Future evolution of risk management for structures

Advancement for the future IEC 62305-2 Ed3

Ernst Ulrich Landers
Universität der Bundeswehr München
UniBwM
München, Germany
ernst-ulrich.landers@unibw.de

Alexander Kern
Aachen University of Applied Sciences
ACUAS
Jülich, Germany
a.kern@fh-aachen.de

Abstract **– The actual version of risk management for structures was issued 2010-12 in IEC 62305-2 Ed2. Enduring discussions show the necessity of a further development towards Ed3. This document offers the evolution of an advanced risk management. Based on its revised definitions, the actual problems are analyzed and solved. All terms are deeply discussed and the relevance of the new solution is shown in comparison with the old and new results for the hospital example of IEC 62305-2 Ed2.**

Keywords – IEC 62305-2; risk management; improved definition of risk and loss; importance of zones; introduction of zone factors; improved definition of saving and benefit.

I. Introduction

For the protection against lightning, risk management is the well established method to determine the need of protection, to select and optimize the protection measures and to evaluate the economic benefit [1]. The development process can be seen in IEC 62305 from edition 1 (2006-01) [2, 3] towards edition 2 (2010-12) [4, 5] accompanied by efforts to develop suitable software [6, 7]. The actual version of the risk management is presented in IEC 62305-2 Ed2 issued 2010-12 [5]. But the enduring discussions at IEC and also at CENELEC level show the necessity for a further evolution of the method with the aim to develop a clear and transparent procedure. Therefore first a strong definition of the basic parameters is presented, which then is used to analyze the actual version in IEC 62305-2 Ed2 and to demonstrate open questions and problems associated with it. Finally a detailed proposal is elaborated, which not only solves these problems, but also allows better inclusion of future aspects like protection of the environment.

II. Risk management procedure

For the risk management the following steps shall be performed:

- identification of the structure and its characteristics;
- identification of relevant types of loss;
- definition of the required one or several zones;
- risk analysis to find the need of protection;
- selection of suitable protection measures;
- loss analysis to determine saving and benefit.

III. Basic definitions

The fundamental terms for the risk management can generally be defined as follows:

A. *Type of loss and type of damage*

The first step is to identify the types of loss (see Table I) relevant to the structure to be protected. There is an important difference between them: The units of the values to be protected for L1, L2 are persons (victims or users not served), whereas for L3, L4 these are currency units (cultural heritage or economic values). For reference purposes below also the types of damage are given in Table I.

TABLE I. TYPE OF LOSS AND TYPE OF DAMAGE

Type of loss			
L1	Human life	L3	Cultural heritage
L2	Public service	L4	Economic values
Type of damage			
D1	Injuries	D3	Failure of systems
D2	Physical damage		

B. *Zones*

For the structure the considered zones (Z1, Z2, Z3 …) shall be defined, which can be inside zones subdividing the volume of the structure or also outside zones around or in the environment of the structure. However, in simple cases the structure can be also only one single zone Z1.

The definition of the zones has fundamental importance, because with this step exclusively the areas are fixed which will be considered in the risk management. The risk analysis shall be performed for each relevant type of loss and for each zone separately, because each zone has its own characteristics and therefore also its own risk. Any sum of risk components over more than one zone is never allowed. Otherwise the resulting loss values can be added to partial or total sums.

Therefore a clear distinction between the definition of risk and of loss is very important.

C. Definition of per unit risk

Risk R (1/a) is the per unit value of a potential average annual loss. Per unit means related to one unit being one person (for L1 or L2) or one currency unit (for L3 or L4). The basic equation for a risk component is

$$R_x = N_y \cdot F_x \cdot PL_x \qquad (1)$$

where

N_y is the number of dangerous events per annum;

F_x is the product of all influencing factors;

PL_x is the portion of loss (definition see V.C).

D. Definition of absolute zone factor

Absolute zone factor ZF_x (units) is the value to be protected related to a zone. The units are persons (for L1 or L2) or currency units (for L3 or L4). The zone factors for the different types of loss are given in Table II.

TABLE II. ABSOLUTE ZONE FACTORS ZF_Y

		L1	L2	L3	L4
D1	ZF_1	$V_Z \cdot T_Z/8760$	0	0	V_A
D2	ZF_2	$V_Z \cdot T_Z/8760$	V_Z	V_B+V_C	$V_A+V_B+V_C+V_S$
D3	ZF_3	$V_Z \cdot T_Z/8760$	V_Z	0	V_S

where

V_Z number of persons relevant for the zone;

T_Z time of presence of persons related to the zone;

V_A value of animals in the zone;

V_B value of building related to the zone;

V_C value of content in the zone;

V_S value of systems and their activities.

E. Definition of absolute loss

Loss L (units/a) is the value of the average absolute annual loss. The units are persons/a (for L1 or L2) or currency units/a (for L3 or L4). The basic equation for a loss component is

$$L_x = R_x \cdot ZF_y \qquad (2)$$

where

R_x is the per unit risk component;

ZF_y is the absolute zone factor (see Table II).

IV. RISK MANAGEMENT IN IEC 62305-2 ED2

A. Definition of an“weighted risk”

In contradiction to the definitions in III.C the IEC 62305-2 Ed2 defines a “weighted risk”, which contains the relative zone factors ZF_y/n_t respectively ZF_y/c_t, which are related to the total value of the structure being the total number of persons n_t (for L1 or L2) or the total value c_t (for L3 or L4). Correctly the “weighted risk” is the relative loss, which is the absolute loss L_x divided by the total value (n_t or c_t). This can easily be evaluated from (D.2) in Annex D, where the absolute loss $C_L = R_4 \cdot c_t$ and therefore $R_4 = C_L / c_t$ is the relative loss and never any “risk”.

To distinguish the per unit risk R defined in III.C from the “weighted risk” defined in IEC 62305-2 Ed2, the latter is named R* here. Especially if the relative zone factor is much less than 1 (only a small part of the total value is concerned), this has severe consequences.

Annex E.4 of IEC 62305-2 Ed2 presents the example of a hospital with four zones: Z1 (outside), Z2 (rooms block), Z3 (operation block), Z4 (intensive care unit). The number of persons is 10 for Z1, 950 for Z2, 35 for Z3 and 5 for Z4 being total n_t = 1000 persons. Due to the inhomogeneous distribution, the relative zone factors differ from 0,95 for Z2 down to 0,05 for Z4.

This leads to the R* values as given here in Table III (taken from Annex E Table E.33). Analyzing each zone separately would suggest, that even for the unprotected structure there is no need for protection for the zones Z1 (outside) with $R^*=0{,}01 \cdot 10^{-5}$ and for Z4 (intensive care unit) with $R^*=0{,}70 \cdot 10^{-5}$, because in both cases R* is below the tolerable risk $R_T=10^{-5}$. Especially for the intensive care unit Z4 this seems not reasonable.

Moreover, if the identical zone Z4 would be placed in a smaller hospital (n_t=100 persons), the “weighted risk” R* will become 10 times higher. This again is not reasonable.

TABLE III. COMPARISON OF “RISK” VALUES (X 10^{-5} 1/A)

Risk definition		Z1	Z2	Z3	Z4
IEC 62305-2 Ed2	R*	0,01	64,4	4,88	0,70
Per unit risk	R	0,89	67,8	139,5	139,5

B. Mixed use of ”percentage of loss” and ”loss”

It is very important to clearly discern between ”percentage of loss”, ”relative loss” and ”absolute loss”. L_T, L_F, L_O (used in Annex C, but not basically defined) are correctly ”percentage of loss” (which not include zone factors). L_A to L_Z and L_E (used in Annex C and defined as L_x in C.2) are correctly ”relative loss” (which include relative zone factors). Finally C_L, C_{RL}, C_{LZ}, C_{RLZ} (used in Annex D and defined as cost of loss) are correctly ”absolute loss” (which include absolute zone factors). As shown below the mixed use of these three different terms leads to severe errors.

C. How to include losses in surrounding or environment

Another important problem is how to include additional losses in the surrounding or environment. In Annex C of IEC 62305-2 Ed2 it is proposed in the equations (C.5) or (C.14), to add simply the additional loss in the surrounding or environment L_E to the initial loss in the structure L_F resulting in the total loss $L_{FT} = L_F + L_E$.

But L_F (correctly ”percentage of loss”) does not include zone factors, whereas L_E (correctly ”relative loss”) include the zone factors for the surrounding or environment (t_e/8760 or c_e/c_t). This mixture of types leads to a severe error: If the total value L_{FT} replaces L_F in the equations (C.3) or (C.12) to determine the values for $L_B=L_V$ ("loss"), L_{FT} will be multiplied again with a zone factor ($n_z/n_t \times t_z/8760$ or $(c_a+c_b+c_c+c_s)/c_t$) valid only for the zone of the structure considered. The portion valid for the surrounding or environment thus finally would be multiplied twice by different zone factors !

Moreover, if more than one zone is defined for the structure, to which zone the additional loss should be added ? There is no correlation defined between the surrounding or environment and the zones of the structure, which could help to answer this question. Otherwise the result of the risk analysis will be very different depending on the zone, to which the additional loss is added.

D. Requirements to solve problems

All these problems pointed out for IEC 62305-2 Ed2 can be solved, if the advanced risk management, defined and explained below in V, will be used in the future. Clear distinction between the per unit risk R and the absolute loss L leads to reasonable results: The results in Table III (taken from Fig. 3 below) show, that the risk values R now are high for the sensitive zones Z3 and Z4. Moreover, they now are independent from the zone factors and therefore remain constant, whether these zones are placed in a big or in a small hospital.

The risk analysis with the criterion $R>R_T$ performed separately for each zone leads then to reasonable new results.

The loss analysis leads to the same loss values for IEC 62305-2 Ed2 and for the new definitions. Therefore also the results for saving (reduction of loss due to protection) and for the economic benefit (profit from protection in case of economic values) are the same.

The problem with additional losses in the surrounding or environment can be solved properly, defining an additional zone for this with its own characteristics. Any mixture between this zone and the zones of the structure is then avoided.

V. ADVANCED RISK MANAGEMENT

Fortunately all basic elements of the risk management of IEC 62305-2 Ed2 can be maintained. But the new concept requires a complete re-arrangement and new interpretations of some important definitions:

A. New definition of risk

The most important change is the new interpretation of risk. **The new defined per unit risk R (1/a)** now is the potential risk for one person (for L1, L2) or for one currency unit (L3, L4).

A simple example for the type of loss of human life (L1) can illustrate this, if for a parking house two zones are defined: Z1 (inside the building) and Z2 (open parking area on the top level). Whereas in Z1 (inside of a "Faraday cage") the risk is negligible, the risk in Z2 (exposed to direct flashes) is very high.

Equation (1) shows, that the risk value R_x depends only on the number of dangerous events N_y, on all influencing factors F_x, which determine the properties of the zone and of the portion of loss PL_x. But the risk value R_x depends not at all on how many or if any persons are present.

The risk criterion $R \le R_T$ shall be performed separately for each zone. If protection is needed, the influencing factors F_x (including global and local protection measures) related to this zone must be changed. Protection is reached, if for all defined zones the criterion $R \le R_T$ is fulfilled.

Because there is no interdependency between the risk values of different zones, they never can be added to a total risk for the whole structure.

It makes no sense, to include in a "weighted risk" the absolute values and the zone factors as in the equations of the tables C.1, C.7, C9, C.11 of IEC 62305-2 Ed2, because this would define a non-existing interdependency. If this would be true, the parking house example would lead to the following unrealistic results:

- At the open parking area on the top level the risk R(Z2) would be zero, if nobody is present there and thus $n_z/n_t=0$ (but the potential risk ever exists).
- The risk R(Z2) would have a certain value, if one person is present in Z2 (top level) and nobody in Z1 (inside) being than $n_z/n_t=1$.
- This risk R(Z2) would be reduced by a factor of 100, if 99 persons are present in Z1 (inside) being now $n_z/n_t=1/100=0{,}01$.

One can easily see the huge differences in the results, which are far away from any technical explanation.

B. Maintained definition of loss

Unlike the new definition of risk, the definition of loss is not changed in principle. But it is important to clarify, that first the **absolute loss L (persons/a)** for L1, L2 or **L (currency units/a)** for L3, L4 should be considered (the absolute loss is defined equally as C_L in Annex D of IEC 62305-2 Ed2). The relative loss is not needed. But if desired it could be defined dividing the absolute loss by the total value n_t or c_t (the "weighted risk" used in IEC 62305-2 Ed2 is in fact such relative loss).

Equation (2) shows, that the absolute loss value L_x depends only on the per unit risk R_x (1/a) and on the absolute zone factors ZF_y (persons or currency units). Introducing now the absolute zone factors, which represent all the values to be protected and their distribution into the zones, the step from the potential per unit risk R_x (1/a) to the absolute amount of loss L_x (units/a) is done. In contrary to the risk, these loss values can be considered separately, as sum in a zone or even as total sum for the whole structure. Moreover the total sum of loss can include additional losses in the environment zone. The sum of values considered then may exceed the total values n_t or c_t of the structure.

C. Advanced risk analysis

The risk analysis requires only the number of dangerous events N_Y, the factors F_X and the portion of loss PL_X.

The number N_Y of dangerous events is defined equally as in IEC 62305-2 Ed2.

The factor F_X is affected by characteristics of the zone and of the structure to be protected, the connected lines and the protection measures provided. **It includes now all factors** defined in IEC 62305-2 Ed2 in Annex B (P_x, C_x, K_x) and in Annex C (r_t, r_p, r_f, h_z).

The portion of potential consequent loss PL_X ranging from 0 … 1 is the typical fraction of the total value, which will be destroyed in case of damage due to one dangerous event. It is affected by the use to which the structure is assigned or by the type of service provided to public. The portion of loss **PL_X is identical with L_T, L_F, L_O** defined in IEC 62305-2 Ed2 in Annex C, because both do not include any zone factors. But the portion of loss has nothing to do with the loss values L_A to L_Z or with the additional loss L_E for the surrounding or environment defined there, because they all include zone factors.

As explained above, a total ”weighted risk” as used in IEC 62305-2 Ed2 generally cannot be defined. Therefore the risk criterion **$R \leq R_T$ shall be performed separately for each zone**. The structure is protected, if the criterion is fulfilled for each zone. If not, the influencing factors F_x (including global and local protection measures) related to this zone must be changed.

D. *Advanced loss analysis*

The loss analysis can be performed only, if the values to be protected and their distribution into the zones are known. Both are needed to define the absolute zone factors in Table II. Then the absolute loss values L_x can be determined from (2).

For all types of loss (L1, L2, L3, L4) the **annual value of saving AV_S** in (persons/a) for L1, L2 or in (currency units/a) for L3, L4 can be defined as difference of the absolute loss without and with protection (this is not the annual saving in money as defined exclusively for L4 in Annex D of IEC 62305-2 Ed2). The saving is a good characteristic value to show the success of the protection measures.

Further the **annual value of benefit AV_B** can be defined as difference of annual saving and the annual cost of protection (for L4 the benefit is identical with the annual saving in money as in Annex D of IEC 62305-2 Ed2). Only the benefit is restricted to the types of loss L3 and L4, because it requires identical units (currency units/a) for the annual saving and for the annual cost of protection (which is not the case for L1 and L2). The economic benefit then is justified, if the **criterion $AV_B > 0$** is fulfilled.

VI. THE HOSPITAL EXAMPLE OF IEC 62305-2

The hospital example of IEC 62305-2 Ed2 now is used to show the differences between the actual risk management and the advanced solution. It is defined as follows:

Zones: Four zones are defined: Z1 (outside), Z2 (rooms block), Z3 (operation block), Z4 (intensive care unit).

Types of loss: Relevant are the types of loss L1 (loss of human life) and L4 (loss of economic value).

Number of persons for L1: The number of persons is 10 for Z1, 950 for Z2, 35 for Z3 and 5 for Z4 being total n_t = 1000 persons.

Economic values for L4: The total value of the structure including content and internal systems is c_t = 90 000 000 USD.

A. *Results for the hospital from IEC 62305-2 Ed2*

As shown in Fig. 1 for the **type of loss L1** (loss of human life) the ”weighted risk” values are added to a total value $R^*=69{,}96 \cdot 10^{-5}$ for the whole structure (without protection). Because the risk criterion $R^* \leq R_T$ is not fulfilled, protection measures are needed.

The protection solution a) according to Annex E.4 of IEC 62305-2 Ed2 is, to install

- a class I LPS;
- coordinated SPD protection (1,5 x) better than for LPL I in zones Z2, Z3, Z4;
- provide zone Z2 with an automatic fire protection system;
- provide zone Z3 and Z4 with a meshed shield.

Using this solution the ”weighted risk” values are reduced to a total value $R^*=0{,}34 \cdot 10^{-5}$ for the whole structure (with protection). The structure now is protected, because the risk criterion $R^* \leq R_T$ is fulfilled.

Risk x1E-5 (1/a)	L1: Without Protection			
	Total R*	RT	Result (Structure)	
Z1	0,01			
Z2	64,37			
Z3	4,88			
Z4	0,70			
Structure	69,96	1	R>RT	Protection needed !!!

Risk x1E-5 (1/a)	L1: With Protection			
	Total R*	RT	Result (Zone)	
Z1	0,00			
Z2	0,29			
Z3	0,04			
Z4	0,01			
Structure	0,34	1	R<=RT	Protected

Figure 1. ”Weighted Risk” result for L1 (IEC 62305-2 Ed2)

As shown in Fig. 2 for the **type of loss L4** (loss of economic values) the absolute annual loss values C_L = 57 185 USD/a (without protection) and C_{RL} = 271 USD/a (with protection) can be calculated from Annex D of IEC 62305-2 Ed2. With annual protection cost of 28 000 USD/a the result for the annual benefit (“annual saving S_M in money”) is 28 914 USD/a. The economic benefit is justified, because the **criterion $S_M > 0$** is fulfilled.

L4: Without Protection			
Loss (USD/a)	Total		
Z1 Z2 Z3 Z4		Result (Structure) Values	
CL = R4 x ct	57.185	Values (Total)	USD
		VST	90.000.000
L4: With Protection		Saving (per year)	USD/a
Loss (USD/a)	Total		
		Protection (Total)	USD
Z1 Z2 Z3 Z4		VP	280.000
		Protection (per year)	USD/a
		AVP	28.000
		Benefit (per year)	USD/a
CRL = R'4 x ct	271	AVB = CL-CRL-AVP	28.914

Figure 2. "Cost/benefit" result for L4 (IEC 62305-2 Ed2)

B. Remarks to the results from IEC 62305-2 Ed2

As explained above, the "weighted risk" values R* in the zones underestimate the risk, especially if the relative zone factor is small against 1. If this would be true, the intensive care unit Z4 should not need any protection.

The total value of "weighted risk" R* for the whole structure makes no sense, because the risk can be considered only separately for each zone. The risk R*(Z1=outside) has nothing to do with the risk R*(Z4=intensive care unit). Therefore adding the risk values of each zone to a total sum is meaningless and should be forbidden.

Following the "cost/benefit" procedure of Annex D in IEC 62305-2 Ed2, the absolute loss values $C_L = R_4 \text{ x } c_t$ and $C_{RL} = R'_4 \text{ x } c_t$ are correct. Thus also the benefit result is correct.

C. Results for the hospital from advanced risk management

As shown in Fig. 3 for the **type of loss L1** (loss of human life) the per unit risk values R are considered **separately for each zone** (no sum for the whole structure is defined).

Without protection, the risk criterion $R \le R_T$ is not fulfilled in any zone except zone Z1 ($R=0{,}89 \cdot 10^{-5} < R_T$). Therefore protection is needed in the zones Z2, Z3, Z4 and the identical protection solution a) will be installed as before.

Using this solution zone Z2 is protected ($R=0{,}31 \cdot 10^{-5} \le R_T$), but zones Z3 and Z4 do not reach sufficient protection ($R=1{,}09 \cdot 10^{-5} > R_T$). This could be accepted, because $R \approx R_T$, or it can be easily amended by a better protection (e.g. coordinated SPD protection (2 x) better than for LPL I in zones Z3 and Z4).

Also for type of loss L1 the **annual value of saving AV_S** can be defined as difference of the absolute loss without and with protection: $AV_S = 0{,}699 - 0{,}003 = 0{,}696$ persons/a. The protection thus will avoid about 99,5% of the initial loss value.

An **economic benefit AV_B cannot be defined** for the type of loss L1, because the units of saving (persons/a) and of the annual cost of protection (USD/a) are incompatible.

Risk x1E-5 (1/a)	L1: Without Protection			
	Total R	RT	Result (Zone)	
Z1	0,89	1	R<=RT	Protected
Z2	67,76	1	R>RT	Protection needed !!!
Z3	139,53	1	R>RT	Protection needed !!!
Z4	139,53	1	R>RT	Protection needed !!!
Risk x1E-5 (1/a)	**L1: With Protection**			
	Total R	RT	Result (Zone)	
Z1	0,02	1	R<=RT	Protected
Z2	0,31	1	R<=RT	Protected
Z3	1,09	1	R>RT	Protection needed !!!
Z4	1,09	1	R>RT	Protection needed !!!

Figure 3. Advanced risk analysis result for L1

As shown in Fig. 4 for the **type of loss L4** (loss of economic values) the absolute annual loss values for the whole structure result in 57 185 USD/a (without protection) and in 271 USD/a (with protection). Thus the annual value of saving is the difference of both with $AV_S = 57\,185 - 271 = 56\,914$ USD/a. The protection thus will avoid about 99,5% of the initial loss value. With the same annual protection cost of 28 000 USD/a finally the annual benefit is $AV_B = 28\,914$ USD/a, and the economic benefit with the **criterion $AV_B > 0$** is justified.

L4: Without Protection			
Loss (USD/a)	Total		
Z1	0	Result (Structure) Values	
Z2	47.898		
Z3	7.832		
Z4	1.455		
Total	57.185	Values (Total)	USD
		VST	90.000.000
L4: With Protection		Saving (per year)	USD/a
Loss (USD/a)	Total	AVS = LST-LST'	56.914
		Protection (Total)	USD
Z1	0	VP	280.000
Z2	196	Protection (per year)	USD/a
Z3	63	AVP	28.000
Z4	12	Benefit (per year)	USD/a
Total	271	AVB = LST-LST'-AVP	28.914

Figure 4. Advanced loss analysis result for L4

D. Remarks to the results of advanced analysis

Generally the risk values ever shall be determined for any type of loss L1, L2, L3, L4 relevant for the structure to be protected (as exemplarily shown here in fig. 3). Neither any values nor their distribution into the zones must be known for this calculation. The risk values can be used for the risk analysis, but they are also needed later (together with the zone factors) to determine the loss values.

The risk analysis for L1 (loss of human life) is shown in fig. 3, considering the risk criterion $R \le R_T$ **separately for each zone**. It now gives realistic results for the risk R: High protection quality is needed for Z3 (operation bloc) and Z4 (intensive care unit), medium quality for Z2 (rooms bloc), and no protection for Z1 (outside). The per unit risk values R here in V are completely different to the "weighted risk" values R* above in IV.

Generally the loss values can be determined only, if all values and their distribution into the zones are known. If so, for all types of loss L1, L2, L3, L4 the loss values can be determined for each component, for each zone and for the whole structure (as exemplarily shown here in fig. 4). The loss values can be used for all types of loss L1, L2, L3, L4 to determine the **saving** as difference of the absolute loss without and with protection. As explained above, the **benefit is restricted** and therefore the **criterion $AV_B > 0$** can be performed only for the **types of loss L3, L4** to justify the economic benefit. The absolute loss values, the saving and the benefit are identical here in V and above in IV (even if this saving is not explicitly used in IV).

The loss analysis for L4 (loss of economic values) is shown in fig. 4. The results are the absolute loss values for each zone and their total sum for the whole structure. New is the useful result for the annual value of saving (difference of the absolute loss without and with protection) showing immediately the success of protection. Finally the annual benefit (same result as in IV) shows, that also the economic criterion is justified.

VII. CONCLUSION

The proposed advanced risk management is an evolution, which allows to solve remaining problems using the actual version of IEC 62305-2 Ed2.

The new per unit risk definition allows the risk analysis independently of the values to be protected and their distribution into the zones. For an identical zone the risk values remain constant, even if the values to be protected or their distribution are changed (which wrongly is not the case for the ”weighted risk” in IEC 62305-2 Ed2). The risk criterion $R \leq R_T$ shall be performed separately for each zone and thus allows a more detailed analysis.

For instance, for the type of loss L1 (loss of human life) protection is needed for a “dangerous” zone, if $R > R_T$, even in case that only one person may be present. The presence of other persons in other zones must not have any influence on this result.

The loss analysis can be performed only, if the values to be protected and their distribution are known. But then the newly defined annual saving (loss without minus loss with protection measures) will show immediately the success of protection.

IEC 62305-2 Ed2 suggests, that there would be two competing methods depending on the types of loss (risk analysis with criterion $R \leq R_T$ for L1, L2, L3 versus cost/benefit analysis with criterion $S_M > 0$ defined in Annex D for L4 only).

In contrary, the new advanced risk management emphasizes the consistent concept valid for all types of loss L1, L2, L3, L4, which includes the risk analysis as well as the loss analysis and the resulting saving. The only exception is the benefit definition, which can be used only for the types of loss L3 and L4. However the decision, if the structure is to protect and if so, with which quality, is fixed for the types of loss L1, L2 only to the risk criterion $R \leq R_T$, whereas for the type of loss L3, L4 the owner is free to use the risk criterion $R \leq R_T$ (defining its own R_T value) or to use the benefit criterion $AV_B > 0$.

REFERENCES

[1] M. Darveniza (AUS), Z. Flisowski (PL), A. Kern (D), E.U. Landers (D), C. Mazzetti (I), A. Rousseau (F), J. Sherlock (GB), G.B. Lo Piparo (I), "Application problems of the probabilistic approach to the assessment of risk for structures and services", Proceedings of the 26th Iternational Conference on Lightning Protection ICLP 2002, pp. 821-826, Cracow, Sep. 2002.

[2] IEC 62305-1 Ed1: 2006-01, "Protection against lightning – Part1: General principles".

[3] IEC 62305-2 Ed2: 2006-01, "Protection against lightning – Part2: Risk management".

[4] IEC 62305-1 Ed2: 2010-12, "Protection against lightning – Part1: General principles".

[5] IEC 62305-2 Ed2: 2010-12, "Protection against lightning – Part2: Risk management".

[6] A.J. Surtees, A. Gillespie, A. Kern, A, Rousseau, "The risk assessment calculator as a simple tool for the application of the standard IEC 62305-2", Proceedings of the VIII Iternational Symposium on Lightning Protection VIII SIPDA, Sao Paulo, Nov. 2005.

[7] Hélio E. Sueta, Luis E. Caires, José Aquiles, Grimoni, Renan R. Duarte, "Development of a risk analysis computer program according to the IEC 62305-2", Proceedings of the X Iternational Symposium on Lightning Protection X SIPDA, Curitiba, Nov. 2009.