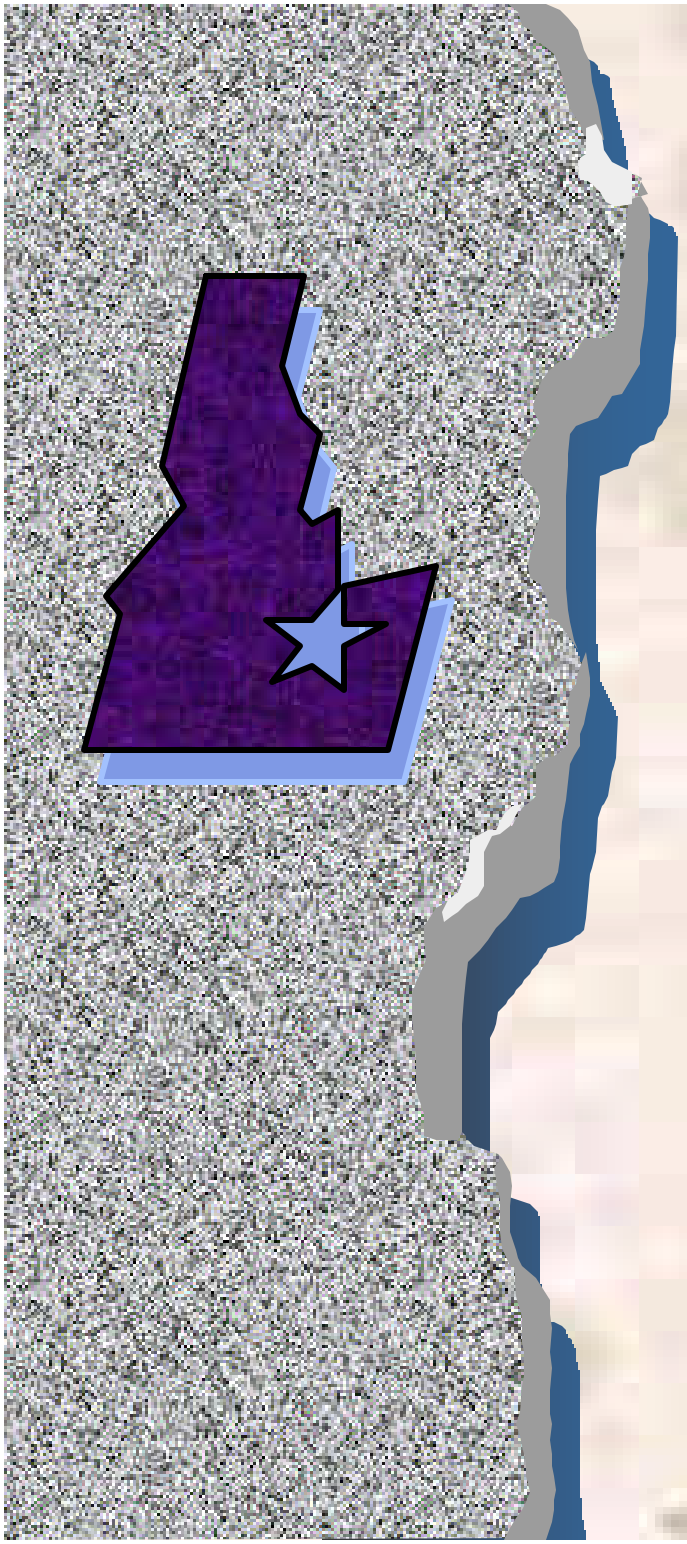

An Overview of Probabilistic Risk Assessment Concepts

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Topics – Overview of PRA

- General concepts behind PRA
- Event tree analysis
- Fault tree analysis
- Data analysis
- PRA Results

General Concepts Behind PRA

- Probabilistic Risk Assessment (PRA) is a analysis that systematically answers:
  - What can go wrong (accident scenario)
  - How likely is it to occur (probability, frequency)
  - What will be the outcome (consequences)

General Concepts (cont.)

- Simplified banking example:
  - What can go wrong
    - ATM machine malfunctions
  - How likely is it to occur
    - Event tree and fault tree used to quantify likelihood
  - What will be the outcome
    - Quantification of customer dissatisfaction and potential of losing business

Event Tree Analysis

- Event tree analysis definition

"An analytical technique for systematically identifying potential outcomes of a known initiating event."

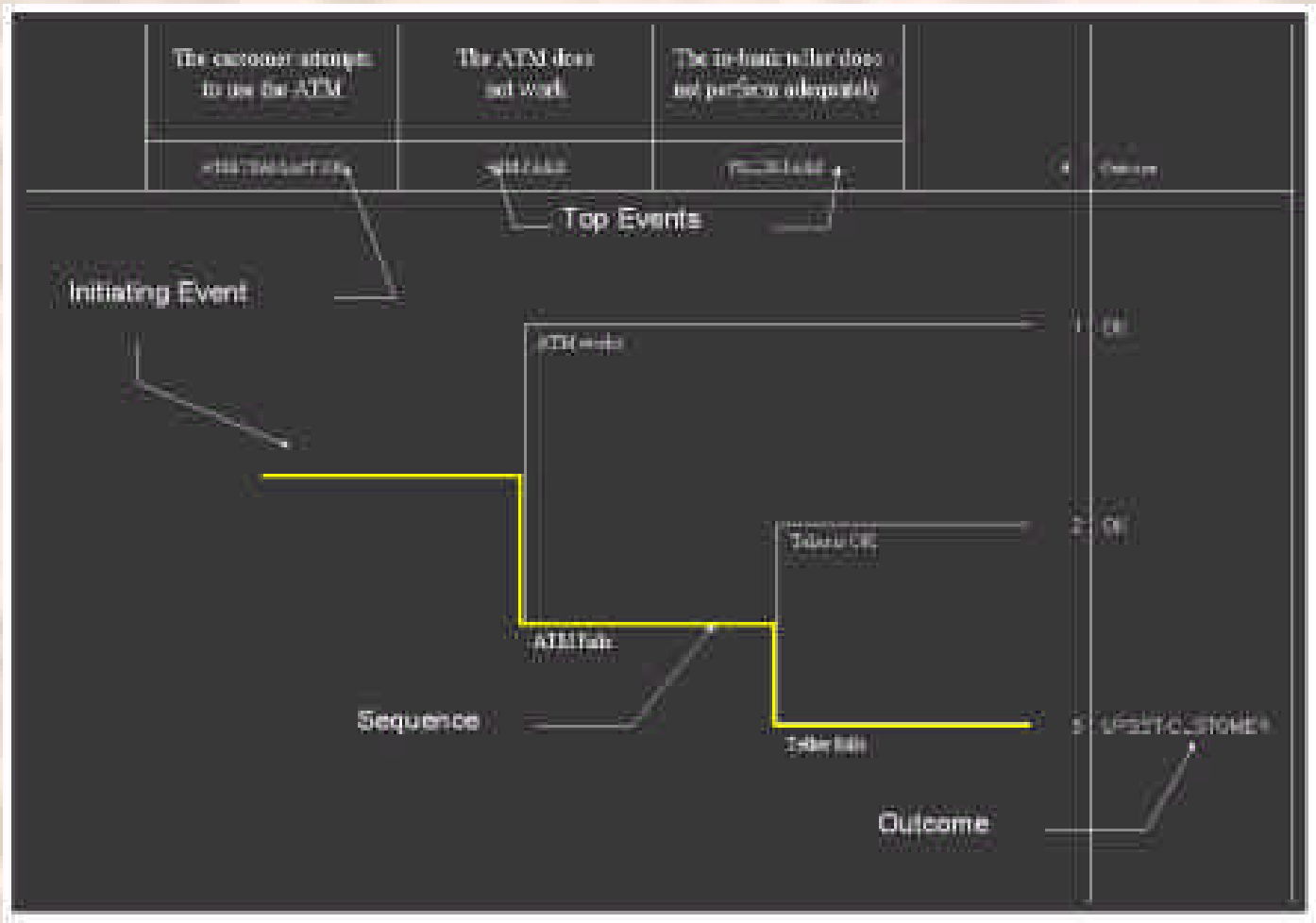
- An "initiating event" is anything that begins a series of actions. Examples include:
  - Power is lost at a computer facility
  - Customer enters a store
  - Jetliner suffers electrical fire
  - Data is entered incorrectly in data-entry form

Event Tree Analysis (cont.)

- The event tree development process:
  - Determine boundaries of analysis
    - What begins the sequence of events (IE)
    - What are the outcomes
  - Define “success criteria”
    - What has to work
  - Event tree heading (top events)
    - What is the order
  - Sequence delineation
    - What are the sequences of interest

Event Tree Analysis (cont.)

- Simplified banking example:



Fault Tree Analysis

- Fault tree analysis definition

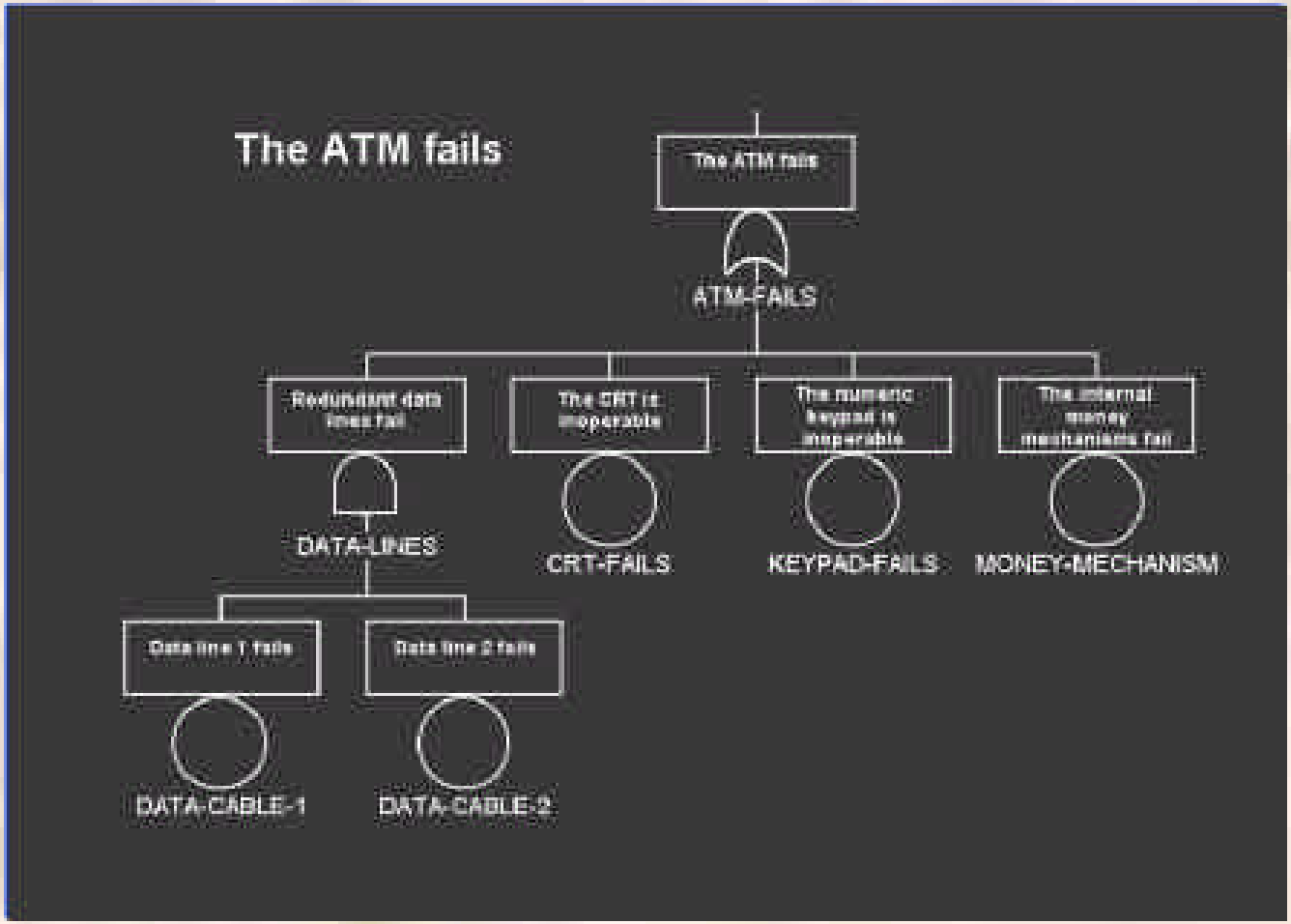
"An analytical technique, whereby an undesired state of the system is specified, and the system is then analyzed in the context of its environment and operation to find all credible ways in which the undesired event can occur."

Fault Tree Analysis (cont.)

- Purpose of fault tree analysis
  - Identify ways in which a system can fail
    - “Minimal cut sets” illustrate ways system can fail
  - Quantify system performance (e.g., unreliability)
  - Models can be used to find:
    - Interrelationships between failure events
    - System failure probabilities
    - Identification of system “weaknesses”

Fault Tree Analysis (cont.)

- Simplified banking example:



Data Analysis

- Data analysis definition

  "Data analysis for probabilistic analysis entails the failure rate (or probability) determination for basic events from available sources of failure information and knowledge."

- A "basic event" represents the lowest level of failure in a fault tree
  - Failure can not be subdivided further
  - Decision to stop failure modeling detail

Data Analysis (cont.)

- Purpose of data analysis
  - Quantifies likelihood of component failure
  - Used in quantification of overall system results
  - Needed to “rank” individual basic events relative to other basic events
    - “Importance measures” are used to rank events
  - Vital for the determination of uncertainty

Data Analysis (cont.)

- Simplified banking example:
  - In the fault tree, several basic events are used:

KEYPAD-FAILS represents failure of the keypad to work for the customer.

Failure experience suggests that, on average, the keypad will not work 3 out of 1000 uses.

Therefore, the failure probability for the keypad is 3E-3.

PRA Results

- Primary results from a PRA include:
  - Minimal cut sets
  - Overall component, system, or plant...
    - Failure probability
    - Risk level (i.e., consequences)
    - Importance measures
  - Design insights
    - Single point failures
    - Most likely combination of failures
    - Identification of “most bang for the buck” components
  - Uncertainty results

PRA Results (cont.)

- Simplified banking example:
  - Probability that customer is upset = 5E-6 (per ATM usage)

Minimal cut sets...

No.	% of Total	Probability	Cut Sets
1	61.2	3.000E-006	ATM-TRANS, KEYPAD-FAILS, TELLER-FAILS
2	81.6	1.000E-006	ATM-TRANS, CRT-FAILS, TELLER-FAILS
3	91.9	5.000E-007	ATM-TRANS, MONEY-MECHANISM, TELLER-FAILS
4	100.0	4.000E-007	ATM-TRANS, DATA-CABLE-1, DATA-CABLE-2 TELLER-FAIL

PRA Results (cont.)

- Simplified banking example (cont.):

  Importance measures…

Event Name	Prob.	F-V	RAW
TELLER-FAILS	1.0E-3	1.0	998
KEYPAD-FAILS	3.0E-3	0.61	200
CRT-FAILS	1.0E-3	0.20	200
MONEY-MECHANISM	5.0E-4	0.10	210
DATA-CABLE-1	2.0E-2	0.081	5
DATA-CABLE-2	2.0E-2	0.081	5

F-V = Percent of time showing up in the total minimal cut sets

RAW = Factor increase in total if basic event fails

PRA Results (cont.)

- Simplified banking example (cont.):
  - Uncertainty results…

Conclusions

- PRA is an analysis that answers:
  - What can go wrong (accident scenario)
  - How likely is it to occur (probability, frequency)
  - What will be the outcome (consequences)
- The SAPHIRE software tool is used to:
  - Model accident scenarios (event trees)
  - Model failure occurrences (fault trees)
  - Model undesired outcomes (end states)