Rail-Road-Expressways: A Technology-Based Vision for Low-Cost High-Capacity, Energy-Efficient Railway Infrastructure for India and the World

Rahul Garg (rahulgarg@iitd.ac.in)
National Resource Centre for Value Education in Engineering and
Department of Computer Science and Engineering,
Indian Institute of Technology, Hauz Khas, New Delhi, INDIA.
15th August 2024

Under the National Infrastructure Pipeline, the Government of India has committed projects worth Rs. 102 lakh crore (USD 1.3 trillion) for Energy, Roads, Railways and urban projects which will make the foundation for holistic infrastructure and give an integrated pathway to our economy. Several infrastructure projects in railways including high speed railways, metro, dedicated freight corridors etc are presently being pursued as a part of this plan.

For a country like India, with a population of over 1.3 billion people, it is extremely important to make investments in transportation technologies that are energy efficient, capital efficient, scalable and low cost. Railways is one of the most energy efficient transportation technologies available to mankind today. However, the present railways technologies do now allow an efficient utilization of its infrastructure, particularly of the railway tracks. Even the most congested railway routes have extremely low utilization[1] (less than 10% in the best case). However, despite such low utilization levels, it is surprising to note that many of the busy routes may be operating close to their maximum operational capacity.

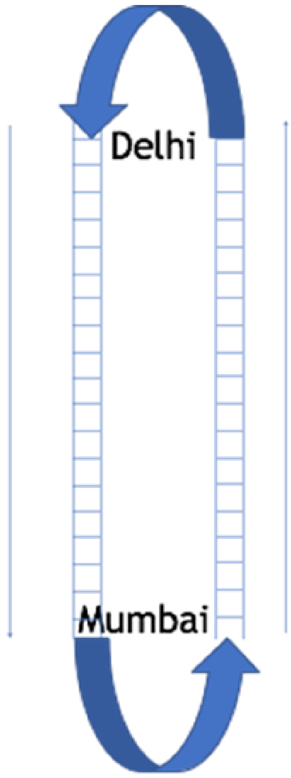
The present day signalling, communication and track switching technologies (which have evolved incrementally over the last 150 years) are the primary reason for the extremely low operational capacity in comparison to the theoretical capacity. This article calls for a re-development of (or, rather a revolution in) these technologies that will allow an operational capacity close to the theoretical capacity. Thus, countries will no longer need to lay new railway tracks for additional dedicated freight corridors or for capacity addition, instead it will be possible to upgrade the existing railways track infrastructure that will support much higher capacity of passenger as well as freight traffic. It will be possible to develop newer forms of transportation such as an integrated rail-road transport which will spur growth in demand leading to more utilization of the rail expressway infrastructure. This may eventually spur a revolution in energy efficient transportation across the world. When combined with suitable business model, it will not only make India self-reliant for its

[1] Utilization of a track is defined as average number of train-coaches transported per second divided by its theoretical capacity which is equal to the maximum train speed (in meters/second) divided by coach length (in meters).

energy and transportation needs, but also make her a thought leader and an exporter of this integrated-rail-road technology to developing as well as developed nations.

Rail-Expressway

A rail expressway is a bidirectional loop of railway line in which the trains are run at nearly **a constant speed**. For instance, if Delhi Mumbai DFC was to be converted into a rail-expressway, one would need to create two loops at Delhi and Mumbai end so that a train going from Delhi to Mumbai, will be automatically put on Mumbai to Delhi track upon reaching Mumbai and likewise for trains coming from Mumbai to Delhi. The trains will never stop or change speeds in expressway. All the trains running on expressway will maintain the same constant speed while on the expressway. As a result, there cannot be any train collision on the expressway. In case a train in the expressway needs to be stopped, all the trains in the expressway will be stopped (which will be an extremely rare event). There cannot be any crossings of any kind (road or rail) on the expressway. All the crossings will have to be converted to bridges[2].



An expressway is a loop where trains may run at a constant speed. The track between any two stations may be converted into a rail expressway by adding loop lines at ends.

The expressway has entry and exit tracks. The trains may enter the expressway through the entry track and exit through the exit track. Before entering the expressway (a) the train must obtain the exact speed of the trains in the expressway (b) there must be space in the expressway where the train may be inserted (c) this space must be available at the exact time when the entering train reaches the entry point of the expressway. For making an exit, there must be capacity to store the exiting train after the exit. The length of entry and exit tracks may be determined by the expressway speed and the maximum planned acceleration and deceleration of the trains and the maximum train length.

Since the trains on the expressway run at a nearly constant speed, there is no longer any need to maintain a large distance between trains. The system will be extremely safe as all the trains run at the same constant speed. In-fact, the entire expressway may be occupied by a single large caravan of back-to-back trains. Needless to say, the track utilization may approach 100%, but the system may initially target an operational capacity of 33% of the theoretical capacity (to optimize costs: see later). With this, the peak daily passenger capacity (assuming 3AC LHB coaches and an expressway speed of 100 Kmph) of this expressway will be approximately 2.281 million passengers per day (13.8 times the daily planned capacity of Terminal 3 of Delhi International Airport). Freight trains may be interspersed with passenger trains seamlessly on the expressway. All the trains are treated in the same manner in the expressway, though their entry and exit points may be different.

Clearly, there will be very small energy loss during the transportation (which will be mainly due to the friction of the rolling-stock and the air drag). Of-course, there may be a need to maintain some

---

[2] If the rail-expressway is provisioned at an operational capacity of less than 33% of its peak theoretical capacity, then rail-road and rail-rail crossings may be retained thereby reducing the costs significantly (see "Cost Optimizations").

regenerative braking capability and high engine power to maintain constant speeds during the gradients in the expressway. The loss due to acceleration and deceleration will be minimised as only the entering and exiting passengers' coaches (or freight coaches) will need to accelerate and decelerate.

The expressway will be completely electrified and will allow very small trains (consisting of only one coach) to operate on its track. This will also allow faster travel time for passengers and freight as they will be grouped into smaller trains to the same destinations with no (or much fewer) intermediate stops. This will significantly improve the total travel time by eliminating most of the halting time in the intermediate stations. In the long-term this may even spur an entirely new manufacturing industry of rail-road cars/buses/trains (see later).

There will be a distributed automated Rail Traffic Control (RTC) system for managing entry and exit to the expressway similar to the way the air traffic control (ATC) manages the take-off and landing of the aeroplanes on the runways.

In order to implement such a rail-expressway, four key technologies will need to be developed: Docking, Switching, Communications and Signalling which are explained briefly below. In addition, several new types of trains and coaches may also be designed which will open up newer streams of traffic on the rail-expressway and newer modes of transportation for the world.

Docking

The trains on the expressway will run as "train-of-trains", with sufficient "breaking gaps" between consecutive trains-of-trains. Each train is a single connected unit with capacity to accelerate, decelerate and maintain the required constant speed in the expressway during gradients. It is also equipped with all the necessary signalling and communication equipment to manage its docking, undocking, entry and exit from the expressway. Generally, a train will enter the expressway after the end of train-of-trains has passed the entry point and then it will attach itself (dock itself) to the train in the front. There may be two types of docking technologies (the exact choice may be finalized by safety and TRL assessments): (a) Physical docking (b) Virtual docking. In Physical docking the train physically connects to the ongoing train-of-trains and becomes a part of it. The train may also get and/or deliver physical thrust form/to the train of trains in addition to the communication signals through wired connections. In virtual docking the train maintains a very small distance (line of sight in all weather conditions) with the train ahead. The longitudinal control may be based on distance estimation technologies with the train ahead.

For undocking, the train must disconnect itself from the train in front as well as train at the back. Suitable distance must be created between these two trains before reaching the exit point. At the exit point, if all the conditions of the exit safety are satisfied, the track will switch the train to the exit track and then quickly switch back to ensure that the next train continues on the expressway. After the train exits, the trains behind it will accelerate and re-dock to the train ahead. The docking will be fully automated and integrated with signalling and switching and will have no need for any manual intervention.

Fast and Reliable Track Switching

To manage the entry and exit of such trains, a suitable distance between the train ahead and the train at the back must be created first. For the trains exiting the expressway, the signalling system should (a) detect the gaps between the trains (b) switch the track for the exiting train after checking for safety (c) switch back the track so that the next train continues to move unhindered in the expressway. Similarly, for the entering train it should (a) check the presence of adequate gaps in the expressway (b) check if the speed of entering train is within limit (c) allow the entering train to merge only if all the safety conditions are satisfied. In case safety conditions are not satisfied, the entering train may miss the entry and can decelerate in the entry track after the entry point. Suitable design choices can be made. The track switching technology needs to be integrated with the docking and signalling and has to be extremely reliable, safe and fast.

As mentioned earlier, the rail expressway allows trains of single coach to operate seamlessly. Therefore, one needs to minimize the minimum “inter-train gap” needed for switching (to minimize acceleration and deceleration of trains in the expressway during switching). This gap could be 1-3 coach length. Therefore, the time available for detection of gaps, safety checks and switching is very small (0.45 – 1.35 seconds). Extremely reliable and fast automated electronic switching technology that can be integrated with signalling and communication technology which will be the backbone of the rail expressway. The switching will be completely automated and integrated with signalling and docking protocols. The driver will only need to request to exit or request to enter the expressway. Longitudinal control of trains, docking, switching and signalling will be fully automated, in a manner comparable to modern aircrafts.

Communication

The trains, sensors on tracks and the switches of the tracks need to communicate reliably with each other. This communication is of a highly localized nature. A switch needs to communicate with the train planning to enter or exit through the switch, nearby trains on the expressway and track sensors on the expressway and entry/exit tracks and the station after the exit. The communication technology must be distributed and tolerant to localized faults with no possibility of single point of failure. In case of localized failures, the corresponding entry or exit point will be made dysfunctional and the expressway will continue to operate safely.

A communication technology that uses the iron rails as a medium may be developed. The two rails of a track may act as two independent communication channels and provide a level of fault tolerance. In addition, multiple bands may be used for additional safety. The switching points must allow the signal to communicate between the entry/exit tracks and the expressway tracks. The signal attenuation along the tracks will naturally provide a localized and robust form of communication. The existing communication technologies such as CDMA and CSMA/CD may be adapted and optimized for the rail medium which may lead to quick development of this technology. Alternatively, a suitable all-weather VHF (or radio) band may be reserved for rail-communications.

Signalling

The signalling technology determines the presence of suitable gaps in the expressway and train speed for entry and suitable capacity in the post-exit stations for managing the exits. This technology will be the backbone for the safety of the rail-expressway. It must be based on distributed and localized information processing to avoid any single point of failure in the system. Localized failures must lead to only closure of the corresponding entry and exit points of the expressway, without impacting the rest of the expressway. The technology must be integrated with suitable sensors installed on the tracks, entry and exit points and signalling system on the trains. The train operator must be able communicate with the switches at the entry and exit points through the use of this signalling system which may allow or deny the request depending on safety and availability of space/capacity on the expressway and/or stations downstream of the exit points.

The localized nature of the signalling technology allows for multiple independent commercial operators (as well as individuals) operating their trains on the common infrastructure of rail-expressway in a manner similar to how multiple airline operators (and individuals) operate on the common shared infrastructure of the airports. Multiple service providers may run their trains using this common infrastructure of rail expressways and stations.

In the extreme case, the system may even allow individuals with cars to commute with their cars on the rail-expressway network (covering only the first and last miles on roads) for daily office commute as well as inter-city commute. Newer services such as private luxury trains may also emerge once the rail expressway is operational.

Technological Feasibility

The car maker Tesla has developed automated full-scale driving (FSD) capabilities that allows the cars to drive autonomously on roads. FSD has longitudinal as well as lateral control of the cars. It also allows for unknown and unseen obstacles that may be discovered while on road. Compared to the technology needed for FSD, the rail expressway needs much simpler technology which has (a) fixed tracks with well-defined entry and exit points (b) sensors on tracks that can track and communicate presence and speed of trains on the tracks (c) suitable communication with trains on the tracks. Only longitudinal control technology for docking will be needed which is already mature. The lateral control will be done by the driver through switching and signalling. Switching technology may require light-weight and strong materials along with fast and strong electromagnets which should be readily available. Communication technology has made rapid advanced in the recent past and it can be easily adapted to the needs for the rail expressway. Signalling technology needs development of simple distributed rule-based protocols with formal verification to avoid errors due to the software bugs. Overall, development of rail expressway doesn't require newer scientific discoveries, but a suitable adaptation of carefully chosen technologies that are available in the market today for the needs of rail-expressway. The key challenge may be to assemble a suitable team of experts who have capability and willingness to develop the required technology for the expressway.

A team comprising Chief architect Kavach signalling system, RDSO or nominee (for evaluating the TRL for Signalling and communications), Chief architect Vande Bharat express, ICF Chennai or nominee (for evaluating the TRL of docking, single coach trains), Chief architect WAG12B, RDSO, or nominee (for evaluating the TRL for traction issues in running a constant speed train-of-trains and readiness of existing rolling stock for expressway), Track switching technology expert, possibly from RDSO (for evaluating the TRL of automated track switching), Tracks technology expert (Civil), RDSO/Railways maintenance (for evaluating the TRL and costing in upgradation of existing tracks in passenger segment and DFCs to expressway), Control Engineer, from IITs/RDSO (for evaluating the TRL of automated docking and undocking) and Computer and Automation expert, IITs/RDSO (for evaluating the TRL for automation and IT related safety issues) may evaluate the technical feasibility of the proposed rail-road expressways and develop detailed designs and technical specifications of the components needed for the expressway.

Cost Optimizations

To enable 100% utilization of the rail-expressway, all rail-road crossings need to have bridges since there will always be a train on the tracks. However, if the rail-expressway is operated at less than 33% capacity, then the rail-road crossings may be operated without the need for a bridge. In this case, each train-of-train will run with a fixed schedule (say in every 30 minutes). The maximum length of the train-of-train in each direction will be 10 minutes (multiplied by the expressway speed). This will give 10-20 minutes for the road traffic to cross depending on the overlap duration of the train-of-trains in opposite directions at the intersection.

The road traffic will no longer have the liberty to remain on the track at the intersection and interfere with the rail-traffic. If that happens, there will be very significant costs of stopping the entire rail-expressway in the best case and accidents in the worst case. Redesign of the rail-road crossings may be required to maximize the throughput of the road traffic while clearing the intersection and provide room for the clearance of the residual road traffic stuck on the tracks in case the intersection closes before complete clearing of the road traffic. Also, on busy intersections, the road traffic in the two directions need to be caged suitably before entering the intersection to avoid a deadlock due to impatient drivers parking on the wrong side of the road when the intersection is closed. Only for very busy intersections, bridges will be needed.

Fencing of the expressway tracks may be another requirement for safety adding to exorbitant costs. To enhance the safety of the rail expressway, a specially designed autonomous inspection-cum-safety vehicle may be run at a braking distance ahead of each train-of-train. Thus, in case there is any disruption in the expressway, the safety vehicle will discover it and signal the rest of the expressway to halt safely. The time available for disruptive elements to enter the rail-expressway and cause a mishap will thus be reduced to the breaking time of the train-of-train (from expressway speed to a complete halt), enhancing the safety with lower costs. Such a design may also work under dense fog conditions, encountered in the winters (as line of sight in the visible optical spectrum will not be used for signalling and communications).

Single coach trains based on EMUs or Vande-Bharat-coaches have very fast acceleration and deceleration and need much smaller runways at entry and exit points thereby requiring lower capital costs to build these. An operational redesign, where small stations only support single coach trains may easily expand the reach of the rail-expressway to all stations at much smaller incremental costs. Such single-coach trains will also enable other long-distance trains to run continuously till their destinations, decreasing the travel time as well as energy costs.

Capacity, Bottlenecks and Demand

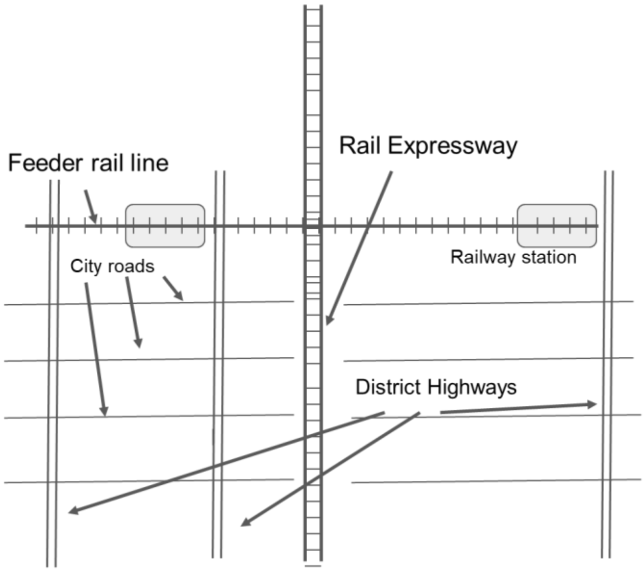
The successive bottlenecks for the rail-expressway which are tracks, coaches, platforms, roads connecting the station and customer demand, are analyzed now.

According to the annual statistical statement 2019-2020, the Indian railways transported 1.15 trillion passenger kilometers in the year 2018-2019 (1.15 TPKY), using a track network of around 100K kilometers. In comparison. a 1.5K kilometer bi-directional rail-expressway route operating at an expressway speed of 100 Kmph at 33% of the theoretical peak capacity, has a capacity to transport 2.6 trillion passengers in a year (2.6 TPKY). This capacity is directly proportional to the length of the expressway tracks and the expressway speed. To realize this capacity, the number of coaches need to be suitably provisioned and the coach utilization needs to be optimized in ways similar to how airlines optimize their airplane utilization. The Indian railways presently owns about 50K passenger coaches. Assuming a run:stop:maintenance (RSM) ratio of 1:1:2 for the coaches, 63K coaches (as on

March 2020) have a capacity of 1.05 trillion passenger kilometers[3] per year (TPKY), which may be improved up to a factor of 4 by improving the RSM ratio.

The next bottleneck is platform capacity, which critically depends on platform length and how long a train needs to stop for boarding and deboarding. A single platform accommodating trains of 24 coaches with an average stopping time of 30 minutes, can support up to 32 million passengers per year. In order to fully load the expressway with passengers from a single port, 56 such platforms need to be built. In reality, there will be many transit passengers along with freight traffic hence the real requirement of the number of platforms at a port will be significantly less.

The city bus/road and metro networks need to be provisioned suitably to optimally utilize the rail-expressway. For this a three tier structure consisting of (i) the rail-expressway as the backbone connected to (ii) perpendicular rail feeder lines with ports/stations connected to (iii) a highway road network running perpendicular to the feeder rail lines may be developed (see the Figure on the right). The railway stations/ports may be built on the feeder lines that provide seamless connectivity to the rail-expressway, leading to a uniform two-dimensional aerial spread of development instead of a linear spread of development along the highways and railway stations. Seamless, integrated rail-road connectivity may be provided to passengers and businesses in the city using such an architecture.



A three tier structure for integrated rail-road network consisting of rail-expressway as the backbone, feeder rail lines and district highways perpendicular to the feeder rail lines.

Once adequate capacity has been built on the rail-expressways, ports and the city infrastructure, the final bottleneck will be passenger demand. This demand may be very sensitive to the time of the day. Congestion pricing may shift this demand only to a limited extent. However, the freight traffic demand is expected to be much more price elastic than the passenger demand. Thus, to optimally utilize the coach and the port infrastructure, the AC as well as the non-AC passenger coaches may be remodeled to support passenger as well as parcel transport. The passenger seats may be foldable to allow for carriage of parcels in compartments when the coach operates in the "freight mode". A suitable standard for small QR-coded mini-containers with "360-degree wheels" may be developed to allow quick loading and unloading of these mini-containers in passenger coaches, when operating

[3] The ASS 2019-2020 reports passenger coach kilometerage of around 23 billion coach kilometers in the year 2018-2019, which implies that on the average a passenger coach travels about 1000 Kms every day. Even if the coach was in operation 24 hours every day, this would mean that its average speed is 41.6 Km/hour including stopping and maintenance time, which seems very impressive to say the least.

in the freight mode. Thus, the same coach and port infrastructure may be optimally utilized for transporting passengers as well as certain types of freight.

The prime minister has set an ambitious target for India to become a developed country by 2050. In order to achieve this goal in a sustainable manner, the rail-expressway will be the key. In a developed country with a population of 1.5B, where citizens commute 50 kilometers per day on an average, the total transport capacity needed will be 27 TPKY. To support this demand, the total length of the rail-expressway route needed will be at least 15,600 Kms, which seems achievable with reasonable investments in the present railways infrastructure of tracks and ports. However, a rolling stock of around 1.6 million coaches will be needed to support this demand. India had a fleet of around 1.7 million buses in 2016. Such a stock may be optimally utilized perhaps by focusing on the roll-on-roll-off model for passenger transport under the 90-10 rail-road model (90% of the travel is on rails and the last 10% of the travel is on roads). Rail-ports along with suitable low-cost technology either through wheel-change, axle fixation or a rail-carrier vehicle may be developed for an efficient carriage of buses on the rail-expressway.

Transition Options

It may not be feasible to suddenly transition the entire railways network to the expressway. Initially, a congested segment may be identified for transition. The segment may be upgraded to the expressway by installing and switching, signalling, communications and entry/exit infrastructure. Initially, a ten minute “expressway slot” may be reserved when this segment is to be operated as an expressway, supporting a 16.5 Kms long train-of-trains at an expressway speed of 100 Km/h. Trains entering the expressway, join the train-of-trains at the end, whereas the exiting trains will continue as regular trains after their exit. There may be separate expressway slots for passenger and freight trains. More such expressway slots may be added as the demand for running more trains in the “expressway mode” picks up.

Another option may be to convert the dedicated freight corridors to rail-expressway and build rail-ports that allow for roll-on-roll-off of trucks, buses and cars. Commercial operators (state transport corporations as well as private operators) may be allowed to run passenger services by rolling-on and rolling-off their buses on the rail-expressway for long distance travel, while covering the first and last 10% of the distance on road.

Once successful, more corridors and sections and time slots may be converted into expressways.

Commercial Model

The railways may run passenger services or freight services on their own. In addition, railways may develop a suitable charging model for other commercial operators. These charges may be decomposed into time of the day dependent *energy charges*, *expressway charges* and *port charges*. The energy charges may be based on the distance travelled, weight of the train and the time of the day dependent electricity charges in case the country adopts a dynamic market-based electricity pricing. The expressway charge may depend on the length of the train, whereas the port charges may depend on the port, length and weight of the train and the length of time it parks at the platform. The port and the expressway charges may have further subdivisions into a utilization independent subcomponent to cover for maintenance and a subcomponent inversely proportional to the utilization to cover the capital cost. In addition, there may be time of the day dependent surcharges or discounts on the base expressway and port charges to incentivize traffic to move to non-peak hours.

For passenger services, a five-tier structure like the one existing today (1AC, 2AC, 3AC, reserved sleeper, unreserved) may be supported. There may be a fixed percentage surcharge on the luxurious classes, redistributed as subsidies to the lower classes. The percentage of surcharges and subsidy may be selected depending on the traffic in each of the classes to balance to a net zero. Other suitable revenue management principles may also be applied, while ensuring the desired social obligations to the passengers.

The ministry of Railways and the ministry of Road Transport and Highways (and at a later date the Ministry of Civil Aviation and the Ministry of Ports, Shipping and Waterways) may be reorganized into a single Ministry of Transportation with three divisions namely, *Infrastructure* – that will be responsible for development and maintenance of railway tracks and roads (and waterways, ropeways at a later date), *Integrated Ports* – that will be responsible for development of integrated ports/stations that enable seamless and efficient passenger and freight transportation and *Services* – that will be responsible for managing the integrated passenger and freight services. IRCTC may be mandated to run a reservation system for integrated rail-road (and later include air and water) services. Since railways is a central government subject and transportation is a state subject, seamless integration requires center-state agreements that may be facilitated through the Niti Ayog. Under such agreements, the state transport corporations may be given licenses to provide integrated national rail-road services in all the participating states if they allow the participating states and the center to provide these services in their state. There may also be a central rail-road transportation services corporation for passenger services and a central postal and logistics corporation to provide freight services in all the participating states. Private operators may also be allowed to provide freight and passenger services. The competition thus introduced will provide improved services with lower costs to the customers of all the classes.

The country need not wait for the proposed reorganization before providing the integrated services. The existing railway stations may be mandated to develop additional bus platforms and IRCTC may be mandated to provide integrated rail-bus reservation services in collaboration with state transportation corporations (with the option of prepaid porter services for luggage transfer). The passengers may be intimated of their “bus-bay numbers” and the mobile numbers of the porters on their mobile phones before their trains reach the destination railway station.

In addition, since the rail-expressway provides extreme predictability of the rail schedules, highly dependable and quick parcel services may be provided by postal and logistic services operators connecting the villages to the towns and cities. Ninety percent of the parcel travel may be on the rail-expressway at the constant speed of (say) 100Kmph and the remaining 10% of the travel may be completed in 6 hours on roads. Thus the cities may be connected to villages up to 600 Kms in 12 hours and up to 1800 Kms in 24 hours. Once such services are in operation, the ubiquitous Internet connectivity along with the e-commerce boom will provide unprecedented opportunities for small scale village based agro industries, thereby reversing the migration from villages to the cities.

These changes will allow rapid development of the industry around the rail-expressway and help the expansion of the rail-expressway as the capital requirements of the rolling stock as well as construction of rail-expressway tracks and highways may be borne by the state transport corporations or the private operators. The ensuing competition due to lowered entry barriers will lead to movement of traffic from road to more energy efficient railways, a net reduction in overall logistics costs, much improved passenger public transportation experience, reduction in nation's dependence on oil and better quality of life for the Indian citizens.

Further Developments

Rail-ports which directly load cars, buses, trucks from road onto trains may be promoted in future on a suitable roll-on-roll-off model. Drone-ports may also become operational in the not-so-distant future, which will load drone taxis on the train. Rail-ports will allow the last mile connectivity using buses/cars/trucks/drones while the bulk of the distance will be covered with buses/car/trucks/drones on an energy efficient and stress-free train transportation. Individuals may be able to productively utilize their time while on the train.

The railways may open up the standards for the trains and the signalling and switching and communication technologies so that automobile manufacturers may make trains/coaches/car-carriers/drone-carriers that are ready to run on the rail-expressway – similar to how cars run on roads. Manufacturers may develop new rail-road ready cars for individuals for seamless and comfortable transportation. A new energy efficient manufacturing industry based on rail-road-expressways may take shape in the long run.

Multiple train operators may own and run trains catering to different needs. Freight trains, parcel trains, passenger trains, luxury trains, train-cruises, overnight-train-hotels, car-trains etc. may become operational on the shared infrastructure of rail-expressway.

Door-to-door long-distance travel facilities may be provided by service providers (luxury taxis may picks a passenger from home and seamlessly transports to the train on the rail-expressway and then seamlessly transport to the final destination). Hotel operators may also run luxury overnight sleeper trains on the rail-expressway for overnight long-distance travel along with door-to-door service.

The present model of personally owned cars on roads is unsustainable for a country like India and will be catastrophic for the planet (even in the presence of electric vehicles). The rail-expressway will provide a suitable path to migrate to a sustainable, low-cost and energy efficient transportation for private as well as public transport while saving the planet earth from the disaster that is staring at us in our eyes.

Acknowledgements

This document has benefitted from discussions with many people. These include Mr. Sushant Kumar Mishra (IRTS) Retd. Additional Member Traffic & Secretary, Railways Board, Mr. Sanjeeb K Mishra, Secretary Com CoE, National Recruitment Agency and many others who have provided valuable inputs in shaping up this idea and document.

Dedication

This idea is dedicated to our forefathers, who bore the hardships of the most devastating famines in world history and yet paid excessive taxes to finance what was called "The Famine Insurance Fund" (1878-1905), proceeds of which were subverted to finance the construction of what is now a part of the Indian Railways.

In memory of Late Mr. D. P. Garg who dedicated his life in the service of the Indian Railways.