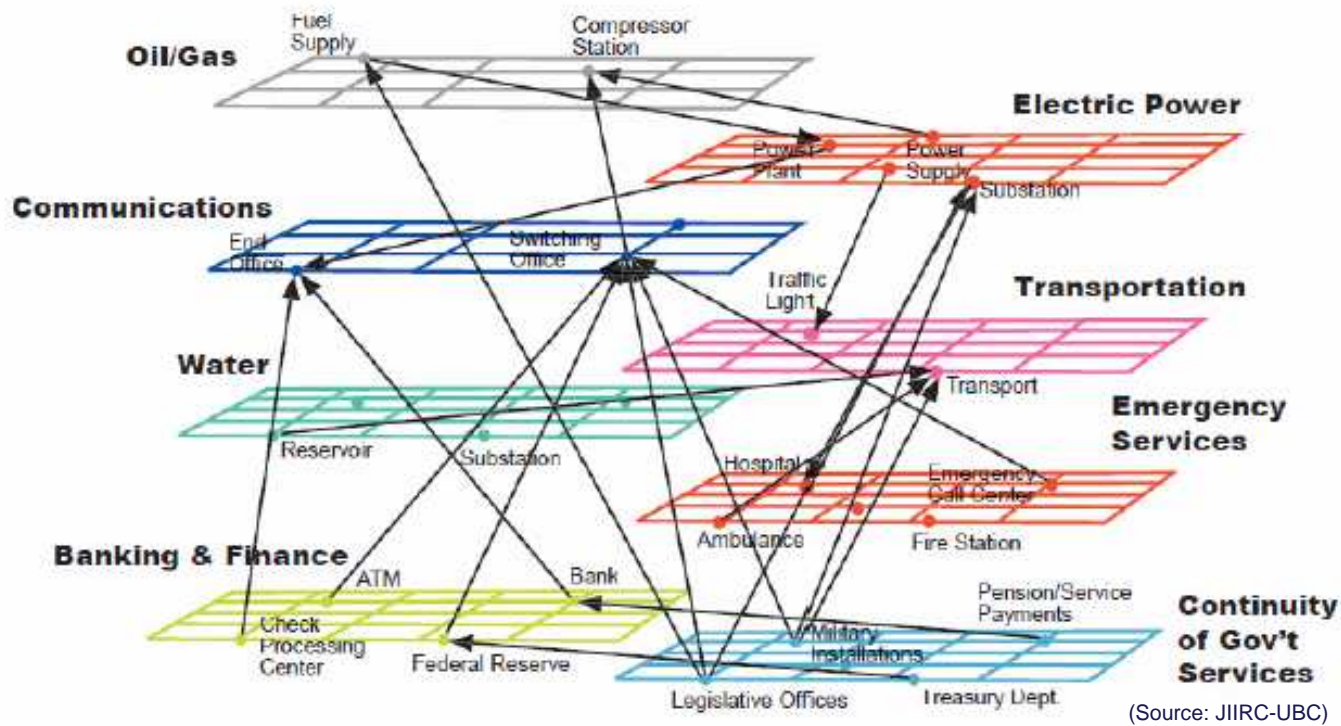


Progress Report: CCSF Lifelines Council Interdependency Study



Lifelines Council Meeting #9

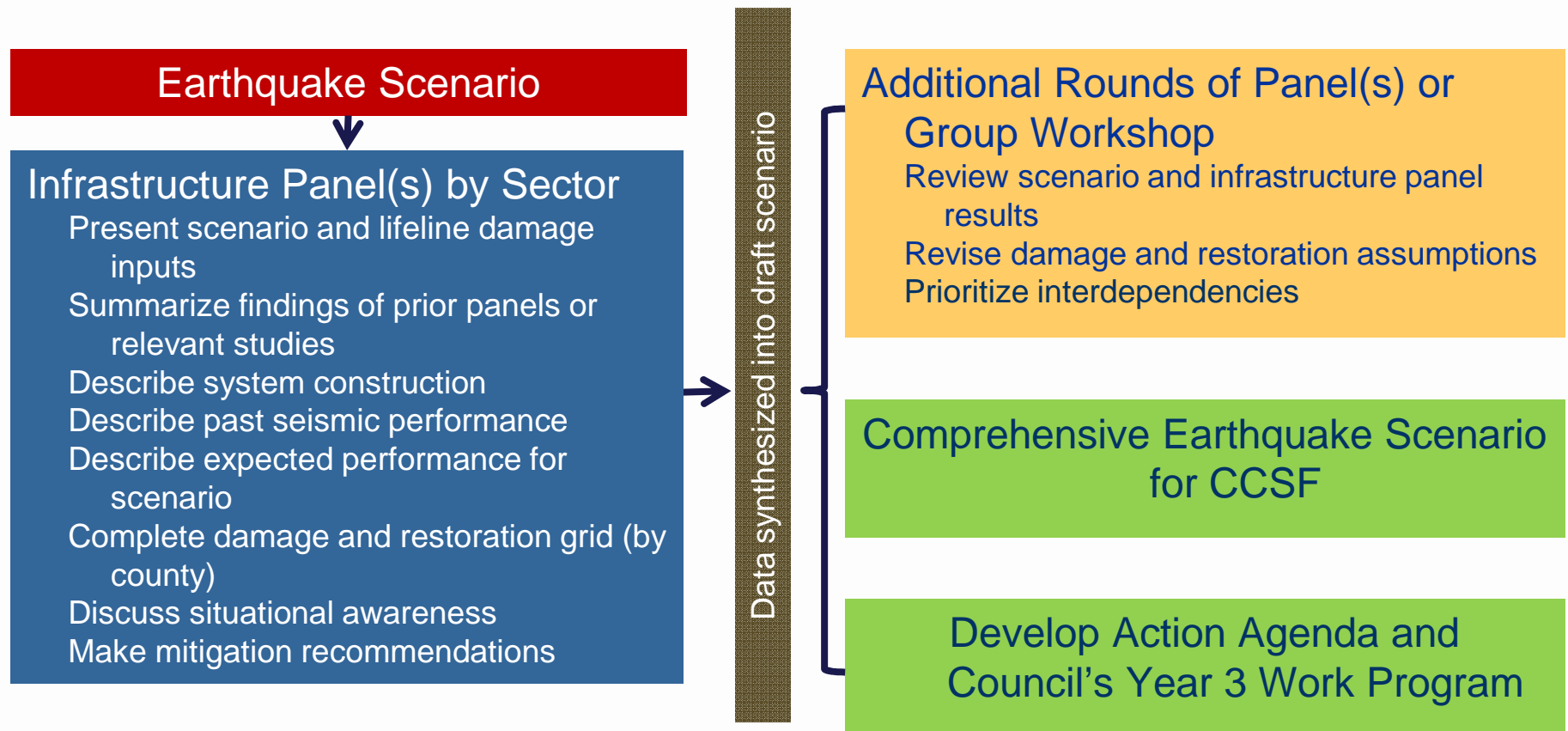
September 6, 2012

Interdependency Study Goals (Near-term 2 – 5 years)

- Build a workable understanding of system interdependencies, and consequences of existing conditions ,to help expedite response and restoration planning among agencies
- Identify key assets and restoration priorities/schemes to prioritize post-disaster restoration and reconstruction activities for the city, and ultimately the region
- Develop a collective set of lifelines performance expectations under current conditions

Lifelines Council Interdependency Study Approach

(modeled after Chang et al (Vancouver) and Porter et al (Southern California))



Interdependency Study Progress to Date and Next Steps

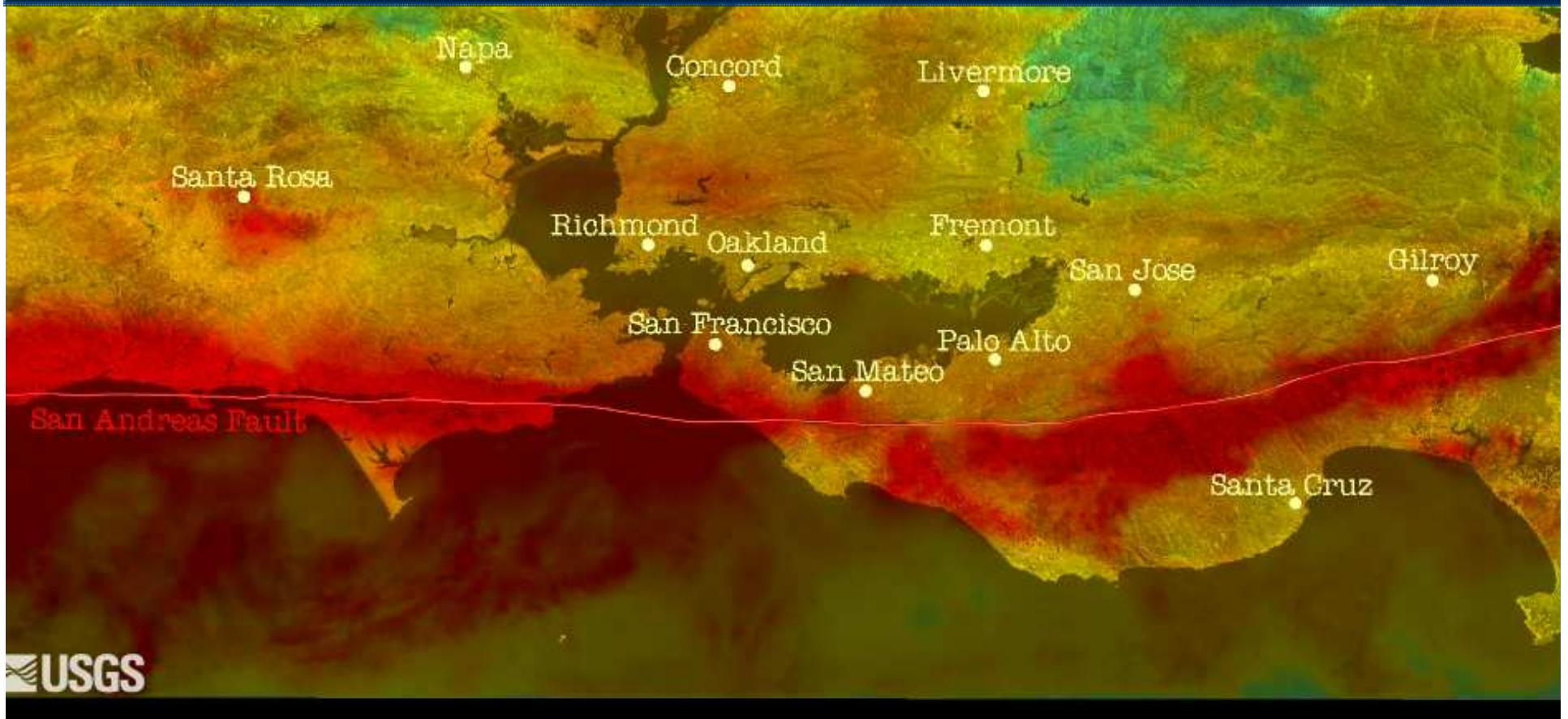
- √ Design study, select scenario, and develop discussion guide (April – October 2011)
- √ Pilot testing of scenario and finalize discussion guide (Nov 2011 –Jan 2012)
- ☐ Infrastructure operator and panel discussions (January – November 2012)
- ☐ Synthesize discussions into integrated scenario and interdependency insights; operator review and approval (November 2012 – January 2013)
- ☐ Presentation to the Lifelines Council and other groups, as appropriate (Spring 2013)

M7.9 San Andreas Earthquake Scenario affecting 19-counties in Northern California

(EERI, Charles A. Kircher et al. 2006)

Time=75.0 s

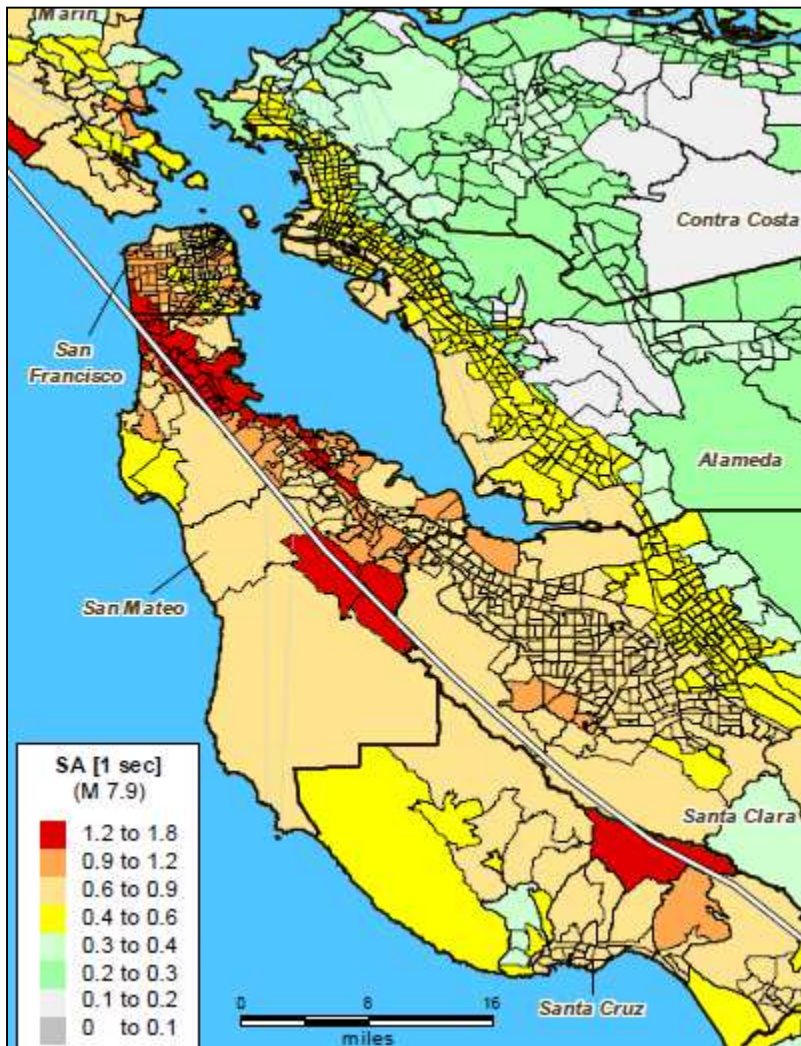
I II III IV V VI VII VIII IX X
Shaking Intensity



Summary of Building Damage and Loss Results Due to Ground Shaking and Ground Failure – Total Study Region

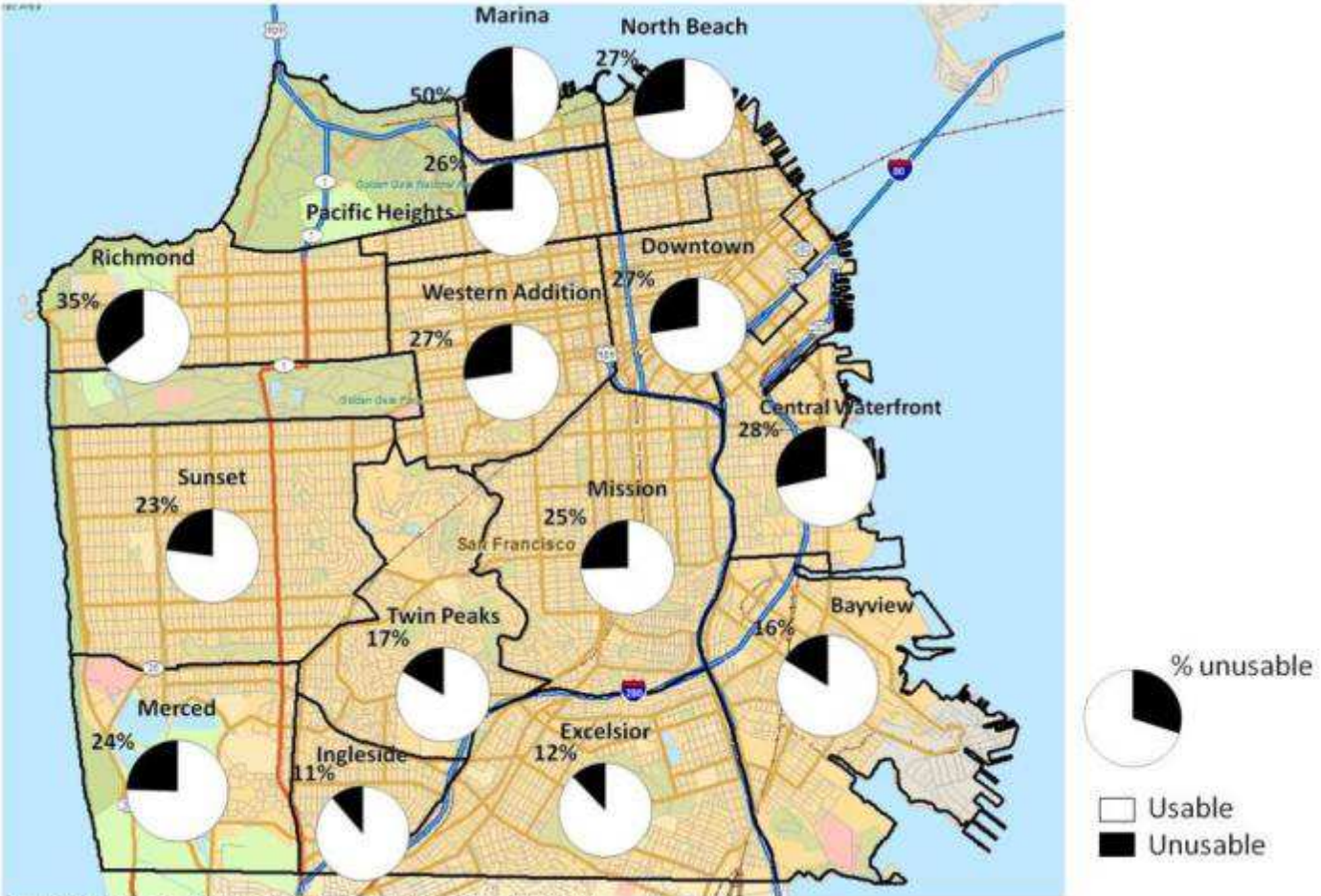
Damage or Loss Parameter	Population or Exposure	Scenario Earthquake	
		1906 MMI	M7.9
Number of Severely Damaged Buildings			
Residential Buildings	2,800,000	80,000	120,000
Commercial Buildings	70,000	7,000	10,000
Social Losses due to Building Damage			
Displaced Households	3,700,000	170,000	250,000
Serious Injuries - Nighttime	10,300,000	4,000	8,000
Serious Injuries - Daytime		6,000	13,000
Immediate Deaths - Nighttime	10,300,000	800	1,800
Immediate Deaths - Daytime		1,600	3,400
Direct Economic Losses due to Building Damage (Dollars in Billions)			
Structural System	\$300	\$15	\$20
Nonstructural Systems	\$800	\$57	\$75
Contents and Inventory	\$500	\$14	\$17
Business Interruption (BI)	NA	\$8	\$11
Total Building and Contents	\$1,500	> \$90	> \$120

Residential Impacts (San Francisco)



- 15,000 – 24,000 single family dwellings with extensive or complete damage (12% to 20% of 125,000 total)
- 7,000 – 11,000 other residential buildings with extensive or complete damage (19% to 30% of 37,000 total)
- 60,000 – 88,000 households initially displaced (18% to 27% of ~330K)
- 14,000 – 22,000 people seeking shelter (out of ~800K)

Housing Units Usable and Unusable after a M7.2 San Andreas Earthquake (SPUR/CAPSS)

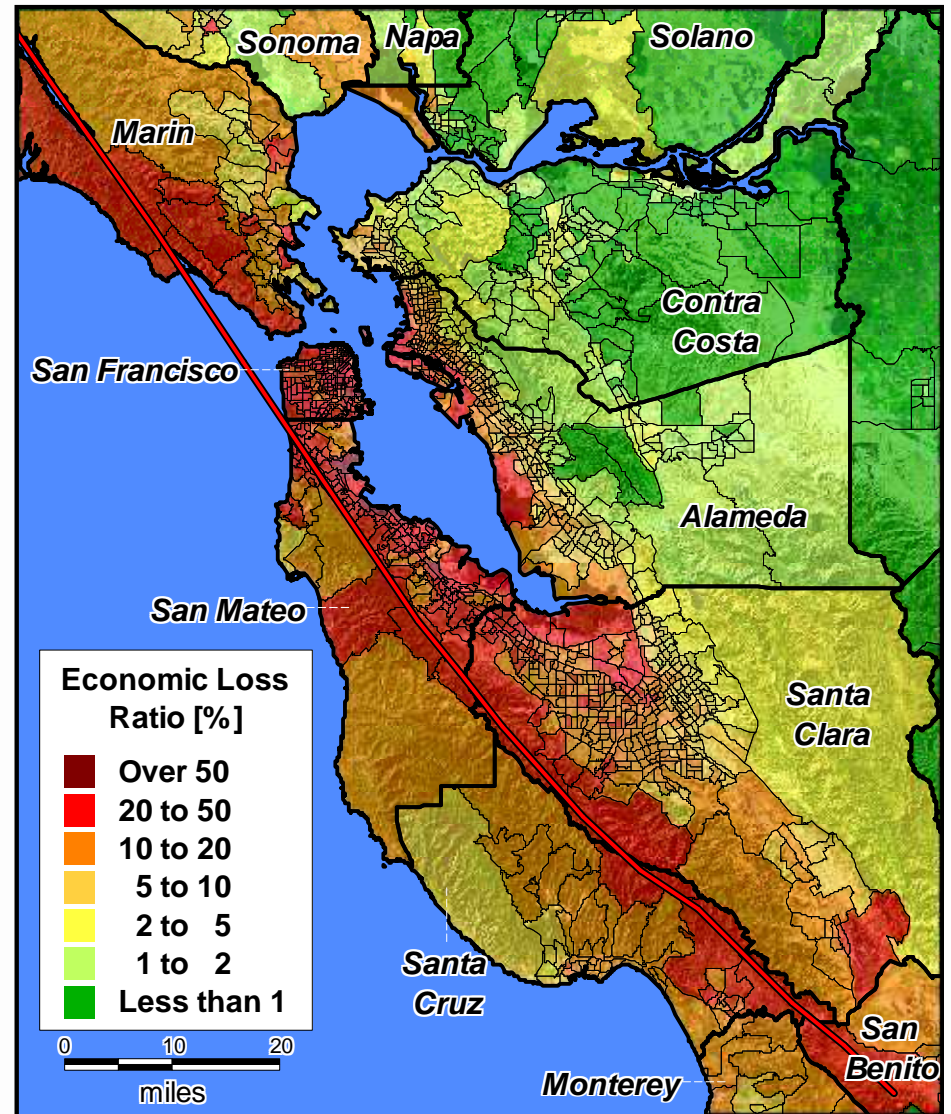


Sources: SFGIS, Census 2000 and SPUR analysis of CAPSS Hazus Output Data

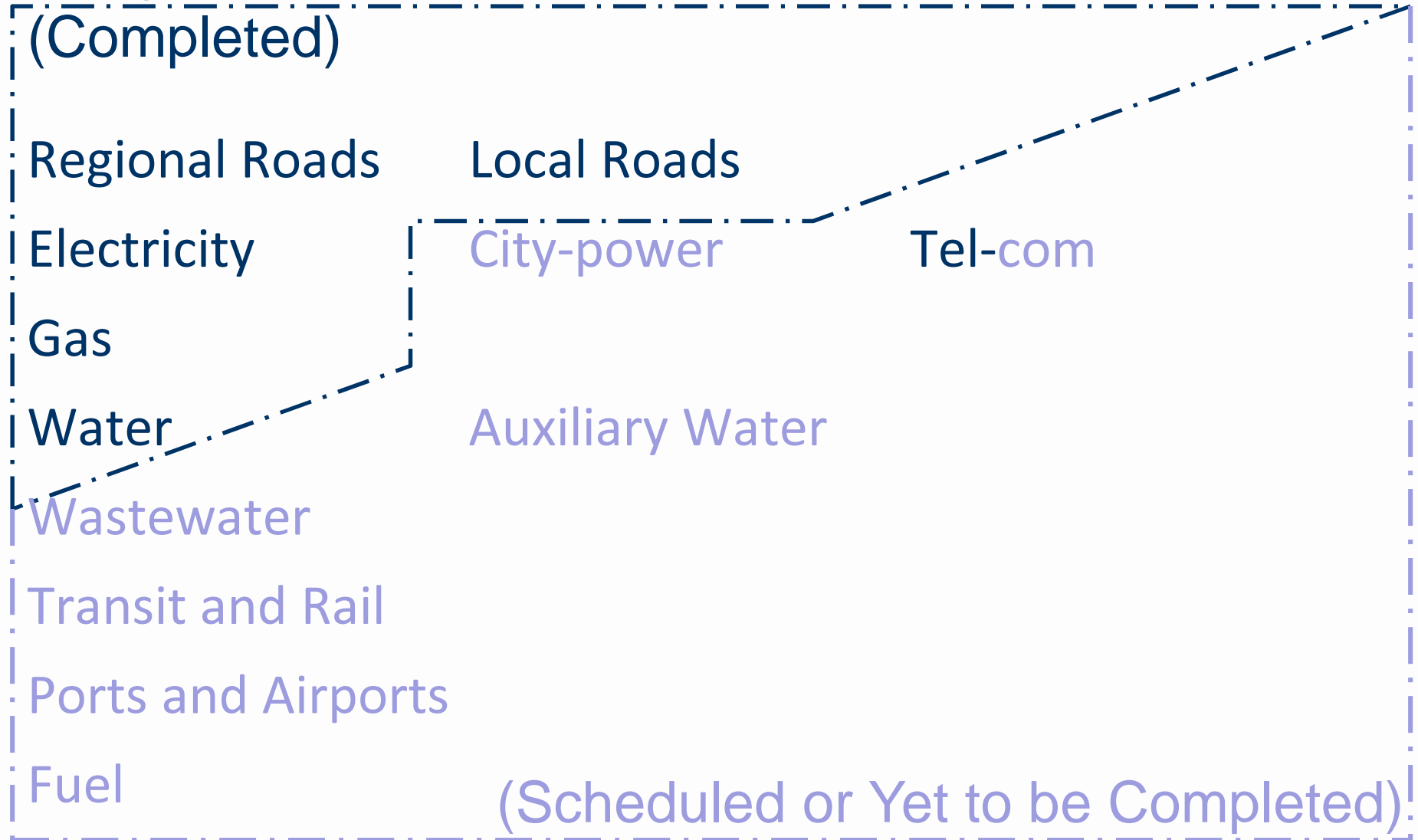
Total Direct Economic Loss

Direct Economic Building Loss due Ground Shaking/Failure (M7.9)	
County	Loss Ratio
Alameda	7.4%
San Francisco	25.9%
San Mateo	24.6%
Santa Clara	11.9%
Other Counties	2.7%
All 19 Counties	9.0%

- Fire - Plus 5% - 15%
- Lifelines - Plus 5% - 15%
- Total Loss: **\$150 billion**



Progression of Interdependency Interviews



Roads (Regional + Local)

Redundancy ensures regional functionality, but the level of service will be significantly impacted.

Primary regional access routes from the south – El Camino, 101, and 280.

City road clearance focus first on access for emergency response, areas needing assistance (hospital, fire and police), then supply routes – most likely starting from the south.

Road clearance and repair could take a year. Full reconstruction would take longer.

Image © 2012 TerraMetrics
© 2012 Google
Data LDEO-Columbia NSF, NOAA
Data SIO, NOAA, U.S. Navy, NGA, GEBCO

Electricity

Transmission lines up the peninsula are pretty robust. DC line from East Bay can't provide independent service

SF has no electric generation capacity

Critical substation could experience significant damage, resulting loss of all 3 transmission lines

Much of SF distribution system is underground, subject to significant damage, and more challenging to repair

Image © 2012 TerraMetrics

© 2012 Google

Data LDEO-Columbia, NSF, NOAA

Data SIO, NOAA, U.S. Navy, NGA, GEBCO

Google earth

Gas

3 transmission lines up the peninsula meet at single point. If 2 lose transmission, then resulting pressure loss could curtail service citywide

SF gas distribution system is underground, but in flexible plastic pipe. If transmission lost, system restoration will take months

Image © 2012 TerraMetrics

© 2012 Google

Data LDEO-Columbia, NSF, NOAA

Data SIO, NOAA, U.S. Navy, NGA, GEBCO

Google earth

Water

High reliability of transmission system.

Deliver water to 3 of 5 of SF turnouts (70%) within 24 hours of a disaster; 100% in 30 days

Uncertain reliability of distribution system; portions will be damaged.

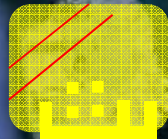


Image © 2012 TerraMetrics

© 2012 Google

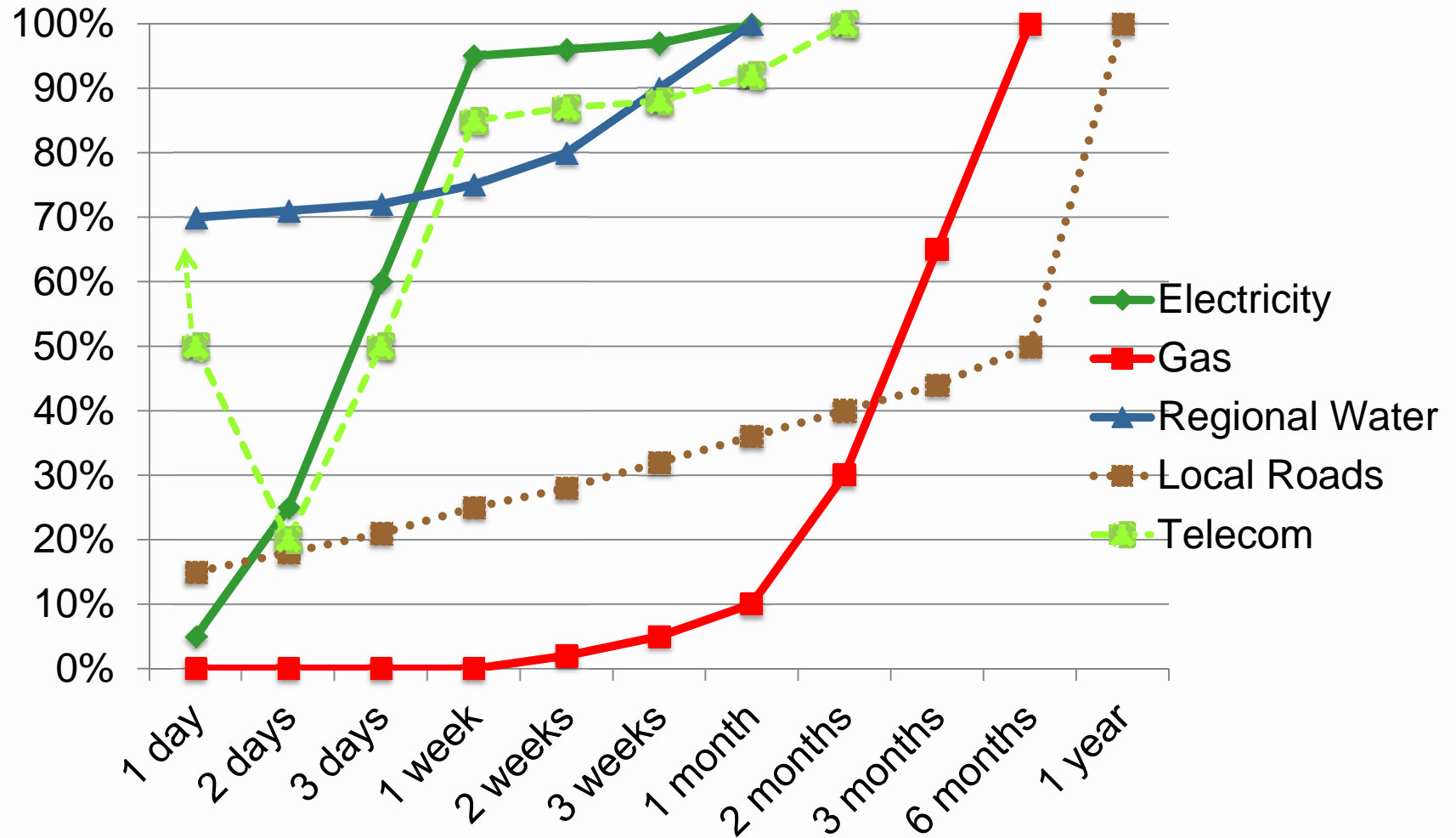
Data LDEO-Columbia, NSF, NOAA

Data SIO, NOAA, U.S. Navy, NGA, GEBCO

Google earth

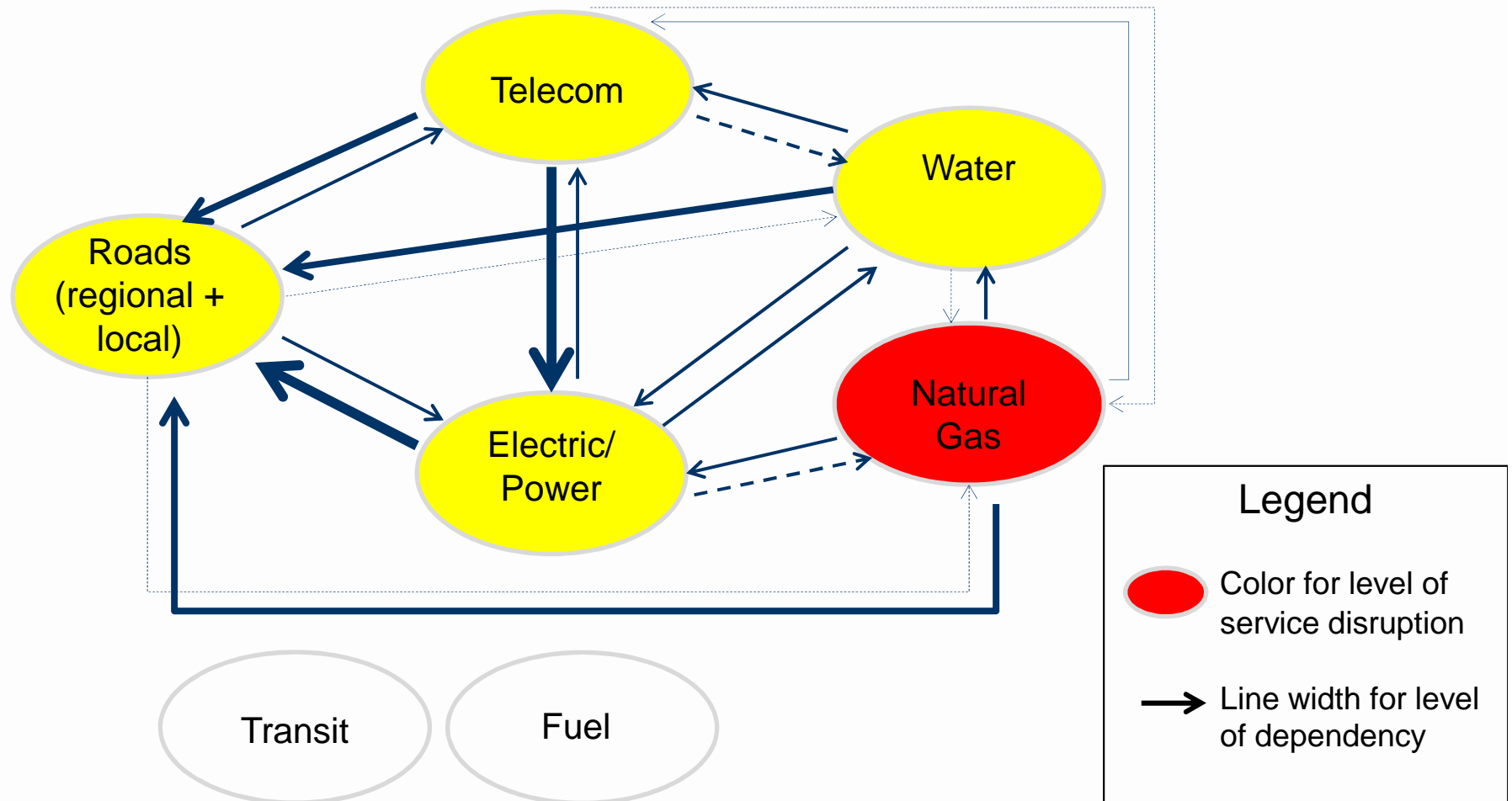
System Restoration

(Progress Report ; September 2012)



Lifeline Interdependencies in San Francisco

(Progress Report ; September 2012)



Critical Interactions among San Francisco Lifelines (Progress Report ; September 2012)

(Yao et al 2005, based on Kameda, Nojima, 1992; Scawthorn 1993; and others)

- **Functional disaster propagation, and cascading interactions**, due to failure of interdependence among lifelines
 - Roads (regional + local) and most operators
 - Electricity and telecommunications
- **Collocation and restoration interaction**, physical disaster propagation among lifeline systems
 - Underground water failures impacting underground electricity and gas
 - Roads (local) and buried infrastructures such as sewers
- **General interaction**, between internal components of a lifeline system
 - Electrical substation failure
 - Water turnout failures
 - Loss of generator power

Study Insights/Issues

(Progress Report ; September 2012)

- Resilience (Level of Service) standards vary considerably among systems, and so will likely restoration times
- Range of system conditions/restoration characteristics: older vs. newer, fixed vs. flexible, reliable vs. sensitive, smart vs. not-so-smart, complex and inter-related vs. independent
- Restoration priorities and communications/ decisions will come from varying management organizations/levels: national, state/region EOC, city of SF EOC, and system DOCs
- Common concerns about system restoration – access, credentialing and basic services for personnel, mutual aid/resources, communications, temporary staging/equipment storage areas
- Critical “choke” points affecting city’s resilience – no local power generating source and limitations of generators/fuel, older buried and ‘less smart’ distribution systems (e.g. gas, water, sewer)

TARGET STATES OF RECOVERY FOR SAN FRANCISCO'S BUILDINGS AND INFRASTRUCTURE									
INFRASTRUCTURE CLUSTER FACILITIES	Event occurs	Phase 1 Hours			Phase 2 Days		Phase 3 Months		
		4	24	72	30	60	4	36	36+
CRITICAL RESPONSE FACILITIES AND SUPPORT SYSTEMS									
Hospitals									×
Police and fire stations			×						
Emergency Operations Center									
Related utilities						×			
Roads and ports for emergency				×					
CalTrain for emergency traffic				×	×				
Airport for emergency traffic				×					
EMERGENCY HOUSING AND SUPPORT SYSTEMS									
95% residence shelter-in-place									×
Emergency responder housing				×					
Public shelters								×	
90% related utilities								×	×
90% roads, port facilities and public transit								×	
90% Muni and BART capacity							×		
HOUSING AND NEIGHBORHOOD INFRASTRUCTURE									
Essential city service facilities								×	
Schools								×	
Medical provider offices									×
90% neighborhood retail services									×
95% of all utilities								×	
90% roads and highways									×
90% transit								×	
90% railroads								×	
Airport for commercial traffic					×				
95% transit								×	
COMMUNITY RECOVERY									
All residences repaired, replaced or relocated									×
95% neighborhood retail businesses open									×
50% offices and workplaces open									×
Non-emergency city service facilities									×
All businesses open									×
100% utilities									×
100% roads and highways									×
100% travel									×

Source: SPUR analysis



SAN FRANCISCO PLANNING + URBAN RESEARCH ASSOCIATION

TARGET STATES OF RECOVERY

Performance measure

Description of usability after expected event

BUILDINGS LIFELINES

Category A: Safe and operational

Category B: 100% restored safe and usable in 4 hours during repairs

Category C: 100% restored safe and usable in 4 months after moderate repairs

Expected current status

SPUR Lifelines Performance Standards

- For the “expected earthquake” (M7.2 San Andreas)
- For critical facilities, 100% of service levels resumed within 4 hours
- For housing and neighborhood infrastructure, 90% service restoration with 72 hours, 95% within 30 days, and 100% within 4 months
- For balance of the city, systems restored as buildings repaired and returned to operations: 90% service restoration with 72 hours, 95% within 30 days and 100% within 3 years (36 months)

Details on Next Steps

- Infrastructure operator and panel discussions:
 - ✓ PG&E (electric and gas), Caltrans (regional roads), SFPUC (water), SFDPW (city roads and debris), Verizon (telecom)
 - ATT (telecom; September 2012)
 - Comcast and other telecommunications operators
 - SFPUC (wastewater), (power), and (auxiliary water)
 - BART, MUNI, and other transit operators panel
 - Port/airport operators (include WRDA) panel
 - Fuel and refineries panel
- Develop integrated scenario and interdependency insights (November - December 2012)
- Operator review and approval (January 2013)
- Presentation to the Lifelines Council and other groups, as