RUSSIAN FEDERAL NUCLEAR CENTER– ALL-RUSSIAN RESEARCH INSTITUTE OF EXPERIMENTAL PHYSICS (RFNC-VNIIEF)

РОССИЙСКИЙ ФЕДЕРАЛЬНЫЙ ЯДЕРНЫЙ ЦЕНТР ВНИИЭФ

# *Modeling Services:*

# *«From simulation to optimization»*

**The chief of scientifically-**
**Research laboratory**
**Oleg Kovalenko**

# Why modeling and optimization are necessary?

## MODELING GOALS :

- Understanding of the object internal nature;
- An event forecast;
- System optimization;
- Statement proofs.

## Conclusion:

- All purposes of modeling are directed on performance of decision-making;
- The head purpose of modeling is improvement of quality of decision-making.

# Why is poor quality of decisions accepted by the person?

## Reasons of low efficiency of decisions (without modeling):

① Underestimation and erratic perception of effects of feedback and delay;

② Simplification of a reality and selective usage of the information;

③ Time limitation of decision-making process;

④ Uncertainty and complexity of environment.

**Conclusion:**

*1. The dynamic system complexity increase sharply reduces efficiency of decision-making and its quality.*

*2. The person always makes the decision on the basis of own intellectual **models** of a real system based on the linear dependences.*

*3. In process of complication of system and time reduction of decision-making they become reactive and chaotic.*

*4. The effect of training is reduced to increase of velocity of decision-making, but raises their efficiency a little.*

# Super Computer Applications

**The head purpose:** Improvement of quality of decision-making (Remained)

**Super COMPUTER Modelling Advantages:**

Allows to raise essentially computing complexity of modelling (reduces computing time).

**Consequence:**

Allows to solve the problems which solution has been unattainable for a reasonable time

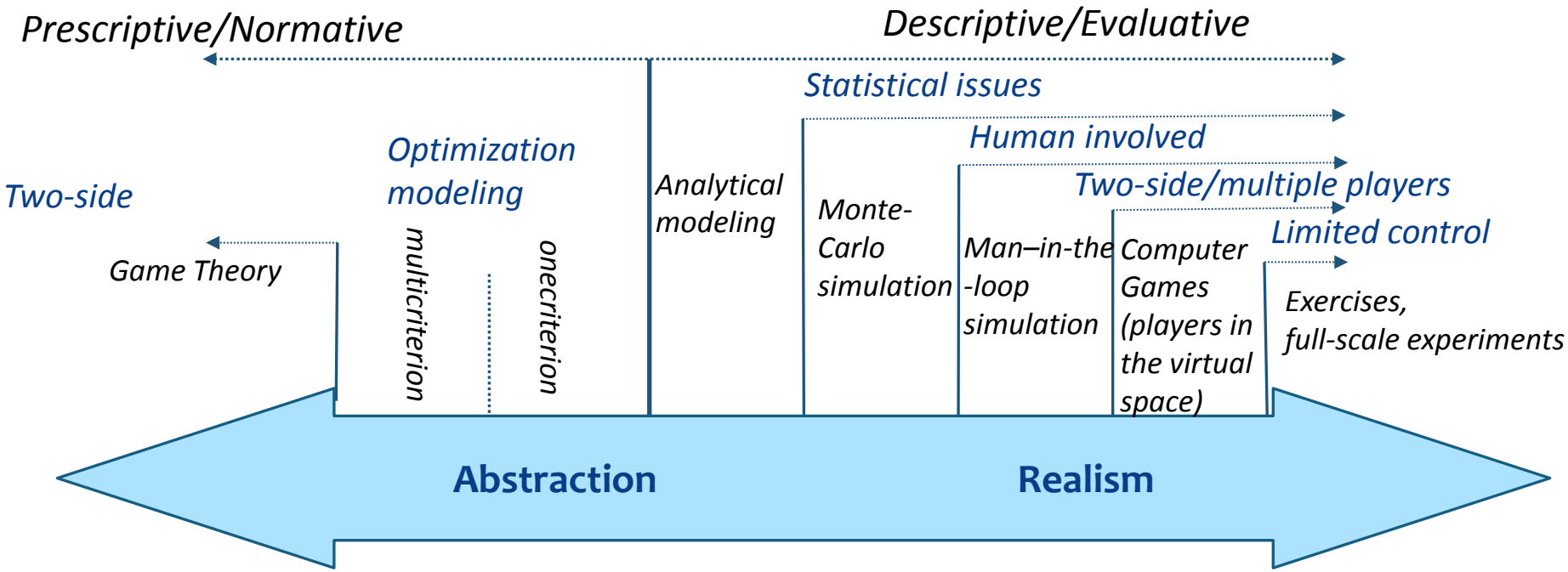
**Remarks:**

1. Raise of computing complexity yet does not mean raise of accuracy of modeling.
2. Accuracy of modelling is attained by mathematical algorithm improvement.

**Super computer modeling limitations:**

1 . It is required to higher qualification of programmers.
2. Complexity of mathematical algorithms raises.
3. The number of experts perceiving the task decision as a whole decreases.

# Modeling Classification

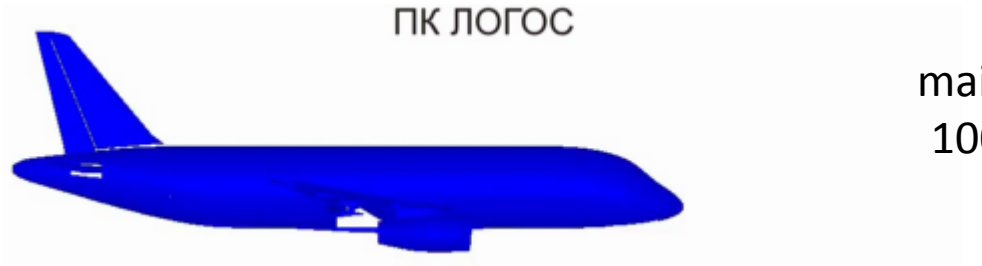


# Rough Landing SuperJet-100
## (The Software Package LOGOS)

**Full-scale experiment**

Validation

**Simulation**

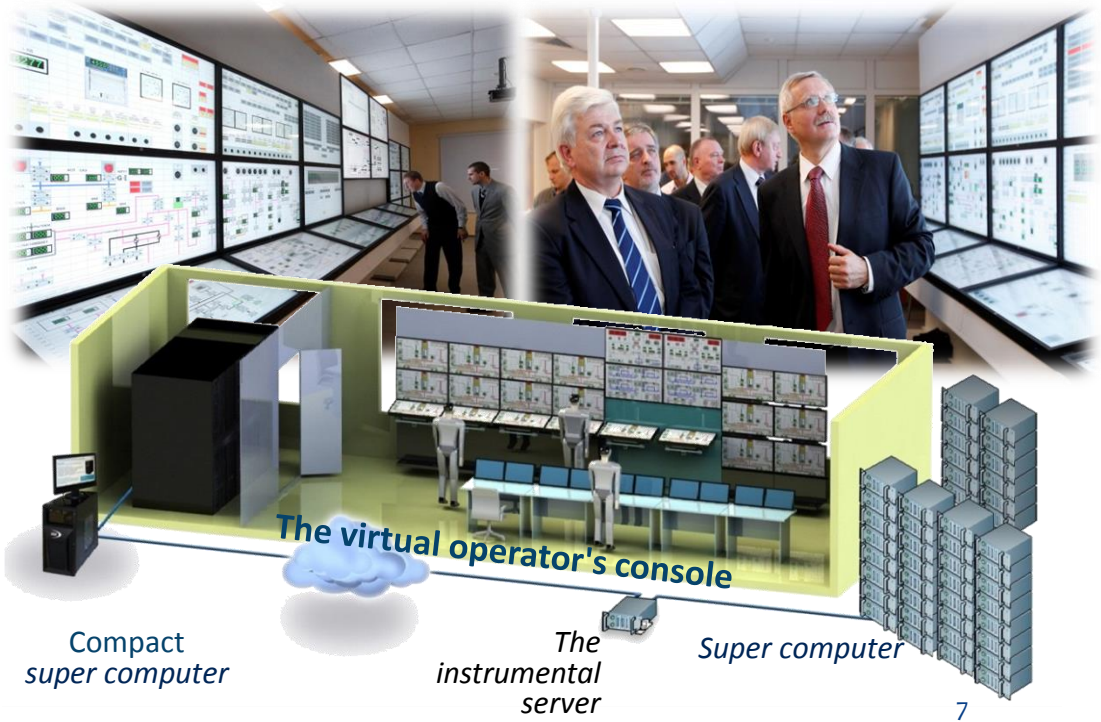



**Result:**

Acceptance in maintenance SuperJet-100 without *full-scale experiments*

# The Virtual Power Unit (SPBAEP)

## Program-technical complex «The virtual power unit of the atomic power station




- Modeling of all main systems of the power unit;
- hand-hold courses of operation technology of the nuclear power plant in various modes (on the basis of LNPP-2 project);

**Result:**

Improvement of professional skill of actions of operators of the atomic power station in regular and exception situations

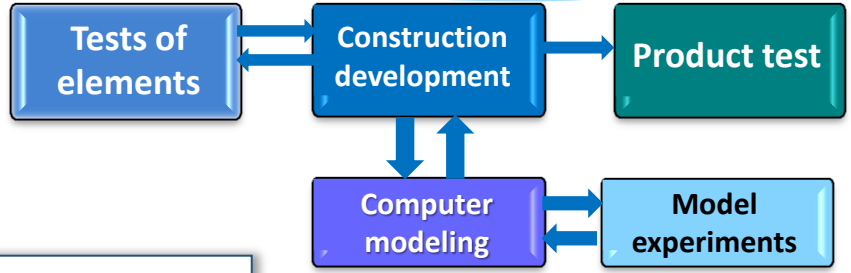
# Supercomputer Modeling Technologies

## Traditional design technology

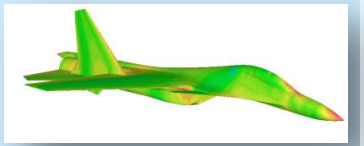
A)


## The modern design technology

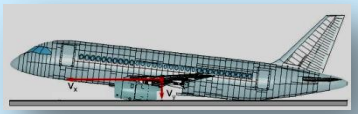
B)




## Tasks of the big dimensionality

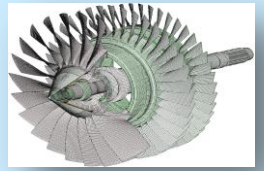


Calculation of aerodynamic characteristics. Dimensionality of the task about 50.000.000 calculating points. Time of calculation of one point (a flight mode) nearby 150 h.

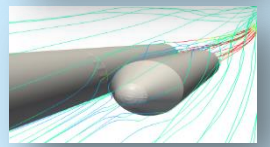


Crash landing SSJ 100 (without the chassis). Dimensionality of the task about 8.000.000 calculating points. Calculation time nearby 120 h. Carrying out of full-scale tests is impossible.

•Hit of a bird in a head part of a fuselage. Dimensionality of the task about 1.000.000 calculating points. Calculation time nearby 50 h.



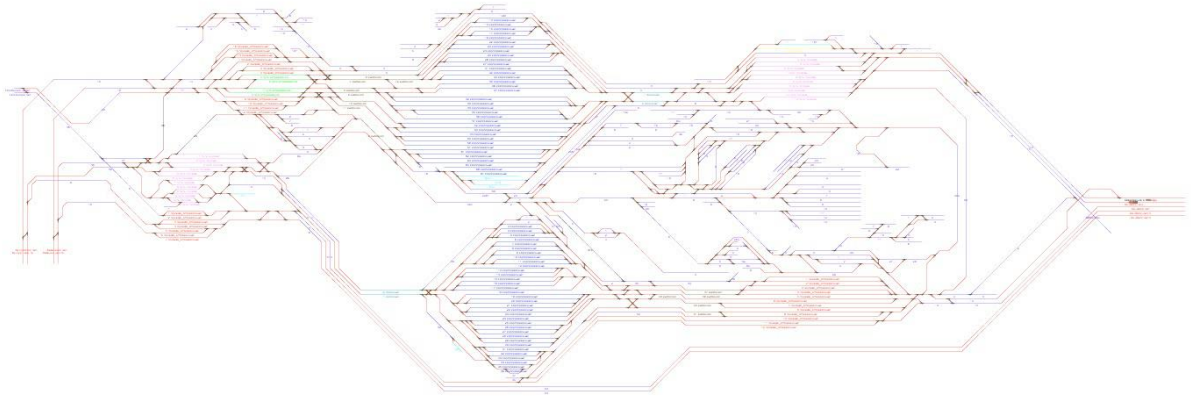
The combined calculation of aeroelasticity tasks . Dimensionality of the task about 60.000.000 calculating points. Decision time nearby 300 h.



**Supercomputer technologies**

# Monte-Carlo Simulation of Operation of Ekaterinburg-Hump Station

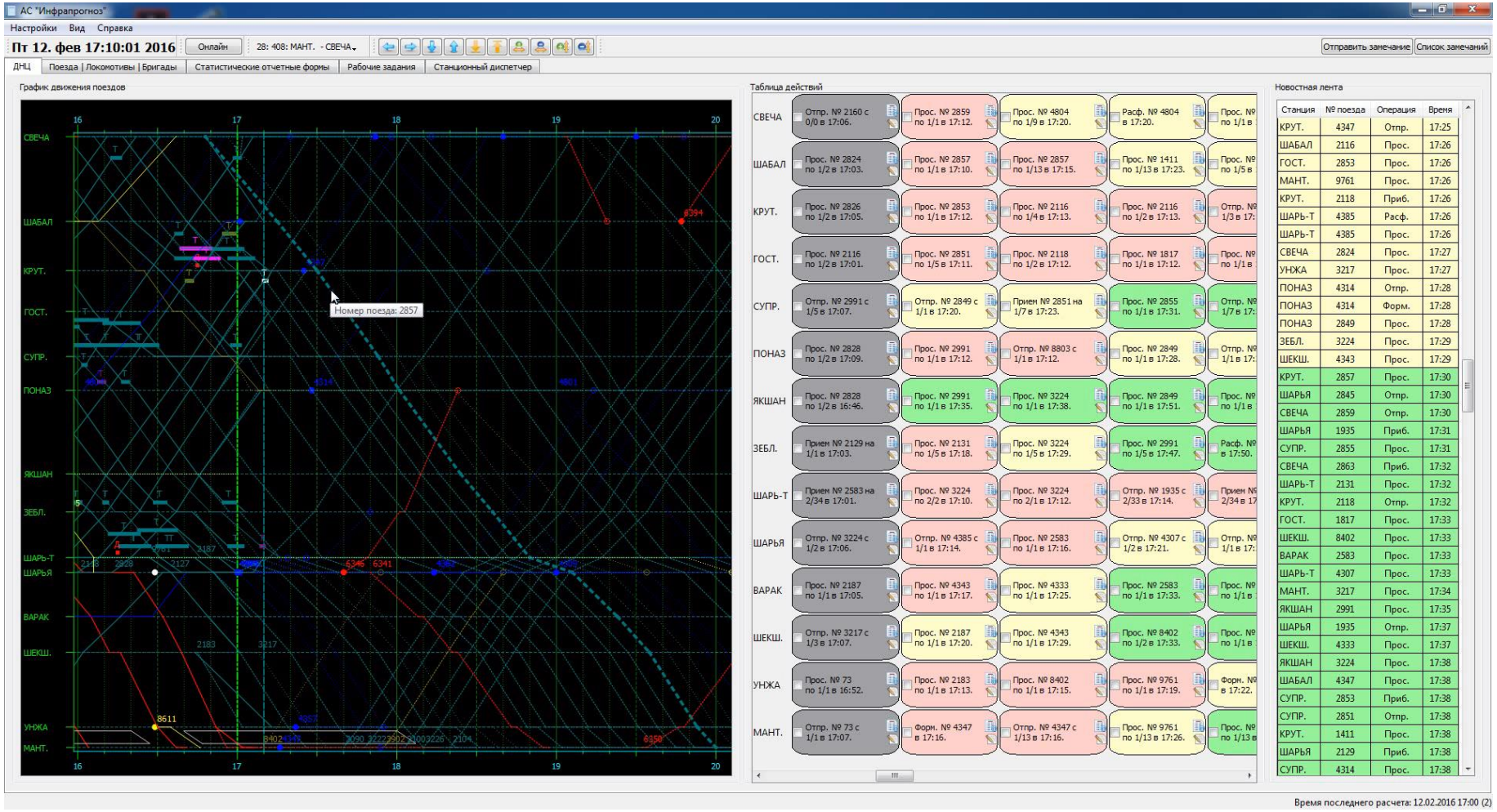
Модель сортировочной станции г.Екатеринбург



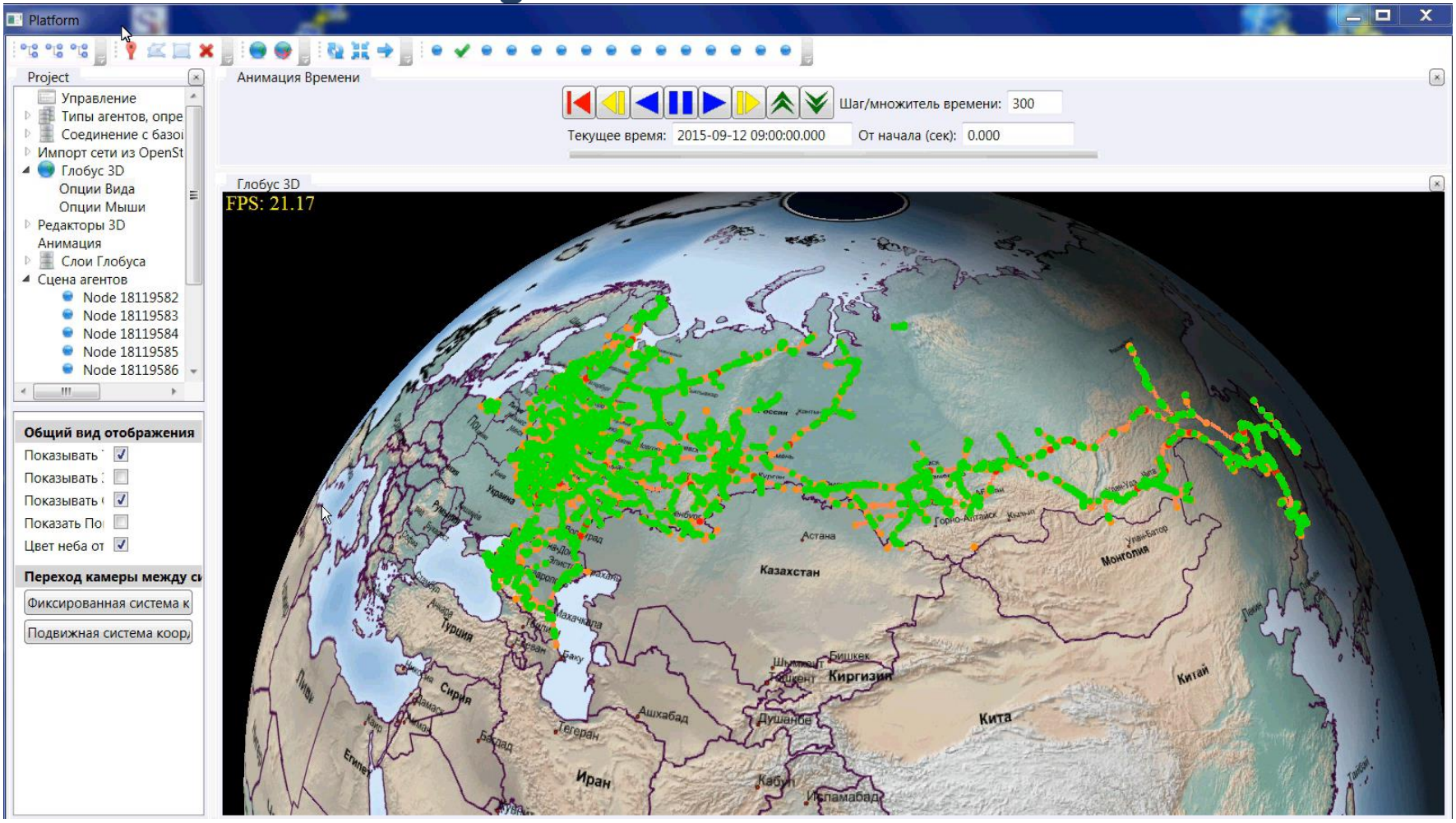
**Result**

Bottlenecks of the station technology and the station net are discovered

# Automized System Based on the Optimization Modeling (AS “InfraPrognoz”)



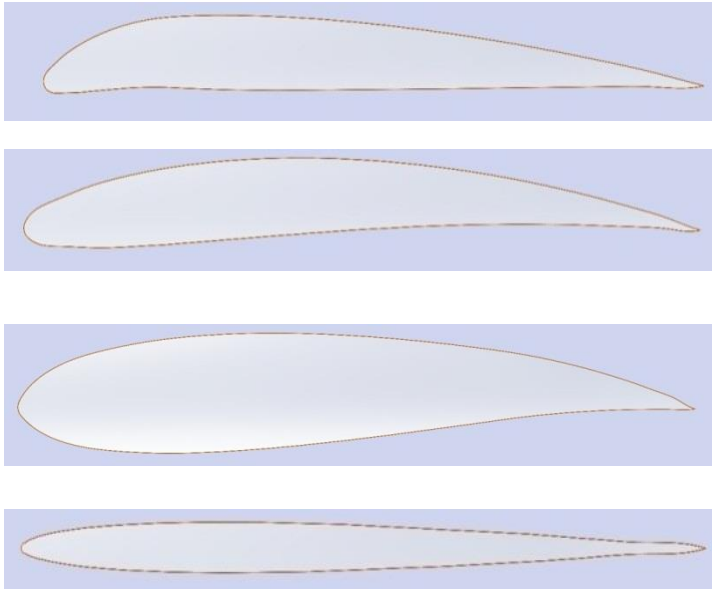
# InfraPrognoz Calculation Visualization

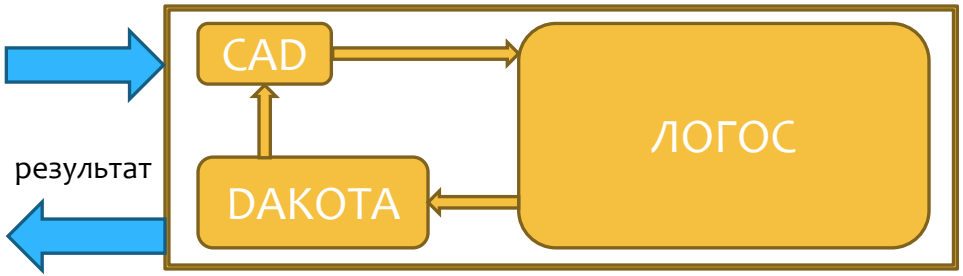


# Multicriteria Optimization

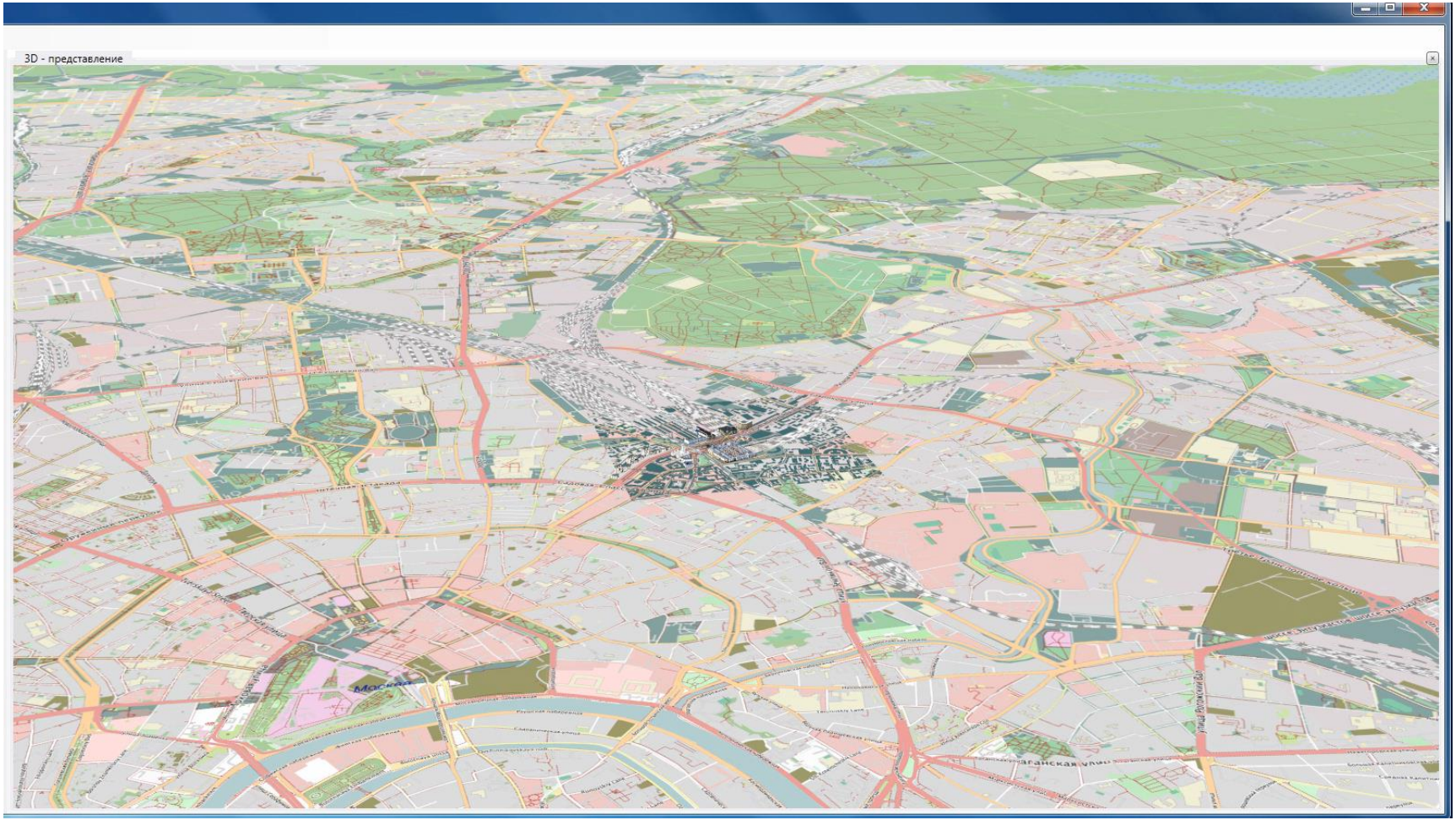
For the solution of problems of multicriteria optimization are used:

- CAD systems (SolidWorks, ProEngineer) – modification of geometry;
- CAE system (LOGOS of development of VNIIEF) - calculation of criterion functions;
- Optimizer (DAKOTA) – calculation of optimum parameters.

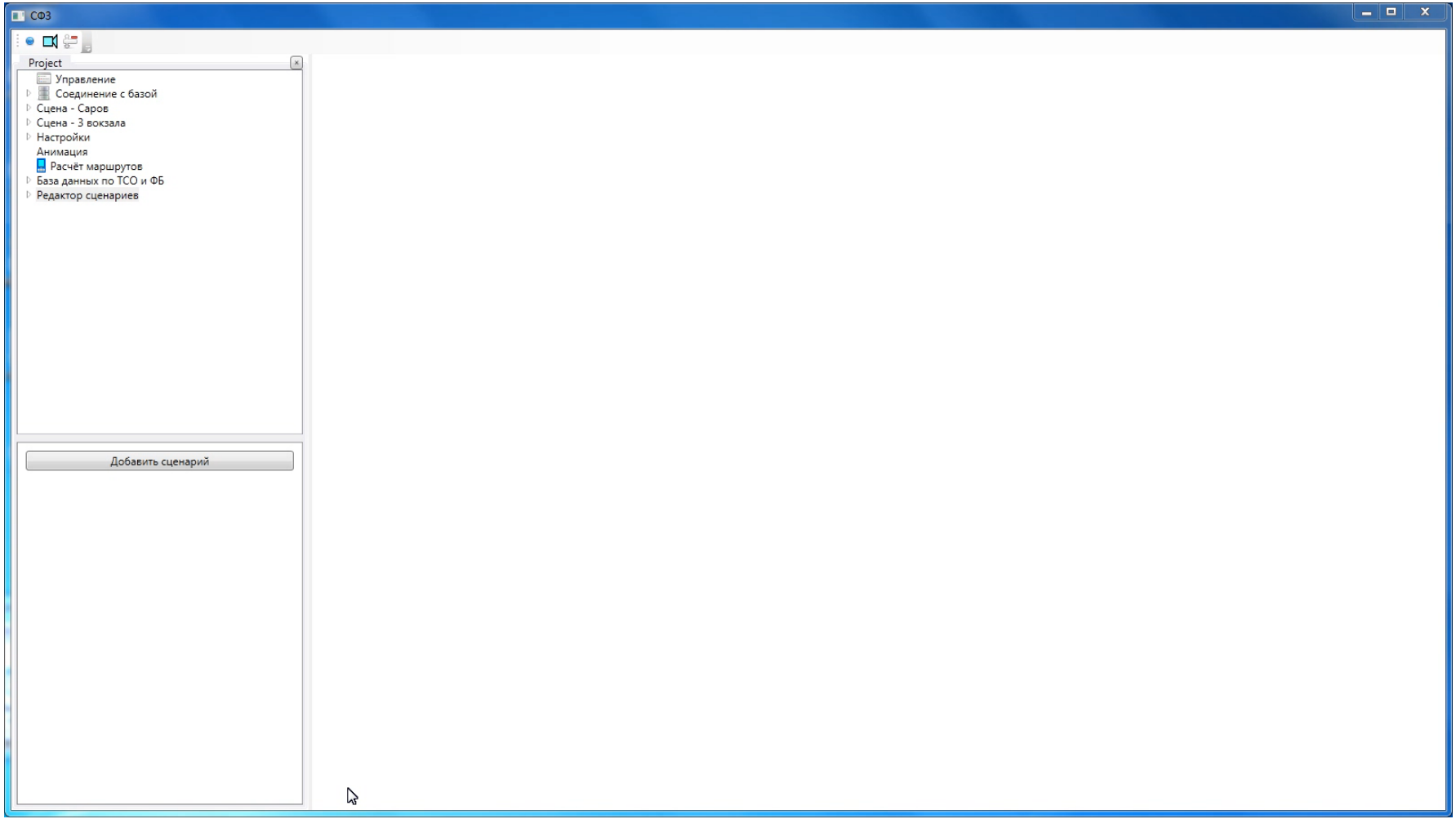




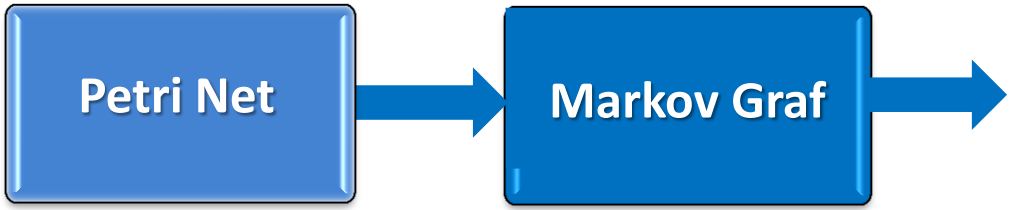
# 3D Visualization Platform for a Simulation



# Macro- language for Multiagent Modeling – Nested Petri Nets



# Generation of the Markov Renewal Equations




$$\mathbf{V}(t) = \mathbf{\Psi}(t) + \int_0^t \mathbf{Q}(\tau) \cdot \mathbf{V}(t-\tau) \cdot d\tau$$

$$\mathbf{V}(0) = \mathbf{I}$$

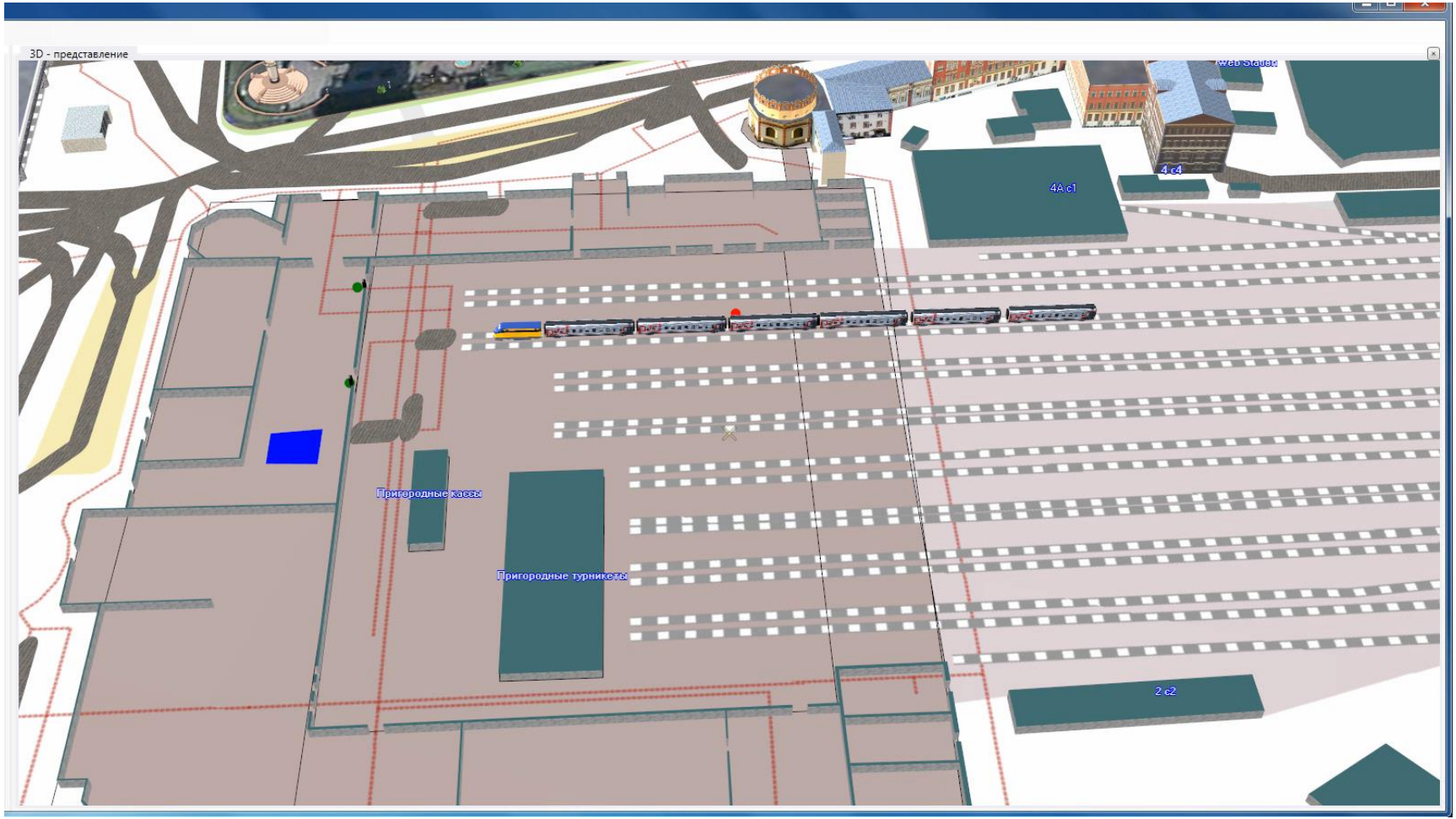
$$\mathbf{P}^T(t) = \mathbf{P}^T(0)\mathbf{V}(t)$$

$\mathbf{V}(t)$ - Conditional Transition Probability Matrix

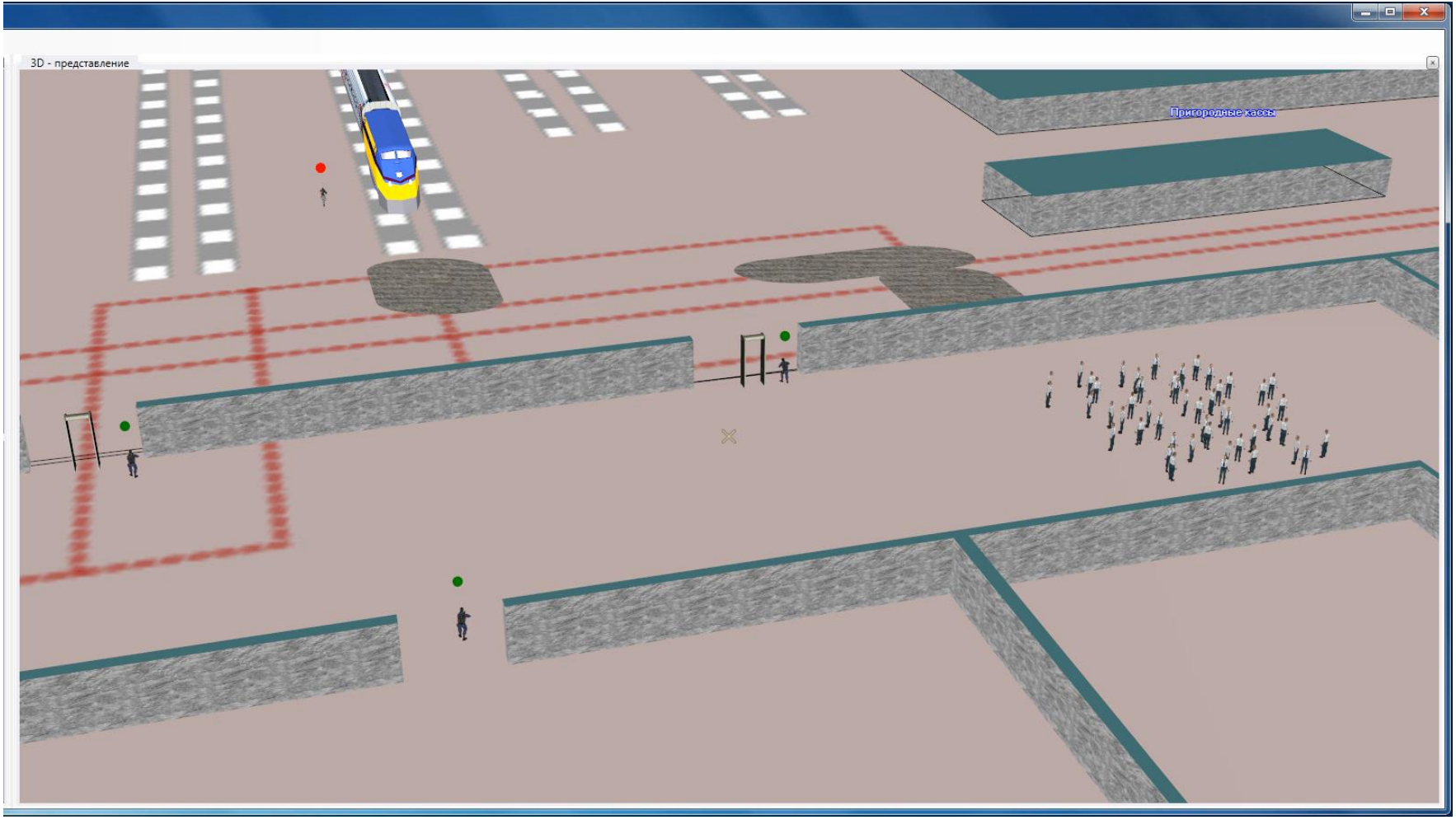
$\mathbf{Q}(t)$ – Semimarkov Kernel

$\mathbf{P}^T(t)$ – Probability Vector to be in the States

# Estimation of physical defense of the object (the variant 1 - 2 security guards)



# Estimation of physical defense of the object (the variant 2 - 3 security guards)



# Thanks !

## References:


1. Каталевский, Д.Ю., Основы имитационного моделирования и системного анализа в управлении, 2015.

2. Alan R. Washbu, Moshe Kress, Combat Modeling, 2009.



RUSSIAN FEDERAL NUCLEAR CENTER –
All-Russian Scientific Research Institute of Experimental Physics (RFNC-VNIIEF)