CS 5371 - Software Safety & Risk Analysis

Lecture 4 – Event-Tree Analysis (ETA)

ETA

- Complimentary technique to FTA
- Defines the consequential events which flow from the primary ‘initiating’ event.
- Event trees are used to investigate the consequences of loss-making events in order to find ways of mitigating, rather than preventing, losses.
Stages in carrying out event tree analysis

- Identify the primary event of concern.
- Identify the controls that are assigned to deal with the primary event such as automatic safety systems, alarms on operator actions.
- Construct the event tree beginning with the initiating event and proceeding through failures of the safety functions.
- Establish the resulting accident sequences.
- Identify the critical failures that need to be addressed.

More on ETA

- Typically use Boolean (or binary) logic gates.
- Start on the left with the initiating event and progress to the right, branching progressively.
  - The initiating event is typically specified as an expected annual frequency (e.g. 2 times per year) and the success/failure for each system as a probability.
- Each branching point is called a node.
- Calculate the frequency of each final outcome by multiplying along the branches, travelling from left to right from initiating event to final outcome.
- The sum of each success/failure probability pair, at each specific node adds up to 1.
- The sum of all the final outcome frequencies will add up to equal the frequency of the initiating event (think about it).
Event Tree: Car Accident

- Given potential initiating event, what possible outcomes?
  - Deer runs into road
  - Brakes applied?
  - Brakes function?
  - Braking effectiveness?
Deer in Road Event Tree

Deer runs into road

Brakes Applied
- Brakes Function
  - abrupt Glancing blow
  - effective Safe stop
  - late Glancing blow
- Brakes not Applied
  - partial Glancing blow
  - complete Collision at speed

Brakes not Applied
- Collision at speed

Deer in Road Event Tree Probabilities

Deer runs into road

Brakes Applied
- Brakes Function
  - (P = 0.99) Glancing
    - (P = 0.25) abrupt Safe
    - (P = 0.60) effective Glancing
    - (P = 0.15) late Glancing
- (P = 0.01) Brakes Fail
  - partial (P = 0.60) Glancing
    - complete (P = 0.40) Collision
  - complete (P = 0.40) Collision

Brakes not Applied
- Collision

(Frequency 80/year)
## Probabilities

<table>
<thead>
<tr>
<th>Outcome</th>
<th>Sub-outcome</th>
<th>Calculation</th>
<th>Probability</th>
</tr>
</thead>
<tbody>
<tr>
<td>Safe Stop</td>
<td>(none)</td>
<td>$0.8 \times 0.99 \times 0.6$</td>
<td>0.4752</td>
</tr>
<tr>
<td>Collision</td>
<td>Glancing</td>
<td>$0.8 \times (0.99 \times 0.15 + 0.99 \times 0.25 + 0.01 \times 0.6)$</td>
<td>0.3216</td>
</tr>
<tr>
<td>At speed</td>
<td></td>
<td>$0.2 + 0.8 \times 0.1 \times 0.4$</td>
<td>0.2032</td>
</tr>
</tbody>
</table>

## Calculate Frequencies

- Deer runs into road (Frequency 80/year)
  - Brakes Applied (P = 0.8)
  - Brakes Fail (P = 0.01)
  - Brakes not Applied (P = 0.2)
- Brakes Function
  - (P = 0.99)
  - (P = 0.25) abrupt
  - (P = 0.60) effective
  - (P = 0.15) late
- Glancing
  - (P = 0.01) partial
  - (P = 0.60) complete
- Collision
  - (P = 0.40) complete
# Group Exercise

<table>
<thead>
<tr>
<th>Initiating event</th>
<th>Start of fire</th>
<th>Sprinkler system does not function</th>
<th>Fire alarm is not activated</th>
<th>Outcomes</th>
<th>Frequency (per year)</th>
</tr>
</thead>
</table>

Explosion

\[
10^{-2} \text{ per year}
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