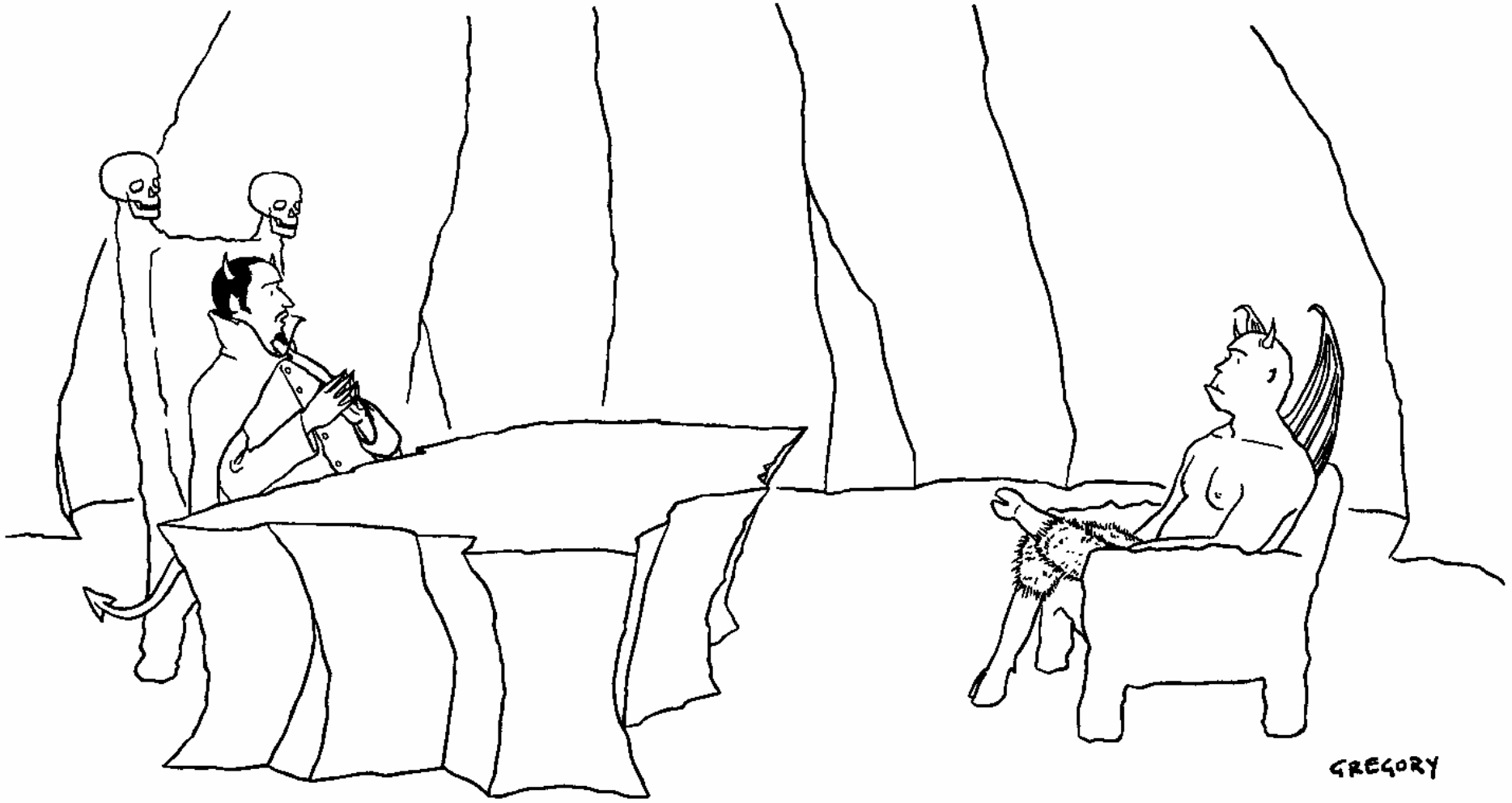


"I need someone well versed in the art of torture—do you know PowerPoint?"

Resilience Engineering: Managing the Residual Risks of Risk Assessment

John Wreathall

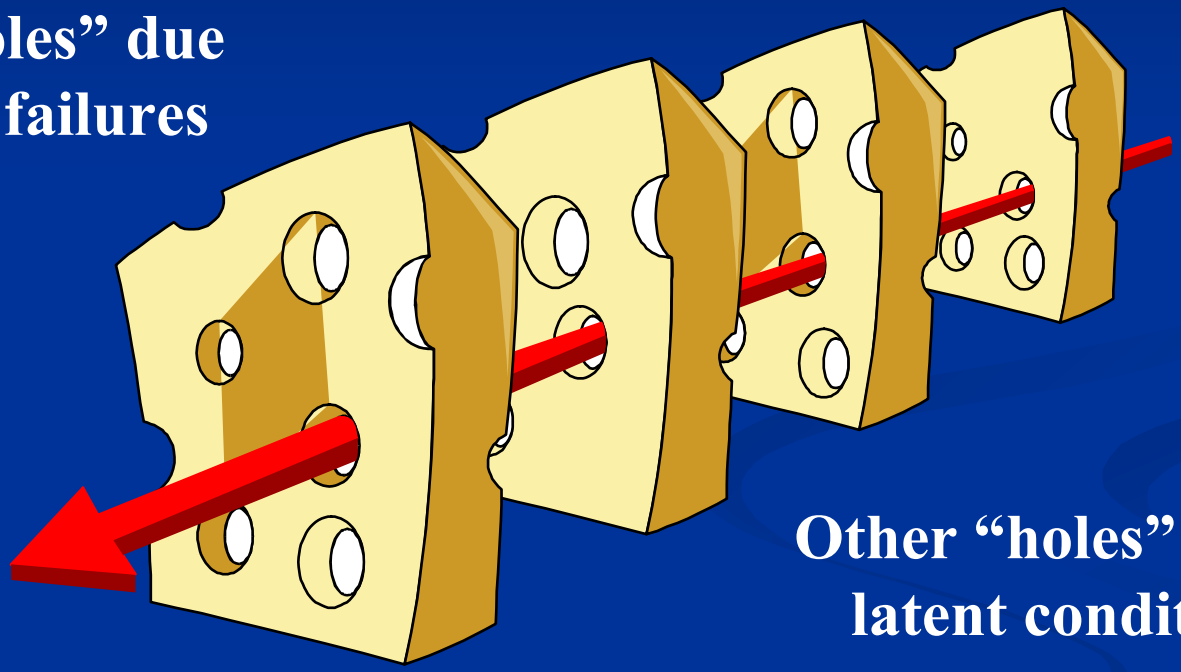
Workshop: Open Initiative for Next Generation PSA
Washington, DC
October 3rd, 2007

Probabilistic Safety Assessment (PSA/PRA)

- A quasi-static assessment of risk
  - As designed
  - As modified
- Weak representation of human performance
  - Under-developed models despite investment in 2nd Gen HRA modeling research
  - Lack of relevant meaningful data
- Minimal representation of organizational performance
  - *At best*, representation of retrospective performance is implicit in plant-specific data
- Helpful for measuring substantial departures from reference points
  - Regulatory audits
- Limited help in *proactive* day-to-day safety management

The Old 'Swiss Cheese' Model

Some "holes" due to active failures



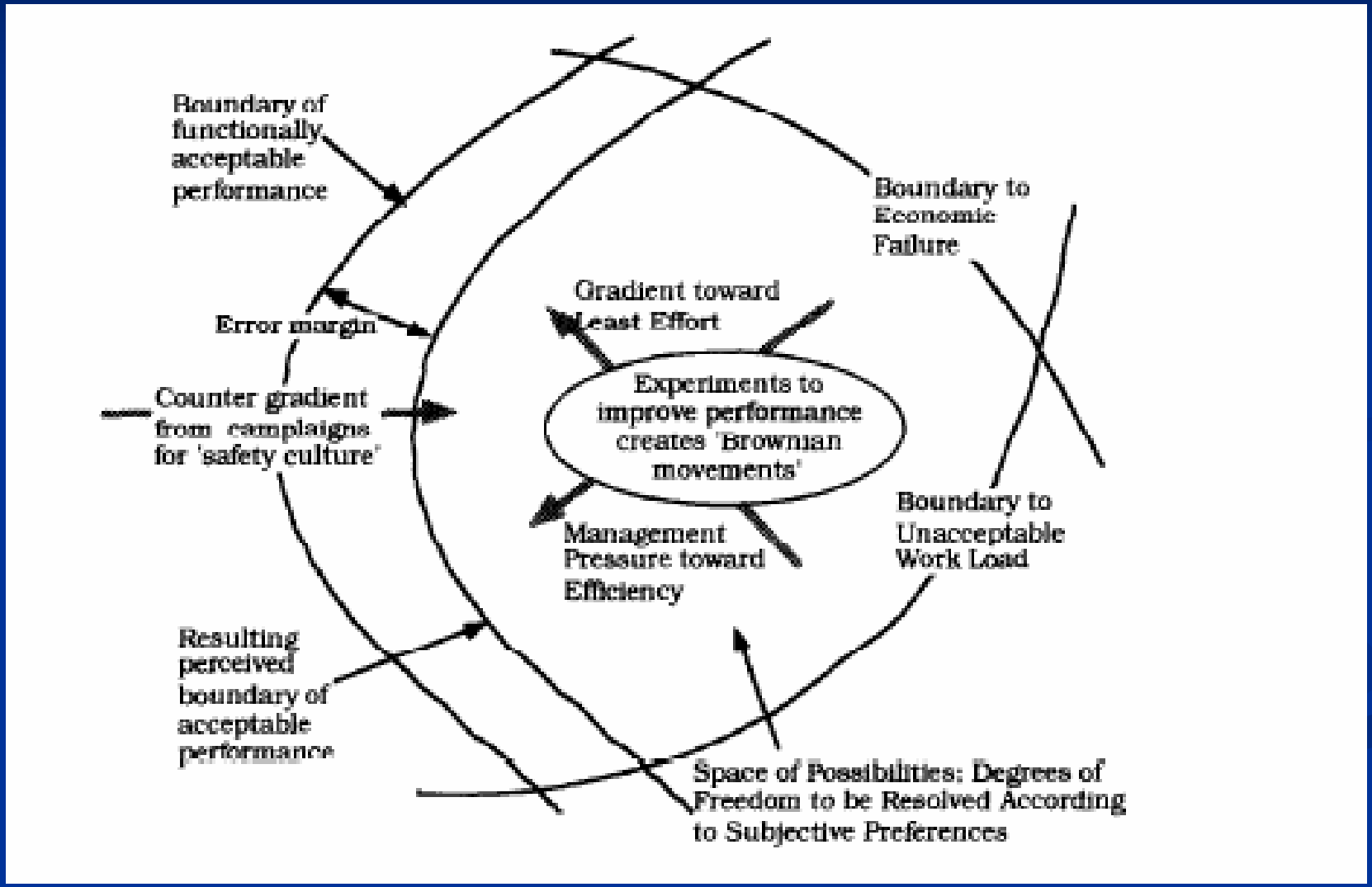
Hazards

Other "holes" due to latent conditions

Harm

PSA can be thought of as modeling the likelihood of a hazard passing through a set of 'holes'. Resilience is partly about managing the state of the holes, ***particularly the latent conditions***.

Rasmussen's 'Boundary Model'& Safety Management Pressures



From Rasmussen, *Risk management in a dynamic society: a modelling problem,* Safety Science (1997)

Properties of Resilient Systems

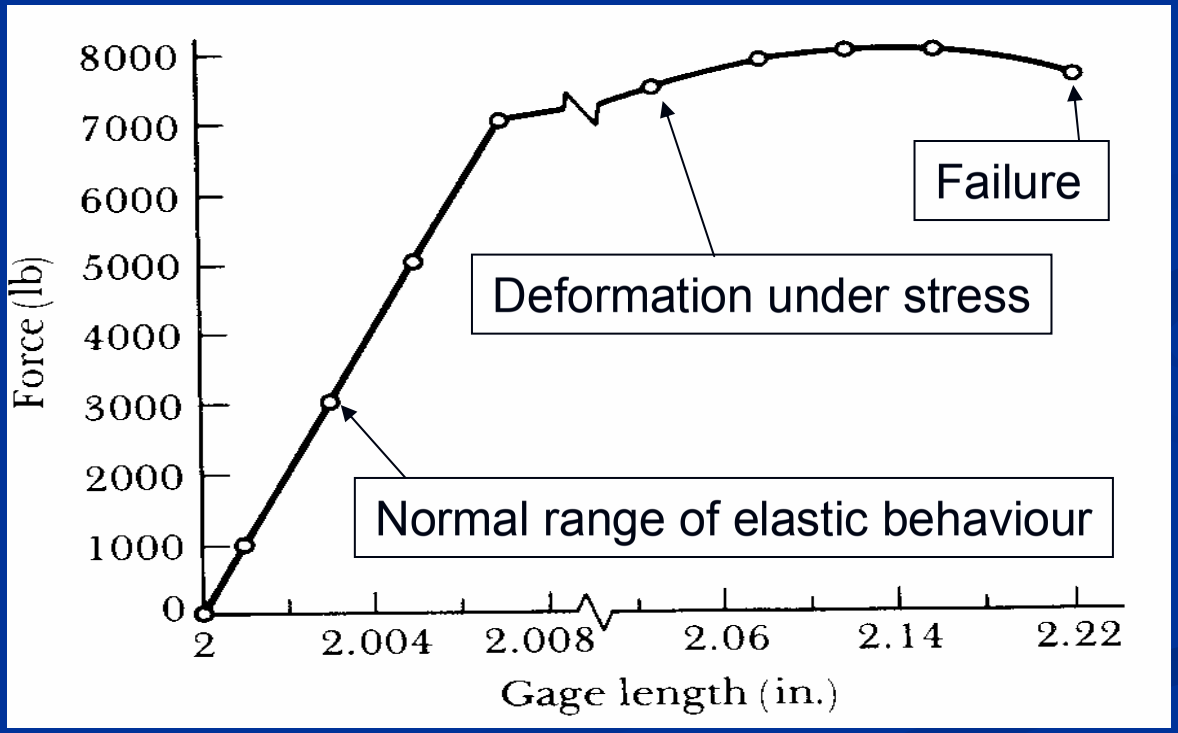
- **Buffering capacity**
  - System absorbs or adapts to disruptions without fundamental breakdown
- **Flexibility**
  - System can restructure or reconfigure in response to external changes or pressures
- **Tolerance**
  - System can perform close to performance boundaries and degrades gracefully as it approaches them
- **Managing margins**
  - System manager has understanding of how close it is to performance boundaries and can anticipate/control future trajectory

Buffering

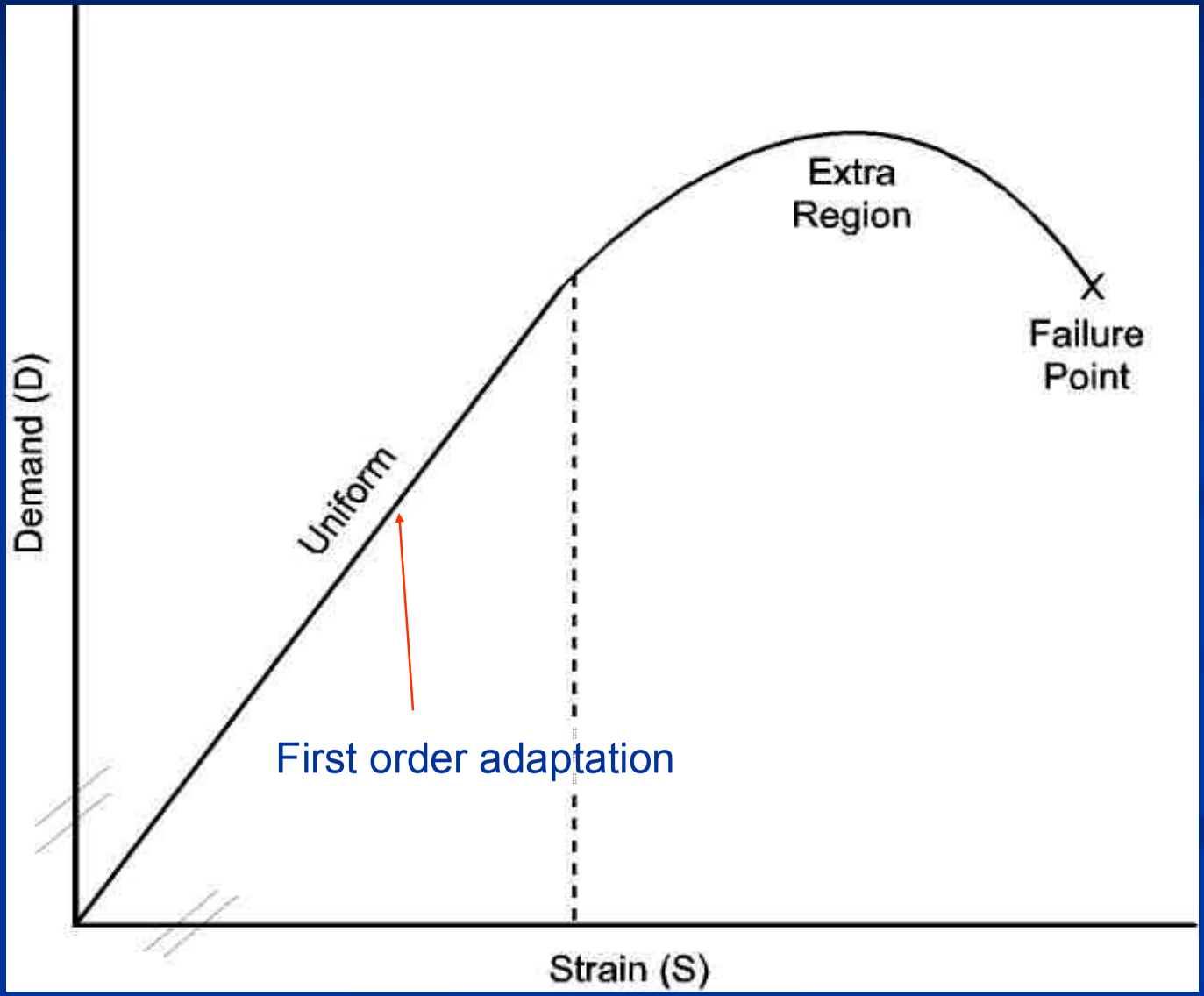
- Accomplished by having reserves of the *right kind* that can be deployed at the *right time*
- Knowing the *right kind* and *time* requires knowledge about the system's current state and its direction (*see later*)
- Reserves are often thought of as 'fat' to be cut to improve production performance
  - 'Faster-better-cheaper'
  - 'Just-in-time' processes

Flexibility & tolerance
- An engineering analogy

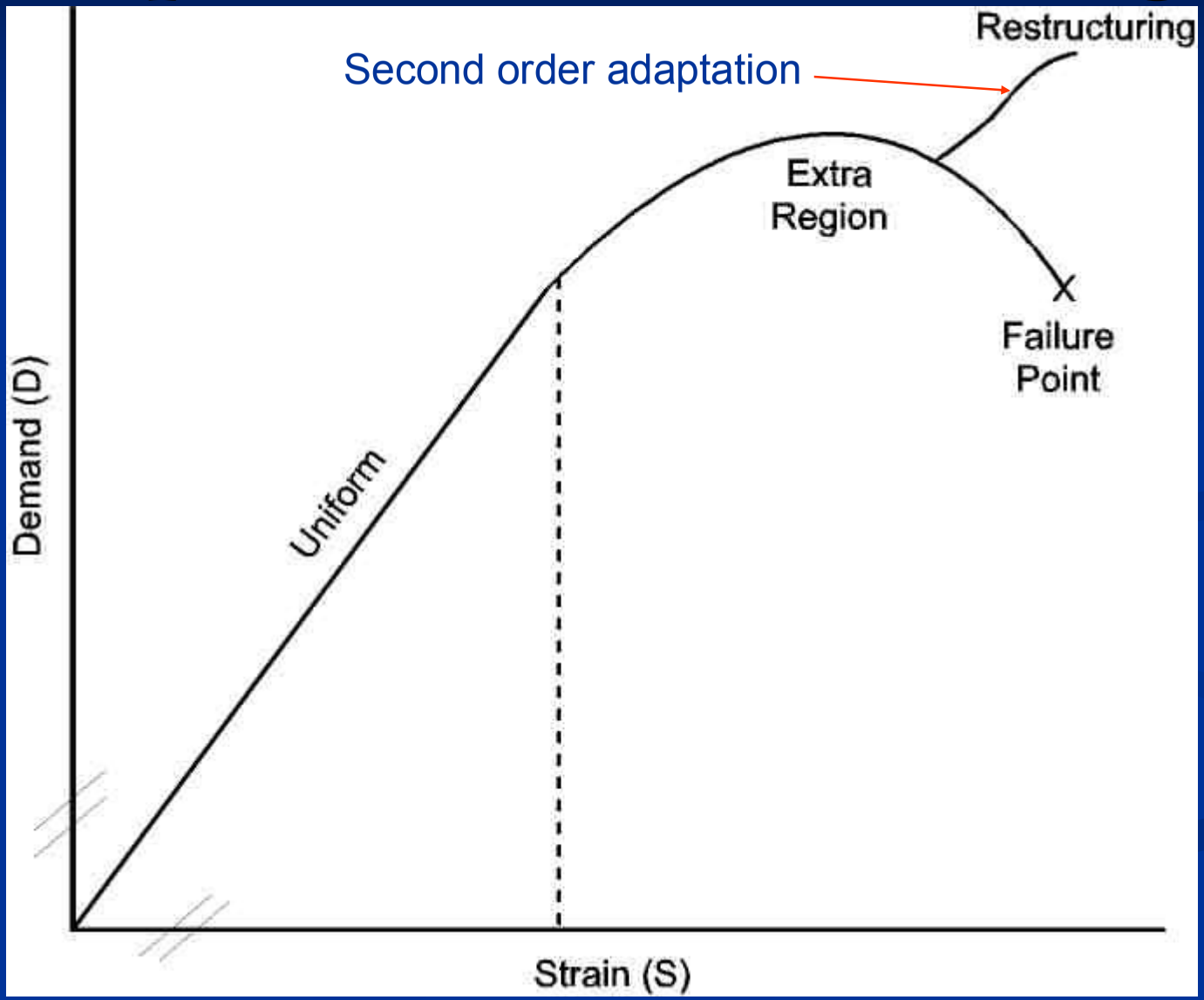
- Think of the relationship between stress and strain in material properties:



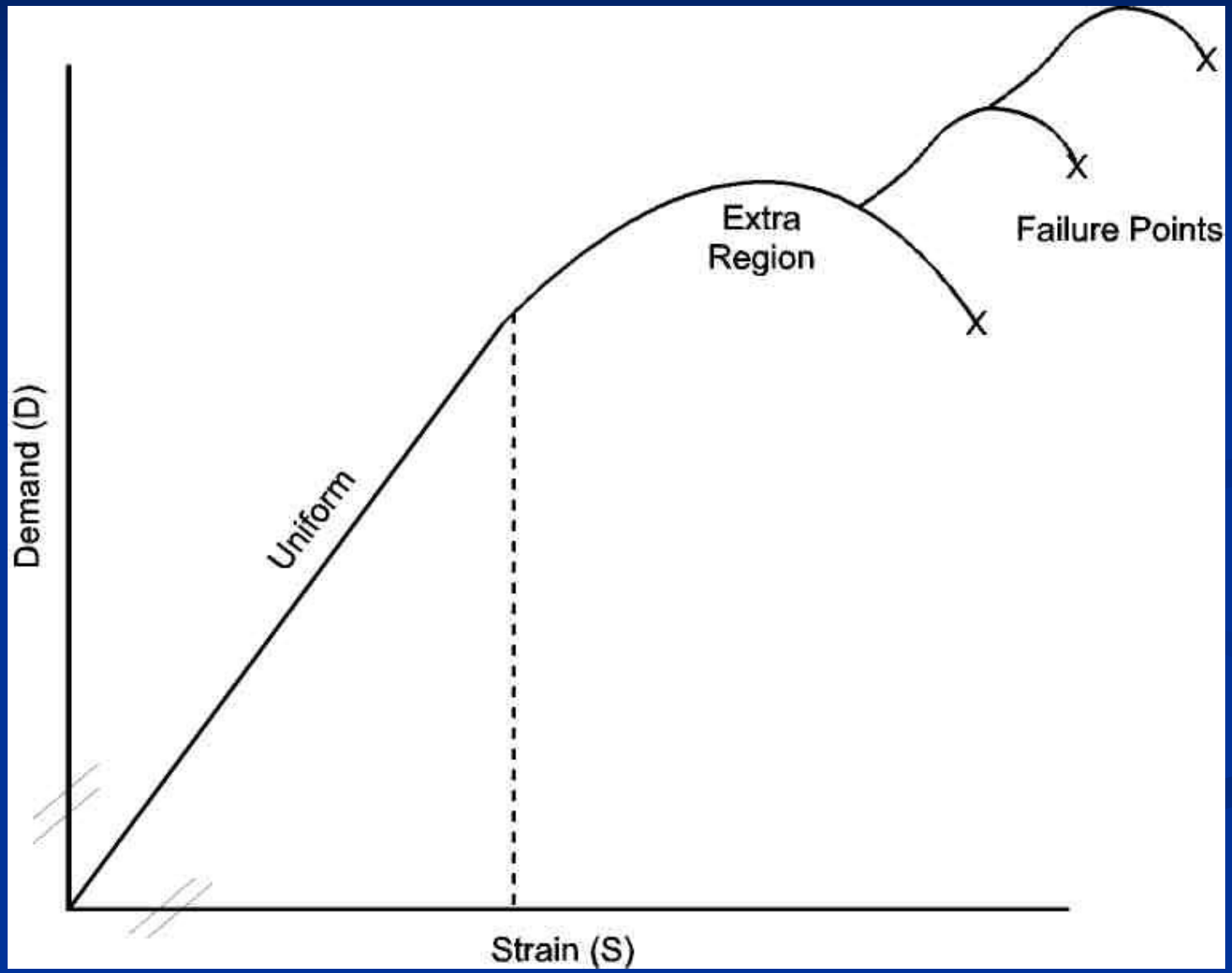
Adaptation & Restructuring



Adaptation & Restructuring



Adaptation & Restructuring



Knowing Where You Are on the 'Stress/Strain Curve'

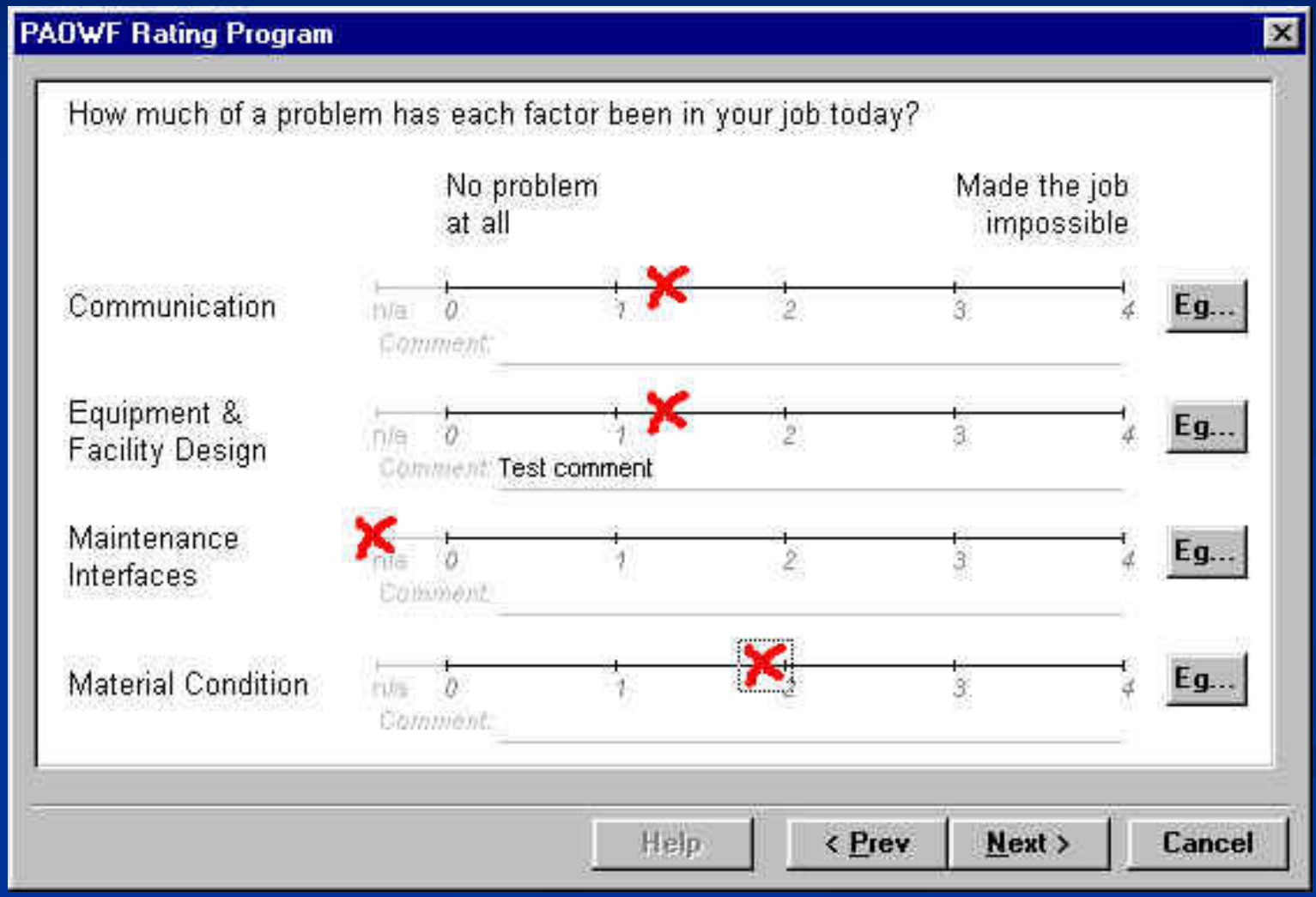
- Monitor performance about levels of demand (stress) and strain (1st and 2nd order adaptations)
  - Examine sample work events (*not <u>just</u> failures*) & activities <u>continuously</u> for information about how work is being performed
    - Identify the challenges to getting work done
      - Stressors like time & workload pressures, economic challenges, etc.
    - Identify what adaptations are being used
      - Use of work-arounds, short cuts, improvisations, work deferrals, etc., to "meet demands"

Managing at the Margins

- Use workplace performance indicators for data gathering for specific work functions
  - Example: EPRI's PAOWF software tool*
    - What are the problems in getting work done?
    - How did you overcome problems & create adaptations?
    - What defenses remain?

* See: EPRI Reports: 1000918, *PAOWF Users' Guide*, 2001, & 1003033, *Final Report on Leading Indicators of Human Performance*, 2001

Example: EPRI PAOWF Ratings

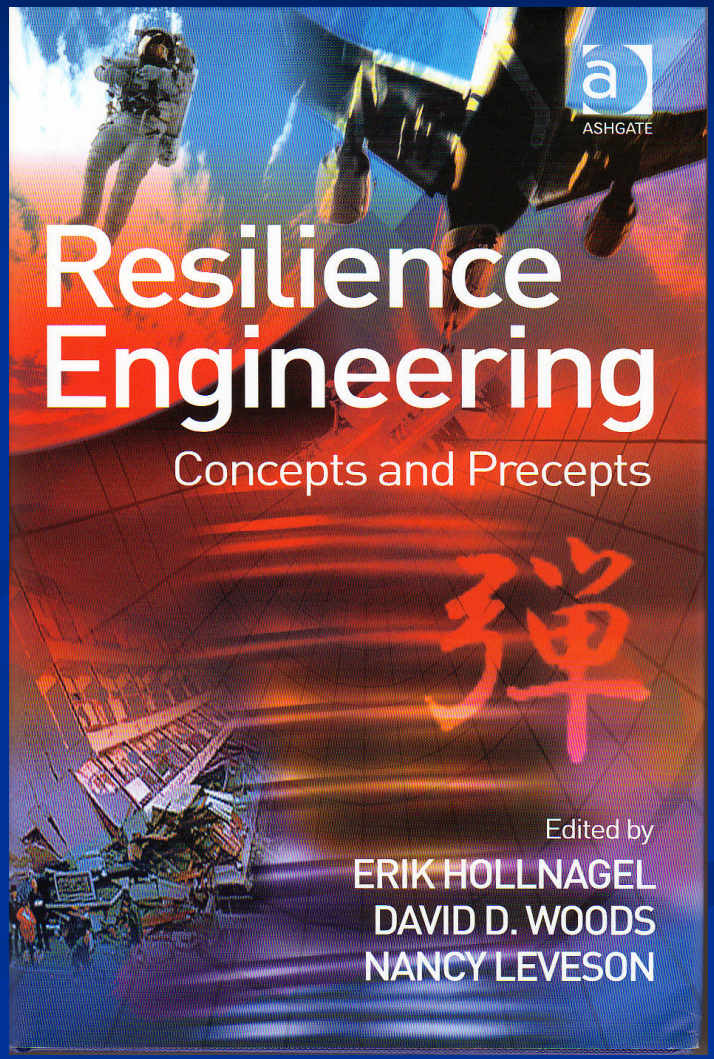


Summary

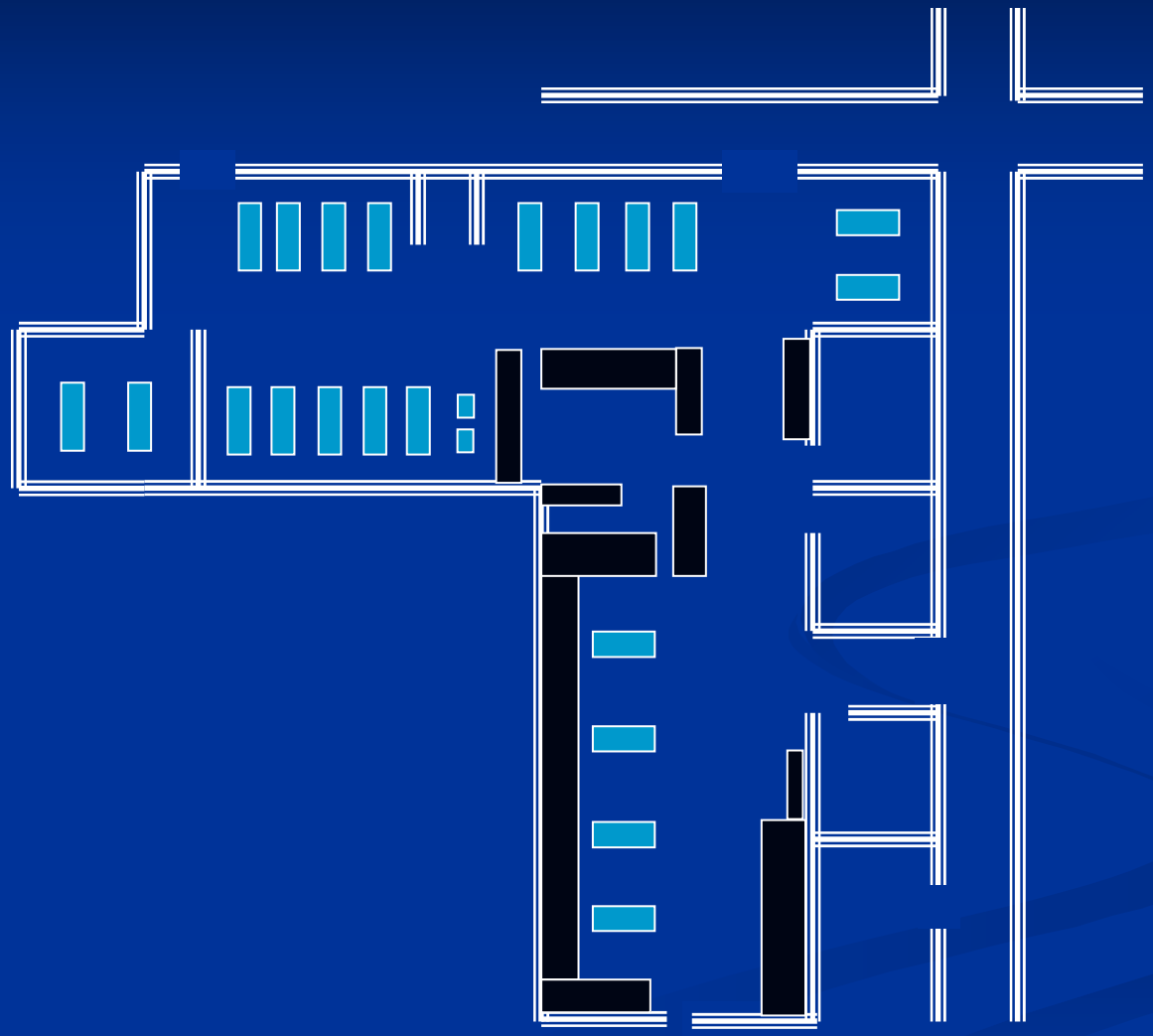
- Key aspects of resilience engineering:
  - **Manage** how organization copes with disruptions and variations that challenge the mechanisms/models of adaptiveness built into the organization
  - **Monitor** how the organization adapts and to what
  - **Understand** mechanisms to adjust underlying performance models and means for adaptiveness
- Controls risk resulting from organizational decision-making & management processes that produce unrecognized drift toward failure boundaries
  - Safety & economic boundaries

More Information

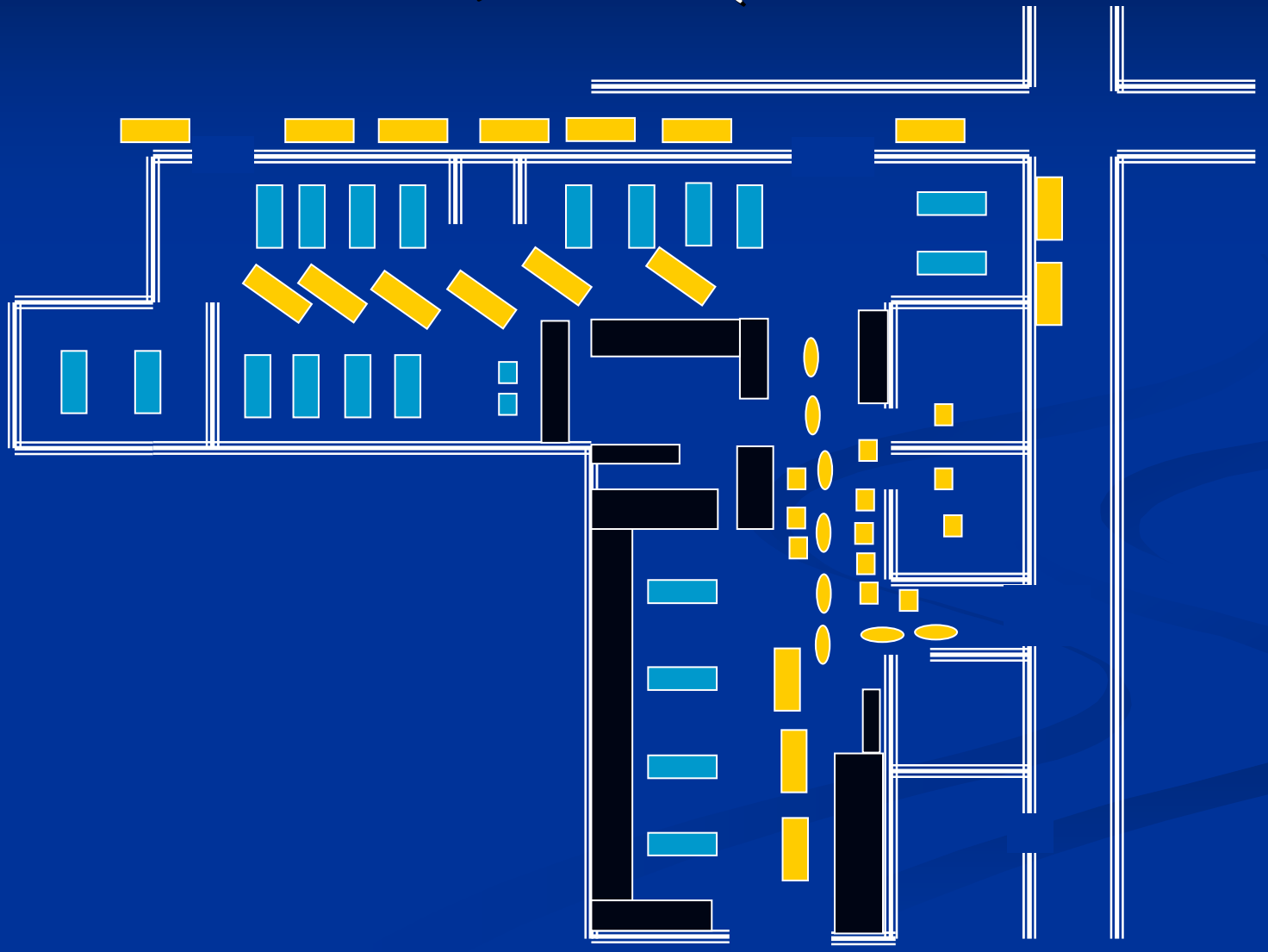
- 1st International workshop on Resilience Engineering, Söderköping, Sweden, 2004
  - *Resilience Engineering: Concepts & Precepts* (Ashgate) 2006
- 2nd International workshop on Resilience Engineering, Juan-les-Pins, France, 2006
  - http://www.resilience-engineering.org/
  - *Resilience Engineering: Remaining Sensitive to the Possibility of Failure* (Ashgate) in press



Example: ER ICU design layout



ER ICU layout & occupancy December 15, 2005 (reconstructed)



Adaptation - 1

Adaptation - 2

Resilient adaptations in ER example

1. **Attempts to increase buffers**
   - Use of irregular space
     - hallways, office, storage room/kitchen
   - Chair patients and 'borrowing' resilience
2. **Sacrificing lower level goals**
   - Pain management, privacy, satisfaction
   - Increased inefficiencies
     - Tying up ambulance crews for long periods
   - EKG delays
3. **'Feed forward' strategies**
   - Test & x-ray ordering
     - Anticipates future opportunity
     - Displaces / spreads problem to other areas
4. **Disturbance management**
   - Simple accounting