Critical Infrastructure Dependencies

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Physical dependencies are a fundamental consideration when assessing the resilience of critical infrastructure, and, ultimately, the resilience of a region. Critical infrastructure assets support the functioning of a region by providing essential resources used by other critical infrastructure, government entities, and/or the general public.

Dependencies must be considered when addressing the resilience, risk, and business continuity of every facility. The latest version of the National Infrastructure Protection Plan (NIPP) and PS-Prep standards highlight the importance of considering the dependencies and interdependencies among critical infrastructure:

- NIPP, 2013: *"Effective risk management requires an understanding of the criticality of assets, systems, and networks, as well as the associated dependencies and interdependencies of critical infrastructure."*[1]
- NFPA1600: *"Business Impact Analysis (BIA) may identify time-critical functions, recovery priorities, dependencies, and interdependencies so that recovery time objectives can be established and approved."*[2]
- NFPA1600: *"The BIA shall identify dependencies and interdependencies across functions, processes, and applications to determine the potential for compounding impact in the event of an interruption or disruption."*[3]
- ASIS SPC.1-2009: *"Risk assessment and impact analysis should consider its dependencies on others and others dependencies on the organization, including critical infrastructure and supply chain dependencies and obligations."*[4]

Dependencies are the linkages between two critical infrastructure assets, through which the state of one infrastructure influences or is correlated to the state of the other. It is important to thoroughly characterize dependencies when seeking to reduce the extent to which the facility is directly affected by the missions, functions, and operations of other critical infrastructure assets.

Every facility needs specific resources to support its operations. A disruption in the supply of these resources can have severe impacts on business continuity. The dependence of an infrastructure on a resource is characterized by the use of the resource, whether there are redundant services (e.g., internal production or alternative fuels), what protections are in place to maintain service (e.g., the electric transformers at a facility are protected by fencing, locked gates, privacy slats and crash bars) and what backup mechanisms exist if primary service is lost (e.g., emergency generator or UPS).

Lastly, the criticality of the resource to operations is determined by estimating the time it will take for the facility to experience a severe impact once primary service is lost, what percentage of facility operations can be maintained with and without backup service in place (e.g., a backup electric generator may only provide power to run a plant at 50 percent production) and if any external regulations/policies are in place that require shut down of the facility due to service disruption of a critical resource (e.g., a fire code that requires evacuation of a building if water service is lost or production/operations specifications for a constant temperature for chemical manufacturing).

All this information can be combined into interactive dependencies curves that will allow anticipation in and management of the effect of a disruption in critical resources supply (Figure 1).

Figure 1 – Illustrative Dependency Curve

The characterization of physical dependencies is the first step in understanding interdependencies as well as cascading and escalating failures. A good understanding of daily dependencies as well as new dependencies occurring in time of emergency is needed to integrate critical infrastructure business continuity and emergency action plans at a regional level. They constitute the basis for identifying common needs and prioritizing resources supply during an emergency. For example, if the electric power supply is disrupted in a region, asset emergency action plans and resilience measures are often

[1] DHS. 2013. NIPP 2013, Partnering for Critical Infrastructure Security and Resilience, p. 2.
[2] NFPA. 2013. NFPA 1600® Standard on Disaster/Emergency Management and Business Continuity Programs, 2013 Edition, P. 5.
[3] NFPA. 2013. NFPA 1600® Standard on Disaster/Emergency Management and Business Continuity Programs, 2013 Edition, P. 7.
[4] ASIS International. 2009. ASIS SPC.1-2009, Organizational Resilience: Security, Preparedness, and Continuity management Systems – Requirements with Guidance for Use, American National Standard, p. 23.

similar. They usually involve the use of a backup generator with 3-4 days of autonomy and a priority (specific agreement) for refueling. The similar plans for all infrastructures need to be integrated to ensure that enough fuel will be available in the region when refueling is needed. This need for fuel is typically a physical dependency in time of disaster. Simple information, such as presented the dependency curve in Figure 1, would help highlight these types of dependencies.

Generation of dependency curves is only the first step considering dependencies and interdependencies in risk and resilience management. Rinaldi, Peerenboom, and Kelly in 2001 have defined four types of dependencies/interdependencies (physical, geographic, cyber, and logic).[5] All these types of dependencies/interdependencies present several dimensions that should be considered (Figure 2) highlighting the fact that interdependencies is a very complicated problem as well.

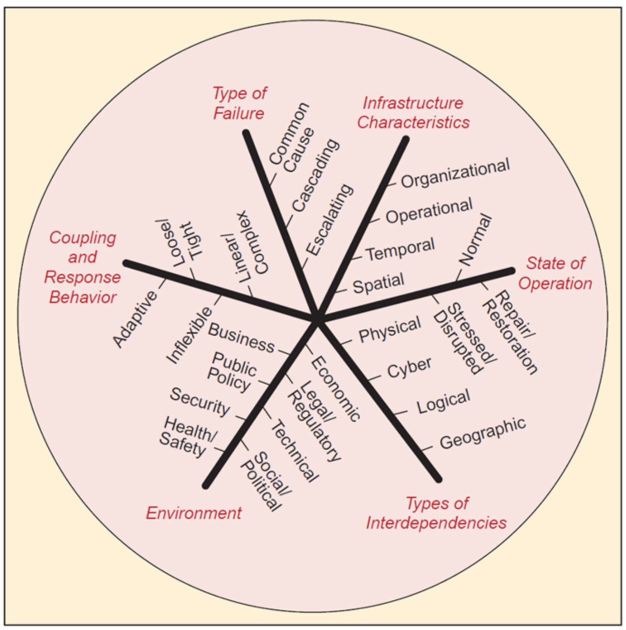

Figure 2 – Dimensions for describing infrastructure interdependencies.[6]

The dependency curves are a first step in the discussion of the possible ways to operationalize the elements and concepts that must be considered to integrate the notion of dependencies and interdependencies in risk and resilience management methodologies. Several tools or methodologies addressing critical infrastructure dependencies and interdependencies already exist or are under development however, a common framework allowing the integration of all these tools, is still lacking.

Keywords—dependency; interdependency; critical infrastructure; resilience

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[5] Rinaldi, S.M., J.P., Peerenboom, and T.K., Kelly. 2001. Identifying, Understanding, and Analyzing Critical Infrastructure Interdependencies, IEEE Control Systems Magazine, pp. 11-25.

[6] Rinaldi, S.M., J.P., Peerenboom, and T.K., Kelly. 2001. Identifying, Understanding, and Analyzing Critical Infrastructure Interdependencies, IEEE Control Systems Magazine, pp. 11-25.