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ПРОБЛЕМЫ АНАЛИЗА РИСКА

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On the Way to Legal and Economic Regulation of Risk Levels – Declaration of the Russian Scientific Society for Risk Analysis

Andrey Bykov
Editor-in-Chief

Dear readers!

The 12th International Scientific and Practical Conference on the issues of protection of population and territories from emergencies "Interdisciplinary Studies of Life Safety Issues: Current State and Prospects" and the Scientific and Practical Symposium "Technological Catastrophes and Safety Problems" were held in Moscow, April 18-20, 2007.

Based on the analysis of ongoing radical changes and their trends, and on the basis of discussion of papers presented at the Conference and Symposium, we passed a resolution, which, among other things, includes the following recommendations:

- in view of the interdisciplinary nature of current problems of public safety and the need for consolidated efforts in the area of fundamental and applied research, the concerned federal agencies, together with the Russian Academy of Sciences, should continue their efforts to create a RAS department for interdisciplinary studies that would include, among others, subdivisions for issues of population safety, sustainable development and ecology;
- in view of the growing significance of efforts directed towards formation of safety culture for emergency risk reduction and the increasing role of modern information telecommunication technology in informing and alerting people in places of public accommodation and gathering, to organize and conduct, in May 2008, the 13th International Scientific and Practical Conference on Issues of Protection of Population and Territories from Emergencies, the Conference theme being "**Current Topical Issues of Formation of Life Safety Culture**".

The Conference will be organized jointly by EMERCOM of Russia, the Russian Academy of Sciences and the Russian Scientific Society for Risk Analysis. The working languages of the Conference will be Russian and English; simultaneous translation will be available during all plenary and parallel sessions.

The Conference will include plenary sessions and discussions on actual issues and main results of interdisciplinary research in the field of **life safety culture of population** in present-day conditions.

Participation in the Conference will be free of charge. Participants cover all their travel expenses, accommodation.

The topics of plenary sessions and the exact dates of the Conference will be announced by the end of this year.

We have the pleasure to invite all interested parties to take part in the Conference and to send their application forms and abstracts of their papers by fax to +7(495) 443-84-94, or e-mail to csi430@yandex.ru or csi3@mchs.gov.ru, or mail to the EMERCOM of Russia Center for Strategic Research, Davydkovskaya str., 7, Moscow, 121352, Russia, with a reference mark «XIII Conference».

The application should include the following information: full name of the participant, academic degree; job title and current position, address, contact phone, fax, and e-mail address, title of the presentation.

Abstracts should be in Microsoft Word, Times New Roman, 12 pt, and should not exceed 600 words.

The deadline for submitting application forms and abstracts is March 1, 2008.

The accepted abstracts will be published by the opening of the Conference. After the Conference, full versions of papers recommended by the Conference Organizing Committee will be published in the Conference Proceedings (in Russian) or in our journal, if submitted by the authors in accordance with the relevant requirements.

Dear collegues!

On April 20, 2007, in the wake of the International Scientific and Practical Conference on the issues of protection of population and territories from emergencies, the All-Russian Public Organization Russian Scientific Society for Risk Analysis held its Reporting and Election Conference. Delegates from regional branches and invited representatives from government agencies and scientific research organizations listened to and discussed the reports made by M.I. Faleev, President of the Russian Scientific Society for Risk Analysis, S.E. Shameshev, a member of the Auditing Committee, V.A. Akimov, a member of the Research Council, S.V. Strelko, Chairman of the Executive Committee, and A.A. Bykov, Editor-in-Chief of the "Issues of Risk Analysis" scientific journal.

The Conference approved the activities of the Society's executive bodies, passed a resolution and the **Declaration of the Russian Scientific Society for Risk Analysis "On the Value of Statistical Life".**

Acknowledging the significance of this recommendatory document for creation of a legal framework for regulation of individual and societal risks, we have made it the **main topic of the issue**. The Declaration, its explanatory note and selected materials of the Society's Conference are presented in the **Information Window.**

As it is not possible for us to publish the full texts of all contributed articles in the English version of the Journal, most of the articles fully published in the Russian version are herein presented only by abstracts. The subjects of the articles include the development of industrial safety certificates for hazardous facilities, quantitative assessment of ecological impacts of industrial pollution. In addition to it, the articles by specialists from the Typhoon Research and Production Association and the Kazan State University discuss problems in the field of hydrometeorological safety.

And finally, let me remind you that our journal is a subscription edition and it is not sold retail. If you wish to subscribe to the journal, please contact our editorial office at: E.Kostenko@dex.ru or csi2@mchs.gov.ru

Russian Scientific Society for Risk Analysis Reporting and Election Conference RESOLUTION (April 20, 2007)

Having listened to and discussed the reports of M.I. Faleev, President of the Russian Scientific Society for Risk Analysis, S.V. Strelko, Chairman of the Executive Committee, and S.E. Shameshev, a member of the Auditing Committee, the Conference acknowledges that certain efforts were made in the reporting period to ensure further development of the Society, accomplishment of its charter purposes and implementation of its priorities.

The scientists and engineers from the Society's regional branches have made certain contribution to implementation of the Society's policy, improvement of procedures for risk analysis and management, strengthening safety and security of population and territories.

At the same time, however, the Russian Scientific Society for Risk Analysis, as an all-Russian public organization, has not succeeded in forming its own impartial stand and attitude in relation to promotion of industrial safety via risk analysis and management. Insufficient efforts were made to consolidate the efforts of scientists and engineers of the Society's regional branches for developing risk criteria, efficiently contributing to the process of drafting technical regulations, creation and development of a system of technical regulation, standard methods for risk assessment, development of legal framework, requirements and indicators related to risks, processes and phenomena.

There is still no system of material, technical and financial support of the Society's activities.

Cooperation of the Russian Scientific Society for Risk Analysis with expert organizations and insurance companies on the issues of methodological support of risk analysis and management remains unsatisfactorily low.

The Conference resolves as follows:

1. To approve the work of the Presidium, Executive Committee and Research Council of the Russian Scientific Society for Risk Analysis as satisfactory;

2. To approve the report of the Auditing Committee;

3. To adopt the draft Declaration of the Russian Scientific Society for Risk Analysis "On the Value of Statistical Life" (annexed) and to request both the Executive Committee and the Research Council to bring the Declaration, in three months' time, to the attention of the concerned ministries, governmental agencies and the public at large.

4. In 2007—2009, the priority areas for the activities of the All-Russian Public Organization Russian Scientific Society for Risk Analysis shall be as follows:

• enhancing the efforts of the Presidium, Research Council, and Executive Committee for promoting closer cooperation of scientists, engineers, representatives of industry, government agencies and the public for implementation of national policies in the field of technical regulation, standardization of risk levels, and safety promotion via economic mechanisms;

• promoting practical application of the Society's Declarations "On Permissible Risk Levels" and "On the Value of Statistical Life";

• enhancing the efforts of regional branches in tackling their tasks and performing their charter activities;

• participation in the development and monitoring of federal and regional research programs in the field of risk analysis and management;

• further efforts to create a training system for specialists in risk analysis and management;

• organization of scientific and practical workshops and conferences on the problems of risk analysis and management;

• generalization of risk regulation experience, including expert examination and auditing.

• information and publishing activities;

• cooperation with international organizations.

5. To ensure a successful implementation of the policies of the All-Russian Public Organization Russian Scientific Society for Risk Analysis, the following shall be done:

5.1. The Executive Committee together with the Research Council are instructed to work out, in the 3rd quarter of 2007, an action plan for implementation of the Society's priorities for 2007—2009, including, among other things, organization and holding of international scientific and practical conferences, and submit the plan to the Presidium for approval;

• in 2007: to work out and implement a package of measures for preparation of draft basic risk indicators and a national standard on maximum permissible risk levels in the key spheres of life of society and the state, and to bring them before the Presidium of the Society in the 4th quarter of 2007;

• in the 1st six month of 2008: to work out, taking into account actual trends in safety audit, and bring before the Presidium proposals on creating a system of voluntary certification in the field of public safety and territorial security in the Russian Federation.

5.2. The Executive Committee is instructed as follows:

• in 2007—2008: to develop and implement a system of material, technical, financial and information support for the activities of the Society regional branches and central bodies;

• in the 2nd quarter of 2008: jointly with the Research Council and the Editorial Board of the journal "Issues of Risk Analysis", to prepare and submit to the Presidium a proposal on stimulation of the work of the Society's regional branches and members, improvement of the Society's web-site design and contents;

• in the reporting period: to review the membership composition of regional branches, develop a databank of researchers and engineers engaged in risk analysis and management in different spheres of life of society and the state; report at the next conference of the Society the findings of the review and proposals for a more efficient application of their skills and knowledge.

5.3. The Research Council is instructed as follows:

• in order to enhance the Society's coordinating role, to plan and organize in the reporting period efforts for systematization and accounting of the activities of regional researchers and engineers in the field of risk analysis and management, harmonization of the activities with those of leading research teams and the International Society for Risk Analysis;

• to develop and implement in the reporting period a system for collection, generalization and communication of best practices in the field of risk research, organization of R&D efforts for risk analysis and management, risk regulation;

• it is recommended that the expediency should be discussed of the establishment of risk analysis and management sections for key areas of public and individual safety and security.

5.4. The Editorial Board of the journal «Issues of Risk Analysis», jointly with the Executive Committee, are instructed as follows:

• to work out proposals for the Presidium concerning further funding of the Journal;

• to ensure that both Russian and English electronic versions of the Journal be available on the web-site of the Society;

• to work out proposals for the Presidium concerning practical steps for including the journal "Issues of Risk Analysis" into the "List of Leading Peer-Reviewed Journals and Publications Issued in the Russian Federation", in which the main scientific findings of dissertations for the scientific degrees of doctor and candidate of sciences must be published.

Russian Scientific Society for Risk Analysis Declaration on the Value of Statistical Life

1. As shown by international and domestic experience, informed decision-making in the field of ensuring the safety and security of population, state, and environment can be best achieved through the use of normative economic models of risk management. Risk is understood as a measure of occurrence of events entailing damage to the population, environment and/or economy.

2. In its "Declaration on Permissible Risk Levels", the Russian Scientific Society for Risk Analysis (hereinafter referred to as The Society), in pursuit of its purpose of preparing well-founded proposals in the field of ensuring the safety of population, man-made and natural environments, has worked out recommendations for defining maximum permissible levels of individual and social risks, which levels would limit hazardous impacts on man, technical objects and environment and set the range of acceptable values. As a further step in this direction, the Society claims that it is necessary to introduce normative standards for the monetary value of statistical life, an economic parameter that would regulate risk level within the range of acceptable values.

3. Providing for an appropriate level of safety is directly connected with establishing maximum permissible risk levels, or risk standards, as well as with setting and attaining acceptable risk targets. Specific target values depend on the country's level of social, economic, and technological development, as well as other factors, and are largely achieved via consideration and proper estimation of the value of statistical life.

4. In normative economic models of risk management, the monetary value of statistical life is used for the following purposes:

4.1. calculation of damage due to loss of human life (permanent losses) in emergency situations;

4.2. calculation of damage prevented due to a reduction of expected number of deaths as a result of a better population safety organization and technologies, as well as implementation of preventive measures for risk reduction;

4.3. optimization of risk reduction and emergency mitigation arrangements and related costs as an integrated part of strategies and/or programs of social and economic development at regional and national levels;

4.4. to determine social or corporate compensations to families of those killed in emergencies;

4.5. to determine insurance compensations payable in public and private sectors of life insurance (accident insurance) for occupational activities as specified by the law of the Russian Federation.

5. The said standards are based on the level of social and economic development of the Russian Federation and on current international practice and vary depending on purposes stated in item 4. The standards suggested by the Society are voluntary, purpose-oriented and reflect the specifics and nature of hazard.

6. For purposes stated in items 4.1—4.3, a reasonable range of the monetized value of statistical life in today's Russia is 15 to 110 mln rubles. The Society's recommendation is **30—40 mln rubles.** For purposes stated in items 4.4—4.5, a reasonable range of the monetary value of statistical life in today's Russia is 1.5 to 15 mln rubles. The Society's recommendation is **7—10 mln rubles.**

On Methodology for Economic Valuation of Statistical Life (Explanatory Note)

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Abstract
The paper describes approaches and methods for determining the value of statistical life (VoSL). As shown in the paper, the key methods for VoSL assessment make use of the williness-to-pay approach, which follows from the general economic theory of value. The paper provides an overview of VoSL estimates obtained by Russian and foreign authors using utility theory, actuarial approach, international comparison, socio-economic surveys of customer preferences and studies of wage-risk tradeoffs in labor markets. Based on the performed analysis, VoSL point estimates and variation ranges are proposed, which can be recommended for use in Russia for the following purposes: calculation of damage from loss of human life (permanent losses) in emergency situations; calculation of damage prevented owing to reduction of the expected number of deaths through improvement of public safety, as well as implementation preventive risk-reducing measures; optimization of risk reduction and emergency mitigation activities and related costs as an integrated part of strategies and/or programs of socio-economic development at regional and national levels; to determine the size of government or corporate payments to families of those killed in emergencies; to determine the amount of insurance compensation in the public and private sectors of life insurance (accident insurance) for occupational activities specified by the law of the Russian Federation.

Key words:
individual, collective, population risk, damage in natural terms, risk assessment and evaluation, value of statistical life, risk cost, utility theory, actuarial mathematics, theory of value, socioeconomic damage, willingness-to-pay.

Contents

Introduction

Since 1980s, risk analysis has been the theoretic framework for public policies in the area of industrial and environmental safety, emergency risk management in many countries worldwide. A review of international and domestic experience in the field of life-saving activities clearly shows that risk analysis methodology is apparently the most reliable analytical tool for scientifically based estimation of risks to human health and life. Risk estimates allow ranking of risk sources and factors according to their significance and thereby setting risk management priorities, areas of cost-effective activities for risk level optimization and search for the ways of risk minimization [1—6]. Risk analysis methods can also help to determine reasonable compensations to families of those killed in emergency situations.

Economic assessment of risks to human health and life is one of the most important and controversial issues in many studies devoted to risk and damage assessment. The issue is undoubtedly of great interest since the cost of risk to health and life is often quite high compared with those of other risks. For instance, studies of the consequences associated with the operation of coal power stations in European countries [7] and Russia [8, 9] showed that over 90% of those consequences that are assessable in economic indicators are threats to human health.

One of the central problems in the economic optimization of risk is certainly the task of economic assessment of health and life risks associated with accidental exposure of a population to industrial hazards, as well as with chronic exposure to a polluted environment. The Rosgortehnadzor inspection agency issued practical guidelines for risk analysis of hazardous industrial facilities [10], wherein it is stated that a statistically expected monetary or physical is an important characteristic of risk for regulatory purposes in the fields of industrial safety and insurance.

This paper deals with approaches and methods used for placing a monetary value on a statistical life (value of statistical life, VoSL).

1. The Concept of Socio–Economic Damage

The value of statistical life is the basis of the concept of socio-economic damage from loss of health and life in a population exposed to accidental or routine environmental pollution. The concept assumes a linear relationship between physical indicators (collective or population mortality risk R, physical damage here is understood as the total number of lost years of life expectancy G by a population at risk) and socio-economic damage Y accounting for economic losses due to an adverse impact on the population health (Fig.1). In other words, according to the concept,

$$Y = \alpha \cdot R,$$

where the proportionality factor α is the cost of risk to life measured in monetary units (RUR, USD, EUR) per extra death, or

$$Y = \beta \cdot G,$$

where the proportionality factor β is the cost of physical damage to life (lost years of life expectancy) measured in monetary units (RUR, USD, EUR) per lost year of life expectancy.

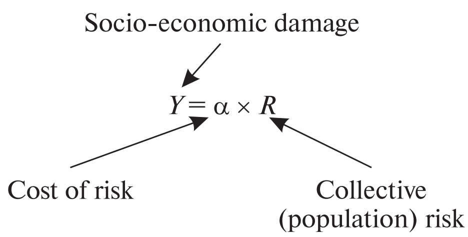

Fig. 1. Concept of socio-economic damage

The cost of risk to a human life should not be equaled to the value (or price) of an identified life. Rather than that, the VoSL is the cost of risk to life. Specifically, the economic value of a health or life risk reflects, among other things, the societal willingness to pay for avoiding the risk, or the willingness to compensate for voluntary acceptance of (exposure to) risk. The cost of risk to health or life is not equivalent to the cost of an identified life or damage from the death of a specific person, but rather it is the risk cost, which is divided among all members of the exposed population. This value is based on a collective exposure to risk, without identifying the persons who may die. It would be therefore more appropriate to use the term ‘the value of statistical life’ (VoSL).

As an illustration of the above said, Fig. 2 shows a qualitative dependence of the price of individual risk cost on the extent of individual risk.

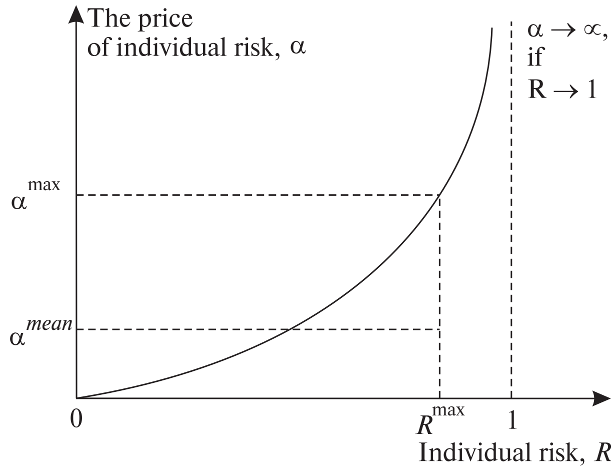

Fig. 2. A graphic illustration of difference between the price of risk and the price of life

The price of risk is the averaged α^{mean}

$$\alpha^{mean} = \frac{\int_0^{R_{max}} \alpha(R)dR}{R^{max}},$$

or the maximum α^{max} cost of a risk unit, where the individual risk R varies in the range of 0 to R^{max}.

The price of an identified life can be determined by passing to the limit:

$$R \to 1.$$

In this case, as evident from Fig. 2,

$$\alpha \to \infty.$$

Same as with other risks, the cost an individual assigns to a risk to life depends on the likelihood of occurrence and the extent of expected damage (consequences).

The economic assessment of risk to life (health) implies converting assessments expressed in physical units into monetary ones. Exposure-related health damage can be measured by the sum of money the society is willing to pay to avoid or prevent the exposure. Such evaluations are based on the economic theory of value. The basic approach to determining the economic significance of consequences to life/health implies the construction of ‘market-nonmarket benefits’ indifference curves, e.g. ‘market consumer benefits — safety level (quality of the environment)’. Fig. 3 presents indifference curves for 'market—nonmarket' goods. If a socio-economic system is at point (1) on the indifference curve, then a transition to point (2) on the curve would mean an increase of nonmarket benefits ΔN_b (a better environment, health status, safety, etc.) along with a certain decrease in market benefits ΔM_b. Therefore, the desire to improve the environment, safety, or to reduce risks must come along with the society's willingness to trade off a part of its market benefits, i.e. the willingness to pay. Fig. 3 also shows that, with the development of economy, the indifference curves tend to shift upwards and rightwards, which means that both sets of benefits, market and nonmarket, increase.

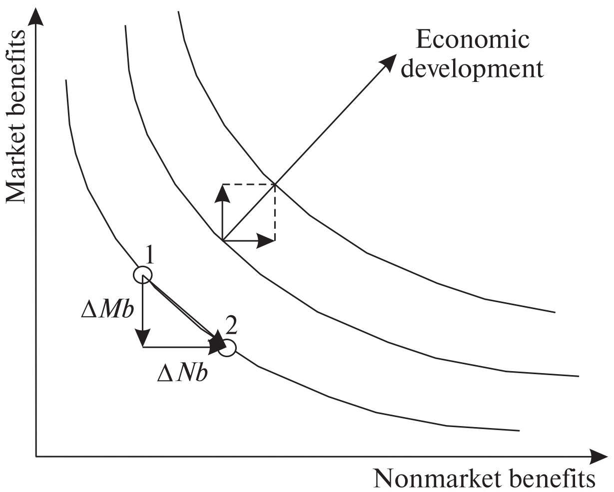

Fig. 3. Indifference curves for 'market-nonmarket' benefits

Customers (or population) have sets of preferences both for market and nonmarket goods and benefits (e.g., the quality of environment or the level of safety or risk). If so, then it is possible to assess, how individuals value the quality of environment, their own health and life in relation to other goods, i.e. by finding out the amount of other goods they are willing to trade off in return for a better health. Expressing these goods in monetary terms is the most adequate way to assess the willingness of people to trade off alternative desirables, and the concept of socio-economic damage is actually based on the assessment of the society's attitude toward accidental industrial impacts or routine environmental pollution and implicitly reflects the societal willingness to pay for the quality of health and environment.

The theory of user value and the ensuing 'willingness to pay' methods for the assessment of socio-economic damage to health and life allow easing the implicit conflict of interests between the social group that takes on additional risks and the one that benefits from the produced goods, because the large beneficiary social groups are implicitly willing to 'share' some part of the benefits with the smaller groups that have to bear higher risks [4, 11].

2. Basic Approaches to Valuation of Statistical Life

According to the theory of user value, the 'willingness to pay' methods are the key ones for the assessment of cost of risk to life (health). The willingness to pay (WTP) can be estimated in several ways. In a general case, a **socio-economic survey** should be conducted to identify and measure various preferences. When such survey is focused on a hypothetical improvement of health, the economic measure is defined as the sum of individual WTPs for a given improvement. Assuming that individuals use market and nonmarket benefits, the WTP would be an appropriate assessment of the individual desire or willingness to exchange benefits. It is however problematic to properly design, conduct and analyze such surveys.

Therefore, the cost of risk to life or health is often evaluated using approximate methods, of which those based on labor market studies are apparently most close to the 'willingness to pay' philosophy [12].

2.1. Valuation of Statistical Life Based on Labor Market Studies

This approach, though approximate, is simpler than socio-economic surveys of the WTP and, as one will see from the data review in the next section, the resulting cost-of-risk estimates, if properly adjusted, are very similar to those obtained in socio-economic surveys/исследованиях.

In a labor market study (Fig. 4), statistical techniques are applied to determine the differences in wages and fatality risks in an industrial or commercial sector associated with higher risks. The approach is based on the theoretical assumption that, in a competitive labor market, workers engaged in industrial activities associated with increased risk $+\Delta R$, would receive extra pay (premium) $+\Delta B$ for risk. This extra pay is equal to the part of income $-\Delta B$, which they could trade off in return for the risk reduction $-\Delta R$, although, as illustrated by Fig. 4, this assumption is not quite correct in a general case.

We will denote the thus estimated value α of α_c

$$\alpha_c \approx \frac{+\Delta B}{+\Delta R}.$$

For Russia, a labor market study-based estimate [6] of the cost of physical damage such as reduced life expectancy is about 45,000 USD per lost year of life expectancy, the variation range being very broad: from 1 thousand USD to 500 thousand USD per lost year of life expectancy.

From the point of view of risk perception (the extent of risk aversion), the worker cohort under study does not adequately represent the entire exposed population; hence the estimate should be adjusted to account for:

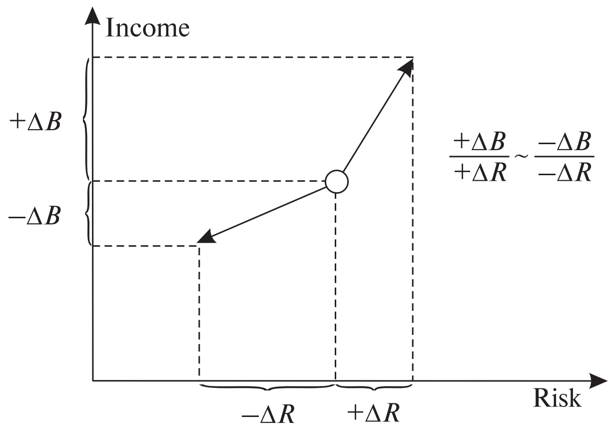

Fig. 4. Estimation of the cost of risk to life based on labor market studies

(1) age-specific differences in attitude toward risk: e.g., elder people show a greater risk aversion; in the 'wages-risks' studies, workers are younger and generally less risk aversive than the general population; having less years of life to lose, elderly people are less willing to pay, which is untypical of risk aversion behavior;

(2) the influence of income on the willingness to pay;

(3) the fact that the general population is more aversive of risk;

(4) the fact that job-related risks are taken on voluntarily, whereas pollution-related risks are imposed. Thus, riskier jobs attract 'risk-tolerant' people and the extra pay for risk is set at that lowest possible level, which allows attracting enough labor.

Taking into account the above mentioned factors, the results obtained for a limited cohort of workers were adjusted for the general population. As a result of the adjustment, the cost of a lost year of life expectancy for the general population was calculated to be ≤135,000 USD [6]

With the assumption that one additional death is approximately equivalent to a loss of 30 years of life expectancy, the cost of physical damage can be converted into the cost of risk (value of statistical life) with the following result:

$$\alpha_c \leq \textit{4 million USD} \approx \textbf{105 million rubles}$$
per additional life lost.

Table 1

A review of VoSL estimates from different studies

	Author, year of publication	*Assessment methods, source of information*	*Average risk*	*Annual income, USD (1990)*	*VoSL, million USD*
1	Smith [18], (1976)	USA census data: occupation and wages	n.a.	22640	7.2
2	Smith [19], (1976)	Current review, 1967, 1973. USA statistics.	0.0001	n.a.	4.6
3	Viscusi [20], (1978)	A review of labor conditions. USA statistics for 1969—1970.	0.0001	24800	4.1
4	Marin and Psacharopoulos [21], (1982)	Analysis of occupational mortality in Great Britain. Data from Census 1977	0.0001	11300	2.8
5	Dillingham [22], (1985)	A review of labor force quality. USA statistics for 1982	0.00008 0.00014	20800	2.5—5.3 0.9
6	Moore and Viscusi [23], (1988)	A study of income behavior. USA statistics for 1982	0.00005 0.00008	19400	2.5 7.3
7	Moore and Viscusi [24], (1988)	A review of labor force quality. USA statistics for 1977 г. Discounting	0.00006	24200	7.3
8	Moore and Viscusi [25], (1989)	Income behavior. USA statistics for 1982. Markov's structured model was used.	0.0001	19200	7.8
9	Moore and Viscusi [26], (1990)	A study of income behavior. USA statistics for 1982. The use of a structured life cycle model.	0.0001	19200	16.2
10	Kniesner and Leeth [27], (1991)	Annual data book, Japan, 1986	0.00003	40000	7.6
		Australian data on industrial accidents in 1984-1985.	0.0001	18200	3.3
11	Blomquist [28], (1979)	The use of safety belts to reduce the risk of accidental mortality in a car crash, 1972	n.a.	29800	1.2
12	Atkinson and Halvorsen [29], (1990)	Choosing between the risk of a motor vehicle accident and the cost to avoid it, 1986	n.a.	n.a.	4.0

	Author, year of publication	Assessment methods, source of information	Average risk	Annual income, USD (1990)	VoSL, million USD
13	Gerking, de Haan and Schulze [30], (1988)	1984 survey in the USA to assess the willingness to pay for a reduction of occupational risk (WP), willingness to take on extra risk in return for a compensation (WC)	n.a.	n.a.	3.4 (WP) 8.8 (WC)
14	Jones-Lee [31], (1989)	1982 Census, Great Britain. Willingness to pay to reduce the risk of a motor vehicle accident	n.a.	n.a.	3.8
15	Viscusi, Magat, and Huber [32], (1991)	1987 Census, USA. Willingness to pay to reduce the risk of a motor vehicle accident	n.a.	43800	2.7 (median) 9.7 (mean)

Note: n.a. — data not available

2.2. A Review of Foreign VoSL Estimates

For developed economies, the most reasonable estimates of the value of statistical life $\alpha \cong \alpha_c$ based on socio-economic or labor market studies fall within the range of 3—7 million USD. The mean point estimate of 4.8 million USD (variation range: 0.6—13.5 million USD) was obtained based on the review of more than 25 studies, five of which were contingent valuation surveys, in which people were asked direct questions concerning their willingness to pay, while the rest were 'wage—risk' correlation studies, in which the willingness to pay was assessed based on labor market studies measuring extra pay offered for a riskier job on labor market (See [12] and references therein).

The results of other studies valuating statistical life in developed economies are discussed in publications [5, 8, 9, 13—17] and their estimates of the value of statistical life $\alpha \equiv VoSL$ range within 0.9—6.2 million USD, with the mean estimate being:

$$VoSL = 5.4 \text{ million USD.}$$

Some estimates are given in Table 1, which also presents the respective values of the risk of death and average incomes of surveyed groups [9].

Interestingly, the mean VoSL estimate obtained with survey-based methods was α_c = 5.7 million USD (variation range: 2.7—9.7 million USD), while the mean VoSL based on the other evaluation methods was α = 5.3 million USD (variation range: 0.9—16.2 million USD).

The very broad variation of $\alpha \equiv$ VoSL estimates obtained by different authors reflects, in the first place, a number of methodological problems. For instance, underestimations may be due to the fact that riskier jobs are chosen by people who tend to be less sensitive to risk. Some of them may even enjoy additional risk. Therefore, lower premiums are required to urge such people to accept these riskier jobs, hence — lower cost-of-risk estimates.

On the other hand, there are other important factors behind higher-than-average payment for labor. Market leaders usually pay higher wages even for less riskier jobs. This can result in overestimation of the VoSL.

On the whole, taking account of the VoSL estimates presented in the previous section, the value of a statistical life lies within the following range:

$$0.3 \text{ million USD} \le VoSL \le 16.2 \text{ million USD.}$$

2.3. Valuation of Statistical Life Based on International Comparison

In 2005, the Working Group of the Risk Assessment Task Force under the Interagency Scientific Council for Human Ecology and Environmental Health of the Russian Academy of Medical Sciences and the RF Health Ministry developed draft guidelines for economic assessment of health damage from exposure to environmental factors. The guidelines recommend specific (reference) values of economic damage z from the impacts of environmental factors, including natural and technological emergencies, on the health of the population.

The proposed methodology is based on the idea of drawing on the U.S. and EC experience by those countries (Russia among them) that still have no nationally established specific (reference) values of economic damage z (this indicator is in some cases equivalent to the VoSL). It has been suggested that these values should be selected based on relevant EC recommendations and adjusted using a correction factor, the latter being the ratio of the GNPs[1] per capita. This means that z, which is used e.g. in the EC, should be multiplied by the ratio:

[1] ***For reference.*** Gross national product (GNP) is the total value of all final goods and services produced by a country's residents both on its territory and abroad. GDP includes only those goods that have been produced in a given accounting period. The secondary merchandise market (e.g. second-hand car sale) is not included into GDP. GDP was considered as the main national macroeconomic indicator until 1990s, when it was recognized that the state of the economy of a country is more accurately reflected by the behavior of its Gross Domestic Product (GDP). Since 1991, GDP has been the main indicator in the UN System of National Accounts.

x = GNP per capita (a given country) / GNP per capita (EC).

The authors believe that it would be quite reasonable to use such approach in Russia, at least those health effects that are difficult to assess economically based on currently available data.

In the USA and the EC, the following estimates of the value of statistical life are used in risk analysis: 4.8 million USD (recommended by the U.S. Environment Protection Agency) [33] and 3.1 million EUR (EU Project ExternE) [34]. Table 2 presents selected reference values of economic damage z for Russia, EC and USA. The recommended z values for Russia were proposed by the authors of the above mentioned guidelines. It is, however, unclear how the values were obtained because the guidelines do not state the values of GNP or GDP per capita (European, American, and Russian) that were used in the calculations. If the reference value was the European or American GDP per capita, it is still unclear why this ratio is 10 or more for an accidental death and 4—5 for life expectancy lost as a result of death.

But the **major methodological mistake** was that these international comparisons were not based on GDPs expressed in terms of purchasing power parity (PPP). In economics, the purchasing power parity theory is based on the law of one price for international markets: the purchasing power of a certain amount of money in one market must be equal to its purchasing power in the market of another country, if converted into the currency of this other country using the current exchange rate. Purchasing power parity may also imply a fictitious rate of exchange of two or more currencies that has been calculated based on their purchasing powers relating to certain baskets of goods and services.

In their publications, various international organizations such as the World Bank and Eurostat express the economic indicators of various countries in one currency (mostly in USD) and use PPP-adjusted exchange rates. Here are examples of GDPs per capita adjusted for PPP and expressed in USD (as of 2005):

- Maximum: Luxemburg — 69,800 USD;
- Minimum: East Timor — 400 USD;
- World's average: 8,800 USD;
- World's total amount: 55.5 billion USD[2].

Table 3 ranks a sample of countries according to their GDPs per capita (USD, PPP) in 2005[3]. Russia occupies the 62nd position in this list, next to such countries as Botswana, Malaysia and Costa Rica. In 2005, Russia's GDP (PPP-adjusted) per capita was just over 11,000 that is about a quarter of that of the USA, and about one sixth of that of Luxemburg.

Thus, if the EPA-recommended VoSL = 4.8 million USD [33] is taken and the reference standard and adjusted for Russia by the formula:

$$VoSL_{Russia} = VoSL_{USA} \times (GDP_{PPP,\ Russia} / GDP_{PPP,\ USA}),$$

then

$$VoSL_{Russia} = 4.8 \text{ million USD} \times (11.041 / 41.399) = \mathbf{1.28 \text{ million USD} \sim 36.843 \text{ million RUR.}}$$ [4]

If the foreign data-based mean VoSL estimate of 5.4 million USD is taken as the reference value, then

$$VoSL_{Russia} = 5.4 \text{ million USD} \times (11.041 / 41.399) = \mathbf{1.44 \text{ million USD} \sim 41.448 \text{ million RUR.}}$$

The data presented in this section are summarized in Table 4. The estimates obtained for Russia based on different recommended reference VoSLs fall within the range of 10 to 100 million RUR. The last line of Table 4 presents the recommended value of statistical life: ***~40 million RUR***. It is close to the GDP_{PPP}-based adjustment of the U.S. EPA-recommended VoSL or that of the foreign data-based mean VoSL and is less than the mean (across approaches and recommended values) estimate (***~50 million RUR***) of the VoSLs presented for Russia in Table 4.

Table 2

Selected specific (reference) values of economic damage *z* for Russia (recommended by the Risk Assessment Task Force Working Group under the RAMSc[5] and RF Health Ministry Interagency Scientific Council for Human Ecology and Environmental Health) and other countries (EU and USA) (in RUR, EUR, USD; the currency exchange rate as of November 2005)

Type of damage caused by health impact	*Unit measure*	*Z*		
		RF million RUR / thousand EUR	*EC, thousand EUR*	*USA (EPA), thousand USD*
Life expectancy lost as a result of death	1 person-year	0.6 / 17	73	80
Accidental death	1 case	11 / 315	3100	4800

[2] See: Purchasing power parity. ruWiki.com russian encyclopedia (in Russian).
[3] See: GDP per capita. ruWiki.com russian encyclopedia (in Russian).
[4] The official exchange rate as of the end of period (2005) was 28.78 RUR for 1 USD [*Source: Federal Department of Government Statistics, the Bank of Russia.*]
[5] Russian Academy of Medical Sciences.

Table 3

Countries ranking by GDP per capita, adjusted for purchasing power parity (estimated in 2005)

Place	*Country*	*GDP per capita, thousand USD*
1	Luxemburg	69.800
2	Norway	42.364
3	USA	41.399
4	Ireland	40.610
5	Iceland	35.586
6	Denmark	34.737
7	Canada	34.273
8	Austria	33.615
...		
31	Slovenia	21.911
...		
38	Czech Republic	18.375
39	Barbados	17.610
40	Hungary	17.405
41	Oman	16.862
42	Equatorial Guinea	16.507
43	Estonia	16.414
...		
49	Lithuania	14.158
50	Argentina	14.109
51	Poland	12.994
...		
60	Botswana	11.410
61	Malaysia	11.201
62	Russia	11.041
63	Costa Rica	10.434
...	World's average	8.800
78	Belarus	7.711
79	Maldives	7.675
80	Republic of Macedonia	7.645
...		
83	Panama	7.283
84	People's Republic of China	7.204
85	Dominican Republic	7.203
86	Algeria	7.189
87	Ukraine	7.156
88	Namibia	7.101

It is recommended that this VoSL estimate (up to 40 million RUR) should be used for the following purposes: design estimation of damage from loss of human life in emergency situations of natural and technological origin; design estimation of averted damage associated with reduction of expected mortality through improvements to public safety, as well as implementation of preventive measures for risk reduction; optimization of risk reduction and emergency mitigation measures and their costs as an integral part of strategies and/or programs for socio-economic regional and national development.

However, it is not recommended that this value be used when setting death compensations to families of those killed in certain emergency situations. For these purposes, the VoSL should be evaluated using other approaches as described in the next section. It is important to note that, according to the ideology of other approximate methods, the VoSL may generally depend on many parameters including age, sex, professional education and skills, etc.

3. Other Approaches to Economic Evaluation of Statistical Life

3.1. Valuation of Statistical Life Based on Utility Theory

If an impact on health results in death it is necessary to assess the economic ***damage from premature death***. For this purpose, the following approaches are most frequently used [4—6, 35, 36].

The first approach rests upon the theory of utility, i.e. a certain utility function is defined to describe the economic or social utility of an individual to society. A premature death would mean the loss of social utility associated with the individual. Then, the related socio-economic damage equals to the lost utility expressed in economic terms. Within this approach, there are great uncertainties as to the grounds for selection of a function describing the social utility of an individual.

A) For example, it is often assumed (explicitly or implicitly) that the social utility of individual can be measured using annual per capita income of the population. In this case, a ***hypothesis*** is assumed that for society ***the economic utility of individual is equal to his/her income***. With this approach, annual average income per capita is the measure of the social utility of a statistical individual.

Table 5 presents reference statistical data according to [37].

In 2006 (see Table 5), the monthly average per capita money income of the population was 9911 rubles, or 118,932 rubles per year. Assuming that the overall average remaining life expectancy is 30 years and that the average per capita income I_{aver} and the discount rate E remain unchanged during this period, one may approximately assess the economic utility (EU) of a statistical individual as the total amount of current (discounted) per capita income over the remaining life expectancy by the formula:

Table 4

A summary of VoSLs obtained by methods described in this section

Valuation approach or VoSL recommended by organization	*Value of statistical life*	
'Willingness-to-pay' methods (foreign data)	***~ 5.4 million USD***	
Recommended by European Commission	***3.1 million EUR***	
Recommended by U.S. EPA	***4.8 million USD***	
'Willingness-to-pay' methods (Russia)	***Up to 4 million USD (Russia)***	***~ 105 million RUR***
GDP_{PPP}-based adjustment of the U.S. EPA recommended VoSL	***~1.3 million USD***	***~38 million RUR***
GDP_{PPP}-based adjustment of the foreign data-based mean VoSL	***~1.5 million USD***	***~ 42 million RUR***
Proposed by the RAMS-RF Health Ministry Interagency Scientific Council	***315 thousand EUR (Russia)***	***11 million RUR***
With provision for uncertainties	***0.3 ÷ 4 million USD***	***10 ÷ 110 million RUR***
Mean	***~1.9 million USD***	***~50 million RUR***
Recommended value	**1.3 million USD**	**40 million RUR**

Table 5

Key indicators of living standards[1)]

	2006	*% to 2005*	*December 2006*	*% to*		*For reference*		
				Decem-ber 2005	*Novem-ber 2006*	*2005, as % to 2004*	*December 2005, % to*	
							Decem-ber 2004	*Novem-ber 2005*
Money income (average, per capita), RUR	9911	123.5	14757	120.5	143.5	125.2	130.4	143.6
Real disposable money income		110.0		109.0	143.7	111.1	117.7	142.0
Gross monthly average wage per worker:								
nominal, RUR	10736	124.5	14354	125.8	127.0	126.9	127.5	126.7
real		113.5		115.4	126.0	112.6	114.9	125.7

[1)] *Preliminary data for 2006 and December 2006.*

$$\boldsymbol{VoSL} \equiv EU = I_{aver}\int_0^{30}\exp(-Et)dt \approx I_{aver}/E \approx$$

$$\approx \mathbf{1.5\ million\ RUR} \sim \textit{56.5 thousand USD}^{6}.$$

The discount rate E can be found based on the actual bank interest rate per annum as follows:

$$E = \ln(1+i).$$

The discount rate taken as 0.08 year^{-1}.

B) The economic utility of individual can also be assessed based on gross domestic product per capita. It is assumed that a premature death causes an economic damage equal to the current (discounted) GDP per capita over the remaining life expectancy of a statistical individual (or a certain part of this GDP).

Table 6 presents statistical data on nominal volume of used GDP [37].

According to these data, a preliminary estimate of Russia's GDP in 2006 was 26,621.3 billion RUR in current prices. According to the same source [37], the resident population of the Russian Federation as of December 1, 2006, was 142.2 million. Therefore, GDP per capita in 2006 was about 187,210 RUR or ~ 7.11 thousand USD per year. With the assumption that the remaining life expectancy of a statistical individual is 30 years and that during this period the GDP per capita and discount rate E (taken as 0.08 year^{-1}) remain unchanged, one can evaluate a statistical life or the loss from a premature death by the formula:

$$VoSL = GDP_{per\ capita}\int_0^{30}\exp(-Et)dt \approx GDP_{per\ capita}/E \approx$$

$$\approx \mathbf{2.34\ million\ RUR} \sim \textit{88.877 thousand USD}$$

6 The official exchange rate as of the end of 2006 was 26.33 RUR for 1 USD [*Source: Federal Department of Government Statistics, the Bank of Russia.*]

Table 6

Nominal volume of used GDP (in current prices, billion RUR; before 1998 – trillion RUR)

	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006
Gross domestic product	1428.5	2007.8	2342.5	2629.6	4823.2	7305.6	8943.6	10817.5	13243.2	17048.1	21614.7	26621.3
including:												
Final consumption expenditures of	1016.6	1435.9	1776.1	2003.8	3285.7	4476.8	5886.8	7448.8	9024.7	11401.4	14360.4	17728.2
Households	719.8	1007.8	1235.2	1462.3	2526.2	3295.2	4318.1	5408.4	6540.1	8405.6	10625.8	12880.0
Public administration	272.5	391.4	493.5	492.6	703.2	1102.5	1469.9	1913.3	2330.6	2847.5	3598.3	4714.6
Non-profit organizations providing services to households	24.3	36.7	47.4	48.9	56.3	79.1	98.8	127.1	154.0	148.3	136.3	133.6
Gross savings	363.4	475.2	514.8	393.5	715.3	1365.7	1963.1	2170.5	2755.1	3559.0	4349.9	5415.6
Gross fixed capital formation[1)]	301.1	401.6	428.5	424.7	693.9	1232.0	1689.3	1938.8	2432.3	3130.5	3848.4	4795.4
Change to tangible current asset value	62.3	73.6	86.3	–31.2	21.4	133.7	273.8	231.7	322.8	428.5	501.5	620.2
Net export	48.5	84.8	51.6	175.4	822.2	1463.1	1133.7	1167.5	1502.0	2086.5	2931.9	3372.4
Export	418.4	523.5	579.3	821.0	2084.6	3218.9	3299.6	3813.7	4655.9	5860.4	7592.0	9019.1
Import	369.9	438.7	527.7	645.6	1262.4	1755.8	2165.9	2646.2	3153.9	3773.9	4660.1	5646.7
Statistical discrepancy	0.0	11.9	0.0	56.9	0.0	0.0	–40.0	30.7	–38.6	1.2	–27.5	105.1

[*] Including net acquisition of valuables.

As evident from the above approximate calculations, the utility theory-based VoSL lies within the range of **1.5÷2.5 million RUR,** or about ***50÷100 thousand USD***.

3.2. Valuation of Statistical Life Based on Actuarial Approach

Not questioning the conceptual appropriateness of the above described approaches for evaluation of the economic utility of a statistical person, it should be noted, however, that a more correct mathematical apparatus should be used that would take into account the time-of-death randomness. Calculations of this kind are widely used in actuarial mathematics (e.g., see [38]). For instance, it is rather easy to show that the economic utility of a statistical person of the age of x should be assessed with the use of periodic net rates of life-long insurance because actuarial computations of net premiums (in Russian insurance literature, it is defined as the basic component of net premium) are based on the 'principle of equivalence', i.e. the expected discounted total receipts and indemnities are set equal [39]. For example, the following formula can be readily obtained for the assessment of the VoSL:

$$VoSL = I / P_x^{(m)},$$

where I — monthly income (or GDP) per capita, $P_x^{(m)}$ — periodic (monthly: $m = 12$) net rate of life-long insurance of a statistical person of the age of x.

For example, according to [40], the monthly gross rate of life-long insurance is 0.318% for a 37-year old man (based on statistical data [41]) and 0.181% for a woman of the same age, with the arithmetic mean being 0.25% (though, of cause, it is more correct to use a gender-weighted average).

In their operations and actuarial computations, Russian insurers usually take the net rate as being ≤0.7 of the gross rate. Therefore, for approximate quantitative assessments it may be assumed that:

$$P_{37}^{(12)} \approx 1.75 \times 10^{-3}.$$

Thus, if I is

1) monthly income per capita (December 2006: 14,757 RUR, Table 4), then

$$VoSL = 14{,}757 / 1.75 \times 10^{-3} \approx \mathbf{8.433\ million\ RUR} \sim \mathbf{\mathit{320.265\ thousand\ USD}};$$

2) monthly GDP per capita (monthly average for the year of 2006: 15,601 RUR or 592.5 USD), then

$$VoSL = 15{,}601 / 1.75 \times 10^{-3} \approx \mathbf{8.915\ million\ RUR} \sim \mathbf{\mathit{338.582\ thousand\ USD}}.$$

As evident from the above approximate calculations, the VoSL estimate based on actuarial approach falls within the range of **8÷9 million RUR,** or about ***300÷350 thousand USD***. It should be noted that this estimate is about 4 times as high as those calculated by the above formulas that ignore the randomness of the time of death and are, therefore, not quite correct. Besides, to provide for multiple unaccounted factors of uncertainty, the estimated range should be apparently extended to ***200÷500 thousand USD***.

Table 6 summarizes data presented in this section. For Russia, the estimates settle within the range 1×10 million RUR. The last line of Table 7 states the recommended value of statistical life (**~8.7 million RUR)**, which is the averaged estimate obtained with the use of the actuarial approach, the most correct method. This estimate is above the mean VoSL estimate based on approaches presented in Table 7 (**~5.3 million RUR**).

The value of statistical life (~8.7 million RUR) can be recommended for use for the following purposes: setting the sums of public or corporate compensations to families of those who died in emergency situations; 2) setting insurance compensations in the system of public or private life insurance for occupational activities defined by the law of the Russian Federation.

The next section gives an idea of currently paid compensations.

4. The Practice of Paying Death Compensations to Beneficiaries

In case of certain major emergency situations arising from accidents, disasters, or acts of terrorism, the government and/or insurance companies (under compulsory insurance schemes) provide welfare payments and compensations. If people got killed is such emergencies, their beneficiaries are entitled to death compensations.

Information on actual compensations paid to victims of various accidents, disasters, acts of terrorism that took place in Russia in 1999—2001 can be found, among other sources, in [36] (Source: Kommersant-Daily, Moscow). The amount of compensation varied in a broad range of ***850÷47,600 USD***, being, on average, just above ***10,700 USD*** [36].

According to the law of the Russian Federation, certain occupations are subject to the so-called compulsory social insurance, in which case the compensations are paid from the state budget. These occupations include, in the first place, the military, the law enforcement personnel and other categories.

The insured amount was calculated by multiplication of the salary by 25 and taking into account of the number of beneficiaries, i.e. the family composition. The average insurance sum for military officers is about 200 thousand rubles. For reference, a U.S. soldier serving in Iraq is insured for ***250 thousand USD***.

Another example is the public prosecution personnel and legal investigators. If such employee dies in discharge of duty, his/her family will be paid an equivalent of his/her salary for 15 years of work, but no more than 4 million RUR. The employees of the Federal Revenue Service have lower salaries; hence their compensations are smaller, of about 1 million rubles.

Table 7

VoSL estimates based on approaches described in this section

Evaluation approach	*Value of statistical life*	
Utility theory (income per capita)	~ 60 thousand USD	~ 1.5 million RUR
Utility theory (GDP per capita)	~ 90 thousand USD.	~ 2.5 million RUR
Actuarial approach (income per capita)	~ 320 thousand USD	~ 8.5 million RUR
Actuarial approach (GDP per capita)	~ 340 thousand USD	~ 9 million RUR
Taking account of uncertainties	50÷500 thousand USD	1.3÷13 million RUR
Mean value	~200 thousand USD	~5.3 million RUR
Recommended value	~330 thousand USD	~8.7 million RUR

Table 8

Compensations to victims of major accidents, disasters, terrorist attacks in Russia in 1999—2001 [36]

Event	*Date*	*Number of fatalities*	*Amount of compensation, USD*
Sinking of Kursk submarine	12.08.00	118	28,600—47,600
Sibir airline Tupolev-154 crash over the Black sea	04.10.01	78	20,000
Methane explosions at the mines Zyrianovskaya and Barenzburg	01.12.97 18.09.97	67 23	11,800—15,200 15,000
Vladivostok-Avia Tupolev-154M crash over Irkutsk	03.07.01	145	2000—10,200
Act of terrorism at Dubrovka theatre (Source: Kommersant-Daily 11.06.2003.)	23-26.10.2002	129	about 3300
Acts of terrorism in residential buildings in Moscow	09.09.99, 13.09.99	about 300	3290
IRS Aero Ilyushin-18 crash near Kaliagin	19.11.01	25	1700
Act of terrorism on Pushkin Square, Moscow	08.08.00	13	1000
Storm in Moscow	24.07.01	5	850

For other occupations, such as fire fighters, miners, sailors, public sector employees, etc. there is no compulsory social insurance imposed by law. Yet, industrial (branch) regulations require insurance for such activities, though do not establish the specific insurance mechanism.

Therefore, it is not uncommon that the only source of insurance compensation for the death of an employee at work is the Social Insurance Fund (SIF), to which all employers are obliged to pay regular contributions.

The family of a person who died at work is entitled to a lump-sum payment. The amount of payment is defined by the law on the SIF budget for the relevant year. For 2007, it is set at 46.9 thousand rubles. The amount does not depend on the nature of production, salary of the deceased, or the form of enterprise ownership.

The lump-sum insurance benefit can be paid to any family member of the deceased. The dependents, including under-age children (children under 18 or, if full-time students, under 23 years of age), are entitled to monthly payments. Other dependents, including parents of the deceased, if their dependency proven in court, are entitled to lifetime monthly payments.

Monthly payments payable the dependents are calculated as follows:

The average wage of the deceased wage earner is equally divided by the number of dependents plus the wage earner. For instance, if a wage earner had three dependents and earned 10 thousand rubles per month, then 10000/4=2500 rubles.

If a person dies on his way from/to the job or (e.g. in transport) в транспорте, the family will not be entitled to any payments from the SIF because such cases are not covered by the compulsory insurance against occupational accidents.

Compulsory life insurance of air passengers is stipulated by the RF Air Code. For flights within the country, the amount of compulsory insurance payment is 1000 minimum monthly wages. However, the regional authorities, the air company involved or the government may make specific decisions on each case. The relatives of the deceased have the right to refer to the court. At its recent board meeting, the RF Ministry of Transport suggested that the compensation be increased up to 75 thousand USD per victim. The UTair airline demonstrated its goodwill and guaranteed payment of 75 thousand USD to families of air passengers killed in the crash at the Samara airport on March 17, 2007. For international flights, the amount of payment is 20 thousand USD, as specified by the Warsaw Convention. There is also the Montreal Convention, which provides for payments larger by an order of magnitude, but Russia has not yet ratified the convention. The victims/ beneficiaries receive compensation in accordance with the RF Civil Code, based on wages, medical costs.

At the end of 2003, by agreement with the Russian government, Ukraine paid to families of Russian citizens killed in the crash of the Tupolev-154 hit by a Ukrainian missile the same compensations as it did to Israeli citizens under the relevant Israel-Ukraine agreement, i.e. ***200 thousand USD*** per victim.

In the USA ([36], source: Kommersant-Daily), the average amount of compensation to families of victims is ***1 million USD*** for judicial cases and ***415 thousand USD*** for extrajudicial cases. Quite large sums of money per victim (***1.85 million USD***) were paid to families of those killed in the Pan Am plane crash over Lockerby in 1988. In some cases, the compensation reached ***10 million USD*** per family. Families of those killed in the act of terrorism on September 11, 2001, received ***250 thousand to 7 million USD***, with the average government compensation per victim being **1.5 million USD**.

Voluntary life insurance is a common practice abroad. People may insure themselves or get insured by their employers. There are also mixed forms of insurance, where employers pay a part of insurance contributions for their employees. In return, the government gives the employers certain tax benefits. In this case, the size of compensation for death or loss of labor capacity is not limited. It may well be 10 million USD if the employer or the employee is willing to pay the required insurance premium. As to death compensations paid by Russian insurance companies, their amounts are limited by the resources of Russian insurers. On the whole, the sum of voluntary life insurance varies in a broad range of ***1 thousand — 5 million USD*** both in Russia and abroad.

Conclusion. Current Recommendations on VoSL Estimates for Use in Russia

Based on the review of different approaches to valuation of statistical life and respective VoSL estimates, and taking into account the relatively lower per capita income in Russia as compared with better-off countries and hence a significantly lower willingness of the Russian population to exchange market goods for non-market ones, it is recommended that for the purposes of design estimation of damage from loss of human life (permanent loss) in emergency situations, design estimation of averted damage associated with reduction of expected mortality through improvements to public safety, as well as implementation of preventive measures for risk reduction; optimization of risk reduction and emergency mitigation measures and their costs as an integral part of strategies and/or programs for socio-economic regional and national development, it is recommended that **the VoSL estimate should be taken from the range of 30—40 million RUR**.

For other purposes, such as setting social and corporate payments to families of those killed in emergencies, setting insurance compensations in the system of public or private insurance (against accidents) for occupational activities defined by the law of the Russian Federation, **it is recommended that VoSL should be taken from the range of 7—10 million RUR.**

It should be once more underlined that the recommended VoSL estimates should only be considered in the context of Russia's present economic situation. As the economic position strengthens and the economic growth stabilizes, these estimates should be revised for higher values. This is a necessary condition for the effective functioning of economic mechanisms of risk management.

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Paper Abstracts

Characteristics of the Kazan Climate and Environment

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Abstract
The paper discusses changes in various climate parameters that took place in Kazan in the 20th century and are of practical interest for organizers of community services. The environmental conditions have been indirectly evaluated via the index of biological effectiveness of climate, hydrothermal factor, and flammability index in the warm season of year. The trends in basic characteristics of heating period and other applied climate parameters are presented.

Key words:
climate, basic climate parameters, natural environment, applied climate parameters, climate continentality.

Tsunami

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Abstract
The paper gives a brief overview of tsunami wave parameters. With the US tsunami detection system taken as an example, modern technical means of tsunami detection are described. They allow early detection of tsunamis, so that measures can be taken to protect the population. Current problems in early tsunami detection in the Russian Far East are identified. The efforts made his field in Russia are described.

Key words:
subduction, earthquake, tsunami, energy, magnitude, isochrones, ocean, depth, velocity, early detection, seismic silent zone, method, sensor, systems, radar, map, equations, linear theory

Development of Industrial Safety Certificates (by the Example of a Gas Station Safety Certificate)

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Abstract
The paper covers a range of issues concerning the development of safety certificates for hazardous industrial facilities. It provides a brief background information on why and how the decision was made as to the necessity of safety certificates, what the safety certificate is needed for. The paper gives a detailed account of problems arising in the course of safety certificate development. When working at a safety certificate one has to estimate the probabilities of four sets of values. A critical review is given of the probability estimation methods recommended by the normative document 03-418-01. Methodical shortcomings are highlighted: serious difficulties arise due to acute shortage of publicly available necessary statistical and reference data, the lack of guidelines on the assessment of the uncertainty of obtained estimates. To “complete” the methodology of risk analysis, it is suggested that humanitarian damage caused by technological accidents be evaluated in terms of money using the appropriate method developed at EMERCOM of Russia (2002).
It is suggested that themethodical guidelines on safety certificate development should be revised to eliminate the said drawbacks. Appended to the paper is an abridged safety certificate of a typical gas filling station.

Key words:
Safety certificate for a hazardous industrial facility, industrial safety declaration, risk analysis, uncertainty of probability estimates, statistical data analysis, fault-tree construction money equivalent of humanitarian damage.

Assessing Ecosystem Risks Related to Middle–Timan Bauxite Mine Expansion

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Abstract
The paper discusses the methodology for quantitative assessment of ecosystem effects related to atmospheric pollution from industrial facilities. It is suggested that critical loads of pollutants be used as recipient-specific reference doses and risks be characterized based on excessive load analysis. The proposed methods for ecosystem risk assessment were pilot-tested within EIA for the expansion of the Middle-Timan Bauxite Mine (the Komi Republic); key findings of the pilot project are presented.

Key words:
environmental risk assessment, critical loads of pollutants, ecosystems

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