Technische Universität Kaiserslautern

0101 **se**da 010100

software engineering dependability

Safety and Reliability of Embedded Systems

(Sicherheit und Zuverlässigkeit eingebetteter Systeme)

Fault Tree Analysis
Conducting a Fault Tree Analysis

- FTA in the Process Context
- The FTA Procedure

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

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

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!**

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!**

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**

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**

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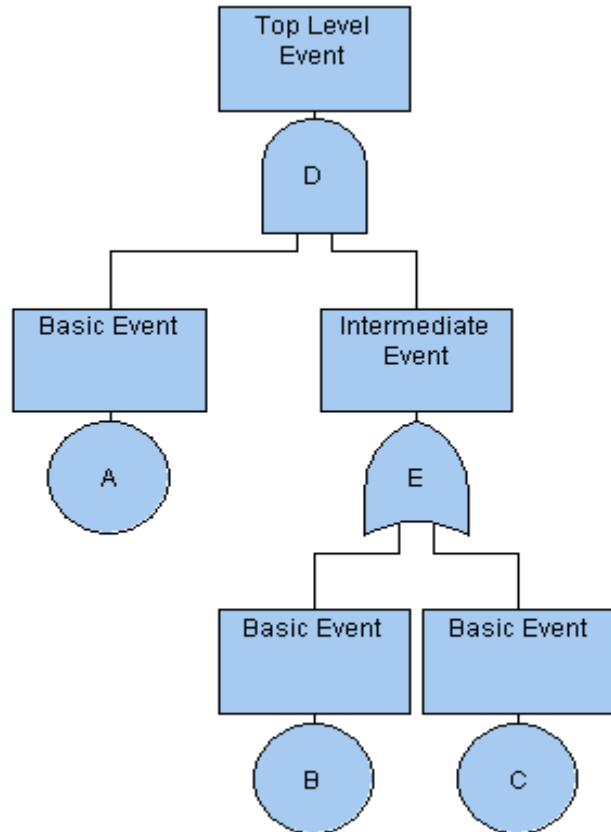
7. Construct the fault tree
   - Go backward in small steps
   - Always ask for *all immediate* predecessors of an event
   - Predecessors are necessary and sufficient causes
   - Name intermediate events
   - Take care of repeated events, distinguish the equal from the same

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

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**