Core Flight System
Command and Data Dictionary Utility
Tutorial

Engineering Directorate
Software, Robotics, and Simulation Division

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1.0 Description

The Core Flight System (CFS) Command and Data Dictionary (CDD) utility, or CCDD, is a software tool for managing the command and telemetry data for CFS and CFS applications. See JSC-37494, Core Flight System Command and Data Dictionary Utility User's Guide, for details on the CCDD application. This tutorial provides an example of setting up a project using CCDD, populating the project's data tables, and using the project data to create output files.

Questions or comments concerning this document or the CCDD application should be addressed to:

Johnson Space Center
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Houston, TX 77058

2.0 Requirements

CCDD must be installed per the user's guide, including access to a PostgreSQL server. The user must have a valid login role on the PostgreSQL server.

3.0 Tutorial

The following paragraphs lead the user through the basics of using the CCDD application, beginning with creating a new project, adding data tables to the project, entering data, and using a script to generate an output product from the project's data. The paragraphs follow a specific order, with successive ones building on previous ones. The results may not be the ones expected if the steps are executed out of order.

3.1 Start CCDD

Start the CCDD application. The main application window appears (see Figure 1). A login dialog may also appear depending on the postgres server's authentication settings; enter your postgres user login and password. In the **Project** column "*server*" is shown once a connection to the postgres server is established, or "*none*" if the connection to the server doesn't exist. The server must be connected in order to proceed with the tutorial. The **User** column indicates the name of the user that is connected.

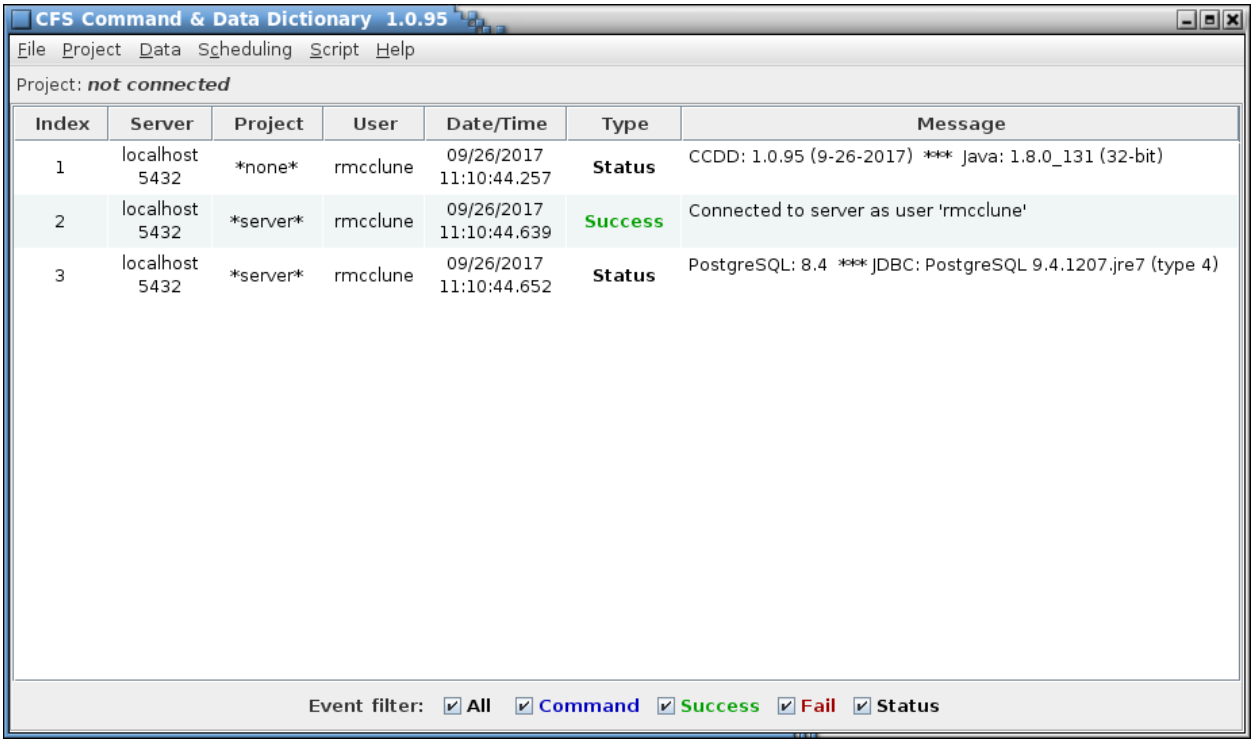

Figure 1. CCDD main application window

3.2 Create a project

In the main window's menu bar select **Project | New**. A dialog appears similar to that shown in Figure 2 with the postgres and your user roles under the **Select project owner** heading (more roles may also be present if extant on the postgres server).

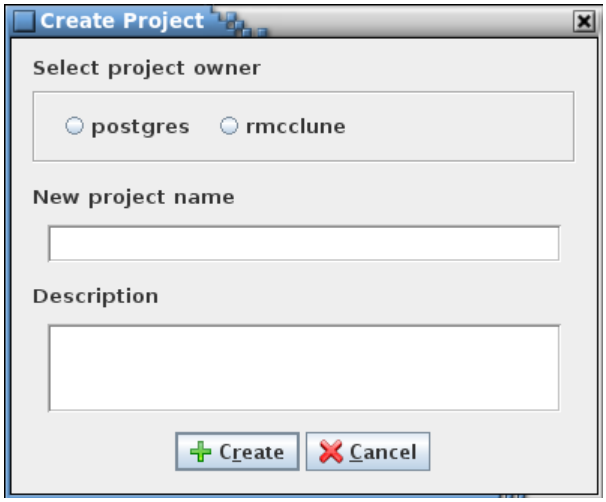

Figure 2. Create Project dialog

Select the radio button for your user as the project owner. Only the owner is allowed to make changes to the data stored in the project. It's possible to assign a generic owner and then link the users to this generic owner, allowing multiple users to make changes. In the **New project name** input field type

"MyProject" as the project name. The project name has constraints as to characters allowed, length, and uniqueness. Enter a description for the project in the **Description** field (this can be altered later if desired). Press the **Create** button to create the new project. The event log displays a message when the project is successfully created (or if an error occurs).

Now that the project exists data can be added to it. Data is stored as tables and table entries in the postgres database. The project isn't entirely empty initially; aside from a number of necessary internal tables and postgres functions, the table types, data types, and reserved message IDs are populated with default information. CCDD handles all of the transactions with the database, reading and writing data to the tables as needed. These transactions are reflected in the main window's event log entries.

A project must be opened before in order to alter the data within it. In the main window's menu bar select **Project | Open**. The **Open project** dialog that appears displays all of the CCDD projects for which the current user has access. Select "MyProject" from the dialog and press the dialog's **Open** button. The event log indicates that the project is open and locked. Locking the project prevents all but the current user from making updates the project.

3.3 Create a data table

The primary location for a project's data are in structure and command tables. A structure table mimics information commonly found in a C language structure. In the main window's menu bar select **Data | New table(s)**; the **New table** dialog appears.

By default table types exist for structure and command tables. These table types may be modified, and additional types can be added. A table type serves as the template for new tables, defining the columns and input constraints for that type of table. Select the **Structure** radio button under the **Select table type** heading. Enter "myStruct" as the table name in the **Table name(s)** field. A table name must begin with a letter or underscore, and can contain letters, numerals, and underscores. In the **Description** field enter "My structure table". Figure 3 shows the completed dialog. Press the **Create** button to create the table.

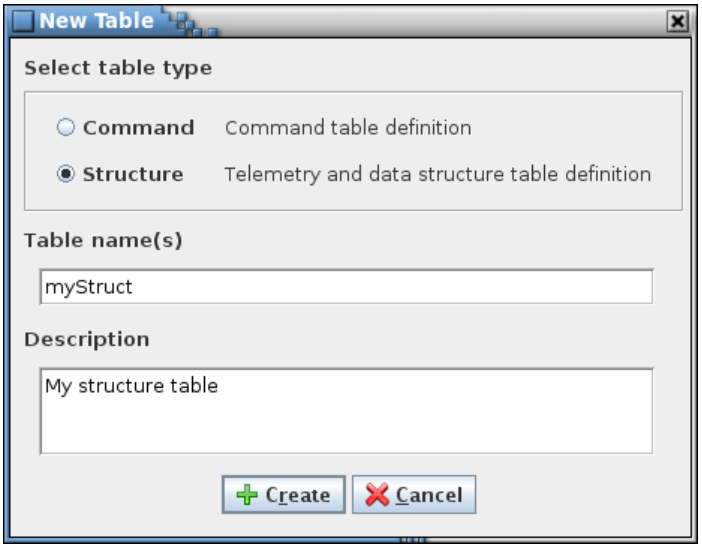

Figure 3. New Table dialog

3.4 Open a data table for editing

Now that a table exists in the project data can be entered into it. The first table created represents a structure, so the data to be entered will be variable names, data types, etc. In the main window's menu bar select **Data | Edit table(s)**, which causes the **Edit Table** dialog to appear (see Figure 4). Data tables are displayed using a tree format (similar to folders and files on a computer). The tables are arranged under two headings, **Prototypes** and **Parents & Children**. The tree is initially collapsed, so only these two headings are displayed. Select the **Expand all** check box below the tree, as shown in the figure, to display the tables under each heading.

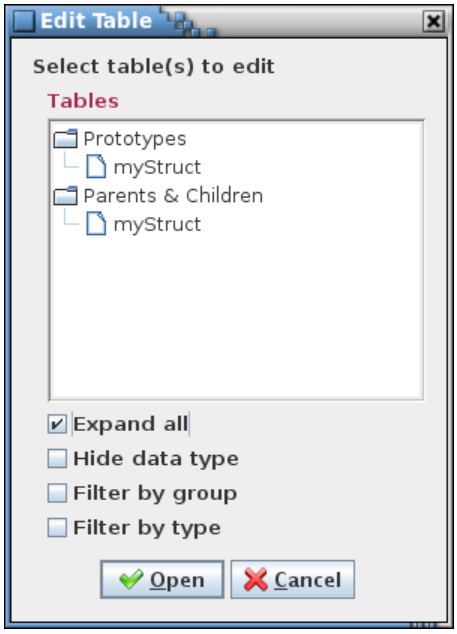

Figure 4. Edit Table dialog

All tables created using the **Data | New table(s)** command appear under the **Prototype** heading. A prototype can be thought of as a "rubber stamp" from which copies of the table are made. The copies are created when a table becomes the "child" of another table; that is, the child is referenced by the parent table. In practice this only occurs with structure tables since a structure can have a variable with another structure as the data type. The tables under the **Parents & Children** heading reflect this relationship. Any table that isn't referenced by another table appears in the first level under the **Parents & Children** heading; these are referred to as "root" and "top-level" tables in the user's guide. Child tables appear on subsequent "nest" levels. This nesting can extends to any depth, dependent on the structure references.

Use the mouse or keyboard to select the table "myStruct" from either heading (these represent the same table since "myStruct" is both a prototype and a root table). Press the **Open** button to open the table in a table editor.

3.5 Edit a data table

3.5.1 Add a variable

In the previous section the table "myStruct" was selected from the table tree in the **Edit table(s)** dialog for editing. The table editor, shown in Figure 5, appears. The editor can be resized if needed. The editor consists of a menu bar (along the top), the table (initially empty), the description field, and a number of buttons. A tab above the table displays the table's name (if multiple table are open then a tab appears for each table). Notice that the table's description, entered when the table was created, appears in the **Description** field.

The buttons provide a means of accessing some of the more commonly used editor commands; these (and other) commands can also be found in the editor's menu bar. CCDD has a number of editor and manager dialogs for altering the project's data. A common attribute of these editors and managers is that no data is actually stored in the project's database until the user explicitly chooses to do so. As long as there are unstored changes an asterisk appears beside the table's name in the tab. Also, if the table is closed and there are unstored changes a dialog appears allowing the user to choose between continuing (and discarding the changes) or returning to the editor.

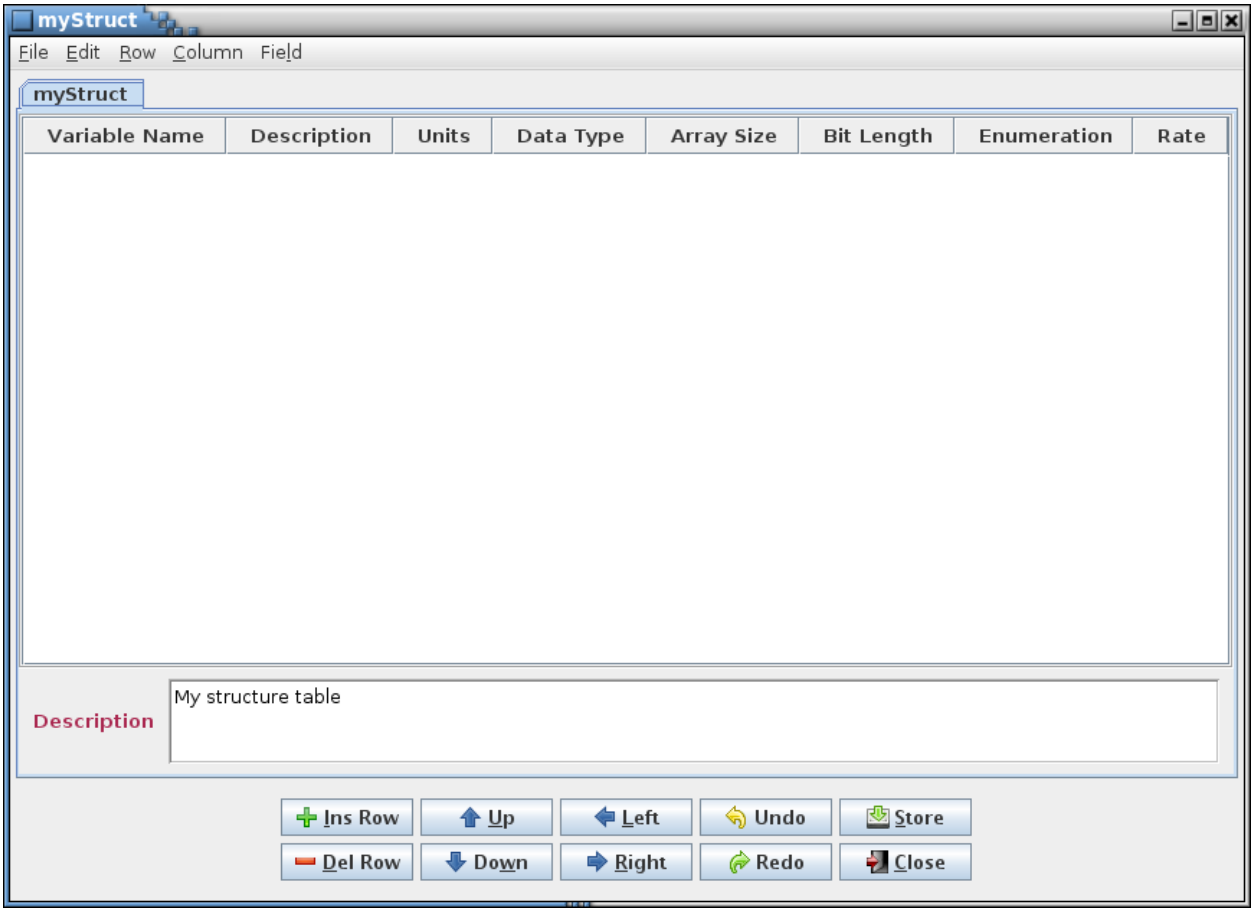

Figure 5. Table editor

A row must be inserted into the table before data can be entered, so press the **Ins Row** button (or alternatively, select **Row | Insert row** from the editor's menu bar). An empty row appears in the table as in Figure 6.

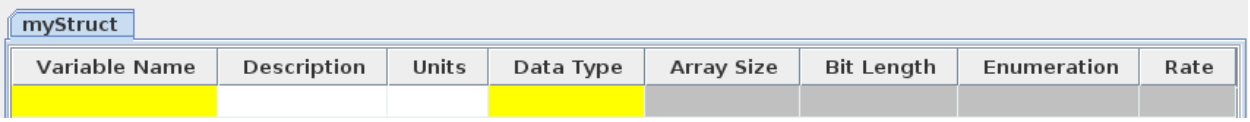

Figure 6. Empty row inserted into the data table

A cell with a gray background cannot be edited. Entering data into the other cells can determine if the grayed out cell becomes available for editing; if so, the cell's background changes to white. A cell with a yellow background indicates that a value is required in the cell. "Required" in this context means that the row needs this information at a minimum under normal circumstances and serves as a reminder to the user – the CCDD application doesn't enforce entering data into cells deemed as "required".

Since this table represents a structure each row is a variable definition, so a variable name and data type are required at a minimum to define the variable. In the **Variable Name** cell enter "myVar1". Notice that the **Array Size** cell is now editable. Select the **Data Type** cell using the mouse or keyboard; a combo box appears from which a data type is chosen (Figure 7).

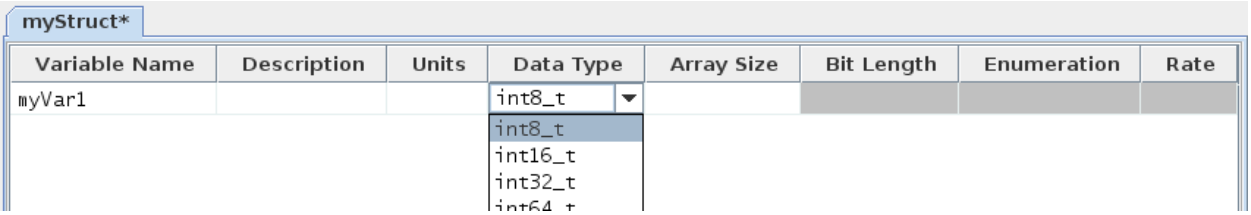

Figure 7. Variable name and data type

The choice of data type is constrained to those appearing in the list. There are two types of data type: primitive and structure. Primitive data types are those representing integers, floating points, characters, or pointers (a later section demonstrates changing the primitive data types). Structure data types appear if there are other structure tables defined – this is how child structures are created. Notice that "myStruct" doesn't appear in the data type combo box. This is because a structure isn't allowed to reference itself. In fact, CCDD prevents displaying any structure that would result in a circular reference, regardless of the depth of child structures involved. For this tutorial select "uint16_t", a two byte unsigned integer as the data type for variable "myVar1". The remaining cells that were grayed out are now editable.

Press the **Store** button to store the table, including the newly defined variable, into the project database. Press the **Okay** button in the confirmation dialog appears; the data is now stored (the event log records this action).

3.5.2 Create an array variable

Continuing from the last section, press the **Ins Row** button again to insert a second row into the table. The new row appears below the original row. New rows appear at the bottom of the table unless a row in the table is highlighted (i.e., one or more cells in the row is selected), in which case the row is inserted immediately below the highlighted row.

In the new row enter “myArray1” as the variable name and select “float” as the data type. Notice that the **Bit Length** and **Enumeration** cells are grayed out since this information isn’t applicable to a floating point value. Enter “3” into the **Array Size** cell. This creates a single dimensional array with three members. The members aren’t visible by default; change this by selecting **Row | Expand arrays** in the editor’s menu bar (or by double clicking the right mouse button while the mouse pointer is in any row in the **Array Size** column). Three more rows, one for each array member, are displayed underneath the new row, which is the array’s definition row. Notice that many of the cells for the members cannot be edited since these are dependent on the definition, whereas others, such as the **Description**, can be assigned per member. See Figure 8.

myStruct*

Variable Name	Description	Units	Data Type	Array Size	Bit Length	Enumeration	Rate
myVar1			uint16_t				
myArray1			float	3			
myArray1[0]			float	3			
myArray1[1]			float	3			
myArray1[2]			float	3			

Figure 8. Array definition and array member rows

If the array definition row is changed then the array’s members are updated to reflect the change. Change the array size from “3” to “4” and note that another member row is automatically inserted with the array information in place. Change the array size back to ‘3” and the added member row is removed. Changing the variable name or data type for the array’s definition also updates the members accordingly. The array member rows can be hidden again performing the menu command or the mouse action again. Store the changes in the project database.

3.5.3 Rearrange the rows

A variable’s position within the table can be changed by selecting a cell in the row, then pressing the **Up** and **Down** buttons (or using the equivalent **Row** menu commands). Use the mouse or keyboard to highlight any cell in one of the “myArray1” rows, then press the **Up** button. The entire array, definition and member rows, is moved above the row containing the variable “myVar1” (Figure 9).

myStruct*

Variable Name	Description	Units	Data Type	Array Size	Bit Length	Enumeration	Rate
myArray1			float	3			
myArray1[0]			float	3			
myArray1[1]			float	3			
myArray1[2]			float	3			
myVar1			uint16_t				

Figure 9. Variable “myArray1” moved above “myVar1”

Rows representing more than one variable can be moved as a block. The variables must be contiguous, so any intervening variables are moved as well. Store the changes in the project database.

3.5.4 Rearrange the column order

The order in which the columns are displayed can be changed if desired. This is accomplished by one of three methods: the Left and Right buttons, the equivalent **Column** menu commands, or dragging the

column using the mouse. For the button or menu method highlight a cell in the column(s) to be moved, then issue the command. Note that intervening columns are moved as well if the selected columns aren't contiguous. To use the mouse, position the mouse pointer over the column header, then press and hold the left or right mouse button. Move the mouse to reposition the column(s). Column order changes are recalled if stored in the project database. The ordering is stored by table and user; in other words, each user can order the columns in each table to their own liking and the columns appear in that order when the table is reopened.

3.5.5 Enumerations

The enumeration column provides a means of defining enumerated values and their corresponding text values (and potentially other information). Since the enumerations are based on integer values, the **Enumeration** column is editable only when the **Data Type** column is a type of signed or unsigned integer. The format for an enumeration isn't fixed – the user is free to enter the data as desired as long as the separator characters are consistent within each enumeration. The script data access methods can then automatically detect the separation characters when parsing an enumeration.

In general the format has each enumerated value and its parameters separated from the next one by a separation character (or characters). The separation character could be a comma, for example. The individual parameters for each enumerated value are separated by another character (or characters); for example a vertical bar (|). At a minimum each enumerated value requires a text representation to go with it. Other parameters may also be added as parameters to each enumerated value; an example would be text and background colors for use when coloring the text on a display.

For the tutorial the variable "myVar1" will be given enumeration parameters for the values 0 and 1, with the value of 0 associated with the text "Off", and the value 1 with "On". This is done by entering "0 | Off, 1 | On" in the **Enumeration** cell for the variable "myVar1". Figure 10 shows the table with the change entered. Store the changes in the project database.

myStruct

Variable Name	Description	Units	Data Type	Array Size	Bit Length	Enumeration	Rate
myArray1			float	3			
myArray1[0]			float	3			
myArray1[1]			float	3			
myArray1[2]			float	3			
myVar1			uint16_t			0|Off,1|On	

Figure 10. Enumerated variable

DO SOMETHING WITH THE ENUMERATION IN THE TUTORIAL SCRIPT

3.5.6 Data fields

Some data associated with a table may not be appropriate in a tabular format. For example, a value that is the same for every row, or a value that applies to the entire table (the table description falls into this category). To account for this type of information the CCDD application allows for one or more data fields to be assigned to each table. These fields appear between the table's **Description** field and the buttons in the table editor.

Select the menu command **Field | Manage fields**. The **Data Field Editor**, shown in Figure 11, is displayed.

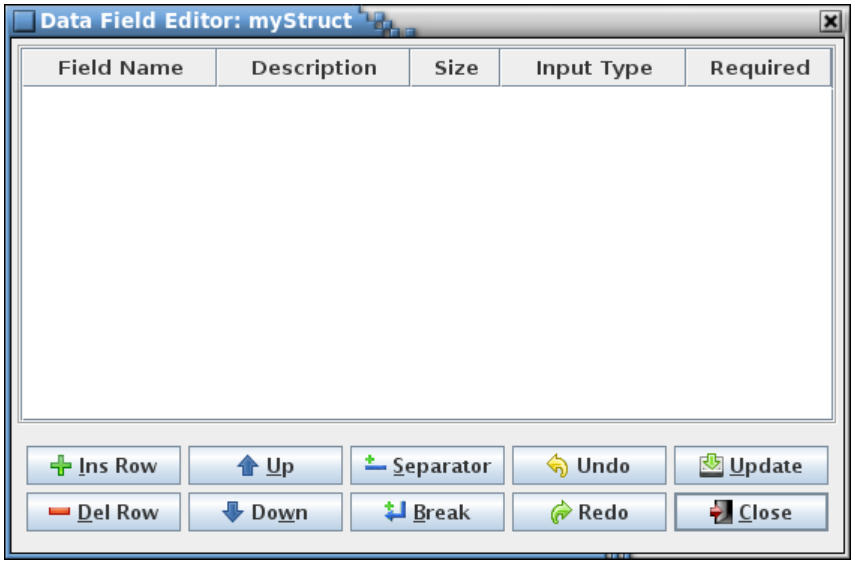

Figure 11. Data field editor

As with the table editor, it initially is empty. A data field is added by pressing the **Ins Row** button (Figure 12).

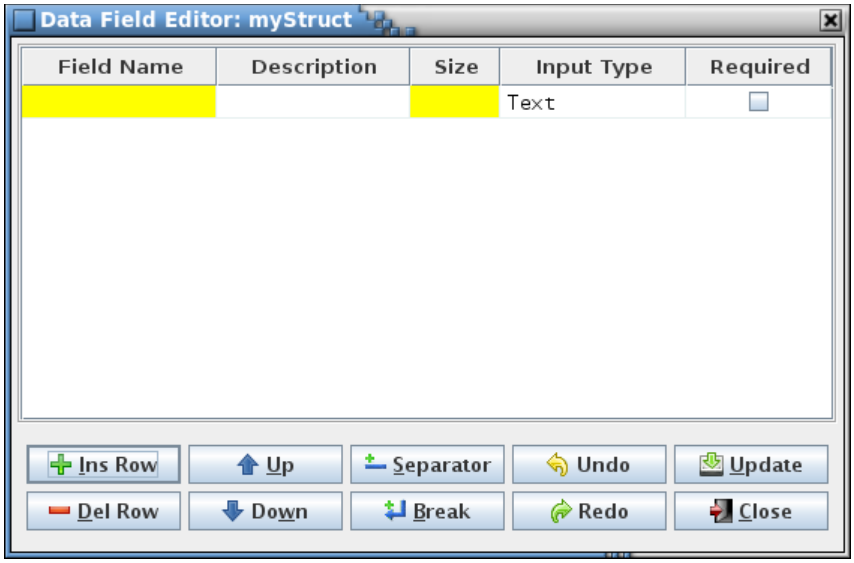

Figure 12. Data field editor with row inserted

Again, as with the table editor, a cell with a yellow background is considered required. However, in this case, a value must be entered for these cells. The **Field Name** is the text that appears beside the input field when it's displayed. The **Description** cell is optional; its text appears as a tool tip when the mouse pointer is hovered over the field. The **Size** cell determines the width in characters of the field. Note that this doesn't constrain the number of characters that can be entered into the field. The **Required** cell contains a check box; if selected the field's background color is yellow until a value is entered.

The **Input Type** cell, when selected, displays a combo box containing all of the available input types. The input type constrains the characters that can be entered into the data field. A large number of types are

provided. The default is “Text”, which allows any characters to be entered, though leading and trailing white space characters are removed. Some of the data types have specific uses not associated with data fields (e.g., “Variable name” and “Array index”); these can be used to constrain the input value, but any additional meaning isn’t used by the data field.

For the tutorial three data fields will be created, named “Subsystem”, “Message ID Name” and “Message ID”. Press the Ins Row button two more times to provide a total of three empty rows. In the **Field Name** column type the three field names. Use “7”, “15”, and “6” for the three field sizes, respectively. For the three input types use “Alphanumeric”, “Message ID name”, and “Message ID”. Selected the **Required** check box for the “Subsystem” row. The editor should appear as in Figure 13.

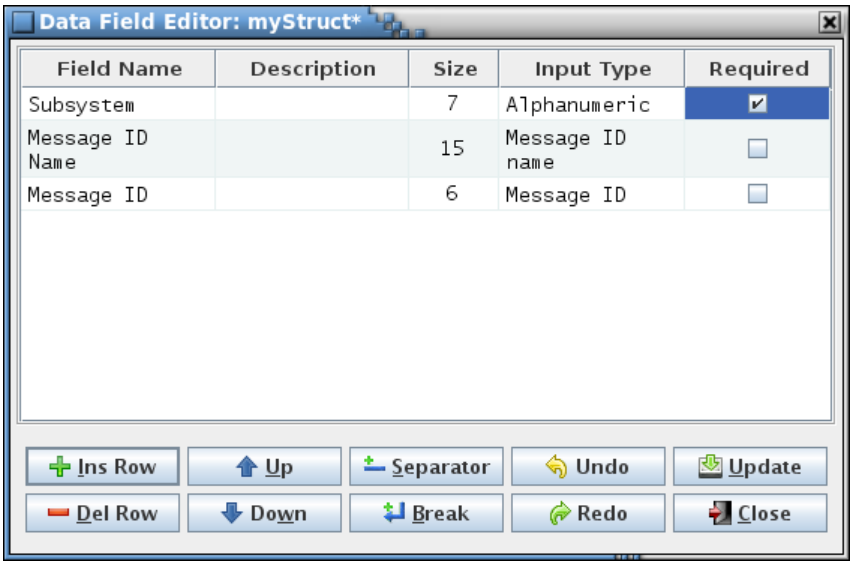

Figure 13. Data field editor with fields defined

The input types “Message ID Name” and “Message ID” impose the constraints on their respective fields, the first limits the name to the same format as a variable name, and the second to hexadecimal values. Beyond that these input types are recognized by the application when assigning message IDs and when associating message ID names and values. This is discussed further in a section 3.13 of this tutorial.

Press the **Update** button. This causes the fields to be displayed into the table editor. It does not store the fields in the project’s database; this is done using the table editor’s **Store** button. Exit the data field editor by pressing its **Close** button. The table editor should now appear as in Figure 14.

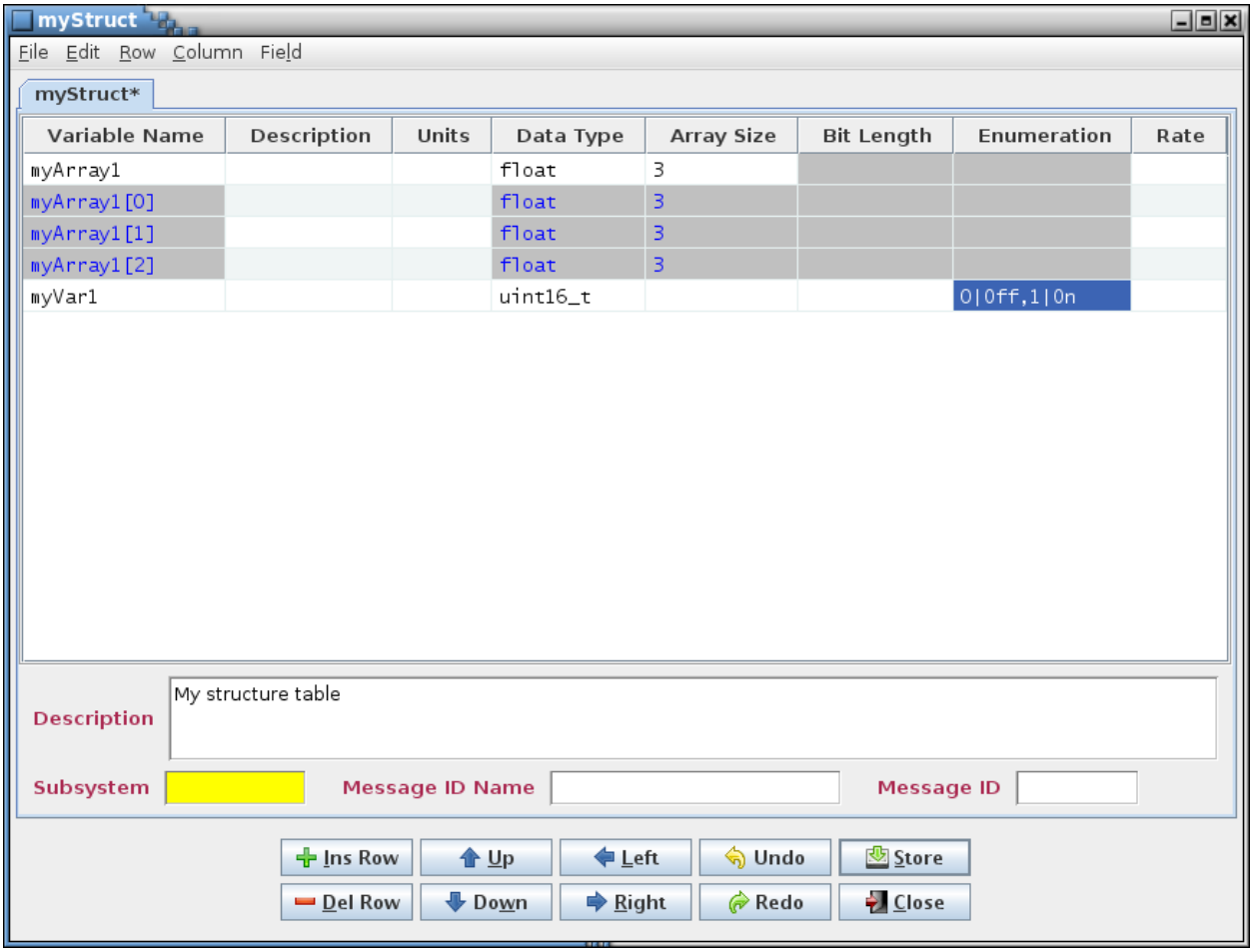

Figure 14. Table with data fields added

Since the **Required** check box was selected for the "Subsystem" field and the field is empty its background is yellow. The data fields can be edited the same as is done for the table cells and **Description** field. Enter "MySystem" in the **Subsystem** field and "MY_MSG_ID" for the **Message ID Name**. Type "q" into the **Message ID** field and press the **Store** button. A dialog appears indicating that the field contains invalid characters, and that a message ID is expected. Fields and cells with the "Message ID" input type are expected to be hexadecimal values (with or without the leading "0x"). All table cells and data fields are checked for valid inputs based on their respective input types. Press the warning dialog's **Okay** button. The "Message ID" field reverts to its former value, in this case empty. Leave the field empty and press the **Store** button to store the changes. Leave the table editor open for now.

3.6 Edit a table type

As demonstrated previously the table types are used as a template for creating tables. CCDD comes with two table types defined, **Structure** and **Command**. However, these types contain only the fundamental columns for these types of tables. For example, the **Command** table type has columns for only one argument, but multiple arguments may be needed. The table type editor allows altering the table type templates and creation of new ones.

Open the table type editor by selecting **Data | Manage table types** from the main window menu bar. The editor appears as shown in Figure 15.

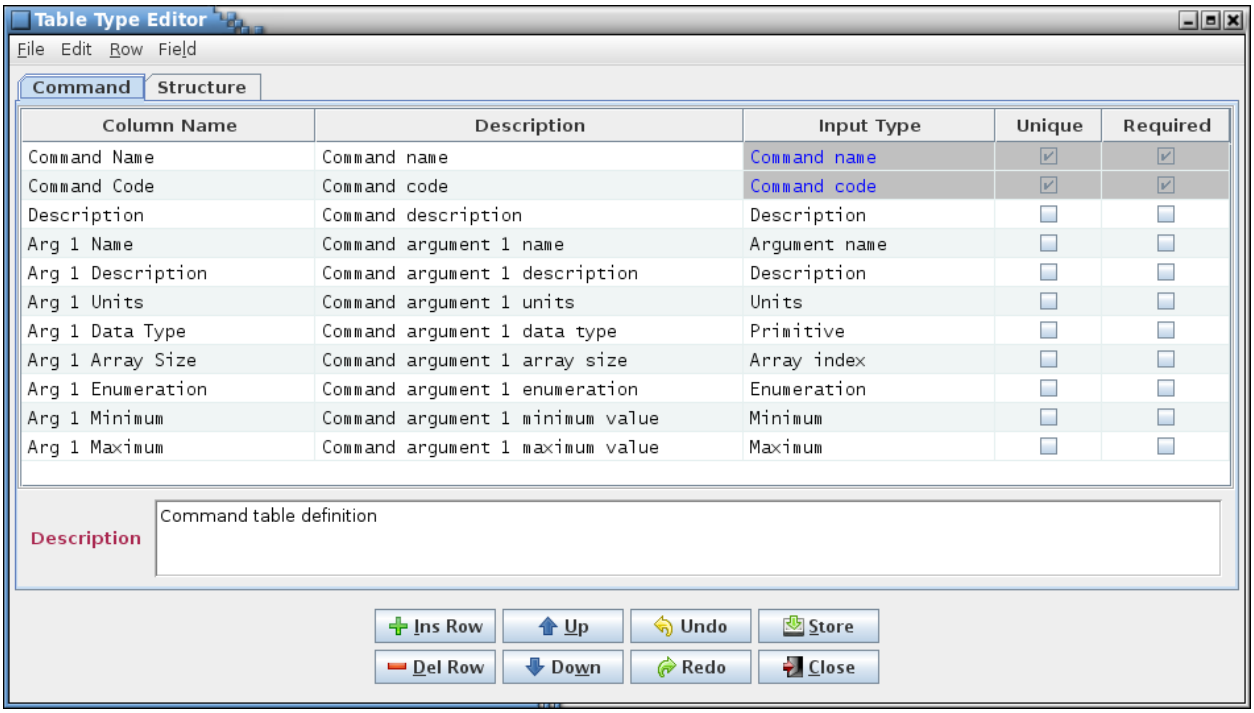

Figure 15. Table type editor

The table type editor appears very similar to the table editor, and operates in a similar manner. Each row in the table represents a column that is displayed in a table created from the table type. Select the **Structure** tab and the editor now displays the structure table type information (Figure 16).

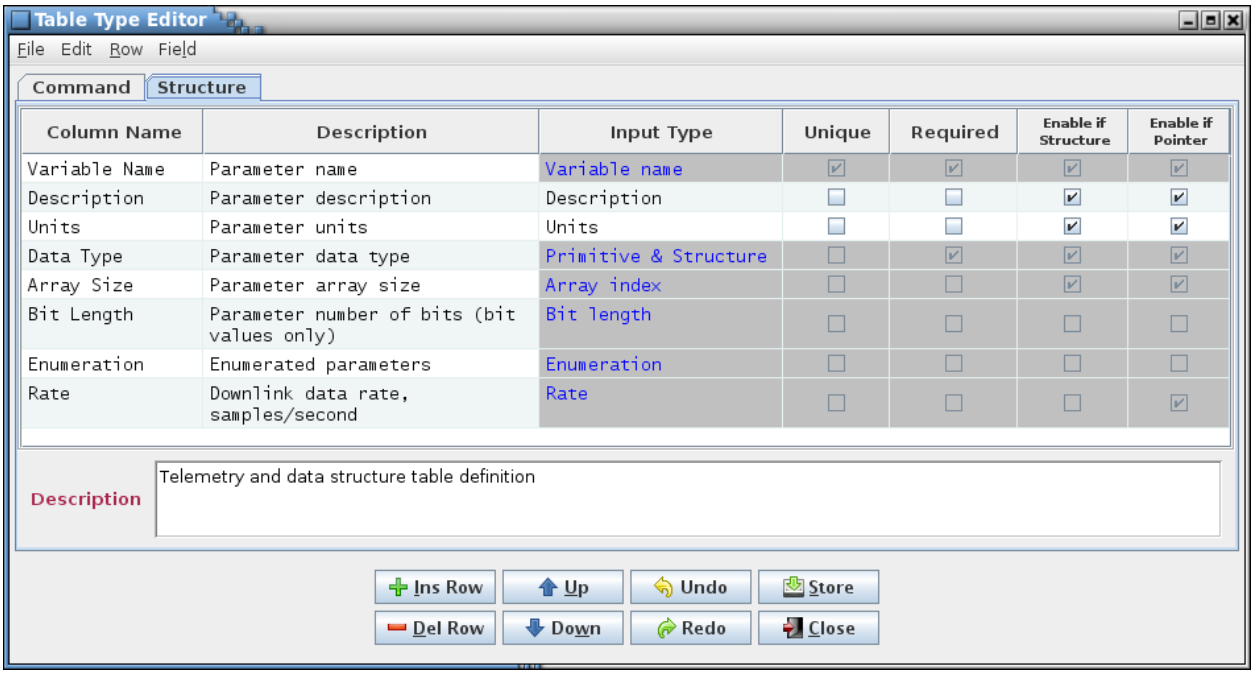

Figure 16. Default structure table type

Certain rows in the table type have grayed out cells. These rows are considered fundamental for describing the table type (in this case a structure) and cannot be altered or removed. For example, a structure, in order to be a structure, must contain a variable name and therefore must have a row for it.

Compare the rows in the structure table type to the columns in the "myStruct" table in the table editor (which should still be open). Notice that the text in the rows for the **Column Name** column match the columns names in the table editor's column headers. The order of the column definitions determines the initial order of the columns when a table of the type is created (but recall that the order can be changed in the table editor if desired). The **Description** column contains text that is used as tool tip text when the mouse pointer is hovered over the column's header in the table editor.

The **Input Type** column performs like the one in the data field editor described previously. Input types are used to define and constrain the input in a table cell. The first row in the table type editor defines the **Variable Name** column. Its input type is "Variable name", which constrains the values input to valid C language variable names. It also acts as a flag to other parts of the application that this value is a variable name. A structure table type may only have a single variable name column defined. The name of the column may be anything, but the input type must be "Variable name" for it to be recognized as such.

The remaining columns are described in detail in the user's guide.

For the tutorial anew column will be added to the "Structure" table type. In the table type editor press the **Ins Row** button; an empty row appears at the bottom of the table. Enter values in the row so that it appears as shown in Figure 17.

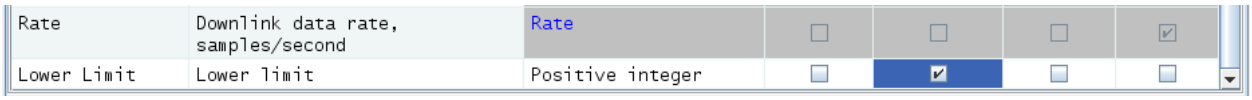

Figure 17. New structure table type column definition

The new column has the name "Lower Limit" and only accepts positive integer values (whole numbers > 0). The column is marked as "required", so in the table editor its background is yellow until a value is entered into it. Press the **Store** button in the table type editor and confirm the update. Select the table editor containing "myStruct" and notice that the new column has been automatically added to the table Resize the editor or use the horizontal scroll bar at the bottom of the table if necessary for the column to be visible. Figure 18 shows the editor's appearance with the new column.

myStruct

Variable Name	Description	Units	Data Type	Array Size	Bit Length	Enumeration	Rate	Lower limit
myArray1			float	3				
myArray1[0]			float	3				
myArray1[1]			float	3				
myArray1[2]			float	3				
myVar1			uint16_t			0|Off,1|On		

Figure 18. Structure table "myStruct" with the new "Lower limit" column

Notice that each "myArray1" array member can have its own value for the new column, as can the array definition row. If a value is entered in an array's definition row it is automatically propagated to every member. Attempt to enter values that are not positive integers (the input type assigned to the new

column); a warning dialog appears when cell editing ends and the cell reverts to its former value. Enter the values “1”, “2”, “3”, and “4” for the “myArray1” array members and “myVar1” respectively – see Figure 19. Store the updates.

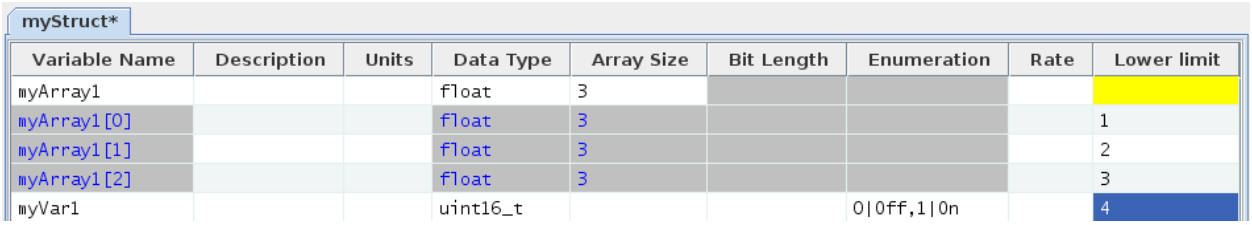

Figure 19. New column with values entered

3.6.1 Table type data fields

As with tables, data fields can be assigned to a table type. However, the purpose differs; data fields for a table type are used as part of the template for tables of the type. In other words, when a table is created of the type, the table also has data fields automatically assigned to it based on the ones in the type definition. Open the table type’s data field editor using the **Field | Manage fields** menu command. The data field editor appears. It differs in one way to the data field editor when opened in the table editor (described earlier); it includes an extra column, **Applicability**. This column only appears if the table type references a structure, so if the data field editor is opened for the **Command** table type this column does not appear.

For the tutorial a default data field, named “Subsystem” as in the table “myStruct”, should be included with all root tables. Press the **Ins Row** button to add a new row in which to define a new data field. Enter “Subsystem” for the **Field Name** and “7” as the **Size**, and leave the **Input Type** as “Text”.

The **Applicability** column determines what tables are assigned the data field (both existing tables and any new ones). The three types of applicability are “All tables”, “Roots only”, and “Children only”. “All tables” means that any table of this type that’s created or exists is assigned the data field if it doesn’t already have it. For “Roots only” only root tables are assigned the field, but not child tables. Finally, “Children only” assigns the data field only when a child table is created. When the column is selected a combo box appears displaying the three choices. Select “Children only” from the list, the press the **Update** button to create the data field, which appears beneath the table in the table type editor (see Figure 20).

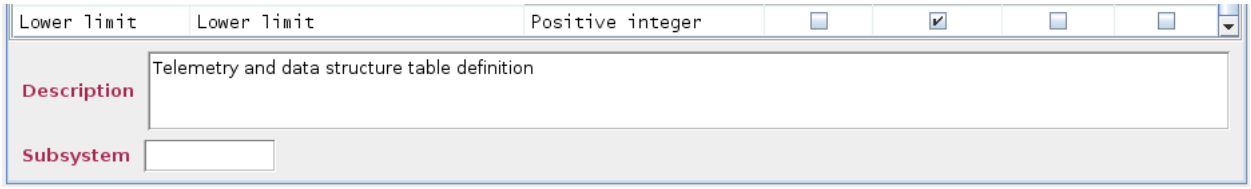

Figure 20. Table type with default field assigned

If a value is entered into the data field it is treated as a default value, so when a table of this type is created then the data field has the default value until changed by the user. Press the **Store** button to store the updates to the **Structure** table type. Note that the open table editor “myStruct” is unchanged; it’s a root table so the field doesn’t apply, and even if it were a child table it already has a field with this name so the new field wouldn’t be added. Close the table type editor.

3.7 Create a child table

A table is a child table if it is referenced by another table. In practice this is when a structure table uses another structure as a data type for a variable. Create a new structure table named "myChildStruct". To do this use the **Data | New table(s)** command, then select **Structure** as the table's type and enter the name "myChildStruct" in the **Create Table** dialog. Edit the table by executing the **Data | Edit table(s)** command and selecting the table from the **Prototypes** or **Parents & Children** headings in the table tree. At this point the new structure isn't a child since it isn't referenced by another structure, so for now it meets the classification of a root table. Notice that the table is opened in a separate table editor than the one for the table "myStruct". When opening a table or tables via the main window menu command a new table editor is created. If you want the table to open in an existing editor use that editor's **File | Edit table(s)** command instead.

Add a variable to "myChildStruct" as shown in Figure 21.

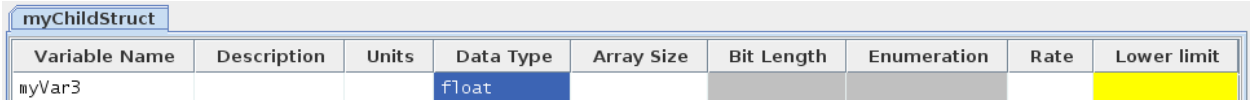

Figure 21. Variable added to structure "myChildStruct"

Select the table editor for "myStruct" and create a new variable "myChildVar", then select its **Data Type** column. The combo box containing the data types appears and at the bottom of the list is the structure name "myChildStruct". Select this structure as the data type, then store the change in the project database. The variable "myChildVar" is now a structure of type "myChildStruct".

Use **File | Edit table(s)** in the table editor displaying "myStruct" to open the table tree, then select the "Expand all" check box. Undre the **Parents & Children** heading the table "myStruct" now has a sub-structure, "myChildStruct.myChildVar". The form of the child's name is [*data type*].[*variable name*]. Select the **Open** button and the child is opened under a separate tab in the same editor as "myStruct". Notice that the tab contains the name of the root table ("myStruct") and the variable ("myChildStruct.myChildVar"). This is the format even when there are multiple nest levels of structures referencing structures; however, hovering the mouse pointer over the tab provides a tool tip showing the full path to the variable (as well as the tables' type name). Compare "myChildStruct.myChildVar" to its prototype table, "myChildStruct", in the other open table editor (see Figure 22).

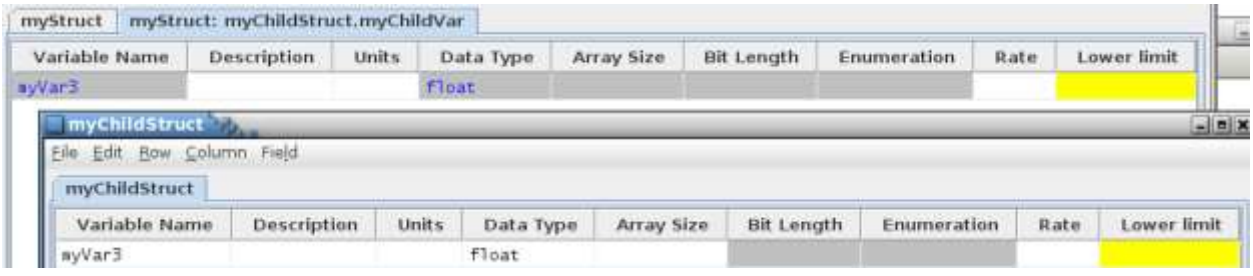

Figure 22. A child table and its prototype

"myChildStruct.myChildVar" represents an instance of the structure "myChildStruct". As such, it inherits the characteristics of "myChildStruct", such as variable names, data types, array sizes, data fields (and their values), etc. Some of these characteristics are immutable; in other words, these can't be changed in "myChildStruct.myChildVar" since doing so would make it no longer an instance of "myChildStruct". The cells containing the non-changeable items are grayed out. The remaining cells can be altered. An

instance of a table always inherits the values in its prototype's cells, but if altered in the instance then the instance's values override the inherited values. Data fields (and their values) are inherited only at the point when the instance is created. Data fields added, removed, or altered in the prototype afterwards are not propagated to existing child tables.

To demonstrate inheritance of table values, in "myChildStruct" enter the text "myVar3 description" in the **Description** column for variable "myVar3", then store the update. Notice that the description for "myVar3" in the editor for "myChildStruct.myChildVar" is automatically updated as well. Now edit the **Description** column in "myChildStruct.myChildVar" for "myVar3" and change it to "custom myVar3 description", and store the change. The contents of the two tables should appear as in Figure 23.

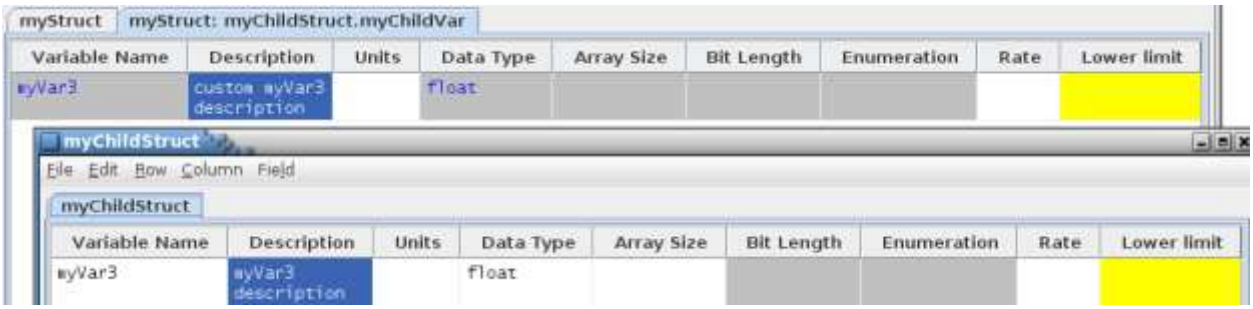

Figure 23. Overriding inheritance of a table cell

Close the editor for "myChildStruct.myChildVar" by selecting the **Close** button for its editor (The editor window remains since the table "myStruct" is still open in it; closing "myStruct" as well would cause the editor window to disappear as well). Reopen "myChildStruct.myChildVar", but this time use the short cut method: position the mouse pointer over the data type cell for variable "myChildVar" in "myStruct", then double click the right mouse button; "myChildStruct.myChildVar" is opened in the same editor window with "myStruct" as before. Notice that "myChildStruct.myChildVar" retains the custom value in the **Description** column that was entered previously, and no longer inherits the description from the prototype. Edit the description in "myChildStruct.myChildVar" again, delete the text from the **Description** cell, then store it, then close and reopen myChildStruct.myChildVar". The description remains empty and doesn't inherit from the prototype since a blank cell is considered an overriding value as well.

To restore inheritance to a cell, select the cell, then in the editor's menu bar select **Edit | Replace selected | With prototype**. The contents of the cell is replaced with that from the prototype ("myVar3 description" in this case), preceded by a special flag character as shown in Figure 24. Store the change to restore inheritance to the description cell (note that the special flag character is removed).

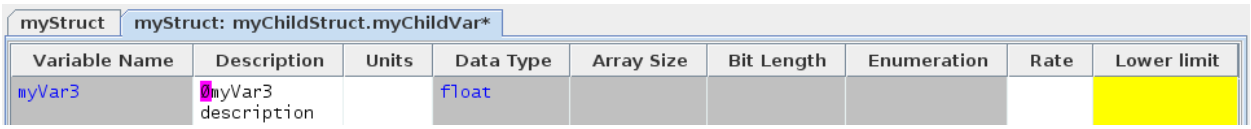

Figure 24. Restoring a cell's inheritance

3.8 Grouping tables

The number of data tables in a project can become large, making it more time consuming to locate a table and difficult to keep track of which tables are related. The group manager provides a means of

more easily managing the tables. Open the group manager (Figure 25) using the main window's menu bar **Data | Manage groups** command.

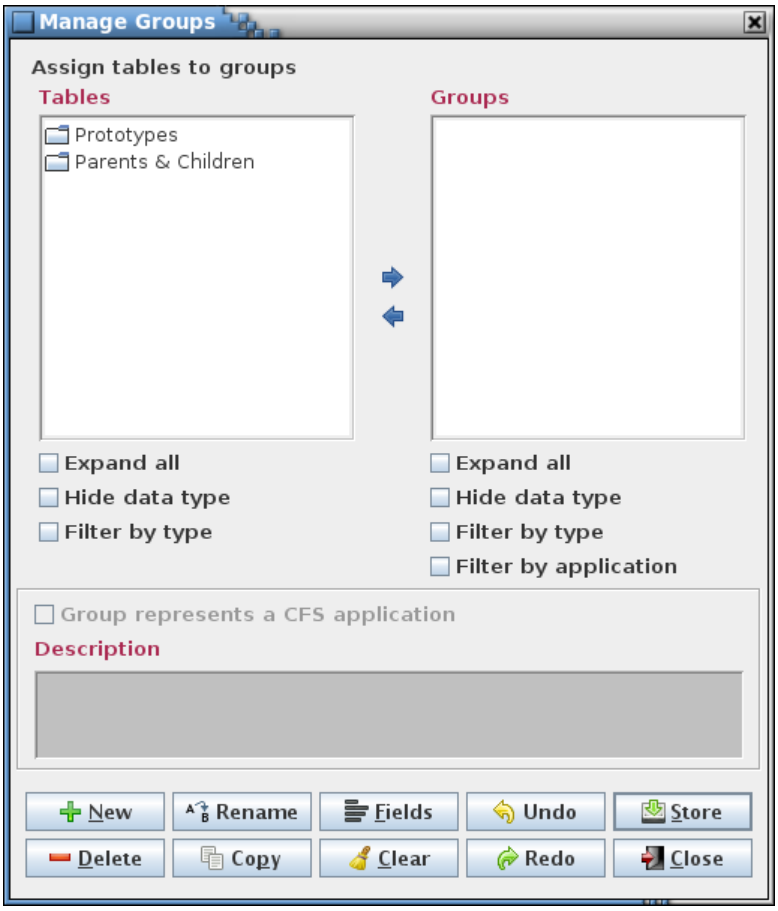

Figure 25. Group manager

The group manager allows tables, selected from the table tree in the upper left (and which acts just like the table tree when opening a table for editing), so be assigned to groups in the group tree in the upper right. A group must be created before a table can be assigned, so press the **New** button and in the dialog that appears enter the group name "My Group", then press the **Okay** button. The group "My Group" appears in the group tree. Expand the table tree and select the table "myStruct" using the mouse or keyboard. In the group tree select "My Group". Now press the right arrow button between the two trees – "myStruct" appears as a member of the group "My Group". Notice that the child table of "myStruct", "myChildStruct.myChildVar", is included automatically. Figure 26 shows the result of assigning the table to the group.

Figure 26. Assigning a table to a group

Any number of tables may be assigned to a group. Any number of groups may be created, and a table can belong to as many groups as desired. Deleting a group has no effect on the tables that were assigned to it.

Create a second group, “Working tables”, and assign “myStruct” and “myChildStruct” to it. The group manager appears as in Figure 27.

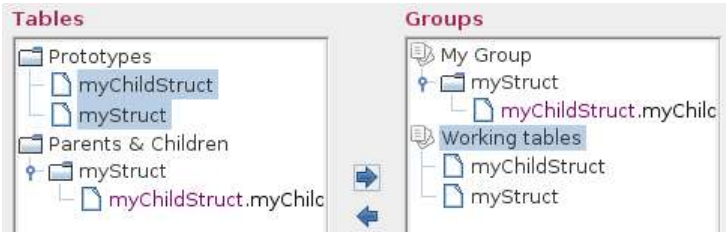

Figure 27. Multiple groups

Press the **Store** button to store the new groups in the project database, then exit the group manager by pressing the **Close** button. In the main window select **Data | Edit table(s)** to open the table tree for selecting a table to edit, then select the “Expand all” and “Filter by group” check boxes below the tree (see Figure 28; the dialog has been resized so that all of the tree is visible).

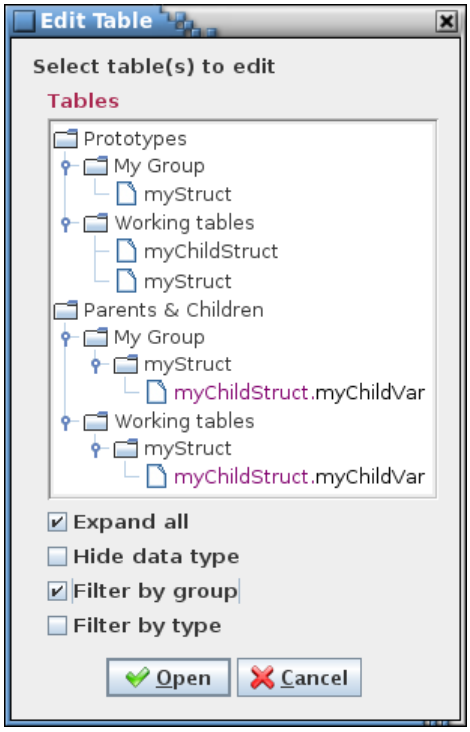

Figure 28. Table tree, filtered by groups

The tree’s headings, **Prototypes** and **Parents & Children** now include the group names, **My Group** and **Working tables**, as subheadings. Under the subheading are the tables that are assigned to the group. A table is selected from the tree just as before. Select **Cancel** to remove the dialog.

Grouping tables has benefits when creating script associations; this is explained in section 3.9.

3.8.1 Group data fields

As with table types and data tables, data fields may be assigned to groups. These group data field assignments, as with table types and tables, can be accessed in the scripts and used in whatever way the user desires.

Select the group "My Group" from the group tree, then press the **Fields** button, which becomes active once a single group is selected. The data field editor appears; the editor behaves exactly as it does for the table type and table editors. Add the field as indicated in Figure 29.

Field Name	Description	Size	Input Type	Required
Group field		10	Text	☐

Figure 29. Group data field

The group manager now appears as in Figure 30.

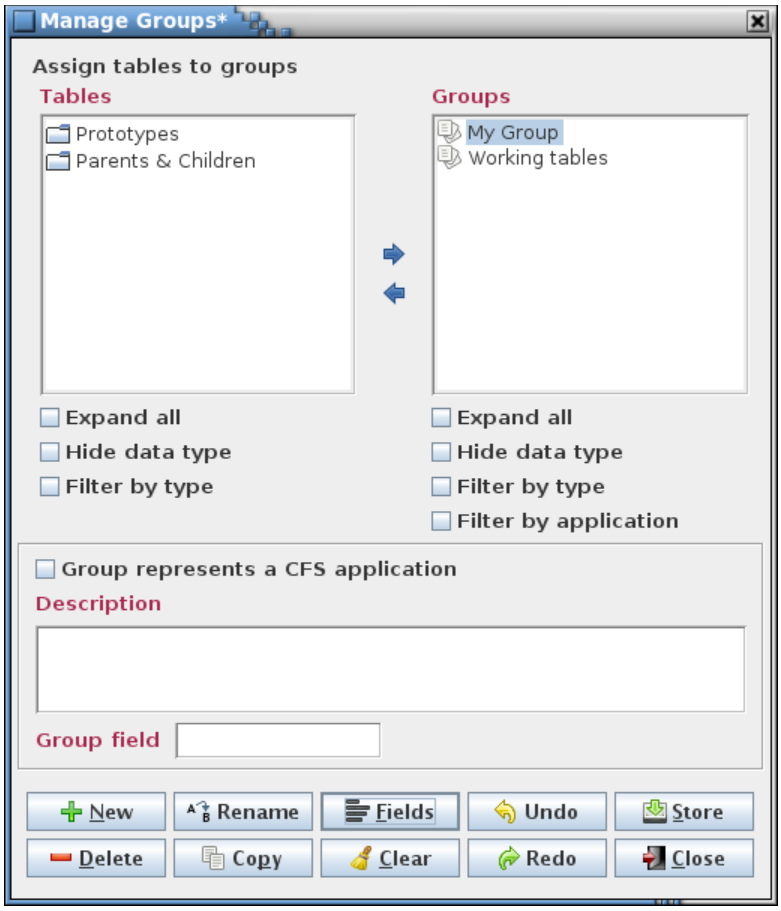

Figure 30. Group with data field assigned

Enter the text "My Group's data field" into the "Group field" data field and store the changes. Close the group manager by pressing the **Close** button.

3.8.2 CFS applications

A specialized use of group data fields is in deeming a group as representing a CFS application. In the group manager after selecting a group the check box “Group represents a CFS application” can be set. When this is done a number of data fields are automatically assigned to the group. The contents of these fields is used by the application scheduler and its companion script in order to create the CFS scheduler application’s (SCH) message definition and schedule definition tables.

3.9 Create a script association

Create a tutorial.js script for the tutorial to use…

In this section the data tables that have been created previously are “associated” with a JavaScript script. This association is then executed – the script is run using the data from the tables in order to produce an output file.

Associations are created using the script manager. In the main window command menu select **Script | Manage**; the script manager appears (Figure 31).

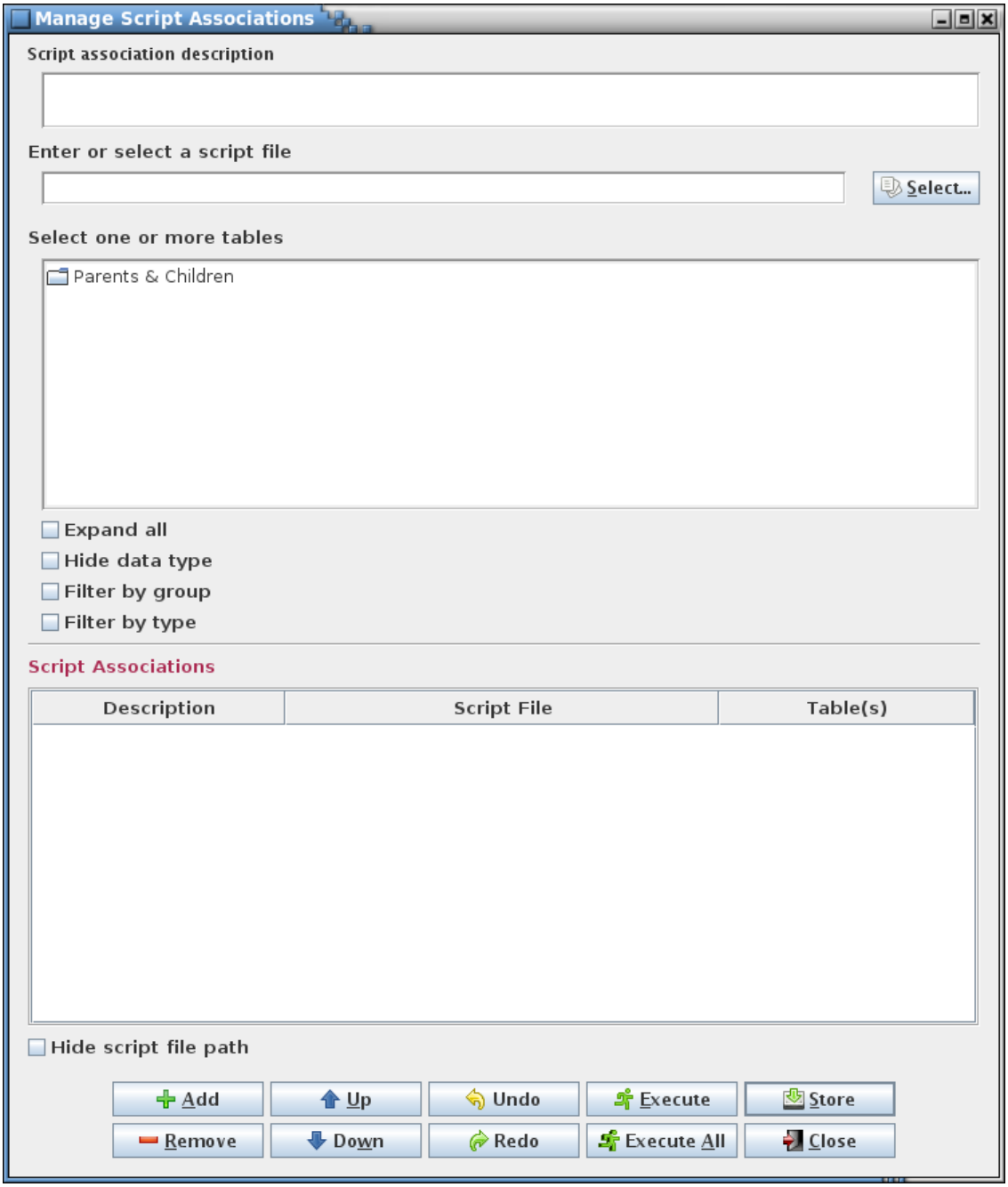

Figure 31. Script manager

The script manager is divided into five main parts (from top to bottom): the association description field, the script file field, a table tree, a table of associations, and command buttons. At a minimum an association needs a script file. Not all scripts need a data table explicitly associated with them, but usually an association needs one or more tables as well to be assigned. A special script for this tutorial is provided as part of the CCDD installation files. The script, tutorial.js, is found in the **scripts** folder, located in the folder in which CCDD is installed. Select the script by pressing the **Select…** button, then in the script selection dialog (Figure 32) navigate to the **scripts** folder and select the file tutorial.js.

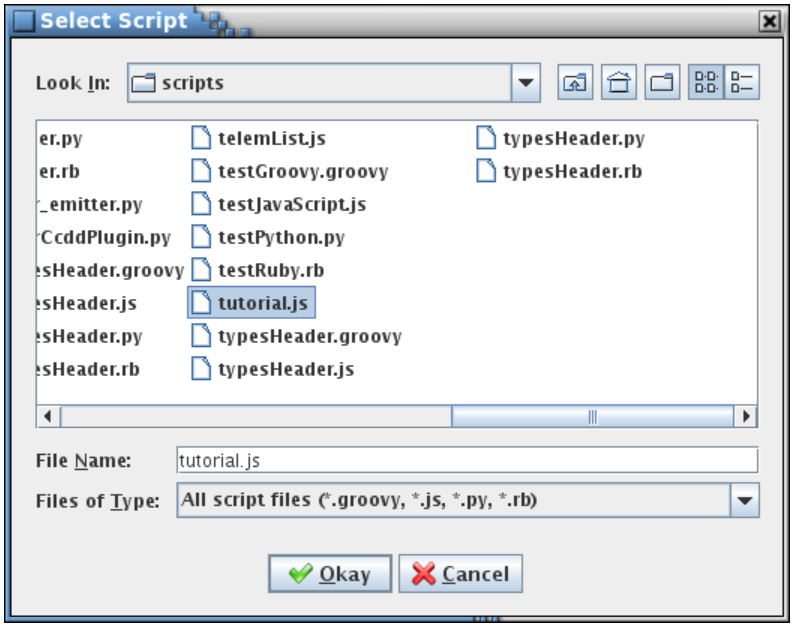

Figure 32. Script selection dialog

Press the **Okay** button. The script, including its full file path, appears in the script manager's script field.

The table tree, located in the center of the script manager, acts the same as in other table trees already encountered in this tutorial, but with the exception that the prototype tables are not available. Expand the tree by using the mouse, keyboard, or by selecting the **Expand all** check box. Select the table "myStruct", then press the **Add** button. The script associations table displays the new association (Figure 33). When a table is selected, all of the data from its child tables are automatically included, so these do not need to be explicitly selected when creating the association (though it doesn't create any problems if they are selected). In this case the data from the child table "myChildStruct.myChildVar" will be provided to the script along with that from "myStruct".

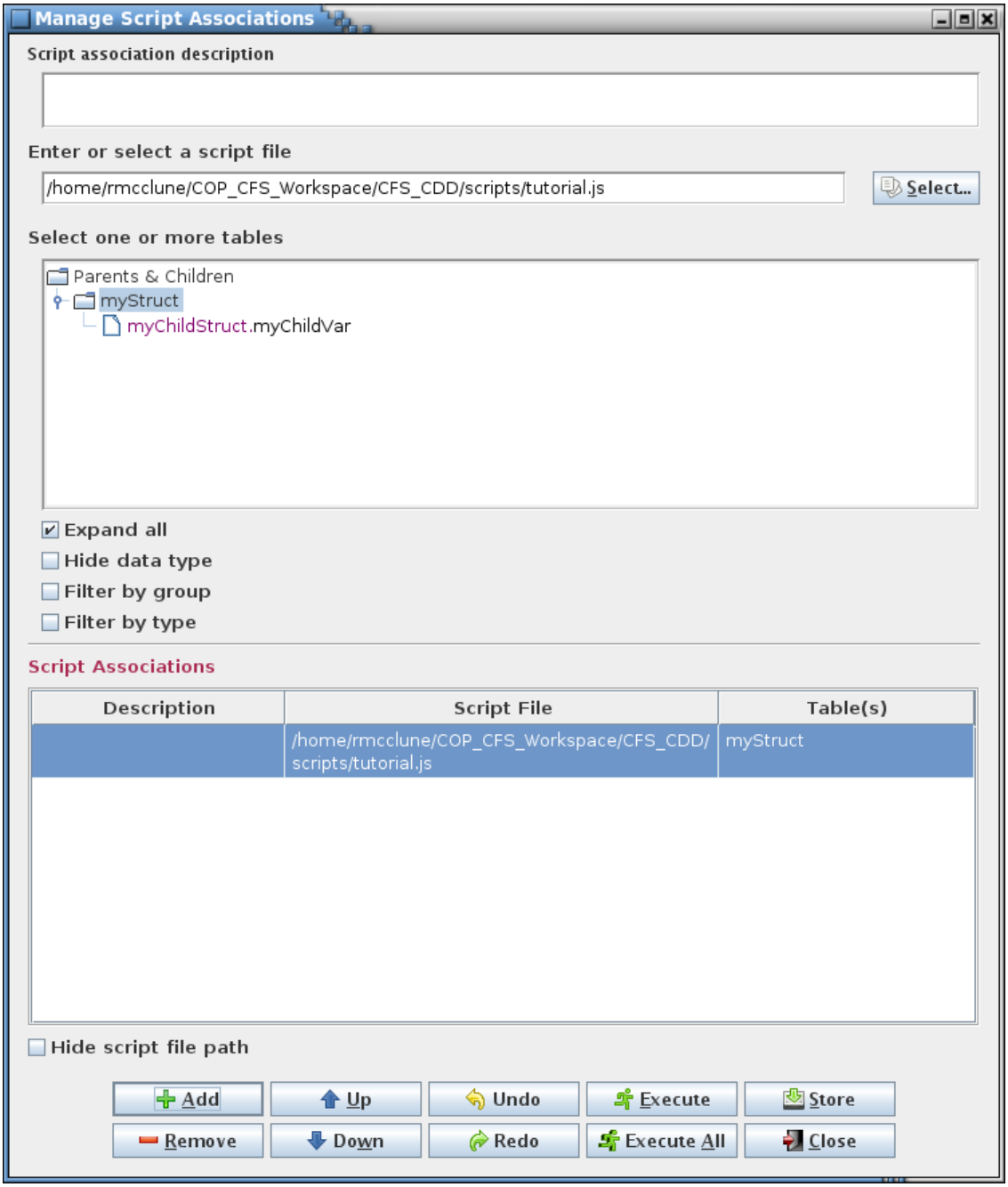

Figure 33. Script associated with a table

Select the **Filter by group** check box under the table tree and note that the two groups created earlier appear. A third group, "*All tables*", also appears in the table tree; this group is created automatically and contains all tables. Notice that the group "Working tables" only contains "myStruct" and its child table, but does not show the table "myChildStruct". This is because "myChildStruct" is only a prototype table, not a root or child table, and this table tree doesn't display prototypes. Select the group "My Group" and press the **Add** button. A second association is added to the table (Figure 34). In the Table(s) column for the first association created it shows "myStruct", but for the new association it shows

"Group:My Group". At this point these associations are functionally identical; if executed both access the data from "myStruct" and it' child table "myChildStruct.myChildVar". The advantage of assigning a group instead of a table is that if the group member tables are altered the association doesn't need to be changed; all tables belonging to the group are accessed by the script. In the case where a table is assigned to the script and another table is desired to be added, a new association must be created. The manager allows assigning both tables and groups to a script in a single association.

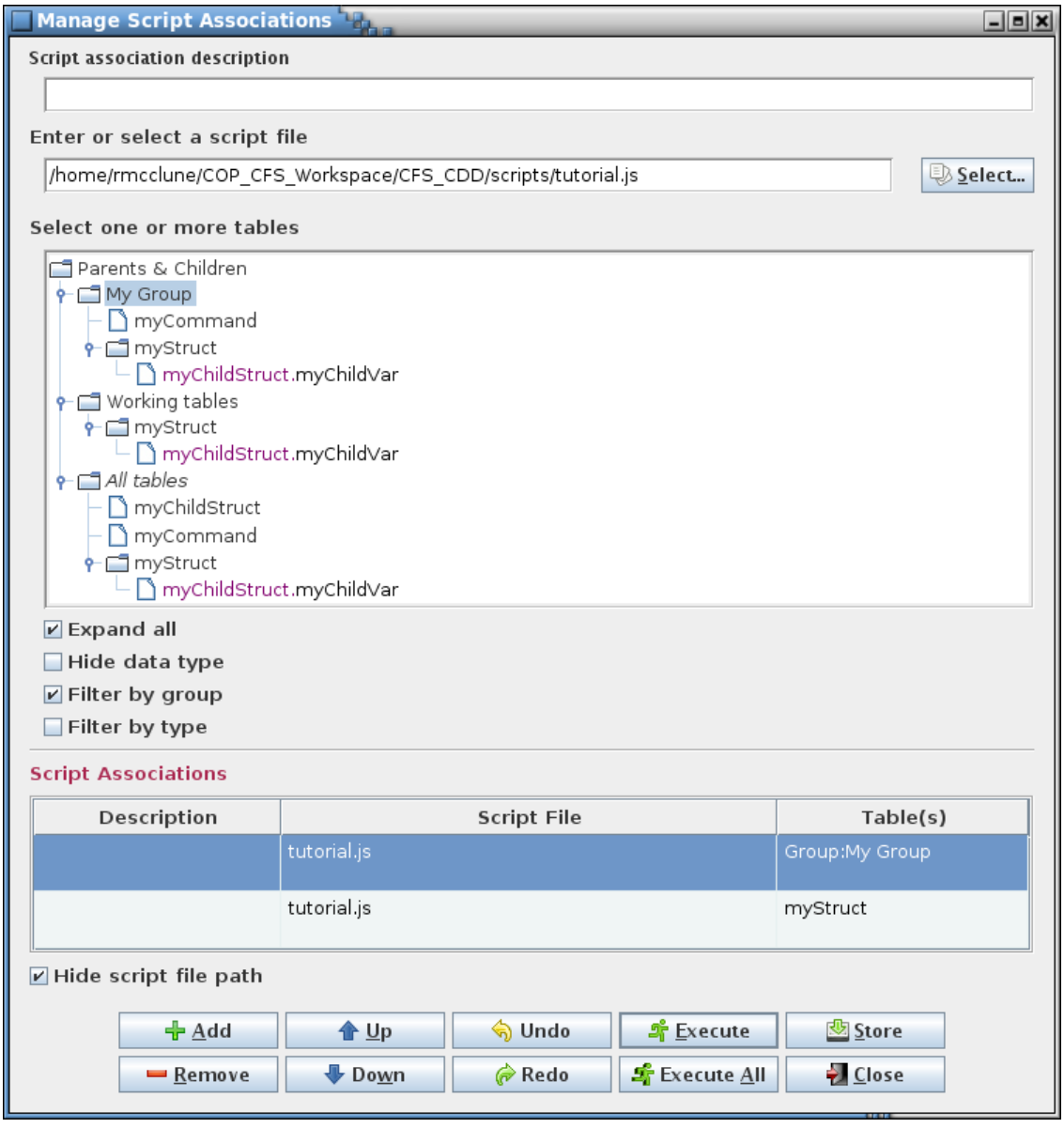

Figure 34. Script associated with a group

Press the **Store** button to store the associations in the project database. By storing the associations, these can be executed at a later time without having to recreate them.

3.10 Execute a script association

A script association may be executed from within the script manager or from the script executive (accessed using the main window **Script | Execute** command from the menu bar). The executive displays only the script association table and no changes can be made to the associations from this dialog. The manager and executive can't be open simultaneously; opening one closes the other.

Select the association specifying the table "myStruct" using the mouse or keyboard. The entire line in the table is highlighted. Press the **Execute** button to execute this association. A dialog briefly appears while the script is running. This dialog allows halting execution of the script, returning control to the CCDD application. Halting a running script can be used, for example, to stop execution in the event the script contains an infinite loop.

The script, `tutorial.js`, creates an output file, `tutorial.output`, in the same folder from which the CCDD application was started. Use a file editor to locate and open the output file. Figure 35 shows the contents of the file.

```
/* Created : Wed Oct 25 09:43:59 CDT 2017
   User    : rmcclune
   Project : MyProject
   Script  : /home/rmcclune/COP_CFS_Workspace/CFS_CDD/scripts/tutorial.js
   Table(s): myStruct,
             myStruct,myChildStruct.myChildVar
   Group(s): My Group
*/

Table : myStruct
  Type       : Structure
  Description: My structure table

  | Variable Name | Description            | Units | Data Type     | Array Size | Bit Length | Enumeration | Rate | Lower limit |
  | ------------- | ---------------------- | ----- | ------------- | ---------- | ---------- | ----------- | ---- | ----------- |
  | myArray1      |                        |       | float         | 3          |            |             |      |             |
  | myArray1[0]   |                        |       | float         | 3          |            |             |      | 1           |
  | myArray1[1]   |                        |       | float         | 3          |            |             |      | 2           |
  | myArray1[2]   |                        |       | float         | 3          |            |             |      | 3           |
  | myVar1        | myVar1 description abc |       | uint16_t      |            |            | 0|Off,1|On  |      | 4           |
  | myChildVar    |                        |       | myChildStruct |            |            |             |      |             |

  Data Fields:
    Name: Subsystem        Value: MySystem
    Name: Message ID Name  Value: MY_MSG_ID
    Name: Message ID       Value: 0x0900


Table : myStruct,myChildStruct.myChildVar
  Type       : Structure
  Description:

  | Variable Name | Description        | Units | Data Type | Array Size | Bit Length | Enumeration | Rate | Lower limit |
  | ------------- | ------------------ | ----- | --------- | ---------- | ---------- | ----------- | ---- | ----------- |
  | myVar3        | myVar3 description |       | float     |            |            |             |      |             |
```

Figure 35. Script output file

3.11 Data types

CCDD provides a means of changing the primitive data types. This can be as simple as changing the names of the existing primitives, or can include the addition of new types, such as structure pointers. The changes are made via the data type editor, accessed using the main menu command **Data | Manage data types**. When executed the dialog shown in Figure 36 is displayed. A number of primitive types are provided by default.

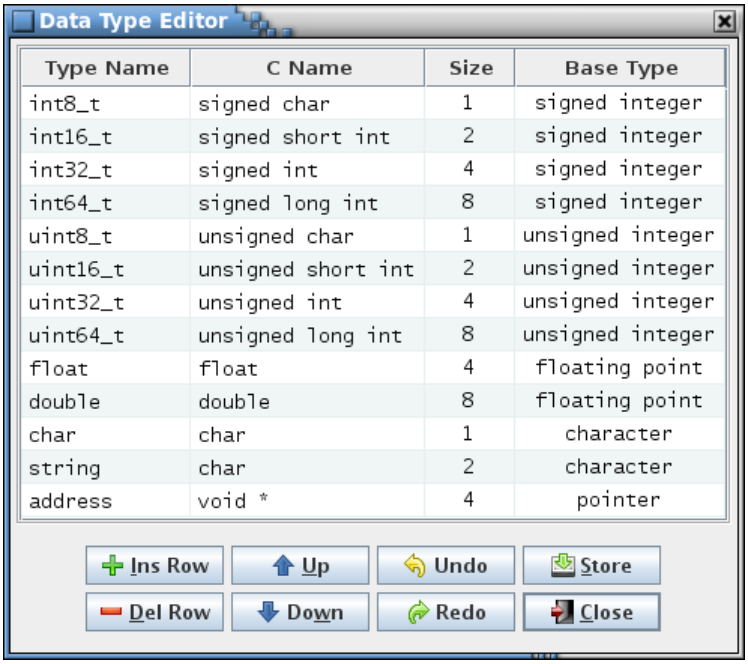

Figure 36. Data type editor

Each data type is constructed from one of five base types and a byte size. For example, the first primitive in the editor, int8_t, has a base type of "signed integer" with a size of 1 byte. The type and C names are user definable; a minimum of one of these names must be entered (the reason for having two names is so that the information can be used to create `#typedef` statements in a C header file created by a script). CCDD uses the **Type Name** (if present; if not, then the **C Name**) for display in the Data Type column combo boxes. If the existing names, sizes, or base types are altered, then when the changes are stored any existing use of the data type is updated in the data tables.

For the tutorial create a pointer to structure "myChildStruct". Insert a new line into the editor table using the **Ins Row** button. Select "pointer" as the base type in the **Base Type** combo box that appears when the cell is selected, and "4" as the size. Edit the **C Name** column. The structure name, "myChildStruct", can be typed directly, but instead press the Ctrl-S keys. This causes a combo box to appear listing all of the structure table names. Choose "myChildStruct" from the list. The asterisk, denoting a pointer, is automatically appended to the name if not entered by the user. Enter "myChildStruct_ptr" for the **Type Name**. The result should look like Figure 37.

Type Name	C Name	Size	Base Type
myChildStruct_ptr	myChildStruct*	4	pointer

Figure 37. New data type

Press the **Store** button, then close the data type editor. Open "myStruct" in a table editor if not already open. Select one of the **Data Type** column cells in order to show the combo box (Figure 38) and notice that the new pointer type, "myChildStruct_ptr", appears in the list. The list always displays the primitives before any structure references, and the order of the primitives is the same as in the data type editor.

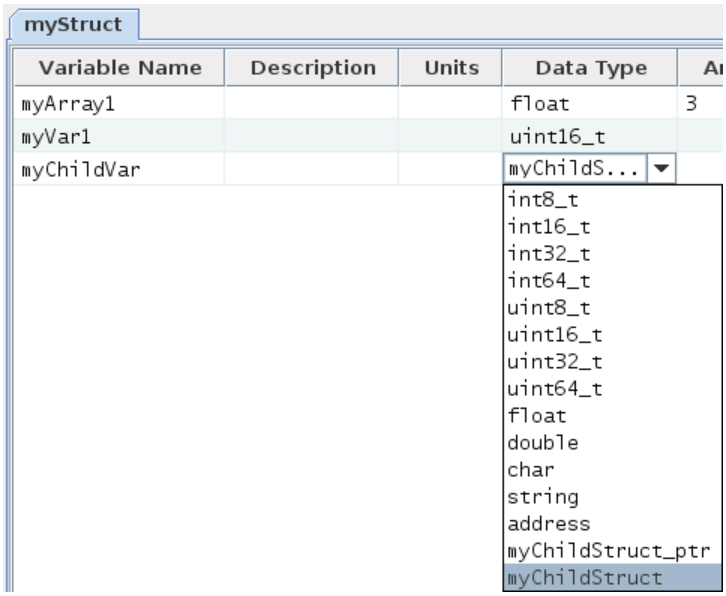

Figure 38. Added data type

3.12 Macros

Macros are text strings that are used to represent a numeric or text value. The CCDD utility allows macros to be inserted within the data table cells. The benefit of using a macro is that it can be used across numerous tables, and if the value needs to change it can be done in a single place rather than in each individual table. Macros are created and updated in the macro editor (Figure 39), accessible via the main menu **Data | Manage macros** command. Each macro consists of a macro name and a value, which may be blank.

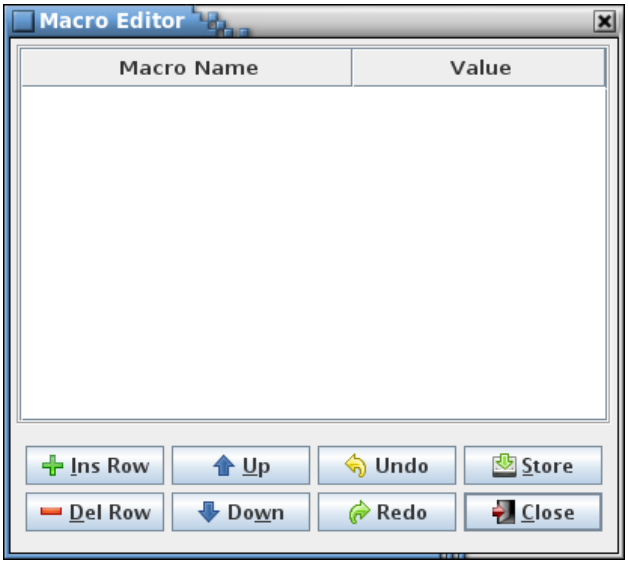

Figure 39. Macro editor

To add a macro, insert two rows into the macro editor table using the **Ins Row** button. In the first row enter “aNumber” in the **Macro Name** column and “5” in the **Value** column, and in the second row enter

"someText" in the **Macro Name** column and "abc" in the **Value** column (see Figure 40). Store the changes and close the macro editor.

Macro Name ▲	Value
aNumber	5
someText	abc

Figure 40. Added macros

Open "myStruct" in a table editor if not already open. Edit the description column for the variable "myVar1". Type "myVar1 description ", then press the Ctrl-M keys. A combo box appears displaying a list of macros (Figure 41).

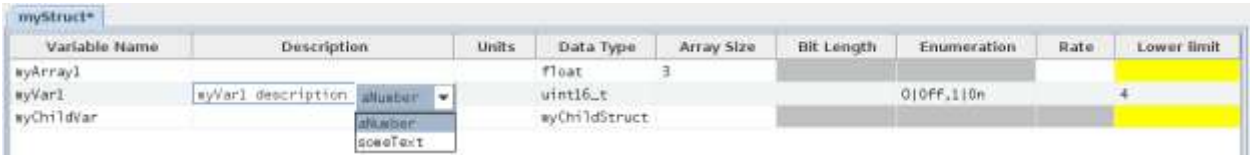

Figure 41. Macro combo list

Select the macro "someText" from the list; the cell value displays "##someText##", highlighted by a colored background. The leading and trailing "##" delimiting characters indicate to the application that a macro is in use. The macros can be typed directly (which must include the delimiter characters) in place of using the Ctrl-M sequence and combo box.

Expand the array "myArray1" by positioning the mouse pointer over an **Array Size** column cell and double clicking the right mouse button. Edit the array size for "myArray1" and delete the current value (3), then press the Ctrl-M keys. A combo box appears displaying a list of macros (Figure 42).

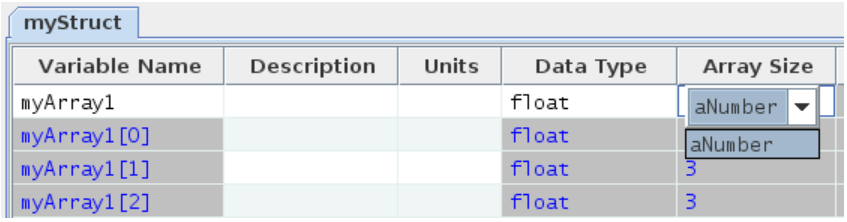

Figure 42. Macro combo list; filtered

Notice that only the macro "aNumber" appears in the list. Macros with values that are invalid based on the column's input type are filtered from the list; in this instance the macro "someText" has a value of "abc", which is not valid in the **Array Size** column, which only accepts array index values (in the format #<,#<,…>>). Select "aNumber" from the list and press Enter to end editing in the cell. Notice that the **Array Size** entries for "myArray1"'s array definition and members all show the macro, and that the number of members has expanded to 5, the value of the macro (Figure 43).

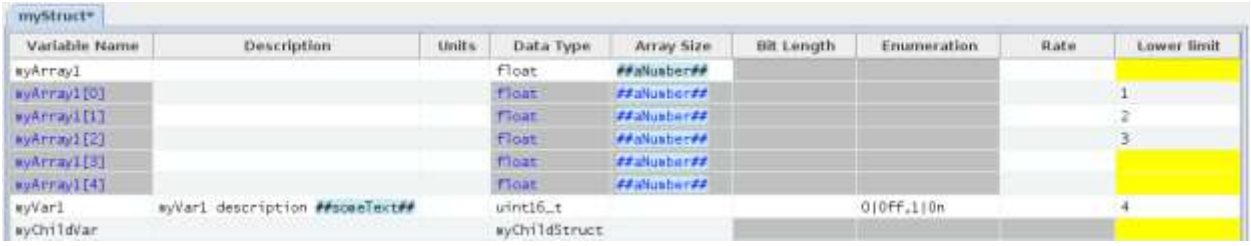

Figure 43. Array size change via macro update

Press and hold the keys Ctrl+Shift-M; the macros in the table are replaced by the macro values. Release the keys and the macro names are restored. Also, if the mouse pointer is hovered over a cell containing a macro a toll tip appears showing the cell value with the macro(s) replaced by the macro value(s).

Store the changes to the table, but leave the table editor open, and reopen the macro editor. Change the value for the macro "aNumber" from 5 to 3 and store the change; the array is restored to its former number of members.

3.13 Message IDs

CFS communicates within and between the core system and applications using messages. The message content depends on the information being transferred, such as telemetry values or commands. Each message is assigned an identification number, or message ID, that is used to identify the message to the listeners on the message bus so that the proper recipients can act on the message content. In general the IDs must be unique; otherwise a message could be mistaken for another and acted on erroneously. The CCDD application provides means for assigning message IDs (manually and automatically) and for detecting duplicate values. Input types are used to define a table cell or data field as containing a message ID or message ID name (recall these input types were used for the data fields created in section 3.5.6 of this tutorial), which CCDD can then use to locate these cells and fields.

IDs can be automatically assigned by selecting **Data | Message IDs | Assign IDs** from the main window menu. The dialog shown in Figure 44 appears.

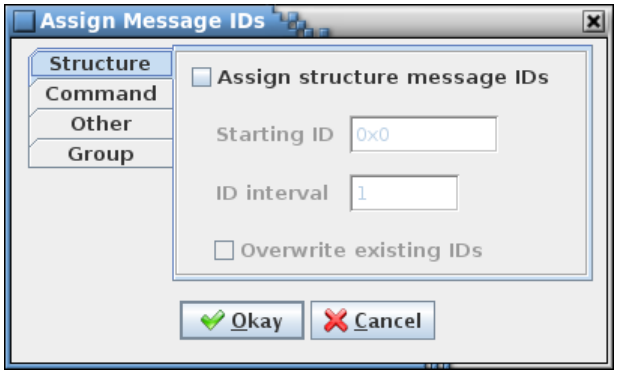

Figure 44. Assign message IDs dialog

The dialog has four tabs arranged down the left side. These allow assignment of IDs to the cells and data fields for a particular type of table (structure, command, or other table type), and to data fields associated with groups.

Using the "Structure" tab select the check box labeled **Assign structure message IDs**. This indicates that structure table message ID references are to be updated. The two fields, **Starting ID** and **ID interval**, are now enabled. IDs are assigned beginning with the starting ID; subsequent ID values are spaced according to the ID interval. Set **Starting ID** to "0x110" (the ID values are in hexadecimal format; the leading "0x" can be omitted). The **ID interval** is a decimal value and with it set as "1" the first ID assigned will be "0x0110" followed by "0x0111", "0x0112", etc. The Overwrite existing IDs check box determines if message ID cells and fields already containing a value should retain the present value or

receive a new one. Since no ID has been assigned yet the setting for this box irrelevant. Select the **Okay** button to assign the message IDs to the structure tables.

Open "myStruct" in a table editor if not already open. Below the table are the three data fields assigned earlier, one of which, names "Message ID", has an input type of "Message ID". Notice that the field, which had been empty, now contains the value "0x0110".

Reopen the message ID assignment dialog and again check the **Assign structure message IDs** check box. For the starting ID enter "0x810". Select the **Overwrite existing IDs** check box, then press the **Okay** button. Look again at the value of the "Message ID" data field for table "myStruct" – it shows "0x0900" and not "0x0810". This is due to having ID values reserved.

In the main window execute the **Data | Message IDs | Reserve IDs** command. This produces an editor as shown in Figure 45.

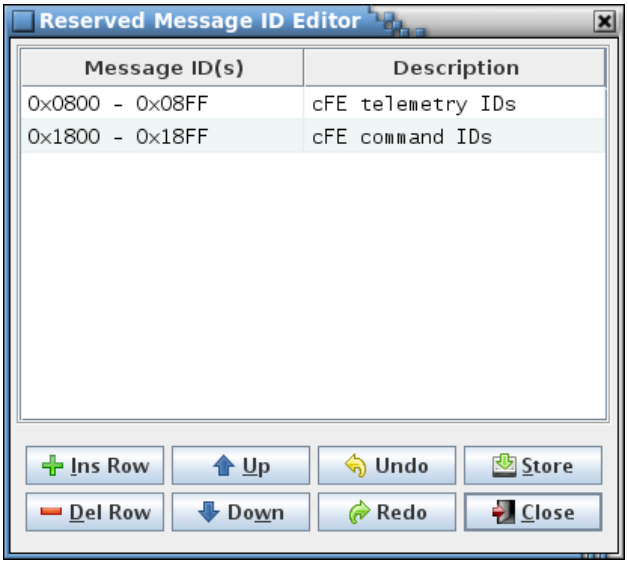

Figure 45. Reserve ID editor

The reserve ID editor allows defining single IDs or ranges of IDS that the automatic ID assignment feature ignores when assigning IDs. By default the ID ranges used by CFS telemetry and commands are reserved (these can be changed or deleted). In the example above the value "0x810" was entered as the starting ID value. The automatic assignment feature determined that this ID is reserved, so it added the interval value (1) to the ID to get "0x0811". This value also falls within the reserved range, so the process is repeated until the value doesn't fall within the reserved range, in this case "0x0900", which is the first non-reserved value after the first reserved range.

3.14 Commands

3.14.1 Add a command argument to the Command table type

Command tables are used to store information pertinent to commanding the target vehicle or device. Command tables are created and edited exactly as is done for structure tables, except that the table type **Command** is selected in the **New Table** dialog (Figure 3) when a command table is created. Figure 46 shows the default command table definition in the table type editor.

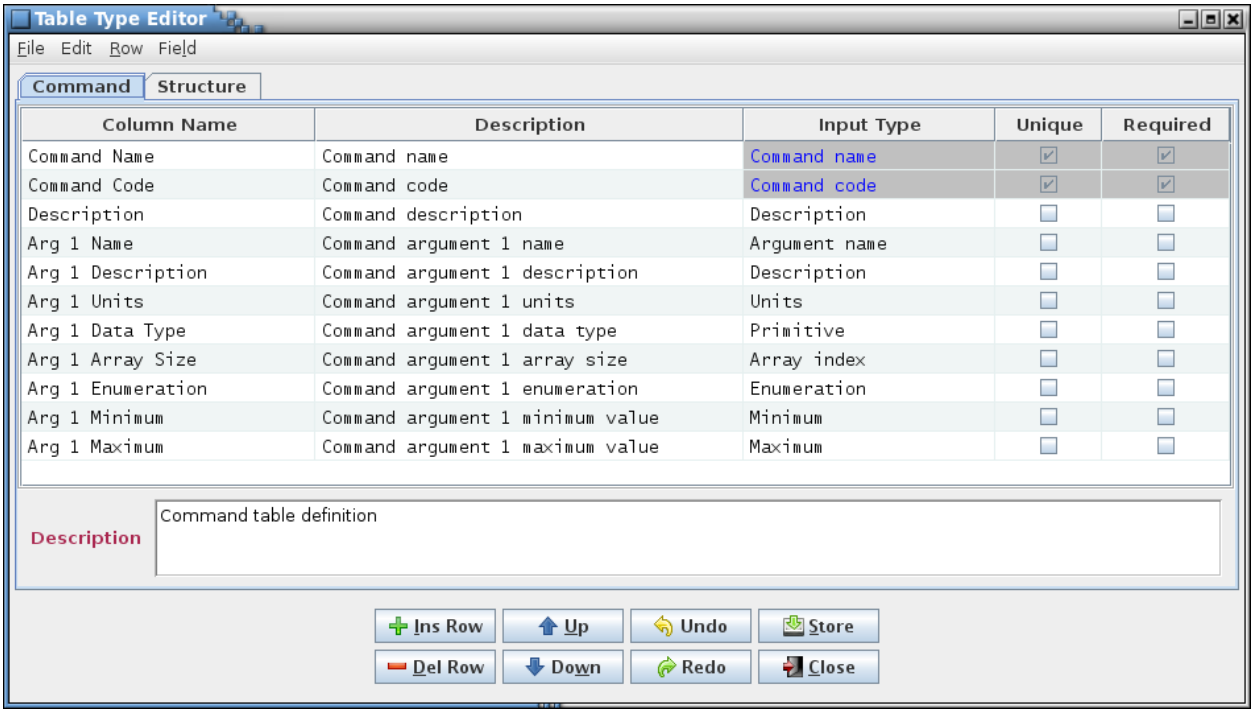

Figure 46. Command table type

Two columns are required to distinguish a command table, one with an input type of “Command name”, and one of “Command code”. A command generally has one or more arguments associated with it. The default type definition includes columns for a single command argument. Each argument requires at a minimum a column with the input type “Argument name”. The number of columns in the command’s table type definition with this input type determines the maximum number of arguments the command can handle.

Other columns can be added to the definition. These can apply in general to the entire command, or specifically to individual arguments. The position of the column definition determines how the column’s association is interpreted. Any column before the first argument name column is assumed to apply to the entire command. All columns following an argument name column (except the columns with input type “Command name” and “Command code due to their special input types) until the next argument name column or the end of the table type, are assumed to be associated with that argument name column. Looking at the default definition in Figure 46 the column **Description** applies generally since it precedes the first argument name column. All of the columns following the column **Arg 1 Name** apply to the first argument since these follow the argument name column definition and no other argument is defined.

Open the table type editor for the **Command** type. Insert a new row at the end of the table by selecting a cell in the last row and pressing the **Ins Row** button. Enter “Arg 2 Name” in the **Column Name** column. The column names have no bearing on deciding which argument the column belongs to, but it’s suggested that a consistent naming scheme be used. In the **Input Type** column select “Argument Name” as the input type. Similarly, add a data type column for the second command argument. Finally, add a column named “Arg 2 Mode” with the input type of “Positive integer”. Figure 47 shows the completed second argument rows. Store the changes.

Command | Structure

Column Name	Description	Input Type	Unique	Required
Description	Command description	Description	☐	☐
Arg 1 Name	Command argument 1 name	Argument name	☐	☐
Arg 1 Description	Command argument 1 description	Description	☐	☐
Arg 1 Units	Command argument 1 units	Units	☐	☐
Arg 1 Data Type	Command argument 1 data type	Primitive	☐	☐
Arg 1 Array Size	Command argument 1 array size	Array index	☐	☐
Arg 1 Enumeration	Command argument 1 enumeration	Enumeration	☐	☐
Arg 1 Minimum	Command argument 1 minimum value	Minimum	☐	☐
Arg 1 Maximum	Command argument 1 maximum value	Maximum	☐	☐
Arg 2 Name		Argument name	☐	☐
Arg 2 Data Type		Primitive	☐	☐
Arg 2 Mode		Positive integer	☐	☐

Figure 47. Command table type with second command argument columns

3.14.2 Create a command table and add command information

Create a new table, “myCommand”, based on the **Command** table type. See paragraph 3.3 on details for creating a new table. Open the table “myCommand” in the table editor (**Data | Edit table(s)**). Insert rows and enter the command information as shown in Figure 48.

Note that even though a command has columns for entering argument information, these may remain blank if the argument doesn’t apply (such as with a “no-op” command). Also notice that certain columns are grayed out. The minimum and maximum value cells become active once a numeric data type (e.g., float, uint16) is entered. An enumeration only applies if the argument’s data type is an integer (signed or unsigned).

Store the changes to the command table.

myCommand

Command Name	Command Code	Description	Arg 1 Name	Arg 1 Description	Arg 1 Units	Arg 1 Data Type	Arg 1 Array Size	Arg 1 Enumeration	Arg 1 Minimum	Arg 1 Maximum	Arg 2 Name	Arg 2 Data Type	Arg 2 Mode
NO_OP	0x00	No operation											
SET_PRESSURE	0x01	Initialize	int_pressure	Internal pressure	atm	float			0	50	ext_pressure	float	3

Figure 48. Command information added to table “myCommand”

3.14.3 Execute a script using the command information

Open the group manager (**Data | Manage groups**) and assign the table "myCommand" to the group "My Group". Store the change and close the group manager.

Open the script executive (**Script | Execute**). Select the script association that specifies the group "My Group" in the **Table(s)** column. Since a group is used instead of specific tables (as in the other association shown in the associations table) the association doesn't have to be altered in order to access the information in the new command table. Execute the selected association by pressing the **Execute** button.

When the script completes execution open the output file `tutorial.output`, located in the same folder from which the CCDD application was started. Figure 49 shows the contents of the file. Notice that the contents of the new command table, "myCommand", is included with the structure tables. Below the table definitions the information for each command and its arguments (if any) is displayed.

```
/* Created : Mon Oct 30 10:03:10 CDT 2017
   User    : rmcclune
   Project : MyProject
   Script  : /home/rmcclune/COP_CFS_Workspace/CFS_CDD/scripts/tutorial.js
   Table(s): myCommand,
             myStruct,
             myStruct,myChildStruct.myChildVar
   Group(s): My Group
*/

Table : myCommand
  Type       : Command
  Description:

  | Command Name | Command Code | Description  | Arg 1 Name   | Arg 1 Description | Arg 1 Units | Arg 1 Data Type | Arg 1 Array Size | Arg 1 Enumeration | Arg 1 Minimum | Arg 1 Maximum | Arg 2 Name   | Arg 2 Data Type | Arg 2 Mode |
  | ------------ | ------------ | ------------ | ------------ | ------------------ | ----------- | ---------------- | ----------------- | ------------------ | -------------- | -------------- | ------------ | ---------------- | ----------- |
  | NO_OP        | 0x00         | No operation |              |                    |             |                  |                   |                    |                |                |              |                  |             |
  | SET_PRESSURE | 0x01         | Initialize   | int_pressure | Internal pressure  | atm         | float            |                   |                    | 0              | 50             | ext_pressure | float            | 3           |


Table : myStruct
  Type       : Structure
  Description: My structure table

  | Variable Name | Description            | Units | Data Type     | Array Size | Bit Length | Enumeration | Rate | Lower limit |
  | ------------- | ---------------------- | ----- | ------------- | ---------- | ---------- | ----------- | ---- | ----------- |
  | myArray1      |                        |       | float         | 3          |            |             |      |             |
  | myArray1[0]   |                        |       | float         | 3          |            |             |      | 1           |
  | myArray1[1]   |                        |       | float         | 3          |            |             |      | 2           |
  | myArray1[2]   |                        |       | float         | 3          |            |             |      | 3           |
  | myVar1        | myVar1 description abc |       | uint16_t      |            |            | 0|Off,1|On  |      | 4           |
  | myChildVar    |                        |       | myChildStruct |            |            |             |      |             |

  Data Fields:
    Name: Subsystem        Value: MySystem
    Name: Message ID Name  Value: MY_MSG_ID
    Name: Message ID       Value: 0x0900


Table : myStruct,myChildStruct.myChildVar
  Type       : Structure
  Description:

  | Variable Name | Description        | Units | Data Type | Array Size | Bit Length | Enumeration | Rate | Lower limit |
  | ------------- | ------------------ | ----- | --------- | ---------- | ---------- | ----------- | ---- | ----------- |
  | myVar3        | myVar3 description |       | float     |            |            |             |      |             |


Command: NO_OP
  Code : 0x00
  Arg 1:
  Arg 2:

Command: SET_PRESSURE
  Code : 0x01
  Arg 1:
    Arg 1 Name         Value: int_pressure
    Arg 1 Data Type    Value: float
    Arg 1 Description  Value: Internal pressure
    Arg 1 Units        Value: atm
    Arg 1 Minimum      Value: 0
    Arg 1 Maximum      Value: 50
  Arg 2:
    Arg 2 Name       Value: ext_pressure
    Arg 2 Data Type  Value: float
    Arg 2 Mode       Value: 3
```

Figure 49. Script output file with commands

3.15 Importing and exporting tables

Create a table defn in spreadsheet, then import into project

It can be convenient at times, when access to the CCDD is unavailable, to be able to define a table and then import the information into the application. CCDD allows importing table definitions from files. The supported file formats are comma-separated values (CSV), electronic data sheet (EDS), JavaScript Object Notation (JSON), and Extensible Markup Language (XML) Telemetric and Command Exchange (XTCE). For this tutorial a table will be created in CSV format using a spreadsheet application and then imported into the CCDD project as a new table. Note that CCDD also can import data into an existing table in the project.

CCDD expects the information provided in CSV format to be parsed into sections, which define what data follows. Examples of the sections are those for the table definitions, table type definitions, and data type definitions. The CCDD user's guide provides details on the section content.

3.16 Telemetry scheduling

3.16.1 Telemetry rates

3.16.2 Linking variables

3.16.3 Bit length and bit-packing

The **Bit Length** column allows assigning a specific number of bits to for the variable to occupy. When variables of the same data type are created adjacent to one another in the table and both are assigned bit lengths then the application assumes these variables are packed together as a bit field within the same byte or bytes (dependent on the data type) if the combined length of the bits doesn't exceed the number of bits for the data type.

3.16.4 Creating the housekeeping copy table