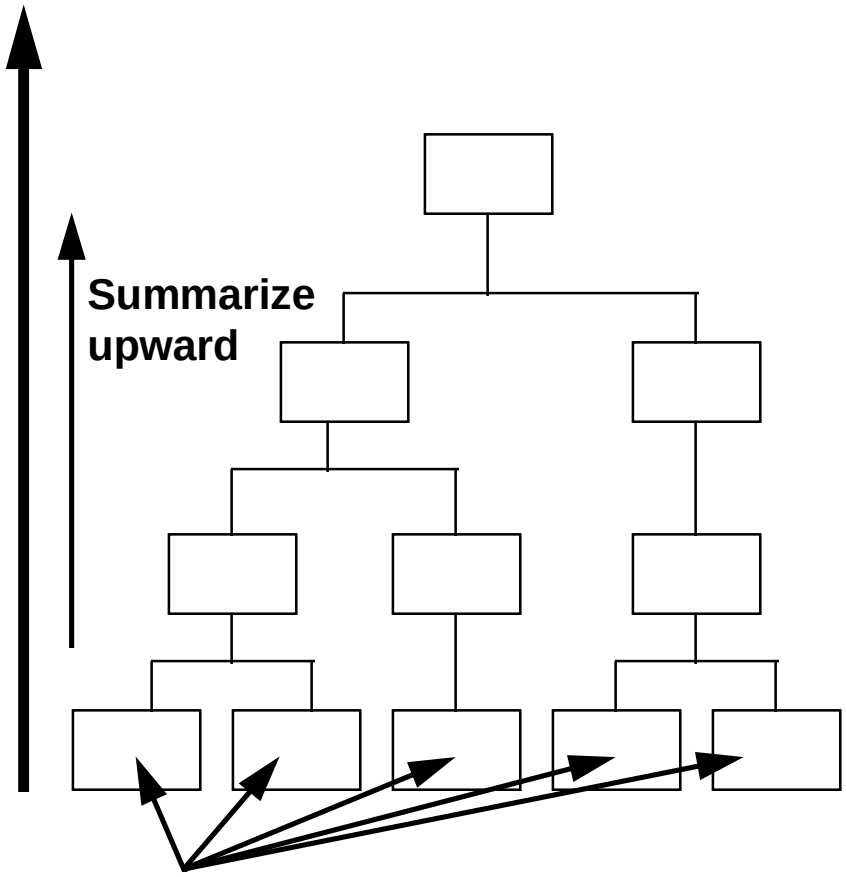
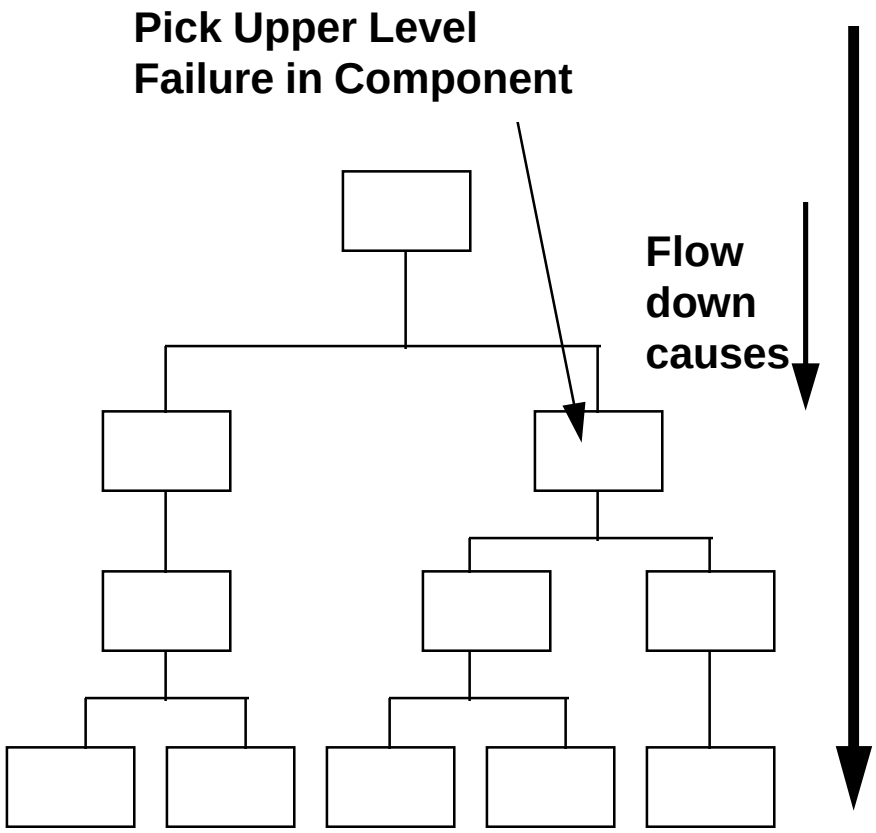
TOOLS OF RELIABILITY ANALYSIS -- Introduction and FMEAs

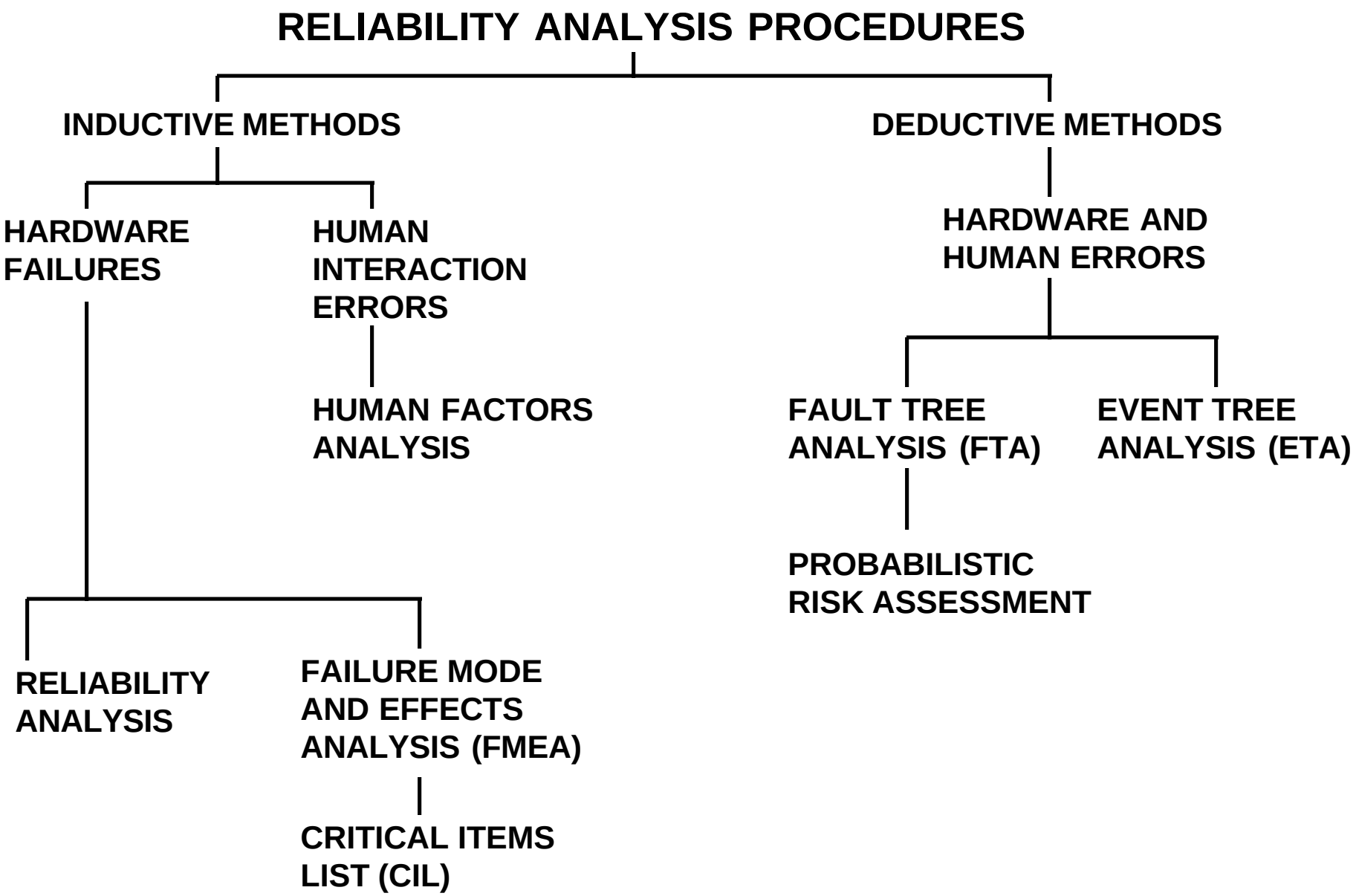
RELIABILITY ANALYSIS PROCEDURES

INDUCTIVE PROCEDURES (Bottom-Up Analysis)



DEDUCTIVE PROCEDURES (Top-Down Analysis)




RELIABILITY ANALYSIS PROCEDURES
INDUCTIVE METHODS
DEDUCTIVE METHODS
HARDWARE FAILURES
HUMAN INTERACTION ERRORS
HARDWARE AND HUMAN ERRORS
HUMAN FACTORS ANALYSIS
FAULT TREE ANALYSIS (FTA)
EVENT TREE ANALYSIS (ETA)
PROBABILISTIC RISK ASSESSMENT
RELIABILITY ANALYSIS
FAILURE MODE AND EFFECTS ANALYSIS (FMEA)
CRITICAL ITEMS LIST (CIL)

FAILURE MODE AND EFFECT ANALYSIS

(09 con't)

DEFINITION

- **A methodology to analyze and discover: (1) all potential failure modes of a system, (2) the effects these failures have on the system and (3) how to correct and or mitigate the failures or effects on the system. [The correction and mitigation is usually based on a ranking of the severity and probability of the failure]**

Benefits of FMEA

- **FMEA is one of the most important tools of reliability analysis. If undertaken early enough in the design process by senior level personnel it can have a tremendous impact on removing causes for failures or of developing systems that can mitigate the effects of failures.**
- **It provides detailed insight into the systems interrelationships and potentials for failure.**
- **FMEA and CIL (Critical Items List) evaluations also cross check safety hazard analyses for completeness.**

BACKGROUND

- The failure mode and effects analysis (FMEA) is the most widely used analysis procedure in practice at the initial stages of system development.
- The FMEA is usually performed during the conceptual and initial design phases of the system in order to assure that all possible failure modes have been considered and that proper provisions have been made to eliminate all the potential failures.

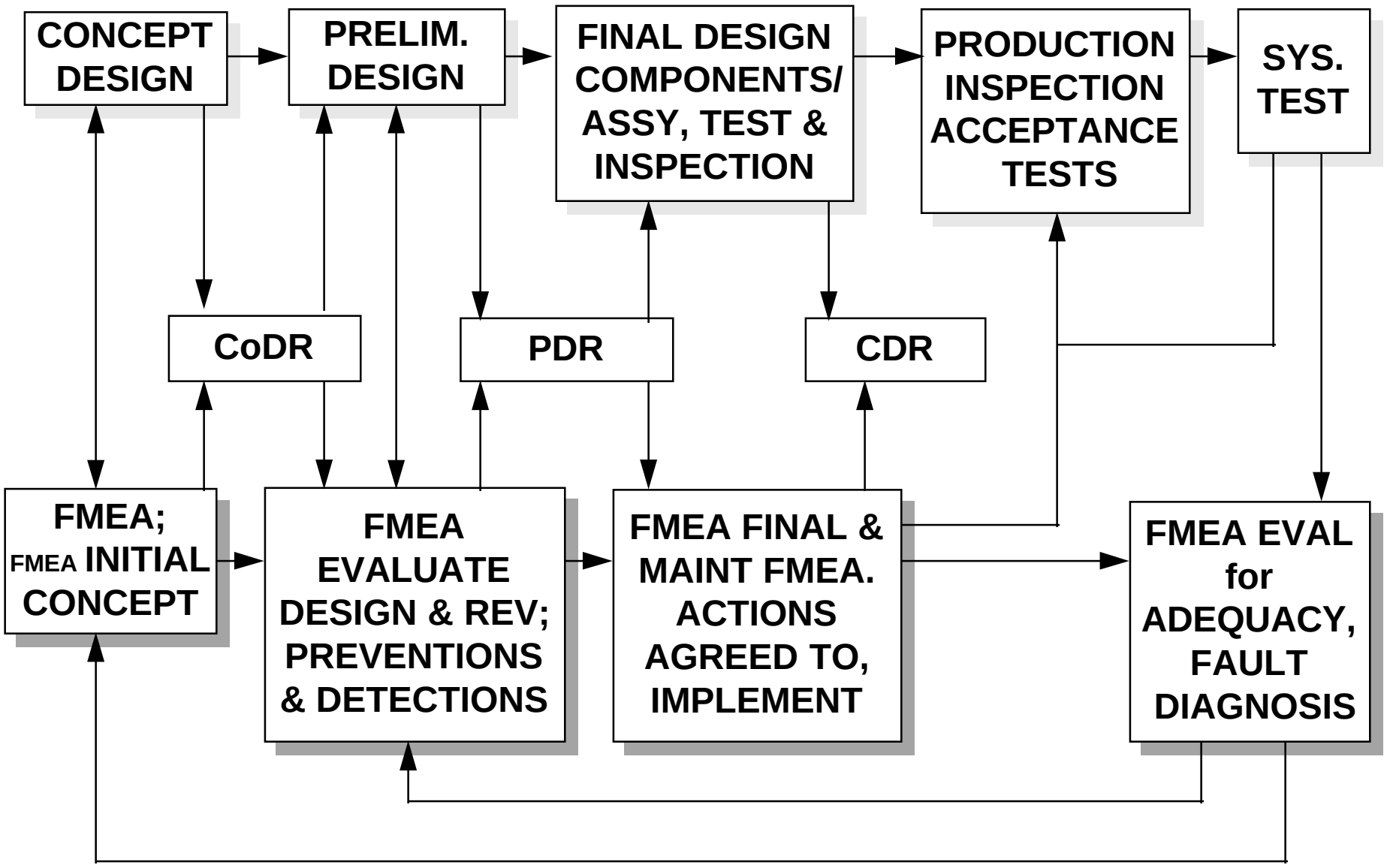
OBJECTIVES:

- **Be able to answer (or perform):**
- **Explain terminology: FMEA, CIL, REDUNDANCY, COMMON MODE FAILURE, etc.**
- **What are the benefits of FMEA and when should they be applied in the design program?**
- **Be able evaluate levels of criticality & redundancy.**
- **Be able to perform a components FMEA and a system FMEA.**
- **Know how to apply the results of a FMEA.**

FAILURE MODE AND EFFECT ANALYSIS

- PURPOSE/TYPES/USES.
- PROCEDURE.
- DATA REQUIREMENTS & TERMS/TYPES.
- WHY AND HOW DO THINGS FAIL?
- PERFORMING A FMEA.
- ADDITIONAL INFORMATION.
  - Critical Items List

System Engineering: FMEA



TYPES

- **Functional**
- **Hardware**
- **FMEA with Criticality Analysis (FMECA)/Critical Items List**
- **Other variations.**

USES--Short Term

- Identify critical or hazardous conditions.
- Identify potential failure modes
- Identify need for fault detection.
- Identify effects of the failures.

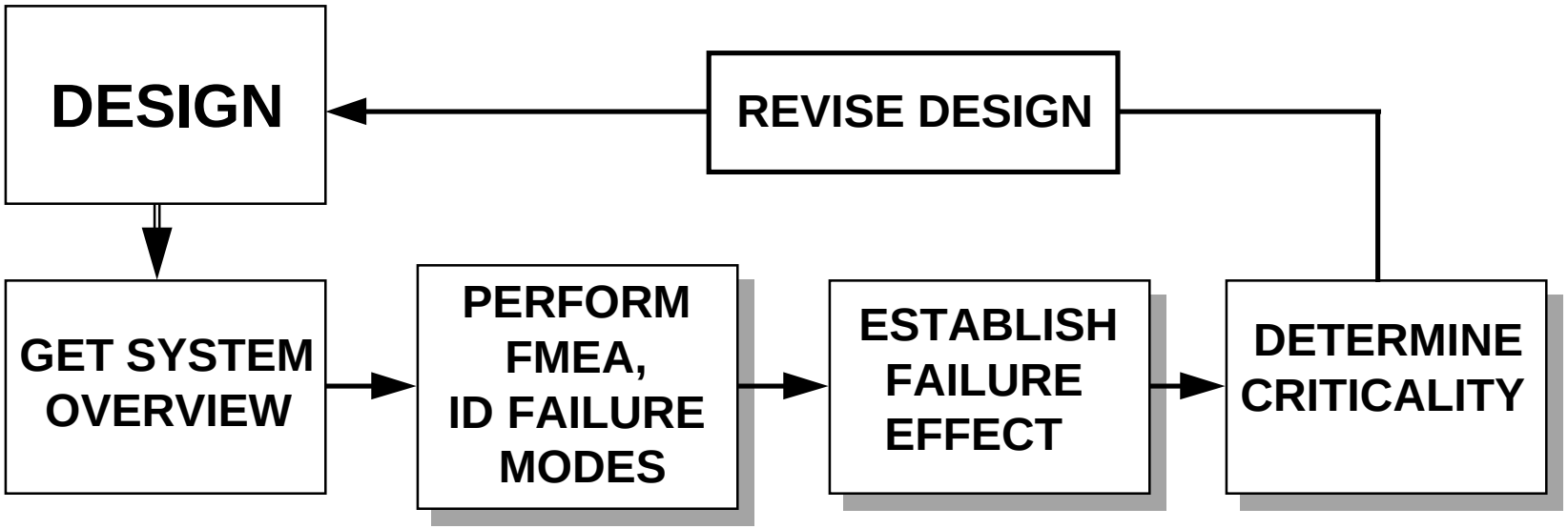
USES--Long term.

- Aids in producing block-diagram reliability analysis
- Aids in producing diagnostic charts for repair purposes.
- Aids in producing maintenance handbooks.
- Design of built-in test (BIT), failure detection & redundancy.
- For analysis of testability.
- For retention as formal records of the safety and reliability analysis, to be used as evidence in product safety litigation.

PROCEDURE

- Get an overview of the system:
  - Determine the function of all componentry.
  - Create functional and reliability block diagrams.
  - Document all environments and missions of sys.
- ID all potential failure modes of each component.
- Establish failure effect on the next level of the sys.
  - Determine failure detection methods.
  - Determine if common mode failures exits.
- Determine criticality of the failure, ranking & CIL.
  - Develop CIL
  - Corrective actions/retention rationale.
- Provide suitable follow-up or corrective actions.

PROCEDURE-FLOWCHART

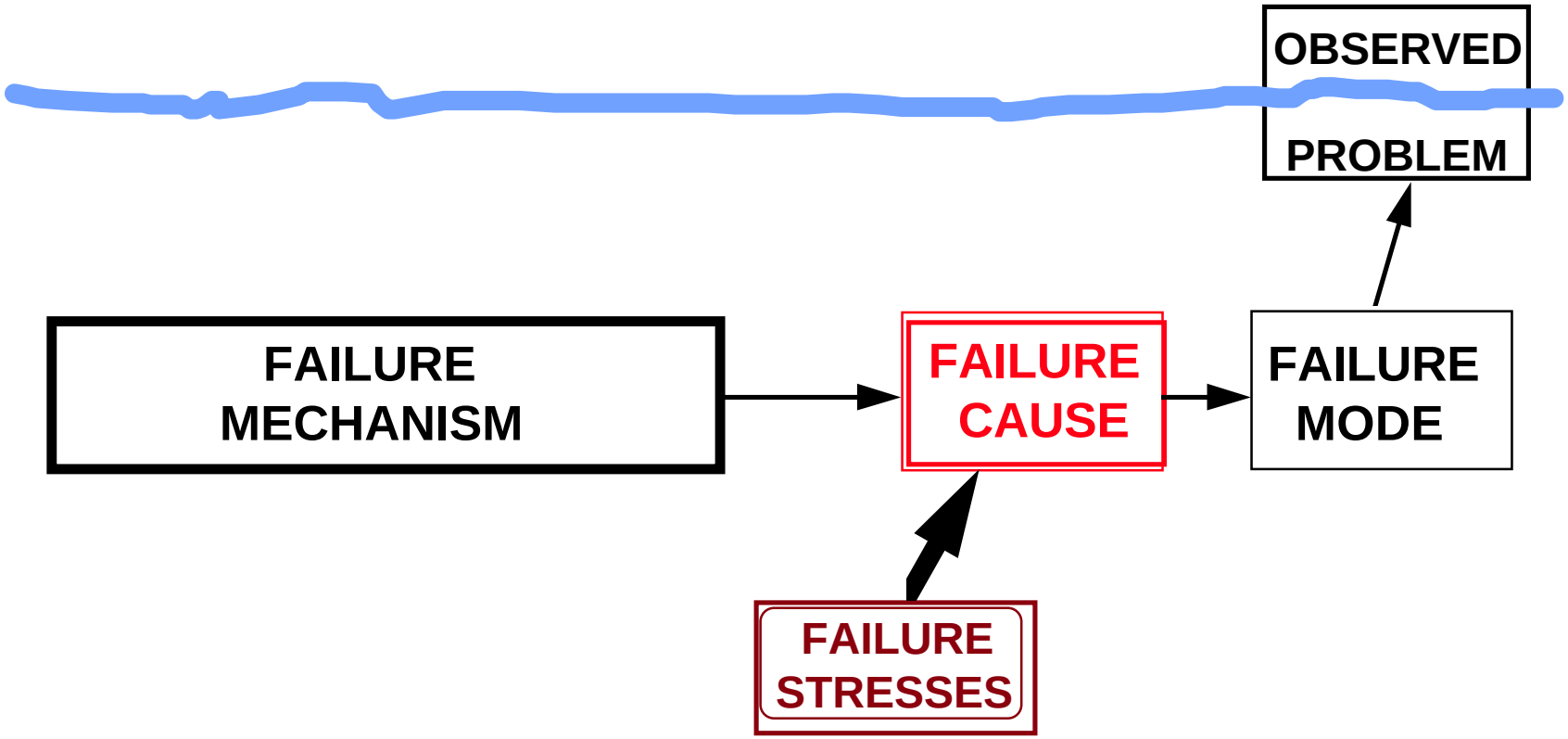


TERMS: FMEA WORKSHEET

Title:_____
System:_____ **Page ___ of ____**
Analyst:_____ **Date:**_____

Description	Function	Failure Mode	Cause of Failure	Effect of Failure	Corrective Action Detection	Crit./ Rank

FAILURE TERMS REVIEW:
THE PROCESS OF FAILURE



WHY DO THINGS FAIL?
(Failure Mechanisms)

- fatigue/fracture
- structural overload
- electrical overload
- wear (lube failure)
- wear (contamination)
- wear
- seal failure
- chemical attack
- oxidation

material removal

radiation

HOW DO THINGS FAIL? (Failure Mode)

- In what ways can they fail?
- How probable is this failure?
- Do one or more components interact to produce a failure?
- Is this a common failure?
- Who is familiar with this particular item?
- PROBLEM--VALVE(P)

OPTIONAL PROB: CHEM MICRO EXP

Review--PURPOSE OF FMEA???

- **The purpose is to identify the different failures and modes of failure that can occur at the component, subsystem, and system levels and to evaluate the consequences of these failures.**

CONCLUSION--BENEFITS OF FMEA

- Identify critical or hazardous conditions.
- Identify potential failure modes
- Identify need for fault detection.
- Identify effects of the failures.

END>MORE

ADDITIONAL INFORMATION

CRITICALITY ANALYSIS

- Assign critically categories based on redundancy, results of failure, safety etc.
- Develop criteria for what failure modes are to be included in a critical items list (CIL).
- Develop screens to evaluate redundancy.
- Analyze each critical item for ways to remove it, or develop “retention rational” to support the premise that the risk can be retained.
- Cross check critical items with hazard reports.

CRITICALITY CATEGORIES (TYP.)

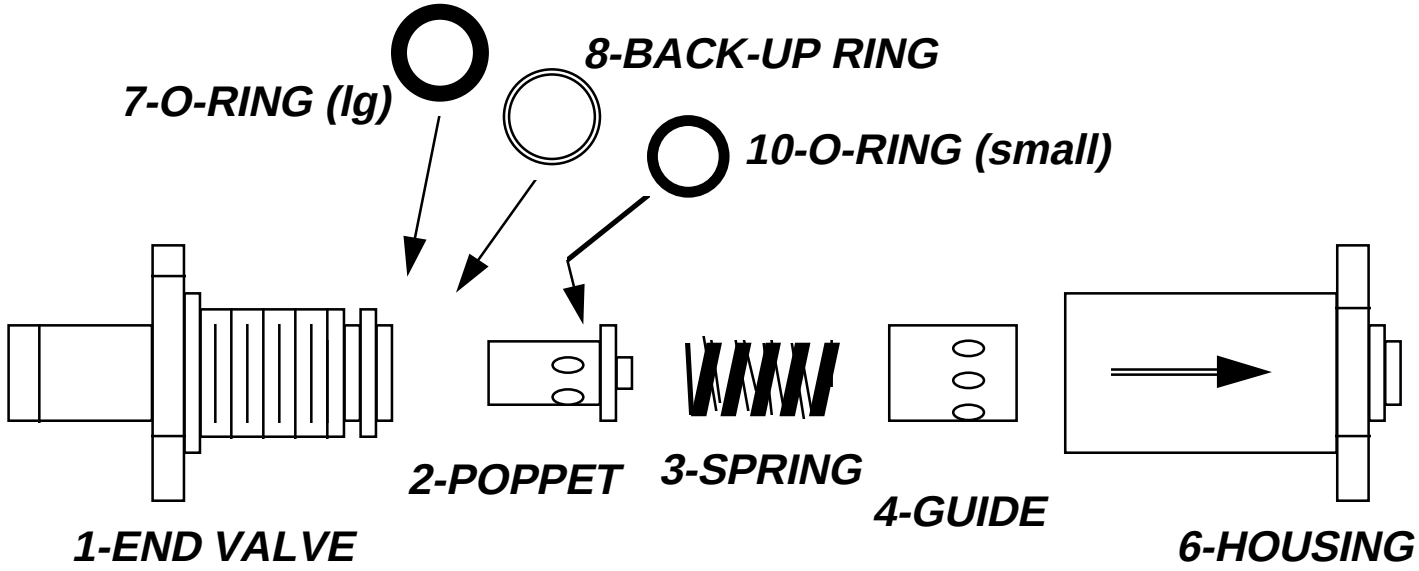
- **1** Single failure point that could result in loss of vehicle or personnel.
- **1R** Redundant items, where if all failed, the result is loss of vehicle or personnel.
- **1S** A single failure point of a system component designed to provide safety or protection capability against a potential hazardous condition or a single point failure in a safety monitoring system (e.g. fire suppression system).
- **1SR** Redundant components, where if all failed, the result is the same as 1S above.
- **1P** A single failure point which is protected by a safety device, the functioning of which prevents a hazardous condition from occurring.
- **2** Single point failure that could result in loss of critical mission support capability.
- **3** All other.

Analyze Critical Items

- Redesign item, add redundant unit, etc.
- Prepare retention rationale for item.
  - What current design features minimize the probability of occurrence.
  - What tests can detect failure modes during acceptance tests, cert. tests, prelaunch and/or on-orbit checkout.
  - What inspections can be performed to prevent the failure mode from being mfg, into hardware.
  - What failure history justifies the CIL retention.
  - How does operational use of the unit mitigate the hardwares failure effect.
  - How does maintainability prevent the failure mode.

END

PROBLEM--VALVE



FFF

RELIABILITY BLOCK DIAGRAM of _____

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FMEA WORKSHEET

Title:_____

System:_____ **Page ___ of ____**

Analyst:_____ **Date:**_____

Description	Function	Failure Mode	Cause of Failure	Effect of Failure	Corrective Action Detection	Crit