

# Intelligent Drive



(From the left) Tasuku Maruyama, Munenori Matsuura, Shigeo Usui, Eiji Shibata, Toshio Masuda, Kouji Kaneda, and Kenichi Yamamoto

## Featured Article 1

The New Added Values Proposed by Subaru: SI-DRIVE & SI-Cruise, The Legacy's Cutting-Edge Systems that Bring You a Truly *Sophisticated* Driving Experience

## SI-DRIVE & SI-Cruise

Since its debut, we have continued our ceaseless development efforts on the Legacy in order to continue satisfying our customers' expectations.

The Legacy's driving performance has been rated very highly by a great many customers.

In 2006, two newly developed, cutting-edge systems were incorporated into the Legacy: the *SI-DRIVE* and the *SI-Cruise*.

These systems, which deliver a more pleasurable driving while at the same time offering just the environmental and safety performance the current age seeks, are exemplary of the innovative technologies unique to Subaru.

### SI-DRIVE = Allows Drivers to Select One of Three Driving Characteristics According to the Circumstances



**Toshio Masuda**  
General Manager  
Subaru Product &  
Portfolio Planning Division

#### An Added Value Proposed by Subaru: *Intelligence*

"Subaru has continued to create appealing and unique products like our symmetrical AWD, combined with horizontally-opposed SUBARU BOXER engines and our turbo engines, and the stellar performance born of these products has won us the support of a great many customers. However, as times change, the sense of values our customers seek in vehicles will change as well. Products that are focused solely on optimal performance are becoming obsolete, and customers are seeking new values to be added to their cars.

To respond to such expectations, we have developed *SI-DRIVE*, which was born out of our musing about "how pleasant it would be if car features could be selected according to the circumstances of the drive or driving style, or change depending on the mood or preference of the driver". Using this system, a married couple, for instance, can share a single Legacy, which offers a powerful performance of 280ps. A single car can satisfy both the husband and the wife, because the husband can fully enjoy its sporty performance on his days off, while the wife can take comfortable drives through town in power-saving mode. Each family member can use the car as he or she sees fit, and select the performance type that best matches his or her mood or circumstances. This ability to select performance types represents the Legacy's newly

added value, and is the true *intelligence* of the Legacy.

The purpose of Intelligent mode, one of the system's three selectable driving modes, is not only to meet customers' expectations for environmental performance and fuel economy, but also to deliver a function whereby customers can still actively step on the accelerator and enjoy the sensation of driving even in a power-saving mode. The word "eco" often implies a negative image of sacrificing driving performance, but making such a sacrifice was the last thing we wanted to do. Hence, we named it "Intelligent mode", not "Eco mode", because we didn't want our customers to think this mode's only purpose was to improve fuel economy."

**Atsushi Atake**  
Staff Manager  
Subaru Product & Portfolio Planning Division

"To develop *SI-DRIVE*, we repeatedly conducted driving tests while always keeping the question of "what advantages can this system deliver to customers?" in mind. The result is Intelligent mode, which our customers describe as "an eco to enjoy", not "an eco to endure".



**Kenichi Yamamoto**  
Staff Manager  
Subaru Engineering Division  
Total Vehicle Performance Integration Dept.

"When Mr. Masuda first came to me with the idea of *SI-DRIVE*, I felt we would only be able to make this dream come true if we all pushed ourselves and really committed to the development effort. As I approved this new set of values, I explained the importance of *SI-DRIVE* not only to the Legacy development staff but also to those who were in charge of other jobs, and had every one of us work together as one."



## A Drive filled with Communication between the Drivers and the Car

We thoroughly verified the best position for the SI-DRIVE Selector and the best style for the meter display. The Multi-Information Display enables drivers to visually confirm the current driving setting. SI-DRIVE proposes the concept of *driving with communication*, a sense of unity between the drivers and the car.



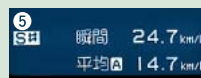
The difference between average and instantaneous fuel economy is calculated and shown on the ECO Gauge, displayed with positive (+) or negative (-) symbols to facilitate fuel-efficient driving.



The Info-Eco Lamp remains lit up as long as the car is running with excellent fuel efficiency in Intelligent mode.



To make the three driving modes easily understood visually, a graph is displayed showing the torque output of each mode.



Various information useful for driving, such as both average and instantaneous fuel economy, can also be displayed.

The SI-DRIVE selector, which allows users to switch among the three selectable modes, is located in an ideal position. Sport Sharp mode can also be selected by use of a switch located on the steering wheel.

## SI-Cruise = Reduces the Burden on Drivers by means of the Full Speed Range Adaptive Cruise Control (FSRACC)

### A Perfectly Precise Control That Eliminates the Gap between Man and Machine

"In order to provide a reliable, safe driving experience, we equipped the Legacy released in 1999 with the ADA (Active Driving Assist), which utilizes stereo cameras to assist drivers in operating the car. Although the system was very effective, we faced the problem of not being able to offer it to as many customers as we wished because the system was expensive. To resolve this issue, we developed SI-Cruise, which is based on the technologies of SI-DRIVE and also incorporates the newly developed SI-Radar Cruise Control (SUBARU Intelligent Radar Cruise Control). In addition, we worked to make the price affordable for our customers. The system assists in the prevention of most collision accidents that occur when drivers doze off, are staring at the car navigation display or glance aside for a second while driving.

The other feature of the SI-Cruise system is the control function, which can be adjusted with extreme precision. For instance, in circumstances under which the driver has just realized "I have to step on the brake", the brake will automatically be activated in an extremely natural manner. This system, which offers high-quality performance, has been perfected, and leaves no gap between human senses and machine functions. Naturally, combining the SI-Cruise system with SI-DRIVE allows excellent environmental performance, for example by improving fuel economy under actual conditions.

In the future we plan to continue our developmental efforts on the SI-DRIVE and the SI-Cruise to further enhance their performance."

### SI-Radar Cruise Control [with Full Speed Range Adaptive Cruise Control (FSRACC)]

The lidar mounted inside the front grille detects the tracking distance and the difference in driving speed between the driver's car and the car ahead. This system, by optimally controlling equipment such as the engine, transmission and brakes, maintains a precise tracking (following) distance. The speed range controllable under this system is wider than that of conventional Adaptive Cruise Control (ACC), covering from approximately 0km/h to 100km/h.



When the car is moving at a low speed due to a traffic jam, etc., it automatically accelerates and decelerates in synch with the movement of the car ahead until it comes to a complete stop, thereby reducing the burden on drivers of having to constantly adjust and control the car's speed.

**Eiji Shibata**  
Staff Manager  
Subaru Engineering Division  
3rd Vehicle Research & Experiment Dept.

"The first condition for popularizing the SI-Cruise was to reduce development costs and make it affordable for customers. In addition to just cutting costs, however, we also had to create a product that would truly shine. We evolved the ADA's control functions, and persistently sought to create a pleasant, comfortable feeling for people while driving."



**Shigeo Usui**  
Manager  
Subaru Engineering Division  
Interior & Electronic Design Dept.

"If we had focused exclusively on enhancing controls that solely shadow the movements of the car in front then if the car in front accelerates too fast, our car's fuel economy rate would deteriorate. To avoid this problem, we designed the SI-Cruise control to work in harmony with SI-DRIVE, and also made the FSRACC to function in line with SI-DRIVE's selected driving mode, achieving a superior performance that upholds both the convenience of FSRACC with fuel efficiency. By combining SI-DRIVE and the SI-Radar Cruise Control (SUBARU Intelligent Radar Cruise Control), we were able to further heighten the "Intelligent" product value.



**Munenori Matsuura**  
Subaru Engineering Division  
Interior & Electronic Design Dept.

"The technology of the ADA cultivated over the years is what made it possible to create the SI-Cruise system. The only way we were able to achieve success was to have the guts as engineers to patiently repeat trial-and-error over and over during the testing.





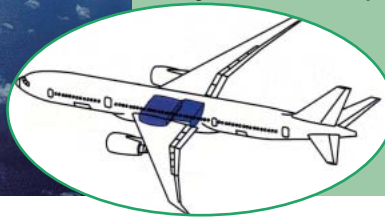
## Featured Article 2

# The Composite Structure Technologies of FHI

are Contributing to Energy Conservation and Global Warming Prevention by Reducing the Weight of Aircraft

FHI was the pioneer of composite aircraft component production in Japan back in the 1970s, and since then we have continued our development efforts, focusing on the unique properties of composites, the fact that they are lightweight yet very strong.

Because of FHI's reputation for advanced composite structure technologies and leadership, we are now participating in the Boeing 787 program, for the next-generation transport airplane.



FHI is responsible for the 787 Center Wing, the critical component supporting both wings and the entire body structure.

(Above) Boeing 787 (by courtesy of the Boeing Company)

(Below) Blue portion: the Center Wing section where FHI Aerospace Company is responsible for development.

## FHI's History of Composite Structure Development



### Composites, Which are Both Lightweight and Strong, Significantly Contribute to Improved Fuel Economy

**Shoichiro Tozuka**

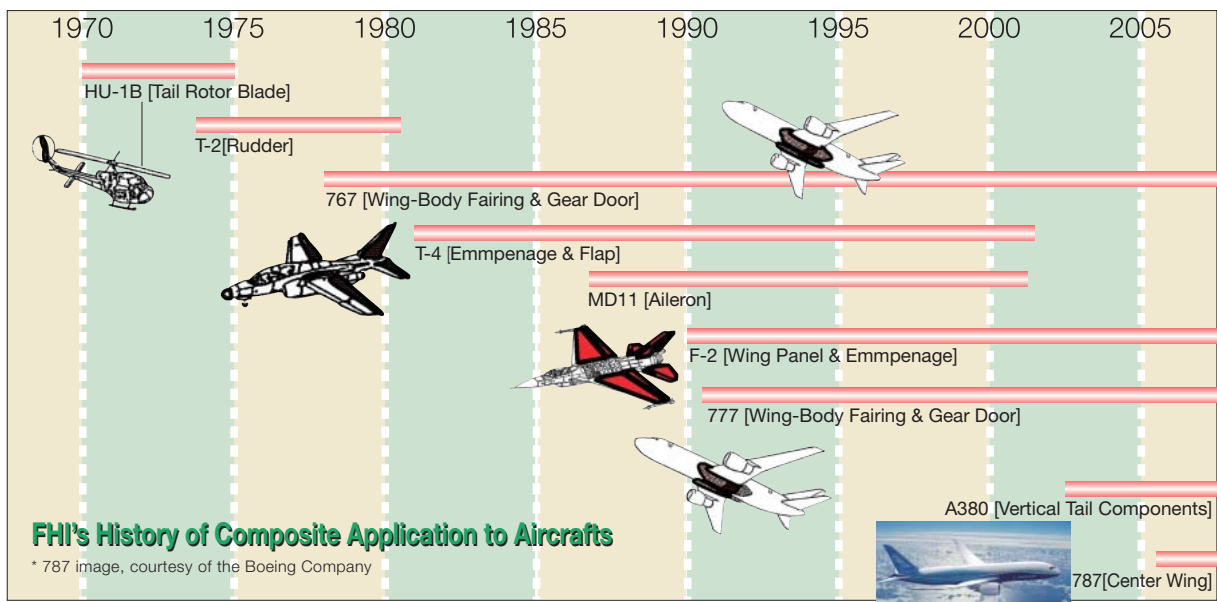
General Manager, Aircraft Engineering Dept. & Project General Manager 787 Engineering, Aerospace Company

Composites are reinforced plastics made of fiber and thermosetting resin which have been cured under high temperature and pressure. FHI started development of aircraft components using GFRP<sup>\*1</sup>, a composite material made of glass fibers, in the 1970s.

In the 1980s, we began research into CFRP<sup>\*2</sup>, a composite material made of carbon fibers, and succeeded in building aircraft components using CFRP, including the wing-body fairings and gear doors of

the Boeing 767, the first composite components produced in Japan.

The Boeing 787 is the very first commercial transport airplane to use composites for major structures such as wings and body. Through use of composites, it achieved significant weight reduction as well as a drastic improvement in fuel economy<sup>\*3</sup>. Furthermore, using composites enabled creation of a better equipped interior environment, making flights even more enjoyable for passengers.



\*1 GFRP: Glass Fiber-Reinforced Plastic, a plastic material reinforced by glass fibers. Commonly used in small shipbuilding industries, windmill rotors, aerospace industries and many other commercial applications because of its superior flexibility in process and formability.

\*2 CFRP: Carbon Fiber-Reinforced Plastic, a plastic material reinforced by carbon fibers. Because it is lightweight and strong, CFRP is used in many structural applications for the aerospace industries, in construction industries and in car manufacturing like Formula One racecars, etc.

## The Process of Making the Boeing 787's Center Wing

A center wing is located at the intersection of the wing and fuselage and is referred to as “the heart of the airplane”, the most vital part of the airplane.

### 1 Design ↔ Analysis

#### Computer-Assisted 3D Design



I was in charge of designing the outer panels, the largest part of the center wing and formulating the wing contour.

During the early stages of my assignment, I worked at Boeing in Seattle.

The 3D data created by computers was used as the basis for the entire process, from NC programming, molding thru to assembly.

**Sachie Arakawa**  
Designer  
787 Engineering

#### Carrying Out Rigorous Analysis to Ensure In-Flight Safety



**Katsuya Ikeda**  
Project Manager  
787 Engineering



**Shigekazu Uchiyama**  
Lead Analyst  
787 Engineering

Metal parts are made by cutting pieces out of a metal ingot, but with composites, parts are made by stacking up layers of thin, fabric-like materials.

Because the strength and characteristics of parts made of composites vary depending on factors such as the direction of each layer as it is piled up, after the design is complete we conduct careful and rigorous analysis under a variety of conditions.

### 2 Casting/Molding



One type of carbon fiber fabric



Large-scale autoclave installed at the Handa West Plant



Example of a sectional view of a part formed by the autoclave  
Stacked layers of carbon fibers are visible.



**Yukio Nakajima**  
Manager  
Parts Fabrication Manufacturing  
Engineering Sec.  
Production Engineering Dept.



**Yuichi Egami**  
Assistant Manager  
Parts Fabrication Manufacturing  
Engineering Sec.  
Production Engineering Dept.

#### Using Large Devices, Even Large Parts can be Cast/Molded in One Sitting

Sheets of fabric made of carbon fibers are stacked up in a manner that is based on the design data while being injected with thermosetting resin.

The sheets are then pressurized and heated in a device called an “autoclave”, filled with nitrogen, and formed into a lightweight, strong composite material.

To develop the center wing for the Boeing 787, we

installed a large-scale autoclave at the brand new Handa West Plant.

Using this large-scale autoclave, the upper and lower panels of the center wing, can be manufactured by one shot of cure cycle. The numerous other parts and components are made at other sites to cover the entire 787 center wing fabrication.

### 3 Assembly

#### Composites Improve Efficiency of Assembly



**Jun Yamakami**  
PM787 Group  
Production Engineering Dept.

For metal structures, riveting techniques are commonly used to create assemblies, but for composite parts, we employ a bonding process to join parts. This bond assembly technology is basically the same technology used to manufacture CFRP parts.

The entire wing box serves as the integral fuel tank, so if rivets are used, significant sealing application is required to prevent any leakage of fuel. On the other hand, the 787's panel skin and stringers are bonded together in such a way that such sealant is no longer required. Eliminating rivets has reduced the weight of the center wing and at the same time improved the efficiency of assembly.

### 4 Completion

#### Delivering the Center Wing to Boeing for the Final Assembly



The Boeing 787 Center Wing. The first article was delivered on January 12, 2007.

\*3 Improved Fuel Economy: With the Boeing 787, the fuel efficiency has been improved by at least 20% compared to other aircrafts of the same class. (Information taken from the Boeing Web site; other improvements, such as improved aerodynamic and engine performance, are included in this figure.)

# Service Robot



## Featured Article 3

# Subaru's Service Robots: Doing the Back-Breaking Jobs and Contributing to an Improved Work Environment and More

Subaru has been a pioneer in creating business models in the field of service robot development.

In recognition of Subaru's performance in this area, our "Building Cleaning Robot System", which was developed and produced by Subaru in December of last year and commercialized jointly with Sumitomo Corporation, received the Grand Prize of the first annual Robot Awards (the 2006 Robot Awards) established by the Ministry of the Economy, Trade and Industry. It is anticipated that social needs for service robots to take over back-breaking, dangerous jobs will continue to grow as the population ages and the birthrate declines.

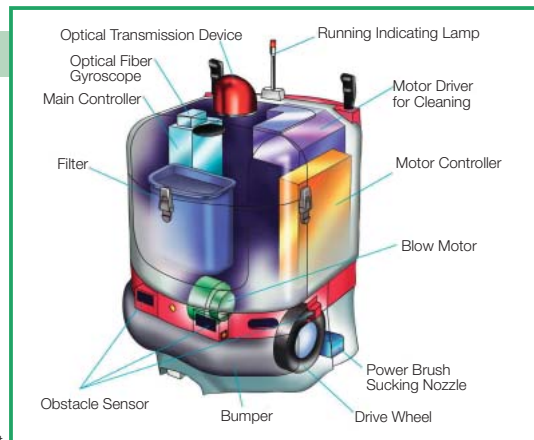
In this article, we'd like to introduce the technologies behind Subaru's service robots.

## What are Service Robots?

When people think about the term "a robot for practical, general use", many picture some kind of "industrial robot" being used in manufacturing plants.

Unlike such industrial robots, a "service robot" is one that takes over back-breaking or dangerous jobs such as cleaning buildings, and contributes to society and its company by improving the work environment, ensuring operator safety and/or reducing labor costs.

Image of the Cleaning Robot

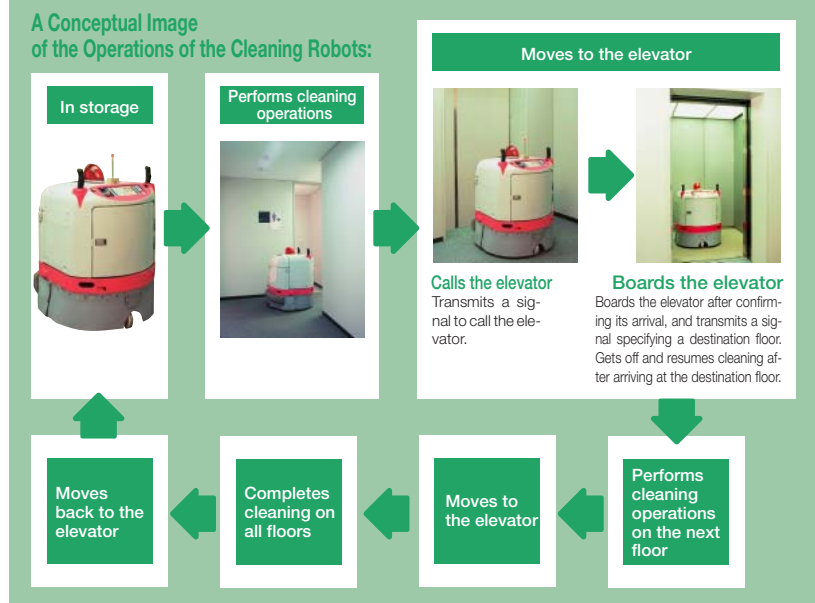


## How our Building Cleaning Robot System Works

High-rise buildings are usually cleaned late at night, and the floors to be cleaned are quite large. Janitors have a lot of work to do and their work environment is quite severe. Subaru's cleaning robots have a unique unmanned servicing function, whereby they move from a storage area to each floor using an elevator, clean the floors and go back to the storage area automatically. Our cleaning robots are currently in operation at about ten high-rise buildings, including Harumi Triton Square and Roppongi Hills in Tokyo (see the picture below), and also at Centrair (the Chubu International Airport).



### A Conceptual Image of the Operations of the Cleaning Robots:



## Enhancing Flexibility for a Variety of Workplaces

Subaru's cleaning robots have been customized to work in a variety of work environments. They are becoming more flexible to fit in workplaces other than high-rise buildings, and at the same time, work on them is leading to derivative products for a variety of purposes.

### Pharmaceutical Companies

Manufacturing companies' plants are made to have a high degree of airtightness overall, and the aisles are usually made quite narrow.

This is precisely the sort of environment in which our cleaning robots can demonstrate their unique features, that is, *being small and having an excellent turning radius*.

In addition to our cleaning robots, we have developed "transportation robots", which can transfer heavy drug containers to each manufacturing line; they are currently being used in pharmaceutical plants.



To ensure sanitation, the bodies of the robots delivered to pharmaceutical companies are made of stainless steel and are not painted. Furthermore, a three-layer filter that includes a high-performance filter layer called a *hepa*filter, is installed in the air exhaust system of the robots to meet the extremely strict in the 10,000 or lower class air purification requirement.



Starting from the left, the hepa-filter for use at pharmaceutical companies, a filter for regular cleaning robots, and a filter for regular vacuum cleaners for domestic use.



Because the drug containers used at pharmaceutical companies weigh at least 150kg, handling the containers has been a back-breaking job for operators. These transportation robots provide unmanned services including arranging empty containers in rows, placing containers onto manufacturing lines and even moving full containers, thereby significantly improving operating efficiency and minimizing the number of operators that have to work on the manufacturing lines during the night.

### Children's Nursing Home

Cleaning robots delivered to children's nursing homes for mentally impaired children are decorated with painted figures such as cute-looking cats, or designed to play music while cleaning so that the children find the robot fun and adorable. To prevent children from getting tangled up with a working robot, the bumper is customized in various ways, including being equipped with sensors.



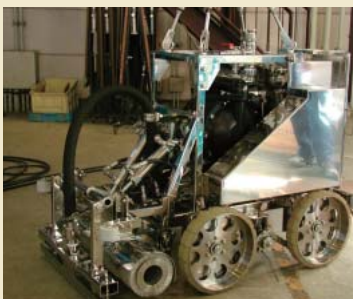
### High-Rise Condominiums

Subaru's cleaning robots have also been introduced to high-rise condominiums, which are currently experiencing a construction boom in and around cities. Because the refuse picked up at condominiums includes fallen leaves and small stones, and thus is different from the refuse collected in indoor environments such as high-rise office buildings, modifications have been made to the robot's brushes and other equipment. In addition, since the robots also operate in joint-ownership spaces of condominiums such as hallways, they were intentionally designed to create a certain degree of operational noise to alert residents or passersby that the robot is in operation.



## These Robots also Stand Ready to Serve People in Other Ways

In addition to cleaning, Subaru's service robots can take over various other back-breaking or dangerous jobs.



### Underwater Radioactive Waste-Removing Robots

These robots are designed to operate inside the pools used to store reactor parts at nuclear power plants. They help not only to improve operating efficiency but also to significantly reduce human operators' exposure to radiation.



### Landmine-Detecting Robots

These robots can safely detect landmines that remain buried underground in disputed regions and so forth. Even during the verification testing for these robots in Croatia, they received a very positive evaluation.

## THE SUBARU DIFFERENCE Reusing and Recycling Manufacturing without waste at SIA.



The SIA plant is located in an area certified as a Backyard Wildlife Habitat. <sup>\*1</sup>

### Featured Article 4

## Social and Environmental Activities at SIA, Our Manufacturing Facility in North America

FHI's five affiliated companies in North America (SIA, SOA, RMI, SCI and SRD)\*\* established the North American Environmental Committee in June 2003 under the organizational control of the FHI Corporate Environment Committee, and have worked to promote various environmental conservation activities.

In this article, we would like to describe the success of three affiliates in North America, including SIA, in acquiring integrated ISO14001 certification, as well as SIA's social and environmental activities.

**\*\*SIA=Subaru of Indiana Automotive, Inc. ; SOA=Subaru of America, Inc. ; RMI=Robin Manufacturing U.S.A., Inc. ; SCI=Subaru Canada, Inc. ; SRD=Subaru Research & Development, Inc.**

### FHI's Manufacturing and Sales Companies in the U.S. Have Acquired Integrated ISO14001 Certification

SIA, Subaru's plant for producing completed automobiles in the U.S., acquired ISO14001 certification in November of 1998. This was before even the Gunma Manufacturing Division managed to acquire the same certification in March of 1999, and the very first such acquisition within the entire FHI Group. All five affiliates have now acquired ISO14001, starting with RMI in 2003, the year when the North American Environmental Committee was established, and ending with SRD in 2005.

Also, SIA, SOA and RMI achieved the integrated ISO14001 certification on December 21, 2006 as their further advanced activity. The achievement is highly valued by the registration agency for two reasons. First, they are combining several different

"organizations" under one certificate. Secondly, they have taken a "corporate-wide" approach to the EMS covering from the manufacturing facilities, sales companies, administrative offices, distribution warehouses, and technician training centers.



Mr. Takagi, Chairperson of Corporate Environment Committee (right) and Mr. Kasai, SIA Senior Executive Vice President (then) with Integrated ISO14001 certification

### The Seventh North American Environmental Committee

FHI's five affiliated companies in North America (SIA, SOA, RMI, SCI and SRD) established the North American Environmental Committee together with FHI under the organizational control of the FHI Corporate Environment Committee. Since the first committee meeting, which was held in June of

2003, the five affiliates have continued to conduct activities and exchange opinions on current and future environmental conservation activities.

Three representatives of the U.S. Environmental Protection Agency (EPA) participated in the Seventh North American Environmental Committee meeting held at SIA in March 2007 to survey SIA as a company with advanced waste material reduction activities and to collect information on successful cases of the EPA's Waste Wise Program.<sup>\*2</sup>

Besides SIA, SRD is also participating in the program as a Waste Wise partner. SIA made a remarkable achievement by winning the Gold Achievement Award as a new partner in 2006.

At the Seventh Committee meeting, the integrated ISO14001 certification acquired by the three affiliates was reported, and the participants discussed whether to set up a website<sup>\*3</sup> to introduce the environmental activities of the companies belonging to the Committee. The Committee's activities were very well received by the EPA members.



The presentation by the EPA members.



The participants in the North American Environmental Committee

<sup>\*1</sup>: The National Wildlife Federation published the fact that in 2003 SIA became the first automobile plant in the U.S. to be certified as a Backyard Wildlife Habitat.

<sup>\*2</sup>: Waste Wise is a voluntary partnership program established by the U.S. Environmental Protection Agency aiming to reduce waste materials by means of recycling those materials, etc. They provide assistance, such as by providing help desks and research on successful cases, to more than 1,900 partner organizations, and grant awards to organizations that have made outstanding achievements.

## SIA's Social and Environmental Activities – the Environmental Activities Won Various Awards

### Zero waste material directly landfilled has been achieved

SIA achieved zero waste material directly landfilled on May 4, 2004 and has continued to maintain the status since then until fiscal 2006. SIA has also continually improved to a 99.6% recycling rate.

Some of the unique environmental projects conducted at SIA for reusing and recycling include:

#### [Solvent Re-use]

SIA installed an on-site solvent recovery unit which processes approximately 60,000 gallons/year to be re-used on-site.

#### [Oil Re-use]

A centrifuge is brought on-site which results in 6,000 gallons of oil to be re-used each year.

#### [Oil Absorbent Re-use]

Used absorbents are sent to be laundered and clean absorbents are returned to SIA for re-use. During 2005 and 2006, over 27,000lbs were sent for re-use.

#### [Solvent Soaked Rag Recycling]

A centrifuge is brought on-site and the solvent is collected for recycling. The rags are taken off-site melted and added to plastic polymers and then formed into automobile wire harnesses.

These environmental achievements have been recognized by the Indiana Governor's Award for Environmental Excellence in 2003 and 2006 and by the Environmental Protection Agency Waste Wise Award New Partner Gold Achievement in 2006.



Trophies for the three awards



The environmental achievements are also being displayed at North American Subaru Dealerships

### Community Involvement

SIA strives to have a positive impact on the community.

#### [STARS Program\*4]

The STARS program was started by SIA in 2005 and currently over 3,600 students and teachers are participating in the program. Participating schools will compete against each other annually with SIA awarding schools based on their environmental efforts and accomplishments.



STARS presentation at the 2007 ceremony



2007 High School students involved with SIA STARS

### The SIA Vehicle for Learning Program

SIA donates vehicles to local educational outreach program. Over 400 vehicles have been donated to Indiana schools for vocational/career programs. This program enables SIA to re-use the vehicles while students are provided with state-of-the art equipment and enhances the quality of the Indiana vocational/career programs for current and future student involvement.



Mr. Oikawa, SIA President and CEO (then), visiting a school who received donated vehicles

\*3 The environmental activities of North American Environmental Committee (NAEC) are disclosed on the Web site (English only): <http://www.subaru-earth.com/staging/>

\*4 STARS (Students/Teachers Achieving Recycling Success) Program: The educational outreach program promoted by SIA to assist local schools with reduce / reuse / recycle efforts to achieve recycling.