DISCONNECTED:
UNDERSTANDING COMMUNICATION SYSTEM FAILURES DURING DISASTERS

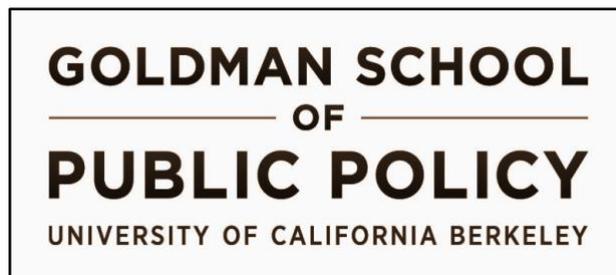
Image Source: Scale Focus

June 12, 2020

Scott Adams
2020 Master of Public Affairs

TABLE OF CONTENTS

"There's been a failure of foresight the last several decades. Scenario analysis could have projected this. We should have hardened our systems years ago, now we don't have the systems we need."

- Monika Stoeffl, California Resiliency Alliance

EXECUTIVE SUMMARY

In our technology-dependent world, communications systems are our lifelines. We count on them for situational awareness, emergency alerts and warnings, disaster response, vital information, social connectedness, work, education and healthcare.

Due to climate change, California has experienced an increasing number of large-scale disasters over the last two decades. During recent disasters, our communications systems, which are highly reliable and dependable in normal conditions,[1] have failed. These failures compromise situational awareness, impact alert and warnings, impede vital communications between multiple stakeholders, and can lead to unnecessary loss of life and other social harms. Too little is understood about what causes these failures, who is responsible for them, and how to fix them. Leaders at all levels must work together to increase the resilience of our communications systems and promote redundant means of communications for use during inevitable future disasters.

Communication systems are defined as systems through which entities and individuals send and receive information. They include wireless, wireline and landline phone networks; and alert and warning systems.

Communication networks consist of tens of thousands of components, or facilities, that require power to operate. These networks fail during disasters when power is lost due to infrastructure damage; large segments of the power grid are deenergized during Public Safety Power Shutoffs (PSPS); or due to the lack of adequate backup power at communications network facilities and end user premises. Congestion contributes to failures when portions of a network go down and diminish its capacity to handle increased call volumes during emergencies.

Alert and warning system failures commonly result from the use of alerting systems with limited capabilities; or a lack of training and authorization on the Federal Emergency Agency's (FEMA) Integrated Public Alert and Warning System (IPAWS). Local warning systems and social media platforms require individuals to opt-in to receive alerts and cater to only the most information-hungry individuals. Their effectiveness is limited by low subscriber numbers. IPAWS is a more robust system that enables message transmission through multiple pathways to numerous redundant devices. IPAWS allows authorities to target all individuals in an area,

---

1Critical Infrastructure Analysis of Telecom or Natural Disasters

using enhanced geo-fencing capabilities, without requiring that residents opt-in. A relatively small percentage of California entities are authorized on this system,[2] and some who are, don't know how to use it, or choose not to.[3]

The following recent disasters in California were examined to understand the causes and impacts of communication system failures:

- the 2017 North Bay Wildfires;
- the 2018 Camp Wildfire (Paradise, CA);
- the 2018 Woolsey Wildfire (Malibu, CA);
- the 2019 Public Safety Power Shutoff;
- and 2020 Coronavirus COVID-19 Pandemic Shelter in Place.

In each case, communications systems failed with dire consequences.

The incidents in this report are not anomalies. Rather, they are harbingers of things to come and evidence that a complex set of trends have created a "new normal" that California's leaders and residents must confront and respond to with immediate, broad-sweeping action:

- Wildfires are becoming larger and more frequent;
- Large portions of the state are at high fire risk;
- Our aging power grid sparks fires;
- Large-scale planned outages to prevent fires are the norm;
- Power grid hardening will take years and cost billions;
- Dependence on Mobile and Internet-based technologies leave us vulnerable;
- Extended Shelter in Place exposes us to concurrent disasters.

These solutions will help fix the problem:

- Expedite and coordinate energy grid and communications network hardening and resilience efforts;
- Increase the availability and duration of backup power at communications facilities, critical institutions, businesses and residences;
- Increase production and use of high-tech temporary communications networks (COWS, COLTS and Flying COWS);
- Create regional stockpiles in Mutual Aid Regions closer to disaster areas;

---

[2] As of 2/25/2020, 120 local California agencies have been authorized, or are in the process of being authorized to use IPAWS. This represents a small portion of California's 58 counties, 421 cities, and hundreds of other police, fire and emergency response agencies. https://www.fema.gov/alerting-authorities
[3] Strait, Ryan, How IPAWS Could Have Saved Lives in California's Wildfires, Civic Plus, https://www.civicplus.com/blog/ps/how-ipaws-could-have-saved-lives-in-the-california-wildfires

- Develop "non-wired" technology solutions for high-risk, rural areas;
- Educate stakeholders about the "new normal", encourage self-reliance, and the adoption of localized, "back to the future" or analog solutions;
- Leverage existing and generate new funding sources in this tough economic climate.

Several constraints must be overcome, chief among them:

- Psychological biases: Myopia, amnesia, optimism, inertia, and simplification prevent preparing for, and investing in disaster resilience efforts;
- Priorities: The Coronavirus Pandemic has shifted the state's focus from housing, homelessness, education and climate change; to public health, unemployment, and a looming tsunami of state and local government budget deficits;
- Jurisdictional authority: Disputes over who has it, or lack of formal authority, prevents decisive action and perpetuates voluntary efforts without accountability;
- Resources: Government expenditures to address the Coronavirus Pandemic and lost tax revenues due to Shelter in Place have depleted the state's once flush "rainy day" fund and will necessitate massive cuts to existing budgets and programs.

Overcoming constraints is possible but will require leadership, collaboration, education and advocacy:

- Leadership: Stakeholders at all levels must keep disaster resilience front and center despite the challenges presented by the Coronavirus Pandemic and establish a structural framework to prevent our psychological biases from "kicking the can" down the road;
- Collaboration: Stakeholders must break down silos, share information, expertise, combine resources, leverage available human capital, and shift from reactive to proactive disaster planning;
- Education: Stakeholders must be made aware of the "new normal," the challenges our communication systems face, and how self-reliance is required in the short term;
- Advocacy: Stakeholders must lobby congressional leaders to include resources in potential future Coronavirus Relief bills, and encourage the state legislature to move forward with a Resilience Bond, or package of bonds, on the November 2020 ballot.

"If we want to deliver communications during disasters with the same expectations of communications during non-disasters, we have to change the way we do business." - Belia Ramos, Napa County Supervisor

Recommendations

Given the size, scale and complexity of the problem, multiple stakeholders throughout the state must work together to solve this problem. Given the interdependencies between power and communications, and regional and localized needs and constraints, no single invention will be the answer. However, a programmatic response, that deploys set of interventions implemented collectively, would drastically reduce failures and provide governments, businesses and residents with resilient and redundant communications systems.

#1: Joint Power & Communications Safety and Resilience Task Force

Immediately establish a statewide Task Force led by a senior advisor who reports directly to the Governor. Require mandatory participation of key decision makers from power and communication companies and technology firms. The Task Force should collaborate and proactively plan grid resilience efforts that acknowledges the interdependence of power and communications grids. The Task Force's main focus should be safety, resilience, redundancy and grid modernization.

#2: Grid Safety and Resilience and Corps

Establish a Grid Safety and Resilience Corps to support needed workforce and economic development during and after the Coronavirus Pandemic. Recruit and pair retired professionals, permitting specialists, university professors, and unemployed college graduates and laborers with private and public sector entities to work on state and local Safety and Resilience projects to provide expertise, management and staffing of projects that foster resilience, redundancy and modernization of both grids.

#3: Statewide Public Awareness Campaign & Action Plan

Implement a State funded multi-media campaign, designed by California Office of Emergency Management, the California State Association of Counties and the California League of Cities. Target multiple stakeholders focusing on top-down, bottoms up safety and resilience and the urgency of the "new normal." Specific messaging for local governments focusing on increased adoption of IPAWS, implementation of "self-reliant" smart practices for redundant communications means; the development of Action Plans that prepare for "worst case" scenarios and leveraging and growing CERT Teams and neighborhood resilience groups. Specific messaging for neighborhoods and residents on increasing use of Battery and Hand

Crank Radios; switching from cordless to corded phones for POTS users; deploying residential backup power; and forming neighborhood safety and resilience groups.

#4: Advocate For Funding

Lobby congress for resilience and infrastructure funding in future Coronavirus Relief bills. Lobby state legislature for funding for safety and resilience efforts in Resilience Bond, or package of Bond Measures, and place on November 2020 ballot.

> *"We have to train ourselves to plan for things we can't even articulate."*
> -Michael Picker, former President, California Public Utilities Commission

Conclusion

Communication systems are our lifelines. System failures during disasters are devastating and lead to loss of life and other social harms. Fixing this multi-layered problem is complex and will take time, effort and resources.

Stakeholders at all levels must "Think Big" to fix the problem. We must utilize the same wartime mentality exhibited in response to the Coronavirus Pandemic to prepare California for the challenges presented by the "New Normal" by expediting efforts to increase the resilience and redundancy of our power and communications systems.

California possesses a wealth of leaders at the state and local government levels, and within the corporate, non-profit and community ranks who have demonstrated their ability to react and respond to crises. Those leaders need to shift from reactive response to proactive measures.

California can "Meet the Moment," increase the resilience of our communications systems, and improve the safety of our communities by: establishing a collaborative framework; tapping into the state's vast human capital; educating our communities how to prepare; and advocating for and generating resources to support these efforts.

ACKNOWLEDGEMENTS

Cover Image Credit: Scale Focus

> *"This can happen to anyone at any time. Governments at every level need to prepare. You need to be ready."* - Reva Feldman, City Manager, Malibu

INTRODUCTION

In our technology-dependent world, modern communications systems are our lifelines. We count on them for situational awareness, emergency alerts and warnings, disaster response, vital information, social connectedness, work, education and healthcare

Due to climate change, California has experienced an increasing number of large-scale disasters over the last two decades. During recent disasters, the communications systems we depend on for critical informational needs and societal functions, which are typically reliable and dependable in normal conditions,[4] have failed. These failures compromise situational awareness, impact alert and warnings, impede vital communications between multiple stakeholders, and can lead to unnecessary loss of life and other social harms. Too little is understood about the causes of these failures, who is responsible for them, and how to fix them.

Leaders at all levels must work together to increase the resilience of our communications systems and promote redundant means of communications for use during inevitable future disasters.

To understand communications system failures during disasters, this project examined the following recent large-scale events in California:

- 2017 North Bay Wildfires
- 2018 Camp Wildfire (Paradise, CA)
- 2018 Woolsey Fire (Malibu, CA)
- 2019 Public Safety Power Shutoff
- 2020 Coronavirus COVID-19 Pandemic Shelter in Place

Definition Of Communications Systems

Communication systems are defined in this report as systems through which entities and individuals send and receive information and include wireless, wireline and landline phone networks, and alert and warning systems.

[4](PDF) Critical Infrastructure Analysis of Telecom for Natural Disasters

Wireless Networks (Mobile and Cellular): Wireless networks transmit wireless signals to mobile and smartphones users. Wireless network signals are delivered via vast networks of towers, macrocells and small cells that depend on fiber lines to carry signals between critical facilities.

Wireline Networks (Cable, Internet and VoIP): Wireline networks deliver internet, voice over internet protocol (VOIP) phone service, and video services, through a complex architecture of thousands of facilities including headends, nodes, amplifiers and powerpacks connected by fiber lines, or hybrid fiber coaxial wire systems, that deliver service signals from the origination point to end-users.

Landline Phone Network (Plain Old Telephone System): Landline phone systems or Plain Old Telephone Systems (POTS) deliver service via copper wire strung along poles and between central switching stations.

Alert and Warning Systems: Three different types of alert and warning systems are used in California: local municipal systems, private sector systems and FEMA's Integrated Public Alert and Warning Systems (IPAWS). Local municipal alert and warning systems such as Sonoma County Alerts allow first responders the ability to notify residents and businesses by telephone, mobile phone, text message, email, and social media.[5] Private sector systems include Code Red,[6] Everbridge,[7] and Nixle,[8] and work similarly to municipal alert systems. Both of the first two systems required residents to opt-in to receive alerts and warnings. FEMA's IPAWS transmits alerts via several pathways: the Emergency Alert System (EAS) (broadcast, cable, satellite, and wireline services); Wireless Emergency Alert (WEA) (cell phones and mobile devices); NOAA Weather Radio (NWR), (radio stations in all 50 states).[9] These systems require government agencies to secure authorization to use them, but residents that residents opt-in to receive alerts.

5 SoCoAlert, https://socoemergency.org/home/prepare/stay-informed/socoalert/
6 https://www.onsolve.com/landing/sign-up-for-codered-emergency-alerts/
7 Everbridge, https://www.everbridge.com/solutions/alert-residents-and-visitors/
8 Nixle, https://www.nixle.com/about-us/
9 https://www.fema.gov/ipaws-components

RECENT SYSTEM FAILURES

2017 North Bay Wildfires

Figure 2: A map including all 2017 wildfires in the NBNCBC region (Source: 2017 Statewide Fire Map)

In October of 2017, a storm of fires swept across the state's North Bay region. As fires closed in on thousands of residents in multiple communities, their local emergency alert systems failed,[10] and left many residents vulnerable and without warning.[11] During its peak, 21 major wildfires raged in the North Bay region, which ultimately burned over 245,000 acres, destroyed nearly 9,000 structures, and killed 43 people.[12]

A post-disaster survey of residents in Mendocino, Napa and Sonoma conducted by the North Bay North Coast Broadband Consortium found that in the 3-county area, 66% of residents lost landline services, 78% of residents lost cellular services, and 69% of residents lost Internet services.[13] Napa County experienced the most severe impacts. Many of these outages impacted residents that were geographically far away from the actual burn areas.
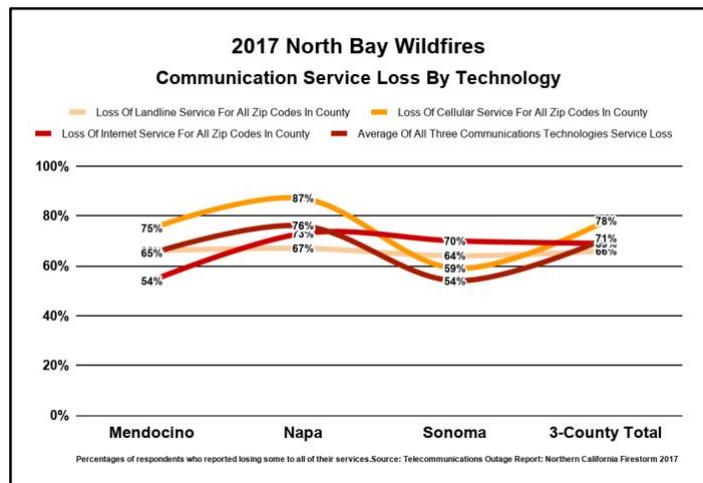
"When the conflagration of fires broke out and destroyed the cell towers, we were cut off. There was nothing. Not understanding the vulnerabilities of our system was the greatest challenge." - Napa County Supervisor Belia Ramos

10 As desperate calls poured in, an emergency alert system failed many, Los Angeles Times Oct. 11, 2017
11 Alarming failures left many in path of California wildfires vulnerable and without warning, Los Angeles Times, Dec. 29, 2017
12 https://www.cafirefoundation.org/wildfires-october-2017/
13 Telecommunications Outage Report: Northern California Firestorm 2017

2018 Camp Wildfire (Paradise, California)

Image Source: San Francisco Chronicle

On November 8th, 2018, the Camp Fire broke out in northern California. The fire lasted for 17 days, killed 85 people, burned over 150,000 acres, and destroyed more than 18,000 buildings,[14] making it the most destructive and deadliest wildfire in California history.[15] It devastated the community of Paradise and all communications systems failed forcing authorities and residents to resort to analog means of communication.[16]

The fire destroyed the town's utility poles, damaging or disabling 66 cell towers, causing phones to go silent and calls to be dropped as surviving towers became overloaded by traffic. As a result, only a fraction of residents received emergency alerts or evacuation orders from local authorities.[17]

> *"The overhead infrastructure was destroyed. Power and communications went out as soon poles started to burn. People were driving around honking horns and yelling at each other to leave."*
>
> - Charles Brooks, Rebuild Paradise Executive Director

14 Haggerty, Colleen A Year After The Camp Fire Nearly Leveled Paradise, California, Vox Oct 23, 2019
15 Top 20 Deadliest California Wildfires, Cal Fire, Sept. 29, 2019
16 Krieger, Lisa M. Camp Fire created a black hole of communication/In disasters, our high-tech communities are reduced to 1940s-era responses, The Mercury News, Dec. 16, 2018
17 A Frantic Call, A neighbor's knock, but few official alerts as wildfires closed in . . .Only a fraction of residents received emergency alerts or evacuation orders from local authorities, *New York Times - 11/21/18*

2018 Woolsey Wildfire (Malibu, California)

32. The Woolsey Fire approaches homes on November 9, 2018, in Malibu. #
David McNew / Getty

On November 9th, 2018, the Woolsey Fire blazed through Los Angeles and Ventura Counties in southern California. The fire burned for days leaving a trail of destruction in its wake. In total, the fire scorched 96,949 acres, destroyed 1643 structures,[18] and forced the evacuations of nearly 250,000 residents.[19]

The largest impact was in Malibu, were because 2000 power poles burned, all of the communications systems failed and forced the City to move their Emergency Operation Center to neighboring Santa Monica.[20] Post-event analysis determined that the Alert LA County tool, including its application for wireless emergency alerts and the radio/TV Emergency Broadcast System, was vastly underutilized, and local alerting authorities over-relied on Twitter without considering that many residents weren't on the platform and may not have even had internet service.[21]

> *"We lost power and cell towers. Our entire way of communicating went down. We pushed out information, but it wasn't landing. Some residents didn't know to evacuate and were unable to get information after. A lesson learned is that in the future we will communicate with by posting information on sandwich boards in key locations throughout the city."* -Malibu City Manager, Reva Feldman

[18] Woolsey Fire Incident Update, LA County Fire, November 25, 2018,
https://www.fire.lacounty.gov/woolsey-fire-incident/
[19] Chandler, Jenna, Report: What went wrong during the Woolsey Fire response, LA Curbed, October 23, 2019 https://la.curbed.com/2019/10/23/20929229/woolsey-fire-report-response
[20] Interview Reva Feldman, City Manager of Malibu
[21] Chandler, Jenna Report: What went wrong during the Woolsey Fire response Oct. 23, 2019

2019 Public Safety Power Shutoff

In October of 2019, the state's investor-owned utilities implemented a Public Safety Power Shutoff that left over two million residents in 34 counties without power, some for up to six days.[22] Data from the height of the PSPS on October 28th, showed significant communications network and service outages. 57% of cell towers in Marin County lost power, and 28% went down in Sonoma. Cable and wireline companies reported 454,722 subscribers lost service; which also included the loss of telephone, television, and Internet services.[23]

Data Source: FCC

The PSPS forced businesses and schools to close for several days causing economic harm,[24] educational disruptions,[25] and government leaders scrambling to support their residents.

> *"We improvised. We set up charging stations with wifi at our community centers that had backup generators. Hundreds of residents came to charge their phones and use our wifi. Runners used radios in the field and volunteers staffed information kiosks throughout the city to make sure residents were informed."*
> - Rebecca Woodbury, Director of Digital Service & Open Government, San Rafael

22 https://abc7news.com/5654707/
23 Communications Status Report for Areas Impacted by California Public Safety Power Shutoffs Federal, Communications Commission October 28, 2019
24 https://www.reuters.com/article/california-wildfire-pge/in-california-food-spoils-businesses-close-as-power-outages-imposed-idUSL2N26V1C1
25 https://www.nbcbayarea.com/news/local/bay-area-school-closures-due-to-pge-power-shutoffs/1961792/

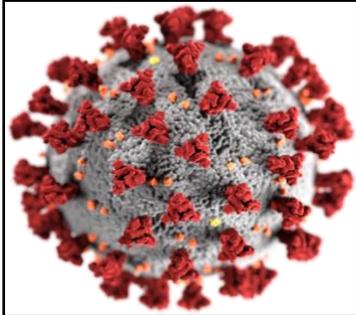# 2020 Coronavirus (COVID-19) Shelter in Place

Image Source: Cal Matters

The coronavirus pandemic has forced leaders around the globe to make tough decisions to help flatten the curve of Covid-19 infection rates and mitigate the strain a large-scale influx infection would have on the state's medical capacities. When California issued its Shelter in Place order in March of 2020, it relegated 40 million California residents to their homes for several months,[26] and shined a light on the state's persistent digital divide.

Residents with high-speed home internet connections and computers immediately shifted to video platforms and experienced relatively painless transition to remote work and online educational instruction. But for two significant segments of the population: nearly two-thirds of the state's rural households whose communities lack broadband infrastructure; and almost 1.2 million low-income students whose families can't afford internet home subscriptions, the transition has been painful.[27] School districts have scrambled to support students with a patchwork of solutions. Many are dismantling school computers labs and purchasing personal wifi hotspots to provide students with computers and home connectivity, depleting unbudgeted resources without knowing how they will be replenished.

> *"This is not a regular disaster, there's no certainty and end point. The layers are so complicated. Schools used to have to educate kids, feed them and make them safe. Now we are working to bridge the digital divide because kids can't work from home. School district are spending their own money and resources on the problem and aren't sure how either will be replenished."*
>
> - Mary Nicely, Sr. Advisor, State Superintendent of Public Instruction

26 Angst, Maggie Gov. Newsom expands Bay Area shelter-in-place to all of California Mercury News March 27, 2020
27 California moves to close digital divide as schools shift online

COMMON FAILURES AND CAUSES

After studying each disaster, a common set of outcomes emerges. In each of the three wildfire events, the wireless, wireline and landline networks, and alert and warning systems failed. During the October 2019 PSPS, all three communications networks failed. In each event except for the 2020 Coronavirus Shelter in Place, significant power loss occurred because of power grid failure or a voluntary de-energization.

Common System Failures During Disasters				
Disaster	**Wireless (Mobile)**	**Wireline (Cable/VoIP)**	**Landline (POTS)**	**Alert & Warning System**
2017 NB Wildfires	🚫	🚫	🚫	🚫
2018 Camp Wildfire	🚫	🚫	🚫	🚫
2018 Woolsey Wildfire	🚫	🚫	🚫	🚫
2019 PSPS	🚫	🚫	🚫	
2020 Coronavirus		🚫		

How Power Outages Impact Communication Networks

Communications networks consist of complex architectures of tens of thousands of components (facilities) that depend on power to operate. Wireless and wireline networks will experience service outages unless they have backup power installed at network facilities.[28] If power outages occur, and backup power sources are available at facilities within the communication grid, a backup battery is triggered. When that fails, either a permanent generator is triggered or a temporary generator is deployed. Thereafter, for as long as an outage occurs generators have to be monitored and refueled. In some cases, road access and employee safety prevent refueling and power and communications signals are lost.

Ordinarily, the landline voice service (POTS) using copper lines generally has service during a power outage because the central office that serves the residence as backup power provides the electricity necessary to operate a corded telephone during a power outage. Cordless phones require the end user to maintain the

---

28 https://www.cpuc.ca.gov/deenergization/

batteries in those devices, so that the home portion of the telephone service can operate in a power outage.[29]

Loss of power also has user-side impacts as most homes and devices (mobile phones, wireless phones, modems, and computers) lack any form of backup power. It is the responsibility of the customer to obtain the required backup power in the residence to have working telephone service during an outage event. [30]

In densely populated urban areas, communications networks have more robust mesh networks and redundant facilities that can handle network traffic when facilities are damaged. Rural areas have linear networks and more single points of failure where outages can cripple service to a large number of customers.[31]

Lack of Wireline Infrastructure and Barriers to Service

While wireline network failures weren't caused by the 2020 Shelter in Place, they were amplified by it. Sparsely populated, rural areas lack wireline service because building out infrastructure to these areas, where homes are spread out over large distances and setback from roads, is too costly and doesn't meet current private sector business models.[32] Urban students lack wireline service due to constraints related to cost of service and lack of awareness of low-cost options, barriers to associated low-cost requirements and restrictions,[33] and lack of perceived need.[34]

Lack of Training and Inadequate Alert & Warning Systems

Alert and warning system failures commonly result from the use of alerting systems limited capabilities, reliance on social media platforms, and lack of training and authorization on FEMA's more robust Public Alert and Warning System (IPAWS). Because local warning systems and social media platforms require opt-in to receive alerts, they appeal to only the most information-hungry individuals and have low subscriber numbers. When these systems are deployed they only reach a small portion of the population. IPAWS enables message transmission through multiple pathways to numerous redundant devices and offers enhanced geo-fencing capabilities that allows authorities to target all individuals in an area without requiring that they opt-in to receive messages.

29 https://www.cpuc.ca.gov/deenergization/
30 https://www.cpuc.ca.gov/deenergization/
31 Interview with former CPUC President Michael Picker
32 https://broadbandcouncil.ca.gov/wp-content/uploads/sites/68/2018/07/Closing-the-Digital-Divide-UC-Riverside-May-2018.pdf
33 http://www.cetfund.org/progress/annualsurvey
34 Lack of perceived need is caused by of many factors including the reliance on mobile phones, lack of computers skills and training.

> *"Our system was not designed with the anticipation that a power company would shut off power to over 2 million people at once."*
> Rhonda Johnson - President, AT&T California, Letter to CPUC President Batjer regarding inquiry into communication failure during the October 2019 PSPS.

JUSTIFICATION FOR ACTION

The incidents in this report are not anomalies. Rather, they are harbingers of things to come and evidence that a complex set of trends have created a "new normal" that California's leaders and residents must confront and respond to with immediate, broad-sweeping action.

Wildfires Are Becoming Larger and More Frequent

Wildfires in California are becoming larger and more frequent. 20 of the largest and most damaging wildfires in California history have occurred in the last 2 decades.[35] Ten of the most destructive fires have happened in the last decade, including the 2018 Camp Wildfire; the 2017 Tubbs and Nunn North Bay Wildfires; and the 2018 Woolsey Wildfire in Malibu that were examined in this report.[36]

Large Portions Of The State At High Fire Risk

Many parts of the state are at extreme risk of wildfires.[37] Contributing to this are increasing temperatures due to climate change, high fuel load in our woodlands and low moisture levels because of reduced snowpack and droughts.[38] A reported 2.7 million Californians live in zones designated by Cal Fire as "Very High Fire Hazard Severity Zones."[39] 75 California towns and cities (with populations above 1,000) are almost fully contained within Very High Fire Hazard Severity Zones.[40]

Our Aging Power Grid Sparks Wildfires

The aging power grid sparks a large number of fires annually. A Wall Street Journal report found that equipment from PG&E led to more than 1,500 fires from June 2014 to December 2017.[41] Though most of fires were not large-scale disasters,

35 https://lao.ca.gov/Publications/Report/3918

36 https://www.fire.ca.gov/media/5511/top20_destruction.pdf

37 Main Types of Disasters and Associated Trends, Budget Policy Post, Legislative Analyst's Office Jan 10,2019

38 https://lao.ca.gov/Publications/Report/3918

39 https://www.directrelief.org/2019/07/which-california-communities-are-most-vulnerable-to-wildfires/

40 Reese, Phillip What's the wildfire risk in your community? Sacramento Bee April 11, 2019

41 Gold, Russell, Katherine Blunt and Rebecca Smith, PG&E Sparked at Least 1,500 California Fires. Now the Utility Faces Collapse. Wall Street Journal, Jan. 13, 2019

six of the most destructive fires in the last decade were caused by power lines,[42] including the Camp Wildfire, which was caused by PG&E. Because of the state's inverse condemnation laws,[43] PG&E's liability is in the billions of dollars and has forced it into bankruptcy.

Public Safety Power Shutoffs and Outages Are The Norm

Between October 2017 and December of 2019, California had 50,000 blackouts impacting 51,000,000 customers.[44] 2,734 of those were Public Safety Power Shutoffs (PSPS) impacting 2.7 million customers. The longest was 6 days and the average outage was almost 48 hours. Investor-owned utilities plan to use PSPS during fire seasons until they harden their entire grids, which could take up to 10 years and cost billions of dollars.[45] PSPS are triggered by any combination of conditions including high winds, low humidity levels, dry vegetation, fire threat, real-time observations, and red flag warnings declared by the national weather service.[46]

Dependence On Mobile & Internet-Based Communications Leaves Us Vulnerable

Our dependence on mobile and internet-based communications leaves us vulnerable. As of 2016, there were approximately 56.4 million voice communication subscriptions in California: 48 million mobile, 8.2 million internet-based, and 5.2 million landlines. 85% of 911 calls were made from mobile and internet-based phone lines.[47] Mobile and internet-based communications systems share much of the same infrastructure (fiber lines for back haul) with each other and power companies.[48] The decline in landline subscriptions, which provided some redundancy as they often have indepedent power sources, have resulted in reduced upkeep and there are plans to decommission these networks.[49]

Networks Aren't Designed To Withstand Large-Scale Outages

In ongoing proceedings at the CPUC to examine communication networks' failures during PSPS, one provider conceded that their system was, "*not designed with the anticipation that a power company would shut off power to over 2 million people at*

---

42 https://www.fire.ca.gov/media/5511/top20_destruction.pdf

43 Baker, David R. The California Rule That Doomed PG&E: Inverse Condemnation, Bloomberg Jan 2019

44 https://www.bloomenergy.com/bloom-energy-outage-map

45 Balaraman, Kavya, PG&E CEO: System hardening will be completed long after I retire, Utility Drive, January 20, 2020

46 Public Safety Power Shutoff: The Power of Being Prepared

47 Safety Principles for Communications Providers, 2019, CPUC, Staff Authored Report, Pg. 5 and 6

48 Fiber lines and communications facilities are often strung overhead on aging power wood power poles that make up most of our decrepit power grid which are vulnerable to high winds and wildfires.

49 Young, Samantha AT&T Wants to Decommission Landlines in California, April 7, 2016

once."[50] Data compiled by the California Public Advocates Office examining the length of power outages at California macro cell sites that lost commercial power during PSPS events in 2018 and 2019, supports that assertion. It shows that 50% of macrosites that lost power for between 24 and 72 hours, and 8% lost power for over 72 hours.[51] Similar data shows that over 75% of macrocell sites have only eight hours or less of backup power capacity.[52]
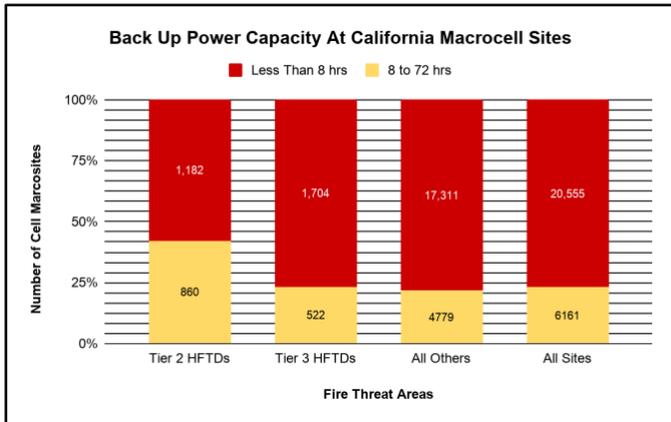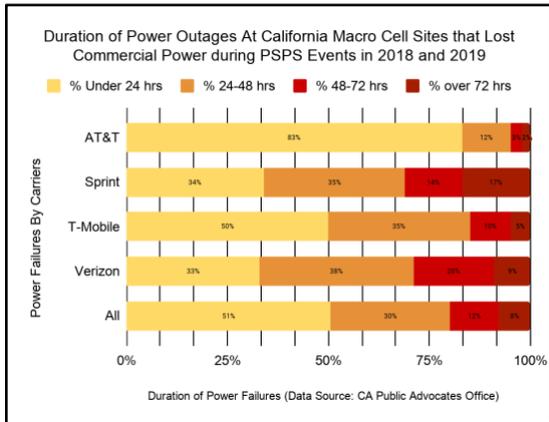
Shelter In Place Could Extend Into The Fire Season

The Coronavirus (COVID-19) Shelter in Place has only increased the dependence on mobile and internet-based technology for 40 million California residents. Expectations are that it will take 12-18 months to develop vaccine and Shelter in Place could extend into the year which could overlap with fire season, which begins in May and tapers off October and November. In this scenario, California residents could be sheltering in place during the fire season,[53] and wildfires, or large-scale, multi-day PSPS implemented to prevent them, could lead to instances where communities are battling concurrent disasters and lack the communication services required to manage disaster response, send alerts and warnings, and support other societal functions.
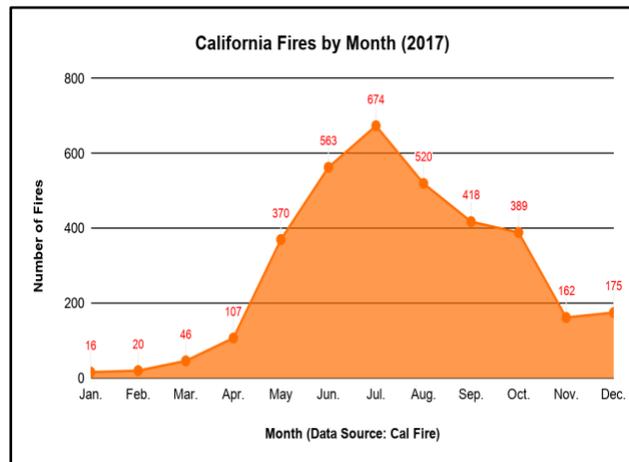
50 AT&T's Response to CPUC President Batjer's Letter
51 http://docs.cpuc.ca.gov/PublishedDocs/Efile/G000/M333/K154/333154308.PDF
52 Ibid.
53 2017 Wildfire Activity Statistics

The current regulatory regime that allows communications networks to deploy infrastructure and backup power on a voluntary basis, with no accountability, won't get the job done. Limited collaboration will persist but it will be mostly reactive during disasters response efforts. Residents will have fewer means to receive information during disasters due to our dependence on mobile and internet-based systems and limited residential backup power for devices. Local governments will continue to use inadequate alert and warning systems, or not have proper training to use them.

SOLUTIONS

Expedite Infrastructure Improvements

Power companies have plans in place to upgrades their grids over the next several years. Communications companies also have plans but they lack transparency. Due to the voluntary nature of the upgrades there is little accountability in ensuring they are followed through in a timely manner. Neither are happening fast enough.

⇒ Expedite the undergrounding of power and communications infrastructure where feasible, or hardening of above-ground infrastructure, shared by power and communications companies. Swap out aging wood poles for metal or composition poles to help withstand high winds and fallen trees minimize the need for PSPS. Rapidly increasing the segmentation of the power grid will also reduce to size and scale of de-energization during PSPS which compromise communication networks.

Although communications providers claim to have backup power at most critical network facilities, that data is not publicly available, and many are vulnerable to power outages. Ongoing CPUC proceedings are contemplating rules to mandate 72 hours of backup power at all facilities and secondary and small cell sites.[54] Communications providers have legitimate feasibility concerns regarding the costs of deploying system-wide backup power, blight, fire hazard to due equipment sparkage, lack of commensurate backup power on the end-user side, and questions the CPUCs authority to impose these requirements.

⇒ Deploy and increase above ground backup power capacity at critical communications network facilities where feasible. Pilot underground backup power projects where blight and sparkage are concerns. Target upgrades at locations that support cell towers for 911 calls, and near critical institutions including public safety agencies, hospitals, schools, data centers to keep them running during disasters.

Deploy High-Tech Solutions

Deploy temporary mobile communication network technologies, or "Barn Animals:" including Cellular on Wheels (COWS), Cellular on Light Trucks (COLTS), and Cellular on Drones (Flying Cows), which have been successful in providing temporary communications service in past disasters. Little is known about how

---

[54] https://www.cpuc.ca.gov/deenergization/

many are available for use during disasters, where they are stored and located, and the decision guidelines that providers use when deploying them.

⇒ Inventory the available resources in California, encourage and incentivize the production of new units, develop clear guidelines and process for requesting and using them, and create stockpiles in the state's Mutual Aid regions.

There remain serious cost and topographical challenges to deploying and maintaining wireline infrastructure in rural areas. Linear path networks have multiple single points of failure and demonstrated vulnerabilities in disasters. Other non-wired technology may need to be developed to address rural needs.

⇒ Research and develop new technologies to provide communications in rural areas that are not dependent on wireline services to the premises. Promising new technologies should be explored including but not limited to microwave technology,[55] Google's Loon,[56] and AT&T's FirstNet Blimps.[57] Issues research grants and develop pilots to test these and other technologies.

Back to the Future Technology and Analog Solutions

Several local governments have implemented "Back to the Future" technologies to provide redundant communications for when total system failures occur. Lake County and Malibu installed pole-mounted air raid sirens. Sonoma County reprogrammed public safety vehicles with European-style high-low sirens. Each provides redundant means of communication and alternate tones to increase situational awareness during disasters.

⇒ Encourage local governments to deploy any or all of these analog technologies appropriate to their unique geographies to create redundant communications systems for alerting residents of looming threats and during disasters.

Many local governments have outdated emergency management and disaster plans that don't factor in the "new normal" and "worst case" scenarios.

⇒ Encourage local governments to develop "worst-case" scenario disaster plans that include hardening community centers with backup generators to support charging stations and wifi networks; deploy information hubs, kiosks and sandwich boards; and create and grow CERT teams and neighborhood

---

[55] https://www.cablefree.net/wirelesstechnology/microwave/
[56] https://loon.com
[57] https://about.att.com/story/2019/fn_hits_one_million.html

resilience groups to share and exchange information during disasters. These tactics have proven successful in Malibu, San Rafael and other communities.

On a small scale, there are many actions that individuals can take to build the resilience and increase the redundancy of communications system at their premises.

⇒ Encourage residents to purchase backup power supplies for home communications devices (modems, phones and computers), switch from wireless phones to corded phones for landline customers; and encourage the purchase of hand crank or battery-operated NOAA weather radios for backup communications

Increase Adoption and Training on IPAWS

Sonoma County saw a vast improvement in alerting practices between the 2017 wildfires and the Kincaid Wildfires in 2018. The improvement was attributed to training emergency personnel on IPAWS, increasing their knowledge of the system capabilities and issuing WEA alerts for evacuations and warnings.[58]

⇒ Encourage and incentivize local governments to "opt-in to use the Integrated Public Alert and Warning System. IPAWS allows alerting authorities to send alerts to all individuals in a geographic area, on multiple devices pathways, and platforms without requiring residents opt-in. Provide financial assistance to agencies to purchase the required compatible software and train employees on the system.

[58] Impact of Kincade fire in Sonoma County blunted by lessons from 2017 Johnson, Julie North Bay firestorm, The Press Democrat November 2, 2019

CONSTRAINTS

Numerous constraints prevent the prioritization and funding of resilience and redundancy into our communications systems to address their vulnerabilities.

Psychology

In *The Ostrich Paradox, Why We Underprepare For Disasters*, Robert Meyer and Howard Kunreuther at the Wharton Risk Management and Decision Process Center outlined Six Behavioral Biases that explain the tendencies and challenges that leaders and individuals face when confronted with taking the necessary steps and making investments to prepare for future disasters:[59]

Myopia	Focus on short future time horizons when appraising costs and benefits of protective investments.
Amnesia	Quickly forget the lessons of past disasters.
Optimism	Underestimate losses that will occur from future hazards.
Inertia	Maintain the status quo when uncertain measures.
Simplification	Attend to only a subset of the relevant facts when making choices involving risk.
Herding	Base choices on the actions of others.

> *"Immediately after any disaster, for first six months or year, people focus on the issue and then attention phases away, and solutions don't get implemented. Then the next thing happens. Great ideas aren't solutions if they don't to happen."*
>
> - Reva Feldman, City Manager, City of Malibu

Jurisdictional Authority

Jurisdictional authority complicates the ability to address the problem. Local governments whose communities bear the brunt of communication systems failures

---

[59] Meyer, Robert and Howard Kunreuther, The Ostrich Paradox: Why We Underprepare for Disasters, Wharton Risk Management and Decision Process Center, Issue Brief May 2018

have very little authority over communications networks. The Federal Communications Commission and the California Public Utilities Commission have some, but neither agency has authority over the deployment and maintenance of infrastructure or backup power requirements. While both agencies provide guidance and recommendations, the lack of clear authority allows private sector companies to voluntary upgrade their networks, on their timeline, with little oversight and accountability. Lack of jurisdictional authority also makes it challenging to secure the necessary data to assess the problem. Information and data on vulnerable facilities and locations with backup power is often withheld on the grounds that it is proprietary, and once turned over to the state, due to sunshine laws, could fall into the hands of competitors or bad actors.

A converse structure is in place for alert and warning systems which favor a bottoms-up approach: local cities and counties have the alerting authority to make their own decisions on what alert systems they use; the federal government provides backbone tools like the IPAWS, and the state government provides recommendations and guidelines through the Office of Emergency Services.

Cooperation

Power and communications companies generally get high marks for their collaboration with each other and the government during disaster response. They typically work well together in responding to wildfires. Communication companies have responded well to the Coronavirus Pandemic by implementing measure contained in the Federal Communication Commissions Keep Americans Connected pledge.[60]

But very little coordination and cooperation exists between the three groups in non-disaster times on resilience efforts. This has been highlighted in complaints about the coordination in advance of PSPS.[61] This stems from several factors including: the tension between government regulators, power, and communications companies who are leery of burdensome regulatory efforts that might stifle innovation and reduce profits; the natural tension between communications providers competing for market share and reluctance to share information, data and resources; and the tenant-renter relationship between power companies who control the time and manner in which communication providers attach to their utility poles.

Priorities

Before the Coronavirus Pandemic, the state and local governments' top priorities were housing, homelessness, education and climate change. Now, the world has

---

[60] https://www.fcc.gov/keep-americans-connected
[61] https://www.utilitydive.com/news/pge-failed-on-so-many-levels-in-executing-mass-power-shutoff-cpuc-tells/565405/

been turned upside down, and attention has understandably shifted to public health, jobs and a looming tsunami of state and municipal budget deficits as a result of Shelter in Place. [62] It will be important for leaders to recognize the threats our state faces from climate change and disasters to make a place for resilience and redundancy of power and communications grids on the priority list.

Funding

In response to the Coronavirus Pandemic, the state has spent massive amounts of money on our public health system and unemployment benefits. The state went from having a booming economy, to record low unemployment and gaping local and state budget deficits which will require budget cuts to existing programs and massive layoffs.[63] Finding resources in this time of scarcity will be challenging and require advocacy and creativity.

Other Policies

The obligation of California's power companies to provide dependable and reliable power complicates the issue.[64] In a current, ongoing CPUC proceeding on the subject, the CPUC President has recommended at least 72 hours of back up at communications facilities to keep them running during disasters.[65] Communications providers have pushed back on the proposal, questioning the fairness of the logic of the proposal, given that CPUC has allowed power companies to deenergize their grids for durations longer than 72 hours during PSPS.

Some believe that housing policies that allows construction of new homes deeper into the woodland fire interface is the main culprit. They opine whether managed retreat policies currently being considered for coastal communities threatened by sea level rise and cliff erosion,[66] might be a better to solve to address the fire risks that rural communities face.

Given the above, there is a need for a sober policy discussion of what reasonable expectations of service and reliability should be in rural areas serviced by linear line networks that contain multiple single points of failure during disasters. Due to challenging topography it is infeasible and uneconomic to build more resilient and redundant mesh networks in these areas. Due to the likely infeasibility of manage retreat, investment in research and development of non-wired communications solutions might make more sense.

[63] https://www.mercurynews.com/2020/05/14/how-will-california-fill-54-billion-coronavirus-hole-in-budget/
[64] https://docs.cpuc.ca.gov/PUBLISHED/GENERAL_ORDER/108114.htm#P59_1414
[65] Actions to Hold Communications Companies Accountable and Increase Public Safety, CPUC
[66] https://www.eenews.net/stories/1062762225

> *"We should say next normal instead of new normal. I don't want to go back to normal because it wasn't working. A lot of things that weren't working, weren't obvious to us. Now they are. We need new approaches to get beyond the pandemic."*
> *- Cynthia Murray, CEO, North Bay Leadership Council*

OVERCOMING CONSTRAINTS

Leadership

Leadership will be required at all levels of our society from within the ranks of elected and government officials, to private and non-profit sectors, right down to the neighborhood level, to place resilience and redundancy of both grids near the top of California's priority list. Leaders will need to understand the issue and commit to educating others of its severity. California has a strong Governor and state and local elected officials who have risen to the occasion and made tough and innovative decisions in response to COVID-19. They have proven they can lead in times of crisis and can lead on this issue.

Collaboration

This problem will require an all-hands on deck approach. A framework must be set in place to break down silos and foster collaboration between government agencies, power companies and communications service providers. This means sharing data and expertise to proactively coordinate and expedite resilience efforts, looking toward how that could lead to the "smart" modernization of both grids from network facilities to customer premises. It means sharing responsibility and deploying as much available financial resources and human capital as is necessary to fix the problem.

Education

Some solutions may take a long time to approve and implement. Stakeholders must be made aware of the "new normal," the challenges our communication systems face, and how self-reliance is required in the short term. Localities should not wait for the state and federal governments to come to the rescue. Instead, they should look at their options and deploy low-cost, easily implementable Back to the Future solutions to build redundant communication systems, and create "worst case scenario" disaster action plans.

Advocacy

To overcome resistance from the communications providers and government entities, a mix of new funding, and existing incentives must be leveraged and deployed. Stakeholders must lobby congressional leaders to include resources in a potential future Coronavirus Relief bills, and encourage the state legislature to

move forward with a Resilience Bond, or package of bonds, on the November 2020 ballot. Stakeholders be should be made aware of and leverage existing incentives programs like the state's Self Generation Incentive Program (SGIP) for battery storage,[67] and new investment tax credits should be considered to help communication companies fund the deployment of backup power if they address resilience and/or use renewable generation and battery storage technologies.

[67] https://www.cpuc.ca.gov/sgip/

RECOMMENDATIONS

Given the size, scale and complexity of the problem, the government and private sector must work together to solve this problem. Because of the interdependencies between power and communications, regional and localized needs and constraints, no single invention will be the answer. A program with a set of interventions implemented collectively, will drastically reduce failures during future disasters and provide our communities with resilient and redundant communications systems.

#1: Joint Power & Communications Safety and Resilience Task Force

Immediately establish a Joint Power & Communications Safety and Resilience Task Force at the state-level headed by a senior advisor who reports directly to the Governor. The Task Force would mandate participation of key decision makers from power and communication companies and provide a framework for proactive collaboration and synchronized planning of resilience efforts that acknowledges the interdependencies of power and communications grids. The Task Force's main aims will be the safety, resilience, redundancy and modernization of the power and communications grids. The Task Force members would engage in the following activities:

- Share resources and sync efforts to expedite resilience projects;
- Establish recommendations for removing obstacles and streamlining permitting and regulatory processes that add cost and delays to resilience efforts;
- Inventory/establish a catalogue of available "Barn Animals," generators and shared resources and establish stock piles within mutual aid regions;
- Pilot backup power projects with renewable energy sources and battery technologies such as underground batteries to address concerns about sparkage and blight; and
- Identify and leverage SGIP and other state and federal incentive programs to offsets communications companies offset cost of system-wide upgrades.

#2: Grid Safety and Resilience and Corps

Establish a Grid Safety and Resilience and Corps to support much needed workforce and economic development and provide expertise and staffing on projects identified by the Task Force. The Corps would pair retired professionals, permitting specialists, university professors, graduating college students, out-of-work laborers with private and public sector entities to work on state and local Safety and Resilience projects. Members of the Corps would perform the following tasks:

- Design modern grids focusing on resilience, redundancy and modernization;
- Manage and conduct grid (resilience, redundancy and modernization) projects;
- Staff and bolster existing permitting capacity and streamline processes; and
- Work on forest management and defensible space projects around grid facilities and critical institutions in high-risk areas.

> *"Wake up, wake up others, stay woke!"*
> - James Gore, Sonoma County Supervisor

#3: Statewide Public Awareness Campaign

Fund and implement a multi-media Statewide Public Awareness Campaign. The campaign will be designed by the California Office of Emergency Services, the California State Association of Counties and the California League of Cities and target multiple stakeholders highlighting the urgency of the "new normal" and inform them of the availability on top-down and bottoms up safety and resilience solutions.

Specific focus for local governments:

- Increase city and county adoption of IPAWS, support training for staff members;
- Highlight "self-reliant" smart practices outline low-cost, quickly implementable solutions;
- Encourage installation of pole-mounted air raid sirens in targeted communities;
- Encourage reprograming public safety vehicles with high low sirens and other redundant forms of communications like mobile PA systems;
- Develop plans to establish information hubs at community centers with generators, charging stations and separate wifi;
- Encourage the development and proliferation of community CERT Teams and neighborhood resilience groups.

Specific focus for neighborhoods and residents:

- Encourage home use of Battery and Hand Crank Radios;
- Encourage switch from to corded phones for POTS users;
- Encourage deployment of customer premise-based backup power (SGIP); and
- Encourage participation in neighborhood safety and resilience groups.

> *"Some think we should retreat on a resilience bond: our data shows that voter sentiment is still high and hasn't wavered much. Because of that, and other factors, it might be the time to go even bigger."*
>
> <div align="right">- Dave Metz, FM3 Research</div>

#4: Advocate For Funding

Lobby congress and the state legislature to make resilience and infrastructure funding a top priority. While budgets are strained due the Coronavirus Pandemic, record-low interest rates means debt is cheap which may present a window of opportunity to finance corrective measures with bonds. Recent polling indicates that voters' opinions favor action on climate and reliance have not changed much during the Coronavirus Pandemic and if tied to jobs and workforce development, innovation and protecting future generations that legislation and ballot initiatives may find public support.

Key opportunities include:

- Future Federal Coronavirus Relief Bill;
- Statewide Resilience Bond for November 2020 ballot;
- Statewide Infrastructure Bond As Part of Package of Bond Measures on the November 2020 ballot.

> "This can happen to anyone at any time. Governments at every level need to prepare. You need to be ready." -Reva Feldman, City Manager, Malibu

CONCLUSION

Communication systems are our lifelines. System failures during disasters are devastating to communities and residents and lead to loss of life and other social harms. Fixing this multi-layer problem is complex and will take time, effort and resources.

Stakeholders at all levels need to "Think Big" to fix the problem. We must utilize the same wartime mentality exhibited in response to the Coronavirus Pandemic and apply that to prepare California for the challenges presented by the "New Normal" and expedite efforts to resilience and redundancy into our power grid and communications systems.

California possesses a wealth of leaders at the state and local government levels, and within the corporate, non-profit and community ranks who have demonstrated their ability to react and respond to crises. Those leaders need to shift from reactive response to proactive measures.

California can "Meet the Moment" and increase the resilience of our communications systems and the safety of our communities by establishing a collaborative framework; tapping into the state's vast human capital; educating our communities how to prepare; and advocating for and generating resources to support these efforts.

> *"Any community that thinks they don't need to invest in this is dead wrong. If you are too busy dealing with other issues to make sure your community is safe…then expect retribution after the fact. Learn from others, learn from our experience."* - James Gore, Sonoma County Supervisor

SOURCES AND REFERENCES

Baker, David R. The California Rule That Doomed PG&E: Inverse Condemnation, Bloomberg Jan. 15 2019, https://www.bloomberg.com/news/articles/2019-01-15/the-california-rule-that-doomed-pg-e-inverse-condemnation

Bay Area Urban Areas Security Initiative (Uasi) Public Information & Warning Workgroup, Mass Notification Seminar Summary Report, March 14 & 15, 2018 http://bayareauasi.org/sites/default/files/resources/MassNotification-Seminar_Summary_Final.pdf

Brown, Alex, "Across the U.S., states are bracing for more climate-related disasters", Los Angeles Times, January 30, 2020 https://www.latimes.com/world-nation/story/2020-01-30/states-climate-disasters

Burroughs, James E., Three Factors Leading To The Failure Of Communications In Emergencies, Walden University, 2017 https://scholarworks.waldenu.edu/cgi/viewcontent.cgi?article=4765&context=dissertations

De-Energization (PSPS), California Public Utilities Commission, www.cpuc.ca.gov

El Khaled, Zayan and Hamid Mcheick, Case Studies Of Communications Systems During Harsh Environments: A Review Of Approaches, Weaknesses, And Limitations To Improve Quality Of Service. International Journal Of Distributed Sensor Networks 2019, Vol. 15(2) https://journals.sagepub.com/doi/full/10.1177/1550147719829960

Esposito, Christian, and Antonios Gouglidis, David Hutchison, Andrei Gurtov, Bjarne E. Helvik, Poul E. Heegaard, Gianluca Rizzo, Jacek Rak, On The Disaster Resiliency Within The Context Of 5g Networks: The Recodis Experience*

http://www.research.lancs.ac.uk/portal/en/publications/-(deecf716-8426-49e7-9ff9-322caba79e77).html

Everbridge, https://www.everbridge.com/solutions/alert-residents-and-visitors/

Fagan, Kevin Verizon, under fire for throttling firefighters' data speed, lifts caps for first responders – San Francisco Chronicle, Aug. 24, 2018 https://www.sfchronicle.com/california-wildfires/article/Verizon-under-fire-for-throttling-13181210.php

FEMA's Oversight Of The Integrated Public Alert & Warning System (IPAWS), Office Of The Inspector General, United State Department Of Homeland Security November 19, 2018 https://www.oig.dhs.gov/sites/default/files/assets/2018-11/OIG-19-08-Nov18.pdf

Ghilarducci, Mark S., 2019 State Of California Statewide Alert & Warning Guidelines, Cal Office of Emergency Services, March 2019 http://calalerts.org/documents/2019-CA-Alert-Warning-Guidelines.pdf

Haggerty, Colleen A Year After The Camp Fire Nearly Leveled Paradise, California, Vox Oct 23, 2019 https://www.vox.com/the-highlight/2019/10/16/20908291/camp-fire-wildfire-california-paradise-survivors

Hart, Angela California Wildfires Reveal Alert System Shortcomings – Government Technology August 7, 2018 https://www.govtech.com/public-safety/California-Wildfires-Reveal-Alert-System-Shortcomings.html

Johnson, Syndey, California Moves to Shift the Digital Divide, Ed Source, April 16, 2020 https://edsource.org/2020/california-moves-to-close-digital-divide-as-schools-shift-online/629281

Krieger, Lisa M. Camp Fire created a black hole of communication/In disasters, our high-tech communities are reduced to 1940s-era responses, The Mercury News, Dec. 16, 2018 https://www.mercurynews.com/2018/12/16/camp-fire-created-a-black-hole-of-communication/?utm_medium=social&utm_campaign=socialflow&utm_source=twitter.com&utm_content=tw-mercnews

Main Types Of Disasters And Associated Trends, California Legislative Analyst's Office, January 20, 2019 https://lao.ca.gov/Publications/Report/3918

Nixle, https://www.nixle.com/about-us/

O'Reilly, Gerard et al, Critical Infrastructure Analysis Of Telecom For Natural Disasters Conference: Telecommunications Network Strategy And Planning Symposium, 2006. Networks 2006. 12th International https://www.researchgate.net/publication/224280321_Critical_Infrastructure_Analysis_of_Telecom_for_Natural_Disasters

Pescaroli, G., et al, Cascading Effects And Escalations In Wide Area Power Failures: A Summary For Emergency Planners

Rogers, Sara, 2017 CALIFORNIA WILDFIRES, Cal Fire Foundation, October 12, 2017 https://www.cafirefoundation.org/wildfires-october-2017/

Romero, Simon, A Frantic Call, A neighbor's knock, but few official alerts as wildfires closed in ...Only a fraction of residents received emergency alerts or evacuation orders from local authorities - New York Times – November 21, 2018 https://www.nytimes.com/2018/11/21/us/paradise-fires-emergency-alerts.html

Staff Authored Report, Safety Principles for Communications Providers, California Public Utilities Commission, 2019

Sandhu, H. S., S. Raja. 2019. "No Broken Link: The Vulnerability Of Telecommunication Infrastructure To Natural Hazards." Sector Note For Lifelines: The Resilient Infrastructure Opportunity, World Bank, Washington, DC. http://documents.worldbank.org/curated/en/951991560791754833/pdf/No-Broken-Link-The-Vulnerability-of-Telecommunication-Infrastructure-to-Natural-Hazards.pdf

 SoCoAlert, https://socoemergency.org/home/prepare/stay-informed/socoalert/

St John, Page Alarming failures left many in path of California wildfires vulnerable and without warning, Los Angeles Times, Dec. 29, 2017 https://www.latimes.com/local/lanow/la-me-fire-warnings-failure-20171229-story.html

St. John, Paige, et al., As desperate calls poured in, an emergency alert system failed many – Los Angeles Times October, 11, 2017 https://www.latimes.com/local/lanow/la-me-napa-fire-distress-calls-20171011-story.html

Strait, Ryan, How IPAWS Could Have Saved Lives in California's Wildfires, Civic Plus, https://www.civicplus.com/blog/ps/how-ipaws-could-have-saved-lives-in-the-california-wildfires

Telecommunications Outage Report: Northern California Firestorm 2017, North Bay North Coast Broadband Consortium, April 2018 https://ecfsapi.fcc.gov/file/1053130424752/EAS-1.-NBNCBC-Telecommunications-Outage-Report-2017-Firestorm.pdf

INTERVIEWS

Passey, David - Director of External Affairs, FEMA Region 9, Personal Interview

Picker, Michael - former President, California Public Utilities Commission, Personal Interview

Chong, Rachelle - former member, FCC and California Public Utilities Commission, Personal Interview

Pierce, Michael - Communications Division, California Public Utilities Commission, Personal Interview

Nicely, Mary - Senior Advisor, Office of the State Superintendent of Public Instruction, Personal Interview

Wink, Mike - Battalion Chief, CAL FIRE - South Lake County Fire Protection District, Personal Interview

York, Brian - Battalion Chief, CAL FIRE, St. Helena Emergency Command Center, Personal Interview

Browning, Abby - Chief, NGO & Private Sector Partnerships, Cal OES, Personal Interview

Stoeffl, Monika - Executive Director, California Resiliency Alliance, Personal Interview

Crout, Stephen - Director, Policy and Resilience Programs, Smart Cities Council, Personal Interview

Ramos, Belia - Member, Napa County Board of Supervisors, Personal Interview

Gore, James - Member, Sonoma County Board of Supervisors, Personal Interview

Feldman, Reva - City Manager, City of Malibu, Personal Interview

Murray, Cynthia - CEO, North Bay Leadership Council, Personal Interview

Brooks, Charles - Executive Director, Rebuild Paradise Foundation, Personal Interview

Nicholls, Mike - Sonoma Mendocino County Economic Development Board, Personal Interview

Hogeboom, Jim - Superintendent of Schools, San Rafael City Schools, Personal Interview

Woodbury, Rebecca - Director of Technology, City of San Rafael, Personal Interview

Gardner, Quinn - Emergency Manager, City of San Rafael, Personal Interview

Metz, Dave - FM3 Research, Personal Interview