

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

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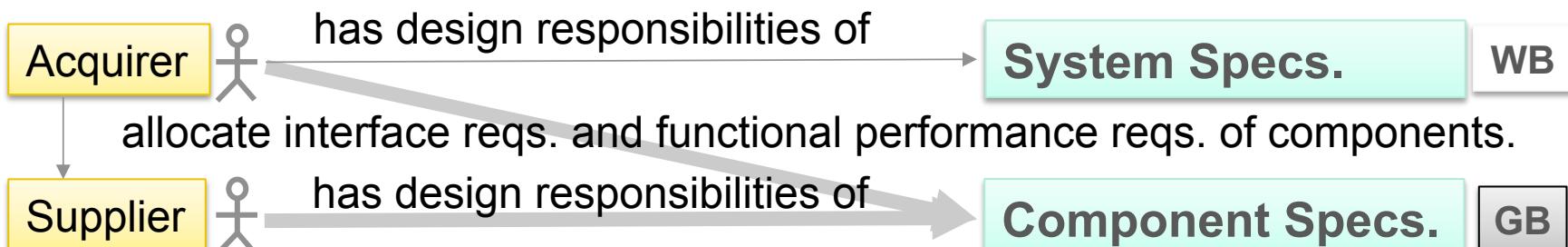
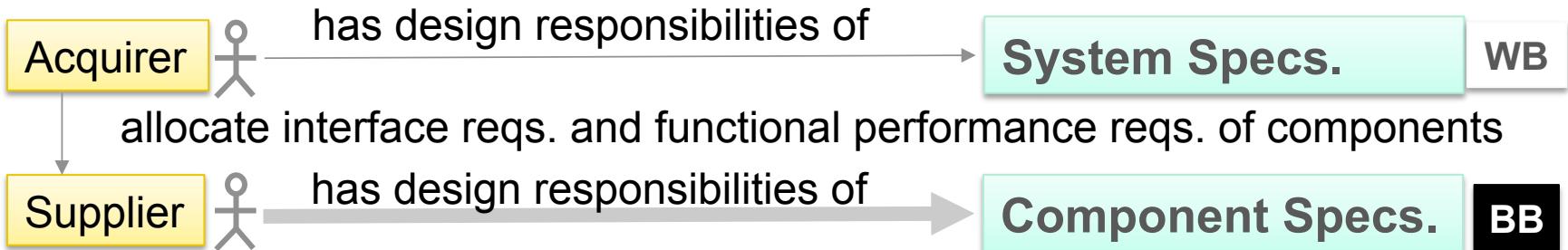
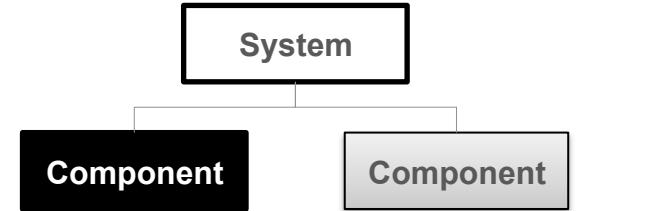
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- 1. Usual problems of generic top-down SE process for the gray-box item design**
- 2. The middle-out SE process to overcome the problems of gray-box item design**
- 3. Case study of middle-out SE process application for Automotive Lock Housing Assembly design**
- 4. Summary**



Whit Box, Gray Box & Black Box

Concept of Whit Box, Gray Box & Black Box items



WB White box item

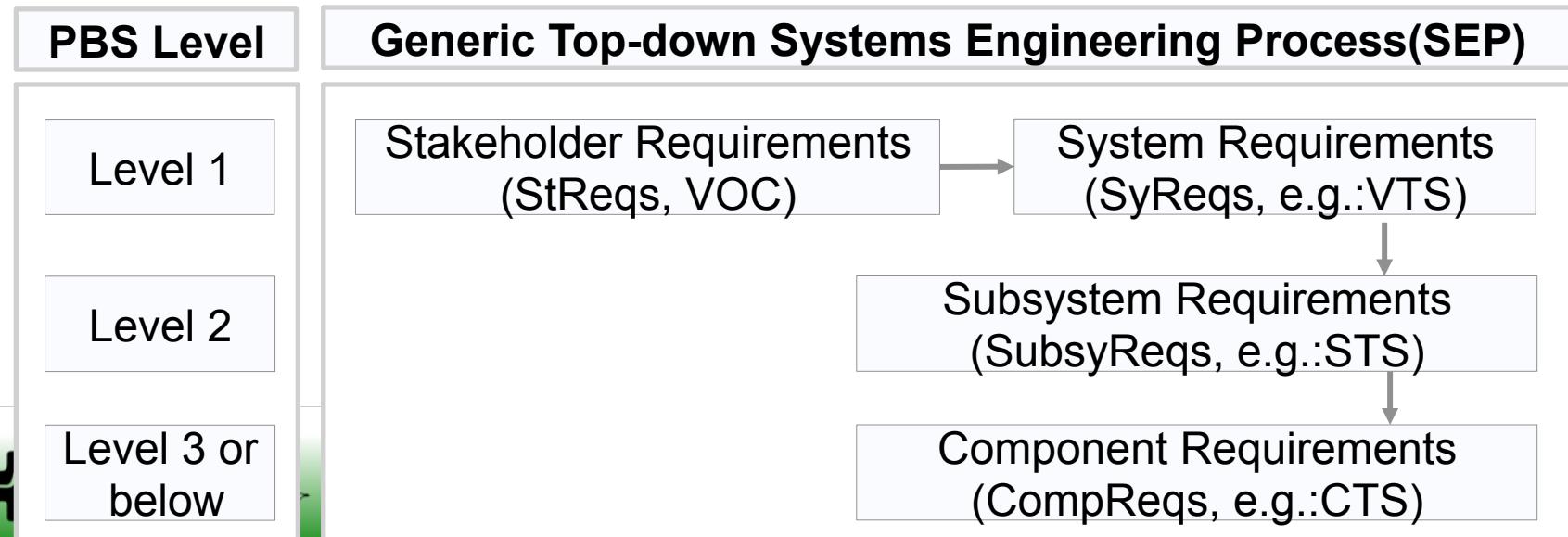
GB Gray box item

BB Black box item



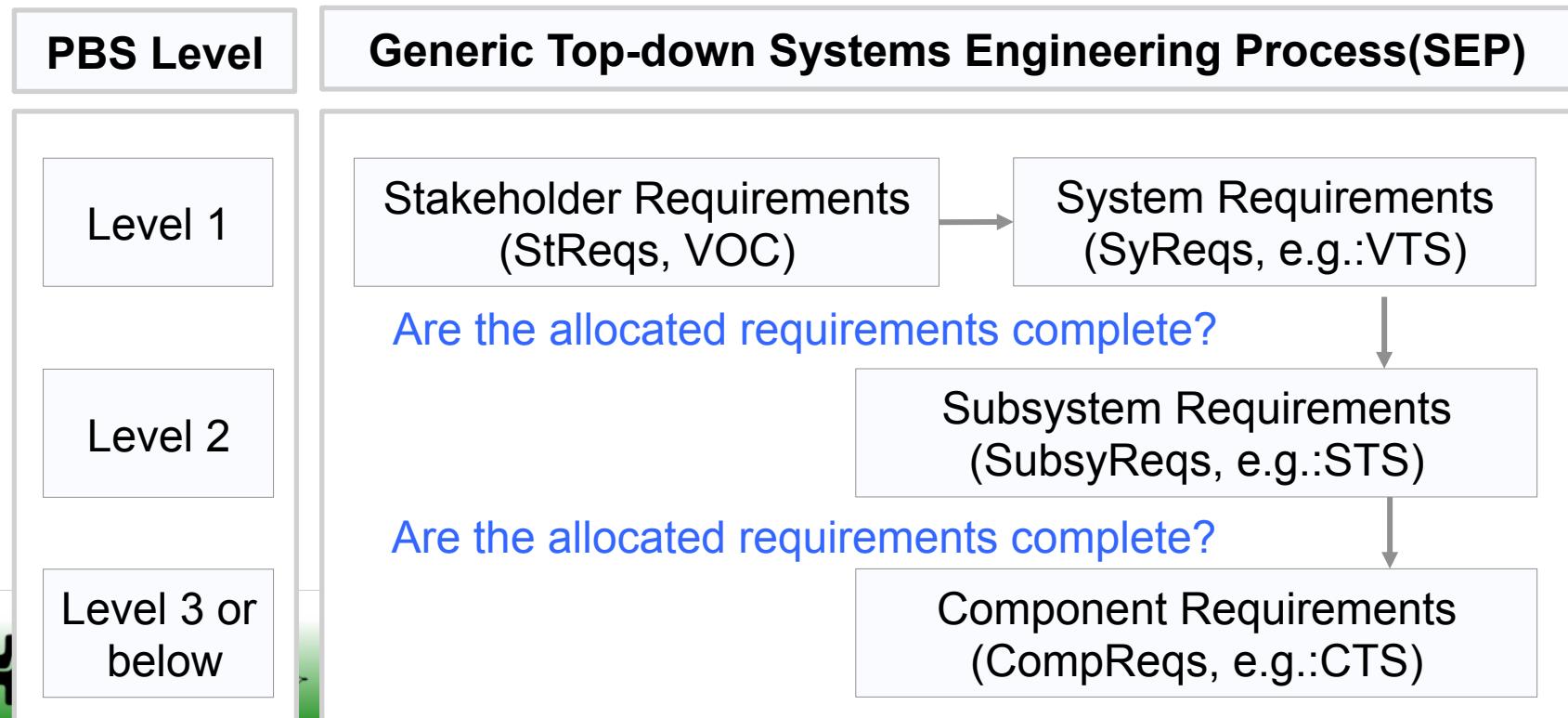
Generic Top-down SEP

- 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.

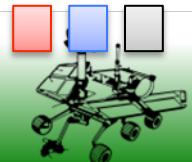
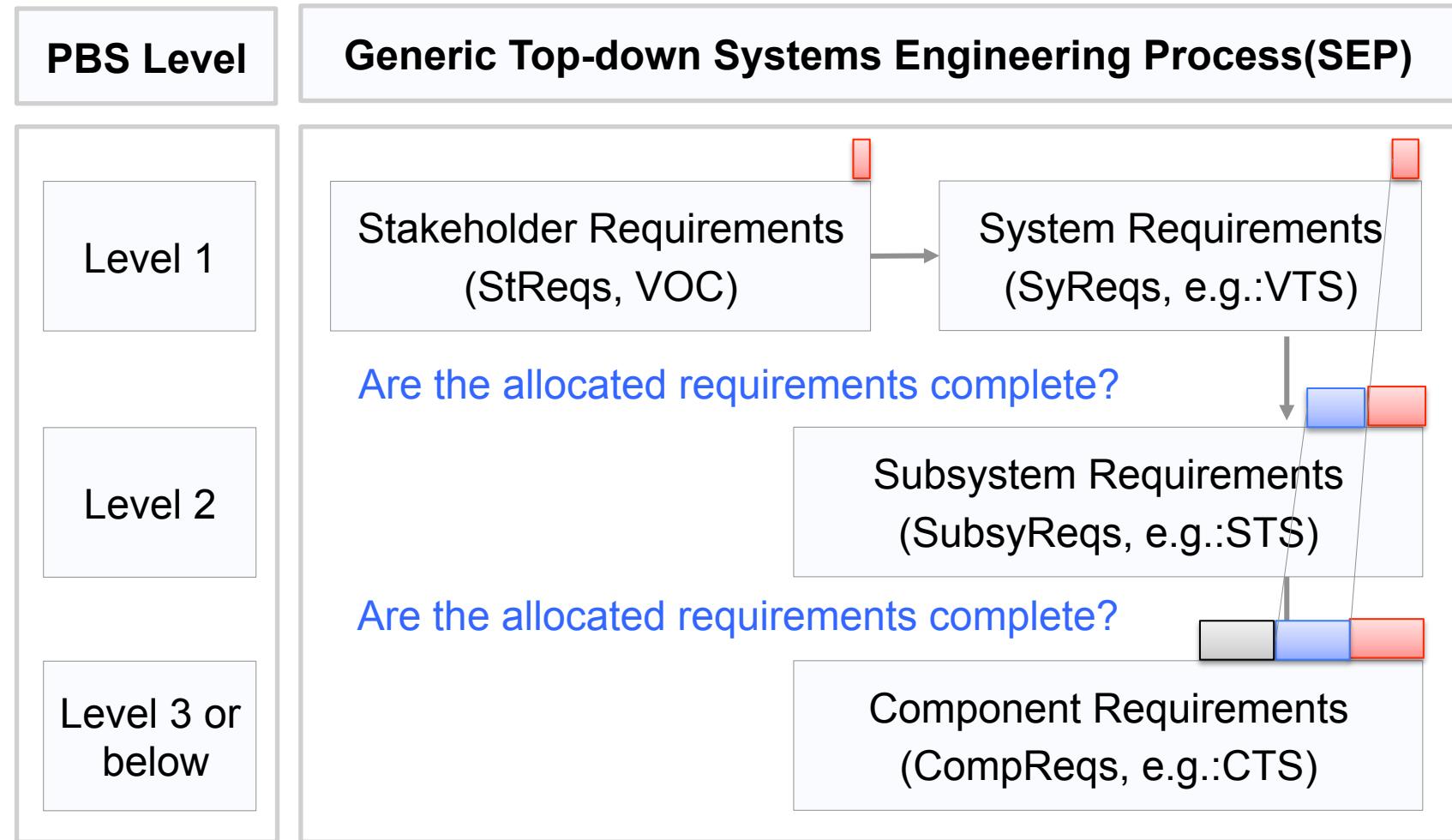


Usual Problems of Generic Top-down SEP

- 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.

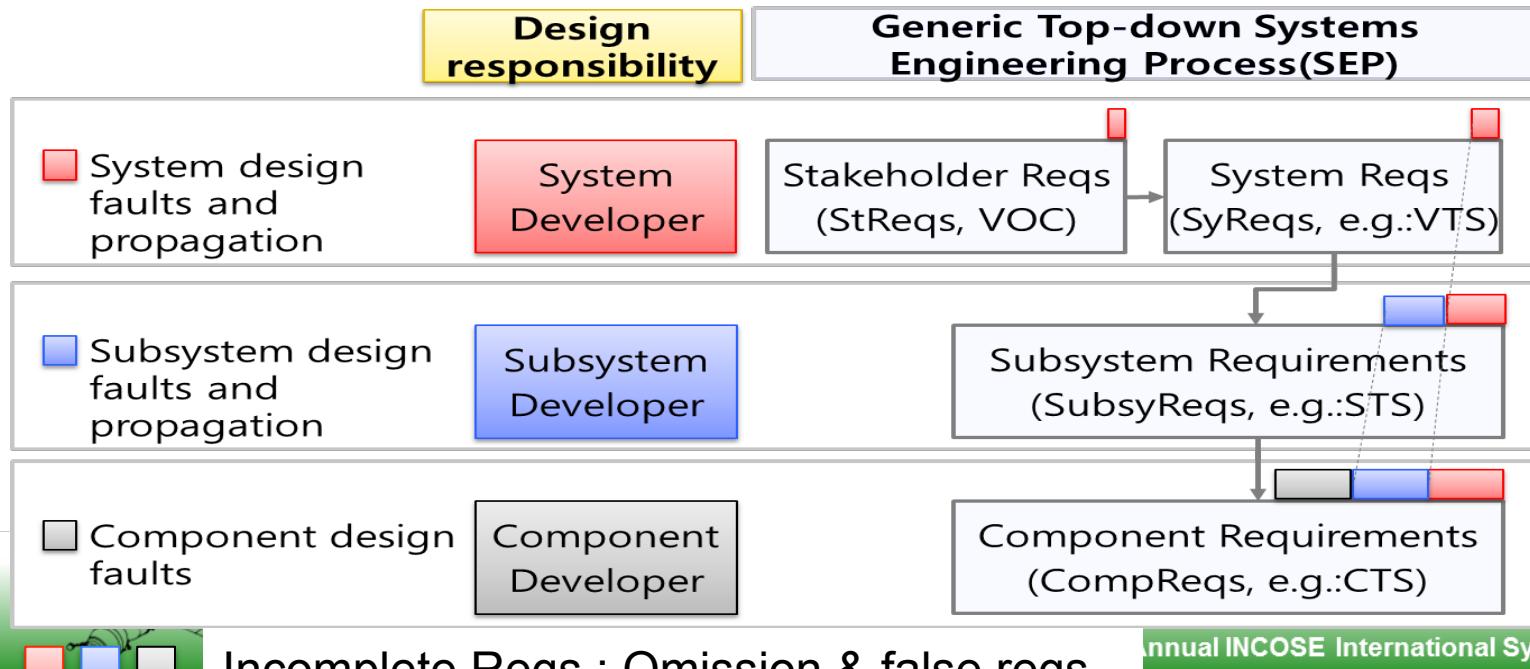


Design faults flow down



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 transfer based on the clearly defined design responsibilities relative to the gray-box item.



Problems of Top-down SEP for Gray-Box Items

Design responsibility

Generic Top-down Systems Engineering Process(SEP)

System Developer

Stakeholder Requirements
(StReqs, VOC)

System Requirements
(SyReqs, e.g.:VTS)

Practical responsibility of incomplete reqs. f
or Gray-box items.

Subsystem Developer

Subsystem Requirements
(SubsyReqs, e.g.:STS)

GB
WB, BB

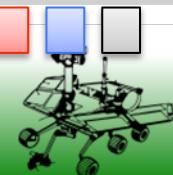
Practical responsibility of incomplete reqs. f
or Gray-box items.

Component Developer

Component Requirements
(CompReqs, e.g.:CTS)

GB
WB, BB

Incomplete Reqs.: Omission & false reqs.



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**



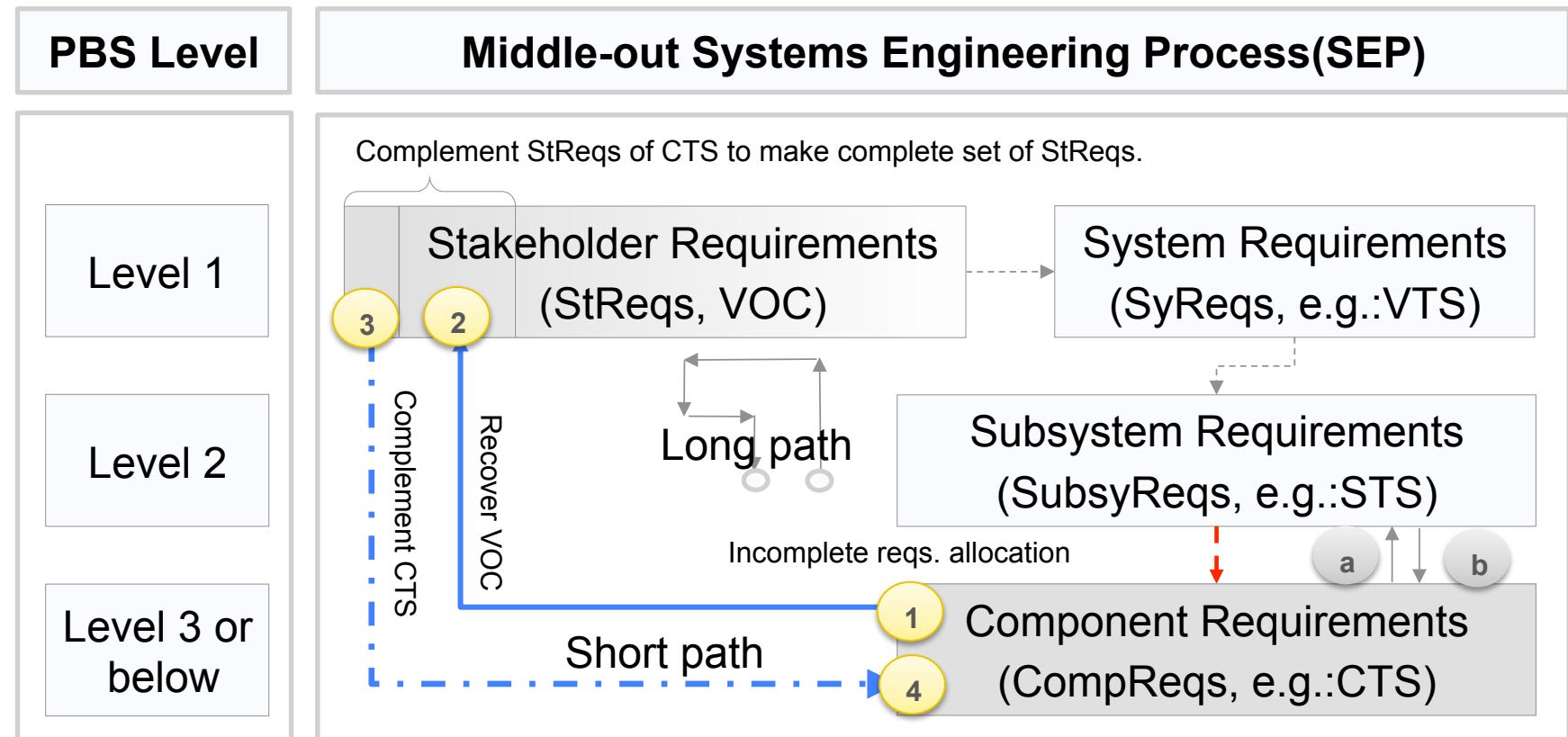
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Middle-out Systems Engineering Process(SEP)

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

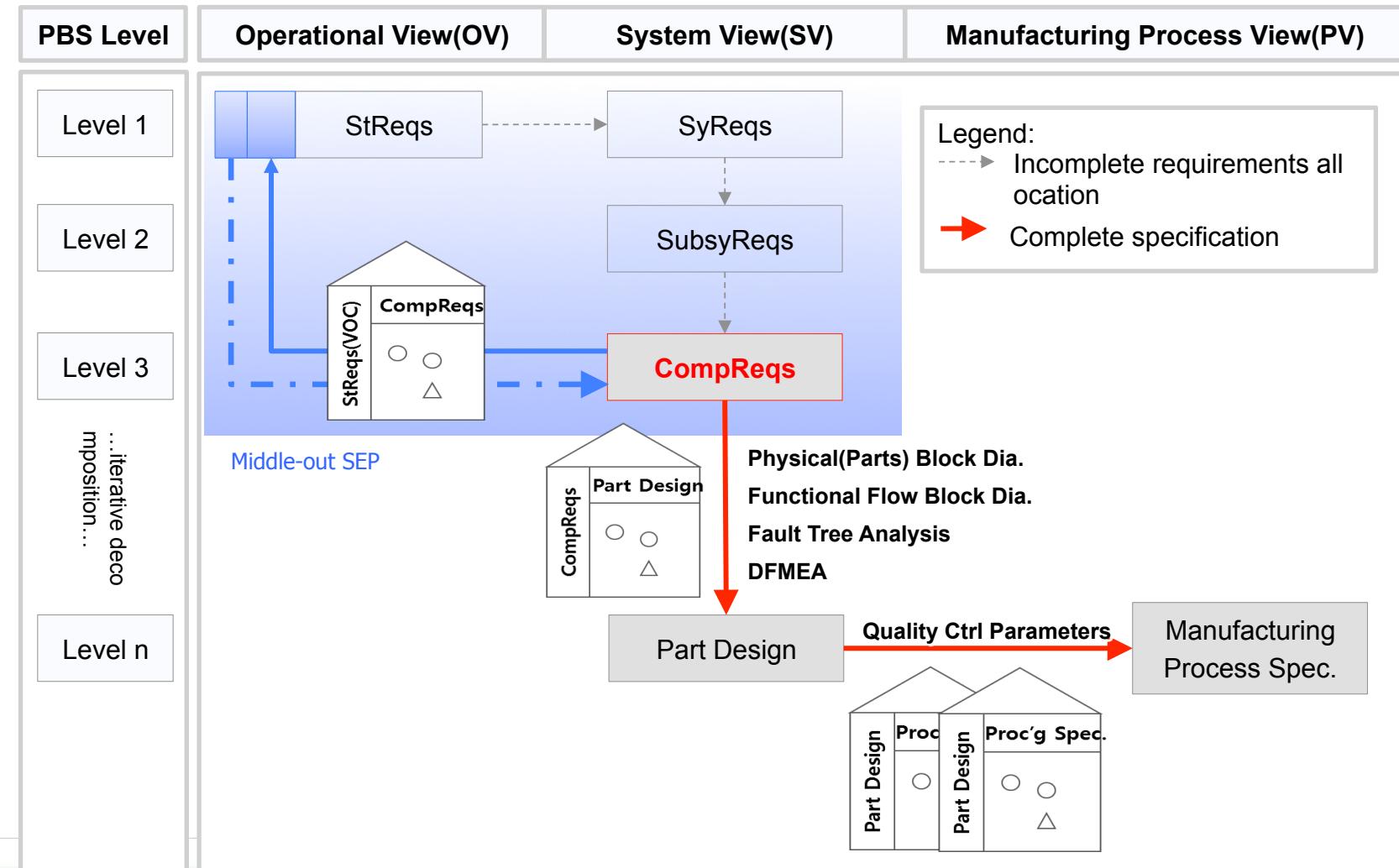


Middle-out Systems Engineering Process(SEP)

- ❑ **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 to 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 component.**
 - Complement the stakeholders requirements relevant to the component.
- 4. Transform the complemented stakeholders requirements to the component requirement to develop complete set of component requirements.**
 - Trace the StReqs to component requirement and re-complement the component 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 worry by Middle-out SEP

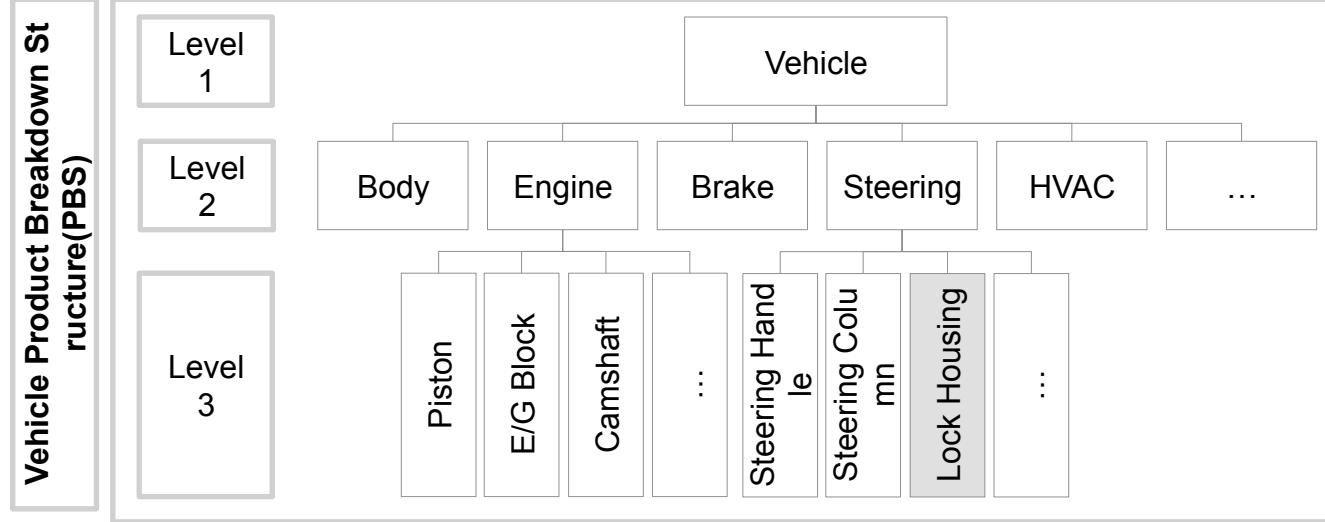


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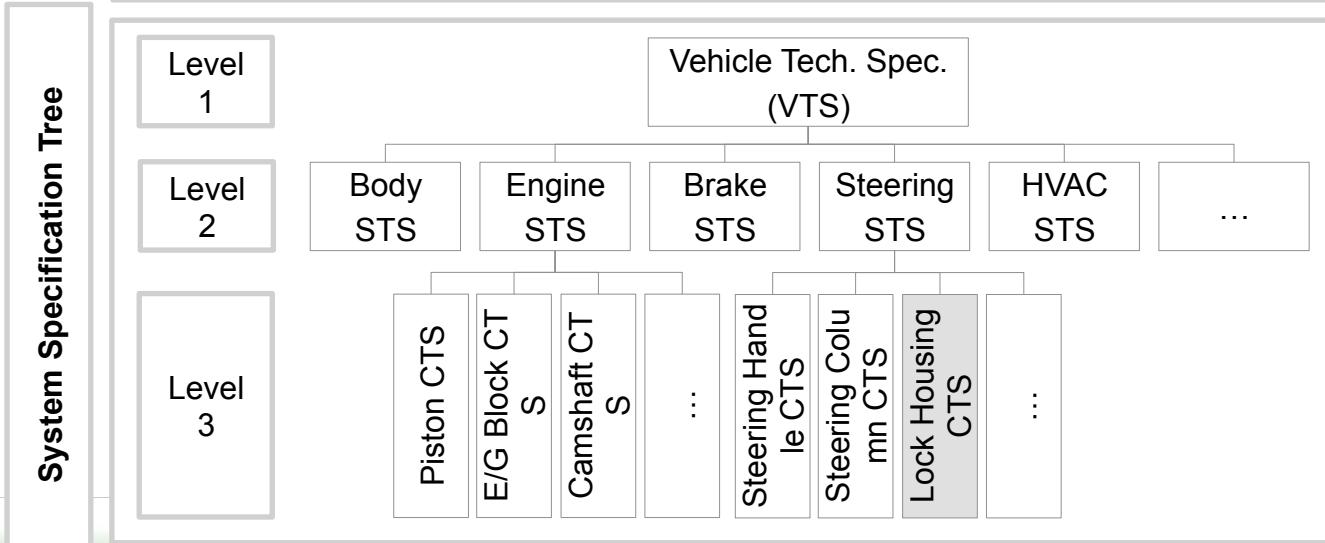


Physical Hierarchy of Vehicle & Lock Housing Assembly as a GB item



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

- Vehicle(system),
- Subsystem,
- Component



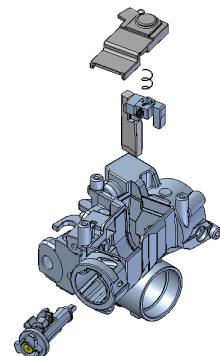
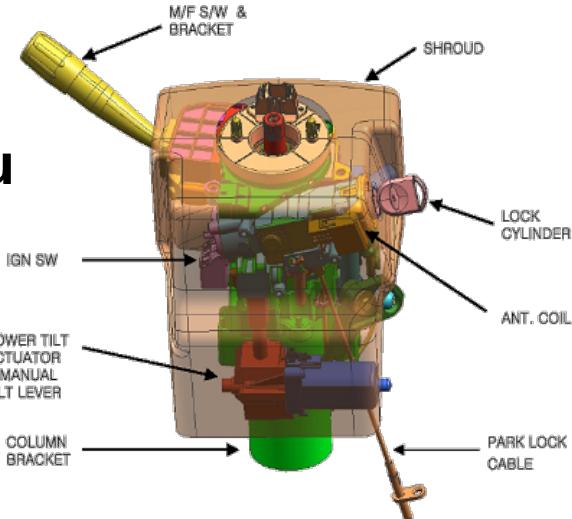
Corresponding technical specs

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

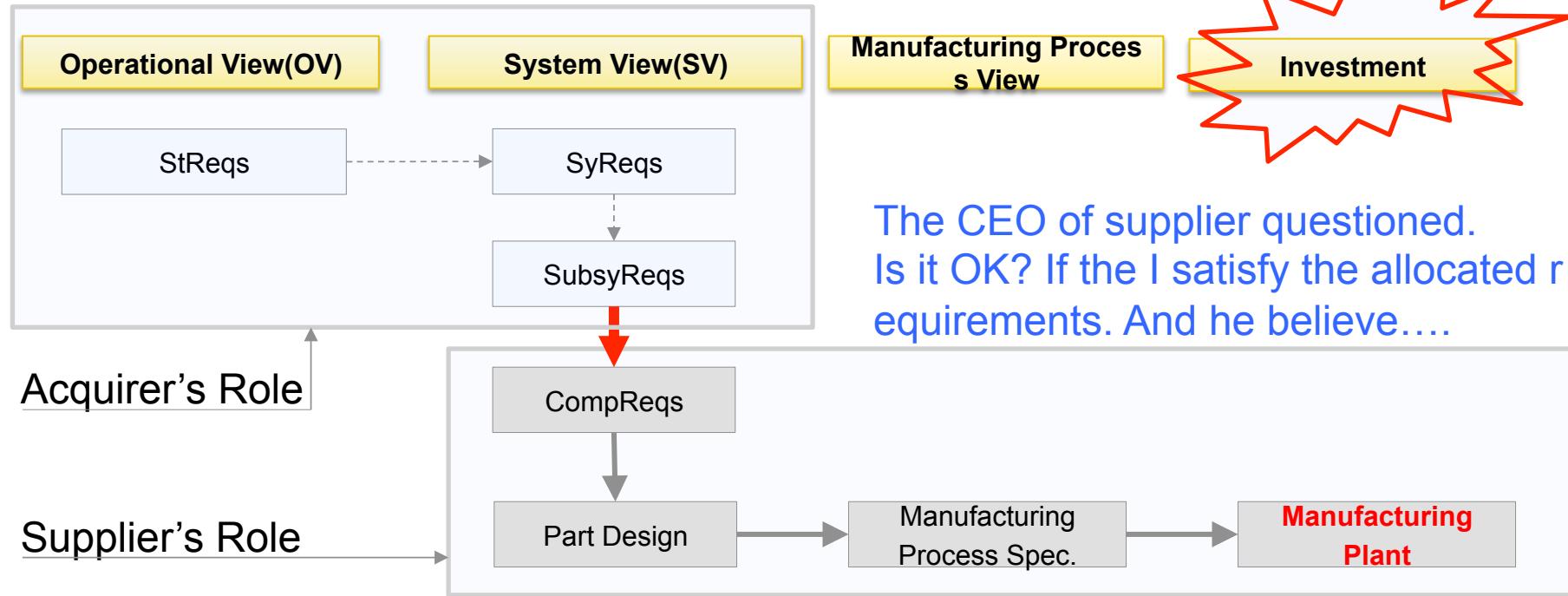


Lock Housing Assembly

- 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.

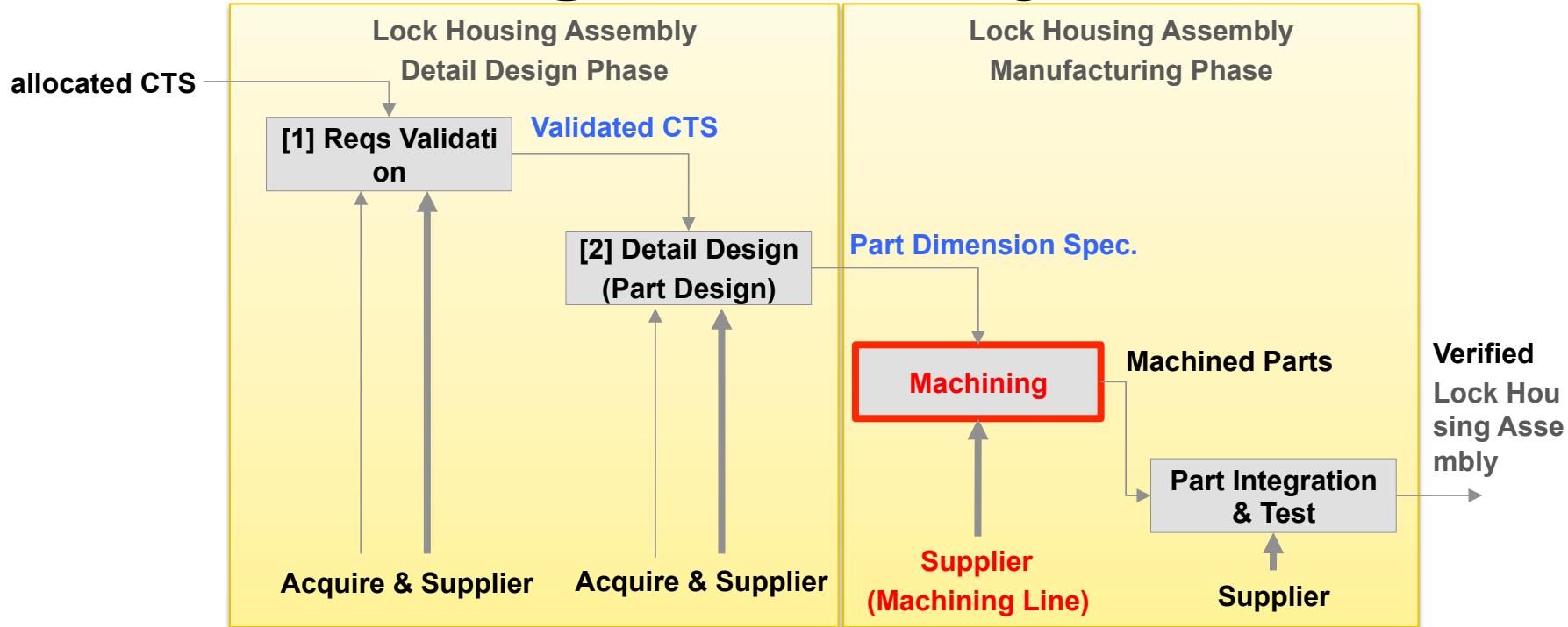


Development problem of Lock Housing Assembly – Possibility of Big Loss!

- 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?



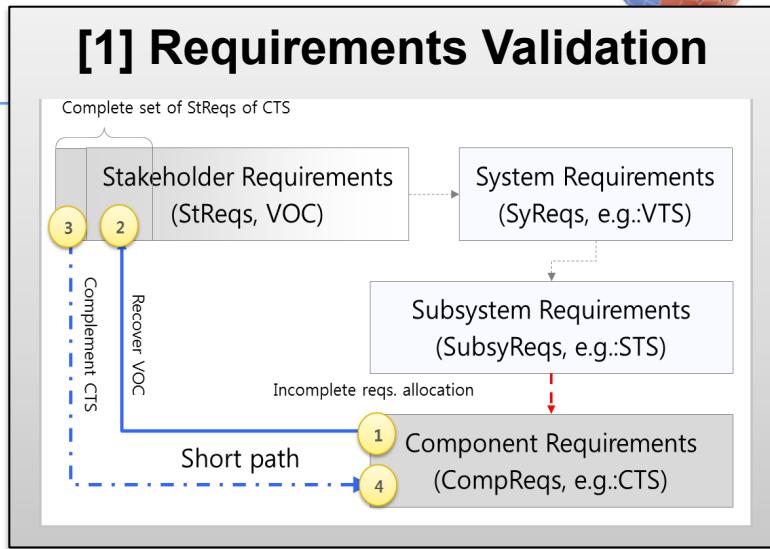
- One question is “**Is it ok if I satisfy just the allocated CTS?**”
 - In other words, “How can we confirm that the allocated CTS is the total set of design requirements of Lock Housing Assembly?” → **Validate the allocated CTS by Middle-out SEP**
- The other question is “**What design parameters of 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 the allocated CTS by the Middle-out SEP

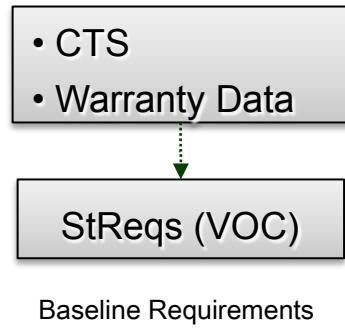
ref.) MECE: Mutually Exclusive & Collectively Exhaustive Rule



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)



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	

- 1 MVSS 102 (Shift Lever 관련 법규)
- 2 MVSS 114 (Anti-theft)
- 3 MVSS 302 (Flammable)
- 4 키 삽입 기능
- 5 키 휘从容 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 휘从容 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 램프이 설계 정비 개념 : Lock Bolt Assy 최소 정비 단품임
- 21 수명기간 내 습도 조건에서 기능 이상 품질을 갖는 것
- 22 수명기간 내 온도 조건에서 기능 이상 품질을 갖는 것
- 23 수명기간 내 먼지 조건에서 기능 이상 품질을 갖는 것
- 24 수명기간 내 진동 조건에서 기능 이상 품질을 갖는 것
- 25 수명기간 내 충격 조건에서 기능 이상 품질을 갖는 것
- 26 수명기간 내 충격 조건에서 기능 이상 품질을 갖는 것
- 27 제조 및 운송중 사용 환경에 대한 내구성
- 28 천화경 재료의 사용(예:6가 Cr 사용 금지)
- 29 리사이클링 재료 사용
- 30 품번 및 미터 표기
- 31 제조 생산 Lot 표기
- 32 리사이클링 재료 부품 재질 표기
- 33 주조성(호흡성, 풍도로 설계)
- 34 가공성(재료 설정, Tool 접촉성 풍도로 설계)
- 35 조립성(조립 자동화 고려 설계)
- 36 한 부품 사양으로 6차종 공용
- 37 의도하지 않는 조향능력 상실(steering lock) 방지
- 38 차량출동시 Housing에 걸리는 하중을 지지할 것
- 39 Park 상태에서 만 시동 될 것(급발진 등 방지)
- 40 화재 시 유독가스 발생 없을 것
- 41 화재 시 불붙지 말 것
- 42 승객이 감지할 수 있는 미음 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 Christmas 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



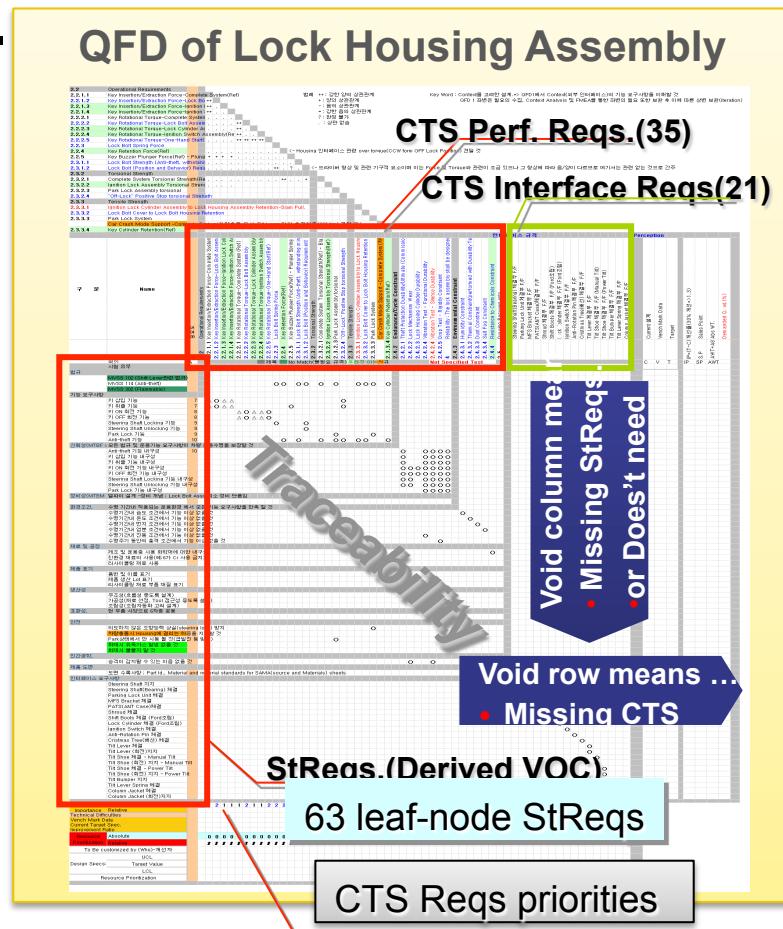
12 Categories

63 StReqs

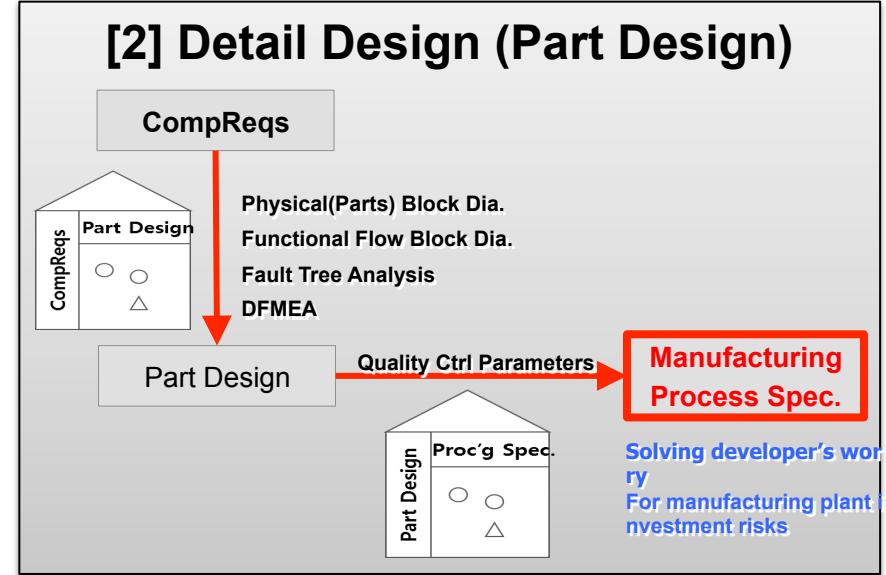
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Middle-out SEP Application(2/2)

- **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



No.	Focused detail design by generic SEP	Applied Methods
1	Part design	<ul style="list-style-type: none"> • Physical(Parts) Block Dia. • Functional Flow Block Dia. • Fault Tree Analysis • DFMEA
2	Define Dimensional Quality Control Parameters	<ul style="list-style-type: none"> • Relation matrix • Dimensional quality control chart for critical dimension of parts

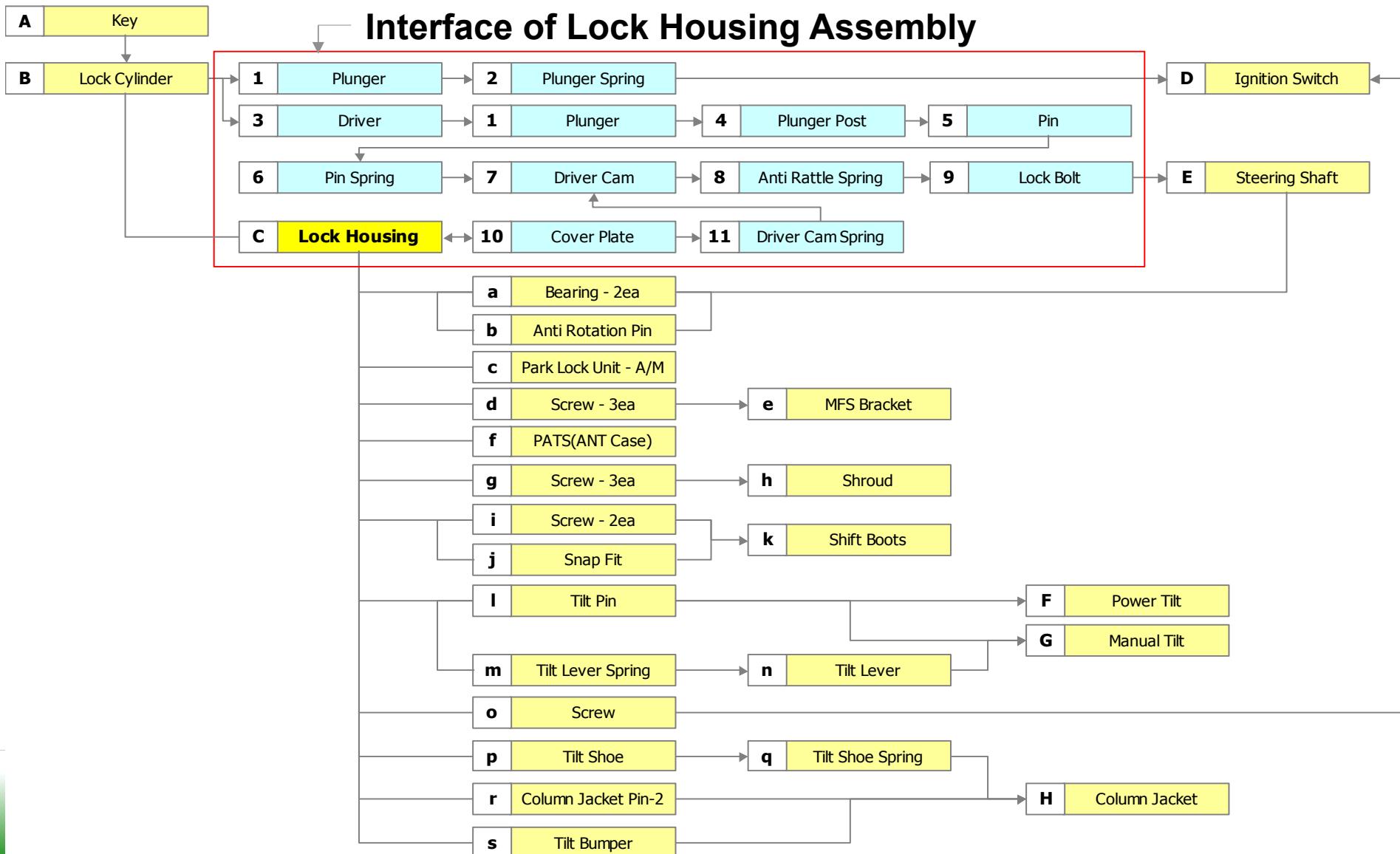
Detail design of Parts by Generic SEP

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

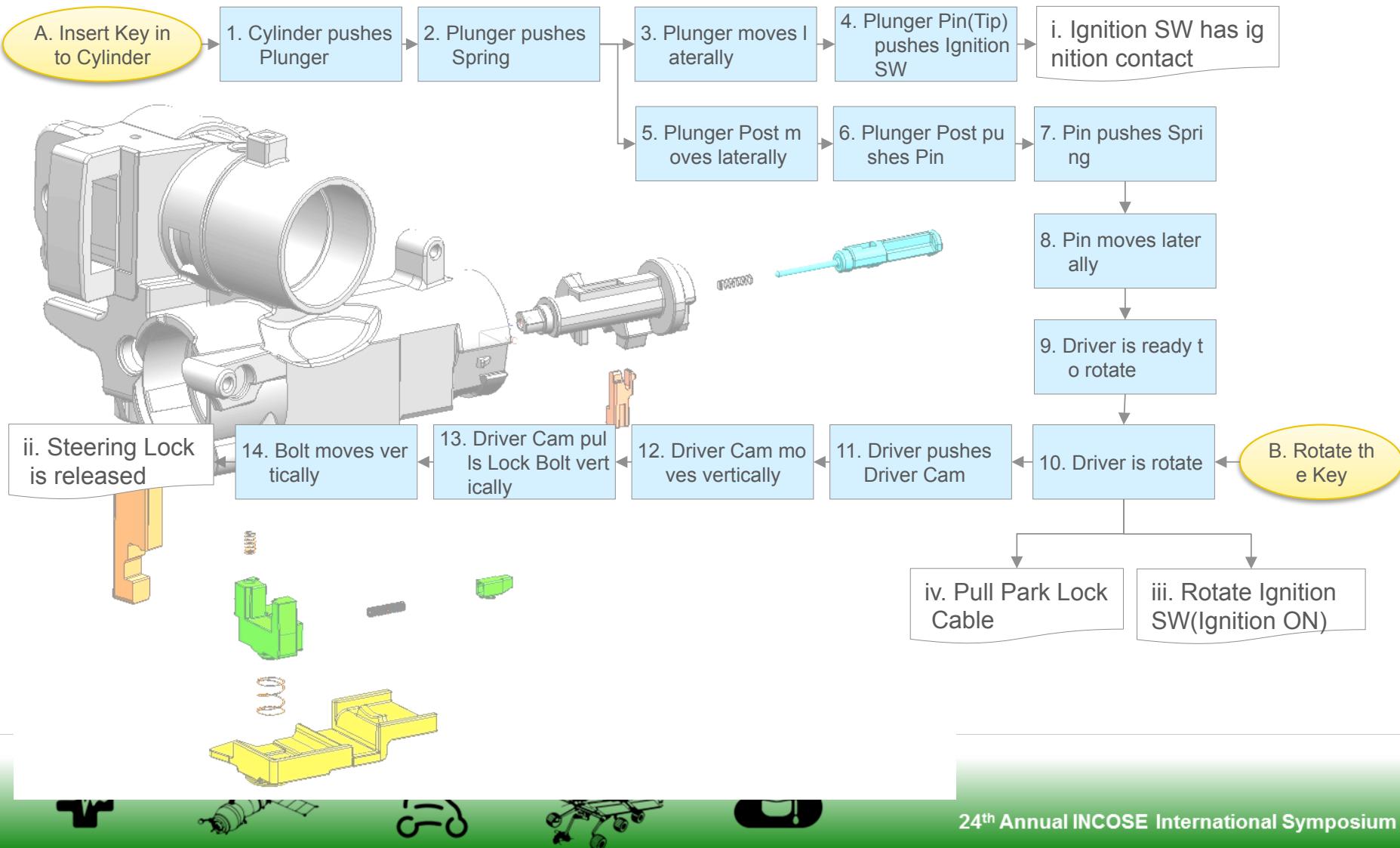
- Methods applied for Part design
 - Physical(Parts) Block Dia.
 - Functional Flow Block Dia.
 - Fault Tree Analysis
 - DFMEA



Physical(Parts) Block Diagram



Functional Flow Block Diagram



Fault Tree Analysis

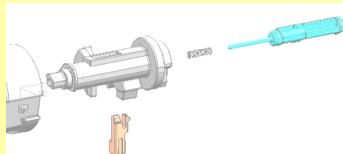
1st Level 10 Failure Modes of Lock Housing Assembly

- P1 Ignition contact does not 'ON'.
- P2 Ignition

Evolved to 2nd & 3rd Level Failure Modes



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

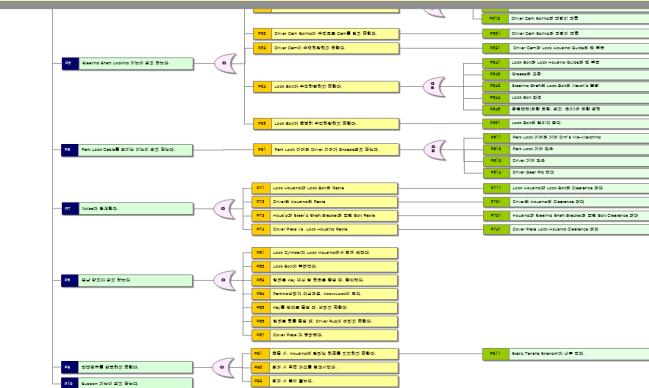
Housing Component

P7 Noise.

P8 Anti-theft function does not work

P9 Does not meet the safety regulations.

P10 Support function fails.



CTS to Parts Function Correlation Matrix

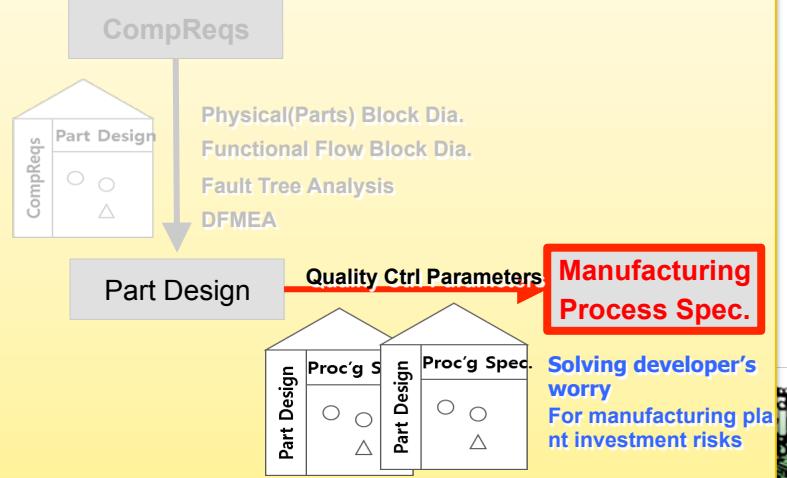
CompReqs		Lock Housing Assembly CTS										Parts Functions										
		Part Design										Parts Functional Performance Specs										
CompReqs		Part Design										Parts Functional Performance Specs										
												Importance										
												P11) Cylinder pushes Plunger.										
												P12) Plunger pushes Spring										
												P13) Plunger moves to Ign'tn SW.										
												P14) Plunger Tip push Ignition SW										
												P21) Driver rotates reversly.										
												P23) Plunger returns 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										

Relation matrix between Lock Housing Assembly CTS and Parts Functions



Parts Function to Physical Characteristics Correlation Matrix

Detail Design (Part Design)

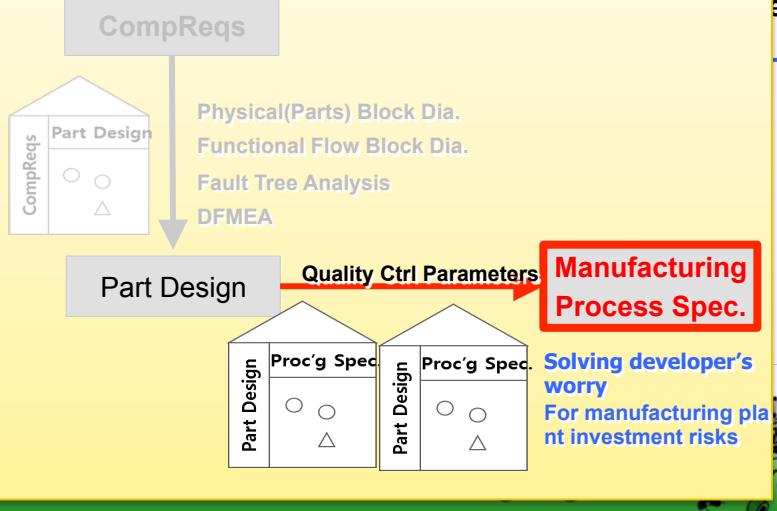


Physical Characteristics of Parts

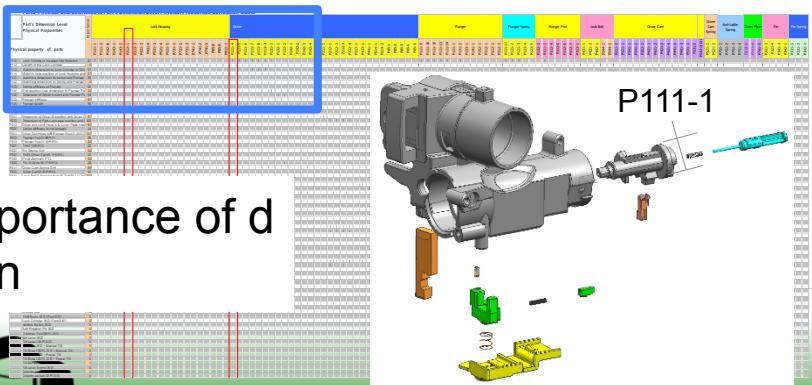
Parts Physical Characteristics to Parts Dimension Correlation Matrix

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	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																			

Detail Design (Part Design)



each dimension		33	54	30	0	##	27	27	59	64	99	16	16	27	27	27	27	35	59
Total importance of dimension		33	54	30	0	##	27	27	59	64	99	16	16	27	27	27	27	35	59



Relation Matrix CTS to Part's Dimension

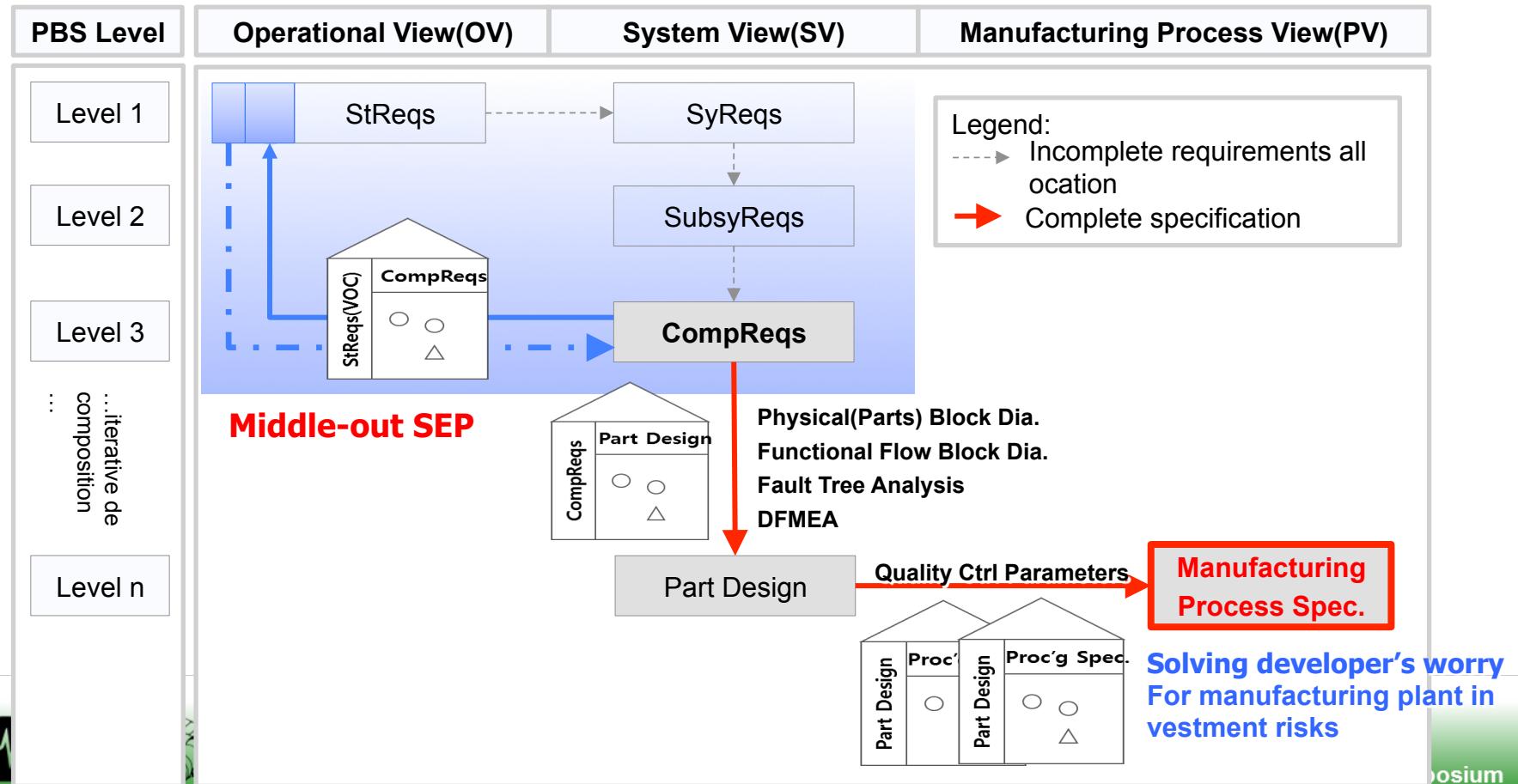
Relation Matrix of Lock Housing Assembly CTS to Part's Dimension Level Physical Properties

		Part's Dimension Level Physical Properties	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
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								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	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	1	1	1	1		
2.2.3	Lock Bolt Spring Force	3																																
	Traced	Sc	or	33	54	30	16	16	137	67	10	11	10	18	2	82	82	82	14	54	59	64	99	51	175	79	41	35	35	3	3	3	3	3559915935



Summary

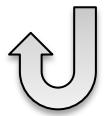
❑ Solving Gray-box item developer's worry by Middle-out SEP



Ref.

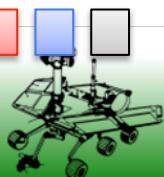
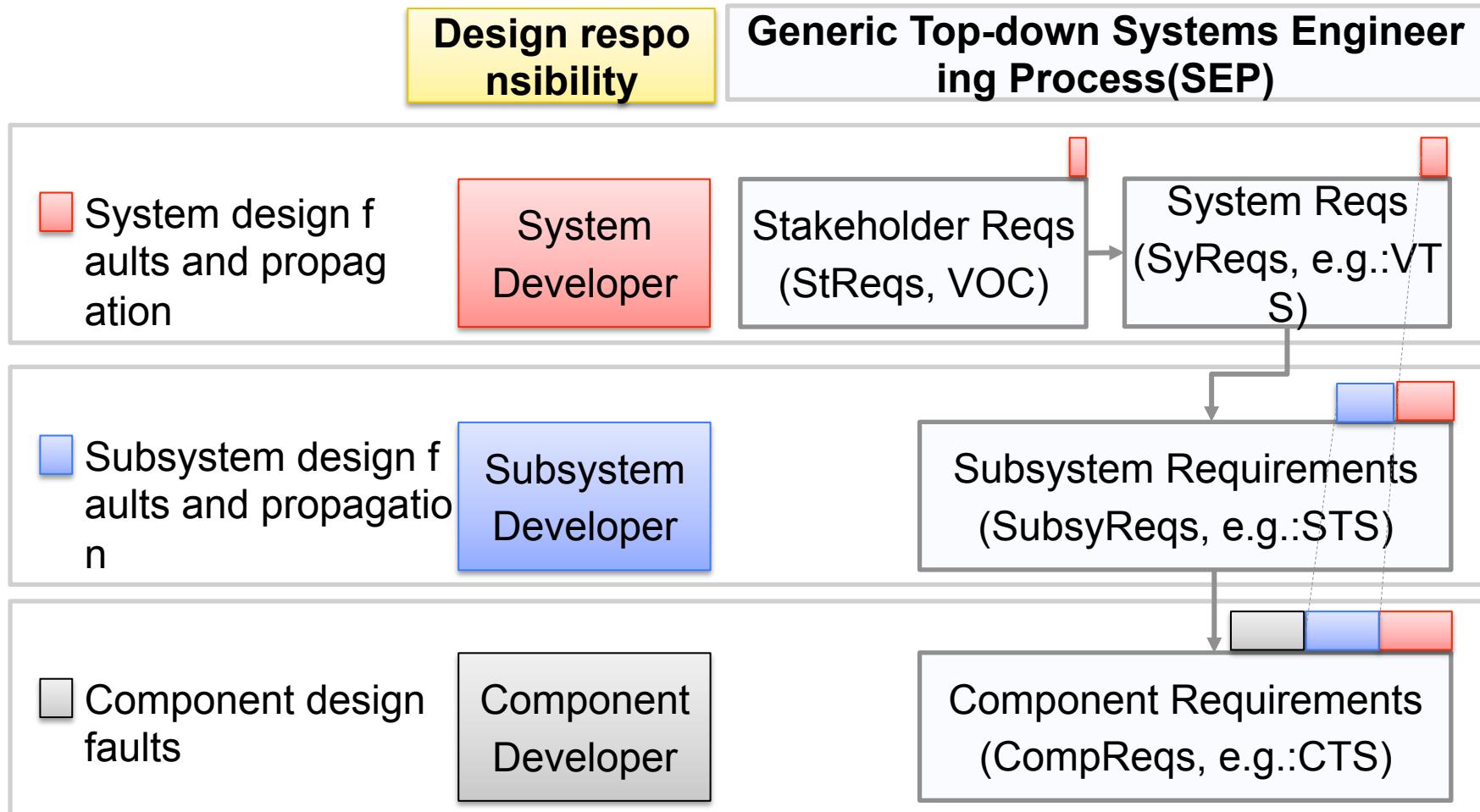


Terms

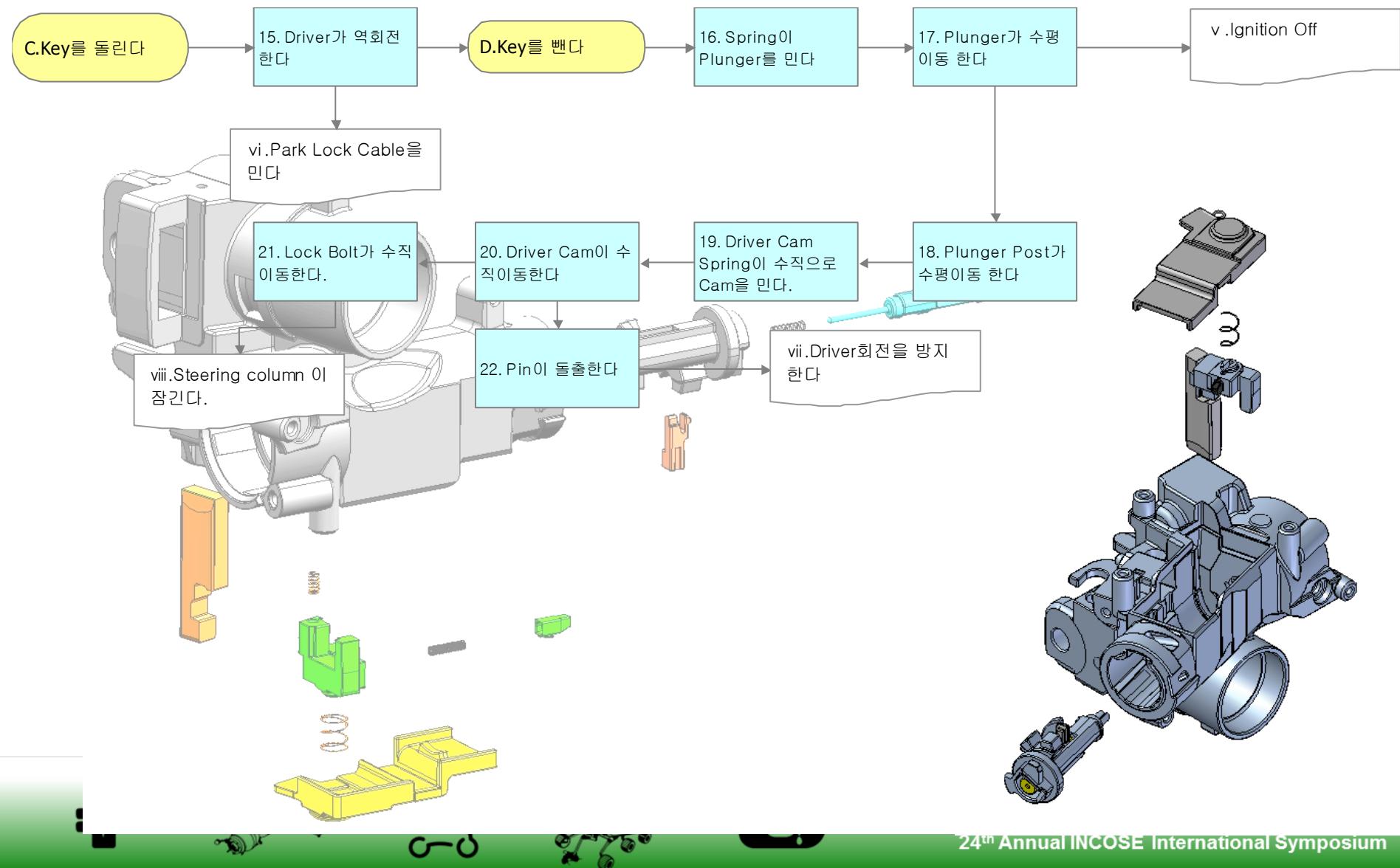


Integration level	Car maker's description
White box	<ul style="list-style-type: none">• All the engineering decision is made by the acquirer.• Design responsibility completely belongs to the acquirer(car maker).• BIW (Body-In-White) and related components are white box items.
Gray box	<ul style="list-style-type: none">• 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	<ul style="list-style-type: none">• 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.

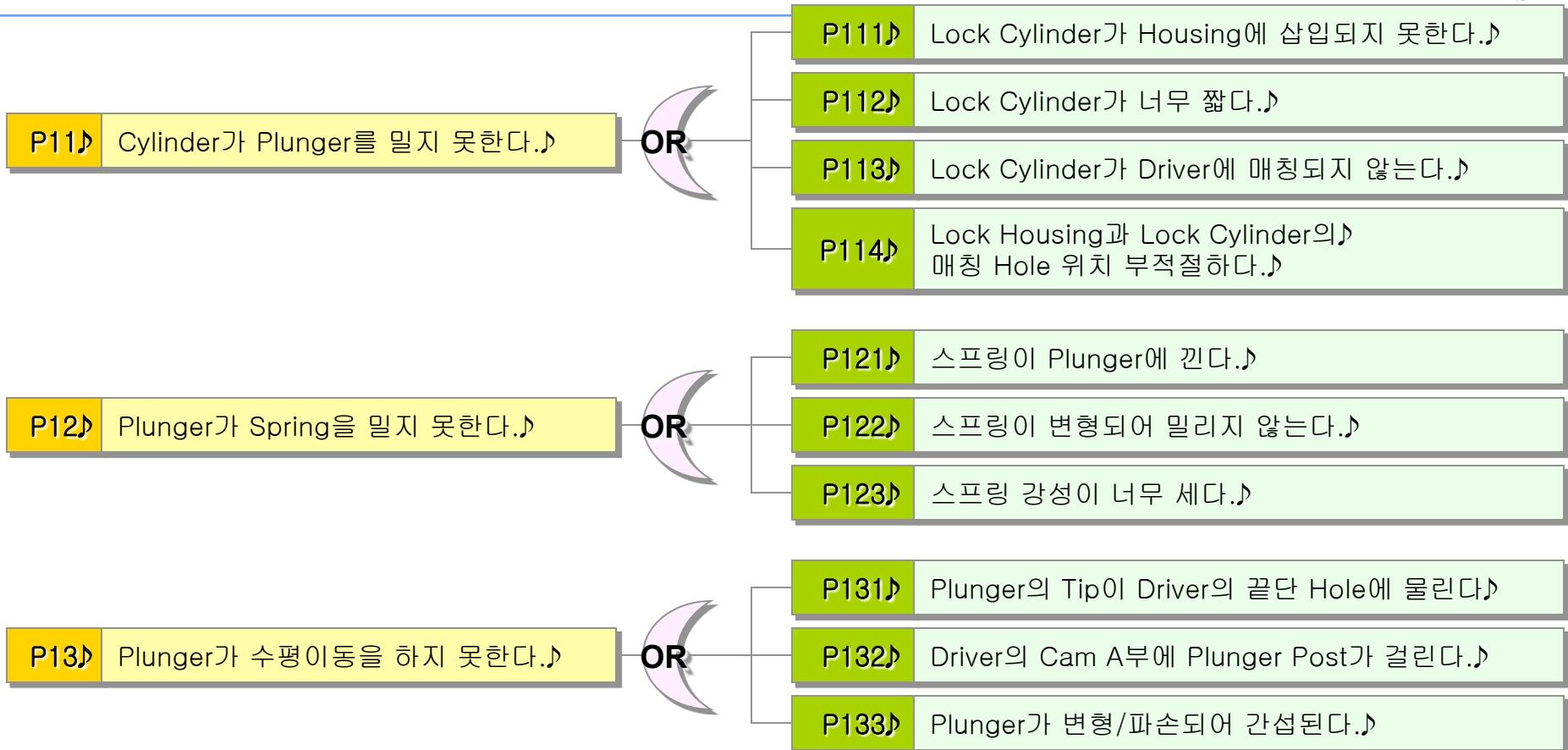
Responsibilities of design for WB & BB Items



Functional Flow Block Diagram(2)



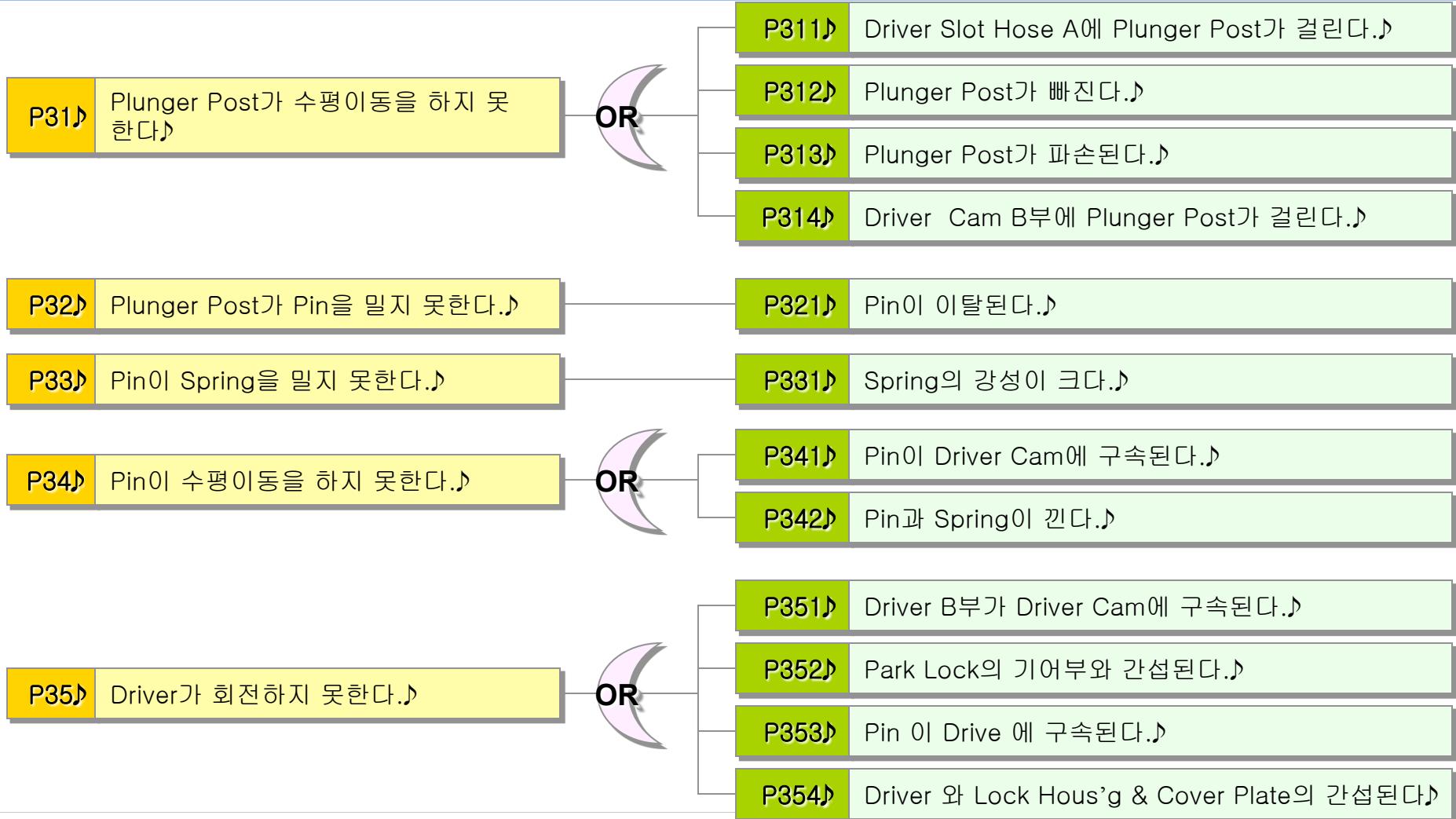
FTA (Fault Tree Analysis) – LEVEL 2-1



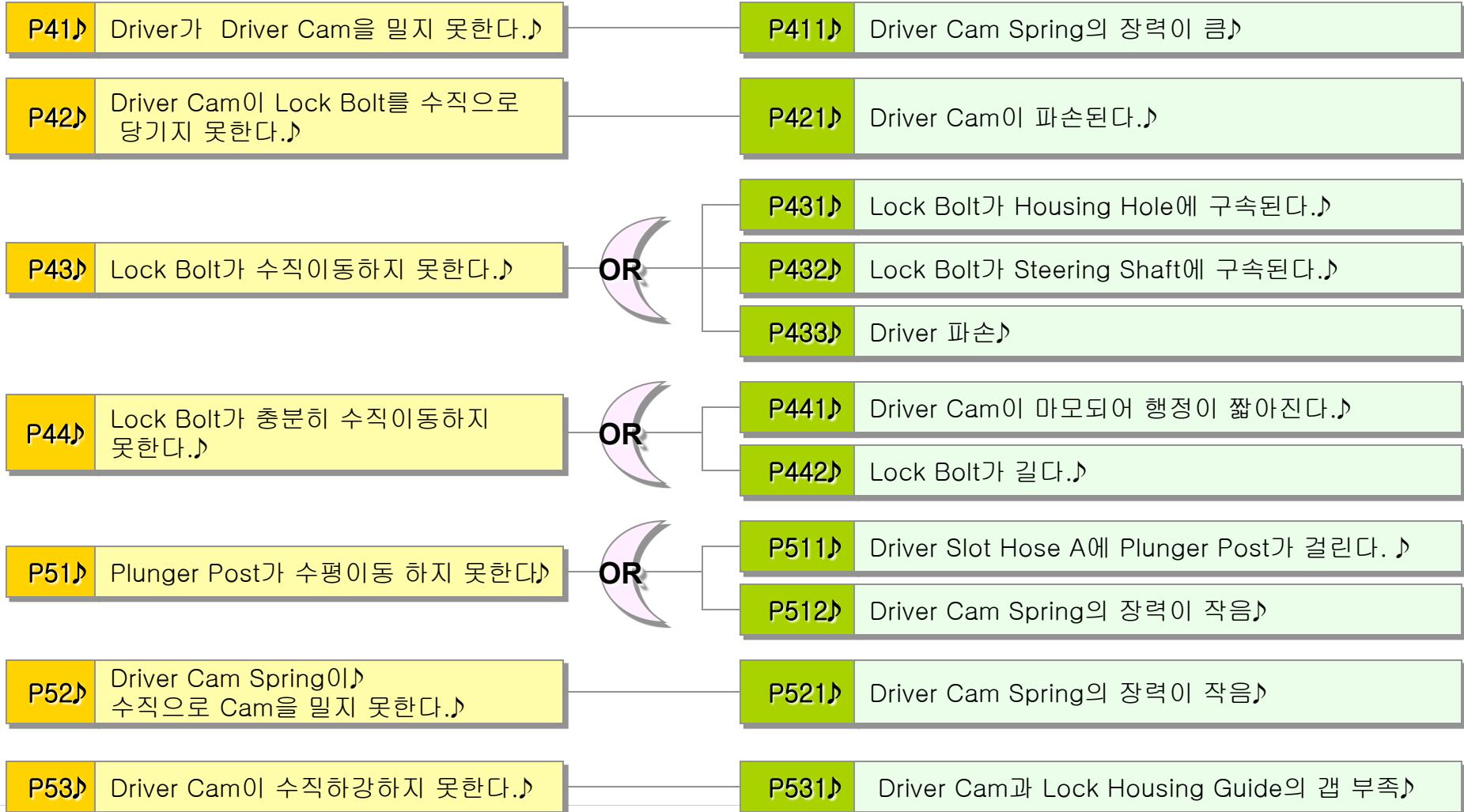
FTA (Fault Tree Analysis) – LEVEL 2-2



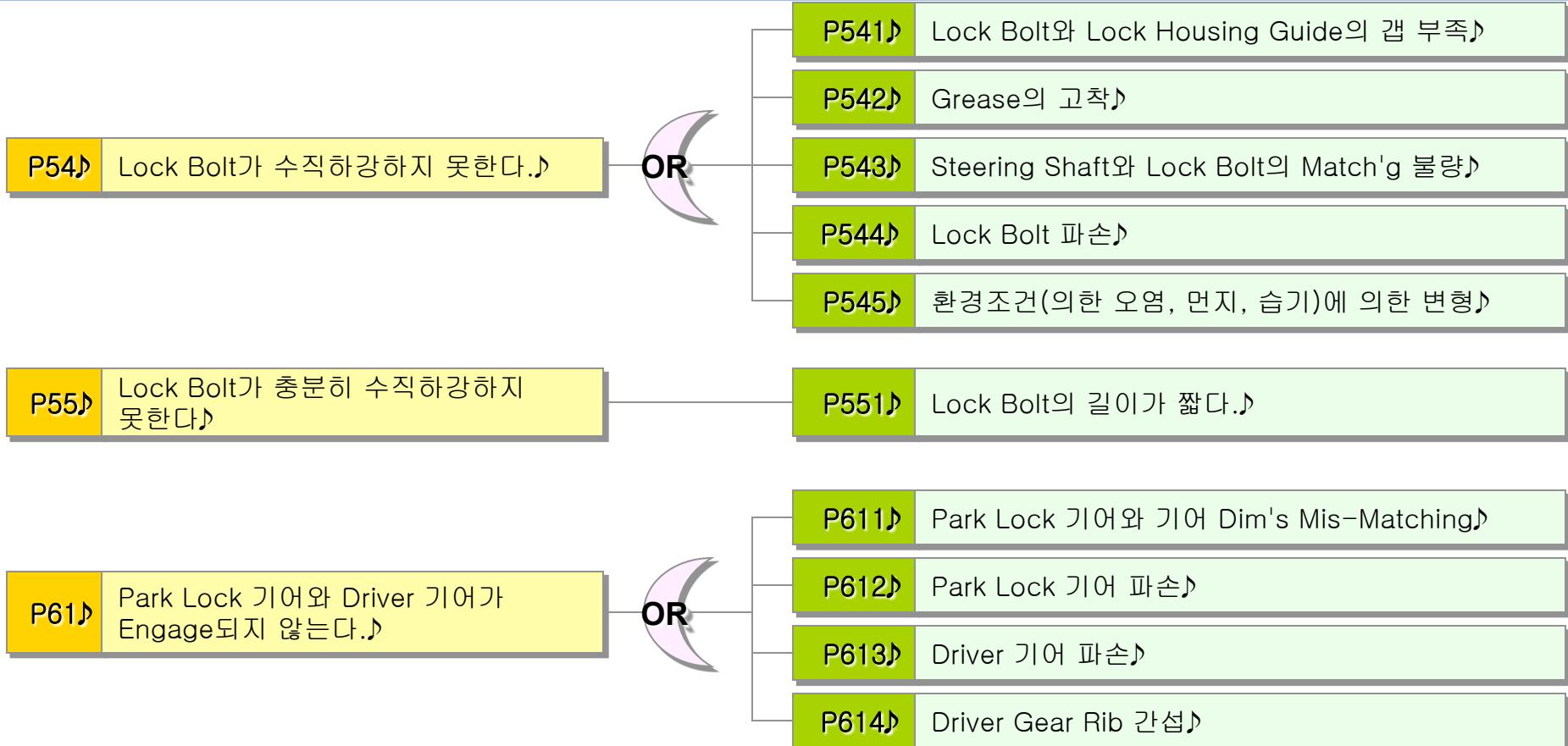
FTA (Fault Tree Analysis) – LEVEL 2-3



FTA (Fault Tree Analysis) – LEVEL 2-4



FTA (Fault Tree Analysis) – LEVEL 2-5



FTA (Fault Tree Analysis) – LEVEL 2-6

P71▶ Lock Housing과 Lock Bolt의 Rattle▶	P711▶ Lock Housing과 Lock Bolt의 Clearance 과다▶
P72▶ Driver와 Housing의 Rattle▶	P721▶ Driver와 Housing의 Clearance 과다▶
P73▶ Hous'g과 Steer'g Shaft Bracket의 조립 Bolt Rattle▶	P731▶ Housing과 Steering Shaft Bracket의 조립 Bolt Clearance 과다▶
P74▶ Cover Plate Vs. Lock Housing Rattle▶	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 훨을 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.▶	
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Design FMEA

Failure Mode for Function

- 1 Actuator Plunger Post does not allow needed travel
- 2 Audible noise while driving
- 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 Failure 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 to assemble Park lock cable & EPL
- 2 Not able to 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 미 반영	
	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 끼다.				
4		P143	I/S의 장착위치가 멀다.				
5		P153	I/S의 장착 위치가 가깝다.				
6		P211	Driver B부위가 Driver Cam에 구속된다.				
7		P342	Pin과 Spring이 끼다.				
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

Subcomponents Physical Characteristics to F/F design Correlation Matrix



Lock Housing

Special Charascts

KPC QCI
F/F ◇, ▷
S/C ◎, ▶

Special Charascts	1 ◇ TILT PIVOT HOLE(INTF)	2 ◇ TILT PIVOT HOLE(INTF)	3 ◇ TILT SCREW PIVOT HOLE(S)(INTF)	4 ◇ KEY CYL RET PIN HOLE(INTF)	5 ◇ KEY CYL RET PIN HOLE(SAFETY)	6 ◇ IGN SW BORE	7 ◇ IGN DRIVER CLEARANCE	8 ◇ SHROUD MNT SCREW HOLE	9 ◇ SHROUD MNT BOSS	10 ◇ KEY CYL KEY WAY PROFILE	11 ◇ KEY CYL E-CLIP CLEARANCE	12 ◇ KEY CYL E-CLIP CLEARANCE	13 ◇ PATS TAB DISTANCE	14 ◇ PATS TAB DISTANCE	15 ◇ TILT TAB WIDTH	16 ◇ PATS RET TAB WIDTH	17 ◇ KEY CYL KEY WAY WIDTH	18 ◇ TATS RET TAB WIDTH	19 ◇ TATS TAB DISTANCE	20 ◇ SHROUD MNT BOSS	21 ◇ SHROUD MOUNT SCREW HOLE	22 ◇ PKLOCK INTW WIDTH	23 ◇ PKLOCK INTW HEIGHT	24 ◇ PKLOCK INTW (SAFETY)	25 ◇ PARK LOCK INTW	26 ◇ PARK LOCK INTF	27 ◇ PARK LOCK INTF	28 ◇ SHROUD MNT BOSS	29 ◇ TILT LEVER INTF	30 ◇ TILT LEVER INTF	31 ◇ TILT LEVER INTF	32 ◇ SHROUD MNT SCREW HOLE	33 ◇ TILT BUMPER INTF	34 ◇ ANTI-ROTATION PIN HOLE	35 ◇ COL/MFS MOUNTING HOLE	36 ◇ COL/MFS MOUNTING BOSS	37 ◇ MFS/SHFT BOOT MNT BOSS	38 ◇ MFS/SHFT BOOT MNT HOLE	39 ◇ MFS/SHFT BOOT MNT HOLE	40 ◇ COL INTF	41 ◇ HOUSING O.D.	42 ◇ CLUTCH MOUNTING FOR COL	43 ◇ COL/SHFT BOOT SCREW HOLES	44 ◇ TILT HANDLE H-HOOK	45 ◇ TILT HANDLE H-HOOK	46 ◇ SHIFT BOOT HOOK	47 ◇ TILT LEVER MNT MNT BOSS	48 ◇ TILT T-ARMED WIDTH	49 ◇ BEARING BORE DIAMETER	50 ◇ DIST BETWEEN BEARING BORES	51 ◇ LOCK BOLT SLOT SIZE	52 ◇ BEARING BORE DIAMETER	53 ◇	54 ◇ TILT BUMPER HEIGHT	55 ◇ IGN SW DATUM	56 ◇ IGN SW DATUM	57 ◇ IGN SW DATUM TO DRIVER	58 ◇ IGN SW DATUM TO PLUNGER	59 ◇ PLUNGER LENGTH(SAFETY)	60 ◇ IGN DRIVER TIP WIDTH	61 ◇ IGN DRIVER TIP RADIUS	62 ◇ IGN DRIVER D RADIUS	63 ◇ IGN DRIVER D WIDTH	64 ◇ IGN DRIVER D RADIUS	65 ◇ IGN DRV R BASE TO D/L	66 ◇ PARK LOCK INTF	P111-1	P111-2	P111-3	P111-4	P111-5	P111-6	P111-7	P111-8	P111-9	P111-10	P111-11	P111-12	P111-13	P111-14	P111-15	P111-16	P111-17	P111-18	P111-19	P111-20	P111-21	P111-22	P111-23	P111-24	P111-25	P111-26	P111-27	P111-28	P111-29	P111-30	P111-31	P111-32	P111-33	P111-34	P111-35	P111-36	P111-37	P111-38	P111-39	P111-40	P111-41	P111-42	P111-43	P111-44	P111-45	P111-46	P111-47	P111-48	P111-49	P111-50	P111-51	P111-52	P111-53	P111-54	P111-55	P111-56	P111-57	P111-58	P111-59	P111-60	P111-61	P111-62	P111-63	P111-64	P111-65	P111-66	P111-67	P111-68	P111-69	P111-70	P111-71	P111-72	P111-73	P111-74	P111-75	P111-76	P111-77	P111-78	P111-79	P111-80	P111-81	P111-82	P111-83	P111-84	P111-85	P111-86	P111-87	P111-88	P111-89	P111-90	P111-91	P111-92	P111-93	P111-94	P111-95	P111-96	P111-97	P111-98	P111-99	P111-100	P111-101	P111-102	P111-103	P111-104	P111-105	P111-106	P111-107	P111-108	P111-109	P111-110	P111-111	P111-112	P111-113	P111-114	P111-115	P111-116	P111-117	P111-118	P111-119	P111-120	P111-121	P111-122	P111-123	P111-124	P111-125	P111-126	P111-127	P111-128	P111-129	P111-130	P111-131	P111-132	P111-133	P111-134	P111-135	P111-136	P111-137	P111-138	P111-139	P111-140	P111-141	P111-142	P111-143	P111-144	P111-145	P111-146	P111-147	P111-148	P111-149	P111-150	P111-151	P111-152	P111-153	P111-154	P111-155	P111-156	P111-157	P111-158	P111-159	P111-160	P111-161	P111-162	P111-163	P111-164	P111-165	P111-166	P111-167	P111-168	P111-169	P111-170	P111-171	P111-172	P111-173	P111-174	P111-175	P111-176	P111-177	P111-178	P111-179	P111-180	P111-181	P111-182	P111-183	P111-184	P111-185	P111-186	P111-187	P111-188	P111-189	P111-190	P111-191	P111-192	P111-193	P111-194	P111-195	P111-196	P111-197	P111-198	P111-199	P111-200	P111-201	P111-202	P111-203	P111-204	P111-205	P111-206	P111-207	P111-208	P111-209	P111-210	P111-211	P111-212	P111-213	P111-214	P111-215	P111-216	P111-217	P111-218	P111-219	P111-220	P111-221	P111-222	P111-223	P111-224	P111-225	P111-226	P111-227	P111-228	P111-229	P111-230	P111-231	P111-232	P111-233	P111-234	P111-235	P111-236	P111-237	P111-238	P111-239	P111-240	P111-241	P111-242	P111-243	P111-244	P111-245	P111-246	P111-247	P111-248	P111-249	P111-250	P111-251	P111-252	P111-253	P111-254	P111-255	P111-256	P111-257	P111-258	P111-259	P111-260	P111-261	P111-262	P111-263	P111-264	P111-265	P111-266	P111-267	P111-268	P111-269	P111-270	P111-271	P111-272	P111-273	P111-274	P111-275	P111-276	P111-277	P111-278	P111-279	P111-280	P111-281	P111-282	P111-283	P111-284	P111-285	P111-286	P111-287	P111-288	P111-289	P111-290	P111-291	P111-292	P111-293	P111-294	P111-295	P111-296	P111-297	P111-298	P111-299	P111-300	P111-301	P111-302	P111-303	P111-304	P111-305	P111-306	P111-307	P111-308	P111-309	P111-310	P111-311	P111-312	P111-313	P111-314	P111-315	P111-316	P111-317	P111-318	P111-319	P111-320	P111-321	P111-322	P111-323	P111-324	P111-325	P111-326	P111-327	P111-328	P111-329	P111-330	P111-331	P111-332	P111-333	P111-334	P111-335	P111-336	P111-337	P111-338	P111-339	P111-340	P111-341	P111-342	P111-343	P111-344	P111-345	P111-346	P111-347	P111-348	P111-349	P111-350	P111-351	P111-352	P111-353	P111-354	P111-355	P111-356	P111-357	P111-358	P111-359	P111-360	P111-361	P111-362	P111-363	P111-364	P111-365	P111-366	P111-367	P111-368	P111-369	P111-370	P111-371	P111-372	P111-373	P111-374	P111-375	P111-376	P111-377	P111-378	P111-379	P111-380	P111-381	P111-382	P111-383	P111-384	P111-385	P111-386	P111-387	P111-388	P111-389	P111-390	P111-391	P111-392	P111-393	P111-394	P111-395	P111-396	P111-397	P111-398	P111-399	P111-400	P111-401	P111-402	P111-403	P111-404	P111-405	P111-406	P111-407	P111-408	P111-409	P111-410	P111-411	P111-412	P111-413	P111-414	P111-415	P111-416	P111-417	P111-418	P111-419	P111-420	P111-421	P111-422	P111-423	P111-424	P111-425	P111-426	P111-427	P111-428	P111-429	P111-430	P111-431	P111-432	P111-433	P111-434	P111-435	P111-436	P111-437	P111-438	P111-439	P111-440	P111-441	P111-442	P111-443	P111-444	P111-445	P111-446	P111-447	P111-448	P111-449	P111-450	P111-451	P111-452	P111-453	P111-454	P111-455	P111-456	P111-457	P111-458	P111-459	P111-460	P111-461	P111-462	P111-463	P111-464	P111-465	P111-466	P111-467	P111-468	P111-469	P111-470	P111-471	P111-472	P111-473	P111-474	P111-475	P111-476	P111-477	P111-478	P111-479	P111-480	P111-481	P111-482	P111-483	P111-484	P111-485	P111-486	P111-487	P111-488	P111-489	P111-490	P111-491	P111-492	P111-493	P111-494	P111-495	P111-496	P111-497	P111-498	P111-499	P111-500	P111-501	P111-502	P111-503	P111-504	P111-505	P111-506	P111-507	P111-508	P111-509	P111-510	P111-511	P111-512	P111-513	P111-514	P111-515	P111-516	P111-517	P111-518	P111-519	P111-520	P111-521	P111-522	P111-523	P111-524	P111-525	P111-526	P111-527	P111-528	P111-529	P111-530	P111-531	P111-532	P111-533	P111-534	P111-535	P111-536	P111-537	P111-538	P111-539	P111-540	P111-541	P111-542	P111-543	P111-544	P111-545	P111-546	P111-547	P111-548	P111-549	P111-550	P111-551	P111-552	P111-553	P111-554	P111-555	P111-556	P111-557	P111-558	P111-559	P111-560	P111-561	P111-562	P111-563	P111-564	P111-565	P111-566	P111-567	P111-568	P111-569	P111-570	P111-571	P111-572	P111-573	P111-574	P111-575	P111-576	P111-577	P111-578	P111-579	P111-580	P111-581	P111-582	P111-583	P111-584	P111-585	P111-586	P111-587	P111-588	P111-589	P111-590	P111-591	P111-592	P111-593	P111-594	P111-595	P111-596	P111-597	P111-598	P111-599	P111-600	P111-601	P111-602	P111-603	P111-604	P111-605	P111-606	P111-607	P111-608	P111-609	P111-610	P111-611	P111-612	P111-613	P111-614	P111-615	P111-616	P111-617	P111-618	P111-619	P111-620	P111-621	P111-622	P111-623	P111-624	P111-625	P111-626	P111-627	P111-628	P111-629	P111-630	P111-631	P111-632	P111-633	P111-634	P111-635	P111-636	P111-637	P111-638	P111-639	P111-640	P111-641	P111-642	P111-643	P111-644	P111-645	P111-646	P111-647	P111-648	P111-649	P111-650	P111-651	P111-652	P111-653	P111-654	P111-655	P111-656	P111-657	P111-658	P111-659	P111-660	P111-661	P111-662	P111-663	P111-664	P111-665	P111-666	P111-667	P111-668	P111-669	P111-670	P111-671	P111-672	P111-673	P111-674	P111-675	P111-676	P111-677	P111-678	P111-679	P111-680	P111-681	P111-682	P111-683	P111-684	P111-685	P111-686	P111-687	P111-688	P111-689	P111-690	P111-691	P111-692	P111-693	P111-694	P111-695	P111-696	P111-697	P111-698	P111-699	P111-700	P111-701	P111-702	P111-703	P111-704	P111-705	P111-706	P111-707	P111-708	P111-709	P111-710	P111-711	P111-712	P111-713	P111-714	P111-715	P111-716	P111-717	P111-718	P111-719	P111-720	P111-721	P111-722	P111-723	P111-724	P111-725	P111-726	P111-727	P111-728	P111-729	P111-730	P111-731	P111-732	P111-733	P111-734	P111-735	P111-736	P111-737	P111-738	P111-739	P111-740	P111-741	P111-742	P111-743	P111-744	P111-745	P111-746	P111-747	P111-748	P111-749	P111-750	P111-751	P111-752	P111-753	P111-754	P111-755	P111-756	P111-757	P111-758	P111-759	P111-760	P111-761	P111-762	P111-763	P111-764	P111-765	P111-766	P111-767	P111-768	P111-769	P111-770	P111-771	P111-772	P111-773	P111-774	P111-775	P111-776	P111-777	P111-778	P111-779	P111-780	P111-781	P111-782	P111-783	P111-784	P111-785	P111-786	P111-787	P111-788	P111-789	P111-790	P111-791	P111-792	P111-793	P111-794	P111-795	P111-796	P111-797	P111-798	P111-799	P111-800	P111-801	P111-802	P111-803	P111-804	P111-805	P111-806	P111-807	P111-808	P111-809	P111-810	P111-811	P111-812	P111-813	P111-814	P111-815	P111-816	P111-817	P111-818	P111-819	P111-820	P111-821	P111-822	P111-823	P111-824	P111-825	P111-826	P111-827	P111-828	P111-829	P111-830	P111-831	P111-832	P111-833	P111-834	P111-835	P111-836	P111-837	P111-838	P111-839	P111-840	P111-841	P111-842	P111-843	P111-844	P111-845	P111-846	P111-847	P111-848	P111-849	P111-850	P111-851	P111-852	P111-853	P111-854	P111-855	P111-856	P111-857	P111-858	P111-859	P111-860	P111-861	P111-862	P111-863	P111-864	P111-865	P111-866	P111-867	P111-868	P111-869	P111-870	P111-871	P111-872	P111-873	P111-874	P111-875	P111-876	P111-877	P111-878	P111-879	P111-880	P111-881	P111-882	P111-883	P111-884	P111-885	P111-886	P111-887	P111-888	P111-889	P111-890	P111-891	P111-892	P111-893	P111-894	P111-895	P111-896	P111-897	P111-898	P111-899	P111-900	P111-901	P111-902	P111-903	P111-904	P111-905	P111-906	P111-907	P111-908	P111-909	P111-910	P111-911	P111-912	P111-913	P111-914	P111-915	P111-916	P111-917	P111-918	P111-919</
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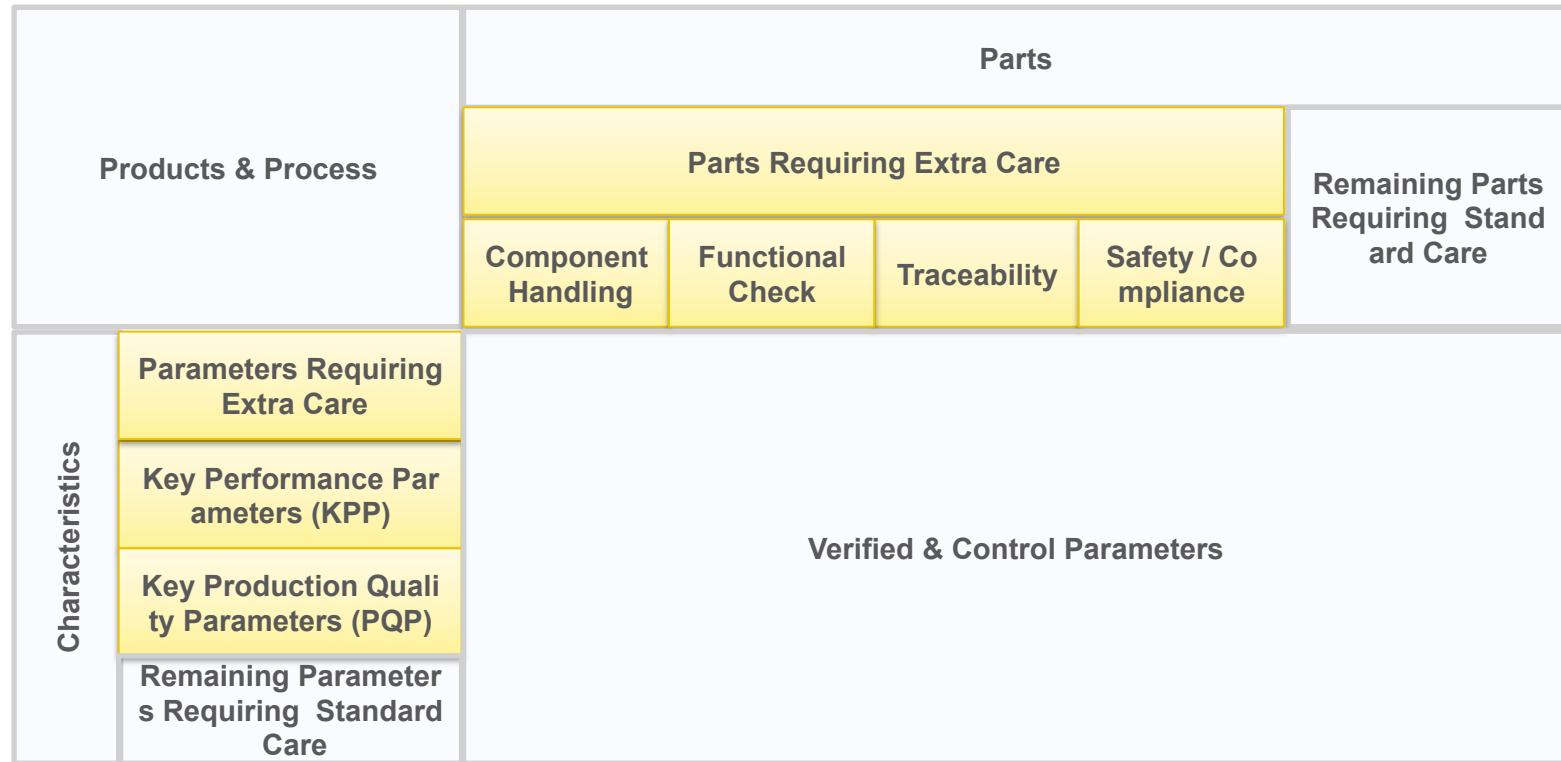
Failure Mode Critical Dimension

No	FTA-Code	Failure Mode	Critical Dimension												Remark
			P111-1	P111-2	P114-1	P412-6	P413-1	P413-2	P212-1	P213-3	P431-3	P431-4	P111-3	P111-4	
1	P111	Lock Cylinder can not inserted into Housing.	◎												
2	P112	Length of the Lock Cylinder is too short.		◎											◎, 32, 32.5, 32.5, 32.5, 32.5
3	P113	Don't Matching of Lock Cylinder to Driver													설정치와 일치하지 않음
4	P114	Miss matching Machine hole position of Lock Housing and Lock Cylinder				◎									설정치와 일치하지 않음
5	P121	Spring get jammed tightly within Plunger													CAM 작동
6	P122	Spring did not work due to deformation													
7	P123	Spring strength is too high													설정치 30 미만
															설정치 30 미만

No	FTA Code	Failure Mode	DESIGN PARAMETERS							
			Lock Housing							
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



Traceability

