HIGH SPEED RAIL ROLLING STOCK TECHNOLOGY

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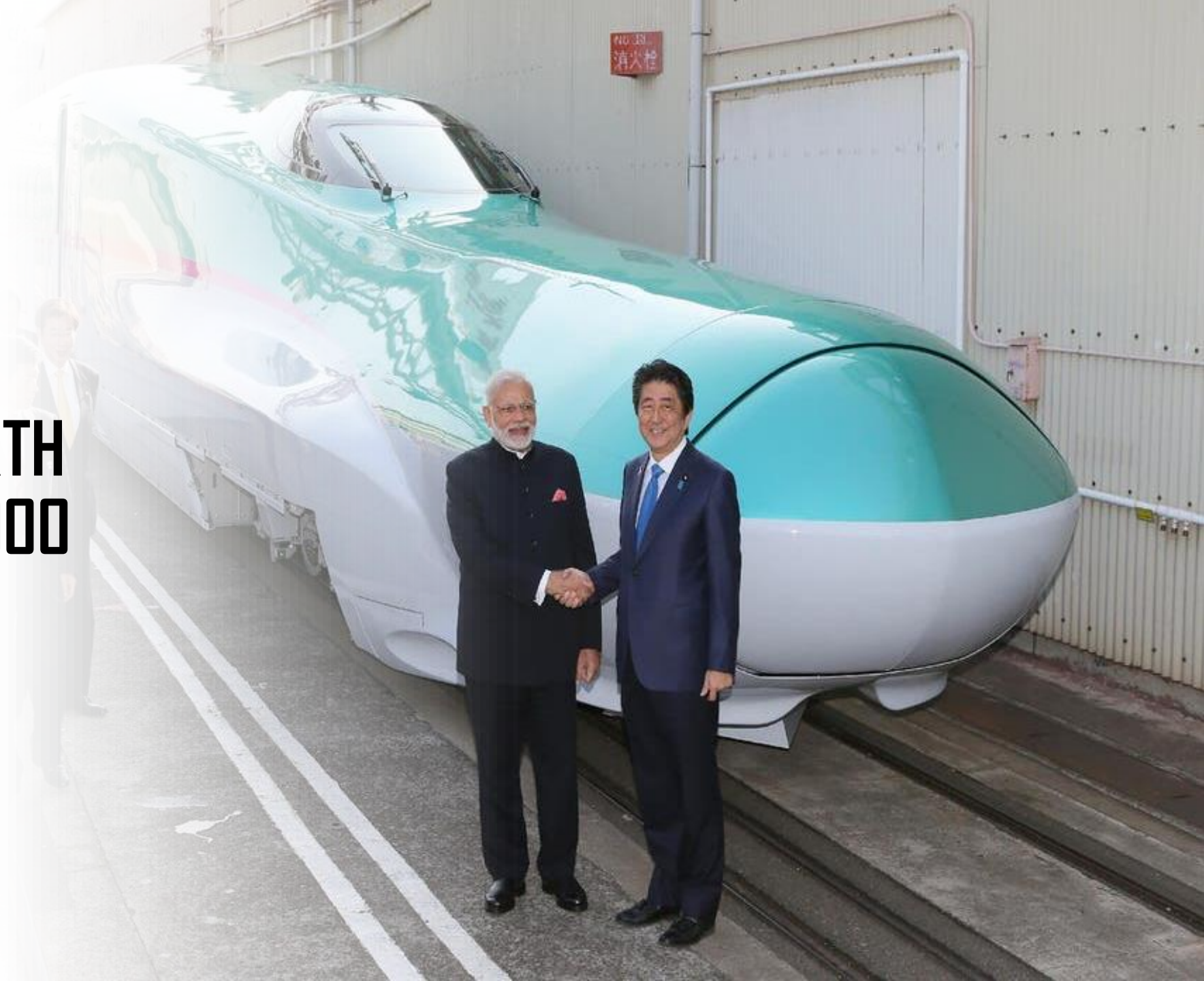
Professor(IRIMEE)

HANDSHAKE WORTH
Rs 1000000000000



OBJECTIVE

By the end of this lecture, participants will be able to-

Understand	The design requirements of a High speed rail rolling stock
Explain	the difference between Concentrated Power train and Distributed Power train
Describe	briefly the history of HSR
Explain	Aspects of high speed rolling stock being incorporated in MAHSR

BULLET TRAIN

High Speed Rail (WHAT)

- Operational speed greater than 200 Kilometer per hour on existing track
- Operational speed greater than 250 Kilometer per hour on new track
- Significantly faster than traditional railway trains
- E.g.- Bullet Train (Japan)
  - ICE (Germany)
  - TGV (France)
  - CRH (China)

VANDE BHARAT EXPRESS

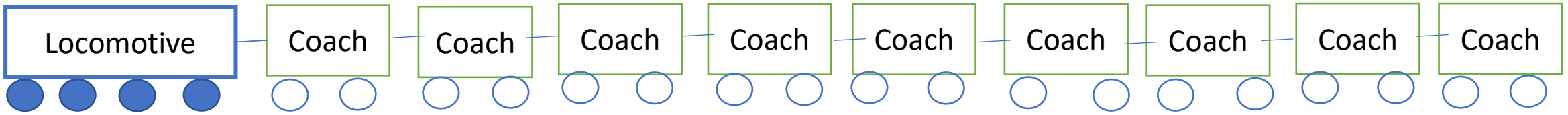
SEMI HIGH-SPEED RAIL

Operational speed between 160 Kilometer per hour to 200 kilometer per hour

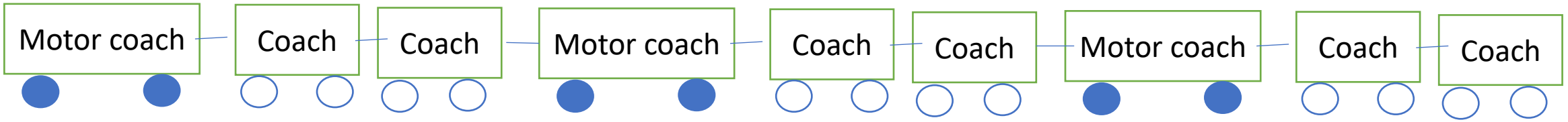
e.g. Vande Bharat Express, Gatiman Express

HOW

Concentrated Power train



Distributed Power train



History of HSR (WHEN & WHERE)

1964 - JAPAN – SHINKANSEN

(210 KMPH)

Distributed Power EMU trainset with 6 motor coaches

1983-FRANCE
TGV -300 Kmph

Developed by ALSTOM

Concentrated Power

1991-Germany-ICE1-280Kmph Developed by Siemens Concentrated power

WHICH COUNTRY HAS THE LARGEST HIGH-SPEED RAIL NETWORK TODAY ?


China has more High Speed Trains than the rest
of the world combined!


2008
KAZAKHSTAN
MONGOLIA
KYRGYZ REPUBLIC
Urumqi
Harbin
Changchun
Shenyang
D.P.R. OF KOREA
REP. OF KOREA
Hohhot
BEIJING
Qinhuangdao
Dalian
Baoding
Tianjin
Yantai
Shijiazhuang
Taiyuan
Jinan
Qingdao
Xining
Lanzhou
Yellow Sea
Zhengzhou
Xi'an
Xuzhou
Nanjing
Wuxi
Hefei
Shanghai
Wuhan
Hangzhou
Ningbo
Chengdu
East China Sea
Chongqing
Changsha
Nanchang
Wenzhou
Fuzhou
Kunming
CHINA
Existing HSR
New HSR

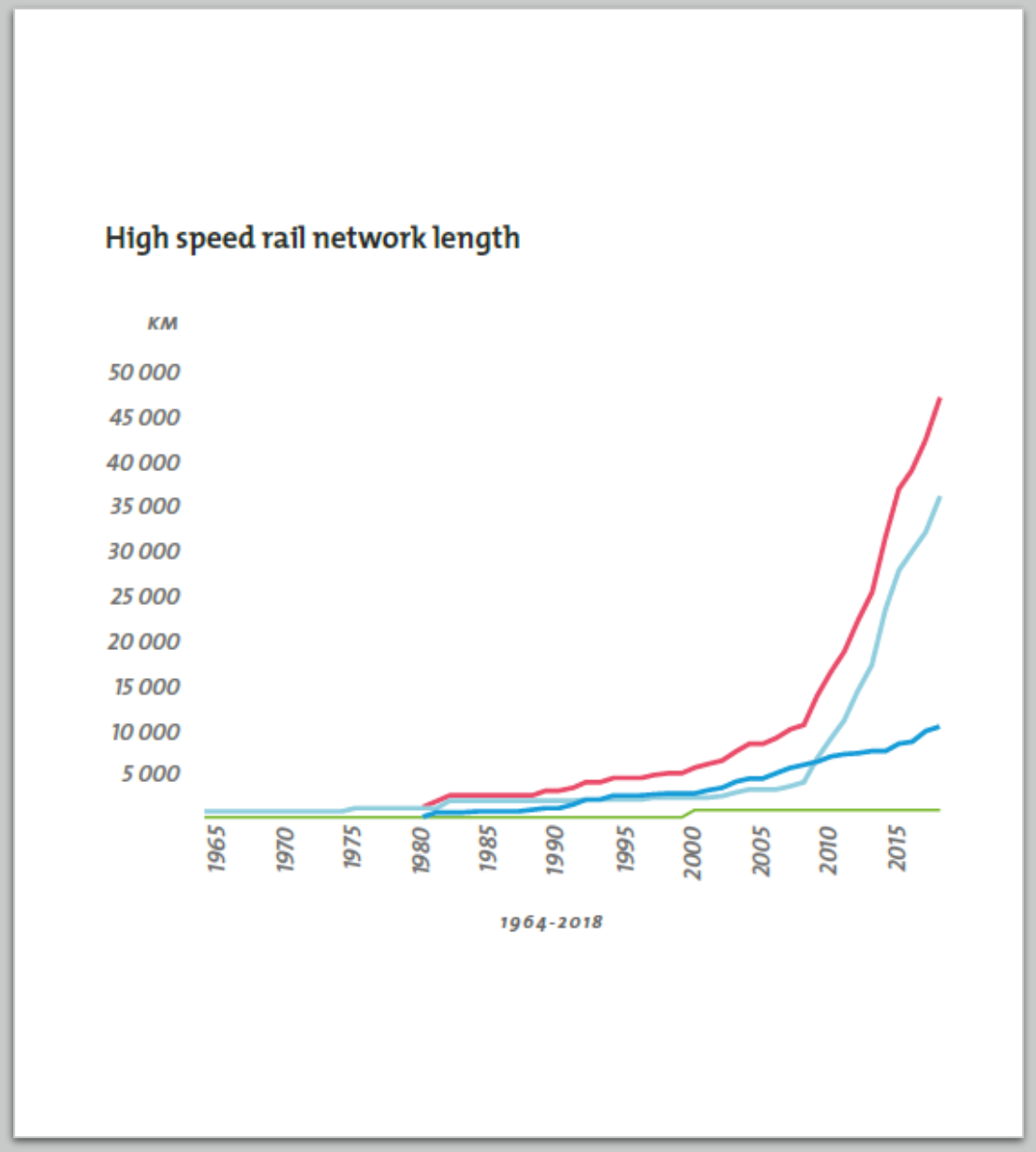

2017
KYRGYZ REPUBLIC
CHINA
Existing HSR
New HSR
Selected cities:
• Other cities
• Major cities
Province boundaries
International boundaries
Urumqi
Zhangye
Xining
Lanzhou
Baoji
Xi'an
Hohhot
Wulanchabu
BEIJING
Changchun
Hunchun
Shenyang
Dandong
D.P.R. OF KOREA
REP. OF KOREA
Qinhuangdao
Dalian
Baoding
Shijiazhuang
Tianjin
Yantai
Rongcheng
Taiyuan
Jinan
Qingdao
Yellow Sea
Zhengzhou
Xuzhou
Nanjing
Wuxi
Hefei
Shanghai
Hangzhou
Ningbo
East China Sea
Dujiangyan
Jiangyou
Wanzhou
Chengdu
Leshan
Chongqing
Wuhan
Anqing
Huangshi
Jiujiang
Yichang
Nanchang
Changsha
Zhuzhou
Hengyang
Wenzhou
Fuzhou
Guiyang
Kunming
Guilin
Liuzhou
Xiamen
Guangzhou
Shenzhen
Hong Kong SAR, China
Zhuhai
Nanning
Fangchenggang
Beihai
LAO
VIETNAM
Haikou
0
250
500 Kilometers

HSR in CHINA

- 1997 – China launched large scale speed up campaign
- 1999 – China star EMU was developed indigineously (Vmax = 250 Kmph). Was a commercial failure
- January, 2004 – Chinese government identified 4 North-South and 4 East-West corridors for High speed rail
- October, 2004 – Chinese Railway ordered 60 sets of CRH 2A rolling stock from Kawasaki, 40 sets of CRH5A from Alstom, 60 sets of CRH1A from Bombardier. All had to adapt their HSR train-sets to China's own common standard and assemble units through local joint ventures (JV) or cooperate with Chinese manufacturers.
- 2008 – First commercial High speed rail trains were operated.
- 2013 – Independent innovation started. China standard EMUs with individual Intellectual Property Rights

WHY HSR?

- **1,600** million passengers per year carried by high speed trains in the world
- **80%** modal split obtained by high speed trains in relation to air transport when travel time by train is less than 2.5 hours.
- HSR stations are important nodal points in city centres and they serve wider social functions, by offering accessibility to a comprehensive and wide range of services, such as shopping facilities

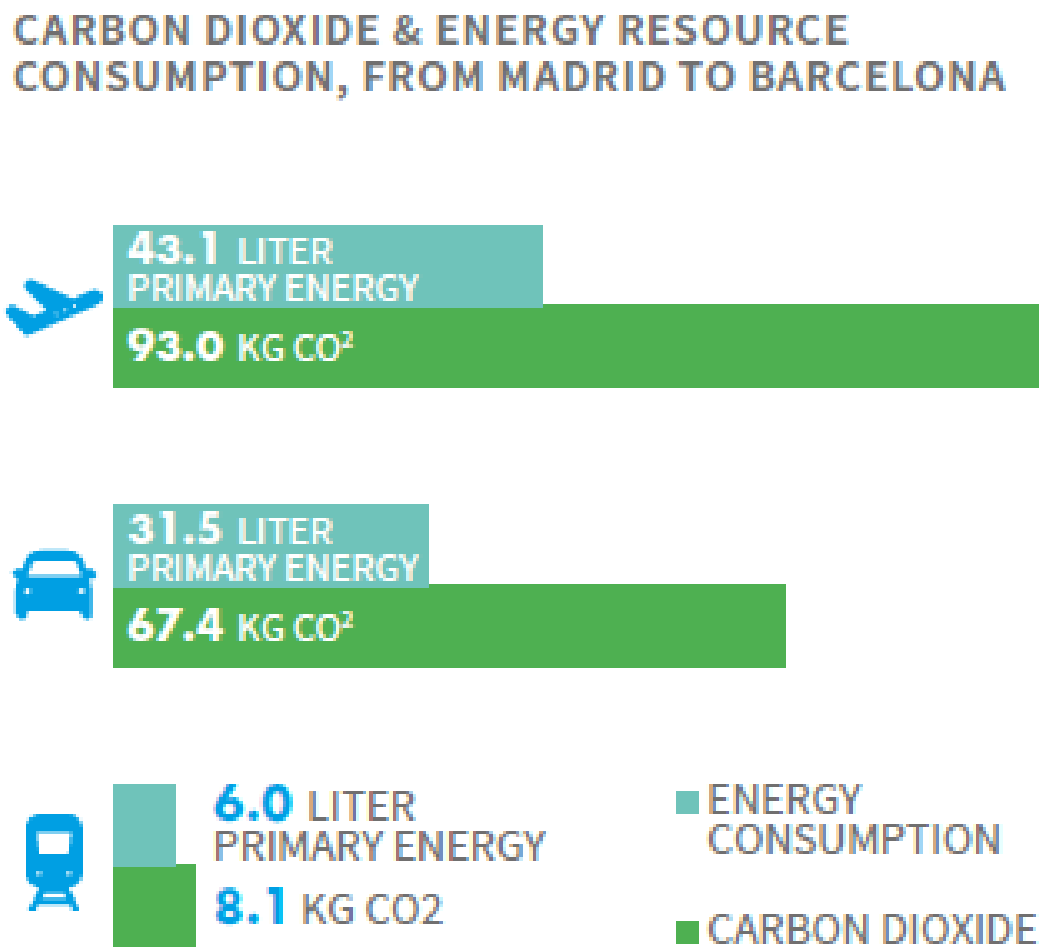


WHY HSR?

HSR provides city centre to centre connectivity. Lesser Door to Door travel time.

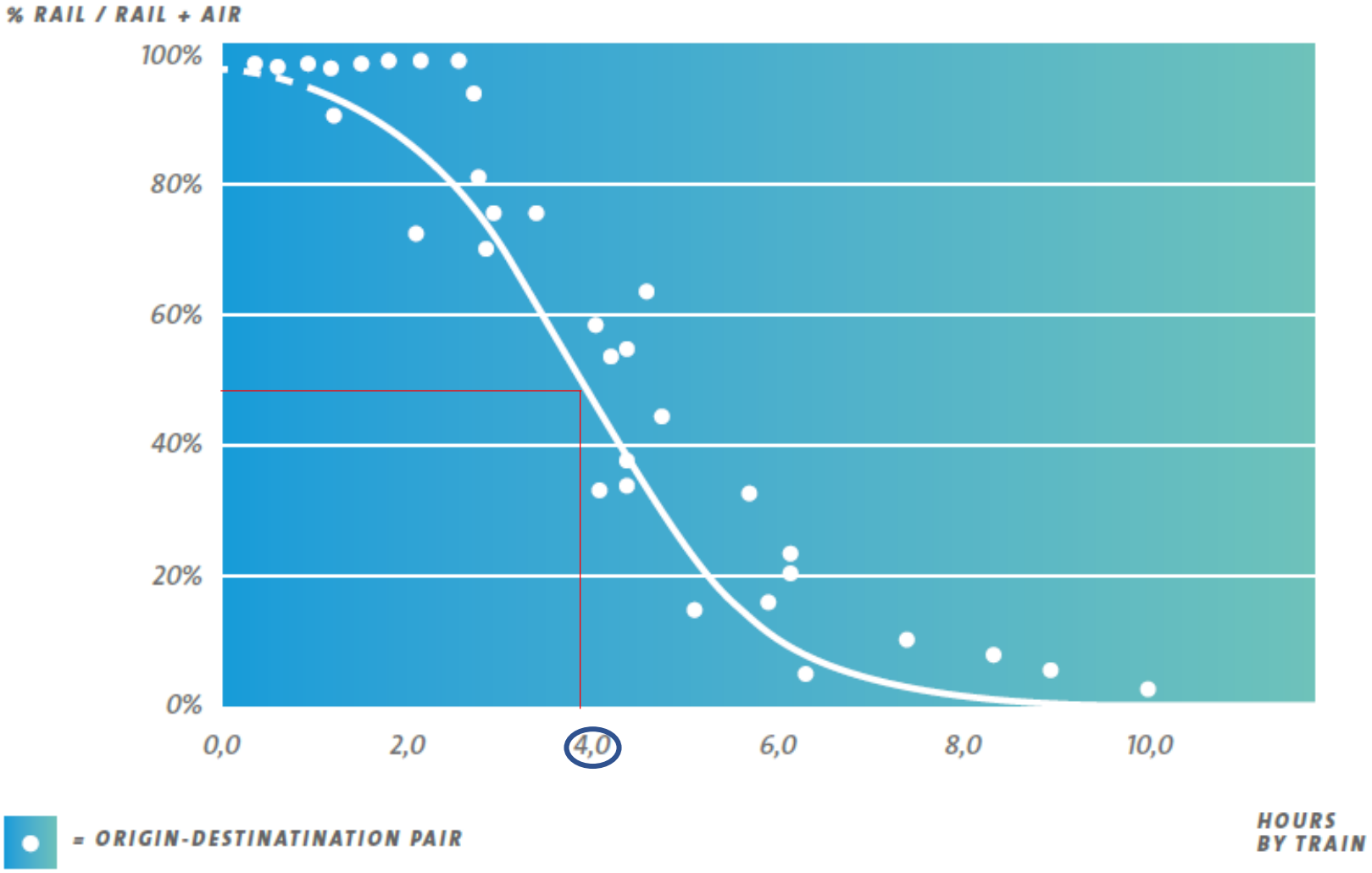
WHY HSR ?

- Energy efficient
- Lesser carbon footprint



Rail market share on the rail + air market in France

(PASSENGERS)

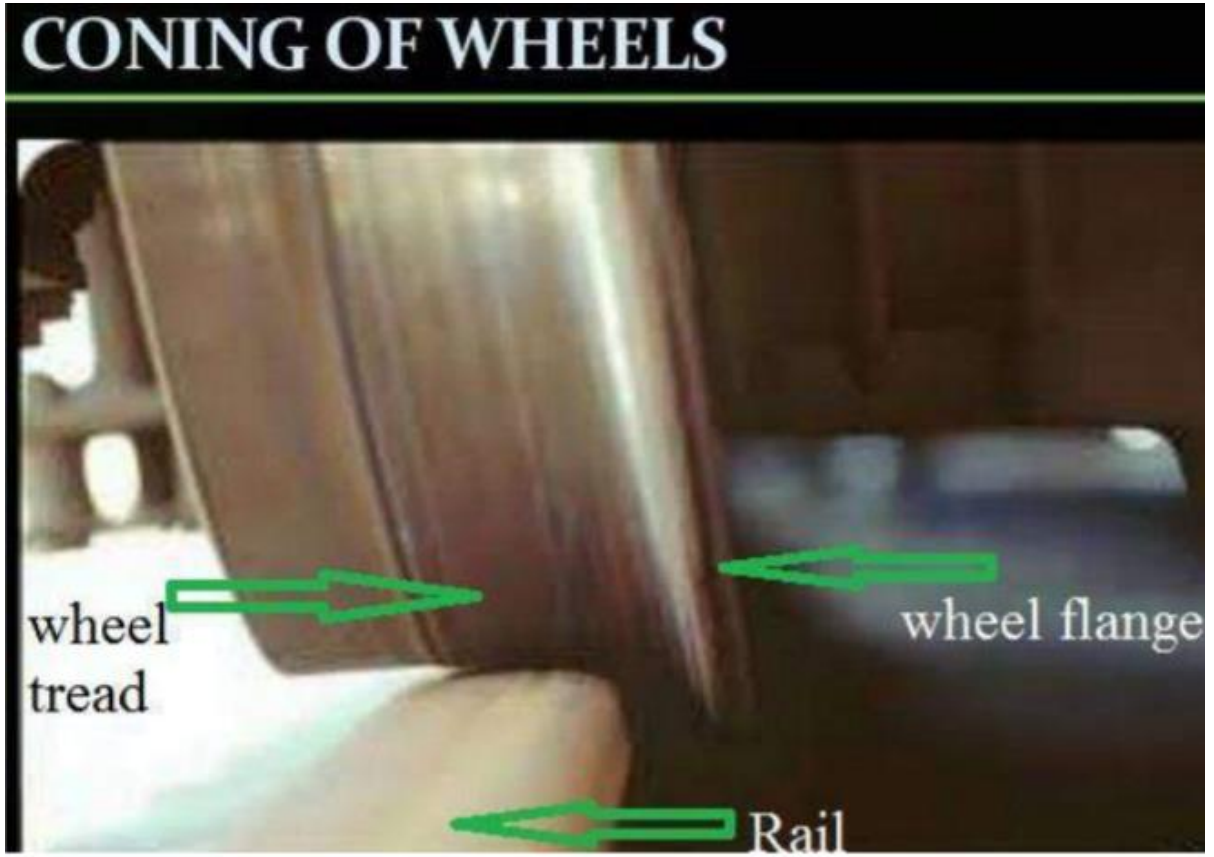


Rolling stock requirement

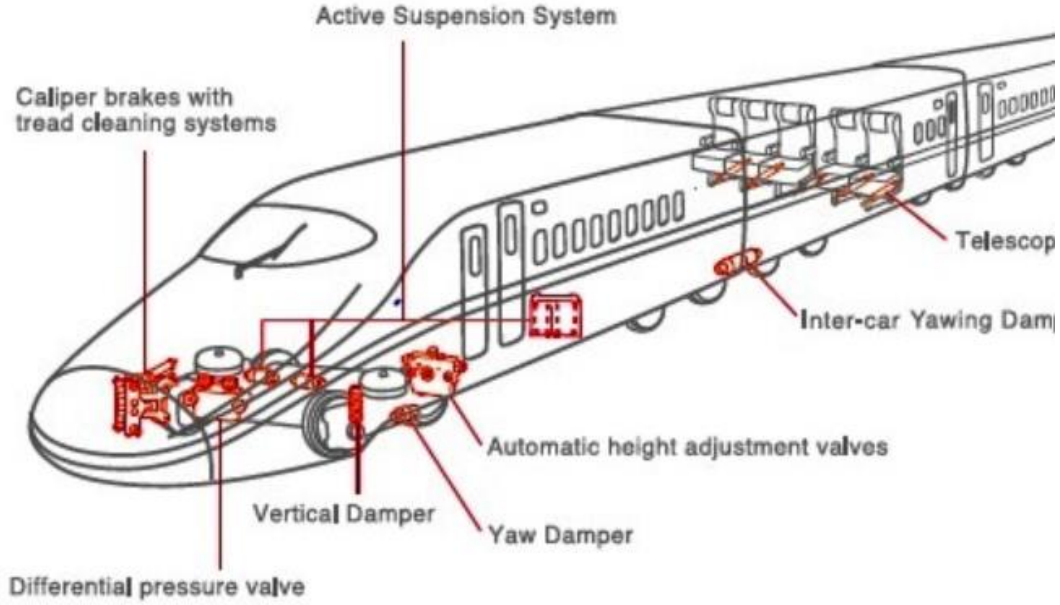
- Self propelled, fixed composition and bi-directional
- High level of technology
- Limited axle load (11 to 17 tons for 300 km/h)
- High traction power (approx. 11 to 24kW per ton)
- Power electronic equipment: GTO, IGBT based Control circuits
- Computer network. Automatic diagnostic system
- Optimised aerodynamic shape
- In-cab signalling system/s
- Several complementary braking systems
- High level of RAMS (Reliability, Availability, Maintainability and Safety)
- Airtight structure

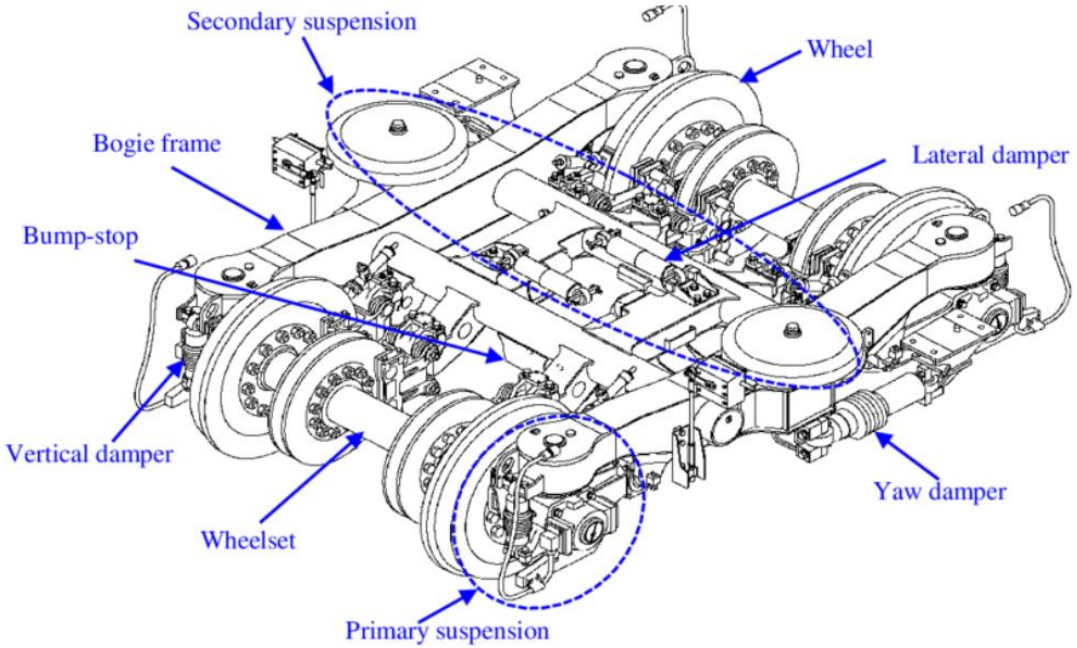
Wheel

- Flatter tread, Wheel conicity should be 1:40, 1:60 or 1:80



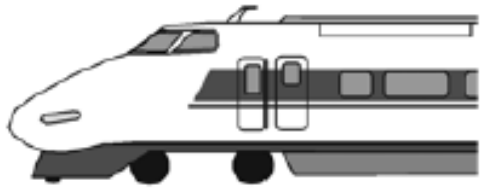
SUSPENSION


Active Suspension System
Caliper brakes with
tread cleaning systems
Telescop
Inter-car Yawing Dam
Automatic height adjustment valves
Vertical Damper
Yaw Damper
Differential pressure valve


Secondary suspension
Wheel
Bogie frame
Lateral damper
Bump-stop
Vertical damper
Yaw damper
Wheelset
Primary suspension

AERODYNAMIC BODY DESIGN

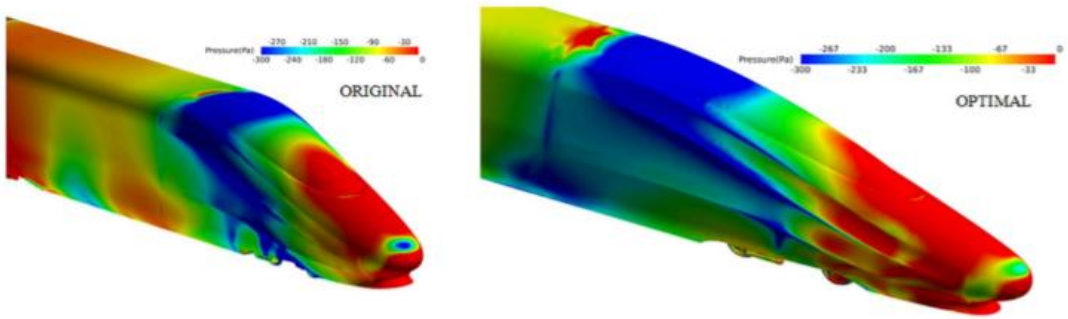
Series 0 (1964)



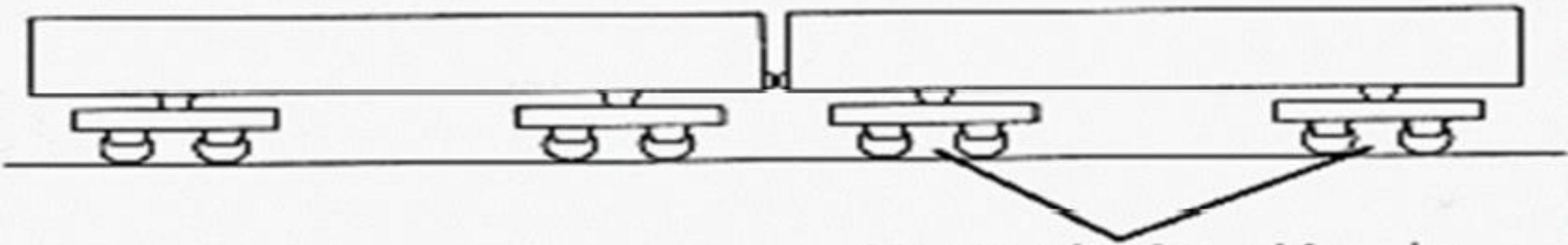
Series 100 (1985)

Series 300 (1992)

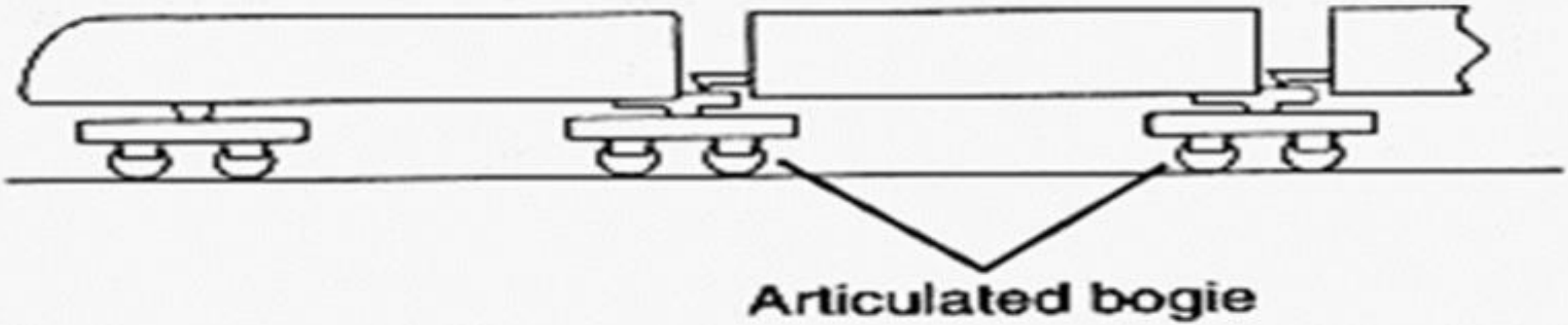
Series 700 (1999)



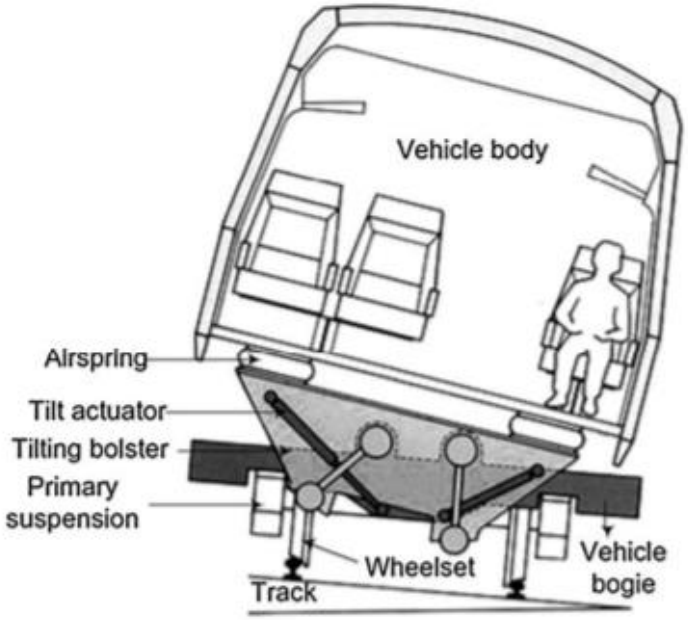
(a) Non-articulated cars

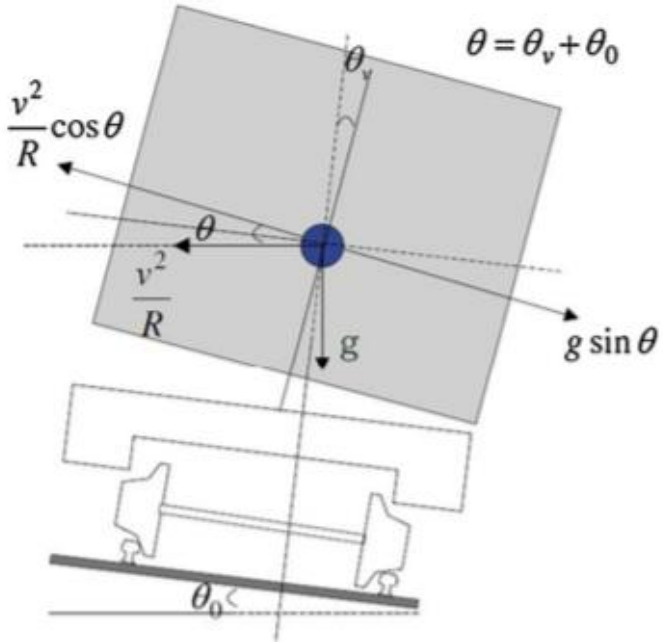


(b) Articulated cars



Carbody Tilting





MAHSR ROLLING STOCK

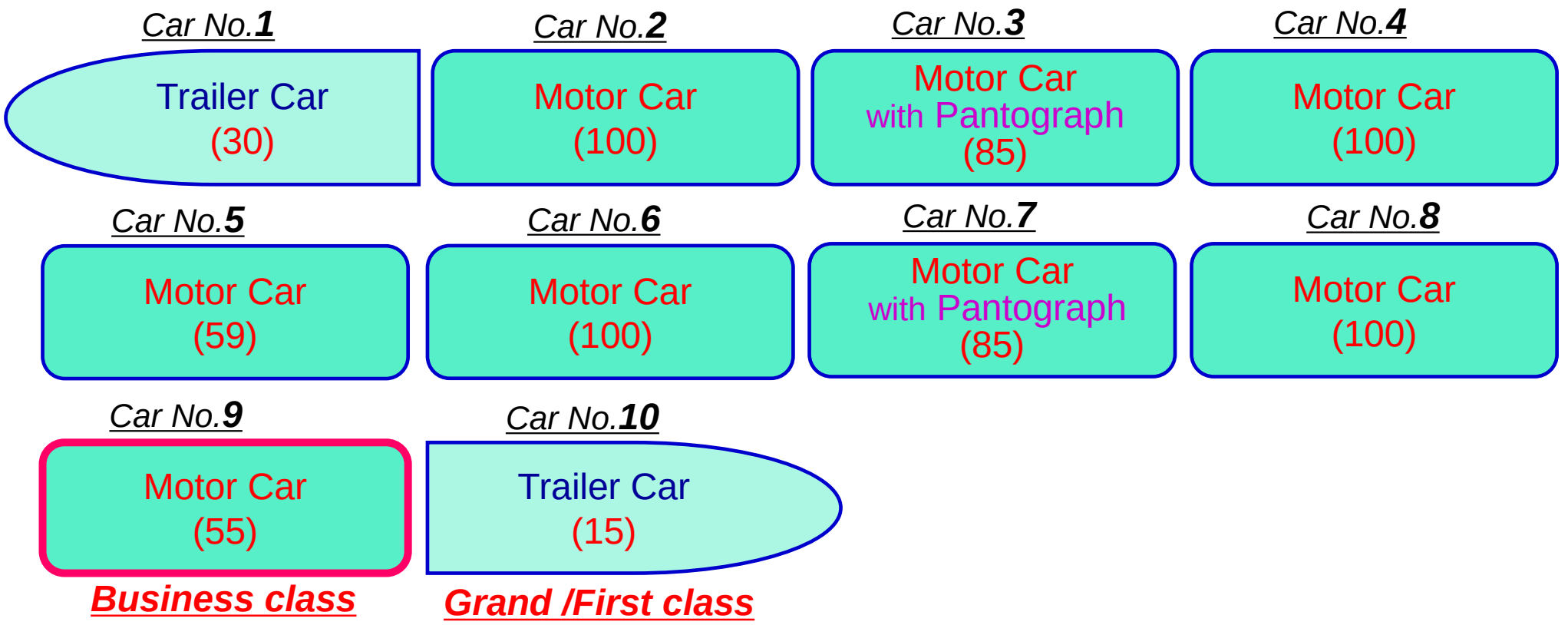
E5 series Shinkansen, Top speed – 320 kmph

General Overview

TRAIN OPERATION PLAN					
Year		**Start of Operation (SOO)**	**After 10 Years**	**After 20 Years**	**After 30 Years**
Train Configuration		10	10/16	16	16
Number of Rakes		24	24 +11	44	71
Number of Train Trip (per day/one-direction)		35	51	64	105
Train Capacity		750	750/1250	1250	1250
Traffic Volume (day/one direction)		17,900	31,700	56,800	92,900
	Peak Hour:	3	4	6	8
	Off peak:	2	3	3	6

- **Operational Control Centre**: **Sabarmati & Maintenance Depot/Workshop** (Rolling Stock): **Thane, Sabarmati & Surat**
- **Train Acceleration:** 0 to 320 Km/h in 310 s (distance - 18 Km)
- **Braking:** Service brake: 320 to 0 Km/h in 167s (distance - 8.5 Km)
- **Power failure** detection brake: 320 to 0 Km/h in 78s (distance - 3.87 Km)
- **Classes of coach:** 3 types (Standard, Business, Grand Class)
- **Tentative Fare:** Standard class 1.5 times of AC-I (about INR 3000)
- **Annual Energy requirements** (Trains, Stations etc): 1100 million unit

MAHSR Rolling Stock

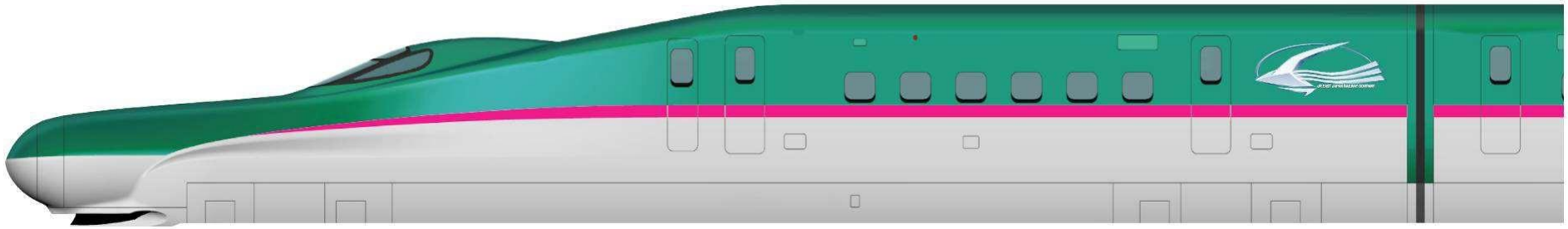


- **10 car train (8-Motorized & 2-Trailer) 729 Seats - Start of Operation**
- **16 car train (14-Motorised & 2-Trailer) 1250 Seats – After 10 years**

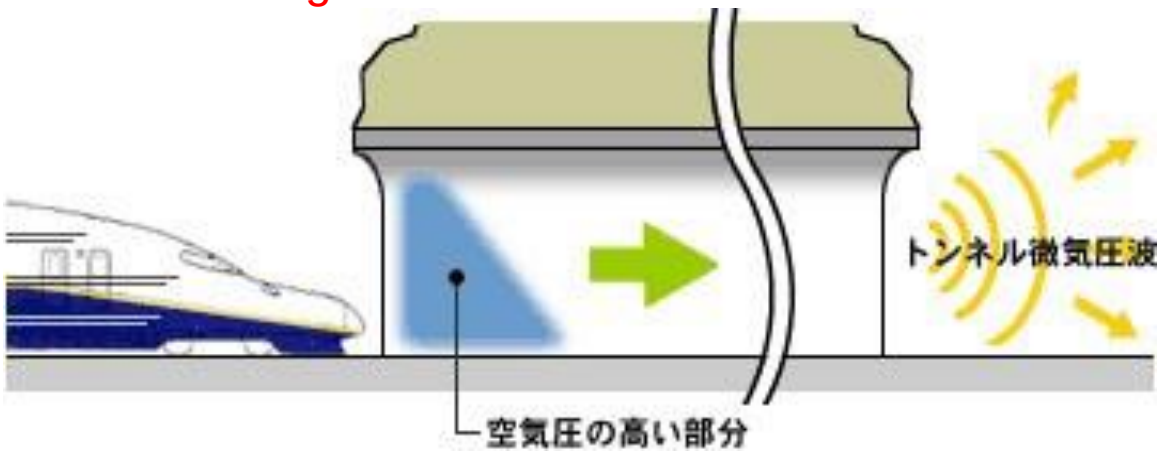
Achieving High Speed

Aerodynamic Design

For high speeds, air drag is to be minimized.
Aerodynamically designed Car body with long nose to reduce drag

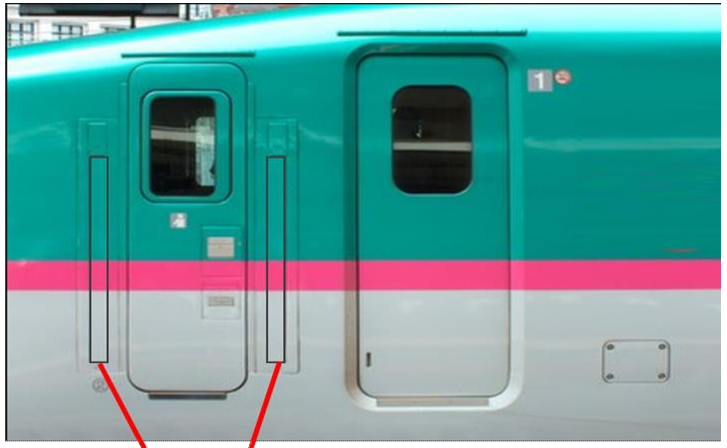


When high speed train exits a tunnel, a blasting sound is generated due to micro pressure waves. To reduce this micro pressure, the front car is designed with a nose section.



Achieving High Speed

Reducing Air Drag



Open : Low speed

Close : High speed

Fairings fitted all around the gaps between cars

Side and Bottom covers for Bogies and other underframe mounted equipment

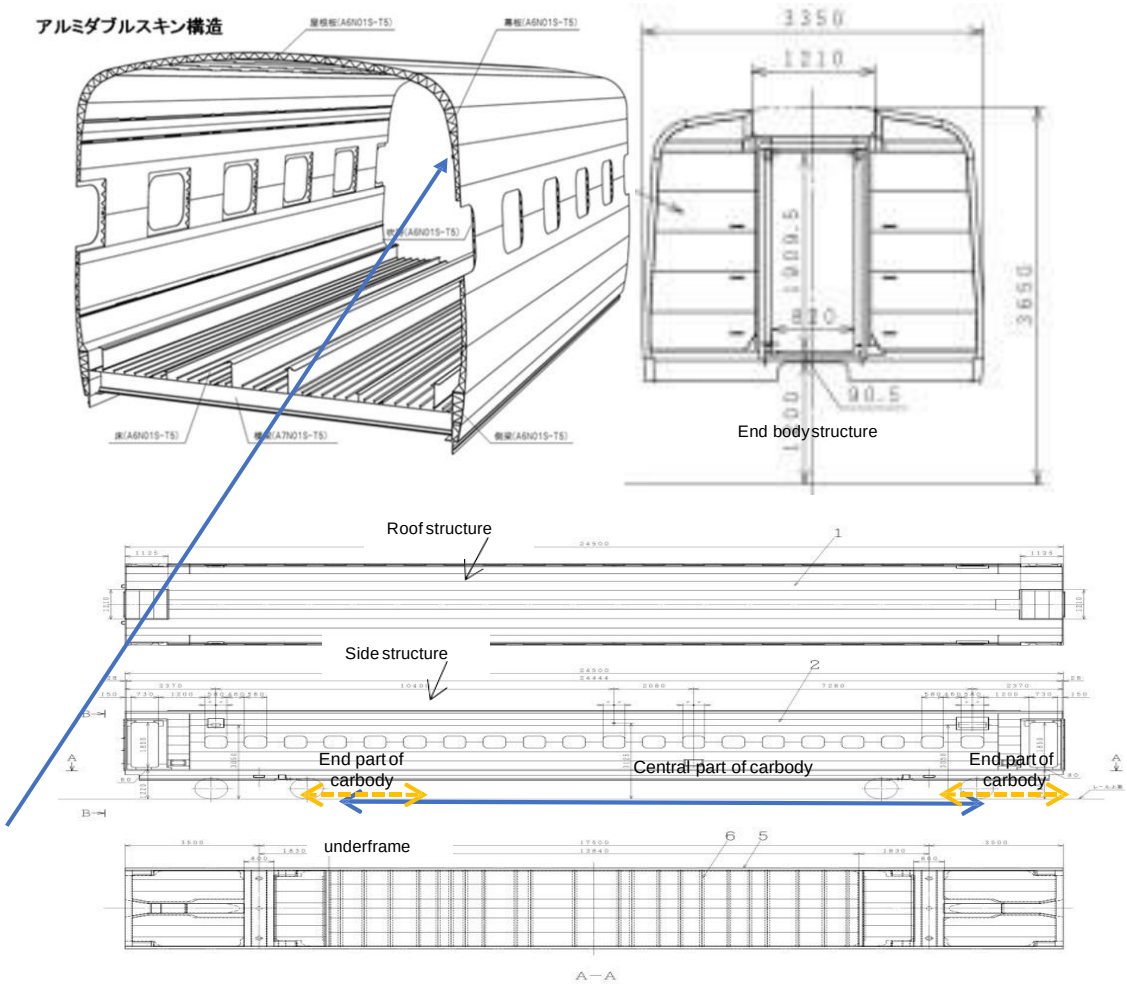
Passenger Comfort

Avoiding Ear Pressure in tunnels

- The car body is pressurized to avoid discomfort to passengers due to drop in pressure inside the passenger cabin in tunnel.

- To achieve this complete car body is made air tight and a pressure inside the car is kept above the atmospheric pressure.

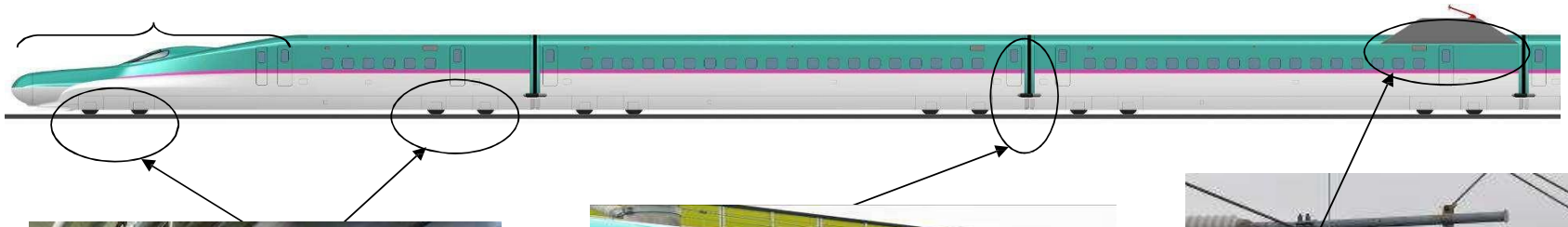
Cross section area = 10.8m^2



Double skin hollow Aluminum extrusions with truss section

Passenger Comfort

Noise Mitigation



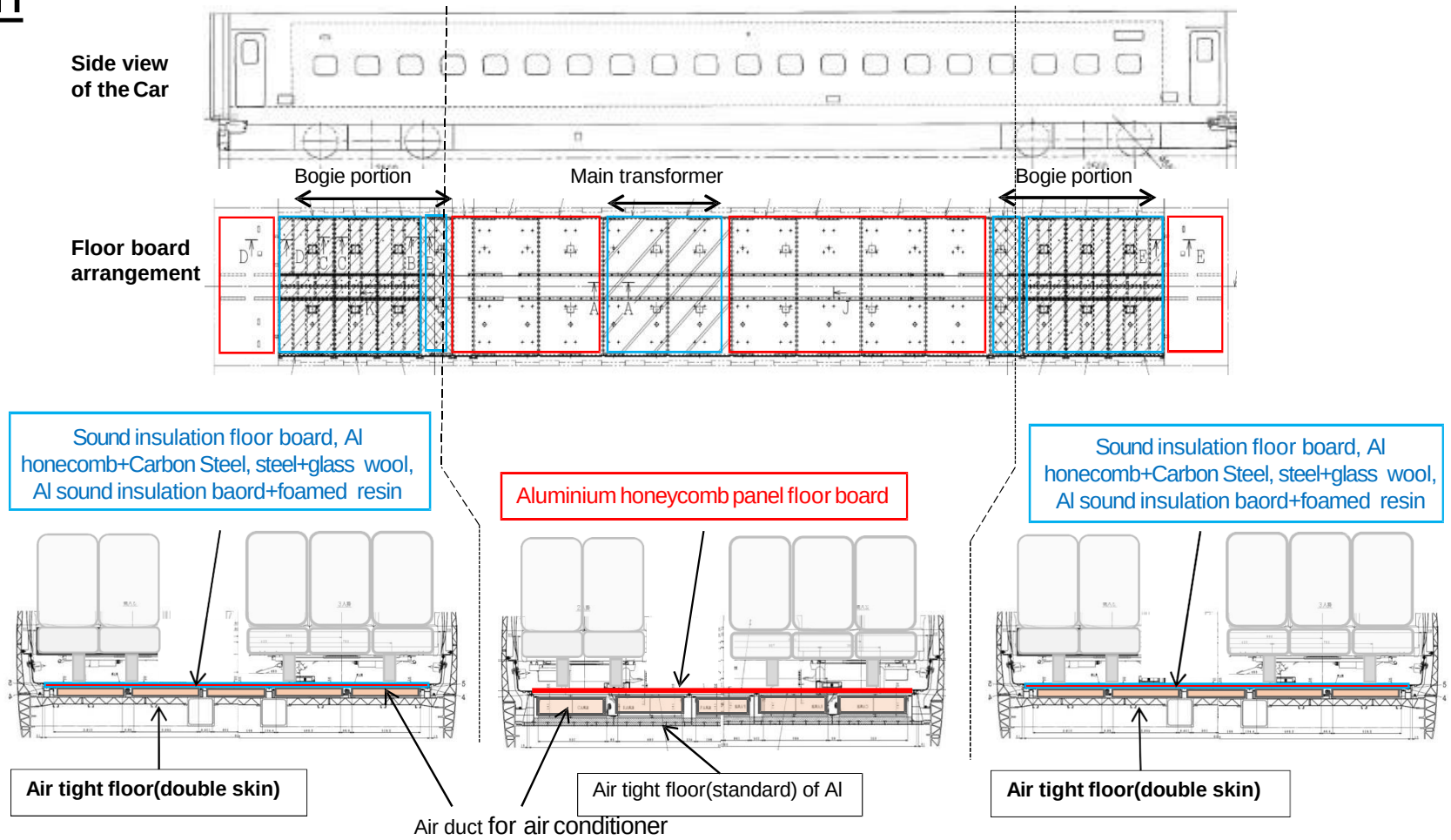
Bogie covers
Sound-absorbing construction

Fairing (Smooth covers) between cars

Pantograph noise insulation panel

Passenger Comfort

Noise Mitigation

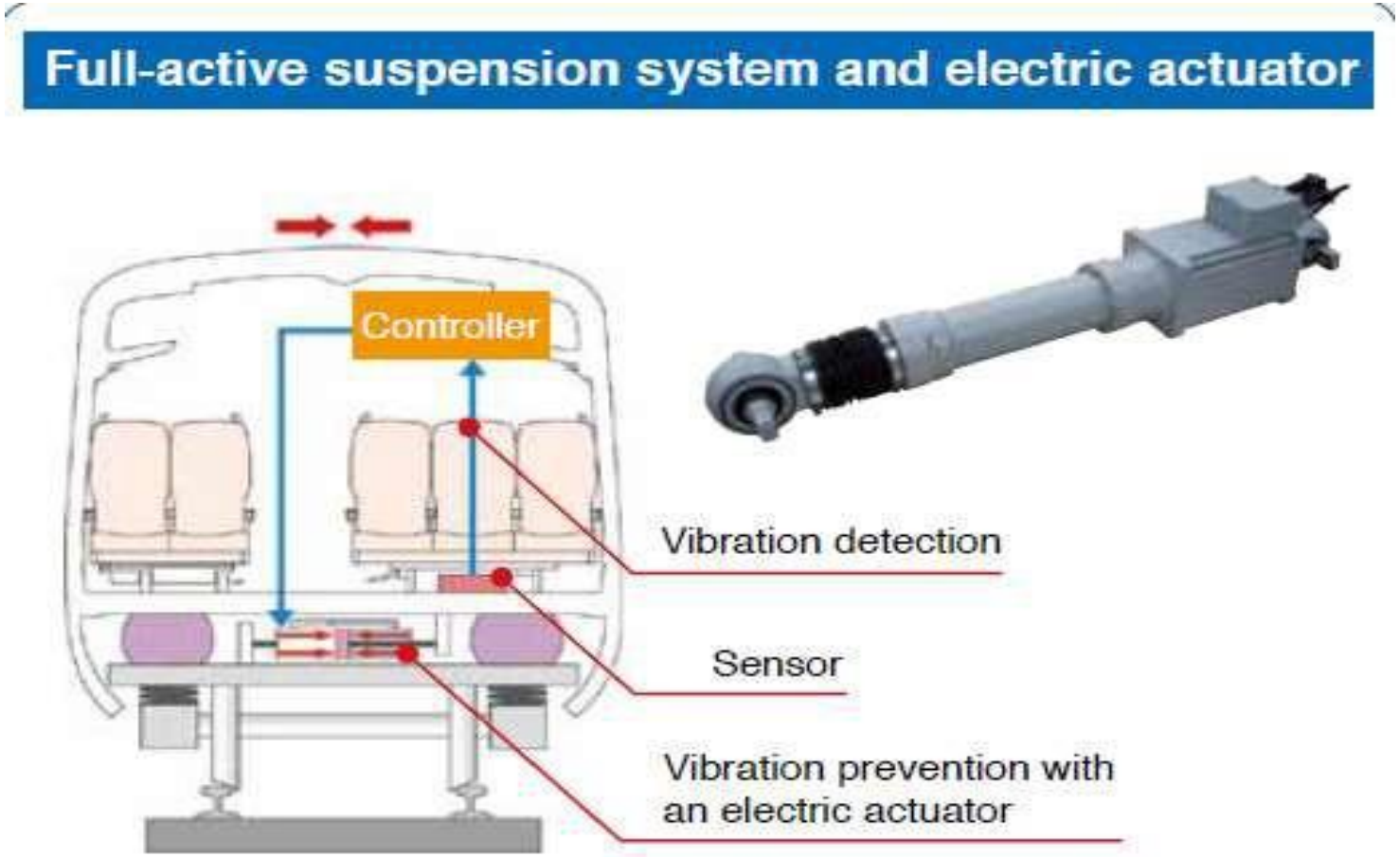


Sound proofing in the floor -- Inside noise < 70 dB (A)

Passenger Comfort

Special Lurch Control System

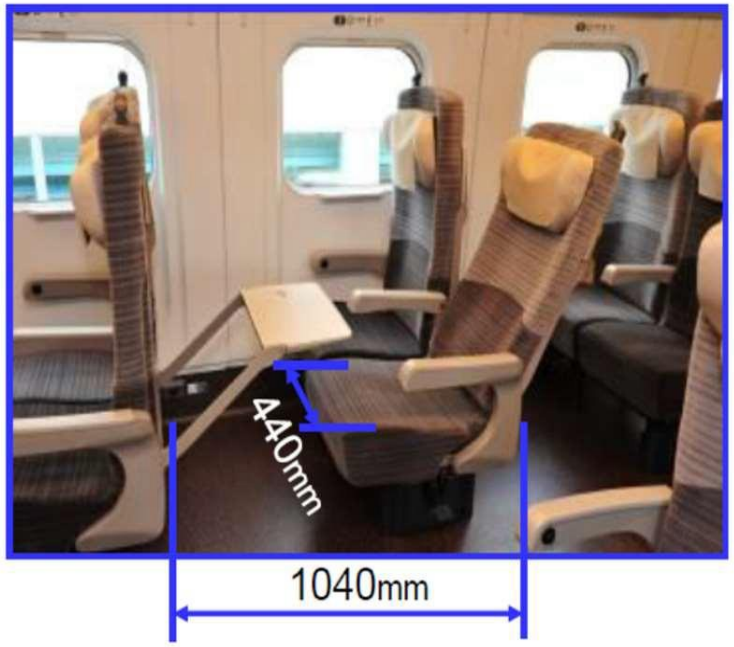
Intelligent control system that detects car body swaying and then reduces lateral vibrations.



Passenger Comfort

Ergonomically designed interiors

Business class



Standard class

Seat pitch : **1300**mm,
width : **520**mm

Grand/First class

- **Soft indirect lighting**
- **Seat leg rests operate in conjunction with seat tilting.**
- **Seatback has an improved shape**
- **Reading lamp is installed in a seatback upper corner.**

- **All seats have adjustable headrests**
- **When a seat is reclined, a seat sliding mechanism operates in tandem.**
- **Flip-up type Armrests (middle ones)**

Passenger Comfort

Modernised toilets

Men's urinal

Women's toilet

Men &Women's

Wheelchair accessible toilet

Women's washroom

Men and Women's washroom

Wheelchair accessible washroom

Passenger Comfort

Passenger Interface

- Voice communication system - Public address (PA) system; Automatic announcement system; Emergency call equipment; Wired / Wireless interphone (for crew).
- Staff rooms
- Refrigerator-freezer, hot-case, boiling water facility and tea and coffee maker, hand towel warmer (Business class)
- Space for On-board sellers

LCD type Passenger information display

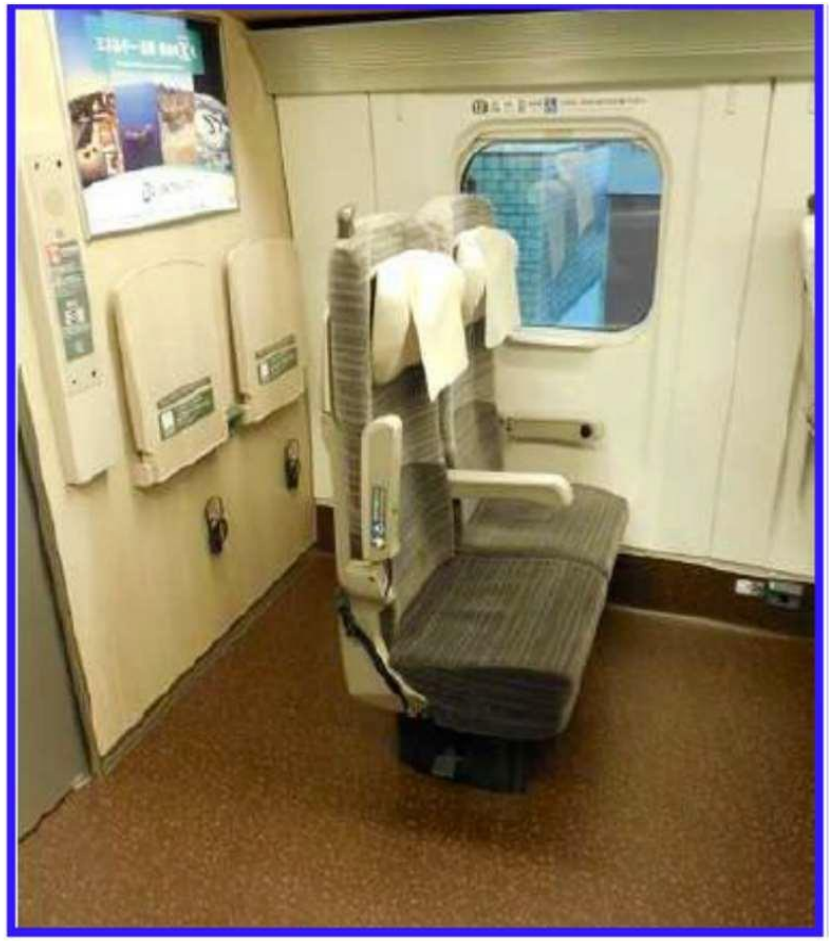
- English, Hindi, Gujarati and Marathi
- Train name and number
- Current station, next stopping station and destination
- Schedule and expected time to reach next stop and destination stations
- Information in emergency situations
- Text news
- Door-opening side
- Speed

Passenger Comfort

Facilities for the differently abled

Business class

Wheelchair fixing belt



Standard class

Passenger Comfort

Multi-purpose room - Folding bed, baggage rack, mirror, etc. especially for sick persons or child feeding women.

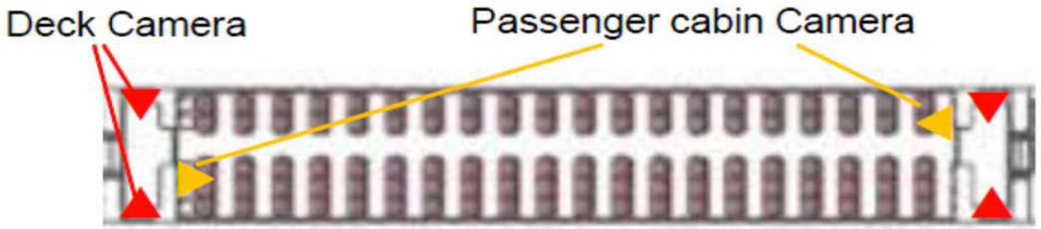
Passenger Comfort

Emergency Intercom System

- Intercom talking with train crew by pushing button
- It is installed all passenger cabins (both sides of cabin end) and all toilets

Security

- Recording the image to on-board memory recorder for about one week
- Both sides of entrance door/deck and passenger cabin
  (total 56 units for MAHSR Trainset)



Camera arrangement

End wall of passenger cabin

Over the door of entrance deck

Automatic Seat Rotation & Cabin Cleaning

- Automatic seat rotation system
- For very short time (7min.) cleaning at the terminal station of Tokyo (Special demand for JR East, not for passenger comfort)

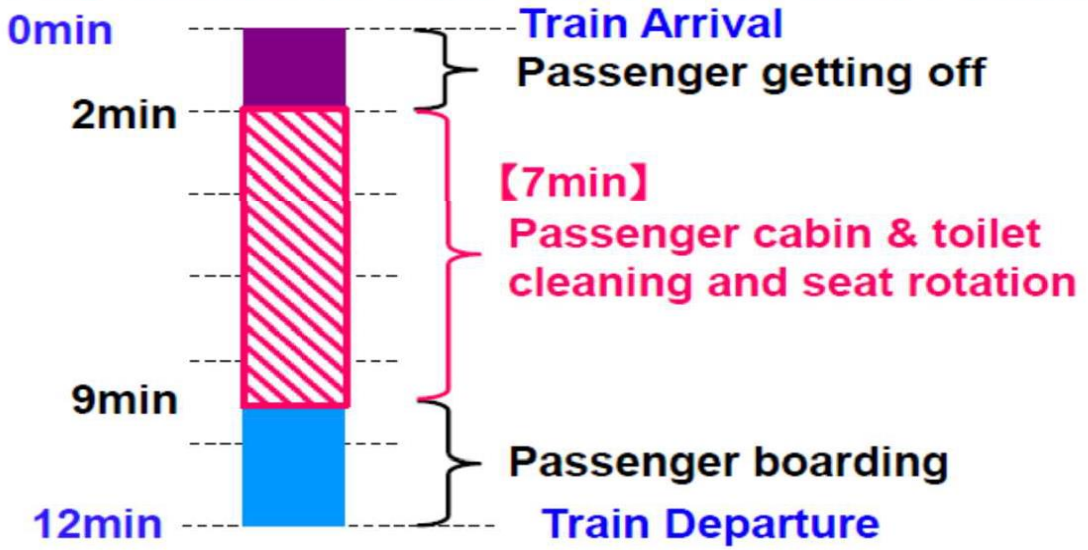
Push button of
seat rotation
(for cleaning staff)

South bound

North bound

Passenger cabin cleaning

Very short time Turn back at the Tokyo station



Various Maintenance Schedules

Schedule	Periodicity of schedules	Downtime for Schedule	Main Items Attended
Daily Inspection	48 hours	2 hrs.	Functional check of brake system, propulsion system, air-conditioners, pneumatic devices through S-TIMS; Check of bogies, wheels, pantographs, doors, interior equipment, toilets / washrooms, public address devices, headlights, taillights, wipers; Consumables, light repairs
Regular Inspection	30,000 km or 30 days	8 hrs.	All items of DI; Check of underfloor equipment; UST of axles
Bogie Inspection	600,000 km or 18 months	5 day	Bogie components (Bogie frame, Wheelset, Damper, WN Coupling, Axle Spring, Axle box, Axle bearing, Traction motor) are disassembled, inspected and re-assembled; Final inspection after bogie assembling; Test run in depot and on main line
General Inspection	1,200,000 km or 36 months	20 days	Uncoupling of cars of trainset; Disassembling of bogies; Disassembling of roof, underfloor, and interior equipment, Inspection, repair and overhaul of equipment (almost all major equipment are inspected, repaired and overhauled – Pantograph, Tight lock coupler, Seats, Doors, Toilet WC, Master controller, Brake controller, Traction converter, Blower, APU, Battery, S-TIMS unit, Air-conditioner, Ventilation equipment, Waste & Water tanks, Compressor); Painting; Air tightness of car body and wiring continuity test; Exchange of bogies; Coupling of cars into train set; Final inspection, Test run in depot and on the main line
Wheel re-profiling	Based on noise/ vibration, wheel profile data	2 days	As per requirement, Without de-coupling the trainset
ATC Characteristics Inspection	90 days	8 hrs.	
Train Radio Inspection	a. 6 months b. 1 year	8 hrs.	a. Train radio function check b. Measurement of radio output power and radio frequency
Un-scheduled repair	Whenever necessary	As per nature of repairs	As per requirement, Without de-coupling the trainset

General Inspection Train

- To ensure safety for the high speed railway operation
  - Periodic inspection of the track, S&T and electrical facilities
  - Accurate measurement during running

- Manufactured year; 2001, Design basis; E3 Shinkansen (1997)
  - Maximum speed: 275 km/h
  - Train formation; 5M1T; 5 motor cars and 1 trailer car

General Inspection Train for MAHSR

Basic Concept

- Measuring/inspection equipment;
  - based on the **East-i.**
  - proven technology.
- Carbody and sub systems;
  - based on the **commercial Train Set for MAHSR**

Design basis; E5

Maximum speed: 320 km/h

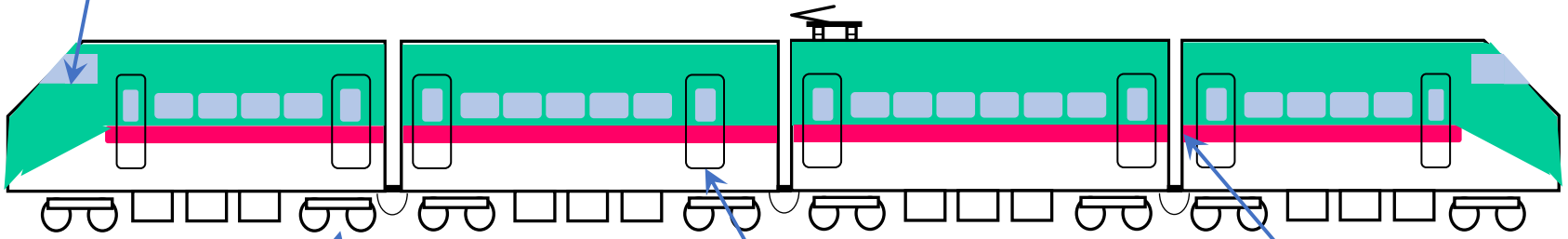
Train formation: 4M2T; 4 motor cars and 2 trailer car

Daily Inspection

Check function in cabin (Brake, Propulsion system, Air-conditioning, etc.)

Check Pantographs / check contact strips

Within 48 hours



Check Bogies and Wheels / check Brake linings

Check Doors

Check Rest rooms

Regular Inspection

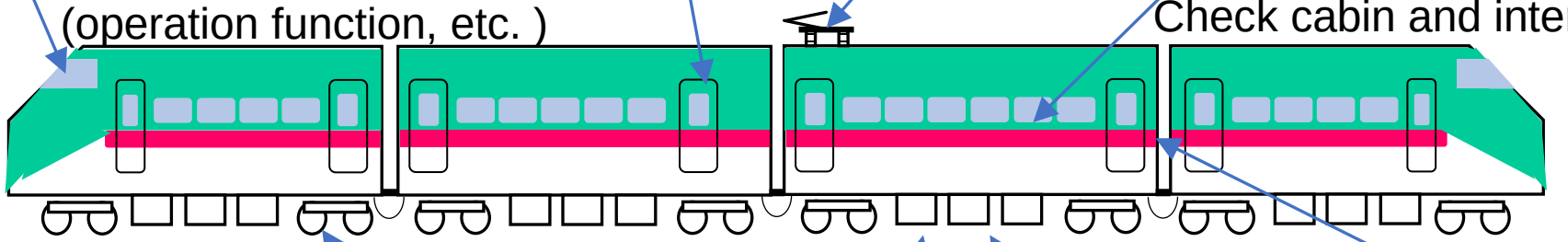
Within 30,000 km or 30 days

Check Doors

Inspection of Pantographs / Replacement of contact strips

Check function in cabin, (operation function, etc.)

Check cabin and interior



Inspection of Bogies and Wheels / Replacement of Brake linings

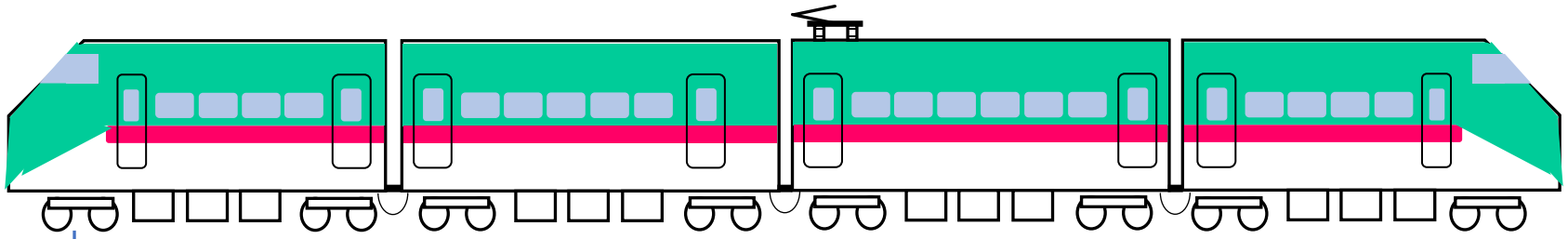
Ultrasonic flaw inspection for hollow axle

Clean or exchange air filter

Check equipment

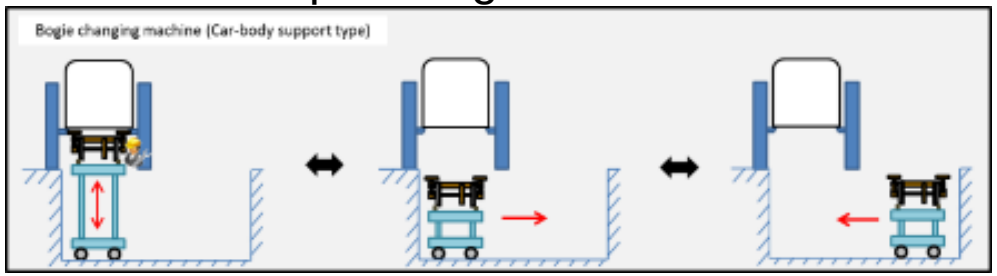
Check Rest rooms

Bogie Inspection

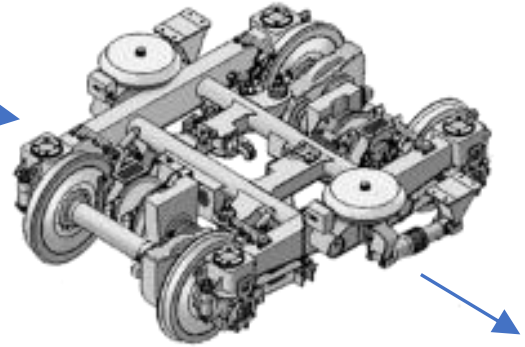


Within 600,000 km or 18 months

Bogies are exchanged with spare bogies

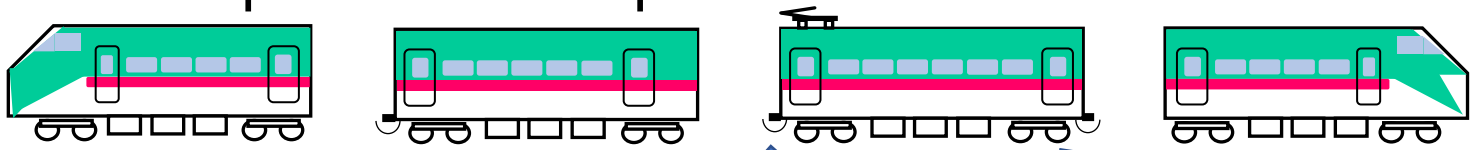


Bogie components are disassembled, inspected and assembled



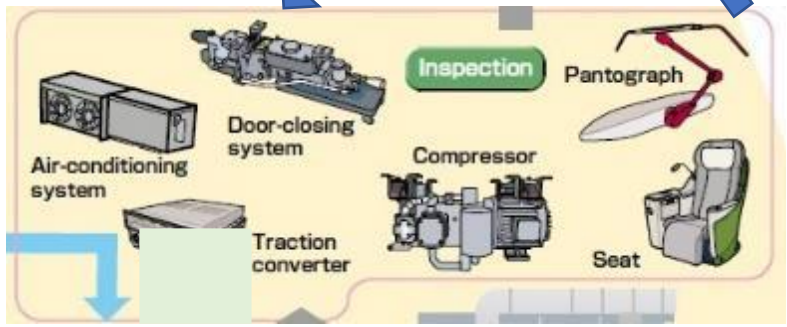
General Inspection

Almost all equipment are inspected and repaired



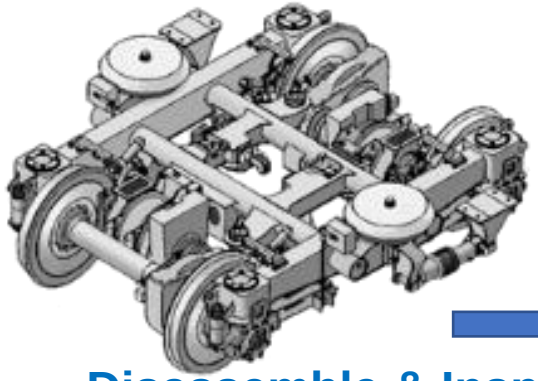
Within 1,200,000 km or 36 months

Disassemble



Assemble

Body Paint



Disassemble & Inspected

Depot Machinery – A Summary

Type of Machine	D-2	D-1	Some Examples
Tester	63	02	Bogie Running Test Machine, ATC Tester, Oil Damper Tester
Data reader	15	07	Data Management terminal, DS-ATC data reader, Other Data Readers
Measurement	17	04	Wheel-axle Ultrasonic Flaw Detector, Thrust Clearance Measurement Machine
Oil/Grease filling	05	00	Bearing Oil Filling Machine, TM Grease Filling Machine
Painting	27	00	Automatic Car body Painting Machine, Automatic Polishing Machine
Special Purpose	63	13	Wheel Lathe, Wheel-axle Ultrasonic Flaw Detector, Bogie Exchange Lifting Machine
Assembly / Disassembly	25	00	Wheel Fitting Press, Bogie Assembly Machine
Cleaning/Drying	59	04	Bogie Washing Machine, Gear Box / Axle Box Flushing Machine, Automatic Car body Washing Machine
Cranes	12	02	Overhead Traveling Crane, Balancing Crane, Jib Crane
Compressor	10	02	Air Compressor (High), Air Compressor (Low)
Heaters	06	00	Bearing Induction Heater, WN Gear Coupling Induction Heater
Material handing	13	01	Traverser, Underfloor Equipment Lifter, Forklift, Battery Car
Storage	08	01	Wheel Set / Wheel Disc Storage Machine, TM Storage Machine
Working Platform	07	01	Underfloor Inspection Vehicle, Lifting Deck Car, Working Deck
General Purpose	21	04	Charging Machine, Punching Press, Arc Welding Device
Total	**351**	**41**	**Summary Machines Sabarmati - 273 Different Types, 351 Specifications, 1023 Nos.**

Surat Depot

- Roof Safety Step;
- Door Locking Device for Roof Deck;
- Underfloor Wheel Lathe
- Battery Pusher
- Portable compressor
- Forklift.

Some Key Machines for Safe Running at 320 km/h

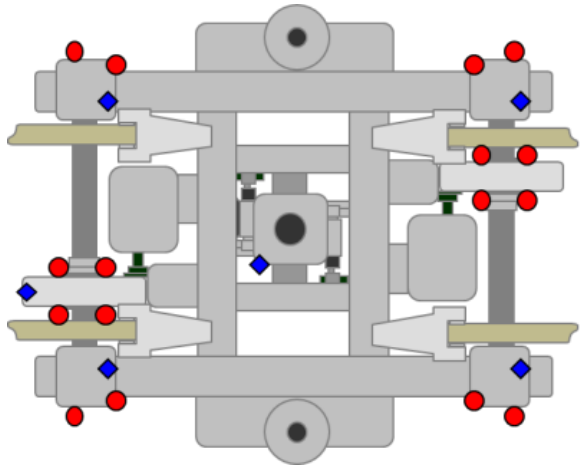
- Automatic Carbody Washing Machine
- Bogie Running Test Machine
- Wheel-Axle Ultrasonic Flaw Detector
- Car Body Airtight Tester, etc.
- Automatic paint machine

Automatic Carbody Washing Machine

- Automatic Trainset washing
  - Car body is sprayed with detergent and washed by RO water (inbuilt RO system) .
  - Distributed Washing Stations – Chemical & Water
  - Speed 5 km/h or less
  - Water Consumed : 340 L per car (ETP recycled Water)
- Machine Parameters / Configuration
  - Chemical washing units (03 Nos.):
    - Detergent spraying & brushing, 40 litres/minute
    - Water spraying & brushing, 100 litres/minute
  - Water washing units (01 Nos.):
    - Washing Water spraying rate 440 litres/minute
    - RO water spraying rate 280 litres/minute
  - Control Room at 2 Locations

Bogie Running Test Machine

- Need - Malfunction of bogie leads to serious accident
- Test of the overhauled Bogie at 320 km/h under load
- Main Parameters
  - Driving wheels (4 nos.) drive the Machine in both directions
  - Testing room
  - Measuring and operation room (Sound proof)
  - Air is supplied to air suspension to simulate the car body load.
- Measurements
  - Vibration and Temperature of axle bearing, traction gear bearing, traction gear, and traction motor
  - Air leakage from air suspension and piping
  - Voltage and rotation speed of tachometer generator
  - Oil leakages



Wheel-Axle Ultrasonic Flaw Detector

- Higher loads and vibrations on the axle in high speed running
- Detector detects flaws on hollow axle
- Main Parameters
  - Automatic Flaw detection and whether axle is passed or failed
  - Memory - Approx. 80 Axles.
  - Only 01 operator is required
  - Automatic calibration with test axle

Car Body Airtight Tester

- Need - Car body is pressurized for passenger comfort
- Tester measures the airtightness of car body
- Main Parameters
  - Tester supplies air into the car body through car end cover until the test pressure (400 mm Aq (millimetre aqua or water column) or 0.04 Kgf/cm^2) is reached
  - Measures the time taken for the pressure to reduce from 400 mm Aq to 100 mm Aq or 0.01 Kgf/cm^2 (should be 40 sec or more).
  - Automatically judges whether the car body has passed / failed the test
  - Machine equipped with car end cover set

A Modern Paint Workshop

- **Automatic Car Body Painting Machine**
  - Moving device - moves vertically and longitudinally
  - Robotic device – movement in all required directions
  - Painting is automatically stopped if ventilation stops
- **Booth with Ventilation**
  - Collects and exhausts paint mist and organic solvents through filter and duct to the outdoors
  - Ventilation and Exhaust System (3850 m^3/min)
  - Explosion proof lighting

SUMMARY

HSR operational speed greater than 200 Kmph

Distributed power trains desirable for HSR

Japan was the pioneer in the field of HSR

China is the current world leader in HSR

India will adopt HSR from Japan

HSR will boost the economy and will create employement

THANK YOU