ASH QRA User Manual

User Manual Version: 0.30

By: Steve Booth

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Corresponding ASH Version: **ASH v 0.30**

Contents

1.0 Introduction

This manual describes the ASH QRA Model.

Section 2 describes the interface.

The interface comprises four Control Panels, which each have a number of Buttons, relating to corresponding Datasheets.

In the following sections each Control Panel is described, and then each Button and its part in the overall QRA process is detailed.

Appendix 1 contains a detailed description of the ASH QRA Theory, concerning:

- Events, Inventories and Consequence Analysis Overview
- Inventories and Mass Fractions
- Consequence Analysis
- Ignition Probabilities
- Immediate Fatality Fractions

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2.0 Interface

On starting the QRA application, the user is presented with the interface, which comprises:

- Menu Bar
- Four Tabs:
  - Main Tab
  - Consequence Tab
  - Escalation Tab
  - Results Tab

2.1 Menus

The following menus are available:

Table 1 - Control Panel Menus

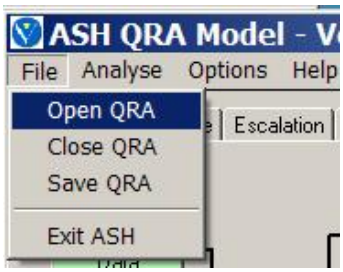
Menu		Action
File	Open QRA	Open a QRA file (.qni)
	Close QRA	Close a QRA file (.qni)
	Save QRA	Save a QRA file (.qni)
	Exit Control Panel	If a qni file is open, closes ASH and Excel. If a qni file is not open, closes ASH.
Analyse	Analyse All	Analyses the entire QRA
	Analyse Escalation	Analyses the Escalation tab part of the QRA
	Analyse Consequences	Analyses the Consequences tab part of the QRA
Options	Do Consequence Analysis	This is a switch to determine if ASH should carry out the Consequence Analysis. Refer to Section 4.2.
Help	About	Information
	Developer Tools	For developer only
	Activate	For developer only

2.2 Opening a QRA file

QRA files are Excel workbooks with file suffix .qni

The user must open an existing file or a blank file to create a new QRA.

To open a QRA, select MENU : File : Open QRA



The application performs a series of checks when opening the qni file, and alerts the user to any issues or problems. This information can be saved to a log file if required.

2.3 Control Panel Overview

2.3.1 Introduction

The Control Panel always stays on top of other Windows, and shrinks when it loses the focus in Windows (i.e. something else is clicked). This means that it is always easily accessible, but shrinks out of the way when the user is looking at something else. The most suitable place for the Control Panel on the screen is to the top right.

The Control Panel can be maximised by clicking the Unshrink button.

2.3.2 Control Panel Tabs

Each of the four tabs on the Control Panel shows a flowchart, comprising a number of Buttons, which represents the flow of data through the QRA. Each Button represents an underlying data set in the QRA, and corresponds directly with a sheet (or sheets) in the QRA workbook file (.qni).

In general, right clicking on a Button jumps to the Datasheet corresponding to that Button in the qni file.

Left clicking on a button does one of two things:

If the button data is input data, the data is checked.

If the button data is calculated data, the data is calculated.

2.3.3 Relationship between Control Panel and Excel

The Control Panel manipulates Excel, and hence the workbook that is active in Excel. This can cause difficulties for the user if one or more additional Excel workbooks is open as well as the qni file.

1) If the additional workbook is the focus of Excel (rather than the qni file), then if the user clicks a Button, the Control Panel will not be able to find the corresponding sheet in the workbook and will give an error message: “Error: Cannot find the sheet: <sheet name>”.

2) If the user closes the Control Panel, this will close Excel, including any workbooks that are open in addition to the qni file.

2.3.4 Button Colours / Change Control

- Buttons are colour coded to assist the user, and reflect the status of the underlying data:
- Green – data is current
- Yellow – data has been changed on the Button / Sheet
- Red – input data to the Button / Sheet has been changed, and the Button / Sheet needs to be recalculated.

On each sheet will be found Status Boxes (red, green or yellow, indicating Pass or Fail), these should be left alone.

2.4 QRA File (.qni) Overview

The data file for a specific QRA is an Excel workbook with the file suffix ".qni". The qni file must contain sheets of the correct name, and with the data in the correct locations. These are called the core sheets. The user may add other sheets to the qni file if required.

Note that all the calculations are carried out by the Control Panel, no calculations are carried out in the worksheets (with the exception of Travel Risk, Non-Hydrocarbon Risk and the summary QRA Results on the Main Tab).

The User should not introduce any Excel Formulae on any of the Core Sheets – these formulae will be erased by the Control Panel and only the values left.

However the user is free to add worksheets to the qni files, and these may contain links to other sheets.

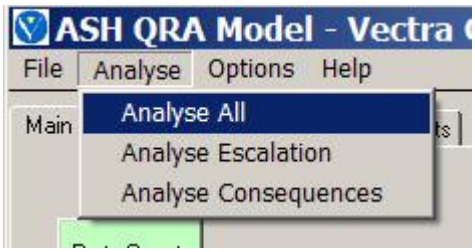
2.5 Building and Working with a QRA

2.5.1 Building a QRA

To build a QRA the start point is a previous or blank qni file, which is then populated with data for the QRA in question.

2.5.2 Working with a QRA

The user can modify input data for a QRA, and then rerun the QRA either stagewise, by clicking on an individual Button, or rerun the entire analysis by selecting Menu : Analyse : Analyse All.



2.5.3 Data Colour Coding

Data in the sheets is colour coded, with the following conventions.

- Yellow data is input by the user.
- Any other coloured data (e.g. blue, purple) is calculated by the application.

2.5.4 Data Formatting

Generally the user is responsible for the formatting of the data in the sheets, i.e. colour coding, borders, number formats etc.

2.5.5 Calculations

All calculations are carried out by the ASH QRA application, i.e. no calculations are carried out using formulas or macros within the Excel QRA qni file.

There are two exceptions:

1) Change Control – the worksheets themselves detect when a change has been made to the data contained within them. This is done using macro code attached to each sheet.

2) Dead sheets – the following sheets draw data from other sheets and calculate internally using formulas in cells:

   - Travel Risk
   - Non-Hydrocarbon Risk
   - QRA Summary Results

2.5.6 User Guide Conventions

Bold Italic – indicates the name of a sheet or workbook.

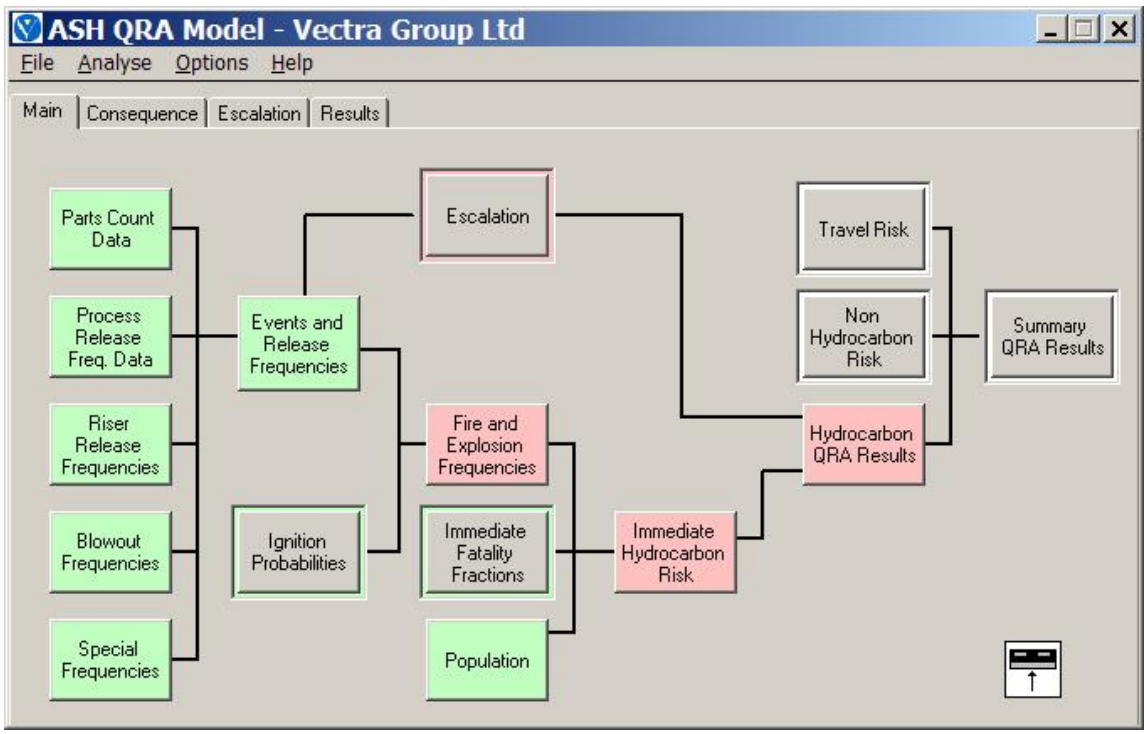
2.6 Error Handling

There is limited error detection in ASH, and the User is responsible for making sure that the correct data is input to the correct locations.

ASH will not crash, and will usually give an informative error message. However in extreme cases the error will be trapped, but no specific error message will be given.

The warning and error messages are summarized at the end of the calculation in the Progress window.

3.0 Main Tab



3.1 Introduction

Table 2 lists the corresponding Datasheets for each Button on the Main Tab. Each Datasheet can be accessed by clicking the corresponding Button.

Table 2 – Main Tab Buttons and Datasheets

Button Title	Datasheet Title
Parts Count Data	Parts Count
Process Release Freq. Data	Process Release Frequency Data
Riser Release Frequencies	Riser Release Frequencies
Blowout Frequencies	Blowout Frequencies
Special Frequencies	Special Frequencies
Events	Events
(Ignition Probabilities)	(Ignition Probabilities)
(Escalation)	n/a
Fire and Explosion Frequencies	Fire and Explosion Frequencies
(Immediate Fatality Fractions)	(Immediate Fatality Fractions)
Population	Population
Immediate Hydrocarbon Risk	Immediate Hydrocarbon Risk
Travel Risk	Travel Risk
Non-Hydrocarbon Risk	Non-HC Risk

Button Title	Datasheet Title
Hydrocarbon QRA Results	Hydrocarbon Results
Summary QRA Results	QRA Results

3.2 Events

An Event is defined as a combination of an Inventory and a Location. It is a set of release cases, very small, small, medium and large.

This is the most important Sheet in the QRA as it defines the Events, which are the hazard scenarios for the QRA.

Other parts of the QRA reference the Main Event List on this sheet. Data on other Sheets must typically correspond exactly to this list.

The data starts at row 9. The columns are as follows.

Input Data	Description
Event ID	An alphanumeric ID for the Event. (e.g. MOD-INV). There must be no gaps in the list. The application will assume the list ends at the first blank line. Right Click on an Event ID to jump to the Escalation Sheet for that Event.
Event Type	Must be either: Process Riser Blowout Special
Event Description	Any alphanumeric text
Location	The module where the event occurs
Inventory ID	The inventory corresponding to the Event. (This information is not required if the *Do Consequence Analysis* switch is off)
Release Type	The release type required for the inventory corresponding to the Event. This must be either Gas, Liquid or Two-Phase. (This information is not required if the Do Consequence Analysis switch is off)
MAH	Events may be classified in groups, the group name must be given here. MAH = Major Accident Hazard.
FB Hole Size	For riser events, the application needs to know the full bore hole diameter. (This information is not required if the Do Consequence Analysis switch is off)
Bund Name	For liquid releases, this is the name of the associated bund. (This information is not required if the Do Consequence Analysis switch is off)
Spare Data	Not used.

Calculated Data	Description
Event Release Frequencies	Calculated from: Parts Count Data Process Release Frequency Data Riser Release Frequencies Blowout Frequencies Special Frequencies

3.3 Parts Count Data

Sheet ***Parts Count***

The Parts Count must be given for all process events.

The Multiplication Factor row allow the release frequency to be factored, and must contain a number between 0 and 1.

E.g. if an Event is live only 25% of the time, this would be 0.25. For a pig launcher used 5 days per year, do the normal parts count and set the Multiplication factor to 5/365.

The default value is 1.

The Equipment Description should match that in the Process Release Frequency Data. There must be no blank lines.

3.4 Process Release Frequency Data

The Equipment Description should match that in the Parts Count Data. There must be no blank lines.

The release frequency data should be input for each equipment item.

3.5 Riser Release Frequencies

Release Frequency data should be provided for all Riser Events, these are calculated by the User and input manually.

3.6 Blowout Frequencies

Release Frequency data should be provided for all Blowout Events, these are calculated by the User and input manually.

3.7 Special Frequencies

Release Frequency data should be provided for all Special Events, these are calculated by the User and input manually.

Special Events include scenarios such as HIPPS Failure, Gas Lift releases or releases in Concrete Legs.

3.8 Ignition Probabilities

Clicking on this Button jumps to Sheet ***Ignition Probabilities*** (Consequence Tab).

3.9 Escalation

This Button shows the position of the Escalation Tab in the QRA flowsheet.

3.10 Fire and Explosion Frequencies

This calculates Fire and Explosion Frequencies for all Events from:

Release Frequencies on the Events sheet.

Ignition Probabilities on the Ignition Probabilities sheet.

3.11 Immediate Fatality Fractions

Clicking on this Button jumps to Sheet ***Immediate Fatality Fractions*** (Consequence Tab).

3.12 Population

The user is required to enter the following information, for up to 6 personnel groups.

- The Number of Personnel in each worker group
- The Rotation factor (proportion of time spent offshore) for each group
- The Area list – modules or Areas where personnel may be present. (Note the user may define alias areas, e.g. to represent a collection of modules)
- Probability of being in area – these should add up to 1
- Average No in Area – the Probability of being in area x No of Personnel in Each Worker Group.

3.13 Immediate Hydrocarbon Risk

Immediate Hydrocarbon Risk is calculated for each Event and for each Personnel Group from the following.

- Fire and Explosion Frequencies
- Immediate Fatality Fractions
- Population Data

See Section 4.13 for the calculation of Immediate Fatality Fractions.

3.14 Travel Risk

This sheet is a conventional spreadsheet to calculate Travel Risks, using Excel Formulas. Note that the Input Data is by Excel Links.

Input Data

Data	Sheet
People in Group	Population
Rotation Factor	Population

3.15 Non-Hydrocarbon Risk

This sheet is a conventional spreadsheet to calculate Non-Hydrocarbon Risks, using Excel Formulas. Note that the Input Data is by Excel Links.

Input Data

Data	Sheet
People in Group	Population
Rotation Factor	Population

3.16 Hydrocarbon QRA Results

TRIF, PLL and IRPA data is calculated for each Event, drawn from the Immediate Hydrocarbon Risk and Escalation sheets.

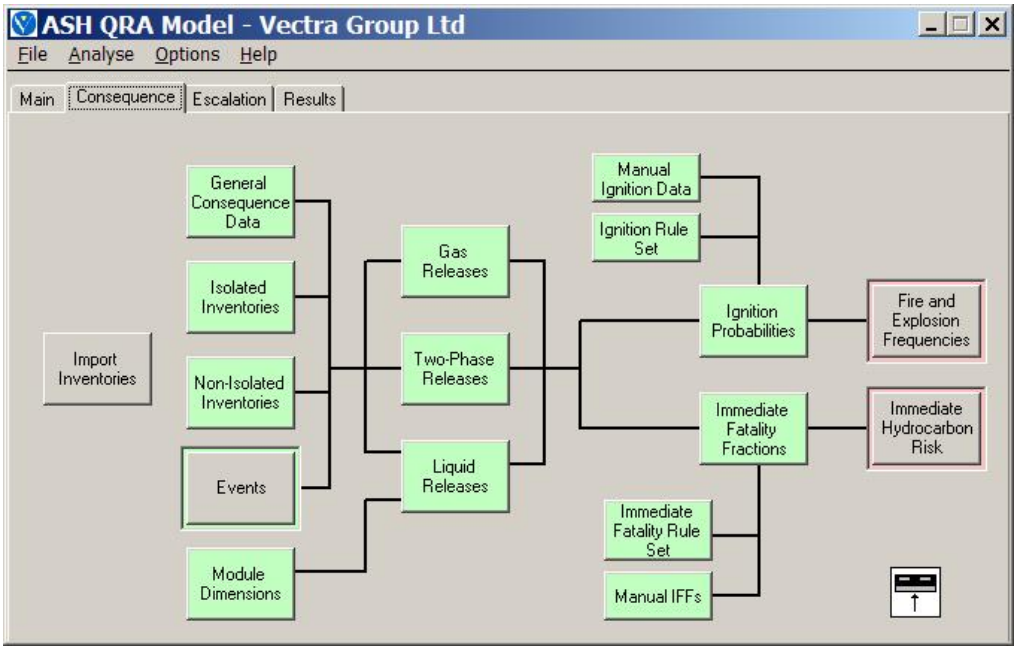
3.17 Summary QRA Results

This sheet is a conventional spreadsheet to summarise Risks, using Excel Formulas. Note that the Input Data is by Excel Links. The data is drawn from a variety of other sheets as follows.

Input Data

Data	Sheet
Initial PLL	Module PLL
People in Group	Population
Rotation Factor	Population
Delayed Hydrocarbon TRIF	Hydrocarbon Results
Travel Hazards	Travel Risk
Non-Hydrocarbon	Non-HC Risk

4.0 Consequence Tab



4.1 Introduction

The Consequence Tab calculates the consequences of hydrocarbon releases. Starting with Inventory data, calculating time dependent gas, two-phase and liquid releases and fire sizes, and then using appropriate rule sets, ignition probabilities and immediate fatality fractions.

The details of the underlying theory and calculations are given in Appendix 1.

Table 3 – Consequence Tab Buttons and Datasheets

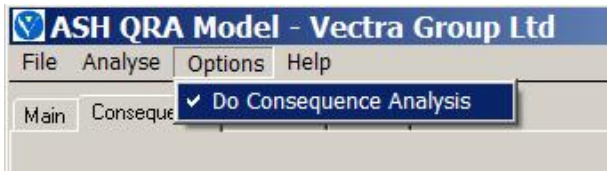
Button Title	Datasheet Title
Import Inventories	n/a
General Consequence Data	General Consequence Data
Isolated Inventories	Isolated Inventory Summary
Non-Isolated Inventories	Non-Isolated Inventory Summary
(Events)	(Events)
Module Dimensions	Module Area
Gas Releases	Jet Fires
Two-Phase Releases	Two Phase
Liquid Releases	Pool Fires
Manual Ignition Data	Manual Ignition Probabilities
Ignition Rule Set	Ignition Models
Immediate Fatality Rule Set	IFF Model
Manual IFFs	Manual IFFs
Ignition Probabilities	Ignition Probabilities

Button Title	Datasheet Title
Immediate Fatality Fractions	Immediate Fatality Fraction
(Fire and Explosion Frequencies)	(Fire and Explosion Frequencies)
(Immediate Hydrocarbon Results)	(Hydrocarbon Results)

As per the convention, left clicking on a Button performs the necessary checks or calculations, and right clicking takes the user to the corresponding Sheet.

4.2 Consequence Analysis Switch

The Options Menu contains a switch – "Do Consequence Analysis". The handing of the Consequence Analysis depends on the state of this switch.



Do Consequence Analysis – active

In this case the full Consequence Analysis is carried out. This culminates in the calculation of Ignition Probabilities and Immediate Fatality Fractions.

Do Consequence Analysis – not active

In this case no Consequence Analysis Data is required, and no Consequence Analysis is carried out.

Ignition Probabilities are input manually – sheet ***Manual Ignition Probabilities***, and carried forward (by the User or by the *Analyse All* command) to sheet ***Ignition Probabilities***.

Immediate Fatality Fractions are input manually – sheet ***Manual IFFs***, and carried forward (by the User or by the *Analyse All* command) to sheet ***Immediate Fatality Fractions***.

4.3 Import Inventories

This Button advises the user that Inventory Data should be manually imported.

4.4 General Consequence Data

This Sheet contains general data to be used in the Consequence Analysis.

4.4.1 Jet Fire Correlation Constants

Jet and Two-Phase fires are modelled using a correlation of the form:

Flame Length $L = a \times Q^b$ (G4)

L	Flame Length	m
Q	Release Rate	kg/s
a & b	Constants depending on hole size	-

The user defines the values of the constants a & b, for each of the four event types.

4.4.2 Global Data

The default values are:

Table 4 - Global Data Default Values

Variable	Value
Gas Constant R	8314
Discharge Coefficient CD - GAS	0.8
Discharge Coefficient CD - LIQUID	0.6
Ratio of Specific Heats (Gamma)	1.2

4.4.3 Liquid Fuel Burning Rate

For the pool fire calculations, the fuel type is defined by name. The data here is the Fuel Burning Rate in $kg/m^2/s$. Up to 20 fuel types are allowed.

4.4.4 Other Data

This data, and its default values, is as follows.

Probability of Muster before Ignition 0.5

This is the Probability that someone can muster to the TR before ignition, i.e. before muster impairment takes place.

Probability of Escape by other means 0.2

This is the Probability that someone whose escape route is impaired manages to escape by other means, e.g. direct to sea.

Probability of Fatality if TR and TEMPSC Impaired 0.9

If both the TR and the TEMPSCs are impaired by an event, it is assumed that most people, default 90%, will be killed. However a small number may find a means of evacuation and rescue.

Probability of Fatality during TEMPSC Evacuation 0.08

TEMPSC evacuation has a risk associated with it. The default weather averaged value is an 8% probability of fatality.

4.5 Isolated Inventories

An Event in the QRA is defined as a release from a specific Inventory in a specific Module, and the Inventory and Module applicable to each Event is defined in the Events sheet.

Inventories are either Isolated by ESD valves, or Unisolated in the event of ESD failure, where it is usually assumed that each inventory is then increased by adding to it the largest adjacent inventory.

Inventories may be calculated manually, or may be calculated using the ASH Inventory Program.

An inventory is characterised as comprising of Free Gas, Flash Gas, Oil and Water. Flash Gas is the gas that is normally in the liquid phase, but will flash when the release occurs. For the inventory table,

Free Gas and Flash Gas are combined to be the Gas Fraction, the remaining hydrocarbon liquid is the Oil Fraction, and any water is the Water Fraction. Further information on inventory definition is given in Appendix 1.

The Isolated Inventories are defined in this sheet. The following information is required for each inventory.

Total Inventory Pressure (bara) – the inventory pressure.

Total Inventory Temperature (K) – the inventory temperature.

Gas Volume (m3) – this is the volume of the gas part of the inventory, which comprises both the gas phase, and also any flash gas.

Gas Density (kg/m3) – the density of the gas phase.

Gas MW – the molecular weight of the gas phase.

Liquid Density (kg/m3) – the density of the liquid phase.

Gas Mass (kg) – the mass of the gas fraction of the inventory, comprising both free gas and flash gas.

Oil Mass (kg) – the mass of the liquid hydrocarbon fraction of the inventory.

Water Mass (kg) – the mass of the water fraction of the inventory.

Total Inventory Mass (kg) – the total mass of the inventory.

Total Inventory Density (kg/m3) – the overall inventory density.

The data in the table should be internally consistent.

4.5.1 Liquid Release Data

Liquid Head (m) – this is the liquid head for liquid release calculations. It is only required for releases from atmospheric storage, and for process releases the pressure dominates.

Fuel Type – this is a user defined fuel name, so that ASH can use the name to retrieve fuel burning rate data from the Liquid Fuel Burning Rate table on the ***General Consequence Data*** sheet.

4.5.2 Blowdown Data

To enable ASH to calculate the effect of blowdown on releases, the Time (minutes) to a target blowdown Pressure (barg) is input for each inventory. If no data is given, then it is assumed that there is no blowdown.

4.6 Non-Isolated Inventories

The same data is required for each inventory as for the isolated inventories, with the exception of Liquid Release Data and Blowdown Data.

4.7 (Events)

Clicking this button switches to the ***Events*** sheet (Main Tab).

4.8 Module Dimensions

This sheet is used to define module and bund dimensions for use in the consequence analysis.

4.8.1 Area Data

The module or bund names, and the area of each module or bund, are input by the user.

Module Area is used in the Immediate Fatality Fraction calculations if the area model is used.

Bund Area is used in liquid release and pool fire calculations where the area of the pool is limited to the bund area.

4.8.2 Immediate Fatality Fraction Multiplier

When ASH calculates Immediate Fatality Fractions (Section 4.13) this multiplier is used. For example, a particular module may have deluge, and an allowance for this may be made by reducing the calculated IFF.

4.8.3 Immediate Fatality Fraction Limit

This value places an upper limit on the IFF for the module, for example to allow for a flame footprint extending outside of the module. If the value is 0 or blank then it is assumed to be 1.

4.9 Gas Releases

For each inventory which has at least one Event of Release Type “Gas”, the consequences of a release from the gas part of the inventory is calculated.

Details of the theory of gas release consequences are given in Appendix 1.

Consequences are calculated for each of the four combinations of ESD and blowdown success or failure, and for each of the four release hole sizes.

The hole sizes are taken from sheet ***General Consequence Data***. For riser releases where the release diameter is full bore, the full bore diameter is taken from the ***Events*** sheet.

The user is required to enter, in the sheet Jet Fires cells G8 to P8, the times at which consequences are to be calculated. The standard times should be used: 0, 1, 5, 10, 20, 30, 40, 50, 60, 90.

The time dependent release rate and jet fire lengths (using the correlation constants from sheet ***General Consequence Data*** – Section 4.4.1) are calculated.

The time to subsonic flow and to jet fire <2m is also calculated.

Hazard Ranges and Areas

To the right of the main consequence table, ASH calculates Hazard Ranges and Hazard Areas to three thermal radiation levels. This data is used for Immediate Fatality and Muster Fatality calculation.

The Hazard Range is the range in the direction of the jet to the specified radiation level. The Hazard Area is the area of the contour to the specified radiation level.

The data is calculated for the initial release conditions only, i.e. it is not time-dependent, and is calculated for isolated cases only.

The Hazard Range and Hazard Width is calculated from the release rate using a correlation of the form

$$\textbf{Hazard Range / Width} = a \times Q^b$$

Where Q = Release Rate (kg/s)

The values of the constants a and b are specified on the sheet ***IFF Model*** in table Area Model Parameters.

4.10 Two-Phase Releases

Two-phase releases are calculated for each inventory that has at least one Event of Release Type "Two-Phase", in a similar way as for gas releases.

Details of the theory of gas release consequences is given in Appendix 1.

4.11 Liquid Releases

Liquid release consequences are calculated for every Event of Release Type "Liquid".

Details of the theory of liquid release consequences are given in Appendix 1.

Liquid release consequences are calculated for Isolated and Unisolated cases, and for each of the four hole sizes. Blowdown is not taken into account.

Consequences are:

Initial Release Rate (kg/s)

Pool Diameter (m) – the equilibrium pool diameter such that the release rate is equivalent to the total burning rate. If the pool diameter is governed by the bund area, then the pool diameter is the diameter of a circle of equivalent area to the pool. This is indicated by the text "Bund Area" to the right of the table.

The Event Bund Name is specified in the ***Events*** sheet. The bund area is specified in sheet ***Module Area***. The Fuel Type for each inventory is specified in sheet ***Isolated Inventory Summary***, and the burning rate corresponding to each Fuel Type is specified in sheet ***General Consequence Data***.

Fire Duration (min) – calculated from the inventory mass, pool diameter and fuel burning rate.

4.12 Ignition Probabilities

The calculation of ignition probabilities is described in Appendix 1.

4.13 Immediate Fatality Fractions

The calculation of Immediate Fatality Fractions is described in Appendix 1.

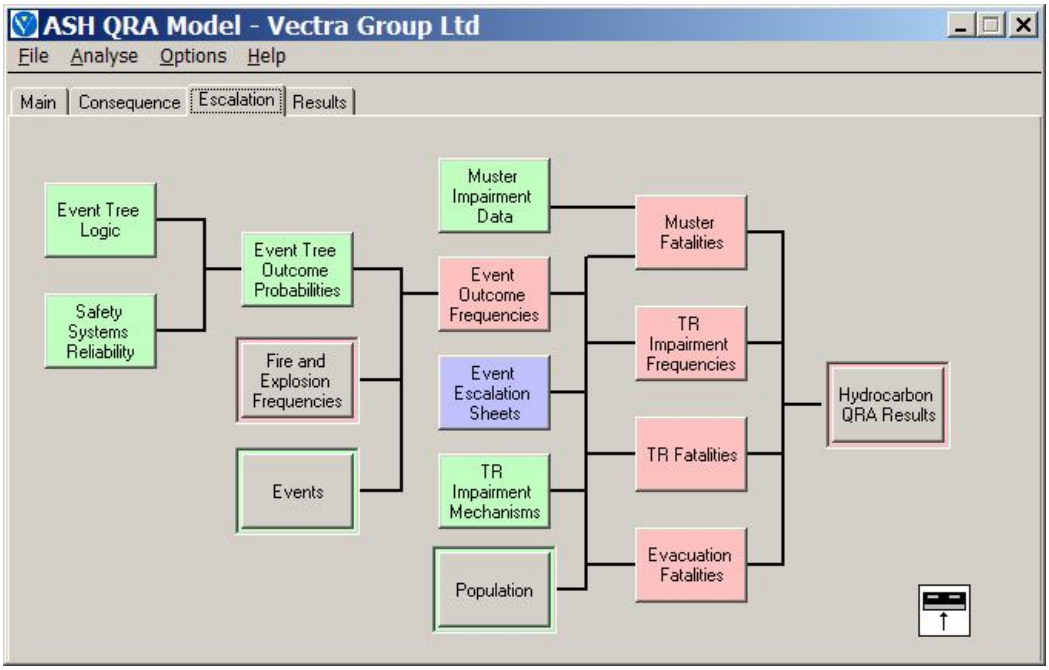
4.14 Fire and Explosion Frequencies

Clicking on this Button jumps to Sheet ***Fire and Explosion Frequencies*** (Main Tab).

4.15 Immediate Hydrocarbon Risk

Clicking on this Button jumps to Sheet ***Hydrocarbon Results*** (Main Tab).

5.0 Escalation Tab



5.1 Introduction

Table 5 – Escalation Tab Buttons and Datasheets

Button Title	Datasheet Title
Event Tree Logic	ETL
Safety Systems Reliability	Reliability
Event Tree Outcome Probabilities	ET Outcome Probabilities
(Fire and Explosion Frequencies)	(Fire and Explosion Frequencies)
(Events)	(Events)
Muster Impairment Data	Muster Probabilities
Event Outcome Frequencies	Event Outcome Frequencies
(Event Escalation Sheets)	Events
TR Impairment Mechanisms	TRIM Names
(Population)	(Population)
Muster Fatalities	Muster Fatalities
TR Impairment Frequencies	TRIF Summary
TR Fatalities	TR Fatalities
Evacuation Fatalities	Evac Fatalities
(Hydrocarbon QRA Results)	(Hydrocarbon Results)

5.2 Event Tree Logic

Sheet ***ETL***.

The branch probabilities for the Event Tree used by ASH are defined in sheet ***Reliability***.

The data on sheet ***ETL*** defines the cell references for ASH to retrieve event tree branch probabilities from sheet ***Reliability***.

This data is for internal use by ASH and should only be changed by the experienced user, and then only if changing the format of the data on sheet ***Reliability.***

5.3 Safety Systems Reliability

Sheet ***Reliability***.

This sheet inputs the failure probabilities for Safety Systems. Failure Probabilities are input for each event, and for Very Small, Small, Medium and Large releases.

The following probability data is required:

Fire and Gas System

The probability of failure of the F&G system to detect and activate on a gas release. Performance data from the F&G system may be used as an input here. The F&G system is more likely to detect larger releases.

ESD System

The ESD system is likely to be activated by the F&G system, hence there are two sets of probabilities for ESD system failure: for F&G Operating and for F&G Failure.

Blowdown System

In the standard ASH data setup, the F&G failure cases are not distinguished for blowdown. (This could be changed in conjunction with the cell references on sheet ETL).

Deluge System

In the standard ASH data setup, the F&G failure cases are not distinguished for deluge. (This could be changed in conjunction with the cell references on sheet ETL).

Probability of Explosion Failing Deluge / ESD

This data is not required by ASH. However, as an input to the ESD/EDP/deluge failure probabilities, it represents a way of accounting for the possibility that a fire or explosion may disable emergency systems.

5.4 Event Tree Outcome Probabilities

On this sheet, ASH calculates the Event Tree Outcome Probabilities for each release case.

This data is for internal use by ASH and should not normally be changed. However this data may be changed manually for sensitivity studies.

5.5 Muster Impairment Fatalities

Muster fatalities occur due to personnel located on the plant being trapped in hazardous conditions. This is described by the following equation:

> Muster Fatalities = Frequency of Ignited Event x (No of personnel – immediate fatalities) x muster impairment probability

Sheet ***Muster Probabilities***

This sheet has two functions:

1) The program populates the sheet with event data

2) The user populates the sheet with muster impairment probabilities.

The muster fatalities are then calculated from the Muster Impairment Probabilities.

Event Data

Left clicking on sheet ***Muster Probabilities*** results in the program retrieves the following data for each event.

- Event ID
- Event Type
- Event Description
- Event Location
- Release Type
- Release Size
- Escape Route Impairment by Fire
- Distance and Area to 5kW/m2
- Duration of the Isolated/Blowdown case

Muster Impairment Probabilities

The event data is used to manually arrive at Muster Impairment Probabilities (MIPs).

A MIP for a given event/size and module is defined as the probability that the event/size causes impairment of escape from that module.

The suggested method is as follows.

1) Enter Modules across the top of the MIP table (cell N8 onwards)

For each event:

2) Grey out the same module as the event (the event cannot impair escape from the module it is in, this is immediate fatality)

Note this is the same information for all events of a given module

3) Grey out modules not affected by the event

Note this is the same information for all events of a given module

4) Apportion impairment probabilities, based on Impairment Distance and Area

Use the following guidelines

0.0 Definitely not impaired

0.1 Small chance of impairment

0.3 More likely than not to be unimpaired

0.5 Even chance of impairment

0.7 More likely than not to be impaired

0.9 Probably impaired

1.0 Definitely impaired

For events with similar consequences the user can simply duplicate the data.

Bear in mind that events have an Immediate fatality effect on adjacent modules anyway.

Also, smoke due to liquid fires should be considered for muster impairment.

An explosion is always followed by a fire, so the impairment probabilities for explosion are the same, unless they are higher. In this which case, use the higher probability value.

Muster Fatalities

This sheet comprises the calculated Muster PLLs and Muster IRPAs for each event.

All MIPS are then multiplied by 0.5 before being applied – this is to account for escape before ignition. This value is set in General Consequence Data tab (**Probability of Muster before Ignition**).

If muster of personnel in the process areas is impaired, then it is assumed that 80% of personnel affected will become fatalities. This assumes that some personnel who are unable to reach the TR may still escape the platform by some other means, i.e. tertiary escape facilities and then be rescued.

These values are defined on sheet ***General Consequence Data*** in the **Other Data** table.

5.6 TR Impairment Mechanisms

ASH calculates TR Impairment Frequencies for identified TR Impairment Mechanisms (TRIMs).

The input data for sheet ***TRIM Names*** comprises up to 12 TR Impairment Mechanism (TRIM) names. ASH uses probability data for each Mechanism from the Escalation Sheets to calculate TRIFs for each TRIM.

Escalation Sheet Type 1 is the default format – this value should not be changed.

5.7 Event Escalation Sheets

Every Event has an Event Escalation Sheet. This is used to input the TR Impairment Probability data.

For an Event with ID <EventID> , the Escalation Sheet should be named E-<EventID> so that it can be recognised by ASH.

Button **Event Escalation Sheets**

Left clicking this button – ASH checks to make sure that all Escalation Sheets are present in the qni file.

Right clicking this button - jumps to the ***Events*** sheet. On the ***Events*** sheet, Right Click an Event ID gives the option to jump to the Event's Escalation Sheet.

5.7.1 Escalation Sheet Format

The Escalation Sheet contains two tables, one for TR Impairment Probabilities, and one for TR Fatality Probabilities. Each table allows data to be entered for V, S, M and L releases, and has room for up to six TR Impairment Mechanism probability data sets to be input for each release size.

First row - the TR Impairment Mechanism name should be entered.

Second Row – the time (minutes) to TR Impairment

Rows marked E1 to E33 – these correspond to the 33 outcomes of the event tree. E1 to E16 are Explosion, E17 to E32 are Fire, and E33 is unignited gas.

In each cell, the probability of TR Impairment should be entered. Hence the user specifies the probability of TR Impairment for every combination of:

- Event
- Release Size
- Event Tree Outcome
- Mechanism
- Time

In the TR Fatality Probability Table, the user enters the probability of TR Fatality corresponding to the TR Impairment Probability above. This value is the Probability of TR Fatality *given that the TR Impairment Mechanism has been realised.* This value will sometimes be 1.0.

In other words, this data allows the analysis to account for:

(1) The probability that the event that causes TR Impairment (e.g. an explosion) will result in fatalities to personnel in the TR.

(2) The probability that the event may impair the TR and simultaneously impair the evacuation facilities (usually the TEMPSC), such that personnel in the TR are unable to evacuate and become fatalities.

5.8 TR Impairment Frequencies, TR Fatalities and Evacuation Fatalities

5.8.1 Data sheet summary

R-Clicking on each button takes the user to the corresponding sheet.

Sheet ***TRIF Summary***

- This sheet comprises the calculated TR Impairment Probability and TR Impairment Frequency for each Event and each TR Impairment Mechanism.

- Sheet ***TRIF by Time*** gives a more detailed breakdown of TR Impairment Frequency, by time interval. This sheet can be accessed from the Results Tab.

Sheet ***TR Fatalities***

- This sheet contains the calculated TR Fatalities, for each Event, in terms of each Population Group's PLL and IRPA.

Sheet ***Evac Fatalities***

- This sheet contains the calculated Evacuation Fatalities, for each Event, in terms of each Population Group's PLL and IRPA.

5.8.2 Calculation of TRIF and Associated Fatalities

L-Clicking on any of the three buttons causes ASH to carry out the calculation. This is done as follows.

5.8.3 Input Data

Event Outcome Frequencies – from sheet ***Event Outcome Frequencies***

TR Impairment Mechanism Names – from sheet ***TRIM Names***

Event Escalation Sheets – two data tables, TR Impairment Probabilities and TR Fatality/Evacuation Probabilities

TR Fatality Factor – from sheet ***General Consequence Data***

Evacuation Fatality Probability - from sheet ***General Consequence Data***

Population after Muster Fatalities – from sheet ***Population***

5.8.4 TRIF by Time

TRIF for each event, for each TRI Mechanism, for each Time, is calculated and put into Sheet "TRIF by Time".

Up to 12 TR Impairment Mechanisms (TRIMs) are allowed in total, and each one has a number 1 to 12. Up to 6 TRIMs are allowed for a given event.

This calculation operates as follows.

TRIF CALCULATION FOR EACH EVENT

From Event Escalation Sheet E-XXX (e.g. E-A1, E-A2 etc)

FOR size V, S, M, L

Get the 6 TRIM Names

Get the corresponding 6 TRIM Numbers

Get the 6 TRIM Times – adjust if necessary (see below)

FOR outcome E1 to E33

Get the 6 TR Impairment probabilities P[1]

Adjust the 6 probabilities P **à** Q (see below)

FOR the 1 to 6 TRIMs on E-XXX sheet

TRIF = Event Outcome Frequency x Adjusted Probability Q

Evacuation Impairment Frequency[2] = sum(TRIF x TR Fatality Probability[3])

Evacuation Success Frequency = sum(TRIF x (1-TR Fatality Probability))

Add TRIF into sheet "TRIF by Time"

at Event Row

at Mechanism TRIM No

at TRI Time, 5 min intervals to 60 min, or 60+ min

NEXT TRIM

NEXT outcome

NEXT size

On sheet "TRIF by Time", sum each TRIM TRIF and Total TRIF

Calculate TR Fatalities for the Event

FOR each Crew Group

TR Fatality PLL = Evac Impairment Frequency x No Crew[4] x TR Fatality Factor

TR IRPA = TR PLL / No Crew x Rotation Factor

Calculate Evacuation Fatalities for the Event

FOR each Crew Group

Evacuation PLL = Evac Success Frequency x No Crew[1] x Evac Fatality Probability

Evacuation IRPA = Evacuation PLL / No Crew x Rotation Factor

Notes

1 – From the top table in the Escalation Sheet

2 – This is the frequency with which people are fatalities in the TR (directly or because of inability to evacuate). It is summed for all outcomes of the event.

3 – From the bottom table in the Escalation sheet

4 – Number of Crew after Muster Fatalities – from Population sheet.

TRIM Time Adjustment

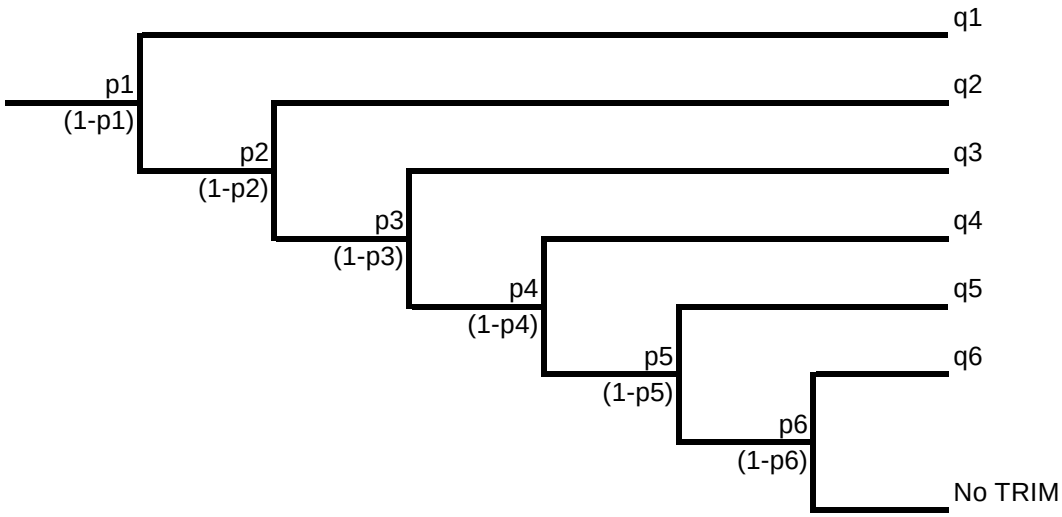
TR Impairment Times are entered in the Evacuation Sheets. The allowed times are 5 to 60 minutes in 5 minute intervals, and >60 minutes. If any other times are entered, ASH adjusts them to the nearest allowed time.

Adjusting TR Impairment Probabilities

It is assumed that TRIMs 1 to 6 in the event sheets are sequential in time.

If a TRIM can cause TR Impairment at a particular time with a certain probability, this affects the probability of TR Impairment by subsequent mechanisms from the same event, because if an event has caused TR Impairment by one mechanism, then it cannot subsequently impair it by another.

Thus the probabilities of TRIMP are adjusted according to the following tree, where P_{1-6} are the probabilities in the Escalation Sheet, and Q_{1-6} the adjusted probabilities.



Q1=P1

Q2 = (1-P1)P2

Q3 = (1-P1)(1-P2)P3

Q4 = (1-P1)(1-P2)(1-P3)P4

Q5 = (1-P1)(1-P2)(1-P3)(1-P4)P5

Q6 = (1-P1)(1-P2)(1-P3)(1-P4)(1-P5)P6

5.8.5 TR Impairment Summary

Sheet ***TRIF Summary.***

TR Impairment Frequencies are entered into the right hand table.

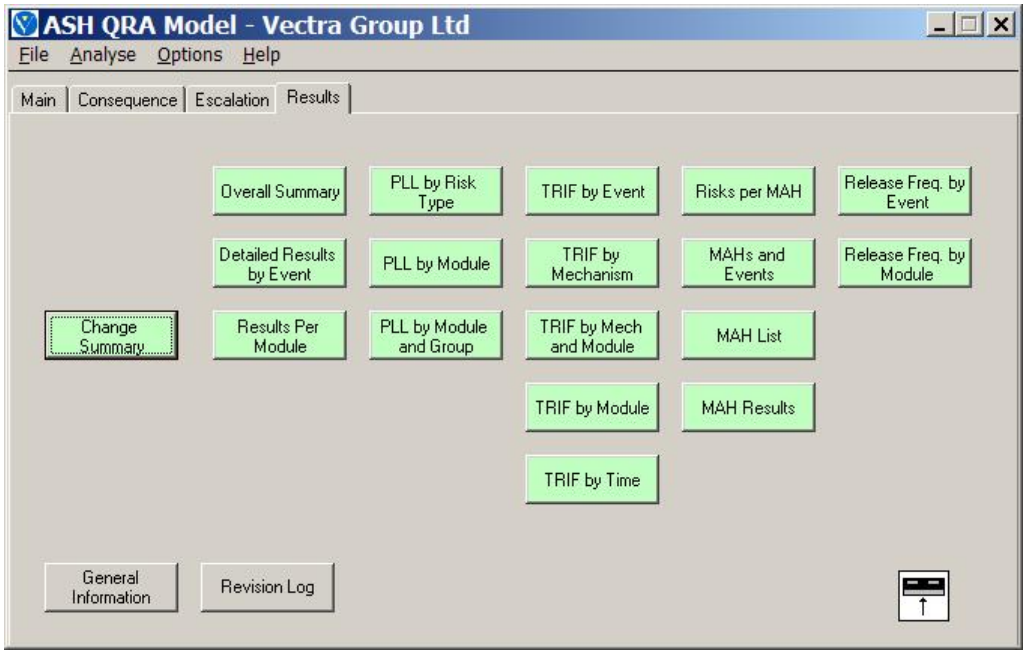
TR Impairment Probabilities are entered into the left hand table. These are calculated as

TR Impairment Probability = TR Impairment Frequency / Event Frequency

5.8.6 TR Fatalities and Evacuation Fatalities

These are calculated as above and entered into sheets ***TR Fatalities*** and ***Evac Fatalities.***

6.0 Results Tab



A number of sheets in the qni file are devoted to the presentation of the QRA results, and these are accessed via the Results Tab. The correspondence between Buttons and Datasheets is shown in Table 6.

Table 6 – Results Tab Buttons and Datasheets

Button Title	Datasheet Title
Change Summary	Change Summary
General Information	General Information
Overall Summary	Overall Summary
Detailed Results by Event	Event Results
Results per Module	Results per Module
Revision Log	Revision Log
PLL by Risk Type	PLL Breakdown
PLL per Module	PLL per Module
PLL by Module and Group	Module PLL
TRIF by Event	TRIF by Event
TRIF by Mechanism	TRIF Breakdown
TRIF by Mech and Module	Mechanism per Module
TRIF by Module	TRIF per Module
TRIF by Time	TRIF by Time
Risks per MAH	Risks per MAH
MAHs and Events	MAHs and Events
MAH List	MAH List

Button Title	Datasheet Title
MAH Results	MAH Results
Release Freq. by Event	Release Frequencies
Release Freq. by Module	Module Release Frequencies

Most of the Button / Sheet combinations simply present results. Left clicking on any of the Buttons will populate the Results Sheets. Right clicking on any of the Buttons jumps to the corresponding Datasheet.

Change Summary

This Datasheet summarises the results of the QRA in a single column, column D. Each time that the QRA is run, it allows the results of the new run to be compared to the old run.

Each time that the QRA is run, the existing results are transferred to Column E (Old) and the new results are then entered in Column D (New). ASH calculates the percentage change in column F (% Change).

At the same time, data in Column K onwards is shuttled one space to the right, and the results that were in Column E, the previous old results, are transferred to column K. This means that a summary of all the results for all revisions of the QRA may be retained.

Yellow Cells – Data Input Required

Optional data may be entered into the yellow cells as follows.

Crew Group for IRPA – the IRPA results in rows 34 to 44 are for a specific crew group. This cell should contain a value between 1 and 6 to indicate the desired crew group.

Run Tag – a user defined Tag to indicate the run – this is usually the qni revision number

Benchmark – this column contains a results set that the user may wish to define as a Benchmark, or base case, so that the effects of various sensitivities can be seen. Column I shows the percentage difference between the New Results (Column D) and The Benchmark Results (Column H).

Risks per MAH

MAH names/areas are entered by the user and these cells are not overwritten by ASH.