***CEV Flight Dynamics Team***

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**From:** Joel Henry - ORION GN&C Software Functional Manager

**Subject:** Orion GN&C MATLAB/Simulink Standards (SIA Action #2)

**Date:** October 1st, 2011

## Executive Summary

This document satisfies Action #2 of the GN&C Flight Software (FSW) Structured Improvement Activity (SIA) project and represents the efforts of the MATLAB/Simulink standards splinter group formed soon after the SIA event.

The MATLAB/Simulink standards splinter group was tasked to define an initial version of the MATLAB/Simulink guidelines and standards. These standards and guidelines are to be used in the GN&C Flight Software (FSW) algorithm development effort by each of the GN&C MODE teams.

*(Signature of Author)*

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**Orion GN&C**
**MATLAB/Simulink Standards**

Version 15
October 1$^{st}$, 2011GN&C Structured Improvement Activity/LM21 Project Team

## REVISION HISTORY

| Ver. | Date | Originator | Description |
|---|---|---|---|
| 0.0 | 07/19/08 | CSDL/Ian T. Mitchell | |
| 1.0 | 09/02/08 | CSDL/Ian T. Mitchell | Added memo format. |
| 2.0 | 11/03/08 | CSDL/Ian T. Mitchell | Feedback from splinter group. |
| 3.0 | 12/03/08 | CSDL/Ian T. Mitchell | Splinter group review. |
| 4.0 | 04/09/09 | CSDL/Joel Henry | Further splinter group review and feedback from the Entry Pathfinder project |
| 5.0 | 04/15/09 | CSDL/Joel Henry | Minor corrections |
| 6.0 | 4/30/2009 | CSDL/Joel Henry | Added ORION specific naming standards for models, m-files, and root-level buses |
| 7.0 | 7/15/2009 | CSDL/Joel Henry | Minor corrections and clarifications |
| 8.0 | 11/17/2009 | CSDL/Joel Henry | Added/modified standards based on lessons learned from the Entry/Orbit/Ascent Translation process |
| 9.0 | 11/1/2010 | NASA/Joel Henry | •Added MA Check field to every standard to indicate whether an automated Model Advisor check exists for this standard<br>Updated the following standards:<br>• jh_0070: Model Configuration Settings<br>• jh_0109: Merge Blocks<br>• jh_0042: Required Software<br>Added the following standards<br>• mj_0001: CSU Input Bus Naming<br>• jh_0111: Bus Ordering and Alignment<br>• jh_0117: Shared CSUs Across Domains<br>• jr_0001: Use of Atomic functions for Subsystems<br>• mj_0002: Junction Box Composition<br>• jy_0010: Graphical Functions<br>• jr_0002: Number of nested if/for statement blocks<br>Removed the following standards<br>• db_1037: States in state machines |
| 10.0 | | NASA/Joel Henry | Added the following standards<br>• dm_0001: Signal and Bus Element Naming Convention<br>Updated the following standards:<br>• jh_0006: Setup files for bus initialization<br>• hyl_0204: Standard Units |
| 11.0 | | NASA/Joel Henry | Updated the following standards:<br>• dm_0001: Signal and Bus Element Naming Convention |
| 12.0 | 4/11/2011 | LM/David Shoemaker<br>NASA/Joel Henry | Added the following standards<br>• jph_0010: Use of Masks<br>Updated the following Standards:<br>• dm_0002: Enumerated Types Usage<br>• dm_0003: Enumerated Types Header Files<br>• dm_0004: Enumerated Types RTW Settings<br>• dm_0005: Enumerated Types Description<br>• jr_0003: Enumeration Name Convention<br>• ek_0002: Recursive Functions (changed to mandatory)<br>Removed the following standards<br>• jh_0055: Use of Masks (replaced with jph_0010) |
| 13.0 | 5/5/2011 | NASA/Joel Henry | Added the following standards<br>• jh_0202: Testable Unit<br>• jh_0200: Guidelines for Managing Model Complexity |

| | | | |
|---|---|---|---|
| | | | • jh_0201: eML Function Types<br>• jr_0004: Error Handling<br>Removed the following standards<br>• hyl_0206: Only Boolean inputs to encoder blocks<br>• jr_0001: Use of Atomic Functions for Subsystems<br>• jh_0001: Use of ARINC blocks for partition to partition data flow<br>• jh_0005: Setup files for model parameter initialization<br>• jh_0006: Setup files for bus initialization<br>• bd_0137: States in state machines<br>• jy_0010: Graphical Functions<br>• hyl_0208: Prevention of divide-by-zero<br>• hyl_0209: Prevention of negative square root<br>• hyl_0203: Model Publishing<br>• jh_0011: Model release<br>Updated the following Standards:<br>• jh_0042: Required Software<br>• jh_0079: Model and Matlab Filenames<br>• na_0004: Simulink model appearance<br>• na_0004: Port block name visibility in Simulink models<br>• jm_0010: Port block names in Simulink models<br>• dm_0001: Signal and Bus Element Naming Convention<br>• hyl_0301: Block naming convention<br>• db_0112: Indexing<br>• db_0144: Use of Subsystems<br>• jh_0049: Use of Model References or Reusable Subsystems<br>• jph_0010: Use of Masks<br>• na_0012: Use of Switch vs. Case vs. If-Then-Else Action Subsystem<br>• db_0116: Simulink patterns for logical constructs with logical blocks<br>• jr_0001: Enumeration Name Convention<br>• na_0006: Guidelines for mixed use of Simulink and Stateflow<br>• na_0007: Guidelines for use of Flow Charts, Truth Tables and State Machines<br>• im_0001: Guidelines for mixed use of Simulink and eML<br>• im_0008: Source lines of eML<br>• im_0009: Number of called function levels<br>• jh_0110: eML Function Reuse<br>• jh_0029: m-files<br>• jh_0030: Extrinsic function<br>• jh_0073: eML Header<br>• Modeling Guidelines Chart |
| 14.0 | 9/1/2011 | NASA/Joel Henry | Added the following standards<br>• jh_0050: Model References Simulation Mode<br>• jh_0052: Directory Structure<br>Updated the following Standards:<br>• dm_0001: Signal and Bus Element Naming Convention<br>• jc_0141: Use of Switch block<br>• jh_0021: Restricted Variable Names |
| 15.0 | 10/1/2010 | NASA/Joel Henry | Added the following standards<br>• do_0001: Declaring Local Variables in eml<br>Updated the following Standards:<br>• jh_0064: eML if statement |

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# ABBREVIATIONS AND ACRONYMS

| | |
|---|---|
| CEV | Crew Exploration Vehicle |
| FDT | Flight Dynamics Team |
| FSW | Flight Software |
| GN&C | Guidance, Navigation and Control |
| UML | Unified Modeling Language |
| CSU | Computer Software Unit |
| PSP | Pilot Support Package |
| MAAB | Mathworks Automotive Advisory Board |
| SDP | Software Development Plan |
| eML | Embedded Matlab |
| ARINC | Avionics Application Standard Software Interface |
| SDK | Software Development Kit |
| MRB | Model Reference Block |
| V&V | Verification and Validation |

# 1 INTRODUCTION

This document describes the standards and guidelines that the Orion Crew Exploration Vehicle (CEV) Flight Dynamics Team (FDT) will use while developing the Guidance, Navigation and Control (GN&C) algorithms in the MATLAB/Simulink environment.

The GN&C algorithms developed in this manner will be delivered to the Flight Software (FSW) team and C++ source code will be auto-generated and integrated with other flight software components.

This standards and guidelines document has been developed using the Mathworks Automotive Advisory Board (MAAB) guidelines document as a starting point with additions from the joint Orion NASA/Contractor team.

# 2 RELATED DOCUMENTATION

## 2.1 Applicable Documents

This document is a child document to the Orion GN&C Algorithm Development Plan, which specifies the overall plan for FDT development, testing and delivery of GN&C algorithms.

Table 1 lists the documents applicable to this MATLAB Standards document.

**Table 1 - Applicable Documents**

| Reference No. | Title |
|---|---|
| | Control Algorithm Modeling Guidelines Using MATLAB®, Simulink®, and Stateflow®, Version 2.0, MathWorks Automotive Advisory Board (MAAB), July 27, 2007 |
| CEV-GNC-11-014 | GNC Model Development Cyclomatic Complexity Guidelines Memo |
| FltDyn-CEV-11-52 | Error Handling and Logging Guidance |

## 2.2 Information Documents

**Table 2 - Information Documents**

| Reference No. | Title |
|---|---|
| LM CEV-T-005 | LM Software Development Plan (SDP) |

# 3 PURPOSE AND DESCRIPTION

The purpose of this document is to define standards and guidelines for how the FDT will implement and model their GN&C algorithms in the MATLAB/Simulink environment. Such standards will foster consistency across all of the FDT's five mode teams (Ascent Abort, Orbit, Entry, Navigation and Integrated GN&C), and provide for tighter cohesion in the GN&C design, improve readability and interpretation, and ultimately expedite module integration and testing.

The Priority field in each of the standards indicates the importance. The three priority types are Mandatory, Strongly Recommended, and Recommended. The descriptions of each of these types are below:

- **Mandatory** – flagged in inspection, must be fixed before any release (no schedule relief, “shall”)
- **Strongly Recommended**, flagged in inspection, should be high-priority to fixing before release, but –if resource limited – could be released in engineering releases, but must be fixed prior to flight (i.e., there may be some schedule relief for fixing this, is a “shall“) and required approval for acceptance.
- **Recommended** – flagged in inspection, not required fixed before release or flight. (“nice to have”, or “guideline”, a “should”)

# 4 STANDARDS

## *4.1 System Requirements*

### 4.1.1 jh_0042: Required Software

<table>
<tr><td><b>ID: Title</b></td><td><b>jh_0042: Required Software</b></td></tr>
<tr><td>Priority</td><td>Mandatory</td></tr>
<tr><td>Scope</td><td>ORION</td></tr>
<tr><td>MATLAB Version</td><td>See Description/Version</td></tr>
<tr><td>MA Check</td><td>No</td></tr>
<tr><td>Prerequisites</td><td>None</td></tr>
<tr><td>Description</td><td>The minimum required software for use with the ORION GN&C FSW models is as follows:<br><br>The use of blocks from Simulink toolboxes are prohibited for CSU development.
<table>
<tr><td>Description</td><td>Software</td><td>Version</td></tr>
<tr><td>Minimum Required for Simulation at CSU level</td><td>Matlab<br>Simulink<br>Stateflow<br>C++ Compiler (ex. Visual Studio C++ 2008 for Win32)</td><td>2010b SP1<br>2010b SP1<br>2010b SP1</td></tr>
<tr><td>Minimum Required for Simulation at Domain Level</td><td>Those listed above<br>ARINC PSP (Pilot Support Package)</td><td><br>2.1</td></tr>
<tr><td>Required for Code Generation</td><td>Real-Time Workshop<br>Real-time Workshop Embedded Coder</td><td>2010b SP1<br>2010b SP1</td></tr>
</table>
</td></tr>
</table>

| | | | |
|---|---|---|---|
| | | Stateflow Coder<br>Trick PSP<br>Microsoft SDK (needed for ARINC PSP on Win32) | 2010b SP1<br>1.8<br>6.1 or later |
| | Required for Advanced Model Analysis | Simulink Verification and Validation | 2010b SP1 |
| | Required for Running Unit Tests | System Test | 2010b SP1 |
| Rationale | ☑ Readability<br>☑ Workflow<br>☑ Simulation<br>☑ Verification and Validation<br>☑ Code Generation | | |
| Last Change | V1.3 | | |

### 4.1.2 jh_0043: Approved Platforms

| **ID: Title** | **jh_0043: Approved Platforms** |
|---|---|
| Priority | Mandatory |
| Scope | ORION |
| MATLAB Version | 2010b |
| MA Check | No |
| Prerequisites | None |
| Description | The supported OS environments are listed below:<br>Windows 32-bit<br>Linux 32-bit<br>Environments other than these are not compatible with the PSPs (Pilot Support Packages) and the USA S-function utilities |
| Rationale | ☑ Readability<br>☑ Workflow<br>☑ Simulation<br>☑ Verification and Validation<br>☑ Code Generation |
| Last Change | V1.1 |

## *4.2 File and Directory Naming Conventions*

### 4.2.1 ar_0001: Filenames

| **ID: Title** | **ar_0001: Filenames** |
|---|---|
| Priority | Mandatory |
| Scope | MAAB |
| MATLAB | All |

<table>
<tr><td>Version</td><td></td></tr>
<tr><td>MA Check</td><td>Yes</td></tr>
<tr><td>Prerequisites</td><td>None</td></tr>
<tr><td>Description</td><td>A filename conforms to the following constraints:
<table>
<tr><td>FORM</td><td>filename = name.extension<br><b>name</b>: no leading digits, no blanks<br><b>extension</b>: no blanks</td></tr>
<tr><td>UNIQUENESS</td><td>all filenames within the parent project directory</td></tr>
<tr><td>ALLOWED CHARACTERS</td><td><b>name</b><br>a b c d e f g h i j k l m n o p q r s t u v w x y z A B C D E F G H I J K L M N O P Q R S T U V W X Y Z 0 1 2 3 4 5 6 7 8 9 _<br><b>extension</b>:<br>a b c d e f g h i j k l m n o p q r s t u v w x y z A B C D E F G H I J K L M N O P Q R S T U V W X Y Z 0 1 2 3 4 5 6 7 8 9</td></tr>
<tr><td>UNDERSCORES</td><td><b>name</b>:<br>• can use underscores to separate parts<br>• cannot have more than one consecutive underscore<br>• cannot start with an underscore<br>• cannot end with an underscore<br><b>extension</b>:<br>• should not use underscores</td></tr>
</table></td></tr>
<tr><td>Rationale</td><td>☑ Readability ☐ Verification and Validation<br>☑ Workflow ☐ Code Generation<br>☐ Simulation</td></tr>
<tr><td>Last Change</td><td>V1.0</td></tr>
</table>

### 4.2.2 jh_0079: Model and Matlab Filenames

<table>
<tr><td><b>ID: Title</b></td><td><b>jh_0079: Model and Matlab Filenames</b></td></tr>
<tr><td>Priority</td><td>Mandatory</td></tr>
<tr><td>Scope</td><td>ORION</td></tr>
<tr><td>MATLAB Version</td><td>All</td></tr>
<tr><td>MA Check</td><td>No</td></tr>
<tr><td>Prerequisites</td><td>None</td></tr>
<tr><td>Description</td><td>The file names for the Simulink model files and embedded Matlab script files must conform to the following guidelines:
<table>
<tr><td>CSU Simulink model name</td><td><3 letter Domain abb.>_<CSU abb.>_CSU.mdl</td></tr>
<tr><td>Eml functions</td><td><3 letter Domain abb.>  <CSU abb.>  <function name>.m</td></tr>
</table></td></tr>
</table>

| | | |
|---|---|---|
| | stored as separate *.m files | *Note: **ALL** separately stored *.m files (a.k.a “dot-M” files) must have the **eml.inline(‘never’);** declaration (described in jh_0202: Testable Unit) |
| | “Model reference” model used once within a single CSU | <3 letter Domain abb.>_<CSU abb.>_<function name>_MR.mdl |
| | “Model reference” model used multiple times within a single CSU | <3 letter Domain abb.>_<CSU abb.>_<function name>_MR.mdl |
| | “Model reference” model used within multiple CSUs in single Domain | <3 letter Domain abb.>_<abb of the CSU source>_<function name>_MR.mdl<br>*one of the CSUs will be the main source of the model – this is the CSU abb to use in the naming |
| | “Model reference” model used within a multiple CSUs in multiple Domains | GNCLib_<function name>.mdl<br>*this model must reside in the GNC Shared Model Library |
| Rationale | ☑ Readability<br>☑ Workflow<br>☐ Simulation | ☐ Verification and Validation<br>☐ Code Generation |
| Last Change | V1.1 | |

### 4.2.3 ar_0002: Directory names

| **ID: Title** | **ar_0002: Directory names** | |
|---|---|---|
| Priority | Mandatory | |
| Scope | MAAB | |
| MATLAB Version | All | |
| MA Check | Yes | |
| Prerequisites | None | |
| Description | A directory name conforms to the following constraints: | |
| | FORM | directory name = name<br>**name**: no leading digits, no blanks |
| | UNIQUENESS | all directory names within the parent project directory |
| | ALLOWED CHARACTERS | **name**:<br>a b c d e f g h i j k l m n o p q r s t u v w x y z A B C D E F G H I J K L M N O P Q R S T U V W X Y Z 0 1 2 3 4 5 6 7 8 9 _ |
| | UNDERSCORES | **name**: |

| | |
|---|---|
| | • can use underscores to separate parts<br>• cannot have more than one consecutive underscore<br>• cannot start with an underscore<br>• cannot end with an underscore |
| Rationale | ☑ Readability ☐ Verification and Validation<br>☑ Workflow ☐ Code Generation<br>☐ Simulation |
| Last Change | V1.0 |

### 4.2.4 jh_0052: Directory Structure

| | |
|---|---|
| **ID: Title** | **jh_0052: Directory Structure** |
| Priority | Mandatory |
| Scope | ORION |
| MATLAB Version | All |
| MA Check | No |
| Prerequisites | ar_0002: Directory Names |
| Description | The directory structure for the ORION project shall mimic the example below:<br><br>Junction Box models should be placed in the following directory:<br><3 Letter Domain> / <JBox_Name>.mdl<br><br>CSUs should be placed in the following directory:<br><3 Letter Domain> / <CSU Name> / <CSU_Name>.mdl<br><br>CSU Memos should be placed in the following directory:<br><3 Letter Domain> / <CSU Name> / Memo<br><br>Unit Tests should be placed in the following directory:<br><3 Letter Domain> / <CSU Name> / Unit_Tests |
| Rationale | ☐ Readability ☐ Verification and Validation<br>☑ Workflow ☐ Code Generation<br>☐ Simulation |
| Last Change | V1.0 |

## *4.3 Simulink*

### 4.3.1 Diagram Appearance

#### 4.3.1.1 na_0004: Simulink model appearance

| | |
|---|---|
| **ID: Title** | **na_0004 Simulink model appearance** |

<table>
<tr><td>Priority</td><td>Recommended</td></tr>
<tr><td>Scope</td><td>MAAB</td></tr>
<tr><td>MATLAB Version</td><td>All</td></tr>
<tr><td>MA Check</td><td>Yes</td></tr>
<tr><td>Prerequisites</td><td>None</td></tr>
<tr><td>Description</td><td>The model appearance settings should conform to the following guidelines when the model is released.  The user is free to change the settings during the development process.<br><br>Note:  The CSU_template.mdl file, included in the ORION Library, has the recommended settings in place.<br><br>
<table>
<tr><th>View Options</th><th>Setting</th></tr>
<tr><td>Model Browser</td><td>unchecked</td></tr>
<tr><td>Screen color</td><td>white</td></tr>
<tr><td>Status Bar</td><td>checked</td></tr>
<tr><td>Toolbar</td><td>checked</td></tr>
<tr><td>Zoom factor</td><td>Normal (100%)</td></tr>
<tr><td><b>Block Display Options</b></td><td><b>Setting</b></td></tr>
<tr><td>Background Color</td><td>white</td></tr>
<tr><td>Foreground Color</td><td>black</td></tr>
<tr><td>Execution Context Indicator</td><td>unchecked</td></tr>
<tr><td>Library Link Display</td><td>none</td></tr>
<tr><td>Linearization Indicators</td><td>checked</td></tr>
<tr><td>Model/Block I/O Mismatch</td><td>unchecked</td></tr>
<tr><td>Model Block Version</td><td>unchecked</td></tr>
<tr><td>Sample Time Colors</td><td>none</td></tr>
<tr><td>Sorted Order</td><td>unchecked</td></tr>
<tr><td><b>Signal Display Options</b></td><td><b>Setting</b></td></tr>
<tr><td>Port Data Types</td><td>unchecked</td></tr>
<tr><td>Signal Dimensions</td><td>unchecked</td></tr>
<tr><td>Storage Class</td><td>unchecked</td></tr>
<tr><td>Test point Indicators</td><td>checked</td></tr>
<tr><td>Viewer Indicators</td><td>checked</td></tr>
<tr><td>Wide Non-scalar Lines</td><td>checked</td></tr>
<tr><td><b>Simulation</b></td><td><b>Setting</b></td></tr>
<tr><td>Simulation Mode</td><td>Normal</td></tr>
</table></td></tr>
<tr><td>Rationale</td><td>☑ Readability<br>☑ Workflow<br>□ Simulation<br>□ Verification and Validation<br>□ Code Generation</td></tr>
<tr><td>Last Change</td><td>V2.2</td></tr>
</table>

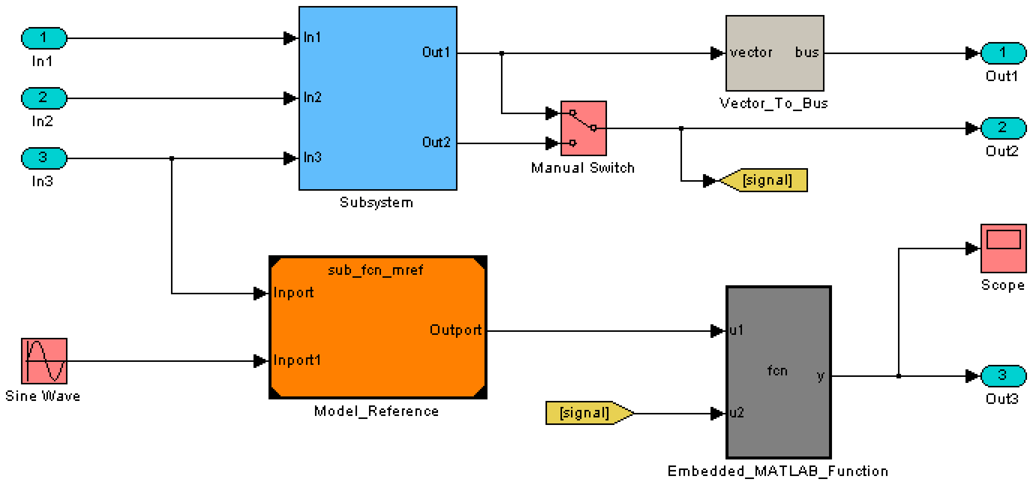
### 4.3.1.2 jh_0007:  Blocks in a model

| **ID: Title** | **jh_0007: Blocks in a model** |
|---|---|
| Priority | Recommended |
| Scope | ORION |
| MATLAB Version | All |
| MA Check | No |
| Prerequisites | None |
| Description | Each layer of a model must be printable and readable on 11x17 size paper.<br>The use of the CSU_template.mdl file and the ORION library will enforce this standard using borders. |
| Rationale | ☑ Readability<br>☑ Workflow<br>□ Simulation<br>□ Verification and Validation<br>□ Code Generation |
| Last Change | V1.2 |

### 4.3.1.3 db_0043: Simulink font and font size

| **ID: Title** | **db_0043: Simulink font and font size** |
|---|---|
| Priority | Strongly recommended |
| Scope | MAAB |
| MATLAB Version | All |
| MA Check | Yes |
| Prerequisites | jh_0007: Blocks in a Model |
| Description | All text elements (block names, block annotations and signal labels) except free text annotations within a model must have the same font style and font size. Fonts and font size should be selected for legibility.<br>Note: The ORION Library blocks adhere to this standard and do not need to be changed.<br>Note: The selected font should be directly portable (e.g. Simulink/Stateflow default font) or convertible between platforms (e.g. Arial/Helvetica 12pt).<br>Note: The CSU_template.mdl file, included in the ORION Library, has a Title text box and Description text box that are of the recommended format. |
| Rationale | ☑ Readability<br>☑ Workflow<br>□ Simulation<br>□ Verification and Validation<br>□ Code Generation |
| Last Change | V2.1 |

#### 4.3.1.4 hyl_0103: Model color coding

| **ID: Title** | **hyl_0103: Model color coding** |
|---|---|
| Priority | Strongly recommended |
| Scope | ORION |
| MATLAB Version | All |
| MA Check | Yes |
| Prerequisites | None |
| Description | The background color **shall** be set to:<br>a) Light blue for subsystems blocks<br>b) Orange for referenced models<br>c) Cyan for inport and outport blocks<br>d) Yellow for From, Goto, and Goto Visibility tags<br>e) Red for non-ORION Library blocks<br>(Colorspec RGB value = [1.000000, 0.501961, 0.501961])<br>f) White for Library blocks<br>g) Gray for Embedded Matlab Blocks<br>h) Light Brown for Domain level blocks (non-CSU)<br>(Colorspec RGB value = [0.792157, 0.772549, 0.725490])<br>Note: The blocks in the ORION Library are set to the required background color<br>Example:<br> 1<br>In1<br>2<br>In2<br>3<br>In3<br>In1<br>In2<br>In3<br>Out1<br>Out2<br>Subsystem<br>vector<br>bus<br>Vector_To_Bus<br>Manual Switch<br>[signal]<br>1<br>Out1<br>2<br>Out2<br>sub_fcn_mref<br>Inport<br>Inport1<br>Outport<br>Model_Reference<br>Sine Wave<br>[signal]<br>u1<br>u2<br>fcn<br>y<br>Embedded_MATLAB_Function<br>Scope<br>3<br>Out3 |
| Rationale | ☑ Readability<br>☐ Workflow<br>☐ Simulation<br>☐ Verification and Validation<br>☐ Code Generation |
| Last Change | V2.1 |

### 4.3.2 Model Configuration Options

The model configuration options should be set to those indicated in the Appendix 5.1.

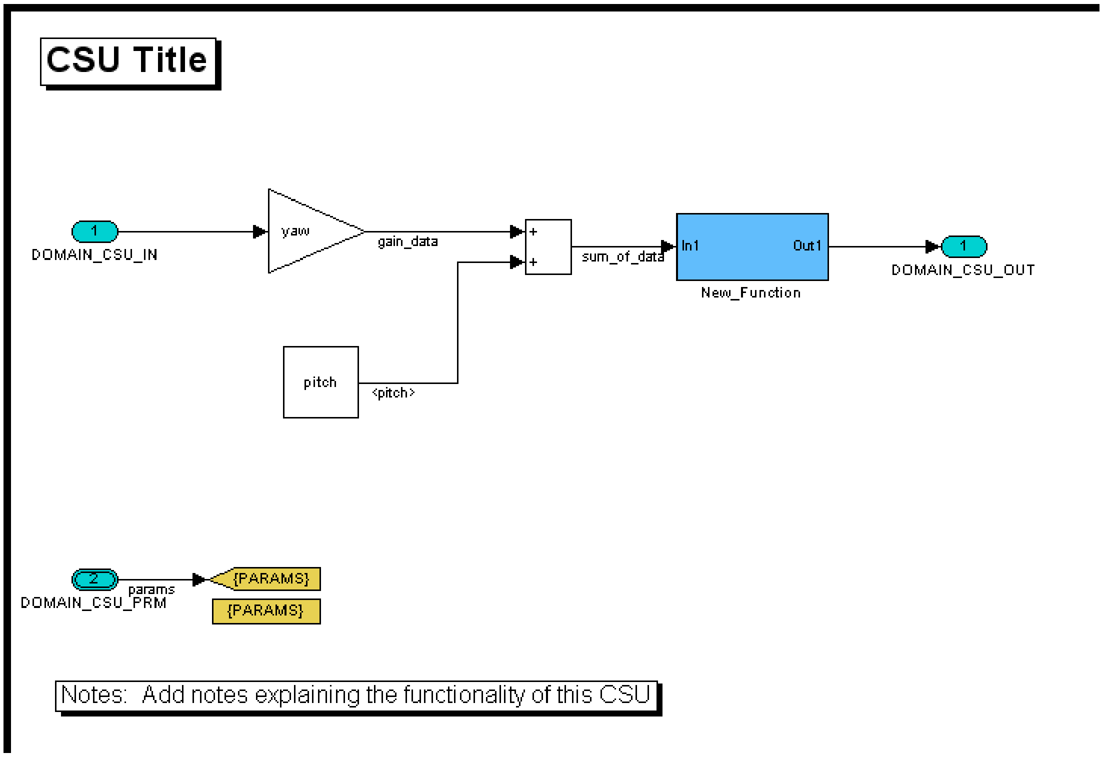
#### 4.3.2.1 jh_0070: Model Configuration Settings

| **ID: Title** | **jh_0070: Model Configuration Settings** |
|---|---|
| Priority | Mandatory |
| Scope | ORION |
| MATLAB Version | All |
| MA Check | No |
| Prerequisites | None |
| Description | Each CSU must have the model configuration settings set to the configuration object specified below – which are included in the latest version of the ORION Library.<br><br>CSUs: set to CSUCfgSet or CSUCfgSetMR<br>Junction Boxes: set to JBoxCfgSet<br>Domains and above: EmptyBoxCfgSet<br><br>Note: These settings will ensure consistency and compatibility across all CSUs and allow proper generation of autocode.<br><br>Note: The ORION Library includes the CSUCfgSet which is a configuration object that complies with all of these settings. Also, the CSU_template model included in the ORION Library uses this config file. |
| Rationale | □ Readability<br>□ Workflow<br>☑ Simulation<br>□ Verification and Validation<br>☑ Code Generation |
| Last Change | V1.1 |

### 4.3.3 Model Documentation

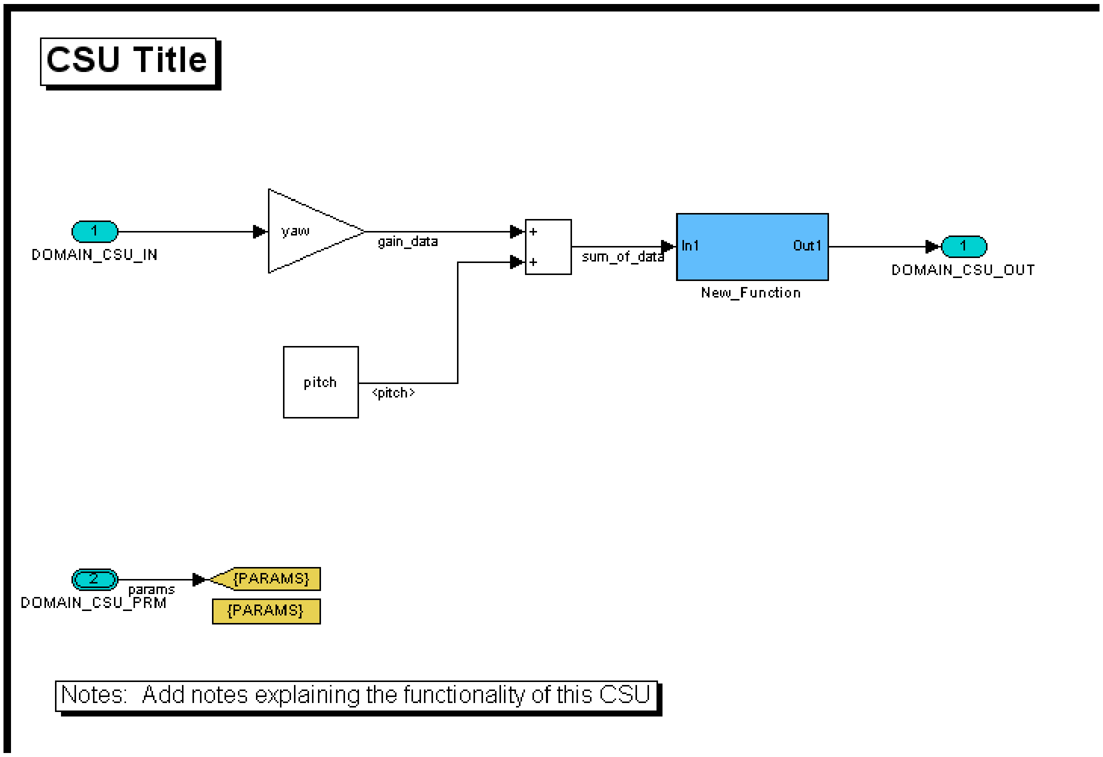
#### 4.3.3.1 hyl_0112: Title on each page

| **ID: Title** | **hyl_0112: Title on each page** |
|---|---|
| Priority | Strongly recommended |
| Scope | ORION |
| MATLAB Version | All |
| MA Check | No |
| Prerequisites | None |

| | |
|---|---|
| Description | Each page **shall** have a title. This allows pages to be easily identified when printed.<br>Example:<br><br> CSU Title<br>1<br>DOMAIN_CSU_IN<br>yaw<br>gain_data<br>+<br>+<br>sum_of_data<br>In1<br>Out1<br>New_Function<br>1<br>DOMAIN_CSU_OUT<br>pitch<br><pitch><br>2<br>params<br>DOMAIN_CSU_PRM<br>{PARAMS}<br>{PARAMS}<br>Notes: Add notes explaining the functionality of this CSU<br>Note: The title will not transfer to the autocode |
| Rationale | ☑ Readability<br>□ Workflow<br>□ Simulation<br>☑ Verification and Validation<br>□ Code Generation |
| Last Change | V2.1 |

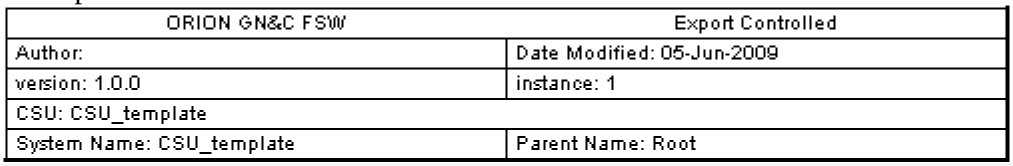
### 4.3.3.2 hyl_0113: Notes on each page

| **ID: Title** | **hyl_0113: Notes on each page** |
|---|---|
| Priority | Strongly recommended |
| Scope | ORION |
| MATLAB Version | All |
| MA Check | No |
| Prerequisites | None |
| Description | At least one note should be placed on each page explaining the function contained on that page. Additional notes should be placed on the page as needed. The goal is to |

| | |
|---|---|
| | document each page with the rationale, assumptions, and intent of the design. The notes should not contain algorithms. Instead, references should be made in the notes to the algorithm specification.<br><br>Comments should not be index specific because the index used in the autocode may differ.<br><br>Example:<br><br> CSU Title<br>1<br>DOMAIN_CSU_IN<br>yaw<br>gain_data<br>+<br>+<br>sum_of_data<br>In1<br>Out1<br>New_Function<br>1<br>DOMAIN_CSU_OUT<br>pitch<br>&lt;pitch&gt;<br>2<br>params<br>DOMAIN_CSU_PRM<br>{PARAMS}<br>{PARAMS}<br>Notes:  Add notes explaining the functionality of this CSU<br><br>Note:  The notes will not transfer to the autocode |
| Rationale | ☑ Readability ☑ Verification and Validation<br>☐ Workflow ☐ Code Generation<br>☐ Simulation |
| Last Change | V2.0 |

### 4.3.3.3 hyl_0202: Use of revision/trace block

| **ID: Title** | **hyl_0202: Use of revision/trace block** |
|---|---|
| Priority | Strongly recommended |
| Scope | ORION |
| MATLAB Version | All |
| MA Check | Yes |

| | |
|---|---|
| Prerequisites | None |
| Description | Each model **shall** have a revision block that maintains a unique identification trace tag, a version number which matches the version in the Configuration Management system, modification date, and author.<br>This block is included in the ORION library as the **Model_Info** block.  It contains the following info:<br>• Author<br>• Date Modified<br>• Version and Instance (controlled by the CM Synergy database)<br>• CSU name<br>• Current System Name<br>• Parent system Name<br>This block is automatically included in the CSU_template.mdl and in all new subsystems from the ORION Library.<br>Example:<br><br>ORION GN&C FSW — Export Controlled<br>Author: — Date Modified: 05-Jun-2009<br>version: 1.0.0 — instance: 1<br>CSU: CSU_template<br>System Name: CSU_template — Parent Name: Root |
| Rationale | □ Readability<br>☑ Workflow<br>□ Simulation<br>☑ Verification and Validation<br>☑ Code Generation |
| Last Change | V2.2 |

### 4.3.3.4 hyl_0114: Documentation of deviations to standards

| **ID: Title** | **hyl_0114: Documentation of deviations to standards** |
|---|---|
| Priority | Strongly recommended |
| Scope | ORION |
| MATLAB Version | All |
| MA Check | No |
| Prerequisites | hyl_0113: Notes on each page |
| Description | Any deviations from the standards **shall** be documented in the notes. |
| Rationale | ☑ Readability<br>☑ Workflow<br>□ Simulation<br>☑ Verification and Validation<br>□ Code Generation |
| Last Change | V2.0 |

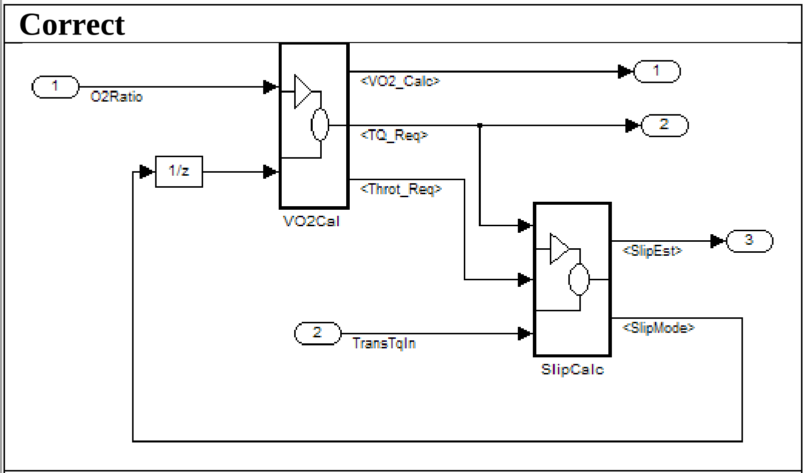
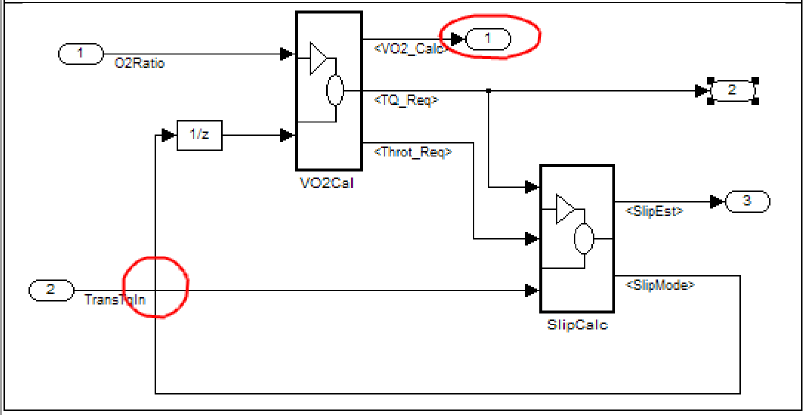
## 4.3.4 Inports and Outports

### 4.3.4.1 jc_0211: Usable characters for Inport block and Outport block

<table>
<tr><td><b>ID: Title</b></td><td><b>jc_0211: Usable characters for Inport block and Outport block</b></td></tr>
<tr><td>Priority</td><td>Strongly recommended</td></tr>
<tr><td>Scope</td><td>MAAB</td></tr>
<tr><td>MATLAB Version</td><td>All</td></tr>
<tr><td>MA Check</td><td>Yes</td></tr>
<tr><td>Prerequisites</td><td>None</td></tr>
<tr><td>Description</td><td>The names of all Inport blocks and Outport blocks should conform to the following constraints:
<table>
<tr><td>FORM</td><td><b>name</b>:<ul><li>should not start with a number</li><li>should not have blank spaces</li><li>carriage returns are not allowed</li></ul></td></tr>
<tr><td>ALLOWED CHARACTERS</td><td><b>name</b>:<br>a b c d e f g h i j k l m n o p q r s t u v w x y z<br>A B C D E F G H I J K L M N O P Q R S T U V W X Y Z<br>0 1 2 3 4 5 6 7 8 9 _</td></tr>
<tr><td>UNDERSCORES</td><td><b>name</b>:<ul><li>can use underscores to separate parts</li><li>cannot have more than one consecutive underscore</li><li>cannot start with an underscore</li><li>cannot end with an underscore</li></ul></td></tr>
</table></td></tr>
<tr><td>Rationale</td><td>☑ Readability ☐ Verification and Validation<br>☑ Workflow ☑ Code Generation<br>☐ Simulation</td></tr>
<tr><td>Last Change</td><td>V2.1</td></tr>
</table>

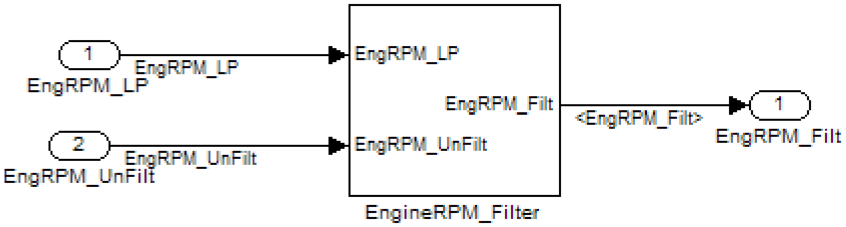
### 4.3.4.2 mdb_0042: Port block in Simulink models

| **ID: Title** | **mdb_0042: Port block in Simulink models** |
|---|---|
| Priority | Strongly recommended |
| Scope | ORION (modified MAAB db_0042) |
| MATLAB Version | All |
| MA Check | No |

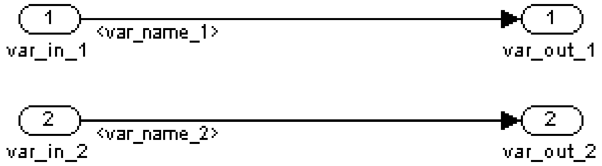
| | |
|---|---|
| Prerequisites | None |
| Description | In a Simulink model, the ports comply with the following rules:<br>• Inports should be placed on the left side of the diagram, but they can be moved in to prevent signal crossings.<br>• Outports should be placed on the right side, but they can be moved in to prevent signal crossings.<br>• Duplicate Inports shall not be used.<br>• Inputs and outputs should be left and right justified<br>**Correct**<br> 1<br>O2Ratio<br>1/z<br>VO2Cal<br><VO2_Calc><br>1<br><TQ_Req><br>2<br><Throt_Req><br><SlipEst><br>3<br><SlipMode><br>SlipCalc<br>2<br>TransTqIn<br>**Incorrect**<br> 1<br>O2Ratio<br><VO2_Calc><br>1<br><TQ_Req><br>2<br>1/z<br><Throt_Req><br>VO2Cal<br><SlipEst><br>3<br><SlipMode><br>2<br>TransTqIn<br>SlipCalc<br>Notes on the incorrect model<br>• Inport 2 should be moved in so it does not cross the feed back loop lines.<br>• Outport 1 should be moved to the right hand side of the diagram. |
| Rationale | ☑ Readability<br>☐ Workflow<br>☐ Simulation<br>☐ Verification and Validation<br>☐ Code Generation |
| Last Change | V2.0 |

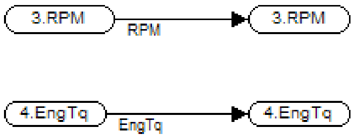
### 4.3.4.3 na_0005: Port block name visibility in Simulink models

| | |
|---|---|
| **ID: Title** | **na_0005: Port block name visibility in Simulink models** |
| Priority | Strongly recommended |

| | |
|---|---|
| Scope | MAAB |
| MATLAB Version | All |
| MA Check | Yes |
| Prerequisites | None |
| Description | The name of an Inport or Outport should not be hidden. ("Format / Hide Name" is not allowed.)<br><br> 1<br>EngRPM_LP<br>EngRPM_LP<br>2<br>EngRPM_UnFilt<br>EngRPM_UnFilt<br>EngRPM_LP<br>EngRPM_Filt<br>EngRPM_UnFilt<br>EngineRPM_Filter<br><EngRPM_Filt><br>1<br>EngRPM_Filt<br>Note: the correct setting is applied to the Inport and Outport blocks in the ORION Library. |
| Rationale | ☑ Readability<br>☐ Workflow<br>☐ Simulation<br>☐ Verification and Validation<br>☐ Code Generation |
| Last Change | V2.2 |

### 4.3.4.4 jc_0081: Icon display for Port block

| **ID: Title** | **jc_0081: Icon display for Port block** |
|---|---|
| Priority | Recommended |
| Scope | MAAB |
| MATLAB Version | R14 and later |
| MA Check | Yes |
| Prerequisites | None |
| Description | The ‘Icon display’ setting should be set to ‘Port number’ for Inport and Outport blocks.<br>**Correct**<br><br> 1<br>var_in_1<br><var_name_1><br>1<br>var_out_1<br>2<br>var_in_2<br><var_name_2><br>2<br>var_out_2<br>**Incorrect** |

| | |
|---|---|
| |  <br>Note: the correct setting is applied to the Inport and Outport blocks in the ORION Library. |
| Rationale | ☑ Readability<br>□ Workflow<br>□ Simulation<br>□ Verification and Validation<br>□ Code Generation |
| Last Change | V2.1 |

### 4.3.4.5 jm_0010: Port block names in Simulink models

| **ID: Title** | **jm_0010: Port block names in Simulink models** |
|---|---|
| Priority | Strongly recommended |
| Scope | MAAB |
| MATLAB Version | All |
| MA Check | Yes |
| Prerequisites | db_0042: Ports in Simulink models<br>na_0005: Port block name visibility in Simulink models<br>na_0009: Entry versus propagation of signal labels |
| Description | The names of Inport blocks and Outport blocks must match the corresponding signal or bus names.<br>**Exceptions:**<br>• When any combination of an Inport block, an Outport block, and any other block have the same block name, a suffix or prefix should be used on the Inport and Outport blocks.<br>• One common suffix is "_In" for Inports and "_Out" for Outports.<br>• Any suffix or prefix can be used on the ports, however the selected option should be consistent.<br>• Library blocks and reusable subsystems that encapsulate generic functionality. |
| Rationale | ☑ Readability<br>☑ Workflow<br>☑ Simulation<br>□ Verification and Validation<br>□ Code Generation |
| Last Change | V2.2 |

### 4.3.4.6 jh_0018: Variable type casting

| **ID: Title** | **jh_0018: Variable type casting** |
|---|---|
| Priority | Recommended |

| | |
|---|---|
| Scope | ORION |
| MATLAB Version | All |
| MA Check | No |
| Prerequisites | None |
| Description | All CSU top level inputs and outputs must be set to the appropriate Simulink bus object. The bus explicitly defines all of the attributes of the data including the type, dimension, and rate. This will ensure compatibility with the higher level empty box architecture.<br>Also, if model reference blocks are used within a CSU, the input and output data attributes should be explicitly defined in the ports (dimension, bus type, data type) |
| Rationale | ☐ Readability<br>☐ Workflow<br>☑ Simulation<br>☑ Verification and Validation<br>• Code Generation |
| Last Change | V1.0 |

## 4.3.5 Signals and Buses

Signal labels are used to make model functionality more understandable from the Simulink diagram. They can also be used to control the variable names used in simulation and code generation. Signal labels should be entered only once (at the point of signal origination). Often it is desirable to also display the signal name elsewhere in the model. In these cases, the signal name should be inherited until the signal is functionally transformed. (Passing a signal through an integrator is functionally transforming. Passing a signal through an Inport into a nested subsystem is not.) Once a named signal is functionally transformed, a new name should be associated with it.

Signals may be scalars, vectors, or buses. They may carry data or control flows. Unless explicitly stated otherwise, the following naming rules apply to all types of signals.

### 4.3.5.1 jc_0221: Usable characters for signal line name

| **ID: Title** | **jc_0221: Usable characters for signal line names** |
|---|---|
| Priority | Strongly recommended |
| Scope | MAAB |
| MATLAB Version | All |
| MA Check | Yes |
| Prerequisites | None |
| Description | All named signals should conform to the following constraints:<br>FORM \| **name**:<br>• should not start with a number |

| | | |
|---|---|---|
| | | • should not have blank spaces<br>• carriage returns are not allowed |
| | ALLOWED CHARACTERS | **name**:<br>a b c d e f g h i j k l m n o p q r s t u v w x y z<br>A B C D E F G H I J K L M N O P Q R S T U V W X Y Z<br>0 1 2 3 4 5 6 7 8 9 _ |
| | UNDERSCORES | **name**:<br>• can use underscores to separate parts<br>• cannot have more than one consecutive underscore<br>• cannot start with an underscore<br>• cannot end with an underscore |
| Rationale | ☑ Readability<br>☑ Workflow<br>☐ Simulation | ☐ Verification and Validation<br>☑ Code Generation |
| Last Change | V2.1 | |

## 4.3.5.2 jh_0040: Usable characters for Simulink Bus names

| **ID: Title** | **jh_0040: Usable characters for Simulink Bus Names** | |
|---|---|---|
| Priority | Strongly recommended | |
| Scope | MAAB | |
| MATLAB Version | All | |
| MA Check | Yes – this check is covered by jc_0221 | |
| Prerequisites | None | |
| Description | All Simulink Bus names should conform to the following constraints: | |
| | FORM | **name**:<br>• should not start with a number<br>• should not have blank spaces<br>• carriage returns are not allowed |
| | ALLOWED CHARACTERS | **name**:<br>a b c d e f g h i j k l m n o p q r s t u v w x y z<br>A B C D E F G H I J K L M N O P Q R S T U V W X Y Z<br>0 1 2 3 4 5 6 7 8 9 _ |
| | UNDERSCORES | **name**:<br>• can use underscores to separate parts<br>• cannot have more than one consecutive underscore<br>• cannot start with an underscore<br>• cannot end with an underscore |
| Rationale | ☑ Readability<br>☑ Workflow<br>☐ Simulation | ☐ Verification and Validation<br>☑ Code Generation |

| | |
|---|---|
| Last Change | V1.0 |

### 4.3.5.3 bn_0002: Signal name length limit

| | |
|---|---|
| **ID: Title** | **bn_0002: Signal name length limit** |
| Priority | Strongly recommended |
| Scope | ORION |
| MATLAB Version | All |
| MA Check | Yes |
| Prerequisites | jc_0221: Usable characters for signal line names |
| Description | The names of all signals must be unique. The Compiler limit of 32 characters must be observed when creating signal names that are used for variable names in code.<br>32 characters is the maximum limit<br>Example:<br>Signal_Value_Argument_Variable_Example - should be changed to<br>signal_Value_Argument_Variable_Ex |
| Rationale | ☑ Readability<br>☐ Workflow<br>☐ Simulation<br>☑ Verification and Validation<br>☑ Code Generation |
| Last Change | V2.2 |

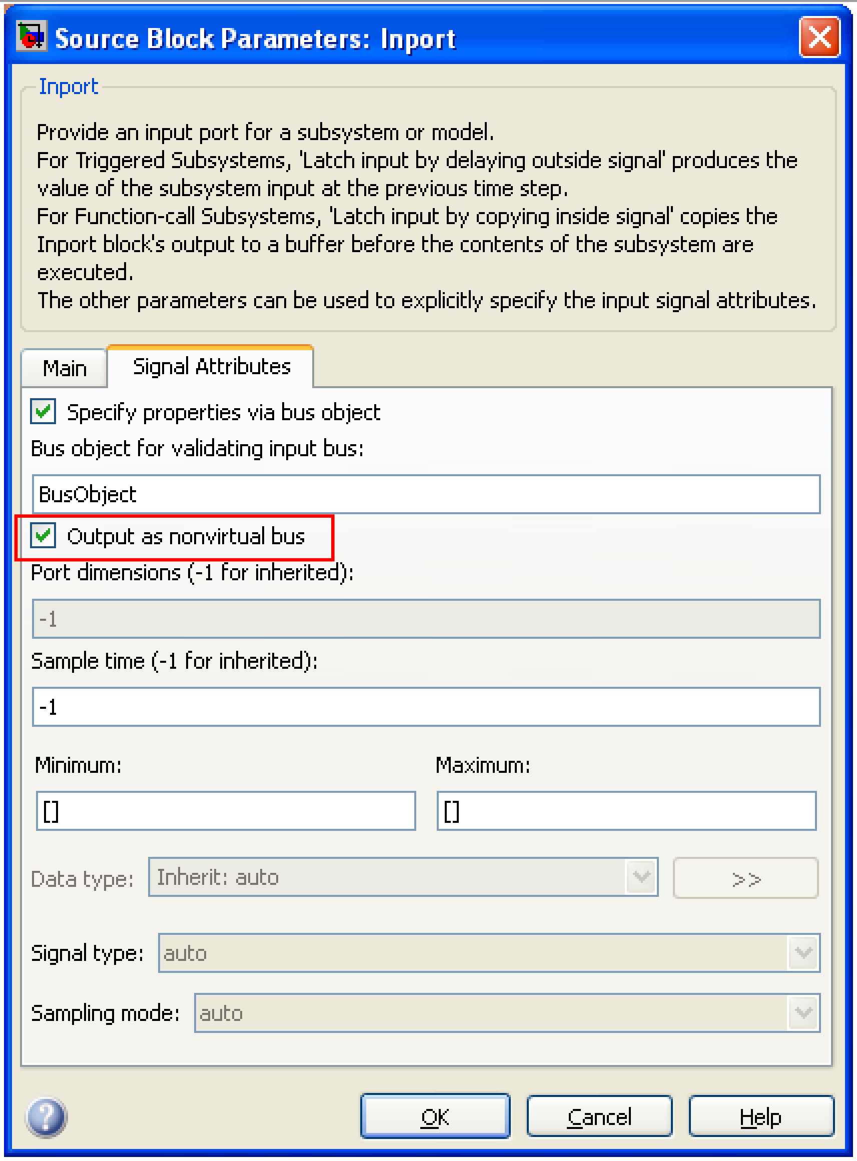
### 4.3.5.4 jh_0041: Simulink Bus Name Length Limit

| | |
|---|---|
| **ID: Title** | **jh_0041: Simulink Bus name length limit** |
| Priority | Strongly recommended |
| Scope | ORION |
| MATLAB Version | All |
| MA Check | Yes – this check is covered by bn_0002 |
| Prerequisites | jh_0040: Usable characters for Simulink Bus Names |
| Description | The names of all Buses must be unique for the entire software model unless the contents of the bus are identical. Bus names must start with a capital letter. The Compiler limit of 32 characters must be observed when creating signal names that are used for variable names in code.<br>32 characters is the maximum limit<br>Example:<br>BUS_Value_Argument_Variable_Example - should be changed to<br>BUS_Value_Argument_Variable_Ex |

| | |
|---|---|
| Rationale | ☑ Readability ☑ Verification and Validation<br>☐ Workflow ☑ Code Generation<br>☐ Simulation |
| Last Change | V1.1 |

### 4.3.5.5 jh_0051: Simulink Bus Format

| **ID: Title** | **jh_0051: Simulink Bus Format** |
|---|---|
| Priority | Mandatory |
| Scope | ORION |
| MATLAB Version | All |
| MA Check | Yes |
| Prerequisites | jh_0040: Usable characters for Simulink Bus Names |
| Description | The root level of a CSU should have 2 inports and 1 outport and follow the following standard:<br><br>Input port and bus object name:<br>• <3 letter Domain abb.>_<CSU abb.>_IN<br>Input parameter port and bus object name:<br>• <3 letter Domain abb.>_<CSU abb.>_PRM<br>Output port and bus object name:<br>• <3 letter Domain abb.>_<CSU abb.>_OUT<br>Internal bus object name (these are buses that are not used outside of the CSU):<br>• <3 letter Domain abb.>_<CSU abb.>_<your_internal_bus_name><br><br>The script that loads the CSU input, output, and parameter buses to the workspace should use the following naming convention:<br>• loadCSUBuses_<3 letter Domain abb>_<CSU abb>.m<br>The script that loads the internal bus to the workspace should use the following naming convention:<br>• loadIntlBuses_<3 letter Domain abb>_<CSU abb>.m<br><br>The top level IO ports should be set to non-virtual to ensure that the bus structure is retained in the autocode.  The following diagram shows the dialog box for an input port with the “Output as non-virtual bus” option checked.  Version 2.0 of the Orion Library has this option set by default for the input ports/output ports/ and bus creator blocks. |



Source Block Parameters: Inport

Inport

Provide an input port for a subsystem or model.
For Triggered Subsystems, 'Latch input by delaying outside signal' produces the value of the subsystem input at the previous time step.
For Function-call Subsystems, 'Latch input by copying inside signal' copies the Inport block's output to a buffer before the contents of the subsystem are executed.
The other parameters can be used to explicitly specify the input signal attributes.

Main | Signal Attributes

☑ Specify properties via bus object

Bus object for validating input bus: BusObject

☑ Output as nonvirtual bus

Port dimensions (-1 for inherited): -1

Sample time (-1 for inherited): -1

Minimum: []

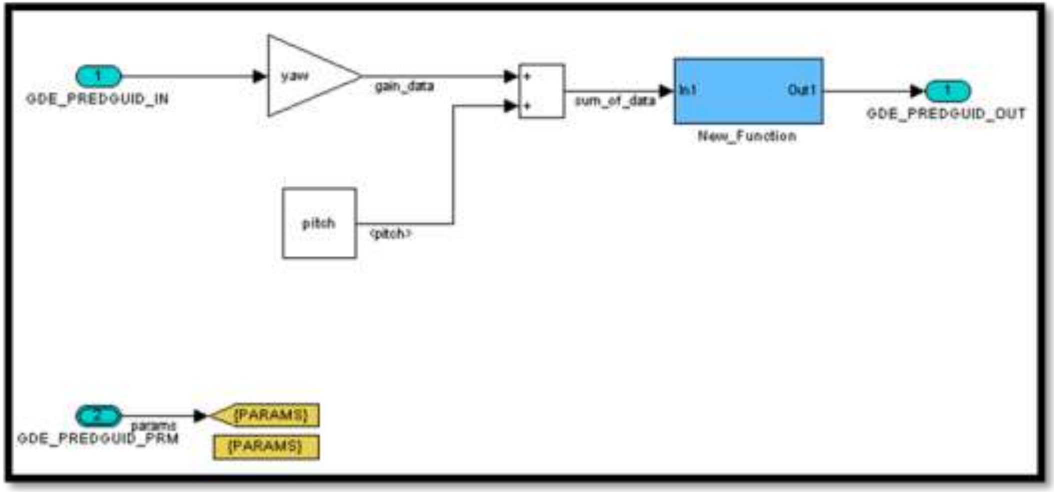
Maximum: []

Data type: Inherit: auto

Signal type: auto

Sampling mode: auto

Example of root level of CSU model – the IN/OUT/PRM ports are shown:



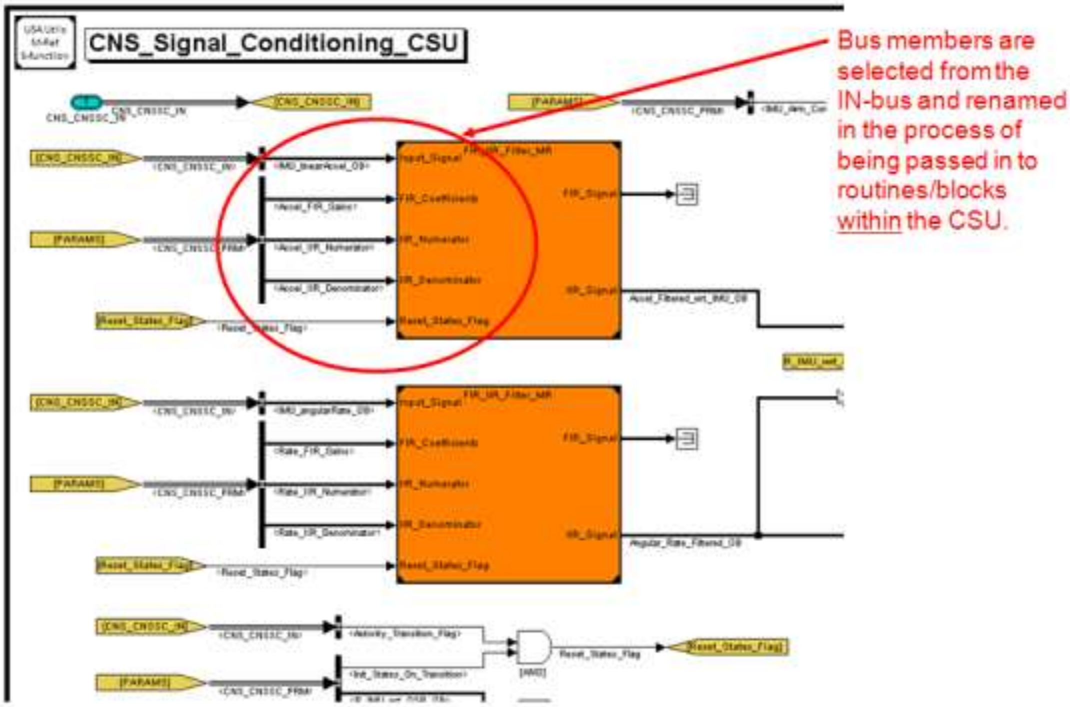
| | |
|---|---|
| | Large Simulink Buses should contain nested buses to improve data organization similar to that of structured data.  Organizing the buses into nested buses greatly increases the accessibility of the data.<br><br>**Warning:  when using nested buses do not name the element the same name as the bus type.  This will cause errors in the autocode.  Also, the element name and bus type should not differentiate on case alone.**<br><br>For example:<br><br>A quaternion Bus may consist of the following signals:<br><br>BUS_quat_dbl:<br>• s (1x1) double<br>• v (3x1) double<br><br>The input bus may contain multiple quaternions as following:<br>BUS_Input<br>• Input_data (3x3) double<br>• quat1(BUS_quat_dbl)<br>• quat2(BUS_quat_dbl)<br><br>Note:  The ORION Library uses the following buses for quaternion and euler math.  These buses are automatically loaded when the library is used.<br>• BUS_euler_dbl:<br>  ○ yaw:  (1x1) double<br>  ○ pitch:  (1x1) double<br>  ○ roll:  (1x1) double<br>  ○ sequence: (1x1) int32<br>• BUS_euler_sgl:<br>  ○ yaw:  (1x1) single<br>  ○ pitch:  (1x1) single<br>  ○ roll:  (1x1) single<br>  ○ sequence: (1x1) int32<br>• BUS_quat_dbl:<br>  ○ s: (1x1) double<br>  ○ v: (1x1) double<br>• BUS_quat_sgl:<br>  ○ s: (1x1) single<br>  ○ v: (1x1) single |
| Rationale | ☑ Readability ☑ Verification and Validation<br>☑ Workflow ☑ Code Generation<br>☐ Simulation |
| Last Change | V1.3 |

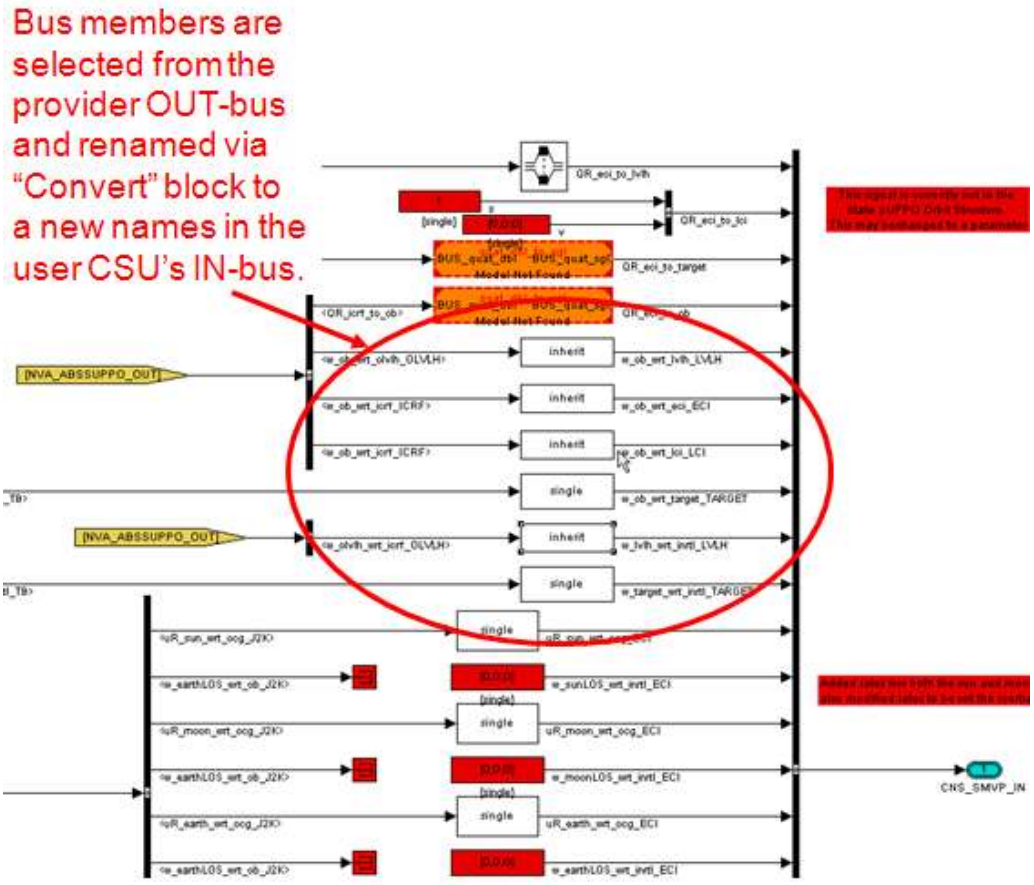
### 4.3.5.6 dm_0001: Signal and Bus Element Naming Convention

| **ID: Title** | **dm_0001: Signal and Bus Element Naming Convention** |
|---|---|
| Priority | Strongly recommended |
| Scope | ORION |
| MATLAB Version | All |
| MA Check | No |
| Prerequisites | |
| Description | Signal and Bus Element names shall adhere to the following convention:<br>• The first letter of each word contained in a signal or bus element name shall be capitalized.<br>• Each word contained within a signal or bus element name shall be separated with a single underscore or with no space at all.<br>• For multi-word signal or bus element names the first letter of second and subsequent words shall be capitalized (example: Multi_Word_Identifier or MultiWordIdentifier).<br>• Blank characters shall not be used to separate words use to form signal or bus element names.<br>• When a signal or bus element name contains an acronym, the acronym should be represented in uppercase letters (upper case capitalization).<br><br>Note: This does not apply to the common quaternion and euler buses used by blocks in the ORION Library. |
| Rationale | ☑ Readability ☐ Verification and Validation<br>☐ Workflow ☑ Code Generation<br>☐ Simulation |
| Last Change | V1.3 |

### 4.3.5.7 mj_0001: CSU Input Bus Naming

| **ID: Title** | **mj_0001: CSU input Bus Naming** |
|---|---|
| Priority | Recommended |
| Scope | ORION |
| MATLAB Version | All |
| MA Check | No |
| Prerequisites | jh_0051: Simulink Bus Format |
| Description | CSU input bus types should have field names identical to their upstream CSU output bus field names whenever possible. This facilitates traceability and reduces error potential. Exceptions may be made on a case by case basis to keep CSUs generic or for other reasons. Variable name changes inside of CSUs are permissible at the CSU developer’s discretion. |

| | |
|---|---|
| | Example of acceptable internal signal name changes with selected CSU inputs feeding subsystems with differing input port names:<br><br> CNS_Signal_Conditioning_CSU<br>CNS_CNSSC_IN<br>[CNS_CNSSC_IN]<br>[PARAMS]<br>&lt;CNS_CNSSC_IN&gt;<br>&lt;CNS_CNSSC_PRM&gt;<br>&lt;IMU_linearAccel_O9&gt;<br>&lt;Accel_FIR_Gains&gt;<br>&lt;Accel_IIR_Numerator&gt;<br>&lt;Accel_IIR_Denominator&gt;<br>[Reset_States_Flag]<br>&lt;Reset_States_Flag&gt;<br>FIR_IIR_Filter_MR<br>Input_Signal<br>FIR_Coefficients<br>IIR_Numerator<br>IIR_Denominator<br>Reset_States_Flag<br>FIR_Signal<br>IIR_Signal<br>Accel_Filtered_wrt_IMU_O9<br>&lt;IMU_angularRate_O9&gt;<br>&lt;Rate_FIR_Gains&gt;<br>&lt;Rate_IIR_Numerator&gt;<br>&lt;Rate_IIR_Denominator&gt;<br>Angular_Rate_Filtered_O9<br>&lt;Activity_Transition_Flag&gt;<br>&lt;Init_States_On_Transition&gt;<br>[AND]<br>Reset_States_Flag<br>Bus members are selected from the IN-bus and renamed in the process of being passed in to routines/blocks within the CSU.<br>Do not change the variable names at the Junction Box Level (shown below) |

| | |
|---|---|
| | <br>Bus members are selected from the provider OUT-bus and renamed via "Convert" block to a new names in the user CSU's IN-bus.<br> QR_eci_to_lvlh<br>[single]<br>QR_eci_to_lci<br>BUS_quat_dbl BUS_quat_sgl<br>Model Not Found<br>QR_eci_to_target<br><QR_icrf_to_ob><br>[NVA_ABSSUPPO_OUT]<br><w_ob_wrt_olvlh_OLVLH><br>inherit<br>w_ob_wrt_lvlh_LVLH<br><w_ob_wrt_icrf_ICRF><br>w_ob_wrt_eci_ECI<br>w_ob_wrt_lci_LCI<br>_TB><br>single<br>w_ob_wrt_target_TARGET<br><w_olvlh_wrt_icrf_OLVLH><br>w_lvlh_wrt_invtl_LVLH<br>w_target_wrt_invtl_TARGET<br><uR_sun_wrt_ocg_J2K><br><w_earthLOS_wrt_ob_J2K><br>w_sunLOS_wrt_invtl_ECI<br><uR_moon_wrt_ocg_J2K><br>uR_moon_wrt_ocg_ECI<br>w_moonLOS_wrt_invtl_ECI<br>CNS_SMVP_IN<br><uR_earth_wrt_ocg_J2K><br>uR_earth_wrt_ocg_ECI<br>w_earthLOS_wrt_invtl_ECI |
| Rationale | ☑ Readability ☐ Verification and Validation<br>☐ Workflow ☑ Code Generation<br>☐ Simulation |
| Last Change | V1.0 |

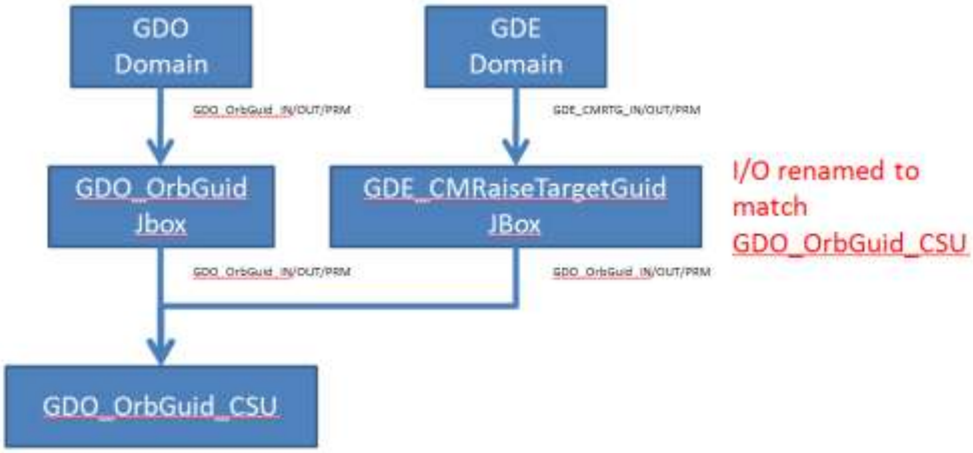
### 4.3.5.8 jh_0111: Bus Ordering and Alignment

| | |
|---|---|
| **ID: Title** | **jh_0111: Bus Ordering and Alignment** |
| Priority | Mandatory |
| Scope | ORION |
| MATLAB Version | All |
| MA Check | No |
| Prerequisites | jh_0051: Simulink Bus Format |
| Description | All elements in a Simulink Bus should be ordered largest to smallest to prevent data from overlapping a 32-bit boundary. This restriction is related to a limitation on the target processor that must be realized in the source of the autocode to prevent issues.<br><br>Bus must be ordered based on data type in descending order of size, i.e. double > |

| | |
|---|---|
| | single > uint32 > uint16 > uint8 (Boolean is treated like an uint8).<br><br>For Example, the following bus will correctly fall on 32-bit boundary.<br>float a;<br>float b<br>uint8 c[3];<br><br>However, this bus will not:<br>float a;<br>uint8 c[3];<br>float b; |
| Rationale | ☐ Readability<br>☐ Workflow<br>☐ Simulation<br>☐ Verification and Validation<br>☑ Code Generation |
| Last Change | V1.0 |

### 4.3.5.9 jh_0117: Shared CSUs Across Domains

| **ID: Title** | **jh_0117: Shared CSUs Across Domains** |
|---|---|
| Priority | Mandatory |
| Scope | ORION |
| MATLAB Version | All |
| MA Check | No |
| Prerequisites | jh_0051: Simulink Bus Format |
| Description | In some rare cases, a CSU may be used in more than one domain. This CSU will perform the same function in each CSU and is not modified in any way.<br><br>If this is the case one of the domains should be selected as the owner of the CSU. The CSU will be named using the domain prefix of the parent Domain. In the other/non-owner Domain, the CSU is referenced in a Junction box with I/O/PRM naming specific to the domain and function of the CSU. Within this Junction box, the signals will be renamed to correspond to the naming convention of the referenced CSU model:<br><br>**Note**: The configuration set of the CSU must be set to use "**CSUCfgSetMR**". This will ensure that the code produced for the CSU can be called from multiple domains.<br><br>Example:<br><br>The GDO_OrbGuid_CSU is used within both the GDO and GDE domains. The GDO domain is chosen as the parent. The I/O/PRM naming is tied to the GDO Domain: |

| | |
|---|---|
| | • GDO_OrbGuid_IN<br>• GDO_OrbGuid_OUT<br>• GDO_OrbGuid_PRM<br><br>For this CSU to be used in the GDE Domain, a separate CSU naming scheme must be used for the Junction box.  In this case, the new name is GDE_CMRaiseTargetGuid. The I/O/PRM naming entering and leaving the Junction box is as follows:<br><br>• GDE_CMRTG_IN<br>• GDE_ CMRTG _OUT<br>• GDE_ CMRTG _PRM<br><br>Within the Junction box, the buses are renamed to match that of the GDO_OrbGuid I/O/PRM.<br><br>• GDE_ CMRTG _IN renamed to GDO_OrbGuid_IN<br>• GDE_ CMRTG _OUT renamed to GDO_OrbGuid_OUT<br>• GDE_ CMRTG _PRM renamed to GDO_OrbGuid_PRM<br><br><br> GDO Domain<br>GDE Domain<br>GDO_OrbGuid_IN/OUT/PRM<br>GDE_CMRTG_IN/OUT/PRM<br>GDO_OrbGuid Jbox<br>GDE_CMRaiseTargetGuid JBox<br>I/O renamed to match GDO_OrbGuid_CSU<br>GDO_OrbGuid_IN/OUT/PRM<br>GDO_OrbGuid_IN/OUT/PRM<br>GDO_OrbGuid_CSU<br><br>This approach will ensure full CSU code reusability across domains. |
| Rationale | ☑ Readability<br>☑ Workflow<br>☑ Simulation<br>☐ Verification and Validation<br>☑ Code Generation |
| Last Change | V1.0 |

### 4.3.5.10 na_0010: Grouping data flows into signals

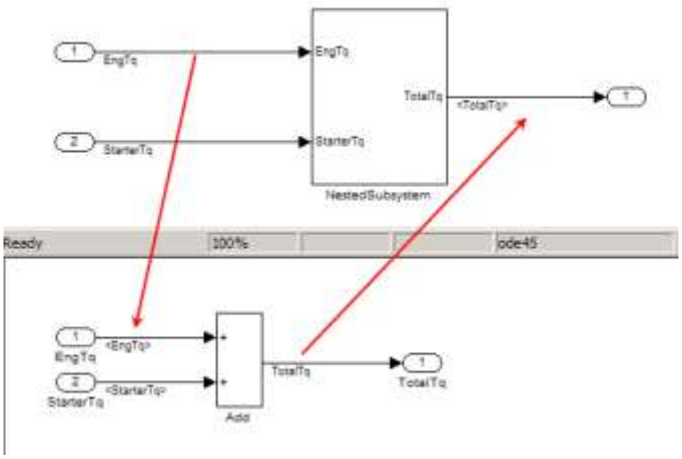
| **ID: Title** | **na_0010: Grouping data flows into signals** |
|---|---|

<table>
<tr><td>Priority</td><td>Strongly recommended</td></tr>
<tr><td>Scope</td><td>MAAB</td></tr>
<tr><td>MATLAB Version</td><td>All</td></tr>
<tr><td>MA Check</td><td>Yes</td></tr>
<tr><td>Prerequisites</td><td>None</td></tr>
<tr><td>Description</td><td>Vectors<br>The individual scalar signals composing a vector must have common functionality, data types, dimensions and units. The most common example of a vector signal is sensor or actuator data that is grouped into an array indexed by location. The output of a Mux block must always be a vector. The inputs to a Mux block must always be scalars.<br><br>All vectors must be **Column** vectors (nx1)<br><br>Buses<br>Signals that do not meet the vectorization criteria described above must only be grouped into bus signals. Bus selector blocks may only be used with a bus signal input; they must not be used to extract scalar signals from vector signals.<br><br>Examples<br>Some examples of vector signals include:
<table>
<tr><th>Vector type</th><th>Size</th></tr>
<tr><td>Column vector</td><td>[n 1]</td></tr>
<tr><td>Wheel speed vector</td><td>[Number of wheels 1]</td></tr>
<tr><td>Cylinder vector</td><td>[Number of cylinders 1]</td></tr>
<tr><td>Position vector based on 2-D coordinates</td><td>[2 1]</td></tr>
<tr><td>Position vector based on 3-D coordinates</td><td>[3 1]</td></tr>
</table>
<br>Some examples of bus signals include:
<table>
<tr><th>Bus Type</th><th>Elements</th></tr>
<tr><td rowspan="5">**Sensor Bus**</td><td>Force Vector [Fx; Fy; Fz]</td></tr>
<tr><td>Position</td></tr>
<tr><td>Wheel Speed Vector $[\Theta_{lf} ; \Theta_{rf} ; \Theta_{lr} ; \Theta_{rr}]$</td></tr>
<tr><td>Acceleration</td></tr>
<tr><td>Pressure</td></tr>
<tr><td rowspan="2">**Controller Bus**</td><td>Sensor Bus</td></tr>
<tr><td>Actuator Bus</td></tr>
<tr><td>**Serial Data Bus**</td><td>Coolant Temperature</td></tr>
</table>
</td></tr>
</table>

| | |
|---|---|
| | Engine Speed,<br>Passenger Door Open |
| Rationale | ☑ Readability<br>☑ Workflow<br>☐ Simulation<br>☐ Verification and Validation<br>☑ Code Generation |
| Last Change | V2.1 |

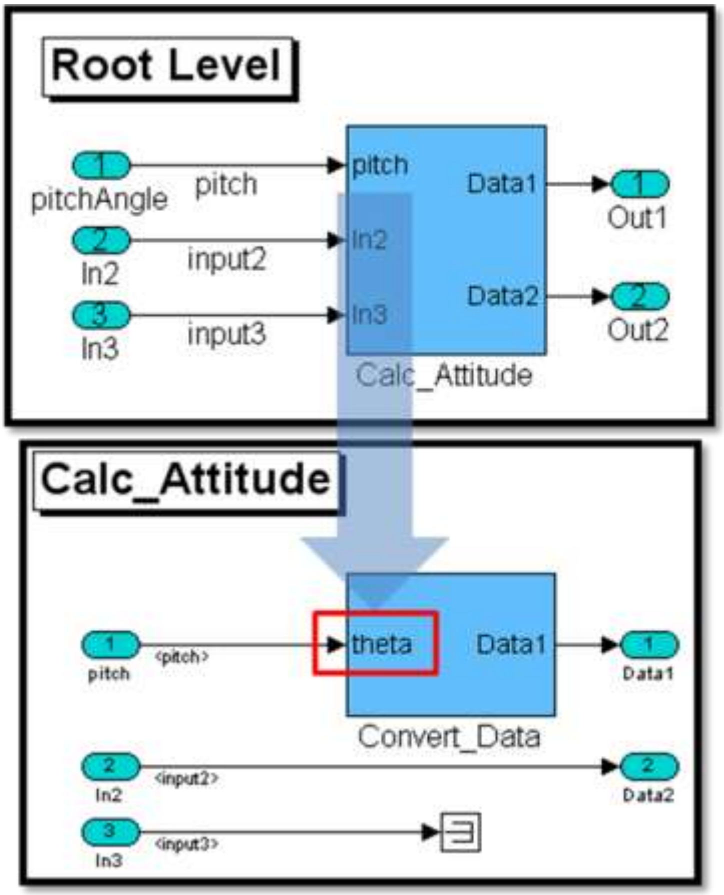
### 4.3.5.11 na_0009: Entry versus propagation of signal labels

| **ID: Title** | **na_0009: Entry versus propagation of signal labels** |
|---|---|
| Priority | Strongly recommended |
| Scope | MAAB |
| MATLAB Version | All |
| MA Check | Yes |
| Prerequisites | na_0008: Display of labels on signals |
| Description | If a label is present on a signal, the following rules define whether that label shall be created there (entered directly on the signal) or propagated from its true source (inherited from elsewhere in the model by using the ‘<’ character).<br>1. Any displayed signal label must be *entered* for signals that:<br>a. Originate from an Inport at the Root (top) Level of a model<br>b. Originate from a basic block that performs a transformative operation (For the purpose of interpreting this rule only, the Bus Creator block, Mux block and Selector block shall be considered to be included among the blocks that perform transformative operations.)<br>2. Any displayed signal label must be *propagated* for signals that:<br>a. Originate from an Inport block in a nested subsystem<br>**Exception:** If the nested subsystem is a library subsystem, a label may be *entered* on the signal coming from the Inport to accommodate reuse of the library block.<br>b. Originate from a basic block that performs a non-transformative operation<br>c. Originate from a Subsystem or Stateflow chart block<br>**Exception:** If the connection originates from the output of a library subsystem block instance, a new label may be *entered* on the signal to accommodate reuse of the library block. |

|  |  |
|---|---|
|  |  1<br>EngTq<br>2<br>StarterTq<br>EngTq<br>StarterTq<br>TotalTq<br><TotalTq><br>1<br>NestedSubsystem<br>Ready<br>100%<br>ode45<br>1<br><EngTq><br>EngTq<br>2<br><StarterTq><br>StarterTq<br>+<br>+<br>Add<br>TotalTq<br>1<br>TotalTq |
| Rationale | ☑ Readability<br>☑ Workflow<br>☐ Simulation<br>☑ Verification and Validation<br>☑ Code Generation |
| Last Change | V2.0 |

## 4.3.5.12 hyl_0311: Naming of signals passed through multiple subsystems

|  |  |
|---|---|
| **ID: Title** | **hyl_0311: Naming of signals passed through multiple subsystems** |
| Priority | Strongly recommended |
| Scope | ORION |
| MATLAB Version | All |
| MA Check | Yes |
| Prerequisites | None |
| Description | Names of inports/outports should not change between a subsystem and its parent, with the allowable exception that the first layer of subsystems may change a top-level in/out name (at the CSU root level). If such a change is performed, all first layer subsystems **shall** use the same name change for consistency. [Example: A signal called "pitchAngle" can be input, and changed to "pitch" on a 1st subsystem layer, but you cannot change this name to "theta" in a lower subsystem.] This standard is completed for convenience within the model.<br>Example:<br>**Incorrect** |

| | |
|---|---|
| |  Root Level<br>1<br>pitchAngle<br>pitch<br>2<br>In2<br>input2<br>3<br>In3<br>input3<br>pitch<br>In2<br>In3<br>Data1<br>Data2<br>Calc_Attitude<br>1<br>Out1<br>2<br>Out2<br>Calc_Attitude<br>1<br>pitch<br>&lt;pitch&gt;<br>theta<br>Data1<br>Convert_Data<br>1<br>Data1<br>2<br>In2<br>&lt;input2&gt;<br>2<br>Data2<br>3<br>In3<br>&lt;input3&gt; |
| Rationale | ☑ Readability<br>☑ Workflow<br>☐ Simulation<br>☑ Verification and Validation<br>☐ Code Generation |
| Last Change | V2.1 |

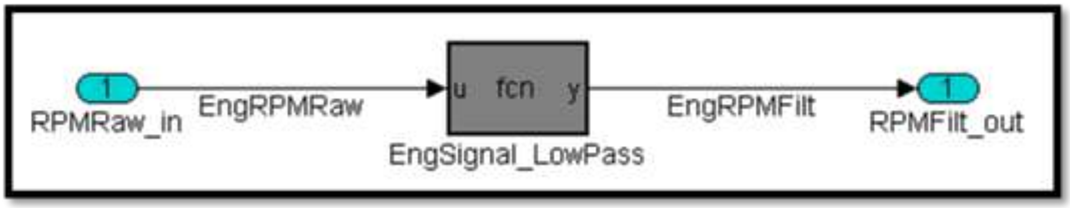
### 4.3.5.13 na_0008: Display of labels on signals

| **ID: Title** | **na_0008: Display of labels on signals** |
|---|---|
| Priority | Recommended |
| Scope | MAAB |
| MATLAB Version | All |
| MA Check | Yes |
| Prerequisites | None |

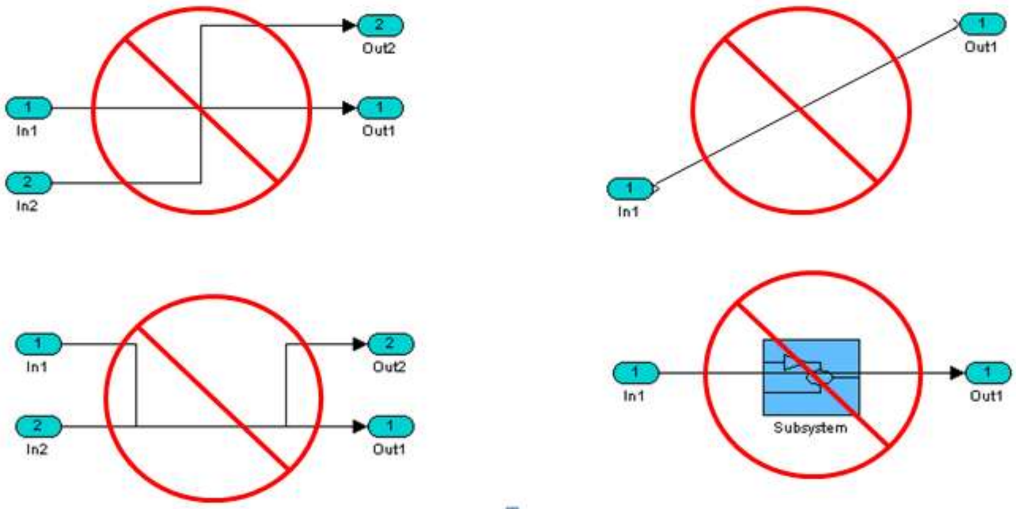
| | |
|---|---|
| Description | A label must be displayed on any signal originating from the following blocks:<br>• Inport block<br>• From block (block icon exception applies – see Note below)<br>• Subsystem block or Stateflow chart block (block icon exception applies)<br>• Bus Selector block (signal labels are automatic)<br>• Demux block<br>• Selector block<br>A label must be displayed on any signal connected to the following destination blocks (directly or via a basic block that performs a non transformative operation):<br>• Outport block<br>• Goto block<br>• Bus Creator block<br>• Mux block<br>• Subsystem block<br>• Chart block<br>• Embedded Matlab Block<br>Note: Block icon exception (applicable only where called out above): If the signal label is visible in the originating block icon display, the connected signal need not also have the label displayed *unless* the signal label is needed elsewhere due to a destination-based rule.<br>In addition, a label *may* be displayed on any other signal of interest to the user. |
| Rationale | ☑ Readability ☑ Verification and Validation<br>☑ Workflow ☑ Code Generation<br>□ Simulation |
| Last Change | V2.1 |

### 4.3.5.14 db_0097: Position of labels for signals and buses

| **ID: Title** | **db_0097: Position of labels for signals and buses** |
|---|---|
| Priority | Strongly recommended |
| Scope | MAAB |
| MATLAB Version | All |
| MA Check | No |
| Prerequisites | None |
| Description | The labels must be visually associated with the corresponding signal and not overlap other labels, signals or blocks. |

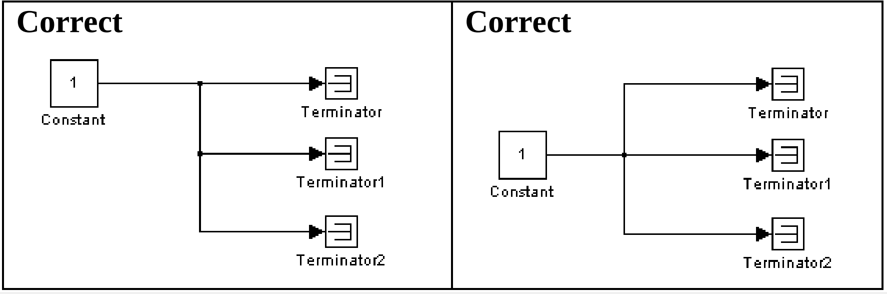
| | |
|---|---|
| | Labels should be located consistently below horizontal lines and close to the corresponding source or destination block.<br><br>Correct:<br><br> 1<br>RPMRaw_in<br>EngRPMRaw<br>u<br>fcn<br>y<br>EngSignal_LowPass<br>EngRPMFilt<br>1<br>RPMFilt_out |
| Rationale | ☑ Readability<br>☑ Workflow<br>☐ Simulation<br>☐ Verification and Validation<br>☐ Code Generation |
| Last Change | V2.0 |

### 4.3.5.15 hyl_0110: Branching line format

| **ID: Title** | **hyl_0110: Branching line format** |
|---|---|
| Priority | Strongly recommended |
| Scope | ORION |
| MATLAB Version | All |
| MA Check | No |
| Prerequisites | None |
| Description | All branch lines **shall** have a "solder-joint" showing the connection point. Line branches should be made as short as possible, avoid crossing other lines as much as possible and not cut across blocks.<br><br>**Examples of Incorrect Signal Line Usage**<br><br> 2<br>Out2<br>1<br>In1<br>1<br>Out1<br>2<br>In2<br>1<br>Out1<br>1<br>In1<br>1<br>In1<br>2<br>Out2<br>2<br>In2<br>1<br>Out1<br>1<br>In1<br>Subsystem<br>1<br>Out1 |

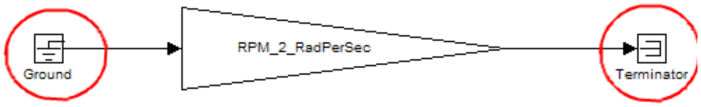
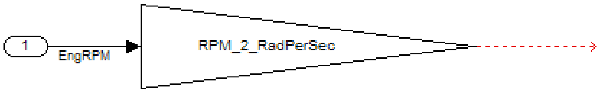
| | |
|---|---|
| Rationale | ☑ Readability<br>☐ Workflow<br>☐ Simulation<br>☐ Verification and Validation<br>☐ Code Generation |
| Last Change | V2.1 |

### 4.3.5.16 mdb_0032: Simulink signal appearance

| **ID: Title** | **mdb_0032: Simulink signal appearance** |
|---|---|
| Priority | Strongly recommended |
| Scope | ORION (modified MAAB db_0032) |
| MATLAB Version | All |
| MA Check | No |
| Prerequisites | None |
| Description | Signal lines<br>• Should not cross each other, if possible.<br>• Are drawn with right angles.<br>• Are not drawn one upon the other.<br>• Do not cross any blocks.<br>• Can be split into two or three sub lines at a single branching point<br><br>**Correct**<br>**Correct**<br> 1<br>Constant<br>Terminator<br>Terminator1<br>Terminator2<br>1<br>Constant<br>Terminator<br>Terminator1<br>Terminator2 |
| Rationale | ☑ Readability<br>☑ Workflow<br>☐ Simulation<br>☐ Verification and Validation<br>☐ Code Generation |
| Last Change | V2.0 |

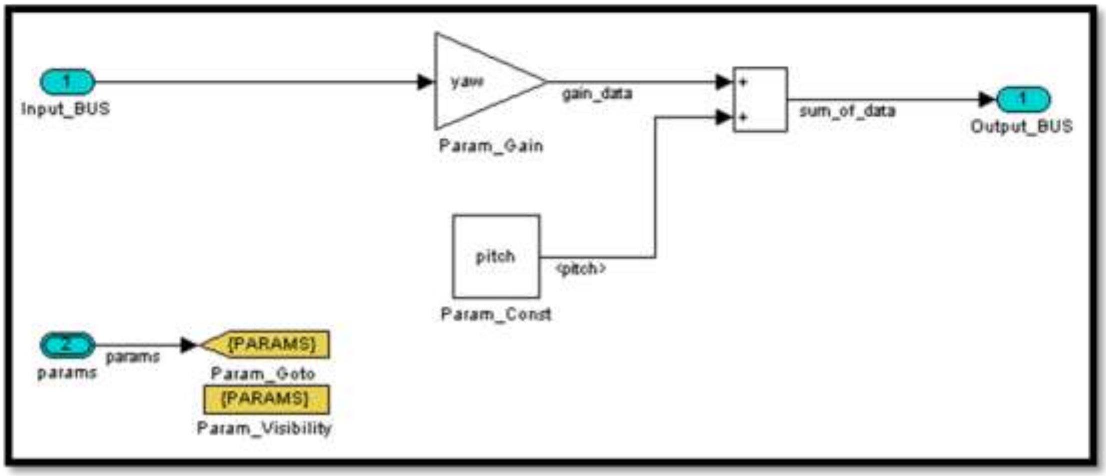
### 4.3.5.17 db_0081: Unconnected signals, block inputs and block outputs

| **ID: Title** | **db_0081: Unconnected signals, block inputs and block outputs** |
|---|---|
| Priority | Mandatory |
| Scope | MAAB |
| MATLAB Version | All |
| MA Check | Yes |
| Prerequisites | None |
| Description | A system must not have any: |

| | |
|---|---|
| | • Unconnected subsystem or basic block inputs.<br>• Unconnected subsystem or basic block outputs<br>• Unconnected signal lines<br>• An otherwise unconnected input should be connected to a ground block<br>• An otherwise unconnected output should be connected to a terminator block<br>**Correct**<br> <br>**Incorrect**<br> |
| Rationale | ☑ Readability<br>☑ Workflow<br>☐ Simulation<br>☑ Verification and Validation<br>☐ Code Generation |
| Last Change | V2.0 |

### 4.3.5.18 jh_0061: Use of Parameters

| **ID: Title** | **jh_0061: Use of Parameters** |
|---|---|
| Priority | Mandatory |
| Scope | ORION |
| MATLAB Version | All |
| MA Check | No |
| Prerequisites | None |
| Description | Parameters may be accessed without connecting signal lines throughout the CSU model. The following blocks make up the Parameter interface for the ORION Library:<br>• Param_Gain<br>• Param_Const<br>• Param_Goto<br>• Param_Visibility<br>• Param_From<br>The data on the parameter bus can be accessed by using the Param_Gain, Param_Const, and Param_Goto blocks. The Param_Gain and Param_Const let you select any data that is on the Parameter bus directly without using a bus selector and connecting the signal line to the root level. |

|  |  |
|---|---|
|  | The example below shows how the parameter input bus should be used. It is connected directly to a Goto block that is visible throughout the entire CSU model.<br><br> 1<br>Input_BUS<br>yaw<br>Param_Gain<br>gain_data<br>+<br>+<br>sum_of_data<br>1<br>Output_BUS<br>pitch<br><pitch><br>Param_Const<br>2<br>params<br>params<br>[PARAMS]<br>Param_Goto<br>[PARAMS]<br>Param_Visibility<br>Note: the Param_Visibility block does not pass through model reference blocks or atomic subsystems. To use data from the parameter bus in these systems, it must be taken as an input using the Param_From block. |
| Rationale | ☑ Readability<br>□ Workflow<br>□ Simulation<br>□ Verification and Validation<br>□ Code Generation |
| Last Change | V1.0 |

### 4.3.6 Blocks

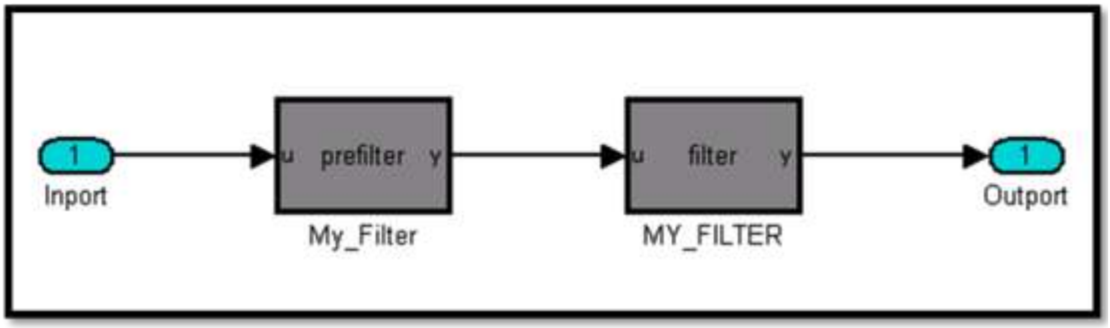
This section generically applies to individual blocks that are used in the models.

#### 4.3.6.1 hyl_0302: Usable characters for Block Names

| **ID: Title** | **hyl_0302: Usable characters for block names** |
|---|---|
| Priority | Strongly recommended |
| Scope | ORION |
| MATLAB Version | All |
| MA Check | Yes |
| Prerequisites | jc_0201: Usable characters for Subsystem names |
| Description | All named blocks should conform to the following constraints:<br>FORM — **name**:<br>• should not start with a number<br>• should not have blank spaces<br>• carriage returns are not allowed |

| | | |
|---|---|---|
| | ALLOWED CHARACTERS | **name**:<br>a b c d e f g h i j k l m n o p q r s t u v w x y z<br>A B C D E F G H I J K L M N O P Q R S T U V W X Y Z<br>0 1 2 3 4 5 6 7 8 9 _ |
| | UNDERSCORES | **name**:<br>• can use underscores to separate parts<br>• cannot have more than one consecutive underscore<br>• cannot start with an underscore<br>• cannot end with an underscore |
| Rationale | ☑ Readability<br>☑ Workflow<br>☐ Simulation<br>☐ Verification and Validation<br>☑ Code Generation | |
| Last Change | V2.0 | |

### 4.3.6.2 hyl_0305: Block name uniqueness

| **ID: Title** | **hyl_0305: Block name uniqueness** |
|---|---|
| Priority | Strongly recommended |
| Scope | ORION |
| MATLAB Version | All |
| MA Check | Yes |
| Prerequisites | None |
| Description | Block names **shall** not be made unique by using case.<br>Example:<br>**Incorect**<br> 1<br>Inport<br>u<br>prefilter<br>y<br>My_Filter<br>u<br>filter<br>y<br>MY_FILTER<br>1<br>Outport |
| Rationale | ☑ Readability<br>☐ Workflow<br>☐ Simulation<br>☐ Verification and Validation<br>☑ Code Generation |

| | |
|---|---|
| Last Change | V2.1 |

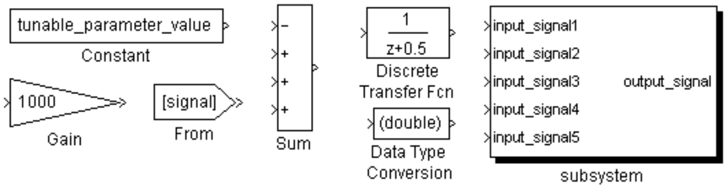
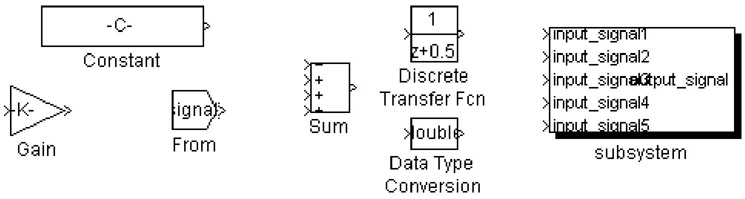
### 4.3.6.3 hyl_0309: Block name usage

| **ID: Title** | **hyl_0309: Block name usage** |
|---|---|
| Priority | Recommended |
| Scope | ORION |
| MATLAB Version | All |
| MA Check | No |
| Prerequisites | None |
| Description | Block names may be left as the default name (i.e., "greaterThan"), but if a better name is available, the user is encouraged to use it. It is desirable for the blocks to be named with the intent rather than the value. For example, it would be better to name a constant with the value of zero “initialSelection” than to name it “zero”. |
| Rationale | ☑ Readability ☑ Verification and Validation<br>☐ Workflow ☑ Code Generation<br>☐ Simulation |
| Last Change | V2.1 |

### 4.3.6.4 jh_0062: Constant Block Naming

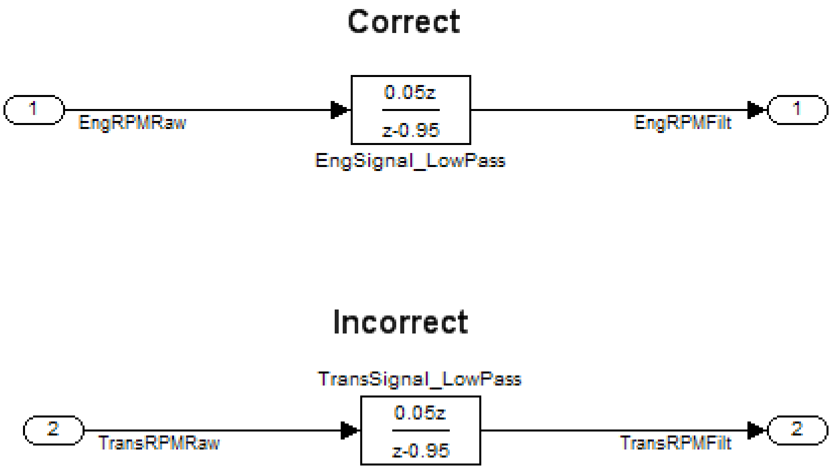
| **ID: Title** | **jh_0062: Constant Block Naming** |
|---|---|
| Priority | Strongly Recommended |
| Scope | ORION |
| MATLAB Version | All |
| MA Check | Yes |
| Prerequisites | None |
| Description | Constant blocks should be named according to the data that they contain. This will aid in the traceability of the autocode produced.<br>Note: this standard does not apply to the Param_Const block. |
| Rationale | ☑ Readability ☑ Verification and Validation<br>☐ Workflow ☑ Code Generation<br>☐ Simulation |
| Last Change | V2.1 |

### 4.3.6.5 jm_0002: Block resizing

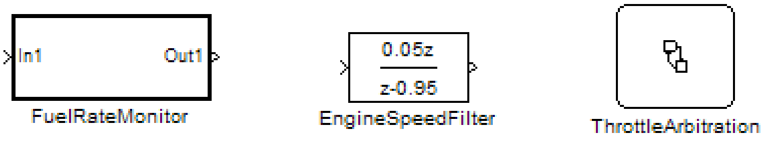
| **ID: Title** | **jm_0002: Block resizing** |
|---|---|
| Priority | Mandatory |
| Scope | MAAB |
| MATLAB Version | All |
| MA Check | No |
| Prerequisites | None |
| Description | All blocks in a model must be sized such that their icon is completely visible and recognizable. In particular, any text displayed (e.g. tunable parameters, filenames, equations) in the icon must be readable.<br>This guideline requires resizing of blocks with variable icons or blocks with a variable number of inputs and outputs. In some cases it may not be practical or desirable to resize the block icon of a subsystem block so that all of the input and output names within it are readable. In such cases, the user may hide the names in the icon by using a mask or by hiding the names in the subsystem associated with the icon. In this approach, the signal lines coming into and out of the subsystem block should be clearly labeled in close proximity to the block.<br>**Correct**<br><br> tunable_parameter_value<br>Constant<br>1000<br>Gain<br>[signal]<br>From<br>−<br>+<br>+<br>+<br>Sum<br>1<br>z+0.5<br>Discrete Transfer Fcn<br>(double)<br>Data Type Conversion<br>input_signal1<br>input_signal2<br>input_signal3<br>input_signal4<br>input_signal5<br>output_signal<br>subsystem<br>**Incorrect**<br><br> -C-<br>Constant<br>-K-<br>Gain<br>ignal<br>From<br>Sum<br>1<br>z+0.5<br>Discrete Transfer Fcn<br>ouble<br>Data Type Conversion<br>input_signal1<br>input_signal2<br>input_signal3<br>output_signal<br>input_signal4<br>input_signal5<br>subsystem |
| Rationale | ☑ Readability<br>☐ Workflow<br>☐ Simulation<br>☐ Verification and Validation<br>☐ Code Generation |
| Last Change | V2.0 |

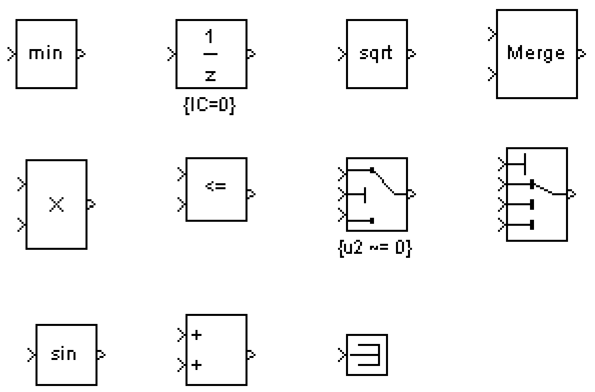
### 4.3.6.6 db_0142: Position of block names

| **ID: Title** | **db_0142: Position of block names** |
|---|---|
| Priority | Strongly recommended |
| Scope | MAAB |
| MATLAB | All |

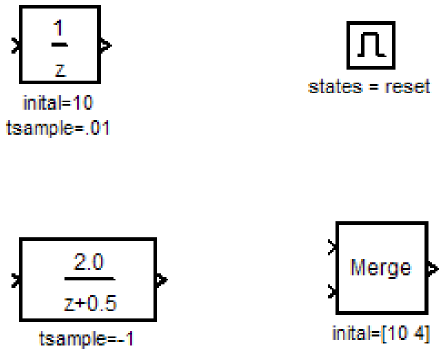
| | |
|---|---|
| Version | |
| MA Check | Yes |
| Prerequisites | None |
| Description | If shown, the name of each block should be placed below the block.<br><br> Correct<br>1<br>EngRPMRaw<br>0.05z<br>z-0.95<br>EngSignal_LowPass<br>EngRPMFilt<br>1<br>Incorrect<br>TransSignal_LowPass<br>2<br>TransRPMRaw<br>0.05z<br>z-0.95<br>TransRPMFilt<br>2 |
| Rationale | ☑ Readability<br>☑ Workflow<br>☐ Simulation<br>☐ Verification and Validation<br>☐ Code Generation |
| Last Change | V2.0 |

### 4.3.6.7 jc_0061: Display of block names

| **ID: Title** | **jc_0061: Display of block names** |
|---|---|
| Priority | Recommended |
| Scope | MAAB |
| MATLAB Version | All |
| MA Check | Yes |
| Prerequisites | None |
| Description | • The block name should be displayed when it provides descriptive information.<br><br> In1<br>Out1<br>FuelRateMonitor<br>0.05z<br>z-0.95<br>EngineSpeedFilter<br>ThrottleArbitration<br>• The block name should not be displayed if the block function is known from its appearance. |

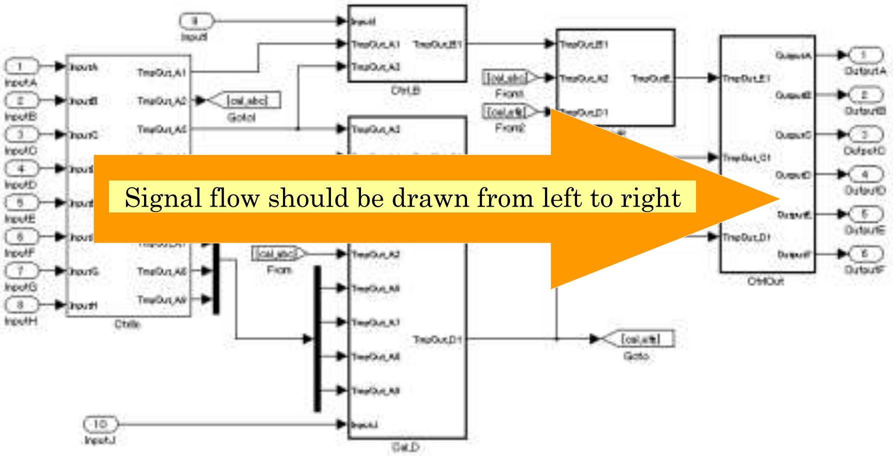
| | |
|---|---|
| |  min<br>1<br>z<br>{IC=0}<br>sqrt<br>Merge<br><=<br>{u2 ~= 0}<br>sin<br>+<br>+ |
| Rationale | ☑ Readability<br>☐ Workflow<br>☐ Simulation<br>☐ Verification and Validation<br>☐ Code Generation |
| Last Change | V2.1 |

### 4.3.6.8 db_0140: Display of basic block parameters

| **ID: Title** | **db_0140: Display of basic block parameters** |
|---|---|
| Priority | Recommended |
| Scope | MAAB |
| MATLAB Version | All |
| MA Check | Yes |
| Prerequisites | None |
| Description | Important parameters with values other than the block’s default values should be displayed. Many blocks within the ORION Library have important parameter values displayed by default.<br>Note: The attribute string is one method to support this. The block annotation tab allows the users to add the desired attribute information.<br>**Correct**<br> 1<br>z<br>inital=10<br>tsample=.01<br>states = reset<br>2.0<br>z+0.5<br>tsample=-1<br>Merge<br>inital=[10 4] |

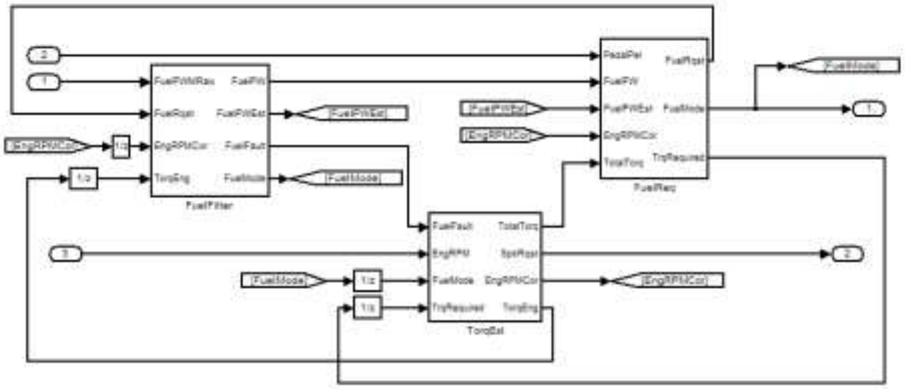
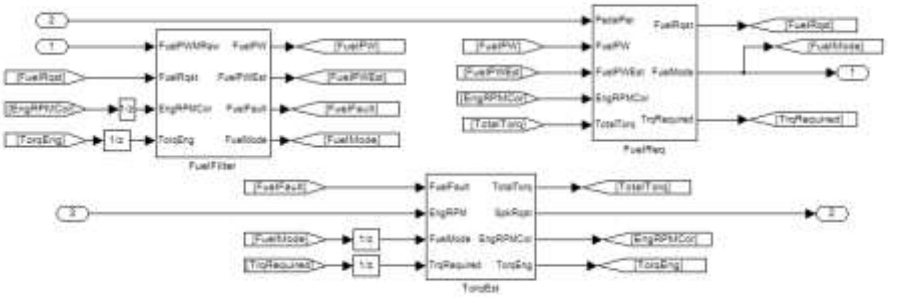
| | |
|---|---|
| Rationale | ☑ Readability ☑ Verification and Validation<br>☐ Workflow ☐ Code Generation<br>☐ Simulation |
| Last Change | V2.1 |

### 4.3.6.9 mdb_0141: Signal flow in Simulink models

| **ID: Title** | **mdb_0141: Signal flow in Simulink models** |
|---|---|
| Priority | Strongly recommended |
| Scope | ORION (modified MAAB db_0141) |
| MATLAB Version | All |
| MA Check | No |
| Prerequisites | None |
| Description | • The signal flow in a model is from left to right.<br>  • Exception: Feedback loops<br>• Sequential blocks or subsystems are arranged from left to right.<br>  • Exception: Feedback loops<br>• Parallel blocks or subsystems are arranged from top to bottom.<br><br>Signal flow should be drawn from left to right<br> InputA<br>InputB<br>InputC<br>InputD<br>InputE<br>InputF<br>InputG<br>InputH<br>InputJ<br>[cal_abc]<br>Goto<br>From<br>CtrlB<br>CtrlOut<br>OutputA<br>OutputB<br>OutputC<br>OutputD<br>OutputE<br>OutputF |
| Rationale | ☑ Readability ☑ Verification and Validation<br>☑ Workflow ☐ Code Generation<br>☐ Simulation |
| Last Change | V2.0 |

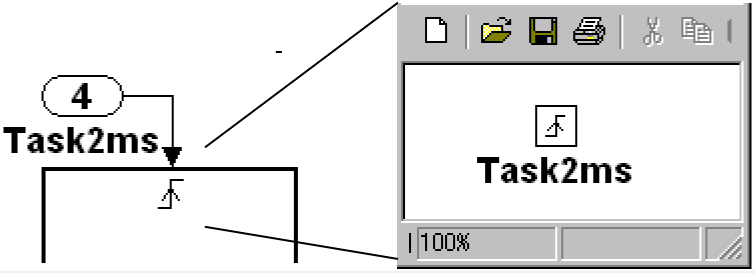
### 4.3.6.10 jc_0171: Maintaining signal flow when using Goto and From blocks

| **ID: Title** | **jc_0171: Maintaining signal flow when using Goto and From blocks** |
|---|---|
| Priority | Strongly recommended |
| Scope | MAAB |
| MATLAB | All |

| | |
|---|---|
| Version | |
| MA Check | No |
| Prerequisites | None |
| Description | • Visual depiction of signal flow must be maintained between subsystems.<br>• Use of Goto and From blocks is allowed provided that<br>  • At least one signal line is used between connected subsystems.<br>  • If the subsystems are connected both in a feed forward and feedback loop then at least one signal line for each direction must be connected.<br>**Correct**<br> FuelFilter<br>FuelPWMRaw<br>FuelRqst<br>EngRPMCor<br>TorqEng<br>FuelPW<br>FuelPWEst<br>FuelFault<br>FuelMode<br>FuelReq<br>PedalPel<br>TotalTorq<br>TrqRequired<br>TorqEst<br>EngRPM<br>SpkRqst<br>1/z<br>[FuelPWEst]<br>[EngRPMCor]<br>[FuelMode]<br>1<br>2<br>3<br><br>**Incorrect**<br> FuelFilter<br>FuelReq<br>TorqEst<br>[FuelPW]<br>[FuelPWEst]<br>[FuelFault]<br>[FuelMode]<br>[FuelRqst]<br>[EngRPMCor]<br>[TorqEng]<br>[TotalTorq]<br>[TrqRequired]<br>1/z<br>1<br>2<br>3 |
| Rationale | ☑ Readability ☑ Verification and Validation<br>☑ Workflow □ Code Generation<br>□ Simulation |
| Last Change | V2.0 |

### 4.3.6.11 jc_0281: Naming of Trigger Port block and Enable Port block

| **ID: Title** | **jc_0281: Naming of Trigger Port block and Enable Port block** |
|---|---|
| Priority | Strongly recommended |
| Scope | J-MAAB |
| MATLAB | All |

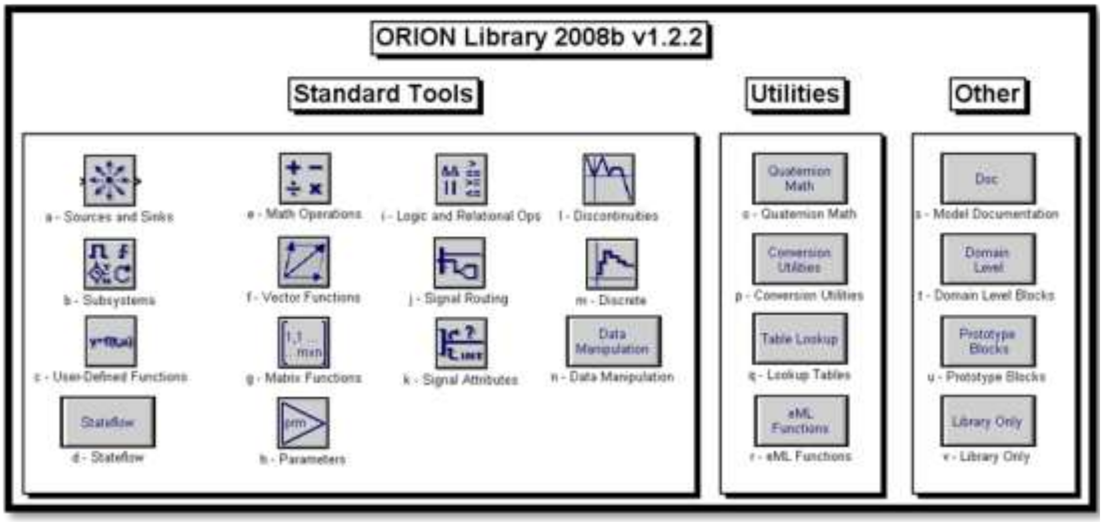
| | |
|---|---|
| Version | |
| MA Check | Yes |
| Prerequisites | None |
| Description | For Trigger port blocks and Enable port blocks<br>• The block name should match the name of the signal triggering the subsystem.<br><br> |
| Rationale | ☑ Readability<br>☐ Workflow<br>☐ Simulation<br>☐ Verification and Validation<br>☐ Code Generation |
| Last Change | V2.0 |

## 4.3.7 Block Usage

The acceptable blocks that can be used for ORION GN&C models are restricted. The ORION Library contains all of the blocks that are deemed useable in models.

### 4.3.7.1 hyl_0201: Use of standard library blocks only

| **ID: Title** | **hyl_0201: Use of standard library blocks only** |
|---|---|
| Priority | Mandatory |
| Scope | ORION |
| MATLAB Version | All |
| MA Check | Yes |
| Prerequisites | None |
| Description | Only compliant Library blocks from the Orion GN&C Algorithm Library should be used in the models. If non-compliant blocks are used, it **shall** have foreground color of red (Colorspec RGB value = [1.000000, 0.501961, 0.501961])<br><br>The ORION library contains a section of non-compliant blocks in the "Prototype Blocks" section. These blocks are already colored red. The purpose of this set of blocks are for development only and should not be included in the final models<br><br>The Domain Level Blocks section contains blocks that should only exists at the domain level and are prohibited at the CSU level. |

| | |
|---|---|
| |  ORION Library 2008b v1.2.2<br>Standard Tools<br>Utilities<br>Other<br>a - Sources and Sinks<br>e - Math Operations<br>i - Logic and Relational Ops<br>l - Discontinuities<br>b - Subsystems<br>f - Vector Functions<br>j - Signal Routing<br>m - Discrete<br>y=f(t,u)<br>c - User-Defined Functions<br>1,1 ... m,n<br>g - Matrix Functions<br>k - Signal Attributes<br>Data Manipulation<br>n - Data Manipulation<br>Stateflow<br>d - Stateflow<br>prm<br>h - Parameters<br>Quaternion Math<br>o - Quaternion Math<br>Conversion Utilities<br>p - Conversion Utilities<br>Table Lookup<br>q - Lookup Tables<br>eML Functions<br>r - eML Functions<br>Doc<br>s - Model Documentation<br>Domain Level<br>t - Domain Level Blocks<br>Prototype Blocks<br>u - Prototype Blocks<br>Library Only<br>v - Library Only |
| Rationale | ☑ Readability<br>☑ Workflow<br>☑ Simulation<br>☑ Verification and Validation<br>☑ Code Generation |
| Last Change | V2.1 |

## 4.3.7.2 jh_0101: Use of Right-Handed Quaternions only

| **ID: Title** | **jh_0101: Use of Right-Handed Quaternions Only** |
|---|---|
| Priority | Mandatory |
| Scope | ORION |
| MATLAB Version | All |
| MA Check | Yes |
| Prerequisites | None |
| Description | Orion GN&C models shall only use right-handed quaternions. The ORION GN&C Library does not support the use of left-handed quaternions. |
| Rationale | ☑ Readability<br>☑ Workflow<br>☑ Simulation<br>☑ Verification and Validation<br>☑ Code Generation |
| Last Change | V1.0 |

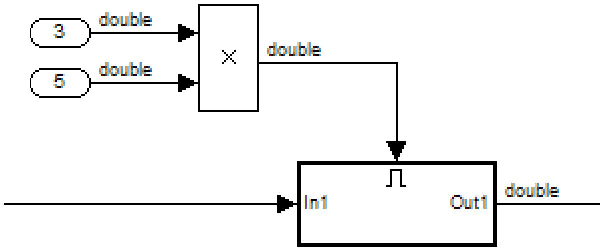
## 4.3.7.3 na_0003: Simple logical expressions in If Condition block

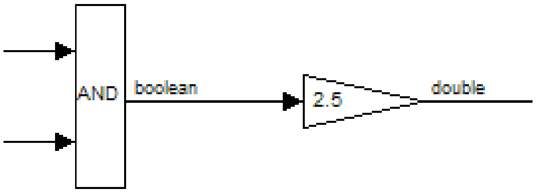
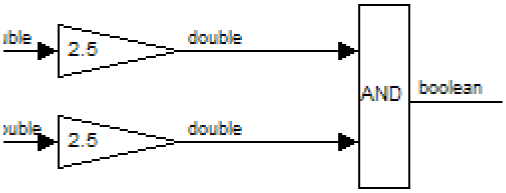
| **ID: Title** | **na_0003: Simple logical expressions in If Condition block** |
|---|---|
| Priority | Mandatory |

<table>
<tr><td>Scope</td><td>MAAB</td></tr>
<tr><td>MATLAB Version</td><td>All</td></tr>
<tr><td>MA Check</td><td>Yes</td></tr>
<tr><td>Prerequisites</td><td>None</td></tr>
<tr><td>Description</td><td>A logical expression may be implemented within an If Condition block instead of building it up with logical operation blocks if the expression contains two or fewer primary expressions. All inputs to an If Condition block must be the same data type. A primary expression is defined here to be one of the following:<br>• An input<br>• A constant<br>• A constant parameter<br>• A parenthesized expression containing no operators except zero or one instances of the following operators: < , <= , > , >= , ~=, ==, ~ . (See below for examples)<br><br><b>Exception:</b><br><br>A logical expression may contain more than two primary expressions if both of the following are true:<br>• The primary expressions are all inputs<br>• Only one type of logical operator is present<br><br>Examples of acceptable exceptions:<br><br>• u1 | u2 | u3 | u4 | u5<br>• u1 & u2 & u3 & u4<br><br>Examples of primary expressions include:<br><br>• u1<br>• 5<br>• K<br>• (u1 > 0)<br>• (u1 <= G)<br>• (u1 > U2)<br>• (~u1)<br><br>Examples of acceptable logical expressions include:<br><br>• u1 | u2<br>• (u1 > 0) & (u1 < 20)<br>• (u1 > 0) & (u2 < u3)<br>• (u1 > 0) & (~u2)<br><br>Examples of unacceptable logical expressions include:</td></tr>
</table>

<table>
<tr><td></td><td>• u1 &amp; u2 | u3 (too many primary expressions)<br>• u1 &amp; (u2 | u3) (unacceptable operator within primary expression)<br>• (u1 &gt; 0) &amp; (u1 &lt; 20) &amp; (u2 &gt; 5) (too many primary expressions that are not inputs)<br>• (u1 &gt; 0) &amp; ((2*u2) &gt; 6) (unacceptable operator within primary expression)</td></tr>
<tr><td>Rationale</td><td>☑ Readability ☐ Verification and Validation<br>☑ Workflow ☐ Code Generation<br>☐ Simulation</td></tr>
<tr><td>Last Change</td><td>V2.1</td></tr>
</table>

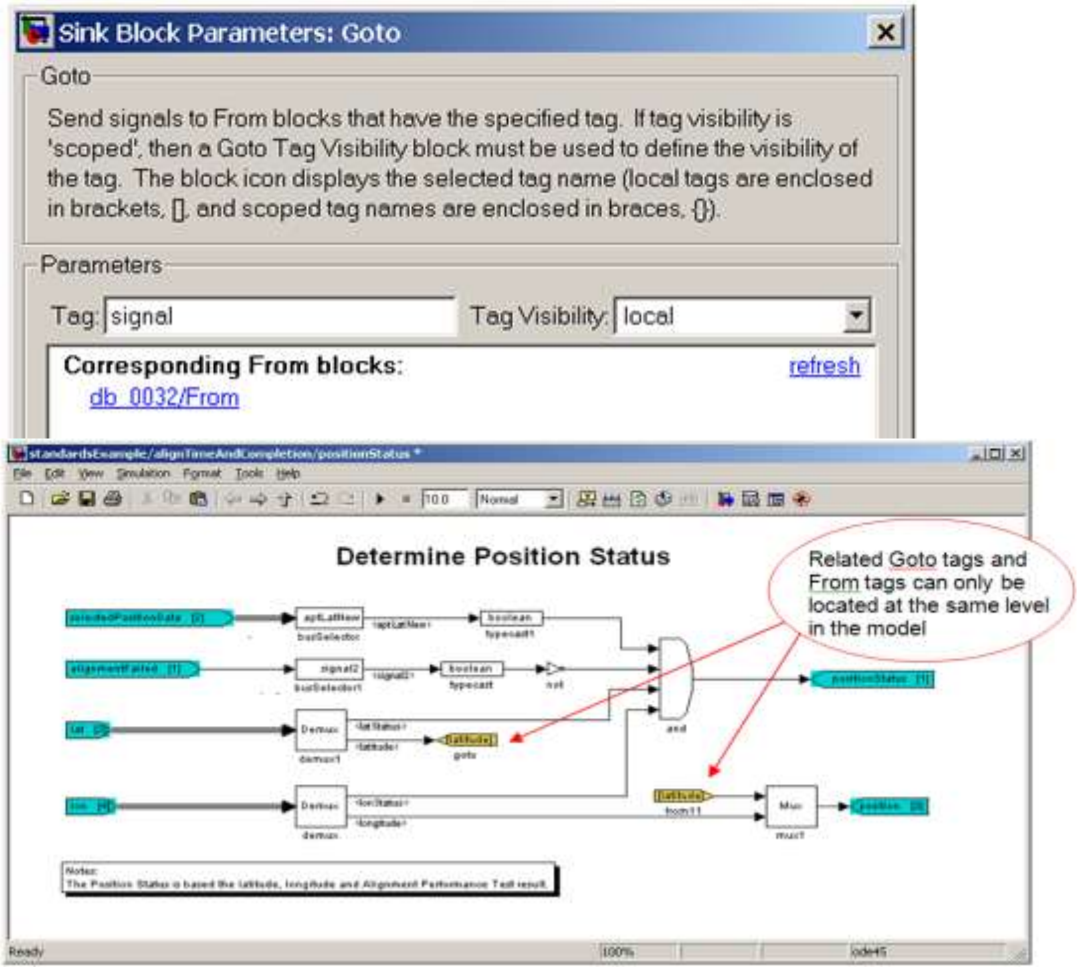
## 4.3.7.4 na_0002: Appropriate implementation of fundamental logical and numerical operations

| | |
|---|---|
| **ID: Title** | **na_0002: Appropriate implementation of fundamental logical and numerical operations** |
| Priority | Mandatory |
| Scope | MAAB |
| MATLAB Version | All |
| MA Check | No |
| Prerequisites | None |
| Description | • Blocks that are intended to perform numerical operations must not be used to perform logical operations.<br>**Incorrect**<br> 3<br>5<br>double<br>double<br>×<br>double<br>In1<br>Out1<br>double<br>• A logical output should never be directly connected to the input of blocks that operate on numerical inputs.<br>• The result of a logical expression fragment should never be operated on by a numerical operator.<br>**Incorrect** |

| | |
|---|---|
| | <br> <br>- Blocks that are intended to perform logical operations must not be used to perform numerical operations.<br>- A numerical output should never be connected to the input of blocks that operate on logical inputs.<br>**Incorrect**<br><br> ıble<br>2.5<br>double<br>›uble<br>2.5<br>double<br>AND<br>boolean |
| Rationale | ☑ Readability ☐ Verification and Validation<br>☑ Workflow ☐ Code Generation<br>☐ Simulation |
| Last Change | V2.0 |

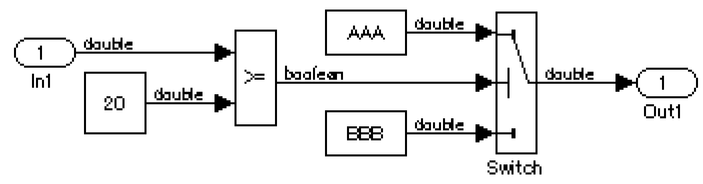
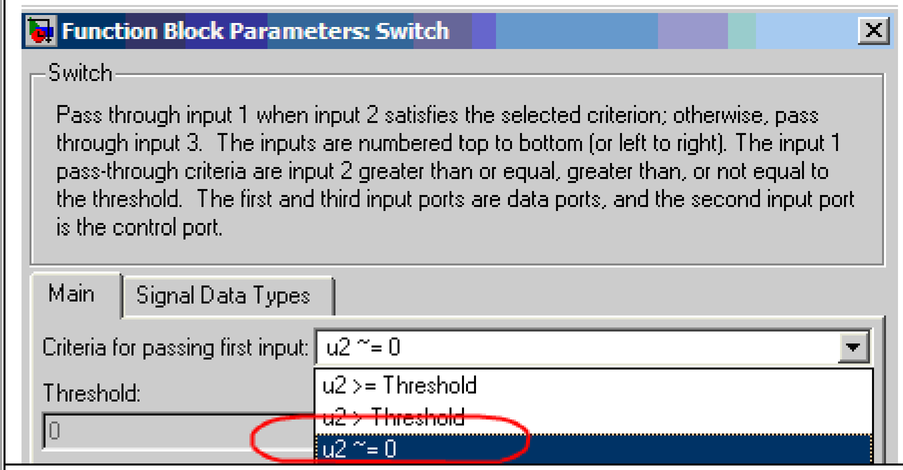
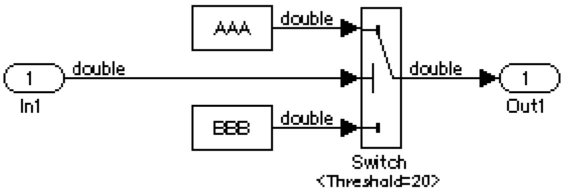
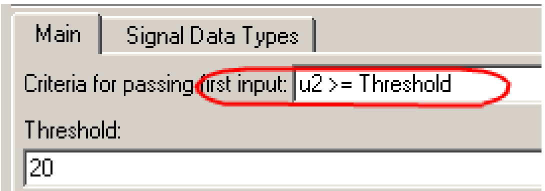
### 4.3.7.5 na_0011: Scope of Goto and From blocks

| **ID: Title** | **na_0011: Scope of Goto  and From blocks** |
|---|---|
| Priority | Strongly recommended |
| Scope | MAAB |
| MATLAB Version | All |
| MA Check | Yes |
| Prerequisites | None |
| Description | For signal flows the following rules apply:<br>- From and Goto blocks must use local scope. |

| | |
|---|---|
| | <br>Sink Block Parameters: Goto<br>Goto<br>Send signals to From blocks that have the specified tag. If tag visibility is 'scoped', then a Goto Tag Visibility block must be used to define the visibility of the tag. The block icon displays the selected tag name (local tags are enclosed in brackets, [], and scoped tag names are enclosed in braces, {}).<br>Parameters<br>Tag: signal<br>Tag Visibility: local<br>Corresponding From blocks:<br>db_0032/From<br>refresh<br>standardsExample/alignTimeAndCompletion/positionStatus *<br>Determine Position Status<br>Related Goto tags and From tags can only be located at the same level in the model<br>Notes:<br>The Position Status is based the latitude, longitude and Alignment Performance Test result.<br> File Edit View Simulation Format Tools Help<br>10.0<br>Normal<br>aptLatNew<br>busSelector<br><aptLatNew><br>boolean<br>typecast1<br>signal2<br>busSelector1<br><signal2><br>boolean<br>typecast<br>not<br>and<br>positionStatus [1]<br>Demux<br>demux1<br><latStatus><br><latitude><br>[latitude]<br>goto<br>Demux<br>demux<br><lonStatus><br><longitude><br>[latitude]<br>from11<br>Mux<br>mux1<br>position [2]<br>Ready<br>100%<br>ode45<br>Note: This rule does not apply to the Parameter Goto Block for passing static data throughout a CSU. |
| Rationale | ☑ Readability<br>☑ Workflow<br>☐ Simulation<br>☐ Verification and Validation<br>☑ Code Generation |
| Last Change | V2.0 |

### 4.3.7.6 jc_0141: Use of the Switch block

| **ID: Title** | **jc_0141: Use of the Switch block** |
|---|---|
| Priority | Strongly recommended |
| Scope | MAAB |
| MATLAB Version | All |
| MA Check | Yes |
| Prerequisites | None |
| Description | The block parameter “Criteria for passing first input” should be set to u2~=0. |

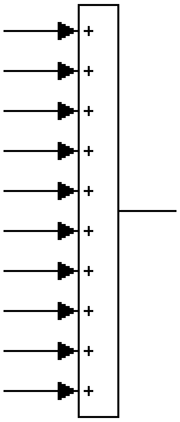
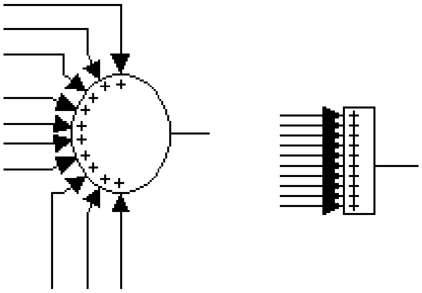
| | |
|---|---|
| | The block parameter "Criteria for passing first input" must not be set to u2>Threshold for R13 versions of MATLAB.<br><br>The logic for the switch block should be defined on the same level as the switch block itself.<br><br>**Correct**<br> 1<br>In1<br>double<br>20<br>double<br>>=<br>boolean<br>AAA<br>double<br>BBB<br>double<br>double<br>Switch<br>1<br>Out1<br><br>Function Block Parameters: Switch<br>Switch<br>Pass through input 1 when input 2 satisfies the selected criterion; otherwise, pass through input 3. The inputs are numbered top to bottom (or left to right). The input 1 pass-through criteria are input 2 greater than or equal, greater than, or not equal to the threshold. The first and third input ports are data ports, and the second input port is the control port.<br>Main \| Signal Data Types<br>Criteria for passing first input: u2 ~= 0<br>u2 >= Threshold<br>u2 > Threshold<br>u2 ~= 0<br>Threshold: 0<br><br>**Incorrect**<br> AAA<br>double<br>1<br>In1<br>double<br>BBB<br>double<br>double<br>Switch<br><Threshold=20><br>1<br>Out1<br><br>Main \| Signal Data Types<br>Criteria for passing first input: u2 >= Threshold<br>Threshold: 20<br><br>Note: This criteria is not available to change in the ORION Library. The criteria is locked to "u2 ~= 0". |
| Rationale | ☑ Readability ☐ Verification and Validation<br>☑ Workflow ☐ Code Generation<br>☐ Simulation |
| Last Change | V2.1 |

### 4.3.7.7 hyl_0207: Limiting input to multiport switches

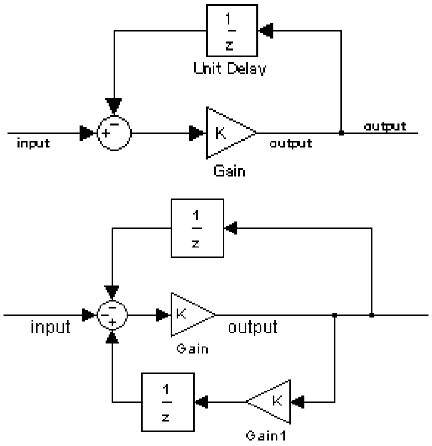
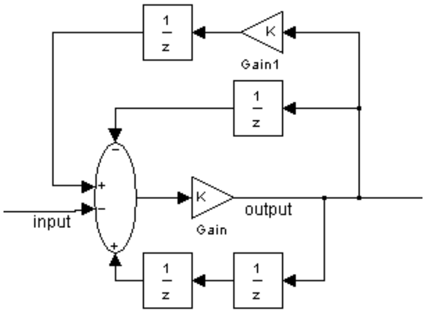
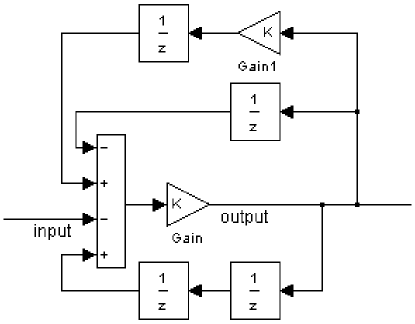
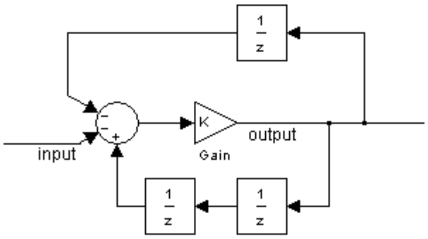
| **ID: Title** | **hyl_0207: Limiting input to multiport switches** |
|---|---|
| Priority | Mandatory |
| Scope | ORION |
| MATLAB Version | All |
| MA Check | No |
| Prerequisites | None |
| Description | Logic input to Multiport Switch Blocks **shall** never be less than one, or greater than the number of switch ports on the block. The user ensures this by the model-design or upstream limiting.<br>Note: One based indexing [1, 2, 3,…] is used for Matlab/Simulink |
| Rationale | □ Readability<br>□ Workflow<br>☑ Simulation<br>☑ Verification and Validation<br>☑ Code Generation |
| Last Change | V2.1 |

### 4.3.7.8 jc_0121: Use of the Sum block

<table>
<tr><th>ID: Title</th><th>jc_0121: Use of the Sum block</th></tr>
<tr><td>Priority</td><td>Recommended</td></tr>
<tr><td>Scope</td><td>MAAB</td></tr>
<tr><td>MATLAB Version</td><td>All</td></tr>
<tr><td>MA Check</td><td>Yes</td></tr>
<tr><td>Prerequisites</td><td>None</td></tr>
<tr><td>Description</td><td>Sum blocks should:
<ul>
<li>Use the “rectangular” shape.</li>
<li>Be sized so that the input signals do not overlap.</li>
</ul>
<table>
<tr><th>Correct</th><th>Incorrect</th></tr>
<tr><td></td><td></td></tr>
</table>
</td></tr>
</table>

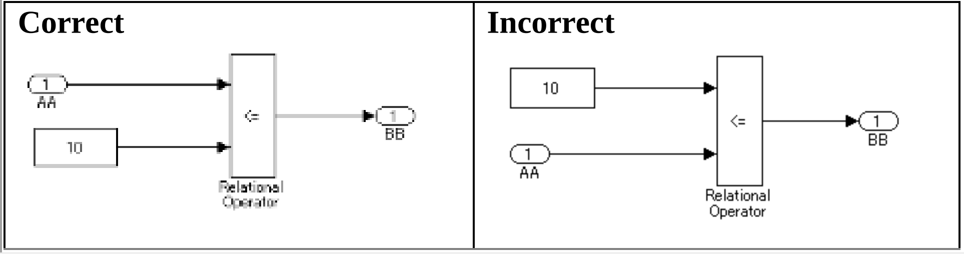
| | |
|---|---|
|  |  |

- The round shape can be used in feedback loops.
  - There should be no more than 3 inputs.
  - The inputs may be positioned at 90,180,270 degrees.
  - The output should be positioned at 0 degrees.

| **Correct** | **Incorrect** |
|---|---|
|  1<br>z<br>Unit Delay<br>input<br>K<br>output<br>output<br>Gain<br>1<br>z<br>input<br>K<br>output<br>Gain<br>1<br>z<br>K<br>Gain1 |  1<br>z<br>K<br>Gain1<br>1<br>z<br>input<br>K<br>output<br>Gain<br>1<br>z<br>1<br>z |
| **Correct** | **Incorrect** |
|  1<br>z<br>K<br>Gain1<br>1<br>z<br>input<br>K<br>output<br>Gain<br>1<br>z<br>1<br>z |  |

| | |
|---|---|
| Rationale | ☑ Readability<br>☐ Workflow<br>☐ Simulation<br>☐ Verification and Validation<br>☐ Code Generation |
| Last Change | V2.0 |

### 4.3.7.9 jc_0131: Use of Relational Operator block

| | |
|---|---|
| **ID: Title** | **jc_0131: Use of Relational Operator block** |
| Priority | Recommended |
| Scope | J-MAAB |
| MATLAB Version | All |
| MA Check | Yes |
| Prerequisites | None |
| Description | When the relational operator is used to compare a signal to a constant value the constant input should be the second (lower) input.<br> Correct<br>1<br>AA<br>10<br><=<br>Relational Operator<br>1<br>BB<br>Incorrect<br>10<br>1<br>AA<br><=<br>Relational Operator<br>1<br>BB |
| Rationale | ☑ Readability<br>☐ Workflow<br>☐ Simulation<br>☐ Verification and Validation<br>☑ Code Generation |
| Last Change | V2.0 |

### 4.3.7.10 hyl_0211: Prohibit use of test points

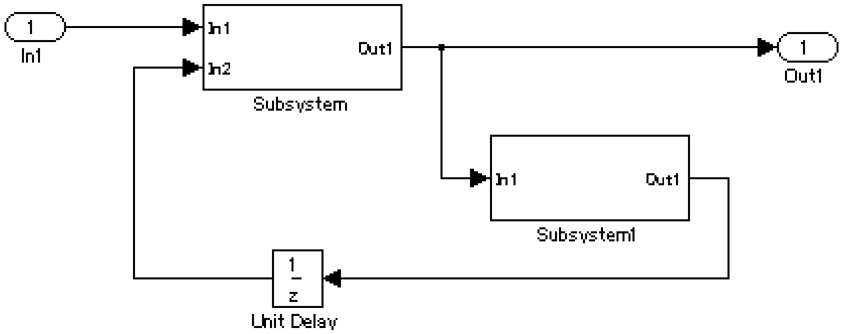
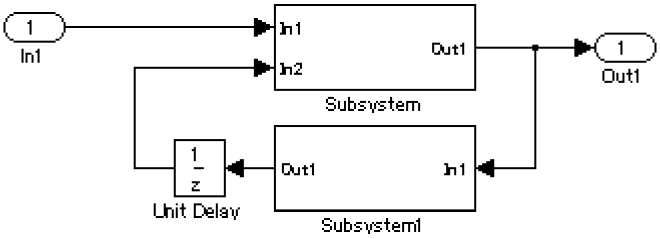
| | |
|---|---|
| **ID: Title** | **hyl_0211: Prohibit use of test points** |
| Priority | Strongly recommended |
| Scope | ORION |
| MATLAB Version | All |
| MA Check | Yes |
| Prerequisites | None |
| Description | Test points **shall** not be used in the final models. However, the use of test points can be used during development for testing purposes.<br>The configuration set used by the ORION GN&C FSW models ignores test points when autocode is produced so there is not affect to code generation. |
| Rationale | ☐ Readability<br>☐ Workflow<br>☑ Simulation<br>☐ Verification and Validation<br>☐ Code Generation |
| Last Change | V2.1 |

### 4.3.7.11 jh_0109: Merge Blocks

| **ID: Title** | **jh_0109: Merge Blocks** |
|---|---|
| Priority | Strongly Recommended |
| Scope | ORION |
| MATLAB Version | All |
| MA Check | No |
| Prerequisites | None |
| Description | Care must be taken when using the Merge Block.  There are a few rules of thumb that must be followed when using merge blocks:<br>• The signals entering a merge block must not branch off to any other block.  The merge block must be the signals' only destination<br>• When using Merge Blocks with buses:<br>○ All buses must be absolutely identical.  The number of elements, element names, element order, element data type, and element size must match exactly between all buses being merged<br>○ All buses must be of the same virtuality (i.e. all non-virtual or all virtual).  It is recommended to use non-virtual buses and create a bus object for the buses being merged.  This is the most fail safe way to prevent inconsistencies.<br>○ All bus lines entering a merge block must not branch off to any other block.  The merge block must be the bus lines only destination<br>○ Do not use the **Signal_Conversion** block on signals feeding Merge blocks.  The **Signal_Conversion** block may create an intermediate variable that is assigned every cycle.  This may force the Merge block to use the data from that signal, regardless of the state of the other signals. |
| Rationale | ☐ Readability ☐ Verification and Validation<br>☐ Workflow ☐ Code Generation<br>☑ Simulation |
| Last Change | V1.1 |

### 4.3.7.12 mjc_0111: Direction of Subsystem

| **ID: Title** | **mjc_0111: Direction of Subsystem** |
|---|---|
| Priority | Strongly recommended |
| Scope | ORION (modified J-MAAB jc_0111) |
| MATLAB Version | All |
| MA Check | No |

| | |
|---|---|
| Prerequisites | None |
| Description | Subsystems must not be reversed except when used in feedback loops.<br>**Correct**<br><br> 1<br>In1<br>In1<br>In2<br>Out1<br>Subsystem<br>1<br>Out1<br>In1<br>Out1<br>Subsystem1<br>1<br>z<br>Unit Delay<br>**Correct**<br><br> 1<br>In1<br>In1<br>In2<br>Out1<br>Subsystem<br>1<br>Out1<br>1<br>z<br>Unit Delay<br>Out1<br>In1<br>Subsystem1 |
| Rationale | ☑ Readability<br>☐ Workflow<br>☐ Simulation<br>☐ Verification and Validation<br>☐ Code Generation |
| Last Change | V2.0 |

### 4.3.8 Block Parameters

#### 4.3.8.1 db_0112: Indexing

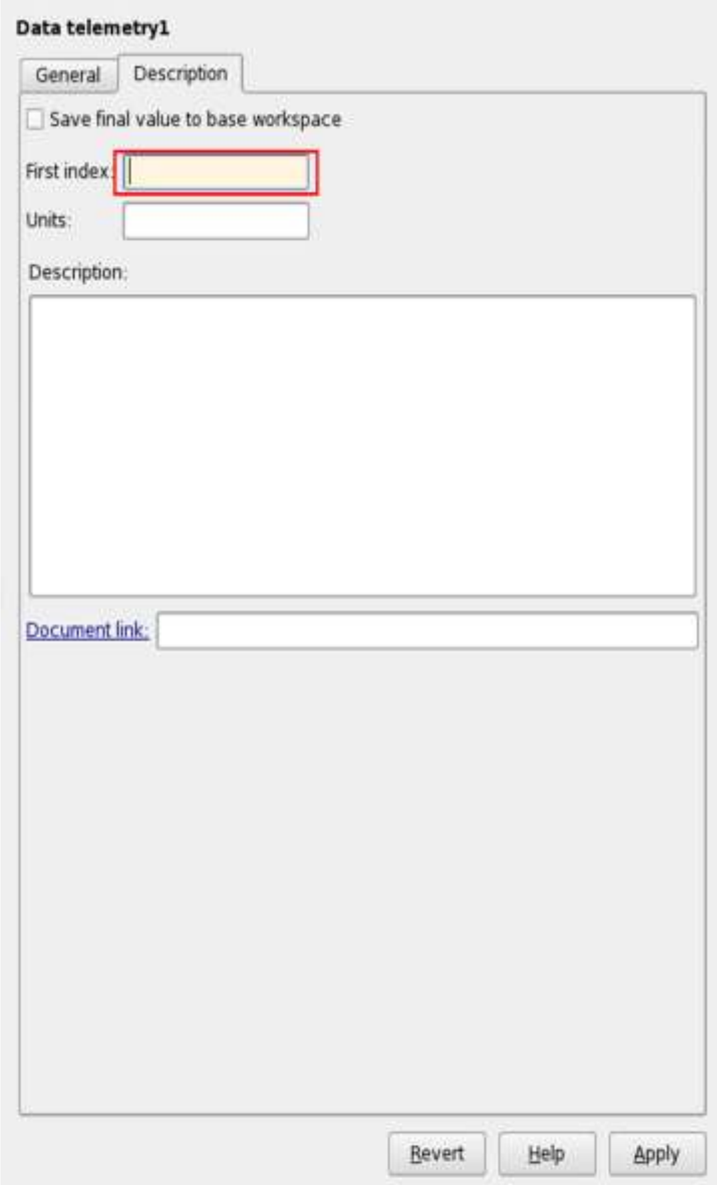
| **ID: Title** | **db_0112: Indexing** |
|---|---|
| Priority | Strongly recommended |
| Scope | MAAB |
| MATLAB Version | All |
| MA Check | Yes |
| Prerequisites | None |
| Description | One based indexing [1, 2, 3,…] is used for<br>• MATLAB<br>  • Workspace variables and structures<br>  • Local variables of m-functions<br>  • Global variables<br>• Simulink<br>  • Signal vectors and matrices |

  - Parameter vectors and matrices
  - M-coded S-Function input and output signal vectors and matrices
  - M-coded S-Function parameter vectors and matrices
  - M-coded S-Function local variables

Zero based Indexing [0, 1, 2, ...] is used for

- Simulink
  - C-coded S-Function input and output signal vectors and matrices
  - C-coded S-Function input parameters
  - C-coded S-Function parameter vectors and matrices
  - C-coded S-Function local variables
- Stateflow
  - Custom c-code variables and structures
  - Buses
  - Input and output signal vectors and matrices
  - Parameter vectors and matrices
  - Local variables
- C-Code
  - Local variables and structures
  - Global variables

**Model explorer view of Stateflow chart for setting the First Index**

| | |
|---|---|
| |  Data telemetry1<br>General<br>Description<br>☐ Save final value to base workspace<br>First index:<br>Units:<br>Description:<br>Document link:<br>Revert<br>Help<br>Apply |
| **Rationale** | ☑ Readability<br>☑ Workflow<br>☐ Simulation<br>☐ Verification and Validation<br>☑ Code Generation |
| Last Change | V2.3 |

### 4.3.8.2 db_0110: Tunable parameters in basic blocks

| **ID: Title** | **db_0110: Tunable parameters in basic blocks** |
|---|---|
| Priority | Strongly recommended |
| Scope | MAAB |
| MATLAB Version | All |
| MA Check | No |

| | |
|---|---|
| Prerequisites | None |
| Description | All tunable parameters must be fed into the model through the Parameter input bus. Tunable parameters must not be accessed from the Matlab workspace via constant blocks, gain blocks, and other blocks that have parameter inputs.<br>This standard ensures that the autocode will retain the parameter structure and tunability. |
| Rationale | ☑ Readability<br>☑ Workflow<br>☐ Simulation<br>☐ Verification and Validation<br>☑ Code Generation |
| Last Change | V2.1 |

### 4.3.9 Subsystems

#### 4.3.9.1 jc_0201: Usable Characters for Subsystem Names

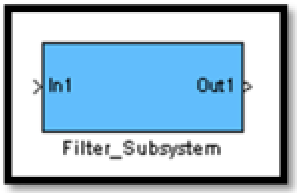
<table>
<tr><th>ID: Title</th><th>jc_0201: Usable characters for Subsystem names</th></tr>
<tr><td>Priority</td><td>Strongly recommended</td></tr>
<tr><td>Scope</td><td>MAAB</td></tr>
<tr><td>MATLAB Version</td><td>All</td></tr>
<tr><td>MA Check</td><td>Yes</td></tr>
<tr><td>Prerequisites</td><td>None</td></tr>
<tr><td>Description</td><td>The names of all Subsystem blocks should conform to the following constraints:
<table>
<tr><td>FORM</td><td><b>name</b>:<ul><li>should not start with a number</li><li>should not have blank spaces</li><li>carriage returns are not allowed</li></ul></td></tr>
<tr><td>ALLOWED CHARACTERS</td><td><b>name</b>:<br>a b c d e f g h i j k l m n o p q r s t u v w x y z<br>A B C D E F G H I J K L M N O P Q R S T U V W X Y Z<br>0 1 2 3 4 5 6 7 8 9 _</td></tr>
<tr><td>UNDERSCORES</td><td><b>name</b>:<ul><li>can use underscores to separate parts</li><li>cannot have more than one consecutive underscore</li><li>cannot start with an underscore</li><li>cannot end with an underscore</li></ul></td></tr>
</table></td></tr>
<tr><td>Rationale</td><td>☑ Readability<br>☑ Workflow<br>☐ Simulation<br>☐ Verification and Validation<br>☑ Code Generation</td></tr>
<tr><td>Last Change</td><td>V2.1</td></tr>
</table>

### 4.3.9.2 bn_0001 Subsystem name length limit

| **ID: Title** | **bn_0001: Subsystem Name Length Limit** |
|---|---|
| Priority | Strongly recommended |
| Scope | ORION |
| MATLAB Version | All |
| MA Check | Yes |
| Prerequisites | jc_0201: Usable characters for Subsystem names |
| Description | The names of all Subsystem blocks must be unique. Compiler limits must be observed when creating subsystem names that are used in code or system filenames.<br>32 characters is the maximum limit<br>Example:<br>Subroutine_Function_Algortihm_Example becomes<br>Subroutine_Function_Algortihm_Ex<br>This_is_a_Really_Long_Subsystem_Name becomes<br>A_Really_Long_Subsystem_Name |
| Rationale | ☑ Readability ☑ Verification and Validation<br>☐ Workflow ☑ Code Generation<br>● Simulation |
| Last Change | V2.1 |

### 4.3.9.3 hyl_0307: Use of subsystem name

| **ID: Title** | **hyl_0307: Use of subsystem name** |
|---|---|
| Priority | Strongly recommended |
| Scope | ORION |
| MATLAB Version | All |
| MA Check | Yes |
| Prerequisites | None |
| Description | No block **shall** be named "subsystem" (or "subsystem1" "subSystem1,” etc.) or have “subsystem” in the name.<br>Example:<br>**Incorrect** |

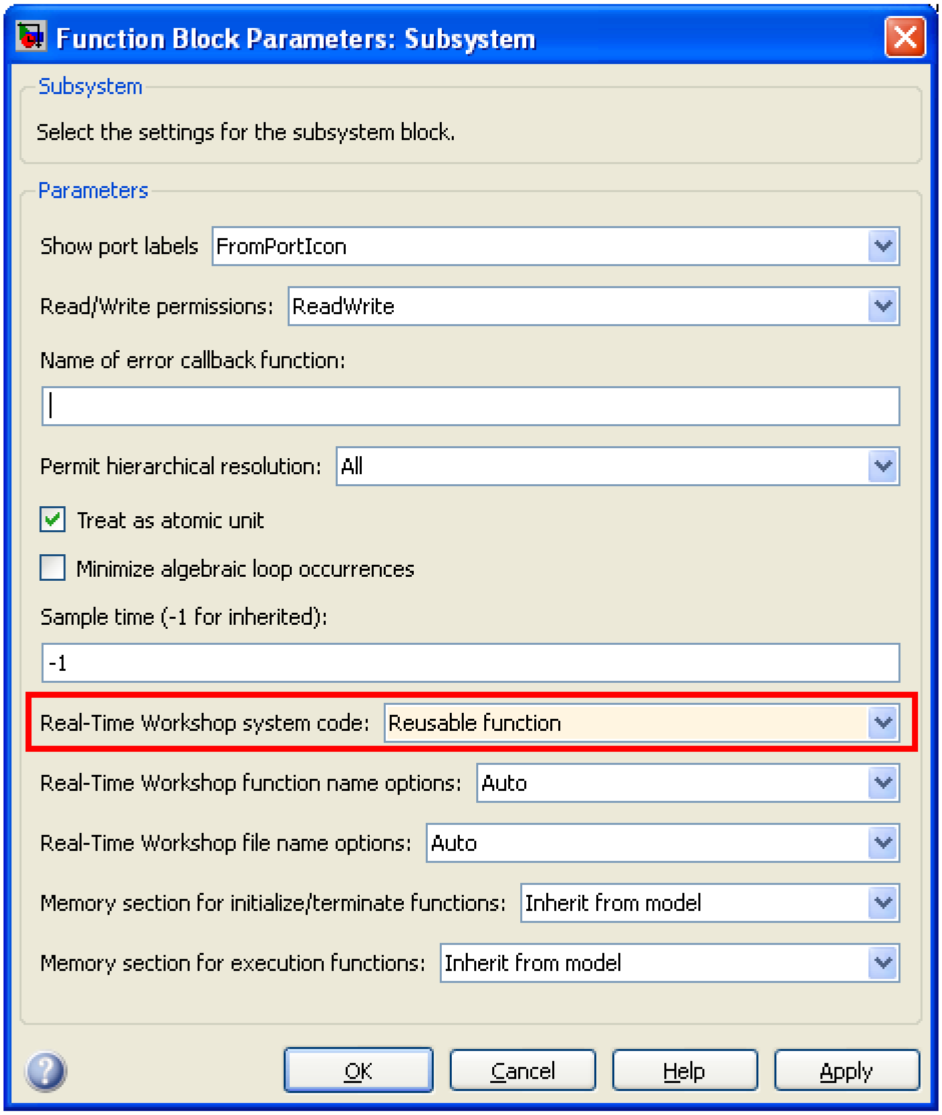
| | |
|---|---|
| |  |
| Rationale | ☑ Readability ☐ Verification and Validation<br>☑ Workflow ☑ Code Generation<br>☐ Simulation |
| Last Change | V2.1 |

### 4.3.9.4 db_0144: Use of Subsystems

| **ID: Title** | **db_0144: Use of Subsystems** |
|---|---|
| Priority | Strongly recommended |
| Scope | MAAB |
| MATLAB Version | All |
| MA Check | No |
| Prerequisites | None |
| Description | Blocks in a Simulink diagram should be grouped together into subsystems based upon a functional decomposition of the algorithm, or portion thereof, represented in the diagram.<br><br>Grouping blocks into subsystems primarily for the purpose of saving space in the diagram should be avoided. Each subsystem in the diagram should represent a unit of functionality required to accomplish the purpose of the model or sub model. |
| Rationale | ☑ Readability ☑ Verification and Validation<br>☑ Workflow ☑ Code Generation<br>☐ Simulation |
| Last Change | V2.2 |

### 4.3.9.5 jh_0049: Use of Model References or Reusable Subsystems

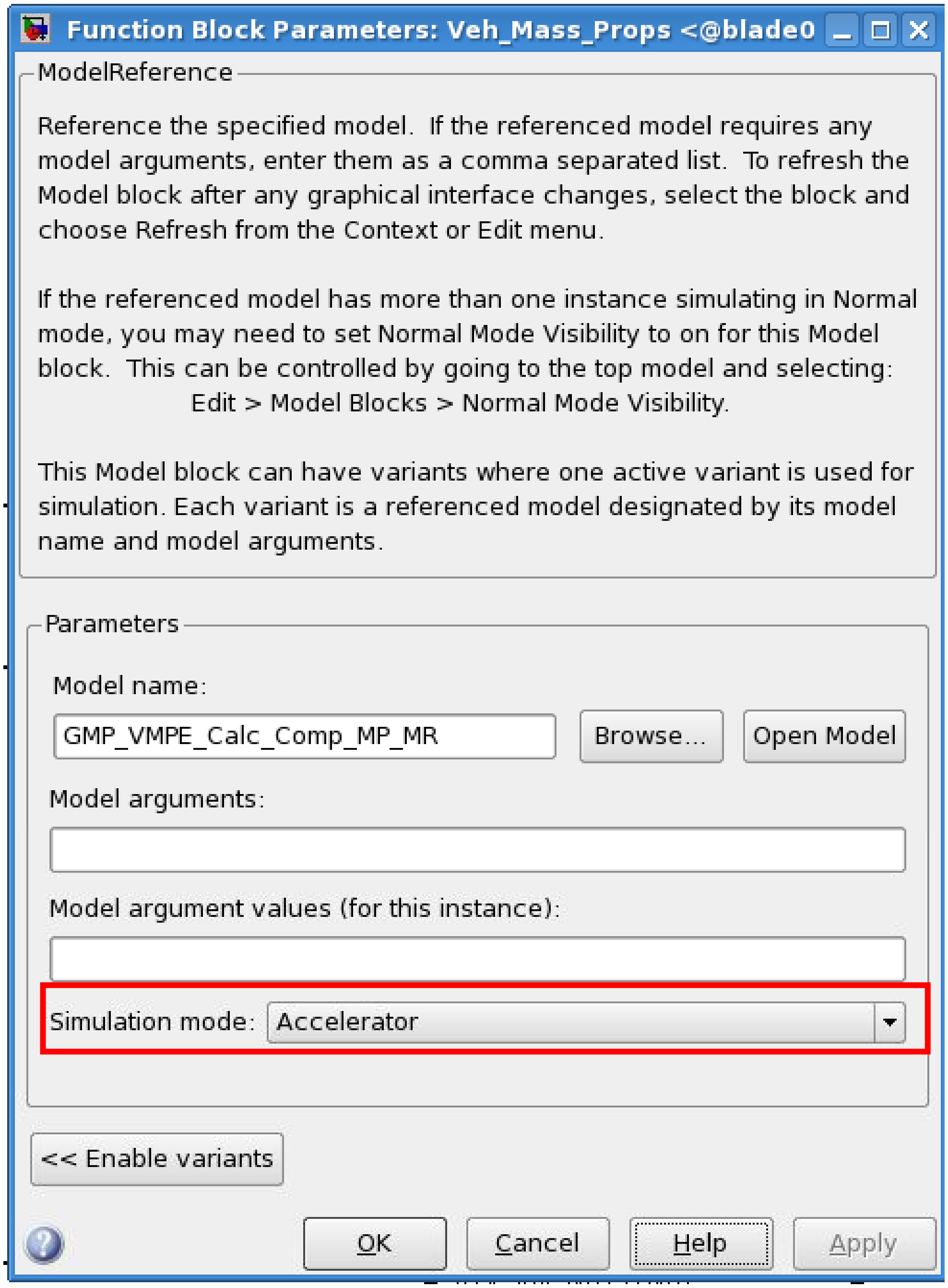
| **ID: Title** | **jh_0049: Use of Model References or Reusable Subsystems** |
|---|---|
| Priority | Strongly recommended |
| Scope | ORION |
| MATLAB Version | All |
| MA Check | Yes |

| | |
|---|---|
| Prerequisites | **jh_0202: Testable Unit** |
| Description | Only subsystems that reside in the ORION Library should be set to be a “Reusable Function”. This setting is shown in the Subsystem Parameter Dialog window below.<br><br>Function Block Parameters: Subsystem<br>Subsystem<br>Select the settings for the subsystem block.<br>Parameters<br>Show port labels FromPortIcon<br>Read/Write permissions: ReadWrite<br>Name of error callback function:<br>Permit hierarchical resolution: All<br>☑ Treat as atomic unit<br>☐ Minimize algebraic loop occurrences<br>Sample time (-1 for inherited): -1<br>Real-Time Workshop system code: Reusable function<br>Real-Time Workshop function name options: Auto<br>Real-Time Workshop file name options: Auto<br>Memory section for initialize/terminate functions: Inherit from model<br>Memory section for execution functions: Inherit from model<br> <br>If a complex subsystem within a CSU is used multiple times it may be converted into a standalone model (.mdl) and referenced via the model reference block. This will ensure reusability of the autocode. Refer to jh_0202: Testable Units for a further description of how do decompose a model using Model Reference.<br>eML functions may not be shared between CSUs or Model References directly. If an eML function is used by multiple models, the eML function should be wrapped in a Simulink model and called as a Model Reference that contains an eML block that calls the function. |
| Rationale | ☑ Readability ☑ Verification and Validation |

| | |
|---|---|
| | ☑ Workflow ☑ Code Generation<br>□ Simulation |
| Last Change | V1.1 |

### 4.3.9.6 jh_0050: Model References Simulation Mode

| **ID: Title** | **jh_0050:  Model References Simulation Mode** |
|---|---|
| Priority | Strongly recommended |
| Scope | ORION |
| MATLAB Version | All |
| MA Check | No |
| Prerequisites | **none** |
| Description | Models that contain model reference blocks should have the blocks set to be in "Accelerated" Model.  This setting can be changed by right-clicking on a model reference block, selecting ModelReference Parameters, and then selecting "Accelerator" for the Simulation mode.<br>See the GUI below: |



Function Block Parameters: Veh_Mass_Props <@blade0

ModelReference

Reference the specified model. If the referenced model requires any model arguments, enter them as a comma separated list. To refresh the Model block after any graphical interface changes, select the block and choose Refresh from the Context or Edit menu.

If the referenced model has more than one instance simulating in Normal mode, you may need to set Normal Mode Visibility to on for this Model block. This can be controlled by going to the top model and selecting:
Edit > Model Blocks > Normal Mode Visibility.

This Model block can have variants where one active variant is used for simulation. Each variant is a referenced model designated by its model name and model arguments.

Parameters

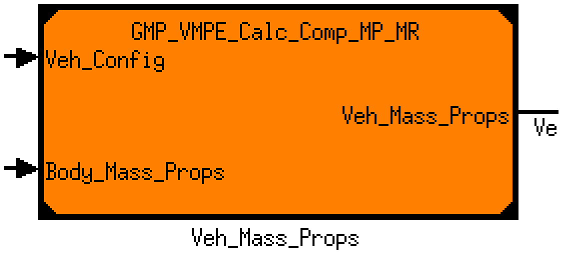
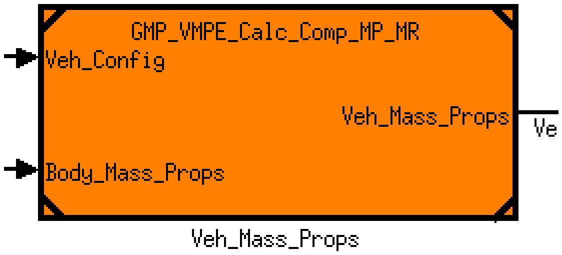
Model name: GMP_VMPE_Calc_Comp_MP_MR

Model arguments:

Model argument values (for this instance):

Simulation mode: Accelerator

The Simulation mode for a model reference block can be determined by the block graphic. Model Reference blocks that are in “Accelerator” mode have filled in black triangles on the corners of the block.

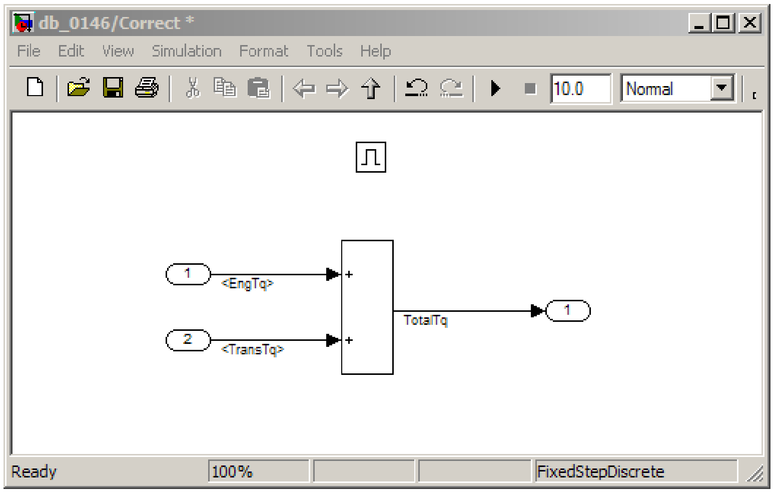
| | |
|---|---|
| | <br> GMP_VMPE_Calc_Comp_MP_MR<br>Veh_Config<br>Veh_Mass_Props<br>Ve<br>Body_Mass_Props<br>Veh_Mass_Props<br>Model Reference Block – Accelerated Mode<br>Model Reference blocks that are in “Normal” mode have empty triangles on the corners of the block.<br><br> GMP_VMPE_Calc_Comp_MP_MR<br>Veh_Config<br>Veh_Mass_Props<br>Ve<br>Body_Mass_Props<br>Veh_Mass_Props<br>Model Reference Block – Normal Mode |
| Rationale | □ Readability<br>□ Workflow<br>☑ Simulation<br>□ Verification and Validation<br>□ Code Generation |
| Last Change | V1.0 |

### 4.3.9.7 db_0146: Triggered, enabled, conditional Subsystems

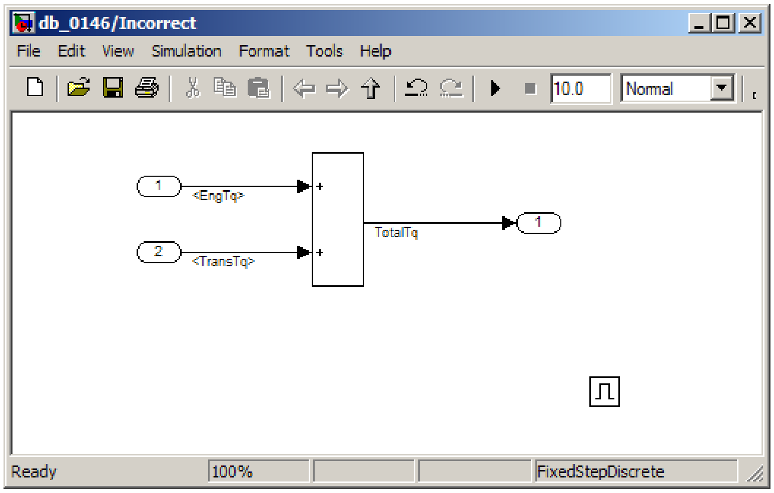
| **ID: Title** | **db_0146: Triggered, enabled, conditional Subsystems** |
|---|---|
| Priority | Strongly recommended |
| Scope | MAAB |
| MATLAB Version | All |
| MA Check | Yes |
| Prerequisites | None |
| Description | The blocks that define subsystems as either conditional or iterative should be located at a consistent location at the top of the subsystem diagram. These are:<br>• Function call<br>• Enabled<br>• Triggered<br>• If / Else Action |

Exception: Only trigger blocks can be used for model reference models at the root level. These trigger blocks can only be set to “function call” and only one is allowed at the root level.

**Correct**



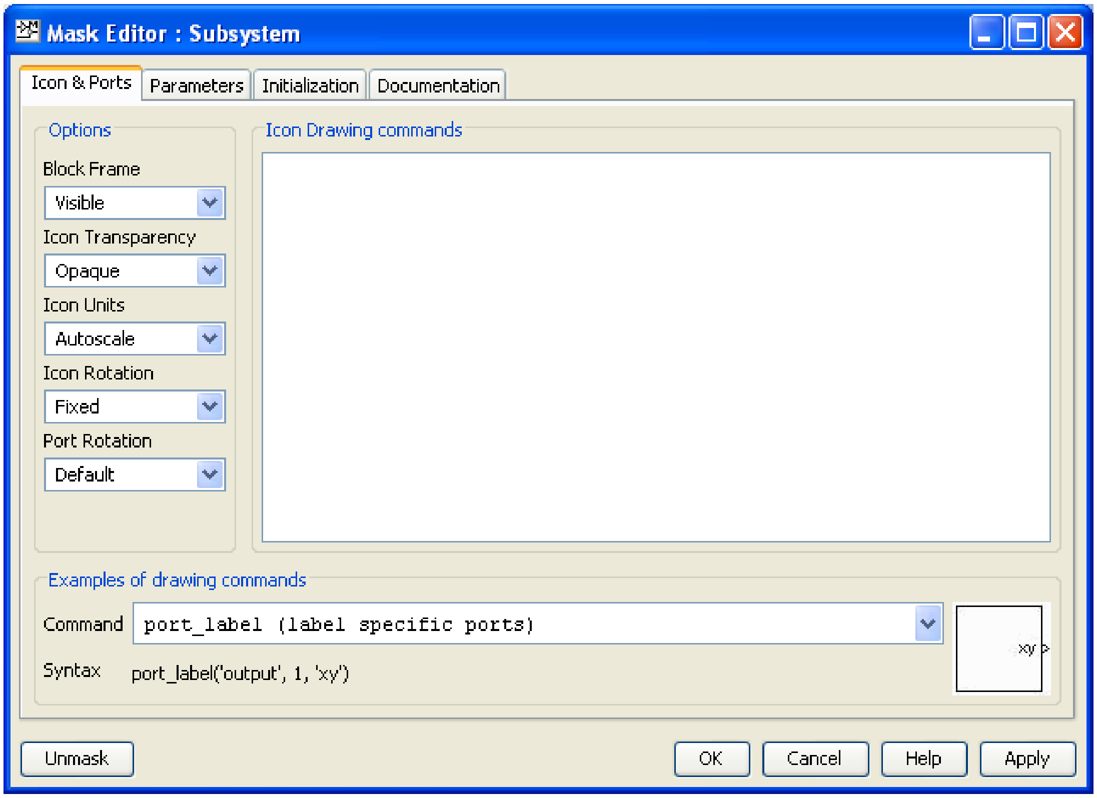
**Incorrect**

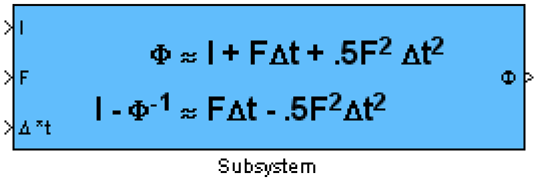


| | |
|---|---|
| Rationale | ☑ Readability ☑ Verification and Validation<br>☑ Workflow ☐ Code Generation<br>☐ Simulation |
| Last Change | V2.1 |

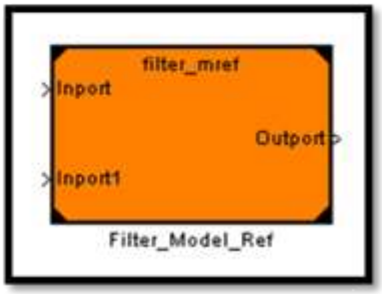
### 4.3.9.8 jph_0010: Use of Masks

| **ID: Title** | **jph_0010: Use of Masks** |
|---|---|
| Priority | Recommended |
| Scope | ORION |

| | |
|---|---|
| MATLAB Version | All |
| MA Check | No |
| Prerequisites | |
| Description | The use of “Masks” can greatly increase the readability of a Simulink model by replacing the generic subsystem appearance with an icon that better illustrates the underlying math. Masks are only permitted for Subsystem blocks and blocks in the ORION Library and shall not be used anywhere else in a CSU model.<br><br>When creating Masks for subsystems, only the “Icon & Ports” tab may be modified in the Mask Editor.<br><br><br> Mask Editor : Subsystem<br>Icon & Ports<br>Parameters<br>Initialization<br>Documentation<br>Options<br>Icon Drawing commands<br>Examples of drawing commands<br>xy<br>Unmask<br>OK<br>Cancel<br>Help<br>Apply<br>Block Frame: Visible<br>Icon Transparency: Opaque<br>Icon Units: Autoscale<br>Icon Rotation: Fixed<br>Port Rotation: Default<br>Command: `port_label (label specific ports)`<br>Syntax: port_label('output', 1, 'xy')<br><br>Mask Editor<br><br>No entries shall be made in the “Parameters”, “Initialization”, or “Documentation” tabs of the Mask Editor.<br><br>Mask “dialogs” are not permitted for non-ORION Library blocks. Mask dialogs are automatically created by Simulink when parameters are added to a masked Subsystem, therefore, adding parameters to a mask is not allowed.<br><br>All inports and outports of a subsystem shall be labeled with their symbolic representation or underlying port name when masking a subsystem.<br><br>See the Appendix for “<u>Subsystem Masking Methods and Guidelines”</u> for more |

| | |
|---|---|
| | information on how to create Masks.<br>Example of proper use of a Subsystem Mask:<br> I<br>F<br>Δ *t<br>Φ ≈ I + FΔt + .5F² Δt²<br>I - Φ⁻¹ ≈ FΔt - .5F²Δt²<br>Φ<br>Subsystem |
| Rationale | ☑ Readability ☑ Verification and Validation<br>☑ Workflow ☐ Code Generation<br>☐ Simulation |
| Last Change | V1.0 |

### 4.3.9.9 hyl_0308: Use of reference model name

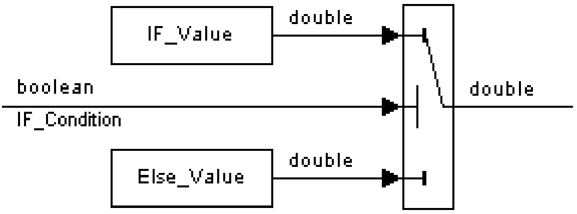
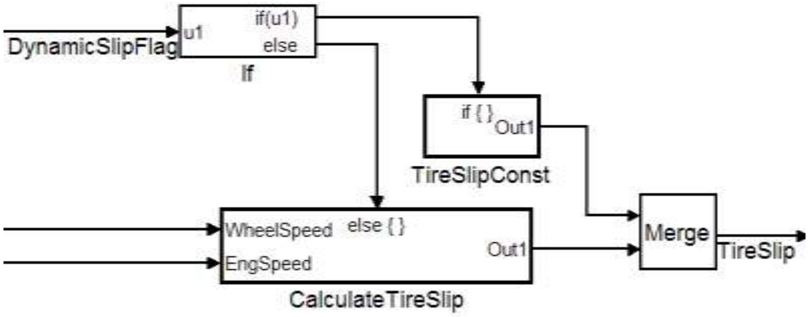
| **ID: Title** | **hyl_0308: Use of reference model name** |
|---|---|
| Priority | Strongly recommended |
| Scope | ORION |
| MATLAB Version | All |
| MA Check | Yes |
| Prerequisites | None |
| Description | No block **shall** be named “referenced model” (or “referenced model1,” referencedModel1,” etc.).<br>Example<br>**Incorrect**<br> filter_mref<br>Inport<br>Outport<br>Inport1<br>Filter_Model_Ref |
| Rationale | ☑ Readability ☐ Verification and Validation<br>☑ Workflow ☑ Code Generation<br>☐ Simulation |

| | |
|---|---|
| Last Change | V2.0 |

### 4.3.10 Subsystem Patterns

The following rules illustrate sample patterns used in Simulink diagrams. As such they would normally be part of a much larger Simulink diagram.

#### 4.3.10.1 na_0012: Use of Switch vs. Case vs. If-Then-Else Action Subsystem

| **ID: Title** | **na_0012: Use of Switch vs. Case vs. If-Then-Else Action Subsystem** |
|---|---|
| Priority | Strongly recommended |
| Scope | MAAB |
| MATLAB Version | All |
| MA Check | No |
| Prerequisites | None |
| Description | The **Switch** block:<br>• Should be used for modeling simple *if-then-else* structures if the associated *then* and *else* actions involve only the assignment of constant values.<br><br> IF_Value<br>double<br>boolean<br>IF_Condition<br>double<br>Else_Value<br>double<br>The **if-then-else action subsystem** construct:<br>• Should be used for modeling *if-then-else structures* if the associated *then* and/or *else* actions require complicated computations. This will maximize simulation efficiency and the efficiency of generated code (Note that even a basic block, for example a table look-up, can require fairly complicated computations.)<br><br> DynamicSlipFlag<br>u1<br>if(u1)<br>else<br>If<br>if { }<br>Out1<br>TireSlipConst<br>WheelSpeed<br>else { }<br>EngSpeed<br>Out1<br>CalculateTireSlip<br>Merge<br>TireSlip<br>• Must be used for modeling *if-then-else* structures if the purpose of the construct is to avoid an undesirable numerical computation, such as division by zero. |

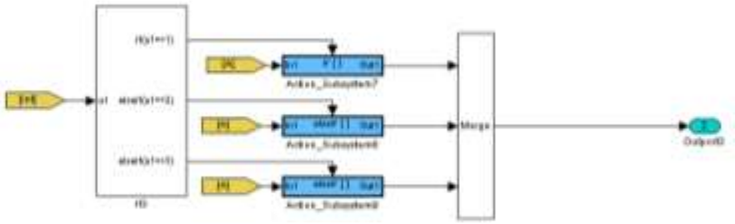
- Should be used for modeling *if-then-else* structures if the explicit or implied *then* or the *else* action is just to hold the associated output value(s).

In other cases, the degree of complexity of the *then* and/or *else* action computations and the intelligence of the Simulink simulation and code generation engines will determine the appropriate construct.

These statements also apply to more complicated nested and cascaded *if-then-else* structures and *case* structure implementations.

Generally, the If/Then block, Case block, and Switch Simulink blocks can be used to create the same logic functionality in a Simulink model. However, the autocode of these may slightly differ. Here are some Example block constructs and the resulting autocode to illustrate the differences. Pay special attention to the last example involving a switch blocks and model reference blocks.

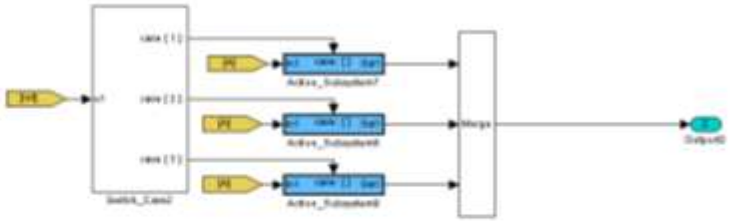
**If/Then Block Example:**



**Resulting Autocode:**

```
if (IfThen_test_U.int_j == 1U) {
  IfThen_test_B.Merge3 = 333.0 * IfThen_test_U.data;
} else if (IfThen_test_U.int_j == 2U) {
  IfThen_test_B.Merge3 = 444.0 * IfThen_test_U.data;
} else {
  if (IfThen_test_U.int_j == 3U) {
    IfThen_test_B.Merge3 = 555.0 * IfThen_test_U.data;
  }
}
```

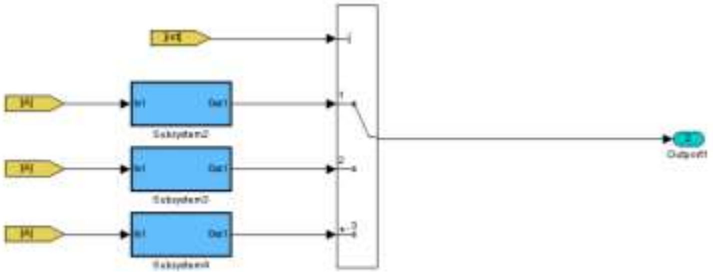
**Case Block Example:**



**Resulting Autocode:**

```
  switch (Case_test_U.int_o) {
  case 1:
   Case_test_B.Merge3 = 333.0 * Case_test_U.data;
   break;

   case 2:
   Case_test_B.Merge3 = 444.0 * Case_test_U.data;
   break;

   case 3:
   Case_test_B.Merge3 = 555.0 * Case_test_U.data;
   break;
 }
```

**Switch Block Example:**

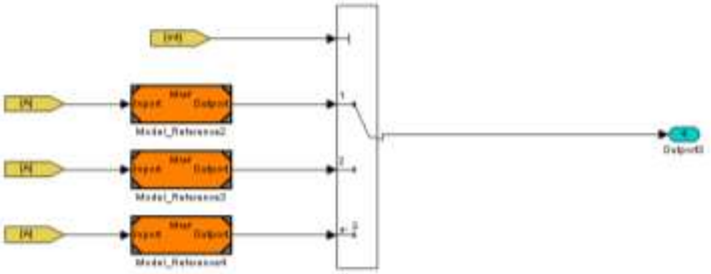


**Resulting Autocode:**

```
  switch (Switch_test_U.int_j) {
  case 1:
   Switch_test_Y.Outport1 = 333.0 * Switch_test_U.data;
   break;

  case 2:
   Switch_test_Y.Outport1 = 444.0 * Switch_test_U.data;
   break;

  default:
   Switch_test_Y.Outport1 = 555.0 * Switch_test_U.data;
   break;
 }
```

The switch case will autocode similarly to the If/Then or Case constructs with one exception.  If a subsystem related to a Switch block contains a Model Reference block, this Model reference block will not be called from within the case statement.  The call to the model reference will occur on each pass, regardless of the outcome of the logic.  Only the data will be assigned within the case statement.  This type of construct should be avoided to prevent unnecessary computations.

**Switch Block with Model Reference Example:**



**Resulting Autocode:**

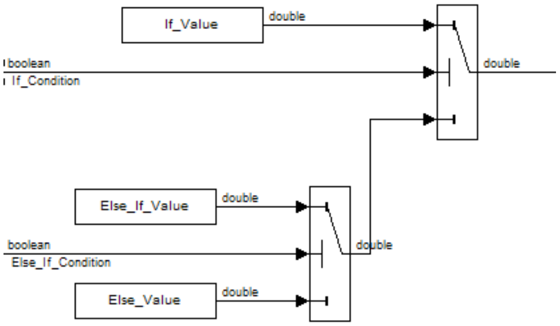
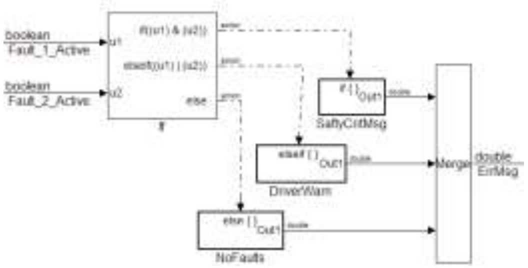
```
mr_Mref(&Switch_test_U.data, &rtb_Model_Reference2);

mr_Mref(&Switch_test_U.data, &rtb_Model_Reference3);

mr_Mref(&Switch_test_U.data, &rtb_Model_Reference4);

switch (Switch_test_U.int_j) {
 case 1:
  Switch_test_Y.Outport3 = rtb_Model_Reference2;
  break;

 case 2:
  Switch_test_Y.Outport3 = rtb_Model_Reference3;
  break;

 default:
  Switch_test_Y.Outport3 = rtb_Model_Reference4;
  break;
}
```

| | | |
|---|---|---|
| Rationale | ☑ Readability<br>☑ Workflow<br>☐ Simulation | ☐ Verification and Validation<br>☐ Code Generation |
| Last Change | V3.0 | |

### 4.3.10.2 db_0114: Simulink patterns for If-then-else-if constructs

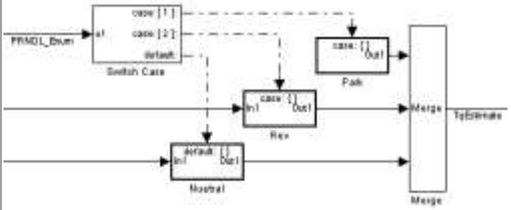
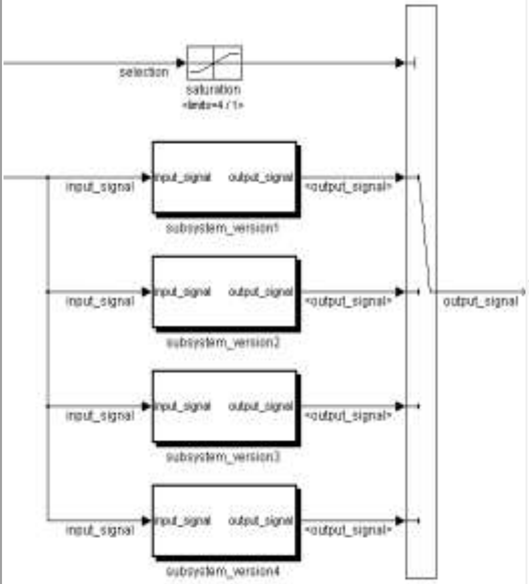
| **ID: Title** | **db_0114: Simulink patterns for If-then-else-if constructs** |
|---|---|
| Priority | Strongly recommended |
| Scope | MAAB |
| MATLAB Version | All |
| MA Check | No |
| Prerequisites | None |
| Description | The following patterns should be used for If-then-else-if constructs within Simulink: |

| Equivalent Functionality | Simulink pattern |
|---|---|

<table>
<tr><td></td><td>IF THEN ELSE IF with switch blocks<br><br><em>if (If_Condition) {</em><br><em>output_signal = If_Value;</em><br><em>}</em><br><em>else if (Else_If_Condition) {</em><br><em>output_signal = Else_If_Value;</em><br><em>}</em><br><em>else {</em><br><em>output_signal = Else_Value;</em><br><em>}</em></td><td>
</td></tr>
<tr><td></td><td>IF THEN ELSE IF with if/then/else subsystems:<br><em>if(Fault_1_Active &amp; Fault_2_Active)</em><br><em>{</em><br><em>ErrMsg = SaftyCrit;</em><br><em>}</em><br><em>else if (Fault_1_Active</em> | <em>Fault_2_Active)</em><br><br><em>{</em><br><em>ErrMsg = DriveWarn;</em><br><em>}</em><br><em>else</em><br><em>{</em><br><em>ErrMsg = NoFaults;</em><br><em>}</em></td><td>
</td></tr>
<tr><td></td><td colspan="2">A maximum of 10 cases should be used with the pattern shown above. If there are more than 10 cases, eML or Stateflow should be used to implement the logic.</td></tr>
<tr><td>Rationale</td><td>☑ Readability<br>☑ Workflow<br>□ Simulation</td><td>□ Verification and Validation<br>☑ Code Generation</td></tr>
<tr><td>Last Change</td><td colspan="2">V2.1</td></tr>
</table>

### 4.3.10.3 db_0115: Simulink patterns for case constructs

| **ID: Title** | **db_0115: Simulink patterns for case constructs** |
|---|---|
| Priority | Strongly recommended |
| Scope | MAAB |
| MATLAB Version | All |
| MA Check | No |

<table>
<tr><td>Prerequisites</td><td>None</td></tr>
<tr><td>Description</td><td>The following patterns are used for case constructs within Simulink:
<table>
<tr><th>Equivalent Functionality</th><th>Simulink Pattern</th></tr>
<tr><td>Case<br>With switch case block<br><br><em>switch (PRNDL_Enum)<br>{<br>case 1<br>  TqEstimate = ParkV;<br>  break;<br>case 2<br>  TqEstimae = RevV;<br>  break;<br>default<br>  TqEstimate = NeutralV;<br>  break;<br>}</em></td><td> </td></tr>
<tr><td>CASE<br>with multiport switch and subsystems:<br><br><em>output_version1 = function_version1(input_signal);<br>output_version2 = function_version2(input_signal);<br>output_version3 = function_version3(input_signal);<br>output_version4 = function_version4(input_signal);<br><br>switch (selection) {<br>case 1:<br>output_signal = output_version1;<br>break;<br>case 2:<br>output_signal = output_version2;<br>break;<br>case 3:<br>output_signal = output_version3;<br>break;<br>default:<br>output_signal = output_version4;<br>}</em></td><td> </td></tr>
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<td></td>
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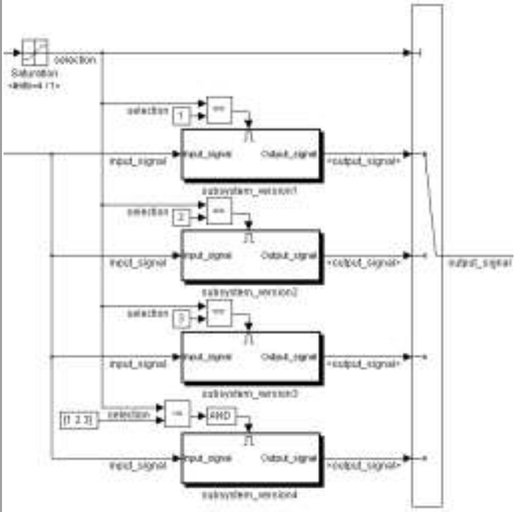
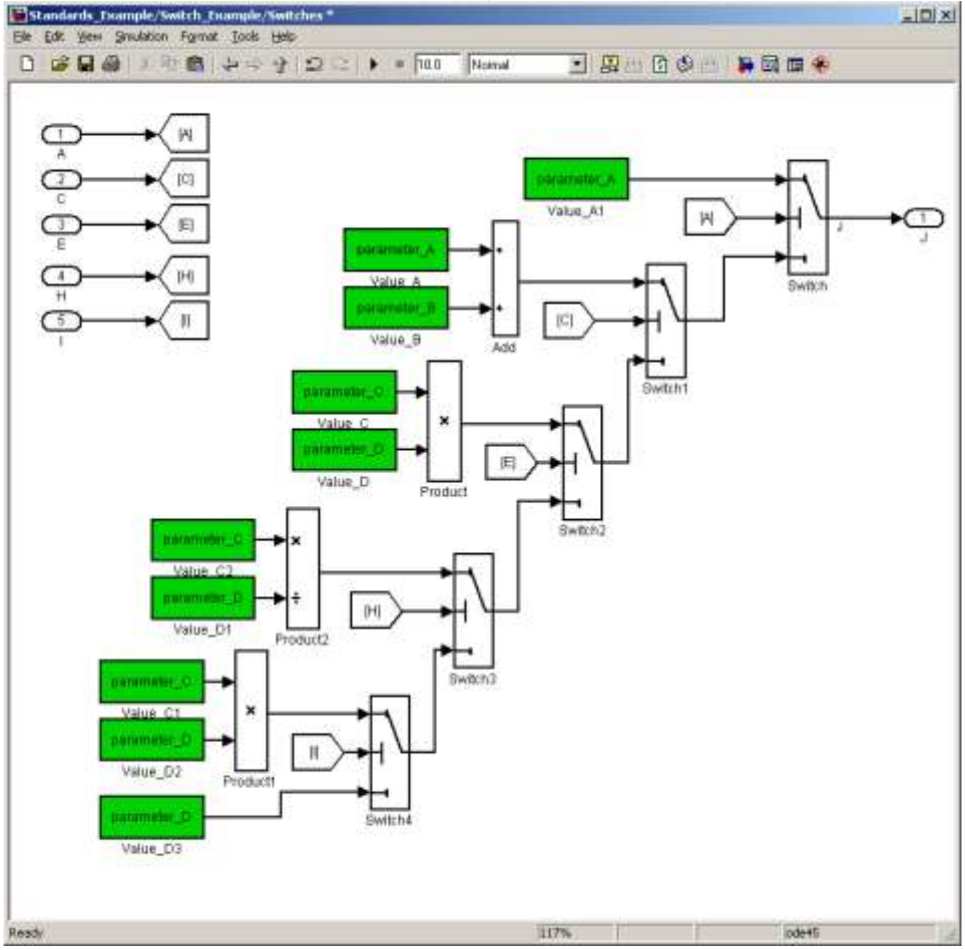
<table>
<tr>
<td>CASE<br>with multiport switch and<br>enabled subsystems:<br><br><i>switch (selection) {<br>case 1:<br>output_version1 =<br>function_version1(input_signal);<br>output_signal = output_version1;<br>break;<br>case 2:<br>output_version2 =<br>function_version2(input_signal);<br>output_signal = output_version2;<br>break;<br>case 3:<br>output_version3 =<br>function_version3(input_signal);<br>output_signal = output_version3;<br>break;<br>default:<br>output_version4 =<br>function_version4(input_signal);<br>output_signal = output_version4;<br>}</i></td>
<td>


</td>
</tr>
</table>
<br>A maximum of 10 cases should be used with the pattern shown above. If there are more than 10 cases, eML or Stateflow should be used to implement the logic.
</td>
</tr>
<tr>
<td>Rationale</td>
<td>☑ Readability ☑ Verification and Validation<br>☑ Workflow ☐ Code Generation<br>☐ Simulation</td>
</tr>
<tr>
<td>Last Change</td>
<td>V2.1</td>
</tr>
</table>

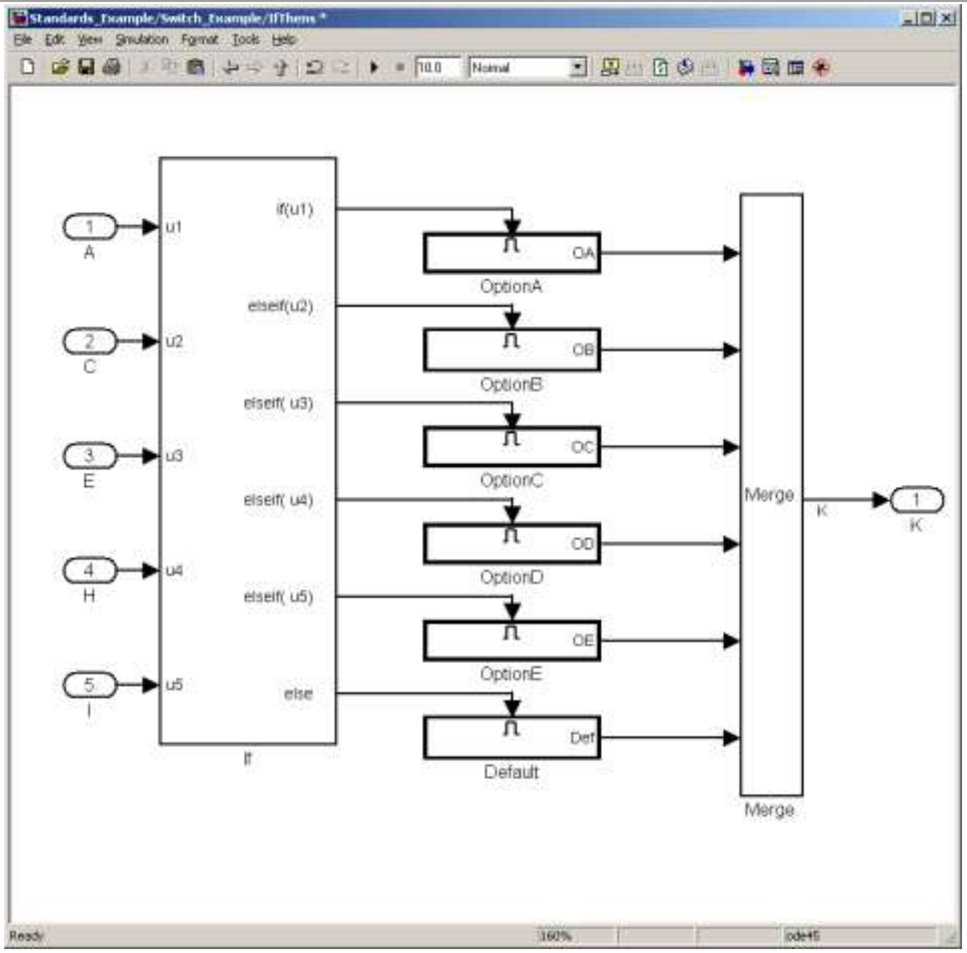
### 4.3.10.4 bn_0003: Use of If-Then-Else Action Subsystem to Replace Multiple Switches

| | |
|---|---|
| **ID: Title** | **bn_0003: Use of If-Then-Else Action Subsystem to Replace Multiple Switches** |
| Priority | Strongly recommended |
| Scope | ORION |
| MATLAB Version | All |
| MA Check | No |
| Prerequisites | **na_0012: Use of Switch vs. If-Then-Else Action Subsystem**<br>**db_0114: Simulink patterns for If-then-else-if constructs** |
| Description | The use of multiple switches must be appropriate to the degree of complexity of the *then* and/or *else* action computations and the intelligence of the Simulink simulation and code generation engines. A switch construct of more than 3 switches (1 IF path, 2 ELSE-IF paths, and 1 ELSE) must use an if-then construct for readability. |

A 5 switch construct such as this.  May be fine for simple computations.

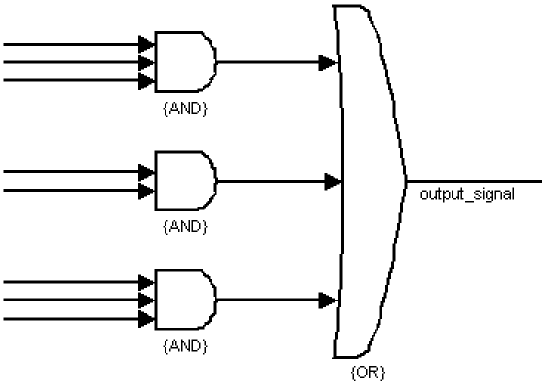
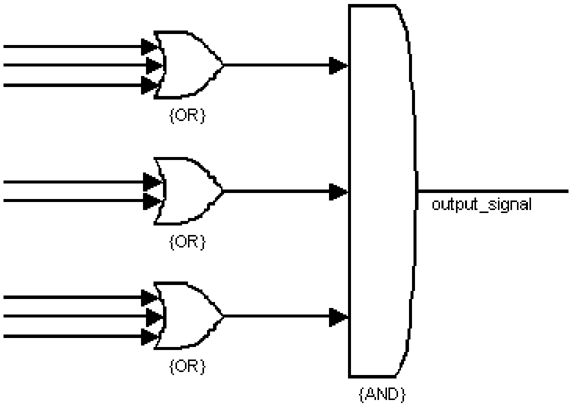


But, the structure is more readable using if-then block and actions subsystems.

| | |
|---|---|
| |  Standards_Example/Switch_Example/IfThens *<br>File Edit View Simulation Format Tools Help<br>10.0<br>Normal<br>1<br>A<br>2<br>C<br>3<br>E<br>4<br>H<br>5<br>I<br>u1<br>u2<br>u3<br>u4<br>u5<br>if(u1)<br>elseif(u2)<br>elseif( u3)<br>elseif( u4)<br>elseif( u5)<br>else<br>If<br>OA<br>OptionA<br>OB<br>OptionB<br>OC<br>OptionC<br>OD<br>OptionD<br>OE<br>OptionE<br>Def<br>Default<br>Merge<br>Merge<br>K<br>1<br>K<br>Ready<br>160%<br>ode45<br>These statements also apply to more complicated nested and cascaded *if-then-else* structures and *case* structure implementations. |
| Rationale | ☑ Readability<br>☑ Workflow<br>□ Simulation<br>□ Verification and Validation<br>□ Code Generation |
| Last Change | V2.0 |

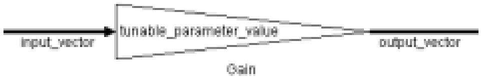
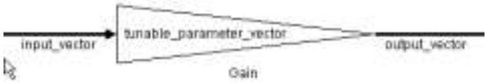
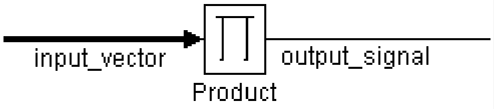
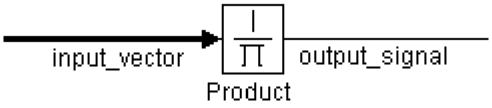
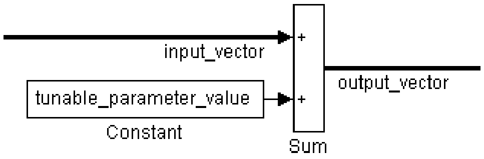
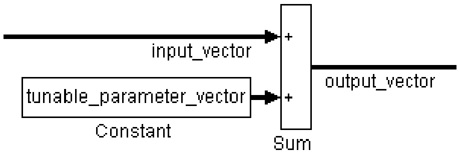
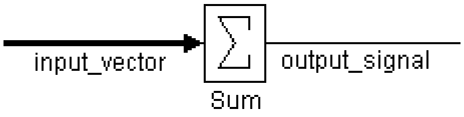
### 4.3.10.5 db_0116: Simulink patterns for logical constructs with logical blocks

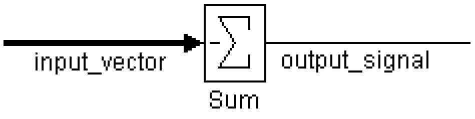
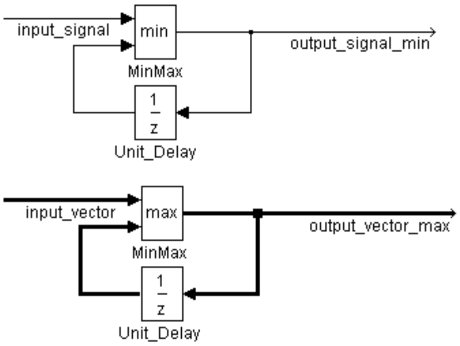
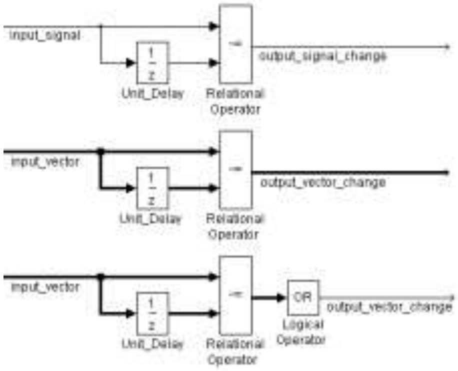
| **ID: Title** | **db_0116: Simulink patterns for logical constructs with logical blocks** |
|---|---|
| Priority | Strongly recommended |
| Scope | MAAB |
| MATLAB Version | All |
| MA Check | No |
| Prerequisites | None |

<table>
<tr><td>Description</td><td>
<table>
<tr><td colspan="2">The following patterns are used for logical combinations within Simulink:</td></tr>
<tr><th>Equivalent Functionality</th><th>Simulink pattern</th></tr>
<tr><td>Combination of logical signals: conjunctive</td><td>
</td></tr>
<tr><td>Combination of logical signals: disjunctive</td><td>
</td></tr>
</table>
</td></tr>
<tr><td>Rationale</td><td>☑ Readability ☑ Verification and Validation<br>☑ Workflow □ Code Generation<br>□ Simulation</td></tr>
<tr><td>Last Change</td><td>V1.1</td></tr>
</table>

### 4.3.10.6 db_0117: Simulink patterns for vector signals

| | |
|---|---|
| **ID: Title** | **db_0117: Simulink patterns for vector signals** |
| Priority | Strongly recommended |
| Scope | MAAB |
| MATLAB Version | All |
| MA Check | No |
| Prerequisites | None |
| Description | The following patterns are used for vector signals within Simulink: |

| Equivalent Functionality | Simulink Pattern |
|---|---|
| Vector loop:<br>for (i=0; i>input_vector_size; i++)<br>{<br>output_vector(i) = input_vector(i) * tunable_parameter_value;<br>} |  input_vector<br>tunable_parameter_value<br>output_vector<br>Gain |
| Vector loop:<br>for (i=0; i>input_vector_size; i++)<br>{<br>output_vector(i) = input_vector(i) * tunable_parameter_vector(i);<br>} |  input_vector<br>tunable_parameter_vector<br>output_vector<br>Gain |
| Vector loop:<br>output_signal = 1;<br>for (i=0; i>input_vector_size; i++)<br>{<br>output_signal = output_signal * input_vector(i);<br>} |  |
| Vector loop:<br>output_signal = 1;<br>for (i=0; i>input_vector_size; i++)<br>{<br>output_signal = output_signal / input_vector(i);<br>} |  |
| Vector loop:<br>for (i=0; i>input_vector_size; i++)<br>{<br>output_vector(i) = input_vector(i) + tunable_parameter_value;<br>} |  input_vector<br>+<br>tunable_parameter_value<br>Constant<br>+<br>output_vector<br>Sum |
| Vector loop:<br>for (i=0; i>input_vector_size; i++)<br>{<br>output_vector(i) = input_vector(i) + tunable_parameter_vector(i);<br>} |  input_vector<br>+<br>tunable_parameter_vector<br>Constant<br>+<br>output_vector<br>Sum |
| Vector loop:<br>output_signal = 0;<br>for (i=0; i>input_vector_size; i++)<br>{<br>output_signal = output_signal + input_vector(i); |  |

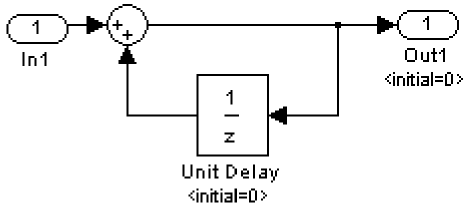
|  |  |  |
|---|---|---|
|  | } |  |
|  | Vector loop:<br>output_signal = 0;<br>for (i=0; i>input_vector_size; i++)<br>{<br>output_signal = output_signal - input_vector(i);<br>} |  |
|  | Minimum or maximum of a signal or a vector over time: |  input_signal<br>min<br>MinMax<br>1<br>z<br>Unit_Delay<br>output_signal_min<br>input_vector<br>max<br>MinMax<br>1<br>z<br>Unit_Delay<br>output_vector_max |
|  | Change event of a signal or a vector: |  input_signal<br>1<br>z<br>Unit_Delay<br>~=<br>Relational Operator<br>output_signal_change<br>input_vector<br>1<br>z<br>Unit_Delay<br>~=<br>Relational Operator<br>output_vector_change<br>input_vector<br>1<br>z<br>Unit_Delay<br>~=<br>Relational Operator<br>OR<br>Logical Operator<br>output_vector_change |
| Rationale | ☑ Readability<br>☑ Workflow<br>☐ Simulation<br>☑ Verification and Validation<br>☑ Code Generation |  |
| Last Change | V1.0 |  |

## 4.3.10.7 jc_0351: Methods of initialization

| ID: Title | **jc_0351: Methods of initialization** |
|---|---|
| Priority | Recommended |
| Scope | MAAB |
| MATLAB Version | All |
| MA Check | No |
| Prerequisites | db_0140: Display of block parameters |
| Description | **Simple initialization:** |

- Blocks such as the Unit Delay, that have an initial value field can be used to set simple initial values.
- To determine if the initial value needs to be displayed see db_0140.

**Example**



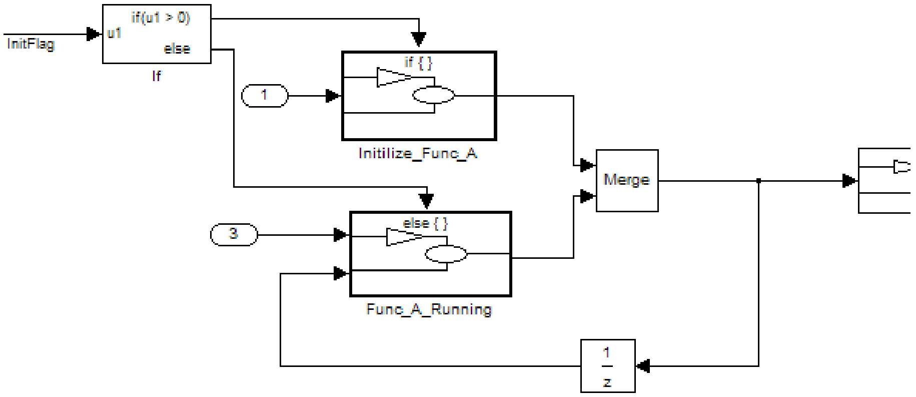
**Initialization that requires computation:**

For complex initializations the following rules hold.

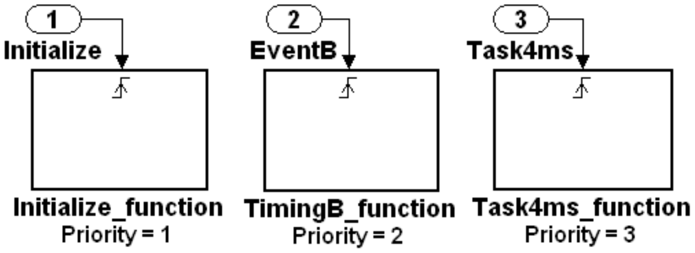
- The initialization should be performed in a separate subsystem.
- The initialization subsystem should have a name that indicates that initialization is performed by the subsystem.

Complex initializations can either be done at a local level (Example A) or at a global level (Example B) or a combination.

**Example A**



**Example B**



| | | |
|---|---|---|
| Rationale | ☐ Readability<br>☑ Workflow<br>☐ Simulation | ☐ Verification and Validation<br>☐ Code Generation |
| Last Change | V2.0 | |

### 4.3.11 Enumerations

#### 4.3.11.1 dm_0002: Enumerated Types Usage

| **ID: Title** | **dm_0002: Enumerated Types Usage** |
|---|---|
| Priority | Mandatory |
| Scope | Orion |
| MATLAB Version | 2010B and Later |
| MA Check | No |
| Prerequisites | None |
| Description | Enumeration types shall be used instead of integer types (and constants) to select from a limitied series of choices (SDP OCS Rule 137). This includes implementation of enumerated types throughout the code. |
| Rationale | ☑ Readability<br>☑ Workflow<br>☐ Simulation<br>☐ Verification and Validation<br>☑ Code Generation |
| Last Change | V2.1 |

#### 4.3.11.2 dm_0003: Enumerated Types Header Files

| **ID: Title** | **dm_0003: Enumerated Types Header Files** |
|---|---|
| Priority | Mandatory |
| Scope | Orion |
| MATLAB Version | 2010B and Later |
| MA Check | Yes |
| Prerequisites | None |
| Description | When defining an enumerated type within MATLAB, the “getHeaderFile” method must be declared such that the return value follows the format of:<br>`‘SmlkEnum_<EnumType>.h’`<br>This will ensure that the RTW Auto-Coder completes a #include of this file instead of generating it’s only declaration within the <Model Reference>_types.h file. Additionally, this header file must be created (using generate_enum_header.m) to be consistent with the Orion Standard of generating headers files separate from RTW to facilitate communication of interfaces with Rhapsody. |
| Rationale | ☑ Readability<br>☑ Workflow<br>☐ Simulation<br>☐ Verification and Validation<br>☑ Code Generation |
| Last Change | V2.1 |

### 4.3.11.3 dm_0004: Enumerated Types RTW Settings

<table>
<tr><th>ID: Title</th><th>dm_0004: Enumerated Types RTW Settings</th></tr>
<tr><td>Priority</td><td>Mandatory</td></tr>
<tr><td>Scope</td><td>Orion</td></tr>
<tr><td>MATLAB Version</td><td>2010B and Later</td></tr>
<tr><td>MA Check</td><td>Yes</td></tr>
<tr><td>Prerequisites</td><td>None</td></tr>
<tr><td>Description</td><td>When defining an enumerated type within MATLAB, the “addClassNameToEnumNames” method must be declared such that the return value is “true”.  This will cause the RTW auto-coder to pre-pend the enumerations with the type definition to prevent name conflicts with identifiers in Real-Time Workshop generated code.<br>Example:<br>MATLAB Declaration:
<pre>
enumeration
    IDLE(1)
    AUTO_ENTRY_CM_RCS_CNTRL(2)
    AUTO_TOUCHDOWN_ROLL_CNTRL(4)
end

function retVal = addClassNameToEnumNames()
    retVal = true;
end
</pre>
Generated Header File Declaration:
<pre>
typedef enum { /* CNC_ModeEnum */
    CNC_ModeEnum_IDLE                = 1,
    CNC_ModeEnum_AUTO_ENTRY_CM_RCS_CNTRL = 2,
    CNC_ModeEnum_AUTO_TOUCHDOWN_ROLL_CNTRL = 4
} CNC_ModeEnum;
</pre></td></tr>
<tr><td>Rationale</td><td>☑ Readability<br>☑ Workflow<br>☐ Simulation<br>☐ Verification and Validation<br>☑ Code Generation</td></tr>
<tr><td>Last Change</td><td>V2.1</td></tr>
</table>

### 4.3.11.4 dm_0005: Enumerated Types Description

| **ID: Title** | **dm_0005: Enumerated Types Description** |
|---|---|
| Priority | Recommended |
| Scope | Orion |
| MATLAB | 2010B and Later |

| | |
|---|---|
| Version | |
| MA Check | Yes |
| Prerequisites | None |
| Description | When defining an enumerated type within MATLAB, the “getDescription” method should return a value that enables the parsing of both the typedef and element descriptions. The format shall consist of the following:<br>&lt;enumeration1&gt;: &lt;enumeration1 description&gt; \n<br>&lt;enumeration2&gt;: &lt;enumeration2 description&gt; \n<br>etc<br>Example:<br>`function retVal = getDescription()`<br>`    % GETDESCRIPTION  Optional string to describe enumerations`<br>`    retVal = sprintf([...`<br>`        'CNC_ModeEnum: This Enumeration describes the Modes used by the CM Controls (CNC) Domain\n',...`<br>`        'IDLE: No Domain CSUs are called\n',...`<br>`        'AUTO_ENTRY_CM_RCS_CNTRL: The CM RCS Control Law CSU generetes commands for CM Thruster Logic\n',...`<br>`        'AUTO_TOUCHDOWN_ROLL_CNTRL: The CM Roll Control CSU generated commands for CM Thruster Logic\n'...`<br>`         ]);`<br>`end` |
| Rationale | ☑ Readability<br>☑ Workflow<br>☐ Simulation<br>☐ Verification and Validation<br>☑ Code Generation |
| Last Change | V2.1 |

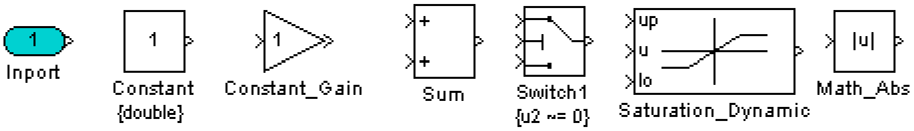
### 4.3.11.5 jr_0003: Enumeration Name Convention

| | |
|---|---|
| **ID: Title** | **jr_0003: Enumeration Name Convention** |
| Priority | Recommended |
| Scope | Orion |
| MATLAB Version | 2010B and Later |
| MA Check | Yes |
| Prerequisites | None |
| Description | Enumeration names should be defined using all CAPS with names separated by underscores. Enumerated typedef should follow the same naming convention outlined Standard dm_0001.<br>Examples:<br>`classdef(Enumeration) CNC_ModeEnum < Simulink.IntEnumType`<br>`    enumeration`<br>`        IDLE(1)`<br>`        AUTO_ENTRY_CM_RCS_CNTRL(2)`<br>`        AUTO_TOUCHDOWN_ROLL_CNTRL(4)` |

| | |
|---|---|
| | <br>`    end`<br>`end` |
| Rationale | ☑ Readability ☐ Verification and Validation<br>☑ Workflow ☑ Code Generation<br>☐ Simulation |
| Last Change | V2.1 |

## *4.4 Model Architecture*

**Basic Blocks**
This document uses the term “Basic Blocks” to refer to blocks from the ORION Library; examples of basic blocks are shown below.



### 4.4.1 Simulink®, eML, and Stateflow® Partitioning

#### 4.4.1.1 jh_0202: Testable Units

| **ID: Title** | **jh_0202: Testable Unit** |
|---|---|
| Priority | Mandatory |
| Scope | ORION |
| MATLAB Version | All |
| MA Check | No |
| Prerequisites | |
| Description | Testable Units<br>There are two forms of testable units. In Simulink, a testable unit is an individual model or eML function that can be executed separately without modification. For the autocode, a testable unit is simply a function. Ideally, each testable unit in Simulink will translate into a single testable unit in the autocode. This approach aids in the management of complexity and maximizes unit test reuse between model and autocode. Testable units should be limited in functional scope to one or a few related system functions. |

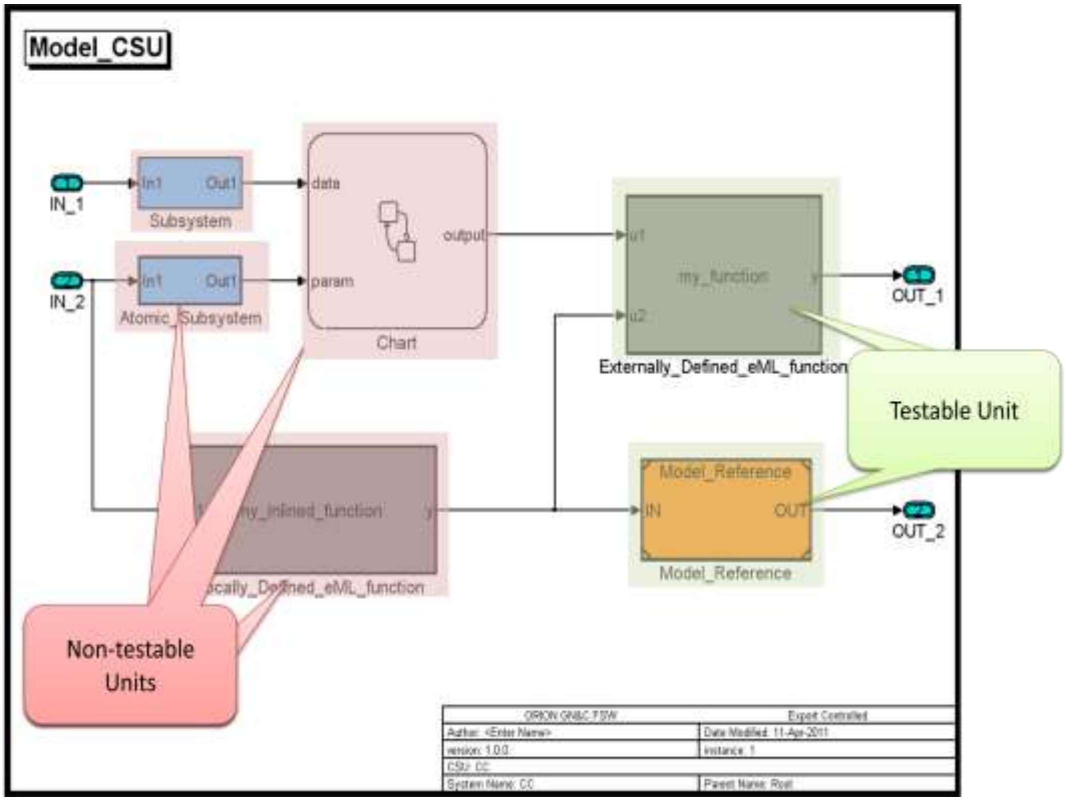
**Individually Testable Components in Simulink**

- Individual Simulink Models (CSUs, Model References(MR) aka “dot-mdl” files)
- Externally saved Matlab Functions (“dot-m” files)

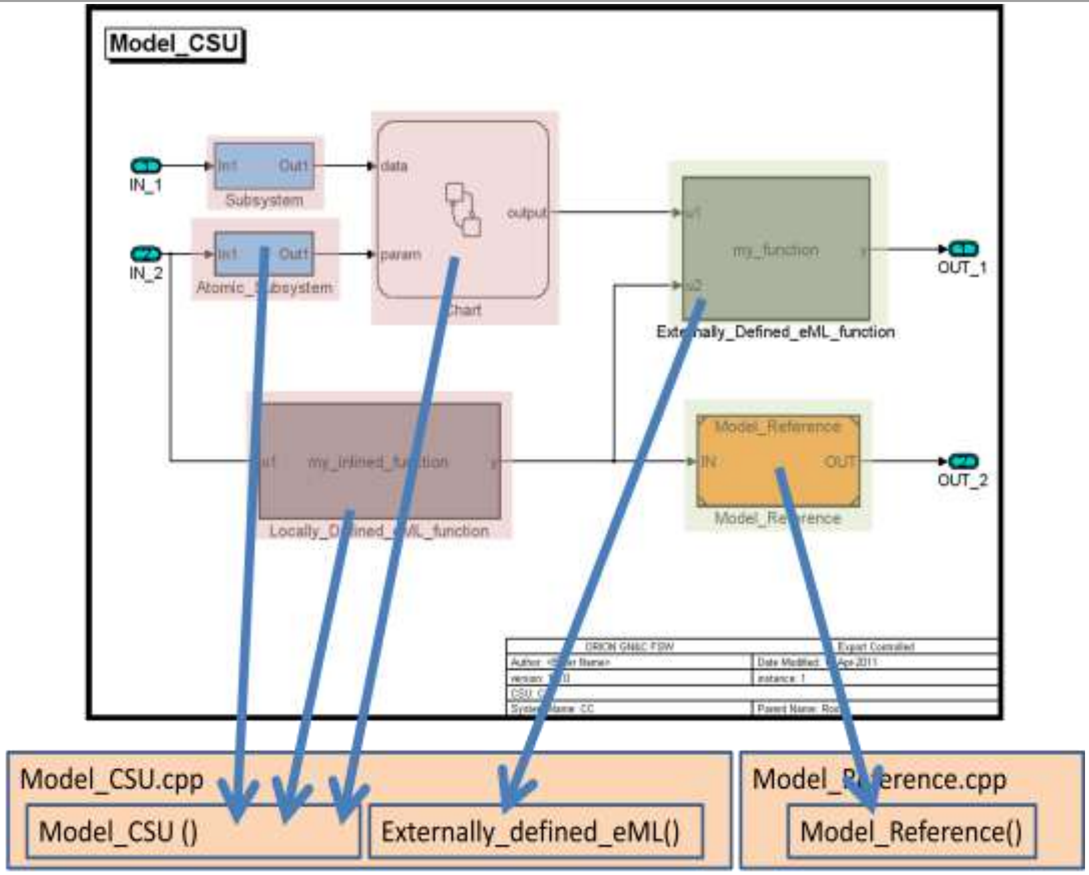
**Non-Individually Testable Components in Simulink**

- Subsystems (including atomic)
- Stateflow charts
- locally defined embedded matlab functions (those that exist only in the model, not as external *.m files)

The illustration below shows the testable and non-testable components of a Simulink model.



Furthermore, the resulting autocode for a testable component will be a single stand-alone function. The illustration below shows where the resulting code is placed for units in a model.



As seen by the above illustration:

- The MRB will autocode into a separate cpp file with an individually testable function. Each .mdl file will generate a separate .cpp.
- Externally defined eML functions (that include the eml.inline('never'); declaration) will autocode into the main cpp file as a separate function that is individually testable
- All other blocks will be "inlined" into the main cpp file as a part of the main cpp function.

Note: there are some ORION library utility functions and atomic subsystems/charts that are configured to autocode as separate functions.

Important Note: All Externally defined *.m files ("dot-m") are Testable units and should be represented as a single function in the autocode. An Embedded Matlab function will only be autocoded as a separate function if the following declaration is present after the function call:

```
eml.inline('never');
```

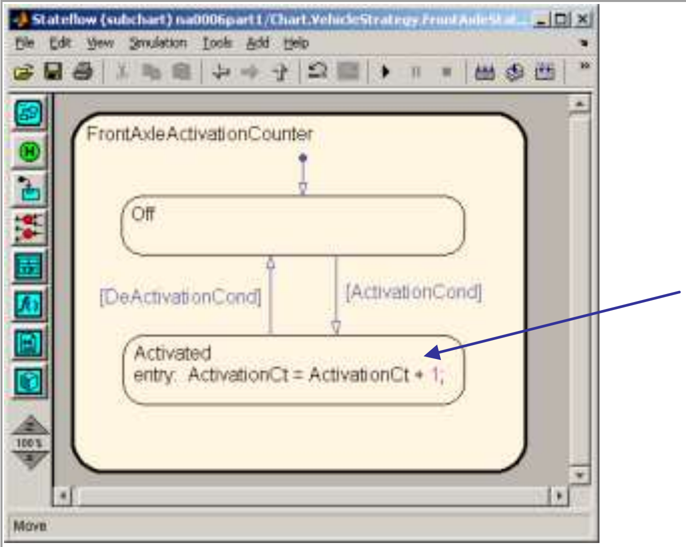
For example:

```
function [att_out] = NVA_EKF_update_ref_att(phi, att_in)
%#eml
eml.inline('never');
```

| | |
|---|---|
| | ...<br>...<br>...<br>A further description of the ORION Definition of a “Testable Unit” can be found within the “GNC Model Development Cyclomatic Complexity Guidelines” memo (Doc #: CEV-GN&C-11-014).<br>Link on ICE<br>https://ice.exploration.nasa.gov/Windchill/netmarkets/jsp/document/view.jsp?oid=document~wt.doc.WTDocument%3A2240757958&u8=1 |
| Rationale | ☑ Readability ☑ Verification and Validation<br>☑ Workflow ☑ Code Generation<br>☑ Simulation |
| Last Change | V1.0 |

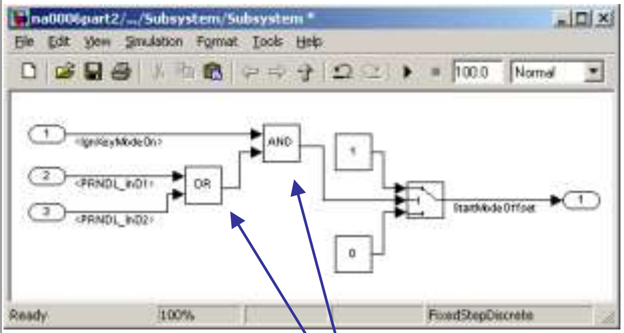
### 4.4.1.2 na_0006: Guidelines for mixed use of Simulink and Stateflow

| **ID: Title** | **na_0006: Guidelines for mixed use of Simulink and Stateflow** |
|---|---|
| Priority | Recommended |
| Scope | MAAB |
| MATLAB Version | All |
| MA Check | No |
| Prerequisites | none |
| Description | The choice of whether to use Simulink or Stateflow to model a given portion of the control algorithm functionality should be driven by the nature of the behavior being modeled.<br>• If the function primarily involves complicated logical operations, Stateflow should be used.<br>  • Stateflow should be used to implement modal logic – where the control function to be performed at the current time depends on a combination of *past and present logical conditions.*<br>• If the function primarily involves numerical operations, Simulink or Embedded Matlab should be used.<br>Specifics:<br>• If the primary nature of the function is logical, but some simple numerical calculations are done to support the logic, it is preferable to implement the simple numerical functions using the Stateflow action language. |


Stateflow (subchart) na0006part1/Chart.VehicleStrategy.FrontAxleStat...
File Edit View Simulation Tools Add Help
FrontAxleActivationCounter
Off
[DeActivationCond]
[ActivationCond]
Activated
entry: ActivationCt = ActivationCt + 1;
100%
Move

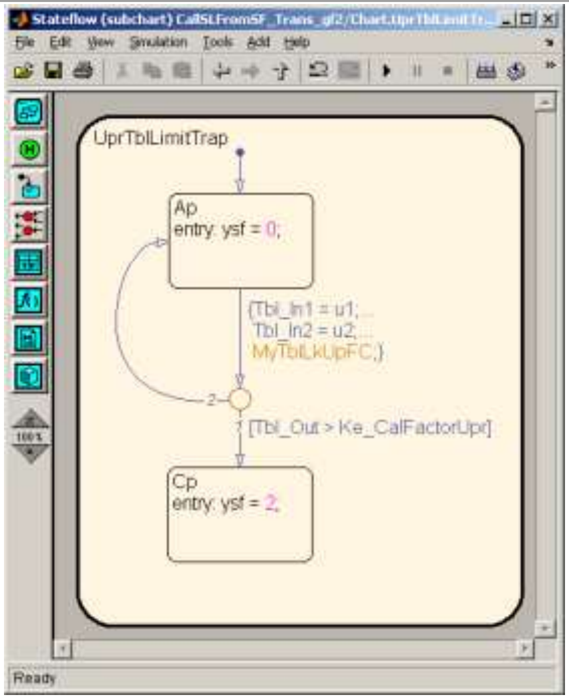
Embedded
simple
math operation

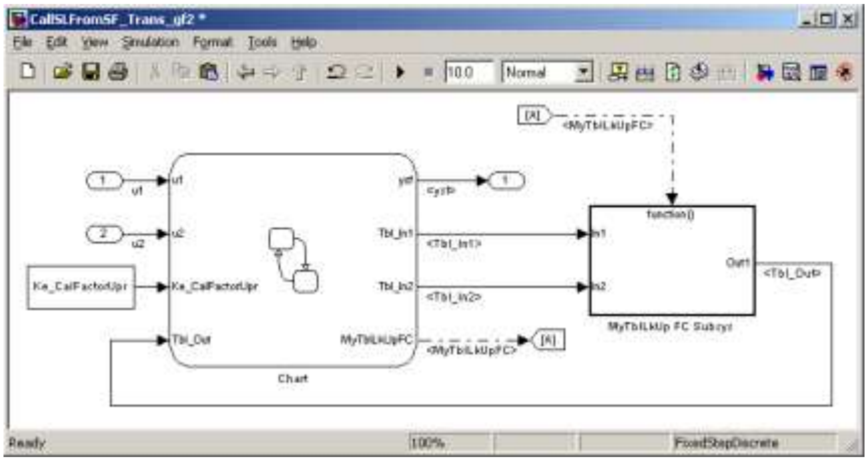
- If the primary nature of the function is numerical, but some simple logical operations are done to support the arithmetic, it is preferable to implement the simple logical functions within Simulink.

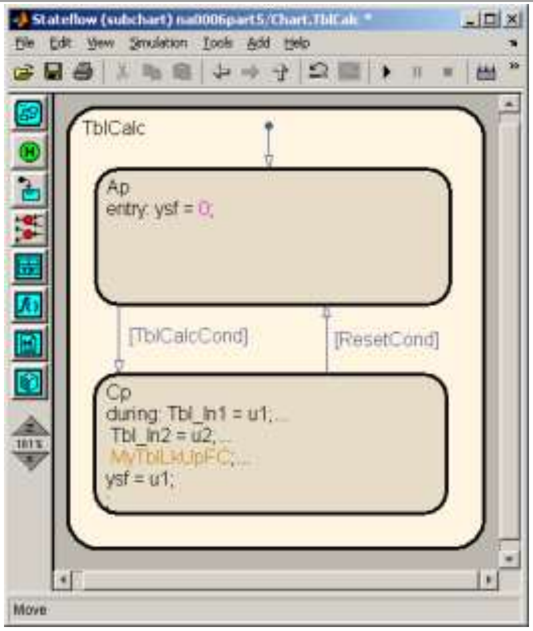


Embedded
simple
logic operations

- If the primary nature of the function is logical, and some complicated numerical calculations must be done to support the logic, a Simulink subsystem should be used to implement the numerical calculations. Stateflow should invoke the execution of this subsystem using a function-call.


Stateflow (subchart) CallSLFromSF_Trans_gf2/Chart.UprTblLimitTr...
File Edit View Simulation Tools Add Help
100%
UprTblLimitTrap
Ap
entry: ysf = 0;
{Tbl_In1 = u1;...
Tbl_In2 = u2;...
MyTblLkUpFC;}
2
1
[Tbl_Out > Ke_CalFactorUpr]
Cp
entry: ysf = 2;
Ready


CallSLFromSF_Trans_gf2 *
File Edit View Simulation Format Tools Help
10.0
Normal
[A]
<MyTblLkUpFC>
1
u1
u1
2
u2
u2
Ke_CalFactorUpr
Ke_CalFactorUpr
Tbl_Out
ysf
<ysf>
1
Tbl_In1
<Tbl_In1>
Tbl_In2
<Tbl_In2>
MyTblLkUpFC
<MyTblLkUpFC>
[A]
Chart
function()
In1
In2
Out1
<Tbl_Out>
MyTblLkUp FC Subsys
Ready
100%
FixedStepDiscrete


Stateflow (subchart) na0006part5/Chart.TblCalc *
File Edit View Simulation Tools Add Help
Move

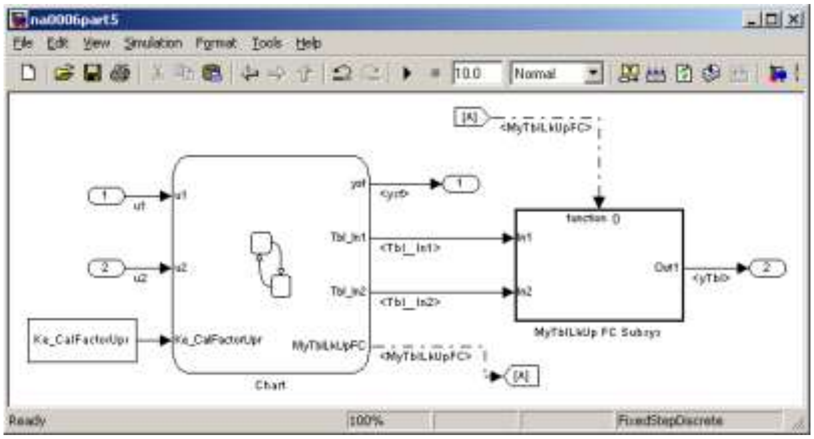
TblCalc

```
Ap
entry: ysf = 0;
```

[TblCalcCond]

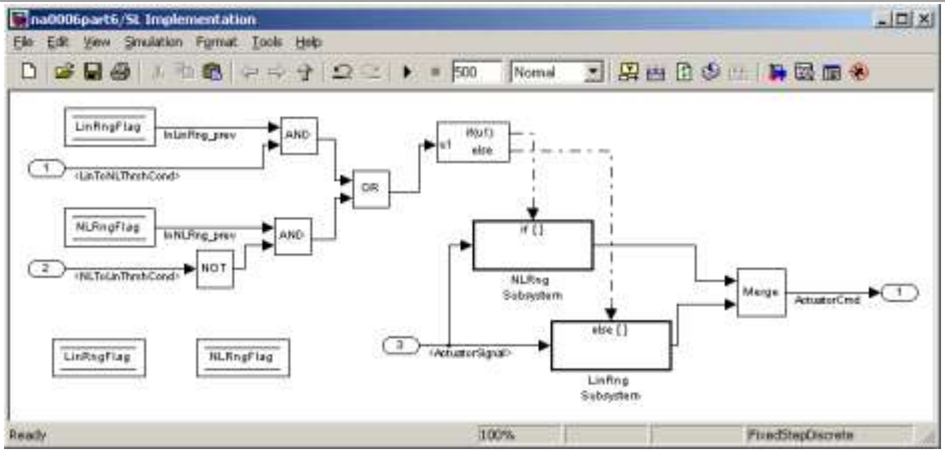
[ResetCond]

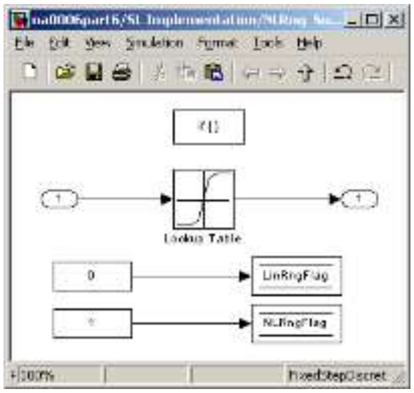
```
Cp
during: Tbl_In1 = u1;...
 Tbl_In2 = u2;...
 MyTblLkUpFC;...
ysf = u1;
```



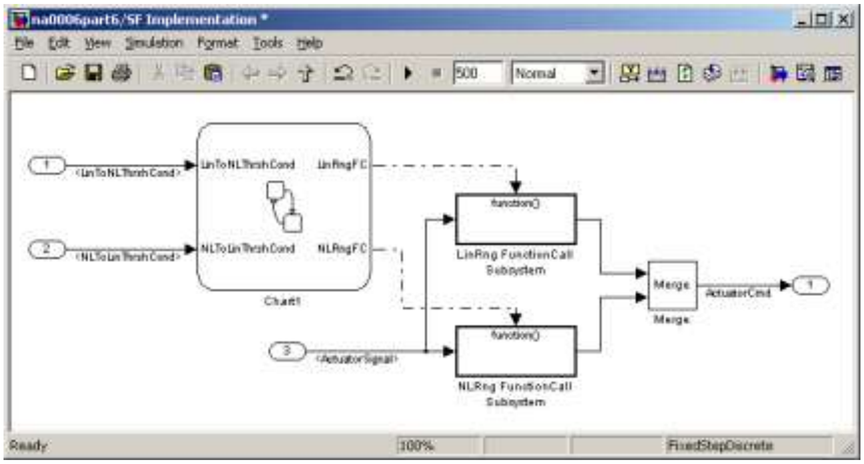
- Stateflow should be used to implement modal logic – where the control function to be performed at the current time depends on a combination of *past and present logical conditions*. (If there is a need to store the result of a logical condition test in Simulink, for example, by storing a flag, this is one indicator of the presence of modal logic – that would be better modeled in Stateflow.)

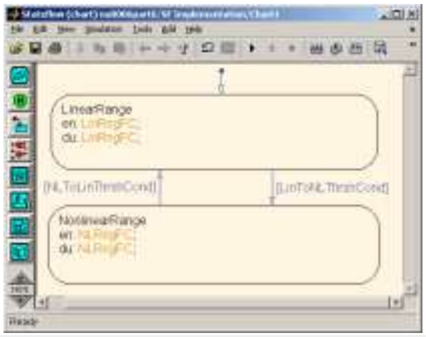
**Incorrect**


na0006part6/SL Implementation
File Edit View Simulation Format Tools Help
500
Normal
LinRngFlag
lnLinRng_prev
AND
1
<LinToNLThrshCond>
OR
if(u1)
else
u1
NLRngFlag
lnNLRng_prev
AND
2
<NLToLinThrshCond>
NOT
if { }
NLRng
Subsystem
Merge
ActuatorCmd
1
else { }
3
<ActuatorSignal>
LinRngFlag
NLRngFlag
LinRng
Subsystem
Ready
100%
FixedStepDiscrete


na0006part6/SL Implementation/NLRng Su...
File Edit View Simulation Format Tools Help
if { }
1
1
Lookup Table
0
LinRngFlag
1
NLRngFlag
100%
FixedStepDiscret

## Correct


na0006part6/SF Implementation *
File Edit View Simulation Format Tools Help
500
Normal
1
<LinToNLThrshCond>
LinToNLThrshCond
LinRngFC
2
<NLToLinThrshCond>
NLToLinThrshCond
NLRngFC
Chart1
function()
LinRng FunctionCall
Subsystem
Merge
Merge
ActuatorCmd
1
3
<ActuatorSignal>
function()
NLRng FunctionCall
Subsystem
Ready
100%
FixedStepDiscrete


Stateflow (chart) na0006part6/SF Implementation/Chart1
File Edit View Simulation Tools Add Help
LinearRange
en: LinRngFC;
du: LinRngFC;
[NLToLinThrshCond]
[LinToNLThrshCond]
NonlinearRange
en: NLRngFC;
du: NLRngFC;
Ready

| | |
|---|---|
| | • Simulink should be used to implement numerical expressions containing continuously-valued states, e.g., difference equations, integrals, derivatives, and filters.<br>Refer to the “Modeling Guidelines Chart” in the Appendix for a table detailing the proper algorithm type implementation for the Simulink/Stateflow/eML tools. |
| Rationale | ☑ Readability<br>☑ Workflow<br>☑ Simulation<br>☑ Verification and Validation<br>☑ Code Generation |
| Last Change | V2.1 |

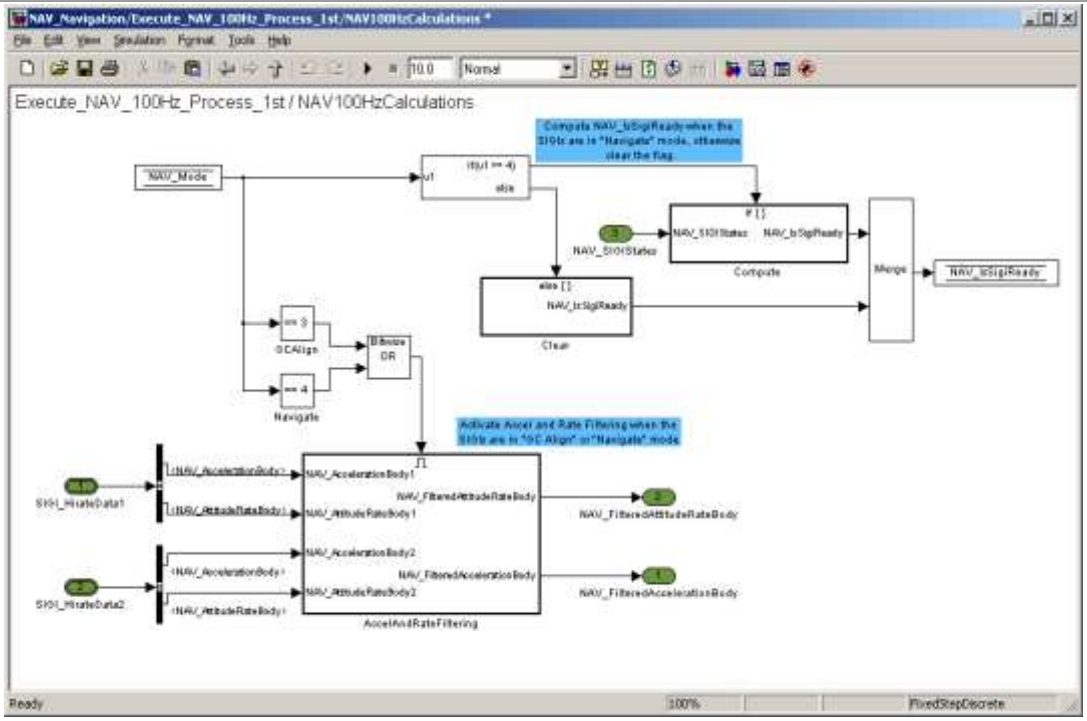
### 4.4.1.3 na_0007: Guidelines for use of Flow Charts, Truth Tables and State Machines

| **ID: Title** | **na_0007: Guidelines for use of Flow Charts, Truth Tables and State Machines** |
|---|---|
| Priority | Recommended |
| Scope | MAAB |
| MATLAB Version | All |
| MA Check | No |
| Prerequisites | na_0006: Guidelines for Mixed use of Simulink and Stateflow |
| Description | Within Stateflow, the choice of whether to utilize a flow chart or a state chart to model a given portion of the control algorithm functionality should be driven by the nature of the behavior being modeled.<br>• If the primary nature of the function segment is to calculate modes of operation or discrete-valued states, then state charts should be used. Some examples are a diagnostic model with pass, fail, abort, and conflict states, or a model that calculates different modes of operation for a control algorithm.<br>• If the primary nature of the function segment involves if-then-else statements, then flowcharts or truth tables should be used.<br>Specifics:<br>• If the primary nature of the function segment is to calculate modes or states, but if-then-else statements are required, it is recommended that a flow chart be added to a state within the state chart. (refer to 7.5 Flowchart Patterns) |
| Rationale | ☑ Readability<br>☑ Workflow<br>☑ Simulation<br>☑ Verification and Validation<br>☑ Code Generation |
| Last Change | V2.0 |

### 4.4.1.4 im_0001: Guidelines for mixed use of Simulink and eML

| **ID: Title** | **im_0001: Guidelines for mixed use of Simulink and eML** |
|---|---|

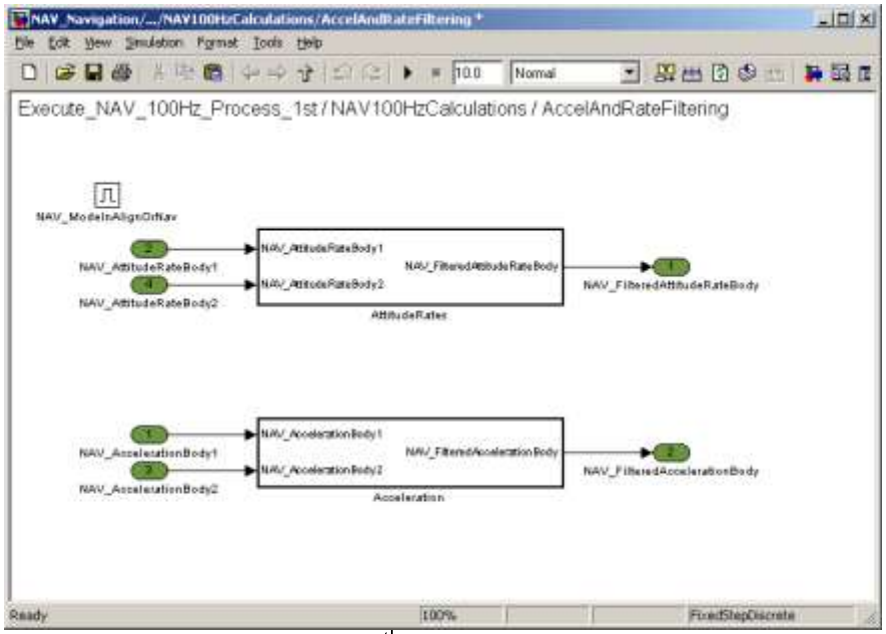
| | |
|---|---|
| Priority | Recommended |
| Scope | ORION |
| MATLAB Version | All |
| MA Check | No |
| Prerequisites | None |
| Description | The choice of whether to use Simulink or eML to model a given portion of the control algorithm functionality should be driven by the nature of the behavior being modeled.<br>There is no hard and fast rule for when eML should be used versus Simulink except for modeling concepts that are difficult to implement in a graphical environment (e.g. iterative loops).  eML could be used to simplify a cluttered diagram by implementing low level math.<br>Need to avoid a straight c to .m conversion activity by the GN&C developers.<br>PA-1 Example:<br>• NAV100HzCalculations represents one CSU within the 100 Hz rate group within the NAV domain<br>• There are additional CSUs at the 100 Hz rate group layer<br>• Note that data stores usage is not in the current standards and guidelines document |



Compute NAV_bSigReady when the SIGIs are in "Navigate" mode, otherwise clear the flag.

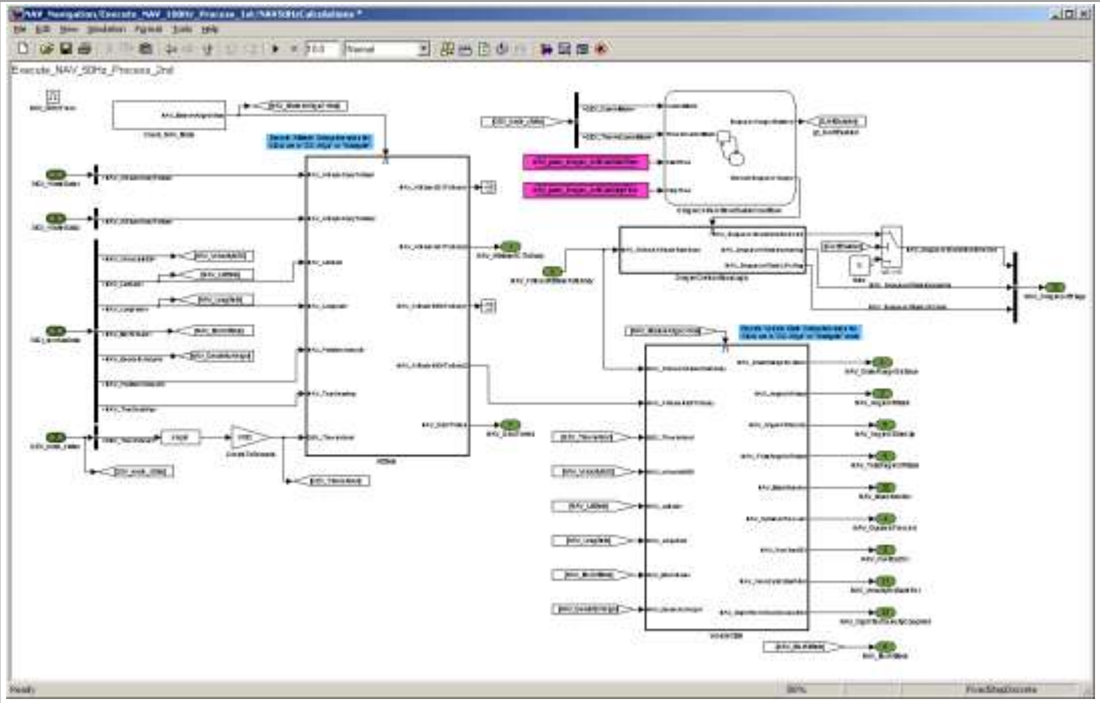
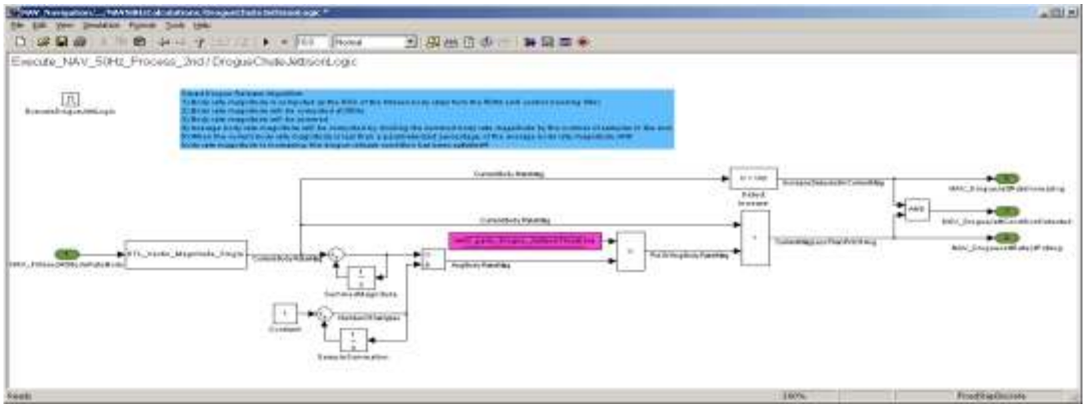
Activate Accel and Rate Filtering when the SIGIs are in "GC Align" or "Navigate" mode

NAV100Hz Calculations is decomposed into “AttitudeRates” and “Acceleration”


NAV_Navigation/.../NAV100HzCalculations/AccelAndRateFiltering *
File Edit View Simulation Format Tools Help
10.0
Normal
Execute_NAV_100Hz_Process_1st / NAV100HzCalculations / AccelAndRateFiltering
NAV_ModeInAlignOrNav
2
NAV_AttitudeRateBody1
4
NAV_AttitudeRateBody2
NAV_AttitudeRateBody1
NAV_AttitudeRateBody2
NAV_FilteredAttitudeRateBody
AttitudeRates
1
NAV_FilteredAttitudeRateBody
1
NAV_AccelerationBody1
3
NAV_AccelerationBody2
NAV_AccelerationBody1
NAV_AccelerationBody2
NAV_FilteredAccelerationBody
Acceleration
2
NAV_FilteredAccelerationBody
Ready
100%
FixedStepDiscrete

An eML block performs the 8th order filtering function

- NAV50HzCalculations represents a second CSU within the 100 Hz rate group within the NAV domain
- Simple Stateflow chart is being used to execute drogue detection logic
- Note that some implementation aspects (such as NAV mode in this example) is being moved a level above the CSU

| | |
|---|---|
| | <br>DrogueChuteJettisonLogic is implemented as Simulink blocks<br><br>Refer to the “Modeling Guidelines Chart” in the Appendix for a table detailing the proper algorithm type implementation for the Simulink/Stateflow/eML tools. |
| Rationale | ☑ Readability ☑ Verification and Validation<br>☑ Workflow ☑ Code Generation<br>☑ Simulation |
| Last Change | V2.2 |

### 4.4.1.5 jh_0200: Guidelines for Managing Model Complexity

| **ID: Title** | **jh_0200: Guidelines for Managing Model Complexity** |
|---|---|
| Priority | Mandatory |

| | |
|---|---|
| Scope | ORION |
| MATLAB Version | All |
| MA Check | No |
| Prerequisites | none |
| Description | The developer **shall** manage the model complexity in accordance with the “GNC Model Development Cyclomatic Complexity Guidelines” memo (Doc #: CEV-GN&C-11-014).<br><br>Link on ICE:<br>https://ice.exploration.nasa.gov/confluence/pages/worddav/preview.action?fileName=ErrorHandlingGuidance.docx&pageId=106041166 |
| Rationale | ☑ Readability<br>☑ Workflow<br>☑ Simulation<br>☑ Verification and Validation<br>☑ Code Generation |
| Last Change | V1.0 |

### 4.4.1.6 ek_0010: Simulink algorithm States recommendations

| **ID: Title** | **ek_0010: Matlab/Simulink algorithm States recommendations** |
|---|---|
| Priority | Strongly recommended |
| Scope | ORION |
| MATLAB Version | All |
| MA Check | No |
| Prerequisites | None |
| Description | Algorithm states may be implemented using 1 of 3 possible options :<br>• **‘Standard’ Simulink**<br>o Do not use the “Data Store Memory” blocks<br>o Recommend the use of “unit delay” blocks<br>▪ Unit delay blocks visualizes the feedback loop w/ states<br>• A caution is that it can also make the diagram harder to read<br>▪ multiple (independent) ‘states’ structures may be passed back in the feedback path, if necessary.<br>• Facilitates reset capability<br>o “unit delay” blocks will most likely require restart a capability – use block with restart trigger & external ICs<br>o External states will be loaded from the “Parameter Bus”<br>▪ CSU will be a model reference block – parameter bus will be passed by reference.<br>o Init trigger condition will come as an input on the “Input Bus”<br>▪ Multiple initialization types may be implemented through the use of different initialization inputs and/or initialization enumeration(s)<br>o Forces the creation of Simulink ‘State’ buses, as well as Inputs / Outputs / Parameters |

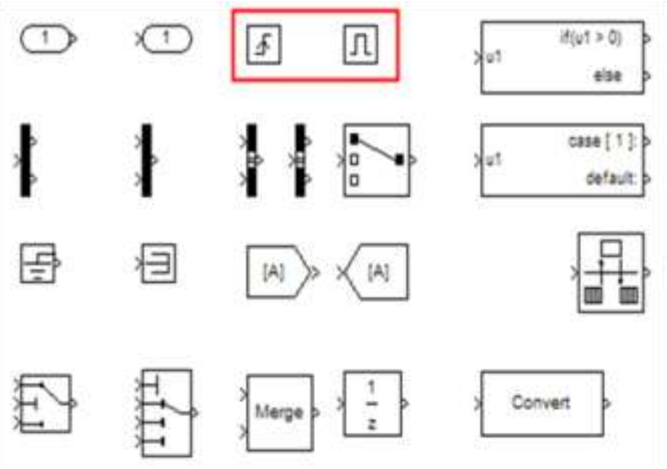
| | |
|---|---|
| | • **Embedded Matlab**<br>o 1) Recommend use of persistent (i.e., 'static') data structure(s) at eML block level, but not below<br>▪ Persistent structures should not be used below the eML block level to keep external m-functions reentrant.<br>▪ Pass states & parameters via structures into any m-file subfunctions which require them<br>▪ Keeping persistent structures at eML block level permits different copies of the eML block to be called from different locations.<br>▪ Using this method, algorithm developers will not need to create Simulink State buses, since the states can be represented internally to the block.<br>o 2) another option restricts the use of 'persistent' data structs<br>▪ States would be handled as described above using the unit delay block<br>▪ Does not alleviate any of the concerns/issues with states internal to an eML block described in 1)<br>▪ Requires creation of the states bus<br>• **Stateflow**<br>o Useful for some algorithms which require internal Moding<br>o Should capture the logic of an algorithm only –<br>▪ Math is reserved for external subsystems or eML functions.<br>▪ Cannot easily visualize data flow within Stateflow, only logical flow.<br>o Stateflow can be interfaced directly to eML<br>o Stateflow can be used to trigger subsystems<br>o Internal States may be required in a Stateflow model (e.g., a persistence counters, latching logic, etc… ).<br>▪ May also be handled using external unit delay blocks as described above – this option requires creating state buses. |
| Rationale | ☑ Readability ☐ Verification and Validation<br>☐ Workflow ☑ Code Generation<br>☑ Simulation |
| Last Change | V1.0 |

## 4.4.2 Subsystem Hierarchies

### 4.4.2.1 mdb_0143: Similar block types on the model levels

| **ID: Title** | **mdb_0143: Similar block types on the model levels** |
|---|---|
| Priority | Recommended |
| Scope | ORION (modified NA-MAAB db_0143) |
| MATLAB Version | All |
| MA Check | Yes |
| Prerequisites | None |
| Description | Every level of a model must be designed with building blocks of the same type. (i.e. only subsystems or only basic blocks). |

<table>
<tr><td></td><td>
<table>
<tr><td colspan="2"><b>Blocks which can be placed on every model level:</b></td></tr>
<tr><td>Inport<br>Outport<br>Enable (not on highest model level)<br>Trigger (not on highest model level)<br>Mux<br>Demux<br>Bus Selector<br>Bus Creator<br>Selector<br>Ground<br>Terminator<br>From<br>Goto<br>Switch<br>Multiport Switch<br>Merge<br>Unit Delay<br>Rate Transition<br>Type Conversion<br>Data Store Memory<br>If block<br>Case block</td><td>Note: Trigger and Enable blocks cannot be placed at the root level.  Enable blocks cannot be placed at the top level of Model Reference Systems

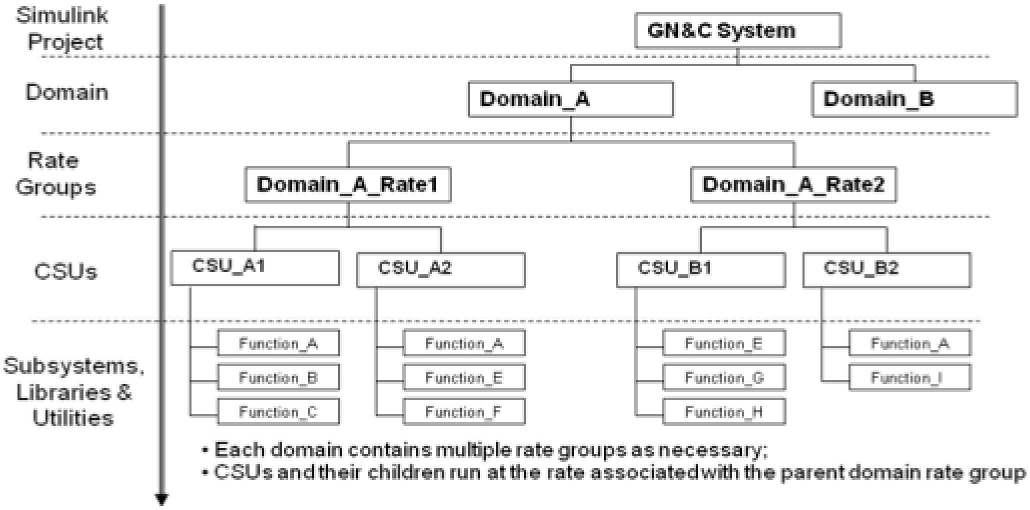

</td></tr>
</table>
</td></tr>
<tr><td>Rationale</td><td>☑ Readability<br>☑ Workflow<br>☐ Simulation<br>☑ Verification and Validation<br>☐ Code Generation</td></tr>
<tr><td>Last Change</td><td>V2.1</td></tr>
</table>

## 4.4.3 ORION GN&C Model Architecture Decomposition

This section is specific to the architecture used in the ORION GN&C models.

### 4.4.3.1 im_0015: ORION GN&C Model Architecture

| **ID: Title** | **im_0015: ORION GN&C Model Architecture** |
|---|---|
| Priority | Mandatory |
| Scope | ORION |
| MATLAB Version | All |
| MA Check | No |
| Prerequisites | None |
| Description | • The model hierarchy should correspond to the functional structure of the overall |

| | |
|---|---|
| | GN&C system.<br>• Model references shall be used for each domain and each CSU.<br>• Blocks in a Simulink diagram should be grouped together into subsystems based upon a functional decomposition of the algorithm, or portion thereof, represented in the diagram.<br> Simulink Project<br>Domain<br>Rate Groups<br>CSUs<br>Subsystems, Libraries & Utilities<br>GN&C System<br>Domain_A<br>Domain_B<br>Domain_A_Rate1<br>Domain_A_Rate2<br>CSU_A1<br>CSU_A2<br>CSU_B1<br>CSU_B2<br>Function_A<br>Function_B<br>Function_C<br>Function_A<br>Function_E<br>Function_F<br>Function_E<br>Function_G<br>Function_H<br>Function_A<br>Function_I<br>• Each domain contains multiple rate groups as necessary;<br>• CSUs and their children run at the rate associated with the parent domain rate group |
| Rationale | ☑ Readability ☑ Verification and Validation<br>☑ Workflow ☑ Code Generation<br>☑ Simulation |
| Last Change | V1.0 |

### 4.4.3.2 im_0003: Controller model

| | |
|---|---|
| **ID: Title** | **im_0003: Controller model** |
| Priority | Mandatory |
| Scope | ORION |
| MATLAB Version | All |
| MA Check | No |
| Prerequisites | None |
| Description | Control models are organized using the following hierarchical structure.<br>• Top layer / root level<br>• Trigger layer<br>• Structure layer<br>• Data flow layer |
| Rationale | □ Readability □ Verification and Validation<br>☑ Workflow □ Code Generation<br>□ Simulation |

| | |
|---|---|
| Last Change | V2.1 |

### 4.4.3.3 im_0004: Top layer / root level

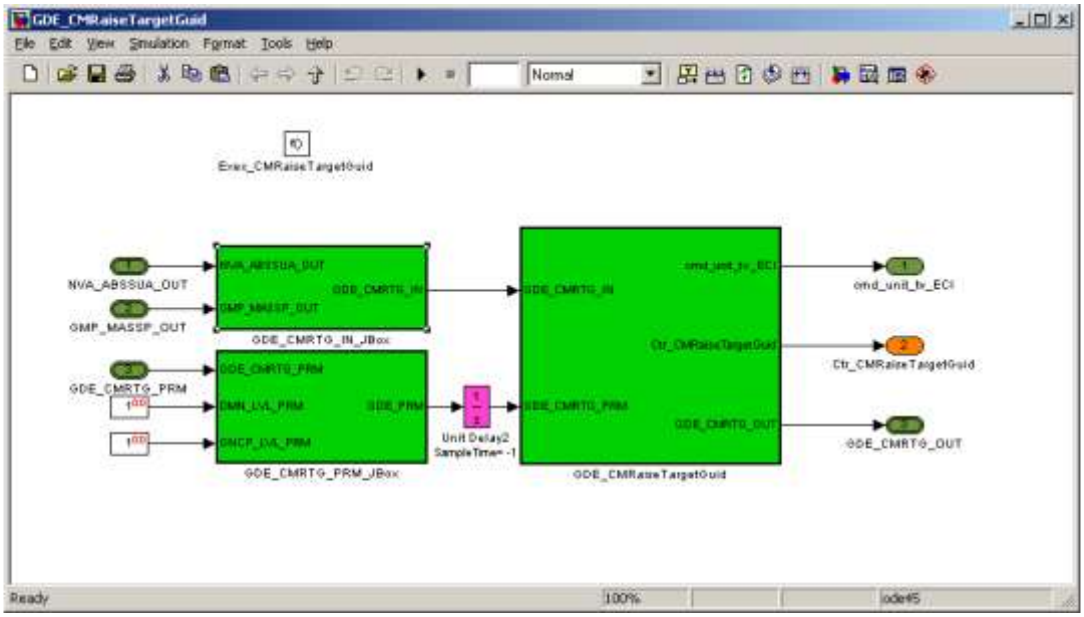
| **ID: Title** | **im_0004: Top layer / root level** |
|---|---|
| Priority | Mandatory |
| Scope | ORION |
| MATLAB Version | All |
| MA Check | No |
| Prerequisites | None |
| Description | The top layer comprises the following:<br>• GN&C process scheduler<br>• GN&C executive<br>• GN&C domains<br>The GN&C executive and GN&C domains are Function-Call Subsystems and the GN&C process scheduler acts as the functional call initiator.<br>The process scheduler is a Stateflow chart that calls each of the domains at the model base rate. |
| Rationale | ☐ Readability<br>☑ Workflow<br>☐ Simulation<br>☐ Verification and Validation<br>☐ Code Generation |
| Last Change | V2.1 |

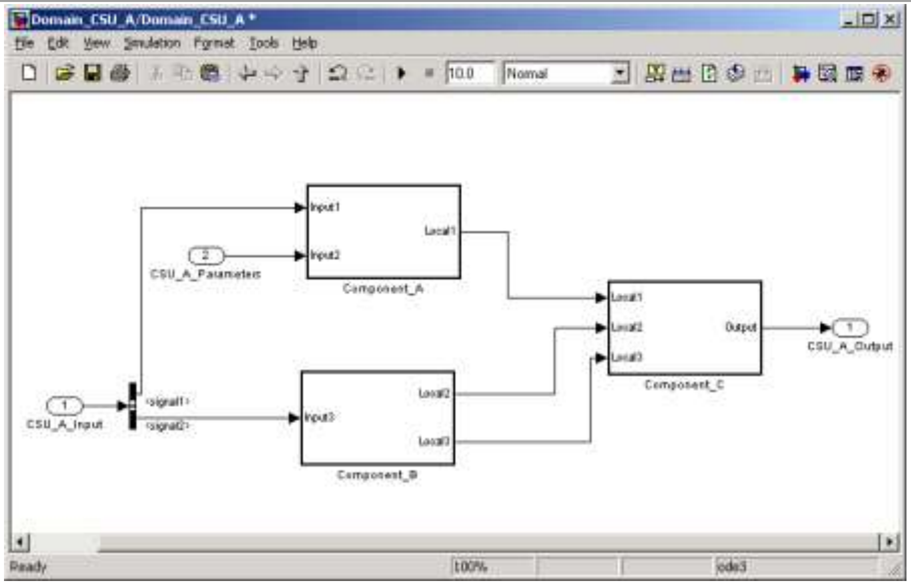
### 4.4.3.4 im_0005: Trigger layer

| **ID: Title** | **im_0005: Trigger layer** |
|---|---|
| Priority | Mandatory |
| Scope | ORION |
| MATLAB Version | All |
| MA Check | No |
| Prerequisites | None |
| Description | There are two trigger layers below the top layer.<br>The first trigger layer corresponds to the domain rate group layer. Each domain rate group is represented by a Triggered Subsystem that is called by the process scheduler. The process scheduler models the ARINC process table and is not included in the auto-coded model.<br>The second trigger layer corresponds to the CSU execution layer. Each CSU within a rate group is represented by a Model Reference block. The CSUs are activated via a function-call signal according to the domain mode for the current GN&C activity. The domain mode is defined by the GN&C executive at the top layer. Domain level and CSU level initialization also occurs at this level. |

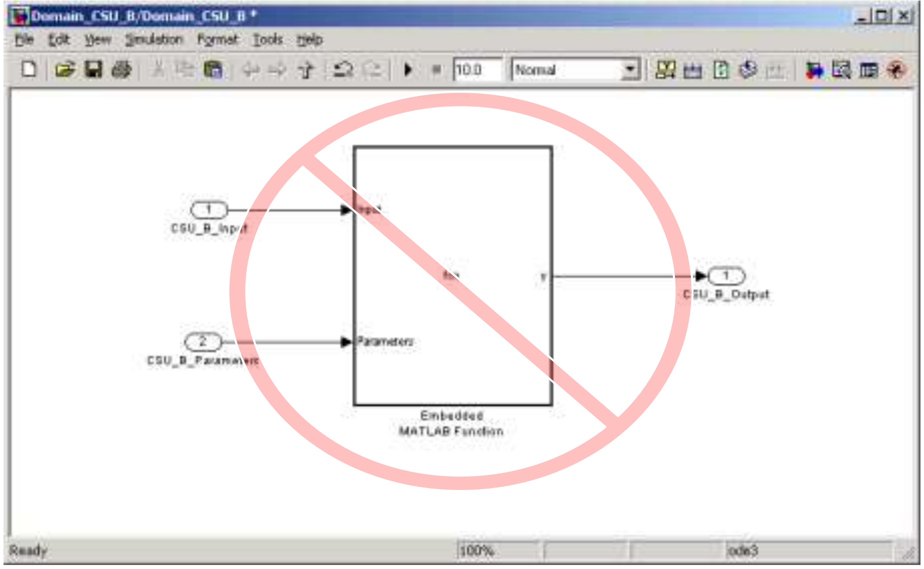
| | |
|---|---|
| | |
| Rationale | ☑ Readability ☐ Verification and Validation<br>☑ Workflow ☑ Code Generation<br>☐ Simulation |
| Last Change | V2.1 |

### 4.4.3.5 im_0006: Structure layer

| **ID: Title** | **im_0006: Structure layer** |
|---|---|
| Priority | Mandatory |
| Scope | ORION |
| MATLAB Version | All |
| MA Check | No |
| Prerequisites | None |
| Description | The structure layer contains the first level of functional decomposition for each CSU. Depending upon the complexity of the CSU, there may be one or multiple structure layers with a functional decomposition occurring at each successive layer.<br>At the very first CSU structure layer, junction boxes are used to consolidate multiple input buses and multiple parameter buses into a single input bus and single parameter bus respectively.<br> GDE_CMRaiseTargetGuid<br>File Edit View Simulation Format Tools Help<br>Normal<br>Exec_CMRaiseTargetGuid<br>1<br>NVA_ABSSUA_OUT<br>2<br>GMP_MASSP_OUT<br>3<br>GDE_CMRTG_PRM<br>1<br>1<br>NVA_ABSSUA_OUT<br>GMP_MASSP_OUT<br>GDE_CMRTG_IN<br>GDE_CMRTG_IN_JBox<br>GDE_CMRTG_PRM<br>DMN_LVL_PRM<br>GNCP_LVL_PRM<br>GDE_PRM<br>GDE_CMRTG_PRM_JBox<br>Unit Delay2<br>Sample Time= -1<br>GDE_CMRTG_IN<br>GDE_CMRTG_PRM<br>cmd_unit_tv_ECI<br>Ctr_CMRaiseTargetGuid<br>GDE_CMRTG_OUT<br>GDE_CMRaiseTargetGuid<br>1<br>cmd_unit_tv_ECI<br>2<br>Ctr_CMRaiseTargetGuid<br>3<br>GDE_CMRTG_OUT<br>Ready<br>100%<br>ode45<br>Examples:<br>Each CSU should be decomposed into lower level functions. |



A single eML block should not contain the algorithm of the entire CSU.



A single eML block is only acceptable if there is little functionality at this level. Use of eML at a lower level is acceptable.

| | |
|---|---|
| Rationale | ☑ Readability<br>☑ Workflow<br>☑ Simulation<br>☑ Verification and Validation<br>☑ Code Generation |
| Last Change | V2.1 |

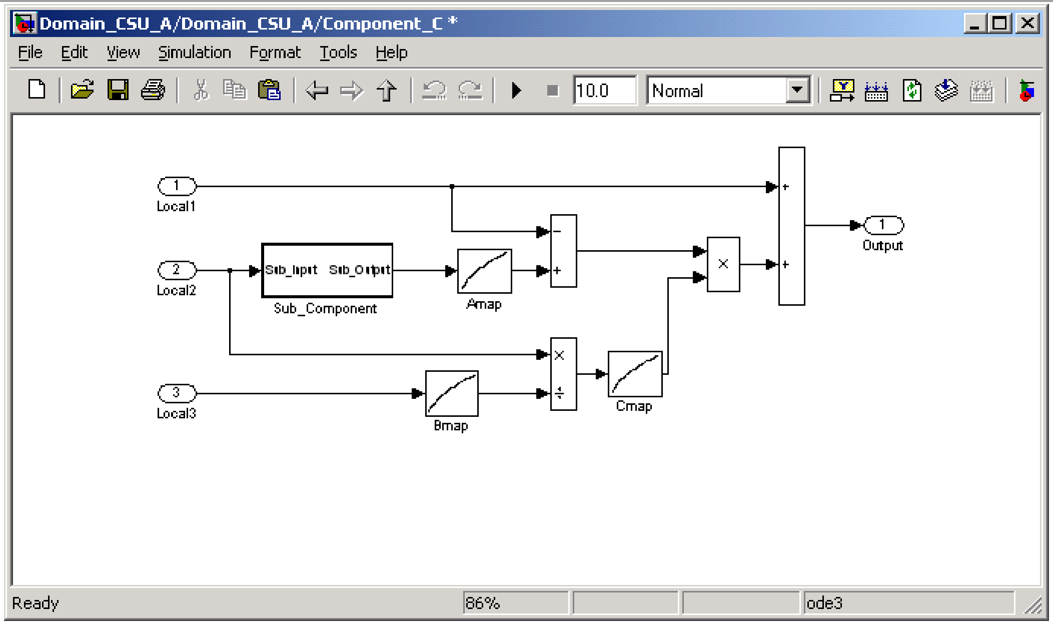
### 4.4.3.6 mj_0002: Junction Box Composition

| ID: Title | mj_0002: Junction Box Composition |
|---|---|
| Priority | Mandatory |
| Scope | ORION |

|  |  |
|---|---|
| MATLAB Version | All |
| MA Check | No |
| Prerequisites |  |
| Description | No math operations should occur in the Junction Boxes.  The Junction boxes should only be used to organize bus data for the corresponding CSU input.  This is mainly done with the use of Bus_Selector, Bus_Creator, and Convert blocks.  Data type conversion is allowed.<br>For example, if a model is designed to use single precision yet receives the data from another CSU with double precision, the data should be converted in the Junction Box – not the CSU.<br>Note:  Math operations include Quaternion Conjugation and Matrix Transformation. |
| Rationale | ☑ Readability ☐ Verification and Validation<br>☑ Workflow ☑ Code Generation<br>☐ Simulation |
| Last Change | V1.0 |

### 4.4.3.7 im_0007: Data flow layer

| **ID: Title** | **im_0007: Data flow layer** |
|---|---|
| Priority | Mandatory |
| Scope | ORION |
| MATLAB Version | All |
| MA Check | No |
| Prerequisites | None |
| Description | The data flow layer is where the algorithmic computations occur. The example shown below uses allowable Simulink blocks but more complex algorithmic computations may also be implemented in eML.<br>This is a continuation of the example shown for the structure layer. |

| | |
|---|---|
| |  Domain_CSU_A/Domain_CSU_A/Component_C *<br>File Edit View Simulation Format Tools Help<br>10.0<br>Normal<br>1 Local1<br>2 Local2<br>3 Local3<br>Sub_Input Sub_Output<br>Sub_Component<br>Amap<br>Bmap<br>Cmap<br>1 Output<br>Ready<br>86%<br>ode3 |
| Rationale | ☑ Readability ☑ Verification and Validation<br>☑ Workflow ☑ Code Generation<br>☑ Simulation |
| Last Change | V2.1 |

### 4.4.3.8 jh_0056: Sample Times

| **ID: Title** | **jh_0056: Sample Times** |
|---|---|
| Priority | Mandatory |
| Scope | ORION |
| MATLAB Version | All |
| MA Check | Yes |
| Prerequisites | None |
| Description | All blocks at a CSU level should not have explicitly defined sample times. The sample times should be set to -1 (inherited). The executive will control the sample time of the individual CSUs.<br>The only exception is for the "Constant" block which has the sample time set to "inf".<br>This standard does not apply to the Domain level and above.<br>Note: Most of the blocks in the ORION Library have the sampling time locked at to "-1" and the parameter does not appear in the block mask. |
| Rationale | ☑ Readability ☑ Verification and Validation<br>☑ Workflow ☑ Code Generation<br>☑ Simulation |

| | |
|---|---|
| Last Change | V2.1 |

## 4.5 Stateflow

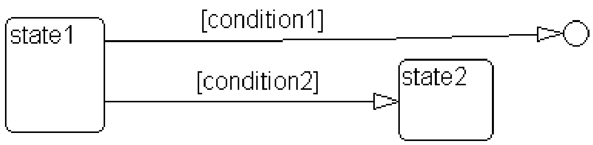
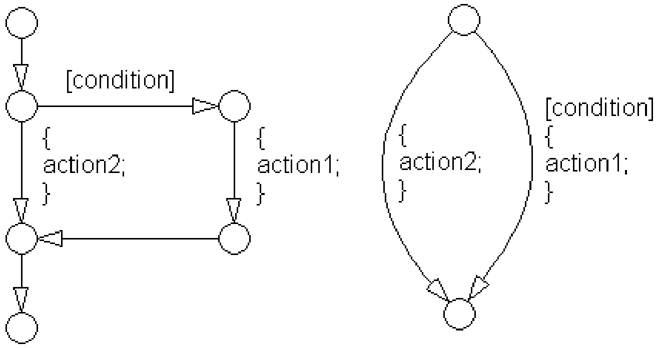
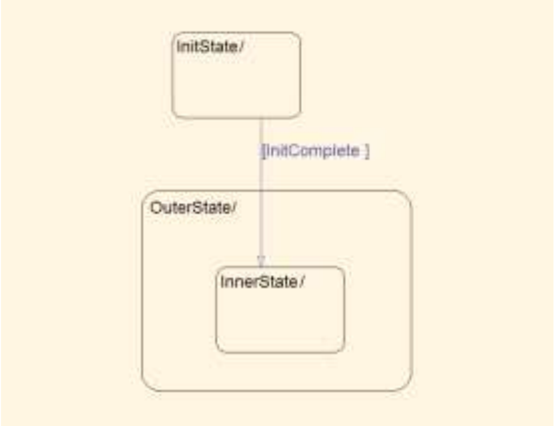
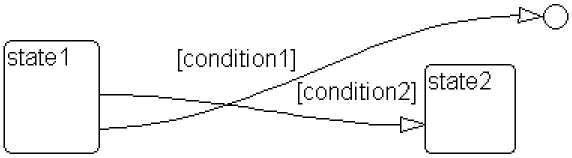
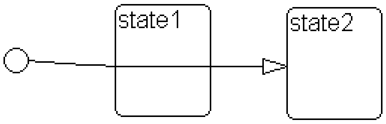
### 4.5.1 Chart Appearance

### 4.5.1.1 db_0123: Stateflow port names

| | |
|---|---|
| **ID: Title** | **db_0123: Stateflow port names** |
| Priority | Strongly recommended |
| Scope | MAAB |
| MATLAB Version | All |
| MA Check | Yes |
| Prerequisites | None |
| Description | The name of a Stateflow input/output should be the same as the corresponding signal.<br>Exception: Reusable Stateflow blocks may have different port names. |
| Rationale | ☑ Readability<br>☑ Workflow<br>□ Simulation<br>□ Verification and Validation<br>□ Code Generation |
| Last Change | V1.0 |

### 4.5.1.2 db_0129: Stateflow transition appearance

| | |
|---|---|
| **ID: Title** | **db_0129: Stateflow transition appearance** |
| Priority | Strongly recommended |
| Scope | MAAB |
| MATLAB Version | All |
| MA Check | No |
| Prerequisites | None |
| Description | Transitions in Stateflow:<br>• Do not cross each other, if possible.<br>• Are not drawn one upon the other.<br>• Do not cross any states, junctions or text fields.<br>• Are allowed if transitioning to an internal state.<br>Transition labels can be visually associated to the corresponding transition.<br>**Correct** |

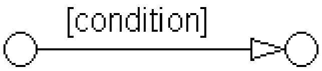
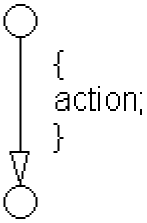
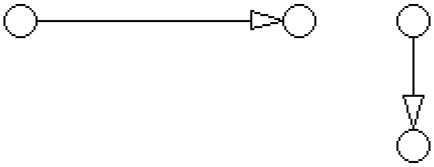
| | |
|---|---|
| |  <br> [condition]<br>{<br>action2;<br>}<br>{<br>action1;<br>}<br>{<br>action2;<br>}<br>[condition]<br>{<br>action1;<br>}<br> <br>**Incorrect**<br> <br> |
| Rationale | ☑ Readability<br>☑ Workflow<br>☐ Simulation<br>☐ Verification and Validation<br>☐ Code Generation |
| Last Change | V2.0 |

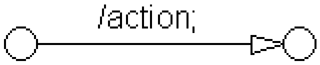
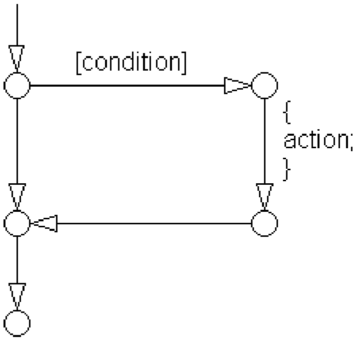
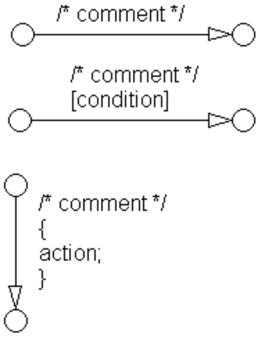
### 4.5.1.3 db_0133: Use of patterns for Flowcharts

| | |
|---|---|
| **ID: Title** | **db_0133: Use of patterns for Flowcharts** |
| Priority | Strongly recommended |
| Scope | MAAB |
| MATLAB | All |

| | |
|---|---|
| Version | |
| MA Check | No |
| Prerequisites | None |
| Description | A Flowchart is built with the help of Flowchart patterns (e.g. IF-THEN-ELSE, FOR LOOP, etc.):<br>• The data flow is oriented from the top to the bottom.<br>• Patterns are connected with empty transitions. |
| Rationale | ☑ Readability<br>☑ Workflow<br>☐ Simulation<br>☑ Verification and Validation<br>☐ Code Generation |
| Last Change | V1.0 |

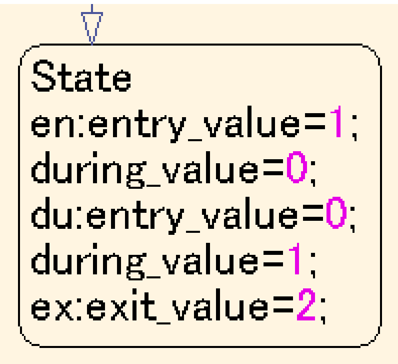
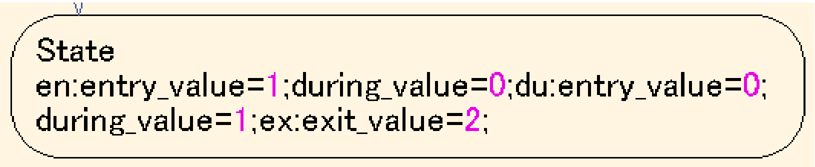
### 4.5.1.4 db_0132: Transitions in Flowcharts

| **ID: Title** | **db_0132: Transitions in Flowcharts** |
|---|---|
| Priority | Strongly recommended |
| Scope | MAAB |
| MATLAB Version | All |
| MA Check | Yes |
| Prerequisites | None |
| Description | The following rules apply to transitions in Flowcharts:<br>• Conditions are drawn on the horizontal.<br>• Actions are drawn on the vertical.<br>• Loop constructs are intentional exceptions to this rule.<br><br>A transition in a Flowchart has a condition, a condition action or an empty transition.<br>Transition with condition:<br> <br>Transition with condition action:<br> <br>Empty transition:<br> |

| | |
|---|---|
| | Transition actions are not used in Flowcharts. Transition actions are only valid when used in transitions between states in a state machine, otherwise they are not activated because of the inherent dependency on a valid state to state transition to activate them.<br>Transition action:<br> <br>At every junction, except for the last junction of a flow diagram, exactly one unconditional transition begins. Every decision point (junction) must have a default path.<br> <br>A transition may have a comment, and the comment must be placed above the code to ensure proper placement in the autocode:<br> /* comment */<br>/* comment */<br>[condition]<br>/* comment */<br>{<br>action;<br>} |
| Rationale | ☑ Readability ☑ Verification and Validation<br>☑ Workflow ☑ Code Generation<br>☐ Simulation |
| Last Change | V2.1 |

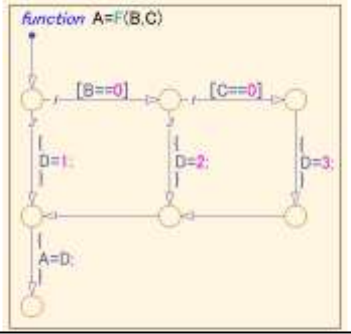
### 4.5.1.5 mjc_0501: Format of entries in a State block

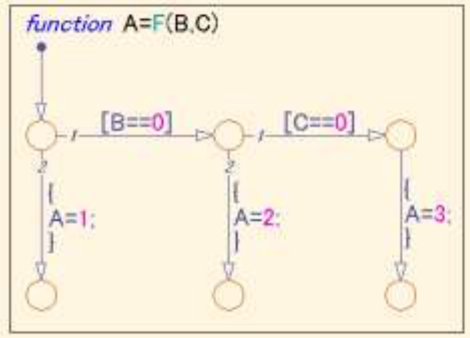
| **ID: Title** | **mjc_0501: Format of entries in a State block** |
|---|---|
| Priority | Recommended |
| Scope | ORION (modified MAAB jc_0501) |
| MATLAB Version | All |
| MA Check | No |
| Prerequisites | None |
| Description | A new line should be: |

| | |
|---|---|
| | • Started after the completion of an assignment statement “;”.<br>Comments should be placed above the referred code to ensure proper placement in the autocode.<br>**Correct**<br><br>State<br>en:entry_value=1;<br>during_value=0;<br>du:entry_value=0;<br>during_value=1;<br>ex:exit_value=2;<br>**Incorrect**<br>Failed to start a new line after the completion of an assignment statement “;”.<br><br>State<br>en:entry_value=1;during_value=0;du:entry_value=0;<br>during_value=1;ex:exit_value=2; |
| Rationale | ☑ Readability<br>☐ Workflow<br>☐ Simulation<br>☐ Verification and Validation<br>☑ Code Generation |
| Last Change | V2.1 |

### 4.5.1.6 jc_0511: Setting the return value from a graphical function

| **ID: Title** | **jc_0511: Setting the return value from a graphical function** |
|---|---|
| Priority | Mandatory |
| Scope | J-MAAB |
| MATLAB Version | All |
| MA Check | Yes |
| Prerequisites | None |
| Description | The return value from a graphical function must be set in only one place. |

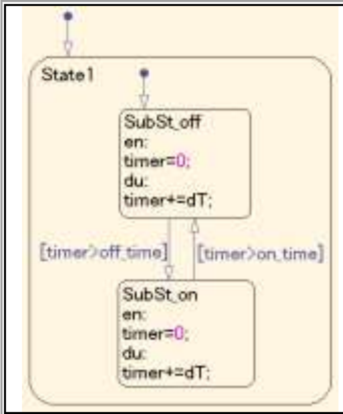
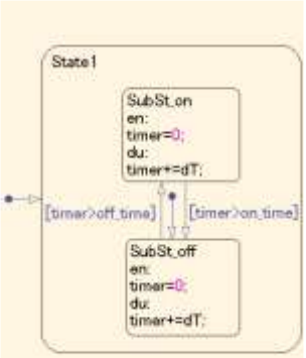
<table>
<tr><td></td><td>
<table>
<tr><td><b>Correct</b><br>Return value A is set in one place<br>


</td></tr>
<tr><td><b>Incorrect</b><br>Return value A is set in multiple places.<br>


</td></tr>
</table>
</td></tr>
<tr><td>Rationale</td><td>☐ Readability ☐ Verification and Validation<br>☑ Workflow ☑ Code Generation<br>☐ Simulation</td></tr>
<tr><td>Last Change</td><td>V2.0</td></tr>
</table>

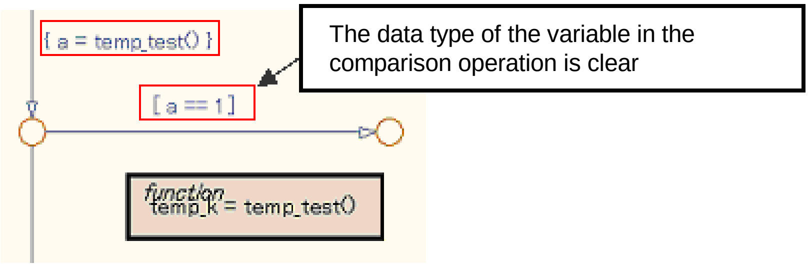
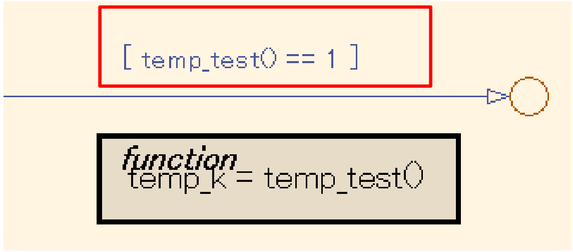
### 4.5.1.7 jc_0531: Placement of the default transition

<table>
<tr><td><b>ID: Title</b></td><td><b>jc_0531: Placement of the default transition</b></td></tr>
<tr><td>Priority</td><td>Recommended</td></tr>
<tr><td>Scope</td><td>J-MAAB</td></tr>
<tr><td>MATLAB Version</td><td>All</td></tr>
<tr><td>MA Check</td><td>Yes</td></tr>
<tr><td>Prerequisites</td><td>None</td></tr>
<tr><td>Description</td><td>
<ul>
<li>Default transition is connected at the top of the state.</li>
<li>The destination state of the default transition is put above the other states in the same hierarchy.</li>
</ul>
<table>
<tr><td><b>Correct</b></td><td>
<ul>
<li>The default transition is connected at the top of the state.</li>
<li>The destination state of the default transition is put above the other</li>
</ul>
</td></tr>
</table>
</td></tr>
</table>

|  |  |  |
|---|---|---|
|  |  State1<br>SubSt_off<br>en:<br>timer=0;<br>du:<br>timer+=dT;<br>[timer>off_time]<br>[timer>on_time]<br>SubSt_on<br>en:<br>timer=0;<br>du:<br>timer+=dT; | states in the same hierarchy. |
|  | **Incorrect**<br> State1<br>SubSt_on<br>en:<br>timer=0;<br>du:<br>timer+=dT;<br>[timer>off_time]<br>[timer>on_time]<br>SubSt_off<br>en:<br>timer=0;<br>du:<br>timer+=dT; | • Default transition is connected at the side of the state (State 1).<br>• The destination state of the default transition is lower than the other states in the same hierarchy (SubSt_off). |
| Rationale | ☑ Readability<br>☐ Workflow<br>☐ Simulation | ☐ Verification and Validation<br>☐ Code Generation |
| Last Change | V2.0 |  |

### 4.5.1.8 jc_0521: Use of the return value from graphical functions

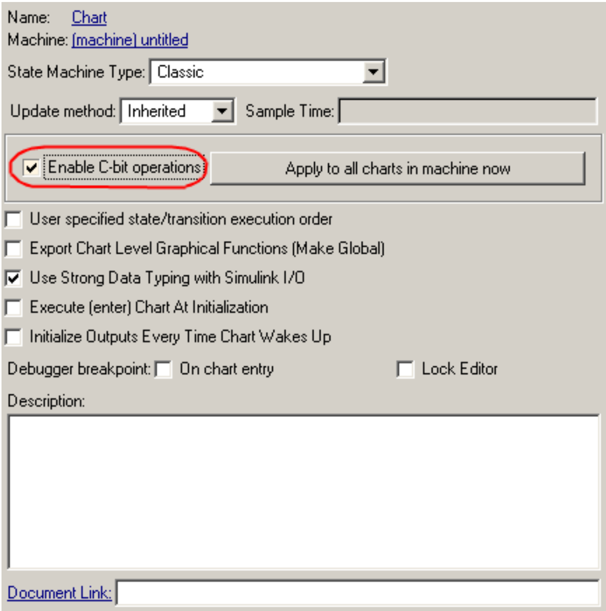
| **ID: Title** | **jc_0521: Use of the return value from graphical functions** |
|---|---|
| Priority | Recommended |
| Scope | J-MAAB |
| MATLAB Version | All |
| MA Check | No |
| Prerequisites | None |
| Description | The return value from a graphical function should not be used directly in a comparison operation.<br>**Correct**<br>An intermediate variable is used in the conditional expression after the assignment of the return value from the function "temp_test" to the intermediate variable "a". |

| | |
|---|---|
| |   { a = temp_test() }<br>[ a == 1 ]<br>function temp_k = temp_test()<br>The data type of the variable in the comparison operation is clear<br>**Incorrect**<br>Return value of the function "temp_test" is used in the conditional expression.<br> |
| Rationale | ☑ Readability<br>☐ Workflow<br>☐ Simulation<br>☐ Verification and Validation<br>☐ Code Generation |
| Last Change | V2.0 |

### 4.5.2 Stateflow data and operations

#### 4.5.2.1 na_0001: Bitwise Stateflow operators

| **ID: Title** | **na_0001: Bitwise Stateflow operators** |
|---|---|
| Priority | Strongly recommended |
| Scope | MAAB |
| MATLAB Version | All |
| MA Check | No |
| Prerequisites | None |
| Description | The bitwise Stateflow operators (&, \|, and ^) should not be used in Stateflow charts unless bitwise operations are desired.<br>If bitwise operations are desired, the "Enable C-bit Operations" needs to be enabled.<br>1. From the File Menu \ Chart Properties.<br>2. Select Enable C-bit operations. |



Name: Chart

Machine: (machine) untitled

State Machine Type: Classic

Update method: Inherited  Sample Time:

☑ Enable C-bit operations  Apply to all charts in machine now

☐ User specified state/transition execution order

☐ Export Chart Level Graphical Functions (Make Global)

☑ Use Strong Data Typing with Simulink I/O

☐ Execute (enter) Chart At Initialization

☐ Initialize Outputs Every Time Chart Wakes Up

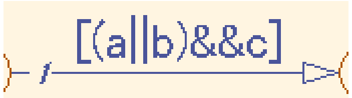
Debugger breakpoint: ☐ On chart entry  ☐ Lock Editor

Description:

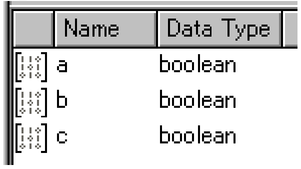
Document Link:

**Correct**

Use “&&” and “II” for Boolean operation.

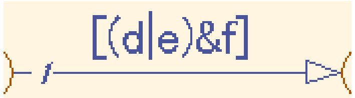


`[(a||b)&&c]`

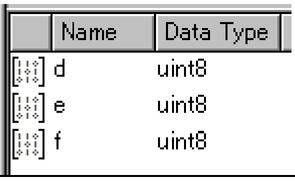


| Name | Data Type |
|---|---|
| a | boolean |
| b | boolean |
| c | boolean |

Use “&” and “I” for bit operation.



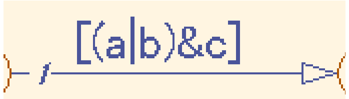
`[(d|e)&f]`



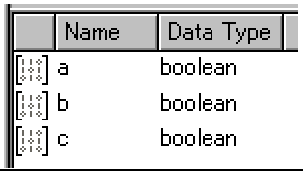
| Name | Data Type |
|---|---|
| d | uint8 |
| e | uint8 |
| f | uint8 |

**Incorrect**

Use “&” and “I” for Boolean operation.



`[(a|b)&c]`

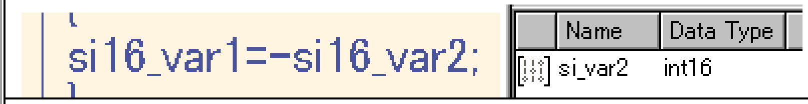
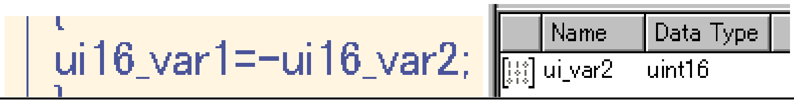


| Name | Data Type |
|---|---|
| a | boolean |
| b | boolean |
| c | boolean |

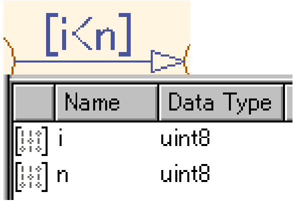
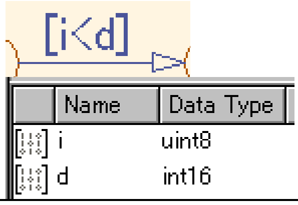
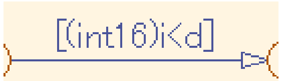
| | |
|---|---|
| Rationale | ☐ Readability ☐ Verification and Validation<br>☐ Workflow ☑ Code Generation<br>☑ Simulation |
| Last Change | V 2.0 |

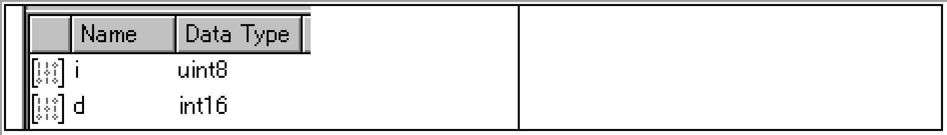
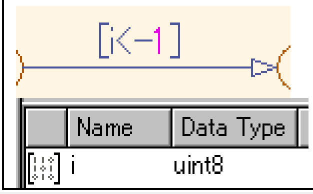
### 4.5.2.2 jc_0451: Use of unary minus on unsigned integers in Stateflow

| **ID: Title** | **jc_0451: Use of unary minus on unsigned integers in Stateflow** |
|---|---|
| Priority | Recommended |

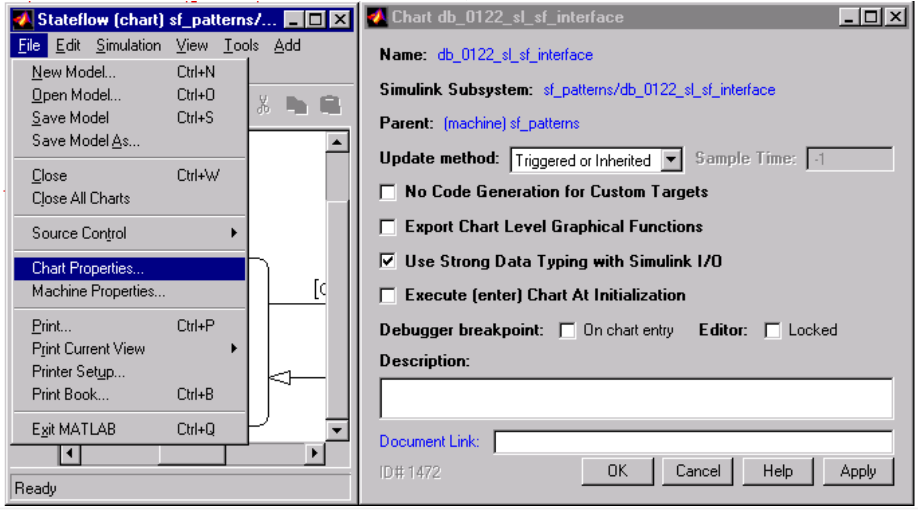
| | |
|---|---|
| Scope | MAAB |
| MATLAB Version | All |
| MA Check | No |
| Prerequisites | None |
| Description | Do not perform unary minus on unsigned integers.<br>**Correct**<br><br>{<br>si16_var1=-si16_var2;<br>}<br>Name \| Data Type<br>si_var2 \| int16<br>**Incorrect**<br><br>{<br>ui16_var1=-ui16_var2;<br>}<br>Name \| Data Type<br>ui_var2 \| uint16 |
| Rationale | ☑ Readability<br>☑ Workflow<br>☐ Simulation<br>☐ Verification and Validation<br>☑ Code Generation |
| Last Change | V2.0 |

## 4.5.2.3 na_0013: Comparison operation in Stateflow

| | |
|---|---|
| **ID: Title** | **na_0013: Comparison operation in Stateflow** |
| Priority | Recommended |
| Scope | MAAB |
| MATLAB Version | All |
| MA Check | No |
| Prerequisites | None |
| Description | • Comparisons should be made only between variables of the same data type.<br>• If comparisons are made between variables of different data types then the variables need to be explicitly type cast to matching data types.<br>**Correct**<br>Same data type in “i” and “n”<br><br>[i<n]<br>Name \| Data Type<br>i \| uint8<br>n \| uint8<br>**Incorrect**<br>Different data type in “i” and “d”<br><br>[i<d]<br>Name \| Data Type<br>i \| uint8<br>d \| int16<br>**Correct**<br><br>[(int16)i<d] |

| | |
|---|---|
| | <br>Name Data Type<br>i uint8<br>d int16<br>- Do not make comparisons between unsigned integers and negative numbers.<br>**Incorrect**<br><br> <br>Name Data Type<br>i uint8 |
| Rationale | ☐ Readability ☐ Verification and Validation<br>☑ Workflow ☑ Code Generation<br>☐ Simulation |
| Last Change | V2.0 |

### 4.5.2.4 db_0122: Stateflow and Simulink interface signals and parameters

| **ID: Title** | **db_0122: Stateflow and Simulink interface signals and parameters** |
|---|---|
| Priority | Strongly recommended |
| Scope | MAAB |
| MATLAB Version | All |
| MA Check | Yes |
| Prerequisites | None |
| Description | A Chart uses strong data typing with Simulink (The option "Use Strong Data Typing with Simulink I/O" must be selected).<br><br> Stateflow (chart) sf_patterns/...<br>File Edit Simulation View Tools Add<br>New Model... Ctrl+N<br>Open Model... Ctrl+O<br>Save Model Ctrl+S<br>Save Model As...<br>Close Ctrl+W<br>Close All Charts<br>Source Control<br>Chart Properties...<br>Machine Properties...<br>Print... Ctrl+P<br>Print Current View<br>Printer Setup...<br>Print Book... Ctrl+B<br>Exit MATLAB Ctrl+Q<br>Ready<br>Chart db_0122_sl_sf_interface<br>Name: db_0122_sl_sf_interface<br>Simulink Subsystem: sf_patterns/db_0122_sl_sf_interface<br>Parent: (machine) sf_patterns<br>Update method: Triggered or Inherited Sample Time: -1<br>☐ No Code Generation for Custom Targets<br>☐ Export Chart Level Graphical Functions<br>☑ Use Strong Data Typing with Simulink I/O<br>☐ Execute (enter) Chart At Initialization<br>Debugger breakpoint: ☐ On chart entry Editor: ☐ Locked<br>Description:<br>Document Link:<br>ID# 1472<br> |
| Rationale | ☑ Readability ☑ Verification and Validation<br>☑ Workflow ☐ Code Generation |

| | |
|---|---|
| | ☐ Simulation |
| Last Change | V2.0 |

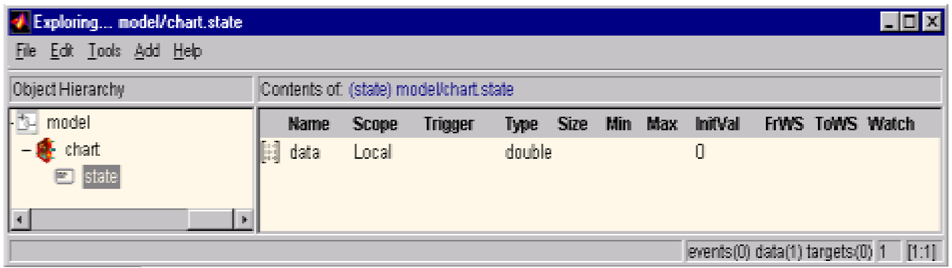
### 4.5.2.5 db_0125: Scope of internal signals and local auxiliary variables

<table>
<tr><td><b>ID: Title</b></td><td><b>db_0125: Scope of internal signals and local auxiliary variables</b></td></tr>
<tr><td>Priority</td><td>Strongly recommended</td></tr>
<tr><td>Scope</td><td>MAAB</td></tr>
<tr><td>MATLAB Version</td><td>All</td></tr>
<tr><td>MA Check</td><td>Yes</td></tr>
<tr><td>Prerequisites</td><td>None</td></tr>
<tr><td>Description</td><td>

Internal signals and local auxiliary variables are "Local data" in Stateflow:

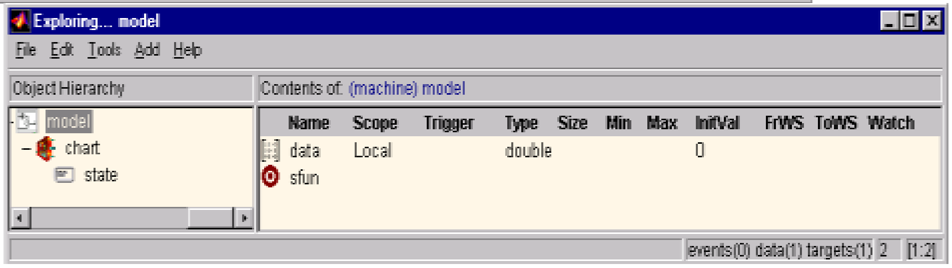
- All local data of a Stateflow block must be defined on the chart level or below the Object Hierarchy.
- There must be no local variables on the machine level (i.e. there is no interaction between local data in different charts).
- Parameters and constants are allowed at the machine level.

**Correct**


Exploring... model/chart.state
File Edit Tools Add Help
Object Hierarchy
model
chart
state
events(0) data(1) targets(0) 1 [1:1]

Contents of: (state) model/chart.state

<table>
<tr><th>Name</th><th>Scope</th><th>Trigger</th><th>Type</th><th>Size</th><th>Min</th><th>Max</th><th>InitVal</th><th>FrWS</th><th>ToWS</th><th>Watch</th></tr>
<tr><td>data</td><td>Local</td><td></td><td>double</td><td></td><td></td><td></td><td>0</td><td></td><td></td><td></td></tr>
</table>



Contents of: (machine) model

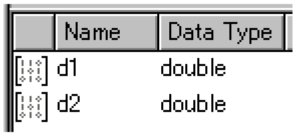
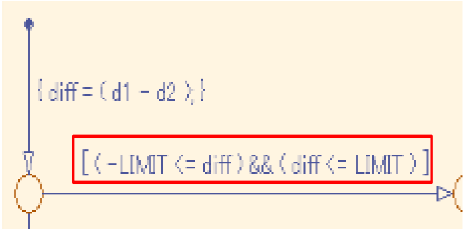
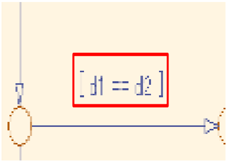
<table>
<tr><th>Name</th><th>Scope</th><th>Trigger</th><th>Type</th><th>Size</th><th>Min</th><th>Max</th><th>InitVal</th><th>FrWS</th><th>ToWS</th><th>Watch</th></tr>
<tr><td>data</td><td>Local</td><td></td><td>double</td><td></td><td></td><td></td><td>0</td><td></td><td></td><td></td></tr>
<tr><td>sfun</td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
</table>

**Incorrect**

</td></tr>
<tr><td>Rationale</td><td>☑ Readability ☑ Verification and Validation<br>☑ Workflow ☐ Code Generation<br>☐ Simulation</td></tr>
<tr><td>Last Change</td><td>V2.0</td></tr>
</table>

### 4.5.2.6 jc_0481: Use of hard equality comparisons for floating point numbers in Stateflow

| | |
|---|---|
| **ID: Title** | **jc_0481: Use of hard equality comparisons for floating point numbers in Stateflow** |

| | |
|---|---|
| Priority | Recommended |
| Scope | MAAB |
| MATLAB Version | All |
| MA Check | No |
| Prerequisites | None |
| Description | • Do not use hard equality comparisons (Var1 == Var2) with two floating point numbers.<br>• If a hard comparison is required a margin of error should be defined and used in the comparison (LIMIT in the example).<br>• Hard equality comparisons can be done between two integer data types.<br>**Correct**<br><br>Name \| Data Type<br>d1 \| double<br>d2 \| double<br><br>{diff = (d1 - d2);}<br>[(-LIMIT <= diff) && (diff <= LIMIT)]<br>**Incorrect**<br><br>[d1 == d2] |
| Rationale | ☐ Readability<br>☑ Workflow<br>☐ Simulation<br>☑ Verification and Validation<br>☑ Code Generation |
| Last Change | V2.0 |

### 4.5.2.7 jc_0491: Reuse of variables within a single Stateflow scope

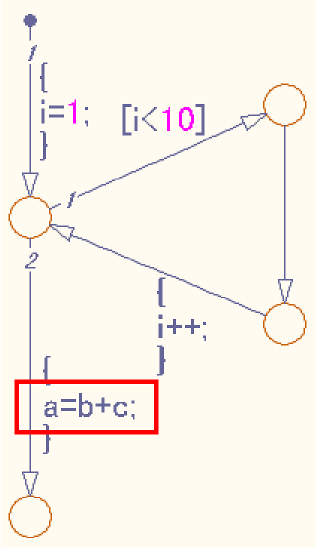
| **ID: Title** | **jc_0491: Reuse of variables within a single Stateflow scope** |
|---|---|
| Priority | Recommended |
| Scope | MAAB |
| MATLAB Version | All |
| MA Check | No |
| Prerequisites | None |
| Description | The same variable should not have multiple meanings (usages) within a single |

Stateflow scope.

<table>
<tr>
<td>

**Correct**

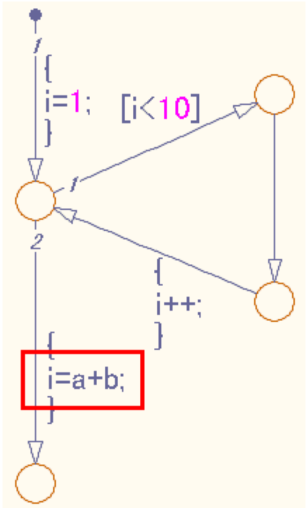
Variable of loop counter must not be used other than loop counter.



</td>
<td>

**Incorrect**

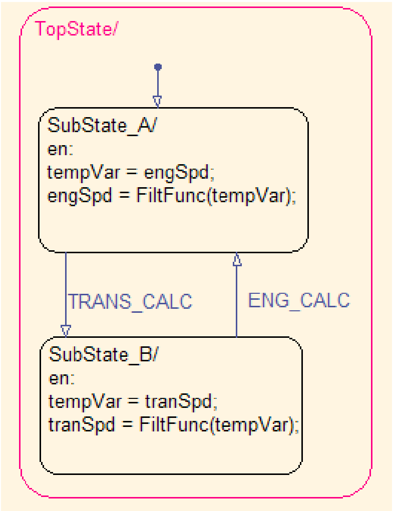
The meaning of the variable "i" changes from the index of the loop counter to the sum of a+b

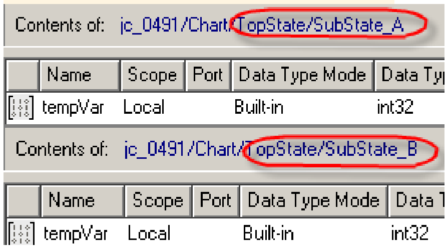


</td>
</tr>
<tr>
<td>

**Correct**

tempVar is defined as local scope in both SubState_A and SubState_B





Contents of: jc_0491/Chart/TopState/SubState_A

| Name | Scope | Port | Data Type Mode | Data Ty |
|---|---|---|---|---|
| tempVar | Local | | Built-in | int32 |

Contents of: jc_0491/Chart/TopState/SubState_B

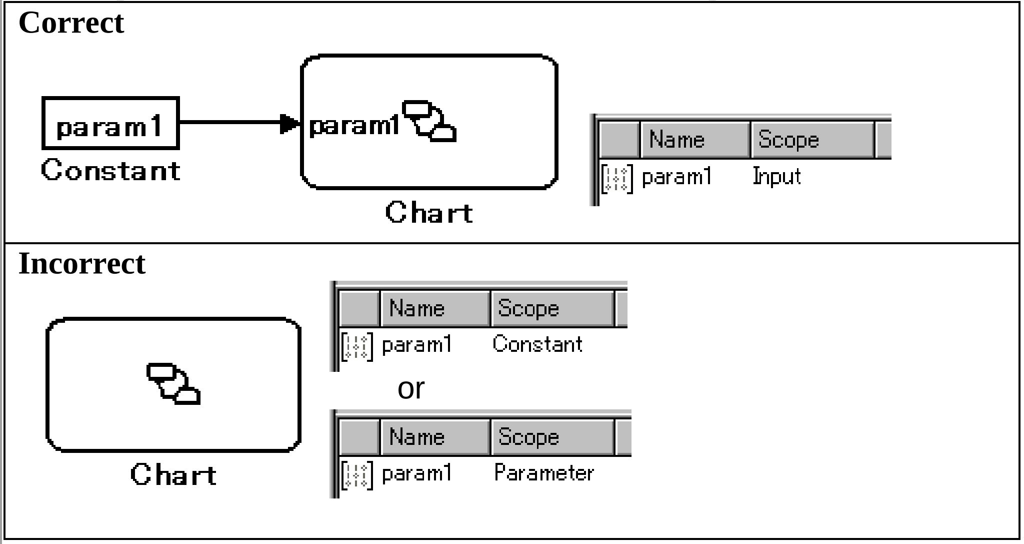
| Name | Scope | Port | Data Type Mode | Data T |
|---|---|---|---|---|
| tempVar | Local | | Built-in | int32 |

</td>
<td></td>
</tr>
</table>

| | |
|---|---|
| Rationale | ☑ Readability ☐ Verification and Validation<br>☑ Workflow ☑ Code Generation<br>☐ Simulation |

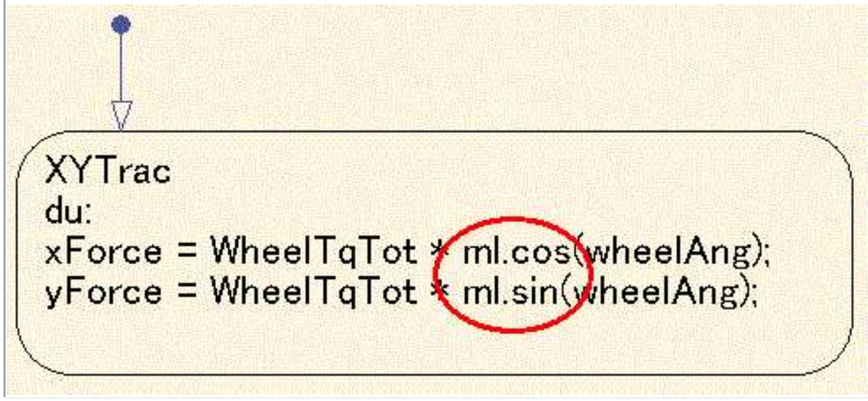
| | |
|---|---|
| Last Change | V2.0 |

### 4.5.2.8 jc_0541: Use of tunable parameters in Stateflow

| **ID: Title** | **jc_0541: Use of tunable parameters in Stateflow** |
|---|---|
| Priority | Strongly recommended |
| Scope | MAAB |
| MATLAB Version | All |
| MA Check | Yes |
| Prerequisites | None |
| Description | Tunable parameters should be included in a Chart as inputs from the Simulink model.   Correct<br>param1<br>Constant<br>param1<br>Chart<br>Name Scope<br>param1 Input<br>Incorrect<br>Chart<br>Name Scope<br>param1 Constant<br>or<br>Name Scope<br>param1 Parameter |
| Rationale | ☑ Readability<br>☑ Workflow<br>☐ Simulation<br>☐ Verification and Validation<br>☑ Code Generation |
| Last Change | V2.0 |

### 4.5.2.9 db_0127: MATLAB commands in Stateflow

| **ID: Title** | **db_0127: MATLAB commands in Stateflow** |
|---|---|
| Priority | Mandatory |
| Scope | MAAB |
| MATLAB Version | All |
| MA Check | No |

| | |
|---|---|
| Prerequisites | None |
| Description | The following rules apply to logic in Stateflow:<br>• MATLAB functions are not used.<br>• MATLAB instructions are not used.<br>• MATLAB operators are not used.<br>• Project-specific MATLAB functions are not used.<br>**Incorrect**<br><br>XYTrac<br>du:<br>xForce = WheelTqTot * ml.cos(wheelAng);<br>yForce = WheelTqTot * ml.sin(wheelAng); |
| Rationale | ☑ Readability ☑ Verification and Validation<br>☑ Workflow ☑ Code Generation<br>☐ Simulation |
| Last Change | V2.0 |

### 4.5.2.10 jm_0011: Pointers in Stateflow

| | |
|---|---|
| **ID: Title** | **jm_0011: Pointers in Stateflow** |
| Priority | Strongly recommended |
| Scope | MAAB |
| MATLAB Version | All |
| MA Check | No |
| Prerequisites | None |
| Description | In a Stateflow diagram, pointers to custom code variables are not allowed. |
| Rationale | ☑ Readability • Verification and Validation<br>☑ Workflow ☑ Code Generation<br>☐ Simulation |
| Last Change | V1.0 |

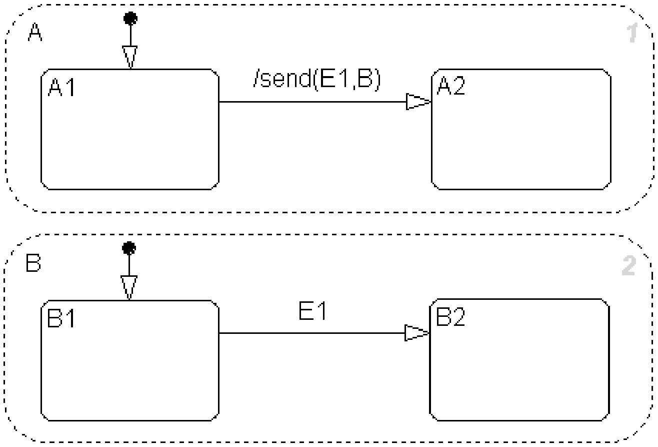
## 4.5.3 Events

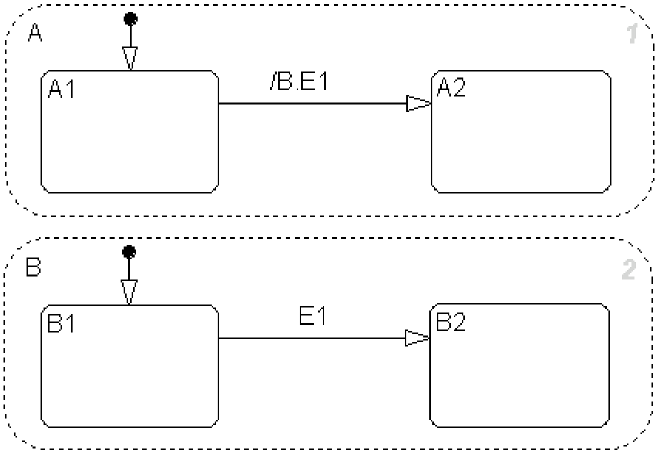
### 4.5.3.1 db_0126: Scope of events

| | |
|---|---|
| **ID: Title** | **db_0126: Scope of events** |
| Priority | Mandatory |

| | |
|---|---|
| Scope | MAAB |
| MATLAB Version | All |
| MA Check | Yes |
| Prerequisites | None |
| Description | The following rules apply to events in Stateflow:<br>• All events of a Chart must be defined on the chart level or lower.<br>• There is no event on the machine level (i.e. there is no interaction with local events between different charts). |
| Rationale | ☑ Readability<br>☑ Workflow<br>□ Simulation<br>☑ Verification and Validation<br>□ Code Generation |
| Last Change | V2.0 |

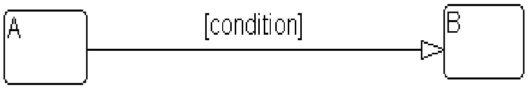
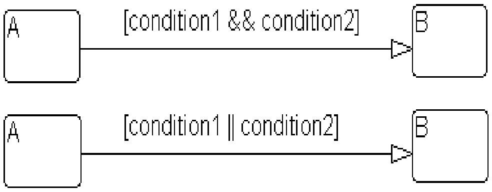
### 4.5.3.2 jm_0012: Event broadcasts

| **ID: Title** | **jm_0012: Event broadcasts** |
|---|---|
| Priority | Strongly recommended |
| Scope | MAAB |
| MATLAB Version | All |
| MA Check | No |
| Prerequisites | db_0126: Scope of events |
| Description | The following rules apply to event broadcasts in Stateflow:<br>• Directed event broadcasts are the only type of event broadcasts allowed.<br>• The send syntax or qualified event names are used to direct the event to a particular state.<br>• Multiple send statements should be used to direct an event to more than one state.<br>Example using the send syntax:<br> A<br>A1<br>/send(E1,B)<br>A2<br>1<br>B<br>B1<br>E1<br>B2<br>2<br>Example using qualified event names: |

| | |
|---|---|
| |  |
| Rationale | ☑ Readability<br>☑ Workflow<br>☐ Simulation<br>☑ Verification and Validation<br>☑ Code Generation |
| Last Change | V1.0 |

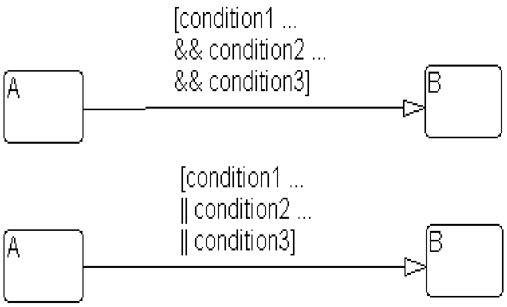
## 4.5.4 Statechart Patterns

### 4.5.4.1 db_0150: State machine patterns for conditions

<table>
<tr><th>ID: Title</th><th>db_0150: State machine patterns for conditions</th></tr>
<tr><td>Priority</td><td>Strongly recommended</td></tr>
<tr><td>Scope</td><td>MAAB</td></tr>
<tr><td>MATLAB Version</td><td>All</td></tr>
<tr><td>MA Check</td><td>No</td></tr>
<tr><td>Prerequisites</td><td>None</td></tr>
<tr><td>Description</td><td>The following patterns are used for conditions within Stateflow state machines:
<table>
<tr><th>Equivalent Functionality</th><th>State Machine Pattern</th></tr>
<tr><td>ONE CONDITION:<br>*(condition)*</td><td> </td></tr>
<tr><td>UP TO THREE CONDITIONS, SHORT FORM:<br>(The use of different logical operators in this form is not allowed, use sub conditions instead)<br>*(condition1 &amp;&amp; condition2)*</td><td>

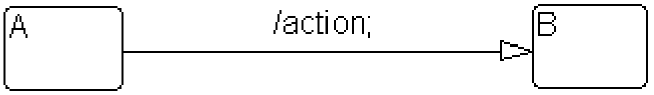
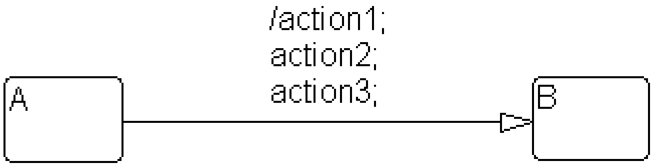
A<br>[condition1 &amp;&amp; condition2]<br>B<br>A<br>[condition1 || condition2]<br>B

</td></tr>
</table>
</td></tr>
</table>

<table>
<tr><td></td><td><table>
<tr><td><em>(condition1 || condition2)</em></td><td></td></tr>
<tr><td>TWO OR MORE CONDITIONS, MULTILINE FORM:<br>A sub condition is a set of logical operations, all of the same type, enclosed in parentheses.<br>(The use of different operators in this form is not allowed, use sub conditions instead)<br><br><em>(condition1 ...<br>&& condition2 ...<br>&& condition3)</em><br><br><em>(condition1 ...<br>|| condition2 ...<br>|| condition3)</em></td><td> </td></tr>
</table></td></tr>
<tr><td>Rationale</td><td>☑ Readability<br>☑ Workflow<br>□ Simulation<br>☑ Verification and Validation<br>□ Code Generation</td></tr>
<tr><td>Last Change</td><td>V2.0</td></tr>
</table>

### 4.5.4.2 db_0151: State machine patterns for transition actions

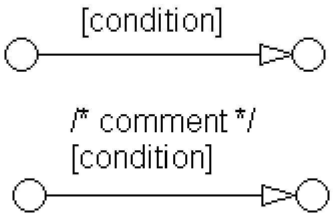
<table>
<tr><td><strong>ID: Title</strong></td><td><strong>db_0151: State machine patterns for transition actions</strong></td></tr>
<tr><td>Priority</td><td>Strongly recommended</td></tr>
<tr><td>Scope</td><td>MAAB</td></tr>
<tr><td>MATLAB Version</td><td>All</td></tr>
<tr><td>MA Check</td><td>No</td></tr>
<tr><td>Prerequisites</td><td>None</td></tr>
<tr><td>Description</td><td>The following patterns are used for transition actions within Stateflow state machines:<table><tr><th>Equivalent Functionality</th><th>State Machine Pattern</th></tr></table></td></tr>
</table>

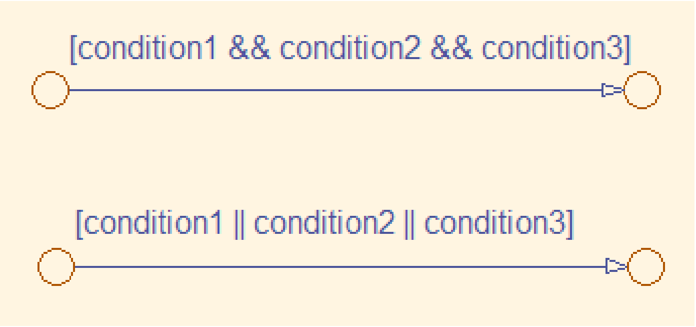
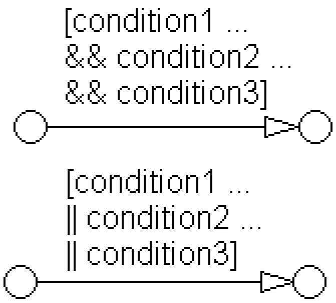
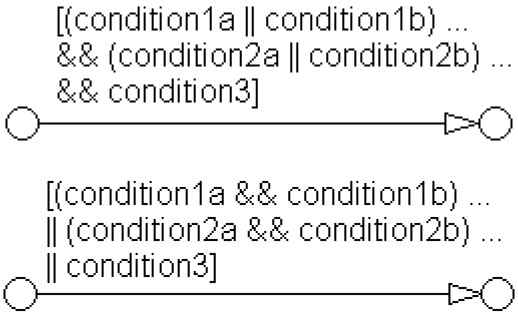
| | | |
|---|---|---|
| | ONE TRANSITION ACTION:<br>*action;* |  |
| | TWO OR MORE TRANSITION ACTIONS, MULTILINE FORM: (Two or more transition actions in one line are not allowed)<br>*action1;*<br>*action2;*<br>*action3;* |  |
| Rationale | ☑ Readability<br>☑ Workflow<br>☐ Simulation<br>☑ Verification and Validation<br>☐ Code Generation | |
| Last Change | V1.0 | |

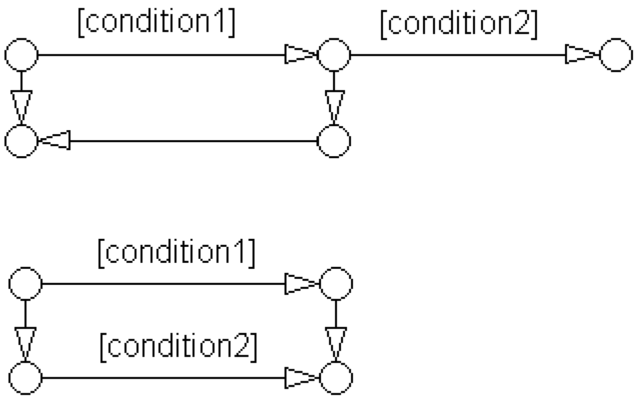
## 4.5.5 Flowchart Patterns

The following rules illustrate sample patterns used in flow charts. As such they would normally be part of a much larger Stateflow diagram.

### 4.5.5.1 db_0148: Flowchart patterns for conditions

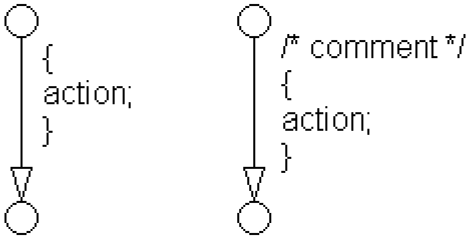
| ID: Title | **db_0148: Flowchart patterns for conditions** | |
|---|---|---|
| Priority | Strongly recommended | |
| Scope | MAAB | |
| MATLAB Version | All | |
| MA Check | No | |
| Prerequisites | None | |
| Description | The following patterns are used for conditions within Stateflow Flowcharts: | |
| | **Equivalent Functionality** | **Flowchart Pattern** |
| | ONE CONDITION:<br>*[condition]* |  |

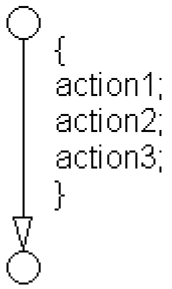
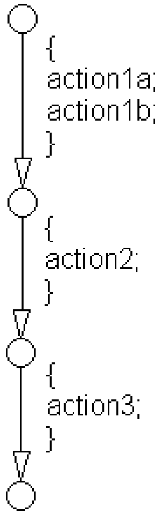
| | | |
|---|---|---|
| | UP TO THREE CONDITIONS, SHORT FORM: (The use of different logical operators in this form is not allowed, use sub conditions instead.)<br>*[condition1 && condition2 && condition3]*<br>*[condition1 \|\| condition2 \|\| condition3]* | <br>[condition1 && condition2 && condition3]<br>[condition1 \|\| condition2 \|\| condition3] |
| | TWO OR MORE CONDITIONS, MULTILINE FORM: (The use of different logical operators in this form is not allowed, use sub conditions instead.)<br>*[condition1 ...*<br>*&& condition2 ...*<br>*&& condition3]*<br>*[condition1 ...*<br>*\|\| condition2 ...*<br>*\|\| condition3]* | <br>[condition1 ...<br>&& condition2 ...<br>&& condition3]<br>[condition1 ...<br>\|\| condition2 ...<br>\|\| condition3] |
| | CONDITIONS WITH SUBCONDITIONS: (The use of different logical operators to connect sub conditions is not allowed. The use of brackets is Mandatory.)<br>*[(condition1a \|\| condition1b) ...*<br>*&& (condition2a \|\| condition2b) ...*<br>*&& (condition3)]*<br>*[(condition1a && condition1b) ...*<br>*\|\| (condition2a && condition2b) ...*<br>*\|\| (condition3)]* | <br>[(condition1a \|\| condition1b) ...<br>&& (condition2a \|\| condition2b) ...<br>&& condition3]<br>[(condition1a && condition1b) ...<br>\|\| (condition2a && condition2b) ...<br>\|\| condition3] |

| | | |
|---|---|---|
| | CONDITIONS, WHICH ARE VISUALLY SEPARATED:<br>(This form can be mixed up with the patterns listed above.)<br>*[condition1 && condition2]*<br>*[condition1 \|\| condition2]* |  [condition1]<br>[condition2]<br>[condition1]<br>[condition2] |
| Rationale | 1. Readability<br>☑ Workflow<br>□ Simulation | ☑ Verification and Validation<br>□ Code Generation |
| Last Change | V2.0 | |

### 4.5.5.2 db_0149: Flowchart patterns for condition actions

| | |
|---|---|
| **ID: Title** | **db_0149: Flowchart patterns for condition actions** |
| Priority | Strongly recommended |
| Scope | MAAB |
| MATLAB Version | All |
| MA Check | No |
| Prerequisites | None |
| Description | The following patterns are used for condition actions within Stateflow Flowcharts: |

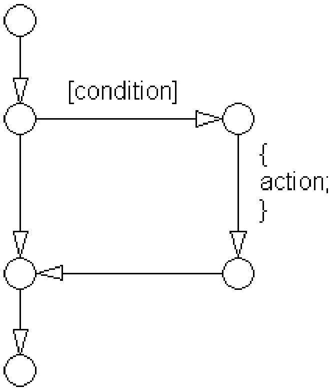
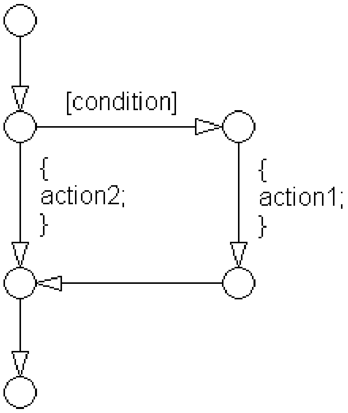
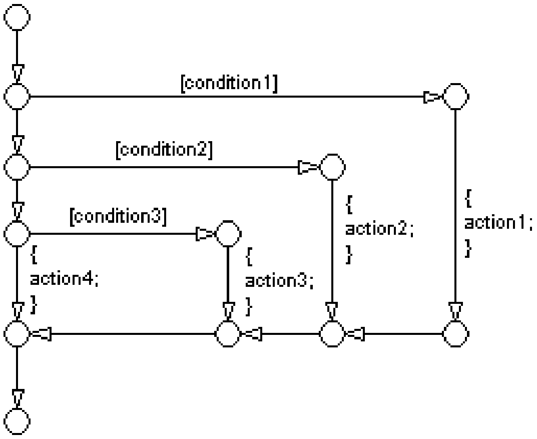
| **Equivalent Functionality** | **Flowchart Pattern** |
|---|---|
| ONE CONDITION ACTION:<br>action; |  |

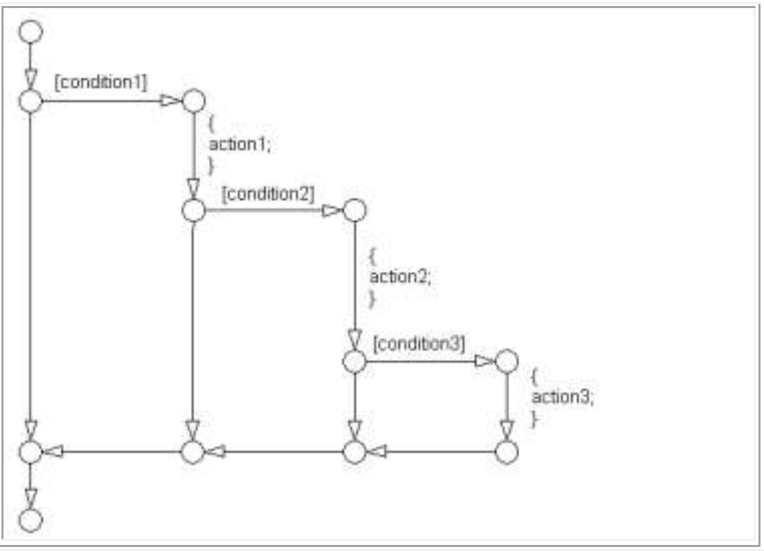
| | | |
|---|---|---|
| | TWO OR MORE CONDITION ACTIONS, MULTILINE FORM:<br>(Two or more condition actions in one line are not allowed.)<br>action1; ...<br>action2; ...<br>action3; ... |  |
| | CONDITION ACTIONS, WHICH ARE VISUALLY SEPARATED:<br>(This form can be mixed up with the patterns listed above.)<br>action1a;<br>action1b;<br>action2;<br>action3; |  {<br>action1a;<br>action1b;<br>}<br>{<br>action2;<br>}<br>{<br>action3;<br>} |
| Rationale | ☑ Readability<br>☑ Workflow<br>☐ Simulation | ☑ Verification and Validation<br>☐ Code Generation |
| Last Change | V1.0 | |

### 4.5.5.3 db_0134: Flowchart patterns for If constructs

| | |
|---|---|
| **ID: Title** | **db_0134: Flowchart patterns for If constructs** |
| Priority | Strongly recommended |
| Scope | MAAB |
| MATLAB Version | All |
| MA Check | No |
| Prerequisites | db_0148: Flowchart patterns for conditions<br>db_0149: Flowchart patterns for condition actions |
| Description | The following patterns are used for If constructs within Stateflow Flowcharts: |

| **Equivalent Functionality** | **Flowchart Pattern** |
|---|---|

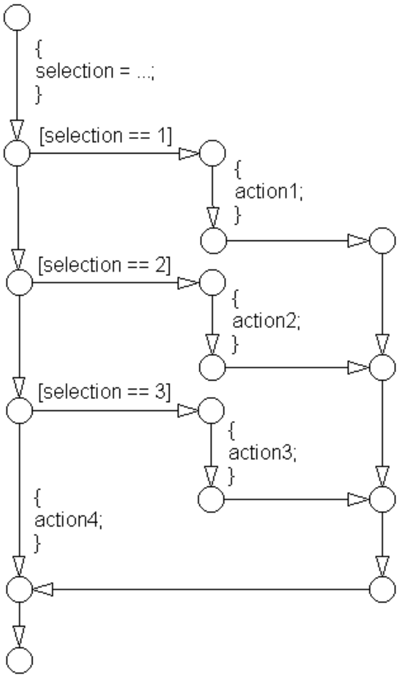
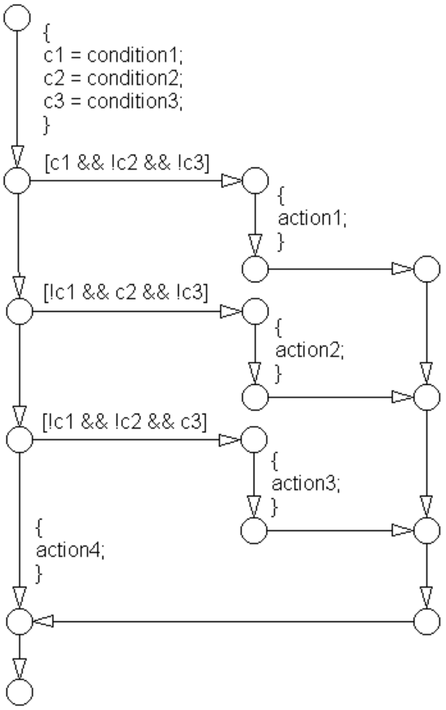
| | |
|---|---|
| IF THEN<br>if (condition){<br>action;<br>} |  |
| IF THEN ELSE<br>if (condition) {<br>action1;<br>}<br>else {<br>action2;<br>} |  |
| IF THEN ELSE IF<br>if (condition1) {<br>action1;<br>}<br>else if (condition2) {<br>action2;<br>}<br>else if (condition3) {<br>action3;<br>}<br>else {<br>action4;<br>} |  [condition1]<br>[condition2]<br>[condition3]<br>{<br>action4;<br>}<br>{<br>action3;<br>}<br>{<br>action2;<br>}<br>{<br>action1;<br>} |

| | |
|---|---|
| | Cascade of IF THEN<br>if (condition1) {<br>    action1;<br>    if (condition2) {<br>        action2;<br>        if (condition3) {<br>          action3;<br>        }<br>    }<br>}   [condition1]<br>{<br>action1;<br>}<br>[condition2]<br>{<br>action2;<br>}<br>[condition3]<br>{<br>action3;<br>} |
| Rationale | ☑ Readability<br>☑ Workflow<br>□ Simulation<br>☑ Verification and Validation<br>□ Code Generation |
| Last Change | V1.0 |

### 4.5.5.4 db_0159: Flowchart patterns for case constructs

| **ID: Title** | **db_0159: Flowchart patterns for case constructs** |
|---|---|
| Priority | Strongly recommended |
| Scope | MAAB |
| MATLAB Version | All |
| MA Check | No |
| Prerequisites | db_0148: Flowchart patterns for conditions<br>db_0149: Flowchart patterns for condition actions |
| Description | The following patterns must be used for case constructs within Stateflow Flowcharts: |

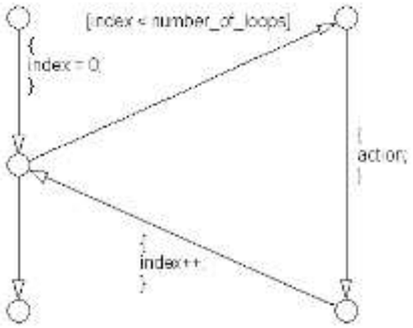
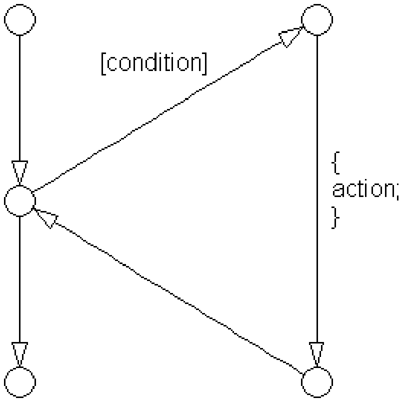
| **Equivalent Functionality** | **Flowchart Pattern** |
|---|---|

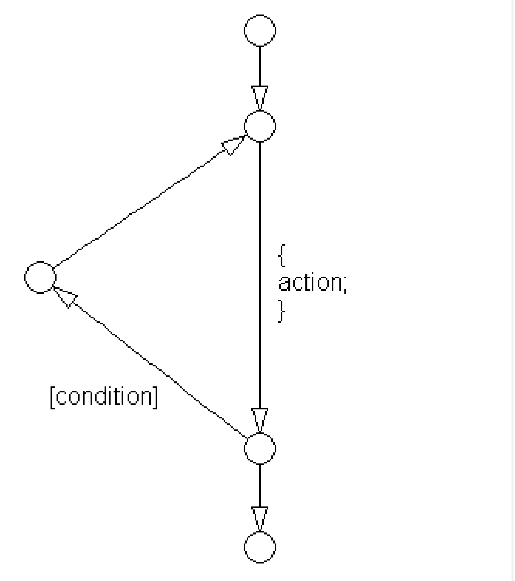
| | |
|---|---|
| CASE with exclusive selection<br>selection = ...;<br>switch (selection) {<br>    case 1:<br>        action1;<br>    break;<br>    case 2:<br>        action2;<br>    break;<br>    case 3:<br>        action3;<br>    break;<br>    default:<br>        action4;<br>} |  {<br>selection = ...;<br>}<br>[selection == 1]<br>{<br>action1;<br>}<br>[selection == 2]<br>{<br>action2;<br>}<br>[selection == 3]<br>{<br>action3;<br>}<br>{<br>action4;<br>} |
| CASE with exclusive conditions<br>c1 = condition1;<br>c2 = condition2;<br>c3 = condition3;<br>if (c1 && !c2 && !c3) {<br>    action1;<br>}<br>elseif (!c1 && c2 && !c3) {<br>    action2;<br>}<br>elseif (!c1 && !c2 && c3) {<br>    action3;<br>}<br>else {<br>    action4;<br>} |  {<br>c1 = condition1;<br>c2 = condition2;<br>c3 = condition3;<br>}<br>[c1 && !c2 && !c3]<br>{<br>action1;<br>}<br>[!c1 && c2 && !c3]<br>{<br>action2;<br>}<br>[!c1 && !c2 && c3]<br>{<br>action3;<br>}<br>{<br>action4;<br>} |

| | | |
|---|---|---|
| Rationale | ☑ Readability<br>☑ Workflow<br>☐ Simulation | ☑ Verification and Validation<br>☐ Code Generation |
| Last Change | V1.0 | |

### 4.5.5.5 db_0135: Flowchart patterns for loop constructs

| **ID: Title** | **db_0135: Flowchart patterns for loop constructs** |
|---|---|

<table>
<tr><td>Priority</td><td>Recommended</td></tr>
<tr><td>Scope</td><td>MAAB</td></tr>
<tr><td>MATLAB Version</td><td>All</td></tr>
<tr><td>MA Check</td><td>No</td></tr>
<tr><td>Prerequisites</td><td>db_0148: Flowchart patterns for conditions<br>db_0149: Flowchart patterns for condition actions</td></tr>
<tr><td>Description</td><td>The following patterns must be used to create Loops within Stateflow Flowcharts:
<table>
<tr><th>Equivalent Functionality</th><th>Flowchart Pattern</th></tr>
<tr><td>FOR LOOP<br>for<br>(index=0;index<number_of_loops;index++)<br>{<br>    action;<br>}</td><td>
</td></tr>
<tr><td>WHILE LOOP<br>while (condition) {<br>    action;<br>}</td><td>
</td></tr>
</table></td></tr>
</table>

| | | |
|---|---|---|
| | DO WHILE LOOP<br>do {<br>    action;<br>}<br>while (condition); |  |
| Rationale | ☑ Readability ☑ Verification and Validation<br>☑ Workflow □ Code Generation<br>□ Simulation | |
| Last Change | V1.0 | |

## *4.6 Embedded MATLAB (eML)*

### 4.6.1 jh_0201: eML Function Types

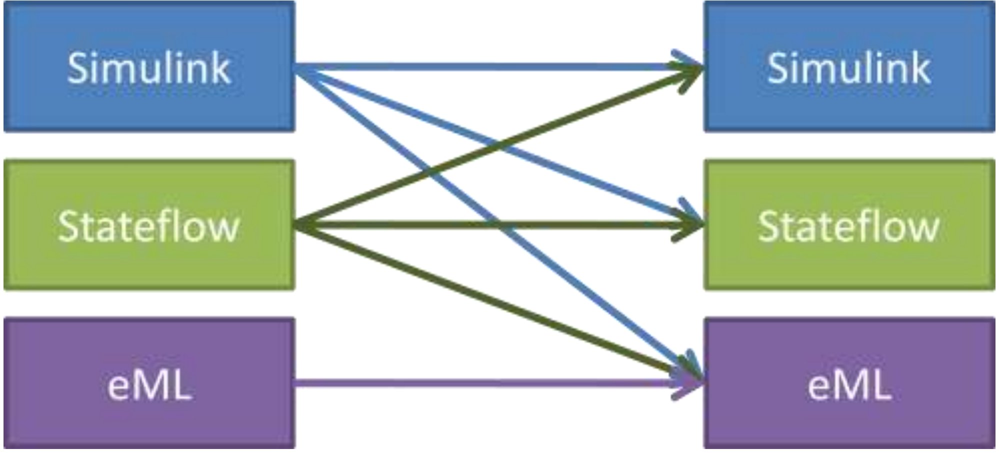
| **ID: Title** | **jh_0201: eML Function Types** |
|---|---|
| Priority | Mandatory |
| Scope | ORION |
| MATLAB Version | All |
| MA Check | No |
| Prerequisites | jh_0073: eML Header<br>jh_0079: Model and Matlab Filenames<br>jh_0202: Testable Units<br>jh_0200: Guidelines for Managing Model Complexity |
| Description | eML Functions can exist in one of two forms:<br>1. As an eML function that is written directly into an eML block<br>• The eML code only exists within the model that contains it and is not separately stored or separately editable.<br>• The only interface to the eML function is the eML block in which it resides<br>• A full header is still required |

2. As an externally saved “dot-m” file
   - Externally saved “dot-m” files are considered “Testable Units”
   - These functions may be called from multiple interfaces from within a **single** Model (see limitations below)
   - These functions are fully defined in a separate file
   - A full header is required
   - The declaration on the line immediately succeeding the function declaration must have the following code
     - **eml.inline(“never”);**
     - This declaration will ensure that the function is autocoded as an independent function and is fully testable. This will also maintain a One-to-One Testable Unit-to-autocode function (see jh_0202: Testable Units)

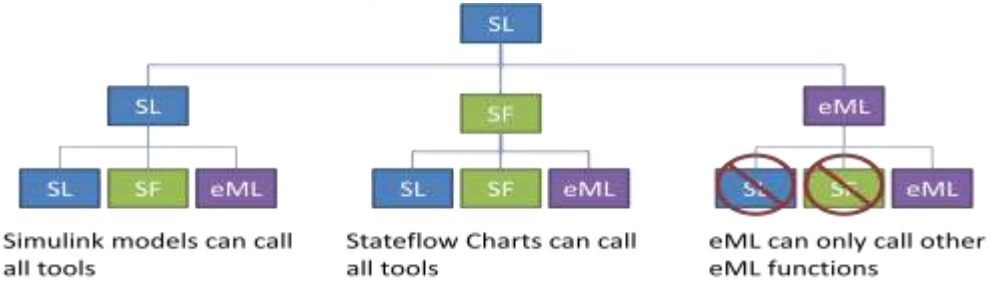
**Major Limitations related to the use of eML:**

The current version of the Simulink tool has 2 major limitations that need to be taken into account when developing eML functions.

1. **Interface Limitation:** Eml code can’t call Simulink models or Stateflow Charts. The following diagrams below shows the calling abilities of each of the 3 tools (Simulink, Stateflow, eML).



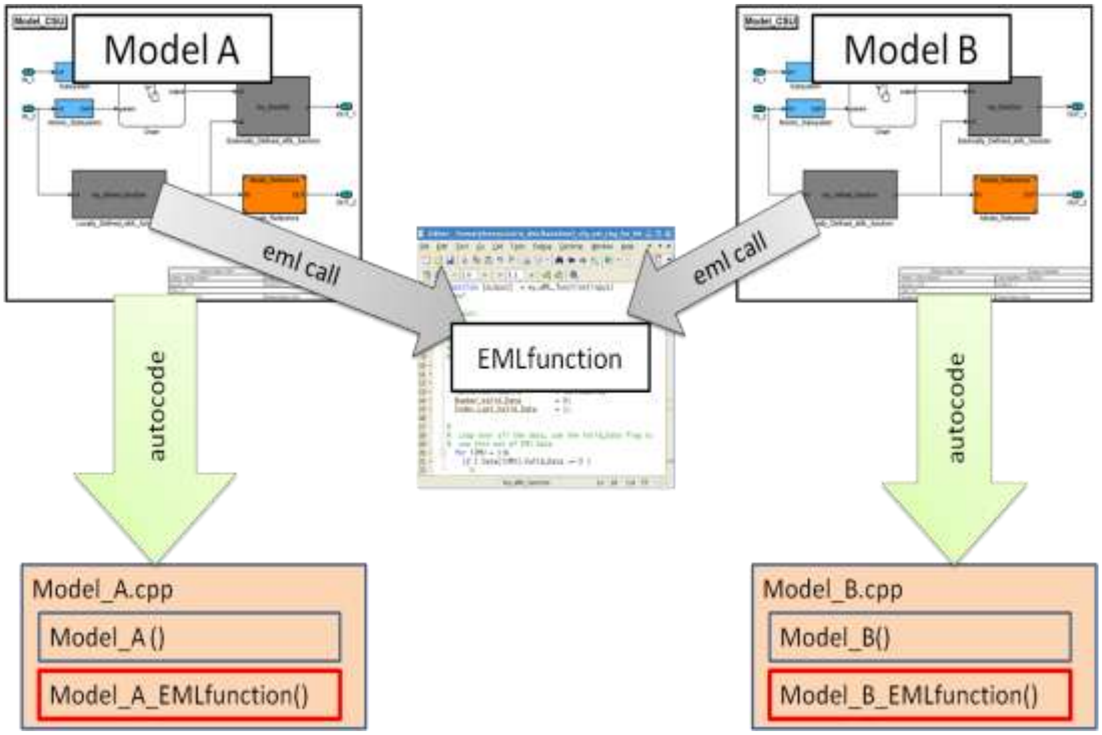
Once an eML function is used, all function calls below that model must also be eML.


SL
SL
SF
eML
SL
SF
eML
SL
SF
eML
SL
SF
eML
Simulink models can call all tools
Stateflow Charts can call all tools
eML can only call other eML functions

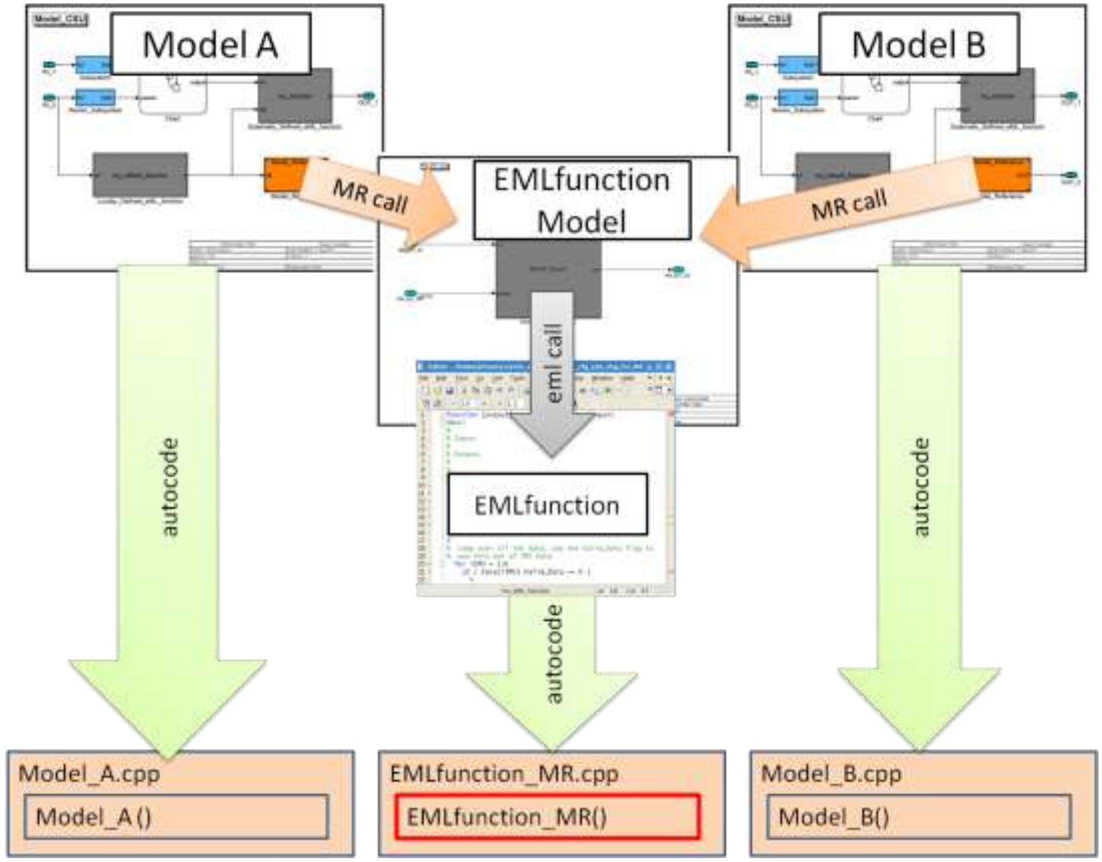
2. **Duplication in Autocode:** eML Functions are only reused in the autocode

when they are called multiple times from within the **same** model. eML functions that are shared between models will result in multiple instances of the function in the autocode. The only way to ensure that eML code is not coded multiple times when used by multiple models is to wrap it in a Simulink model and call it using the Model Reference feature.

The Diagram below illustrates the current limitation with eML and Real-Time Workshop. The shared eML function, “EMLfunction”, will be present in the autocode for both “Model A” and “Model B”.



To work around this limitation, eML functions can be “wrapped” in a Simulink model that only contains an eML block. The diagram below illustrates this approach that is consistent with the ORION project direction:

| | |
|---|---|
| |  Model A<br>Model B<br>MR call<br>EMLfunction Model<br>MR call<br>eml call<br>EMLfunction<br>autocode<br>autocode<br>autocode<br>Model_A.cpp<br>Model_A ()<br>EMLfunction_MR.cpp<br>EMLfunction_MR()<br>Model_B.cpp<br>Model_B()<br>This approach will create a single autocoded function for the "EMLfunction" that is only called by the code for "Model A" and "Model B". |
| Rationale | ☑ Readability<br>☑ Workflow<br>☑ Simulation<br>☑ Verification and Validation<br>☑ Code Generation |
| Last Change | V1.0 |

### 4.6.2 im_0008: Source lines of eML

| ID: Title | im_0008: Source lines of eML |
|---|---|
| Priority | Mandatory |
| Scope | ORION |
| MATLAB Version | All |
| MA Check | Yes |
| Prerequisites | jh_0201: eML Function Types |
| Description | Each eML function must have less than 60 source lines of code. This restriction applies to eML functions that reside at the Simulink block diagram as well as externally defined eML functions (a.k.a. "dot-m" files). The 60 source lines of code limitation is not additive and applies to each function individually. |

| | |
|---|---|
| | |
| Rationale | ☑ Readability<br>☑ Workflow<br>☐ Simulation<br>☑ Verification and Validation<br>☑ Code Generation |
| Last Change | V1.1 |

### 4.6.3 im_0009: Number of called function levels

| **ID: Title** | **im_0009: Number of called function levels** |
|---|---|
| Priority | Mandatory |
| Scope | ORION |
| MATLAB Version | All |
| MA Check | No |
| Prerequisites | None |
| Description | There shall be no more than 3 levels of function calls allowed from the eML function block that resides at the Simulink block diagram level. The eML function block that resides at the Simulink block diagram level counts as the first level – unless it is simply a wrapper for an externally defined eML function (a.k.a. “dot-m” file).<br>This includes functions that are defined within the eML block and those in separate .m files<br>For example:<br>if the eML function block with function foobar1 calls foobar2, a subfunction or other user defined function residing in an external file, that subfunction or function, foobar2, may similarly call another subfunction or function, such as foobar3. This would constitute 3 levels of function calls (the first level eML function block function, foobar1, it’s called subfunction or function, foobar2, at the second level, and the third level subfunction or function call, foobar3). No further calls to subfunctions or functions would be allowed from foobar3, as this is the third and last allowed level.<br>Note: A call to a USA utility function does not count as a level. |
| Rationale | ☑ Readability<br>☑ Workflow<br>☐ Simulation<br>☑ Verification and Validation<br>☑ Code Generation |
| Last Change | V1.3 |

### 4.6.4 jr_0002: Number of nested if/for statement blocks

| **ID: Title** | **jr_0002: Number of nested if/for statement blocks** |
|---|---|
| Priority | Strongly Recommended |

| | |
|---|---|
| Scope | ORION |
| MATLAB Version | All |
| MA Check | No |
| Prerequisites | None |
| Description | There shall be no more than 3 levels of nested if/for statement blocks allowed within an eML function block that resides at the Simulink block diagram level, or a lower level. |
| Rationale | ☑ Readability ☑ Verification and Validation<br>☑ Workflow ☑ Code Generation<br>☐ Simulation |
| Last Change | V1.2 |

### 4.6.5 jh_0110: eML Function Reuse

| **ID: Title** | **jh_0110: eML Function Reuse** |
|---|---|
| Priority | Mandatory |
| Scope | ORION |
| MATLAB Version | All |
| MA Check | No |
| Prerequisites | None |
| Description | eML functions can only be called multiple times within the same Model (CSU or Model Reference). The same eML function can be called by separate eML blocks, but only if they reside in the same model. Shared eML functions should not be called directly. If a shared function is written in eML and needs to be used in multiple CSUs, the eML function should be wrapped in a Simulink model and called through model reference.<br><br>The reason for this standard is as follows. The autocoder, Real-Time Workshop, does not have knowledge of shared eML functions. Due to this limitation, the autocoder will create a version of the eML function each time that it is used across models or eML blocks. Each autocode version may be coded in a different way depending on how it was called and the method that the RTW autocoder used to optimize the function and fold it into the surrounding operations. The existence of multiple versions of the same function makes the V&V process significantly more difficult because each of the instances of the reused eML function will need to be verified and validated. Therefore, this method is not compatible with the ORION GN&C Architecture.<br><br>Wrapping the eML function in a Simulink wrapper ensures only one instance of the autocode for that function and creates a generic function interface that is identical for all users of the function. This Simulink function can be called from either Simulink |

| | |
|---|---|
| | or Stateflow. |
| Rationale | ☐ Readability ☑ Verification and Validation<br>☐ Workflow ☑ Code Generation<br>☐ Simulation |
| Last Change | V1.1 |

### 4.6.6 im_0010: Number of inline function calls

| **ID: Title** | **im_0010: Number of inline function calls** |
|---|---|
| Priority | Mandatory |
| Scope | ORION |
| MATLAB Version | All |
| MA Check | Yes |
| Prerequisites | None |
| Description | There shall be no more than 12 inline function calls allowed within each eML block. |
| Rationale | ☑ Readability ☑ Verification and Validation<br>☑ Workflow ☑ Code Generation<br>☐ Simulation |
| Last Change | V1.0 |

### 4.6.7 jh_0063: eML block input/output settings

| **ID: Title** | **jh_0063: eML block input/output settings** |
|---|---|
| Priority | Recommended |
| Scope | ORION |
| MATLAB Version | All |
| MA Check | Yes |
| Prerequisites | None |
| Description | All inputs and outputs to eML blocks should have the DataType and Size explicitly defined via the Model Explorer (e.g. they can't be set to "DataType:Inherit: Same as Simulink" and "Size:-1"). This provides a more rigorous data type check for eML blocks and prevents the need for using assert statements.<br>Note: For vector inputs, enter the size in one of the following formats:<br>• Column vector: [3, 1]<br>• Row vector: [1, 3] |
| Rationale | ☐ Readability ☑ Verification and Validation<br>☐ Workflow ☑ Code Generation |

| | |
|---|---|
| | ☑ Simulation |
| Last Change | V1.0 |

### 4.6.8 jh_0021: Restricted Variable Names

| **ID: Title** | **jh_0021: Restricted Variable Names** |
|---|---|
| Priority | Mandatory |
| Scope | ORION |
| MATLAB Version | All |
| MA Check | Yes |
| Prerequisites | None |
| Description | Avoid using reserved C variable names such as const, TRUE, FALSE, infinity, nill, double, single, enum, for eML code. These names may conflict with the compiler after the model is autocoded.<br>Avoid, using variable names that conflict with eML library functions such as "conv". A list of all eML library function names can be found in the eML users guide.<br>The variable names "i" and "j" should not be used for looping. These names may conflict with those used by Real-time Workshop.<br>Note: This standard only applies to variable names used within eML |
| Rationale | □ Readability □ Verification and Validation<br>□ Workflow ☑ Code Generation<br>□ Simulation |
| Last Change | V1.2 |

### 4.6.9 jh_0064: eML if statement

| **ID: Title** | **jh_0064: eML if statement** |
|---|---|
| Priority | Mandatory |
| Scope | ORION |
| MATLAB Version | All |
| MA Check | No |
| Prerequisites | None |
| Description | Variables used in if statements must be of the same data type. This will prevent Matlab from automatically downcasting the data type for the variables so that they will be comparable. If this rule is not followed, the model may produce unexpected results. |

| | |
|---|---|
| | No type casting is needed for hard coded constants used in an if statement. The constants will be promoted to the same type as the variable. |
| Rationale | □ Readability<br>□ Workflow<br>☑ Simulation<br>☑ Verification and Validation<br>☑ Code Generation |
| Last Change | V1.1 |

### 4.6.10 jh_0023: Arrays

| | |
|---|---|
| **ID: Title** | **jh_0023: Arrays** |
| Priority | Mandatory |
| Scope | ORION |
| MATLAB Version | All |
| MA Check | No |
| Prerequisites | None |
| Description | This standard is enforced automatically by the m-lint tool.<br>eML does not support dynamic memory allocation. This presents an issue when using arrays. This was one of the most common errors found in the conversion process from Matlab to eML. The size of arrays must be declared before values can be assigned to the array. For example:<br>○ The following code will generate an error:<br>*r_ECI(1) = 20187984;*<br>*r_ECI(2) = 421063;*<br>*r_ECI(3) = -7806383;*<br>○ The array size must be determined before any values are assigned as follows:<br>*r_ECI = [0 0 0]; %this declares the array as a 1x3 array*<br>*r_ECI(1) = 20187984;*<br>*r_ECI(2) = 421063;*<br>*r_ECI(3) = -7806383;*<br>○ The following code will also work since the array size is being declared as it is being assigned a value:<br>*r_ECI = [20187984 421063 -7806383];*<br>○ Now that the array is initialized the values can change but the size of the array may not change. For example, the following code will generate an error:<br>*r_ECI = [20187984 421063 -7806383];* |

| | |
|---|---|
| | *r_ECI = [20187984 421063 -7806383 10000]; %the size of the array has already been set and can’t change*<br>○ This rule also applies to structures. Once a structure has been read or passed to a function, fields can no longer be added to it. For example, the following code will generate and error:<br><br>*Constant.A = 20187984;*<br>*Constant.B = 421063;*<br>*myVar = Constant.A; %the structure is used here*<br>*Constant.C = -7806383; %another field can’t be added*<br><br>Also, cell arrays and mx arrays are not allowed by eML. |
| Rationale | ☐ Readability<br>☐ Workflow<br>☑ Simulation<br>☐ Verification and Validation<br>☐ Code Generation |
| Last Change | V1.0 |

### 4.6.11 jh_0024: Strings

| | |
|---|---|
| **ID: Title** | **jh_0024: Strings** |
| Priority | Strongly recommended |
| Scope | ORION |
| MATLAB Version | All |
| MA Check | No |
| Prerequisites | None |
| Description | The use of strings is not recommended. eML stores strings as character arrays and these arrays can't be resized to accommodate a string value of different length due to lack of dynamic memory allocation. Also, stings are not a supported data type in Simulink so eML blocks could not pass the string data outside the block.<br><br>For example the following code will produce an error:<br><br>*name = ‘rate_error’; %this will create a 1 x 10 character array*<br>*name = ‘x_rate_error’; %this will cause an error because the array size is now 1 x 12 instead of 1 x 10* |
| Rationale | ☑ Readability<br>☐ Workflow<br>☑ Simulation<br>☐ Verification and Validation<br>☑ Code Generation |
| Last Change | V1.0 |

### 4.6.12 jh_0025: Structures

| **ID: Title** | **jh_0025: Structures** |
|---|---|
| Priority | Mandatory |
| Scope | ORION |
| MATLAB Version | All |
| MA Check | No |
| Prerequisites | None |
| Description | This standard is enforced automatically by the m-lint tool.<br><br>Once a structure has been read or passed to a function, fields can no longer be added to it. For example, the following code will generate and error:<br>*Constant.A = 20187984;*<br>*Constant.B = 421063;*<br>*myVar = Constant.A; %the structure is used here*<br>*Constant.C = -7806383; %another field can't be added*<br>Field values may be changed, just not added after being accessed. For example, the following code is acceptable:<br><br>*Constant.A = 20187984;*<br>*Constant.B = 421063;*<br>*myVar = Constant.A; %the structure is used here*<br>*Constant.A =51146 ; %an existing field value can be manipulated* |
| Rationale | □ Readability<br>□ Workflow<br>☑ Simulation<br>□ Verification and Validation<br>□ Code Generation |
| Last Change | V1.0 |

### 4.6.13 jh_0026: Switch/case statements

| **ID: Title** | **jh_0026: Switch/case statements** |
|---|---|
| Priority | Mandatory |
| Scope | ORION |
| MATLAB Version | All |
| MA Check | No |
| Prerequisites | None |
| Description | This standard is enforced automatically by the m-lint tool.<br><br>When using "switch" and "case" statements you may not use a variable or structure in the "case" expression; this value must be constant. The following code will |

| | |
|---|---|
| | generate an error:<br>*switch( iopt )*<br>  *case enum.LVLH % Local Vertical, Local Horizontal*<br>    *uy = -uh;*<br>    *uz = -ur;*<br>    *ux = cross( uy, uz );*<br>  *case enum.WIND_REL % Aerodynamic angles*<br>    *ux = uv;*<br>    *uy = -uh;*<br>    *uz = cross( ux, uy );*<br>  *otherwise % Default to Aerodynamics angles*<br>    *ux = uv;*<br>    *uy = -uh;*<br>    *uz = cross( ux, uy );*<br>*end*<br>- The conditions of each case must not reference a structure value. The following code fixes this error:<br><br>*switch( iopt )*<br>  *case 1 %enum.LVLH = 1*<br>    *uy = -uh;*<br>    *uz = -ur;*<br>    *ux = cross( uy, uz );*<br>  *case 2 %enum.WIND_REL = 2*<br>    *ux = uv;*<br>    *uy = -uh;*<br>    *uz = cross( ux, uy );*<br>  *otherwise*<br>    *ux = uv;*<br>    *uy = -uh;*<br>    *uz = cross( ux, uy );*<br>*end* |
| Rationale | □ Readability<br>□ Workflow<br>□ Simulation<br>□ Verification and Validation<br>□ Code Generation |
| Last Change | V1.0 |

### 4.6.14 jh_0027: Multiple Code Paths

| | |
|---|---|
| **ID: Title** | **jh_0027: Multiple Code Paths** |
| Priority | Mandatory |
| Scope | ORION |
| MATLAB Version | All |
| MA Check | No |

<table>
<tr><td>Prerequisites</td><td>None</td></tr>
<tr><td>Description</td><td>

This standard is enforced automatically by the m-lint tool.

If a variable affects the output of a function it must be assigned in all possible paths of the code. For example, the following code contains multiple paths based on the value of “iopt”.

```
function [ux, uy, uz ] = comp( ipot, uh, ur )
  switch( iopt )
    case 1
      uy = -uh;
      uz = -ur;
      ux = cross( uy, uz );
    case 2
      ux = uv;
      uy = -uh;
      uz = cross( ux, uy );
end
```

If the variable “iopt” does not equal either 1 or 2, then the variables ux, uy, and uz will never be assigned a value. Consider always using “otherwise” with a “switch” statement and also using an “else” with an if/then statement. In the code below, all paths of the function will assign a value to each of the output variables.

```
function [ux, uy, uz ] = comp( iopt, uh, ur )
  switch( iopt )
    case 1
      uy = -uh;
      uz = -ur;
      ux = cross( uy, uz );
    case 2
      ux = uv;
      uy = -uh;
      uz = cross( ux, uy );
    otherwise
      ux = -uv;
      uy = uh;
      uz = cross( ux, uz );
end
```

This rule also applies to the “return” function so that necessary code is not skipped. It is recommended that the “return” statement not be used.

</td></tr>
<tr><td>Rationale</td><td>□ Readability<br>□ Workflow<br>☑ Simulation<br>□ Verification and Validation<br>□ Code Generation</td></tr>
<tr><td>Last Change</td><td>V1.0</td></tr>
</table>

### 4.6.15 jh_0029: m-files

| | |
|---|---|
| **ID: Title** | **jh_0029: m-files** |
| Priority | Mandatory |
| Scope | ORION |
| MATLAB Version | All |
| MA Check | No |
| Prerequisites | None |
| Description | This standard is enforced automatically by the m-lint tool.<br>All eML files that are stored as separate m-files must be in a common directory. All eML files must have the %#eml declaration after the function declaration at the beginning of the code. |
| Rationale | ☑ Readability ☐ Verification and Validation<br>☑ Workflow ☑ Code Generation<br>☑ Simulation |
| Last Change | V1.2 |

### 4.6.16 jh_0030: Extrinsic function

| | |
|---|---|
| **ID: Title** | **jh_0030: Extrinsic function** |
| Priority | Mandatory |
| Scope | ORION |
| MATLAB Version | All |
| MA Check | No |
| Prerequisites | None |
| Description | This standard is enforced automatically by the m-lint tool.<br>Use of extrinsic functions is not allowed. |
| Rationale | ☐ Readability ☐ Verification and Validation<br>☐ Workflow ☑ Code Generation<br>☑ Simulation |
| Last Change | V1.1 |

### 4.6.17 ek_0002: Recursive functions

| | |
|---|---|
| **ID: Title** | **ek_0002: Recursive functions** |
| Priority | Mandatory |
| Scope | ORION |

| | |
|---|---|
| MATLAB Version | All |
| MA Check | No |
| Prerequisites | None |
| Description | The use of recursive function calls shall be avoided.<br><br>The SPD restricts the use of recursion:<br><br>**OCS Rule 109 (AV Rule 119)**<br>Functions **shall not** call themselves, either directly or indirectly (i.e. recursion **shall not** be allowed).<br>**Rationale**: Since stack space is not unlimited, stack overflows are possible.<br>**Exception**: Recursion will be permitted if it can be proven that adequate resources exist to support the maximum level of recursion possible. |
| Rationale | ☑ Readability<br>☐ Workflow<br>☑ Simulation<br>☐ Verification and Validation<br>☑ Code Generation |
| Last Change | V1.1 |

### 4.6.18 ek_0003: Global Variables

| **ID: Title** | **ek_0003: Global Variables** |
|---|---|
| Priority | Strongly recommended |
| Scope | ORION |
| MATLAB Version | All |
| MA Check | No |
| Prerequisites | None |
| Description | This standard is enforced automatically by the m-lint tool.<br><br>The use of global variables is not allowed. Variables created in an eML function are only accessible to that function. This rule also applies to subfunctions within eML blocks. For example, a subfunction within an eML block cannot see the variables used by the main eML function unless these variables are passed to the function with the function call.<br><br>Use persistent variables or unit delay blocks for maintaining values between function calls. See standard ek_0010. |
| Rationale | ☑ Readability<br>☐ Workflow<br>☑ Simulation<br>☐ Verification and Validation<br>☑ Code Generation |

| | |
|---|---|
| Last Change | V1.0 |

### 4.6.19 jh_0073: eML Header

| **ID: Title** | **jh_0073: eML Header** |
|---|---|
| Priority | Mandatory |
| Scope | ORION |
| MATLAB Version | All |
| MA Check | Yes |
| Prerequisites | None |
| Description | eML functions should have a header that contains the following information before the function declaration:<br>• Function name<br>• Description of function<br>• Assumptions and Limitations<br>• Developer Name, email, and phone number<br>• Description of changes from previous versions is applicable<br>• Lists of inputs and outputs<br>Example:<br>`%*******************************************************************`<br>`% FUNCTION NAME:`<br>`%    util_vec_unitize`<br>`%`<br>`% DESCRIPTION:`<br>`%   Normalizes/unitizes a vector of size 3`<br>`%`<br>`% INPUT:`<br>`%   double b - input 3 vector`<br>`%`<br>`% OUTPUT:`<br>`%  double y - normalized/unitized 3 vector`<br>`%`<br>`% ASSUMPTIONS AND LIMITATIONS:`<br>`%   None`<br>`%`<br>`% MODIFICATION HISTORY (INCLUDING INITIAL IMPLEMENTATION):`<br>`%   01/02/03 - Louis Breger (CSDL), email, phone #`<br>`%     * Initial implementation`<br>`%`<br>`%   02/06/03 - Chinwe Nyenke (CSDL), email, phone #`<br>`%     * Added protection for divide by zero` |
| Rationale | ☐ Readability ☑ Verification and Validation<br>☑ Workflow ☐ Code Generation<br>☐ Simulation |

| | |
|---|---|
| Last Change | V1.1 |

### 4.6.20 jh_0093: Parameter Bus for eML

| | |
|---|---|
| **ID: Title** | **jh_0093: Parameter Bus for eML** |
| Priority | Recommended |
| Scope | ORION |
| MATLAB Version | All |
| MA Check | No |
| Prerequisites | None |
| Description | For embedded Matlab blocks, the entire parameter bus should be input if used and the separate elements of the bus accessed within the code instead of passing each element used as a function argument. |
| Rationale | ☐ Readability<br>☐ Workflow<br>☐ Simulation<br>☐ Verification and Validation<br>☑ Code Generation |
| Last Change | V1.0 |

### 4.6.21 jh_0084: eML Comments

| | |
|---|---|
| **ID: Title** | **jh_0084: eML Comments** |
| Priority | Mandatory |
| Scope | ORION |
| MATLAB Version | All |
| MA Check | No |
| Prerequisites | None |
| Description | All eML functions should be properly commented to describe functionality. |
| Rationale | ☐ Readability<br>☐ Workflow<br>☐ Simulation<br>☑ Verification and Validation<br>☑ Code Generation |
| Last Change | V1.0 |

### 4.6.22 do_0001: Declaring Local Variables in eML

| | |
|---|---|
| **ID: Title** | **do_0001: Declaring Local Variables in eML** |
| Priority | Mandatory |
| Scope | ORION |

| | |
|---|---|
| MATLAB Version | All |
| MA Check | No |
| Prerequisites | None |
| Description | A local eML variable shall be explicitly type cast when it is intend to have a data type other than an inherited type or double. The properties (class, size and complexity) of a variable are inherited from the right side of an assignment when the variable is first assigned.  First assignments to a constant results in a data type of “double”<br><br>For example:<br>State = prevState; % State is set to the type of “prevState”<br>Num_Of_Samples = 0; % Num_Of_Samples is of type double<br>Buff_Size = uint32(6)  % Buff_Size is of type uint32<br><br>Local eML variables used as counters should be typed as an int or uint.  This will prevent the code from having logic comparisons to reals.<br><br>Local eML variables used as an array index should be typed to an int.  This will prevent the code from having extra (int32_t) type casts.<br><br>**Exceptions**:<br>The index variable of a for-loop does not require a type cast if the index variable is first assigned in the for-loop expression.  The index variable will default to a type int32. |
| Rationale | ☐ Readability<br>☐ Workflow<br>☐ Simulation<br>☐ Verification and Validation<br>☑ Code Generation |
| Last Change | V1.0 |

## *4.7 Code Development Standards*

### 4.7.1 hyl_0204: Standard units

| **ID: Title** | **hyl_0204: Standard units** |
|---|---|
| Priority | Mandatory |
| Scope | ORION |
| MATLAB Version | All |
| MA Check | No |
| Prerequisites | None |
| Description | The models shall output signals in English units unless otherwise required by external interfaces.<br>• Force, mass, and length units shall be LBF, SLUG, and FT (respectively) unless |

otherwise required by an external interface

- The units abbreviation shall follow the convention outlined in the table blelow.

| Abbreviation | Description |
|---|---|
| A | Amps |
| Bit | Bits |
| Byte | Bytes |
| BTU | British Thermal Units |
| C | Degrees Celsius |
| Character | Characters |
| CT | Counts |
| DEG | Degrees |
| F | Degrees Fahrenheit |
| **FT** | **Feet** |
| G | Gravitational Acceleration |
| GB | Gigabyte |
| HR | Hour |
| Hz | Hertz |
| IN | Inches |
| KBit | Kilobit |
| KByte | Kilobyte |
| KHz | Kilohertz |
| KV | Kilovolt |
| **LBF** | **Pounds Force** |
| LBM | Pounds Mass |
| MA | Milliampere |
| MB | Megabyte |
| Min | Minutes |
| MSec | Milliseconds |
| MV | Mill volts |
| **NA** | **Not Applicable** |
| ND | Non Dimensional |
| QTI | Quanta In |
| QTO | Quanta Out |
| R | Degrees Rankin |
| **Rad** | **Radians** |

| | |
|---|---|
| **Sec** | **Seconds** |
| **SLUG** | **Slugs** |
| TB | Terabyte |
| V | Volts |
| VAR | Variable Units |
| Words | Standard word size for a computing platform |

| | |
|---|---|
| Rationale | ☐ Readability ☑ Verification and Validation<br>☐ Workflow ☑ Code Generation<br>☑ Simulation |
| Last Change | V3.0 |

### 4.7.2 jr_0004: Error Handling

| **ID: Title** | **jr_0004: Error Handling** |
|---|---|
| Priority | Mandatory |
| Scope | ORION |
| MATLAB Version | All |
| MA Check | No |
| Prerequisites | None |
| Description | The developer **shall** add error handling in accordance with the “Error Handling and Logging Guidance” memo (Doc #: FltDyn-CEV-11-52).<br>Link on ICE:<br>https://ice.exploration.nasa.gov/confluence/pages/worddav/preview.action?fileName=ErrorHandlingGuidance.docx&pageId=106041166 |
| Rationale | ☐ Readability ☑ Verification and Validation<br>☐ Workflow ☑ Code Generation<br>☑ Simulation |
| Last Change | V1.0 |

## *4.8 Configuration Management*

### 4.8.1 jh_0004: MATLAB artifacts under configuration control

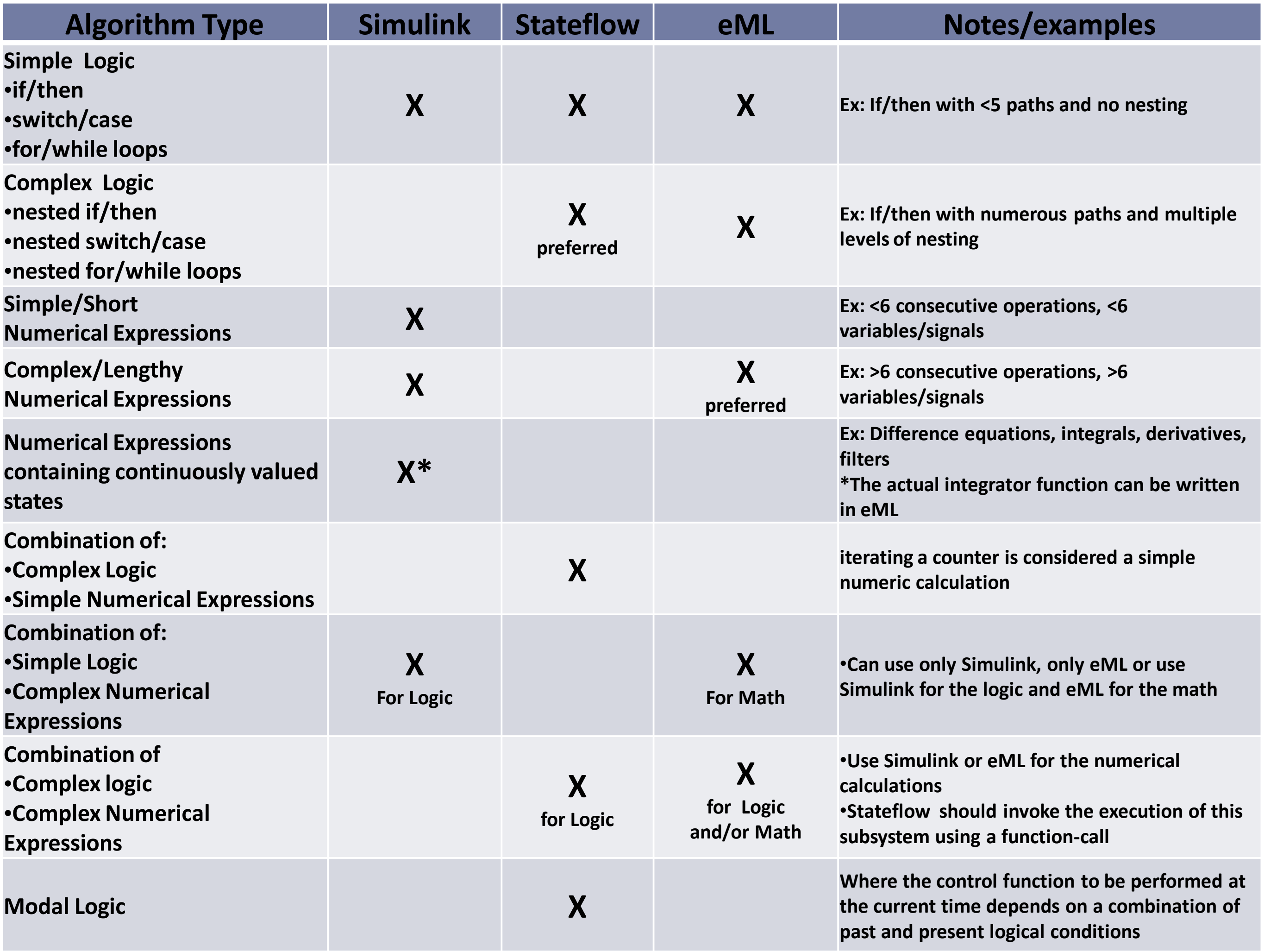
| **ID: Title** | **jh_0004: MATLAB artifacts under configuration control** |
|---|---|
| Priority | Mandatory |

| | |
|---|---|
| Scope | ORION |
| MATLAB Version | all |
| MA Check | No |
| Prerequisites | None |
| Description | If a Configuration Management tool is used the following files should be included for each project:<br>• *.mdl files<br>• *.m setup scripts<br>• *.h files used for buses and ARINC blocks<br>• Utility files and models needed for simulation (*.c, *.cpp, etc.)<br><br>Some Simulink generated files are specific to the environment in which the simulation is executed. This may cause issues when simulating the model in a different environment. These files are not needed for simulation and will be recreated once the model is run again. To avoid potential issued do not include the following files in a project:<br>• *.mex* files<br>• slprj directory<br>• sfprj directory<br>• *_rtw directory<br>• *.mat files created by running model<br>• Other files generated from running the model |
| Rationale | ☐ Readability<br>☑ Workflow<br>☐ Simulation<br>☐ Verification and Validation<br>☐ Code Generation |
| Last Change | V1.0 |

# 5 Appendix

## 5.1 *Modeling Guidelines Chart*

The following table shows a guideline for which tool to use for different types of algorithms



| Algorithm Type | Simulink | Stateflow | eML | Notes/examples |
|---|---|---|---|---|
| Simple Logic<br>•if/then<br>•switch/case<br>•for/while loops | X | X | X | Ex: If/then with <5 paths and no nesting |
| Complex Logic<br>•nested if/then<br>•nested switch/case<br>•nested for/while loops | | X<br>preferred | X | Ex: If/then with numerous paths and multiple levels of nesting |
| Simple/Short Numerical Expressions | X | | | Ex: <6 consecutive operations, <6 variables/signals |
| Complex/Lengthy Numerical Expressions | X | | X<br>preferred | Ex: >6 consecutive operations, >6 variables/signals |
| Numerical Expressions containing continuously valued states | X* | | | Ex: Difference equations, integrals, derivatives, filters<br>*The actual integrator function can be written in eML |
| Combination of:<br>•Complex Logic<br>•Simple Numerical Expressions | | X | | iterating a counter is considered a simple numeric calculation |
| Combination of:<br>•Simple Logic<br>•Complex Numerical Expressions | X<br>For Logic | | X<br>For Math | •Can use only Simulink, only eML or use Simulink for the logic and eML for the math |
| Combination of<br>•Complex logic<br>•Complex Numerical Expressions | | X<br>for Logic | X<br>for Logic and/or Math | •Use Simulink or eML for the numerical calculations<br>•Stateflow should invoke the execution of this subsystem using a function-call |
| Modal Logic | | X | | Where the control function to be performed at the current time depends on a combination of past and present logical conditions |

## 5.2 *Configuration Settings*

List of configuration settings

## 5.3 *Model Advisor Standards Checks Summary*

| ID: Title | Priority | Scope | MA Check |
|---|---|---|---|
| ar_0001: Filenames | Mandatory | MAAB | YES |

| | | | |
|---|---|---|---|
| ar_0002: Directory names | Mandatory | MAAB | YES |
| bn_0001: Subsystem Name Length Limit | Strongly recommended | ORION | YES |
| bn_0002: Signal name length limit | Strongly recommended | ORION | YES |
| bn_0003: Use of If-Then-Else Action Subsystem to Replace Multiple Switches | Strongly recommended | ORION | NO |
| db_0043: Simulink font and font size | Strongly recommended | MAAB | YES |
| db_0081: Unconnected signals, block inputs and block outputs | Mandatory | MAAB | YES |
| db_0097: Position of labels for signals and buses | Strongly recommended | MAAB | NO |
| db_0110: Tunable parameters in basic blocks | Strongly recommended | MAAB | YES |
| db_0112: Indexing | Strongly recommended | MAAB | YES |
| db_0114: Simulink patterns for If-then-else-if constructs | Strongly recommended | MAAB | NO |
| db_0115: Simulink patterns for case constructs | Strongly recommended | MAAB | NO |
| db_0116: Simulink patterns for logical constructs with logical blocks | Strongly recommended | MAAB | NO |
| db_0117: Simulink patterns for vector signals | Strongly recommended | MAAB | NO |
| db_0122: Stateflow and Simulink interface signals and parameters | Strongly recommended | MAAB | YES |
| db_0123: Stateflow port names | Strongly recommended | MAAB | YES |
| db_0125: Scope of internal signals and local auxiliary variables | Strongly recommended | MAAB | YES |
| db_0126: Scope of events | Mandatory | MAAB | YES |
| db_0127: MATLAB commands in Stateflow | Mandatory | MAAB | YES |
| db_0129: Stateflow transition appearance | Strongly recommended | MAAB | NO |
| db_0132: Transitions in Flowcharts | Strongly recommended | MAAB | YES |
| db_0133: Use of patterns for Flowcharts | Strongly recommended | MAAB | NO |
| db_0134: Flowchart patterns for If constructs | Strongly recommended | MAAB | NO |
| db_0135: Flowchart patterns for loop constructs | Recommended | MAAB | NO |
| db_0140: Display of basic block parameters | Recommended | MAAB | YES |
| db_0142: Position of block names | Strongly recommended | MAAB | YES |
| db_0144: Use of Subsystems | Strongly recommended | MAAB | NO |
| db_0146: Triggered, enabled, conditional Subsystems | Strongly recommended | MAAB | YES |
| db_0148: Flowchart patterns for conditions | Strongly recommended | MAAB | NO |
| db_0149: Flowchart patterns for condition actions | Strongly recommended | MAAB | NO |
| db_0150: State machine patterns for conditions | Strongly recommended | MAAB | NO |
| db_0151: State machine patterns for transition actions | Strongly recommended | MAAB | YES |
| db_0159: Flowchart patterns for case constructs | Strongly recommended | MAAB | NO |
| dm_0001: Signal and Bus Element Naming Convention | Strongly recommended | ORION | YES |
| ek_0002:  Recursive functions | Mandatory | ORION | YES |
| ek_0003:  Global Variables | Strongly recommended | ORION | m-lint |
| ek_0010:  Matlab/Simulink algorithm States recommendations | Strongly recommended | ORION | NO |
| hyl_0103: Model color coding | Strongly recommended | ORION | YES |
| hyl_0110: Branching line format | Strongly recommended | ORION | NO |
| hyl_0112: Title on each page | Strongly recommended | ORION | YES |
| hyl_0113: Notes on each page | Strongly recommended | ORION | YES |
| hyl_0114: Documentation of deviations to standards | Strongly recommended | ORION | NO |
| hyl_0201: Use of standard library blocks only | Mandatory | ORION | YES |
| hyl_0202: Use of revision/trace block | Strongly recommended | ORION | YES |
| hyl_0203: Model publishing | Recommended | ORION | NO |
| hyl_0204: Standard units | Mandatory | ORION | NO |
| hyl_0206: Only boolean inputs to encoder blocks | Strongly recommended | ORION | NO |
| hyl_0207: Limiting input to multiport switches | Mandatory | ORION | NO |
| hyl_0208: Prevention of divide-by-zero | Mandatory | ORION | NO |
| hyl_0209: Prevention of negative square root | Mandatory | ORION | NO |
| hyl_0211: Prohibit use of test points | Recommended | ORION | YES |

| | | | |
|---|---|---|---|
| hyl_0301: Block naming convention | Strongly recommended | ORION | YES |
| hyl_0302: Usable characters for block names | Strongly recommended | ORION | YES |
| hyl_0305: Block name uniqueness | Strongly recommended | ORION | YES |
| hyl_0307: Use of subsystem name | Strongly recommended | ORION | YES |
| hyl_0308: Use of reference model name | Strongly recommended | ORION | YES |
| hyl_0309: Block name usage | Recommended | ORION | NO |
| hyl_0311: Naming of signals passed through multiple subsystems | Strongly recommended | ORION | YES |
| im_0001: Guidelines for mixed use of Simulink and eML | Strongly recommended | ORION | NO |
| im_0003: Controller model | Mandatory | ORION | NO |
| im_0004: Top layer / root level | Mandatory | ORION | NO |
| im_0005: Trigger layer | Mandatory | ORION | NO |
| im_0006: Structure layer | Mandatory | ORION | NO |
| im_0007: Data flow layer | Mandatory | ORION | NO |
| im_0008:  Source lines of eML | Mandatory | ORION | YES |
| im_0009:  Number of called function levels | Mandatory | ORION | NO |
| im_0010:  Number of inline function calls | Mandatory | ORION | YES |
| im_0015: ORION GN&C Model Architecture | Mandatory | ORION | NO |
| jc_0061: Display of block names | Recommended | MAAB | YES |
| jc_0081: Icon display for Port block | Recommended | MAAB | YES |
| jc_0121: Use of the Sum block | Recommended | MAAB | YES |
| jc_0131: Use of Relational Operator block | Recommended | J-MAAB | YES |
| jc_0141: Use of the Switch block | Strongly recommended | MAAB | YES |
| jc_0171: Maintaining signal flow when using Goto and From blocks | Strongly recommended | MAAB | NO |
| jc_0201: Usable characters for Subsystem names | Strongly recommended | MAAB | YES |
| jc_0211: Usable characters for Inport block and Outport block | Strongly recommended | MAAB | YES |
| jc_0221: Usable characters for signal line names | Strongly recommended | MAAB | YES |
| jc_0281: Naming of Trigger Port block and Enable Port block | Strongly recommended | J-MAAB | YES |
| jc_0351: Methods of initialization | Recommended | MAAB | NO |
| jc_0451: Use of unary minus on unsigned integers in Stateflow | Recommended | MAAB | YES |
| jc_0481: Use of hard equality comparisons for floating point numbers in Stateflow | Recommended | MAAB | YES |
| jc_0491: Reuse of variables within a single Stateflow scope | Recommended | MAAB | NO |
| jc_0511: Setting the return value from a graphical function | Mandatory | J-MAAB | YES |
| jc_0521: Use of the return value from graphical functions | Recommended | J-MAAB | YES |
| jc_0531: Placement of the default transition | Recommended | J-MAAB | YES |
| jc_0541: Use of tunable parameters in Stateflow | Strongly recommended | MAAB | YES |
| jh_0001:  Use of ARINC blocks for partition to partition data flow | Mandatory | ORION | NO |
| jh_0004:  MATLAB artifacts under configuration control | Mandatory | ORION | NO |
| jh_0005:  Setup files for model parameter initialization | Strongly recommended | ORION | NO |
| jh_0006:  Setup files for bus initialization | Strongly recommended | ORION | NO |
| jh_0007:  blocks in a model | Recommended | ORION | YES |
| jh_0011:  Model release | Mandatory | ORION | NO |
| jh_0018: Variable type casting | Recommended | ORION | YES |
| jh_0021:  Restricted Variable Names | Mandatory | ORION | YES |
| jh_0023:  Arrays | Mandatory | ORION | m-lint |
| jh_0024:  Strings | Strongly recommended | ORION | YES |
| jh_0025:  Structures | Mandatory | ORION | m-lint |
| jh_0026:  Switch/case statements | Mandatory | ORION | m-lint |
| jh_0027:  Multiple Code Paths | Mandatory | ORION | m-lint |
| jh_0029:  m-files | Mandatory | ORION | m-lint |
| jh_0030:  Extrinsic function | Strongly recommended | ORION | m-lint |

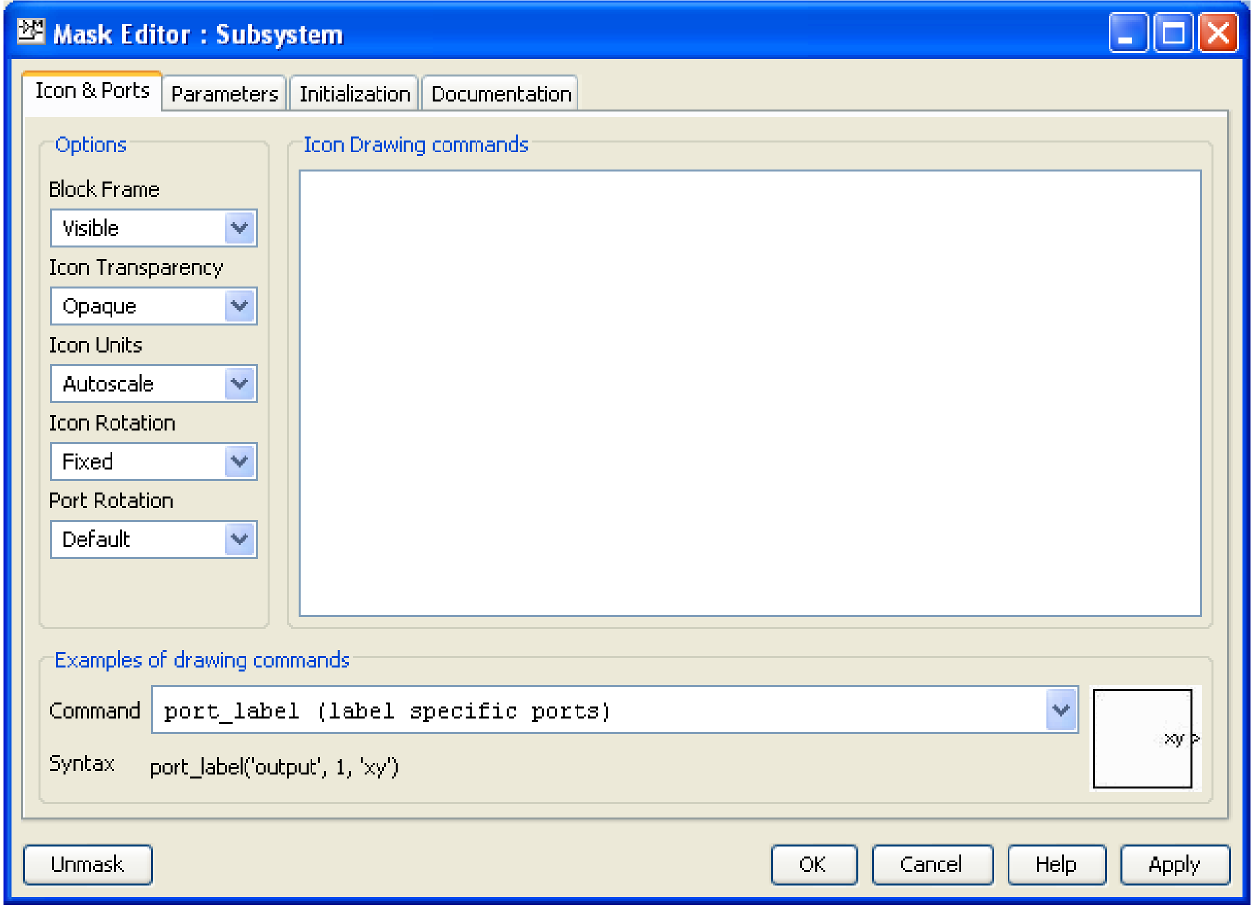
| | | | |
|---|---|---|---|
| jh_0040: Usable characters for Simulink Bus Names | Strongly recommended | MAAB | YES<br>(jc_0221) |
| jh_0041: Simulink Bus name length limit | Strongly recommended | ORION | YES<br>(bn_0002) |
| jh_0042: Required Software | Mandatory | ORION | NO |
| jh_0043: Approved Platforms | Mandatory | ORION | NO |
| jh_0049: Use of Model References or Reusable Subsystems | Strongly recommended | ORION | YES |
| jh_0051: Simulink Bus Format | Strongly recommended | ORION | YES |
| jh_0055: Use of Masks | Mandatory | ORION | YES |
| jh_0056: Sample Times | Mandatory | ORION | YES |
| jh_0061: Use of Parameters | Mandatory | ORION | NO |
| jh_0062: Constant Block Naming | Strongly Recommended | ORION | YES |
| jh_0063: eML block input/output settings | Recommended | ORION | YES |
| jh_0064: eML if statement | Mandatory | ORION | NO |
| jh_0070: Model Configuration Settings | Mandatory | ORION | YES |
| jh_0073: eML Header | Mandatory | ORION | YES |
| jh_0079: Model and Matlab Filenames | Mandatory | ORION | NO |
| jh_0084: eML Comments | Mandatory | ORION | YES |
| jh_0093: Parameter Bus for eML | Recommended | ORION | NO |
| jh_0109: Merge Blocks | Strongly Recommended | ORION | NO |
| jh_0101: Use of Right-Handed Quaternions Only | Mandatory | ORION | NO |
| jh_0110: eML Function Reuse | Mandatory | ORION | NO |
| jh_0111: Bus Ordering and Alignment | Mandatory | ORION | NO |
| jh_0117: Shared CSUs Across Domains | Mandatory | ORION | NO |
| jm_0002: Block resizing | Mandatory | MAAB | NO |
| jm_0010: Port block names in Simulink models | Strongly recommended | MAAB | YES |
| jm_0011: Pointers in Stateflow | Strongly recommended | MAAB | YES |
| jm_0012: Event broadcasts | Strongly recommended | MAAB | YES |
| jr_0002: Number of nested if/for statement blocks | Strongly recommended | ORION | YES |
| mdb_0032: Simulink signal appearance | Strongly recommended | ORION | NO |
| mdb_0042: Port block in Simulink models | Strongly recommended | ORION | YES |
| mdb_0141: Signal flow in Simulink models | Strongly recommended | ORION | NO |
| mdb_0143: Similar block types on the model levels | Recommended | ORION | YES |
| mj_0001: CSU input Bus Naming | Recommended | ORION | NO |
| mj_0002: Junction Box Composition | Mandatory | ORION | NO |
| mjc_0111: Direction of Subsystem | Strongly recommended | ORION | YES |
| mjc_0501: Format of entries in a State block | Recommended | ORION | YES |
| na_0001: Bitwise Stateflow operators | Strongly recommended | MAAB | YES |
| na_0002: Appropriate implementation of fundamental logical and numerical operations | Mandatory | MAAB | NO |
| na_0003: Simple logical expressions in If Condition block | Mandatory | MAAB | YES |
| na_0004 Simulink model appearance | Recommended | MAAB | YES |
| na_0005: Port block name visibility in Simulink models | Strongly recommended | MAAB | YES |
| na_0006: Guidelines for mixed use of Simulink and Stateflow | Strongly recommended | MAAB | NO |
| na_0007: Guidelines for use of Flow Charts, Truth Tables and State Machines | Strongly recommended | MAAB | NO |
| na_0008: Display of labels on signals | Recommended | MAAB | YES |
| na_0009: Entry versus propagation of signal labels | Strongly recommended | MAAB | YES |
| na_0010: Grouping data flows into signals | Strongly recommended | MAAB | YES |
| na_0011: Scope of Goto and From blocks | Strongly recommended | MAAB | YES |
| na_0012: Use of Switch vs. If-Then-Else Action Subsystem | Strongly recommended | MAAB | NO |
| na_0013: Comparison operation in Stateflow | Recommended | MAAB | NO |

## *5.4 Subsystem Masking Methods and Guidelines*

The following document outlines methods and guidelines of masking a subsystem block with its representative equation and provides examples for getting started. It also briefly summarizes the masking requirements as defined by the Orion Modeling Standards document.

**Masking a Subsystem:**

To mask a subsystem block, right click the block and select “Mask Subsystem” from the menu. The following dialog appears:



Block Frame: Visible

Icon Transparency: Opaque

Icon Units: Autoscale

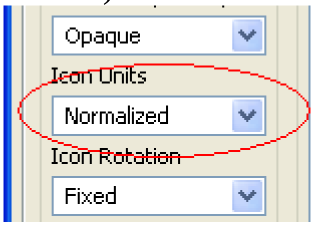
Icon Rotation: Fixed

Port Rotation: Default

Command: `port_label (label specific ports)`

Syntax: `port_label('output', 1, 'xy')`

- The following Option should be set:
  - **Icon Units** = “Normalized” (scales text positions as normalized values when the block is resized)



Opaque

Icon Units: Normalized

Icon Rotation: Fixed

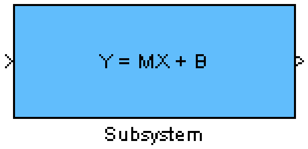
- As per the modeling standards, mask dialogs and therefore mask parameters (on the “Parameter” tab) are not allowed. Only change settings on the “Icon & Ports” tab

- All further mask settings are made by calling functions from within the “Icon Drawing Commands” pane.
- To make changes to a mask after the dialog is closed, right click the block and select “Edit Mask” from the menu.

**Displaying text:**
Use Matlab’s **disp()** function to center a single line of text on the mask.

- Example:

```
disp('Y = MX + B','texmode','on')
```

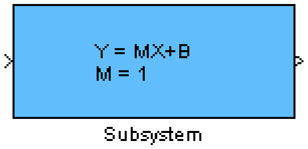


- Use “disp” function for masks whose equation occupies a single line. “disp” automatically centers its text string on the subsystem.
- “disp” does not permit multiple lines to be displayed. To display multiple lines, use **text()**

Use Matlab’s **text()** function to display multiple lines of text on the mask.

- Example:

```
text(.3,.6,'Y = MX+B','texmode','on')
text(.3,.4,'M = 1','texmode','on')
```



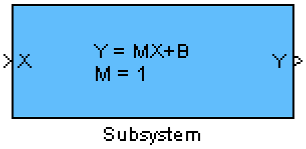
- The “text” function requires x & y positions as the first two arguments. To display multiple lines, call text() once for each line, giving each call different position coordinates.
- Set “Icon Units” equal to “Normalized” in the left hand Options pane of the mask editor in order to make the position values scale as normalized values when the block is resized.

**Labeling a Port:**

Once a block is masked, the underlying port names will no longer be displayed on the subsystem. To enhance readability and understandability, the inputs and the outputs of the subsystem model should be labeled to match variables in its function. Matlab’s **port_label()** function permits this.

Note: The port label function permits the use of TeX commands to label a port with a symbol. If you choose not to label the port with its representative symbol, then it is suggested to label the port with the same name as the underlying inport/outport for consistency.

- Extend the previous example by adding the following lines:
  - `port_label('input',1,'X','texmode','on')`
  - `port_label('output',1,'Y','texmode','on')`



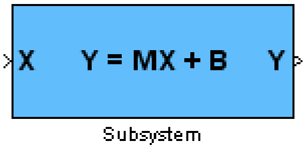
### Using TeX commands:

The previous examples set the “texmode” parameter to “on”; however, they did not make use of TeX commands within the text string. From the Matlab Help documentation:

> “When the text `Interpreter` property is `Tex` (the default), you can use a subset of TeX commands embedded in the string to produce special characters such as Greek letters and mathematical symbols.” 2

The following example shows how to set the mask’s text and port labels to **bold** and 14 point font using TeX commands:

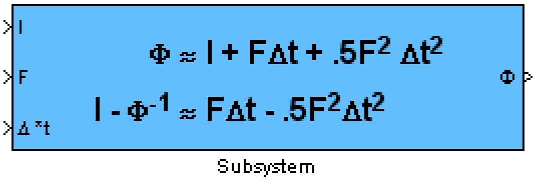
```
port_label('input',1,'\bf\fontsize{14}X','texmode','on')
port_label('output',1,'\bf\fontsize{14}Y','texmode','on')

disp('\bf\fontsize{14}Y = MX + B','texmode','on')
```



Note:

- The ‘\’ character indicates an embedded TeX command to Matlab’s TeX interpreter
- All mask disp() and text() strings should be **boldface** and 14 point font for readability.
- There are many more TeX commands supported by Matlab’s TeX interpreter, search the help file for “TeX Character Sequence Table” for a table of supported commands, or see the Appendix in this document.

### Advanced TeX Example:


I
F
Δ *t
$\Phi \approx I + F\Delta t + .5F^2\ \Delta t^2$
$I - \Phi^{-1} \approx F\Delta t - .5F^2\Delta t^2$
Φ
Subsystem

```
port_label('input',1,'I','texmode','on')
port_label('input',2,'F','texmode','on')
port_label('input',3,'\Delta *t','texmode','on')
port_label('output',1,'\Phi','texmode','on')
text(.26,.7,'\bf \fontsize{14}\Phi \approx I + F\Deltat + .5F^2
\Deltat^2','texmode','on')
text(.15,.3,'\bf \fontsize{14}I - \Phi^{-1} \approx F\Deltat -
.5F^2\Deltat^2','texmode','on')
```

Note – The Matlab TeX interpreter does not recognize TeX numerator/denominator commands for representing fractions.

**Reference:**

1 - Summary of Requirements

- Mask dialogs are not allowed, therefore creating mask parameters is not allowed (because they automatically create mask dialogs)
- Port Labeling commands are to be grouped together ahead of Disp() or Text() commands in the Icon Drawing Commands pane
- All mask disp() and text() strings are to be **bold** and 14 point font; port labels can be left at their default settings
- All ports are to be labeled with their representative symbol or underlying port name
- Set option **Icon Units** = "Normalized"

2 - MathWorks – Matlab TeX Character Sequence Table
http://www.mathworks.com/help/techdoc/ref/text_props.html#String

| Character Sequence | Symbol | Character Sequence | Symbol | Character Sequence | Symbol |
|---|---|---|---|---|---|
| \alpha | α | \upsilon | υ | \sim | ~ |
| \angle | ∠ | \phi | Φ | \leq | ≤ |
| \ast | * | \chi | χ | \infty | ∞ |
| \beta | β | \psi | ψ | \clubsuit | ♣ |

| Character Sequence | Symbol | Character Sequence | Symbol | Character Sequence | Symbol |
|---|---|---|---|---|---|
| \gamma | γ | \omega | ω | \diamondsuit | ♦ |
| \delta | δ | \Gamma | Γ | \heartsuit | ♥ |
| \epsilon | ε | \Delta | Δ | \spadesuit | ♠ |
| \zeta | ζ | \Theta | Θ | \leftrightarrow | ↔ |
| \eta | η | \Lambda | Λ | \leftarrow | ← |
| \theta | θ | \Xi | Ξ | \Leftarrow | ⇐ |
| \vartheta | ϑ | \Pi | Π | \uparrow | ↑ |
| \iota | ι | \Sigma | Σ | \rightarrow | → |
| \kappa | κ | \Upsilon | ϒ | \Rightarrow | ⇒ |
| \lambda | λ | \Phi | Φ | \downarrow | ↓ |
| \mu | μ | \Psi | Ψ | \circ | ∘ |
| \nu | ν | \Omega | Ω | \pm | ± |
| \xi | ξ | \forall | ∀ | \geq | ≥ |
| \pi | π | \exists | ∃ | \propto | ∝ |
| \rho | ρ | \ni | ∍ | \partial | ∂ |
| \sigma | σ | \cong | ≅ | \bullet | • |
| \varsigma | ς | \approx | ≈ | \div | ÷ |
| \tau | τ | \Re | ℜ | \neq | ≠ |
| \equiv | ≡ | \oplus | ⊕ | \aleph | ℵ |

| Character Sequence | Symbol | Character Sequence | Symbol | Character Sequence | Symbol |
|---|---|---|---|---|---|
| \Im | ℑ | \cup | ∪ | \wp | ℘ |
| \otimes | ⊗ | \subseteq | ⊆ | \oslash | Ø |
| \cap | ∩ | \in | ∈ | \supseteq | ⊇ |
| \supset | ⊃ | \lceil | ⌈ | \subset | ⊂ |
| \int | ∫ | \cdot | · | \o | o |
| \rfloor | ⌋ | \neg | ¬ | \nabla | ∇ |
| \lfloor | ⌊ | \times | x | \ldots | … |
| \perp | ⊥ | \surd | √ | \prime | ′ |
| \wedge | ∧ | \varpi | ϖ | \0 | Ø |
| \rceil | ⌉ | \rangle | 〉 | \mid | \| |
| \vee | ∨ |  |  | \copyright | © |
| \langle | 〈 |  |  |  |  |