D-Case Modeling Environment Integration

Demonstration

Cruise Control System Specification

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Revision History

Revised Date	Description
2014/01/27	Created

1 Scope

1.1 Objective

This document describes the specification of the cruise control system development used for demonstration of D-Case and SysML collaboration.

1.2 Definition of words

ID	Abbreviation	Word	Meaning
1	CC	Cruise Control	The function to maintain the speed without continuing stepping on an accelerator.
2	PCS	Pre-Crash Safety	The function which supports collision evasion with an obstacle.

2 System Architecture

2.1 System Architecture Outline

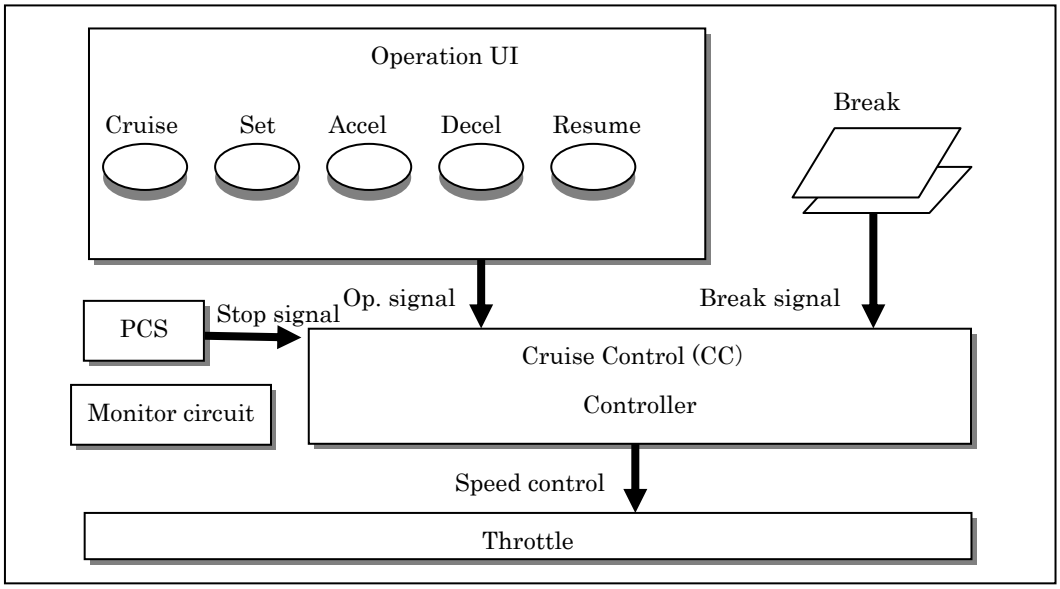

Figure 1 System architecture

2.2 Main Elements of the System

Element ID	Element	Description
C_01	Operation UI	UI which arranges the button for a driver to direct cruise control
C_02	Break	Brake mechanism for a driver to slow down or stop a car

C_03	CC controller	The controller for judging the control scheme of cruise control
C_04	Throttle	Actuator to control speed
C_05	Monitor circuit	The circuit which CC operates as operation of a driver intention and supervises that acceleration is proper within the limits

3 Function

Cruise Control (CC) system controls speed set by driver.

4 Constraints

4.1 Constraints for Development Process

- [CY_01] Derivation development is adopted. Next system has functional safety based on ISO 26262.
- [CY_02] CC is safe.

4.2 Architecture and Constraints of the System

- [CY_11] CC has 5 buttons on UI: Cruise, Set, Accel, Decel, and Resume.
- [CY_12] Driver controls CC via UI and brake pedal.
- [CY_13] Driver can always set CC in driving the car.

4.3 Circumference System, Hardware, or Software

Type	Name	Version
OS which is used.	xxx	1.23

5 Use Case

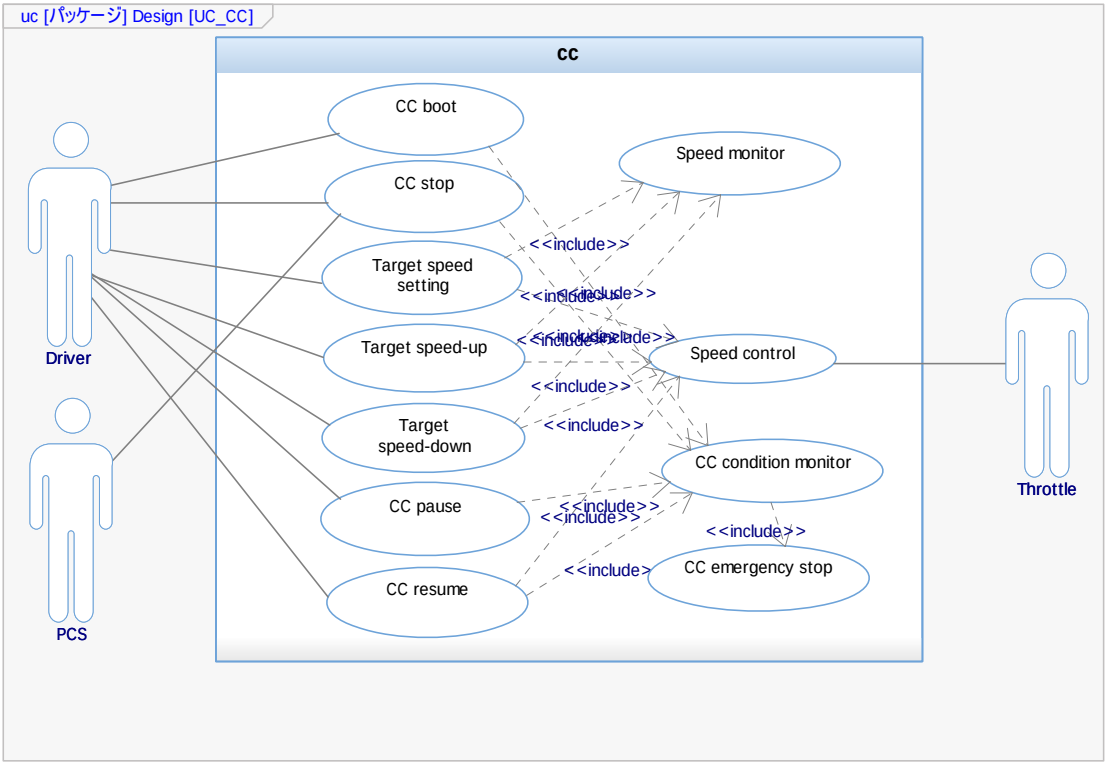

Figure 2 Use Case Diagram

Use Case ID	Name	Description
UC_01	CC boot	CC is booted.
UC_02	CC stop	Return controls to the driver
UC_03	Target speed setting	Set the target speed.
UC_04	Target speed-up	Raise the target speed.
UC_05	Target speed-down	Lower the target speed.
UC_06	CC pause	Temporarily return controls to the driver.
UC_08	CC resume	Resume CC which has been paused.
UC_09	Speed control	Control speed of the vehicle.
UC_10	CC condition monitor	Monitor the CC condition.
UC_11	CC emergency stop	Emergently stop CC if some abnormity is detected.
UC_12	Speed monitor	Monitor the speed of the vehicle.

6 Detail Function

CC is requested to realize the following functions by CC program which is developed.

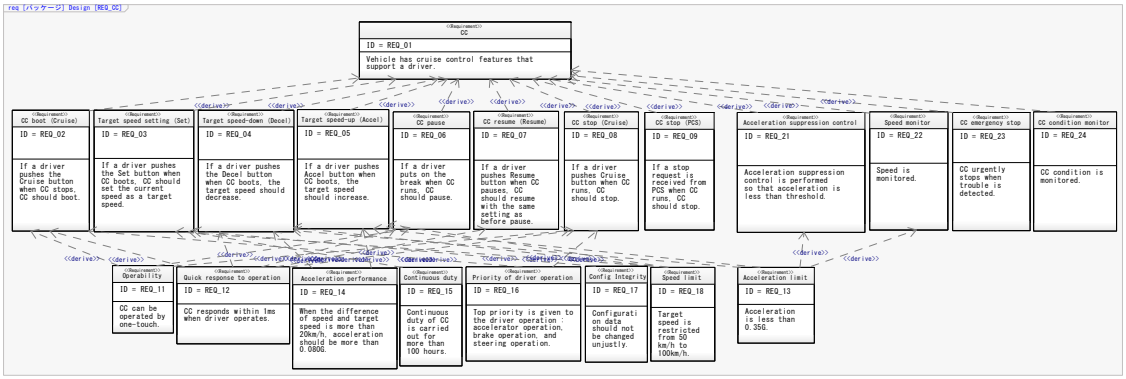

Figure 3 Requirement Diagram

6.1 Requirements about Functions

- [REQ_01] Vehicle has cruise control features that support a driver.
- [REQ_02] If a driver pushes the Cruise button when CC stops, CC should boot.
- [REQ_03] If a driver pushes the Set button when CC boots, CC should set the current speed as a target speed.
- [REQ_04] If a driver pushes the Decel button when CC boots, the target speed should decrease.
- [REQ_05] If a driver pushes Accel button when CC boots, the target speed should increase.
- [REQ_06] If a driver puts on the break when CC runs, CC should pause.
- [REQ_07] If a driver pushes Resume button when CC pauses, CC should resume with the same setting as before pause.
- [REQ_08] If a driver pushes Cruise button when CC runs, CC should stop.
- [REQ_09] If a stop request is received from PCS when CC runs, CC should stop.

6.2 Requirements about Performance, Quality

- [REQ_11] CC can be operated by one-touch.
- [REQ_12] CC responds within 1ms when driver operates.
- [REQ_13] Acceleration is less than 0.35G.
- [REQ_14] When the difference of speed and target speed is more than 20km/h, acceleration should be more than 0.080G.
- [REQ_15] Continuous duty of CC is carried out for more than 100 hours.
- [REQ_16] Top priority is given to the driver operation：accelerator operation, brake operation, and steering operation.

- [REQ_17] Configuration data should not be changed unjustly.
- [REQ_18] Target speed is restricted from 50 km/h to 100km/h.

6.3 Requirements about Functional Safety

- [REQ_21] Acceleration suppression control is performed so that acceleration is less than threshold.
- [REQ_22] Speed is monitored.
- [REQ_23] CC urgently stops when trouble is detected.
- [REQ_24] CC condition is monitored.

7 Hazard Analysis

7.1 Hazard Analysis by HAZOP

ID	Output	Guide Word	Situation	Hazard
H_01	CC Controller	More	After CC boots	Excessive acceleration from driver's intention
H_02	CC Controller	No or not	Break is stepped on after CC bots	Different CC condition from driver's intention

7.2 Hazard Analysis by FTA

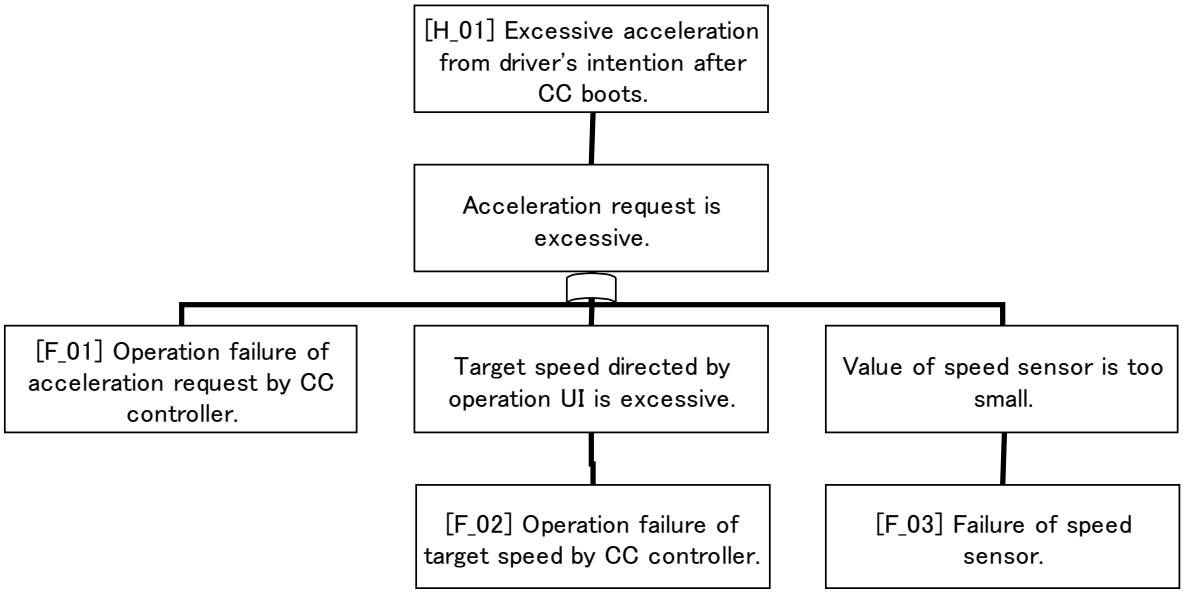

Figure 4 FTA Diagram (1)

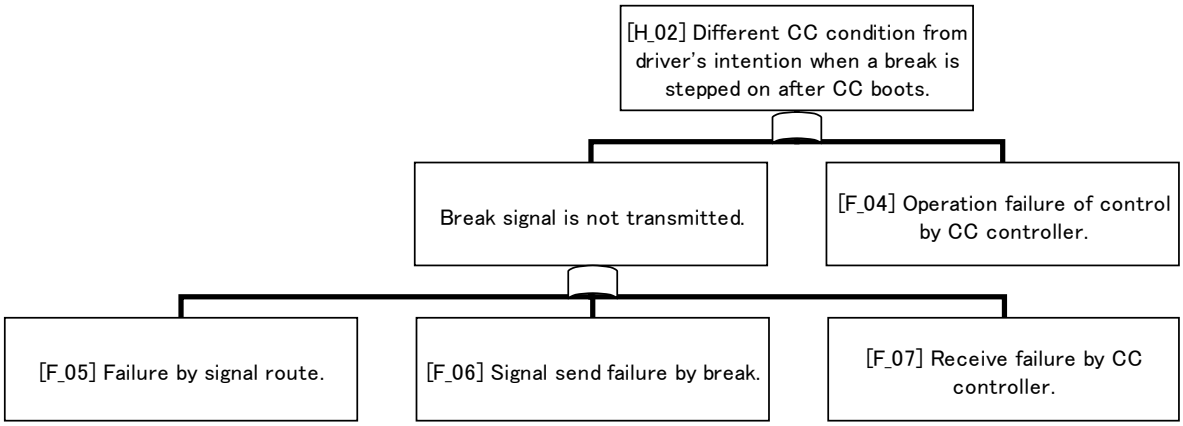

Figure 5 FTA Diagram (2)

7.3 Influence Analysis by FMEA

ID	Component	Failure mode	Factor	Severity of influence	Frequency	Difficulty of detection	Risk priority	Provision	
								S/W	H/W
F_01	CC Controller	Operation failure (acceleration request)	Program bug	6 (M)	1 (L)	5 (M)	30	[A_01] Acceleration suppression control	[A_02] Speed monitor circuit
F_02	CC Controller	Operation failure (target speed)	Program bug	3 (L)	1 (L)	1 (L)	3		
F_03	Speed sensor	Abnormal value	Breakdown	9 (H)	5 (M)	1 (L)	45	[A_03] CC emergency stop	[A_04] CC condition monitor circuit
F_04	CC Controller	Operation failure (control)	Program bug	9 (H)	1 (L)	1 (L)	9		
F_05	Transmission route	Abnormal value	Breakdown	9 (H)	5 (M)	1 (L)	45		
F_06	Brak	Operation failure (send)	Breaking of wire	9 (H)	1 (L)	1 (L)	9		
F_07	CC Controller	Operation failure (receive)	Breaking of wire	9 (H)	1 (L)	5 (M)	45		

8 Function Block Outline

8.1 Block Definition Diagram

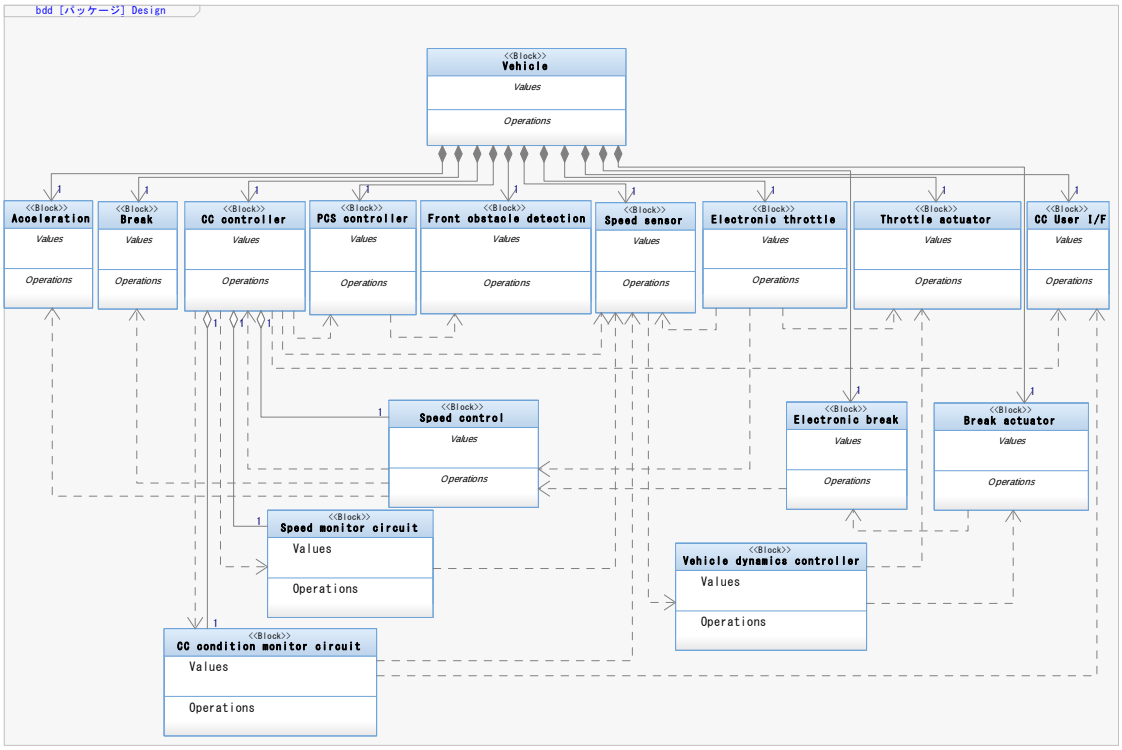

Figure 6 Block Definition Diagram

8.2 Functional Block Consisting of the System

Block ID	Block Name	Description	Role Allotment	Related Block ID
BL_01	CC controller	Control cruise.	S/W	BL_02 BL_08
BL_02	PCS controller	Control PCS.	S/W	BL_01
BL_03	Break	Transmit break signals to CC.	Trans: S/W	BL_01
BL_04	Front obstacle detection sensor	Detect front obstacles and transmit to PCS.	Trans: S/W	BL_03
BL_05	Speed sensor	Transmit speed to CC controller.	Trans: S/W	BL_01
BL_06	Electronic throttle	Transmit acceleration requests to actuator.	Trans: S/W	BL_07
BL_07	Throttle actuator	Actuate throttle.	Trans: S/W	BL_06

BL_08	Vehicle	A vehicle including CC.	S/W and H/W	BL_01
BL_09	CC User I/F	Transmit operation signals directed by driver to CC.	User UI: H/W, Trans: S/W	BL_03
BL_10	Speed monitor circuit	Monitor acceleration that speed is proper within the limits.	Trans: S/W, Circuit : H/W	BL_11
BL_11	Speed control	Calculate acceleration request based on condition of acceleration, break, and CC controller.	S/W	BL_10
BL_12	Vehicle dynamics controller	Simulate vehicle speed and acceleration.	S/W	BL_05 BL_07
BL_13	Acceleration	Transmit acceleration signals to CC.	Trans: S/W	BL_01
BL_14	CC condition monitor circuit	Monitor that CC operates as operation of a driver intention and supervises that acceleration is proper within the limits.	Trans: S/W, Circuit : H/W	BL_11
BL_15	Electronic break	Transmit break request to actuator.	Trans: S/W	BL_16
BL_16	Break actuator	Drive a break.	Trans: S/W	BL_15

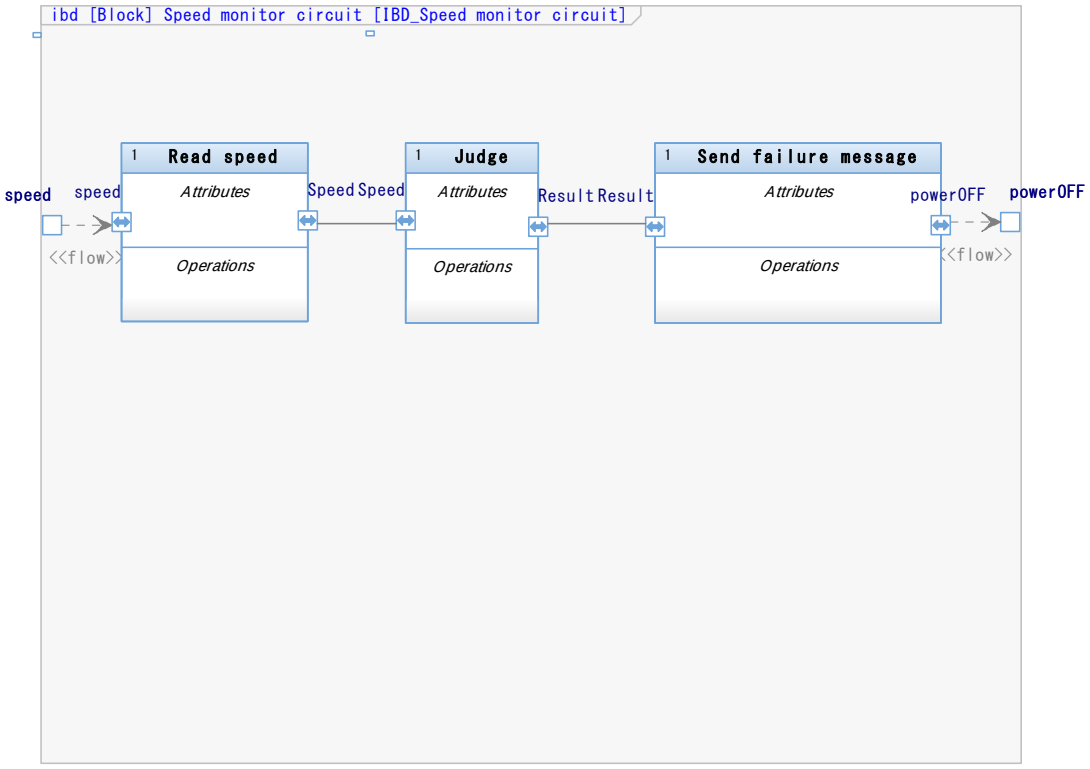

Figure 7　Internal Block Diagram

8.3　Relation of Use Case and Function Block

Use Case ID	Use Case Name	Block ID	Block Name
UC_01	CC boot	BL_01 BL_09	CC controller CC User I/F
UC_02	CC stop	BL_01 BL_09	CC controller CC User I/F
UC_03	Target speed setting	BL_01 BL_05 BL_09	CC controller Speed sensor CC User I/F
UC_04	Target speed-up	BL_01 BL_09	CC controller CC User I/F
UC_05	Target speed-down	BL_01 BL_09	CC controller CC User I/F
UC_06	CC pause	BL_01 BL_03	CC controller Break
UC_08	CC resume	BL_01 BL_09	CC controller CC User I/F

UC_09	Speed control	BL_11	Speed control
UC_10	CC condition monitor	BL_14	CC condition monitor circuit
UC_11	CC emergency stop	BL_01	CC controller
UC_12	Speed monitor	BL_10	Speed monitor circuit

8.4 Relation of Constraints

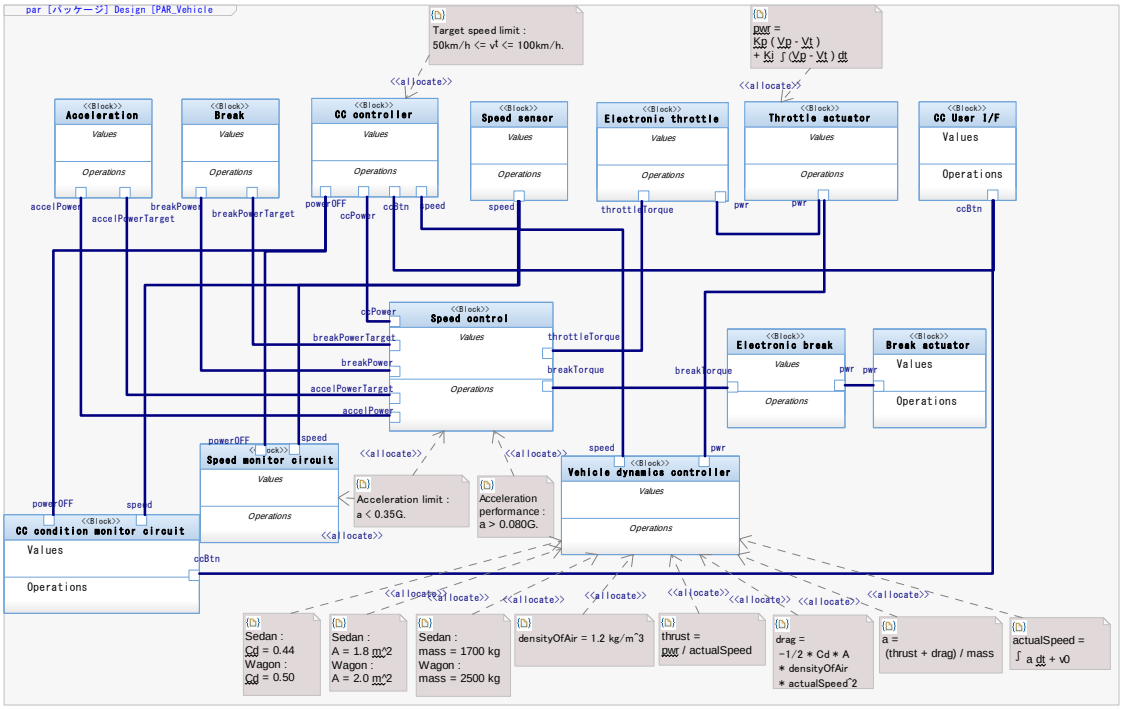

Figure 8 Parametric Diagram

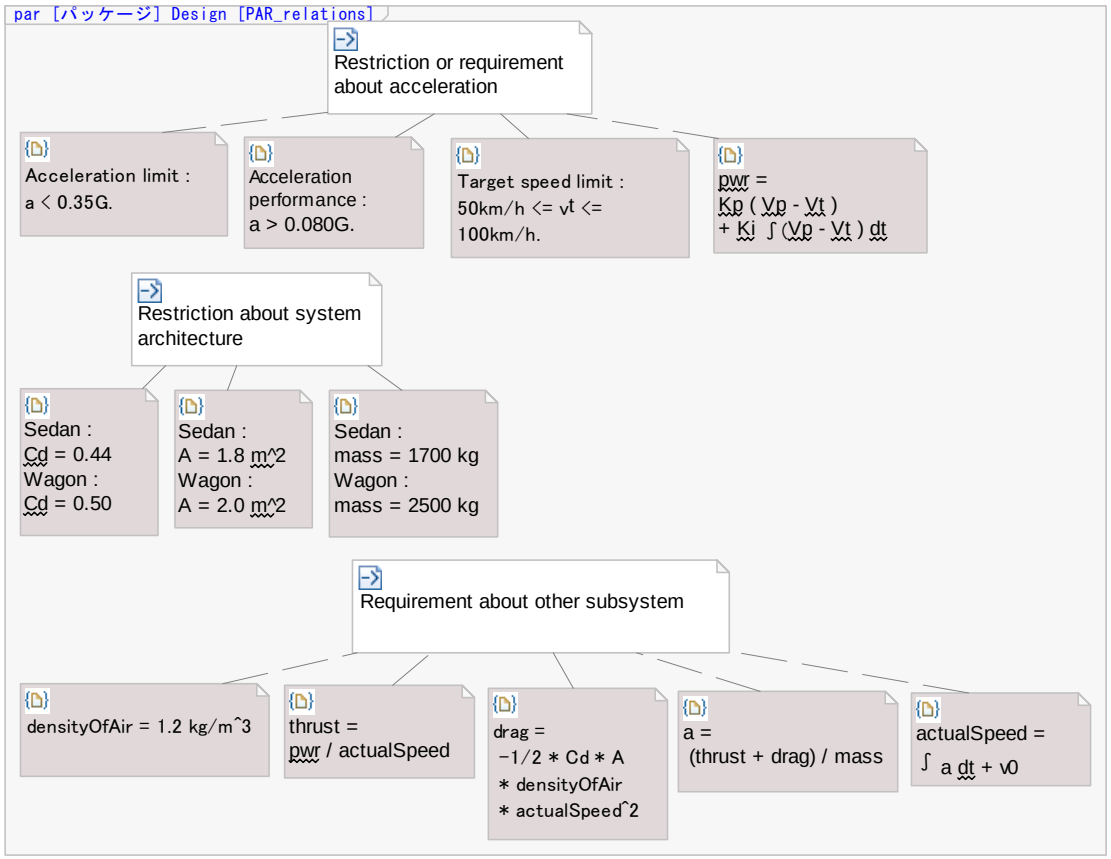

Figure 9　Parametric Diagram (relations)

Constraint Block ID	Constraint Block Name	Description
PAR_01	Restriction of acceleration limit	Acceleration limit : a < 0.35G.
PAR_02	Restriction of acceleration performance	Acceleration performance : a > 0.080G.
PAR_03	Restriction of speed limit	Target speed limit : 50km/h <= vt <= 100km/h.
PAR_04	Restriction of PI control	pwr = Kp (Vp - Vt) + Ki ∫ (Vp - Vt) dt
PAR_05	Restriction of projected area	Sedan : A = 1.8 m^2 Wagon :

		A = 2.0 m^2
PAR_06	Restriction of vehicle mass	Sedan： mass = 1700 kg Wagon： mass = 2500 kg
PAR_07	Restriction of Cd value	Sedan： Cd = 0.44 Wagon： Cd = 0.50
PAR_08	Restriction of air density	densityOfAir = 1.2 kg/m^3
PAR_09	Restriction of thrust	thrust = pwr / actualSpeed
PAR_10	Restriction of drag	drag = -1/2 * Cd * A * densityOfAir * actualSpeed^2
PAR_11	Restriction of equation of motion	a = (thrust + drag) / mass
PAR_12	Restriction of speed	actualSpeed = ∫ a dt + v0

8.5 State Machine Diagram

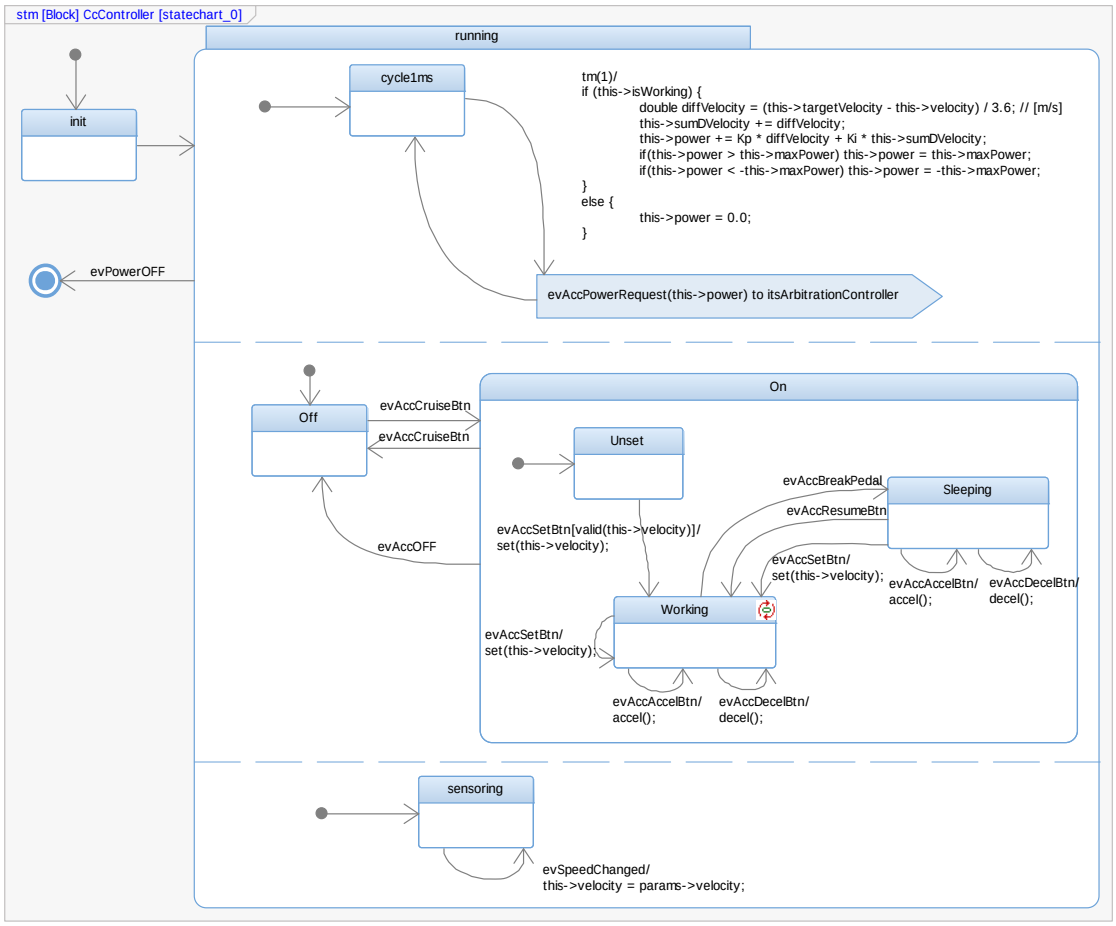

Figure 10 State Machine Diagram