JR EAST operates 12,000 trains every day on the Shinkansen and narrow gauge lines extending over a total of about 7500 km, and carries a total of about 16,000,000 passengers. To support this means of transportation, maintenance is carried out day in and day out. Our maintenance work covers a broad spectrum of work including cars, electricity, stations, lines and civil engineering work. The objects of maintenance include about 13,000 cars and a huge amount of equipment on electrified sections stretching about 5,500 km with the tracks measuring a total distance of 12,000 km. In the long 130-year history of railways, maintenance of the cars and wayside devices has made a significant contribution to the progress of the railway system. On the other hand, it is a fact that there are problems yet to be solved.

The conditions of railway equipment differ greatly according to the time elapsed since installation. For example, some tunnels and bridges are less than twenty years old, while others are nearly 100 years old. Some cars have been built by using the most up-to-date technologies, while others were built by technologies developed almost 30 years ago. As described above, objects to be maintained have been constructed and installed at various time periods. And a great variety of technologies have been used for their construction. Further, many of the maintenance methods still depend on human labor and many conventional methods are still used.

Fig. 2 shows the breakdown of the annual expenditures and the number of employees on the payroll in JR East. Both the maintenance-related cost and manpower account for a larger percentage (almost 30%) in the entire railway business. Therefore, innovation in efforts to cut the cost of maintenance work is extremely important for the railway business.

Based on the mid-term management concept of "New frontier 21", the JR East group is making efforts to achieve an "e@train", which symbolizes a railway system that should materialize in future. The following describes the problems that must be solved by the maintenance division in order to make a contribution to achieving the goal of the mid-term concept:
- Further reduction of the maintenance cost which currently accounts for about 30 percent of the business expenses
- Improvement of the level of "safety and stable transportation"
- Compatibility with the ever-diminishing work force in the future
The divisions directly in charge of maintenance work are currently making efforts to plan and implement various measures. The Car Maintenance Division is aiming at creating an inspection system suitable for recent cars which are designed based on new technologies. The Equipment Maintenance Division is developing a maintenance framework that ensures maintenance work to be done in close cooperation with each of the organizations belonging to the JR East group.

In an effort to establish the world’s top level maintenance technologies, the Technical Center is committed to promote “Research and development for maintenance innovation” by setting up three major roles; “Cost reduction”, “Advanced reliability” and “Support of maintenance work”. (See Fig. 3).

The most important thing in the innovation of maintenance is to create cars and facilities that require little maintenance work. For the inspection and other work that are still required, we are trying to introduce an intelligent system using IT and other new technologies rapidly advancing in the world.

In the past, we were engaged in development projects separately for each technological field, such as rolling stock, facilities and electricity. At present, however, we are committed to development of the optimum technologies for the boundary area straddling different technological domains, for example, between cars and rails or between contact wires and pantographs.

Further, we are trying to achieve a railway system that contributes to the creation of a recycling-based society more friendly to the environment. At the same time, we are developing more effective measures for protection against snow. (See Fig. 4).

3.1 Optimization of technologies in boundary areas
3.1.1 Wheel and rail
Wear and fatigue occur to the wheel and rail due to making contact with each other. The repair costs for wear and fatigue account for the greater percentage of car and track repair costs. The cost reduction has been tried in each field so far. However, comparison between them indicates that the rail repair cost is about four times that of wheel repair. Accordingly, a greater emphasis will be placed on reduction of the rail repair cost in promoting research and development of materials and profiles of the wheels and rails, and their management methods. (See Fig. 5).
For this purpose, a “wheel/rail contact testing machine” and “material loading test machine” are used to conduct testing and verification under various conditions including combinations of wear profile in addition to the design profile. We are working on the optimum profile and material, and lubrication method. (See Fig. 6).

3.1.2 Contact wire and pantograph
Similarly to the wheel and rail, contact between the contact wire and pantograph results in maintenance work. Since trolley wire repair charges are more than ten times those of the contact strip of pantographs, we are promoting research and development projects in this boundary area with particular attention paid to the reduction of the repair costs for trolley wires. (See Fig. 7).

3.1.3 Next-generation turnout and switch
Although a turnout is a track component and a switch machine is a signal component, they should be considered as a total system. Based on this concept, in order to achieve the goals of “reduced time and effort for the required maintenance” and “greater resistance to switching failure”, we have been engaged in the project of developing a next-generation turnout and switch machine. As for the present status of the development, we have reached most of goals of the development. Based on the present achievements, we are planning to develop longer turnouts and special switches as well as the next-generation type products for Shinkansen.

3.1.4 Common database for maintenance
Technology information systems have been configured so far for each of the car and facility systems. If individual systems such as rolling stock, facilities, and electricity are...
shared by other systems, the following work will be facilitated:
- Coordination of maintenance work among different systems
- Checking of other system facilities in construction works
- Checking the causes of failures in the boundary domain
This is anticipated to make significant contribution to maintenance optimization. To achieve this, we are proceeding with "Study of a common database for maintenance."

3.2 Cars and facilities that minimize maintenance
One of the most important themes is the research and development of highly reliable cars and facilities that require the minimum time and effort for maintenance. Up to now, we have developed the aforementioned next-generation turnout and switch as well as TC type low-maintenance track and integrated contact wire. To expand the line section where these products are introduced, further cost reduction is essential. Development for this purpose is being carried out using a "full-sized track test equipment (Fig. 8)" and "weather-resistant environment test laboratory".

3.3 Incorporating inspection and maintenance work into an intelligent system
Even if innovation of cars and equipment reduces maintenance greatly, some inspection or maintenance work will be necessary. So development is needed toward improving the reliability and cost performance of such work.
For example, we are proceeding with "development of a tunnel lining inspection car" so that tunnel defects can be detected by nondestructive test to prevent concrete from separating.
Further, to give an example of managing the wheel tread, we are constructing a business system to optimize wheel management through centralized management of the information on the wheel turning equipment, flat sensor and wheel profile measuring instrument.

3.4 Energy and environment
Energy and environmental issues are two of the most important themes in the 21st century. Various types of highly efficient energy systems have already been studied in various quarters. In this Center, we have combined the power generation system such as the one using a micro gas turbine and solar light, and the energy storage system such as a redox flow battery and NAS battery. We are also making an evaluation of operation performances and reliability of these products. We aim to establish the optimum energy supply system in the station building.
For minimizing the burden on the environment, we are proceeding with the so-called environmental 3Rs; Reduction of waste generated in the car, Reuse of old parts and Recycling of the used products as materials.

3.5 Measures for preventing snow damage
Snow on the track, snow carried onto the turnout, snow on the wayside devices such as contact wire support beam and snow on the truck and pantograph of the car disturb the operation of trains. Railway workers in the snowy districts have been combating the snow every winter. To assist in their combat, study is being made to develop a high-performance snow remover and a snow melting apparatus using a new heating element.
4 Internalization of basic railway technologies

4.1 Owning the basic theory and evaluation technologies
The “full-sized track test equipment”, “wheel/rail rolling test equipment”, “contact wire holder vibration fatigue test equipment” and “weather-resistant environment test laboratory” are installed in the laboratory building of the Research and Development Center of JR East. They are used to obtain effective and high-speed achievement in research work. In this process, we try to cultivate and accumulate the basic theories on the behavior and durability of the track, truck and contact wire, and evaluation techniques. We also try to provide field support to improve maintenance and management techniques, thereby “internalizing the basic railway technologies.”

4.2 Accumulation of maintenance and management techniques
In many cases, maintenance and management techniques are accumulated through the process of solving problems in the field. In the Technical Center where “support of maintenance work” is one of the major objectives of the organization, we are making efforts to contribute to the accumulation of maintenance and management techniques including human resource development through the process of research and development.

Further, in establishing the Research and Development Center of JR East, it was intended to serve as a research and development center for the entire JR East group. To realize this objectives, we have a personnel exchange program from the group company. Young maintenance researchers transferred from three group companies are jointly working on research and development projects at the Technical Center.

5 Conclusion
We have given a brief introduction of our research and development activities on maintenance. In the future, we will take a more positive stance in cooperating with other companies including related manufacturers, as well as the Railway Technical Research Institute, universities and other research institutes outside the company. Through these efforts, we wish to ensure that maintenance technology as the greatest core technology of the JR East group will grow to become the world's top-level technology.