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Electrical & Computer ENGINEERING

Safety Requirements

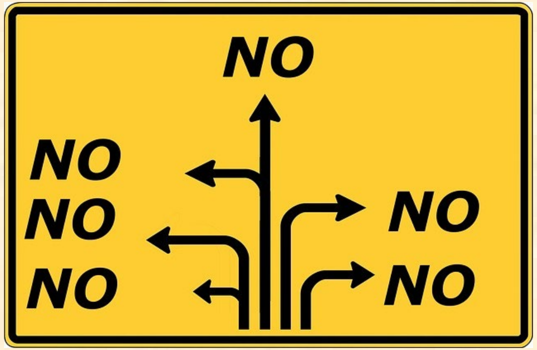
"I cannot conceive of any vital disaster happening to this vessel. Modern shipbuilding has gone beyond that."

– *EJ Smith (Captain of the RMS Titanic)*

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.

Safety Requirements

- **Anti-Patterns for Safety Requirements:**
  - No specifically identified safety requirements
  - All functional requirements are safety critical
  - Safety requirements can't be validated



- **Specifying safety:**
  - Safety goals: "working" is not the same as "safe"
    - How hazards are avoided at system level
    - Can involve correctness, backup systems, failsafes, …
    - Often what the system ***does not do*** is as important as what it does
  - Safety requirements:
    - More detailed safety-specific requirements allocated to subsystems

Identifying Safety-Related Requirements

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- Overly-simplistic approach:
  - Start with system requirements
  - Annotate critical system requirements
  - Then, annotate supporting requirements
  - Problem:
    Most requirements can become critical
- Too many system components promoted to highest criticality level
  - Allocating even one critical requirement to component makes whole thing critical

Requirement Annotation Approach:

☒ R01. Lorem ipsum dolor sit amet, consectetur adipiscing elit.
R02. Nam suscipit odio aliquam massa finibus, id imperdiet.
☒ R03. Quisque vehicula quam ut dui venenatis varius.
☒ R04. Nulla posuere diam ac augue bibendum, vitae laoreet.
R05. Pellentesque aliquam sem sit amet justo porttitor.
☒ R06. Vestibulum scelerisque lacus ac neque volutpat, dictum.
☒ R07. Ut venenatis ante in ligula efficitur, congue posuere.
☒ R08. Nam a nulla ultrices, tempor quam et, fringilla nisl.
☒ R09. Vestibulum a arcu interdum, placerat eros non, ultrices.
☒ R10. Ut commodo odio eu elit porttitor facilisis.
☒ R11. Etiam et sem eu eros congue sollicitudin.
☒ R12. Proin tincidunt arcu quis dui tristique volutpat.
R13. Fusce quis magna aliquet, venenatis sem ac, rhoncus.
☒ R14. Cras vel nulla eget orci semper varius scelerisque tellus.
☒ R15. Cras mollis lorem vitae libero sollicitudin lobortis.
R16. Vestibulum luctus nisi ac nibh varius congue.
☒ R17. Maecenas consequat augue eu venenatis euismod.
☒ R18. Quisque viverra felis in est ornare consectetur.
☒ R19. Cras pellentesque turpis sit amet justo scelerisque.

Safety Envelope Requirements Approach

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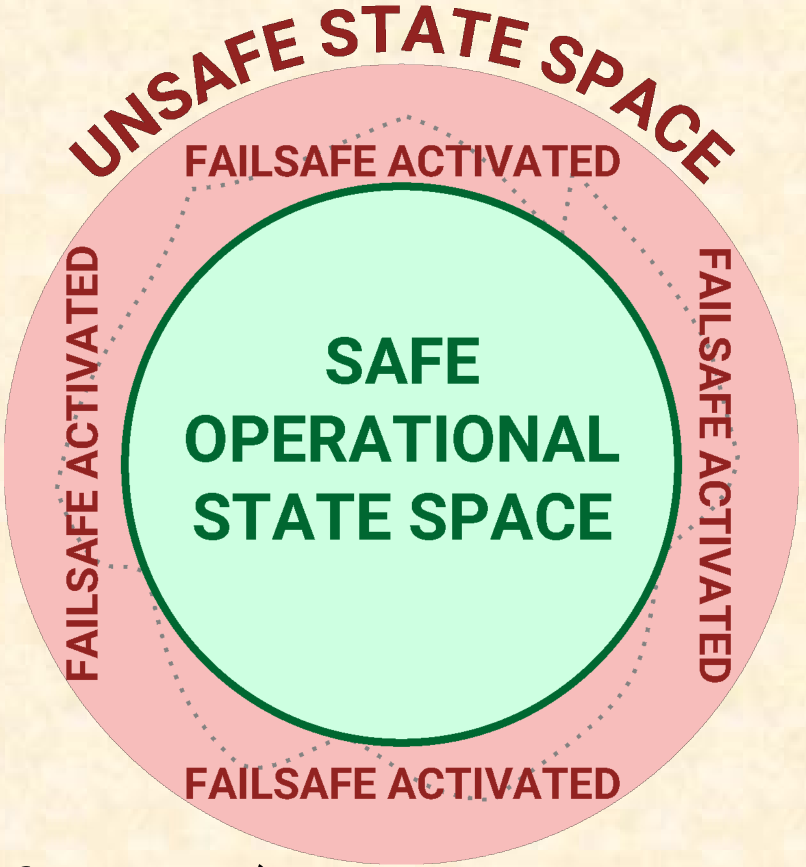
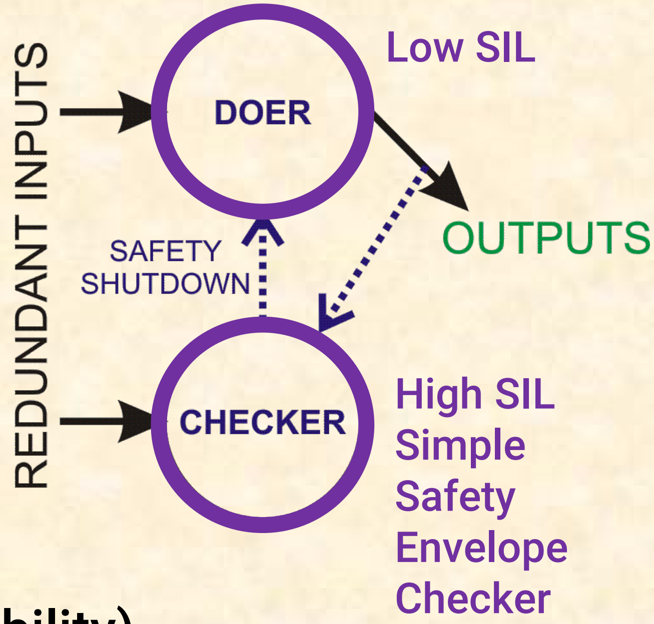
- Safety Envelope:
  - Specify unsafe regions for safety
  - Specify safe regions for functionality
    - Deal with complex boundary via:
      - » Under-approximate safe region (reduces permissiveness)
      - » Over-approximate unsafe region
  - Trigger system safety response upon transition to unsafe region
- Partition the requirements:
  - Operation: functional requirements
  - Failsafe: safety requirements (safety functions)



Architecting A Safety Envelope System

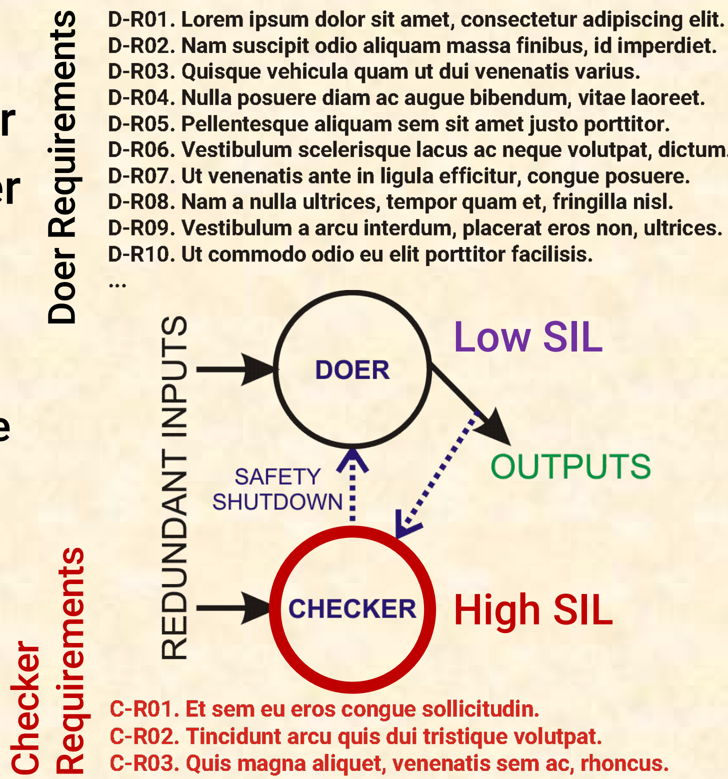
- "Doer" subsystem
  - Implements normal functionality
  - Allocate functional requirements to Doer
- "Checker" subsystem
  - Implements failsafes (safety functions)
  - Allocate safety requirements to Checker
- Checker is entirely responsible for safety
  - Doer can be at low SIL (failure is lack of availability)
  - Checker must be at high SIL (failure is unsafe)
    - Often, Checker can be much simpler than Doer

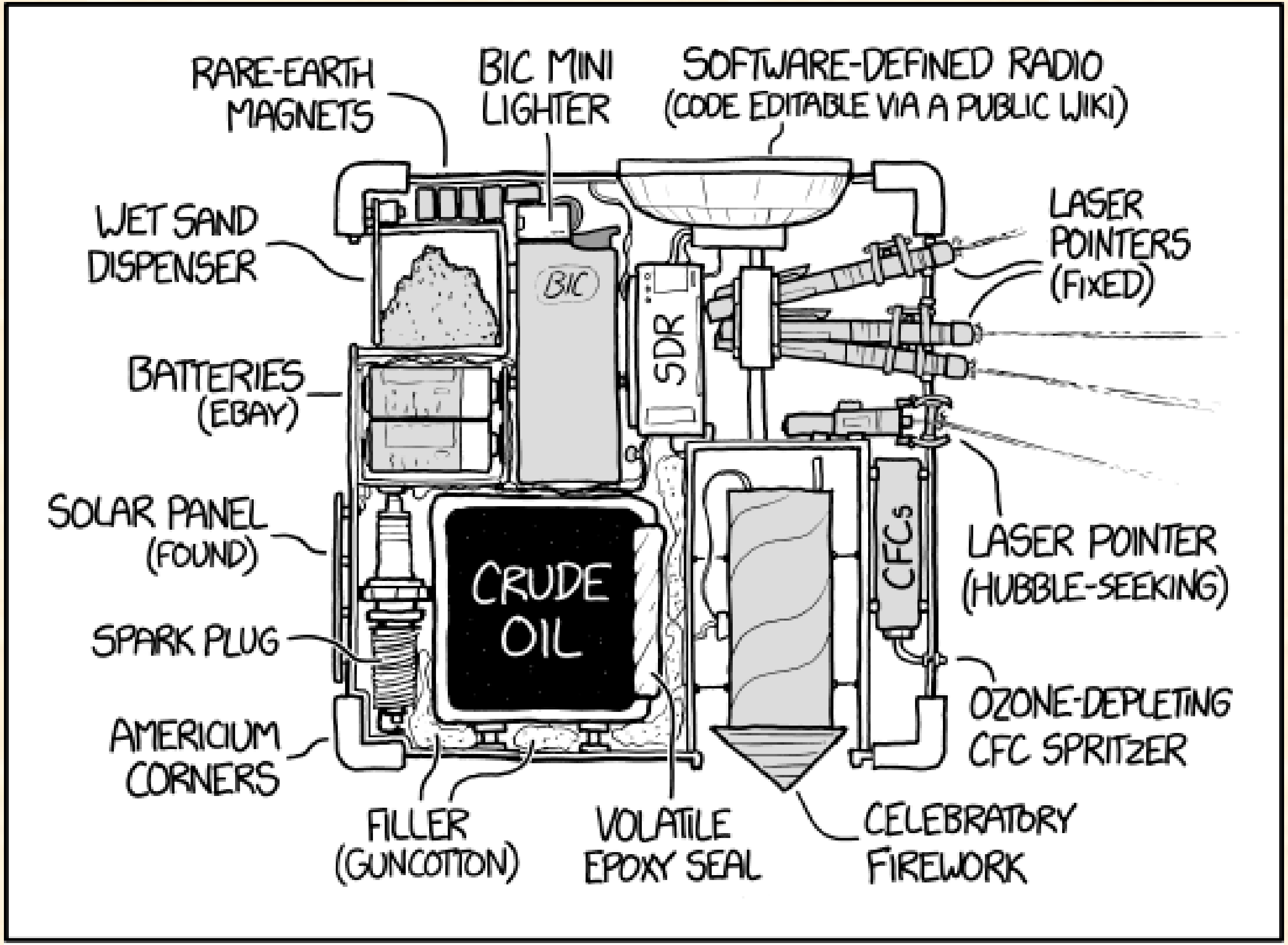
Doer/Checker Pair



Safety Requirements Best Practices

- Doer/Checker pattern
  - Functional requirements allocated to low-SIL Doer
  - Safety requirements allocated to high-SIL Checker
- Good safety requirements
  - Trace to system-level safety goals
    - Orthogonal to normal functional operation if possible
  - Make safety simple to validate (test, peer review)
    - Safety testing mostly exercises the Checker box
- Pitfalls:
  - Tradeoff between simplicity and permissiveness
    - Doer optimality costs Checker validation effort
  - Fail-operational functions may require multiple Doer/Checker pairs





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

https://xkcd.com/1992/