / Sheet Winding (propeller arm, boom)
Size	Aircraft Maximum Overall Length 1923 mm / Maximum Overall Width 2181 mm / Overall Height 669 mm
Weight	Aircraft Maximum Takeoff Weight 24.9 kg or less

FAZER R

YAMAHA
Yamaha Motor Co., Ltd.

CFRP tail rotor

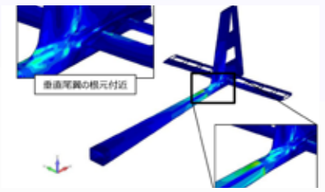
Complete set of CFRP parts

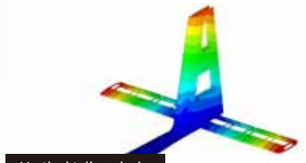
Contribution of Lightweighting of Body and Functional Parts to Improve Performance, Such as Higher Functionality of Aircraft and Increased Payload Capacity.

The industrial unmanned helicopter FAZER R has been striving to be the best partner in response to changes in the agricultural environment through its innovative technology. Achievement of high-quality spraying performance has led to realization of a reduction in the workload. It features a body made of CFRP and functional parts made of CFRP that have achieved design and the most lightweight. Our company has been involved from the development stage and has combined our unique design and analysis know-how with Yamaha's technology to complete the current part. In addition, the use of CFRP has reduced weight, resulting in higher functionality and increased payload capacity, thereby contributing to improve the performance of Yamaha's unmanned helicopter. Each CFRP part was molded with use of autoclave method to achieve shapes that would be difficult to mold using other methods. We used our own materials and equipment to produce the parts, which contributed to quality assurance and price reduction.

Scope of support

Development Part	Body / Functional Parts / Cover / Propeller etc.
Required Characteristics	Lightweight / Rigidity / Fatigue Resistance / Corrosion Resistance / Vibration Damping / Design / Impact Energy
Development Scope	Structural Analysis / Fluid Analysis / Design / Material Selection / Evaluation Testing / Prototyping Molding Method Selection / Manufacturing / Production Technology / Mass Production
Development Period	Approx. 3 years
Molding Method	Autoclave
Size	Aircraft Overall Length 3665 mm / Overall Width 770 mm / Overall Height 1078 mm
Weight	Total Aircraft Weight (with oil / fuel tanks full) 71 kg





Vertical tail analysis

SOLAR PHOENIX

NEDO / SKY Perfect JSAT Corporation / Tokai University

A Fully Composite Solar Plane That Has Achieved Lightweighting While Efficiently Securing Strength and Rigidity

This aircraft is the result of a project commissioned by New Energy and Industrial Technology Development Organization (NEDO), National Research and Development Agency. Toray Carbon Magic received orders from SKY Perfect JSAT Corporation and Tokai University for designing, performing structural analysis, and manufacturing a full composite aircraft (wing length 16 m) in 2019. The hybrid composite structure, which uses carbon fiber, aramid fiber, and glass fiber in the right places, was optimized using FEA, and combined with Toray's high-elasticity and high-strength fibers, it efficiently ensured strength and rigidity, achieving the target weight reduction. The aircraft has completed several flight tests, accomplishing its initial objectives, and future technological developments are anticipated.

Scope of support

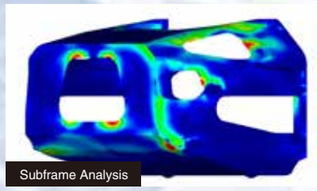
Application	Electric Aircraft Drones (unmanned aerial vehicles)
Development Part	Aircraft
Required Characteristics	—
Development Scope	—
Development Period	—
Molding Method	Autoclave
Size	Overall Length 6,200 mm / Overall Width 16,000 mm / Overall Height 1,900 mm
Weight	—

NISSAN LEAF NISMO RC

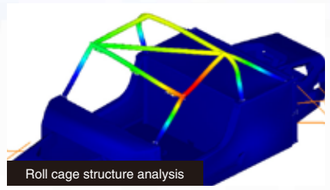
nismo
Nissan Motorsports International Co., Ltd.

Cooperating in Development and Manufacturing of Major Structural Components and Contributing to Lightweighting on Overall Vehicle and Optimization on Weight Balance

The new EV racing concept car NISSAN LEAF NISMO RC_02 was developed with the following concept as NISMO.
1. Demonstrate the outstanding performance of Nissan Intelligent Mobility.
2. Incorporate NISMO's racing technology, dynamically demonstrate the potential of Nissan EVs.
As Toray Carbon Magic, the significant lightweight has been achieved in the component development of key components such as the monocoque and subframe by cooperating in strength analysis and manufacturing process design, etc. with use of our advanced technology. Monocoque, subframe, crash box, and wing which are the main structural components, were made of CFRP with use of autoclave molding method. Lightweight has been achieved while maintaining the necessary rigidity. The roll cage of the monocoque chassis was subjected to structural analysis and reinforced with CFRP, which resulted in a smaller diameter of 38 mm and a thinner wall. It has been achieved that the subframe is approximately 25% lighter than the steel subframe of the previous model. Additionally, costs were reduced by using a common design for the front and rear. In addition, as for the roof, which is an exterior component, VaRTM was used for the molding method. The VaRTM molding method does not require prepreg materials or autoclave equipment, making it possible to reduce molding costs for planar, simple shaped parts for the roofs and bonnets.


Subframe Analysis

Subframe


Roll cage structure analysis


CFRP reinforced roll cage


CFRP reinforced roll cage


Roof (VaRTM)


Rear spoiler

Scope of support

Development Part	Monocoque Chassis / Common Front and Rear Subframe / Crash Box / Wing / Roof
Required Characteristics	Lightweight / Rigidity / Impact Energy Absorption
Development Scope	Structural Analysis / Design / Material Selection / Evaluation Testing / Prototyping / Molding Method Selection / Manufacturing / Production Technology
Development Period	Approx. 6 months
Molding Method	Autoclave (monocoque, common front and rear subframe, crash box, wing) / VaRTM (roof)
Size	Vehicle Overall Length 4546 mm / Overall Width 1942 mm / Overall Height 1212 mm
Weight	Total Vehicle Weight 1220kg

'TORAY' Toray Carbon Magic

CRF450 RALLY

HONDA The Power of Dreams HRC HONDA RACING

Honda Motor Co., Ltd. / Honda Racing Co., Ltd.

Contribution to Reduction in Prices by Realization of The Integration of Parts and Most Lightweight, and Establishment of The Production Technology for Autoclave

The Paris-Dakar race vehicle CRF450 RALLY was developed as a prototype machine for rally based on a commercial enduro machine. Our company was involved from the prototyping stage of development and made important parts for the rear frame, tower bracket, and skid plate out of CFRP. By combining the manufacturing methods used for racing parts with Honda's technology, our company contributed to the integration of parts for the most lightweight vehicle. In addition, we established the production technology for the autoclave to contribute to the reduction in prices and conducted production with the use of our own materials and equipment to contribute to quality assurance.

Scope of support

Development Part	Frame Parts / Cover Parts
Required Characteristics	Lightweight /Rigidity / Fatigue Resistance / Corrosion Resistance / Vibration Damping / Design / Impact Energy Absorption
Development Scope	Structural Analysis / Fluid Analysis / Design / Material Selection / Evaluation / Testing / Prototyping / Molding Method Selection / Manufacturing / Production Technology
Development Period	Approx. 12 months
Molding Method	Autoclave
Size	Vehicle Body Overall Length 2100 mm / Overall Width 790 mm / Overall Height 1120 mm
Weight	—

'TORAY' Toray Carbon Magic

RC213V-S

HONDA The Power of Dreams　HRC HONDA RACING

Honda Motor Co., Ltd. / Honda Racing Co., Ltd.

Reduction in Prices with Establishment of Mass Production Technology for Autoclave Molding, and Contribution to Quality Assurance by Production with Use of Our Own Materials and Equipment.

The MotoGP replica model RC213V-S was developed not to reproduce the power performance but to reproduce as closely as possible the packaging and riding feel of the completed vehicle. Our company was involved from the prototype production stage of development and completed each CFRP part by combining Honda's technology with the manufacturing methods used for racing parts. We established the mass production technology for autoclave molding, which contributed to reduction in prices. In addition, we also contributed to quality assurance by producing with use of our own materials and equipment.

Scope of support

Development Part	Cowl Parts / Air Cleaner Parts / Cover Parts
Required Characteristics	Lightweight / Rigidity / Vibration Damping / Design
Development Scope	Design / Material Selection / Evaluation Testing / Prototyping / Molding Method Selection / Manufacturing / Production Technology / Mass Production
Development Period	Approx. 3 years
Molding Method	Autoclave
Size	Vehicle Body Overall Length 2100 mm / Overall Width 790 mm / Overall Height 1120 mm
Weight	Vehicle Body Weight 170 kg

AERO Carbon

GLOBE-TROTTER
ENGLAND 1897

Globe-Trotter Inc.

Highly resilient, durable, and ultra-lightweight new carbon shell material. Approximately 20% lighter than conventional suitcases.

AERO Carbon is a new material for travel cases developed by the British luxury brand GLOBE-TROTTER, and is exclusive to Globe-Trotter. Toray Carbon Magic considered the processing technology for the shell and has been involved in its production.

Scope of support

Application	Consumer goods
Development Part	Case
Required Characteristics	—
Development Scope	—
Development Period	—
Molding Method	Autoclave
Size	Overall Width 550mm / Overall Height 790mm / Overall Length 240mm (Aero 4 Suitcase) Overall Width 390mm / Overall Height 550mm / Overall Length 175mm (Aero 4 Cabin Case) Overall Width 395mm / Overall Height 570mm / Overall Length 175mm (Aero 2 Cabin Case)
Weight	—

'TORAY' Toray Carbon Magic

TOKAI CHALLENGER 2019

学校法人東海大学
Tokai University

Realization of Ultra-Lightweight CFRP Body Optimized Through Aerodynamic / Structural Analysis

Toray Carbon Magic has been supporting the Tokai University Solar Car Team in the biennial World Solar Challenge since 2011, and the machine competing in the 2019 competition (shown on the left) is the fifth model, Tokai Challenger 2019. In the ultra-lightweight CFRP body optimized through aerodynamic/structural analysis, an adoption of Toray's next-generation carbon fiber M40X has been done to further improve specific rigidity/specific strength, contributing to the high performance of the new machine.

Scope of support

Application	Electric Vehicle Racing Machine
Development Part	Body
Required Characteristics	Lightweight / Rigidity / Freedom of Shape / Short-term Development
Development Scope	Structural Analysis / Fluid Analysis / Material Selection / Prototyping
Development Period	Approx. 6 months
Molding Method	Autoclave
Size	Vehicle Body Overall Length 4970 mm / Overall Width 1200 mm / Overall Height 1000 mm
Weight	Vehicle Weight 142 kg

GENESIS , *v*

Xiborg

Xiborg Co., Ltd.

Xiborg's Competitive Prosthetic Blades for Top Athletes

The prosthetic blade for sprinters was optimized using the latest CFRP design and analysis methods, and commercialized after overcoming a variety of challenges by making full use of Toray's delicate autoclave molding technology with the use of high-performance prepreg in order to embody Xiborg's concept based on research and development to efficiently convert an athlete's powerful leg strength into forward momentum. In addition, the CFRP structure, which pursues light weight while still allowing for a large deformation, is one of the cutting-edge composite technology challenges, such as ensuring strength and durability. Through this development, Toray Carbon Magic was able to obtain a large amount of data and valuable know-how, and this technology is beginning to be used in the industrial and automotive fields.

Scope of support

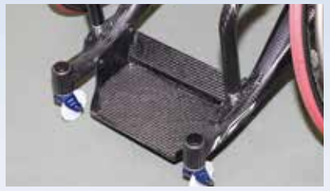
Application	Sports / Parasports
Development Part	Leaf Spring
Required Characteristics	—
Development Scope	Material Selection / Evaluation Testing / Prototyping
Development Period	—
Molding Method	Autoclave
Size	W70 x D330 x H440mm
Weight	865g

'TORAY' Toray Carbon Magic

PARABADMINTON WHEELCHAIR

MATSUNAGA

MATSUNAGA MANUFACTORY Co., Ltd.



World's First Para-badminton Wheelchair which adopted Carbon Frame

Based on Matsunaga Manufactory's aluminum frame wheelchair for badminton, optimizing the lightweight and the high rigidity, we have created a CFRP frame wheelchair. In badminton competition that requires quick forward and backward movements, the combination of lightweight and high rigidity has the potential to contribute to enable players to catch up with the shuttlecock more quickly than ever before, improving the accuracy of shots and reducing fatigue.

Scope of support

Application	Sports / Parasports
Development Part	Frame
Required Characteristics	—
Development Scope	—
Development Period	—
Molding Method	Autoclave
Size	Overall Length 800 mm / Overall Width 733 mm / Overall Height 527 mm (frame only)
Weight	Total Weight 10 kg