Critical Infrastructure Logical Dependencies and Interdependencies

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Critical infrastructure dependencies and interdependencies are fundamental considerations when assessing the resilience of infrastructure and, ultimately, the resilience of a region. Critical infrastructure assets support the functioning of a region by providing essential resources and services used by other critical infrastructure, government entities, and the population. The needs and connections shared between different assets and across sectors warrant greater inclusion of these considerations in infrastructure analyses. Guidance documents such as the PS-Prep standards, the 2013 National Infrastructure Protection Plan (NIPP), or the recent Quadrennial Energy Review (QER), highlight the need to integrate the consideration of dependencies and interdependencies in risk and resilience assessments.

Several taxonomies have been created to categorize complex systems dependencies and interdependencies. Pederson, Dudenhoeffer, Hartley, and Permann used five interdependency categories; 1) physical, informational; 2) geospatial; 3) policy/procedural; and 4) societal.[1] Rinaldi, Peerenboom, and Kelly categorized the relationships between infrastructure assets, operations, and systems as 1) physical, 2) cyber, 3) geographic, or 4) logical.[2] These two taxonomies are very similar. They both address physical and cyber relationships (or physical and informational connections), geographic or geospatial colocation, and a logical (societal and procedural) relationships. Although the three first categories are relatively well defined, logical dependencies have since been described in the literature as a catch-all category of human activities that simply do not fit within the other categories. The term is widely used but it has suffered from little further refinement beyond its identification. The lack of deeper inquiry into the human interests and activities that define these logical dependencies, such as business continuity principles and economic market forces, societal aspirations and development, access and distributive justice, is a significant deficiency in the holistic understanding of community resilience we seek to build.

The predominant approach to the study of infrastructure science seeks to enhance physical and cyber resilience and reduce the risk of disruption or destruction from natural hazards, accidents, or security threats. Most of the work uses a combination of top-down and bottom-up approaches to analyze interconnections of infrastructure and assess resilience from a technical point of view. The logical dependencies of infrastructure too often elude these assessments. A multidisciplinary or “socio-technical” point of view is needed to fully elucidate the full range of influences acting upon infrastructure, from the individual asset to the sector level.

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[1] P. Pederson, D. Dudenhoeffer, S. Hartley, M. Permann, Critical Infrastructure Interdependency Modeling: A Survey of U.S. and International Research, August 2006, available online at www.inl.gov/technicalpublications/Documents/3489532.pdf, accessed on September 23, 2014.

[2] Rinaldi, S.M., Peerenboom, J.P., Kelly, T.K. (2001) Identifying, understanding, and analyzing critical infrastructure interdependencies. IEEE Control Systems Magazine 21, available at http://ieeexplore.ieee.org/stamp/stamp.jsp?tp=&arnumber=969131.

Refining the concept of logical dependency and defining the elements characterizing this type of critical infrastructure relationship is essential in order to draw connections between infrastructure and its management, from the operator to the policy-maker. Future assessments will then be developed on the basis of the ability to incorporate the social, behavioral, economic, political, and legal forces that operate on and result from infrastructure management. This capability will enable policy-makers, economic actors, infrastructure operators, and community planners to draw more meaningful and actionable conclusions about the fundamental relationship between critical infrastructure sectors and their impact on community resilience.

The objective of this presentation is to propose the concepts that can be used for characterizing and assessing logical dependencies and interdependencies, and to generate a discussion on the possible ways to operationalize the elements and concepts that must be considered to integrate the notion of logical dependencies and interdependencies in risk and resilience management methodologies.

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