Using the Benefits of Model-Based Design to Develop AUTOSAR Basic Software Modules

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Agenda

1. Why use MBD for Developing AUTOSAR BSW Modules?
2. CAN State Manager (CanSM)
3. Challenges Encountered in Developing CanSM using MBD
4. Results of Our Experiment

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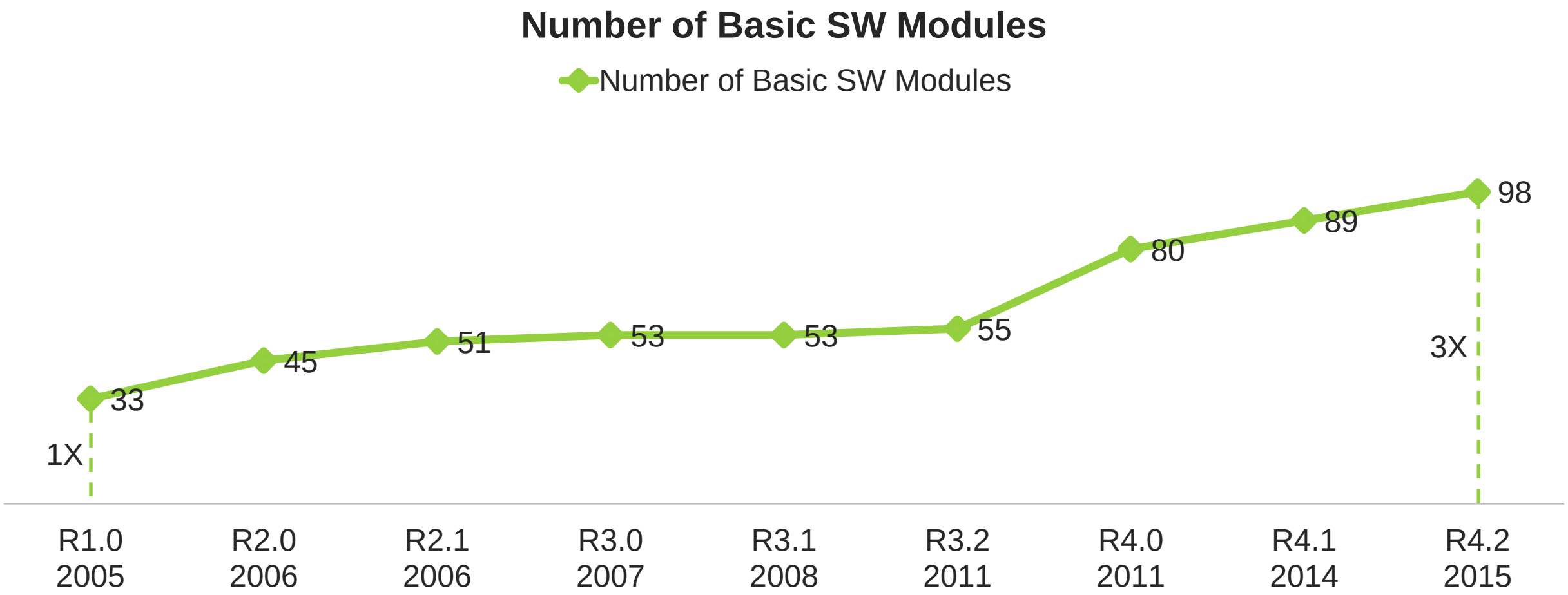
AUTOSAR Embraces Complexity



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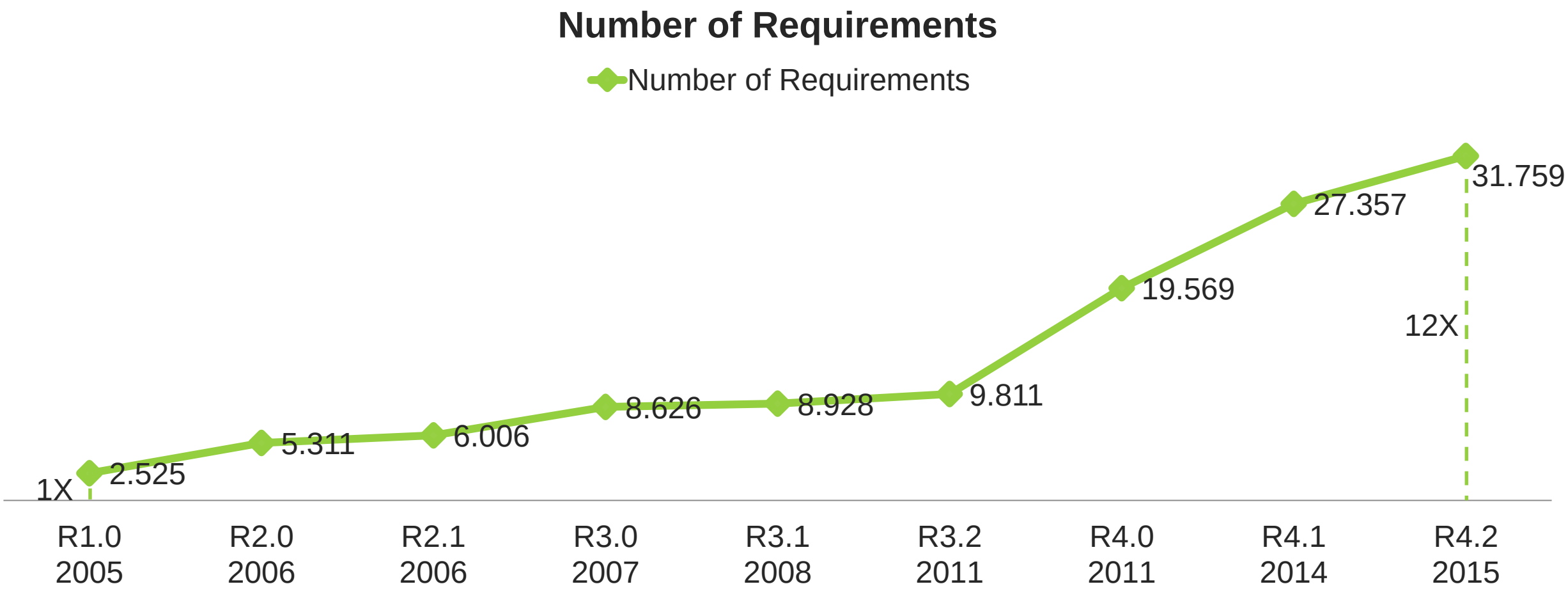
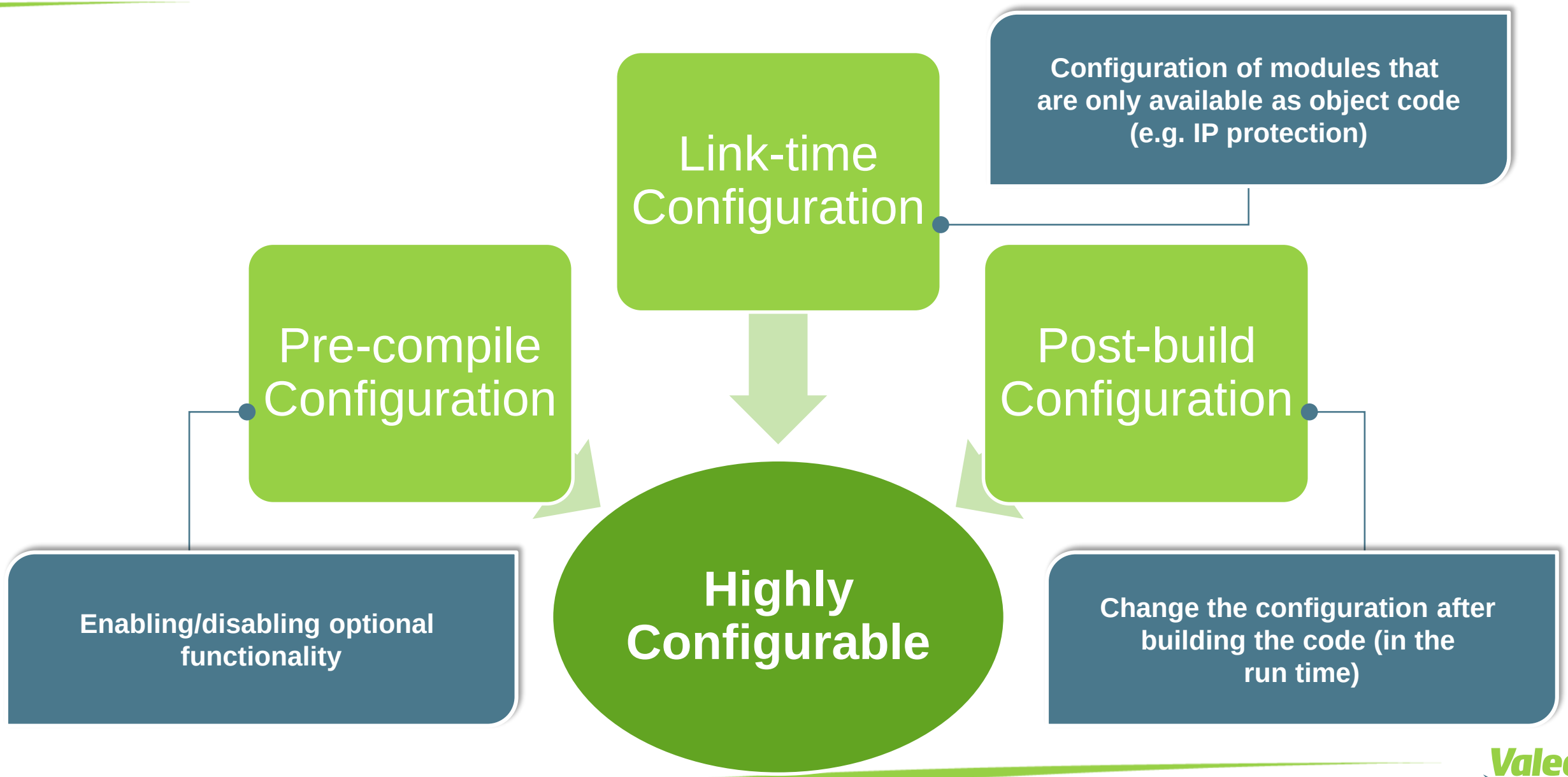
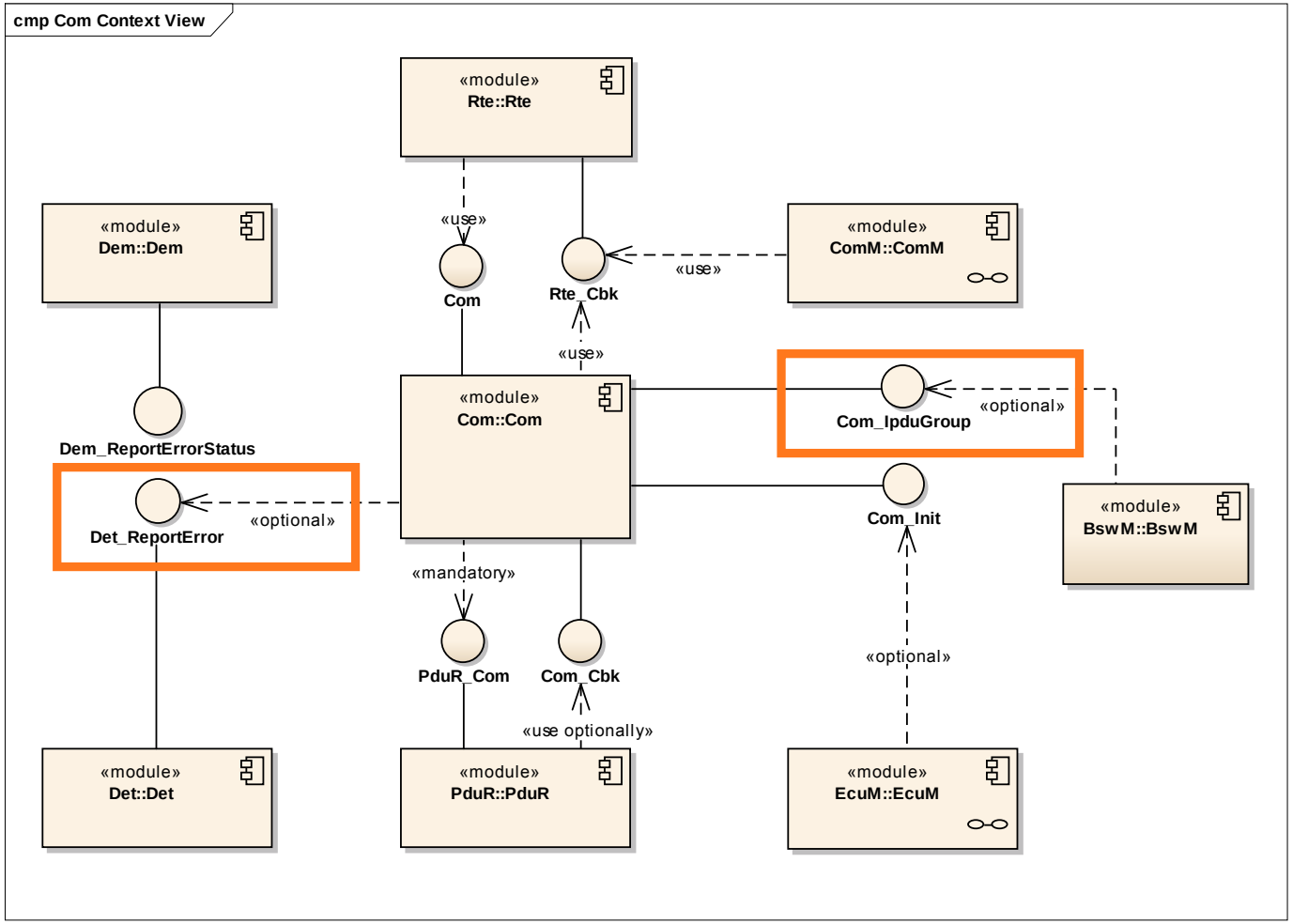


Characteristics of AUTOSAR Basic Software Modules



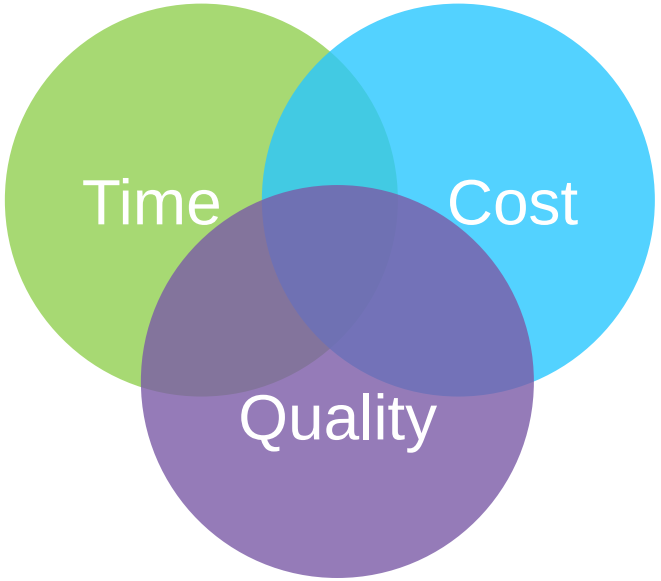
Characteristics of AUTOSAR Basic Software Modules

- Standard Interfaces and Standard Types



Motivations for using MBD for Developing AUTOSAR BSW Modules

- In our case MBD is selected to provide the following benefits:
  - Shorter development time
  - Better re-usability and maintainability of design / model.
  - Improvement of the product quality



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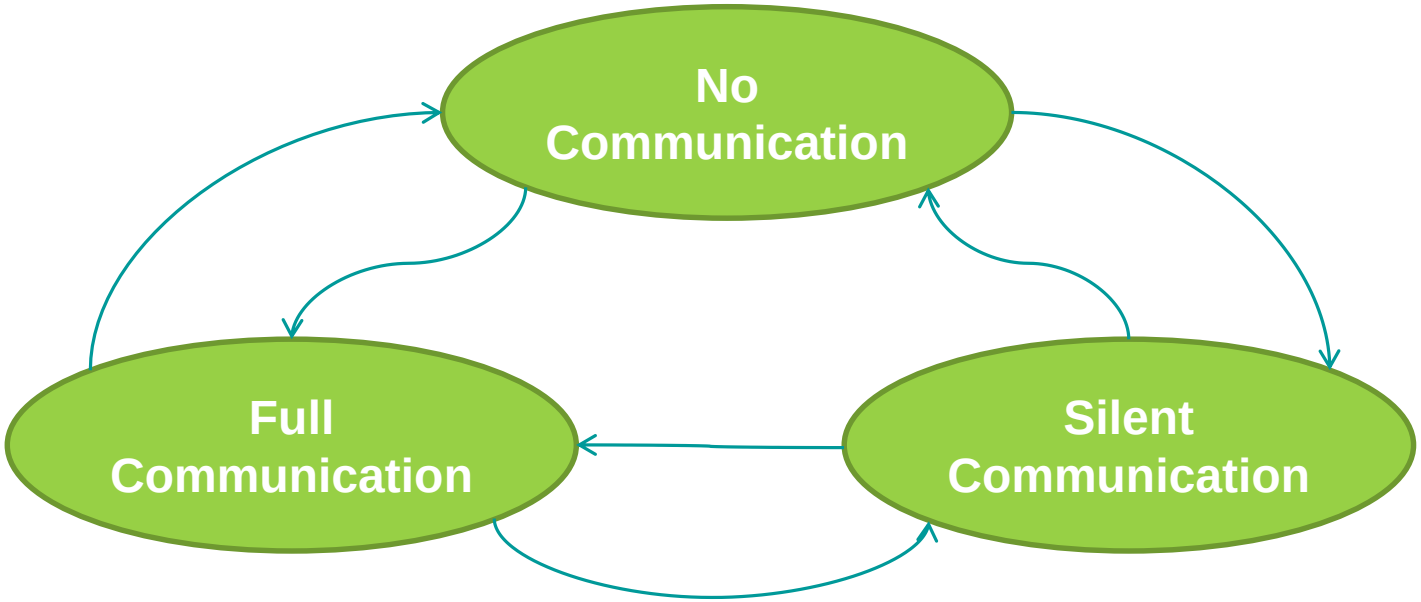
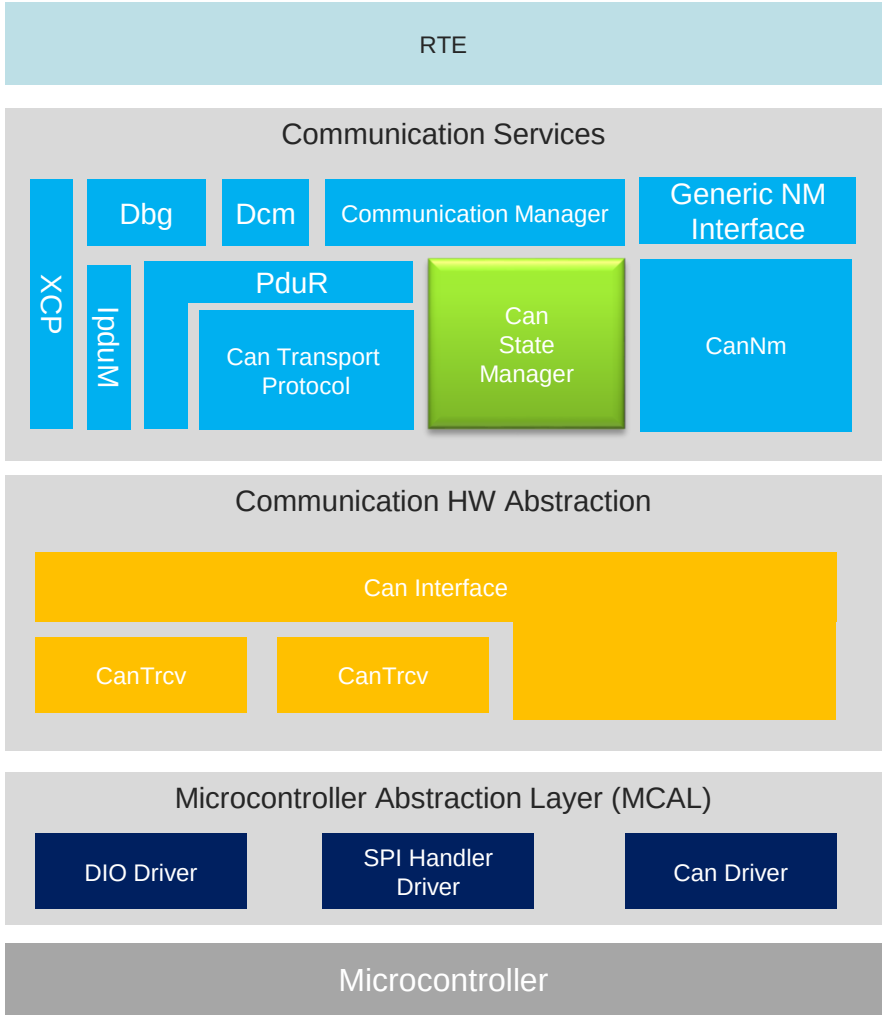
CAN State Manager

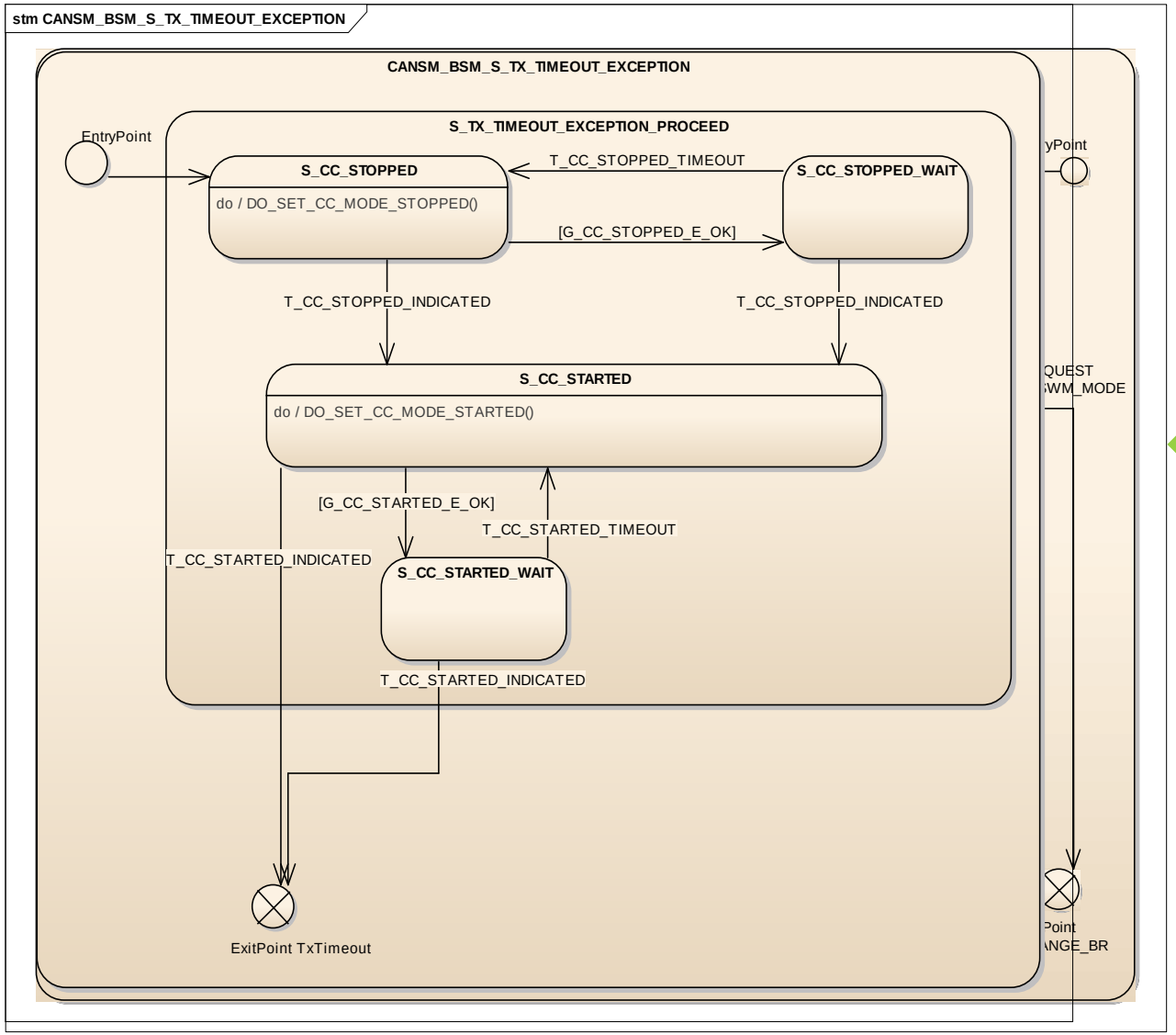
- One of the basic software communication stack modules.
- Responsible for managing the states of the Can networks.

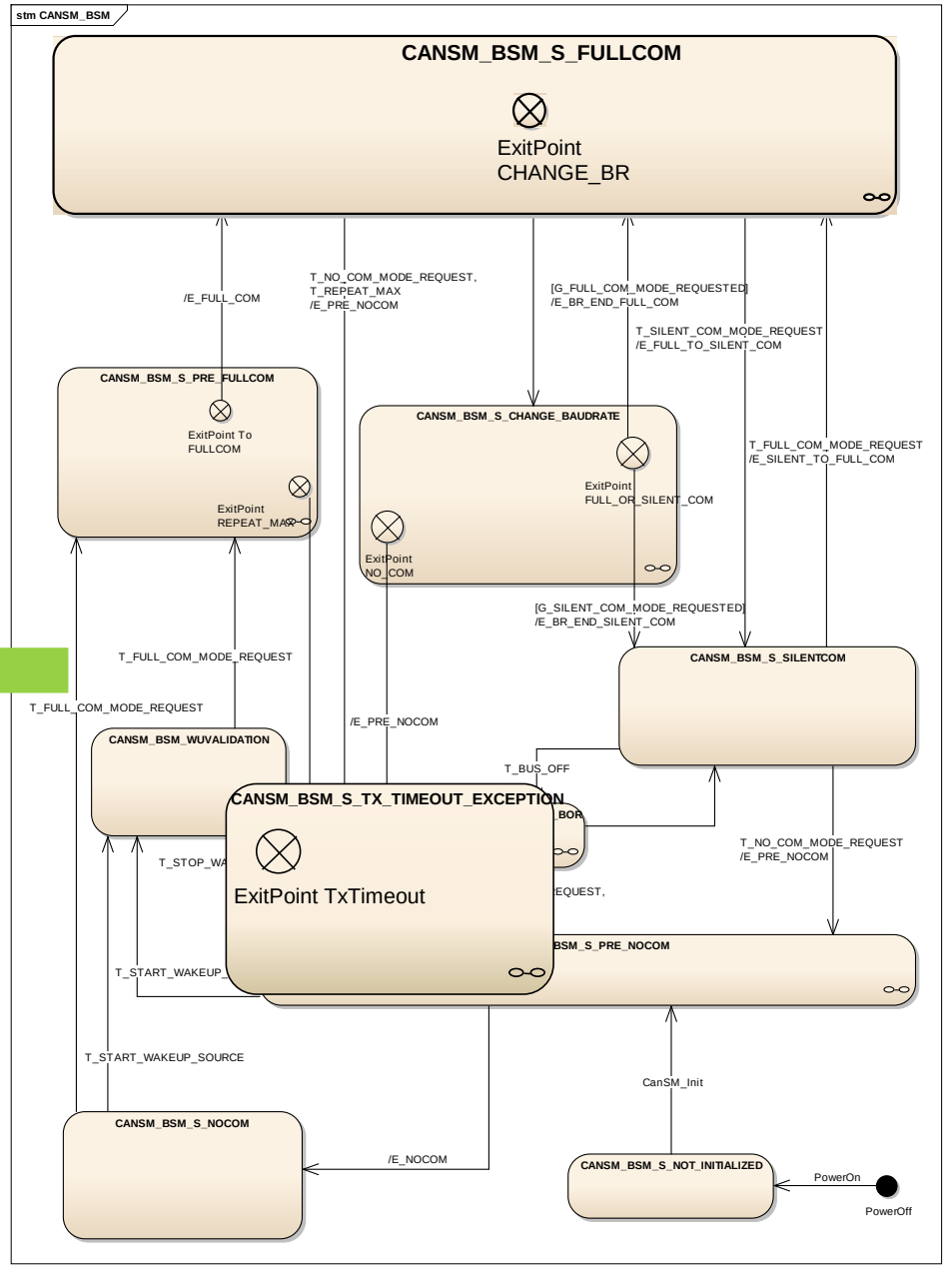




CAN State Manager

State Machine Complexity





CAN State Manager

Module Complexity

- 280 requirements.
- 26 Configuration parameters.
- 18 Provided Interfaces.

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Valeo

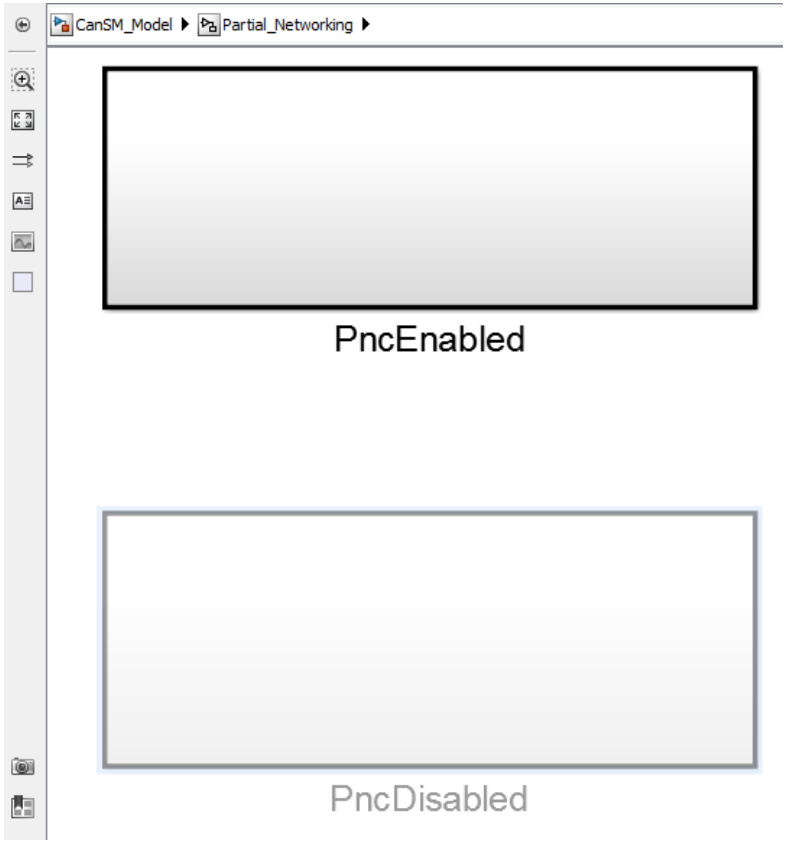
Pre-compile Configuration

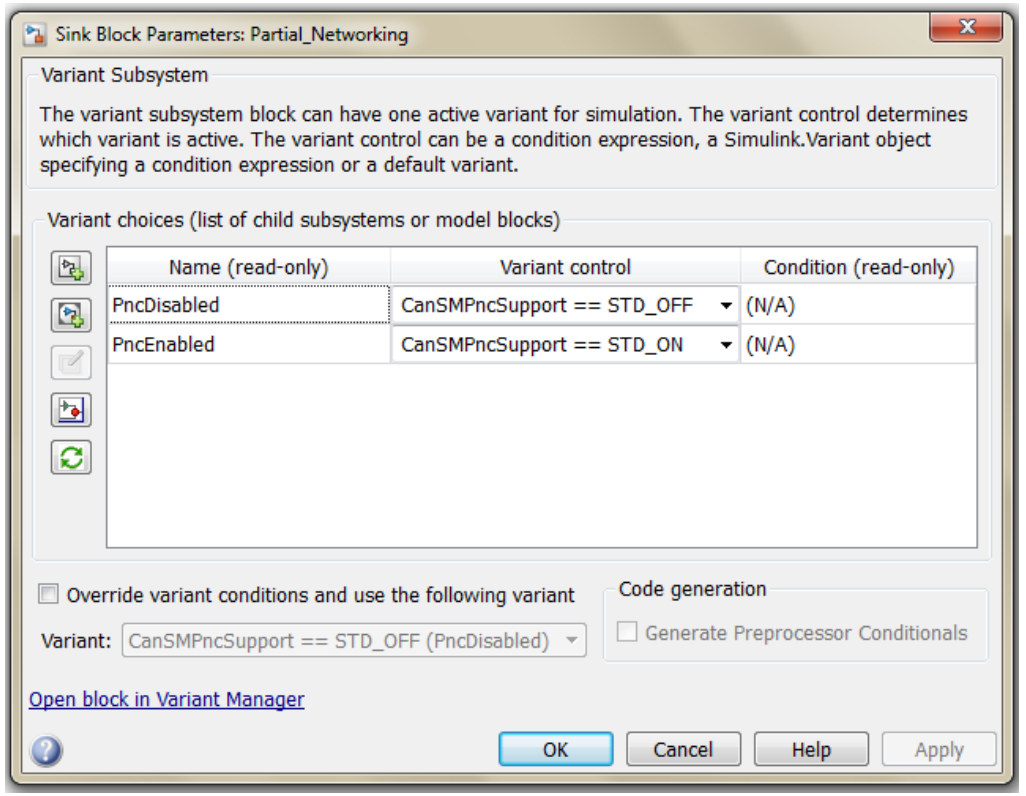
SWS_BSW_00029: If the BSW Module contains optional functionality, then this functionality shall be enabled (STD_ON) or disabled (STD_OFF) by a Pre-compile time configuration parameter.

```
652         if (CanSM_au8eNetRept[u8NetId] >
653             CanSM_pkstreGlobalConfig->ku8ModeReqRepMax)
654         {
655
656 #if CanSMDevErrorDetect == STD_ON
657
658           Det_ReportError(CANSM_MODULE_ID, CanSM_u8INSTANCE_ID,
659                           CanSM_u8MAIN_FUNCTION_ID, CANSM_E_MODE_REQUEST_TIMEOU
660
661 #endif
662
663           CanSM_au8eCurInd[u8NetId] = (uint8_T)CanSM_u8NET_REPT;
664           CanSM_au8eNetRept[u8NetId] = 0U;
665         }
```

Pre-compile Configuration

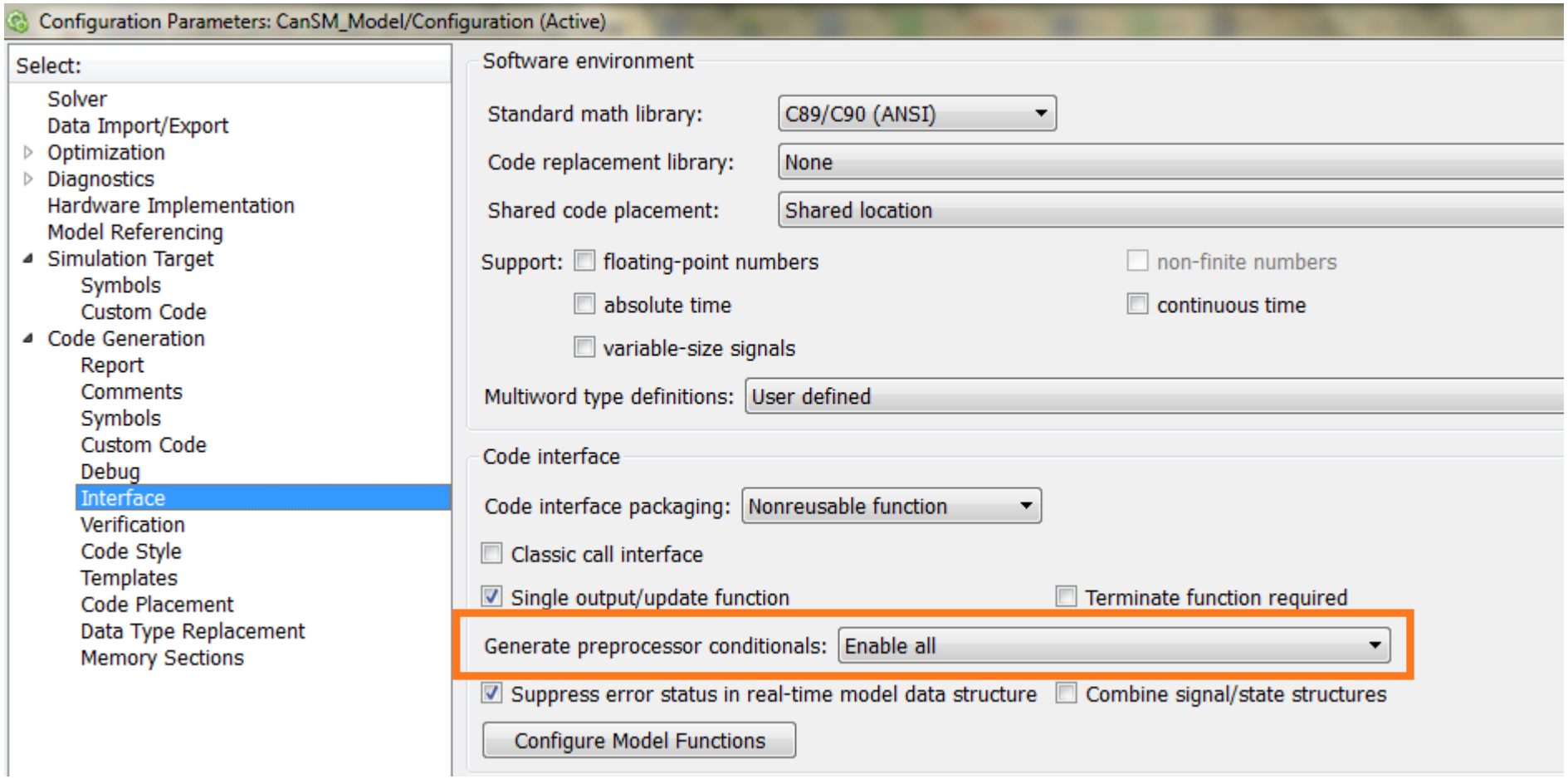
- Using “Variant Subsystem” to generate pre-compile configuration





Pre-compile Configuration

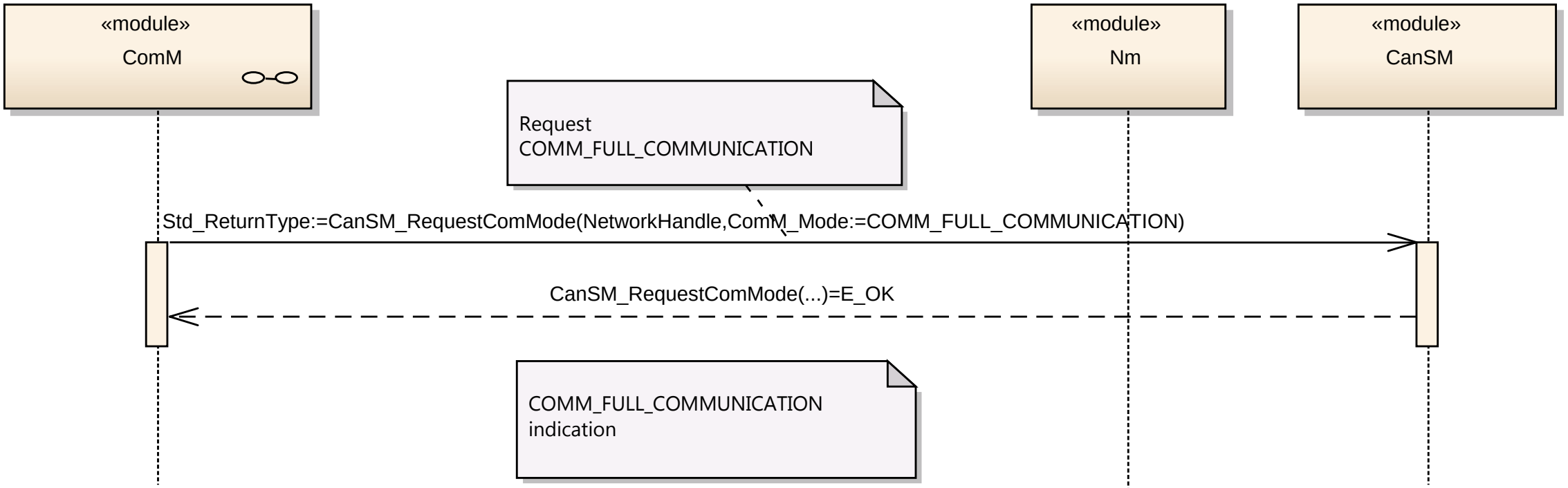
- Generate preprocessor conditional for with variant model blocks.



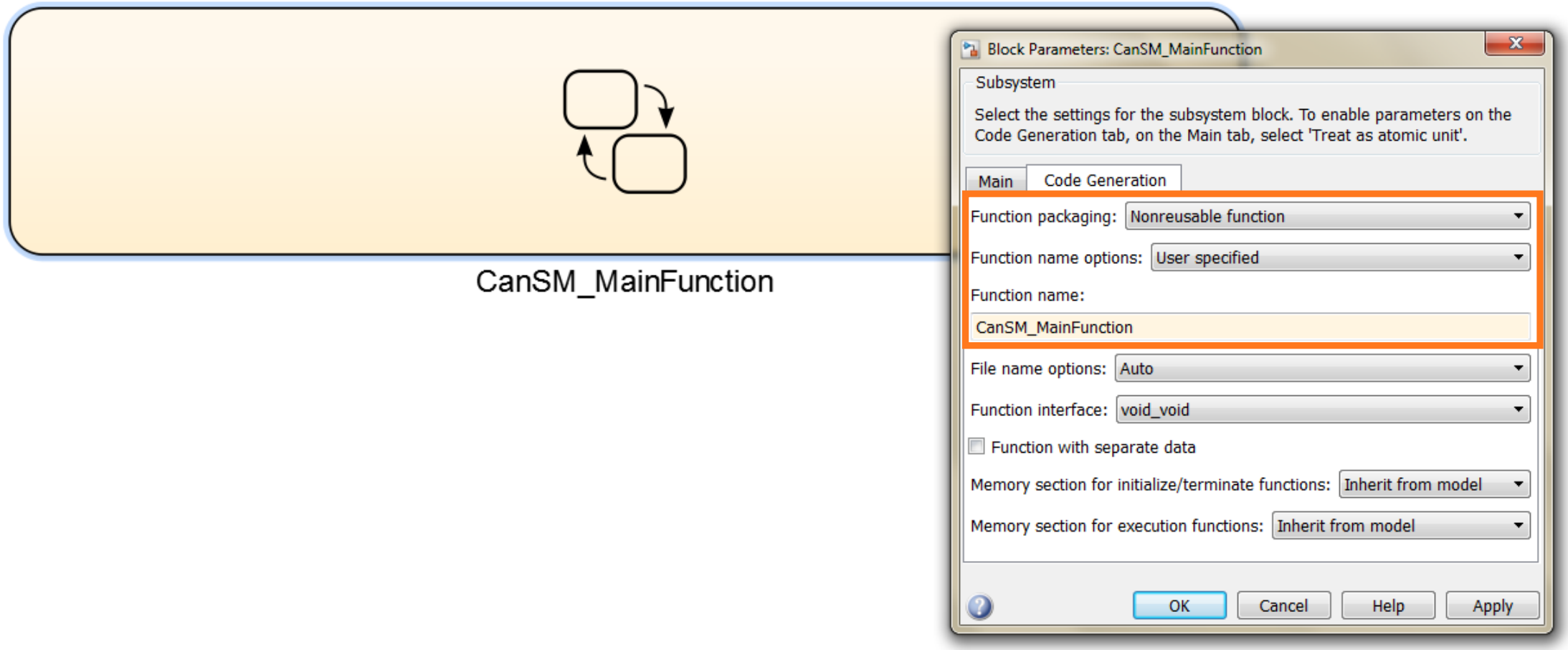
Standard Interfaces

SRS_Can_01142 : The CAN State Manager shall offer a network abstract API to upper layer

Example scenario: "Network status change upon Communication Manager module (ComM) request"

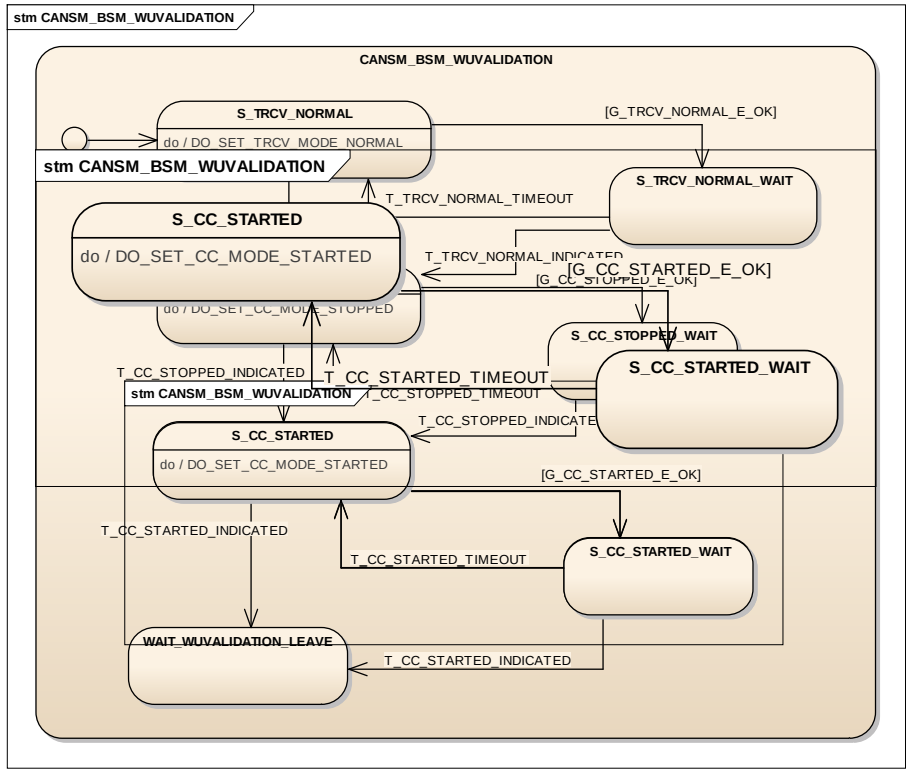


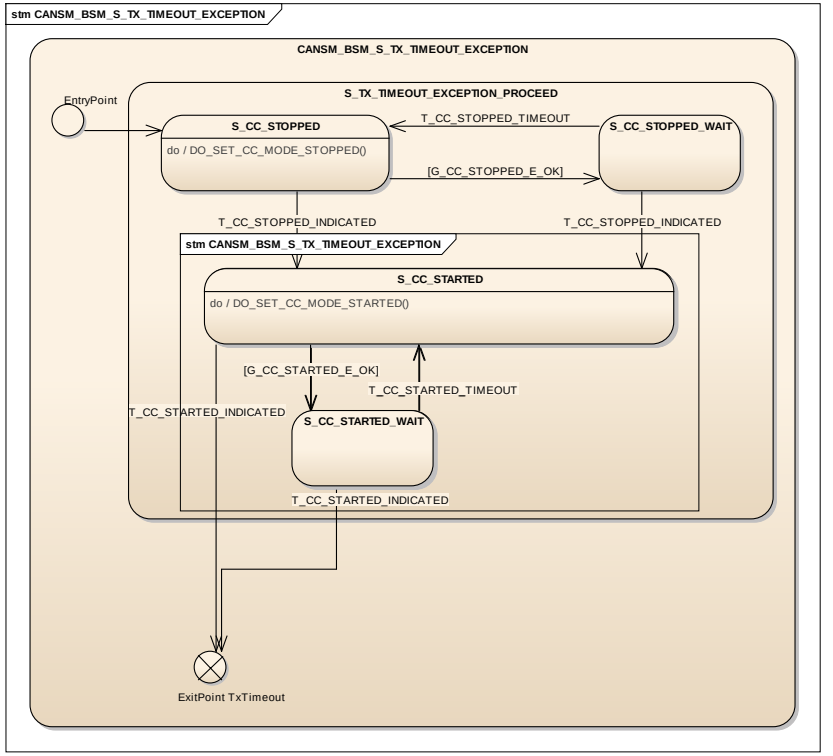
Standard Interfaces



Code Duplication

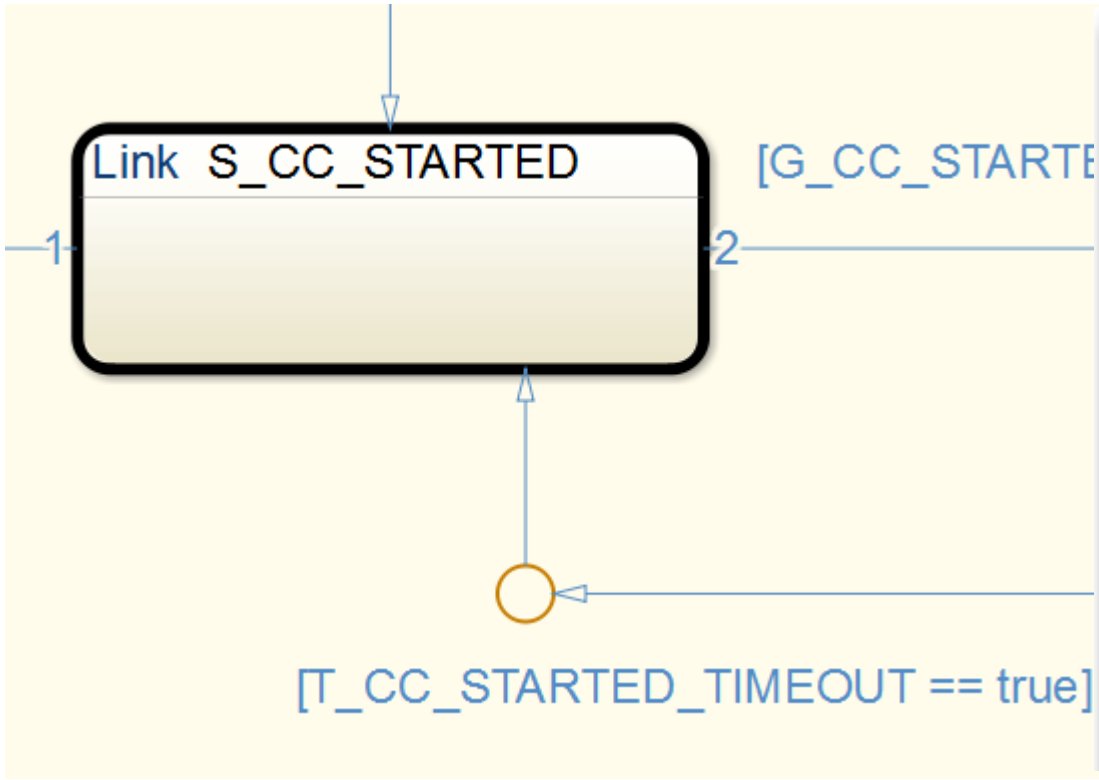
SWS_BSW_00127: The BSW Module implementation shall avoid duplication of code.

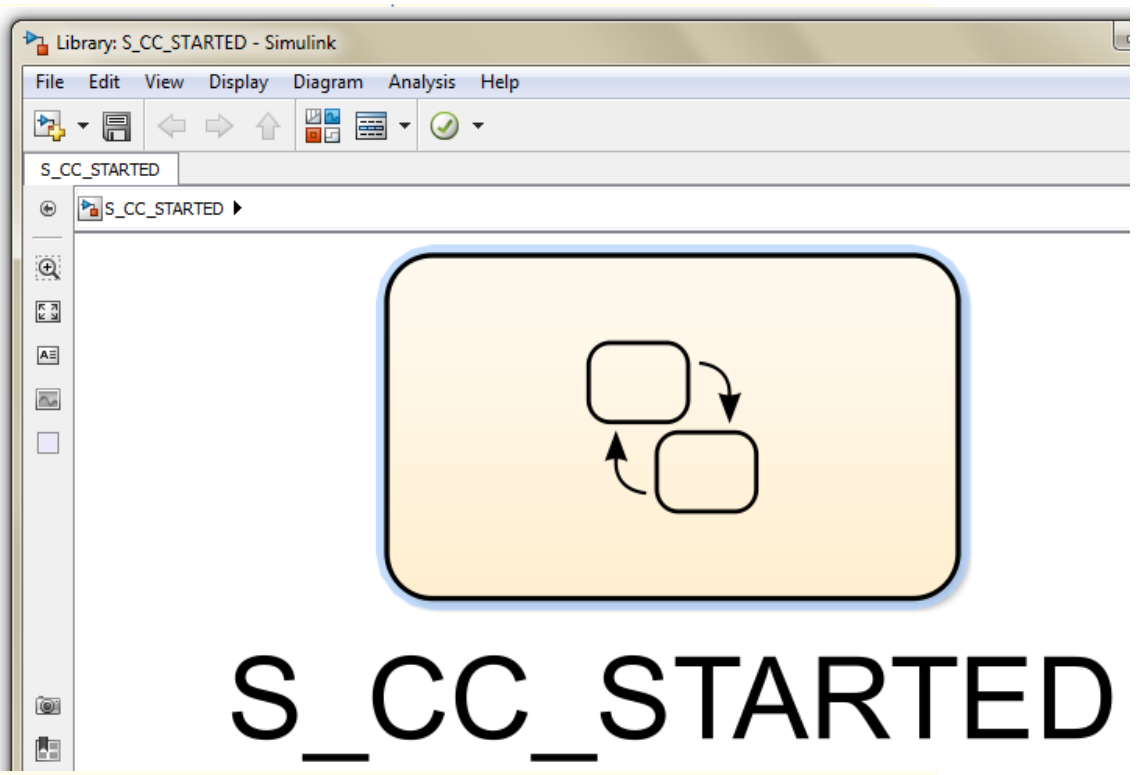




Code Duplication

- Using library of atomic sub-chart to avoid code duplication.





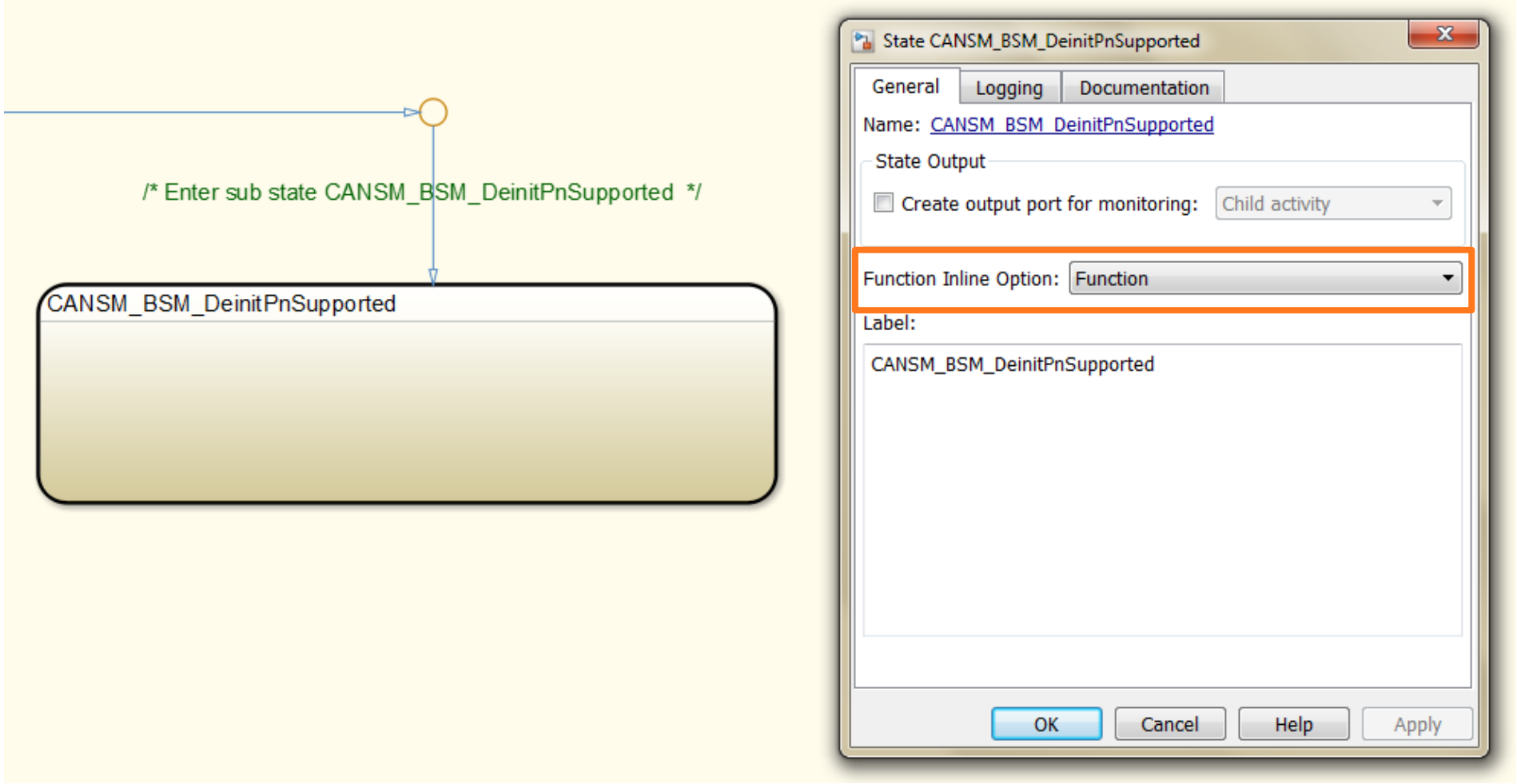
Compliance with MISRA C Rules

SWS_BSW_00115: If the BSW Module implementation is written in C language, then it shall conform to the MISRA C 2004 Standard

- Source complexity (Cyclomatic Complexity): Number of linearly independent paths should not exceed a certain limit.
- Implicit and explicit type conversions (Casting). Example: casting from integer to pointer is prohibited.
- Parentheses “(” and “)” should be used to emphasis expressions.
- The final clause of a switch statement shall be the default clause.

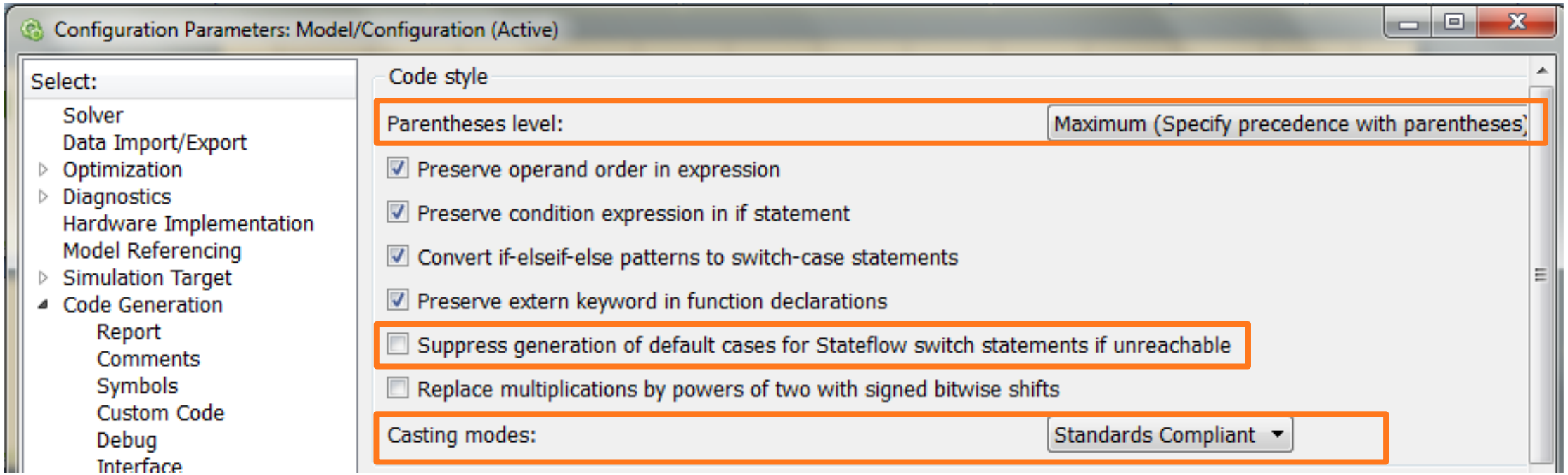
Compliance with MISRA C Rules

Cyclomatic Complexity control by separating atomic parts in separate functions

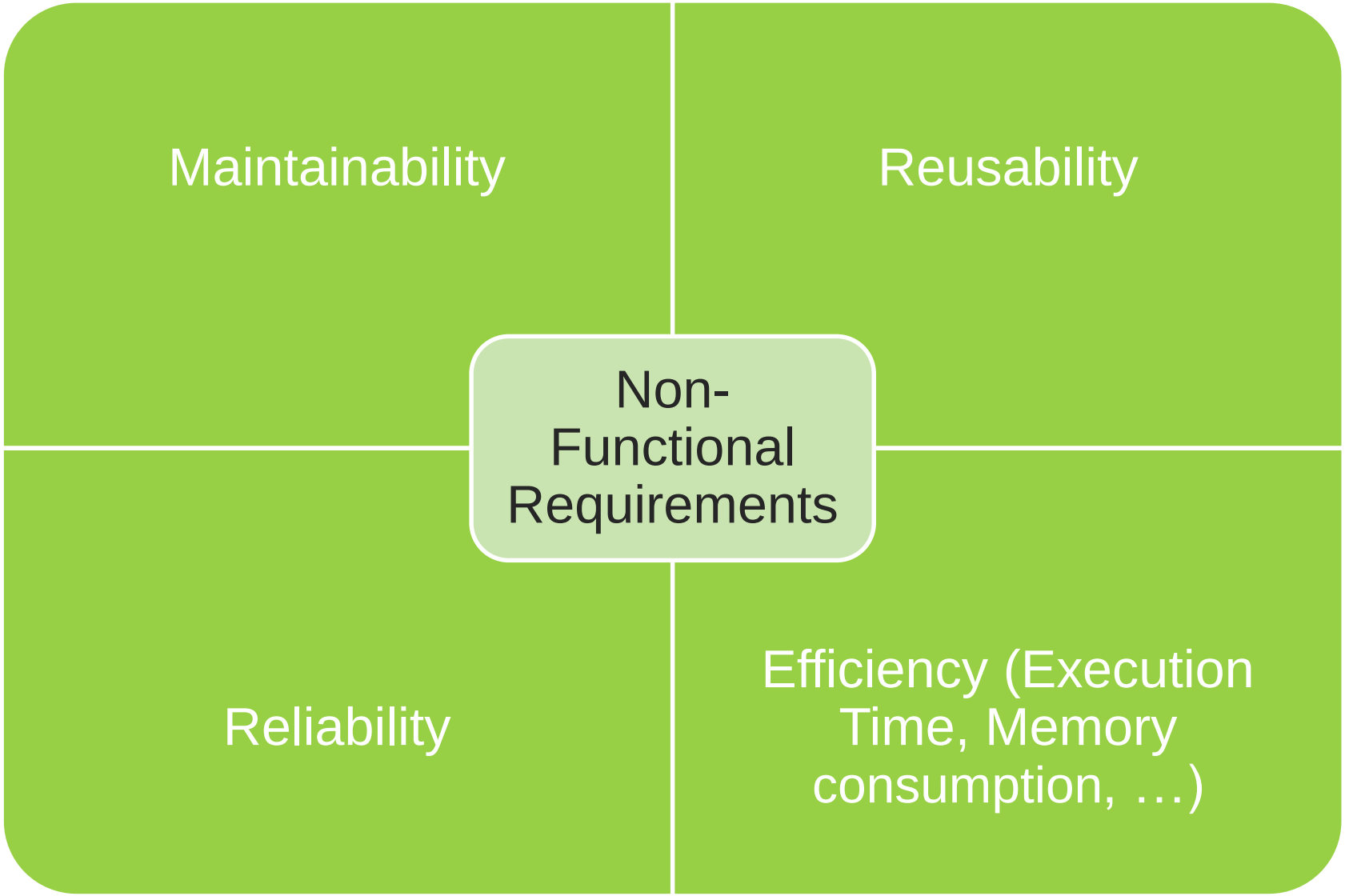


Compliance with MISRA C Rules

- Implicit and explicit type conversions (Casting)
- Parentheses level
- The final clause of a switch statement

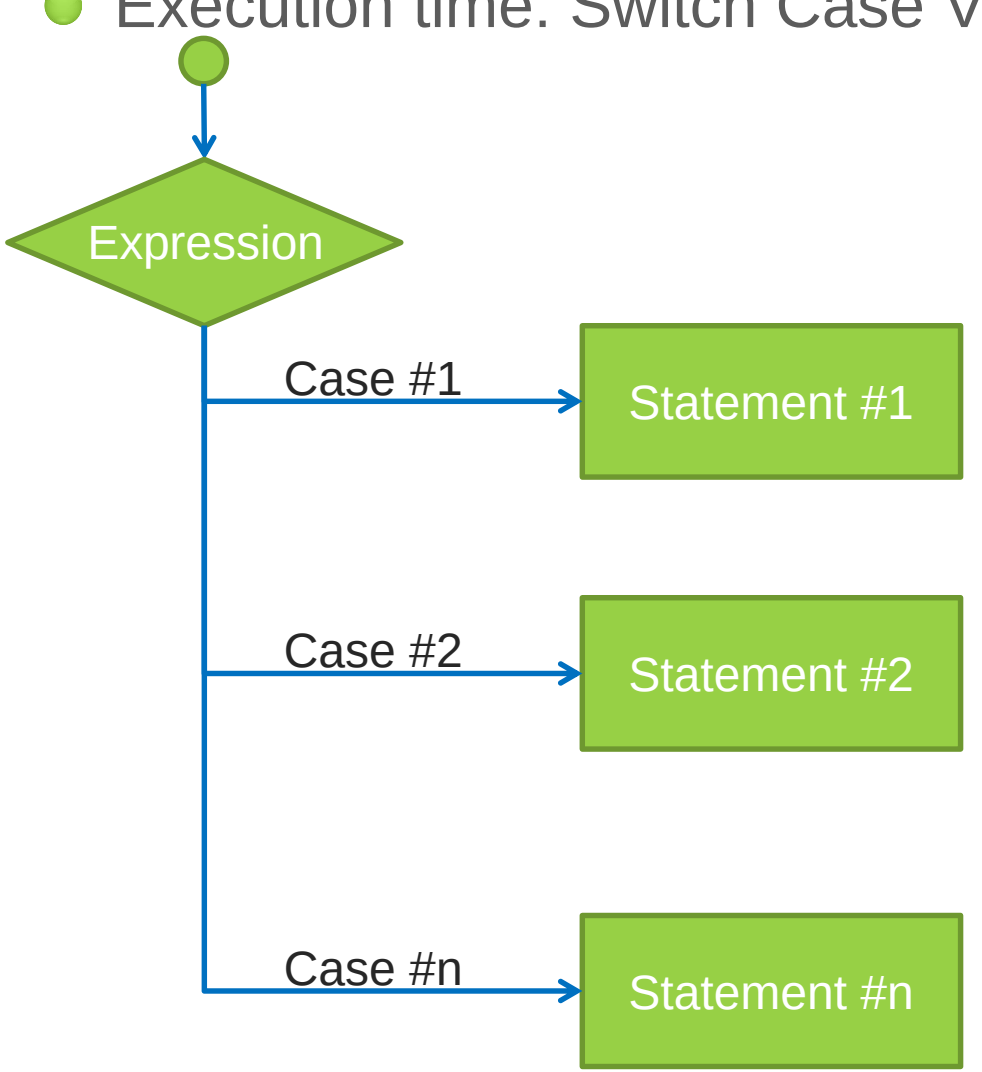


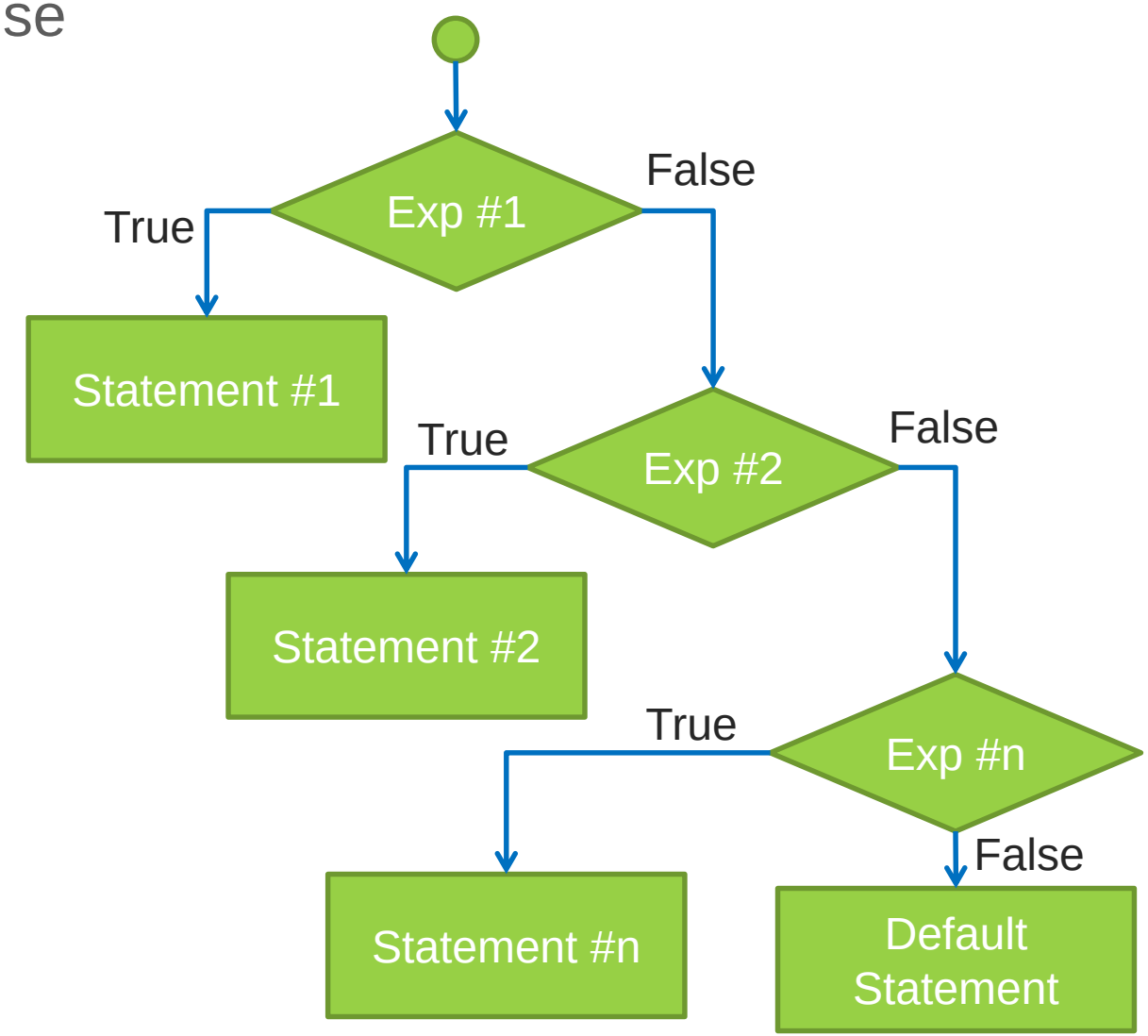
Non-Functional Requirements



Non-Functional Requirements

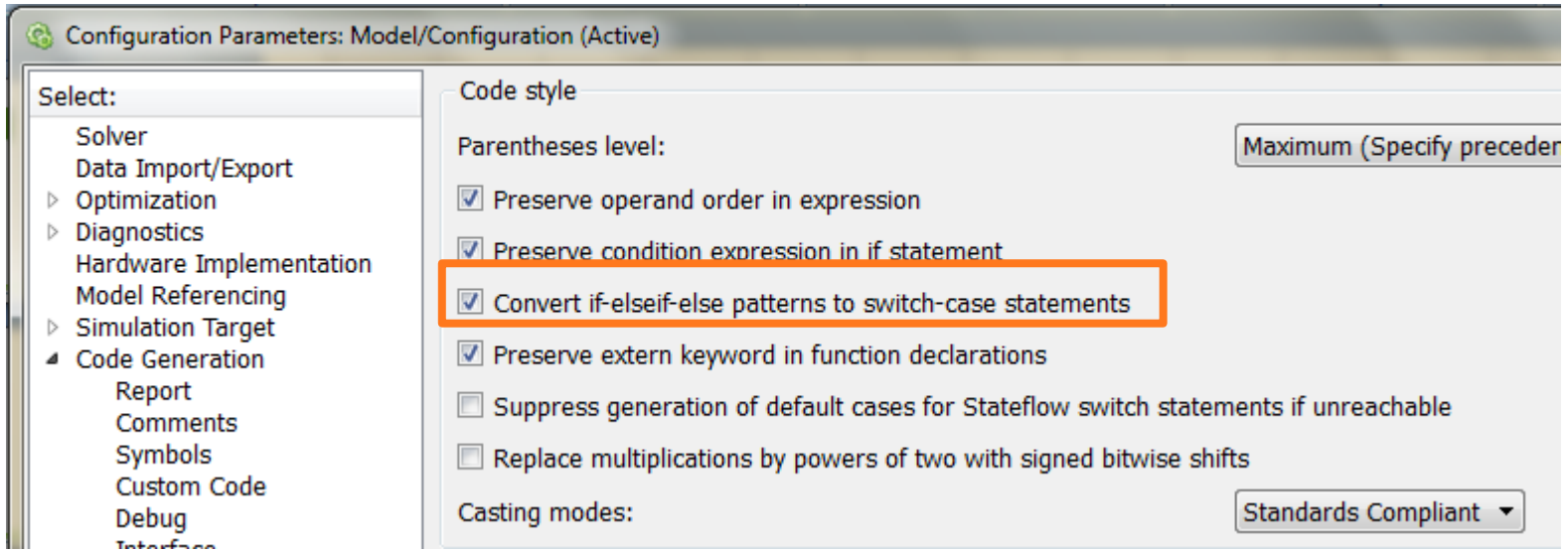
- Execution time: Switch Case Vs If Else





Non-Functional Requirements

- Execution time optimization: Code generation with Switch Case instead of If Else



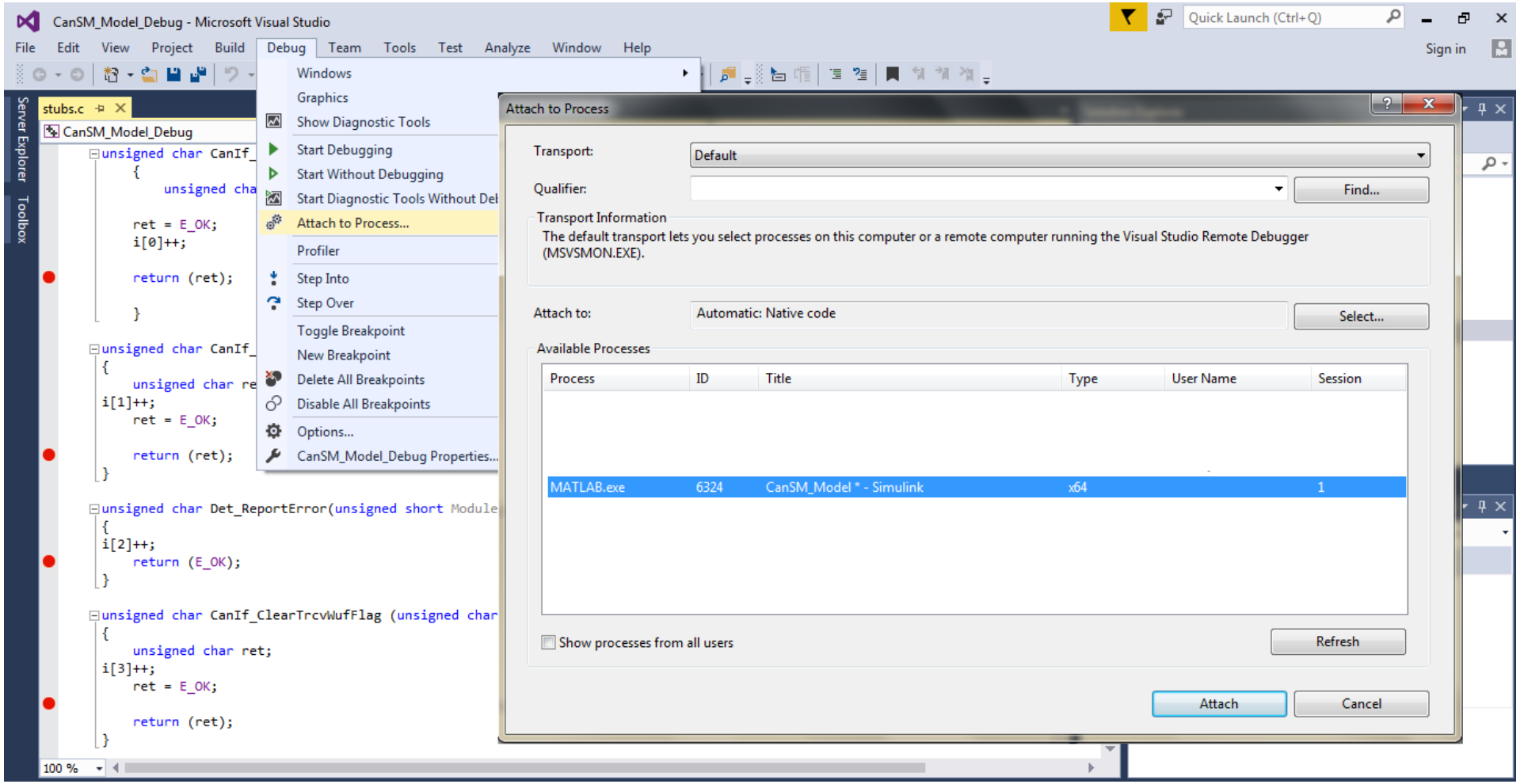

```
976   /* During 'NoPnPrNoCom': '<S304>:1' */
977   switch (localDW->u8_is_NoPnPrNoCom)
978   {
979    case CanSM_Model_IN_NPnCtrSlp:
980     NPnCtrSlp(u8NetId, localDW);
981     break;
982
983    case CanSM_Model_IN_NPnCtrStp:
984     NPnCtrStp(u8NetId, localDW);
985     break;
986
987    case CanSM_Model_IN_NPnTrcNor:
988     NPnTrcNor(u8NetId, localDW);
989     break;
990
991    case CanSM_Model_IN_NPnTrcStd:
992     NPnTrcStd(u8NetId, localDW);
993     break;
994
995    default:
996     /* During 'z': '<S304>:9' */
997     break;
998   }
```

Smoke Testing

- Smoke testing is non-exhaustive software testing, ascertaining that the most crucial functions of a program work, but not bothering with finer details.
- Smoke testing is not a substitute for traditional testing mechanism.

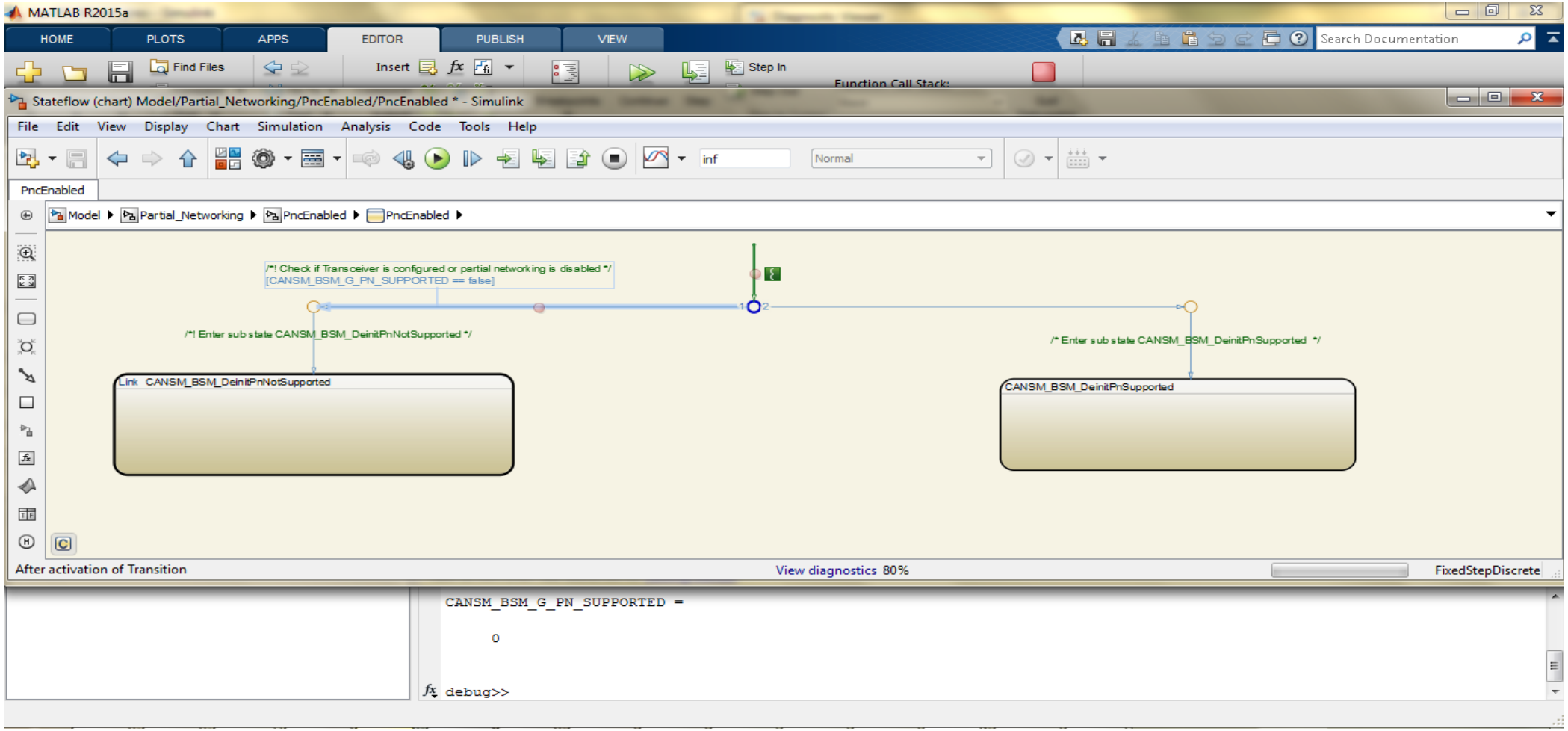
Smoke Testing

- Attaching Microsoft Visual Studio to Matlab process.



Smoke Testing

- Debugging in the Model and the manual code.



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Results of The Provided Solution

- Development time is about 18% less than the other manually developed modules with similar size.
- Bug fixing is about 34% shorter than the other manually developed modules with similar size.
- Number of issues found during testing phase is about 30% less than the other manually developed modules with similar size.

Automotive technology, naturally