Portable Work Zone Data Collection

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ODOT ITS Designer

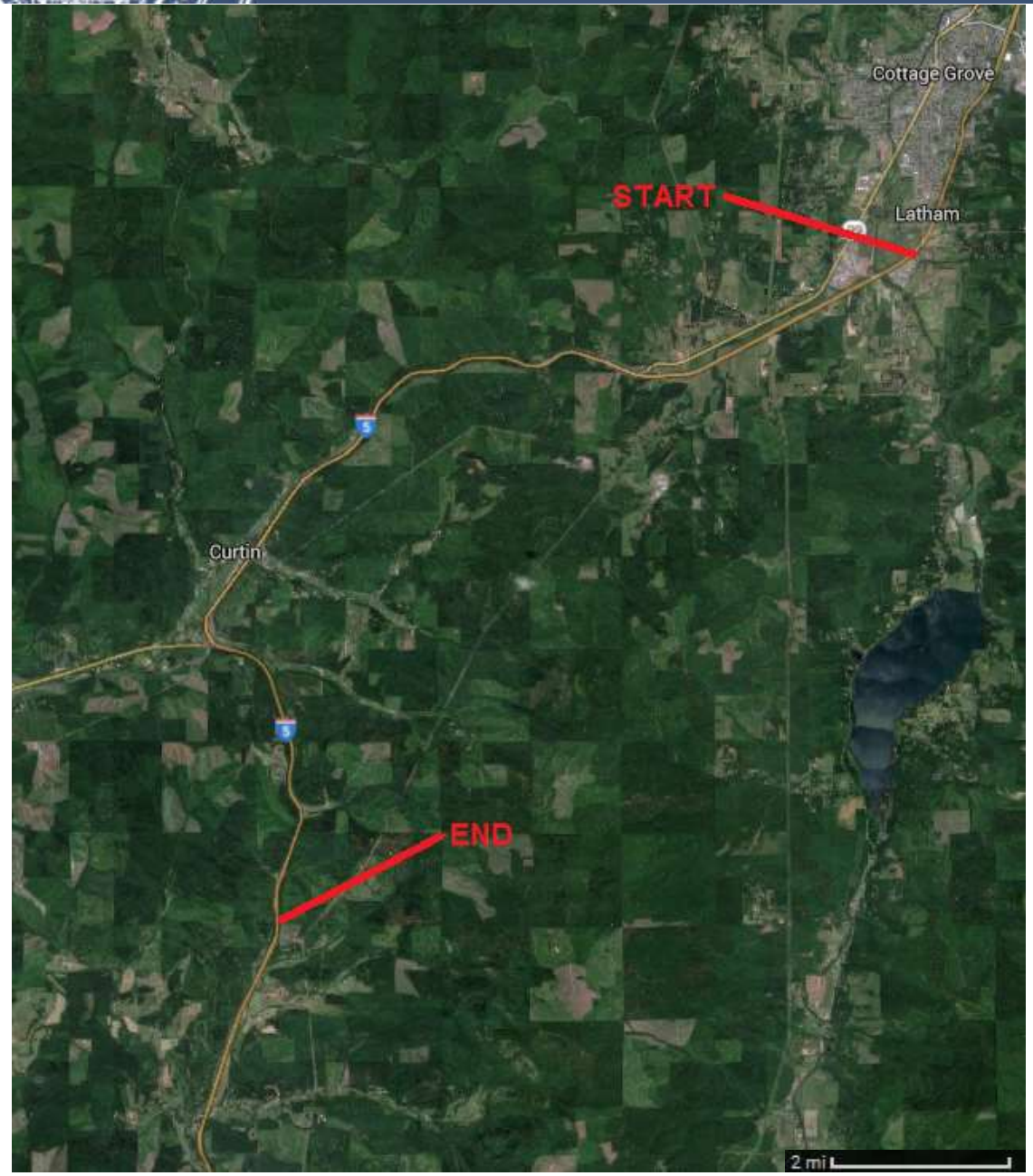
Year 1

- Construction Zone Travel Time project.
- Provide work zone information to public.
- Test OSU Bluetooth travel time sensors in new application.

Oregon State University OSU

Year 1 - Construction Zone

- 15 mile repaving project on I-5.
- North of Roseburg and South of Cottage Grove.
- Project anticipated having a large impact to traffic flow.
- ITS project goals:
  - Test the Bluetooth travel time technology in a new application.
  - Inform the public of traffic impact.
  - Analyze the impact of traffic delay.

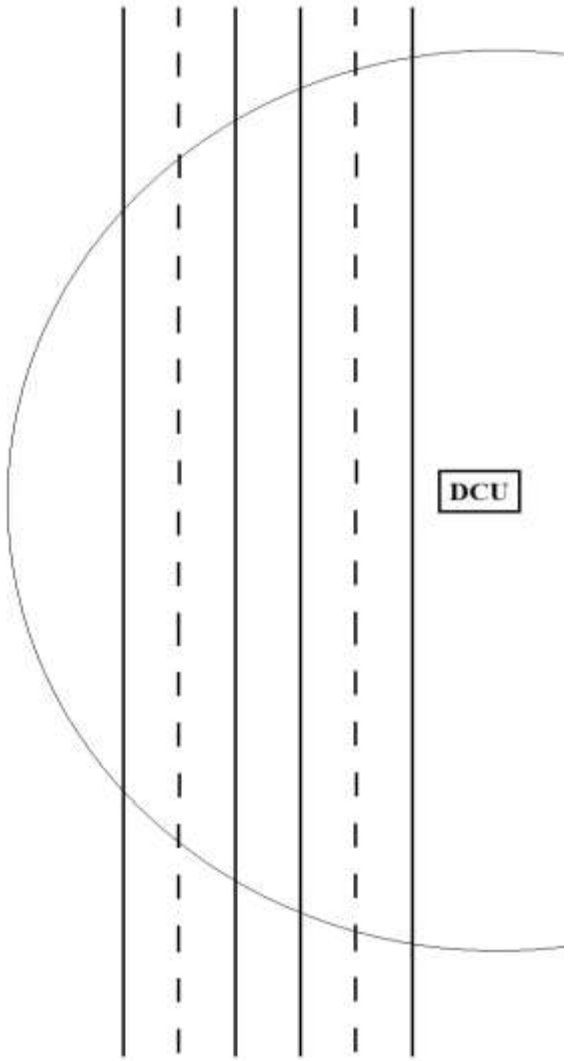

Cottage Grove
START
Latham
Curtin
END
2 mi

Travel Time Collection

- Device collects Bluetooth MAC addresses.
- Stores the data and presents it with a web interface.
- ODOT database collects the MAC addresses from the web interface.
- Database subtracts timestamps to determine travel time.

Bluetooth Collection Device

- The larger gain antenna provides a collection radius of 600 feet.
- The DCU will ask for Bluetooth MAC addresses every few seconds.
- Multiple MAC addresses will be reduced to the one with best RSSI.
- Studies have shown that roughly 6% of vehicles have Bluetooth devices.



Public Security/Privacy

- DCUs transmit hashed Bluetooth MAC Addresses and signal strength.
- Hashed MAC Addresses are halved when received.

```
2014/07/01 12:05:11
3e8f4d4d21f6746aa31cbd9d0b5000fd, 2014-07-01 11:05:51, 1, -67, 0:1:95:1D:93:FB
65d4681a7fdc720bd07b517fdaa287ed  2014-07-01 11:06:12, 1, -61, 0:1:95:1D:93:FB
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```
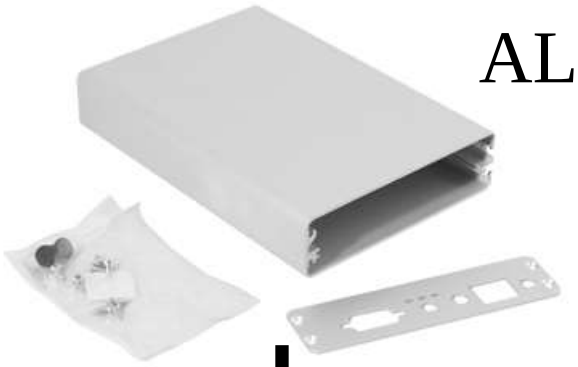
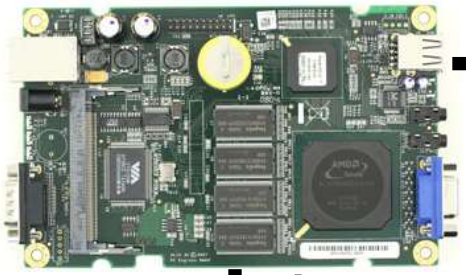

Data Collection Unit Components



ALIX Enclosure

2.4 GHz 9dBi
Omni Antenna

Bluetooth to
USB adapter



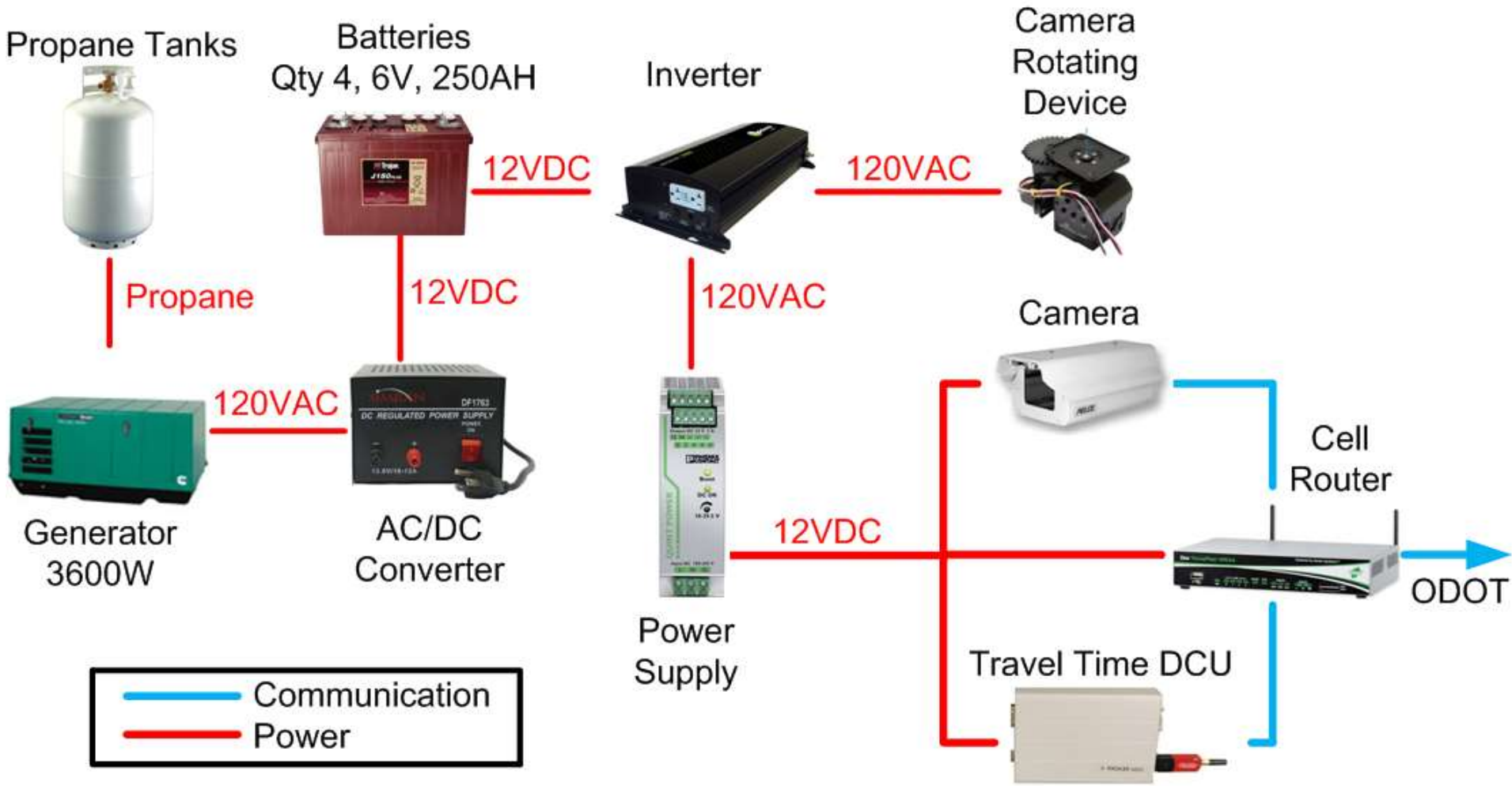
ALIX.3D3

4GB compact flash card
Linux operating system

Year 1 – Trailer #1

- Custom built camera trailer.
- Propane powered.
- Bluetooth DCU installed.
- Communicates via a wireless router.

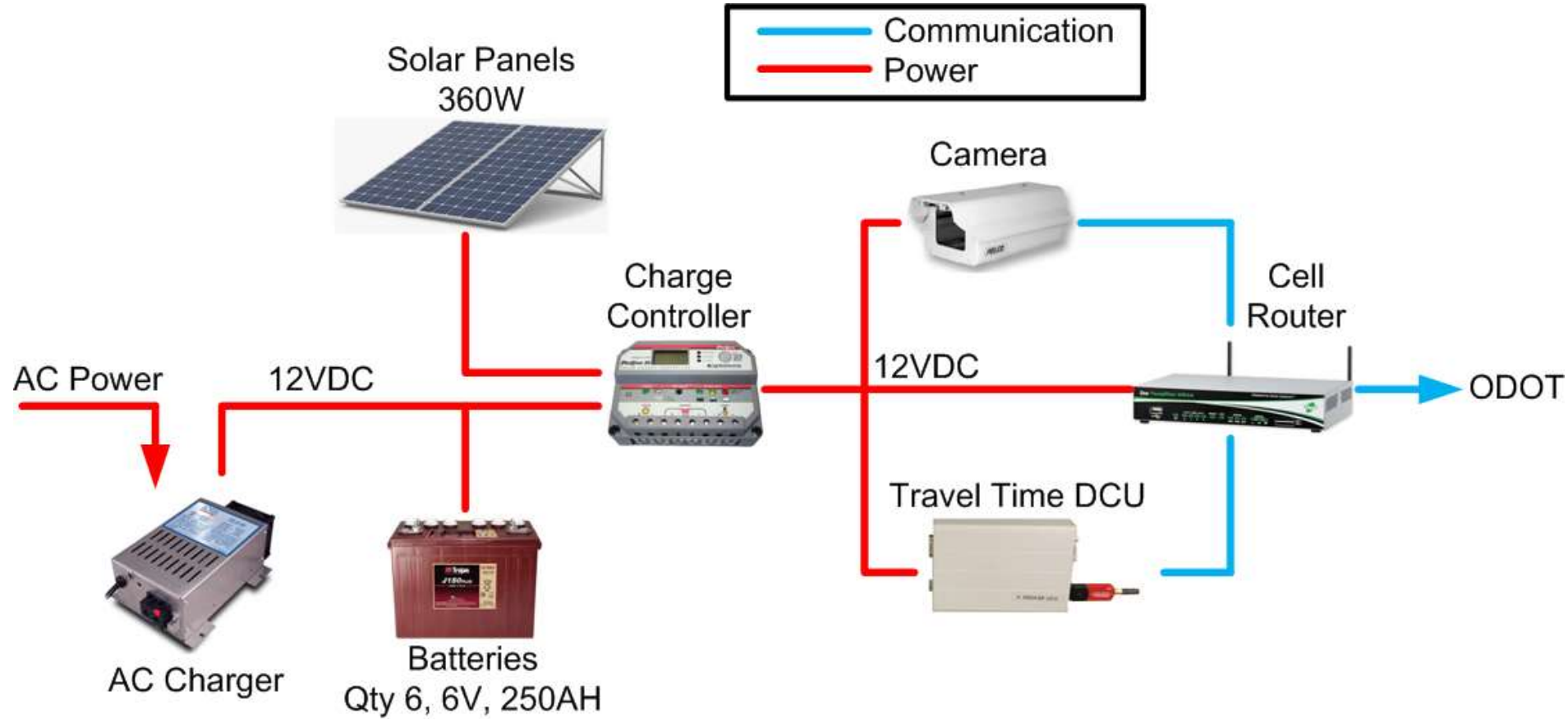
Year 1 – Trailer #1



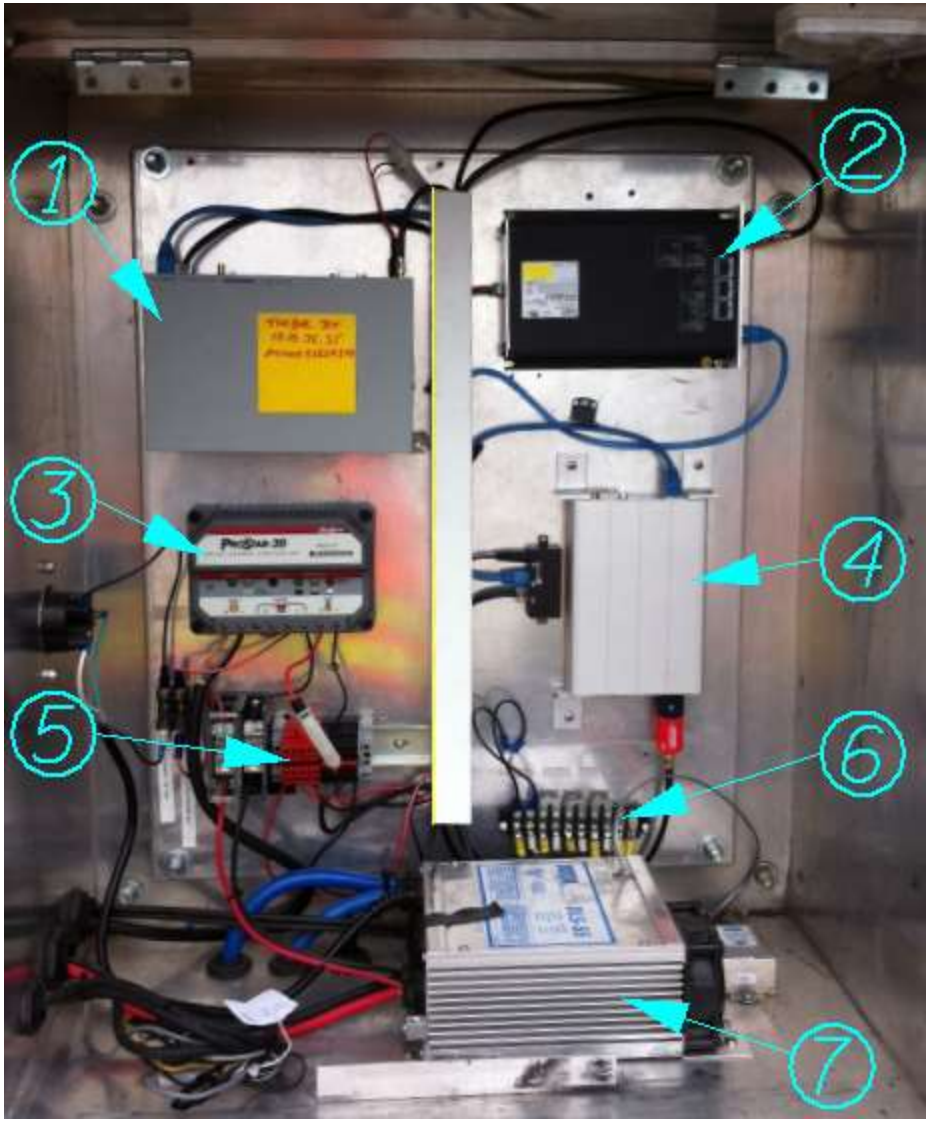
Year 1 – Trailer #2

- Refurbished PCMS trailer.
- Message sign removed, and camera mast added.
- Solar powered.
- Camera and Bluetooth DCU installed.
- Communicates via a wireless router.

Year 1 – Trailer #2



Trailer Cabinet

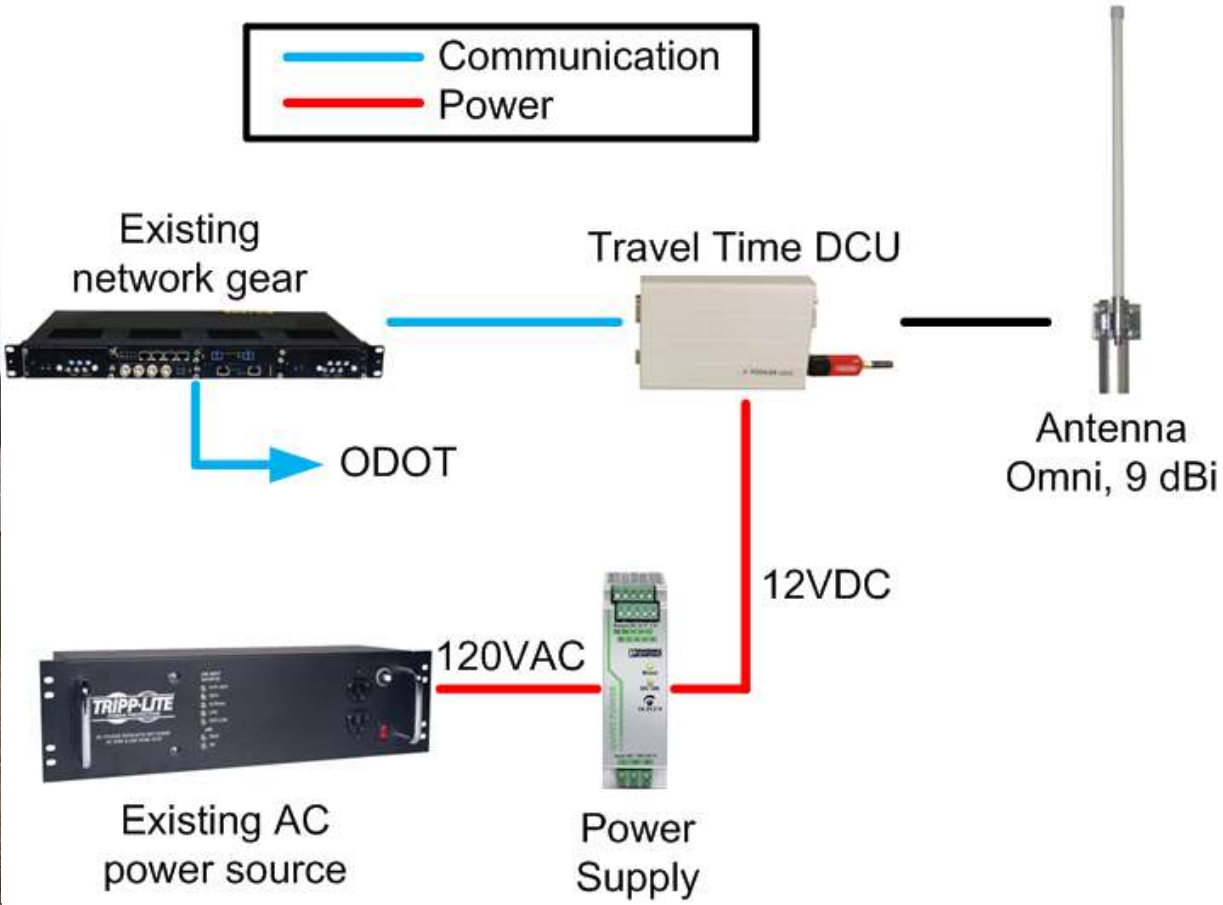


#	Description
1	Wireless router
2	Camera encoder
3	Charge controller
4	Bluetooth DCU
5	Terminal blocks
6	Trailer brake wiring
7	AC battery charger

Utilizing Existing ITS Equipment in Zone

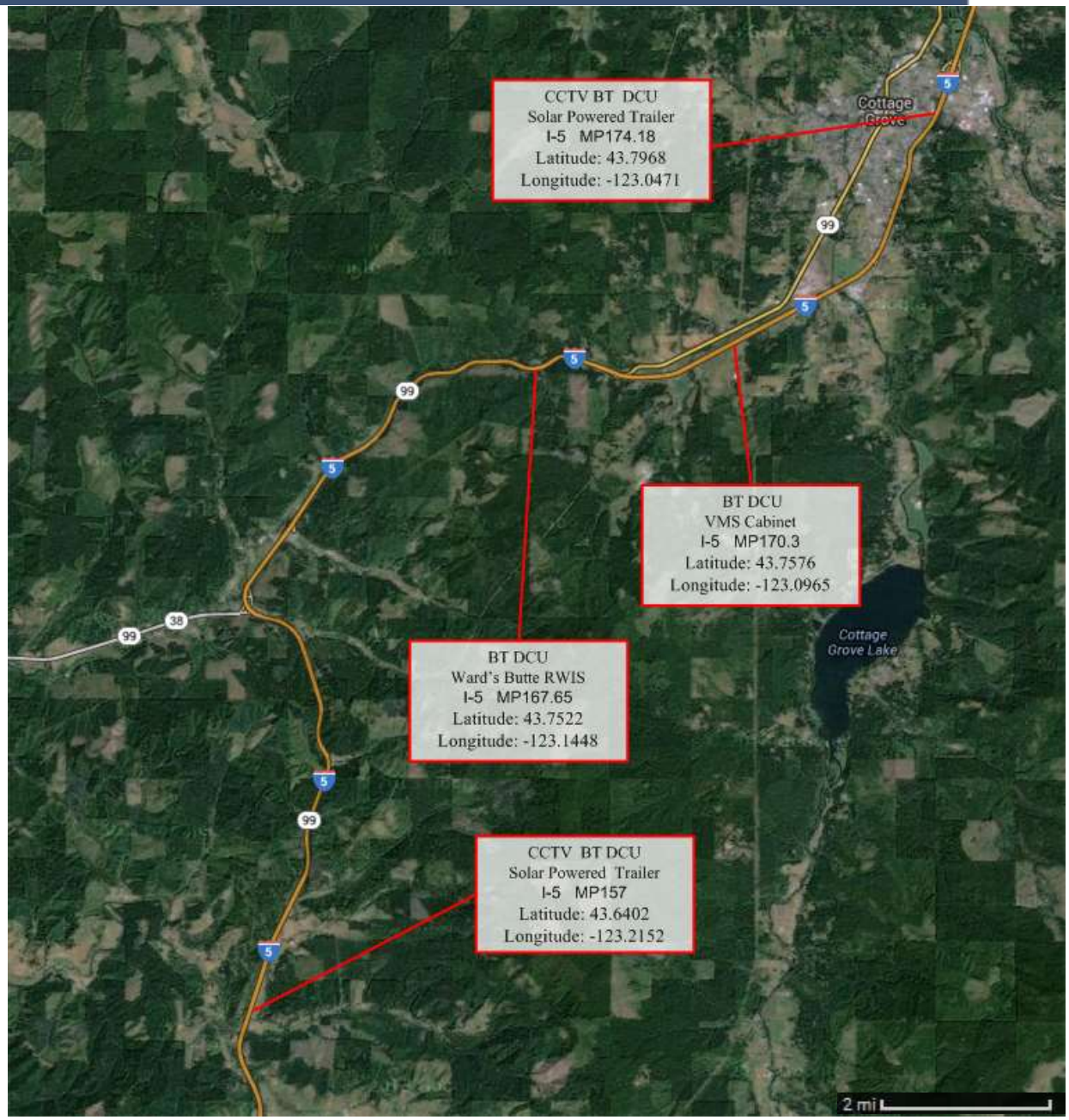
- Additional DCUs were added to provide greater travel time accuracy.
- Temporary DCUs were added to a VMS sign cabinet and an RWIS cabinet that were located within the construction zone.

Integration of BT Units

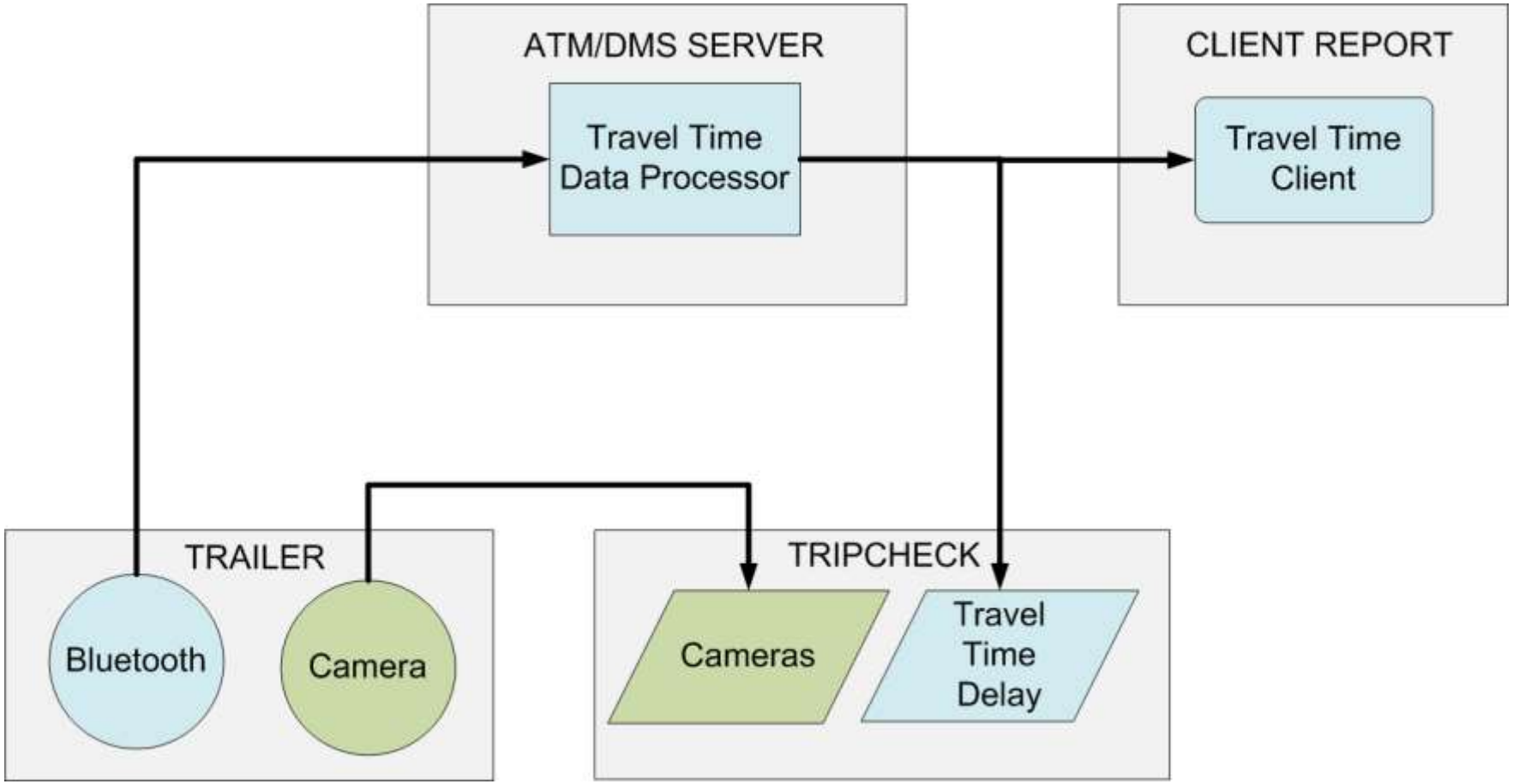


Year 1 – Device Locations

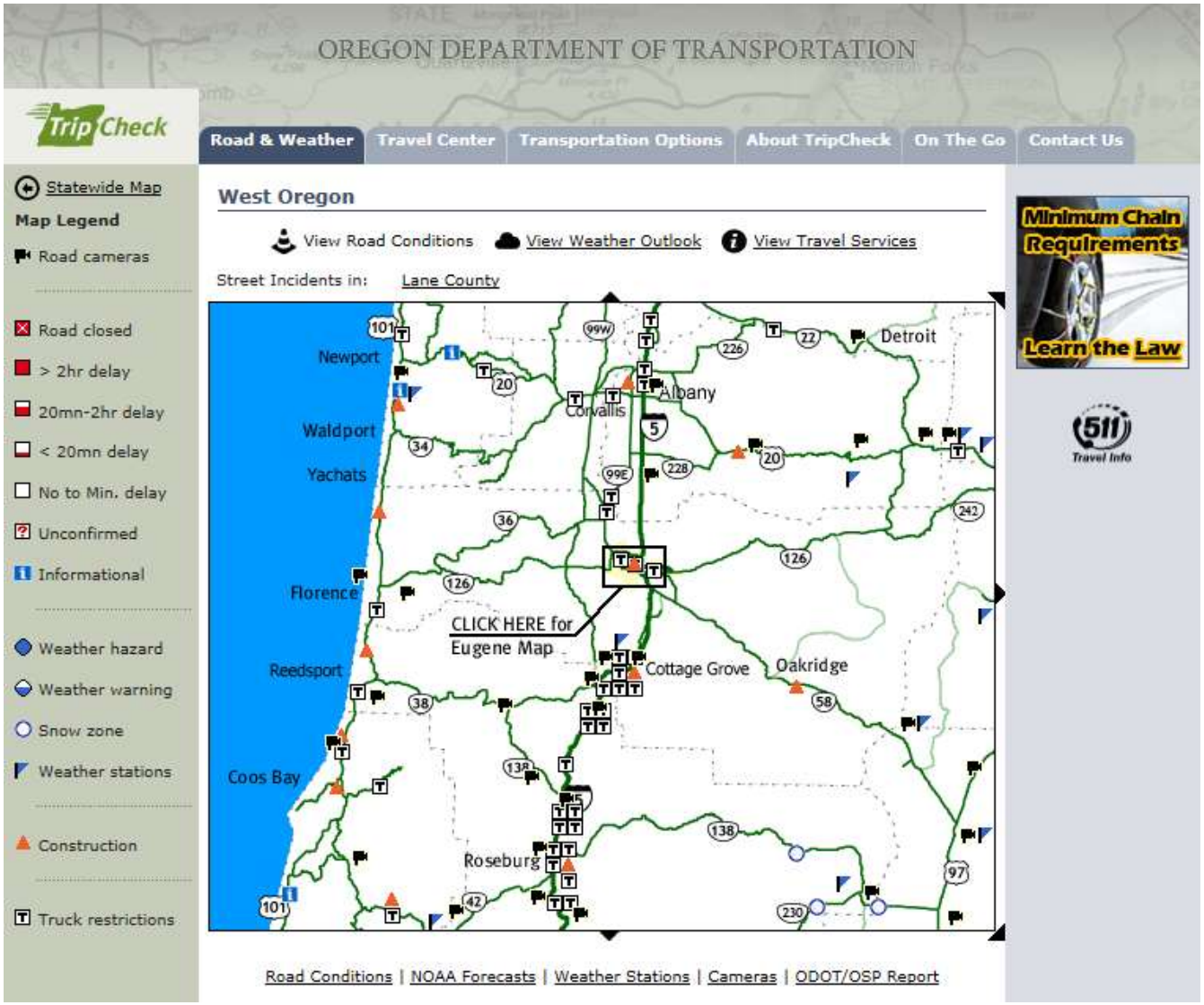
- Trailers are placed outside the bounds of the construction zone to detect queues.
- Intermediate DCUs provide sections of travel times within the zone.
- Locations are limited by existing infrastructure and the number of portable trailers.


CCTV BT DCU
Solar Powered Trailer
I-5 MP174.18
Latitude: 43.7968
Longitude: -123.0471
BT DCU
VMS Cabinet
I-5 MP170.3
Latitude: 43.7576
Longitude: -123.0965
BT DCU
Ward's Butte RWIS
I-5 MP167.65
Latitude: 43.7522
Longitude: -123.1448
CCTV BT DCU
Solar Powered Trailer
I-5 MP157
Latitude: 43.6402
Longitude: -123.2152
Cottage Grove
Cottage Grove Lake
2 mi

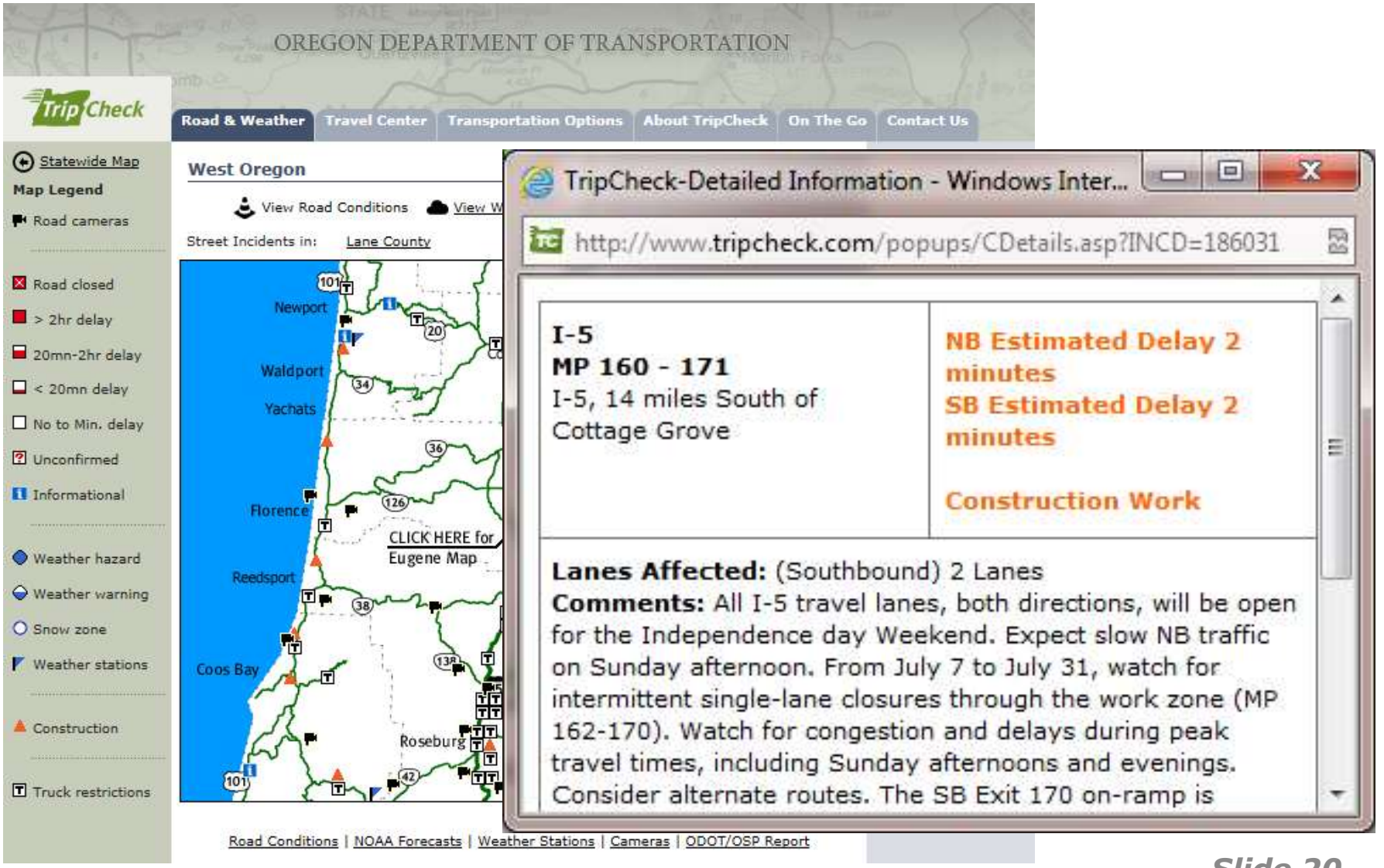
ODOT Central Services



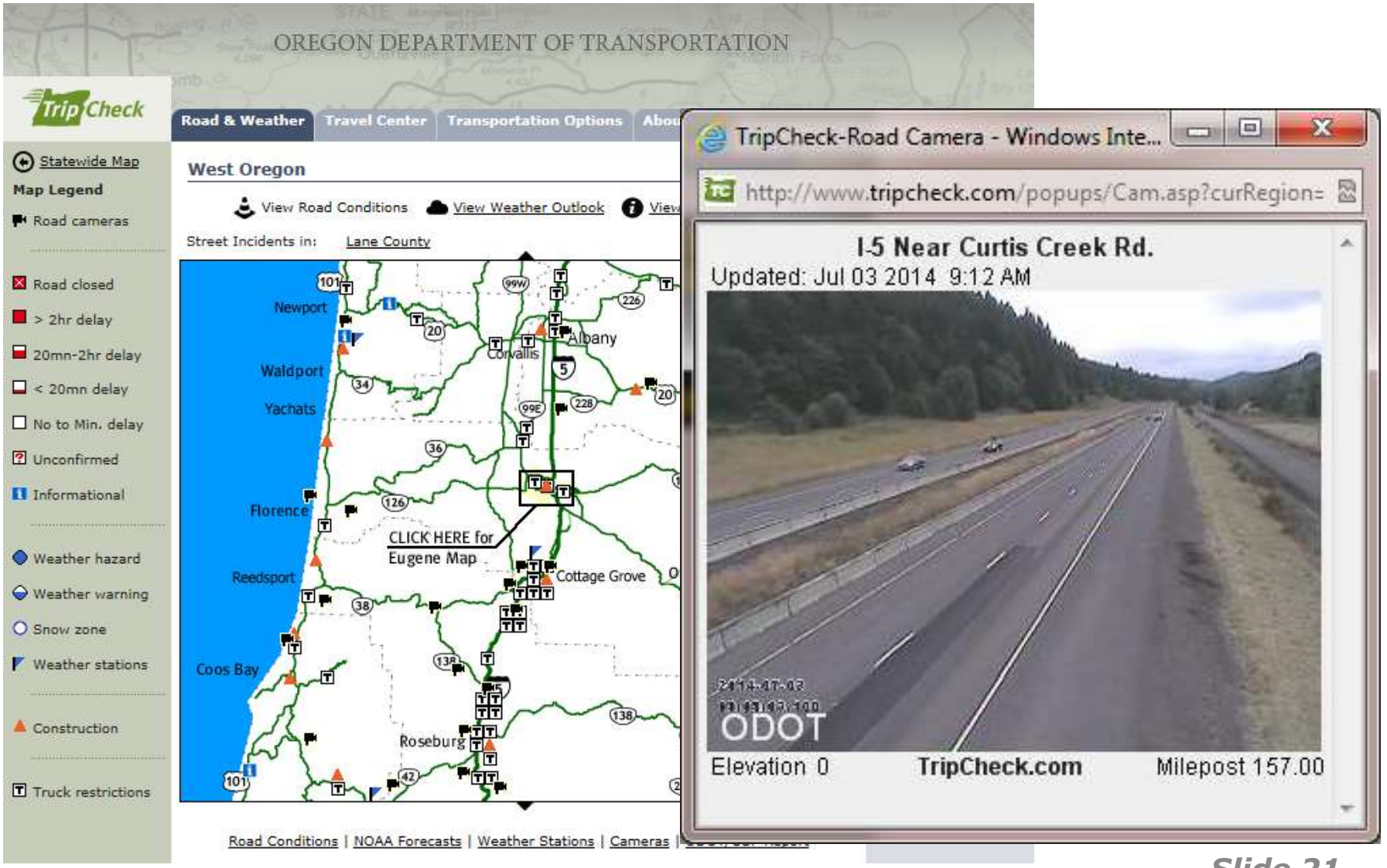
Public Information - Travel Delay



Public Information - Travel Delay



Public Information - Cameras



Year 1 - Operational Experience

- Propane trailer component failure.
- Constant refueling of propane.
- Trailer location adjustments due to large delays.
- Bluetooth travel time bugs:
  - Delay maximum was reached on several occasions.
  - DCU interface and web hosting lockup.
  - Periods with unrealistic travel time.
  - Cell connectivity issues.
  - System *"fills in"* travel time data for failed segments.

Year 1 – Trailer #3

- Replacement for propane trailer.
- Custom built camera trailer.
- Solar powered.
- PTZ camera
- Bluetooth and network gear installed.

Lessons Learned

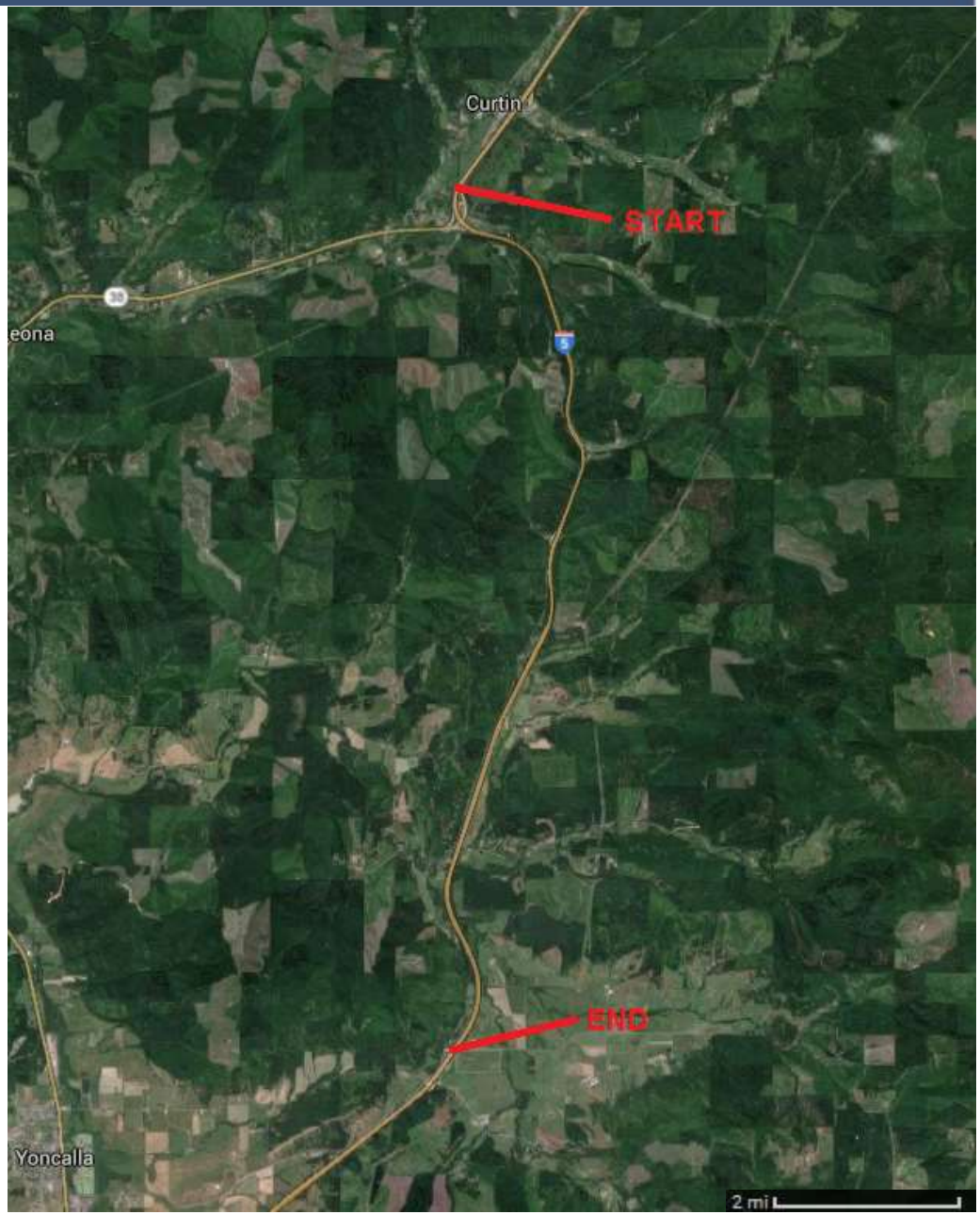
- Use solar powered trailers.
- Better understanding of Bluetooth travel time system.
- More equally spaced detectors for analysis.
- Barricade equipment needs to be included.
- PTZ cameras do not travel well.

Year 2

- Construction Zone Travel Time became Smart Work Zone.
- Traffic financed project.
- Project scope transitioned to enhancing safety and reducing congestion.
- Traffic impact analysis.

Year 2 - Construction Zone

- 9 mile repaving project on I-5.
- Project anticipated having a large impact to traffic flow.
- Work Zone Traffic partnered with ITS.
- ITS/Traffic project goals:
  - Inform the public, local and web users, of traffic impact.
  - Analyze the impact of traffic delay.
  - Analyze the vehicle count, congestion, and classification of I-5 traffic impacted by construction.

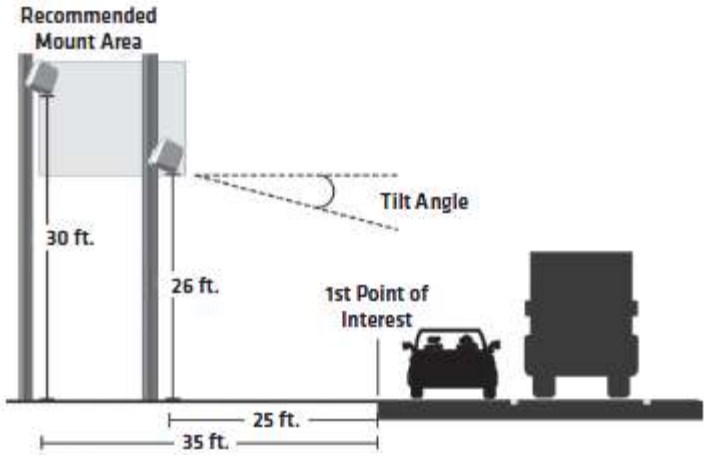

Curtin
START
eona
END
Yoncalla
2 mi

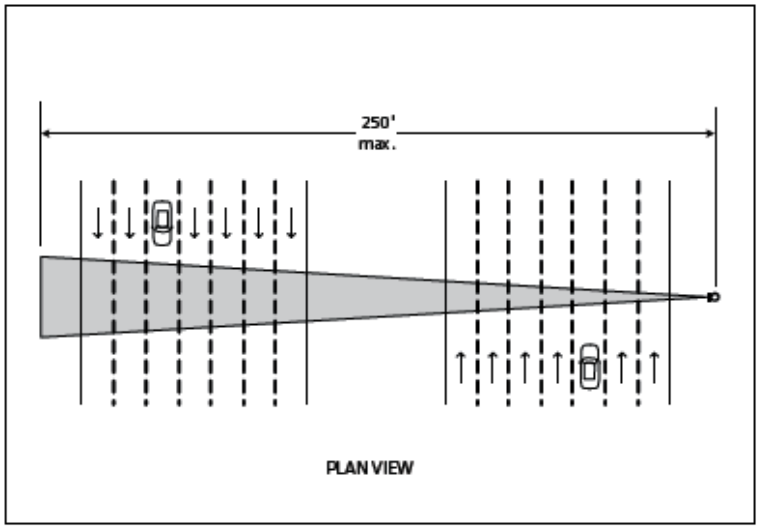
Bluetooth Travel Time Upgrades

- DCU Upgrades
  - BT to USB adapter failure recognition.
  - Web service lockup detection and reboot.
  - DCU auto-reboot.
  - RS-232 adapter instead of USB.
  - Files are easier to configure.

- Software Upgrades
  - Delay maximum removed.
  - Eliminated route redundancy (duplicate MACs at one location causing additional routes).
  - Delay time can be used by VMS.
  - Historical data collection.

Traffic Sensor





- Radar sensor measuring traffic perpendicular to the roadway.
- Able to monitor all northbound and southbound lanes from either side of the roadway.
- Provides volume counts, average lane speed, and vehicle size classification.
- 9,000 data intervals stored in sensor.

Traffic Sensor Components

RS-485

RS-485

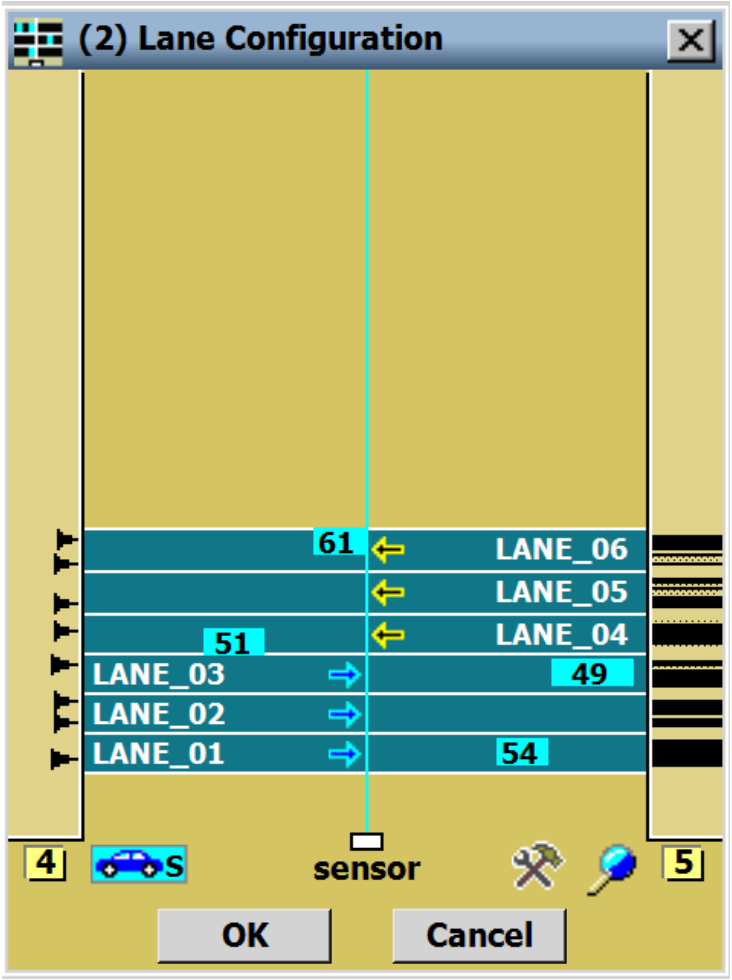
Wavetronix
Smart Sensor HD

Surge
Protector

Serial to
Ethernet
Converter

Traffic Sensor Configuration

- Lanes are automatically generated when vehicles pass by.
- Areas can be disregarded.
- Configuration needs to be done at each trailer deployment.
- Configuration is saved in device and loads automatically when power cycled.



Year 2 – Trailers

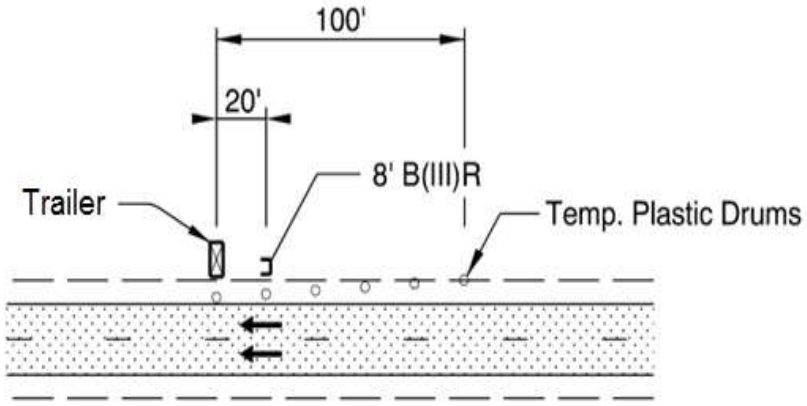
- 4 trailers were built.
- Included cameras, travel time sensors, and radar traffic sensors.
- Solar powered systems.
- Custom sensor mast and solar panel mounts were created and attached to PCMS frames.
- Trailers cost around $30,000.


B

Portability

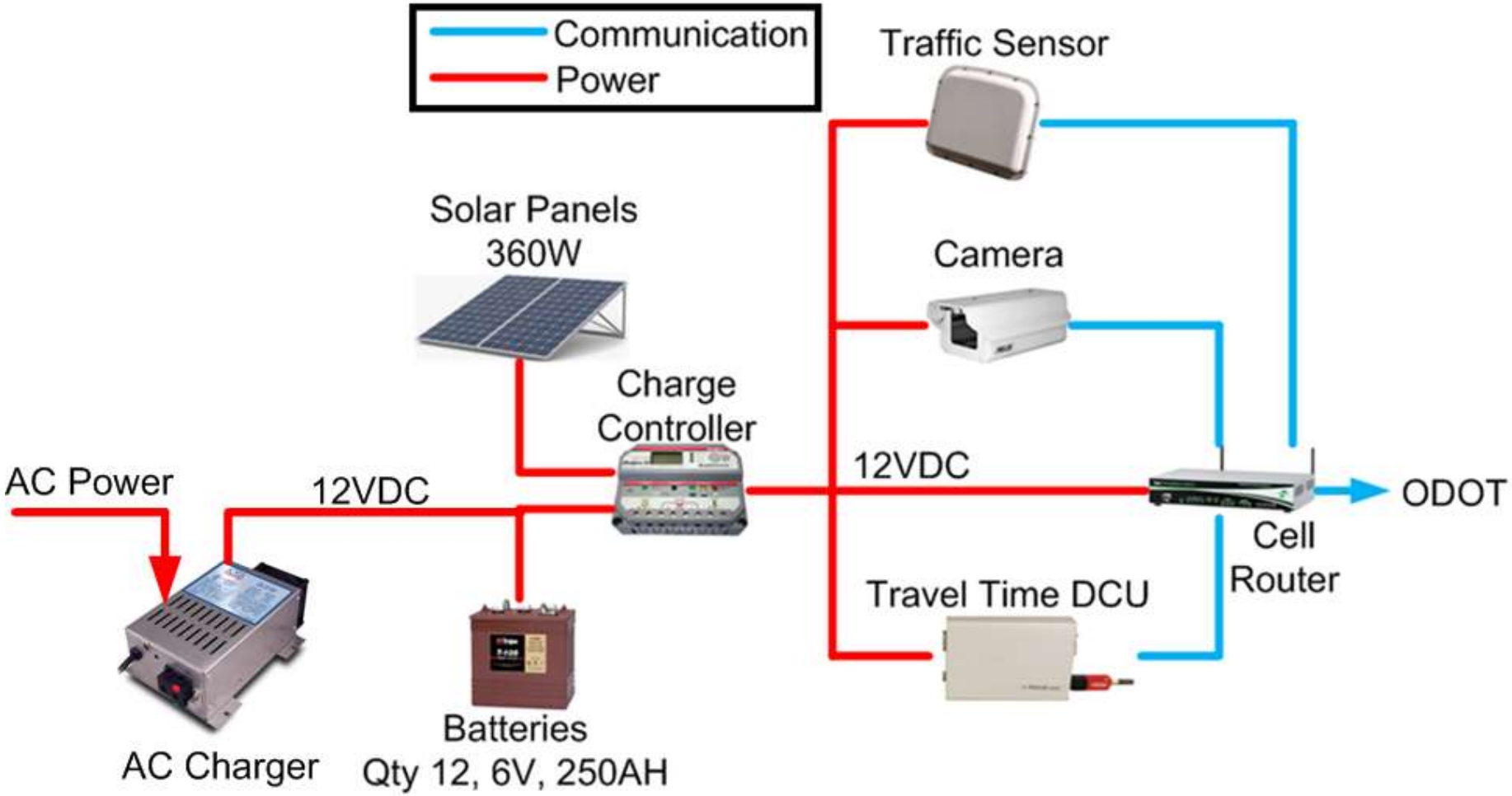
- 6 barrels and a barricade are required for roadside deployment within the clear zone.
- During travel this equipment can all be attached to the trailer for ease of portability.
- Toolboxes and additional trailer hitches are included in each trailer.
- Sensor carrying cases were added for safer transportation.

Barrels and Barricade

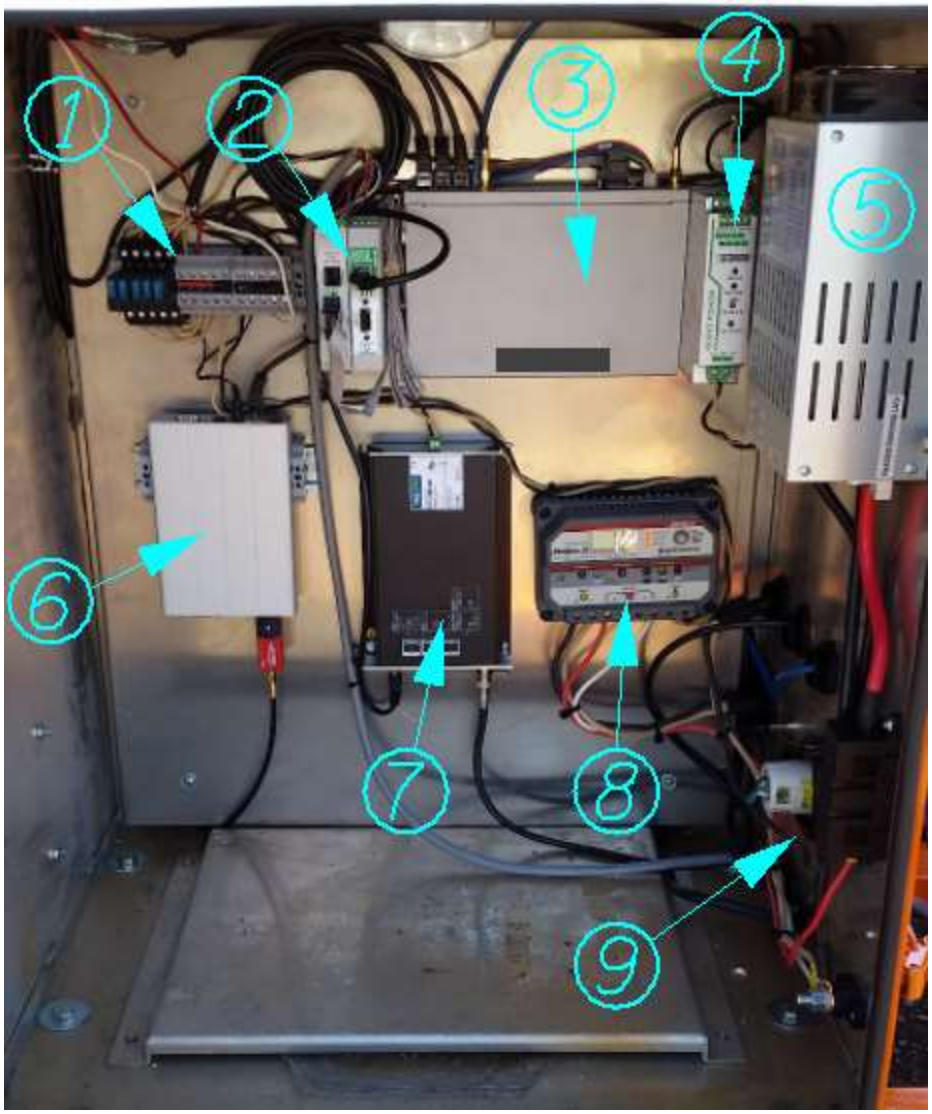


Trailer Deployment

Trailer Design

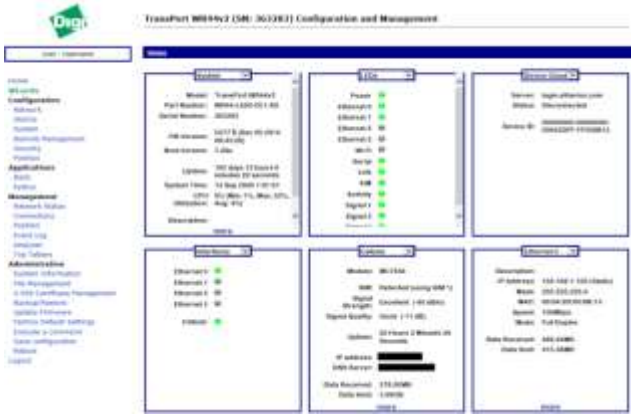


Trailer Cabinet

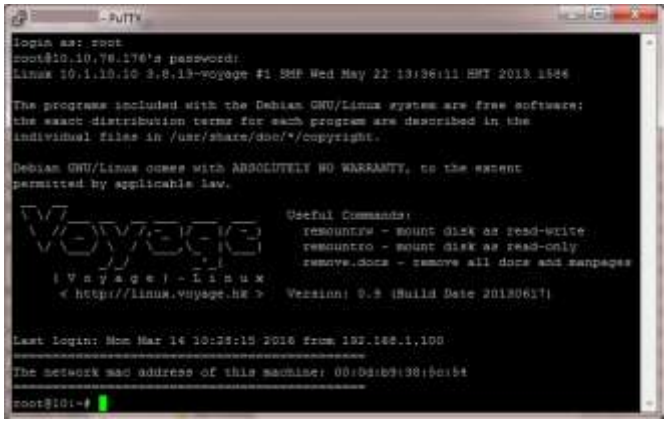


#	Description
1	Terminal blocks
2	Radar signal converter
3	Wireless router
4	Power supply
5	AC battery charger
6	Bluetooth DCU
7	Camera encoder
8	Charge controller
9	Trailer brake wiring

Remote Access



Wireless Router

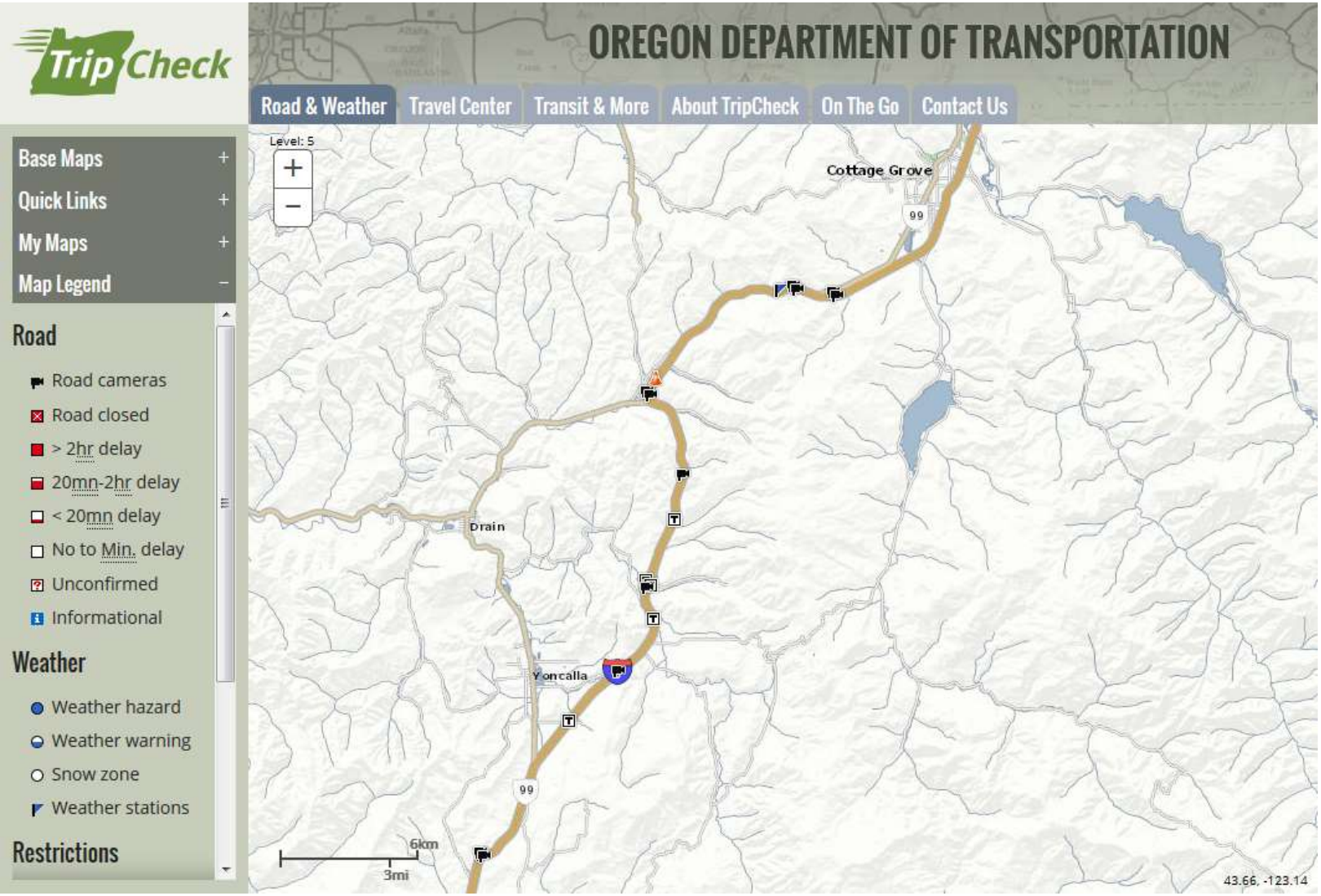


Bluetooth DCU

Camera Encoder

Radar Traffic Sensor

Public Information - TripCheck



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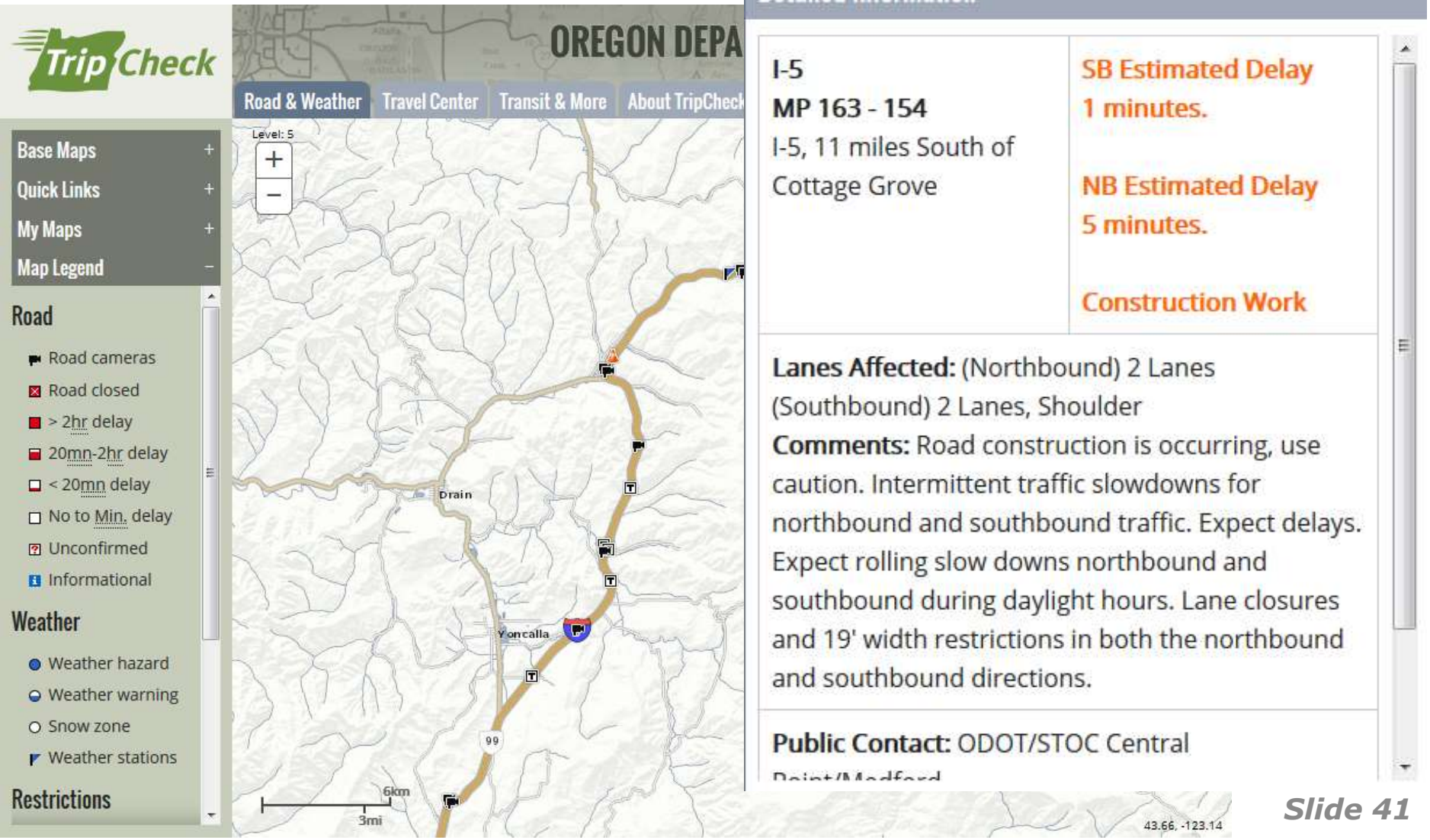
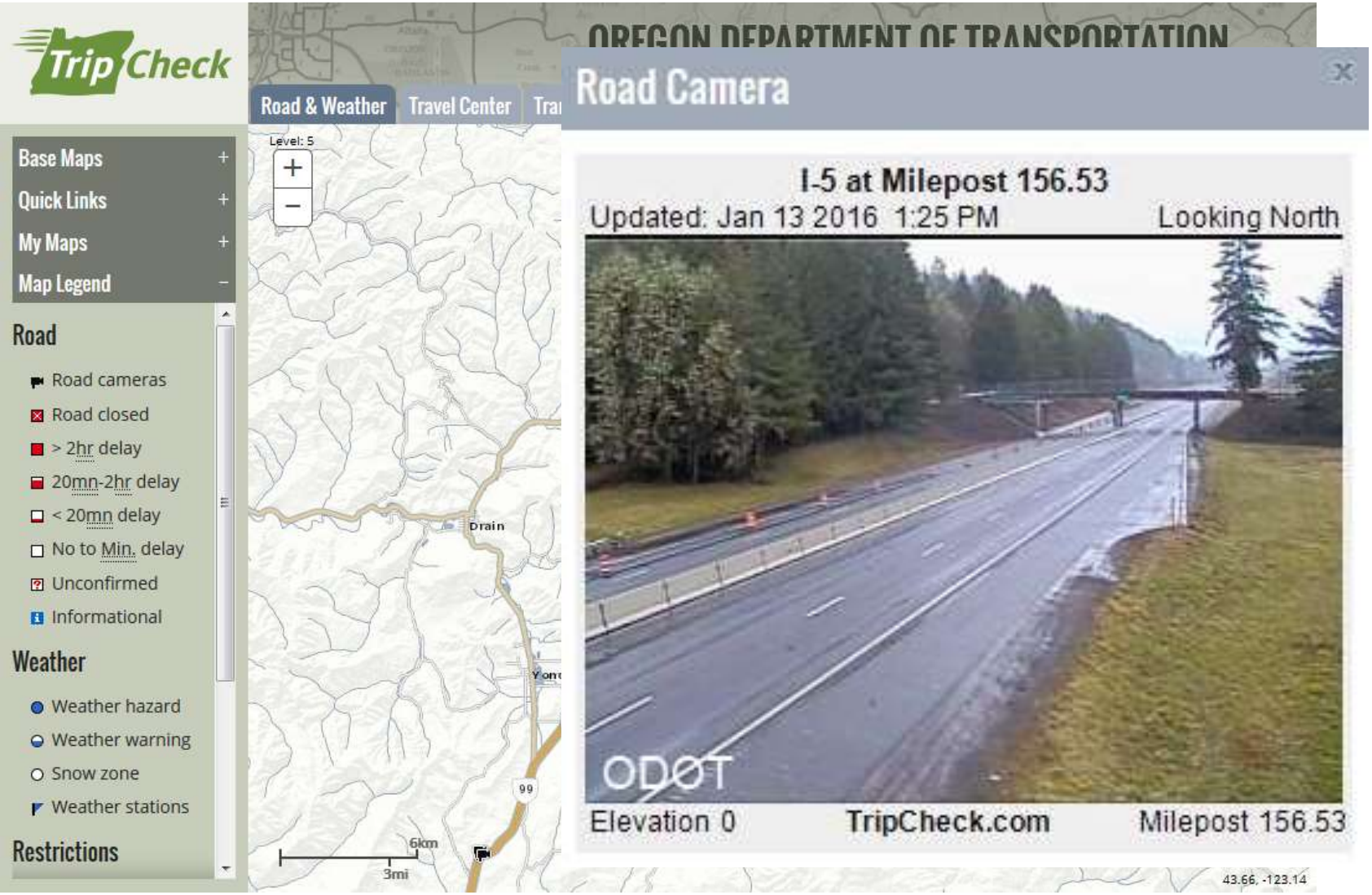


Public Information - TripCheck



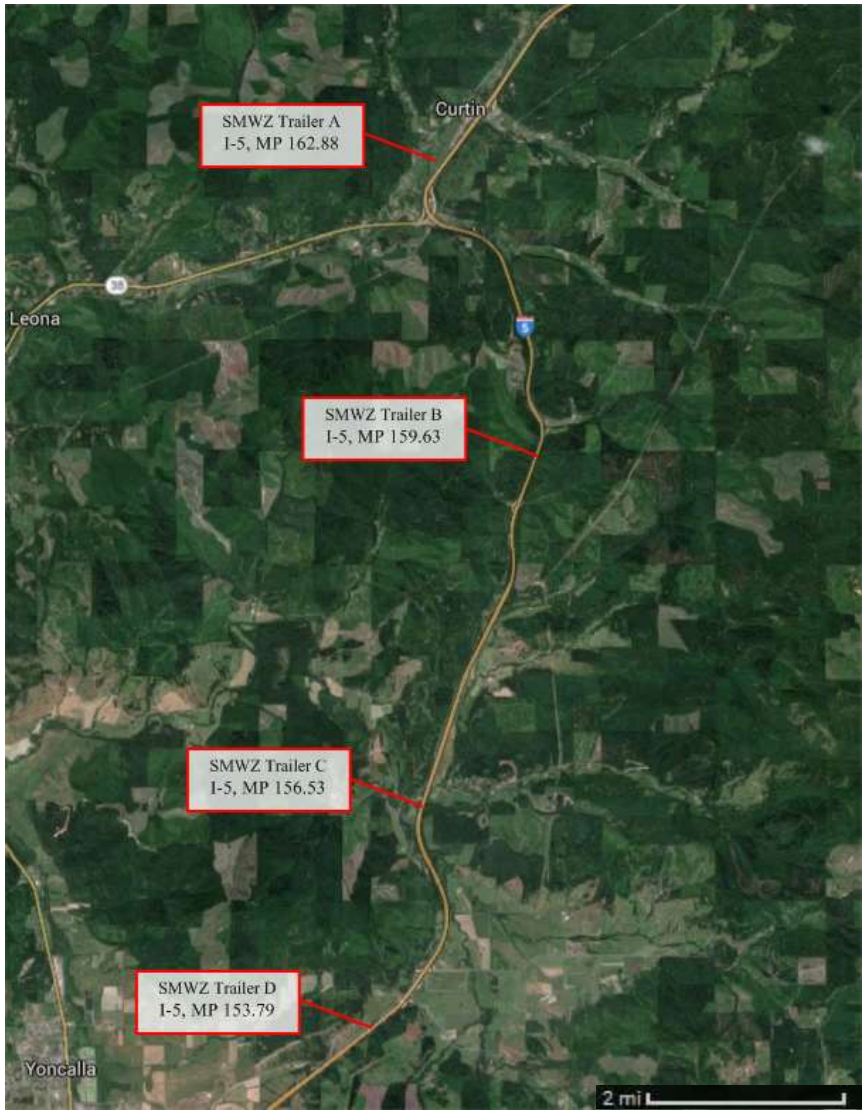
Camera Images Saved

- Camera images are saved every 5 minutes for 10 days.
- Allows for data validation and monitoring traffic patterns.
- Large congestion events are recorded for analysis.

Camera Time Lapse

Year 2 – Equipment Placement

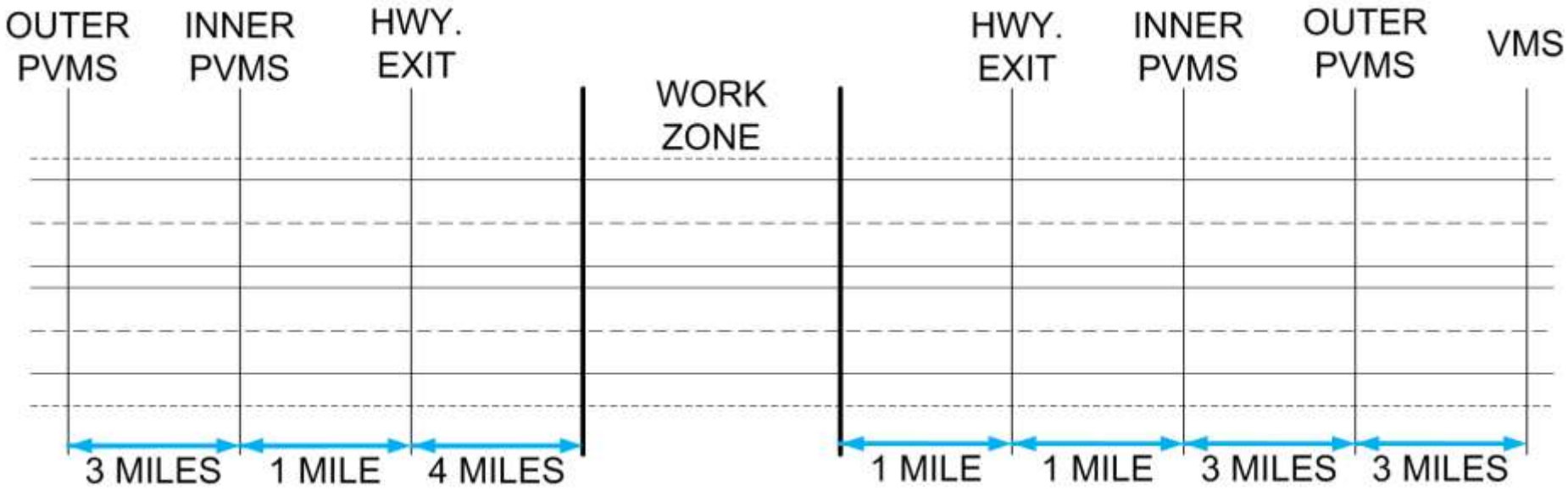
- Portability of the midpoints allows for a more dynamic view of the zone.
- Trailers were relocated at various times to focus on different work points.
- Deployment locations are only limited by the landscape and road height.



Public Information – Message Signs

- PVMS and VMS provide travelers of real time travel delay at the beginning of the construction zone.

Public Information – Message Signs



Message Signs – Inner PVMS

- Messages posted on signs are determined only from travel time data.
- Delay values posted are in 5 minute increments.
- Values round up, so 1 second of delay is reported as 5 minutes.
- There is a constant message displayed.
- During periods of no delay "--" is the placeholder.

Message Signs – Inner PVMS

Panel 1

Panel 2

Message Signs – Outer PVMS & VMS

- Activated when travel time delay is greater than 5 min.
- Messages will automatically clear when delay is reduced.
- After congestion reaches a certain threshold the message signs display:

WZ AHEAD		CURRENT
CONSIDER	→	WZ DELAY
ALT RTE		XX MIN

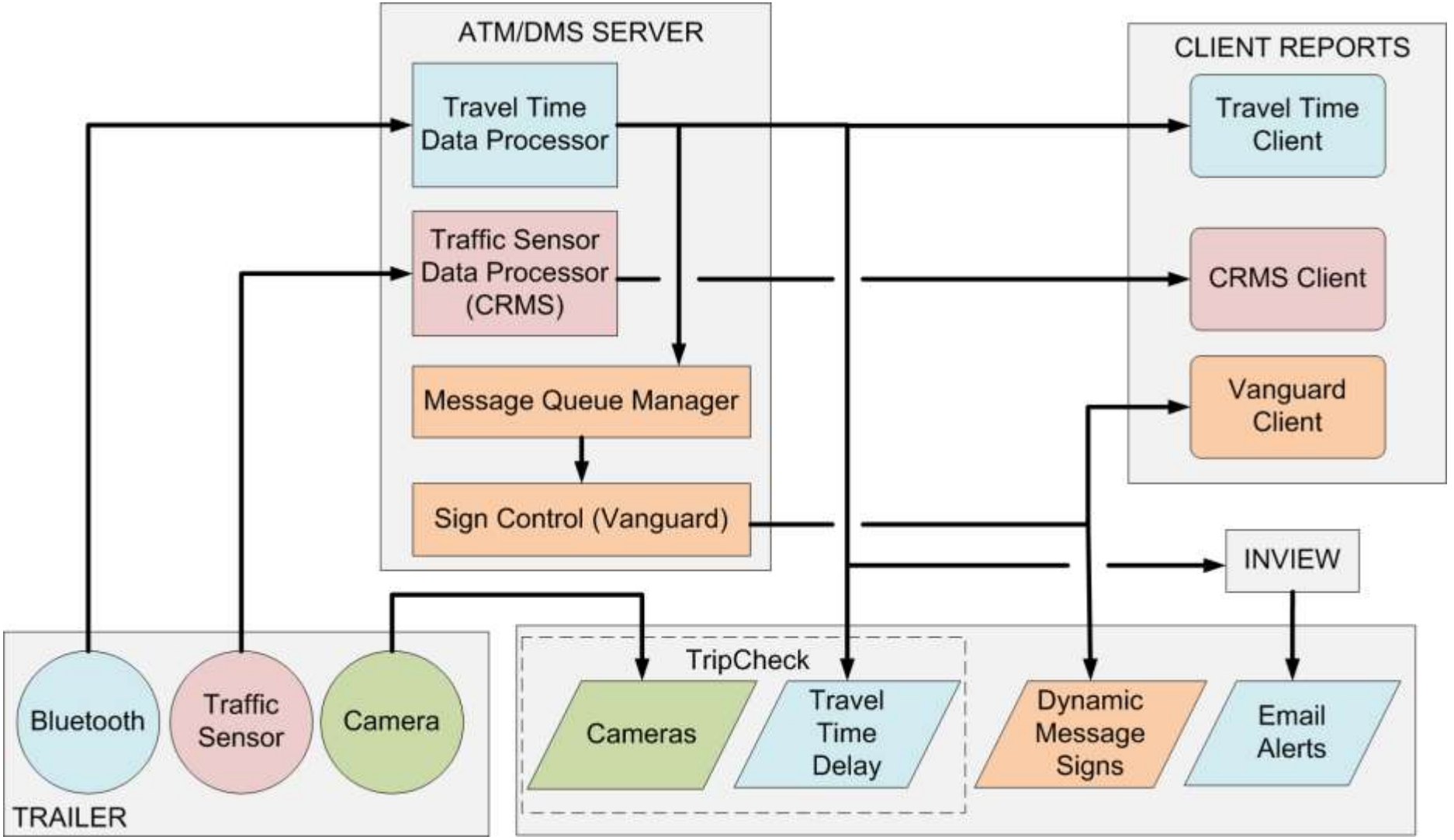
- VMS is activated when delay is greater than 20 min.

CONGESTION AHEAD
MP 154-162 SEVERE
DELAY XX MINUTES

ODOT Notifications

- When traffic delay reaches a certain threshold notifications are sent to designated personnel via text and email.
- Allows for project manager to take corrective action to reduce the traffic backup.
- Alert messages are saved for historical reports.

ODOT Central Services



Traffic Analysis Benefit

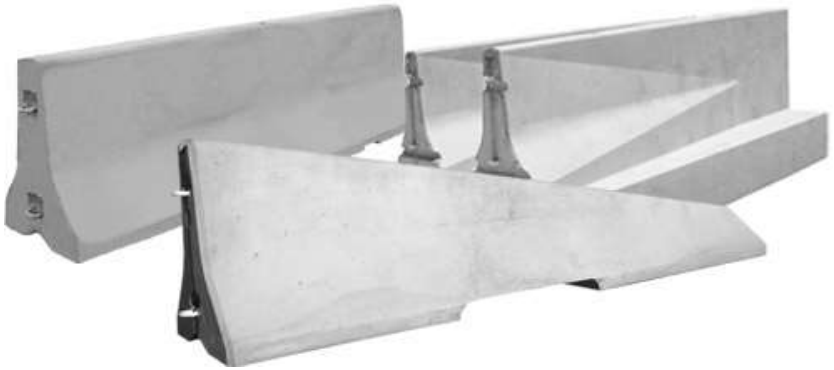
- The sensors from the trailers provide the following data:
  - Travel time (1 min. updates).
  - Volume by lane (20 sec. updates).
  - Speed by lane (20 sec. updates).
  - Occupancy by lane (20 sec. updates).
  - Vehicle classification (20 sec. updates).
  - Historical camera images.

Traffic Analysis Benefit

- Prior to construction, traffic data allows for prediction of work zone traffic.
- Lane closure strategies can be developed to improve flow.
- Vehicle counts can be used for project funding.

Year 2 - Operational Experience

- Project location impacts sun exposure.
- Abnormally heavy rain this year.
- Generator used frequently to charge batteries.
- Radar firmware issues.
- Radar is sensitive to reflections caused by median barriers or trees.




A

Future Improvements

- Battery voltage monitor with email notification.
- Secondary power system, onboard generator.
- Powered adjustment of the traffic sensor and camera on the mast.