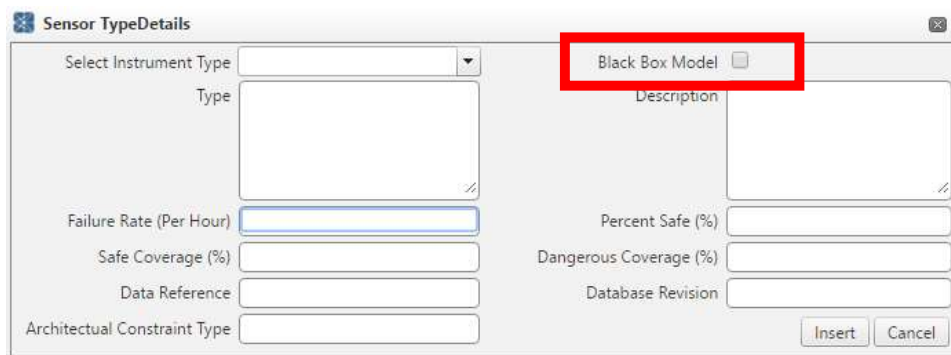# Vertigo SIS Lifecyle Management

Working with Black Box Models

Working With Black Box Models

In this tutorial we'll be looking at the use of black box models in Vertigo. Black box models allow us to override the default functionality of Vertigo when running SIL Verification calculations.

Black box models are applied to instrument types on the instrument type details form. An instrument type can be defined as a black box model by checking the checkbox in the top right corner of the form.

Not all instrument types can be defined as black box models. Only Sensor Types, Logic Solver Types and Final Element Types can be black box models. A Process Connection, Sensor Interface or Final Element Interface can not be defined as a black box model.

When the black box model checkbox is checked on an instrument type details form, the available inputs on the form will change. By default, Vertigo uses the following values to calculate the PFD$_{avg}$ and spurious trip rate (STR) for an instrument type.

- Failure Rate
- Percent Safe Failures
- Safe Coverage Factor
- Dangerous Coverage Factor

Using a black box model will allow you to override this default functionality and enter the PFD$_{avg}$ and STR directly. Black box models are a useful tool when modeling sensor, logic solver or final element subsystems which are too complex to be represented using the simplified equations defined by *ISA TR84.00.02-2002 Part 2*. They are also useful when working with vendor FMEDA data where the only available data is PFD$_{avg}$ and STR (or mean-time-to-fail spurious).

We'll get started with black box models by applying a black box model to a sensor type however, this process is identical for logic solver types and final element types as well.

Start by clicking on the add button in the main navigation toolbar and selecting Sensor Type from the dropdown list. This will display the sensor type details form.
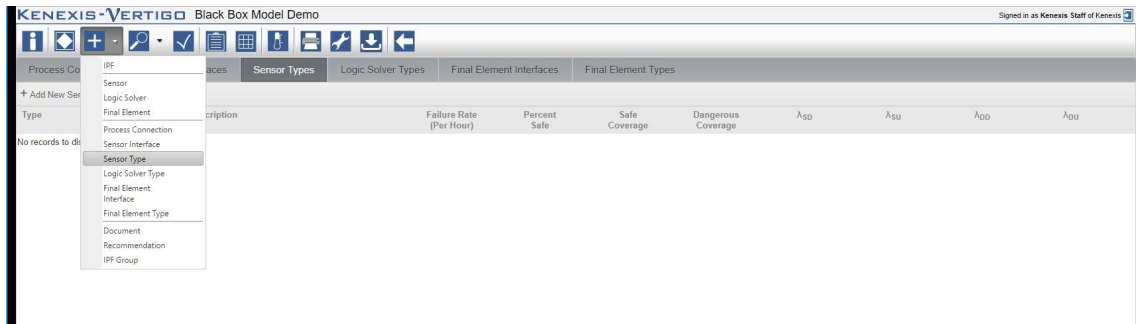
Once the sensor type Details form is open, select custom component for the Select Instrument Type Dropdown. This will allow us to create a local failure rate model rather than importing data from a library.
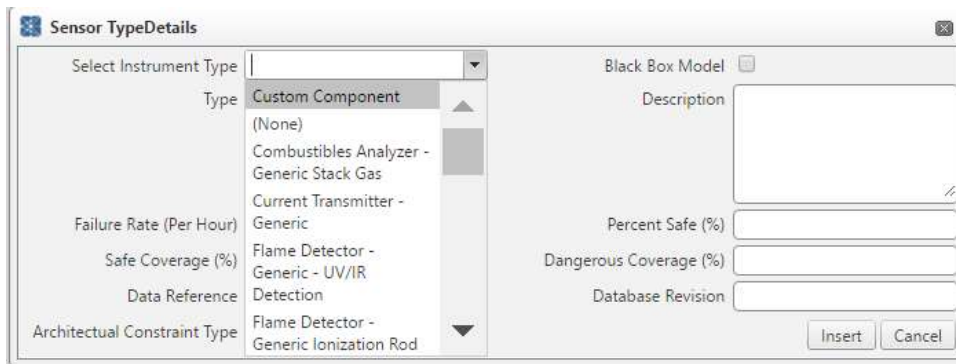
Next, click on the black box model checkbox in the top right corner of the form to define this sensor type as a black box model. After clicking the checkbox, the form should display as follows.

Now we can rename the Type field and add a meaningful description to our sensor type. Enter the following for the "Type" and "Description" fields.

> Type: My First Black Box Model
> Description: This is the PFD_{avg} and STR for a complex subsystem

Next, we can directly enter the PFD and STR. This data could come from a variety of sources but most commonly it is the result of some sort of reliability analysis done outside of Vertigo. The source of this data could be the results of a fault tree analysis study performed using the Kenexis Arbor fault tree analysis application. If so, we can create a link between the Arbor study and this instrument type. We'll look at how to make this link later in the tutorial, for now enter the following PFD_{avg} and STR.

> PFD_{avg}: 1.0E-02
> STR: 1.0E-07

The next set of fields on the black box model form are "Hardware Fault Tolerance" and "Max SIL Approved". These fields are required for Vertigo to properly calculate the achieved SIL for a SIF containing a black box model.

Determination of whether a SIF can achieve minimum hardware fault tolerance requirements, as defined by IEC 61511 / ISA 84, is handled seamlessly by Vertigo. By default, Vertigo will analyze the system fault tolerance and safe failure fractions based on the selected voting configurations and failure rate data entered. However, because this data is not specified for a black box model, we as users need to inform Vertigo when the maximum achievable SIL is for the subsystem characterized by our block box model.

Suppose our black box model characterized a 1oo2 vote on two pressure transmitters. This would mean that our hardware fault tolerance is one and our max SIL Approved would be SIL 2 (assuming the predominant failure mode of the transmitters are to the safe state). Understanding the minimum hardware fault tolerance requirements for each SIL is not the intent of this tutorial, however understanding these requirements is important if you intend to use the black box model functionality of Vertigo.

For now, we'll assume the following for our Black Box Model.

Hardware Fault Tolerance: 1
Max SIL Approved: 2

The next two fields, are Data Reference and database Revision. These fields allow us to track to source of data used to generate the PFD_{avg} and STR we entered for our black box model. These fields are for informational purposes only. They are not required and the information entered here will not affect the SIL Verification calculations. For now, let's enter the following.

Data Reference: The Source of this Black Box Model

Database Revision N/A

The final field on our form is architectural constraint type. This not a required field for a black box model instrument type. The architectural constraint type, as defined by IEC 61511 / ISA 84, is used by Vertigo when calculating the maximum achieved SIL with fault tolerance considerations. However, when using a black box model, we explicitly state the maximum achieved SIL so the architectural constraint type is not required. It is recommended to it be specified here for informative purposes. Let's say our black box model contains type "B", enter B for architectural constraint type.

At this point our black box model is fully defined and we can click insert to save the changes.

To view the sensor type that was created, click on the view button in the main navigation toolbar and selected Sensor Types from the dropdown.
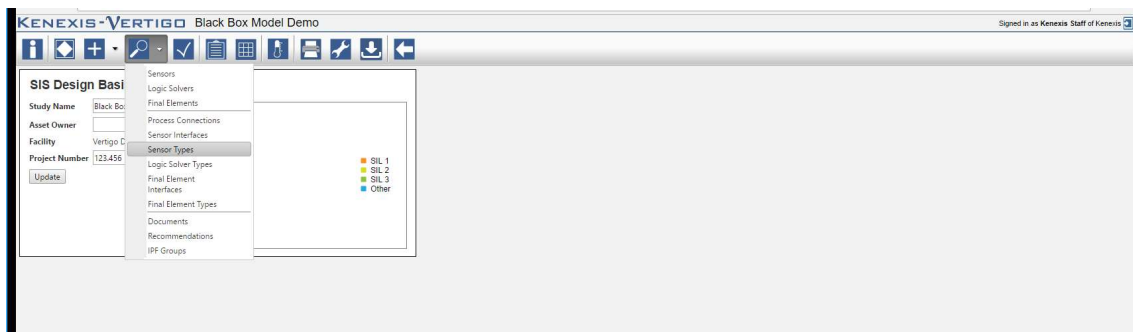
This will navigate to the sensor types grid view where we can view, edit, and delete our models. You'll notice in this grid that many of the columns are not populated with data for the black box model. This is because the default columns in this grid display fields which are not specified for black box model. Missing data in the grid is an obvious sign that an instrument type is a black box model.

Now that we have created our sensor type we can apply this sensor type to Sensors, the same we would with any other senor type. However, when a sensor type is a black box model many of the controls on the Sensor details form will be disabled as they have no application for black box models.

The final thing we'll look at this this tutorial is linking the results of an Arbor fault tree analysis study to a black box model in Vertigo. You may have noticed two link labels on the Sensor Types form, highlighted below.

These link labels can be used to link the current instrument type to the results of an Arbor fault tree analysis study. Clicking on one of the links will display a dropdown menu to right. This dropdown menu can be used to select for any Arbor fault tree analysis studies in the same facility as the active Vertigo study. Linked Arbor studies must be in the same facility as the Vertigo study. You can not create this link across multiple facilities.

In this case, there are two Arbor studies defined in this facility "My First BBM – PFD" and "My First BBM – STR".

When you link an Arbor study to the PFD$_{avg}$ field, the PFD$_{avg}$ field will be populated with the unavailability of the top gate of the Arbor fault tree.

When you link an Arbor study to the STR field, the STR field will be populated with the frequency of the top gate of the Arbor fault tree.

If you are creating an Arbor study that will be linked to an STR field for a black box model it's important to note that you must work in time units of hours. Arbor is unitless, meaning that it is your responsibility as the user to select the time units you intent to work in and make sure that you are using those units consistently. Vertigo is not unitless. The expected value for STR is in failure per hour, which is why the units of time in a linked Arbor study must be hours.

We hope you found this tutorial helpful and enjoyable. If you have any questions about the steps performed in this tutorial or need any further assistance please don't hesitate to contact Kenexis support staff at support@kenexis.com.