In Search of Adversities, from a Resilience Perspective

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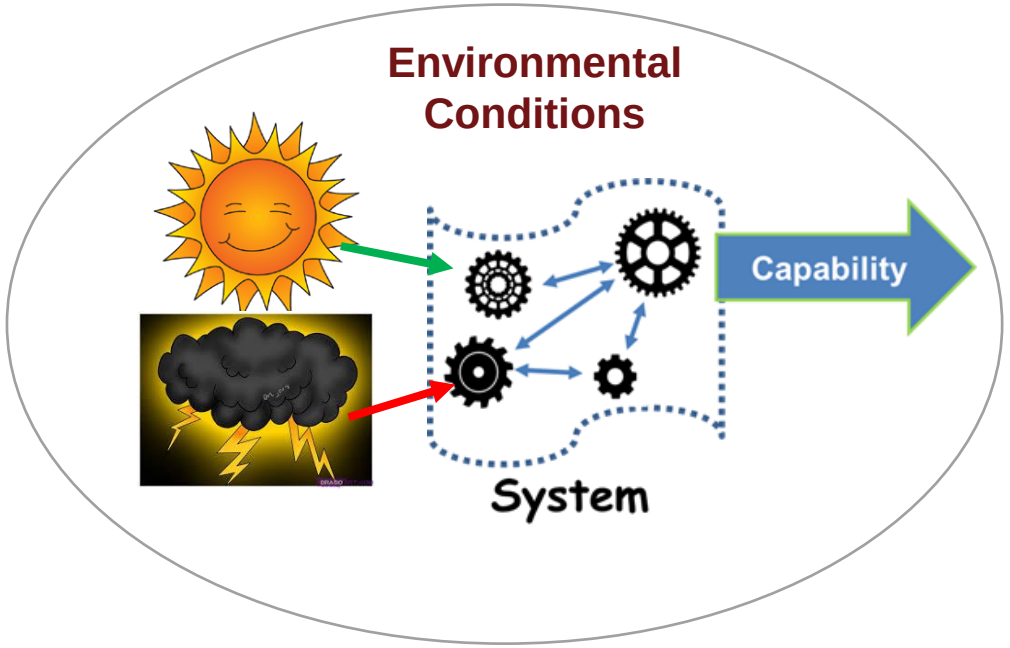
Systems Engineering Foundation of Resilience

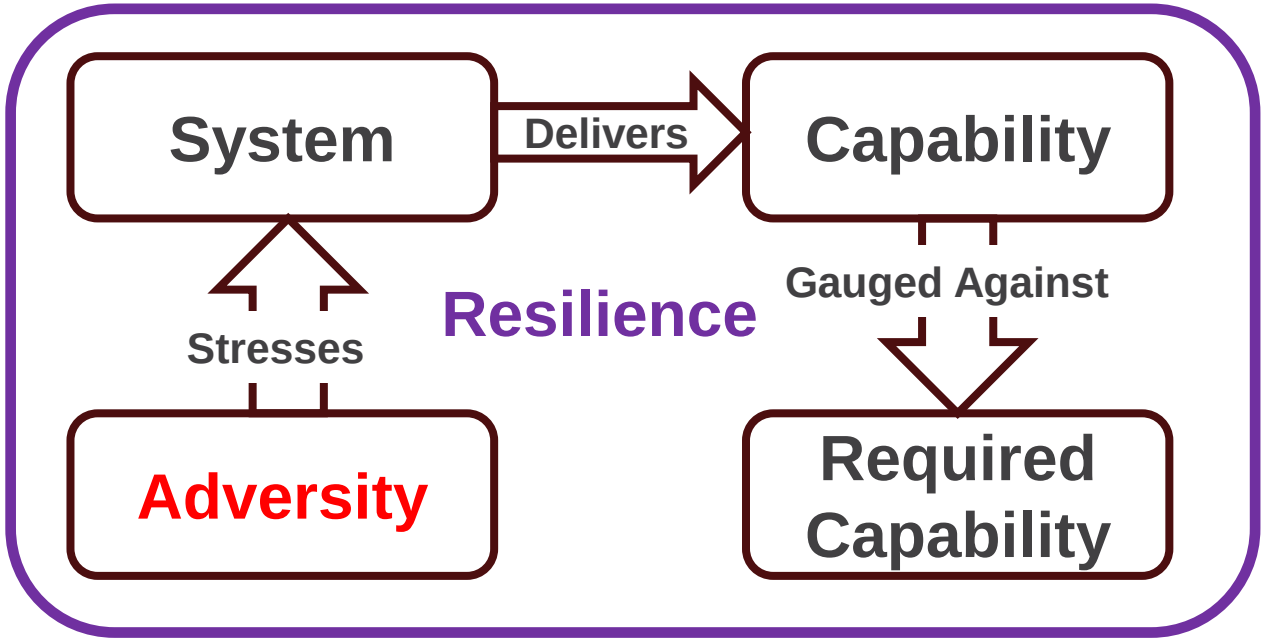


Adversity – <for the purpose of resilience> anything that can degrade the desired capability of the system – directly or indirectly

What we mean by resilience

- **INCOSE Definition of Resilience**
  - *Resilience is the ability to deliver required capability when facing **adversity**.*

Resilience is the System's Ability to Deliver Required Capability in the Face of Adversity



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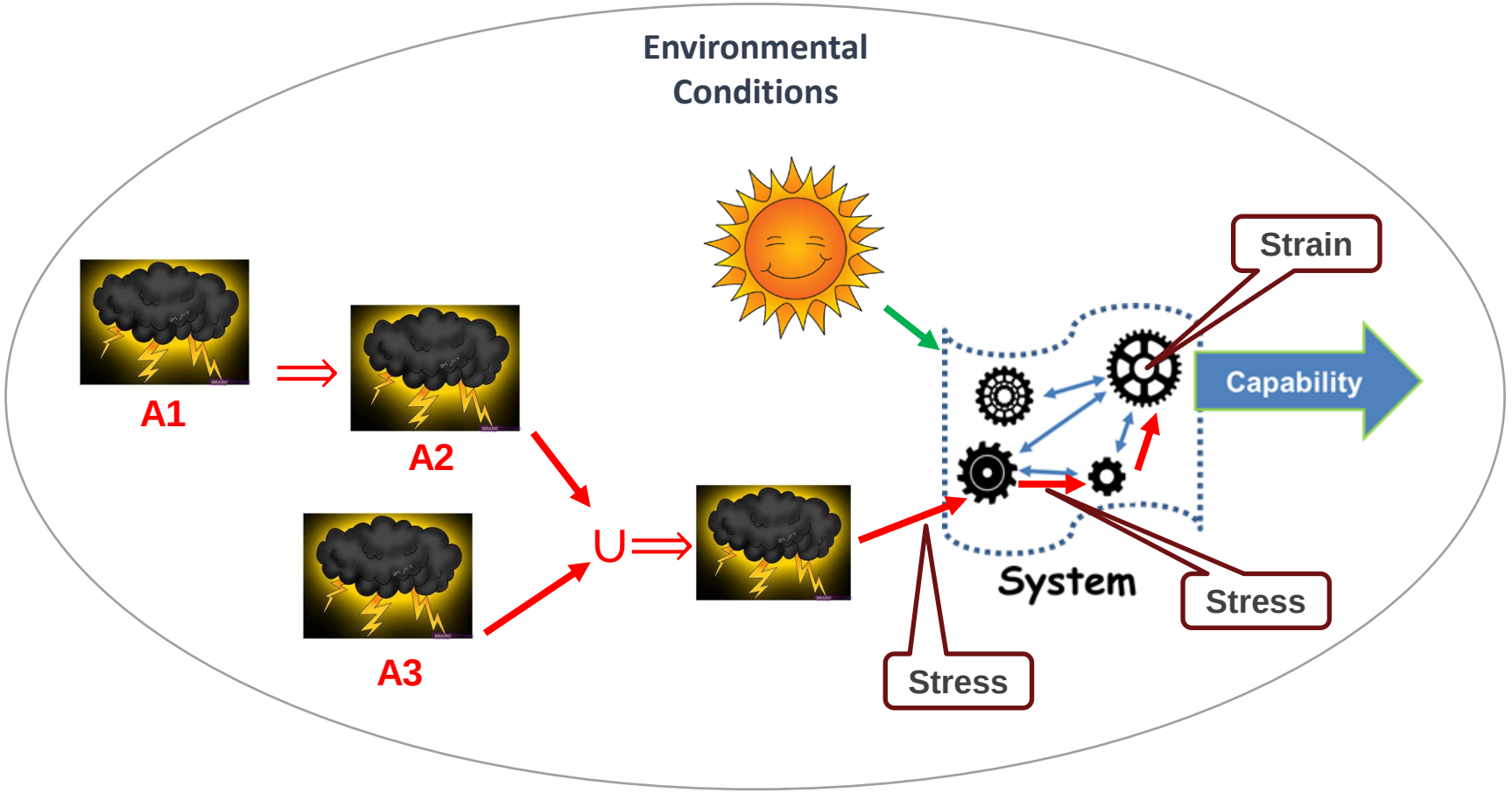
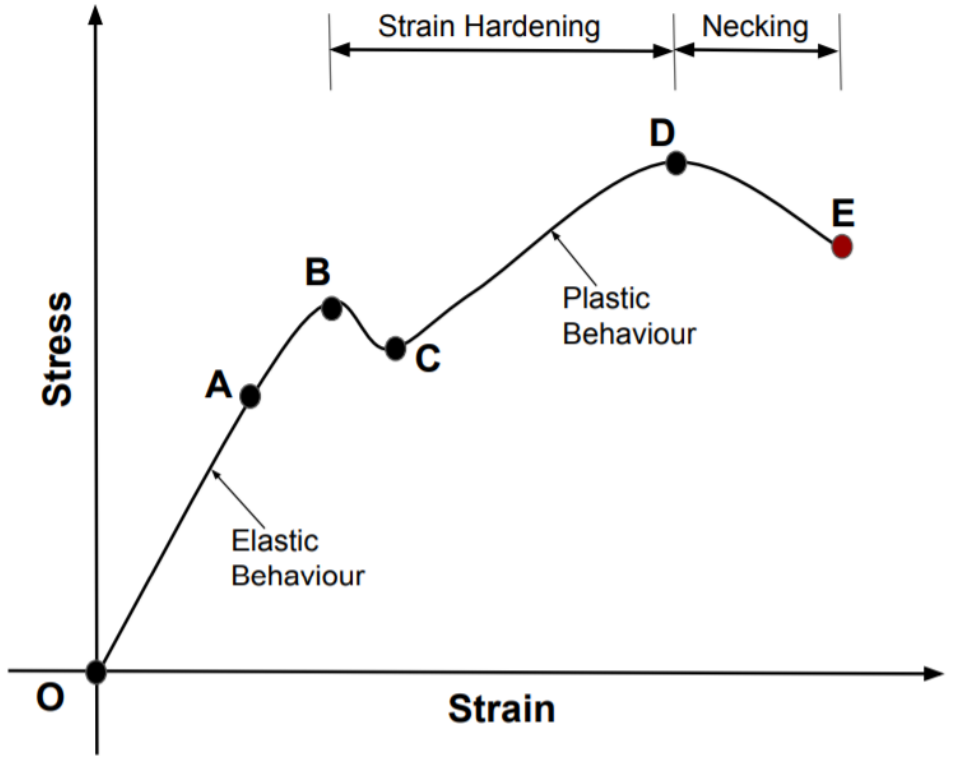
Typology for Adversity

- from within the system | from the system's environment
- natural | human | machine
- <machines> faults | errors | failures
- <human errors> of omission | of commission
- <human> friendly | neutral | opponent
- intentional | unintentional
- malicious | non-malicious
- threats | attacks
- misuse | abuse
- chronic | acute | intermittent
- known | unknown
- nominal | abnormal
- hazards | vulnerabilities
- defects | flaws | weaknesses
- emergence | side effects
- scarcity of personnel | material | consumables
- degradation of enabling systems or resources

Causal Chains of Adversity may Lead to Stress on the System



Stress Strain Curve

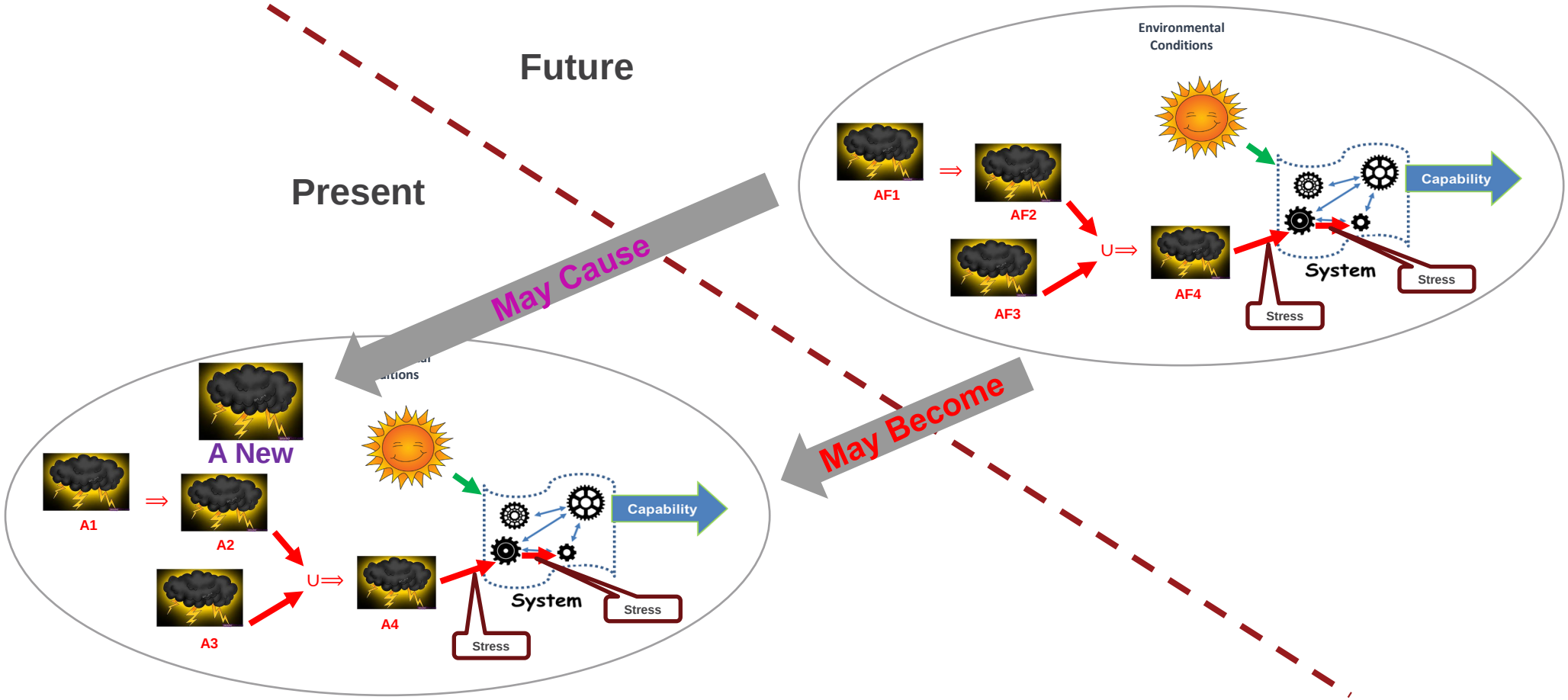


OA : Proportional Limit
B : Upper Yield Stress Point
C : Lower Yield Stress Point
D : Ultimate Stress Point
E : Fracture

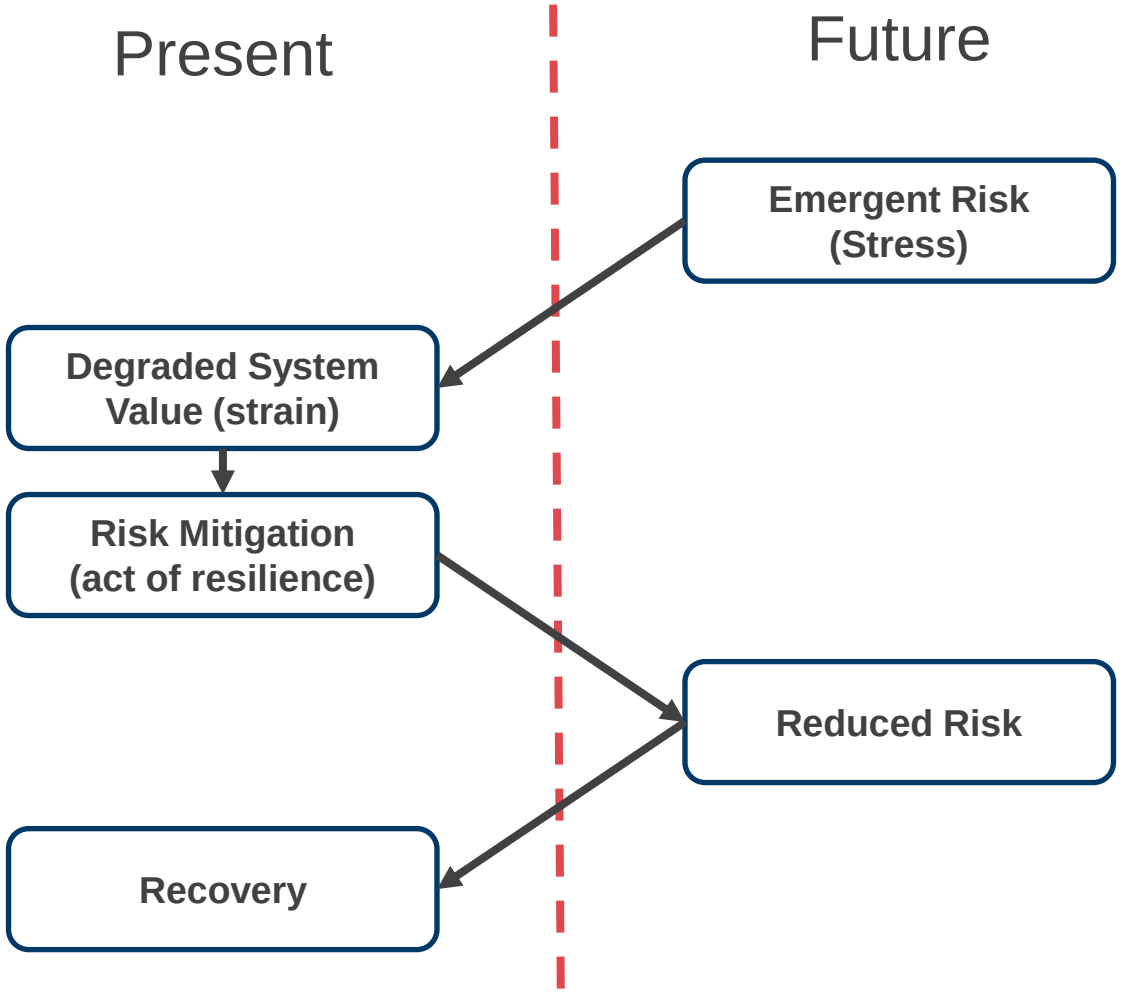
Stress – adversity that directly affects the system

Strain – change, modification, or damage of the system

Risks in the Future, are Adversities … and may cause new current adversities!



Resilience Time Travel



Summing this up

- Stresses
- Strains
  - Elastic
  - Plastic
- Current (actual/extant)|Future(potential/non-extant)Risks

More Information

- Join the INCOSE Resilient Systems Working Group
- Contact John S. Brtis, jbrtis@johnsbrtis.com
- System Resilience - SEBoK (sebokwiki.org)
- *Systems Engineering Handbook, v*. 5, section 3.1.9 “Resilience Engineering”

Backup Slides

Natural Language Resilience Requirement Pattern

The <system, mode(t), state(t)> encountering <adversity(t)> which imposes <stress(t)> thus affecting delivery of <capability of interest, required capability(t), capability metric> during <scenario timeframe> and under <scenario constraints(t)> shall achieve <resilience target(t)> for <resilience metric>

10CFR50.46 – Acceptance Criteria for Emergency Core Cooling System (ECCS) for Light Water Reactors (LWRs)

This resilience requirement comes from the Nuclear Regulatory Title 10, Code of Federal Regulations, Section 50.46. It specifies the required ability of the emergency core cooling system in terms of resilience of the light water reactor system of systems. Note that the "required capability": the integrity of the zircaloy cladding is left implicit.

(a)(1)(i) Each LWR with zircaloy cladding must provide ECCS **<system>** designed so that calculated cooling performance **<resilience metric/strain>** following postulated LOCA **<adversity>** conforms to criteria in paragraph (b)

(b)(1) Peak cladding temperature shall not exceed 2200 degrees F **<resilience metric/strain, resilience target>**

(b)(2) Maximum cladding oxidation, <**resilience metric/strain**> shall nowhere exceed 0.17 times the total cladding thickness before oxidation. **<resilience target>** [followed by modeling assumptions] **<resilience target assessment method>**

…

(c) LOCAs are hypothetical accidents **<adversity>** that result in the loss of reactor coolant **<stress>,** at a rate in excess of the capability of the reactor coolant makeup system, …

Resilience to Emergent Risks is Particularly Germane to Organizational Resilience

- Themes frequently seen in organizational resilience
  - Managing continuity of operations through emergencies and other adverse events
  - Focus on processes to ensure core functions can withstand disruptions, interruptions and adversities
  - Resilient organization require resilient employees
  - Focuses on dynamic change before it is needed; remaking the future rather than defending the past
  - Techniques for imagining unknown-unknowns and planning for them
- Cyber/physical resilience can learn a lot from organizational resilience.