Network Reliability and Resilience

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Reliability and Resilience

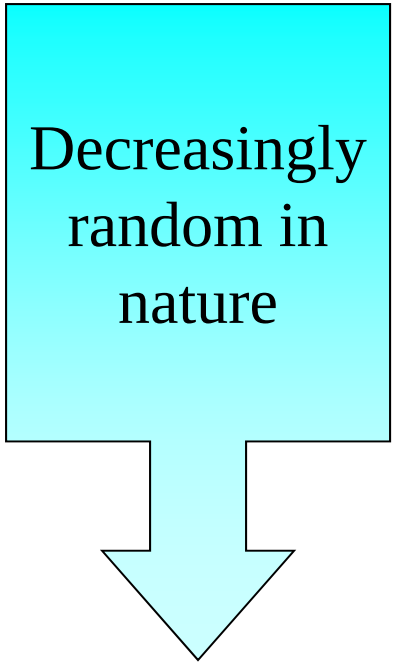
- Reliability
  - Low probability of failure
- Resilience
  - Consequences of failure are designed to be small
  - Return to normal function is rapid

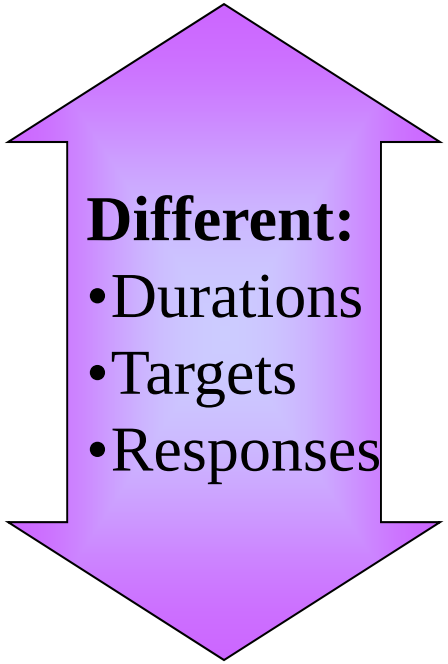
Outline

- Framework for network resilience
- Industry perspectives
- Examples of research at NU
- Directions for future work and collaboration

Sources of Supply Chain or Network Unreliability

- Natural disasters
- Weather
- Congestion of facilities
- Business failures
- Economics, Energy, Environment
- Labor disruptions
- Terrorist actions



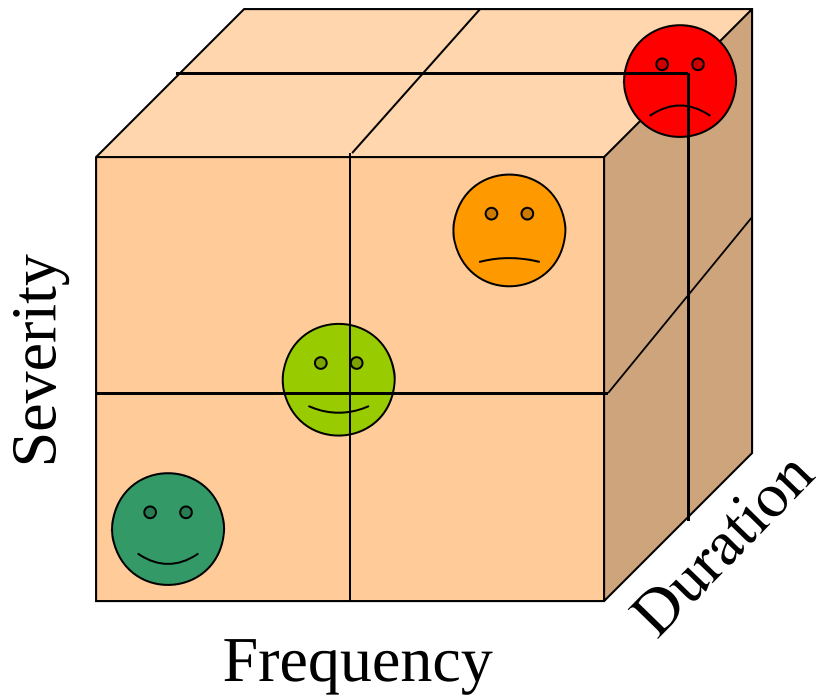


We live in an uncertain world.

Reliability/Resilience Taxonomy: Frequency/Severity

		Frequency	
		Low	High
Severity	Low		
	High		

Reliability/Resilience Taxonomy: Duration is also important

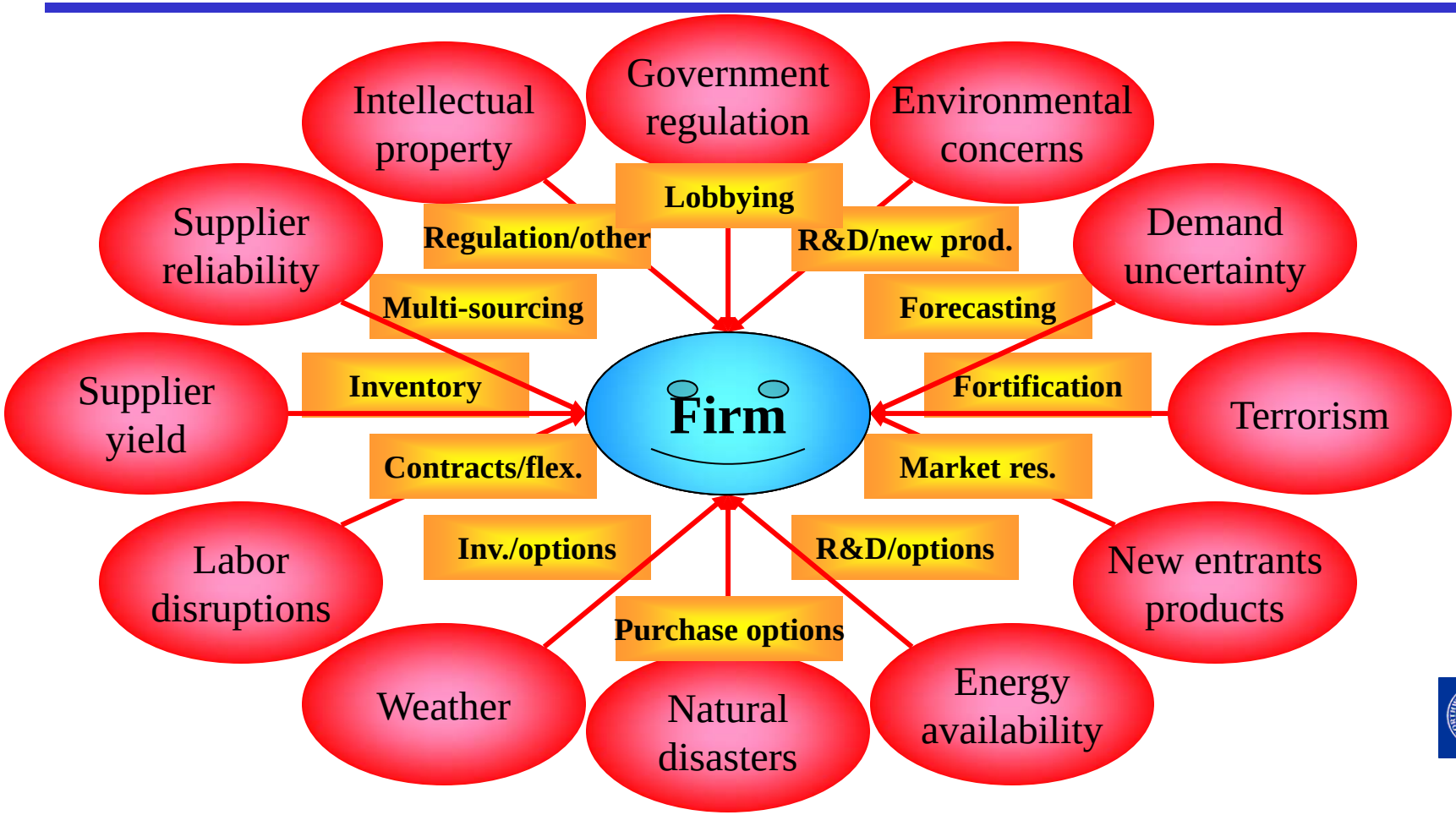


Frequency – how often does something fail

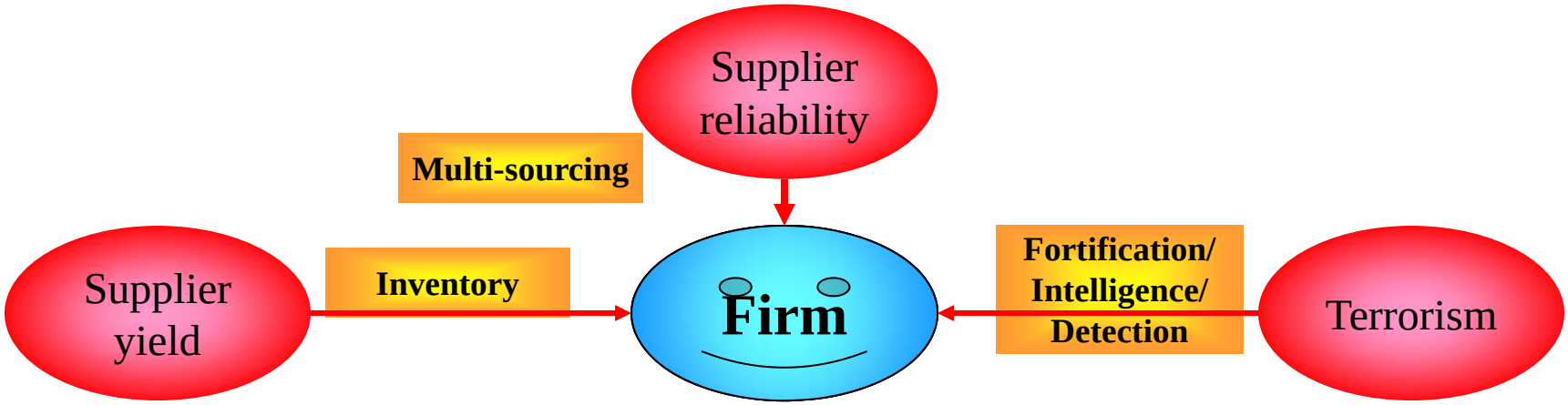
Severity – what fraction of network capability is lost
– what is the cost?

Duration – how long is it disabled

Threats and countermeasures



Threats and countermeasures

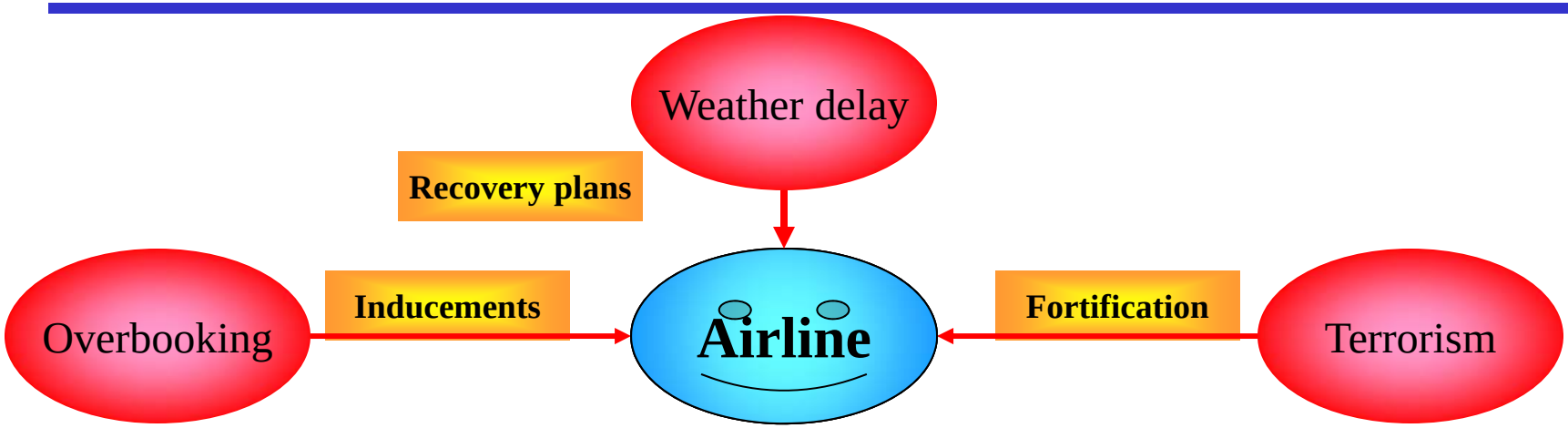


Yield – high frequency, short duration, low consequence, unpredictable

Supplier reliability – lower frequency, longer duration, moderate consequence, may be targeted

Terrorism – very low frequency, long duration, high consequence, targeted

Threats and countermeasures

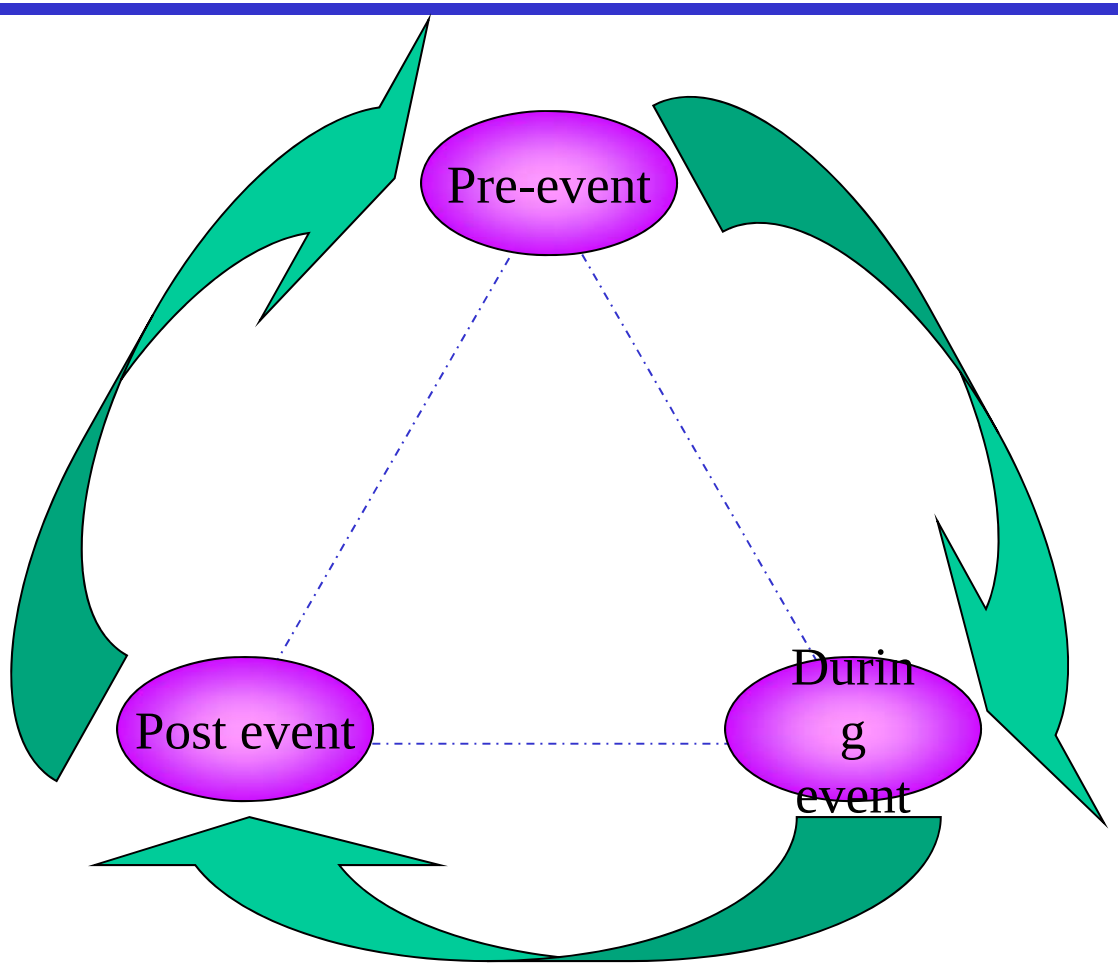


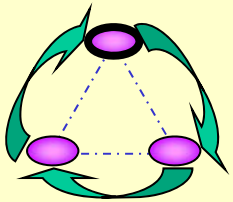
Overbooking – high frequency, few flights impacted, low consequence, somewhat unpredictable

Weather delay – lower frequency, longer duration, moderate to high network consequences, may be foreseen

Terrorism – very low frequency, very long duration, high consequence, targeted at vulnerable facilities

Event planning is a cycle



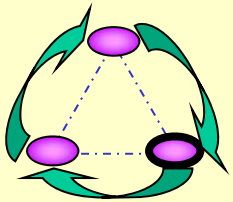


Pre-event planning

- **Prevent** events
- **Defend** against events (harden facilities)
- **Design** systems to be resilient with respect to failures

- **Prevent** overbooking via improved forecasting
- **Defend** against terrorism via screening
- **Design** routes and networks to be robust w.r.t. weather delays

- **Prevent** shortages thru better forecasting
- **Defend** against shortages via safety stock
- **Design** products for substitutability; networks with multiple suppliers

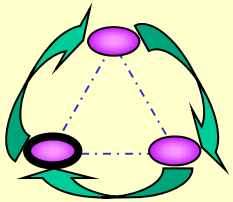


During event

- **Detect** events
- **Diagnose** event
- **Prescribe** action
- **Communicate** action
- **Coordinate** response
- **Control** response

- **Detect** weather problems early
- **Diagnose** severity of disruption due to weather
- **Prescribe** response (reroute aircraft, call in backup crews)
- **Communicate** passengers
- **Coordinate** with other airlines and hotels
- **Control** entire response

- **Detect** shortages by monitoring key suppliers
- **Diagnose** shortage severity (total, partial)
- **Prescribe** actions (draw on safety stock, invoke contracts)
- **Communicate** plans with plants, suppliers, and customers
- **Coordinate** response across system
- **Control** production

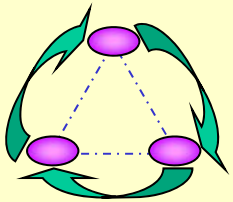


Post event

- **Recovery** actions
- **Redesign** system for better response
- **Reconstruct** system

- **Recovery** actions to reposition aircraft and crews
- **Redesign** network, routes, aircraft assignments, *response system*
- **Reconstruct** *may not be applicable in weather case except in the extreme*

- **Recovery** actions to get production back and marketing to recover market share
- **Redesign** supply chain to mitigate future shortages (improve forecasting, safety stock, multi-source)
- **Reconstruct** supply chain and replenish safety stocks



Key observations

- **Network effects** make pre-event, during event and post-event difficult
- **Solutions must encompass**
  - Detection and Diagnosis
  - Communication and Coordination
  - Recovery and Redesign

Questions for Industry

- How do you think about resilience?
- How do you ensure resilience?
- How do you monitor your network(s)?
- What is the impact of a network failure?
- How do you contain/recover from failures?
- What “unmet needs” do you have?