

## Guidance Document

# G1299

# Guidance on Civil Engineering Asset Strategic and Tactical Risk Models

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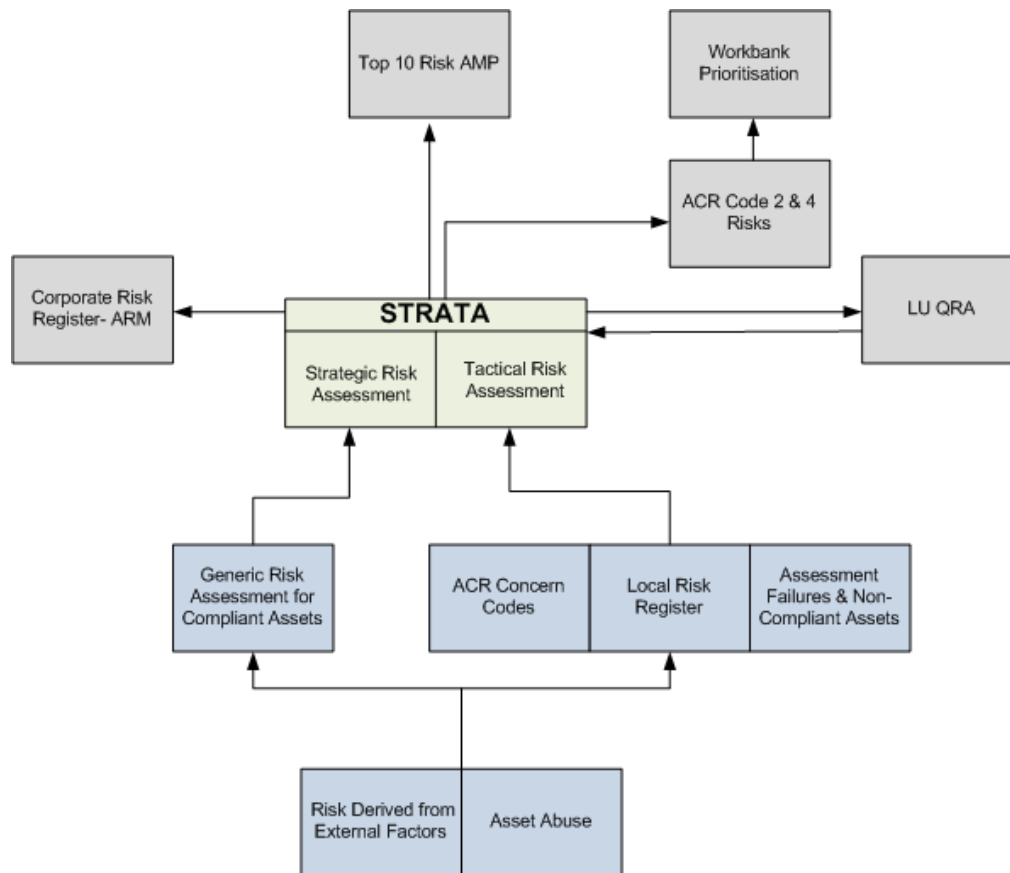
## 1 Purpose

- 1.1 The purpose of this Guidance is to describe a process that can be used to identify, record, assess and report performance and safety risk presented by the Civil Engineering asset (note that in the current version of STRATA performance risk is calculated from NACHs values attributable to service loss). The guidance describes the main elements of the framework, operation of the process, and how outputs are used to report risk or communicate to other processes within LU. A diagram showing the overall structure of the model is included in this guidance as Figure 2 on Page 26.

## 2 Scope

- 2.1 This guidance applies to anyone with responsibility for any aspect of Civil Engineering asset within LU; and also to anyone engaged in any process that is informed by Civil Engineering asset risk. The scope of the guidance is to enable users to understand:
- a. Process responsibilities and accountabilities (Section 3.1 and Section 4).
  - b. The structure and main elements of the process (Section 3.2 and Section 3.3).
  - c. How to operate the process and retain a suitable audit trail (Section 3.4).
  - d. Process outputs and use as reports or as information feeds to other processes (Section 3.5).
  - e. Interfaces with other risk process and models in LU (Section 3.6).
  - f. Process elements maintenance and update (Section 3.7).
- 2.2 This document describes the principles and method applied to evaluate and manage performance and safety risk arising from London Underground Civil Engineering assets excluding those on the Jubilee, Northern and Piccadilly Lines currently managed by JNP.
- 2.3 The Civil Engineering Asset Strategic and Tactical Risk Models (STRATA) are one element within the overall architecture for management of Civil Engineering asset risk. This guidance relates closely to Document G1235 Process for Managing Civil Engineering asset risk; particularly in relation to information exchange and interaction between elements within the overall architecture.
- 2.4 The key relationships between the risk models used to assess and manage Civil Engineering asset risk are shown in the Figure 1 below:

Figure 1 : Overview of Models used to support Civil Engineering Asset Risk Management



- 2.4 In addition to the above diagram; Appendices B (Civil Engineering Asset Risk Management Process - Page 32) and C (Local Risk Register Process - Page 33) provide context for STRATA within the overall business management arrangements.

### 3 Guidance

#### 3.1 Civil Engineering Asset Risk Process Responsibilities and Accountabilities

- 3.1.1 Responsibilities and accountabilities for the Civil Engineering Asset Risk Process are tabulated in the RACI matrix agreed by all stakeholders. A list of stakeholders is included in this guidance under Section 4 – Responsibilities.

#### 3.2 Civil Engineering Asset Risk Process Overview

- 3.2.1 The Civil Engineering asset risk process is intended to provide a single facility for identification, recording, assessment and application of Civil Engineering asset risk information. The process is structured to provide consistent risk information using the best available asset data and to provide outputs that are directly usable in other LU risk processes.
- 3.2.2 A fundamental assumption in the Civil Engineering asset risk process is that the Civil Engineering asset is essentially benign (i.e. does not present performance or safety risk) unless or until it behaves in a way outside its design intent. This is summarised in five behaviour descriptions for each asset sub type aligned with the asset definitions used as the basis for Asset Condition Reporting (ACR). This is discussed in more detail in Section 3.3 below.

- 3.2.3 The process uses a three stage assessment method to evaluate safety risk. This recognises that, while asset behaviour has a likelihood of occurrence and a safety impact, the safety impact will not happen each and every time the behaviour occurs. For this reason a conditional probability is applied to the behaviour likelihood to evaluate safety risk. This mimics a highly simplified event tree as employed to model safety impacts in the LU QRA. By contrast performance impact is assumed to result every time the behaviour occurs.
- 3.2.4 Risk presented by the Civil Engineering asset is concentrated in a subset of the total asset population. Assets that are compliant with relevant standards, do not exhibit known condition concerns (as defined by ACR), are not unduly susceptible to external damage and do not have any other tendency to any of the behaviours on account of location or intrinsic properties, present a relatively low and residual risk. These are grouped within the risk process under Strategic Risk Assessment (SRA).
- 3.2.5 The majority of risk attributable to the Civil Engineering asset arises from assets that are known to be non compliant or exhibit condition concerns, or that have any of the tendencies to behaviour discussed in paragraph 3.2.4 above. To address the issue of concentration of risk in a subset of the population, and to ensure resource is deployed only where it will add value, the Civil Engineering asset risk process operates at two levels. Each asset within this group is subject to an individual Tactical Risk Assessment (TRA).
- 3.2.6 Strategic assessment (SRA) assigns a risk level to all assets that do not require a specific assessment. Risk is assessed at whole asset level on the basis of asset sub type and line. The likelihood is assumed to be shared between all assets in the assessed group. Safety impact and conditional probability is assumed to be the same for all assets in the group. Performance impact duration is assumed to be the same for each asset in the group. For SRA, likelihood is selected from a pre defined list (subject to suitable justification); and the performance impact effect and duration is that defined in the asset rules table (see paragraph 3.3.2 below). No variation from the pre defined values is permitted for SRA.
- 3.2.7 Tactical assessment (TRA) evaluates performance and safety risk for a particular asset that exhibits one or more of the characteristics described in paragraphs 3.2.5 above; or where the business believes that a specific risk assessment is required for the asset for any other reason. TRA assigns an asset specific behaviour likelihood, safety impact and conditional probability to the asset. Performance is evaluated on the basis of the impact at the location. In the general case likelihood is selected from a pre defined list (subject to suitable justification); and the performance effect and duration is that defined in the asset rules table (see paragraph 3.3.2 below). However, TRA includes the capability to modify likelihood, and performance effect and duration to specific values where this is necessary for a particular asset.
- 3.2.8 In practice the risk process at SRA and TRA level is operated through a single spreadsheet file which contains all rules and reference information (as discussed in Section 3.3 below). The Strategic and Tactical Risk Assessment (STRATA) uses a single form to carry out safety and performance risk assessments. The difference between strategic and tactical assessment is in the way the risk information is applied when updating the data table. The data is either applied to a single line in the table asset (TRA); or apportioned across multiple lines in the data table corresponding to all assets within the asset sub type/line combination (SRA).

### 3.3 Risk Process Information Modules

- 3.3.1 The Civil Engineering asset risk process is built up from a number of tables and lists that define and control the core model parameters (referred to in subsequent paragraphs as modules). Paragraphs 3.3.2 to 3.3.5 below describe the content of each module and its function within the process. Modules are subject to ongoing review and update as the risk process develops. The definitive versions of the

modules reside within the current electronic version of STRATA located in Civil Engineering core asset information. Hence this guide does not include hard copy versions of the modules. Users wishing to view or review the current modules are referred to the current version of the STRATA file.

- 3.3.2 **Asset Rules Tables.** In order to achieve consistency in risk assessments certain parameters are fixed in a formal rules table for the particular asset group. These Asset Rules Tables (four in total; one each of Bridges & Structures; Deep Tube Tunnels; Earth Structures and Pumps & Drainage) are subject to review and approval by the relevant Profession Head. Note that Track Drainage is included in the current version of the rules tables although ownership currently resides with the Track asset discipline. The parameters specified in the rules tables are then called forward by the model and used in calculation of performance and safety risk. The elements included within asset rules table are:
- Asset Definition.** The asset is defined in terms of asset type (e.g. Bridges and Structures) and asset sub types (e.g. cable and pipe bridge; footbridge etc). These definitions are part of the annual asset condition reporting process (ACR). The asset rules tables mimic the ACR asset definition to ensure consistency in risk assessment (and hence ready use of risk model outputs) with the asset management process. Asset definitions are owned within the ACR and are reviewed and approved by Civil Engineering asset Profession Heads as part of the annual cycle.
  - Asset Behaviours.** Asset behaviours are defined in five categories that are believed to represent the full range of potential behaviours through which the asset can present a risk. Specifically the behaviours are Immediate Complete Collapse (ICC); Progressive Complete Collapse (PCC); Partial Collapse (PC) Loss of Integrity (LOI) and Structural Distortion (SD). The rules tables define these scenarios in terms of physical asset characteristics for each asset sub type/behaviour combination (or notes where the behaviour is not considered credible for the combination). These definitions ensure that behaviour likelihoods are assigned on a consistent basis for particular assets. Behaviour definitions are owned by the Civil Engineering asset Profession Heads.
  - LU QRA Top Event Match.** This is a key rule set to determine the credible safety impacts arising from particular asset behaviours; and supports reporting of asset/behaviour/likelihood information to the LU QRA. Each asset sub type has a set of LU QRA Top Events assigned that (in the view of the Profession Head; taking account of the Top Event definitions) represent credible safety outcomes. These are included as an integral part of the STRATA risk form. Assigning safety impacts directly derived from the LU QRA Top Events enables generates reports that link Civil Engineering asset behaviour likelihoods with LU QRA base events on a line specific basis. The Top Events used are those defined by HSE at the time of the assessment; and for working purposes can be taken as those in the most recent LU QRA Summary Report. Change to Top Event definitions or structure would prompt an STRATA/LU QRA match review initiated by HSE as discussed in Section 3.6 below. LU QRA Top Event matching is owned by the Civil Engineering asset Profession Heads.
  - Performance Impact Type and Duration.** The basis of performance impact is derived from the most probable service disruption effect and duration attributable to asset behaviour together with the unit financial values applicable to the type of disruption at the asset location. The rules tables include generic estimates of the duration and percentage effect of asset behaviours in terms of partial line closure and full station closure (full line closure is not considered credible). These are used to generate location specific financial values (derived from NACHS) applicable to the asset and location. The financial values are site specific for station closure and zoned for partial line closure. TRA includes the capability to vary performance durations and percentage effect from the generic values for a particular location.

Performance impact is calculated on an individual asset basis for the whole asset population irrespective of whether the asset is subject to SRA or TRA. The model assumes that performance impact will be experienced at the specified levels for each and every behaviour event (i.e. no conditional probability is applied). Performance disruption type and duration definitions are owned by the Civil Engineering asset Profession Heads.

- 3.3.3 Likelihood rating scales (including likelihood and conditional probability).** The risk assessment process requires that a likelihood value be assigned to the each behaviour that is considered to be risk initiator (up to a maximum of three behaviours). Likelihood can be assigned as a SRA value, in which case it represents the likelihood of the behaviour as a total value across the total number of assets in the defined asset sub type/line combination; or as a TRA value in which case it represents the likelihood of occurrence of the behaviour for a particular asset. For TRA the likelihood may be judgemental (selected from a pre defined scale); or, if detailed assessment data or other evidence is available, assigned as a point value. The basis of SRA likelihood assignment will always be judgemental. The method includes a judgemental likelihood scale based on descriptions of the chance that the behaviour will occur in a year. All Civil Engineering asset safety risk assessments (SRA and TRA) in STRATA require a conditional probability value (see 3.2.3 above and Section 3.4 below). This is based on a judgemental scale of the chance that that the behaviour will result in the selected safety impact; performance impacts are assumed to result from each occurrence of a behaviour. The likelihood and conditional probability scales form a module within the spreadsheet.
- 3.3.4 Safety Impact Linkage to the LU QRA.** A key feature of Civil Engineering asset risk assessment is that safety impacts are derived directly from LU QRA data (the definitive source of safety impact in LU). Tables that mimic the line specific LU QRA event trees are included as modules in STRATA. These include decision points in the relevant LU QRA event sequence; and the sequence end point fatality and weighted injury values. The event tree decision points are carried forward into the risk assessment form as linked selection lists that call forward safety impact values from the relevant line event sequence end points.
- 3.3.5 Performance financial impact.** Financial impact arising from performance shortfall is evaluated using values derived from NACHs 2014. At present the credible performance effect of the Civil Engineering asset is limited to averaged values for full station closure and partial line suspension. Adjustment to partial station closure is effected through application of the percentage effect factor for the asset sub type/behaviour combination in the asset rules tables. These two performance categories are considered sufficient to estimate performance impact for current purpose; although the categories and application may be extended in a future version of the model. The performance financial impact module includes day averaged full station closure NACHs values; and zoned partial line closure NACHs values for all LU stations and lines (including JNP to future proof STRATA for additional scope). These unit performance values are combined with the duration and extent for asset sub type/behaviour combinations defined by the Profession Head which in the asset rules tables (see 3.3.2 (d) above).

## 3.4 Process Operation – Risk Review and Update

- 3.4.1 Combined Strategic Risk Assessment and Tactical Risk Assessment (STRATA).** The assessment process is operated through a single spreadsheet. The core of the file is a table containing a data line for each non JNP Civil Engineering asset aligned with the asset catalogue (Ellipse). The file is accessed through an entry sheet containing a set of buttons. Navigation through the file and access to reports and outputs is carried out using the buttons to step from sheet to sheet. Many of the key parameters in the risk assessment are encapsulated in the information modules (the set of tables and lists that define and control the core model parameters) – see Section 3.3 above. A single proforma is used to assess risk. The proforma is either

applied to a single asset (TRA) or to the group of asset sub type/line combination that are covered by SRA. The following sub sections set out the process for completion of a Civil Engineering asset risk assessment and the key practical differences between SRA and TRA. To help understanding of the process and operation Figure 2 (Page 26) shows an overview of the structure of STRATA; and Figure 3 (Page 27) is a diagram of the risk review and update process

**3.4.2 Terminology protocol.** To assist the user; in the following description operation of a button is shown in *red italic text*. Terminology used below matches the title cells in the Risk Assessment Form adjacent to the fields being edited.

**3.4.3 Recall of the existing risk assessment data.** Each asset in the risk data table (and therefore each asset in Ellipse) has individual risk data assigned. New risk assessments will be required only where an asset is added to the catalogue. In such cases addition of the asset and assigning of initial risk values will be carried out by the process administrator in consultation with the relevant Profession Head. In order to review or update a risk the existing risk information should be recalled from the data table. The following describes the process for recall and editing from opening the file which automatically displays the Entry Sheet.

- Access the Risk Review Sheet. Operate the *Risk Assessment Form* button on the Entry Sheet.
- Select whether you wish to edit a TRA (specific asset) or SRA (group of compliant assets) using the dropdown list 'Select Assessment Type'.
- Where a TRA is being retrieved; enter the asset LCS/Asset No code against the 'Enter Asset Code' box. This will auto populate the 'Asset Location' and 'Current Assessment Type' boxes.
  - Where the 'Asset Location' and 'Current Assessment Type' boxes show error messages the LCS/Asset No reference does not match that in the master data table.
  - Where the 'Current Assessment Type' box shows 'SRA' the asset is currently assigned to the SRA population. In this case a TRA can be created if required.
  - It is acceptable for a competent user to assign a risk assessment regime different to that recommended. In such a case this must be justified in the corresponding box to assure model information credibility and integrity.
- Where a SRA is being retrieved; Select the 'Asset Type'; 'Asset Definition' and 'Line' from the drop down lists against the corresponding yellow boxes.
- Operate the *Retrieve Risk* button.
- The existing risk information for the specific asset (TRA); or asset sub type/line combination (SRA) you have selected will then be recalled to the Risk Review Sheet.
- The list of assets covered by a SRA can be accessed from the Risk Review sheet by operating the *Show SRA Contributors* button to navigate to the SRA Contributors sheet.
- The list of assets covered by a SRA can be accessed from the Risk Review sheet by operating the *Show SRA Contributors* button to navigate to the SRA Contributors sheet.
- To return to the Risk Review Sheet; operate the *Return to Risk Review* button on the SRA Contributors sheet.

- For details of the risk review and edit sheet content, refer to 'Editing the Risk Assessment Form' in Paragraphs 3.4.4 to 3.4.33 below.
- 3.4.4 **Editing the Risk Assessment Form.** The following describes the generic process for editing risk information. In general cells are protected where data entry is not permitted to prevent misuse. Note that the number of items required in review is limited as compared with previous versions of SRA and TRA. This is due to fixing of many of the parameters through the information modules.
- 3.4.5 For information and to support review or update of a TRA or SRA:
- The list of assets within the asset sub type category that currently have a TRA, and the current safety and performance values; can be viewed from the Risk Assessment sheet by operating the **Show TRA Assets** button.
  - The list of assets contributing to a SRA (within the selected asset sub type/line combination) can be accessed from the Risk Assessment sheet by operating the **Show SRA Contributors** button.
  - Return from either TRA Assets or SRA Contributors to the Risk Assessment sheet is achieved through operating the **Risk Assessment Form** button on the relevant sheet.
- 3.4.6 The basic asset risk parameters Asset Code; Asset Location; Asset Type; Asset Definition; Line (described in Para 3.4.3 above ) are non editable fields in the context of risk review and update.
- 3.4.7 Risk Assessment Category. Can be changed from SRA to TRA and vice versa. This fundamentally affects the way in which risk is calculated and will change the risk value recorded in the data table once the record is updated. SRA or TRA is selected from the drop down list against Current Asset Assessment Category.
- Selection of TRA instead of SRA will clear the form and require entry of parameters for the TRA. This must then be updated using the **Update TRA** button once the TRA is complete.
  - Selection of SRA instead of TRA does not require further data entry or modification by the user other than operation of the **Update SRA** button which will update the asset record with SRA values.
- 3.4.8 Operation of the relevant risk update button (**Update TRA** or **Update SRA**) will clear all existing risk assessment information in the master table which will not then be retrievable without returning to an archived version of STRATA.
- 3.4.9 Asset Behaviour. Up to three asset behaviours can be accommodated in any assessment. These can be different or duplicated. The Risk Assessment form can be used to assess three different types of behaviour (e.g. ICC; PC and SD); or to assess up to three different scenarios of the same behaviour (e.g. for a bridge parapet, PC due to inherent condition; PC due to general third party activity; PC due to vehicle impact).
- 3.4.10 Asset behaviours are selected using the drop down lists against the Asset Behaviour Cells in Section 2 of the Risk Assessment form. Selection of the behaviour recalls the behaviour description from the asset rules table into the cell below the selection. Where the description is shown as 'not credible' an alternative should be selected as the Profession Head view (through the rules table) is that the behaviour is encompassed within one of the other behaviour options for the asset.
- 3.4.11 Cells are provided for each Asset Behaviour to clarify the scenario that would result in the behaviour (Scenario Description), and to explain how the behaviour would be realised in practice (Behaviour Clarification). These entries are important to allow

anyone examining the assessment to understand the logic underpinning any judgement based values (e.g. likelihood selection) assigned in the assessment.

- 3.4.12 For an asset currently designated as TRA the retrieved information shows the selected assessment regime (TRA) and also the regime recommended automatically from condition and assessment information in the master data table. Where the recommended and currently assigned regimes are different, a justification must be entered in the relevant cell to explain why TRA has been selected.
- 3.4.13 The annual review process requires review of all assets for which the automatic routine has recommended TRA but SRA has been assigned by the user. This is not controversial or an error in the system. It is possible that a significant number of assets will fall into this category for very good reason. However the integrity of the model information requires that these discrepancies are understood and justified.
- 3.4.14 Behaviour Likelihood. This is assigned separately to each selected behaviour. Where behaviours are duplicated for the same scenario (e.g. to differentiate between different potential impacts) the likelihood would normally be the same. Where behaviour is duplicated for different scenarios (see example in Para 3.4.9 above) the assigned likelihood would normally be different.
- 3.4.15 Safety risk is calculated separately for each behaviour through selecting safety impact and assigning conditional probability. Performance risk will be calculated for each behaviour scenario.
- 3.4.16 For all SRA assessments, (and for the vast majority of TRA assessments), behaviour likelihood will be assigned by:
  - Selecting 'Choose from List' against the Likelihood Source Cell.
  - Selecting the most appropriate likelihood description against the Choose from List cell. This automatically calls forward a more detailed description of the context of choosing the likelihood, and the equivalent years per event value. The numerical likelihood value is also recalled to the form and used in subsequent stages of the calculation.
- 3.4.17 Care is needed to when using judgement to assign TRA behaviour likelihood values for a particular asset to ensure these are not over estimated.
- 3.4.18 When populating asset behaviour likelihood for SRA the value should be assigned as the total likelihood for all assets in the SRA sub set (how to view all SRA contributing assets is described in Para 3.4.3 above).
- 3.4.19 Where detailed assessment means that a specific accurate behaviour likelihood value is available for a particular asset (TRA), this can be entered by selecting the 'Direct Number (TRA Only)' option against the Likelihood Source Cell. This allows direct entry of likelihood values into the highlighted cells. Direct entry numbers are more difficult to validate and must be supported by suitable justification.
- 3.4.20 Asset Abuse contribution. Asset abuse is sources of risk that are not inherent in the asset or condition. This is essentially initiation of asset behaviours from mechanisms within the operating environment. These are defined as:
  - LU/Contract Activity – behaviour resulting from planned work within the control of the LU family (e.g. maintenance or refurbishment works on Civil Engineering assets, or on assets within other disciplines) resulting in the defined asset behaviour.
  - Outside Party – behaviour resulting from activity of a third party with or without the knowledge of LU (e.g. road contractors causing damage to overbridge decking during works).



- Cross Asset Interaction – this covers two scenarios. (1) Behaviour induced by an asset other than the Civil Engineering asset (e.g. rolling stock bogie failure results in derailment and train striking bridge abutment). (2) Behaviour of the Civil Engineering asset cascading onto other assets (e.g. Loss of Integrity (seepage) in a brick tunnel results in disruption of the signalling or communications asset). For this category of asset abuse the user is required to select and prioritise up to three non Civil Engineering asset disciplines that contribute to or are affected by the Civil Engineering asset behaviour; and to indicate the overall mitigation strategy in place to manage the cross asset aspects of the risk.
- External Factors – this category includes challenges to the asset that are beyond the design intent. These can result in asset behaviour (e.g. abnormal load above design capacity resulting in structural distortion) or failure of the asset to cope with and extreme event (e.g. a rainfall demand above design capacity of the pumping system results in flooding).
- Asset abuse is important as this gives a value for risk which is not within the control of the Civil Engineering community. For any of the above categories the user is required to estimate the percentage contribution of the asset abuse source to the likelihood. Only one Asset Abuse category can be assigned to each behaviour.

3.4.21 Safety Impact. Safety impact values are determined through selection of one or more Top Events relevant to the asset behaviour; followed by selection of a sequence using interactive menus. The safety impact value assigned for the sequence is populated from the safety impact tables (which are in turn derived from the LU QRA) when a valid complete sequence has been selected.

3.4.22 When the risk review sheet is accessed, the start configuration is that Top Event titles are visible effectively as rows under each asset behaviour (i.e. in three columns); the sequence selection detail is hidden. Top Events that have a sequence assigned under a particular behaviour are highlighted as red cells. Selected sequence details can be viewed for any Top Event by operating the **Expand** button in the relevant header row. Details for all Top Event sequences in the assessment can be viewed by operating the **Expand all Safety Impact** button. Similarly individual Top Event sequences or all Top Events can be compressed using the **Compress** and **Compress all Safety Impact** buttons.

3.4.23 When detail of the event sequence for any Top Event is displayed, the sequence can be edited. Care is needed in this process. There is a high degree of dependency in the sequence lists (as in the LU QRA event trees) and hence it is not advisable to selectively change particular points in the middle of a completed sequence. Note that a particular Top Event can be applied only once to any behaviour scenario. To change a Top Event sequence (and hence change the safety impact value):

- Operate the **Reset Top Event Description** button in the relevant sequence header row. This resets the sequence entries to the null “-” value.
- Select the sequence points from the lists that appear to the right of the populated cells. The first cell in the sequence requires selection of the line relevant to the asset. Interdependency from the LU QRA is built into the sequence population. Selection of an option against a populated cell in the left hand column in the sequence selection determines the next decision branch point.
- The Top Event Impact Value cell at the bottom of the sequence selection will show ‘Sequence invalid or incomplete’ until a correct and valid sequence has been selected. Once a valid sequence is in place the Top Event Impact Value cell will show the impact value for the sequence and line exactly as per the LU QRA.