Requirements Completeness Excel Macro
Quick Reference

For Version 2.0, Release 20090504

Scope

This document describes the keywords that can be used with the Requirements Completeness macro for Excel.

The requirements completeness macro clarifies the requirements turmoil by taking a set of functional requirements and determining if all of the system outputs can be derived from the system inputs through an unbroken chain of requirements. The requirements start out as English language statements. The user generates a summary of the data used in each requirement. The macro checks the summary for completeness.

Requirements Analysis Diagrams

The Requirements Completeness macro automatically generates one or more Requirements Analysis diagrams whenever it is run. These diagrams are generated as text files with the same name as the spreadsheet file, but with a .txt extension. The free, open source, Graphviz utility from http://www.graphviz.org/ is needed to turn the text file into a graphic file. The Requirements_Completeness_Quick_Reference.bat file shows how to invoke Graphviz through the *dot* interface to produce a .pdf file. Graphviz comes with several manuals. "Drawing graphs with *dot*" explains the *dot* interface.

Example System

Requirements for the Furnace Control System

Throughout this document there will be references to the Furnace Control System (FCS). The Furnace Control System is a very simple system that was created to demonstrate the key words in the Requirements Completeness macro. The system mimics the thermostat for a furnace. The system measures the temperature. When it gets too cold, the system turns on the furnace. When it gets too warm, the system turns off the furnace. Actually, the system (thermostat) opens and closes a relay. Outside of the system (thermostat) the relay then turns on the furnace and the blower. The furnace has an igniter which must be replaced after some number of ignitions, so the system counts the number of times the furnace has been turned on.

There are several features that seem out of place in this system. Most glaring is that the temperature is referred to by three different names. Not something that would really happen in a system with only a few requirements, but something that always happens in a system with a few hundred requirements. Multiple names were used to provide an example of the AKA key word. Also, in a real system there would be a way to reset the count of ignitions.

The Furnace Control System has the following requirements:

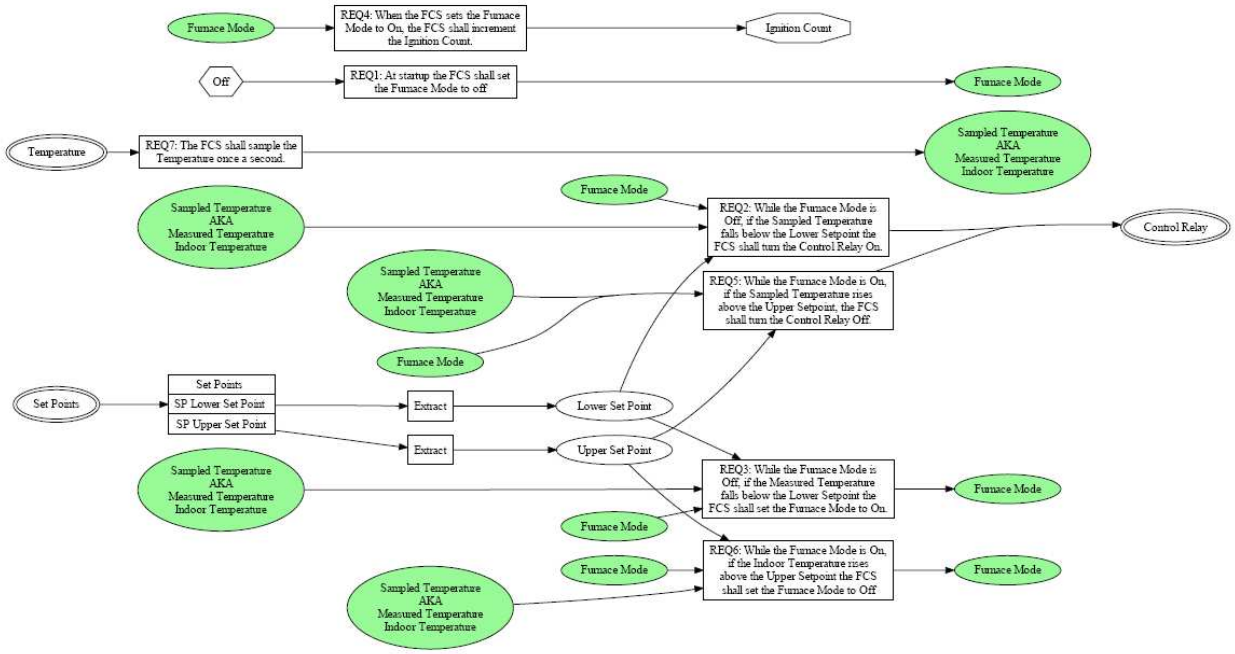
- REQ1 At startup the FCS shall set the **Furnace Mode** to off.
- REQ2 While the **Furnace Mode** is Off, if the **Sampled Temperature** falls below the **Lower Set Point** the FCS shall turn the Control Relay On.
- REQ3 While the **Furnace Mode** is Off, if the **Measured Temperature** falls below the **Lower Set Point** the FCS shall set the Furnace Mode to On.
- REQ4 When the FCS sets the **Furnace Mode** to On, the FCS shall increment the **Ignition Count**.
- REQ5 While the **Furnace Mode** is On, if the **Sampled Temperature** rises above the **Upper Set Point**, the FCS shall turn the Control Relay Off.
- REQ6 While the **Furnace Mode** is On, if the **Indoor Temperature** rises above the **Upper Set Point** the FCS shall set the Furnace Mode to Off
- REQ7 The FCS shall sample the **Temperature** once a second.

Excel Spreadsheet for the Furnace Control System

Ref Version	ID	Description	◉ Update Status	Type	Defined Name	Arguments		
				FirstRow				
		System Outputs		_				
				Output	Control Relay			
		System Inputs		_				
				Input	Temperature			
				Input	Set Points			
		Administrivia		_				
				Struct	Set Points	SP Lower Set Point	SP Upper Set Point	
		Extract		Process	Upper Set Point	SP Upper Set Point		
		Extract		Process	Lower Set Point	SP Lower Set Point		
				Define	Sampled Temperature	Global		
				Define	Furnace Mode	Global		
				Const	Off			
				AKA	Sampled Temperature	Measured Temperature	Indoor Temperature	
				Group	Control_Relay	REQ2	REQ3	
	REQ1	At startup the FCS shall set the Furnace Mode to off		Process	Furnace Mode	Off		
	REQ2	While the Furnace Mode is Off, if the Sampled Temperature falls below the Lower Setpoint the FCS shall turn the Control Relay On.		Process	Control Relay	Furnace Mode	Sampled Temperature	Lower Set Point
	REQ3	While the Furnace Mode is Off, if the Measured Temperature falls below the Lower Setpoint the FCS shall set the Furnace Mode to On.		Process	Furnace Mode	Furnace Mode	Measured Temperature	Lower Set Point
	REQ4	When the FCS sets the Furnace Mode to On, the FCS shall increment the Ignition Count.		Process	Ignition Count	Furnace Mode		
				Debug	Ignition Count			
	REQ5	While the Furnace Mode is On, if the Sampled Temperature rises above the Upper Setpoint, the FCS shall turn the Control Relay Off.		Process	Control Relay	Furnace Mode	Sampled Temperature	Upper Set Point
	REQ6	While the Furnace Mode is On, if the Indoor Temperature rises above the Upper Setpoint the FCS shall set the Furnace Mode to Off		Process	Furnace Mode	Furnace Mode	Indoor Temperature	Upper Set Point
	REQ7	The FCS shall sample the Temperature once a second.		Process	Sampled Temperature	Temperature		
				LastRow				

The spreadsheet for the Furnace Control System is in the Requirements_Completeness_Quick_Reference.xls file.

Requirements Analysis Diagram for the Furnace Control System



The Requirements Analysis diagram is in the Requirements_Completeness_Quick_Reference.pdf file. The Requirements Analysis diagram is generated automatically by the Requirements Completeness macro whenever it runs.

Keywords

_ (Underscore), Feature, Comment

ID	Description	Update Status	Type	Defined Name	Arguments	
	System Outputs		_			

The _ (Underscore), Feature and Comment keywords are used in the Type column to keep the Requirements Completeness macro from processing that row. Thus the row can be used for a comment, heading, or anything else. Separating the spreadsheet into sections with labels in a larger font size is one use. When a large number of requirements are exported from a requirements database and imported into the spreadsheet, it is easier to set the entire Type column to the underscore character, and later change the underscore to Process one requirement at a time rather than making them all Process and then trying to clean up the errors.

Feature, Comment and underscore all create a comment. Underscore is in the list because it is the character that is most nearly invisible and thus does not distract from the comment or heading.

The comment created by the Feature keyword is intended to be used to label non-functional requirements. When a large number of requirements are imported from a database, not all of them will be functional requirements. Rather than delete the non-functional requirements, they can be kept around by setting the Type column to Feature.

AKA

ID	Description	Update Status	Type	Defined Name	Arguments	
			AKA	Sampled Temperature	Measured Temperature	Indoor Temperature

The AKA (Also Known As) keyword is used in the Type column to define a list of synonyms. Any number of synonyms can be listed in the Argument columns. Without a tool to enforce consistency, two or more different names will be used for the same data item, especially in a system where the requirements document has multiple authors. In the example at the beginning of the document, both REQ2 and REQ3 refer to the same data item. The data item is called Temperature in REQ2, Measured Temperature in REQ3 and Sampled Temperature in REQ7.

The label for the data item as it appears in the Requirements Analysis diagram includes all of the synonyms, with the text from the Defined Name column at the top of the list.

Comment

See _ (Underscore), Feature, Comment.

Const

ID	Description	Update Status	Type	Defined Name	Arguments	
			Const	Off		

The Const keyword is used in the Type column to define a constant. Const cannot have any arguments. The name defined by a Const keyword is read-only (i.e. it cannot appear in the Defined Name column in a Process requirement).

The symbol for a Const on the Requirements Analysis diagram is a hexagon. It has outgoing arrows, but no incoming arrows.

Debug

ID	Description	Update Status	Type	Defined Name	Arguments	
	When the FCS sets the Control Relay to On, …		Process	Ignition Count	Furnace Mode	On
			Debug	Ignition Count		

The Debug keyword is used in the Type column to define a data item which is never used. Debug cannot have any arguments. A Debug redefines the Defined Name of a Process as a write-only data item. Especially in embedded systems, there can be requirements that intentionally generate a data item that is neither used as an input to another requirement nor used as a system output. These data items are like the black box recorder on an airplane, write-only.

The symbol for a Debug data item in the Requirements Analysis diagram is an octagon. It has incoming arrows, but no outgoing arrows.

Define

ID	Description	Update Status	Type	Defined Name	Arguments	
			Process	Furnace Mode	Off	
			Define	Furnace Mode	Global	

The Define keyword is used in the Type column to associate an attribute with a Defined Name. Currently, the only attribute is Global. See the description of the Global keyword for the details.

Feature

See _ (Underscore), Feature, Comment.

FirstRow

ID	Description	Update Status	Type	Defined Name	Arguments	
			FirstRow			

The FirstRow keyword is used to indicate where the Requirements Completeness macro begins processing. If there is more than one occurrence of the FirstRow keyword, the last one is used. FirstRow and LastRow are like pairs of parenthesis (), square brackets [] or curly braces {}. The macro uses the innermost pair, i.e. the last occurrence of FirstRow and the first occurrence of LastRow.

Global

ID	Description	Update Status	Type	Defined Name	Arguments	
			Define	Furnace Mode	Global	

The Global keyword is used in the Arguments column of a Define declaration or Process requirement.

Global is an attribute that only affects the layout of the Requirements Analysis diagram. Normally there is only one symbol drawn on the Requirements Analysis diagram for each data item no matter how many requirements it appears in. When a data item is used in many different requirements, the diagram becomes overly tangled with crossing lines. The Global attribute specifies that the symbol for the data item will be drawn separately in each place that it is used. This eliminates the crossing lines, but produces many disconnected occurrences of the data item. Global symbols are shaded green to help visually connect the scattered occurrences.

Group

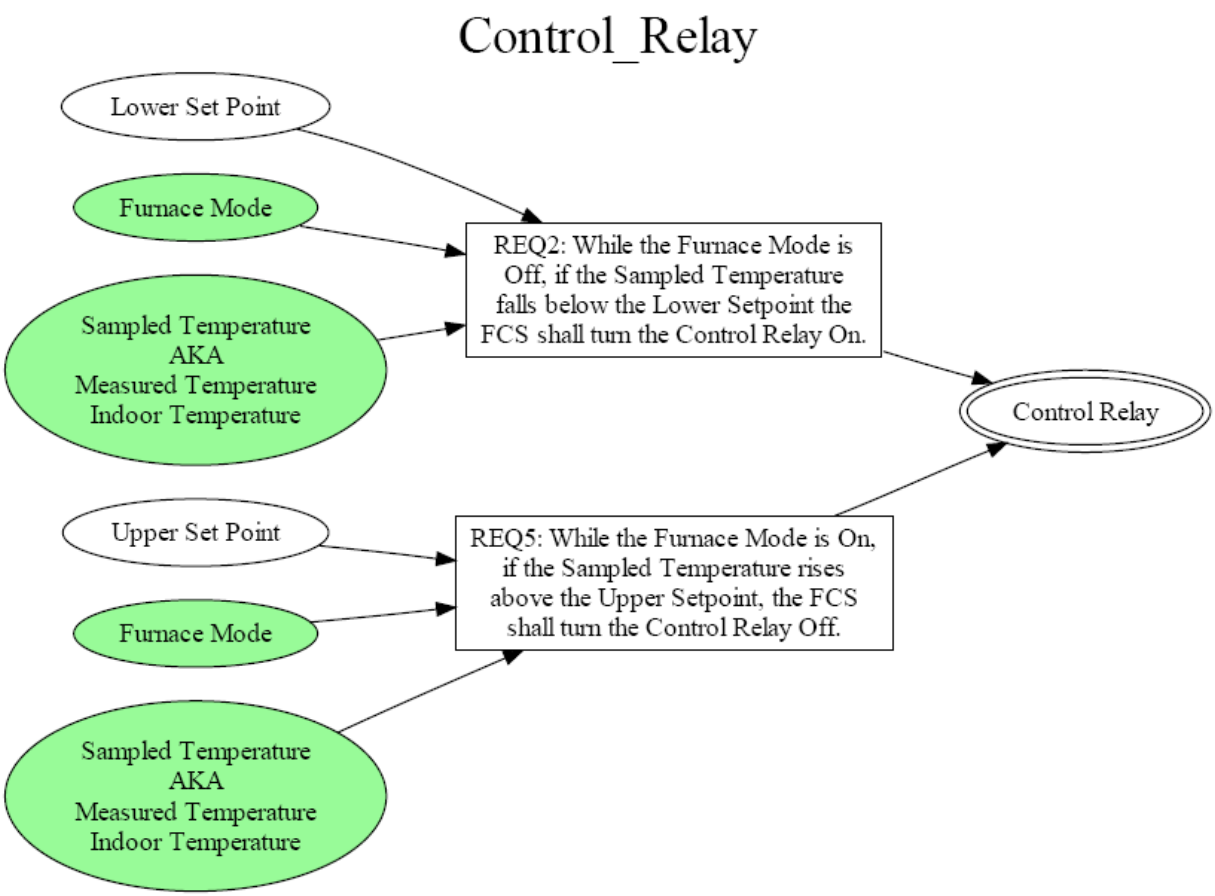
ID	Description	Update Status	Type	Defined Name	Arguments	
			Group	Control_Relay	REQ2	REQ5

The Group keyword is used in the Type column to define a new Requirements Analysis diagram that contains only the requirements listed in the Arguments columns. The entries in the Arguments columns are the requirement identifiers listed in the ID column of Process requirements. A new Requirements Analysis diagram is generated which contains only the listed requirements, and the data items that flow

into or out of those requirements. The new Requirements Analysis diagram file name is the same as the name of the spreadsheet, with the text from the Defined Name column appended to it. The Group keyword does not change any of the analysis done by the Requirements Completeness macro, nor does it change the original Requirements Analysis diagram.

A separate drawing that contains a subset of the full system is useful when you want to examine the details of a subsystem, or a scenario, or all of the requirements that affect a single data item. It is also useful in a requirements review meeting if the meeting is intended to cover a specific subset of the requirements.

The example shows all of the requirements that are directly involved with turning the Control Relay on and off.



Input

ID	Description	Update Status	Type	Defined Name	Arguments	
			Input	Temperature		

The Input keyword is used in the Type column to define a system input. Inputs are read-only. That means they cannot be used in the Defined Name column of a Process requirement.

For an Input that is also a Struct, the struct elements can appear as Arguments. I.e., if the Input has arguments, the Input becomes a Struct.

The symbol for an Input on the Requirements Analysis diagram is an oval with a double border. Inputs are always at the far left of the diagram. Inputs that are also Structs have an oval with a double border with an outgoing arrow to a rectangle that is divided into slots.

LastRow

ID	Description	Update Status	Type	Defined Name	Arguments	
			LastRow			

The LastRow keyword is used in the Type column to stop the Requirements Completeness macro from processing any more rows. The remainder of the spreadsheet is ignored. FirstRow and LastRow can be used to debug a small number of requirements in the middle of a large spreadsheet. Since any rows following LastRow are ignored, the spreadsheet could be extended with various kinds of reporting information or metrics. FirstRow and LastRow are like pairs of parenthesis (), square brackets [] or curly braces {}. The macro uses the innermost pair, i.e. the last FirstRow and the first LastRow.

Output

ID	Description	Update Status	Type	Defined Name	Arguments	
			Output	Control Relay		

The Output keyword is used in the Type column to define a system output. Outputs are write-only. That means they cannot be used as in the Arguments columns of a Process requirement.

For an Output that is also a Struct, the struct elements can appear as Arguments. I.e., if the Output has arguments, the Output becomes a Struct.

The symbol for an Output on the Requirements Analysis diagram is an oval with a double border. Outputs are always at the far right of the diagram.

Process

ID	Description	Update Status	Type	Defined Name	Arguments	
REQ1	At startup the FCS shall …		Process	Furnace Mode	Off	

The Process keyword is used in the Type column to define a functional requirement. The Defined Name column has the data item created or modified by the requirement. The Arguments columns have the data that is used by the requirement. The first blank cell in the Arguments columns marks the end of the arguments list.

The symbol for a Process on the Requirements Analysis diagram is a rectangle which contains the ID and the Description. In addition, there is an outgoing arrow to the data item in the Defined Name column and incoming arrows from each of the data items in the Arguments columns.

Struct

ID	Description	Update Status	Type	Defined Name	Arguments	
			Struct	Setpoints	SP Lower Setpoint	SP Upper Setpoint

The Struct keyword is used in the Type column to define a collection of data items (struct elements) as a single name. There can be any number of Structs defined in the spreadsheet, but every element must have a unique name. To insure that element names are unique across all Structs, it is helpful to put some kind of an acronym as a prefix to each element name.

For an Input or an Output that is also a Struct, the struct elements can appear as arguments in the Input or Output requirement.

The symbol for a Struct is a rectangle that is divided into slots. The upper slot has the Defined Name. The remaining slots have the Arguments.

Revision History

05/17/2009 1st Edition