Vector NG Rus

Registration Number N013 dd 11-Oct 2016

Copy #1

Long-term railway infrastructure forecasting

Platform for cooperation

Materials for internal use

Vector NG Rus — Developing partner

Российские железные дороги — Russian Railways

ПКТБ ЦКИ — Providing testing field partner

Designing and Technological Office on Informatization Systems

фрии ПРЕАКСЕЛЕРАТОР — Technological and methodological partner

Contents

Selected team projects

Sphere of interests and competence of the company Vektor NG Rus

State Policy

- New quality of life
- ✓ ***Innovative development and modernization of the economy***
- National security
- Balanced regional development
- Effective State

State Programs

43 State Programs

- …
- ✓ *The development of the aviation industry*
- …
- ✓ *Development of the Transport System*

Subprograms and federal target programs

212 Subprograms and 45 federal target programs

- …
- ✓ *Sub-program "Ensuring the implementation of the Russian Federation, the state program" Development of Transport System*
- ✓ *"Federal Target Program "Development of Transport System of Russia (2010 - 2020 years)"*

Events, government contracts

More than 700 audits and over 1,000 government contracts

- …
- ✓ *"Ensuring the effective development of transport and technological infrastructure"*
- ✓ *"Scientific and technical support of the program "Development of export of transport services"*
- ✓ *"Ensuring the implementation of the federal target program "Development of Transport System of Russia (2010 - 2020 years)"*

Areas of research and a portfolio of products developed by the company and decisions

1. **Technology of long-term prediction of complex structured processes based on artificial intelligence systems**
2. **Big Data**: collection and processing of structured and unstructured data sets (statistics and economics of settlements of the Russian Federation, statistics of cargo and passenger transportation, economics of Transport sector facilities)
3. **Applied research in the field of transport:** a study and long-term forecasting of passenger traffic, freight transport logistics
4. **Corporate Finance** (including financial modeling), the establishment of control and monitoring of projects (portfolio of over 200 projects)

MISSION of Vektor NG Rus - the creation of a practical groundwork for increasing the capitalization of the underlying assets of the Transport sector through the implementation of cutting-edge applications and technological innovations, and not by means of short-term speculative mechanisms

Approved purpose and mechanisms of realization of the Transport Strategy

Long-term development of the Russian transport system

1. Formation of an integrated transport space in Russia
2. Ensuring the availability, scope and competitiveness of transport services
3. Integration into the global transport space and implementation of the country's transit potential.
4. Improving the transport system safety
5. Reducing the harmful effects of transport on the environment

The approved purpose formed the specific requirements for the complex tasks associated with the creation of an effective implementation of the Transport Strategy Management System

1. Reciprocal linking strategies of the constituent regions of Russia with the Russian Federation Transport Strategy
2. Linking Transport Strategy with resource provision industries
3. Development and adoption of effective implementation of the organizational model of the Transport Strategy
4. Development of the system of control and supervision in transport
5. Development of statistical systems in transport
6. Creating a system for monitoring the implementation of federal target programs and strategies
7. Creation of information and analytical realization of the Transport Strategy Management System
8. Creating a system of strategic planning on the basis of transport and economic balance
9. Creation and development of the automated information-analytical management system of transport industry

One of the major stages of the implementation of the Strategy - the creation of a unique system (model), capable of forming contingency scenarios for the development of processes, based on which we can confidently make operational and strategic decisions

Products of Vektor NG Rus – compliance with tasks of the Transport Strategy

Forecast | Big Data | Corporation finance, monitoring

- A long-term forecast of socio-economic development of the regions of the Russian Federation and all populated settlements has been developed
- **Forecast for passenger traffic is more accurate than all other methods in the world if artificial intelligence systems is used**
- A forecast model of traffic flow and logistics has been developed
- Models of long-term strategic development of the airline have been developed - the forecast, optimization and planning of the route network and aircraft fleet, a model of flexibility and pricing has been created
- A model of the mutual influence of the different modes of transport has been developed
- The project work is actively used by the MSU supercomputer

Forecast | **Big Data** | Corporation finance, monitoring

- More than 8 GB of information from 12 statistical databases, for passenger traffic (monthly statistics, 4 types of transport) have been processed
- More than 140 GB of data in the work on logistics project have been processed
- Dozens of indicators for 100% urban and 100% urban-type settlements and 100% of the regional centers of the Russian Federation in the dynamics since 2000 have been processed
- Full information about all airports of the Russian Federation - the location, the strip, airport taxes, fuel costs, passenger traffic, timetables, types of aircraft and airlines

Forecast | Big Data | **Corporation finance, monitoring**

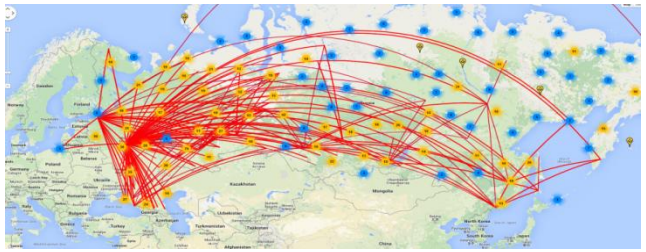
- Financial and economic models of airlines, airports, aircraft manufacturers have been developed
- PPP models have been created
- **Volumes of state grants and federal funding have been forecast**

Readyness state of VNG products

Reciprocal linking strategies of the constituent regions of Russia with the Russian Federation Transport Strategy	
Linking Transport Strategy with resource provision industries	
Development and adoption of effective implementation of the organizational model of the Transport Strategy	
Development of the system of control and supervision in transport	
Development of statistical systems in transport	
Creating a system for monitoring the implementation of federal target programs and strategies	
Creation of information and analytical realization of the Transport Strategy Management System	
Creating a system of strategic planning on the basis of transport and economic balance	
Creation and development of the automated information-analytical management system of transport industry	

The company has developed tools to solve large-scale problems defined by Transport Strategy until 2020. The Team of Vektor NG Rus is ready to finalize and customize products for specific customer requirements

”Know-How” application in the forecasting of transport systemsм



Long-term demand for passenger traffic

Reliable rout net

Production model

Transport systems types for market

Forecasts with maximum accuracy

Decision Solving Of decreasing dimention

Machine Learning

Econometics models

Economics state policy

KPI’s of regional developmen t

Scenarios of development

Our products have been approved

Ростех

МИНПРОМТОРГ РОССИИ

ERNST & YOUNG

Problem solutions with the help of models of Artificial Intelligence

The input parameters for the model of artificial Intelligence

A lot of long-term macroeconomic scenario model of 83 subjects of the Russian Federation

A database "fact-forecast" economic indicators of human settlements of the Russian Federation (city, village, rural settlements)

Analyzed the route network and ground infrastructure of the USSR since 1962

A unique database is created to predict the demand for transportation

119019, Москва, ул. Новый Арбат, д. 21. Тел +7 (916) 341-46-54, alex.berezin@vektorng.com, www.vektorng.com
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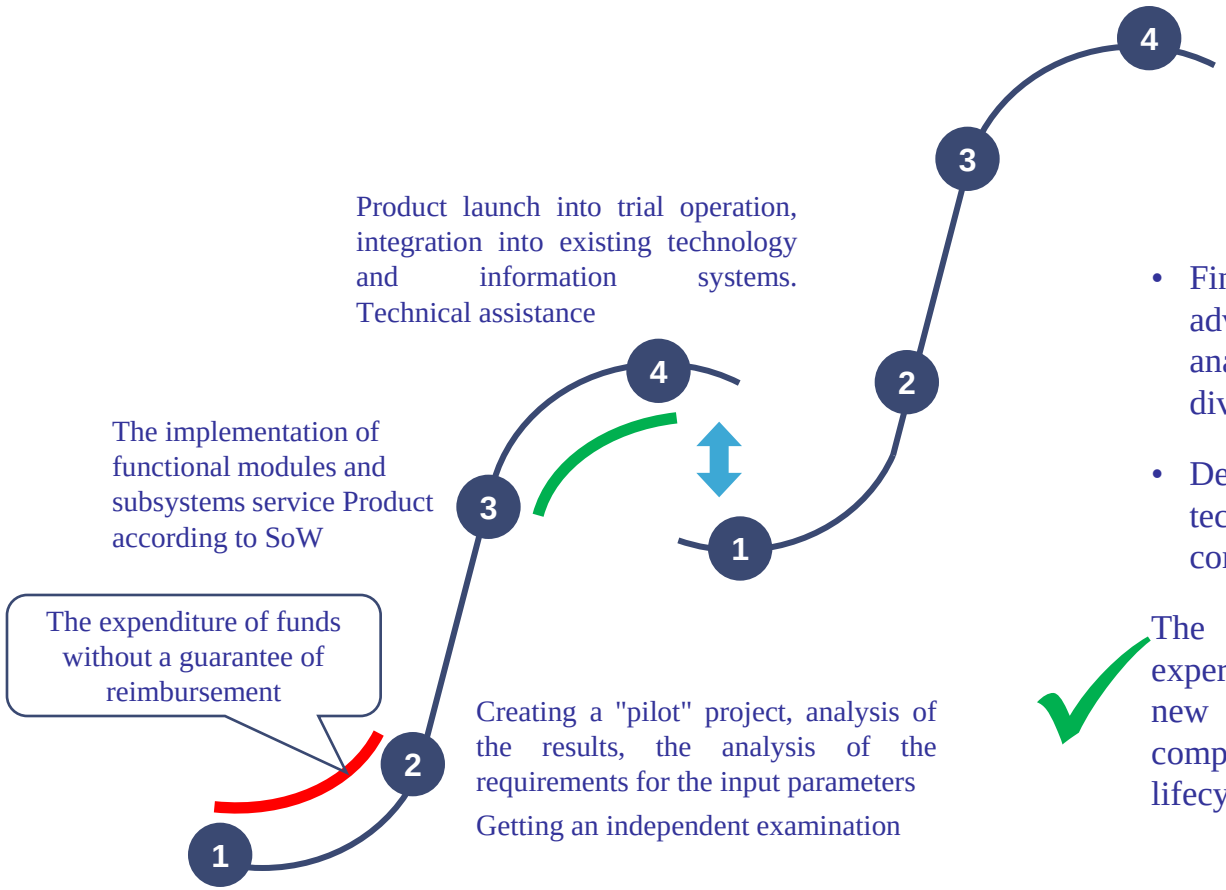
The life cycles of technology research and development



- Financing the development of new, advanced technologies that have no analogues on the market require the diversion of investment resources
- Development of "from scratch" technology associated with high risk of complete loss of investment

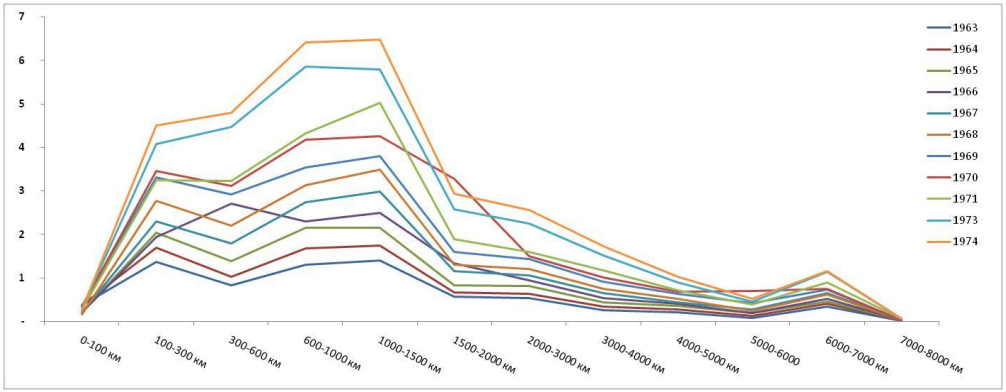
The company "Vector NG Rus" has experience in research and development of new high-tech projects and the successful completion of stages of high-risk technology lifecycle

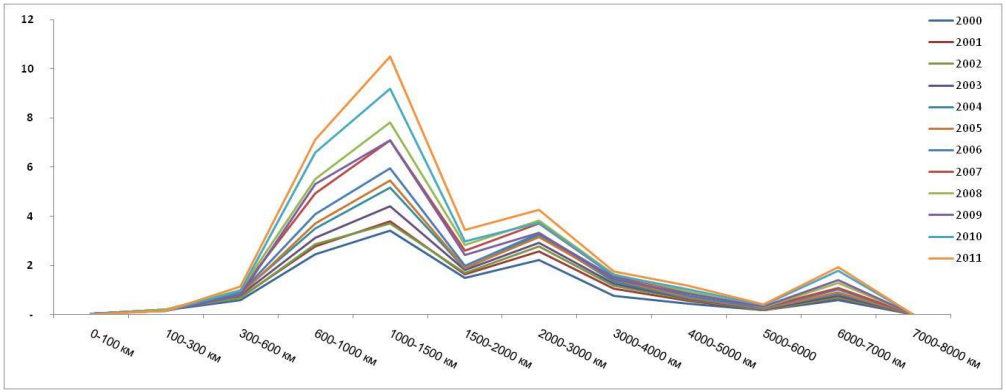
Contents

Infrastructure forecasting today - tomorrow's route network

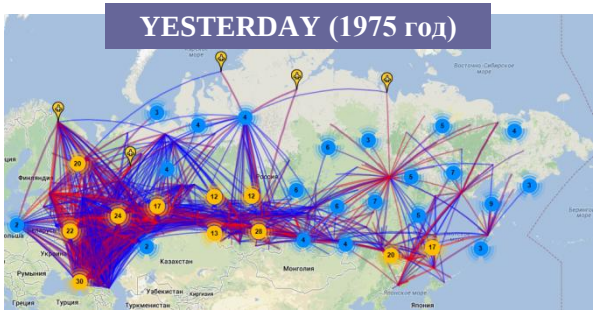
Different historical periods have significant differences (on the example of air traffic):

* Focusing on regional and intra-regional traffic in the USSR
* Shifting the focus to "profitable" shoulder range 1000-1200 km

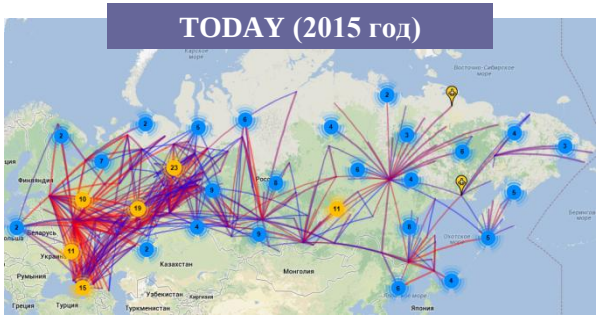




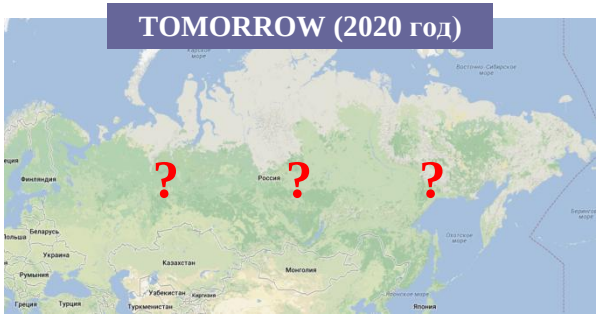
YESTERDAY (1975 год)



TODAY (2015 год)



TOMORROW (2020 год)



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Mathematical apparatus forecasting the development of regional economies

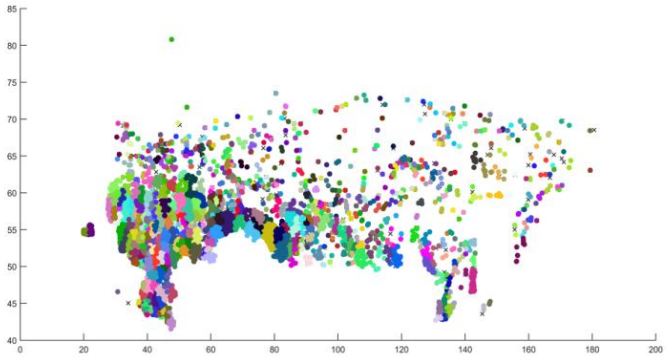
The structure of the model

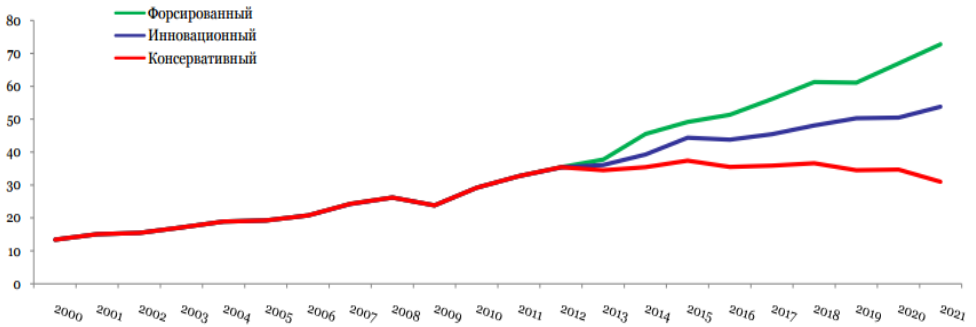
- Regression **analysis of the relationship between economic and statistical** variables
- Enough **high quality forecast on short- and medium-term horizon**, in the absence of structural changes in the economy

Forecasting demand for food products

- In its work, the specialists of Vector NG Rus use **a large block of statistics and economic indicators** beginning since 2000, after occurred structural shifts – collapse of the USSR and 1998 crisis

Indicators	Existing models	Model Vector Ji En Rus
Number of options	15-20	About 40
Method modeling	Autoregressive and moving average	Models of Artificial Intelligence





The inaccuracy of medium- and long-term forecasts of macroeconomic Econometric models is compensated by the application of advanced mathematical apparatus based on the model of artificial intelligence in conjunction with fundamental analysis of inter-industry relations

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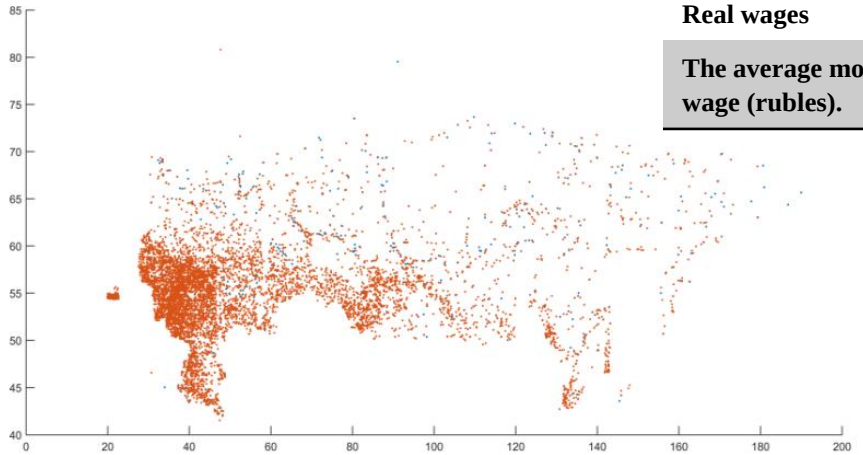
Formation of agglomerations

Principles of the formation

- The agglomeration radius (the nearest neighbor method, KNN)
- Recalculated and updated information on the agglomerations on an annual basis is carried out
- An average value or regional importance depending on the type of index is calculated

$$\tilde{p}_j = \frac{\sum_{i=1}^{N} p_i N_i}{\sum_{i=1}^{N} N_i}$$

MAIN FACTORS	METHOD OF CALCULATION	T
Population of agglomeration	sum	g
Average monthly salary	average	g
Population (thous. Pers.)	nearest town	R
Index of real GRP	nearest town	R
Rated GRP (mln. Rub.)	nearest town	R
Real wages	average	g
The average monthly nominal wage (rubles).	average	g



Non-standard methods used for forecasting

SOLUTION

Due to the great complexity of the problem, to predict traffic **advanced mathematical tools** have been used

Microstructural model of long-term development of the regions (the Leontiev's theory of input-output balance)

Forecasting the development of regional economies (model developed IEF RAS)

For each region of the Russian Federation forecasting of **23 economic indicators are** carried out, agglomeration - 40

Prediction of economic indicators are made for the period **up to 2050**

Forecasts of all the indicators are made **separately for each of the macroeconomic scenario**

The apparatus of artificial neural networks

Forecasts of all the indicators are made separately for each of the macroeconomic scenario

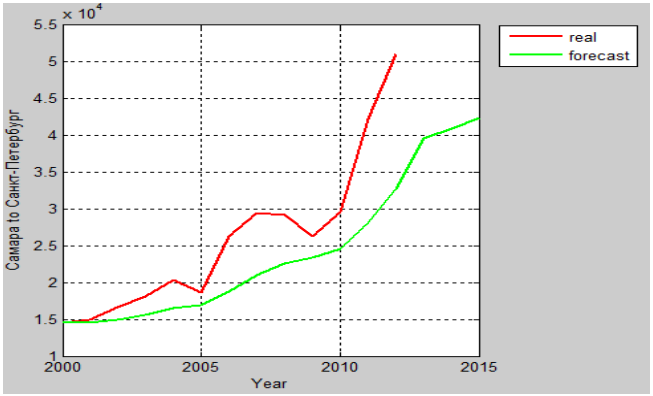
- Forecasting demand for passenger traffic and creature best route network region
- Assessment of the existing terrestrial infrastructure in the region and proposals for optimization by (a) isolation agglomerations at which will be exist long-term stable demand on transportation, and (b) determining agglomerations which are can close by reason lack of demand
- Determination of the capacity of freight containers (excess / negative) by overlay on developed (modeled) optimal route net existing route

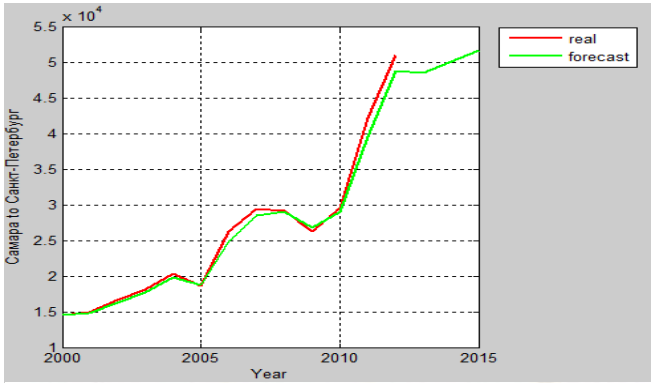
Entropic transport model (gravity model)

Taking into account historical relationships between different passenger traffic

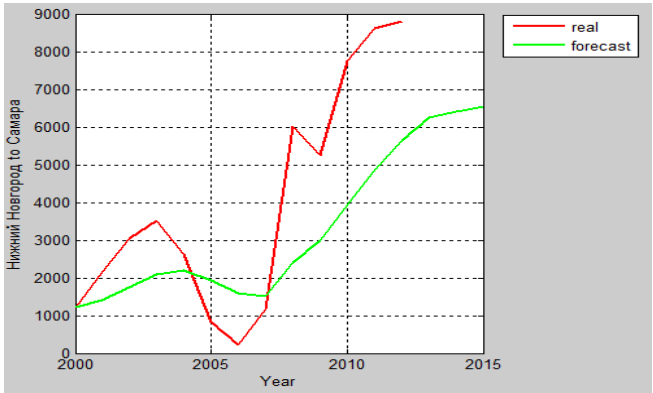
The choice of the mathematical apparatus - Traditional vs Intelligent

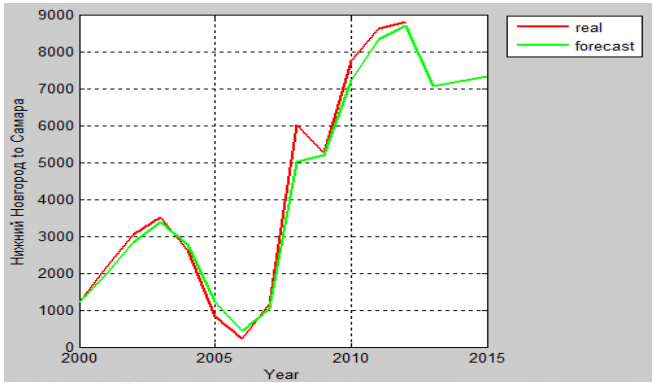
"Samara - St. Petersburg"





"Samara - Nizhny Novgorod"





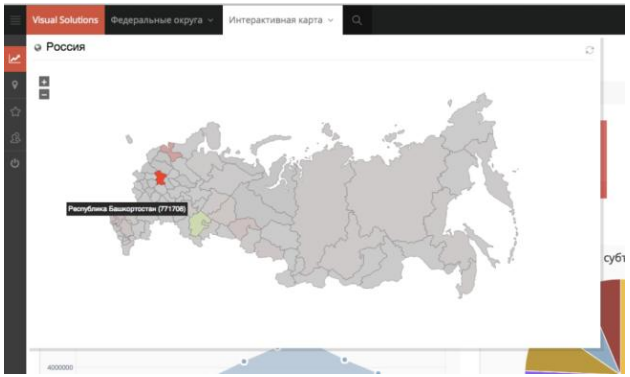
The forecast obtained with the help of our company developed the mathematical apparatus

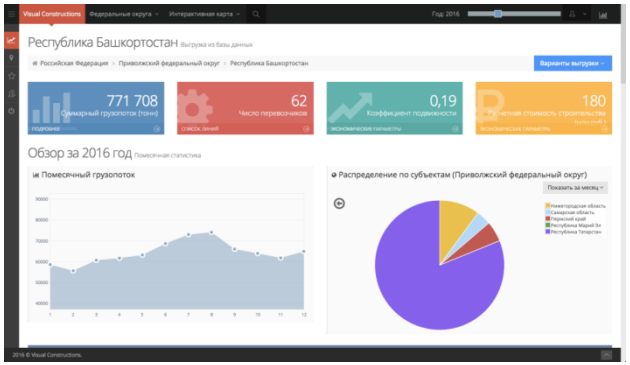
- "Samara – St. Petersburg", the error is not more than 3.9%
- "Samara - Nizhniy Novgorod", the error is not more than 7.2%

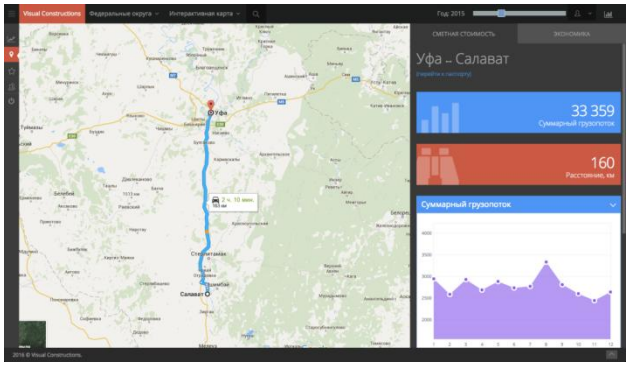
Main potential of using neural networks in transportation models is due to its ability in recognizing and forecasting data patterns that are too complex for the traditional statistical models. Learning ability of neural networks allow them to adjust to dynamically changing environments and hence is much more flexible tool than traditional statistical models.

Ernst&Young report on air passenger transportation demand model developed by Vektor NG Rus. 25 April 2013

The calculation of the budget for basic infrastructure backbone of railway stations







1. The monitoring system cost estimated prices with the necessary amount of input data will help shape the estimated prices of construction resources and the need for financing the construction of the basic infrastructure of the core network in the automatic mode.
2. System operation will occur in the following sequence:
   - Collection of primary source data on the manufacturer of construction resources.
   - Formation of the necessary baseline data on transport infrastructure, on the basis of which a transport scheme of delivery of construction raw materials will be calculated
   - Calculating the cost of transport and logistics component on basis identified vehicles schemes delivery (one the guise of transport or multimodal scheme delivery different species transport from disaggregated about form of transport by to each section transport scheme and taking into account the of expenses on loading - unloading work).
   - The development of the resource and technological models of basic infrastructure and the calculation of the cost of construction for any selected agglomeration area in the territory of the Russian Federation

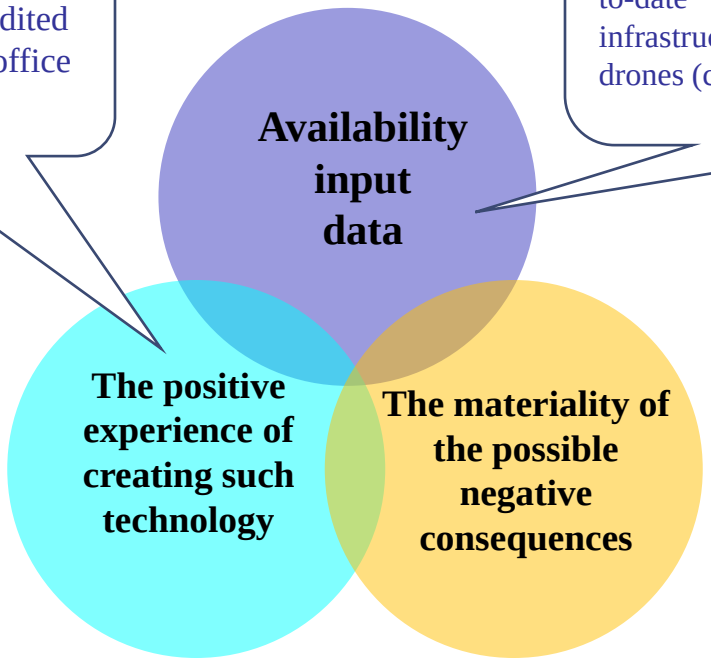
Contents

Development Systems developments forecasting failures

Successful conditions of implementation of the system

Our AI model has been audited Ernst & Young European office

Collection of data in the format:
processing of existing data,
to-date information about the current state of infrastructure - automation of walkers, the use of drones (circled and scanning railways).



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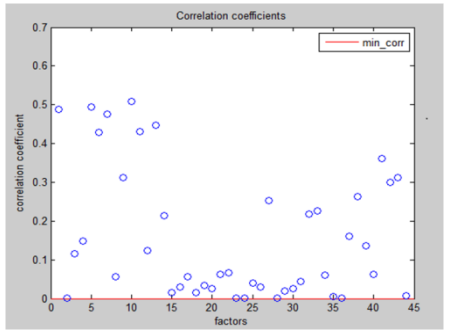
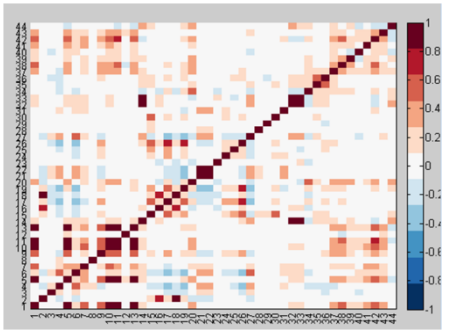
The basis of the system operating time to failure prediction - AI model

Decision reducing the dimension of problems

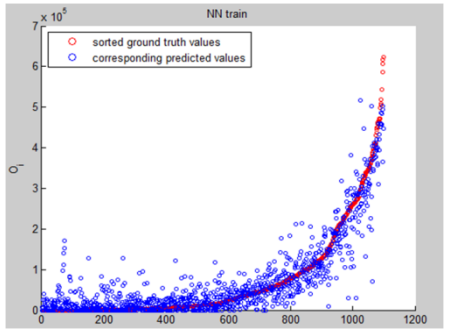
To reduce sound and increase the accuracy of the forecast made search and removal of non-essential factors

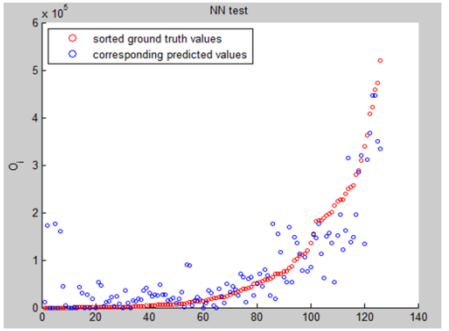




Decision reducing for development of Artificial integrity

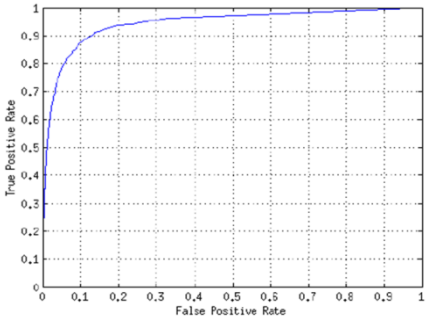
The behavior of the model created in the training and test data

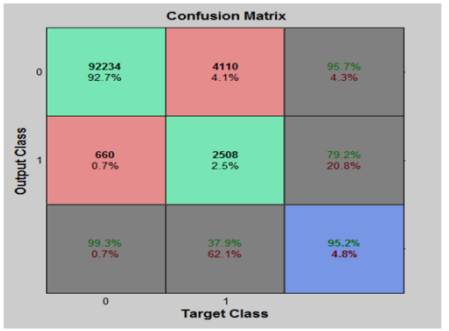




The solution of the task of the most accurate forecasts

Artificial Intelligence models built based on machine learning algorithms, predicts the occurrence of an event with an accuracy of 95.2% in the chosen time horizon.

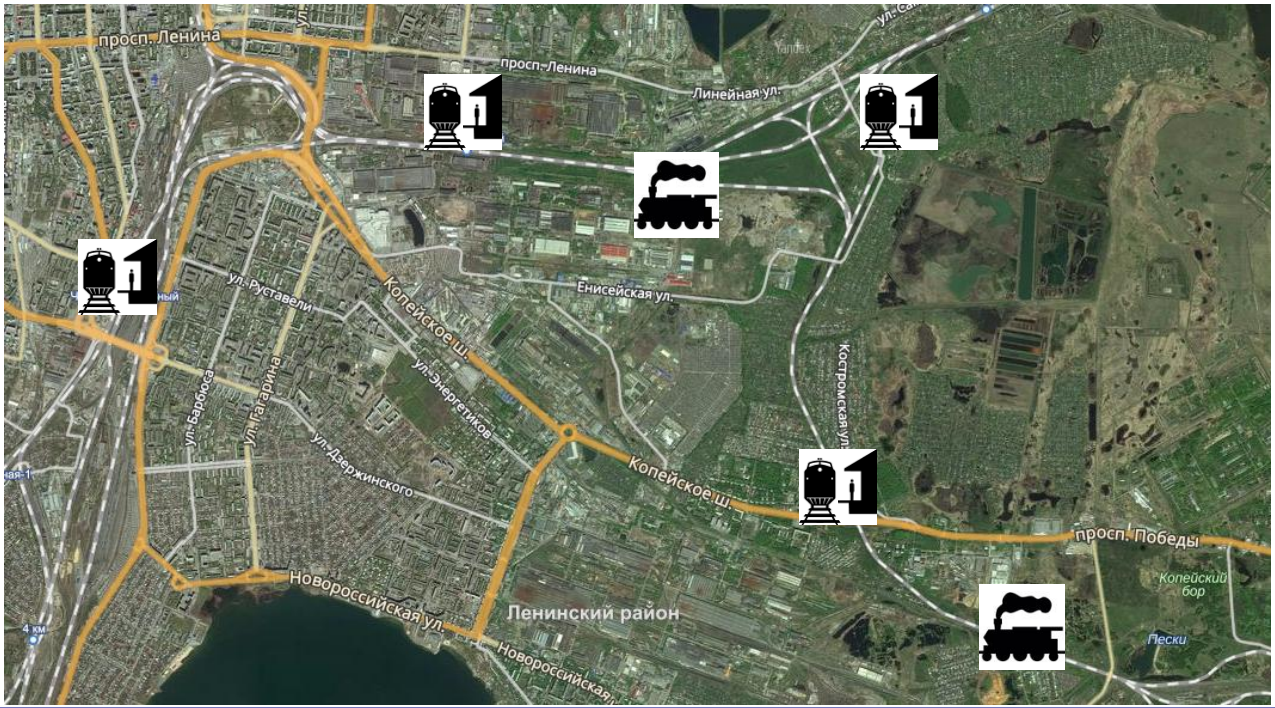




Further development on the example of failure monitoring

Short-term forecasting and monitoring services of railway infrastructure

Asset Id	5 Minute Risk	14 Day Risk	
IDP-XT-2.0.3-0008a2090702	0.0116	0.2734	Details
PX_ASSET_ID-2.0.3-000bab8b0914	0.9604	0.5355	Details
IDP-XT-2.0.3-0008ab8b0b0c	0.0119	0.2632	Details
IDP-XT-2.0.3-9841ee054ef6	0.1504	0.2437	Details



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Development of forecasting failures System

Models of artificial intelligence will be used as a basis of the mathematical apparatus Predictive Maintenance Plan (Forecasting System MTBF)

Based on the fact that the possible causes of equipment failure describes a wide range of settings, the task of teaching Artificial Intelligence model is reduced to the very determination of dependence.

A model that can provide the user with a reliable prediction of the timing of the ultimate technical condition will be built (trained) on selected and successfully tested data

1. Creating a Pro-Forma lifecycle equipment

- Creating a basic schedule for tinning investigated for life - the formation of the database in terms of the work, the work schedule, the need for materials and components, historical information on faults and their causes

2. Creating mathematical apparatus predicting MTBF

- In selected groups of equipment, developed the system calculates the forecast time to failure. On the basis of the forecast uptime issues warning system: in the current situation (failure prognosis for 5-10 minutes - alert emergency services and stop system) and on certain horizon (forecast failure for 7-14 days)

3. The construction schedule for the maintenance and repair

- Individual schedules for equipment groups are integrated into the overall map of repairs and maintenance of equipment
- A need at financing is determined on basis consolidated indicators volumes works, schedule purchase of components is adjusted, illiquid and excess reserves are determined.

4. Optimizing Maintenance Capex program on forecasting horizon

- A scenario analysis of the distribution of work in the forecasting horizon is prepared
- Expected monetary flow is stress tested by temporary shear graphic arts works selected scenarios work equipment and its service, etc..

Expected effect of the introduction of the Mean time between failures system

1. **Projected costs** for the volumes and terms depending on the scenario of the base railway control network of stations and spans, the seasonality of activities, acquisition of equipment conditions.
2. Clarification of the scope of work and budget for the **warranty maintenance** of transport infrastructure.
3. **Reduced** line Pro-Forma Balance Sheet "Reserves" through working capital management.

- Routine management.
- The alignment of standards.
- The release of the add. savings through management of working capital.

4. **Increase operational efficiency** by reducing the budget for Maintenance Capex

Practical application of competences (1/3)

The complete model of the transport industry involves the development of mathematical models that meet the interests of these participants in the transport system of Russia: State operators, alternative modes of transport, manufacturing, transport and logistics hubs and population.

Government | Transp. balance | Operators | Production | Agglomeration | Population

1. The definition of subsidies, their scope, targeting programs measures support effect for recipient subsidies, public and budget.
2. Objective range of operators who planned support conditions, planning effect from accepted measures support.
3. Evaluating the effectiveness of the consolidation of operators established with hand State definition permissible level governmental intervention at operating activity.
4. Evaluation of investment attractiveness of the start of production in the Russian Federation of certain types of TC, determine the need of investments in the start-up of production, forecast markets, evaluation of the effect for the state and the population.
5. Optimization of rates and charges of the transport system participants, the most efficient in terms of budget efficiency and transport safety.

Government | **Transp. balance** | Operators | Production | Agglomeration | Population

6. Model competition between rail and other modes of transport in passenger and cargo transportation.
7. Assessment of synergies, the management of transport and economic balance.

Practical application of competences (2/3)

Government | Transp. balance | **Operators** | Production | Agglomeration | Population

8. Construction of optimal route network based on long-term development strategy of the operator - member transport system.
9. Optimization of rolling stock. Defining the boundary conditions of acquisition of home-produced park of technical equipment.
10. Selection of effective management and staff incentive mechanisms to build the most profitable, high-quality and safe operation of the transport company.
11. Evaluation of investments in marketing, advertising and PR.
12. Modeling prioritization at mix route network : international , mixed , high-speed and commuter transportation.
13. Model competition between modes of transport on the price and quality of service. The calculation of the elasticity of demand for tickets for the price and income.

Government | Transp. balance | Operators | **Production** | Agglomeration | Population

14. Evaluation of investment attractiveness of the production of various types of rolling the vehicle, determine the need of investments in the start-up of production.
15. Planning the organization of production and the required amount and types of the technical equipment in the Russian Federation.

Practical application of competences (3/3)

Government | Transp. balance | Operators | Production | **Agglomeration** | Population

16. The sequence of actions for the integration of regional development strategies in the transport strategy of the Russian Federation aimed at the success of the long-term development of territories.
17. Evaluation of the budget and the impact of each activity on development of transport agglomerations.
18. Building policy of region management regarding to the operators.
19. Determination and prediction of optimal rates of regional subsidies.
20. Formation of a progressive system of relations in the PPP format.

Government | Transp. balance | Operators | Production | Agglomeration | **Population**

21. Forecast demand for passenger - and cargo each view transport between any pair of cities RF until 2030 the year .
22. The calculation of the degree of influence the cost of the railway ticket (as well as non-price factors) on the demand for transportation between any pair of cities in Russia.
23. The relationship between stimulating traffic and improving living standards.

The customer will receive a modeling tool and planning base core network railway stations, and communications between them, including:

- ✓ **The mathematical apparatus for prediction of transport systems**
- ✓ **The device collection and statistical processing**
- ✓ **Vehicle balance model**