Safety and Reliability of Embedded Systems

(Sicherheit und Zuverlässigkeit eingebetteter Systeme)

Fault Tree Analysis
Conducting a Fault Tree Analysis

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FTA in the Process Context

- FTA is *one* technique for probabilistic risk assessment
- It must be embedded in a safety respecting process, assuring
  - construction of correct, reliable and safe hardware and software
  - analysis and validation of safety and reliability of the whole system in its operation environment throughout all process phases
- It should be accompanied / preceded by
  - Preliminary Hazard Analysis
  - FMEA
  - Event Tree Analysis

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The FTA Procedure

1. Identify the objective
2. Get familiar with operation and success criteria of the system
3. Define the top-event
4. Define the scope
5. Define resolution
6. Define ground rules
7. Construct the FT
8. Evaluate the FT
9. Interpret and present the results

adapted from:
- FT Handbook with Aerospace Applications
- IEC 61025
- DIN 25424

The FTA Procedure

1. Objective
   - All stakeholders should agree on what is to be examined
   - The objective should be stated in written
   - The objective should refer to a failure of the system in application domain vocabulary
   - The objective determines the top-event, the scope, the resolution

☝ **An FTA is a big effort: You should know what it's for!**

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The FTA Procedure

2. Operation and success criteria of the system
   - System functions
   - System structure / components
   - Environmental conditions
   - Auxiliary supplies

Use block diagrams, software models, requirement specifications!

A hierarchical schema of the system is helpful

System structure and correlated failures can be found by an FMEA

Domain experts should participate

☝ **Be sure to understand what you are examining!**

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The FTA Procedure

3. Define top-event
   - Tight cooperation with customer / system integrator
   - If in doubt, try several possibilities and select later
   - Possibly more than one top-event

   ☝ **A wrong or unclear top-event makes the analysis useless!**

4. Define the scope
   - Can be system / component boundary (if well defined)
   - Can be broader than that (e.g. including power supply, operator...)
   - Write down assumptions about the parts that are not supposed to fail

   ☝ **Before starting make clear what to examine and what not**

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The FTA Procedure

5. Define resolution
   - In complex systems it is impossible to model each detail
   - Before starting, define where to stop
   - For system level FTA, it may be useful to stop at the components

☝ **In practice, often too many events are considered that actually play no role!**

6. Define ground rules
   - Naming of events
   - Modeling of recurring structures
   - Write down rules and train all participants

☝ **If cooperation between different companies or departments or later reuse of FTs is an issue, it is worthwhile to set up rules**

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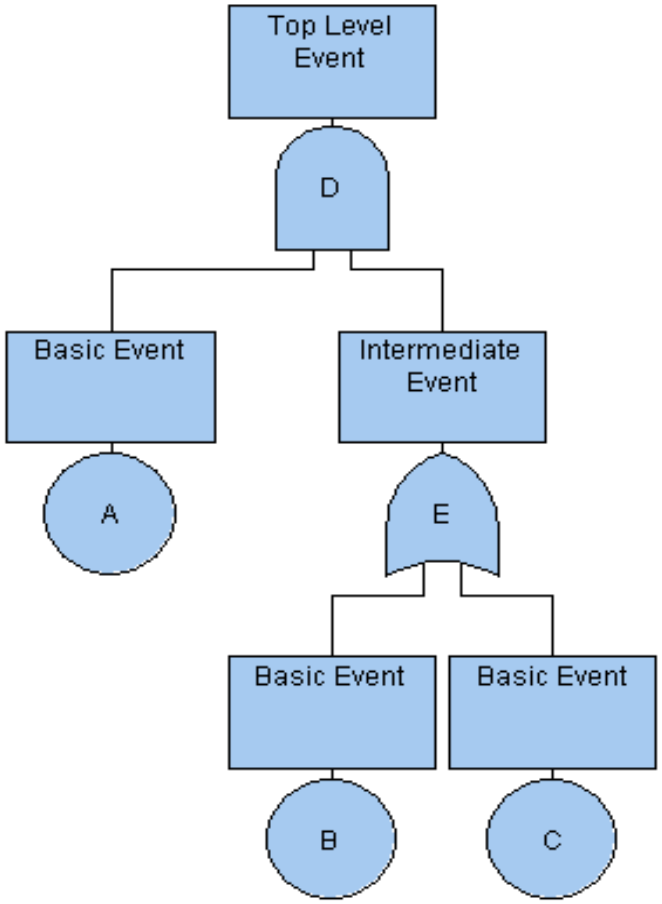
The FTA Procedure



7. Construct the fault tree
   - Go backward in small steps
   - Always ask for *all immediate* predecessors of an event
   - Predecessors are necessary and sufficient causes
   - Name intermediate events
   - Take care of repeated events, distinguish the equal from the same

☝ **The goal is to depict an uninterrupted causal chain, not to (try to) find the most basic causes quickly**

The FTA Procedure

8. Evaluate the fault tree
   - Set parameters correctly (e.g. resolution)
   - Apply qualitative analysis to find minimal cut sets
   - Apply quantitative analysis to get top-event probability and importances of minimal cut sets

☝ **Evaluation is a mechanical job and should be left to the computer**

9. Interpret and present the results
   - Is the probability in the expected / tolerable range?
   - What are the main influences to the top-event?
   - Where should corrective actions be applied?
   - What can be learned about the system structure?

☝ **A probability figure alone is not useful**

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