Hazard Analysis and FMECA

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Introduction

- Hazards:
  - Create risk of accident or incident;
  - Risk of fire from hazard of matches, lightning etc.
- Hazard analysis:
  - Component of risk assessment.
- FMECA/FMEA:
  - Failure Modes, Effects and Criticality Analysis;
  - Primarily qualitative approaches;
  - Methodological support reduces subjectivity?

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Hazard Analysis

- Safety case
  - Argument why proposed system is safe;
  - Key argument is that hazards are identified;
  - Significant risks are then mitigated.

- Lots of Hazard Analysis techniques:
  - fault tress (see later);
  - cause consequence analysis;
  - HAZOPS;
  - FMECA/FHA/FMEA...

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Failure Modes, Effect and Criticality Analysis

- Technique has its origins in the Cold War:
  - MIL STD 1629A (1977!);
  - Amazing that it is still a core technique.
- Relatively simple idea:
  - Analyse each potential failure;
  - Determine impact of system(s);
  - Assess its criticality;
  - Fix the major concerns.
- Compare this with IEC61508?
  - Hazard analysis to identify SIL,
  - Software tools etc appropriate to integrity level.

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Failure Modes, Effect and Criticality Analysis

1. Construct functional block diagram.
2. Use diagram to identify any associated failure modes.
3. Identify effects of failure and assess criticality.
4. Repeat 2 and 3 for potential consequences.
5. Identify causes and occurrence rates.
6. Determine detection factors.
7. Calculate Risk Priority Numbers.
8. Finalise hazard assessment.

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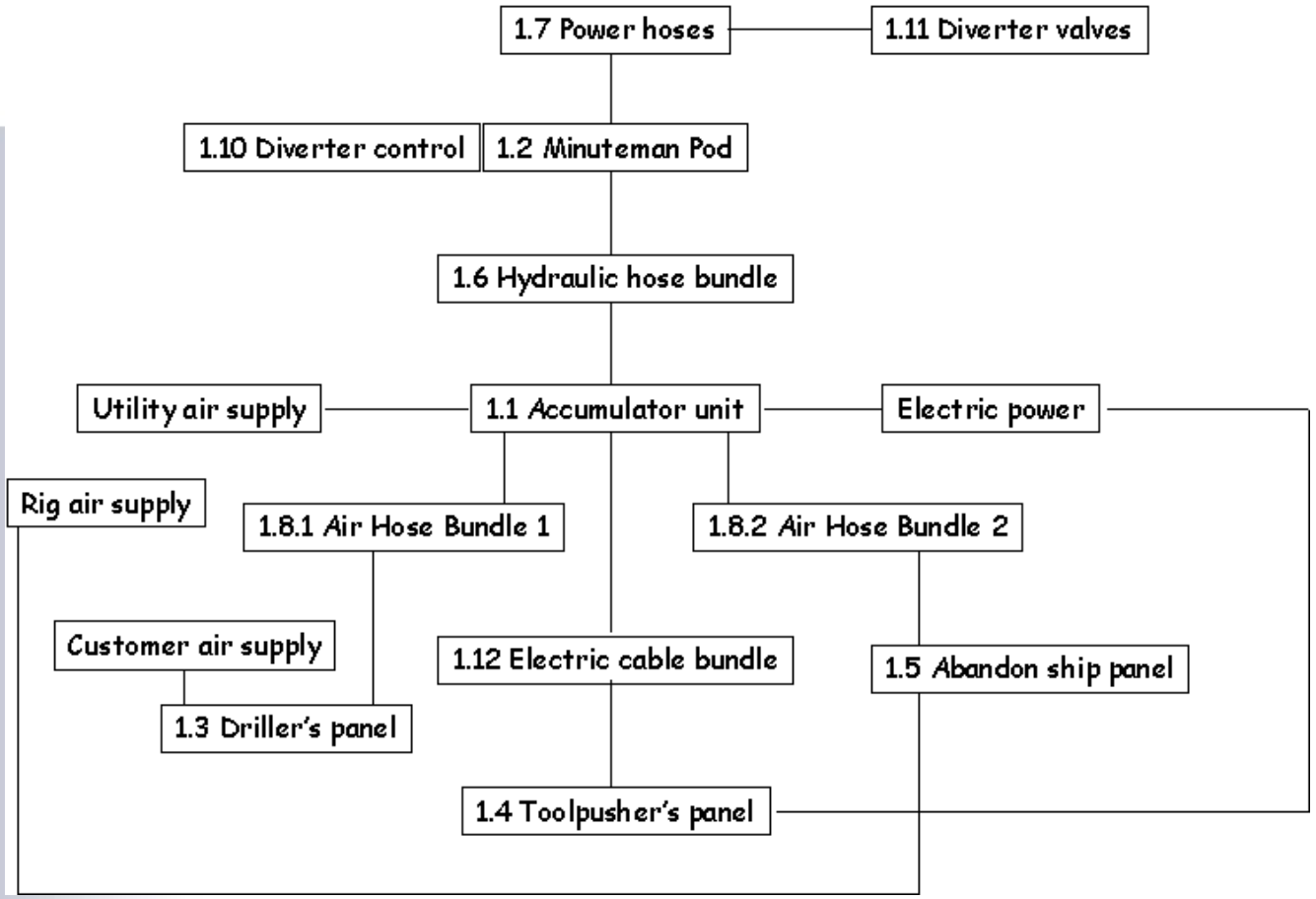
Failure Modes, Effect and Criticality Analysis

- Step 1: Functional Block Diagram
- Establish scope of the analysis.
- Break system into subcomponents.
- Different levels of detail?
- Some unknowns early in design?

Minuteman Example



- Ack: J.D. Andrews and T.R. Moss, Reliability and Risk Assessment, Longman, Harlow, 1993 (ISBN-0-582-09615-4).

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Failure Modes, Effect and Criticality Analysis

- Step 2: Identify Failure Modes
- Many different failure modes:
  - complete failure;
  - partial failure;
  - intermittant failure;
  - gradual failure;
  - etc.
- Not all will apply?
- Compare with HAZOPS guidewords

FMECA - Step 3: Assess Criticality

10. Hazardous without warning: Very high severity ranking when a potential failure mode affects safe operation or involves non-compliance with a government regulation without warning.

9. Hazardous with warning: Failure affects safe product operation or involves noncompliance with government regulation with warning.

8. Very High: Product is inoperable with loss of primary Function.

7. High: Product is operable, but at reduced level of performance.

6. Moderate: Product is operable, but comfort or convenience item(s) are inoperable.

5. Low: Product is operable, but comfort or convenience item(s) operate at a reduced level of performance.

4. Very Low: Fit & finish or squeak & rattle item does not conform. Most customers notice defect.

3. Minor: Fit & finish or squeak & rattle item does not conform. Average customers notice defect.

2. Very Minor: Fit \& finish or squeak \& rattle item does not conform. Discriminating customers notice defect.

1. None No effect

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Failure Modes, Effect and Criticality Analysis

- Step 4: Repeat for potential consequences
- Can have knock-on effects.
- Additional failure modes.
- Or additional contexts of failure.
- Iterate on the analysis.

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Failure Modes, Effect and Criticality Analysis

- Step 5: Identify Cause and Occurence Rates
- Modes with most severe effects first.
- What causes the failure mode?
- How likely is that cause?
- risk = frequency x cost

FMECA - Step 5: Identify Occurrence Rates

- Very High: Failure almost inevitable
  - Rank 10: 1 in 2
  - Rank 9: 1 in 3
- High: Repeated failures
  - Rank 8: 1 in 8
  - Rank 7: 1 in 20
- Moderate: Occasional failures
  - Rank 6: 1 in 80
  - Rank 5: 1 in 400
  - Rank 4: 1 in 2000
- Low: Relatively few failures
  - Rank 3: 1 in 15,000
  - Rank 2: 1 in 150,000
- Remote: Failure is unlikely
  - Rank 1: 1 in 1,500,000

Failure Modes, Effect and Criticality Analysis

- Step 6: Determine detection factors.
  - Type (1):These controls prevent the Cause or Failure Mode from occurring, or reduce their rate of occurrence.
  - Type (2): These controls detect the Cause of the Failure Mode and lead to corrective action.
  - Type (3): These Controls detect the Failure Mode before the product operation, subsequent operations, or the end user.
- Can we detect/control failure mode?

Failure Modes, Effect and Criticality Analysis

10. Absolute Uncertainty: Control does not detect a potential Cause of failure or subsequent Failure Mode; or there is no Design Control

9. Very Remote: Very remote chance the Design Control will detect a potential Cause of failure or subsequent Failure Mode

8. Remote: Remote chance the Design Control will detect a potential Cause of failure or subsequent Failure Mode

7. Very Low: Very low chance the Design Control will detect a potential Cause of failure or subsequent Failure Mode

6. Low: Low chance the Design Control will detect a potential Cause of failure or subsequent Failure Mode

5. Moderate: Moderate chance the Design Control will detect a potential Cause of failure or subsequent Failure Mode

4. Moderately High: Moderately high chance the Design Control will detect a potential Cause of failure or subsequent Failure Mode

3. High: High chance the Design Control will detect a potential Cause of failure or subsequent Failure Mode

2. Very High: Very high chance the Design Control will detect a potential Cause of failure or subsequent Failure Mode

1. Almost Certain: Design Control will almost certainly detect a potential Cause of failure or subsequent Failure Mode

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Failure Modes, Effect and Criticality Analysis

- Step 7: Calculate Risk Priority Numbers
- Risk Priority Numbers (RPN)
- RPN = S x O x D, where:
  - S - severity index;
  - O - occurence index;
  - D - detection index.
- A partial number line 0..1,000.

Failure Modes, Effect and Criticality Analysis

- Step 8 - Finalise Hazard Analysis
- Must document the analysis...
- ...and response to analysis.
- Use FMECA forms.
- Several formats and tools.

Documentation

FMECA Worksheet

System: Date: Author: Approved by:

Function	Failure Mode	Failure Effect		Severity	Occurrence rate	Detection Method	Notes
		System	Local				

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FMECA Tool Support

FMECA, Part PENTIUM PRO

	Item/Description	Name/Function	Failure Mode	Local Effect
1	Pentium Pro Processor. Microprocessor which provides a central processing unit and an internal cache.	Controls the primary operation of the personal computer.	Processor Section Failure	The Pentium Pro Chip Fails.
2			Address Section Failure	The Pentium Pro Chip Fails.
3			Memory Section Failure	Failure of the internal memory of the Pentium Pro causes erroneous information to be generated.
4				
5				
6				
7				
8				

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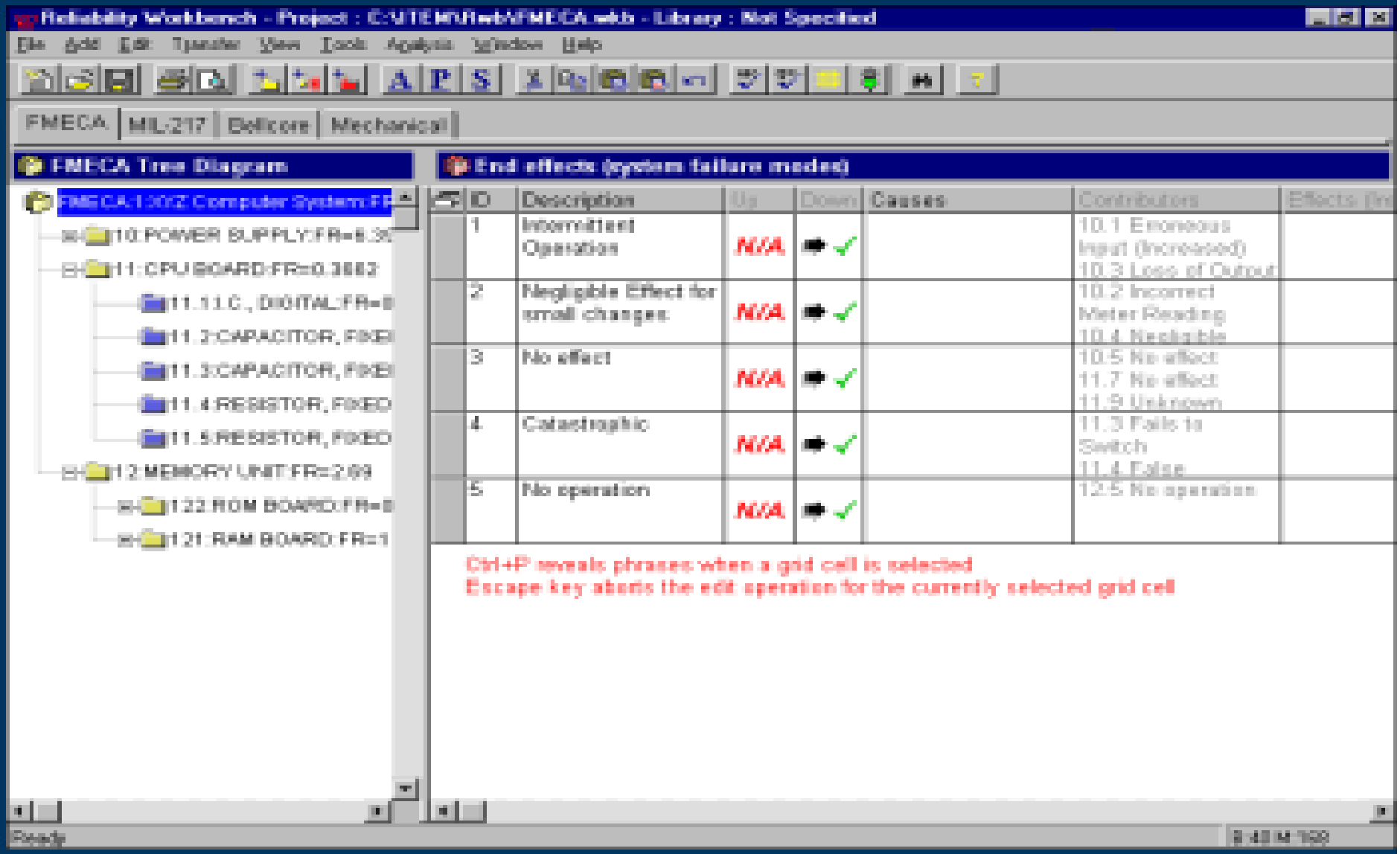
FMECA Tool Support



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Conclusions

- Hazard analysis.
- FMECA/FMEA.
  - qualitative approach;
  - but is it subjective?
- Next more quantitative approaches.

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Any Questions…