

An Infrastructure Development model to make travel, food and shelter virtually free to all!

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The author is a First Class First with Distinction Engineering graduate and an M.Tech from IIT/Kharagpur. Having served a decade in railway open line in various capacities, another decade in Railway research at RDSO & IIT, worked abroad as consultant till 1990. He was involved with the Konkan railway project from the beginning of construction (1990) as a Chief Engineer, Director (Projects) and finally as the Managing Director till date. He has original contributions of new theories in rail-wheel and track-vehicle interactions in railway technologies recognized and published in the world forums. He holds

several patents abroad and in India for his inventions. His inventions cover railway technologies, Anti-collision Devices, Sky Bus Metro- in all 17 patents are assigned by him to the President through Konkan Railway Corporation, the royalty streams valued (by PwC) at over Rs 8000 cr, if nurtured over next three years. He believes it is in the realm of reality to make food, travel, communication and dwelling virtually free to all humans on the planet through bold application of science and technology to infrastructure development.

Abstract

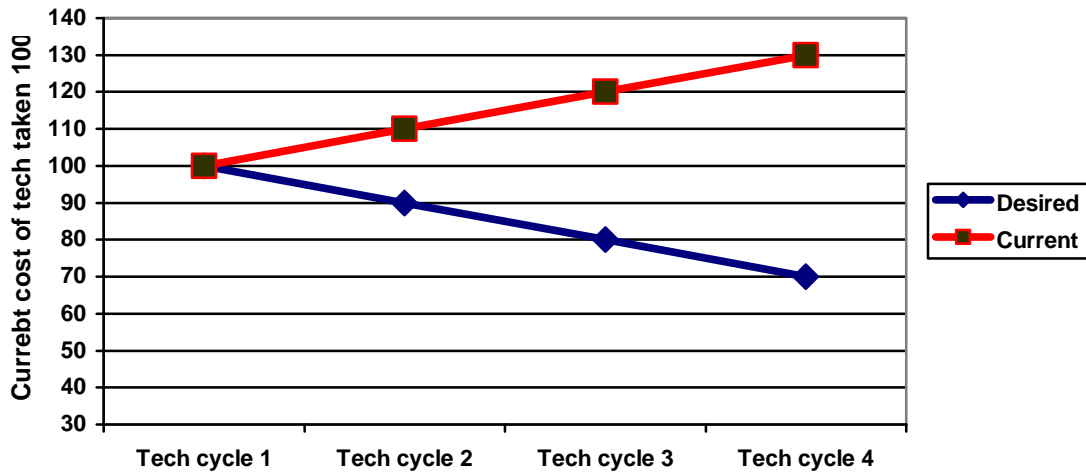
It is the cosmic reality human is part and parcel of the universe and neither owns exclusively the resources nor creates any, on his own. A trustee at best, but localised in time and space frame, causes distortions in access rights causing unequal distribution of wealth. Infrastructure development is the instrument through which the humans address the improvement of quality of life, and knowledge in action is the technology, which forms the driving engine to deliver the infrastructure. Intellect is the precious gift to humans, which used properly, can yield development model, which progressively improves quality of life while reducing the costs of services, thus becoming a wealth generator- wrong approaches currently prevailing, lead to financially unviable models, effectively eroding value and wealth of one community to enrich another exploitative community, which in long term is unsustainable and makes all poorer. Through application of knowledge embedded devices and re-engineering known technologies, it is demonstrated how we can change the pace of infrastructure development to create a win-win strategy of self-sustaining & wealth generating infrastructure, ultimately leading to a situation of virtually free travel, food and dwellings! A real life case of development of the Sky Bus Metro technology in our country is shown to be capable of making the urban transport virtually free with vastly improved quality of service! Such paradigm shift in infrastructure-development is unbelievable, but true!

1. Introduction: The most precious gift given to us, humans, is intellect. The way we make use of the same with proper attitude makes all the difference to the prevailing quality of life in terms of food, shelter, transport and communications. Intellect has no barriers, nor limits – it is an eternally renewable resource. From generation to generations, since the human species have learnt to pass on the results in the form of knowledge of their experiences from grandfather to grandchild, the cycle of intellect

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improvement is endless and continuously progresses on an upward curve. However, greed and desire to prevail over others is a constant ingredient amongst humans. The distortion in the societal development and again, amongst societies is visible in terms of disparities in living styles and access to and use of resources – and the spectrum covers extremely poor people to extremely rich people with means of controlling the very processes of distribution and allocation of the resources. Exploitative mechanisms always rear their heads and history has shown cycles of transformation in our societies. Countries moving from peaks of achievements to downs, and those down and exploited, fight back and strive to reach the peaks.

Tech. Development Cycles



2. Intellect & Infrastructure: The intellect is the running common thread in all these activities and infrastructure is the medium through which we draw benefits of resources delivering benefits to the society.

The backbone is infrastructure for humans to provide for their basic needs in an efficient manner conserving energy resources efforts and resources. The development in science and knowledge is put into action, which manifests as technology, which in turn controls the basic infrastructure of a community. A society's core strength, hence arises from the basic capability to generate newer concepts and newer technologies, which progressively meet the most important critical requirement of reducing input efforts, while increasing quantitatively and qualitatively the output in terms service or product. Alternatively to deliver the same level of service, the costs should progressively reduce.

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3. Innovation: If the society is unable to innovate to find such technologies, which, progressively reduce costs and add value, then what happens is, we end up losing the basic wealth and burn our future for our current comforts. Obviously we cannot sustain such development model for long- the planet has a way of correcting the imbalance sooner than later.

3.1 In the matter of tele-voice communication, we are already seeing a revolution taking place within last 5 years! The prices have been steadily falling and those who adopt the competitive edge technologies are able to survive the crashing unit prices, and scales of massive utilization make the difference. The more expensive legacy wired systems charging phenomenal amounts have given away to virtually free conversation across continents!

3.2 The revolution is on. The digital revolution has similar impacts on other areas of traditional human endeavours- provided we open up our minds and adopt as well as adapt.

4. Knowledge embedded devices: It is time to now consider designing systems based on knowledge embedded devices, widely distributed and networked to handle multiple tasks, which otherwise normally handled by groups humans. The advantages are obvious.

- ♦ Productivity levels soar beyond our expectations of old legacy development models
- ♦ Quality levels get re-defined
- ♦ A paradigm shift in the way we think and work is caused
- ♦ All the rule based working is built in and fault tolerance and recovery processes

built into the network

4.1 Production systems, agricultural activities, road constructions, shelters, transport systems linking the material transportation covering movement of raw materials to production centers, finished items to consumers, city house keeping functions- all community services can be progressively managed by the knowledge embedded devices inter-connected to mutually consult, analyse and take actions based on consensus.

With no additional productivity-linked heightened expectations to be fulfilled as time progresses, in such economy driven by the knowledge embedded devices, the initial capital cost gets recovered in the initial years at current economic prices, and from then

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on the services will progressively cost less and less, in comparative economic terms, as proportion of the earning capacity of the community.

Transport: can we make an urbanite travel free virtually?

Ports: Can we make port operations cost less and less – bringing down the costs to virtually drop by more than 80%?

Can we make agricultural produce reach markets/consumers at progressively lowered costs?

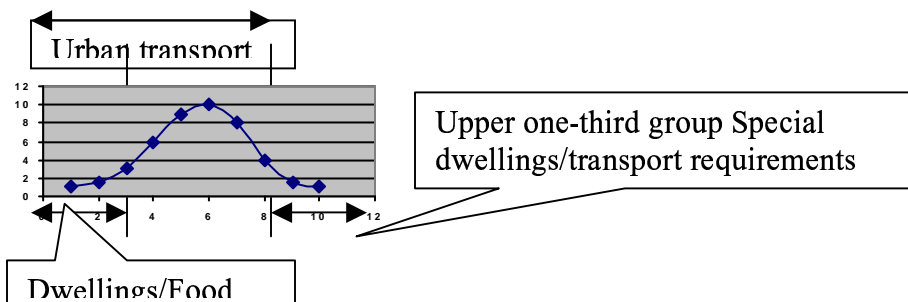
The cost of production of energy –can we make to fall continuously over a period?

General mass scale dwellings: can we make them with falling unit costs with application of known technologies?

5. Approach: The stress will be to make use of as much as possible known proven technologies, re-engineer and adopt cross-discipline developments, breaking compartmental thinking, thinking afresh the basic requirements and produce non-conventional but actually workable combination of technologies. This mode of thinking can produce tremendous boost to value-engineer cost-effective solutions, adding continuously to the wealth of the community.

6. Cardinal principle: It is time for engineers and technologists to impose upon themselves the cardinal requirement that their actions should pass the test that in creation and operation of assets forming the infrastructure for societal sustenance, should be such as to truly add value and wealth to the community, and not an instrument to transfer wealth out of the community.

7. Postulation-differences remain: One should not confuse that by the above approach we are creating a society of “no-needs, hence no motivation to excel”. The postulation here is that, whatever we do the bell-curve of distribution of wealth and driving people to reach the better zone of the curve remains. To amplify, the above steps only addresses the populations at the lower one-third of the zone of the bell curve distribution, but the drive to go to the upper one-third of the distribution continues.



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It is the upper one-third group in the society who create the bench mark levels to be attained by others and motivation levels remain to shift from lower levels. The bell curve distribution remains and the shift as a whole takes place in time. By addressing the transport requirements, we can see we today take care of two-third of the urban population's requirement.

8. A practical application: We will now deal with a few areas of our infrastructure to demonstrate the above, mentioned concepts:

Sky Bus Metro – a paradigm shift in urban transportation:

The model shows how over 5 to 7 years an urban habitat can virtually have free transportation within their community.

Transport requirements of new economy emerging in the new millennium- Improve quality of life while reducing costs:

- ◆History shows when technologies are outdated they actually become economically un-affordable, typical financial disasters!

- ◆A society which forces their future progeny to pay for today's comfort is not sustainable

- ◆Today's transport solutions based on last century's technologies like elevated/underground rail based systems are violating this cardinal principle-we should not rob wealth of our grand children!

- ◆Human life and quality improvement at reducing costs should be perceived as the focus of the new millennium

- ◆Infrastructure therefore has to cost less but deliver more to be a value generator: technology innovation alone can help

- ◆Sky Bus Metro technology is the break-through in transport technology from our country to cause such paradigm shift to make transport costs to fall while quality of life improves for all including handling cargo – providing a holistic transport solution.

9. The Challenge

- ◆ Urban space remains frozen
- ◆ Populations are shifting to urban habitats
- ◆ Mass transit capacity
 - occupying less and less urban space,

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- while being pollution-free
- affordable by common users
- with point to point connectivity
- Be integrated, avoiding inter-modal transfers
- Safer than existing systems-value human life
- Better quality of travel
 - ◆ Air-conditioned
 - ◆ Noise-free
 - ◆ Virtually no-wait service

9. Sky Bus technology as offered by Konkan Railway meets the above requirements, and helps us re-define the thinking and planning for urban transport.

9.1 Description: Heavy 52/60 kg /m rails placed at standard gauge floating in elastic medium and damped by inertia of measured mass held in a 8 mX 2m box enclosure, supported over a 1m dia. columns spaced at 15 m and located at 15 m distance from each other, in the divider space in between lanes on a road- way, at a height of 8m above road surface- provides the support and guidance for powered bogies which can run at 100 kmph, with the coach shells suspended below , carry passengers in air conditioned comfort, can follow existing road routes, while existing traffic on roads continue.

9.1 The fixed structure at 8 m height above road level is aesthetically pleasing and there is no concern of claustrophobic feeling for road users.

9.2 Aesthetic and eco-friendly, the Sky Bus can never derail, capsize nor collide- by design as well as by construction, hence is safer than existing rail-based system. At Rs 500 m or US\$12m/km in India, the system is noise-free and pollution-free with 18000pphpd, scalable to 72000 pphpd as required. With no signalling and having no points and crossings, it is a unique mass-transit system, which can be put up within two years in any crowded & congested city. In



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addition to moving people Sky Bus system can carry standard 20ft containers, boosting its capacity utilization to double that of other existing systems.

10. Legal provisions: Sky Bus metro falls under tramway category, under Art 366(20) of Constitution of India, since it operates along existing roadways and within municipal limits, hence excluded from Railway Act. However all technologies are railway based and substantially provisions of Railway Act apply with additional provisions required to operate safely in conjunction with road users, who are sharing the transport zone along with the Sky Buses over-head. So a special Sky Bus metro Act has been drafted to cover the legal requirements.

11. The components of SKY BUS

- Sky way
- Sky bogies
- Sky coaches
- Sky stations
- Traverser arrangements at terminals

11.1 Sky way

- In the middle of road way pile foundations support 1 m dia column approximately 8 m high, and space at 15 m all along the roadway
- The sky way consists of a concrete box structure carried over a series of piers at a height of 8 m above existing road level
- Two rails fixed with appropriate fastenings within the concrete box support and guide the sky bogie
- There are no points & crossings-



11.2 Sky Bogie

- Standard two axle bogies used in metros for speeds of 100 kmph are used (but can have higher speeds, if required up to 160 kmph)- of standard gauge.
- Linear induction motor technology is incorporated-with 4th rail driving which is above the bogie/or 3 Ph AC motors with regenerative power capability.
- Third rail is used for current collection
- Braking-bogie mounted

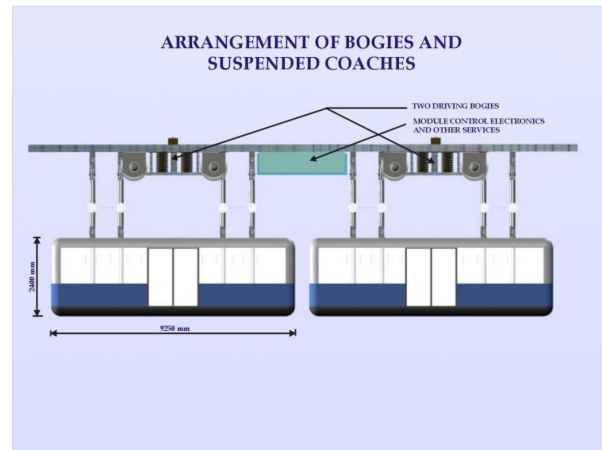
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- Regenerative
- Disc brakes
- Emergency mechanical brakes

11.3 Design loads:

Max axle load 12 tonnes

- Weight of bogie-2 axle motor: 5 t
- tare weight of coach: 6.5 t
- weight of equipment: 2t
- passenger load: 9 t
- total for a bogie: 24 t
- axle load: 12 t



11.4 Sky Coaches

- Double walled light shells with wide large windows are suspended from the sky bogies
- Controlled banking on curves- 100m radius curves can be handled.
- Air conditioned and with automatic doors
- Audio visual information to passengers
- Special 4m wide sliding doors for quick entry and exit of passengers
- Each pair carries 300 persons and service every one minute or 30 seconds is possible.



11.5 Sky station description

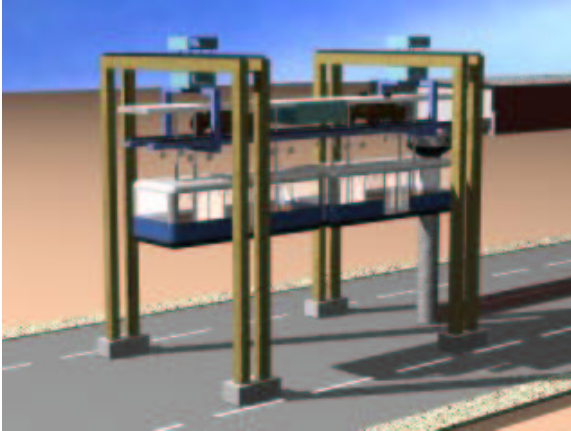
- Unlike conventional mass transit systems, Sky Bus needs smaller stations
- Service is every 30 seconds or 1 minute that is virtually no waiting time for passengers
- Totally automated without drivers or guards-and access control is also electronic

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by prepaid cards being swiped in

- Stations act as only access facility, and not as passenger holding area

11.6 Traverser: There are no points and crossings. The traverser is the system which automatically shifts the sky bus units for balancing the loads/ changing routes too as



well as shift units to depot lines etc.

Proven technologies and a very simple solution by merely re-engineering the components constitute Sky Bus:

12. Sky Bus: Performance, Costs & Benefits

♦ Passengers per hour in peak period 40,000 to 80,000 on a route

♦ Service every minute

<u>Financials of a typical 10km route module of a Sky Bus Metro Network in a city.</u>											
1	Route length Double line	10	Km								
2	Cost /route km	Rs 500	m								
3	Cost of the project	Rs 5000	m								
4	Realisation	30% of designed capacity	350,000 journeys								
5	Ridership	300,000 journeys local commuters									
6	Floating	50,000 day-travellers visiting/ non-monthly									
7	Only Fare Box collections considered. No other income is assumed.										
8	Incomes not considered: Advertisement, real estate leasing , city house keeping, container service										
9	Monthly card holders travel at average 50ps per km										
	9.1	Sell monthly travel cards TWO for total km	1000 (peak 500+500 non-peak)								
	9.2	Both the cards can be used at any time travel, but charging rate depends on time									
	9.3	The TWIN cards issued to a family at total price of Rs 500									
10	Floating occasional travellers										
	10.1	Min journey charges	Rs 15								
	10.2	Day card of 50 km	Rs 100								
11	Est. revenues										
	11.1	Monthly cards	150,000 Rs 900 m								
	11.2	Daily journey trips	50000 Rs 262.5 m								
		Total Rs	1162.5 m								
12	For standard 10 km route										
	Expenses on operation and maintenance (O&M)										
	1.	Fees to KRCL for management	50 m								
	2.	Engineers+staff 150 to 200	20 m								
	3.	Energy costs major component	150 m								
	Repairs costs increased with age										
	O&M expenses increased with annual 1% increase in volume of traffic for energy.										
13	Assumptions to work out IRR										
	No inflation in unit rates for fares considered.										
	Volume increase in traffic by annual 1%.										
14	Project IRR (20yrs)	18%									
15	Tax & depreciation:		It is assumed that we should be able to maintain debt without redemption at 15% /annum comfortably over the 20 years.								
	Depreciation at 5%	25 cr									
	Then net taxable income after interest and depreciation will be taxed at 30%										
16	Return on Equity :	24%	<table border="1"> <tr> <td>Equity</td> <td>30%</td> <td>Debt</td> <td>70%</td> </tr> <tr> <td>Equity</td> <td>1500</td> <td>m</td> <td>3500</td> </tr> </table>	Equity	30%	Debt	70%	Equity	1500	m	3500
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♦ Grid network covers existing roads-point to point service

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♦Rs 500 m per route km of double line capital cost for 40,000 passengers/hour capacity during peak

- ♦Two years construction period after financial closure.
- ♦Capital can be recovered in 5 to 7 years
- ♦Full private funding possible, being financially viable.

12.1 Free travel for life to those who own flats/assets in the city after 7 years:

Once the capital is recovered over 5 to 7 years, the residents/occupants, will be entitled for free life-time free travel, for one time payment of Rs 15000.

For a 10km route approximately, 2 lac users , when they pay, funds collected amount to Rs 3000 m. This is used as equity to expand raising debt of twice the amount, which means Rs 10 b worth additional network, providing annual 15% returns. Floating populations continue to be charged, which will be sufficient to pay for the operating expenses. The result is the urban travel becomes virtually free for life at a mere one time payment of 1% of value of his flat!

13. Network of Sky Bus Metro in a city

- ♦ Any metro can be sufficiently served by a grid network of 100km route length
 - Two routes of 20km length : 40 km
 - Four routes across of 10km : 40 km
 - Four routes feeders of 5km : 20 km
- ♦ About 200 sq.km area can be served!
- ♦ The system can move 100,000 to 200,000 passengers per hour in either direction- with flexible transport transfer capacity
- ♦ At average lead of 7 km , the system can handle more than 6 m commuters every day assuming utilisation of 50% of capacity!
- ♦ The investment is of the order of Rs 500 b for this system and can be up and ready within 3 years! Provides integrated solution, handles cargo too!
- ♦ For such service, the current elevated/underground metro systems while being comparatively less safe, cost Rs 1200 b to 2500 b, and also will take not less than 7 to 8 years to construct. Still requires inter-modal transfer costs to be incurred additionally. Pollution of trucks continues.

14. Time Scale of developments

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- ♦ The innovative concept paper was presented by Mr B. Rajaram at a World Congress on railways at Bolgna University, in the year 1989 titled as ' Sky Wheels'.
- ♦ After due engineering, the Sky Bus Metro technology was presented by Mr. B. Rajaram as MD Konkan Railway, to the Government of India in the year 2000-2001.
- ♦ **Dr APJ Abdul Kalam, Scientists like Dr Anil Kakodkar** as well as a working Commissioner of Railway Safety affirm technically the system to be feasible and safer than existing systems. (Year-2001)
- ♦ Independent consultants like ICRA/ PwC confirm IRR of 14 to 15% (Yr 2001-02)
- ♦ Private industries expressed confidence by investing their own funds to put up Rs 7 cr worth Sky Bus prototypes- a miracle by itself!(Yr.2003)
- ♦ Then Ministry of Railways authorised Konkan Railway to spend Rs 50 cr to put up 1.6 km test track at Margao-getting ready within the cost to be operated in August 2004.

15. World Potential

- ◆ Market exists all over the world for the financially viable urban transport
 - Even as on date expression of interest cases add up to Rs 500 b- simply based on the concept itself!
 - Our country stands to gain from this market as more than 95% is indigenously manufactured.

16. Implications for India

◆Polluted cities causing wasteful fossil fuel consumption being congested lowering average speeds of vehicles, will become wonderful healthy places to attract more investments

◆Investment of Rs 500 b over next 5 years covering 1000km of Sky Bus metro in 10 cities can save wasted fossil fuel worth Rs 50 b per annum and improve quality of life for all at affordable price.

◆This funding could be fully outside Government resources- private funding possible being financially viable!

16.1 Industries benefit:

- Cement : 5,500,000 MT Steel:2,800,000 MT
- Construction : Rs 150 b Manufacture: Rs 50 b
- Employment :20000 permanent & 200,000 temporary/annum
- Financial services: Rs 15 b Software/devices:Rs 20 b

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- Consultancy/design supervisory services: Rs 30 b

♦With international market the above figures will be doubled, in 5 years!

This investment of Rs 500 b in India adds annually a surplus cashflow of Rs 100 b recurring only from the fare box collections!

17. Skycon, Skyjet & Skyrail technologies

- ♦ Sky Bus Metro technologies lead to other transport applications
- ♦ Skycon is the application in Ports- the container handling and the Port operations get quantum jump in productivity almost five fold- causes a paradigm shift in designing and operating Ports.
- ♦ Skyjet is another application linking major metros bringing the metropolitan cities at 1000 km within travel times of 7 hours! Delivers containers too with the same speed! Hence high speed travel becomes financially viable in our country at affordable prices.
- ♦ Skyrail is an application for mountainous areas allowing almost vertical lifts and radius of turning less than 20m, with capability to deliver any defence equipment, free from climatic conditions.
- ♦ The scope of all these applications has not been factored in.

18. SALIENT FEATURES OF TEST TRACK FOR SKY BUS METROMADGAON

18.1 The world's first test track for Sky Bus Metro is being constructed at Madgaon in the open area along the Railway Track near Madgaon railway station. The test track geometry and the structure has been designed to demonstrate the dynamic behaviour of the Sky Bus Metro i.e. the oscillations of the coaches, rail wheel interaction etc and proving the cutting edge technologies proposed in Sky Bus Metro and Integration of various subsystems of Sky Bus Metro.

18.2 The Test Track is proposed to be a part of future Center of Excellence for testing and certifying various subsystems of Sky Bus Metro. Keeping this in view the test track is provided with dual gauge to conduct trials with both Broad Gauge and Standard Gauge bogies. To facilitate this Concrete block design with twin rail seat is developed. By shifting one rail from one rail seat to the other the system will change from Standard Gauge to Broad gauge and vice versa.

18.3 Two types of elevated track structure are being tried viz. Closed Box structure and Open Rib structure. These types enable understanding structure and vehicle interaction temperature variations in the guide way portion, noise reduction etc.

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18.4 The following are the salient features of the test track :

1. Length of test track - 1.6 km
2. Maximum test speed - 100 KMPH
3. Steepest gradient - 1 in 50 (2%)
4. Radius of Sharpest curve - 100 m
5. Radius of flattest curve - 875m
6. Maximum radius of vertical curve - 3375 m
7. Power supply - 750 V DC / 1500 V DC through
Third Rail
8. Gauge of the track - Standard gauge – 1435 mm and
Broad gauge – 1676 mm

9. Elevated track structure is with two designs :

- Closed Box Structure
- Open Rib Structure

19. Sky Bus Metro – new millennium's transport solution: affordable by all common citizens on the planet- a gift from India to the world!

- ◆ Sky Bus is the first non-invasive rapid mass transit system giving benefits of rail and flexibility to follow roads.
- ◆ Unlike existing ones, Sky Bus technology carries cargo for city and eliminates trucks too!
- ◆ Urban transport is made financially viable and affordable by the common man today to be within his living means.
- ◆ The utilization of infrastructure created for urban transport of commuters, is doubled because the Sky Bus technology allows cargo also to be handled, providing house keeping functions also to the city- which existing metro technologies cannot render.
- ◆ The perennial financial burden that the current urban transport solutions are, will now become history, with the advent of Sky Bus Metro technology. The public administrations will gain and the common citizen is benefited.
- ◆ Skycon will revolutionise the Port working all over the world and the Skyjet systems will redefine the working lifestyles of people and cargo delivery time cycles will be

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influenced not only for industry but also for agriculture.

- ◆ The automated systems progressively bring down the costs of transport in the goods and services availability.
- ◆ Extensive use of knowledge embedded systems are used in a network configuration in the technology proposed and lays the foundation for a future of falling costs, as is already happening in the tele-communication sector.

20. Intellect, Inspiration & Infrastructure: The driving engine for cost reductions in the various services can be provided by developing infrastructure as demonstrated above utilizing the technologies in an innovative manner. The intellect is the most precious asset given humans, to manage the cosmic resources in a sustained manner to create win-win strategy of application of knowledge to develop technologies to add value and not erode wealth with wrong technologies.

20.1 We should be inspired to liberate our mindsets to fully realize our potential to develop such technologies to create infrastructure which synergises with forces of nature for the benefit of entire human species by making transport, food and shelter virtually free.

20.2 This is incrementally visible to us when for improved quality of service, we are able to reduce the unit cost of service, while developing infrastructure. If we constantly strive to implement this principle, we shall move gradually to a world where

- ◆ Agricultural activities are managed by knowledge-embedded-devices (KED)
- ◆ Transported automatically by KED driving the process
- ◆ Shelters mass manufacture through KED controlled processes/ transported and mass erected through substantially KED enabled processes.

20.3 It is the responsibility of those upper one-third group of human society to ensure that through the application of their intellect and technology, ensure that the lower one-third group in the society shall have the access to the basic infrastructure at affordable prices, for gradually improving quality of life at progressively reducing costs, measured in terms of their earning capacity. Every human at the lowest step of the ladder shall also become a supervisor in role of a system driven by KEDs!

21. It is well within the realm of reality for the human society to build a knowledge based society, where the basic infrastructure facilities like fine quality food, shelter,

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travel and communications will cost very negligible portion of value of their contribution to the society. Then the society will move to the next level of knowledge enrichment, freed from currently manifest day to day struggle with natural resources for survival.

References:

List of Patent applications:

- 1.

List of Papers in International Rail Conferences:

- 2.