1 INTRODUCTION

A systemic framework for objective and credible assessment of risks is developed and proposed to underpin qualitative or quantitative approaches to this discipline. This is broadly referred to as the Seven Stage Risk Assessment Process here referenced as SSRAP. The process and its rationale are detailed in an ESSS Code of Practice (ESSS_COP_RA_01).

To demonstrate the purpose and functions of each one of seven-stages in the systematic approach to evaluation and management of risks, a series of Case Studies are conducted, each generally focused on a particular stage within the process. These Case Studies are generally illustrative and are intended to supplement and support the training programme for the SSRAP, developed and offered by ESSS.

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1.1 Purpose

When using quantitative techniques for risk assessment, known as fault tree and consequence tree analysis, it is necessary to identify the most important base events and barriers.

The purpose of this report is to present a technique for computation of importance and apportionment, applied to Cause-Consequence models, developed by ESSS.

1.2 Scope

This paper depicts a process for assessment of importance of Base events to the frequency or probability of Critical Event and Base Events and Barriers to the risk (product of frequency or probability of consequence and loss of the consequence) of the Consequences arising from the Critical Event.

Importance is defined as a measure of the contribution a component makes to the top event probability or frequency or to the consequence probability or frequency.

Apportionment is defined as a measure of the fractional contribution a component makes to the top event probability or frequency or to the consequence risk, relative to the total of contributions of all the other components of the logical structure of the Cause-Consequence model.

2 APPORTIONMENT AND IMPORTANCE ANALYSIS

2.1 Cause-consequence model tree

For the purpose of understanding the process to be described lets assume following model structure. Two hazards are modelled using the cause-consequence modelling technique. Two independent models are subsequently integrated into one model. This integration is achieved trough grouping of similar consequences into entities refereed to as Virtual Consequences.

The two hazards are presented by two Critical Events, “K” and “H”. Critical Event “K” is caused by three base events, Xa, Xb and Xc and Critical Event “H” is caused by three base events, Ya, Yb and Yc. There are two mitigating measures, Barriers X1, X2, Y1 and Y2, in place between both Critical Events and the corresponding Source Consequences, SCX1, SCX2, SCX3,. SCY1, SCY2, and SCY3. Source Consequences are defined as consequences emerging directly from the hazard. Two models are integrated by means of grouping the similar consequences into higher level groupings, refereed to as Virtual Consequences. For example, Source Consequences SCX1 and SCX2 are assumed to be similar and hence these two are grouped/merged into the Virtual Consequence VCL11. Following the same logic, Virtual Consequences VCL11 and VCL12 are assumed to be similar and the two are merged into the Virtual Consequence VCL21.

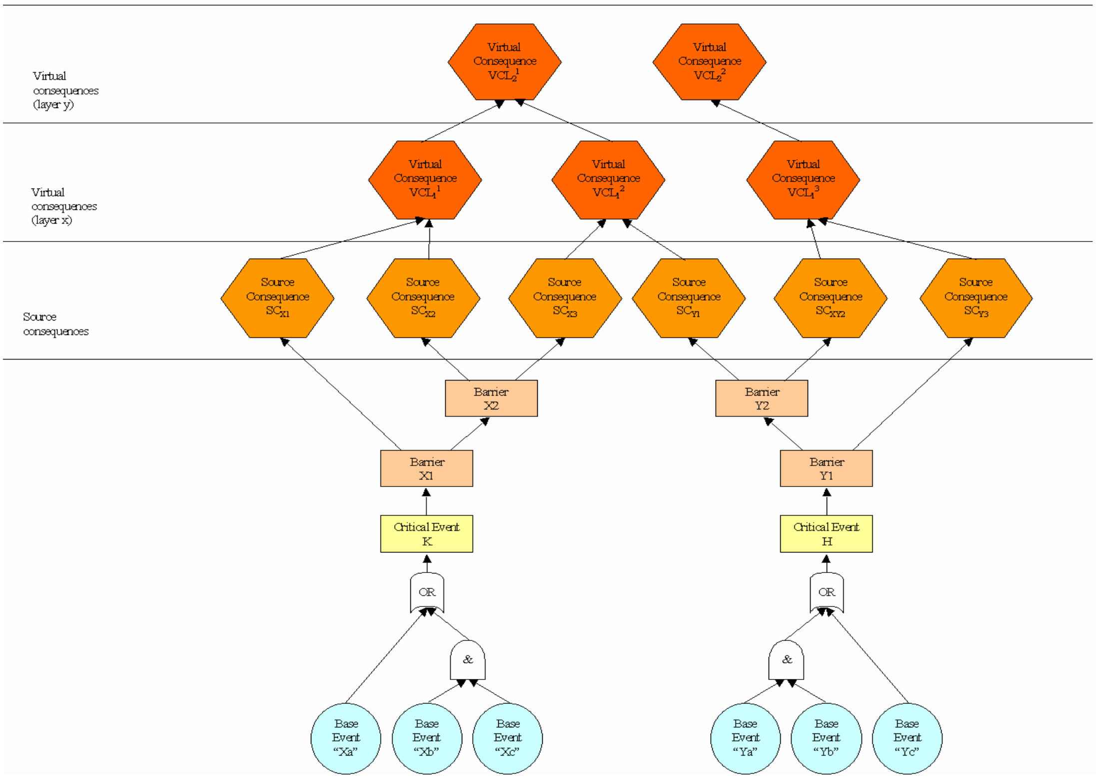

Figure 1: Example of an integrated Cause-Consequence model

2.2 Apportionment of a Consequence to lower level Consequences

Apportionment of a Consequence generated in a model to the lower level Consequences is calculated as a proportion of the Risk contributed to the Consequence by the lower layer Consequences. Therefore, if R_{vj}^{l} is a risk of the Consequence ‘j’ (1 ≤ j ≤ n) at Layer ‘l’ (1 ≤ l ≤ n), then,

$$R_{vj}^{l} = \sum_{i=1}^{i=n} R_{vi}^{l-1} \qquad \textit{equation 1}$$

Hence, fractional contribution of the Consequence ‘x’ (1 ≤ x ≤ n) at lower layer ‘l-a’ (1 ≤ l ≤ n; 1 ≤ a ≤ n; l > a) to the Consequence ‘j’ (1 ≤ j ≤ n), at layer ‘l’ equals to:

$${}^{vj}A_{vx}^{l-a} = \frac{R_{vx}^{l-a}}{R_{vj}^{l}} = \frac{R_{vx}^{l-a}}{\sum_{i=1}^{i=n} R_{vi}^{l-a}} \qquad \textit{equation 2}$$

Where:

R_{vx}^{l-a}	Is a risk of the lower layer Consequence ‘x’ (1 ≤ x ≤ n), at layer ‘l-a’ whose contribution is calculated.
R_{vj}^{l}	Is a risk of the Consequence ‘j’ at layer ‘l’ analysed.

2.3 Apportionment of a Consequence to Source Consequences

Source (Real) Consequences are consequences arising directly from the model before any grouping has taken a place.

If R_{vj}^{l} is a risk of the Consequence ‘j’ at any layer ‘l’ and ${}^{vj}R_{si}^{cek}$ is a risk of any Source Consequence ‘i’ (1 ≤ i ≤ n), arising from any Critical Event ‘k’ (1 ≤ k ≤ n) and feeding the Consequence ‘j’, then,

$$R_{vj}^{l} = \sum_{k=1}^{k=n} \sum_{i=1}^{i=n} {}^{vj}R_{si}^{cek} \qquad \textit{equation 3}$$

Where:

$\sum_{k=1}^{k=n} \sum_{i=1}^{i=n} {}^{vj}R_{si}^{cek}$	Is a total of risk of all Source Consequences ‘i’, comprising the similar losses, and arising from different Critical Events ‘k’

Hence, the fractional contribution of the Source Consequence ‘y’, arising from the Critical Event ‘h’ and feeding the Consequence ‘j’, to the Consequence ‘j’ at any layer ‘l’ equals to: