Complexity, Coupling, and Catastrophe

Perrow’s Predictions (1984)

- Before 1984
  - Three Mile Island
  - Petrochemical
  - Teneriffe, etc.
  - Torrey Canyon
  - Gemini, Apollo 13
  - HMS Canberra

- Since 1984
  - Chernobyl
  - Bhopal
  - Singapore 006, etc.
  - Exxon Valdez
  - Challenger
  - Gulf War

System elements

- Part (a single component)
- Unit (a functionally related collection of parts)
- Subsystems (an array of units)
- System
Incident

- Damage limited to parts or a unit, whether the failure disrupts the system or not.
- There are many more incidents than accidents.

Accident

- A failure in a subsystem or the system as a whole, that damages more than one unit and in doing so disrupts the on-going or future output of the system.

Component Failure Accident

- One or more component failures (part, unit, or subsystem) that are linked in an anticipated sequence.
System (Normal) Accident

- An accident involving unanticipated interactions of multiple failures.

Victims

- First party (operators)
- Second party (non-operating system personnel or system users)
- Third party (innocent bystanders)
- Fourth party (fetuses and future generations)

Common-mode connections
Typical Positive Feedback loop

- Microphone
- Amplifier
- Speaker

Typical Negative Feedback loop

- Control
- Sensor
  - Measurement or Comparison
  - Feedback

Radar Assisted Collisions
Linear Systems
- Spatial segregation
- Dedicated connections (not common-mode)
- Segregated sub-systems
- Easy Substitutions
- Few feedback loops
- Single purpose controls
- Direct information
- Extensive understanding

Complex Systems
- Proximity of components
- Common-mode connections
- Interconnected sub-systems
- Limited Substitutions
- Feedback loops
- Multiple and interacting controls
- Indirect information
- Limited Understanding

Specialization and knowledge
- “Specialized personnel tend not to bridge the wide range of possible interactions…”
- As we saw with Taylorism, the organization of work activities affects the distribution of knowledge, which in this case affects the ability of the system to recover from error and failures.
Tight Coupling

- Delays in processing not possible
- Invariant sequences
- Unifinality (only one way to do the job)
- Little slack
- Buffers designed-in
- Substitutions designed-in

Loose Coupling

- Processing delays possible
- Order of sequences can be changed
- Alternative methods available
- Slack in resources
- Buffers and redundancies fortuitously available
- Substitution fortuitously available