**TRN Resource: Relationship Between Risk and Resilience**

## Mapping of Resilience Attributes to Risk

Risk is the “relationship between a particular hazard or threat that might degrade the performance of infrastructure and the consequences that might result from a degradation of performance.[[1]](#footnote-2)” Risk is determined through analysis of: (1) the probabilities of different types of hazards or threats occurring (H); (2) the probabilities that the site’s vulnerabilities would prevent the site from withstanding those hazards and threats and maintaining critical missions (V); and (3) the consequences should the hazards or threats occur and the site’s protective systems fail (C). At a high level, risk is calculated by multiplying the hazards or threats, vulnerabilities, and consequences:

$$Risk \left(R\right)=Hazards and Threats \left(H\right)\*Vulnerability \left(V\right)\*Consequence(C)$$

Resilience is the ability to anticipate, prepare for, and adapt to changing conditions and to withstand, respond to, and recover rapidly from disruptions, whatever the cause of that disruption. Resilience is often characterized using attributes such as resourcefulness, redundancy, robustness, and recovery. Enhanced resilience will reduce unacceptable risk by improving one or more of the resilience attributes. An organization that has prepared for and is able to respond quickly to a disruption to reduce the downtime of a mission is more resilient than an organization that has not prepared for such events. The organization could accomplish this by reducing a vulnerability (e.g., increasing the reliability of redundant energy or water systems), reducing a consequence (e.g., creating a work-from-home plan in the event of an outage), or reducing the probability that the hazard or threat (an outage) would occur (e.g., working with the utility to add a new water supply line to the site). In each case, these resilience-enhancing actions reduce risk. A successful resilience solution will reduce unacceptable risk and increase resilience. The following table shows a few example solutions that address the components of risk through the four attributes of resilience. These examples are intended to be illustrative only. More potential solutions are provided in the Solution Development module.

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|  | **Risk Components** |
| **Resilience Attributes** |  | **Hazard** | **Vulnerability** | **Consequence** |
| **Resourcefulness:** the ability to skillfully prepare for, respond to, and manage a crisis or disruption as it unfolds | Reduce likelihood of loss of operations through effective business continuity planning, training, supply chain management, and communications.  | Training personnel in the use of redundant systems and testing and maintaining those systems on a regular basis to reduce potential for failure of redundant systems during a disruptive event. | Reduce consequences of a disruption through ensuring that response and recovery plans and site-level emergency plans are in place and exercised. |
| **Redundancy:** the availability of redundant systems to support the primary source in case of failure | Reduce likelihood of loss of mission capabilities due to a hazard or threat through redundancy in supply infrastructure.  | Reduce vulnerability to disruptions in primary supply through implementation of redundant systems and independence of systems.  | Reduce consequences of a disruption through enhancing ability to transfer or meet mission critical functions at another site.  |
| **Robustness:** the ability to maintain critical operations and functions in the face of a crisis | Reduce probability that the hazard will lead to loss of energy and water supply through design of primary infrastructure to withstand relevant hazards and threats.  | Reduce vulnerability to relevant hazards and threats through design of redundant systems to withstand those hazards and threats, testing and performing O&M on systems, ensuring redundant system supplies, and training personnel to use redundant systems.  | Reduce consequences of a disruption by relocating key operations and functions during emergency situations. |
| **Recovery:** the ability to return to and/or reconstitute normal operations as quickly and efficiently as possible after a disruption  | Reduce length of utility disruption through utility continuity of operations plans, equipment, and spare parts in place to return to normal operations as quickly as possible.  | Reduce vulnerability to relevant hazards and threats through design of redundant systems to have rapid start-up for fast recovery time. | Reduce long-term consequences after a disruption occurs through mutual aid/supply agreements and recovery plans and ensuring that extra equipment and parts are available. |

1. Gutteling and Wiegman 1996, FEMA 2005, and NRC 2010. [↑](#footnote-ref-2)