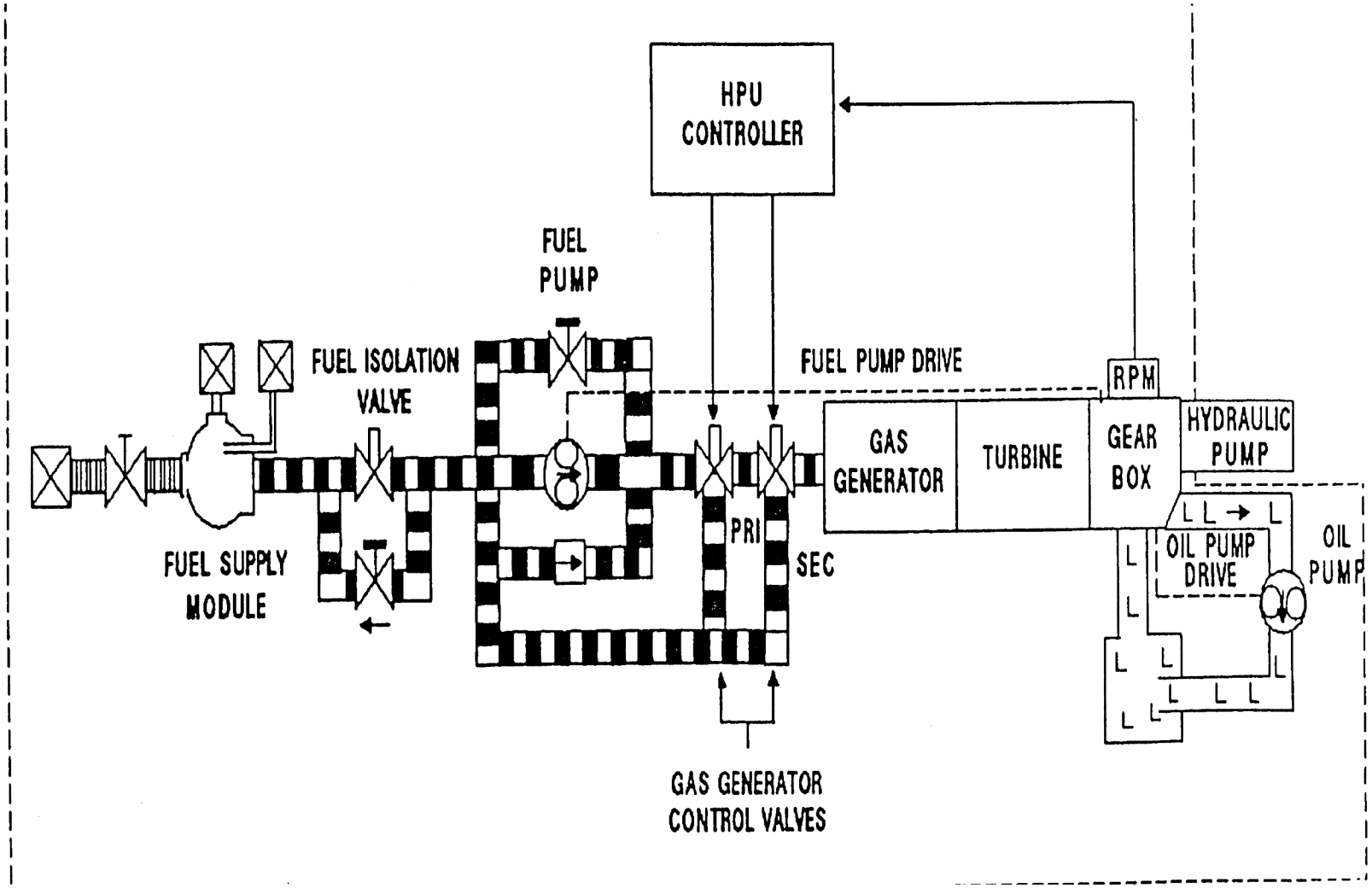
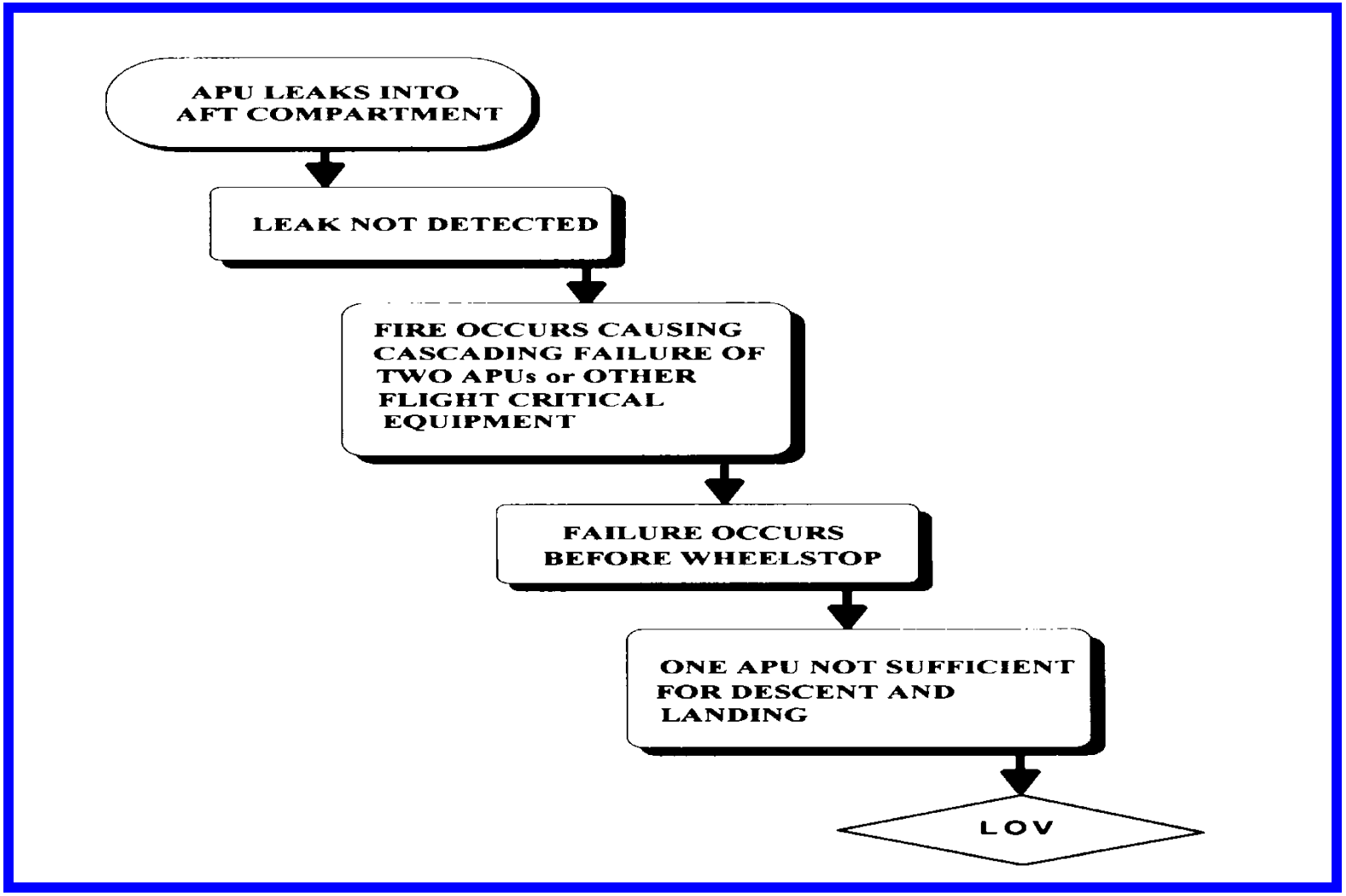
Space Shuttle PRA Proof-of-Concept Study

- Objective: Determine, for the Space Shuttle APU, if PRA can find high risk areas that the traditional FMEA/CIL and HA techniques did not.
- Method: Used available shuttle and surrogate/generic data, within a phased event tree/fault tree risk model, to determine APU risk with uncertainties, significant scenarios, and significant failure modes.
- Reference Book
  - Frank, M., Choosing Safety: A Guide to Using Probabilistic Risk Assessment and Decision Analysis in Complex, High Consequence Systems, RFF (Resources for the Future) Press, 2008. Pages 137-163

Typical APU Schematic

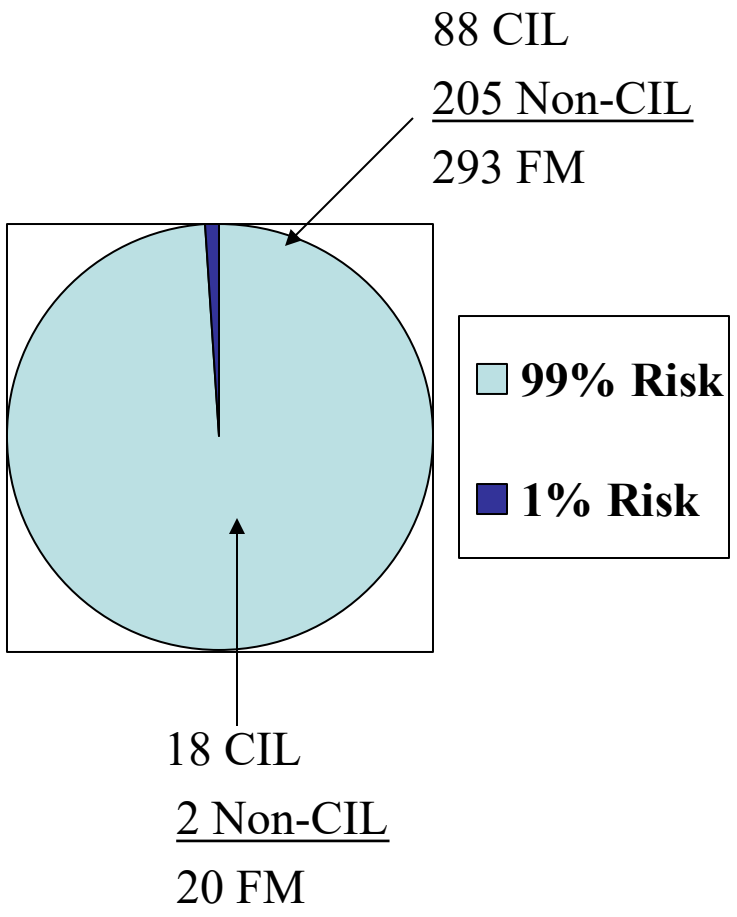


Highest Safety Risk Scenario



Findings of POC Study

- NASA's identified hazards and FMEA failure modes are not ranked via quantitative risk estimates
- Basic events in risk model corresponded to failure modes from NASA's FMEA process.



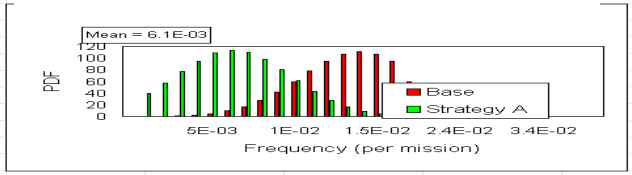
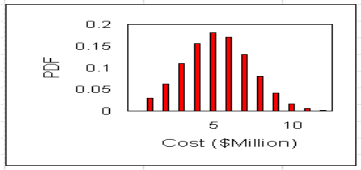
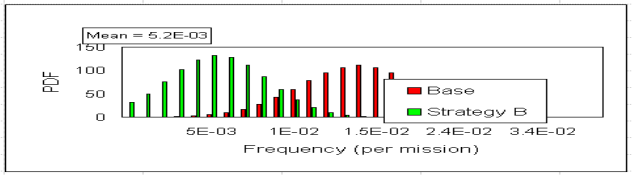
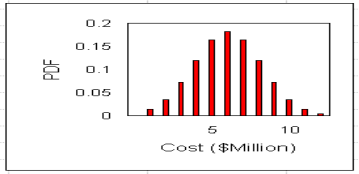
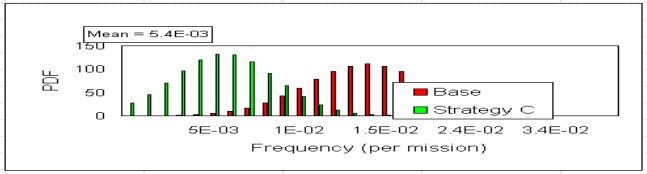
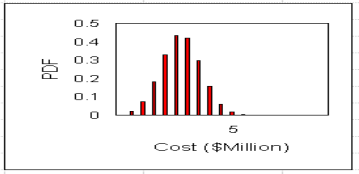
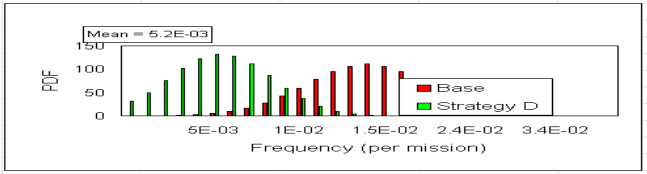
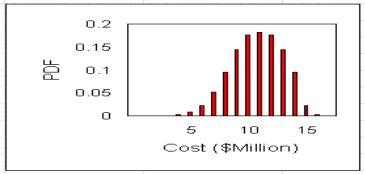
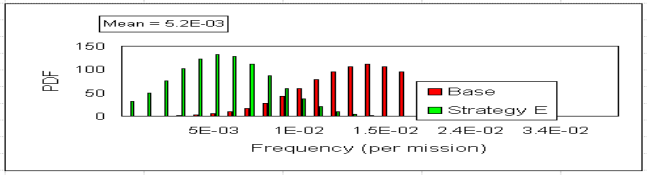
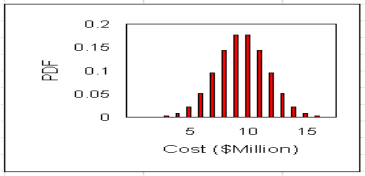
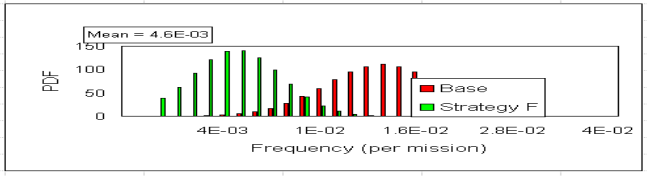
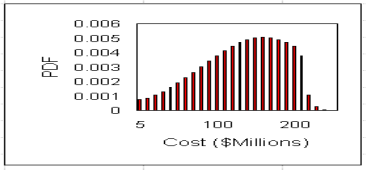
Findings of POC Study

- Scenarios comprising approximately 40% of the risk were not identified in NASA's hazard analyses.
- Part of the efficacy of risk assessment is its ability to "Integrate" across failure modes, hazards and system boundaries.
- NASA's approach to redundancy was not failure mode specific.
  - Three APUs on shuttle for operational redundancy increased risk of fire and explosion because hydrazine leakage was dominant failure mode.

Best APU Risk Reduction Strategy

- Objective: Find the best alternative modification of the Space Shuttle APU considering both safety improvement and cost.
- Method: Using a baseline risk assessment of Space Shuttle APU, modify risk model for each alternative strategy. Obtain cost to implement each strategy. Use various decision analyses to decide on best overall alternative.

Results of Cost and Safety Studies

Strategy	Description	Safety of Strategy (Frequency of Loss of Vehicle)	Cost of Strategy
A	Leak Detection System		
B	Barriers		
C	Inert AFT Compartment		
D	Inert Atmosphere Inside Barriers		
E	Fire Suppression inside Barriers		
F	One of Three APUs Fully Capable of Descent and Landing		

Findings of APU Risk Reduction Study

- There is no single best
- The results depend on:
  - decision rule that is used (e.g. least loss or maximum benefit-to-cost)
  - the relative emphasis that the decision-maker puts on cost v. safety