

PAPER • OPEN ACCESS

Innovative projects of the development of high-speed transport in Russia

To cite this article: V M Fomin *et al* 2019 *J. Phys.: Conf. Ser.* **1404** 012077

View the [article online](#) for updates and enhancements.

You may also like

- [Initiation of Richtmyer–Meshkov instability by a detonation wave](#)
A V Kashkovsky, Yu V Kratova and A A Shershnev
- [Features of the interaction of localized free-stream disturbances with the straight and swept wing boundary layer](#)
M M Katasonov, V V Kozlov, A M Pavlenko et al.
- [Studying of the resonator depth influence on amplitude-frequency characteristics operating flow in the two-channel system](#)
A V Primakov and A A Zhilin



ECS
The
Electrochemical
Society
Advancing solid state &
electrochemical science & technology

DISCOVER
how sustainability
intersects with
electrochemistry & solid
state science research

Innovative projects of the development of high-speed transport in Russia

V M Fomin, V Y Malov and D G Nalivaychenko

Khristianovich Institute of Theoretical and Applied Mechanics
4/1, Institutskaya str., Novosibirsk, 630090 Russia

denis@itam.nsc.ru

Abstract. Continuous development of transport systems at the state level is an urgent task, the success of which will largely determine the dynamics of improving the quality of life and trade and economic efficiency of regions, cities and the state as a whole. To make a qualitative transition to a fundamentally new concept of transport is possible only based on scientifically sound approaches and fundamental analysis of all aspects of the creation and operation of the transport system.

1. Introduction

The modern World is characterized by a tendency to "Accelerate changes", and changes in almost everything: in new types of goods and services, in the media, in the Internet. But perhaps the most important changes relate to the growth in the speed of both the delivery of goods and services to the final consumer, and in the speed of movement of people themselves. It is difficult, if not impossible, to accurately predict the new types of needs that may arise in 10, especially in 20 and 30 years. But the need to increase the speed of movement of material bodies will certainly increase. Aviation, of course, partially solves these problems, but it also has a physical limit on the volume of transportation of both goods and passengers.

For Russia, as the largest power by the territory, it is land transport that has always been the basis for the implementation of the tasks of maintaining the unity of economic, political and social spaces.

Traditional modes of transport, road and rail, in its modern form, in the very near future will not meet the challenges of qualitative acceleration of the movement of goods and people. In Russia, rail transport is one of the leaders of passenger and freight transport. The development and modernization of rail transport is on the way to creating an extensive network of high-speed railway. However, it is already obvious that for the used technology of movement "wheel-rail", there are problems of two technological limits. First, it limits the dynamics of acceleration and braking, which depend on the adhesion of the wheel with the rail and the reliability of current collection at speeds above 350 km/h. Secondly, with the growth of speed, the power costs for overcoming the aerodynamic resistance to the movement of the vehicle grow.

The most effective way to simultaneously overcome two limits can be the implementation of vacuum-levitation transport, the principle of which is a fruitful symbiosis of two ideas, the concept of transport on magnetic suspension in an artificially created vacuum inside a sealed overpass.

The emergence of fundamentally new types of land transport, including, perhaps, vacuum magneto-levitation transport is a matter of the near future. Russia needs to be at the forefront of both scientific and technological developments here. It is necessary to once again become world leaders in



the field of innovative solutions in the field of transport and implement the idea of an Asia-Europe transport bridge using domestic technologies. The latter is sure to cause a multiplier effect in many other sectors of knowledge and economy. Reducing the time of movement of people is sure to increase the possibility of social control over the vast, but still sparsely populated regions of the country.

At present, the idea of vacuum-levitation transport is actively discussed all over the world in popular science literature, at international conferences dedicated to the transport of the future and trends in the development of rail transport. A number of foreign companies (ET3, Hyperloop Transportation Technologies Inc., Hyperloop One) actively propagate the idea of vacuum-levitation transport (VLT), offering its implementation at the expense of investors. In China, at the end of September 2019, a new state program was approved with a goal to achieve a speed of 600÷1000 km/h on land rail transport. Obviously it will be a magnetic levitation transport for which China has the necessary technology and economic resources.

Despite the bold beliefs of the representatives of the above organizations, the analysis of the literature review allows us to judge the insufficient or complete lack of scientific and technical justification of the basic aspects of VLT. A qualitative transition to a fundamentally new concept of transport is only possible based on scientifically sound approaches and fundamental analysis of all aspects of the creation and operation of the transport system.

2. Problem setup

One of the most important aspects of this approach is the task of identifying the needs of the national economy, the need to create completely new industries, materials, and the intensification of the use of new logistics schemes in remote and sparsely populated areas of the country. For this purpose, the development of theoretical and methodological schemes of a comprehensive assessment of options for creating new forms of transport systems in their unity with the transport system of the country as a whole, ensuring the satisfaction of the needs for interregional industrial and social relations, as well as in creating favorable conditions for entering world markets. The solution of this task will require improvement of the calculation tools that means study of compatibility of models of development of the whole country, models of transport systems and models that reflect the interests of individual industrial and social structures. As a result, it is expected to create a user-friendly system of calculations, with the conclusion of the results of decisions on a cartographic basis, which dramatically increases the susceptibility of information.

The proposed method is based on an optimization inter-sectoral interregional model, supplemented by a block of direct links, which makes it possible to estimate the load of individual sections of the transport network. This model is supplemented by a group of models for the formation of a support transport network with the allocation of separate sections for new vacuum-levitation transport and possible transshipment points. The economic approach in market economy conditions should remain in demand, because only such a vision of the future development of the country's economy is able to evaluate the options that meet the requirements of maintaining social control over vast but sparsely populated territories of the Asian part of Russia.

In the practice of world economic and geographical sciences, certain components of spatial development problems, taking into account the transport factor, have been successfully solved for a long time. These are the tasks of inventory optimization, optimization of transportation, logistics, and development of cities and agglomerations.

In this regard, names must be noted of U Aizard, A Lesh, L Kantorovich, A G Granberg, L Mani, S Tarkhov and the program TACIS. The approach covered in this paper, as a continuation of the work of A. G. Granberg, is that the criterion of optimality when choosing options in the proposed approach is the indicator of final consumption, proportionally divided by regions of the country in accordance with living conditions and population. The fundamental differences between our approach and the profit indicator of a separate entity of economic relations, a separate transport and logistics company or GDP indicator for a particular region. In our proposed approach, the transport system is represented by all modes of transport interacting with each other complementary and / or interchangeable. The

models are designed by us taking into account the interaction of different transport modes and possible and necessary transshipment supported by the appropriate software protected by a patent. Spatial intersectoral models are also original and have no analogues in other countries and research teams.

3. Mathematical model

The basis for the study was the optimization model- of the inter-sectoral balance of production with a restriction on the production labor resource [1]. In this case, the basic model of interindustrial balance is combined with the restriction on the production resource and the condition of maximizing the final consumption (z) is added. To simplify the task, it was decided do not use dual variables and capacity constraints in the model. Taking into account the accepted assumptions the formal generalized model looks as follows:

$$\begin{aligned} z &\rightarrow \max! \\ (E - A) \cdot X - \alpha z &\geq Q \\ f \cdot X &\leq C \\ X &\geq 0 \end{aligned}$$

The initial data for the model are the matrix A , the row vector of coefficients f , the vector-columns of the consumption structure α with the condition that the sum of these coefficients is equal to one, and Q - vector "other" needs of the national economy (defense, balance of exports-imports, etc.), as well as labor restriction C . Let's say a few words about a matrix A , since it is key to the model. Matrix A contains the coefficients of direct costs of products of the i -th industry for the production of a unit of products of the j -th industry. Data for matrix A , coefficients f , α , Q and C were taken from previous studies. The row and column "Vacuum Levitation Transport" were added to the matrix A . The introduction of this column into the optimization model will help to understand how the final consumption will change when the transport system is put into operation. Also, the corresponding parameters were added to the arrays f , α and Q . The main difficulty was the selection of parameters for the above data sets, since the technical documentation does not mention the materials and methods of manufacturing parts for the pipe and capsule of the transport system. Therefore, strong assumptions were made about the similarity of the rows and columns "VLT" and "AVIA", except for the indicators of capital investments, which were significantly increased. It was decided that the coefficients f , α and Q in the respective categories will be similar, but with minor changes. Not much more manpower is needed to build a transport system VLT than for conventional transport. It is assumed that VLT occupies a place in the structure of consumption the same place as the industry "AVIA", and the state for its own needs (vector-column Q) will need the services of this new type of transport as much as other types of transport as extremely promising.

In the absence of other cost indicators, the indicators of the VLT variant were generally based on estimates of "Hyperloop" indicators.

4. Results and discussions

The results of preliminary calculations using the proposed approach for the integration of VLT into the prospective 2035 inter-industry balance have shown the following:

- The growth rate of final consumption in the country during the implementation of the VLT project by 2035 is slightly reduced: by 0.5-0.9 points, which is about 400-700 billion rubles of final consumption annually;
- At the same time accelerated development is required by machine building and construction complexes;

- Metallurgy (ferrous and nonferrous) industries are growing at a faster pace. The accelerated growth of the energy sector is explained not only by the needs of VLT, but also by the growth of the metallurgical complex, which is the main consumer of electricity;
- The growth rates of the industries focused on the final consumption of the population are slightly reduced: agriculture, light and food, services, etc.;
- The industries related to scientific and design studies, which are required in many related (with VLT) industries, receive a noticeable acceleration

If we conduct another computations with a model in which we assume the implementation of this project at an accelerated pace not for 20, but for 10 years, the annual losses in terms of final consumption will amount to more than 1.2 trillion rub or 0.12 points reduction in its growth rate.

The structure of export-import supplies has a significant impact on the final consumption index. It is desirable to change it in the direction of reducing exports, especially products of extractive industries.

The use of the model with a more detailed nomenclature of industries and / or with a spatial component could give us more accurate data to which industry and in which region it is useful to activate the corresponding production activity.

Acknowledgments

The research was carried out within the framework of the RAS Presidium Program in 2018-2020 (project No. AAAA-A18-118021590034-6).

References

- [1] Granberg A G 2003 *Fundamentals of Regional Economy: Textbook for Universities* (M.: Higher School of Economics) p 495