

4R Framework for Identifying and Evaluating Resiliency in Transportation System Assets and Organizations

4R Attributes

- **Robustness:** The strength of an asset (e.g., roads, bridges, and/or culverts) to withstand future flooding threats.
- **Redundancy:** The presence of a backup system or plan to maintain access during a flood event.
- **Resourcefulness:** Ability to identify, diagnose, and treat problems with available resources.
- **Rapidity:** Ability to restore functionality in a timely way.

A Resilient Transportation Asset

- Is safe to fail - during unpredicted conditions, recognizing that the possibility of failure can never be eliminated, there is a plan in place to withstand and recover from unexpected events and challenges.
- May involve system redundancy (e.g., maximizing use of frontage lanes, breakdown lanes, managed lanes), detour routes, or alternative modes.
- Includes equipment to monitor and alert to potential threats or failures before they occur.
- Is designed in such a way that it is quick to restore functionality, containing losses and avoiding disruptions.

A Resilient Transportation Organization

- Has an organizational mindset of enthusiasm for challenges, problem solving, agility, flexibility, innovation, and taking opportunity.
- Understands interconnectedness and vulnerabilities across all aspects of agency function.
- Has established relationships, prearranged mutual aid arrangements and regulatory partnerships.
- Has established response plans in place to mobilize when events occur.

Flood

Flooding and erosion affecting highways resulting from heavy rainfall and/or riverine flooding. There is a risk that flooding occurs, leading to asset/route damage that causes mobility and safety impacts, as well as increased asset management cost.



Organizational Examples

- CDOT has developed a Resiliency Improvement Plan (RIP) approved by FHWA. (Resourcefulness)
- Having an Incident Command Center (ICC) with cross-trained staff and protocols in place that can be quickly set up after a major flooding event. (Resourcefulness)
- CDOT has a Traffic Incident Management (TIM) program that involves multiple agencies to restore normal travel operations after an event. (Robustness)
- CDOT has three Traffic Operations Centers (TOC) that keep an eye on roads and coordinate incident response, monitor traffic, and distribute information to keep travelers in the know. (Redundancy, Rapidity)

Technical Examples

- Moving alignment of roadway horizontally outside of the floodplain onto bedrock, raising road vertically out of floodplain, or moving road away from river bends where water has significant erosive force. (Robustness)
- Design local access structures to withstand 100-year events to reduce potential for debris build-up and damage to the adjacent highway; this may involve consolidation of local access routes. (Redundancy, Robustness)
- Use alternative delivery methods to engage the contractor during pre-construction design options and constructability reviews to select the most cost beneficial resilient option. (Resourcefulness)
- Protection for a minimum 15-ft drivable surface for emergency access to allow for rapid recovery of emergency access. (Rapidity, Robustness)
- Establish detour routes. (Redundancy)