Broadband Communications Design Strategies and Considerations

For ITS Applications in District 2

The Evolution of Communications System Architecture and Supporting Emerging Technologies

Jeremiah Pearce P.E., Caltrans District 2

Keith Koeppen P.E., Caltrans District 2

Kenny Shipley, Caltrans District 2

Abstract

The availability of robust high-speed communication options continue to be limited in remote rural areas of Northern California. Caltrans District 2 has made improvements by installing State-owned point-to-point microwave communications infrastructure to expand the availability of high-speed communications through the Interstate 5 corridor. In addition, the State of California has invested $3.25 billion into an ambitious plan to provide broadband capabilities to rural areas of California through the Middle Mile Broadband Network (MMBN). As the MMBN projects are designed and constructed a broader communications strategy has been developed to fit within the architectural framework of District 2's existing point-to-point microwave and fiber-optic communications systems.

This presentation will outline the strategy, design, and implementation of Caltrans District 2's Field Element Network (FEN) communications systems and highlight two private point-to-point microwave projects that support the strategic direction of District 2's communications plan.

List of Acronyms

POTS – Plain Old Telephone Service

ISDN – Integrated Services Digital Network

ISM – Industrial, Scientific, and Medical (License free spectrum)

TMC – Transportation Management Center

TMS – Transportation Management System

IP – Internet Protocol

ITS – Intelligent Transportation System

CWWP2 – Caltrans Commercial Wholesale Web Portal 2

List of Acronyms

RSL – Received Signal Level

MMBN – Middle Mile Broadband Network

CAV – Connected and Autonomous Vehicles

CCTV – Closed Circuit Television

CMS – Changeable Message System

RWIS – Road Weather Information System

HAR – Highway Advisory Radio

CDT – California Department of Technology

POP – Point-of-presence

References

- Relevant Past Presentations
  - “Microwave Communications for Rural ITS Applications”, Ian Turnbull, June 2006 http://www.westernstatesforum.org/Documents/2006/2006%20WSRTTIF%20Turnbull.pdf
    - Relevant topics
      - Deployment strategy
      - Frequency planning
      - Path clearances and calculations
      - Reliability requirements
      - Link Budget

References

- Relevant Past Presentations
  - “Field Element Network Design for a Rural Transportation Management Center, Parts One and Two” Ian Turnbull and Jeremiah Pearce, June 2012
- Relevant topics
  - Small, winter operations, wildfires, floods, major freight corridor incidents, etc.
  - Harsh field conditions, telecommunications issues
  - TMC architecture (Dial-on-Demand, ITS Node, etc)

References

- Relevant Past Presentations
  - “Field Element Network Design for a Rural Transportation Management Center, Parts One and Two” Ian Turnbull and Jeremiah Pearce, June 2012

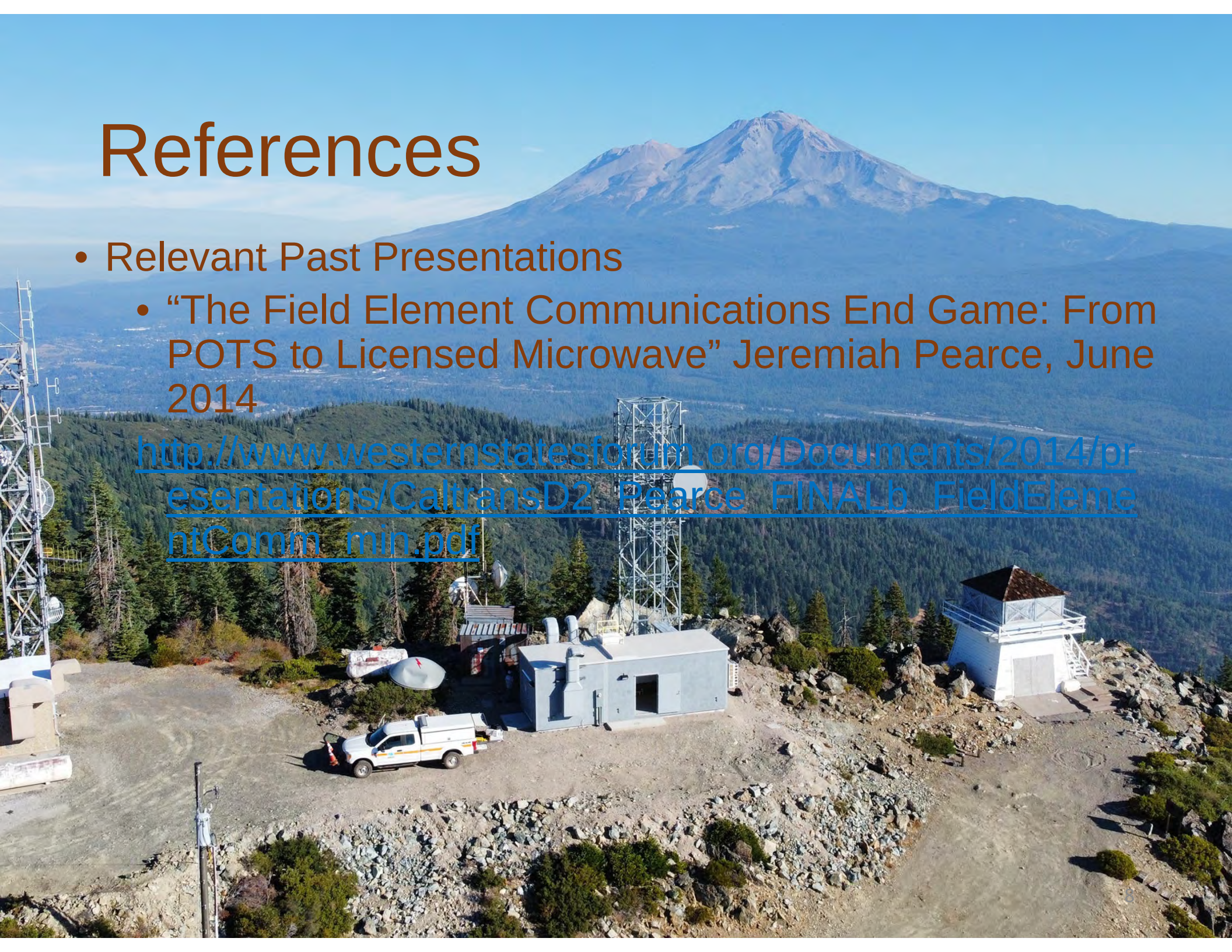
http://www.westernstatesforum.org/Documents/2012/presentations/CaltransD2_Turnbull_FINAL_FEN-TMCPrequel.pdf

http://www.westernstatesforum.org/Documents/2012/presentations/CaltransD2_Pearce_Final2_FEN_TMC_Part2.pdf

References

- Relevant Past Presentations
  - “The Field Element Communications End Game: From POTS to Licensed Microwave” Jeremiah Pearce, June 2014

http://www.westernstatesforum.org/Documents/2014/presentations/CaltransD2_Pearce_FINALb_FieldElementComm_min.pdf



References

- Relevant Past Presentations
  - “Cellular Communications in Rural Applications” Keith Koeppen, June 2018

http://westernstatesforum.org/Documents/2018/Presentations/CaltransD2_Koeppen_FINAL_WEB_CellularCommInRuralApplications.pdf

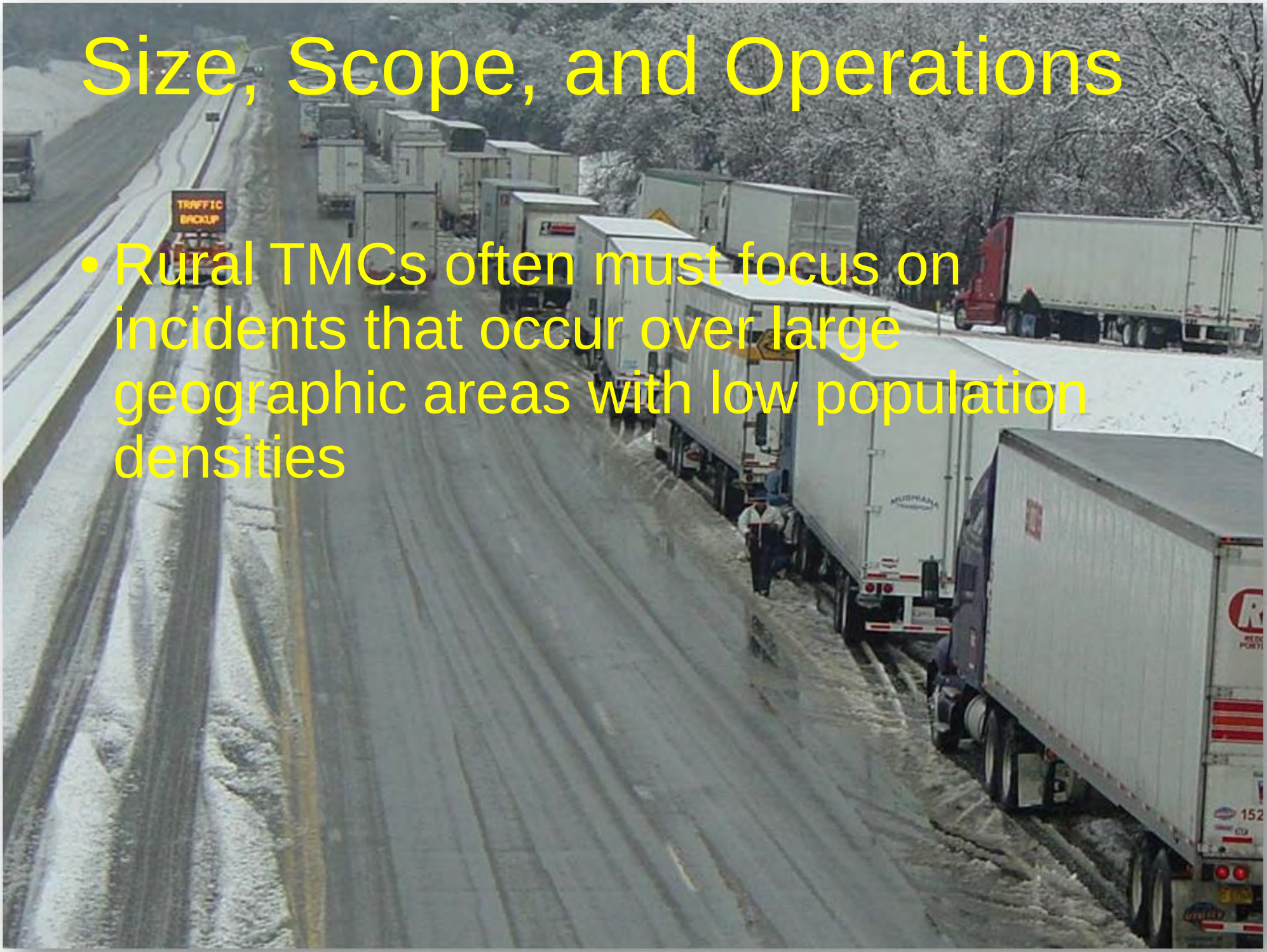
References

- “Engineering Considerations for Microwave Communications Systems” GTE Lenkurt, 1970
- “Standards and Guidelines for Communication Sites – R56” Motorola, 2000

- **Photos Courtesy Of,**
  - **Ian Turnbull**
  - **Keith Koeppen**
  - **Lonnie Hobbs**
  - **Jeff Worthington**
  - **Google Images**


CCTV - Closed Circuit Television Camera | RWIS - Road Weather Information System | CCTV/RWIS
Southwestern Oregon Cams
Southcentral Oregon Cams
Southeastern Oregon Cams
District 2 is comprised of seven counties in Northeastern California
Caltrans District 2 Map
Northwestern California Cams
SISKIYOU
MODOC
SHASTA
LASSEN
TRINITY
TEHAMA
PLUMAS
BUTTE
SIERRA
NEVADA
Happy Camp
Seiad
Yreka
Fort Jones
Etna
Grass Lake
Dorris
Alturas
Weed
Mt. Shasta
McCloud
Callahan
Bartle
Adin
Bieber
Nubieber
McArthur
Fall River Mills
Burney
Hat Creek
Old Station
Willow Creek
Trinity Center
Gibson
Lakehead
Weaverville
Hayfork
Redding
Bella Vista
Palo Cedro
Shingletown
Anderson
Cottonwood
Platina
Red Bluff
Corning
Los Molinos
Orland
Chico
Chester
Mill Creek
Susanville
Greenville
Quincy
Beckwourth

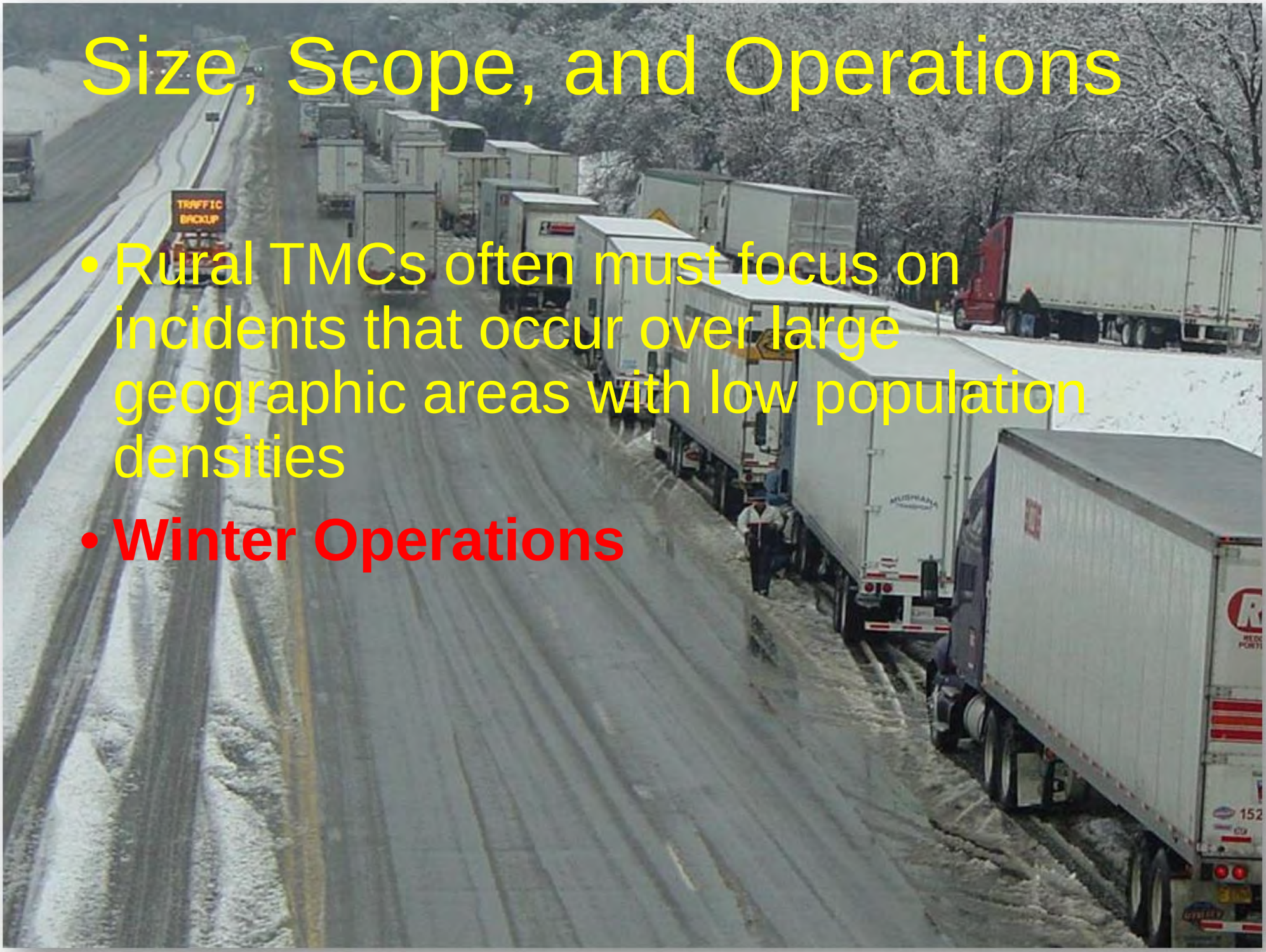
Size, Scope, and Operations



- Rural TMCs often must focus on incidents that occur over large geographic areas with low population densities

Photo by Keith Koeppen/ D2 ITS Engr & Support

Size, Scope, and Operations



- Rural TMCs often must focus on incidents that occur over large geographic areas with low population densities
- **Winter Operations**

Photo by Keith Koeppen/ D2 ITS Engr & Support

Size, Scope, and Operations

- Rural TMCs often must focus on incidents that occur over large geographic areas with low population densities
- Winter Operations
- **Wildfire**

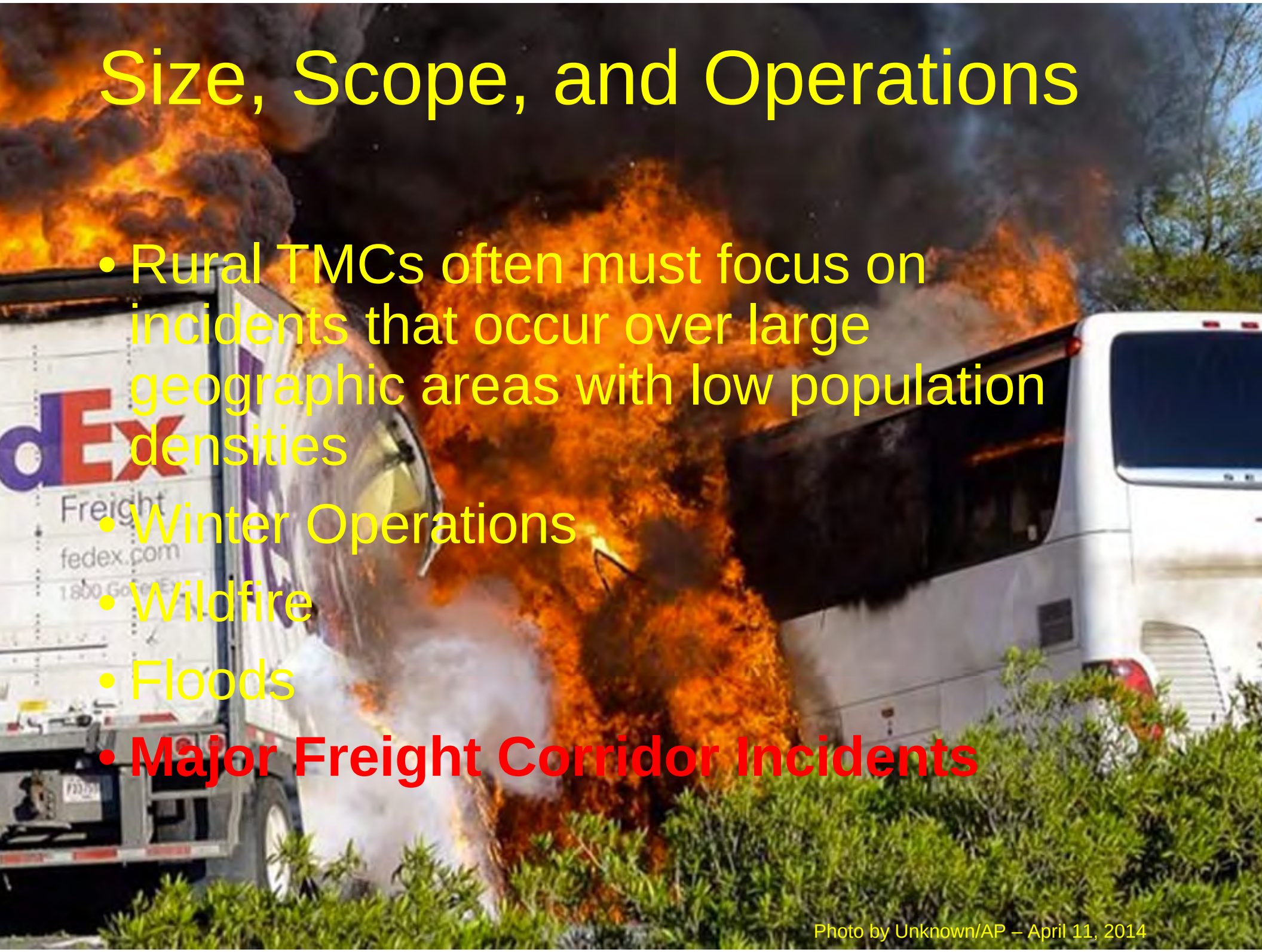
Photo by Matthew Henderson / ONFIRE PHOTOS

Size, Scope, and Operations

- Rural TMCs often must focus on incidents that occur over large geographic areas with low population densities
- Winter Operations
- Wildfire
- **Floods**

Photo by Randy Pench/The Sacramento Bee

Size, Scope, and Operations



- Rural TMCs often must focus on incidents that occur over large geographic areas with low population densities
- Winter Operations
- Wildfire
- Floods
- **Major Freight Corridor Incidents**

Photo by Unknown/AP – April 11, 2014

Size, Scope, and Operations

Size, Scope, and Operations

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Size, Scope, and Operations

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- They are generally not staffed 24/7 unless there is an event or during winter operations
- This may be changing soon

Size, Scope, and Operations

- The Rural TMC collects data from the following sources:

Size, Scope, and Operations

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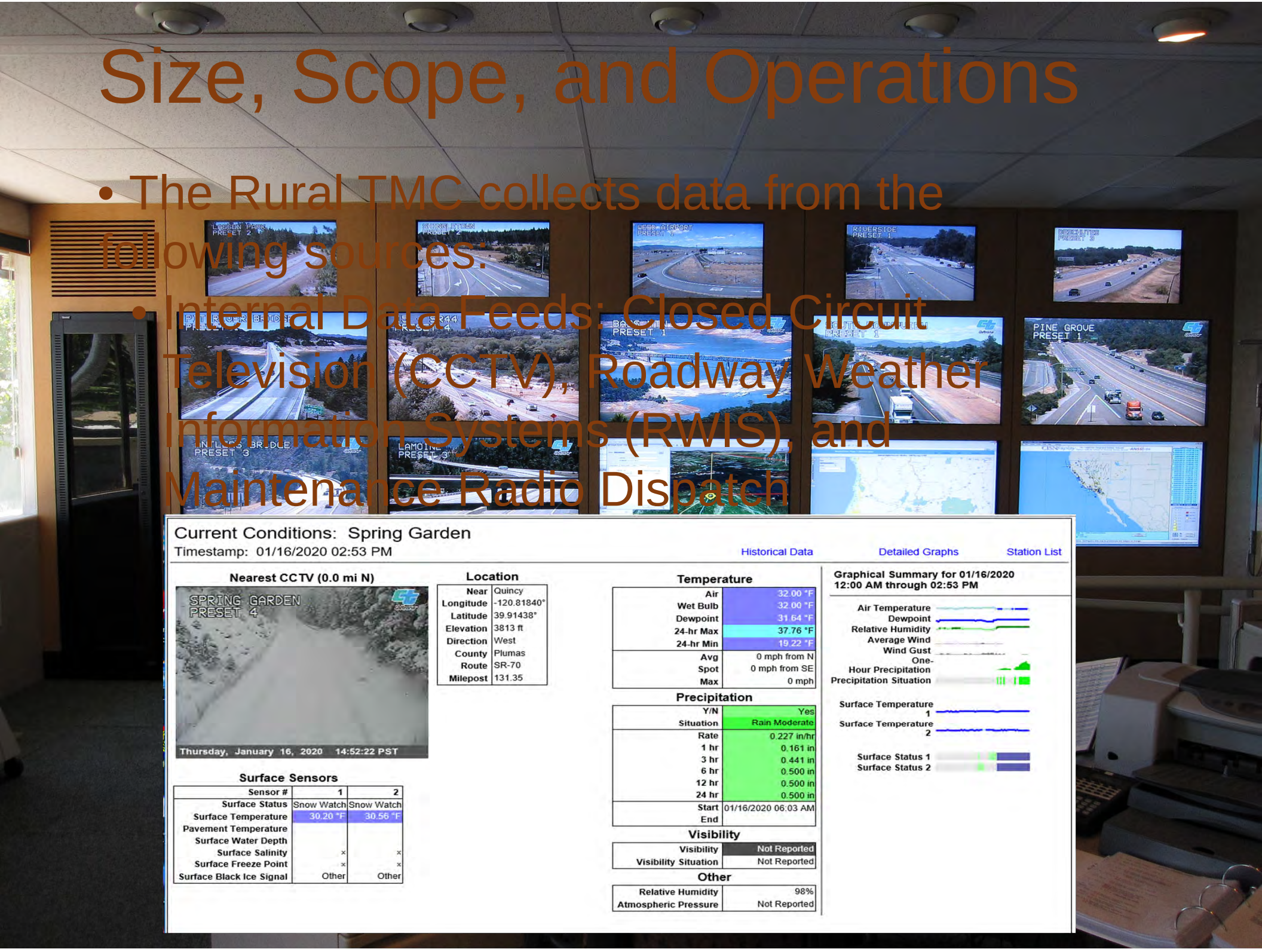
  - Internal Data Feeds: Closed Circuit Television (CCTV), Roadway Weather Information Systems (RWIS), and Maintenance Radio Dispatch



Size, Scope, and Operations

- The Rural TMC collects data from the following sources:
  - Internal Data Feeds: Closed Circuit Television (CCTV), Roadway Weather Information Systems (RWIS), and Maintenance Radio Dispatch
  - External Data and Partners: California Highway Patrol, National Weather Service, CalFire, etc.

Size, Scope, and Operations

Size, Scope, and Operations

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Size, Scope, and Operations

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- Changeable Message Sign (CMS, VMS, DMS)

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- The Rural TMC then controls various ITS elements to communicate en-route traveler information through the following:
- Highway Advisory Radio (HAR) System

Size, Scope, and Operations

- The Rural TMC then controls various ITS elements to communicate en-route traveler information through the following:
- The Caltrans Commercial Wholesale Web Portal 2 (CWWP2)

Caltrans :: Commercial Wholesale Web Portal :: Version 2

Description

California has 12 unique districts that have Intelligent Transportation Syste
the individual district ITS data available in a uniform manner. ITS field data
Chain Controls has been reviewed and given precise location information
Wholesale Web Portal 2 (CWWP2).

The ITS datasets in the CWWP2 are provided in four different documente
Text - TXT) so that third party application developers can integrate Caltran

Conditions of Use

Please read the Conditions Of Use before using these data sets.

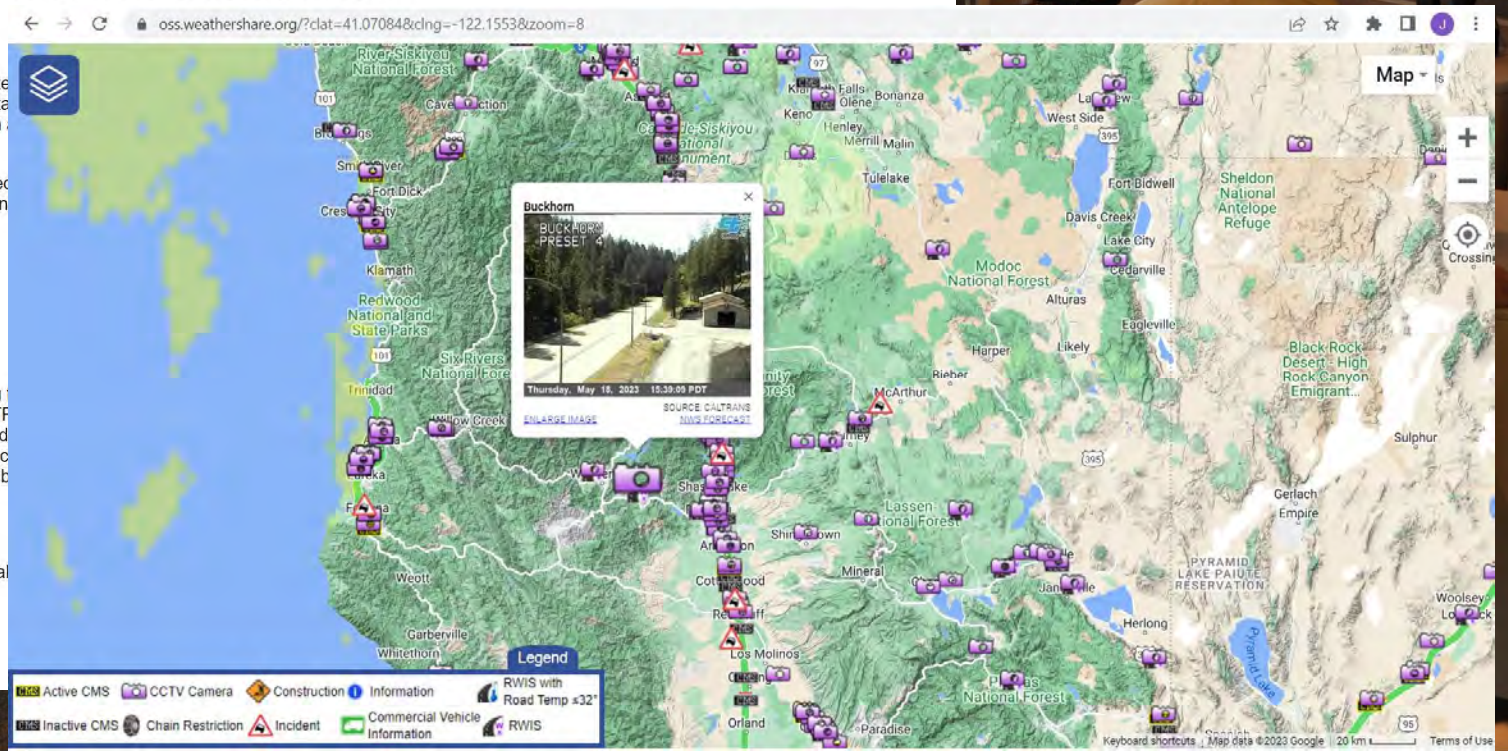
Announcements

- October 20, 2020 : On November 9, 2020 Caltrans will be migrating
be available until November 9th, 2020 and will be redirected to HTTP
and applications that utilize the CWWP2 as necessary to accommod
- July 23, 2019 : On October 1, 2019 traveler information data files loc
in your application. Please start using this website as soon as possib

Data Format and File Layout

Data is available in four file formats that contain the same information to a

- CSV - Comma Separated Values
- JSON - JavaScript Object Notation
- TXT - Text file with delimeter value of "ÿ" or 0xFF
- XML - Extensible Markup Language



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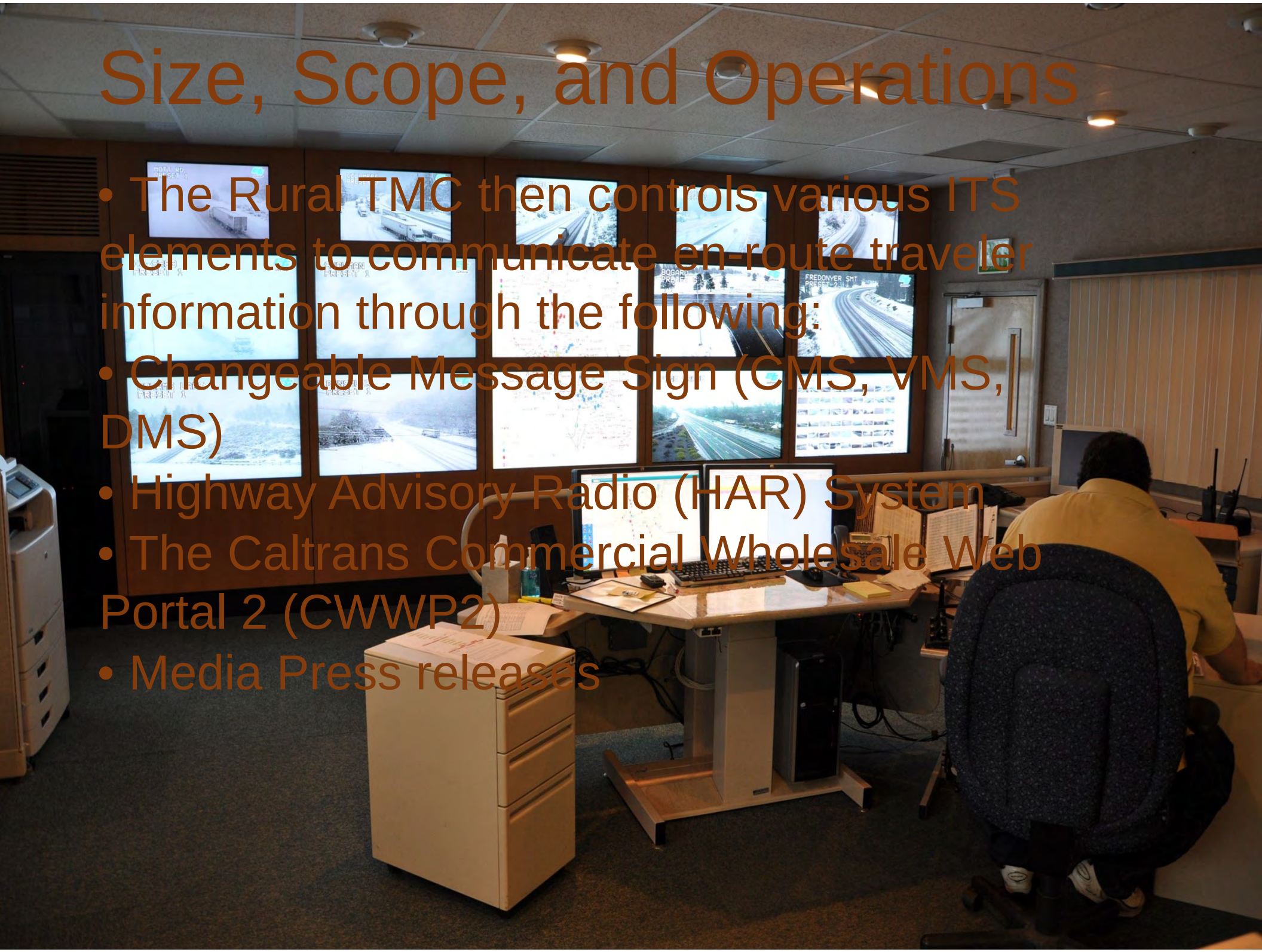

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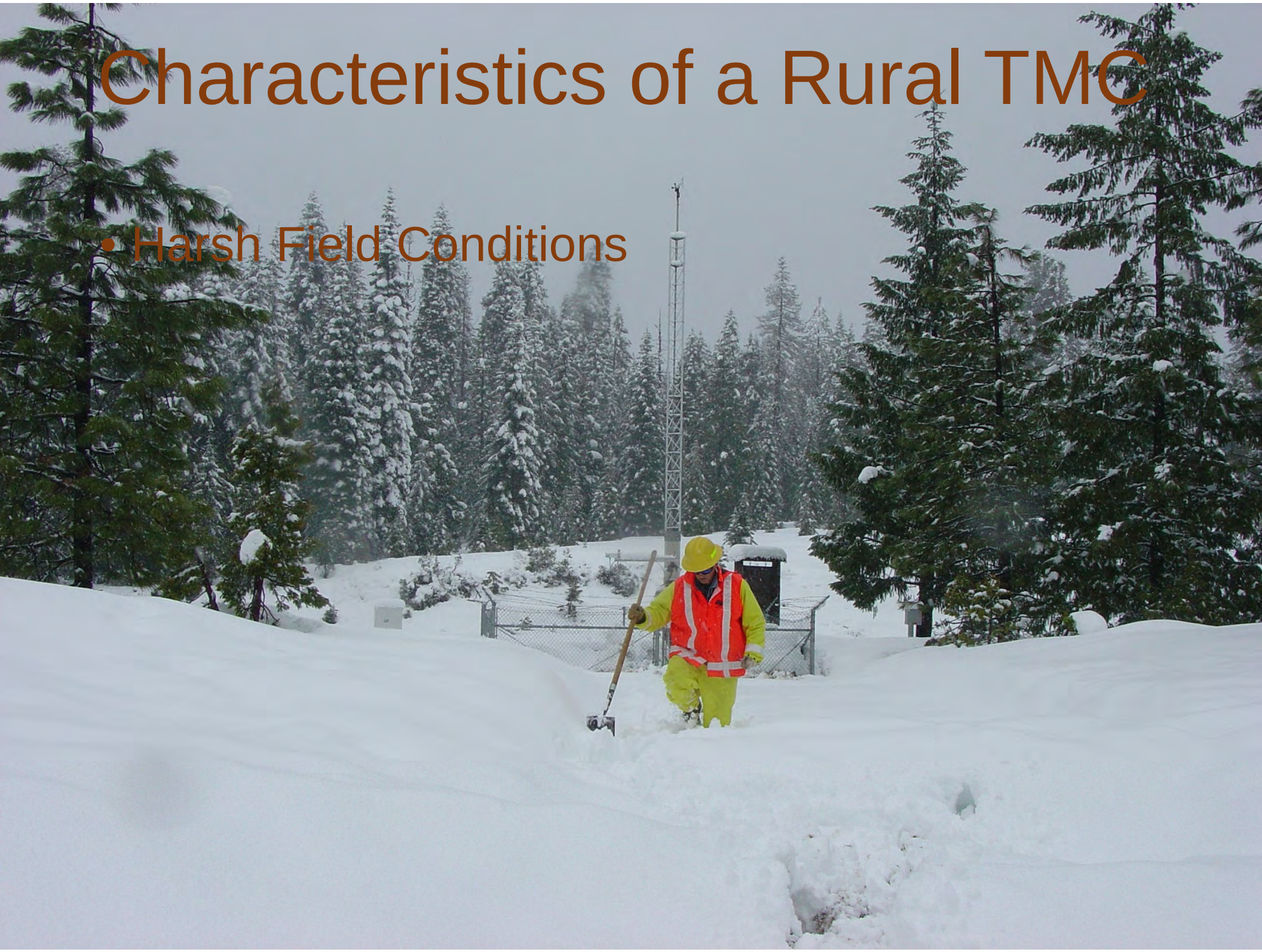
- Changeable Message Sign (CMS, VMS, DMS)
- Highway Advisory Radio (HAR) System
- The Caltrans Commercial Wholesale Web Portal 2 (CWWP2)
- Media Press releases

Characteristics of a Rural TMC

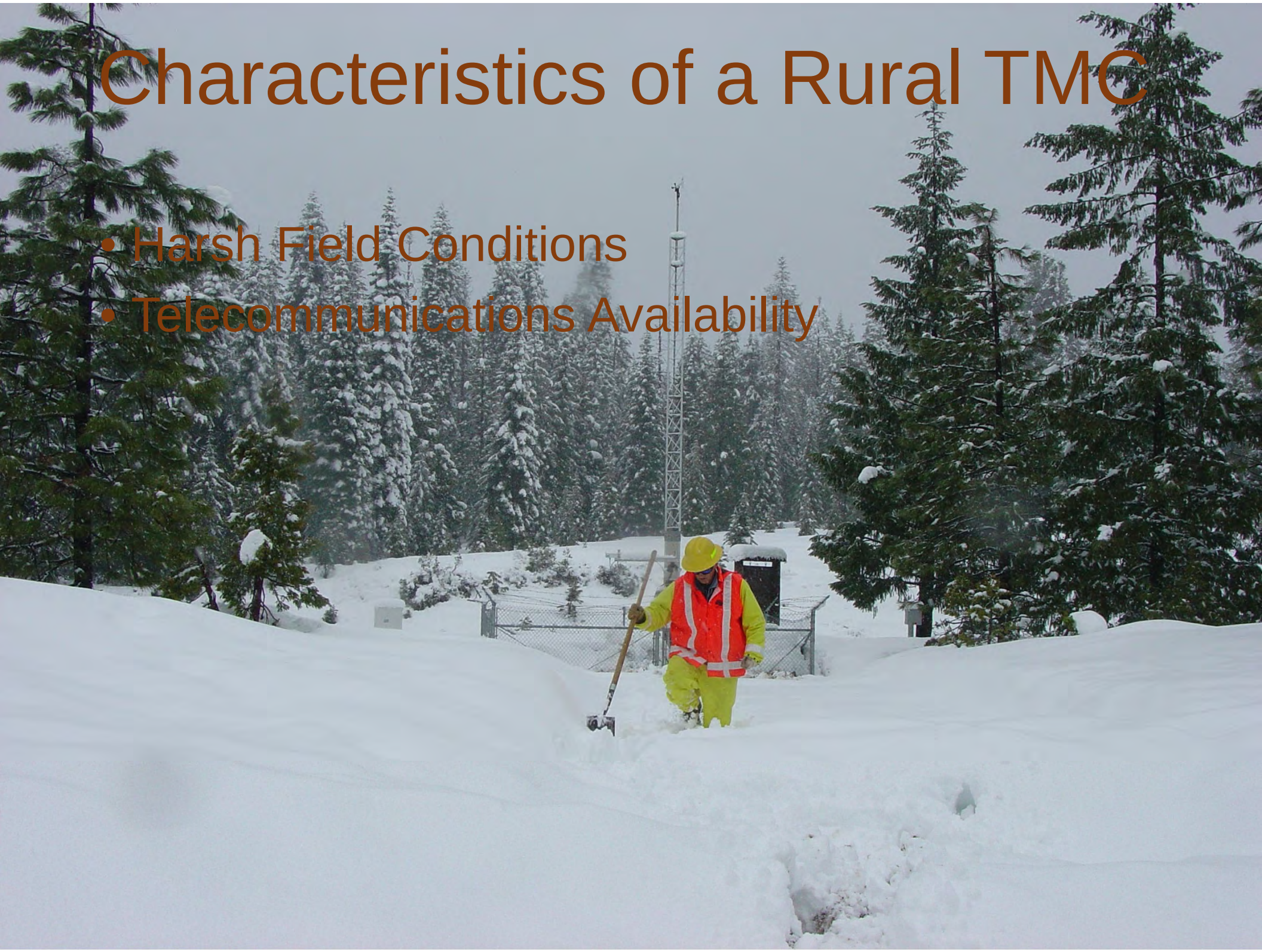
Characteristics of a Rural TMC

- Harsh Field Conditions



Characteristics of a Rural TMC

- Harsh Field Conditions
- Telecommunications Availability



Harsh Field Conditions

In addition to the typical conditions we see with sensitive electronic equipment on the roadside (dust, humidity, vibration, etc.):

- Winter temperatures of –30° F in some locations and summer temperatures of +120° F in the Sacramento Valley
- Heavy Mountain Snow
- Extreme wildfire risks and behavior
- Valley Floods
- The field conditions can be as challenging as anywhere in the US

Telecommunications

Telecommunications

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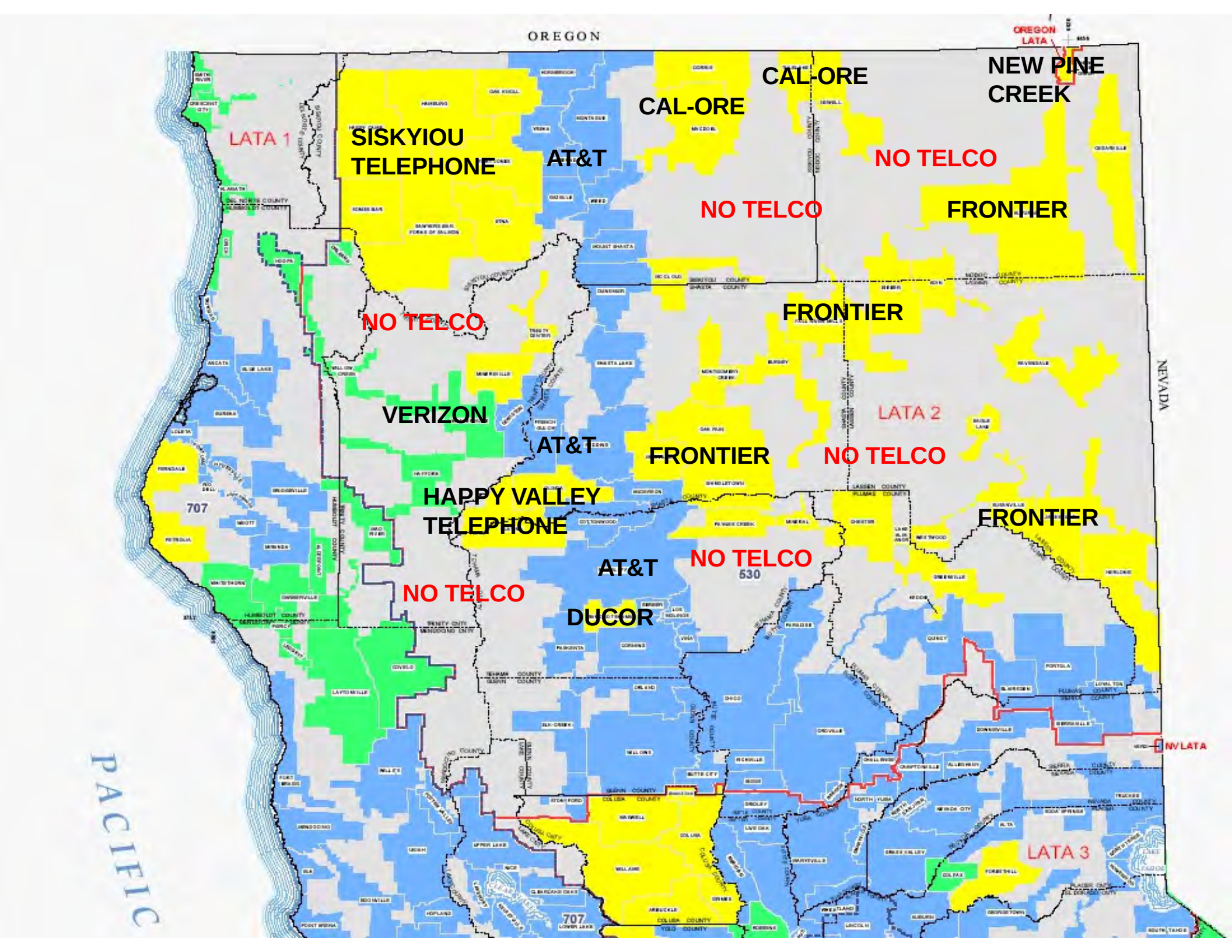
- District 2 is served by a total of eight different telcos of varying size and capability


OREGON
OREGON LATA
NEW PINE CREEK
CAL-ORE
CAL-ORE
LATA 1
SISKYIOU TELEPHONE
AT&T
NO TELCO
FRONTIER
NO TELCO
FRONTIER
NEVADA
VERIZON
LATA 2
AT&T
FRONTIER
NO TELCO
HAPPY VALLEY TELEPHONE
707
FRONTIER
AT&T
NO TELCO
530
NO TELCO
DUCOR
NV LATA
LATA 3
707
PACIFIC

Telecommunications

- Telco services available in cities are often not available in rural areas
- District 2 is served by a total of eight different telcos of varying size and capability
- Many areas of the District have no designated telephone company

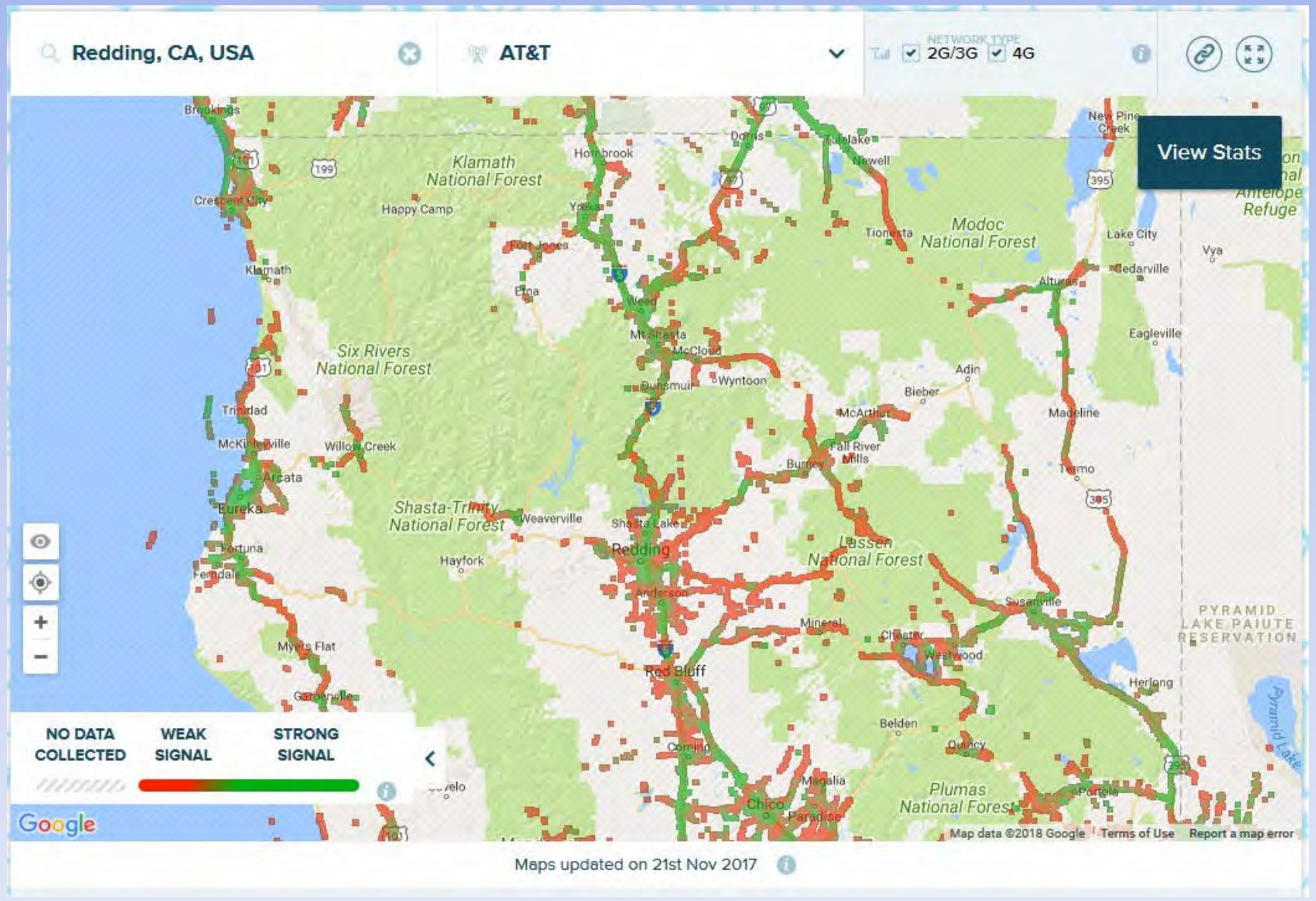
Telecommunications

District 2 Telco Services generally limited to:

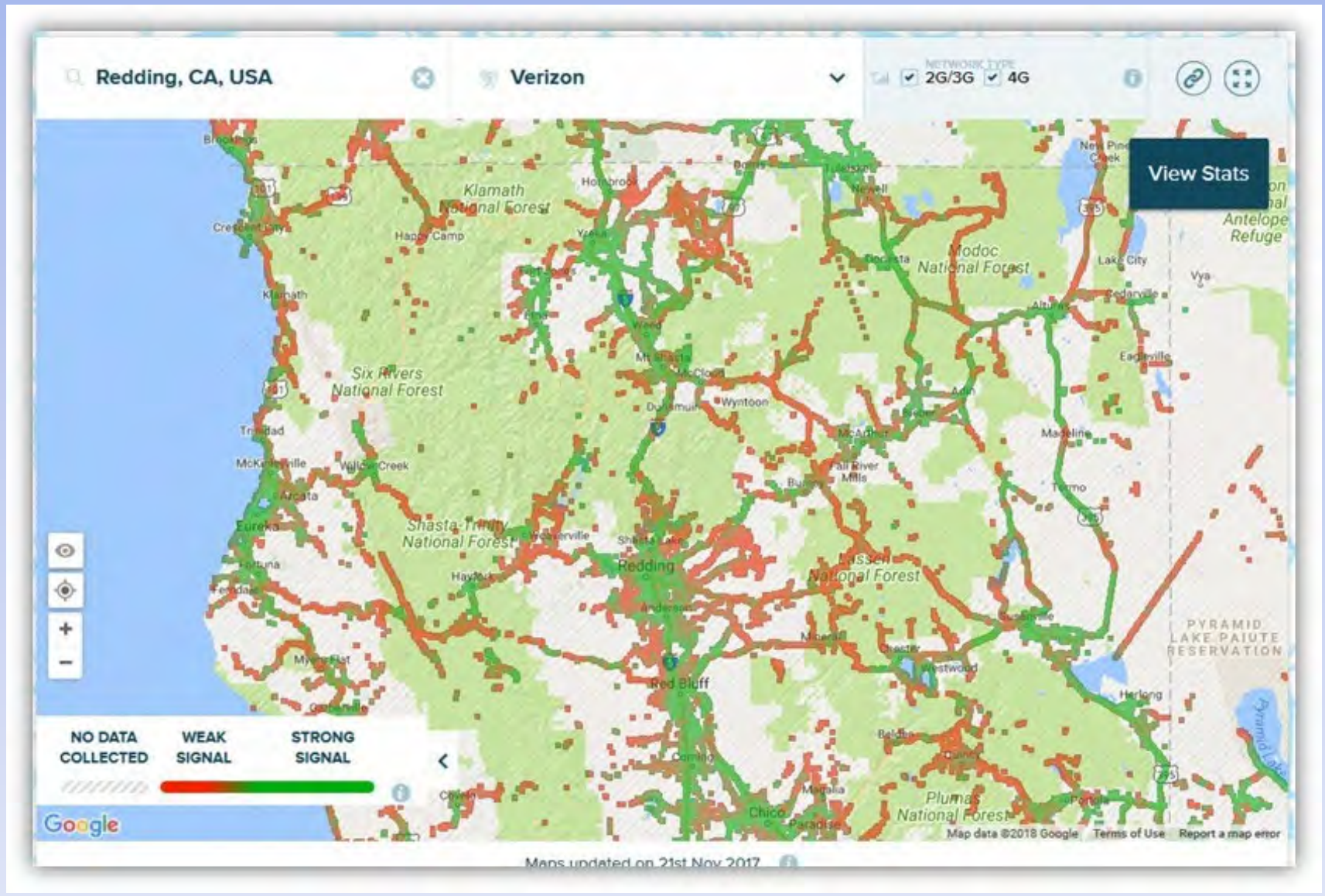
- POTS
- ISDN (AT&T area only)
- Land-line telco broadband/Leased-line (limited)
- Cellular (limited)
- Satellite
- Public/Private Fixed Wireless (limited)

- Not all services are available in all areas

Cell Coverage Map – AT&T



Cell Coverage Map – Verizon



Telecommunications

District 2 Utilizes the following Services for TMS:

- **POTS**
- **ISDN (AT&T area only)**
- ~~Land-line telco broadband/Leased-line (limited)~~
- **Cellular (limited and only with a POTS backup)**
- ~~Satellite~~
- ~~Public/Private Fixed Wireless (limited)~~

- Not all services are available in all areas

Telecommunications

In addition, District 2 utilizes the following Department-owned communications infrastructure for TMS:

- **Fiber**
- **Point-to-Point Microwave**

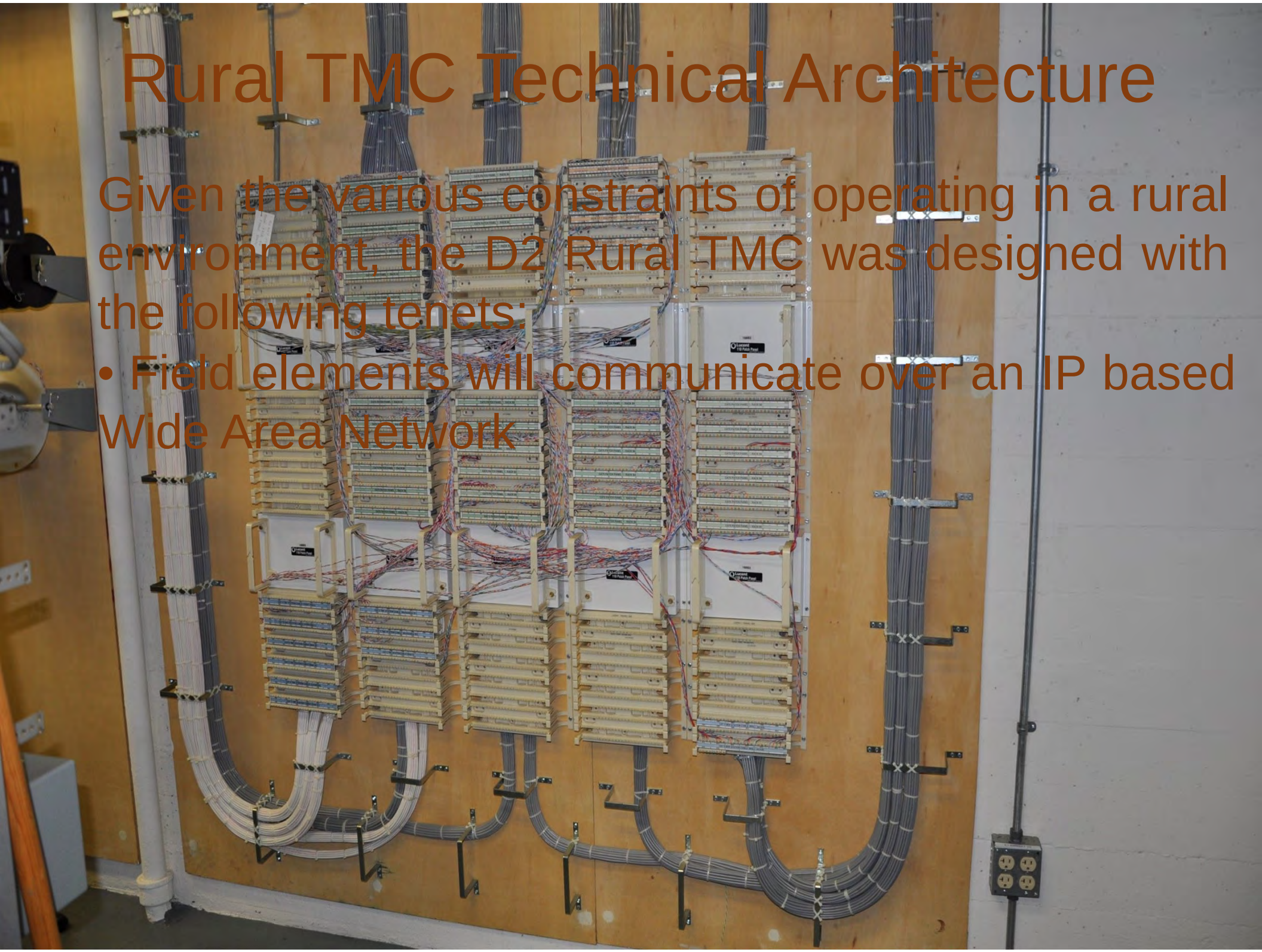
Rural TMC Technical Architecture

All of this requires a robust technical architecture that will support reliable operations during the most severe conditions.

Rural TMC Technical Architecture

Given the various constraints of operating in a rural environment, the D2 Rural TMC was designed with the following tenets:

Rural TMC Technical Architecture



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Rural TMC Technical Architecture

Given the various constraints of operating in a rural environment, the D2 Rural TMC was designed with the following tenets:

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- All cabling will use a standards based, structured cabling approach

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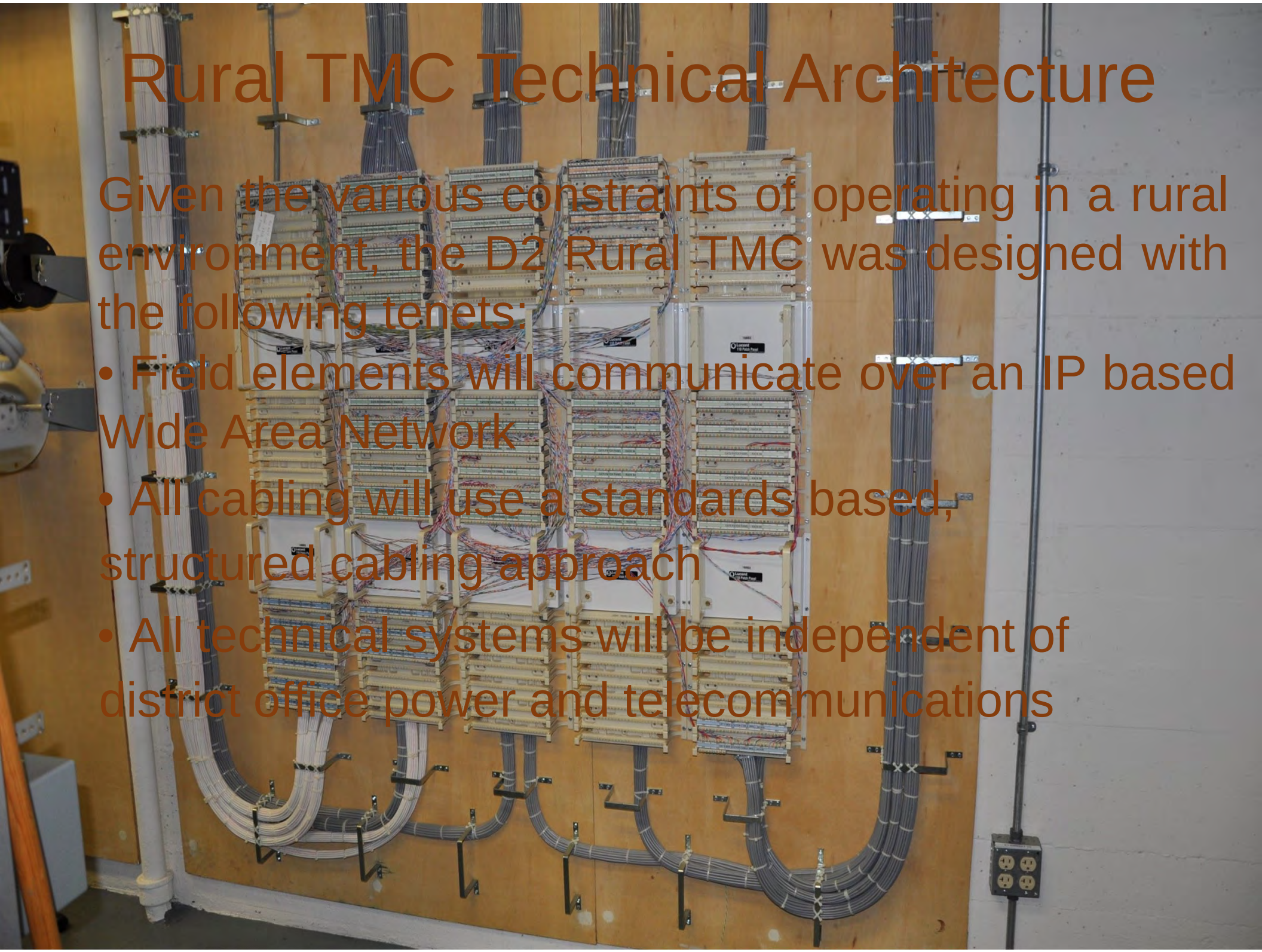

Given the various constraints of operating in a rural environment, the D2 Rural TMC was designed with the following tenets:

- Field elements will communicate over an IP based Wide Area Network
- All cabling will use a standards based, structured cabling approach
- All technical systems will be independent of district office power and telecommunications

Rural TMC Technical Architecture

Given the various constraints of operating in a rural environment, the D2 Rural TMC was designed with the following tenets: (continued)

- All technical system will be independent of Enterprise IT and HQ services

Rural TMC Technical Architecture

Given the various constraints of operating in a rural environment, the D2 Rural TMC was designed with the following tenets: (continued)

- All technical system will be independent of Enterprise IT and HQ services
- All Department owned communication links designed to 5-9's reliability

Planning and Strategy (Legacy)

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  - District 2 has a general plan to expand coverage of the District's Point-to-Point Microwave System to Mt Top communications sites with strategic vantage points of the State Highway System

Planning and Strategy (Legacy)

- Communications Planning
  - District 2 has a general plan to expand coverage of the District's Point-to-Point Microwave System to Mt Top communications sites with strategic vantage points of the State Highway System
  - District 2 has a general plan for fiber in the Redding area (Shasta Lake to Anderson and East to Palo Cedro

Planning and Strategy (Legacy)

- Communications Strategies

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  - During site construction install the highest reliable, least costly utility service

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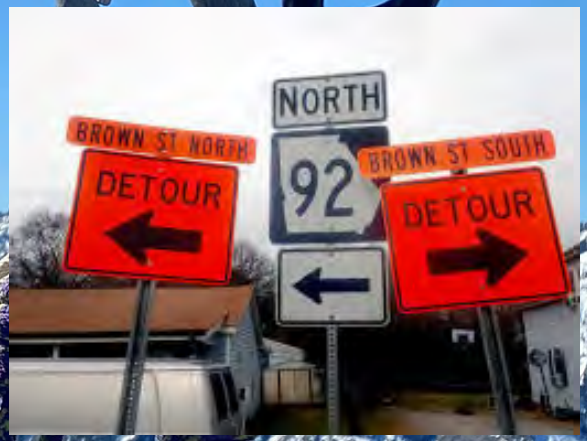
Planning and Strategy (Legacy)

- Communications Strategies
  - During site construction install the highest reliable, least costly utility service
  - Upgrade to ISM band microwave as a separate project if line-of-site is available
  - Upgrade to licensed microwave
  - Opportunistic upgrades (as funding allows)

Recent Changes



Recent Changes

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  - TOPD 21-10 “TMS Telecommunication Cost Management”
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- Middle Mile Broadband Network (MMBN)

Change Impact

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Advancing Technology

- How does this impact our deployment strategy and link planning efforts?

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Advancing Technology

- How does this impact our deployment strategy and link planning efforts?
- Industry drives the availability of parts and equipment, we are forced to mitigate obsolescence
  - POTS and ISDN
  - Analog Video
  - Network Equipment
  - Security
  - Etc.

Change Impact

Advancing Technology

- How does this impact our deployment strategy and link planning efforts?
- Industry drives the availability of parts and equipment, we are forced to mitigate obsolescence
- New applications and solutions often require new technology
  - CAV
  - Data Analytics
  - Etc.

Change Impact

Advancing Technology

- How does this impact our deployment strategy and link planning efforts?
- Industry drives the availability of parts and equipment, we are forced to mitigate obsolescence
- New applications and solutions often require new technology
- TMS technology evolution has been and will continue to be an ongoing issue

Change Impact

Caltrans Traffic Operations Statewide Communications Plan – June 2020

- How does this impact our deployment strategy and link planning efforts?

Change Impact

Caltrans Traffic Operations Statewide Communications Plan – June 2020

- How does this impact our deployment strategy and link planning efforts?
- Provides a tool to the District's to enhance communications planning efforts

Change Impact

Traffic Operations Division Policy

- How does this impact our deployment strategy and link planning efforts?
- TOPD 21-10 “TMS Telecommunication Cost Management”
  - “Districts shall consolidate communications lines and services to the extent possible”
  - “Districts should initiate projects to connect field elements to nearby available fiber”

Change Impact

Traffic Operations Division Policy

- How does this impact our deployment strategy and link planning efforts?
- TOPD 21-10 “TMS Telecommunication Cost Management”
- TOPD 22-03 “Statewide TMS Broadband Plan and Communication Management”
  - “Districts should identify their financially unconstrained plan and maximize the opportunity to build out their broadband infrastructure by including broadband communications in Transportation Management System (TMS) and other projects to the extent possible”

Change Impact

Traffic Operations Division Policy

- How does this impact our deployment strategy and link planning efforts?
- TOPD 21-10 “TMS Telecommunication Cost Management”
- TOPD 22-03 “Statewide TMS Broadband Plan and Communication Management”
- Requires significant investment by the Districts with no allocated funds for the work

Change Impact

Middle Mile Broadband Network (MMBN)

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Change Impact

Middle Mile Broadband Network (MMBN)

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Change Impact

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- Caltrans partnering to provide design and construction support

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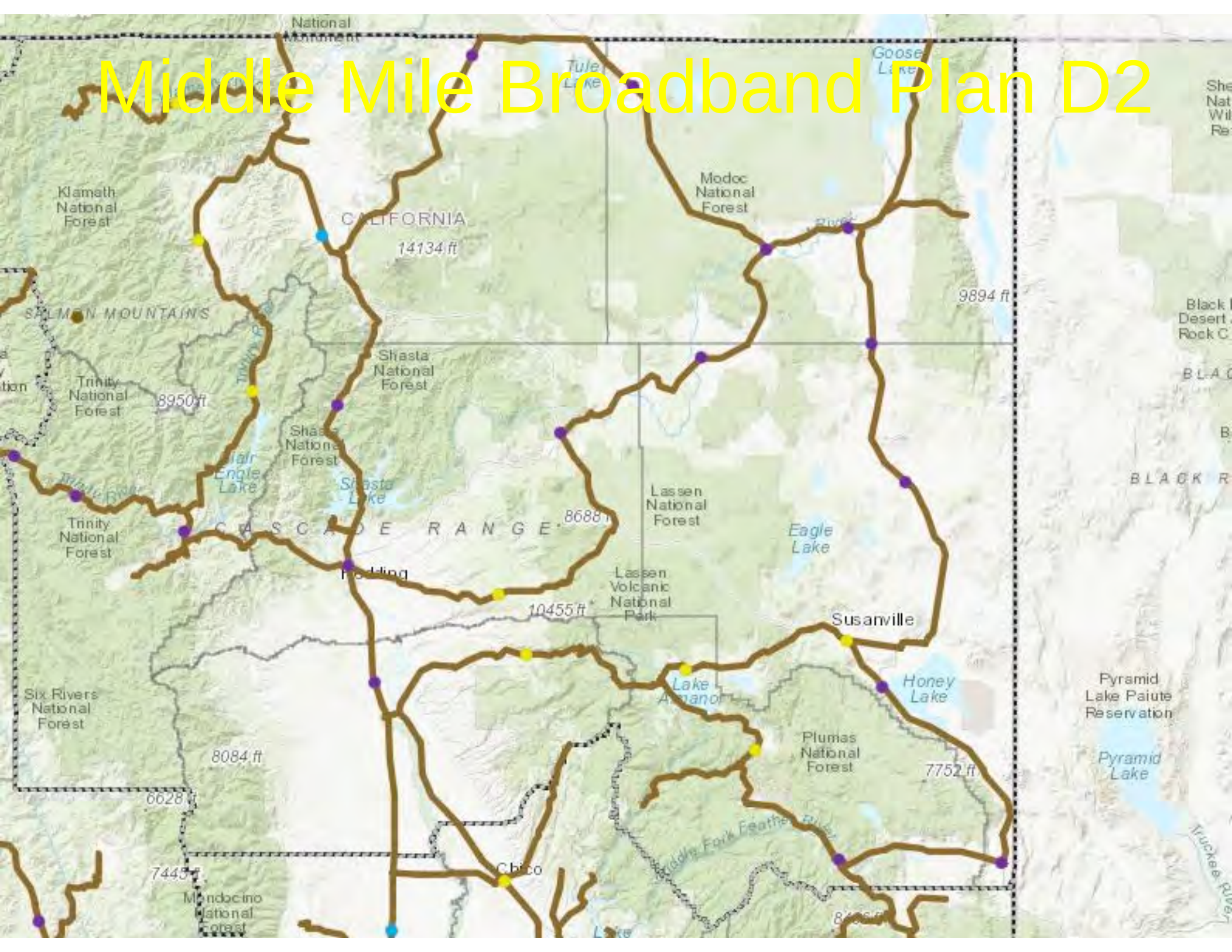
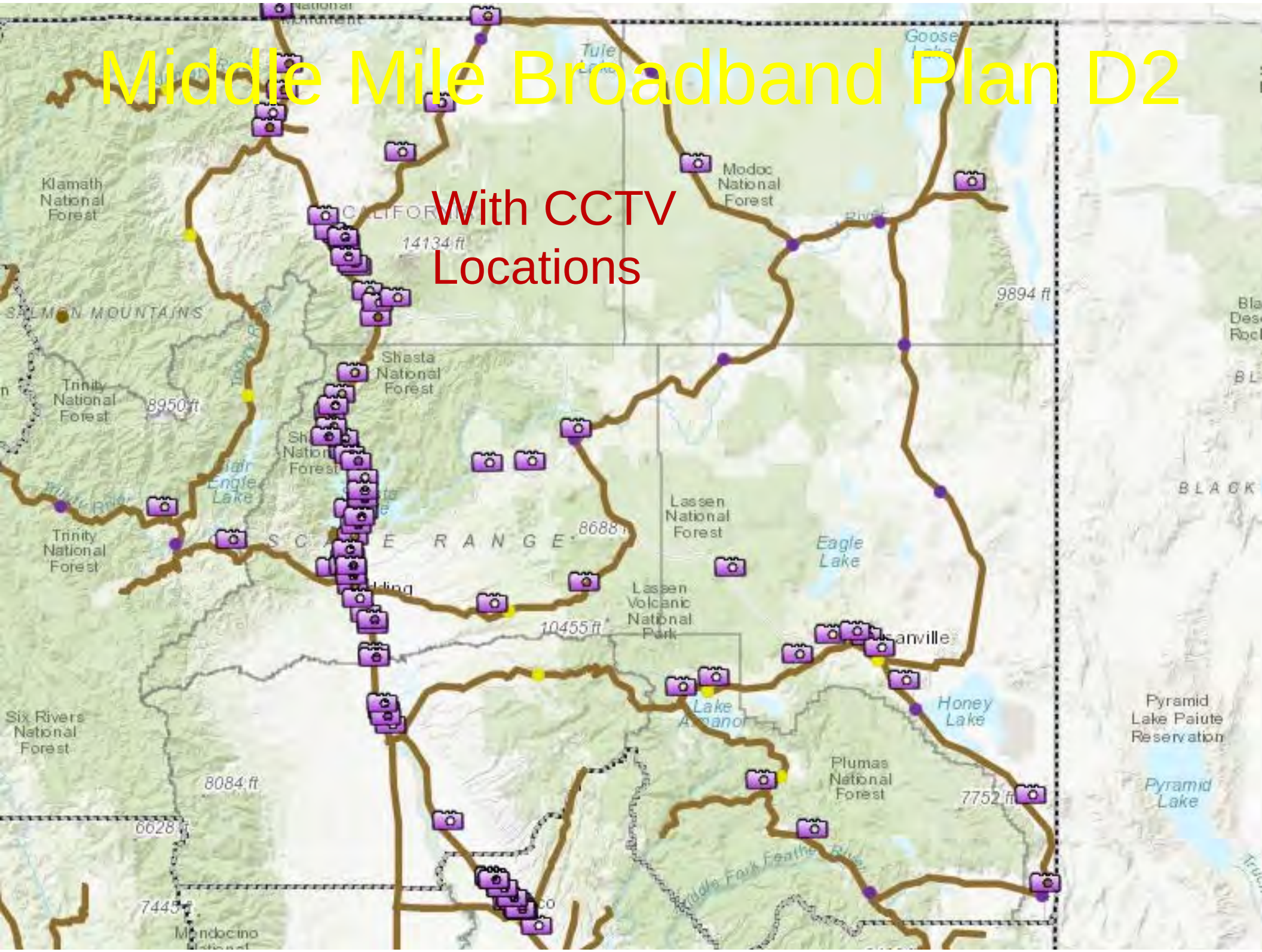
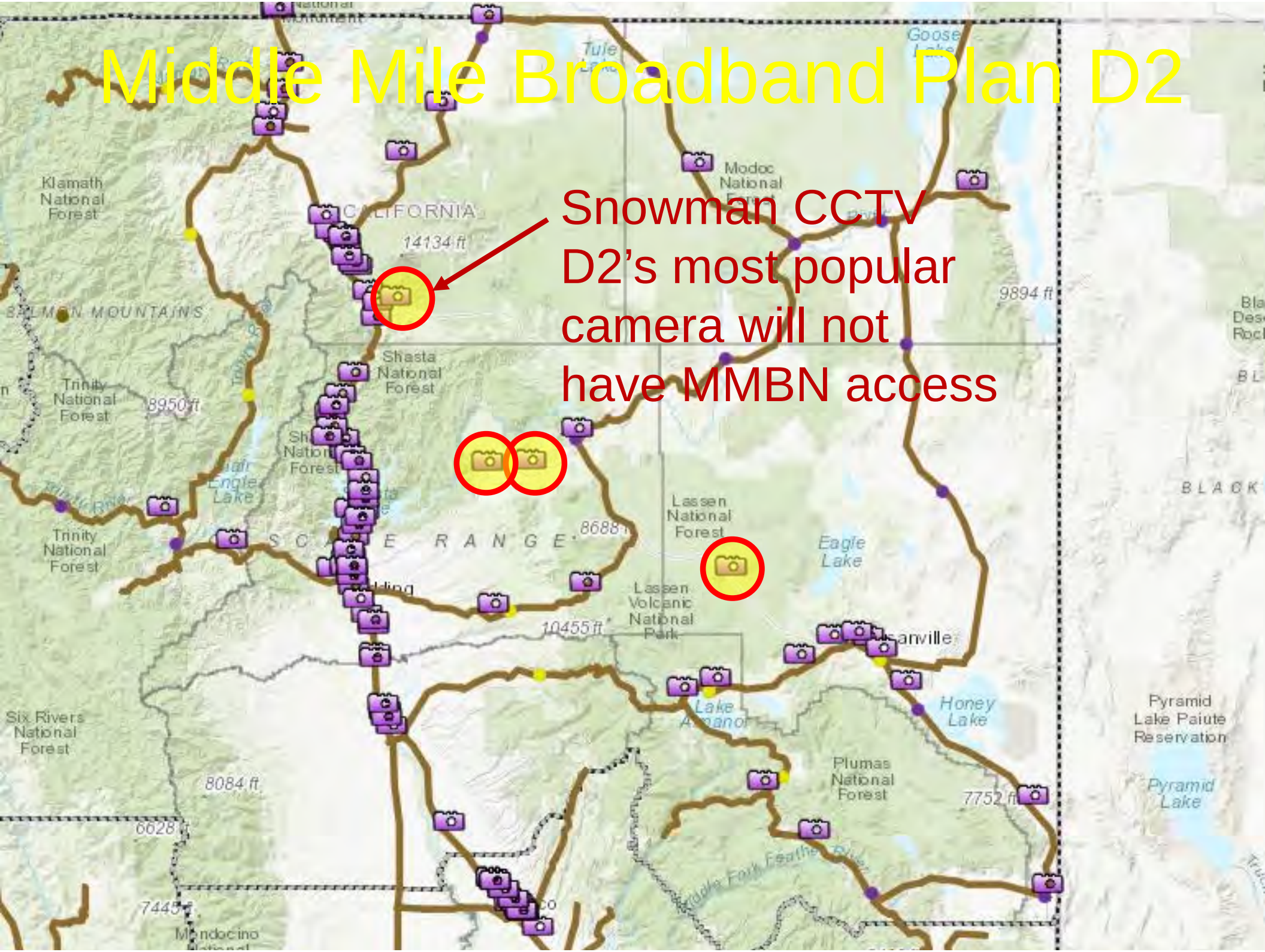
- What is it (SB 156)?
- $3.25B plan to deploy 10,000 miles of fiber optic communication within the State Highway R/W to underserved rural communities of CA
- CA Department of Technology is the facility owner
- Caltrans partnering to provide design and construction support
- All projects will be completed by December 2026


Middle Mile Broadband Plan D2
Klamath National Forest
CALIFORNIA
14134 ft
Modoc National Forest
9894 ft
SALMON MOUNTAINS
Trinity National Forest
8950 ft
Shasta National Forest
Trinity River
Shasta Lake
Lassen National Forest
8688 ft
CASCADE RANGE
Eagle Lake
Redding
Lassen Volcanic National Park
10455 ft
Susanville
Six Rivers National Forest
8084 ft
6628 ft
Lake Almanor
Honey Lake
Plumas National Forest
7752 ft
Pyramid Lake Paiute Reservation
Pyramid Lake
Chico
Mendocino National Forest
Goose Lake


Middle Mile Broadband Plan D2
With CCTV
Locations
Klamath
National
Forest
Modoc
National
Forest
14134 ft
9894 ft
SALMON MOUNTAINS
Shasta
National
Forest
Trinity
National
Forest
8950ft
Lassen
National
Forest
8688 ft
Eagle
Lake
Lassen
Volcanic
National
Park
10455 ft
Honey
Lake
Pyramid
Lake Paiute
Reservation
Pyramid
Lake
Six Rivers
National
Forest
8084 ft
6628 ft
Plumas
National
Forest
7752 ft
7445 ft
Mendocino


Middle Mile Broadband Plan D2
Snowman CCTV
D2's most popular
camera will not
have MMBN access
Klamath
National
Forest
CALIFORNIA
14134 ft
Modoc
National
Forest
9894 ft
Shasta
National
Forest
Trinity
National
Forest
8950ft
Trinity
National
Forest
Lassen
National
Forest
8688 ft
Eagle
Lake
Lassen
Volcanic
National
Park
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Lake
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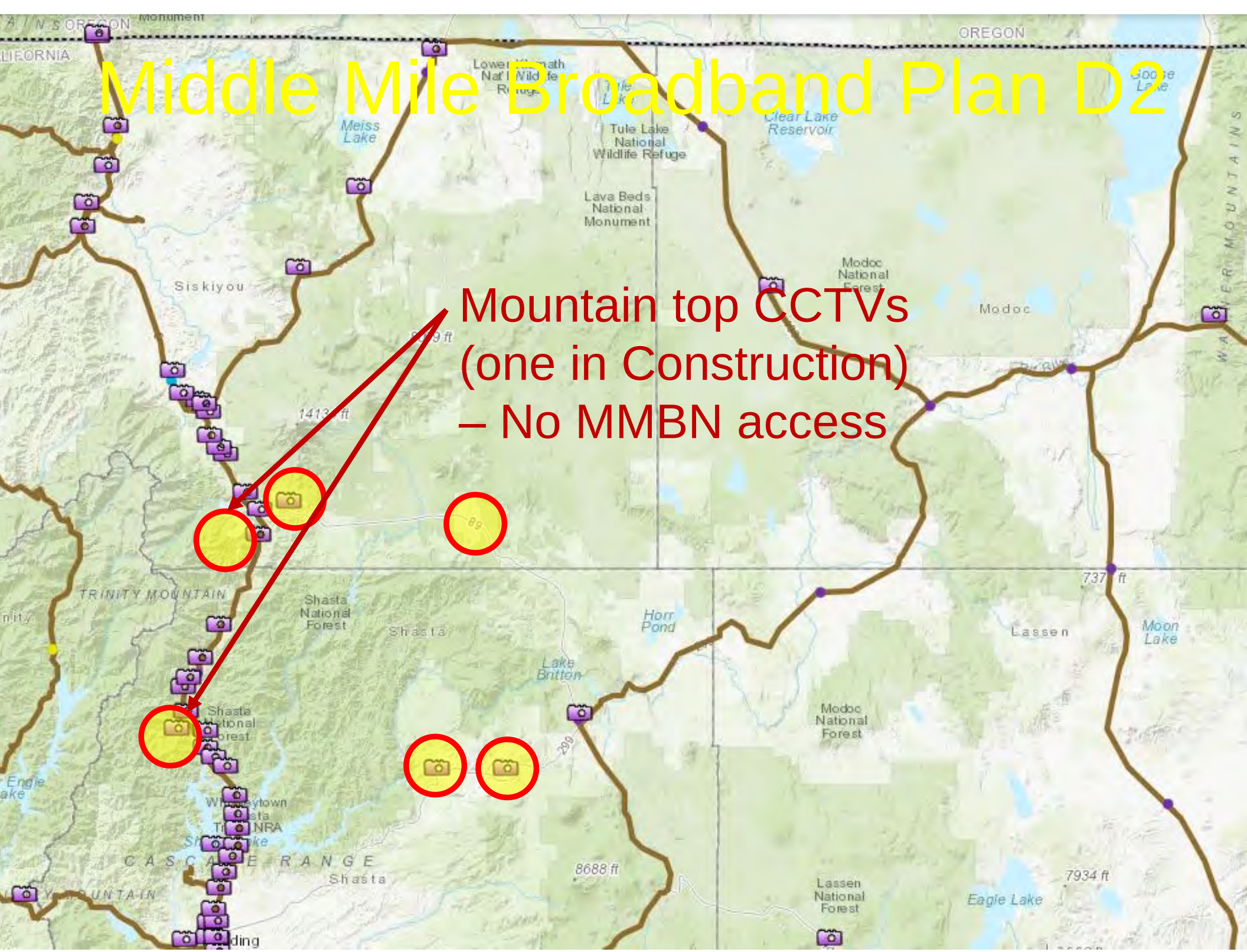
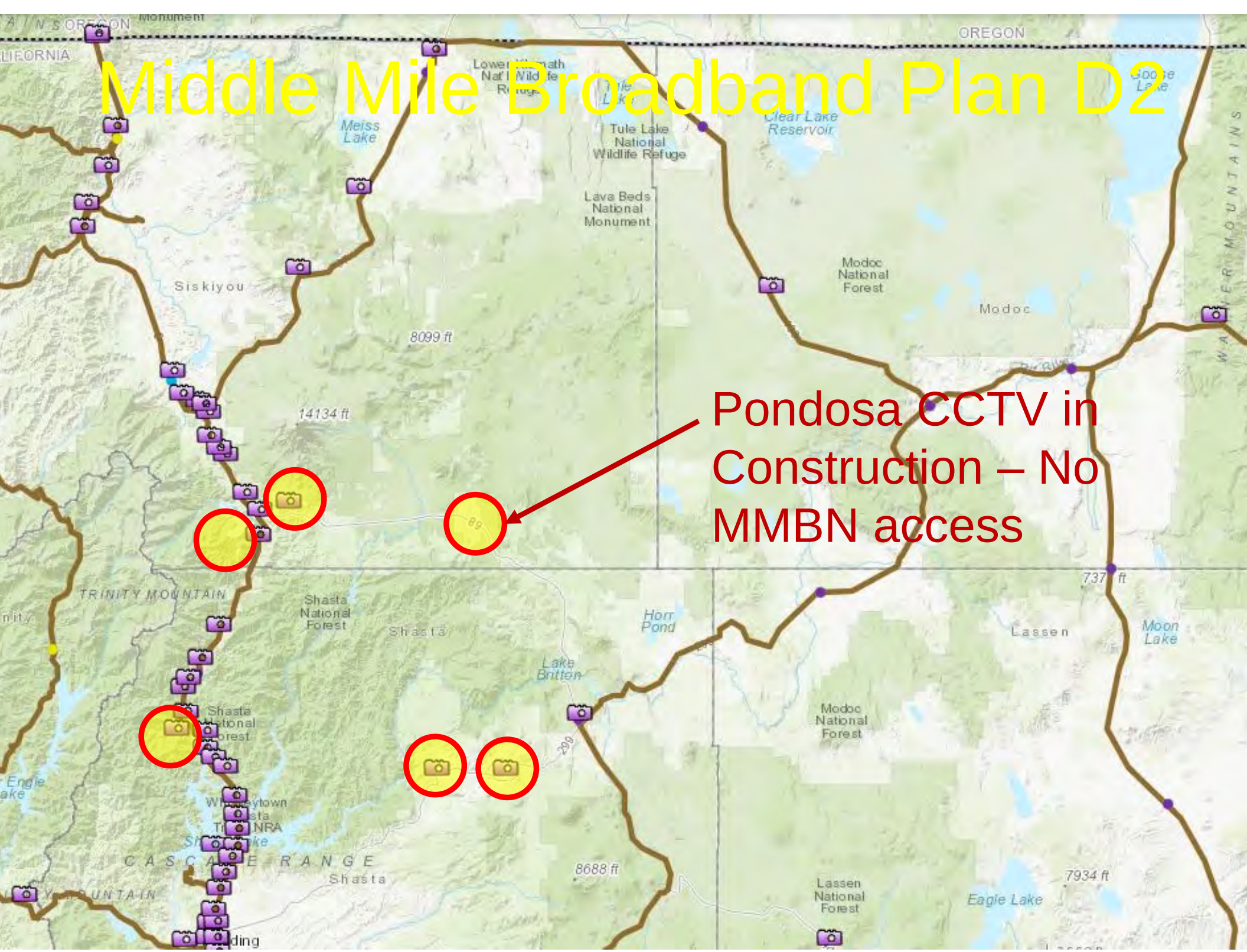
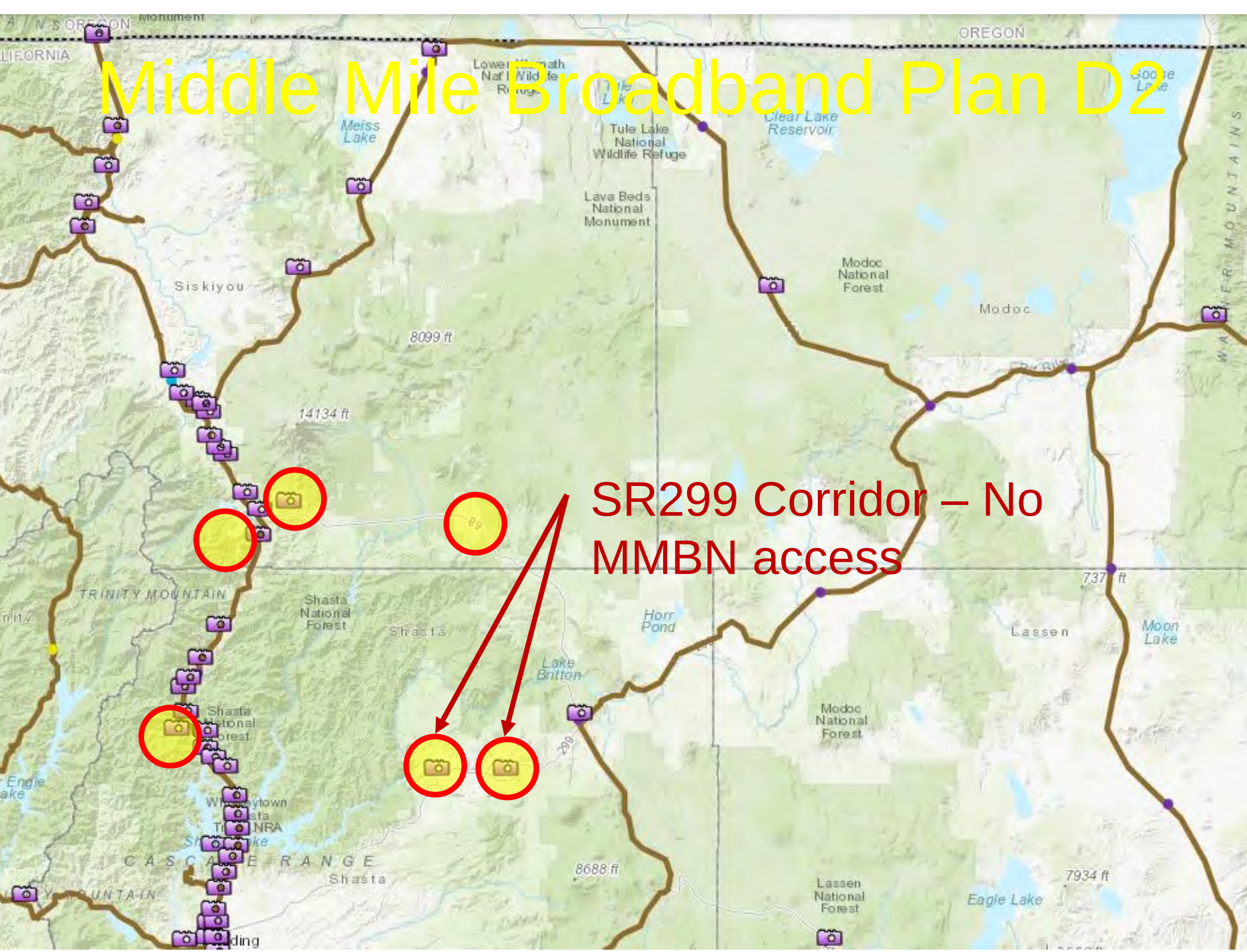
7445 ft
Mendocino


Middle Mile Broadband Plan D2
Mountain top CCTVs
(one in Construction)
– No MMBN access
OREGON
Meiss Lake
Tule Lake National Wildlife Refuge
Clear Lake Reservoir
Lava Beds National Monument
Modoc National Forest
Modoc
Siskiyou
TRINITY MOUNTAIN
Shasta National Forest
Shasta
Horr Pond
Lake Britton
Lassen
Moon Lake
Modoc National Forest
CASCADE RANGE
Shasta
8688 ft
Lassen National Forest
Eagle Lake
7934 ft
737 ft

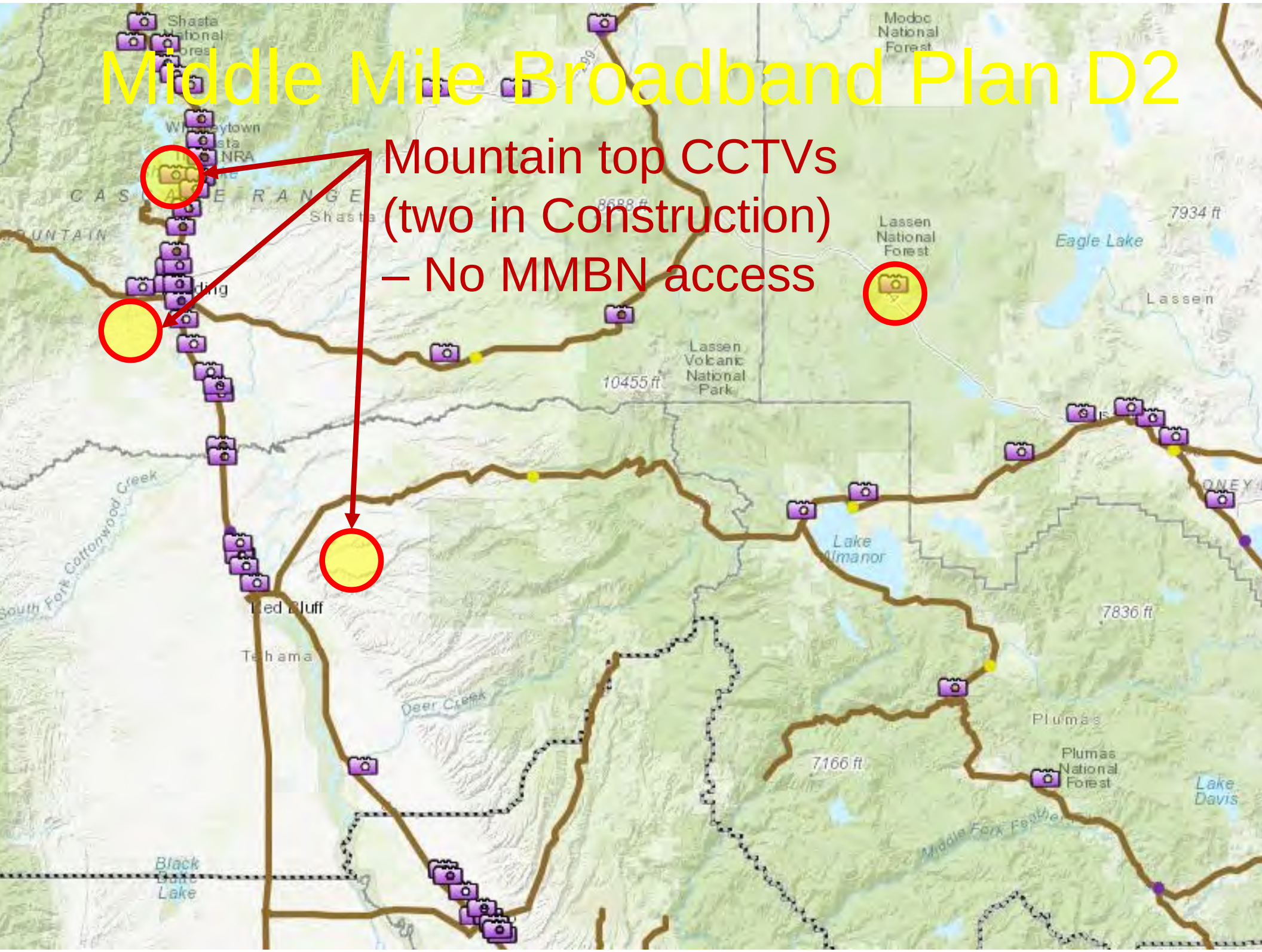
Middle Mile Broadband Plan D2



Middle Mile Broadband Plan D2




Middle Mile Broadband Plan D2
Bogard CCTV– No MMBN access
Modoc National Forest
Lassen National Forest
Eagle Lake
7934 ft
8688 ft
Shasta
Lassen Volcanic National Park
10455 ft
Lassen
Red Bluff
Tehama
Deer Creek
South Fork Cottonwood Creek
Lake Almanor
7836 ft
7166 ft
Plumas
Plumas National Forest
Lake Davis
Middle Fork Feather
Black Lake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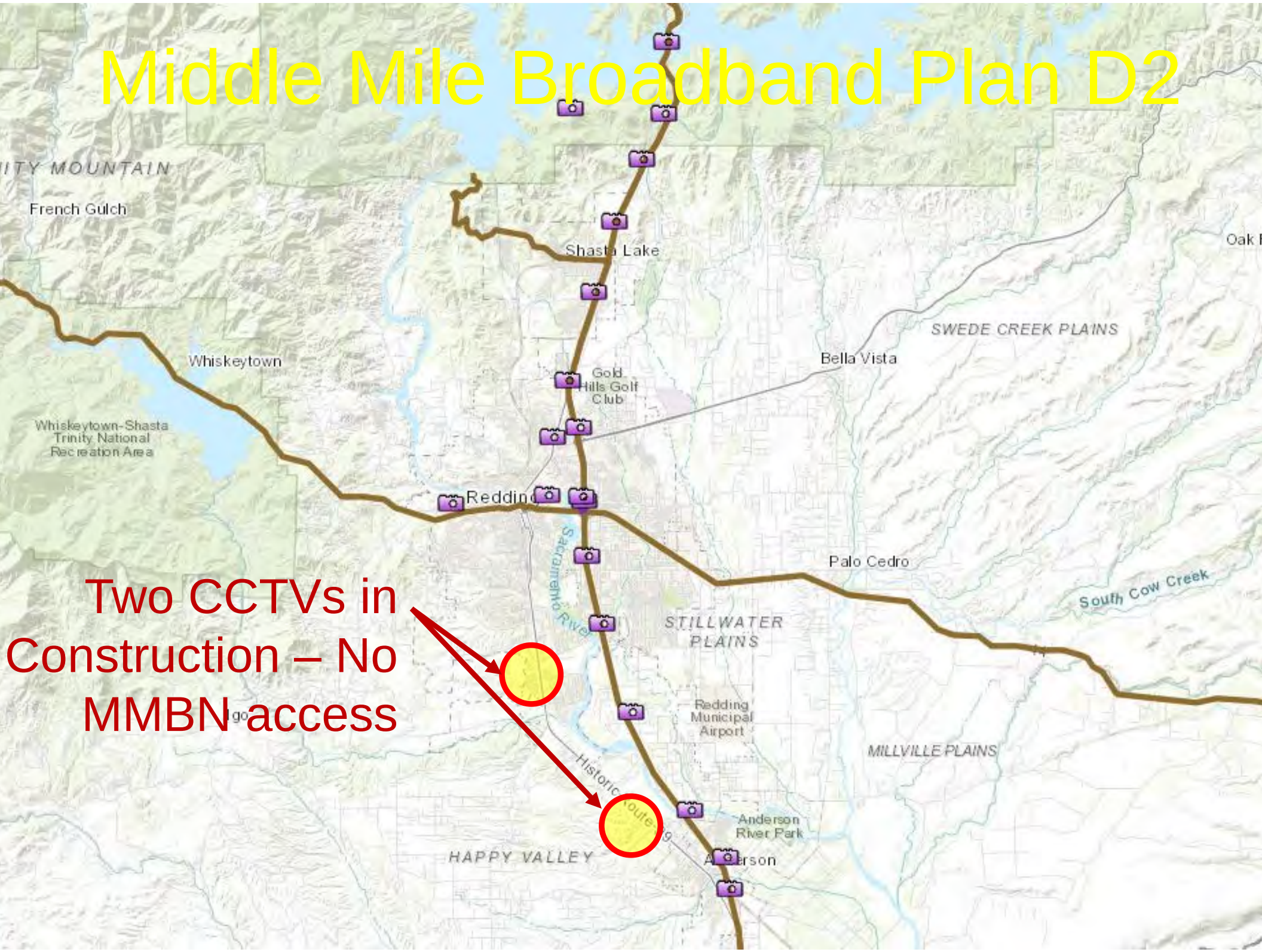
Lake

Middle Mile Broadband Plan D2



Change Impact

Middle Mile Broadband Network (MMBN)

- Concerns

Change Impact

Middle Mile Broadband Network (MMBN)

- Concerns
  - Architectural and design unknowns

Change Impact

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  - Sharing potential unclear and has changed several times

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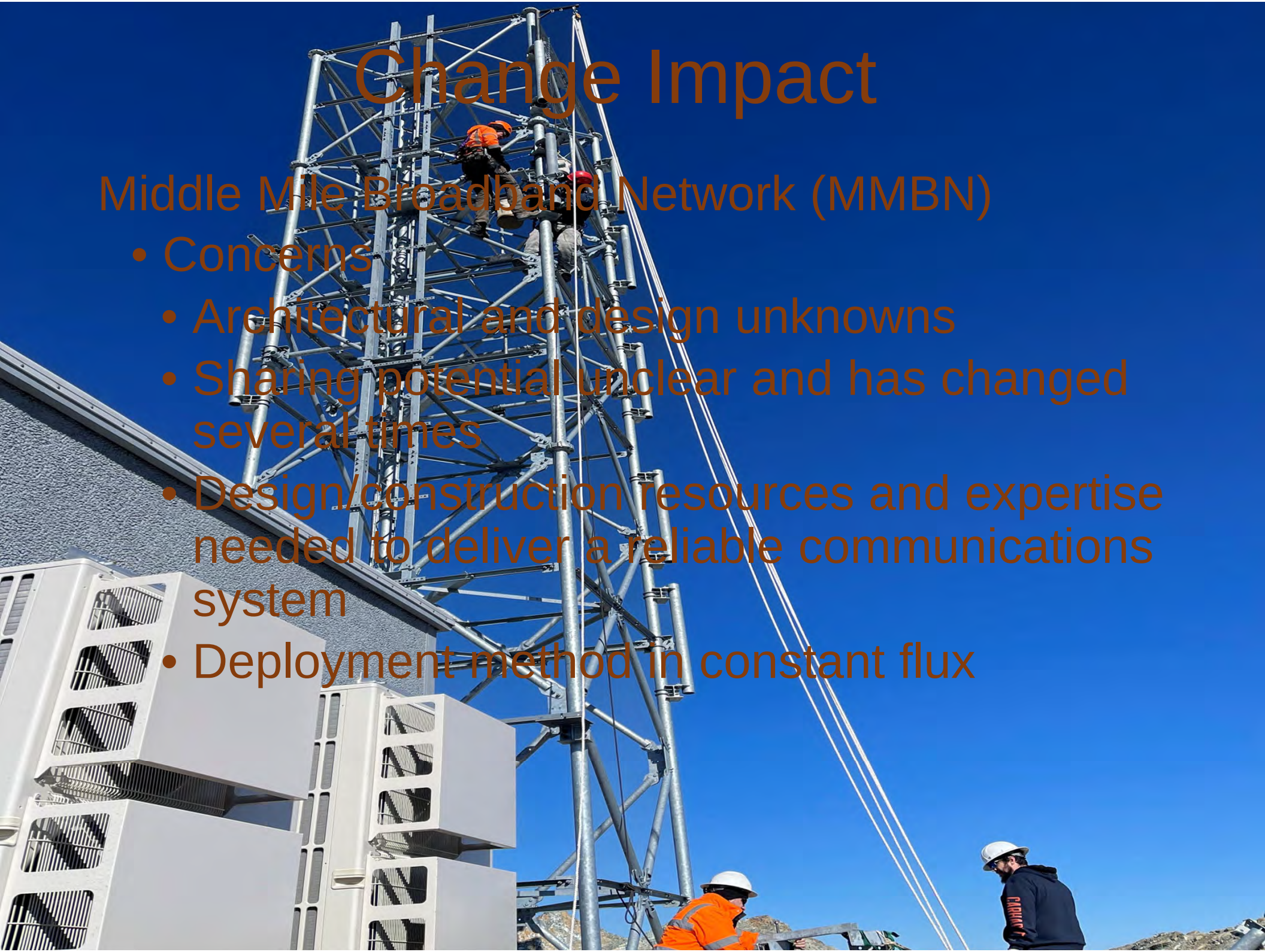
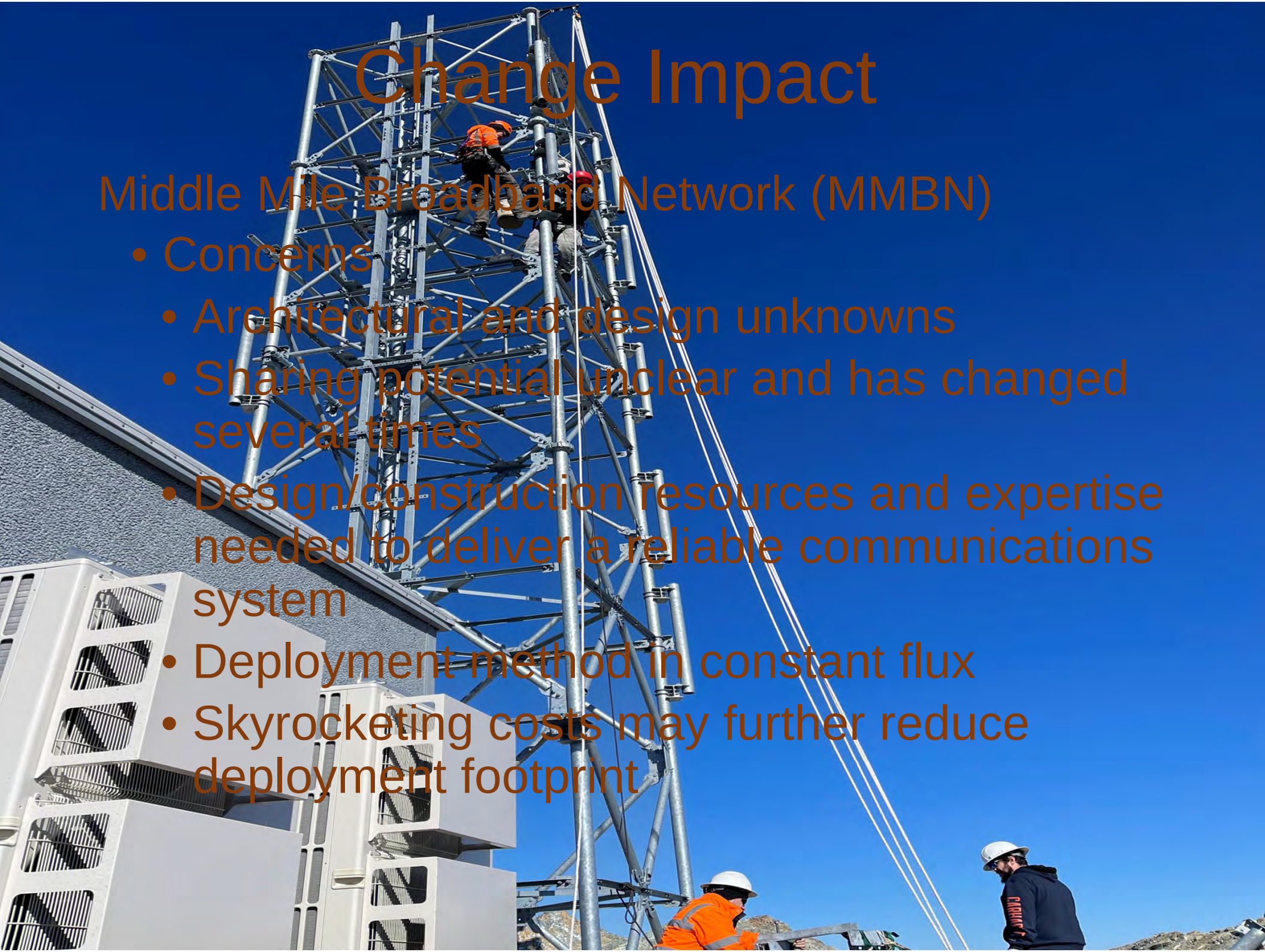
  - Design/construction resources and expertise needed to deliver a reliable communications system
  - Deployment method in constant flux



Change Impact

Middle Mile Broadband Network (MMBN)

- Concerns
  - Architectural and design unknowns
  - Sharing potential unclear and has changed several times
  - Design/construction resources and expertise needed to deliver a reliable communications system
  - Deployment method in constant flux
  - Skyrocketing costs may further reduce deployment footprint



Change Impact

Middle Mile Broadband Network (MMBN)

- Concerns (continued)
  - CDT ownership, maintained by a 3rd party utility

Change Impact

Middle Mile Broadband Network (MMBN)

- Concerns (continued)
  - CDT ownership, maintained by a 3rd party utility
  - Currently no fiber path directly to the D2 TMC, all network traffic routed to Goldcamp Data Center in District 3

Change Impact

Middle Mile Broadband Network (MMBN)

- Concerns (continued)
  - CDT ownership, maintained by a 3rd party utility
  - Currently no fiber path directly to the D2 TMC, all network traffic routed to Goldcamp Data Center in District 3
  - Will require a dedicated POP in Redding TMC

Change Impact

Middle Mile Broadband Network (MMBN)

- Concerns (continued)
  - CDT ownership, maintained by a 3rd party utility
  - Currently no fiber path directly to the D2 TMC, all network traffic routed to Goldcamp Data Center in District 3
  - Will require a dedicated POP in Redding TMC
  - All MMBN connections will be treated as a public/private utility in the communications planning process

Department-Owned Infrastructure

Department-Owned Infrastructure

Advantages:

Department-Owned Infrastructure

Advantages:

- Not dependent on a 3rd party to provide a critical service

Department-Owned Infrastructure

Advantages:

- Not dependent on a 3rd party to provide a critical service
- Ability to monitor and troubleshoot every step of the path (RSL Relay)

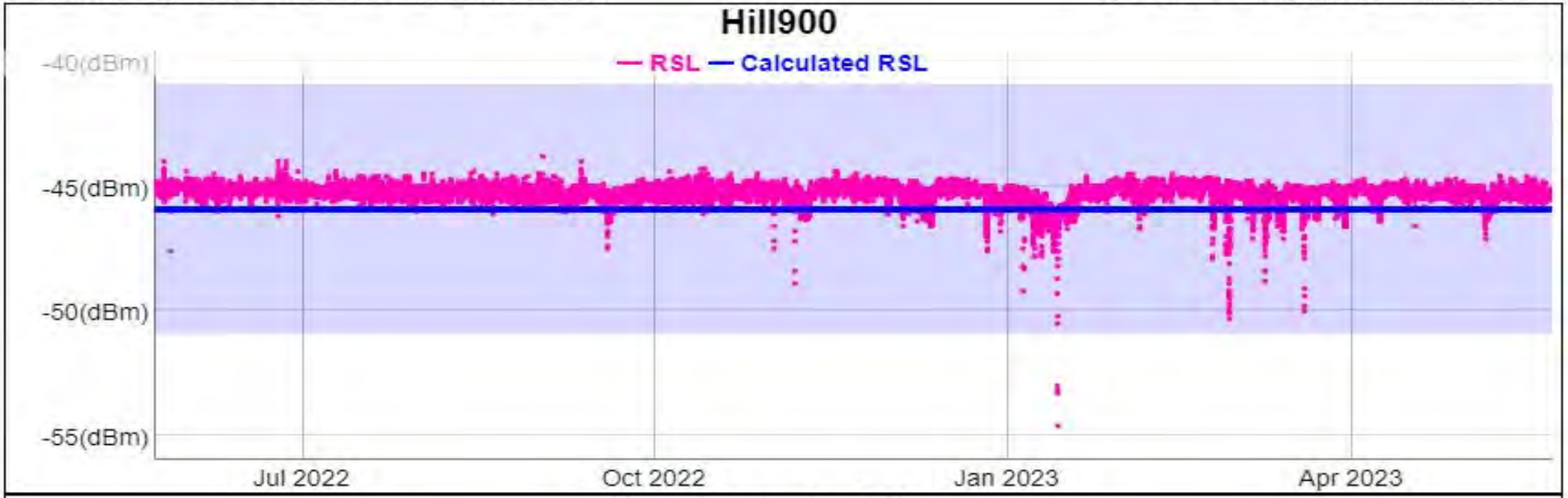
Link Status

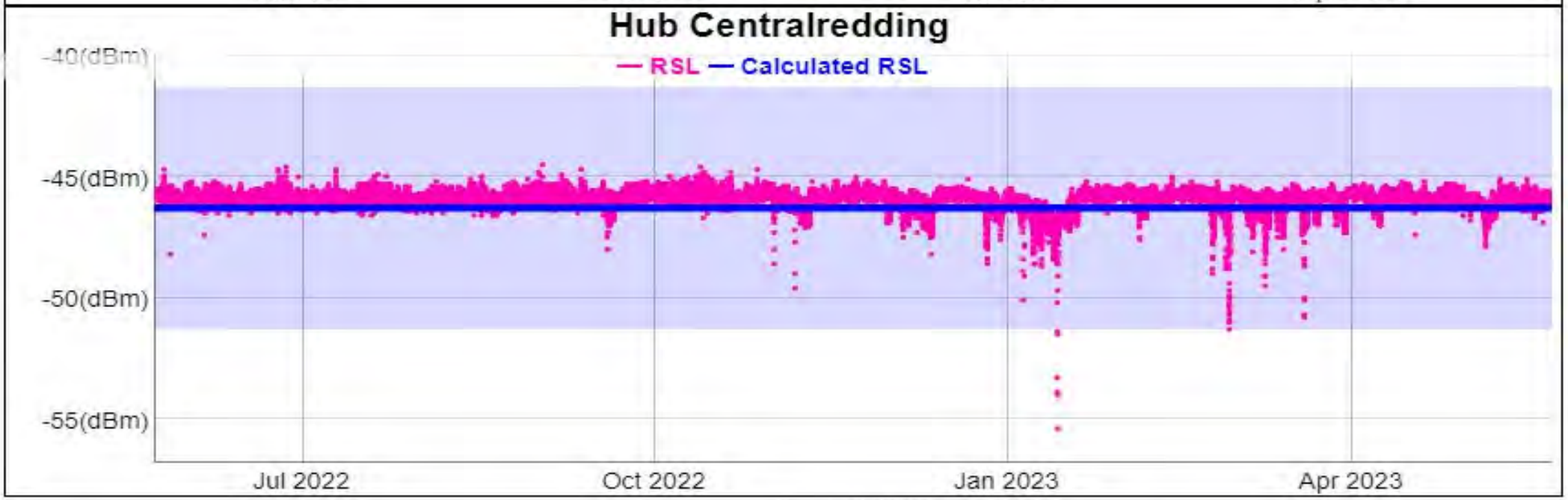
Hill900->Hub_CentralRedding

Last 1 Year(s)

Note:

Shift+Drag to move Graph.
Double click to return to normal.
Click and drag on graph to zoom. (Horizontal or Vertical)





Department-Owned Infrastructure

Advantages:

- Not dependent on a 3rd party to provide a critical service
- Ability to monitor and troubleshoot every step of the path (RSL Relay)
- In District 2, more reliable than public and private service providers

Department-Owned Infrastructure

Advantages:

- Not dependent on a 3rd party to provide a critical service
- Ability to monitor and troubleshoot every step of the path (RSL Relay)
- In District 2, more reliable than public and private service providers
- Zero monthly re-occurring telecommunications costs

Department-Owned Infrastructure

Disadvantages:

Department-Owned Infrastructure

Disadvantages:

- Capital investment costs can be higher (but not always!)

Department-Owned Infrastructure

Disadvantages:

- Capital investment costs can be higher (but not always!)
- As communications system grows, resource needs increase, but not necessarily resource $

Department-Owned Infrastructure

As described earlier, District 2 utilizes the following Department-Owned communications infrastructure:

Department-Owned Infrastructure

As described earlier, District 2 utilizes the following Department-Owned communications infrastructure:

- Fiber
  - Constructed in 2012
  - Commissioned in 2016
  - 18-mile backbone path in the Redding area and several short stubs in remote areas to consolidate communications
  - Currently no cable path to the TMC, fiber network traffic utilizes the point-to-point microwave system to backhaul data to the TMC

Department-Owned Infrastructure

As described earlier, District 2 utilizes the following Department-Owned communications infrastructure:

- Fiber
- Point-to-Point Microwave
  - First link deployed 2006
  - System has expanded to provide coverage over 100-miles along I-5 from Corning to Weed connecting dozens of TMS elements to the TMC via a high throughput network connection

Department-Owned Infrastructure

Why does District 2 use Microwave?

Department-Owned Infrastructure

Why does District 2 use Microwave?

Advantages

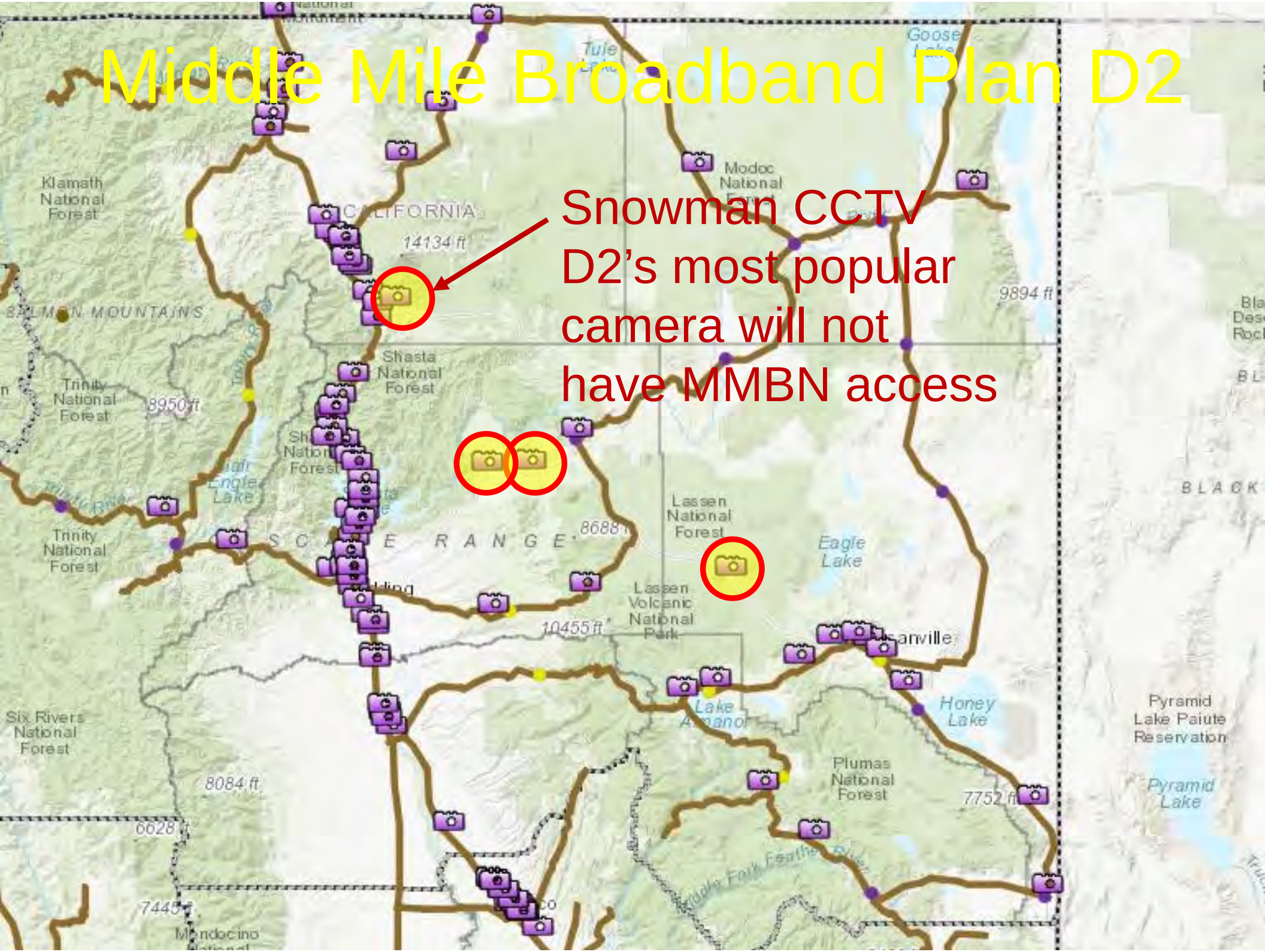
- High throughput possible
- Low latency
- More reliable than rural telcos
- More reliable during a crisis than the PSTN and the cellular system
- In general, less costly / mile to install compared to fiber – **1/10 the cost!**

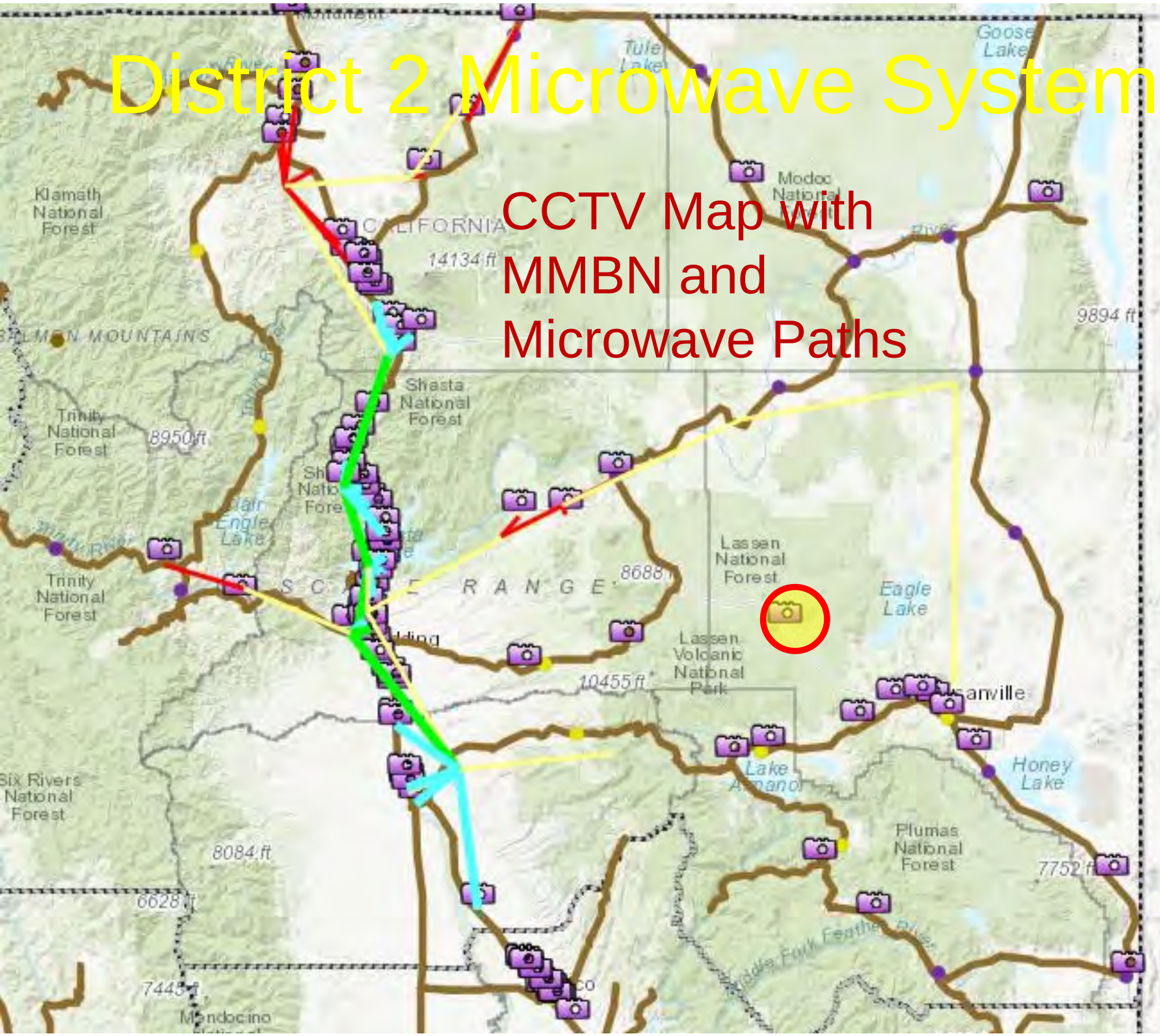
Limitations

- Line-of-site requirements
- Physical limitation of antennas on a tower (for point-to-point star topologies)
- Internal bureaucratic processes take time to get a project through
- Lack of institutional knowledge (construction standards)

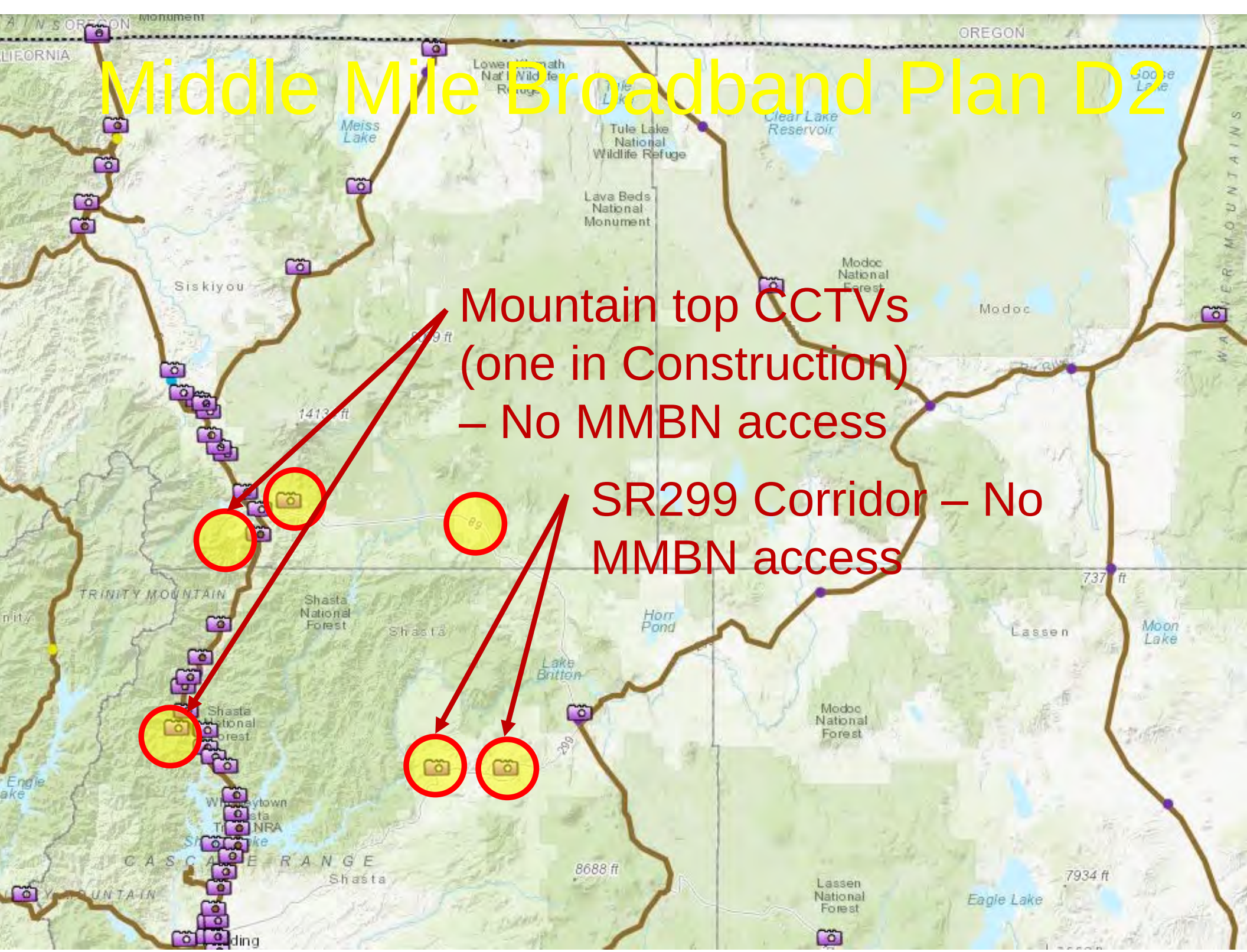
Department-Owned Infrastructure

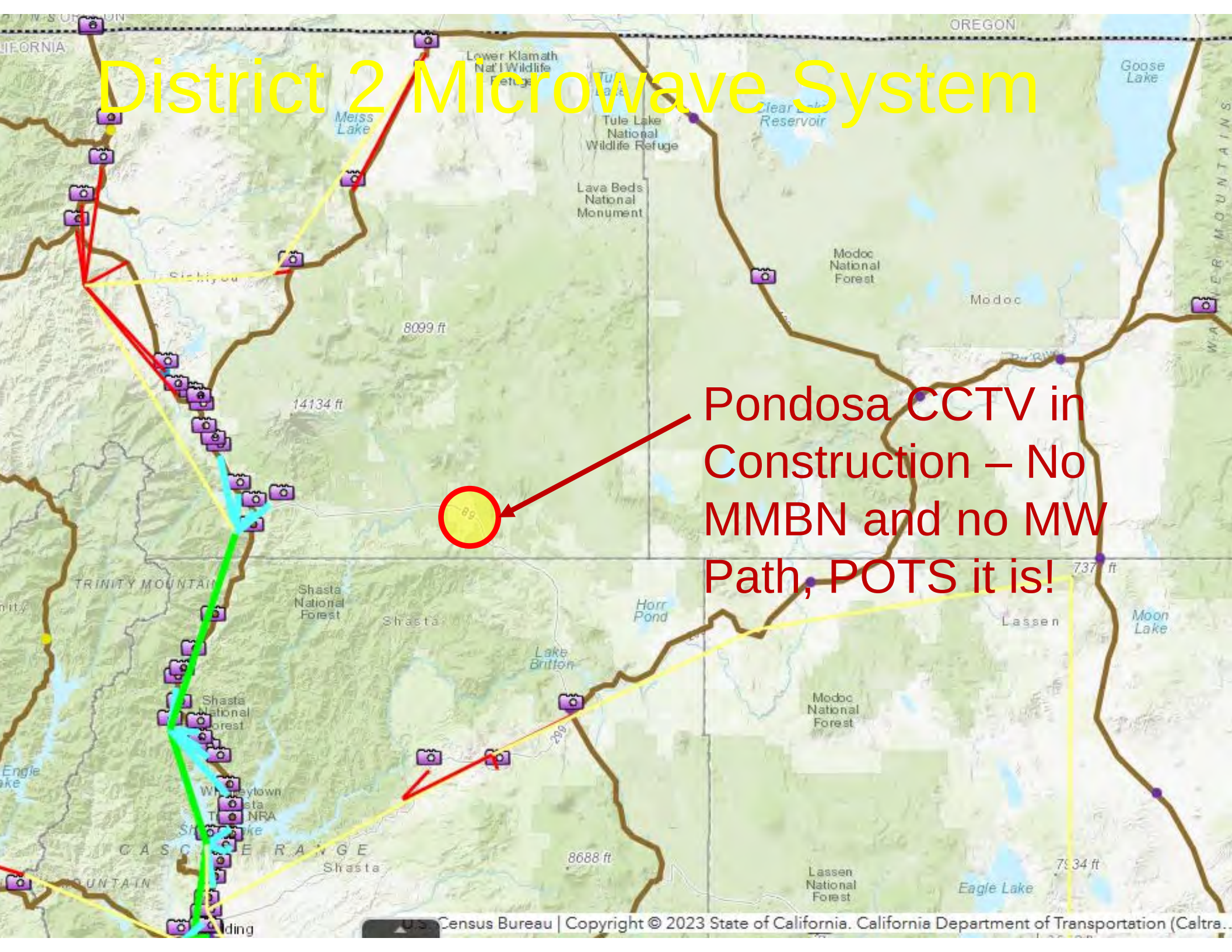
Why will District 2 continue to use Microwave after the MMBN deployment?


Middle Mile Broadband Plan D2
Snowman CCTV
D2's most popular
camera will not
have MMBN access
Klamath
National
Forest
CALIFORNIA
14134 ft
Modoc
National
Forest
9894 ft
Shasta
National
Forest
Trinity
National
Forest
8950ft
Trinity
National
Forest
Lassen
National
Forest
8688 ft
Eagle
Lake
Lassen
Volcanic
National
Park
10455 ft
Honey
Lake
Pyramid
Lake Paiute
Reservation
Pyramid
Lake
Six Rivers
National
Forest
8084 ft
6628 ft
Plumas
National
Forest
7752 ft
7445 ft
Mendocino


District 2 Microwave System
CCTV Map with MMBN and Microwave Paths
Klamath National Forest
CALIFORNIA
14134 ft
Modoc National
9894 ft
Shasta National Forest
Trinity National Forest
8950 ft
Lassen National Forest
8688 ft
Eagle Lake
Lassen Volcanic National Park
10455 ft
Honey Lake
Pyramid Lake Paiute Reservation
Pyramid Lake
Plumas National Forest
7752 ft
Six Rivers National Forest
8084 ft
6628 ft
7443 ft
Mendocino
Goose Lake
Tule Lake
BLACK

Middle Mile Broadband Plan D2




District 2 Microwave System
Pondosa CCTV in Construction – No MMBN and no MW Path, POTS it is!
OREGON
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Clear Lake Reservoir
Goose Lake
Meiss Lake
Lava Beds National Monument
Modoc National Forest
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8099 ft
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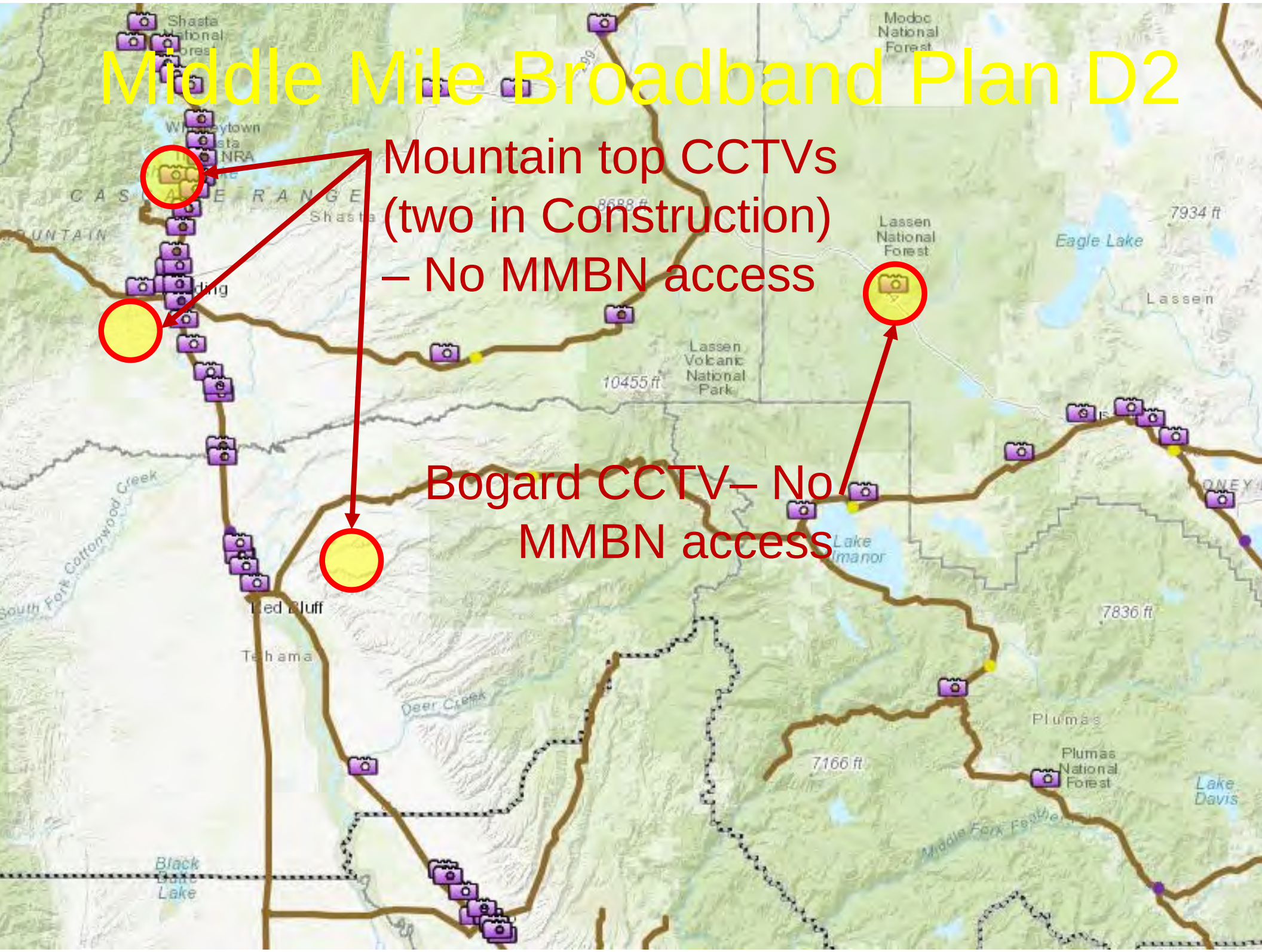
TRINITY MOUNTAINS
Shasta National Forest
Shasta
Horr Pond
Lake Britton
Lassen
Moon Lake
Modoc National Forest
CASCADE RANGE
8688 ft
Lassen National Forest
Eagle Lake
Census Bureau | Copyright © 2023 State of California. California Department of Transportation (Caltra...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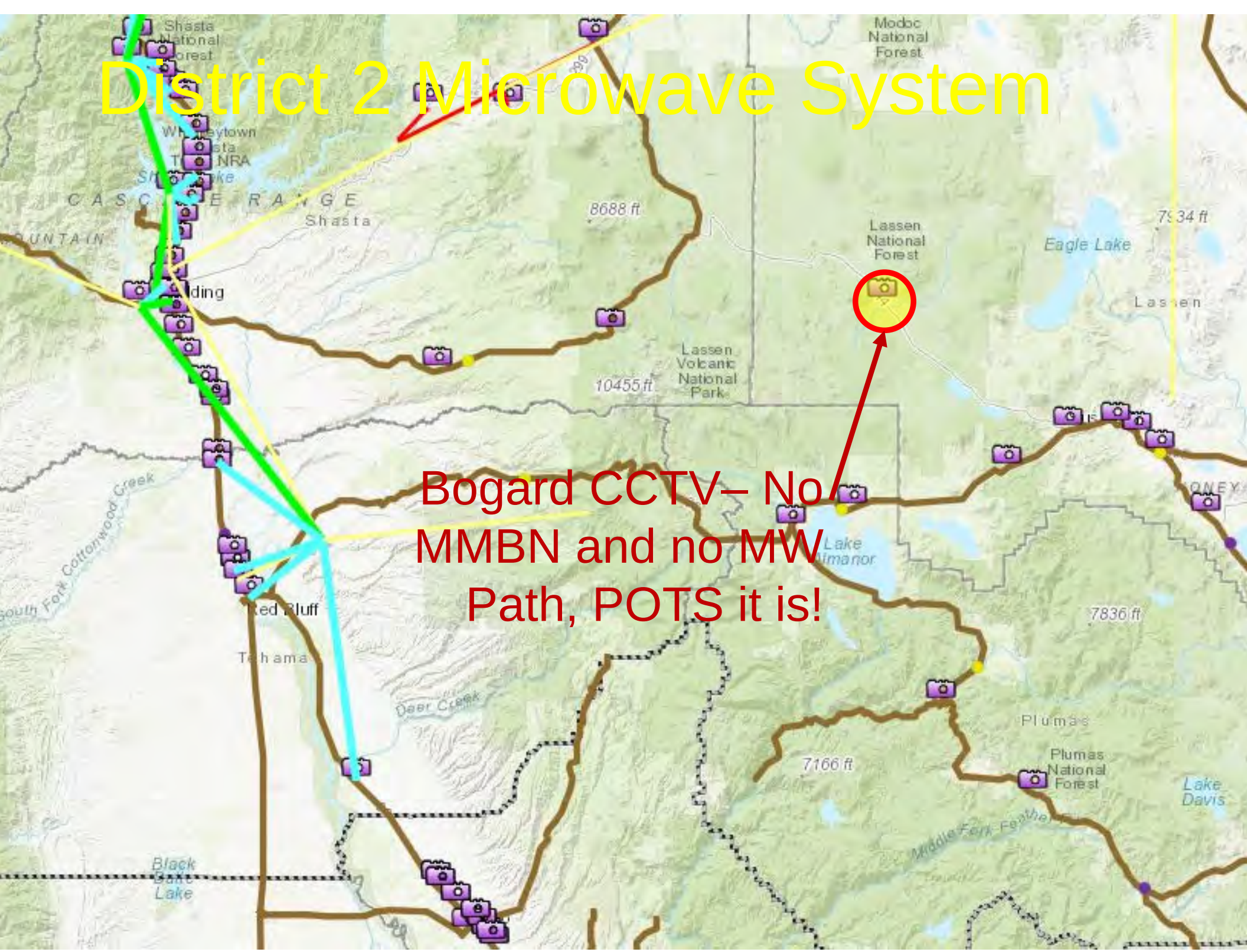
Black
Lake
Shasta
NRA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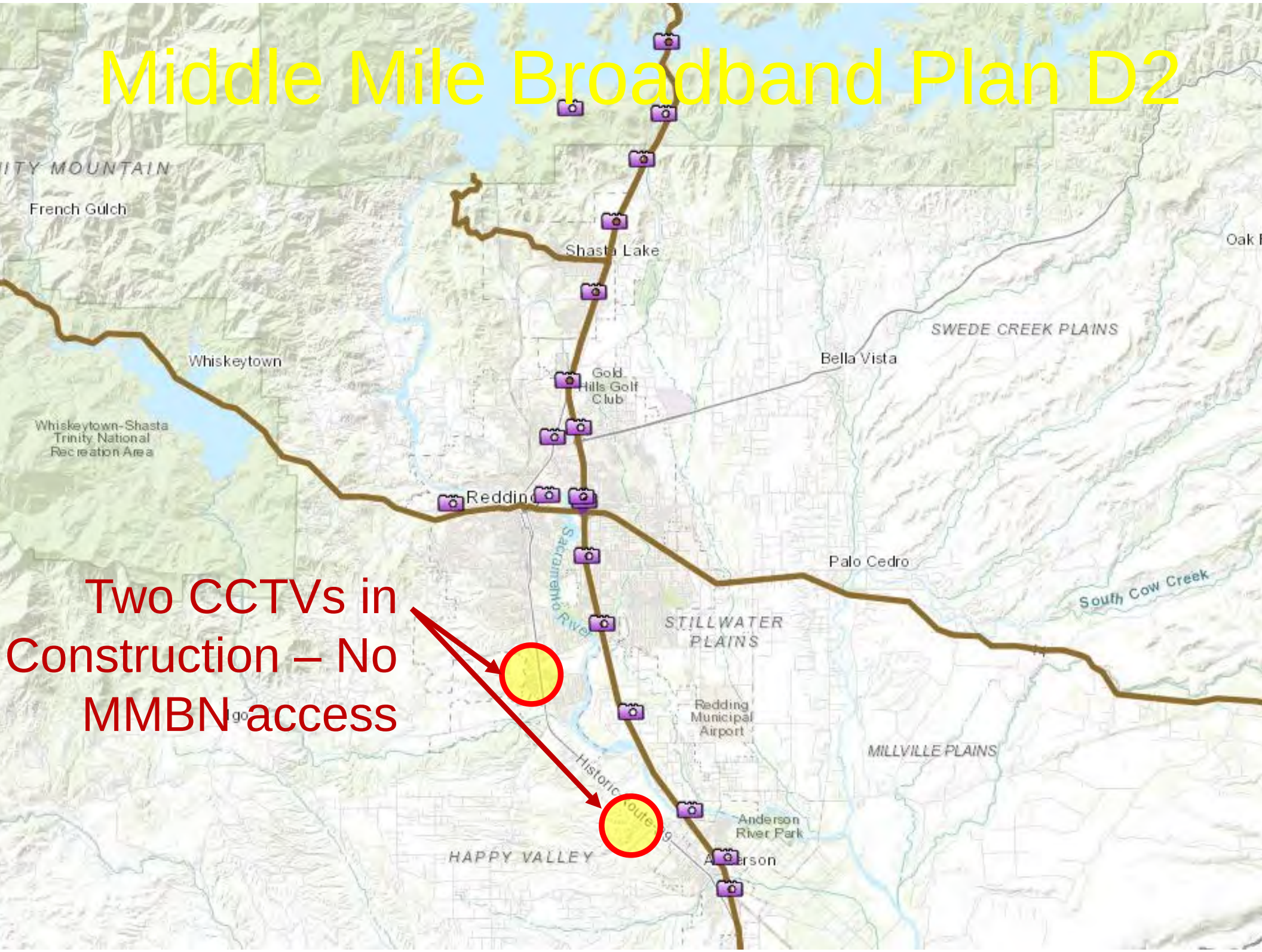
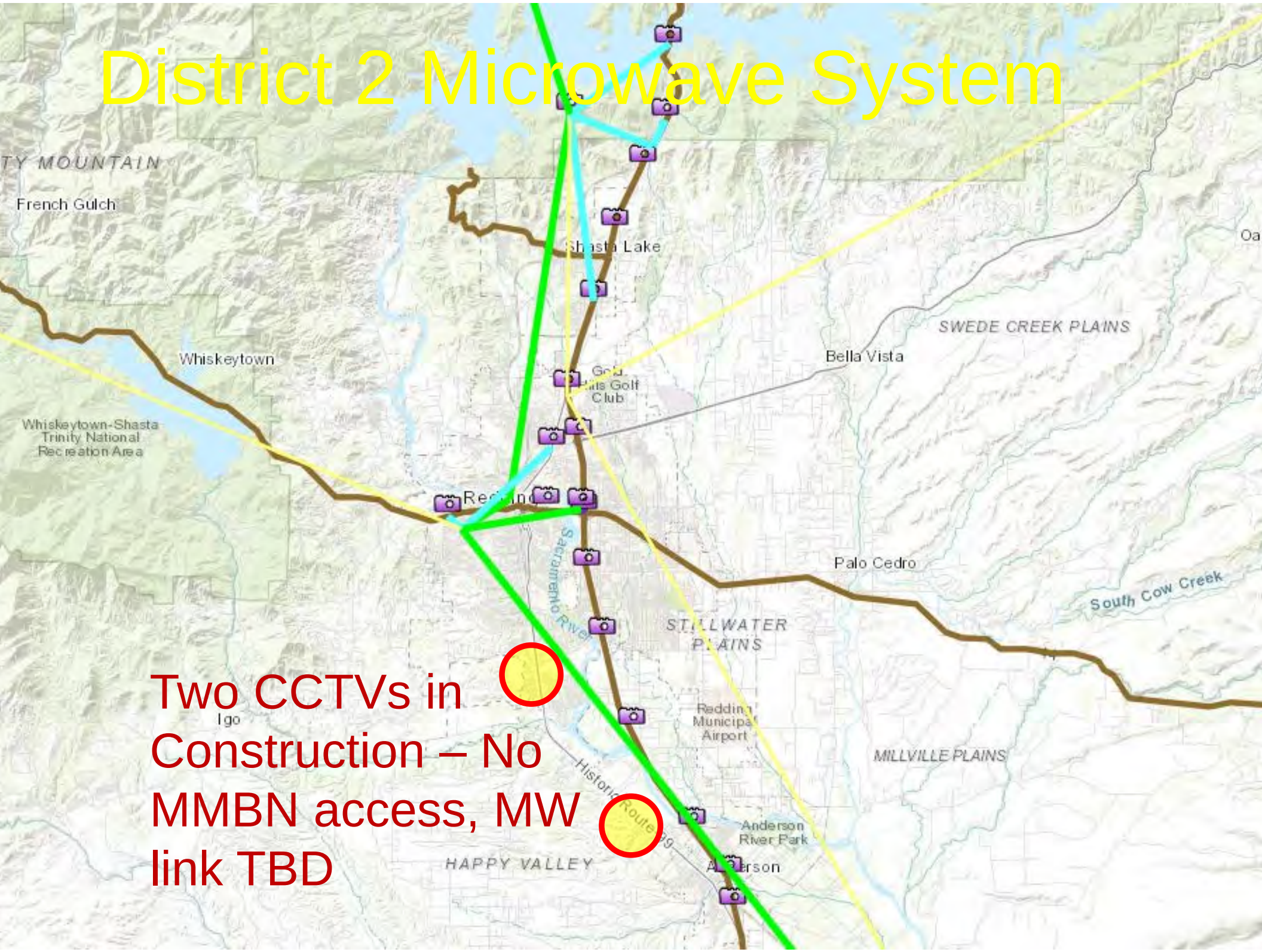
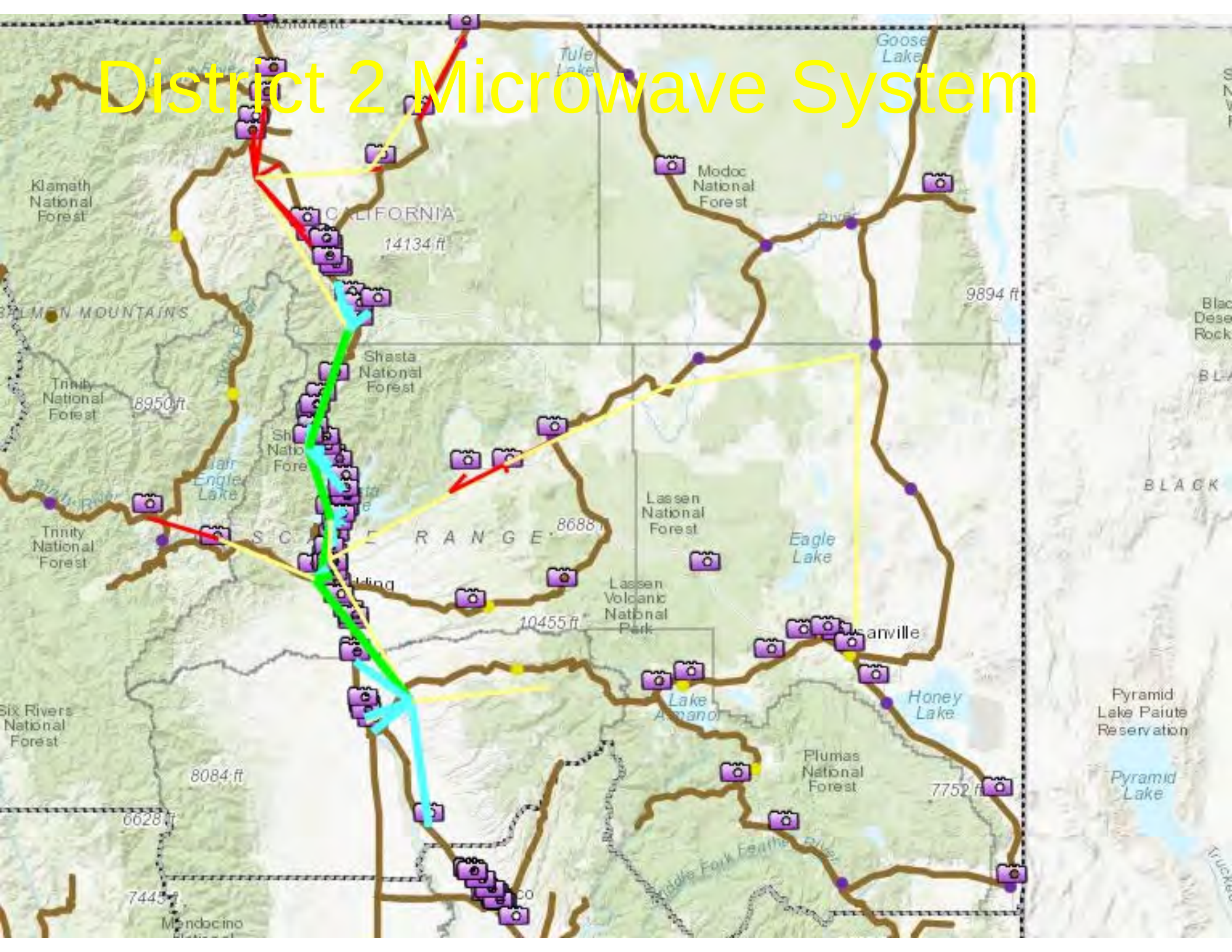
Middle Mile Broadband Plan D2



District 2 Microwave System



Two CCTVs in Construction – No MMBN access, MW link TBD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Six Rivers National Forest
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6628 ft
Mendocino
Goose Lake
Tule Lake
Lake Almanor
Eagle Lake

Planning and Strategy (Legacy)

- Communications Planning
  - District 2 has a general plan to expand coverage of the District's Point-to-Point Microwave System to Mt Top communications sites with strategic vantage points of the State Highway System
  - District 2 has a general plan for fiber in the Redding area (Shasta Lake to Anderson and East to Palo Cedro

Planning and Strategy (Updated)

- Communications Planning
  - Reduce the District's overall monthly TMS telecommunications costs
  - Continue expanding coverage of the District's Point-to-Point Microwave System
  - Expand fiber in the Redding area to the TMC and SR273 redundant paths
  - Maintain a District wide TMS communication plan
  - If MMBN meets our reliability needs, we will use the microwave system as a low-cost highly reliable redundant

Planning and Strategy (Legacy)

- Communications Strategies
  - During site construction install the highest reliable, least costly utility service
  - Upgrade to ISM band microwave as a separate project if line-of-site is available
  - Upgrade to licensed microwave
  - Opportunistic upgrades (as funding allows)

Planning and Strategy (Updated)

- Communications Strategies
  - During site construction, install last mile connection to MMBN or install the highest reliable, least costly utility service
  - Upgrade to ISM band microwave as a separate project if line-of-site is available
  - Upgrade to licensed microwave
  - Scope communications consolidation efforts into Capital projects as funding allows
  - Continue to utilize hybrid communications backhaul opportunities
  - Opportunistic upgrades (as funding allows)

Projects

Let’s highlight two recent microwave projects

- Tuscan Buttes
- Mt Bradley

Questions?