High Speed Rail in India -
What, Why, When, Where & How?

at
Gujarat Technological University, Ahmedabad
August 31, 2014

Gaurav Agarwal,
Director, Railway Board
Ministry of Railways, India
gauravagar@yahoo.com

Why this discussion relevant here?

Recent initiatives :

1. **Indian Railways to set up four universities in India over five years: Railway Budget 2014-15**

2. **Fellowships in Universities for Railway-related Research–**

indianrailways.gov.in-- No. 2013 E(TRG)/30/6 dtd 07.08.2014

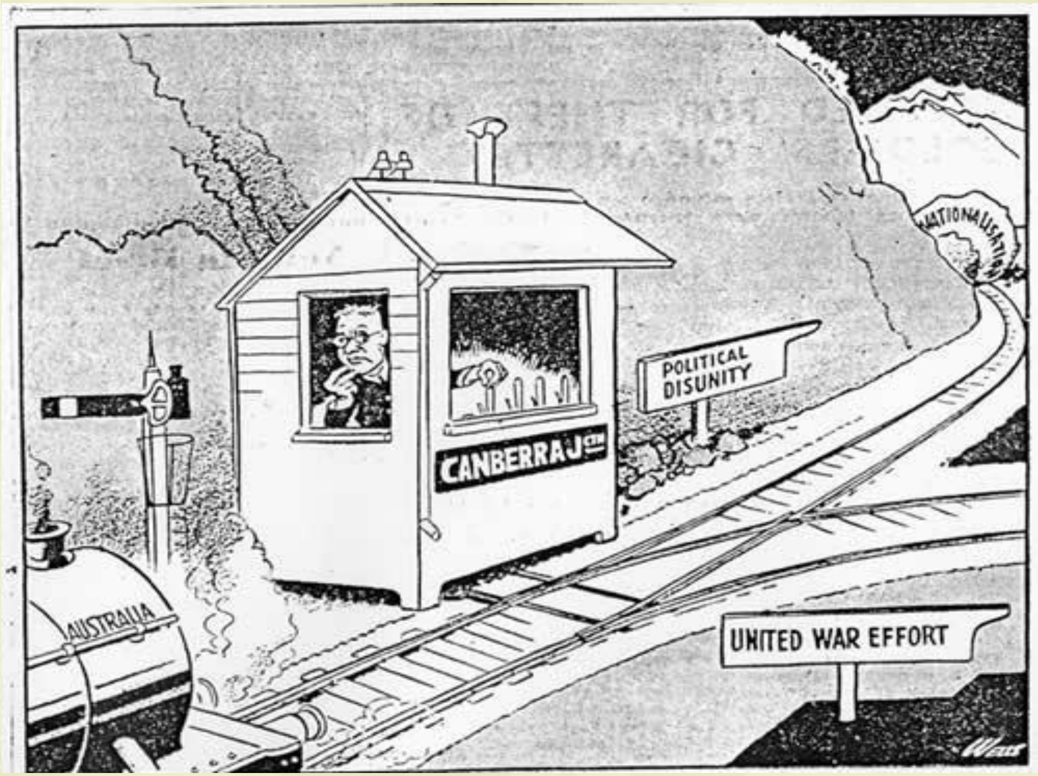
Outline

- Introduction to High Speed Rail
- Why High Speed Rail ?
- Key Issues and Challenges
- International scenario
- India : Options and path ahead

Overview of Indian Railways

- ❖ Biggest railway network under a single employer
- ❖ 2 crore passengers & 4 MT freight /day
- ❖ 3-tiers, All assets indigenously, Research, Training and export
- ❖ Mission areas : Metro rail projects, High speed, Dedicated freight corridors, IT

Commercial vs social ???



What is High Speed Rail ?

What is High Speed Rail?

As per UIC definition,

- **Trains running at speed of <u>200 kmph on upgraded track</u> and <u>250 kmph or faster on new track</u> are called High Speed Trains.**

- **These services may require separate, dedicated tracks and "sealed" corridors in which grade crossings are eliminated through the construction of highway underpasses or overpasses.**

UIC- Union internationale des chemins de fer -199 members

In the <u>US (US Federal Railroad Administration), train having a speed 180KMPH</u>.

RECORDS IN TRIAL RUNS/ COMMERCIAL SERVICES

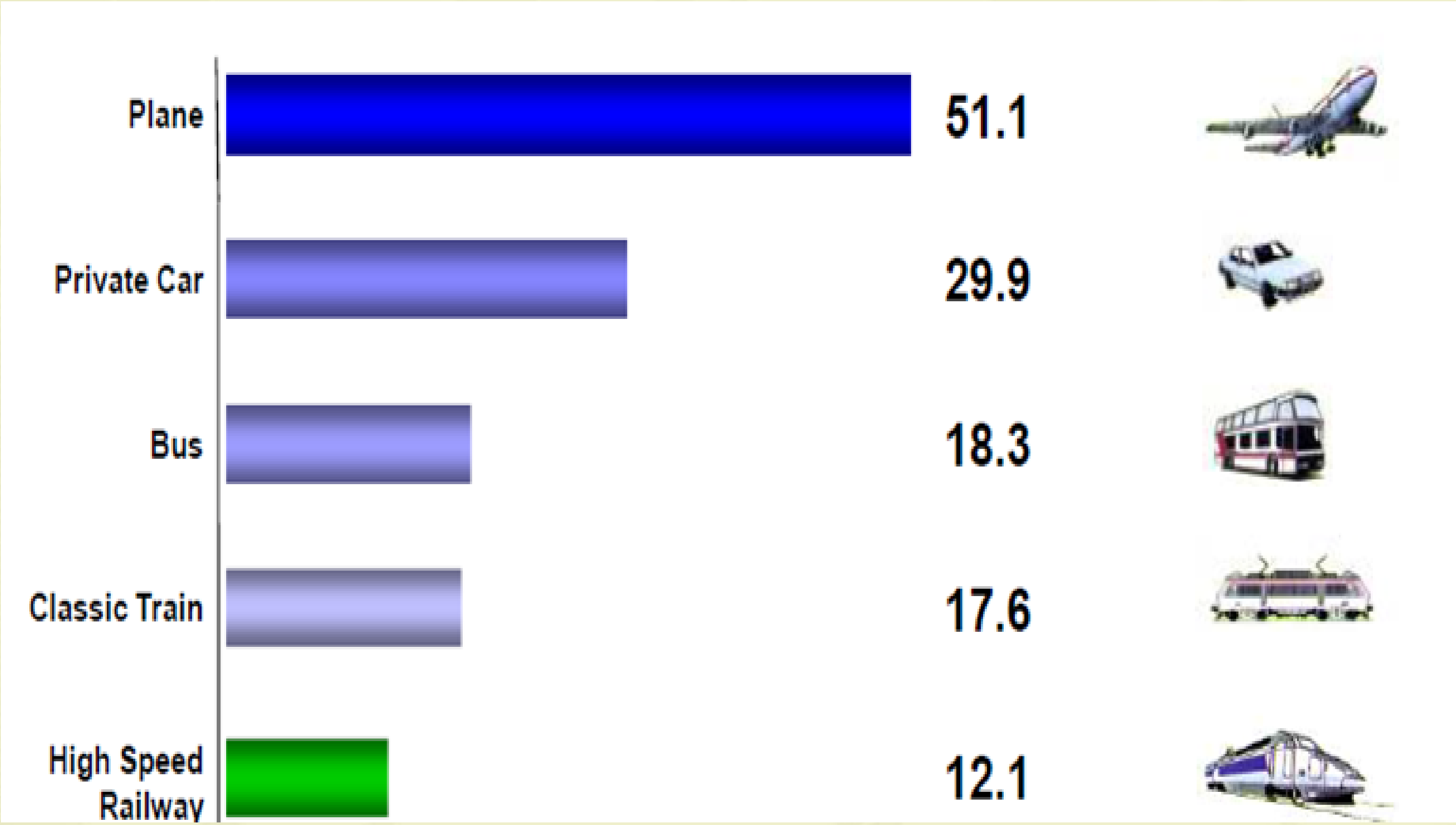
1963 - Japan - Shinkansen - 256 km/h (First country to develop HSR technology)
1965 - West Germany - Class 103 locomotives - 200 km/h (Second country to develop HSR technology)
1967 - France - TGV 001 - 318 km/h (Third country to develop HSR technology)
1972 - Japan - Shinkansen - 286 km/h
1974 - West Germany - EET-01 – 230 km/h
1974 - France - Aérotrain - 430.2 km/h (high speed monorail train)
1975 - West Germany - Comet - 401.3 km/h (steam rocket propulsion)
1978 - Japan - HSST-01 - 307.8 km/h (Auxiliary rocket propulsion)
1978 - Japan - HSST-02 – 110 km/h
1979 - Japan - Shinkansen - 319 km/h
1979 - Japan - ML-500R (unmanned) - 504 km/h
1979 - Japan - ML-500R (unmanned) - 517 km/h
1981 - France - TGV - 380 km/h
1985 - West Germany – Inter City Experimental - 324 km/h
1987 - Japan - MLU001 (manned) - 400.8 km/h
1988 - West Germany – Inter City Experimental - 406 km/h
1988 - Italy - ETR 500-X - 319 km/h (Fourth country to develop HSR technology)
1988 - West Germany - TR-06 - 412.6 km/h
1989 - West Germany - TR-07 - 436 km/h
1990 - France - TGV - 515.3 km/h

-

1992 - Japan - Shinkansen - 350 km/h
1993 - Japan - Shinkansen - 425 km/h
1993 - Germany - TR-07 - 450 km/h
1994 - Japan - MLU002N - 431 km/h
1996 - Japan - Shinkansen - 446 km/h
1997 - Japan - MLX01 - 550 km/h
1999 - Japan - MLX01 - 552 km/h
2002 - Spain - AVE Class 330 - 362 km/h (Fifth country to develop HSR technology)
2002 - China - China Star - 321 km/h (Sixth country to develop HSR technology)
2003 - China - Siemens Transrapid 08 – 501 km/h
2003 - Japan - MLX01 - 581 km/h (current world record holder)
2004 - South Korea - HSR-350x - 352.4 km/h (Seventh country to develop HSR technology)
2006 - Germany - Siemens Velaro - 404 km/h (unmodified commercial trainset)
2007 - France - V150 - 574.8 km/h
2007 - Taiwan - 700T series train - 350 km/h
2008 - China - CRH3 - 394.3 km/h
2010-China- CRH380 -420 km/h

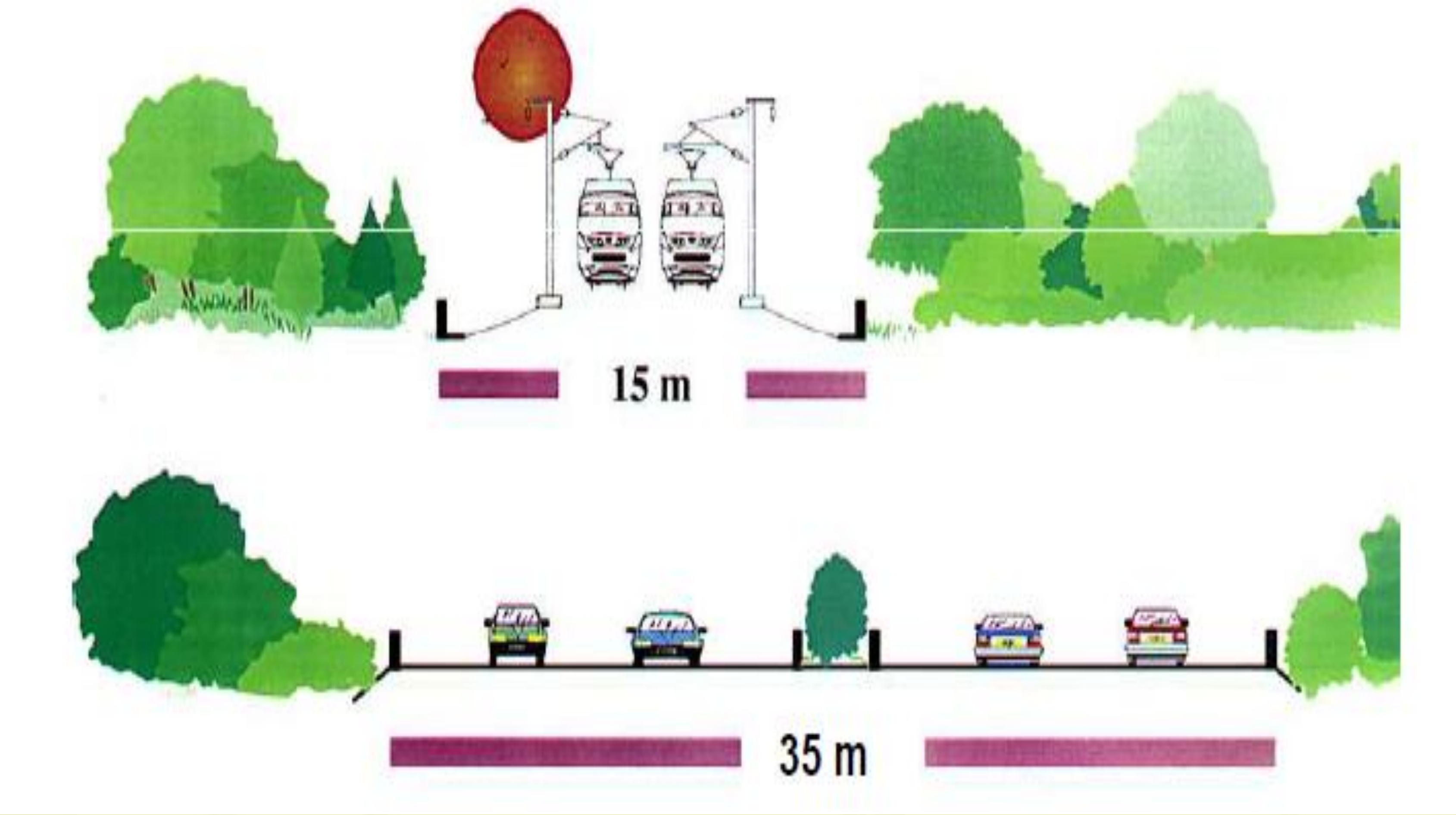
Why High Speed Rail in India ?

Energy Efficiency



Fuel equivalent : per passenger-Kms (grams)

Land requirements are small



Decogesition and capacity addition

	High Speed Rail	Motorway
Lanes	Double track	2 x 3 lane
No. of vehicles / hour/direction	12 (5 minutes)	4500 (0.8 seconds)
Passengers /vehicle	1000	1.7
Capacity / hour	12000	7650

Increasing urbanisation

Major challenges :

- **Increasing urban population**
- **Dramatic increase in private vehicles**
- **Excessive man-hours lost in traffic congestion**

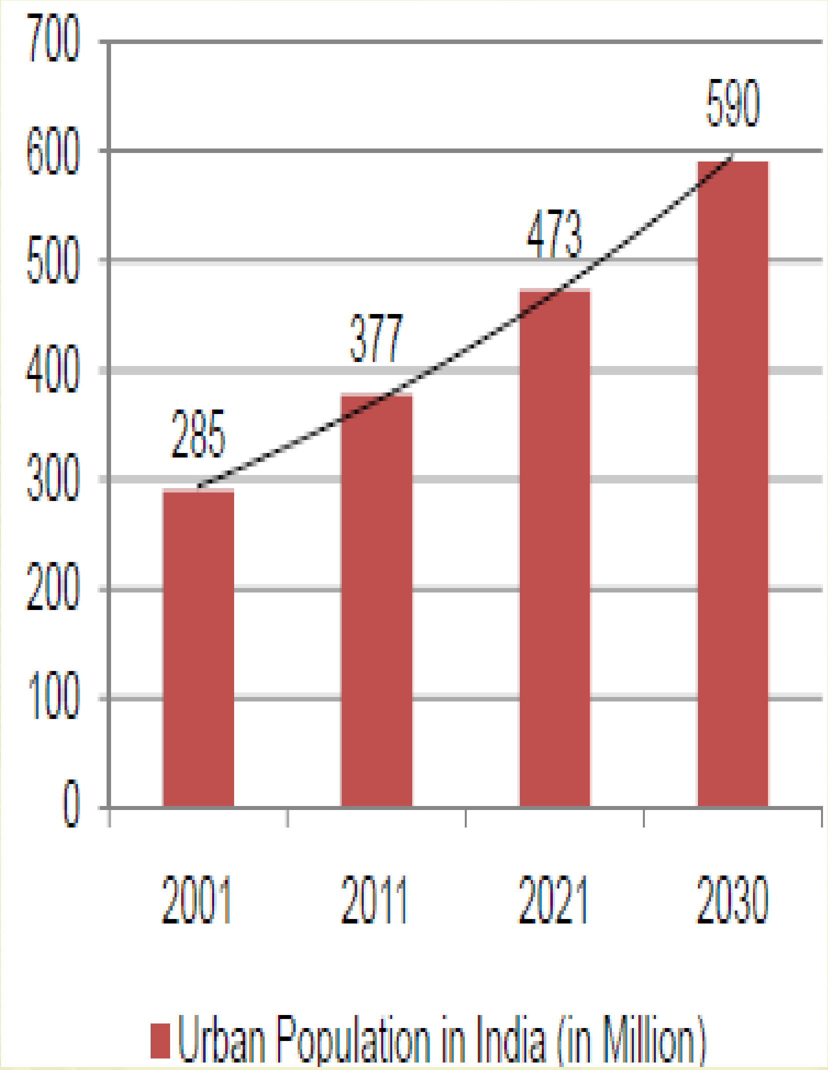
Rapid urbanisation

Mckinsey Global Institute (MGI) projections :

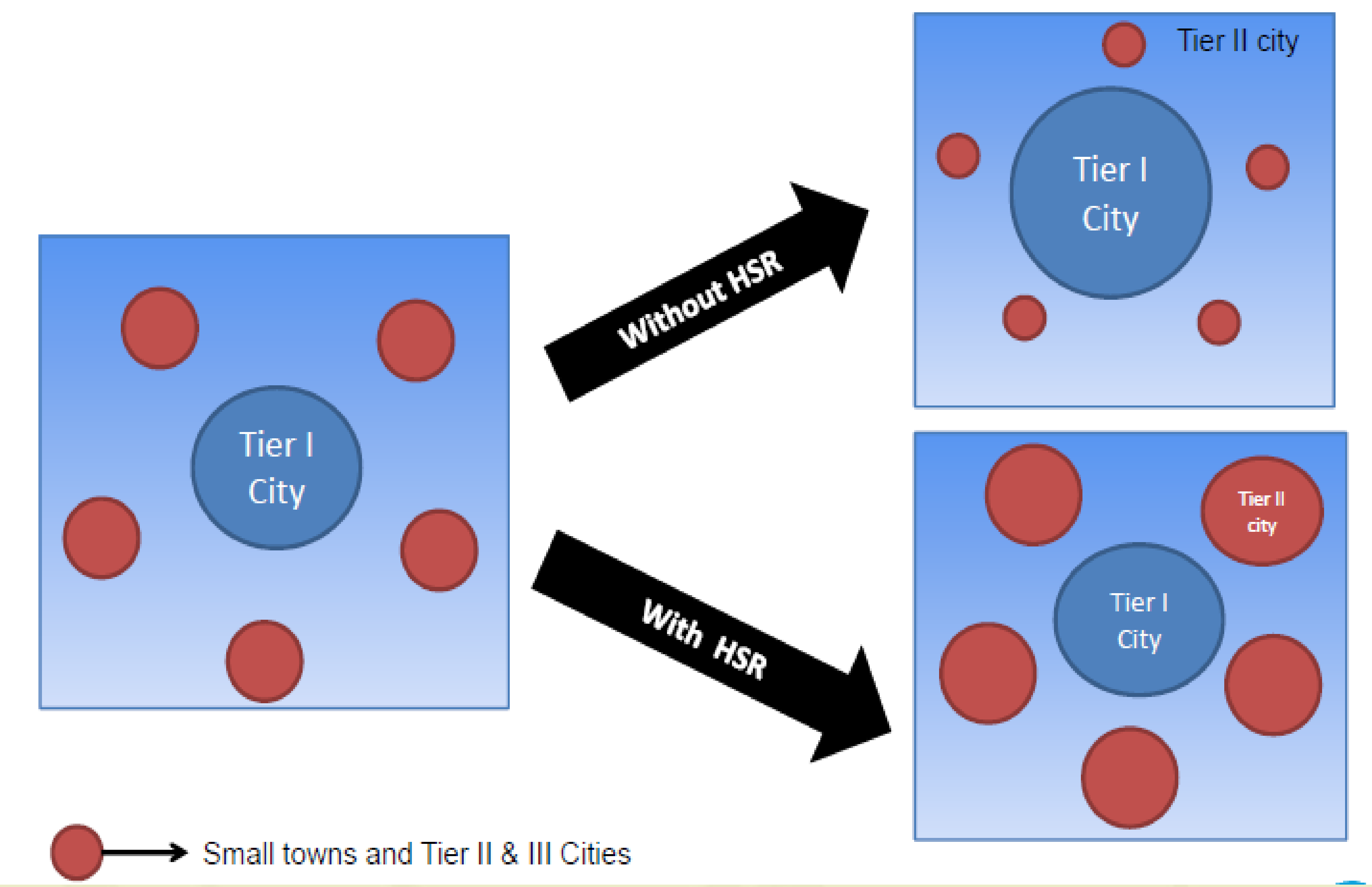
By 2030, 40 % of India's projected population urbanized

Growing demand of intercity transport – between Metro city and 2nd/3rd tier city

In absence of HSR, traffic segment of airlines/cars growing at 15-20% /year

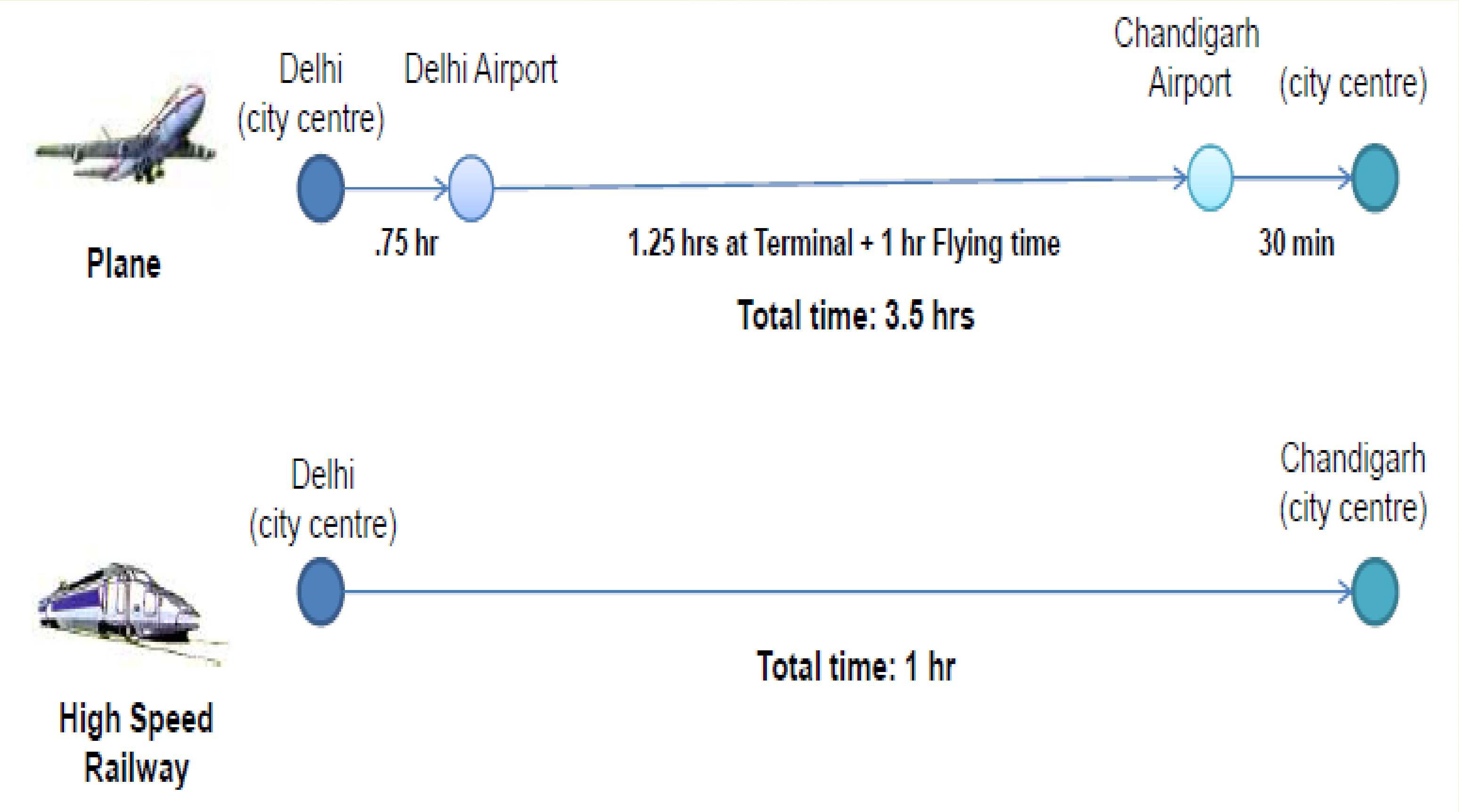


Decongestion options

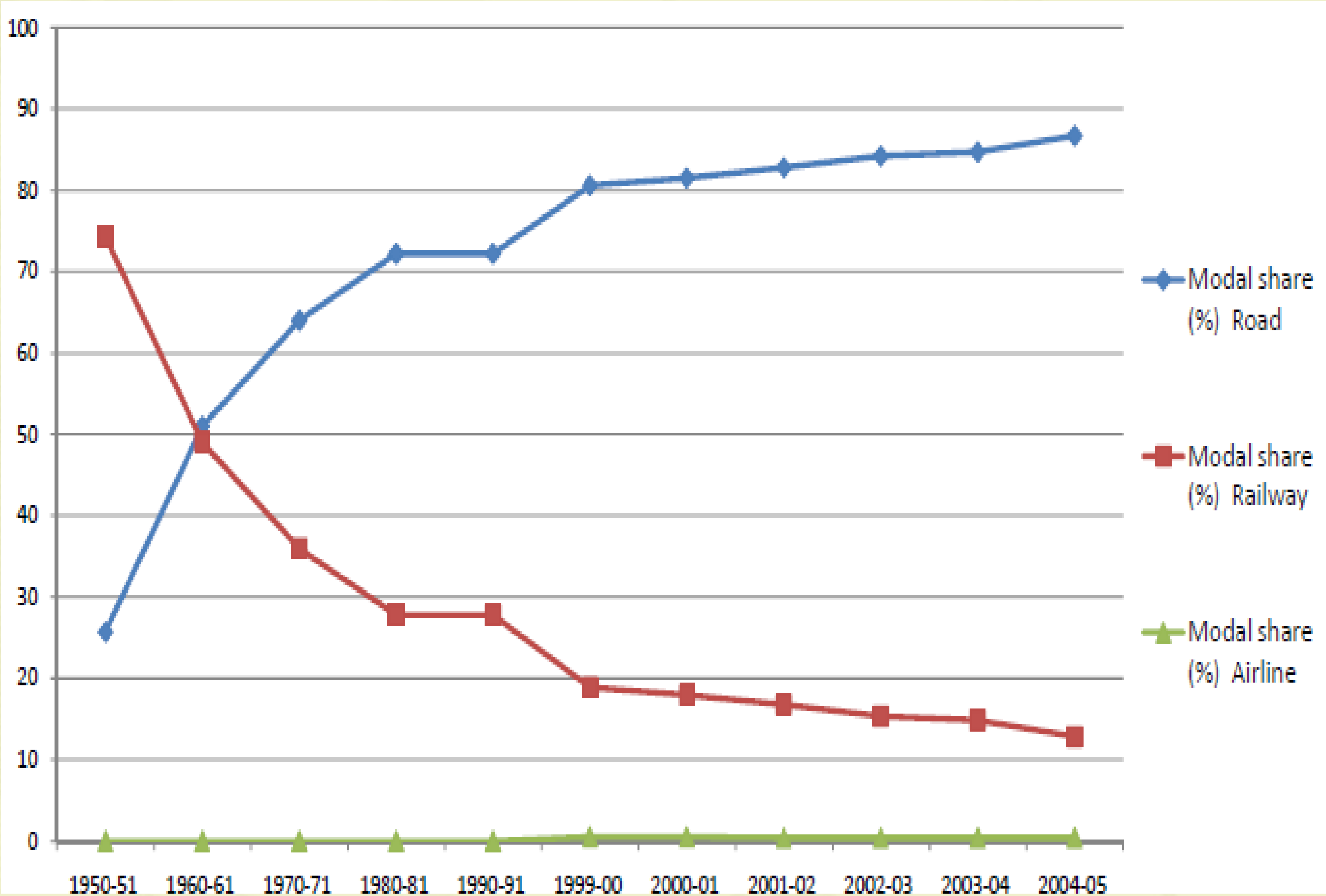


Travel time

Example : Delhi to Chandigarh – Distance 245 Kms



Decreasing rail modal share

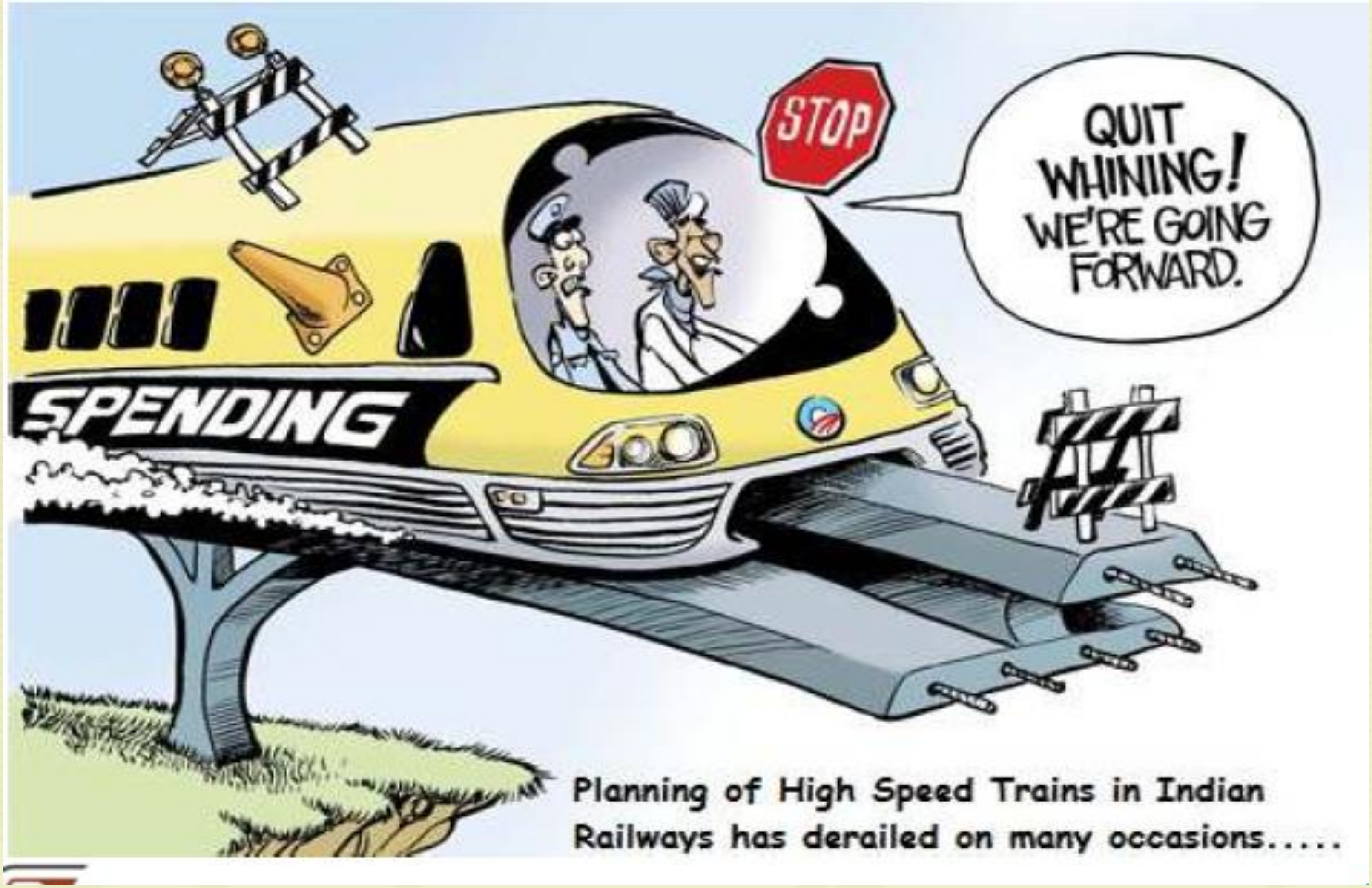


Benefits of High Speed Rail

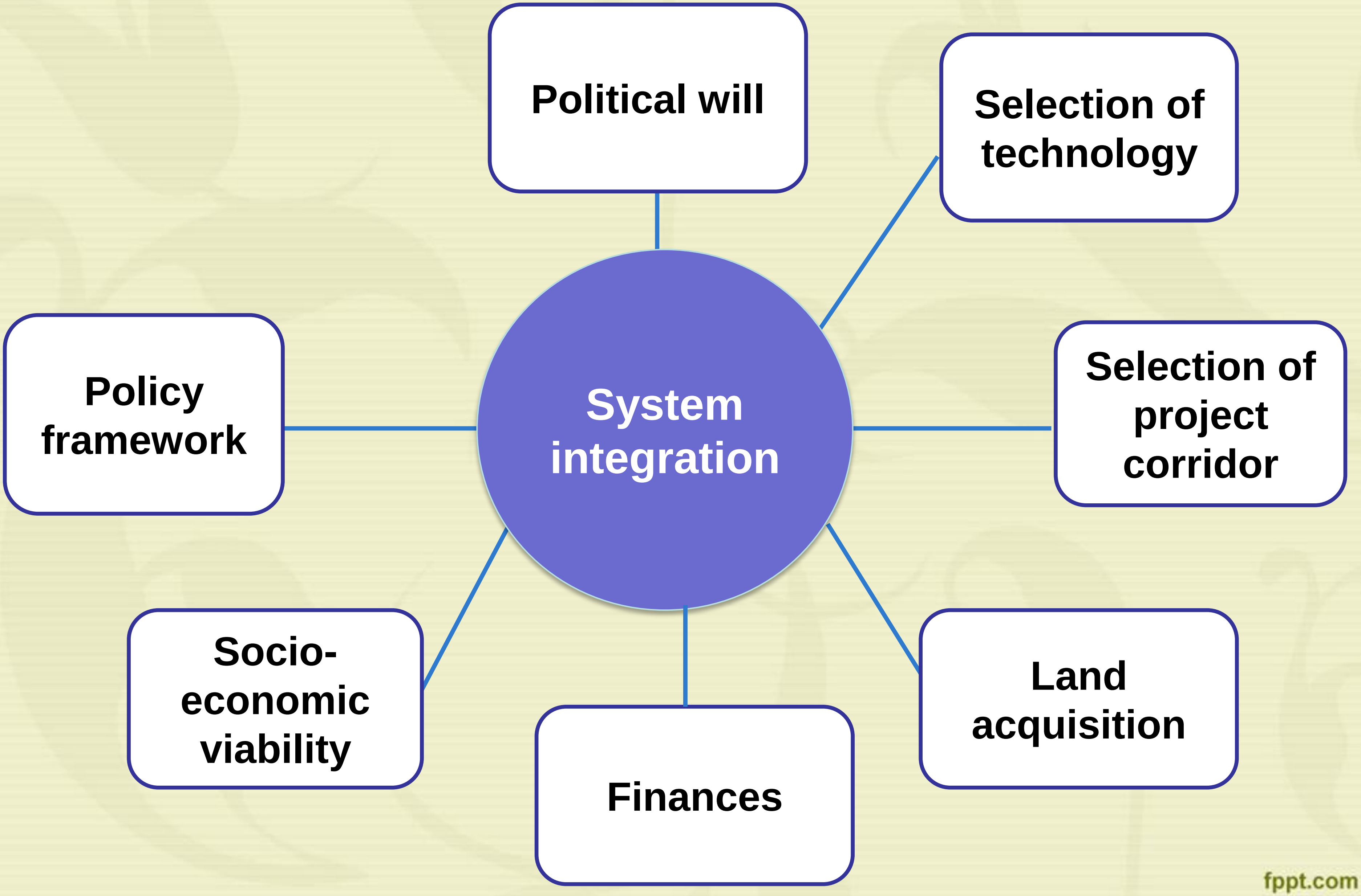
- Energy efficient mode
- Lesser land, lesser time
- More capacity, decongestion
- Urbanisation, inclusive growth
- Indigenous fuel options

What are the challenges to High Speed Rail ?

Challenges to High Speed Rail in India



Key issues and challenges

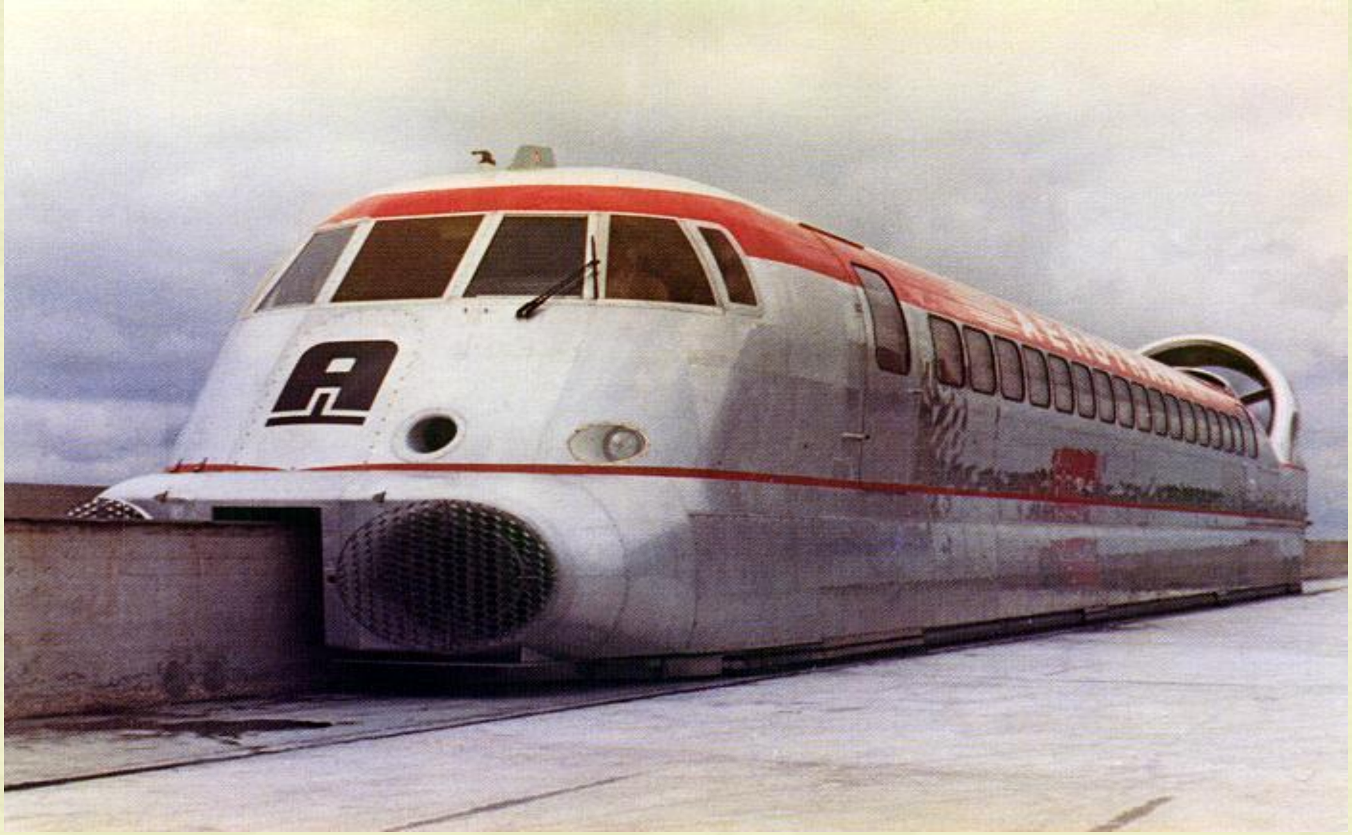


Various technologies in High Speed Rail systems

- **Aérotrain**
- **TGV**
- **Maglev**
- **Shinkansen**
- **Transrapid**
- **High speed tilting train**

Aérotrain

A hovercraft train developed in France from 1965 to 1977.
Similar to that of the magnetic levitation train
To suspend the train so the only resistance is that of air resistance
Less friction, less energy requirements, less construction costs, less noise
Project abandoned due to lack of funding and the adoption of TGV



Maglev- Magnetic levitation

Lift, suspends, guides and propels trains - very large number of magnets
Faster, quieter and smoother than wheeled mass transit systems

Most of the power used is needed to overcome air drag, as with any other high speed train.

Maglev- Magnetic levitation

Recorded speed of a Maglev train is 581 KMPH achieved in Japan in 2003- 6 km/h faster than the conventional TGV speed record.

First commercial Maglev officially opened in 1984 in Birmingham, England.
On an elevated 600-metre section of monorail track between Birmingham International Airport and Birmingham International railway station, running at speeds up to 42 km/h, Eventually closed in 1995 due to reliability and design problems.

Shinkansen

Shinkansen **also known as** ***the bullet train*** **is a network of high-speed railway lines in Japan**

Operated by four Japan Railways Group companies.

The Tōkaidō Shinkansen - World's busiest high-speed rail line.

Shinkansen

Route planning

- Uses tunnels and viaducts, with a minimum curve radius of 4,000 meters.
- The Shinkansen system is built without road crossings at grade.

Track

- Shinkansen uses standard gauge.
- Continuous welded rail.
- Long rails are used, joined by expansion joints to minimize gauge fluctuation due to thermal elongation and shrinkage.

Signal system

- **An ATC (Automatic Train Control) system, eliminating the need for trackside signals.**
- **Centralized traffic control**
- **All tasks relating train, track, station and schedule are managed and monitored by computer**

Electricity

- **25,000 V AC overhead power supply**

French Railways -TGV

***Train à Grande Vitesse*, high-speed train**

Record : 3 April 2007 -   574.8 km/hr

Opened in 1981 between Paris and Lyon
Inital 480 Kms, Now 1887 Kms

<u>Infrastructure (RFF - State owned)</u>
Money borrowed from international markets supported by government guarantee

<u>Operator (SNCF -Private operator)</u>
Rolling stock procured through lease commitments

SNCF payes access charges to RFF

Transrapid

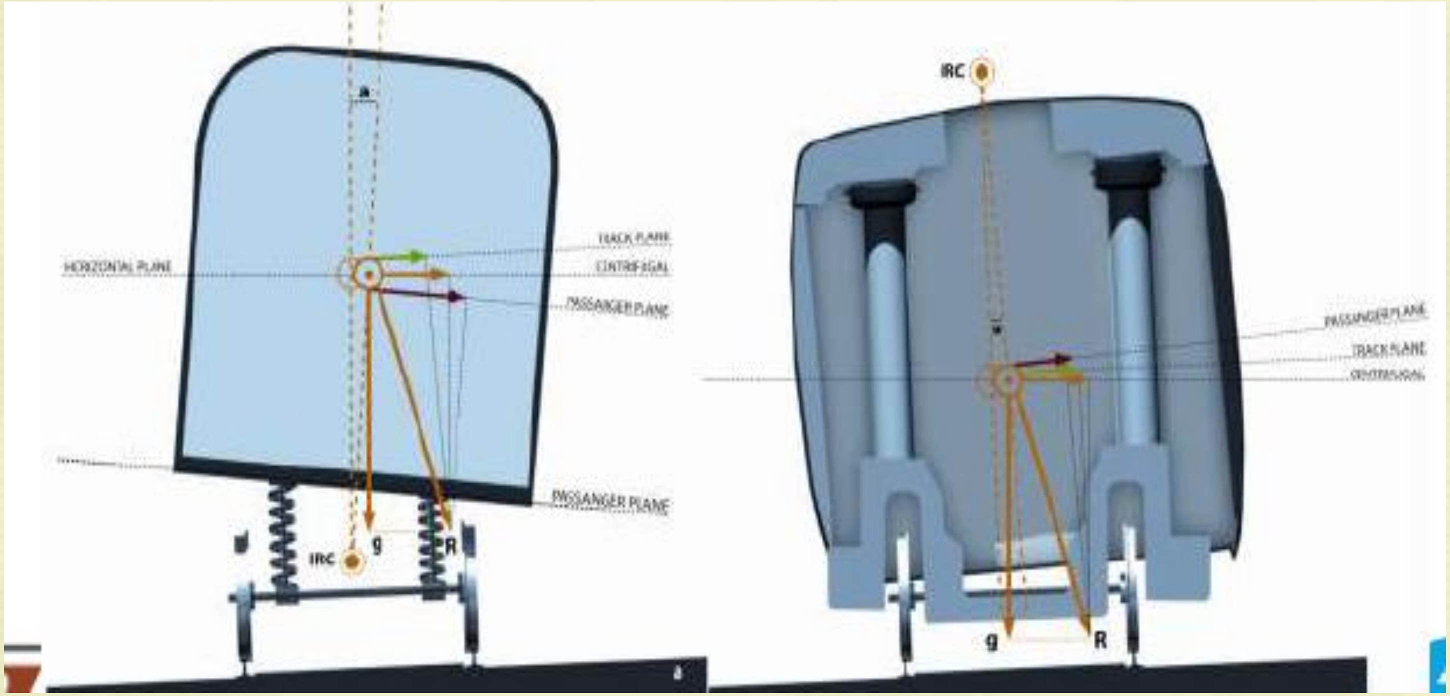
German high-speed monorail train using magnetic levitation.
Next version, the Transrapid 09, designed for 500 KMPH speed.

In 2004, the first commercial implementation was completed.
30.5 km network connects Shanghai Pudong International Airport.

High speed tilting train

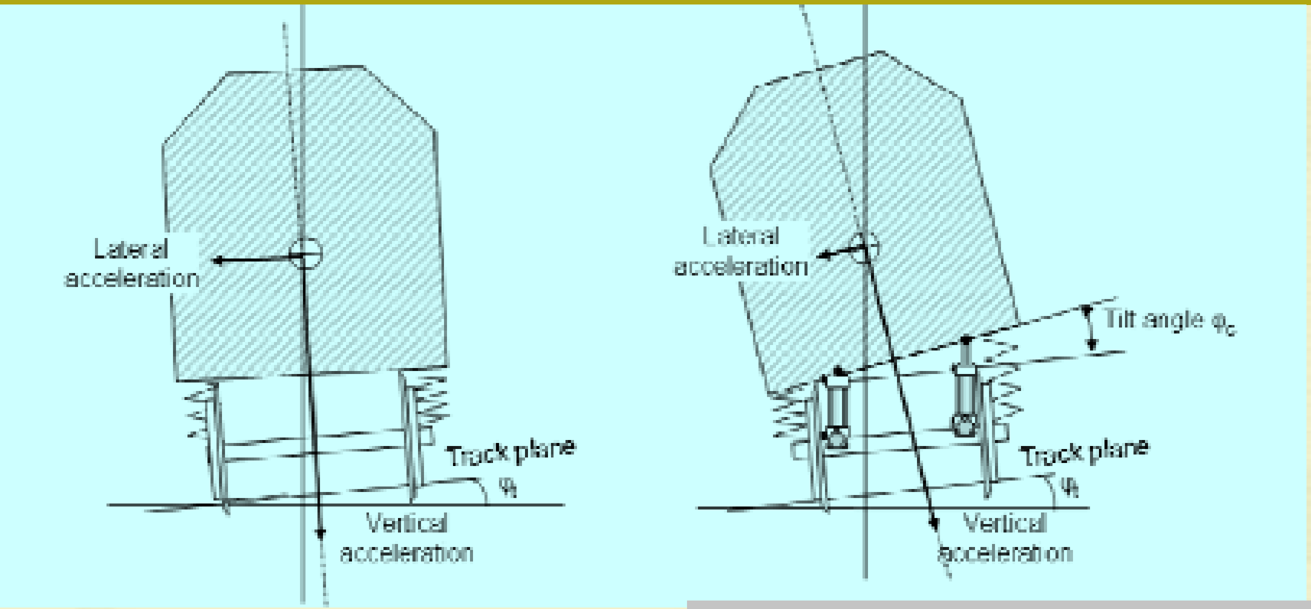
It combines high speed and tilting technology.
The train tilts around curves to counter the impact of centrifugal force.

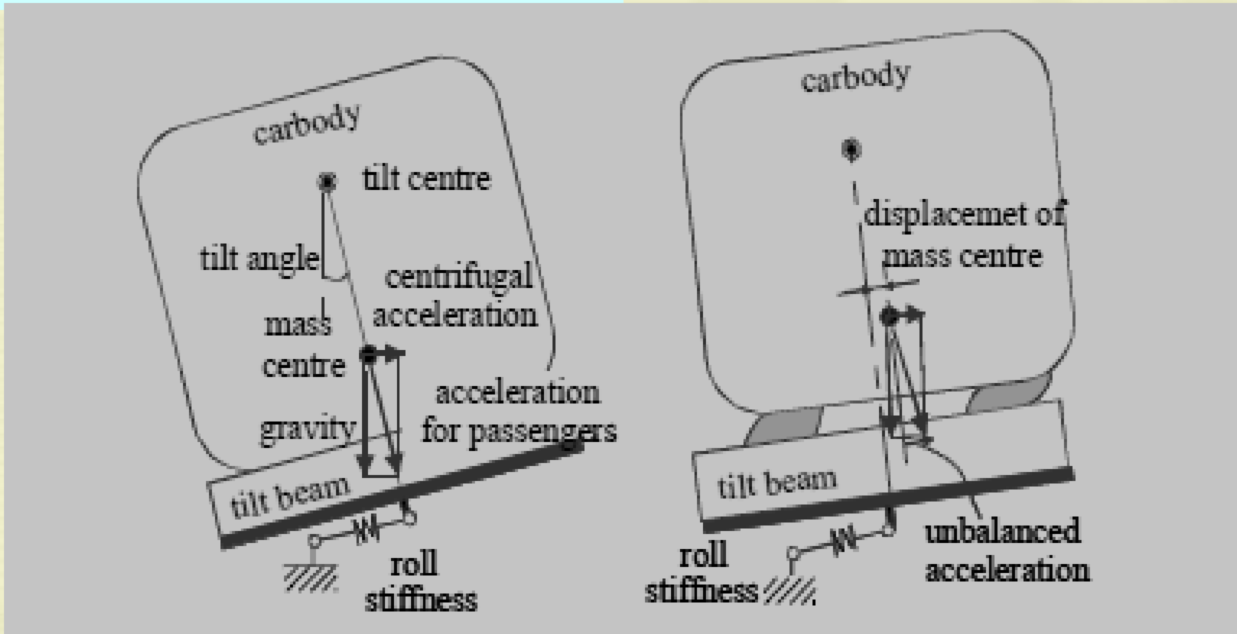
What is Tilting train ?



Tilting plane and tilting using bogie suspension arrangements

What is Tilting train ?





(a) Without secondary suspension (b) With secondary suspension

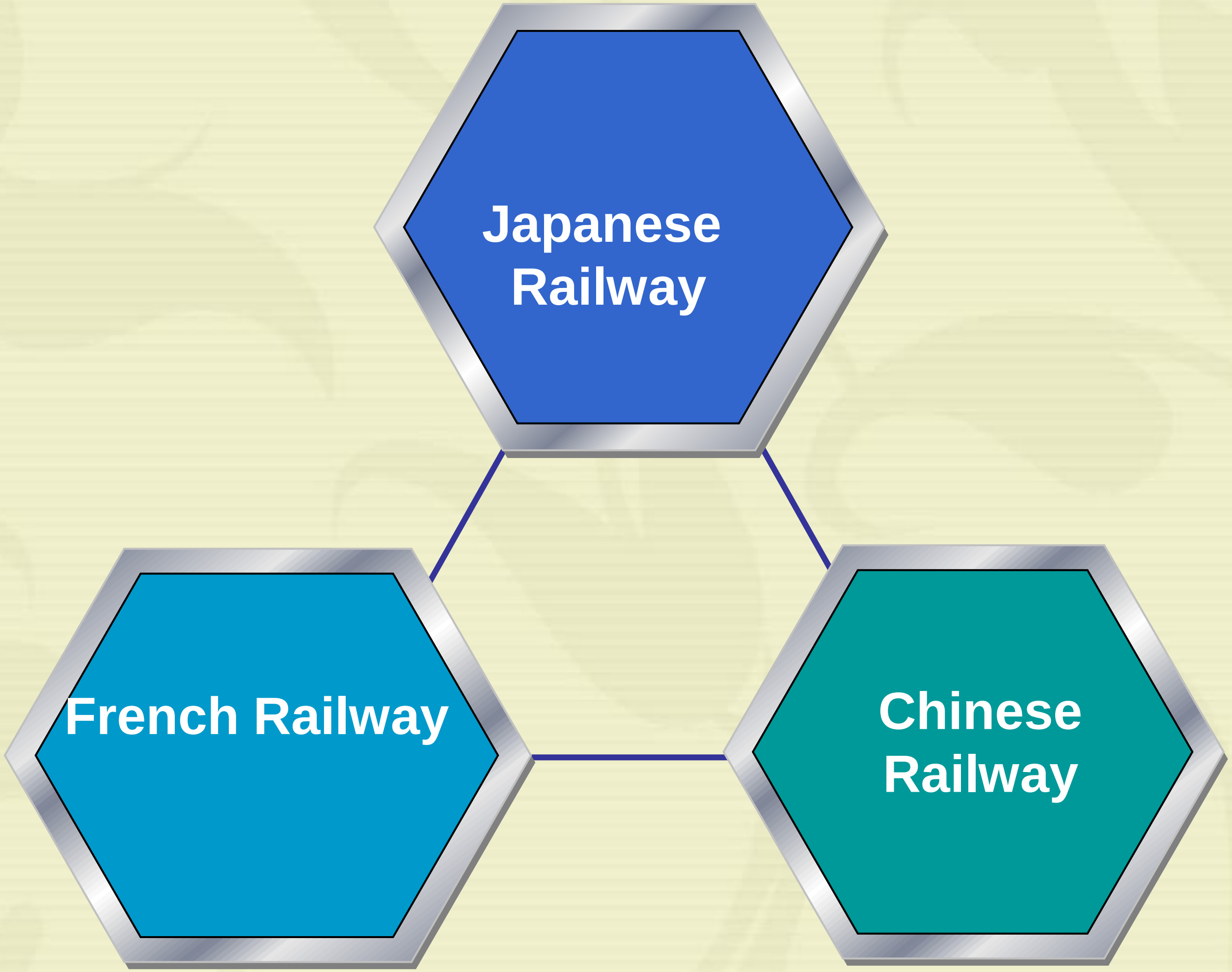
Trackless train

The train that never stops

PRT System

Skybus technology- Goa, India

International case studies



Japan

- **Operated by JR Group companies.**
- **The Shinkansen also known as the bullet train.**
- **The Tōkaidō Shinkansen is the world's busiest high-speed rail line.**
- **Shinkansen train-sets running at 300 KMPH since 1990 and 350 KMPH train- sets consisting of 6 motor cars since 1995.**

Taiwan High Speed Rail (THSR)

- A privately-managed and funded transport schemes to date
- Technology is based mainly on Japan's Shinkansen system
- Started on January 05, 2007
- Length of rail network-345 Km
- From Taipei to Kaohsiung
- Project cost-US$18 Billion
- Max. speed of 300 km/h

France- TGV

- The TGV (*Train à Grande Vitesse*, meaning *high-speed train*) is France's high-speed rail service.
- Operated by SNCF Voyages, the long-distance rail branch of SNCF, the French national rail operator.
- A TGV test train driven by Eric Pieczak set the record for the fastest wheeled train, reaching 574.8 km/h (357.2 mph) on 3 April 2007

Italy

- 1978 connected Rome with Florence (254 km).
- Speed of the train -- 250 km/h.

South Korea

- KTX -operational in April 2004.
- Maximum speed of the KTX is 300 km/h.
- Derives its technology directly from France's Alstom TGV.

Belgium

- A high-speed rail network providing mostly international connections from Brussels to France, Germany and The Netherlands.
- Network began with the opening of the HSL 1 to France in 1997.
- Four high-speed train services currently operate in Belgium: Thalys, Eurostar, Inter City Express (ICE) and TGV.
- Route length of 3,374 kilometres which is Double track and Electrified.

UK

- **The Channel Tunnel Rail Link (CTRL), now known as *High Speed 1* (HS1), was the first new mainline railway to be built in the UK for a century and was constructed by London and Continental Railways.**
- **A mixture of 300 km/h (186 mph) Eurostar international services and 225 km/h (140 mph) South-eastern domestic passenger services use High Speed 1.**
- **In the early 2000s, a number of Train operating companies introduced diesel multiple units (DMUs) capable of 125 mph (201 km/h) speeds.**

United States

- Only one high-speed line: Amtrak's Acela Express service,
- Northeast Corridor—from Boston via New York, and Washington, D.C.
- Average speed 68 mph but briefly reaching 150 mph (240 km/h) at times.
- A federal allocation of $8 billion for HSR projects has prompted U.S. federal and state planners to establish HSR service along ten more rail corridors.

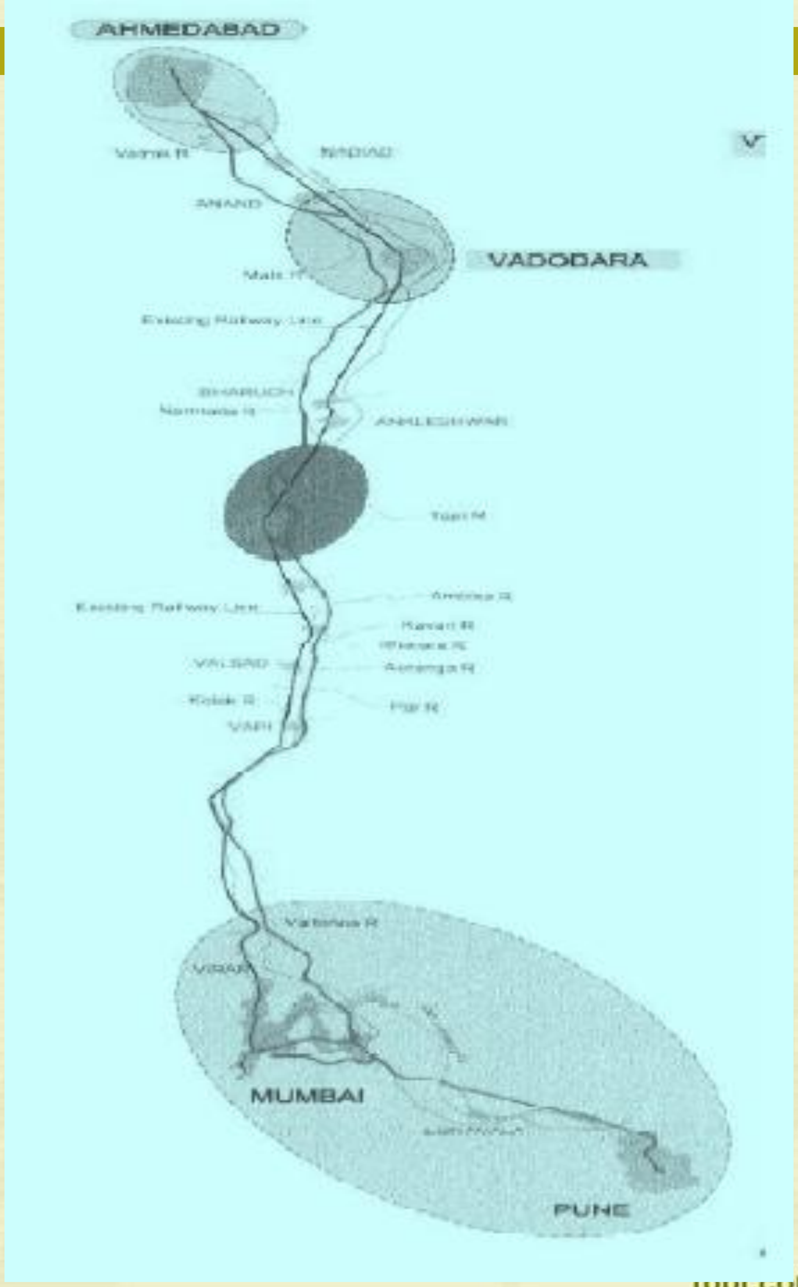
Can Indian achieve HSR ?

When and How ?

HSR projects under consideration

Project corridors	Status
Pune-Mumbai-Ahmedabad	Final report submitted
Delhi-Agra-Lucknow-Varanasi-Patna	Final report submitted
Howrah-Haldia	Final report submitted
Hyderabad-Dornakal-Vijaywada-Chennai	Draft Final report submitted
Chennai-Bangalore-Coimbatore-Chennai	Draft Final report submitted
Delh-Chandigarh-Amritsar	Consultant yet to be engaged
Delhi-Jaipur-Ajmer-Jodhpur	Consultant yet to be engaged

Mumbai-Ahmedabad Corridor



<u>Salient features</u> :

Maharashtra: 176 Kms

Dadra-Nagar-Haveli : 6 Kms

Gujrat : 364 Kms

Total-546 Kms

Teminals : Mumbai & Ahmedabad

Intermediate stations: Navi Mumbai,
Surat &
Vadodara

Depot: Ahmedabad (Geratpur)

Mumbai-Ahmedabad Corridor

Speed and time

Horizon year of the project : 2021

Expected operational speed : 350 km/hr

Expected commercial speed : 286 km/hr

Travel time : 01 hour, 52 minutes

350 Km/Hr → 300 Km/Hr : 12 minutes more,
27 % energy less

Mumbai-Ahmedabad Corridor

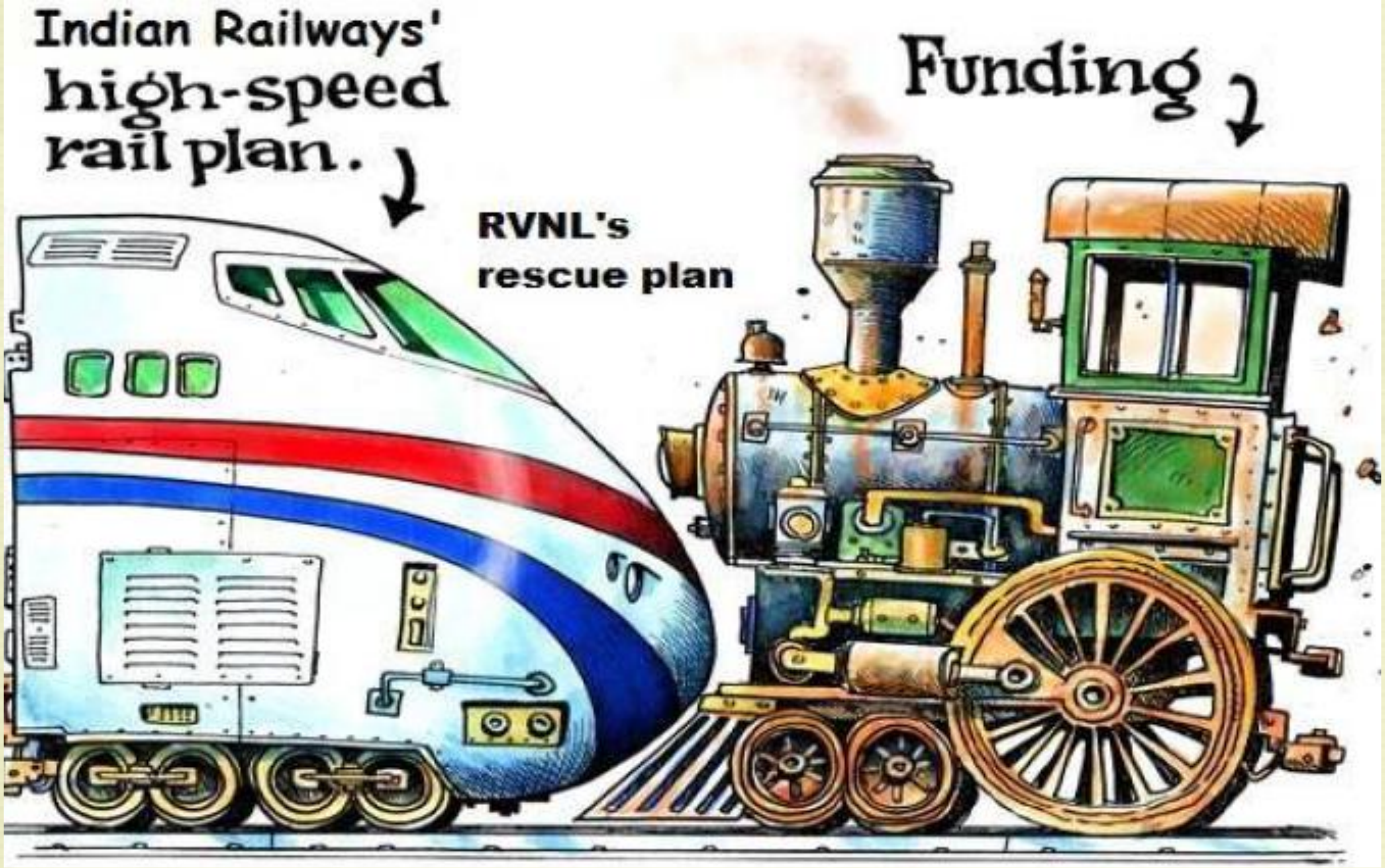
Costs

1. Construction : Rs 45,000 Cr

   (per Km : Rs 80 Cr)

2. Rolling stock : Rs 5000 Cr

High Speed Rail challenge in India ?



Implementation options-Which model ?

- PPP : Public Private Partnership- DBOT
- Non-PPP : EPC (Engineering, Procurement and commission)
- FDI: Foreign Direct Investment

DESIGN & DEVELOPMENT

MOTIVE POWER

Mode Of Traction

- End Loco Concept
- Multiple Unit Concept

Motive Power

Brake System

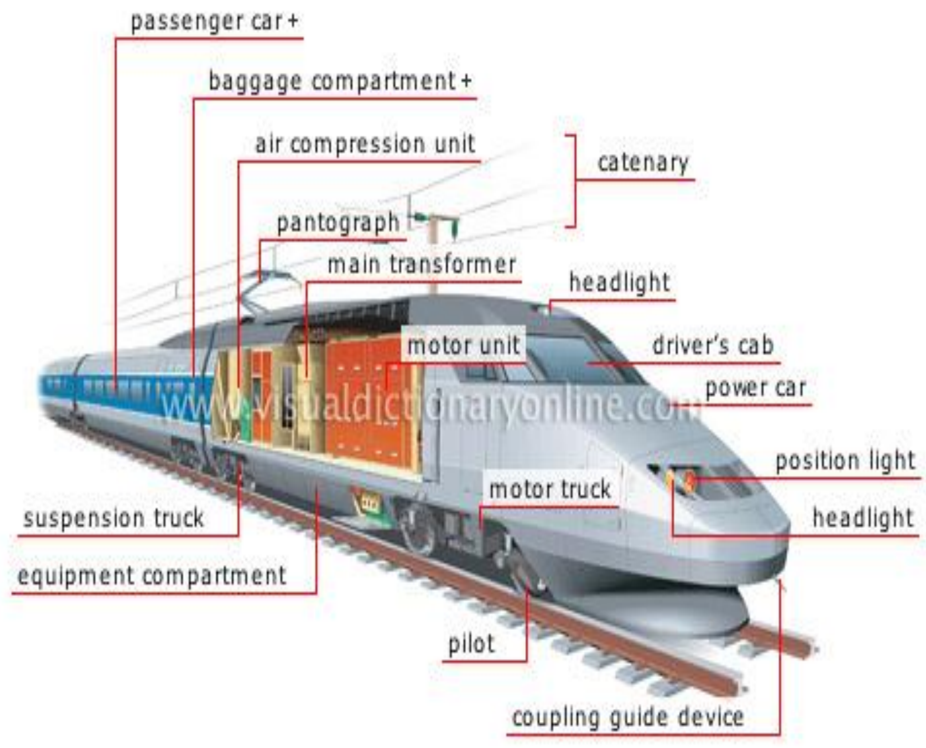
Bogie

Aerodynamic Profiling

Pantograph

Automatic Train Control

Noise Reduction Measures



DESIGN REQUIREMENTS FOR HIGH SPEED RAILS

SHELL DESIGN

- AERODYNAMIC PROFILE
- SEALED GANGWAYS
- TYPE OF TOILET SYSTEM
  - AIR CRAFT TYPE VACUUM TOILET
  - CONTROLLED DISCHARGE TOILET

BOGIE DESIGN

- LIGHT WEIGHT
- WHEEL PROFILE
- AXLES
  - SOLID
  - HOLLOW
- SPRINGS
  - STEEL
  - RUBBER
- AIR SUSPENSION

COACH

- **SEAT DESIGN**
  - Comfortable
  - Light weight
- **BRAKE SYSTEM**
  - Disc type
  - Magnetic
  - EP Brake
- **EMERGENCY EXIT**
- **PASSENGER ALARM SYSTEM**
- **DRAFT AND BUFFING GEAR**
- **AIR CONDITIONING**
- **NOISE REDUCTION**
  - Noise control measures
  - Floor & bogie interface to reduce noise
  - Low noise wheel

Semi-high speed Delhi-Agra trials

New Delhi-Agra Section

140 Km/hr (Intermittent) to 160 KMPH (Continuous)

9 semi-high speed trains in 2014-15

Points to ponder- Technological choices ??

Should Indian Railways go in for quantum jump in speed like 450 KMPH or gradual increase in train speed 200 KMPH → 250 KMPH →300KMPH → 350 KMPH→ more.

Should the traction technology be wheel on rail or Maglev?

Should the design of coaches be single deck or double deck?

Should there be trains of less number of coaches with more frequency or longer trains with less frequent service?

Points to ponder- Policy choices ??

1. Outright import of equipment including rolling stock and track

2. Transfer of Technology with various alternatives:

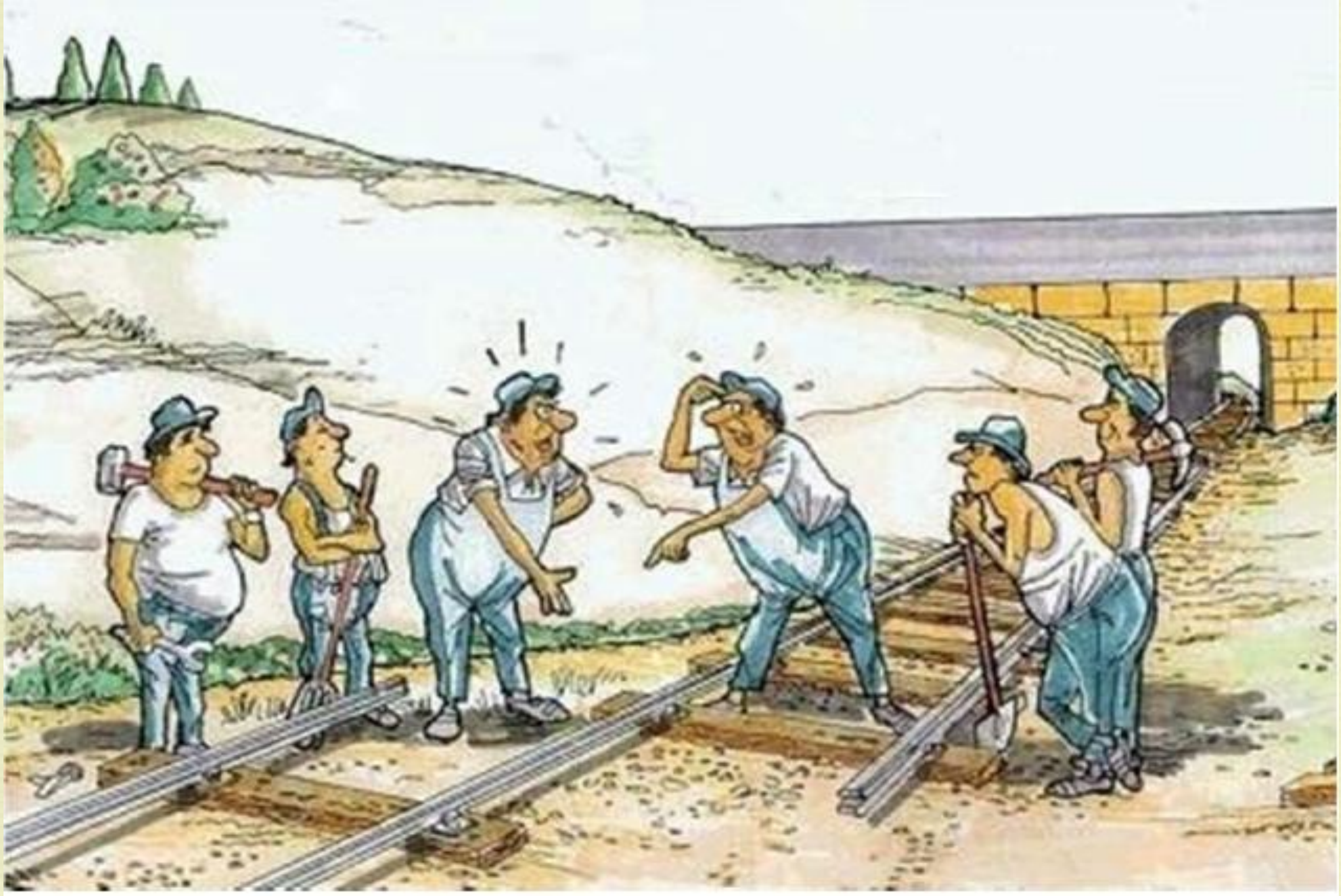
-- Foreign turnkey project

-- Study overseas and implementation by India

-- For operating speeds above 160 KMPH, technology may have to be imported and adapted

3. Indigenous development(s)

Path Ahead ??



Dedicate tracks to passenger trains

Dedicate tracks on existing trunk lines to passenger trains, by building separate corridors for freight trains, and build separate tracks for busy suburban traffic in Mumbai and other cities where traffic is equally busy. Without slower freight and suburban traffic, fast-express trains can run at the speed limit of rolling stock, the track or railroad switch, whichever is lowest among those that apply.

Upgrade tracks for 160-200 KMPH

- Upgrade the dedicated passenger tracks with heavier rails, and build the tracks to a close tolerance geometry fit for 160-200 KMPH. High-speed tracks to be maintained and inspected using automation to ensure required track geometry. Perform more frequent inspection to ensure high confidence of safety at high-speed.
- Design, manufacture and deploy railroad switches, with thick web construction and movable crossings that permit 50 KMPH to alleviate this bottleneck to speed.

Upgrade locomotives and coaches

- Improve coaches, which can support 200 KMPH, with stainless steel bodies and crash-worthy designs, incorporating passenger and crew protection, and fire-retardant materials. Equip coaches with electro-pneumatic brake systems to enhance safe operations at 160-200 KMPH.
- Develop locomotives with output of 9000 to 12000 hp for hauling of 24-26 coach long passenger trains to 160-200 KMPH.