



# U.S. ARMY COMBAT CAPABILITIES DEVELOPMENT COMMAND AVIATION & MISSILE CENTER

FAILURE REVIEW BOARD TRAINING

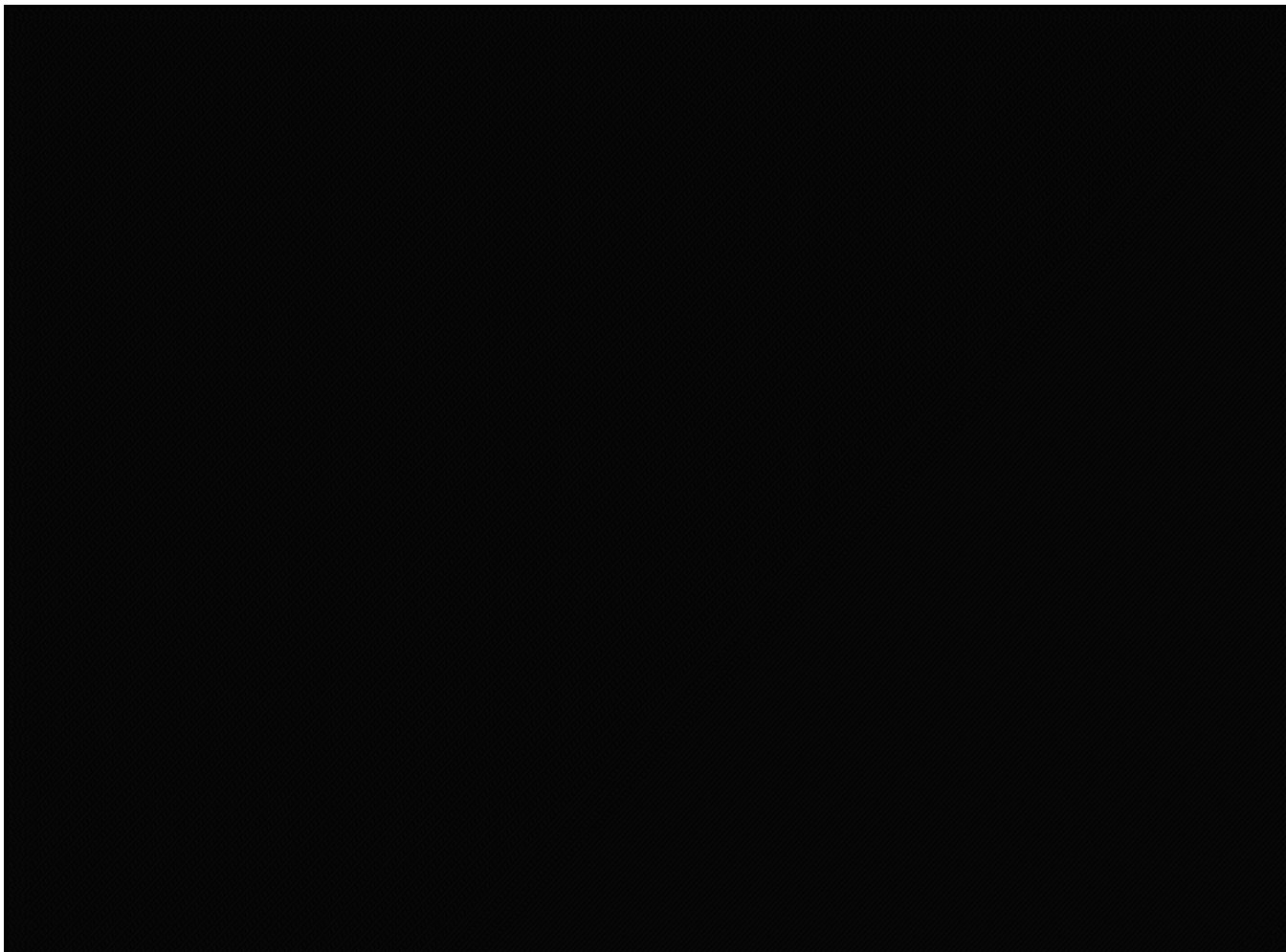
02 NOVEMBER 2023



# RAM ENGINEERING & SYSTEM ASSESSMENT DIVISION

## FAILURE REVIEW BOARD (FRB) TRAINING

# FRB TRAINING



# FRB TRAINING



## ▪ FRB PURPOSE

- A systematic, structured, rigorous procedure for root cause determination is needed
- Task at hand is to:
  - Outline possible causes of failure
  - Document rationale both for and against causes
  - Determine the root cause of the failure or most probable cause of failure
    - Identify failed subsystem and narrow down to LRU, part, or component (lowest level possible)
    - Root Cause: Cause of failure determined by evidence presented and is repeatable
  - Formulate corrective action(s) and develop a plan to implement
  - Report to next level management for subsequent actions and guidance

# FRB TRAINING



- **Standards**

- MIL-HDBK-2155 Failure Reporting and Corrective Action System (FRACAS);  
Section 4.3 Failure Review Board
- ANSI / AIAA S-102.1.5-2009 Performance-Based Failure Review Board  
Requirements (Updated in 2019)
- Most contractors have and will follow their internally approved FRB rules and  
process
- The Government should ensure that requirements to conduct FRBs are stated in  
the contract Scope of Work – usually part of the FRACAS paragraph

# FRB TRAINING



- **Types of FRBs**

- No formal name for different types, but contractual language will describe an ongoing or Persistent FRB associated with FRACAS trends or an Ad-hoc FRB when failure events occur
  - **Persistent** – Analyst report to Chairs/Board and recommend items for FRB study and correction normally associated with ongoing production or Repair and Return contract
  - **Ad-hoc** – Any one individual failure can trigger an FRB (ex: Development Testing, Qualification, Acceptance, SRP testing, etc.), dependent on contract language – normally associated with Development Testing, post fielding surveillance testing, or post fielding operational failures

# FRB TRAINING



- **Organization And Members**

- Chartered by Program Manager or other Ranking Management Official
- Chaired by Government or Co-chaired with Prime Contractor
  - Contractor usually takes technical lead
  - Depending on contract language, Government FRB chair or delegate approves / dis-approves resources needed for contractor recommended failure investigations, testing, and analysis
- Members:
  - Chief Engineer or delegate, Program Management Lead, Systems Engineering, Quality Manager, Reliability Engineering, SMEs as appropriate
- Members need to be empowered with a level of responsibility and authority to make FRB relevant decisions for their organizations
- Failure Investigation Team (FIT): Sometimes a FIT is established, which is made up of a subgroup of FRB members or Test Personnel/SMEs outside of the FRB to conduct specific test/analysis and report back to the FRB

# FRB TRAINING

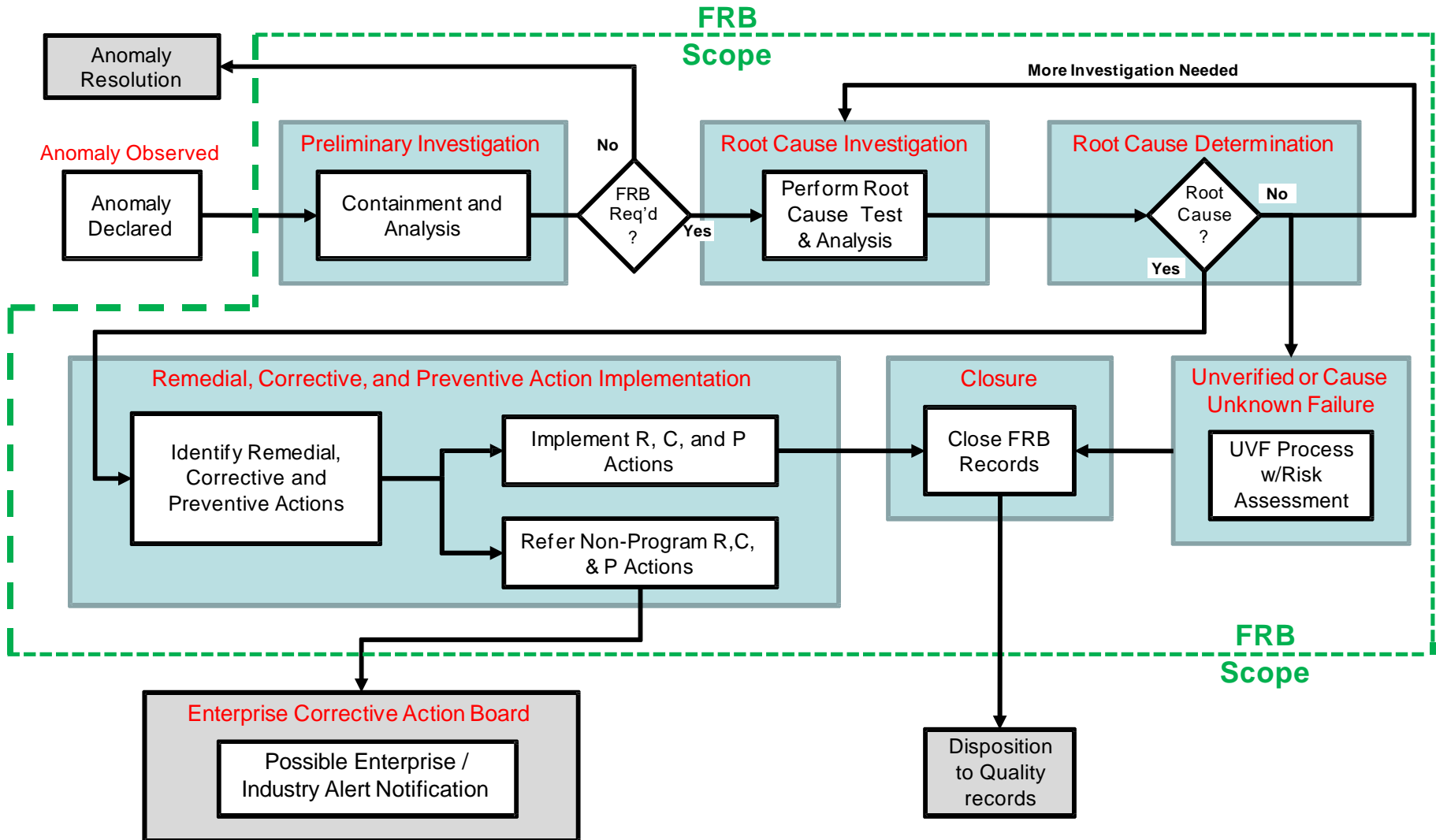


- **Process**

- Preservation of test setup, documentation of environmental conditions and personnel involved, and test data resulting from failure event
- Analysis of Test Incident Report (TIR), Failure Analysis Report (FAR), and/or FRACAS database information
- Decide upon analysis method to pursue; Fault Tree, Fish-Bone Diagram, etc...
- Analysis and documentation of evidence both for and against each cause
- Assignment and performance of testing and analysis
- Agreement on each box or branch with respect to probability of cause
- Assignment of root cause or likely root cause
  - Objective evidence and duplication of the failure mechanism is needed to declare a root cause
  - If failure mechanism cannot be duplicated, then a “most likely” root cause can be named
- Development of corrective action (CA)
- FRB reports to higher management depending on significance of incident
- FRB will monitor the CA implementation and testing to ensure the CA has its intended effect



# FRB TRAINING



# FRB TRAINING



## • When a Failure / Anomaly Occurs

- Personnel present when the anomaly / failure occurs should ensure that testing is halted, the configuration is preserved, and logical steps are taken to triage the incident
  - Operator oversight? Can the remedy be applied immediately? Example – reattach cable, report incident and continue testing
  - If test setup is not found in error, document test configuration and results in Test Incident Report – halt testing
  - Notification of failure event to the Lead Government and Contractor Engineers responsible for the UUT
- Contractual language in SOW will dictate whether the incident is resolved locally or brought to the FRB for investigation
  - If in TMRR or EMD acquisition phase, normally all failures after Development Testing starts are handled by an FRB
  - If in Production phase, failures are normally the result of an inspection or acceptance test failure; failure mechanisms are addressed when a trend is evident and/or Production yields are not being met
  - If system is fielded, severity of event (catastrophic/critical) will usually determine FRB involvement or if issues with Reliability or spares repair

# FRB TRAINING



- **When a Failure / Anomaly Occurs (continued)**

- Review information in the Test Incident Report (TIR), Failure Analysis Report (FAR), and/or FRACAS Database on the incident
- Develop and document top level investigation plan to guide the FRB
  - Problem Statement
  - Goals – to include schedule when applicable
  - Approach – Data Review / Analysis / Testing / Destructive Physical Analysis, etc.
  - Test and Analysis Resources – Contractor / Government Facilities or Labs, Personnel
  - Program Constraints – Budget, Schedule, Classification

# FRB TRAINING



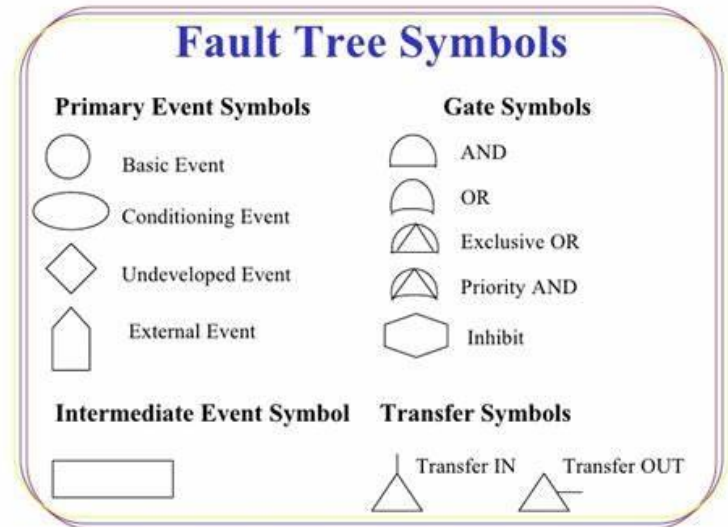
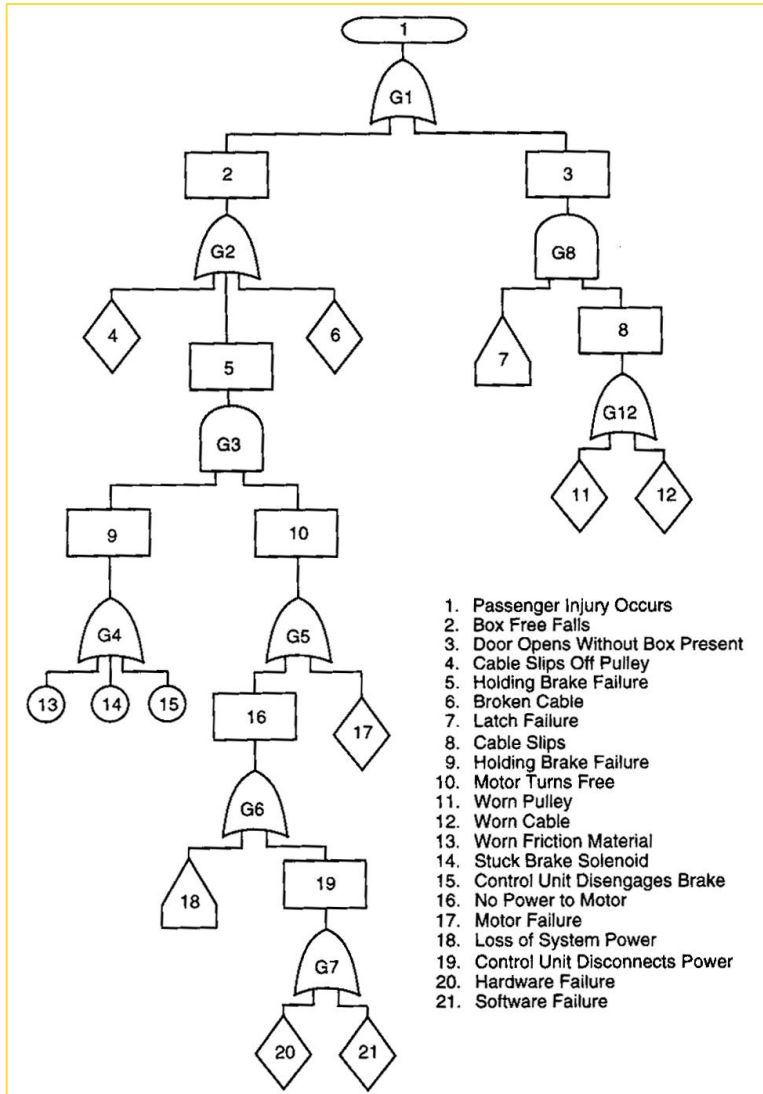
- **Techniques**

- Fault Tree
- Fish Bone Diagram (Ishikawa)
- Brainstorming
- 5 Why's
- State Diagrams
- Process Mapping / Flow Charts
- Fault Tree / Fish Bone Hybrid (most common in our work)
  
- The list above is just a summary of the techniques that an FRB can employ

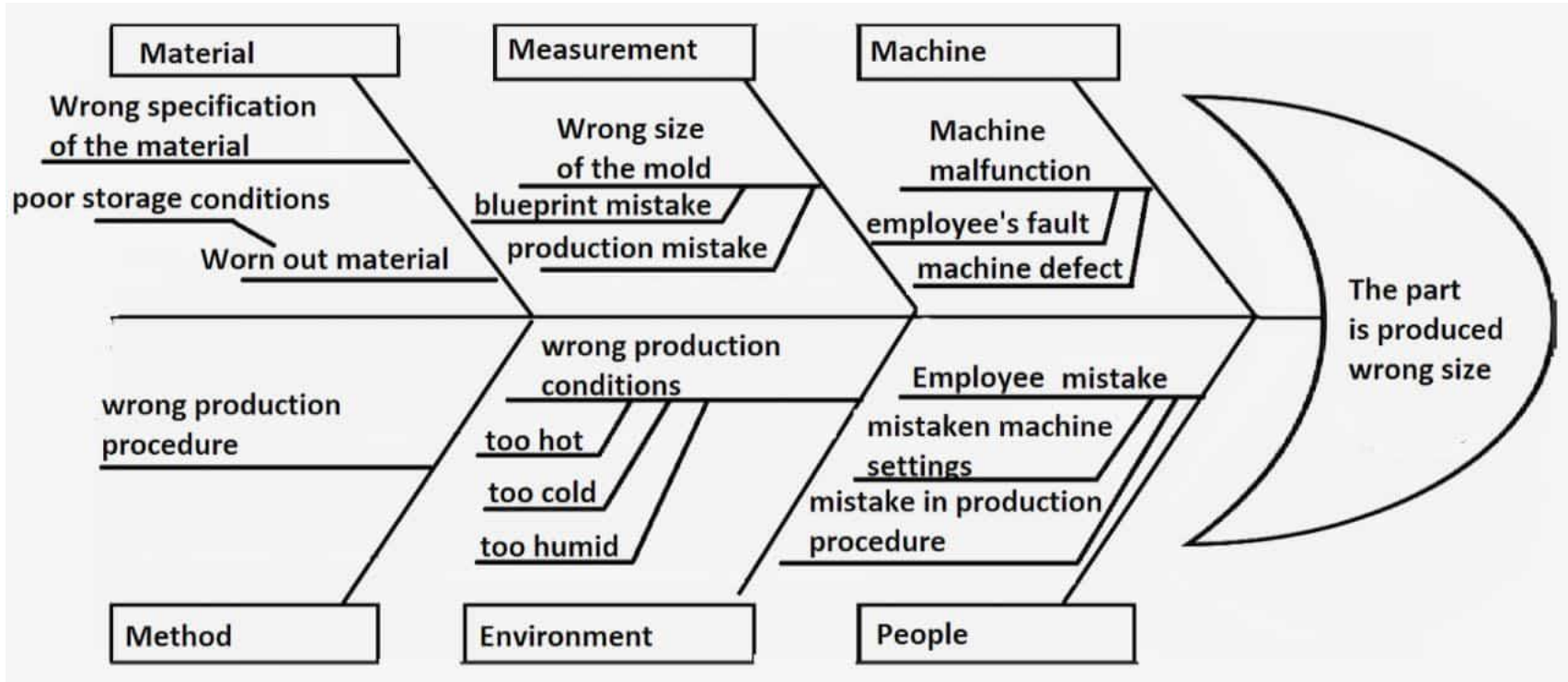
# FRB TRAINING – NOTIONAL FAULT TREE



Electromechanical Passenger Elevator



# FRB TRAINING – FISH BONE (ISHIKAWA) DIAGRAM



# FRB TRAINING - BRAINSTORMING



- **BRAINSTORMING**

- A group activity in which a facilitator writes down the spontaneous ideas of members that are focused on theorizing causes and attributes leading to the failure incident
- The facilitator then, with the help of the group, logically organizes the responses
- This can be a starting point for further analysis using one of the other failure analysis techniques



# FRB TRAINING – 5 WHYS



- **Issue: The Jefferson Memorial is deteriorating**

## 1. Why?

Too much washing

## 2. Why?

Excess bird droppings

## 3. Why?

A lot of spiders to eat

## 4. Why?

A lot of gnats to eat

## 5. Why?

The lights are consistently left on



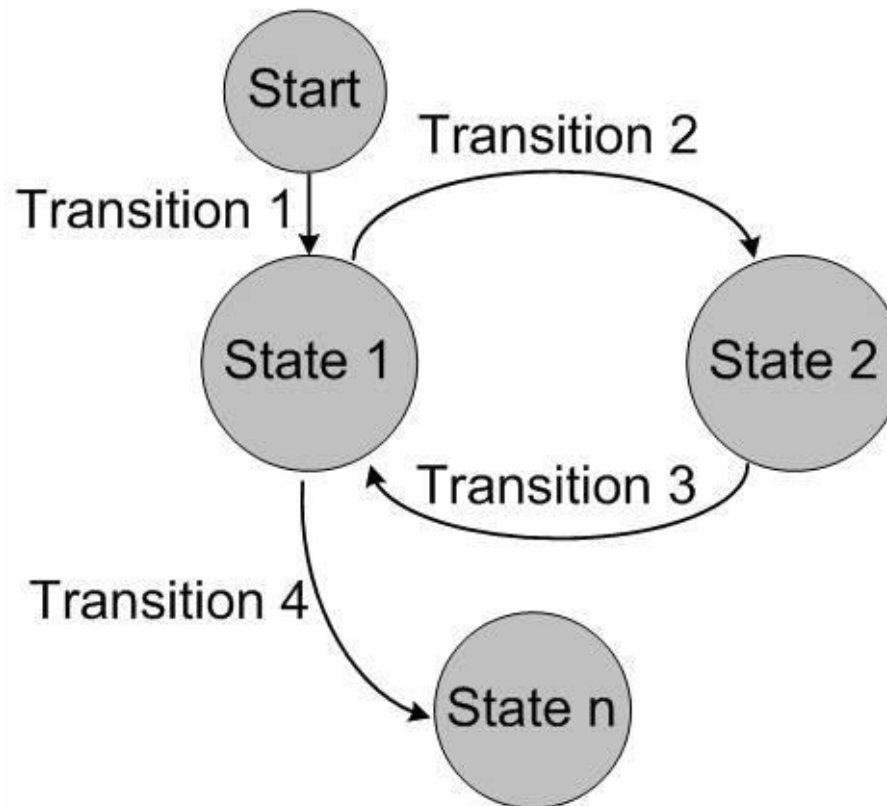


# FRB TRAINING – STATE DIAGRAM



- **State Diagram**

- Used to design or analyze the dynamic aspect of the system.
- It defines the state of the components and state changes triggered by an event. Events are internal and external factors influencing the system.

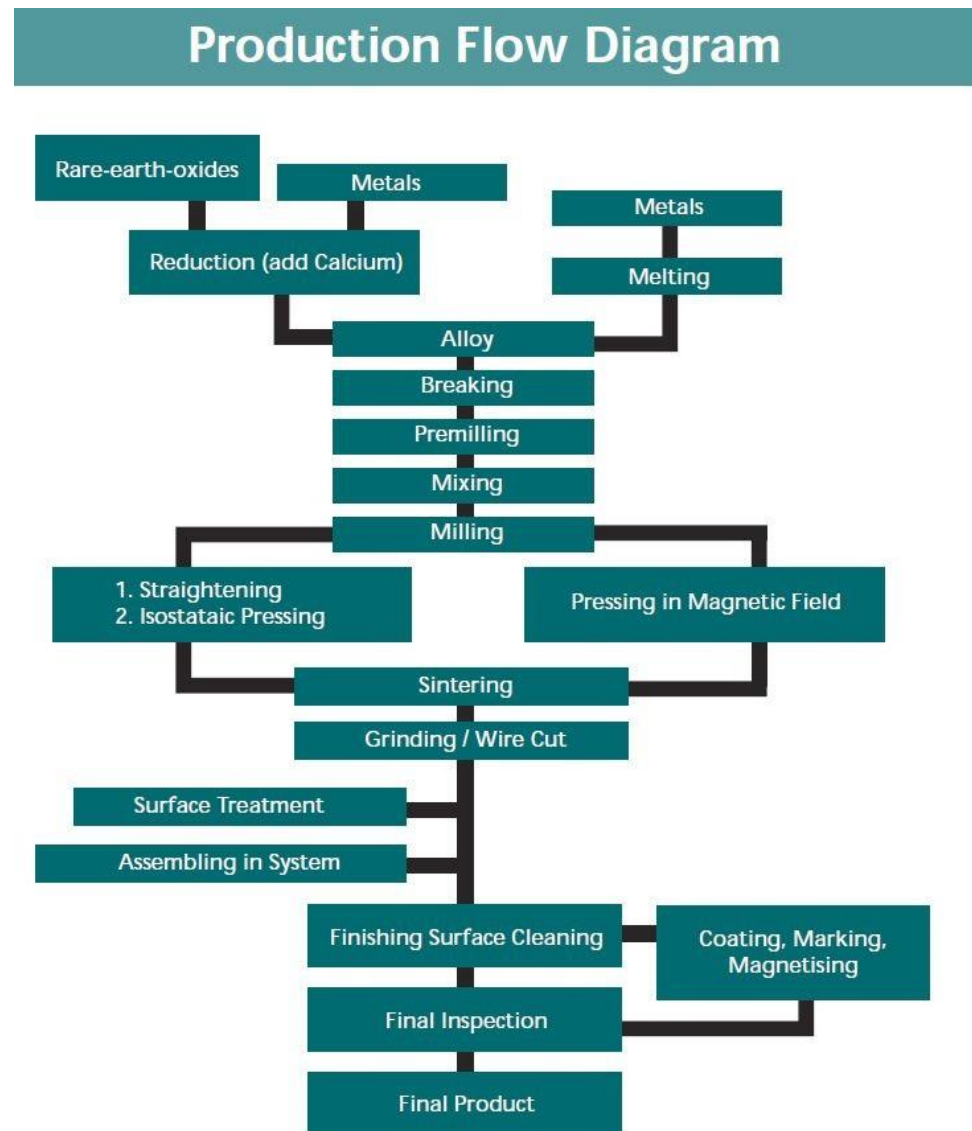


# FRB TRAINING – PROCESS MAP / FLOW CHART

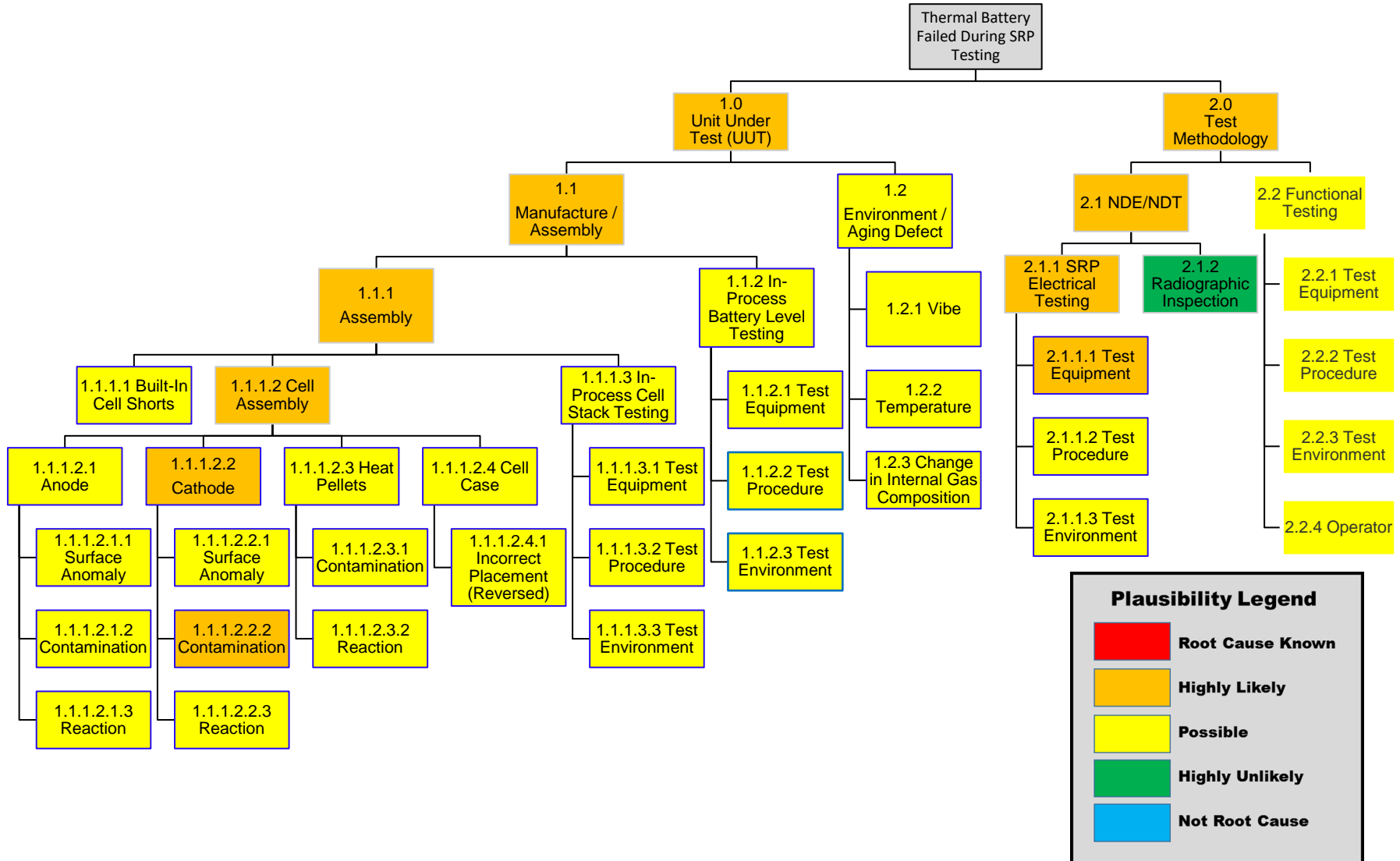


- **Process Maps and Flowcharts**

- Graphically shows the steps in a workflow or production process
- Gives all FRB members an understanding of the inputs and outputs of each process step
- Allows analysis of the step(s) that may contribute to failure modes and can help to isolate failure causes
- Subsequent, more detailed, process maps or flow charts can be used in order to isolate root causes



# FRB TRAINING – HYBRID FAULT TREE / FISH BONE DIAGRAM EXAMPLE



# FRB TRAINING – CAUSATION RATIONALE EXAMPLE



## Fault Tree Branch: 1.1.1.2.2.2 Contamination

**Potential Failure Mode:** *Cathode pellets contaminated with foreign material causing improper voltage output*

**Status:** Open

Supporting Evidence	Refuting Evidence	Additional Data / Test Required
<ul style="list-style-type: none"> <li>• Dissection of sister battery showed various metal filings imbedded into cathode pellets</li> <li>• Cathode pellet stamping tools examined and found to be worn and damaged</li> </ul>	<ul style="list-style-type: none"> <li>• Two sister batteries were functioned with no anomalies noted</li> </ul>	<ul style="list-style-type: none"> <li>• What amount of contamination can be tolerated within cathode pellets?</li> <li>• Action for study to be approved.</li> </ul>

**Conclusion:**

# FRB TRAINING – CAUSATION RATIONALE EXAMPLE



## PRACTICAL EXERCISE

**A: You are an SRP Engineer witnessing component testing of a rocket motor squib and the device fails to fire after the fire signal is sent to the device.**

**B: You are a RAM Engineer co-located in a Project Office and receive notice from your contractor counterpart that an airborne electromechanical hydraulic pump has failed qualification testing. The pump fails to produce the minimum flow rate at the pressure required.**

➤ **Task: Choose one of the above incidents and develop a simple, first impression fault tree, fish bone diagram, or hybrid showing the possible causes and/or components for the FRB to investigate.**



THANK YOU.



**U.S. ARMY**