



ASSET MANAGEMENT OF A HEAVY HAUL RAILWAY IN NORTH AMERICA

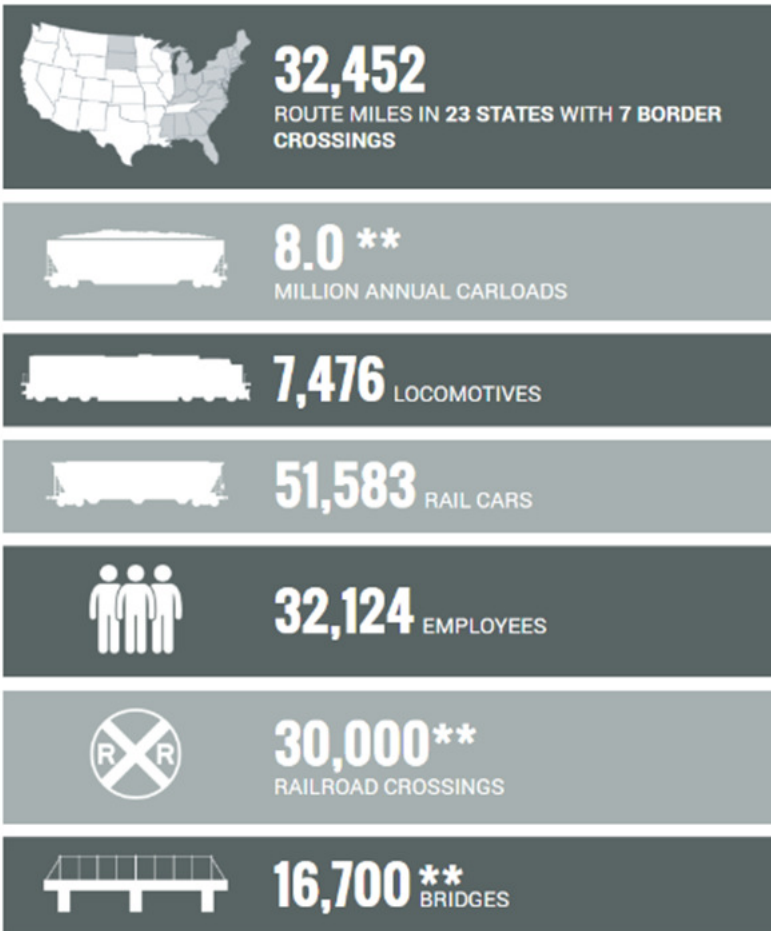
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Stephen Ashmore – Union Pacific Railroad

5/8/2023



Union Pacific Railroad

Fast Facts



* As of December 31, 2021 ** Figures are rounded

- 37,173 Switches
- 4,082 Installed Derails
- 365 Crossing Diamonds
- 3,102 Industrial Route Miles
- > 6,600 Yard Miles
- 6,741 Miles of Curved Track
- 2,853 Lubricators
- 5,178 Buildings
- 5,072 Pieces of Work Equipment



2022 Full Year

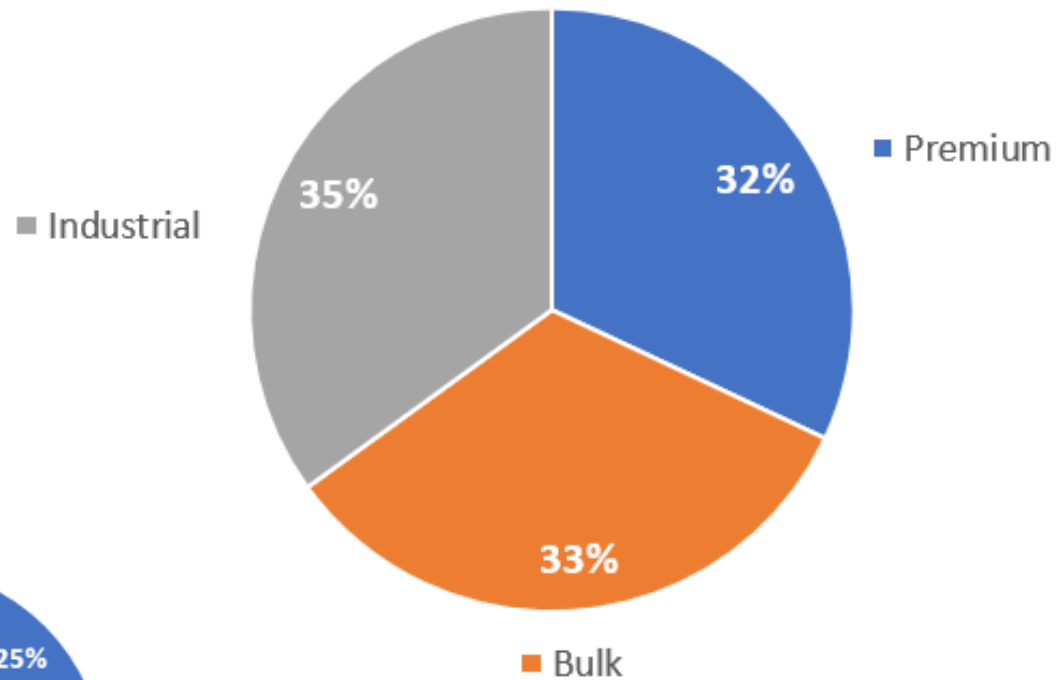
Operating Statistics

	<u>2022</u>
Freight Car Velocity (Daily Miles Per Car)	191
Average Train Speed (MPH)	23.8
Average Terminal Dwell Time (Hours)	24.4
Train Length (Average in Feet)	9329

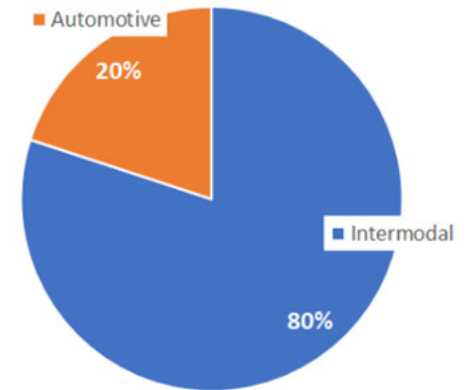


2022 Traffic Mix

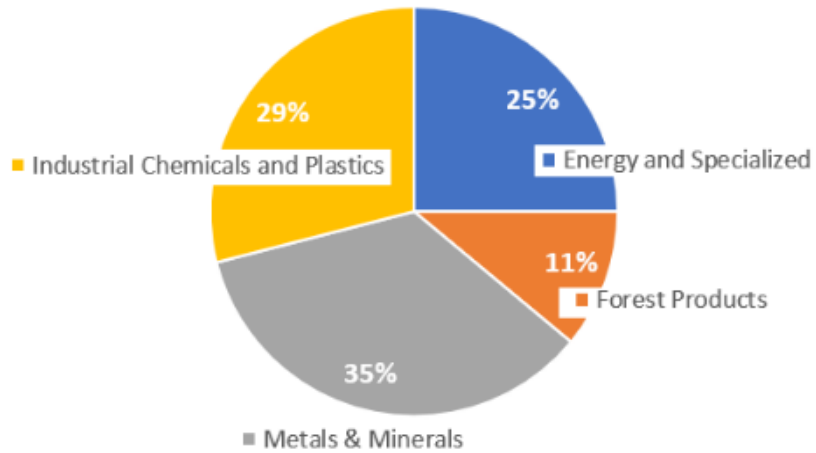
Freight Revenues



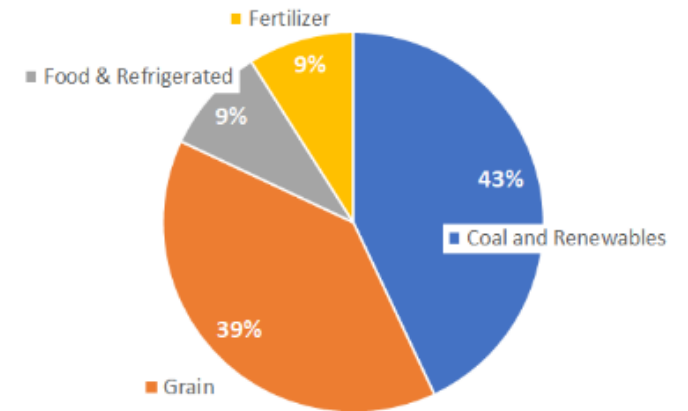
Premium



Industrial



Bulk



High Demand Environment

Rail Car Weights



Locomotives:
390 – 423,000 Lbs.
176 – 191,689 Kg.

Freight Cars (Multiple Types):

Empty: 60 – 90,000 Lbs.
27 – 41,000 Kg.

Loaded (Avg.): 160 – 220,000 Lbs.

72 – 100,000 Kg.

Maximum: 268 – 315,000 Lbs



Average Wheel Loads:

- Empty Cars:	5 – 10 Kips
- Loaded Cars:	27 – 40 Kips
- Locomotives:	30 – 40 Kips

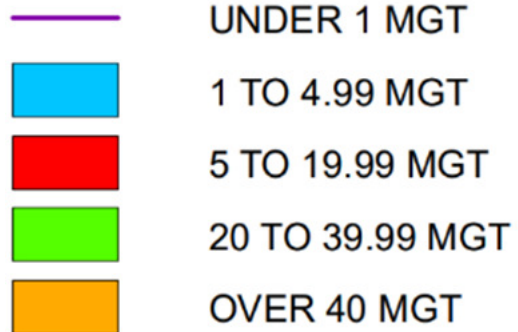
Peak Wheel Loads:

- 60 – 120 Kips (10 – 20%)

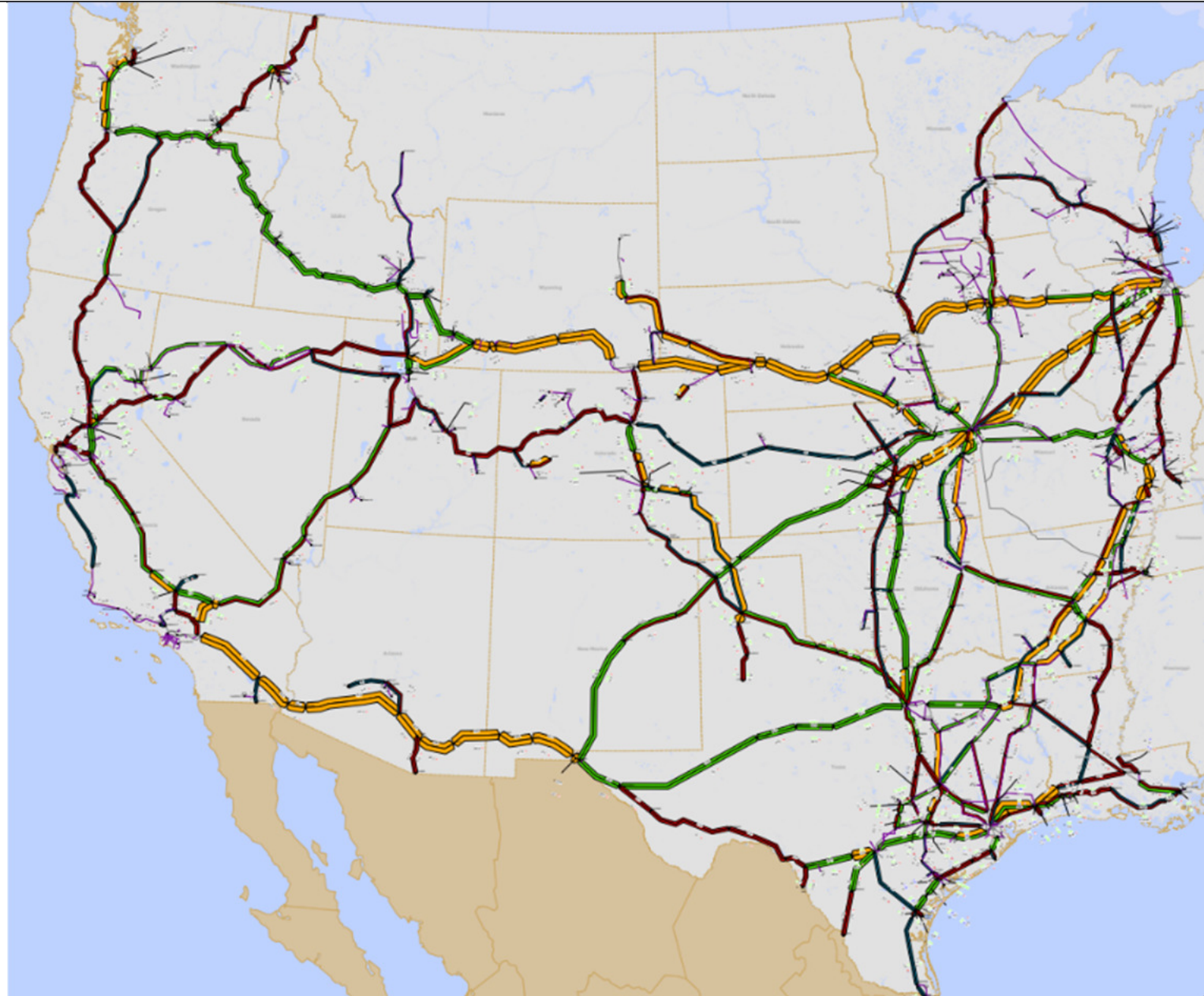
2022

Tonnage

Legend



U.S. Ton = 2,000 Lbs.
40 MGT = 8×10^{10} Lbs. Annually!



Class of Track Breakdown

Track Classification	UP Miles	Percentage	Freight Speed (MPH)	Freight Speed (KPH)	Passenger Speed (MPH)	Passenger Speed (KPH)
Class 1	8150	19%	10	16.1	15	24.1
Class 2	4062	10%	25	40.2	30	48.3
Class 3	4000	9%	40	64.4	60	96.6
Class 4	12934	31%	60	96.6	80	128.7
Class 5	11849	28%	80	128.7	90	144.8
Class 6	1151	3%	110	177.0	110	177.0



What Challenges Do We Have as Engineers?

- Determine where to go with limited Capital Investment
- How do we continue to run a primarily wood tie railroad?
- Leveraging automation and technology to make our jobs more efficient and safe
- Deal with the impacts of climate change on our operating environment
- How do we design and maintain an infrastructure where train length, weight and speed is always increasing?
- Utilizing data analytics to help us find problems before they impact operations



2022 Capital Program vs. Historical

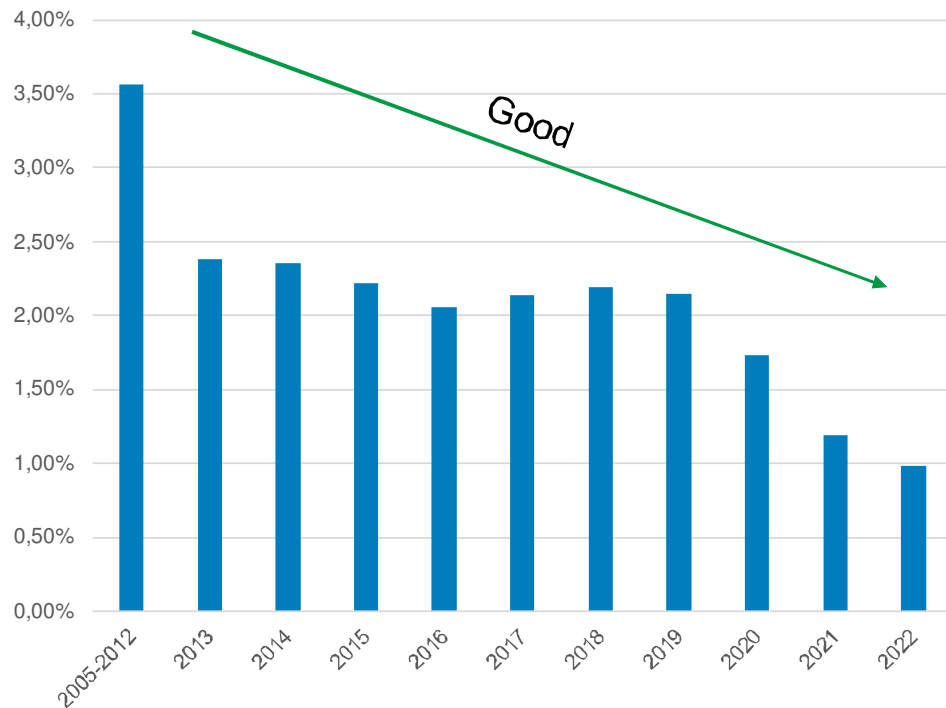
Project Type	2021	2022	2023
Rail	\$ 242	\$ 260	Forecasted Similar to 21 / 22 @ \$1.885 Billion
Ties	\$ 420	\$ 440	
Yard / Industrial Leads	\$ 110	\$ 115	
Misc. Track Projects	\$ 123	\$ 139	
Bridge	\$ 282	\$ 260	
Signal	\$ 141	\$ 140	
Regional Track	\$ 252	\$ 252	
Equipment/Facilities	\$ 185	\$ 160	
Operating Technologies	\$ 56	\$ 40	
Other	\$ 140	\$ 99	
Grand Total	\$ 1,951	\$ 1,905	

- Forecasted 2022 Final – Subject to Change
- Values in Millions

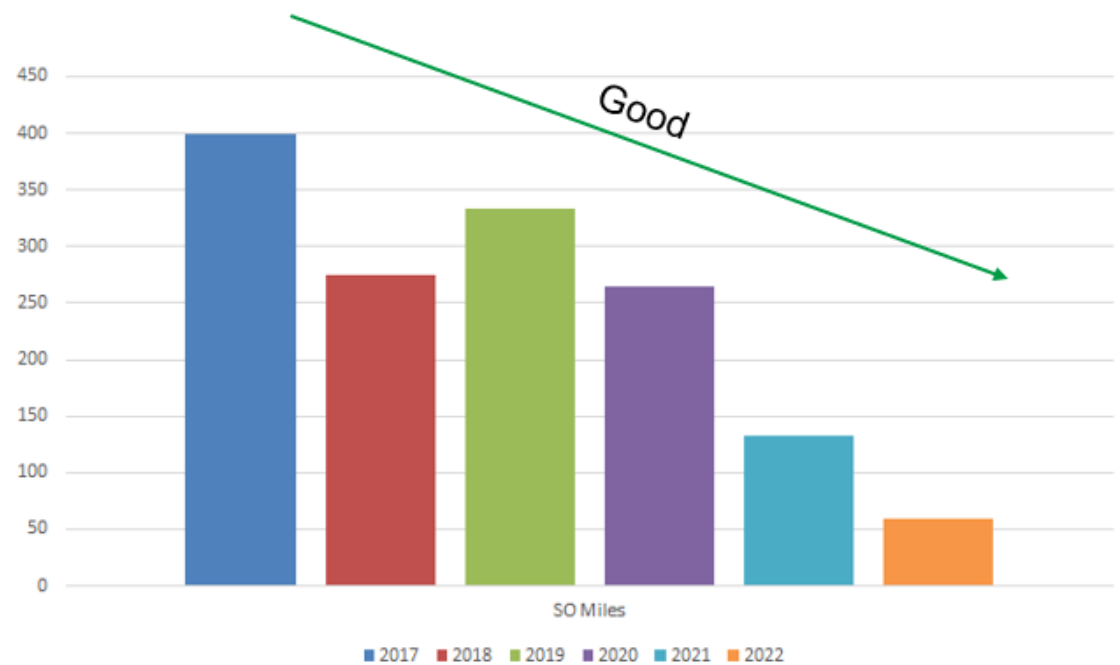


Slow Order Improvement Over Time

Percentage of Network Slow Ordered - Average



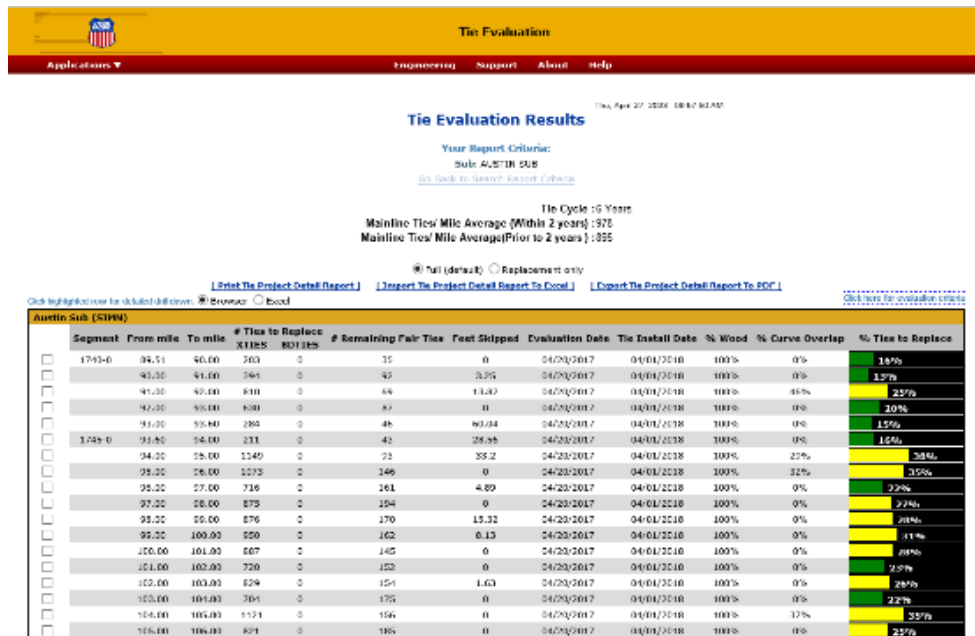
Tie Condition Slow Orders – Avg Miles



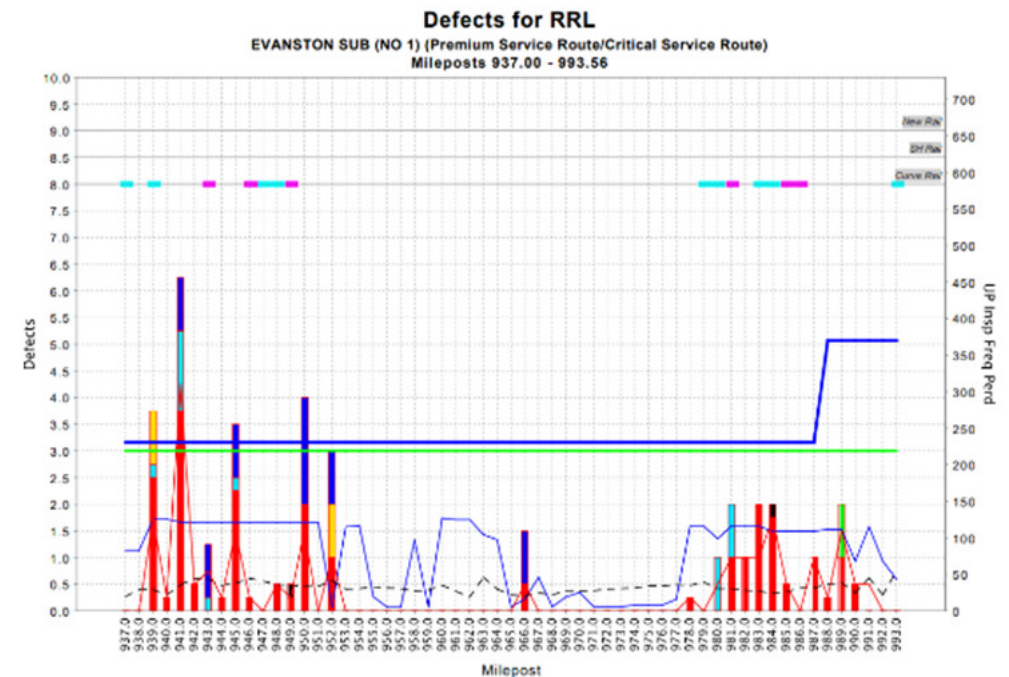
Determining Where to Replace Infrastructure



Tie Evaluation:



Rail Evaluation:



Crosstie (Sleeper) Technology Progression Implementation on UP

1865



Wood Ties

> 87 Million (27k
Miles)

> 89% of Network

1986



Concrete

~ 10.2 Million (3900
Miles)

1998

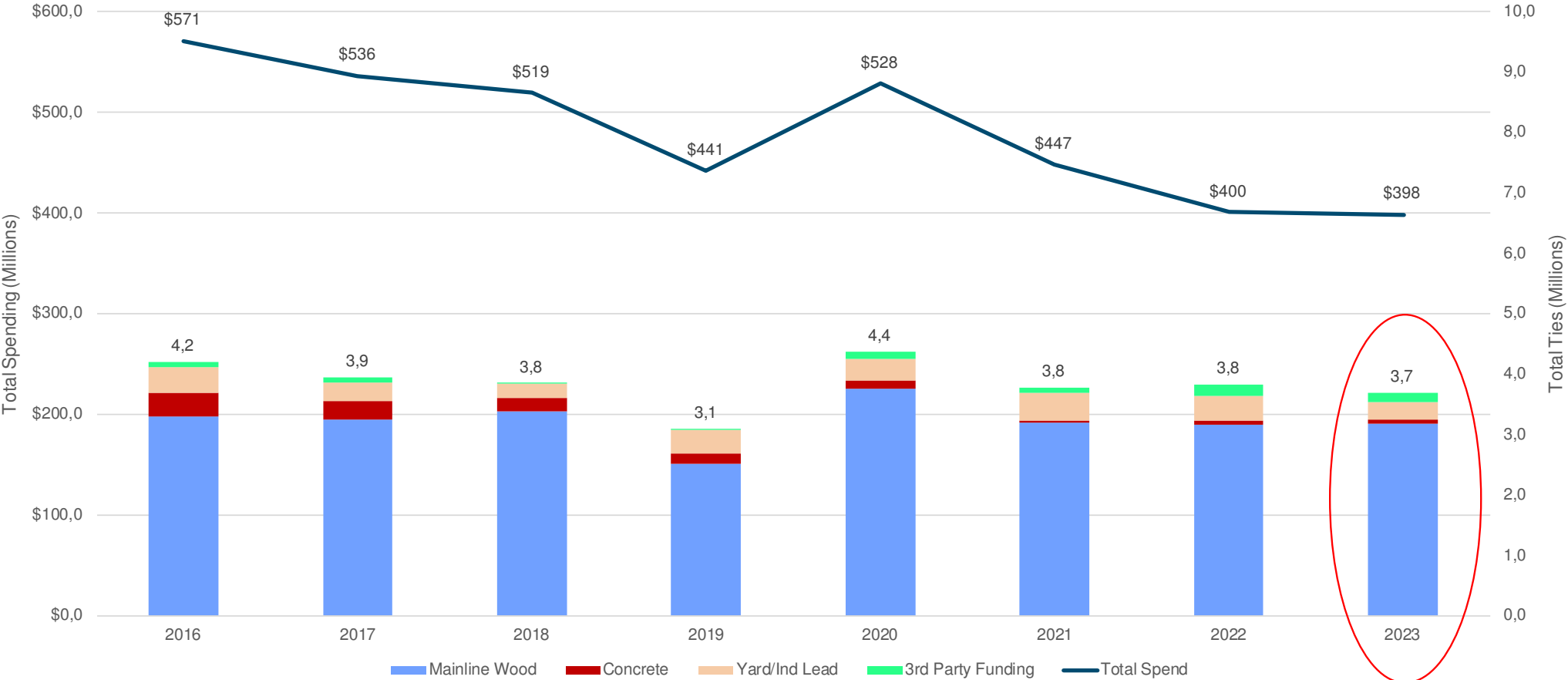


Composite

< 1 Million



Annual Tie Renewal Program



2023 Estimated



Constant Use of Resources

Wood Tie Replacement

Strategic Tie Replacement

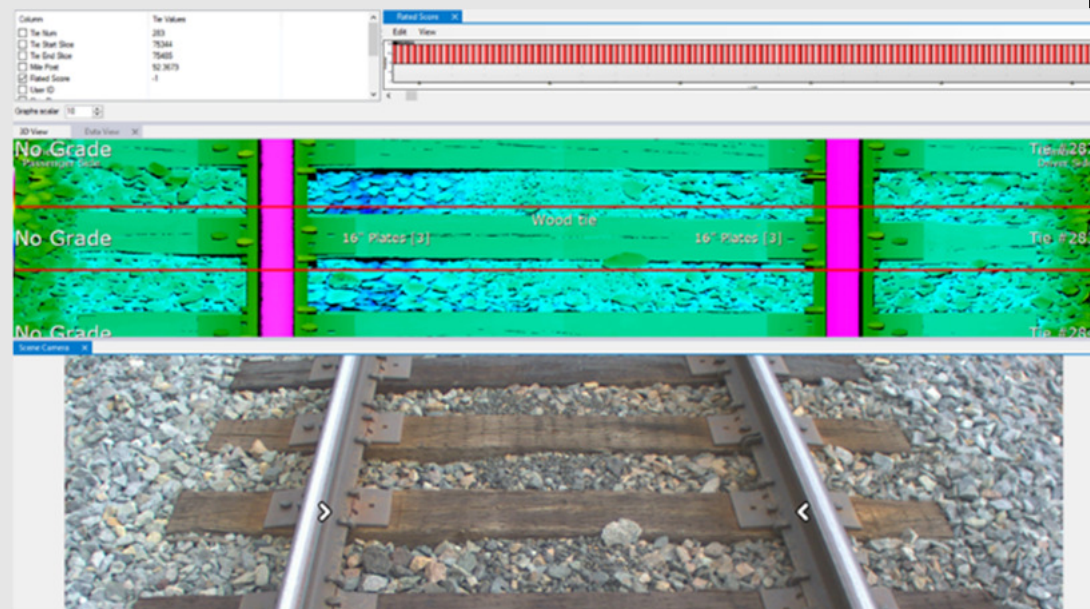
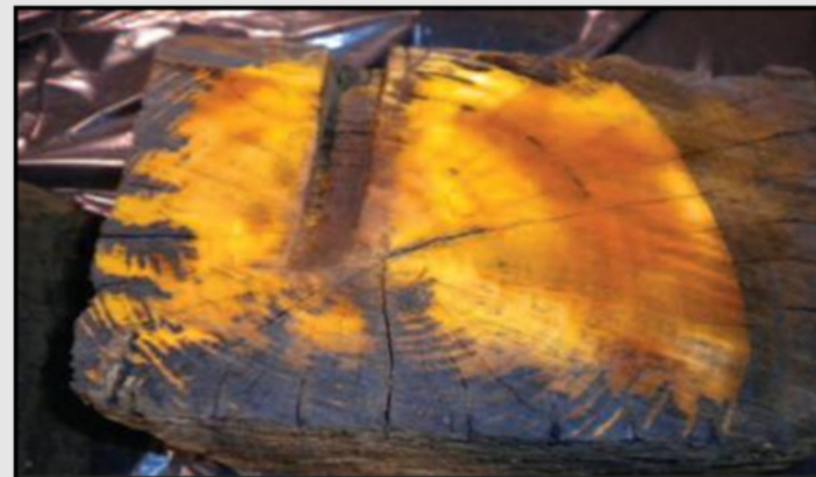
Cycle 1 – Five Ties Replaced

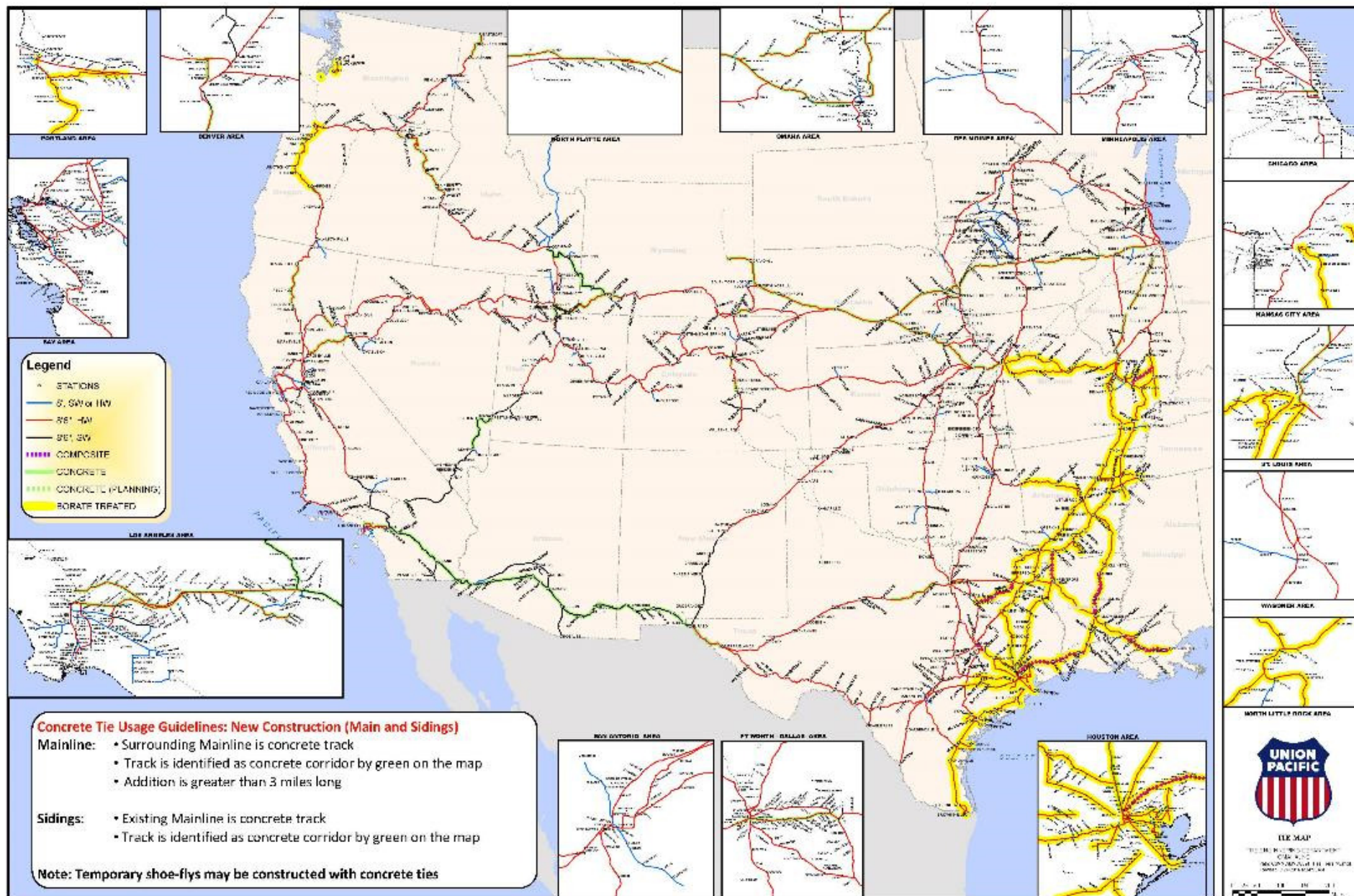


Cycle 2 – Eight Ties Replaced



Cycle 3 – Four Ties Replaced





Continuing to Push Composite Tie Usage

	MOE (X1000)	MOR
Average Failed Ties Removed from Track	165	1850
Average Performing Tie Removed from Track	230	2480
UPRR Recommended Minimum Threshold *	250	3400

* Pending Further Evaluation and Testing

Wood Tie Species:	MOE (X1000)	MOR
White Oak	1100 - 1350	9000 - 15000
Red Oak	1200 - 1300	7300 - 9000
Gumwood	1150 - 1350	7100



UP Geometry Fleet – Modernizing Our Capabilities



Evaluation Cars

- EC4 & EC5
- 90 Ton, 70 MPH
- 70k Mi Annually



Hyrail Geometry

- 8 Light Geometry
- GRMS – Gage Restraint Measuring



ATGMS (Boxcar)

- 3 In Service
- 120 Ton, 70 MPH
- 160K Miles Annually



LTGMS (Locomotive)

- 7 In Service
- 220 Ton, 70 MPH
- 180k – 240k Mi Annually

Future Fleet Estimates
10 Years

5 ATGMS

EOY 23

3 ATGMS

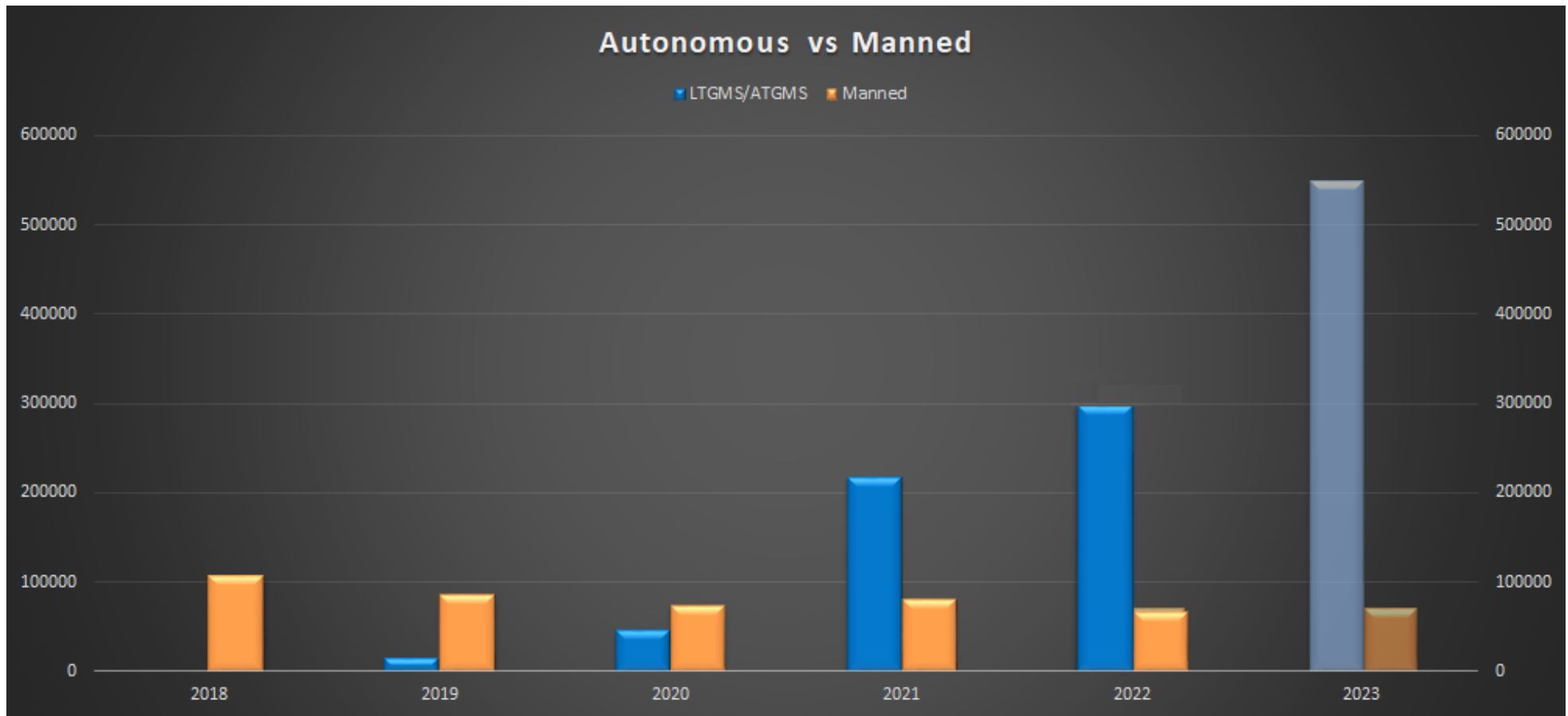
~3 Years

5 ATGMS

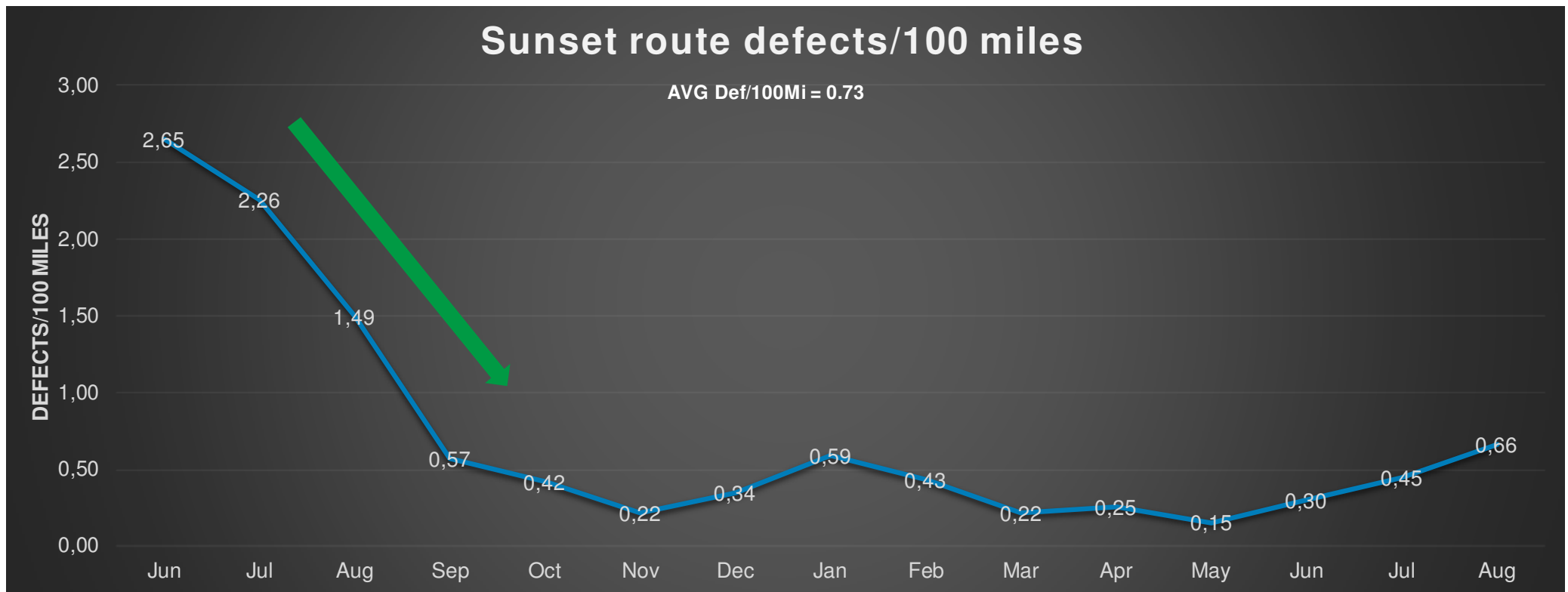


Union Pacific Geometry Program

2023 Forecasted vs. Historical

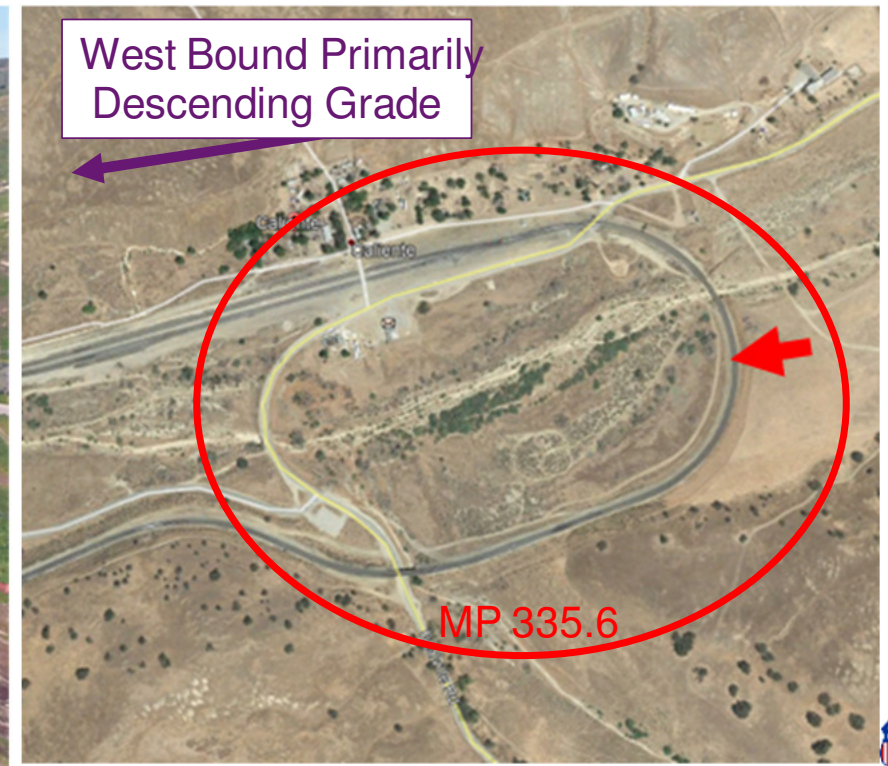


UP Autonomous Testing – What are we seeing?



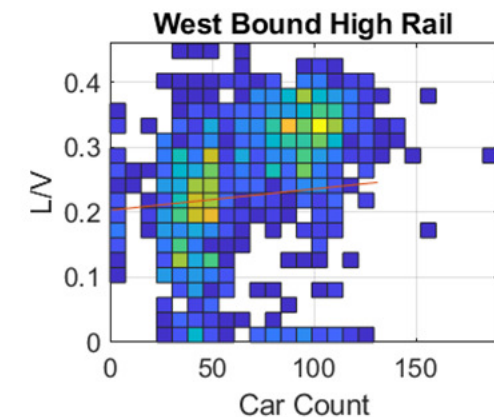
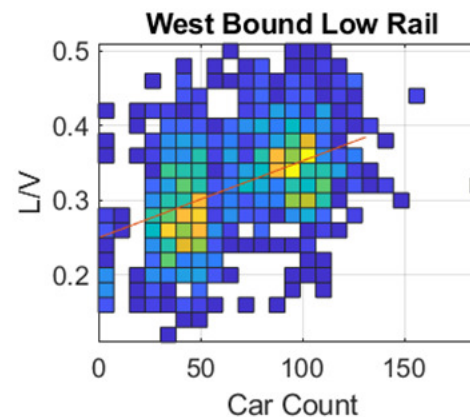
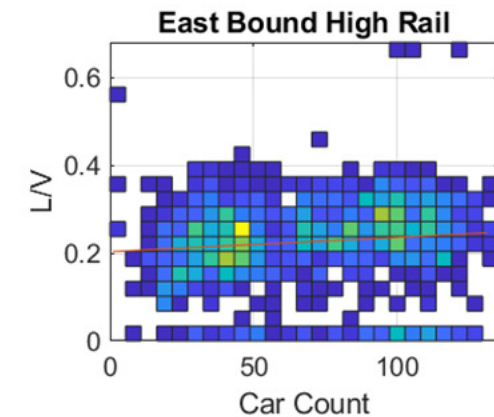
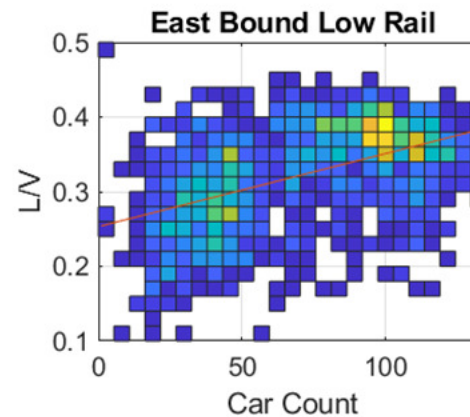
Horseshoe Curve – Caliente California

- One of the most severe operating environments on the Union Pacific
- 10 Degree curve, 31 MPH operating speed



Horseshoe Curve – Monitoring Stations

- Very large variance in L/V depending on train length, operating speed, train handling and train makeup
- Not uncommon to see L/V in excess of 0.4
- Very common to see trains operating well below maximum authorized speed
 - Curve Speed 31 MPH
 - Avg. Speed 19.2 MPH



Tie Unloading

1925 Loading Ties - Wyoming



Current State – 1990's - Today



The Future of Automation – Tie Unloading



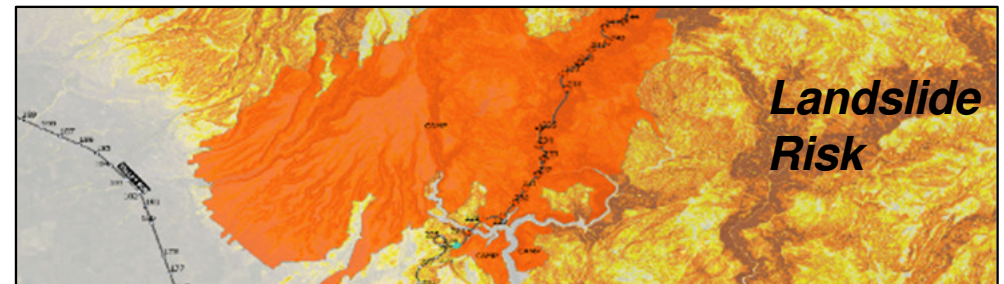
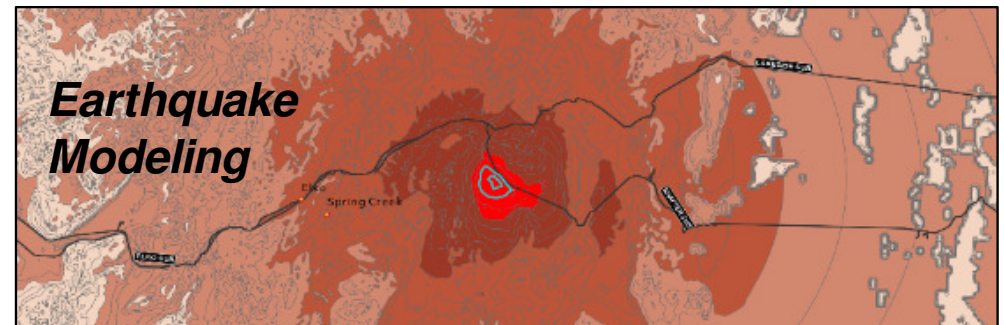
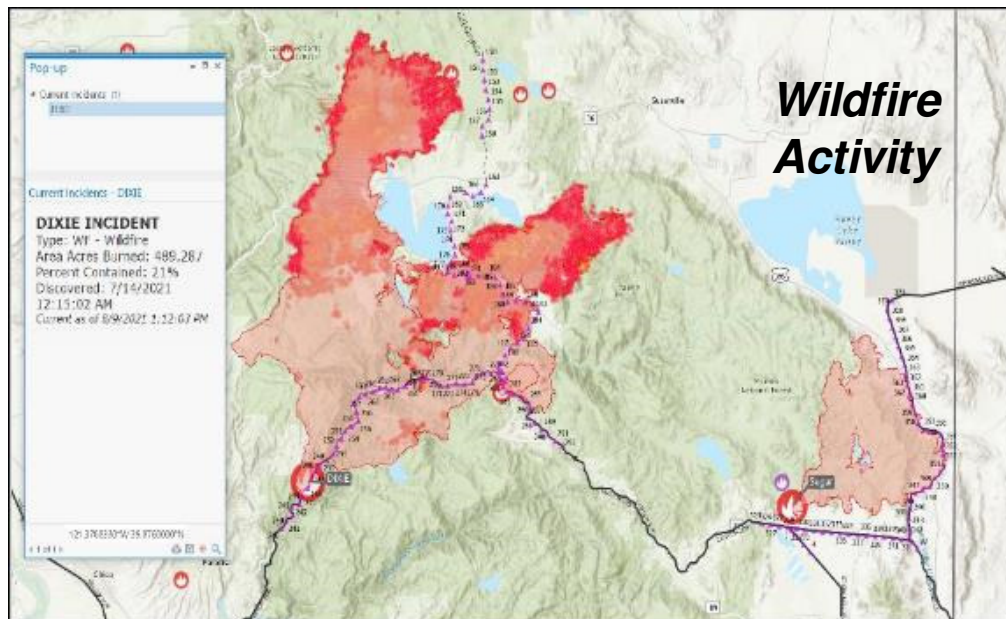
Operating and Capacities:

- 60 car train
- 560 ties per car
- 33,600 ties per unit train
- ~3 min per car / 3 hrs per train
- Cuts time required to unload ties by 95%



Geospatial and Mapping

- **Earthquake Modeling** – Defines shake area and reduces inspection footprint
- **Predictive Capabilities** – Wildfires, Landslides, Flooding

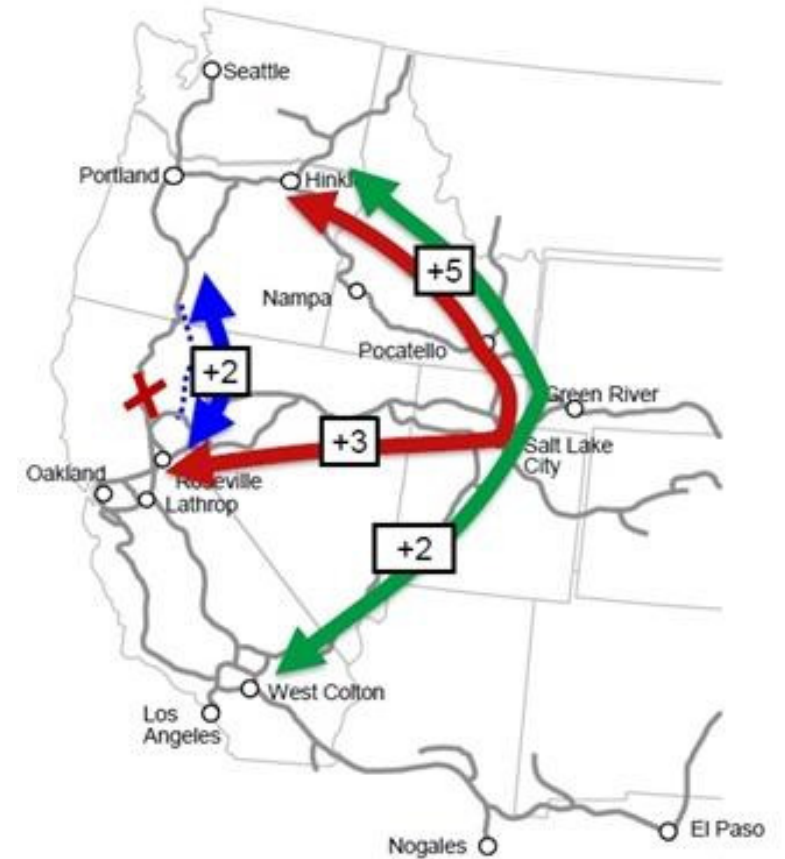


Wildfires – Historic Impact – Climate Change

Lava Fire (Black Butte Sub) 6/28/2021 – 8/1/2021



The Lava Fire damaged the Union Pacific's Dry Canyon Bridge located near Hotlum, California.



2021/22 Wildfires – Historic Impact



- Dixie Fire (Canyon Sub)
– 7/4/2021 – 8/1/2021



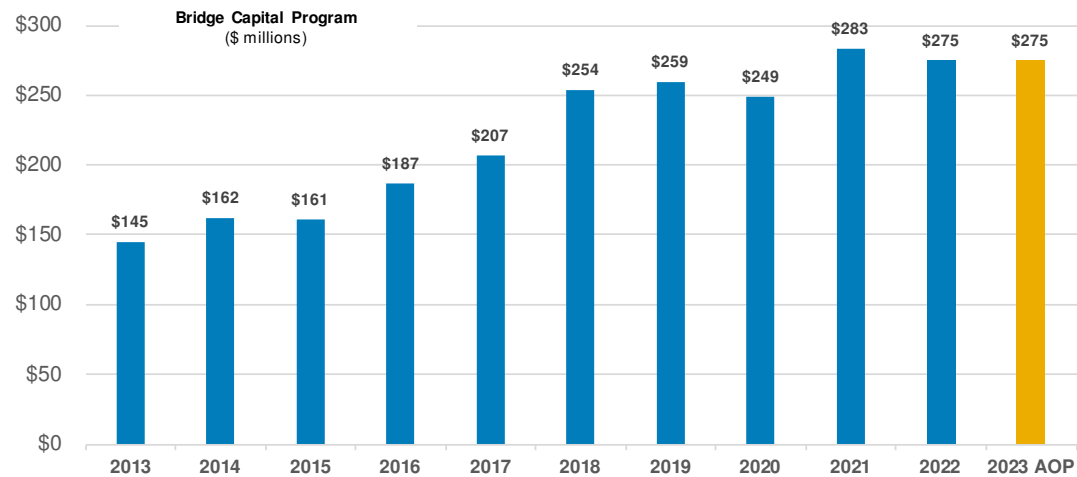
- Beckwourth Fire (Winnemucca Sub)
– 7/11/2021 – 7/12/2021



Palestine Subdivision – September 2022



Structures Capital Investment



- Continue to address Timber Bridges
 - 59.5 miles remain on UP system
- Average a bridge replaced at a rate of one every other day



Wister, CA – The Bubbling Mud Pot



- Caused by water or sulfurous gas being pushed up through soil and sediment
- Active since the 1950s, but aggressively began moving toward our tracks in 2018
- Efforts to install sheet pile to slow the movement of the mud pot were only mildly successful
- In 2018, constructed Shoofly tracks around the mud pot to continue to run business at a slightly reduced speed
- Currently impacting California highway 111, approx. 4 – 6 months away from being clear of tracks at which time UPRR will correct alignment



California Atmospheric River

- 750" of snowfall during the season – the second highest total ever recorded

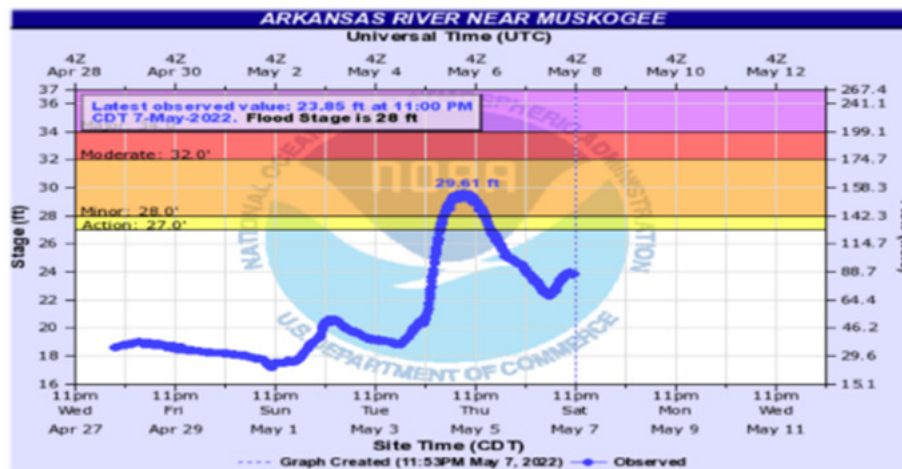


Austin, TX Development Impact



Wagoner Sub MP563 Slope Failure

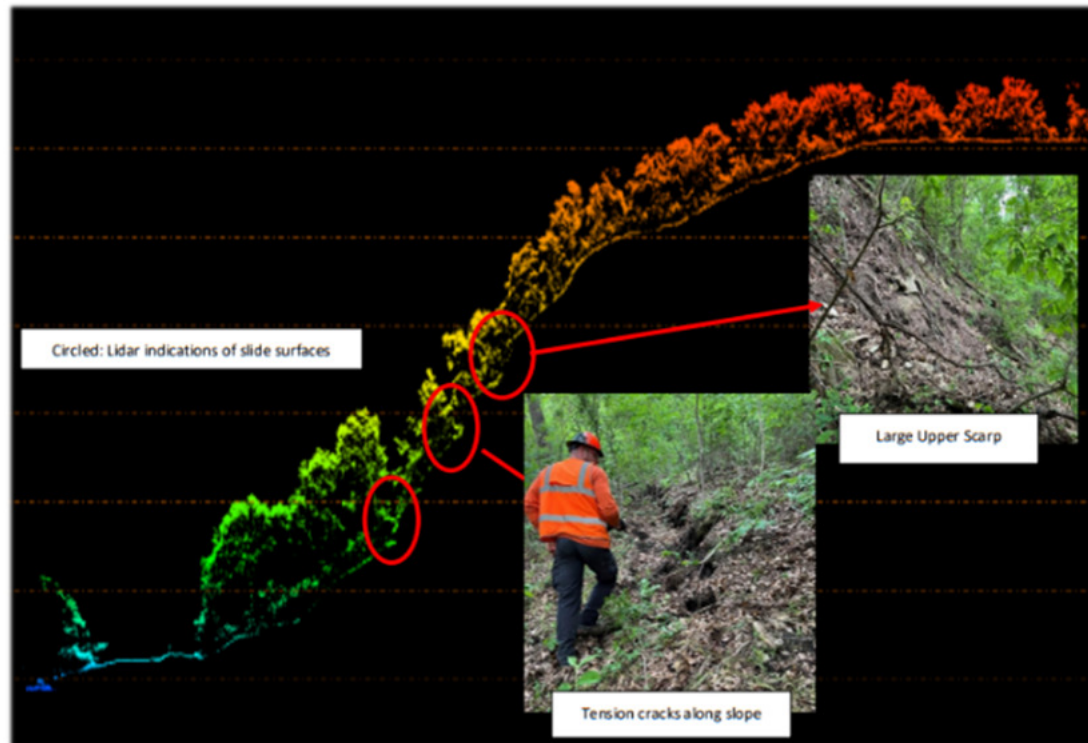
- Greater than 8 inches of rain in 24-hour period in early May 2022
- Over 5 inches of rain fell in a 3-hour period – Greater than 500-year flood event
- Massive waterflow spike in Arkansas river coinciding with the slope failure event – large amount of runoff toward the river
- Estimated repair cost \$2-5M initial stabilization repairs, \$3M long term repair (US Dollars)
- Repair completed as in December 2022
- Failure section was ~1100 feet long and over 150 feet high – Loose rock layer with clay soils

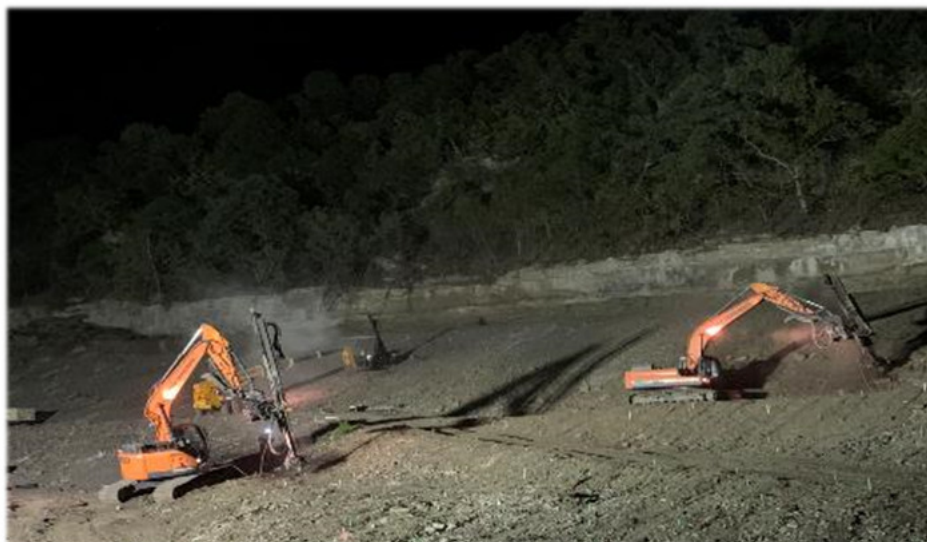


Stabilizing the Slope - May



Discovering the Scope of the





Slope following initial clearing and repair work - June



Draining the Slope - August



**Horizontal Drain
Wagoner Slope Stabilization
10/18/2022**



Video Courtesy of our
contractor Rock
Supremacy

Installing Additional Drainage – September



Repair Nearing Completion - November



Final Pins and Drainage Installed – December

