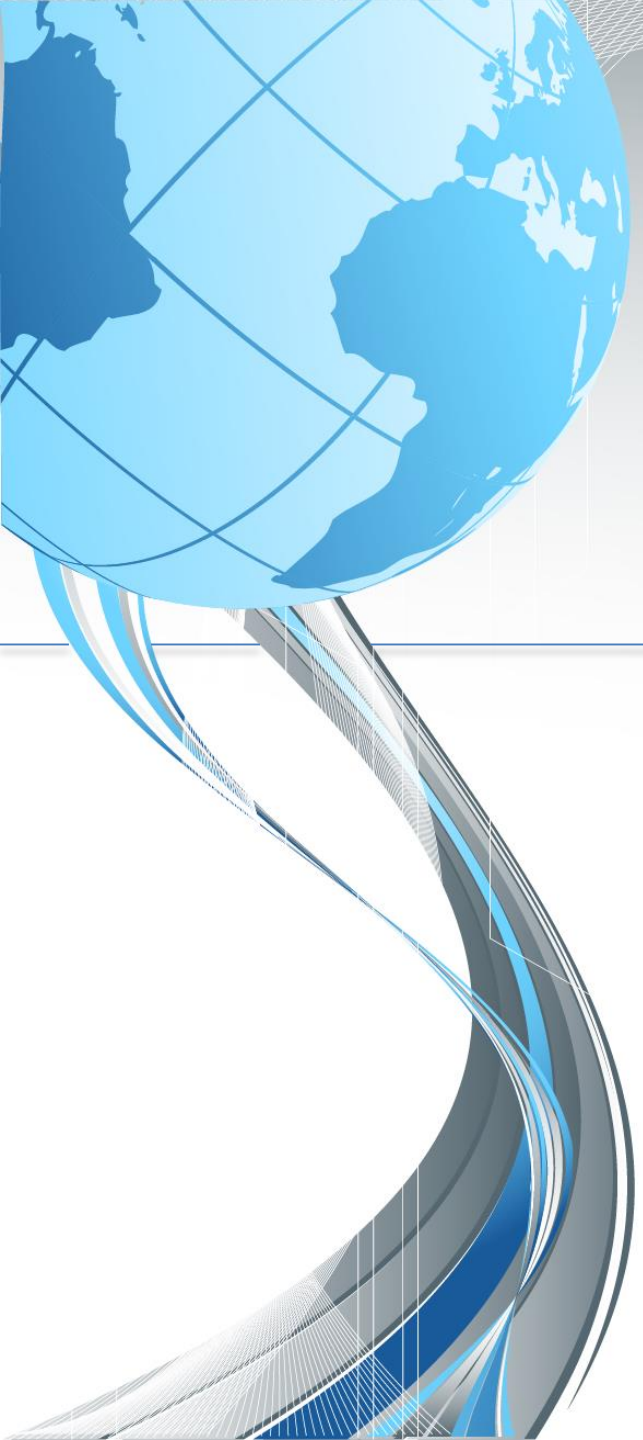

# AIAG – VDA FMEA Handbook
# 자동차 산업의 통합된 FMEA 접근법

2019. 07. 10

이범식 수석컨설턴트

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CMMI Institute Partner

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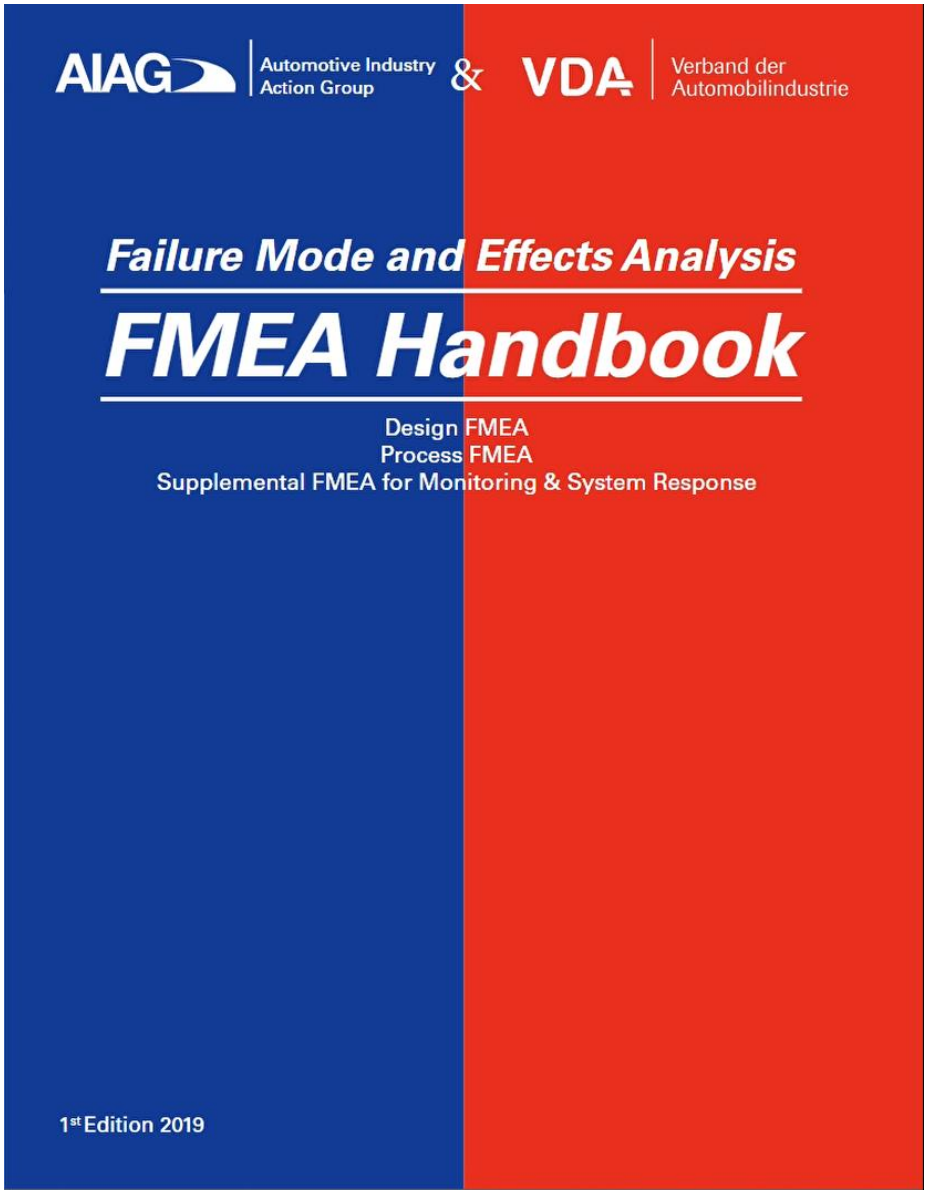


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# 1. AIAG-VDA FMEA Handbook 소개

## ❖ The 7-Step Approach

<New AIAG VDA FMEA Whitepaper
: Improvements, Benefits & Financial Impact of the AIAG & VDA FMEA Handbook–AIAG /2019>

| System Analysis | | | Failure Analysis and Risk Mitigation | | | Risk Communication |
|---|---|---|---|---|---|---|
| 1st Step | 2nd Step | 3rd Step | 4th Step | 5th Step | 6th Step | 7th Step |
| Planning & Preparation | Structure Analysis | Function Analysis | Failure Analysis | Risk Analysis | Optimization | Result Documentation |

## ❖ Enhanced FMEA Planning & Preparation

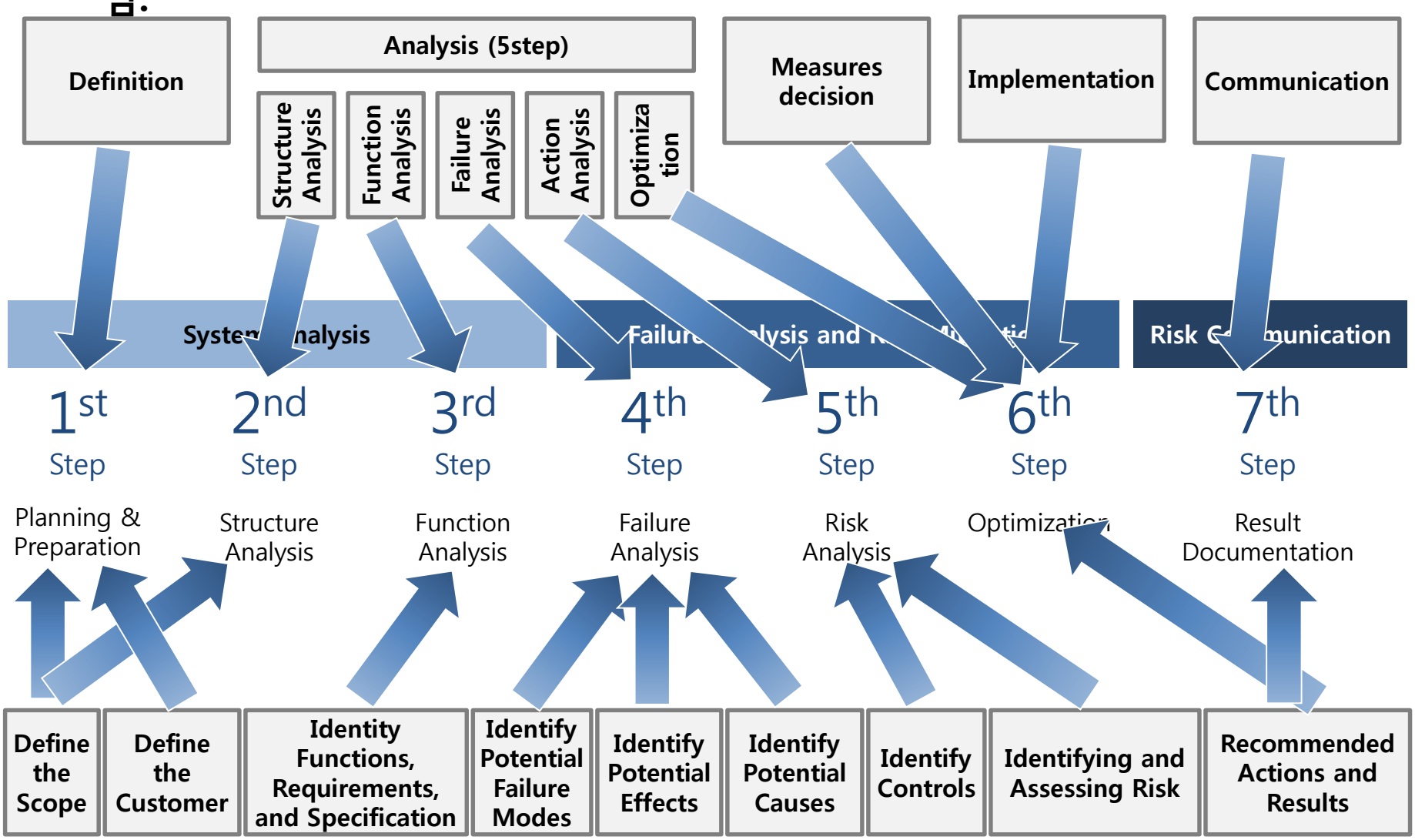
- (FMEA) Project identification
- Project plan: inTent, Timing, Team, Tasks, Tool (5T)
- Analysis boundaries : What is included and excluded from the analysis
- Identification of baseline FMEA with lessons learned
- Basis for the Structure Analysis step

## ❖ Increased Criteria Specificity

- More specificity in the criteria to determine levels for Severity, Occurrence, and Detection ratings.
- Action Priority (AP) replaces RPN (Risk Priority Numbers).

# 1. AIAG-VDA FMEA Handbook 소개

❖ 기존 VDA, AIAG FMEA 대비 차이점 : 큰 틀에서 보면 완전히 새로운 것은 아님.



# 1. AIAG-VDA FMEA Handbook 소개

| System Analysis | | | Failure Analysis and Risk Mitigation | | | Risk Communication |
|---|---|---|---|---|---|---|
| 1st Step | 2nd Step | 3rd Step | 4th Step | 5th Step | 6th Step | 7th Step |
| Planning & Preparation | Structure Analysis | Function Analysis | Failure Analysis | Risk Analysis | Optimization | Result Documentation |

| System Analysis | | |
|---|---|---|
| **Planning & Preparation** | **Structure Analysis** | **Function Analysis** |
| Project identification | Visualization of the analysis scope | Visualization of functions |
| Project plan: inTent, Timing, Team, Task, Tool (5T) | Structure tree of equivalent: block diagram, boundary diagram, digital model, physical parts | Function tree/net or function analysis form sheet and parameter diagram |
| Analysis boundaries: What is included and excluded from the analysis | Identification of design interfaces, interactions, close clearances | Association of requirements or characteristics to functions.<br>Cascade of customer (external and internal) functions with associated requirements |
| Identification of baseline FMEA with lessons learned | Collaboration between customer and supplier engineering team (interface responsibilities) | Collaboration between engineering teams (systems, safety, and components) |
| Basis for the Structure Analysis step | Basis of the Function Analysis | Basis of the Failure Analysis step |

# 1. AIAG-VDA FMEA Handbook 소개

| Failure Analysis and Risk Mitigation | | | Risk Communication |
|---|---|---|---|
| **Failure Analysis** | **Risk Analysis** | **Optimization** | **Results Documentation** |
| Establishment of the Failure chain | Assignment of **existing and/or planned** controls and rating of failure | Identification of the actions necessary to reduce risks | Communication of results and conclusions of the analysis |
| **DFMEA**<br>Potential Failure Effects, Failure Modes, Failure Causes for each product function.<br>**FMEA-MSR**<br>Potential Failure Cause, Monitoring, System Response, Reduced Failure Effect | **DFMEA**<br>Assignment of Prevention Controls to the Failure Causes<br>Assignment of Detection Controls to the Failure Causes and/or Failure Modes<br>**FMEA-MSR**<br>Assignment of a Rationale for Frequency Rating<br>Assignment of Monitoring Controls<br>Analysis of Provisions for functional safety and regulatory compliance | Assignment of responsibilities and deadlines for action implementation | Establishment of content of the documentation |
| Identification of product failure causes using a parameter diagram or failure network | **DFMEA**<br>Rating of Severity, Occurrence and Detection for each failure chain Evaluation of Action Priority<br>**FMEA-MSR**<br>Rating of Severity, Frequency and Monitoring for each failure chain Evaluation of Action Priority | Implementation of actions taken including confirmation of the effectiveness of the implemented actions and assessment of risk after actions taken | Documentation of actions taken including confirmation of the effectiveness of the implemented actions and assessment of risk after actions taken |
| Collaboration between customer and supplier (Failure Effects) | Collaboration between customer and supplier (Severity) | Collaboration between the FMEA team, management, customers, and suppliers regarding potential failures | Communication of actions to reduce risks, including within the organization, and with customers and/or supplier as appropriate |
| Basis for the documentation 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 requirements and prevention and detection controls | Record of risk analysis and reduction to acceptable levels. |

## ❖ Product General Evaluation Criteria Severity (S)

| Product General Evaluation Criteria Severity (S) | | | |
|---|---|---|---|
| Potential Failure Effects rated according to the criteria below | | | Blank until filled in by user |
| **S** | **Effect** | **Severity criteria** | **Corporate or Product Line Examples** |
| **10** | **Very High** | Affects safe operation of the vehicle and/or other vehicles, the health of driver or passenger(s) or road users or pedestrians. | |
| **9** | | Noncompliance with regulations. | |
| **8** | **High** | **Loss** of primary vehicle function necessary for normal driving during expected service life. | |
| **7** | | **Degradation** of primary vehicle function necessary for normal driving during expected service life. | |
| **6** | **Moderate** | **Loss** of secondary vehicle function. | |
| **5** | | **Degradation** of secondary vehicle function. | |
| **4** | | Very objectionable appearance, sound, vibration, harshness, or haptics. | |
| **3** | **Low** | Moderately objectionable appearance, sound, vibration, harshness, or haptics. | |
| **2** | | Slightly objectionable appearance, sound, vibration, harshness, or haptics. | |
| **1** | **Very low** | No discernible Failure Effect. | |

- **Warning의 유무와 관계 없이 신체 상해에 관련된 Effect는 S10 (Safety is 10 regardless of warning, and 9 is regulatory).**

## ❖ Occurrence Rating

- O describes the occurrence potential of the failure cause during the **lifecycle of the vehicle**, taking into account the associated preventive action.
- In the preventive preparation of the FMEA, O-value expected according to the current state of knowledge is assessed **before the execution of the detection actions.**
- After the application of the detection action during development and verification of the effectiveness of the preventive actions, the **O-evaluation is either confirmed or corrected according to the result of the detection action.**

- The Occurrence is the likelihood that a specific cause/mechanism will occur resulting in the failure mode **within design life.**

- The Occurrence rating describes the potential of the failure cause to **occur in customer operation**, according to the rating table, **considering results of already completed detection controls.**

## ❖ Action Priority DFMEA – High, Medium, Low

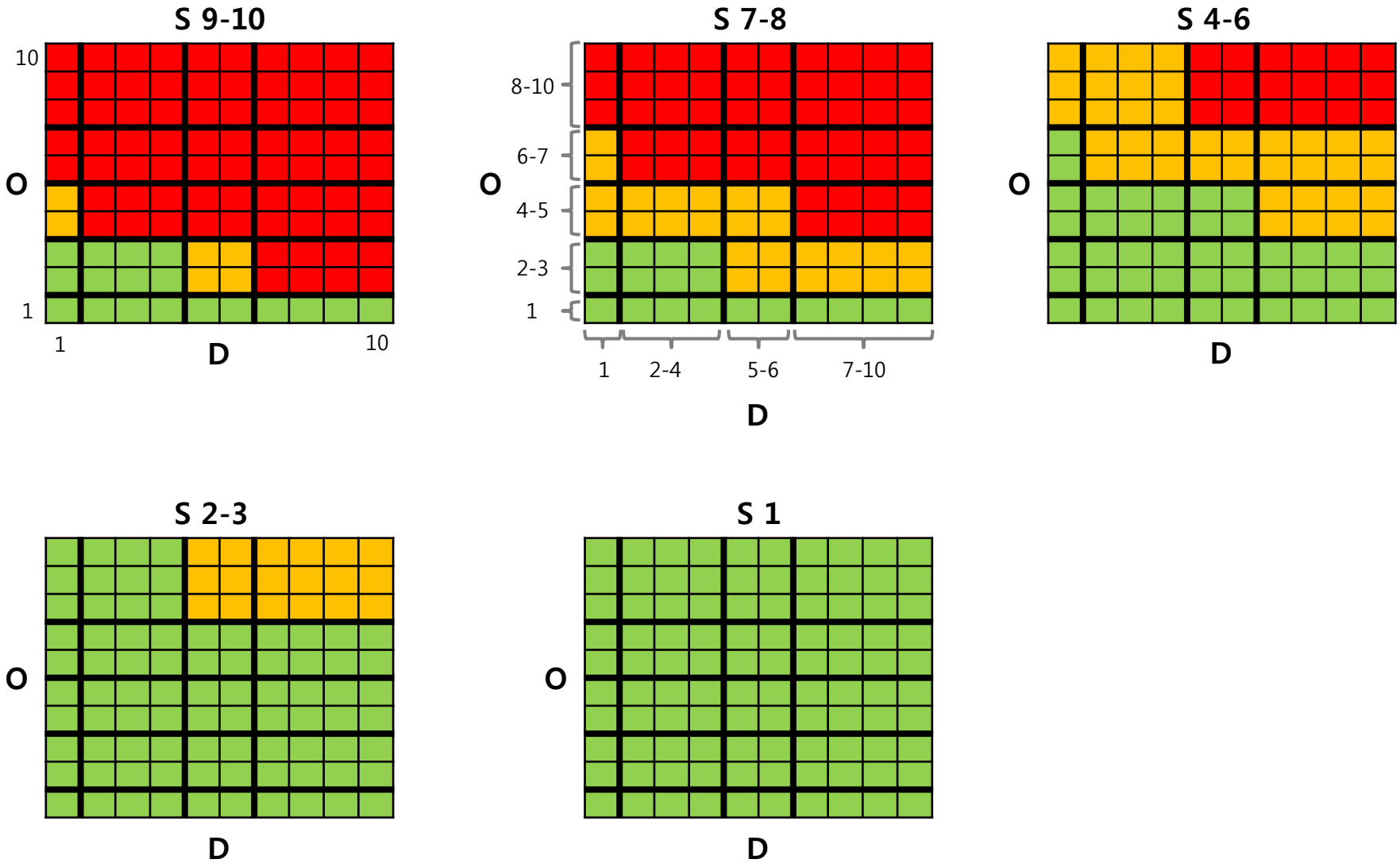
**Priority High (H):** Highest priority for review and action. The team **needs** to either identify an appropriate action to improve Prevention and/or Detection Controls or justify and document why current controls are adequate.

**Priority Medium (M):** Medium priority for review and action. The team **should** identify appropriate actions to improve prevention and/or detection controls or discretion of the company, justify and document why current controls are adequate.

**Priority Low (L):** Low priority for review and action. The team **could** identify actions to improve prevention and/or detection controls.

# 1. AIAG-VDA FMEA Handbook 소개

## ❖ Action Priority DFMEA & PFMEA – High, Medium, Low



# 2. 새로운 분석 접근법의 적용

## ❖ Draft version의 적용 후 Feedback - VDA <FMEA Alignment VDA and AIAG - VDA QMC /February 2018>

| | DFMEA | | | | PFMEA | | | | D&PFMEA | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Question** | **1** | **2** | **3** | **4** | **1** | **2** | **3** | **4** | **1** | **2** | **3** | **4** |
| Introduction | 0 | 0 | 0 | 10 | 0 | 0 | 0 | 12 | 0 | 0 | 0 | 22 |
| Basis of FMEA | 0 | 0 | 0 | 10 | 0 | 0 | 0 | 12 | 0 | 0 | 0 | 22 |
| External and Internal Req. | 0 | 0 | 0 | 10 | 0 | 0 | 2 | 10 | 0 | 0 | 2 | 20 |
| Demand for Action & Timing | 0 | 0 | 0 | 10 | 0 | 0 | 3 | 9 | 0 | 0 | 3 | 19 |
| Definition and Description | 0 | 0 | 0 | 10 | 0 | 0 | 1 | 11 | 0 | 0 | 1 | 21 |
| **1st Step: Scope definition** | 0 | 0 | 2 | 8 | 0 | 0 | 2 | 10 | 0 | 0 | 4 | 18 |
| **2nd Step: Structure analysis** | 0 | 0 | 2 | 8 | 0 | 0 | 1 | 11 | 0 | 0 | 3 | 19 |
| **3rd Step: Function analysis** | 0 | 0 | 4 | 6 | 0 | 0 | 3 | 9 | 0 | 0 | 7 | 15 |
| **4th Step: Failure analysis** | 0 | 0 | 0 | 10 | 0 | 0 | 0 | 12 | 0 | 0 | 0 | 22 |
| **5th Step: Risk analysis** | 0 | 0 | 2 | 8 | 0 | 0 | 5 | 7 | 0 | 0 | 7 | 15 |
| **6th Step: Optimization** | 0 | 0 | 1 | 9 | 0 | 0 | 2 | 10 | 0 | 0 | 3 | 19 |
| Annex | 0 | 0 | 1 | 9 | 0 | 0 | 5 | 7 | 0 | 0 | 6 | 16 |
| Rating chart: Severity | 0 | 0 | 1 | 9 | 0 | 0 | 2 | 10 | 0 | 0 | 6 | 16 |
| Rating chart: Occurrence | 0 | 0 | 1 | 9 | 0 | 0 | 5 | 7 | 0 | 0 | 3 | 19 |
| Rating chart: Detection | 0 | 0 | 0 | 10 | 0 | 1 | 3 | 7 | 0 | 1 | 3 | 17 |
| FMEA Spreadsheet & Rep | 0 | 0 | 1 | 9 | 0 | 0 | 3 | 8 | 0 | 0 | 4 | 17 |
| **Percentage** | **0%** | **0%** | **9%** | **91%** | **0%** | **0%** | **19%** | **80%** | **0%** | **0%** | **15%** | **85%** |

| | |
|---|---|
| Question 1 | I don't get it |
| Question 2 | I understand partially, but would need some help in application |
| Question 3 | I understand the major concepts, but have some questions on the details |
| Question 4 | I get it, it is clear |

# 2. 새로운 분석 접근법의 적용

## ❖ Draft version의 적용 후 Feedback - AIAG

<FMEA Alignment VDA and AIAG - VDA QMC /February 2018>

| | DFMEA | | | | PFMEA | | | | D&PFMEA | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Question** | **1** | **2** | **3** | **4** | **1** | **2** | **3** | **4** | **1** | **2** | **3** | **4** |
| Introduction | 0 | 0 | 0 | 11 | 0 | 0 | 2 | 16 | 0 | 0 | 2 | 27 |
| Basis of FMEA | 0 | 0 | 0 | 11 | 0 | 0 | 1 | 17 | 0 | 0 | 1 | 28 |
| External and Internal Req. | 0 | 1 | 2 | 7 | 0 | 0 | 3 | 15 | 0 | 1 | 5 | 22 |
| Demand for Action & Timing | 0 | 0 | 2 | 10 | 0 | 0 | 2 | 15 | 0 | 0 | 4 | 25 |
| Definition and Description | 0 | 0 | 3 | 8 | 0 | 0 | 3 | 15 | 0 | 0 | 6 | 23 |
| **1st Step: Scope definition** | 0 | 0 | 4 | 7 | 0 | 0 | 5 | 13 | 0 | 0 | 9 | 20 |
| **2nd Step: Structure analysis** | 0 | 3 | 6 | 2 | 0 | 1 | 7 | 10 | 0 | 4 | 13 | 12 |
| **3rd Step: Function analysis** | 0 | 5 | 5 | 1 | 0 | 7 | 8 | 3 | 0 | 12 | 13 | 4 |
| **4th Step: Failure analysis** | 0 | 2 | 8 | 1 | 0 | 1 | 6 | 10 | 0 | 3 | 14 | 11 |
| **5th Step: Risk analysis** | 0 | 1 | 5 | 4 | 0 | 1 | 3 | 13 | 0 | 2 | 8 | 17 |
| **6th Step: Optimization** | 0 | 1 | 5 | 4 | 0 | 1 | 1 | 15 | 0 | 2 | 6 | 19 |
| Annex | 0 | 0 | 1 | 3 | 1 | 1 | 2 | 11 | 1 | 1 | 3 | 14 |
| Rating chart: Severity | 0 | 1 | 3 | 6 | 0 | 0 | 7 | 10 | 0 | 1 | 10 | 16 |
| Rating chart: Occurrence | 0 | 1 | 3 | 6 | 0 | 0 | 8 | 9 | 0 | 1 | 11 | 15 |
| Rating chart: Detection | 0 | 1 | 3 | 6 | 0 | 0 | 4 | 13 | 0 | 1 | 7 | 19 |
| FMEA Spreadsheet & Rep | 0 | 2 | 3 | 1 | 0 | 1 | 4 | 9 | 0 | 3 | 7 | 10 |
| **Percentage** | **0%** | **11%** | **32%** | **58%** | **0%** | **4%** | **24%** | **72%** | **0%** | **7%** | **27%** | **66%** |

| | |
|---|---|
| Question 1 | I don't get it |
| Question 2 | I understand partially, but would need some help in application |
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# 2. 새로운 분석 접근법의 적용

## ❖ Draft version의 적용 후 Feedback – VDA&AIAG

<FMEA Alignment VDA and AIAG - VDA QMC /February 2018>

| | VDA-DFMEA | | | | AIAG-DFMEA | | | |
|---|---|---|---|---|---|---|---|---|
| **Question** | **1** | **2** | **3** | **4** | **1** | **2** | **3** | **4** |
| **1st Step: Scope definition** | 0 | 0 | 2 | 8 | 0 | 0 | 4 | 7 |
| **2nd Step: Structure analysis** | 0 | 0 | 2 | 8 | 0 | 3 | 6 | 2 |
| **3rd Step: Function analysis** | 0 | 0 | 4 | 6 | 0 | **5** | 5 | 1 |
| **4th Step: Failure analysis** | 0 | 0 | 0 | 10 | 0 | 2 | 8 | 1 |
| **5th Step: Risk analysis** | 0 | 0 | 2 | 8 | 0 | 1 | 5 | 4 |
| **6th Step: Optimization** | 0 | 0 | 1 | 9 | 0 | 1 | 5 | 4 |

| | |
|---|---|
| Question 1 | I don't get it |
| Question 2 | I understand partially, but would need some help in application |
| Question 3 | I understand the major concepts, but have some questions on the details |
| Question 4 | I get it, it is clear |

- **VDA 기반의 FMEA를 수행하던 조직은 변경에 대한 대응에 특별한 어려움이 없을 것으로 판단됨**
- **AIAG 기반의 FMEA를 수행하던 조직은 구조분석→ 기능분석 → 고장 분석으로 이어지는 새로운 방법론에 대한 학습/연습 필요**

# 2. 새로운 분석 접근법의 적용

## ❖ New DFMEA Standard Template 이용

Design Failure Mode and Effect Analysis (DESIGN FMEA)

PLANNING & PREPARATION (STEP 1)

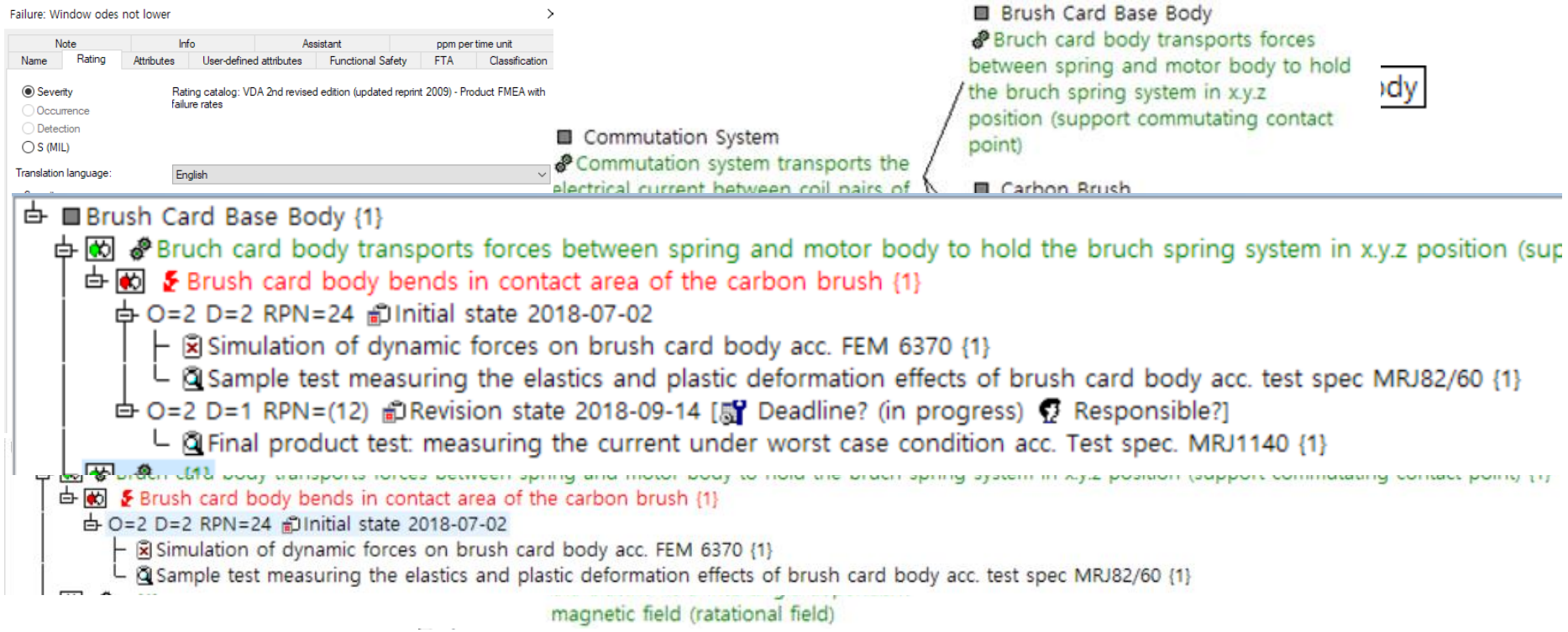
| | | | | | |
|---|---|---|---|---|---|
| Company Name: | Acme Automotive | Subject: | PX123 Upper Jacket | DFMEA ID Number: | 12345 |
| Engineering Location: | Munich, Germany | DFMEA Start Date: | 19-Mar-2018 | Design Responsibility: | S, Gray |
| Customer Name: | Jackson Industry | DFMEA Revision Date: | 25-Sep-2018 | Confidentiality Level: | Confidential |
| Model/ Year/ Platform: | 2020 PX123 | Cross Functional Team: | See Team List | | |

| | CONTINUOUS IMPROVEMENT | STRUCTURE ANALYSIS (STEP 2) | | | FUNCTION ANALYSIS (STEP 3) | | | FAILURE ANALYSIS (STEP 4) | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Issue # | History/ Change Authorization (As Applicable) (This column is optional) | 1. Next Higher Level | 2. Focus Element | 3. Next Lower Level or Characteristic Type | 1. Next Higher Level Function and Requirement | 2. Focus Element Function and Requirement | 3. Next Lower Level Function and Requirement or Characteristic | 1. Failure Effect (FE) to the Next Higher Level Element and/or Vehicle End User | Severity (S) of FE | 2. Failure Mode (FM) of Focus Element | 3. Failure Cause (FC) of the Next Lower Level or Characteristic |
| | | Window Lifter Motor | Commutation System | Brush Card Base Body | Convert electrical energy into mechanical energy according to parameterization | Communication system transports the electrical current between coil pairs of the electromagnetic converter | Brush card body transports forces between spring and motor body to hold the brush spring system in x, y, z position (support commutating contact point) | Torque and rotating velocity of the window lifter motor too low | 6 | Angle deviation by commutation system intermittently connects the wrong coils (L1, L3 and L2 instead of L1, L2 and L3) | Brush card body bends in contact area of the carbon brush |

| RISK ANALYSIS (STEP 5) | | | | | | OPTIMIZATION (STPE 6) | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Current Prevention Control (PC) of FC | Occurrence (O) of FC | Current Detection Controls (DC) of FC or FM | Detection (D) of FC/FM | DFMEA AP | Filter Code (Optional) | DFMEA Preventive Action | DFMEA Detection Action | Responsible Person's Name | Target Completion Date | Status | Action Taken with Pointer to Evidence | Completion Date | Severity (S) | Occurrence (O) | Detection (D) | DFMEA AP | Filter Code (Optional) | Remarks |
| Simulation of dynamic forces on brush card body acc. FEM 6370 | 2 | Sample test: measuring the elastics and plastic deformation effects on brush card body acc. test spec MRJ82/60 | 2 | L | | None | Final product test: measuring the current under worst case conditions acc. Test spec MRJ1140 | Test Engineer Mr. Max Mueller | dd.mm.yyyy | planned | | | 6 | 2 | 1 | L | | |

# 3. 새로운 분석 접근법의 적용

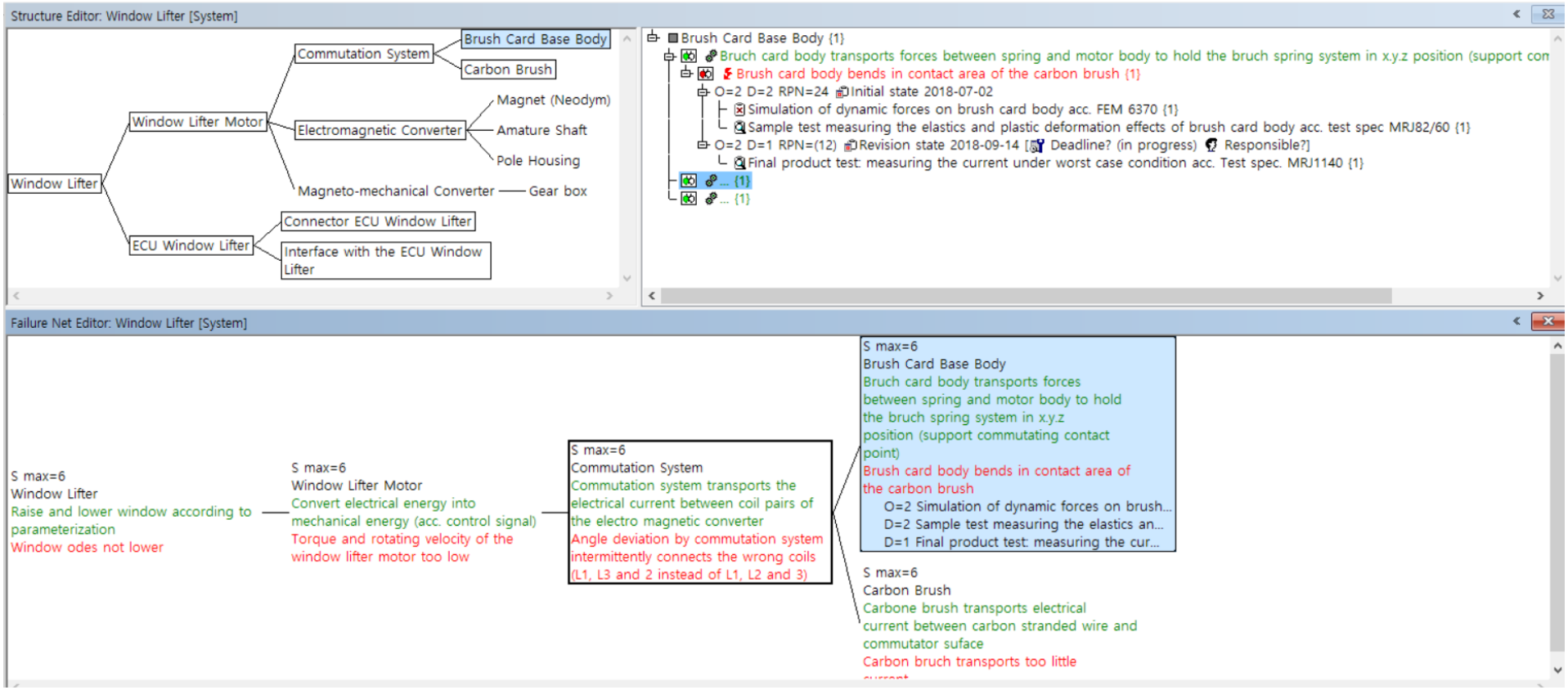
## ❖ 전용 도구의 이용




2nd Step

# 3. 새로운 분석 접근법의 적용

## ❖ 전용 도구의 이용

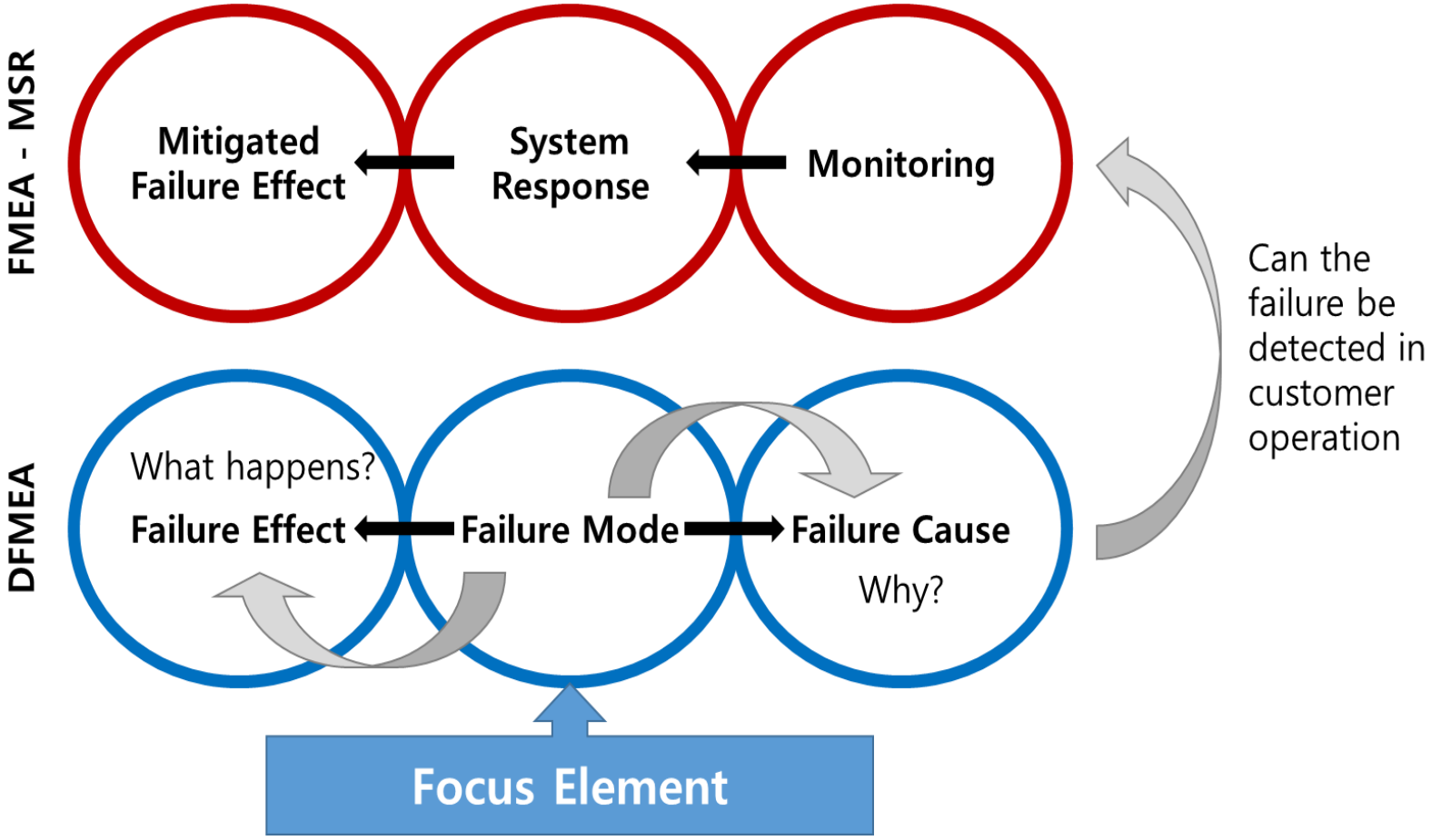



- **FMEA 수행 접근법을 그대로 반영하여 구현된 도구 사용을 통해 보다 효과적인 FMEA수행 가능**

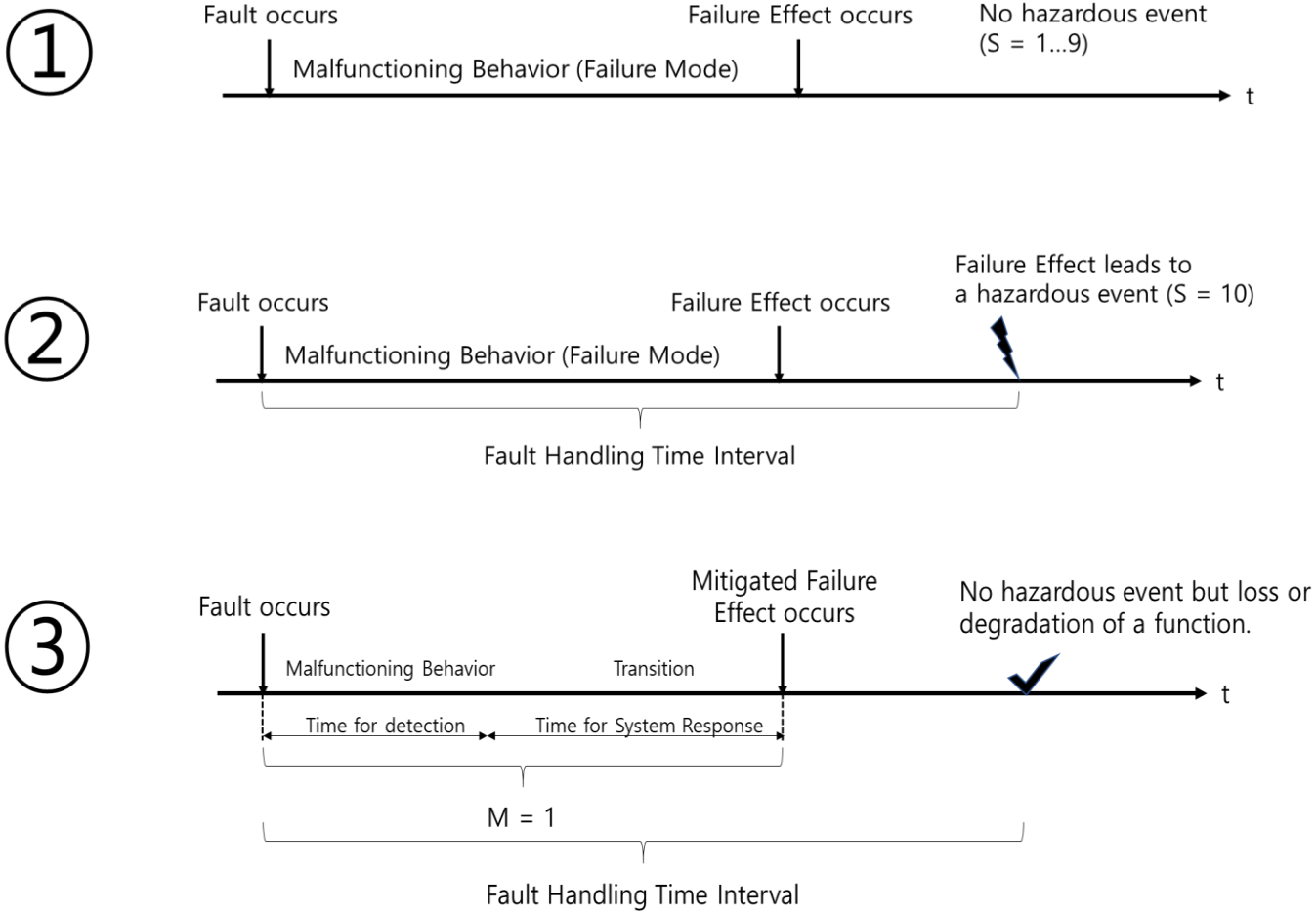
## ❖ Supplemental FMEA for Monitoring and System Response 주요 개념

- 발생한 고장 원인 또는 고장 모드가 Customer Operation동안 운전자 또는 시스템에 의해 감지되는가?
- Customer Operation = End-user operation + in-service operation + maintenance operation
- F (frequency)는 고려되는 Customer Operational Condition과 고장이 발생할 가능성
- M (monitoring)은 고장 모드 또는 고장 원인의 감지 및 시스템 반응의 적절성 및 적시성
- DFMEA에서의 감지는 보완적인 FMEA-MSR에서의 모니터링과 다르다. Detection controls는 개발 및 validation에서 요구사항의 충족을 입증하기 위한 테스팅의 능력을 문서화한다. 이미 시스템 설계의 일부인 모니터링의 경우, validation은 모니터링과 시스템 반응이 의도한대로 동작하는지를 입증하기 위한 것이다. 반대로 FMEA-MSR의 모니터링은 사양이 충족되었다는 가정하에, 고객 운용에서 결함 감지 성능의 효과성을 평가한다. 모니터링 등급은 모니터링된 결함에 대한 시스템 반응의 안전 성능 및 신뢰성을 포함한다. 이것은 안전 목표 달성의 평가에 기여하고 안전 컨셉을 도출하는데 사용될 수도 있다.
- VDA FMEA  Annex A2.1의 FMEA for Mechatronical Systems을 보다 구체화 함

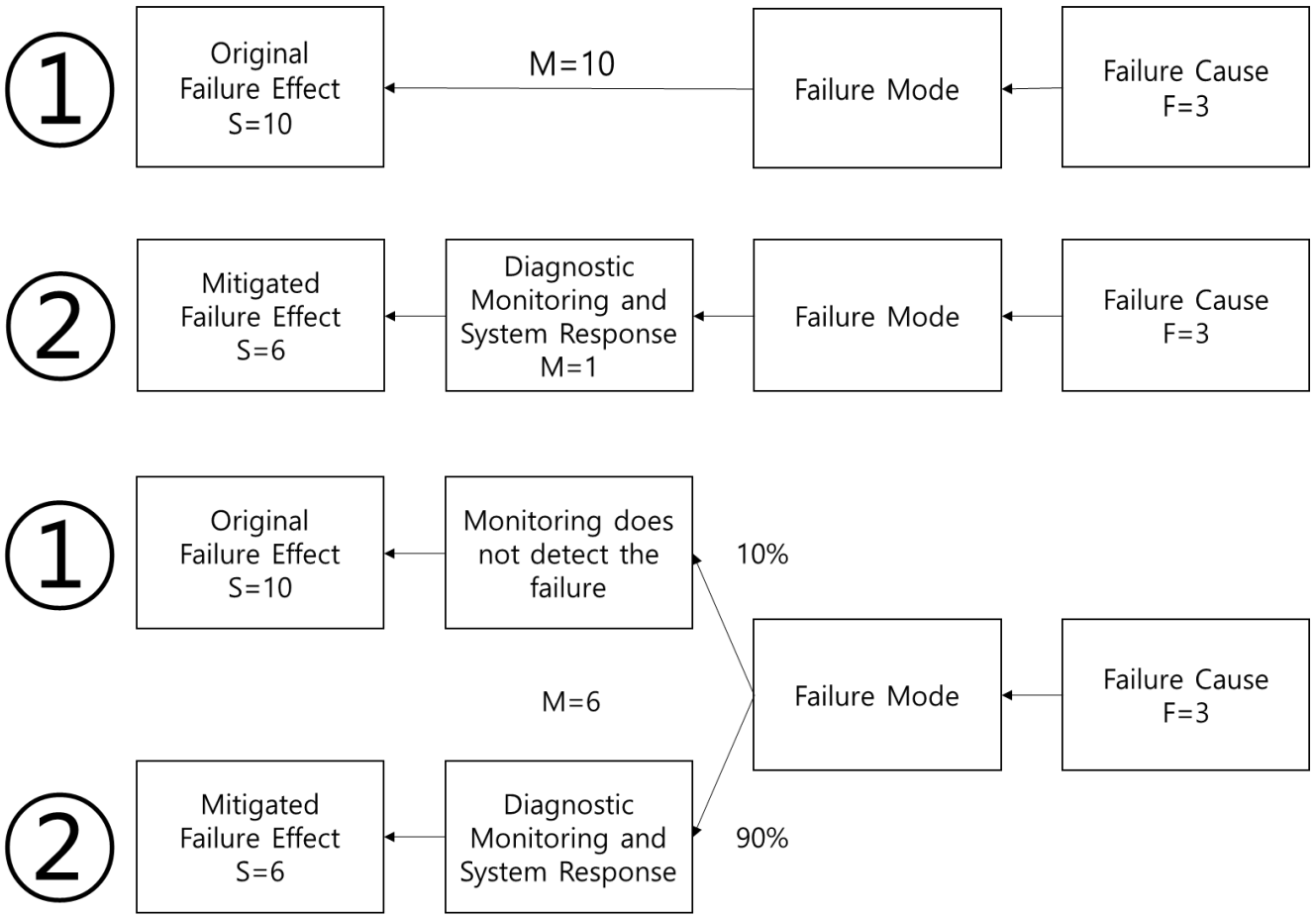
## ❖ Supplemental FMEA for Monitoring and System Response, 접근 방법



## ❖ Severity 10, 1~9의 구분 및 Monitoring수단의 적용 유무에 따른 결과(Effect)의 차이



## ❖ Monitoring이 M=1으로 평가되는 경우에만 Severity를 완화된 새로운 Effect에 대한 Severity로 교체 가능



## ❖ FMEA-MSR의 Monitoring 평가 기준

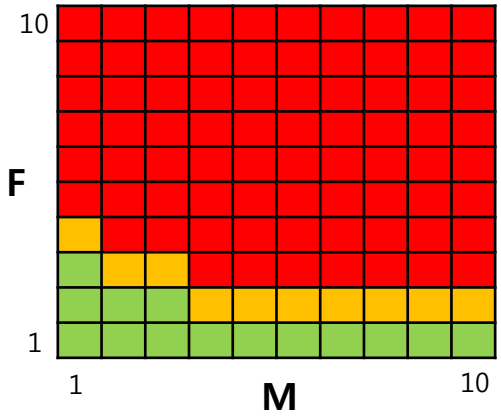
| Frequency Potential (F) for the Product | | | |
|---|---|---|---|
| Frequency criteria (F) for the estimated occurrence of the Failure Cause in relevant operating situations during the intended service life of the vehicle | | | Blank until filled by user |
| **F** | **Estimated Frequency** | **Frequency criteria – FMEA-MSR** | Corporate or Product Line Examples |
| **4** | **Low** | Failure Cause is predicted to occur rarely in the field during the intended service life of the vehicle. **At least ten occurrences in the field are predicted.** | |
| **3** | **Very low** | Failure Cause is predicted to occur in isolated cases in the field during the intended service life of the vehicle. **At least one occurrence in the field is predicted.** | |
| **2** | **Extremely low** | Failure Cause is predicted not to occur in the field during the intended service life of the vehicle based on prevention and detection controls and field experience with similar parts. Isolated cases cannot be ruled out. **No proof it will not happen.** | |
| **1** | **Cannot Occur** | Failure Cause cannot occur during the intended service life of the vehicle or is virtually eliminated. **Evidence that Failure Cause cannot occur. Rationale is documented.** | |

| Percentage of relevant operating condition in comparison to overall operating time | Value by which F may be lowered |
|---|---|
| <10% | 1 |
| <1% | 2 |

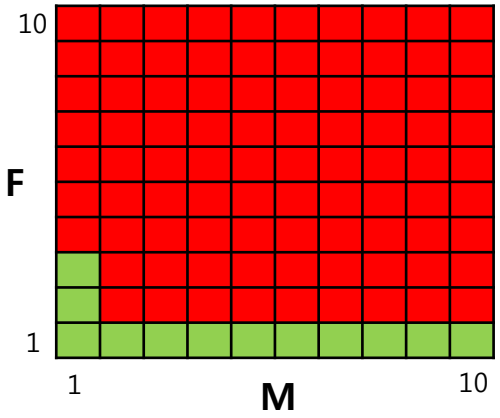
NOTE: Probability increases as number of vehicle are increased
Reference value for estimation is one million vehicle in the field.

## ❖ Action Priority FMEA-MSR – High, Medium, Low

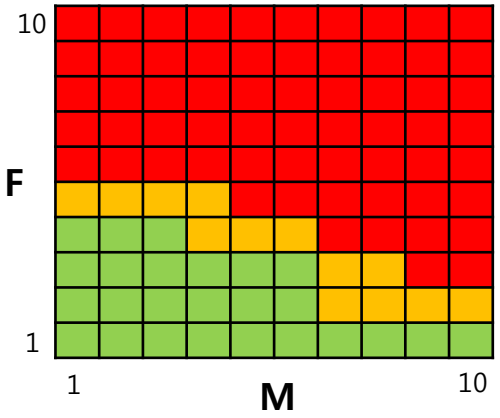
S 10



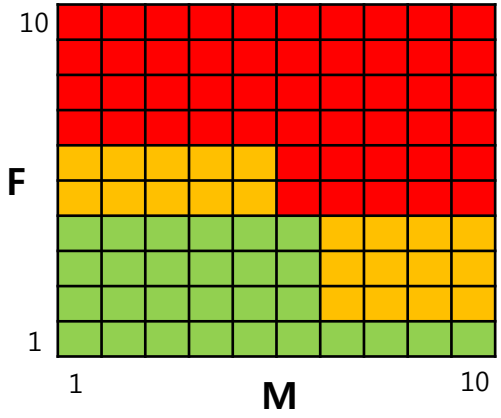

S 9



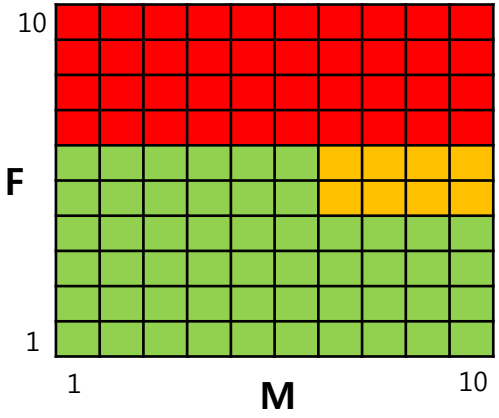

S 7-8



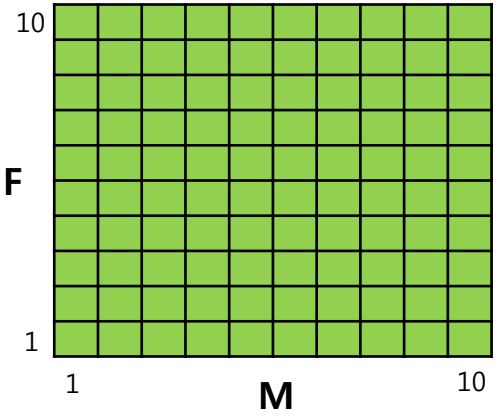

S 4-6




S 2-3




S 1



Smart
System
**Software**

**Process**
**Product**
Professional
People

Durable
Delivery
**Deployment**

# SPID

**Improvement**
**Innovation**
Intelligent

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