

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
			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

Туре	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.

-	eq (Ny7-9) Design	[KEU_CC] /										
					Citaquir	(Create						
				ID = RE	EQ 01		1					
				Vehicle	e has cruise contr	ol features that	-					
				support	t a driver.		\$					
				:22		N 1 1 1	4					
					The cedering	and contraction			(ther +we)))			
	((Beguinement))	((Requirement))	((der.ive))- ((der.ive))	exp (depirement))	(Reviewert))	(Requirement))	(derive)	<(derive>>	«(derive») «(derive»)-	(/Benirmetti)		(/[an.(cano?))
	CC boot (Cruise)	Target speed setting (Set)	Target speed-down (Decel)	Target speed-up (Accel)	CC pause	CC resume (Resume)	CC stop (Cruise)	OC stop (PCS)	Acceleration suppression control	Speed monitor	CC emergency stop	CC condition monitor
	ID = REQ_02	ID = REQ_03	ID = REQ_04	ID = REQ_05	ID = REQ_06	ID = REQ_07	ID = REQ_08	ID = REQ_09	ID = REQ_21	ID = REQ_22	ID = REQ_23	$ID = REQ_24$
	If a driver	If a driver pushes	If a driver pushes	If a driver pushes	If a driver	If a driver	If a driver	If a stop	Accelerative concernation	Sneed in	CC urgent ly	00
	pushes the Cruise button	CC boots, CC should	the Decel button when CC boots, the	Accel button when CC boots, the	puts on the break when CC	pushes Resume button when CC	pushes Cruise button when CC	request is received from	control is performed	monitored.	stops when	monitored.
	when CC stops, CC should boot	set the current speed as a target	target speed should	target speed	runs, CC	pauses, CC	runs, CC	PCS when CC	so that acceleration is less than threshold		detected.	
		speed.				with the same	silouru scop.	should stop.				
					· .	before pause.						
	111	·	the second	K	7-5-44		>>					
			1	Thereing	Sec. 2	492255			(charging) -	~ ~		
	< <der i="" td="" ve<=""><td>>>> ((derive>>></td><td></td><td>tesekevenervester tester ive>></td><td><com veedor-ive="">></com></td><td>Tider Ive A- (668911897)</td><td>(antivensite)</td><td>20000</td><td></td><td>ve>></td><td></td><td></td></der>	>>> ((derive>>>		tesekevenervester tester ive>>	<com veedor-ive="">></com>	Tider Ive A- (668911897)	(antivensite)	20000		ve>>		
		Operability Qui	(Requirement)) ok response to operation	(Requirement)) Acceleration performance	Continuous duty	(Requirement)) Priority of driver operat	Config Integrit	(Requirement)) Speed limit	(Gequirement)) Acceleration limit			
		ID = REQ_11 ID	= REQ_12	ID = REQ 14	$ID = REQ_{15}$	ID = REQ_16	1D = REQ_17	ID = REQ_18	ID = REQ_13			
		CC can be			-		_					
		operated by wh	en driver operates.	When the difference of speed and target	Continuous duty of CC	Top priority is given the driver operation	to Configurati	Target	Acceleration is less than			
		one-touch.		speed is more than 20km/h_acceleration	is carried	accelerator operation,	should not	restricted	0.356.			
				should be more than 0 0806	more than	steering operation.	unjustly.	km/h to				
					Too nours.			100km/h.				

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	More	After CC boots	Excessive acceleration
	Controller			from driver's intention
H_02	CC	No or not	Break is stepped	Different CC condition
	Controller		on after CC bots	from driver's intention

7.2 Hazard Analysis by FTA



Figure 4 FTA Diagram (1)





Figure 5 FTA Diagram (2)

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

7.3 Influence Analysis by FMEA



8 Function Block Outline

8.1 Block Definition Diagram



Figure 6 Block Definition Diagram

- Block ID Block Name Description Role Related Block ID Allotment BL_01 CC controller Control cruise. S/W BL_{02} **BL_08** PCS controller Control PCS. S/W BL_{02} BL_01 BL_03 Transmit break signals to Trans: S/W BL_01 Break CC. BL_04 Front obstacle Detect front obstacles Trans: S/W BL_{03} detection sensor and transmit to PCS. Trans: S/W BL_{05} Speed sensor Transmit speed to CC BL_01 controller. Electronic Trans: S/W BL_{06} Transmit acceleration BL_07 throttle requests to actuator. BL_{06} BL_07 Throttle Actuate throttle. Trans: S/W actuator
- 8.2 Functional Block Consisting of the System



BL_08	Vehicle	A vehicle including CC.	S/W and	BL_01
			H/W	
BL_09	CC User I/F	Transmit operation	User UI:	BL_03
		signals directed by driver	H/W, Trans:	
		to CC.	S/W	
BL_10	Speed monitor	Monitor acceleration that	Trans: S/W,	BL_11
	circuit	speed is proper within	Circuit :	
		the limits.	H/W	
BL_11	Speed control	Calculate acceleration	S/W	BL_10
		request based on		
		condition of acceleration,		
		break, and CC controller.		
BL_12	Vehicle	Simulate vehicle speed	S/W	BL_{05}
	dynamics	and acceleration.		BL_07
	controller			
BL_13	Acceleration	Transmit acceleration	Trans: S/W	BL_01
		signals to CC.		
BL_14	CC condition	Monitor that CC operates	Trans: S/W,	BL_11
	monitor circuit	as operation of a driver	Circuit :	
		intention and supervises	H/W	
		that acceleration is		
		proper within the limits.		
BL_15	Electronic	Transmit break request	Trans: S/W	BL_16
	break	to actuator.		
BL_16	Break actuator	Drive a break.	Trans: S/W	BL_15





Figure 7 Internal Block Diagram

Use Case ID	Use Case Name	Block ID	Block Name
UC_01	CC boot	BL_01	CC controller
		BL_09	CC User I/F
UC_02	CC stop	BL_01	CC controller
		BL_09	CC User I/F
UC_03	Target speed	BL_01	CC controller
	setting	BL_{05}	Speed sensor
		BL_09	CC User I/F
UC_04	Target speed-up	BL_01	CC controller
		BL_09	CC User I/F
UC_05	Target	BL_01	CC controller
	speed-down	BL_09	CC User I/F
UC_06	CC pause	BL_01	CC controller
		BL_03	Break
UC_08	CC resume	BL_01	CC controller
		BL_09	CC User I/F

8.3 Relation of Use Case and Function Block



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

8.4 Relation of Constraints



Figure 8 Parametric Diagram





Figure 9 Parametric Diagram (relations)

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



		A = 2.0 m^2
PAR_06 Restriction of		Sedan :
	vehicle mass	mass = 1700 kg
		Wagon :
		mass = 2500 kg
PAR_07	Restriction of Cd	Sedan :
	value	Cd = 0.44
		Wagon :
		Cd = 0.50
PAR_08	Restriction of air	densityOfAir = 1.2 kg/m^3
	density	
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	a =
	equation of motion	(thrust + drag) / mass
PAR_12	Restriction of speed	actualSpeed = $\int a dt + v0$



8.5 State Machine Diagram



Figure 10 State Machine Diagram