SCIENTIFIC-RESEARCH INSTITUTE ON ECONOMICS
AND MANAGEMENT IN GAS INDUSTRY
LLC «NIIGAZECONOMIKA»

Main directions of Risk Analysis Center researches

D.T.S., Prof. Valery Lesnykh,
Director of Risk Analysis Center

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Structure of Risk Analysis Center

Director of the Center – Valery Lesnykh, d.t.s., prof.

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Department **№32.1**

”Economic mechanisms of risk management”

(3 emploees)

Igor Dyomkin, d.e.s.

Department **№32.2**

“Risk analysis of oil and gas projects”

(8 emploees)

Alexandr Bochkov, c.t.s.

Department **№32.3**

“Analysis of oil and gas industry functioning stability”

(8 emploees)

Alexandr Kashirin

Department **№32.4**

“Analysis of professional risks in the sphere of energetics”

(3 emploees)

Clients of the Center (2011-2013)

Departments and subdivisions of JSC "Gazprom":

- Prospective Development Department;
- Corporate Costs Management Department
- Personnel Management Department
- Project Management Department
- Situation Center of Chairman of GAZPROM
- Corporate protection service
- Pricing and Economic Analysis Department
- Insurance management

Daughter companies:

- LLC "Gazprom Dobycha shelf"
- LLC "Gazprom Dobycha Orenburg"
- LLC "Gazprom transgaz Moskva"
- LLC "Gazprom transgaz Yugorsk"etc.

Insurance company JSC "SOGAZ" ;

Foreign clients:

- Wingas Transport GmbH

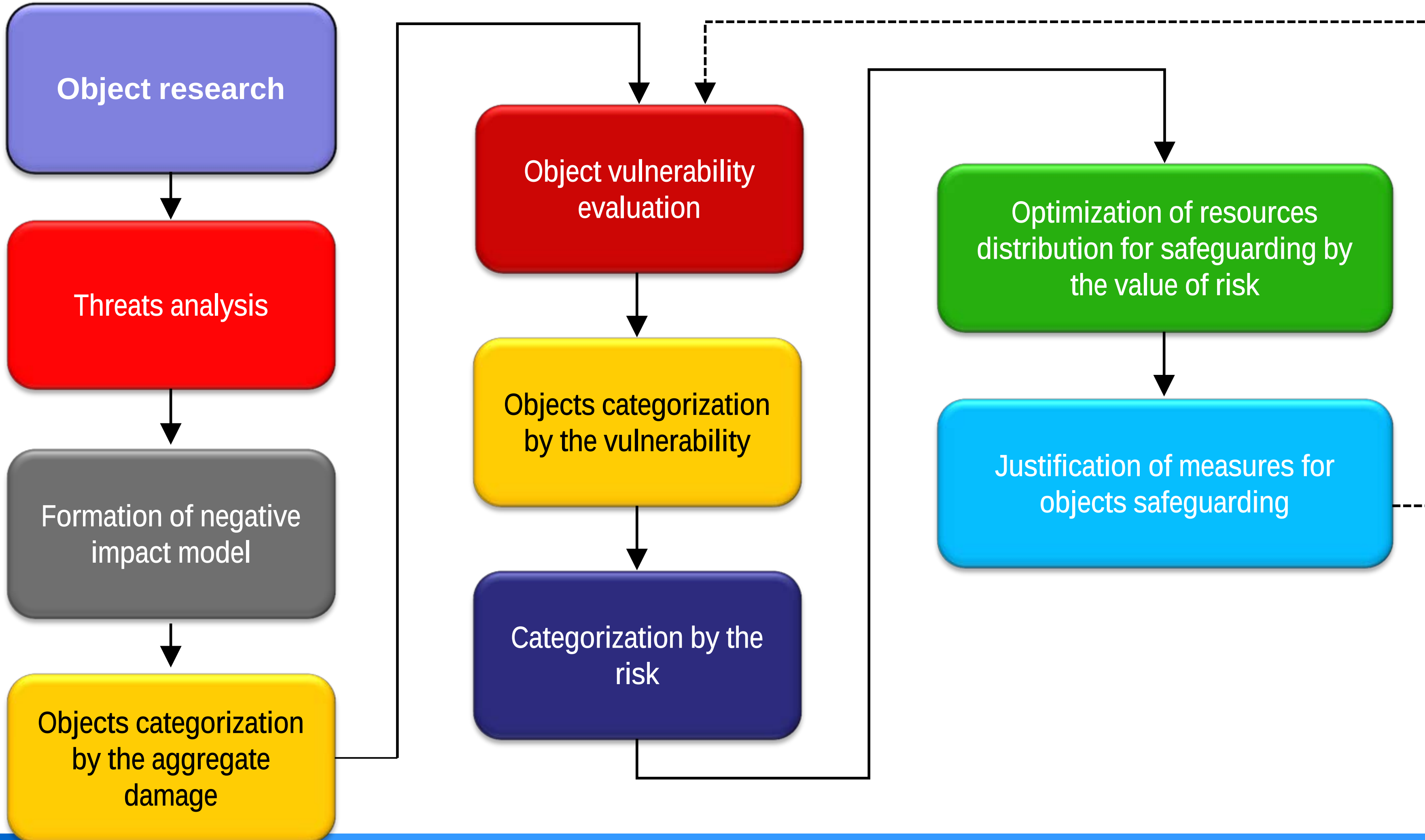
Main directions of Center researches

1. Development of methods and models of analysis and management of project risks, including the instruments of making managerial desicions
2. Development of methods and models of evaluation of objects state, models of contingency and crisis situations forecasting and scenarios of its development
3. Development of methods and models of protectability from illegal actions evaluation, including the evaluation of safety objects system significance
4. Development of regulation base of corporate insurance
5. Occupational risk analysis and management in the sphere of energetics

1

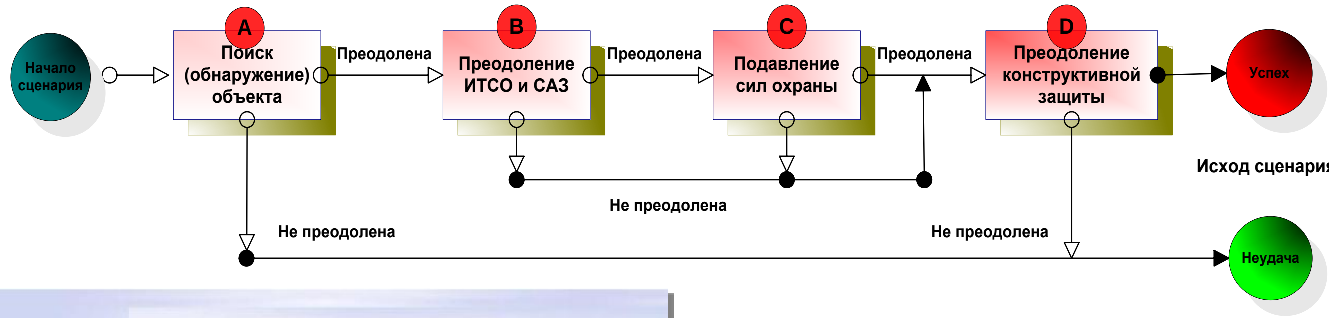
Development of methods and models of protectability from illegal actions evaluation, including the evaluation of safety objects system significance

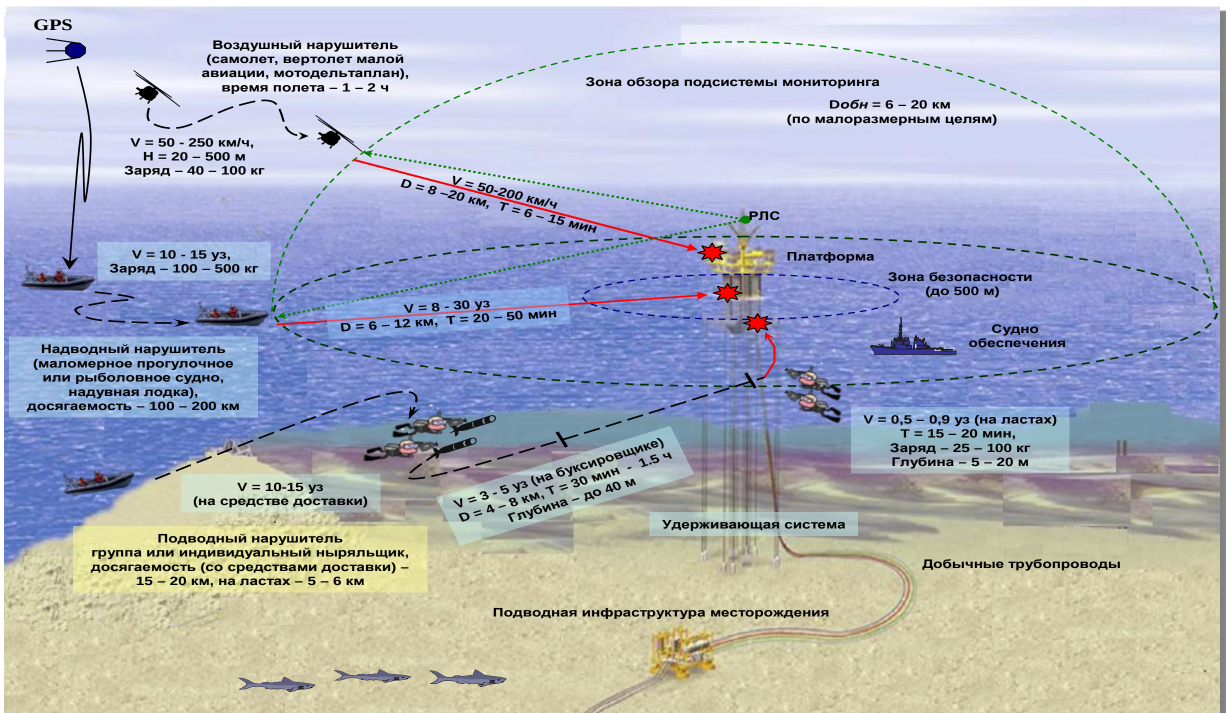
Methodological approach to the task of objects protectability from illegal actions



Methodological base of protectability analysis and evaluation

Definition of impact scenario

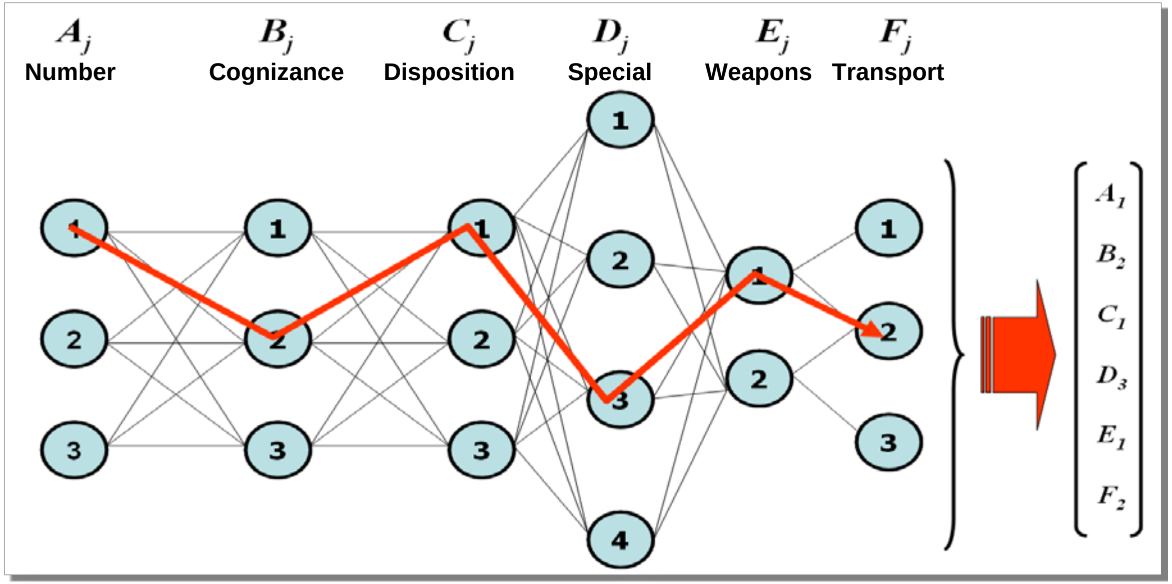




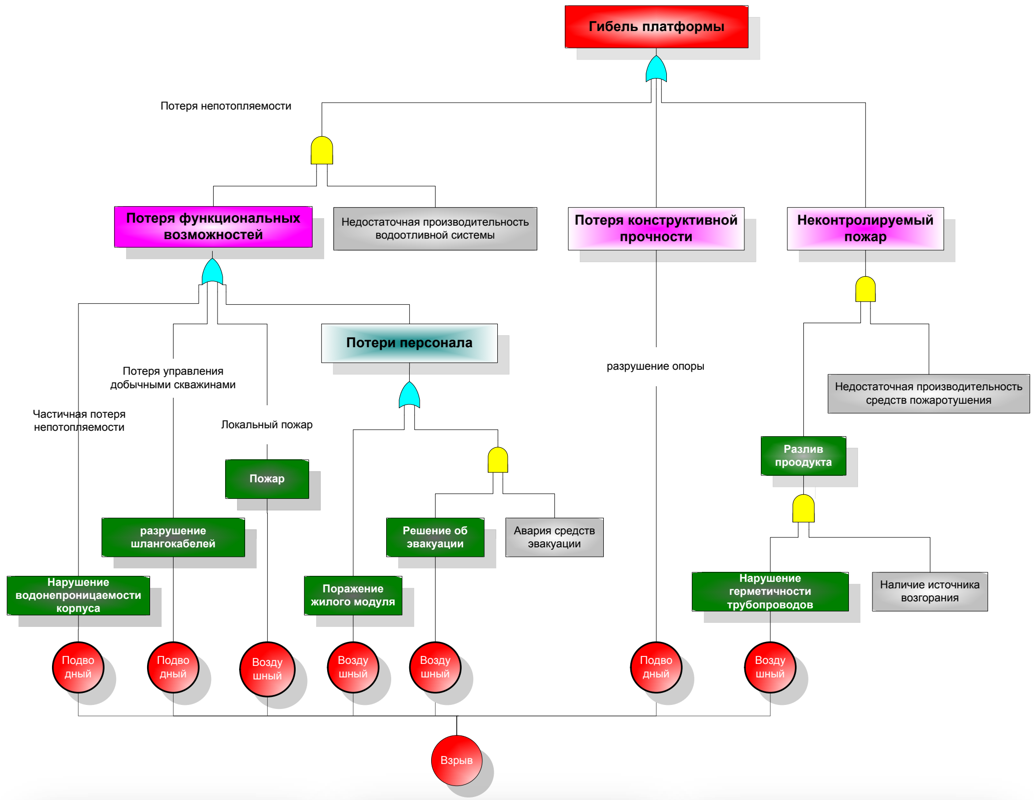
Setting the violator´s model

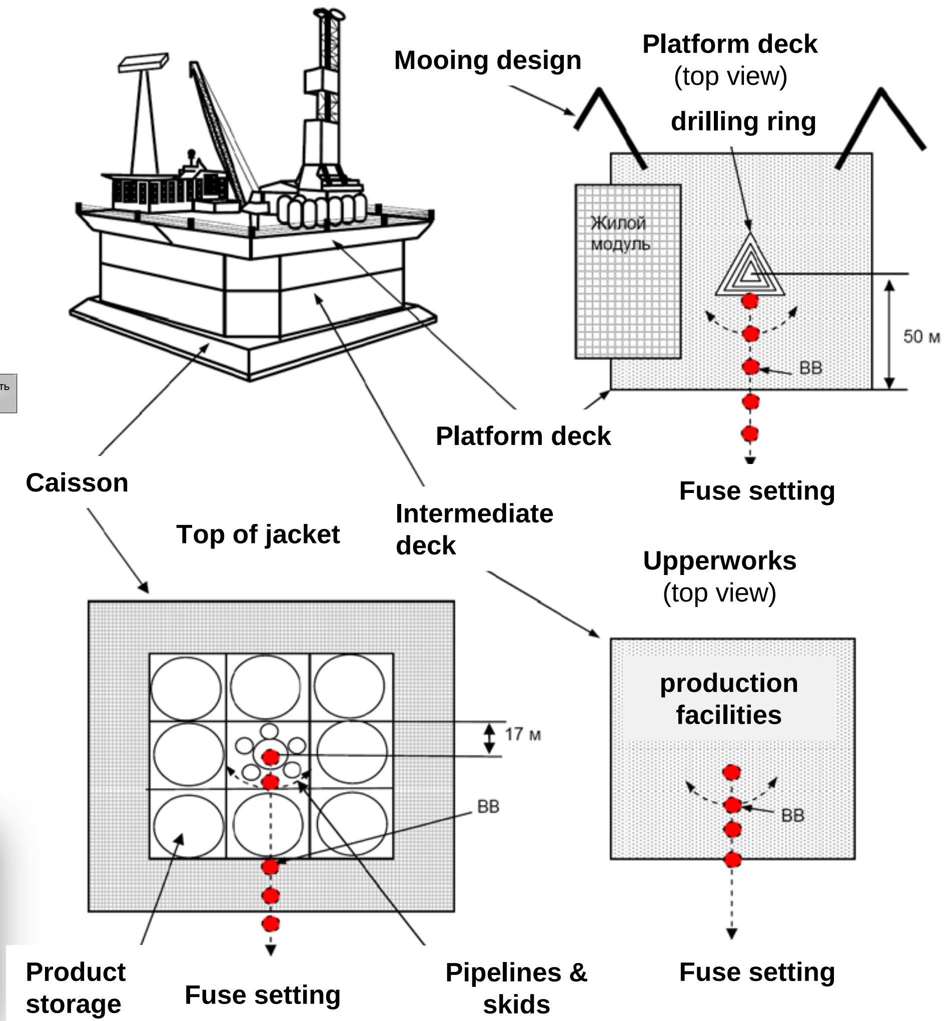
Formalized model of external violator

- Type of violator;
- Category of violator, which can impact on the object;
- Possible objects which could be pursued by violator;
- Motivation of violator's actions;
- Quantity of violators;
- Violators' equipment and armament;
- Degree of violators´ awareness about object, it´s weak points, and safety system;
- Tactics and scenarios of violators´possible actions.



Quantitative models of vital capacity evaluation (on the example of marine and off-shore objects)





Components of aggregate damage, used under categorization

Aggregate damage

Direct losses (1)	Localization expenses (2)	Non-repayable sanitary losses (3)	Indirect damage (4)	Ecological damage (5)
Loss of equipment, uncompleted supplies of production, loss of raw materials	Investigation of accident´s reasons, exclusion of cascade development of emergency situation	Losses for payments and compensations for people, who have been suferred in the result of emergency situation	Losses for the compensation for third parties, loss of professional reputation, missed profit	Losses for the liquidation of negative impact at the environment consequences

Objects classification by the risk of illegal impacts

Category by the aggregate damage x **Category by the non-conditional vulnerability** → **Class by risk**

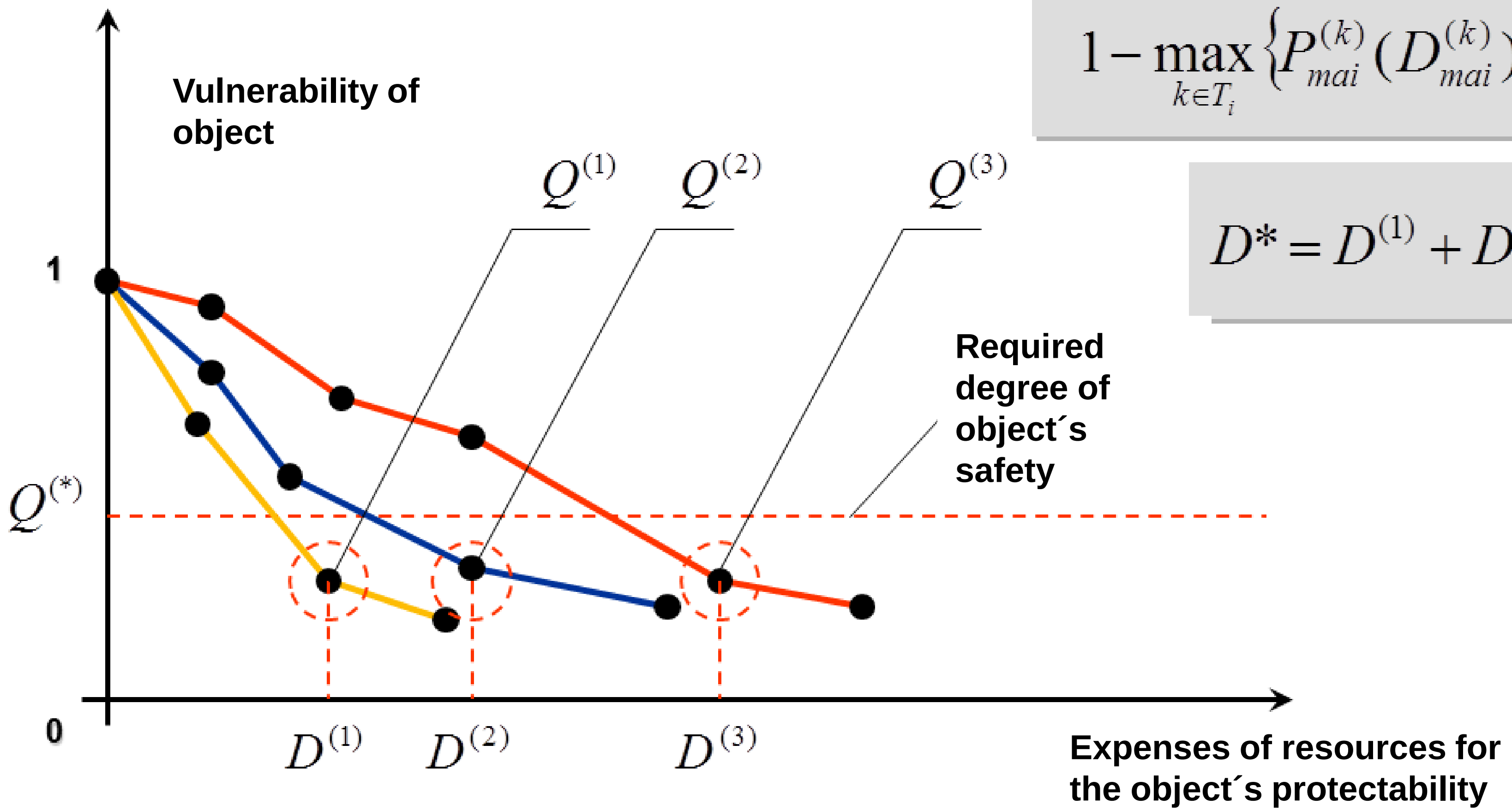
Class	Risk level	Classification criterion	Recommendations
1	**Abnormally**	$R \leq R_1$	**Needs taking measures to increase security as a matter of priority**
2	**Reasonably**	$R_1 < R \leq R_2$	**Needs taking measures to increase security**
3	**Negligible**	$R < R_2$	**Acceptance of security supplement isn't required**

Risks matrix		Category according to total damage				
		5	4	3	2	1
Category according to absolute vulnerability	1	5	4	3	2	1
	2	10	8	6	2	2
	3	15	12	9	6	3
	4	20	16	12	8	4
	5	25	20	15	10	5
	6	30	24	18	12	6

Optimization of expenses for protectability

$$1-\max_{k\in T_i}\left\{P_{mai}^{(k)}(D_{mai}^{(k)})\right\}\le Q^*$$

$$D^*=D^{(1)}+D^{(2)}+D^{(3)}$$



System significance - key terms and definitions

Criticality – is an object´s characteristic, which defines the degree of it´s influence on system´s operability in whole with account of weighed consequences, which have been caused by it´s shutdown for different categories of customers

+

Non-conditional vulnerability - is an object´s characteristic, which characterizes the degree of it´s operability reduction in the conditions of external influence, which fall short of normal conditions of object´s operation

System significance – is an object´s characteristic, which characterizes the degree of it´s importance for fuel and energy complex infrastructure and life sustenance, in the structure of which the object functions

Criterion of system significance

criticality of examined fuel and energy complex object is evaluated by the categority of tasks, ejecution of which is cancelled or delayed in the result of appeared emergency situation

Index of non-conditional vulnerability of object (by the realization of i scenario), is evaluated as dimensionless quantity, is counted by empirically assorted statictical date about characteristics of objects, depending on its territorial placement **(index of “aggressiveness of the environment”)**

$$r_i = \alpha_i w_i \cdot \beta q_i$$

Correcting coefficient, which takes into account all categories of customers (in accordance with the turn of shutdown) and topology of its placement in a region, on whose functioning influences the reduction of productivity of current object,

Correcting coefficient, characterizes the type (group) of object, forms on the base of objects types ranking and reflects the feature of relative “perceptiveness” of objects of given type on the wide range of external changes of factors

Criticality index computation

$$w_i = \sum_{j=1}^{\mu_k} \beta_{ij} \cdot w'_{ij}$$

“weight” of variables of object´s description

Variables of object´s description

Variables of description	Content of variables
Object´s production	Parameters are chosen in the dependence on object´s type
Carrying capacity	Volume of transported fuel and energy
Capacity	Summed capacity of objects
Quantity of isolated critical areas	Quantity of industrial areas, where are placed all installations and dangerous equipment, which require the measures for its safety
Quantity of personal in the object	Labor force, third parties, suppliers, members of their families and people who are connected with them
Period of work	Time of object´s functioning (by years)
Incomplete supplies in the case of accident	Summed volume of fuel and energy supplies, which has not been supplied to the customers in the result of partial or complete stoppage of object
Influence on the market	Influence in the result of object´s damage on the local, govermental and international levels
Replacement object cost	Evaluated cost of object´s substitution (evaluation of costs for the replacement of damaged elements of object).
Time of reconstruction	Characterizes the time of object´s reconstruction in the case of it´s complete or partial damage
Maximum possible damage in the result of accident on the object	Damage, caused by unfavourable development of accident process
Objects of substitution	Share of objects (%) which could substitute completely or partly the current object in case of its failure

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Non-conditional vulnerability index computation

$$q_i = \sum_{j=1}^{\rho} \gamma_{ij} \cdot q'_{ij}$$

“weight” of variables of object´s description

Variables of object´s description

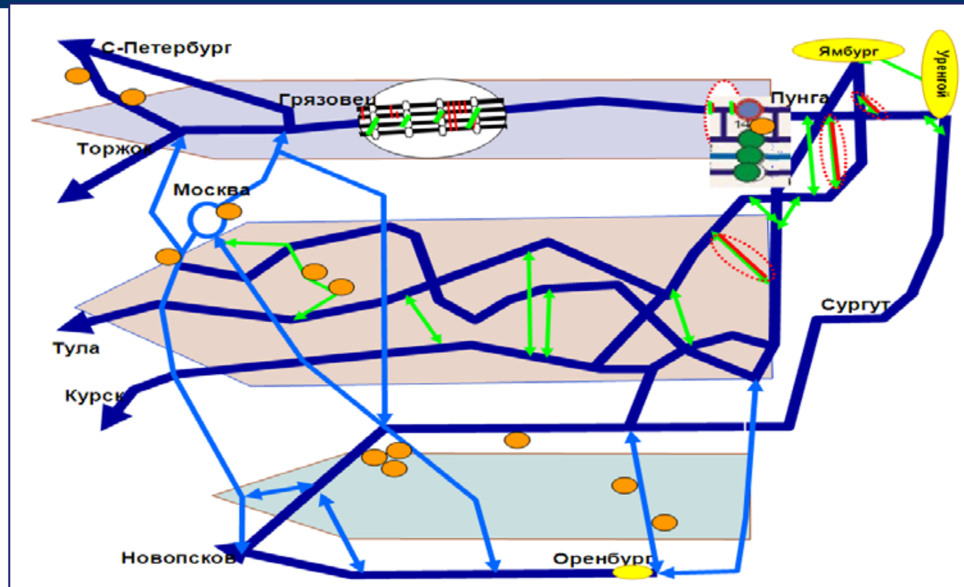
Variables of description	Content of variables
Level of criminal threat	Level of criminal threat in a region of placement, indexes of criminality of regions (ratio of perfomed crimes quantity to the general population size of the regions)
Remoteness from the boundaries	Territorial remoteness from the state boundaries which characterizes the possibility of examined object to be reached by subversive and terrorist groupes which have been prepared abroad
Remoteness from the seat of tension	Territorial remoteness of object from the “hot spots” at the territory of country (places of regional conflicts)
Level of social tension	Index of social and economic prosperity of examined object´s region of placement, for example, the index of child mortality, level of population incomes, its employment, etc.
Quantity of objects-analogues	Quantity of dangerous inductrial objects in the examined object´s region of placement , which influences on the choice of object- target by supposed violator
Quantity of targets in the object	Quantity of independent targets in the object will reduce the possibilities of infliction of damage for the object
Quantity of victims	Quantity of person which can suffer from the destruction of object (third party damag)
Area of possible emergency situation	Maximum area of emergency situation, which can appear as a result of violators’ actions, concerning the examined object

Example of qualitative-quantitative scale

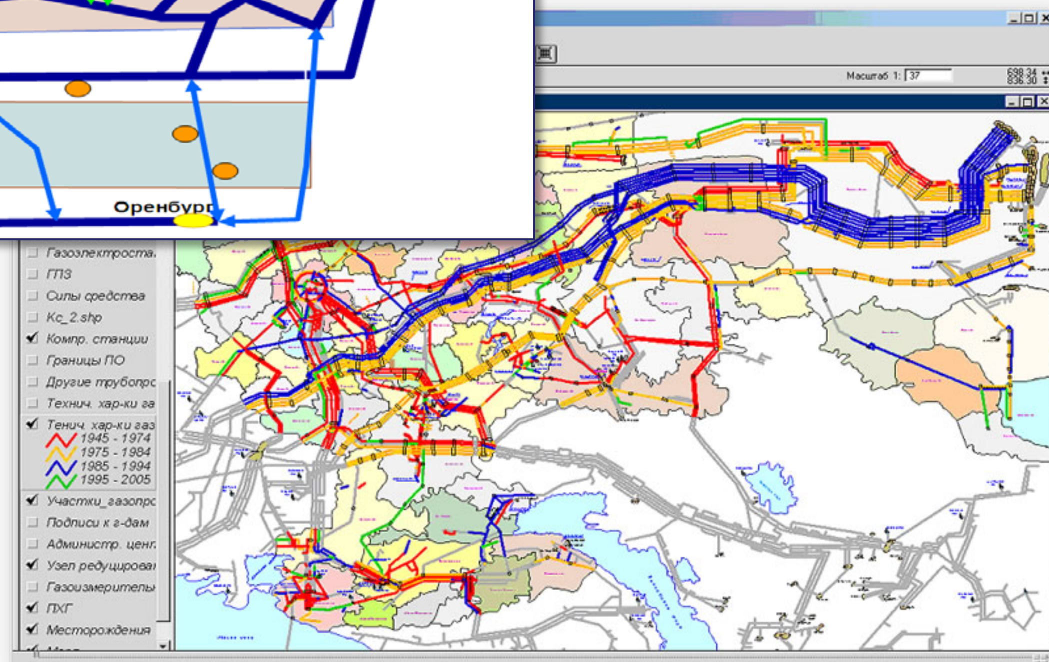
	Level of possible consequences heavyness				
Parameters	1	2	3	4	5
Cost					
Production					
Period of work					
Influence on the market	External	Internal	External and internal		
Objects of substitution	100%	75%	50%	25%	no
Time of reconstruction	By own efforts, Less than 15 days	By regional forces, 15-30 days	By goverment, 30-60 days	With attraction of international efforts, more than 60 days	
Significance of personal	Not required	Necessary	Absolutely necessary	Vitally necessary	
Quantity of personal					

Use of gas flow optimization models

Account of all mechanisms of production supplies reliability control



Account of technological specific character and conditions of objects distribution



Solution of optimization task

$$\left.\begin{array}{l} F = \sum_{i=1}^{m}\sum_{j=1}^{n} c_{ij}x_{ij} \rightarrow \min \\ \sum_{i=1}^{n} x_{ij} \leq a_i;\ j = \overline{1,m}; \\ \sum_{j=1}^{n} x_{ij} \geq b_j;\ i = \overline{1,n}; \\ x_{ij} \geq 0. \end{array}\right\}$$

Extended scheme of ranking algorithm

Stage 1

Comparative evaluation of one-type objects significance within one type

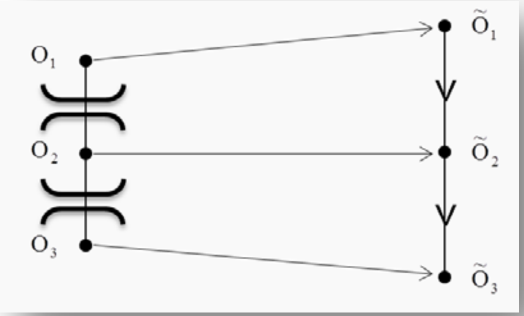
Stage 2

Integration of ranged lists of one-type objects at united and ranged by the system significance list

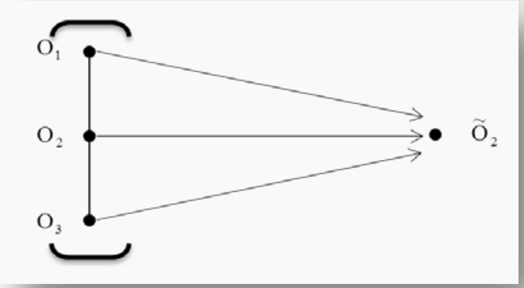
Stage 3

Correction of values of separate objects system significance evaluations with account of special conditions of its' functioning

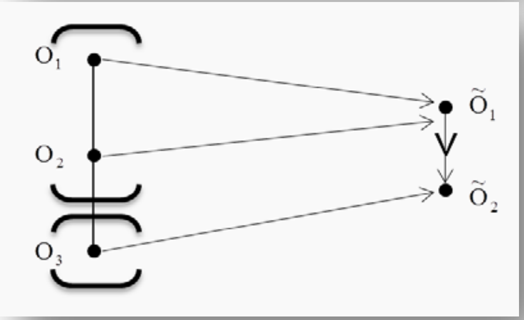
Joining of similar ranged lists



Example A. Every object of one list is considered to be equal to the respective object of another list



Example B. All objects of one list are considered to be equal to the same object of another list



Example C. First two objects of one list are considered to be equal to the same object of another list, and the third object is considered to be equal to the object which is less significant

The receiving of united list of different objects of safety, ranged by the value of system significance

Executed works in the sphere of risks of illegal actions analysis and management

Development of JSC “Gazprom” STO “Objects of JSC “Gazprom” which should be subjects of safety for the protection from the terroristic acts. Classification”

Development of mathematical models and normative documents for the countermeasure to illegal actions on the objects of gas industry of Bolivarian republic Venezuela

Development and justification of methodological ranking instrument of JSC “Gazprom” objects by its system significance

2007 2008 2009 2010 2011 2012

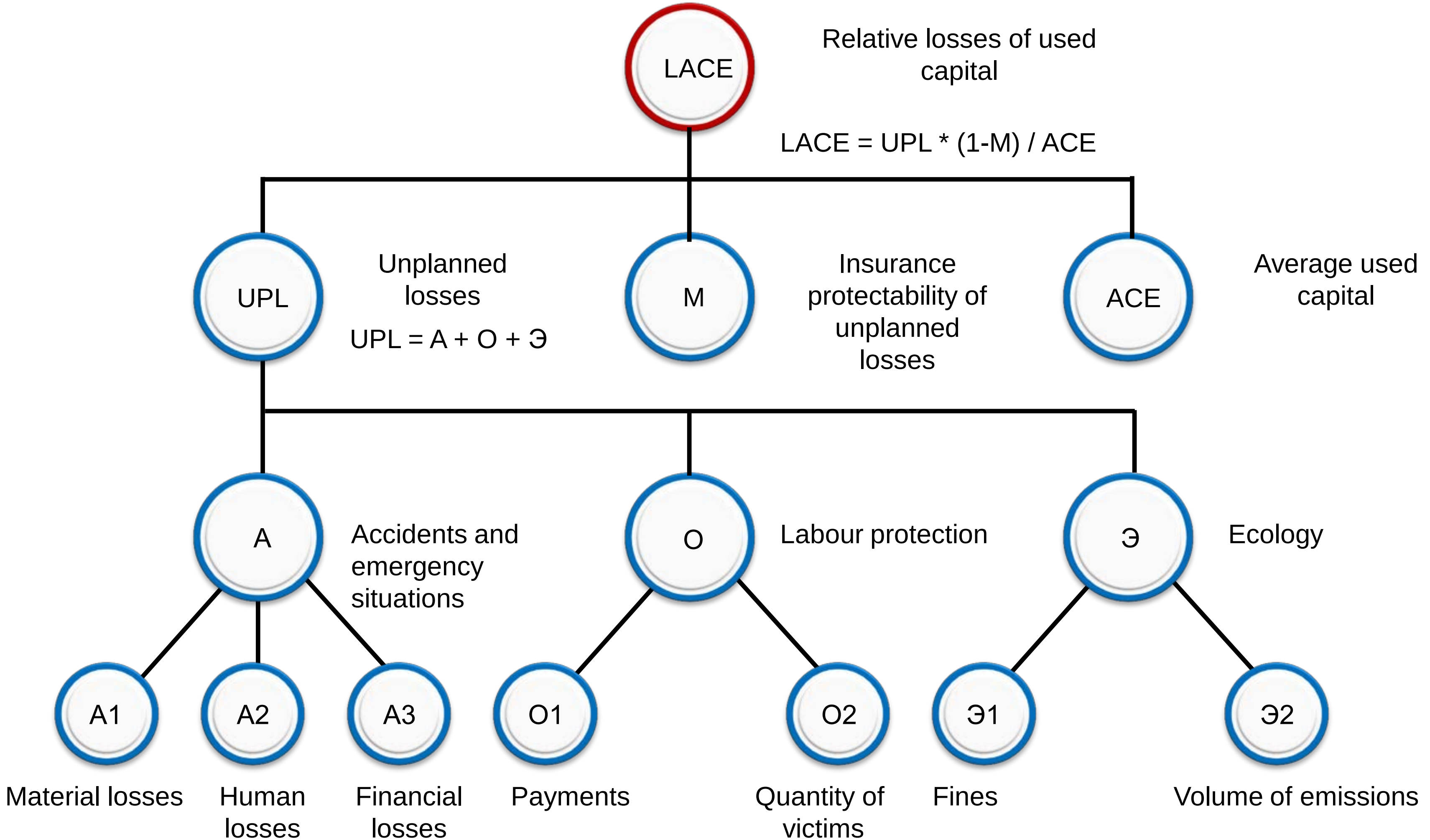
Development of hardware-software complex of JSC “Gazprom” surface facility protectability evaluation on the base of methods of simulation modeling with usage of GIS

Development of conceptual documents for protection systems construction and reduction of risks of illegal actions on the objects of JSC “Gazprom” by the contracts with Corporate protection Service of JSC “Gazprom”

2

Development of methods and models of evaluation of objects state, models of contingency and crisis situations forecasting and scenarios of its development

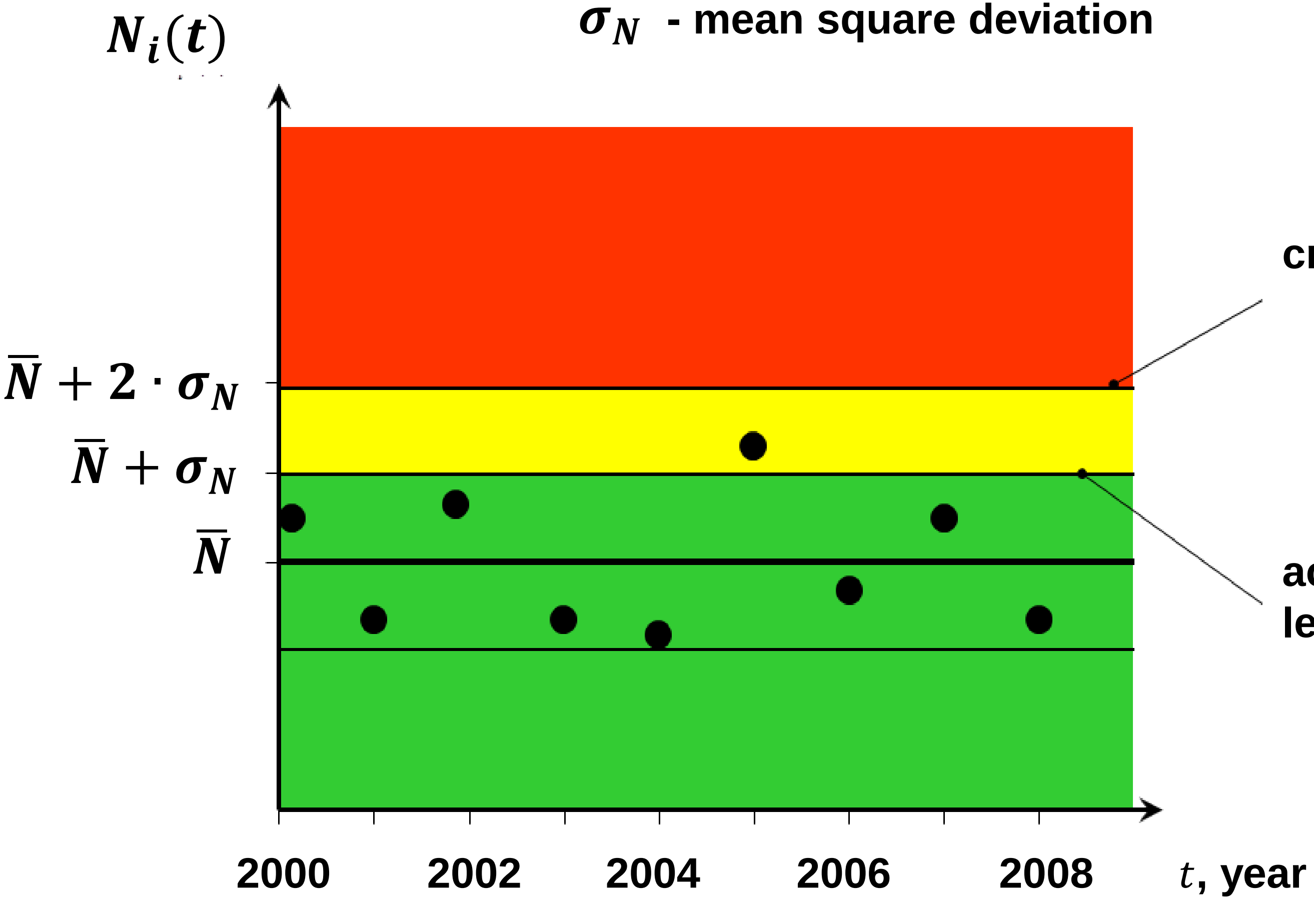
System of natural and economic coefficients for the analysis of system state (HSE)



Principle of identification of crisis and allowable level of coefficients and indices values

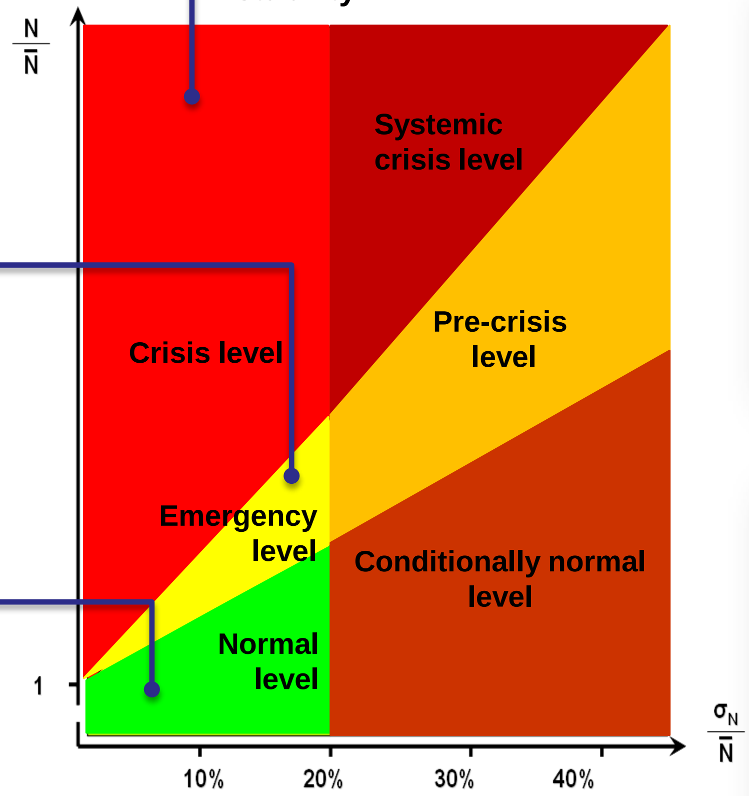
$\overline{N}$ - period average of indicator values

σ_N - mean square deviation

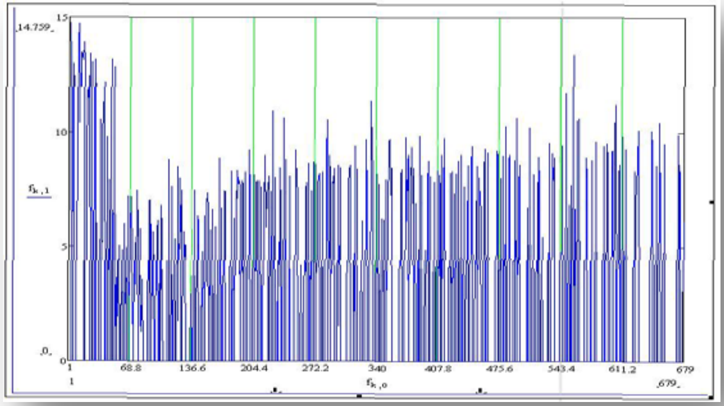


Forecasting of contingency and crisis situations on gas-transport objects

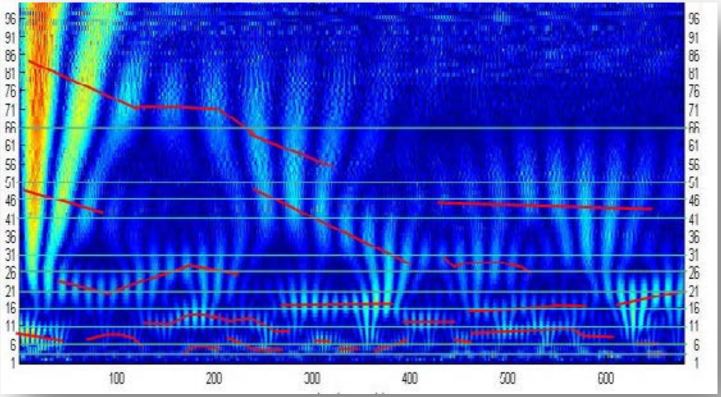
Integrated index of upper level stability



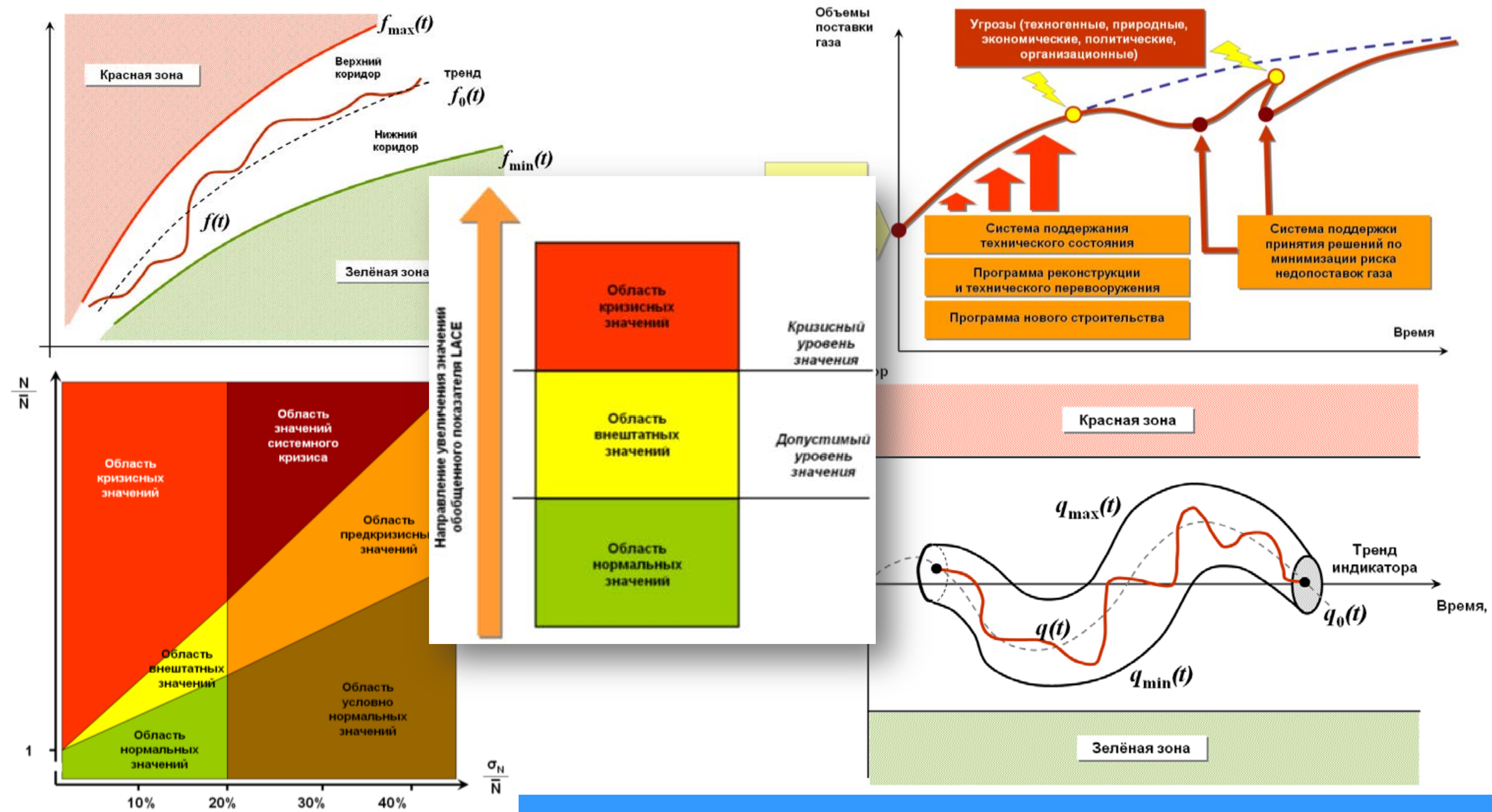
Raw of monitoring by the accident risk



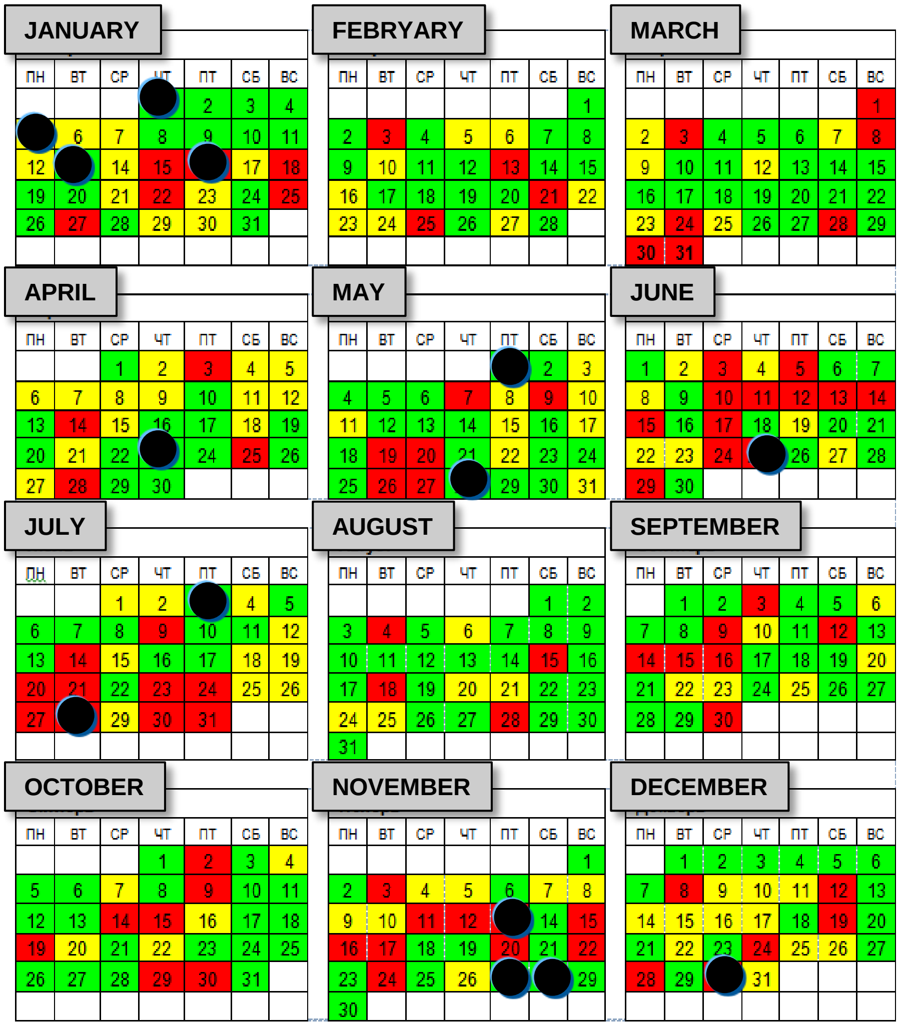
Wavelet-analysis of raw

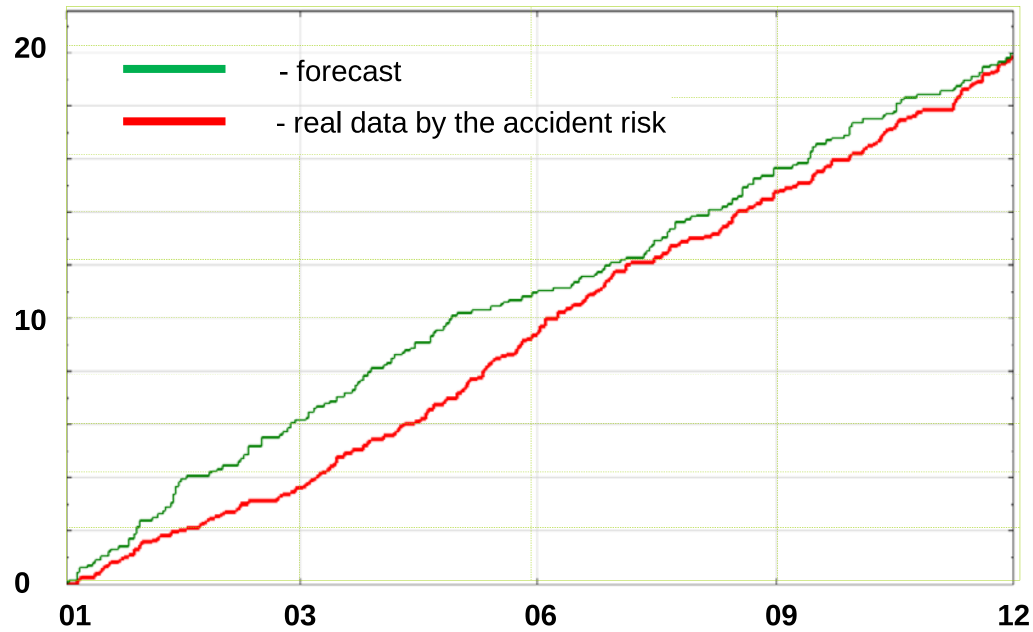


Forecasting of pre-crisis and crisis situations



Pattern-analysis of accident risk





X - Accidents are not expected

X - Accidents are possible with low and medium damage

X - Accidents are possible with high and large-scale damage

● - Actual day of accident according to statistical data

Executed works in the sphere of forecasting of contingency and crisis situations and methods of stability monitoring

2007 — Development of expert-analitical system of contingency and crisis situations forecasting on Russian UGSS objects

2008

2009

2010 — Development of methods of stability monitoring and crisis situations on Russian UGSS objects forecasting with usage of risk indices

2011

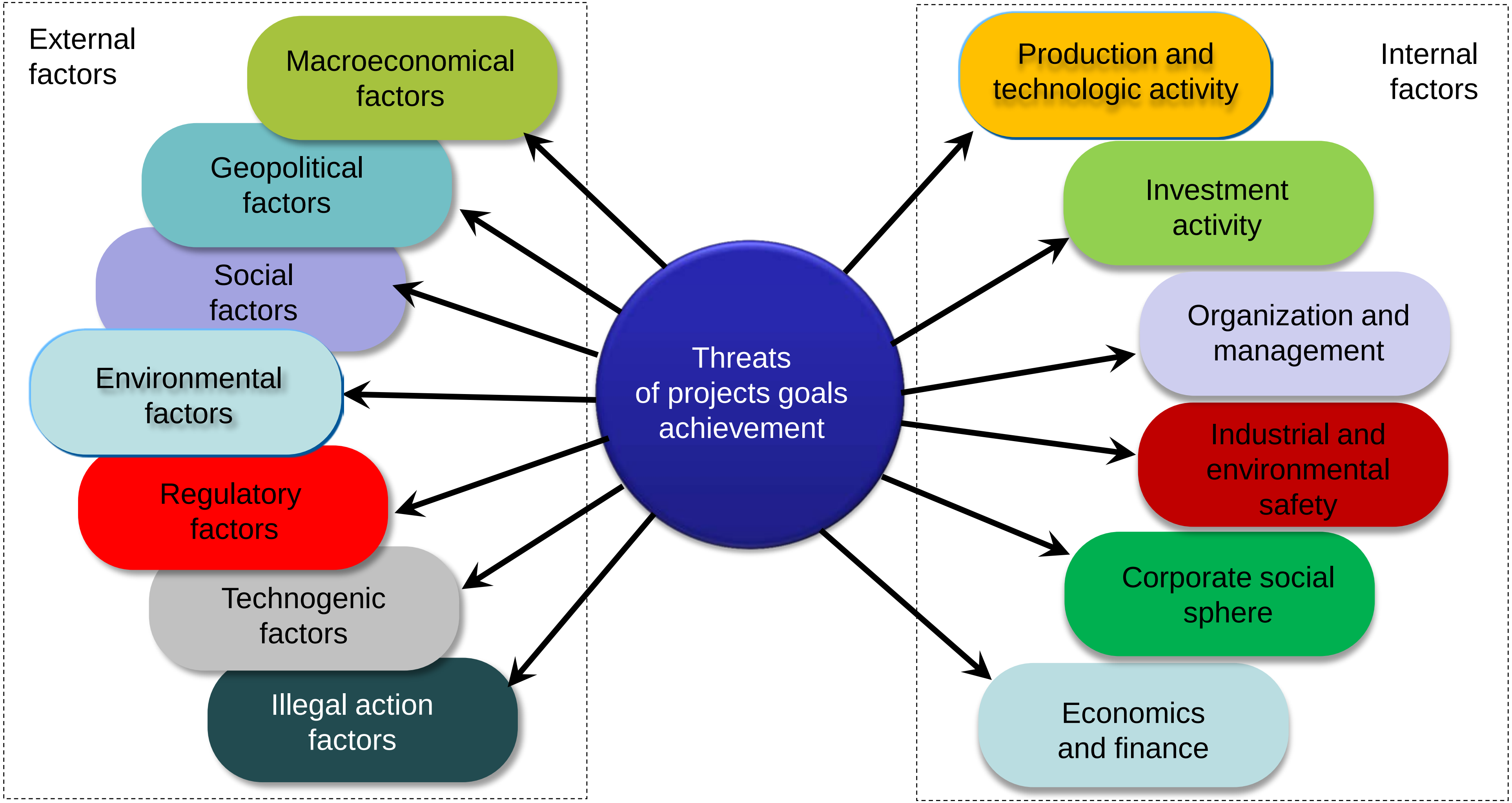
2012 — Development of methodological bases of JSC "Gazprom" activity organizational and normative-methodological support system construction in the sphere of situational management

2012 — Development of methods of forecasting and identification of weakly-formalized threats, directed on the stable functioning of Russian UGSS objects on the base of statistical and semantic analysis of open information sources

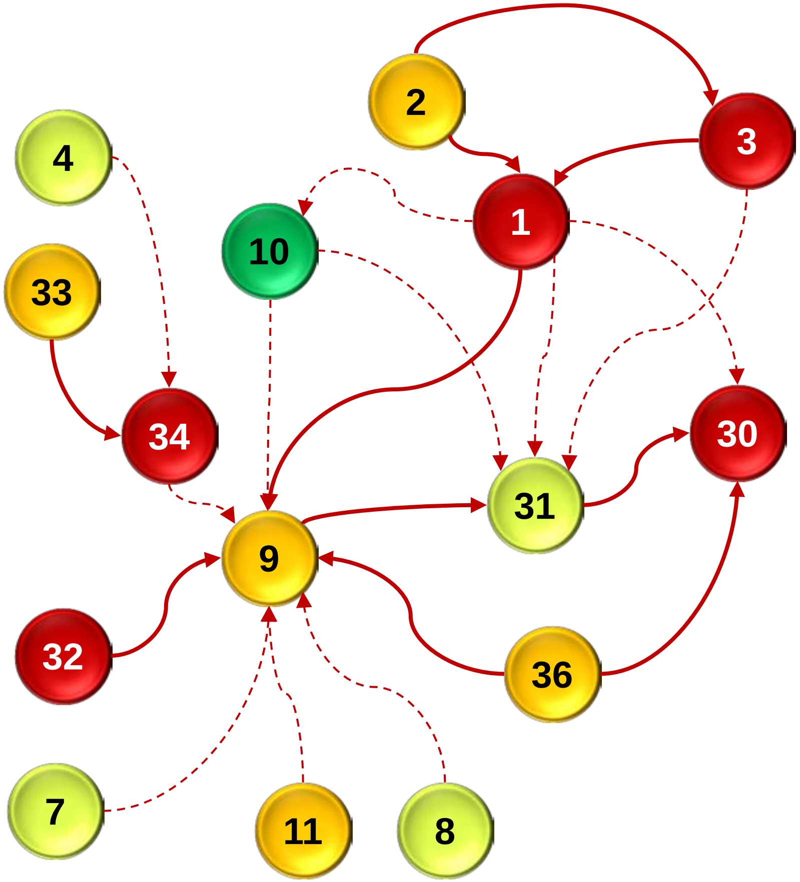
3

Development of methods and models of analysis and management of project risks, including the instruments of making managerial desicions

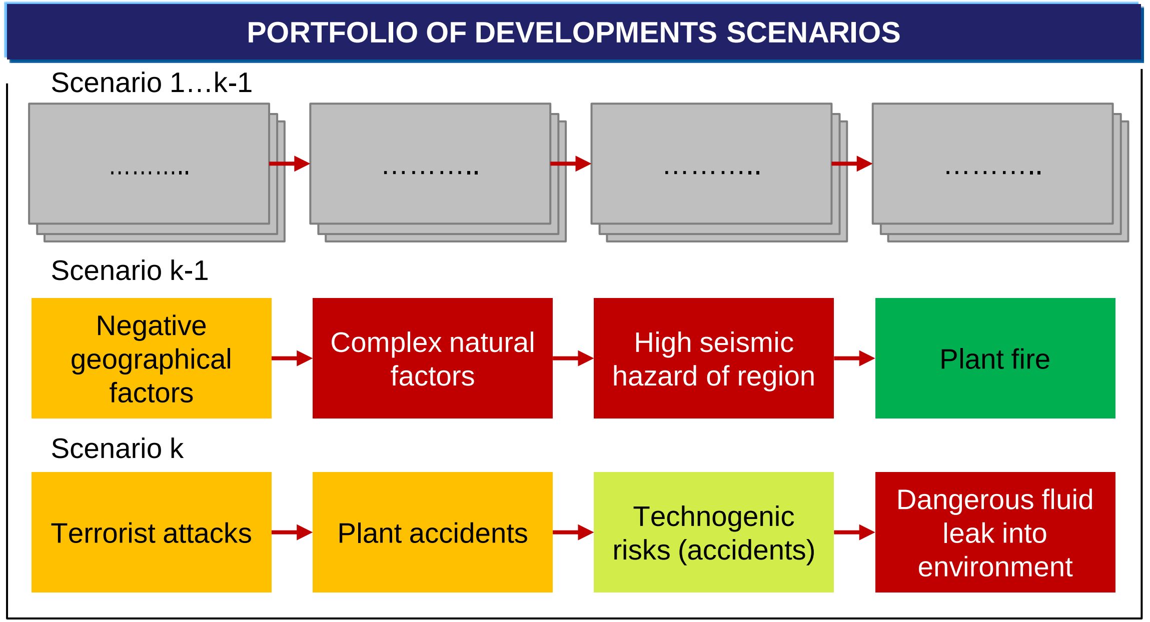
Factors of threats of investment projects successful realization



Identification and qualitative risk assessment of project risks taking into account their interconnection

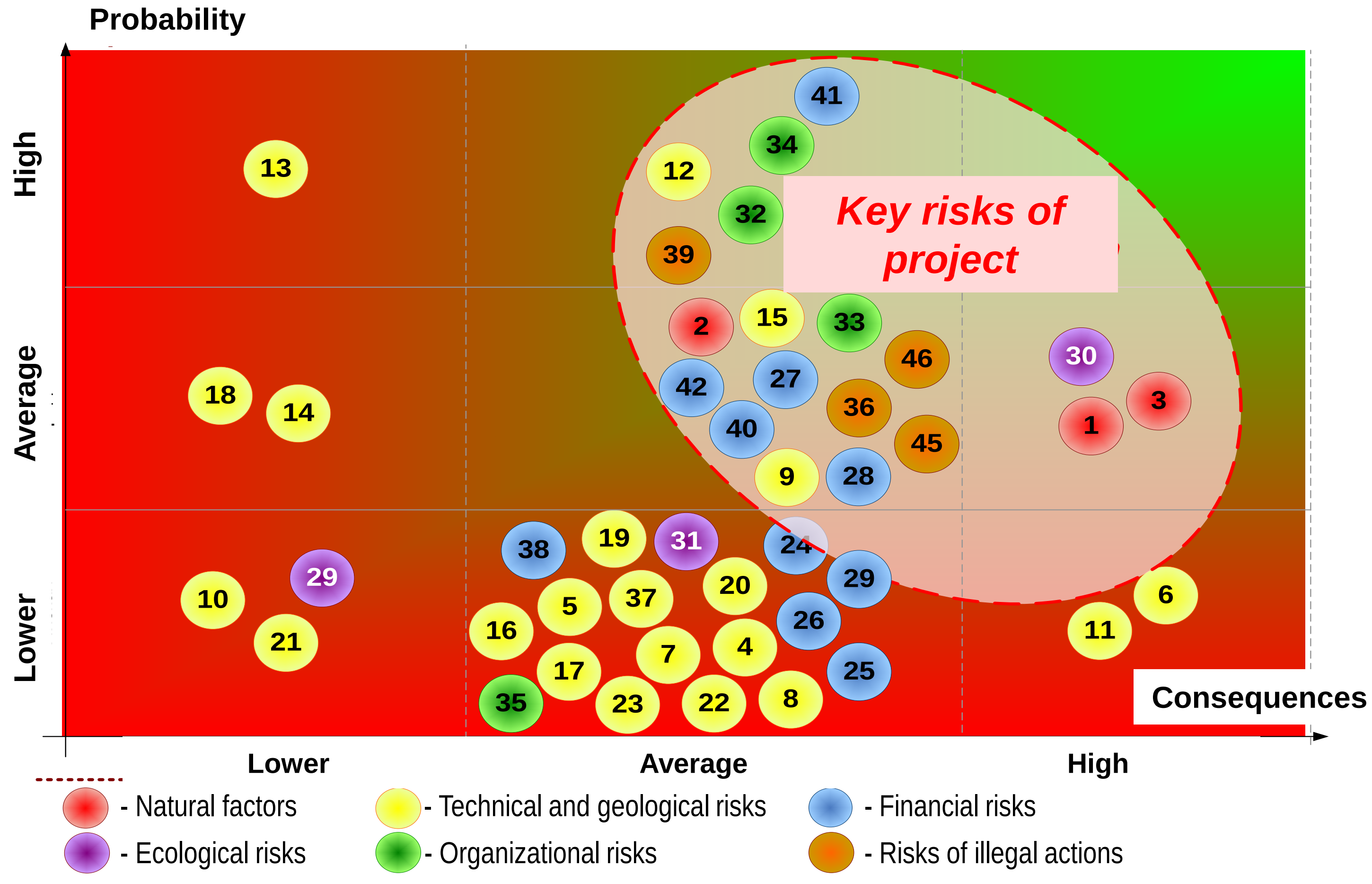


High exposure level
Average exposure level
Low exposure level is not pointed out



1 – high seismic hazard of region
2 – negative geographical factors
3 – complex natural factors
4 – lack of necessary documentation
7 – underwater production new technologies application
8 – underwater pipelining risks
9 – plant accidents
10 – plant fire
11 – accident flowing
30 – dangerous fluid leak into environment
31 – technogenic risks
32 – unsafe practices of local personnel
33 – lack of qualified specialists
34 – defective work of contractor according to on contractual obligations
36 – terrorist attacks

Ranging and risk map construction of oil and gas projects



Quantitative assessment of influence of technical and environmental risks on purposes of oil and gas project

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Input data

- technological schemes of objects of production, processing and gas transportation,
- structure and technical characteristics of used equipment, pipelines and others,
- work schedule on project,
- description of environmental conditions of project realization

Models and instruments

- stochastic network model of project,
- fault trees
- event trees

Resulting assessments

- types and scenarios of risk situation development
- risk event probability (technical and environmental risks)
- risk event realization consequences (in terms of volume, terms and cost)

Results

- scenarios of project development with regard to technical and environmental risks,
- probabilistic distribution of project realization terms and expenses with regard to technical and environmental risks,
- indexes of project risk (expected value of terms and expenses, minimum and maximum values of expenses, expected losses, etc.),
- list of factors of technical and environmental project risks ranged on risk level,
- recommendations about decrease in technical and environmental risks

Quantitative assessment of influence of financial and economical risks on purposes of oil and gas project

Input data

- nomenclature and volume of output
- directions and conditions of product supply
- historical data on product prices
- scenarios of prices trends on product

Models

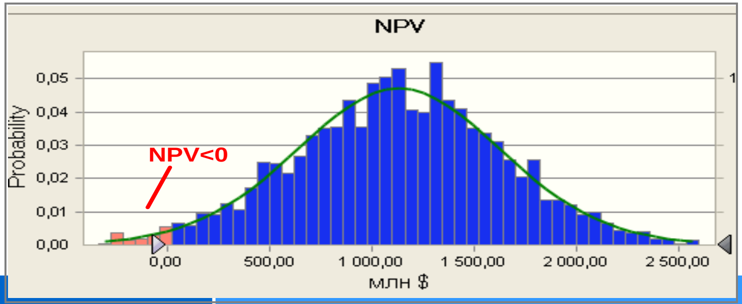
- financial and economical model of project
- stochastic models of product price movement
- models of intermarket correlation

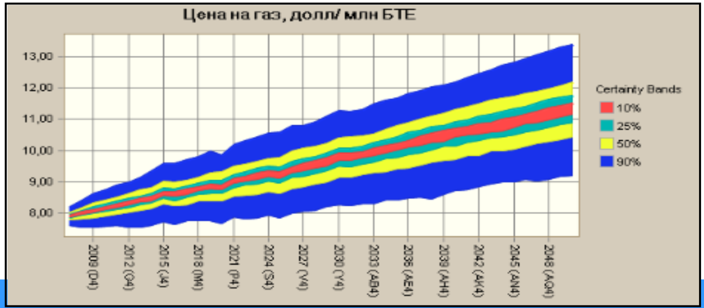
Resulting assessments

- scenarios of stochastic price movement on product in different markets
- probabilistic distribution of product selling price in markets
- correlation coefficients between prices
- assessment of influence of price risk factors on economical project efficiency

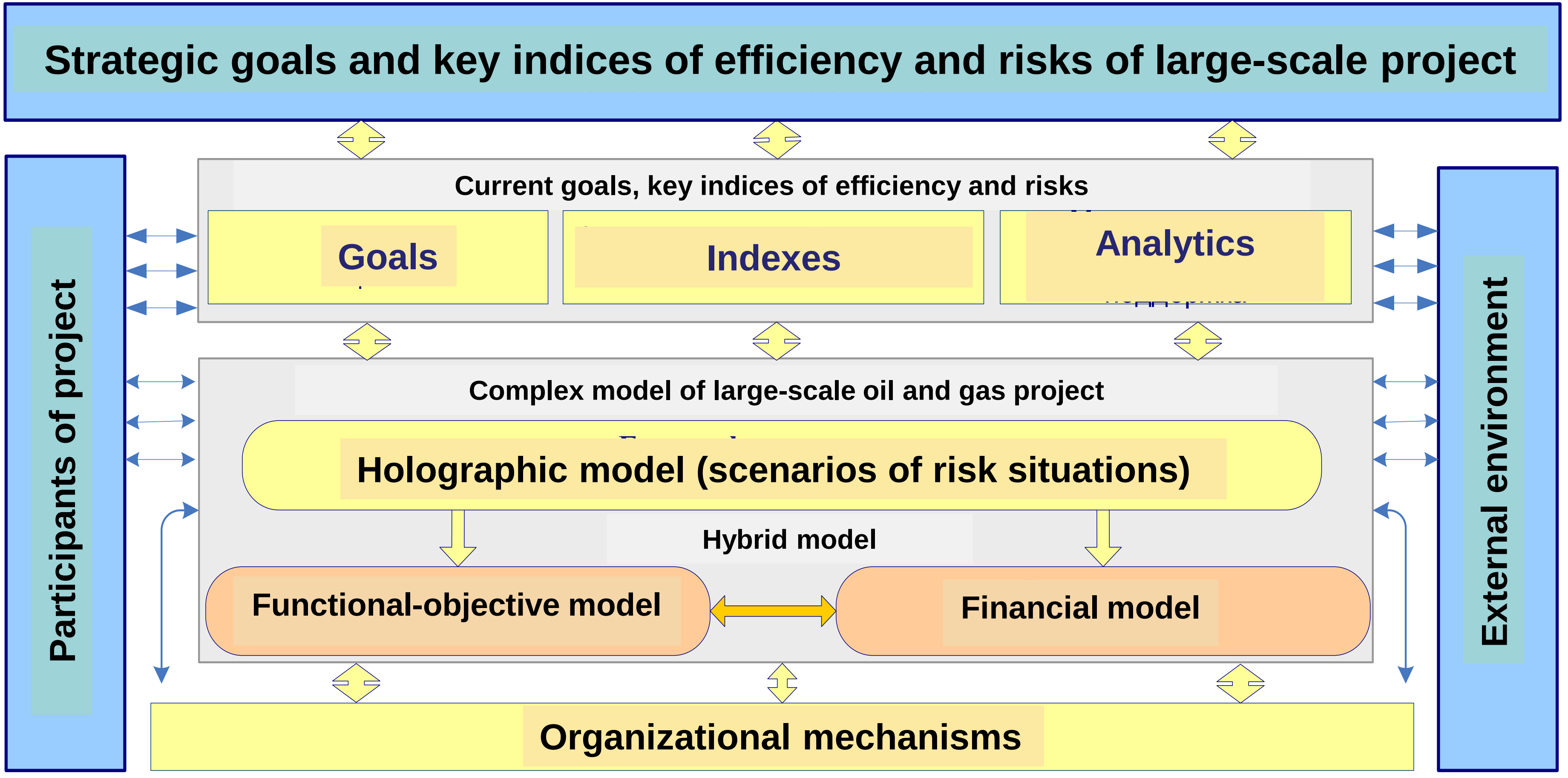
Results

- economical and mathematical model of quantitative assessment of financial and economical project risks,
- probabilistic distribution of indexes of project economical efficiency with regard to financial and economical project risks,
- indexes of project risk (expected value of indexes of project economical efficiency, minimum and maximum values, expected losses, etc.),
- ranged list of financial and economical factors of project risks (price change on products in different markets),
- recommendations about decrease in financial and economical risks





System approach to the risk evaluation and risk management of large-scale project



Holographic model of large-scale oil and gas project risk management

RISKS CLASSIFICATION

- Accidence growth
- Productivity reduction
- Organizational risks
- Financial-economic risks
- Market risks
- Environmental risks
- Others

RISKS SOURCES

Infrastructural components
- Production field
- Drillings
- Drill unit
- Gas pipelines
- Gas processing facility
- Power plant
- Underground gas storage facility
- Others

Participants
- Organizations
- Project creditors
- State
- Insurance company
- Contractor company
- Terroristic organizations
- Others

Personal
- Corporate governance
- Management
- Employees

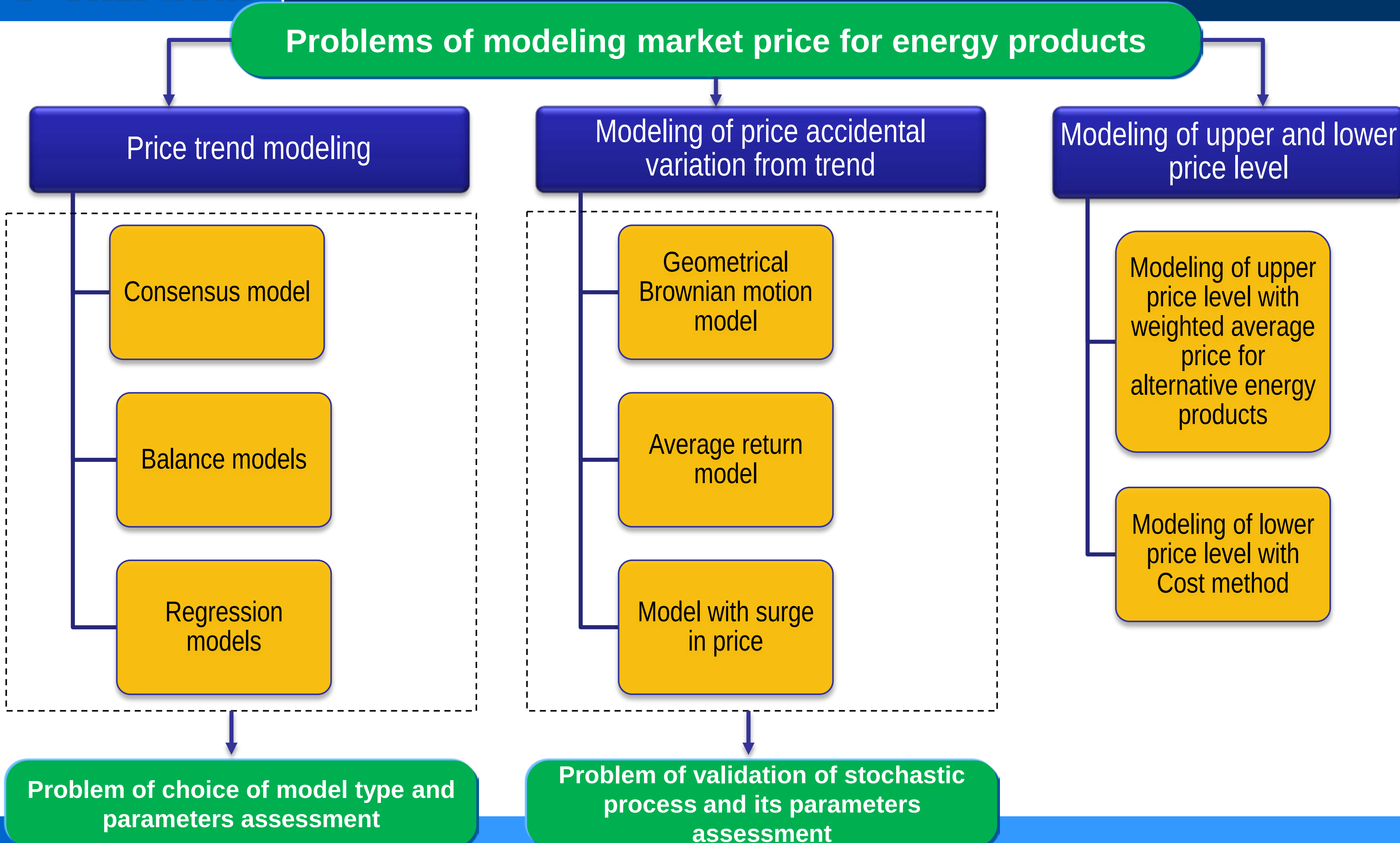
Project management
- Strategic
- Operations
- Overall
- Employees management
- Goal-oriented planning
- Finance management
- Others

Markets
- Demand
- Product pricing
- Inflation
- Currency rate
- Time value of money
- Economic activity
- Others

Geography of supplies
- Gas supply A
- Gas supply B
- Gas supply C
- LNG supply A
- LNG supply B
- LNG supply C

Environmental conditions
- Earthquake
- Wind
- Temperature
- Stream
- Pressure
- Others

Fundamental problems of modeling market price for energy products



Two-state stochastic model of price forecasting for oil trade mark Brent in Europe

Model of decomposition of price time series for oil

$$P_t = T_t \bullet It$$

Regression trend model

T_t

Modeling of trend component of price time series:

$$T_t = -25{,}82 + 0{,}0057 \cdot G_t$$
$$R^2 = 0{,}84$$

where:

T – **average monthly prices for oil trade mark Brent since 2000 till 2010***

G – **GDP of European Union in current prices.**

Geometrical Brownian motion model (GBM)

I_t

Modeling of random component of time series with normalized process of GBD

$$I_t = exp\left(-\frac{\sigma^2}{2}t + \sigma \cdot W_t\right)$$

where:

σ $(\sigma_{мес} = 0{,}09)$ – **monthly volatility of logarithmic price increasing**

W_t - **standard Brownian motion**

* IFM data

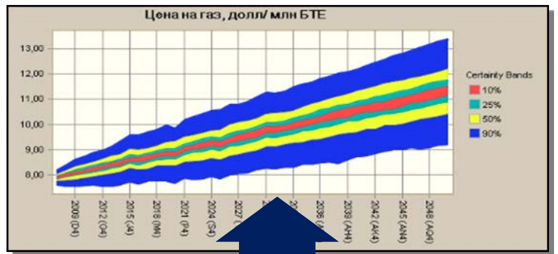
Methodical approach to quantitative assessment of market risks of oil and gas project

Variants of project development

Method of simulation modeling

Variants of market risk reduction

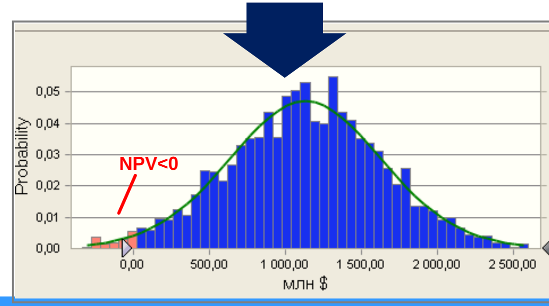
Financial and economical project model in variants section



Prices model for energy products

Quantitative assessment of investment risk indexes

Validation of effective variants of market risk reduction



Determination of correlation dependence between prices

Recommendations on choice rational variants of project development

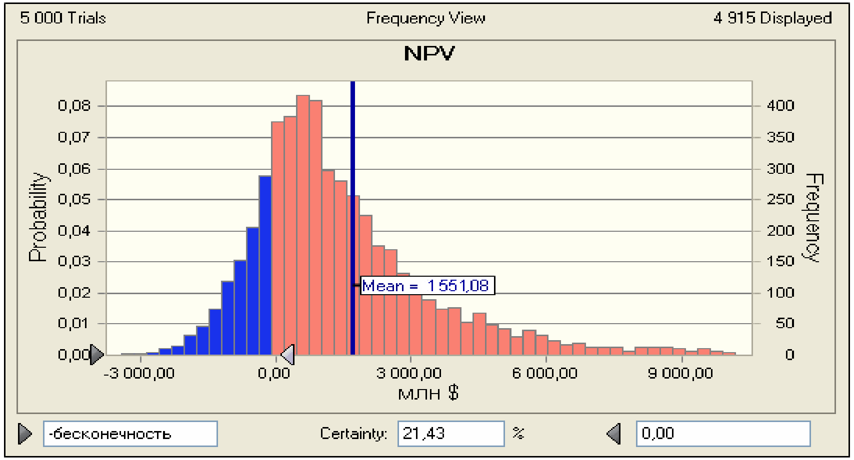
The restrictions of tools use at the management of oil and gas company price risk

Long-term contracts	• The difficulty of conclusion of new long- term contracts and tendency to the reduction of average terms of concluded contracts; • The intention of natural gas consumers to the growth of price flexibility of long-term contracts
Dissipation	• The reduction of company's gross revenue of project realization • The attenuation and possible loss of the control over the project;
Hedging	• The probability of price risk hedging only in short-term period; • The difficulty of evaluation of option's value, the sensitivity of tools' value to the time before expiration , to the volatility of prices and to other parameters;
Arbitrage	• Restricted sphere of application; • Additional expenses for the creation of organizational mechanisms which permit to use the arbitrage
Minimax contracts	• The impossibility of all additional profit earning for account of possible excess of market prices over given maximum levels; • The complexity of development of perfect forecasts of future levels and variations of prices at energy carriers which are necessary for the definition of minimax contracts' parameters; • The difficulty of agreement of minimax contracts' parameters.

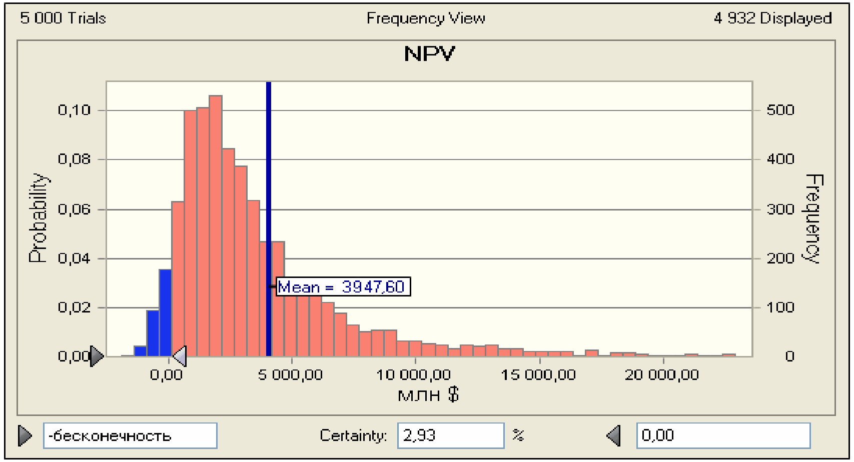
Assessment of economical efficiency and risks of different variants LNG supply (by the example of Project Atlantic LNG T5)

Indexes of economical efficiency		NPV, million US dollars	Probability of getting negative NPV	Average annual return, million US dollars
Being contracted without arbitration	In N. America	1551	21%	224
	In Europe	1880	23%	275
Being contracted with arbitration (substitution of contract obligations)	In N. America	3691	1%	561
	In Europe	3915	5%	595
Arbitration on basis of optimization of spot supply (maximization of price net-back)		3947	3%	604

Being contracted in N. America (without arbitration)



Arbitration on basis of optimization of spot supply



Principles of validation of minimax contracts rational parameters by energy resources supplies to external markets

What parameters of minimax contracts are rational in energy products supply projects?

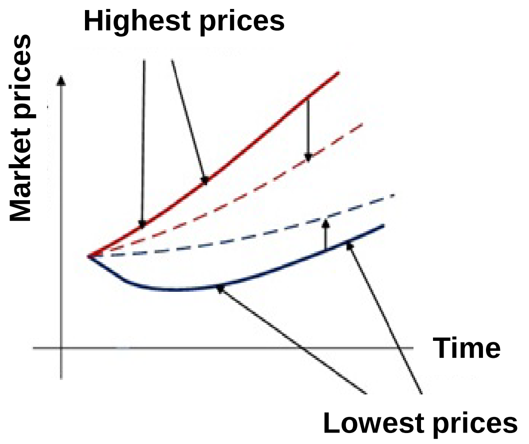
What principle to put at rational minimax prices fixing?

Whether it is favorable to participants to reduce risk at the expense of increase lowest and reduction of highest contract prices?

Principle of equality and invariance of expected losses?

Principle of equality and invariance of loss probability?

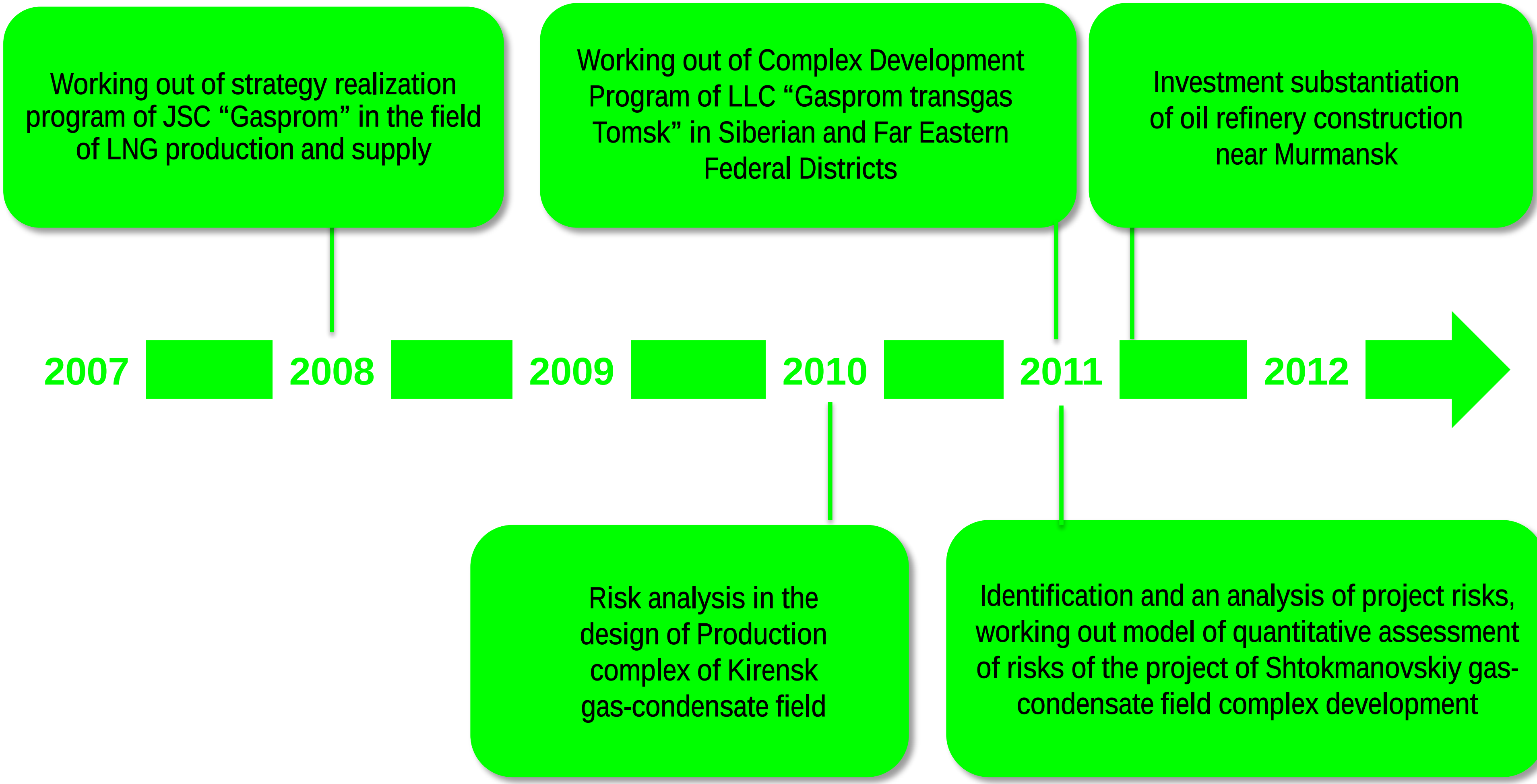
Principles of invariance of position of minimum contract price to expected value and equalities of expected losses in each point of time?



Criteria of rational variant choice:

- ❖ maximizing expected value of net discounted income,
- ❖ restriction of expected losses of project,
- ❖ equal risk of seller and buyer

Executed works in the field of project risks analysis and management

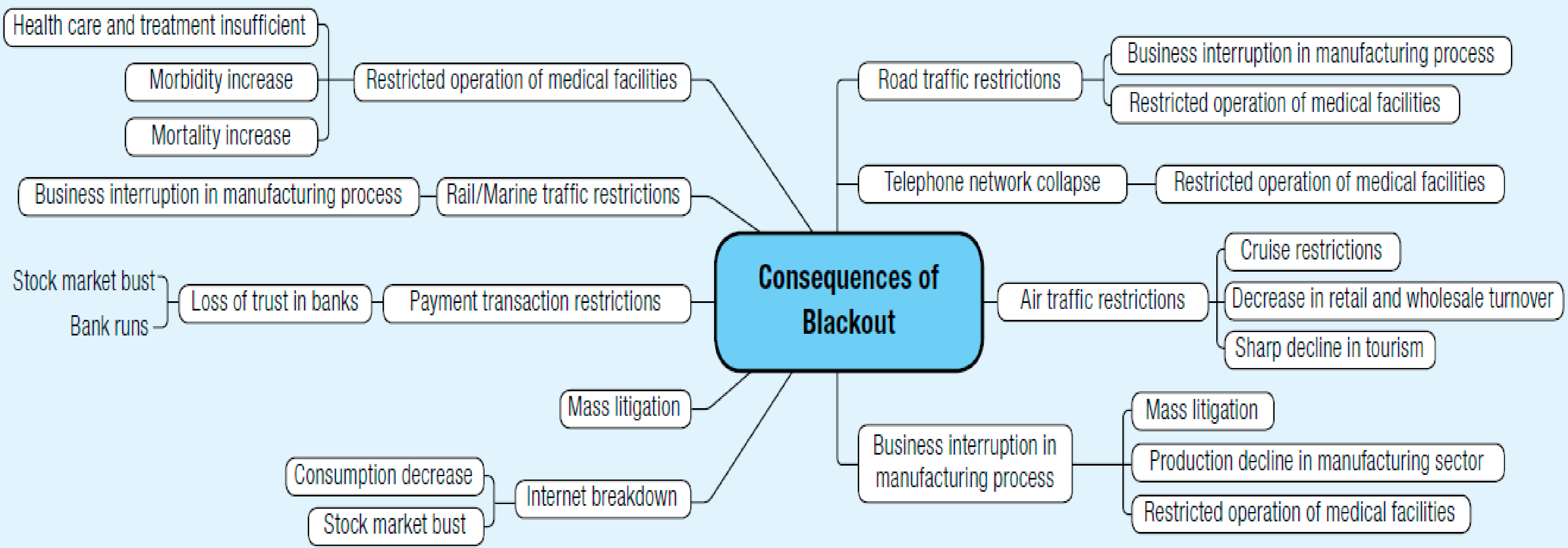


4

Problem of intersystem accidents risk research

Problem of intersystem accidents risk analysis

Consequences of blackouts



(Power Blackout Risks. Emerging Risk Initiative – Position Paper, CRO FORUM, November 2011)

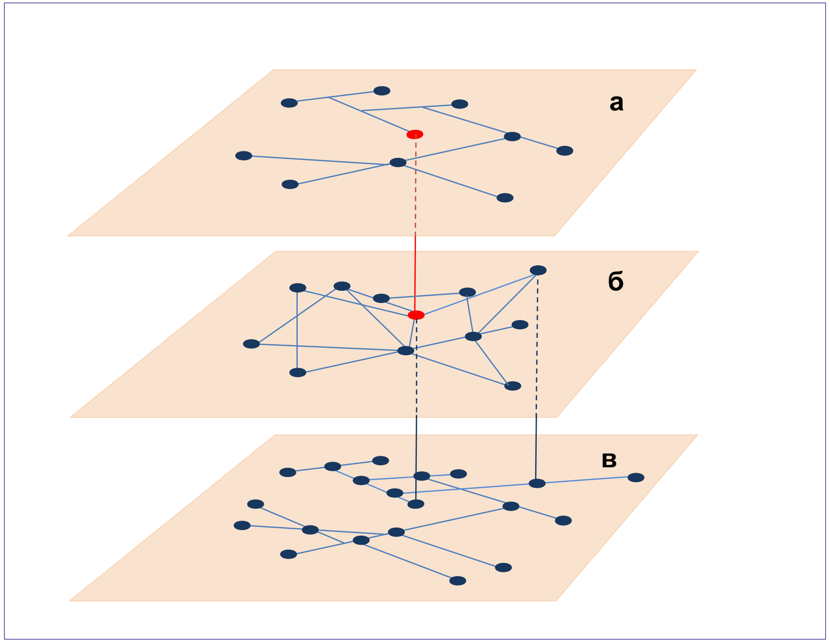
Infrastructural-complex territory – is a territory with high concentration and high level of interaction of infrastructural systems (Moscow and Moscow region, Dusseldorf-Cologne etc.)

Methodological approach to the tipization of intersystem accidents

$C_i^r(t) = \alpha_i(t) L_i^r,$	Maximum acceptable capacity in the nodes of system
$C_k^{l,m}(t) = \beta_k(t) L_k^{l,m}$	Maximum acceptable capacity in the nodes of intersystem interaction
$\tilde{L}_i^r(t) > C_i^r$	Condition of appearance of refusal or accident in the nodes of system
$\tilde{L}_k^{l,m}(t) > C_k^{l,m}(t),$	Condition of appearance of refusal or accident in the nodes of intersystem interaction
$\xi^r(t) = \dfrac{N^r(t)}{N_{tot}^r}$	Degree of network nodes destruction
$\xi^{l,m}(t) = \dfrac{N^{l,m}(t)}{N_{tot}^{l,m}}$	Degree of internetwork nodes destruction

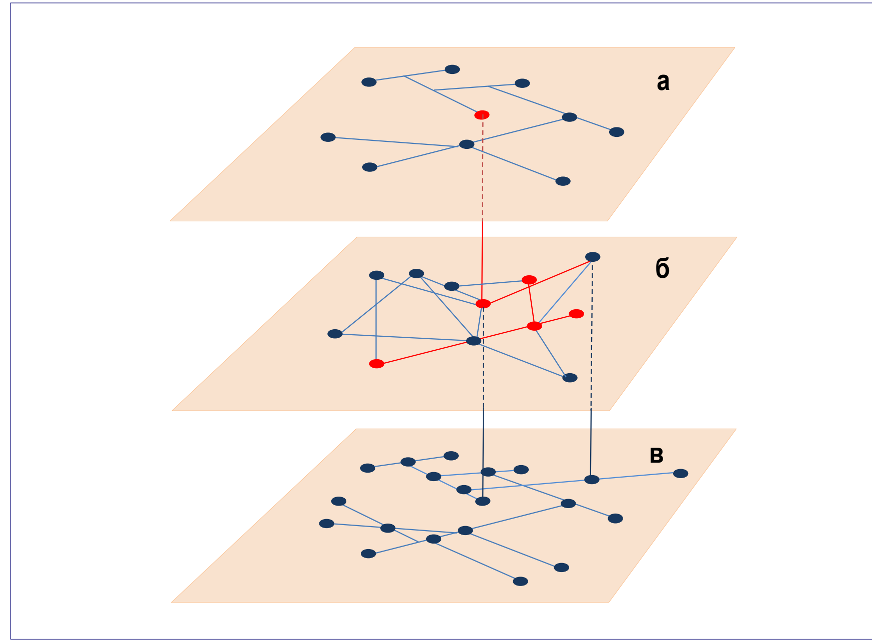
Tipization of intersystem accidents (1)

Type I. Accidents with absence of branching



Degree of network nodes destruction	Degree of internetwork nodes destruction
$\frac{1}{N^{r}_{tot}}$	$\frac{1}{N^{l,m}_{tot}}$

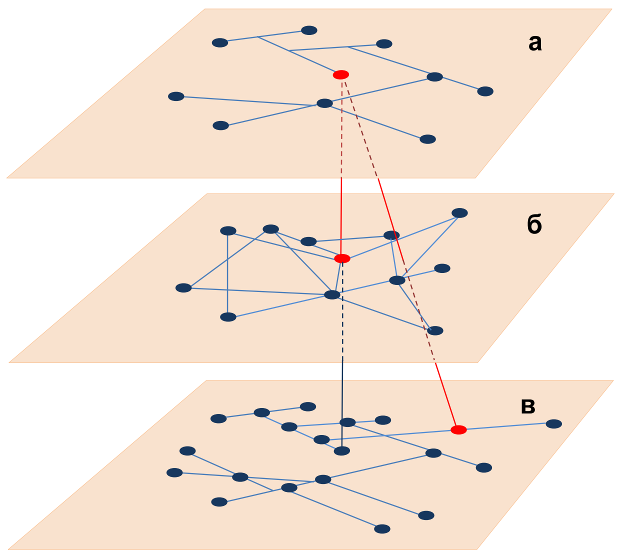
Type II. Accidents with branching in the systems



Degree of network nodes destruction	Degree of internetwork nodes destruction
$\frac{1}{N^{r}_{tot}} < \xi^{r} \leq 1$	$\frac{1}{N^{l,m}_{tot}}$

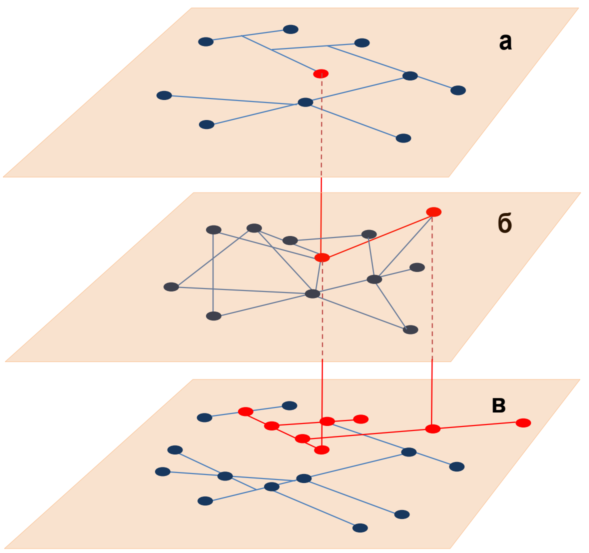
Tipization of intersystem accidents (2)

Type III. Accidents with branching between systems



Degree of network nodes destruction	Degree of internetwork nodes destruction
$\frac{1}{N_{tot}^{r}}$	$\frac{1}{N_{tot}^{l,m}} < \xi^{l,m} \leq 1$

Type IV. Accidents with branching in the systems and between systems



Degree of network nodes destruction	Degree of internetwork nodes destruction
$\frac{1}{N_{tot}^{r}} < \xi^{r} \leq 1$	$\frac{1}{N_{tot}^{l,m}} < \xi^{l,m} \leq 1$

Examples of accidents with branching within systems and between systems (type 4)

Date	Place	Initiative event in a system 1	Consequences in a system 2	Consequences in a system 3
23.01.2012	Leningrad region	Accident at the heating main	Stoppage of heat supply at the houses, mass usage of electrical warming	Mass refusals in the system of power supply
15.06.2012	Saratov (Russia)	Reduction of gas feed at heat electropower station	Stoppage of power generation on the heat-electropower stations	Mass disconnection of utility users, stoppage of electric transport traffic, breach of traffic.

Examples of accidents with branching within systems and between systems (type 4)

Date	Place	Initiative event in a system 1	Consequences in a system 2 *(transport)*	Consequences in a system 3 *(telecommunications)*	Consequences in a system 4 *(community services)*	Consequences in a system 5 *(bank system)*
25.05.2005	Moscow	Fire on the substation, shutdown of transmission facilities in Moscow, Kaluga and Tula regions	Stoppage of electrified transport functioning (subway, trolleybus, commuter trains)	Isolation of basic stations of mobile communication, shutdown of russian node of internet-traffic exchange	Shutdown of water supply stations, aeration stations, hydraulic shock in the sewerage systems	Temporal stoppage of transactions, shutdown of ATM

Approaches to intersystem accidents modeling

TIPES OF MODELS

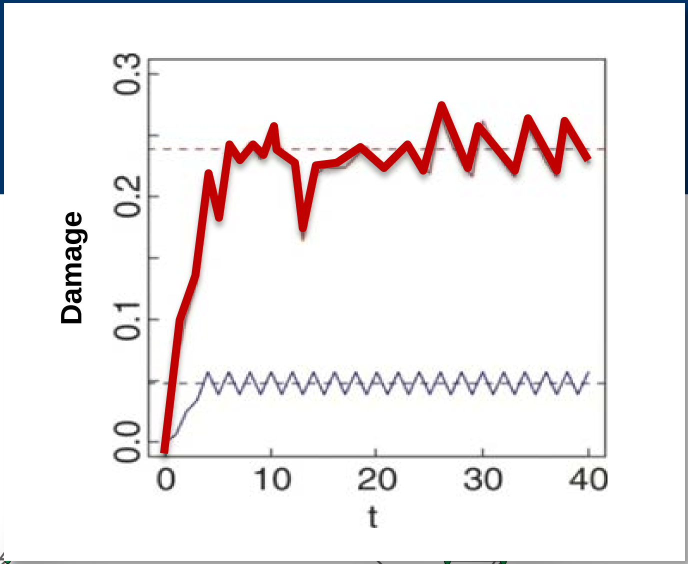
Statistical approach

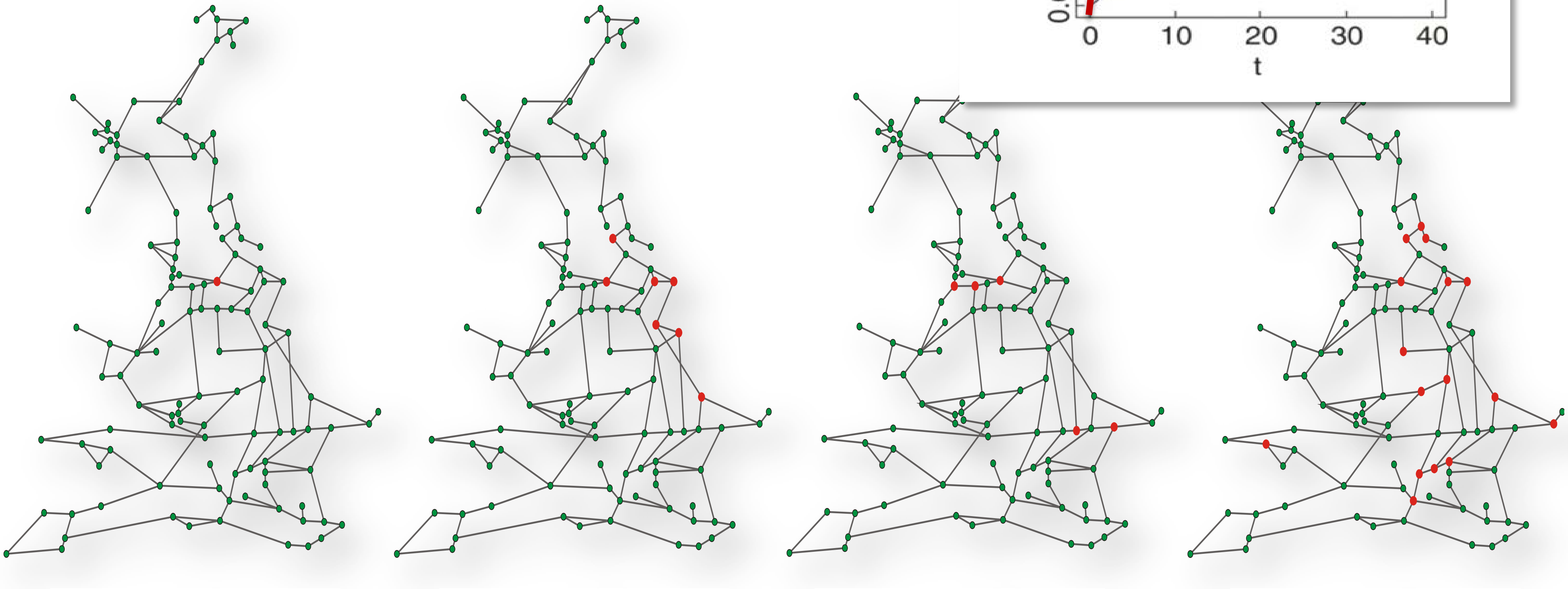
Spread of accident is considered as Galton-Watson process.

Simplified numerical model

I
nteraction of two simplified models of networks through limited number of general nodes is modeled

Preliminary results of modeling





t = 1 t = 2 t = 3 t = 4

Conclusion and proposals

1. Risk analysis Center executes the scaled researches in the sphere of risk analysis, risk management, stability and safety in the energetics.

2. Russian and foreign oil and gas and insurance companies use the results of these researches in the forms of recommendations, standards, mathematical models, algorythms and programs.

3. Taking into account the actuality of Center´s researches it will be reasonable to discuss the possible directions of cooperation for the growth of efficiency and quality of executed researches

THANK YOU FOR ATTENTION

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