AIAG-VDA FMEA
표준제정(1st Edition) 대응전략

㈜에스피아이디

FMEA Module Ver 2.0

- 목 차 -

AIAG-VDA FAILURE MODE AND EFFECTS ANALYSIS (FMEA) Handbook

First Edition

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Published by:

Automotive Industry Action Group

26200 Lahser Road, Suite 200

Southfield, Michigan 48033

Phone: (248) 358-3570 • Fax: (248) 358-3253

APPROVAL STATUS

The AIAG Materials Management Steering Committee and designated stakeholders approved this document for publication on ***Pending Release Date***.

ISBN#:

ACKNOWLEDGEMENTS

The AIAG Quality Steering Committee and the VDA QMA would like to recognize and thank the following companies for the commitment towards the improvement of the FMEA methodology and their contributions of resources during the AIAG-VDA FMEA Handbook project.

Work Group Members

Audi AG
Continental Teves AG
Daimler AG
Daimler Truck North America
FCA US LLC
Ford Motor Company
General Motors
Honda of America Mfg., Inc.
Knorr-Bremse Systeme fur Nutzfahrzeuge GmbH
Nexteer Automotive
ON Semiconductor
Robert Bosch GmbH
Schaeffler Technologies AG & Co KG
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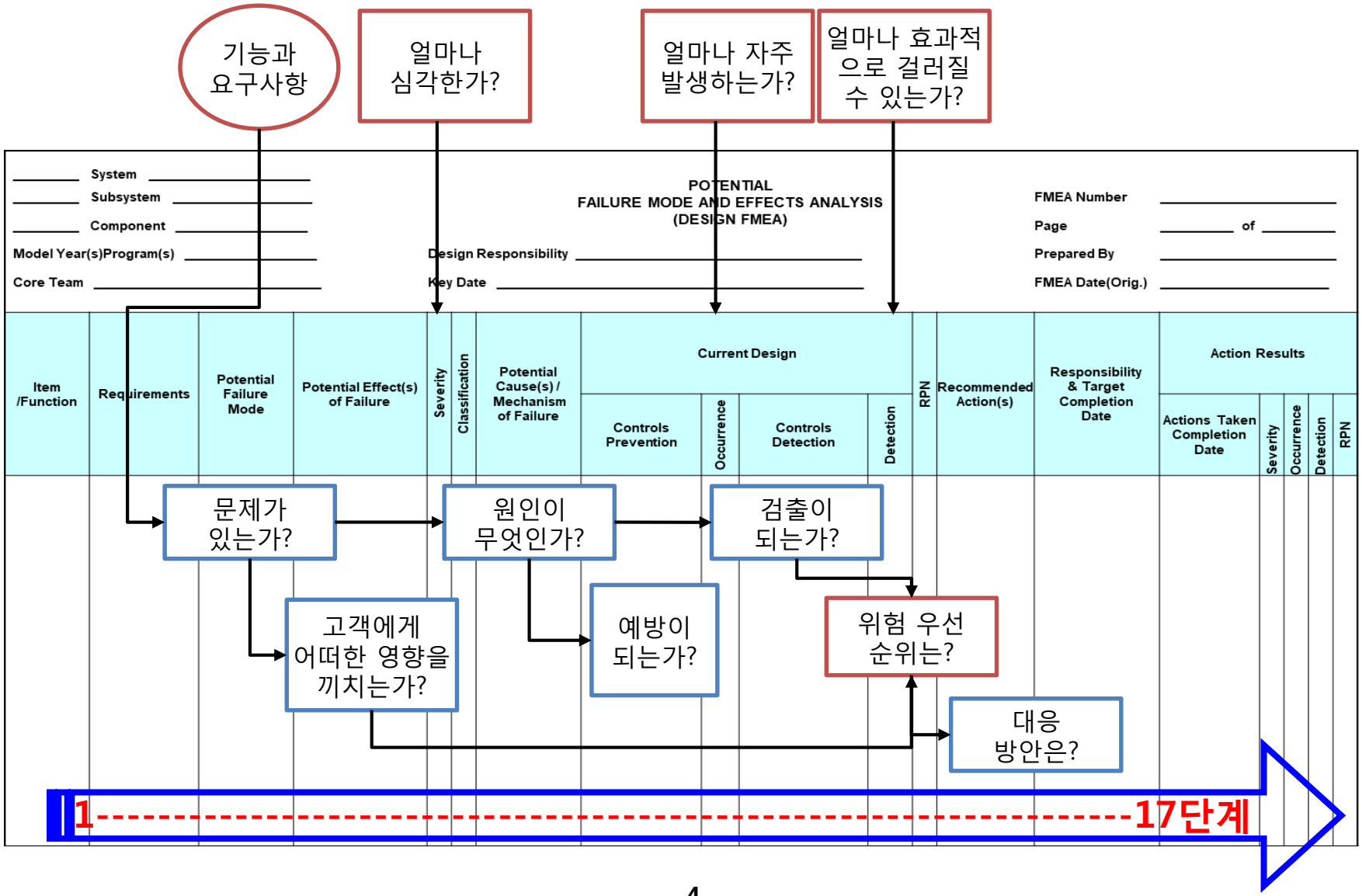
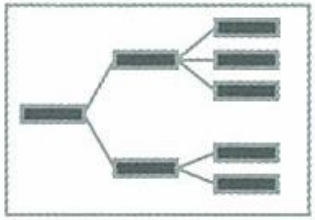
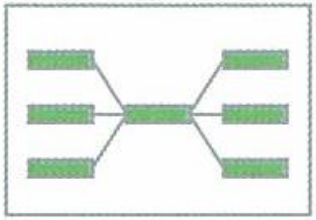
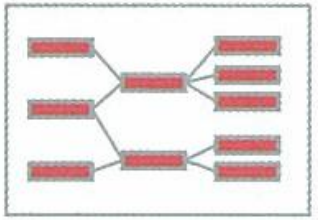
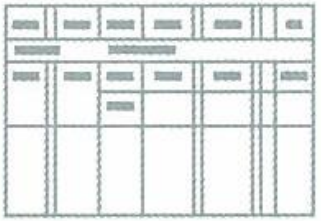
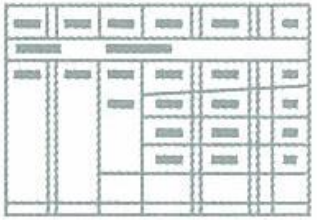
1. 현재 AIAG-FMEA(4th : 2008)



1. 현재 VDA-FMEA(2th : 2012)

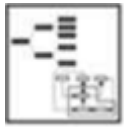
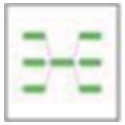
The Five Steps for the Preparation of the FMEA

System Analysis | **Risk Analysis and Actions**

1st Step	2nd Step	3rd Step	4th Step	5th Step
Structure Analysis	Function Analysis	Failure Analysis	Actions Analysis	Optimization
				
• Record and structure the involved elements • Create system structure	• Assign functions to the structure elements • Link functions	• Assign failures to the functions • Link failures	• Document current avoidance and detection actions • Evaluate current status	• Reduce risk with additional actions • Evaluate changed status

2. New FMEA 전개방법

DFMEA는 6단계로 구성되어 있고 FMEA를 수행하기 위해서 6단계를 체계적으로 접근하고 기술적 위험 분석 기록을 알 수 있음.

System Analysis			Failure Analysis and Risk Mitigation		
1st Step Score Definition	2st Step Structure Analysis	3st Step Function Analysis	4st Step Failure Analysis	5st Step Risk Analysis	6st Step Optimization
					
Project identification	System structure for a product or elements of a process	Overview of the functionality of the product or process	Establishment of the failure chain (potential Failure Effects, Failure Modes, Failure Causes) for each product or process function (step)	Assignment of Prevention Controls (existing and/or planned) to the Failure Causes and Failure Modes	Identification of the actions necessary to reduce risks
Project plan	Visualization of the analysis scope using a structure tree or equivalent: block diagram, boundary diagram, digital model, physical parts, or process flow diagram	Visualization of product or process functions using a function tree (function net), function matrix parameter diagram or process flow diagram	Visualization of product or process failure relationships (failure nets and/or the FMEA worksheet)	Assignment of detection controls (existing and/or planned) to the Failure Causes and Failure Modes	Assignment of responsibilities and deadlines for action implementation
Analysis boundaries: What is included and excluded from the analysis	Identification of design interfaces, interactions, close clearances, or process steps	Association of requirements or characteristics to functions and functions to system or process elements	Creation of failure structures by linking the failures in the failure chain	Rating of Severity, Occurrence and Detection for each failure chain	Implementation and documentation of actions taken
Identification of baseline FMEA with lessons learned		Cascade of customer (external and internal) functions with associated requirements	Identification of product noise factors or process sources of variation (4M) using a fishbone diagram, parameter diagram, or failure network Collaboration between customer and supplier (Failure Effects)	Collaboration between customer and supplier (Severity) Action Priority (AP)	Confirmation of the effectiveness of the implemented actions Assessment of risk after actions taken Continuous improvement of the product and process
Basis for the Structure Analysis step	Basis for the Function Analysis step	Basis for the Failure Analysis step	Basis for the record of failures in the FMEA form and the Risk Analysis step	Basis for the product or process Optimization step	Basis for refinement of the product and/or process requirements and prevention / detection controls

2. New FMEA 전개방법

[DFMEA Spreadsheet Failure Structure]

STRUCTURE ANALYSIS(STEP2)			FUNCTION ANALYSIS(STEP3)			FAILURE ANALYSIS(STEP4)			
1. Next Higher Level	2. Focus Element	3. Next Lover Level or Characteristic Type(Geometry, Material, Coating, etc)	1. Next Higher Level Function and Requirement	2. Focus Element Function and Requirement	3. Next Lover Level Function and Requirement or Characteristic	1. Failure Effects(FE) to the Next Higher Level Element and or Vehicle user	Severity(S) of FE	2. Failure Mode(FM) of the Focus Element	3. Failure Cause(FC) of the Next Lover Element or Characteristic
Window Lifter Motor	Electrical Motor	Brush Card Base Body	Convert electrical energy into mechanical energy(acc..control signal)	Commutation system transports the electrical current between coil pairs of the electro magnetic converter	Brush card body transports forces between spring and motor body to hold the brush spring system x, y, z position(support commutating contact point)	Torque and rotating velocity of the window lifter motor too low	6	Commutation system intermittently connects the wrong coils(L1, 3 and 2 instead of L1, 2 and 3), resulting in angle deviation	Brush card body bends in contact area of the carbon brush, due to too low stiffness in carbon brush contact area

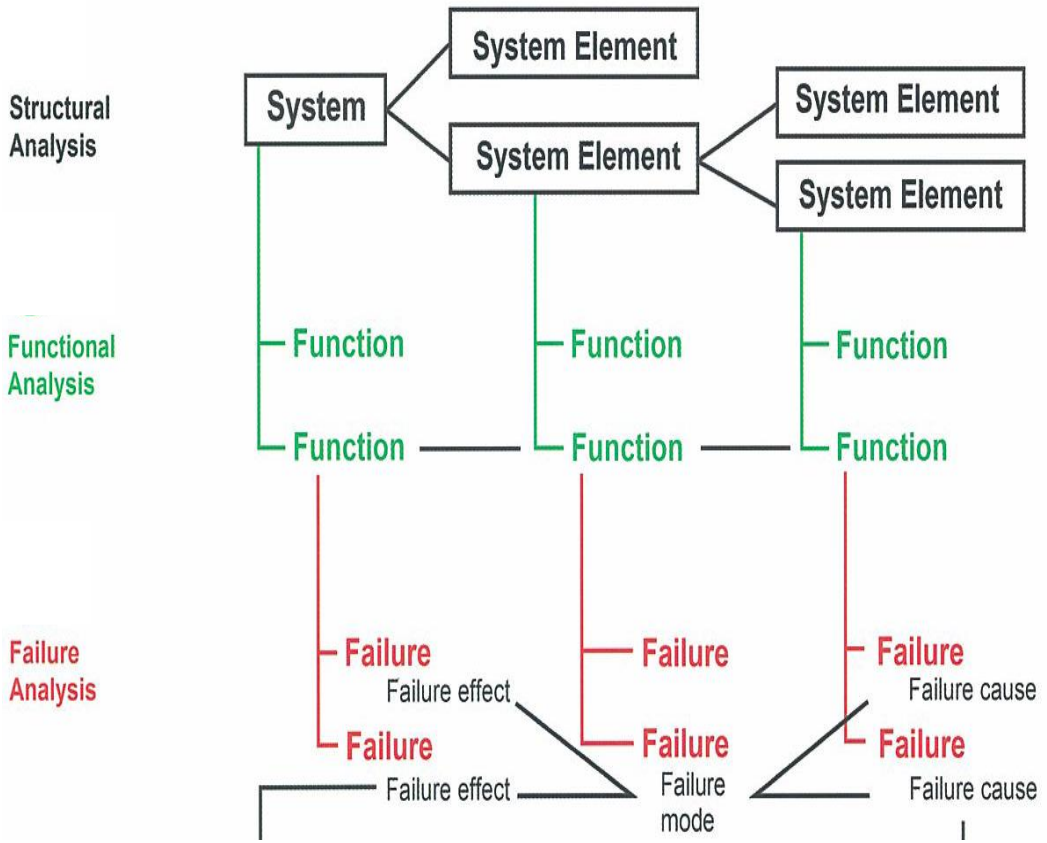
2. New FMEA 전개방법

STRUCTURE ANALYSIS(STEP2)		
1. Next Higher Level	2. Focus Element	3. Next Lover Level or Characteristic Type(Geometry, Material, Coating, etc)
Window Lifter Motor	Electrical Motor	Brush Card Base Body

FUNCTION ANALYSIS(STEP3)		
1. Next Higher Level Function and Requirement	2. Focus Element Function and Requirement	3. Next Lover Level Function and Requirement or Characteristic
Convert electrical energy into mechanical energy(acc..control signal)	Commutation system transports the electrical current between coil pairs of the	Brush card body transports forces between spring and motor body to hold the brush spring

FAILURE ANALYSIS(STEP4)			
1. Failure Effects(FE) to the Next Higher Level Element and or Vehicle user	Severity(S) of FE	2. Failure Mode(FM) of the Focus Element	3. Failure Cause(FC) of the Next Lover Element or Characteristic
Torque and rotating velocity of the window lifter motor too low	6	Commutation system intermittently connects the wrong coils(L1, 3 and 2 instead of L1, 2 and 3), resulting in angle deviation	Brush card body bends in contact area of the carbon brush, due to too low stiffness in carbon brush contact area

[DFMEA Spreadsheet Failure Structure]



2.1 Design FMEA 1st Step: Scope Definition

Design Failure Mode and Effects Analysis(DESIGN FMEA)

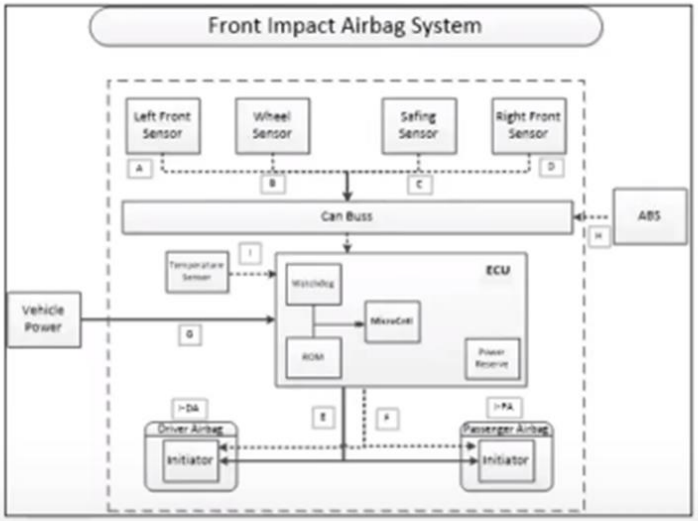
SCOPE DEFINTION(STEP1)

Company Name :	Name of Company responsible for DFMEA	**Subject :**	Name of DEMEA project	**DFMEA ID Number :**	Determined by company
Engineering Location :	Geographical location	**DFMEA Start Date :**	Date DFMEA project started	**Design Responsibility :**	Name of DFMEA owner
Customer Name :	Name of customer(s) or [Product Family)	**DFMEA Revision Date :**	Latest revision date	**el :**	[Business Use, Confidential, Proprietary, etc..]

1st Step: Scope Investigation

5Ts

- FMEA Team
  - Who needs to be on the team?
- FMEA Timing
  - When is this due?
- FMEA Intent
  - Why are we here?
- FMEA Task
  - What work needs to be done?
- FMEA Tool
  - How to conduct analysis?



2.2 Design FMEA 2st Step: Structure Analysis

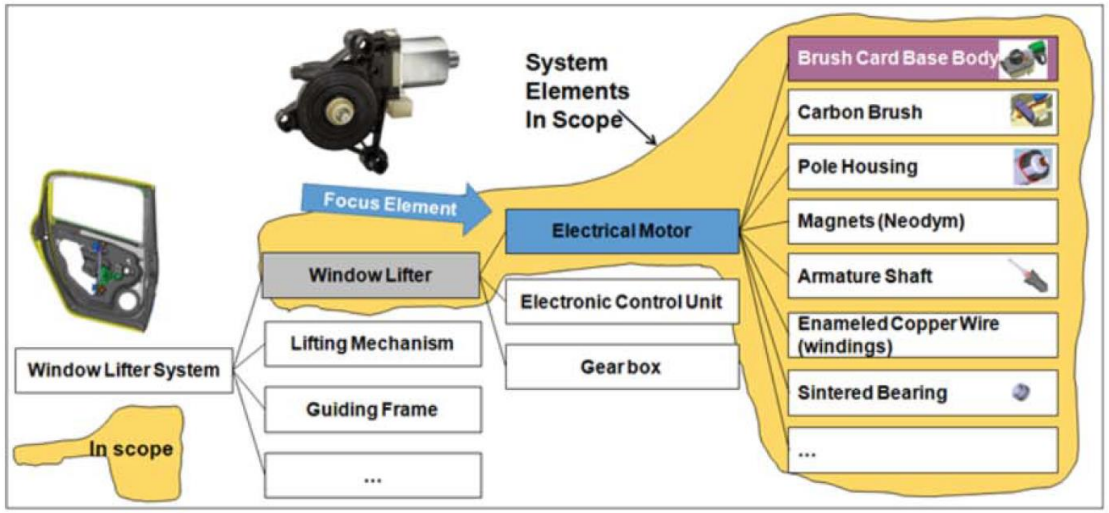
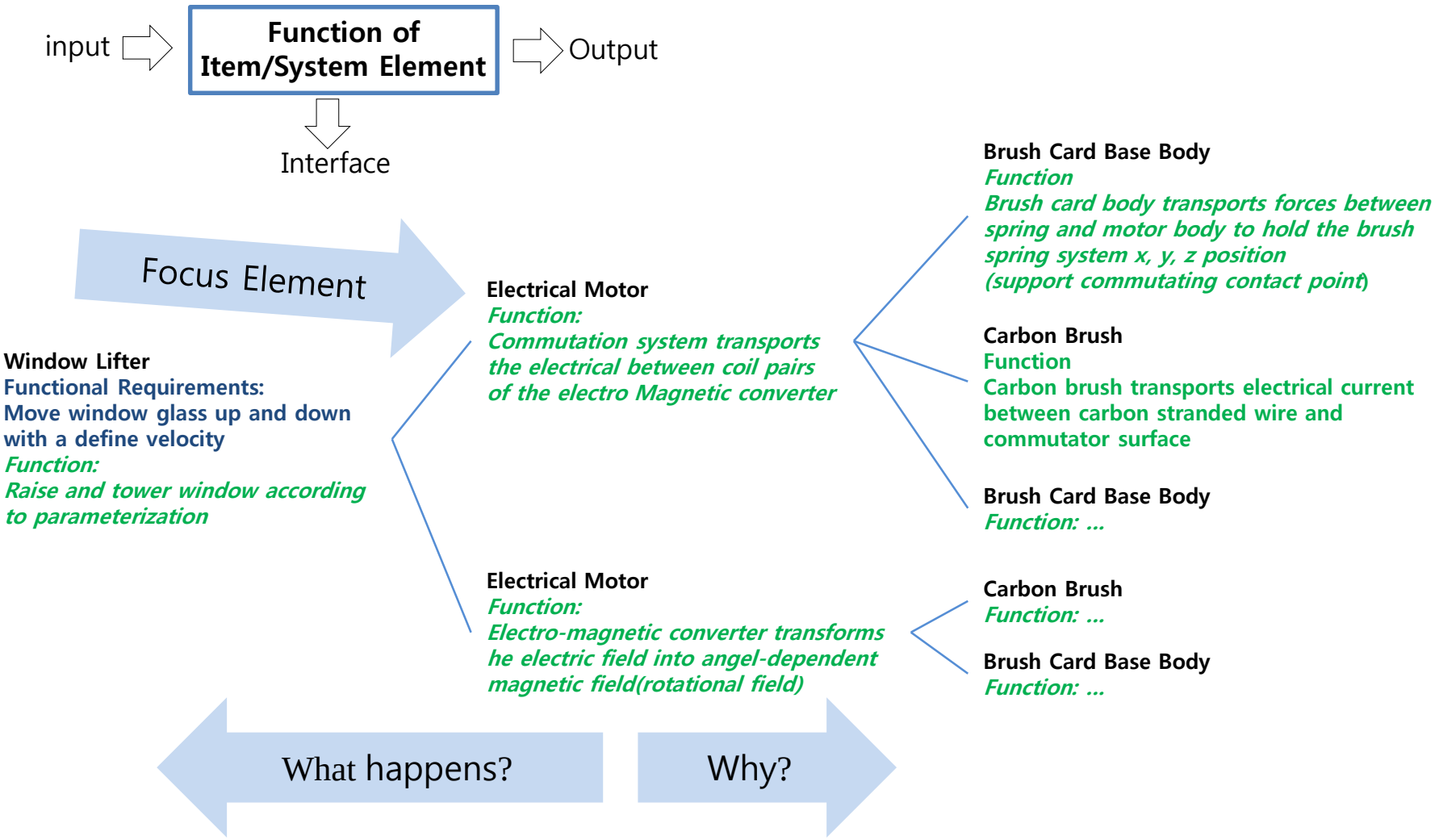


Figure 2.2-2 Example of Structure Analysis using a Structure Tree

STRUCTURE ANALYSIS(STEP2)		
1. Next Higher Level	2. Focus Element	3. Next Lover Level or Characteristic Type(Geometry, Material, Coating, etc)
Window Lifter	Electrical Motor	Brush Card Base Body

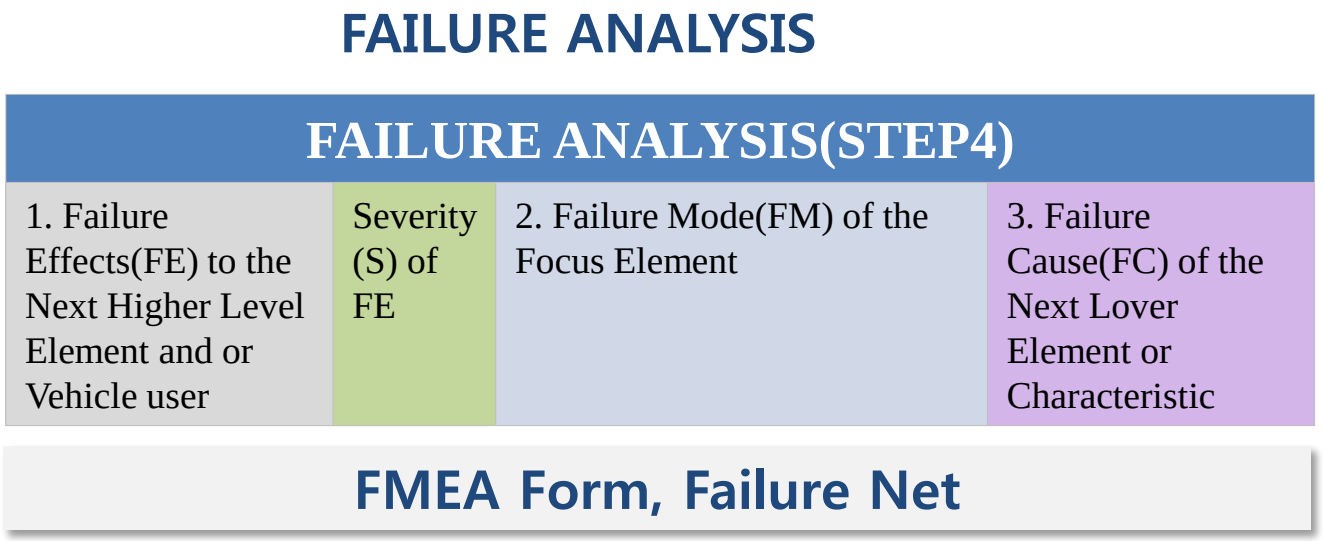
2.3 Design FMEA 3st Step: Function Analysis



[Example of Function Analysis using a Structure Tree]

2.4 Design FMEA 4st Step: Failure Analysis (1/4)

Visualization of the Failure Analysis



2.4 Design FMEA 4st Step: Failure Analysis (2/4)

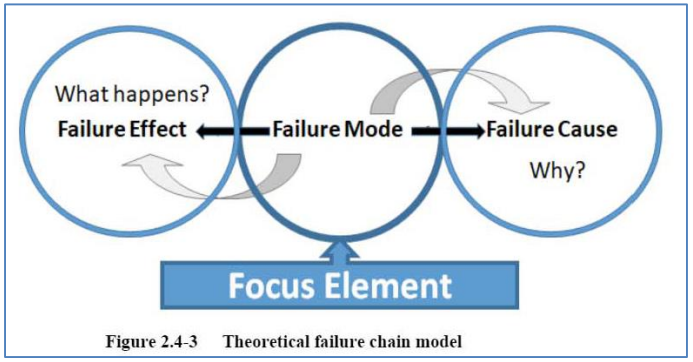
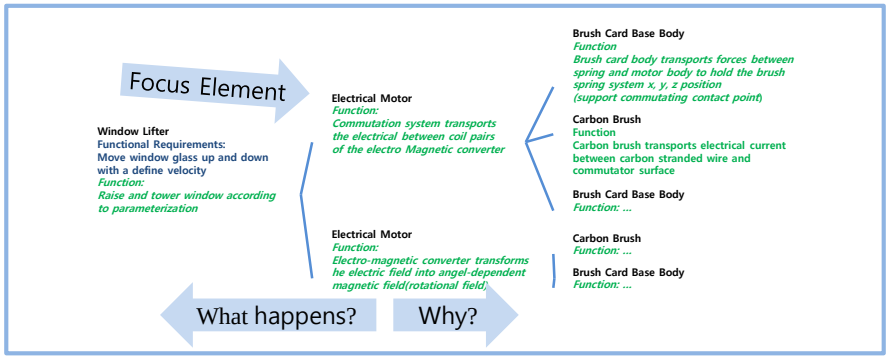


Figure 2.4-3 Theoretical failure chain model



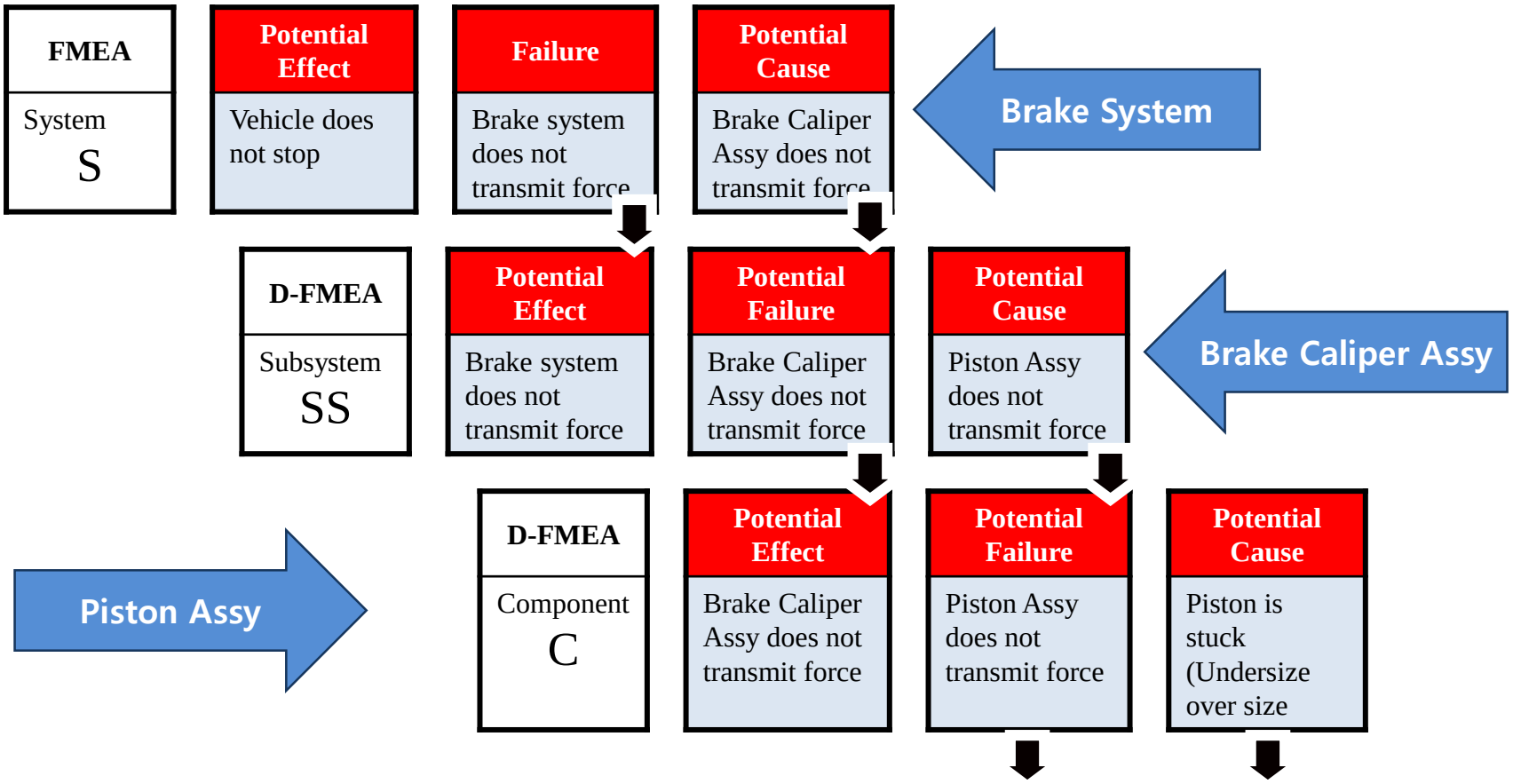
DFMEA Interfaces

Analysis Level	FMEA at Level 1	FMEA at Level 2	FMEA at Level 3	Element (Item/Station)	Failures
Product	FE			Window Lifter System	Window lifting speed to low
System element	FM	FE		Window Lifter FE	Torque and rotating velocity of the window lifter motor too low
Sub-System Element	FC	FM	FE	Electrical Motor FM (Focus Element)	Commutation system intermittently connects the wrong coils (L1, 3 and 2 instead of L1,2 and 3)
Component Element		FC	FM	Brush Card Base Body FC	Carbon brush transports too little current due to high resistance to the commutator surface
(Design) Feature characteristic			FC	Distance brush to commutator	

[Failure Structure at different levels]

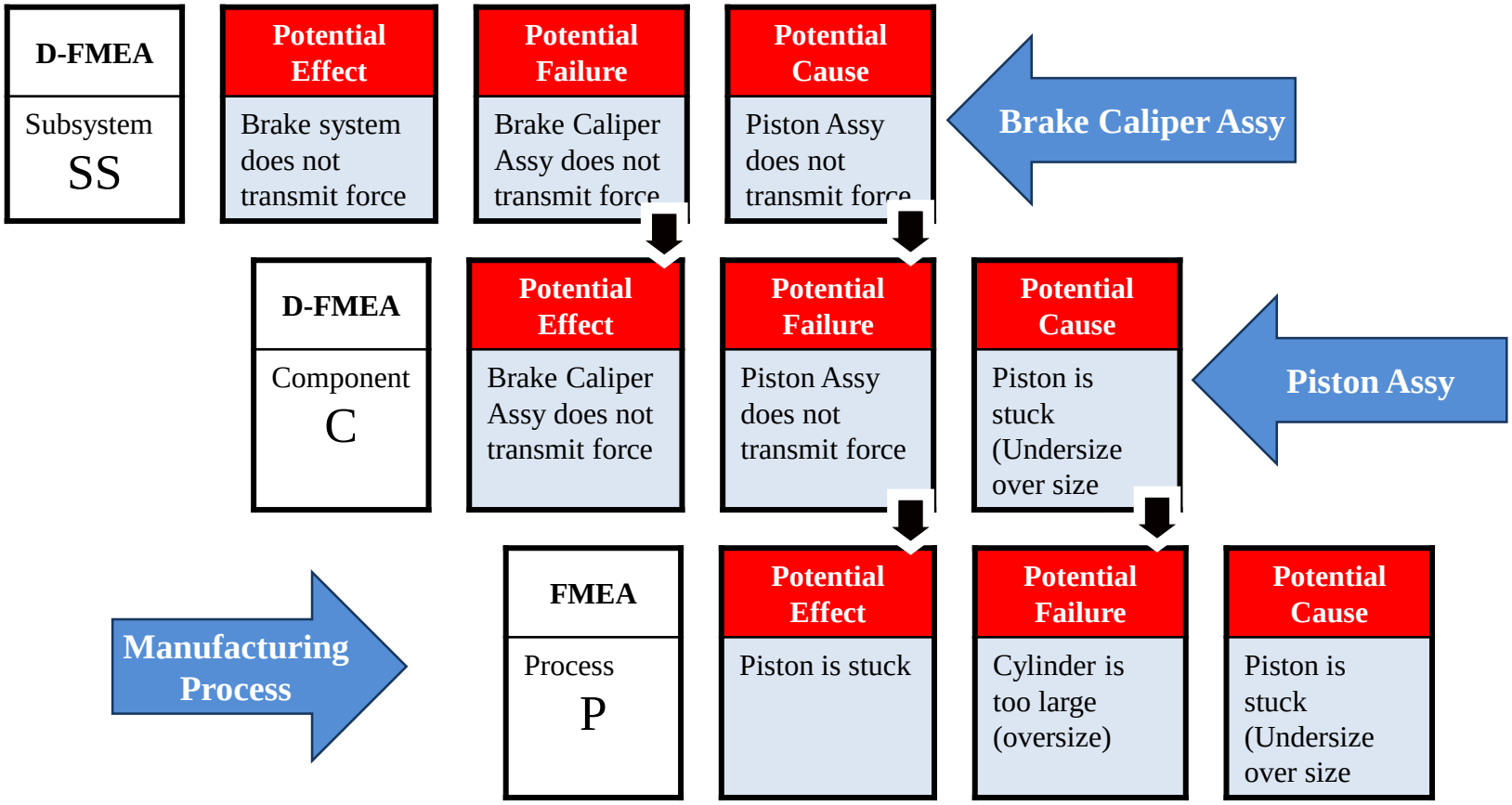
2.4 Design FMEA 4st Step: Failure Analysis (3/4)

FMEA Failure Analysis : Relationships



2.4 Design FMEA 4st Step: Failure Analysis (4/4)

FMEA Failure Analysis : Relationships



2.5 Design FMEA 5st Step: Risk Analysis

[Prevention and Detection in the Design FMEA]

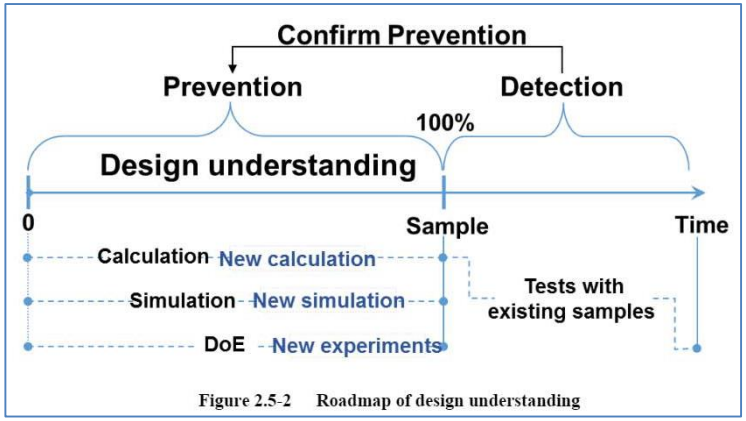


Figure 2.5-2 Roadmap of design understanding

Design element determined

PC:
Review & reaction
Before decision,
e.g. CAE, tolerance study

PC:
Theoretical tests
e.g. DoE, FEA

Ascertain and decide on design

Trial
Component, product, system trials

DC:
-Good/Bad inspection
-Inspection for failures
-Function test over service life, e.g. trend analysis

PC (Preventive) : Preventive actions
DC (reactive) : Detective actions

Design Failure

Time

2.5 Design FMEA 5st Step: Risk Analysis > 평가기준

Product General Evaluation Criteria Severity S	
Potential Failure Effects rated according to what the End User mi	Blank until filled
SEV	S
10	Affects safe op other vehicles passenger(s) o
9	Noncompliance
8	Loss of essent for normal driv life.

Occurrence Potential O for the Product Design				
	Occurrence criteria for potential Failure Causes resulting in the Failure Mode, considering Prevention Controls, rated for the intended service life of the item(Qualitative rating)	History of product usage with-	Use of Best Practices for product de-sign, Design Rules, Company Standards, Lessons Learned, Industry Standards, Material Specifications.	
OCC	Estimated Occurrence			
10	Occurrence during in-tended service life cannot be determined at this time, no preventive controls, or occurrence during intended service life of the item is	te op ur wi		

Table D3 DFMEA DETECTION

Detection Potential D for the Validation of the Product Design			
Detection Controls rated for each detection activity performed prior to delivery of the design for production. The timing of the detection control (before or after technical release) should also be considered as part of the detection rating.			
DET	Ability to Detect	Detection Criteria	Corporate or Product Line Examples
10	Absolute uncertainty	No test or test procedure.	
9	Very remote	Test procedure not designed to specifically detect the cause and/or failure mode.	
8	Remote	Ability of detection control to detect the failure cause or failure mode is remote based on verification or validation procedure, sample size, mission profile, etc.	
7	Very Low	Ability of detection control to detect the failure cause or failure mode is very low based on verification or validation procedure, sample size, mission profile, etc.	

2.5 Design FMEA 5st Step: Risk Analysis > Risk Action (1)

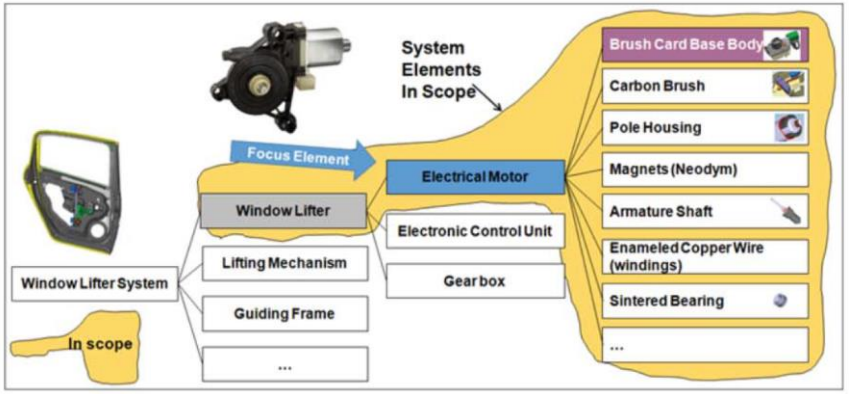
Priority High (H):	Highest priority for action. The team must either identify an appropriate action to improve prevention and / or detection controls or justify and document why current controls are adequate.
Priority Medium (M):	Medium priority for action. The team should identify appropriate actions to improve prevention and / or detection controls, or, at the discretion of the company, justify and document why controls are adequate.
Priority: Low (L)	Low priority for action. The team could identify actions to improve prevention or detection controls.

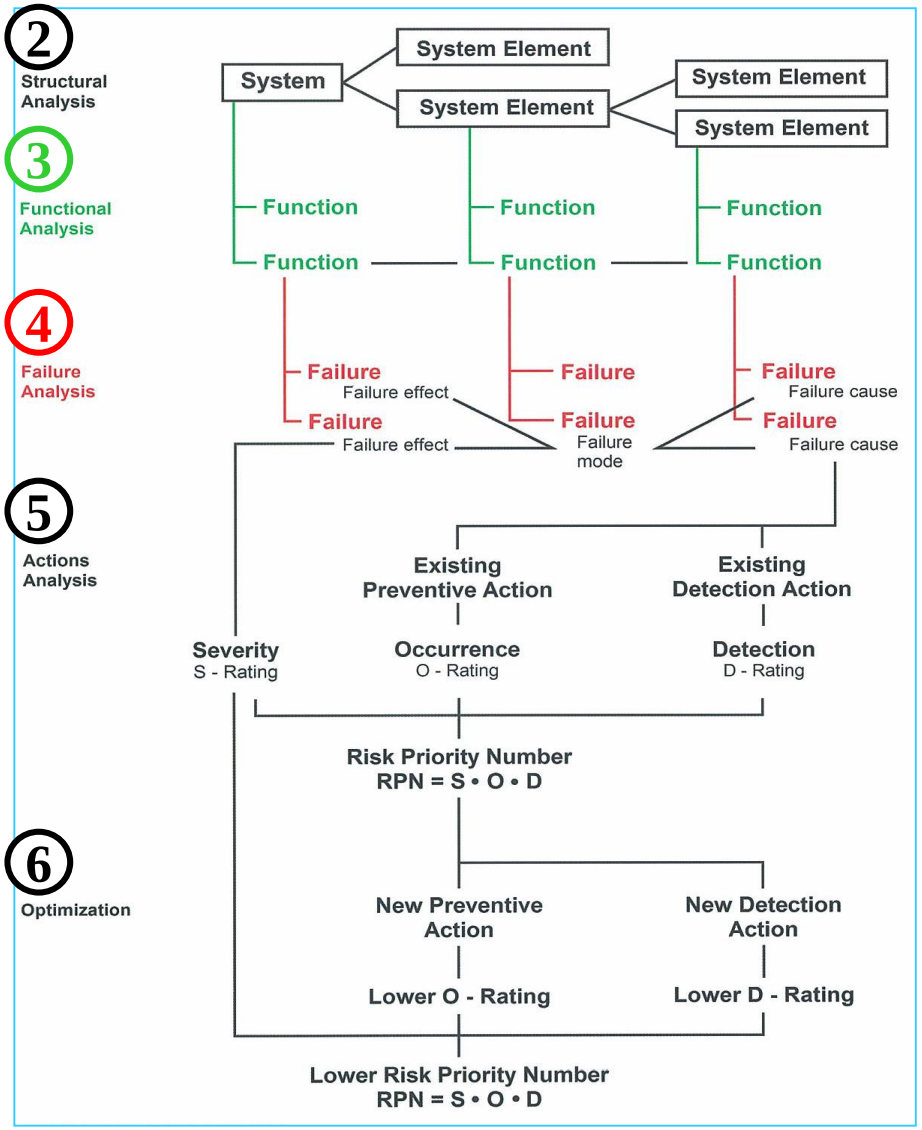
2.5 Design FMEA 5st Step: Risk Analysis > Risk Action (2)

S	O	D	AP	DFMEA Action Priority Logic
9-10	6-10	1-10	H	High priority due to safety and/or regulatory effects that have a **high** or **very high** occurrence rating
9-10	4-5	7-10	H	High priority due to safety and/or regulatory effects that have a **moderate** occurrence rating and **high** detection rating
9-10	4-5	5-6	H	High priority due to safety and/or regulatory effects that have a **moderate** occurrence rating and **moderate** detection rating
9-10	4-5	1-4	M	Medium priority due to safety and/or regulatory effects that have a **moderate** occurrence rating and **low** detection rating
9-10	1-3	7-10	H	High priority due to safety and/or regulatory effects that have a **low** occurrence and **high** detection rating
9-10	1-3	5-6	M	Medium priority due to safety and/or regulatory effects that have a **low** occurrence rating and **moderate** detection rating
9-10	1-3	1-4	L	Low priority due to safety and/or regulatory effects that have a **low** occurrence and **low** detection rating
5-8	8-10	2-10	H	High priority due to the loss or degradation of an essential or convenience vehicle function that has a **very high** occurrence rating
5-8	6-7	7-10	H	High priority due to the loss or degradation of an essential or convenience vehicle function that has **high** occurrence and **high** detection rating
5-8	6-7	5-6	H	High priority due to the loss or degradation of an essential or convenience vehicle function that has **high** occurrence and **moderate** detection rating
5-8	6-7	1-4	M	Medium priority due to the loss or degradation of an essential or convenience vehicle function that has a **high** occurrence and **low** detection rating
5-8	4-5	7-10	H	High priority due to the loss or degradation of an essential or convenience vehicle function that has a **moderate** occurrence rating and **high** detection rating
5-8	4-5	5-6	H	High priority due to the loss or degradation of an essential or convenience vehicle function that has a **moderate** occurrence rating and **moderate** detection rating
5-8	4-5	1-4	M	Medium priority due to the loss or degradation of an essential or convenience vehicle function that has a **moderate** occurrence and **low** detection rating
5-8	1-3	7-10	M	Medium priority due to the loss or degradation of an essential or convenience vehicle function that has a **low** occurrence and **high** detection rating
5-8	1-3	5-6	M	Medium priority due to the loss or degradation of an essential or convenience vehicle function that has a **low** occurrence and **moderate** detection rating

2.5 New Design FMEA Summary

① Scope Definition



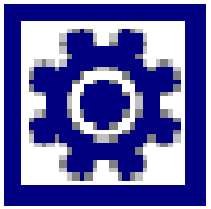


2.5 Design FMEA 5st Step: Risk Analysis > Action Priority(AP)

1.6.4 FMEA Tools

There are numerous FMEA software packages that can be used to develop a DFMEA and PFMEA as well as follow up on actions. This software ranges from dedicated FMEA software to standard spreadsheets customized to develop the FMEA. Companies may develop their own in-house database solution or purchase commercial software. In any case, the FMEA team must have knowledge of how to use the FMEA software for their project as required by the company and/or customer.

- 시중에는 조치분석으로 DFMEA와 PFMEA를 발전시킬 수 있는 다양한 FMEA 소프트웨어 패키지는 많습니다.
- 그 범위(다양성)는 FMEA 전용 소프트웨어에서 FMEA 개발을 위한 개별 맞춤화 된 표준 스프레드시트 등 다양합니다.
- 회사는 자체 데이터베이스 솔루션을 개발하거나 상용 소프트웨어를 구매할 수 있습니다.
- **어떠한 경우에도 FMEA 팀은 회사 및 고객이 요구하는 대로 프로젝트 별로 FMEA 소프트웨어의 사용 방법을 알고 있어야 합니다.**

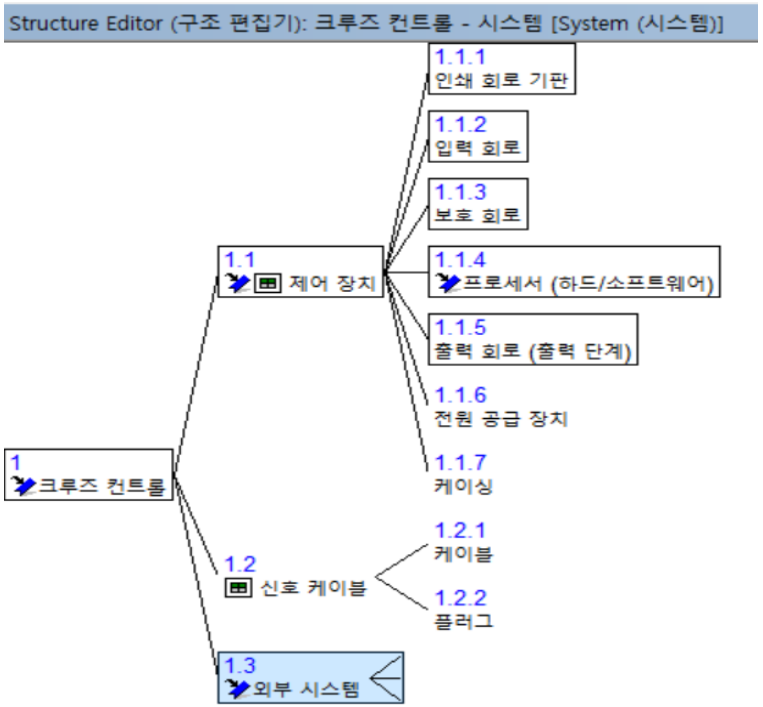


IQ FMEA

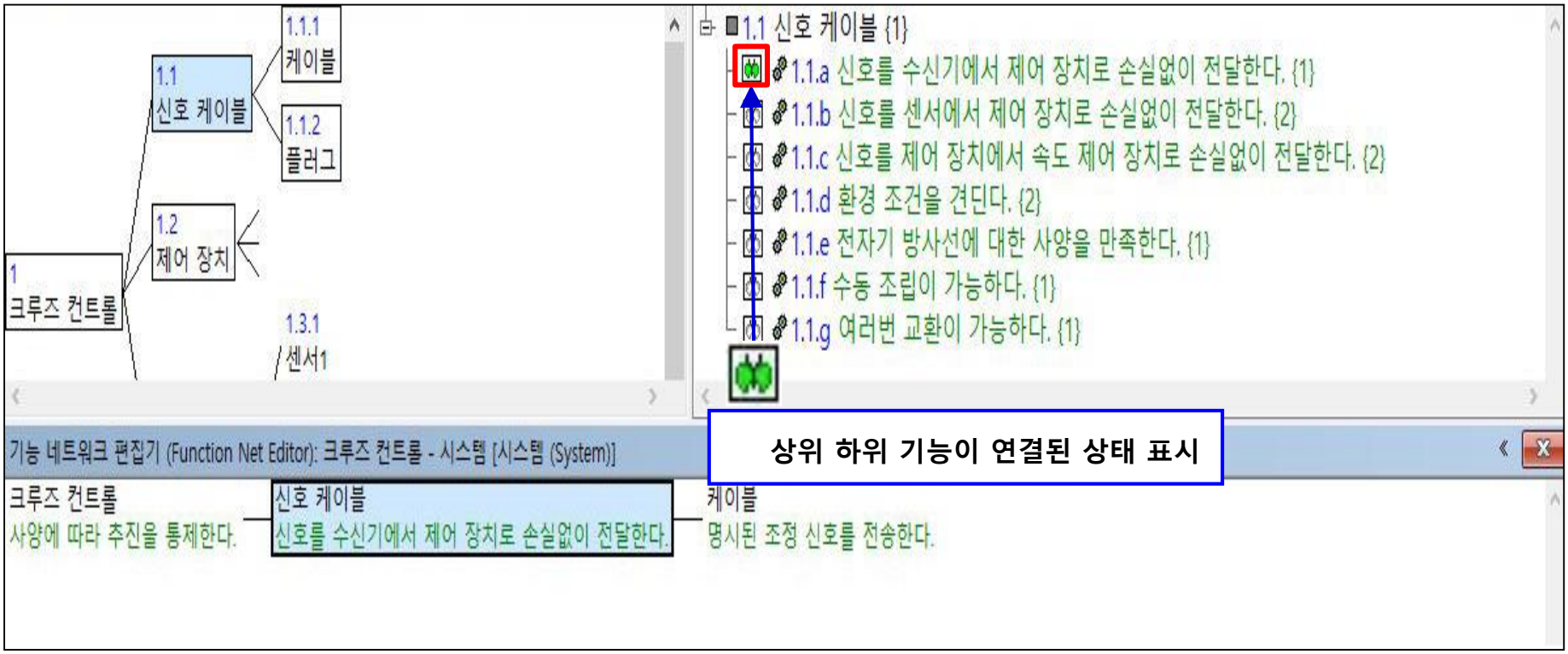
1단계 : Scope Definition

	Design F M E A 크루즈 컨트롤 System	Number (번호): 1.1 Page (페이지):
System (시스템): X Subsystem (하위 ... X Component (구성 ... X		
Item (아이템): 크루즈 컨트롤 - 시스템	Design responsibility (설계 책임): 박창도	Prepared by (준비한 사람): 홍영희, 김원영
Model year(s)/vehicle(s) (모델 연도(들)/자동차(들)): 제어 장치	Completion date (완료 날짜): 2018.09.13	Created (생성됨): 2018-09-01 Modified (수정됨): 2018-09-09
Team (팀): 솔루션 팀		

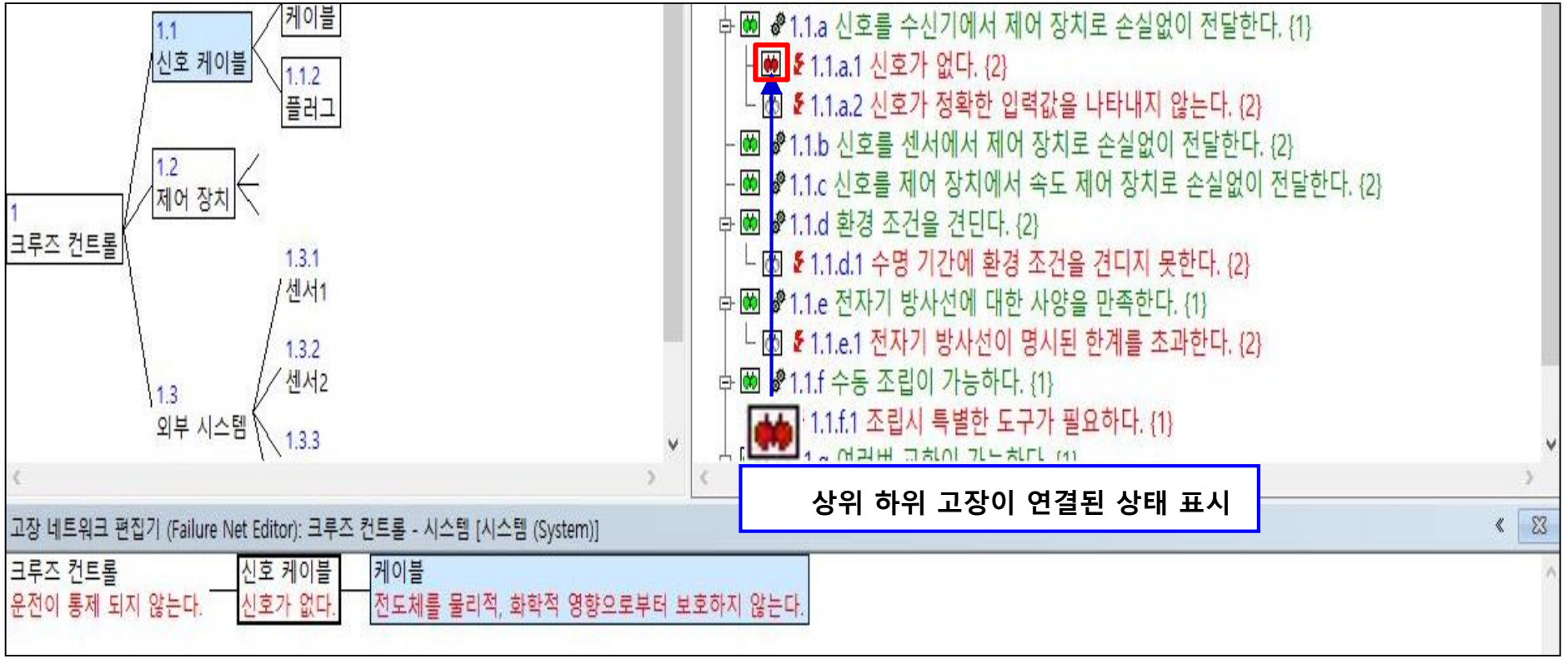
2단계 : Structure Analysis



3단계 : Function Analysis



4단계 : 고장 분석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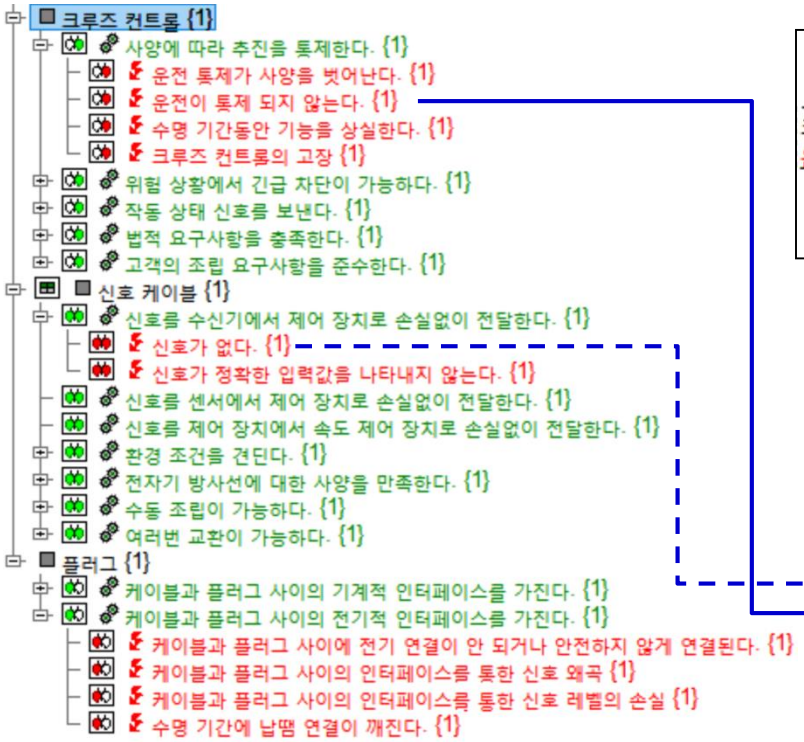
크루즈 컨트롤
1.1
신호 케이블
케이블
1.1.2
플러그
1.2
제어 장치
1.3
외부 시스템
1.3.1
센서1
1.3.2
센서2
1.3.3
1.1.a 신호를 수신기에서 제어 장치로 손실없이 전달한다. {1}
1.1.a.1 신호가 없다. {2}
1.1.a.2 신호가 정확한 입력값을 나타내지 않는다. {2}
1.1.b 신호를 센서에서 제어 장치로 손실없이 전달한다. {2}
1.1.c 신호를 제어 장치에서 속도 제어 장치로 손실없이 전달한다. {2}
1.1.d 환경 조건을 견딘다. {2}
1.1.d.1 수명 기간에 환경 조건을 견디지 못한다. {2}
1.1.e 전자기 방사선에 대한 사양을 만족한다. {1}
1.1.e.1 전자기 방사선이 명시된 한계를 초과한다. {2}
1.1.f 수동 조립이 가능하다. {1}
1.1.f.1 조립시 특별한 도구가 필요하다. {1}
상위 하위 고장이 연결된 상태 표시
고장 네트워크 편집기 (Failure Net Editor): 크루즈 컨트롤 - 시스템 [시스템 (System)]
크루즈 컨트롤
운전이 통제 되지 않는다.
신호 케이블
신호가 없다.
케이블
전도체를 물리적, 화학적 영향으로부터 보호하지 않는다.

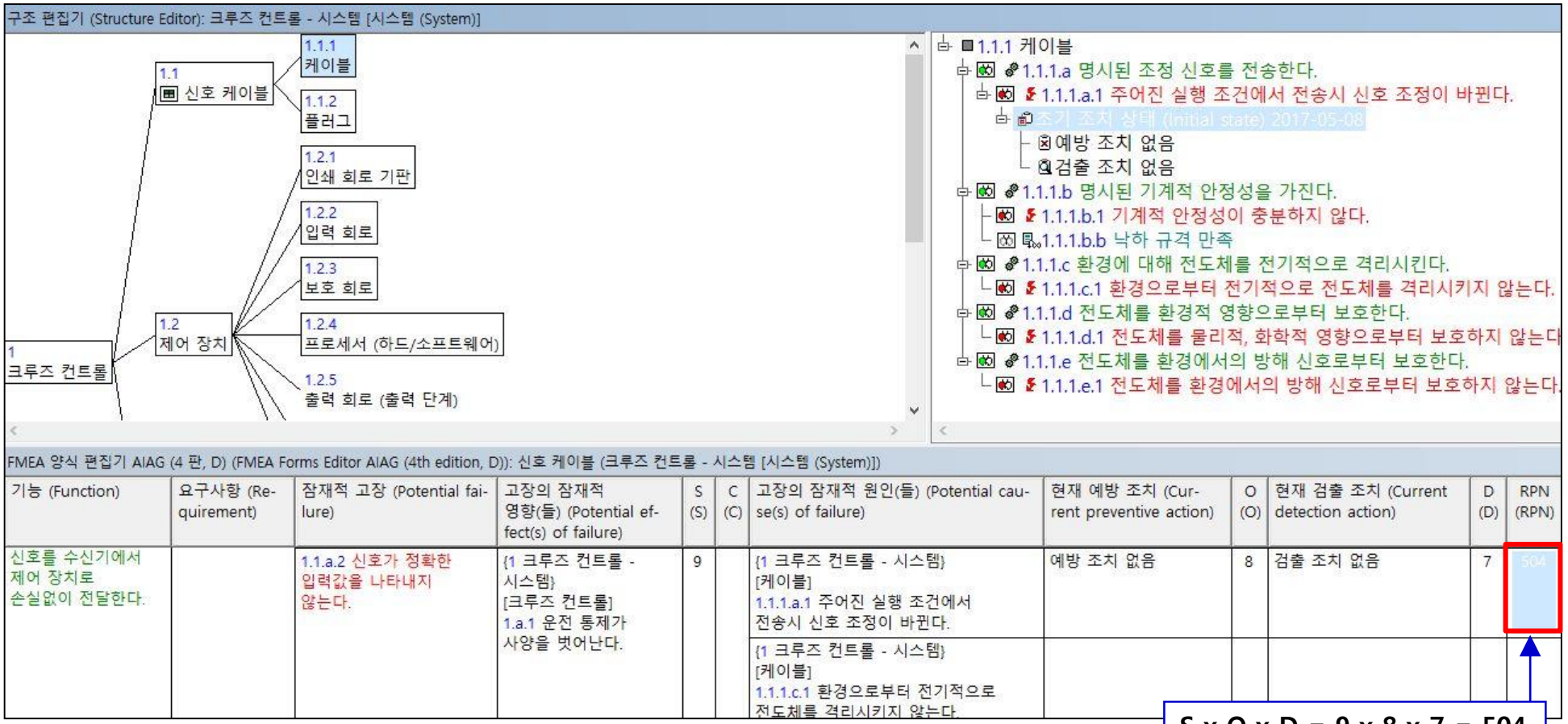
4단계 : 고장 분석



양식 에디터 AIAG (4 쇄, D) (FMEA Forms Editor AIAG (4th edition, D)): 신호 케이블 (크루즈 컨

기능 (Function)	요구 (Requirement)	가능 오류 (Potential failure)	오류의 가능한 효과(들) (Potential effect(s) of failure)	S (S)	C (C)	오류의 가능한 원인(들) (Potential cause(s) of failure)	현재 예방 조치 (Current preventive ... tion)
신호를 수신기에서 제어 장치로 손실없이		1.2.a.1 신호가 없다.	[크루즈 컨트롤] 1.a.2 운전이 통제 되지 않는다.			[플러그] 1.2.2.b.1 케이블과 플러그 사이에 전기 연결이 안 되거나 안전하지 않게 연결된다.	

5단계 : Risk Analysis



- S 값이 2개 이상인 경우, 가장 높은 값을 선택하여 RPN 자동 계산

5단계 : Risk Analysis > Risk Matric

통계 편집기 (Statistics Editor): 리스크 매트릭스 (Risk matrix)

리스크 매트릭스 (Risk matrix)

S (S) xO (O)	번호 (Number)	FMEA-양식 (FMEA form)	시스템 요인 (System element)	기능 (Function)	오류 기능 (Failure)	오류 결과들 (Effects)	C (C)	오류 원인 (Cause)	RPN (RPN)	예방 조치 (Preventive action)	발견 조치 (Detection action)
(7; 10)	2	플러그	와이어와 핀 사이의 납땜 연결	명시된 기계적 안정성을 가진다.	기계적 안정성이 충분하지 않다.	잡는 힘이 너무 약하다.		단면이 너무 작거나 부적절한 기계적 핀의 기하학적 구조	700	FEM 시뮬레이션	프로토타입으로 테스트
						케이블과 플러그 사이에 전기 연결이 안 되거나 안전하지 않게 연결된다.					
		신호 케이블	신호 케이블	신호를 수신기에서 제어 장치로 손실없이 전달한다.	신호가 없다.	운전이 통제되지 않는다.		케이블과 플러그 사이에 전기 연결이 안 되거나 안전하지 않게 연결된다.	700	없음	없음
(7;	3	신호 케이블	신호 케이블	실행 조건과	신호가 없다.	운전이 통제		환경으로부터	(34		현재 알려진

6단계 : Optimization

① 추천 조치 내용이 실행된 조치 칸 으로 이동

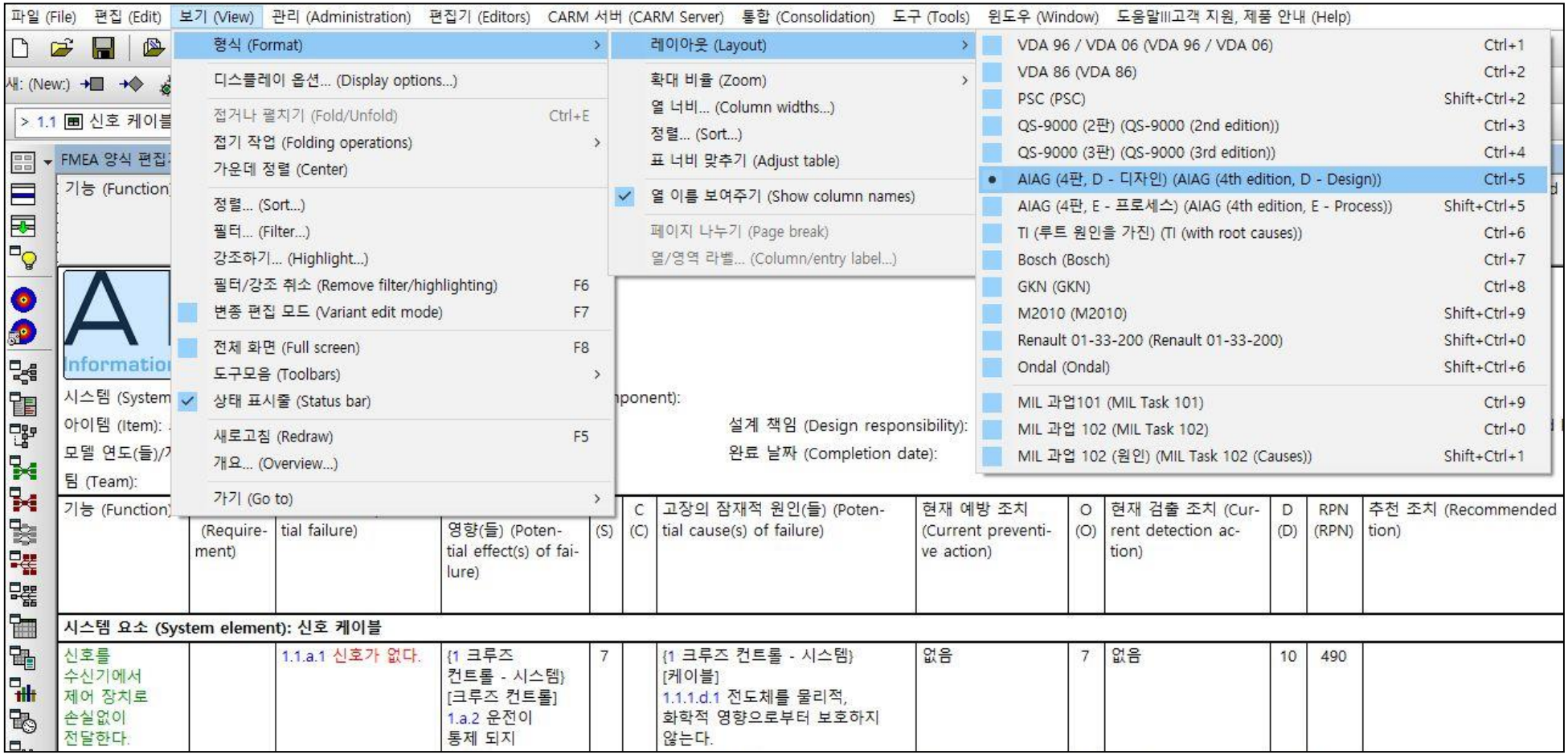
FMEA 양식 편집기 AIAG (4 판, D) (FMEA Forms Editor AIAG (4th edition, D)): 신호 케이블 (크루즈 컨트롤 - 시스템 [시스템 (System)])

기능 (Function)	요구사항 (Requirement)	잠재적 고장 (Potential failure)	고장의 잠재적 영향(들) (Potential effect(s) of failure)	S (S)	C (C)	고장의 잠재적 원인(들) (Potential cause(s) of failure)	현재 예방 조치 (Current preventive action)	O (O)	현재 검출 조치 (Current detection action)	D (D)	RPN (RPN)	추천 조치 (Recommended action)	책임자/마감일 (R/D)	실행된 조치 (Action taken)	S (S)	O (O)	D (D)	RPN (RPN)
신호를 수신기에서 제어 장치로 손실없이 전달한다.		1.1.a.2 신호가 정확한 입력값을 나타내지 않는다.	{1 크루즈 컨트롤 - 시스템} [크루즈 컨트롤] 1.a.1 운전 통제가 사양을 벗어난다.	9		{1 크루즈 컨트롤 - 시스템} [케이블] 1.1.1.a.1 주어진 실행 조건에서 전송시 신호 조정이 바뀐다.	예방 조치 없음	8	검출 조치 없음	7	504	D: (D:) 현재 알려진 실행 조건에서 전송 시뮬레이션을 한다.	홍, 길동, 연구소, 책임 2017-05-11 수정 단계 (in progress)		9	8	7	(504)
						{1 크루즈 컨트롤 - 시스템} [케이블] 1.1.1.c.1 환경으로부터 전기적으로 전도체를 격리시키지 않는다.												
						{1 크루즈 컨트롤 - 시스템} [케이블] 1.1.1.e.1 전도체를 환경에서의 방해 신호로부터 보호하지 않는다.												
						{1 크루즈 컨트롤 - 시스템} [플러그]												

기능 (Function)	요구사항 (Requirement)	잠재적 고장 (Potential failure)	고장의 잠재적 영향(들) (Potential effect(s) of failure)	S (S)	C (C)	고장의 잠재적 원인(들) (Potential cause(s) of failure)	현재 예방 조치 (Current preventive action)	O (O)	현재 검출 조치 (Current detection action)	D (D)	RPN (RPN)	추천 조치 (Recommended action)	책임자/마감일 (R/D)	실행된 조치 (Action taken)	S (S)	O (O)	D (D)	RPN (RPN)
신호를 수신기에서 제어 장치로 손실없이 전달한다.		1.1.a.2 신호가 정확한 입력값을 나타내지 않는다.	{1 크루즈 컨트롤 - 시스템} [크루즈 컨트롤] 1.a.1 운전 통제가 사양을 벗어난다.	9		{1 크루즈 컨트롤 - 시스템} [케이블] 1.1.1.a.1 주어진 실행 조건에서 전송시 신호 조정이 바뀐다.	예방 조치 없음	8	검출 조치 없음	7	504		홍, 길동, 연구소, 책임 2017-05-11 완료됨 (completed)	D: (D:) 현재 알려진 실행 조건에서 전송 시뮬레이션을 한다.	9	8	7	504
						{1 크루즈 컨트롤 - 시스템} [케이블] 1.1.1.c.1 환경으로부터 전기적으로 전도체를 격리시키지 않는다.												
						{1 크루즈 컨트롤 - 시스템} [케이블] 1.1.1.e.1 전도체를 환경에서의 방해 신호로부터 보호하지 않는다.												
						{1 크루즈 컨트롤 - 시스템} [플러그]												

② RPN 괄호 사라짐

6단계 : Optimization > FMEA 양식



제품명	APIS - IQ FMEA
국적	독일
기본 사상	독일 VDA 4. 미국 AIAG Manual
출시 년도	1992년
강점	ISO 26262 포함
	다국적 기업 사용
약점	한글지원 100%
언어	메뉴 언어: 10개국 작성 언어 : 5개국 FMEA 양식 언어 : 23개국
주요고객	국내 : 현대차, 쌍용차, LG전자, LG화학, 삼성SDI, 모비스, 만도, 케피코 국내 60여개 기업 사용 중 해외 : 1,500개 다국적 기업

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AIAG (4th edition)	VDA 86, 96, & 2006
MIL Task 101 / MIL Task 102	Fault tree analysis according to DIN
Deadline tracking according to VDA	Process flow diagrams & Control Plans (Production)
DRBFM forms (Design Review based on Failure Mode)	**ISO 26262:2011 (IQ-FMEA PRO / IQ-RM PRO Software)**
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CONTINENTAL Automotive	MAGNA Steyr	ThyssenKrupp Presta Steering
DAIMLER	MAHLE	TRW Automotive
EPCOS	MANN+HUMMEL	Vaillant
GKN Driveline	MIELE	VALEO
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