Progress Report:
CCSF Lifelines Council Interdependency Study

Lifelines Council Meeting #9
September 6, 2012

(Source: JIIRC-UBC)
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))

Earthquake Scenario

Infrastructure Panel(s) by Sector
- Present scenario and lifeline damage inputs
- Summarize findings of prior panels or relevant studies
- Describe system construction
- Describe past seismic performance
- Describe expected performance for scenario
- Complete damage and restoration grid (by county)
- Discuss situational awareness
- Make mitigation recommendations

Additional Rounds of Panel(s) or Group Workshop
- Review scenario and infrastructure panel results
- Revise damage and restoration assumptions
- Prioritize interdependencies

Data synthesized into draft scenario

Comprehensive Earthquake Scenario for CCSF

Develop Action Agenda and Council’s Year 3 Work Program
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)
# Summary of Building Damage and Loss Results Due to Ground Shaking and Ground Failure – Total Study Region

<table>
<thead>
<tr>
<th>Damage or Loss Parameter</th>
<th>Population or Exposure</th>
<th>Scenario Earthquake</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>1906 MMI</td>
</tr>
<tr>
<td>Number of Severely Damaged Buildings</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Residential Buildings</td>
<td>2,800,000</td>
<td>80,000</td>
</tr>
<tr>
<td>Commercial Buildings</td>
<td>70,000</td>
<td>7,000</td>
</tr>
<tr>
<td>Social Losses due to Building Damage</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Displaced Households</td>
<td>3,700,000</td>
<td>170,000</td>
</tr>
<tr>
<td>Serious Injuries - Nighttime</td>
<td>10,300,000</td>
<td>4,000</td>
</tr>
<tr>
<td>Serious Injuries - Daytime</td>
<td>10,300,000</td>
<td>6,000</td>
</tr>
<tr>
<td>Immediate Deaths - Nighttime</td>
<td>10,300,000</td>
<td>800</td>
</tr>
<tr>
<td>Immediate Deaths - Daytime</td>
<td>10,300,000</td>
<td>1,600</td>
</tr>
<tr>
<td>Direct Economic Losses due to Building Damage (Dollars in Billions)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Structural System</td>
<td>$300</td>
<td>$15</td>
</tr>
<tr>
<td>Nonstructural Systems</td>
<td>$800</td>
<td>$57</td>
</tr>
<tr>
<td>Contents and Inventory</td>
<td>$500</td>
<td>$14</td>
</tr>
<tr>
<td>Business Interruption (BI)</td>
<td>NA</td>
<td>$8</td>
</tr>
<tr>
<td>Total Building and Contents</td>
<td>$1,500</td>
<td>&gt; $90</td>
</tr>
</tbody>
</table>

Kircher & Associates Consulting Engineers
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)
Total Direct Economic Loss

<table>
<thead>
<tr>
<th>Direct Economic Building Loss due Ground Shaking/Failure (M7.9)</th>
</tr>
</thead>
<tbody>
<tr>
<td>County</td>
</tr>
<tr>
<td>-------------------</td>
</tr>
<tr>
<td>Alameda</td>
</tr>
<tr>
<td>San Francisco</td>
</tr>
<tr>
<td>San Mateo</td>
</tr>
<tr>
<td>Santa Clara</td>
</tr>
<tr>
<td>Other Counties</td>
</tr>
<tr>
<td>All 19 Counties</td>
</tr>
</tbody>
</table>

- Fire - Plus 5% - 15%
- Lifelines - Plus 5% - 15%
- Total Loss: $150 billion
Progression of Interdependency Interviews

(Completed)

Regional Roads
- Electricity
- Gas
- Water
  - Wastewater

Local Roads
- City-power
- Tel-com
- Auxiliary Water

Transit and Rail
Ports and Airports
Fuel

(Scheduled or Yet to be Completed)
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.
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.
3 transmission lines up the peninsula meet at a single point. If 2 lose transmission, then resulting pressure loss could curtail service citywide.

SF gas distribution system is underground, but in flexible plastic pipes. If transmission lost, system restoration will take months.
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.
System Restoration
(Progress Report; September 2012)

- Electricity
- Gas
- Regional Water
- Local Roads
- Telecom

Timeline:
- 1 day
- 2 days
- 3 days
- 1 week
- 2 weeks
- 3 weeks
- 1 month
- 2 months
- 3 months
- 6 months
- 1 year

Progress:
- 0%
- 10%
- 20%
- 30%
- 40%
- 50%
- 60%
- 70%
- 80%
- 90%
- 100%
Lifeline Interdependencies in San Francisco (Progress Report; September 2012)

Legend

- **Color** for level of service disruption
- **Line width** for level of dependency

- **Electric/Power**
- **Roads (regional + local)**
- **Telecom**
- **Water**
- **Natural Gas**
- **Transit**
- **Fuel**
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)
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