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STRING TRANSPORTATION SYSTEM (STS) IN QUESTIONS, ANSWERS AND PROJECTS

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String transportation system (STS) in questions, answers and projects

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Given is the general data on STS and answers to 100 questions asked in the course of the Habitat project (FS-RUS-98-S01) performance to the author by opponents, sceptics and advocates of a STS as well as testing results of various scale models with relevant proposals for a testing ground construction and practical application of a STS.

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Part 1. Background information about transportation and STS

Since January 1999 the UN Centre for Human Settlements (Habitat) Project FS-RUS-98-SO1 "Sustainable Development of Human Settlements and Improvement of their Communication Infrastructure through the Use of a String Transportation System (STS)" has been underway in Russia [1].

The key goals and objectives of the Project are as follows:

- to create an alternative to the mass-scale automobilisation of human settlements as a major factor contributing to their sustainable development and to specify the basic conditions providing for a STS realisation;
- to identify the ways for a STS testing in terms of its economic, environmental and technical components as well as in terms of its comfort and travel safety;
- to generalise the available national and international experience, to identify investment attractiveness of a STS, to formulate a strategy, priorities and mechanisms facilitating practical implementation of the Project both in Russia and in other countries.

Taking into account the fact that the Project proposes a principally new transportation system its major focus is on the interpretation of the role and place of transportation in the life of man, country, society and civilisation.

Development of communications always was of a fundamental importance for the social progress contributing to the development of links between different nations, and strengthening their trading and business relations.

Communications or transportation as exchange (circulation) of material and human resources is an indispensable condition for the well-being of individual persons and society as a whole, means of human communication in physical and intellectual space; the way of life and one of the basic cultural values and indicator of civilisation level.

Unsatisfactory condition of a transportation network leads to the disturbances in the normal economic performance, drop in the production rates in the related national economic sectors, unjustified losses in agricultural yield, limited access to the raw resources, reduced job opportunities, higher cost of goods and services, decline in the living standard of population and reduced educational and cultural opportunities, deterioration of environmental quality, difficulties in the elimination of consequences under emergency situations, decline in the national defence preparedness, restricting of foreign trade and tourism, higher death rate of population.

The Project made a comparative analysis of the main existing and future transportation modes and a STS and investigated a possibility to use a STS under conditions of the city of Sochi, Russia.

Which mode of transportation will be chosen by the mankind to enter the new millennium?

1. Railway transportation. In its modern meaning it takes the origin at the beginning of the 19th century though the first track roads already existed in the Ancient Rome. The total length of railways built all over the world is more than 1,000,000 km.

Under the present conditions the cost of 1 km of a two-way road including infrastructure is USD3…5 million, the cost of one passenger coach - USD 1 million, electric locomotive – about USD10 million. Road construction is very cost-intensive including: resource consumption such as metal (steel, copper), reinforced concrete, gravel; large-scale excavation works amounting on the average to 50,000 cub.m/km; and high land requirements - more than 5 ha/km or 10 ha/km including infrastructure.

Difficult geographic conditions necessitate construction of unique structures such as bridges, viaducts, elevated roads, tunnels which results in the increased total cost of the whole system and growing negative environmental impact. The average weighted travel speed is 100…120 km/h.

Wildlife habitat and living environment of the human settlements adjacent to the railway roads is exposed to noise impact, vibration, heat and electromagnetic radiation generated by the moving trains. The total amount of wastes generated by passenger trains during one year amounts to 12 tonnes including 250 kg of feces which is scattered along the road and its right of way over 1 km distance.

Railway transportation is characterised by very high water consumption and heavy water pollution. For example, the total water consumption by railway transportation facilities of Russia alone amounts to about 1 billion cub. m per year whereas wastewater of transportation enterprises contains petroleum products, phenol, creosol, resin, salts of heavy metals. Effluents discharged to water reservoirs give rise to the deterioration of water quality and living conditions of organisms inhabiting water bodies with 1 g of petroleum products contained in the water capable to make 2 tonnes of water unsuitable for drinking purposes.

Every year about 1,000 people and millions of animals are killed in Russia under the wheels of trains.

2. Automobile transportation. It emerged at the end of the last century. Over the past period more than 10 million km of roads were built and about 1 billion of cars were produced.

The cost of a modern highway is USD 5…10 million and its land requirements are estimated at more than 5 ha/km or 10 ha/km including infrastructure. The volume of excavation works exceeds 50,000 cub.m/km. The cost of an average statistics car is about USD 15,000, the average weighted travel speed is 60…80 km/h.

Automobile became one of the main sources of noise and air pollution in the cities. Automobile emissions contain about 20 cancer-generating substances and more than 120 toxic compounds. The source of environmental pollution and deterioration is associated with motor transportation itself and its relevant road infrastructure and engineering and service facilities, especially storage tanks for petroleum products, as well as filling, technical service and car washing stations, etc. which is the cause of natural environment transformation within the adjacent areas.

Noxious components contained in motor transportation exhausts and petroleum evaporation products is a source of air pollution and soil and surface water contamination. Contaminating substances are carried by rain and melted waters to the ground water and more deep-seated water-bearing tables. As a consequence, air, soil and water pollution gives rise to the degradation of vegetation cover. The major pollutants generated in the course of road construction and operation include dust, exhausts, petroleum products, wear products of tires, brake shoes and gears, asphalt and concrete pavements, de-icing salts and sand. Areas immediately adjacent to the highways are exposed to the heaviest pollution which is spread over a stripe of 300 m width and more.

It is also necessary to add the negative impact of various accompanying systems which serve motor transportation such as oil wells and pipelines, oil refinery and asphalt concrete plants, etc.

Embankments and depressions entailed in the highway construction give rise to the degradation of forests as a result of swamping or dehydration of the adjacent areas.

Highways and their infrastructure deprived the mankind of more than 50 million hectares of lands (which is the total area of highways in FRG and Great Britain) and, what is more important, these lands are not of the worst quality.

During the last decade automobile became the main man-made instrument of killing. According to the data of the World Health Organisation more than 900,000 people all over the world are killed annually in the road accidents (including those died as a result of after-accident injuries), millions of them become invalids, and more than 10 million are injured. For comparison: the average number of people killed on the planet every year in military conflicts is about 500,000.

Negative impact of motor transportation on the living environment and human health caused by the high concentration of cars in the cities and super-motorisation of urbanised zones made it necessary to start a search for the new alternatives [2]. As a result of the negative environmental impact of motor transportation and other sources of pollution a number of cities and their agglomerations were put under extreme environmental conditions which hinder their sustainable development and require cardinal measures to improve their communication infrastructure.

3. Aviation has a 100-year history.

It is the most environmentally hazardous and energy-consuming mode of transportation. The summary amount of noxious atmospheric emissions from modern aircraft reaches 30…40 kg/100 passenger/km. The bulk of emissions is concentrated within the area of airports, i.e. in the vicinity of large cities, in the course of flight at small heights and engine reheating. At low and medium heights (up to 5,000…6,000 m) nitrogen and carbon oxides remain in the atmosphere for several days after which they are washed away as acid rains. At upper heights aviation constitutes the only source of pollution. Noxious substances remain in the stratosphere much longer for about one year.

A modern jet liner in terms of its toxicity is equal to 5,000…8,000 cars and the amount of oxygen consumed for fuel combustion is equal to that consumed by more than 200,000 people for breathing. Regeneration of the equal amount of atmospheric oxygen will require several thousands hectares of pine forests or even a larger ocean plankton area.

During a many-hour flight every passenger is exposed to additional irradiation as a result of cosmic natural gamma-radiation and in the aircraft saloon an exposure dose is equal to 300…400 microroentgen/hour against 20 microroentgen/hour which is a standard.

Another important factor entailed in airport construction is related to land allocation. In terms of space requirements it is comparable with railway and highway construction however, lands allocated for airports are located in the immediate vicinity of cities, thus, their value is much higher.

Aviation produces a heavy noise impact, especially within the area of airports, and considerable electromagnetic pollution generated by radar facilities.

Air transportation is the most expensive one. The cost of a modern airliner is as high as USD100 million, while construction costs for a large-scale international airport exceed USD10 billion.

4. High-speed railways (HSR). Their construction was started in the last quarter of our century. Maximum travel speed is 400 km/h, average operating speed - 180…200 km/h.

HSR is an ordinary railway road provided with improved and reinforced track structure (rails, sleepers) and cushion (special reinforced embankment and ballast foundation) and special high-speed rolling stock.

The cost of 1 km of road is USD10…20 million, the cost of 1 coach - USD 2…3 million. Their environmental impact is heavier than that of conventional railways. For example, according to the environmentalists' estimates the environmental impact of the construction of a high-speed railway "St-Petersburg - Moscow" will be equal to that of Chernobyl accident. In this case the net cost of travel will be USD 123 per 1 passenger (with the total length of the route being 660 km). Another example - experts estimated that if in the 21st century development of a densely populated country such as China with its limited and vulnerable agricultural lands is oriented towards HSR construction, in 20…30 years it will be in the face of a nation-wide famine and its scale will be comparable to that of the period of cultural revolution when about 30 million Chinese died of hunger.

HSR requires noise screening facilities and special enclosures to prevent penetration of cattle and wild animals to the railway tracks which could result in the derailment of trains. HSR embankment creates an insurmountable obstacle for wild animals, surface and ground waters.

By the year 2000 as little as 3,100 km of HSR has been built in Europe.

5. Trains on a magnet suspension.

5.1. "Transrapid" (Germany) with an electric magnet suspension using traditional conductors. For a coach length of 25 m the clearance between the rolling stock and the road structure should not exceed 10 mm, otherwise suspension would not work. Such roads place very high and difficult requirements for their construction and operation.

The cost of a road is USD 25…50 million/km, the cost of 1 coach is USD 6…8 million. For example, business-plan of the German "Siemens" Company submitted to the Government of Moscow specified the cost of a "Transrapid" route - "Airport Sheremetyevo - Centre of Moscow" with the total length of 29 km as USD 1.5 billion (not including the cost of land and costs for building and structure demolition). Construction is associated with high building material costs including reinforced concrete and steel for the span beams which are to be massive (though the span length is only 24 m) and supports (to eliminate any displacement under the load, even at portions of 1 mm).

Its travel speed is up to 500 km/h. It is characterised by heavy noise at high travel speeds produced by the bearing beam totally enclosed (on top, bottom and on both sides) by a coach shell and the air sucked in the clearance at high speed. It has a very low energetic efficiency: substation efficiency is 34% (alternating current frequency modulated by a substation is used to form a magnetic field running along the track), efficiency of a linear electric motor is 40%. As a result of multiplication we get a total efficiency of 13.6% which is somewhat higher than that of a locomotive.

5.2. "Maglev" (Japan) - super-conductive magneto-levitating railway road. Coaches are equipped with super-conductive coils and the power of their magnetic field is so high (no similar magnetic field has ever been found in nature either in our Planet or in the solar system and the Galaxy, therefore, imagine how hazard it could be for all live things) that it is capable to provide suspension at the height of 10…20 cm. Travel speed is up to 500 km/h. Coils located in a passenger coach are cooled by three cryogenic circuits of liquefied and gaseous helium and liquefied nitrogen. Jump-type losses in super-conductivity could result in coil explosion equivalent to that of several kilograms of trotyl.

The cost of 1 km of road is USD 20…30, the cost of 1 coach is more than USD 10 million.

6. Monorail is widely spread in the USA, Canada, France**.** A wheel cabin is moving along a beam (ALVEG) or under a beam (SAFEGE) which should have a large cross section in order to ensure the cabin steadiness. A system is characterised by high material consumption for span structures and supports. Because of the unfavourable vibration dynamics of a suspension system and poor aerodymanics qualities of a cabin monorail roads have low travel speeds failing to reach 200 km/h. The cost of 1 km of monorail road is USD 4…10 million.

7. Trolley-bus is used as an urban mode of transportation. It is one of the most clean transportation modes in terms of its environmental impact. It requires hard surface roads and a special infrastructure provided with a feeder line. Therefore, trolley-bus routes are usually more expensive than traditional highways. The cost of a modern trolley-bus is about USD 500,000.

8. High-speed tram. In the recent years is was widely developed in the USA, Canada, Europe, South East Asia, Russia, Ukraine. Travel speed is up to 120 km/h. The cost of routes is USD 6…12 per 1 km. The cost of 1 tram is about USD 1 million.

9. Rail bus – is a variety of a tram which uses a diesel instead of an electric motor. Its production was started in Germany in 1995. The cost of 1 rail bus is USD 2 million.

10. Cable roads. Aerial transportation system designed by a Swiss engineer G. Muller has been already put into service in Canada, USA and Germany. It consists of passenger coaches that are moving along the cables hanged on the light metal supports. It is a relatively low-cost structure (USD 1.5…2 million/km), however, it fails to reach a speed more than 50 km/h.

Discussed above were the main modes of transportation, each of them having a number of alternatives. For example, screen-jet is an alternative of an air-plane, electric car is that of a motor car. These and other modes of transportation the total number of which is more than 200 are the object of research in many countries of the world. Among them is a route for air planes with shortened wings coming through the underground tunnel of 50 m diameter (Japan) or a flying plate which creates vacuum in front of a nasal part of an aircraft (Russia) which in the author’s opinion could be regarded as exotic ones.

Analysis shows that existing and future modes of transportation are associated with high costs and environmental hazard, their construction requires alienation of large areas of valuable lands. None of the transportation modes except a bicycle is capable to cope with noise requirements whereas noise control measures to provide the high-speed roads with necessary noise protection devices would entail higher costs.

The system analysis shows that in the 21st century a road transportation system could take the lead among other transportation modes in terms of its environmental, economic, communication, land-use and safety qualities which is capable to provide the travel speed of 300…500 km/h and comply with the following requirements:

1) the cost of a route including infrastructure is not higher than that of a cable road amounting to about USD 1.5…2 million; in this case resource-consumption for a transportation system (including requirements for building materials and structures, the volume of earth works, consumption of ferrous and non-ferrous metals, etc.) is to be compatible to that for a cable road;

2) transportation passenger module in terms of its comfort is at the level of a modern airliner and its cost is not higher than that of a passenger car;

3) the net travel cost is at the level of local electric trains in Russia - not higher than USD 1…2 per 100 passenger/km (or 10…20 USD/1,000 passenger/km);

4) land requirements are not more than 0.1 ha of land per 1 km of road including infrastructure;

5) does not require construction of embankments, depressions, tunnels, powerful elevated roads, viaducts resulting in the deterioration of landscapes and biocenosis and characterised by poor resistance to the natural disasters (such as earthquakes, flooding, land slips, etc.)

6) in terms of its specific environmental impact the module is less hazardous than a trolley-bus or an electric car with its noxious atmospheric emissions being not more than 10 g per 100 passenger/km;

7) energy costs (fuel consumption) for a high-speed movement will be 5…10 times less than for a modern passenger car (in terms of gasoline consumption - up to 0.5 liter per 100 passenger/km);

8) traffic safety is at the level of aircraft passenger transportation;

9) carrying capacity per 1 route is more than 100,000 passengers and 100,000 tonnes of freight per day;

10) operates as a multi-purpose communication system providing a high-speed circulation of passengers and freights and transmission of electric energy and electronic information.

The given analysis strengthened the author's opinion that none of the existing or future transportation systems could cope with the above mentioned requirements of the 21st century.

This fact inspired the author to design a principally new communication system which eliminates the shortcomings of the existing systems and incorporates the advantages of the future transportation systems. In this case the search for a solution was based on the following requirements: no exotic in terms of engineering and scientific proposals such as magnet suspensions, superconductivity, levitation, anti-gravitation, etc. A system should be based on the well-tested materials, technologies and engineering solutions.

Idea of a string transportation system (STS) was suggested by the author in 1982 when his first publications appeared in the journals “Inventor and Rationalisator” and “Technika Molodezhi” devoted to a planetary non-rocket-borne transportation means to open up near outer space. Based on this idea a STS was developed as an independent project.

It took more than ten years to develop a theoretical scheme and to find engineering, technological and design solutions as well as to optimise environmental, economic and engineering components and to analyse the system advantages and shortcomings. First information about a STS (without details about its engineering essence) was published as late as in 1993 in one of the Belorussian journals. Three more years were spent to get a patent for a principally new STS scheme in the leading world countries through the application to the World Intellectual Property Organisation. The last years were spent to prepare working drawings for a rail-string, supporting structures, infrastructure components, major units of a transportation module, research of aerodynamics, dynamics of a high-speed movement using a hard string (a rail-string) and manufacturing of operating models.

Thus, though so far actually not 1 km of a string road has been built it is possible to draw up its key technical and economic specifications.

STS is a pre-stressed stretched cable-and-beam structure which is fixed on the supports to carry special electric module cars with the total load-carrying capacity of 20 passengers or 5,000 kg of freight [3, 4, 5]. Power supply is provided by special current-carrying rail heads contacting with the cabin wheels. In case electric cars are supplied from an autonomous power system the rail-head and the track as a whole will be cut off current.

The basis of a STS is formed by a beam of high-strength steel wires each of 1…5 mm diameter installed with a dip inside a hollow rail. Instead of wire it is possible to use a high-strength steel strip. The rail is assembled in such a way as to maintain its head ideally smooth after the hollow rail has been filled with solidifying filler, for example, using cement, bitumen or epoxy resin to fix the strings. Therefore, it is possible to eliminate dips or junctions on the whole length of a rail head along which a transportation module wheel is moving. Strings and rails are rigidly fixed on anchor supports located at the intervals of 1…2 km. String dips of 50 mm under the structure weight are observable in the following cases: tension force of 100…500 tonnes, span length of 25…50 m, a rail track mass of 50…150 kg per 1 running meter. It is easy to hide, “to enclose” these dips inside a hollow rail of 15…20 m height.

There is also a great number of intermediate supports installed at 25…100 m intervals with 20…50 intermediate structures per 1 anchor support which will define the total cost of a supporting part. The STS design implies that intermediate supports are exposed predominantly to a vertical load which is light amounting to 25 tonnes at 50m span. It is approximately equal to the load carried by the high-voltage power transmission lines, which makes these both structures close in terms of their design and material consumption. Along the whole length of the route only two terminal anchor supports are exposed to maximum horizontal loads of 1,000 and 500 tonnes for a dual- and one-way track, respectively. More than 90% of the total number of anchor supports are intermediate (or technological) anchor supports which will not be exposed to heavy horizontal loads in the course of operation because the loads on the supports from both sides are counterbalanced.

String and rail have no deformation welds along the whole length and under changed temperature conditions their operating scheme would be similar to that of a telephone cable, a wire of a power transmission line or a cable of a hanging bridge fixed on the supporting structures with a dip and stretching for many kilometres without junctions. The rail is designed as an assembly structure. The estimated temperature gradient is accepted at 100 °C. Such temperature gradient is registered once in 100 years in countries with sharp continental climate or in the mountains; in sub-tropic or tropic zones it will be 20…30 °C lower.

A STS string is made of a wire manufactured today for steel cables (with its ultimate strength up to 200 kgf/mm^2) or pre-stressed reinforced structures and cables of hanging or guying bridges. For a rail-string head it is appropriate to use steel used for railroad rails which in terms of its physical and mechanical qualities is suitable for the purpose. STS is designed as a very rigid track. For instance, with a span of 50m the absolute statistical track deflection caused by a load of 5,000 kg concentrated in the middle of a span will amount to as little as 12.5 mm or 1/4000 of a span length. For comparison: modern bridges including those for the high-speed railways are designed for a permissible relative deflection of 1/400 which is 10 times higher. Dynamic deflection of a STS track under the moving load will be lower - up to 5 mm or 1/10000 of a span. This track will be smoother for the wheels of a transportation module than, for example, the bottom of a salt lake where, as you know, at the end of the 20th century for the first time an automobile managed to exceed the sonic speed - 1,200 km/h.

Factors limiting a maximum STS speed are associated rather with its aerodynamic qualities than with a track smoothness or vibration and “wheel-rail” friction contact. That is why special emphasis in a STS design is laid on its aerodynamic qualities. It was possible to obtain unique results having no analogues in modern high-speed transportation including aviation. Aerodynamic resistance coefficient of a model passenger vehicle measured in a wind tunnel amounted to C_x = 0.075. Measures are proposed to reduce this coefficient to C_x

= 0.05…0.06. Low aerodynamic resistance makes it possible for a 20-passenger vehicle with the engine capacities of 80 kW, 200 kW and 400 kW to reach the speeds of 250…300 km/h, 400…450km/h and 500…550 km/h, respectively. In this case mechanical and electromechanical losses will be insufficient thanks to a high efficiency coefficient of a steel wheel and a motor wheel as a whole amounting to 99% and 92%, respectively.

It is known that as the speed increases the wheel-rail cohesion is diminishing. To reach the travel speeds of 300…350 km/h (with a thrust of 100 kg) and 400…450 km/h (with a thrust of 180 kg) "a wheel-rail" pair in a STS is to have a friction coefficient not less than 0.04 and 0.07, respectively which is easily reachable. Cohesion problems arise only at the travel speeds of 500 km/h and more which require a thrust of more than 300 kgf. However, this problem is also easily solved with the help of a STS. For instance, we designed a principally new scheme for a rubber-covered thrust motor-wheel of 100 kW capacity which is capable to provide the required cohesion and thrust. However, in the foreseeable future such high travel speeds will not be needed and it will be enough to use the most optimal STS speed in the range of 300…400 km/h . In this case it will be easier to ensure higher safety of travel and to reduce energy costs which to a considerable extent affect the cost of travel by high-speed transportation modes including a STS.

Availability of two rims (flanges) and an independent ("automobile") suspension at each wheel will considerably lower the risk of derailment for a transportation module which is, for example, the main cause of road and railway accidents. Module derailment as a result of aerodynamics forces or gusts of side wind is fully excluded which was proved by the wind tunnel tests.

In construction terms the safety of a STS track structure and supports is similar to that of a hanging or guy rope bridge because they are very close in terms of their design, however, in our case the STS strings are much better protected from climatic and mechanical impacts than the bridge cables.

The key elements of an electric car (running gear, suspension, gear transmission) and the systems of electronic control meet the existing requirements for aircraft and high-speed railways. Therefore, on the whole we do not see any obstacles for a STS to become the most safe and reliable mode of land transportation in the future.

It should be noted that in the economic terms the cost of a fully-equipped serial-produced dual-way STS route including infrastructure (terminals, stations, freight terminals, depots, etc.) to be located in various ground feature conditions will be as follows (in million USD): 1.0…1.5 - in the plane; 1.5…2.5 - in the mountains; 1.5…2.5 - above the sea; 5…8 - in the underwater or underground pipe-tunnel.

In design terms a transportation module is simpler than a passenger car, therefore, the cost of a serial-produced module will be at the level of a mini-bus

– USD 20,000…40,000 or USD 1,000…2,000 per 1 seat (for a 20-seat electric car). For comparison, we give the relative cost of the rolling stock in other high-speed systems: aircraft - 100,000…200,000 USD/seat, train on a magnet suspension - 100,000…200,000 USD/seat, high-speed railway - 20,000…30,000 USD/seat.

Net cost of a STS passenger or freight transportation will depend on many factors and first of all on the intensity of a passenger- and freight flow (for the travel speed of 300 km/h), including:

a) passenger traffic, USD/1,000 pass./km: 20…25 (10,000 pass./24 hours); 10…15 (20,000 pass./24 hours); 5…10 (50,000 pass./24 hours);

b) freight traffic, USD/1,000 tonnes/km:6…8 (20,000 tonnes/24 hours); 4…5 (50,000 tonnes/24 hours); 2…3 (100,000 tonnes/24 hours).

Structure of travel costs (for the travel speed of 300 km/h):

a) passenger traffic - track and rolling stock amortization – 65…80%, operation costs - 10…20%, electric power - 5…10%.

b) freight traffic - track and rolling stock amortization – 45…65%, operation costs - 10…20%, electric power - 25…45%.

STS can be designed as technological or specialised routes to be used for various purposes such as: to remove garbage beyond the boundaries of megalopolises; to deliver ore from quarries to the processing plants; to transport coal to heat power stations or oil from oil deposits to refinery plants; to supply large volumes (about 100 million tonnes per year) of a high quality drinking water to the densely populated regions of the world at distances of 5,000…10,000 km, etc. String roads can be also used as freight, passenger (including those for tourist purposes) and freight-passenger routes.

Therefore, technical, economic and environmental qualities of the proposed mode of transportation seem to be very attractive, in particular:

1) construction of STS routes does nor require large land allocations (which is 150…200 times less than for highway or railway construction);

2) STS routes do not require construction of embankments, depressions or tunnels, cutting of forests, demolition of buildings; a STS is easily integrated into an urban environment and is easy for construction under difficult natural conditions such as permafrost, mountains, marshlands, desert, water barriers (rivers, lakes, straits and ocean shelf, etc.);

3) communication system is characterised by a higher resistance to natural disasters (earthquakes, land slides, flooding, hurricanes), and unfavourable climatic conditions (fog, rain, icing, snow drifts, sand storms, severe heat and cold, etc.);

4) thanks to its low material consumption and high technological qualities the cost of a STS route will be lower than that of conventional modes of transportation (by 2…3 times), high-speed railways (by 8…10 times) and highways (by 3…4 times); monorail roads (by 2…3 times), trains on a magnet

suspension (by 15…20 times), therefore, its travel cost will be also the lowest one amounting to 5…8 USD/1,000 passenger/km and 2…5 USD/1,000 tonnes/km.

STS routes are easily matched with electric transmission lines, wind and solar electric power plants, communication lines including fibro-optical ones, therefore, they are likely to serve not only as the high-speed roads but as communication systems as well.

Maximum carrying capacity of a dual-way track is 500,000 passengers (about 200 million passengers per year) and 500,000 tonnes of freight per day (about 200 million tonnes per year).

At the present moment neither a STS developer or experts have any doubt in the system validity in terms of its efficient operation and practicable implementation. The main reason why a STS programme has not been put into practice so far is associated with the lack of finances. For more than 20 years all works for a string transportation system have been carried out thanks to the personal support and enthusiasm of its author which is naturally not enough to further promote it. In fact, no state support has been provided either, though President of Belarus Alexander Lukashenko expressed his personal interest and support of the proposed system. The only actual support in the form of a grant was provided by the UN Centre for Human Settlements (Habitat) in January 1999 and add to it some small private investments.

A mathematical dynamic STS model was developed by the joint efforts of mathematicians from Belarus State University, Petersburg State Transportation University, Voronezh Polytechnic Academy, Academy of Sciences in Byelarus and Ukraine. The major research outcomes are discussed in the author's monograph: "String Transportation Systems: in the Earth and Space" (the city of Gomel, Belarus, 1995). The operational STS model was exhibited at Leipzig Fair (Germany, 1995) and Hanover Industrial Fair (Germany, 1996); and at a number of exhibitions including the Exhibitions of Achievements of Belarus Academy of Sciences (1995, 1996, 1997); "Innovations-98", Moscow (1st Degree Diploma); "Spectransport-99" and "Road-99", Moscow. Everywhere the STS was highly evaluated by the professionals.

How long will it take to put a string system into practice?

A number of STS alternatives were considered and analysed including, in particular, an alternative for the 2nd Crete transportation corridor - "Paris - Moscow". International Conference devoted to the given transportation corridor which took place in the city of Minsk in October 1997 and brought together experts from 14 countries recommended the European Union to consider a STS as a high-speed component of Crete transportation corridors [9]. In 1998 the Government of Belarus applied to the City Government of Moscow with a similar proposal. In this respect it should be noted that the EU Council of

Ministers decided to allocate USD 400 billion for 9 Crete corridors up to the year 2010.

Thus, for example, if financing of a “Paris - Moscow” STS route is opened in 2001 it is likely that a route will be put into service in 2006. One building team will be able to build more than 300 km of road per year, thus, 8 teams working simultaneously at different sections will be able to build the whole route during 1 year – 2005.

In 2001 it is proposed to invite international tenders to design a motor block, undercarriage and saloon for a transportation module and electronic control and safety systems for a STS. Presumably, its participants could be the largest corporations such as “General Electric”, “Microsoft”, “Intel”, “Mitsubishi”, etc., firstly, because the work will be paid and, secondly, because a STS represents a new and very capital-intensive market (according to the experts’ estimates the world market for a STS exceeds USD 1trillion) which is highly attractive for the aforementioned and other corporations. It is proposed that design of STS components submitted to a tender should be finalised during 3 years, i.e. by the year 2004. In 2004 all the above systems as well as alternative systems designed by internal efforts will be tested and optimised on a pilot section of a route planned for design in 2001 and construction in Russia in 2002.

The total cost of a STS route “Paris (London) – Moscow” (with the total length of 3,110 km) is estimated at USD 5.7 billion including USD 5.2 billion - the cost of a track and infrastructure and USD 0.5 billion - the cost of the rolling stock.

Cost distribution by year will be as follows: USD 10 million – in 2001; USD 100 million – in 2002; USD 500 million – in 2003, USD 1 billion – in 2004; USD 4.1 billion – in 2005.

A route put into operation will start to recoup itself in 2006 and the total costs will be repaid during the year 2009. In this case the net cost of travel from Moscow to Paris will be USD 32/passenger, and travel time -7 hours 10 minutes (with a travel distance of 2,770 km and estimated travel speed of 400 km/h). Beginning from the year 2010 the average net profit of a string route will be estimated at about USD 2 billion per year to reach the total of USD 20 billion by the year 2020. That is why a STS programme will be very attractive for investors and resources of non-state investors and joint stock capital will be enough to implement it in full-value.

Construction of a high-speed road network in Russia will require minimal state resources. For example, it is possible to build a STS route network: “Lisbon (London) - Moscow - Lake Baikal - Peking (Seoul -Tokyo) - Delhi - El Kuwait” with the total length of about 30,000 km during the nearest decade with the financial support provided by international investments in the Programme “Live Water of Russia” and the programme will bring the total annual income of USD 100-200 billion enough to pay back construction costs during one year. One more project which is not less attractive for Russia in terms of its currency earnings is focused on Siberia and northern regions with their frosts serving as a sort of natural refrigerator. Today the cost of a high quality food natural ice at the world market is USD 7,000 against USD 500…1,000 – the cost of high quality natural drinking water, which is higher than that of copper and aluminium and 50 times higher than that of oil. At the same time today the total human demand for the high quality bottled drinking water is estimated at 10 billion tonnes per year (for comparison: the annual oil and coal consumption amounts to about 2 and 3.5 billion tonnes, respectively), whereas one half of the world resources is concentrated in Russia (Lakes Baikal, Taimyr, Onega, etc.). Therefore, the programme could be realised only on the basis of a STS which is capable, for example, to deliver water and food ice from Baikal to Madrid at the net price of USD 0.05/liter and USD 0.1/kg, respectively or from Baikal to Moscow at the price of USD 0.03 and 0.07, respectively.

Half of resources earned only by the above STS programme and re-invested in other projects will be enough during the next 40-50 years to build 1 million km of roads so necessary for Russia. And what is more important, these roads will have the lifetime of 100 years, they will not be in need of snow or ice removal and the use of sand and anti-icing salts in winter, they will not be destroyed during 2…3 winter seasons; they will not be drowned in bogs or permafrost, it will not be necessary to patch them every year.

For Russia this task will not be much more difficult, for example, than problems solved by the USA in the 20th century which had to build more than 5 million km of roads to ensure normal vital activity for its 250 million population. Road construction was associated with higher costs and environmental hazard; roads intended for the low-speed motor transportation entailed appropriate infrastructure provision; they gave rise to the promotion of automobile industry with the annual production rates of 1 million cars.

STS, for example, will make it possible to link Europe and Asia with America by a land route “London (Paris) – Moscow – Lake Baikal – Yakutsk – Bering Strait – Calgary- New York”. The route with the total length of 21,000 km and the total cost of about USD 40 billion will be able to pay back its construction costs during 4…5 years.

There are dozens of other string route alternatives which have strategic and geopolitical significance practically for all continents and countries of the world.

Part 2. 100 Questions to the Author

Technical aspects

1. What is it a string transportation system (STS)?

One-way STS track consists of two special current-carrying rail-strings (isolated from each other and from the supports) along which a four-wheel high-speed electric module is moving. In case an autonomous power supply system is used a track structure will be dead. High smoothness and rigidity of a string track structure makes it possible to easily reach the travel speeds of 250…300 km/h which in the future could be increased to 500…600 km/h. It is possible to design a STS route as a multiple-track structure with its tracks located either on common or free standing supports.

2. What is it a rail-string?

A rail-string (in terms of building machinery) is a rigid string consisting of a beam (a specially designed hollow rail) with a number of high-strength steel cables put inside it with a dip and fastened to a summary strength estimated at hundreds of tonnes. A rail and cables are tied with each other to form a single structure. In terms of its qualities a rail-string is a combination of a flexible string and a rigid beam.

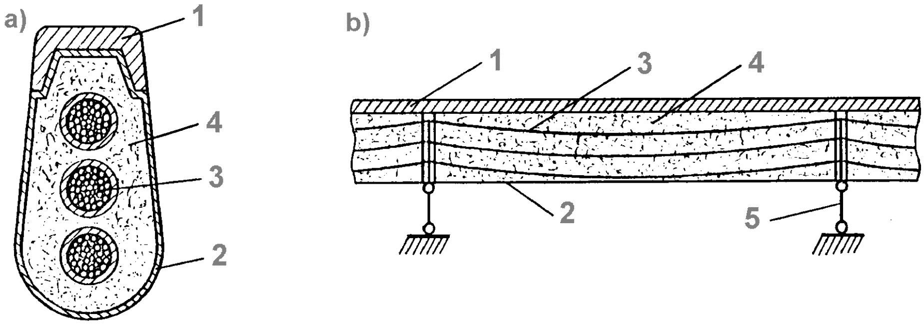
3. Are there any analogues of a rail-string among other building structures?

Its closest analogue is a reinforced concrete bridge beam made of rigid components (reinforced concrete structure) with flexible bunches of steel wires stressed to 100…150 kgf/mm2 tension and put in special channels inside the beam. Beam and bunches of wires are fixed with solidification mixture, for example, cement solution or epoxy resin filled in the channels to make a single structure.

Another analogue is a hanging bridge consisting of a rigidity beam supported by a cable and fixed with a dip. Beam and cable are fixed with suspension to make a single structure.

4. Then what is a principal rail-string distinction?

Design of a rail-string envisages that at spans of 10…100 m the dips of a string (cable) would be equal to 1…10 cm. In this case it is easy to place a string inside a small diameter structure (see fig.).



Design of a rail-string:
a) cross section; b) longitudinal section; 1 - head; 2 - body; 3 - string; 4 - filler; 5 - supporting mast.

5. Longitudinal dimensions and weight of a rail-string?

A rail-string is characterised by the following maximum longitudinal dimensions: width – 10 cm, height – 20 cm. Mass of a running meter is 50…75 kg out of which steel makes 50…75% .

6. Is a rail-string lighter than a railway rail?

Yes, it is. In terms of material consumption a track structure (including two rail-strings) for a one-way STS route is comparable to one modern heavy railway rail (including blocking, bolt fixtures, etc.) of the same length.

7. Does a rail-string require unique materials for its manufacturing?

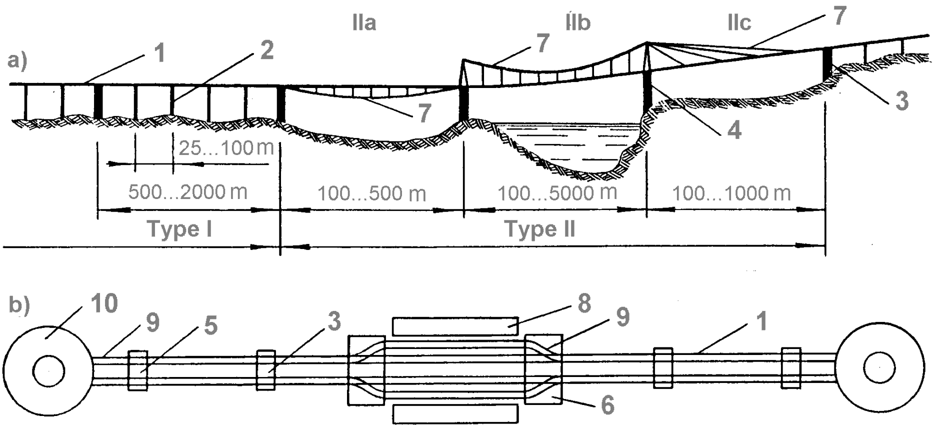
No, it does not. All materials necessary for its manufacturing are produced today by industries of any developed country including Russia. For example, a rail head along which a STS vehicle is moving is made of steel used for railway rails. It can be manufactured at the same rolling mills but equipped with more simple instrumentation because a head profile is simpler than that of a railway rail (it is closer to a channel and its linear mass is much less than that of a rail amounting to 15…30 kg/m).

A STS string is a non-twisted cable made of high-strength steel wires of 1…5 mm diameter. Wire with a tensile strength of 90…350kgf/mm^2 is industrially produced to be used for cables and ropes in hanging and guy rope bridges, reinforced structures, steel cord of automobile tires, etc. Dozens of steel marks produced by the large-serial manufacturers are suitable for a string, therefore, there is no need to list them.

The same is true for other rail-string components, track structure, supports and STS transportation module – all these components are either produced by industry or it is not a problem to master their production.

8. Linear track scheme?

Given below is a linear track scheme.



Linear track scheme.

a) side view; b) top view; 1 – two-way track structure; 2 – supporting mast; 3, 4, 5, 6, - anchor supports including: intermediate, pylon, terminal, switch ones, respectively; 7 – supporting cable; 8 – intermediate station; 9 – track section made of conventional rails (of railway type); 10 – ring terminal.

The following two types of a STS track structure are recognised depending on a span length: I – conventional design (with a span under 100 m); II – including additional supporting cable structure (with a span more than 100 m) with cable fixed: a) at the bottom; b) on the top with a parabolic dip; c) on the top in the form of guy ropes. STS supports are sub-divided into the following three typical categories: anchor (fixed at 500…2,000 m distance and more), brake (at 200…500 m distance and more) and supporting masts (at 10…500 m distance).

9. What is a tension strain of a string?

A tension strain on one rail-string will be equal to 250 tonnes (at the estimated tensile strength of wire being 100 kgf/mm^2 its summary cross sectional area will be 25 sq. cm and the mass - about 20 kg/m; if a string is made of three cables then each cable should be of about 35 mm diameter).

For comparison: cross section of a modern hanging bridge reaches 1,500 mm and its tensile strength is 100,000 tonnes and more. By the way, carrying capacity (including passenger and freight traffic flows) of a STS and a hanging bridge is the same. The ratio between the tension strain of a rail-string and the length of a span will be as follows: 250 tf - 100 m; 500 tf – under 1,000 m; 1,000 tf – under 2,000 m.

10. Maximum possible span?

To support a STS track structure with spans exceeding 100 m in length it is necessary to use a special cable (fixed on the top or bottom) designed like a hanging or guy rope bridge. Light-weight track structure and STS modules make it possible to use cables of 10 cm or 20 cm diameter made of high-strength steel wire sufficient to support spans of 2,000 m and 4,000 m, respectively. Modern composition materials will ensure a maximum span length of 5,000…6,000 m.

11. How rigid is a track structure?

An important quality of a track is its relative rigidity: ratio between the structure deflection under the weight of the estimated load located in the middle (or ¼) of a span and the span length. Modern bridges, including hanging bridges, are designed in Russia for the estimated relative deformation of 1/400. Estimated rigidity of a STS is by one order higher: deflection of a string structure with a 50 m span under the weight of a transportation module amounting to 5,000 kgf will be equal to about 10mm or 1/5000. Therefore, the smoothness of a string track for a moving wheel will be by one order higher than, for example, that of a high-speed railway road laid on a modern reinforced concrete or steel bridge.

Construction (assembly) deflections of various track components under their own weight are given in the Table below.

Deflection of the STS Structure under their 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

12. What about thermal strain?

Neither a rail or a string are exposed to any longitudinal deformation (stretch) with their length being invariable in summer and in winter. Like the wires of telephone or electric transmission lines that are fixed by supporting masts to stretch for many kilometres without any joints a rail and string system is not exposed to thermal strain. However, temperature drop could change its stressed strained state.

Design of a STS track provides for its structure rigidity under the estimated temperature variations. For example, at maximum temperature drop of 100 °C (from +60 °C in summer to –40 °C in winter) the maximum tensile force will range from 7500 kgf/sq.cm (in summer) to 10000 kgf/sq.cm (in winter) and from 0 to 2500 kgf/sq.cm for a string and rail, respectively. Under reduced temperature drop a deformed stress will be proportionally reducing.

13. Temperature variations in a string tension will result in track deflection. Is it dangerous?

In fact, track deflection is observable in a vertical plane which will be proportional to its initial dip and relative variation of tension. At 100 °C temperature drop (or 50 °C more neutral value) a maximum vertical deflection of a track with a 50 m span will amount to about 5 mm or 1/10000. In this case 5 mm upward and downward deflection of a track will be observed in winter and in summer, respectively. This micro-unevenness which is easily compensated by a wheel suspension would not affect smoothness of a vehicle moving at speeds of 500…600 km/h. Furthermore, as far as thermal deflections have an assigned and pre-determined nature a wheel suspension controlled by a computer will correct the travel profile automatically.

14. What is the rolling stock impact on a string tension?

Variations of a string tension will be of about 1% which is attributed to the kinematic qualities of a string track structure. Fig.1 shows a string block system in which a string tension does not depend on external load *P*. This structure is easily transformed in a linear scheme of a greater length (Fig.2).

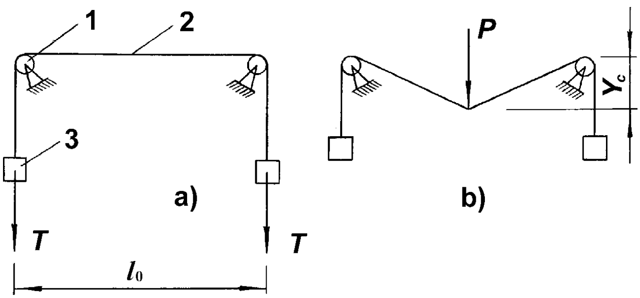


Fig.1. String block system:
a) without external load;
b) with a load;
1 - block;
2 - string;
3 - load.

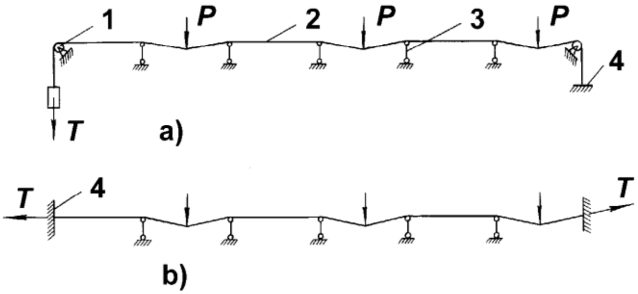


Fig. 2. String linear scheme:
a) with a block at the end of a string;
b) with a string sealed off;
1 – block;
2 – string;
3 – swing support;
4 – fixing (anchor).

Analysis showed that at $P<0{,}01T$ (which is observed in STS) the difference between deformed stress values of structures shown in fig. 1 and 2 does not exceed 1% (more precisely 0.1…0.5%). In engineering estimates this difference could be neglected and the structures could be considered identical. It considerably distinguishes a STS from other building structures, for example, bridges or overpasses. The latter are exposed to millions of loading cycles in the course of their operation and in each case the stress of various components such as reinforced beams increases by 2 and more times. All this results in the development of fatigue and, therefore, reduced lifetime of a structure and growing maintenance and repair costs.

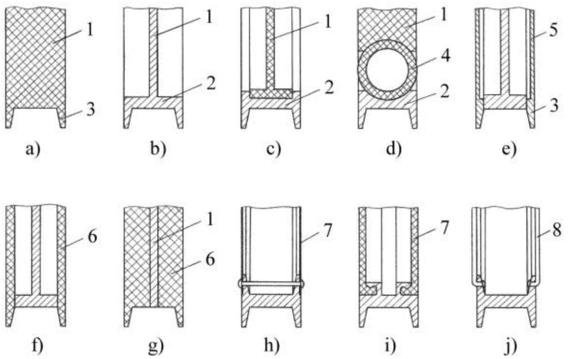
As far as the deformed stress of a STS remains practically invariable during the whole period of its operation irrespective of the number of loads a string transportation system would be characterised by longer durability.

15. How accurate are the track parameters?

Left and right rail-strings will be linked with each other every 5…10 m with special cross cleats which fix a gauge like sleepers of a railway. Side thrust in the interspace, for example, caused by hurricane side wind of 100…150 kgf per 1 wheel will change the gauge width by 1…2 mm as a result of a rail deflection which will not be dangerous for a vehicle moving at speeds up to 500…600 km/h.

16. In case of sliding apart rails how it can affect a vehicle, is it going to fall down?

This risk exists at the railway roads including the high-speed ones which became the cause of many cases of derailment resulting from the fact that the train wheels have one flange. In a STS module each wheel has two flanges (on the left and right side of a rail head, see Fig.) and an independent suspension. Therefore, a transportation module would be non-critical to the gauge width. For example, a wheel suspension can be designed in such a way that the variation of a gauge width by 10 mm would result rather not in derailment but in regular travel conditions. In this respect coming off the track is more typical for cars which are kept from falling to a side ditch, especially under icy condition of roads, only by a frictional force, whereas trains which have rims on their wheel pair are more stable.



Structure of a supporting part of a wheel:
a, b – solid (monolithic) wheel; c, d, h, i, j - combined with a moving rim; e, f, g - combined with moving flanges; 1 – wheel body; 2 – rim; 3 – flange; 4 – elastic toroidal component; 5 – flexible plate; 6 – flexible disk; 7 – membrane; 8 – spoke.

17. As a rule, twisted cable (rope) is used for similar structures. Why a STS string is made of straight wires?

Unlike a crane with its cable constantly winding and unwinding on its drum and folding by its numerous pulleys a STS string is used for a different purpose. In addition to its strength twisted cable is very flexible which is reached thanks to wire intertwisting. Moreover, twisted cable squeezed in a solid whole is not getting fluffy when its separate wires are broken. However, in case some of the wires are broken the total load is re-distributed to expose intact wires to overstrain.

Overstrain also gives rise to wire intertwisting caused by very high contact stress and abrasive wear and as a result, break of cable. Wires of a twisted cable located at an angle to the longitudinal axis (and, therefore, to the longitudinal load) are characterised by a lower carrying capacity and lower elasticity module of a cable: $(1.5…1.8) \cdot 10^6$ kgf/sq.cm against $E=(2…2.1) \cdot 10^6$ kgf/sq.cm for steel.

A STS string is a stationary component which does not require either elasticity or other above mentioned shortcomings of a twisted cable. Instead, it has the following important advantages:

a) in case some wires are broken their length is reduced (a string is put in a protective envelope filled with special anticorrosive mixture like lubricant grease) and their stress is not transmitted to other wires; the structure becomes non-critical to the number of wire breaks;

b) contact stress is absent, therefore, there is no local wear, wire defects, overstrain zones, etc.

c) elasticity module of a strain will be equal to that of steel – (2…2.1) · 10^6 kgf/sq.cm;

d) the lack of elasticity requirements makes it possible to use wire of larger diameters (3…5 mm), thus, a string will have a smaller summary surface and, therefore, it will be characterised by higher corrosion and mechanical resistance and durability.

All the above qualities will contribute to the higher structure durability and lower material consumption, in particular, high-strength steel consumption for a string will be 1.2…1.5 times less than for a twisted cable.

18. What is a string break probability?

Each string consists of several hundreds of high-strength wires put in a protective envelope which is filled with anticorrosive mixture. It is placed in a hollow rail body filled with solidified filler (for example, on the base of epoxy resin). On the top the structure is closed by a rail head which protects a string from external atmospheric and mechanical impacts.

Each high-strength wire is subject to marginal checking before it is installed. Furthermore, a linear STS scheme envisages that under a moving load in the span the tensile stress of a string is varied (increased) by as little as 0.1…0.5%. Therefore, during the whole performance period deformed stress of the most important system component – a string – will be practically invariable (static) which will also contribute to the increased lifetime of a system due to the lack of fatigue accumulation.

Thus, it is possible to forecast that a STS will have a longer lifetime period than that of its closest analogue – a hanging bridge, to be estimated at more than 100 years. In this case, with each wire of a string working independent (all of them are twisted and placed parallel to each other in a string) any wire break (up to 50% of wires) would not result in the falling down of a structure which will be supported by the intact wires the tensile stress of which will be also intact remaining at the level of 1%.

Existing cableways are deprived of the above mentioned advantages: their steel cables are open to the aggressive aerial impact, their wires, especially in the upper external layers, are worn out and broken by rope pulleys, they are vulnerable to external mechanical impacts such as gun fire, etc. Nevertheless, break of cableway ropes with their spans reaching a record distance of 3,000 m is a very rare occurrence.

19. What if a track is fully broken?

Simultaneous breaking of hundreds of wires that are mechanically protected and located at several meters from each other and destruction of two rails simultaneously is very difficult in technical terms. Its probability is close to zero.

The average distance between the vehicles on a track will be more than 1,000 m, therefore, location of a vehicle within a damage span of 50 m length at the moment of break will have less than 1/20 probability. Moreover, only a track broken in front of wheels creates a derailment probability, otherwise a vehicle will be able to escape a damage section.

Therefore, a probability of emergency situation for one of the modules is less than 1/40, even if a track is fully destroyed. Other modules located in front of the damage section will be stopped and send in the opposite direction or to the counter line switched to one-way operation regime.

As soon as a contact between all four wheels of a derailed vehicle and the rails is broken, a flare cartridge of a one-time parachute and air cushions of safety installed in each vehicle will be automatically switched on. Parachute will reduce the high travel speed of a module designed as a high-strength mono-block to prevent its destruction during the landing. Therefore, a probability of human death under the described situation will be much lower than, for example, that under a similar situation of “Formula –1”.

20. What makes a string route so even?

First of all, is there anything more straight than a string strained to a high stress, no matter how uneven or curved it could initially be? All cross sectional track components (a string, rail head and body) are kept in a stretched out condition all time, in winter and in summer.

Secondly, a rail head is polished with a high degree of accuracy along its whole length. In this case any macro-unevenness (above 1 mm or under 1 mm) will be removed either by the track adjustment or abrasion.

Thirdly, regular performance regime of all loaded components (a rail, string, support, piled foundation) is possible only under their elasticity stage without plastic deformations which tend to accumulate and reach critical values.

Therefore, STS does not need a number of works necessary for the normal railway or highway operation such as: packing of sleepers, re-fastening of rails, filling of washouts, pits, pot holes and annealing cracks, etc. A STS rail head which does not have a single joint along the whole length of its track (or to be more precise, there are some joints but without any clearances or height drop) provides for very smooth operation during the whole period to make it really a velvet track.

21. And what about rail deterioration?

A rail, or, more precisely, its head, will be made up of technologically convenient sections, for example, of 10 m length, without any clearances. Deteriorated or defected section of a rail could be replaced, if required. At the same time a STS rail has a longer lifetime period than a rail of a high-speed railway estimated at dozens of years which could be attributed to the following factors: lower (by one order) wheel loads, more favourable dynamics within a “wheel-rail” contact zone, no breaking stress and higher buffer action of all rail-string components which eliminate peak dynamic loads, etc.

22. High mechanical stress is known to result in material relaxation. Is it dangerous?

In fact, mechanical system as any other system tends towards thermodynamic balance. For example, tensile force of a strain wire under invariable elongation will be reducing. For the estimated string strain of 100 kgf/mm^2 and 1,000 m distance between the anchor supports initial wire elongation (tension) will amount to approximately 500 cm or 1/200 of its original length.

Approximately similar initial tension and specific elongation is observed in pre-stressed high-strength wire of various reinforced structures such as bridge components, hanging or guy rope bridges, cables of Ostankino TV tower, springs of transportation vehicles, etc. Pre-pressed wire of reinforced structures is the closest analogue of a STS string which is also straight (in many cases twisted ropes are used and their relaxation is the result of rather a cable squeezing than steel relaxation processes) and fixed to form a solid whole with the structure.

Bridge operation experience gained during many decades showed that relaxation of high-strength steel wire is insufficient and does not pose any hazard. However, it should be remembered that pre-squeezed concrete is characterised by a higher degree of relaxation in reinforced structures than in a STS. Moreover, bridge beams are exposed to bending strain and in this case a beam height is tens of times less than its length, therefore, even insufficient additional tensile strain of a reinforced component or cement will result in the beam deflection under the load which is dozens of times larger.

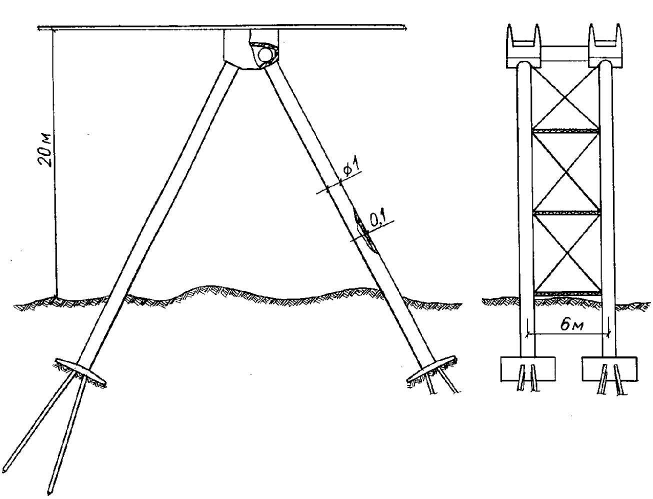
Thus, a strain of a STS rail is characterised by more favourable performance regime and its relaxation is 1…2 orders less hazardous than that of reinforced concrete structures. Therefore, it is possible to conclude that a STS system will survive for at least 100 years (like Eiffel Tower made of steel which is exposed to relaxation as well) without any problem.

23. What is the distance between supports?

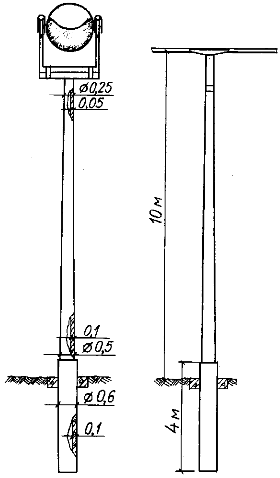
Two types of supports are used:

a) anchor supports with strain anchoring;

b) supporting (intermediate) masts to support a track structure in the interval between the anchor supports (see Fig.).



Anchor support of a dual-way STS route



Intermediate support of small height for a one-way STS route

The following span dimensions are used depending on the ground features and track requirements: 500…2,000 m (up to 10 km, if necessary) for anchor supports; 20…100 m (up to 500 m, if necessary) – for intermediate supports.

24. Is it a straight or a winding track?

As far as a STS is non-critical to the ground features of the site it is possible to design it as a straight line to make the shortest path. If necessary, curves in vertical or horizontal plane are possible. To provide travel comfort for passengers (to reduce G-force impact on curved sections) a radius of curvature is to be not less than 10,000 m, 15,000 m and 20,000 m for the travel speeds of 300 km/h, 400 km/h and 500 km/h, respectively. Under the less curvature radii in a horizontal plane a system will be designed to include turns. Under a radius of curvature less than 1,000 m the travel speed should be reduced to 100…150 km/h.

25. How heavy are the loads on the supports?

In terms of their structure and loads STS supports are close to the high-voltage transmission lines which, as it is known, are exposed to the loads that are by several orders lower than, for example, the loads on modern highway and railway bridges.

Intermediate support of a one-way STS track is exposed to a minimal vertical load of 20 tf (including movable load at 50 m span) and maximum emergency load of 250 tf (at 500 m span).

Anchor supports are estimated for horizontal load of a string. In this case only terminal anchor supports are exposed to the load whereas intermediate, i.e. technological supports (which amount to more than 90% of the total number of anchor supports) are not exposed to horizontal loads in the course of the route operation because the string strain is counterbalanced from both sides of the support.

Therefore, the estimated horizontal stress of 250 tf per 1 rail and 500 tf per an anchor support of a one-way track will be regarded as emergency (in case all strings of the track structure are broken on one side of the support) or technological (in the process of assembly when the given anchor support is terminal because the track is not further extended). Under the regular performance regime anchor supports (except two terminal supports being the most powerful ones) are not exposed to horizontal stress.

26. What is the support height?

Minimal height of supports is 5 m which is necessitated by safe passage of agricultural machinery, wild and domestic animals under the STS track structure. Maximum height of supports which is limited only by the economic feasibility could reach the values of 100 m and more. Optimal height of supports on the plain or slightly rugged terrain is 20…30 m which makes it possible to cross any forest without cutting through, as well as highways and railways, small and medium rivers with minimal environmental impact. At heavily rugged terrain the average height of supports could reach 30…40 m.

27. Is support manufacturing associated with high material consumption?

No, it is not. Reinforced concrete or steel supports are used. Reinforced concrete consumption for supports with the average height of 25 m per 1 km of a dual-way track is about 300 cub. m (for comparison: reinforced concrete consumption for a two-sided enclosure of a high-speed railway reaches 750 cub. m/km). Therefore, STS supports are associated with lower cost and material comsumption than, for example, enclosure of a high-speed railway (without which it is not possible to ensure its 100% safety, because even a moose getting into a track could be a cause of derailment).

Comparison of reinforced concrete consumption for STS supports and railway sleepers shows that material requirements for STS supports would be equal to that for ½ of the total number of sleepers for a track of similar length. In case of steel supports steel consumption is not high either amounting to about 100 t/km for a one-way track which is slightly higher than for a modern heavy railway rail of a similar length (1,000 m).

28. Are supports subject to swinging and if so, how it can affect the track evenness and safety?

A STS track is based on the superstructure of supports exposed to displacement in three main directions: axial, side and downward. For a support of 25 m height displacement of its top in the direction of a vehicle movement (along the track) even at 50 cm (!) will result in the bed lowering of as little as 5 mm, or for a 50 m span the track evenness will be practically intack (for 10 cm displacement the lowering will amount to 0.2 mm).

Downward displacement of supports under the weight of the structure and the rolling stock will depend on the structure compression rigidity and carrying capacity of the foundation and the ground. Piled foundation piled to the depth of 10 m eliminates ground shifts, for example, for a standard pile driven in to the limit of 100 tf exposed to the estimated load of 20 tf (for its displacement a pile is to be washed out for the depth of more than 5 m which is hardly possible even under the flood). Therefore, under the most unfavourable combimations of external loads the estimated vertical displacement of the upper part of a support will be within the limit of 1 mm.

Side displacement of the support top poses the greatest hazard which could lead to the lateral track deflection. In this case deflection within 5 mm limit at a distance of 100 m is considered safe which will provide for the travel safety and comfort at travel speeds of 500 km/h and more. Therefore, intermediate supports are estimated for the high cross-sectional rigidity which under the most unfavourable impacts (such as gusty hurricane wind, side wheel stress, etc.) will result in the cross-sectional vibrations of the support within the permissible limits.

To eliminate the consequences of unforeseeable displacements (for example, as a result of earthquake or land slides, etc.) each support is provided with a system of track adjustment to ensure an accuracy of 0.1 mm.

29. What if a support is destroyed as a result of a terrorist action?

It will not result in the line break, the track will remain uninterrupted. Falling down of a support (each support is fixed to a track structure by a special unfastening device like a lizard tail) will result in doubling of a span and, correspondingly, increased track deformation which will affect wheel suspension but not passengers. Therefore, if several supports are blown up as a result of terrorist actions the track will not be put out of operation. STS is characterised by a high survival probability, equally resistant both to terrorist actions and natural disasters such as earthquakes, storms, severe land slides, floods, etc.

30. What if an anchor support is blown up?

Taking into account a support strength its blowing up will require not less than 10 kg of trotyl and thorough preparations (STS is provided with a ramified security system including electronic control of all track components and vehicles and visual control such as track observation from a specially equipped helicopter). Security service is capable to trace terrorists' preparations and to stop the movement on a dangerous section. Even if an anchor support is destroyed a STS will remain operative because a fixing system provides for power transmission to the next section of a track by-passing a support body. It means that even if an anchor support is broken continuity of a string route will not be interrupted.

31. Driverless vehicle - is it dangerous?

On the contrary. A man (the so-called "human factor") is the weakest, most vulnerable and unsafe link of a traffic flow regulation, especially of a high-speed flow estimated by dozens or sometimes thousands of actors. The Japaneses who were one of the first to understand it showed to the world that over the last two decades high-speed railways in Japan carried more than 5 billion passengers and none of them was killed. They use driverless trains controlled by electronic devices (to calm their passengers at the beginning they put molds of machine operators in the cabins). This experience was taken into account in a STS.

32. How high is a vehicle collision probability?

Its probability is close to zero. Vehicles moving along one line are not expected to catch up with or outrun one another: they are intended to move with invariable speed and distance between them to exceed a braking length necessary for emergency stopping.

STS envisages the following 4 braking regimes: operating (acceleration – 1 m/s^2 braking length – more than 3,500 m at 300 km/h travel speed), urgent (acceleration – 2.5 m/s^2 braking length – 1,400 m), emergency (10 m/s^2 - 350 m) and extreme (50 m/s^2 - 70 m).

Emergency and extreme braking envisages the use of all braking systems including special parachutes and electromagnetic braking systems. It implies simultaneous switching of a flare cartridge to eject a parachute and life-saving air cushions in a passenger saloon to eliminate death injury of passengers (maximum overloading for passengers will be approximately the same as that of a passenger car hit against immovable barrier at the speed of 25 km/h).

Collisions observed, for example, in the motor ways can be attributed to the following factors:

a) each car is driven individually without coordination and consideration of actions of other actors (by-passes, turns, excessive drawing together, driving in counter-flow lane, etc.);

b) the distance between cars in a flow is insufficient (10…50 m) which is often less than a braking length necessary for a vehicle stopping;

c) delayed and often inadequate driver's response to a road accident, etc.

These factors are absent in a STS: movement is controlled from a single centre and duplicated many times by linear (on-line) and on-board computers that are integrated to make a network and, therefore, there is no need in a driver. In this case all manoeuvres (stops, drive in or off the route, changed speeds, etc.) will be adjusted to all road sections with regard to the real conditions of the track, transportation module and weather (wind, rain, snow, etc.).

33. What is a dynamic track rigidity?

Dynamic, rather than static, rigidity is more important for a STS like for any other high-speed transportation system. Investigation of specific structural features of a track and vehicle movement regimes showed that resonance phenomena were absent in a rail-string (for speeds up to 500…600 km/h). Moreover, track vibration observed behind a moving vehicle will be damped over 0.1…0.5 sec. and the next vehicles will be moving along an undisturbed, ideally even track.

The principles used were similar to those applied for a hanging bridge design: any component is to damp the structure vibrations within its own frequence range. Therefore, it is possible to damp all kinds of possible structure vibrations from the low- to high-frequency ones, including the impact of single modules and their flows, wind (including gusty wind), etc. In this case inertion and high strength of a track will contribute to lower dynamic amplitude of structural vibrations amounting to not less than 1/5000 which is less than statical. (For comparison: road bed of a highway is considered even if a clearance between a 3-meter rod and the road surface will be not more than 10 mm, i.e. its relative unevenness does not exceed 1/300).

34. Is the economic efficiency a STS vehicle higher than that of a passenger car?

In comparison with a 5-seat high-speed passenger car a STS vehicle proved to be by approximately 20 times more economically efficient (on conversion to 1 passenger) which is the result of the following factors: improved aerodynamic qualities (3 times); increased electric motor efficiency (more than by 90% against 30% of a real internal-combustion engine efficiency), increased (doubled) holding capacity, reduced (1.2 times) mechanical losses especially in a "wheel-road surface" pair ("steel-steel" for a STS and "rubber-asphalt" for a motor car). Specific electric energy consumption of a STS is as follows: 0.016 kW · hour/t · km and 0.014 kW · hour/pass. · km for freight and passenger traffic, respectively, at the travel speed of 300 km/h; and 0.031 kW · hour/t · km and 0.025 kW · hour/pass · km for the travel speed of 400 km/h, respectively.

The given data refer to the transportation modules of 4,000 kg carrying capacity and 20-seat passenger vehicles with their engine power being 40 and 80 kW (for the speed of 300 km/h) and 100 and 200 kW (for the speed of 400 km/h), respectively. (It is easy to recalculate electric energy consumption on conversion to combustible fuel consumption to get: 1 liter of gasoline = 8.78 kW hour of electric energy).

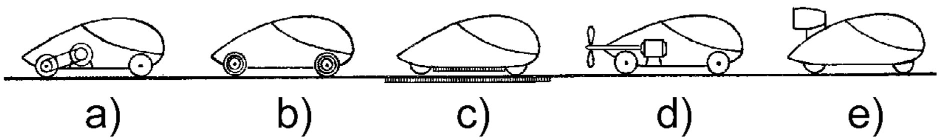
35. What is a module wheel rotation speed?

A transportation module wheel with 50…70 cm diameter has the following rotation speeds depending on its travel speed: 1,500…2,100 rot./min. at 200 km/h; 2,300…3,200 – at 300 km/h; 3,000…4,200 – at 400 km/h; 3,800…5,300 at 500 km/h.

Therefore, even at high travel speeds of a transportation module rotation speed of its wheels and their rotating engines will be ordinary for the modern technical equipment (for example, rotation speed of turbines of a turborjet engine reaches the values of 20,000…30,000 rot./min. and in this case turbine blades are exposed to super-high loads and very high thermal impact).

36. What sort of drive is appropriate for a transportation module?

Figure below shows drive unit alternatives.



Transportation module with various drive unit types:
a), d) – rotation wheel and propeller drive, respectively; b) - motor-wheel; c) - linear electric engine; e) – gas turbine.

It is more reasonable to use motor-wheel (for speeds under 500 km/h) and pusher propeller drive put directly on motor shaft for travel speeds above 500 km/h. Modern wide-blade fan-type propellers are noiseless and have 90% efficiency.

37. How much noise is produced by rattling wheels, moreover that they are made of steel?

No rattle noise at all, even at high travel speeds which is comparable with a high-speed railway having no rail interruption at 1 km length. A rail-string head is dismountable, i.e. easy to replace, if necessary; it has no clearances along the whole route length while any micro- or macro-unevenness are easily grinded off with a special polishing machine.

Therefore, the lack of clearances in the rail joints, improved track evenness, lower wheel mass (a wheel mass is 20…30 kg against almost 1,000 kg of a train wheel pair), automobile (i.e. independent) suspension of each vehicle wheel (compare with a train wheel pair in which vibrations of one wheel give rise to vibrations of the other) are factors which contribute to extremely quiet and smooth movement of a wheel though it is made of steel.

38. Is there any shock when a wheel is over-passing a support?

No, it is not. Firstly, because a rail-string has no joints on the support and there is no difference between this and other sections of the track. Secondly, coming closer to a support a rail deflection (with a relative value of 1/5000) is smoothly reducing to reach zero (at the moment when it passes a support). Thirdly, dynamic deflection of a track under the impact of wheels will be observed behind the wheels at travel speeds above 200 km/h, therefore, no bending is observed when a wheel is passing over a support.

39. Is it possible for a module to be blown off by the side wind?

No, it is not. It was proved by wind-tunnel tests of a transportation module (at scale 1:5). For example, at the travel speed of 250 km/h and hurricane side wind (with 100 km/hour velocity) the tilting effort will be within the limit of 100 kgf which for a module mass of more than 2,000 kg is not associated with any risk of a wheel-rail contact breakage. Derailment implies not only a wheel-rail contact breakage but also important is the break scale which is to exceed suspension move and the height of a wheel flange.

40. Is it possible for a vehicle to fly up at high travel speeds?

This risk exists for a transportation vehicle moving in the immediate vicinity of the ground surface which results from screening effect. For example, tilting effort observed in a high-speed car is attributed to uneven flow-around in the clearance between the car bottom and the road and above the car. Therefore, anti-wing is installed. At 10…20 m height above the ground a screening effect disappears which is attributed to small vehicle dimensions and a STS module body design which provides for symmetrical flow-around eliminating any cross or tilting efforts at any travel speeds.

41. Is a vehicle damaged possible so that it fails to continue its movement?

In this case it will be taken in tow by a transportation module going ahead or behind which is equipped with a special joint.

42. Why the transportation modules are so small?

Indeed, carrying capacity of a passenger (up to 20 seats) and freight (up to 5,000 kg) module contradicts to the advanced development trends including motor, railway and air transportation focused on the increased carrying capacity and overall dimension of transportation vehicles. All this requirements are dictated by the existing problems associated with travel costs and safety of traffic. However, consequences of recent traffic accidents and especially air crashes are shocking in terms of the number of simultaneous human losses caused by the large carrying capacity of transportation units.

The only mode of transportation not affected by the above trend is a passenger car. It has the same carrying capacity and overall dimension as 100 years ago and it is its main advantage which made it an individual, family-type and the most spread mass-scale transportation means (it is difficult to imagine a passenger car, for example, for 100 seats). STS is going to fill the same niche as a passenger car: its passenger will not be bound with a schedule served by a personal or public module (analogue of a taxi). Carrying capacity would depend rather on traffic organisation than on load-carrying capacity of a transportation vehicle – it is known that a sea is made up and evaporated drop by drop.

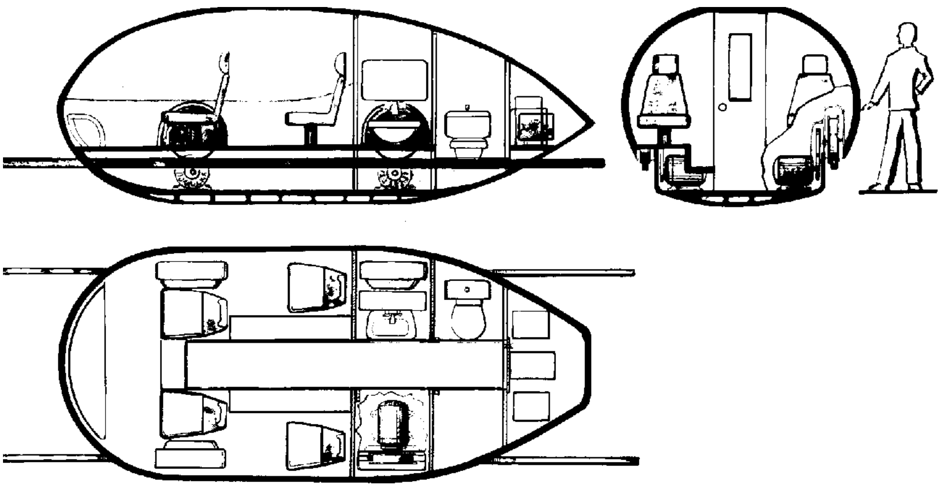
43. A passenger car is not known to be notable for its comfort. And what about a STS?

Most people are used to spend their active time in closed and dense space. Ergonomic qualities of conventional transportation modes make it possible for their passengers to view only the ground surface, road, etc.

STS gives an opportunity to combine efficient solution of its basic functional task – to provide comfortable and quick carrying of passengers to their destinations – and performance of aesthetic functions. Large glazed areas, comfort seats, soft velvet track make an ordinary road pleasant for travellers who have a chance to have a bird’s-eye view of surrounding natural landscapes. Each vehicle is equipped with air conditioning devices supplied with initially clean air taken at 20…30 m heights and lacking the smell of fuel and lubrication, sun-heated asphalt, exhausts of car flows, etc. typical for highways.

Passengers are offered a wide range of additional services such as multi-canal musical and TV programmes, inter-city telephone communication, special services for businessmen, passengers with children and invalids. STS which in terms of its dimensions is close to a mini-van is hermetic, equipped with a system of vacuum or chemical toilets which exclude waste disposal on the track.

Upon passengers’ desire a vehicle can be stopped at any of the intermediate stations, i.e. every 10…20 minutes or at any of the anchor supports, i.e. every 1…2 km (every 15…30 seconds).



Four-wheel long-distance vehicle

44. What about glaze of ice, is it dangerous?

No, it is not, as it is not for a railway road: contact mechanical stress under a steel wheel exceeding 1,000 kgf/sq.cm provides for ice crumbling and blowing off the rail, thus, making it self-cleaning. By the way, a greater hazard for a railway is associated rather with deep snow than glaze of ice to the effect that the train wheels fail to reach a rail and a train is put on its "belly". Both snow and ice pose a hazard for a car which rubber wheels characterised by very small contact stress of 5 kgf/sq.cm result in ice crushing and snow compressing. A motorway not provided with a self-cleaning capacity requires special machines to remove ice and snow from its surface. On the contrary, snow drifts are not so dangerous for a STS, even in the sites of heavy snowfalls, because the snow depth would not exceed 5 m which is lower than STS supports.

45. Maximum travel speed: its limitations and required engine power?

One of the most important advantages of a STS is associated with the fact that it does not use the now fashionable but low-efficient, energy-consuming, not safe and not reliable exotic systems such as magnet suspension including super-conductivity, air cushion, screening effect (screen flyer), turbine, jet engine, etc.

A wheel has not exhausted its possibilities which was proved by a recent (1997) record when for the first time an automobile managed to overcome sonic speed (1,200 km/h). For example, energy efficiency of a steel electric motor-wheel of a STS is more than 90% whereas the total energy efficiency of a train on a magnet suspension ("Transrapid” (Germany) is less than 15%, i.e. at the level of a steam-engine locomotive.

Problems arising at high travel speeds are caused not by a wheel but rather by track unevenness, therefore, bottoms of dried salt lakes are chosen for record routes. A string route will be even more smooth for the wheels of an electric module which is not in need of setting up records because super-high travel speeds in aerial environment are inefficient, non-economical and not harmless for people and nature. STS speed will be limited by aerodynamic qualities rather than by its wheel, track smoothness, vibration dynamics, “wheel-rail” friction contact. Therefore, special attention in a STS is focused on its aerodynamic features.

We managed to obtain unique results having no analogues in the modern high-speed transportation including aviation. Aerodynamic drag coefficient of a model passenger vehicle measured in a wind tunnel amounted to C_x = 0.075. Measures are proposed to reduce this coefficient to C_x = 0.05…0.06.

Low aerodynamic drag makes it possible for a 20-passenger vehicle with the engine capacity of 80 kW, 200 kW and 400 kW to reach the travel speeds of 300…350 km/h, 400…450 km/h and 500…550 km/h, respectively. (It should be noted that at high travel speeds in aerial environment required engine power is growing proportionally to cubic speed with 90…95% and more of its power used to overcome aerodynamic drag). It is known that as the travel speed increases the wheel-rail cohesion is going down. To reach the travel speeds of 300…350 km/h and 400…450 km/h a friction coefficient of a “wheel-rail” pair of a STS with four driving wheels is to be not less than 0.04 (to provide 100 kgf thrust) and 0.07 (to provide 180 kgf thrust), respectively, which is easily reachable.

Cohesion problems arise only at the travel speeds of 500 km/h and more which require more than 300 kgf thrust. However, this problem is also easily solved in a STS. For instance, a principally new scheme designed for a rubber-covered thrust engine-wheel of 100 kW power is capable to provide required cohesion and thrust. At travel speeds exceeding 500 km/h it is reasonable to use the thrust of a propeller put on a shaft of electromotor. Modern propellers are noiseless (noise is generated rather by an engine than a propeller) and reach 90% efficiency. At more than 600 km/h travel speeds an evacuated tube is more appropriate with its air pumped out to 10% of atmospheric pressure. However, it is a faraway future task. Today, it is quite sufficient to have travel speeds of 300…400 km/h.

46. Is everybody ready to take a risk of travelling along the strings at 20…50 m height?

It is purely psychological risk which will be easily eliminated in the future. It was time when people were afraid to travel by trains, cars, then fly by aircraft. Strange as it is, but passenger feels most safe sitting in a car, whereas a car is one of the most efficient man-made killing instruments: the annual number of people killed in road accidents (or died of after-accident injures) all over the world amounts to 990,000 and about 10 million become invalids or disabled (according to the data of the World Health Organisation; their statistics also show that the annual number of death as a result of war injures is much less – 502,000).

Car is even more dangerous for the wildlife being the cause of death of billions of animals (especially small ones) killed not as a result of accidents but by chance. It is not surprising that highways are characterised by high accident rates caused by pedestrians crossing the road at red light signal, or a moose coming in a driveway; glaze of ice, spilled machine oil, snow drift, puncture of tires especially of front running wheels; alcohol intoxication or bad general state, mood or absent-mindedness of a driver; pot holes or outside objects; uncoordinated drivers' actions, especially in the course of maneuvering at turns, by-passes, intersections, etc.

None of the above mentioned causes is attributed either to a STS or to aviation. Therefore, it is not surprising that the number of people killed in air crashes is the lowest (in absolute and relative values). However, factors resulting in aircraft crash are absent in a STS, in particular, a bird does not pose a hazard for a module whereas even a dove coming in a turbine of a plane could be a cause of a catastrophe; a STS module is not subject to a risk of icing, engine stop, shortage or cutting off fuel; bump, thunder storm clouds, lightning; it has no inflammable materials whereas fuel of aircraft tanks tend to explode or inflame when a plane is falling down, etc. Thus, a STS has all prerequisites to become the most safe mode of transportation which could be appreciated by a passenger making a choice of a travel mode.

47. What if supply current is cut off?

Each transportation module has an accumulator battery with constant compensating charge from the network. In case a line is dead currency supply is automatically switched on accumulators. Their energy reserve is enough for a module to get to the nearest station or to the next not de-energized section of the track.

48. What if a track fails to continue its operation and there is nobody to help (war, earthquake, etc.)?

Each module has an emergency hatch in its bottom part and each passenger seat is equipped with a rescue rope and seat belt to help a passenger to descend on the ground.

49. What is a maximum angle of elevation?

On a plain a STS is moving at high speeds with its seats resting upon their supporting part like seats of a conventional train. However, a STS wheel has its peculiarity – it has two (not one) rims which provides for a different wheel-rail supporting pattern within the mountainous sections of a track, i.e. through its rims like a V-belt drive. It makes it possible to increase the frictional force in a "wheel-rail" friction contact by many times and to get a maximum angle of elevation of 45…60°. Naturally, design of a rail on mountainous sections of the route will differ from that on a plain which is also true for a transportation module, its running gear and wheels. In this case a more powerful engine is also required. However, all this makes it possible to cross the mountains and mountainous passes straightforward, eliminating hairpin turns or tunnels.

50. How are terminals and stations designed?

Terminals have a ring-shaped design with a moving (rotating) platform or floor (see Fig. 1 and 2).

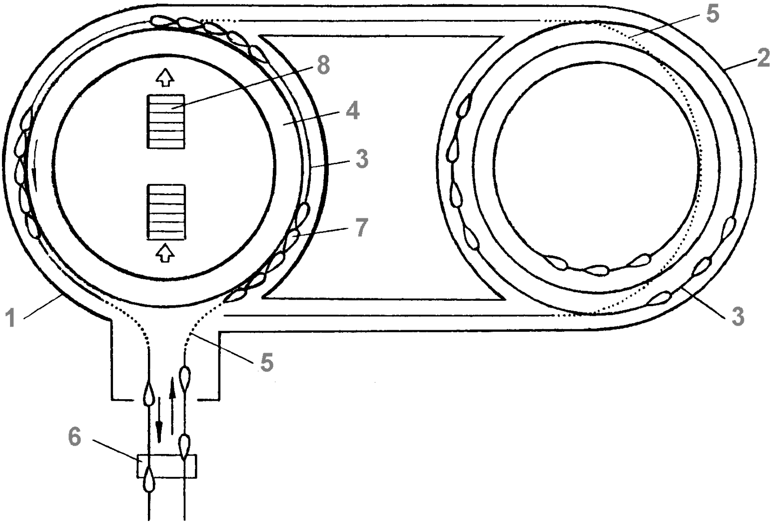


Fig. 1. Terminal scheme.

1 – terminal building; 2 – depot building; 3 – ring track; 4 – ring-shaped moving platform; 5 – switch; 6 – terminal anchor support; 7 – vehicle; 8 – entrance (exit) to the terminal.

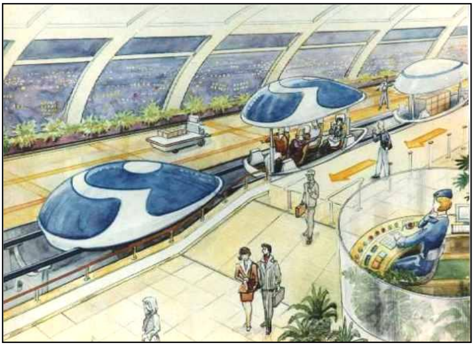


Fig. 2. Freight-passenger terminal

Terminal has about 60 m diameter which can be extended to 100 m and more depending on the intensity of passenger flows (for more than 100,000 passengers per 24 hours). Intermediate stations with intensive passenger flows will be equipped with switching devices and sheds which makes it possible to organise circulation of vehicles independent on the general traffic schedule. Stations with small passenger flows are designed as open platforms located on the route. Loading (unloading) of passengers is facilitated in the course of braking of single not fully-loaded vehicles.

51. How loading and unloading of passengers is arranged in the terminal?

Passengers entering the terminal hall make notice of a luminescent table which accompanies each vehicle (a table is fixed on a vehicle or on the wall in the form of a running line) to indicate the station name, for example, “Terminal”. If a passenger fails to find the necessary station he can get in a vacant vehicle and to press “Terminal” button on a control panel (inside a vehicle). At 0.5 m/sec. travel speed of a moving platform (with a vehicle joined to it) and 50 m diameter of a ring track passenger will have 0.5…2.5 minutes to board a vehicle.

When the saloon is closed (automatically or manually) a vehicle is detached from the moving platform and switched to the line. If for this or that reason a vehicle saloon was not closed or there were no passengers a vehicle returns to the second ring. In a similar way but in a reverse order passengers are unloaded at the destinations. In its general form a scheme reminds a luggage delivery scheme at circular transporters of modern airports. If necessary, some vehicles are sent to a depot located either in a separate building or on the other floor of the terminal.

52. How are freight terminals operating?

Freight terminals intended for automatised loading and unloading of freight modules have a ring-shaped design, like passenger terminals. They are characterised by compactness and high carrying capacity which is achieved through the original technology of loading/unloading operations and the use of specially designed containers for liquid, friable and piece freights. For example, a terminal with about 100 m diameter will have a carrying capacity of about 100,000 tonnes of oil per 24 hours (36.5 million tonnes per year) which is considerably smaller in size than, for example, a sea port of similar carrying capacity.

53. What is a maximum carrying capacity of a track?

For the rolling stock consisting of ten 10-seat vehicles (with 100 m distance between them), travel speed of 300 km/h and circulation frequency of 30 seconds during the peak hours carrying capacity of one line and the route as a whole (two lines in two directions) will be 12,000 pass./hour and 24,000 pass./hour (567,000 pass./24 hours or 210 million pass./year), respectively. In this case a track has a reserve to increase its carrying capacity without construction of additional lines.

Minimal on-line distance between freight modules will be 50 m (one module on one span; 50…100 m – minimal extreme braking distance with a deceleration parachute), therefore, maximum carrying capacity of one line is 24,000 tonnes/hour or 576,000 tonnes/24 hours (210 million t/year) or 48,000 t/hour, 1.15 million t/24 hours, 420 million t/year for a dual-way route, respectively. Actual volume of freight and passenger traffic will be by one order lower, therefore, STS routes will be operating with 10% capacity which, in the end, will contribute to their higher reliability and safety.

54. Is a STS carrying capacity higher than that of an oil pipeline?

Its carrying capacity (in one direction) is up to 210 million tonnes per year, net cost of oil transportation is 1.5…2 times lower than that of an oil pipeline. In this case it is possible to use airtight return containers of 5,000 kg capacity, equipped with an electronic information map to indicate oil composition, extraction site, etc. which prevents mixing of oil extracted in various oil fields as it occurs nowadays and facilitates isolation of light, high-sulphurous and parafin-base oil in the course of refining. Whereas a pipeline is used to transport oil only in one direction, a STS is capable to carry a variety of other goods, alongside with petrol products (such as gasoline, diesel fuel, etc), in both directions, including: ore, coal, sawn timber and other raw materials; food products, building materials, equipment; as well as shift workers, etc.

Moreover, the cost of a STS will be lower than that of an oil pipeline of a similar carrying capacity. Loading and unloading of containers will be arranged on an automatic basis in the small-scale freight terminals of about 100 m diameter.

55. What kind of freights will be carried by a STS?

STS is capable to carry any freights of 4,000…5,000 kg – at high travel speeds; freights of 10…20 tonnes at reduced travel speeds (under 100 km/h), freights of 30…40 tonnes – at special many-wheel platform. Therefore, a STS is appropriate for 99.9% of the mass-scale freights such as: oil and petrol products, coal, ore, food products, furniture, metal-rolling, building materials and structures, chemical products, special freights (liquified gases and cryogen liquids, radioactive and explosive substances, weapon), etc.

Special containers are designed for liquid, friable, piece and special cargo to be fixed with seaport, railway and automobile containers. Containers for perishable goods, for example, food products are provided with temperature control devices (in winter) and air conditioning (in summer); containers for environmentally hazardous freights will have a multi-layer high-strength envelope, etc.

56. Is there a risk of leaf falling caused by a vehicle rushing above the forest?

No, there is not. You even do not feel any air vibration standing at 10…15 m distance from a vehicle rushing at 350 km/h speed which could be attributed to its high aerodynamic qualities (aerodynamic drag coefficient – C_x=0.075) and low module energetics (engine power – 80 kW). In physics terms any transportation system has a zero efficiency coefficient and a STS is not an exception because it has zero useful transportation work: with zero cargo speed at origin and destination and approximately invariable height. In the end, all energy supplied to the vehicle engine is ejected in the form of track and ground vibrations, noise, rattle of wheels, air gusts, etc. in the environment, ultimately converted into heat.

Therefore, environmental impact is evaluated rather by the intensity of energy ejection per 1 unit of a track and energy nature, than by the travel speed. STS is characterised by the lowest energy ejection intensity per 1 unit of a track amounting to 800 J/m or 190 cal/m (against 4,000 and 20,000 J/m for "Mercedes-600" - closest to a STS in terms of its dimensions, and a high-speed train, respectively). Energy ejection is characterised by the most favourable conditions provided by a velvet, joint-free STS track, high damping, light-weight wheels which make it possible to eliminate rattle of wheels; and ideal shape of a vehicle body contributing to the elimination of aerodynamic noise (high-frequency fluctuations caused by turbulent air flows, etc.).

Ejected energy is in the form of added air mass movement and whereas the air mass is relatively large, air movement will be in the form of a slight wind with its velocity decreasing proportionally to the square of the distance from the vehicle. Furthermore, a STS route will be rather free than full of vehicles – immovable observer will see a vehicle passing by at high speed in portions of second with the next one coming only in 30…60 seconds (at the traffic intensity of 20,000…50,000 passengers per 24 hours). Therefore, the average energy ejection is very low amounting to 15…30 W/m · sec.

57. Are there any weather or other travel limitations?

There are none. A STS is not afraid of fog, rain, thunder storm, snow, hail (travel speed can be reduced under heavy hail to avoid damages in a nose part of a module; also armoured modules can be used in areas of hail hazard), glaze of ice, sand and dust storms, hurricane wind. A STS is likely to withstand a tornado waterspout which could be attributed to its high-strength construction, very low sailing effect and high flow-around qualities of building components and a transportation module (for example, tornado is beyond the capacity of modern building structures such as reinforced concrete bridges whereas STS structures are characterised by the higher specific strength, i.e. estimated per 1 unit of surface).

STS is more than any other transportation system resistant to natural disasters such as earthquakes, land slides, heavy rains, floods, high water, attack of desert sands. STS routes are not critical to difficult geographic and climatic conditions, they are easy to build in large marshy areas, jungles, permafrost, deserts with drift sands, mountains, sea shelf.

Figure below shows STS alternatives for various geographic conditions.

STS design alternatives for various geographic conditions

58. What is the traffic intensity?

The average distance (frequency) between two neighbouring 10-seat vehicles (50% loading of a 20-seat vehicle) moving at the speed of 300 km/h to carry two-way passenger flows will be as follows: 7.2 km (or 86 sec.) for the flow of 20,000 pass./24 hours; 2.9 km (35 seconds) – for the flow of 50,000 pass./24 hours; 1.4 km (17 seconds) – for the flow of 100,000 pass./24 hours. For a two-way freight traffic carried by the transportation modules of 4,000 kg carrying capacity the average distance will be as follows: 1,150 m (13.8 sec.), 580 m (6.9 sec.) and 290 m (3.4 sec.), respectively.

59. Is a track provided with accesses and switching devices?

A STS route is equipped with high-speed (for the travel speeds of 300…400 km/h), medium-speed (150…200 km/h) and low-speed (under 100 km/h) switching devices. For, example, high-speed switches will be installed at terminal accesses which will make it possible to arrange non-stop circulation of transit vehicles without deceleration, bypassing the terminal. Switches designed as elaborate engineering structures will have the length of more than 100 m.

Other sections of the track (including stations and stops) are provided with medium-speed switches to make vehicles slow down at their accesses. Traffic control system envisages special time and place for this manoeuvre which implies certain compression of a transportation flow ahead and behind a vehicle to give it 1…2 minutes for menoeuvring at several km distance from the nearest vehicles.

Low-speed switches characterised by the lowest cost and higher safety can be installed actually at each anchor support. It makes it possible for any vehicle to stop practically at any spot allocated for the purpose (information is to be given at least 5…10 minutes before the stop so that a control system could smoothly re-arrange the transportation flow).

In structural terms STS switches are close to the railway switching devices, though they have their peculiar features defined by the two-rim wheels and the need in electric insulation of rails, including a switch.

Furthermore, alongside with horizontal switches vertical devices are also possible as small weight of a transportation module makes them easy to remove to upper or lower level.

60. How to get out if a track height is, for example, 50 m?

It is much simpler and safer than in a plane flying at 10,000 m height which is unable to unload its passengers between the airports. A STS passenger can get out not only in the terminal or station, but in the interval, at any anchor support, i.e. every 1,000 m. Passenger getting in a vehicle gives a command to the on-board computer (by voice or digital code) about his destination. If passenger's choice is a support of 50 m height somewhere in the forest known for its mushrooms, he will have to use a convenient staircase located in a support body to descend to the ground (if it is a frequently visited site, it is possible to install an elevator or an escalator).

Getting off a passenger informs the traffic control system (using on-board computer) about his departure time and destination. There cannot be the slightest doubt that your order is neglected.

Loading and unloading of passengers at terminals and stations is much easier: you get in (or out) a vehicle coming to the terminal building (like modern bus stations). In this case the track height has no significance as it could go several km away from the terminal. High-speed accesses require acceleration (deceleration) lanes of more than 1,000 m length, therefore, switching devices are located several km away from the terminal to which passengers are brought by the branch lines which could enter the terminal building at the ground level.

61. Is it boring to see fragments of structures, trees, etc. swiftly flying before passenger's eyes in the window?

In a plain the highest point of a STS is its rail-string with a moving vehicle, therefore, there are no structural components before passenger's eyes (unlike railways or highways). One of the reasons why 20…30 m height was proposed for a STS route is associated with trees in order to keep them save and sound under the track, i.e. below the level of passenger's eyes and not to spoil a possibility to enjoy a bird's eye view of natural landscapes with a convenient observation sector of 100 m.

62. Are there any “rail-wheel” current collection problems entailed at high travel speeds?

No, there are not. No similar problems arise in the high-speed railways either that are provided with two (not one) current collectors installed on top (overhead) and bottom (rail) and all problems are related to current collection from immovable and flexible copper wire on the top. At high sliding speeds of current collector its trolley wire is sparking, burning, exposed to pitching and rolling as through a point contact moving at speeds of hundreds of km it has to transmit electric power estimated at hundreds and thousands of kilowatt.

At the same time a train wheel is moving (not sliding) along a rail, therefore, electric power is transmitted through a stationary contact (a wheel has zero speed within its contact zone with a rail) which has no clearances thanks to the high contact force between rigid wheel and rigid rail. This “wheel-rail” current collection scheme was used in a STS (left “wheel-rail”-right “wheel-rail”) and in this case operation conditions are more favourable for a STS current collector which requires about 100 kW input power which is by one order less than for an electric train.

63. It is known that strong, especially gusty wind is capable to destroy power transmission lines. And what about a STS?

STS track structure and supports are characterised by higher strength than high-voltage power transmission lines at approximately equal sailing qualities. Taking into account lower sailing capacity of a STS structure and vehicles, the relative track deflection under side wind of 100 km/h velocity will be 1/10,000…1/5,000 which will not have a serious impact on the transportation system operation.

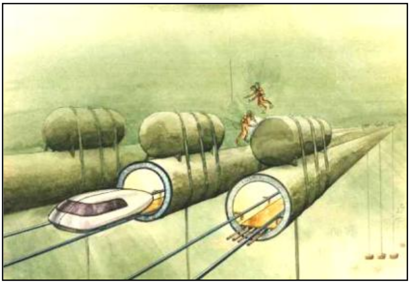
Design of a STS track and supports eliminates resonance effects under gusty wind which otherwise could result in their destruction caused by stalling flutter. In addition to the high-strength structure it could be attributed to the dip of strings which in a STS is estimated at several cm (against several meters in power transmission lines that are easy to shake like swing), strings are “enclosed” inside rigid beams (rails) that in their turn are cross-fixed to form a solid structure difficult to shake even by a hurricane, thus, it is possible to design a STS resistant to any wind, even tornado waterspout.

64. Where else is it possible to use a STS?

STS can be used as a low-speed (under 100 km/h) special purpose transportation: internal transportation to serve logging operations, slag refuse disposal, sand and gravel quarries, coal, ore, oil, gas and other deposits, garbage removal, etc. Lower transportation and traffic safety requirements of a special purpose STS in the absence of passengers will contribute to its lower (by 1.5…2 times and more) cost as compared with other high-speed string routes.

65. Is it possible to lay a STS route along the sea?

STS will become a universal mode of transportation capable to pass across the land and sea. At sea depths under 50 m, for example, a STS route put on the supports installed in the sea bottom will pass at 25…50 m height and more on the shelf above the water surface (depending on building requirements).



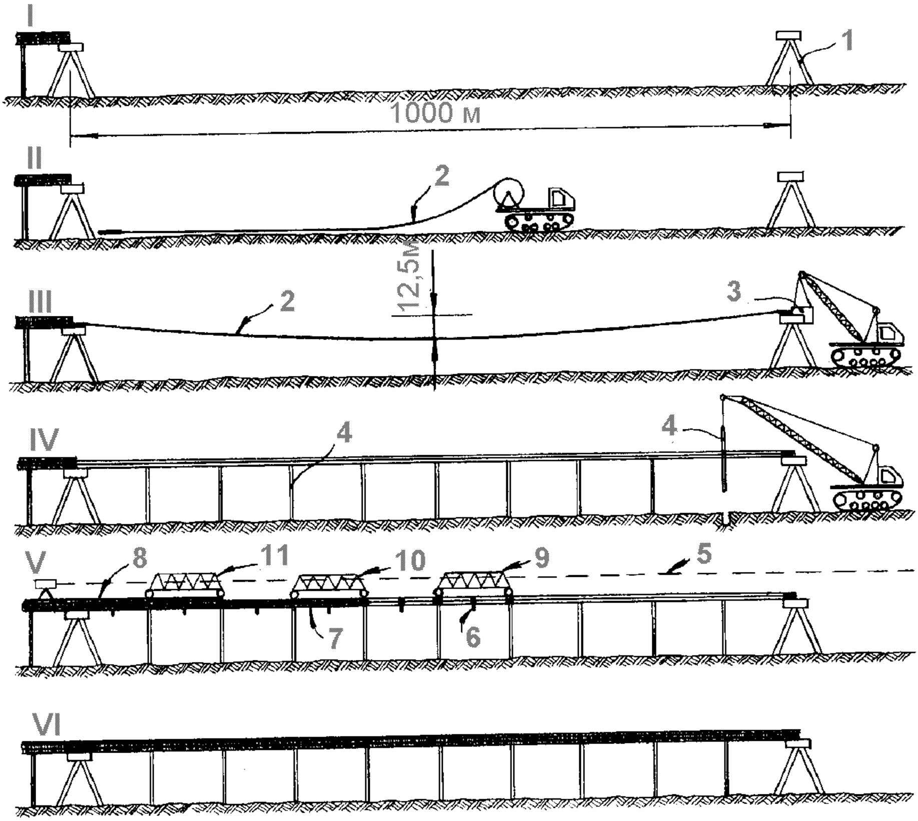
Design alternative
for a sea STS section

At greater depths a STS track can be put in a tunnel (pipe) of 2.5…3 m diameter installed either in the sea bottom (for under 500 m depth) or in the water at 50 m depth (see Fig.).

In the latter case tunnels have zero buoyancy (or to be more precise – excessive buoyancy) and require anchoring every 1…2 km in the sea bottom. Small module weight (under 5,000 kg) and low circulation frequency (on the average every 1,000 m) prevent tunnel submergence. High deflection rigidity and special tunnel design contribute to the high evenness and rigidity of a string track structure under various travel speeds irrespective of the sea (ocean) depth.

66. Does a STS require elaborate building technology?

In technological terms it was possible to start STS construction in the last century when all necessary structural and building materials, mechanisms and equipment were already available. A STS route requires much simpler building technology than a bridge with a similar span (see Fig.).



STS building technology.

1 – anchor support; 2 – cable (string component); 3 – cable adjusting mechanism; 4 – intermediate support; 5 – sight line; 6 – cross plate; 7 – rail envelope; 8 – rail head; 9, 10, 11 – technological platforms to install cross plates, rail envelope and rail head, respectively; I – installation of anchor supports; II – laying of string cables; III – string adjusting and anchoring; IV – installation of intermediate supports; V – assembly of rail components and track structure; VI – ready track section.

Prefabricated string is adjusted to the assigned length with the help of technological devices (with tensile strength used as a control parameter) and fixed rigidly, for example, by welding with anchor supports (in this case not wire itself but its special cap at the end of a string is welded).

Intermediate supports are preliminary installed either in the process of string adjustment or strengthening. When intermediate supports and strings are put in place they are tested by a technological platform capable to move independently and to fix its location against the supports.

Moving from span to span a platform is to specify the whole rail envelope, to fix its designed position, put the filler, set a rail head, cross plates and do other works necessary for track installation. All the above works are easy for mechanisation and automatisation and can be carried out irrespective of weather conditions. All this contributes to higher flow-line construction rates (about 1,000 m per 24 hours), lower labour intensity and net cost.

To eliminate micro-unevenness and micro-waviness of working surfaces of the assembled rail head and its cross gap-free joints they can be grinded away along the whole length. A special combine can be also used to fix a STS string and other stressed rail components which is intended to install assembled intermediate supports moving along the track on its walking support-legs.

Economic aspects

67. Cost of a STS in comparison with other transportation systems?

A STS has the lowest cost among other transportation systems of similar carrying capacity, comfort level and travel speed, etc. The cost of competitive transportation routes built in a plain is as follows: USD 10…15 million/km – for a high-speed railway; USD 20…30 million/km – for "Transrapid" system (train on a magnet suspension, Germany); USD 3…10 million/km – for a motorway; USD 4…8 million/km – for a mono-rail road.

A STS route is many times (3…20 times) cheaper than other known transportation systems which is attributed to its low material consumption (including its track structure and supports); and no need in construction of elevated roads, bridges, viaducts, overpasses and other high-cost structures.

68. How much are the travel costs for passengers?

Passenger fare is lower compared with other high-speed systems being at the level of a railway ticket in an open-plan carriage. Net cost will depend on a number of factors such as the track cost (amortization costs), maintenance costs, cost of electric energy, passenger and freight flows, cost of the rolling stock, estimated travel speed, etc.

Average travel cost for passengers (given are costs minus profit) carried by a STS on a plain at 1,000 distance with the average speed of 300 km/h is as follows: USD15…20 (for dual-way passenger flow of 20,000 pass./24 hours) and USD 5…10 (for 100,000 pass./24 hours and more) – see Table below with "Moscow-London" STS route taken as example.

Table

Travel costs within a STS system: "Moscow - London (Paris)"
at 2,830 km section ("Moscow - London")

Indicator	Traffic volume (in two directions)					
	Passenger traffic, thousand pass./24 hours			Freight traffic, thous. tonnes/24 hours		
	20	50	100	50	100	200
1.Given costs (at 2,830 km section): - USD/pass. - USD/tonne of freight Including:	 72,60 -	 32,71 -	 19,43 -	 - 19,99	 - 16,66	 - 15,01

Indicator	Traffic volume (in two directions)					
	Passenger traffic, thousand pass./24 hours			Freight traffic, thous. tonnes/24 hours		
	20	50	100	50	100	200
1.1. Total transportation costs, including:	66,47	26,58	13,30	6,65	3,32	1,67
- amortization allocations	25,48	10,19	5,10	2,55	1,27	0,64
- maintenance costs	15,51	6,20	3,10	1,55	0,78	0,39
- profit allocations	25,48	10,19	5,10	2,55	1,27	0,64
1.2. Rolling stock costs, total, including:	6,13	6,13	6,13	13,34	13,34	13,34
- amortization allocations	0,63	0,63	0,63	1,05	1,05	1,05
- maintenance costs	0,63	0,63	0,63	1,05	1,05	1,05
- profit allocations	0,63	0,63	0,63	1,05	1,05	1,05
- cost of electric energy	4,24	4,24	4,24	10,19	10,19	10,19
2. Number of vehicles to serve the whole route (at average travel distance of 1,000 km), number of units	1530	3820	7650	19100	38200	76400
3. Cost of the rolling stock, USD million	45,9	114,6	229,5	191,0	382,0	764,0
4. Average distance between the neighbouring vehicles in a transportation flow (single vehicles in one line):						
- time frequency, sec.	86,4	34,6	17,3	6,9	3,5	1,7
- distance, km	9,60	3,84	1,92	0,77	0,38	0,19

69. Cost of freight transportation?

Net cost of freight transportation is low compared with other modes of transportation, though the average speed accepted for calculations is rather high – 300 km/h. Average net cost per 1 tonne of freight to be carried on a plain at 1,000 distance will be as follows: USD 5…6 (for a dual-way freight flow of

50,000 t/24 hours), USD 4…5 (100,000 t/24 hours) and USD 3…4 (200,000 t/24 hours).

70. Cost of 1 km of a STS route?

STS cost differs depending on a number of factors such as: one- or two-way track; on a plain, mountains, sea shelf, tundra, desert; low or high supports, etc. The cost is also strongly related to the infrastructure development (number of terminals, stations, depots, freight terminals, etc.).

The cost of 1 km of an average, well-equipped two-way STS route of serial production will be as follows: USD 1…2 million – on a plain; USD 2…4 million – in the mountains; USD 2…4 on sea shelf above water and USD 5…10 million – in a tube (afloat in the water, on or under sea bottom). In this case the cost of a two-way string transportation line itself (track structure and supports) will be considerably lower amounting to: USD 0.8…1.2 million - on a plain (for average support height of 15…25 m); USD 1.5…2 million – on sea shelf and mountains (for average support height of 35…50 m) and USD 0.5…0.8 million – in a tube. One-way track will be 30…40% cheaper than a two-way road. Tables below show the average material consumption and cost per 1 km (not including the cost of terminals and infrastructure).

Average material consumption and cost per 1 km of a two-way STS route laid on a plain (with “Berlin-Moscow” STS route taken as example)

Structural component	Material	Material consumption per 1 km		Approximate cost, thousand USD/km
		mass, tonnes	volume, cub. m	
1. Rail-string, total, including:				450
1.1. Rail head	Steel	96	-	190
1.2. Rail envelope	Aluminium sheet	5	-	25
1.3. String	Steel wire	79	-	160
1.4. Filler	Composite	-	45	20
1.5. Glue mastic	Composite	1	-	10
1.6. Protective string envelope	Polymer	4	-	20
1.7. String hydro-fuge insulation	Polymer	1	-	10
1.8. Other		-	-	15
2. Cross plates		-	-	20
3. Intermediate supports (15 m height), total,		-	-	190

Structural component	Material	Material consumption per 1 km		Approximate cost, thousand USD/km
		mass, tonnes	volume, cub. m	
including:				
3.1. Poles	Reinforced concrete	-	96	70
3.2. Straight arch and brace	Reinforced concrete	-	46	35
3.3. Metal structures	Steel	10	-	20
3.4. Pile foundation	Reinforced concrete	-	48	48
3.5. Other		-	-	17
4. Anchor supports (15 m height), total, including:		-	-	105
4.1. Support body	Reinforced concrete	-	52	38
4.2. Pile foundation	Reinforced concrete	-	36	36
4.3. Metal structures	Steel	2	-	5
4.4. Anchor fixing	Steel	2	-	10
4.5. Other		-	-	16
5. Excavation and earth moving		-	-	20
6. Rail power supply		-	-	40
7. Control system of supports and track condition		-	-	10
8. Control system of traffic flow		-	-	20
9. Emergency power supply system		-	-	20
10. Traffic flow regulation system		-	-	30
11. Emergency stop platform		-	-	20
12. Design/survey works		-	-	50
13. Cost of land allocation and development		-	-	50
14. Other works		-	-	25
15. Unforeseen expenditures		-	-	50

Structural component	Material	Material consumption per 1 km		Approximate cost, thousand USD/km
		mass, tonnes	volume, cub. m	
TOTAL:				1100

Average material consumption and cost per 1 km of a two-way sea (above-water) STS route (with “Sochi-Adler” STS route coming along the Black Sea shelf taken as example)

Structural component	Material	Material consumption per 1 km		Approximate cost, thousand USD/km
		mass, tonnes	volume, cub. m	
1. Rail-string, total, including:				400
1.1. Rail head	Steel	96	-	144
1.2. Envelope	Aluminium sheet	5	-	25
1.3. String	Steel wire	79	-	120
1.4. Filler	Composite	-	45	20
1.5. Glue mastic	Composite	1	-	5
1.6. Protective string envelope	Polymer	4	-	20
1.7. String hydrofuge insulation	Polymer	2	-	10
1.8. Other		-	-	40
2. Cross plates		-	-	40
3. Supporting cable	Steel wire	79	-	160
4. Supporting structure	Steel	32	-	50
5. Intermediate supports (35 m height), total, including:		-	-	380
5.1.Poles	Reinforced concrete	-	94	47
5.2. Straight arch and brace	Steel	34	-	51
5.3. Top structure	Steel	8	-	16
5.4. Underwater support section and foundation	Reinforced concrete	-	175	88
	Concrete	-	259	52
	Steel	24	-	36
5.5. Hydrofuge insulation of underwater support section	Composite	5	-	15
5.6. Painting of above-water structures	Paint	4	-	12
5.7. Dielectrics	Composite	-	-	26
5.8. Other		-	-	37

Structural component	Material	Material consumption per 1 km		Approximate cost, thousand USD/km
		mass, tonnes	volume, cub. m	
6. Anchor supports (35 m height), total, including:		-	-	270
6.1. Support body	Reinforced concrete	-	102	51
6.2. Underwater section of support and foundation	Reinforced concrete	-	92	46
	Concrete	-	204	41
	Steel	26	-	39
6.3. Hydrofuge insulation and painting of structures	Composite	3	-	9
6.4. Metal structures	Steel	12	-	18
6.5. Anchor fixing	Steel	4	-	20
6.6. Dielectrics	Composite	-	-	18
6.7. Other		-	-	28
7. Excavation and earth moving works		-	-	20
8. Rail power supply system		-	-	40
9. Control system of supports and track condition		-	-	20
10. Control system of traffic flow		-	-	20
11. Emergency power supply system		-	-	20
12. Traffic flow regulation system		-	-	30
13. Emergency stop platform		-	-	20
14. Design/survey works		-	-	50
15. Cost of land allocation and development		-	-	10
16. Other works		-	-	50
17. Unforeseen expenditures		-	-	70
TOTAL:				1650

71. What is the structure of construction expenditures for a STS route?

A STS complex includes: stationary facilities (terminal, stations, depot, freight terminals, repair garages, sub-stations, control system, signalling, communication, switching devices) which require 30…50% of the total expenditures. The share of a track structure and supports amounts to 25…35% (with 15…25% for a track structure and 10…15% - for supports). Other costs include: design, adaptation of research and pilot design results including a pilot track section – 5…10%, rolling stock – 5…10%, other expenditures – 10…15%.

72. What defines the cost of passenger tickets?

Compared with other high-speed transportation systems a STS is characterised by a very low net travel cost, thus, the fare should be raised to ensure a profitability of 100…200% (which will make it possible to pay back the expenditures during 3…5 years).

The structure of expenditures (for 100% profitability) is as follows: balance profit – 50%, track and rolling stock amortization – 22%, maintenance costs – 16%, electric energy– 12% (for average vehicle speed of 300 km/h).

73. Cost structure of freight traffic at 100% profitability?

Balance profit – 50%, electric energy – 30% (for average vehicle speed of 300 km/h), track and rolling stock amortization – 11%, maintenance costs – 9%.

74. Cost of transportation will in many respects be defined by the cost of electric energy?

It should be remembered that a STS is a high-speed transportation associated with considerable power consumption (by the way, less than other high-speed transportation modes) to gain the necessary speed. At the same time the cost of a string route is very low, the share of amortization and maintenance costs is reduced and energy consumption is approximately invariable. It is especially true for the net cost of freight traffic with the share of energy costs amounting to 60% and 80% for the travel speeds of 300km/h and 400 km/h, respectively. For passenger traffic this share is lower amounting to 25% (travel speed – 300 km/h) and 30% (travel speed – 400 km/h).

75. Is the cost of oil transportation by a STS lower than by a pipeline?

The cost is by 1.5…2, or in some cases 2.5…3 times lower which will depend on price-formation policy. A STS route will be repaid not so much by oil transportation as by passenger and freight traffic including food products, building materials and structures, chemical and petroleum products, etc.

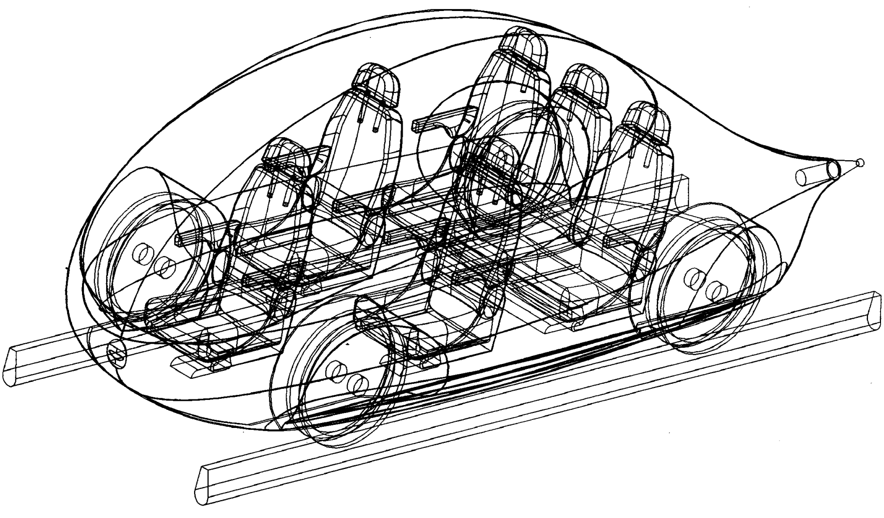
76. What cost of building materials and structures was assigned to calculate the cost of string routes?

The following integrated prices were used as a basis to specify the cost of structures: USD 1,500…5,000/t – assembled metal structures depending on their complexity and steel mark; USD 5,000/t – aluminium structures; USD 750…1,000/cub. m – assembled reinforced concrete structures and USD 500/cub. m – solid reinforced concrete; USD 200/cub. m – concrete. The cost of terminals and technological premises was estimated at USD 3,000/cub. m – terminal building (general construction works plus engineering and technological equipment), USD 1,500/cub. m – depots and garages and USD 1,000/cub. m – area of freight terminals provided with basic services.

77. What is the rolling stock cost?

The cost of a STS rolling stock can be evaluated against the cost of a passenger car which in terms of its dimensions and design is very close to a STS vehicle. The cost of electric engines for a STS of serial production with 25…50 kW power is 1.5…2 times lower than that of an internal-combustion engine of equal power; STS engines are characterised by higher reliability, durability and are easy for maintenance and service. A body of a STS transportation module is cheaper than that of a car of similar size which is attributed to its simple design (lack of radiator, doors, luggage carrier, hood, headlights, marker, braking and other lights, windshield wiper, window raiser, etc.).

High-speed 6-seat passenger vehicle alternative



Undercarriage and suspension of a STS vehicle is also simpler and of lower cost than in a car (no unreliable and high-cost rubber tires, wheel turning mechanisms, simpler operating mechanism for turning moment of nonrotatory wheels, no cross-country travel requirements, etc.).

The cost of rated engine speed and turning moment systems (control block in a STS and gear box, clutch, fuel supply, etc. in a car) is approximately the same in both transportation modes. Drive regulation system of a STS vehicle is much cheaper and simpler as the number of parameters is less: travel speed, distance to the nearest vehicles and on-line location (coordinates).

Driving a car is a complicated task which in spite of the progress of computerisation today is only solvable by driver's brain (driver's factor is very important not only for car driving but also for its cost: nowadays people all over the world – millions of people - spend many hours driving a car, though being very short of time). In a STS vehicle this problem is solved by a low-cost controller provided with appropriate software to be controlled and managed by linear computers integrated in a network. Control system of a car in addition to a driver and executive mechanisms (steering wheel and column, wheel turning mechanisms, clutch pedal, brakes, gear shift mechanism, etc.) includes a system of information visualisation necessary for driving control which is absent in a STS, in particular, windshield wiper in a wind screen to provide for its cleanliness and visibility, headlights and parking lights, marker lights, instrument panel, mirrors, horn signal, etc.

Interior design is approximately the same for a STS vehicle and a car and can be varied depending on customer desire. Furthermore, a number of components is absent in a STS vehicle and transportation system as a whole, for example: fuel tank (and, consequently, the whole chain of accompanying elements such as filling stations on a track, oil refinery plants to produce gasoline and diesel fuel, oil pipelines, oil wells); fuel feed system; exhaust outlet, silencing and combustion system (for example, more strict environmental requirements imposed in the recent years in a number of countries resulted in considerable growth in the cost of cars).

In view of the above said it will be appropriate to forecast that under serial production the cost of a STS vehicle will be 1.5…2 times lower than that of a passenger car or a mini-bus of similar carrying capacity and comfort and, therefore, it will be more accessible for individual use (in the future thanks to STS advantages it will be possible to develop an extensive network of string transportation similar to the existing highway network).

78. What was the estimated cost of a passenger vehicle and transportation module and how it affected the net cost of travel?

Estimated cost of USD 50,000 and USD 20,000 was takes for a 10-seat passenger vehicle and freight transportation module (5,000 kg carrying capacity), respectively. Obviously, these figures are overestimated. Nevertheless, the share of the rolling stock in the total travel cost (amortization and maintenance costs) amounts to as little as 2…6% and 10…20% for passenger and freight traffic, respectively. It means that the rolling stock is not critical to its loading, thus, it is possible to increase the share of 1…5-seat vehicles and to improve their comfort (to provide toilets, washroom, shower, bath).

Moreover, a number of vehicles can be arranged as a hotel single-room or office (to include furniture, computers, modern satellite communications, fax machines, etc.), thus, to be used not only as a means of transportation but as a place of work (especially during mission trips) or rest. Even if the cost of such vehicle is USD 100,000 its fare will be only by 20…30% higher than in other transportation modes.

79. Is it possible to take with you a passenger car and how much will it cost?

Passenger can register his personal car as like any other cargo under 5,000 kg. Taking into account the fact that a car is oversized cargo it will be transported in a specially equipped transportation modules with higher power engines. If a trip is not very long (0.5…1 hour; 150…300 km distance) passenger may stay in a car or to take a passenger vehicle. In this case a car will arrive in a destination simultaneously with its owner who can remove to it immediately. Net cost of a car (1,500 kg mass) transportation, for example, from Berlin to Moscow (distance – 1,830 km) will amount to USD 15…20.

80. How soon STS track expenditures will be paid back and how high are financial risks?

Recoupment period of a STS system depends on the following main factors: loading (volume of passenger and freight traffic), normative operation profitability (and related ticket price), maintenance costs and the cost of electric energy. For example, recoupment period for a concrete track – “Berlin-Moscow” (1,830 km), ticket price – USD 40/pass. (140% profitability) and passenger flow of 50,000 pass./24 hours – will be 8 years. In this case the annual profit will amount to USD 480 million (the cost of a track including infrastructure and the rolling stock is USD 3.9 million). For passenger flow of 100,000 pass./24 hours the track expenses will be paid back during 3.5 years (profit – USD 1.1 billion/year). Travel time to come from the centre of Berlin to the centre of Moscow by a STS even at relatively low average travel speed of 300 km/h will be approximately the same as by plane (about 6 hours) but more safe and comfortable. Therefore, it is appropriate to compare a STS fare with air fare to show that USD 60/pass. is not a high price for a ticket (at 260% profitability). Then, the annual profit of a track will be USD 800 million and USD 1.6 billion for passenger flows of 50,000 and 100,000 pass./24 hours and recoupment period of 4.8 and 2.4 years, respectively.

Financial risks will be minimal because it is a financially sustainable project. Even at 20% loading of the target traffic volume the route will not be unprofitable to give but a small profit. In all our examples the cost of electric energy was taken as USD 0.05 kW/hour.

81. What economic niche - in an individual country or in the world as a whole – is opened by a STS?

Almost 100 years ago Henry Ford with his automobilisation programme managed to make a revolution not only in the USA economy but in the world as a whole. Economic potential of a STS is not less. In its essence and scale a STS is comparable with Internet. Potential niche of a string transportation in the world economy exceeds USD trillion which, for example, is larger than a niche created 20 years ago by Bill Gates and his "Microsoft" Corporation, then unknown and now the richest man of a planet. Potential volume of orders on a STS in a number of countries such as Russia, China, India, USA exceeds USD 100 billion each.

82. How much a track cost depends on the ground features and relief of the site?

The cost of transportation lines is not strongly dependent on the ground features of the site, therefore, STS routes can be built in difficult of access areas such as deserts, marshlands, permafrost, taiga, tundra, jungles, ocean shelf, mountains, etc. For example, if ground features require increased height of supports (from 15m on a plain to 50 m on a rugged terrain), the track cost will be increased only by 20…25% because the share of supports in the total system cost is small (10…15%). Cost increase will be approximately the same for a string route passing across marshland area, desert, permafrost, etc. resulting from the need in additional strengthening of supports and piles.

Environmental aspects

83. What is a planetary environmental impact of a large-scale STS application?

Firstly, consumption of non-renewable energy carriers (such as oil and petroleum products, coal, gas), non-metalliferous materials, ferrous and non-ferrous metals will be reduced which results from the low material- and resource-consumption of a STS including its track and supports which do not require construction of embankments, depressions, overpasses, viaducts, bridges and other resource-consuming facilities.

Secondly, it contributes to lower environmental pollution as a result of: use of electric energy being the most clean energy type; low specific energy consumption (5…10 times less than a car); cautious attitude to vulnerable eco-systems (tundra, permafrost, jungles, marshlands, etc.); use of alternative environmentally sound energy types (wind, sun, etc.).

Thirdly, alienation of fertile agricultural lands for string routes will be reduced because STS routes do not require large land allocations (less than 0.1 ha/km, i.e. the same as for pedestrian or walking path), construction of tunnels, cutting of woods, demolition of buildings.

84. Noxious atmospheric emissions as compared with other transportation modes?

Average noxious atmospheric emissions from motor transportation and high-speed railways amount to 10 g per 1 pass./km and about 0.6 g per 1 pass/km, respectively.

Aviation is responsible for the greatest atmospheric pollution. Summary noxious atmospheric emissions from modern aircraft reach 300…400 g per 1pass.km. The bulk of aircraft emissions is concentrated within the airport zones, i.e. in the vicinity of large cities, generated by aircraft flying at low heights and engine reheating. At low and medium heights (up to 5,000…6,000 m) nitrogen and carbon oxides remain in the atmosphere for several days after which they are washed away as acid rains. At upper heights aviation constitutes the only source of pollution with noxious substances capable to stay in the stratosphere much longer - about 1 year. Even conversion to hydrogen aircraft engines will not solve the problem. Exhaust products of engines harmless near the earth in the form of water vapor are converted into ice crystals at upper heights having a screening effect.

Noxious exhausts of a STS are less that 0.1 g per 1 pass./km, i.e. lower than emissions from a high-speed railway, which results from the lack of dust-generating embankments and gravel cushion and lower deterioration of STS rail, wheels and brake shoes.

Moreover, STS vehicles will be air-tight, provided with vacuum or chemical toilets to exclude environmental pollution with vital activity products, garbage and various technological wastes which is to be removed in special garbage collectors in depots. At the same time as seen from the experience a stripe of land along the highways and railways is exposed to heaviest contamination with passengers' wastes.

Design of freight STS containers excludes leakage of liquid goods (they have no pumps, breech mechanisms, seals, etc. which could be a source of leakage) and spilling of friable freights. Crash could result in derailment of only one vehicle (extreme braking distance of the next vehicle will be less than the distance between two vehicles) with small freight and in this case a parachute is capable to reduce container speed to prevent it from destruction when falling to the ground.

At the same time railway accidents result in the heaviest environmental pollution with tonnes of transported chemical products. Accidents at oil and petroleum product pipelines are often accompanied by atmospheric emissions of thousands tonnes of oil and petroleum products, especially in resource extracting northern regions of Russia characterised by very sensitive eco-system.

Noxious emissions and other key environmental indices are given in Table below.

Key environmental characteristics of various transportation systems (passenger flow - more than 1,000 passenger/hour, freight flow - 1,000 tonnes/hour)

Mode of transportation	Specific energy-resource consumption (litres of gasoline per 100 passenger/km or tonnes/km		Noxious emissions kg/100 passenger/km (or 100 tonnes/km)	Land requirements** ha/100 km
	Passenger traffic	Freight traffic		
1. Railways (up to 100 km/h):				
• arterial	1.1 - 1.4*	0.7 - 1.0*	Over 0.1	300 - 400
• local	1.2 - 1.5*	0.9 - 1.4*	-#-	-#-
• city-wide:				
- underground	1.3 - 1.7*	-	-#-	-
- tram	1.9 - 2.1*	-	-#-	50 - 100
2. Motor transportation (100 km/h):				
• individual car:				
- within the city limits				

Mode of transportation	Specific energy-resource consumption (litres of gasoline per 100 passenger/km or tonnes/km		Noxious emissions kg/100 passenger/km (or 100 tonnes/km)	Land requirements** ha/100 km
	Passenger traffic	Freight traffic		
(average load of 1.6 passengers)	4.7 - 6.3	6.6 - 11.1	over 1	200 - 300
- beyond the city limits (average load of 3.5 passengers)	1.5 - 1.7	5.1 - 9.2	-#-	300 - 500
• bus				
- within the city limits	2.1 - 2.3	-	-#-	200 - 300
- beyond the city limits	1.4 - 1.7	-	-#-	300 - 500
• trolley-bus	1.9 - 2.5*	-	over 0.1	200 - 300
3. Air transportation				
• long-distance (900 km/h)	4.7 - 9.2	51 - 73	over 10	20 - 50
• local (400 km/h)	14 – 19	152 - 202	over 50	10 - 20
4. Sea transportation (50 km/h)	17 – 19	0.38 - 0.95	over 10	5 - 10
5. River transportation (50 km/h)	14 – 17	0.57 - 1.4	-#-	2 - 3
6. Oil pipelines (10 km/h)	-	0.51 - 0.57	over 1***	50 - 100
7. Gas pipelines (10 km/h)	-	5.7 - 6.1	over 1***	-#-
8. Conveyer transportation (10 km/h)	-	4.7 - 9.2*	over 1	-#-
9. Hydro-transportation (10 km/h)	-	2.3 - 4.7*	over 0.1	-#-
10. Cable-rope roads (10 km/h)	0.3 - 0.5*	0.95 - 1.9*	-#-	20 - 30
11. Train on a magnet suspension (400 km/h)	3.5 - 4.5*	-	-#-	100 - 200
12. High-speed railway (300 km/h)	2.5 - 3.5*	-	-#-	300 - 500
13. Monorail (100 km/h)	1.5 - 2.5*	-	-#-	50 - 100
14.String transportati-				

Mode of transportation	Specific energy-resource consumption (litres of gasoline per 100 passenger/km or tonnes/km		Noxious emissions kg/100 passenger/km (or 100 tonnes/km)	Land requirements** ha/100 km
	Passenger traffic	Freight traffic		
on**** (passenger - 10 seats; freight - 5 tonnes of freight) at the speed of:				
- 100 km/h (15 kW engine power)	0.17*	0.17*	below 0.01	10 - 20
- 200 km/h (35 kW engine power)	0.20*	0.20*	-#-	-#-
- 300 km/h (90 kW engine power)	0.34*	0.34*	-#-	-#-
- 400 km/h (200 kW engine power)	0.57*	0.57*	-#-	-#-
- 500 km/h (400 kW engine power)	0.91*	0.91*	-#-	-#-

* estimated for 1 litre of gasoline = 8.78 kW/hour of electric power;
** road including infrastructure;
*** spilling of oil or petroleum products, natural gas emissions;
**** estimated by analogy with other modes of transportation.

85. Electric energy is harmless when consumed by a STS, however, it results in environmental pollution when generated by a power plant?

Hazard is associated no so much with environmental pollution as with concentration of noxious substances. Air, water and food products contain all chemical elements included in Mendeleyev's periodic table that are harmless under appropriate concentrations. Special survey showed a direct relationship between morbidity rate, especially among children, and degree of environmental pollution. For example, in experts' opinion this cause (environmental pollution) is attributive of the reduced life expectancy in Russia approximately by 3…5 years.

According to the estimates substandard water quality "is responsible" for the reduction of life expectancy by 2…3 years. Contribution of acute and chronic food intoxication in reduced life expectancy is estimated at not less than 1…2 years.

Transportation, especially in urban areas is the major source of air pollution caused by atmospheric exhausts immediately in the human living environment. To have a more clear picture let us make a theoretical experiment:

let us take the lowest power transportation vehicle with internal-combustion engine - a moped - and electric appliance of similar power, for example, an iron. Both of them we switch on in our flat (their power is equal). In a minute we'll have the following three alternatives: 1) to use a gas mask not to die of dyspnea; 2) to switch off a moped and to use a bicycle; 3) to invent a transportation vehicle which provides for power consumption as safe as an iron and excludes the need in pushing pedals as a bicycle. We come across similar situations every day and not in theory but in real life, in the house we all live in which is something more than our flat, with thousands or even millions of moving vehicles and not mopeds but rather much more powerful and environmentally hazardous cars.

In fact, heat power plants give rise to environmental pollution but in terms of one unit of power this pollution is lower than that generated by cars and it is observed far from the population concentrations. There are also other, less hazardous or environmentally safe power plants such as hydro-power, nuclear, tidal, geothermal, wind and solar electric power stations.

Furthermore, STS will contribute to the promotion of autonomous energy supply systems based on renewable energy sources such as wind and sun. In terms of direct environmental impact wind energy is one of the most clean energy sources. It does not generate noxious atmospheric emissions and water contamination, does not result in the depletion of limited non-renewable mineral resources and transformation of water regime.

There are principal schemes of wind and solar power plants with vertical axis of rotation which could be combined with STS supports and track structure. It could result in a sharp reduction of capital costs for their construction and maintenance as they do not need any access roads, power transmission lines to supply energy users, etc.

For STS needs it is enough to have an energy source of 100…200 kW power or two wind power stations each of 50…100 kW installed at 1 km distance along the track with their maximum number corresponding to the number of supports, i.e. 10…20 units/km to generate a summary power of 500…2,000 kW/km (for a track characterised by moderate and strong winds). Therefore, the total power of wind power stations of a STS will amount to 0.5…2 million kW per each 1,000 km (at the average wind velocity of 10 m/sec.), the net cost of energy generation will be within USD 0.02/kW and the recoupment period of 6 years. Therefore, in addition to its autonomous energy supply source a STS could become a powerful electric power plant capable to meet the needs of surrounding areas. In this case it is not necessary to have high-cost and environmentally hazardous high-voltage power transmission lines as users' energy supply will be facilitated directly by a STS.

86. What are land requirements for a STS compared with other transportation land users?

A high-speed motorway (including segregation lanes, numerous traffic exchanges in various levels such as “clover leaf” , acceleration and deceleration lanes, recreation parking facilities, filling stations, etc.) requires land allocation in the amount of 5…8 hectares per 1 km of the road. High-speed railway requires special enclosure on both sides and noise protective screens (which also poses an insurmountable obstacle for wild and domestic animals, agricultural machines, etc.). On the whole these roads require land allocations in the amount of 3…4ha/km (Germany data).

Land allocation for modern airports is comparable with right-of-ways for the high-speed railway roads and for this purpose more valuable lands located in the immediate vicinity of cities are used.

As to a STS, it does not require embankments, tunnels bridges, overpasses and other similar facilities associated with large land requirements. Land requirements for one supporting mast and one anchor support amount to about 1 sq. m and 10 sq. m, respectively. Therefore, the total right-of-way along the whole length of a STS route will occupy less than 100 sq. m, i.e. 0.01 ha of land and its conditional width will be within 10 cm which is considerably smaller than land requirements for a pedestrian or walking path.

87. What damage could a STS construction cause to nature? What about other transportation systems?

A string transportation system is characterised by environmental safety not only in the course of its operation but at the stage of construction as well. Special technological equipment (technological platforms and building combines) used for its construction does not require access roads as all necessary building materials and components will be delivered to the construction site along the ready track sections.

Furthermore, its construction implying the use of piled foundation could fully eliminate excavation and earth moving works which could damage the layer of soil with its humus accumulated during millions of years. STS could pass through any terrain without any embankments or land excavation whereas, for example, a modern highway or railway construction is associated with earth removal in the amount of 10,000…50,000 cub. m and 100,000 cub. m for mountainous country. STS is not critical to a span length, therefore, there is no need in cutting of forests or even free standing trees as it is possible to displace any support, if required.

STS is characterised by very low material consumption for its construction which makes it most environmentally clean in technological terms. For example, material consumption for a one-way STS route will be the same as for two railway rails and ½ of the total number of sleepers for a road of similar length (and in this case railway will require additional ½ of sleepers, contact network with copper wire and supports, powerful gravel cushion, earth embankment, bridges, overpasses, viaducts, etc.)

Thus, a STS does not require a great number of blast furnaces, ore, mines (necessary for steel and copper production), cement plants and manufacturing of reinforced concrete products, sand, gravel quarries, intensive motor and railway traffic to deliver building materials, access roads, etc. which could produce additional, sometimes irreversible environmental impact.

88. How heavy is a STS module impact in terms of soil vibration and noise?

A STS module has no projecting parts except its narrow wheels extended for 10 cm from the body; it does not require windshield wipers and headlights (as it is driverless) which at high speeds could be a source of noise. A vehicle body has a perfect aerodynamic shape (aerodynamic drag coefficient C_x=0.075), flow-around is symmetrical not resulting in side or tilting forces, no air flow turbulence (that are especially noisy). Wheels can be made of light metal alloys (with 500…1,500 kgf load per 1 wheel) with the total mass of about 20…30 kg.

Therefore, mass of a STS vehicle will be, for example, by hundreds of times less than that of a train and its length – by tens of times shorter; mass of a spring-free part is tens of times less, track evenness much higher (is there anything more straight than a tight strained string?). Thus, compared with a high-speed train a STS vehicle is a much weaker source of noise and soil vibration. A system of internal and support dampers capable to reduce low- and high-frequency track vibrations will also contribute to lower noise impact of a STS track structure.

89. What are other (non-conventional) hazardous impacts of a STS, for example, electromagnetic radiation as compared with other transportation modes?

STS is a low-voltage line (of 1,000 V voltage), thus, it does not generate electromagnetic pollution and can pass at large heights (up to 100 m) above housing estates, agricultural lands, natural reserves and parks. The lack of sliding electric contacts in a "vehicle-contact network" pair , low (by tens of times as compared with a railway) electric capacity of the rolling stock exclude environmental pollution with radio noise. A STS system is free of specific impacts such as powerful electromagnetic pollution of radar and radiation in aviation (during a many-hour flight each passenger is exposed to additional radiation caused by natural cosmic gamma-radiation reaching 300…400 microroentgen/hour against 20mr/h being a standard).

Social and political aspects

90. What are socio-political advantages of a large-scale STS use?

The major socio-political advantages are as follows:

1. Increased communication capacity (business and personal contacts, tourist trips, excursions and recreation trips including long-term recreation and weekends, etc.).

2. Wider possibilities: to work further from home without changing habitual place of residence; to develop sustainable residential zones (housing estates) within the walking distance of STS; to build linear cities open to nature along STS routes; to provide urgent medical aid; not to interfere in human traditional habits in the sphere of transportation services (for example, a possibility to travel at longer distances with a personal car at reasonable prices).

3. Individualisation of travel with the use of a STS transportation module as a personal mode of transportation at more affordable price than a car.

4. Reduced number of accidents at other transportation modes as a result of attraction of a certain part of passenger and freight traffic by a STS (annually about 990,000 people are killed in road accidents including after-injury deaths and millions of handicapped).

5. Better protection of transportation-energy and communication systems from natural disasters (such as flood, land slides, earthquakes, tsunami) and terrorist actions thanks to the interaction of STS control components.

6. Improved transportation qualities: all-weather operation (irrespective of fog, snow, glaze of ice, sand storm, etc. and other unfavourable weather conditions); universal use (including land and sea sections).

7. Contribution to the formation of integrated, interrelated and more safe global environment.

91. Socio-economic advantages of a large-scale STS use?

The major socio-economic advantages are as follows:

1. Reduced share of financial resources necessary for the long-lasting construction projects: low capital intensity of a STS (considerably lower than for any other high-speed transportation system, for example, tens of times lower than for a train on a magnet suspension; shorter recoupment period (3…5 years).

2. Reduced cost of transportation service, higher accessibility and attractiveness for all population groups at higher service quality (speed, comfort, safety).

3. Accelerated and improved integration and cooperation economic links both at the national and international level.

4. Easy access to develop hard to reach areas such as deserts, marshlands, permafrost, taiga, tundra, jungles, ocean shelf, mountains, etc. as the cost of STS lines in not strongly dependent on the ground features of the site.

5. No need in construction of special power transmission and communication lines including fibro-optic ones that are easily integrated with STS.

6. Possibility to form a global high-speed STS infrastructure within short time limits (during 10…15 years) which will have a multiple effect in other industrial sectors.

92. How a STS could contribute to demographic problems solution?

Along STS routes characterised by environmentally sound infrastructure and noiseless vehicles it is possible to build linear cities located within the walking distance and harmoniously integrated in the natural environment. In this case it is not necessary to cut forests, to build highways, etc. resulting in the deterioration of biogeocenosis within the development zone. It will be easy to promote agriculture and environmentally friendly industries; to form the spots of rationally organised society. Construction of linear cities will be associated with lower capital investments than conventional development. Simply, it will give more benefits for a man because living in normal natural and social conditions will be more important than any material possessions. Thus, the first steps will be made towards a new future society built rather on harmony with nature than on opposition.

It should be remembered that land is the major resource used by the existing transportation (first of all high-speed) systems and what is more important – the most valuable resource. In Europe and especially in Western Europe the cost of 1 hectare of land is estimated at millions of dollars as it is either land withdrawn from agricultural use or allocated at the expense of reduced recreation zones or withdrawal from possible development which results in higher built-up densities and deteriorated living conditions of millions of population. For example, some Western experts forecast that if China orients its policy to the large-scale construction of high-speed roads which require allocation of more than 3 ha of land per 1 km, in the 1st quarter of the 21st century it will be in the face of famine that by its scale is comparable with that of the period of cultural revolution which took the lives of more than 30 million people.

STS supports require as little as 0.01 ha/km of land and if they are designed in the form of buildings which in their aggregate will make a linear city, there is no need in additional land allocations. Moreover, a linear city could be built on a so far undeveloped but suitable for living site, for example, a sea shelf located at 1…2 km distance away from the shore (see Fig.).

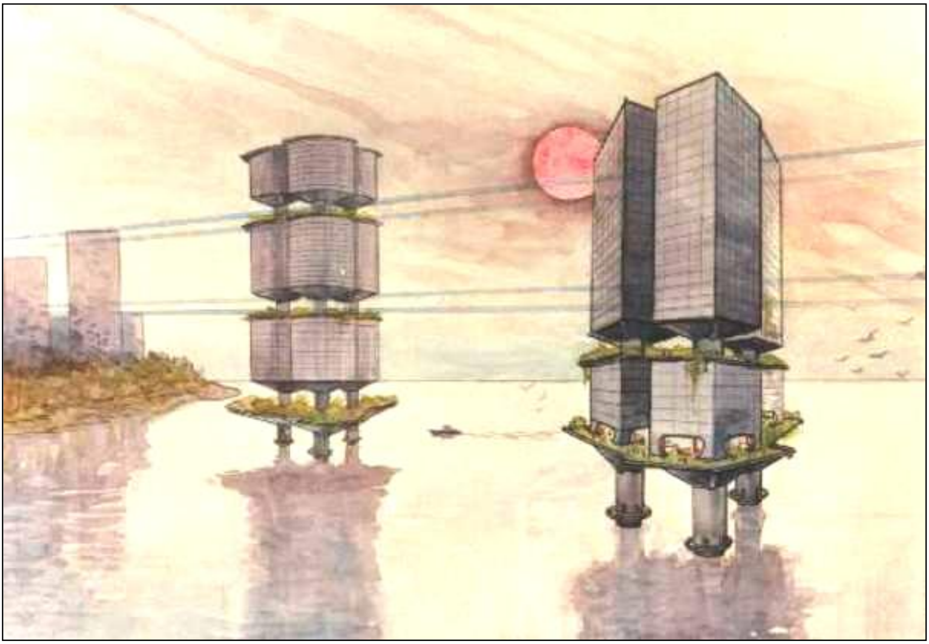


Fig. Linear city on a STS route along the sea shelf

Each STS anchor support could be easily integrated with unusual and architecturally impressive facilities such as a high-rise residential building, sea hotel, restaurant, sports and recreation complex with a filled-in beach around it in the form of an island, etc. with all of them linked with each other by a high-speed, all-weather, storm-resistant track. This solution could increase, for example, the area of Israel (by 300…500 sq. km – 30,000…50,000 ha) or Japan (by 10,000…20,000 sq. km – 1…2 million ha).

93. Is it possible to use a STS for military purposes?

Undoubtedly, like any other transportation system. For example, a motorized division with small arms (about 10,000) could be re-located at 1,000 km distance during 3.5…4 hours. Furthermore, continuous circulation of specially equipped modules containing mobile rocket units could be arranged difficult for detection by external observation aids.

94. How a STS can cross the borders between countries?

STS vehicles moving without stops at a height like aircraft do not need to cross the borders of states but rather need an air corridor. Passengers or freights are to pass through customs at origins and destinations.

For example, provisions of the Russian Constitution related to free circulation of goods and people are currently infringed in Kaliningrad Region which results from the need to cross three borders and to go through three customs in order to move from this region to any other region of Russia. STS helps eliminate this problem because Belarus, Lithuania and Poland (depending on a STS alternative) could provide an air corridor only to handle transit freight and passenger trips.

95. What advantages for Russia could give, for example, construction of a STS in a resource extracting region of the country?

About 80% of industrial potential of the RF is concentrated in the west from the Urals and 80% of its fuel resources is concentrated in the east which necessitates transportation of hundreds of millions of tonnes of fuel every year. It is obvious that until safe nuclear reactors for nuclear power plants are designed it is necessary to find additional energy sources for the region. One of them is Pechora coal basin – the largest one in the European part with its total resources almost twice as large as in Donbass. In addition, Pechora basin is characterised by higher thickness of coal seams, better mining conditions, higher labour efficiency and lower net cost of mining.

STS makes it possible to sharply increase the export of Pechora coal, especially cleaned coal, which high transportation costs to the users make it not competitive at the present day world market. For example, the cost of American caking coal in shipment ports is USD 47/t and the cost of energy coal delivered from SAR to the Netherlands is USD 30/t. The cost of coal transported by a STS from Pechora basin to Kaliningrad port could be by 20…30% lower. Where to sell Pechora coal? Naturally, to Scandinavian countries which today have to buy coal even in the far Columbia.

As it is known Sweden decided to stop construction of nuclear power plants and to replace then by heat power plants using gas and coal for their operation. It could be reasonable to invite Sweden which is a long-established and widely recognised supplier of mining equipment for collaboration with the Russian Federation to develop new areas of Pechora basin. Similar proposals could be made to Finland, Norway and other West European countries which will contribute to the development of Pechora basin to become the largest base of caking and fuel coal in Europe.

Practically, all mining industry of the Russian Federation is concentrated in hard to reach and underdeveloped northern areas the development of which is hardly possible without foreign investments. For example, the RF Government prepared a list of 250 relevant deposits with the total raw resources (oil, gas, coal, copper, silver, etc.) estimated at USD 12 trillion. Among gas and oil deposits Timan-Pechora deposit (situated between Archangelsk and North Urals with 2.4 billion tonnes of explored oil resources) is the largest one which in the future plans 75 million tonnes of oil per year for delivery to Europe.

Further in the east, immediately behind the North Urals there is one more promising oil basin: Priobsk oil field (with 2.4 billion tonnes of explored oil deposits) and neighbouring oil fields of Tyumen which is responsible for more than one half of the total Russian oil output. Development of Timan-Pechora oil fields entails development of Priobsky deposit and a STS communication infrastructure especially provided for the purpose will make it possible to promote development of a sea shelf of Arctic Ocean with even more extensive oil and gas resources.

On the whole, it is a possibility for the region rich in fuel resources to be integrated in the world economy so as to give rise to geopolitical transformations of planetary scale as a result of reduced or fully eliminated dependency of Europe and the West as a whole on Persian Gulf region. In experts' opinion those who control these fuel sources will control, for example, Germany as well.

Yamal peninsula is the youngest region among other vast sub-Arctic areas characterised by extremely vulnerable environment. In fact, it consists of a number of huge ice blocks of 50 m thickness, sort of run aground and overlapped with a layer of sea clay of 1…2 m width. Yamal is situated 20 m above the sea level. It is hardly possible to find any other place on the globe being so vulnerable in terms of modern spatial technology which had to be coloured rather as white covered with ice area than as green lowland.

According to experts' estimates more than 6 million ha of pasture lands in Yamal were damaged as a result of unwise mineral extraction solutions. Their reclamation will require allocation of gigantic financial resources estimated at USD 50…100 billion. Communication infrastructure based on the use of a STS will make it possible to minimise environmental implications of deposit exploitation in the northern regions of Russia and first of all in Yamal peninsula.

It should be emphasised that in future environmental impact will be the major factor to identify development costs of northern regions which is proved by international experience. For example, initial project cost of a gas pipeline in Alaska (USA) was estimated at USD 600 million, however, its construction was blocked as a result of protest made by the public and environmental associations. After the relevant nature conservation measures were taken which turned to be very expensive under permafrost conditions a pipeline was built but then its cost increased to USD 5 billion.

A key question of all without exception northern projects is how oil will be delivered from Russia to other countries of Europe, i.e. which region of Europe will be developing at fastest rates. Proposed STS alternative will make it possible to attract the major share of foreign investments to densely-populated regions of Russia which are going to accommodate a STS route including Kaliningrad region with its port. In future a STS route could be extended in north-east and south-west direction to deliver raw resources from the northern deposits of Russia to the West and to bring western industrial goods and food products to Russia.

STS programme is also in compliance with the future targets of oil delivery to Europe from Kazakhstan (50 million tonnes per year) and Azerbaijan (25 million tonnes per year) as all the above mentioned transportation communications are easily integrated through a STS within the area of city of Smolensk. This development concept of northern areas is interested not only for oil and gas companies of the RF (in particular, Gasprom), but for the Government of Russia (ministry of economy, environment, finances, etc.), local government bodies (that are currently facing serious environmental problems generated by oil and gas developers associated with tundra recovery which requires hundreds of years), as well as the Government of Belarus and western investors capable to evaluate their investment efficiency (expected total volume of investments – USD 200 billion). If a STS infrastructure has one owner (for example, Gasprom of the RF) it is possible to propose a price policy which will make delivery of the Russian raw resources to the West free, as all costs will be included in passenger fare. And in this case a STS fare will be lower than that for railway passengers. As a result Russian goods will be more competitive in the West and will bring additional profit.

Other questions

96. Most serious STS disadvantage?

The only serious STS disadvantage, unfortunately still not eliminated, is associated with the lack of already built at least 1 km of STS track. But, as it is known, this drawback was in its time inherent in highways and railways, aircraft and trains on a magnet suspension, electric cars and other inventions ever made by man.

Nowadays this shortcoming of a string transportation system is easy to eliminate as all basic STS components are available and efficiently operating in various technical fields. For example, one of the project distinctive features is associated with the need to provide an ideally even and very rigid track capable to carry a transportation module wheel which was achieved through the use of steel strings strained to high stress. However, this solution is very close to the design of hanging or guy rope bridges which relevant practical, experimental and theoretical potential gained during hundreds of years was in full value used in working for a STS project.

STS transportation module in its essence is a variety of a high-speed electric car which, in fact, is not supplied with accumulators but through its wheels is switched to the industrial electricity supply network which is regarded as one of its basic advantages. Electric car design experience of the leading world corporations was also used in the STS project. Moreover, poor aerodynamic qualities of a modern car do not allow to gain high travel speeds, therefore, a unique shape of a STS module was proposed having no analogues in the world including aviation with its aerodynamic drag coefficient amounting to C_x=0.075 (patented in a number of countries).

Current development of a STS is at the stage which does not arise any doubts in terms of its operative qualities and validity among its authors and developers as well as among experts and governmental bodies of Belarus, Russia and Ukraine.

97. Why a testing ground for a STS is necessary?

The key stage of practical implementation of a STS implies construction of a pilot testing ground to carry out full-scale pilot industrial testing of a string transportation system. A testing ground includes scientific research complex with a laboratory building, design bureau, assembly unit, autonomous power supply block, storage and other facilities and a pilot STS track.

Construction of a pilot STS track implies the following stages:

1. First, one span (of 1,000 m length) between anchor supports will be built with 20-25 intermediate supports (with their height ranging from 1 to 20 m) installed in between with spans ranging from 10 to 100 m. This section will be used to test building technology of intermediate and anchor supports, strain

adjustment and anchoring, formation of a rail-string and track structure and checking of technical equipment. A track structure and supports will be also exposed to static tests to investigate movement dynamics and behaviour of a transportation module.

2. After that the necessary corrections will be made in the transportation line, module and track design and the track will be extended by 2 km to reach the total length of 3 km. It will make it possible to gain the speed of 250 km/h and to start testing of the high-speed (more than 200 km/h) acceleration/deceleration regimes, control systems and non-standard operation conditions.

3. The final stage envisages extension of the track length to 15 km with its terminal sections designed as rings of about 1,000 m diameter including switching devices which will make it possible to reach the maximum travel speeds of 500-550 km/h. Also tested will be high-speed travel regimes, turns and basic infrastructure components (switching devices and stations).

Approximate cost of the first two stages is estimated at USD 25 million, implementation period – 2.5…3 years. The third stage will be associated with approximately the same cost and time requirements.

Examination and tests of separate units, aggregates and components of the transportation line, module and infrastructure will be also carried out at specially designed laboratory stands.

After a STS has been exposed to a pilot industrial test on a testing ground, standardised and certified it is possible to recommend a high-speed transportation system of a new type for use both in developed and developing countries. If the full-scale tests prove theoretical research and tests of a STS model track and its rolling stock carried out within the framework of the Habitat project a STS could be proposed for the world community as the most environmentally friendly, less capital- and resource-intensive and most economically efficient transportation system capable to cope with the requirements of the 21st century.

The tasks to be solved at the testing ground are as follows:

1) String track structure is not referred to beam or cable structures, therefore, the world experience in construction and operation of bridges and overpasses, mono-rail and cable roads and other transportation is not appropriate for a STS. Thus, a rail-string being the basis of a STS track structure is to be optimised experimentally (rail rigidity, tensile strength of a string, optimal span length, choice of filler and its physical and mechanical qualities, etc.) and tested at low (under 200 km/h), medium (200…300 km/h) and high (300…500 km/h) travel speeds of a transportation module.

2. A STS electric module has four steel wheels with “an automobile” (independent) suspension, each of them with two rims (flanges) which makes a STS rolling stock principally different from that of railway, highway and mono-

rail roads. Furthermore, a module is moving along the two pre-stressed rigid threads (rail-strings) of great length, rested upon rigid (anchor) and flexible (intermediate) supports. It is a principally new scheme of a high-speed track structure for the world experience which moving dynamics is in need of further study. So vibration frequency and amplitude of a rail-string, wheel suspension, module body supports as well as the generation of resonance frequencies in the track components, module and supports are to be further investigated.

3. High-speed movement of small-size modules at 20…30 m height above the ground requires a special approach to their aerodynamic qualities, optimisation of their body shape and impact of climatic factors such as wind, rain, snow, icing, high and low temperatures, etc.

4. STS supports and their components (anchor, intermediate, brake) differ from the supports of bridges, elevated and cable roads, power transmission lines both in terms of their design and static and dynamic loads and specific requirements. All this necessitates experimental study.

5. New track and rolling stock solutions require non-traditional approaches to the infrastructure design which is also to be exposed to experimental testing (including switching devices, terminal components, stations, freight terminals, etc.).

6. New transportation concept is associated with new approaches to its design standards (shape and geometrical dimensions of a rail head and supporting part of a two-rimmed wheel, track width, distance between two contra-flow lines, dimensions of a transportation module, etc.); electro-technical standards (voltage and type of current – direct or alternating, etc.), technological, operational and other standards.

98. How many years has the author been involved in a STS project?

About 20 years, or even 25 years if we take its pre-history (project of a planetary transportation vehicle – a system for the future wide-scale development of near the ground cosmic space based on non-rocket principles which gave rise to a STS idea).

It could seem quite a long period, thought if we remember the history of engineering and automobile and railway transportation their pre-history was much longer. Trains on a magnet suspension required much more time for their development, though only FRG spent for them billions of DM which was not the case with a STS. The former USSR was also involved in magnet suspension projects and spent several billions of dollars during few decades, though not a km was built. Even more simple inventions such as photography required more than 100 years from the moment of its idea to implementation. Thus, inventor has a chance to see his invention with his own eyes, put into life only if he starts his project, especially a large-scale one like a STS, in a relatively young age.

It took the author many years (about 10 years) to formulate and develop his idea, to crystallize its essence, to make the estimates and technical and economic analysis. It took years to promote the calculations, feasibility study, relevant technical solutions, testing of major units and components, specification of STS inherent standards, etc. Several more years were spent to acquire a patent for a principal scheme of a string system in the leading world countries and in this case the major problem was associated rather not with a patent itself but with the lack of finances (which required about USD 100,000). However, in independent experts' opinion the cost of non-material assets created by the author during this period is evaluated at USD 1 billion.

The fact that a STS is still unrealised is attributed to the lack of financial support rather than to the shortcomings of a STS and its unsolved research and technical problems. All works during these 25 years have been carried out at the expense of the author himself, whose financial possibilities are very limited. Without patents (first of them were obtained as late as in 1997) attraction of investments to support the programme was out of the question. It will be only possible to start the fund raising only in the year 2000.

Unfortunately, the author was not lucky to meet in his life a person like S.V.Rakhmaninov. As it is known, famous composer, pianist and conductor who lived in the USA in emigration in the 1920s met another emigrant I.I.Sikorsky, then already known aircraft designer living in poverty. This man, being so far from technics, believed in the poor designer who was fully neglected and had no orders, gave him USD 5,000 (today it is equivalent to USD 500) and said: "I believe in you. Pay back if you can, if not, all right let it be so". Who knows if helicopter industry of the USA could come into existence without this support?

99. What differs investments in a STS programme and a specific STS route?

The same, for example, as in "Automobile" and "Automobile VAZ 2110" programmes. In the former case it is an automobile in general which could have hundreds of modifications (concrete marks), good or bad. Thanks to efficient technical and economic solutions "Automobile" programme has been flourishing for more than 100 years and will be a success further on until a new more efficient programme, for example a STS project, is proposed. As to "Automobile VAZ 2110" programme it could be not very successful and lose in competition with other programmes.

It is approximately the same with a STS. It is possible to build, for example, a STS track "Moscow - N.Novgorod" which for this or that reason could be non-profitable and investor will suffer losses. On the contrary, that who invested money in a STS programme is not going to meet losses. Negative experience is also experience. Then the next transportation line, for example, "Minsk - Moscow" will be built based on the obtained results to become profitable and eliminate possible risks and losses. According to the world statistics profit coefficient of investments in scientific research and experimental design and construction works at the final stage of a research programme will be 1:100 or even 1:1000.

100. What guarantees a STS programme success?

It is the programme itself with its powerful initial potential. It is not even concrete people (and its author as well) and concrete tasks and errors in the course of the programme implementation that identify its success. Let us remember firsts steps in aviation. They were accompanied with numerous errors, unwise solutions, failure to fly up, crashes. Air planes are still crashing and what of it? Aviation created the most powerful niche in the world economy and in not going to give it to somebody else. It started when nothing was actually known even for aircraft designer about aerodynamics which makes the basis of aviation.

Let us remember our recent past when the foundations of rocket construction and modern astronautics were laid. What most difficult problems their designers had to solve! Let us consider only two of them: rocket stability and fuel combustion in a jet engine. In stable state a rocket looks like a pencil put on its edge. Can you imagine something more unstable? Is it appropriate to speak about launch accuracy? Designers neglected these difficulties and today it is hardly possible to find any other system being more accurate than a rocket. A spaceship launched from the Earth at enormous speed is capable to land in the assigned spot of another planet moving at a distance measured by hundreds of millions kilometers. And how about a problem of fuel combustion when the heat power per 1 sq. m of a combustion chamber of a jet engine reaches 1 million kW? It seemed that there were no adequate materials to resist this power but designers managed to find a solution of this problem as well.

Or another example – a train on a magnet suspension – "Transrapid" (Germany), or more precisely, its suspension problems. An ordinary magnet put to a paper-clip, for example, will result in either:

1) a paper-clip remained still lying on the table; or
2) a paper-clip is jumping to stick to a magnet.

However, there is a third, fantastic alternative with a paper-clip hanging in the air not touching either a table or a magnet which was realised in a "Transrapid" project.

STS is free of similar difficult problems. A string system is based on simple mechanics, in figurative sense it is like "iron", known and tested long-long ago including its wheel, drive, rail, track, track structure and supports, control systems, etc. Estimations of a track and supports is the subject of structural mechanics used to design bridges, buildings and facilities; movement of a STS vehicle refers to structural dynamics including dynamics and aerodynamics of a four-wheel car.

The same is true for other STS problems which are either solved in modern engineering or are not difficult to solve based on the knowledge of theory and practice of building structures, railway, highway, aircraft construction, electric engineering and electronics, etc.

Questions about a STS were asked by[*]:

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Part 3. Practical implementation alternatives

3.1. STS as environmentally sound alternative of super-automobilisation

The end of the 20th century saw the urban revolution - for the first time in the human history half of the world population is living in the cities.

As it was stressed by the UN Conference on Human Settlements in Istanbul urban revolution will be going on for the next three decades to the effect that the number of urban residents will grow twice as much as that in the rural areas. Thus, population concentrated in the cities will be by 2.5…3 billion residents more than at the present time and all of them are not only to be housed but also to be provided with infrastructure and job opportunities adequate for the 21st century.

Though the present day and future cities will remain the global financial, industrial and communication centres, concentrations of the whole variety of cultural values, dynamic political life, enormous production, creative and innovation potential, at the same time they became the source of poverty, violence and overloaded communications. Unstable consumption patterns in the highly-dense cities, industry concentration, intensive economic activity, high concentrations of cars and inefficient systems of waste management are the factors showing that the main environmental problems of the future will be associated with the cities.

Let us consider a city from the point of view of its transportation infrastructure.

Streets and crossroads, squares and parking lots, bridges and viaducts, garages and gas stations and other facilities in modern cities are built just for cars. Cars subordinate cities more than people who built them and who (as biological creatures) are in need of other living conditions.

Cars in the city are a main source of air (to 80%) and noise (to 90%) pollution. Adjacent areas are polluted with fuel combustion products containing more than 100 cancer-producing and more than 100 toxic substances, tire and road friction products, de-icing salts, road dust and others. Gas filling and washing stations, car repair shops and other elements of transportation infrastructure are also sources of pollution. Land covered with roads does not breathe and its natural surface and ground water regime is changed. Land is withdrawn from a biospheric oxygen generation system and air cleaning by green plants in places of mass population concentrations.

Every day millions of people sit at wheel to stay in self-contained space of the small size in stress condition for hours, and breathe polluted air with fuel and lubricant steam, fuel combustion products and fumes of heated asphalt.

Every day cars kill thousands of people all over the world, make tens thousand of people cripples and invalids. Billions of people are exposed to negative effect.

Transportation mobility of urban population is constantly growing and in a number of megalopolises the total number of trips in 2000 will be more than by 3 times larger than in 1980. As s result of further urbanisation processes their 6 times increase is possible in the year 2025.

An example of such megalopolises is the city of Mexico, the largest city of the world with more than 20 million population living over 2,000 sq. km area. In total more than 30 million trips are made in Mexico every day using more than 3 million cars and public transportation modes.

It is also necessary to make note of daily resource consumption by these cities and the need to transport these resources to the users. Average drinking water and food consumption per 1 resident amounts to about 1,000 and 2,000 tonnes, respectively. In addition, 2,000 tonnes of wastes and 900 tonnes of environmentally noxious substances are generated. For example, in Mexico motor transportation is responsible for 100% of the total lead concentration and 82% of carbon oxide exhausts which result in considerable deterioration of the atmospheric air quality.

The main reason why cities, megalopolises and mass concentrations of population are formed is a need to guarantee transportation accessibility. Access to places of employment, educational, health and cultural centers, mass-scale recreation and entertainment places, provision of a possibility for physical contacts between people – are factors which brought together at first thousands and then millions of people. That was the way the cities grew and their image has been formed during centuries first by pedestrians, then – by horses that move transportation means, and in 20 century – by rail-road (including trams and underground) and cars (including buses and trolleys). Historically it was transportation communications that have formed the image and spatial pattern of modern cities and megalopolises.

Only the need in transportation access gave rise to the super-high concentrations of residential and industrial developments, population in modern cities and related flows of energy, heat and gas exchange. All this results in the deterioration of natural vegetation and fauna, changed micro-climatic, geological and hydro-geological conditions, absolute numerical domination of man and maximum man-induced transformations of indigenous landscapes. Already today up to 50% of all population diseases in the large cities can be referred to the "city-generating" causes. First of all, they include diseases associated with the overcrowding, air pollution, noise, vibration and electromagnetic radiation.

Time is a limited resource as the day still lasts for 24 hours and human life - approximately for 80 years. Gross national product per capita of population in the developed countries exceeds USD 20,000 at approximately 2,000 working hours per year. Therefore, very roughly 1 hour of civilised human life on the average can be evaluated at USD 10. Thus, in a civilised country daily saving of 1 hour of citizen's time per is more economically justified than saving of 10 liter of gasoline, 100 kg of coal or 10 kg of bread per 1 citizen. At the same time in many cities of the world commuter trips take almost one half of the working day. Travel costs ranging from 4 to 6 hours are considered usual for the Indonesian capital the city of Jakarta. The number of cars in the USA is often close to the maximum carrying capacity of roads. It was estimated that the cost of this problem for the country amounts to USD 1 billion per day including reduced productivity, time losses and deterioration of population health.

But if the role of transportation in the future will remain so great, why not to form the future image of our cities based on new transportation technologies and urban development concepts?

Imagine a chess-board with its squares being natural landscape and lines dividing the board into squares are linear cities of 500 m width, built-up predominantly with cottage buildings (Fig.1).

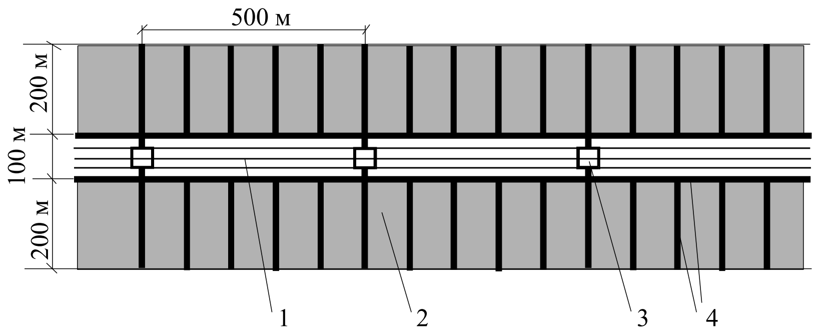

Fig. 1. Linear city:
1 – multi-way high-speed "green" routes (through, reverse, sidetracks); 2 - cottage building area; 3 – high-rise offices, industrial buildings and facilities, cultural, shopping, health and other centers; 4 – pedestrian paths.

Along the city axis in the green stripe of 100 m width above the trees, i.e. at the height of 50 m and over there are high-speed "green" transportation communications. "Green" means that they are secure, they don't threaten to people lives and health (environmentally-friendly, noiseless, high-speed moving safety, etc.), they don't break the harmony of environment including landscape. If such city is 50 km long and the speed of moving is 200 km/h, it will take a person 15…20 minutes to get from one corner to another as a maximum, but as an average – 10…15 minutes. Offices and industrial and other buildings with mass concentrating of people will be also located in middle green area of a city, and everybody will be able to walk towards them. If they are located at 100…500 m distance, it will take a pedestrian not more than 3…5 minutes to get there. At the same time each building is provided with a transportation station located on its roof or top floors to which passengers could get by an escalator or high-speed elevator.

At the residential density of 1 person per 1 linear meter (or 500 m^2 /person) such city will have the total 50,000 population where as a "chess-board" green megalopolis (Fig. 2) formed by 100 such crossing linear cities (50 at the each side, at 1 km distance from each other) could accommodate 5 million population living in comfort over the area of 2550 sq. km.

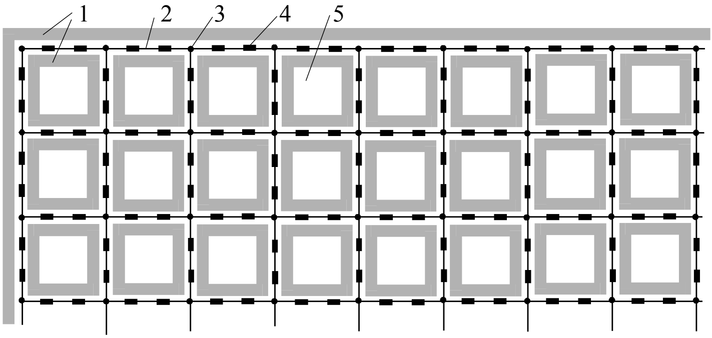

Fig. 2. Green (chess-board) megalopolis:
1 – linear city building area; 2 – "green" high-speed transportation communications; 3 – change stations; 4 – loading/unloading passenger stations; 5 – natural park.

You will be able to get from any point of such megalopolis to any another one just with one change. Maximum travel time (from one corner to another) is 35 minutes; average time is 15…20 minutes. Maximum carrying capacity of a transportation line is 500 thousand passengers and 100 thousand tonnes of freight per day, or over 2 million people (for the total communication network) during the rush hours to move within a megalopolises.

Population concentration (2000 man/km^2) in such city-village will be considerably less then in modern cities. It will be a really green megalopolises, not covered with asphalt and intended exclusively for pedestrian movements. And people will wake up in the mornings not because of car noise but because of birds' songs.

Do we need such cities? There are many other cities built everywhere. You know the city of Las Vegas built especially for entertainment in a desert. Why not to build cities for harmonious life? And for this purpose there are many more beautiful places in the world than a desert.

For realizing this concept a principally new transportation of the 21st century is necessary. A String Transportation System fully complies with these requirements.

High energy efficiency of an electric gear and minimum mechanic and aerodynamic losses provide for the high-speed, safe and comfort passenger and freight trips with less energy consumption (5…10 times less than a car). Compact stations will be combined with upper floors and roofs of buildings and won't require additional land use.

Small cross sectional dimensions of a rail-string with energy and information service lines including environmentally sound optical fiber communications inside it (100 x 200 mm) except other non-traditional pollution: routes will not shadow and do visual intrusion.

Low power (to 50 kW for a vehicle by capacity 20 passengers and carrying capacity of 5 tons), low-level electric tension (about 1000 V) and absence of sliding electric contacts make the STS more faint source of electromagnetic pollution, than trolley-bus. Injury to the Nature during the whole living cycle of the STS will be minimal – during building and exploitation stages and dismantling.

The total length of a high-speed transportation network of the aforementioned chess-board megalopolis is 5,000 km and its cost – about USD 8 billion (i.e. approximately the same as a 660 km high-speed railway “St. Petersburg-Moscow” or a 300 km route “Berlin-Hamburg” of “Transrapid” train on a magnet suspension). During the peak hours a megalopolis could be served by 50,000 modules of the total cost of about USD 1 billion (for comparison: summary cost of 2…3 million cars in a modern megalopolis reaches USD 20 billion).

Thanks to the low cost of a communication system and its rolling stock, low energy consumption for the high-speed travel and low maintenance costs of a STS its net cost of travel will be lower than at any other known urban transportation mode amounting to about USD 0.1/pass. for the average 25 km trip.

Pedestrian linear cities are easily integrated in the existing urban system (Fig. 3).

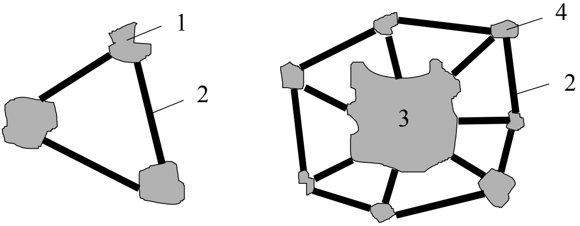

Fig. 3. Linear city in the urban network:
1 – real city;
2 – linear city;
3 – real megalopolis;
4 – city-satellite (airport).

For example, linear cities can concern little and middle cities located at the distance 50…150 km. Concerning cities-satellites and airports with each other and with the megalopolis will be also effective. Having such communication system a passenger from the megalopolis center can get to any city-satellite or airport within 20…25 minutes. It will cost him 0,5…1,5 USD.

It is possible to form a linear eco-polises with a radial-circular pattern of 50…80 m diameter to be located around the existing city or a megalopolises (Fig. 4). In the future it will contribute to the dispersal of large cities and formation of a “waste-free” settlement system providing for the preservation of existing natural landscapes and historic and cultural centres and bringing the processes of urban metabolism closer to the natural processes.

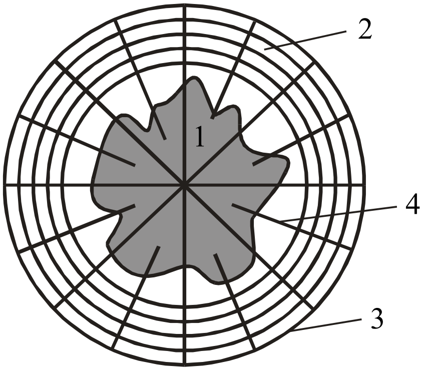

Fig. 4. Linear circular city.
1 – existing city;
2 – linear circular city;
3 – circular high-speed STS route;
4 – radial STS route.

So a STS provides a new urban development concept in the 21st century aimed at the formation of environmentally sound linear cities, in which housing estates, industrial, office, cultural and other buildings and facilities will be situated within a pedestrian distance from the high-speed environmentally-friendly and secure string routes. They will be in harmony with the Nature in all its variety: fields, shelf of the ocean, mountains, taiga, desert, jungle and any other places which God gave us.

If to think about the fate of 3 billion of potential urban residents and to provide at least 1 billion of them with decent conditions for life, work and rest in the 21st century it is necessary to have about 200 such chess-board type megalopolises and to build 2 million km of high-speed roads with 1 km to serve megalopolises themselves and the other 1 km to link them with each other and with other cities. This task can be solved by the efforts of the world community as, for example, over the last 100 years more than 5 million km of transportation communications were built only in the USA, however, they are characterised by higher cost and environmental hazard and lower speeds.

3.2. STS as a basis of consumer market of non-traditional renewable resources of Siberia

High quality drinking water constitutes an important component of the human life support system. It was estimated that minimum 10 billion tonnes of environmentally clean water is necessary to cover the total annual human requirements including manufacturing of food products, medicaments, beer and other drinks. However, water deficit is increasing annually in geometric progression. And it is not possible to make up this deficiency as water in the only consumer product which cannot be replaced with some other product.

Therefore, human demand for clean drinking water is 5 times higher, for instance, than that for oil (today about 2 billion tonnes of oil is extracted annually) or 3 times higher than for coal. Already today the cost of the high quality natural water is 6…8 times higher than the cost of oil (1 USD/liter against 0.15 USD/liter) and 20…30 times higher than the cost of coal. That is why the largest consumer market in the 21st century will be the market of ecologically clean drinking water.

According to the data of the World Health Organisation about 2 billion of the world population are suffering from the drinking water shortage. Only one out of 10 people in the world drinks natural water, the rest of them are using chemically treated, chlorinated or desalted water. For some regions this problem became even more acute than food or fuel supply. People living in the countries of Persian Gulf use desalted sea water; population of Algeria, Hong Kong, Singapore cannot do without imported water. For Arabian countries maintenance of water balance becomes a problem of vital importance, priority task of their national security. Experts do not exclude a possibility of war in the Near East at the beginning of the 21st century which aim will be to take hold rather of water than land.

Research of the recent years broadened our knowledge about the “water factor” and its impact on human morbidity and genofund and the results arouse a great concern. Up to 80% of diseases are associated with the use of polluted water. The quality of water we drink would affect the quality of health of many future generations.

Water makes up 65% of the total weight of an adult human being, it is found even in bones and tooth enamel. Nutriments and salts are absorbed in the blood only in dissolved form. Any chemical processes going on in a living cell are only possible in the presence of water. Brains activity is slowing down without liquid, however, four glasses of water taken with intervals during the day are capable to maintain and increase the vital energy. On the other hand, water is washing out from the human organism all which is not needed or is harmful to it. But it is important that water that we drink be clean and safe.

Water is a universal solvent. Even the most clean water contains more than 800 chemical substances. All of them are necessary for our organism provided that the whole complex of mineral substances is well-balanced and all of them are in the necessary concentrations. Otherwise, constant use of such water could make our life ten years shorter.

Today a fashionable idea is associated with the delivery of drinking water from icebergs which is not the best way to solve the water problem. Firstly, it is distilled ice and distilled water is equally hazardous as polluted water. Secondly, as a matter of fact, the ice is not clean. For example, one of the reasons why the strongest chemical poison DDT was prohibited was caused by the fact that it was found in the lever of pinguins. In nature evaporated water is migrating in the atmosphere clouds for months until it is precipitated in the form of snow in Arctic or Antarctic regions. Distilled water converted into ice already contains atmospheric dust, not always of man-induced nature. For example, in the pre-historic times it was the products of volcano eruption or dust storms and pathogenic micro-flora which, by the way, is still contained in frozen ice and in case of its melting could give rise to unknown diseases.

Homeopathy proves that water has a molecular memory. Million times diluted medicine is a cure. Thus, the question arises whether clean natural water can be replaced by filtered piped water initially contaminated with pesticides, herbicides, nitrates, phosphates, chlor-organic compounds (for example, dioxin, generated in the course of chlorinated water boiling is 68 times more poisonous that potassium cyanide), salts of heavy metals, etc. It is known that filters not only prevent water pollution (its efficiency is not more than 80…90%) but partially absorb the necessary mineral components thus deteriorating the natural mineral balance. In this case homeopathic memory of noxious substances coming through a filter is increased to poison our organism. Toxic effect of water is much more hazardous than that of food because water and dissolved substances and salts of heavy metals are involved in all biochemical processes of a human organism.

There is no other country in the world that has high quality natural drinking water resources as large as Russia, for example, its Lake Baikal.

Baikal is unique in terms of its water resources that are greater than those of the Baltic Sea. In terms of its hydro-chemical qualities its water has no analogues in the world. The Lake is a giant natural water reservoir containing 1/5 of the total global fresh water resources and ½ of the world clean drinking water resources , the best ones. Vital activity of its organic life is still operating irreproachably thanks to the living (endemic) filters. Water in many zones of the Lake is clean. However, aborigine organisms are capable to survive only in such environment and they are ruined coming to Angara the only river flowing from Baikal though its water is very difficult to distinguish from that in the lake.

For million years the natural “Baikal factory” has been generating 60 billion tonnes (60 cub. km) of invaluable liquid mineral brought every year by 300 rivers flowing into Baikal and after its purification flowing through Angara to the Arctic Ocean.

In the course of its purification which takes many years water is losing its molecular memory of the previous pollution. In this case the whole complex of micro-elements brought with rain and spring water is balanced. More than USD 1,000 trillion will be necessary to cover the costs for sea water desalting to get the fresh water in the amount equal to that of Baikal (fresh but not so rich with valuable micro-elements). For comparison: all gold currently extracted in the Earth is evaluated 1,000 times less. In economic terms the cost of Lake Baikal is much higher than that of an oil sea of equal volume which is by hundreds of times higher then the cost of the total global oil resources.

In the southern-west part of Lake Baikal there are deposits of “renewable” ultra-fresh water, its resources are enormous and practically inexhaustible. Baikal water does not require additional treatment, conservants or gassing because of its ecologically purity, slight mineralisation and oxygenation even at the bottom at the depth of about 1.5 km. Water at the depth of 500 m and lower was formed more than 100 years ago, i.e. during the “pre-industrial” period and it fully lacks any technogenic toxicants, salts of heavy metals, chlor-organic substances and pathogenic micro-flora.

Water in the other largest Russian reservoir - lake Taimyr located beyond the North Polar Circle - is even more clean.

Minor share of population is living in the northern zones and here people are in need of warm, whereas the majority living in the tropic or sub-tropic areas are in need of cold. People equally need cold and heat that is why they invented refrigerators and conditioners. It is much more difficult to get cold than heat. For example, the efficiency of a heat engine “energy - heat” can be close to 100% whereas that of the reverse process: “energy - cold” is much lower - 5…10% (the efficiency of a heat power plant is 30…40%, electric transmission line - 80…90%, refrigerator generating cold - 10…15%).

Today the cost of a high quality food natural ice at the world market is USD 3,000, i.e. higher than that of copper and aluminium. At the same time melted water is more useful as its liquid crystal structure and curative properties are preserved for a long time.

Russia is rich in the natural resources which could become its major export potential in the 21st century, in particular, a high quality ultra-fresh water and Siberian frost.

It is reasonable to deliver the Russian drinking water to the European and Asian (India, China, etc.) market in the form of ice to be stored in special terminals - refrigerators. Baikal water brought from the depth of 500 m will be frozen in winter with the use of natural frost at the special plants.

To realise this programme it is necessary to have a principally new transportation of the 21st century which is to be characterised by the following qualities: low cost - as the main consumer is located at the distance of 5,000…8,000 km from Lake Baikal and 6,000…10,000 km - from Taimyr;

high-speed - as water will be spoilt during its long transportation and ice will be melted; ecological purity - as it goes to the densely-populated regions of Europe and Asia; high carrying capacity - as water supplies are estimated at hundreds of million and billion tonnes per year; feasible for the difficult geographic and climatic conditions - as the routes will pass through the zone of permafrost, marshlands, taiga and mountains. Only a STS is capable to meet these requirements.

To realise the Programme “Live Water of Russia” it will be necessary to build about 30,000 km of freaigt and passenger STS routes with the total cost of about USD 30 billion (including infrastructure).

Construction will be carried out on a stage-by-stage basis to facilitate gradual pay-back of expenditures at the expense of freight and passenger traffic.

In engineering terms this task is simpler than, for example, construction of railways in the period of their flourishing. For instance, USA built about 35,000 km of railways during a decade from 1850 to 1860 and more than 115,000 km during 1880-1890, with a pickaxe and spade as there were no bulldozers, excavators, cranes, trucks. It is much simpler to build a STS, especially at the beginning of the 21st century, having the most advanced technical devices, powerful and under-loaded industries and, in particular, building industry not only in Russia but in other interested countries of Europe and Asia.

The Programme is also attractive in the economic terms. The cost of delivery of more than 100,000 tonnes of drinking water per day using a STS system will be 3 USD/1,000 km or 20 USD/t for a medium distance of 6,500 km. Taking into account the selling price of water, costs for water preparation and other costs (including freezing) its actual cost for consumers (for example in Delhi) will be 50 USD/t (5 cents/liter). At the wholesale price of food ice of 250 USD/t (25 cents/kg) its delivery in the amount of as little as 200 million tonnes per year or 0.2 kg/day per 1 potential consumer will be enough to pay back the costs for the whole STS network.

As far as we are interested not only in the economic profit but rather in the health of billions of people in the 21st century it would be reasonable to arrange the marketing and management of the programme in such a way that each potential consumer of a high quality natural drinking water from Russia be its stock-holder. Thus, it will be possible to realise the whole programme at the expense of the joint-stock capital. In this case the programme expenditures will be approximately the same as for the European tunnel programme (a high-speed railway “London-Paris” with a tunnel under La Manche and infrastructure which was built predominantly at the expense of the shareholders’ resources), however, in terms of its efficiency, acuteness and usefulness our system is much better.

A wide assortment of the Russian bottled natural water will be delivered to the world market including: artesian, lake, mineralised, ultra-fresh, curative-medical water, food ice, including relict one, etc. About 1 million of new highly paid jobs will be created in Russia and abroad. In a few years after STS construction it will be possible to increase the delivery of water to 1 billion tonnes per year to give the annual profit of about USD 200 billion. Delivery of water in the form of food ice would save the costs for the generation of the equal amount of artificial cold requiring burning of not less than 1 billion tonnes of coal at the electric power plants with the total capacity of 200 million kW and appropriate refrigerator capacity. Imagine how hazardous it would be for the planetary environment. As to the programme "Live Water of Russia" it is environmentally sound both in terms of its thermodynamics and its impact on the total thermal balance of the planet.

Under the appropriate support of the Government of the Russian Federation and success of a joint-stock activity it will be possible to finalise the programme to the year 2010. The first STS sections, for example, "Moscow - Minsk", "Moscow - Nizhny Novgorod", "Paris - Madrid", "Peking - Delhi", etc. can be built in 2005…2006 and they will be self-repaying in 3…4 years at the expense of passenger and freight traffic, thus, when the STS construction is finalised most of its costs will be paid back.

If half of resources earned with the help of a STS and its programme "Live Water of Russia", in particular, is re-invested it will be possible to build additional 1 million km of roads so necessary for Russia during 40…50 years. They will be high-speed roads with their lifetime estimated at 100 years; they will not be destroyed in 2…3 winters, capable to resist at permafrost or marshland conditions; roads that do not require snow and ice removal, use of sand or de-icing salts in winter, mending and repairing every season.

STS will make it possible to link Europe and Asia with America by a land freight/passenger high-speed route "London (Paris) - Moscow - Lake Baikal - Yakutsk - Bering Strait - Calgari - New York" with the total length of about 21,000 km and the cost of about USD 40 billion capable to pay back the expenditures for its construction during 3…4 years. The route could be used to transport food ice of Siberia alongside with the ice of Alaska (which is of lower quality attributed to its origin) to the American market which is much more extensive, for example, than a market of aerated drinks such as "Coca-Cola" with its total volume of sales during many decades estimated at more than 1 trillion dollars.

It is possible to propose dozens of STS alternatives both strategically and geopolitically significant practically for all continents and countries of the world. If Russia manages to organise serial STS production it will manage to occupy the key positions in the promotion of new global communication policy of the 21st century.

Currently negotiations are going on in Malaysia, Israel, China, Taiwan and a number of European countries to promote the work for a STS Programme.

However, first of all it is Russia that is in need of this high-speed communication network of the 21st century, the greatest country of the world characterised by the most underdeveloped territory and the worst road quality. More than 100 years ago the great Russian writer Nikolai Vassilyevich Gogol said that the two greatest disasters for Russia are associated with poor roads and fools and this famous saying is still valid. Realisation of a STS will demonstrate to the world that in the new millennium Russia will have the best roads built by clever people. And a start can be given in Siberia.

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