

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

## 4R Attributes

- **Robustness:** The strength of an asset or a system to withstand relevant threats
- **Redundancy:** The presence of a backup system or plan
- **Resourcefulness:** Ability to identify, diagnose, and treat problems with available resources
- **Rapidity:** Ability to restore functionality in a timely way

## Technical Examples

- CDOT and CAIC monitor over 500 avalanche paths that can affect Colorado highways. CAIC notifies CDOT of hazardous conditions and CDOT will implement mitigation, traffic control, and public notifications. (Resourcefulness)
- Establishment of detours. (Redundancy)
- Snow sheds, catchment basins, and other hardening measures may be built in avalanche-prone areas. (Robustness)
- Crews regularly conduct helicopter mitigation, ski into the backcountry, and use Avalaunchers, Howitzers, and permanent Remote Avalanche Control Systems (RACs) to trigger slides in avalanche paths that threaten state highways. (Resourcefulness, Rapidity)
- Nine maintenance sections, managed by maintenance superintendents, maintenance supervisors, and over 200 maintenance patrols clear snow. (Redundancy, Rapidity)

## 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.

# SNOW & AVALANCHE

An avalanche is a mass of snow or ice moving down a slope. Large quantities of new snow, high winds, and drastic changes in temperature increase avalanche risk. Avalanches can cause mobility and safety impacts as well as increased asset management costs.



## A Resilient Transportation Asset

- Is designed to withstand and recover from unexpected events and challenges. When there is high risk of avalanche danger, CDOT will close highways at the location of the avalanche path to conduct avalanche control.
- May involve system redundancy (e.g., maximizing use of frontage lanes, breakdown lanes, managed lanes), detour routes, and alternative modes. Has parts, elements, systems, facilities, etc., that satisfy backup functional requirements in the event of disruption of the primary system.
- Includes equipment to monitor and alert to potential threats or failures before they occur. Sufficient materials are on hand to efficiently mobilize in case of emergency.
- Is designed in such a way that it is quick to restore functionality, containing losses and avoiding disruptions.

## Organizational Examples

- To help predict avalanche conditions and identify avalanche mitigation needs, CDOT established an interagency agreement with Colorado Avalanche Information Center (CAIC) to forecast and monitor avalanche conditions. (Robustness)
- Three Incident Command Centers are established with cross-trained staff and protocols in place that can be quickly set up during a major snow event. (Redundancy)
- CDOT has a Traffic Incident Management (TIM) program that involves multiple agencies to restore normal travel operations after an event. (Resourcefulness)
- CDOT Traffic Operations Centers monitor traffic cameras statewide, and dispatch CDOT maintenance personnel as needed when problems arise during all snow events. (Rapidity)