**Item Definition**

**Functional Safety Model of Conventional Cruise Control (CC) System**

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# Abbreviations and terms

BDD: Block Definition Diagram

CEM: Central Electronic Module

ECM: Engine Control Module

SWM: Steering Wheel Module

BCM: Brake Control Module

DIM: Digital Information Module

HAN: Hogeschool van Arnhem en Nijmegen University of Applied Sciences

# Purpose and scope

## Purpose

* + 1. The objective of the item definition is to obtain a thorough understanding of a conventional cruise control system (CCCS), its functionality, interfaces with other (sub) systems and its environment (users, physical, functional and non-functional) so that the required phases of the safety lifecycle can be completed.
    2. The item definition has been created as per relevant patents, documents and diagrams obtained from the internet and HAN Automotive department.

## Scope

* + 1. The scope of this document is limited to the CC (sub) system as given in the description provided by HAN.
    - Functional requirements, which explains the functionality of the CC system.
    - Functional architecture that explain the allocation of FR to functional components and the interfaces with other sub-systems that include the preliminary architecture elements.
    - Operation situations states and modes of the CC, which explains the situations and modes that the CC will be used in.
    1. The CC system is a part of the advance driver assistance systems. The item definition will describe the functionality and allocation of the CC system

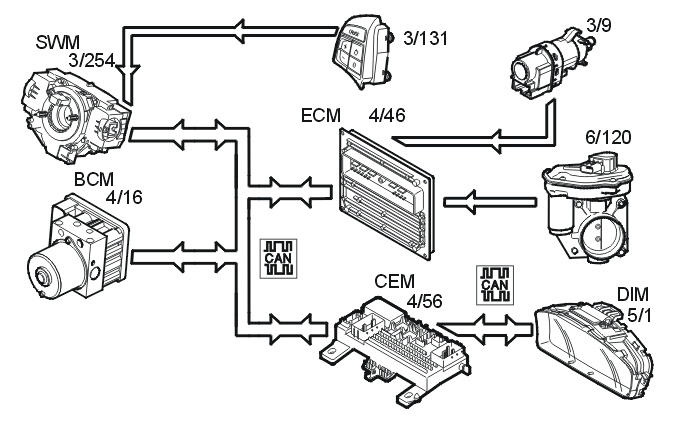
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Figure 3 : Cruise control system – associated components

* + 1. The CC system is associated with the following functional components
    - Driver Interface
    - Vehicle data acquisition system
    - Powertrain components
    - Cruise control module
    1. The CC system is associated with the following physical components (*refer figure1*)
    - Driver input buttons in steering column [3/131, 3/254]
    - Engine control module [ECM]
    - Wheel speed sensor [3/9]
    - Brake and clutch pedal sensor [BCM]
    - Central electronic module [CEM]
    - Throttle sensor
    - Throttle actuator [6/120]
    - Driver information module [DIM]

# State of this document

* 1. This document is in the **draft** status

|  |  |
| --- | --- |
| **Status** | **Description** |
| Draft | The document is under construction. |
| Revised | The document is altered (e.g. by adding or deleting material). |
| Amended | The document is changed (e.g. not by adding or deleting material, but changing material e.g. in case of a fault) or the document is reviewed |
| Approved | The document is approved. |

Table 11 : Document status types

# Related documents

* 1. Remark: Adding related documents is only allowed by appending at the end of the current related documents table (see also paragraph 6.4)

## Document requirements

Document requirements are requirements that apply to this document only. They can be referenced by the X\_Req identifier.

|  |  |  |  |
| --- | --- | --- | --- |
| **Index** | **Unique filename** | **Title of the document** | **File location** |
| N.A. | N.A. | N.A. | N.A. |

Table 12 : Document Requirements

## 3.2 Inputs

Input documents are documents that are needed in order to complete the content of this document. The can be referenced by X\_IN identifier .

|  |  |  |  |
| --- | --- | --- | --- |
| **Index** | **Unique filename** | **Title of the document** | **File location** |
| 1\_IN | Volvo\_c30\_wiring\_doc | Regeleenheden overzicht benamingen | SVN |
| 2\_In | Volovo\_cruise control | Cruise control for motor vehicles | SVN |
| 3\_IN | Overview\_cruise control | CC\_regeling | SVN |
| 4\_In | FSM\_SE\_BreakDown\_BRACE\_v2.pdf | Functional safety for commercial vehicles and mobile machinery using systems engineering | SVN |

Table 13 : Input documents

## Related

Related documents are documents that are not necessarily needed in order to complete the contents of this document. The can be referenced by X\_Rel identifier.

|  |  |  |  |
| --- | --- | --- | --- |
| **Index** | **Unique filename** | **Title of the document** | **File location** |
| N.A. | N.A. | N.A. | N.A. |

Table 14 : Related documents

# Authors

* 1. The authors’ clause contains the names of people who have contributed to this document.

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Table 15 : Authors

# Approver

The approver clause contains the names of the people who approve this document.

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| **Function** | Cluster leader On-Board diagnostics |

Table 16 : Approvers

# Conventions

* 1. Each paragraph in this document had its own identifier: the paragraph identifier. This identifier is generated based on the clause (e.g. 1.1 Purpose clause) that the paragraph is in and an auto incremented number with starting value `1`. The auto incremented numbers are printed in bold, while the clause numbers are shaded.
  2. For every new paragraph, the paragraph identifier is placed on the left side and at the same height equal to the starting point of that new paragraph.
  3. If applicable, an external reference for a paragraph can be given on the footer of the document. This external reference typically refers to the source or origin of the paragraph in question. Footnotes can also be used for the purpose of external references.
  4. Adding related documents to the related documents table (see clause 3) is only allowed by appending at the end of the current related documents table. This way, the reference index identifier can be used to make (persistent) links to the related documents table throughout the whole document. Appending new related documents at the end will not change the index identifier of already existing related documents.
  5. Links to paragraph identifiers in text will be formatted as shaded clause number with normal paragraph identifier (e.g. see paragraph 6.5). Links to related documents will not be made by the paragraph identifier, but by means of the reference index number (e.g. see reference 1). The reference index number will not be formatted as bold. Cites from the bibliography are done by square brackets (e.g. see [X]).
  6. Reviewing of this document is done by posting the comments/remarks in spreadsheet from linking each time the comment/remark to the paragraph identifier or table or figure in question. The review comments/remarks will always be applicable to a certain version of this file; therefore the version number of this document should always be mentioned. More information about this can be found in annexure 13.

# System

## Functionality

7.1.1 This section describes the functional behaviour and architecture of the CC system. The functions will be described by functional requirements which will correspondingly allocated to functional blocks and system states. The functional architecture also describes the interface between CC system and other (sub) systems.

### 7.1.1 Purpose

* + - 1. The purpose of the CC is described in the highest level functional requirement.

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **Alias** | FR01 | **Req.Type** | «functional Requirement» | **Status** | Proposed |
| **Description** | | | | | |
| The cruise control system should maintain the speed of the vehicle upon the drivers demand | | | | | |
| **Rationale** | | | | | |
| Based on the input from the driver, the cruise control system should be able to validate the input and maintain the speed of the vehicle by manipulating the output power from the engine. The cruise control will initially be in off state when the car is started and will go into the off state (Irrespective of the current state) when the ignition is switched off. | | | | | |

### 7.1.2 Scope

7.1.2.1 The system only consists of functionality with respect to the CC. The system is allocated as a sub system of the driver assistance systems. The figure below shows the CC system marked in green.

Figure 4 : Scope of CC system

### 7.1.3 Function description for the CC subsystem

7.1.3.1 The CC system functions are described and modelled in SysML functional requirements. The SysML requirements diagram is displayed in Annexure A. the diagram shows functional requirements (Light Green) derived from a higher abstraction level (Dark Green).

7.1.3.2 The requirements are marked with an id (FRxx) which links the diagram to a detailed description of functionality in

* Annexure A and B: Functional requirements details
* Annexure C: Functional requirements traceability matrix
* Annexure D: Functional Architecture traceability matrix information

### 7.1.4 Non-Functional requirements

7.1.4.1 The non-functional requirements are out of scope of this project and hence they will not be considered.

### 7.1.5 Requirements from other systems and environment

7.1.5.1 None

### 7.1.6 Requirements on other systems and environment

* + - 1. The powertrain system should be capable of interpreting the signal from the cruise control for the actuator.
      2. The powertrain system should be capable of interpreting the signal from the cruise control for the actuator.
      3. The powertrain should be capable of interpreting the request of the CC in order of accelerate or decelerate (engine brake).
      4. The Control units, actuators and sensors should be able to withstand the weather conditions like:
    - Warm
    - Cold
    - Dry
    - Wet
    - Sandy conditions
      1. The engine should be able to limit the torque to protect itself from mechanical damage and stalling.
      2. The ESR should be able to work without using the abs brake system
      3. The control units should be able to deliver the information for the CC system without delay.
      4. The transmission should be able to handle the torque that’s coming out of the engine an deliver it to the wheels.
      5. Signals of cruise control system should have lesser priority compared to ABS, ESP, Airbag and other important emergency system signals

## System/subsystem/sub-subsystem split-up

* + 1. This section displays the functional blocks and a system state which satisfies the defined functional requirements.

### 7.2.1 Functional allocation for subsystem/sub-subsystem

7.2.1.1 As displayed in Annexure D, the functional blocks of CC system satisfying the FR’s are shown in Figure 3. The green marked block represents the pure functionality of CC system.

Figure 5 : BDD diagram of CC system

7.2.1.2 The internal organization of the CC system is also specified as an ibd in Figure 4.



Figure 6 : ibd of the CC System

### Functional state diagram

* + - 1. The safe state determination of the CC system is shown in Figure 5. When the CC is in the active state and driver presses the brake and/or the clutch pedal, the CC system will go to the safe state. Additionally when the driver wishes to put the CC system in standby mode or wishes to manually switch it off, the system will go to the safe state.



Figure 7 : CC system state diagram

### Functional traceability

* + - 1. The above defined functional architecture, system and states satisfy the functional requirements as stated in the traceability matrix as found in Annexure D of this document.
* Functional components satisfying functional requirements
* Functional system and CC states

## Operation modes, system states and operational situations

* + 1. To provide a clear understanding of the situational use of the CC system in context of the vehicle input for the situational analysis (to perform the HARA) needs to be defined.
    2. The situational analysis requires the following concepts in respect to the CC system
* Operational mode – by the driver or automatically by systems logic selected functional state of a system or element.
* Vehicle state – The state of the vehicle.
* Operational situation – such as driving situations, vehicle usage scenarios, environmental conditions, training, experience and ability of the driver.

## 7.3.1 Operational Modes for the CCCS

7.3.1.1 Figure 6 displays the use case diagram including the Operating modes existing for the CCCS system



Figure 8 : Operating Modes CC system

## 7.3.2 Vehicle states corresponding to CCCS

* + - 1. Figure 7 displays the use case diagram including the Vehicle states corresponding to the use of the CCCS.



Figure 9 : Vehicle states for the CC system

## Operational Situation corresponding to CCCS

7.3.3.1 This clause contains:

* Generic operational situation based on vehicle location
* Generic operational situation based on vehicle movement
* System specific operational situation

### 7.3.4 Operational Situation based on vehicle location

7.3.4.1 Figure 7 displays the CCCS corresponding Operational Situations in the context of vehicle location.



Figure 10 : Operation situation based on vehicle location

### 7.3.5 Operational Situation based on vehicle movement

7.3.5.1 Figure 8 displays the CCCS corresponding Operational Situations in the context of vehicle movement.



Figure 11: Operation situation based on vehicle movement

## 7.4 Assumptions and constraints

## 7.4.1 Assumptions

* It is assumed that the engine is able to deliver the requesting torque that the CCS demands
* It is assumed that the CCS is able to communicate back and forth with ABS and ESP system
* It is assumed that the Wheel sensors are responsible for the actual vehicle speed
* It is assumed that the engine and CCS is able to deliver the requesting torque when encounters a disturbance (slope and cross wind).
* It is assumed that the CCS does not use the brake for decreasing the speed.
* It is assumed that the buttons on the steering wheel is the only way to control the CCS
* It is assumed that the environment doesn`t influence the goal of the CCS

## 7.4.2 Constraints

7.4.2.1 The constraints concerning other functions, systems and components and constraints, effects of the system behavior on other systems, the environment of the system including the interactions are as follows:

* The constraints concerning the effect of the item behavior on other items, which is the environment of the item, including interactions.
* Constraints in behavior expected from the item
* Constraints concerning other items and elements are determined

7.4.2.2 The constraints concerning other functions follows:

* The system is not able to directly use the brakes.
* The CCS has no influents on the gear selection.
* The CCS system can only receive information from other systems; the CCS only can request an torque from the engine.
* The CCS is not able to adjust the speed when approaching the car in front of the vehicle(ACCS)
* The CCS is not able to resume the set speed after braking. This need to be requested by the controls on the steering wheel.
* The CCS only work above 30kph