MAJOR IMPLICATIONS OF EFRI-RESIN RESEARCH ON THE CALIFORNIA DELTA FOR RISK ASSESSMENT & MANAGEMENT (RAM) OF INTERCONNECTED CRITICAL INFRASTRUCTURES SYSTEMS (ICIS)

NSF EFRI-RESIN: ASSESSING & MANAGING CASCADING FAILURE VULNERABILITIES OF COMPLEX INFRASTRUCTURE SYSTEMS UNIVERSITY OF CALIFORNIA, BERKELEY

ISU-NSF WORKSHOP ON ENERGY, TRANSPORTATION AND WATER INFRASTRUCTURES: POLICY AND SOCIAL PERSPECTIVES JULY 17-19, 2013

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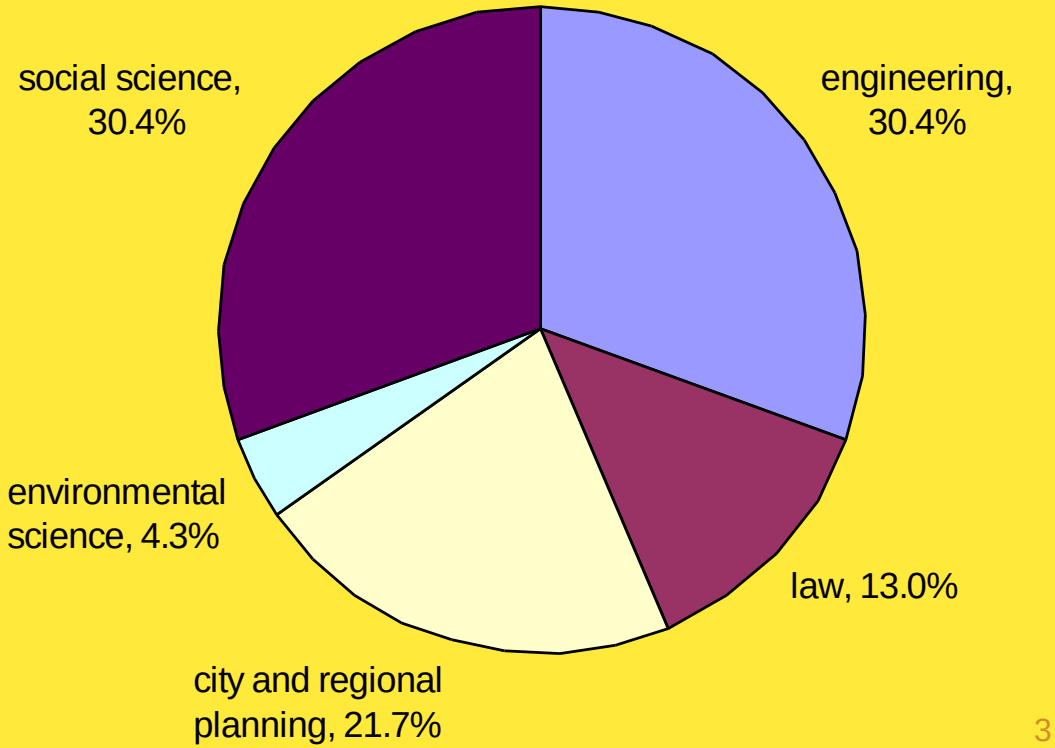
THE AIM OF OUR RESIN IS…

To create, validate, & apply improved Risk Assessment & Management (RAM) approaches for enhanced resilience and sustainability of interconnected critical infrastructure systems (ICIS).

Our RESIN Aim Means Interdisciplinary Research That

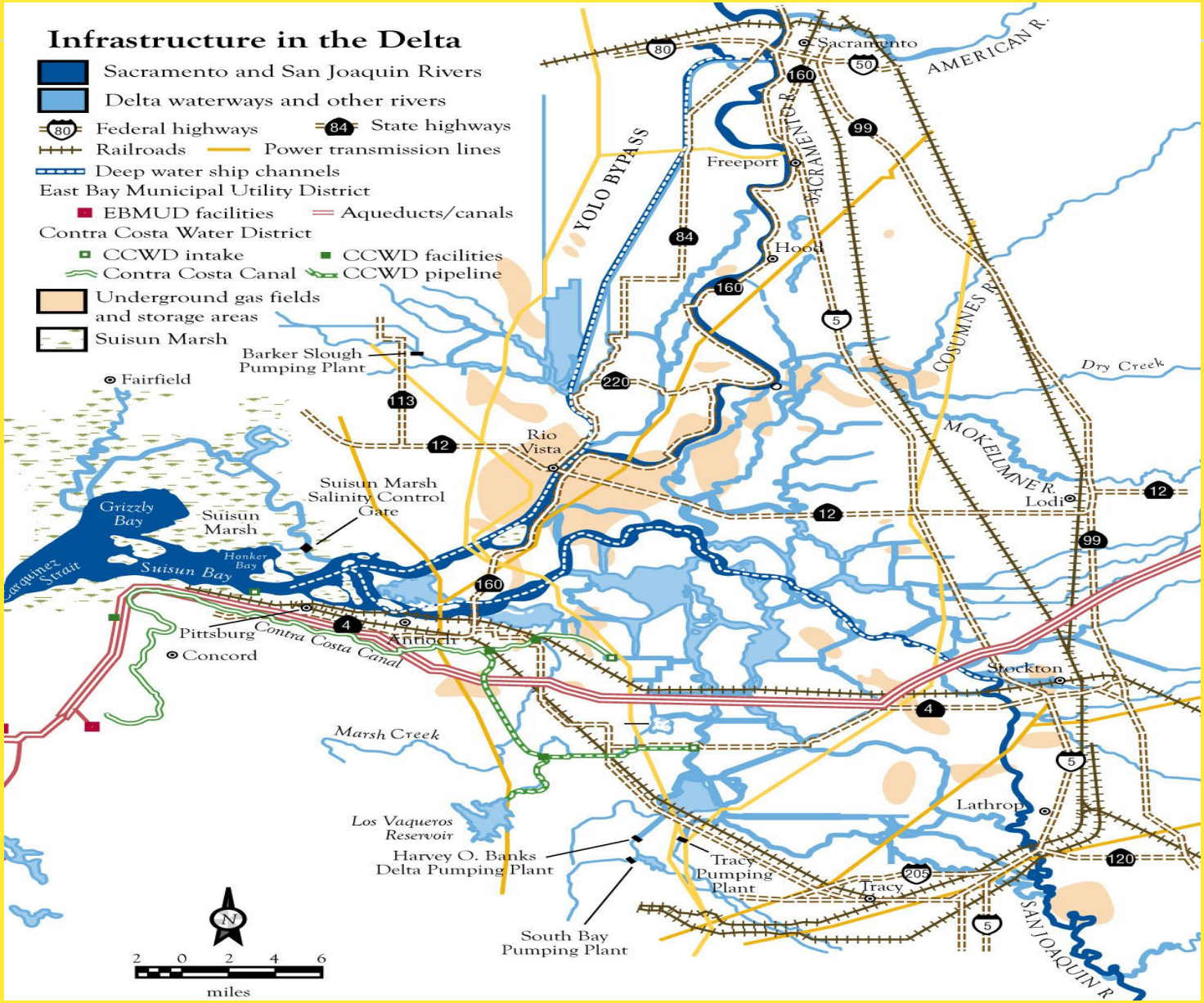
- **highlights differing orientations to risk, resilience & system definitions for sustainability**
- **requires thinking through risk management at different scales in highly engineered, reliable systems before, during & after a disaster**

20 researchers
5 disciplines

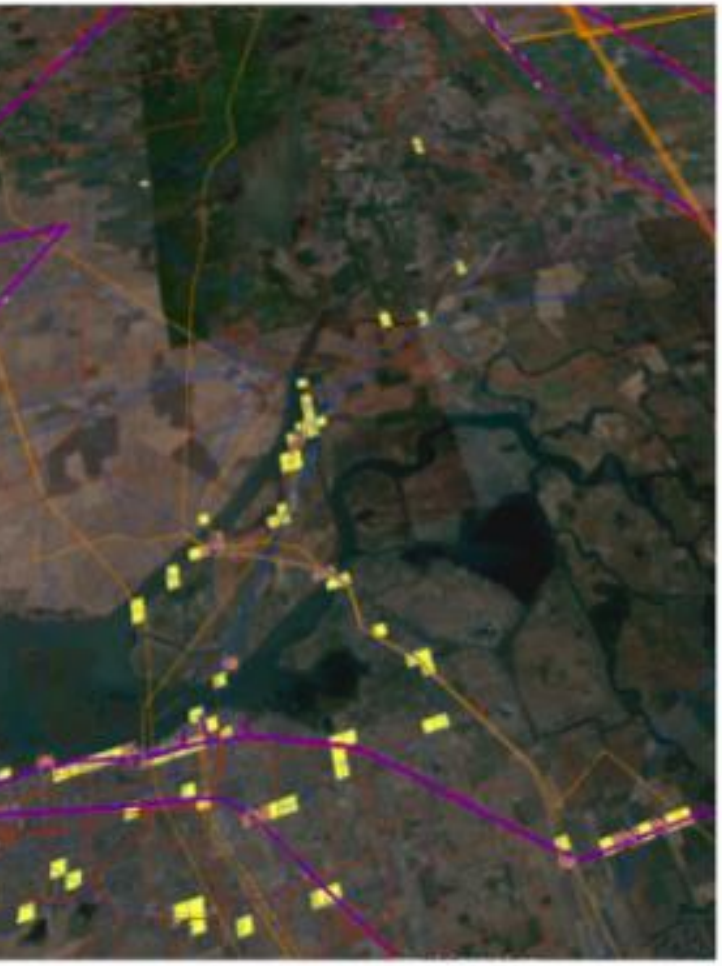


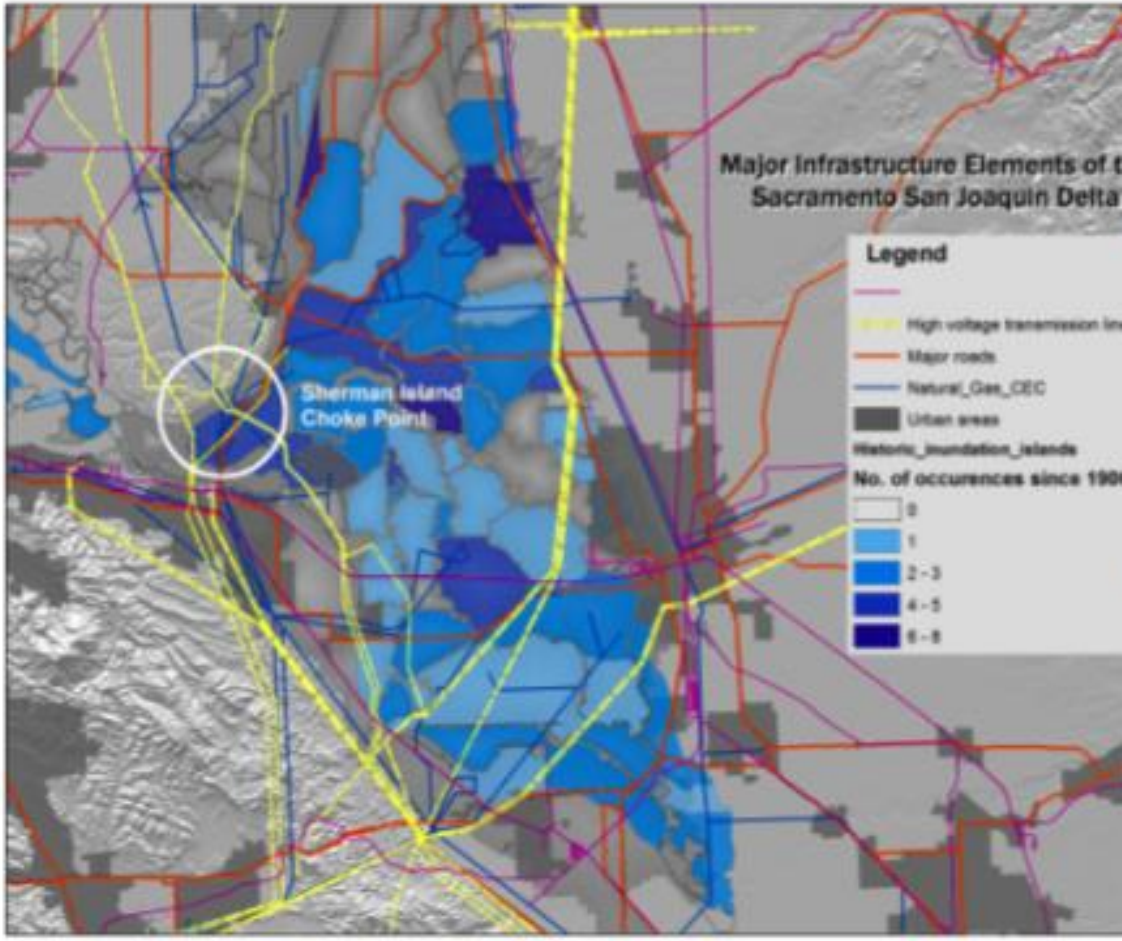
RESIN Resilient and Sustainable Infrastructure Networks

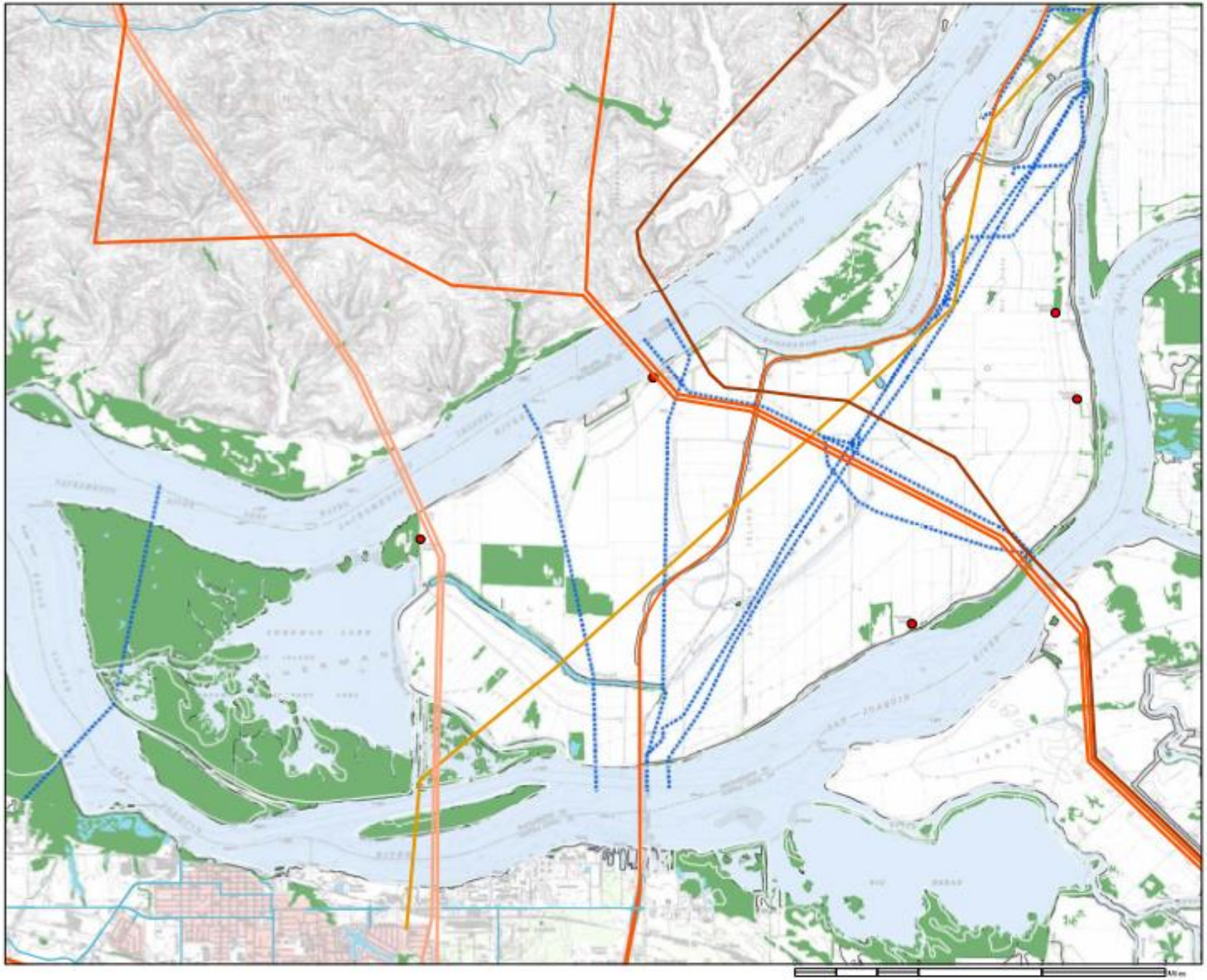
OUR RESIN LABORATORY:



Identify infrastructure clusters where multiple systems are vulnerable to single events





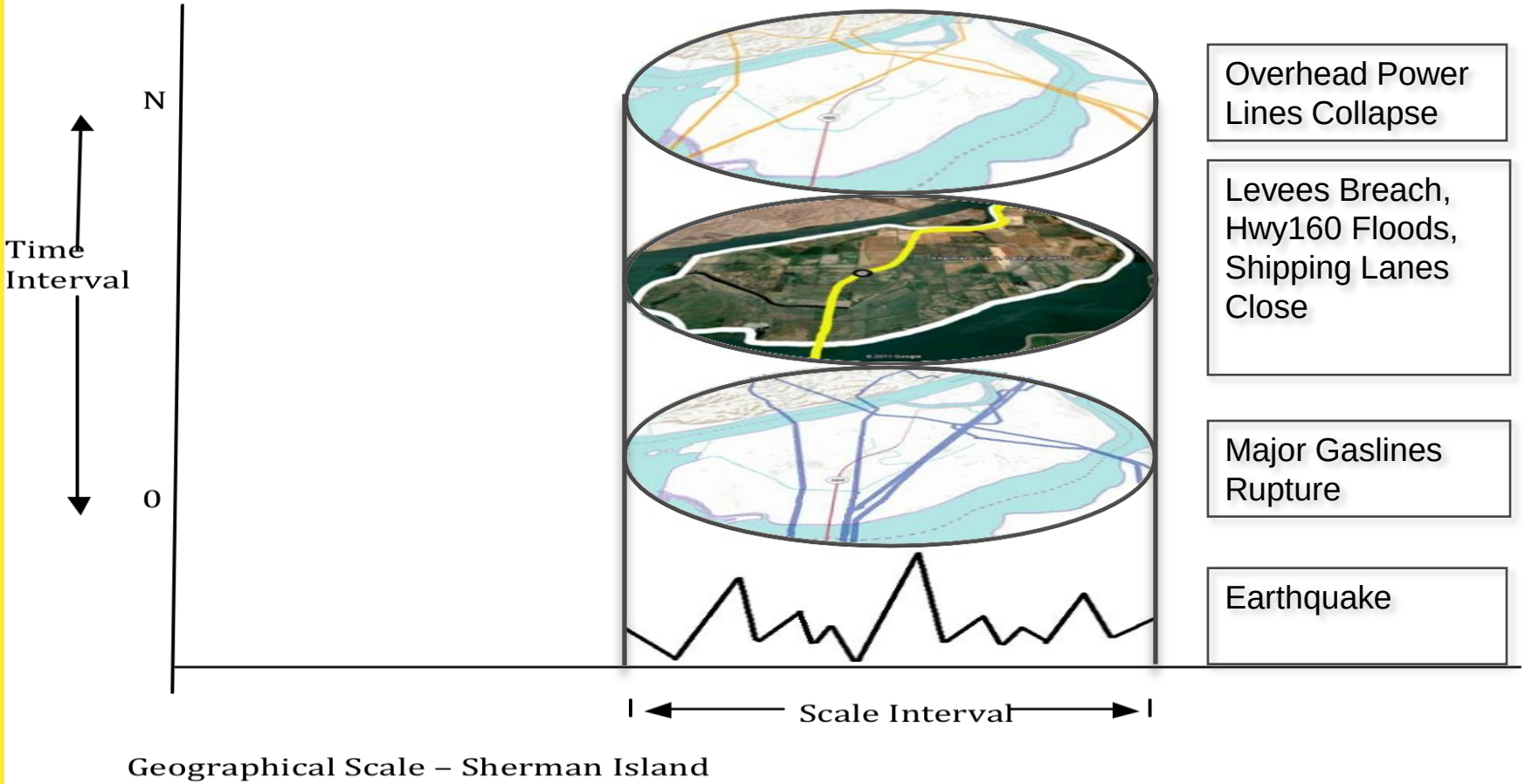


Sherman Island Built-Infrastrucutre

UC Berkeley NSF/RESIN Sherman Island Pilot Project. March 8, 2010

ISU-NSF WORKSHOP: JULY 17-19, 2013

Figure 1 A Cylinder of Spatially Adjacent Infrastructure Elements – Sherman Island




Flooding to -14 feet mean sea level

Annual Pf

3 failure modes Sherman Island 2010

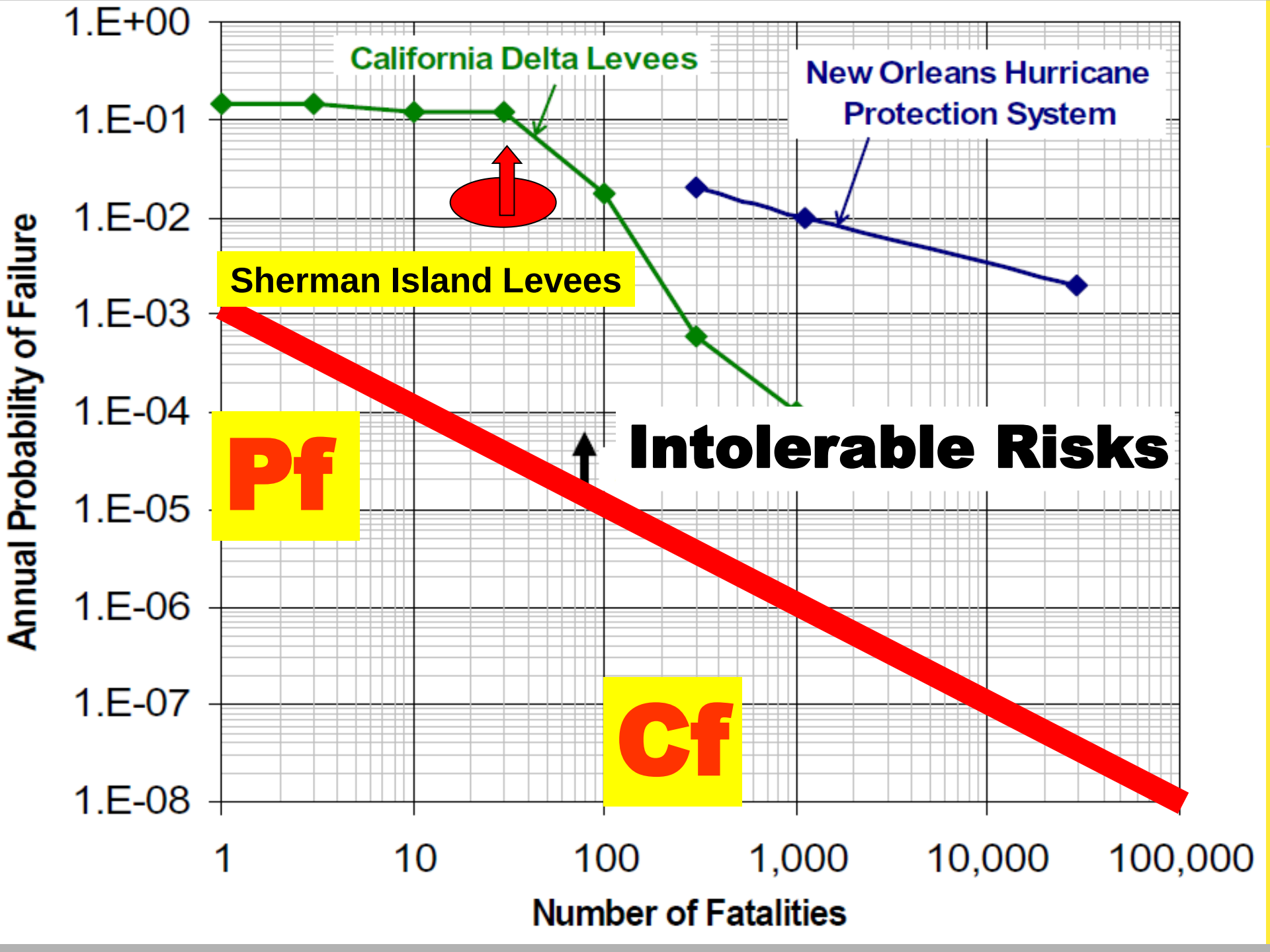
(Slope stability methods are Bishop and Spencer)

Failure Probabilities	$P_{f,\ Seepage}$	$P_{f,\ Overtopping}$	$P_{f,\ Slope\ stability}$
South Side	7.45%	6.60%	3.75% - 23.58% (Deep Failure)
North Side	7.08%	6.60%	5.05% - 29.01% (shallow Failure)

>7% Delta Risk Management Strategy [DRMS]

Mean annual probability of levee failure in the Delta Region from the combined risk of earthquakes, high water and dry-weather failures [2005 conditions]

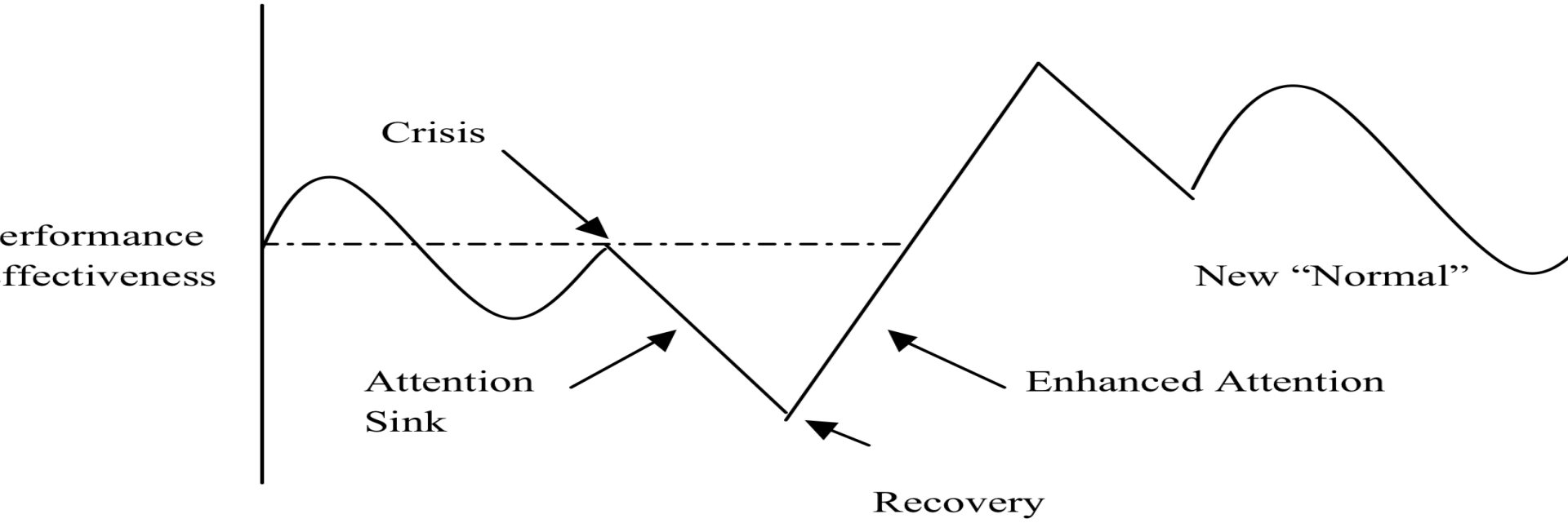
Source: National Science Foundation, # EFRI-0836047


California Delta Levees
New Orleans Hurricane Protection System
Sherman Island Levees
Pf
Intolerable Risks
Cf
Annual Probability of Failure
1.E+00
1.E-01
1.E-02
1.E-03
1.E-04
1.E-05
1.E-06
1.E-07
1.E-08
1
10
100
1,000
10,000
100,000
Number of Fatalities

Whole-Cycle Approach to

Assessing and Managing Infrastructure Reliability:

Horizontal (infrastructural) and Vertical (interinfrastructural)



CASCADES? (LUIIJF ET AL 2008; VAN EETEN ET AL 2011)

CI Sector	Cascade initiating	Cascade resulting	Independent	Total	Sample size
Education	0	3	1	4	4
Energy	146	76	388	609	590
Financial services	1	26	33	60	60
Food	0	4	3	8	8
Government	2	40	26	68	67
Health	1	16	22	39	39
Industry	5	15	7	27	27
Internet	15	51	95	161	160
Postal Services	1	0	0	1	1
Telecommunications	69	125	114	308	295
Transport	19	128	276	423	422
Water	9	18	51	78	76
Total	268	501	1017	1786	1749

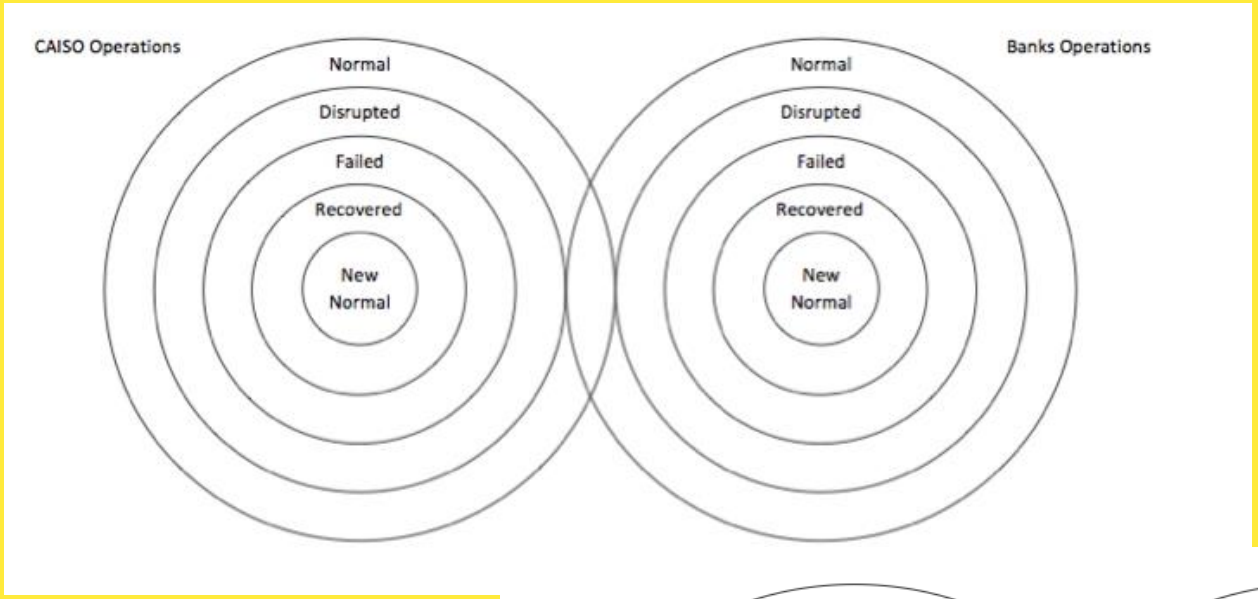
Table 1. Categorisation of number of CI disruption events (number of events).

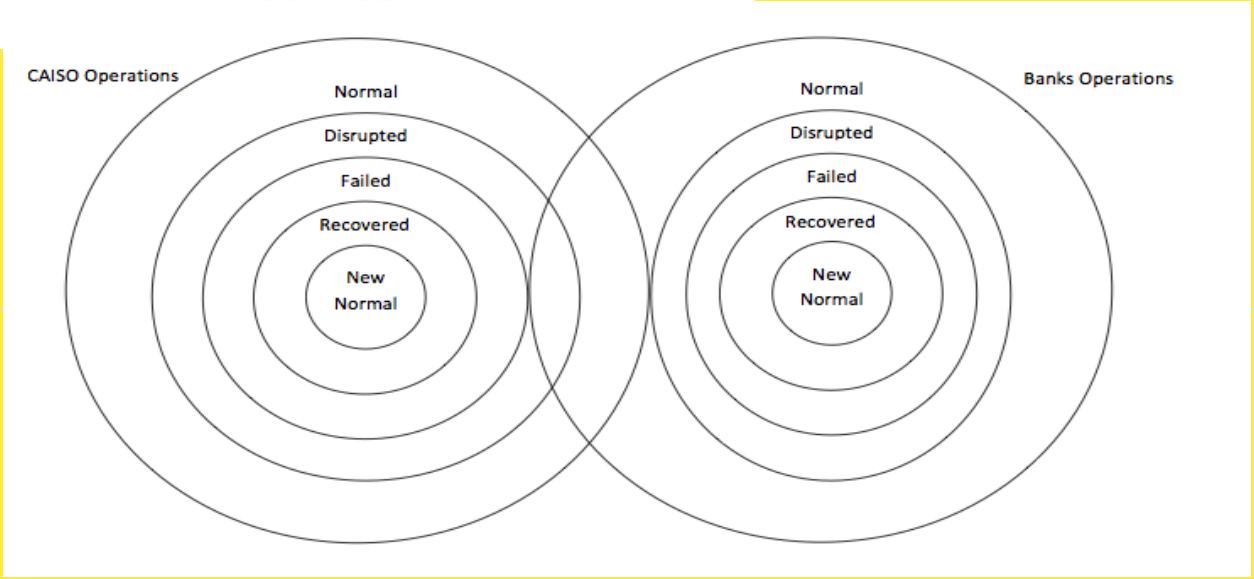
TABLE 4 *Cascading events summed by affected infrastructure*

	Initiating sector									
Affected sector	Energy %	Financial Services %	Government %	Health %	Industry %	Internet %	Telecom %	Transport %	Water %	TOTAL %
Education & research									100	100
Energy	100						0			100
Financial services	27	9				9	55			100
Food	*67*				33					100
Government	26		5	5		11	47	5		100
Health	50			25			13		13	100
Industry	83								17	100
Internet	15					25	60			100
Telecommunications	*48*						52			100
Transport	*67*				2		14	14	2	100
Water	80								20	100
TOTAL	***46.6***	**0.5**	**0.5**	**1.4**	**0.9**	**7.2**	***37.1***	**3.2**	**2.7**	**100**

Note: figures in italics are referenced in the main text.

Overlapping Stages of Infrastructure Operations





ISU-NSF Workshop: July 17-19, 2013

THE GOOD NEWS:
While determination of System Pfs and Cfs is difficult (and by extension difficult for Intersystem Pf and Cf), it can be done and produce potentially useful information for decisionmakers.

THE BAD NEWS:
The primary challenge, however, is to engage decisionmakers (industry, government, affected public) in constructive collaborations to make decisions that promote resilience and sustainability in the sense we have come to define the terms.

The experience thus far shows strong tendencies by decisionmakers (broadly writ again) to preserve the status quo—not just in the public and private sectors responsible for infrastructures, but also methodologically with RAM methods that may well have not been fully validated.

Moreover, current engineering education and professional requirements do not adequately promote realistic assessment of the critically important system resilience and sustainability Pfs and Cfs. Nor do they adequately address 'human and organizational factors' and their requirements for 'acceptable' resilience, sustainability, and reliability.