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Electrical & Computer ENGINEERING

Embedded Software Safety – Overview

"Engineering is achieving function while avoiding failure."

– Henry Petroski

These tutorials are a simplified introduction, and are not sufficient on their own to achieve system safety. You are responsible for the safety of your system.

Is Your System Appropriately Safe?

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- Anti-Patterns for Embedded System Safety:
  - Requirements do not address safety
  - Not using an appropriate safety standard
  - Safety analysis assumes perfect software
  - Redundancy management inadequate
- Actually know system is safe
  - Correctness is only a starting point
    - Requirements and other aspects matter
  - Fault responses must be safe
    - Hardware faults (permanent; transient)
    - Software faults

General Motors recalls 4 million vehicles after software linked to 1 death

https://goo.gl/EgxHEo

By Associated Press SEPTEMBER 9, 2016, 9:55 AM

The company said Friday that in rare cases, the car's sensing and diagnostic module — a tiny computer that senses what the vehicle is doing and controls air bag deployment — can go into test mode. If that happens, the front air bags won't inflate in a crash and the seat belts may not work either.

Defense-In-Depth For Safety

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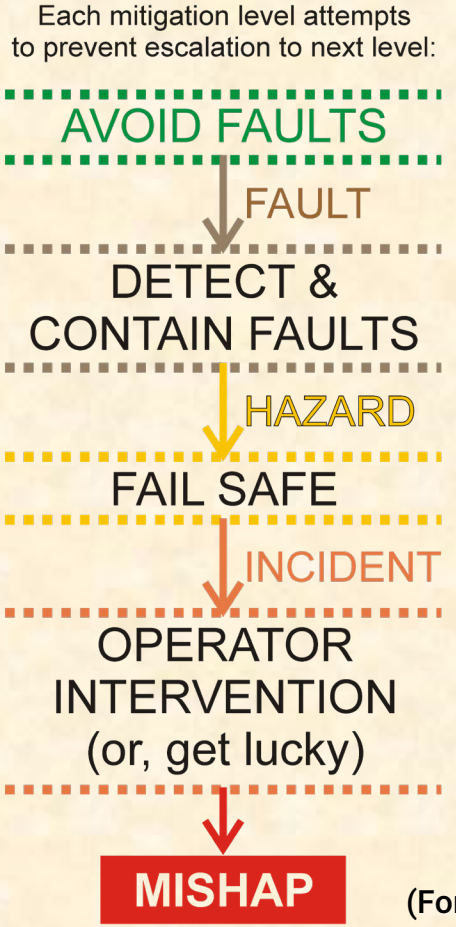

- Avoid faults occurring
  - Careful design of software to avoid software defects
  - Use robust hardware to avoid hardware run-time faults
- Detect and contain faults
  - Error correction HW, redundant CPUs
  - Watchdog timers for failed tasks, exception handling
- Use Fail Safe strategies to mitigate hazards
  - For example, automatic safety shutdown mechanisms
- Incidents require operator intervention (or luck)
  - Operator may be able to react correctly and quickly
  - Incident will be a mishap some fraction of time
- Want to avoid escalation as much as possible
  - E.g., fail safe approaches that work to avoid incidents

(For more information, see Safeware, Leveson 1986, pp. 149-150)

Basic Safety Principles

Adapted from MISRA 1994

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- Safety must be seen to be present
  - System presumed unsafe unless convincing safety argument made
  - Outsider must be able to determine safety purely from documents
- The greater the risk, the greater the need for information
  - Riskier systems require more engineering rigor
- Safety must be built in, not added on
  - If code is created without a safety process, throw it away; start over
- Systematic, random, and malicious faults all matter
  - Consider design errors and transient faults (e.g., soft errors)
  - If it's not secure, it's not safe
- Safety must be argued in writing and demonstrated
  - Failure-free testing isn't enough
- Safety is a lifecycle concern
  - "Mission critical failures" can be considered "safety" as well

Safety Culture: Everyone Is Sure It's Safe

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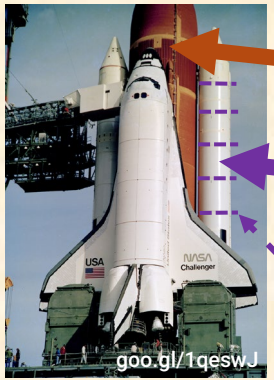
- Space Shuttle Challenger Mishap
  - January 1986 launch explosion; 7 fatalities
  - Dual O-rings keep hot gases inside solid booster
    - History of sometimes failing if too cold
    - At launch, joint temperature was below freezing
  - Booster team told: "prove launch is unsafe"
    - Should have been: "no launch *unless* proven safe"
    - Getting lucky is not the same thing as being safe



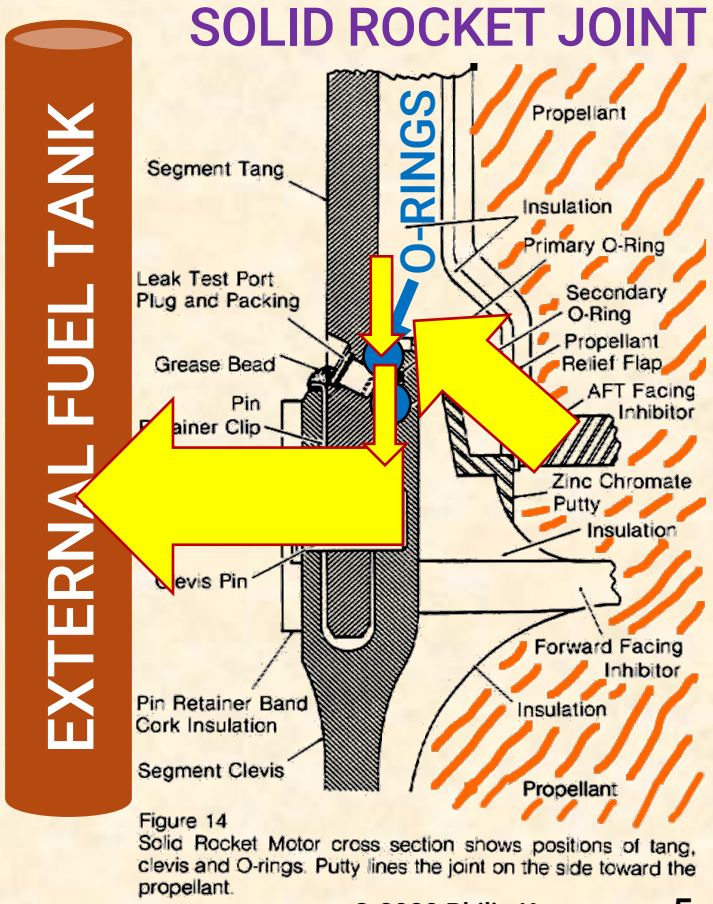


Figure 14
Solid Rocket Motor cross section shows positions of tang, clevis and O-rings. Putty lines the joint on the side toward the propellant.

Overview of Embedded System Safety

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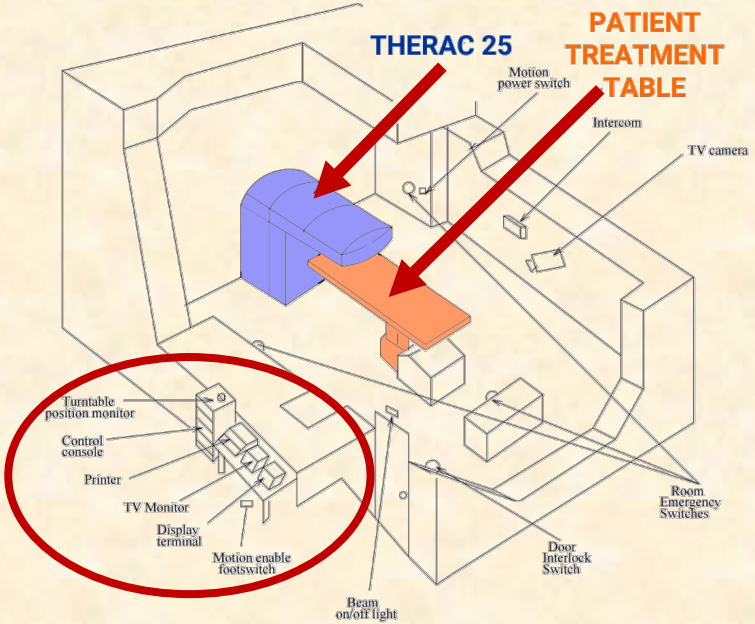
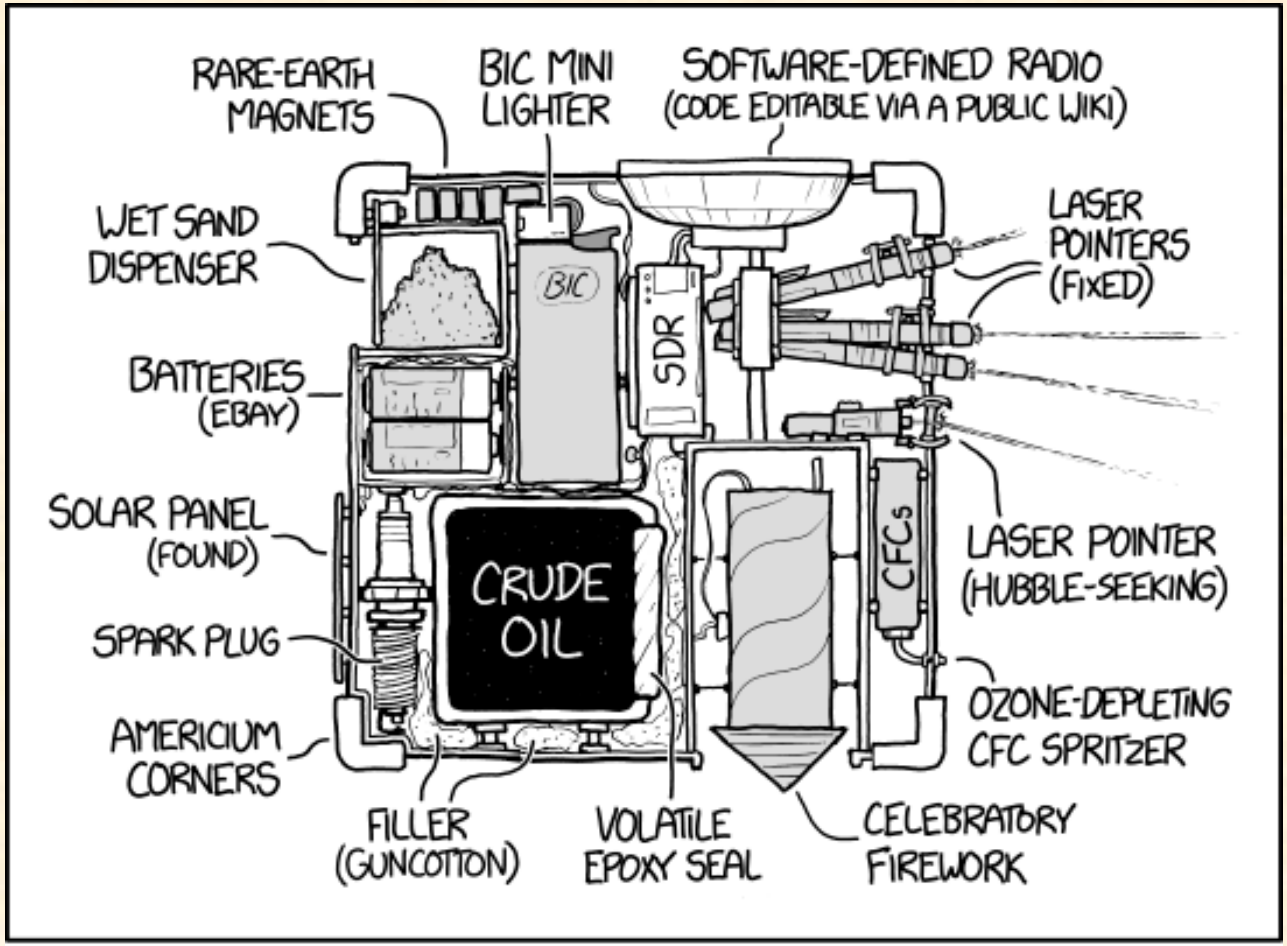
- Safety Topics:
  - Safety Plan & Safety Standards
  - Safety Requirements
  - Critical System Design
  - Dependability
  - Single Points of Failure
  - Redundancy Management
  - Isolation Mechanisms
  - Safety Architectural Patterns



(1985 – 1987) THERAC 25
Software-Controlled Radiation Therapy Mishaps

- Pitfall:
  - Safety isn't just about whether you think it's safe …
    … it's about whether you can prove it is appropriately safe



MY CUBESAT PROPOSAL WAS THE FIRST TO BE REJECTED FOR VIOLATING EVERY DESIGN AND SAFETY REQUIREMENT SIMULTANEOUSLY.

https://xkcd.com/1992/