Idaho National Engineering and Environmental Laboratory

Probability and Statistics for PRA (P-102)

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Section 1: Introduction

- *The "prob and stats" course, P-102, can be decomposed into four general sections*
  - *Probability Theory*
  - *Frequentist (or Classical) Statistical Inference*
  - *Bayesian Statistical Inference*
  - *Uncertainty Analysis in Risk Assessment*
- *Inference:*

  The logical process by which new facts are derived from known facts by the application of inference rules

Section 2: Probability Theory

- Purpose
  - Students will review fundamentals of probability
  - Become familiar with several probability distributions that are commonly encountered in probabilistic risk assessment (PRA)
- Objectives
  - Students will be able to calculate simple probabilities involving
    - "AND", "OR", "NOT" operations
    - Conditional probabilities, independent events
    - Bayes' theorem
    - Poisson, binomial, and exponential distributions
  - Students will understand the terms mean, variance, percentile, and be able to relate these to particular distributions used in the course

Section 3: Frequentist Statistical Inference

- *Purpose*
  - *Students will learn about the most common estimators, and about methods of model validation*
- *Objectives*
  - *Students will learn*
    - *Definition of maximum likelihood estimator (MLE) and confidence interval*
    - *Application of these estimators to Poisson, binomial, and exponential data*
    - *Graphical tools for model validation*
    - *Intro to hypothesis-testing for model validation, with example applications*

Section 4: Bayesian Probability Inference

- *Purpose*
  - *Students will learn subjectivist view of probability, use of Bayesian updating, and applications to commonly encountered kinds of data*
- *Objectives*
  - *Students will learn*
    - *Probability interpreted as a quantification of degree of plausibility*
    - *Bayes' theorem, Bayesian updates*
    - *Use of discrete priors*
    - *Conjugate priors for Poisson, binomial, and exponential data*
    - *Model validation, checking consistency of data and prior*
    - *Jeffreys noninformative prior for Poisson, binomial, and exponential data*
    - *Techniques for using other priors such as lognormal*

Section 5: Uncertainty Analysis in Risk Assessment

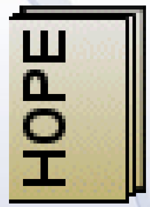
- *Purpose*
  - *Students will see an overview of how Bayesian estimates are obtained in risk assessment*
- *Objectives*
  - *Through examples, students will learn about*
    - *Simulation of distributions with Monte Carlo sampling*
    - *Simulation of a "top event" probability by propagation of distributions through a logic model*
    - *Simple Monte Carlo sampling and Latin hypercube sampling*

Course Reference

- *"Handbook of Parameter Estimation for Probabilistic Risk Assessment," NUREG/CR-6823, September 2003.*

  On the NRC web site at

  www.nrc.gov.reading-rm/doc-collections/
  nuregs/contract/cr6823

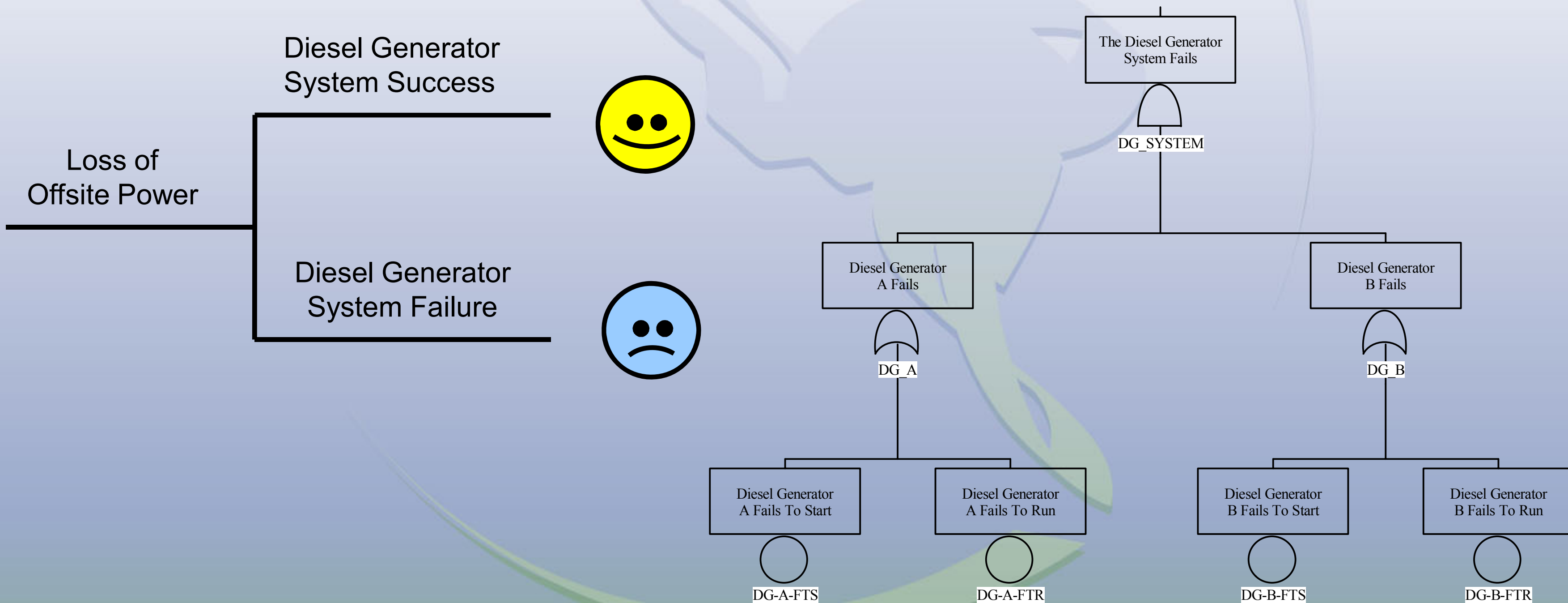


Loss of Offsite Power (LOSP) Example

- The "LOSP example" will be used as a central example throughout most of the course
- A system uses offsite power, but has two standby emergency diesel generators (EDGs)
- Occasionally offsite power is lost (an "initiating event")
  - When this happens the EDGs are demanded to start and run.
- The system
  - Succeeds if either EDG starts and runs for six hours
  - Fails otherwise

LOSP Example

- A PRA will have an event tree representing the scenario
  - Fault trees will represent the diesel generator failures



The Minimal Cut Sets

- *LOSP*DG-A-FTS*DG-B-FTS*
- *LOSP*DG-A-FTS*DG-B-FTR*
- *LOSP*DG-A-FTR*DG-B-FTS*
- *LOSP*DG-A-FTR*DG-A-FTR*