Idaho National Laboratory

INL

LESSON 6

HRA Modeling

Study Guide

Topic: HRA Modeling

Purpose: This lesson introduces HRA modeling. Once errors have been identified, their relationship to each other and to recovery actions can be modeled. Modeling provides insight into the causes, vulnerabilities, recoveries, and possible prevention strategies. Modeling also enables quantification.

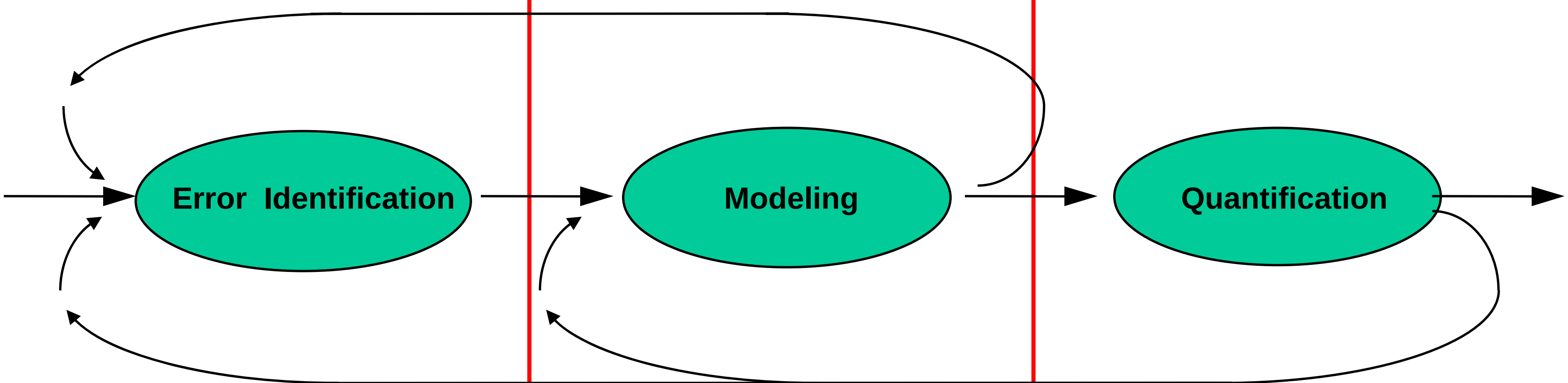
Objectives: At the end of this lesson, students will be able to:

- Explain the usefulness of modeling
- Describe types of models that are commonly used
- Explain the logic used in a HRA event tree and in a fault tree
- Create models for various events
- Recognize other types of modeling

Resources:

- Reason, Chapters 3 and 8; Gertman and Blackman, Chapters 4, 10, and 13

Requirements for Human Reliability Analysis



task analysis
error taxonomies
context
performance shaping factors
errors of commission

fault trees
event trees
generic error models
dynamic event trees

data availability
data bases
simulation
empirical approaches

A Model is … (among other things)

- ***A miniature representation of something***
- ***A description or analogy used to help visualize something (as an atom) that cannot be directly observed***
- ***A system of postulates, data, and inferences presented as a mathematical description of an entity or state of affairs***

Why Model Human Failure Events?

- ***To represent human errors and their mechanisms***
- ***To qualitatively represent roles of personal, task, and environmental performance shaping factors***
- ***To enable error quantification (derive an HEP)***
- ***To provide insight into the causes, vulnerabilities, recoveries and possible prevention strategies associated with various scenarios***

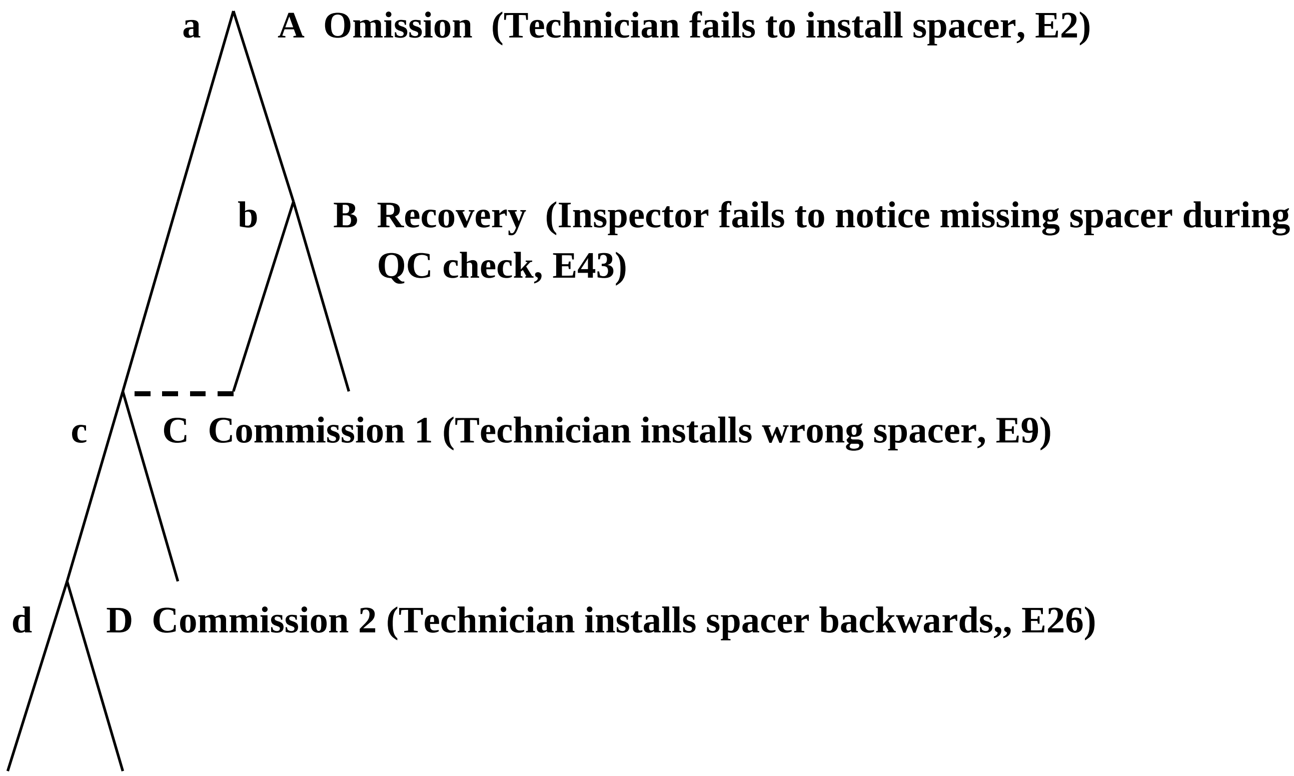
Types of Models Used in HRA

- ***HRA Event Trees***
- ***Fault Trees***
- ***Generic Error Modeling System (GEMS)***
- ***Influence Diagrams***

HRA Event Tree

- ***Developed by Swain and colleagues at Sandia***
- ***Documented in Technique for Human Error Rate Prediction THERP (NUREG/CR-1278)***
- ***Features:***
  - ***Related to systems/functions***
  - ***Event sequence progression***
  - ***End-to-end traceability of scenarios***
- ***Primary use***
  - ***Identification of event sequences which result in some outcome of interest***
  - ***Basis for scenario quantification***

Sample HRA Event Tree



(See Appendix C for HRA Event Tree Tutorial)

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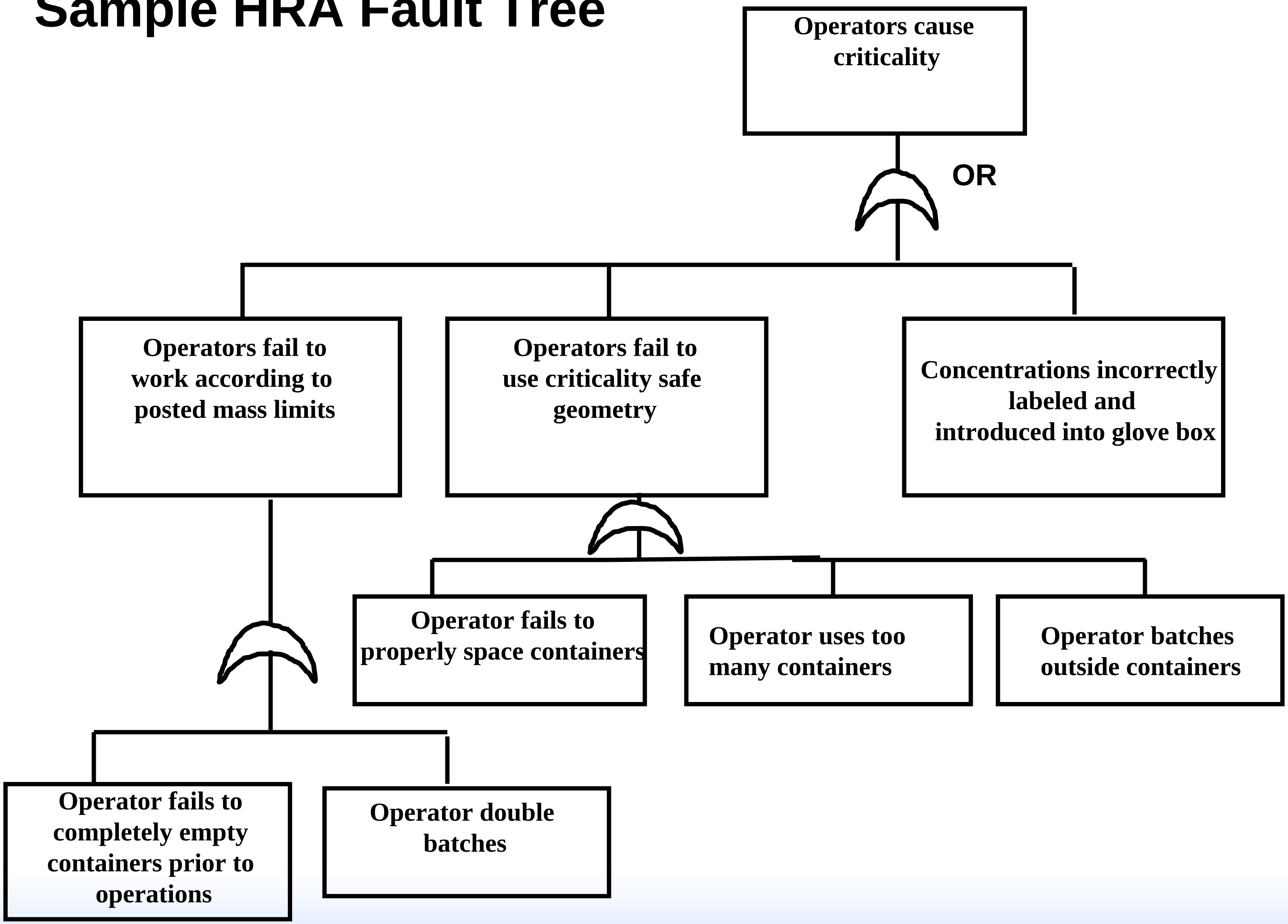
HRA Fault Trees

- ***Can be used to represent the same human actions and logical structures as HRA event trees***

- ***Particularly useful in emphasizing the structure of*** *AND* ***and*** *OR* ***logic***

- ***Unlike HRA event trees, HRA fault trees do not do a good job of showing*** *sequence*

Sample HRA Fault Tree



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#10 HRA Fault Tree and HRA Event Tree Exercise

- ***Team exercise. Get together in your teams***
- ***Using the failures identified in your appendix containing a synopsis from NUREG 6088 (Appendix A) for the misadministration you reviewed earlier, draw a fault tree and an event tree***
- ***Since you didn't perform a task analysis, think about which tasks are important and why, as you design your trees***
- ***Report out and discuss***

Synopsis of Cask Preparation

Remote or manual cask preparation operations consist of gas sampling, venting, lid unbolting and removal, gas and water cool-down, shield plug unbolting, and attachment of the shield-lug lifting fixture. If the cask contains individual spent nuclear fuel assemblies with no dual-purpose canister, it will be filled with water in the preparation pit and then transferred to the cask unloading pool.

These operations are prior to removal of the spent nuclear fuel assemblies from the transport cask from processing in the waste handling building. If the cask gasses are determined to be contaminated during the sampling process, then the cask is supposed to be transferred to a remediation hot cell for special handling and decontamination. If the cask gasses are not determined to be contaminated, then the cask will remain in the routine processing area, where the spent nuclear fuel assemblies will be removed from the transportation cask and ultimately packaged in a disposal container.

Personnel with Fuel Pool Access

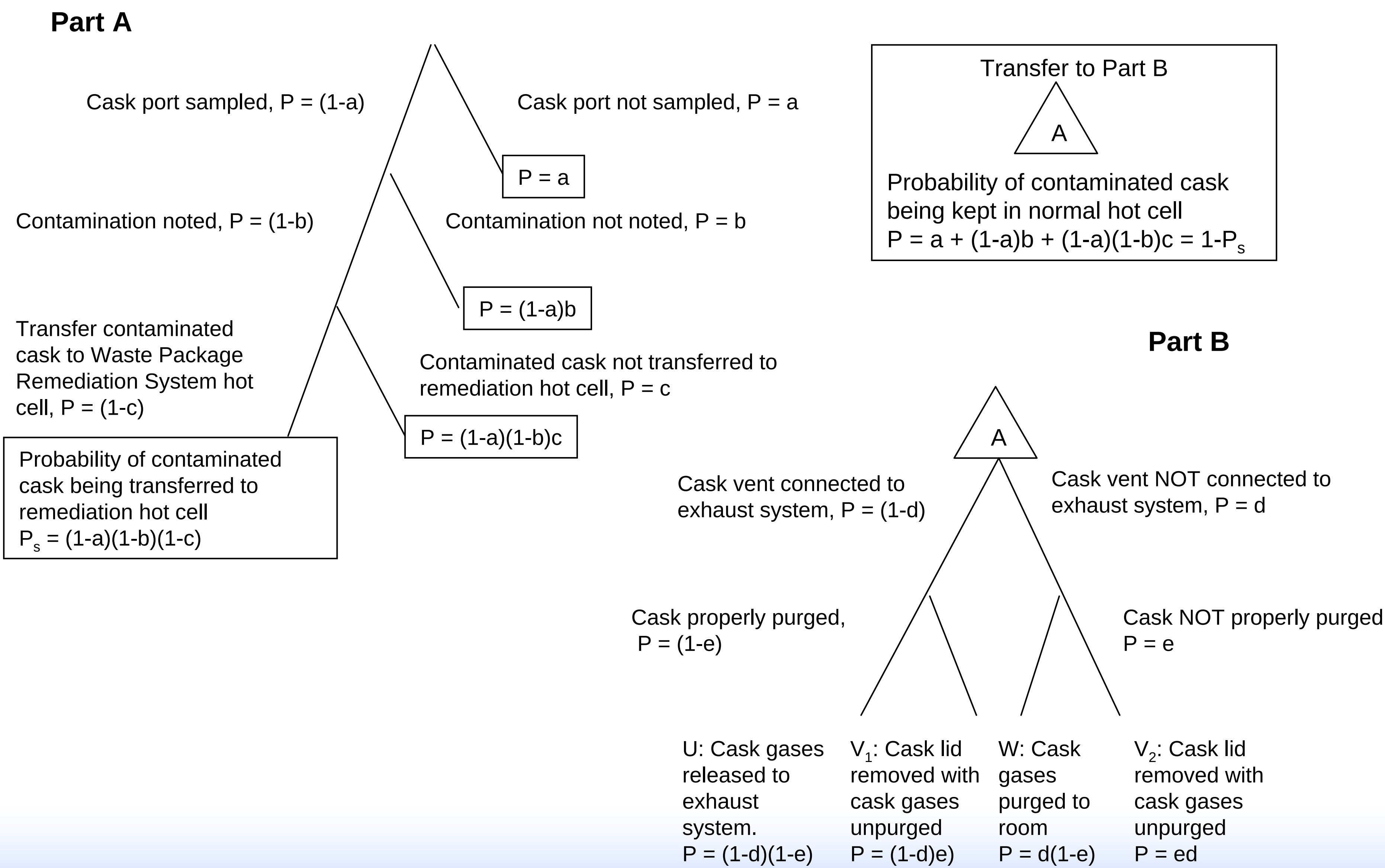
1. Radiation workers	Handle spent nuclear fuel and other radioactive material
2. Maintenance workers	Maintain equipment involved in safety-related tasks, such as hoists, transporters, cranes, and hot-cells
3. Nonradiation workers	Handle excavation, mechanical, and other tasks, but do not handle radioactive material or equipment for handling radioactive material
4. Managers	Do not perform operational tasks, but supervise others in those tasks
5. Security	Provide for physical security for the site
6. Nonsafety facility workers	Ordinary maintenance workers perform common janitorial and other routine tasks
7. Visitors	As with the current facility, visitors are expected on a frequent basis

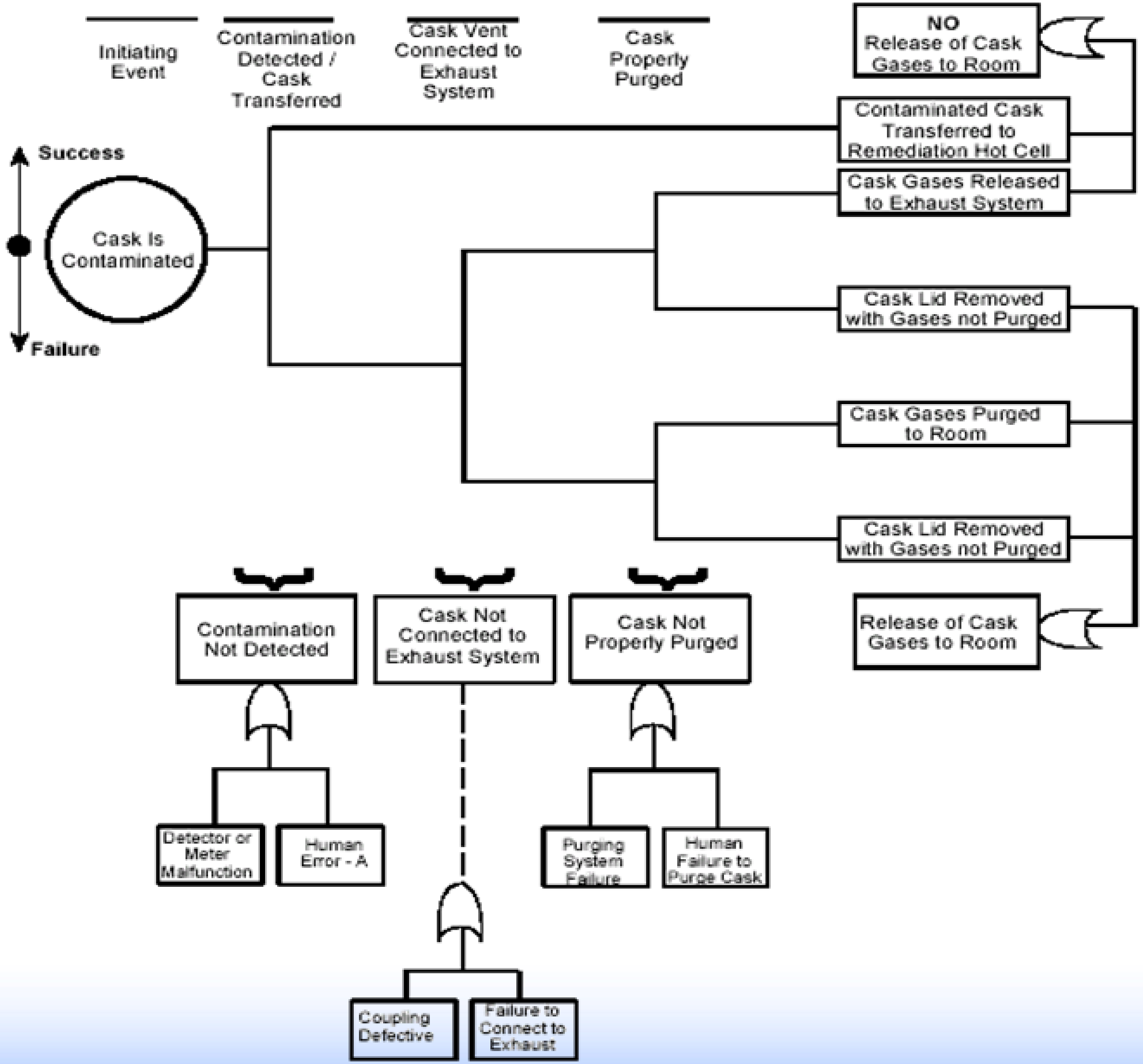
Possible Human Errors:

- ***The cask vent port is not properly connected to the radiation detector***
- ***The radiation detector is not read correctly to identify contamination, when present***
- ***The cask is not transferred to the remediation hot cell, even though contamination is detected***
- ***A contaminated cask is not properly connected to the exhaust system***
- ***A contaminated cask is not properly purged of contaminated cask gases***

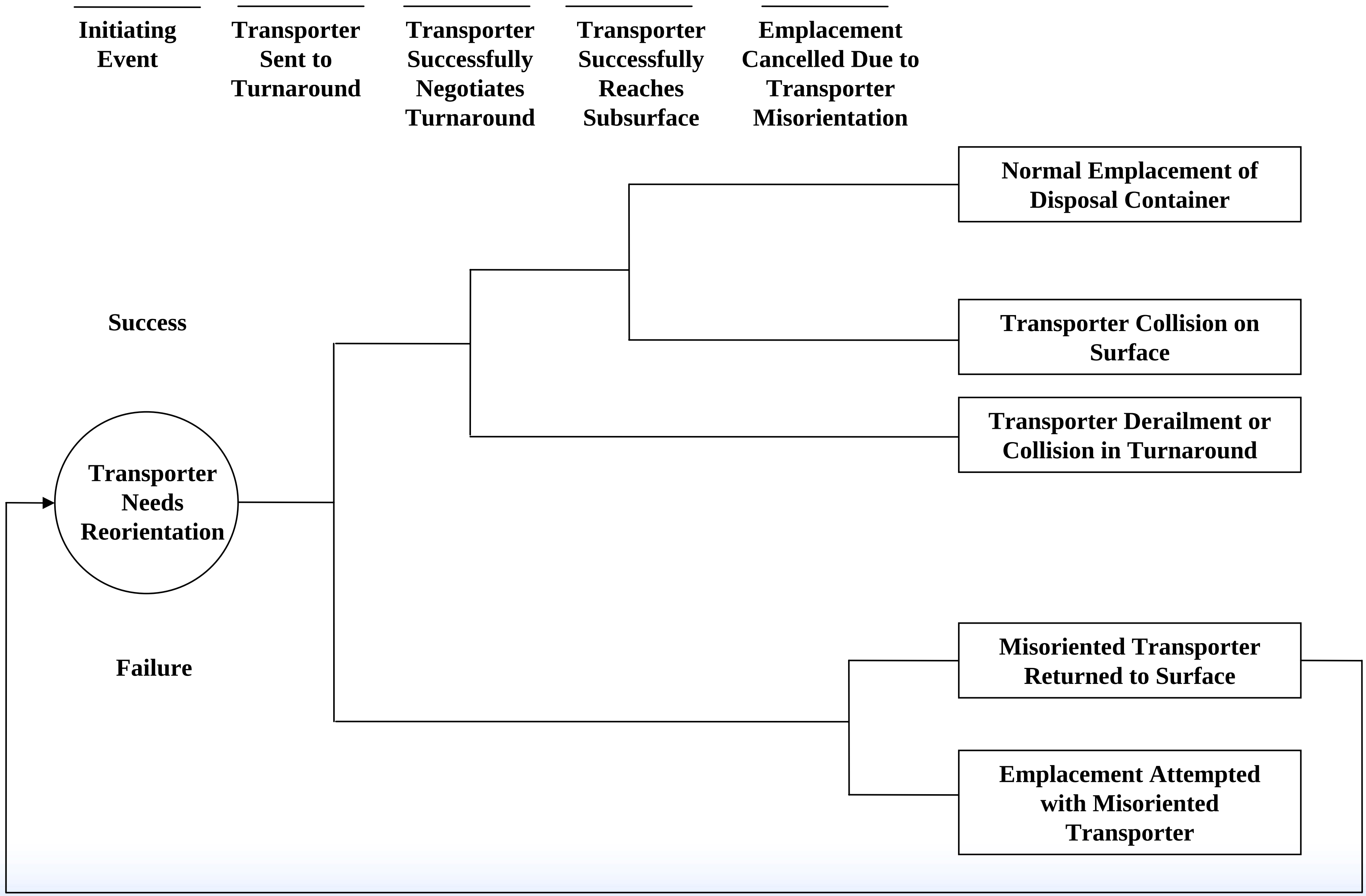
What would a fault tree look like for this scenario?

An event tree?


Part A
Cask port sampled, P = (1-a)
Cask port not sampled, P = a
P = a
Contamination noted, P = (1-b)
Contamination not noted, P = b
P = (1-a)b
Transfer contaminated cask to Waste Package Remediation System hot cell, P = (1-c)
Contaminated cask not transferred to remediation hot cell, P = c
P = (1-a)(1-b)c
Probability of contaminated cask being transferred to remediation hot cell
P_s = (1-a)(1-b)(1-c)
Transfer to Part B
A
Probability of contaminated cask being kept in normal hot cell
P = a + (1-a)b + (1-a)(1-b)c = 1-P_s
Part B
A
Cask vent connected to exhaust system, P = (1-d)
Cask vent NOT connected to exhaust system, P = d
Cask properly purged, P = (1-e)
Cask NOT properly purged, P = e
U: Cask gases released to exhaust system. P = (1-d)(1-e)
V_1: Cask lid removed with cask gases unpurged P = (1-d)e
W: Cask gases purged to room P = d(1-e)
V_2: Cask lid removed with cask gases unpurged P = ed



Initiating Event
Contamination Detected / Cask Transferred
Cask Vent Connected to Exhaust System
Cask Properly Purged
NO Release of Cask Gases to Room
Success
Failure
Cask Is Contaminated
Contaminated Cask Transferred to Remediation Hot Cell
Cask Gases Released to Exhaust System
Cask Lid Removed with Gases not Purged
Cask Gases Purged to Room
Cask Lid Removed with Gases not Purged
Release of Cask Gases to Room
Contamination Not Detected
Cask Not Connected to Exhaust System
Cask Not Properly Purged
Detector or Meter Malfunction
Human Error - A
Purging System Failure
Human Failure to Purge Cask
Coupling Defective
Failure to Connect to Exhaust



Initiating Event
Transporter Sent to Turnaround
Transporter Successfully Negotiates Turnaround
Transporter Successfully Reaches Subsurface
Emplacement Cancelled Due to Transporter Misorientation
Normal Emplacement of Disposal Container
Success
Transporter Collision on Surface
Transporter Derailment or Collision in Turnaround
Transporter Needs Reorientation
Failure
Misoriented Transporter Returned to Surface
Emplacement Attempted with Misoriented Transporter

Event Group	Design Basis Event	Event Location	Structures, Systems and Components Credited to Prevent a Release
Waste Package Drops	Aboveground lifting system drops vertically oriented waste package	Disposal Container Handling System Cell	Disposal Containers
	Above ground lifting system drops horizontally oriented waste package	Disposal Container Handling System Cell	Disposal Containers
	Bed plate rolls out of waste package transporter	Subsurface	Disposal Containers
	Emplacement gantry drops horizontally oriented waste package	Subsurface	Disposal Containers
	Waste package falls onto a sharp object	Disposal Container Handling System Cell or Subsurface	Disposal Containers

Event Group	Design Basis Event	Event Location	Structures, Systems and Components Credited to Prevent a Release
Waste Package Collisions	Waste package collides in lag storage area	Disposal Container Handling System Cell	Disposal Containers
	Transporter collisions at normal operating speeds	Subsurface	Disposal Containers
	Transporter derails without tipover, but with waste package restraint failure	Subsurface	Disposal Containers
	Transporter derails with tipover	Subsurface	Disposal Containers
	Transporter door closes on waste package	Subsurface	Disposal Containers
	Operation of emplacement gantry causes waste package collision	Subsurface	Disposal Containers

Other Modeling Techniques

- *Maintenance Personnel Performance Simulation* ***(MAPPS)--useful for identifying maintenance activities and their sequence and interrelationships***
- *Socio technical Assessment of Human Reliability* ***(STAHR)--useful for describing influences affecting decisions and actions***
- *Generic Error Modeling System* ***(GEMS)--useful for understanding how error mechanisms work***
- *Framework for Assessing Notorious Contributing Influences for Error* ***(FRANCIE)***

Other Modeling Techniques (cont…)

- ***Actuarial Analysis***
- ***Hazard/Barrier Analysis***
- ***Relative Ranking Analysis***
- ***Preliminary Hazard Analysis***
- ***What-if Analysis***
- ***Integrated Safety Analysis***
- ***Hazard and Operability Analysis***
- ***Failure Mode and Effects Analysis (FMEA)***

See Appendix D for more details on these methods

Lesson Summary

Key Points:

- ***HRA event tree is a frequently used method of modeling***

- ***Fault trees are also useful but do not provide as much information (sequence or recovery)***

- ***Several other modeling methods have evolved***