NIST Advanced Manufacturing Series 300-7

# Proposed Expansion of Quality Information Framework (QIF) Standard Schema with Potential Failure Mode and Effects Analysis (FMEA) Information Model

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# Proposed Expansion of Quality Information Framework (QIF) Standard Schema with Potential Failure Mode and Effects Analysis (FMEA) Information Model

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**Acknowledgement**
The authors wish to thank Tom Kramer and John Horst from NIST's Intelligent Systems Division for their valuable input to this research. The authors also wish to thank Craig Schlenoff and Kevin Jurrens from NIST for their review and comments on this paper.

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# 1 Proposal

With the release of Quality Information Framework (QIF) version 2.1 [1], industry is beginning to widely adopt the standard. We propose a next step in enhancing the standard would be to extend QIF beyond inspection to broader manufacturing-quality issues. An illustration for such an extended scope is provided in Figure 1, where additional quality practices could be explored for QIF support. These quality practices include the Automotive Industry Action Group's (AIAG)[1,2] Production Part Approval Process (PPAP) [2] and Advanced Product Quality Planning (APQP) [3]. Since QIF already supports the AS9102 First Article Inspection (FAI) process as practiced within the aerospace industry [4], it would be reasonable to anticipate QIF's abilities to support additional quality processes, including those illustrated in Figure 1.

Therefore, we propose the first quality-focused QIF expansion to be Failure Mode and Effects Analysis (FMEA) [5]. The QIF working group should consider including FMEA as a new feature in QIF[3].

## 1.1 Proposed Integration Structure

Product design and production are core lifecycle functions. FMEA is applied to both, Design FMEA (DFMEA) and Process FMEA (PFMEA), respectively. Meanwhile, QIF encompasses eight parts, including QIF Model-Based Definition (MBD) [6], QIF Plans [7], QIF Resources [8], and QIF Results [9], each addressing a component of a part's quality-measurement process. Given the anticipated interactions between the current parts of QIF and FMEA, it is reasonable for the entire FMEA schema to be proposed as a new part in QIF that is complementary to the existing QIF parts. We propose a new part named *Quality Management (QM)*.

The following alternative ways to integrate FMEA into QIF were also considered but found to be inferior to our proposed solution:

- PFMEA be a part of QIF Plans; this means to consider PFMEA as a part of quality planning analysis. The ambiguity would be that PFMEA covers a much broader scope and inspection planning is only a very small fraction of the PFMEA concerns.

- DFMEA be a part of QIF MBD; this means to consider DFMEA as a supportive method to improve product design. The ambiguity would be that such a support is directed toward the design phase while QIF MBD deals with documenting the design results.

[1] The AIAG was founded by Ford, General Motors, and Chrysler and has grown to include companies such as Toyota, Honda and Nissan, heavy truck and earth moving manufacturers such as Caterpillar Inc. and Navistar International, and many of their Tier One and sub-tier suppliers and service providers.

[2] Product/Company Disclaimer: Certain commercial products or company names are identified in this paper to describe our study adequately. In no case does such identification imply recommendation or endorsement by the National Institute of Standards and Technology, nor does such identification imply that the products or names identified are necessarily the best available for the purpose.

[3] Note that it is not within our proposal to consider any other components in Figure 1.

### 1.2 Document structure

An overview of FMEA is described in the following sections, along with how FMEA and the current QIF could leverage each other. An Extensible Markup Language (XML) based schema definition for FMEA is also described.

Readers should note this document is not intended to define FMEA nor to systematically instruct users on how to practice FMEA, as FMEA has been well practiced over a few decades and plenty of references exist, including [5,10,11].

## 2 Failure Mode and Effects Analysis

FMEA provides a process for users to analyze their respective technical issues. The following briefly describes the process and the associated information elements that are required to support FMEA (see AIAG documents [5,10] for further details):

- Identify the subject of focus (e.g., an item in a product design, a process step) to conduct a FMEA. Note, in general, FMEA is not intended to be conducted for every step in a process or every item in a product but, rather, the key elements that are most at risk.
- Identify and list the function(s) corresponding to the identified subject.
- Identify and list the requirements corresponding to the function(s), process step, and/or item.
- Identify and list what could potentially go wrong (e.g., risks) in association with the identifications. The identified risks are called potential failure mode(s), which are explicitly associated with the previously identified requirement(s), function(s), process step(s), and/or product item(s).
- Identify and list the effect(s) on the subject when each failure mode occurs.
- Severity is "a ranking number associated with the most serious effect for a given failure mode [2,11]." When there are multiple effects, estimate the severity of each and assign a value between 1 and 10. The highest value is to be selected for the remaining steps of the FMEA, as described below.
- Identify and list if there are special product or process feature(s)[4] that need(s) to be addressed. This information element is called *Classification* in FMEA.
- Identify the possible causes for each failure mode.
- For each of the causes, identify and list:
    - Any prevention mechanism(s) that could be installed to prevent the cause and subsequent failure mode from happening.
    - The likelihood of the occurrence of the cause and assign a value between 1 and 10.
    - If there are detection mechanisms that could be installed to detect the happening of the cause and subsequent failure mode.
    - The likelihood of such a cause being detected and assign a value between 1 and 10.
    - The risk priority number (RPN) for the cause, which is equivalent to the multiplication of the Severity, Occurrence, and Detection values.
    - The recommended actions to reduce the chances for the cause to happen; the associated pieces of information that should be documented are:
        - Any identified responsible parties.

[4] The term "feature" is used here in its general definition and not how it is defined in QIF.

        - Any targeted completion dates.
        - Any actions that were taken to address the cause.
        - Any actual completion dates.
    - Any resulting Severity/Occurrence/Detection/RPN values from all the actions that were taken.

A FMEA reporting form is easily built encompassing these elements. An illustration for the body of a FMEA form is shown in Appendix A. Such a form also uses a header to document the associated administrative information.



We developed an XML Schema Definition (XSD) to cover these FMEA elements. Details are described later in this report. Instance files for the XSD are intended to document FMEA results. In the automotive industry, FMEA is often conducted at the beginning stages of a production program, such as for product/part design and manufacturing processes. A FMEA team is commissioned to conduct the FMEA(s). The FMEA process should iterate until the concerns for the failure modes and effects are sufficiently addressed and the resulting risk levels are determined and validated.

## 3 Leveraging QIF for FMEA

QIF and FMEA could benefit significantly from each other for interoperable information sharing. Figure 2 illustrates the specifics; the figure is not intended to show a complete set of the information exchanges, but only some key aspects, including:

Information flow coverage, QIF to FMEA:

- QIF Results (e.g., the Out Of Tolerance arrow) [9] and/or QIF Statistics (e.g., the Process Capability Insufficient arrow) [12] could help define a failure mode on the manufactured product and/or the associated process.
- QIF Results and/or QIF Statistics could help the Prevention Controls (e.g., the Monitor arrows) to reduce the occurrence chances of a failure mode and, likewise, help the Detection Controls in FMEA (e.g., the Meas Result and Meas Trend arrows, respectively) in detecting a failure mode that might be occurring.
- The values provided by QIF Results and/or QIF Statistics could also be used to help identify Recommended Actions in FMEA.
- Dimension Measurement Equipment (DME) characteristics, as modeled in QIF Resources [8], could help identify a failure mode (e.g., the Out Of Calib. arrow).

Information flow coverage, FMEA to QIF:

- A critical dimensional requirement could be identified as a high-risk potential failure mode. Conducting a FMEA could help detect a possible cause and prevent such a failure mode from occurring. These benefit the subject QIF MBD (e.g., the References for Improved Design arrow).
- A resulting Recommended Action could help:
    - Benefit QIF planning, such as determining better suited locations and/or number of points to inspect, (e.g., the # Of Points arrow), responsible parties for conducting the planning actions, targeted completion dates for the recommended inspection plans, etc.

- Identify a QIF Resource in need of calibration.
- Select a DME for inspection.
- Reduce risk and/or improve product/process quality (e.g., via a resulting Engineering Change Request (ECR))

# 4 FMEA Information Models

## 4.1 Overview

The proposed FMEA Schema covers all the information elements required by all the FMEA variants as specified by AIAG. See Appendix B for the modeled variants in the proposed Schema.

In the FMEA Schema, the names for the information substructures and elements are created to best represent the respective columns in the FMEA forms. Same names are used when possible. The intention is to effectively and efficiently map the FMEA Schema elements to the appropriate reporting forms. Another feature in the schema is that the elements are assumed common to both PFMEA and DFMEA unless otherwise explicitly modeled[5].

The FMEA schema uses a modeling style consistent with QIF's XML naming and design rules, as applicable.

## 4.2 Information Model Structures

The main "container" information structure for QIF, `QIFDocument.xsd` is used to encompass both PFMEA and DFMEA (see Fig. 3), but only the needed aspects are used for FMEAs. In other words, the unused aspects should be excluded (by the programmer) in instance files.

Fig. 4 through Fig. 14 show the elemental-information models for PFMEA. They follow the descriptions in Section **Error! Reference source not found.**. DFMEA shares many of the common elemental models and is similar to PFMEA.

Fig. 4 illustrates that FMEA contains a Header and a Body. In Fig. 5, the substructure `ProcessStepSubGroupType` specifies `n` (i.e., multiple) `ProcessStep`s. Meanwhile, `ProcessStep`, itself, is specified, in `ProcessStepType`, as containing a description for the step, the associated function(s) (via `FMEAFunctionSubGroup`), and their respective `id`s.

The same pattern repeats in specifying `n FMEAFunction`s in the substructure of `FMEAFunctionSubGroupType`. Meanwhile, `FMEAFunction`, itself, is specified, in `FMEAFunctionType`, as containing a description for the function, the associated requirements (via `RequirementSubGroup`), and their respective `id`s. See Fig. 6 and Fig. 7.

The same modeling pattern repeats through Fig. 14 where the FMEA is completely modeled in XML. Appendix C maps the FMEA process as described in Section 2 to the elemental schema definitions. DFMEA is similar and its code is not listed.

5 The AIAG specification also uses alpha-numerals to help identify each of the elements in FMEA. For example, Process Step in PFMEA and Item in DFMEA are identified as "a1." These are included as a part of the inline documentation in the schema.

## 5 Summary

A set of FMEA information models are proposed to be included as a part of the QIF standard. Upon presentation of the FMEA information models, the DMSC's QIF working group preliminary accepted the approach. The expanded QIF would interest a broader audience that is concerned with quality above and beyond inspection. The data sharing between FMEA and the other QIF parts also means better utilization of QIF-represented data. Further iterations with the QIF working group are sought to further the evolution of the schema definition, for its application, and for helping group develop roadmaps for QIF.

## 6 Figures

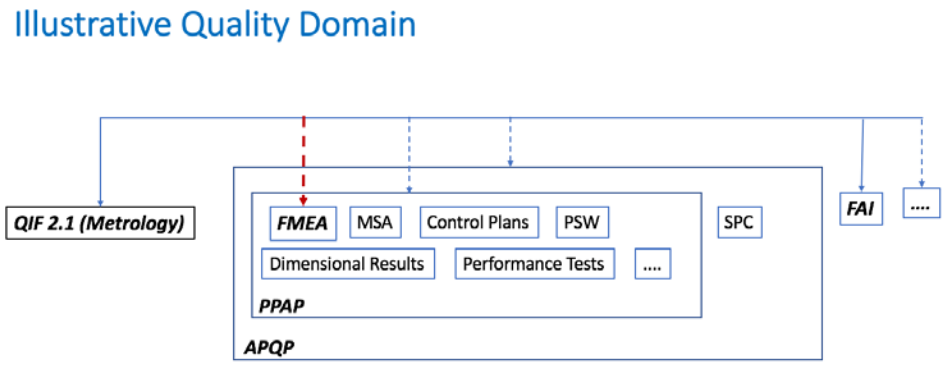


**Fig. 1.** Illustrative Broad-Scope Manufacturing Quality Domain

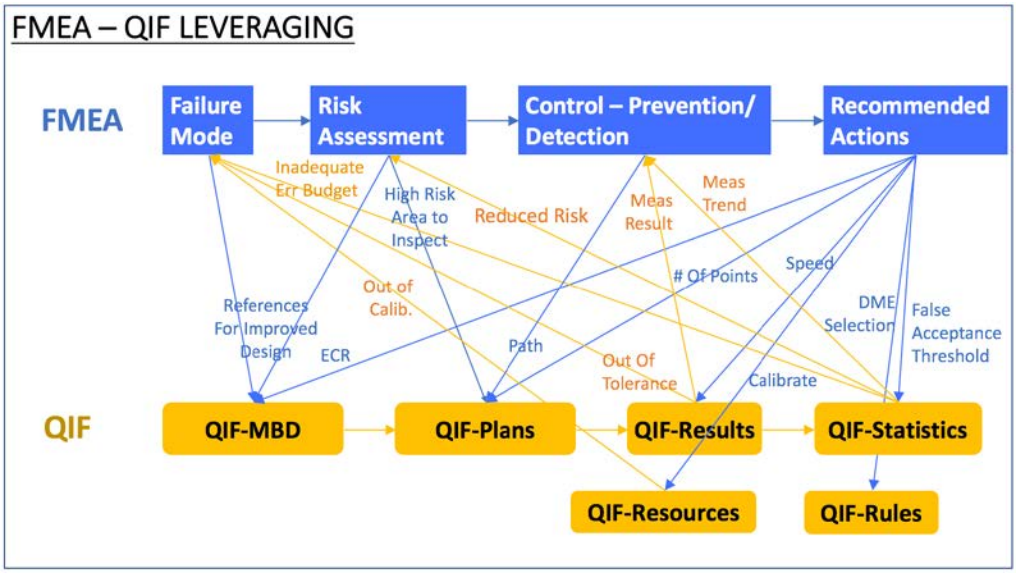


**Fig. 2.** Interactions Between FMEA and QIF

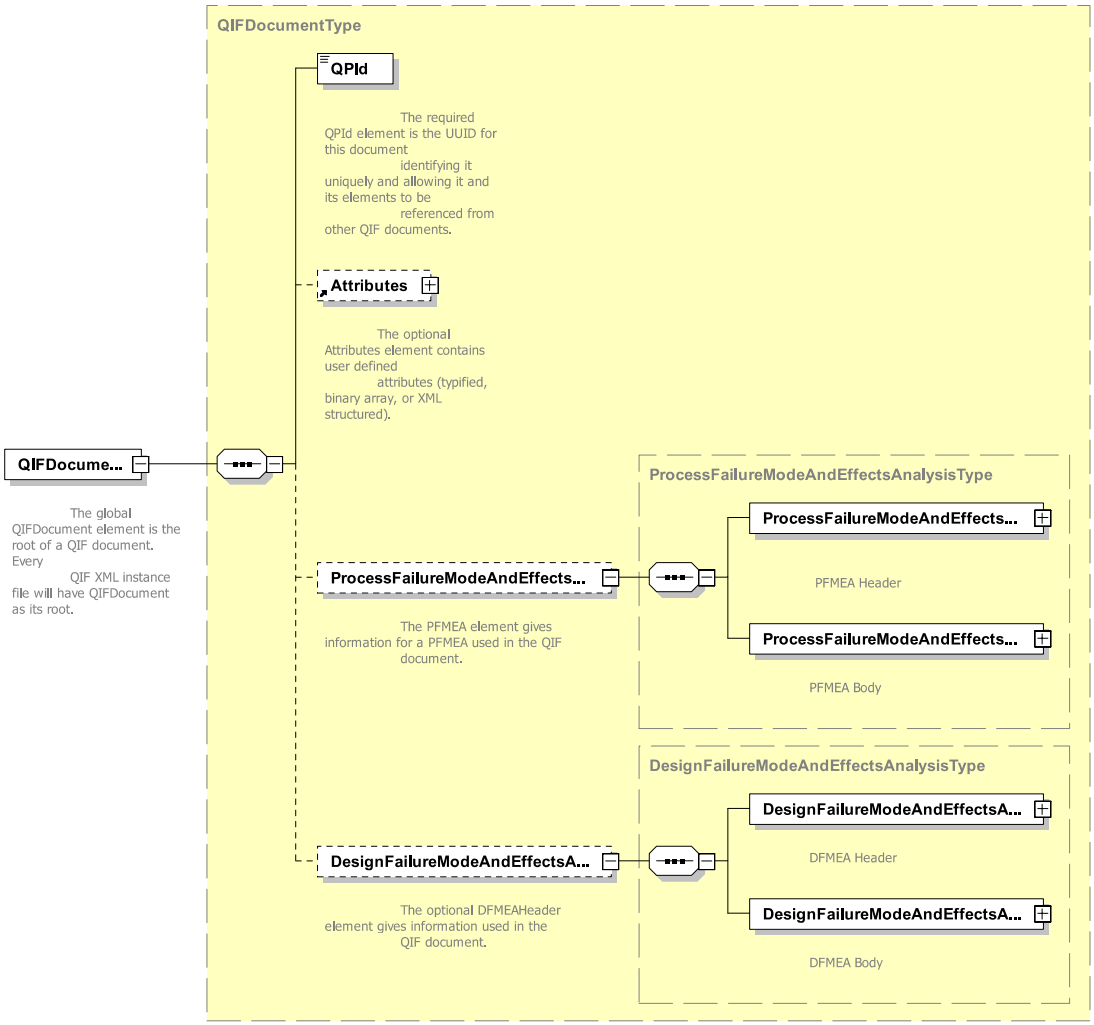


**Fig. 3.** QIF Main Container, QIFDocument.xsd, for PFMEA and DFMEA

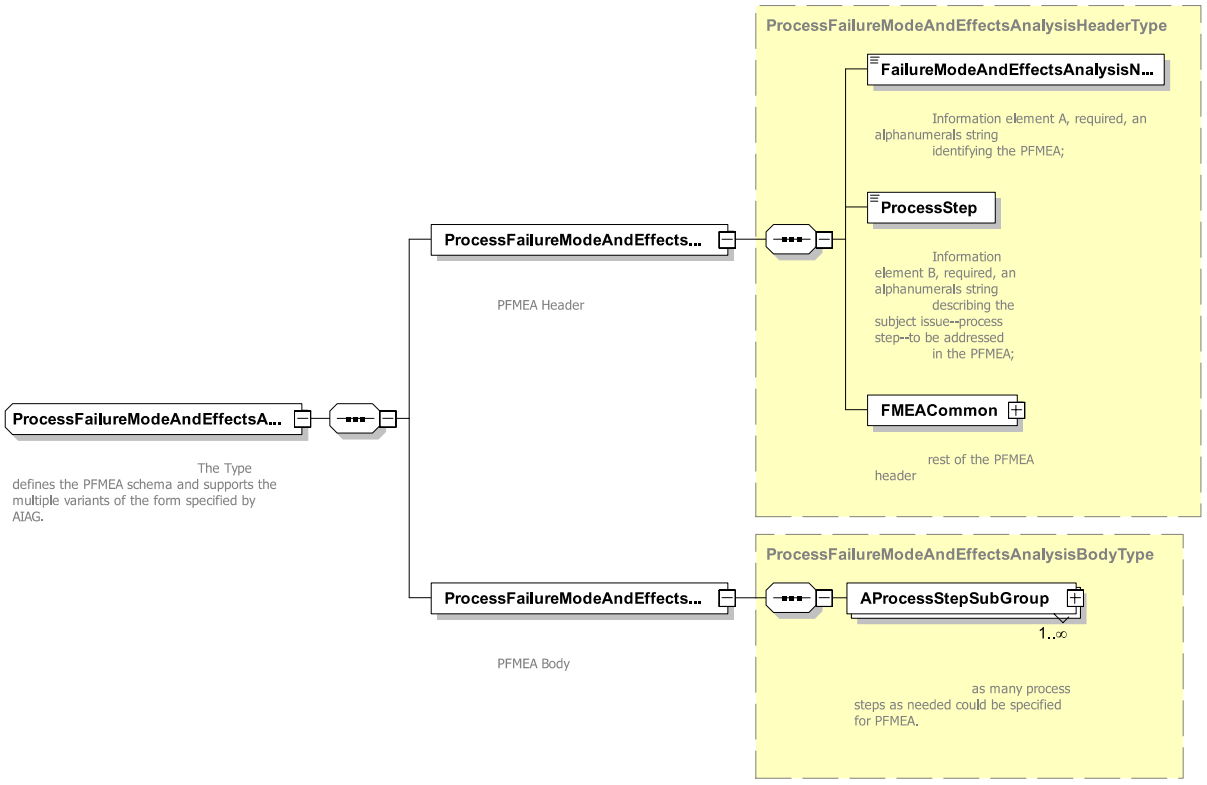


**Fig. 4.** PFMEA Main Aspects: Header and Body

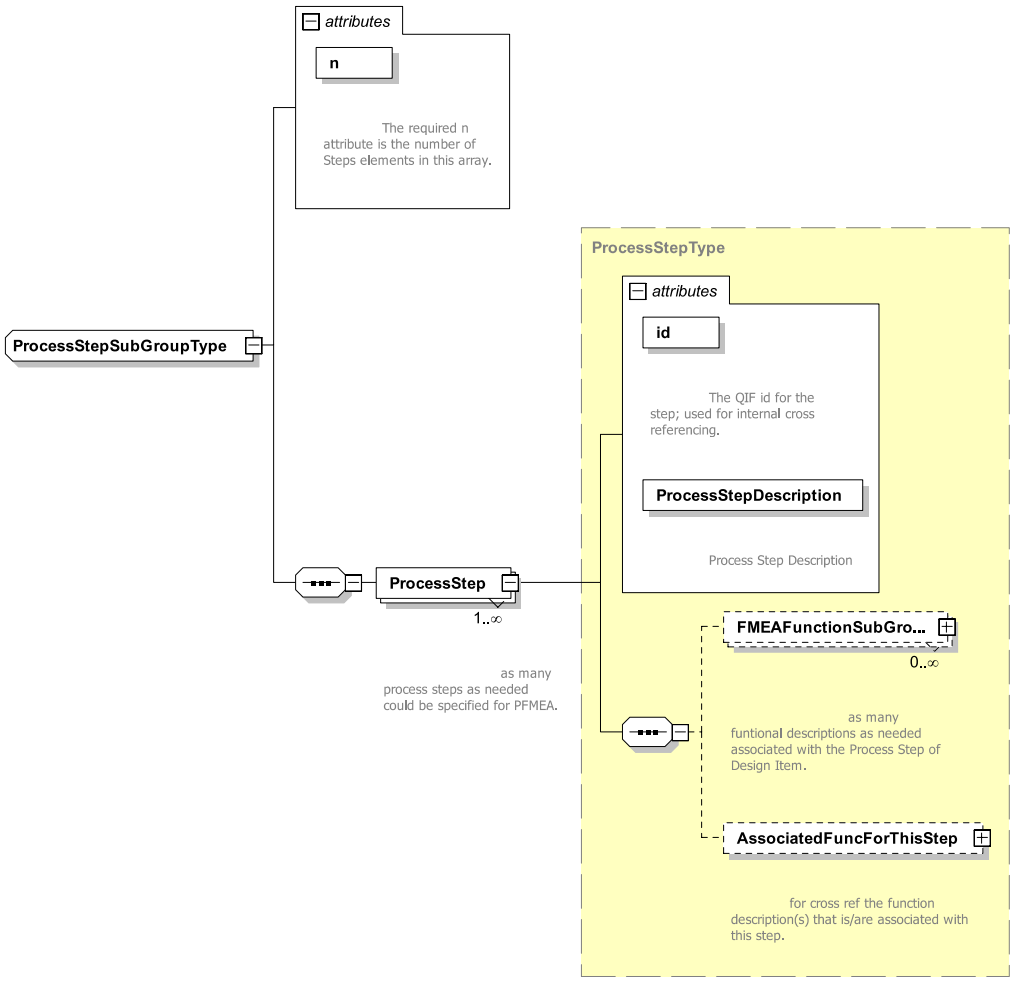


**Fig. 5.** Process Step Subgroup Sub Model, Allowing Analyzing Multiple Process Steps in PFMEA

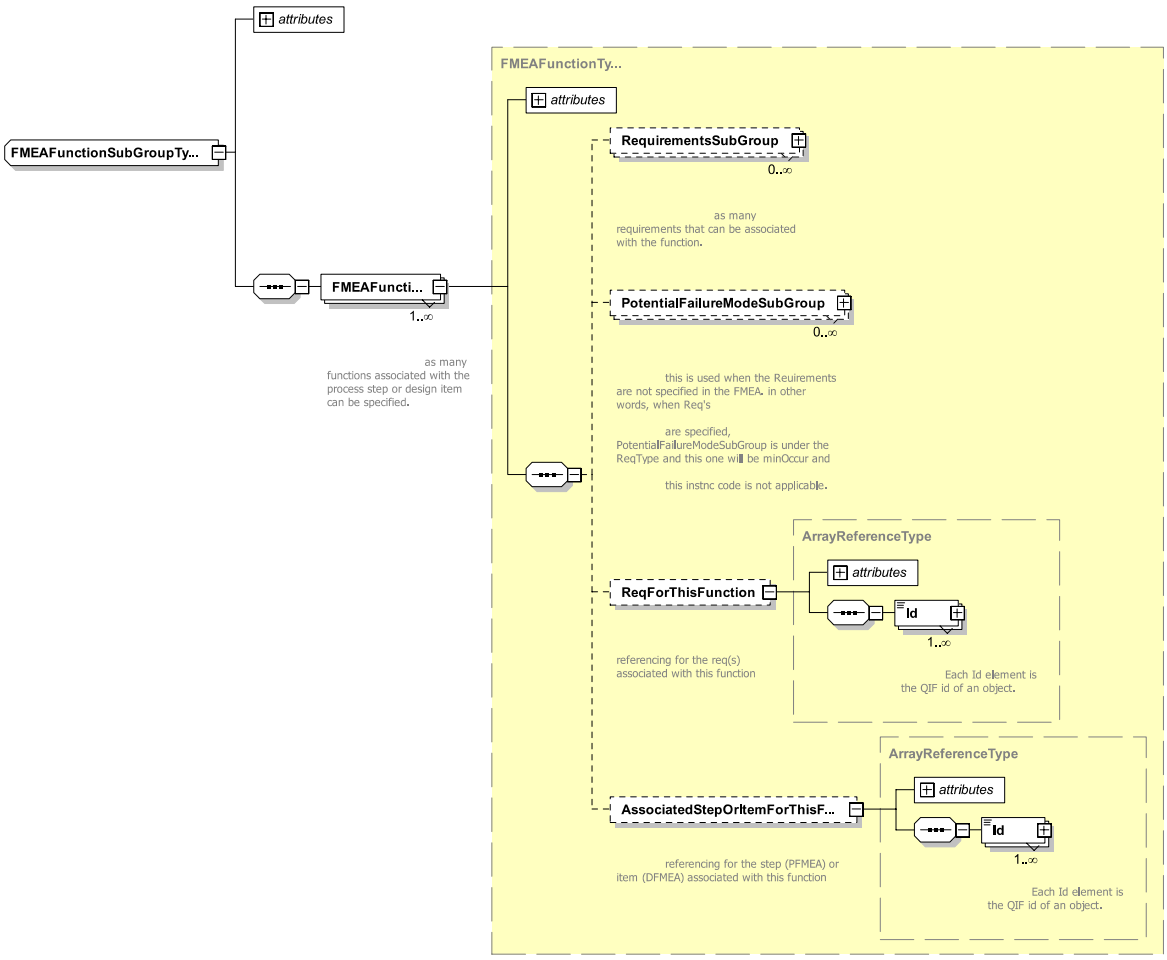


**Fig. 6.** Function Subgroup Sub Model, Allowing Analyzing Multiple Functions

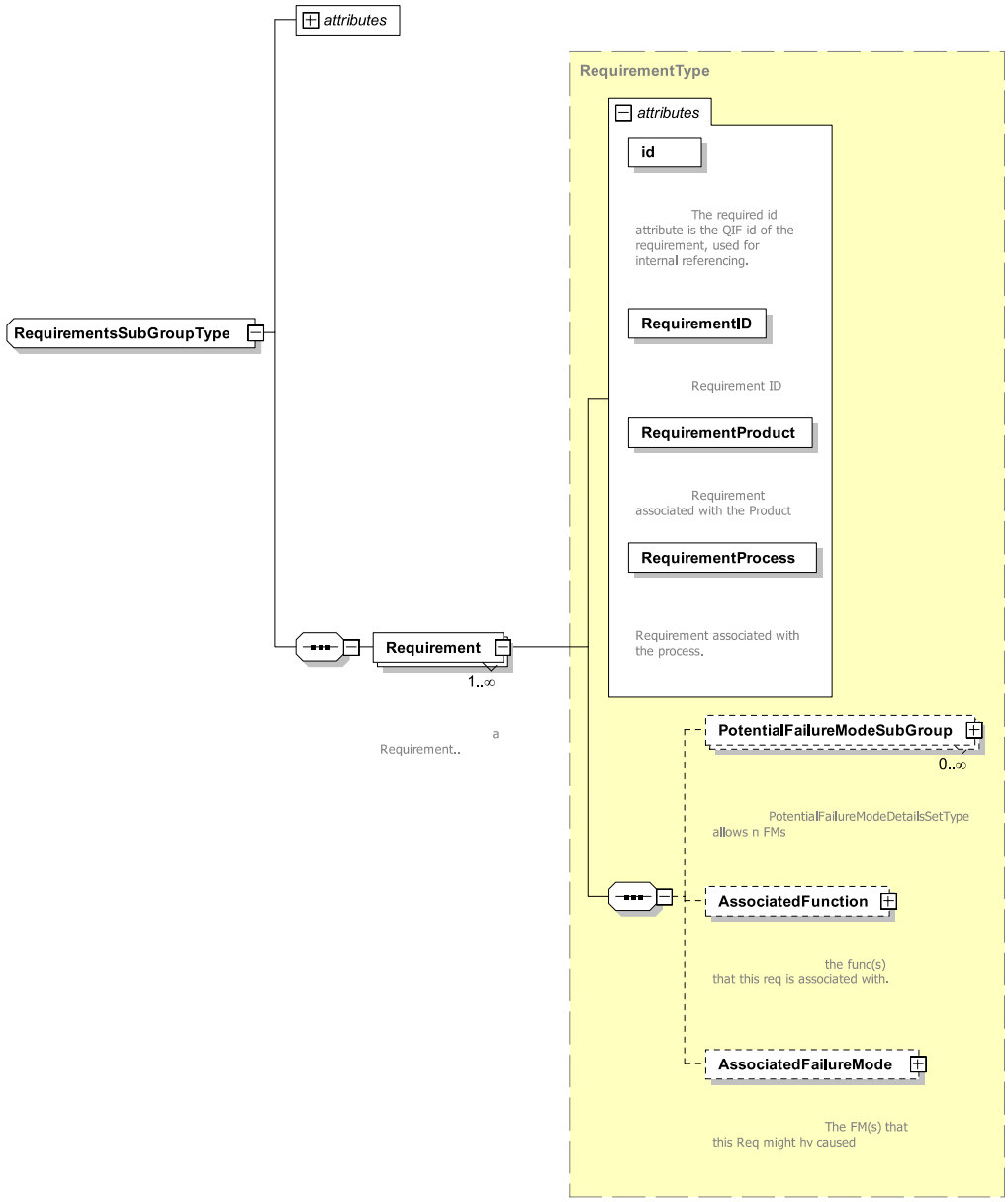


**Fig. 7.** Requirement Subset Sub-Model, Allowing Analyzing Multiple Requirements

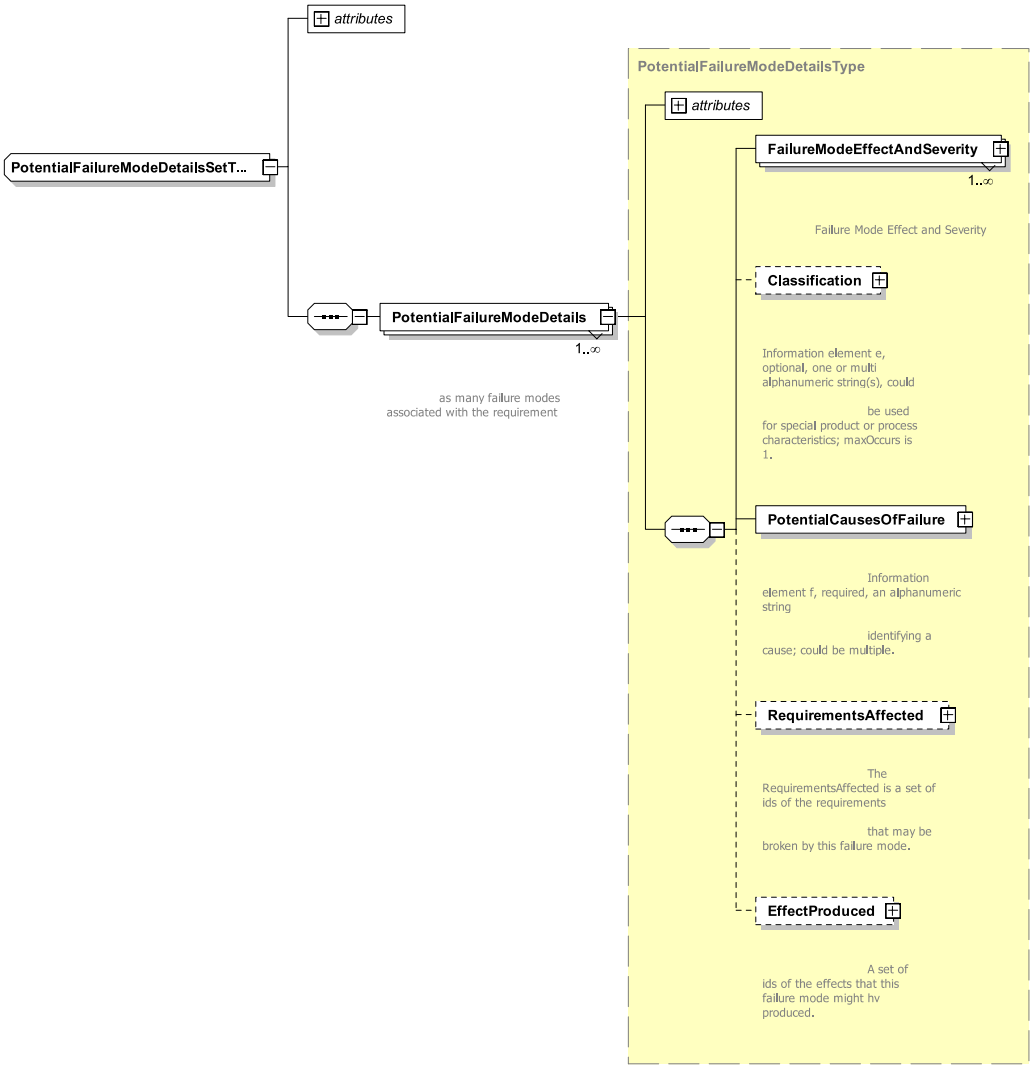


**Fig. 8.** Potential Failure Mode Sub Model

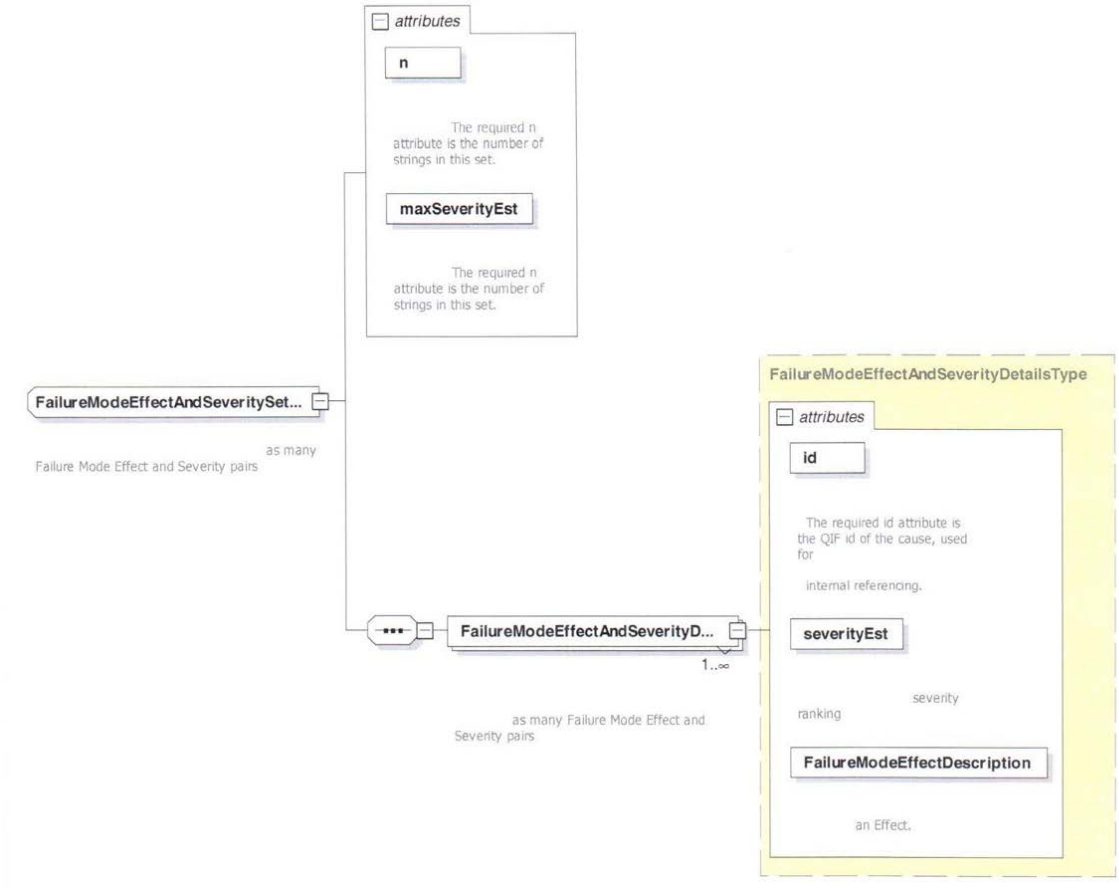


**Fig. 9.** Failure Mode Effects and Severity Sub Model: Parings and Highest Severity

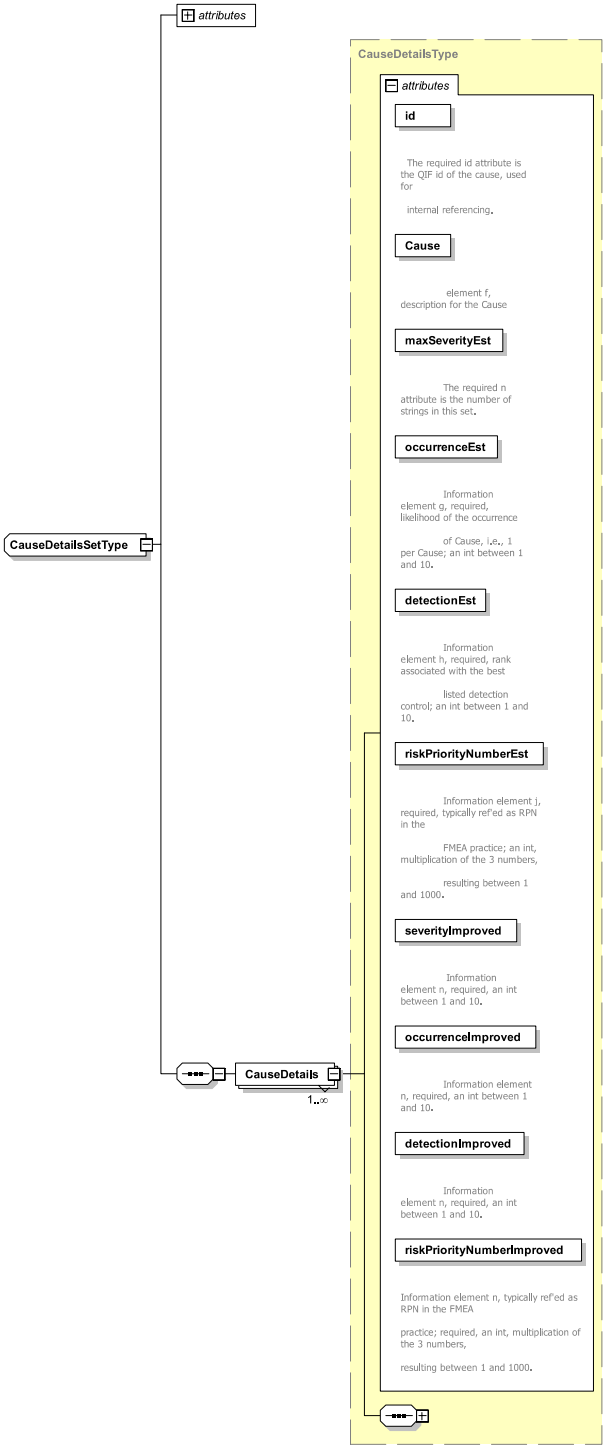


**Fig. 10.** Cause (for The Failure Modes) Sub Model

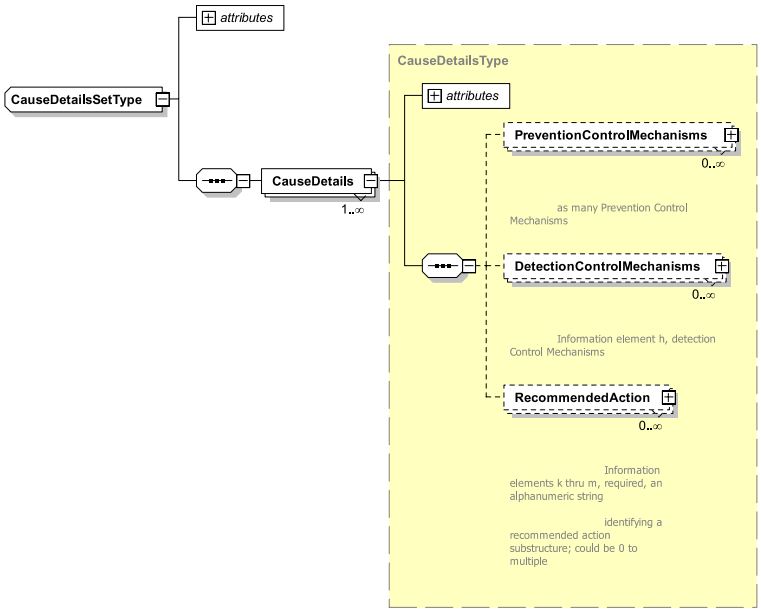


**Fig. 11.** Cause details

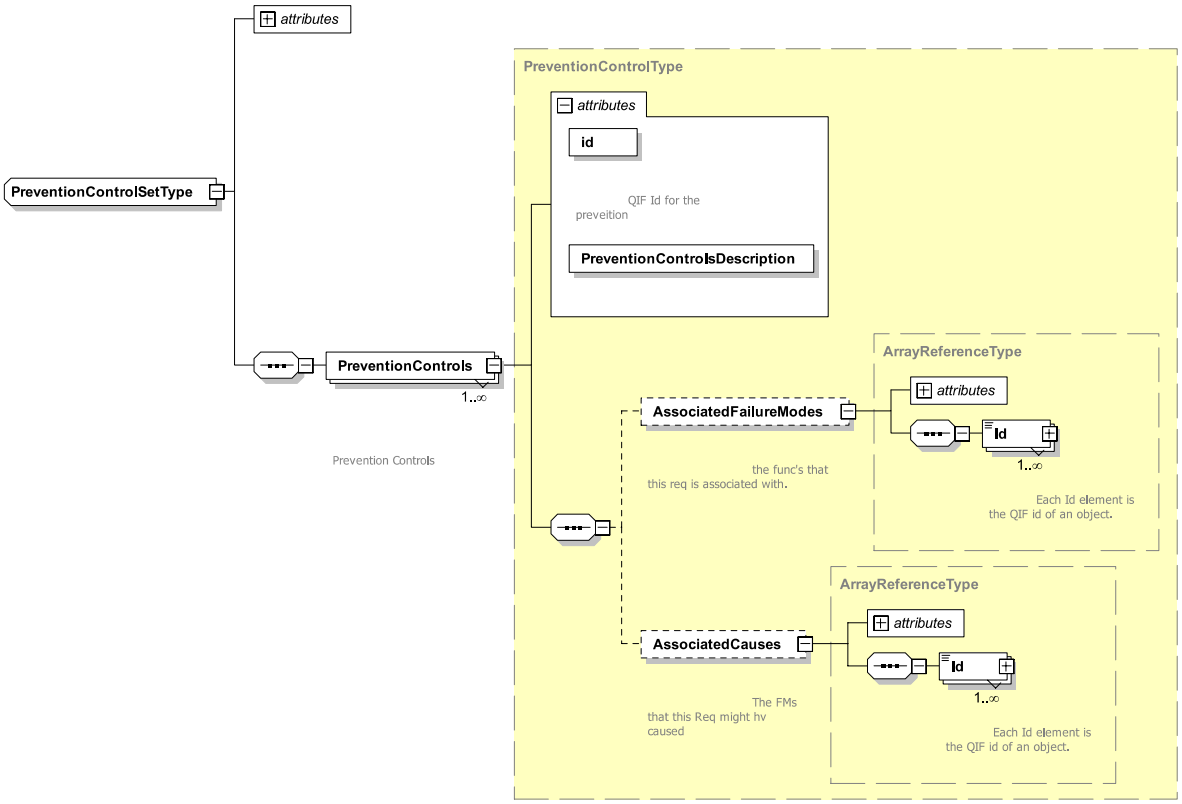


**Fig. 12.** Prevention Control Mechanism Sub Model (Detection Control Mechanism Sub Model Is Similar)

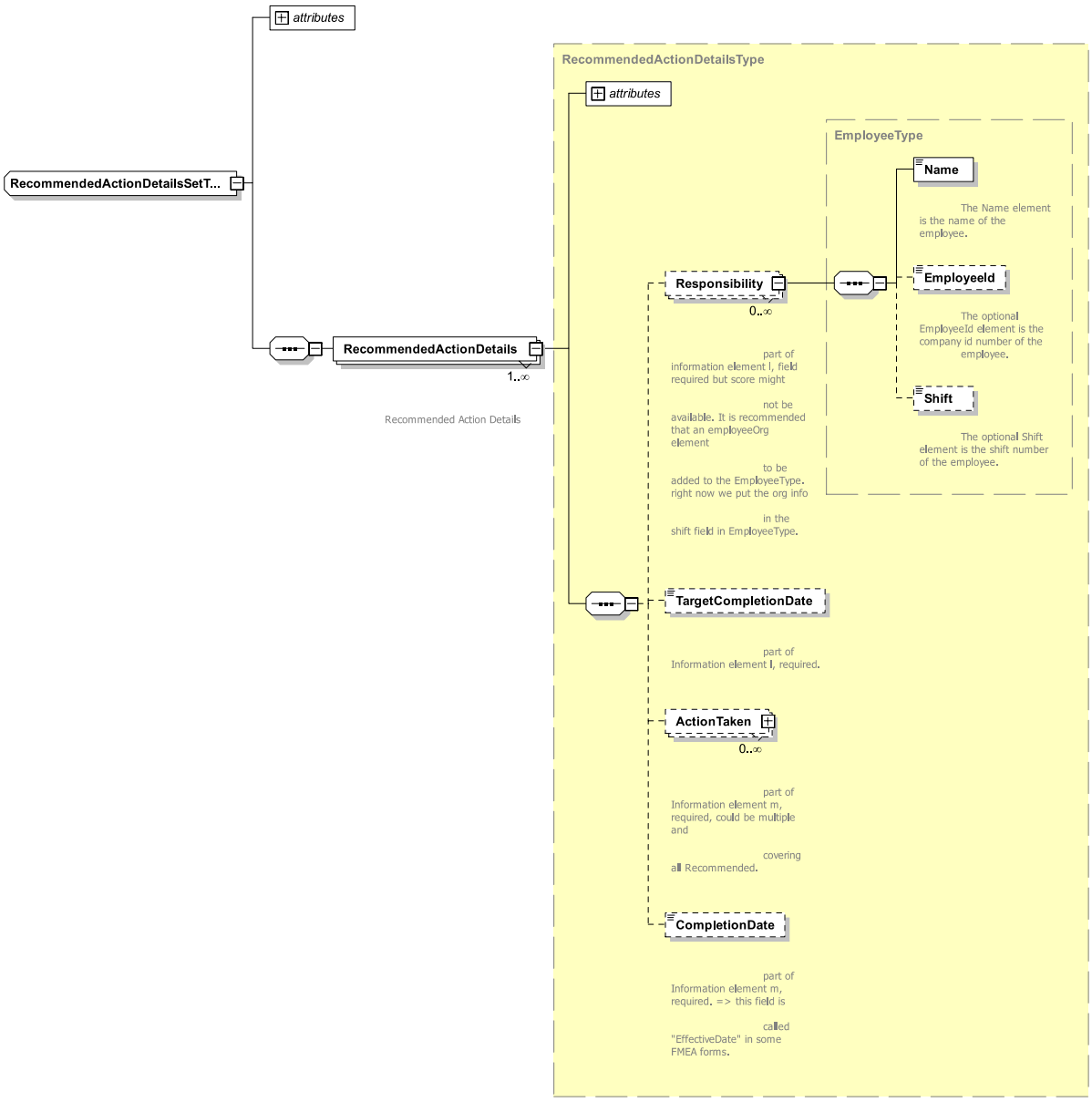


**Fig. 13.** Recommended Action Sub Model

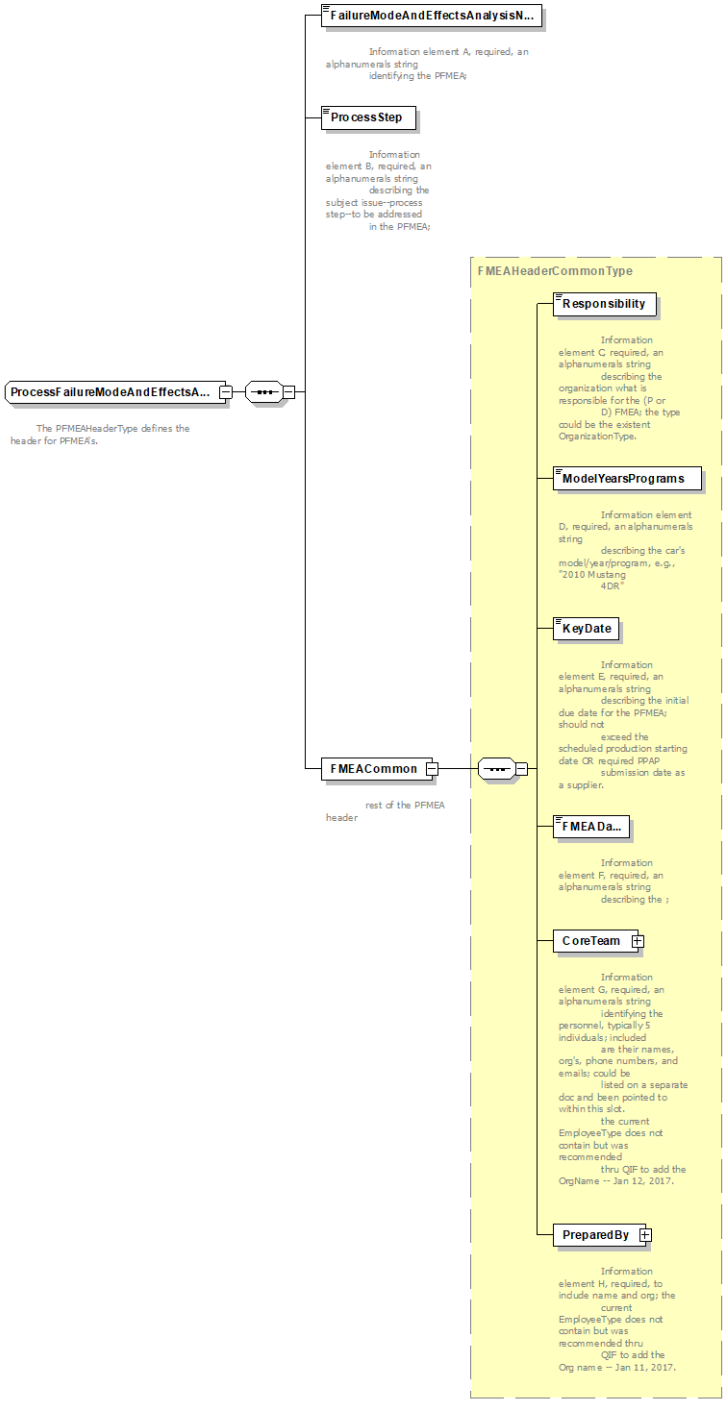


**Fig. 14.** PFMEA Header

## Appendix A: FMEA Illustrative Form – Body

| a1* | a2 | a3 | b | c | d | e | f | h | g | h | i | j | k | l | l | m | m | n | n | n | n |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Process Step (PFMEA) Item (DFMEA) | Function | Requirements | Potential Failure Mode | Potential Effect(s) of Failure | Severity (S) | Classification | Potential Cause(s) of Failure | Current Prevention Control | Occurrence (O) | Current Detection Control | Detection (D) | RPN | Recommended Action(s) | Responsibility | Target Completion Date | Action Taken | Effective/ Completion Date | Severity | Occurrence | Detection | RPN |
| | | | | | | | | | | | | | | | | | | | | | |
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* The alpha numerals on column are the Info element id's that AIAG specified. a3 becomes a2 when Item/Step and Function are in 1 column.

## Appendix B: FMEA Information Model: Form Variants Defined by AIAG

| PFMEA | Form A | Form B | Form C | Form D | Form E | Form F | Form G | | | Form H | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | | | | |
| element ID | element name | | | | | | | | | | | |
| | | | | | | | | | | | | |
| A | FMEA Number | *same from left* | *same from left* | *same from left* | *same from left* | *same from left* | *same from left* | | | *same from left* | | |
| B | Item | | | | | | | | | | | |
| C | Process Responsibility | | | | | | | | | | | |
| H | Prepared by | | | | | | | | | | | |
| D | Model Year(s)/Program(s) | | | | | | | | | | | |
| E | Key Date | | | | | | | | | | | |
| F | FMEA Date (orig) | | | | | | | | | | | |
| G | Core Team | | | | | | | | | | | |
| a1 | Process Step/function Requirements | Process Step/ function | Process Step/function Requirements | Process Step/ function | Process Step/ function | Process Step/ function | Process Step/ function | | | Process Step/ function | | |
| a2 | N/A | Requirements | N/A | Requirements | Requirements | Requirements | Requirements: ID (DFMEA does not breakdown) | Requirements: Product | Requirements: Process | Requirements: ID | Requirements: Product | Requirements: Process |
| b | Potential Failure Mode | *same from left* | | | | | | | | | | |
| c | Potential Effect(s) of Failure | | | | | | | | | | | |
| d | Severity (S) | | | | | | | | | | | |
| e | Classification | | | | | | | | | | | |
| f | Potential Cause(s) of Failure | | | | | | | | | | | |
| g | Occurrence (O) | | Current Process Control: Prevention | Current Process Control: Prevention | Occurrence (O) | Occurrence (O) | Occurrence (O) | | | Current Process Control: Prevention | | |
| h | Current Process Control: Prevention | | Occurrence (O) | Occurrence (O) | Occurrence (O) | Current Process Control: Prevention | Current Process Control: Prevendon | | | Occurrence (O) | | |
| h | Current Process Control: Detection | | | | Current Detection Process Controls | Current Process Control: Detection | Current Process Control: Detection | | | Current Process Control: Detection | | |
| | | | | | Cause | Failure Mode | | | | | | |
| i | Detection (D) | | | | | | | | | | | |
| j | RPN | | | | | | | | | | | |
| k | Recommended Action(s) | | | | | | | | | | | |
| l | Responsibility, Target Completion Date | | | | | Responsibility | Responsibility, Target Completion Date | | | Responsibility, Target Completion Date | | |
| | | | | | | Target Completion Date | | | | | | |
| m | Action Taken, Completion/ Effective Date | | | | | Action Taken | Action Taken, Completion/Effective Date | | | Action Taken, Completion/Effective Date | | |
| | | | | | | Effective Date | | | | | | |
| n | Severity (Improved) | | | | | | | | | | | |
| n | Occurrence (Improved) | | | | | | | | | | | |
| n | Detection (Improved) | | | | | | | | | | | |
| n | RPN (Improved) | | | | | | | | | | | |

| info element (based on PFMEA, column A) | element name | | | | | | element ID |
|---|---|---|---|---|---|---|---|
| | FMEA Number | *same from left* | *same from left* | *same from left* | *same from left* | *same from left* | A |
| | System | | | | | | B(1) |
| | Subsystem | | | | | | B(2) |
| | Component | | | | | | B(3) |
| | Design Responsibility | | | | | | C |
| Prepared by | *same from left* | | | | | | H |
| Model Year(s)/Program(s) | | | | | | | D |
| Key Date | | | | | | | E |
| FMEA Date (org) | | | | | | | F |
| Core Team | | | | | | | G |
| Item/Function Requirements | | Item/Function | Item/Function Requirements | Item/Function | *same from left* | *same from left* | a1 (a1 & a2 when Step and Function are in 2 columns) |
| N/A | N/A | Requirements | N/A | Requirements | | | a2 (a3 when Item and Function are in 2 columns) |
| Potential Failure Mode | | | | | | | b |
| Potential Effect(s) of Failure | | | | | | | c |
| Severity (S) | | | | | | | d |
| Classification | | | | | | | e |
| Potential Cause(s) of Failure | | | | | | | f |
| Occurrence (O) | | | Current Design Control: Prevention | Current Design Control: Prevention | Current Design Control: Prevention | Occurrence (O) | h |
| Current Design Control: Prevention | | | Occurrence (O) | Occurrence (O) | Occurrence (O) | Current Design Control: Prevention | g |
| Current Design Control: Detection | | | | | Current Detection Design Controls<br>Cause / Failure Mode | Current Design Control: Detection | h |
| Detection (D) | | | | | | | i |
| RPN | | | | | | | j |
| Recommended Action(s) | | | | | | | k |
| Responsibility, Target Completion Date | | | | | | Responsibility<br>Target Completion Date | l |
| Action Taken, Effective Date | | | | | | Action Taken<br>Effective Date | m |
| Severity | | | | | | | n |
| Occurrence | | | | | | | n |
| Detection | | | | | | | n |
| RPN | | | | | | | n |

## Appendix C: FMEA Information Model Detailed Elements

**Table 1.** FMEA Information Elements-1

| FMEA INFORMATION REQUIREMENTS AND MODELS | | | |
|---|---|---|---|
| General notes for FMEA:<br>1) Column B lists the information elements that make up the form and column A has the respective ID's as used by AIAG. A FMEA form is composed of two parts: header and body.<br>2) The order of the columns in the body could be modified and additional columns could be added as per agreed to by the involved parties for a FMEA (AIAG PPAP manual, p. 75).<br>3) It is a general principle that all the elements within the FMEA, such as failure mode definitions, effects, the involved numerical rankings, severity, occurrence, and detection, are set up consistently by the organization.<br>4) One way of implementing FMEA would be for individual FMEA forms as QIFDocument instances; QPIds could potentially be used to formally relate. This referencing should be particularly helpful as the training class stated that reuse (as is or expand on) existent FMEA's, whenever applicable, is preferred over creating new ones.<br>5) Note: the AIAG training class: rigorously practiced in automotive industry; Tier 2 supplier has to be certified in order to manufacture for Tier 1; Tier 1 to OEM likewise. it is often to supplier's advantage to conduct FMEA to find out the issues and figure them in the costs as the buyers might not know or be forthcoming in providing such potential failure mode info. | | | |
| **ID** | **PFMEA info element** | *** Info model type (XSD, QIF, or FMEA defined),**<br>*** Relationships (< as partOf, : as typeOf)**<br>*** # of items** | **Element Description/Notes** |
| **Section 1: Form Header** | | | |
| A | **FMEA Number** | string (text/XSD), 1 | for cross referencing, document control, etc. |
| B | **Item**<br>(PFMEA)<br>[Note 1] | string (text/XSD), 1 | * "the name and number of the system, subsystem, or component for which the process is being analyzed." [2, p.75 ]; also see elements B1/B2/B3 for DFMEA below.<br>* Item is also used for element "a" in DFMEA Body. |
| B1 | **System**<br>(DFMEA) | | the id of the system undergoing the FMEA |
| B2 | **Subsystem**<br>(DFMEA) | | the id of the subsystem undergoing the FMEA |
| B3 | **Component**<br>(DFMEA) | | the id of the component undergoing the FMEA |

**Table 2.** FMEA Information Elements-2

| | | | |
|---|---|---|---|
| C | **Responsibility** | * EmployeeType (QIF), 0 - unbounded<br>* note: Type to be expanded to add Org. name. | the organization that is responsible for the subject FMEA |
| D | **Model Year(s)/ Program(s)** | string (text/XSD), 1 | tailored for automotive |
| E | **Key Date** | dateTime (XSD), 1 | "the initial PFMEA due date; should not exceed the scheduled start of production date for a manufacturer and the customer required PPAP submission date for a supplier."<br><br>"the initial DFMEA due date; should not exceed the scheduled production design release date." |
| F | **FMEA Date** | dateTime (XSD), 1 | "the date the original FMEA was completed and the latest revision date" |
| G | **Core Team** | CoreTeam : CoreTeamEmployeeSetType (FMEA) : EmployeeType (QIF), 1 thru 5<br><br>Note: EmployeeType to be expanded to add Org. name. | who will be conducting the FMEA<br><br>Note that the AIAG training manual states that typically 5 people from diff areas, one of them is responsible for filling out the form. |
| H | **Prepared by** | EmployeeType (QIF), 1<br><br>note: Type to be expanded to add Org. name. | see Core Team above |
| **Section 2: Form Body--Form Columns** | | | |
| a1 | **Process Step** (PFMEA) | ProcessStepDescription (string/XSD) > ProcessStepType > ProcessStepSubGroupType, (FMEA), 1 - unbounded | "...the ID or operation being analyzed..." Typically, the organization has established names, IDs, etc., that are used for the manufacturing processes. The PFMEA should use the same identifications.<br><br>Can be combined with Process Function (next element) in a FMEA form. |

**Table 3.** FMEA Information Elements-3

| | | | |
|---|---|---|---|
| a1 | **Item**<br>(DFMEA)<br>[Note 2] | ItemDescription (string/XSD) > ItemType (FMEA) > ItemSubGroupType (FMEA),<br>1 - unbounded | the same approach, as described in PFMEA, should be used here;<br><br>[Note 2]: Item is also used for element "B" in PFMEA Header. |
| a2 | **Function** | FMEAFunctionDescription (string/XSD) > FMEAFunctionType (FMEA) > FMEAFunctionSubGroupType, (FMEA),<br>1 - unbounded | The function(s) are used to describes what the subject FEMA item is for.<br>It is anticipated that only the high risk issues are selected for the FMEA studies.<br><br>Can be combined with PFMEA Process Step or DFMEA Item (previous element) in a FMEA form. |
| a2/ a3 | **Requirements** | RequirementID/ RequirementProduct/ RequirementProcess (string/XSD) > RequirementType (FMEA) > RequirementsSubGroupType (FMEA):<br>0 - unbounded | * The Process or Design are intended to meet the stated requirements. Potential failure modes are anticipated to be resulted (with an estimated occurring likelihood, see below) when the requirements are violated. Therefore, individual failure modes and requirements clearly correspond.<br>* In the AIAG scheme, this column in DFMEA becomes a3 when Item and Function are split as a1 and a2.<br>* [Note 3]: This column becomes a3 when Item/Step and Function are in 2 columns. |
| b | **Potential Failure Mode** | PotentialFailureModeDescription (string/XSD) > PotentialFailureModeDetailsType (FMEA) > PotentialFailureModeDetailsSetType (FMEA),<br>1 - unbounded | * See the Requirements row above.<br>* The AIAG documents stated to assume that the Design is correct when preparing the PFMEA.<br>* The AIAG documents further stated that each requirement may have multiple failure modes. A large number of failure modes identified for a single requirement usually indicates that the requirement(s), item, or function(s) is/are not well defined, such as too complex and not well decomposed.<br><br>See Table IV.2 in AIAG's PPAP FMEA document for examples of Process Step/ Function/ Requirements/ Potential failure modes or Table III.3 for design failure modes. |

**Table 4.** FMEA Information Elements-4

| | | | |
|---|---|---|---|
| c | **Potential Effect(s) of Failure** | FailureModeEffectDescription : string (text/XSD) > FailureModeEffectAndSeverityDetailsType (FMEA) > FailureModeEffectAndSeveritySetType (FMEA),<br>1 - unbounded | * The AIAG documents emphasized that the effects are what the customer(s) might notice and/or experience that do(es) not meet the requirement(s). There is a severity level for an effect that is to be estimated within the FMEA (see below).<br><br>* See Table IV.3 in AIAG's PPAP FMEA document for examples of the effects.<br>* See the corresponding paragraphs in Chapter IV of the AIAG's PPAP FMEA document for further elaborations. |
| d | **Severity (S)** | severityEst : ScoreType (FMEA, value 1-10) > FailureModeEffectAndSeverityDetailsType (FMEA) > FailureModeEffectAndSeveritySetType (FMEA) | * See the consistent scales as stated in the aforementioned general principles.<br>* Used to produce a combined risk priority number (RPN), below.<br>* Table Cr1 in AIAG's PPAP FMEA (Chapters III and IV, respectively) suggested guidelines; recommend to retain Levels 9 & 10 criteria, "failure to meet safety and/or regulatory requirements." |
| e | **Classification** | stringSetType (FMEA),<br>0 - 1 | * This is, generally, used to identify a special characteristics in the manufacturing process or product definition may require additional analysis under the FMEA. |
| f | **Potential Cause(s) of Failure** | Cause (test/XSD) > CauseDetailsType (FMEA) > CauseDetailsSetType (FMEA),<br>(1 - n) Causes per failure mode | * Used to indicate how the requirement(s) is/are violated and results in the failure mode(s); these the identified cause(s) are to be further analyzed for detection/ correction/ control in order to reduce risks and improve quality.<br>* See Table III.5 and Table IV.4 in AIAG's PPAP FMEA document for examples. |
| h | **Current Prevention Control** | PreventionControlsDescriptions > string (text/XSD), PreventionControlType (FMEA)> PreventionControlSetType (FMEA),<br>(0 - n) Controls per Cause | Used to identify the mechanism(s) that is/are to be put in place to prevent the failure mode cause(s) from happening. |
| g | **Occurrence (O)** | occurrenceEst : ScoreType (FMEA, value 1-10),<br>1 per Cause | * A numerical value used to indicate the estimated possibility that a cause will occur.<br>* Used to produce a combined risk priority number (RPN), below.<br>* Note the consistency principle as aforementioned.<br>* See PPAP Table Cr2 in Chapter III & IV, for suggested respective DFMEA and PFMEA occurrence evaluation criteria. |

**Table 5.** FMEA Information Elements-5

| | | | |
|---|---|---|---|
| h | **Current Detection Control** | DetectionControlsDescriptions > string (text/XSD), DetectionControlType (FMEA)> DetectionControlSetType (FMEA),<br>(0 - n) Controls per Cause | Used to identify the mechanism(s) that is/are to be put in place to detect the happening of the failure mode cause(s). |
| i | **Detection (D)** | detectionEst : ScoreType (FMEA, value 1-10),<br>1 per Cause | * A numerical value used to indicate the effectiveness of the listed detection control methods as listed.<br>* Used to produce a combined risk priority number (RPN), below.<br>* Note, the lower, the more effective; use the lowest ranking value for the FMEA study.<br>* See PPAP Table Cr3 (Chapters III & IV, respectively) for suggested the detection evaluation criteria. |
| j | **RPN** | riskPriorityNumberEst : ScoreType (FMEA, value 1-1000),<br>1 | * Def: Risk Priority Number: RPN = Severity (S) x Occurrence (O) x Detection (D).<br>* Note that the high individual values in S, O, or D and not the combined RPN should determine the priorities of actions to be taken (see line #k below). |
| k | **Recommended Action(s)** | RecommendedActionDescription ((text/XSD) > RecommendedActionDetailsType (FMEA) > RecommendedActionDetailsSetType (FMEA),<br>(0 - unbounded) per Cause | The following are the general preferences/priorities in terms of devising recommended actions:<br>* Preventive actions are preferable to detective ones.<br>* The following are the order of priorities: severity, occurrence, and detection.<br>* Proven effective design or process revision(s) may be issued for the purposes.<br>* Note: it is possible that a DFMEA failure mode be transferred and covered in PFMEA (AIAG manual, p22). |
| l | **Responsibility** | EmployeeType (QIF),<br>(0 - unbounded) per Cause | Individual(s) and org(s) responsible for the recommended action(s). |
| l | **Target Completion Date** | dateTime (XSD),<br>(0 - unbounded) per Cause | For each recommended action(s) along with the target completion date. |
| m | **Action Taken** | StringSetType (FMEA)<br>(0 - unbounded) per Cause | the actual action(s) taken. |
| m | **Effective/ Completion Date** | dateTime (XSD),<br>(0 - unbounded) per Cause | Completion date(s) for the aforementioned action(s) taken. |

**Table 6.** FMEA Information Elements-6

| | | | |
|---|---|---|---|
| n | **Severity** | ScoreType (FMEA, value 1-10),<br>1 per Cause, | the reassessed value after all the aforementioned have taken place. Note that even a lower score does not mean that the cause(s) were eliminated and repeated FMEA might be necessary. |
| n | **Occurrence** | ScoreType (FMEA, value 1-10),<br>1 per Cause, | see the Severity line above |
| n | **Detection** | ScoreType (FMEA, value 1-10),<br>1 per Cause, | see the Severity line above |
| n | **RPN** | RiskPriorityNumberType (FMEA, value 1-1000),<br>1 per Cause, | see the Severity line above |

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