INSTITUTE FOR HOMELAND SECURITY

The Human Element in Critical Infrastructure: Strengthening Workforce Preparedness for Restoration and Resumption After Mass Disruption

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January 2025

Abstract:

Critical infrastructure resilience and cybersecurity hinges not just on physical assets but, more importantly, on the people responsible for managing, restoring, and resuming operations and their related technologies post-disruption. This paper examines how building skills and capabilities that prioritize the human element of critical infrastructure can improve performance during recovery and deliver ongoing benefits during routine 'blue skies' operations.

This paper identifies key strategies that strengthen workforce capability across three critical areas: workforce resilience, cross-sector collaboration, and community engagement.

By highlighting practical examples and case studies from Texas and New Zealand, this paper advocates for an approach to strengthening workforce capability that not only bolsters crisis response and recovery but also improves ongoing business operations. Preparing infrastructure and cybersecurity workers for mass disruption—and equipping them with the necessary skills for workforce resilience, collaboration, and engagement—positions organizations to thrive in both crisis and blue skies scenarios.

Introduction and Overview

Mass disruption provides the perfect storm for the exposure of critical infrastructure leaders and practitioners to systemic vulnerabilities. As our world has become increasingly volatile, uncertain, complex, and ambiguous, critical infrastructure practitioners require skills that extend beyond the traditional emphasis on technical specialization, standardized operating procedures, and the linear prediction and management of risk.

There's no denying that the frequency, severity, and cost of recovery from disasters and extreme weather/climate events are increasing. Looking at extreme weather events alone, in the USA as of November 1, 2024, there were 24 events with Consumer Price Index (CPI)-adjusted losses exceeding $1 billion - almost triple the annual average of 8.5 such events across the years 1980-2023 (NCEI, 2024). Over the past four decades, the 5-year average CPI-adjusted cost of these incidents has grown 663%. This scale of extreme damage is not an anomaly, but the continuation of more than four decades of upward trend.

Compounding this is the increasing co-occurrence of multiple disaster events, resulting in the overlapping of recovery from one event with the response to another. Take, for example, the months of April and May 2024 in Texas:

- April 8-11 severe weather in Southern and Eastern Texas
- April 27-28 Texas hailstorms
- May 11-13 severe weather in Southern Texas
- May 16-17 Southern Texas Derecho

These increasingly common circumstances force critical infrastructure workers far from the ordered world of engineering and large-scale systems design into chaotic complexity. The myriad challenges that emerge across traditional industry or geographical divides make solving critical infrastructure disruptions as much about working with people as it is about

physical or cyber assets. As experienced most notably with the 2024 CrowdStrike information technology (IT) outage that affected approximately 8.5 million IT systems around the world (Weston, 2024), IT challenges require solutions, such as workforce resilience to reduce human error, collaboration and engagement, that extend well beyond technical expertise alone. David Weston, the Vice President of Enterprise and OS Security at Microsoft, noted at the time how Microsoft was *"collaborating with other cloud providers and stakeholders, including Google Cloud Platform (GCP) and Amazon Web Services (AWS), to share awareness on the state of impact we are each seeing across the industry and inform ongoing conversations with CrowdStrike and customers"* (Weston, 2024).

This paper demonstrates the human-centric skills and behaviors that, when introduced in daily operations within critical infrastructure, can provide significant benefits not only in the wake of mass-disruption, but to operational efficiency and effectiveness during 'blue skies'.

Gap Assessment or Problem Statement

Times of mass disruption shift us from our relatively predictable and linear daily experience into contexts that are more unordered and unpredictable. Technical industries necessarily emphasize linear and predictable routines to function successfully. This is a useful approach to minimize service disruptions, maximize safety, and minimize cost. The unintended consequence of this approach is that documentation, planning, standard operating procedures (SOPs), and processes are emphasized, and technical expertise and domain-specific specialization are prioritized over interpersonal and human skills, increasingly recognized as 'power skills' (Thomson Reuters, 2022; Forbes, 2024). The history of the previous term soft skills, while not entirely certain, appears to be a mid-20th century U.S. military discovery. Having excelled in training troops for technical equipment use, military leaders learned that

how a group of soldiers was led was a considerable predictor of the group's success. Human factors were identified as critical to technical success in the U.S. Military.

In times of disruption, unexpected issues arise that do not respect the domain boundaries established within companies or industries. Interconnected problems emerge that, in isolation, are manageable, but, when co-occurring, can overwhelm existing services or clash with the needs and processes of adjacent services and providers. Human factors rise to the forefront, for which critical infrastructure workers are often under-prepared.

This paper examines and addresses three key human factors in critical infrastructure in preparedness for large-scale disruption: personal resilience, stakeholder and community engagement, and collaboration.

Personal Resilience

Firstly, without a focus on resilience of the people involved in critical infrastructure, plans and systems are vulnerable. A workforce ready to step up and perform, and sustain that performance under pressure, is a need commonly experienced by critical infrastructure organizations in a crisis environment. However, those typically involved in responding to emergencies have been found to report personal preparedness levels that do not much exceed that of the general population, (Kelenske, 2011; Simmons, 2024).In the wake of disruption and disaster, critical infrastructure workers, responders and their families, are often personally impacted by disasters and emergencies, leaving the workforce on which we rely in times of disaster and mass disruption vulnerable. The consequences of not investing in the resilience of the people involved in our plans are stark. In New Orleans, 250 police officers left the city and failed to show up for work in the wake of Hurricane Katrina, likely because of the need to care for their families (Deflem & Sutphin, 2009).

In Texas, Dr Janelle Rios from The University of Texas Health Science Center at Houston (UTHealth Houston) School of Public Health (SPH), the Prevention, Preparedness, and Response (P2R) Consortium and the Texas Epidemic Public Health Institute (TEPHI), contrasts the differing realities for three vital workers in health-related organizations when Hurricane Harvey hit Houston (Rios, 2023). Rios herself was flooded, but credits her personal circumstances for a resilient outcome and the ability to stay in Houston, recover, and continue to contribute in her health role. “I’ve got wonderful insurance, I have vacation and sick time I can take, I have the ability to work flexibly, and I had the available funds for the cleanup and to raise my home and pay for a generator to be more resilient next time,” (Rios, Texas Epidemic Public Health Institute (TEPHI), 2024).

In contrast, a custodial worker in a part-time role, with a lesser income level, without sick leave or vacation time, and with limited English, had a different experience. She lived in a mobile home near a bayou. Her home wasn’t flooded, but she had a long-standing fear of water and witnessed her daughter’s home three doors down being inundated. During the Hurricane she had to be rescued by boat – a potentially-traumatic experience. She eventually decided she could no longer live in Houston and left her custodial role to return to her home country.

A third woman - a hospital laboratory technician - was flooded three feet into her home and her car was flooded, leaving her stranded and fearful. The trauma of the initial experience and the secondary stress of the overwhelming insurance process meant that, after relocating temporarily with her husband and dog for 8 months, the recovery process was too overwhelming, so she and her family left the state with the subsequent loss of a vital worker.

These three different experiences played out in the wake of the same disaster for women who lived within eight miles of each other. Their stories highlight the need to factor in the resilience of the critical workforce needed to respond to disaster and disruption.

In addition to practical preparedness factors that influence the ability of the critical infrastructure workforce to respond, is the need to prepare the workforce for the challenges of operating under prolonged pressure. High and prolonged pressure environments in the wake of disaster create risk for both workers and organizations. Risks to individual workers are many but include burnout, health impacts, and worker injury. Risks to the organization include turnover, reduced efficiency, project failure, short-term thinking, poor decisions and reputational damage (Wills, 2014). Cognitive Load Theory suggests, in simple terms, that the demands of a post-crisis environment will limit practitioners' cognitive bandwidth, restricting their ability to absorb information, solve problems, make decisions, rationalize, think strategically, collaborate, and to think in new and different ways often required by the situation (Sweller, 2011).

Stakeholder and Community Engagement

The second human factor problem examined in this paper stems from the tendency to undervalue stakeholder and community engagement skills within technical sectors and domains. It is often overlooked that people are at the heart of enacting plans and procedures, and critical infrastructure is ultimately created to serve the needs of people. According to Janelle Rios from TEPHI, the COVID-19 death toll in the United States was higher than necessary, partly due to limitations in communicating information in a way that communities could easily understand, act on, and use to protect themselves. Texas was in the top three states for COVID mortality per capita in 2021 (NCEI, 2024). "I'm guilty of not valuing

communication skills before the pandemic, and I won't make that mistake again," reflects Rios (Rios, Texas Epidemic Public Health Institute (TEPHI), 2024).

Broad-reaching stakeholder and community engagement and collaboration were also at the heart of the response to the 2024 CrowdStrike Outage, the largest information technology outage in history (Weston, 2024).

Crisis, or not, it is naturally easier to work with people who think, speak, and operate like us. Engaging with those from different backgrounds who approach things differently demands extra energy and effort. After a disruption, especially when the challenge is prolonged, time, energy and 'brain space' are scarce. The natural human tendency is to revert to familiar ways of working, with those who think, work and talk like we do, and ignore people and factors we deem to be 'outside' of our work. Yet, in the complex, challenging environment of post-crisis recovery, engaging with external stakeholders is essential and should be approached with deliberate intent and planning.

Take for example, the challenge of repairing and rebuilding the damaged horizontal infrastructure for an entire city in the wake of a devastating earthquake. This was the challenge for the Stronger Christchurch Infrastructure Rebuild Team (SCIRT) in the wake of the Christchurch Earthquakes that occurred in 2010 and 2011.

Former CEO of SCIRT Duncan Gibb states it well, "The challenge is the keep bringing the community along with you. Communication changes with different phases of the disaster response. You need to communicate in as many ways as you possibly can. Not everyone can get on a website or has twitter, so you need to go out and talk to pre-schools, go to retirement villages, community groups, churches, get out there and talk to people. And you need to be doing that ongoing. The community is who we're here to serve. Get out and talk to them," (Gibb, 2015).

Businesses typically experience a 30% reduction in revenue due to infrastructure works nearby. Noise, vibrations, dust, disruption and the extra hassle involved in a customer visiting a business take a toll on businesses that have already been disrupted by an initial crisis event. Initially, the SCIRT teams did not fully understand the significant impact roadworks could have on business operations, particularly for those in retail and hospitality. For example, crews often occupied customer parking spaces, and while SCIRT typically provided a two-week notice for upcoming works, businesses would have benefited from at least three months' notice to facilitate better planning (stock management and staffing for example).

This is a common experience in post-disaster contexts, where front-line infrastructure workers end up in conflict with external stakeholders due to a lack of engagement and planning that involves all affected parties. Over time, SCIRT learned the importance of understanding each business's unique needs, such as peak hours, delivery schedules, and the demographics of their customers—whether they were older patrons wary of uneven footpaths or younger, night-owl customers. This experience highlights the inadequacy of a one-size-fits-all solution and emphasizes the need for flexibility.

Collaboration

The third human-centric challenge examined in this paper points to the gap between the dominant hierarchical organizational models and operational approaches in critical infrastructure, and the collaborative approaches needed to thrive in the wake of crisis.

The traditional industrial model of organization is built on a premise of predictable order, and the scalability of that order. In his seminal 2002 paper on knowledge management, David Snowden highlights the profound difference between this predictable ordered world, and the complex systems of human experience where a traditional ordered approach is unlikely to succeed (Snowden D. , 2002). Leaders and team members who attempt to impose order top-

down in a complex context are likely to fail (Boone, 2007, p. 6), so another approach is needed.

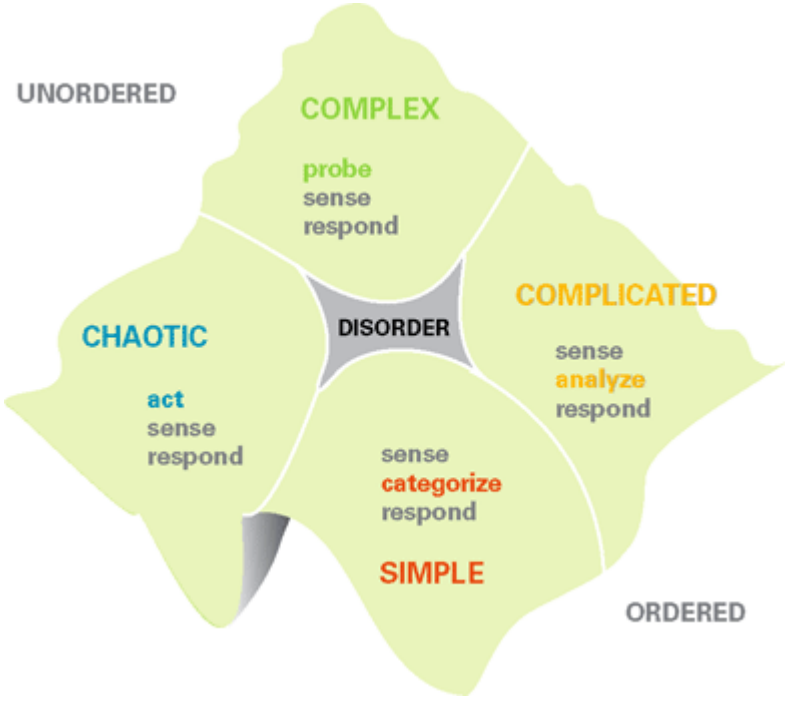

Figure 1: The Cynefin Framework

"Simple and complicated contexts assume an ordered universe, where cause-and-effect relationships are perceptible, and right answers can be determined based on the facts. Complex and chaotic contexts are unordered—there is no immediately apparent relationship between cause and effect, and the way forward is determined based on emerging patterns. The ordered world is the world of fact-based management; the unordered world represents pattern-based management." (Snowden & Boone, 2007).

Simply put, on 'blue skies' days most critical infrastructure organizations operate in the complicated world of predictable order where dedicated teams of experts leverage best practices to ascertain right and wrong answers. The post-disaster context shifts initially into a brief period of chaos and then a long period of complexity. These chaotic and complex post-disaster environments require reaching beyond team and organizational boundaries and ways of operating. There is a need to better prepare critical infrastructure practitioners for the

challenges of complexity including the need to collaborate across systems. In the case of cybersecurity, critical issues can arise simply because of a lack of appreciation for the complexity of reality. CrowdStrike's External Technical Root Cause Analysis of the outage highlighted how a confluence of minor issues and human errors can compound to create highly complex unanticipated issues with far-reaching consequences (CrowdStrike, 2024, p. 2).

Addressing these three problems that currently limit success in a post-crisis environment - lack of workforce resilience, undervaluing of stakeholder and community engagement skills and the need to think systemically and to collaborate across systems - will better set critical infrastructure organizations up for success in the wake of disruption. However, Cognitive Load Theory (Sweller J., 2011) would suggest that learning new skills and ways of operating is more challenging in a post-disaster environment when people have limited cognitive bandwidth. Addressing these gaps in human factors capabilities before disaster strikes is critical for success post-crisis, while also delivering benefits to performance in 'blue skies'. If we want people to think and behave in a particular way under immense pressure, we should first equip them to think and behave in that fashion in the midst of regular routine.

The case studies that follow highlight how these skills have enabled peak performance in post-disaster contexts, whilst also providing significant benefits for 'blue skies' regular work.

Topic Discussion

Managing human factors, as with other organizational imperatives that are critical to success, requires intentional effort. Three distinct skill sets are highlighted as both vital and incredibly useful for post-disaster resumption and 'blue skies': collaboration, stakeholder engagement and communication, and workforce performance and resilience under pressure.

Collaboration

In the wake of a major crisis, restoring and rebuilding critical infrastructure requires more than just technical expertise; it demands intentional collaboration. Intentionality is vital due to the high cognitive load associated with a post-crisis environment.

After a series of major earthquakes rocked the city of Christchurch, New Zealand in 2010 and 2011, 80% of the city's underground infrastructure was damaged. The scale of the task to rebuild and reinstate services was staggering, with over 700 projects equating to NZD $2.2 billion worth of work to be completed over a 5.5-year period.

Asset	Replace/repair	Unit
Water Reticulation	43	miles
Sewers	409	miles
Sewer Pump Stations	136	#
Storm Water	16	miles
Roading - residential	634	miles
Bridges	148	#
Retaining Walls	219	#

Table 1:Underground infrastructure to be replaced or repaired in Christchurch, New Zealand, post-earthquakes in 2010-11

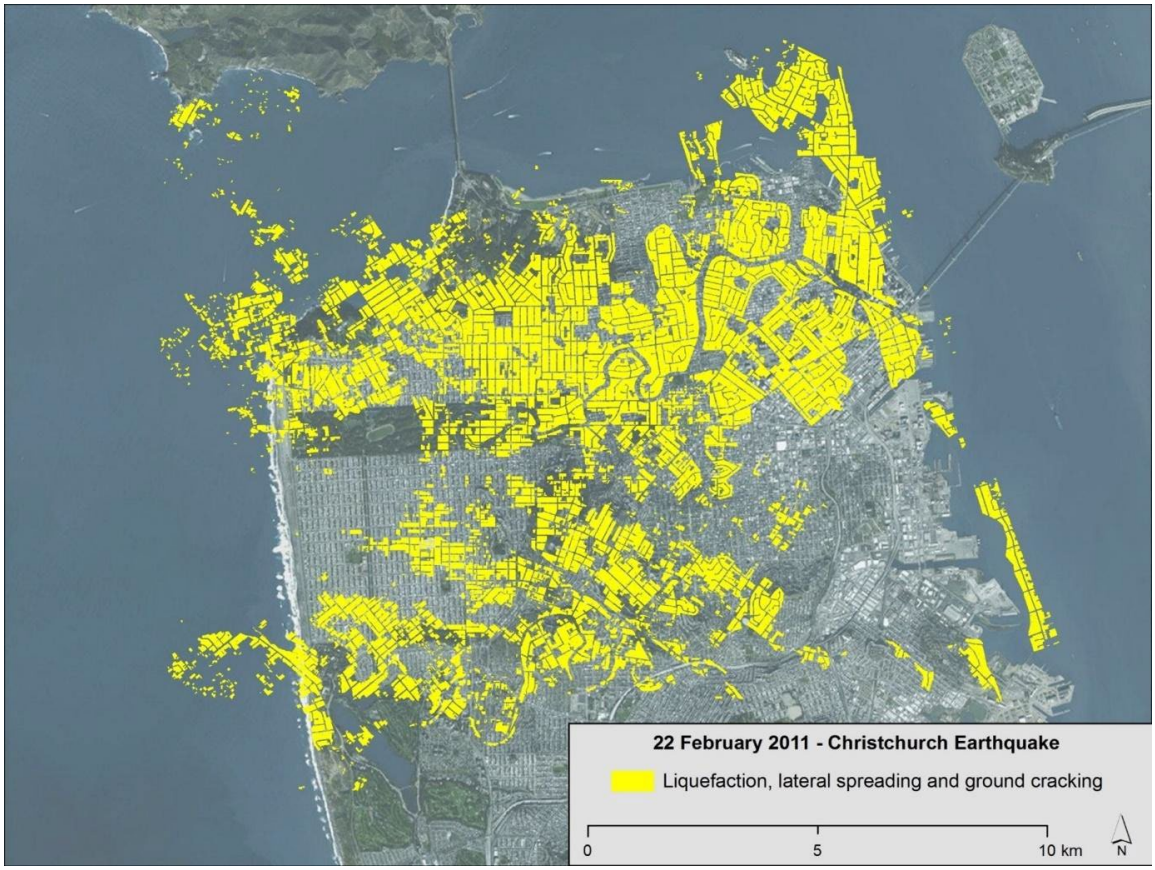

Figure 3: Horizontal infrastructure replacement and repair requirements for the city of Christchurch. Source: Gibb, D. (2015, June). SCIRT: Presentation at East Asian Summit Rapid Disaster Response and Disaster Recovery Workshop. Bali, Indonesia.

Given the uncertainty and scale, a collaborative alliance was established, bringing clients and service providers together to share risk and decision-making.

The commercial model (a private-public partnership) was carefully and intentionally structured in a way that embedded a healthy tension between collaboration and competition between the five civil construction organizations who usually competed for work (SCIRT Learning Legacy). Each team was initially allocated 20% of the work but was measured on key performance indicators that determined whether their share of the work would increase or decrease, fostering competition. Crucially, however, they were also incentivized to work together. A pooled fund was established, where savings from the projects created a "gain pool," and overspending resulted in a "pain pool". Teams that performed well earned a greater share of the pool, whether it was positive or negative. This structure encouraged the high performers to lift the lower performers, creating a shared responsibility for the overall outcome and fostering collaboration. This structure created both opportunities for collaboration and competitive tension, ensuring that the overall outcome benefitted the entire city and industry.

The approach to collaboration was intentionally designed and based on a set of six values: zero harm, community welfare, openness to learning, collective orientation, generosity & trust, and development of people (Resilient Organizations, 2015).

Collaboration wasn't just a principle left to chance. It was 'structured in'. Leadership groups comprised of members from the five competing civil construction delivery teams were created for different functions such as safety, communications, commercial, technical advisory, and quality (de Zwart, 2017). Each leadership group met regularly, created a Terms of Reference, and came up with a plan for what they needed to achieve. As an example, the

safety leadership group shared their intellectual property across the five organizations and collectively designed a standard for personal protective equipment, which has now been rolled out nationally across New Zealand as the leading standard.

For SCIRT, structuring in collaboration proved vital in achieving operational success, timely recovery of services, and community value for the city of Christchurch.

Leadership at the State Office of Risk Management in Texas also recognized the need to 'structure in' collaboration. Executive Director, Stephen Vollbrecht recognized that the siloed structure in place in 2004 resulted in divisions competing for resources rather than working together towards the organization's mission (State Office of Risk Management, 2024; Vollbrecht, 2024). When the mission sets expanded from a dual focus on workers' compensation and health and safety to incorporate enterprise level integrated risk management, including insurance provision, it was clear that the siloed approach could not deliver on the expanded mission sets and was no longer sustainable. Vollbrecht drew inspiration from networked heterarchical structures (as opposed to hierarchical structures) and network-based analysis in computing. Vollbrecht worked with leaders and teams to eliminate the stove-pipe-style structure which restricts the flow of information to vertical lines of control only, aiming to enable, rather than prevent, cross-functional communication.

The resulting structure had teams overlapping in Venn diagram fashion, ensuring a built-in need for communication across teams.

This heterarchical structure ensures the creation of interconnections that rely on each other. How they interact depends on the situation, with an underpinning framework providing guard rails.

Additional attention is given to methods to reinforce cross-team collaboration during daily operations. These efforts include ‘cross-training’ with regular seconding of team members to roles across the organization, and a weekly Leadership Council (LC) - a meeting of all leaders: supervisors, managers, directors and executive staff. Leaders provide an update on where each team is, what has been accomplished, what their next objectives are, and what assistance is needed from other teams. The awareness that a leader may be seconded or be

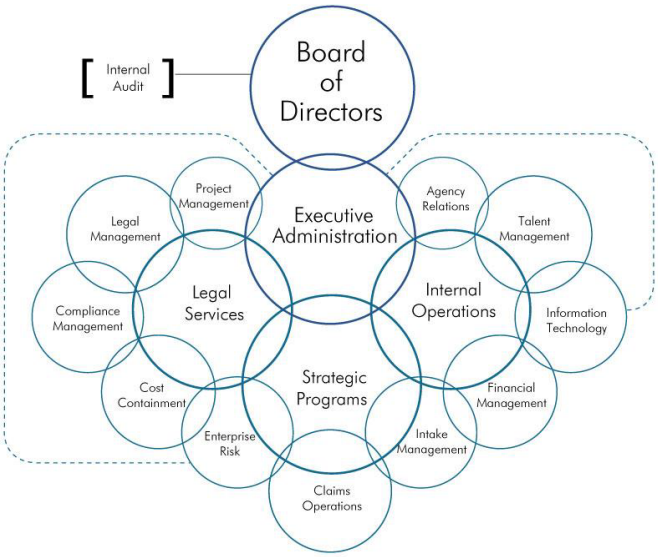

Figure 1: State Office of Risk Management structure

required to ‘step in’ to roles in different teams motivates leaders to listen and learn from the activities and events in other teams with deeper interest. The LC is followed each week by an Executive Council involving executive leadership.

This structure enables collaboration, cooperation and greater teamwork to drive the mission during daily operations. However, the need to revert to a command-control structure based on the Incident Command System (ICS) emerged. For this reason, an ICS structure was later built-in as a 'skeleton' within the organizational structure, and the organization shifts modes in a crisis. While crisis necessitates a temporary shift in structure and organizational approach, the benefits of collaboration and cross-training in 'blue skies' flow into improved operations during major incidents.

Vollbrecht reflects that in addition to driving collaboration, SORM's non-traditional structure delivers other benefits. Traditional structures often engender inflexibility where organizations are not equipped to respond well to sudden shocks, disruption, or changing environments. SORM's non-traditional structure has delivered on improved collaboration for mission delivery, but also created a flexibility that has ensured SORM is a nimble and adaptable organization with the ability to shift depending on the context and to grow with its people.

Intentional efforts to embed collaboration within and between organizations in the critical infrastructure sectors are critical, but cross-sectoral collaboration also yields benefits. It was recognized that a successful recovery and rebuilding for Christchurch would need a collaborative cross-sectoral approach, with community at the heart. An integrated recovery model was established through intentional collaboration across industries and sectors (Canterbury Earthquake Recovery Authority, 2012).

The work of organizations involved in the restoration and rebuilding of essential services was guided by a recovery strategy based on this very collaboration. However, over time, as the pressure weighed heavily and fatigue set in, it became significantly more difficult to collaborate as needed. Determined to "take the theory from the page into practice – on the ground", SCIRT partnered with New Zealand Red Cross to explore and implement collaboration between these key organizations leading recovery efforts in the built and social environments (Gibb & McNaughton, 2014). New Zealand Red Cross (NZRC) played a pivotal role in the post-earthquake recovery efforts in greater Christchurch delivering humanitarian services, offering financial assistance grants, psychosocial support, outreach services, community transport, and support to key social service providers in the broader community. The aim of this collaboration was to enhance service delivery and community resilience in greater Christchurch earthquake recovery projects through collaboration and innovation.

Figure 2 Integrated recovery model: Canterbury Earthquake Recovery Authority. (2012). Recovery strategy for Greater Christchurch: Mahere Haumanutanga o Waitaha. Christchurch: Canterbury Earthquake Recovery Authority.

To counteract human tendencies that make collaboration more difficult under strain and fatigue, the two organizations moved in together - they co-located their teams in one building, sharing breakroom and meeting spaces. The two organizations were able to assist each other's efforts to support the communities of Christchurch through the sharing of expertise and resources. For example, NZRC's outreach volunteers accompanied SCIRT staff in the community, offering a listening ear and valuable information to residents in areas where roadwork was planned or underway. This support allowed SCIRT staff to concentrate on their work more effectively and to integrate psychosocial support with the physical rebuild efforts.

Further advancements in service delivery were enabled for each party by this collaboration also. NZRC staff advised and provided training to SCIRT personnel on topics related to the social recovery and workforce wellbeing and resilience under pressure, which is reflected in SCIRT's high levels of employee engagement and comparatively low stress and burnout. Members of the SCIRT team, in turn, shared their technical expertise in Geographic Information System mapping with the NZRC teams, which aided further targeting of cash grants to improve efficacy of psychosocial recovery objectives.

By deliberately bringing together expertise from the civil infrastructure and humanitarian sectors, the collaboration leveraged the strengths of both organizations to address the massive recovery effort more effectively.

"This was about engineers working with other professionals to do the job better. This is about engineers trying to look past the blinkers that we have on from the training we have to realize that we don't know what we don't know and there are people out there with skills we can utilize to make sure we do things better" (Gibb, 2015).

This intentional alignment of roles and resources enabled a more comprehensive response, ensuring that both physical and psychosocial needs were addressed concurrently. This approach also fostered innovation as teams adapted to each other's perspectives and problem-solving methods. The cross-sector collaboration ensured a more holistic recovery process that considered both infrastructure and the wellbeing of the people who rely on it.

In Texas, at UTHealth Houston, this cross-sectoral collaboration to minimize disruption caused by crisis has been 'structured in' using the concept of 'cross-training'.

"Using a focus group approach, a team of safety professionals from a variety of specialties developed a list of 50 basic health and safety items that any safety specialist should know, inclusive of basic but important information about biosafety that was considered imperative

for staff members to understand. This list was used as the basis for a formal cross-training effort" (Emery, Patlovich, King, & Rios, 2023).

Technical experts across a myriad of technical domains were educated on the 50 things every safety professional should know. The aim is to ensure potential crisis situations are detected early to prevent or minimize the impact of adverse scenarios.

Cross-training in safety domains enables critical infrastructure safety personnel to recognize when issues outside their primary area need attention. For instance, a radiation safety specialist should have basic knowledge of infectious diseases, just as a chemical safety expert should be able to identify a potential biosafety issue. Cross-training equips safety professionals with a foundational understanding of other safety areas, enabling them to spot red flags during routine activities, whether at an oil and gas plant, a pharmaceutical facility, or a university. This approach doesn't require deep expertise in every field but emphasizes knowing key indicators across domains. In the case of cybersecurity, consideration should also be given to the dramatically differing levels of capability workers can have working with modern electronic tools, computers, and software systems as indicated by their prior working experiences or personal exposure outside of work. Particular care should be given to supporting workers to safely recognize and admit gaps in their skills or confidence relating to technology and cybersecurity.

By fostering a systems-oriented perspective, cross-training enables safety specialists to notice when something seems unusual and refer it promptly to the right expert – avoiding the risky 'if it's not in my area of expertise, then it's not my problem' stance. When safety issues are undetected or ignored, the risk to wider critical infrastructure escalates, as minor problems can quickly cascade into larger disruptions with severe impacts. Cross-training reduces the risk of siloed thinking, ensuring safety issues are addressed proactively and collaboratively.

A critical note here is the role that organizational culture, even team culture, plays in driving these improved outcomes. Shifting mindsets from a default stance of 'not my problem' to one of buying into broader collective objectives is, inherently, about culture and interpersonal interactions. Without intentional effort, the positive effects of this work will be missed.

Questions to foster collaborations which enable your organization to prepare for or respond to crises include:

- Who does our work ultimately serve, and how can we intentionally 'structure in' collaboration to better serve their needs?
- Which non-traditional partners can we engage with now to broaden and enhance the advantages of collaboration? Which relationships and partnerships can we form now? Who are our 'wild card' collaborative partners?
- What core values guide our collaboration to effectively manage competing priorities and resolve conflicts under pressure?
- Are our teams equipped with the necessary skills for effective collaboration? How will we address skill-gaps?

Stakeholder/Community Engagement

Stakeholder engagement is a critical skill in the wake of a crisis – a skill that influences success factors in the operational environment. Duncan Gibb, (former) CEO of SCIRT, asserts that "it takes a lot of time and effort and continued supply of information for our clients to start trusting us when they don't have control. And I would suggest that the amount of reporting we did actually went a long way to enabling our clients to let us get on and do the job. And the first two to three years we achieved huge amounts because people were trusting what we were doing" (Gibb, 2015).

Perhaps the most crucial stakeholder of all is community. Gibb, referring to the United Nations Development Program's policy on early disaster recovery (Bureau for Crisis Prevention and Recovery, 2008), states, "One of the guiding principles is a community-centered approach and I realized I had been failing. I thought I was here to tell the community what we were doing. We needed to involve them more and at that point we started changing our approach".

Conscious that ineffective communication leads to rumors, distrust, anger, sabotage and community disengagement, the SCIRT leadership created an intentional Stakeholder Management Plan as the basis of their communication strategy (Gibb & McNaughton, 2014). This strategy helped keep the community informed and involved, identified different methods to communicate at different stages of recovery and used as many channels to reach the community as possible. This was considered important because people respond to honesty; informed people can plan and respond more effectively; and informed people are more resilient and better equipped for recovery.

A selection of objectives from the Stakeholder Management Plan (SCIRT) include:

- To maintain an open and honest dialogue with all residents over the rebuild effort:
    - Work to ensure messages to communities are coordinated with other rebuild efforts
    - Be proactive with communication and make it face-to-face where possible
    - Do what we say we will do
    - Communicate in simple language
- To maintain high levels of customer service in the rebuild effort:
    - Build rapport with affected residents and go the extra mile where required
    - Coordinate all works to minimize disruption to the customer

- To celebrate important milestones
- To encourage all project members to act as project message champions
- To reinforce the importance of safety around rebuild activities for the community, motorists and our people
- To prepare the community for the intensity of the works program
- To maintain goodwill and patience within the community

SCIRT utilized a variety of communication channels to foster open and transparent dialogue with the community throughout the rebuild program. This approach helped promote tolerance and understanding of the disruptive aspects of SCIRT's work.

On designated days, the public was invited to visit the site and meet the team working there (SCIRT). Due to safety concerns, work in residential, commercial, and business areas typically took place "behind the fences." Site visit information days offered a unique opportunity for the local community to observe the work up close and interact with those carrying out the repairs.

These events became a powerful tool for fostering and maintaining community support, encouraging open dialogue and engagement between SCIRT and local residents. The outcomes often included:

- Providing the affected community with face-to-face interaction, which helped build reassurance, trust, understanding, tolerance, and acceptance.
- Allowing the SCIRT Communication Team to gain insight into community concerns, which helped them address these issues more effectively.
- Creating a deeper understanding of the work, giving the community a sense of "ownership."

These events not only had positive outcomes for the community but also instilled pride within the SCIRT team, helping them better understand the community and the impact of their activities.

Face-to-face communication was preferred wherever possible, especially for high-impact projects. In a post-disaster environment, where individuals were managing numerous stressors that affected their ability to process information, this approach became especially crucial. It was also significant in communities where written communication proved less effective. Door-knocking prior to the start of a project helped the SCIRT Communication Team to get to know the community, answer concerns and record any special needs. This can include the need to provide 24/7 driveway access for medical or other assistance. This was important for the communities, but also for project success, for example, where gaining access through private property would assist the running of the project.

The face-to-face communication also took the form of visiting schools. The school visits aimed to educate children about safety around work sites and inform the local community about SCIRT's activities. Over their six-year program, the communications team conducted 170 school visits in Christchurch. SCIRT developed various fun resources for school children, including coloring sheets, stickers, and miniature Traffic Safety Cones.

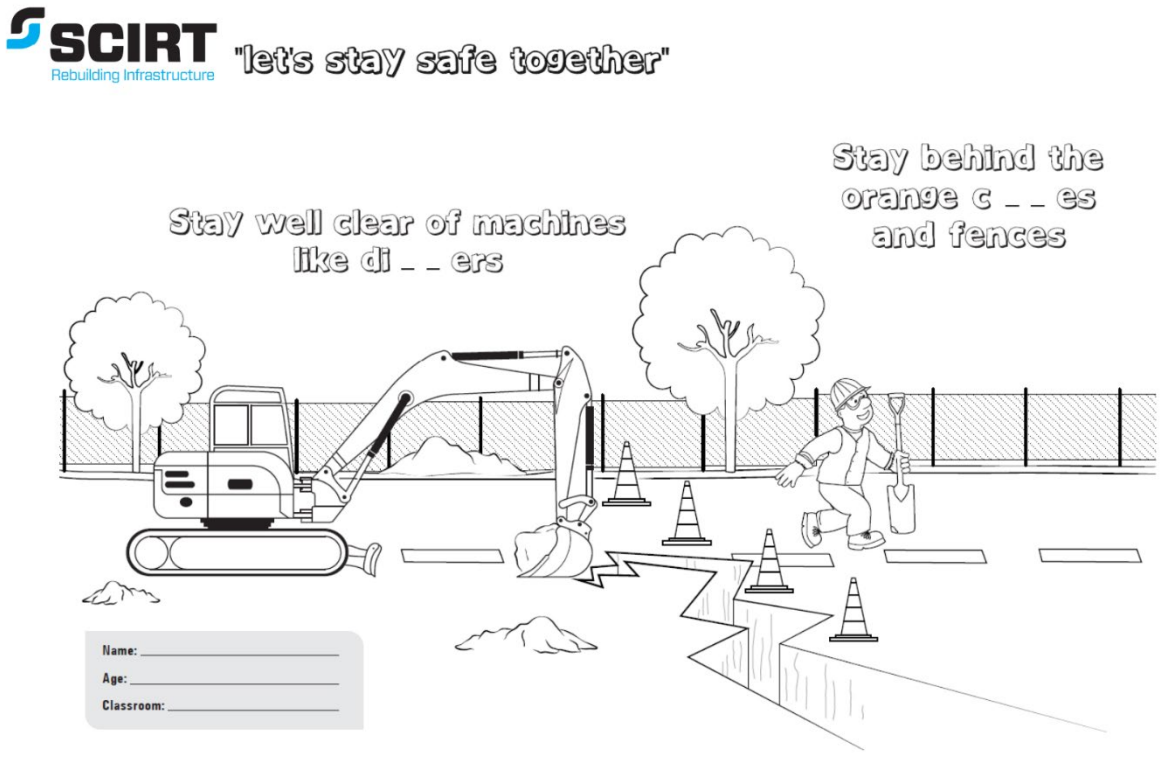

Figure 6: Coloring sheets used in school visits to promote site safety. SCIRT. Colour a construction drawing. SCIRT Learning Legacy. https://scirtlearninglegacy.org.nz/communications-and-community/school-visits/

Another initiative addressed driver frustration and promoted patience and safe driving habits during traffic detours and delays. The SCIRT Communication Team identified a particularly congested area on a major transport route during peak hours, where driver frustration was high and potentially dangerous driving behavior could result. Wearing full SCIRT-branded protective gear and supervised by safety personnel, the team distributed "chocolate fish" (iconic New Zealand sweets) wrapped in a message about the project to stationary drivers at intersections. The chocolate fish were wrapped in an information flyer explaining the cause of the delay and expressing gratitude for drivers' patience and understanding. The flyer's slogan read: "Doing the right thing at roadworks is as Kiwi as … a chocolate fish."

This initiative received overwhelmingly positive feedback and promoted safe driving behavior. With a low cost of under $1 per unit, it was deployed at multiple locations to engage with drivers affected by delays, recognizing and rewarding good driving behavior. It

also fostered tolerance and understanding of SCIRT's work and replaced many a frown with a smile.

A similar approach was taken with business owners. SCIRT recognized that regular face-to-face communication with business owners was essential. It was insufficient to engage only with counter staff or duty managers; direct conversations with owners were crucial. Transparency about the potential impacts of the rebuild was necessary, adhering to the principle of under-promising and over-delivering.

A Business Support program was created with communications that fostered a culture of community backing for affected businesses. SCIRT issued regular traffic updates to inform the community of the best routes to the city, encouraging continued support for inner-city businesses. Additionally, localized “Best way to…” signage was installed to guide customers to individual businesses. To signal that the downtown area remained a viable destination for shopping, dining, and other activities, SCIRT placed 32 large “Open for business” signs along all main routes into the central business district.

Gibb reflected on the learned emphasis on stakeholder and community engagement; “We learned that fundamentally disaster response is not about engineers working on calculators and on computers, it’s about the people we’re here to serve. It’s about the community. And I would like to think our effective interaction was fundamental in helping the community understand what we were doing once we started involving them more. It was fundamental in giving them confidence in what they could do and how they could approach the future because they could see when we would be impacting them and what was going to be happening. And simple things like celebrating success with the community really make a difference to their wellbeing and how they feel.”

With an intentional approach to stakeholder engagement came deliberate efforts to measure the plan's success. External evaluators were brought in to measure the impact of the communication and engagement program. The research involved a six-monthly telephone survey of a representative sample of the Christchurch community and a four-monthly face-to-face survey of 400 – 600 residents and business owners in areas where SCIRT was working. Towards the end of the project after the community had been subjected to more than five years of disruption caused by the work program, the community satisfaction rating with SCIRT was 83%. This is outstanding for the civil engineering industry, but more remarkable given the hardship that communities and businesses within Christchurch were facing in the post-disaster context.

De Zwart states, "This is the civil infrastructure industry. We wear orange and Hi-Viz material. We get down and dirty in drains. We dig up your roads, we put road cones everywhere. We make it hard for you to get around Christchurch with big signs and we frustrate you. We don't have a fantastic reputation at working with the community. This phenomenal community satisfaction rating is because we had an ultimate sense that the people of Christchurch were the heart of this rebuild and the people of SCIRT were at the heart of the culture needed to make that happen" (de Zwart, 2017).

In TEPHI's proactive approach to the threat of H5N1, Rios is acutely aware of the need for community engagement and effective communication with the diverse communities such as dairy farm workers, swine farmers, and backyard poultry flock owners. COVID taught Rios and her team the importance of engaging with various communities, such as small business owners in El Paso (hair salons, tire shops, bakeries…). In this instance, it was essential to train and support local health workers who were already embedded in and trusted by the community (Conway, et al., 2024).

The learning from COVID is shaping the response to the H5N1 threat, including efforts to engage with agricultural workers who primarily speak a language indigenous to Central America. These engagement efforts include relationship building with the agricultural workforce and the use of posters featuring carefully designed infographics and pictograms.

Community engagement and communication skills are now valued and are central to the work of preventing and responding to epidemics for TEPHI. This has included the development of a communication training series for health workers, in partnership with the UT Austin Center for Health Communication (CHC), to better prepare and protect against future infectious disaster outbreaks (TEPHI). Seeking out and developing the skill sets of community engagement and communication sits at the heart of advice Rios gives to other professionals tasked with safeguarding and restoring critical infrastructure.

Questions to help drive stakeholder and community engagement:

- Who does our work ultimately serve, where and how are they already gathering, and how do they want to be engaged?
- What are the biggest potential community or stakeholder risks to the successful delivery of our work, and how can we front-foot engagement for mutual benefit?
- In what ways are we currently communicating with external stakeholders, and how might we iterate that to better meet the needs we see at the front line?
- What training or accreditations exist that may serve staff responsible for engagement?

Workforce performance and resilience under pressure

Winter Storm Uri highlights the power of a personally resilient workforce (City of Austin). The winter storm struck Texas between February 10-18, 2021, causing an estimated $195 billion damage, the highest ever from a natural disaster in the state. Hitting Austin especially hard, Uri brought over six inches of snow, an inch of ice from freezing rain, and prolonged sub-freezing temperatures, adding immense strain to local resources. Supply chains across Texas collapsed, making it difficult to secure essentials like food and safe drinking water. In Austin alone, there were 381 pipeline breaks, and over 200 apartment buildings faced water outages due to plumbing damage. Tens of thousands of Austin households and businesses endured multiple days without power (Douglas, 2023).

Texans aren't well equipped for extreme cold. CapMetro, the regional transportation authority for Austin and surrounding communities, evacuated several government-supported senior living apartment complexes. In total 24 bus trips transported 372 at-risk individuals to warming centers. On an average day, CapMetro transports between 100 to 200 patients for dialysis. This service could not stop for any length of time without serious risk to life. Many of these patients and other residents who depend on CapMetro for transportation did not have access to water or a means of securing food. CapMetro delivered food and water door to door for these at-risk residents. Hospital nurses were stranded, and patients were being discharged to the waiting room of the ER without a means of navigating the treacherous roads with the lack of snow ploughs in Austin. CapMetro arranged a convoy of buses following a grit truck to transport nurses and discharged patients. All in all, this was a herculean effort by dedicated CapMetro team members to keep residents safe during the winter storm.

The After-Action Report, written by an independent party commissioned by CapMetro, highlighted a subset of dedicated personnel who had sufficient disaster-readiness to allow them to work through this challenging period (IEM, 2021). This cohort of people who could

find a way to ‘make it work’ to join the emergency operation endured 31-hour shifts, slept at the office for a week, and were pushed to their limits. The After-Action Report highlighted how vulnerable CapMetro and their customers were when relying on a small core of personnel. The capacity to continue in the same way for another few days was not there. Catastrophic impacts for the vulnerable Austinites who relied on CapMetro for life-preserving services were just around the corner.

The After-Action report highlighted how few Austinites knew what to do when it’s extremely cold. They didn’t have emergency plans or kits or know what these should consist of. And in some instances, they didn’t have the financial resources to adequately prepare. This was true too for CapMetro employees. They may have an interest to work through a crisis period but could not leave their family without the resources and information for their family to be safe in their absence.

The report recommended actions to remove this barrier, ensuring a larger available workforce of essential personnel to assist in times of crisis. Recommendations included ‘developing and promoting a comprehensive personal preparedness program for all employees… and an employee awareness campaign for personal preparedness actions, including incentives to participate in the program such as a starter emergency household kit for those who complete training’, (IEM, 2021, p. 20).

Alex Abdun-Nabi from CapMetro modelled the resulting employee awareness campaign for personal preparedness actions on a successful program, Michigan Ready Responder (Michigan State Police) which in turn, incorporated recommendations and learning from research into emergency responder preparedness conducted by Chris Kelenske (2011). The Michigan Ready Responder was similarly designed to increase individual, family, and

organizational readiness in emergency response professionals so they can continue to provide essential services to the public in a disaster or emergency.

The CapMetro campaign involved the purchasing and collation of 286 tub-sized emergency kits including radios, batteries, flashlights, first aid kits, garbage bags, masks, water meter keys, multi-tools, fire extinguishers… To receive the kit, employees attended a 2-hour in-person training covering hazards, notification systems, why and how to create a plan, insurance essentials, winter driving, generator safety and home fire safety. The aim was to provide employees with the resources, knowledge, plans and confidence to be able to say, "I'm going to be away for two days" and know their family will be alright. Abdun-Nabi reflected that a large portion of CapMetro's employees fall into social vulnerability categories; single parent households or first-generation Americans for example. Helping their employees to have alternative plans in place increased their resilience as a household, in addition to increasing their availability to be deployed to support essential services to the public in an emergency (Abdun-Nabi, 2024).

As a result of the program, more than 130 staff have received training and preparedness kits, providing leadership with the confidence that deploying two core teams will be possible for the next large event, allowing for the rostering of operational teams and a more resilient response (Abdun-Nabi, ReadyCapMetro and personal resilience programs, 2024).

Figure 3 ReadyCapMetro and personal resilience programs evaluation

The team at SCIRT in the wake of the Christchurch earthquakes in New Zealand also set about creating a plan for their most critical resource and success factor – people. 80% of the city's infrastructure was damaged, necessitating the delivery of over $2.2 billion worth of work in a five-and-a-half-year period. This meant the team faced a 'tough ask' according to (former) HR and Peak Performance Manager Belinda de Zwart (de Zwart, 2017). Because the damage was largely underground, there was a great deal of uncertainty about scope, budget and what would be required. People had to deliver a huge amount of work over a sustained period in an ambiguous environment, with the intense pressure to deliver for the people of Christchurch who were already suffering. In addition, SCIRT aimed to involve as many Christchurch residents as possible in the rebuilding process. This decision was partly driven by economic considerations, as there was the need to minimize the impact on the city by avoiding the influx of external workers. Housing and infrastructure were significant challenges, but SCIRT leadership also wanted to empower residents to actively participate in restoring their city. But this meant that many were returning from work each day to homes that were damaged or dealing with insurance issues, and school zones that had changed. SCIRT needed them to perform at a sustained high level to deliver for their city, but leadership also had to carefully consider the team's personal resilience as they lived and worked in a disaster-affected environment.

"We couldn't leave our success to chance; we had to ensure we delivered this work within that timeframe. Intentionality was our biggest lesson. We had to have a plan for the people performance, culture and resilience aspect, as you would for any other aspect of your operation," stated Belinda de Zwart as she shared her lessons after the repair and rebuild of the horizontal infrastructure for Christchurch were complete (de Zwart, 2017).

The leadership team asked themselves, "What do we need to do to create the high performing teams we need?" A Peak Performance Framework was created with the objective of enabling

resilience and high performance in an environment of uncertainty, incorporating actions that would impact delivery.

“The reality is an organization is not systems and procedures. An organization is people. So the most important plan that I think we ever put together is out Peak Performance Plan and it was what drove us to create an environment which enabled people to deliver outstanding outcomes for the people of Christchurch” (Gibb, 2015).

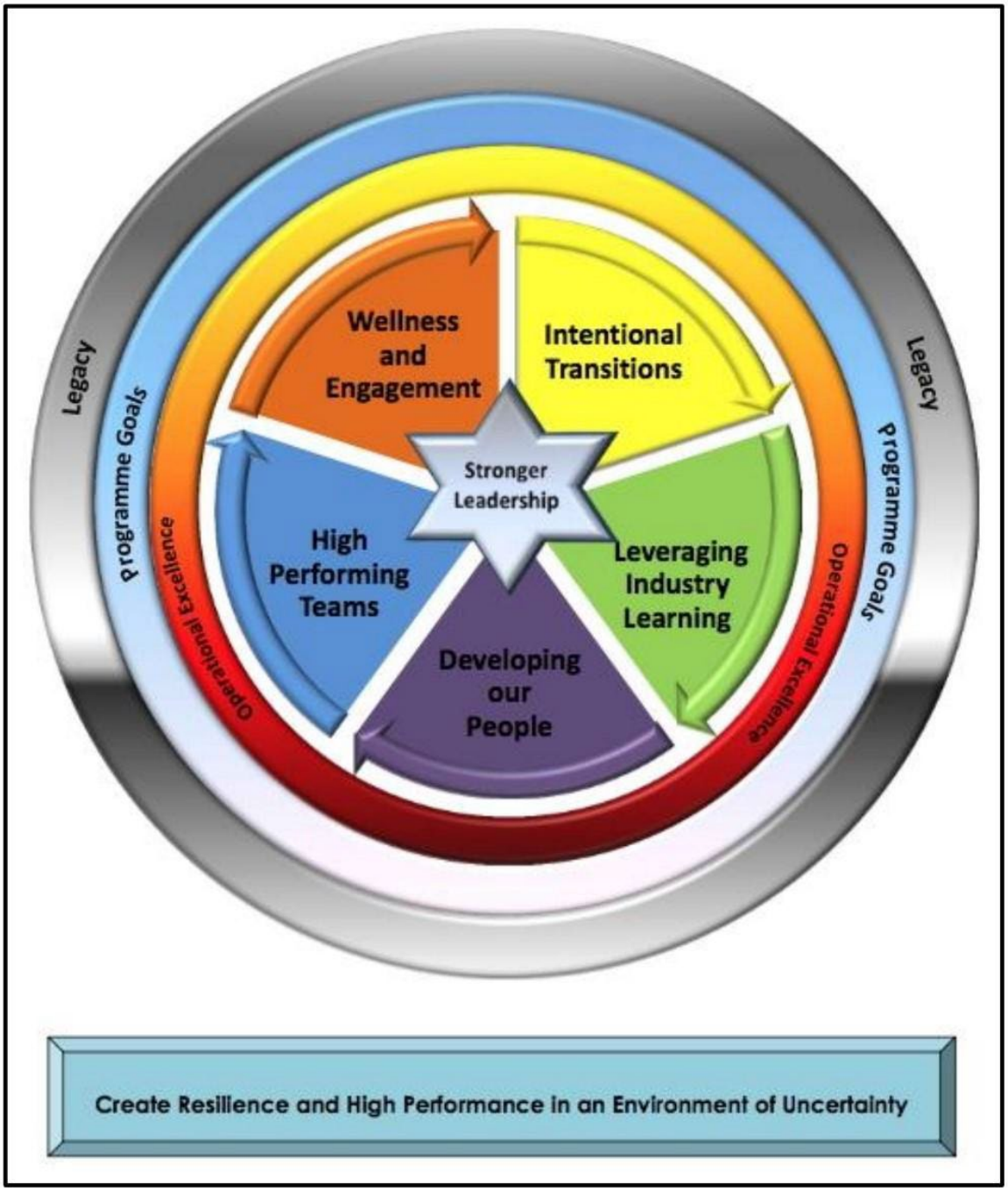

Figure 4 SCIRT's peak performance framework. Source: SCIRT Learning Legacy. (2021). Case study – Creating a high-performance environment, with intent. https://scirtlearninglegacy.org.nz/wp-content/uploads/2021/07/qsr-part_335711.pdf

The Peak Performance plan included an explicit focus on a noble purpose, values and behaviors needed to achieve unrelentingly high performance. The mission, or noble purpose was as follows: *Creating resilient infrastructure that gives people security and confidence in the future of Christchurch.* As Belinda de Zwart points out, there's nothing in this mission statement that talks about shareholder value, or about the miles of pipe or square feet of roads

to be repaired. Rather, the emphasis is on the future of the city, the confidence and security that creating resilient infrastructure provides for the community. Duncan Gibb is famously known for saying, “This is not a pipe or road project. This is a people project.”

“SCIRT is a story about engineers doing what we’re supposed to do and that’s serving society. As engineers we sometimes forget what our core purpose really is. It’s not to draw drawings or to build things, everything we do is actually in service of the community and society and trying to make their life better,” (Gibb, 2015).

In addition to the ‘noble purpose’ there was a visible commitment to the outcomes. Each team posted their goals and progress on the wall in the shared workspace, ensuring transparency and accountability for the teams operating under the tension of competition and collaboration.

Wellness and engagement were incorporated as a key component. People were engaged already – giving so much to aid the rebuild of their city, which meant the challenge was keeping them well and resilient so their performance could be sustained. Every year, a comprehensive Peak Performance Plan, aligned to the Framework, was created, implemented, measured and reviewed.

“The high-performance culture was palpable. We had to balance that with resilience,” de Zwart maintains. “We had people living and working in a disaster zone and pumping high, high performance - giving their all. So, we balanced that with our well-being program.”

“Our wellbeing program; underpinning our high performance was giving people permission to look after themselves, look after their workmates and to really care about what was happening to other people. We as a team needed to look after each other and the wellbeing plan was very helpful in that regard.” Duncan Gibb (former) CEO of SCIRT.

Underpinning the Peak Performance Framework were strong resonating principles. For SCIRT these were:

1) Spirit over ego: Egos had to be put aside, replaced by a spirit of collaboration, teamwork and high performance based around what's best for the people of Christchurch rather than what's best for me or my organization or my profit line.
2) You have the culture that leaders have talked into existence. Leaders carry the language. Language shapes behavior. Collective behaviors make a culture: This meant leadership was important.
3) Inside out: Whatever happens within the organization will flow out to influence realities for the communities we serve.

Leadership influences every aspect of an organization. Knowing this to be true, in February 2012, SCIRT established the "Leadership Wave," which stands for "Wide Angle View Expected." With a management team of only ten overseeing a complex organization of over 2,000 individuals from multiple organizations, it became clear that this small group alone could not shape the culture in such a complex environment.

To address this, SCIRT engaged middle leaders, who came together to form the Leadership Wave. This collaborative group defined the leadership capabilities that would be necessary for the program to be successful and SCIRT then worked to develop those capabilities in these middle leaders, with various leadership development sessions and leadership coaching provided to more than 220 leaders. These leaders were anointed, given the responsibility of leading for the required culture of performance and resilience, and supported to develop the skills to do so.

From the beginning right through to the end of the program there was a similar focus on learning and development of all the team members. A survey of the SCIRT team in 2014

highlighted that 96% felt that their experience at SCIRT helped them grow professionally. 78% gained experience that was different to previous work. And despite the pressure, 85% would recommend SCIRT as a great project (de Zwart, 2017).

Questions to foster peak performance and resilience of your team:

- What does resilience and peak performance mean to your people?
- What other operational benefits or cost reductions can you achieve through enhancing workforce resilience?
- Who leads your industry for performance and worker wellbeing, and what can you learn from them?
- What investment in leadership development is needed to ensure your leaders are equipped to prioritize and sustain their team's wellbeing and resilience?

Way Forward

Purely technical approaches to resuming critical infrastructure and services in post-disaster contexts are simply insufficient for the realities of modern disaster response and recovery. Vital human factors must be anticipated and accounted for.

Developing workforce resilience is necessary for ensuring strong recovery capability. Infrastructure workers are exposed to prolonged-pressure situations, especially during recovery efforts, increasing the risk of burnout and reduced performance over time (Wills 2014). By fostering a culture of resilience, critical infrastructure organizations can ensure that their workforce is prepared to turn up and to handle prolonged stress and operational disruptions, and maintain high levels of performance in both crisis and business-as-usual scenarios.

Collaboration across traditional geographical and industry boundaries is essential for cohesive and efficient recovery and upholding cybersecurity in ‘blue skies’ and post disruption. Sectors such as energy, healthcare, transportation and the associated supply chains must work in tandem to restore critical services. However, barriers such as miscommunication, differing priorities, impacts of fatigue, and bureaucratic processes often hinder collaborative efforts. Collaboration—within organizations, between organizations, and across sectors—is a cornerstone of successful infrastructure recovery.

Finally, developing skills for community and stakeholder engagement drives efficiency and effectiveness of recovery efforts, and strengthens cybersecurity. The manner in which infrastructure organizations engage with stakeholders and affected communities during periods of disruption can either aid or hinder the recovery process. Likewise, IT professionals’ engagement with non-technical staff and other stakeholders can improve or erode cybersecurity. The role of communication and collaborative planning to minimize disruptions to daily life and ensure customer and community satisfaction during the most challenging times is core to effective community recovery.

Developing capacity in critical human factors, such as workforce resilience, collaboration, and stakeholder and community engagement, will serve critical infrastructure organizations well, both in times of crisis and in ‘blue skies’. The following questions have been designed for leaders to support an increased focus on these critical areas.

Summary of questions

Questions to foster **collaboration** to enable your organization to prepare for or respond to crisis include:

- Who does our work ultimately serve, and how can we intentionally ‘structure in’ collaboration to better serve their needs?

- Which non-traditional partners can we engage with now to broaden and enhance the advantages of collaboration? Which relationships and partnerships can we form now? Who are our ‘wild card’ collaborative partners?
- What core values guide our collaboration to effectively manage competing priorities and resolve conflicts under pressure?
- Are our teams equipped with the necessary skills for effective collaboration? How will we address skill-gaps?

Questions to help drive **stakeholder and community engagement**:

- Who does our work ultimately serve, where and how are they already gathering, and how do they want to be engaged?
- What are the biggest potential community or stakeholder risks to the successful delivery of our work, and how can we front-foot engagement for mutual benefit?
- In what ways are we currently communicating with external stakeholders, and how might we iterate that to better meet the needs we see on the front line?
- What training or accreditations exist that may serve staff responsible for engagement?

Questions to foster **peak performance and resilience** of your team:

- What does resilience and peak performance mean to your people?
- What other operational benefits or cost reductions can you achieve through enhancing workforce resilience?
- Who leads your industry for performance and worker wellbeing, and what can you learn from them?
- What investment in leadership development is needed to ensure your leaders are equipped to prioritize and sustain their team's wellbeing and resilience?

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