NDDOT TRIP Program: Distributed Acoustic Sensing (DAS) Along I-29 for Traffic Monitoring

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National STIC Network Meeting
April 19th 2018

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State Transportation Innovation Team (STIT)

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North Dakota STIC

Meet Semi-Annually

STIT Advisory Group

includes:

ND League of Cities

MPO Directors

Local Technical Assistance Program

Industry stakeholders

Transportation Innovations Program (TRIP)

Anyone can submit idea

Team Evaluates & Recommends

NDDOT Executive Office Approves projects

Distributed Acoustic Sensing (DAS) project

Submitted to TRIP

Approved in 2015

TRIP and the DAS Project

- Vendor is Global Innovative Solutions (GIS) of West Fargo, ND partnering with OptaSense, Ltd.

- OptaSense, Ltd is based in the UK
  - Founded in 2007 by parent company QinetiQ, a British defense contractor

- OptaSense DAS systems are **also used for site security, oil and gas monitoring and rail monitoring**

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TRIP and the DAS Project

- **1st installation of its type in North America**
  - NDDOT's installation capable of both traffic counting and traffic management

- Other similar OptaSense traffic installations are present in the UK, New Zealand, The Netherlands and China
  - Primarily for traffic management such as speed

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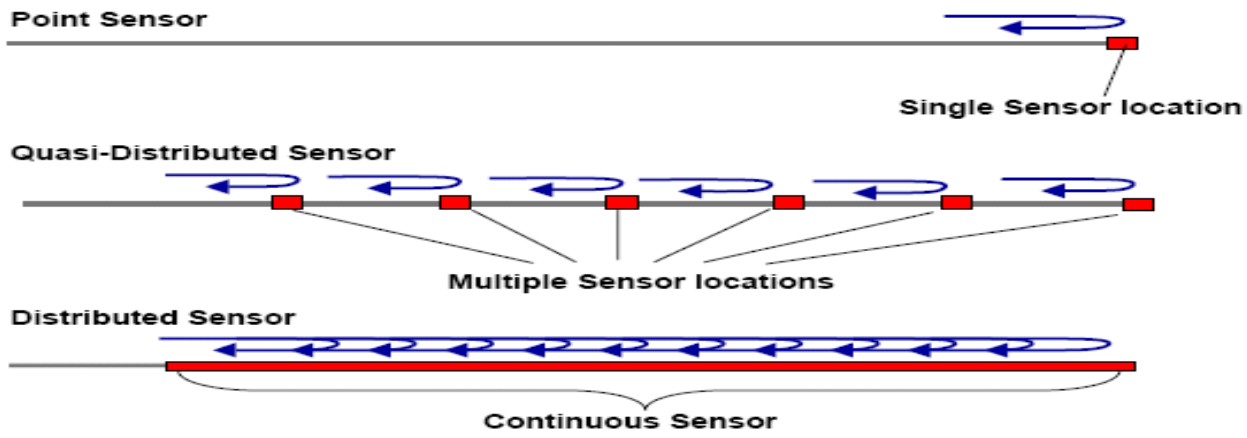
What is Distributed Acoustic Sensing?

- Distributed Acoustic Sensing (DAS) allows for continuous acoustic measurements along the length of an individual optical fiber
- The fiber is the sensor

Example of an NDDOT ATR (point sensor)

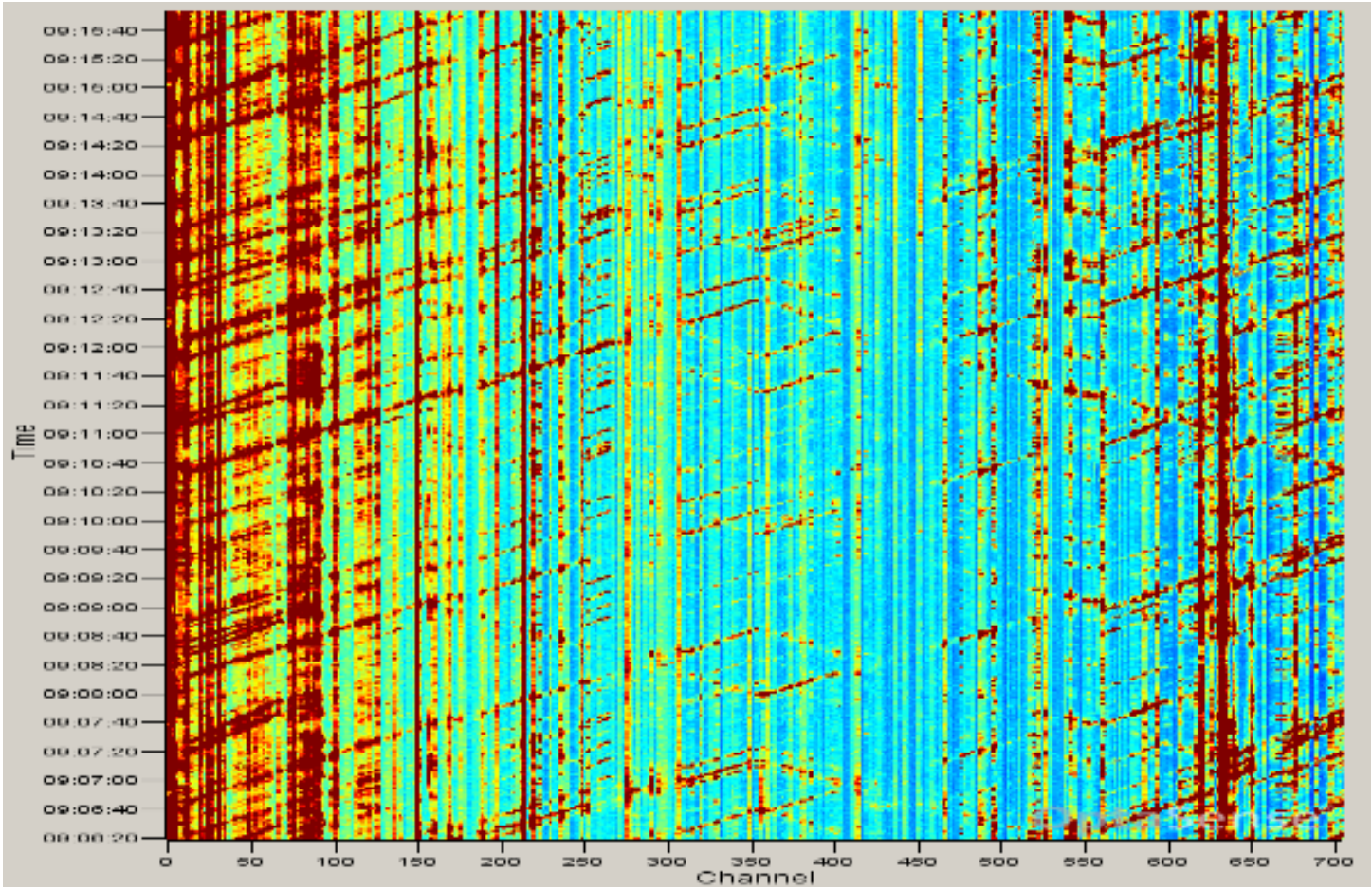


One fiber can replace a variable number of point sensors

What does DAS look like?

- OptaSense's implementation of DAS produces a **Waterfall**

- For the installation in Fargo, it shows signal across the system graphed across time and updating in real time



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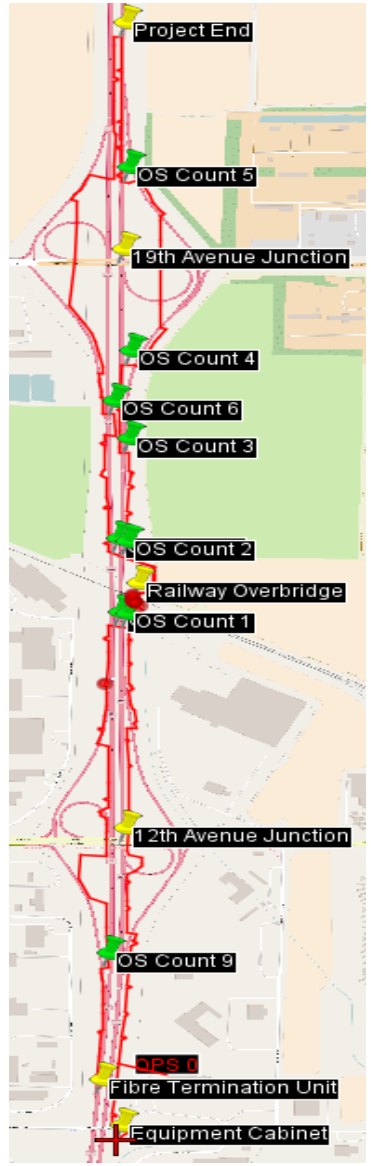
The System

- Located along I-29 in Fargo, ND
- Length is 4.5 miles, including ramps and both sides of I-29.
- 2 centerline miles monitored
- Both parallel sections and areas bored across the Interstate

Aerial of the Project Area

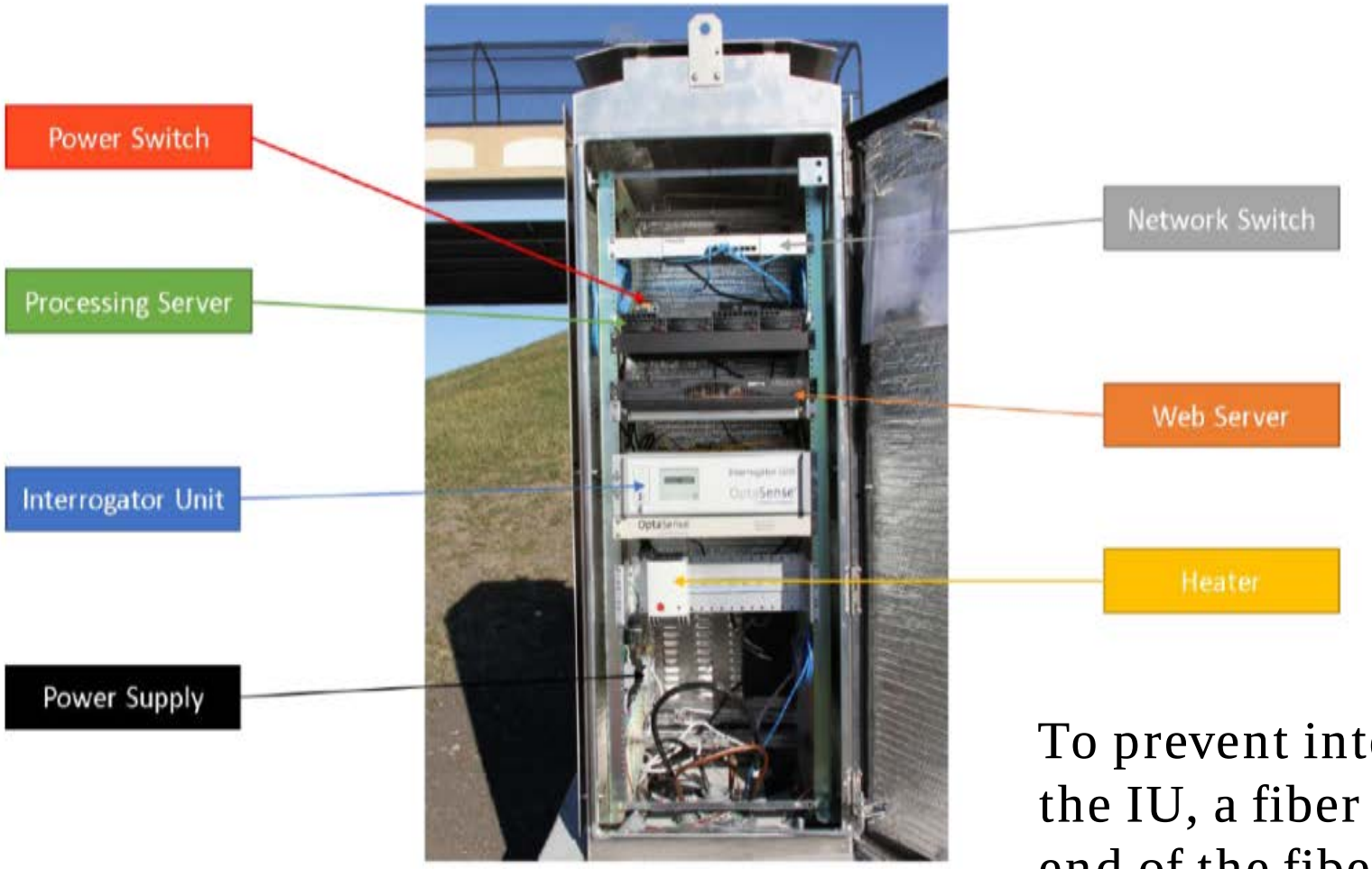


Path of the fiber

Construction of the System

- Only fiber is needed alongside the road
- Minimal traffic impact during installation
- Fiber is buried as close to the shoulder as possible to maximize signal. Fiber is bored across the road where traffic counts are desired.
- Buried 2 feet below grade to minimize impacts from road work and to reduce noise. Fiber in this application is very sensitive to noise.
- Metallic tape covering makes locating the fiber easy during construction projects

The Cabinet



- Cabinet custom built to protect the sensitive electronics from extreme cold of Fargo winters
- **Interrogator Unit (IU) -** receives and measures the signal from the fiber. **Processing Server** (PS) interprets that signal.

To prevent interference from reflected light to the IU, a fiber termination unit is applied to the end of the fiber.

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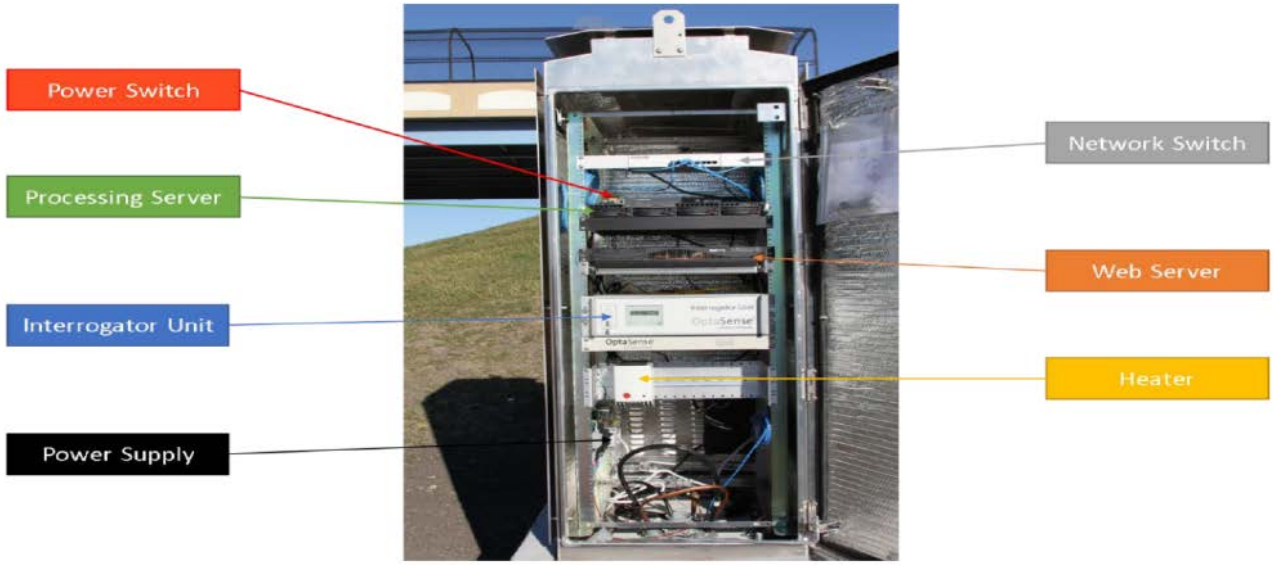
The Cabinet

- **Web Server** (WS) hosts the web interface showing the speed, travel time and traffic volume in real time.

- **Power Supply** is remote controlled - all components are connected via fiber back to NDDOT Fargo District which connects to the Control Unit (CU) in NDDOT Central Office in Bismarck.



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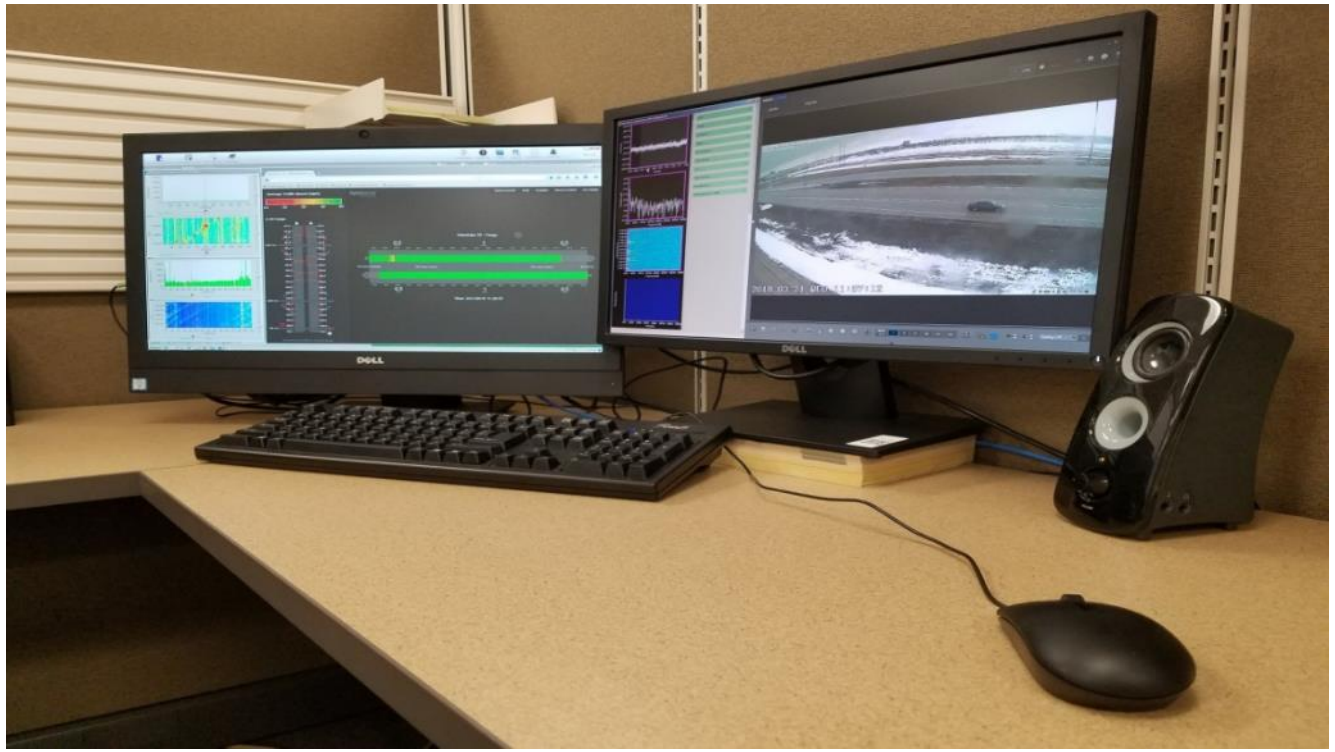
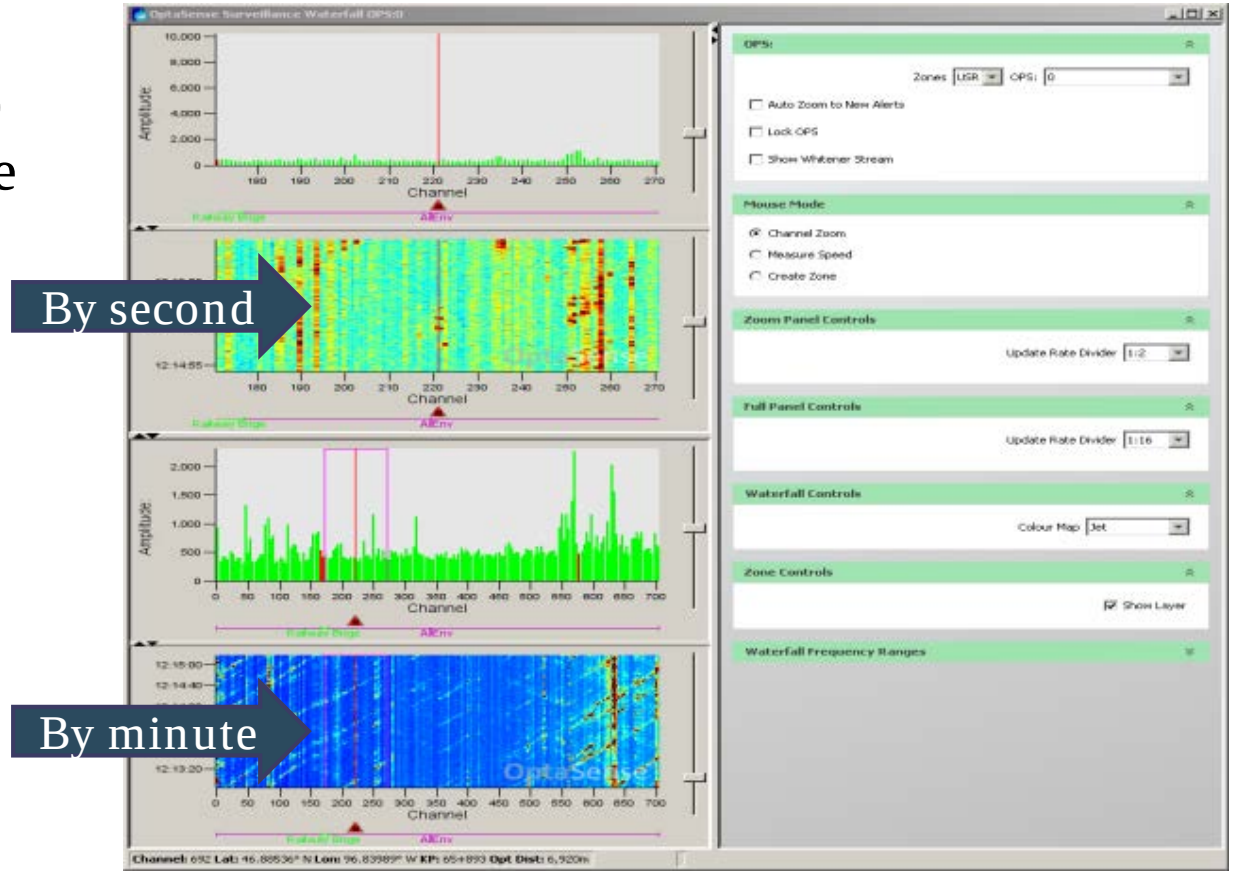
The Control Unit (CU)

- Control for the system is at NDDOT Central Office in Bismarck.
- Consists of an all-in-one PC on Windows 7 and runs OptaSense control software.
- CU is hooked up to a speaker system with a subwoofer.
- Subwoofer is necessary because most of the detectable auditory output is in the low range.



The Control Unit (CU)

- OptaSense software (Operator Interface) has various waterfalls to look at when the system is running.
- **Multiple waterfalls show the same data in different time intervals.**
  - Top one is by second
  - Bottom one is by minute
- One can hear the signal being processed by the entire system at once or one channel at a time.



Example of zooming in on a channel of the waterfall portion of Operator Interface

The Control Unit (CU)

- Can analyze any channel for amplitude, period, frequency and aural replay in real time or played back after the fact.

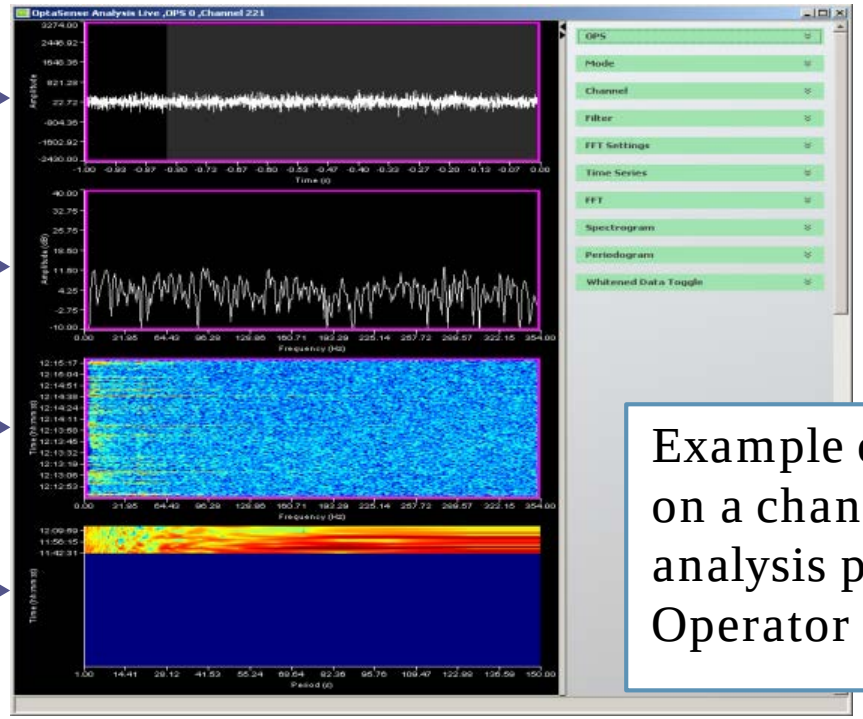
- To check a vehicle count, listen to recording of sound processed by system for auditory confirmation. Can also login to the collocated ATR and check portion of the system

Amplitude vs. Time

Frequency vs. Amplitude

Frequency vs. Time

Period vs. Time



Example of zooming in on a channel of the analysis portion of Operator Interface

Current Traffic Monitoring Capabilities

- Speed
  - Resolution every 10 m (viewable in 50 m segments), in m/s converted to mph
  - Updates every second in real time
- Travel Time
  - Measured between interchanges and between interchanges/ends of the fiber in seconds converted to min.
- Traffic Volume
  - The prototype algorithm is currently measuring 9 locations within the System.
  - Currently outputting vehicles per minute, vehicles per hour and vehicles last hour.
  - Updates once per minute.

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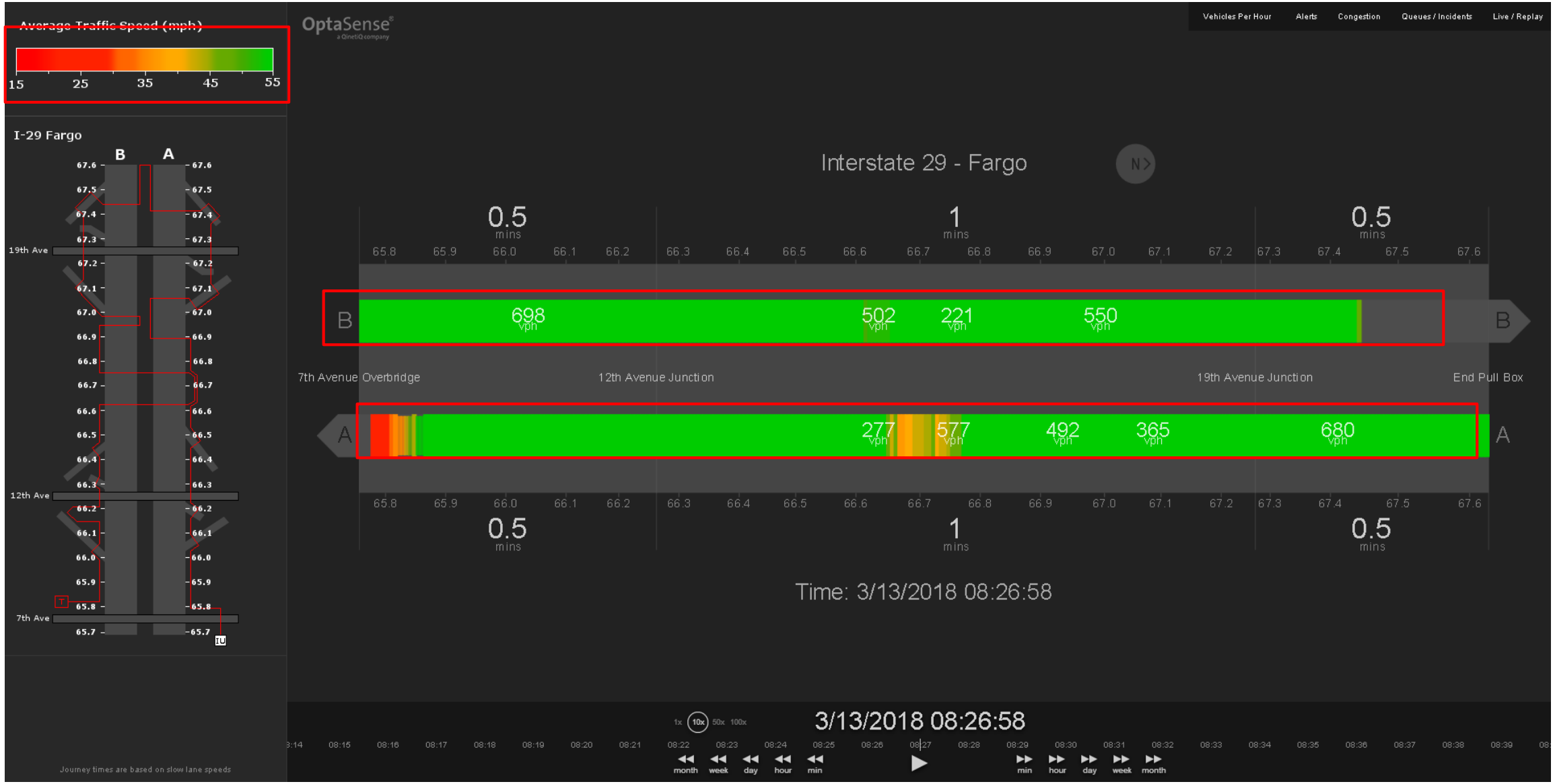
Speed


Average Traffic Speed (mph)
15
25
35
45
55
I-29 Fargo
B
A
19th Ave
12th Ave
7th Ave
Journey times are based on slow lane speeds
OptaSense
Vehicles Per Hour
Alerts
Congestion
Queues / Incidents
Live / Replay
Interstate 29 - Fargo
0.5 mins
1 mins
0.5 mins
698 vph
502 vph
221 vph
550 vph
7th Avenue Overbridge
12th Avenue Junction
19th Avenue Junction
End Pull Box
277 vph
577 vph
492 vph
365 vph
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Time: 3/13/2018 08:26:58
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month
week
day
hour
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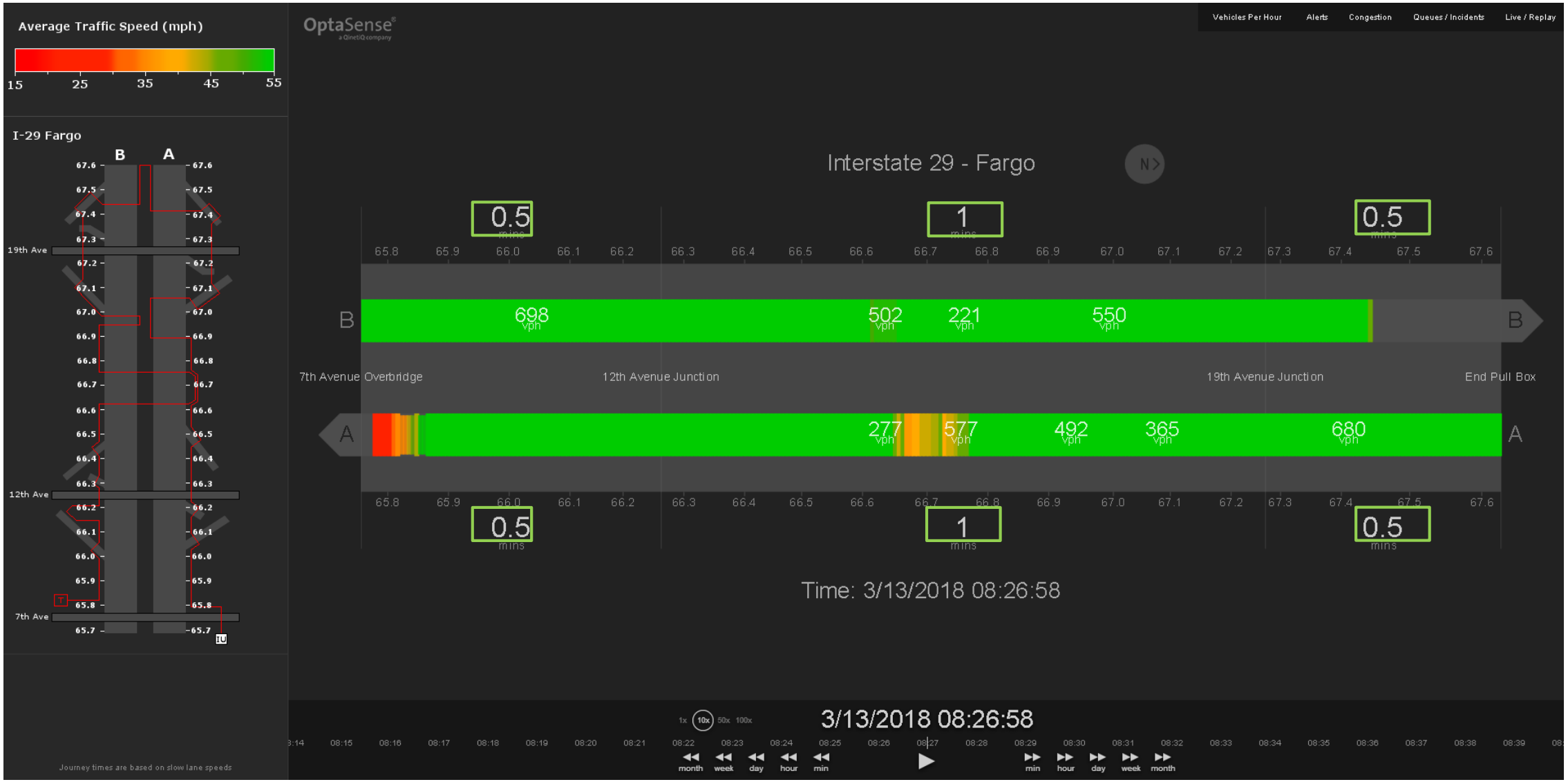
Travel Time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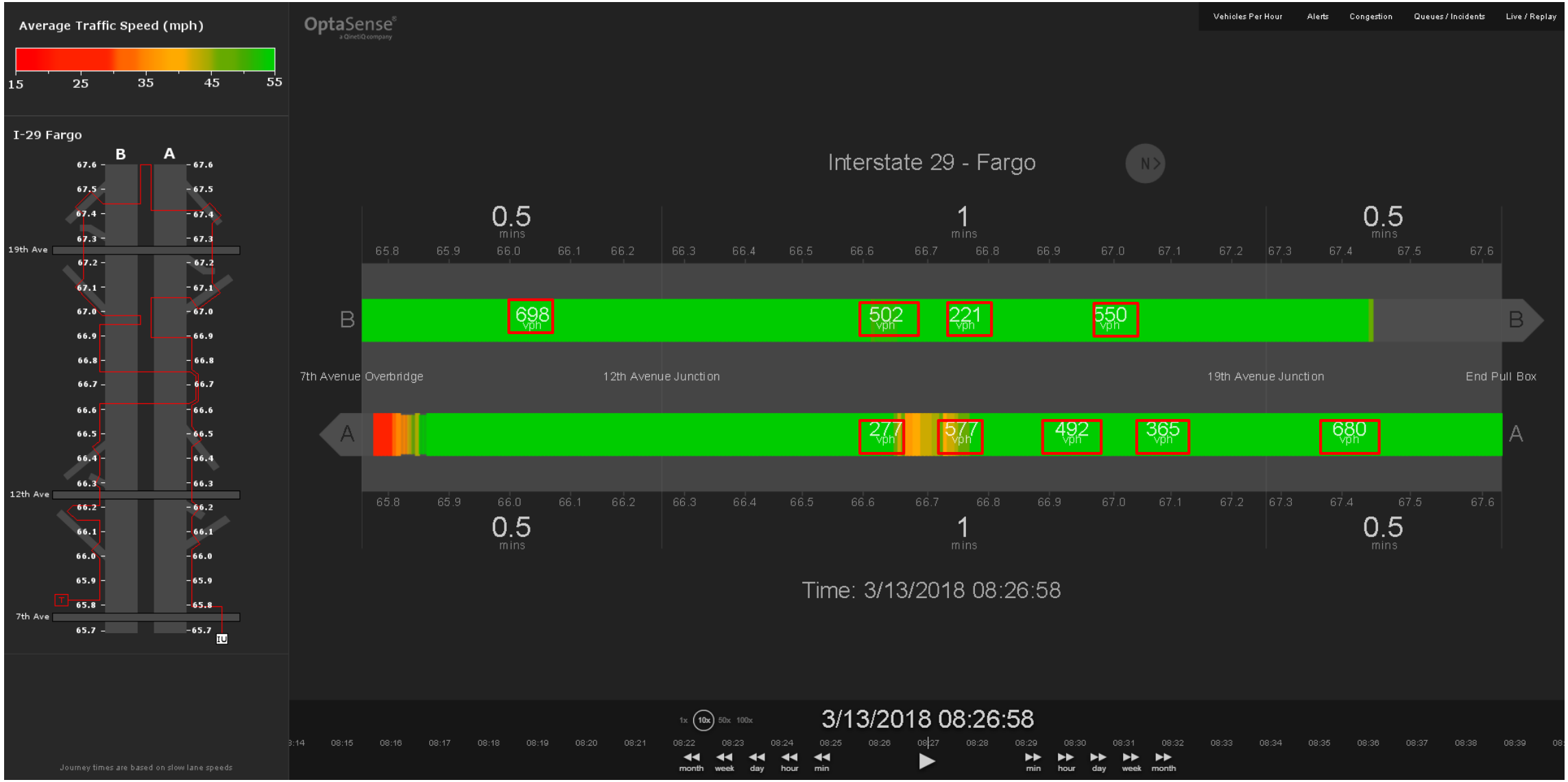
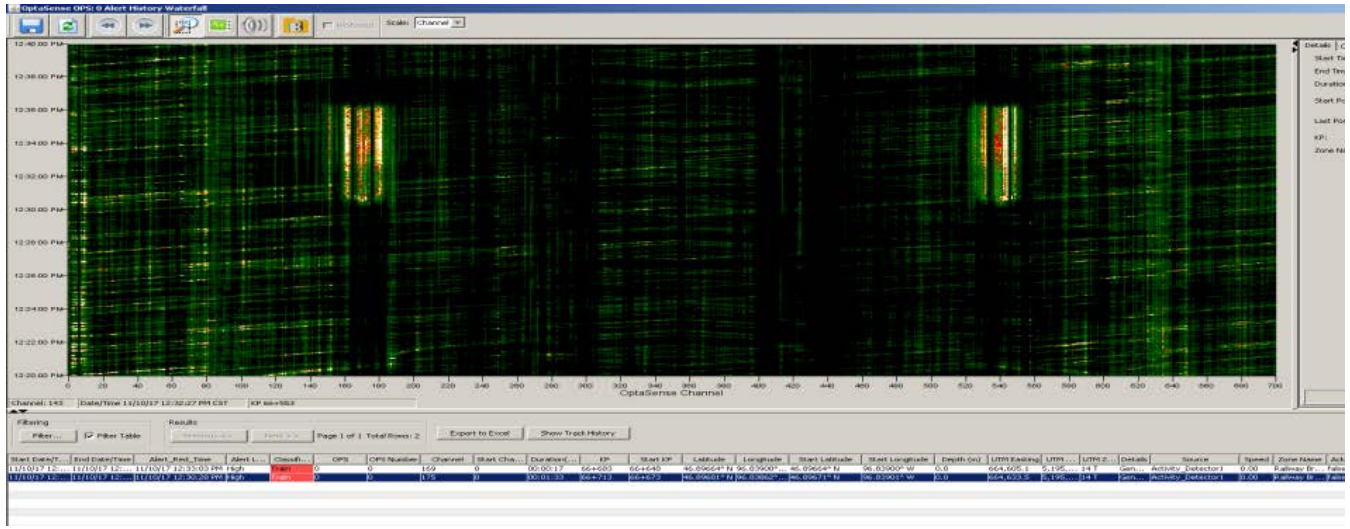
Traffic Volume



Current Traffic Monitoring Capabilities

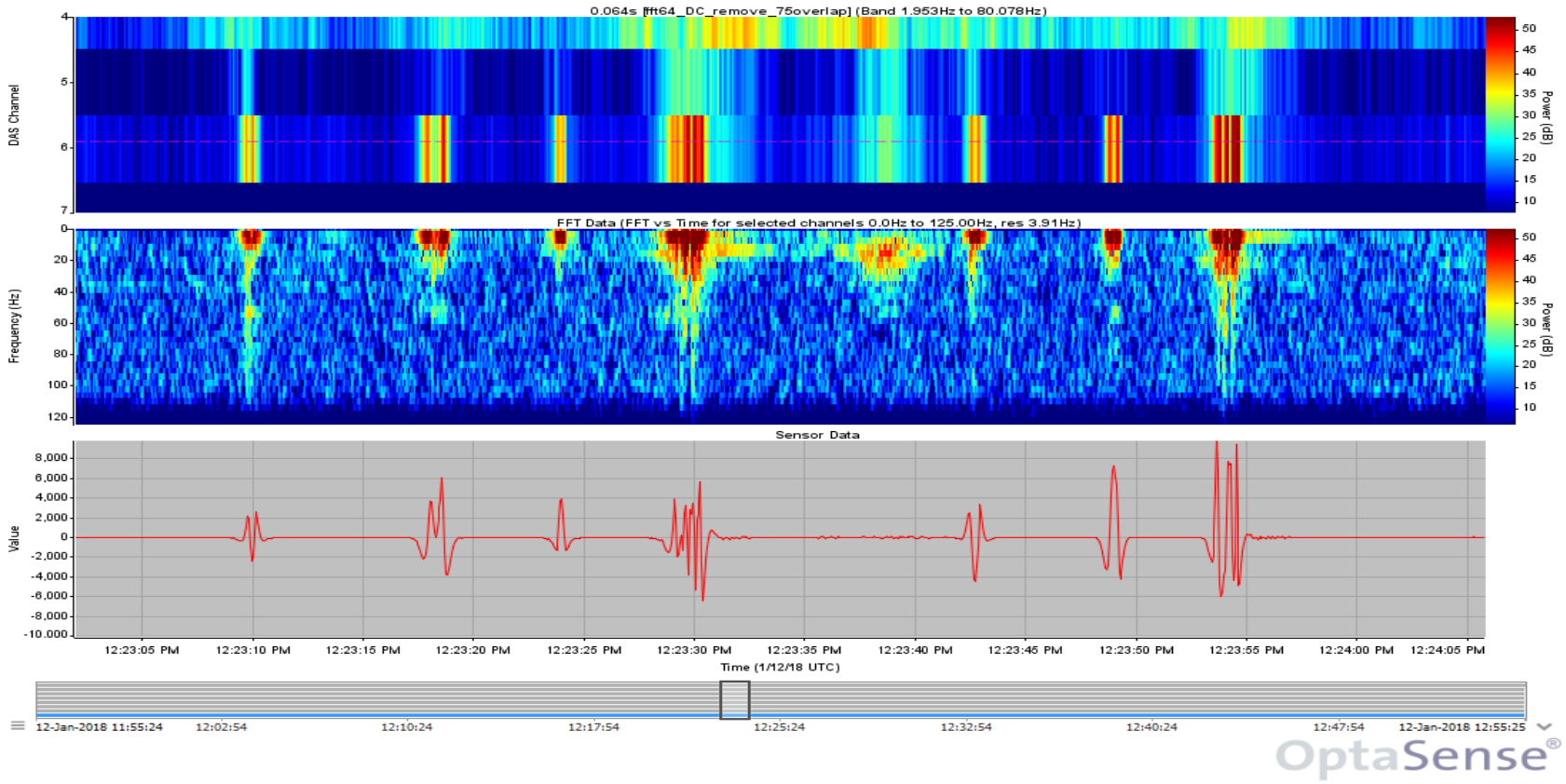
- Trains
  - Trains run on overpass in one location
  - Auditory signature so large it can easily be detected despite the system designed to only detect traffic on I-29
  - Still hard to hear without a subwoofer



Two large blocks of signal are a train passing over either side of I-29

Future Traffic Monitoring Capabilities

- Classification
  - OptaSense is currently **working on a vehicle classification algorithm**



OptaSense®

Example of looking at classification in the raw sensor data

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Future Traffic Monitoring Capabilities

- **Classification**
  - System sensitive enough to **hear difference between light and heavy vehicle**
  - Accurately classifying these differences requires more work between NDDOT and OptaSense
  - Collocation with temporary camera and ATR will provide “ground truth” to verify results

Fargo I-29 ATR collocated with OptaSense system

Temporary camera view collocated with Fargo I-29 ATR

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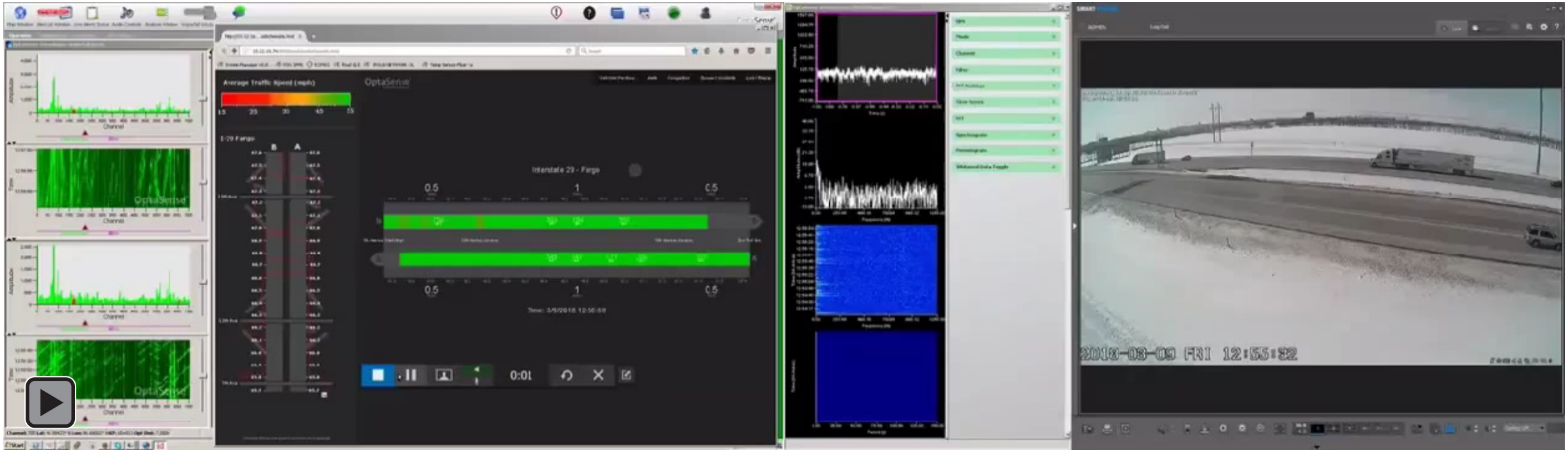
Waterfall

Speed, Time, and Volume

Amplitude, Period, Frequency

Video Feed



The sound output in the low range has been amplified by 15 decibels to account for speakers without a subwoofer

Questions?

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