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Users Guide to the HVACSIM$^+$ Configuration Tool

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Table of Contents

List of Figures

Abstract

HVACSIM+ (HVAC SIMulation PLUS other systems) was introduced by the National Institute of Standards and Technology (NIST) in 1985 as a computer simulation tool to simulate building heating, ventilation, and air conditioning (HVAC) systems. The HVACSIM+ computer program package and manuals have been distributed to hundreds of researchers, students, and consultants in countries around the world [1]. HVACSIM+ input files are configured through a text-based interface, as was common for programs developed in that era. Reviewing the configuration files defining a model in a text editor is a tedious, difficult and error-prone process for a large simulation. The HVACSIM+ Configuration Tool provides a method to visualize the complicated connections between components in a HVACSIM+ model and assist with validation and modifications to those models. This user's guide assumes a working knowledge of HVACSIM+.

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1. Introduction to the HVACSIM+ Configuration Tool

HVACSIM+ (HVAC SIMulation PLUS other systems) was introduced by the National Institute of Standards and Technology (NIST) in 1985 as a computer simulation tool to simulate building systems. The HVACSIM+ computer program package and manuals have been distributed to hundreds of researchers, students, and consultants in countries around the world [1]. HVACSIM+ input files are configured through a text-based interface, as was common for programs developed in that era. Reviewing the configuration files defining a model in a text editor is a tedious, difficult and error-prone process for a large simulation. The HVACSIM+ Configuration Tool (HCT) provides a method to visualize the complicated connections between components in a HVACSIM+ model and assist with validation and modifications to those models. The HCT was created to assist with the development of large HVACSIM+ models used in the NIST Virtual Cybernetic Building Testbed (VCBT) [2], but it should be applicable to the needs of other users. The HCT requires an HVACSIM+ component model configuration file, typically named typar.dat, and can read simulation work files, typically created by the HVACGEN program. The HCT displays a list of component types available for use in the simulation, the sequence of units used in the simulation, and the State Array. It can also export data about the model to spreadsheet files for additional review. The HCT simplifies the process of understanding the many complicated interactions within a model and allows the user to modify the model. This user's guide assumes a working knowledge of HVACSIM+. The HCT uses the component model configuration file from HVACSIM+ and simulation work files produced by HVACGEN, and introduces several new types of file. Each type of file is discussed in Table 1.

Table 1: Summary of files types used by the HCT.

Name	Format	Description
Simulation Work File	SIM	File produced by HVACGEN. Can be entered into the HCT.
Component Model Configuration File	DAT	Provided with HVACSIM+, contains information about component models (types file).
Simulation Information File	XML	Exports simulation configuration for viewing, sorted by data category. Contains data formatted to allow user to create new simulation work file using HVACGEN.
Unit List File	XML	Exports simulation configuration for viewing and editing, sorted by unit. Can be entered back into the HCT after editing.
Unit Sequence File	Text	Imports simple list of type numbers in text format, added as new units to the Unit List. State array and superblock/block assignments must be edited.
Type Crosswalk Data File	XML	Exports simulation configuration for viewing, sorted by unit type. Shows State Array inputs and outputs for all instances of each type.
Data Crosswalk File	XML	Exports simulation configuration for viewing, sorted by unit. Shows time series data for each unit.

2. The User Interface

Interaction with the HCT occurs through the graphical user interface (GUI). The main window displays information to the user, allows the user to enter and save data, and allows the user to open other display windows. The user interface at startup is shown in Figure 1.
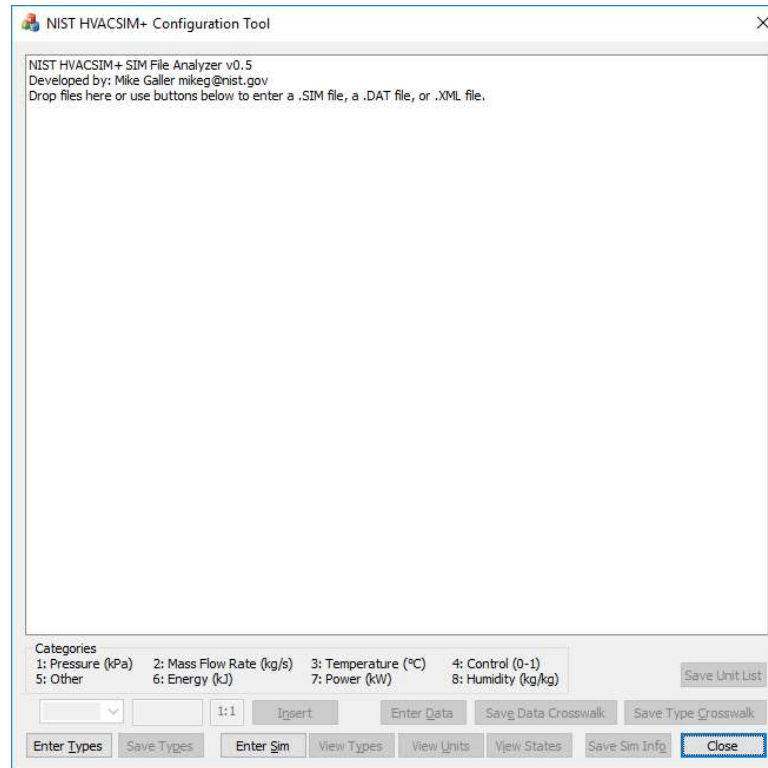
Figure 1: The user interface at startup.

Much of the user interface, starting at the top, is a status window that provides information to the user. Below the status window is a listing of the variable categories used in HVACSIM$^+$ for reference. The bottom section of the user interface contains controls that allow the user to enter and save data. Details about this interface are discussed in the following sections.

2.1. Entering Simulation Configurations

The simulation configuration is the central focus of the HCT. Information about the component models (types) is an important part of the simulation configuration. For the HCT to process a simulation configuration, a component model configuration file (types file) must be entered. Simulation configuration data may be entered from a saved file or manually through the user interface. Saved file formats are simulation work file (*.sim file), unit list XML file, and unit sequence file. If any of the file-based methods are used before component model information is entered, the default component model configuration file (typar.dat) will be searched for in the directory the simulation file is in and used if found. If component model information is not available, the simulation configuration will not be entered. All input files may be dragged and dropped onto the simulation window, including files of different formats at the same time. If multiple files are dragged and dropped at the same time, they will be read in the following order, based on format:

- Component model configuration file(s), typically typar.dat;
- Simulation work files and unit list XML files. Only the first file entered in this category will be read (subsequent files of either format will not be read);
- Unit sequence files. If a simulation work file or Unit List XML file has been read, then units listed in this file will be appended to the Unit List; and
- Time series data files. These are data files in CSV format. Use of this type of file is described in Section 3.5.

Any files which are dropped onto the HCT but not read will be noted in the status window.

2.1.1. Entering a Component Model Configuration File

The component model configuration file (types file) contains information about the component models used in HVACSIM$^+$. The component models are typically labelled "typeXXX" where XXX is a one to three-digit number. A types file may be entered either by selecting the button labeled "Enter Types" located in the lower left side of the interface, or by dragging and dropping the appropriate file onto the user interface. The status window will display progress and a summary of information about the types file. For each type entered, it will display the type number and label, and the label for each input, output, and parameter. When finished, the status window will display the number of type descriptions entered and if there were any errors found in the file. If subsequent types files are entered, the display will include the count of new type descriptions. New types will be appended to the list in the Types List Display Window. This would be useful when merging types files with different subsets of type descriptions. After a types file has been entered, the "Save Types" button is enabled. This allows the user to save a new types file containing all the type descriptions that have been entered, including types from multiple types files. The "View Types" button is also enabled. This allows the user to view the type descriptions in a new window.

2.1.2. Entering Simulation Configuration Files

Simulation configuration information can be entered from simulation work files, unit list files, and unit sequence files. Files are entered by selecting the "Enter Sim" button, which will open a file selection window, or by dragging and dropping the file onto the user interface. Unit list files are explained in Section 3.2, and unit sequence files are explained in Section 3.3. The status window will display progress and a summary of information about the simulation, including information about each superblock and block. For each unit entered it will display the unit number, the type, and the label.

After the file is entered, the State Array will be analyzed for configuration errors. After a file has been entered, the "View Units" and "View States" buttons are enabled. These allow the user to view the Units List and State Array in new windows. The remaining buttons are also enabled. Use of these features is discussed below.

2.2. The Types List Display Window

Selecting the "View Types" button opens the Types List Display Window, shown in Figure 2. This window uses a tree format to show the entire list of types that are available for use in HVACSIM$^+$ based on the types file that has been entered. Each top-level node (root node) on the tree shows the type number and label for a type. Expanding the tree by clicking on the toggle button (⊞) for the top-level node will display the number of inputs, outputs, and

parameters for that type as child nodes. The tree can be further expanded to show details of the inputs, outputs, and parameters. Inputs and outputs will show the category and label for each item. Parameters will show the label. In Figure 2, the node for Type 1, labelled "Fan or pump", has been expanded to show the inputs, outputs, and parameters.
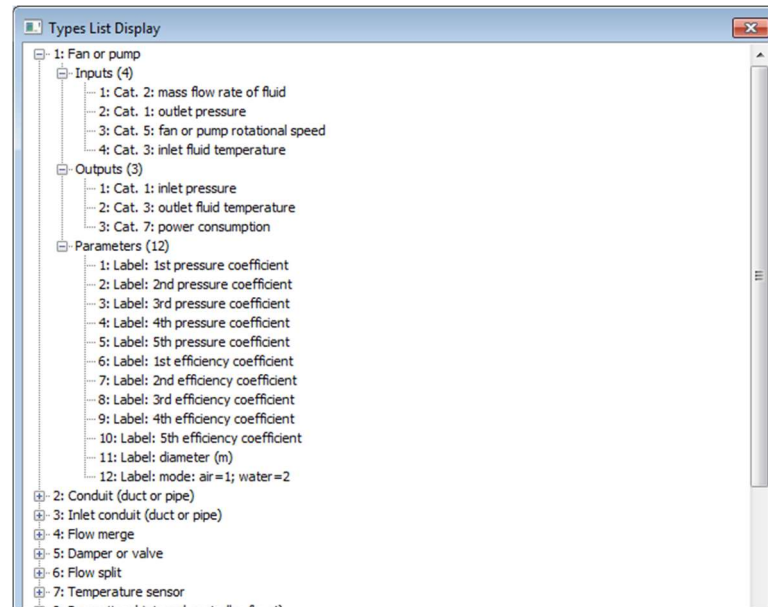
Figure 2: The Types List Display Window.

2.3.   The Units Display Window

Selecting the "View Units" button opens the Units Display Window, shown in Figure 3. This window uses a tree format to show the entire list of units detailed in the simulation work file. Each top-level node on the tree shows the superblock, block, unit number, label, and type. The label is generated when a unit is added to the Unit List and consists of the type number followed by a letter indicating the number of instances of that type that have been implemented. In Figure 2 the highlighted Unit is labelled "51c", indicating it is the third unit of Type 51 in the Unit List.

Expanding the tree by clicking on the box next to a top-level node will display the number of inputs, outputs, and parameters for that unit. The tree can be further expanded to show details of the inputs, outputs, and parameters. Inputs and outputs will show the category, label, and initial value for each item. Parameters will show the label and initial value. In Figure 3 the node for the fourth unit has been expanded to show the inputs, outputs, and parameters.
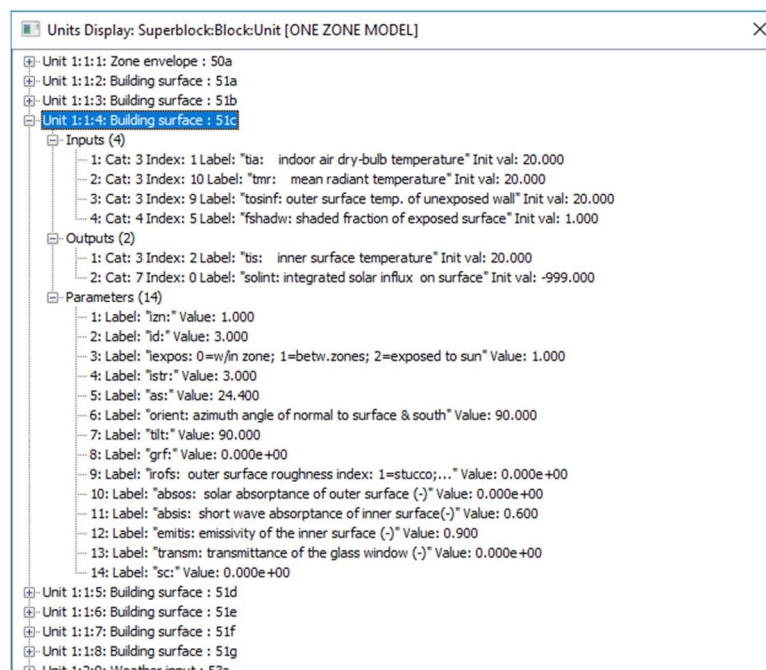
Figure 3: The Units Display Window.

2.4. The State Array Display Window

Selecting the "View States" button opens the State Array Display Window, shown in Figure 4. This window uses a tree format to show the entire State Array. Each top-level node on the tree shows the information for one State Array index, including the category and category index, the total number of units that use that state element as an input, the total number of units that use that state element as an output, the label, and initial value. It will also indicate if it is a boundary variable by showing a '(B)' at the end of the line. The label is taken from the output unit, if available, or the first input label. Expanding the tree by clicking on the box next to a top-level node will display the number of units that use that state element as an input or output. The tree can be further expanded to show details of the inputs and outputs: the unit number, type number, and the index of the input/output in that unit. In Figure 4, the node for the sixth state element has been expanded to show the outputs. The description for that state element shows that it is used to hold data for category 3, index 2 [3:2], is input to 1 unit and output to 1 unit, has label "tis: inner surface temperature", and has an initial value of 20.00. Further expansion of the tree shows that the unit to which it is an output is Unit 4, Type 51, index 1.
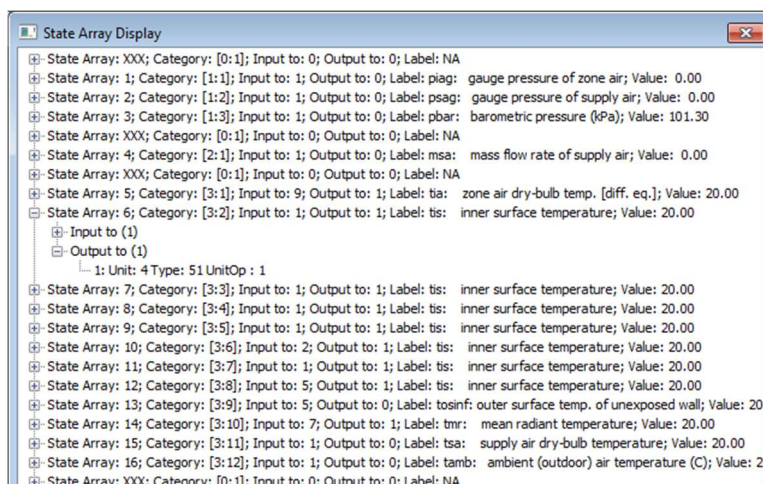
Figure 4: The State Array Display Window.

2.5. Working with the Display Windows

The three display windows are designed to interact with each other to help the user obtain a fuller understanding of the connections between types, units, and the State Array. It does this by reacting in each of the windows when the user selects an item, as applicable. For example, when an input or output of a unit is selected in the Units Display Window, the type of the unit is highlighted in the Types List Display Window, and the associated state vector element is highlighted in the State Array Display Window. Similarly, if an input or output to an element of the State Array is selected in the State Array Display Window, the associated unit is highlighted in the Units Display Window, and the type of that unit is highlighted in the Types Display Window. If a type is selected in the Types List Display Window any instances of that type will be expanded in the Units Display Window. These interactions are intended to simplify tracing data paths through the simulation: selecting an input to a unit will highlight that item in the State Array, selecting the associated output item in the State Array will highlight the unit that is writing the value to the input. This tracing can continue until it leads to a boundary variable or back to the starting unit. When a type description is selected in the Types Display Window, all units of that type are expanded in the Units Display Window, and units of other types are collapsed. This is useful for large simulations.

3. Working with Simulation Configuration and Data Files

The HVACSIM$^+$ Configuration Tool works with several kinds of files. Some files are intended to help increase understanding of the simulation, and some are intended to assist with modifications to the simulation. The specific uses of each type of file are discussed in Table 1.

3.1. Simulation Information files

The "Save Sim Info" button saves a Simulation Information file containing information that can help with making modifications to the simulation configuration, and that can be used with HVACGEN to create a new simulation work file. The file is saved as an XML spreadsheet with multiple worksheets or tabs. The labels for the worksheets are shown in Table 2

The GUI allows the user to view the data in a tree format, which generally focuses on one unit or state item at a time. Viewing the Simulation Information file in a spreadsheet program allows an aggregate view of the data. For example, the parameters for all the units can be viewed on the first worksheet. This can be a very convenient method to compare the parameters when there are multiple units of the same type. Similarly, the data for the State Array assignments can be viewed in aggregate in the State Array worksheet and the category specific worksheets. Note that changes to the values in these worksheets will not be reflected in a new simulation work file unless the changes are also made in the appropriate HVACGEN Stream worksheet.

Table 2: Worksheet labels in the Simulation Information file.

Number	Worksheet Label
1	Unit List
2	State Array
3	HVACGEN Stream Units
4	HVACGEN Stream Init Values
5	Boundary Data
6	Pressure (1)
7	Mass Flow Rate (2)
8	Temperature (3)
9	Control (4)
10	Other (5)
11	Energy (6)
12	Power (7)
13	Humidity (6)

The first worksheet (labelled "Unit List") is a listing of the units used in the simulation, including the superblock, block, type label, type number, the number of inputs, outputs, parameters, and the values of the parameters for each unit. Each item is in a separate column.

The second worksheet ("State Array") is a listing of the State Array, including the location in the State Array, the category, the index for the category, and the label for each element of the array. As with the labels used in the State Array Display Window, the label is taken from the output to that state element, if available, and from the first input if there is no output.

7

The third ("HVACGEN Stream Units") and fourth ("HVACGEN Stream Init Values") worksheets contain text streams that allow the user to create a new simulation work file. The first column of each worksheet is formatted to match the input required by HVACGEN and SLIMCON. The simulation would be recreated by copying the first column of each worksheet sequentially into the HVACGEN and SLIMCON interfaces. This is most beneficial if changes are to be made to the simulation – the relevant information may be modified in the first column of the worksheet, and then the new simulation work file created by copying and pasting the data into HVACGEN and SLIMCON. Changes made solely in other worksheets won't have any effect on the new simulation work file.

The fifth worksheet ("Boundary Data") contains boundary data. The top row of this worksheet contains the labels for the boundary variables. The rows below this should be copied into a boundary data file and adjusted as necessary.

The remaining worksheets are detailed listings of the elements in the State Array separated by category. Each worksheet contains columns listing the State Array index, category index, label, and initial value for each element. It also includes information on the output unit, unit index, and output type if there is an associated output, and information on the input unit, unit index, and input type if there is an associated input. If there are multiple inputs associated with an element, information about subsequent inputs is entered on additional lines.

3.2. Unit List Files

The "Save Unit List" button saves a data file containing information that can help with making modifications to the simulation configuration. Instead of producing output formatted for HVACGEN, the unit list file can be entered directly back into the HCT. The file is saved as an XML spreadsheet with multiple worksheets or tabs.

The first worksheet is a listing of the initial values in the State Array. This sheet also indicates the boundary and reporting state of each element. The remaining worksheets each contain the information for one unit. The information includes the type, a text label, a text note, the superblock and block numbers, the input indexes, the output indexes, and the parameter values. This information may be modified in a spreadsheet editor. Note that the input and output indexes are category indexes, not absolute indexes. The Unit List may be modified by inserting, deleting, or rearranging the worksheets with unit information. Detailed examples of how to use this feature are provided in Section 4.

3.3. Unit Sequence Files

Unit Sequence files are used to enter a series of units, without any specific configuration. They are formatted as text files, with a unit type number entered on each line. There is no header or other configuration data present. The file is read by being dragged and dropped onto the HCT. As with other methods, the types file must either be previously entered or present in the local subdirectory. Models entered using this method will require configuration of the input assignments, superblock and block settings, boundary and reporting settings.

3.4. Type Crosswalk Data Files

The "Save Type Crosswalk" button saves a data file containing information on the inputs instantiated for each type. The information available for each input specifies the source of that data. If the source is the output from a different unit, then the unit number, input index, and type of that unit is shown. If there is no output associated, the word "Boundary" is shown to

indicate that it is a boundary variable. The data is saved as a spreadsheet with a worksheet for each type used in the simulation. The worksheets are labeled with the type number they hold data for, i.e. the worksheet holding data for the units of Type 51 is labeled "T051".

The first column in the worksheet contains the label for each of the inputs for that type. Subsequent columns contain the configuration information for each unit of that type that has been specified in the Units List. For example, if the simulation has four instances of Type 349, there would be four columns in the worksheet containing data for those four units. The example in Figure 5 shows three instances of Type 51. They each have as their first input (label starting with i01 in column A) the first output from unit 10 (U10:01), which is Type 52 (T052). They each have as their second input the first output from unit 1 (U01:01), which is Type 50 (T050). The third and fourth inputs are boundary variables, so there is no unit to reference.

As seen in Figure 5, this view of the model provides a method to review and compare the inputs for multiple units of the same type. As the inputs to sequential units are often also sequential or patterned, this provides an additional method to confirm a correct model configuration.

	A	B	C	D
1	T051- Building surface	U2 Building surface	U3 Building surface	U4 Building surface
2	i01 tia: indoor air dry-bulb temperature	U10:01 T052	U10:01 T052	U10:01 T052
3	i02 tmr: mean radiant temperature	U01:01 T050	U01:01 T050	U01:01 T050
4	i03 tosinf: outer surface temp. of unexposed wall	Boundary	Boundary	Boundary
5	i04 fshadw: shaded fraction of exposed surface	Boundary	Boundary	Boundary

Figure 5: Example of Type Crosswalk data.

3.5.   Data Crosswalk Files
The data crosswalk feature takes State Array time series data and saves it to a spreadsheet, which presents time series data for each unit in a separate worksheet. The time series data for each unit consists of the values of the inputs and outputs at each time step. State Array time series data may be obtained by selection of output variables in the simulation configuration for a small simulation, or by modification of the MODSIM executable. This feature is very useful for debugging a simulation.

3.6.   Modifying the Simulation in the User Interface
While all modifications to the simulation configuration are possible to implement in the output files, some of them are faster and easier to implement using the user interface. Modifications that can be accomplished are currently limited to adding Units, moving inputs and outputs in the State Array, and assignment of boundary variables. Detailed examples of how to use these features are provided in Section 4.

3.6.1. Entering Units Manually
Units may be manually entered through the user interface. A types file must be entered first, as described in Section 2.1.1, to provide the list of types which can be added to the Unit List. A new simulation may then be started by adding the first unit, or units may be added to an existing simulation read in using one of the methods described earlier. The four controls indicated in Figure 6 are used to add a unit as follows:

- Control 1 is a drop-down containing the type numbers for each unit type from the component model configuration file.

- Control 2 is the position in the Unit List for the new unit. If left blank, or if a value larger than the list length is entered, the new unit will be appended to the list.
- Control 3 indicates the superblock:block of the new unit.
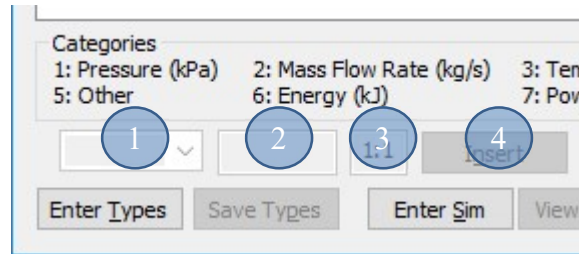- Control 4 is a button used to insert the new unit.

Figure 6: Controls for adding a Unit.

When a unit is added to the simulation, new State Array elements are created for the outputs of that unit. The new State array elements are allocated at the end of the appropriate category. The inputs are assigned to the first State Array element of the appropriate category and must be reassigned by the user. The intent is that the inputs would be moved to the array element with the correct output or moved to a new array element.

A second method of adding units may be used when there is at least one unit already in the simulation. Performing a double right-click on a unit will add another of the same type of unit, inserted after the unit that was clicked on. The outputs for the new unit are inserted immediately after the ones for the existing unit, instead of at the end of the range for that category. This is intended to simplify later manual review of the simulation.

3.6.2. Adding Elements to the State Array
New elements can be inserted into the State Array by double right clicking on an existing element in the State Array Display Window. The new element will be added after the element that was clicked on. This is primarily intended to be used after adding a new unit where one or more of the inputs will be a boundary variable. As only outputs are added when a new unit is created there will initially only be enough elements for non-boundary variables.

3.6.3. Rearranging the State Array
After new units are added to the simulation the inputs will need to be assigned. Initially inputs to new units are assigned to the first position in their category; this will rarely be the correct position. Inputs and outputs in the State Array tree can be clicked and dragged to another location in the State Array in the same category. They can be dropped anywhere on the target element; inputs will remain inputs and outputs will remain outputs. If the dragged item is dropped on an invalid location no changes will be made.

3.6.4. Modifying Boundary Variables
The boundary variable status of an element in the State Array is indicated by the text "(B)" at the end of the description of that element in the State Array Display Window. This status can be toggled by selecting any part of the element and pressing the letter 'b' on the keyboard. The status can also be toggled by navigating to the desired input or output in the Units Display Window and pressing the letter 'b'. Note that only elements with one or more input assignments and no output assignments are eligible to have boundary variable status.

3.6.5. Modifying Reported Variables

The reported variable status of an element in the State Array is indicated by the text "(R)" at the end of the description of that element in the State Array Display Window. This status can be toggled by selecting any part of the State Array element and pressing the letter 'r' on the keyboard. Selecting any part of a unit in the Units Display Window and pressing the letter 'r' will toggle the reporting state for all inputs and outputs of the selected unit. Variables modified by this method are reported in Superblock 1. Reporting a variable in a different superblock will require modification to the HVACGEN input stream.

3.6.6. Modifying Superblock and Block Assignments

The superblock and block assignments of units in the Unit List are indicated in the Units Display Window in the text description for each unit. Each description begins with text similar to "Unit X:Y:Z:" where X is the superblock, Y is the block, and Z is the absolute unit number for that unit. The superblock for units can be incremented by selecting a starting unit and pressing the letter 'S' on the keyboard. All subsequent units will also have their superblock incremented. Pressing the letter 's' will decrement the superblock for the selected unit and all subsequent units. Pressing the letter 'D' or 'd' will increment or decrement the block for units in the selected superblock only.

4. Using the HVS Configuration Tool - Use Cases

This section instructs the user on how to use the HCT through the examples given by use cases, as suggested by ASHRAE Guideline 20-2010 (RA 2016) [3]. Various interactions a user could initially or commonly have with the HCT are described in the use cases presented here. This is not an exhaustive list, but a set chosen to be sufficient to allow a new user to become familiar with and use the HCT. The use cases described here are:

1. Starting the HCT and entering type and simulation work files.

2. Opening and using the display windows.

3. Adding units with the user interface.

4. Adding and modifying elements of the State Array.

5. Modifying the superblock and block.

6. Creating and using a simulation information file.

7. Creating and using a unit list file.

To demonstrate some of the steps involved, system model Example 1 from the HVACSIM$^+$ distribution will be used in this section as appropriate. This example is found in the folder "SAMPLE\system model\example1". This example is also used in the HVACSIM$^+$ User's Guide Update [1] in Section 4. The information flow diagram of this example is provided in **Figure 7**.
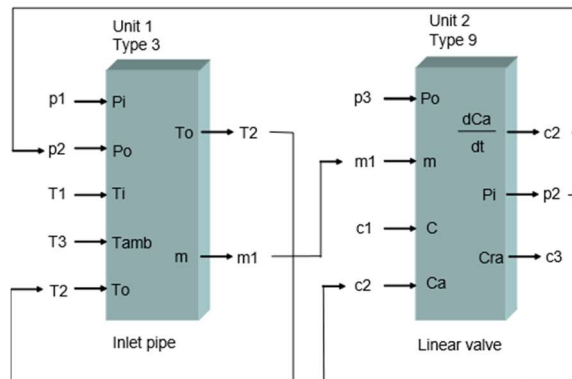

Figure 7: Information flow diagram of Example 1 [1].

4.1. Starting the HCT and Entering Type and Simulation Work Files
When the HCT is first opened, there are only two options available through the interface; to enter a types file or to enter a simulation work file. Files may be dropped onto any portion of the HCT GUI from Windows Explorer (i.e., drag and drop). Multiple files may be selected and dropped at the same time. For this example, select the files typar.dat and example1.sim from the HVACSIM$^+$ distribution and drop them on the HCT.

4.2. Opening and Using the Display Windows
After the types file and simulation work file have been entered, the buttons to open the related display windows will be enabled. The display windows allow the user to view a list of the

12

Types available, the units specified in the simulation work file, and the State Array specified in the simulation work file. The display windows may be opened by selecting the appropriate View button at the bottom of the user interface. To follow this example, open the three windows.

The three display windows work interactively to display information about the model configuration. Expand the trees in each display window to explore details about the model. Note how the selection in one display window will affect the trees in the other two display windows. Open the tree in the Units Display Window to show the outputs for Unit 1 and select the second output. Note the State Array Window tree is now opened to show the State Array element associated with the output selected in the Units Display Window. Open the Inputs node and select the leaf node. Note the Units Display Window selection has changed to match the selection in the State Array Window. This method can be used to trace data flows through the model.

4.3.   Adding Units with The User Interface

After the types file has been entered, units may be entered using the user interface. In this example we will add one each of Type 3 and Type 6, recreating the model from Example 1. The steps are as follows:

- Start the HCT and enter a types file as directed in Section 4.1.
- Open the drop-down window, labelled Control 1 in Section 3.6.1, and select Type 3.
- In the edit box (Control 2) enter the number 1. This will put the new unit at the beginning of the unit array. Note that if this box is left blank it will default to a value of 1, and if a value larger than the number of units in the array is entered the new unit will be placed at the end of the unit array.
- The superblock:block entry (Control 3) does not need to be modified for this example. When modified the values entered will be adjusted as required to be in the range of neighboring units.
- Select the Insert button (Control 4) to add the new unit to the Unit List.
- Repeat to add a Type 9 in position 2 of the Units List.

After the first unit is added the Units Display Window and State Array Display Window will be available. The windows should appear as shown in **Figure 8**. The simulation cannot be used yet because the input and output connections have not been set.
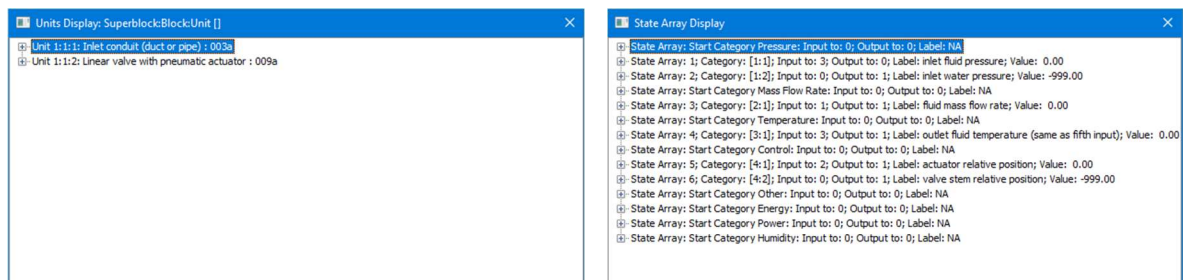

Figure 8: The Units Display Window and the State Array Display Window.

4.4. Adding and Modifying Elements of the State Array

The elements of the State Array must be modified to match the unit inputs and outputs shown in **Figure 7**. When the units were added, each output was assigned to an unused element of the State Array at the end of the appropriate category. However, all the inputs are assigned to the first element of their category. Starting with the inputs to Unit 1, verify that the inputs are correctly assigned and adjust them as necessary. This will include both moving inputs to different State Array elements and creating new State Array elements for boundary variables. When completed, the units and State Arrays should be as shown in **Figure 9**. The nodes in the figure have been expanded where necessary to show all relevant details.
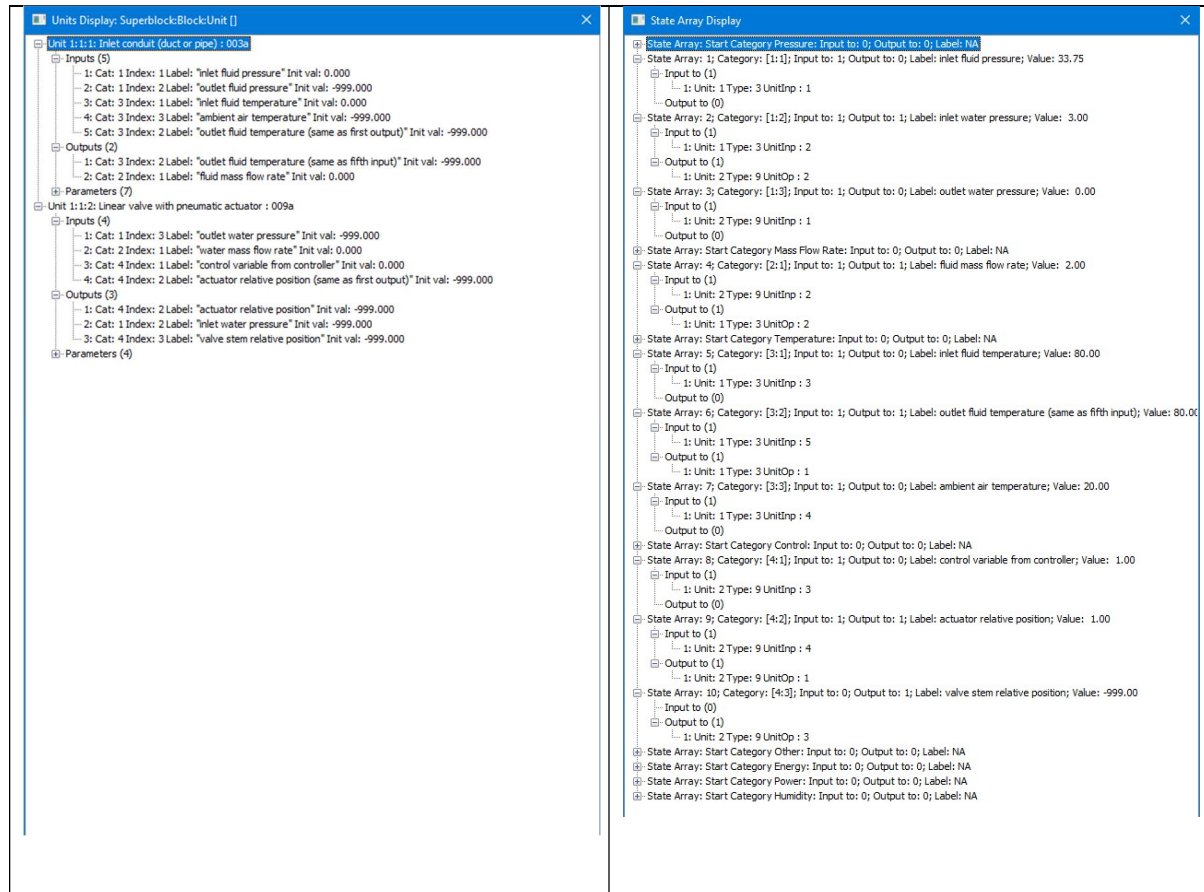

Figure 9: The Units Display Window and State Array Display Window.

4.5. Modifying Boundary and Reported Variables

Example 1 has two boundary variables, which must be set in the model. The first is the inlet fluid temperature, which is the third input to Unit 1. It is also the fifth element in the State Array. Observe these locations in the Units Display Window or the State Array Display Window. Select either location and press the letter 'b'. Observe the label in the State Array Display Window now has the label "(B)" added to the end, indicating a boundary variable. Repeat for the second boundary variable, control value from controller, the third input to Unit 2.

Example 1 has seven reported variables. The first one is the second state array element, inlet water pressure. Select the element and press the letter 'r'. Observe the label in the State Array

14

Display Window now has the label "(R)" added to the end, indicating a reported variable. Repeat for the remaining reported variables, located at array positions 4, 5, 6, 8, 9, and 10. The finished State Array is shown in Figure 10.
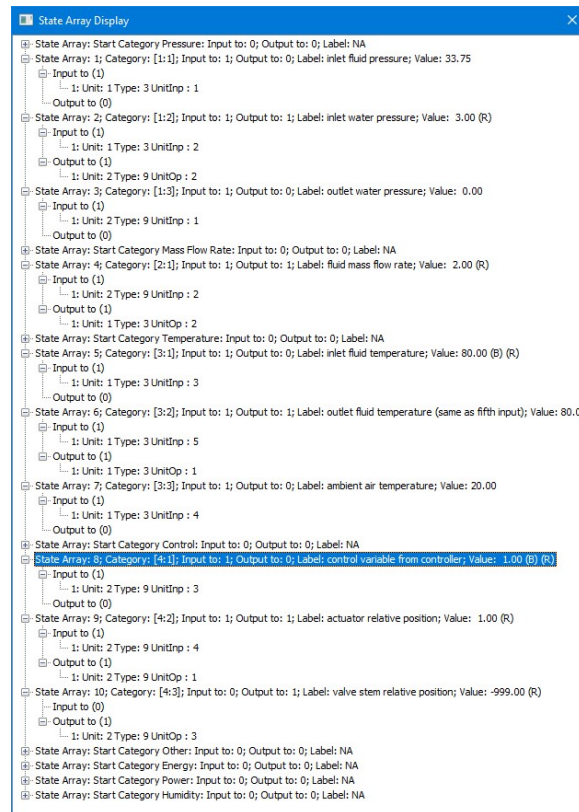

Figure 10: The State Array after boundary and reported variable modifications.

4.6.   Saving and Using the Simulation Information File

The Simulation Information file is saved by selecting the 'Save Sim Info' button. This button is only active when there is one or more units in the unit array. The Simulation Information file is described in detail in Section 3.1.

The HCT does not directly interact with HVACGEN or SLIMCON, but the first columns of the HVACGEN Stream worksheets are designed to be copied into them to produce a simulation work file and a model definition file. The steps to produce these files are:

o   Open a command line window. Change the directory to where you want the files to be located, if it's not opened there. The file typar.dat must be present in this directory.
o   Start HVACGEN on the command line.
o   Copy the first column of the HVACGEN Stream Units worksheet. Be sure to start at the top line, and finish at the line indicated in the worksheet. Note that this may be several hundred lines of text. Paste the text stream into the command line and review the output for errors. If there were no errors, HVACGEN will be ready to enter variable initial values.
o   Copy the first column of the HVACGEN Stream Init Values worksheet, from the top line to (and including) the line indicated by the text "Enter to continue – exits HVACGEN". The final four lines of the column are for SLIMCON. Paste the copied text into the

15

command line. Note that some command line shells will accept the entire column of text, successfully running SLIMCON, but others will fail with an error, requiring SLIMCON to be run separately.

o Start SLIMCON on the command line if necessary. Copy the final three lines of the first column and paste them into the command line. Note that the commands required are very brief, and it may be faster to type them.

The next step is to prepare the boundary data file. The data for this is found in the "Boundary Data" worksheet. Copy the contents of this worksheet, except for the title row, into a file. Adjust the times in the first column and the values in the following columns to meet the needs of your simulation.

4.7.   Creating and Using a Unit List File

The unit list file is saved by selecting the 'Save Unit List' button. This button is only active when there is one or more units in the unit array. The unit list file is described in detail in Section 3.2. The unit list file provides a simple method to edit the simulation and reload the model to the HCT. To modify a simulation, save a unit list file from the HCT and open it in an application that can work with XML worksheets. The following modifications can be made:

- Change initial value of an element of the State Array: Navigate to the State Array worksheet. The second column indicates the initial value of each state array element.

- Change boundary or reporting state: Navigate to the State Array worksheet. The third column indicates the boundary and reporting state for each array element. If the letter 'B' is present that element is a boundary variable. If the letter 'R' is present that column that element is reported. Other letters in that column are ignored.

- Change the value of a unit parameter: Navigate to the worksheet for the unit. In the first column, find the label for the parameter to be changed. The parameter values are in the second column.

After performing these or any other modifications, save the file in the same format and drop the file back onto the HCT. The modifications will be shown in the display windows.

5. Future Work

There are several features that could be added to increase the utility of the HCT. These include: reading and displaying more information from the simulation work file, such as tolerances; editing items such as State Array initial values and parameters; saving output that would simplify creation of updated simulation work files; accepting reported variable output files for data crosswalk files, parsing differential equation entries in the types file to search for potential configuration problems, improving the capability to edit reported variable assignments, and the capability to enter model definition files. Other additional features could be added as the need becomes apparent, or as requested by users of HVACSIM$^+$.

6. References

[1] Park, Cheol, 2008, " HVACSIM$^+$ User's Guide Update", NISTIR 7514.
[2] Bushby, Steven T., et al., 2009, "The Virtual Cybernetic Building Testbed- A Building Emulator", ASHRAE Transactions, Volume 116, Part 1, p37.
[3] ASHRAE Guideline 20-2010 (RA 2016), 2016, "Documenting HVAC&R Work Processes and Data Exchange Requirements," ASHRAE.