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# THE CATERPILLAR TRAIN

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*Abstract*— **Caterpillar trains, an idea meant to take the train system to residential areas, has just won an Indian railway engineer a global competition on innovation at Boston's Massachusetts Institute of Technology (MIT).**
**In a nutshell, the caterpillar train(Non-Conventional transport), or C-Train, envisages a citywide network of lightweight, elevated train coaches running at about 100kmph on a track supported by poles bent into arches.**

**It is one of the best solution to conventional transport system. The Caterpillar train is creating a lot of buzz in western countries as this is more reliable and flexible mode of transportation and looks great into the city.**
**This is a light weight train which can carry a limited number of passengers at a time from one place to another. It takes very less time to travel.**

**The project is a bit costly but its running cost will compensate for its initial cost.**

**The system is supposed to run on high voltage electric current which is much similar to the trains that run but the danger would be less as the current flowing through the line would be comparatively less because of weight, speed, etc.**
**This system will lower down the burden from roads, bring down the level of pollution and most importantly, it would cost less which would save money.**

*Index Terms*— non-conventional, envisage, electricity, flexible, etc.

## I. INTRODUCTION

One of the most efficient way to fight poverty is to create and affordable and efficient mass transit. Usually, the best transportation system are away from rural areas and out of the reach of poor, this gap needs to be bridged by introducing futuristic transit system to the rural places of the country. This would reduce the gap between urban and rural society and boost the rural economic market.
An efficient mass transit model such as mini elevated C-trains which is automated, cheap, fast, reliable and accessible everywhere within small range and for further range it can improve living standard create employment and bring up the standard of living.
Currently, this is one of the most discussed thing around the world as it would not only cause benefit to the humans but also to the environment, which is why a lot of emphasis is given on its development. This runs on renewable source of energy.

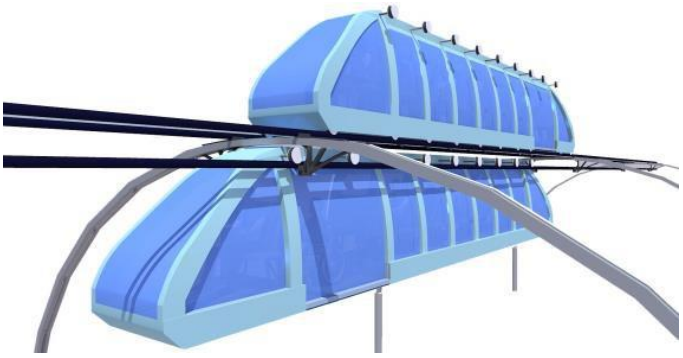


Figure1

The C-train concept is an automated mass transit mode of elevated light weight trains with seating room only. Unlike monorails, whose tracks are supported by pillars which require large sidewalks or other open spaces, the C-Train is supported by arches based on both sidewalks of any street. With support structures taking no more space than existing light poles the C-Train does not have the limitations of space to where it can be built as is the case of monorails. The trains are designed to move above as well as below the rails which allows them to be placed above the middle section of the street so as to be the furthest away from existing buildings on either side of the street.

Figure 2

The C-Train is cheaper and more effective than other overhead transportation system because of light weight and also the

supporting structure design which makes it least visually invasive on the urban landscape. The C-Train is supported by arches instead of pillars that travel both above and below of the middle section of the arc.

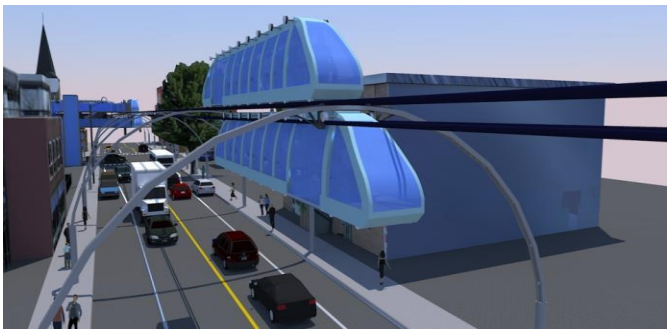


Figure 3

The arches are based on both sides of any sidewalk that allow for a regular concrete light pole. By travelling always in the middle section of the supporting arc by traveling always in the middle section of the supporting arch the C-train is kept as far as possible from the built environment. This ensures the safety of the people inside and outside of the train.

## II. ACTIONS PROPOSED BY C-TRAINS:

1. Accessibility from within an acceptable walking distance.
2. Frequency at a reasonable wait time
3. Speed at acceptable level
4. Comfort and privacy
5. Cost level acceptable to passenger and public expenditure
6. Emission and noise less and must avoid noise.

Figure 4

## III. ELEVATED TRANSPORT IN THE PAST AND PRESENT:

The main advantage of elevated train/transport are the fact that it is free from chaos and traffic limitations and are less expensive than underground transportation. The disadvantages are that the space available is less for building the whole system within the cities, space is a major issue as its construction might create chaos on the road which would be undesirable. Other disadvantage that resulted in their dismantling were high level of noise and issue of hygiene. But overall the whole system can be optimised to eradicate these problems. It runs on poles which is why is does not consume a lot of space compared to metros.

Figure 5

## IV. MONORAILS

As a way to reduce visual light the monorails presents the better alternative for elevated trains and even though it was introduced in the 1960's it never became a widespread mode of transport. Due to increasing population and lack of availability of space this system is most emphasised now days. The images below shows the Seattle monorail and Mumbai monorail. Monorails have covered up the problems faced by elevated train and putted a trademark for upcoming technologies in elevated trains. This will go on improving with passing of time. It has less noise and is constructed on large land areas to avoid any accident.


Figure 6

## V. Personal Rapid Transit

Further progress in elevated transport has been made by using smaller vehicles on specially build guideways often referred as Private Rapid Transit (PRT).The technology was introduces in late 70's but never became a mode of transport to service humans but has been limited to areas such as airports and campuses.


Figure 8

One of the most advanced models to date in elevated mass transit is likely the Sky Train concept currently in testing stages of development. However a lots of concept in the transportation is being laid on around the world but there are some pros and cons related to every concept. Magnet trains (MAGLEV) has been successfully tested in Japan but it is too costly and might be out of reach of normal people. Overall a less costly and efficient way of transportation is the need of current time. One of the successful elevated trains that is METROS are doing exceptionally well without any problem, i.e., elevated trains should be constructed around metros to get success.

## VI. PROPOSED ELEVATED CATERPLLARTRAIN:

We propose a simple model, a new model of public transport, called the C-Train, o address the deficiencies of the existing public transport model. To a large extent, it will ameliorate the problem related to last-mile access, comfort, cost and availability of public transport. In comparison with sky train the C-Train model can be built on simpler technologies and at a significantly lower cost. In fact with the exception of software and electronics for automation, the C-Train can be built on technology as old as electric motor. It will be smooth and flexible way of travelling short distances within a city. It will an EngineeringMasterpiece.

Figure 9

## VII. The Caterpillar name comes from semblance of the C-rain to a caterpillar

### A. Design principles

The C-Train concept of an automated mass transit mode of elevated light weight trains with seating rooms only. The C-Train is designed to minimize the visual impact on the urban landscape through the following features:

Minimal height of train + minimal width helps bringing down the weight and minimally visible supporting structure also. Minimal thickness of track travel both below and above the tracks.

Further without hindering the visuals C-Train allows to be positioned farthest away from the build environment (buildings, lamps, etc.)

At about 10 to 12 seats placed in sequence with two passengers per row, this train has optimised dimensions which reduces its overall weight and improves its efficiency. The low weight also saves the overall cost of the train and material as well. The train is designed to move above and below. C-Train is less visually invasive on the urban landscape.

The C-Train rails are held by arched supporting structure planted on the sidewalks which is more invasive than a concrete pole standing in between the road. Most weight of the train is supported by the arches rather than the train which demands for a higher strength of the pole. The thickness of rail is dependent upon the distance between the supporting arches. The suggested design is for vertically over rails at dimensions of (3*4 inches) though research and development will optimise the other dimensions according to the safety. Advancement in material science may allow the supporting structure to be built with a transparent or semi-transparent material to make the whole system attractive and invasive to the environment.

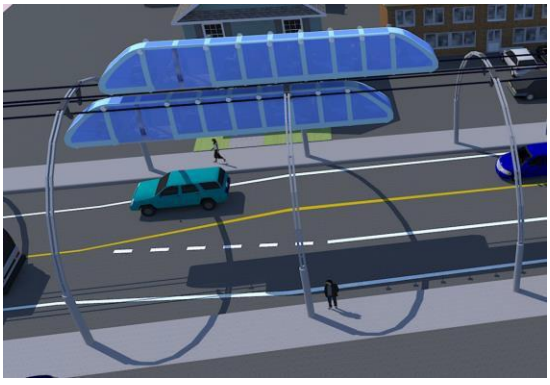
All in all it is going to be the best amongst all the existing elevated transportation systems. The only barrier will be its speed which will always be less due to safety reasons.

Figure 10

The C-Train is much smaller than monorails and designed to move both side of the track and which are held by arches rather than crane supporting structures. The crane supporting structure do not fit well in urban environment while the arches fit well on the roads as shown below in the figure without obstructing the overallview.

Figure 11

This image gives us an overall view of the environment with the installed arches. It is in fact looking wonderful and seems like no burden has been imposed on surrounding or on the roads. Each transport can move freely under the arches and their motion would not be hindered by anyways.



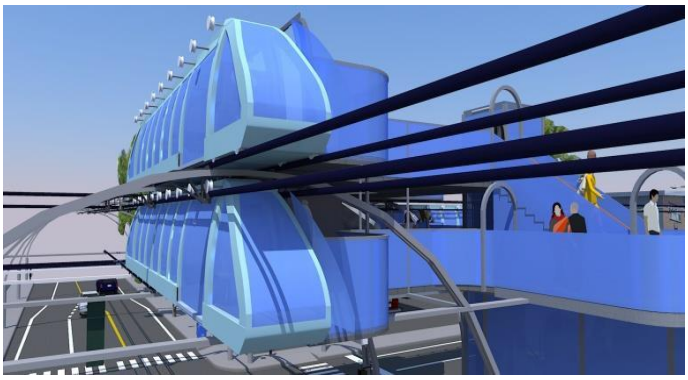


Figure 12

The suggested number of seats are 10 in tandem in an average urban environment. Each row is a private space for a single but with sufficient space for travelling with significant others. This feature is valuable especially in west where there is great premium on privacy. It would be as comfortable as your car.

Figure 13

The concave design of the wheels allows for secure, stable and smooth rolling on the tracks. Additionally, each wheel will have at least one safety wheel for secure and stable rolling on the tracks and these wheels will run horizontally along the grooves within the rail to protect it against derailment. The interior of wheel has rubber covering which will stick tightly to the track to prevent its slipping off. It will also have a shock absorbing system which will minimize the audible noise which is expected to be less than normal electric trains or cars running on tracks or roads.

There will be no noise generated while the train moves and the best part about this storming system is that, the whole window will be transparent engineered glass fibre which will enable you to look outside the train safely and admire the other engineering masterpieces which one will see during his/her journey in this superb train.

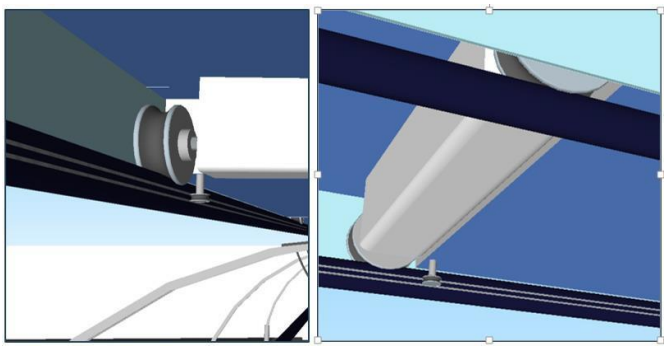


Figure 14

The suggested design is for small electric motors on each axles- distributed at approximately one motor per passenger (in tandem) however, the optimum number and size of motors will be authorised by R&D including the consideration of whether to place the motor on the axel or within the wheel. Electric cable may run along the rails-similar to trolley cables to power the motors.

Each train will have batteries as a backup in case of power loss and also to mitigate the strain on the grid when accelerating as well as regenerating power through breaking. The gate will have sensors that will open it above prescribed limit in case of emergencies.

## VIII. Quick and Easy Entry and Exit

In order to reduce the entry and exit time, the floor of the train is elevated above the platform of the station. Given the height of the train floor above the station floor (shown by arrows) there is a reduction in standing up and sitting down time and effort required for each passenger. The differential in height of vehicle platform versus ground level makes it easy to access, it is similar to sitting in a SUV or a Golf cart. The image shown below is from the test video that shows for an older person it takes less than 3 seconds to exit or enter the vehicle. Given this basic test, with a maximum of 3 seconds required for entry and 3 seconds for exit, a stop is not expected to exceed 6 seconds, therefore an average of 8 to 10 seconds of stop per station may be a reasonable assumption.

Entry and exit problem was a hurdle that was keeping people away from using transport and this problem is smartly managed in this train. It will not cause any problem to people any age group to travel through this train easily. Humans of every age group can enter and exit safely without any risk. In fact this train will be having a special compartment for people on wheelchair so that they feel comfortable while the train is moving, they will not experience any push or vibration as their chair will be fitted on the allotted position in the train.

Figure 15

## IX. Wheelchair Access

Each C-Train will have access to wheelchair in a dedicated area as mentioned above and at that place the floor of the train will be at same level with the platform. Seat fold vertically to make space needed for wheelchair when needed. All stations are designed with elevators for wheelchair access.

Figure 16

## X. Easy Access to Available Seats

Given that all the passengers have to be seated in a C-Train, there is a system to ensure smooth circulation for access to available seats without crowding and competing for seats. While entering a seat each passenger has to select his destination stop. This, combined with infrared or other technologies that detect empty seats, providing to passengers at upcoming stops at green light indicating where to stand for an open seat in the next C-Train. Passengers wait in a line similar

to customer waiting in a bank. This will surely ensure that there is no chaos into the train and only limited amount of passengers can travel at a particular time. Only passengers would be allowed to climb the platform to maintain the load on it within the safe limit.

Figure 17

Each C-Train has at least one section where two seats are facing each other to allow up to 4 people to sit together - couple with a child go to the area of designated for four seats and the green light indicating upcoming open seats.

Capacity

The capacity per train need not to be very high as the C-Train is designed to build over major street and avenue which will eliminate clustering. The image below shows a station is larger at intersection as of two avenue with two lanes in each direction. Station is larger at intersection to accommodate passenger from both C-Train directions, otherwise the station is smaller if not at an intersection. The goal is to take the C-Train to each and every street and corner of the city for everyone to access. It is to have the equivalent of a subway stop at every major intersection. Capacity will surely be optimal level to ensure the proper safety of humans. No compromise will be made with the load as it might be disastrous.

Figure 18

Design mechanism- Switch from travel above to below the tracks and vice-versa. Below Figure 19 & 20.

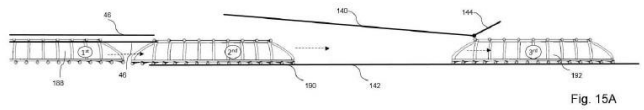


Fig. 15A

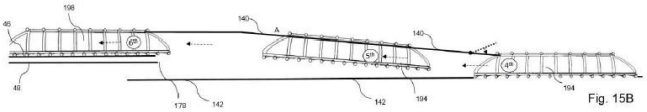
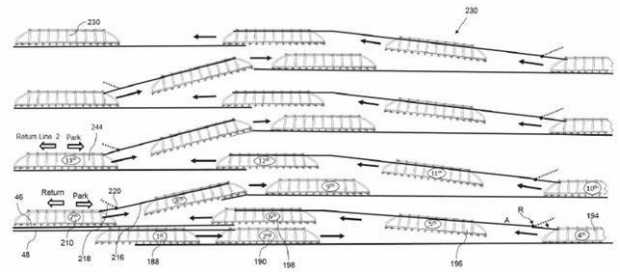


Fig. 15B

"Vertical Depot"- Base on the principles in design mechanism for switching between travel on lower and upper tracks shown above. The strength of the pillar is the main criteria for vertical depot to happen.



The whole system is engineered in such a way that it will not cause any inconvenience to the passengers and would also ensure proper safety of passengers while switching the tracks. No chances of derailment are to occur during track switching. Below figure Intersection of upper tracks

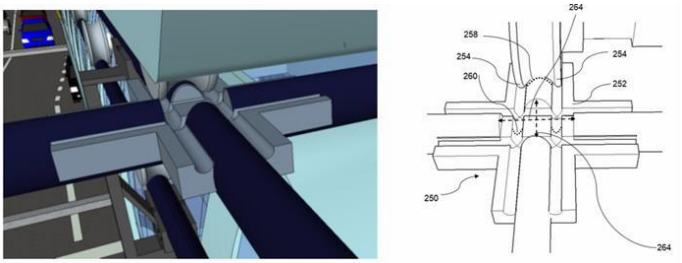


Figure 21

Image below shows Intersection of lower tracks

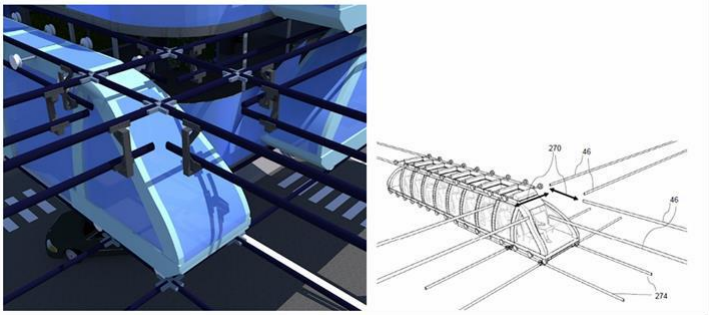


Figure 22

It can be seen in the image above that the intersection of tracks is strong and there are no chances of any accident. There is rubber fitted in between the intersection point to minimise the jerk and impact from the track when train will be travelling on it.

A. WHAT ARE KEY BENEFITS?

A comprehensive solution for mass transit ad complete coverage at a lower cost than all modes till date.

1. Accessibility from an acceptable walking distance.
2. Frequency at a reasonable wait time Frequency at a reasonable waittimes.
3. Speed at acceptable level Speed at acceptable levels.

4. Comfort and privacy.
5. Cost level acceptable to passengers.
6. Emissions and noise free mass transit.

B. Furthermore benefits are:

Improved worker productivity –less stress, less time wasted in traffic less financial strain from car costs, etc.

Greater, equity and employment–Improved service to and from underserved areas would help both employers and workers to reduce poverty.

Improved health – Lower accidents, lower pollution, fewer, less aggravation from traffic.

Improved freight transportation efficiency – Fewer cars on road during rush hours.

Lower public roads expenditures – On road repairs and mass transit.

Climate Change Mitigation- No pollution as runs on electricity.

Higher revenues to local and state governments from capitalizing only newly available lands.

C. WHAT ARE PROPOSAL'S COST?

At present time we can only extrapolate the costs. Assuming that a supporting structure (typically an arc holding the tracks) will be needed at every 20 meters it would come 50 arches per kilometer.
The cost of installing a light pole in one example is $3,500 (including construction by an electrical contractor along with the city's design, inspection and processing).
We will assume from this state the cost for each supporting structure would be $10,000*50 per kilometer=$500k/km.
Tracks resemble oval pipes and measure 4 inches vertically by 3 inches cost of track at $500 per 20 meters at 50 per km = $500k/km
The cost of the stations- placed at every km estimated at $500,000/km including the cost of elevators. The cost of wheelchair accessible elevator in public transport is about $80,000.
The electronic controls for automatic drivers including all the software and hardware estimated at $100,000/km including command and control centers for monitoring.
Each C-Train runs on electric motors and require fewer parts and less material than an average car, therefore we assume that it should not cost more than $50,000 per C-Train and we consider for two C-Trains (two directions) per km
NOTE: Extrapolated numbers are based on post R&D costs assuming construction of the C-train over thousands of miles to benefit from economies of scale.

Costs per Km: $1.7m OR $2.72 m /mile

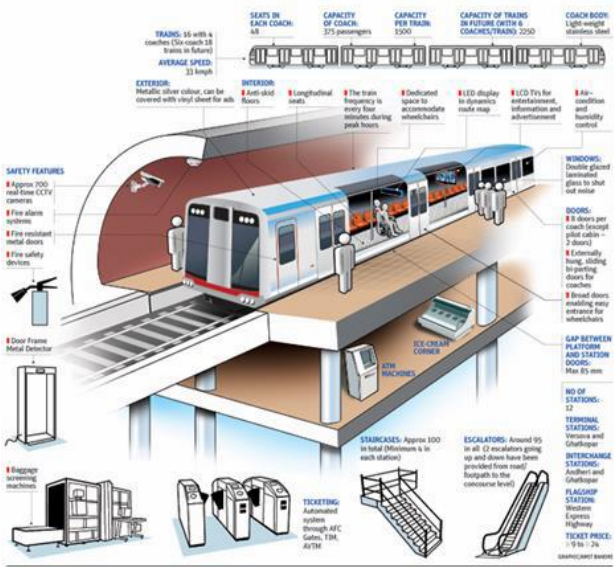
| | |
|---|---|
| Supporting structures | $500k |
| Tracks | $500k |
| Station | $500k |
| electronic controls (hardware and software) | $100k |
| Two trains per km | $100k |
| **Total cost of cTrain model per KM** | **$1.7m/km** |

Figure 23

Concrete poles to support the arches are not any different than similar concrete poles used today. The elevators for wheelchair access at each station are not any different than similar elevators etc.
The interesting lesson from the C-Train is that even if the cost is many times greater than what is estimated above, the model still provides an effective solution for comprehensive mass transit.

## XI. PASSENGER CARRYING CAPACITY

The capacity per train need not be high as the C-Train is designed to be built over every major street and avenue which will eliminate clustering. It appears that the optimal design is for each train to have 10-12 seats in sequence accommodating 1 passenger per seat (however each seat has enough space to accommodate parent with child or a couple traveling together). The C-Train would have a frequency of 10 passengers every 10 seconds i.e. 3600 people per hour per direction. Providing this model on all the areas intensively (with many lines entering the city Centre) will not only obviate the need for buses, trains and subways in a city but can also wean away many commuters from cars.



Passenger's capacity cannot exceed a certain limit due to safety reasons of the train as well as passengers. An optimal passengers will help in avoiding chaos at the platform and would also help in avoiding rush which will avoid small accidents. Unlike current metro system that runs overloaded the C-Train will ensure the entry of passengers who are willing to travel on the basis of first come first.

Frequency of trains will be fast so passengers will not have to wait longer to board a train.

## CONCLUSION

Elevated mass transit holds the solution for comprehensive cure to ill stemming from the shortcoming of mass transit since early days of the first streetcars and buses. This is a comprehensive solution to public transportation.

Ashwani Kumar Upadhyaya, a 1997 batch officer of the Indian Railway Traffic Service has proposed a radical new system of public transport called The Caterpillar Train and according to the Indian Express, this radical idea has won him an award in a global competition for innovation at the Massachusetts Institute of Technology. The contest was organized by MIT's center for collective intelligence and the idea won the popular choice and judges choice categories.

Essentially the caterpillar train will be a network of light weight trains running at low speed close to 100kmph. The seating only coaches will have wheels both above and below them so that they can run on the track and under it. And those wheels will give the train appearance similar to a caterpillar. These tracks are supported by poles joint together to form an arch. The coaches will run on electricity and will have batteries in case of emergencies.

• This is a transportation system of future.

• Although this system is still in its development stages, we hope we can soon see something like this coming to cities in India.

• Since the coaches are small and seating only, the amount of load would be limited. So this means that this type of transportation can also go through residential areas safely. For this reason this idea has been dubbed as 'Internet of Urban Transport'. The biggest advantage of this system is that it will be easy on pocket and could be accessed by each and every one. It will cost fifteenth of the usual metro system. The platforms will have elevators which can be accessed by everyone especially old age people who have problem in walking. Passengers will be able to choose their destination through the console in front of them.

• Unlike existing elevated railways, that often composed of large concrete support that block out street view and look gigantic and big on the streets, the mini C-Train will minimize the visual impact of urban mass transit. The design concept lies on the arches that support the two level of c-train traffic. Other transports like buses, cars, bikes, etc. can easily pass below the moving train with full safety

• The C-Train concept calls for rail that travel on a network of elevated tracks at an average speed of 62 mph. The train infrastructure could be built easily and at low cost as mentioned above

• The design also improves accessibility, making it easier for commuters (A person who travels from one place to another daily for work) to hop on and off the rail cars without clogging up sidewalk traffic for those who are simply walking past.

• A regular pass can be obtained from the authority who travels with the train frequently so that they don't face the problem of choosing destination and paying again and again.

• This whole system is compact and flexible which makes it more attracting. People will be thrilled every time they will travel through this.

• This would reduce the burden of pollution from the environment and control global warming.

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