WYDOT Roadside Wifi & Tablet App.

Mark Kelly
Telecommunications
Comms System Supervisor
Project Development
mark.kelly@wyo.gov
307-777-4838

1

Background

- I've been in the Telecommunications field since 1994. I started with commercial service providers, doing everything from vehicle installs to installing towers/sites.

- Associates degree in Applied Science, Avionics

- I started with WYDOT in 2007 as the District #1 Telecom Supervisor. I was promoted to System Support Supervisor in August of 2014.

- WYDOT Telecom is a diverse group that installs and maintains communications State wide as well as a wide range of customers from WYDOT to other State agencies.

Recognition Of Need
(continued)

- WYDOT was asked by the Federal Highway Administration (FHWA) to submit a grant application for a Weather-Responsive Traffic Management project. We wanted to find a way to improve efficiency in the Transportation Management Center and reduce radio traffic.

- The WiFi & Tablet App was conceived by WYDOT Intelligent Transportation Systems (ITS) Program in 2013.

- ITS saw a need to quickly get road conditions to the traveling public on the WYOROAD web site. http://www.wyoroad.info/

Recognition Of Need

(continued)

- Instead of data being entered manually by a dispatcher, the tablet would allow the maintenance personnel to directly enter the data without involving a dispatcher.

- Since the Transportation Management Center (TMC) dispatch was built in 2007, all road conditions and information was given to a dispatcher via the State Wide Trunked Radio System (WyoLink) (http://wyolink.wyoming.gov/) .

- Road conditions were reported using "10 codes" "8-1/9-1" is the code for "dry road with favorable conditions". This format has been used for 40+ years.

10 Codes

Code	Meaning
10-4	Acknowledgement (OK)
10-7	Out of Service
10-8	In Service
10-13	Weather/Road Report
10-22	Disregard
10-41	Beginning Duty
10-42	Ending Duty
10-43	Information
10-9	Repeat
10-50	Crash
10-W	Windspeed

Advisories

No Unnecessary Travel
Chain Law
Advise No Light Trailers
Black Ice
Falling Rock

8 Codes

Code	Meaning
8-1	Dry
8-2	Wet
8-3	Slick
8-4	Slick Spots
8-5	Drifted Snow
8-6	Closed

9 Codes

Code	Meaning
9-1	Favorable Weather
9-2	Snow
9-3	Rain
9-4	Strong Wind
9-5	Fog
9-6	Blowing Snow
9-7	Reduced Visibility

Wind Guidelines

Strong Wind

	Gusts	
Add 94	35+ MPH	
Lift 94	25 MPH or below	

ANLT

	Gusts	
Add ANLT	50+ MPH	
	Gusts	Time Period
Lift ANLT	40 MPH or below	30 min

C2LHPV / EBOR

	Gusts		
Add C2LHPV	65+ MPH	or	Blowover
	Gusts		Time Period
Lift C2LHPV	55 MPH or below		30 min

Watch for Black Ice

Relative Humidity > 90% and Surface Temperatures < 32°

Recognition Of Need
(Continued)

- The information was posted to the WYOROAD web site by TMC and other information was given to Wyoming Highway Patrol (WHP)

- During snow events, updating the web site was second priority to operations due to the volume of calls.

- The same relay of information was also used to update Dynamic Message Signs (DMS) and Variable Speed Limit Signs (VSL) from the plow drivers as well as WHP.

Recognition Of Need
(Continued)

- Plow drivers would also request information from Roadside Weather Information Stations (RWIS).

- TMC is aided in dispatching plows to an area via Automatic Vehicle Location (AVL).

- "This application was developed to allow WYDOT employees to use a computer to perform the same functions as they have been doing via radio or cell phone, with advantages including direct updates to data bases, easier access to information, and reduced strain on the radio system," Garcia said. "We're optimistic we will achieve our goals, but we want additional feedback from the users as we continue the evaluation process."

  (WYDOT Interchange, Bruce Burrows)

Tablet App Goals

- Reduce radio traffic. Data is sent directly to TMC and Web site.

- Streamline TMC processes. Less data entry required by dispatchers.

- Improve timeliness, accuracy of condition reports.

- Provide more information to maintenance personnel. DMS & VSL information is changed to match current road conditions.

Tablet App Goals
(continued)

- Increase efficiency. Several reports can be sent at once instead of waiting for radio traffic to give report to TMC.

- Improve roadway safety

- Improve Snow Performance Measures. Data is sent directly to the meteorologist working out of the TMC.

Tablet App.

- Funding for the App was through a federal Weather-Responsive Traffic Management Grant with state matching funds that ITS applied for in March 2013. Total project budget, $186K in Federal Grant and $30K of ITS Program funds.

- The grant required federal oversight and evaluation

- **PROPOSED SCHEDULE AND DELIVERABLES (next slide)**

Tablet App.
(Continued)

- October – November 2013, Prepare project concept of operations
- November – December 2013, Project to begin with SE design
- January 2014, Evaluation of Utah's citizen reporting app
- February – October 2014, System development
- September 2014, Training
- September 2014 – May 2015, System evaluation
- January 2015, Preliminary report
- May – June 2015, Documentation of findings and final project report
- July 2015, Final report submission

Tablet App.
(Continued)

- Using Federal "Sole Source", CompassCom was selected as the vendor in November 2013. CompassCom enlisted the help of Neotreks to develop the App and communications to the TMC and Web site.

- The WyoLink P25 VHF Trunked system doesn't have the capability to handle high bandwidth applications like weather maps, but may be used for simple messages, unit positions (Automatic Vehicle Location)AVL for the vehicles, etc.

Tablet App.
(Continued)

- An Android based application was chosen for ease of use on most tablets and smart phones.
- WYDOT ITS selected an "off the shelf"(Samsung Galaxy 4 with 10.1" screen) tablet for cost and ease to replace compared to ruggedized tablets. So far there haven't been any environmental issues with the tablet.
- App development began in April 2014.
- The prototype of the App was presented to WYDOT in August 2014, with the design based off meetings with WYDOT Maintenance Supervisors and their Crew members input.

Tablet App.
(Continued)

- The App design was fine tuned over the summer of 2014 in several phases, I.E. button, text size and page layouts.

- Development tools: Android Studio, an application from Google. Hockeyapp, an online tool for application distribution. It also helps to gather logs and feedbacks from the application. ArcGIS SDK, an application library from ESRI, to display map content. (base map, roads, plows, etc.)

- Test tablets were tested early December 2014, to verify operation and work out any bugs before the Pilot phase was started in Mid December 2014.

Tablet App.
(Continued)

- Initial User training was given in September 2014 and detailed training was in December 2014.

- 20 tablets were deployed in Districts 1 & 3 spanning 5 counties and 420 miles of I-80 & I-25.

- New versions/updates of the App can be downloaded via WiFi.

Tablet App Setbacks

- Connectivity to the LMU & mobile radio.

- Testing the App as coding was changed, due to lack of remote access to WYDOT communications infrastructure.

- Encountered performance and accuracy issues when we used the ArcGIS SDK to identify mile post based on GPS location. The code was recently changed to, geospatial database engine "SpatiaLite", which is much faster and will still work very well with larger datasets (more roads, more mileposts).

- Programming bugs in the App.

- Continued updates to the App.

Tablet App Features-Functionality

- User can login using normal WYDOT login and Password. (Password is required to be changed every 30 days).
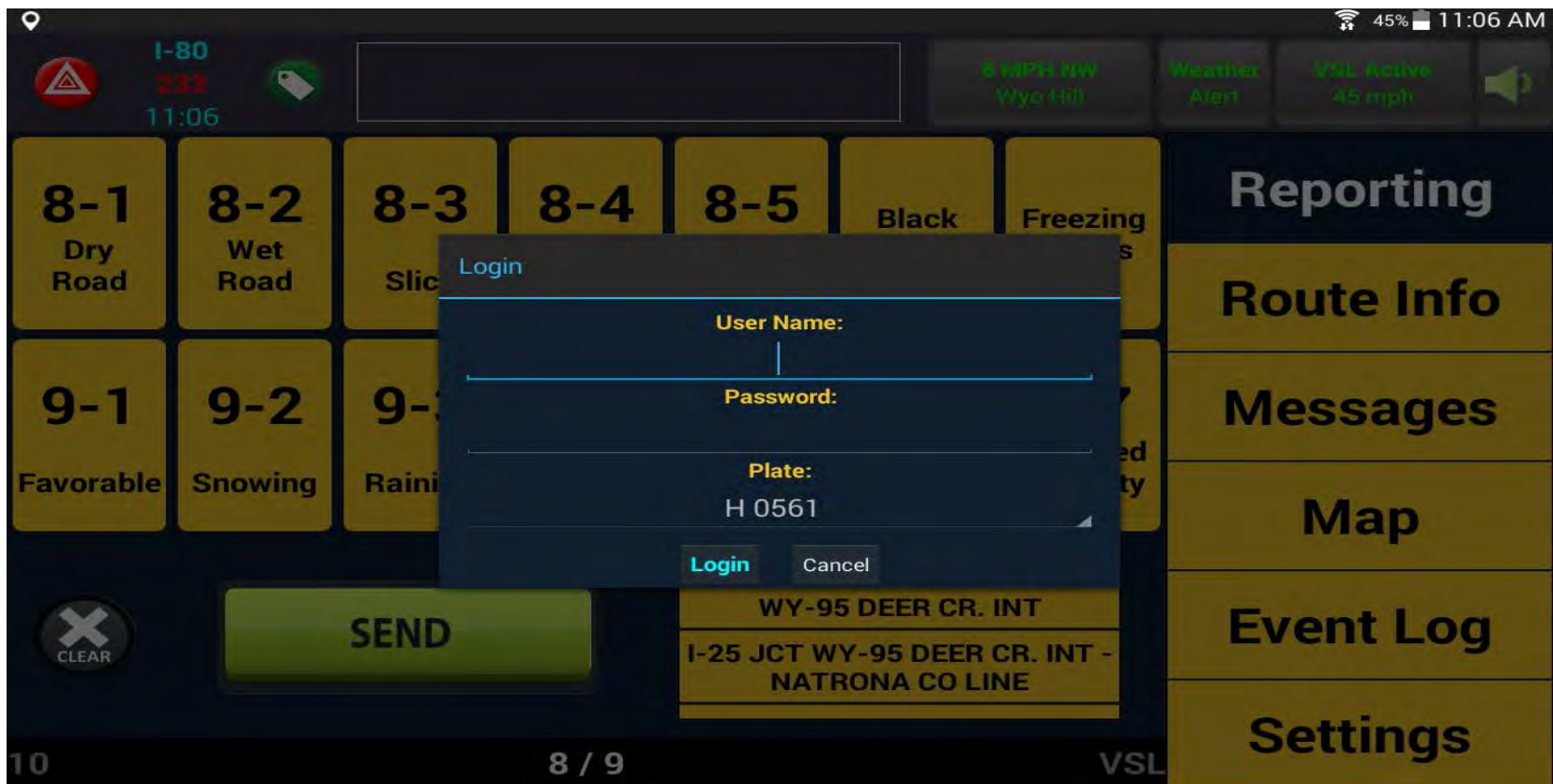
Tablet App Features-Functionality
(Continued)

Overview: Status Bar
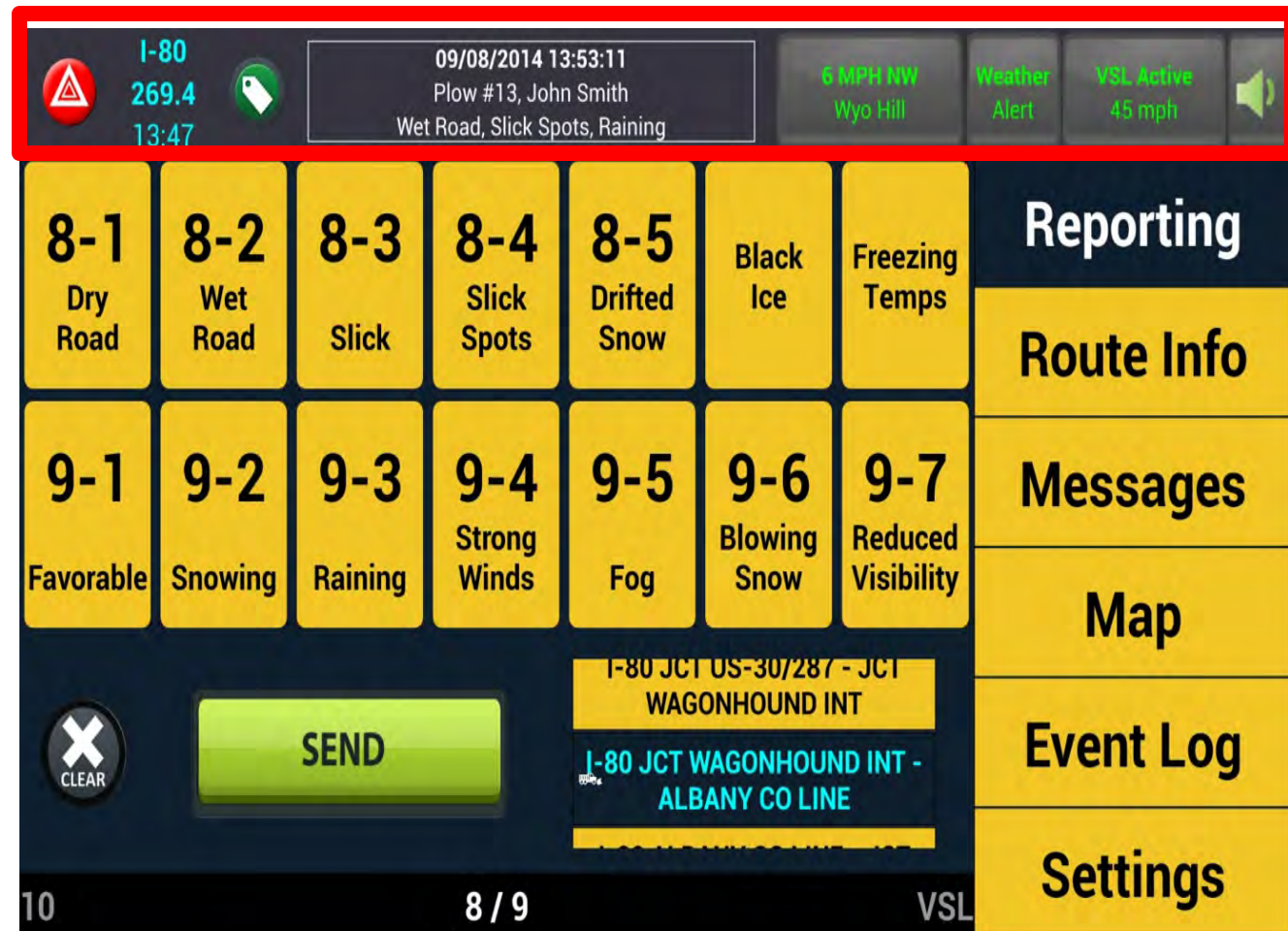
- Emergency Call
- Location
- GeoTag
- Current Road Report
- Wind Speed
- Weather Alert
- Speed Limit
- Volume
- Tablet has "speak" function

18

Tablet App Features-Functionality

(Continued)

Use these buttons to select appropriate 8, 9 or 10 codes

Tablet App Features-Functionality

(Continued)

- Use to select appropriate road section
- List will populate based on where vehicle has travelled
- Current location is pre-selected
- Can select multiple road sections
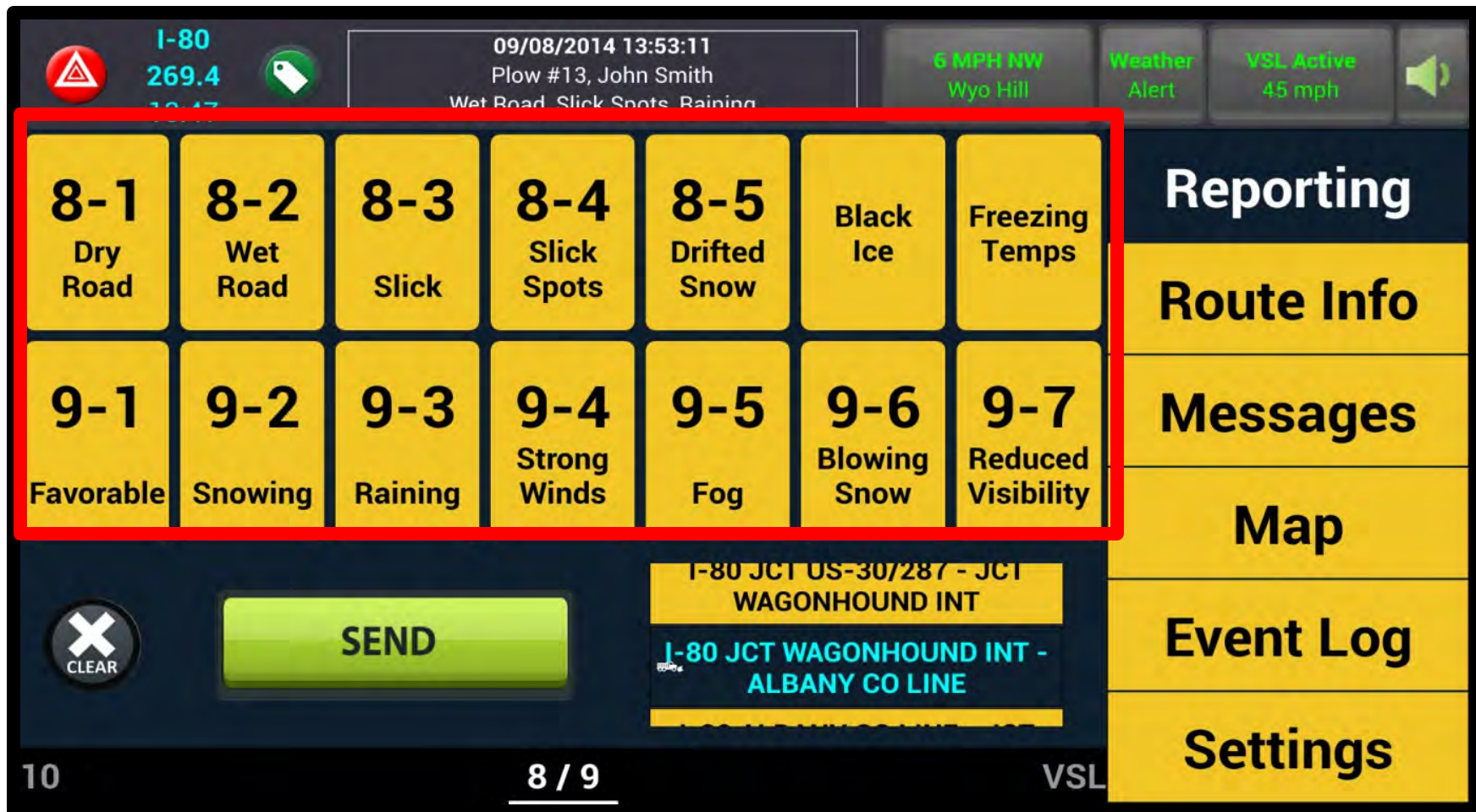
Overview: Location Selection
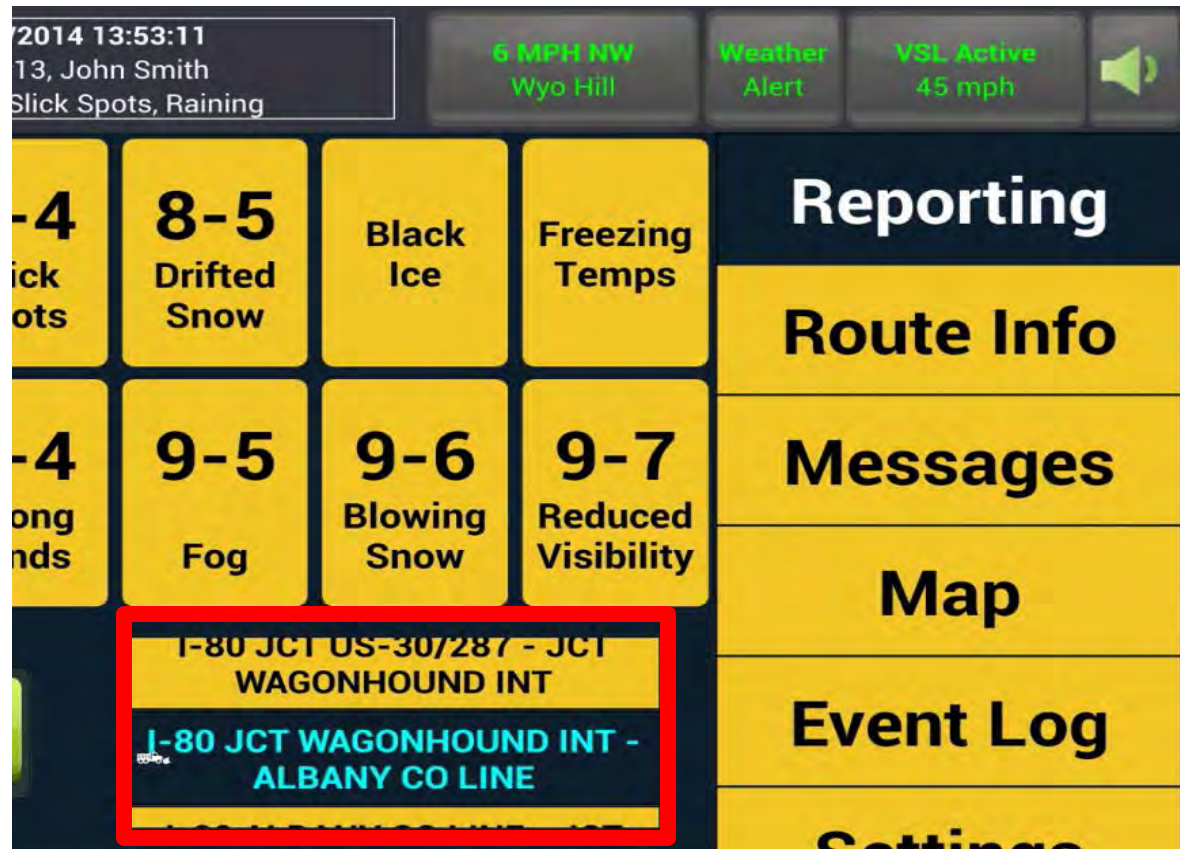
Tablet App Features-Functionality

(Continued)

Overview: Tabs

- Reporting
  - 10 Codes
  - 8, 9 Codes
  - VSLs
  - Snow Performance
- Route Info
  - DMS
  - RWIS
- Messages
- Map
  - Asset Locations
  - Weather Radar
- Event Log
- Settings
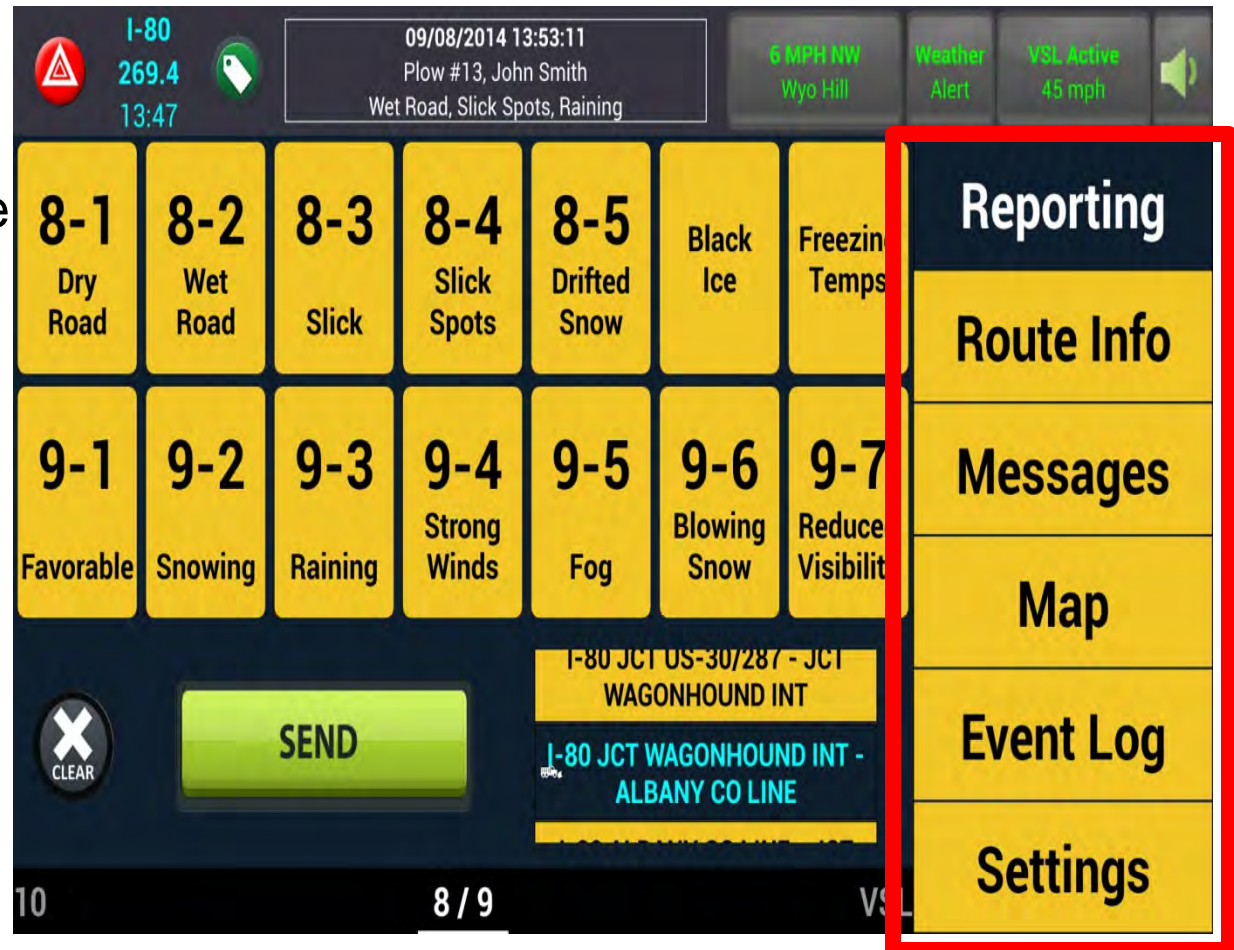
Tablet App Features-Functionality

(Continued)

Overview: Page Reference

- Swipe to move from one page to the next.

- The page you are on is bold and underlined.

- The next pages are on the next slides.
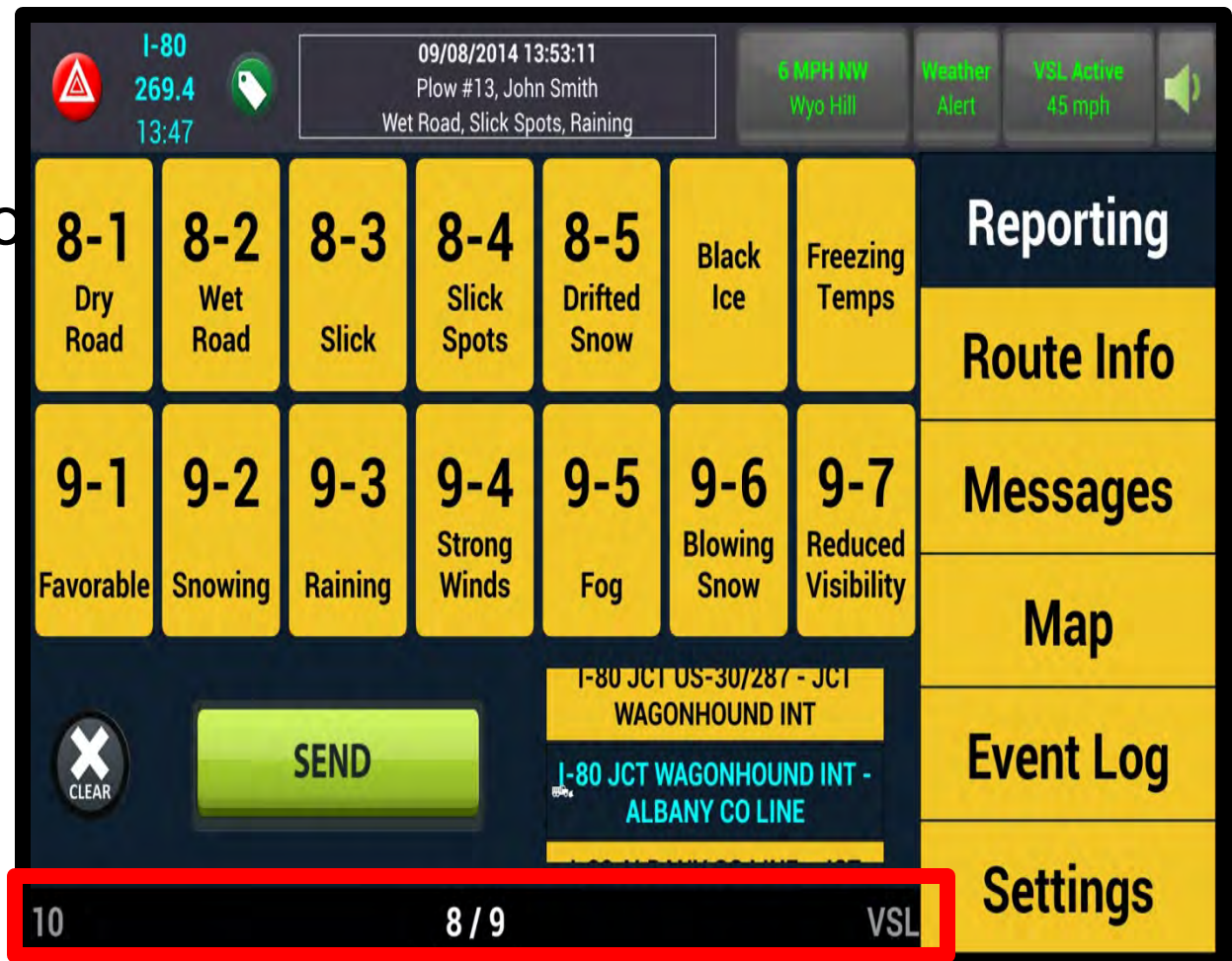
Tablet App Features-Functionality

(Continued)

- Report Road Conditions
- Built-in logic will prevent prohibited reports (for example, dry road with drifted snow)
- Persistence
- Cannot report most advisories, road closures
- Report freezing temperatures
- Auto selects current location; to report in another section, select from a list

Overview: Road Report

Tablet App Features-Functionality

(Continued)

Overview: 10 Codes Real-Time

- Report going in and out of service
- When you select a code and hit send, it will send your exact current location to the TMC
- Provide additional information, if available
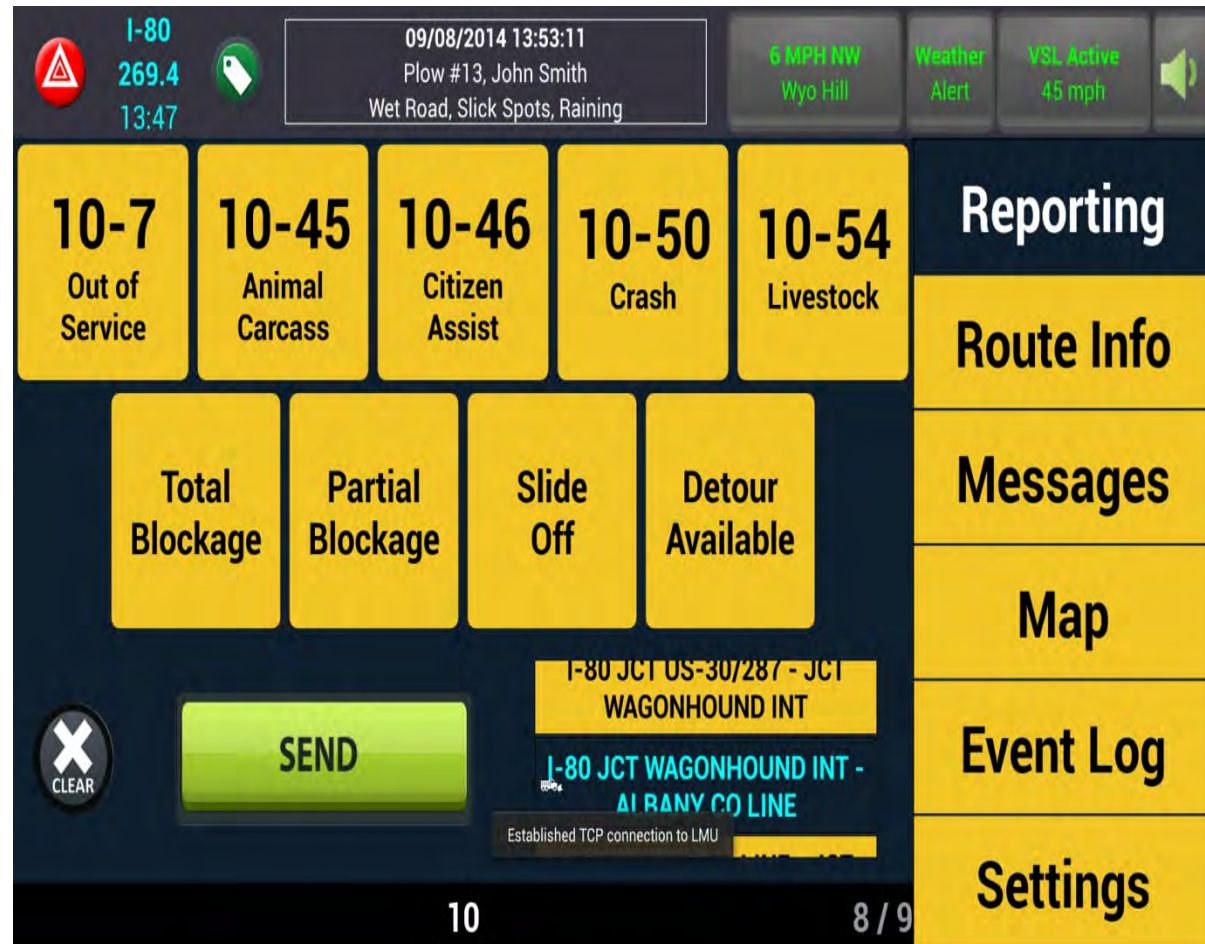
(Continued)

- Will provide information, might not be available at launch

- TMC Recommended speed, based on sight distance, weather and road surface

- Posted speed

- Pace speed, average, plus 5 mph

- Select a recommendation

- Auto-selects current section; choose a different selection from list to apply to a different sign
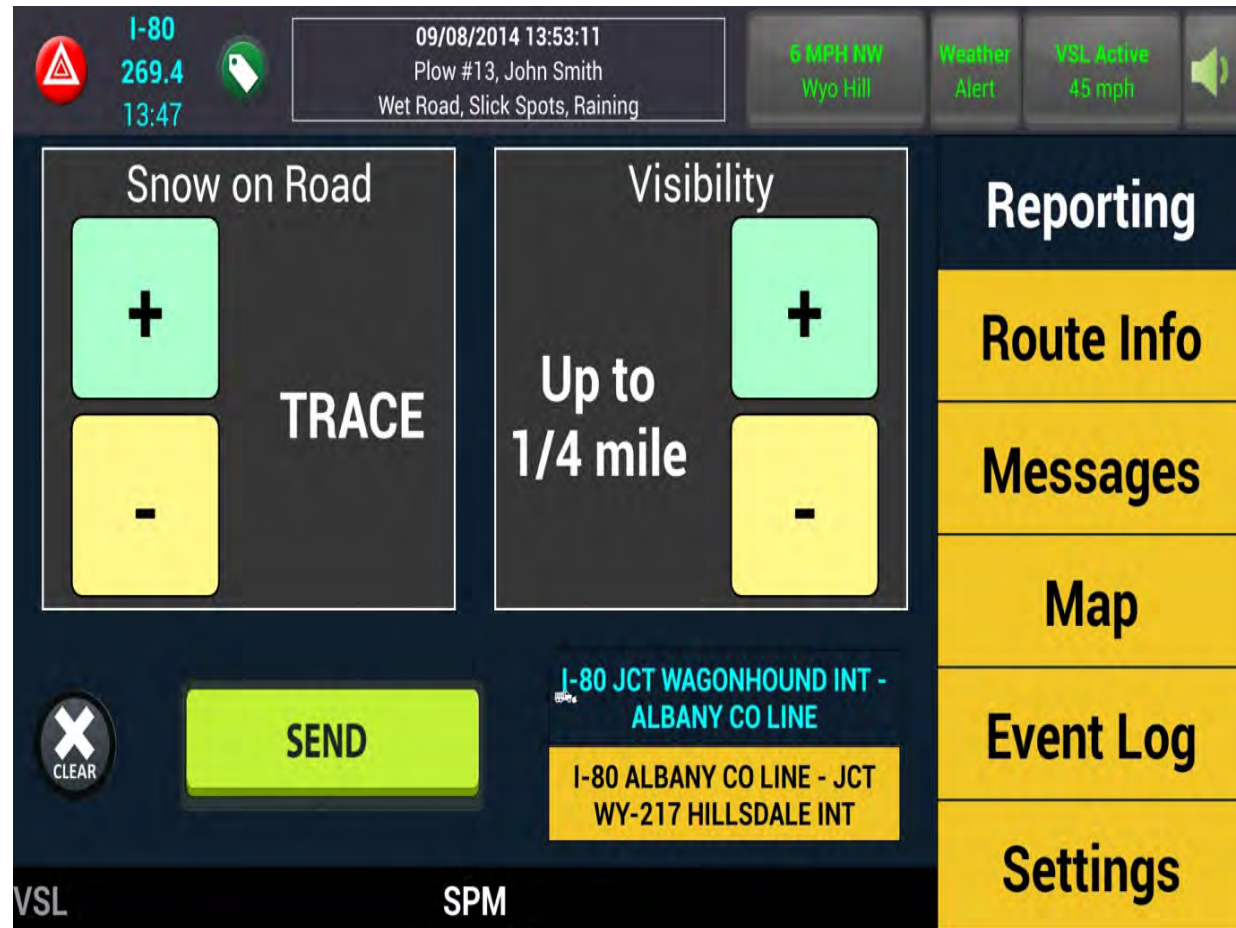
Overview: VSL
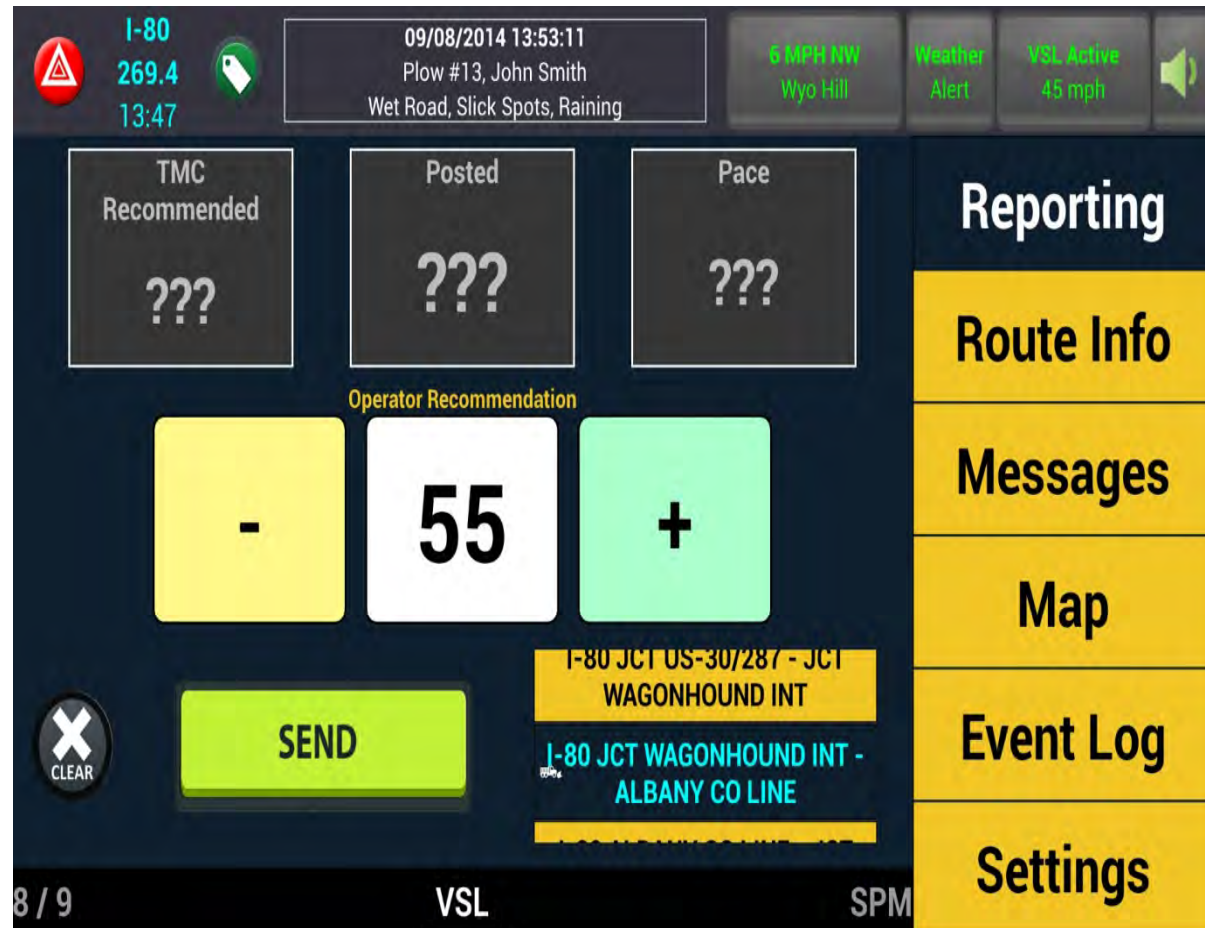
Tablet App Features-Functionality

(Continued)

Overview: Snow Performance Measures

- Information collected by meteorologists to gauge storm severity (snow amount and visibility due to wind speeds), measure WYDOT's response

- Not being collected by every crew

Tablet App Features-Functionality

(Continued)

Overview: DMS

- See what's currently posted on a DMS.

Tablet App Features-Functionality

(Continued)

Overview: RWIS

- See weather information from nearest RWIS

Tablet App Features-Functionality

(Continued)

- Send message to people in other maintenance vehicles
  - Made a higher priority after 4/14/2014 crash; radio and cell networks overwhelmed, data is secondary on WyoLink and can have delays during high voice traffic events.
- Disabled while driving

Overview: Messages
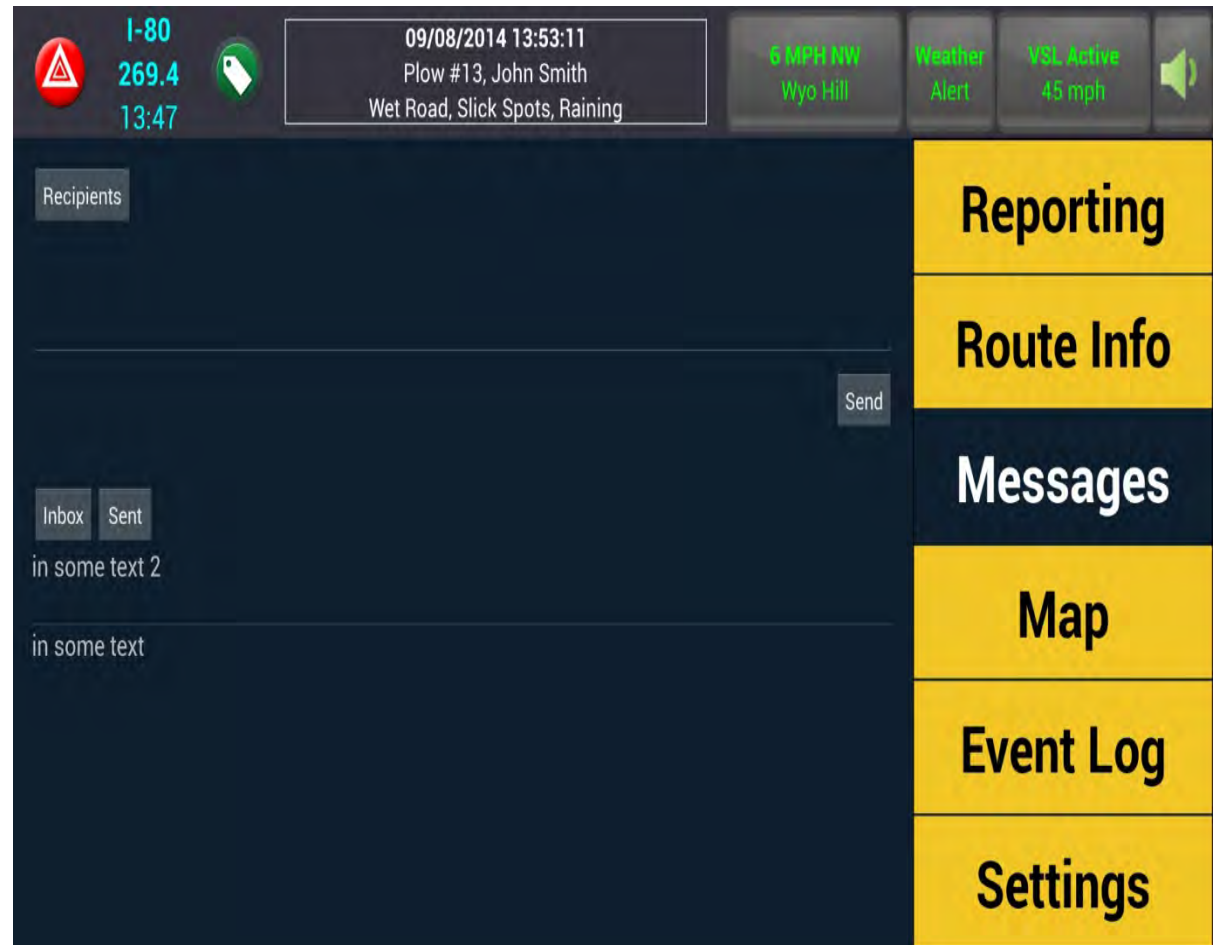
Tablet App Features-Functionality

(Continued)

Overview: Map

- Asset locations
  - Sand piles
  - Hot spots
  - Road closure gates
  - WYDOT vehicles
- Weather radar
  - Wi-Fi only
- GeoTags
- Base maps are stored on the tablet

30
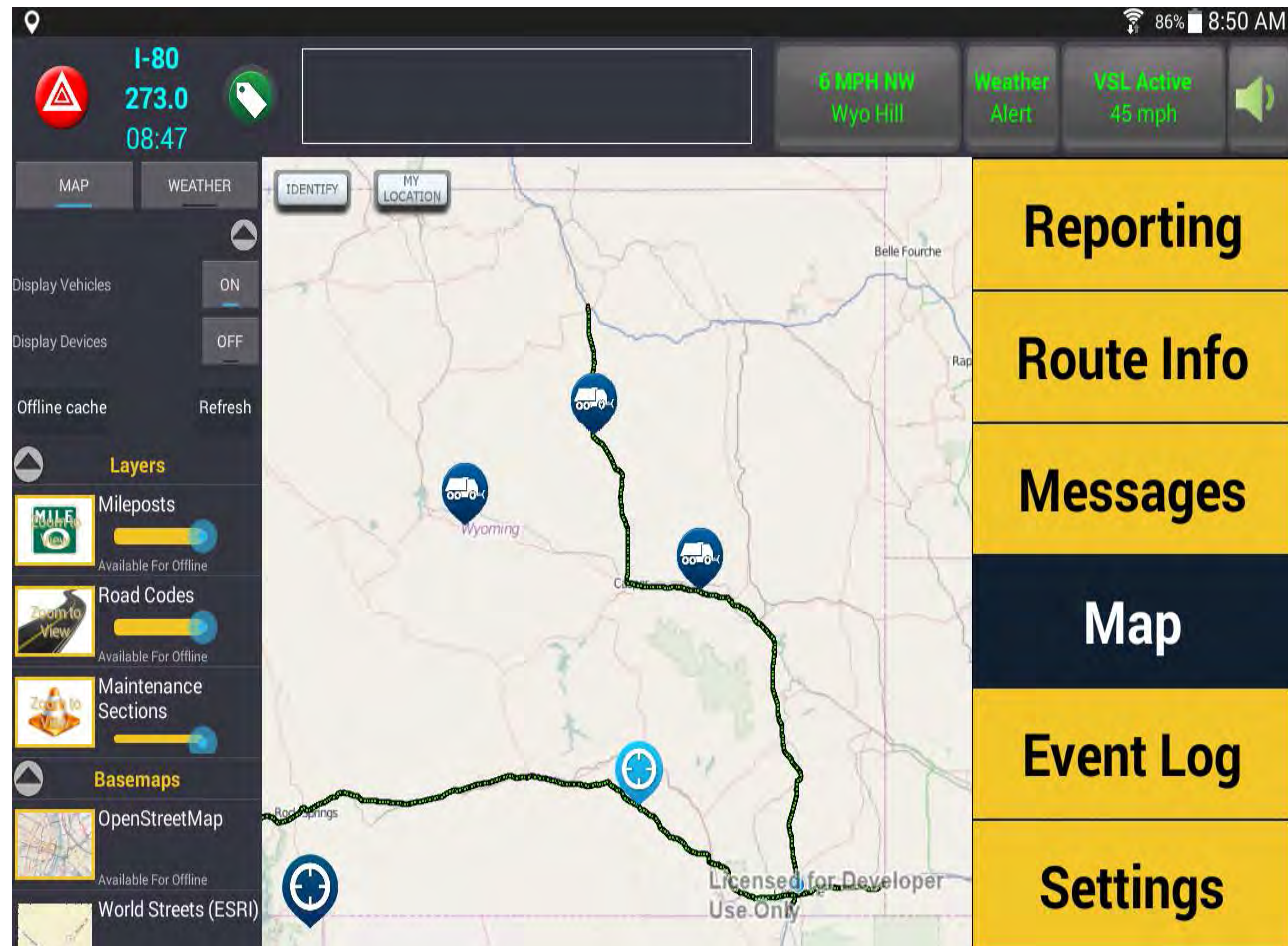
Tablet App Features-Functionality

(Continued)

Overview: Event Log

- See reports you made during your shift
- GeoTags
- Add details to 10 code reports

(Continued)

Overview: 10 Code Post Report

- Add details to events previously sent to the TMC
- Select the down arrow next to report type
- Enter any known information

Tablet App Features-Functionality

(Continued)

Overview: 10 Code Post Report

- Change a Geo Tag to a 10 Code report
- Click arrow on the right
- Select the type of report
- Click "Confirm"
- Enter any available information
- Click "SEND"
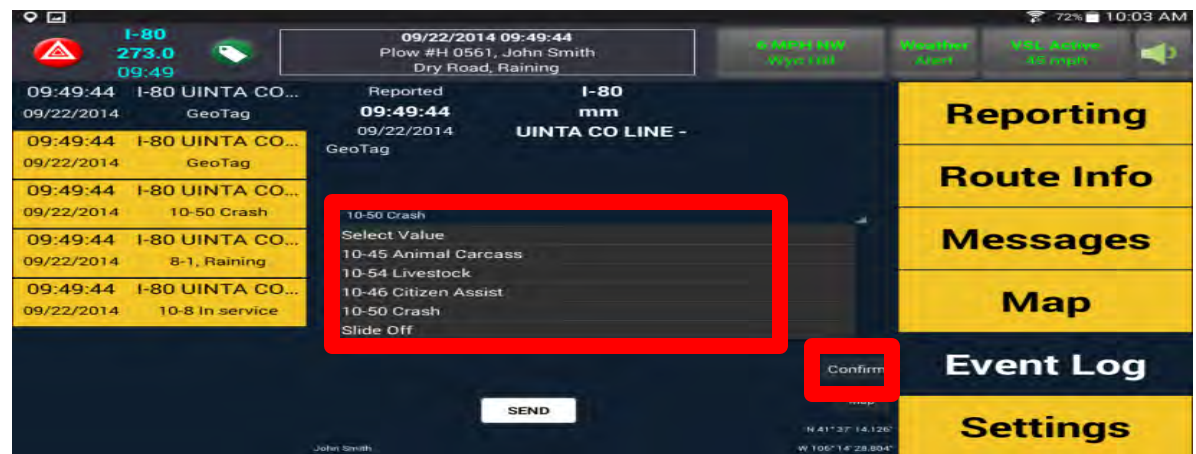
Tablet App Features-Functionality
(Continued)

Hitting "SEND"

- 8, 9 codes
  - Information is sent to a database
    - Website, phone system, most text/email auto updated
    - TMC alerted so DMS and HAR can be updated, some text/email sent
- 10 codes
  - TMC alerted
- VSL
  - TMC alerted to make a change
    - In the future signs could be auto-updated
- SPM
  - Database updated; information shared with meteorologist
- Emergency Call
  - TMC sent your location, directed to alert WHP Dispatch

Tablet App Features-Functionality

(Continued)

- To conform to Texting & Driving laws, some features are disabled while the vehicle is in motion.

- **State Statute 31-5-237. Use of handheld electronic wireless communication devices for electronic messaging prohibited; exceptions; penalties.**

- (a) No person shall operate a motor vehicle on a public street or highway while using a handheld electronic wireless communication device to write, send or read a text-based communication. This section shall not apply to a person who is using a handheld electronic wireless communication device:

- (i) While the vehicle is lawfully parked;

- (ii) To contact an emergency response vehicle;

- (iii) To write, read, select or enter a telephone number or name in an electronic wireless communications device for the purpose of making or receiving a telephone call; or

- (iv) When using voice operated or hands free technology.

- (b) This section shall not apply to a person operating an emergency response vehicle while making communications necessary to the performance of his official duties as an emergency responder.
- (c) Any person who operates a motor vehicle in violation of this section is guilty of a misdemeanor punishable by a fine of not more than seventy-five dollars ($75.00).
- (d) As used in this section:
- (i) "Electronic wireless communication device" means a mobile communication device that uses short-wave analog or digital radio transmissions or satellite transmissions between the device and a transmitter to permit wireless telephone communications to and from the user of the device within a specified area;
- (ii) "Emergency response vehicle" means any ambulance, fire department, law enforcement or civil defense vehicle or other vehicle used primarily for emergency purposes;
- (iii) "Voice operated or hands free technology" means technology that allows a user to write, send or read a text based communication without the use of either hand except to activate, deactivate or initiate a feature or function;
- (iv) "Write, send or read a text-based communication" means using an electronic wireless communications device to manually communicate with any person using text-based communication including, but not limited to, communications referred to as a text message, instant message or electronic mail.

Tablet App Features-Functionality

(Continued)

- ITS Program Manager, Vince Garcia asked for clarification on the State Statute.

- The AG's Office replied; "As long as the user presses buttons which do not require a keyboard, it isn't considered texting".

37

Tablet App Features-Functionality

(Continued)

Transportation Reports And Action Console   (TRAC)

Priority	District	Description
Emergency	2	**EMERGENCY** **Crash** **Torrington - US 85 between Lingle and Jay Em** **Crash Status:** **Vehicle #1: Color: grey, Type: SUV, License Plate: HJK908** **Vehicle #2: Color: brown, Type: semi, License Plate: ABC1234** **Wrecker requested by WYDOT** **Injuries: 23** **Reported by: Plow license plate: H 5555, Operator ID: QW**
High	2	**Livestock** **Muddy Gap - US 287 / WY 789 between Muddy Gap and Jeffrey City** **Detour** **Livestock Status: Type: cow, Color: spotted, Access: gate open, Location: north, Person: yes, Injuries: unknown, Number: 500** **Reported by: Plow license plate: H 8888, Operator ID: QW**
High	2	**Motorist Assist** **Slide Off** **Wheatland - I 25 / US 87 between Wheatland and Exit 92, US 26 - NORTHBOUND** **Motorist Assist Status:** **Vehicle: Color: brown, Type: semi, License Plate: ABC1234** **Slide Off Status:** **Vehicle: Color: brown, Type: semi, License Plate: ABC1234** **Reported by: Plow license plate: H 1234, Operator ID: QW**

TRAC 10 Code Information

Medium	1	**10-13: Cheyenne - I-80 West Upper - Eastbound** Road Conditions: Slick in Spots Atmospheric Conditions: Strong Winds HAR: H000107, H000103 DMS: D000034 at I-80 EB 341.6 (Harriman) Cheyenne Lower Reported by plow: H 1234, operator ID: ivan	N/A	2014-09-19 14:53:42 by ivan
Medium	1	**10-13: Cheyenne - I-80 West Upper - Westbound** Road Conditions: Slick in Spots Atmospheric Conditions: Strong Winds HAR: H000098 DMS: D002833 at I-80 WB 341 (Remount), D000033 at I-80 WB 336.1 (Buford) Laramie Upper, D000035 at I-80 WB 343.7 (Harriman) Cheyenne Upper Reported by plow: H 1234, operator ID: ivan	N/A	2014-09-19 14:53:42 by ivan

TRAC VSL Information

Medium	3	**VSL: Three Sisters, I-80 Westbound at 10.16** Plow recommended speed: 50 Posted speed: 75 Pace speed: 65 TMC recommended speed: 60 Reported by plow: H 0222, operator ID: qwertyuiop

Tablet App Features-Functionality

(Continued)

Live Tablet App

Demonstration.

Tablet App Future Features

- Time reporting

- Email

- Vehicle Inspection Form.

- Precise Information

- Damage Repair Reports

Tablet App Next Steps

- Continue Functionality Improvements.

- Hazardous Material Identification

- More reporting sections to improve functionality.

- Weigh In Motion (WIM) Data

- Expand to more vehicles

43

Tablet Comms

- The tablet has two comms paths to allow maximum coverage for the user.
- The tablet uses the WyoLink (http://wyolink.wyoming.gov/) P25 radio system as one form and WiFi as another. Current radio mobile units are the Motorola XTL5000 and EF Johnson 5300.
- Connection to the radio is achieved using a Bluetooth to serial adaptor and a Cal Amp LMU 4200.
- The current LMU AVL configuration was modified by CompassCom to work with the serial adaptor and the tablet. There were no configuration changes needed in the radio since it was used to send AVL data.
- When the tablet doesn't have comms via WiFi or radio, that data is stored and then sent when comms are re-established.
- The tablet uses its internal GPS for some applications.

Tablet Comms Overview

Public Information Systems

Phone	Web	Email/Text	Mobile App
Iteris	WYDOT	GovDelivery	TBD

AVL

LMU Parser

LDE

Oracle Databroker

VSL DMS HAR

TMC/Weather Forecast

Other States

Vehicle

WYOLINK

Wi-Fi (Primary)

Bluetooth

Road Condition Reporting App	
Send	**Receive**
8 codes	8 codes
9 codes	9 codes
10 codes	10 codes
Alerts	Alerts
Location	Location
VSL	VSL
DR	Weather
Messages	DMS
	RWIS
	Messages

Tablet Communications Diagram

The tablet communicates via WiFi when in range of a WiFi hotspot
or uses the WyoLink system data capabilities when not in WiFi range.
The data is sent to the TMC and posted on the wyoroad web site.
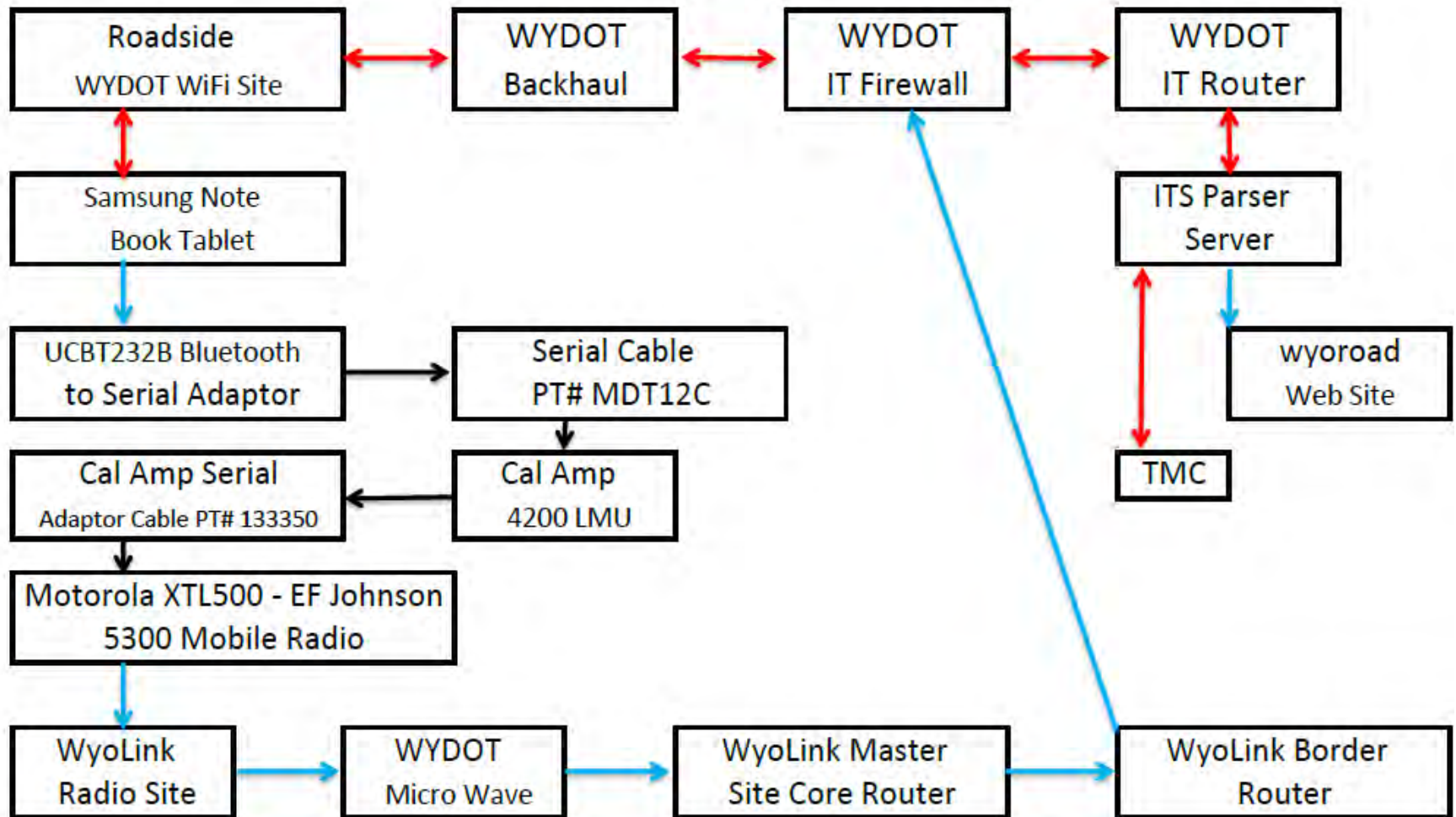
CalAmp 4200 LMU

CalAmp 4200 Wiring Diagram

I/O Connector
Pin1 = In1
Pin2 = In2
Pin3 = In3
All Others: N/A

I/O Port

RED: Battery +
BLACK: GND
WHITE: Ign
GREEN: N/A

Aux1

Power

Aux2

Expansion

P/N 133337-5
9 Pin Female
(DCE)
Serial Adapter

P/N 133350
9 Pin Male
(DTE)
Serial Adapter

15ft M-M Null
Modem Serial
Cable

15ft M-F
Straight Thru
Serial Cable

FORCE Controller
8-N-1, 9600. All
Logging options
enabled

Motorola IV&D
8-N-1, 9600

48
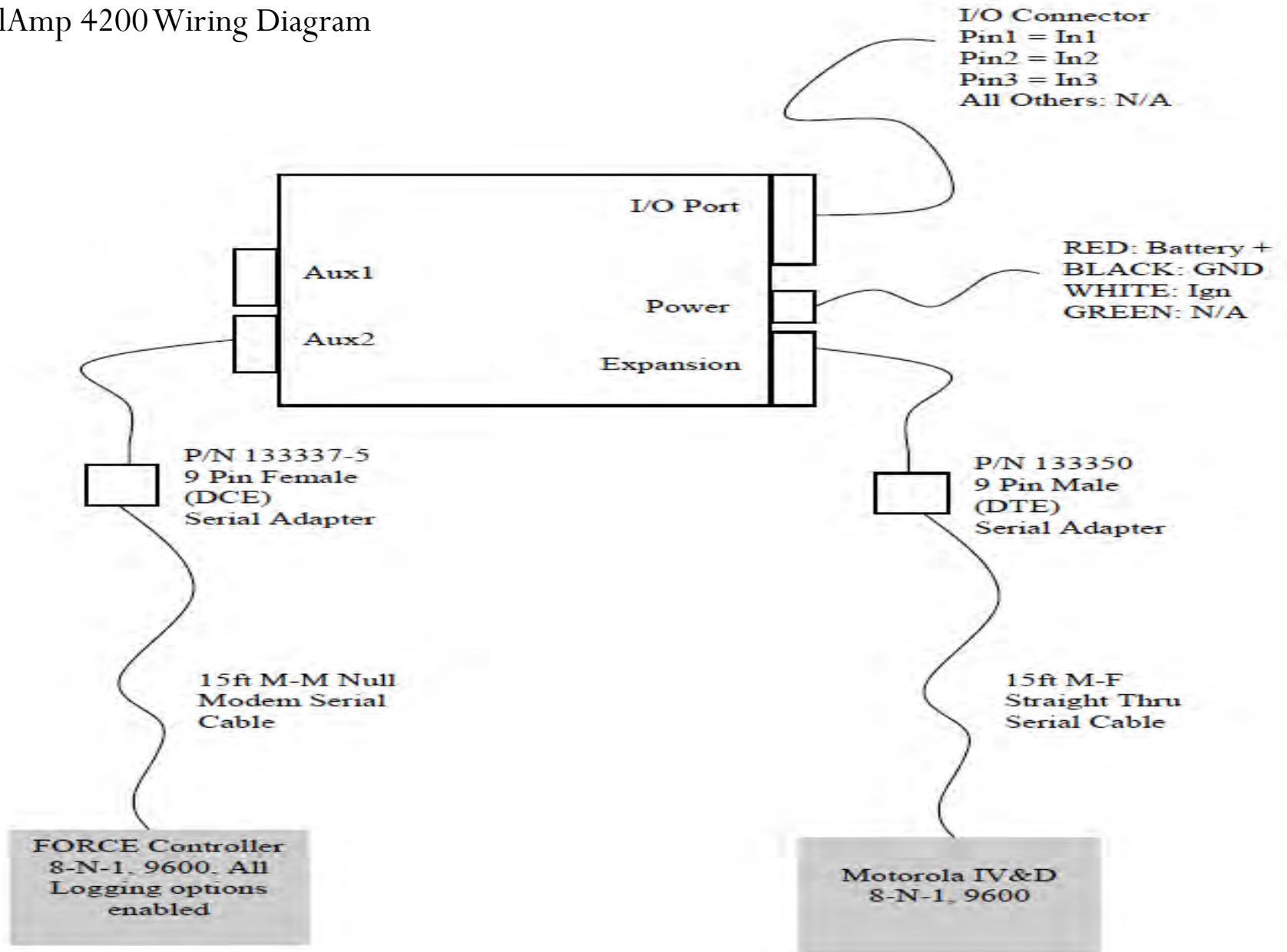
Tablet Comms
(Continued)

- There were a few setbacks in the radio comms configuration.

- The 1st concept of comms between the tablet and LMU was a USB to serial converter but was abandoned due to the LMU not passing the data to the radio. July 2014

- 2nd concept was the Bluetooth to serial adaptor and a Cal Amp 4220 LMU. This was the optimal method due to less wiring connected to the tablet. CompassCom couldn't establish comms to the 4220. August 2014

- 3rd concept was a 4200 LMU with Bluetooth to US Converters serial adaptor (Part # UCBT232). After CompassComm modified the current configuration, reliable comms was achieved. November 2014

- Further testing with the 4220, CompassCom was able to achieve comms, using an older version of firmware in the 4220. Testing continues with the newest firmware version.

Tablet Vehicle Mounting & Field Testing

- The tablet is mounted in vehicles within easy reach of the user, using a Havis universal mount (part # UT-201). A protective rubber case was added to the tablet to help protect it from shock & vibration.

- A coverage test was done in November of 2014 to test comms, data speed on WyoLink & WiFi, functionality and position to the tenth of a mile. The testing proved that the tablet functioned remarkably well on both WyoLink and WiFi.

The tablet
mount is
installed
with in easy
reach of the
driver for ease
of use.

UT201 Universal Mount

RAM-101U-2461

UCBT232B

WYDOT
Roadside WiFi

Roadside WiFi

- To support the high bandwidth applications on the tablet for down loading weather maps and radar images, WiFi hotspots were needed, not only in the WYDOT shops but at the roadside sand sheds.

- The project was started mid August 2014 with a finish date of the 1st of October 2014.

- Initial phase included 13 sites in District 1 & 3 (I-80 corridor).

- Due to time constraints and Telecom's limited knowledge of WiFi Equipment, Kelly Hudson with Versatel Communications was enlisted as a consultant.

Roadside WiFi
(Continued)

- Ubiquiti equipment was chosen for its diversity, ease of use, implementation and cost.

- https://www.ubnt.com/products/

- The primary radios are Rockets and Nano Bridges. The Ubiquiti tough switch was also used where we needed them.

- WYDOT has an existing State wide backhaul network using Cambium PTP, CMM, AP & SM to provide comms to roadside devices.

- The backhaul terminates at WYDOT HQ in Cheyenne, with alternate routes in various locations.

Roadside WiFi
(Continued)

- Access to the WiFi for the tablets is limited to 2 SSID's for Maintenance personnel. Both are not being broadcasted. One SSID is for the roadside WiFi that Telecom maintains and the other is at WYDOT facilities that WYDOT IT maintains.

- WYDOT facilities have SSID's for other WYDOT personnel and guest to access.

WiFi AP Radio Wireless Programming

The LAN settings are left as default.
This lets the radio assign IPs to users

Roadside WiFi AP Radio Performance Page
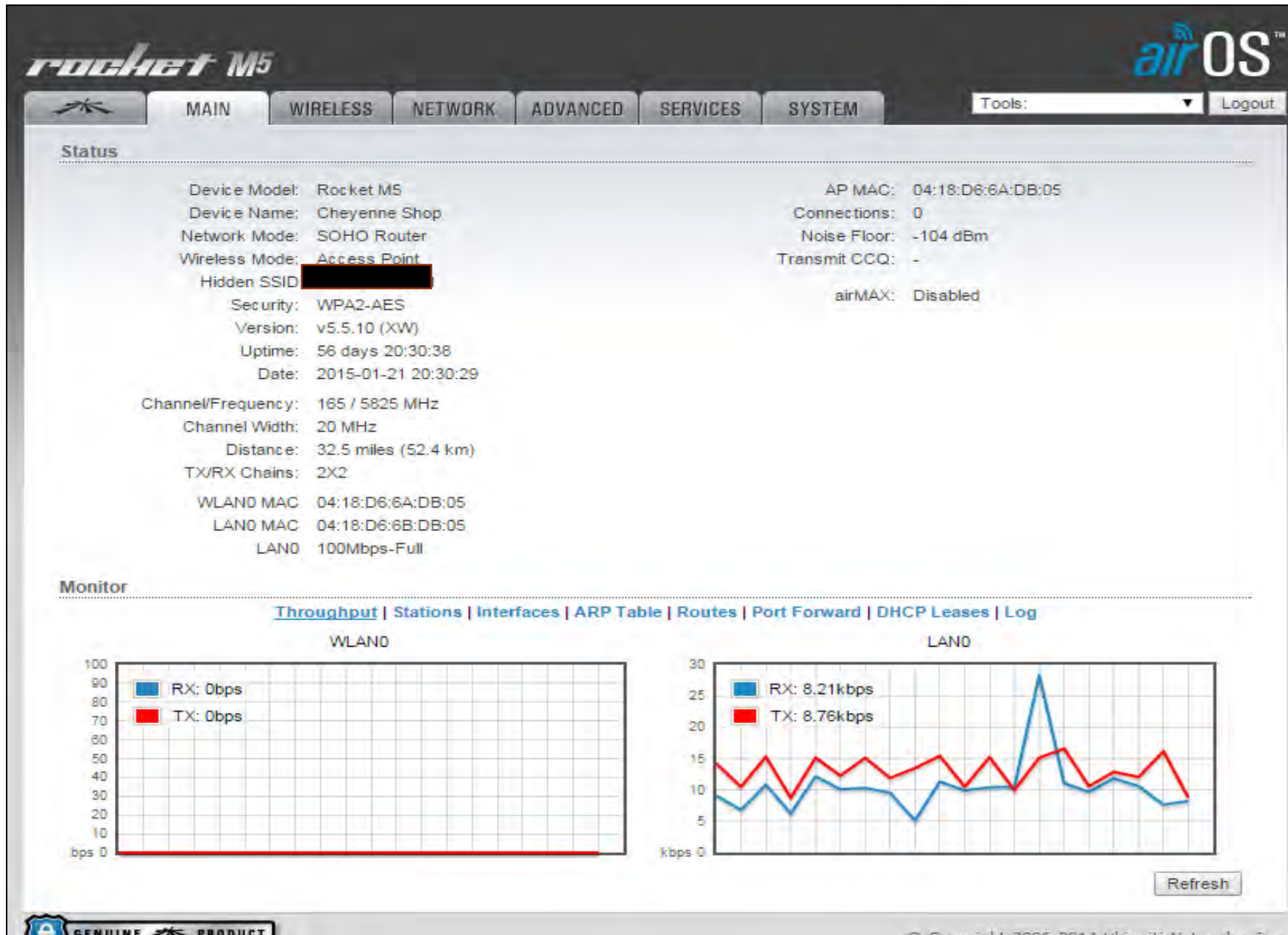
rocket™M

Carrier Class
airMAX™ BaseStation

Models:
M900/M2/M3/M365/M5/M6

NanoBridge™M5

Model:
NB-5G22

rocket DISH

AirMax Carrier Class 2x2 PtP Bridge Dish Antenna

Models: RD-2G-24, RD-3G-26, RD-5G-30, RD-5G-34

Ultimate in RF Performance

Integrated Mount lets you easily snap Rocket M into place

Incredible Range and Speed

UBIQUITI NETWORKS

Ubiquiti Dish Specifications

Antenna Characteristics				
	RD-2G-24	RD-3G-26	RD-5G-30	RD-5G-34
Frequency Range	2.3-2.7 GHz	3.3-3.8 GHz	5.1-5.8 GHz	
Gain	24 dBi	26 dBi	30 dBi	34 dBi
Hpol Beamwidth	3.8 deg. (Rx Dish) 6.6 deg. (Tx Dish)	7 deg. (6 dB)	5 deg. (3 dB)	3 deg. (3 dB)
Vpol Beamwidth	3.8 deg. (Rx Dish) 6.6 deg. (Tx Dish)	7 deg. (6 dB)	5 deg. (6 dB)	3 deg. (6 dB)
F/B Ratio	-50 dB (Rx Dish) -65 dB (Tx Dish)	-33 dB	-34 dB	-42 dB
Max VSWR	1.6:1	1.4:1		
Dimensions	648 mm diameter			1050 mm diameter
Weight	9.8 kg			13.5 kg
Wind Survivability	120 mph			125 mph
Wind Loading	113 lb @ 100 mph			256 lb @ 100 mph
Polarization	Dual Linear			
Cross-pol Isolation	35 dB min			
ETSI Specification	EN 302 326 DN2			
Mounting	Universal pole mount, Rocket M bracket, and weatherproof RF jumpers included			

Ubiquiti Sector Antenna Specifications

	Antenna Characteristics			
Model	AM-9M13	AM-2G15-120	AM-2G16-90	AM-3G18-120
Dimensions* (mm)	1290 x 290 x 134	700 x 145 x 93	700 x 145 x 79	735 x 144 x 78
Weight**	12.5 kg	4.0 kg	3.9 kg	5.9 kg
Frequency Range	902 - 928 MHz	2.3 - 2.7 GHz	2.3 - 2.7 GHz	3.3 - 3.8 GHz
Gain	13.2 - 13.8 dBi	15.0 - 16.0 dBi	16.0 - 17.0 dBi	17.3 - 18.2 dBi
HPOL Beamwidth	109° (6 dB)	123° (6 dB)	91° (6 dB)	118° (6 dB)
VPOL Beamwidth	120° (6 dB)	118° (6 dB)	90° (6 dB)	121° (6 dB)
Electrical Beamwidth	15°	9°	9°	6°
Electrical Downtilt	N/A	4°	4°	3°
Max. VSWR	1.5:1	1.5:1	1.5:1	1.5:1
Wind Survivability	125 mph	125 mph	125 mph	125 mph
Wind Loading	95 lbf @ 100 mph	24 lbf @ 100 mph	19 lbf @ 100 mph	21 lbf @ 100 mph
Polarization	Dual-Linear	Dual-Linear	Dual-Linear	Dual-Linear
Cross-pol Isolation	30 dB Min.	28 dB Min.	28 dB Min.	28 dB Min.
ETSI Specification	N/A	EN 302 326 DN2	EN 302 326 DN2	EN 302 326 DN2
Mounting	Universal Pole Mount, RocketM Bracket, and Weatherproof RF Jumpers Included			

Ubiquiti Sector Antenna Specifications
(Continued)

	Antenna Characteristics			
Model	AM-5G16-120	AM-5G17-90	AM-5G19-120	AM-5G20-90
Dimensions* (mm)	367 x 63 x 41	367 x 63 x 41	700 x 135 x 73	700 x 135 x 70
Weight**	1.1 kg	1.1 kg	5.9 kg	5.9 kg
Frequency Range	5.10 - 5.85 GHz	4.90 - 5.85 GHz	5.15 - 5.85 GHz	5.15 - 5.85 GHz
Gain	15.0 - 16.0 dBi	16.1 - 17.1 dBi	18.6 - 19.1 dBi	19.4 - 20.3 dBi
HPOL Beamwidth	137° (6 dB)	72° (6 dB)	123° (6 dB)	91° (6 dB)
VPOL Beamwidth	118° (6 dB)	93° (6 dB)	123° (6 dB)	85° (6 dB)
Electrical Beamwidth	8°	8°	4°	4°
Electrical Downtilt	4°	4°	2°	2°
Max. VSWR	1.5:1	1.5:1	1.5:1	1.5:1
Wind Survivability	125 mph	125 mph	125 mph	125 mph
Wind Loading	6 lbf @100 mph	6 lbf @100 mph	20 lbf @ 100 mph	26 lbf @ 100 mph
Polarization	Dual-Linear	Dual-Linear	Dual-Linear	Dual-Linear
Cross-pol Isolation	22 dB Min.	22 dB Min.	28 dB Min.	28 dB Min.
ETSI Specification	EN 302 326 DN2	EN 302 326 DN2	EN 302 326 DN2	EN 302 326 DN2
Mounting	Universal Pole Mount, RocketM Bracket, and Weatherproof RF Jumpers Included			

Nano Bridge Specifications

System Information			
Model	NBM9	NB-2G18/NB-5G22/NB-5G25	NBM3/NBM365
Processor Specs	Atheros MIPS 24KC, 400 MHz	Atheros MIPS 24KC, 400 MHz	Atheros MIPS 24KC, 400 MHz
Memory	64 MB SDRAM, 8 MB Flash	32 MB SDRAM, 8 MB Flash	32 MB SDRAM, 8 MB Flash
Networking Interface	(1) 10/100 Ethernet Port	(1) 10/100 Ethernet Port	(2) 10/100 Ethernet Ports

Regulatory/Compliance Information				
Model	NBM9	NB-2G18/NB-5G22/NB-5G25	NBM3	NBM365
Wireless Approvals	FCC, IC	FCC, IC, CE	–	FCC
RoHS Compliance	Yes			

Physical/Electrical/Environmental			
Model	NBM9	NB-2G18/NB-5G22/NB-5G25	NBM3/NBM365
Dimensions (mm)	543 x 440 x 725	NB-2G18: 400 diameter NB-5G22: 326 mm diameter NB-5G25: 400 mm diameter	492 x 440 x 705
Weight (Dish and Mount Included)	5.098 kg	NB-2G18: 2.346 kg NB-5G22: 1.904 kg NB-5G25: 2.304 kg	NBM3: 4.656 kg NBM365: 4.660 kg
Power Supply	24V, 1A PoE	24V, 0.5A PoE	24V, 0.5A PoE
Power Method	Passive PoE (Pairs 4, 5+; 7, 8 Return)	Passive PoE (Pairs 4, 5+; 7, 8 Return)	Passive PoE (Pairs 4, 5+; 7, 8 Return)
Max. Power Consumption	6.5 W	5.5 W	8 W
Gain	10.6 – 11.3 dBi	NB-2G18: 18 dBi NB-5G22: 22 dBi NB-5G25: 25 dBi	21.5 – 22.5 dBi
LEDs	(1) Power, (1) LAN, (4) WLAN	(1) Power, (1) LAN, (4) WLAN	(1) Power, (2) LAN, (4) WLAN
Wind Loading	105 lbf @ 125 mph	NB-2G18: 77 lbf @ 125 mph NB-5G22: 45 lbf @ 125 mph NB-5G25: 77 lbf @ 125 mph	105 lbf @ 125 mph
Wind Survivability	125 mph		
LEDs	(1) Power, (1) LAN, (4) WLAN		
Signal Strength LEDs	Software-Adjustable to Correspond to Custom RSSI Levels		
Enclosure	Outdoor UV Stabilized Plastic		
Mounting	Pole-Mount Kit Included		
Operating Temperature	-30 to 75° C		
Operating Humidity	5 to 95% Non-Condensing		
Shock & Vibration	ETSI300-019-1.4		

Ubiquiti Omni Specifications

Antenna Characteristics					
Model	AMO-2G10	AMO-2G13	AMO-3G12	AMO-5G10	AMO-5G13
Dimensions* (mm)	1030 X 122 X 84	1390 X 122 X 105	1012 X 122 X 105	582 X 90 X 65	799 X 90 X 65
Weight*	2.1 kg	2.4 kg	2.05 kg	0.68 kg	0.82 kg
Frequency Range	2.35 - 2.55 GHz	2.35 - 2.55 GHz	3.4 - 3.7 GHz	5.45 - 5.85 GHz	5.45 - 5.85 GHz*
Gain	10 dBi	13 dBi	12 dBi	10 dBi	13 dBi
Elevation Beamwidth	12°	7°	8°	12°	7°
Max VSWR	1.7:1	1.7:1	1.6:1	1.6:1	1.5:1
Downtilt	4°	2°	4°	4°	2°
Wind Survivability	125 mph	125 mph	125 mph	125 mph	125 mph
Wind Loading	14 lb @ 100 mph	16 lb @ 100 mph	16 lb @ 100 mph	10 lb @ 100 mph	12 lb @ 100 mph
Polarization	Dual-Linear	Dual-Linear	Dual-Linear	Dual-Linear	Dual-Linear
Cross-pol Isolation	25 dB min.	25 dB min.	25 dB min.	25 dB min.	25 dB min.
ETSI Specification	EN 302 326 DN2	EN 302 326 DN2	EN 302 326 DN2	EN 302 326 DN2	EN 302 326 DN2
Mounting	Universal Pole Mount, RocketM Bracket, and Weatherproof RF Jumpers Included				

Ubiquiti Omni Antennas

Total Height with radio 24"

5 GHz
AMO-5G10
AMO-5G13

2.4 GHz
AMO-2G10
AMO-2G13

3 GHz
AMO-3G12

69

UBIQUITI
NETWORKS

TOUGHSwitch™ PoE

Power over Ethernet Managed Switches
Models: TS-5-POE, TS-8-PRO, TS-16-CARRIER
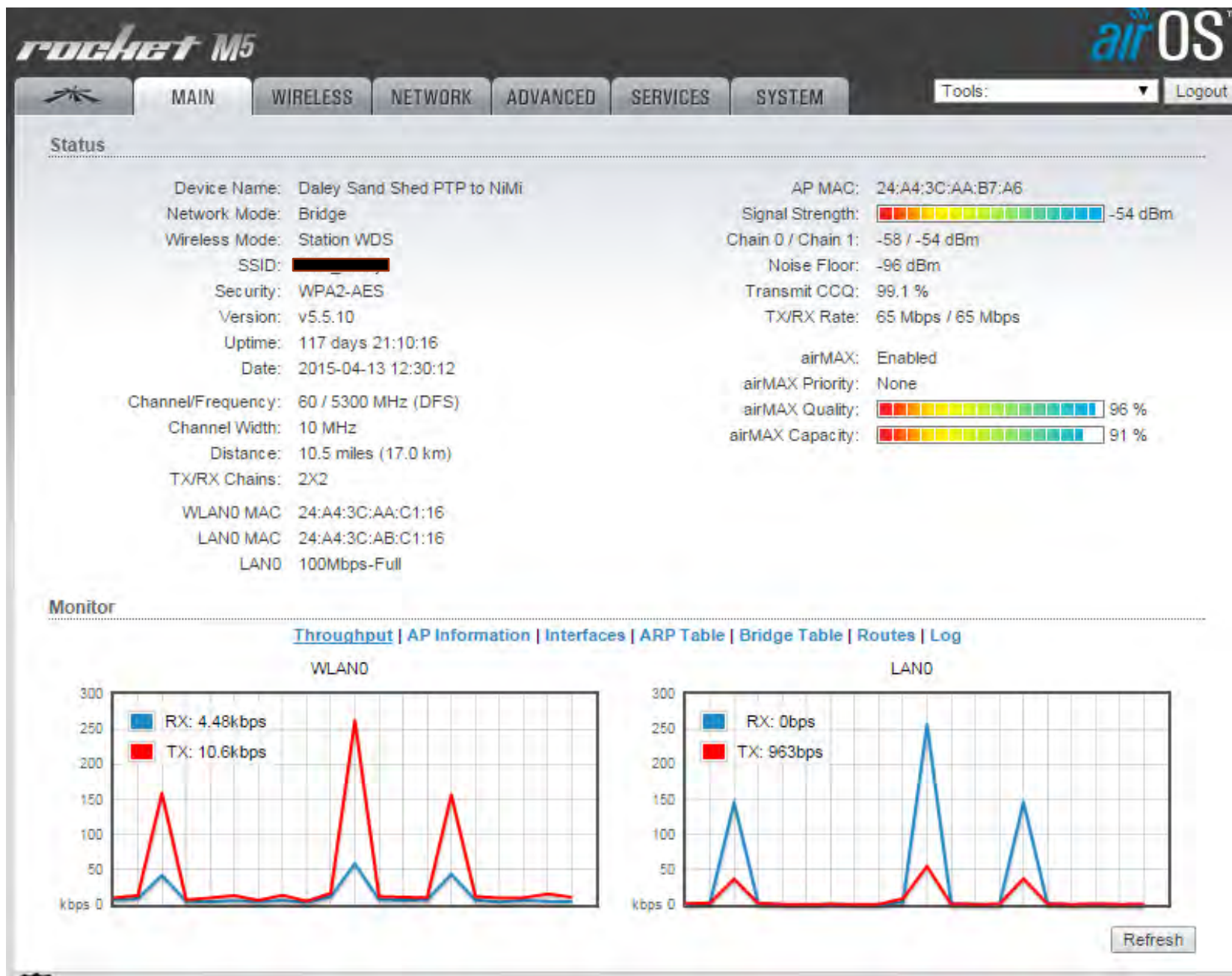
USER GUIDE

Ubiquiti Tough Switch Specifications

5-Port TOUGHSwitch PoE	
Dimensions	197 x 87.5 x 27.3 mm
Weight	250 g
Power Input	24VDC, 2.5A Power Adapter (Included)
Max. Power Consumption	60 W
PoE Out Voltage Range	22-24VDC
Max. PoE Wattage Per Data Port	11.5 W
ESD Rating	24 kV Air / 24 kV Contact
PoE Method	Passive
Button	Reset
USB Port	2.0 Type A (Reserved for Future Use)
Processor	MIPS 24K, 400 MHz
System Memory	64 MB
Code Storage	8 MB
Certifications	CE, FCC, IC
Wall-Mount	Yes
Operating Temperature	-25 to 55° C
Operating Humidity	90% Non-Condensing
PoE Configurable Per Port	
Management	N/A
Data Ports	Off/24V
LEDs Per Port	
Management	Power/Link
Data Ports	PoE, Speed/Link/Activity
Networking Interfaces	
Management Port	(1) 10/100 Ethernet Port
Data Ports	(5) 10/100/1000 Ethernet Ports

Roadside WiFi
(Continued)

- A few of the WiFi sites needed a PTP path installed. The Rocket radio and 30dB gain dish were used for longer paths. The Nano Bridge was used for shorter paths.

- The WiFi radios are Rockets with Omni or sector antennas, depending on the site. 2.4 GHz and 5.8 GHz unlicensed bands were utilized to provide separation from the 2.4 GHz Cambium and other unlicensed radios.

Rocket PTP Station Radio

Device Name: Daley Sand Shed PTP to NiMi
AP MAC: 24:A4:3C:AA:B7:A6
Network Mode: Bridge
Signal Strength: -54 dBm
Wireless Mode: Station WDS
Chain 0 / Chain 1: -58 / -54 dBm
SSID: ▮▮▮▮▮▮▮
Noise Floor: -96 dBm
Security: WPA2-AES
Transmit CCQ: 99.1 %
Version: v5.5.10
TX/RX Rate: 65 Mbps / 65 Mbps
Uptime: 117 days 21:10:16
Date: 2015-04-13 12:30:12
airMAX: Enabled
airMAX Priority: None
Channel/Frequency: 60 / 5300 MHz (DFS)
airMAX Quality: 96 %
Channel Width: 10 MHz
airMAX Capacity: 91 %
Distance: 10.5 miles (17.0 km)
TX/RX Chains: 2X2

WLAN0 MAC 24:A4:3C:AA:C1:16
LAN0 MAC 24:A4:3C:AB:C1:16
LAN0 100Mbps-Full

Monitor

Throughput | AP Information | Interfaces | ARP Table | Bridge Table | Routes | Log

WLAN0
RX: 4.48kbps
TX: 10.6kbps

LAN0
RX: 0bps
TX: 963bps

Rocket Station, AP Information

Status

Device Name:	Daley Sand Shed PTP to NiMi
Network Mode:	Bridge
Wireless Mode:	Station WDS
SSID:	██████
Security:	WPA2-AES
Version:	v5.5.10
Uptime:	117 days 21:10:33
Date:	2015-04-13 12:30:29
Channel/Frequency:	60 / 5300 MHz (DFS)
Channel Width:	10 MHz
Distance:	10.5 miles (17.0 km)
TX/RX Chains:	2X2
WLAN0 MAC	24:A4:3C:AA:C1:16
LAN0 MAC	24:A4:3C:AB:C1:16
LAN0	100Mbps-Full

AP MAC:	24:A4:3C:AA:B7:A6
Signal Strength:	-55 dBm
Chain 0 / Chain 1:	-57 / -58 dBm
Noise Floor:	-96 dBm
Transmit CCQ:	99.1 %
TX/RX Rate:	65 Mbps / 65 Mbps
airMAX:	Enabled
airMAX Priority:	None
airMAX Quality:	97 %
airMAX Capacity:	92 %

Monitor

Throughput | AP Information | Interfaces | ARP Table | Bridge Table | Routes | Log

Access Point   24:A4:3C:AA:B7:A6

Device Name:	NiMi PTP to Da
Product:	Rocket M5
Firmware:	v5.5.10
Connection Time:	27 days 01:41:55
Signal Strength:	-54 dBm
Noise Floor:	-96 dBm
Distance:	10.5 miles (17.0 km)
CCQ:	99%
Last IP:	██████
TX/RX Rate:	58.5 Mbps / 65.0 Mbps
TX/RX Bit Rate:	210.25 bps / 955.73 bps
TX/RX Packets:	641398 / 3754405
TX/RX Packet Rate, pps:	51 / 29
Bytes Transmitted:	61470138 (58.62 MBytes)
Bytes Received:	279421492 (266.48 MBytes)

	Negotiated Rate	Last Signal, dBm
	MCS0	N/A
	MCS1	N/A
	MCS2	N/A
	MCS3	N/A
	MCS4	N/A
	MCS5	N/A
	MCS6	N/A
	MCS7	N/A
	MCS8	N/A
	MCS9	N/A
	MCS10	N/A
	MCS11	N/A
	MCS12	N/A
	MCS13	N/A
	MCS14	N/A
	MCS15	-56

74

It is a good idea on long links to Change the "Distance" from Auto, to the approximate distance.

This tab allows you to Upload/Download Configuration, Firmware and change Login/Passwords

Roadside WiFi
(Continued)

Backhaul and WiFi Diagram

RF Bridges (L2 Switch)

PTP400 To Muddy

PTP To Latham

PTP400 To Divide Hill

PTP400 To Shirley

Line of Resposibility:
- This side of the line is Microwave/Backhaul
- This side of the line is Radio/Service point to the Roadside

Switch Ports

Nine Mile Adtran 3448 Multiservice Router

WAN Port (Alternate Route)

LAN Ports

GPS — CMM

AP 1 | AP 2 | BH to Walcot

SMs | SMs | BH @ Walcot
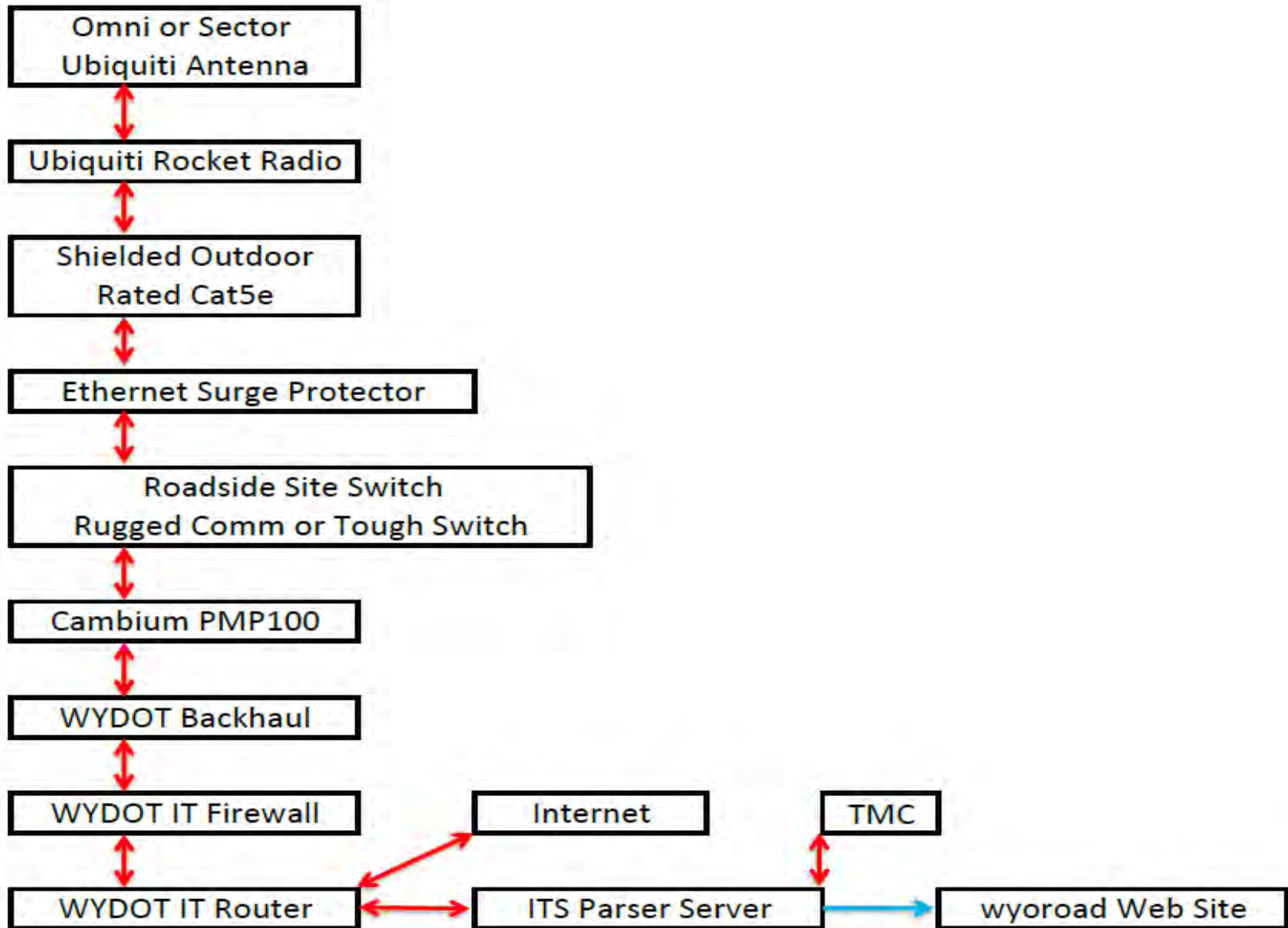
ITS Devices | ITS Devices | GPS — CMM — ITS Devices

AP 1 | AP 2 | AP 3

SMs | SMs | SMs

ITS Devices | ITS Devices | ITS Devices

Battery Backup & Power Monitoring

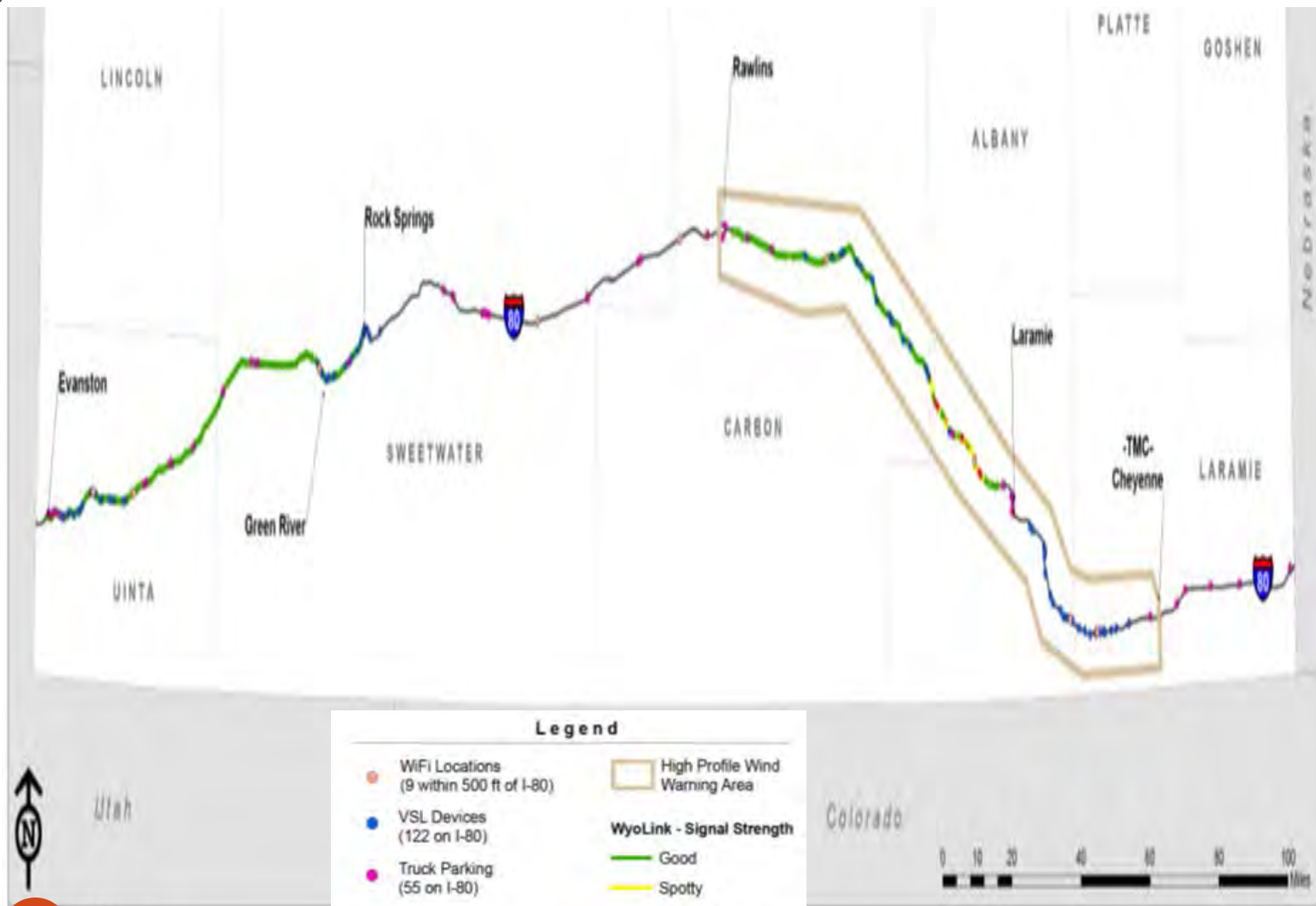Rocket WiFi Radio

Tough Switch
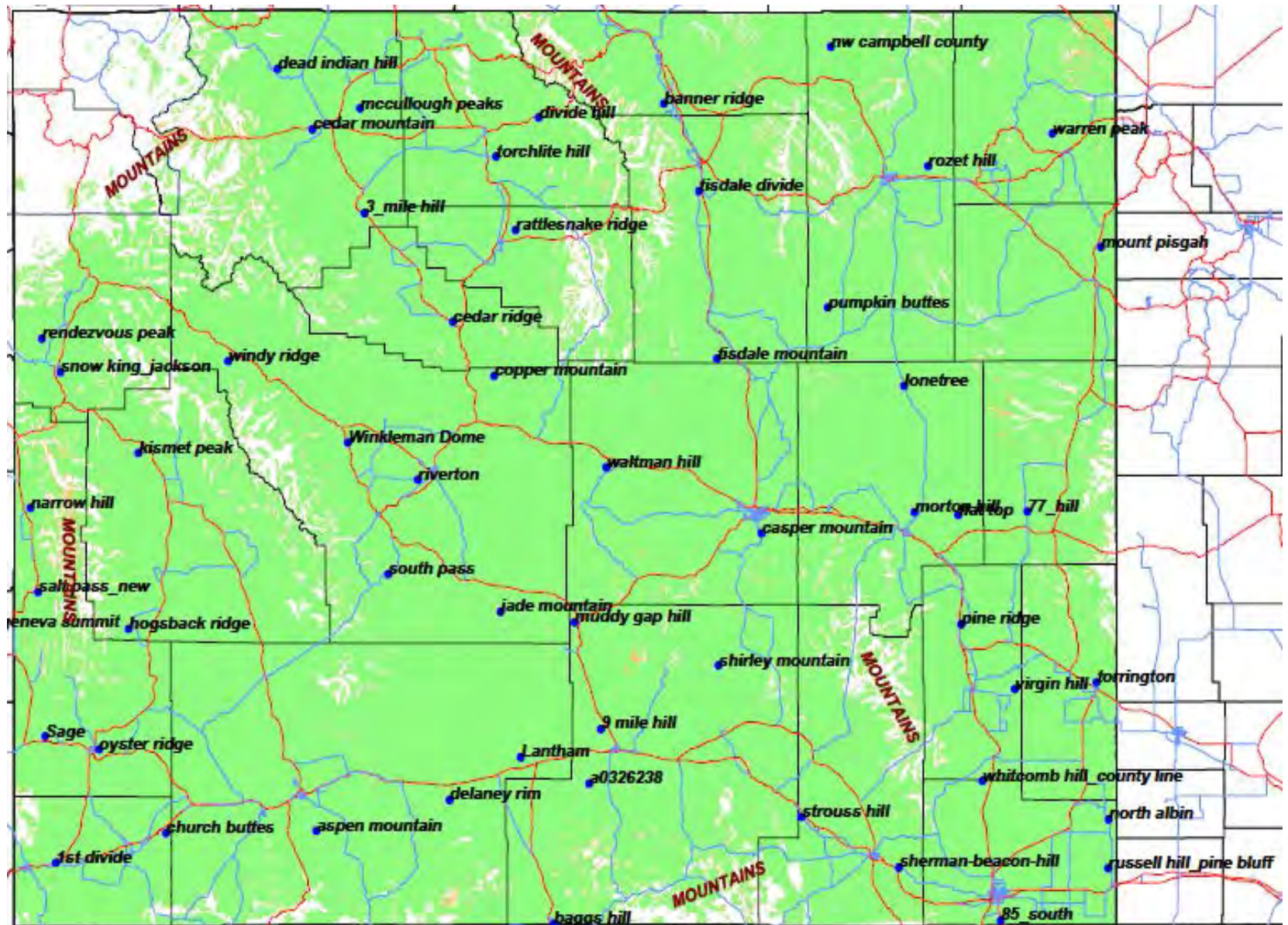
Nano Bridge Client

Nano Bridge AP

Roadside WiFi
(Continued)

- The expected WiFi coverage was the roadside sand yards, approximately 50,000 square feet.

- Actual WiFi coverage is .25 to 1+ miles, depending on terrain, location and antenna.

- Locations with a directional antenna, the power of the radio was turned down to keep the coverage within WYDOT Right of Way and keep from causing interference with homes and businesses.
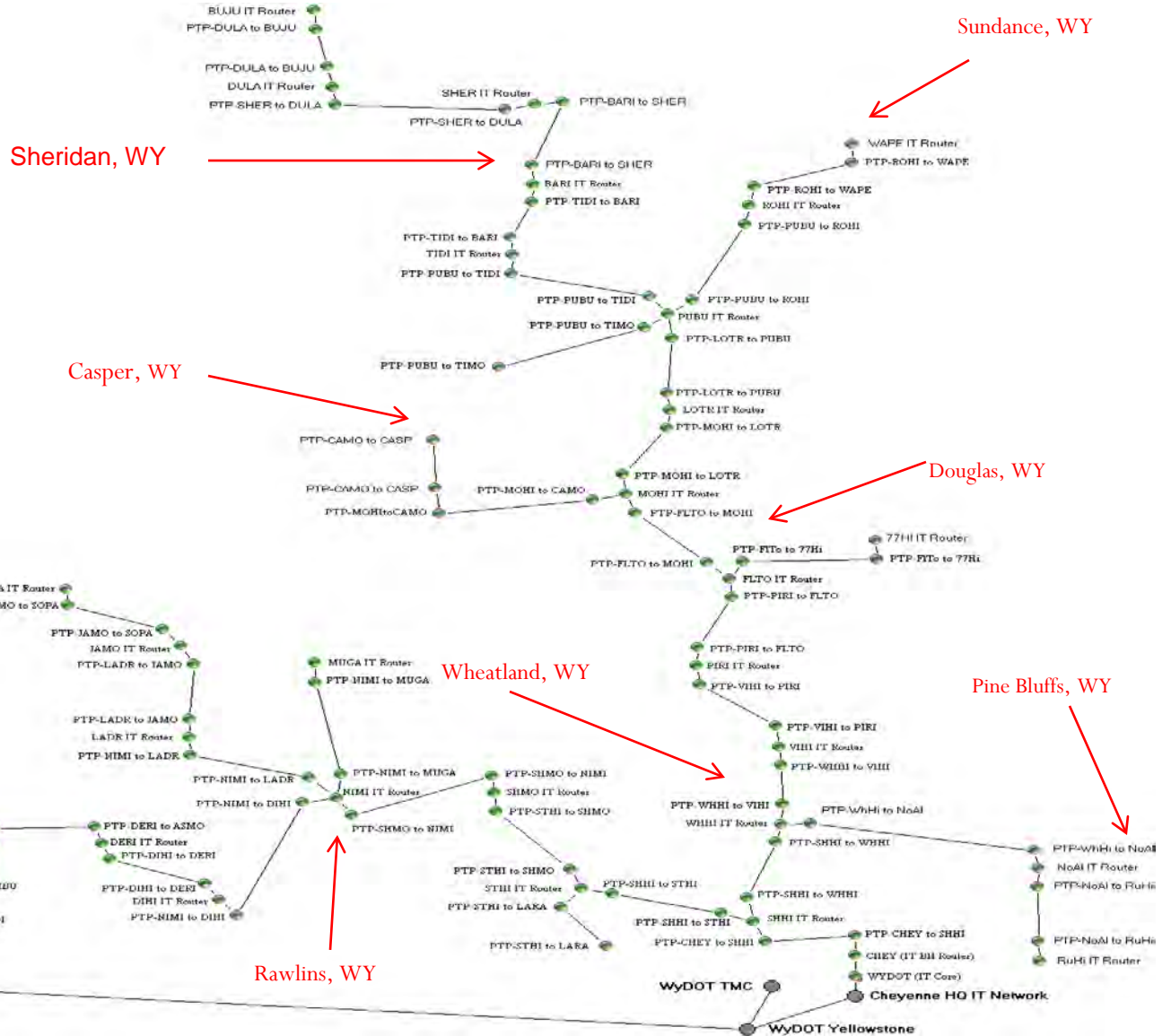
Legend

WiFi Locations (9 within 500 ft of I-80)

VSL Devices (122 on I-80)

Truck Parking (55 on I-80)

I-80, Wyoming

High Profile Wind Warning Area

WyoLink - Signal Strength

— Good

— Spotty

— Unreliable

WyoLink Mobile Coverage Map

Roadside WiFi

(Continued)

WYDOT Backhaul Network & WyoLink Sites

Sundance, WY

Sheridan, WY

Casper, WY

Douglas, WY

Wheatland, WY

Pine Bluffs, WY

Rock Springs, WY

Evanston, WY

Rawlins, WY

Roadside WiFi
(Setbacks-Lessons Learned)

- The only small setback we encountered during deployment was the tablets wouldn't connect to the WiFi very well. We determined that the tablets (and most devices) work better with select frequencies in the 5 GHz band, such as 5745, 5765, 5785, 5805 & 5825.

- The Ubiquiti equipment is very user friendly.

- Spectrum analysis at every location prior to installation is very important.

WyoLink Data For Districts 1 & 3
Radio Voice & Data
As Data usage increases, voice usage decreases

Counts in 1K
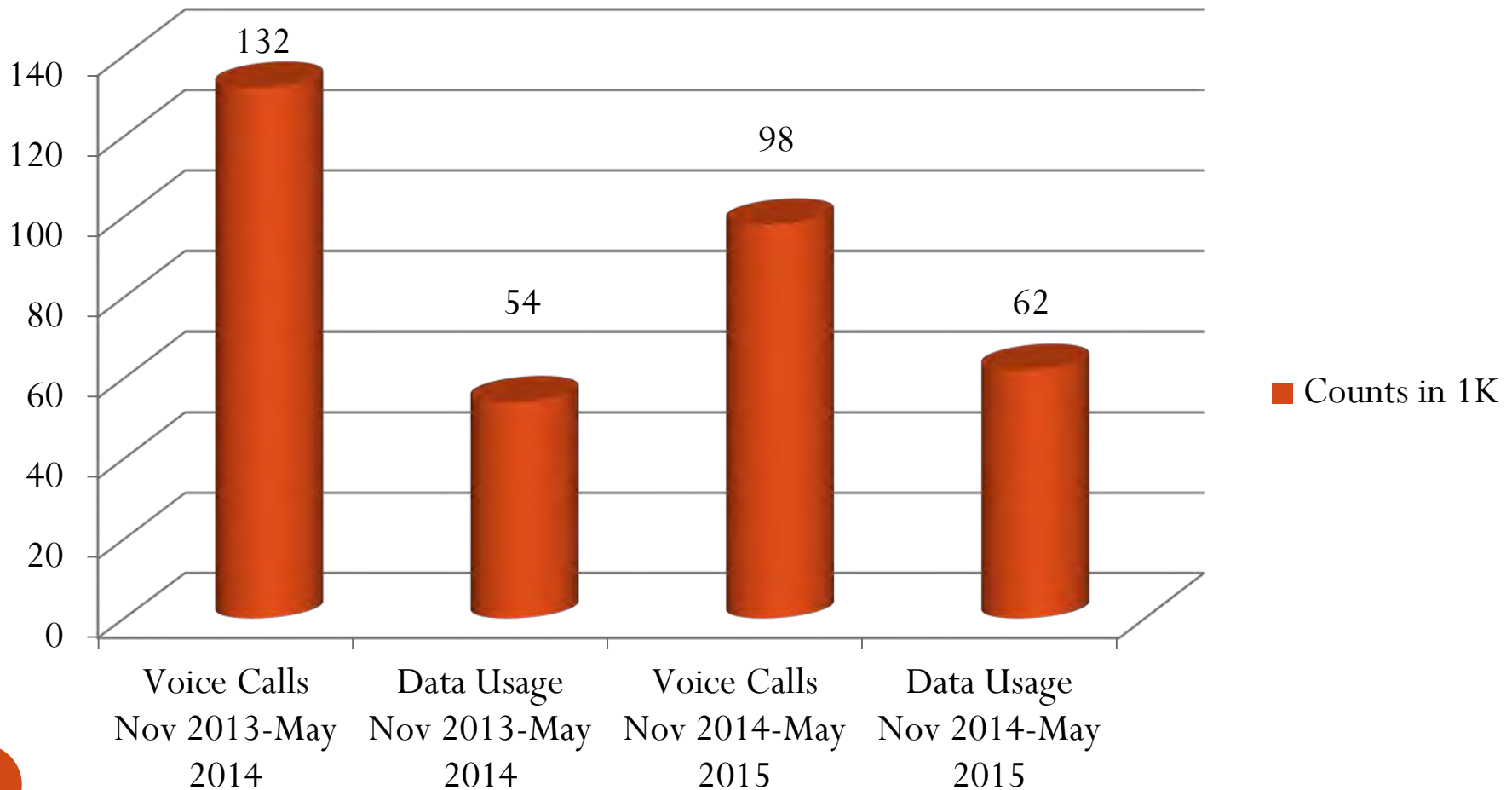
Backhaul Wireless Utilization
Feb 12th to Mar 12th

Monitoring, System Health and Availability is done via Solar Winds

≡ ● Cheyenne Radio Shop

Cheyenne Sandpile WiFi

– ● Daley Sand Shed

Daley Sand Shed PTP to NiMi

Daley Switch

Daley WiFi

Daley WiFi Packet Flux

≡ ● I80 W 343.8

Harriman WiFi

≡ ● Walcott Sand Shed

Walcott Sand Shed PTP to Walcott Relay Tower

Walcott Switch

Walcott WiFi

Walcott WiFi Packet Flux

Backhaul (P1) (32)
Backhaul (P2) (24)
Backhaul (P3) (9)
Backhaul (P4) (6)
TEL-BASI (P1) (39)
TEL-BASI (P2) (6)
TEL-BASI (P3) (17)
TEL-BASI (P4) (1)
TEL-CASP (P1) (39)
TEL-CASP (P2) (13)
TEL-CASP (P3) (25)
TEL-CASP (P4) (2)
TEL-CHEY (P1) (140)
TEL-CHEY (P2) (45)
TEL-CHEY (P3) (34)
TEL-CHEY (P4) (1)
TEL-ROSP (P1) (98)
TEL-ROSP (P2) (36)
TEL-ROSP (P3) (11)
TEL-SHER (P1) (20)
TEL-SHER (P2) (19)
TEL-SHER (P3) (3)
TEL-SHER (P4) (2)
TEL-TELE (D1) (21)
TEL-TELE (D2) (24)
TEL-TELE (D3) (49)
TEL-TELE (D4) (44)
TEL-TELE (D5) (29)
TEL-TELE (HQ) (21)
TEL-TELE (P3) (10)
WIP (Testing) (17)

Monitoring, System Health and Availability is done via Solar Winds

Total Monitored by Telecom   837

Summary

- WYDOT Telecom has added WISP to its list of services.

- The next project on the horizon is Dedicated Short Range Communications (DSRC) and the Connected Vehicle (CV). Later 2016-2017.

Questions?