Electrical & Computer ENGINEERING

18-642:

Safety Requirements

ASSC; 22 May 2019

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.

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

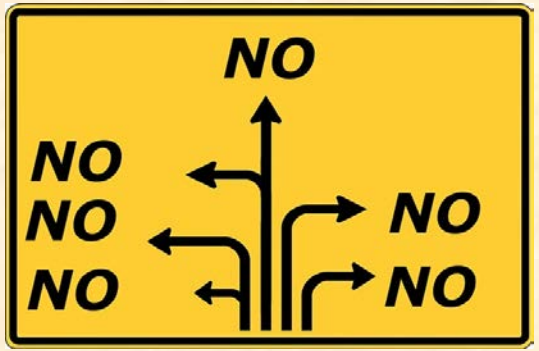
– *EJ Smith (Captain of the Titanic)*

Carnegie Mellon University

Safety Requirements

Edge Case Research

- **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

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Identifying Safety-Related Requirements

Edge Case Research

- **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.

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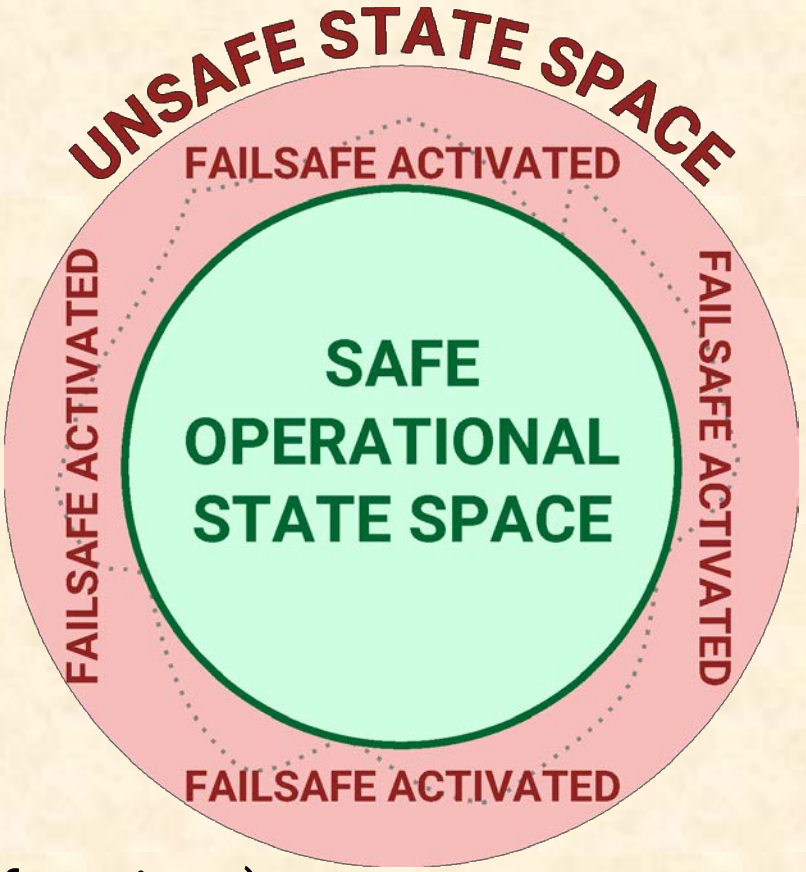
Safety Envelope Requirements Approach

Edge Case Research

- **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)



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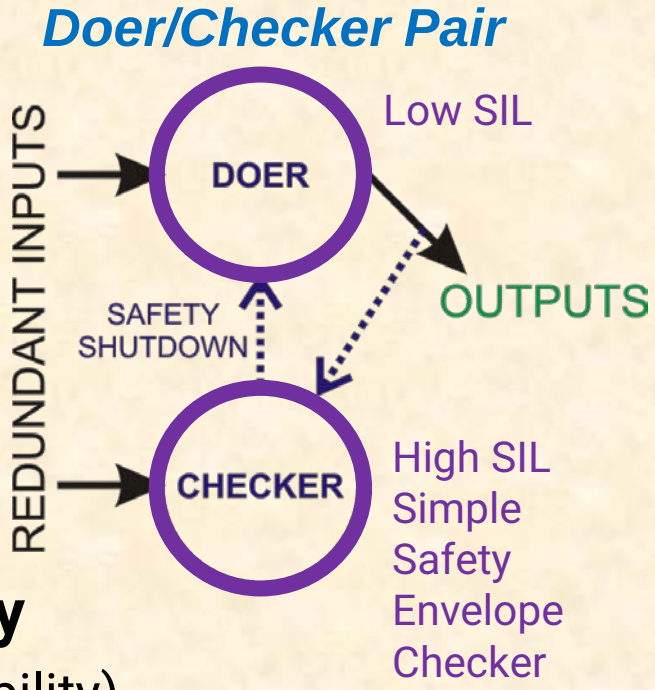
Architecting A Safety Envelope System

Edge Case Research

- **"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



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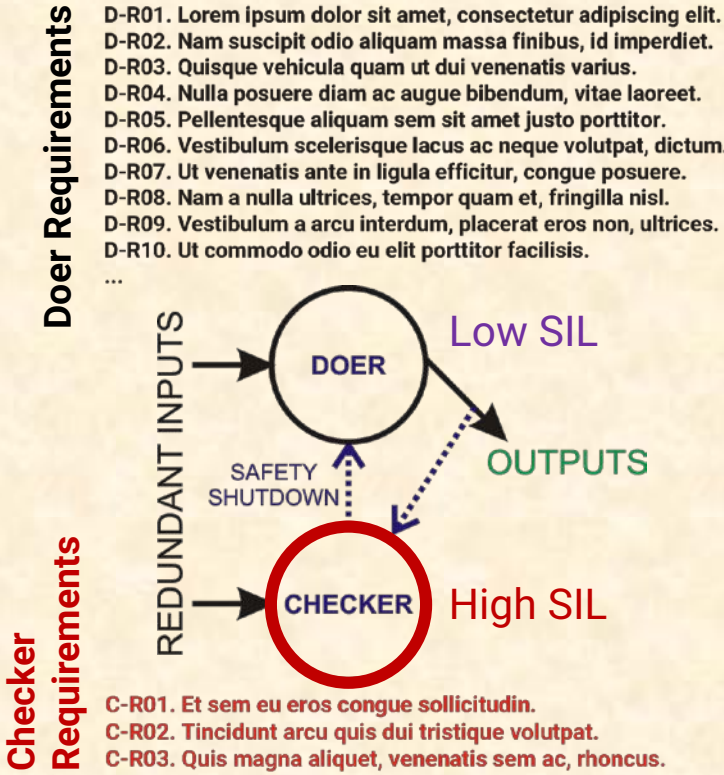
Safety Requirements Best Practices

Edge Case Research

- **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



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