COMMUNICATIONS

COMMUNICATIONS

Jozef Klucka - Vladimir Mozer - Jan Dvorsky *

FIRE LOSSES IN THE SLOVAK REPUBLIC – THEIR CLASSIFICATION AND QUANTIFICATION

The paper deals with approaches to fire loss classification and quantification. Direct and indirect loss, total loss per fire and the relation of direct and indirect loss to the gross domestic product (GDP) are calculated. Furthermore, the Statgraphics Centurion XV package is used to express: total loss prediction for selected probabilities and probabilities for selected total fire loss values. The results are discussed and conclusions drawn in form of recommendations for the Fire & Rescue Services management in the Slovak Republic.

Keywords: Fire, losses, modelling, probability, distribution.

1. Introduction

This paper deals with the topic of fire loss classification and quantification. An analysis was carried out, using the available data which represent direct fire losses in the Slovak Republic. Direct loss was also supplemented by a quantitative expression of indirect loss. The aim of the paper is, based on statistical analysis, to offer managerial information on the probability of total loss in €, as well as the associated probabilities of loss occurrence. The outcomes of the analysis are then transformed into a set of recommendations for the Fire & Rescue Service management.

Loss may be analysed from the following points of view:
- trend,
- occurrence probability,
- interdependencies with other statistical descriptors and benchmark comparison (including international comparison).

The results of these analyses should have a positive impact on the realisation of the management process in the Fire & Rescue Service, as well as on the structure and process of statistical analysis (internal and external communication of processes and results).

2. Analysis

There is a number of approaches to incident loss classification; by an incident we understand, for the purposes of this paper, an event, the consequences of which lead to loss and potential system dysfunction (for more also see [1]).

Losses caused by emergencies are classified also [1] - Fig. 1.
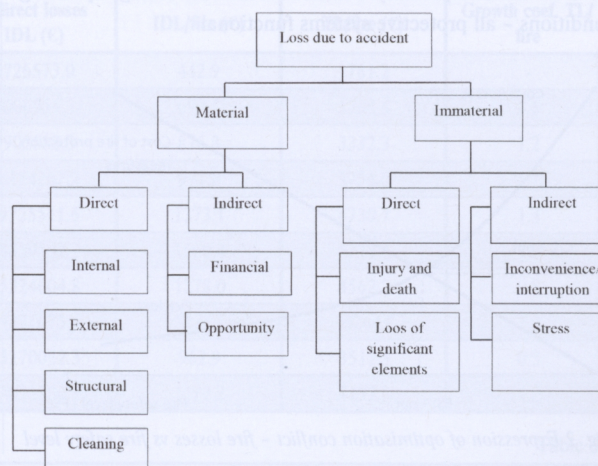
Fig. 1 Emergency-caused losses classification (for more also see [1])

From a fire-safety point of view Ramachandran [2] recognizes five levels in the management hierarchy, each having a different and specific view of topic of costs/losses and benefits. They are as follows: building owners, fire and rescue service, local authorities, government authorities, insurers and fire protection equipment manufacturers. Costs, such as installation of fire protection equipment, insurance premiums are real costs, however, the costs/losses associated with fire consequences are uncertain. Their height is tied to the probability of fire occurrence and the probable fire loss. The reduction of costs resulting from applied preventive measures is considered a benefit in this regard.

* ¹Jozef Klucka, ²Vladimir Mozer, ¹Jan Dvorsky
¹Department of Crisis Management, University of Zilina, Slovakia
²Department of Rescue Services, University of Zilina, Slovakia
E-mail: Jozef.Klucka@fbi.uniza.sk

Another view of costs results from their categorisation into direct – losses caused on the building and equipment due to a fire, and indirect – e.g. loss of production impacting profit, loss of customers, markets etc.

The direct loss on the building is expressed through an estimation of the expected replacement cost of the property damaged (for more also see [2]).

There is a number of approaches for fire loss quantification and they are organisation-specific. The insurance industry uses the following indicators (for more also see [3]):

Estimated maximum loss (EML): Usually expressed as percentage of value of unit under consideration. The fraction is likely to be charged in a serious conflagration.

Maximum possible loss: Financial loss that would occur under catastrophic or extremely unfavourable conditions (Failure of two or more protective systems – active and passive).

Maximum probable loss: Maximum financial loss under normal conditions, for example one protective system failing.

Normal loss expectancy: Financial loss under average operating conditions – all protective systems functional.

Figure 2 illustrates the relationship between fire losses and the cost of fire protection measures. It is obvious, that for a given curve of costs and losses the (FLS – optimum C/L) point represent an optimum level – i.e. for the given level of costs, the losses are at their minimum value.

The extent of economic consequences of an accident is determined by the following elements:
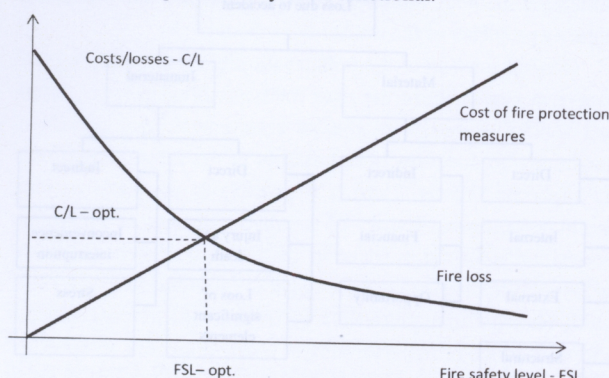- economic consequences are divided into direct and indirect,
- life loss and injuries represent specific forms of loss which are, although difficult, quantifiable
- economic consequences of an accident are driven by system's resilience,
- the ratio of direct and indirect loss is inconsistent among the sources (for more also see [1]), states that the indirect loss represent 25 – 40 % of direct loss,
- there is only a limited theoretic methodology basis and statistical data required for incident consequence quantification.

The current methodology of Slovak Fire & Rescue Service (FRS) recognizes only direct losses. They are recorded in accordance with internal guidelines of FRS (for more also see [4], [5] and [6]).

3. Results

The analysis included the following steps:
- total direct loss calculated from statistic report data was adjusted for inflation; direct loss was also used as the basis for the calculation of indirect loss for the analysed statistical set (see Table 1),
- based on the above total adjusted direct and indirect loss, direct and indirect loss per fire was calculated (see Table 2),

Fig. 2 Expression of optimisation conflict – fire losses vs fire safety level

Direct and indirect loss in SR in 2003 – 2012

Table 1

Year	Inflation (%)	Direct losses-DL (€)	Direct losses with inflation (€)	Indirect losses IDL (€)	Total losses TL (€)	TL - (€)	Growth coef. TL
2003	8.5	18734874.0	20327338.3	6726573.0	27053911.3	8319037.3	-
2004	7.5	19539670.0	21005145.3	7006951.3	28012096.6	8472426.6	1.0
2005	2.7	27003084.0	27732167.3	9902582.3	37634749.6	10631665.6	1.3
2006	4.5	27121208.0	28341662.4	10174267.2	38515929.6	11394721.6	1.0
2007	2.8	46921954.0	48235768.7	19725511.6	67961280.3	21039326.3	1.8
2008	4.6	43493564.0	45494267.9	18339592.7	63833860.6	20340296.6	0.9
2009	1.6	38761305.0	39381485.9	15324004.8	54705490.7	15944185.7	0.9
2010	1.0	69148435.0	69839919.4	31271071.3	101110990.7	31962555.7	1.8
2011	3.9	33561130.0	34870014.1	13170022.3	48040036.4	14478906.4	0.5
2012	3.6	41394490.0	42884691.6	17039230.2	59923921.9	18529431.9	1.2

Where:

$$TL = DL_{inf} + IDL \quad and \quad ID = c \times (DL_{inf})^b$$

where $c = 0.015$; $b = 1.245$ (due to missing data, calculation method form [2] was adopted).

- subsequently, the total adjusted direct and indirect loss was recalculated as a percentage ratio of GDP (see Table 3), and the results were compared with selected European countries (see Table 4 and Table 5),

- finally, the adjusted direct and indirect loss was fitted to an appropriate statistical distribution (see Table 7 and Table 8); these values were then analysed for a relationship between probability and total loss value (variably for each given probability of total loss occurrence and the given amount of total loss) (see Table 9 and Table 10).

Having calculated the direct and indirect losses, their values were divided by the number of fires which had occurred in SR during the monitored period. The outcomes are as follows:

- the average value of direct loss per fire adjusted for inflation is 3 200 € and the average indirect loss per fire is 1 263 €,

- the total loss per fire adjusted for inflation in the monitored period in the range of 1781 − 10 264 €; statistically, year 2010 is interesting due to the significant decrease of the number of fires, compared to preceding period, however, fire loss was extremely high; only a more detailed analysis of individual fires would provide explanation,

- by analysing the total loss per fire, it is possible to state that the development of its value has a significant variability; particularly the period of 2008 − 2012 would require further attention.

The further area of analysis was a comparison of direct and indirect loss in relation to GDP in the monitored period. The obtained results were compared with the published ones (see Table 3).

Direct and indirect loss per fire in SR during the period of 2003 − 2012

Table 2

Year	Sum of fires	Direct losses	/fire (€)	Indirect losses IDL (€)	IDL/fire (€)	TL/fire (€)	Growth coef. TL/fire
2003	15189.0	20327338.3	1338.3	6726573.0	442.9	1781.2	-
2004	10118.0	21005145.3	2076.0	7006951.3	692.5	2768.5	1.6
2005	11294.0	27732167.3	2455.5	9902582.3	876.8	3332.3	1.2
2006	10260.0	28341662.4	2762.3	10174267.2	991.6	3754.0	1.1
2007	14366.0	48235768.7	3357.6	19725511.6	1373.1	4730.7	1.3
2008	11045.0	45494267.9	4119.0	18339592.7	1660.4	5779.4	1.2
2009	11991.0	39381485.9	3284.3	15324004.8	1278.0	4562.2	0.8
2010	9851.0	69839919.4	7089.6	31271071.3	3174.4	10264.0	2.2
2011	13677.0	34870014.1	2549.5	13170022.3	962.9	3512.5	0.3
2012	14413.0	42884691.6	2975.4	17039230.2	1182.2	4157.6	1.2

Relation of direct and indirect loss to GDP in monitored loss

Table 3

Year	GDP (mil. €)	Direct losses with inflation- (€)	Indirect losses -IDL (€)	/GDP (%)	IDL/GDP (%)	IDL/
2003	40 612.00	20 327 338.29	6 726 572.98	0.050%	0.017%	0.331
2004	45 161.40	21 005 145.25	7 006 951.32	0.047%	0.016%	0.334
2005	49 314.20	27 732 167.27	9 902 582.34	0.056%	0.020%	0.357
2006	55 001.60	28 341 662.36	10 174 267.2	0.052%	0.018%	0.359
2007	61 449.70	48 235 768.71	19 725 511.6	0.078%	0.032%	0.409
2008	66 932.30	45 494 267.94	18 339 592.6	0.068%	0.027%	0.403
2009	62 895.50	39 381 485.88	15 324 004.8	0.063%	0.024%	0.389
2010	65 887.40	69 839 919.35	31 271 071.3	0.106%	0.047%	0.448
2011	69 058.20	34 870 014.07	13 170 022.3	0.050%	0.019%	0.378
2012	71 463.00	42 884 691.64	17 039 230.2	0.060%	0.024%	0.397

Direct and indirect loss in selected EU countries [2]   Table 4

Country	Direct losses[*] (%)	Indirect losses[*] (%)
Austria	0.21 (79-80)	0.029
Belgium	0.4 (88-89)	N.A.[**]
Denmark	0.26	0.034
Finland	0.17(88-89)	0.021
France	0.23	0.037
Germany	0.2	0.037
Hungary	0.12 (86-88)	0.028
Netherlands	0.19	0.03
Norway	0.24	0.005
Spain	0.12 (84)	N.A.
Sweden	0.25	0.009
Switzerland	0.23 (89))	0.095
UK	0.19	0.019

[*]Average percentage of GDP

Direct and indirect loss in relation to GDP in selected EU
countries [2]   Table 5

Country	Indirect losses -ID (%GDP)	Direct losses - DL (%GDP)	Ratio IDL/DL
Norway	0.005 (58-60)	0.24	0.021
Sweden	0.009	0.25	0.036
The Netherlands	0.030 (87-88)	0.19 (87-88)	0.158
Austria	0.029 (79-80)	0.21 (79-80)	0.138
Germany	0.037 (87-89)	0.20 (89-90)	0.185
Denmark	0.034	0.26	0.131
Finland	0.021 (88-89)	0.17 (88-89)	0.124
UK	0.019	0.19	0.1
France	0.037 (80-81)	0.23 (81-82)	0.161
Switzerland	0.095 (89)	0.23 (89)	0.413

[**] N.A. – estimate not available

The following is evident from Table 4 and Table 5 (for more
also see [7] and [8]):
- the ratio of direct loss to GDP is significantly lower than in
  other EU countries,
- the ratio of indirect loss to GDP in selected EU countries is
  in agreement with values (see Table 4 and Table 5),
- the ratio of indirect to direct loss is significantly higher in
  SR than in other EU countries; only a more in-depth analysis
  would provide reasons explaining this fact; it was not possible
  at the moment of writing this paper due to limited data
  availability.

The results of the above are determined by the following
factors:
- from the available data, we presume that direct loss is not
  adjusted for inflation,
- the value of direct and indirect loss is determined by limited
  data; the presumed fact of different indirect loss for various
  building groups is simplified (see Table 5).

Statistical modelling of total fire loss comprised a number
of stages, in which a number of distributions and calculation
methods were tested and the most appropriate selected (for
more also see [9] and [10]) The calculations were carried out
in the STATGRAPHICS CENTURION XV package, due to the
computational demands (for more also see [11], [12] and [13]).
The basic selective characteristics (see Table 6) indicate that
the selected group is characterised by a continuous probabilistic
distribution due to a high coefficient of variation – 42.32%.

Basic statistical characteristics of fire loss for the period
of 2003 – 2012   Table 6

Average	5.26792 x
Standard deviation	2.22954 x
Coefficient of variation	42.323%
Kurtosis	1.01213
Skewness	1.37392

The estimated distribution parameters using the maximum
likelihood method (see Table 7)

Parameter estimation for selected probabilistic distributions Table 7

Pareto distribution	Gamma distribution	Lognormal distribution	Weibull distribution	Normal distribution
$\alpha = 0.05649$	$\alpha = 6.61954$	$\mu = 53\ 131\ 800$	$\delta = 2.64796$	$\mu = 52\ 679\ 200$
c = 22 587 800	$\beta = 1.25663$ x	= 23 014 300	c = 59 407 600	= 22 295 400

Kolmogorov-Smirnov test results   Table 8

	Pareto distribution	Gamma distribution	Normal distribution	Weibull distribution	Lognormal distribution
DPLUS	0.17524	0.13652	0.11514	0.13981	0.14653
DMINUS	0.00163	0.08991	0.10939	0.11716	0.12520
DN	0.10163	0.13652	0.11514	0.13981	0.14653
P-value	0.94138	0.99225	0.99937	0.98970	0.98280

The tests were carried out on the 5% significance levels. With 95% level of confidence, the data fit the Lognormal distribution, since the P-value of Kolmogorov-Smirnov test is the highest for this distribution.

Having found that the total fire loss in SR for the period of 2003 – 2012 fits best to the Lognormal distribution, future extreme values for selected probabilities can be predicted.

Total fire loss prediction for selected probabilities   Table 9

Probability of Total fire loss (%)	Total fire loss (€)
20	69 116 700
10	82 948 900
5	96 435 700
2	114 255 000
1	127 929 000

Probabilities for selected total fire loss   Table 10

Total fire loss (€)	Probability of Total fire loss (%)
30 000 000	12.07
50 000 000	52.43
70 000 000	80.85
90 000 000	93.03
110 000 000	97.51

The results from Table 9 and Table 10 can be interpreted as follows:
- with 10% probability, the expected loss in SR for the next year is 82 948 900 €,
- the probability that the total loss will not exceed 70 000 000 € is 80.81%,
- analogically same interpretation applies to other values in Table 9 and Table 10.

Similar logic may be applied to other probabilities of total fire loss.

The analysis of the results yields the following outcomes:
- the average value of total direct loss in the monitored period is 36 568 000 €; the average value of adjusted total direct loss is 37 811 000 €; on average, inflation caused a 4% increase of direct loss,
- the increase of total loss, when compared to the direct loss for the given year, is approximately 44%,
- the average difference of the total and adjusted direct loss is 16 mil. € and the median of this item is 14.5 mil. €,

- the standard deviation value of the difference of total and direct loss is 7.2 mil. €, which suggests a significant variability of the analysed items,
- the average value of indirect loss is 14 868 000 €; the median of this item 13 170 000 €,
- the growth coefficient of total lost has a significant variance; the periods of growth and decrease alternate, with extremes in 2003 – 2004 (4% increase) and years 2010 – 2011 (137% growth).

4. Conclusion

The analysis of fire risk is carried out with the aim of risk reduction in decision making which deals with fire source identification, determination of the probability of a fire starting and consequence quantification. The process of loss analysis is also part of the risk management process. Knowing the probable consequences and their quantification allows to take appropriate measures as part of risk management, which help the organisation (FRS) decrease the risk to an acceptable level. In other words, the realised measures decrease the level of risk from unacceptable to acceptable.

From the presented results it is possible draw the following application conclusions for FRS:
- formulate a methodology for direct fire loss calculation and decide on the way of inflation integration,
- extend the current methodology for indirect fire loss,
- compare direct and indirect loss as part of analyses and quantify loss per fire,
- categorise fires by sectors/industries, and based on these extend the analysis of direct and indirect fire loss for the individual categories,
- carry out a trend analysis for each sector/industry – development of direct an indirect loss in time,
- carry out an international comparison of the direct loss/GDP, indirect loss/GDP, and indirect and direct loss ratios,
- extend loss quantification for life loss and injury factors,
- analyse the methods currently used by the insurance industry for quantification (for more also see [3])

The above proposed measures have an ambition to include the results of statistical analyses into the FRS management more effectively.

References

[1] *Critical Infrastructure Resilience Strategy.* Australian government, Canberra, 2010, (information on: www.ag.gov.au/cca)

[2] RAMACHANDRAN, G.: *Economics of FireP.* Published by E & FN Spon, 1998, ISBN 0-203-78436-7, p. 247.

[3] RASBASH, D. J., RAMACHANDRAN, G., KANDOLA, B., WATTS, J. M., LAW, M.: *Evaluation of Fire Safety.* Wiley, 2004, p. 479, ISBN 0-471-49382-1

[4] *Collection Instructions Presidium Fire and Rescue Service,* No. 25, 2005 Ministry of Interior of the Slovak Republic.

[5] BETAKOVA, J., LORKO, M., DVORSKY J.: *The Impact of the Potential Risks of the Implementation of Instruments for Environmental Area Management on the Development of Urban Settlement,* Environmental impact II, Ancona, 2014, ISBN 978-184564762-9, ISSN 17433541, pp. 91-101.

[6] BUTTON,K.: *Transport Economics,* Edward Elgar, 2010, p. 511

[7] CONTE, A. P. E. (ed.): *Fire Protection Handbook,* vol. I., NFTA, Quincy, 2008, ISBN-13:978-0-87765-758-3, p. 1584.

[8] DVORSKY, J., KLUCKA, J.: *Modelling of the Amount of Economic Losses Causes by Fires in the Region of Zilina,* Fire Protection 2014, Ostrava, ISBN 978-80-7385-148-4, pp. 48-51.

[9] *Keeping the Country Running: Natural Hazards and Infrastructure,* Cabinet Office, London, 2011 (information on: www.cabinetoffice.gov.uk/ukresilience)

[10] KELISEK, A., KLUCKA, J., ONDRUSEK, M., STRELCOVA, S.: Economic Security - A Principal Component of Multilevel Security Concept in Global Economy. *Communications - Scientific Letters of the University of Zilina,* 2011, ISSN 1335-4205, pp. 44-48.

[11] KLUCKA, J., MOZER, V., PANAKOVA, J.: *Development of Fires in Different Categories of Buildings for the Period 1993 - 2012,* The conference of Rescue Services, Proc. of intern. scientific conferences, Zilina, ISBN 978-80-554-0894-1, pp. 91-110.

[12] PANAKOVA, J., KLUCKA, J., MOZER, V.: *Model for Evaluation of Fire Protection Measures Economic Efficiency.* Fire protection 2014, Ostrava, ISBN 978-80-7385-148-4, ISSN 1803-1803 pp. 264-266.

[13] STATGRAPHICS: *Software Statgraphics Centurion XV. 2014.* [online]. [cit. 25 March 2014]. Available: http://www.statgraphics.com/support/download_center.aspx.

COMMUNICATIONS – Scientific Letters of the University of Zilina
Writer's Guidelines

1. Submitted papers must be unpublished and must not be currently under review for any other publication.
2. Submitted manuscripts should not exceed 8 pages including figures and graphs (in Microsoft WORD – format A4, Times Roman size 12, page margins 2.5 cm).
3. Manuscripts written in good English must include abstract and keywords also written in English. The abstract should not exceed 10 lines.
4. Submission should be sent: By e-mail – as an attachment – to one of the following addresses: komunikacie@uniza.sk or holesa@uniza.sk (or on CD to the following address: Zilinska univerzita, OVaV - Komunikacie, Univerzitna 1, SK-10 26 Zilina, Slovakia).
5. Uncommon abbreviations must be defined the first time they are used in the text.
6. Figures, graphs and diagrams, if not processed in Microsoft WORD, must be sent in electronic form (as JPG, GIF, TIF, TTF or BMP files) or drawn in high contrast on white paper. Photographs for publication must be either contrastive or on a slide.
7. The numbered reference citation within text should be enclosed in square brackets. The reference list should appear at the end of the article (in compliance with ISO 690).
8. The numbered references (in square brackets), figures, tables and graphs must be also included in text – in numerical order.
9. The author's exact mailing address, full names, E-mail address, telephone or fax number, the name and address of the organization and workplace (also written in English) must be enclosed.
10. The editorial board will assess the submitted paper in its following session. If the manuscript is accepted for publication, it will be sent to peer review and language correction. After reviewing and incorporating the editor's comments, the final draft (before printing) will be sent to authors for final review and minor adjustments
11. Submission deadlines are: September 30, December 31, March 31 and June 30.