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Innovative technology

“String Transport Yunitskiy”

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Contents

Name of technology

String Transport Yunitskiy (STY)

Section of science and technology

Transport

1. Recommended sphere of application

The share of transportation costs in the total cost of product is constantly growing all over the world. Unfavourable climatic and geographic conditions in CIS countries and especially in Russia give rise to the rapid growth in the level of transportation costs. It results both from the increased length of trips and increased cost of all constituting components of the transportation process including the size of wages, the cost of materials used for road construction and manufacturing of the rolling stock and the cost of fuel consumed by the rolling stock. In this case according to the experts’ estimates the average level of transportation costs in CIS countries is approximately by 50% higher than in Western countries. In a number of regions such as Siberia and the Far East of Russia they are even higher. Therefore, under all natural and climatic conditions the application of STY could be efficient for handling passenger and freight trips within the city area, between cities, countries and continents of any country of the world at the travel speeds ranging from 50 to 500 km/hour.

2. Purpose, goals and objectives of the project

At the present time there is an urgent need in a principally new transportation system based on the advanced technologies and new standards capable to bring about radical changes in the means of transportation.

The future transportation system should meet a number of contradictory requirements such as: high carrying capacity alongside with the small land occupancy and low maintenance and repair costs; minimal negative environmental impact alongside with the high daily running mileage of vehicles; high average travel speed alongside with the reduced fuel consumption and reduced number of road accidents; suitability of a track for the circulation and maneuvering of public and private transportation.

3. Brief description of a replaceable process or a problem to be solved

At the present time railways, motor transportation and aviation are responsible for the major portion of transportation.

One of the main advantages of air transportation is associated with its high travel speeds. However, for medium-distance trips (up to 1,000—1,500 km) the speed of passengers in their “door-to-door” movements remains relatively low (150—200 km/hour). Among the disadvantages of aviation it is necessary to note also its high fuel consumption (6—8 liter per 100 pass.-km), high cost of aircraft (up to USD 100 million and more) and infrastructure: the cost of a modern airport is estimated at USD 3—5 billion and more. Consequently, aviation is characterized by the highest environmental hazard and the net cost of travel among other existing modes of transportation.

One of the main advantages of railway transportation is associated with its low operation costs.

Firstly, the rolling resistance of a steel wheel moving along the steel rails is 10—15 times lower than that of a pneumatic tire moving along the road carriageway at the low speeds, 30-50 times lower at high speeds and 100 times and more lower at super high speeds. Therefore, the rolling stock of a railway has the drive power of 2—3 kWt per 1 ton of the transported freight against 10—20 kWt/t and more in motor transportation and it should be noted that as the speed grows this indicator is sharply deteriorated. Consequently, fuel consumption for the similar amount of the transportation work will be different. This advantage is easily realized in railways thanks to the availability of a gage so that the total length of a railway train could be as long as required, whereas a train in motor transport could include a tractor with only one-two trailers because of the lack of stability while its movement along the road, especially at braking.

Secondly, the service life of rails is 10—20 years and more against 5—10 years of asphalt-concrete surface.

Thirdly, in northern countries there is practically no need to remove ice or snow from railway roads in winter time whereas the relevant maintenance costs of motorways in winter time are very high bearing in mind a long winter period considerably exceeding the summer season within the major territory of CIS countries and especially Russia.

Moreover, railway transportation is notable for its high safety of travel which is attributed to the provision of each wheel with a flange (rim) preventing its derailment.

Among the main advantages of motor transport is a relatively low cost of its rolling stock and most expensive roads as well as its high mobility and compact design of vehicles which contributes to a simplified and lower-cost design of its infrastructure including: access roads, loading and unloading terminals, repair shops, stations, stops, etc.

Among the most significant disadvantages of motor transport is its high accident rates and environmental hazard which is explained by the following reasons: it is friction that keeps the wheels on the carriageway that is located immediately on the earth’s surface, i.e. where 99% of living organisms including human beings are living and where the major bio-mass of the planet is concentrated. As a result more than 1.2 million people are killed in road accidents every year and more than 20 million are injured to become invalids or cripples. Furthermore, annually more than one billion of various animals are killed on the roads.

Among the general disadvantages of the two aforementioned modes of transportation are extremely high material consumption for the construction of their track structures entailing great material (ground, sand, gravel, cement, concrete, asphalt concrete, steel, etc.) and financial costs. Road embankments are also highly material-consuming and, consequently, expensive facilities: soil consumption could reach 100,000 cub. m per 1 km of road and in some locations their construction is absolutely impossible, for example, when passing through the water areas, marshlands or permafrost. Construction of embankments or depressions could cause serious damage to the natural environment resulting from the extraction and removal of great amounts of soil and destruction of a great amount of biological resource giving life to all living creatures in the earth including a fertile layer of soil — humus generated by the living organisms during millions of years. In most cases embankments create barriers for animal migration, flow of ground and surface waters so that very often the damage caused by their construction exceeds their cost. Motorways and railways also require construction of a great number of the high-cost artificial facilities such as bridges, overpasses, drainage systems, etc. In certain cases the cost of lands and soils withdrawn from various land-users for road construction exceeds the cost of the road itself. For example, the total area of lands withdrawn from various land-users for highways construction all over the world is more than the summary territory of Germany and United Kingdom. The cost of this land is estimated at tens not to say hundreds of trillions of dollars.

4. Brief description of the proposed technological process

“String Transport Yunitskiy” could become a transportation system capable to meet the requirements of the 21st century. STY is free from the main disadvantages of railway or motor transport. At the same time it has the advantages of aviation and elevated roads as its transportation module is moving above the ground along the openwork track structure.

STY is designed as a special (rail) automobile on steel wheels put on the string-rails (or under the string-rails). String-rails are installed on the supports: intermediate supports (every 25-50 m and more) and anchor supports (every 2-3 km and more).

There are two types of STY system: under-the-rail STY with a rail car hanged under the track structure and over-the-rail STY with a rail car located above the track structure.

Each STY type is subdivided into five classes: super light, light, medium, heavy, super heavy STY (here we can draw a certain analogue with automobile transport: 1 – bicycle, moped, motorcycle; 2 – passenger car; 3 – mini-bus; 4 – light bus; 5 – heavy bus).

STY passenger rail car that principally differs from a traditional car, railway carriage and aircraft is called a unibus and a freight car – a unicar.

String transport system will become the lowest-cost, most durable, economically efficient and safe transportation system of “the second level” to carry passengers and freights within the city (fig. 1, fig. 4), between cities, countries and continents (fig. 2), as well as to handle specialized transportation of friable, liquid (fig. 3), piece or container freights.

STY advantages over other modes of transportation are attributed to a number of its design, technological and operational peculiarities that are listed below.

4.1. String-rail — is a traditional continuous (not cut along its length) steel, reinforced concrete or steel-and-reinforced concrete beam supplied with a rail head and additionally reinforced with a pre-stressed (stretched) reinforcing — strings. Maximal string tension per 1 rail depending on the span length, mass and travel speed of the rolling stock ranges from 10—20 tons for a super light under-the-rail STY to 1,000-1,500 tons and more for a super heavy high-speed over-the-rail STY. A string-rail that combines the qualities of a flexible thread (at the large span between the supports) and a rigid beam (at the small span, under the wheel of a rail car and above the support) ensures smooth (without shocks) movement of a steel wheel with a soft automobile suspension both in the middle of a span and above the supports. A string-rail is characterized by the high strength, rigidity, evenness, technological production and installation, low material consumption and a wide range of working temperatures — from +70 C° to –70 C°. The lack of technological or temperature joints along the whole length (a rail head is welded as one woven unit) provides an ideally smooth way for the wheels.

Cross-sectional dimensions of a string-rail are close to those of a railway rail and in terms of its metal consumption it is less intensive than a traditional railway rail.

Design string tension in a STY rail depends on the system type (under-the-rail or over-the-rail STY), design mass of the rolling stock and its design speed as well as on the accepted span length. In this case the structural sag of a string at each span in an over-the-rail STY is enclosed inside the rail body whereas the rail head is installed at each span with a structural elevation equal to the design deformation (additional string sag) of a span under the moving module. It results in the increased evenness and smoothness of a track for the rolling stock moving at high speeds in the middle of a span or passing through the supports.

In this case a string-rail is designed so that together with the deflection rigidity of a track and the design string tension to ensure the following size of the vertical curvature radii of a rail under the impact of a moving unibus wheel: not less than 1,000 m, 10,000 m and 20,000 m at the travel speeds up to 100 km/hour, 350 km/hour and 500 km/hour, respectively, within the whole length of the STY route irrespective of weather and climatic conditions.

It also provides for the higher evenness of the road for the rolling stock than in the high-speed elevated railway at “the second level”. In this case the vertical accelerations inside the unibuses caused by the unevenness of the road will be within the range of 0.5 m/sec^2 (in railways they are several times higher). Therefore, a string-rail is capable to ensure a “velvet” track for a moving steel wheel without “jumps” either on the supports or in the middle of the spans.

Fig. 1. Double-track STY in a city, travel speed up to 120 km/hour

Fig. 2. High-speed double-track route, travel speed up to 500 km/hour

Fig. 3. Freight train to carry liquid freights

Fig. 4. Passenger under-the-rail STY route combined with a high-rise building

In terms of its margin of safety a string-rail has no equal among other building structures. For example, a string in an over-the-rail STY has a hundredfold margin of safety under the impact of a moving load — pre-stressed tension of strings remains practically unchanged under the impact of a unibus as the relevant changes are within the range of 10 kgs/cm^2. A under-the-rail STY has a twenty-fold margin of safety.

4.2. String is designed as a high strength pre-stressed reinforced structure in the form of a steel twisted or non-twisted cable of home or foreign production. Depending on the assembling or operation conditions it is possible to use traditional reinforcing cables (seven-wire cables K-7), reinforcing cables with protecting cover or enclosure including protecting lubricant. Cables could be provided by cable plants either ready for use or to be assembled of separate steel high-strength wires in the construction site. Wires of 3—6 mm diameter are used; the amount of wires required for a string-rail could range from several dozens to several hundreds.

4.3. String-rail track structure of an over-the-rail STY is designed as two string-rails to form a gage with the width of 0.75 m, 1.0 m, 1.25 m, 1.50 m or 1.75 m. String-rails are fixed with the help of anchor supports installed every 2-3 km and more and intermediate supporting masts having the spans of 25—50 m and more. A under-the-rail STY has one or two string-rails per one track. In a under-the-rail STY optimal span length is 200-300 m and maximal span length - 3,000 m.

A track in an over-the-rail STY has a structural camber of 10—50 mm in the middle of each span whereas a under-the-rail STY has a sag of 1—50 m and more (depending on the span length — 100—2,000 m and more). There is one more possible alternative of a under-the-rail STY with its track structure leveled as a straight line and supported with an additional cable (like a hanging bridge).

A track structure is equipped with switching devices. It could be designed as a dismountable assembled structure.

A gage in an over-the-rail STY by 2—3 times exceeds the height at which a centre of gravity of the rolling stock above the rail head is located which makes the movement along this track 2—3 times much more stable than the movement of carriages of a traditional high-speed railway. Stability of movement of hanging unibuses in a under-the-rail STY is provided by their hanging location under the track structure.

Track structure of STY could have vertical and horizontal curvatures. Their radii are determined predominantly by the design travel speeds of the rolling stock rather than by the structural peculiarities of the track, i.e. by the laws of physics – centripetal accelerations on the curves should not create discomfort for passengers. Minimal curvature radii of about 10 m are designed for stations, terminals, cargo terminals, depots, i.e. at the sections where the rolling stock is moving at minimal speed – 1-3 km/hour. At these curvatures the rails are designed without strings, i.e. according to the type of traditional railway rails.

It is possible to design STY routes as single-, double- or multi-track roads.

4.4. Supports are subdivided into anchor supports exposed to the horizontal load of strings (installed every 2—3 km and more) and supporting masts exposed to the vertical load (installed every 25—50 m and more). Supports could be made of reinforced concrete (assembled or monolithic), steel welded structures, composite materials or high-strength aluminum alloys. Depending on the soil qualities the foundations of supports could be piled (driving, screw, drilling and rammed or drilling and injective) or slab (monolithic or assembled). Supports together with the solid string-rail form a rigid framework structure; therefore, their load-bearing capacity is increased by 8 times, for example, as compared with a traditional mono-rail road (their cost in STY is accordingly reduced). If the STY supports were replaced by an earth embankment of a similar height its cost will be higher than that of the supports. The optimal supports height is 4—6 m. If necessary, it could be reduced at certain sections of the route to 1 m and less or increased to 10—20 m.

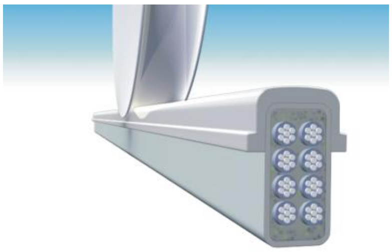


Fig. 5. Design of a string-rail and a wheel

4.5. Wheel is made of the high-strength steel (fig. 5) or high-strength light alloys. It is provided with an independent “automobile” suspension and two rims or derailment side rollers to replace the rims and to eliminate the rolling stock derailment. The rolling resistance coefficient is 0.001—0.002 which is 1.5—2.0 times lower than that of a railway wheel having a conical bearing surface. The total mileage is up to 1 million km and more. The cost of a steel STY wheel is less than that of a pneumatic tire of an automobile and its durability is 10—20 times more.

4.6. Transportation module (unibus) is a variety of an automobile put on the steel wheels. Like an automobile it could use a diesel, gasoline engine, turbine or a combined drive, for instance, “diesel-generator” – energy accumulator – electric engine”. If necessary, its engine could operate on other types of fuel including environmentally clean energy sources; natural gas, hydrogen, spirit, compressed air, flywheel energy accumulator, solar, wind and other energy sources. Furthermore, it is possible use external power sources as is the case with electrified STY or autonomous energy sources — accumulators, energy condenser accumulators, fuel batteries, etc. installed on-board of a unibus (unicar).

A high-speed unibus (fig. 2) has a unique shape characterized by the lowest lift-drag ratio among other known transportation vehicles (C_x=0.07—0.1, which is 3—4 times better than that of a modern sports car; these outcomes were obtained experimentally as a result of numerous wind tunnel tests). A unibus is the most economically efficient transportation vehicle among all known vehicles. Its super-efficiency is especially evident at the low travel speeds, for example, 100 km/hour, traditional for motor transport. A 50-seat over-the-rail unibus with the weight of 10 tons will need as small engine power as 9 kWt to move with the aforementioned speed along the horizontal section of a track (out of which 6.6 kWt — aerodynamic resistance, 1.5 kWt — rolling resistance of a steel wheel, 0.9 kWt — transmission losses). In this case energy consumption (on conversion to fuel) per 100 km of travel will amount to 2 liter (or 0.04 l/100 pass.×km or 0.4 l/1,000 pass.×km), against 1—1.5 l/100 pass.×km of fuel consumed by the best passenger cars which is 20—30 times more).

Unique aerodynamic qualities of a high-speed unibus body constitute its key advantages over other known vehicles including a sports car. For example, it is possible to build a high-speed STY route “Moscow — St. Petersburg” with the length of 660 km using the following two design alternatives of unibuses: 1) patented “string” by-passes with C_x=0.08; 2) their shape was copied from one of the best sports cars “Porsche” (C_x=0.34). The first alternative will be more efficient, namely: fuel savings during the validity period of a patent (20 years) for the transportation volume in the amount of 50,000 pass./24 hours will be estimated at USD 10 billion (!) because the aerodynamic resistance of a 10-seat unibus at the travel speed of 400 km/hour will be 230 kWt instead of 980 kWt. And why not to build not a single route but a network of high-speed roads? Then the summary fuel savings in STY as compared with the traditional solutions will exceed in monetary terms, for example, the current budget of Russia, or in physical terms — the total output of oil and natural gas.

A under-the-rail unibus has even more significant advantages over the traditional modes of urban passenger transportation. Its unique fuel (energy) efficiency results not only from the small losses for the high-speed movement (aerodynamic resistance and rolling resistance of steel wheels) but also from the fact that under the urban traffic regime (frequent stops every 0.5—1.5 km) it does not need any engine to accelerate at the open line or any brakes to brake before stops. All these functions are performed by the earth gravitation thanks to the design string-rail sag having a preliminary assigned value at each span. At the first part of travel between the stations a under-the-rail unibus moving downhill does not need any engine to accelerate smoothly to the speed of 100 km/hour and more. At the second part of travel it is moving uphill, thus no brakes are needed which eliminates additional energy losses (undoubtedly, breaks are available but to perform other functions such as emergency or stopping). Therefore, for example, a 40-seat under-the-rail unibus with a small average engine power of about 6 kWt is capable to gain the speed of 100 km/hour at a 1 km span (open line). At the same time a traditional 40-seat bus has a more powerful engine of 100 kWt and no high-cost measures undertaken at the present time (such as energy recuperators, hydrogen and combined engines, fuel batteries, etc.) to improve its characteristics could make it comparable with a under-the-rail unibus in terms of its efficiency, environmental impact and safety. As to the comfort of intra-city trips (noiseless, high-speed, congestion free, without sudden braking at the intersections, beautiful bird’s-eye views, no bumps or shakes, smooth acceleration and braking (acceleration up to 1 m/sec^2) a under-the-rail STY could be hardly over-passed even in the distant future.

Maximal travel speed of unibuses at a concrete over-the-rail STY depends on the rigidity and dynamic evenness of a string-rail track structure (specially designed for the required maximal speed ranging from 50 to 500 km/hour), engine power and aerodynamic qualities of a unibus body especially designed for the assigned maximal travel speed. Maximal travel speed of under-the-rail unibuses in a under-the-rail STY depends, mainly, on the design sag of a string-rail at the span. At large sags and long spans this speed could reach 150 km/hour, for example, at the sag of 90 m and the span of 3,000 m.

Fig. 6. City bus on a string-rail installed in asphalt

If necessary, practically any known passenger car or a truck (fig. 3), mini-bus or bus (fig. 6) could be installed on a STY track structure according to a customer’s requirement.

4.7. Infrastructure of “the second level”. It includes stations, terminals, loading and unloading terminals, service garages-parks (depots), filling stations located at “the second level” as well as switching devices. Depending on the design speed of unibuses the switching devices are subdivided into low- or high-speed devices and according to the organizational type of traffic — with or without stops (on the move). Switching devices are installed in the stations, terminals, cargo terminals, depots or on anchor supports, if required.

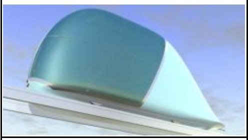
A track structure of STY elevated to the second level opens up wider opportunities for the distribution of stations and terminals. More favorable operation regimes of rail cars contribute to the reduced need in garages and filling stations as compared with traditional motor transport. Compact design of unibuses makes it possible to reduce by 5—10 times the size and, consequently, the cost of terminals, stations and the length of platforms as compared with railways.

5. Technical and economic justifications (feasibility study) to support the application of innovative technologies

The key technical and cost indices of various types of passenger and freight STY for the long (more than 10 km) flatland routes built beyond the boundaries of urban built-up areas are given in tables 1-4 (in the competitive prices for the Russian conditions).

Table 1.

Key technical-economic characteristics of various classes of a passenger over-the-rail STY (double-track flat routes with the length of more than 10 km built beyond the boundaries of urban built-up area*)

Classes of passenger over-the-rail STY	Key technical characteristics of passenger over-the-rail STY	Approximate construction cost** of serial passenger over-the-rail STY depending on their operational speed regimes, mln. USD/km					
		STY component	up to 100 km/hour	up to 200 km/hour	up to 300 km/hour	up to 400 km/hour	up to 500 km/hour
Super-light 	Unibus carrying capacity: • pass. / ton up to 3 / 0.5 Traffic volume*** (24 h.): • thous. pass. / thous. t up to 20 / 2	Track, supports	0,4—0,6	0,6—0,9	0,9—1,2	—	—
		Stations, depots	0,1—0,2	0,2—0,3	0,2—0,3	—	—
		Unibuses	0,1—0,2	0,2—0,3	0,2—0,3	—	—
		Total:	**0,6—1,0**	**1,0—1,5**	**1,3—1,8**	**—**	**—**
Light 	Unibus carrying capacity: • pass. / ton up to 10 / 2 Traffic volume*** (24 h.): • thous. pass. / thous. t up to 50 / 5	Track, supports	0,6—0,9	0,9—1,3	1,3—1,7	1,7—2,2	—
		Stations, depots	0,3—0,4	0,4—0,5	0,5—0,7	0,6—0,8	—
		Unibuses	0,3—0,4	0,4—0,5	0,5—0,7	0,6—0,8	—
		Total:	**1,2—1,7**	**1,7—2,3**	**2,3—3,1**	**2,9—3,8**	**—**
Medium 	Unibus carrying capacity: • pass. / ton up to 25 /5 Traffic volume*** (24 h.): • thous. pass. / thous. t up to 100 / 10	Track, supports	1,0—1,3	1,4—1,7	1,7—2,0	2,0—2,3	2,3—2,7
		Stations, depots	0,4—0,5	0,5—0,6	0,6—0,8	0,7—0,9	0,8—0,9
		Unibuses	0,4—0,5	0,5—0,6	0,6—0,8	0,7—0,9	0,8—0,9
		Total:	**1,8—2,3**	**2,4—2,9**	**2,9—3,6**	**3,4—4,1**	**3,9—4,5**
Heavy 	Unibus carrying capacity: • pass. / ton up to 50 /10 Traffic volume*** (24 h.): • thous. pass. / thous. t up to 200 / 20	Track, supports	1,5—1,9	1,9—2,3	2,3—2,7	2,7—3,2	3,2—3,7
		Stations, depots	0,5—0,7	0,7—0,8	0,8—0,9	0,9—1,1	1,1—1,3
		Unibuses	0,5—0,7	0,7—0,8	0,8—0,9	0,9—1,1	1,1—1,3
		Total:	**2,5—3,3**	**3,3—3,9**	**3,9—4,5**	**4,5—5,4**	**5,4—6,3**
Super-heavy 	Unibus carrying capacity: • pass. / ton more than 50 /10 Traffic volume*** (24 h.): • thous. pass. / thous. t more than 500 / 50	Track, supports	1,9—2,4	2,4—2,9	2,9—3,5	3,5—4,1	4,1—4,7
		Stations, depots	0,7—0,9	0,9—1,1	1,1—1,4	1,4—1,7	1,7—1,9
		Unibuses	0,7—0,9	0,9—1,1	1,1—1,4	1,4—1,7	1,7—1,9
		Total:	**3,3—4,2**	**4,2—5,1**	**5,1—6,3**	**6,3—7,5**	**7,5—8,5**

* the total cost will be 20—50% higher for STY routes built under conditions of rugged terrain or urban built-up environment or for shorter STY routes. The cost of freight routes will be 10—30% lower and the cost of electrified (with a contact network) routes will be 20—30% and more higher. Costs given in the table refer to: an average height of supports of 3 m and a span length of 30 m (as the height of supports and span length increase the cost of STY also increases); with passenger stations located not closer than every 5 km (the increased number of stations results in the increased cost of STY); with depots located not closer than every 100 m as well as proceeding from the assumption that there is not more than one unibus per 1 km of the route (increased number of unibuses leads to the increase in the total cost of the system).

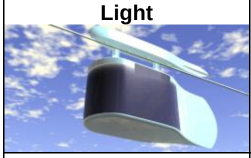
** the given cost (in prices as of January 1, 2010) refers to STY routes with single unibuses (not more than one unibus per 1 span) circulating along the track. The cost of STY with unibuses combined into a train (more than one module per 1 span) will be 25—40% higher; in this case the total STY productivity will not be increased as in order to ensure higher safety the travel intervals of such trains are to be increased as compared with single unibuses

*** the volume of transportation (passenger and freight) given in the table corresponds to about 10% of the maximal design (carrying) capacity of STY (for not more than 1 unibus per one span with the length of 30-40 m). In future with the development of a relevant automatic system to control a high-speed transportation flow it will be possible to increase by several times the indicated volume of transportation in the already-built STY routes.

Note: The cost of activities given in the table does not include the systems of safety and control systems of STY unibuses. Therefore, it is necessary to add to the cost of a serial STY the following expenditures: control centre (dispatcher's room) – USD 0.5-3.0 mln.; linear control system (depending on the type of control): manual (0.05-0.1 mln. USD/km), semi-automatic (0.1-0.3 mln. USD/km), automatic (0.5-1.0 mln. USD/km).

Table 2

Key technical and economic characteristics of various types of an under-the-rail passenger STY (double-track flat routes with the length of more than 10 km built beyond the boundaries of urban built-up area*)

Classes of under-the-rail passenger STY	Key technical characteristics of under-the-rail passenger STY	Approximate construction cost** of serial passenger under-the-rail STY by the operational speed regimes, mln. USD/km			
		STY component	up to 50 km/hour	up to 100 km/hour	Up to 150 km/hour
Super-light 	Unibus carrying capacity: • pass. / ton up to 3 / 0.5 Traffic volume per 24 hours: • thous. pass. / thous. ton up to 20 / 2	Track, supports Stations, depot Unibuses **Total:**	0,3—0,5 0,3—0,5 0,2—0,3 **0,8—1,3**	0,5—0,7 0,5—0,8 0,3—0,4 **1,3—1,9**	0,7—0,9 0,8—1,1 0,4—0,5 **1,9—2,5**
Light 	Unibus carrying capacity: • pass. / ton up to 10 /2 Traffic volume per 24 hours: • thous. pass. / thous. ton up to 50 / 5	Track, supports Stations, depot Unibuses **Total:**	0,6—0,8 0,6—0,9 0,3—0,5 **1,5—2,2**	0,8—1,1 0,9—1,2 0,5—0,7 **2,2—3,0**	1,2—1,5 1,2—1,4 0,7—0,9 **3,1—3,8**
Medium 	Unibus carrying capacity: • pass. / ton up to 25 /5 Traffic volume per 24 hours: • thous. pass. / thous. ton up to 100 / 10	Track, supports Stations, depot Unibuses **Total:**	0,8—1,1 0,9—1,3 0,6—0,8 **2,3—3,2**	1,2—1,5 1,3—1,7 0,8—1,0 **3,3—4,2**	1,5—1,8 1,7—2,1 1,0—1,2 **4,2—5,1**
Heavy 	Unibus carrying capacity: • pass. / ton up to 50 /10 Traffic volume per 24 hours: • thous. pass. / thous. ton up to 200 / 20	Track, supports Stations, depot Unibuses **Total:**	1,2—1,6 1,3—1,7 0,8—1,0 **3,3—4,3**	1,6—2,1 1,7—2,1 1,0—1,3 **4,3—5,5**	2,1—2,6 2,1—2,5 1,3—1,6 **5,5—6,7**
Super-heavy 	Unibus carrying capacity: • pass. / ton up to 50 /10 Traffic volume per 24 hours: • thous. pass. / thous. ton up to 500 / 50	Track, supports Stations, depot Unibuses **Total:**	1,6—2,2 1,7—2,1 1,0—1,3 **4,3—5,6**	2,2—2,8 2,1—2,6 1,3—1,6 **5,6—7,0**	2,8—3,4 2,6—3,5 1,6—2,1 **7,0—9,0**

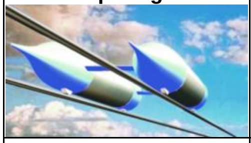
* the total cost will be 20—50% and more higher for STY routes built under conditions of rugged terrain or urban built-up environment or for shorter STY routes. The cost of freight routes will be 10—30% less than that of passenger routes and the cost of electrified (with a contact network) routes will be 15—30% and more higher. Costs given in the table refer to: an average height of supports of 10 m and a span length of 200 m (as the height of supports and span length increase the cost of STY also increases); with passenger stations located not closer than every 2 km (the increased number of stations results in the increased cost of STY); with depots located not closer than every 20 m as well as proceeding from the assumption that there is not more than one under-the-rail unibus per 1 km of the route (increased number of unibuses leads to the increase in the total cost of the system).

** the given cost (in prices as of January 1, 2009) refers to the movement along the under-the-rail STY of single unibuses (not more than two unibuses per 1 span with the length of 100-200 m).

Note: The cost of activities given in the table does not include the systems of safety and control systems of STY unibuses. Therefore, it is necessary to add to the cost of a serial STY the following expenditures: control centre (dispatcher's room) – USD 0.5-3.0 mln.; linear control system (depending on the type of control): manual (0.05-0.1 mln. USD/km), semi-automatic (0.1-0.3 mln. USD/km), automatic (0.5-1.0 mln. USD/km).

Table 3.

Key technical-economic characteristics of various classes of an over-the-rail freight STY (double-track flat routes with the length of more than 10 km built beyond the boundaries of urban built-up area*)

Classes of freight over-the-rail STY	Key technical characteristics of freight over-the-rail STY	Approximate construction cost** of serial freight over-the-rail STY depending on their operational speed regimes, mln. USD/km					
		STY component	up to 100 km/hour	up to 200 km/hour	up to 300 km/hour	up to 400 km/hour	up to 500 km/hour
Super-light 	Unicar carrying capacity: • ton up to 0.5 Traffic volume*** (24 h.): • thous. t up to 5	Track, supports Stations, depots Unicars **Total:**	0,3—0,4 0,05—0,1 0,05—0,1 **0,4—0,6**	0,5—0,7 0,1—0,2 0,1—0,2 **0,7—1,1**	0,7—0,9 0,1—0,2 0,2—0,3 **1,0—1,4**	— — — **—**	— — — **—**
Light 	Unicar carrying capacity: • ton up to 2 Traffic volume *** (24 h.): • thous. t up to 20	Track, supports Stations, depots Unicars **Total:**	0,4—0,6 0,1—0,2 0,1—0,2 **0,6—1,0**	0,6—0,8 0,1—0,2 0,2—0,3 **0,9—1,3**	0,8—1,0 0,1—0,2 0,2—0,3 **1,1—1,5**	1,0—1,2 0,1—0,2 0,3—0,4 **1,4—1,8**	— — — **—**
Medium 	Unicar carrying capacity: • ton up to 5 Traffic volume *** (24 h.): • thous. t up to 50	Track, supports Stations, depots Unicars **Total:**	0,6—0,8 0,15—0,3 0,15—0,3 **0,9—1,4**	0,8—1,0 0,2—0,3 0,2—0,3 **1,2—1,6**	1,0—1,2 0,2—0,3 0,3—0,4 **1,5—1,9**	1,3—1,6 0,2—0,3 0,4—0,5 **1,9—2,4**	1,5—1,8 0,2—0,3 0,5—0,6 **2,2—2,7**
Heavy 	Unicar carrying capacity: • ton up to10 Traffic volume *** (24 h.): • thous. t up to 100	Track, supports Stations, depots Unicars **Total:**	0,8—1,0 0,2—0,3 0,2—0,3 **1,2—1,6**	1,0—1,2 0,2—0,3 0,2—0,3 **1,4—1,8**	1,2—1,5 0,2—0,3 0,3—0,4 **1,7—2,2**	1,5—1,7 0,2—0,3 0,4—0,5 **2,1—2,5**	1,7—1,9 0,2—0,3 0,5—0,6 **2,4—2,8**
Super-heavy 	Unicar carrying capacity: • ton more than 10 Traffic volume *** (24 h.): • thous. t more than 100	Track, supports Stations, depots Unicars **Total:**	1,0—1,3 0,3—0,4 0,3—0,4 **1,6—2,1**	1,3—1,6 0,3—0,4 0,3—0,4 **1,9—2,4**	1,6—1,9 0,3—0,4 0,4—0,5 **2,3—2,8**	1,9—2,2 0,3—0,4 0,5—0,6 **2,7—3,2**	2,2—2,5 0,3—0,4 0,6—0,7 **3,1—3,6**

* the total cost of over-the-rail STY built under conditions of rugged terrain or urban built-up environment or of shorter freight over-the-rail STY routes will be 10—30% higher. The cost of electrified (with a contact network) routes will be 10—20% and more higher. Costs given in the table refer to: an average height of supports of 3 m and a span length of 30 m (as the height of supports and span length increase the cost of STY also increases); with freight terminals located not closer than every 10 km (the increased number of terminals results in the increased cost of STY); as well as proceeding from the assumption that there is not more than 5 unicars per 1 km of the route (increased number of unicars leads to the increase in the total cost of the system).

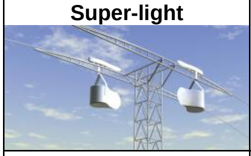
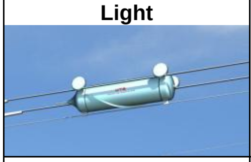
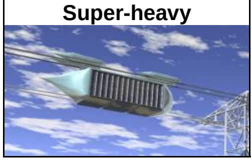
** the given cost (in prices as of January 1, 2010) refers to STY routes with single unicars (not more than one unicar per 1 span) circulating along the track. The cost of STY with unicars combined into a train (more than one unicar per 1 span) will be 10—20% higher.

*** maximal freight traffic volume given in the table corresponds to about 10% of the maximal design (carrying) capacity of an over-the-rail freight STY (for not more than 1 unicar per one span with the length of 30 m). In future with the development of a relevant automatic system to control a high-speed transportation flow it will be possible to increase by several times the indicated volume of transportation in the already-built freight over-the-rail STY routes.

Note: The cost of activities given in the table does not include the systems of safety and control systems of STY unibuses. Therefore, it is necessary to add to the cost of a serial freight over-the-rail STY the following expenditures: control centre (dispatcher’s room) – USD 0.5-2.0 mln.; linear control system (depending on the type of control): manual (0.05-0.1 mln. USD/km), semi-automatic (0.1-0.2 mln. USD/km), automatic (0.3-0.5 mln. USD/km).

Table 4.

Key technical-economic characteristics of various classes of an under-the-rail freight STY (double-track flat routes with the length of more than 10 km built beyond the boundaries of urban built-up area*)

Classes of freight under-the-rail STY	Key technical characteristics of freight under-the-rail STY	Approximate construction cost** of serial freight under-the-rail STY depending on their operational speed regimes, mln. USD/km			
		STY component	up to 50 km/hour	up to 100 km/hour	Up to 150 km/hour
Super-light 	Unicar carrying capacity: • ton up to 0.5 Traffic volume*** (24 h.): • thous. t up to 5	Track, supports Stations, depots Unicars **Total:**	0,2—0,3 0,05—0,1 0,05—0,1 **0,3—0,5**	0,3—0,4 0,1—0,2 0,1—0,2 **0,5—0,8**	0,4—0,5 0,1—0,2 0,1—0,2 **0,6—0,9**
Light 	Unicar carrying capacity: • ton up to 2 Traffic volume *** (24 h.): • thous. t up to 20	Track, supports Stations, depots Unicars **Total:**	0,3—0,5 0,1—0,15 0,1—0,15 **0,5—0,8**	0,5—0,6 0,15—0,25 0,15—0,25 **0,8—1,1**	0,6—0,7 0,15—0,25 0,25—0,35 **1,0—1,2**
Medium 	Unicar carrying capacity: • ton up to 5 Traffic volume *** (24 h.): • thous. t up to 50	Track, supports Stations, depots Unicars **Total:**	0,5—0,7 0,15—0,2 0,15—0,2 **0,8—1,1**	0,7—0,9 0,2—0,3 0,2—0,3 **1,1—1,5**	0,9—1,1 0,25—0,35 0,35—0,45 **1,5—1,9**
Heavy 	Unicar carrying capacity: • ton up to10 Traffic volume *** (24 h.): • thous. t up to 100	Track, supports Stations, depots Unicars **Total:**	0,7—0,9 0,2—0,25 0,2—0,25 **1,1—1,4**	0,9—1,1 0,2—0,3 0,3—0,4 **1,4—1,8**	1,1—1,3 0,3—0,4 0,4—0,5 **1,8—2,2**
Super-heavy 	Unicar carrying capacity: • ton more than 10 Traffic volume *** (24 h.): • thous. t more than 100	Track, supports Stations, depots Unicars **Total:**	0,9—1,2 0,25—0,3 0,25—0,3 **1,4—1,8**	1,2—1,5 0,3—0,4 0,4—0,5 **1,9—2,4**	1,5—1,8 0,4—0,5 0,5—0,6 **2,4—2,9**

* the total cost of under-the-rail STY built under conditions of rugged terrain or urban built-up environment or of shorter freight under-the-rail STY routes will be 10—30% higher. The cost of electrified (with a contact network) routes will be 10—20% and more higher. Costs given in the table refer to: an average height of supports of 10 m and a span length of 200 m (as the height of supports and span length increase the cost of STY also increases); with freight terminals located not closer than every 10 km (the increased number of terminals results in the increased cost of STY); as well as proceeding from the assumption that there is not more than one under-the-rail freight unicars per 1 km of the route (increased number of unicars leads to the increase in the total cost of the system).

** the given cost (in prices as of January 1, 2010) refers to under-the-rail STY routes with single unicars (not more than one unicar per 1 span with the length of 100-200 m).

Note: The cost of activities given in the table does not include the systems of safety and control systems of STY unibuses. Therefore, it is necessary to add to the cost of a serial freight under-the-rail STY the following expenditures: control centre (dispatcher’s room) – USD 0.5-2.0 mln.; linear control system (depending on the type of control): manual (0.05-0.1 mln. USD/km), semi-automatic (0.1-0.2 mln. USD/km), automatic (0.3-0.5 mln. USD/km).

As far as a unibus represents a variety of an automobile, a number of its standards were taken from automobile industry with its hundred-year experience and the most wide-spread distribution among other types of transport machine-building which could be attributed to its advantages. In particular, in terms of its carrying capacity a STY passenger unibus has the following analogues among cars (wheeled vehicles):

- super-light STY — motor bicycle (motorcycle);
- light STY — passenger car;
- medium STY — mini-bus;
- heavy STY — light bus;
- super-heavy STY — heavy bus.

Under the similar operation conditions — the volume of passenger and freight transportation, travel speed of the rolling stock, “the second level” of a track structure, etc. — the cost of STY will be less (see tables 1-4), namely by:

- 5—10 times — than the cost of highways and railways;
- 10—20 times — than the cost of a mono-rail and light metro;
- 15—25 times — than the cost of a train on a magnet suspension and high-speed elevated railways;
- 25—30 times — than the cost of underground.

This comparative analysis included not only the cost of a track structure (as it is commonly accepted) but also the cost of all other constituting components of the transportation system such as the rolling stock, infrastructure and land allocated from land-users.

6. Technical and economic indices related to the labour-energy-nature-conservation of a new process

Thanks to the low contact stresses in a “wheel — rail” pair (20—30 kgs/mm^2 against 70—120 kgs/mm^2 and more in railways) deterioration of a rail head will be less intensive than in railway transport. The thickness of a rail head is designed for the whole service life of STY (50—100 years) — for example, a head of 20—25 mm is enough to carry 500 million tons of freight.

The routes are characterized by all-weather operation; there is no need to remove ice or snow in winter time at temperatures below zero if the height of the supports exceeds that of the snow cover.

Operation costs are reduced to the periodical protection of metal structures against corrosion (once in 10—20 years). With a body of a string-rail made of stainless steel or high-strength aluminum alloys and supports made of reinforced concrete the operational costs will include only seasonal inspection of structures (to reveal structural defects).

Efficiency of STY as compared with other existing ground transportation systems (all routes are double-track, all indices are relative under similar development and operation conditions) is given in Table 5.

Table 5

STY advantages

Indices	**Relative size of indices**	**Justification of STY advantages**
1. Average cost of the transportation system (route*, infrastructure** and the rolling stock***): • STY • motor transport • railway • mono-rail road • train on a magnet suspension	 100% 300—500% 150—200% 1,000—1,500% 1,500—2,000%	Reduced cost of STY is the result of the following factors: low material consumption of a string-rail track structure, supports, rail cars and basic infrastructure components; use of traditional, low-cost and non-deficient materials and initial raw materials, machine-building nodes and aggregates; high production and building technologies of the route, infrastructure and rail cars; low cost and highly efficient operation (without traffic jams, and high-speed all-weather circulation without road accidents, etc.); rail cars (requiring reduced number of vehicles per 1 unit of transportation work); small land occupancy and small volume of earth works.
2. Average net cost of passenger and freight transportation: • STY • motor transport	 100% 300—400%	STY has the lowest net cost of passenger and freight transportation among other known ground transportation systems which results from the low value of its constituting components: 1) low construction costs (low material consumption for the track structure, supports,

* the cost of routes includes the cost of land withdrawn from land-users for the distribution of the transportation system

** the infrastructure includes: stations, terminals, cargo terminals, depots, repair shops, garages, passages, bridges, overpasses, traffic exchanges, filling stations, power transmission lines, power sub-stations, etc. as well as the land they occupy

*** it includes the average cost of passenger and freight rolling stock per 1 km of roads (for highways — motorcycles, passenger cars, mini-buses, buses, trolley-buses, freight vehicles, etc.)

Indices	Relative size of indices	Justification of STY advantages
• railway • mono-rail road • train on a magnet suspension	150—200% 500—800% 800—1,200%	infrastructure, rail cars and the use of the low-cost materials, nodes and aggregates; high construction and production technologies of all components; low volume of earth works and small land allocations; 2) low amortization costs (long service life of the track structure, supports, infrastructure, rail cars and their low cost; 3) low operation costs (small fuel consumption; high durability of the track structure, not requiring repair and restoration works; all-weather operation eliminating the need in the removal of ice and snow from the track in winter time; high operation efficiency of rail cars as a result of the high-speed movement, the lack of congestion and all-weather operation).
3. Area of land occupied by the transportation system (route and infrastructure): • STY • motor transport • railway • mono-rail road • train on a magnet suspension	 100% 5,000—8,000% 3,000—5,000% 150—200% 200—300%	Reduced area of land occupied by the STY is the result of the following factors: elimination of embankments, depressions, multi-level exchanges, bridges and overpasses that in highways or railways require the land-consuming high and long dams to access them; elimination of a wide continuous carriageway resting on a cushion and, consequently, on the earth embankment and ground surface; reduced (by 2—3 times) cross section of supports as compared, for example, with a mono-rail.
4. Volume of soil removed in the course of the route and infrastructure construction: • STY • motor transport • railway • mono-rail road • train on a magnet suspension	 100% 3,000—5,000% 4,000—6,000% 200—300% 400—600%	Reduced volume of soil removed in the course of STY construction is the result of the following factors: elimination of depressions, embankments*; reduced size and depth of the foundations of supports thanks to the reduced loads on the supports as compared with a mono-rail road; elimination of a continuous carriage-way (or a rail-sleeper grid in railways) resting on a cushion and thickened soil; reduced (by 2—3 times) cross section of supports, for example as compared with a mono-rail.
5. Fuel consumption (electric energy) per 1 unit of the transportation work (by the rolling stock at the travel speed of 100 km/hour): • STY • motor transport • railway • mono-rail road • train on a magnet suspension	 100% 1,500—2,500% 200—400% 500—1,000% 800—1,200%	Reduced fuel (electric energy) consumption by STY for passenger and freight transportation is the result of the following factors: lower (by 20—30 times) rolling resistance of a steel wheel moving along the steel rail as compared with a pneumatic tire; cylindrical shape of its bearing surface (in railways it has the form of a cone); two rims or derailment side rollers on each wheel (in railways there is one flange on a wheel) and lack of the wheel pairs (each wheel is provided with an independent suspension); improved aerodynamic qualities of the rolling stock eliminating screening effect (the lack of a continuous carriage-way); higher efficiency of a steel wheel as compared with an electro-magnetic suspension; reduced mass of the rolling stock per 1 unit of freight; improved evenness of the carriageway (due to the elimination of temperature deformation joints and preliminary tension of strings and the rail head).

* the volume of earth works in the course of modern highway and railway construction reaches 100,000 cub. m/km which results in their increased cost and great damage to the natural environment.

Indices	Relative size of indices	Justification of STY advantages
6. Material consumption (except soil) for the route and infrastructure construction and manufacturing of the rolling stock: • STY • motor transport • railway • mono-rail road • train on a magnet suspension	 100% 2,000—3,000% 1,000—1,500% 1,000—1,500% 1,500—2,000%	Reduced material consumption for STY construction (reduced resource-intensity of a system) is the result of the following factors: elimination of a continuous material-consuming carriageway resting on a cushion and embankment (which is replaced by compact, low material-consuming and low-cost string-rails); reduced material consumption for a track structure due to the use of pre-stressed strings (so that a track structure operates rather as a rigid thread than as a bridge beam for deflection) without worsening the strength and rigidity of a track structure; reduced loads on the supports and their foundations (only 1% of supports is exposed to the increased load, i.e. anchor supports); reduced material consumption of a rail car (on conversion to 1 unit of freight) as compared with the traditional rolling stock.
7. Summary environmental pollution in the course of the transportation system construction and operation: • STY • motor transport • railway • mono-rail road • train on a magnet suspension	 100% 1,000—1,500% 300—400% 200—300% 200—300%	Reduced summary environmental pollution (by STY as compared with other transportation systems) is the result of the following factors: significant reduction in fuel (energy) consumption for the transportation of passengers and freights within the whole range of travel speeds (under equal external conditions); no deterioration of pneumatic tires and asphalt and the lack of their smell in hot weather; elimination of dusty, easily destroyed earth embankments and depressions, gravel and other cushions; elimination of the use of anti-icing salts and snow-removing machines in winter; elimination of high electric voltages, currents and strong alternating electromagnetic fields; low resource-intensity of a system contributing to the increased environmental safety at the stage of construction (increased technological ecological purity results from the reduced environmental load on natural environment at the stage of raw materials extraction and processing and implementation of construction and assembly works in the construction site).
8. Summary operation costs (including consumption of fuel, electric energy, repair and maintenance costs of a track, the rolling stock and infrastructure, salary for the staff, etc.): • STY • motor transport • railway • mono-rail road • train on a magnet suspension	 100% 200—300% 150—200% 400—600% 200—300%	Low operation costs of STY are the result of the following factors: low fuel consumption per 1 unit of transportation work; increased service life of a string-rail, supports and rail cars (due to the lack of temperature joints and high evenness of the rail head STY is practically free from the dynamic shock loads of the moving wheels); all-weather operation of the rolling stock (including shower, hail, strong fog, hurricane wind, icing, heavy snow, flooding, etc.); no need to remove ice and snow from the track structure in winter time; under the extreme weather conditions (hurricane wind, shower, flooding, earthquake, tsunami, etc.) no need in the restoration of a track that is not damaged; reduced volume of repair and restoration works due to the increased durability of a system and its reduced material consumption.
9. Traffic accident rates (including injures and death of people, domestic and wild animals): • STY	 100%	High stability of rail cars on the string-rails (thanks to the provision of each unibus wheel with a derailment system and independent suspension and a more stable gage as compared with railways) and "the second level" of circulation eliminating collisions with ground vehicles,

Indices	Relative size of indices	Justification of STY advantages
• motor transport • railway • mono-rail road • train on a magnet suspension	> 10,000% 300—500% 100% 100%	people, domestic and wild animals which makes STY the safest transportation system (accident rates including injures and deaths of people will be lower than in railways and aviation today, i.e. approximately by 1,000 times lower than in highways). Elimination of embankments and depressions does not hinder the flow of ground and surface waters, migration of people and animals, dislocation of agricultural and other technical devices which contributes to the reduced accident rates and increased safety of the system. Elimination of embankments unstable to the mechanical impacts contributes to the increased system resistance to various natural disasters such as floods, tsunami, earthquakes as well as to the terrorist acts (thanks to the high margin of safety of supports and a track structure and difficult to access string-rail elevated to a considerable height).
10. Summary negative environmental impact (in the course of construction and operation of the route, infrastructure and the rolling stock): • STY • motor transport • railway • mono-rail road • train on a magnet suspension	100% 1,500—2,000% 500—800% 200—300% 300—500%	Environmental impact of STY will be minimal at all stages of its life cycle which could be attributed to the following factors: suspension systems of the rolling stock relative to the track structure (i.e. a steel wheel) — are characterized by the highest efficiency coefficient among all known and future solutions (99,9%) which could be hardly over-passed in future (for example, electromagnetic suspension of a “Trans-rapid” train, Germany, has the efficiency of 40%), therefore, a rail car in the aggregate with its high aerodynamic qualities is the most economically efficient vehicle among all known vehicles with its minimal environmental impact; jointless rail track with a smooth rolling surface (the working surface of a rail is polished to eliminate micro-unevenness) makes the wheels to move noiseless within the whole range of speeds; improved aerodynamic qualities of rail cars (4—5 times better than of sports cars according to the experimental data) eliminate aerodynamic noises within the whole range of speeds; unlike other ground transportation systems construction of STY routes will not result in the destruction of natural landscapes and bio-cenoses and will contribute to the reduced numbers of people and animals killed in road accidents; small volume of earth works and small area of land allocated for STY construction will result in the minimal withdrawal of fertile soils with its valuable humus generated during millions of years implying land-use and oxygen-generation processes necessary to maintain its constant and continuous rehabilitation in the atmosphere of the planet.

STY advantages become even more evident if we use a scale factor. For example, in addition to the existing 900,000 km of highways and 90,000 km of railways (USA has 6.4 million km and 230,000 km, respectively) in the 21st century Russia has to build 3—5 million km of new roads without which the national economy of this enormous country will not be able to develop successfully. At least 100,000 km of them should be the high-speed roads. If they were built with the use of the Russian string technologies the resulting possible savings for Russia could be estimated at USD 5 trillion dollars (!) as compared with the use of the Japanese high-speed railways (elevated alternative, i.e. located at “the second level”). About 200,000 high-speed unibuses circulating along these roads could replace 5 million passenger cars and 5,000 high-speed railway trains with the summary power of their engines exceeding 300 million kWt. Whereas for the high-speed unibus stock the power of 50 million kWt is enough to give the power savings in the amount of 250 million kWt. But it should be noted that this figure also implies energy (fuel) consumption, environmental pollution and, consequently, ecology and, finally, resources (material and financial), that are limited.

7. New consumer qualities of the product

STY as a transport system is characterized by the higher consumer qualities, namely:

- reduced net cost of travel as compared with railway or motor transportation (by 1.5—2 times and more and 3—5 times and more, respectively);
- reduced fuel (electric energy) consumption per 1 unit of transportation work as compared with railway or motor transportation (by 1.5—2 times and more and 5—6 times and more, respectively);
- reduced level of environmental pollution per 1 unit of transportation work as compared with railway or motor transportation (by 3—4 times and more and 10—15 times and more, respectively);
- reduced amount of lands allocated for the track and infrastructure as compared with railway or motor transportation (by 30—50 times and more and 50—80 times and more, respectively);
- reduced operation costs per 1 unit of transportation work as compared with railway or motor transportation (by 2—3 times and 4—6 times, respectively);
- multi-purpose use: a string-rail could be used to accommodate fibro-optical and wire communication lines, cable electric transmission lines, supports and string-rail track could accommodate cell and radio-relay communications, wind and solar power plants, etc.

- other advantages — see above, item 6.

Taking into account significant technical and economic advantages of STY over the traditional and future transportation systems it could be referred to the breakthrough technologies.

8. Qualitative requirements imposed on raw and other materials

The product meets the state standards of CIS countries and Russia as well as the relevant requirement imposed on passenger and freight transport, including the high-speed transport, in the UN, USA and EU countries.

9. Proposed suppliers of complete units

Russian, Byelorussian and foreign companies.

10. Stage and level of development

During the 2001—2009 period STY building technologies including its track structure, supports and the key nodes and structural components were successfully tested at the single-track testing ground built in Russia (town of Ozyory, Moscow Region, fig.7). The key characteristics of the stand were as follows:

- length — 150 m;
- summary tension of strings — 450 ts (at = 20 °C);
- height of supports — up to 15 m;
- maximal span — 48 m;
- maximal mass of the moving load — 15 t;
- relative rigidity of the largest span under the load — 1/1,500;
- metal consumption by the track structure — 120kg/m;
- slope of the route — 100‰.

In winter time a modified truck ZIL-131 installed on the steel wheels according to the STY standards could easily ascend the track with 50 mm of ice (ice was immediately broken under the moving wheel and thrown down the rail so it was specially frozen).

Fig. 7. Testing ground (October, 2001)

At the testing ground the following components and parts were examined:

- various strings (twisted cables of 27 mm and 15.2 mm diameter made of wire with 3 mm and 5 mm diameter, respectively);
- anchor fixing of strings;
- relaxation of pre-stressed strings (during 6 years no relaxation was observed in a cable K-7 with 15.2 mm diameter with the estimated stress of 10,400 kgs/cm^2);
- piled, drill-injective and slab foundations of intermediate and anchor supports;
- special, high-strength concrete for a string-rail;
- two-rim steel wheel damped with a rubber interlayer between the rim and the nave (which showed reliable and stable movement — during 6 years of operation there was no contact between the rim and the rail head as the standard movement regime was provided by a toroidal bearing surface of the wheel);
- wheel-rail cohesion (minimal friction coefficient in a "wheel — rail" pair during the rain and icing was 0.15—0.2 which makes it possible to design high-speed STY routes with a protracted slope up to 150—200‰);
- rightness of estimates including strength and rigidity of supports, track structure and strings under the impact of the rolling stock, seasonal temperature changes, wind, icing, etc.

STY testing ground in the town of Ozyory was necessary to test the key nodes and components of a new system belonged to its first generation (it fulfilled the role similar to that, for example, of the first wooden aircraft built by Wright brothers that showed the livability of a new transportation system). After that the system was optimized and at the present time STY Ltd. offers for realization the third generation of string-rail roads (an analogue in aviation is an all-metal ”Boeing” aircraft offered to the market 30 years after the first flight of the aircraft built by Wright brothers).

Therefore, today there are all opportunities to design and build the low-cost, reliable, durable, fast-implemented and fast repaid string roads.

A string-rail track structure and STY supports are designed as a transportation elevated road in compliance with the requirements of the Russian norms (SNiP 2.05.03-84* “Bridges and Pipes”) as well as with the basic provisions of the relevant bridge norms of the USA and EU countries. Therefore, like bridges STY does not require any certification (except a unibus). It only needs the state expertise at the relevant bodies and tests in the course of its putting into operation.

11. Information about the main inventions (patents) in string technologies

- Anatoly Yunitskiy. Linear Transport System. Patent of the Russian Federation No. 2080268, classification B 61 B 5/02, 1994;
- Anatoly Yunitskiy. Linear Transport System. Patent of Republic of South Africa No. 95/2888, classification B 659, 1994;
- Anatoly Yunitskiy. Linear Transport System. Patent of Ukraine No. 28057, classification B 61, B 13/04, 1994;
- Anatoly Yunitskiy. Rail of the Transport System of Yunitskiy (variants) (2 inventions). Euro-Asian Patent No. 003484, classification E 01 B 5/08, 2001;
- Anatoly Yunitskiy. Rail of the Transport System of Yunitskiy. Euro-Asian Patent No. 003485, classification E 01 B 5/08, 2001;
- Anatoly Yunitskiy. High-speed Transportation Module. Euro-Asian Patent No. 003490, classification B 62 D 35/00, 2001;
- Anatoly Yunitskiy. High-speed Transportation Module. Euro-Asian Patent No. 003533, classification B 62 D 35/00, 2001;
- Anatoly Yunitskiy. High-speed Transportation Module. Euro-Asian Patent No. 003534, classification B 62 D 35/00, 2001;

- Anatoly Yunitskiy. High-speed Transportation Module. Euro-Asian Patent No. 003535, classification B 62 D 35/00, 2001;
- Anatoly Yunitskiy. High-speed Transportation Module of the Transport System of Yunitskiy. Patent of the Russian Federation No. 2201368, classification B 62 D 35/00, 2001;
- Anatoly Yunitskiy. High-speed Transportation Module of the Transport System of Yunitskiy. Patent of the Russian Federation No. 2201369, classification B 62 D 35/00, 2001;
- Anatoly Yunitskiy. Rail of the Transport System of Yunitskiy (variants) (2 inventions). Patent of the Russian Federation No. 2201482, classification E 01 B 25/00, 2001;
- Anatoly Yunitskiy. High-speed Transportation Module of the Transport System of Yunitskiy. Patent of the Russian Federation No. 2203194, classification B 62 D 35/00, 2001;
- Anatoly Yunitskiy. High-speed Transportation Module of the Transport System of Yunitskiy. Patent of the Russian Federation No. 2203195, classification B 62 D 35/00, 2001;
- Anatoly Yunitskiy. Rail of the Transport System of Yunitskiy. Patent of the Russian Federation No. 2204636, classification E 01 B 25/00, 2001;
- Anatoly Yunitskiy. Rail of the Transport System of Yunitskiy: Manufacturing and Assembling Technology (2 inventions). Patent of the Russian Federation No. 2204637, classification E 01 B 25/00, 2001;
- Anatoly Yunitskiy. Rail of the Transport System of Yunitskiy. Patent of the Russian Federation No. 2204638, classification E 01 B 25/00, 2001;
- Anatoly Yunitskiy. Rail of the Transport System of Yunitskiy and Manufacturing Technology (2 inventions). Patent of the Russian Federation No. 2204639, classification E 01 B 25/00, 2001;
- Anatoly Yunitskiy. Rail of the Transport System of Yunitskiy. Patent of the Russian Federation No. 2204640, classification E 01 B 25/00, 2001;
- Anatoly Yunitskiy. Rail of the Transport System of Yunitskiy. Patent of the Russian Federation No. 2208675, classification E 01 B 25/00, 2001;

- Anatoly Yunitskiy. High-speed Transportation Module of the Transport System of Yunitskiy. Patent of the Russian Federation No. 2211781, classification B 62 D 35/00, 2001;
- Anatoly Yunitskiy. Transport System. Patent of the Russian Federation No. 2211890, classification E 01 B 25/00, 2001;
- Anatoly Yunitskiy. High-speed Transportation Module of the Transport System of Yunitskiy. Patent of the Russian Federation No. 2217339, classification B 62 D 35/00, 2001;
- Anatoly Yunitskiy. Transport System of Yunitskiy (variants) and its Building Technology (4 inventions). Patent of the Russian Federation No. 2220249, classification E 01 B 26/00, 2002;
- Anatoly Yunitskiy. Transport System of Yunitskiy (variants) and its Building Technology (3 inventions). Patent of the Russian Federation No. 2223357, classification E 01 B 26/00, 2002;
- Anatoly Yunitskiy. Transport System of Yunitskiy (variants) and its Building Technology (3 inventions). Patent of the Russian Federation No. 2224064, classification E 01 B 26/00, 2002;
- Anatoly Yunitskiy. Transport System of Yunitskiy (variants) and its Building Technology (2 inventions). Euro-Asian Patent No.004917, classification E 01 B 26/00, 2002;
- Anatoly Yunitskiy. Building Technology of High-rise Building Using Concrete Forms and Shaft-wall System (2 inventions). Euro-Asian Patent No. 004188, classification E 04 B 1/35, 2002;
- Anatoly Yunitskiy. Rail Track Structure of the Transport System of Yunitskiy (variants) (3 inventions). Euro-Asian Patent No. 004391, classification E 01 B 25/00, 2003;
- Anatoly Yunitskiy. String Transport System (variants), Manufacturing and Assembling Technology of a Span Section of a String Rail Thread (3 inventions). Euro-Asian Patent No. 005017, classification E 01 B 25/24, 2003;
- Anatoly Yunitskiy. Transport System. Euro-Asian Patent No. 005534, classification E 01 B 25/00, 2004;

- Anatoly Yunitskiy. Transport System of Yunitskiy (variants) and its Building Technology (4 inventions). Euro-Asian Patent No. 006359, classification B 61 B 3/00, 2004;
- Anatoly Yunitskiy. Transport System of Yunitskiy (variants) and its Building Technology (3 inventions). Euro-Asian Patent No. 006111, classification B 61 B 3/00, 2004;
- Anatoly Yunitskiy. Transport System of Yunitskiy (variants) and its Building Technology (3 inventions). Euro-Asian Patent No. 006112, classification B 61 B 3/00, 2004;
- Anatoly Yunitskiy. String Transport System of Yunitskiy. Patent of the Russian Federation No. 2324612, classification B 61 B 5/00, 2006;
- Anatoly Yunitskiy. String Transport System of Yunitskiy and construction methods of a string transport system. Patent of the Russian Federation No. 2325293, cl. B 61B 3/02, 2006.

12. Proposed investments

In the 21st century the world demand in the routes of the “second level” could be estimated at 30—35 million km including 3—5 million km and more in Russia, 2—3 million km and more in China, 1—2 million km and more in India, 300,000—500,000 km and more in Kazakhstan. In this case 90—95% of this market could be captured by STY. The rest 5—10% will be covered by mono-rail and cable roads, trains on a magnet suspension and elevated motorways and railways. The length of STY routes could range from 1 to 10,000 km and more and the volume of investments in the relevant projects could amount from USD 10 million to 10—20 billion and more.

Required volume of investments to provide a demonstration and research testing unit for STY with the aim to expose all STY standards to the experimental and industrial tests and to get the demonstration speeds from 50 to 500 km/hour is estimated at about USD 150-200 million for a 3-year period. It is also possible for STY to get a large-scale access to the world market without a testing ground and then the first built or put into operation routes will serve as the testing units for the “second level” routes at the first stages of their operation. In this case the key STY components will be preliminary tested at the laboratory or field stands.

13. Sales markets

Transport system of "the second level" intended to carry passengers and freights within cities, between cities, countries and continents at the travel speeds ranging from 50 to 500 km/hour as well as to carry specialized freights such as friable, liquid, piece and container freights necessary in all cities, countries and continents. At the present time this market is predominantly occupied by highways and railways. This market of the transportation services of "the second level" will operate as an additional new market like, for example, a market of mobile telephone communications additionally created to the existing market of communications not to replace but rather to supplement it.

14. Possible access to the world market

It is possible and according to the independent experts' assessments the cost of this market in the 21st century will exceed USD 100 trillions.

15. Technology transfer

- implementation of scientific research and experimental design works (laboratory and field stands, scientific research testing ground of STY);
- purchase of licenses and "know-how";
- construction;
- development of new production units;
- technical re-equipment;
- expansion of existing production units;
- quasi-internal transfer: technology transfer within countries, alliances, unions, associations of independent juristic persons.

16. Possibility and efficiency of import replacement

All STY components including a string-rail track structure, supports, the rolling stock and infrastructure could be manufactured using the home-made raw materials and complete units without worsening technical and economic characteristics of the system in any industrially developed country of the world having automobile-, railway- and aircraft-building industry.

17. Additional information

STY awards:

- 2 golden medals of All-Russia Exhibition Centre: 1998 and 2002;
- Diploma of the 1st degree at the International Fair-exhibition “Innovations-98” awarded for String Transport of Yunitskiy to the winner of the competition of scientific and technological developments. October 20—23, 1998 (Moscow, All-Russia Exhibition Centre);
- Certificate of the Laureate of the National Competition “Russian Brand” — golden quality mark for the “Project of a Passenger Module” Decision No. 14 of October 16, 2001 (Moscow);
- Certificate of the Laureate of the National Competition “Russian Brand” — golden quality mark for the “Project of a Freight Module” Decision No. 14 of October 16, 2001 (Moscow);
- Certificate of the Laureate of the National Competition “Russian Brand” — golden quality mark for the “String Transport Technologies” Decision No. 14 of October 16, 2001 (Moscow);
- Diploma of the Laureate of the National Award of the Transport Sector of Russia – “Golden Chariot” in the nomination “Project of the Year” (by the joint decision of the State Duma of the RF Federal Assembly and the RF Ministry of Transport, December 12, 2009, Moscow).

Support provided by the UN:

- UN Grant for the project No. FS-RUS-98-S01 “Sustainable Development of Human Settlements and Improvement of their Communication Infrastructure through the Use of a

String Transportation System” (1998—2000);

- UN Grant for the project No. FS-RUS-02-S03 “Provision of Sustainable Development of Human Settlements and Protection of Urban Environment through the Use of a String Transportation System” (2002—2004).

18. Information about the implementing organization of the innovative project

String Technologies Yunitskiy LLC, Russia, Moscow, 115487, Nagatinskaya st., 18/29, tel./fax: +7-495-680-52-53, +7-499-616-15-48, e-mail: a.yunitskiy@gmail.com, http://www.yunitskiy.com, skype: Anatoly Yunitskiy.

19. Project resources

Resources involved by the present time:

- technologies;
- finances;
- production;
- marketing.

Resources to be attracted:

- finances;
- marketing;
- administrative and lobbying resources;
- production.

20. Proposed alternatives to involve new partners in the project implementation

Investments, credits, partnership, strategic partnership, joint-stock, orders for concrete passenger, freight or passenger/freight STY routes.

21. Proposed forms to compensate the use of resources provided by the new partners

- share in the joint production;
- percent in a credit agreement;
- privileges in the product sales;
- financial relations;
- payment of services;
- distributor, dealer or agent agreement;
- provision of commercial information.

22. Payback period of the project costs

2—5 years depending on a concrete STY route and a concrete investment project for the development of an infrastructure facility including STY as one of its components.