INCOSE International Symposium
Las Vegas, NV
June 30 - July 3, 2014

The Middle-out SE for Gay-Box Item &
Case Study of Automotive Lock Housing Assembly

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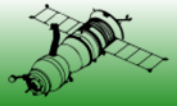
June 30, 2014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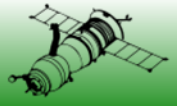
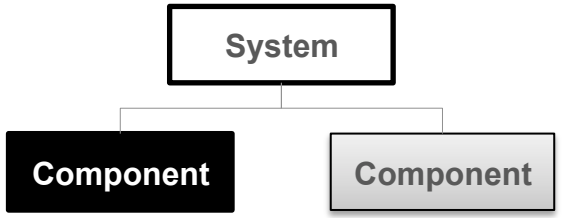
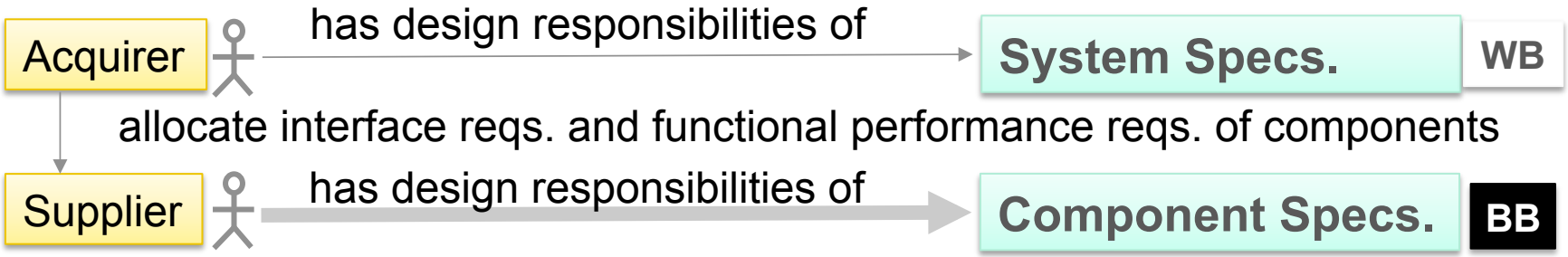
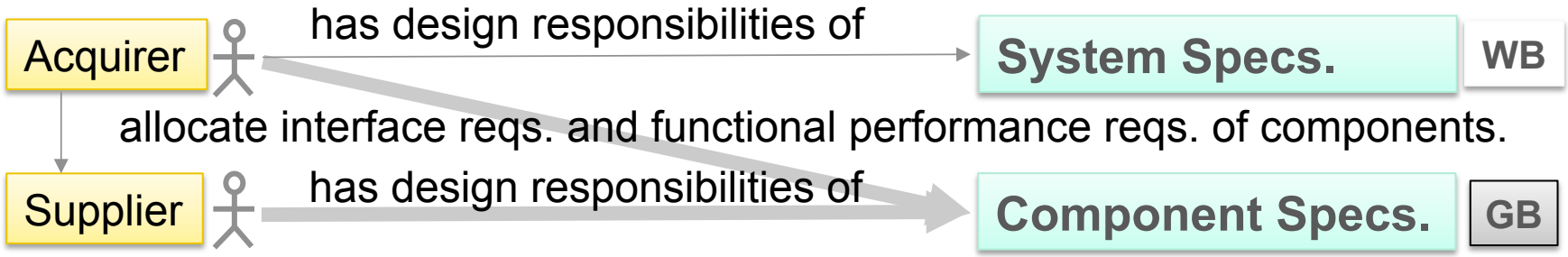



Whit Box, Gray Box & Black Box

Concept of Whit Box, Gray Box & Black Box items



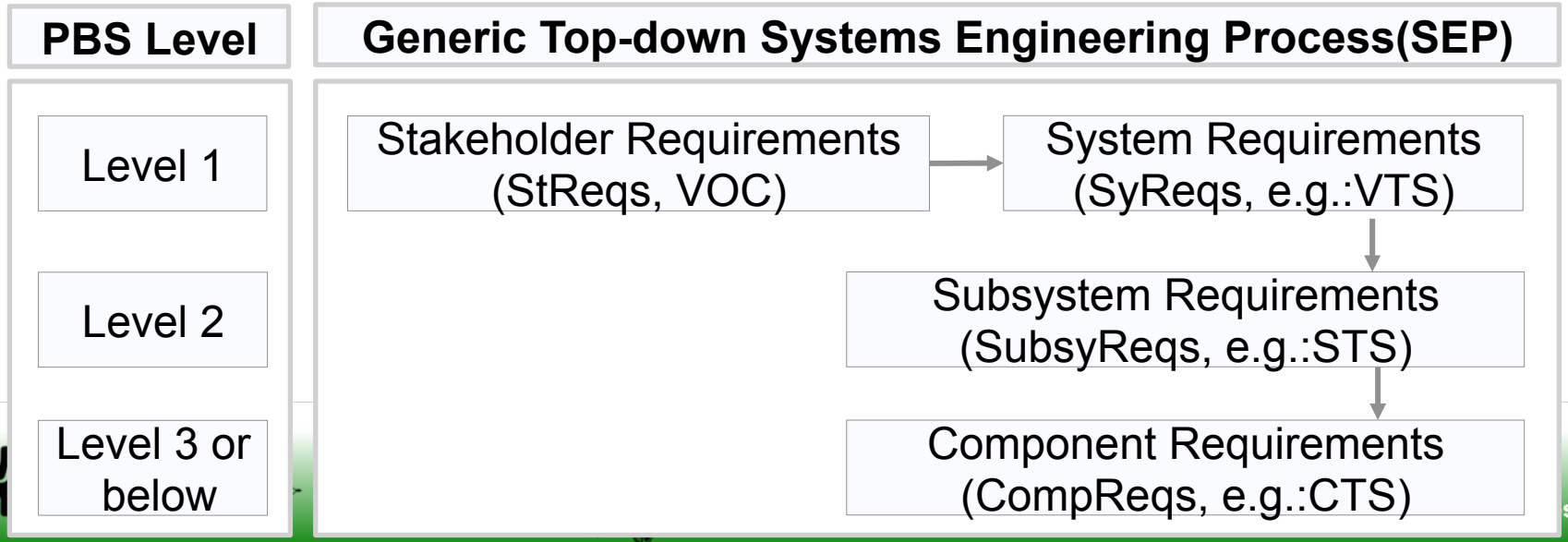




WB White box item GB Gray box item BB Black box item

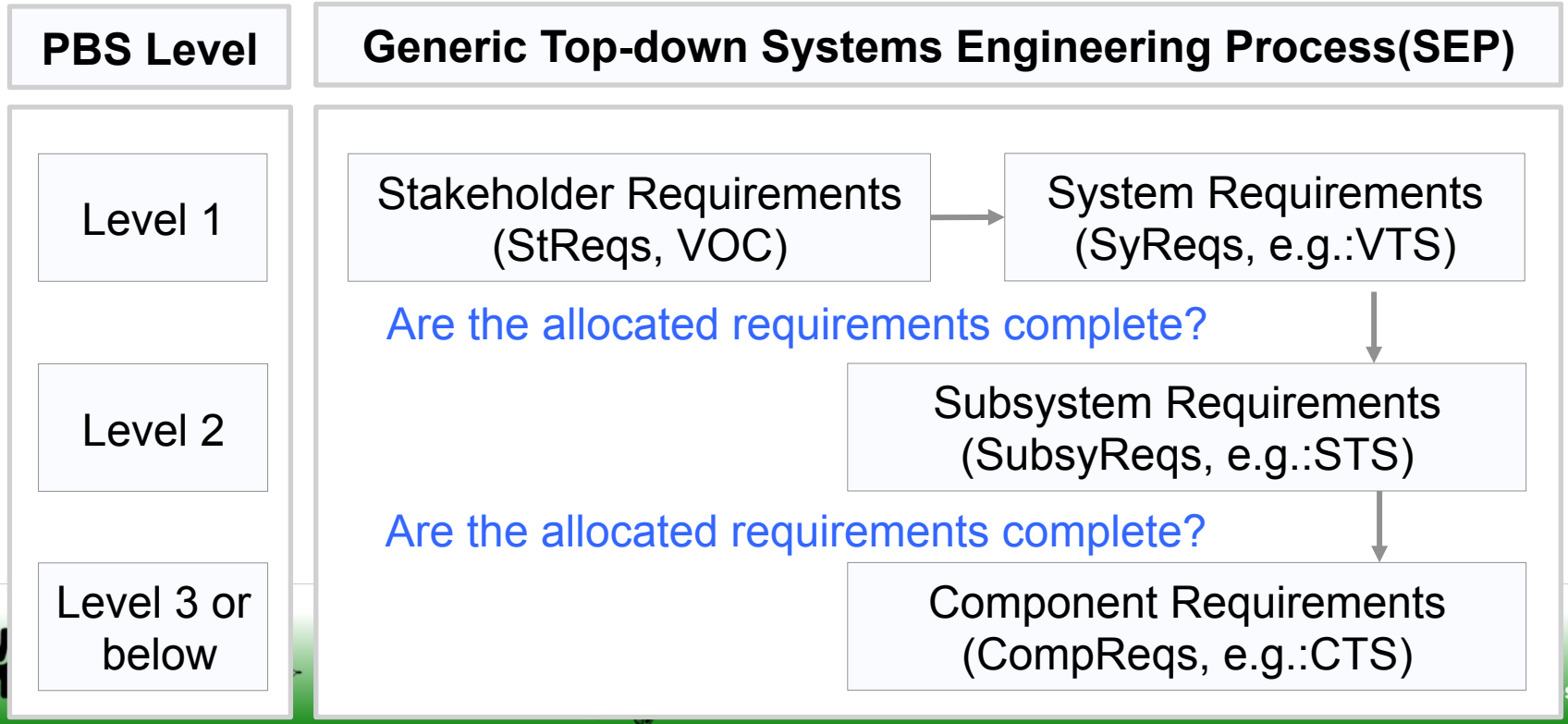
Generic Top-down SEP

- **In the case of white box and black box items, we could apply the generic top-down systems engineering process.**
  - System architect develops system requirements and allocates the subsystem requirements.
  - Subsystem designer develop subsystem requirements based on the allocated requirements.
  - The component designer develop the detail design of the component based on the allocated requirements.

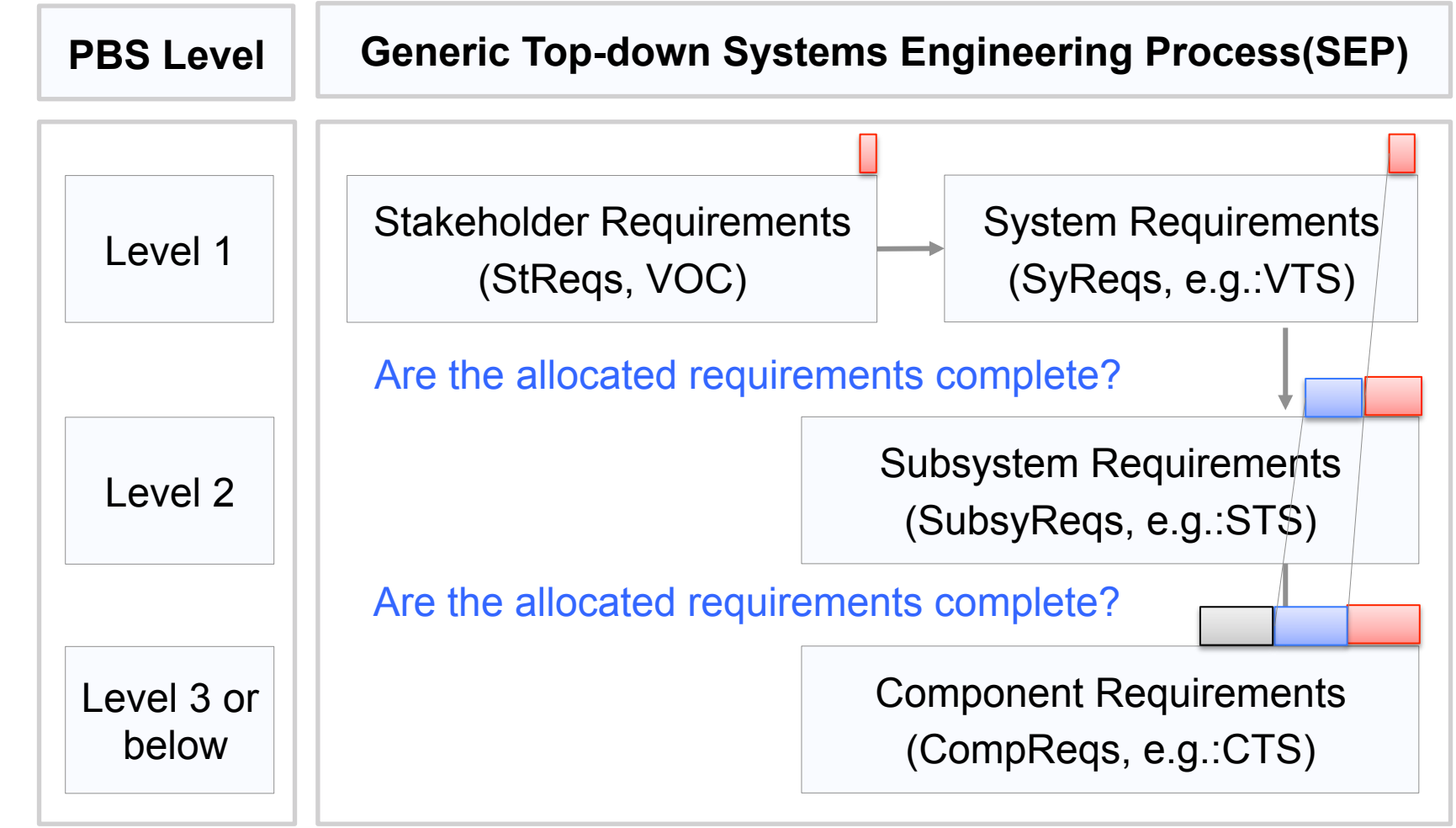


Usual Problems of Generic Top-down SEP

- The subsystem supplier could validate the allocated requirements.
- In the case of the supplier of Level 3 or below, it is not easy to validate requirements.



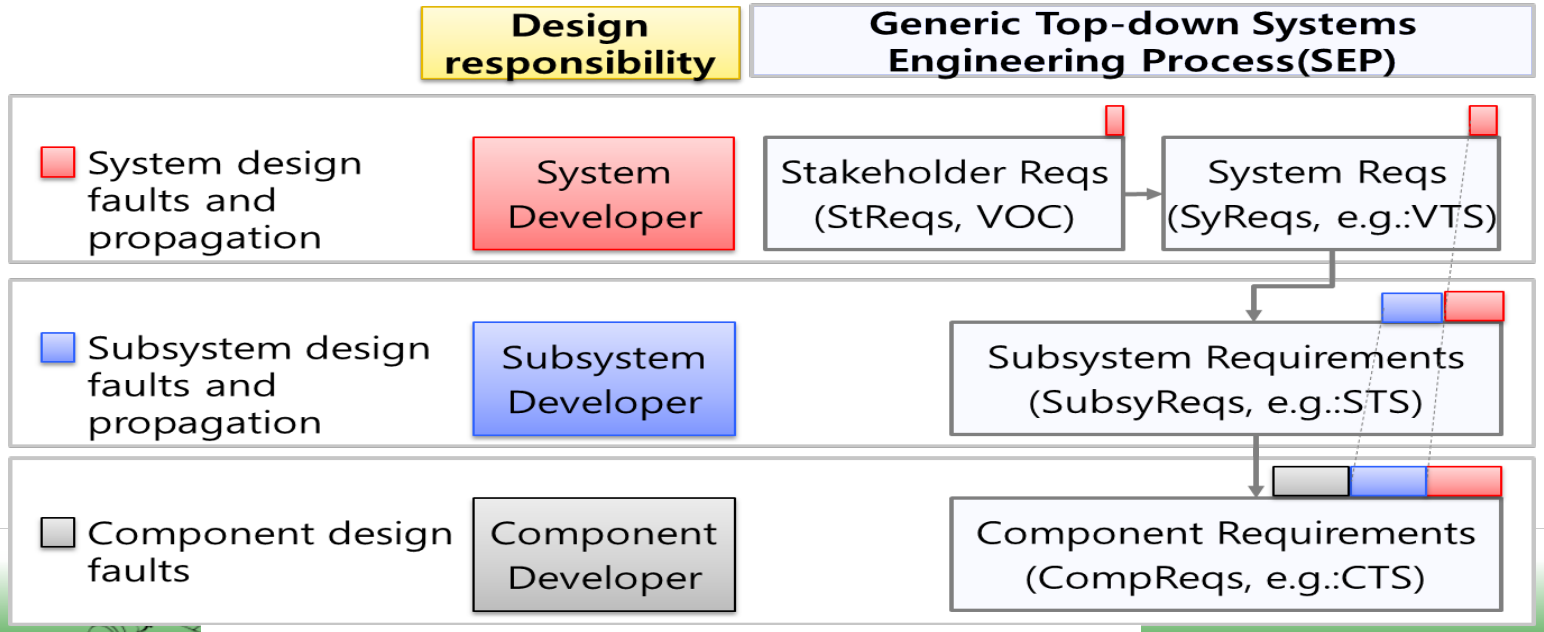
Design faults flow down



Responsibilities of design for WB & BB Items

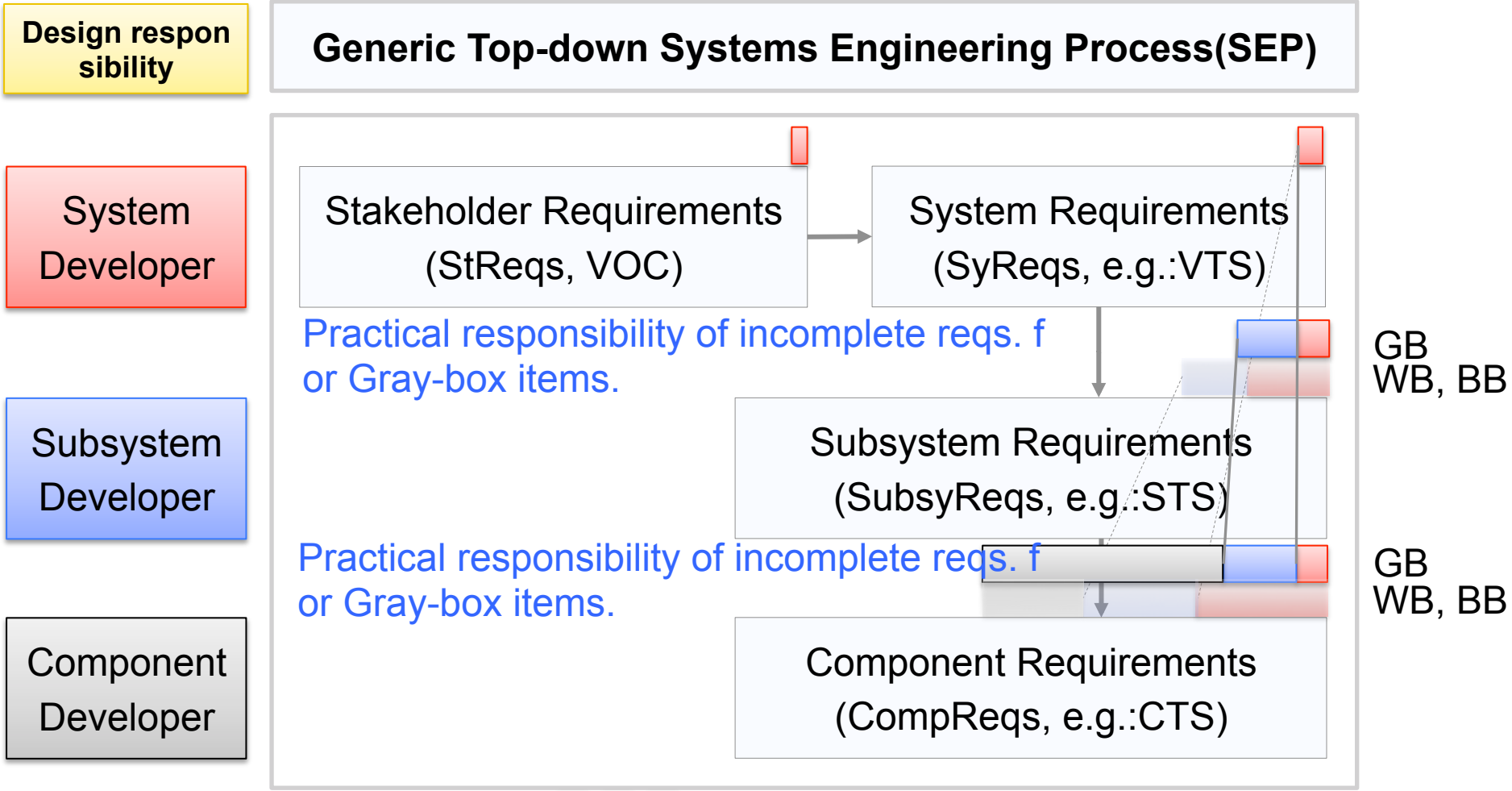
- **In the case of Generic top-down SE process for White-Box & Black-Box Items,**

if the allocated requirements have some deficiencies , the supplier could be protected from design risk tra nsfer based on the clearly defined design responsibil ities relative to the gray-box item.



Incomplete Reqs.: Omission & false reqs.

Problems of Top-down SEP for Gray-Box Items



Problems of generic SEP for Gray-Box Items

- **Prob.1: The shared design responsibility itself could cause incompleteness of design.**
  - The shared design responsibility means that the design responsibility could not define clearly.
- **Prob.2: The squeezed development schedule and short resources cause incompleteness of design.**
  - For the 3rd & below level gray-box item development, the system level and subsystem level designers focus on critical design decision and, due to the squeezed development schedule and short resources, practically and frequently, it is hard to care for completeness of allocated requirements and the detail design for gray box item, therefore, the gray box item supplier has much more responsibilities than the system(e.g. vehicle) designer.
- ➔ **Results: Design risks are transferred to gray box item supplier.**

e.g.: Transferred responsibility of incomplete reqs for Gray-box items.

- **Thus, from the viewpoint of gray box item supplier, it is important to have some strategy to overcome this design risks.**

Overcome Strategy of the Design risks for Gray-box Item

- **Compared with the white box and black box item, the gray box item design process is not appropriate to adopt the generic top-down systems engineering process due to the possible deficiency of requirements allocated to the gray box item.**
  - Need effective requirement validation process for Level 3 or below gray-box item developer.

- **The component designer should suppose possible deficiency of allocated requirements to embrace the unbalance of design responsibility proactively, especially in the case of gray box items, rather than white box and black box items.**

- **For the gray box item designer, to achieve the integrity of design which could overcome the possible deficiency of the allocated requirements, this presentation suggests the middle-out systems engineering process**

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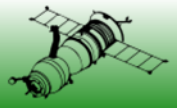
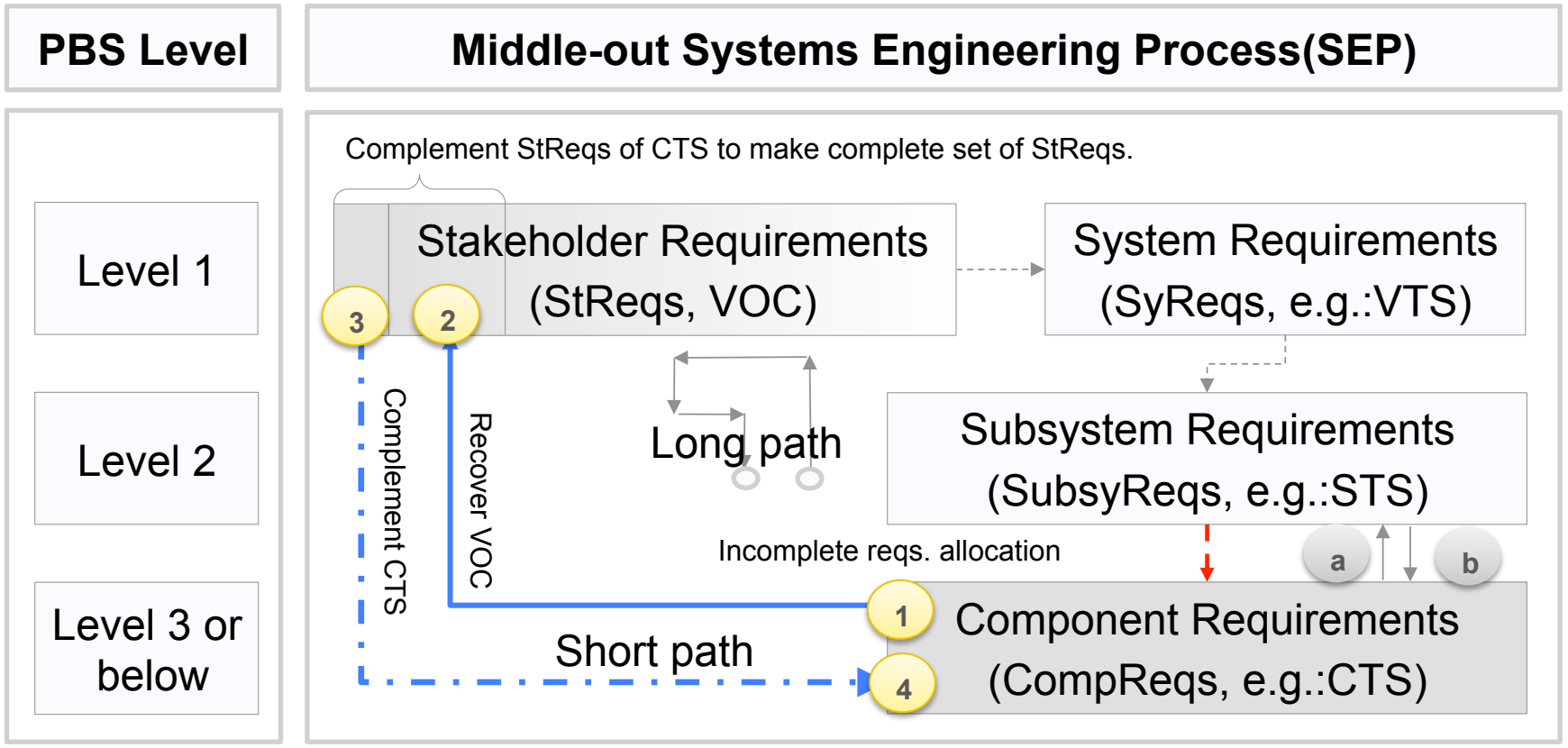



Middle-out Systems Engineering Process(SEP)

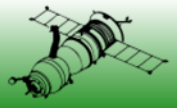
- **Middle-out SE process as a requirements validation process for level 3 or below gray-box item supplier.**



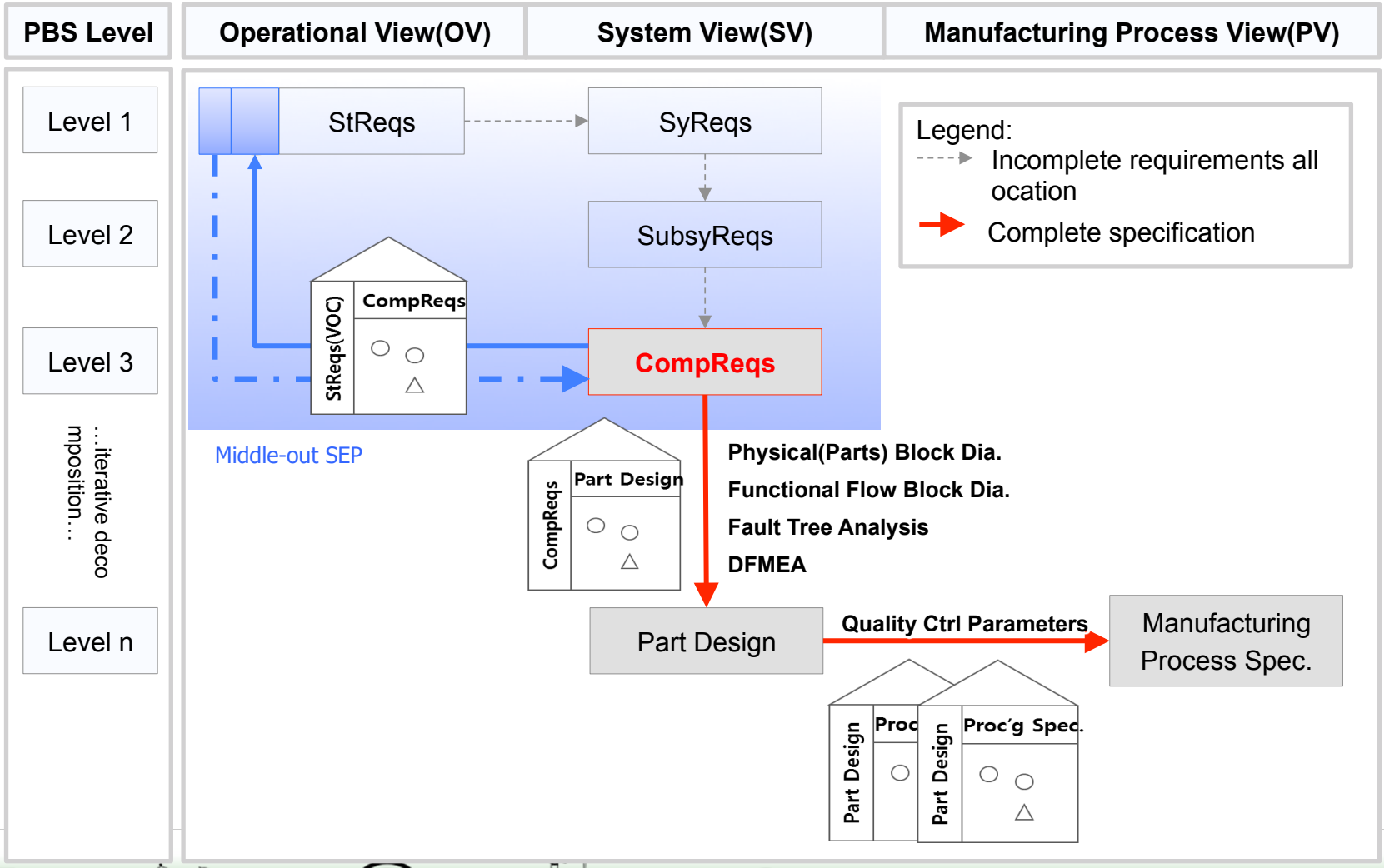
Middle-out Systems Engineering Process(SEP)

- **Middle-out SEP starts from middle of system hierarchy.**
  - Start from allocated requirements of 3rd level component or below.

1. **Translate the initially allocated component requirement t o stakeholders requirements relevant to the component.**
2. **Check the integrity of the developed StReqs.**
   - e.g.) check omission and overlap of stakeholders requirements.
3. **Develop complete set of StReqs relevant to the compone nt.**
   - Complement the stakeholders requirements relevant to the component.
4. **Transform the complemented stakeholders requirements to the component requirement to develop complete set o f component requirements.**
   - Trace the StReqs to component requirement and re-complement the compon ent requirement based on the complete set of StReqs.
5. **Validate the integrity of component requirement.**
6. **Start detail design of the component.**


Solving Gray-box item developer's w orry by Middle-out SEP



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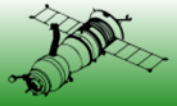
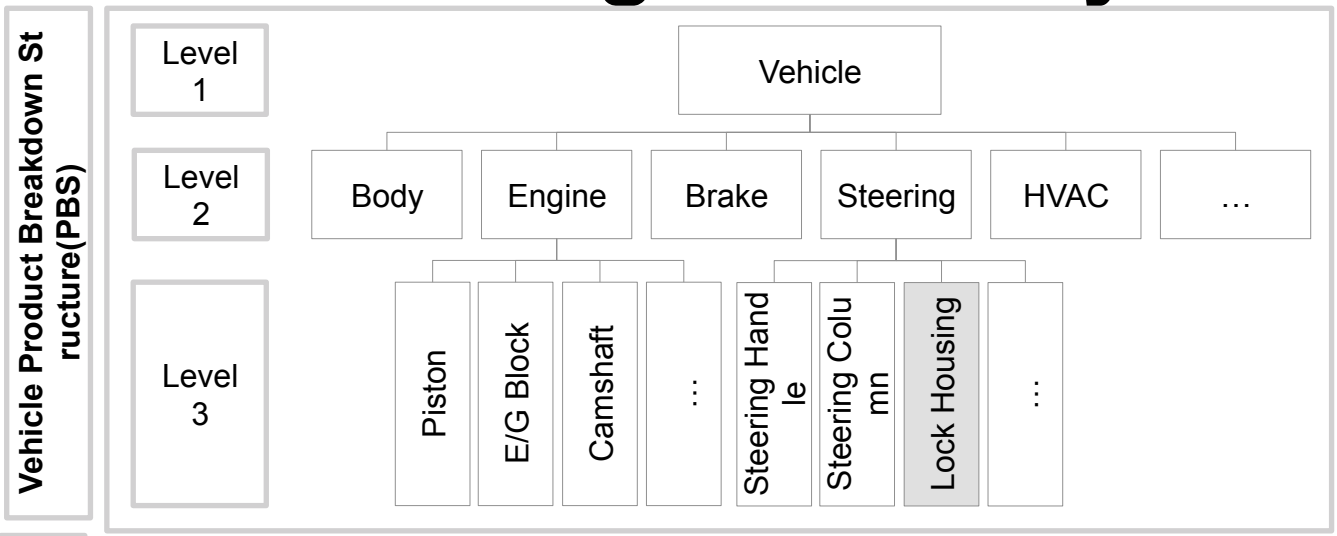
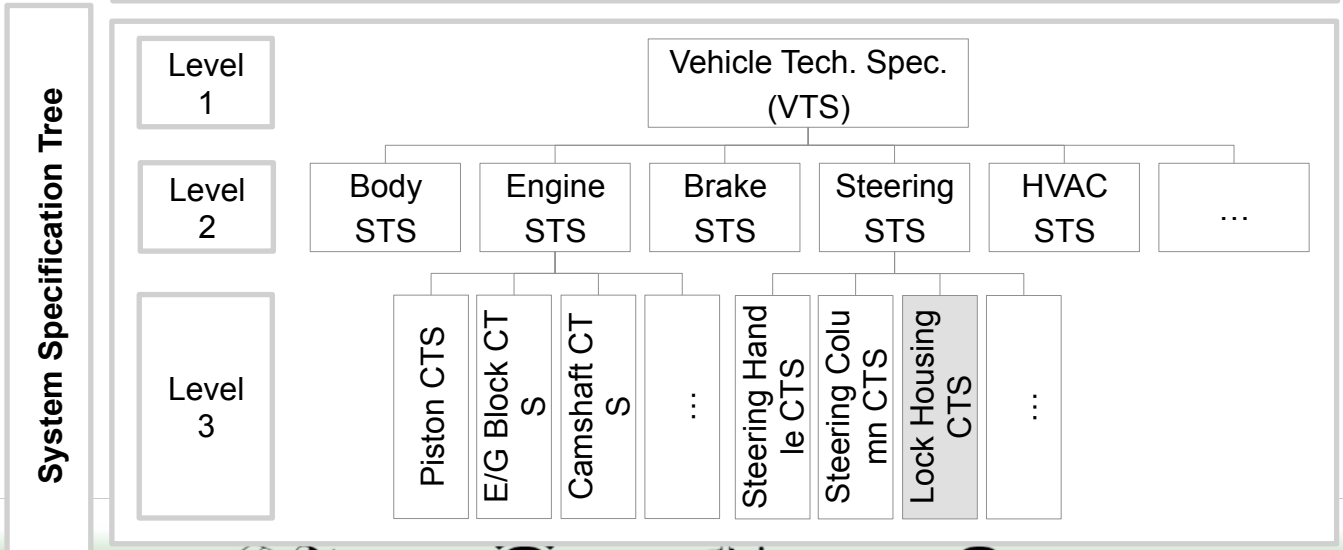



Physical Hierarchy of Vehicle & Lock Housing Assembly as a GB item





For convenience, this presentation call the name of each level of system hierarchy as

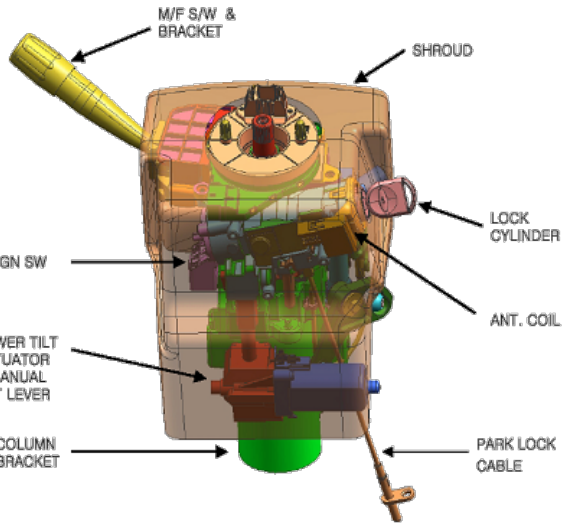
- Vehicle(system),
- Subsystem,
- Component

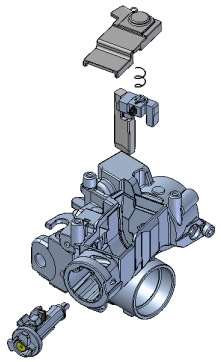
Corresponding technical specs

- VTS: Vehicle(system) technical spec
- STS: Subsystem technical specs
- CTS: Component technical specs

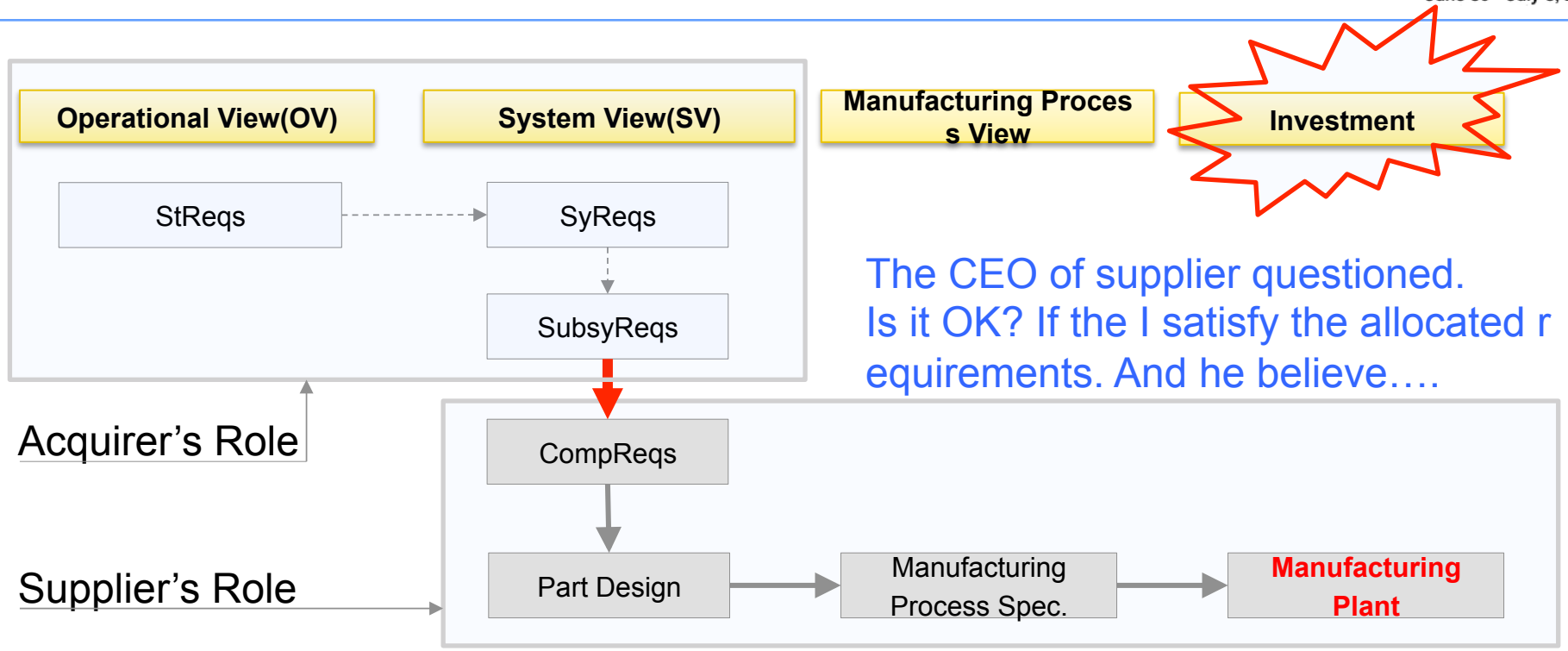
Lock Housing Assembly

- **Figure shows the Lock Housing Assembly which built in the part of Steering Subsystem.**
- **The Lock Housing Assembly's main function is**
  - to hold a key ignition switch and
  - To deliver the ignition force to the key ignition switch.
- **Generally Lock Housing Assembly was used to be made of iron.**
- **For the purpose of reducing the vehicle weight, the car company decided to adopt magnesium Lock Housing Assembly.**
- **The design integration level of Lock Housing Assembly is Gray-box item.**





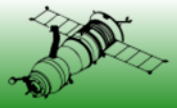
Gray-box item developer's worry



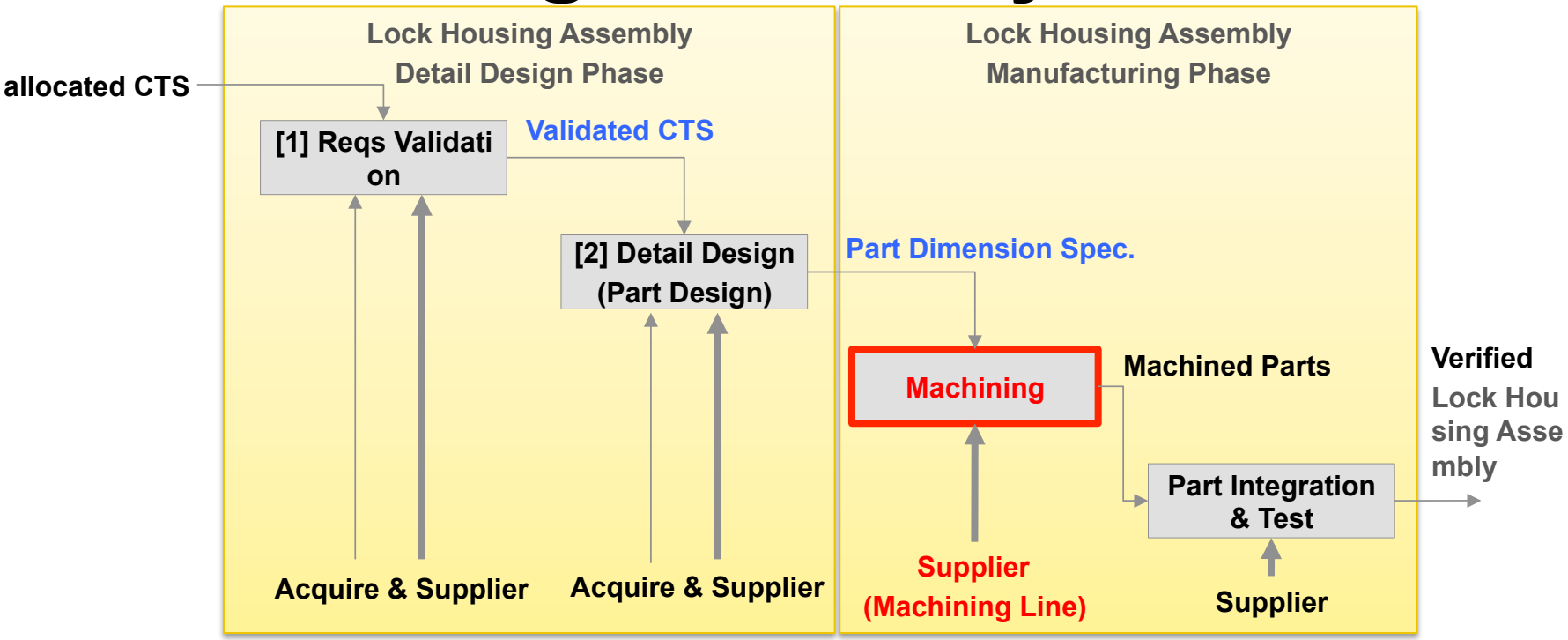
- The acquirer need new magnesium Lock Housing Assembly to reduce vehicle weight.
- **The supplier shall invest new machining line** to supply the new magnesium Lock Housing Assembly.

Development problem of Lock Housing Assembly – Possibility of Big Loss!

- Vehicle designer's requirements on the magnesium Lock Housing Assembly are documented in Lock Housing Assembly CTS (Component Technical Specification) and delivered to the CTS supplier.
- The supplier have to develop the detail design of the new magnesium Lock Housing Assembly with vehicle designer and subsystem designer.
- And the supplier have to invest big money for new manufacturing plant of the magnesium Lock Housing Assembly.
- The CEO of the supplier worry about the design faults of the CTS which could lead to big performance liquidated damage(LD).
- Because the design responsibilities are shared by the vehicle developer(L1), steering subsystem developer(L2) and the Lock Housing Assembly supplier(L3), the Lock Housing Assembly maker's engineers should be able to meet not only the requirements documented on the allocated Component Technical Specification(CTS) but also requirements undocumented.

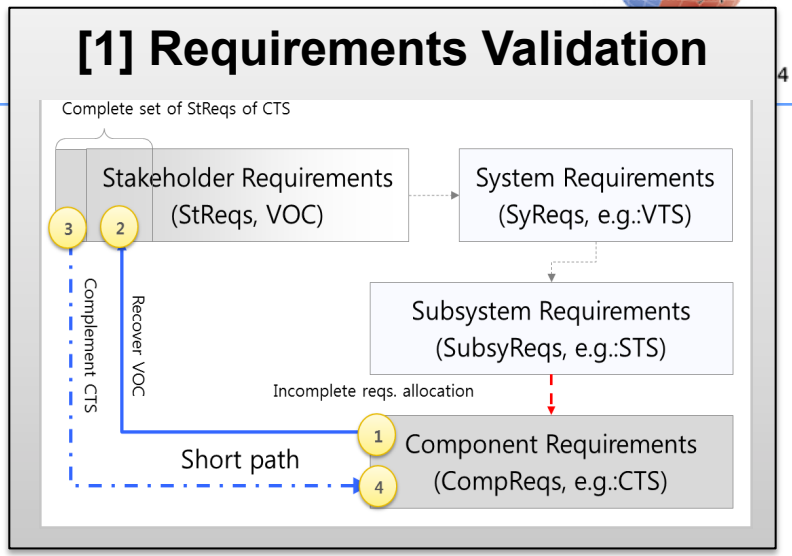

How can achieve high quality of Lock Housing Assembly?



- **One question is "Is it ok if I satisfy just the allocated CTS?"**
  - In other words, "How can we confirm that the allocated CTS is the total set of design requirements of Lock Housing Assembly?" ➔ **Validate the allocated CTS by Middle-out SEP**
- **The other question is "What design parameters of lock housing should be controlled and monitored in manufacturing process to get high quality?" ➔ Focused detail design on the machining dimension.**

The Middle-out SEP for Lock Housing Assembly

- **Validation process of th e allocated CTS by the Middle-out SEP**

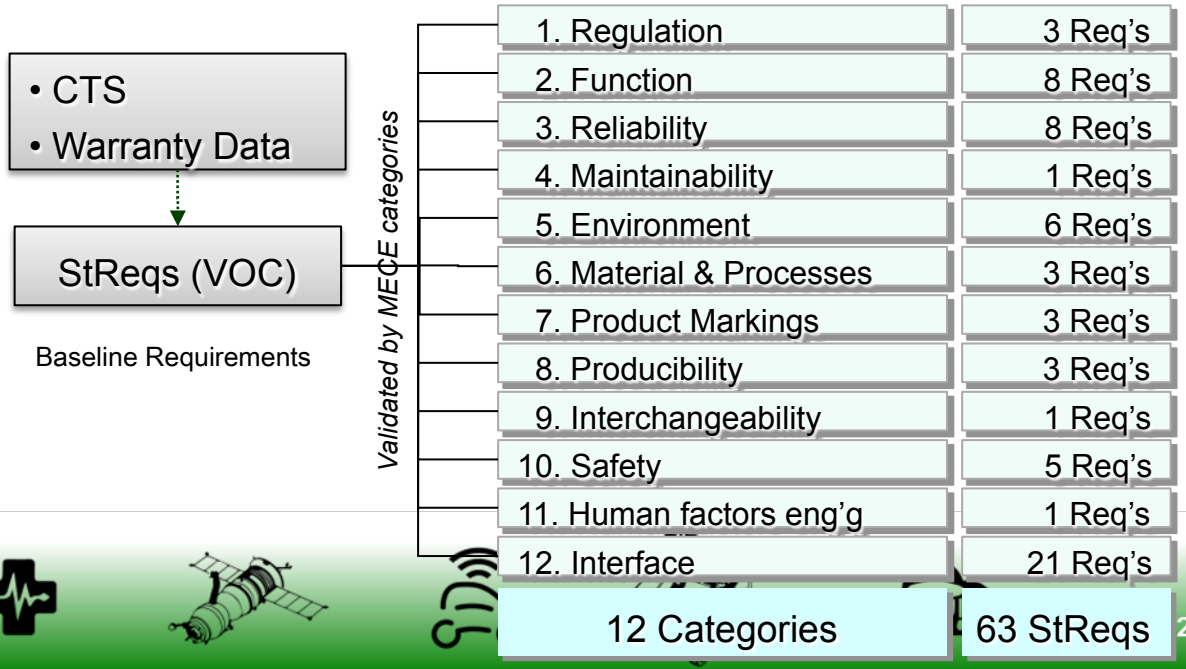


ref.) MECE: Mutually Exclusive & Collectively Exhaustive Rule

No.	Middle-out SEP	Applied Methods
1	Transform the initially allocated CTS to recover StReqs relevant to the Lock Housing Assembly CTS.	Operational Concept, Functional Analysis Use Warranty data
2	Complement the allocated CTS to develop complete set of StReqs.	
3	Check the integrity of the developed StReqs. (e.g. check omission and overlap of StReqs)	MECE Category
4	Develop complete set of StReqs. This complete set of StReqs is used as baseline of design.	QFD chart
5	Trace the StReqs to CTS and complement the CTS based on the complete set of StReqs.	Traceability analysis
6	Validate the integrity of CTS.	

Middle-out SEP Application(1/2)

1. **Transform the initially allocated CTS to recover StReqs relevant to the Lock Housing Assembly CTS.**
   - Operational Concept, Functional Analysis
2. **Complement the allocated CTS to develop complete set of StReqs.**
   - Use Warranty data
3. **Check the integrity of the developed StReqs. (e.g. check omission and overlap of StReqs)**
   - MECE Category (based on Use Warranty data & MIL-STD-961E)

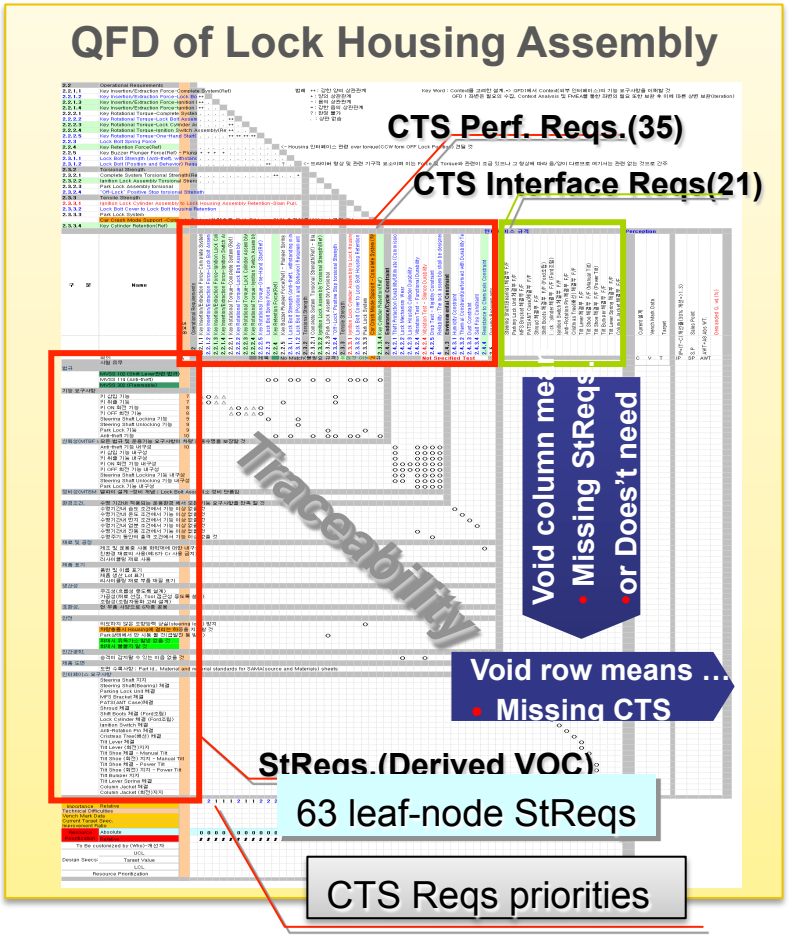


1 MVSS 102 (Shift Lever관련 법규)
2 MVSS 114 (Anti-theft)
3 MVSS 302 (Flammable)
4 키 삽입 기능
5 키 취출 기능
6 키 ON 회전 기능
7 키 OFF 회전 기능
8 Steering Shaft Locking 기능
9 Steering Shaft Unlocking 기능
10 Park Lock 기능
11 Anti-theft 기능
12 Anti-theft 기능 내구성
13 키 삽입 기능 내구성
14 키 취출 기능 내구성
15 키 ON 회전 기능 내구성
16 키 OFF 회전 기능 내구성
17 Steering Shaft Locking 기능 내구성
18 Steering Shaft Unlocking 기능 내구성
19 Park Lock 기능 내구성
20 델파이 설계 -정비 개념 ; Lock Bolt Assy 최소 정비 단품임
21 수명기간내 습도 조건에서 기능 이상 없을 것
22 수명기간내 온도 조건에서 기능 이상 없을 것
23 수명기간내 먼지 조건에서 기능 이상 없을 것
24 수명기간내 염분 조건에서 기능 이상 없을 것
25 수명기간내 진동 조건에서 기능 이상 없을 것
26 수명주기 동안의 충격 조건에서 기능 이상 없을 것
27 제조 및 운용중 사용 화학재에 대한 내구성
28 친환경 재료의 사용(예:6가 Cr 사용 금지)
29 리사이클링 재료 사용
30 품번 및 이름 표기
31 제품 생산 Lot 표기
32 리사이클링 재료 부품 재질 표기
33 주조성(흐름성 좋도록 설계)
34 가공성(재료 선정, Tool 접근성 좋도록 설계)
35 조립성(조립자동화 고려 설계)
36 현 부품 사양으로 6차종 공용
37 의도하지 않은 조향능력 상실(steering lock) 방지
38 차량충돌시 Housing에 걸리는 하중을 지지할 것
39 Park상태에서 만 시동 될 것(급발진 등 방지)
40 화재시 유독가스 발생 없을 것
41 화재시 불붙지 말 것
42 승객이 감지할 수 있는 이음 없을 것
43 Steering Shaft 지지
44 Steering Shaft(Bearing) 체결
45 Parking Lock Unit 체결
46 MFS Bracket 체결
47 PATS(ANT Case)체결
48 Shroud 체결
49 Shift Boots 체결 (Ford조립)
50 Lock Cylinder 체결 (Ford조립)
51 Ignition Switch 체결
52 Anti-Rotation Pin 체결
53 Cristmas Tree(배선) 체결
54 Tilt Lever 체결
55 Tilt Lever (회전)지지
56 Tilt Shoe 체결 - Manual Tilt
57 Tilt Shoe (회전) 지지 - Manual Tilt
58 Tilt Shoe 체결 - Power Tilt
59 Tilt Shoe (회전) 지지 - Power Tilt
60 Tilt Bumper 지지
61 Tilt Lever Spring 체결
62 Column Jacket 체결
63 Column Jacket (회전)지지

Middle-out SEP Application(2/2)

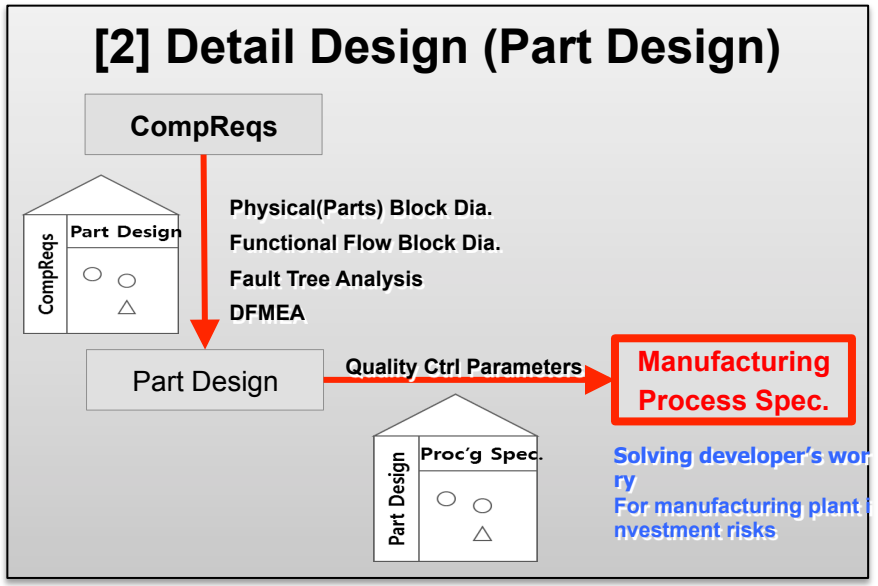
- **Develop complete set of StReqs. This complete set of StReqs is used as baseline of design.**
  - QFD chart
- **Trace the StReqs to CTS and complement the CTS based on the complete set of StReqs.**
  - Traceability analysis
- **Validate the integrity of CTS.**

- **Existing V&V plans were traced to the complemented CTS and reviewed & updated.**
  - 3 omitted development tests were added
  - 2 development tests were adjusted.



Focused detail design on the machining dimension

- Detail design process and methods



No.	Focused detail design by generic SEP	Applied Methods
1	Part design	• Physical(Parts) Block Dia. • Functional Flow Block Dia. • Fault Tree Analysis • DFMEA
2	Define Dimensional Quality Control Parameters	• Relation matrix • Dimensional quality control chart for critical dimension of parts

Detail design of Parts by Generic SEP

- **Based on the complete set of Lock Housing Assembly CTS, the detail design of parts could be done using generic SEP**

- **Methods applied for Part design**
  - Physical(Parts) Block Dia.
  - Functional Flow Block Dia.
  - Fault Tree Analysis
  - DFMEA

Physical(Parts) Block Diagram

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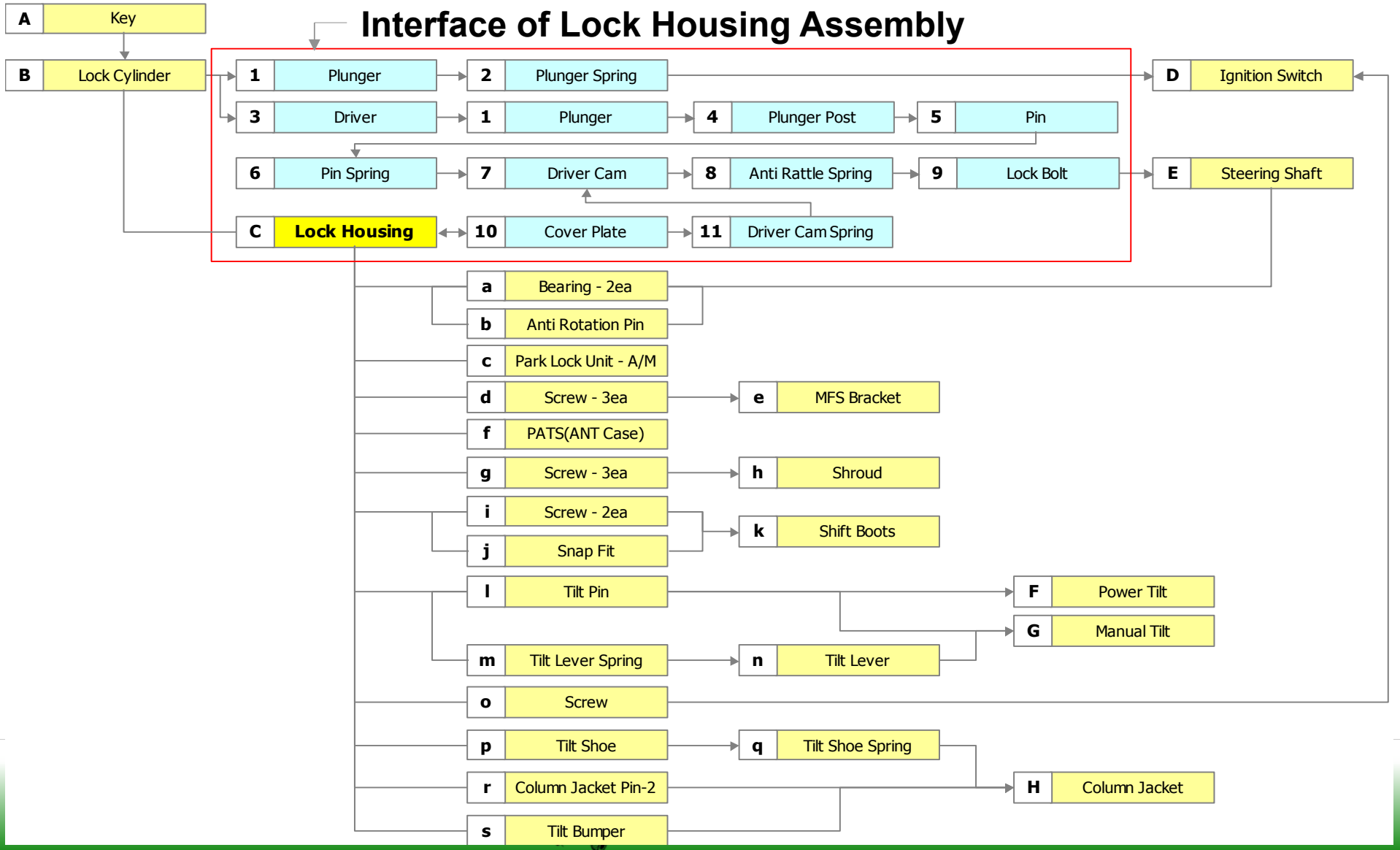
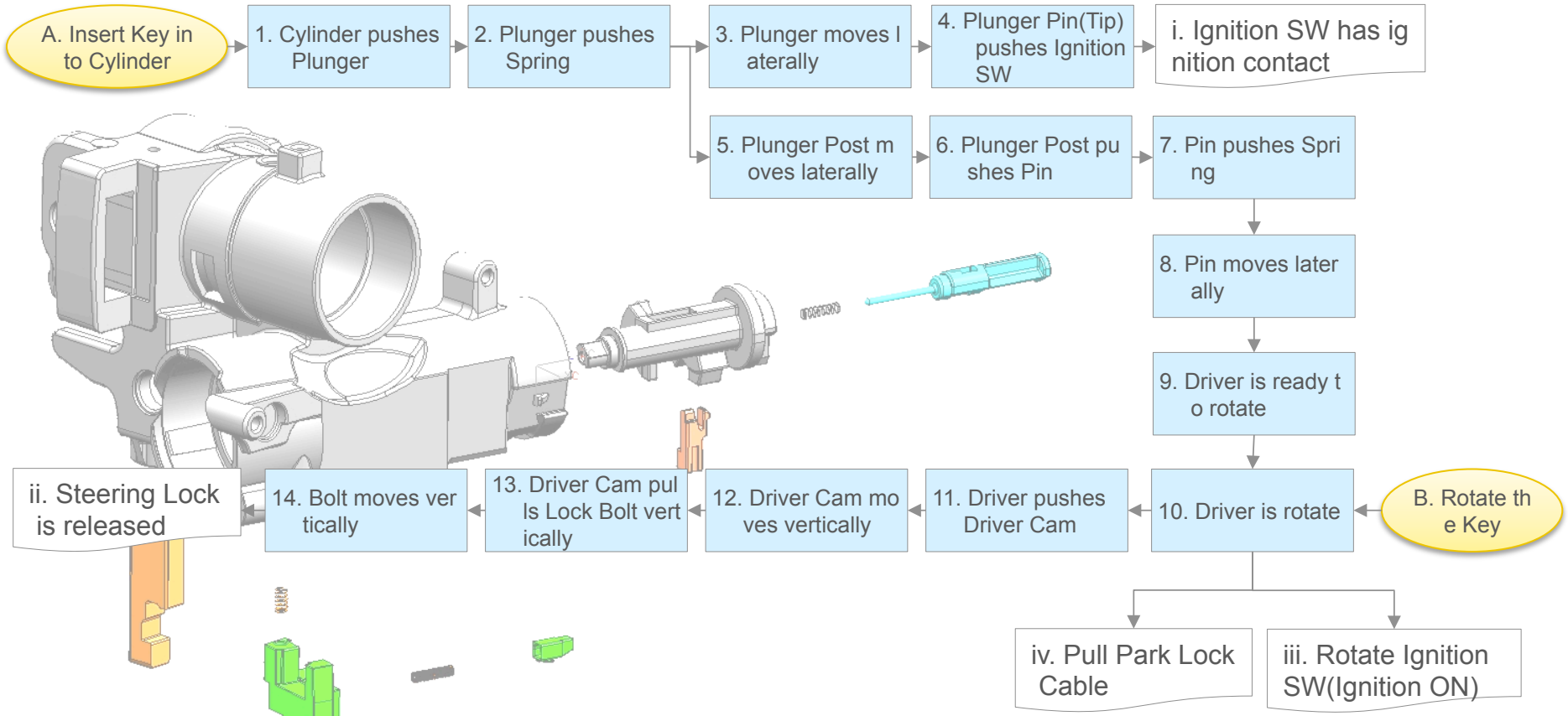


Functional Flow Block Diagram



Fault Tree Analysis

1st Level 10 Failure Modes of Lock Housing Assembly

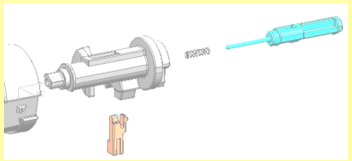
Evolved to 2nd & 3rd Level Failure Modes

Housing Compon

P1 Ignition contact does not 'ON'.

P2 Ignition ...

P11 Cylinder cannot push Plunger.



OR

- **P111** Lock Cylinder can not insert Housing
- **P112** Lock Cylinder too short
- **P113** Lock Cylinder can not match Driver
- **P114** Lock Housing and Lock Cylinder matching Hole position error

P7 Noise.

P8 Anti-theft funtion does not work

P9 Does not meet the safety regulations.

P10 Support function fails.

CTS to Parts Function Correlation Matrix

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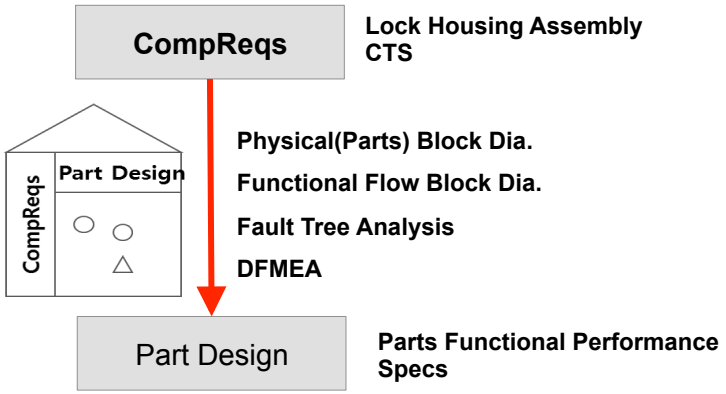

Lock Housing Ass'y CTS		Parts Functions / Importance	P11) Cylinder pushes Plunger.	P12) Plunger pushes Spring	P13) Plunger moves to Ignt'n SW.	P14) Plunger 'Tip push Ignition S/W	P21) Driver rotates reversly.	P23) Plunger roturns to original position	P31) Plunger Post moves laterally	P32) Plunger Post pushes Pin.	P33) Pin pushes Spring.	P34) Pin moves laterally	P35) Driver rotates reversely	P41) Driver pushes Driver Cam.	P42) Driver Cam pulls Lock Bolt vertically.	P43) Lock Bolt moves upward.	P52) Driver Cam Spring pushes up the Cam	P53) Driver Cam moves up.	P54) Lock Bolt moves down vertically	P61) Park Lock gear engages with Drive.	P71) Lock Housing and Lock Bolt Rattles	P72) Driver & Housing Rattles
2.2	Functional Requirements																					
2.2.1.1	Key Insertion/Extraction Force-Complete System(Ref)	3																				
2.2.1.2	Key Insertion/Extraction Force-Lock Bolt Assembly	3	1	1	1	1		1	1	1	1	1										
2.2.1.3	Key Insertion/Extraction Force-Ignition Lock Cylinder Assembly(Ref)	2																				
2.2.1.4	Key Insertion/Extraction Force-Ignition Switch Assembly(Ref)	2																				
2.2.2.1	Key Rotational Torque-Complete System(Ref)	2																				
2.2.2.2	Key Rotational Torque-Lock Bolt Assembly	3											1	1	1	1	1	1	1	1		
2.2.2.3	Key Rotational Torque-Lock Cylinder Assembly(Ref)	2																				
2.2.2.4	Key Rotational Torque-Ignition Switch Assembly(Ref)	2																				
2.2.2.5	Key Rotational Torque-One-Hand Start(Ref)	3											1	1	1	1	1	1	1	1		
2.2.3	Lock Bolt Spring Force	3															1					
2.2.4	Key Retention Force(Ref)	3																				
2.2.5	Key Buzzer Plunger Force(Ref) - Plunger Spring Force	3		1																		
2.3.1.1	Lock Bolt Strength (Anti-theft, withstanding min 300 Nm)(375 Nm까지 수행함)	2.5																				

Relation matrix between Lock Housing Assembly CTS and Parts Functions

Parts Function to Physical Characteristics Correlation Matrix

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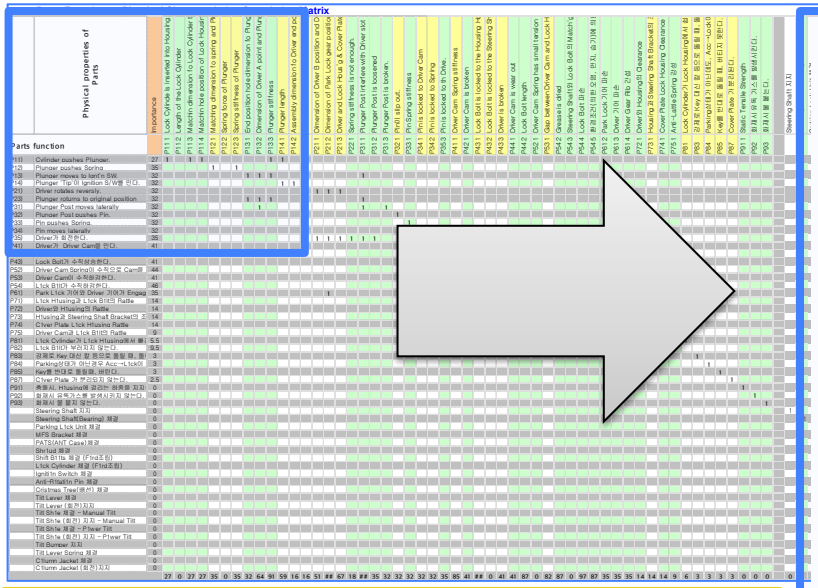

Detail Design (Part Design)

CompReqs

Physical(Parts) Block Dia.
Functional Flow Block Dia.
Fault Tree Analysis
DFMEA

Part Design → Quality Ctrl Parameters → Manufacturing Process Spec.

Part Design — Proc'g S

Part Design — Proc'g Spec.

Solving developer's worry
For manufacturing plant investment risks

Physical Characteristics of Parts

Parts function	Importance	P111 Lock Cylinder is inserted into Housing.	P112 Length of the Lock Cylinder	P113 Matching dimension of Lock Cylinder to Driver	P114 Matching hole position of Lock Housing and Lock Cylinder	P121 Matching dimension fo spring and Plunger	P122 Spring force of Plunger	P123 Spring stiffness of Plunger	P131 End position hole dimension fo Plunger Tip and Driver	P132 Dimension of Driver A point and Plunger Post	P133 Plunger stiffness	P141 Plunger length
P11)Cylinder pushes Plunger.	27	1		1	1						1	1
P12) Plunger pushes Spring	35					1		1				
P13) Plunger moves to Ignt'n SW.	32								1	1	1	
P14) Plunger 'Tip push Ignition S/W	32											1
P21) Driver rotates reversly.	32											
P23 Plunger roturns to original positi on	32								1	1	1	

Parts Physical Characteristics to Parts Dimension Correlation Matrix

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Part's Dimension vs. Physical Characteristics		Importance	Lock Housing				Driver								Plunger						
Physical Characteristics of parts			P111-1	P111-2	P142-6	P911-1	P111-4	P111-5	P111-6	P131-1	P132-1	P132-2	P142-1	P142-2	P111-9	P111-10	P111-12	P111-13	P111-14	P121-1	P131-2
P111	Lock Cylinder is inserted into Housing.	27	1	1			1	1	1	1					1	1	1	1	1		1
P112	Length of the Lock Cylinder	0																			
P113	Matching dimension of Lock Cylinder to Driver	27																			
P114	Machine hole position of Lock Housing and Lock Cylinder	27		1																	
P121	Matching dimension of spring and Plunger	35																		1	
P131	End position hole dimension of Plunger Tip and Driver	32								1											1
P132	Dimension of Driver A point and Plunger Post	64									1	1									
		91																			
		59																			
	each dimensio		**33**	**54**	**30**	**0**	**##**	**27**	**27**	**59**	**64**	**99**	**16**	**16**	**27**	**27**	**27**	**27**	**27**	**35**	**59**

Detail Design (Part Design)

CompReqs

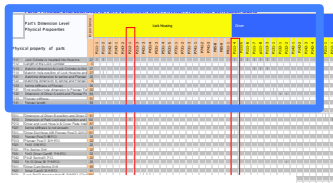
CompReqs — Part Design

Physical(Parts) Block Dia.
Functional Flow Block Dia.
Fault Tree Analysis
DFMEA

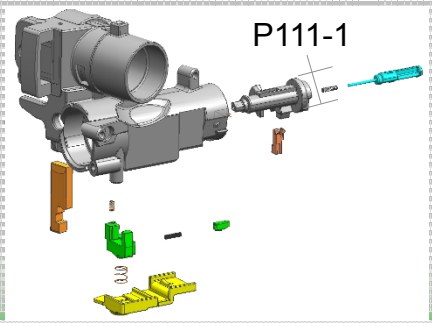
Part Design → Quality Ctrl Parameters → Manufacturing Process Spec.

Part Design — Proc'g Spec.
Part Design — Proc'g Spec.

Solving developer's worry
For manufacturing plant investment risks



Total importance of dimension



33 54 30 16 16 137 67 101 101 82 82 82 14 14 14 17 17 17

Relation Matrix CTS to Part's Dimension

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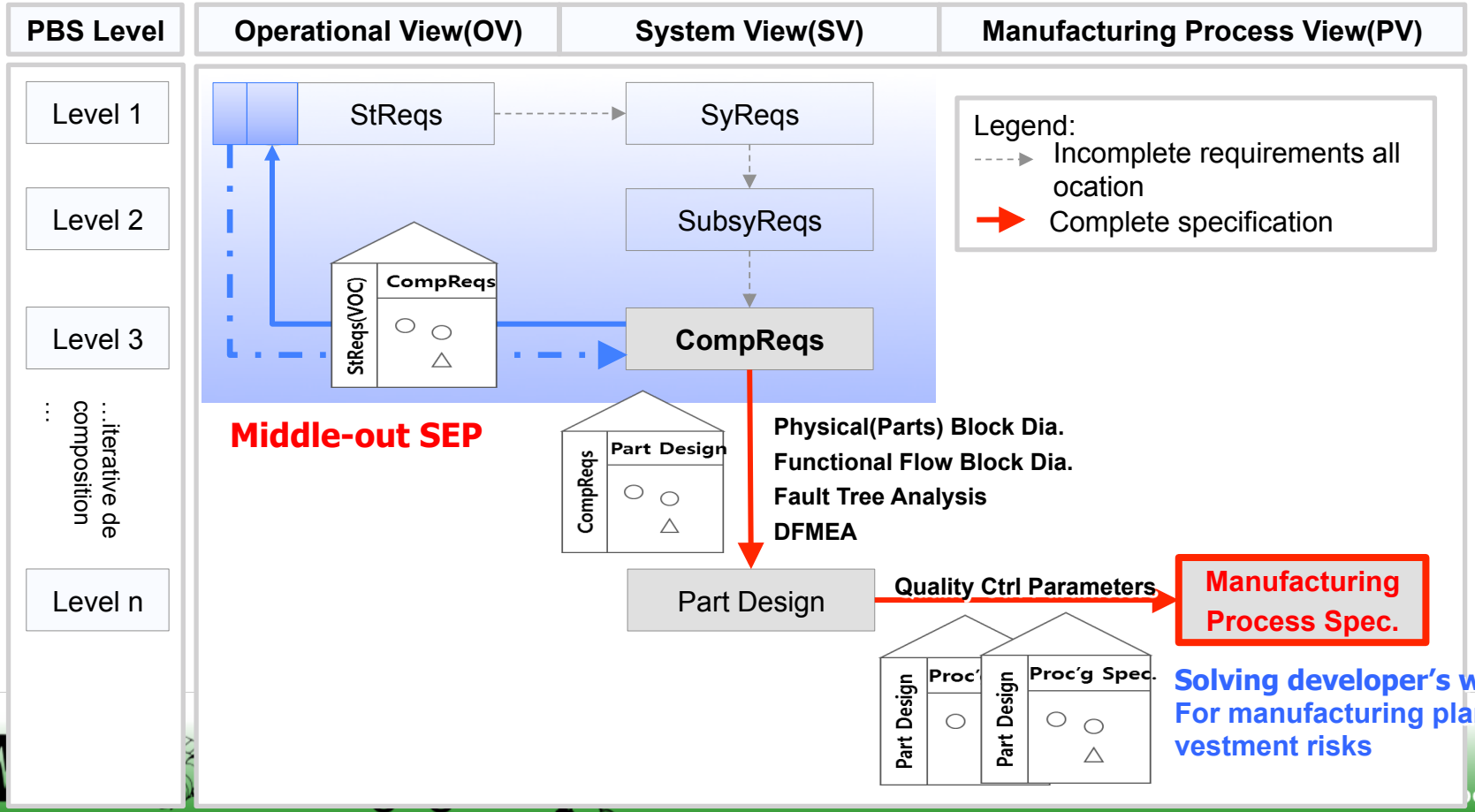
Relation Matrix of Lock Housing Assembly CTS to Part's Dimension Level Physical Properties

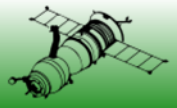
Part's Dimension Level Physical Properties / Lock Housing Assembly CTS		Importance	Lock Housing													Driver															Plunger				
			P111-1	P111-2	P142-6	P143-1	P143-2	P212-1	P213-3	P431-3	P431-4	P531-3	P531-4	P531-5	P731-1	p113-1	P113-3	P132-1	P132-2	P211-1	P212-2	P433-1	P441-1	P614-1	P614-2	P85-1	P85-2	P85-3	P85-5	P85-6	P121-1	P131-2	P133-1	P141-1	P312-3
2.2	Operational Requirements																																		
2.2.1.1	Key Insertion/Extraction Force-Complete System(Ref)	3																																	
2.2.1.2	Key Insertion/Extraction Force-Lock Bolt Assembly	3	1		1	1	1									1	1	1	1												1		1		
2.2.1.3	Key Insertion/Extraction Force-Ignition Lock Cylinder Assembly(Ref)	2																																	
2.2.1.4	Key Insertion/Extraction Force-Ignition Switch Assembly(Ref)	2																																	
2.2.2.1	Key Rotational Torque-Complete System(Ref)	2																																	
2.2.2.2	Key Rotational Torque-Lock Bolt Assembly	3							1	1	1	1	1	1						1	1	1	1	1	1										1
2.2.2.3	Key Rotational Torque-Lock Cylinder Assembly(Ref)	2																																	
2.2.2.4	Key Rotational Torque-Ignition Switch Assembly(Ref)	2																																	
2.2.2.5	Key Rotational Torque-One-Hand Start(Ref)	3						1	1	1	1	1	1	1						1	1	1	1	1	1										1
2.2.3	Lock Bolt Spring Force	3																																	
	Traced	Score	33	54	30	16	16	137	67	101	101	82	82	82	14	54	54	59	64	99	51	175	79	41	35	35	3	3	3	3	3	35	59	91	59	35

Summary

Solving Gray-box item developer's worr y by Middle-out SEP



Ref.


Terms

Integration level	Car maker's description
White box	• All the engineering decision is made by the acquirer. • Design responsibility completely belongs to the acquirer(car maker). • BIW (Body-In-White) and related components are white box items.
Gray box	• Design is a formalized joint activity with the acquirer and supplier. • The allocated requirements to the gray box items are given by the vehicle designers and the design of inner parts of a gray box item is done by the supplier. • But the design decisions are done jointly and the design responsibilities are shared. • Automotive lock housing assembly and lots of vehicle components belong to the gray box item.
Black box	• Car maker(acquirer) allocates specifications to the black box item supplier. • The allocated specifications are composed of interface specifications (e.g. outer dimensions) and a few performance specifications. • The design responsibility of allocated specifications completely belongs to car maker. • The design responsibility of black-box items completely belongs to the component designers. Airbag might be black box item.

Responsibilities of design for WB & BB Items

Design responsibility	Generic Top-down Systems Engineering Process(SEP)		
System design faults and propagation	System Developer	Stakeholder Reqs (StReqs, VOC)	System Reqs (SyReqs, e.g.:VTS)
Subsystem design faults and propagation	Subsystem Developer	Subsystem Requirements (SubsyReqs, e.g.:STS)	
Component design faults	Component Developer	Component Requirements (CompReqs, e.g.:CTS)	

Incomplete Reqs.: Omission & false reqs.

Functional Flow Block Diagram(2)

C.Key를 돌린다

15. Driver가 역회전 한다

D.Key를 뺀다

16. Spring이 Plunger를 민다

17. Plunger가 수평 이동 한다

v .Ignition Off

vi .Park Lock Cable을 민다

18. Plunger Post가 수평이동 한다

19. Driver Cam Spring이 수직으로 Cam을 민다.

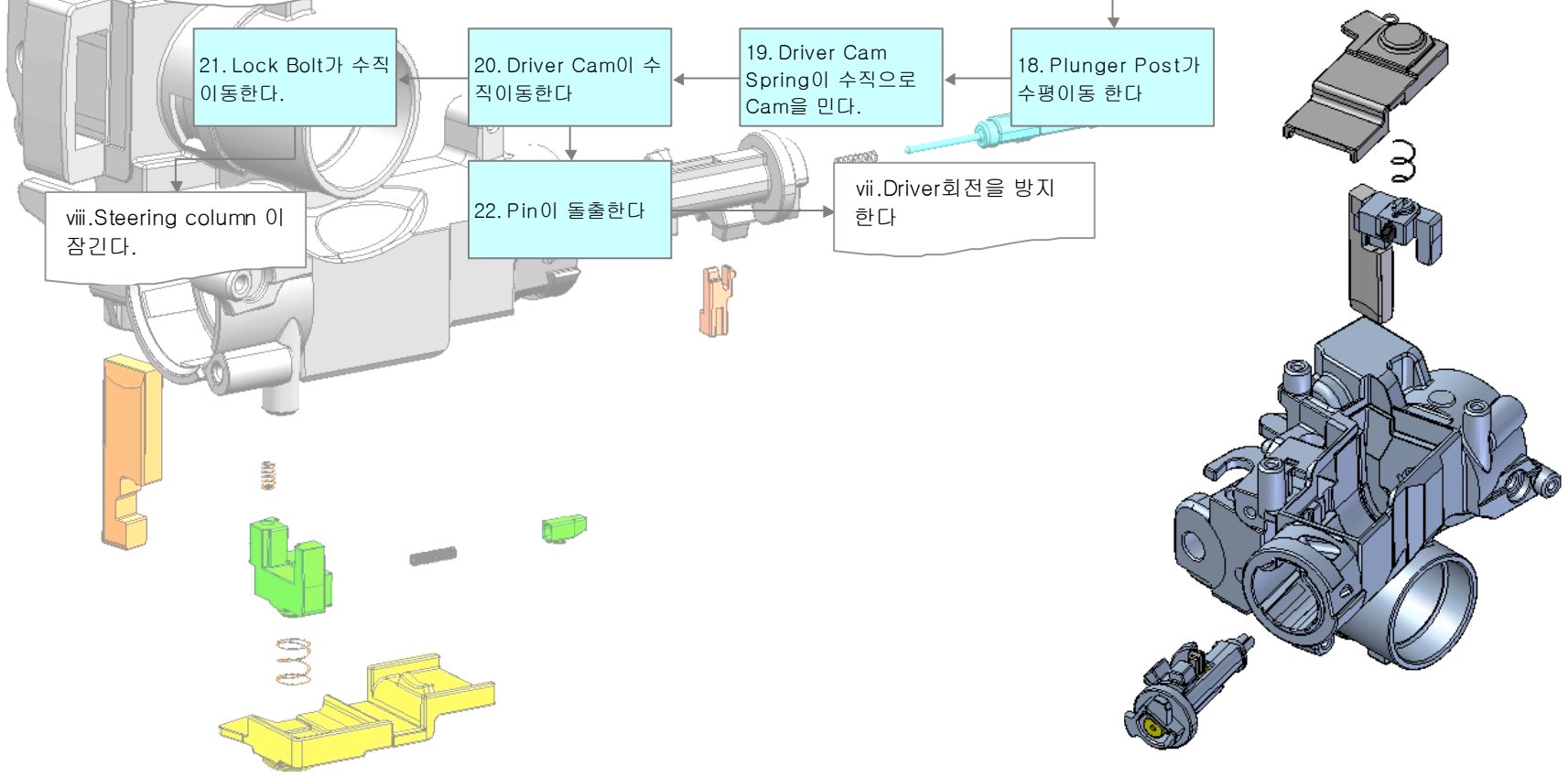
20. Driver Cam이 수직이동한다

21. Lock Bolt가 수직 이동한다.

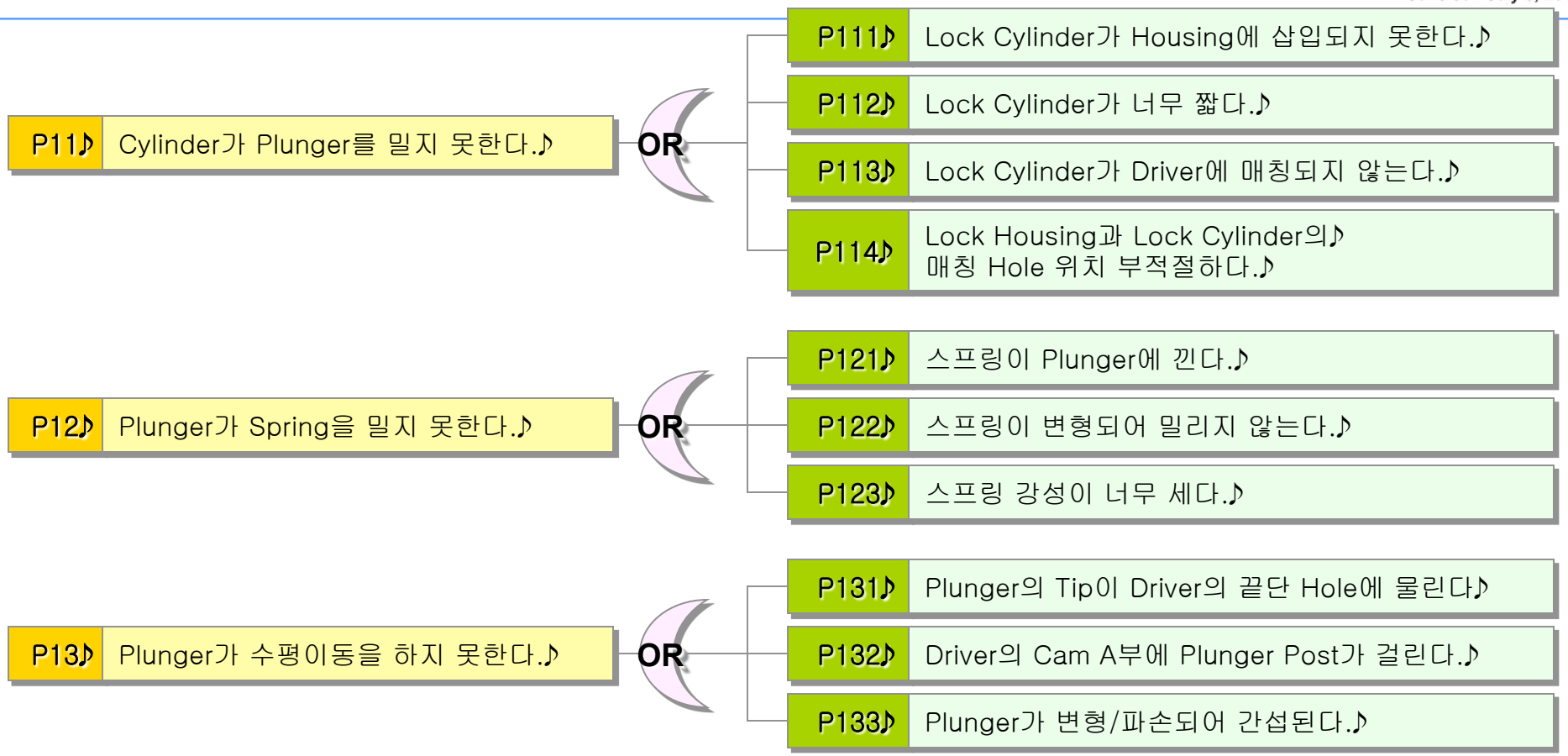
22. Pin이 돌출한다

vii .Driver회전을 방지 한다

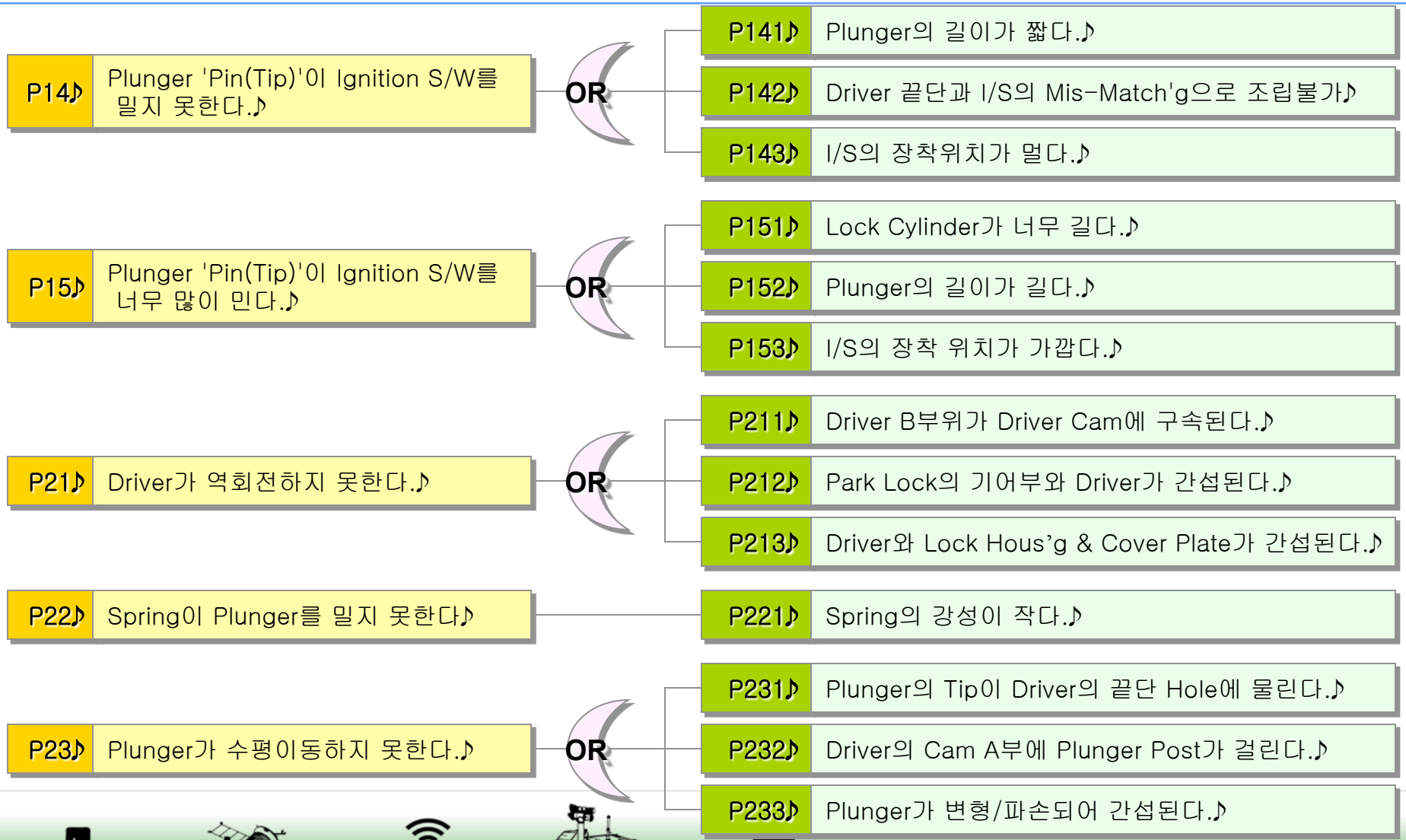
viii .Steering column 이 잠긴다.



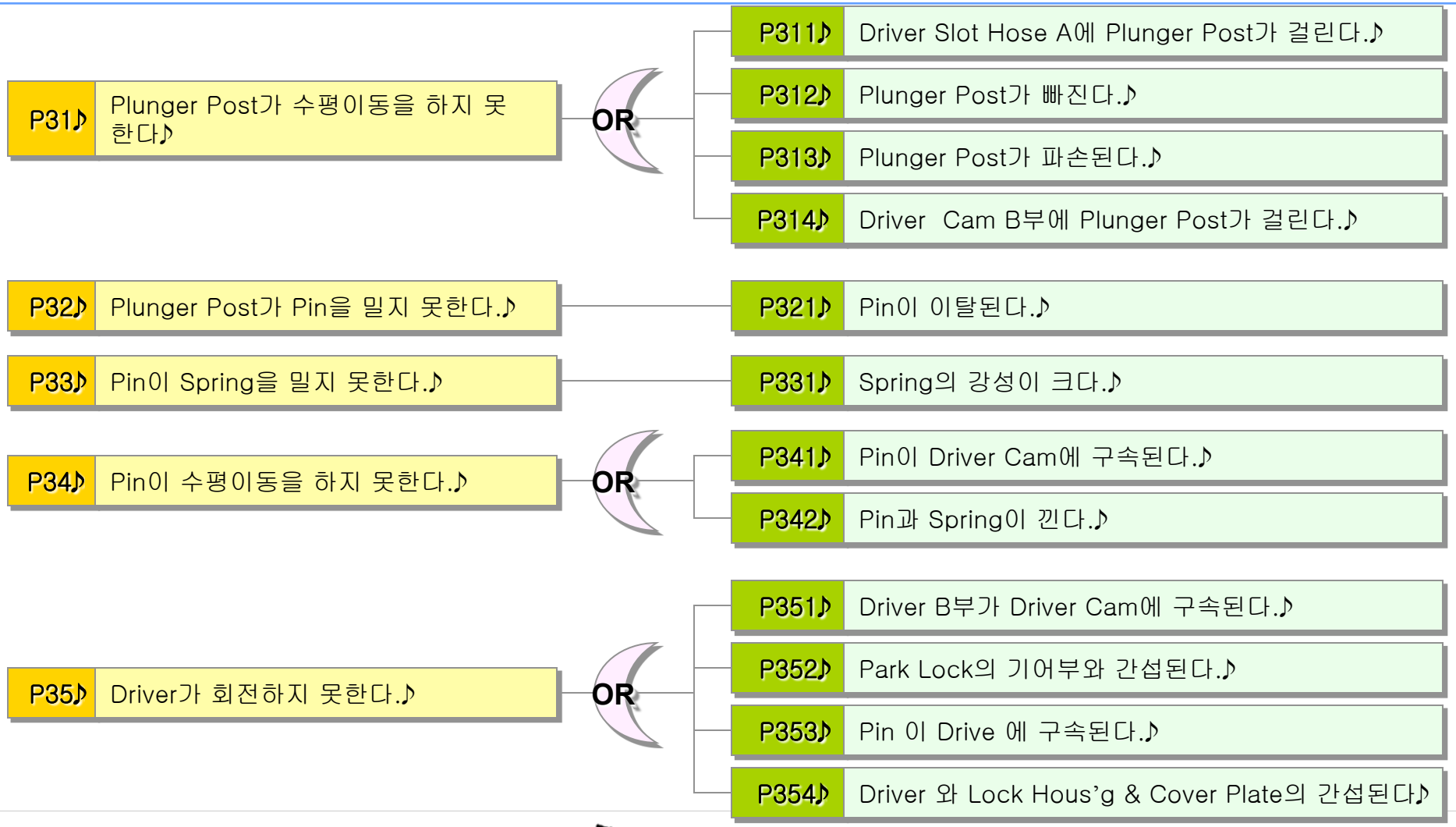
FTA (Fault Tree Analysis) – LEVEL 2-1



FTA (Fault Tree Analysis) – LEVEL 2-2



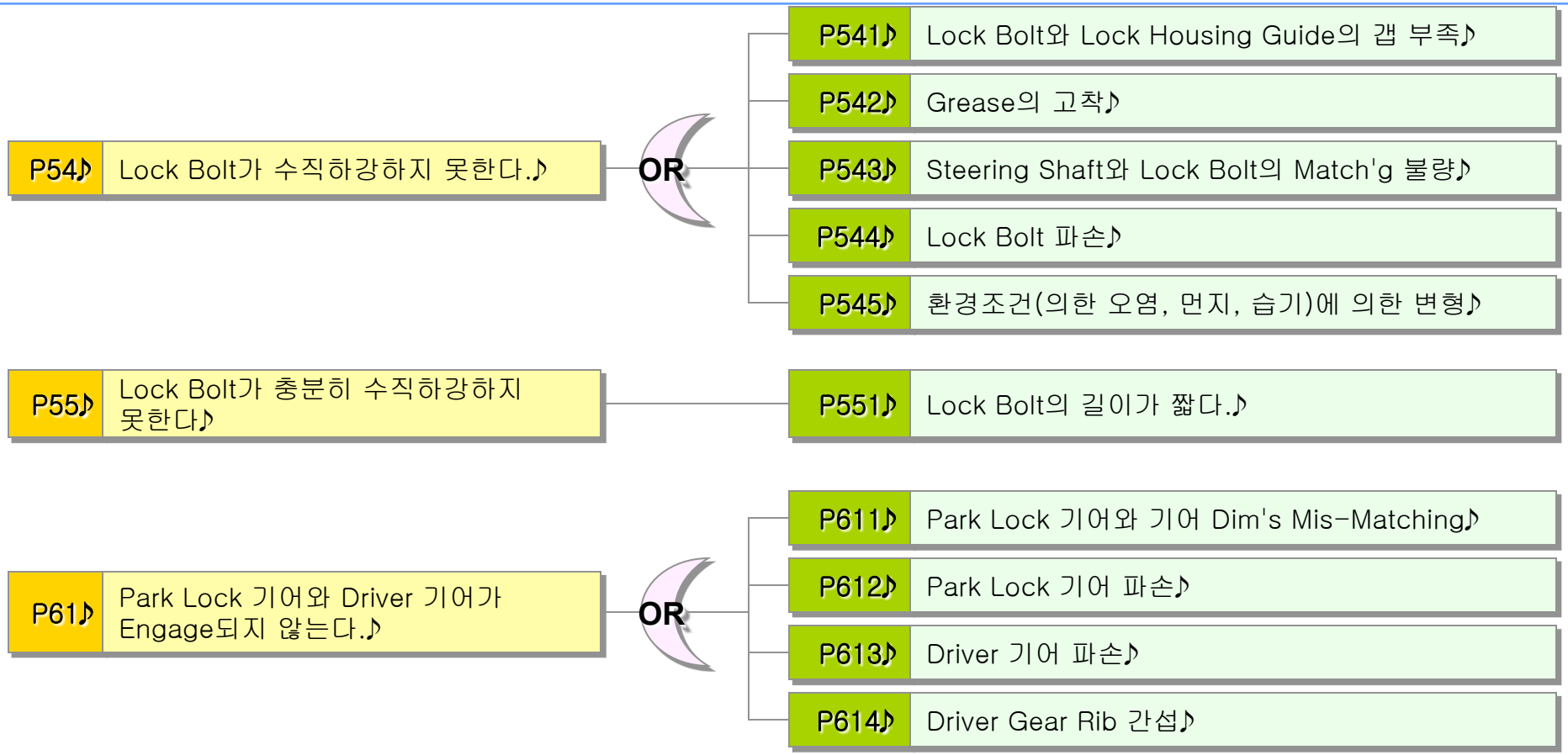
FTA (Fault Tree Analysis) – LEVEL 2-3



FTA (Fault Tree Analysis) – LEVEL 2-4

- P41♪ Driver가 Driver Cam을 밀지 못한다.♪
  - P411♪ Driver Cam Spring의 장력이 큼♪
- P42♪ Driver Cam이 Lock Bolt를 수직으로 당기지 못한다.♪
  - P421♪ Driver Cam이 파손된다.♪
- P43♪ Lock Bolt가 수직이동하지 못한다.♪
  - OR
    - P431♪ Lock Bolt가 Housing Hole에 구속된다.♪
    - P432♪ Lock Bolt가 Steering Shaft에 구속된다.♪
    - P433♪ Driver 파손♪
- P44♪ Lock Bolt가 충분히 수직이동하지 못한다.♪
  - OR
    - P441♪ Driver Cam이 마모되어 행정이 짧아진다.♪
    - P442♪ Lock Bolt가 길다.♪
- P51♪ Plunger Post가 수평이동 하지 못한다♪
  - OR
    - P511♪ Driver Slot Hose A에 Plunger Post가 걸린다. ♪
    - P512♪ Driver Cam Spring의 장력이 작음♪
- P52♪ Driver Cam Spring이♪ 수직으로 Cam을 밀지 못한다.♪
  - P521♪ Driver Cam Spring의 장력이 작음♪
- P53♪ Driver Cam이 수직하강하지 못한다.♪
  - P531♪ Driver Cam과 Lock Housing Guide의 갭 부족♪

FTA (Fault Tree Analysis) – LEVEL 2-5



FTA (Fault Tree Analysis) – LEVEL 2-6

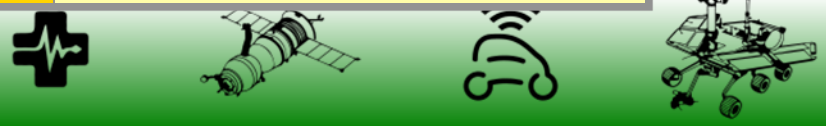
P71♪	Lock Housing과 Lock Bolt의 Rattle♪
P72♪	Driver와 Housing의 Rattle♪
P73♪	Hous'g과 Steer'g Shaft Bracket의 조립 Bolt Rattle♪
P74♪	Cover Plate Vs. Lock Housing Rattle♪

P711♪	Lock Housing과 Lock Bolt의 Clearance 과다♪
P721♪	Driver와 Housing의 Clearance 과다♪
P731♪	Housing과 Steering Shaft Bracket의 조립 Bolt Clearance 과다♪
P741♪	Cover Plate Lock Housing Clearance 과다♪

P81♪	Lock Cylinder가 Lock Housing에서 쉽게 빠진다.♪
P82♪	Lock Bolt가 부러진다.♪
P83♪	강제로 Key 대신 칼 등으로 돌릴 때, 돌아간다.♪
P84♪	Parking상태가 아닌데도, Acc→Lock이 된다.♪
P85♪	Key를 반대로 돌릴 때, 버티지 못한다.♪
P86♪	강제로 휠을 돌릴 때, Driver Rug가 버티지 못한다.♪
P87♪	Cover Plate 가 분리된다.♪

P91♪	충돌 시, Housing에 걸리는 하중을 지지하지 못한다♪

P911♪	Static Tensile Strength가 너무 작다.♪



Design FMEA

Failure Mode for Function

1 Actuator Plunger Post does not allow needed travel
2 Audible noise while driviving
3 Does not fit into Lock Housing
4 Does not provide required travel when Key in
5 Fail to retain
6 Fail to snap in
7 Failure to Tilt
8 Failure to operate of Park lock cable & EPL
9 Faiurel to Tilt
10 Jam Internal Parts
11 Lack of engagement between Lock Bolt and strg shaft
12 Lock Bolt broken by strg shaft rotational force
13 Lock Cylinder cannot engage Driver
14 Lock Housing does not meet requirements
15 Lost function
16 Noise for Cover plate
17 Noise from internal parts of Lock housing assembly
18 Pin pop out from Driver Cam
19 Pin was not popped out from Driver Cam
20 Provides too little travel when Key in
21 Provides too much travel when Key in
22 When key inserted and can not rotate Lock cyl'
23 When key inserted and rotated into Run position, the strg shaft cannot rotate
24 When rotated back into Off Lock position and with key removed, the strg shaft can rotate (Lock Bolt will not fire)
25 Will not return to original position

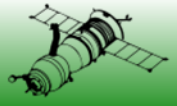
Failure Mode for Interface

1 Not able ot assemble Park lock cable & EPL
2 Not able ot rotate Lock CYL'
3 Not able to assemble Anti rotation pin
4 Not able to assemble Bearing
5 Not able to assemble Ignition switch
6 Not able to assemble MFS Bracket
7 Not able to assemble PATS
8 Not able to assemble Shift boots
9 Not able to assemble Shroud
10 Not able to assemble Tilt bumper
11 Not able to assemble Tilt lever
12 Not able to assemble Tilt lever spring
13 Not able to assemble Tilt pin
14 Not able to assemble Tilt Pivot Pin
15 Not able to rotate Lock CYL' & Park lock cable & EPL
16 Not retracted far enough between 46° and 0°

DFMEA Vs. FTA

구 분		Design FMEA	FTA	FMEA Vs. FTA	Remarks
Failure Mode	Function	25	54	29	18 Items 미반영
	Interface	16	-	-	
Stack Review		35	36	4	4 Items(with S/Shaft 3)

No	FTA-Code			Failure Mode	RPN				Remark
					S	O	D	R	
1			P113	Lock Cylinder가 Driver에 매칭되지 않는다.					
2			P114	Lock Housing과 Lock Cylinder의 매칭 Hole 위치 부적절하다.					
3			P121	스프링이 Plunger에 낀다.					
4			P143	I/S의 장착위치가 멀다.					
5			P153	I/S의 장착 위치가 가깝다.					
6			P211	Driver B부위가 Driver Cam에 구속된다.					
7			P342	Pin과 Spring이 낀다.					
8			P421	Driver Cam이 파손된다.					
9			P433	Driver 파손					
10			P441	Driver Cam이 마모되어 행정이 짧아진다.					
11			P442	Lock Bolt가 길다.					
12			P542	Grease의 고착					
13			P731	Housing과 Steering Shaft Bracket의 조립 Bolt Clearance 과다					
14		P83		강제로 Key 대신 칼 등으로 돌릴 때, 돌아간다.					
15		P85		Key를 반대로 돌릴 때, 버티지 못한다.					
16			P911	Static Tensile Strength가 너무 작다.					
17		P92		화재시 유독 가스를 발생시킨다.					
18		P93		화재시 불 붙는다.					현실성에 대한 재평가 필요


Critical to Quality Dimension from KPP

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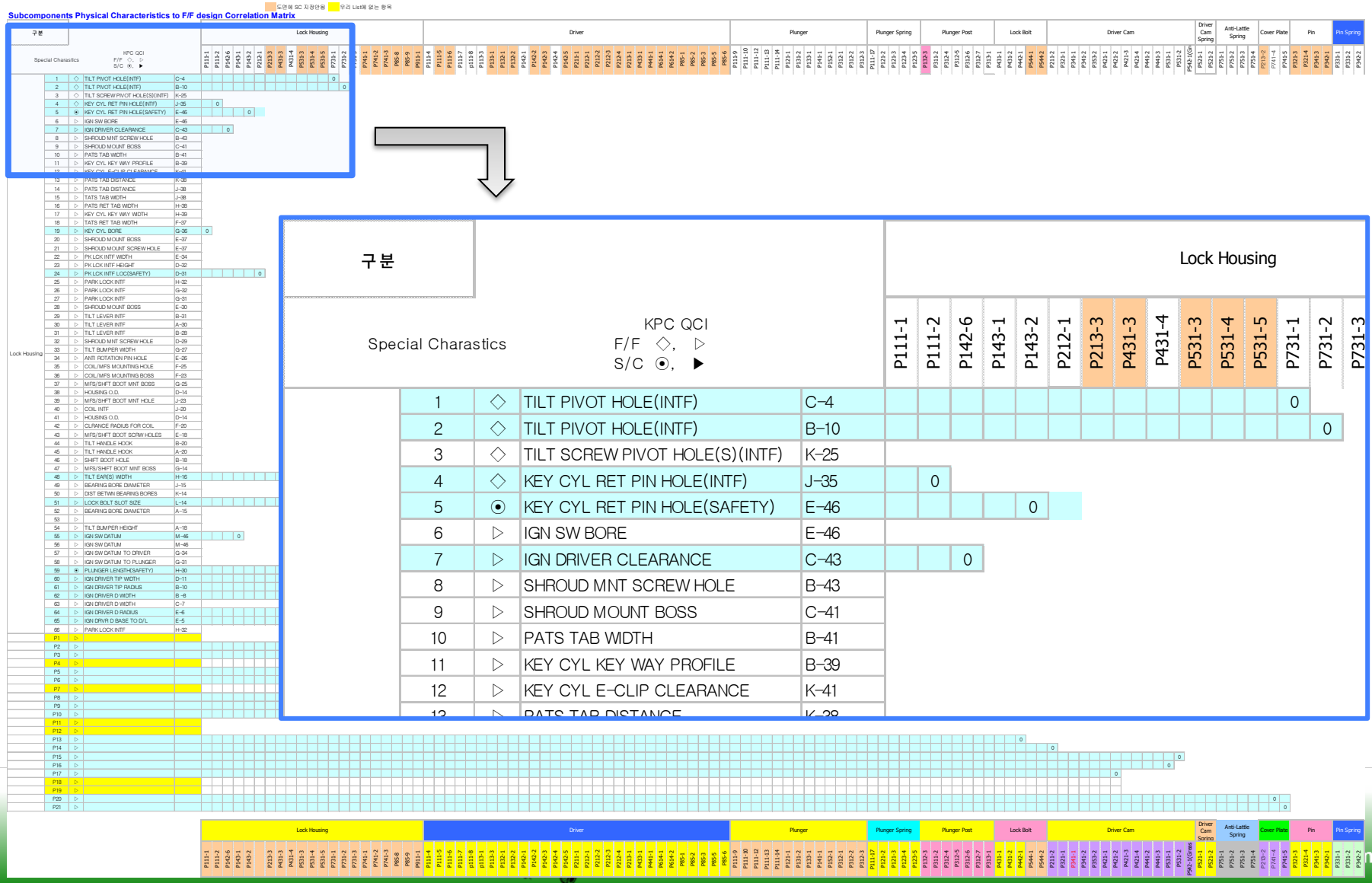
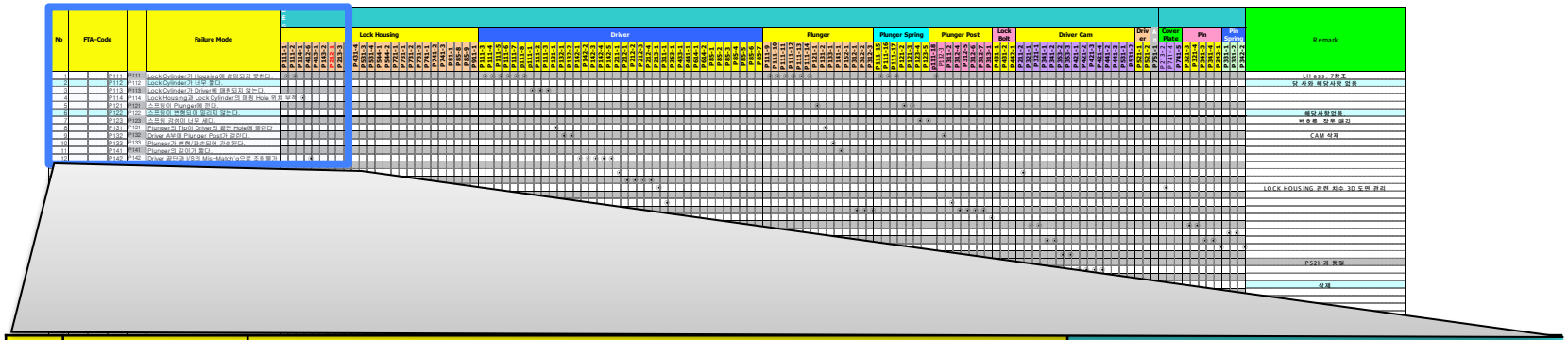


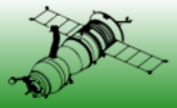
Failure Mode Critical Dimension



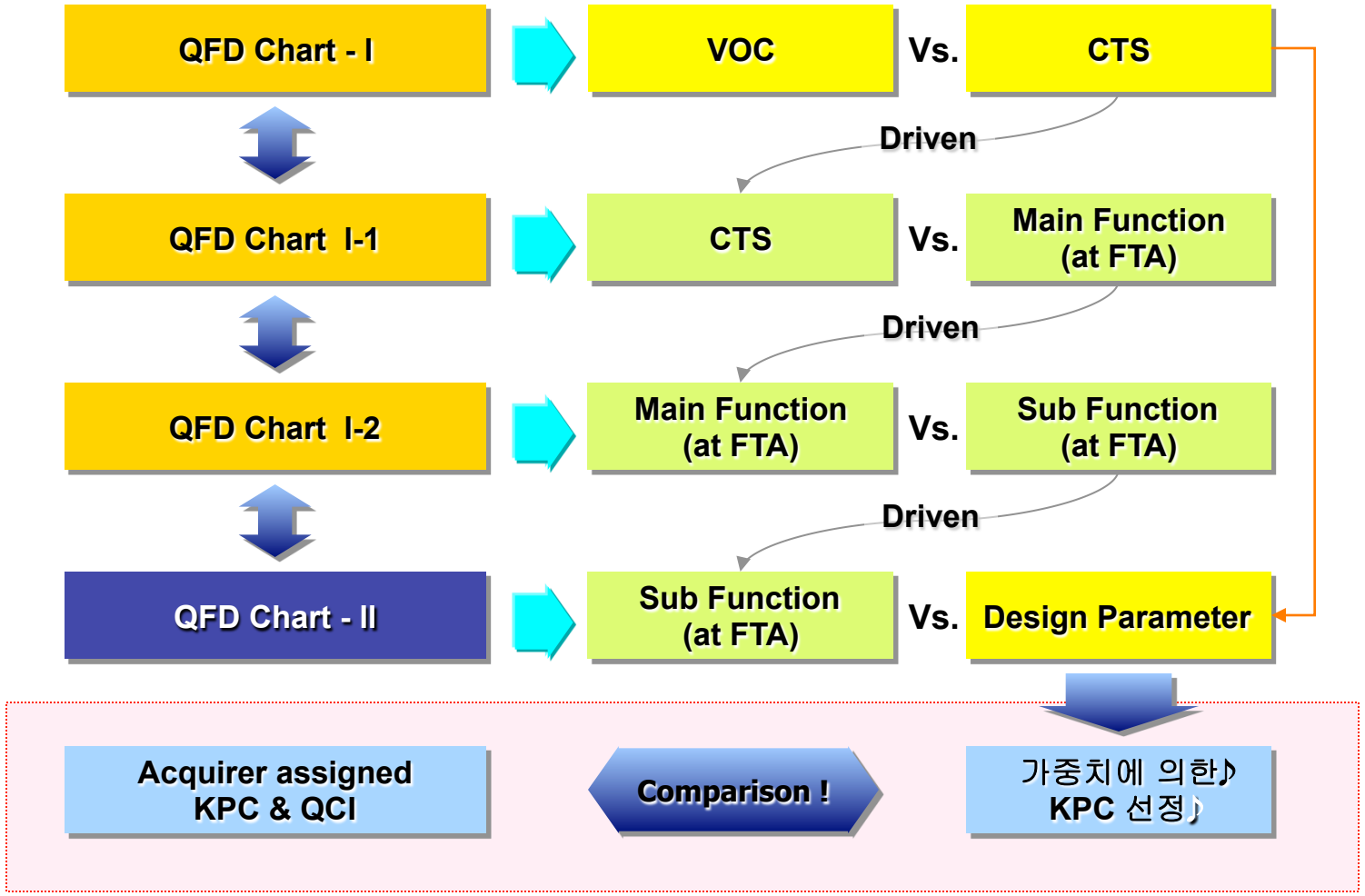
No	FTA Code	Failure Mode	DESIGN PARAMETERS									
			Lock Housing									
			P111-1	P111-2	P114-1	P412-6	P413-1	P143-2	P212-1	P213-3	P431-3	P431-4
1	P111	Lock Cylinder can not inserted into Housing.	⊙	⊙								
2	P112	Length of the Lock Cylinder is too short.										
3	P113	Don't Matching of Lock Cylinder to Driver										
4	P114	Miss matching Machine hole position of Lock Housing and Lock Cylinder			⊙							
5	P121	Spring get jammed tightly within Plunger										
6	P122	Spring did not work due to deformation										
7	P123	Spring strength is too high										

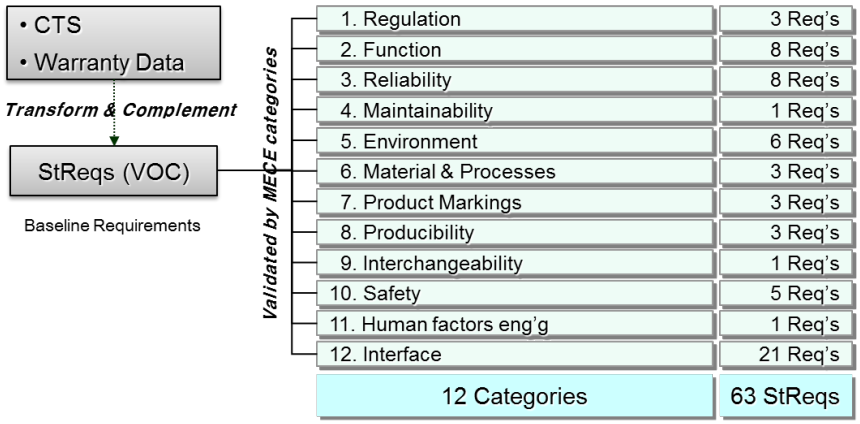
KPP & PQP

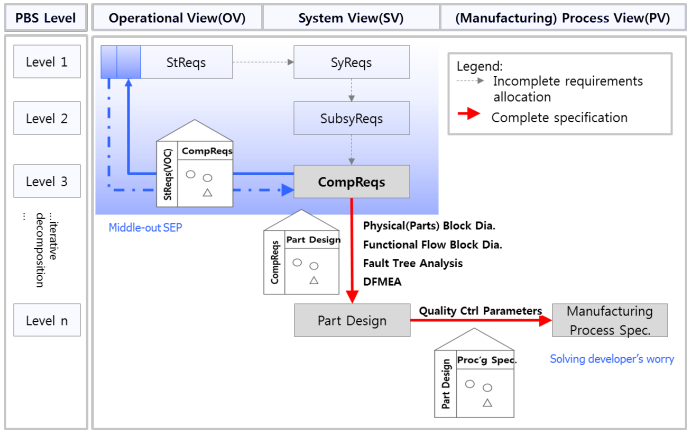
Products & Process		Parts			
		Parts Requiring Extra Care			Remaining Parts Requiring Standard Care
		Component Handling	Functional Check	Traceability	Safety / Compliance
Characteristics	Parameters Requiring Extra Care	Verified & Control Parameters			
	Key Performance Parameters (KPP)				
	Key Production Quality Parameters (PQP)				
	Remaining Parameters Requiring Standard Care				


Traceability




• CTS
• Warranty Data
Transform & Complement
StReqs (VOC)
Baseline Requirements
Validated by MECE categories
1. Regulation 3 Req's
2. Function 8 Req's
3. Reliability 8 Req's
4. Maintainability 1 Req's
5. Environment 6 Req's
6. Material & Processes 3 Req's
7. Product Markings 3 Req's
8. Producibility 3 Req's
9. Interchangeability 1 Req's
10. Safety 5 Req's
11. Human factors eng'g 1 Req's
12. Interface 21 Req's
12 Categories
63 StReqs


PBS Level
Operational View(OV)
System View(SV)
(Manufacturing) Process View(PV)
Level 1
Level 2
Level 3
iterative decomposition
Level n
StReqs
SyReqs
SubsyReqs
CompReqs
StReqsVOC
CompReqs
Part Design
Middle-out SEP
Legend:
Incomplete requirements allocation
Complete specification
Physical(Parts) Block Dia.
Functional Flow Block Dia.
Fault Tree Analysis
DFMEA
Part Design
Quality Ctrl Parameters
Manufacturing Process Spec.
Part Design
Proc'g Spec.
Solving developer's worry