YUNITSKIY STRING TRANSPORT: MEETING THE TIME AND SPACE CHALLENGES

All ideas in this article are based on research delivered by Yunitskiy school. With its 40-year tradition, the school, in different years, united hundreds of technicians and scientists from different countries. For each of the concepts represented here, you can find a detailed scientific rationale in the monographs and articles, which became the result of decades of an effort made by the head of the school and his followers. Some of the most important sources are referred to in the Bibliography. Please, see the illustrations to the article on the inside cover of the magazine.

INTRODUCTION: AH, THOSE ROADS

Russia's geographical position and vast territory reflect specific features and magnitude of the challenge for an effective transportation network. Large areas with challenging environmental conditions and topography are the main reason for the uneven spatial dispersal of people, distribution of production facilities and mineral deposits. This, in turn, automatically adds to the complexity of the logistics and creates imbalances in the economic development, requiring the use of administrative resources to be compensated.

In this article, the Yunitskiy string transport, today marketed as SkyWay, is outlined as a possible comprehensive response to transportation challenges. SkyWay is an innovative passenger and cargo transportation system that can be used in complex climatic and terrain conditions. The system features an unprecedented wide range of specifications, exceptional performance, low construction cost and minimal energy consumption ensuring high-speed carriage.

WHAT IS A YUNITSKIY STRING TRANSPORT?

In terms of technical performance, the effectiveness of string transport rests on five pillars:

- the transportation system is based on an innovative string rail, i.e. a bundle of steel strands in the steel body tensioned between the anchor supports;
- a unified track structure suitable for all kinds of passenger and cargo carriage by steel-wheeled vehicles;
- exceptional aerodynamic characteristics of the rolling stock (according to the results of wind tunnel tests, drag coefficient Cx = 0.06)
- vehicles can be assembled of modules of different purposes and configurations;
- secondary infrastructure.

In the most general terms, this transport system is a network of string rails tensioned between anchor supports and supported by the intermediate lightweight supports, at a height of one meter or more above the ground. Some anchor supports that bear the bulk of the load can be at the same time passenger stations and terminals, loading and unloading terminals, etc. One anchor support can accommodate a number of infrastructure facilities; hence, an unprecedented level of unification of cargo and passenger flows is achieved. Transportation processes are fully automated, as the transportation is performed by special steel-wheeled vehicles equipped with an automatic control system. Minimum safe traffic interval on the line is two seconds; that is why the string transport is superior to the traditional rail transport in terms of its carrying capacity.

Vehicles running on the overpass-type track structure are capable of speeds up to 500 km/h in a normal environment and up to 1,250 km/h in rarefied-gas tunnels (in forevacuum). Generally, high speeds are possible due to elevated rails, which help removing "ground effect". The ground effect causes at least a twofold reduction in aerodynamic characteristics of the traditional transport. An additional benefit in terms of speed is the use of a "steel rail plus steel wheel" combination providing an efficiency of about 99.8%. This level is unattainable not only for pneumatic tires but even for electromagnetic suspension. All these factors add to the extreme economic viability of the system.

A prototype vehicle currently under testing, named unibike after its inventor Anatoliy Yunitskiy, has a power consumption of 2 liters per 100 kilometers at 150 km/h, or 0.7 liters per 100 km at 100 km/h (electricity to fuel conversion). In general, the system is a highly effective transportation solution, with its construction and operation costs being much more affordable than those for any existing alternatives. Its elevated track structure and a variety of possible configurations offer opportunities to create, in the long term, a unified transport network to satisfy the whole range of transportation needs. At the same time, such a network will tremendously enhance security and speed up passenger and cargo transportation, while crucially reducing the harmful impact produced on the environment [5, p. 7–14].

ALTERNATIVE TRANSPORT SYSTEMS: ADVANTAGES AND DISADVANTAGES

SkyWay is not the only alternative transport system being developed today. Maglev and vacuum tube trains are the most striking trends. The car sector (unmanned robomobils) is also rapidly evolving.

The main disadvantages of maglev trains are their technological sophistication, high cost and limited area of application. Vacuum tube transportation systems raise a host of issues and doubts about their safety [3, p. 6–15]. As for the trend toward electric robomobils, it seems to be a partial solution. Autopiloted rides on the real roads will be exposed to human factors, unfavorable weather conditions and other bottlenecks. And switching to electric cars will not solve the problem of too many cars [6, p. 7–13].

In contrast to the other transport systems, which are expensive and controversial in a number of aspects, the string transport has no fundamental flaws. SkyWay obtained a number of positive high-level expert assessments (Institute of Transport Problems of the Russian Academy of Sciences, Expert Council under the Ministry of Transport of the Russian Federation, etc.) [2, p. 3]. The cost of construction of string transport railroads proved to be comparable to that originally claimed by the developers (i.e. 2–3 times cheaper than motor roads, 2 times cheaper than conventional railroads, and 10 times cheaper than high-speed magnetic levitation roads), as evidenced by the construction of test tracks being underway now in Belarus. It is obvious that the development of the string transport and integration into the existing transport network will make each new kilometer of string roads cheaper due to ramp-up, expansion and decentralization of the production.

THE CORNERSTONES OF CIVILIZATION: SILICON AND STRING RAIL

In its genesis and development, the Yunitskiy string transport is a complex synergy of engineering solutions. In general, it is something new, although the majority of its components have been separately known for a long time. At the core of the string transport, there is a relatively simple idea that has already been implemented before in different areas of industrial and civil construction: pre-stressing [3, p. 6–16]. This solution, being innovatively applied in the string transport, has opened up enormous opportunities for the sector development. The same was the case with silicon that had become known long before the advent of sophisticated computers and solar energy,

National Technology Initiative
SkyWay
Transportation Strategy 21st Century No. 35, 2016/17

but developed its full potential only later in those two areas.

Parallels between string rails as the basis for the string transport and silicon as the basic raw material for the production of semiconductor devices can be drawn in several aspects. Silicon has allowed a remarkable increase in the speed of information transmission. String transport would increase the speed of movement of physical objects. The speed increase allows for an increase in output and low cost, and a variety of features and applications of these two "elements" will allow for the industry unification. Therefore, passenger and cargo transportation by the string transport can be developed in the same way as the production of electric appliances that are actually integrated into a single network, both on the local and global levels. The same would soon become possible in the transportation sector: a unified global rail network – "Transnet" – can be created.

It is possible and appropriate, from the technical and economic points of view, that the Transnet will absorb and complement the Internet, take over the information transmission functions, and thus serve as a universal communication device that will be capable of providing an unprecedented level of socio-economic consolidation. While the Internet is the core of the fifth technological paradigm, the Transnet will be the core of the sixth technological paradigm. Today's Russia has all the necessary resources for this upgrade [6, p. 49–51].

INSTANTANEOUS MOVEMENT: MOBILITY 5.0

The transition to the sixth technological paradigm will involve a transition to a new form of mobility, which we call Mobility 5.0 in a similar way to the well-established concept Mobility 4.0. Mobility 4.0 is commonly understood as a set of fundamental changes in the transportation industry, that occur in direct correlation with the development of automated transportation systems (rail, road and air transport) and its integration into a single transport and information network. For a particular passenger or cargo, such a single network will be a digitized transit corridor providing optimal transportation in terms of time, distance, energy costs, etc. The upgrade to Mobility 5.0 assumes the achievement of the prior form of mobility with a possibility of a qualitatively different level of unification, which completely excludes transportation intermediaries. The absence of intermediaries, combined with the fully automated control over vehicles and the transport network, ensures "instantaneous movement", i.e. moving over any distance no longer requires that a person should make any special effort. One will spend time not on moving, but rather on everyday activities; as a consequence, movement itself will become virtually instantaneous. This is what the Mobility 5.0 means.

WHERE A COMMUNICATIONS NETWORK BEGINS

The following issues are of undoubted interest: possible mechanisms for the implementation of the string transport in different regions; the ways to scale up a string railroad network and possibilities and prospects of using string railroads for Russia and the entire world. Naturally, as semiconductor devices, which became primarily used in the forefront of technological progress (in the military and space industries and computer science), the Yunitskiy string transport will be implemented first in the areas where the need for it is the greatest. This is why the string transport will not be first implemented in long-distance, interurban communications. In the same way, construction of string railroads in the context of developing difficult terrains seems inappropriate at the initial stage of development of innovative road systems. These promising and important objectives will be solved on a stage-by-stage basis. The solution involves gradual advance, starting with the establishment of short-distance transport communications, whereby the string transport shows maximum efficiency in the shortest time.

The string transport will start developing with local cargo lines and urban roads: connections between production enterprises and marshalling yards; between places of natural resource extraction and ports; between airports; passenger lines over intra-urban watersheds, etc. The string transport, constructed and commissioned to connect systems of that kind, as if extends conveyor lines beyond extracting and manufacturing enterprises. These solutions allow significant reduction of transportation costs and thus increase of profits. Further expansion of communications systems will exponentially strengthen the effect. As a consequence, there will be an organic growth of the system and its consistent integration into a network, just as it was with the Internet. From this point on, it will be impossible to hinder the growth. Due to the combination of technical and operational characteristics, SkyWay is the first transport system, which will not only require no subsidies, but will bring high profits [3, p. 47].

TRANSPORT NETWORK: POTENTIAL AND ADVANTAGES

One of the most significant advantages of the technology is the possibility to construct a unified communications network based on the Yunitskiy string transport that will ensure high-speed transportation and feature an unlimited potential for expansion. No other transport mode allows anything like this.

Furthermore, it is impossible to underestimate the benefits that the exclusion of transport intermediaries would bring to a single country and the entire world.

Motor road transport, because of its being one-dimensional, cannot be structured into a global network. First, this would involve the separation of the road and vehicles, with separate control and shock absorption system. Second, the motor road may occupy the same space only once, at least twice (through the construction of expensive elevated roads), while the string transport allows an almost unlimited number of levels within the same vertical. Third, in many places the construction of the embankment under roads is not possible, while supports and poles for the string transport can be installed even in permafrost, bogs, sands or sea shelves.

Rail and air transports are even less suitable to address the challenge of creating a unified network. They cannot be thought of as transportation means in an urban environment. Aviation in addition requires expensive infrastructure centers to be constructed and causes enormous damage to the environment. Sea and river transport modes do not function on the land.

As for the string transport, it is able to meet all (or almost all) transportation needs by linking roads into a single system with no fundamental limitations for expansion. String rail makes it possible to combine high-speed interurban and intra-urban transportation, passenger and cargo transportation. Besides, telecommunication lines, power supply lines, Wi-Fi, etc. may be placed inside the string rail so that laying a road to a particular place on the planet will automatically ensure the comprehensive development of the area, together with all the necessary accompanying infrastructure, and preserve the fertile soil layer for farming [6, p. 51–52].

Looking ahead, SkyWay network can be combined with a power grid. In this case, the energy consumption for passenger and cargo transportation within the network will not exceed one-fifth of the amount of energy that it will be able to produce. This entails intermediate supports with solar panels and wind turbines mounted on them. The technological base to implement such a solution already exists. The raw material base, thanks to the string transportation, can be considerably enhanced: due to the emerging opportunity of developing hard-to-reach deposits of lithium, which can later be used to produce energy storage devices to store the energy generated within the transport network. In addition, this energy can be transmitted within the system, along the lines enclosed in the string rail body [6, p. 153–154].

In its genesis and development, Yunitskiy string transport is a complex synergy of engineering solutions. In general, it is something new, although the majority of its components have been separately known for a long time.

National Technology Initiative
SkyWay
Transportation Strategy 21st Century No. 35, 2016/17

As for the string transport, it is able to meet all (or almost all) transportation needs by linking roads into a single system with no fundamental limitations for expansion. Cities connected by the string transport at speeds up to 1,250 km/h actually turn into a single linear city.

CITIES WITHIN THE TRANSNET NETWORK

Cities connected by the string transport at speeds up to 1,250 km/h actually turn into a single linear city. New satellite cities can be built on absolutely different principles. They can be completely or almost completely pedestrian ones. Dominant buildings, towering over other buildings and combining the functions of passenger stations and housing, industrial, recreational, and cultural centers, etc., would serve as their logistics centers. At distances up to 500 meters (a comfortable walking distance) around the dominant buildings, people will be housed or production will be concentrated, together constituting infrastructure clusters. Linear cities may unite an unlimited number of such clusters, which are located along the same line at an average distance of 1 km from each other, optimal to meet the requirement of transport accessibility.

Due to high speeds, the length of a linear city can reach hundreds or even thousands of kilometers. Some clusters can be used for living, others for work, etc. String railroads will be considerably cheaper than motor roads; they will not waste the expensive urban lands and can be integrated with utility facilities and power supply systems, etc. Thus, they will make housing cheaper, more affordable and comfortable, by eliminating the need for transportation [6, p. 157–158, 171–174].

EXAMPLES FROM THE WORLD PRACTICE: SPEED, DISTANCE AND COST RACE

So that this trend – to place production facilities and residential developments following the logic of linear cities – could be delineated more clearly, the example of creating modern conurbations in China may be cited. Shanghai – Nanjing – Hangzhou conurbation, with a population of over 100 million people and its GDP exceeding 20% of all-China's GDP, has become possible due to the development of a network of high-speed roads. You can get from one city to another within 1–2 hours. Mentality of the region inhabitants is being changed; the boundaries between the suburbs and the city center are becoming blurred. Mobility of inhabitants is growing; the movement of labor, services and goods is becoming faster; economic efficiency is being increased; both educational institutions and jobs are becoming more accessible. The effect is enormous. It is an inspiring example. By 2025, the EU plans to launch a high-speed transportation corridor between Oslo, Gothenburg and Copenhagen. Yet, currently available high-speed transportation systems can be as expensive as USD 100 million per 1 km.

SkyWay roads cost USD 3 million for 1 km and more. At the same time, it can have the same or even better speed parameters, i.e. up to 500 km/h through the air and up to 1,250 km/h in forevacuum tubes. This may ten times, in comparison with all the other high-speed systems, increase the economic impact of the solution for creating conurbations in order to develop any region

EXPLORATION OF REMOTE AREAS: ARCTIC

New type settlements, linear cities and factories connected by the string transportation – this is the best way to develop difficult terrain and difficult climate areas such as the Arctic. In the Arctic wilderness or on the Arctic coast, the construction of multi-story buildings does not make economic sense, whereas the idea of linear settlements and secondary, string rail infrastructure is precious. The construction of settlements in the form of a "cluster type city" takes into account the specifics of traditional northern farming practiced by indigenous ethnic groups. It allows the use of track structure elements (anchor supports) for housing units that will have electricity, heating and communication, Internet and navigation access points [1]. At the same time, safe and fast travelling and comfortable accommodation open up tremendous prospects for the development of the region's mineral deposits, whereas the availability of efficient transport, for delivering the raw materials produced to the areas where they will be processed [3, p. 57]. In addition, due to the Yunitskiy string transport, it will be possible to construct ports of special configurations on almost any part of the coast, since in that case mooring areas can be several kilometers seaward from the shore, at depths of 20–30 m and more, and cargo will be delivered there using string overpasses.

OTHER PERSPECTIVES

For Russia, the construction of rapid, environmentally sustainable and inexpensive string rail roads will open up unlimited prospects for its economic development. Further, it can contribute, in a very short time, to the explosive GDP growth. After having connected Russia, these roads will connect the entire continent; they will pave a new trade route from Europe to Asia, lay the foundation for the development of hard-to-reach areas and tourism. Besides, the string transport will be able to establish fundamentally new, previously non-existent markets, e.g. for water or cold transportation. In Russia, Lake Baikal has enormous naturally-renewable supply of clean fresh water, which is not used today. When the network of string railroads reaches the lake, its water will become an inexhaustible source of wealth. Especially, in winter when the water will be naturally frozen, and the natural ice, with the market price being several thousand dollars per tonne, will be delivered to the hot and densely populated regions of the world, such as South India and China[3,p.73–74].

For this country, the added value produced by a growing string transport network will include not only transit profits, development of new areas, exploration of mineral deposits, etc. The construction of roads will require labor mobilization, employment growth, and more raw materials for laying new service lines and, therefore, it will stimulate production. The number of production facilities will also grow; currently unprofitable facilities (because of transportation problems) could be restored.

ON THE THRESHOLD OF THE FUTURE: RUSSIA AS AN OBSERVER OR AS A WINNER

Today, SkyWay is of great interest to lobbying groups from Australia, USA, Slovakia, Germany, Turkey, Canada, India, China, United Arab Emirates, Philippines, Russia and other countries. There are almost no places on the world map that have never experienced transportation problems. By addressing the challenges, the string transport provides a powerful stimulus for the development of the economy as a whole: it contributes to better communication, raises domestic consumption, and ensures the acceleration of foreign trade turnover. Transportation infrastructure is like a circulatory system of the country, whose effective operation affects the health of the whole organism. Russia has always had

There are almost no places on the world map that have never experienced transportation problems. By addressing the challenges, the string transport provides a powerful stimulus for the development of the economy as a whole: it contributes to better communication, raises domestic consumption, and ensures the acceleration of foreign trade turnover.

National Technology Initiative
SkyWay
Transportation Strategy 21st Century No. 35, 2016/17

troubles associated with the operation of that system, but now we have a remedy, i.e. technology that can effectively address the existing challenges and enable the country to recover first and then grow. We believe that the only way for Russia is technological modernization and new industrialization, which is to be implemented as soon as possible with the use of innovations, including SkyWay. In this case, Russia will be capable of occupying a leading position in the Eurasian region and becoming a state of a new type, which will meet the relevant requirements of the 21st century.

Authors:
S. A. Sibiryakov, V. I. Baburin,
A. V. Sukhodoev, E. O. Petrov

Research supervisor:
A. E. Yunitskiy

Bibliography:

1. Litovskiy, V. V. The Concept of Placing Productive Forces in the Arctic on the Basis of the Yunitskiy's Secondary Infrastructure and the Space Model of the Polar Lace Transport Network for "Mobile Communities" / Bulletin of the Murmansk State Technical University. Murmansk: 2016 - V. 19, No. 2. - P. 431-442. URL: http://yunitskiy.com/author/2016/2016_113.pdf (accessed date: Jan 24, 2017).
2. Minutes No. 16 of the Meeting of the Expert Council for the Improvement of Innovativeness of Public Procurement in the Transport Sector dtd. February 11, 2016. URL: https://itk-mdl.asutk.ru/upload/doc/%D0%9F%D0%A0%D0%9E%D0%A2%D0%9E%D0%9A%D0%9E%D0%9B%2016%20-%20%D0%BF%D1%80%D0%B0%D0%B2%D0%BA%D0%B0%202.pdf (accessed date: Jan 24, 2017).
3. Yunitskiy, A. E. String Transport System (ITS) in Questions, Answers and Projects / A. E. Yunitskiy. - M.: 2000. - 75 pages. URL: http://yunitskiy.com/author/2000/2000_17.pdf (accessed date: Jan 24, 2017).
4. Yunitskiy, A. E. String Transport Systems: A New Land Transport Technology / A. E. Yunitskiy. - M.: 2004. - 55 pages. URL: http://yunitskiy.com/author/2004/2004_09.pdf (accessed date: Jan 24, 2017).
5. Yunitskiy, A. E. String Transport Systems: on Earth and in Space. – Gomel: 1995. - 337 pages. URL: http://yunitskiy.com/author/1995/monograph1chapter11.pdf (accessed date: Jan 13, 2017).
6. Yunitskiy, A. E. Sustainable Development of Human Settlements and the Improvement of Their Communication Infrastructure with the Use of the String Transport System. The Final Report on the Project of the United Nations Centre for Human Settlements No. FS-RUS-98-S01 / Project Manager A. E. Yunitskiy. - M.: 2000. - 179 pages. URL: http://yunitskiy.com/author/2000/2000_01.pdf (accessed date: Jan 24, 2017).