

RISE

2018 TRANSPORTATION
RESILIENCE INNOVATIONS SUMMIT AND EXCHANGE

Incorporating Resilience into Decision-making at CDOT

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Colorado Department of Transportation

October 10, 2018



COLORADO
Department of Transportation



U.S. Department of Transportation
**Federal Highway
Administration**



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AASHTO

2013 Colorado Floods - Community

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2013 Colorado Floods

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US 34 Big Thompson Canyon, Credit: CDOT



Coal Creek in Lafayette, CO. Credit: Will Von Dauster, NOAA.



US 34 Big Thompson Canyon

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Resilience

RISE

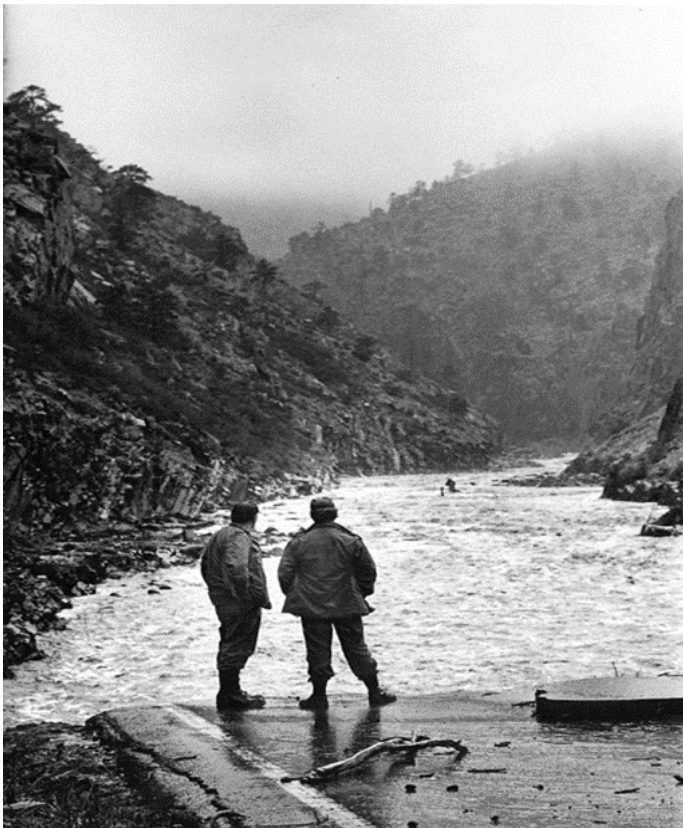
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- Ability of our system to withstand the impact of physical events, and to recover as quickly as possible when damaged.
- re-sil-i-ence
 - The ability of communities to rebound and adapt to or thrive amidst changing conditions - including economic hardships, disasters and changes in climate - and maintain quality of life, healthy growth, economic vitality, durable systems and conservation of resources for present and future generations.
- *Colorado Resiliency Framework HOUSE BILL 18-1394 - Section 3*

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Motivation

1976 and 2013 floods destroyed many of the same facilities



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CDOT Risk and Resilience Vision

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- Reduce Disruption to Traveling Public and Economic Activity
- Resilience Integration
 - Make Resilience part of every CDOT activity
 - Change in mindset
- Resource Allocation/ Optimization
 - CDOT has limited set of resources
 - Resource allocation impacts outcomes
 - Resilience helps us optimize the outcome

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Statewide Plan – Roadmap for the Future

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Colorado Statewide Transportation Plan: Transportation Matters



EXTREME WEATHER

Key Strategic Policy Action – Resiliency and Redundancy

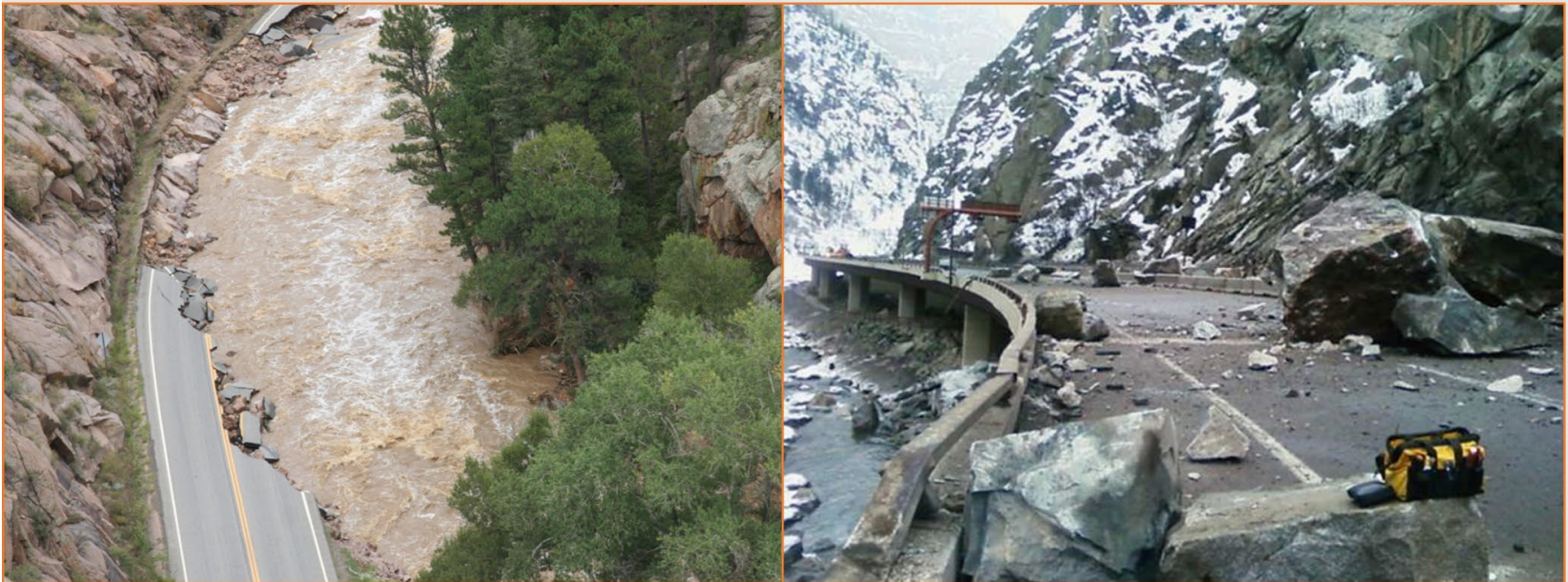
“Adopt CDOT policies that consider risk, resiliency and redundancy in planning, project selection, programming, design, and construction”

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I-70 Corridor Risk and Resilience Pilot Study

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I-70 Corridor Risk and Resilience Pilot Study



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Risk and Resilience
For Highways



I-70 Corridor R&R Pilot Study

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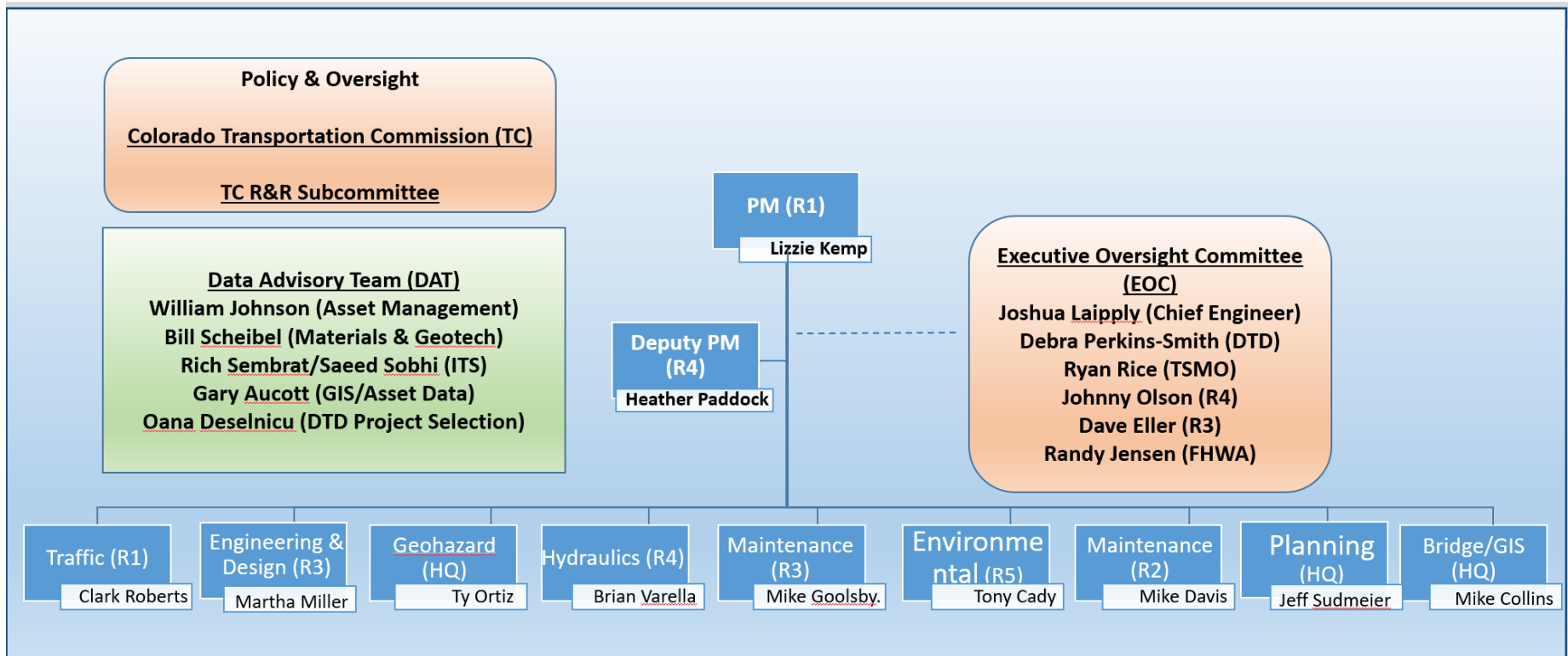
- “Pilot” the data, assumptions, and methodology needed to quantify:
 - What are CDOT’s *assets*?
 - Location, value, condition, criticality
 - What are relevant *physical threats*?
 - Likelihood and location
 - What *impact* would they have on our system?
 - What are the *optimal investments* we can make now to improve resiliency in advance of future events?



I-70 Corridor R&R Pilot Study Team

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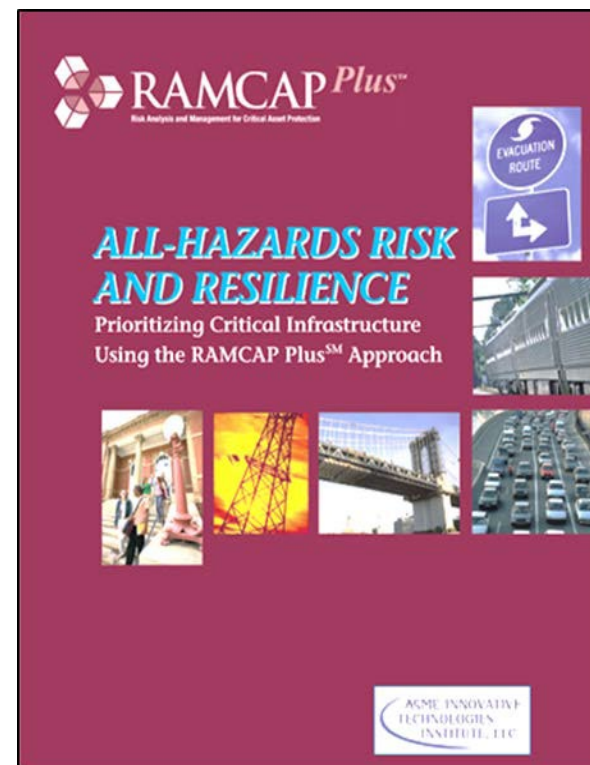
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I-70 Risk and Resilience Pilot

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- Analysis of risk potential and assessment of system resilience of I-70 from Kansas to Utah
- Proactive look at optimal investments we can make now, in advance of future events, to improve system resilience
- Builds on 7-step RAMCAP (Risk Analysis & Mgmt for Critical Asset Protection) process utilized in flood recovery effort



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I-70 Corridor R&R Pilot Study

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RAMCAP PlusSM

RAMCAP PlusSM
Risk Analysis and Management for Critical Asset Protection

ALL-HAZARDS RISK AND RESILIENCE
Prioritizing Critical Infrastructure Using the RAMCAP PlusSM Approach

ASME INNOVATIVE TECHNOLOGIES INSTITUTE, LLC

R&R for Highways

1) Asset Characterization	What assets exist and which are critical?
2) Threat Characterization	What threats and hazards should be considered?
3) Consequence Analysis	What happens to assets if a threat or hazard occurs? Expected asset losses, economic impacts, injuries, lives lost?
4) Vulnerability Analysis	What are asset vulnerabilities that would allow a threat or hazard to result in expected consequences?
5) Threat Assessment	What is the likelihood that a terrorist, natural hazard or dependency/location hazard will occur to asset?
6) Risk/Resilience Assessment	What is anticipated total risk and asset resilience? Risk = Consequences x Vulnerability x Threat Resilience = Service Outage x Vulnerability x Threat
7) Risk/Resilience Management	What options are there to reduce risk and increase resilience? How much will each mitigation measure reduce risk and increase resilience? How much does each mitigation measure cost? What is the calculated benefit/cost ratio?

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- **I-70 ASSETS**

- Bridge
- Bridge Approach
- Roadway Prism
- Post-Tensioned Concrete Slab
- National Bridge Inventory (NBI) Culverts
- Minor Culverts
- Walls
- ITS/VMS
- Traffic Control Centers
- Tunnels

- **I-70 THREATS**

- Avalanche
- Flood (scour)
- Flood (overtopping, debris)
- Fire (wildland)
- Landslide
- Rockslide
- High Wind
- Tornadoes
- Bridge Strikes

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Pilot - Final Proposed Criteria for Asset Criticality

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	SOCIAL	ENVIRO	ECON
• <u>Usage</u> : AADT + Roadway Classification	✓	✓	✓
• <u>Economic Impact</u> : Freight value (\$) + Tourism value (\$)			✓
• <u>Social Impact</u> : SoVI	✓		
• <u>System Impact</u> : System Redundancy	✓	✓	✓

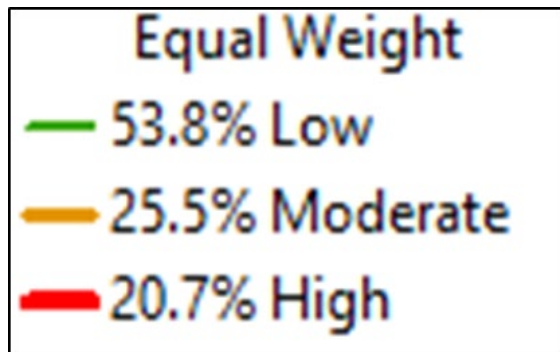
Equal weight assigned to each of the six selected variables.

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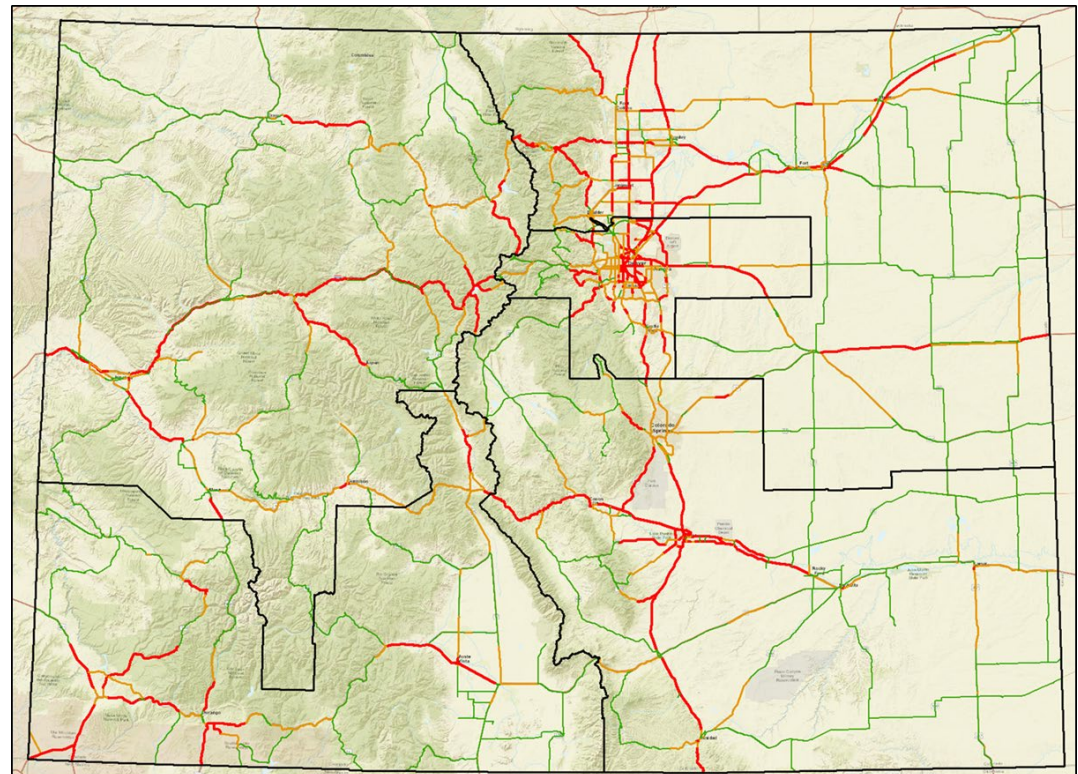
Pilot - Final Proposed Criticality Map for System Resilience

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AADT	16.7%
ASHTO Road Classification	16.7%
Freight \$ (County)	16.7%
Tourism \$ (County)	16.7%
SoVI	16.7%
Redundancy	16.7%



Reminder: Criticality reflects the importance of each asset to overall operations within CDOT's network as related to system resilience only. Criticality is part of Step 1 in a 7-step Risk and Resilience Analysis process.

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I-70 Risk and Resilience Pilot

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$$\text{Risk (\$)} = C \times V \times T$$

R = Risk. Potential loss due to analyzed event, \$

C = Consequence. Outcome of an event occurrence, \$

V = Vulnerability. Given event has occurred, probability of that estimated consequences will be realized, %

T = Threat. Likelihood event will occur, %

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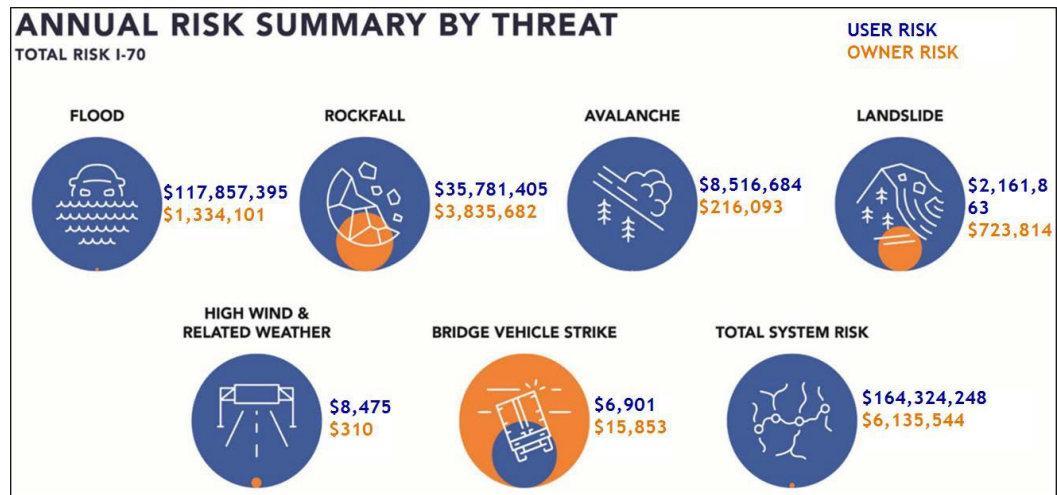
I-70 Pilot Results

User Risk

- Value of Time
- Vehicle Running Costs

Owner Risk

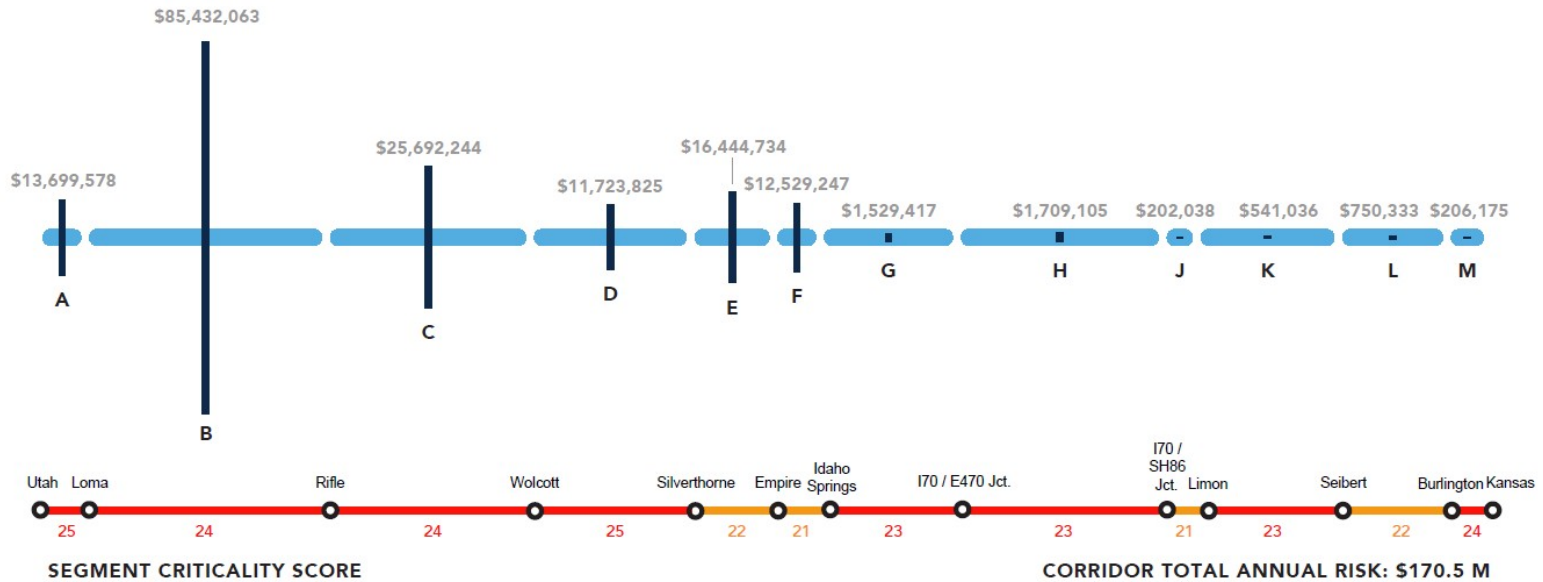
- Asset Replace in Kind



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I-70 Pilot Results

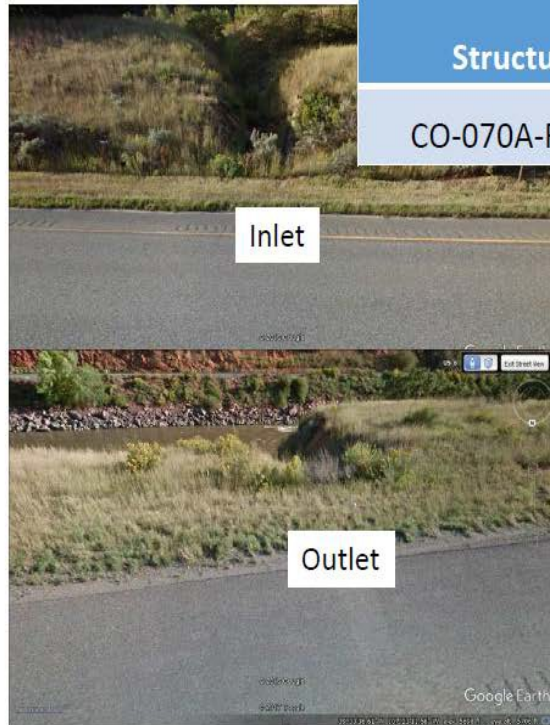
ANNUAL TOTAL RISK BY CORRIDOR SEGMENT



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Example 1: Non-NBI Culvert - Flood

Structure ID	Milepost	Region	Resilience Segment	Criticality	Total Annualized Risk
CO-070A-RS00140	112.9	3	C	High	\$1,325,151



Analyzed Economic Viability –

- 72" Concrete Culvert
- Concrete Box Culvert

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Example 1: Non-NBI Culvert - Flood

Proposed Mitigation	Description	Proposed Hydraulic Design	Cost of Mitigation
Option 1	Replacement of existing culverts with Two 72" concrete pipes (1 each direction) with headwalls	50-yr (roadway overtopping at 100-yr event)	\$500,000/culvert \$1M/site
Option 2	Replacement of existing culverts with Two 8' x 8' CBC (1 each direction) connected with a concrete chute and improvements to private crossing above interstate	100-yr (NO roadway overtopping at 100-yr event)	\$800,000/culvert \$1.6M/site



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Example 1: Non-NBI Culvert - Flood

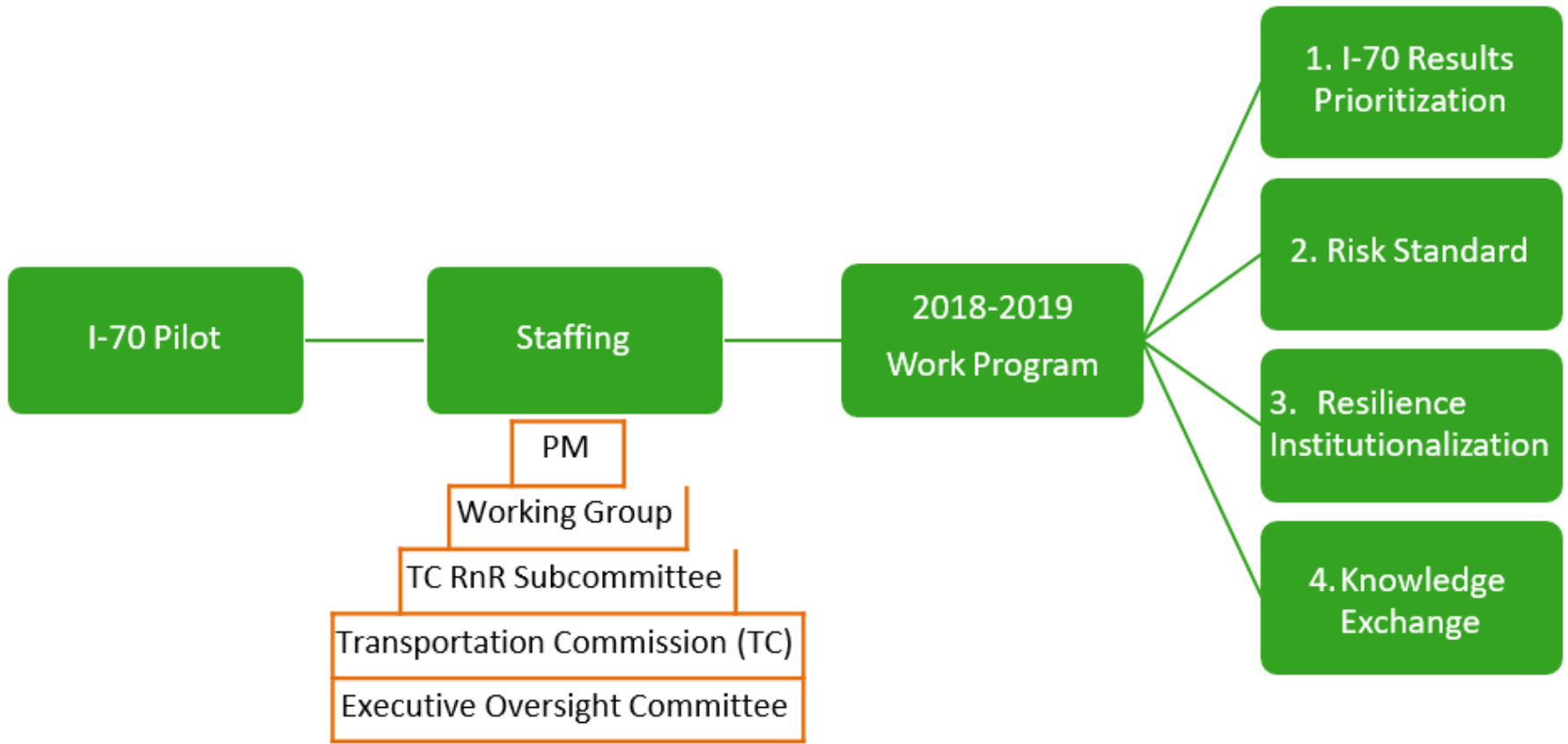
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Mitigation	Reduction in Annualized Owner Risk	% Reduction in Annualized Owner Risk	Reduction in Annualized User Risk	% Reduction in Annualized User Risk	Reduction in Annualized Total Risk	% Reduction in Annualized Total Risk	B/C Owner Risk	B/C Total Risk
Option 1	\$ 5,900	76%	\$ 1,217,276	92%	\$ 1,223,176	92%	0.17	35.6
Option 2	\$ 7,481	76%	\$1,278,337	97%	\$1,285,819	97%	0.14	23.4

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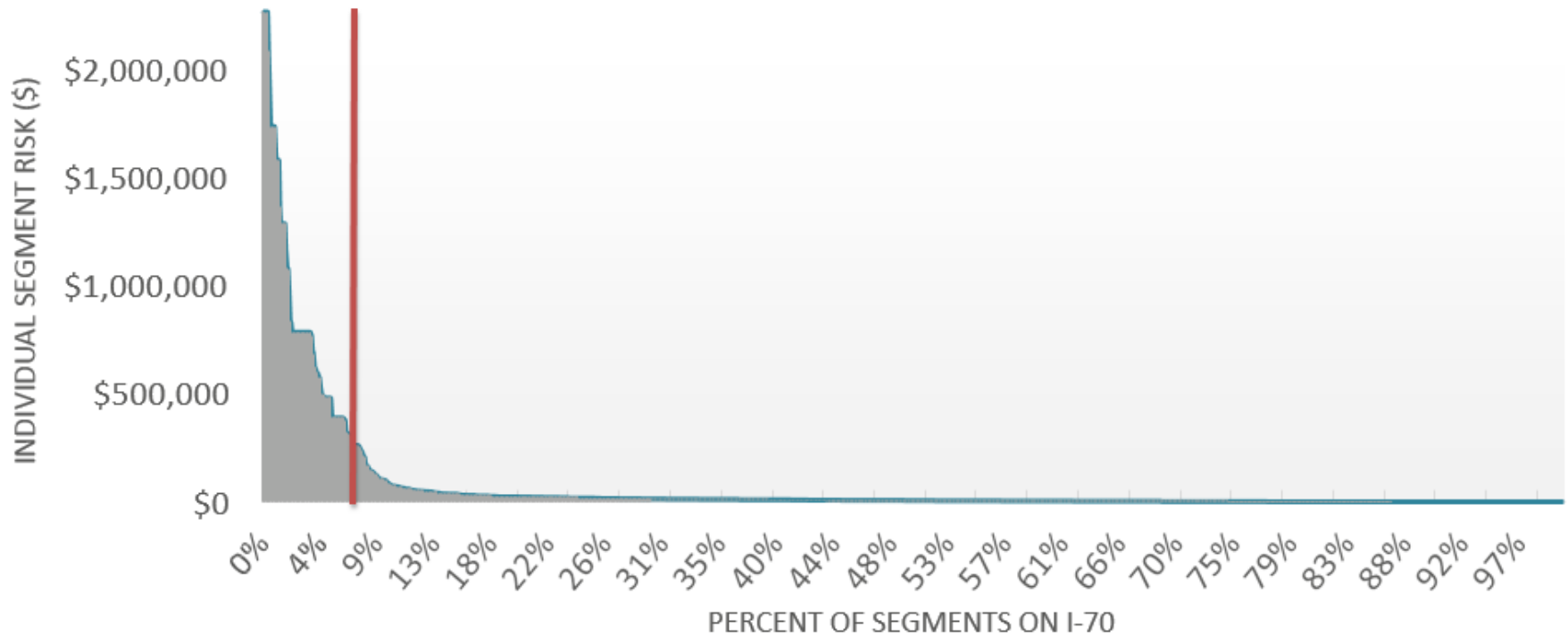
Next Steps



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1. I-70 Results Prioritization

7% of analyzed segments contribute to 67% of risk on I-70



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1. I-70 Results Prioritization

	Threat	Asset	Location	Comments
1	Avalanche	Roadway	Vail Pass, MM 186.3-186.4	Considered in the Vail Pass NEPA
2	Rockfall (multiple locations)	Roadway	E Georgetown, MM 229.1-229.4	Checking with Geohazards Program
3	Rockfall (multiple locations)	Roadway	E US 40 Junction, MM 235.4-236	Checking with Geohazards Program
4	Flood	NBI Culvert	US 40 Junction, MM 232.2-232.25	On Bridge Enterprise eligibility list
5	Rockfall (multiple locations)	Roadway	W Glenwood Spgs, MM 110.5-110.53	Checking with Geohazards Program
6	Rockfall (multiple locations)	PTCS	Glenwood Canyon, MM 121.9-125.01	Checking with Geohazards Program
7	Avalanche	Roadway	Vail Pass, MM 187.2-187.3	Considered in the Vail Pass NEPA
8	Landslide	Roadway	MM 213.13-213.24	Considered in Tunnel Inspection Work
9	Flood	Minor Culvert	De Beque, MM 57-58	Not on Critical Culvert List
10	Avalanche	Roadway	Copper Mtn, MM 196.9-197	Has not been an issue of concern for Maintenance, looking at probabilities

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1. I-70 Results Prioritization

GOAL

- Act on the I-70 Risk and Resilience Pilot results

DETAILS

- Use RnR Working Group and asset managers to identify process for addressing highest-risk assets
- Process example: Culverts
 - Cross Check to Critical Culvert list
 - Cross check to NEPA, PEL, EA
 - Cross check to 4-year program of projects
 - If not addressed in above, determine next steps

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2. Develop Risk Assessment Standard for Colorado

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GOAL

- Develop standardized approach for conducting transportation risk and resilience assessments in Colorado
- Establish methodology, parameters and default values to use

BENEFITS

- Consistent assessments regardless of location, geography, facility type, team conducting the study, etc.

TIMELINE

- May-June, 2018: SOW finalized, reviewed by Working Group
- Fall 2018: Kickoff
- Duration: 18-24 months

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3. Institutionalize Resilience at CDOT

GOAL

- Integrate resilience into core DOT functions



BENEFITS

- Common understanding and definition of resilience in Department, identification of resilience integration opportunities (pilots)

TIMELINE

- May-June, 2018: SOW finalized, reviewed by Working Group
- Fall 2018: Kickoff; Duration: 12 months

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Risk-Based Investment Decision-making

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CDOT Project Selection Criteria

1. Incorporate Resiliency
 2. Data Driven Process
- National Highway Freight Program Projects



February 2016, rockfall closed I-70 in Glenwood Canyon 2 weeks

Freight Project Selection



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National Highway Freight Program Eligibility and Evaluation Criteria

Scoring Method					
Basic Eligibility					
1. Is on the National Highway Freight Network (IHFN) or is a freight intermodal or freight rail project (federal requirement)					
2. Is an eligible activity under the National Highway Freight Program (federal requirement)					
3. Is on a Colorado Freight Corridor or other facility with evidence of significance to freight					
4. Project readiness: Project must be able to go to Ad no later than June 30 of the following fiscal year (June 30, 2019)					
MODA Evaluation: Goal Areas and Supporting Criteria					
	Low Score (1)	High Score (5)	Usage (Impact)	Criterion Score (Scale x Usage)	
				Lowest	Highest
A. Safety (Goal Area)					
A1. Freight Safety	Project not likely to provide noticeable improvement to freight safety	Project directly addresses known truck safety issues, and identified strategies have high likelihood of improving safety on the most critical freight corridors in the region		1	20
A2. Freight Safety: High-volume truck crash locations	Project does not address any high-volume truck crash locations	Project fully addresses one or more high-volume truck crash location	LOSS 1 = 1 LOSS 2 = 2	1	20
A3. Freight Safety: Commercial vehicle hotspots	Project does not address any commercial vehicle hotspots	Project fully addresses one or more commercial vehicle hotspot	LOSS 3 = 3 LOSS 4 = 4	1	20
A4. Freight Safety: Shoulders	Project does not address shoulders under 8'	Project includes shoulders under or equal to 8' with intention of widening to at least 10'		1	20
B. Maintaining the System (Goal Area)					
B1. Asset Management - Maintenance	No changes to maintenance needs	Significant reduction to maintenance needs		1	5
B2. Asset Management - Infrastructure	No change to existing infrastructure	Existing infrastructure is replaced	n.a.	1	5
C. Mobility (Goal Area)					
C1. Freight Mobility	Project not likely to provide noticeable improvement to freight mobility	Project directly addresses known truck mobility issues, such as bottlenecks, and identified strategies have high likelihood of improving mobility on the most critical freight corridors in the region	Rural, AADT-Low (<2,000) = 1 Rural, AADT-Med (2,000-4,000) = 2 Rural, AADT-High (>4,000) = 3 Urban, AADT-Low (<30,000) = 1 Urban, AADT-Med (30,000-45,000) = 2 Urban, AADT-High (>45,000) = 3	1	15
C2. General Mobility	Project not likely to provide noticeable improvement to general mobility	Compared to other recent projects in the region, project will provide a typical improvement in mobility and/or access in the vicinity of economic drivers such as military installations, major agricultural facilities, or other freight generator		1	15
D. Economic Vitality (Goal Area)					
D1. Economic Connectivity	No noticeable economic impact resulting from the project	Compared to other recent projects in the region, project will provide a historically large improvement in mobility and/or access in the vicinity of economic drivers such as military installations, major agricultural facilities, or other freight generator.	Rural, Truck AADT-Low (<200) = 1 Rural, Truck AADT-Med (200-600) = 2 Rural, Truck AADT-High (>600) = 3 Urban, Truck AADT-Low (<1,000) = 1 Urban, Truck AADT-Med (1,000-2,500) = 2 Urban, Truck AADT-High (>2,500) = 3	1	15
D2. Regional Importance	Not critical to regional connectivity	Critical to regional connectivity		1	15
E. Other Considerations					
E1. Truck Parking	Project provides no new truck parking facilities; improvement to parking existing facilities, or operational or technological enhancements to improve truck parking	Project provides significant new truck parking facilities in an area of need, or significant improvement to existing facilities in an area of need, or significant operational or technological enhancements to improve truck parking.	n.a.	1	5
E2. Risk, Resilience, Redundancy	Project does not reduce risk or increase resilience or redundancy of transportation infrastructure	Project provides historically large improvement in the risk, resilience, or redundancy of transportation infrastructure by incorporating betterments that mitigate the risks of economic, social, or environmental impacts, relative to other locations in the region	n.a.	1	5
E3. Sustainability and Environmental Impacts	Project does not increase sustainability or reduce impact of environmental hazards	Project has specific components which increase sustainability or reduce environmental impact of commercial vehicles	n.a.	1	5

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Freight Project Selection

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E2. Risk, Resilience, Redundancy

<p>Project does not reduce risk or increase resilience or redundancy of transportation infrastructure</p>	<p>Project provides historically large improvement in the risk, resilience, or redundancy of transportation infrastructure by incorporating betterments that mitigate the risks of economic, social, or environmental impacts, relative to other locations in the region</p>
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Legislative Support for Resiliency in State Agencies

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- Colorado Resiliency Office (DOLA) Statewide Resilience Integration
 - HB 18-1394 - Concerning Amendments to the Colorado Disaster Emergency Act to Address All Phases of Emergency Management.
 - Signed 5/24/2018
 - Section 17. 24-32-122 Directs the Colorado Resiliency Office (CRO) to create and maintain the Resiliency and Community Recovery Program "to provide technical assistance to state agencies for the implementation of resilience policies and procedures and to institutionalize resilience practices across Departments and Agencies."

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Legislative Support for Resiliency Investment

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- HB 18-1394

“All state departments shall conduct studies and adopt measures to reduce the impact of, and actions contributory to, a disaster”

- CRO tasked with

1. Developing metrics and targets to measure the short-and long-term success of resilience efforts and actions.

2. CO Resiliency Institutionalization Project

Develop a shared approach for guiding internal investment and budgeting using a resilience lens.

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Key Take Aways

- Support at All Levels of Government and Department
- Agency Champions – Point Person
- Consider at Every Stage in Project Life-cycle Decision-making



Shahn Sederberg | CDOT

THANKYOU!

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