NEW TRANSPORT LINES

TECHNICAL OFFER

String Transport Line

"Washington-Baltimore-Philadelphia-New York"

Minsk 1996

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Circular String Transport Line "Washington-Baltimore-Philadelphia-New York”

1. String Transport System

1.1. Principal Route Diagram

The String Transport System (STS) is a string rail route to carry electrical wheel vehicles. A specific feature of the route are the strings within the rails stretched to the total force 250 tf per rail. The strings are rigidly secured to anchored supports spaced every 500...2000 m, the route structure being carried by intermediate supports spaced every 25...100 m. The strings within the rails deflection to about 5 cm, with the deflection increasing to the span center and reducing to zero over the supports. Hence, the rail head maintaining the vehicle wheel statically has no deflection or joints throughout its stretch. While remaining highly straight and rigid the STS rigid structure promises to allow speeds of 500 km/h and more. Appendix 1 demonstrates design, technological and other STS features in more detail.

1.2. Line Route Diagram

Fig.1 shows the route line diagram. The optimum spacing between intermediate supports is 50 m. This spacing can be reduced to 10...20 m along the stretches with more intricate profiles or increased to 100 m. When the spacing is larger (the modern materials allow to have the spacing 5,000 m and more) the route structure will be supported with ropes or cables (like suspended bridges).

Considering that the STS is easily adaptable to the terrain profile it can run along the shortest cuts or straight. When necessary, the route structure can be curved both vertical and horizontal planes. For comfort (so that passengers are not affected by overloading along curved stretches) the curvature radii should be at least 20...50 thous.m.

1.3. Route Structure

Depending upon the span the STS structure is divided into two typical types: I - common design (the span is up to 100 m); II- additional supporting cable structure (the span is over 100 m) with the cable arranged: (*a*) underneath; (*b*) above with parabolic deflection (*c*) above as guy ropes.

1.3.1. Rail-String

Fig. 2 shows the rail-string design. Each rail head is a current carrier electrically insulated from the carrying structure and other supports and rails. Each rail has three strings from wires 1...3 mm in diameter stretched with the total force 500 tf for the route structure and 1000 tf for the double-track route. The wires in a string are encapsulated in a protective shell between the supports, they are not linked together being arranged in a special corrosion resistant composition. The strings are rigidly secured in the anchored supports. Appendix 1 gives a more detail description of the design.

1.3.2. Carrying Cable

Like the strings in the rail, the carrying cable is made from heat resistant steel wires enclosed into a protective watertight shell. The free space in the cable is filled up with a corrosion resistant filler. The longer the span the greater is the cable diameter. For example, due to a low material consumption for the route structure and its light weight, the cable 100 mm in diameter carries the STS span 1000...1500 m long, i.e. it allows to cross wide rivers in a single span.

1.3.3. Route Structural Rigidity

The STS route structure requires little materials, about 100 kg/m, still allowing to achieve a highly strong tensioning of the strings. It has a typical small deflection of the structural elements both under its own weight and moving vehicles (see Table 1)

Table 1

Deflection of the STS Structure under its Own Weight

Span, m	Static (erection) deflection of structural elements			
	string in rail		guy cable	
	Absolute deflection, cm	Relative deflection	Absolute deflection, m	Relative deflection
25	1,6	1/1600	-	-
50	6,3	1/800	-	-
75	14,1	1/530	-	-
100	25	1/400	0,25	1/400
250	-	-	1,56	1/160
500	-	-	6,25	1/80
750	-	-	14,1	1/53
1000	-	-	25	1/40

The deflection figures in Table 1 determine the height of the STS spans, their sliminess and aesthetic appearance. In any case, the STS structure is much slimmer than bridges, road arteries, viaducts and other similar structures of highways and railways as well as girders of monorails.

The strings will have a deflection after erection concealed within the rail. When the span is 25...50 m the string will have the relative deflection 1/1600...1/800 and the absolute deflection 1.6...6.3 cm in respect to the span. This deflection is easily accommodated within a specially designed rail 20...25 cm high.

In any case, the above deflections appear after erection without affecting the smoothness of rail heads which are very rectilinear when unloaded. The route curvilinearity in the vertical plane appears under a moving load, it is induced by winds and moving vehicles in the vertical plane. The maximum static deflection produced by a vehicle (2,500 kgf) braked in the span center is will be within 1/800 for the rail and 1/2400 for the span supported by the cable. Dynamic deflection at speeds over 200 km/h will be significantly less than those indicated above (within 1/10,000...1/2,000, or within 5...15 mm in absolute figures). These figures prove that the STS is more rigid (in respect to the rolling stock) than railways, bridges and highway loops which have a greater estimated deflection under nominal loads.

The structural features of the route structure and the modes of movement of the vehicles have been investigated and defined in order to eliminate resonance phenomena in the rail-string. Moreover, oscillations will appear and remain behind a moving vehicle, they will attenuate within 0.1...0.5 s, next vehicles will run along undeflected, perfectly smooth rails.

Variations of temperature-induced deformations of rail-strings are compensated by temperature strains, hence, variations of the span relative deflection will insignificantly affect the rail-string smoothness when the span between supports remains unchanged. The string will not have any deformation seams along its stretch, in response to temperature variations it will behave like a telephone wire or power transmission lines which are also suspended with deflection between supports without joints for several kilometres, like the strings in the rail. Temperature variations from -50^{o}C (winter) to +50^{o}C (summer) will cause relative deflection variations within 1/10,000 basically without any effect upon the route smoothness.

Elongation strains in the string will add approximately 500 kgf/cm^2 in the summer and deduct the same 500 kgf/cm^2 in the winter. A smaller temperature difference will produce a milder strain deformation of the rail-string.

Taking into account a highly streamlined design of the STS and the vehicles, the relative deflection of the STS route structure under the influence of lateral winds blowing with the speed 100 km/h will amount to 1/10,000...1/5,000 without affecting the transport line's performance.

The route's smoothness will not be affected by the ice appearing on the STS structural elements in mountains. Yet, considering its small cross section, stream lining, high- and low-amplitude oscillations and other factors inhibiting icing, the latter can be fully eliminated. For example, special modules equipped with gas turbine engines to melt ice film with a hot air stream can be sent regularly along the route during the most risky winter periods.

1.4. Supports

The carrying structure of the supports comprises two basic types: (a) the anchored supports to undertake horizontal forces produced by string and cable elements; (b) carrying supports to undertake just the vertical load of the STS route structure.

The anchored supports can be spaced at 0.5...2 km (the optimum span is 1 km) depending upon the terrain relief. The maximum horizontal loads experienced just by the terminal anchored supports (they are affected by one-way loading): 1,000 tf for the double-track and 500 tf for the single-track routes.

The intermediate anchored supports (they comprise over 90% of the total number) will not experience any significant horizontal load in operation, because the forces acting upon the support from each side will become mutually balanced. In accordance with the terrain relief the carrying supports will be spaced at 25...100 m (the optimum span is 50 m). The minimum vertical load upon the support (together with the moving weight) is 10 tf (the span is 20 m), the maximum load is 25 tf (the span is 100 m).

The terrain relief and the longitudinal route profile and the layout will determine how tall the supports should be. Table 2 is a guide for practically any terrain relief showing that they should be 25 m tall on the average.

The supports are described in Appendix 1 in more detail.

Fig. 4-11 demonstrates the versions of single-track STS routes and their supports for various geographic conditions.

Table 2

Determination of Average Tallness of Supports

Tallness of supports, m	Proportion of the supports in their total number, %
5	5
10	8
20	55
30	15
40	10
50	5
100	2
Total: average tallness of supports -25 m	100

The carrying supports experience slight vertical, transverse and longitudinal loads (for example, the transverse loads appear during braking, they are transmitted by the rail-strings to the anchored supports. Therefore, the supports have typical small cross-sections, light foundations occupying little area and requiring little earthwork. It is specifically significant not to encroach upon the proprietary rights of land owners which may create serious problems. The STS can be run in a single span (5,000 m long) 50...100 m high over expensive land plots with economical land use. Since the STS is a "transparent" structure (almost without shadow) it will be ecologically clean, with a low noise level, it can run over residential areas, game preservations, parks, etc.

1.5. Vehicle

The vehicle accommodates 10 persons (during peak hours) or 2,000 kg cargo, the engine is 200 kW with energy delivered through wheel which contact the current conducting rail heads (the right and the left). The drive can be designed as two motor wheels 100 kW each. A perfect shape of the vehicle body has been selected with the aerodynamic resistance factor Cx=0.075 (the model was tested in the aerodynamic tube) allowing to minimize the aerodynamic losses and noise at high speeds.

The vehicle can operate as a routed taxi from the boarding station to the destination without any driver steered by the on-board computer. The latter is controlled and guided by line and central computers. The vehicle is described in Appendix 1 in detail.

1.6. Terminals and Stations

Terminals will be circular with moving (rotating) platforms (Fig. 3) or floors. The terminal diameter is about 60 m which can be increased up to 100 m or more where passenger traffic is greater (over 100 thous. passengers during 24 h).

Intermediate stations with significant passenger traffic will have switches and sheds to pass the vehicles irrespective of the main schedule (Fig. 1). The stations with smaller passenger traffic are made as open platforms along the route.

The boarding (landing) of passengers is effected after braking individual vehicles with vacant seats. The route is designed to have 4 terminals and 5 stations.

1.7. Management of Passenger Traffic

1.7.1. Boarding and Landing

Upon entering into the terminal the passenger sees a lighted sign on each vehicle (the sign can either be on the vehicle wall or on the terminal wall as a moving line of information) indicating the destination name, for example, "the terminus". If the required destination is not indicated the passenger can board a vacant vehicle and press the "terminus" button (inside the vehicle). Passengers will have 0.5...2.5 min to board if the moving platform with the vehicle on it has the speed 0.5 m/s and the circular route is 50 m in diameter. After the door is shut (automatically or manually) the vehicle is released from the moving platform, the switch transfers it to the track line. In case the door has not been shut or the boarding has not been completed or there no passengers the vehicle is returned to the second round on the platform. Similarly the passengers land at their destination in reverse order. In its general implementation it resembles the handling of baggage along circular conveyers at modern airports. If necessary, some vehicles may be directed to workshops in a separate building or at another floor of the terminal.

1.7.2. Traffic

Vehicles are grouped together electronically into trains of five vehicles with the space between them 100 m. The control system along the entire route maintains the same speed of the vehicles in the train and the spacing between them. To maintain the traffic 1,000 passengers per hour one train of five vehicles should leave the terminal every three minutes. The average spacing between the trains will be 20 km at a speed of 400 km/h.

This spacing is sufficient for manoeuvring when passengers board or land at intermediate stations. The running trains will be grouped at boarding stations and by adding vehicles at intermediate stations (at the head or at the tail). Therefore, the control system will both send vehicles and control their location co-ordinating their "synchronisation" in time. Some stations may have special marshalling facilities to accumulate vehicles. The speed will be set from 200 km/h (steep ascents) to 400...450 km/h along horizontal stretches and descents. Line and central computers will control traffic by accumulating information about the location, speed, destination and condition of all major units (the running gear and the drive, in the first place) of each vehicle. Modern control software allows to arrange the transport traffic of STS vehicles with 100-percent safety without man's involvement.

A system similar to the one developed in Japan for the self-controlled Mitsubishi car can be employed to control the STS vehicles. Each vehicle will have three on-board TV, infrared and ultrasound systems running simultaneously. The on-board computer will receive signals from the vehicles ahead to analyze and adjust the proper speed and the spacing. Also, there will be mutual information exchanges and with the line and central computer systems to check the location, speed, condition of the route structure, supports, switches, irregularities, track defects, etc. The on-board computer system will employ microprocessors to process the data from built-in sensors, TV and IR cameras, mechanical means. Relevant commands will be issued for various executive mechanisms. The operations of manoeuvring are automatically co-ordinated with the route line computer system in order not to affect the transport traffic.

1.7.3 Travelling Time

Table 3

Time spent by a passenger to travel from Washington to New York

Ser.Nos	Transportation process	Time,min
1	Waiting for a vehicle to arrive	1
2	Boarding	2
3	Waiting until start	1
4	Joining the main traffic	1
5	Acceleration to 400 km/hour	3
6	Traffic along the route	42
7	Decelration	2
8	Driving into the terminal	1
9	Landing	1
10	Unforeseen time losses	1
	Total:	55

1.7.4 .Route Traffic Capabilities

When trains comprise 10 ten-seat vehicles moving with the speed 400 km/h with the interval 30 seconds, the traffic of a single line during peak hours will amount to 12,000 passengers/h and 24,000 passengers along the route (with two oppositely directed lines (or 576,000 passengers every 24 hours). There is a margin to increase the traffic without adding more lines.

1.8. Safety and Reliability

1.8.1. Safety at Terminals

The safety of passengers is achieved by the synchronisation of speeds and the circular terminal platform, for example, by joining them with mechanical means. The platform should move with the speed 0.3 m/s for the passenger traffic 2,000 passengers per hour with a full rotation during 8.7 min (when the outer diameter is 50 m).

Safe electrical voltage (12 or 24 Volts) or batteries in vehicles, or electrical current of the same voltage supplied through the rail track will exclude shock hazards.

1.8.2. Transport Line Electrical Safety and Reliability

Safety is ensured by a relatively small voltage in the line (within 1,000 v), insulation of current carrying rail heads and supports and by non-conductive vehicle bodies made from composite materials. Hence, in case a vehicle misses the rail track it will not produce any short-circuiting between rail heads.

When the traffic reaches 1,000 passengers per hour along a leg 100 km long, 25 vehicles will run simultaneously with the total power of motors 5,000 kW. No additional transmission lines to supply the STS and its infrastructure, because the rail-string will allow to transmit the electrical power over 10,000 kW (up to 100,000 kW if it has a special design). Therefore, the STS should be connected to the existing grid every 100...200 km.

1.8.3. Traffic Safety

Traffic safety is achieved by failure-free operation of all the systems effective to maintain the routine mode of traffic: the computerized control means, reliable electronic systems, communication lines and measuring instruments, executive mechanisms of switches and drive controls and the braking system, reliable mechanical members of the route structure, STS supports, etc. A hundred-percent safety of the traffic processes is evidenced by the experience of operation of high-speed railways in the world. For example, high-speed railways in Japan have transported over 5 billion passengers during 20 years of operation without any accidents or casualties. In case of power failure each vehicle is equipped with a battery and an emergency starting motor which will deliver the vehicle at a slower speed to one of the stations or emergency stop platforms on each anchored support, i.e. after every 1,000 m.

1.8.4. STS Structural Reliability and Functioning

STS cable and string elements of rails and carrying structures are exposed to the utmost strain. Since they are in a corrosion resistant medium in a special shell and in a mechanically strong body protecting them against external effects, their service life can amount to hundreds of years. Also, the travelling load alters the stress-strain state of these elements only by one per cent (see Appendix 1, p. 8) this state remains basically unchanged during the entire period of operation extending the service life and saving operation costs.

Since the string elements are located in different remote places (mutually isolated wires in the strings of the left and right rails, the one-way and back lines, the upper and lower strings, etc.), the probability that they snap simultaneously is close to zero, even in case of disasters, such as earthquakes, floods, hostilities, etc.). Even when 90% of carrying wires snap, the structure will not collapse, unlike other structures, such as bridges, highway loops, viaducts, modern skeleton buildings, etc.

The STS route structure remains highly durable even when destroyed by terrorists. A support is secured to the route structure with a special unfastening mechanism which releases it making just the rail-string span longer and increasing its corresponding deflection. It will not destroy the integrity of the route even in the case when all the intermediate supports between adjacent anchored supports (twenty one supports one after another) are destroyed.

The results of the STS vehicle tests in the aerodynamic tube at a speed 250 km/h have manifested that lateral winds blowing with the speed within 100 km/h produce lateral capsizing forces within 100 kgf. They will not affect the functioning of the transport system, the more so they will not force the vehicle off the rails.

1.9. Attractive Appearance and Comfort

The majority of the people spend their active time in a closed, limited space. Due to the ergonomics the common transport means allow to see some land surface, a portion of the road, etc.

The STS both solves the problems of comfort and its functional objective to fast deliveries of passengers to their destinations. Large windows, comfortable seats, soft silky tracks transform a common trip into the delight of enjoying the sights of nature from the birds' flight.

The appearance of slim route structures, support and stations will fit into the natural landscape without impairing the ecology or destroying even fine natural components and the historical architectural styles along the route adding islands of modern architectural shapes.

Each vehicle will be air conditioned, passengers will enjoy a broad variety of other services, multichannel music and TV, world telephone communications, special services for businessmen, passengers with children, disabled people. The STS vehicles are airtight equipped with a system of pressurized or chemical water closets to accumulate waste.

Passengers can command vehicles to stop at any intermediate station, i.e. after every 5...7 minutes.

1.10. Feasibility Indicators

Table 4 introduces the feasibility indicators of a double-track route 1 km long and Table 5 shows the transport system costs.

The following aggregate prices were used to evaluate the cost of structures: metallic structures depending upon their complexity and steel grade - 2,000...5,000 US $/t; aluminium structures - 5,000 US $/t; reinforced concrete structures - 500 US $/m3; cast concrete structures - 250 US $/m3. Five intermediate stations have been projected each US$ 5 million. The cost of terminals (four) and service buildings was estimated 3,000 US $ per m^2 of the area (general construction works plus engineering and technological equipment) and 1,500 US $/m2 of the area of garages (workshops).

The cot of a double-route track will be US$ 1.1 and that of the complete 300 km route together with its infrastructure US$ 600 millions.

Table 6 lists the major feasibility indicators, Table 7 lists the costs of transportation (the cost of transportation of one passenger and a ton of cargo). The following parameters unlisted in the Tables were used for the estimates: cost of electrical energy - 0.03 US $/kW x h; returns yielded by the transport system: 80% from the passenger traffic and 20% from the cargo traffic.

The cost of transportation of a passenger over a distance of 300 km from Washington to New York at the passenger traffic 50,000 passengers during 24 hours will amount to 3.99 US$, one ton of cargo (at 100,000 tons during 24 hours) will cost 1.87 US$. The transport system will yield a profit of 36 mln US$ a year.

The profit can be increased significantly by raising the price of tickets to 10 US$ (the price of railway tickets). It will yield an additional profit of 110 mln US$ (at 50,000 passengers during 24 hours). The transport system will pay back its cost during 2.4 years. The line will yield US$ 36 million a year.

The STS route can support high passenger and cargo traffic. The short travelling time (55 minutes) and low cost will make possible to make round business travels within a single day, tourist, business, shopping trips, etc.; it will broaden employment opportunities in various communities.

Table 4

Consumption of materials and cost of one km of a double-track route

Structural element	Material	Consumption of materials per km		Tentative cost, Thous.. US$ per km
		mass, tons	volume, m^3	
1. Rail-strings. total				380
Including:				
1.1 Heads	Steel	60	-	120
1.2. Body	Al sheet	5	-	25
1.3. String	Steel wire	80	-	160
1.4. Filler	Composite	-	40	20
1.5. Gluing wax	Composite	1	-	10
1.6. String protective sheath	Polymer	4	-	20
1.7. String water insulation	Polymer	1	-	5
1.8. Others		-	-	20
2. Cross plates		-	-	40
3. Intermediate supports, total		-	-	170
Including:				
3.1. Posts	Reinforced Concrete	-	160	80
3.2. Cross pieces, stay guys	Steel	15	-	30
3.3. Support upper structures	Steel	10	-	30
3.4. Foundation	Cast concrete	-	80	20
3.5. Others		-	-	10
4. Anchored supports, total		-	-	70
Including				
4.1. Support bodies	Reinforced concrete	-	80	40
4.2. Foundation	Cast Concrete	-	40	10
4.3. Metallic structures	Steel	3	-	6
4.4. Anchor fixtures	Steel	1	-	5
4.5 Others		-	-	9
5. Earthwork		-	-	20
6. Rail power supply system		-	-	30
7. System to monitor the conditions of supports and route structure		-	-	20
8. System to monitor transport traffic		-	-	20
9. Emergency power supply system		-	-	20
10. Transport traffic control system		-	-	50
11. Emergency stop points		-	-	50
12. Surveying and mapping		-	-	50
13. Cost of land and its preparation for construction		-	-	50
14. Other tasks		-	-	50
15. Unforeseen expenses		-	-	80
TOTAL:				1100

Table 5

Cost of a double-track STS transport line

'Washington-Baltimore-Philadelphia-New York'

Ser. Nos	Description of route elements	Q-ty, volume	Item cost, thous. US$	Total cost, mln US$
1	Way structure	300 km	420	126
2	Supports	300 km	240	72
3	Terminals	4 pc.	30000	120
4	Garages-workshops	4 pc.	15000	60
5	Earthwork	300 km	20	6
6	Rail power supply system	300 km	40	12
7	System monitoring the condition of the way structure	300 km	20	6
8	Control system of transport traffic	300 km	20	6
9	Emergency power supply system	300 km	20	6
10	Transport traffic control system	300 km	50	15
11	Intermediate stations	5 pc.	5000	25
12	Surveying	300 km	50	15
13	Cost of land and its preparation for construction	300 km	50	15
14	Research and development	-	-	25
15	Pilot single-track STS leg	20 km	1000	20
16	Other elements of the route transport infrastructure	-	-	10
17	Others	-	-	20
18	Unforeseen expenses	-	-	41
	TOTAL:			600

Table 6

Engineering and Economic Indicators of the STS
Washington-Baltimore-Philadelphia-New York Line

Indicator	Magnitude
1. Transport line characteristics	
1.1. Total cost, million US$	600
1.2. Depreciation deductions, , %	5
1.3. Annual operation cost and cost of maintenance and routine repairs, thous.US$	50
1.4. Term until fully repaid, years	20
1.5. Route stretch, km	300
2. Vehicle characteristics	
2.1 Cost, thous. US$:	
- passenger	30
- cargo	10
2.2. Number of seats:	
- business class	10
- first class	5
- deluxe	1
2.3. Carrying capacity, kg:	
- passenger	1000
- cargo	2000
2.4. Transport module weight (net), kg	1500
2.5. On-line utilisation factor	0,5
2.6. Reserve park of vehicles, %	20
2.7. Average annual speed, km/hour	400
2.8. Engine power. kW:	
- passenger	200
- cargo	100
2.9. Vehicle annual run, thousand km:	
- passenger	1190
- cargo	1190
2.10. Annual transportation volume by one transport module(along a 300 km leg):	
- passengers	39500
- cargo, tons	7910
2.11. Specific power losses for traction:	
- passenger, kW x h/ passenger x km	0,05
- cargo, kW x hour/ton x km	0,12
2.12. Depreciation deductions, %	10
2.13. Annual operation cost, %, versus vehicle cost	10
2.14. Term until repaid, years	10

Table 7

Cost of Transportation along 'New York-Washington Line' (300 km)

Indicator	Scope of transportation (both ways)					
	passengers, thousands/day			cargo, thous.tons/day		
	20	50	100	50	100	200
1. Reduced costs:						
- US$/pass.	8.91	3.99	2.34	-	-	-
- US$/ton of cargo	-	-	-	2.29	1.87	1.67
Including:						
1.1. Costs along the transport line, total	8.22	3.30	1.65	0.82	0.40	0.20
Including:						
- depreciation deductions	3,29	1,32	0,66	0,33	0,16	0,08
- operation cost	1.64	0,66	0,33	0,16	0,08	0.04
- deductions for profit	3,29	1,32	0,66	0,33	0,16	0,08
1.2. Cost of vehicles, total	0.69	0.69	0.69	1.47	1,47	1,47
Including:						
- depreciation deductions	0,08	0,08	0,08	0,13	0,13	0,13
- operation cost	0,08	0,08	0,08	0,13	0,13	0,13
- deductions for profit	0,08	0,08	0,08	0,13	0,13	0,13
- energy cost	0.45	0.45	0.45	1.08	1,08	1,08
2. Number of vehicles for the entire route, pcs	180	450	900	2300	4600	9200
3. Cost of vehicles, million, US$	5.4	13.5	27	23	46	92
4. Average traffic interval between vehicles (single vehicles along one line)						
- seconds	86,4	34,6	17,3	6,9	3,5	1,7
- spacing, km	9,60	3,80	1,90	0,77	0,38	0,19

2. Comparison of the STS Performance and Economics with other High-Speed Route alternatives

2.1. High-Speed Railways

High-speed railways (HSRW) designed for speeds 250...300 km/h are becoming more and more popular in the world. Their extension has gained priority in the transport, for example, the Council of Ministers of the European Community projects to invest about 200 billion ECU (until the year 2010) into their construction.

The common railway transport is not suitable for high speeds. Moreover, the earth bed subsidence should not exceed 1 mm, hence loose soil should be removed to a depth of several meters to erect such railways.. As a rule, loose soils occupy lowlands, flooded lands, marshy land, which are a natural water system accumulating and distributing moisture among rivers. Back-filling (and compacting) in great volumes will impair the natural water flow with serious risk of dehydration of some territories, swamping of others, losses of forested lands, arable fields, etc. In fact, the high-speed route embankments will become a dike (a dam) for soil and surface water. Also, such lines will require a special enclosure (from both sides) and noise screens to fence off wild and home animals, agricultural activities, etc. In general, a high speed line will require 3.2 hectares (the data for Germany), the entire route will require 960 hectares to be vacated.

The STS route creates no ecological problems, it does not need embankments, tunnels, bridges or conduits. Its carrying support occupies just about 1 m^2 of land, the anchored support occupies 10 m2. One STS km will thus require less than 100 m^2 of land or 0.01 hectare, the conventional width of the vacated land will be within 10 centimetres. It is much less than occupied by a walking path or a trail.

The span is not a critical parameter for the STS. hence forests or separate trees in the spots where supports are to be erected may remain, since each support can be shifted any way in process of construction.

The STS route will not inhibit migration of soil and surface water, reptiles, agricultural or any other land use. The STS will be a low-voltage route without any electromagnetic noise, it can pass quite high (up to 100 m) over houses, fields and pastures, over wild life preservations. Absence of sliding contacts between the vehicle and the contact grid and a modest electric power of vehicles (compared with railways) will not create radio interference in the environment.

The STS will specifically require much less materials for its erection, hence it will be the most ecologically clean. For example, a one-track STS route as long as a railway can be erected from the material needed for a single rail and one sleeper out of three (letting alone the second rail and two more sleepers, the copper contact wire grid and carrying supports, a thick ballast bed, earthen embankments, bridges, conduits, viaducts, etc.). Hence, the STS erection will not require so many blast furnaces, iron ore or mines (to produce steel and copper), cement factories and plants to produce reinforced cement blocks, sand and broken stone quarries, so much haulage of construction materials by trucks and railway cars, etc., all which would impose an extra, sometimes irreversible burden upon the nature.

A high-speed train is a rather strong source of noise and soil vibrations, which is not surprising with its weight of hundreds of tons, its length of hundreds of meters and locomotion consuming thousands of kilowatts. The train has a great variety of projecting pieces, connectors, joints each acting as a noise source. One wheel pair weighs about a ton, it would sure hit against microroughnesses, letting alone macroroughnesses of rail joints, for example.

The STS vehicle has no projections, excepting narrow wheel protruding for 10 centimetres. It does not even need any windshield wipers or projectors (since there is no pilot) which would also produce noise at high speeds. The wheels can be fabricated from light alloys (the load per wheel is 500...750 kgf), hence they would weigh between 10...20 kg. Hence, the STS vehicle will be hundreds of times less that the railway train, it will be dozens of times shorter, the weight of the spring-suspended portion will be hundreds of times less, the route will be much smoother (what can be more straight than a tensioned string?). Therefore, the STS vehicle will produce hundreds of times less noise or soil vibration.

The STS major advantage is its small cost. For example, experts of the European Bank of Reconstruction and Development have evaluated that a high-speed route between Saint-Petersburg and Moscow (660 km) will cost 6...8 billion US $, the cost of transportation of a single passenger will cost 123 US$ (approximately as much as along European high-speed routes). The same route between Washington and New York may be estimated to cost 3...3.5 billion US$, the cost of transportation over 300 km will be US$. 56. These figures exceed 5...10 times those for the STS.

2.2. Analysis of Motor Transport Capabilities

The automobile transport is known to be unable to compete with railways and air transport at distances above 200...400 km and more serving as a complement of the integral transport system.

Lack of competitiveness of the automobile transport as a major means of the future passenger and cargo traffic along the Washington-York route is apparent due to the following reasons:

- even erection of a new multilane motorway will not truly increase the speed and the comfort of the automobile transport which will be much less than that of the STS with an average speed of a passenger car being below 100...110 km/h, the buses will be still slower. It means that the time needed to reach from the downtown Washington to the downtown New York will be at least 3...4 hours, while an STS vehicle covers the distance within 55 minutes;
- erection of such motorway (with the account of dividing strips, multiple loops at various elevations of the "clover leaf" types, acceleration and deceleration strips, parking lots for rest, etc.) will require a strip 2.5...3 times wider than a high-speed railway for the same passenger traffic or 750...900 (!) than for a STS;
- exhaust into the atmosphere by the STS will be less than the HSRW with its 0.6 gramms per passenger-kilometer, or automobiles with their more than 10 gramms per passenger kilometer;
- the STS vehicles will be airtight with all the waste collected and dumped at depots. Experience manifests that the strip along motorways is most exposed to waste disposed by car passengers.

2.3. STS versus Aviation

The STS is advantageous when compared with the air transport due to the following considerations.

Research of transport means has allowed to discriminate clearly between the competitiveness of the air and railway transport. The so-called "transport niches" are implied defining the range of distances and speeds at which a transport means provides passengers with the utmost comfort and speed all with the least energy losses.

The analysis includes whether the absolute speed of transport means is essential for passengers or the time to reach an airport or a railway station, waiting until departure, baggage handling or the actual time of travelling. The distance is estimated between destinations as the so-called "zones of equal accessibility" located downtown. Hence, an air passenger needs 3...4 hours to travel from the downtown Washington to the downtown New York will require 3...4 times longer than the STS.

However, the ecological safety is the governing factor in all these comparisons. Modern aeroplanes release totally 300...400 g/passenger-kilometre or 500...600 times more harmful substances into the atmosphere than the high-speed railways or the STS, respectively. Actually, this parameter is expected to reduce 3...5 times when aviation switches over to the double-contour turbojet engines.

The major share of the exhaust accumulates exactly in the vicinity of airports, i.e. around large cities when planes fly low and the engines are boosted.

At low and medium altitudes (up to 5,000...6,000 m) the atmospheric pollution with nitrogen and carbon oxides persists for several days, after that they are trapped by moisture and produce acidic precipitation.

Aviation is the sole pollutant at higher altitudes with the harmful substances persisting in the atmosphere much longer, about one year. Even conversion to hydrogen engines fails to solve the problem. Harmless releases of the engines as water vapours close to the land surface convert into ice crystals shielding land.

Moreover, the noise effect is specifically strong around airports and electromagnetic noise around radar stations.

It is an important factor to consider that airports require land areas comparable with those for high-speed railways, yet these areas are located straight near cities implying that they are more valuable.

The major factor is the travel cost which will exceed several times that of the STS when the cost of travelling to the airport and back is added.

Thus, the Washington-New York passenger future traffic lines manifest obvious advantages of the string transport routes.

2.4. Applicability of Transport Means with Magnetic Suspension

Magnetic suspension transport (MST) requires solution of sizeable scientific and engineering problems. Actually, the MST is still being experimented upon, though a number of countries have erected separate short stretches. Alternatives of implementation of the “Transrapid” System (FRG) and electrodynamic suspension and linear synchronous motors have been evaluated, they require to employ the effect of superconductivity. The USA has little experience in this domain and basically none with the electrodynamic suspension and linear synchronous motors. The MST requires 4...5 times more investment than high-speed railways and 30...50 times more than the STS. For example, the projected Transrapid route Berlin-Hamburg (Germany) 300 km long is estimated to cost 19 billion DM. Hence, a MST route may be estimated to cost 12 billion US$.

This amount is enough to extend the STS to the West (New York-Los Angeles - 4,000 km; 7 billion US$), to the South (Washington-Houston, 1,800 km; 3 billion US$) and to the North (New York-Montreal, 600 km; one billion US$).

3. Stages of Implementation of the STS Project

The primary objective is to complete research and development (25 million US$) to select, optimise and adapt to the terrain relief and operation conditions of design, technological, engineering and other solutions, the know-how accumulated by the author during 15 preceding years and the specialists which he attracted to cooperate and then at the “NTL Transportlinien GmbH (Germany) and the NTL Company, Ltd. (Belarus). A program had been developed to develop the design of the transport line and the vehicle (with all their components) with the account of wages of designers and other staff, the cost of materials and standard pieces, equipment, expenses to attract contractors, etc. The program has been developed for the conditions in the Republic of Belarus, it can be easily adapted to the conditions of any other country with the help of correction factors.

A special designing bureau should be created together with several laboratories (to investigate motion dynamics; control, communications and safety systems; electric motors and power supply and reliability of structures) and major services (the general designer, the chief economist, the chief process engineer, the chief engineer, the chief construction engineer, the chief power engineer, the chief communications expert). This stage can be accomplished within 2...3 years providing the corresponding finances become available and 40...60 designers are recruited. Research and development can be combined with the erection of a pilot STS leg 10...20 km long.

Then the pilot route leg (20 million US$) should be erected and pilot vehicles should be fabricated (2 million US$). With sufficient finances it can be accomplished within 1...2 years. The pilot leg can be erected in any country where investors believe their investments can enjoy protection and the designer can be sure of the proper protection of the intellectual property and the copyright. The special designing bureau should also be established in this country.

The route survey can be started parallel to the erection of the pilot leg as well as the survey of other transport lines if there are clients for such projects. It will allow to become leaders of the world super high speed transport market in the 21-st century.

The STS, due to its strong competitiveness, will be able to conquer the markets of high-speed communications. It will create a new economic niche by forcing out high-speed railways, trains with magnetic suspension and aviation. Because the route between Washington and New York will lay foundation to the creation of an international net of high-speed string routes.

Appendices:

1. Chapters 1-2 of the Manuscript "*String Transport Systems on Earth and in the Space*" / A.E. Younitsky, 337 pp., ill., Gomel, 1995.
2. Information Materials on____ pages.

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NTL Stock Company (Belarus)