Safety and Reliability of Embedded Systems

(Sicherheit und Zuverlässigkeit eingebetteter Systeme)

Fault Tree Analysis
Conducting a Fault Tree Analysis

Content

- ☐ 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

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!

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!

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

The FTA Procedure

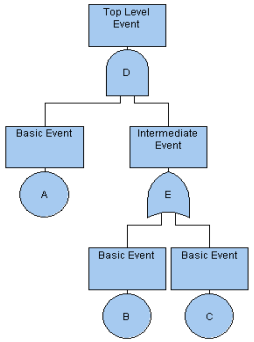
5. Define resolution
   - In complex systems it is impossible to model each detail
   - Before starting, define where to stop
   - For system level FTA, it may be useful to stop at the components

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

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**