INFRASTRUCTURE INTERDEPENDENCIES
Backgrounder

In the past decade across the nation, the critical infrastructures and other essential service providers that enable our communities to thrive and grow have become increasingly interconnected and interdependent. These infrastructures include energy (electric power, natural gas, fuels); telecommunications, transportation (rail, road, maritime); water and water treatment systems; banking and finance; emergency services; government services; hospitals, healthcare and public health; agriculture and food; commercial facilities; nuclear reactors; materials and waste; dams and levees; manufacturing; chemical facilities; and postal and shipping. To a large degree, this trend towards ever greater linkages has been created by our growing reliance on electronic systems, computer processing and the Internet for managing and operating these infrastructures. This interconnectivity and the resulting interdependencies can exist at multiple levels of increasing complexity and extend beyond a community, a state, and nations, creating unexpected vulnerabilities and significant consequences.

Although emergency and business continuity practitioners are beginning to focus on interdependencies, we remain limited in our understanding of them, the vulnerabilities they create, and how to prevent or lessen their impacts. Disruptions in one infrastructure can cascade, ultimately affecting more than one infrastructure, affecting essential government services, businesses, and individuals in an entire region with far-reaching health and human safety, economic, environmental, and national security consequences.

Examples of Infrastructure Dependencies and Interdependencies

Water and waste water systems, are dependent on a wide range of infrastructures and other essential services, including electric power to run pumps and control systems, petroleum fuels for transportation of repair and maintenance personnel, communications to handle the ordering of chemicals and other supplies and equipment and direct operations, all modes of transportation for supply and shipping, and financial systems to support billing, payments, and other business services. Likewise electric power utilities depend on natural gas, coal, and petroleum to fuel generators, as well as on road and rail transportation to deliver fuels to the generators, water for cooling and to reduce emissions, and telecommunications to monitor system status and system control, e.g., Supervisory Control and Data Acquisition (SCADA) systems and energy management systems.

Similarly, other infrastructures depend on water and electric power and other infrastructure services.

- Computer, process control, telecommunications, and other systems that run infrastructures depend upon water for cooling. Water systems may require electric power for operating pumps and need logistics and transportation for supplying water treatment chemicals.

- Natural gas fuels critical gas-fired generators in the electric power system. Electric power in turn may be required to operate the critical systems that are essential for delivering gas (e.g., control systems, storage operations, and compressor stations).

- A substation in an electrical distribution system can provide electric power to a key telecommunications switching center, and rail transportation depends on electric power for signaling, crossing protection, monitoring, and other terminal operations. Under certain conditions, failure or loss of power in a substation, for example, directly affects operations at a telecommunications switching center.

- The telecommunications center, in turn, supports SCADA systems for natural gas and oil pipelines, as well as electric power, water, and transportation systems that support electric power.

- Agriculture and food processing, warehousing and distribution, and manufacturing are dependent on all the major infrastructures, for example power for processes and refrigeration, communications for shipping and logistic; all modes of transportation for shipping materials and products, and financial systems to support purchasing of materials and sales of goods.

When infrastructure failures occur and repair crews and replacement components are needed, service providers also depend on other infrastructures, including telecommunications/IT, petroleum fuels (for vehicle and emergency generator fuel), road transportation, and, in some cases, rail transportation. Other dependencies, because of their location or exposure to the environment, are not physically linked but are coupled. A common utility corridor that consists of overhead or underground electric power transmission and distribution lines, underground pipelines, and telecommunications cables dramatically illustrates such dependencies. In many instances, multiple infrastructure assets are co-located, for example along bridges, roadways, or in a single location can increase susceptibility to and likelihood of simultaneous outages due to physical hazards, such as a flood, explosion, fire, and earthquake, as well as sabotage.

Another type of dependency can exist in complex systems without a direct link. The failure of a substation, for example, can lead to reconfiguration of the electric network, which, in turn, can overload a similar substation within the system if the demand exceeds capacity. In such cases, a direct link usually does not exist, and the failure occurs only when certain conditions are imposed (e.g., maximum load conditions). Natural hazards, such as earthquakes or extreme weather conditions, clearly show how threats can affect multiple infrastructures at the same time. Such threats also reveal interdependencies that can complicate or delay response and mitigation or recovery of a particular infrastructure from an incident.

Why a Holistic Regional Risk Mitigation Approach is Important

Because these dependencies and interdependencies remain little understood, the emergency management and continuity of operations plans of critical infrastructures, other service providers, and businesses are at best adequate to address localized disasters and not major incidents and disasters with regional consequences, including supply chain disruptions. These plans do not take into account extensive and prolonged impacts that may include disruption or destruction of critical components, systems, and facilities, causing outages of weeks or months and shortages of supplies, personnel, and capabilities to restore critical services. Such widespread and prolonged service disruptions can cause huge regional economic and psychological impacts that can significantly diminish commerce and cause the relocation of residents in affected communities. At the same time, economic constraints pose additional challenges for states, localities, and stakeholder organizations, which have limited manpower, funds, and technical expertise to assess all-hazards vulnerabilities from interdependencies, and identify and remedy them.

Whether a natural disaster, manmade incident, or pandemic, there is clearly a need for a holistic regional strategy to improve the resilience of our infrastructures and other essential services, as well as the communities and regions that depend upon them. This all-hazards, multi-jurisdiction, cross-sector approach to preparedness and resilience includes detection, prevention, mitigation, response, recovery/restoration, training, exercises, and community outreach. It requires utilities and other service providers to examine external linkages that affect their operational and business continuity. It also necessitates bringing together local public, private, and non-profit stakeholders with state and federal partners in collaboration to share information and understand and address regional vulnerabilities and consequences posed by infrastructure interdependencies.