1. Preface

East Japan Railway Company (EJR) possesses railway network consisting of 17 lines in Tokyo metropolitan area. 14 million passengers are transported every day. The number of the train is 8200 and the number of the vehicles being used is 8000. The halves of vehicles have been exchanged by new-models in these 10 years. EJR has developed next generation commuter vehicles called AC-Train (Advance Commuter Train). As for the future railway transportation of Tokyo metropolitan area, it is important to raise service level and cost performance about commuter transport. Also the new transport services suitable for the new century are needed. Advanced technology including information technology (IT) has been made use of to realize them.

2. Development Concept of AC-Train

Goals for development of AC-Train are expressed with five concepts to be shown next
(1) Improvement of passenger services
   _ Offer of information services in the vehicles by use of IT
   _ Offer of comfortable transport space
(2) Safety improvement of transport
   _ Reliability improvement of vehicles
   _ Early restoration of transport difficulty
   _ Improvement of safety toward passengers
(3) Decrease of life cycle cost
   _ System change of train set structure
   _ Renovation of body structure
   _ Direct Driving synchronous Motor (DDM)
   _ Autonomous and decentralized power control system
(4) Barrier-free
   _ Consideration to the wheelchair-use passengers
   _ Consideration to the passengers who have difficulties in the sense of sight or hearing
(5) Ecology
   _ Saving energy
   _ Zero-emission

Development of technology has been advanced in tow territories shown below to attain these goal concepts.
(a) Big system changes of vehicle structure and electric systems
3. Big system change in AC-Train

3-1. System change of train set structure
As for most Japanese commuter vehicles, the length of car-body is 20 m and each vehicle is equipped with 2 bogies. This connection type has the advantage that division and connection of train set can be done easily in the middle of transport operation. However fixed train sets are increasing recently. So we have attempted the system change of train set structure.
In the concrete, the length of vehicles in the middle of train set is shortened even in 13 m, and a bogie is arranged at the connecting point between two vehicles.
The number of bogies and electric parts in the whole train set can be decreased by adopting articulated vehicles. Moreover the width of car-body becomes wider, then we can provide comfortable transport space rather than before.

3-2. Renovation of car-body structure (Stainless Double-Skin Method)
Even if it isn’t painted on the surface, clean condition is maintained for a long time with body surface made of stainless steel. Stainless steel is used widely as a material for commuter vehicles for the reason in Japan.
On the other hand, aluminum has been used for Shinkansen or Limited express vehicles recently. That is because Aluminum Double Skin Method has been introduced for manufacturing car body-shell.
We have developed and succeeded in the Stainless Double-Skin Method for manufacturing commuter vehicles.

![Fig.1 Stainless Double-Skin method](image)

- This method needs fewer parts, and the structure is simple. → It reduces the processes of design and manufacturing.
- Use of the inner side of the double-skin panels → It reduces interior finishing work.
Honeycomb-shaped member is put into between two sheets of shin stainless steel. These are combined by laser welding and become a sort of module-panel. Module-panels are put together and body-shell is completed. We call such way of manufacturing as Stainless Double-Skin Method. The advantages of this method are the two points written below.

1. This method needs fewer materials and the structure is simple
2. Use of the inner side of double-skin panels reduces interior finishing work

3-3. Direct driving synchronous motor (DDM)

At present, as for the Japanese commuter vehicles, cardan driving induction motor is widely used. We have advanced the development of DDM as a main driving system in place of this.

As for the DDM system, a rotor of the motor is connected directly with an axle through the joint. Some problems of cardan driving system can be dissolved by introducing this system. The advantages of DDM are as the following.

1. More over 5% are reduced in electric power consumption by improvement of motor efficiency
2. Maintenance is unnecessary for a long time by the shutting up structure
3. Noise surrounding of the motor is decreased with 15 dB

**Fig.2 DDM (Direct Drive Motor) System**
3-4. Autonomous and decentralized power control system

Integration and functional centralization have been advanced so far about the control system of the vehicles. The whole cost reduction of the system has proceeded by this thing. But, a big influence is given to the whole system of the vehicle when a trouble occurs in the important electric part in the case of integrated system. So we have decided to turn the control system to decentralized one by the idea contrary to before. An example in the power control system is stated below.

Four motors were being controlled so far with one VVVF control devices. From now, one motor is controlled respectively with four small-sized VVVF control devices. Even if there is a trouble in one VVVF control device, an influence to give to the whole is small by this.

4. IT use in AC-Train

4-1. Concepts about IT use for vehicles

It is important to innovate the function of railway vehicles by the information technology. The concept is that IT makes it possible [The information to want is always provided everywhere].

In the concrete, the network inside the train should be combined with various networks on the ground. Networks on the ground are for example the Internet, networks between dispatcher and vehicle depots and so on. Information service to the passengers or transport function will be improved due to the combination of networks. Concrete contents are as it is next.

(1) Improvement of passenger service (the offer of various information service in the vehicles)
- Guidance information: train operation, tourist guidance etc.
- Reservation of train seats or hotel staying
- News and advertisements
- Internet communication

(2) Improvement of safe and stable transport (the improvement of reliability, support in the transport difficulty and safety for passengers)
- Mutual back up system by the application of IT
- Self-examination function and emergency restoration function
- Transmission of monitoring data and visual image to the dispatcher
- Electrical transmission of instruction from the dispatcher
- CCD monitoring of passengers’ safety

(3) Cost reduction
- Train information system by the application of widely-use transmission technology

4-2. The offer of information service

It has become one of the advanced services that various kinds of information are provided to the passengers inside the vehicle. As for AC-Train, radio transmission unit, server and information LAN are equipped. Each vehicle is equipped with large displays and Internet displays for the individual passenger. The characteristics of these information platforms are reliability, generality and economies. These characteristics are very important to introduce it into the transport in Tokyo metropolitan area on a large
scale. The functions possible in this information platform are the followings.

- Image information indication to the display in the vehicle
- Homepage and e-mail can be done through the display arranged at each seat or each passenger’s mobile
- Train operation information received from dispatcher center can be indicated on the display inside vehicles

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4-3. The stability improvement of the transport by IT use

(1) The mutual back up system
The down time tends to become bigger once Automatic Train Protection, Door operating control unit or Brake control unit brakes down. Especially, as for highly frequent railway transport of Tokyo area, transport may fall into the disorder greatly. Usually countermeasure is to double these units, but weight and cost may increase. So attention have been paid to that these units are equipped plurally already, and each unit backs up each other in case one is broken down. Information transmission technology is used for this system.

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**Fig. 3 Outline of Information Service System**
(2) Self-examination function and emergency restoration function
Recently, electronic control system has been introduced widely into the railway vehicle. Once a trouble happens, the condition judgment and temporary repairs take time compared before. So, vehicles themselves are made to have a self-examination function, and a result is notified to a driver by monitoring system. Furthermore, temporary repairs are made automatically if necessary.

(3) The transmission of trouble information to dispatcher
The judgment and instruction of dispatcher become precise if the conditions of the spot are conveyed when a trouble occurs. For example, all the information of the monitor equipped on the vehicle will be transmitted to the dispatcher in the case of the breakdown. Image information in front of the train will be also transmitted in the case of the accident in the crossing.

4-4. Train information system by the application of widely-used transmission Technology
EJR has applied information technology for development of monitoring systems of vehicles. A development history in the monitoring function is shown in the Fig 5.
Monitoring device made its debut as the 1st generation in 1988. At this stage, monitoring of equipment performance, control command over service equipment and recording of onboard tests were carried out. After that, TIMS (Train Information Management System) developed in 1998 exceeded a monitor’s level through the generation. As for TIMS, reduction of electric wires through the train, automated inspection before departure from depots and optimization of train control were realized.

As for AC-Train, we have introduced ETERNET, widely used transmission technology, and arranged terminal devices rather flexibly. The cost reduction of the system has been attained by ETERNET. Moreover, we have got the prospect that 60% of electric wires in each vehicle can be eliminated by using general-purpose communication chip LON (Local Operation Network). This New Train Information System has the ability of 10Mbps and this is 4 times as TIMS. The outline of the system is shown in the Fig 6.

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- Monitoring of equipment performance
- Control command over service equipment
- Recording of data on trial runs and onboard tests
- Control command over power running/brake system, etc.
- Facilitation of data write/read
  - Reduction of electric wires through train
  - Automated inspection before departure from depots
  - Optimization of train control

**Fig.5 History of Monitoring Functions**
5. Conclusion
The test vehicles of AC-Train are being manufactured at present with the aim of the completion within 2001. AC-Train consists of 5 vehicles. General description of the AC-Train is shown in the Fig 7.
Various functions will be examined and the reliability will be verified through the endurance test. After that, mass production will be planned as a commuter train of the next generation for Tokyo metropolitan area.