On 3rd July 2014, a high-speed train shot off from the New Delhi Railway Station and chugged into Agra 100 minutes later. With further fine-tuning the train is expected to complete the journey between Delhi and Agra in 90 minutes flat travelling at a speed of 160 km, possibly from November. Currently the Bhopal Shatabdi takes 126 minutes to reach Agra from Delhi at an average of 110 km per hour.

With the successful trial of the semi high-speed train, and commercial operations expected to begin in November the dream of high-speed trains in India, popularly called “bullet trains”, may soon be realised. After the Delhi to Agra successful trial run, the Indian Railways will run similar trains for Kanpur and Chandigarh from the national capital. There are also plans to run bullet trains between Mumbai and Ahmedabad with 350 km/h speed on elevated tracks.

What Are High Speed Trains?
High-speed trains are commonly called bullet trains. But the term “Bullet Train” is only an unofficial nickname for the first high-speed train of Japan, Shinkansen, and is not an official term used anywhere in the world. But high-speed railways are often viewed as the essence of infrastructure development of a region or nation, showpieces of progress and rank
high up when it comes to quality of life indicators.

The European Union defines High Speed Rail as rails that operate at a minimum speed of 200 km per hour on tracks built specially for high-speed travel. The International Union of Railways (UIC) states that High Speed Railways are a combination of all the elements that constitute the system: infrastructure, rolling stock and operating conditions. High-speed trains are broadly classified into two categories based on the technology employed:

Tilt technology: Trains having the capability to tilt their body inwards the curve are called tilting trains. The tilt inwards reduces the lateral acceleration felt by the passengers, allowing the train to pass curves at higher speed while maintaining ride comfort. A high-speed tilting train can operate at 200 km/h for upgraded track and 250 km/h or even faster for new track. The first tilting train in regular public service was the 381-series electric multiple unit train between Nagoya and Nagano operated by the Japanese National Railways (JNR), which entered revenue service from 10 July 1973 on the Shinano limited express. Acela Express in USA is using tilting technology that allows the train to travel at 240 km/h on upgraded track. It is the fastest trainset in America run between Washington, DC and Boston. Another example is the Japanese Shinkansen N700-series with a maximum speed of 300 km/h. It can tilt up to one degree and can maintain 270 km/h of speed run between Tokyo and Osaka.

But building new tracks with large curve radii is costly and can only be justified where the passenger base is large. Tilting has today become a mature technology accepted by most operators, but the popularity is impacted by low reliability and motion sickness on certain services.

Non-tilt technology: In this category trains run on straight special tracks or tracks with large curve radius. For higher level of passenger comfort exclusively new tracks are laid down on which trains can run with 250 km/h or more speed. One of the key advantages of such a system is increase in the efficiency of rail freight transport. Since passenger trains have their exclusive tracks, it gets almost exclusive use of the conventional rail system.
Japanese Shinkansen is one of the fastest high-speed trains in the world. There are 2387 kilometres of high-speed railway lines in Japan linking the major cities of the islands Honshu, Kyushu, and soon Hokkaido. E5 series Shinkansen is the fastest model of high speed train in Japan having 320 km/h operating speed.

The French TGV has repetitively made world records for speed from 380 km/h in 1981, then 515 km/h in 1990 and 574 km/h in 2007. China has the world’s longest line of 2,298 km Beijing-Guangzhou high-speed railway. It is also the most heavily used high-speed rail network in the world. All the high-speed trains in China reach a speed of 350 km/h.

Features of High Speed Train
1. High Speed
Almost all of the most developed countries of the world have their own high-speed rails. But how do these rails move at such a high speed, almost equal to an aircraft. There are many factors that allow high-speed trains to fly at such great speeds.

Shape: When designing the carbody of high-speed rails much consideration is given to aerodynamics. High-speed rails have a streamlined body. The entire carbody is made sleek with a very long and slender nose. The nose is shaped to minimize air resistance and pressure change when the train runs into a tunnel. Also, when the train runs with the nose at the rear end, it is free from rolling. Since the under floor profile also affects air resistance, it is made as smooth and flush as possible. Because of aerodynamics design running noise is also minimized.

Materials Used: High-speed rail cars are made up of aluminium alloy because aluminium alloys are light in weight and thus reduce the carbody weight, thereby increasing the speed of the train. Commonly car bodies of high speed trains are made up of hollow, extrusion-formed aluminium alloy. Since aluminium alloy is also mechanically strong, corrosion and vibration resistant, easy to build and has soundproofing performance, it is widely used all over the world.

Special Tracks: Gauge (distance between two parallel rails) used for high-speed trains differs country to country but most high-speed rails use a standard gauge of 1435 mm width. It is to avoid tight curves, which reduce speed. Curve radius is typically above 4.5 km.

They also use continuous welded rail (CWR). In a conventional track rail ends are connected together with bolted joints. The rails have a gap in between for thermal expansion in the summers. These joints result in wear and tear of the wheel and weaken the track. It also reduces passenger comfort when wheels run over these joints.

High-speed trains run on continuous welded rail. The CWR tracks are welded together in lengths of hundreds of kilometers long at some construction courtyard. They are then transported to the required place and welded together in one long rail. This gives a continuous smooth surface for the train to roll along. There are also few joints in CWR but these are not straight joints. The joint is created by cutting the ends of butting rail. The ends of each butting rail thus overlap each other, which enables the trains to run smoothly with less friction.

Although the continuous welded rails are more expensive than jointed tracks, they need less maintenance and significantly reduce vibrations and misalignment.

2. Environment
High-speed lines are driven by electric power that reduces the use of oil in transportation. Electricity is generated by renewable sources (wind, ocean and geothermal etc.) and greenhouse gas
emission is significantly lower than other modes of transportation. High-speed trains are three times energy efficient than cars and six times than planes.

High-speed trains have electric locomotive (electric engine) powered by electricity through overhead lines. Power is collected through the catenary (overhead line) using pantograph (hinged electric rod device) on the roof of the train. A valve on the pantograph’s pneumatic cylinder prevents the bobbing motion that causes loss of contact with the overhead cable.

In the conventional braking system, energy is converted to heat and is thus wasted. Whereas high-speed trains use regenerative braking because it slows down the train by converting mechanical energy into electrical energy. This generated electricity can be used for meeting the power demand or is stored for further use. Regenerative braking in trains leads to reduction of carbon dioxide emissions and thereby boosts green credentials.

The brake material used in high-speed trains is made up of carbon fiber composite instead of graphite metal powder or metal fiber used in conventional trains. Carbon fiber composite material has high strength, light weight, good heat resistance and other advantages.

3. Safety
In-cab signaling in train signaling systems enables high speed trains to safely minimize time between trains at stations in order to prevent trains from colliding. It can automatically apply the brakes to stop or slow trains if proper initiatives are not taken by the operator in dangerous conditions.

Crushed stones packed around and in between the rail tracks are known as ballast. Ballasted tracks need regular maintenance because the track can deform under high speed and load, additionally wearing the rolling stock and reducing comfort inside the train. Therefore, high-speed train lines rest on non-ballasted or slab track. Slab track is a multilayered (made up of asphalt or concrete) system that assures track stability, requires less maintenance cost, bears high load and has a long service life.

4. Driving Technologies
Conventional trains are driven by traction motors connected to the axles of the locomotive while the coaches are just pulled along. Electric Multiple Units (high speed trainsets) do not have locomotives. All the equipment that would’ve been in the locomotive (transformers, rectifiers, etc.) is distributed throughout the train under passenger coaches. This enables EMUs (Electric Multiple Units) to have traction motors attached to the wheels of many coaches and not just the leading ones, making them very quick to accelerate and very fast.

In other words, what would have been one single locomotive is distributed as multiple units throughout the train, which is also why coaches cannot be detached and used on another train easily. They are faster, more powerful and have higher carrying capacity since passenger cabins can be extended to the very front of the train.

The Shinkansen trains are generally of this type. However, not all high-speed trains are EMUs. Some like the TGV, Eurostar and ICE2 have all their equipment located in two dedicated “power cars” at either end of the train (the “pointed” cars). These power cars

**SPACE TRAVEL ON EARTH**

One can go from New York to London within one hour and New York to Beijing in two hours if the technology ET3 patented by Daryl Oster (an American engineer working on aeronautical and marine design) sees the light of the day. ET3 stands for Evacuated Tube Transport Technologies. It is a proposed design for super high-speed rail transportation, which claims a high speed up to 4000-5000 mph.

ET3 works on the Maglev concept with a tube from which air is drawn to create a vacuum. Car-sized passenger capsules could carry up to six persons. ET3 is silent as there would be no air to create sonic vibrations and it needs 1/10th of the cost of high-speed rails. This is because the ET3 capsules weigh only 183 kg and the vehicles are so light that they need only 1/20th of the material to build. ET3 uses far less power per passenger mile than high-speed trains. The technology is currently being tested.
do all the driving and essentially act as locomotives and hence no passenger cars will have any “powered” wheels, except maybe one bogie next to the power cars. But they are still one entirely contiguous unit which makes them a mixture of EMU and conventional train.

Maglev Vision
Maglev (magnetic levitation) is a method of propulsion in which a wheel-less vehicle (maglev train) floats above its tracks, suspended by a magnetic field. Maglev trains can reach speeds up to 300 miles per hour. Regular high-speed trains can travel at a speed of 180 miles per hour but this creates an enormous amount of friction and heat. Also, high-speed trains use electric motors and need a third rail for transferring the power to the vehicle which then provides the propulsive forces.

But maglev trains do not need these moving parts on board and hence significantly reduce wear and tear, energy loss and maintenance cost. They are smoother than wheel mass transit because of their non-dependence on traction and friction and they are also unaffected by bad weather conditions. Unlike the conventional trains they are not running on metal tracks but on specially constructed guideways (rail track preventing derailment).

The first commercial maglev train opened in 1984 in Birmingham, England. The trains ran on 600-meter tracks with a speed up to 42 km/h between Birmingham International Airport and Birmingham International railway station. The system was closed in 1995 due to design and maintenance problems.

The highest speed attained by the manned superconducting magnetically levitated (SCmaglev) train is 581 km/h (361 mph) in 2003 in Japan. The JR Central's MLX01 operated on the...
Yamanashi Maglev Test Line, Yamanashi Prefecture, Japan, on 2 December 2003. But the most well known currently commercially operating maglev train is the German built Transrapid train in Shanghai, China. It is in operation since April 2004 running to and from the Longyang Road station at the city’s center and Pudong airport. It has achieved a top speed of 431 km/h and averages 266 km/h. It achieved a speed of 501 km/h during a test run on 12 November 2003.

Now, how do these maglev trains run? Maglev trains run on the basic principle of magnets according to which like poles repel and opposites attract. The train would be levitated with the track and train magnets facing each other on the opposing side.

Transrapid is the maglev train in Germany developed on electromagnetic suspension technology. In this system the train is wrapped around the track and the electromagnets of the train get attracted towards the ferromagnetic stators on the underside of the guideway, which levitates the train. The train is levitated about 1 cm above the guideway even when travelling at a low speed or not moving at all.

There are guidance magnets embedded in the train’s body so that it follows the direction of the guideway track. It is equipped with onboard battery power supply in the event of power failure so that train will not crash on to the guideway.

JR-Maglev is the magnetic levitation train developed by the Central Japan Railway Company and Railway Technical Research Institute (association of Japan Railways Group). Unlike the German maglev system, Japan uses electrodynamic suspension technology. In this technology the train is levitated by the repulsive force between the levitation magnet and the guideway magnet.

The key difference between the two is that the Japanese trains use super-cooled superconducting electromagnets. Also, the Japanese trains are levitated about 10 cm above the guideway. A superconductive metal (material that produces no electrical resistance below certain temperature) is used in the coils of the train, which produces the strong magnetic field. One potential drawback of this system is that the train must roll on rubber tires until it reaches a liftoff speed of about 62 miles/h (100 km/h).

The Inductrack is a type of electrodynamic suspension system that uses permanent room temperature magnets to produce the magnetic field unlike using cooled superconducting magnets. Inductrack uses a power source to accelerate the train until it begins to levitate. The track is an array
of electrically shorted circuits containing insulated wires and these circuits are aligned like rungs in a ladder. As the train moves the magnetic field repels the magnets causing the train to levitate. An inductrack levitates the train about 2.54 cm above the track but until now there is no commercial version of inductrack.

Communication on High-speed Railways

High-speed railways also have advanced technical requirements for high-speed railway communication services. The Global System for Mobile Communications-Railways (GSM-R) is an international wireless communication standard for railway communication. It is mainly used to transmit data between trains and railway regulation centers.

When the train passes over a Eurobalise, it transmits its new position and its speed, and then receives back agreement (or disagreement) to enter the next track and its new maximum speed. Through GSM-R, trains have a constant circuit-switched digital modem connection to their respective train control centers. If the modem connection is lost, the train will automatically stop.

But GSM-R is specifically used for train control and not for passenger communications like logging on to the...
There can be no doubt that high-speed railways in India will significantly reduce clogging on roads and reduce the travel time. High-speed rail transportation is an energy efficient mode of transport as it runs on electric motor and reduces dependence on oils.

India has one of the largest rail networks in the world but does not have any high-speed rail.

Internet, sending or receiving emails, online gaming, messages, etc. while in transit. Two major challenges have been identified for not supporting high-rate broadband data services:
- Frequent handovers cause quick battery drain and makes mobile communication access much difficult
- Poor link quality due to Doppler frequency shift

For this purpose, two different network architectures have been designed for inside and outside the train. Transceiver antenna on the top of the train connected to the wireless access point inside the train to communicate – no call handover occurs here. On the outside of the train Base Station directional antennas are used for less energy consumption. These antennas can cover an area of radius 10 km for the trains having speed nearly 500 km/h.

The railways base stations are connected to the base station controller, mobile switching center and PSTN (public switched telephone network) just like the conventional cellular system and there is also a point-to-point connection line between two adjacent base stations to transfer the control information. When the train passes through the overlapping area of the cells, the handover occurs and all the controls are transferred from the previous base station to the next base station. The maximum distance between the overlapped boundaries is 690 m, so it will take 5 seconds for a train to pass through the overlapping area. During this period of time, the handoff can occur smoothly.

High Speed Railway in India

India has one of the largest rail networks in the world but does not have any high-speed rail (HSR) line capable of supporting speeds of 200 km/h or more. High-speed corridors have been proposed but not implemented.

The Ministry of Railways’ White paper “Vision 2020” submitted to the Indian Parliament on 18 December 2009 envisioned to raise the speed of passenger trains from 130 km/h to 160-200 km/h using conventional technology and to identify the intercity routes for the implementation of high-speed rail projects to provide train services at 250-350 km/h speed. An expert group of the Indian Railways identified the following high-speed railway corridors:
- Delhi-Chandigarh-Amritsar (450 km)
- Pune-Mumbai-Ahmedabad (650 km)
- Hyderabad-Dornakal-Vijayawada-Chennai (664 km)
- Howrah-Haldia (135 km)
- Chennai-Bangalore-Coimbatore-Ernakulam (850 km)
- Delhi-Agra-Lucknow-Varanasi-Patna (991 km) and
- Ernakulam-Trivandrum (194 km).

The Mumbai-Ahmedabad high-speed railway line has been selected for implementation in the 12th Five-year Plan. The High Speed Rail Corporation (HSRC) Ltd. was also set up on 29 October 2013 to make high-speed trains a reality in the country.

But there is a need to look into safety and security aspects and rails (in terms of technology). High-speed trains need special tracks (standard gauge tracks) for supporting high speed. Therefore, for safe and efficient operations, India has to build or upgrade the existing broad gauge tracks. Land acquisition, huge capital investment and resource issues also need to be addressed.

However, there can be no doubt that high-speed railways in India will significantly reduce clogging on roads and reduce the travel time. High-speed rail transportation is an energy efficient mode of transport as it runs on electric motor (electricity generated by renewable sources of energy) and reduces dependence on oils. It would have a great bearing on the economic growth of the country as well as it would create many jobs.

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