



RELEASE NOTES

PHAST™

SAFETI™

Taking hazard and risk analysis one step further

VERSION: 8.7

DATE: July 2022





Reference to part of this report which may lead to misinterpretation is not permissible.

No.	Date	Reason for Issue	Prepared by	Verified by	Approved by
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Date: July 2022

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## 1 NEW FEATURES

### 1.1. CFD calculations for standalone jet fires and new extension licence

Phast Lite	Phast	Phast 3D	Safeti Lite	Safeti	Safeti 3D
					

Following the release of Phast 8.6, where CFD modelling was introduced for standalone pool fire scenarios, this new version of Phast allows CFD modelling for standalone jet fire scenarios.

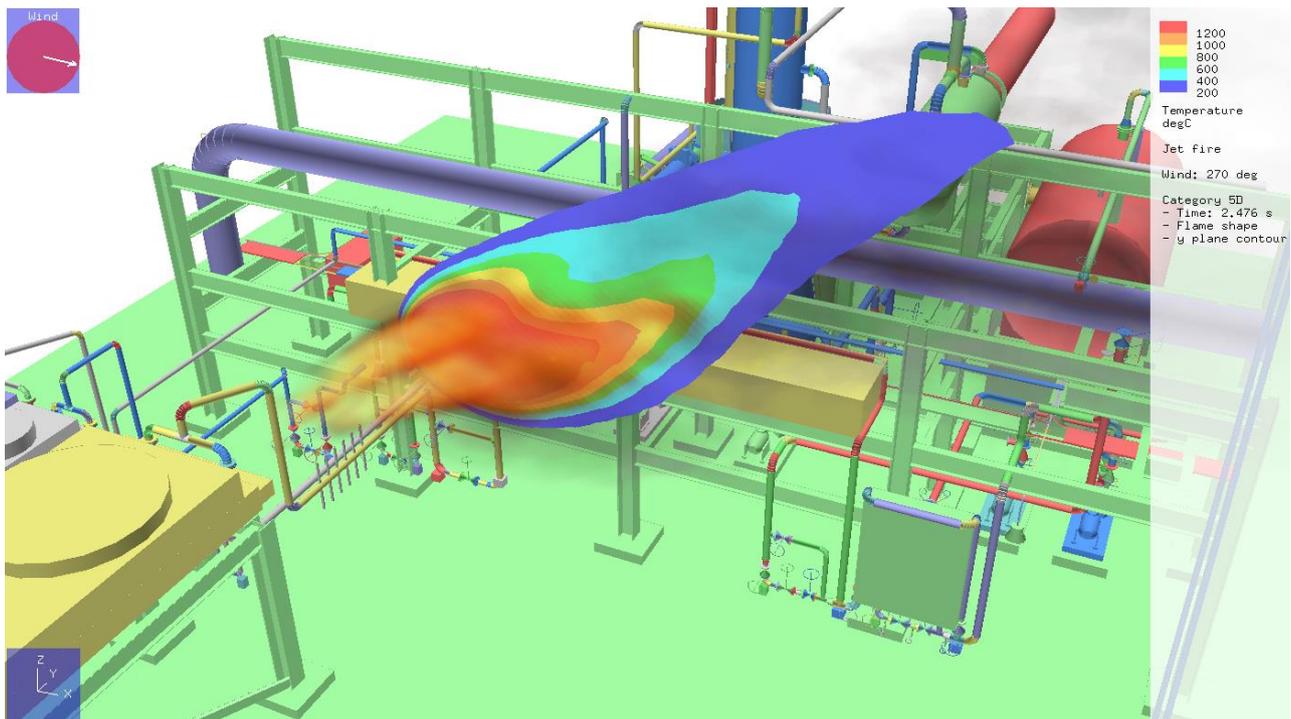
To support the CFD calculations, the following modifications have been made to the standalone jet fire dialogs:

- Model (API, Cone, Miller) specific data has been moved to the **Jet fire** tab on the standalone jet fire and there have been some regrouping of fields to make the interface clearer and easier to use. The **Jet fire** tab now has the following groupings:
  - Release location
  - Jet fire model
  - Release orientation
  - Release characteristics

The **Release orientation** group contains fields for defining the orientation, or direction, of the release. The **Release characteristics** group contains fields for defining the source term data for the release / jet fire.

- A new **Rotation about the z-axis** field is available, on the **Release orientation** group. This defines the direction of the release in a horizontal plane. This field in combination with the **Inclination of jet from horizontal** field allows the release to be pointed in any direction in three dimensions.
- A new **Wind direction** tab, allowing the user to specify the wind direction. In previous versions of Phast, the horizontal component of the release direction would always be parallel to the x-axis, and the crosswind angle was measured from this release direction. In Phast 8.7, however, given the introduction of CFD modelling for standalone jet fires, it's possible for the horizontal component of the release to be in any direction. For ease of use, it has been decided the wind direction should be specified as an angle independent of the release direction as opposed to a crosswind angle measure from the release direction.
- The **Crosswind angle** field is now calculated automatically from the **Rotation about the z-axis** and the **Wind direction** field and is not editable.
- Fields introduced on the **Jet fire** parameters tab to specify the temperature levels of interest and the number of calculations steps.

As with standalone pool fire scenarios, results of the CFD calculations for standalone jet fires are presented in the 3D viewer in the form of radiation and temperature isosurfaces and isocontours, in 2D graphs (where requested) and in reports (where requested).



As part of these improvements and following the introduction of the **Phast CFD – pool fires** licence alongside Phast 8.6, a new **Phast CFD – jet fires** licence is available for purchase. This new licence allows 3D geometry files to be used in the CFD calculations. If Phast 8.7 is being used without the new Phast CFD – jet fires licence, CFD calculations can still be performed for standalone jet fires, but the 3D geometry files will not be used in the calculations. The following table clarifies the modelling capability whether the new licence is present.

Feature	Phast 8.7 without purchase of Phast CFD – jet fires licence	Phast 8.7 with purchase of Phast CFD – jet fires licence
Insert 3D geometries for visualization	✓	✓
Jet fire modelling using CFD	✓	✓
Temperature profiles	✓	✓
Independent release and wind directions	✓	✓
3D geometries used in the CFD calculations	✗	✓

## 1.2. Support for more materials and mixtures when running CFD calculations

Phast Lite	Phast	Phast 3D	Safeti Lite	Safeti	Safeti 3D
					

In Phast 8.6 and 8.61, there was a limitation of 13 materials that could be used for CFD calculations. In Phast 8.7 this limit has been lifted so that now any\* material can be used when running CFD calculations. Further, mixtures are now supported in CFD calculations.

It should be noted that if you edit any of the properties of a component, these edited properties will not be used by the CFD calculations. The CFD calculations, powered by KFX, utilise their own version of the DIPPR database, which is based on the unedited properties of the components in Phast. This will be addressed in a future release.

\* There is an exception that any material containing lead (e.g. Tetraethyl lead) cannot be used in CFD calculations.

## 1.3. Classic and CFD grid parameters

Phast Lite	Phast	Phast 3D	Safeti Lite	Safeti	Safeti 3D
					

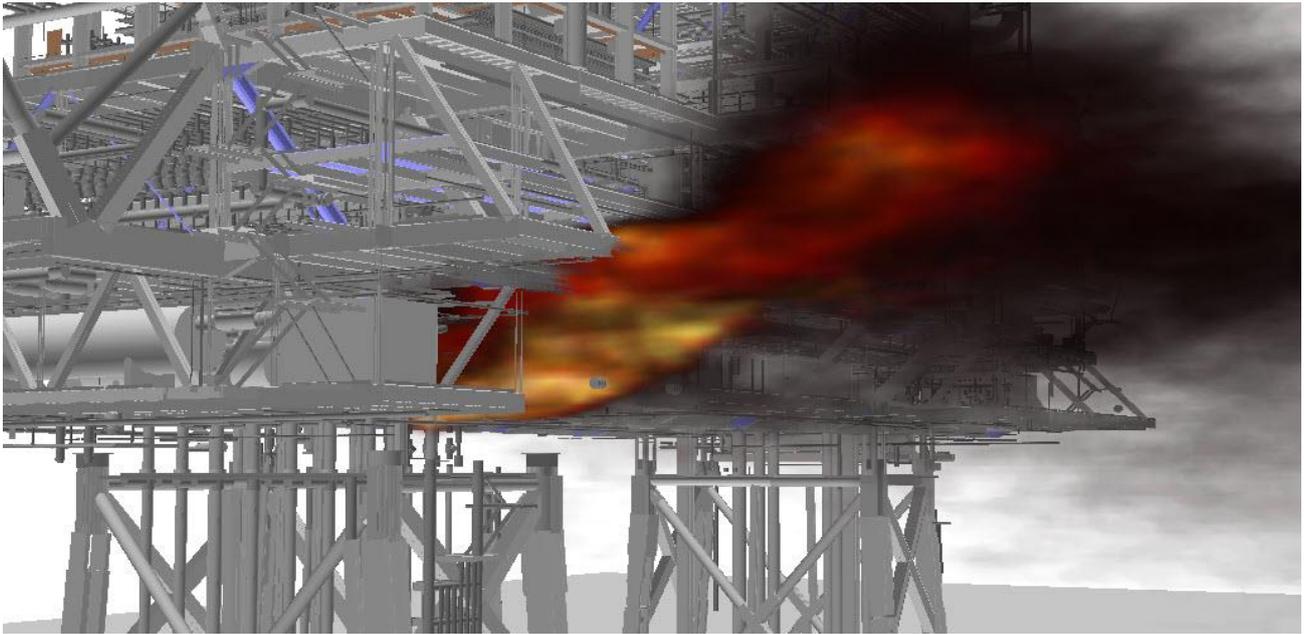
The **3D calculation parameters** on the Parameters tab from previous versions have been merged with the **Grid parameters**, now renamed to **Classic grid parameters**. The fields within the **Classic grid parameters** are used to define the grids when performing classic (non-CFD) calculations in Phast.

A new **CFD grid parameters** object is available on the **Parameters** tab. This allows a grid to be defined for CFD calculations. By default, the “Phast calculated” method will be selected, where the grid size is calculated by the Classic radiation modelling, which is run before the start of the CFD calculations. This modelling calculates the size of the box that will fit the effect zone to the **Minimum thermal radiation intensity level** set in the CFD grid parameters. If required, the grid size can be user-defined.

## 1.4. Visualising flames in the 3D viewer

Phast Lite	Phast	Phast 3D	Safeti Lite	Safeti	Safeti 3D
					

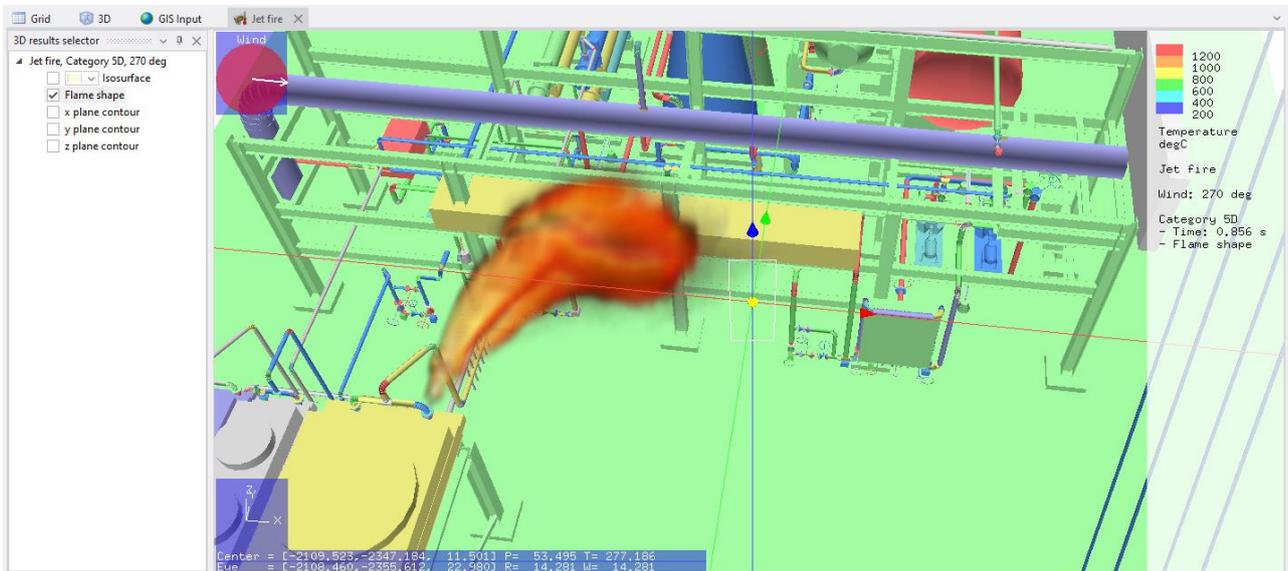
Flames (including smoke) for standalone pool fire and jet fire scenario can be viewed in the 3D results viewer for CFD calculations.



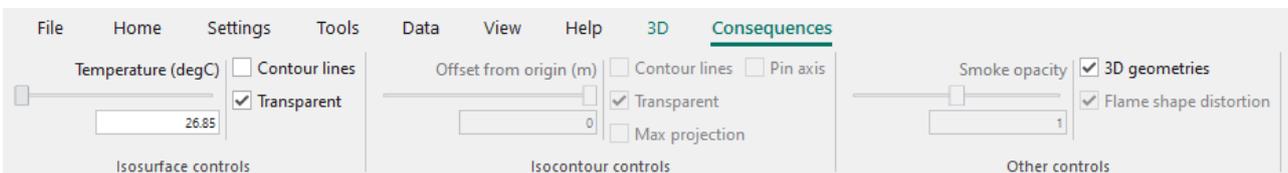
### 1.5. 3D viewer and ribbon bar improvements

Phast Lite	Phast	Phast 3D	Safeti Lite	Safeti	Safeti 3D
<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

A new **3D results selector** panel is available within the 3D results viewer, providing options for the user to select the results to be viewed (isosurfaces, flame shape and isocontours).



The Consequences tab of the ribbon bar has been tidied following movement of some of the controls to the new **3D results selector** panel, and the legend on the right side of the 3D results viewer has been tidied, removing redundant text.



## 1.6. Number of calculations steps

Phast Lite	Phast	Phast 3D	Safeti Lite	Safeti	Safeti 3D
	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>			

The Standalones>Jet fire (CFD) and Pool fire (CFD) reports display the number of time steps run for CFD calculations.

## 1.7. Geometry file(s) used in calculations are retained and displayed in subsequent 3D results views

Phast Lite	Phast	Phast 3D	Safeti Lite	Safeti	Safeti 3D
	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>			

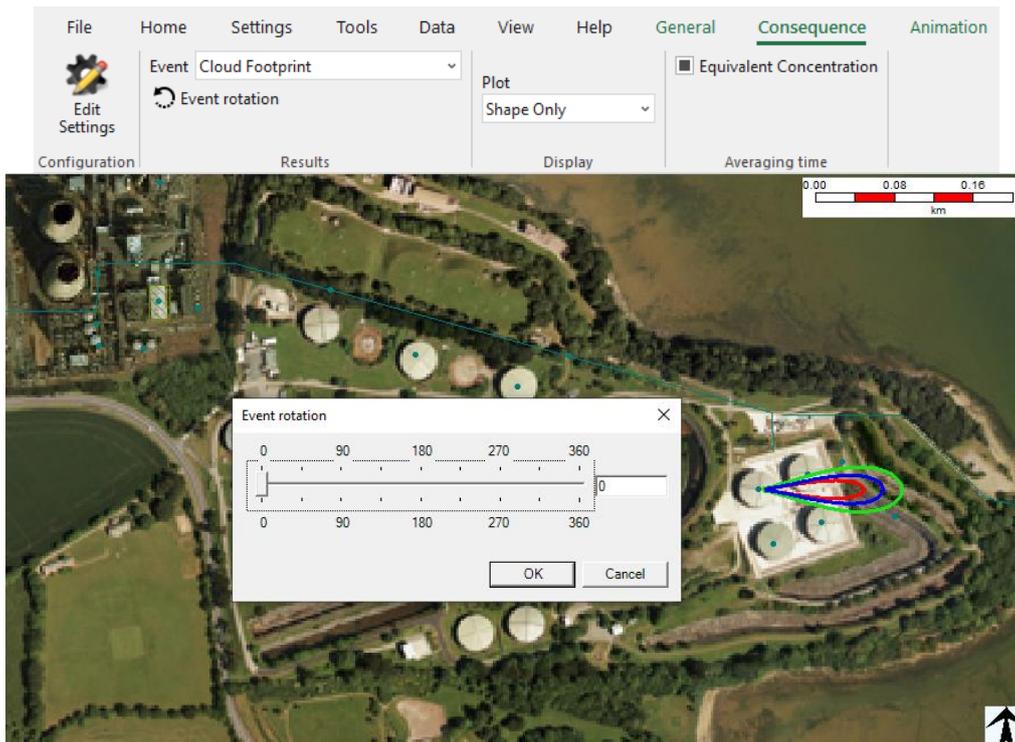
In version 8.6 and 8.61, the 3D geometries displayed in the 3D results viewer would not necessarily be the same 3D geometries used in the calculations. This would be the case, for example, if any geometries had been excluded from the calculations; a new instance of the 3D results viewer – that is, opened after calculations had finished – would display all geometries, including those that had been excluded from calculations.

## 1.8. Event rotation in the GIS consequence results

Phast Lite	Phast	Phast 3D	Safeti Lite	Safeti	Safeti 3D
<input checked="" type="checkbox"/>					

In previous versions of Phast and Safeti, the GIS consequence results view allow users to modify the “Wind direction” clockwise between 0 to 360 degrees (initial wind direction of 0 degrees i.e., wind coming from North to South).

In version 8.7, for standalone pool and jet fires, there is a wind direction tab allowing users specify the wind direction. Thus, for consistency with 3D viewer and graphing results (where X-axis points to East), wind direction on the GIS has been renamed to “event rotation”. The event rotation is measured anti-clockwise relative to East where 0 degrees rotation corresponds to an event pointing East.



## 1.9. Classic 3D thermal radiation calculations

Phast Lite	Phast	Phast 3D	Safeti Lite	Safeti	Safeti 3D
					

In previous versions of Phast, a user wanting to view thermal radiation results from classic (non-CFD) calculations in Phast's 3D viewer would have to define a grid for 3D calculations by specifying the **Number of 3D grid layers** and **3D grid step size in 3rd dimension** on the **3D calculation parameters** (see Section 1.3). In practice this meant running the calculations for the standalone fire scenario, viewing the 2D thermal radiation contour graphs, specifying the 3D grid then re-running calculations before viewing the results in the 3D viewer.

In version 8.7, the grid extent is determined automatically by Phast, meaning the user is not required to define a grid before calculations. The user can specify the **Number of 3D grid layers**, via the **Classic grid parameters** (see Section 1.3); however, this field controls the resolution of the 3D calculations, not the grid extent.

## 1.10. OpenXML format for data input/output

Phast Lite	Phast	Phast 3D	Safeti Lite	Safeti	Safeti 3D
					

The Microsoft Excel data input/output options now read/write Excel OpenXML documents directly. This improves performance and means it is not necessary to have Microsoft Excel installed to utilise the various Excel input/output options in Phast/Safeti.

## 1.11. Compressed study files in \*.psc format

Phast Lite	Phast	Phast 3D	Safeti Lite	Safeti	Safeti 3D
					

Studies from version 6.7 or earlier saved in the compressed format (\*.psc) are no longer supported – that is, they cannot be upgraded directly to version 8.7.

## 1.12. CUDA 11.6

Phast Lite	Phast	Phast 3D	Safeti Lite	Safeti	Safeti 3D
					

On PCs with NVIDIA graphics cards, Safeti 8.7 utilises a newer version of CUDA (version 11.6) during risk calculations than previous Safeti versions. To benefit from the performance benefit this offers, please update your version of CUDA: <https://www.nvidia.com/Download/index.aspx>.

## 1.13. Performance

Phast Lite	Phast	Phast 3D	Safeti Lite	Safeti	Safeti 3D
					

The 'smart mode' run functionality has been optimised for studies which already contain partially run results, where some, but not all, results have already been run. There are two typical use cases:

- Users adjusting a study with results carrying out further sensitivity analysis / modifying some data on scenarios that invalidates part of the results in the study, meaning these scenarios need re-running.



- Users who have run their study to consequence and switch to running risk mode.

In 'smart mode' the decision on whether to run in series or parallel has been optimised as well as the time taken finding results per run row. This second point is particularly important for customers with made run rows in their studies. The combination of these two optimisations has resulted in significantly reduced run times for these types of studies.

## 2 BUG FIXES

The following bugs have been fixed in this release:

Bug #	Description
260567	Explosion and Fire details reports display duplicate values for each point of a long pipeline geometry
310605	<p>Typo on “Property Database” document provided within Technical Documentation.</p> <p>Maximum surface emissive power (SEP) for Propane is 160kW/m<sup>2</sup> (and for Ethane is 170 kW/m<sup>2</sup>). Ethane in the text should be Propane.</p> <p>In Table 7 after the text in the same document, max SEP for ethane is shown as 170 as in the product, not 160 as shown in the text.</p>
328681	Geometry is not shown when excluded from calculations.
336105	“Export to KFX...” option for user defined source scenario (with multiple observers) using the old segment averaging logic instead of multiple observers.
341775	DIGFOR runtime error when temp folder has non-ASCII characters.
345487	Stacked results causing slowdown when moving from Run row to run row during risk calculations.
346147	Maximum overpressure at defined distances downwind for TNT and BST explosion methods is reported as zero.
348076, 357510	Not possible to “Run CFD” when using any non-ASCII characters in pool fire scenario, weathers and geometry file names.
350613	Export graphs option does not export all graphs available (Safeti lite license users).
361472	The liquid long pipeline depressurisation model (Pipe break – PBRK) fails to capture valve dynamics correctly where there is initial pump inflow and active isolation valves operating between the pump and the breach.
351670	Unable to add a background image for standalone jet fire radiation contour plots.
352415	<p>Standalone radiation calculation can get turned off after Run in parallel.</p> <p>Run in parallel can cause the selected state of the Standalone Radiation calculation check boxes (which are all unset initially) to be lost after the file has been re-combined and revert to its initial state. Results will include the user's choice of radiation calculation, but a subsequent re-run would not include the radiation results as the dialog had been changed.</p>
354211	CTOX11 errors generated in Phast and Safeti 8.61 when combining graphs involving flammable-only and toxic/both scenarios.
355029	Component gets automatically added to mixture for upgraded file.
355158	Changing flammable/toxic flag for a material within the standard list of components does not get updated/reflected in the icons.

Bug #	Description
358560	Incorrect rainout with non-zero bund height.
362264	Temperature and Offset label are incorrect when language used by PC contains commas instead of decimal points
363084	Adding new custom 3D object(s) after previously run CFD calculations is/are shown in the 3D results view.
364033	Ignition modelling not working at the far edge of the cloud if using fraction of LFL.
365873	The geometry transform function (Move, Rotate and Scale) did not work when the operating system was using particular locales (e.g., Norwegian).
367174	With the flame shape turned on in the 3D results viewer for CFD calculations, turning 3D geometries off and back on again via the Consequences tab of the ribbon bar would result in the 3D geometry being cropped.
369892	Long file names for 3D geometry files are now supported.
370854	Safeti study with empty risk transect fails to open.
371334	Wrong pool substrate temperature picked up by scenarios. For cases that rain out, the temperature of the surface the pool forms on can be specified on the weather. However, this value was ignored, and instead the atmospheric temperature was used. As surface temperature affects heat transfer to the pool, this could result in pools that evaporated too slowly or too quickly. Normally the difference between ground and air temperature will be small so it is not expected this will have a big impact on results in general.
372691	HF data incorrectly displayed in Admin Materials. By default, pure hydrogen fluoride uses special thermodynamic modelling for dispersion based on its reactivity with atmospheric water vapour. However, when opening the Admin Materials application, the "reactivity with atmosphere" property incorrectly shows hydrogen fluoride to be "not strongly reactive". If users then save the system materials, this will be persisted and used in future Phast or Safeti runs.
372872	In the standalone Miller jet fire model, it was possible to model symmetrically opposite crosswind effects but observe non-symmetrical radiation ellipse results (see screenshot below as example). This issue was due to a weakness in the radiation ellipse sizing model which sometimes failed to locate the more appropriate ellipse dimensioning in the crosswind direction (i.e., take proper account of flame-tilt due to deflection from crosswind effects).
377840	The explosion frequency shown in the ignition risk report did not previous include explosions occurring on detonation event tree branches. Detonations are now included in the explosion frequency sum for each event.

### 3 KNOWN ISSUES AND WORKAROUNDS

There are some known issues that have not been fixed in this version, described below.

47065	Mandation of plant boundary in run row grid
Description	In the Run Row Grid, the <b>Plant Boundary</b> field is never shown as mandatory even if “ <b>Use free field modelling</b> ” is set to Free field (plant boundary) in the Flammable parameters. If a given Run Row has only toxic Scenarios selected or if all flammable Scenarios are modelled with 100% probability of immediate ignition, then the risk calculations will run successfully for the Run Row even if no plant boundary is selected in the Run Row Grid, since the calculations will not involve the modelling of free field delayed ignition outcomes. However, if the Run Row has flammable Scenarios that are modelled with an immediate ignition probability less than 100%, the risk calculations will give an error about a plant boundary not being specified.

47066, 47093	Time-varying discharge calculations may fail for a mixture
Description	<p>The discharge calculations may fail for a time-varying Scenario if the material is a mixture, especially if the conditions are near the critical point.</p> <p>The time-varying calculations are more likely to run successfully if you simplify the mixture, e.g., to two components that have similar properties. If the calculations still fail with the simplified mixture, you should perform the time-varying calculations using a single pure component.</p> <p>Non-time-varying calculations with the Leak or Short pipe scenarios may run successfully for the mixture, especially if you have a licence for the multi-component modelling and select the multi-component option for the Equipment item. With the initial release rate from these calculations and with time-varying results for a simplified mixture or single component, you could make an estimate of the time-varying behaviour and define this in a User-defined source Scenario.</p>

47089	The Normal boiling point can be edited for a mixture that is using the Phast64 property method template, and this will give inconsistencies in the modelling
Description	<p>If you set the template for a mixture to Phast64 and click on Calculate, the <b>Normal boiling point</b> will be one of the fields in the list of properties that is enabled and editable. However, if you change the value, you will find that inconsistencies occur for Equipment items that have the mixture selected, both in the calculations of phase and limits in the Materials tab, and in the consequence calculations for Scenarios.</p> <p>If you have edited the normal boiling point for any mixture, you should reset it to the calculated value by editing the mixture and clicking on Calculate.</p>

47242 Upgraded standalone pool vaporization Models from v6 not included in any Model Selection

**Description** If you upgrade a v6.54 or v6.7 file that includes a standalone Pool Vaporization Model, the Model will be upgraded as a Spill Scenario under an AST Equipment item, but it will be removed from the Model Selection which means that it will not be included when you run the calculations, no matter which Run Row is selected.

The upgrade is handled in this way because the standalone Pool Vaporization Model cannot be used in the risk calculations, but the Spill Scenario can. The Spill Scenario will be incomplete on upgrade because there is no event frequency specified, and it is removed from the Model Selection so that it does not cause problems with the risk calculations.

You should decide whether you want to include the Scenario in the risk calculations. If you decide not to include it but you do want to be able to run the consequence calculations for it, you should create a separate Model Selection and Run Row for it, and only run the consequences calculations for that Run Row.

49587 Consequence results are cleared for a long pipeline item when you change the failure frequency data

**Description** If you run the consequence calculations for a long pipeline and then change any of the settings for the failure frequency in the Risk tab for the item, the results of the consequence calculations will be cleared even though the values for frequency are not relevant to the consequence calculations.

50765 The translucency used to display risk contours is the value set in the Risk Contour Styles, not the values set for the individual risk levels in the Risk Preferences

**Description** The Contours tab of the Risk Preferences dialog shows the colours that will be used for the risk contours for each level of risk and allows you to edit the colour. The inputs for setting the colour includes an **A** field that is set by default to 100%, which corresponds with zero translucency. If you reduce the value for **A**, the Risk Preferences dialog will display a colour that has the appropriate level of translucency applied, but the Risk Contour Plots will not use this level and will instead use the level that is set for Translucency in the Risk Contour Style dialog. To open the Risk Contour Style dialog, select Risk (Initial) from the Styles gallery in the Settings tab of the Ribbon Bar.

The settings in the Risk Contour Style dialog are applied to all contours, and the default value for Translucency is set to zero. If you change the settings in the dialog, you must generate a new Risk Contour Plot to see the effect of the changes.

67975 Dispersion results for vertical releases

Description The dispersion calculations for vertical releases can be problematic, particularly when determining downwind concentrations. The algorithms are based on tangents to the centreline, and therefore vertical or near vertical clouds can run into difficulties that require special handling. In some cases, it has become apparent that this can lead to concentration predictions that are generally over-conservative. In most cases these problems can be solved by reducing the release angle, so it is just off vertical, e.g., to 85 degrees from the horizontal.

90431 Issue about Material to Track is not used for risk calculations when using "Concentration and Risk based" termination Criteria

Description When calculating risk, Safeti ignores the selection for material to track. It uses the whole mixture concentration and assumes the concentration of interest in the model to be that of the mixture. This is a problem for the users especially when they are using the dispersion termination criteria of "Concentration and Risk based" to get the frequency contours of exceeding a particular toxic concentration, and the toxic concentration comes from a dominant toxic component which they have selected in the Material to Track.

92123 Parameter vulnerabilities not showing radiation intensities

Description The outdoor and indoor vulnerabilities on the parameter set, enabled via the workspace dialog, do not display fireball, jet fire and pool fire radiation intensities.

92124 Parameter vulnerabilities not updating when number of radiation levels is updated

Description The outdoor and indoor vulnerabilities on the parameter set, enabled via the workspace dialog, are not updated to reflect the number of radiation levels specified on either the jet fire, pool fire or fireball and BLEVE blast parameters.

186394 Blank field(s) in consequence tables

Description Distance downwind to defined concentrations may show a blank field when a concentration of interest is not reached.

However, "n/a" is presented in case of other consequence types (i.e., jet fires, pool fires, fireballs, etc.).

"Not reached(\*)" will be included instead to be consistent and ensure users understand the context (i.e., it depends on the height of interest).

215145 Import of multiple Microstation 8 files

**Description** If you have multiple Microstation 8 CAD connections, the GIS will display the first one listed on the Map tab only. It is not possible to display multiple Microstation 8 CAD connections on the GIS simultaneously.

If you delete any Microstation 8 CAD connections from your study, you must close any GIS views and re-open them before you are able to add further Microstation 8 CAD connections.

Please note that it is possible to display multiple connections of other CAD formats, including Microstation 7, on the GIS.

240385 Option in the dialog of whether to include pool fires for flammable pool sources

**Description** Logic within the modelling can cause pool sources to give pool fire results. However, some users will not want this; instead, they might want to model dispersion from the pool source resulting in flash fire effects only.

Pool sources of flammable material will not produce pool fires unless the following warning is seen *“UDM3 1128: Mass conservation check failed. Released mass exceeds observer and pool mass by <fraction>. Switching to equivalent pool approach.”*

In those circumstances the pool fire effects can be prevented by switching the **Method to handle mass conservation failure to None**. Note this can lead to underestimates in the amount of mass and concentrations in the dispersing cloud.

It is proposed that, in a future release, users will have the option of whether to include pool fire effects with any pool sources.

241724 Problem displaying images when inserting a georeferenced image after an interactively placed image

**Description** Inserting a georeferenced raster image followed by a non-georeferenced image does not cause any problems. However, inserting a non-georeferenced raster image followed by a georeferenced image causes the GIS display to go blank and it is impossible to view them.

249990 Consequence data grid uses the averaging time in the parameters rather than the averaging time defined in the scenario

**Description** The consequence data grid for toxic/flammable scenarios will always use the averaging times in the Toxic/flammable parameters irrespective of the setting chosen for the averaging time within the scenario.

The summary report displays the consequence distances for the averaging time specified in a scenario.

251699 Default weathers from a new workspace are maintained and imported weathers are merged when importing from excel

Description The merging in of weathers is currently set by design. After importing from excel please ensure to delete the default weathers from the new workspace if not required.

254979 Running a pool fire scenario using CFD calculations causes a crash when the study file is located in a OneDrive folder

Description A crash will occur when running a pool fire scenario using CFD calculations if the study file is located in a OneDrive folder. Please save and run the study file from the local drive.

285845 Crash when editing weather directions in Phast 3D

Description A crash may occur when editing the weather folder in Phast 3D. When the weather folder dialog is open, a random sequence of the actions below could cause the program to crash.

- Clear All
- Select All
- Select\Deselect individual weather directions
- Navigate to Angular offset or Number of directions
- Ensure that the study is saved before making changes in the weather folder dialog to avoid losing data.

298348 Upper limit for volume inventory may sometimes be too large

Description This applies to time varying leaks and short pipe scenarios. Following message "Specified input mass (X) kg too large for vessel volume [TVD2 10]" may appear in some cases where the volume inventory is too large.

Workaround:

1. Switch to mass inventory specification to get the correct limits applied
2. Reducing inventory

312490 Long pipeline: Discontinuity following irrelevant valve closure at upstream end

Description A valve closes at the upstream end causing a discontinuity when there is no pumped inflow. The closure of the valve at the upstream end should not impact the flow in any way.

The workaround is to manually remove this valve.

313967 Support removed for opening of .psc files from Phast/Safeti 8.7

Description Workaround 1: Unzip the .psc file and extract/save the .psu file on your local hard disk. The .psu file can be upgraded and opened in 8.7.

Workaround 2: install/use a previous version to upgrade .psc study files.

314616 During and after CFD calculations temperature at a point is not updated in the legend when the user SHIFT+clicks in the 3D viewer

Description SHIFT+click in the 3D viewer during and after CFD calculations have been completed does not update the temperature at a point in the legend.

Please generate a new instance of the 3D results viewer via the 3D dropdown of the ribbon bar or the right-click menu of your pool fire scenario to ensure this works correctly.

316319 User-defined isocontour planes in 2D graphs are not available yet

Description No contours will be shown on the **Standalone Pool Fire Radiation/Temperature on a Plane (CFD)** 2D graphs when requesting to plot a user-defined contour plane.

322883 Flammable cases may produce blank fire radiation graphs where the related fire scenario does not exist

116518

Description As per title. Please ignore those blank graphs.

323154 Flame shapes do not show immediately on standalone 2D graphs if only a contour plot is requested

370523

Description The flame shape will not be shown immediately on radiation contour graphs for standalone equipment when requesting only radiation/temperature contours. A workaround is either to uncheck/check the **Show Flame Shape** checkbox available in Graph Tools > Consequence tab or to request extra types of results required in the Calculations tab before running calculations (e.g., radiation/temperature at a point calculation)

327380 Relief valve and Disc rupture (short pipe scenario types) report mass in tail pipe

Description There should be no inventory in the tail pipe at the onset of relief action.

Workaround:

1. Right-click on the scenario to create a user-defined scenario
2. Change the end time in the user-defined to reflect the actual release inventory, using the following formula:  $\text{Release end time} = \text{Actual release inventory} / \text{Release rate}$  reported by Phast
3. Re-run the user-defined source

330895 Time-varying fireball radiation calculations throwing “Math 25” errors

Description For the dynamic fireball model, radiation effects are reported at the time giving maximum radiation impact at the location/plane of interest. It appears the numeric method employed in determining the time at which maximum radiation impact is experienced at some elevated heights of interest is struggling to find a unique solution (hence the error).

A potential workaround is to select any of the static fireball models (e.g. Roberts/TNO hybrid). Note that with the static fireball models, radiation transect results at a fixed effect height is largely insensitive to release height as well.

To model the impact of observer elevation relative to different release height (or, to be more precise, fixed fireball trajectory), users could set up the linked scenario cases in question as standalone fireball scenarios, model radiation versus distance results at relevant heights of interest and extract the desired distances to radiation intensities from the radiation transect results.

333869 GIS radiation contours not displayed for Standalone fire scenarios

Description As per title. Note that there are radiation contours results for Standalone fire scenarios when requesting graphs.

335277 Sonic velocity calculations fail

Description Following message “Negative argument to square root function [Note: The MDE message contains 1 parameter values (X) but there are 0 place holders in the reference message description.]. [MATH 1]” may appear in some cases where the sonic velocity (non-default velocity capping method) has been applied by the user.

The failing cases are due to the property system failing to calculate the sonic velocity.

The errors can be avoided by selecting the default “Fixed velocity” capping method instead.

335641      Link to KFX geometry in .json file is not valid if Phast temp directory has been deleted

Description      The path to the KFX geometry is a temporary location, which gets deleted after X days, meaning that if the .json file is imported into KFX after this period, the KFX geometry will not load.

Workaround: create a copy of the combined.kfx geometry from Phast temp directory and place it in the same location as the JSON file.

Note: Phast temp directory can be found by opening .json file in notepad (or similar) and find "GeometryFile" path (e.g., "GeometryFile":  
 "C:\\Users\\[username]\\AppData\\Local\\DNV\\Temp\\Safeti\_Phast\_8\_7\_0\\d0bd4bfc-97f7-4572-ad62-5a54ffa56053\\Combined.kfx".

335831      BLEVE blast results in "Consequence Data" does not show distance correspond to beyond 3 overpressure levels

Description      As per title. Functionally to support more than 3 overpressure levels within "Consequence Data" results for BLEVE blast scenario will be added in future versions.

336752      3D Dispersion (Classic) results currently do not use the material to track

Description      As per title. Note that the dispersion graphs use the material to track

336811      Default "3D calculation parameters" may not be applicable to all scenarios

Description      As per title.

Workaround:

1. Run the scenario with default 3D calculation parameters
2. Generate 2D dispersion graphs to see the extend/boundaries of the cloud and check:
  - Sideview graph for "x" - maximum downwind direction and "z" - maximum elevation
  - Footprint graph for "y" - maximum crosswind direction
3. Adjust the 3D calculation parameters accordingly based on point 2
4. Rerun
5. Regenerate the 3D results

352553      On occasion, since version 8.4, the GIS does not open when launching Phast/Safeti

Description      We continue to explore the cause of this issue, which seems to affect Chinese versions of Windows only. In the interim, we have seen some customers have success with performing a Windows update, a manual update to .Net 3.5 and restarting Phast/Safeti until the GIS loads successfully.

                         If you are experiencing this issue consistently, please contact [software.support@dnv.com](mailto:software.support@dnv.com).

353831      CFD calculations can become suspended

Description      In rare occasions, the CFD calculations can become suspended when attempting to cancel / stop them. This causes Phast to appear to be continuously attempting to stop calculations without them ever being stopped, rendering the program unusable. If this happens, a force closure of Phast via the Task Manager is required.

363045      Failing to find radiation ellipses of an elevated pool fire

Description      Phast could fail to find radiation existing ellipses for standalone fire models in some cases and has been observed in a case of elevated pool fire so far. This problem relates to the searching method used by Phast to locate defining points of the ellipse, i.e., the downwind, upwind and crosswind locations, and may occur for ellipses near to the flame. The searching method could fail to locate any one of the defining locations because of searching step size or complex scenarios, such as ellipses below elevated pool fires.

Workaround:

                         Use footprint contours. Please note that contour plots are generated using point observer, the footprint results will be slightly more conservative compared to radiation vs distance and radiation ellipses, which are calculated using optimized planar observer.

366356      Missing green tick after a CFD run has finished successfully

Description      As designed. Running of CFD allows the user to select the weather(s) they are interested in running the CFD calculations for. If a selection is made then upon completion of the calculations the standard classic selection is applied and then the results status for the scenario is determined. This can mean that no 'green tick', to indicate successfully run calculations appears next to the scenario. This is as designed as there are missing results for the other weathers.

372533      Radiation on transect does not show results on upwind points

Description      For standalone models of jet fire, pool fire or fireball, radiation predicted along a transect starts from the release point into a specified direction. No radiation is calculated on the transect beyond the release point in the opposite direction. In Phast/Safeti 8.7, wind can be set in any direction for standalone fire models, starting a transect from the release point can miss critical results on the transect in certain wind directions and this is an area for improvement.

372734      Blank input supertab after running risk results. It may happen occasionally.

Description      Workaround 1: Disconnect the remote desktop session and reconnect.

                         Workaround 2:

1. Save file or Archive > Save
2. Close Safeti
3. Reopen Safeti
4. File > Open saved study file

377321,      Potential Errors in graphing calculations for toxic materials  
377331

Description      When generating graphs following a calculation involving a toxic material (regular results graphs or toxic footprints on the GIS plot) there is potential to be presented with a set of error messages when attempting to create the plots:

                         ConseqInitialiseCtoxForGraphs: CONSEQ 6: Unhandled runtime error during graphic calculations

                         ConseqInitialiseCtoxForGraphs: MATH 8: Invalid probability in probit calculation

                         Workaround

                         This behaviour has been observed when the probit calculation method "Prefer Probit" has been selected in the toxic parameters. Changing this selection to "Use Probit" creates the graphs as intended so it is recommended to change to this setting in the event of this error.

377926, Geometry not shown for "Classic (non-CFD)" results

376510

Description Geometry may be missing from 3D temperature or radiation results after running classic (non-CFD) calculations and generating results in the 3D viewer.

Workaround: click on "Fit All" button to visualize the geometry/geometries with temperature/radiation results.

379616 Flame shape disappears after generating 3D temperature/radiation results when clicking on "Zoom In" or "Zoom Out" buttons through the Ribbon > 3D tab

Description Workaround: uncheck and check "Flame shape" from 3D results selector

N/A Retrieving results in the event of crash during parallel calcs

Description A crash during parallel calculations will cause the user's psux to be absent of any results from the calculations. The user may at this point assume that running calculations in the parallel was a wasted effort. However, it may be possible to retrieve results by locating a **Result.psux** file in the temporary folder used for parallel calculations.

The temporary folder is located here, depending on your version:

C:\Users\[UserID]\AppData\Local\DNV\Temp\Safeti\_Phast\_8\_7\_0\[Unique tag]\Parallel\[Unique tag]

This file could be beneficial particularly for large studies. If there is a crash during parallel calculations and you wish to retrieve results, please copy the **Result.psux** file to a safe location, because this file will eventually be deleted automatically from the temporary folder.



## 4 LARGE STUDY GUIDANCE

### 4.1 Background

Learning from experience of building and running large studies is important for the user. As such this section provides some guidance on this topic.

The 64-bit version of Phast/Safeti is a significant improvement over older 32-bit version. Testing has shown that users will now be able run large studies in the 64-bit version, without some of the significant workarounds that were required in the 32-bit version. There are, however, some considerations for large studies that users should be aware of.

#### 4.1.1 Slow operations

Some operations become slower as the size of the workspace increases, including the following:

- Working with the nodes in the Study Tree, especially with Equipment and Scenario nodes in the Models tab.
- Using the Grid View to change or view the values for input data.
- Using the GIS Input View, e.g., adding new data, or moving around the view.
- Exporting input data values to Excel.
- Running the calculations.
- Viewing consequence results for a large number of Scenarios.
- Saving an analysis to file.
- Opening a file that has the risk results database packaged inside (default).
- Upgrading a large analysis from a previous version of the program.

#### 4.1.2 Calculation times

Calculations for large studies, naturally, will take longer to run. With **Run mode** on the **Settings** tab set to **Smart (recommended)**, the software will automatically decide whether to run calculations in series or in parallel, depending on your study and the specification of your PC. If **Parallel** mode is chosen, the software will automatically split the study into a series of files and run consequence calculations for these on separate cores of your processor simultaneously. Once the consequence calculations in parallel are complete, the software will automatically recombine these files and will run risk calculations in series.

The **Parallel** mode for large studies in particular will significantly reduce calculation times compared with running in **Series**.

#### 4.1.3 Database size

The free-to-distribute SQL included with Safeti has a capacity of 10 GB. With the default settings in Safeti, it is unlikely this 10 GB limit will be reached. However, if users set the **Level of detail in risk results** to **Full details of outcome contributions** on the **Risk preferences**, the likelihood of reaching the 10 GB limit is dramatically increased.

### 4.2 Large study guidance

There are a number of options available to the user, listed below.

#### 4.2.1 PC specification

The installation notes provide recommendations on PC spec, depending on your use case. In addition, if you are purchasing a new computer it is recommended to have a NVIDIA graphics card that is CUDA enabled (e.g., the M series), as the calculations for individual risk are able to run on either multiple CUDA cores or multiple CPU cores.

Aspects of the consequence calculations will run on multiple CPU cores if the option to **Enable multithreading for dispersion and toxic calculations** is checked in the Workspace dialog, and multiple CPU cores will be used to run consequence calculations for multiple Scenarios at the same time if the Run mode is set to *Smart (recommended)* or *Parallel* in the Settings tab of the Ribbon Bar.

### 4.2.2 Building the model

Build the model gradually, examining intermediate results and performing sensitivity assessments to see if the number of variables can be reduced.

You should run consequence calculations and examine the results before proceeding to the risk calculations. If the results for particular scenarios or weathers are very similar, you can reduce the size of the workspace by combining or removing scenarios and weathers.

Having examined the range of consequence results, you might decide to perform some limited runs of the risk calculations, with a selection of scenarios of different sizes and types, and with different levels of detail in the modelling of the number of weather directions, populations and ignition sources. If these sensitivity assessments show that the differences in the levels of detail do not give significant differences in the calculated levels of risk, you can reduce the size of the workspace by using a lower level of detail.

### 4.2.3 Using Microsoft Excel

Many users find it more efficient to define and import their Study data, especially Model data, using the Microsoft Excel input spreadsheet available with Phast/Safeti.

The process of importing data with Microsoft Excel using the options in the Tools tab of the Ribbon Bar is quicker and requires less memory than inserting nodes directly in the Study Tree and using the input dialogs or the Grid View to set the input values. Having the input data defined in Excel also means that you can edit and maintain the data easily over the course of an analysis, i.e. to make changes that affect a large number of Scenarios as assumptions change, and then reimport the data into the program.

If you need to copy or move a large number of Equipment and Scenario nodes from one part of the Study Tree to another, it is better to export the data to Excel, edit the Excel file to set the path for the Equipment items to the path for the new location (i.e. under a different Study or Folder), and then import from the Excel file. If you try to copy (or cut) and paste a large number of nodes directly in the Study Tree, the demands on memory may cause the program to freeze, but this will not happen if you use Excel.

### 4.2.4 Dividing your analysis into separate psux files

In terms of running calculations, the requirement to divide your analysis into separate psux files is dramatically less in the 64-bit version compared with the 32-bit version. However, if you find the user interface for your large study file to be too slow, you have the option of dividing the analysis into separate psux files and using the Study Manager to combine the high-level risk results.

The Study Manager is installed when you install Safeti. Please refer to the Study Manager release notes for more information.

There are two approaches to dividing an analysis between separate workspace files:

1. Dividing different aspects of the input data between different files but running all types of relevant risk calculations for each file.

For example, you might define the Equipment for different units in different files, or you might define the daytime and the night-time conditions for weather, population and ignition sources in different files.

2. Having the same input data in each file but running separate aspects of the risk calculations for each file.



The Diagnostics option in the Settings tab of the Ribbon Bar allows you to control which aspects of the risk calculations to run for that workspace file, e.g., whether to calculate only individual risk, or only societal risk, or both.

There are several tools and methods you should use when working with an analysis that involves multiple files.

*Use Excel input/output to maintain the input data across multiple files*

With both approaches, you will have several workspace files that have a lot of data in common, e.g., population and ignition data, weather data, etc. Input values are frequently revised during the course of an analysis, and the Excel input/output tool is the quickest and most reliable way of keeping the values consistent across all of the files in the analysis.

*Save the consequence results to file before starting the risk calculations*

If you use the second approach - or if you think that you might use it- you should start with a single workspace file, run the consequence calculations for that workspace and then save the file with the results. You can then create a copy of the workspace file for each type of risk results that you want to run separately, set the Diagnostic options in each file, and then proceed to run the risk calculations for each file. It is always advisable to run the consequence calculations on their own before proceeding to the risk calculations so that you can examine the results and make any appropriate adjustments to the assumptions and input values, but running them separately in this way also makes it easier to adopt the second approach, as you will not have to rerun the consequence calculations for each separate file.

*Use Archive instead of Save / Save As to save the workspace file after running the risk calculations*

The *Archive* option in the File tab of the Ribbon Bar saves the workspace as a special format of \*.psux file that has the database of risk results embedded inside it, along with any map image files that are used by the workspace. The Study Manager only allows you to import workspace files that are in this format and will give an error message if you try to import a workspace file that was saved with either the *Save* or *Save As* options.

*Note:* if you use the Console tool to run the calculations for a workspace (as described above), the Console will always save the calculated workspace in the exported format. This means that you will be able to import the calculated workspace into the Study Manager immediately after the Console has completed the calculations, and you do not have to open the workspace in the Safeti program first in order to use *Export Workspace* to create a version of the workspace in the exported format.

*Put Route Models and Long Pipeline Models in separate workspace files*

The Route Model and the Long Pipeline Model can involve modelling a large number of Scenarios at a large number of different locations, and the calculations can consume a lot of time and memory.

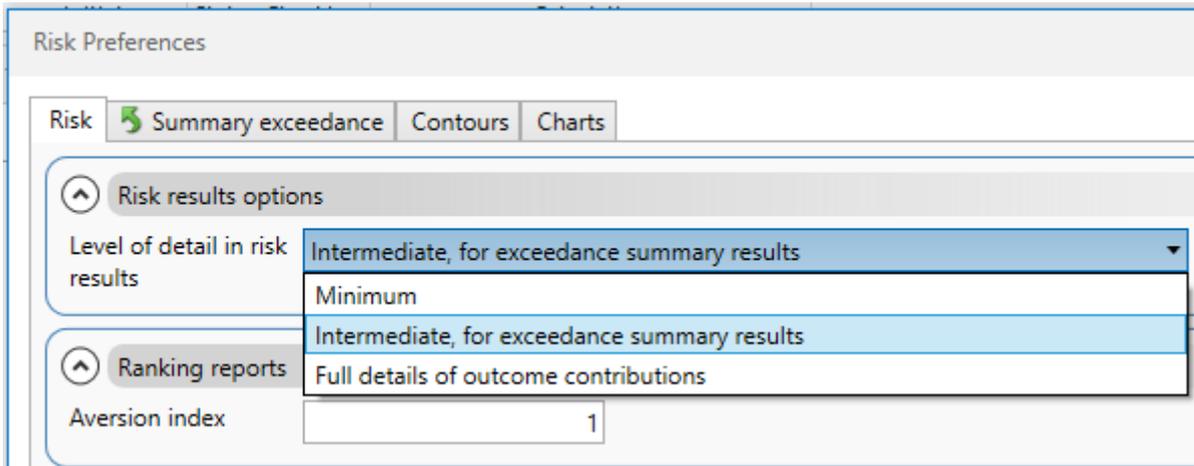
To make the analysis more manageable, you should place each Route Model and each Long Pipeline Model in its own workspace file.

## 4.2.5 Reduce memory usage and storage of risk results

There are two dialog options that can have a significant effect on the performance in terms of the memory usage and the size of the risk results.

*In the Risk Preferences dialog: Produce detailed risk results*

The Risk tab of the Risk Preferences dialog contains an option to specify the **Level of detail in risk results** as shown.

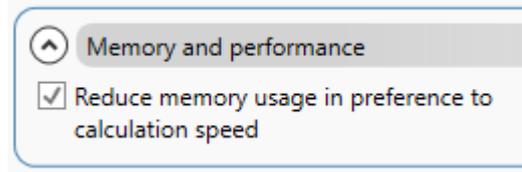


By default for a new Workspace or upgraded study, this will be set to the **Intermediate** option, and your risk results databases are highly unlikely to reach the 10 GB limit.

If you require the **Full details of outcome contributions** to be stored in the risk results database, please note that for large studies especially this will cause the database to be significantly greater in size, and the 10 GB limit could be reached.

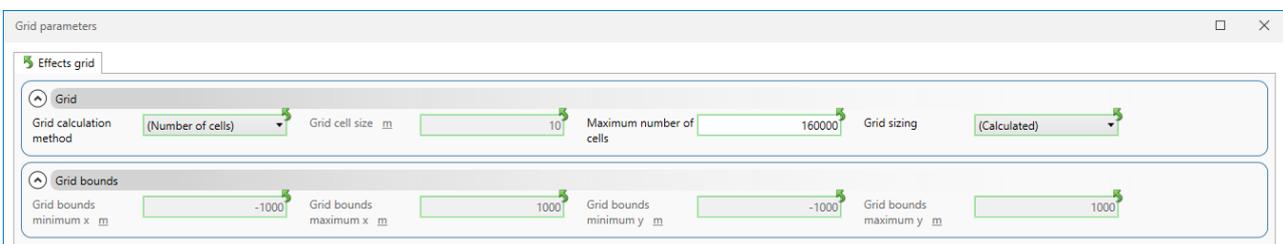
*In the dialog for the workspace node: Reduce memory usage in preference to calculation speed*

The dialog for the workspace node at the top of the Study Tree includes the option to **Reduce memory usage in preference to calculation speed**, as shown in the illustration of part of the dialog. When this option is checked, measures will be taken during calculations to reduce memory usage. This will reduce the risk that the program will run out of memory and crash, but it will make the calculations run more slowly.



#### 4.2.6 Reduce the number of grid cells

The number of grid cells defines the resolution of the risk calculations. By default, the number of grid cells will be limited to 160,000. Users could reduce the **Maximum number of cells** to reduce the resolution of the risk calculations. For example, reducing to 40,000 could have a marked impact on calculation times and database size. It is worth noting that in version 6.7, the **Maximum number of cells** was 40,000.

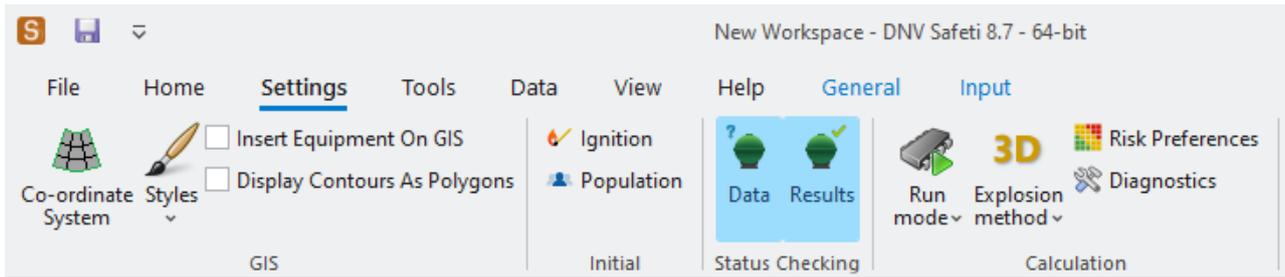


#### 4.2.7 Turn off features in the program window that use a lot of memory and reduce performance

There are two types of feature that can be turned off to improve performance:

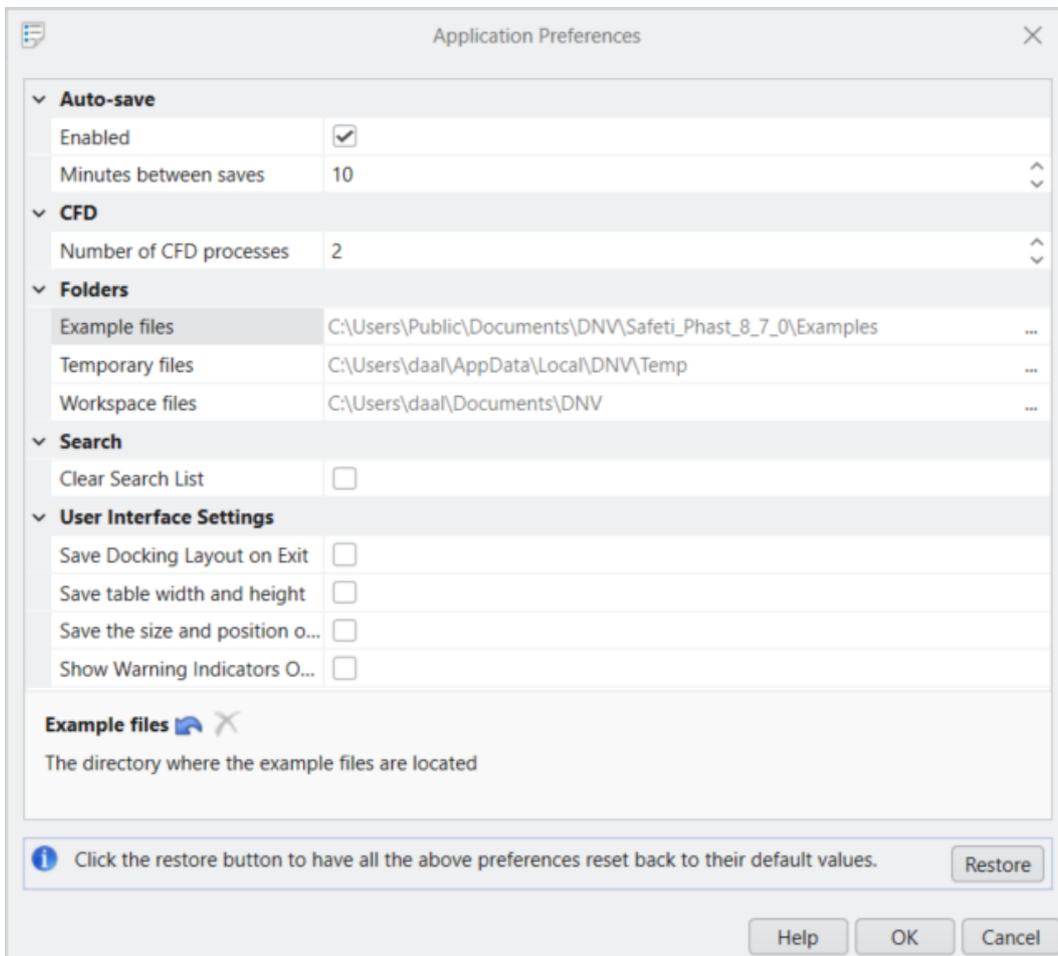
*The Status Checking options in the Settings tab of the Ribbon Bar*

The Settings tab of the Ribbon Bar includes two toggle buttons for turning on and turning off the checking of the status of input data and results. By default, they are both turned on, as shown in the illustration.



These checks can be very time-consuming with a large analysis, leading to long pauses after each change of input values. You should turn off the checks while you are working on the input data for the analysis, and then turn them back on when you are ready to run the calculations.

The status checking will also be dramatically slower if the user has opted to **Show Warning Indicators on Tree** via the **Application Preferences**.



*The types of View that require constant updating as you move around the Study Tree and change data*

Some of the Views in the program window change their content depending on what Study Tree node or another item is selected elsewhere in the program. As you move around the program between different items, these Views must be updated constantly, and this is very time-consuming. You can improve performance if you close these views whenever you are not actively using them.

The Views that you should close wherever possible are the following:

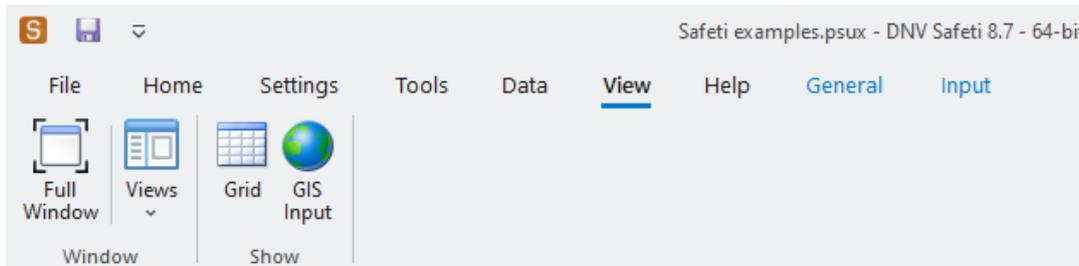
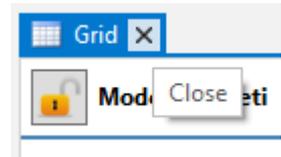
- The Grid View



- The GIS Input View
- The GIS Configuration View that is displayed when you are working in the Run Row Super tab

To close a View, click on the *Close* button at the right of the tab for the View, as shown in the illustration.

To reopen a View after you have closed it, select the option for that View in the View tab of the Ribbon Bar, as shown.



#### 4.2.8 Avoid generating consequence reports and graphs that cover large number of scenarios

When you select the option to view consequence reports or graphs, the Report View or Graph View will include the results for all the Scenarios that are covered by the current node that is selected in the Study Tree. If there are a lot of Scenarios under the current node, the Report View or Graph View will be very large and will consume a very large amount of memory.

Whenever you view a consequence Report or Graph, you should try to limit the number of Scenarios covered to a maximum of about 20. This should ensure that the Report or Graph is small enough to be responsive as you work with it, and that the program does not run out of memory while displaying it.

#### 4.2.9 Hard disk space

The risk results for a single large workspace can occupy many gigabytes of disk space or more. Before you start the risk calculations for any large workspace, you should check the amount of free hard disk space.

If you wish to remove old database of risk results which might be taking up space on your C: drive, you can simply delete them from the following locations:

`C:\ProgramData\DNV\Safeti_Phast_8_7_0\DatabaseStorage`

#### 4.2.10 Use the Console tool to run calculations

The Console is an application that runs in a Windows Command Prompt window, and that runs the Safeti consequence and risk calculations separate from the program window. The program window and the operations of its various features consume memory, so using the Console maximises the amount of memory available for the calculations.

The Console will run the calculations for all the workspace files in a specified folder, which means that you can run the entire analysis with a single command.

Once the calculations have been run in the Console, you can run either the Safeti program or the Study Manager and view the results. The Console always save the calculated workspaces in the exported format which means that you will be able to import the calculated workspace into the Study Manager immediately after the Console has completed the calculations, and you do not have to open the workspace in the Safeti program first in order to use Export Workspace to create a version of the workspace in the exported format.

To use the Console, take the following steps:

1. Ensure you have local administration rights for the computer. If you do not, ask your IT department to arrange this for you.
2. Create or choose a folder for storing the workspace files for the analysis. **The path to the workspaces folder must not contain any spaces.**
3. Create or choose a folder for storing the consequence and risk results for the analysis. **The results folder must be different from the workspaces folder, and the path must not contain any spaces.**
4. For each workspace in the analysis, set up the input data in Safeti, and save the workspace to a \*.psux file in the folder for the analysis. **The names of the \*.psux files must not include any spaces.**
5. Exit from the Safeti program.
6. If you have made any changes to the administration files in setting up the data for the analysis, you must copy the changed administration files from the folder that is used by the full Safeti program to the folder that is used by the Console.

The full Safeti program works with administration files located in this folder:

*C:\ProgramData\DNV\Safeti\_8\_7\_0\Admin*

whereas the Console uses files located in this folder:

*C:\Program Files\DNV\Safeti\_Phast\_8\_7\_0\configuration*

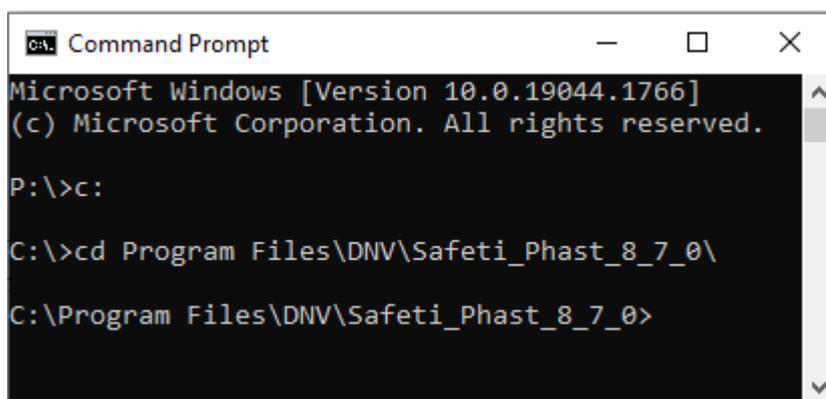
Before you copy the edited files from the *ProgramData* folder, you should create backup copies of the original files under the *Program Files* folder. This will allow you to return to the original files later, if required.

7. Locate the Windows Command Prompt application. You can find it in the Start Menu by searching for "cmd", as shown in the illustration.



8. Run the Command Prompt.
9. Type in commands to move to the C: drive and then to the folder for the Safeti program files, as shown in the illustration.

The folder for the Safeti program files is *C:\Program Files\DNV\Safeti\_Phast\_8\_7\_0*.



10. Enter a command of the following form to run the Console:

*phastconsole /pdrunrisk [path to workspace files folder] [path to results folder] /s*

For example, if the path to the folder of workspace files is:

*C:\Data\TestCases*

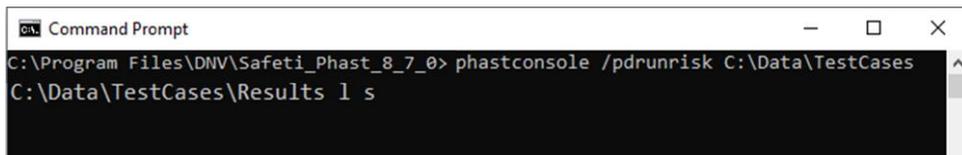
and the path to the results folder is

*C:\Data\TestCases\Results*

Then the command would be as follows:

*phastconsole /pdrunrisk C:\Data\TestCases C:\Data\TestCases\Results /s*

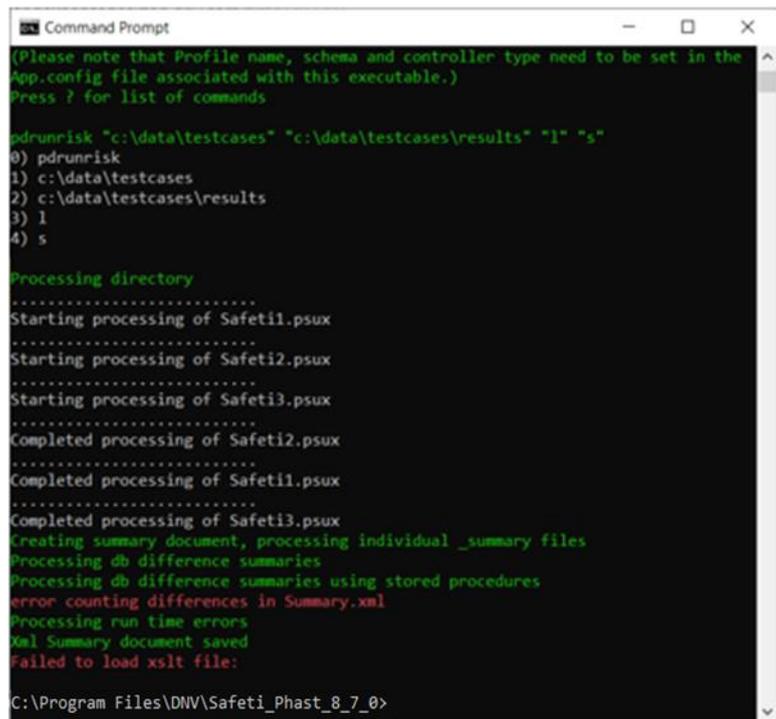
The illustration below shows the command for this example in the Command Prompt window.



After you press *Enter* to start the Console running, messages will appear in the Command Prompt window about the process of starting the calculations. A separate Console window will then open for each workspace file as it is run by the Console. These Console windows are similar to Command Prompt windows, but the title bar contains a special version of the Safeti icon  and the title is the path to the PhastConsole application file. The Console window will close automatically when the calculations for that workspace are complete.

The Console window displays the messages that would normally be written to the Output View in the program window during the calculations. These messages are also written to a file with a name of the form *[workspace name]\_log.txt* in the workspace files folder. For example, if the workspace file is *ChlorinePlant.psux*, the log file will be called *ChlorinePlant\_log.txt*.

The calculations in the Console for a given workspace create a new *.psux* file in the results folder that has the same name as the original workspace, and that contains all of the input data and also all of the results. The workspace files that are created in the results folder are in



the exported format that has the database of risk results inside the file itself. These are the format of files that you can import into the Study Manager, which means that you will be able to import the calculated workspace into the Study Manager immediately after the Console has completed the calculations, and you do not have to open the workspace in the Safeti program first in order to use Export Workspace to create a version of the workspace in the exported format.

11. Close the Command Prompt window when the calculations for all of the workspaces are complete

At the end of the calculations you will see messages in the window about creating a summary document and processing difference summaries, and these messages will include some red error messages, as shown in the illustration. The Console application includes features for performing regression testing (i.e. comparing the results for the latest run with results from a previous run), and these messages are produced by the regression

testing features. These error messages do not indicate that a problem occurred in the calculations for any of the workspaces, and you can always ignore them.

- To view the results, you can either import them into the Study Manager from the calculated workspaces in the results folder or run the Safeti program and open the calculated workspaces.

In practice it is most convenient to save the commands to run the Console in \*.bat files and execute the \*.bat files either from the Command Prompt window or directly using Windows Explorer.

You can type "?" in the Console to get help on the commands

If you enter just phastconsole in the Command Prompt window, without adding the command text given in Step 10 above, the Console will start up in "interactive mode". In this mode, you can type "?" to get help on the different commands that are available.

Type "?" on its own to see a list of all arguments and commands, as shown below:

```
> ?
?
Arguments:
/Product:          Specifies product to run eg /Product:Safeti
/Features:         Feature flag settings eg /Features:IgnoreSyncTokens=true;HyperThreading=true
/MaterialsDirectory: Tells it where to find the materials file eg /MaterialsDirectory:"C:\FolderName"
/TempDirectory:   Location of temp folder eg /TempDirectory:"C:\FolderName"
/DatabaseDirectory: Location of database folder eg /DatabaseDirectory:"C:\FolderName"
/UseResults       Ensures existing results are not cleared
/Language:        Language to be used eg /Language:en-GB
/Database:        The database settings eg /Database:Server=ServerName;AdminUser=AdminUserName;AdminPassword=Password
/NumberOfProcesses: Number of processes to use when running in parallel eg /NumberOfProcesses:8
/Min              Minimize console window of any spawned processes
/DevMode          Activates developer mode [for internal use]
/CustomVersion    Indicates a custom mode/version [for internal use]
```

Type "?" followed by the name of a command to see details of using that command, as shown below for the pdrunrisk command used in Step 10 above:

```
> ? pdrunrisk
? pdrunrisk
0) ?
1) pdrunrisk

NAME
    pdrunrisk - calculate risk and save a directory of files
SYNOPSIS
    where mandatory inputs are:
        input directory[full path]
        output directory[full path]
    where optional inputs are:
        selection [guid | runrowset | root]
        l [log to file]
        s [save file after it is recalculated]
        -donotforcedetailedrisk [does not force detailed risk results]
DESCRIPTION
    This command processes the given directory running risk calculations. For each file
    results cleared [unless /UseResults], recalculated and then the results are saved.
```

The illustration above shows -donotforcedetailedrisk as an optional input for pdrunrisk. It is important to use this option if database size is an issue for your analysis.

## 4.2.11 Upgrade your SQL Server

If you require the **Full details of outcome contributions** for the **Level of detail in risk results** and you run out of space on your SQL server, you can upgrade the server. Please contact our Technical Support Team for further information.



## About DNV

We are the independent expert in risk management and quality assurance. Driven by our purpose, to safeguard life, property and the environment, we empower our customers and their stakeholders with facts and reliable insights so that critical decisions can be made with confidence. As a trusted voice for many of the world's most successful organizations, we use our knowledge to advance safety and performance, set industry benchmarks, and inspire and invent solutions to tackle global transformations.

## Digital Solutions

DNV is a world-leading provider of digital solutions and software applications with focus on the energy, maritime and healthcare markets. Our solutions are used worldwide to manage risk and performance for wind turbines, electric grids, pipelines, processing plants, offshore structures, ships, and more. Supported by our domain knowledge and Veracity assurance platform, we enable companies to digitize and manage business critical activities in a sustainable, cost-efficient, safe and secure way.