

**UNIVANCE CORPORATION**

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**23/09/2014**

# Applying STAMP/STPA to Human Safety System for Four Wheel Drive Power-train

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1. Company Introduction
2. Overview of Analysis Flow
3. STAMP/STPA application to 4WD System  
STAMP/STPA  
Human Mental Model analysis  
Method in the Past
4. Results and Observations

# Company Introduction

- Founded in 1937
- Head Office Plant in JAPAN
- Overseas Operations: USA, INDONESIA, THAILAND

## Main Products

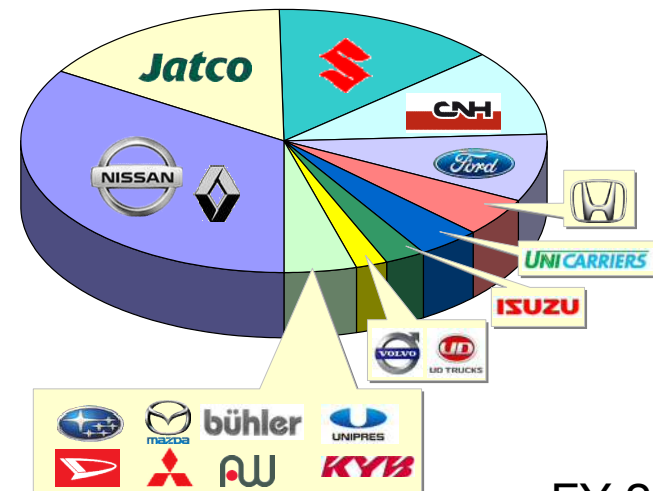


Transmission



Transfer case

## Customers



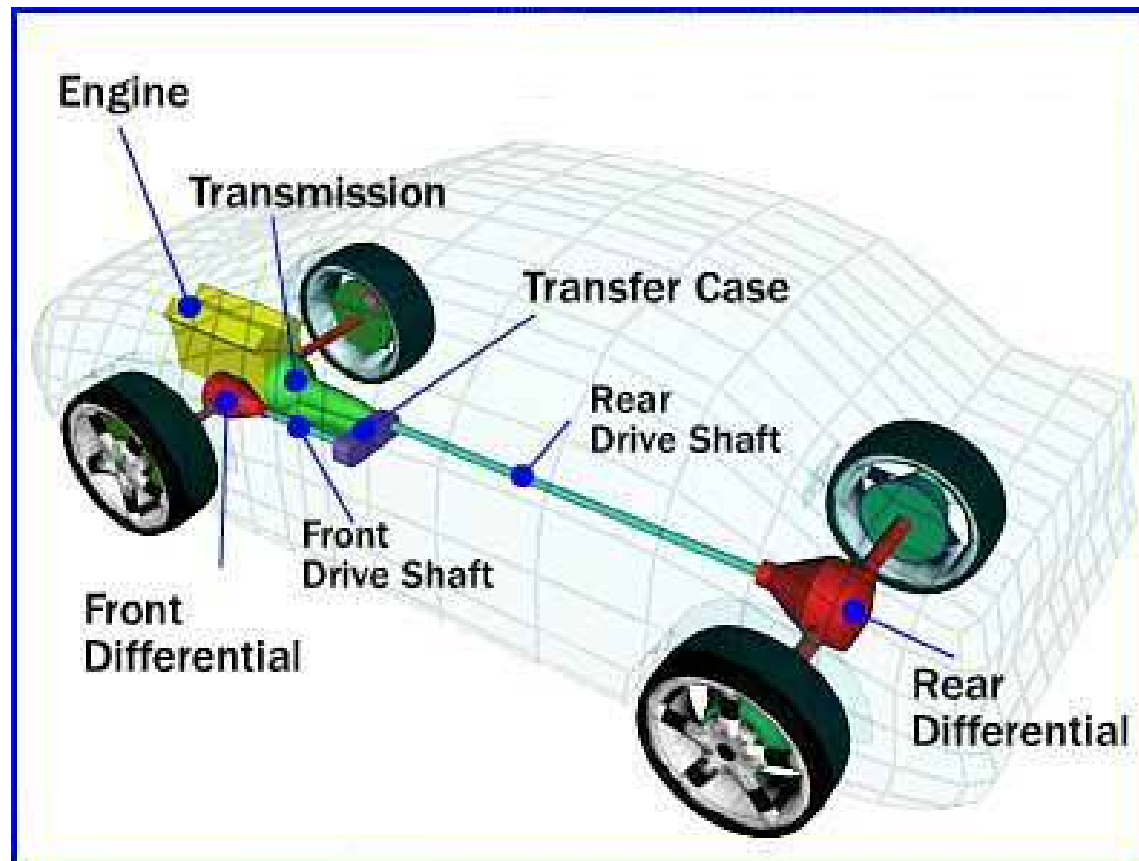
FY 2013

- ISO26262 [ISO11] regulates the required safety of components in the system
  - whole system safety
- We are open to evaluate new methods
  - includes human factor

We confirmed the effectiveness of STAMP method for incident investigation

# Product: 4WD System

4WD (Four-wheel drive) system gives power to all four wheels



Picture Source: <http://www.4wds.co.nz/>

**Step 0:** Identify potential accidents and hazards



**Step 1:** Building functional control structure



**Step 2:** Recognizing hazard scenarios caused by an inappropriate control action



**Step 3:** Recognizing the potential cause that leads to hazard scenario.

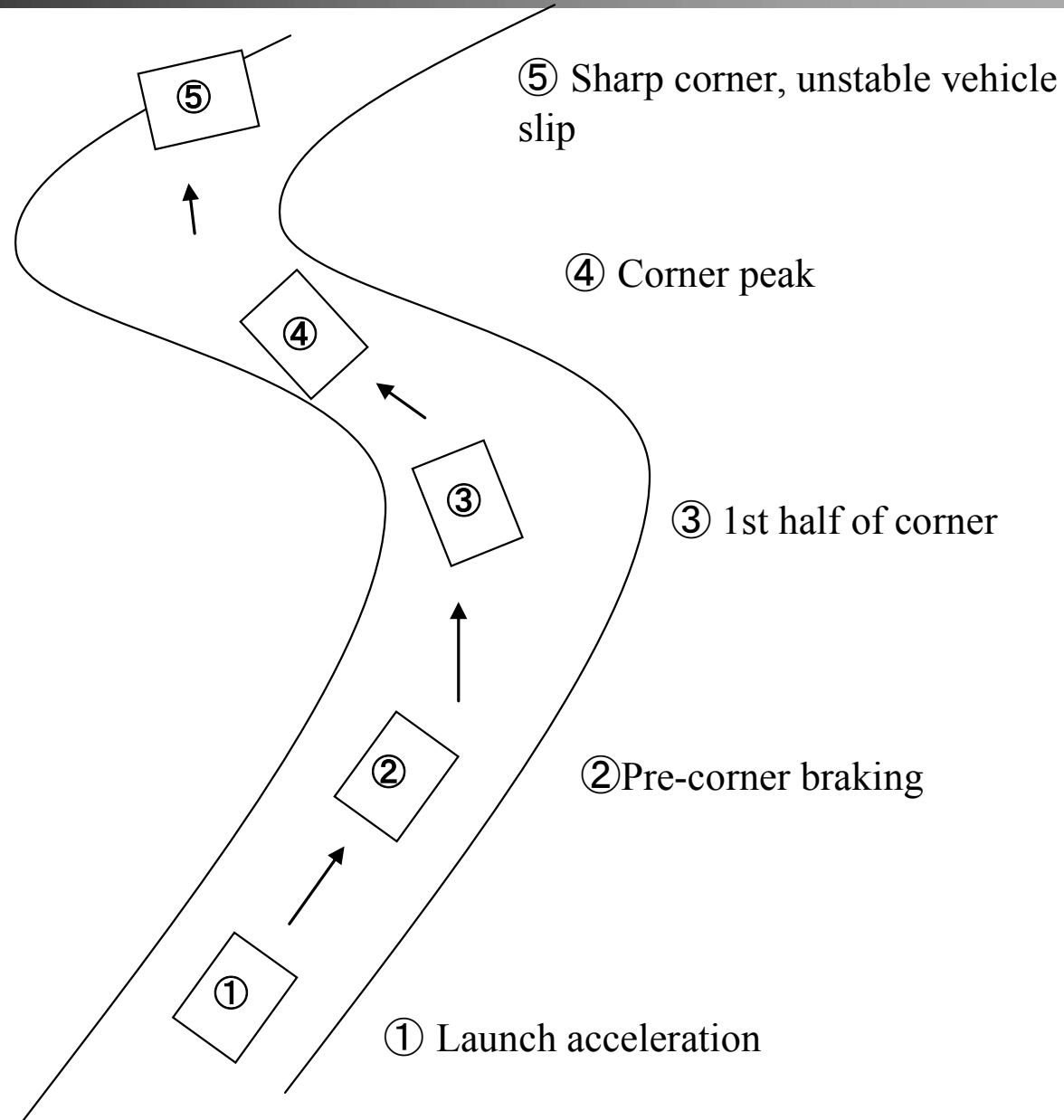


Human Mental Model Analysis



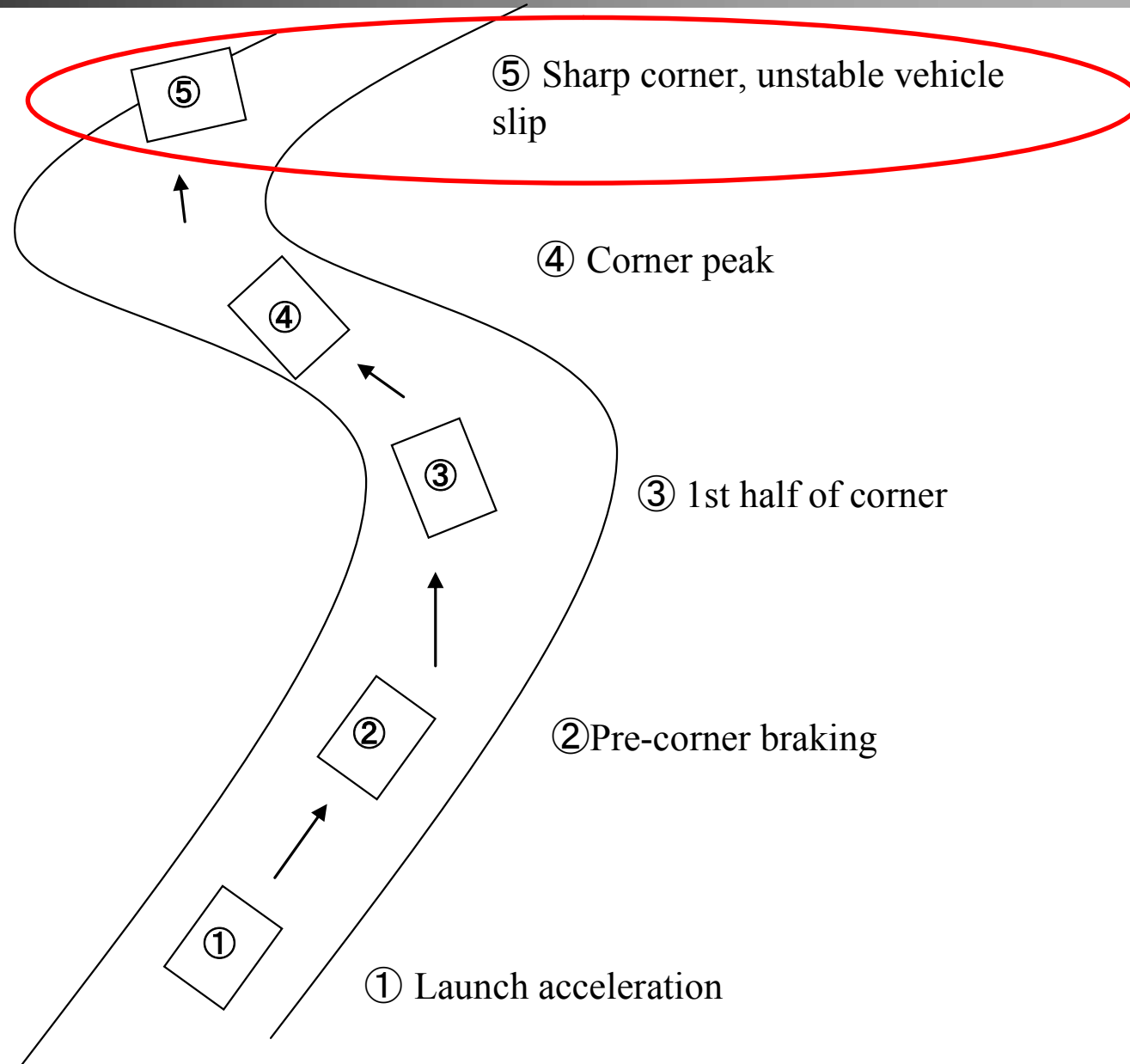
Method in the Past

# Step 0: Identify the potential accident





# Step 0: Identify the potential accident



## Building control structure:

- Focusing on dynamic process
- Considering that the accident is not caused only by failure of a single component

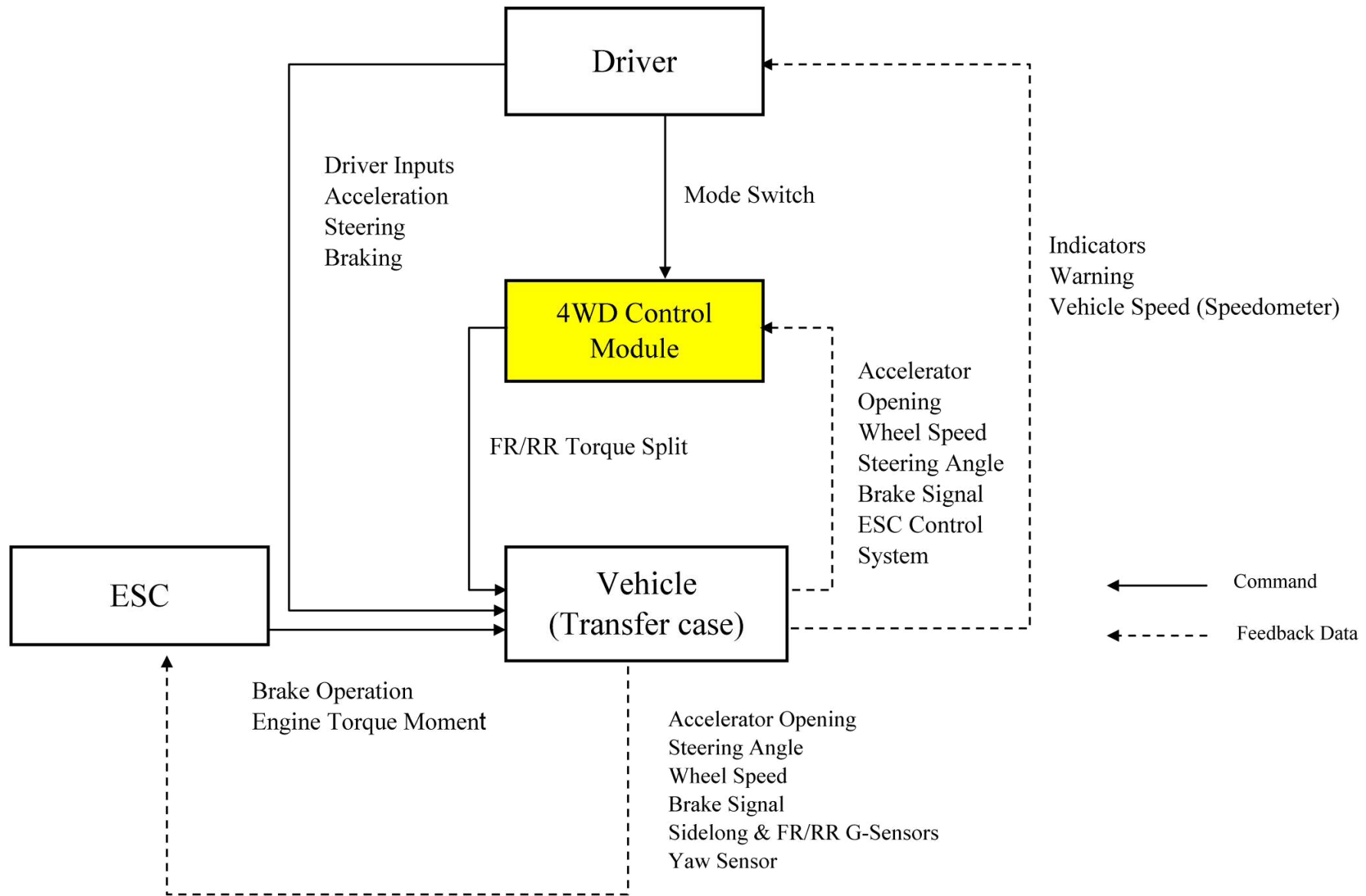
## Four elements in the system:

- 4WD System
- Vehicle (Transfer Case)
- Human
- Electronic Stability Control (ESC)

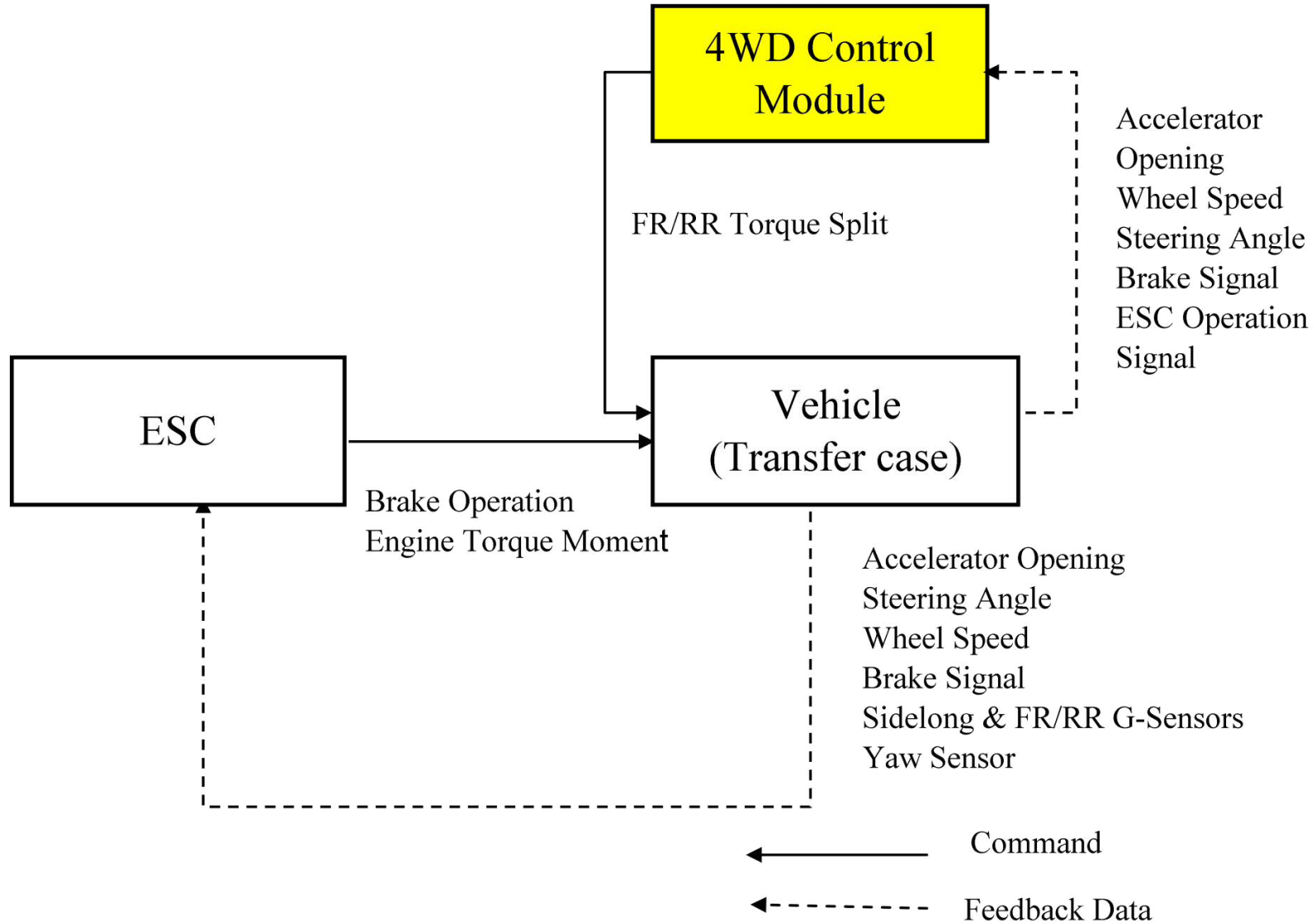


Picture Source: <http://www.redpartidos.org>

# Step1: Building control structure



# Step2: Recognizing Hazard Scenarios



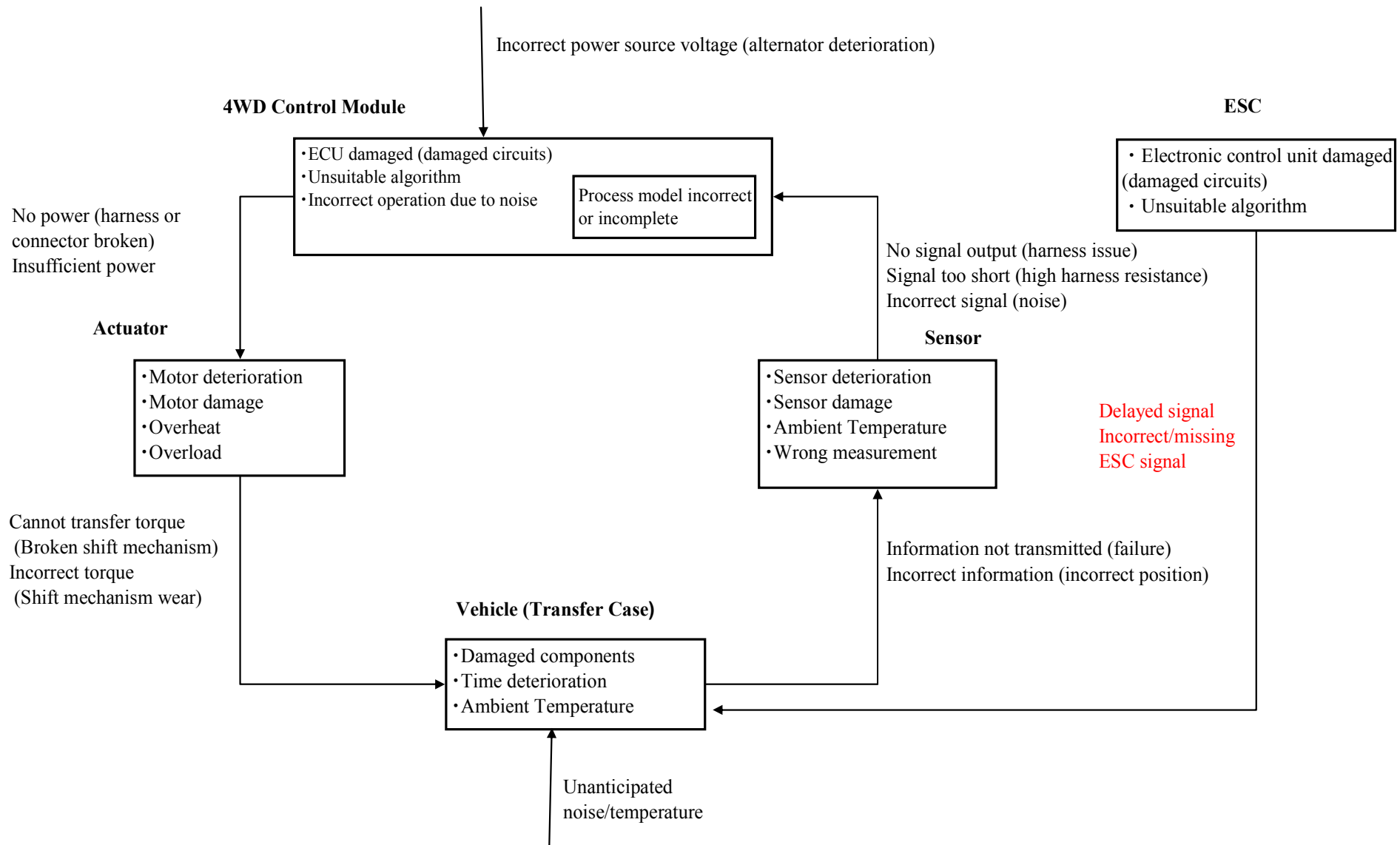
# Step 2: Recognizing Hazard Scenarios

Command	No Command	Incorrect Command	Incorrect Timing	Command Stopped Too Soon
<b>4WD Control Module FR/RR Torque Split Command to Vehicle (Transfer Case)</b>	ESC will give command to the vehicle; no problem.	Incorrect FR/RR torque split command will interact with brakes, while ESC in operation. Vehicle might slip (UCA01-1).	Will interfere with brakes if FR/RR torque split command turned off too late while ESC in operation. Vehicle might slip (UCA01-2).	FR/RR torque split command will be given by ESC to vehicle; no problem.
<b>ESC Command to Vehicle (Transfer Case)</b>	Depending on drivers skills the vehicle might slip in difficult road bend if there is no ESC signal to the vehicle (UCA02-1).	NA	Depending on drivers skills the vehicle might slip in difficult road bend if the ESC signal to the vehicle is delayed (UCA2-2).	Depending on drivers skills the vehicle might slip in difficult road bend if the ESC signal to the vehicle stops too early (UCA2-3).

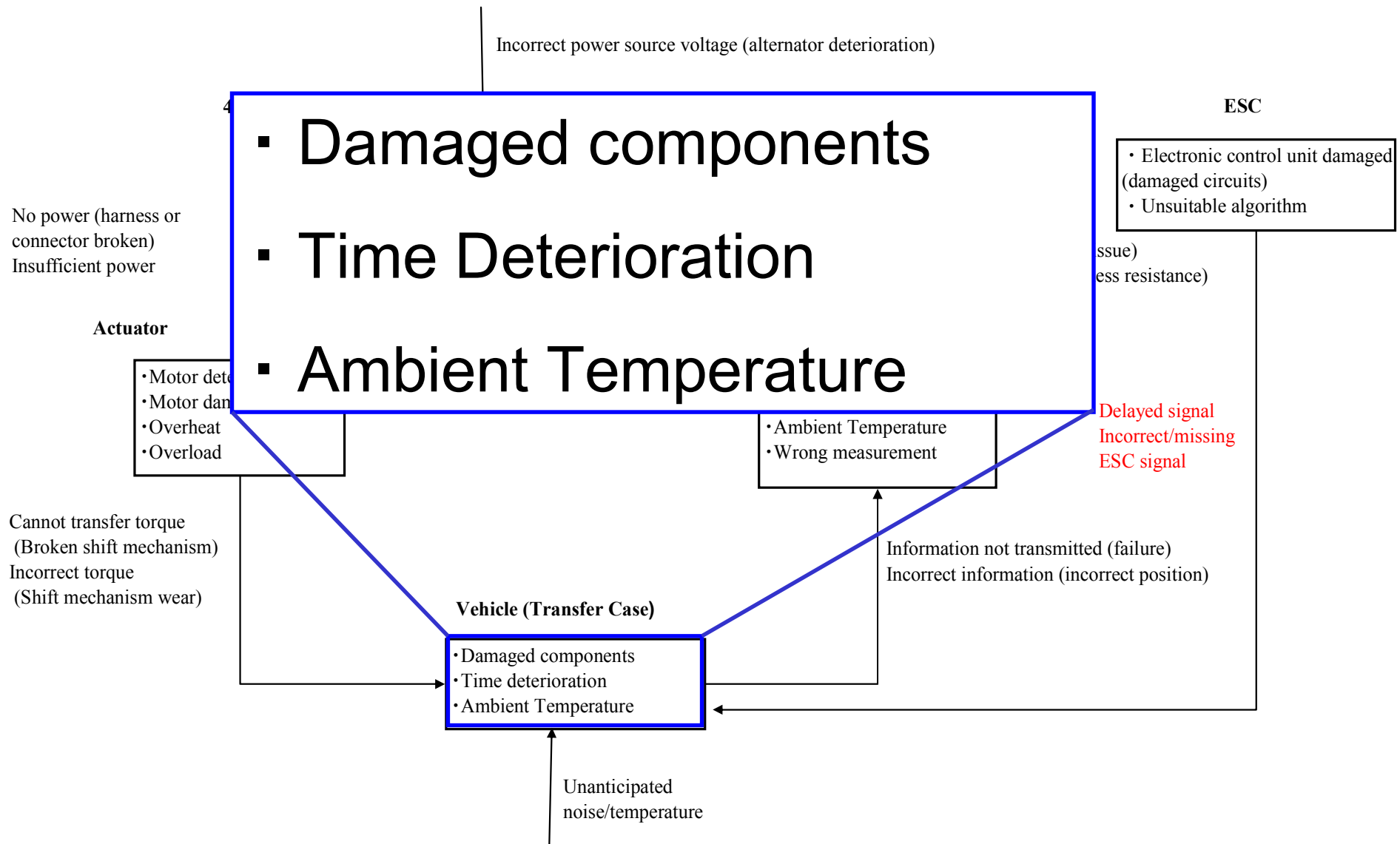
# Step 2: Recognizing Hazard Scenarios

Command	No Command	Incorrect Command	Incorrect Timing	Command Stopped Too Soon
<b>4WD Control Module FR/RR Torque Split Command to Vehicle (Transfer Case)</b>	ESC will give command to the vehicle; no problem.	Incorrect FR/RR torque split command will interact with brakes, while ESC in operation. Vehicle might slip (UCA01-1).	Will interfere with brakes if FR/RR torque split command turned off too late while ESC in operation. Vehicle might slip (UCA01-2).	FR/RR torque split command will be given by ESC to vehicle; no problem.
<b>ESC Command to Vehicle (Transfer Case)</b>	Depending on drivers skills the vehicle might slip in difficult road bend if there is no ESC signal to the vehicle (UCA02-1).	NA	Depending on drivers skills the vehicle might slip in difficult road bend if the ESC signal to the vehicle is delayed (UCA2-2).	Depending on drivers skills the vehicle might slip in difficult road bend if the ESC signal to the vehicle stops too early (UCA2-3).

# Step 3: Recognizing the potential cause

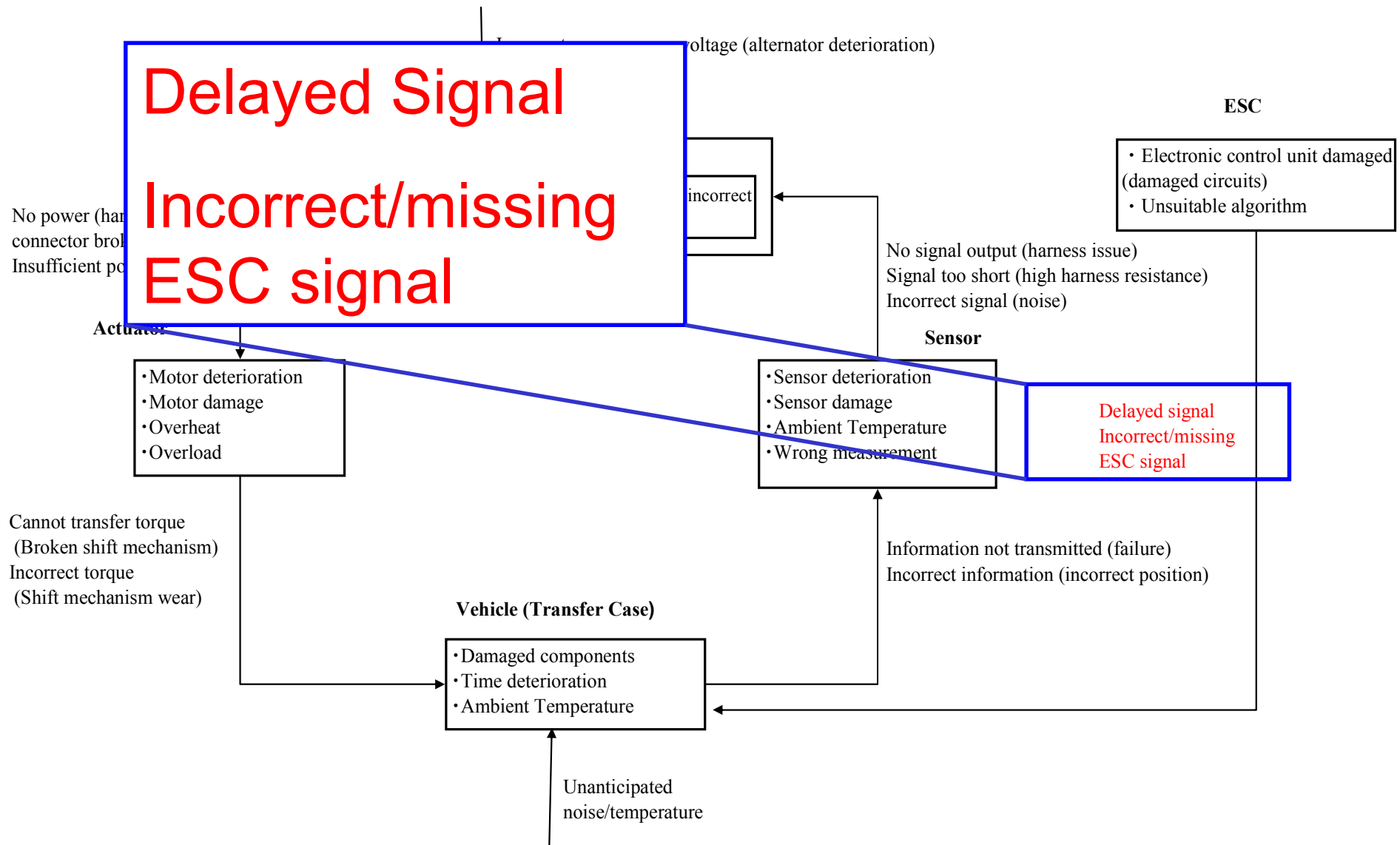


# Step 3: Recognizing the potential cause

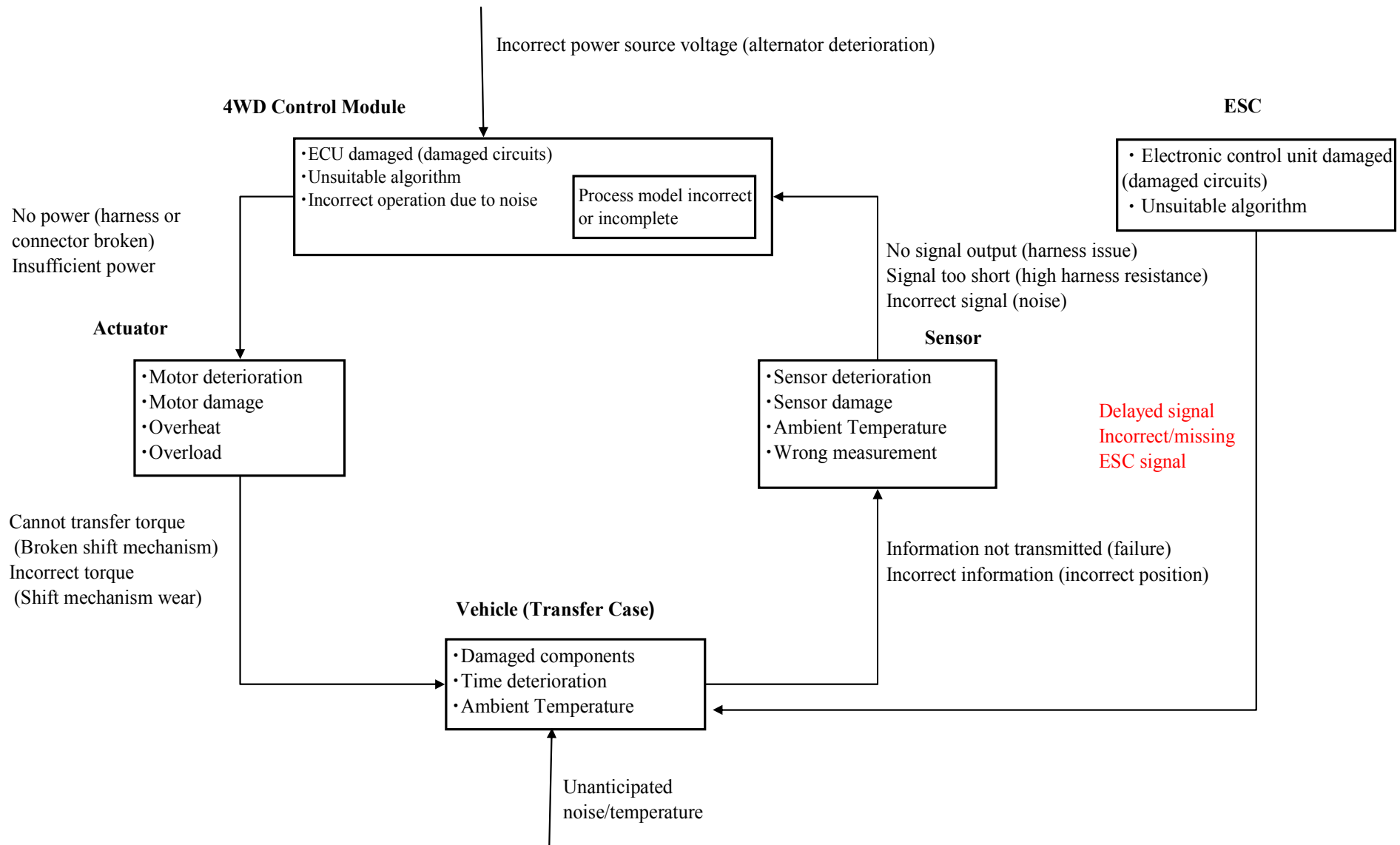


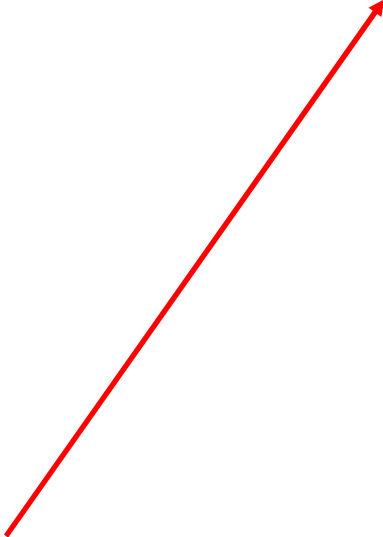


# Step3: Recognizing the potential cause



# Step 3: Recognizing the potential cause





Depending on drivers skills the vehicle might slip in difficult road bend if the ESC signal to the vehicle is delayed (UCA2-2).

Human Mental Model Analysis:

Skill-based behavior -> **Experienced Driver**

Rule – based behavior -> **Regular Driver**

Knowledge-based behavior -> **Inexperienced Driver**

Human Recognition behavior could be divided:

- Detection
- Identification
- Decision
- Action

## Human Mental Model Matrix

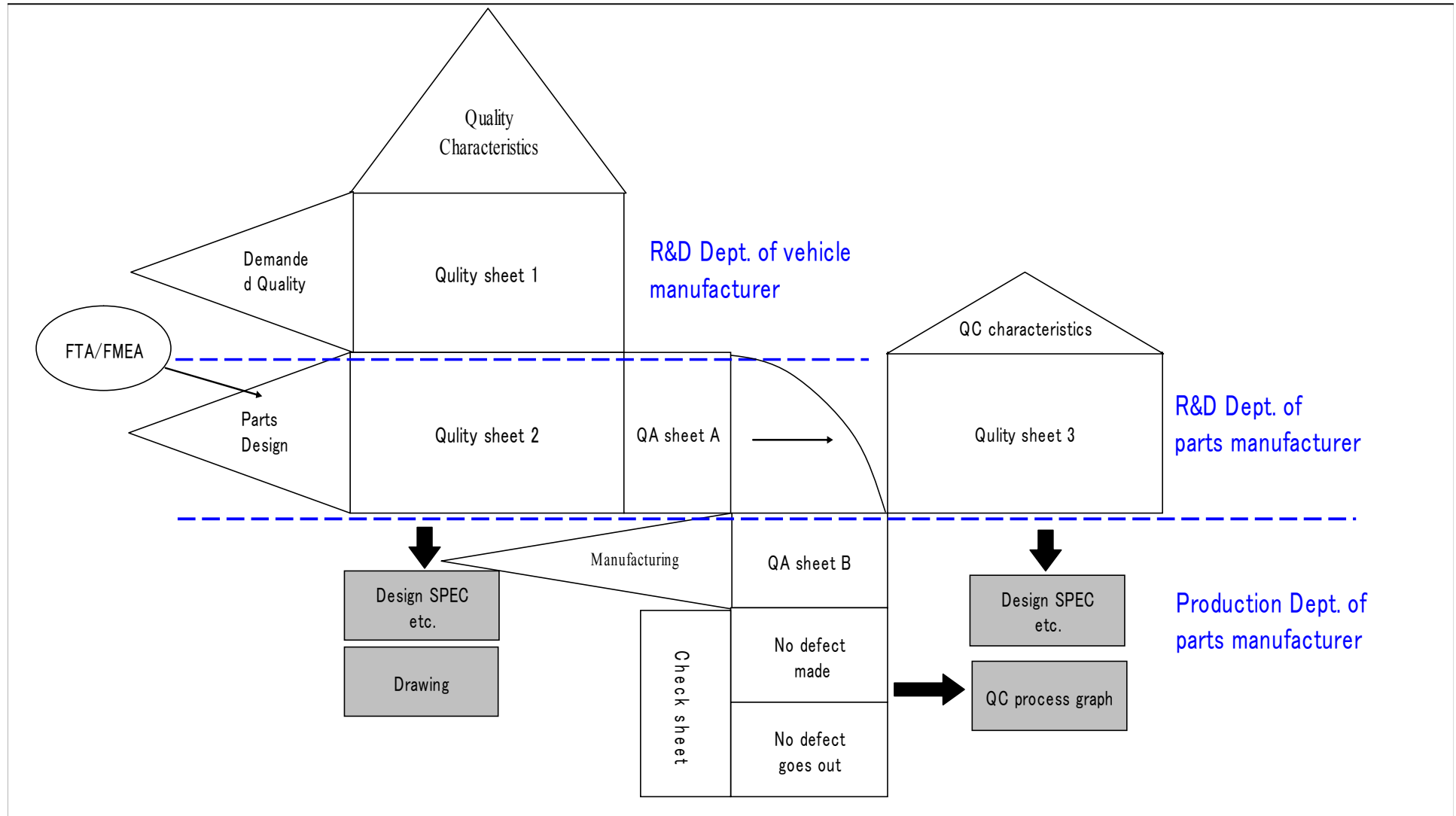
	PROCESS			
LAYER	①Detection	②Identification	③Decision	④Action
(I)SKILL-BASED BEHAVIOR				
( II )RULE-BASED BEHAVIOR				
(III)KNOWLEDGE- BASED BEHAVIOR				

# Human Mental Model Analysis

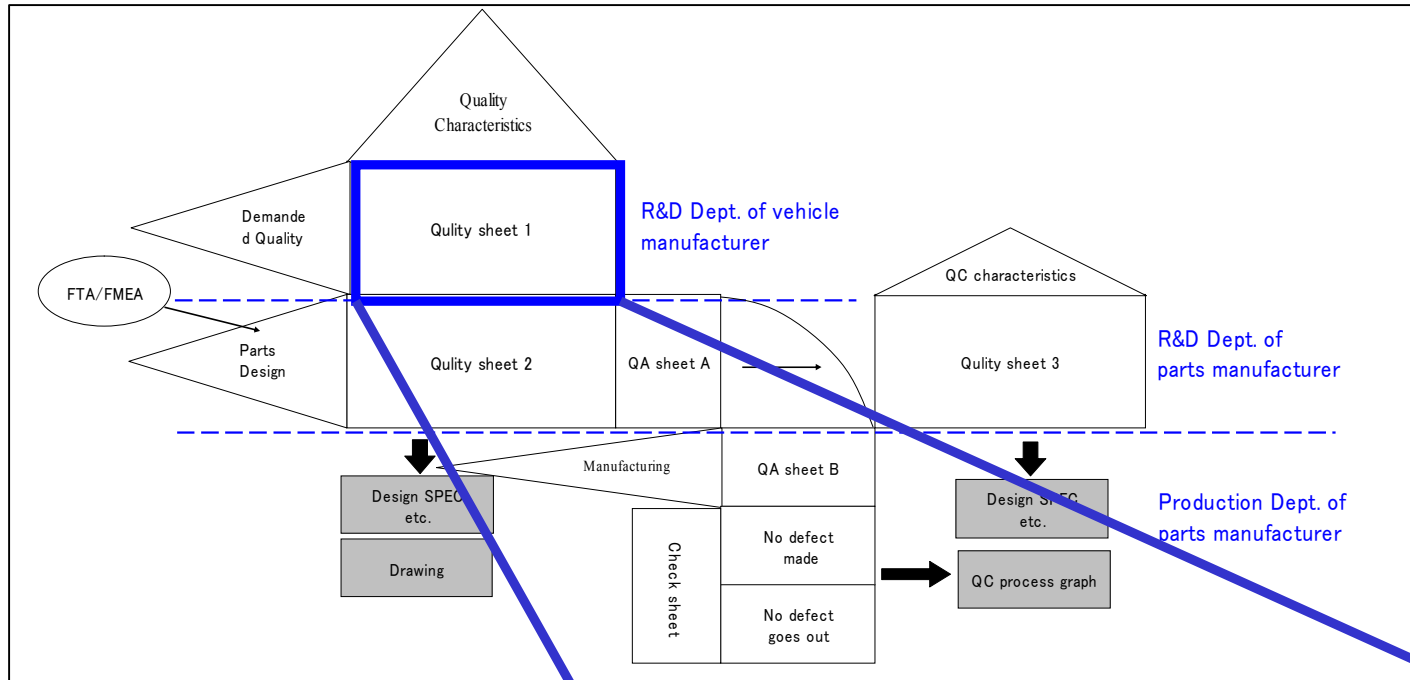


Layer	Process			
	1. Detection	2. Identification	3. Decision	4. Action
<b>SKILL-BASED BEHAVIOR</b> <b>Professional Driver</b>	Sharp road bend/curve detected.			Successfully cornering.
<b>RULE-BASED BEHAVIOR</b> <b>Regular Driver</b>	Sharp road bend/curve detected.	Identify , that vehicle will slip.	Decide to reduce vehicle speed and change vehicle direction.	<b>Incorrectly assume</b> that it is OK to enter the corner without slowing down.
<b>KNOWLEDGE-BASED BEHAVIOR</b> <b>Inexperienced Driver</b>	Sharp road bend/curve detected.	Identify danger.	Decide to reduce vehicle speed and change vehicle direction.	<b>Unsure how much to slow down</b> , make the wrong assumption, enter the corner too fast.

## Quality Function Deployment



# Quality Sheet 1



Quality Characteristics					Characteristic	Initial		Technical Details		xx			
Quality Demanded						Value							
Product Name	Function	Quality Characteristics	Quality required (Primary)	Quality required (Secondary) in detail	Priority		A	A	A	A	A	B	B
Part A	As a detail of x	safety	hard to get hurt	Stable when accelerating at the sharp road curve	B								
				Stable when braking at the sharp road curve	A	△				⊙			
				Stable when road lane changing at the sharp curve	A				○	○			

# Method in the Past

Quality Characteristics					Characteristic	Initial		Technical Details				xx				
								xx		xx						
Quality Demanded					Value	x	x	x	x	x	x	x	x	x		
						x	x	x	x	x	x	x	x	x		
						x	x	x	x	x	x	x	x	x	x	
						x	x	x	x	x	x	x	x	x	x	
Product Name	Function	Quality Characteristics	Quality required (Primary)	Quality required (Secondary) in detail	Priority	A	A	A	A	A	A	B	B	B		
Part A	As a detail of ×	safety	hard to get hurt	Stable when accelerating at the sharp road curve	B								○			
		suitability	easy to drive	Stable when braking at the sharp road curve	A		△						◎			
				Stable when road lane changing at the sharp curve	A			○	○							

Quality Characteristics	Quality required (Primary)
safety	hard to get hurt
suitability	easy to drive



- STAMP/STPA within human mental model matrix is valuable method for safety engineering
- Additional guidance needed for Human Mental Model Analysis
- Explore additional opportunities for STPA process enhancement
- UNIVANCE will continue to enhance methodology for product development in the future.

# Thank You!