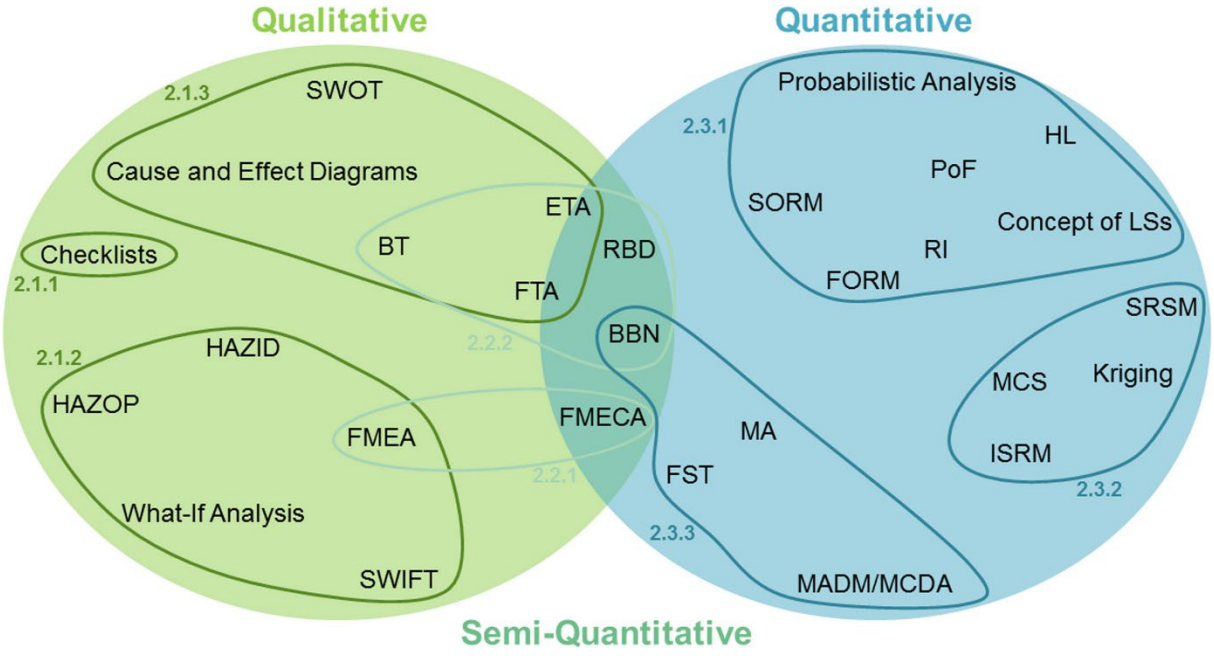
國立臺北大學自然資源與環境管理研究所
110 學年度第二學期『環境災害與風險管理』

課程講義（12）：危害分析、系統可靠度與模擬工具軟體
I Hazard Analysis, Systems Reliability and Simulation Software

- INTRODUCTION
  - □ Risk Assessment Steps: A Generic Procedure
    - ⇨ Identification of hazards likely to result in disasters: What hazardous events may occur?
    - ⇨ Estimation of the risks of such events: What is the probability of each event?
    - ⇨ Evaluation of the consequences of the derived risk: What is the likely loss created by each event?
  - □ Methods for Performing Reliability, Maintainability, and Safety Analysis
    Dhillon, B.S. (2013). *Safety and Human Error in Engineering Systems*, CRC Press, Boca Raton, F.L.
    Dhillon, B.S. (2020). *Reliability, Maintainability, and Safety for Engineers*, CRC Press, Boca Raton, F.L.
    - ⇨ Fault Tree Analysis (FTA)
    - ⇨ Failure Modes and Effect Analysis (FMEA)
    - ⇨ Failure Mode Effects and Criticality Analysis (FMECA)
    - ⇨ Markov Method, Cause and Effect Diagram, Probability Tree Analysis
    - ⇨ Hazard and Operability Analysis (HAZOP)
    - ⇨ Technique of Operations Review (TOR)
    - ⇨ Job Safety Analysis (JSA)
    - ⇨ Interface Safety Analysis (ISA)
  - □ Reliability-based Methods for Risk Analysis
    Leimeister, M. and A. Kolios. (2018). "A review of reliability-based methods for risk analysis and their application in the offshore wind industry", *Renewable and Sustainable Energy Reviews*, 91:1065-1076.
    - ⇨ Sheet-based, Table-based, and Diagrammatic qualitative reliability methods
    - ⇨ Life Cycle Stages of an offshore wind project: Design (D), Construction (C), Operation (O), Maintenance (M), and Life Cycle Planning (LC)



- FAULT TREE ANALYSIS (FTA)
  - Event Tree, Decision Tree, and Fault Tree
  - Safety, Reliability, Risk, and Industrial Hazards
  - Components: Result, Gates (and/or), Fault Events (input/output)

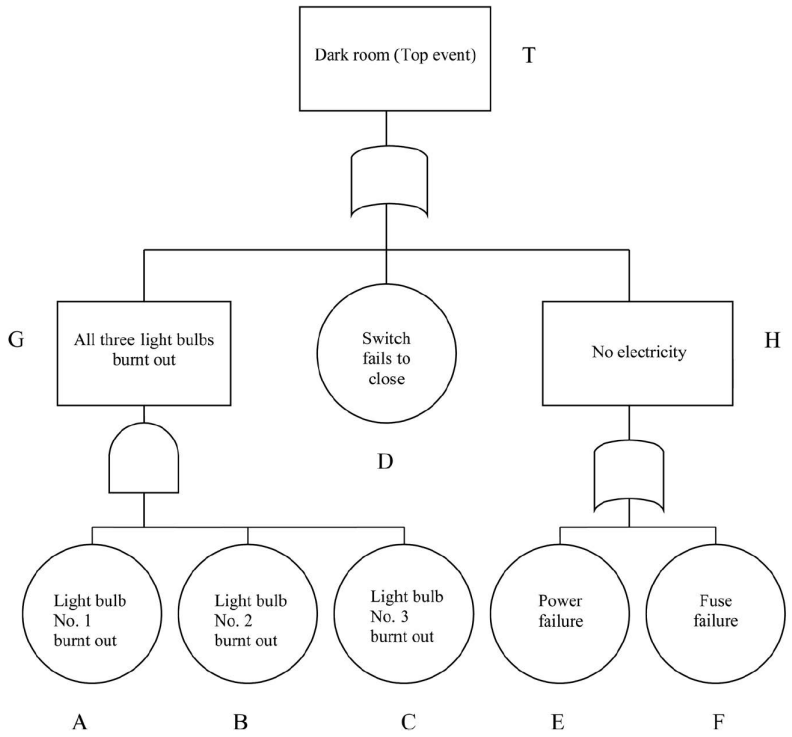


Figure 4.2 A fault tree for the top fault event: dark room.

- FMEA, FMECA AND HAZOP
  - An Overview of FMEA and FMECA (http://www.weibull.com/basics/fmea.htm)
  - Failure Modes and Effect Analysis (FMEA) 失效模式與效應分析
  - Failure Mode Effects and Criticality Analysis (FMECA) 失效模式效應與關鍵性分析
  - Hazard and Operability Analysis (HAZOP) 危害及可操作性分析
    https://www.safeopedia.com/2/1205/prevention-and-control-of-hazards/injury-prevention/hazard-and-operability-studies-the-basics
  - Hazard Analysis (HAZAN)
    https://www.safeopedia.com/definition/4857/hazard-analysis-hazan

- RISK ANALYSIS SOFTWARE
  - Statistics and Probability: Calculation, Fitting, and Visualization
  - Event Tree, Value Tree, Fault Tree, and Decision Tree
  - Reliability and Safety => Fault and Failure
    ⇨ Fault Tree Analysis, FMEA, and FMECA
    ⇨ Risk Priority Numbers (RPN) for Failures: Severity, Occurrence & Detectability
  - Process and Operation => Hazard and Operability
    ⇨ Process Hazards Analysis: HazOp, Job Safety Analysis, etc.
    ⇨ Brainstorming, Countermeasures, and Cost Assessment

POTENTIAL
FAILURE MODE AND EFFECTS ANALYSIS
Front Door L.H.

FMEA Type
Item 1.1.1 - Front Door L.H. Process Responsibility Body Engineering
Model Year(s)/Vehicle(s) 20XX/Lion 4dr/Wagon Key Date 3/10/2015
Core Team A. Tate Body Engrg, J. Smith - OC, R. James - Production, J. Jones - Maintenance

FMEA Number 1450
Page 1 of 1
Prepared By J. Ford - X6521 - Assy Ops
FMEA Date (Orig.) 3/10/2015 (Rev) 3/21/2015

Name / Function / Requirements	Potential Failure Mode	Potential Effect(s) of Failure	SEVi	Classification	Potential Cause(s) of Failure	OCCi	Current Process Controls (Prevention)	Current Process Controls (Detection)	DETi	RPNi	Recommended Action(s)	Responsibility & Planned Completion Date	Action Results: Actions Taken & Actual Completion Date	SEVr	OCCr	DETr	RPNr
1.1.1 - Front Door L.H.																	
Op. 70 Manual application of wax inside door/ cover inner door, lower surfaces with wax to specification thickness.	Insufficient wax coverage over specified surface	Allows integrity breach of inner door panel. Corroded interior lower door panels. Deteriorated life of door leading to: - Unsatisfactory appearance due to rust through paint over time - Impaired function of interior door hardware	7		Manually inserted spray head not inserted far enough	8		Visual check each hour - 1/shift for film thickness (depth meter) and coverage.	5	280	Add positive depth stop to sprayer.	Mfg Engrg - 3/10/2003	Stop added, sprayer checked on line.	7	2	5	70
											Automate spraying.	Mfg Engrg - 3/10/2003	Rejected due to complexity of different doors on same line.				
					Spray head clogged- Viscosity too high- Temperature too low- Pressure too low.	5	Test spray pattern at start-up and after idle periods, and preventive maintenance program to clean heads.	Visual check each hour - 1/shift for film thickness (depth meter) and coverage.	5	175	Use Design of Experiments (DOE) on viscosity vs. temperature vs. pressure.	Mfg Engrg - 3/10/2003	Temp and press limits were determined and limit controls have been installed - control charts show process is in control Cpk = 1.85.		1	5	35
					Spray head deformed due to impact	2	Preventive maintenance program to maintain heads.	Visual check each hour - 1/shift for film thickness (depth meter) and coverage.	5	70					2	5	70

Figure 1: Process FMEA (PFMEA) in the Automotive Industry Action Group (AIAG) FMEA-4 format.
https://www.weibull.com/basics/fmea_fig1.htm

- **Risk Priority Numbers: RPN = Severity × Occurrence × Detection**
- **Criticality Analysis**
  Mode Criticality = Expected Failures × Mode Ratio of Unreliability × Probability of Loss
  Item Criticality = SUM of Mode Criticalities