User Manual

Cybersafety Application Tool

Version 1.0
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Introduction

Cybersafety Application Tool (CAT) is an online application that facilitates an integrated, holistic safety and security analysis using the **Cybersafety method [1] [2]**. The Cybersafety method [1][2] is based on the System-theoretic Accident Model and Processes (STAMP) [3] [4] accident-causality framework which is an alternative to the traditional Chain-of-events model. In the STAMP world view, accidents are considered to be a result of loss of a control and violation of safety and security constraints rather than individual component failures [3] [4].

The basic steps in the Cybersafety method are shown in Figure 1 below [1][2]; it consists of four steps:
Step 1: Define the basis of the analysis by identifying unacceptable losses for the system as well as high-level system hazards that could be exploited to result in those worst possible outcomes.
Step 2: Develop a model of the hierarchy of controllers and their interactions that together enforce safety and security constraints on system operation (Controllers include human operators, automated systems, management, and even government and regulatory entities)
Step 3: Identify control actions that could be hazardous and lead to system disruption or damage.
Step 4: Hypothesize scenarios and identify causal factors that would cause the constraints to be violated or cause the controlled to issue unsafe commands, given malicious actions of an attacker. The results are then used to identify new requirements that would prevent the worst possible outcomes identified in Step 1 of the analysis.

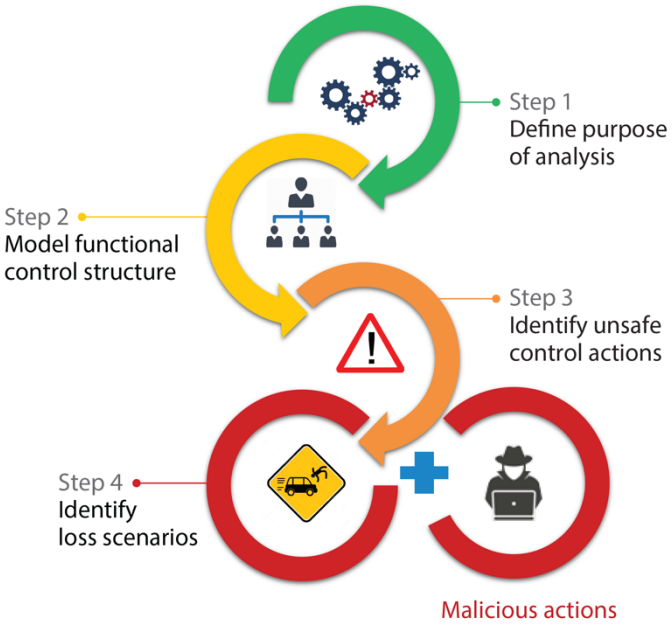

Figure 1 - Overview of Cybersafety Method [1]

The **Cybersafety Web Application Tool** was developed with a goal to improve efficiency of the analysis while reducing analyst workload. It was also developed with a goal to provide a superior user experience that integrates an advanced drawing tool while providing traceability throughout the analysis.

This document provides a step-by-step guide to use the tool and elaborates the many features the tool offers.

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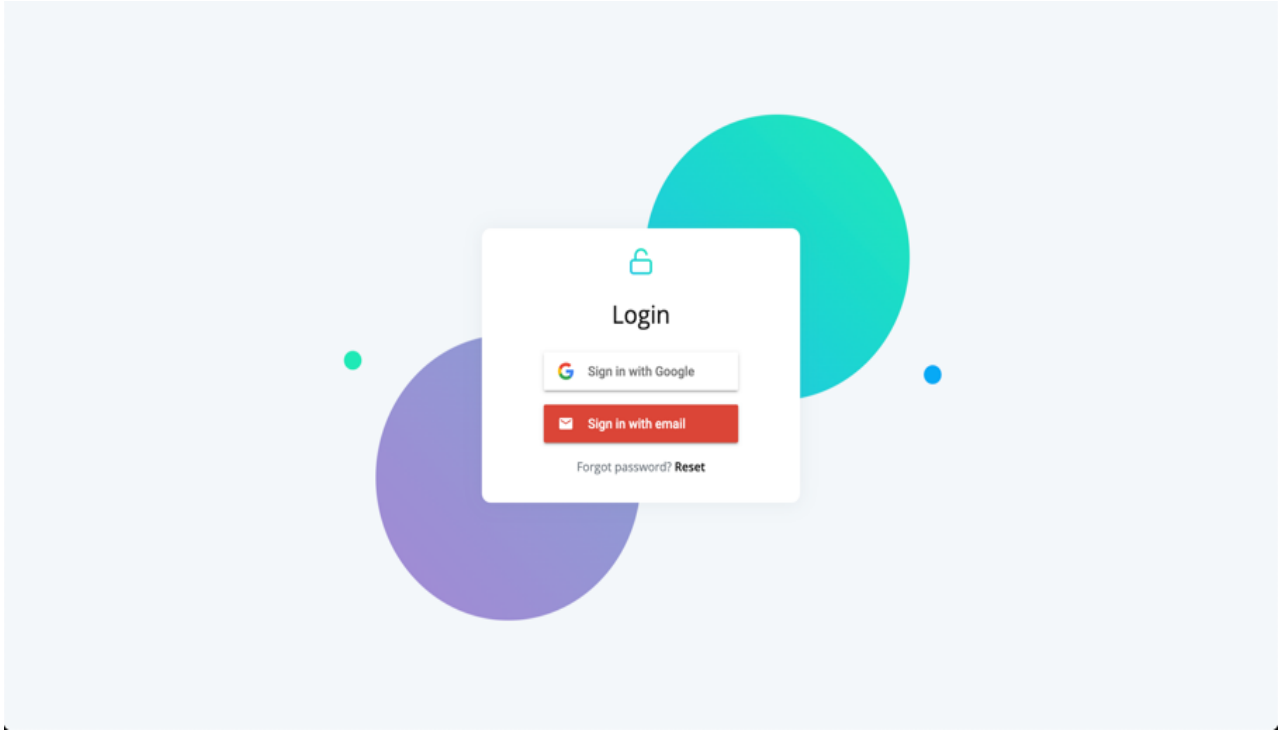
User Log In

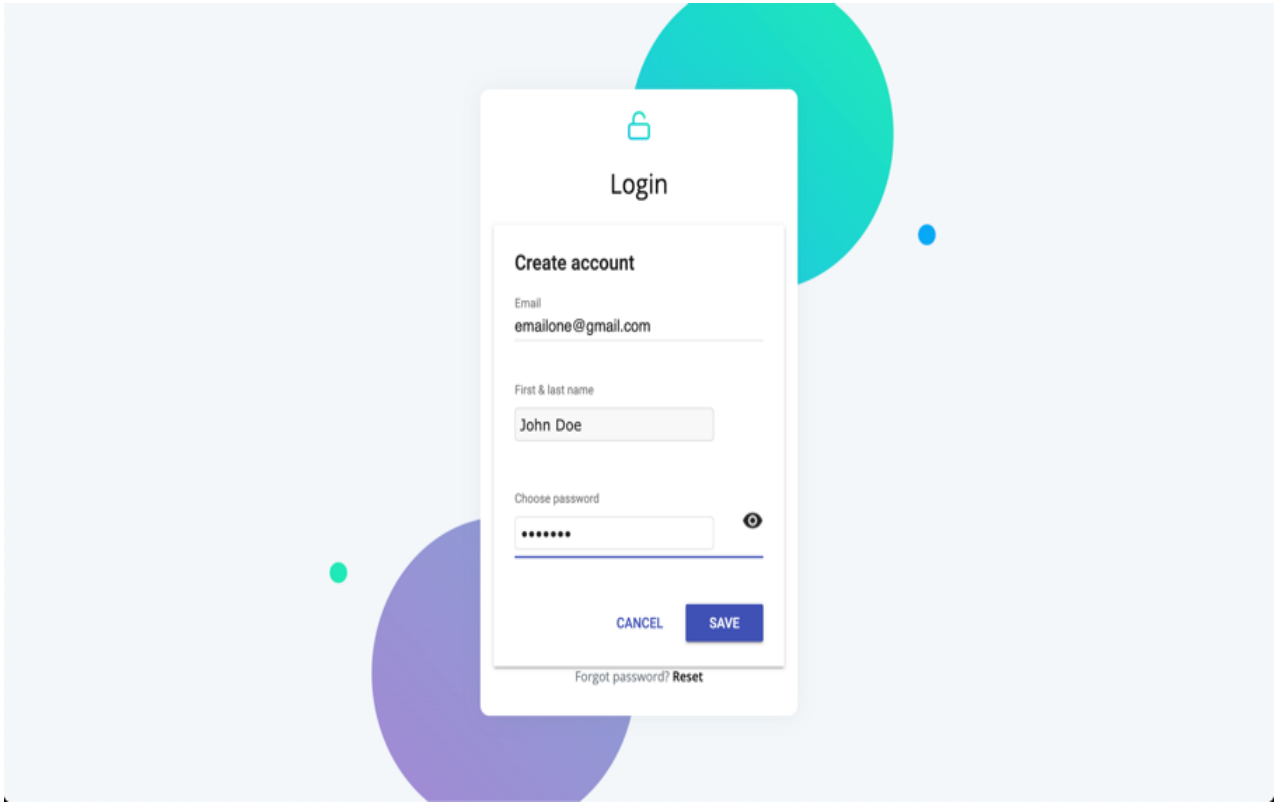
1. To open the Cybersafety web application, simply enter the following URL in a web browser: https://stamp-webapp.web.app/

2. First time users will be greeted with a login screen



3. The user can sign in either using a Google account or creating a new account using a valid email address

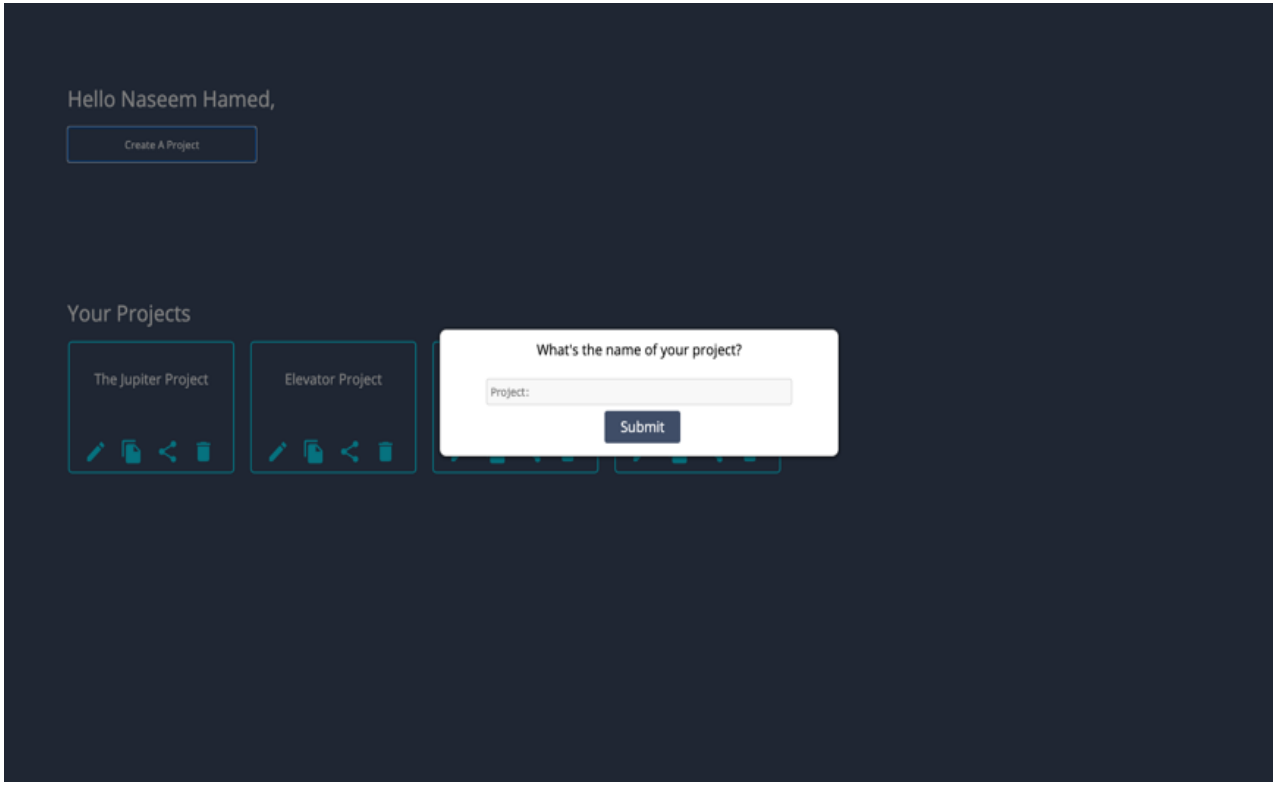
4. Fill out the small form and submit to enter the Cybersafety Project Homepage



Project Homepage

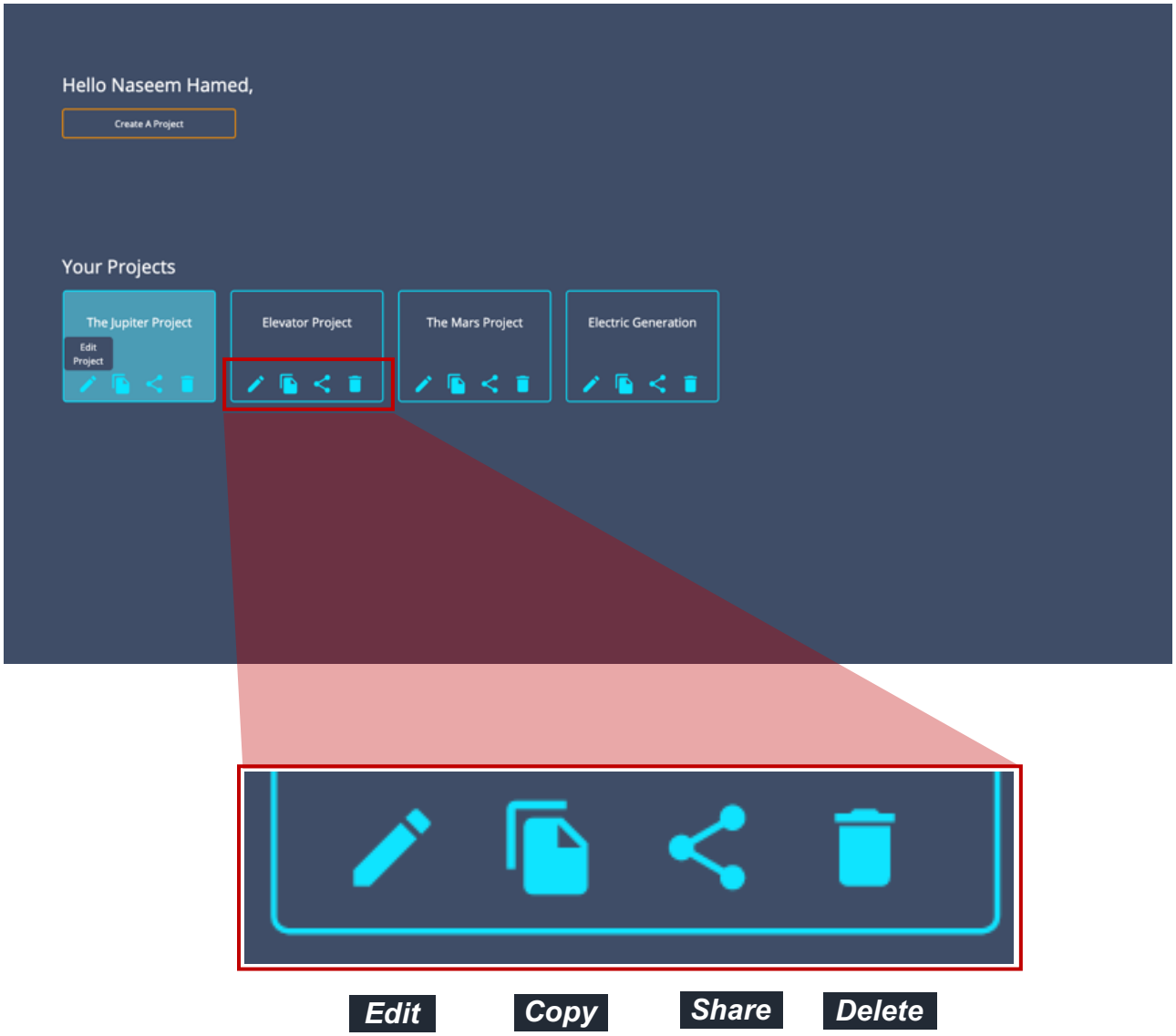
1. The Project Homepage enables the user to create a new project or enter an existing project

2. Click the create project button and choose a name for a new project **or** choose from the list of existing projects to get started



3. Note that each project has the following options:

   a. **Edit:** Change project name
   b. **Copy:** Make a copy of this project
   c. **Share:** Click this icon to share the project with other team members by entering their email address
   d. **Delete:** Clicking this icon would delete the project; **NOTE** that a popup would ask for a user confirmation before deletion

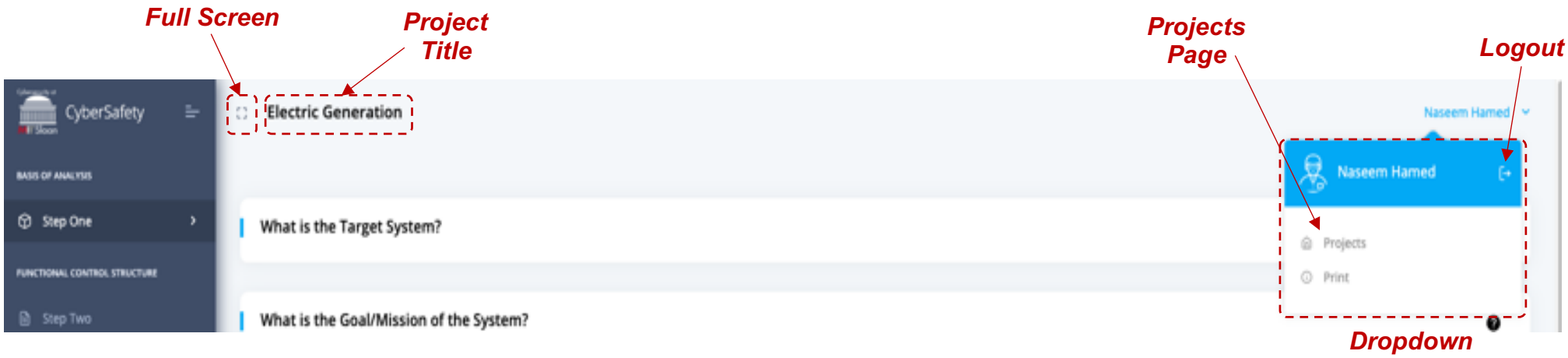


Tool Layout

1. After creating a new project and clicking on it, the user enters the project space

2. The first thing to note is the navigation bar at the top of the screen. From left to right, there is button to enter full screen mode, the project title as well as a dropdown menu.

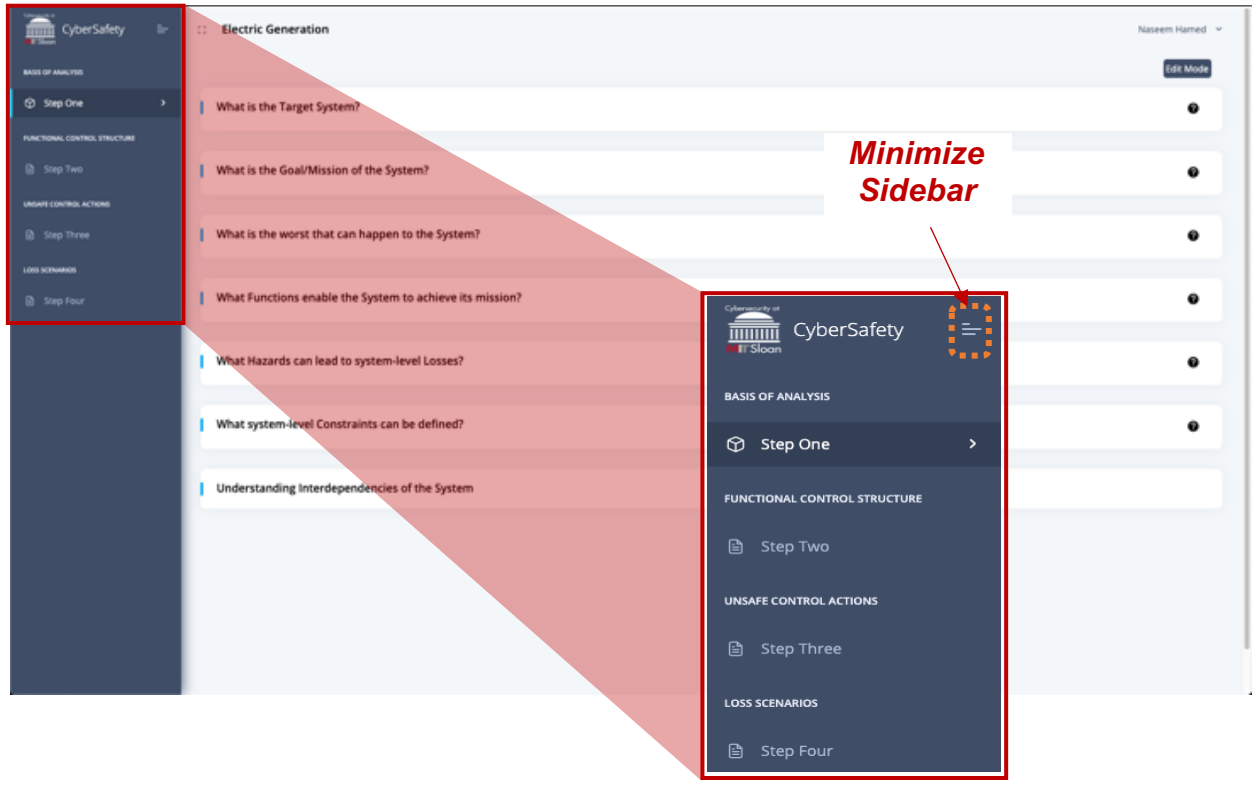
3. The dropdown menu provides options to go back to the project homepage, print the current page or logout of the web application



1. The Sidebar on the left of the page has links to the various Steps of the Cybersafety method. Note that the Cybersafety method consists of four steps:

   - STEP – 1: Define Basis of the Analysis
   - STEP – 2: Model the Functional Control Structure
   - STEP – 3: Identify Unsafe Control Actions
   - STEP – 4: Generate Loss Scenarios

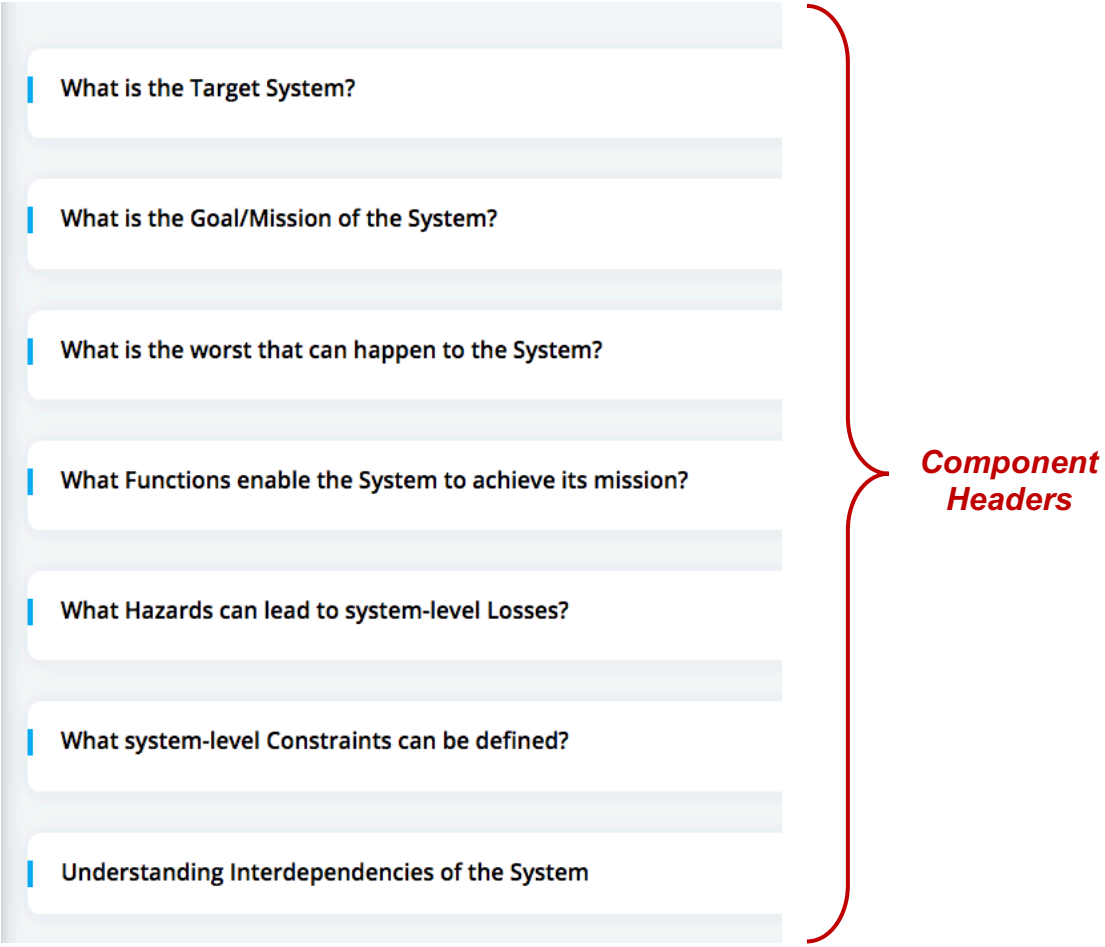
2. To get additional screen real-estate click the minimization button at the top right of the sidebar



Step One – Basis of the Analysis

1. **STEP-1** enables the user to define the foundation or basis of the analysis by posing several questions. This step includes identifying the:

   I. Target System
   II. System Mission
   III. System-Level Losses
   IV. Critical Functions
   V. System-level Hazards
   VI. System-Level Constraints
   VII. System Interdependencies

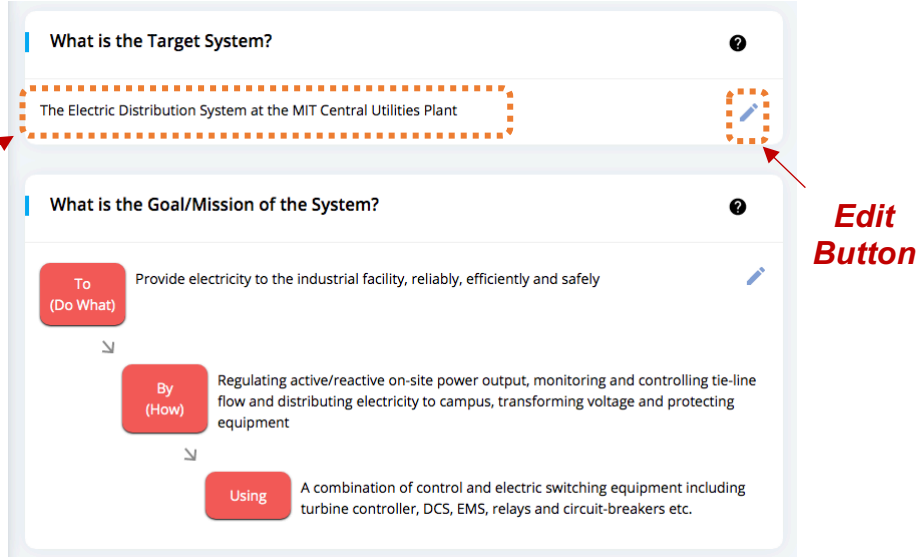


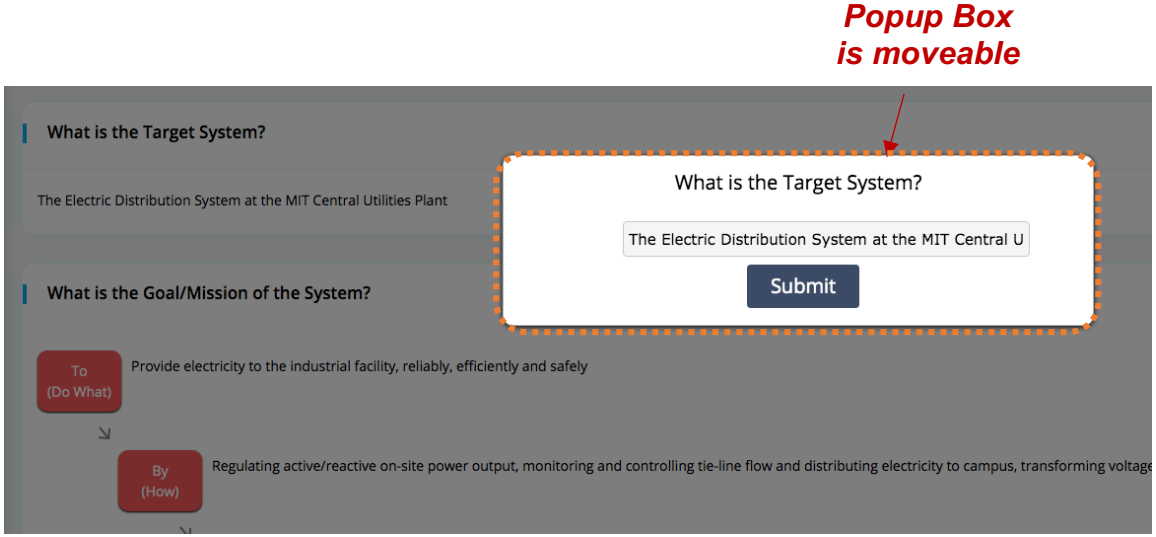
2. Clicking on each component header allows the user to view the component and add or edit data in it

3. To add or edit data simply click on the text (or blank space) in the dropdown component or click the edit button

4. A popup will show up; simply complete the fields in the text box and hit Submit to update the database.

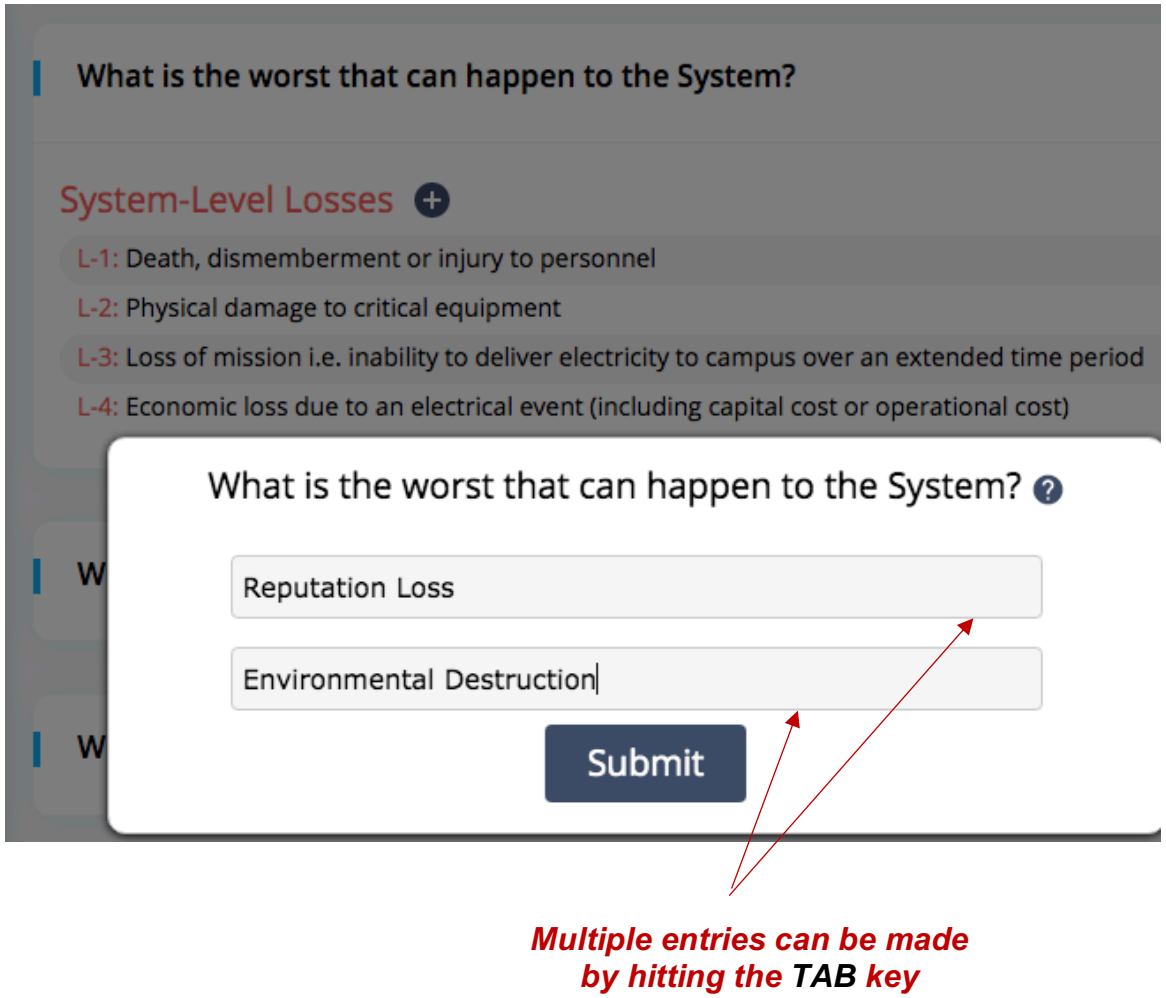
5. NOTE that all popup boxes are moveable; this enables uncovering obscured information on the screen





6. CAUTION: Clicking anywhere outside the popup box without hitting submit makes the box disappear without updating the database

7. NOTE that when entering information in the popup box, hitting TAB on the keyboard allows the user to create multiple entries.

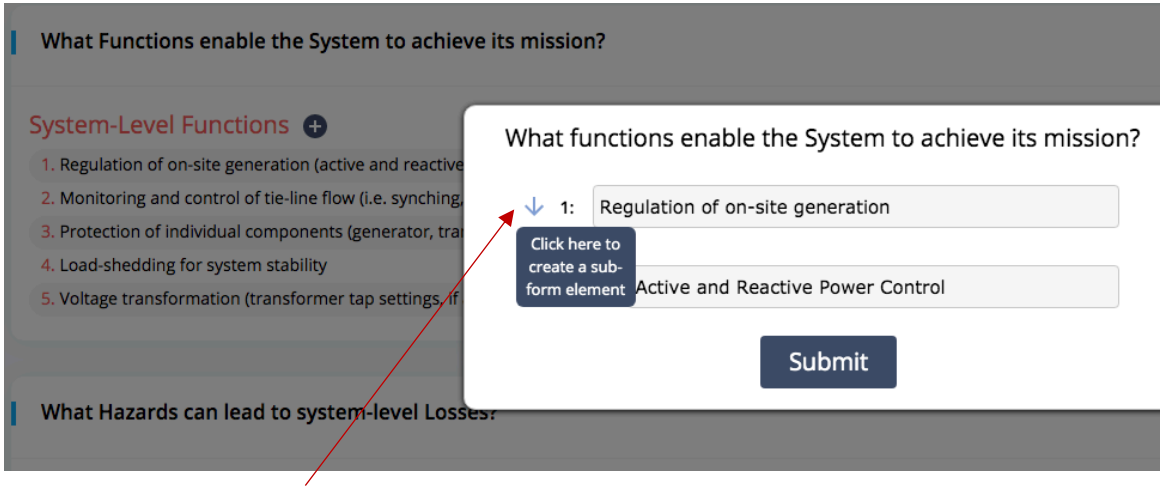


Multiple entries can be made by hitting the TAB key

8. This tool also provides the feature to enter subcategories for System-level functions, hazards and constraints.

9. Simply Click the downward arrow to define a subcomponent (hazard, constraint, function etc.)

10. Again, hitting TAB would enable the user to make multiple entries at the sub-component level within the popup box

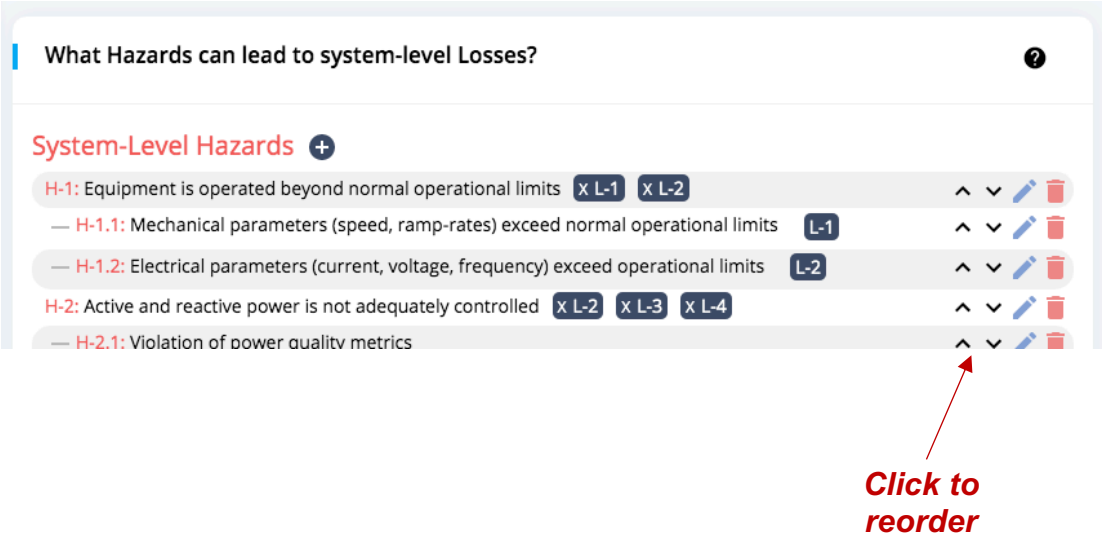


Click to define subcomponent

11. Note that the tool automatically keeps track of numbering for components and subcomponents

12. The order or numbering for any loss, function, hazard etc., may be updated by clicking the up/down arrows ^ v next to the item

13. Clicking the delete button deletes the hazard, loss, constraint etc.; if the 'parent' component is deleted, all associated 'children' are automatically deleted and the list is automatically renumbered



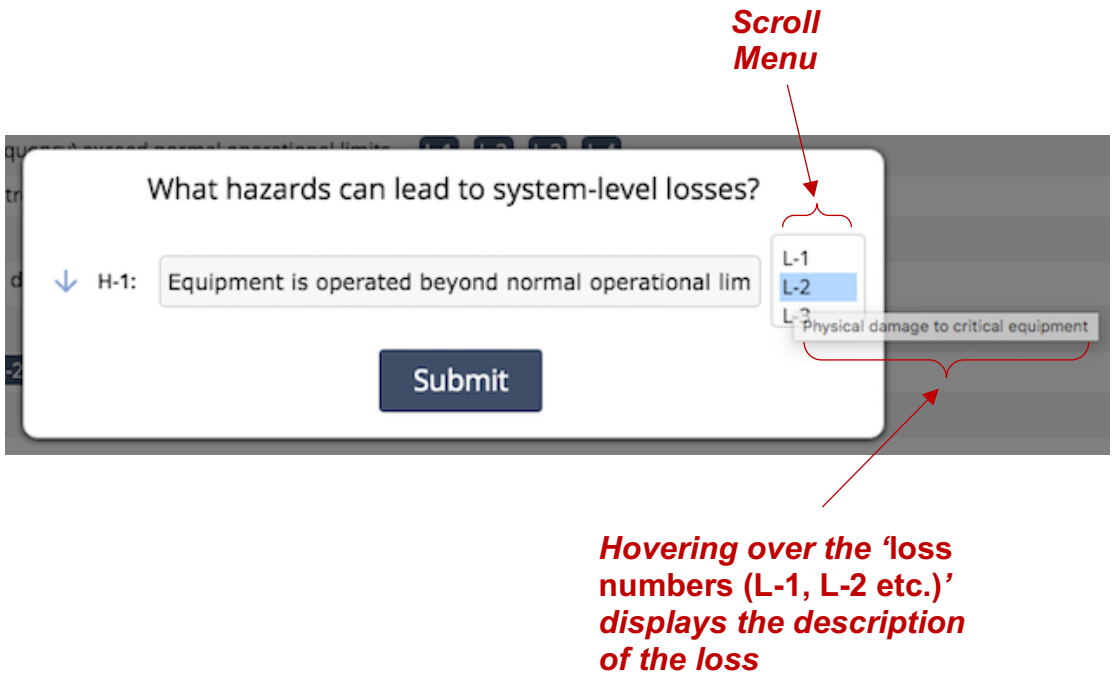
14. When entering system-level hazards the user has the option to associate a system-level loss with the hazard

15. This is done by simply selecting the associated system-level loss from the scroll menu on the right

16. NOTE that multiple losses can be associated by pressing the CTRL key on the keyboard

17. NOTE that hovering over the losses in the scroll menu displays the description of the loss inside the scroll menu

18. Likewise, system-level hazards can be associated to system-level constraints by following the same approach

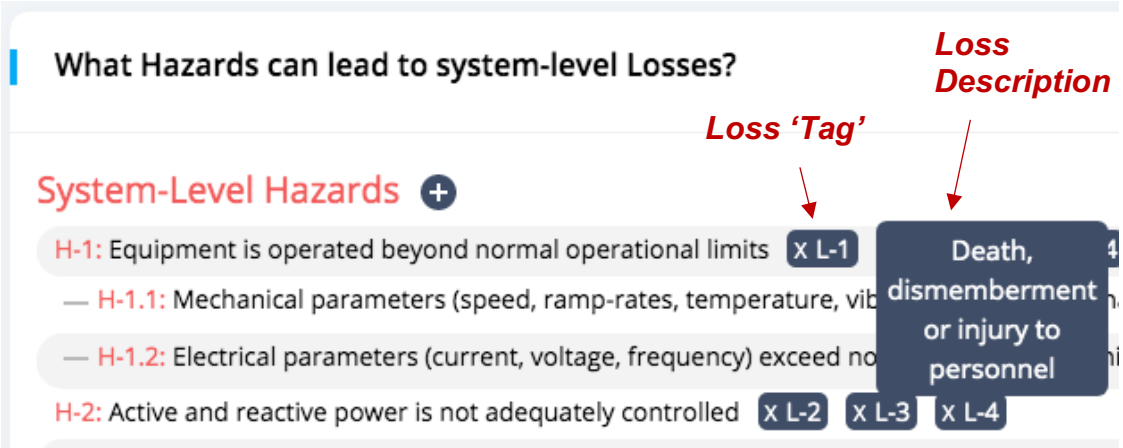


19. Once the associations between losses, hazards and constraints are defined, they appear as tags next to the associated hazard /constraint

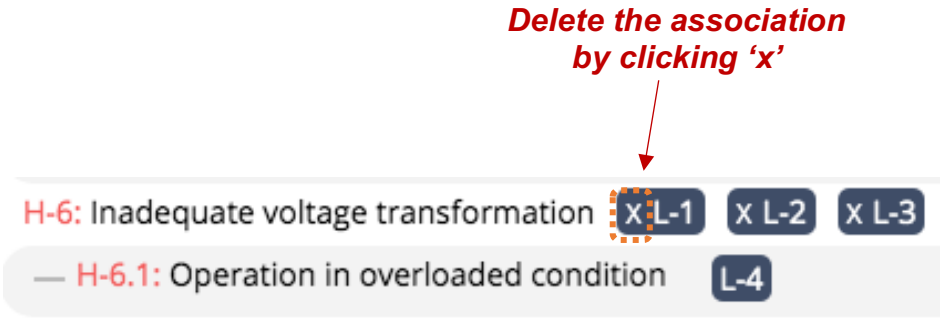
20. Hovering over a tag reveals the associated item description (i.e. loss/hazard)

21. Note that the tool does not require association of any losses with hazards or hazards with constraints. The associations can be made at any time without impacting stability of the tool or progression to next steps

22. The associations can be made at any time i.e. at the time an item (hazard/ constraint) is initially defined or later by simply clicking a hazard or constraint and selecting the associated loss/hazard – it does not matter!



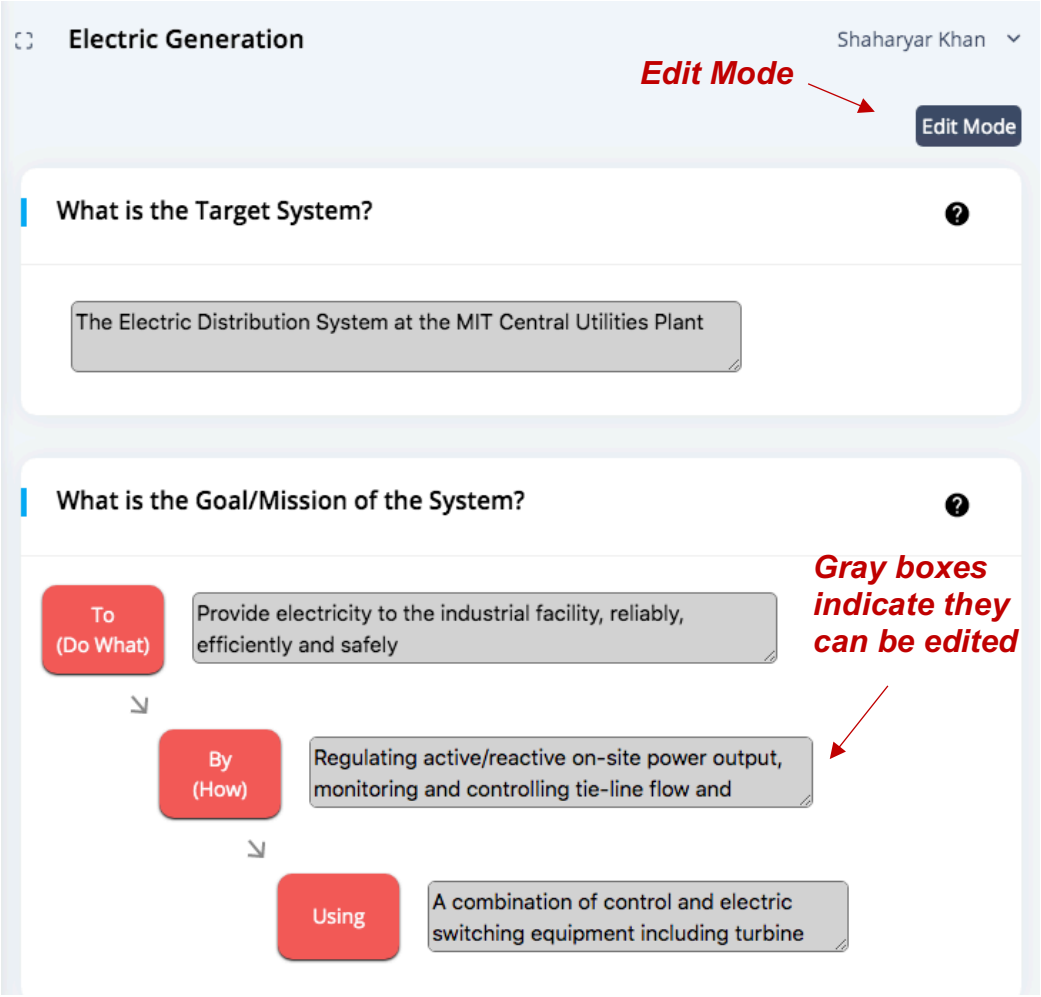
23. NOTE that if an associated loss is deleted, the tag automatically gets deleted from the hazard. The same is also true for a hazard associated with a constraint; this ensures traceability throughout the analysis



24. NOTE also that an associated tag can also be deleted by clicking the 'x' on the tag

25. Edit Mode button: This button is located at the top-right of the page; clicking on it converts all the fields into editable textboxes for easy editing on the fly. The user can simply TAB through the textboxes to update any information.

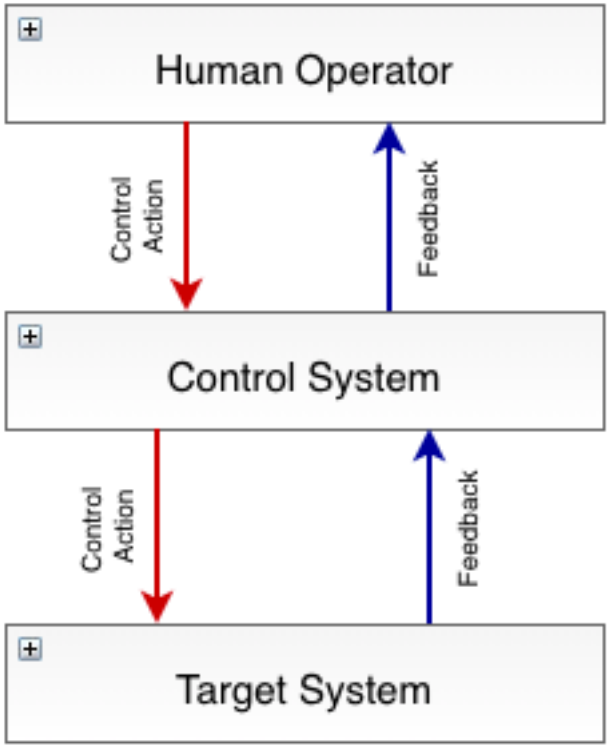
26. To SAVE any text edit, press enter in the textbox after making the edit or click the Edit Mode button again.



Step Two – Model the Functional Control Structure

1. **STEP-2** enables the user to model the functional control structure. For increased flexibility and versatility, a digrams.net (formerly draw.io) frame is embedded inside the Cybersafety tool

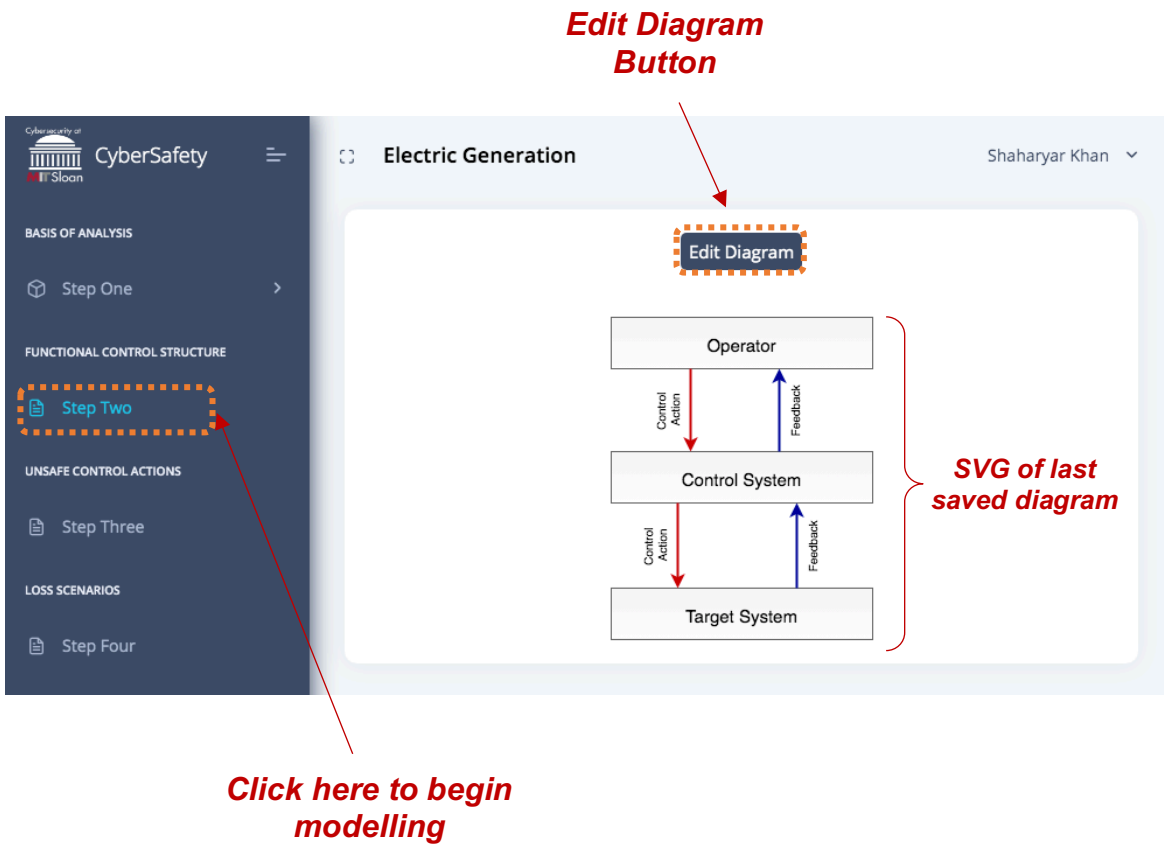
2. Embedding the tool in such a way enables the user to perform the analysis in an integrated fashion in one place without keeping track of multiple files across different platforms (MS Excel, Visio, Word etc.)



3. To begin modelling the functional control structure simply Click on Step Two from the Side bar

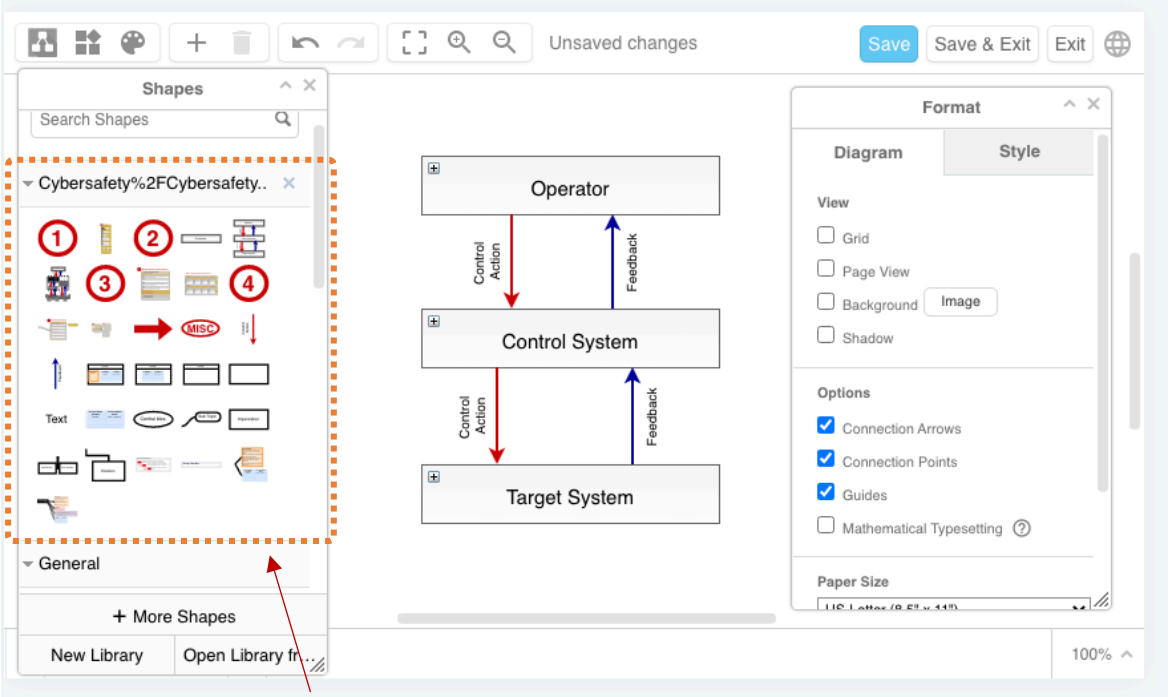
4. Step Two consists of an Edit Diagram button and an SVG of the last saved diagram

5. Clicking on the Edit Diagram button will open a diagrams.net (draw.io) window and allow the user to edit a diagram using the custom Cybersafety library.



6. Digrams.net is equipped with a number of features to make all kinds of visually aesthetic diagrams.

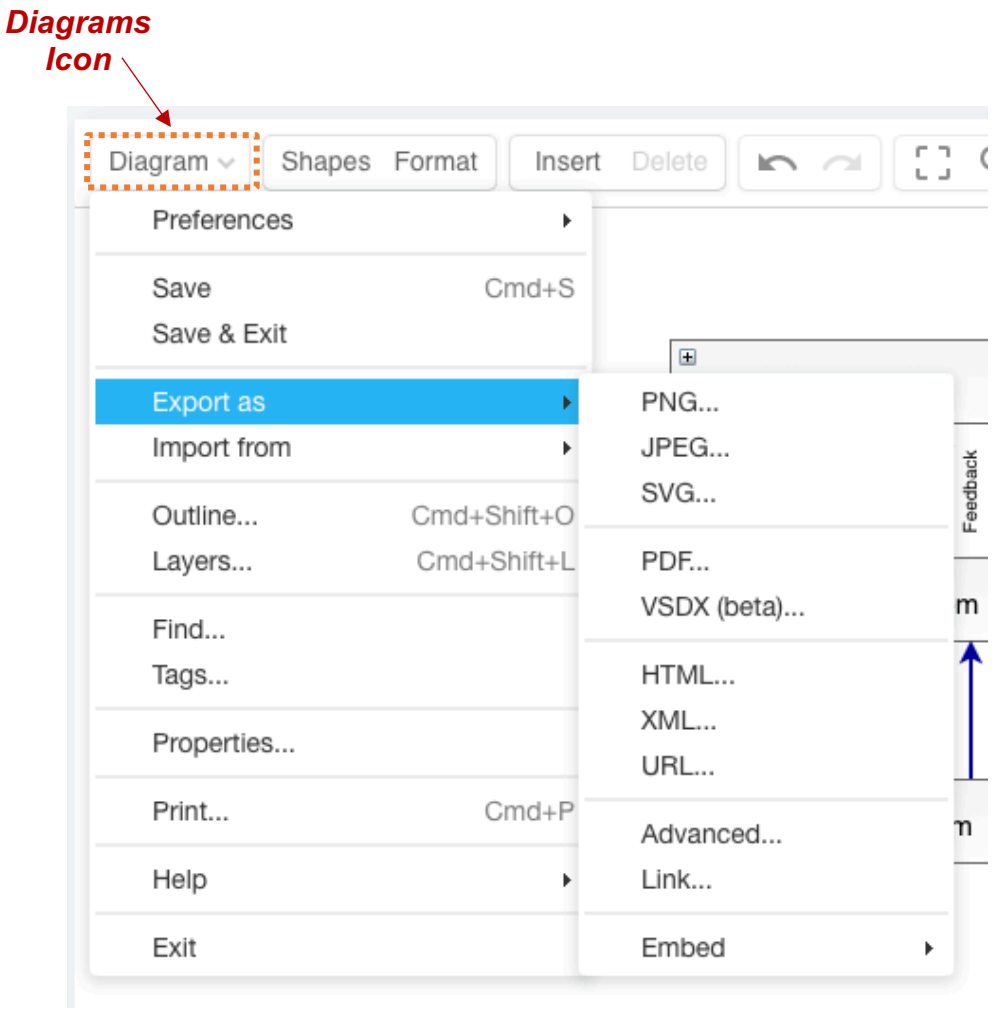
7. Although there are too many features to exhaustively list in this manual, we will list some of the more important features that can improve modeling the functional control structure



Cybersafety Custom Library

8. Clicking on the Diagrams Icon, the user has the option to import a diagram made in a different application (Visio etc.)

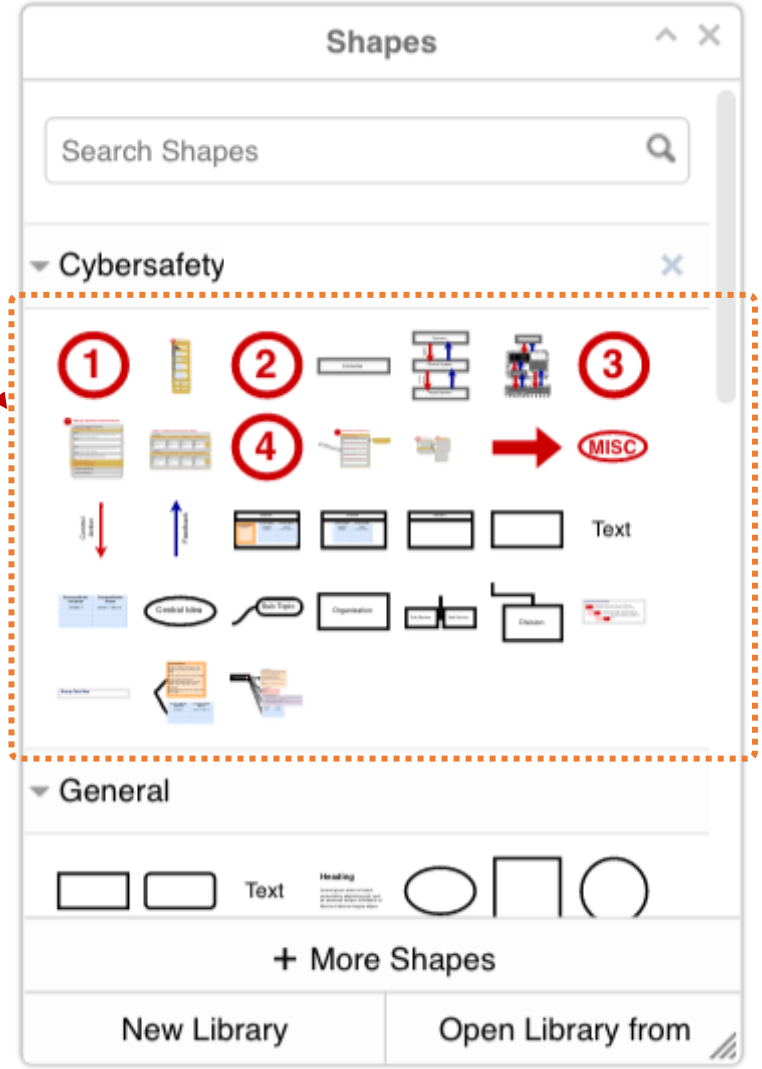
9. The user also has the option to export a diagram into a number of different formats (PNG, JPEG etc.)



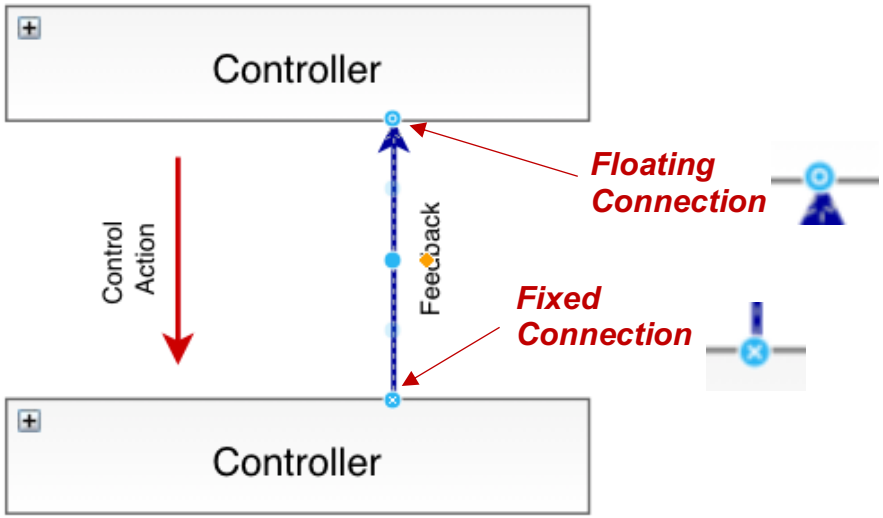
10. The custom Cybersafety library has a number of shapes that are pre-formatted for modelling the function control structure.

11. Simply Drag & Drop a shape onto the project page to get started

Drag & Drop Shapes from the library on to the page

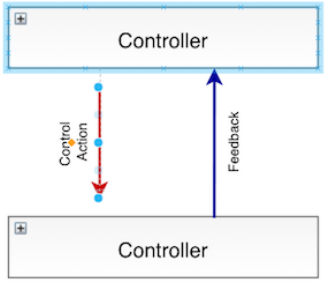


12. NOTE that two types of connections can be made between controllers; the blue feedback arrow is fixed in position (rep. by a ‘x’) with respect to the bottom controller and floating with respect to the top controller (rep. by a ‘o’); using the ‘floating connection’ feature one can easily change the position of the various controllers

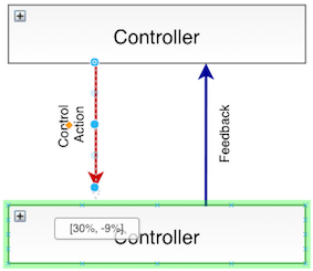


13. To make a floating connection, Drop the arrow point in the middle of the controller box when it is highlighted blue

14. To make a fixed connection, Drop the arrow point at the boundary of the controller box when it is highlighted green



For floating point connection

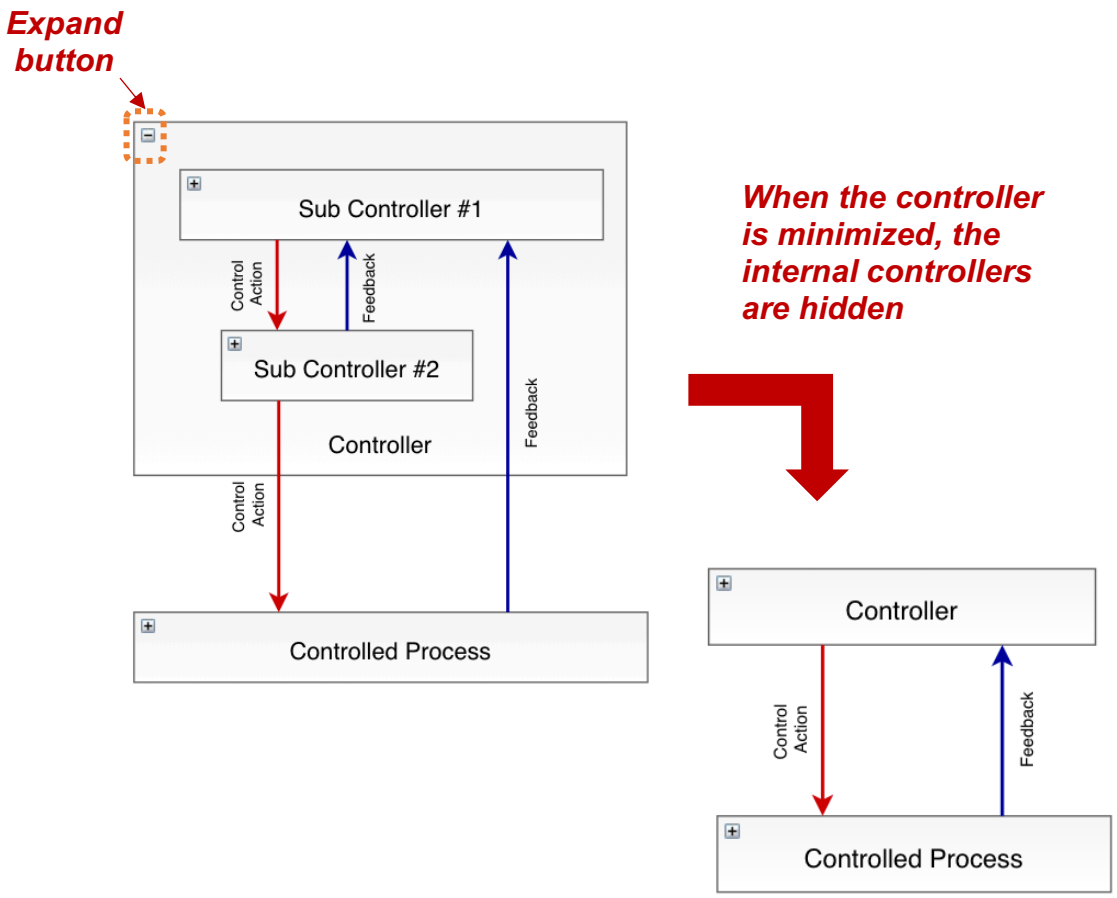


For fixed point connection

15. The Cybersafety app allows creating complex functional control diagrams at different levels of abstraction

16. Simply click the expand button '+' in the top left corner of the controller box and Drag and Drop additional controllers/arrows inside the expanded box

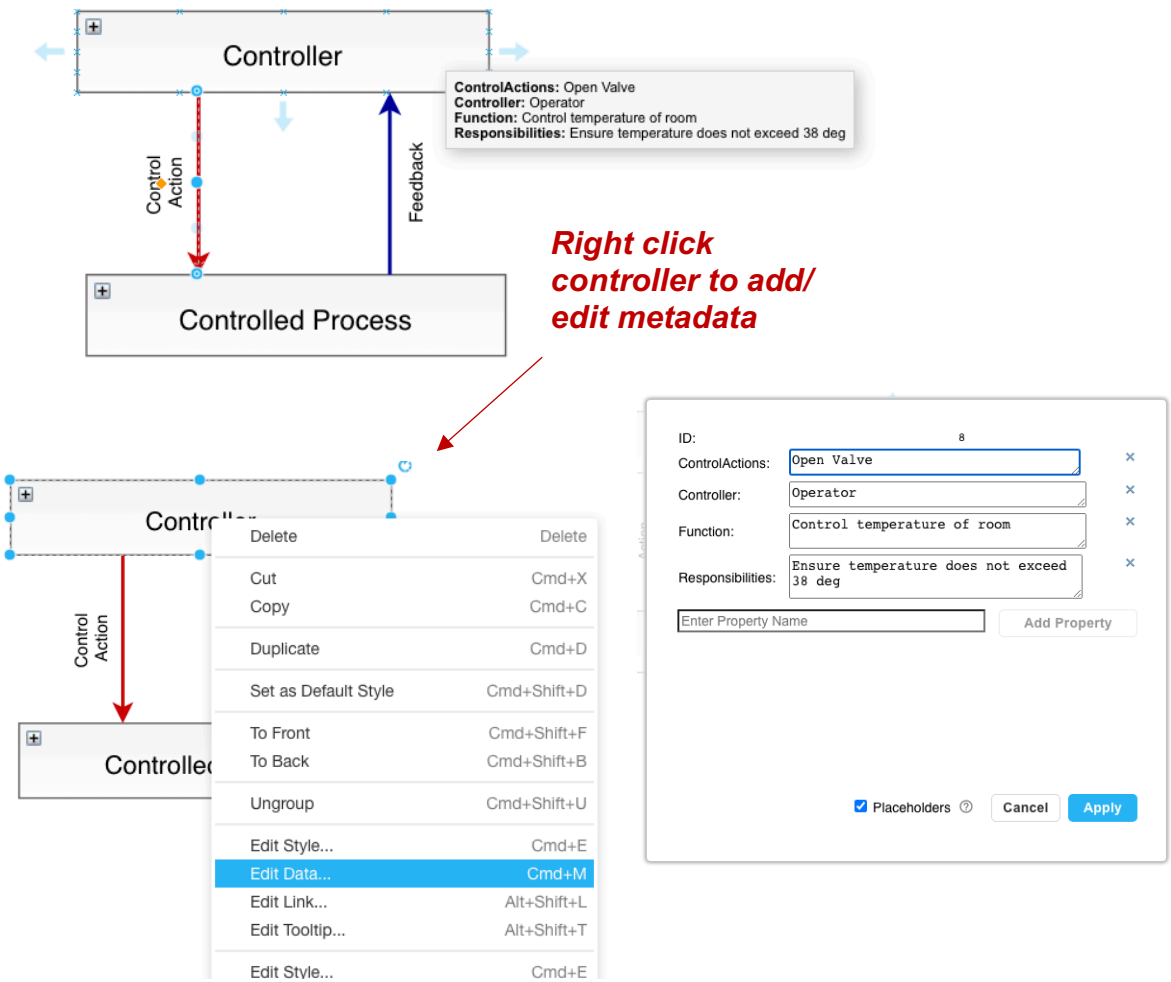
17. When the box is minimized, all the detail inside the box is automatically hidden and the arrows become connected to the controller at the higher-level of abstraction



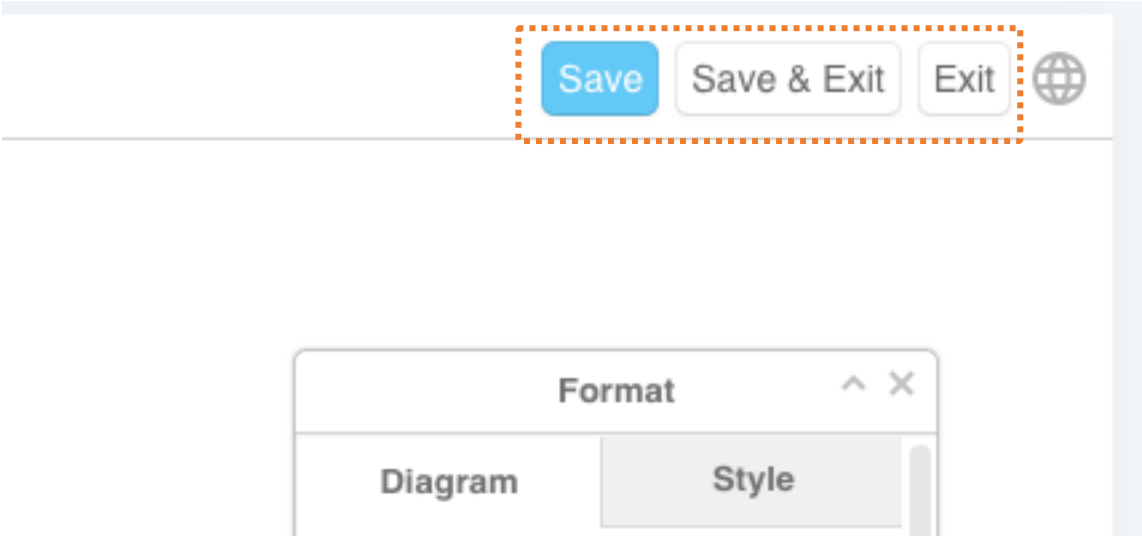
18. Hovering over any controller, displays important information about the controller, including:
    - Function/Goal of the Controller
    - Safety & Security Responsibilities
    - Control Actions

19. In order to enter this information, Select a Controller and Press CTRL+M **or** Right Click the controller and select Edit Data

20. Enter necessary information in the form and click Apply to save.



21. Once the modelling of the functional control diagram is complete, Click Save and Exit in the top right corner



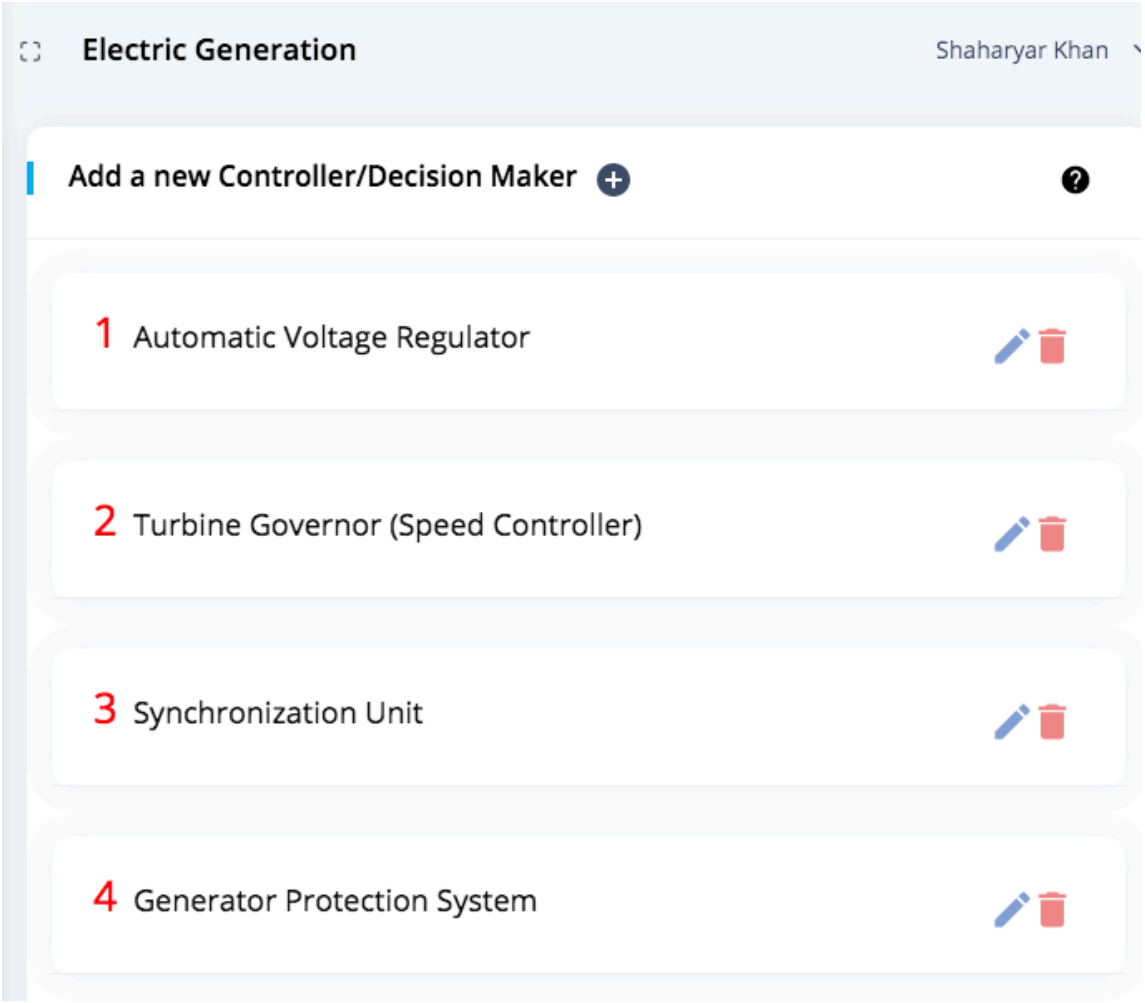
22. NOTE that inadvertently closing the webpage or clicking a menu bar item would prompt the user to properly exit the application. Properly exiting the application requires the user to click on Exit (without saving) or Save and Exit; this feature prevents against loss of work due to inadvertently exiting the diagrams.net application

Step Three – Identify Unsafe Control Actions (UCA)

1. **STEP-3** enables the user to identify hazardous control actions for each of the controllers

2. The layout for Step 3 presents each of the controllers as a 'collapsed card'

3. To define a new controller, simply click the plus icon ⊕ at the top of the page and enter the name of the controller

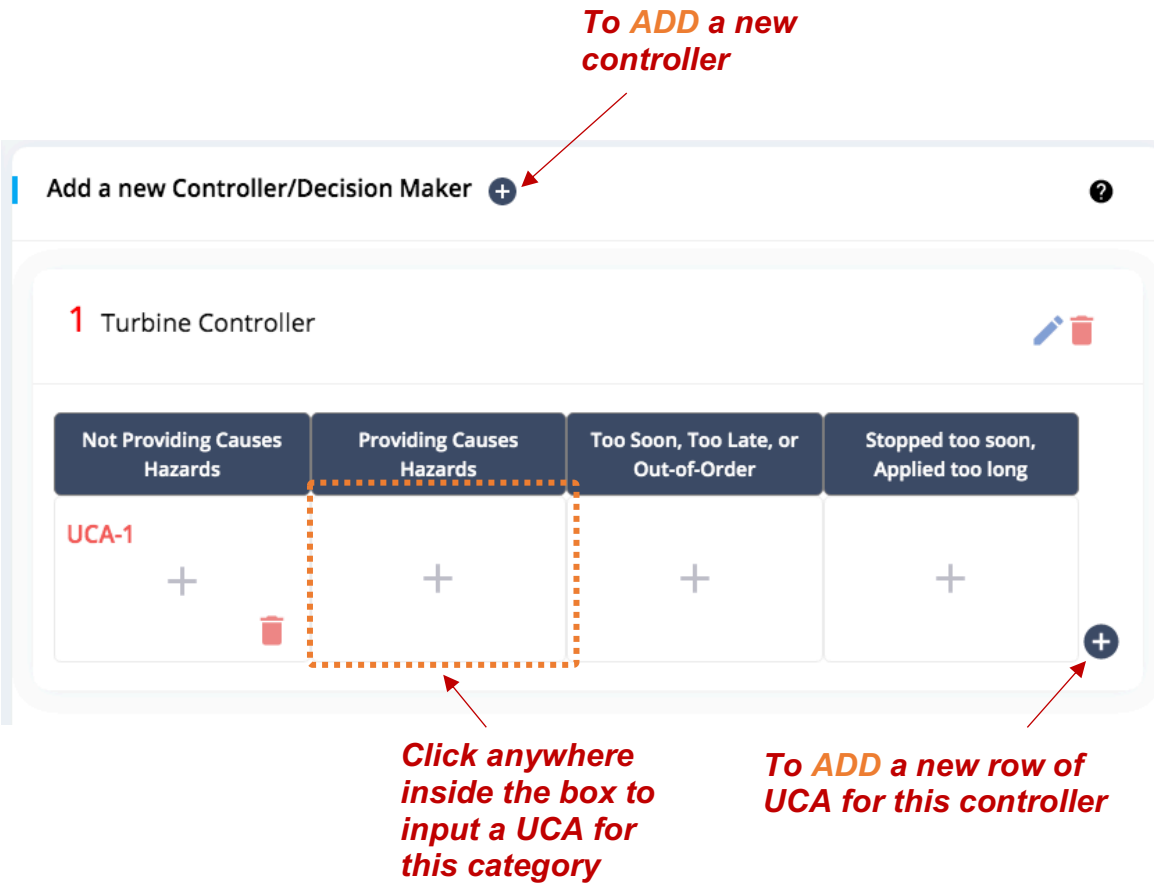


4. Clicking on the controller card expands its contents which shows a table with four types of UCAs:

   - Not Providing (a control action) causes a hazard
   - Providing (an incorrect) control action causes a hazard
   - Providing a control action too soon, too late or out-of-order causes a hazard
   - Stopping the control action too soon or applying it for too long causes a hazard

5. To add a UCA for this controller, simply click anywhere inside the box with the plus symbol + and enter the UCA

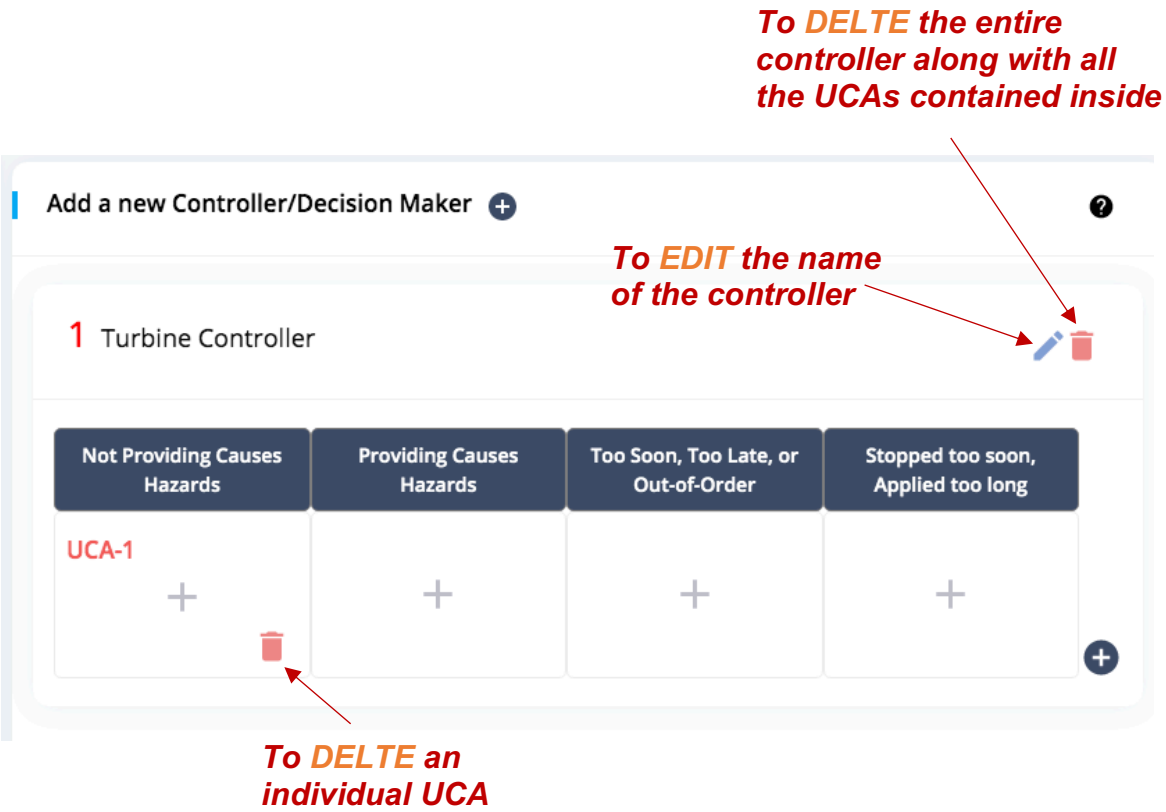
6. To define a new row of UCAs, simply click the plus icon ⊕ on the right of the table



7. Clicking the delete button inside the UCA box, deletes the individual UCA

8. Clicking the delete button for the controller card deletes the controller along with ALL the UCAs contained within; the user is prompted for a confirmation when attempting this

9. The name of the controller can be edited anytime by clicking the Edit Icon

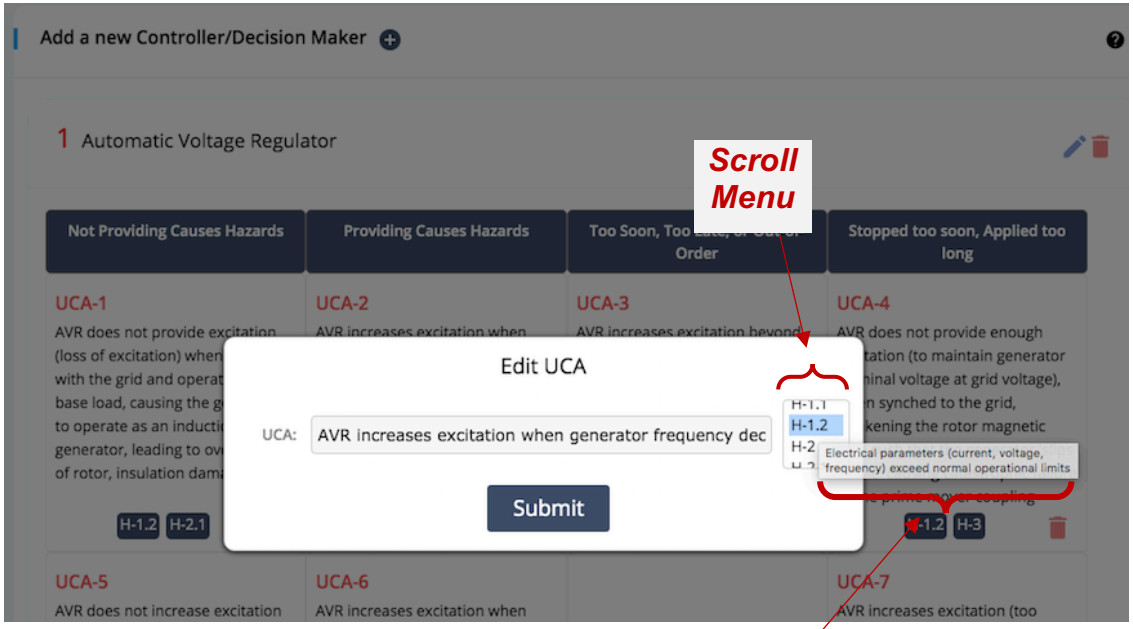


10. When identifying UCAs, the Hazards associated with the UCA can also be defined; similar to Step 1, the user has the option to select multiple associated hazards from the Scroll Menu

11. Multiple hazards can be selected by pressing the CTRL key

12. Hovering over the hazard reveals the description of the hazard

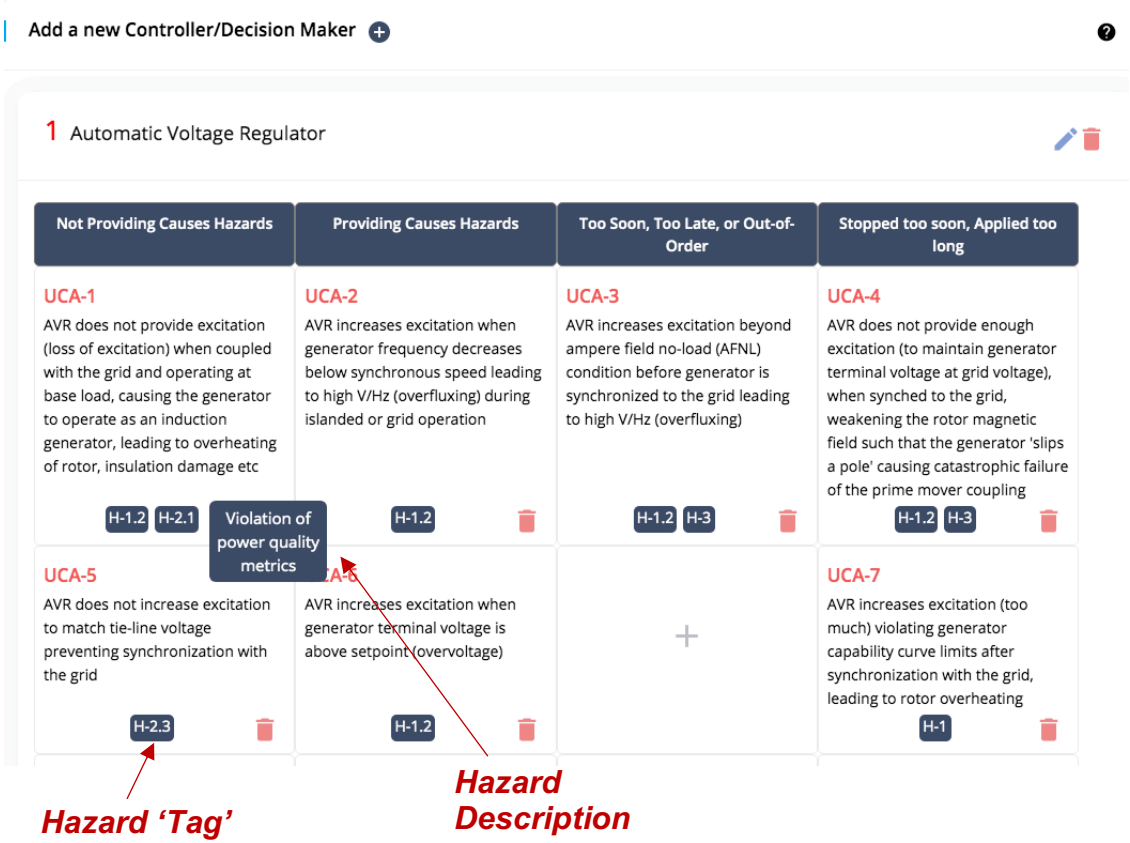
13. The associated hazards can be updated anytime by clicking anywhere inside the UCA box and selecting the correct associated hazards



Hovering over the 'loss numbers (L-1, L-2 etc.)' displays the description of the loss

14. After hazards are associated with UCA's, they appear as tags in the UCA table – hovering over the tags reveals the description of the hazard

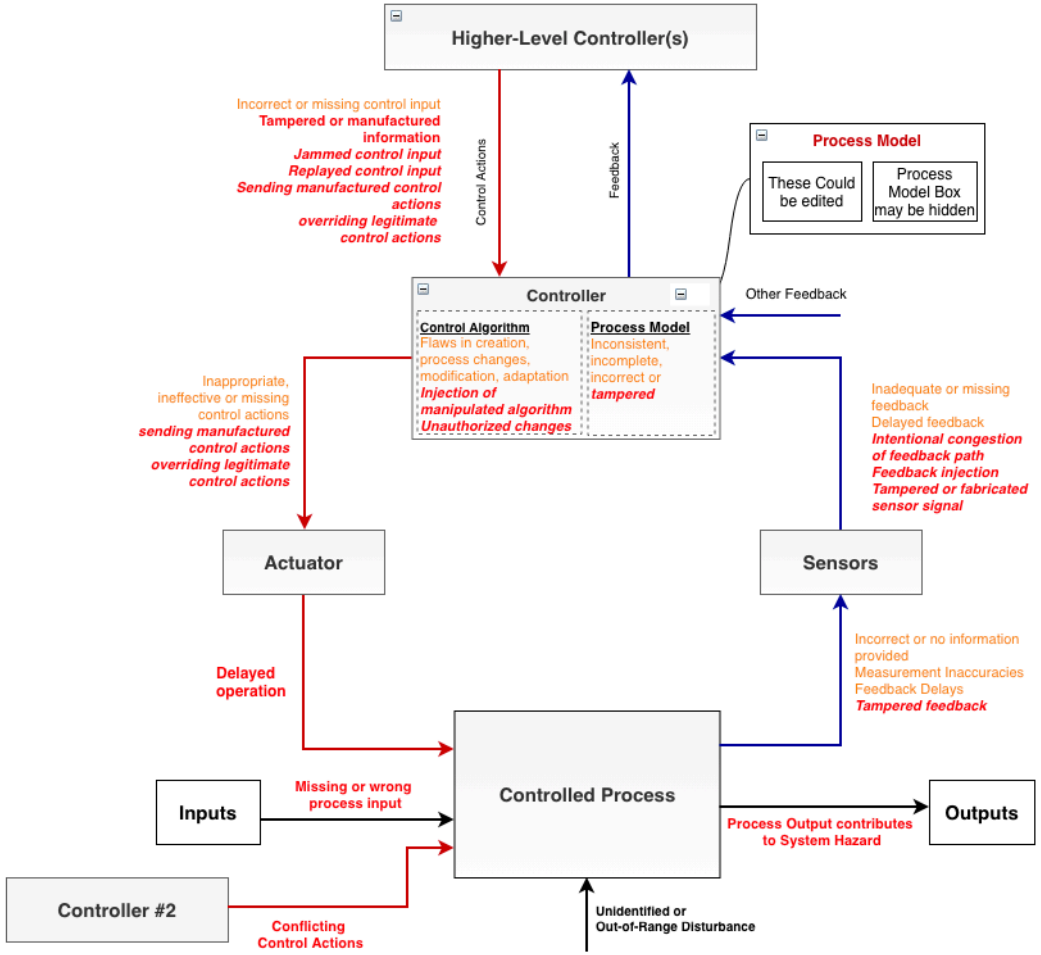
15. Note that the UCA's are automatically numbered; If any UCA is deleted, the remaining UCA numbers are automatically updated – the location of the UCA in the table does not matter



Step Four – Generate Loss Scenarios

1. **STEP-4** enables the user to generate loss scenarios. The basic idea is to go around each control loop and identify causal factors that would:
   a. Cause the controller to issue unsafe commands or,
   b. Prevent the execution of safe commands by the controller

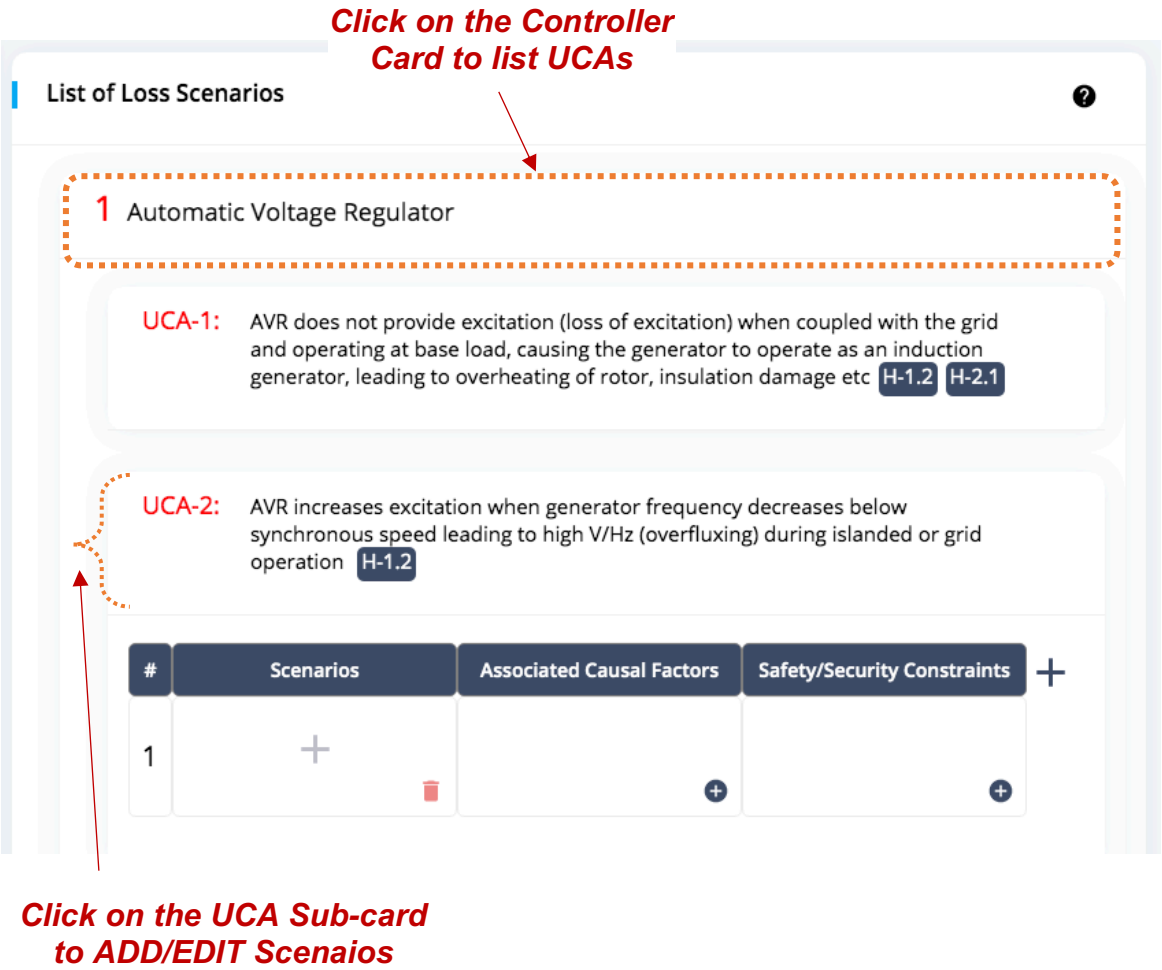
2. The figure shows a generic control loop with sample attack scenarios superimposed around the control Structure



3. The layout for Step 4 is similar to Step 3 in that each of the controllers identified in Step 3 are listed

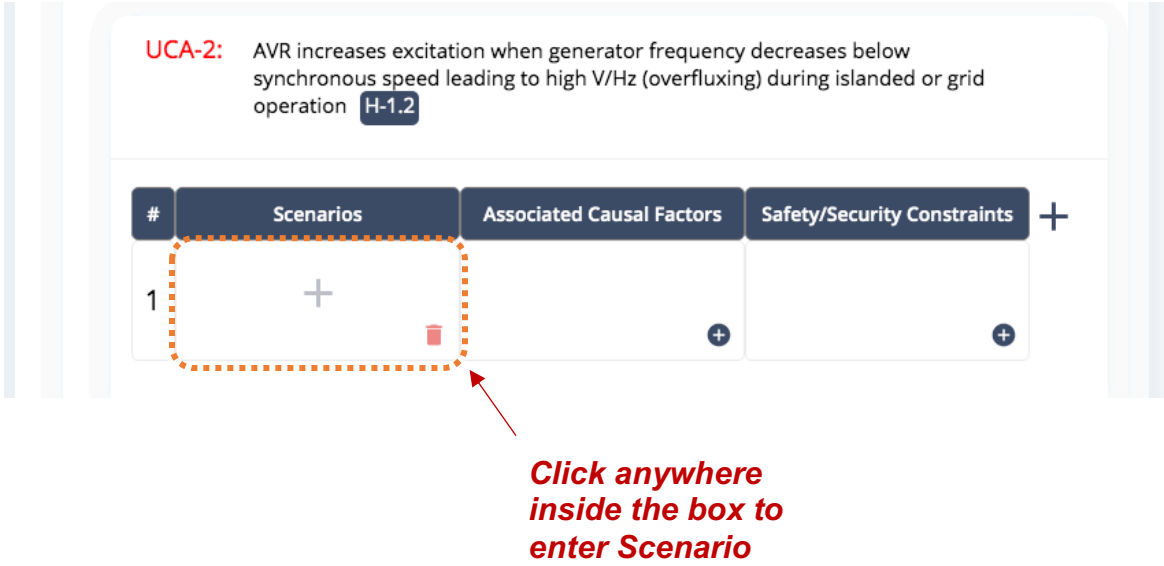
4. Clicking on any Controller card lists the UCAs as a 'sub-card' shown in the Figure (as opposed to a UCA Table shown in Step 3)

5. Clicking on UCA sub-card allows the user to input Scenarios, Causal Factors and Mitigation requirements in the form of Safety/Security Constraints

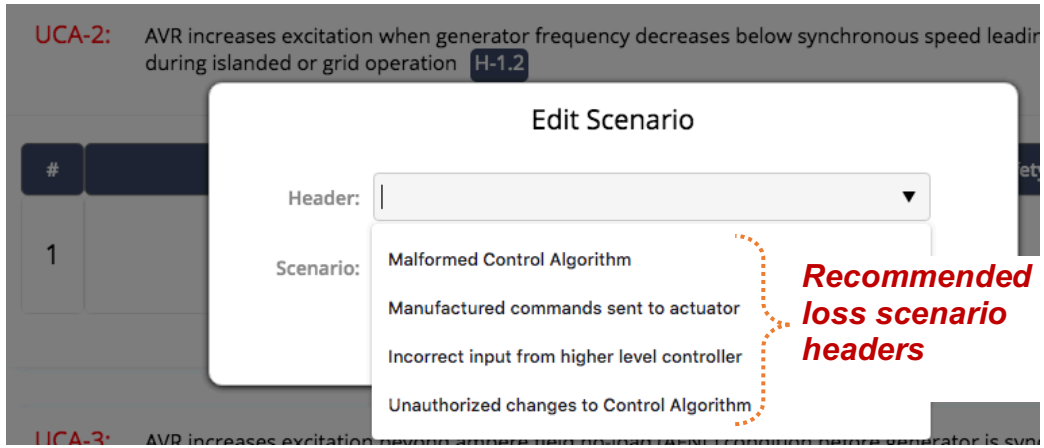


6. The Scenarios have a 1-to-many relationship with Causal Factors

7. To add a scenario, click anywhere inside the scenario box with the plus symbol + ; a popup would show up which enables the user to define a Scenario header/category along with the Scenario;

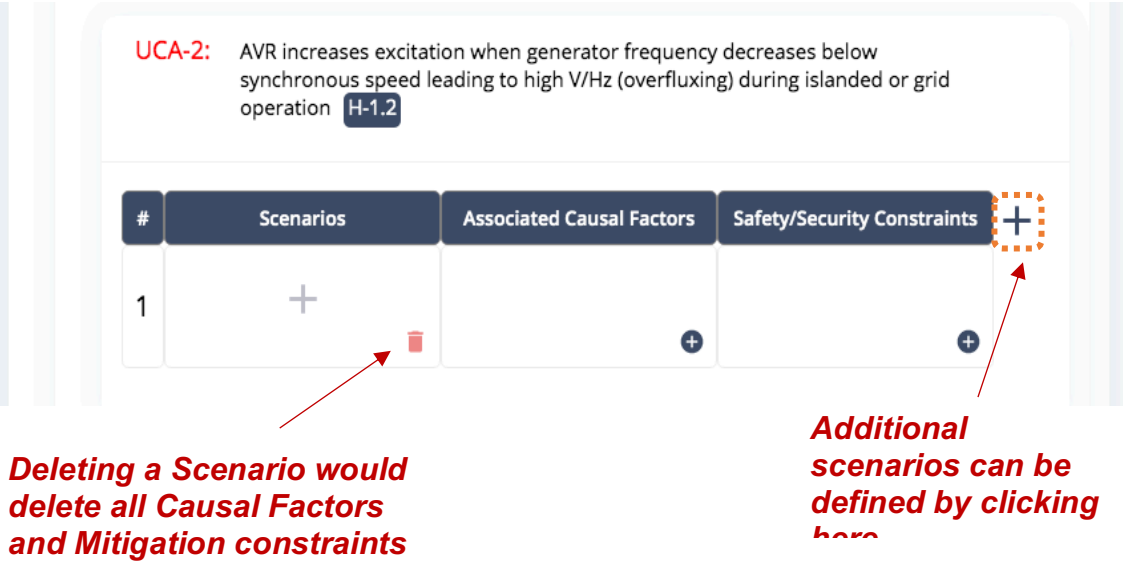


8. NOTE that the header comes pre-filled with recommended loss scenario headers; the user also has the option to define their own scenario header



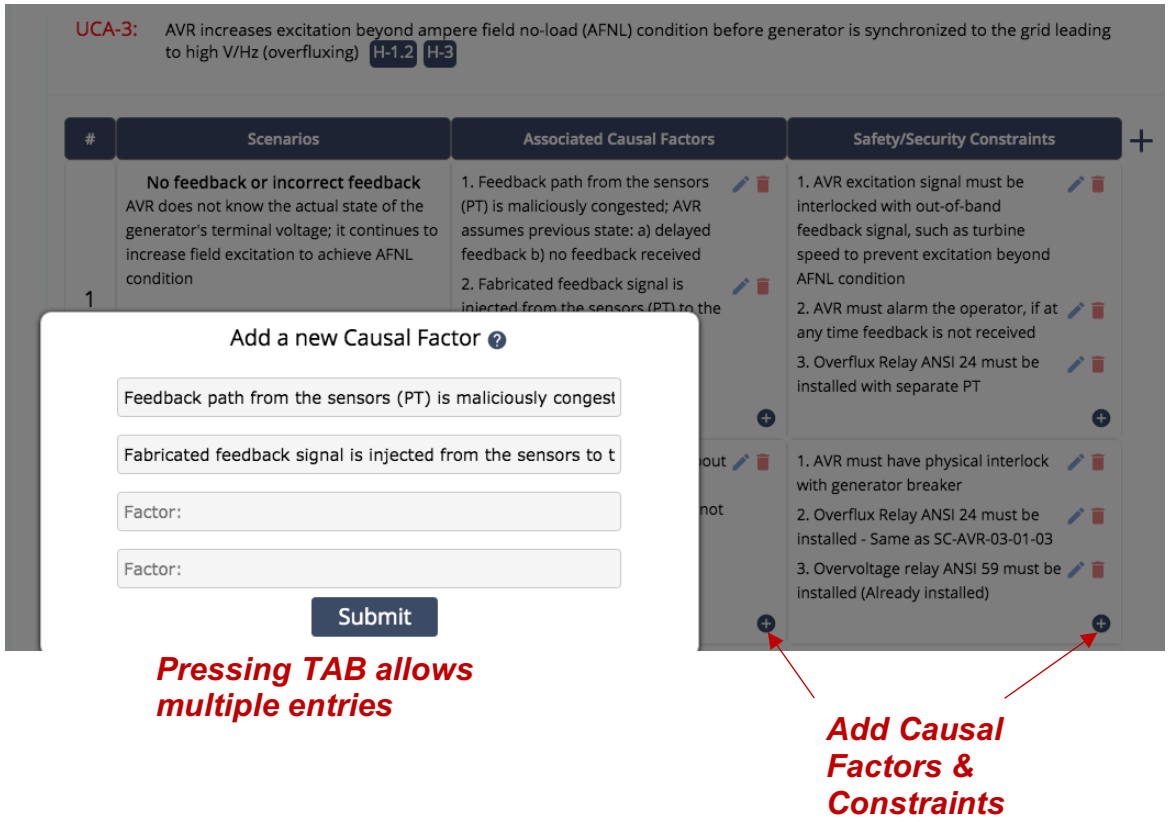
9. To delete a scenario, click the delete icon; NOTE that deleting a scenario, deletes ALL associated causal factors and constraints

10. Multiple Scenarios can be defined for each UCA; click the plus icon + on the right of the table to add another row of scenarios



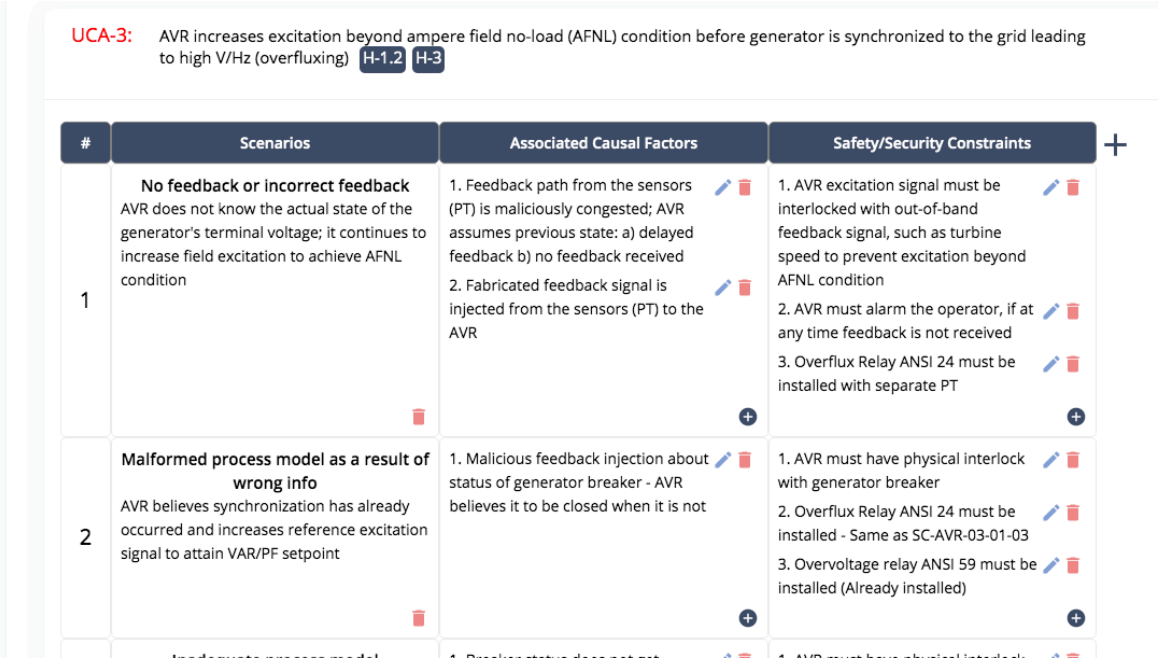
11. Causal factors and mitigation constraints can be added by clicking the plus icon inside the respective boxes; NOTE that pressing the TAB key allows addition of multiple entries in one go

12. NOTE that the scenarios, causal factors and constraints are automatically numbered by the tool



13. To make any edits to any scenario, causal factor or constraint, simply click on the item that requires changes or click the Edit Icon

14. This concludes the step-by-step guide for using the **Cybersafety Web Application Tool**



UCA-3: AVR increases excitation beyond ampere field no-load (AFNL) condition before generator is synchronized to the grid leading to high V/Hz (overfluxing) H-1.2 H-3

#	Scenarios	Associated Causal Factors	Safety/Security Constraints
1	**No feedback or incorrect feedback** AVR does not know the actual state of the generator's terminal voltage; it continues to increase field excitation to achieve AFNL condition	1. Feedback path from the sensors (PT) is maliciously congested; AVR assumes previous state: a) delayed feedback b) no feedback received 2. Fabricated feedback signal is injected from the sensors (PT) to the AVR	1. AVR excitation signal must be interlocked with out-of-band feedback signal, such as turbine speed to prevent excitation beyond AFNL condition 2. AVR must alarm the operator, if at any time feedback is not received 3. Overflux Relay ANSI 24 must be installed with separate PT
2	**Malformed process model as a result of wrong info** AVR believes synchronization has already occurred and increases reference excitation signal to attain VAR/PF setpoint	1. Malicious feedback injection about status of generator breaker - AVR believes it to be closed when it is not	1. AVR must have physical interlock with generator breaker 2. Overflux Relay ANSI 24 must be installed - Same as SC-AVR-03-01-03 3. Overvoltage relay ANSI 59 must be installed (Already installed)

*Please email Shaharyar Khan (shkhan@mit.edu) or Dr. Stuart Madnick (smadnick@mit.edu) for more information

References

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2. N. Stauffer, Energy Futures, Spring 2019 Issue, Protecting our Energy Infrastructure, http://energy.mit.edu/news/protecting-our-energy-infrastructure/ (accessed Oct 5, 2020)

3. N.G. Leveson, J.P. Thomas, STPA Handbook, 2018. http://psas.scripts.mit.edu/home/ (accessed Oct 5, 2020).

4. N. Leveson, Engineering a Safer World: Systems Thinking Applied to Safety, The MIT Press, 2012