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THE RISK ASSESSMENT CALCULATOR AS A SIMPLE TOOL FOR THE APPLICATION OF THE STANDARD IEC 62305-2

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Abstract - IEC Technical Committee 81 has created the new IEC 62305 series of standards on Lightning Protection [1, 2, 3, 4, 5]. Working Group 9 has been tasked with developing Part 2 of this five part series. IEC 62305-2 [2] deals with the assessment and management of risk to structures and personnel. This document is currently in its FDIS (Final Draft International Standard) stage and has been circulated to National Committees.

This paper details the so-called Simplified IEC Risk Assessment Calculator software tool as described in Informative Annex J of IEC 62305-2. This tool is based on calculations and methods detailed in the standard and is intended as a simplified implementation of the more rigorous treatment of risk management found in the written document. The tool is designed to be relatively intuitive for users who wish to obtain an initial assessment of risk sensitivity, but should not be considered a substitute to a full understanding of the methods provided in the standard when dealing with more complicated structures or those where greater risks to personal or system operation are involved.

1 INTRODUCTION

The simplified IEC Risk Assessment Calculator is intended to function as a companion, and not alternative, to the written standard. Its intended purpose (and limitations) may be summarised as follows:

- To promote the risk management methods detailed in the standard in a simplified and user-friendly format, thereby gaining wider adoption within the lightning protection community by lightning protection installers and general contractors.
- To enable more general users of the IEC 62305-2 standard to conduct calculations on typical structures without requiring that they first have an in-depth knowledge of the details and methodologies covered in the body of the standard.
- The software does not implement the full functionality of the written standard – such an implementation would have added unintended complexity to the tool. Users are encouraged to use the written standard for a more detailed treatment of risk when assessing complicated structures or special circumstances.
- The tool is intended to provide an assessment of the risk components pertaining to relatively uncomplicated structures. As such, certain parameters found in the written standard are defaulted to fixed values within the software and the user only permitted to make selections from a limited subset of choices.
- It is not intended to handle the calculation of risk exposure to services [5].

2 OPERATION OF THE SOFTWARE TOOL

The user interface of the IEC Risk Assessment Calculator has been designed to fit on a single screen for ease of use. The user starts by making selections from drop-down selection boxes. After each selection, a complete recalculation of the background algorithms is automatically performed and the results are displayed in the “Calculated Risks” frame.

As with the written standard, the software tool calculates the risk components of the four areas of risk:

R_1 : The risk of loss of Human Life
R_2 : The risk of loss of Essential Service
R_3 : The risk of loss of Cultural Heritage value, and
R_4 : The risk of Economic loss

It further subdivides these risk components into the contributions from a direct lightning discharge and the contribution from an indirect discharge. These calculated risk components are then compared to “Tolerable Risk values” as provided in the standard. Where the calculated risk is lower than the tolerable risk, it is highlighted in Green. Likewise, where the calculated risk exceeds the tolerable risk, it is highlighted in Red, thereby indicating to the user that protection measures must be taken to lower the risk exposure.

The software tool is unable to provide direction as to how this should be achieved; rather, it is the responsibility of the user in conjunction with an understanding of the standard and the interaction of risk components, to make these adjustments. The tool does, however, provide the user with a quick and interactive means of assessing which parameters effect the particular risk component needing reduction and also of the relative sensitive of these parameters in making this adjustment. For the more experienced user, a report of the individual components associated with the four loss categories can be viewed by clicking the "Calculations" button (see [2]). This information can be printed and used in conjunction with the written standard to better analyse the risk results and determine protection measures to improve these where necessary.

Parameters used in the algorithms to calculate the risk components, are divided into three categories:

- Those where the user can make choices as per the options provided in the written standard.
- Those where the user's choices are restricted to a subset of the options provided in the written standard.
- Those where the values are fixed as constants and inaccessible to be altered.

This data can be viewed in Table 1 through to Table 6. The reference made here are to tables, equations and sections of IEC 62305-2 [2]. The equations and algorithms used in the software code, however, are not described in this paper due to the limited space.

The software tool offers standard windows based features including: the ability to print results, store and retrieve project files, use of interactive tooltips which provide guidance to the user as to the purpose of each drop-down control, an online upgrade facility and the ability to configure the interface for multiple languages and for multiple lightning ground flash density or isoceraunic maps. The interface currently supports seven different languages. The software has been developed in such a way as to allow National Committees to develop their own translations for local market consumption. The last features are intended to allow the IEC TC81 Working Group to update the database upon which the software relies, with new options and parameters as these become available. It is intended that updates of the software will be limited to releases that coincide with amendments to the written standard. No working group, or IEC central office, support of the software is envisaged. The tool is provided on an "as is" basis and is informative, not normative, to the standard.

3 SUMMARY

The Risk Assessment Software Calculator is a new approach being adopted by the IEC, under its Technical Committee 81, to promote the wider use of their standards by providing easy to use software tools. This concept is in its infancy, and as such, the authors are encouraging the lightning community to thoroughly test and evaluate the software and provide feedback to TC81 WG9 via their national committees. As stated at the outset, this software is intended as a "simplified" tool, and by no means exhausts all the possibilities which software implementation opens up. It can be expected that more comprehensive, commercial packages will become available in the future which will enable lightning protection experts to conduct more detailed risk assessment studies. For more information a comprehensive 17-page paper describing especially the algorithms is available upon request from the authors. Furthermore this paper will in due course be a part of the library function of the about the Risk Assessment Software Calculator [2]. This paper is a continuation of a paper given at the 2004 ICLP in Avignon, France [6] taking into account the latest changes and modifications in the Risk Assessment Software Calculator.

4 ACKNOWLEDGEMENTS

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5 REFERENCES

[1] IEC 62305-1, Ed. 1: *Protection against lightning - Part 1: General principles* (FDIS stage).
[2] IEC 62305-2, Ed. 1: *Protection against lightning - Part 2: Risk management* (FDIS stage).
[3] IEC 62305-3, Ed. 1: *Protection against lightning - Part 3: Physical damage to structures and life hazard* (FDIS stage).
[4] IEC 62305-4, Ed. 1: *Protection against lightning - Part 4: Electrical and electronic systems within structures* (FDIS stage).
[5] IEC 62305-5, Ed. 1: Protection against lightning - Part 5: Services (CDV stage).
[6] Surtees, A.J.; Gillespie, A.; Kern, A.; Rousseau, A.: Development of a risk assessment calculator based on a simplified form of the IEC 62305-2 standard on lightning protection. *27th International Conference on Lightning Protection (ICLP)*, Avignon (FR), 2004.

6 DATA ENTRY TABLES

TABLE 1: STRUCTURE UNDERGOING RISK ASSESSMENT		
L, W, H	Structure length in metres	**User entered**
H_p	Height of highest roof protrusion metres	**User entered**
r_f	Probability that a dangerous discharge will initiate a fire, explosion, mechanical destruction or chemical release *Annex C, Table C.4*	- Risk of explosion – 1.0 - High risk of mechanical and thermal effects. High or significant risk of fire or mechanical damage, roof of combustible material e.g. thatched roof - 10^{-1} - Ordinary risk of mechanical and thermal effects. Significant use of combustible building material, e.g. timber frame; or risk of mechanical damage, e.g. significant masonry dislodged - 10^{-2} - Low risk of mechanical and thermal effects (e.g. modern reinforced concrete building) - 10^{-3} - None - No risk of mechanical and thermal effects (all metal structure) - 0
Ks1	Screening effectiveness of external structure *Based on Annex B, Equation B.3*	- Poor - Brick, masonry, flammable material, timber or non conducting material, unprotected roof installations with electrical lines to inside, e.g. antennae - 1.0 - Average - Continuous reinforced concrete or steel columns or down conductors (maximum spacing 20m) - 0.2 - Good - All metal construction - 10^{-2}
Ks2	Screening effectiveness of zones internal to structure *Assume no internal spatial screening of zones inside building*	**Fixed** factor - 1.0
P_A	Probability that lightning will cause a shock to animals or human beings inside and up to 3m outside of the structure due to dangerous step and touch potentials *Annex B, Table B.1*	**Fixed** factor - 1.0 (i.e. No protection measures adopted)
D_m	Distance from structure that a lightning strike to ground creates a magnetic field great enough to induce an over-voltage exceeding the impulse level of equipment internal to the structure *Annex A, Section A.3*	**Fixed** factor - 250m

TABLE 2: ENVIRONMENTAL INFLUENCES		
C_d	Location factor (valid for direct strikes to structure) Describes the influence of the surrounding (as a function of their height) on the number of strikes direct to the structure undergoing risk assessment *Annex A, Table A.1*	- Structure in large area of structures or trees of the same height or greater height - 0.25 - Structure surrounded by smaller structures, e.g. tall building in a rural area – 0.5 - Isolated structure with no other structures or objects within a distance of 3 x height from the structure. e.g. structure in a rural area – 1.0 - Isolated structure on hilltop or knoll – 2.0
C_e	Environmental factor (valid for indirect strikes to the service lines) Describes the service line density, i.e. the probability of service lines to catch lightning induced magnetic fields, which is as a function of the surrounding *Annex A, Table A.4*	- Rural (i.e. sparse e.g. farms) - 1 - Suburban (e.g. large housing development or suburb; buildings usually lower than 10 m) - 0.5 - Urban (e.g. town or city; building's heights usually ranging between 10 m and 20 m) – 0.1 - Urban with tall buildings (i.e. buildings higher than 20 m) – 0
N_g	Annual ground flash density	**User entered**
T_d	Number of thunder days per year	Computed as information

TABLE 3: ELECTRICAL / ELECTRONIC EQUIPMENT LOCATED WITHIN THE STRUCTURE		
K_{s3}	Screening effectiveness of internal wiring type *Annex B, Table B.5 (reduced number of choices).*	- Unscreened wiring - 1.0 - Screened (continuously) wiring - 0.1
Ks4	Correction factor for rated impulse withstand voltage of equipment	**Fixed** factor - 1.0 (applies to rated impulse withstand voltage of 1.5 kV)

TABLE 4: CONDUCTIVE SERVICE LINES *There are three types of service lines – power (can be either overhead or underground), other overhead, and other underground. Any number of service lines can be selected.* *Note: they must be in different routes, and for each route the worst-case service line attributes must be entered.*		
General assumptions for all types of service lines		
L	Length of service lines (power, other overhead, other underground) *Based on Annex A, Table A.3*	**Fixed** value - 1000m (the effective length of the service lines is determined from the selection of C_d and C_e)
L_a, W_a, H_a	Dimensions of adjacent structure *Simplification made - assume there are no adjacent structures having impact on the number of direct strikes to the service lines*	**Fixed** value - 0m
Power Lines:		
pl	Power line type.	- Aerial - 1.0 / Buried - 2.0 / None – 0
P_{LD0} P_{LI0}	Probability of failure of electrical/electronic equipment due to direct (P_{LD0}) or indirect (P_{LI0}) strikes to power service line based on external wiring type *Annex B, Table B.6 and Table B.7 (reduced number of choices).*	- Unscreened wiring - $P_{LD0} = P_{LD0} = 1.0$ - Screened cable with screen earthed or wiring in continuous metal conduit that is earthed - $P_{LD0} = 0.4$ / $P_{LI0} = 0.02$
C_{t0}	Correction factor for the presence of a distribution transformer Annex A, Table A.4 (Note: A transformer is only possible for the power line)	- line without a transformer - 1.0 - line with a two windings transformer - 0.2 (HV/LV-transformer or isolation transformer)
Other Overhead Service Lines:		
n_{oh}	Overhead Service Lines in separate routes	**User entered** - number of overhead service lines in separate routes
P_{LD1} P_{LI1}	Probability of failure of electrical/electronic equipment due to direct (P_{LD1}) or indirect (P_{LI1}) strike to other overhead service lines based on external wiring type *Annex B, Table B.6 and Table B.7 (reduced number of choices)*	- Unscreened wiring - $P_{LD1} = P_{LD1} = 1.0$ - Screened cable with screen earthed or wiring in continuous metal conduit that is earthed - $P_{LD1} = 0.4$ / $P_{LI1} = 0.02$
H_{cl}	Height of conductors above ground	**Fixed** value - 6m
D_{L1}	Lateral distance away from the overhead line at which the effects of indirect strikes need to be considered Based on *Annex A, Table A.3*	**Fixed** value - 500m
Conductive Underground Services - Electrical Services		
n_{ug}	Number of underground service lines in separate routes	**User entered** - number of underground service lines in separate routes
P_{LD2} P_{LI2}	Probability of failure of electrical/electronic equipment due to direct (P_{LD2}) or indirect (P_{LI2}) strike to other underground service lines based on external wiring type *Annex B, Table B.6 and Table B.7 (reduced number of choices)*	- Unscreened wiring - $P_{LD2} = P_{LD2} = 1.0$ - Screened cable with screen earthed or wiring in continuous metal conduit that is earthed - $P_{LD2} = 0.4$ / $P_{LI2} = 0.02$
2	Soil resistivity.	**Fixed** factor - 500 ohm metres.

TABLE 5: TOLERABLE RISK AND LOSS FACTORS FOR THE INDIVIDUAL TYPES OF LOSS		
Type of Loss 1 - Loss of Human Life		
h_1	Special hazards Increasing factor applied to damage factor for fire and overvoltage when risk of loss of human life is aggravated by special hazards *Annex C, Table C.5*	- No special hazard – 1 - Low level of panic (building with less than three floors and less than 100 people) – 2 - Difficulty of evacuation, immobilised people – 5 - Average level of panic (sport or cultural structure with between 100 and 1000 people) – 5 - High level of panic (theatres, concert halls, cultural & sport events with more than 1000 people) – 10 - Hazards for surroundings or environment – 20 - Contamination of surroundings or environment – 50
L_{f1}	Loss factor for fire *Annex C, Table C.1*	- Hospitals, hotels, civil buildings - 0.1 - Industrial properties, commercial activities, schools, offices - 0.05 - Public entertainment buildings, churches, museums - 0.02 - Other structures - 0.01
L_{o1}	Loss factor for overvoltages *Annex C, Table C.1* *(option "0" added).*	- Properties with risk of explosion – 10^{-1} - Hospitals - 10^{-3} - Structures with safety critical systems e.g. high rise buildings with elevator - 10^{-5} - Structures with no safety critical systems - 0
R_{T1}	Tolerable risk Loss of human life or permanent injuries per year *Section 5.4, Table 7*	**Fixed** value for loss of human life - 10^{-5}
L_{t1}	Loss factor for step and touch voltages (due to step and touch voltages inside, and up to 3m outside, the structure) *Annex C, Table C..*	**Fixed** value - 10^{-4}
r_a	Reduction factor for step and touch voltages as a function of the type of surface of soil or floor *Annex C, Table C.2 (worst case assumed)*	**Fixed** value - 10^{-2}
Type of Loss 2 – Unacceptable Loss of Essential Service to the Public		
L_{f2}	Loss factor for fire *Annex C, Table C.6*	- Gas supply, water supply - 10^{-1} - Radio, TV, telecommunications, power supply, railway - 10^{-2} - No essential service function associated with the structure - 0.0
L_{o2}	Loss factor for overvoltages *Annex C, Table C.6*	- Gas supply, Water supply - 10^{-2} - Radio, TV, telecommunications, power supply, railway - 10^{-3} - No essential service function associated with the structure - 0.0
R_{T2}	Tolerable risk Loss of essential service to the public per year *Section 5.4, Table 7*	**Fixed** value for unacceptable loss of service to the public - 10^{-3}
Type of Loss 3 - Loss of Cultural Heritage *(It is assumed that there are no necessary electronic devices inside)*		
L_{f3}	Loss factor for fire *Annex C, Section C.4*	- Typical value - 0.1 - No cultural heritage value - 0.0
R_{T3}	Tolerable risk Loss of cultural heritage per year *Section 5.4, Table 7*	**Fixed** value for loss of cultural heritage - 10^{-3}

TABLE 5: CONTINUED		
Type of Loss 4 - Economic Loss *Consequently the procedure to evaluate the economic convenience of protection measures has to be based on a pure economic consideration (see IEC 62305-2, Section 5.6 and Annex G). However, in this simplified software the realization of this investigation of the cost-effectiveness of protection measures is not possible due to the in that case in addition necessary input parameters. Therefore, like for the types of loss 1 – 3, also for the economic loss a value for the tolerable risk has to be selected by the user. It has to be clearly stated, that this simplified procedure is not fully in line with the procedure in the written standard.*		
h_4	Increasing factor applied to situation where environmental hazards exist *Annex C, Table C.5 (reduced number of options)*	- No special hazard – 1 - Hazards for surroundings or environment – 20 - Contamination of surroundings or environment – 50
L_{f4}	Loss factor for fire Unacceptable economic loss due to fire (average value of possible loss / total value of structure, contents & activities). *Annex C, Table C.7* *(estimated values for different structures).*	Typical values of economic loss: - Hospitals, industrial properties, museum, agricultural properties - 0.5 - Properties for public use, hotels, offices, schools, commercial activities, public entertainment, churches - 0.2 - Others - 0.1
L_{o4}	Loss factor for overvoltages Unacceptable economic loss due to overvoltages (average value of possible loss / total value structure, contents & activities). *Annex C, Table C.7* *(estimated values for different structures).*	- Risk of explosion – 10^{-1} - Hospitals, hotels, industrial properties, offices, commercial activities - 10^{-2} - Museum, properties for public use, agricultural properties, schools, public entertainment, churches – 10^{-3} - Others - 10^{-4}
L_{t4}	Loss factor for step and touch voltages Unacceptable economic loss due to step and touch voltages inside, and up to 3m outside, the structure. *Annex C, Table C.7.*	- Agricultural properties with animals inside or outside the structure – 10^{-2} - Agricultural properties with no animal shock risk – 0
R_{T4}	Tolerable risk Economic loss per year.	- Depends on the structure owner's requirement. Range available is 10^{-1} … 10^{-5} - Suggested default value if unknown – 10^{-3} (i.e. 1 in 1000 year probability of economic loss; this is the same value like for type of loss 3 – unacceptable loss of service to the public).

TABLE 6: PROTECTION MEASURES IMPLEMENTED IN THE STRUCTURE		
E	Reduction of the probability of damage due to a Lightning Protection System (LPS) depending on the class of the selected LPS Takes into account interception and sizing efficiencies *Annex B, Table B.2*	- Class I – 0.02 - Class II – 0.05 - Class III – 0.1 - Class IV – 0.2 - No LPS protection – 1.0
r	Reduction factor for fire protection measures *Annex C, Table C.3.*	- No protection measures - 1.0 - Extinguishers, hydrants, manual alarm installations, fixed manually operated extinguishing installations - 0.5 - Protected escape routes, fire proof compartments, automatic alarms protected from overvoltage, automatically operated extinguishers, operating time of escape routes less than 10 minutes - 0.2
SP	Surge protection Note: The user's selection of surge protection applies to all services and the entire structure being protected. Assumes surge protection is applied to either all OR none of the internal equipment within the structure.	- No surge protection – 0 - Equipotential bonding SPDs at the entry points of service lines – 1.0 - Full Surge Protection "*Coordinated SPD protection*" as detailed in IEC 62305-4: - 2.0

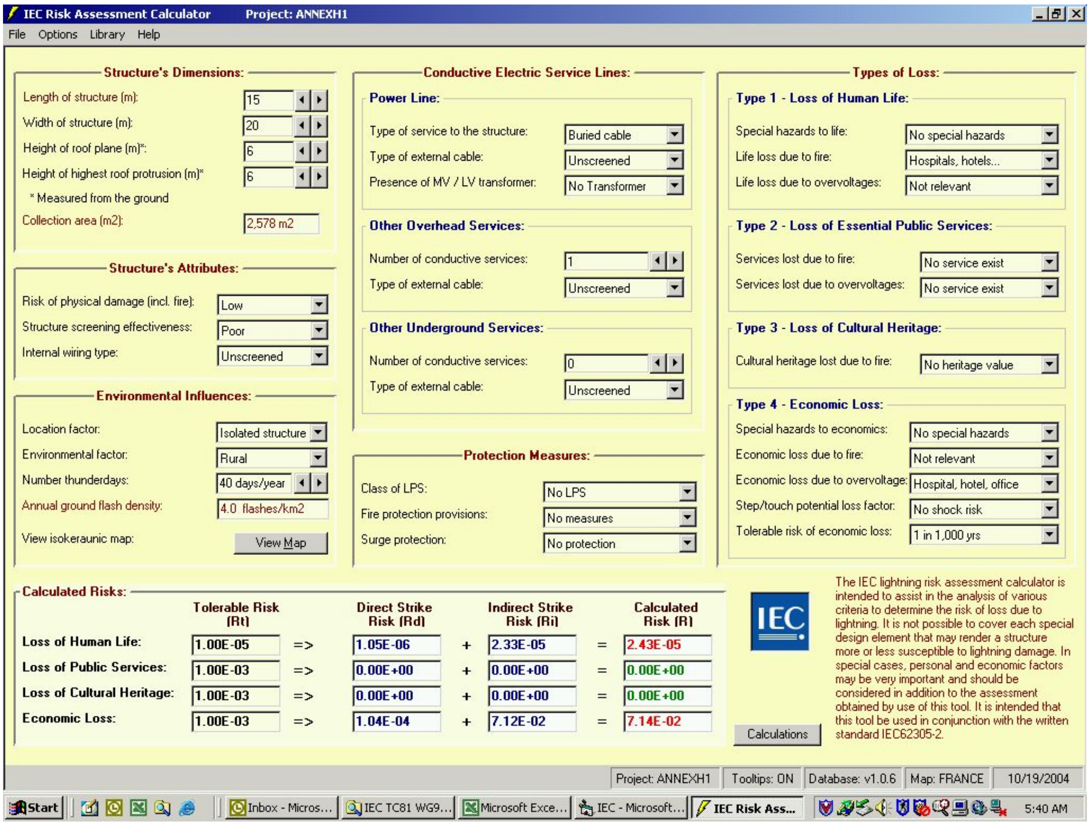

Figure 1 - Main User Interface showing user-entered input parameters and menu structure (example 1 of IEC 62305-2, Annex H – without protection measures).

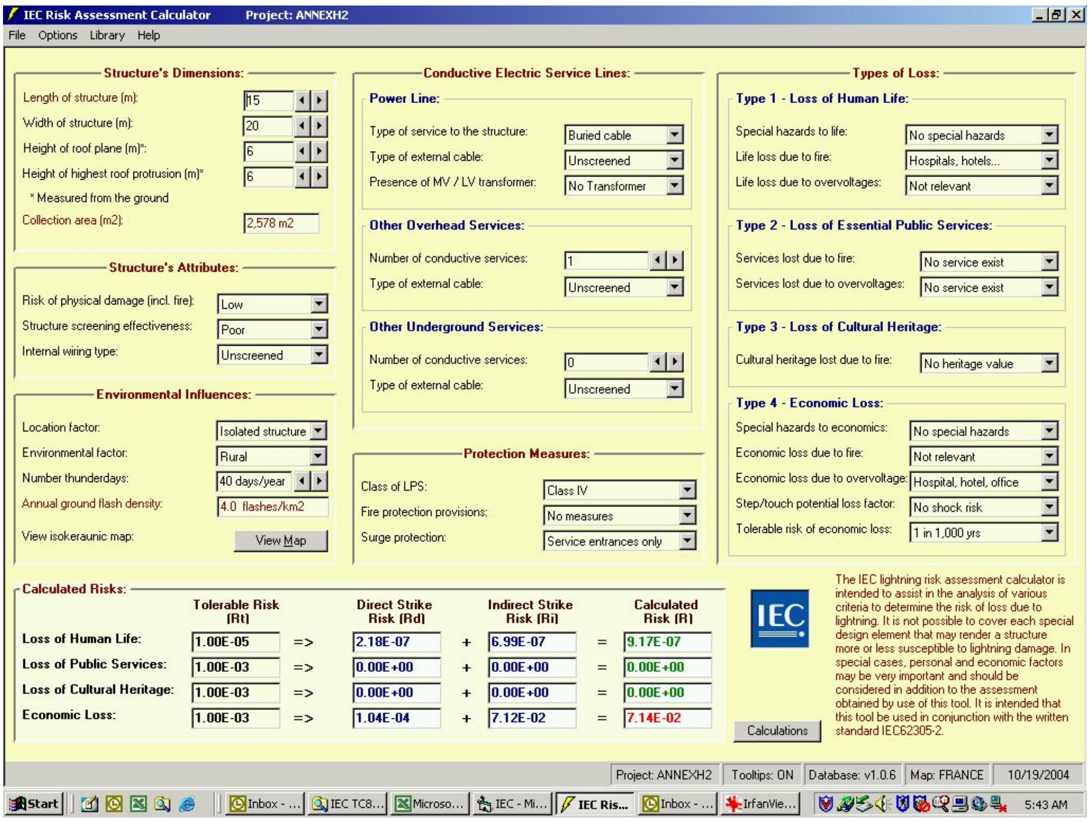

Figure 2 - Main User Interface showing user-entered input parameters and menu structure (example 1 of IEC 62305-2, Annex H – with protection measures).