In order to improve customer service and strengthen competitiveness by shortening time to arrival and increasing comfort, JR East established the "Shinkansen High-speed Project" in April 2002, and is proceeding with technical development increasing the speed of the Shinkansen. Furthermore, the High-speed Test Train type E954 (FASTECH360S), a Shinkansen exclusive type, was completed in June 2005, and various running tests are being performed at this time.

On the other hand, JR East’s Shinkansen network also has mini-Shinkansen (operation using direct service between conventional and Shinkansen tracks), and it is critical that this transport system be maintained when making future speed increases through operation of both Shinkansen exclusive railcars and train cars that provide direct service between conventional and Shinkansen tracks. Therefore, it is essential to develop a train car for use on tracks that are for direct service between conventional and Shinkansen rails which has high-speed running capability and environmental performance at the same level as train cars specific to Shinkansen. The purpose of this project is to build a prototype test train and perform various tests on a train car for use on tracks that are for direct service between conventional and Shinkansen rails which has technical issues that differ from those of a train car specific to Shinkansen. The type E955 (FASTECH360Z) was recently completed.

Reducing the time to arrival is effective for ensuring the competitiveness of the Shinkansen for transportation between long distance cities, and therefore increasing the running speed is critical, but it is also important to increase the technical level in a variety of areas such as reliability, environmental compatibility, and comfort. Therefore, the issues for increasing the speed of the Shinkansen and the related development have been organized into 4 main areas, namely;

- increasing running speed,
- ensuring reliability,
- compatibility with the environment, and
- increased comfort.

The type E955 is a 6 car train. The middle cars are Traction cars, while for the end cars, the leading bogie is a Trailer bogie and the other bogies are Traction bogies, creating a 0.5 Traction 0.5 Trailer setup. This is the result of ensuring the necessary number of driving axles for high-speed running while reducing the overall mass of the train in a short version train such as a 6 car train.

Furthermore, as a countermeasure for noise, the type E955 minimizes exposure of the car body over the top of the noise barrier, and therefore the height of the car body is lower than the E3 series. The E3 series has a part of the air-conditioning unit placed on top of the roof and therefore the car height is 370 mm taller than the E2 series. However, with the type E955, the air-conditioning unit is placed under the floor, so the roof height is the same (3,650 mm) as the type E954.
3.2 Technical characteristics of the type E955

3.2.1 Increasing running speed

(1) Main electrical circuit system
The type E954 is similar to the type E954 in ensuring sufficient output to stably run at 360 km/h while working to reduce the size and weight of the equipment. With the type E955 whose car body is smaller, however, the equipment lid and side skirts have been integrated for the large equipment such as the main power converter, eliminating the double construction and making even better use of space.

For comparison evaluation, one unit of the type E955 will use an induction motor drive system while the other unit will use a permanent magnet synchronous motor drive system. Similar to the type E954, the permanent magnet synchronous motor drive system will use a self-ventilated cooling system for the traction motor, and the electric fan for the traction motor has been eliminated.

As previously mentioned, with the type E955, the lead cars are 0.5M 0.5T, but the main power converter for driving the traction motor for the bogie is placed between adjacent middle cars. Therefore, main power converters for 6 motors including the adjacent lead cars are located on E955-2 and E955-5 respectively.

(2) Bogies
The bogies of the type E955 are the same as for the type E954, and can be categorized into 3 types based on differences such as the use of different axle box suspension equipment, etc. The basic structure of each is common with the type E954, but improvisations have been added for running on sharp curves on conventional line.

The wheelbase was set to 2,250 mm for the E3 series where the emphasis was on curving performance on conventional line segments, but achieving high-speed running stability at 360 km/h is difficult at this wheelbase, so for the type E955, the wheelbase was set to 2,500 mm, similar to the Shinkansen exclusive cars. However, there is concern about increased lateral force through sharp curve sections of conventional line with this design, so a switchable type yaw damper is used in order to reduce the damping force when running on conventional line.

Furthermore, the axle mounted disk brake equipment on the T axles has been completely eliminated in order to improve the performance of the brake disk lining on the type E955, and the mass below the T bogie springs has been dramatically reduced.

(3) Current collecting system
One measure for achieving stable high-speed current collecting performance is to use a pantograph with a multi-fractionated contact strip (a construction where the contact strip is fractionated with each part supported by a spring in order to flexibly follow the vibrating overhead contact wire), similar to the type E954.
(4) Train set torque control and brake control
In order for the driving forces and the braking forces of the wheels to effectively be transferred to the rails, when wheel slip or skidding occurs, the torque and brake distribution based on the axle position in formation has been optimized, and train set torque control and brake control is used in order to achieve acceleration forces and braking forces through the entire formation.

3.2.2 Ensuring reliability
(1) Ensuring reliability of bogie and bogie components
As previously mentioned, the basic construction of the type E955 bogie is the same as the type E954, and the strength of the bogie frame, wheels and axles have been designed based on that experience. Similar to the type E954, the driving device uses a new system which implements double helical gears which do not generate thrust forces during torque transmission. Therefore, the load on the axle bearing is reduced, reliability during high-speed running can be increased, and furthermore, the use of smoothly engaging double helical gears will help reduce noise and vibration.

(2) Increasing performance of basic brake equipment
Two types of basic brake equipment are used for comparison testing, but both designs are capable of handling the increased load associated with higher speeds, and have superior friction coefficient and temperature characteristics than current designs. The fastening system for the brake disk was changed from the current internal circumference fastening system to a center fastening system which has less thermal deformation, and the brake lining also uses a split design which suppresses the occurrence of heat spots. Furthermore, the brake calipers use a pneumatic system which eliminates the conventional pneumatic to hydraulic pressure conversion, thus simplifying the construction and reducing the weight.

(3) Bogie monitoring system
In order to always monitor the running condition of the bogie and immediately issue a warning if problems occur, the same bogie monitoring system as that used in the type E954 has been implemented. This system detects problems in the bogie snaking behavior, axle bearing problems, and drive equipment problems that could potentially have a direct effect on safety during high-speed running. A controller judges the status of the bogie based on information from acceleration sensors and temperature sensors placed on each bogie, and if a problem is detected, a signal is sent to the train car information controller.

(4) Snow damage countermeasures
In order to reduce the amount of snow which clings to the car body, the shape of the car around the bogie has been improved to eliminate the introduction of air currents, and snow is melted by a heater.

(5) Earthquake safety
In order to ensure safety in case of emergencies such as an earthquake, the emergency braking performance has been increased and an aerodynamic drag increasing device has been added as a supplemental means for shortening the emergency breaking distance. Safety measures for earthquakes are continuing to be investigated as countermeasures for the Joetsu Shinkansen derailment that occurred during the Chuetsu earthquake which occurred in Niigata Prefecture in 2004, and various verification tests are scheduled using high-speed test trains as required.

3.2.3 Environmental compatibility
(1) Noise suppression
In order to suppress noise during high-speed running, low noise pantographs, pantograph noise insulating plates, full circumference vestibules between cars, snowplow covers, and noise absorbing construction on the bottom of the car body have been implemented, similar to the type E954, but there are differences on the following points because of the unique restrictions of train cars used for through operation of Shinkansen and ordinary line.

1. Low noise pantograph
On the type E954, comparison tests are being performed using 2 types of low noise pantographs, namely a <shaped arm type and a single arm type. However, with the type E955, the range of the working height is broad because of extended running on conventional line sections, and therefore only the <shaped arm type was used because of the difficulties of tracking with a single arm type pantograph.
Furthermore, the support structure (insulator placement) differs from the type E954 in order to suppress the pantograph folding height to meet the restrictions for conventional line. PS9037A insulators are located to the left and to the right and PS9037B insulators are located to the fore and to the aft. This is primarily for comparative evaluation for aerodynamic noise.

2. Pantograph noise insulating plate
With FASTECH, the target speed is very fast, so pantograph noise insulating plates are used in addition to a low noise pantograph, but a fixed pantograph noise insulating plates will exceed the car limits for conventional lines, so the type E955 uses a movable noise insulating plates which is stored away on conventional line sections.
Full circumference hoods between cars

In order to suppress aerodynamic noise that occurs in the spaces between railcars, a full circumference hood has been established between the railcars for FASTECH. With the type E954, a hard type vestibule using a linking mechanism was implemented, but with the type E955, a soft type hood a rubber plate was implemented for comparison. This vestibule tracks displacement not only by the stretching of the rubber plate, but air enters and is discharged from a tube attached to the mounting points of the rubber plate in order to change the “stiffened” of the rubber plate. At speeds over 110 km/h on the Shinkansen sections, the rubber plate is stiffened, but it is relaxed at speeds under 90 km/h. This ”stiffening” adjustment of the rubber plate is not performed on conventional line sections.

Snowplow cover

In order to suppress aerodynamic noise generated from the snowplow during high-speed running, the snowplow is covered with a cover when not in use, similar to the type E954, but with the type E955, the movable construction has been simplified and the reliability of the operation is improved.

(2) Controlling tunnel micro-pressure waves

The front shape affects the control of tunnel micro-pressure waves, and for the type E954, comparison tests were performed by making 2 different shapes (arrow-line and stream-line) with different rates of cross-section change. However, with the type E955, the effect of the difference in lead length for a shape with a similar rate of cross-section change (arrow-line) will be confirmed. Therefore, E955-1 will have a lead length of 13 m, and E955-6 will have a lead length of 16 m.

Both lead cars were replaced for the type E954 only in the lead length comparison tests but for the type E955, the direction of the entire train set will be changed, and when a new car is introduced, the status will be reversed so that E955-1 will be car 16 to the Hachinohe side, and E955-6 will be car 11 on the Tokyo side. This is because of difficulties in changing only the lead car due to the construction of the main electrical circuit.

(3) Ground vibration control

Similar to the type E954, the axle load and axle position of the type E955 have been determined by simulation from the viewpoint of suppressing ground vibration, and the average axle load for the formation was set to 11.5 t, and the maximum axle load was set to 12.5 t for unlinked cars.

3.2.4 Increased comfort

(1) Riding comfort

Similar to the type E954, an electromagnetic actuator type vibration preventer and a body tilting mechanism utilizing an air spring stroke side lifting system (maximum incline angle 2°) was introduced in order to improve riding comfort.

(2) Internal quietness

A new thin double skin construction will be tested on the roof of E955-4. This is a thin version of the current aluminum double skin member, and the construction compensates for the insufficient strength using the beam shape of the frame. Therefore, the mass per unit area of the panel which corresponds to the outer plate is dramatically reduced and the difference in mass compared to the interior panel is reduced and therefore improved noise insulation can be anticipated by using a double panel construction for the outside plate and the interior panel. All other body structures are identical to the type E954, and
construction such as elastic support of interior materials, and increased air in the side windows and floating floor have been implemented.

(3) Interior design and seating
With regards to the interior design, the test train car is in the "Near Future Comfort Mobility Space Proposal Stage". Car E955-2 will have a special car concept passenger area and car E955-3 will have a normal car concept passenger area. Both of these designs will differ from the designs tested on the type E954 in order to expand the range of comparison evaluation.

With regards to sanitary space, the basic structure will be the same as the type E954, but details such as the color will be different. Incidentally, the sanitary space of the type E955 will also function as the storage space for the pantograph noise insulating plate. Therefore, the effective width will be narrower than the restrictions of the body width on conventional line, but the space will not have a restricted feel because of a design which uses many curved surfaces in the partition wall.

![Fig.7: Interior (Left: E955-2, Right: E955-3)](image)

(4) Air-conditioning equipment
Similar to the type E954, 3 types of air-conditioning equipment with characteristic duct structures and temperature controls are used, and comparison evaluations are scheduled. All of the air-conditioning equipment is centralized and integrated with connecting ventilation equipment. In addition to conventional heating and cooling functions and dehumidifying functions, there is also a moisturizing function in the winter heating system.

4 **High-speed running tests**

The type E955 was completed in March 2006, and running tests have been performed between Sendai and Kitakami as well as the Akita Shinkansen (using conventional line) on the Tohoku Shinkansen line. For the time being, the type E955 will run individually to confirm running safety and environmental performance, but from this summer, high-speed passing tests will be performed with the type E954, and combined running tests with the type E954 are scheduled for this fall. These tests are scheduled to be performed through the end of fiscal year 2007.