FMEA/CIL 201

RAMS TRAINING SUMMIT

PAUL BRITTON NASA

GWYER SINCLAIR NASA

RYAN DETERS BASTION TECHNOLOGIES

FMEA/CIL SKILLS

- Who will be good at FMEA?
  - Analytical, Methodical, Skeptical, Imaginative

FMEA/CIL SCOPE

- FMEA/CIL is a powerful design-analysis tool (and communication tool)
- What are the reliability and safety expectations?
  - Risk understanding and acceptance
  - Design influence
- FMEA is bottoms-up. Where is the bottom? Where is the top?
  - What should be the boundaries of the analysis?
  - Initial Criticality Assessment
- Are there down stream requirements that depend on FMEA/CIL results?

TERMINOLOGY

Item under Analysis

Immediate Effect

Next Higher Assembly Level

Next Effect

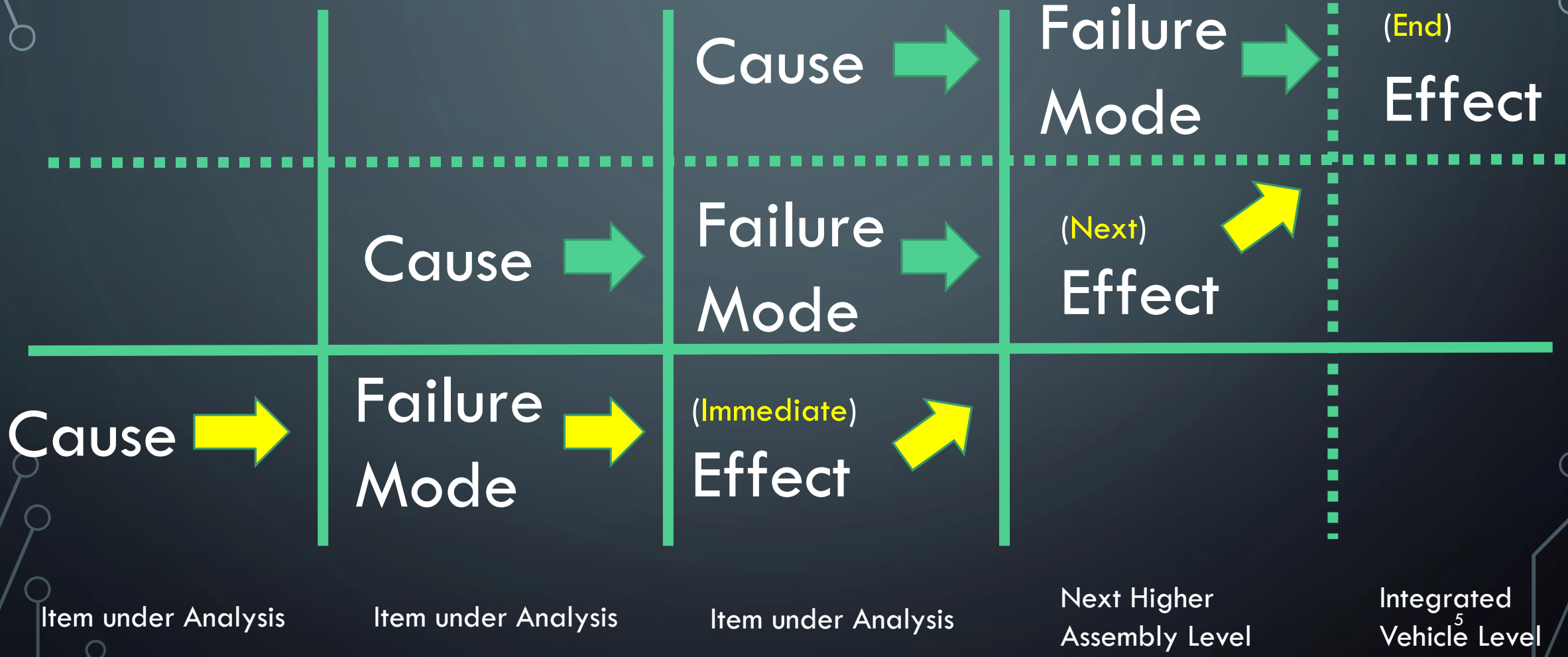
Integrated Vehicle Level

End Effect

The FMEA intends to identify all failure modes at the ***bottom level*** and to categorize the worst-case severity of the end effect by determining the worst-case ***Criticality*** of each failure mode.

The bottom. Example 1: ***hardware level*** = individual components or circuit paths. Example 2: ***functional level*** = LRU or box level. The intent is to drive reliability and safety into the architecture, testing, operations and detailed design as earlier as possible.

MORE TERMINOLOGY

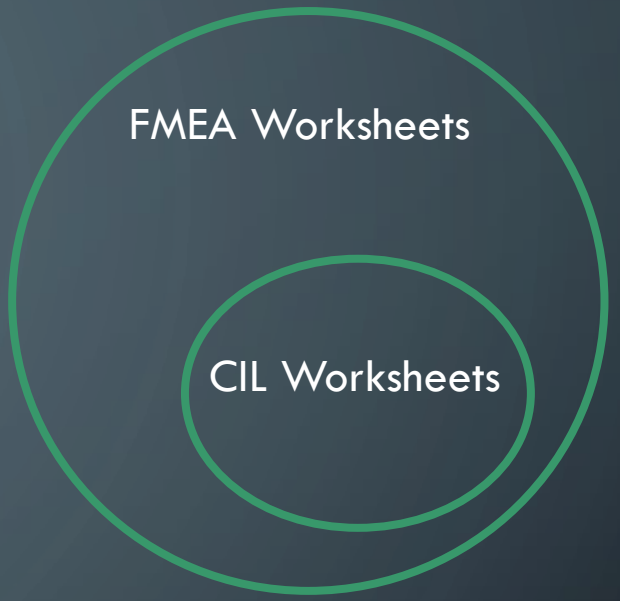


FMEA/CIL USE-CASES

- Criticality can help inform risk-based decisions
- Design influence
- Test and Inspection influence
- Support down-stream analysis and requirements

CIL WORKSHEET FIELDS

- Prepared by Information
- Hardware Information
  - Item Name, Part Number, Schematic ID, System Location, etc
- Item Function Description
- Failure Mode
- Failure Causes
- End Failure Effect by Phase or Operational Mode
- Worst Case Criticality
- Failure Detection
  - Failure Detection, Software Response, Corrective Action
- Retention Rational
  - Design, Test, Inspection, Failure History
- References
  - Operational Requirements, Hazard Reports, Supplier FMEA, Other related databases



QUESTIONS

CRITICALITY DEFINITIONS

Criticality	Definition
1	Failure that could result in loss of life or vehicle
1S	Failure in safety or hazard monitoring system that could prevent system from detecting a hazardous condition or fail to operate during such condition
1R	Redundant hardware that, if all failed, could cause loss of life or vehicle
3	Failure that could cause degradation to mission objectives

CIL RETENTION RATIONALE

Retention rationale consists of controls to minimize the risk associated with the critical item

- Design
  - Manufacturing controls, safety factors, unique physical characteristics
- Tests
  - Identify specific tests performed that would detect presence of failure
- Inspections
  - Identify specific Inspections performed that would detect presence of failure
- Failure History
  - Summary of all previous occurrences and actions taken
- Operational Use
  - Description of operations to mitigate or limit effect
    - Malfunction Procedures, Operating Constraints, Crew Training

FMEA EXAMPLE

Worksheet #:	CCC-ELE-SYS-ASSEM-PART-###	**System:**	Element X	**Reliability Eng.:**	Peter
Rev:	G	**Subsystem:**	System M	**Reliability Mgr.:**	Paul
Date Modified:	4/9/1920	**Design Eng.:**	Fred	**Integrated Rel. Eng.:**	Peter
Failure Mode:	Leakage - External	**Design Mgr.:**	Sally	**Integrated Rel. Mgr.:**	Paul

PART INFORMATION

1	**LRU Name:**	Fill/Drain Line, System, Element	**Dwg Nbr:**	201-#######, Rev -	**Supplier Item Name:**	Fill-Drain Duct Assembly
	LRU Nbr:	201-#######-#	**Dwg Find Nbr:**	2	**Supplier Item Nbr:**	#####-101
	Item Name:	Fill/Drain Line, System, Element	**Dwg Qty:**	1	**Supplier Dwg Nbr:**	#####-101, Rev -
	Item Nbr:	201-########-#	**Schematic Nbr:**	201-#######, Rev -	**Supplier Dwg Find Nbr:**	N/A
	LCN:	N/A	**Schematic ID:**	AA-B#	**Supplier Name:**	ABCDEFG Inc

ITEM FUNCTION & FAILURE CAUSES

Item Function:

The fill/drain line is an XYZ-### Inconel line that spans between the fill/drain disconnect and the fill/drain valve. The line is insulated. The line includes flexible joints that allow for limited movement of the line. The line includes a pressure and temperature port near the fill/drain valve interface. This worksheet analyzes the line fails by external leakage.

Failure Causes:

1. Defective sealing surfaces on the flange
2. Failure of tube/bellows weld
3. Failure of bellows longitudinal weld
4. Initial crack in tube propagates due to cyclic loading
5. Excessive vibration
6. Improper installation (bolt torqueing)
7. Mishandling
8. TPS pressure collapse resulting in excessive structural loads
9. Excessive interface forces/moments at the Fill/Drain Valve
10. Excessive interface forces/moments at the Quick Disconnect
11. Excessive interface forces/moments at the vehicle attachment points
12. Excessive flange deflection
13. Fatigue failure of instrumentation boss
14. Deformation due to cyclic loading
15. Damage to line induced by small line support loads