Failure Mode Effect Analysis (FMEA) Schema Extension Users Guide

Vitech

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Intermediate	**Student**

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1. PURPOSE

The Failure Mode Effect Analysis Schema extension was developed to support failure mode analysis of system design models. As a part of many system design processes the design team is tasked with conducting a failure mode effects analysis (FMEA). The basic FMEA process examines design entities and evaluates the system architecture to identify ways in which the system fails to meet designed performance. For example, failure of a fuse in a control circuit would cause inoperability of the system. System failures can occur because of the failure of component in the physical architecture, failure of function to properly execute, failure of an interface and/or link, or failure to meet a requirement. Accordingly, a failure mode can be associated with than one entity in an architecture. And, the failure can be created by one or more causes.

When a failure mode and failure cause pair meets a threshold (as defined by the program), then a **Failure Reduction** effort is taken to minimize the Hazard and Risk to system operation. Therefore, one more schema class is added to account for **Failure Reduction** actions.

To meet this situation, the schema is extended by adding new classes to identify **Failure Mode**, **Failure Cause**, and **Failure Reduction** as shown in the following diagram.

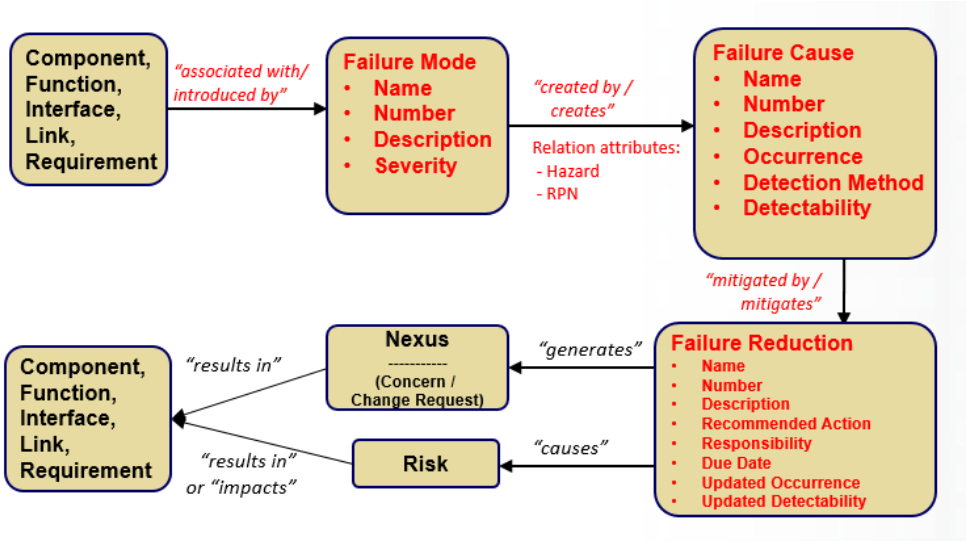

Figure 1. Overall FMEA Schema Extension

In design processes that require a failure reduction analysis, the design team is required to document the analysis and, in some cases, provide specific documentation and traceability to system entities. The schema extension also provides additional report queries to provide Excel spreadsheets reporting the result of FMEA on the system design.

2. DETAILS OF SCHEMA EXTENSION

List of Schema Changes from Base Schema

- Added New relation pairs:
  - introduced by / associated with – associated with identifies the Failure Mode that a design element introduces
    - **Component, Function, Interface, Link, Requirement** associated with **Failure Mode**
    - **Failure Mode** introduced by **Component, Function, Interface, Link, Requirement**
  - created by / creates – created by identifies the Failure Cause by which a Failure Mode is introduced.
    - **Failure Mode** created by **Failure Cause**
    - **Failure Cause** creates **Failure Mode**
      - Relation Attributes:
        - Hazard – the product of severity and occurrence rate
        - RPN – Risk Priority Number: the product of severity, occurrence, and detectability
  - mitigated by / mitigates – mitigated by identifies actions taken to reduce a Failure Cause
    - **Failure Cause** mitigated by **Failure Reduction**
    - **Failure Reduction** mitigates **Failure Cause**
- Added New class:
  - **FailureMode**
    - *Attributes:*
      - Name
      - Number
      - Description
      - Severity
      - Severity Rank
    - *Relations:*
      - augmented by with target class **ExternalFile**, **Text**
      - categorized by with target class **Category**
      - created by with target class **FailureCause**
      - documented by with target class **Document**
      - introduced by with target classes **Component, Function, Interface, Link, Requirement**
      - packaged by with target class **Package**
  - **FailureCause**
    - *Attributes:*
      - Name
      - Number
      - Description
      - Occurrence
      - Occurrence Rank
      - Method / Control
      - Detectability
      - Detectability Rank
    - *Relations:*
      - augmented by with target class **ExternalFile**, **Text**
      - categorized by with target class **Category**
      - creates with target class **FailureMode**
      - documented by with target class **Document**
      - mitigated by with target class **FailureReduction**
      - packaged by with target class **Package**

- **Failure Reduction**
  - Attributes
    - Name
    - Number
    - Description
    - Recommended Action
    - Responsibility
    - Due Date
    - Updated Occurrence
    - Updated Detectability
  - *Relations:*
    - augmented by with target class **ExternalFile**, **Text**
    - categorized by with target class **Category**
    - causes with target class **Risk**
    - documented by with target class **Document**
    - generates with target class **ChangeRequestPackage** and **Concern**
    - mitigates with target class **FailureCause**
    - packaged by with target class **Package**

- Class changes:
  - Category
    - Added target classes **FailureMode, FailureCause,** and **FailureReduction** to categorizes relationship
  - Change Request Package
    - Added target class **FailureReduction** to generated by relation
  - Component
    - Added relation associated with and target class **FailureMode**
  - Concern
    - Added target class **FailureReduction** to generated by relation
  - Document
    - Added target class **FailureMode, FailureCause,** and **FailureReduction** to documents relationship
  - ExternalFile
    - Added target class **FailureMode, FailureCause,** and **FailureReduction** to augments relationship
  - Function
    - Added relation associated with and target class **FailureMode**
  - Interface
    - Added relation associated with and target class **FailureMode**
  - Link
    - Added relation associated with and target class **FailureMode**
  - Package
    - Added target class **FailureMode, FailureCause,** and **FailureReduction** to packages relationship
  - ProgramActivity
    - Added compliance with relation with target class **Standard**
  - Requirement
    - Added relation associated with and target class **FailureMode**
  - Risk
    - Added target class **FailureReduction** to caused by relation
  - Text
    - Added target class **FailureMode, FailureCause,** and **FailureReduction** to augments relationship

3. FAILURE MODE FACILITY

The schema extension includes a unique facility named “Failure Mode Analysis”. This facility is designed to provide a focused view of the underling schema for specialist performing FMEA activities.

List of Classes in the FMEA Facility includes:

- Category
- Change Request Package
- Component
- Concern
- Document
- External File
- Failure Cause
- Failure Mode
- Failure Reduction
- Function
- Interface
- Item
- Link
- Requirement
- Risk
- Text
- Verification Requirement

4. HIERARCHY DEFINITION

A unique hierarchy definition is provided as part of the schema extension. A hierarchy named “Failure Reduction Hierarchy” is provided to show traceability from a Failure Reduction entity to the Risk, Concern, or Change Request associated with the Failure Reduction entity and then to the system model entity (Component, Function, Interface, Link, and/or Requirement). The hierarchy definition is shown in the following diagram.

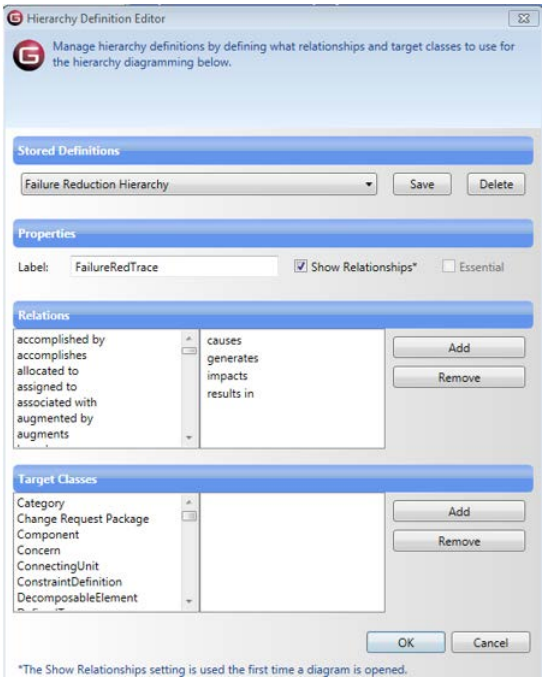

Figure 2 Failure Reduction Hierarchy

5. TABLE DEFINITIONS

FMEA analysis is generally documented by a table showing the system design entities with attributes from the associated failure mode, failure cause, and failure reduction. This schema extension provides customized table definitions in the excel extension to report on the FMEA analysis.

There are three report tables provided in the Schema Extension: FMEA Basic Report, FMEA Extended Report, and FMEA Extended Report with Rec Action.

The FMEA Basic Report provides for a basic table listing Failure, Failure Description, Severity, Cause of Failure, Occurrence, Detection Method, and Detectability. The table definition is shown in the following diagram.

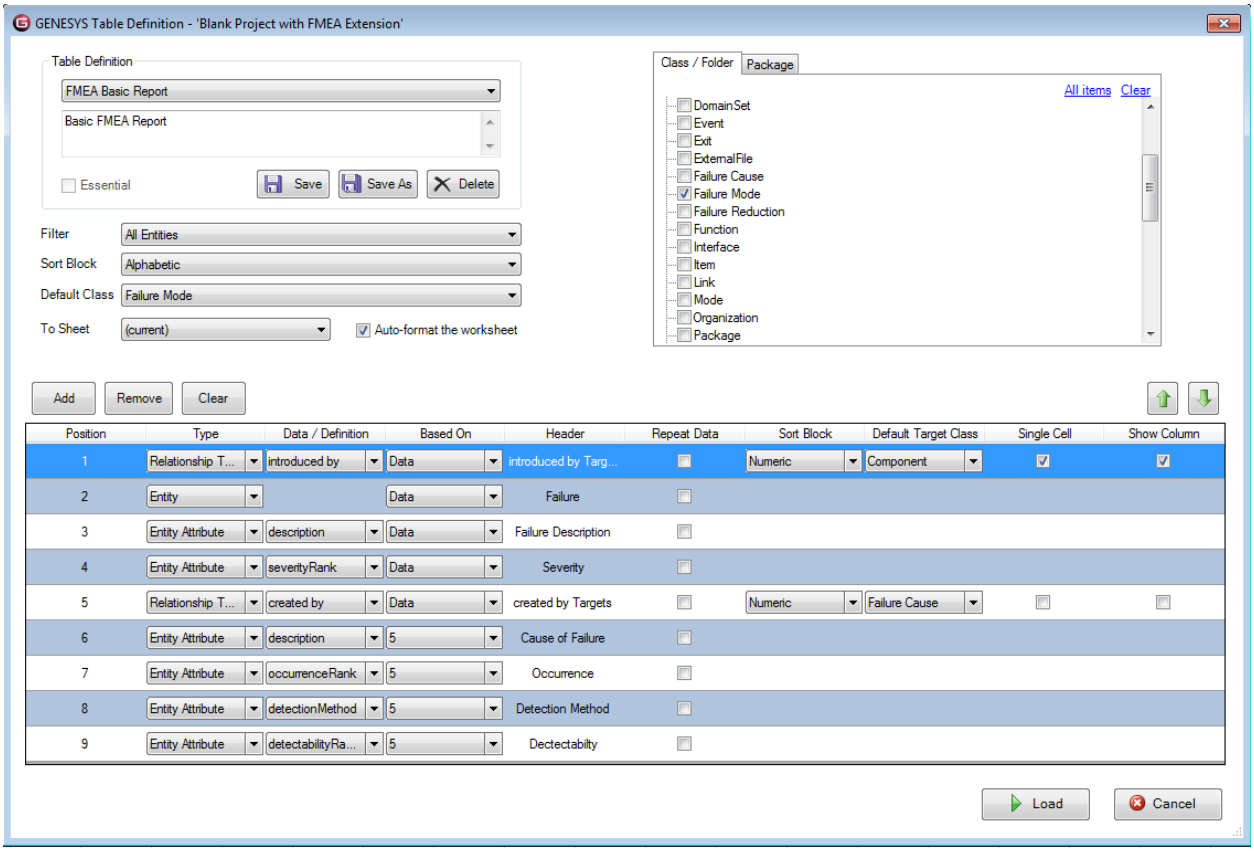

Figure 3 FMEA Basic Report

When executed and formatted in Excel, the results of this table will look similar to the following example.

System Element	Failure	Failure Description	Severity	Cause of Failure	Occurrence	Detection Method	Dectectabilty
Cooling Motor and Fan Assembly	Fan Vibration and Interference	Audible Noise, vibration; increased motor wear.	5	Fan Center of Gravity off axix of rotation causing 2-plan imbalance.	5	Design calls for lightweight fan with minimum band mass, part thickness.	4
Cooling Motor and Fan Assembly	Misalignment of Fan and Shroud	Fan and shroud mis-aligned cause reduction or complete loss of	7	Fan contacts shroud, noise or motor burnout.	2	Designed for easy assembly and alignment.	3
Cooling Motor and Fan Assembly	Motor Burnout	Motor Burnout causes loss of cooling to the system.	5	Overheating of motor assembly due to lack of air circulation around motor.	2	Vent holes in motor casing, fins in fan hub pull air throught motor body.	5
Cooling Motor and Fan Assembly	Reduced Fan Efficiency	Fan motor is assembled 120 degrees off nominal angle causes reduction of cooling effectiveness.	6	Symmetrical spacing of screw holes allows for non-unique mounting of fan motor.	7	Cuurent design requires visual verification of assembly.	7
				Misassebly of Fan and Motor causes pinched wire.	7	Visual Inspection of Fan and Motor assembly.	6

Figure 4 FMEA Basic Report Example

The FMEA Extended Report expands the basic table to include columns in the table for Hazard Value and Risk Priority Number (or RPN). Hazard Value and RPN are relation attribute values on the "created by / creates" relation. The table definition is provided in the following diagram.

Position	Type	Data / Definition	Based On	Header	Repeat Data	Sort Block	Default Target Class	Single Cell	Show Column
1	Relationship Ta...	introduced by	Data	System Element	☐	Numeric	Component	☑	☑
2	Entity		Data	Failure	☐				
3	Entity Attribute	description	Data	Failure Description	☐				
4	Entity Attribute	severityRank	Data	Severity	☐				
5	Relationship Ta...	created by	Data	created by Targets	☐	Numeric	Failure Cause	☐	☐
6	Entity Attribute	description	5	Cause of Failure	☐				
7	Entity Attribute	occurrenceRank	5	Occurrence	☐				
8	Entity Attribute	detectionMethod	5	Detection Method	☐				
9	Entity Attribute	detectabilityRank	5	Dectectabilty	☐				
10	Relationship	created by	Data	created by Targets	☐	Alphabetic	Category	☐	☐
11	Relationship Att...	hazardValue	10	Criticality	☐				
12	Relationship Att...	riskPriorityNumber	10	RPN	☐				

Figure 5 FMEA Extended Report definition

When executed and formatted in Excel, this table report will provide the following information.

System Element	Failure	Failure Description	Severity	Cause of Failure	Occurrence	Detection Method	Dectectability	Criticality	RPN
Cooling Motor and Fan Assembly	Fan Vibration and Interference	Audible Noise, vibration; increased motor wear.	5	Fan Center of Gravity off axix of rotation causing 2-plan imbalance.	5	Design calls for lightweight fan with minimum band mass, part thickness.	4	25	100
Cooling Motor and Fan Assembly	Misalignment of Fan and Shroud	Fan and shroud mis-aligned cause reduction or complete loss of cooling.	7	Fan contacts shroud, noise or motor burnout.	2	Designed for easy assembly and alignment.	3	14	42
Cooling Motor and Fan Assembly	Motor Burnout	Motor Burnout causes loss of cooling to the system.	5	Overheating of motor assembly due to lack of air circulation around motor.	2	Vent holes in motor casing, fins in fan hub pull air throught motor body.	5	10	50
Cooling Motor and Fan Assembly	Reduced Fan Efficiency	Fan motor is assembled 120 degrees off nominal angle causes reduction of cooling effectiveness.	6	Symmetrical spacing of screw holes allows for non-unique mounting of fan motor.	7	Cuurent design requires visual verification of assembly.	7	42	294
				Misassebly of Fan and Motor causes pinched wire.	7	Visual Inspection of Fan and Motor assembly.	6	42	252

Figure 6 FMEA Extended Report example

The last custom table provided in the schema extension takes the report one step further to look at Failure Reduction methods for those failure modes with a high RPN. Using the above example, one would expect that the last two rows of the table, the ones with an RPN value greater than 200, would have a failure reduction associated with them. The FMEA Report with Failure Reduction includes the identification of the Failure Reduction method in the table. Adding six additional rows to the definition of the FMEA Extended Report definition will provide this table. The details of the additional rows is provided in the following diagram.

13	Relationship ...	mitigated by	5	mitigated by Targets	☐	Alphabetic	Category	☐	☐
14	Entity Attribute	recommende...	13	Recommended A...	☐				
15	Entity Attribute	responsibility	13	Responsibility	☐				
16	Entity Attribute	dueDate	13	Due Date	☐				
17	Entity Attribute	updatedOccu...	13	Updated Occurre...	☐				
18	Entity Attribute	updatedDete...	13	Updated Detecta...	☐				

Figure 7 Added Rows on FMEA Extended Table

Again, when executed and formatted in Excel, this table will yield results similar to the following:

System Element	Failure	Failure Description	Severity	Cause of Failure	Occurrence	Detection Method	Detectability	Criticality	Risk	Recommended Action	Responsibilit	Due Date	Updated Occurrence	Updated Detectability
Cooling Motor and Fan Assembly	Fan Vibration and Interference	Audible Noise, vibration; increased motor wear.	5	Fan Center of Gravity off axix of rotation causing 2-plan	5	Design calls for lightweight fan with minimum band mass,	4	25	100					
Cooling Motor and Fan Assembly	Misalignment of Fan and Shroud	Fan and shroud mis-aligned cause reduction or complete	7	Fan contacts shroud, noise or motor burnout.	2	Designed for easy assembly and alignment.	3	14	42					
Cooling Motor and Fan Assembly	Motor Burnout	Motor Burnout causes loss of cooling to the system.	5	Overheating of motor assembly due to lack of air	2	Vent holes in motor casing, fins in fan hub pull air	5	10	50					
Cooling Motor and Fan Assembly	Reduced Fan Efficiency	Fan motor is assembled 120 degrees off nominal angle causes reduction of cooling effectiveness.	6	Symmetrical spacing of screw holes allows for non-unique mounting of fan motor.	7	Cuurent design requires visual verification of assembly.	7	42	294	Develop a unique, non-symmetrical bolt pattern for the motor / fan	Joe Engineer	31-Aug-17	2	2
				Misassebly of Fan and Motor causes pinched wire.	7	Visual Inspection of Fan and Motor assembly.	6	42	252	Develop a unique, non-symmetrical bolt pattern for the motor / fan	Joe Engineer	31-Aug-17	2	2

Figure 8 FMEA Report with Failure Reduction

6. INSTRUCTION FOR USE

In order to use this extension a project administrator will have to import the GNSX file containing the schema extension into the existing project.

1. From GENESYS, select Application Menu >> Import.
2. Use the file browser to select C:\Program Files (x86)\Vitech\GENESYS 6 Collaborative Edition\Extensions\FailureModeEffectAnalysisExtention.gnsx and click Open.
3. In the import wizard, you will see the Project “Failure Mode Effect Analysis Schema” in the Project listing. Select “Next” to continue to Step 2.
4. Select the second radio button which says “Import Into Project:” and select your project from the drop-down list. Select “Next” to continue to Step 3.
5. Review the screen to ensure that you have selected to import “Failure Mode Effect Analysis Schema” into your project. Select “Import” to start the import process.

Once the import completes click OK and the schema extension is ready to be used. Once you have imported the extension you will not need to import it again. Simply export your database using the default export option and the schema and data are contained within one GNSX file.

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