Advanced Traffic and Weather Visualization Platform

www.inl.gov

Idaho National Laboratory

Idaho National Laboratory

IDAHO TRANSPORTATION DEPARTMENT

IBM | The Weather Company

Agenda

Why move to a hyper local/accurate weather forecasting system

Current RWIS Sites supporting the Idaho National Lab

Data Sources

IBM Forecast Model powered by Watson

Dashboard and Video Analytics

Future Enhancements

Idaho National Laboratory

2,000 employees transported each workday

890 Square mile area

62 Motor Coach routes

50 miles separate most facilities from local communities

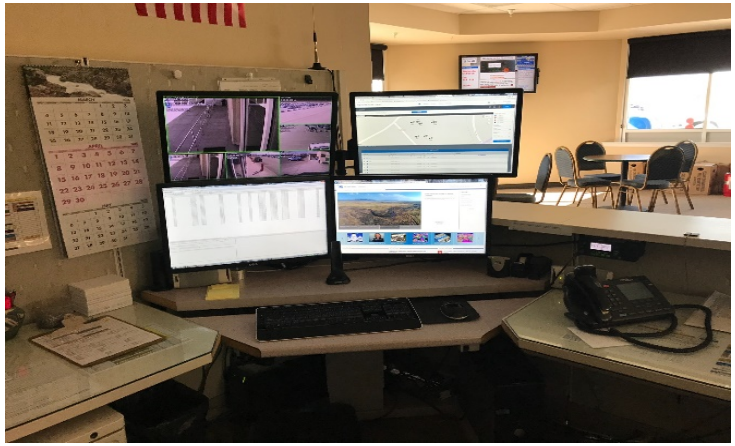
22 hour a day bus operations

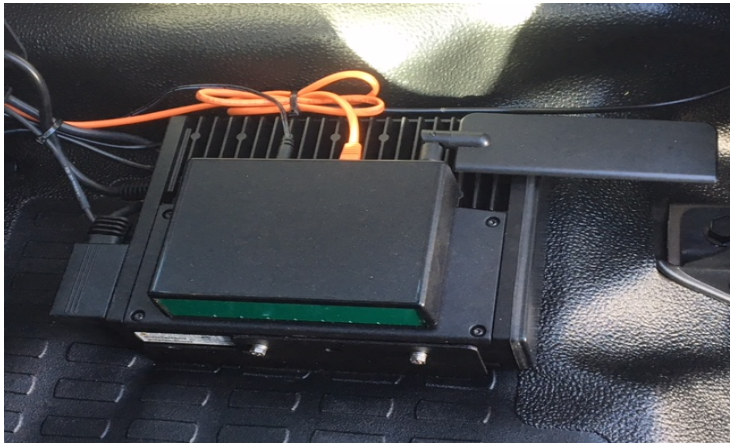
4 major roadways traveled: Interstate I-15, US Hwy 20, 26 & 33

Acronyms Used

- **INL** - Idaho National Laboratory
- **ITD** - Idaho Transportation Department
- **Zonar** - brand name of preloaded table computer used in INL vehicles
- **POI** - point of interest
- **KPI** - key performance indices
- **API** - application protocol interface
- **DVR** - digital video recorder
- **GPS** - satellite global positioning system
- **WS** - wind speed
- **AI** - artificial intelligence
- **TWC** - The Weather Company

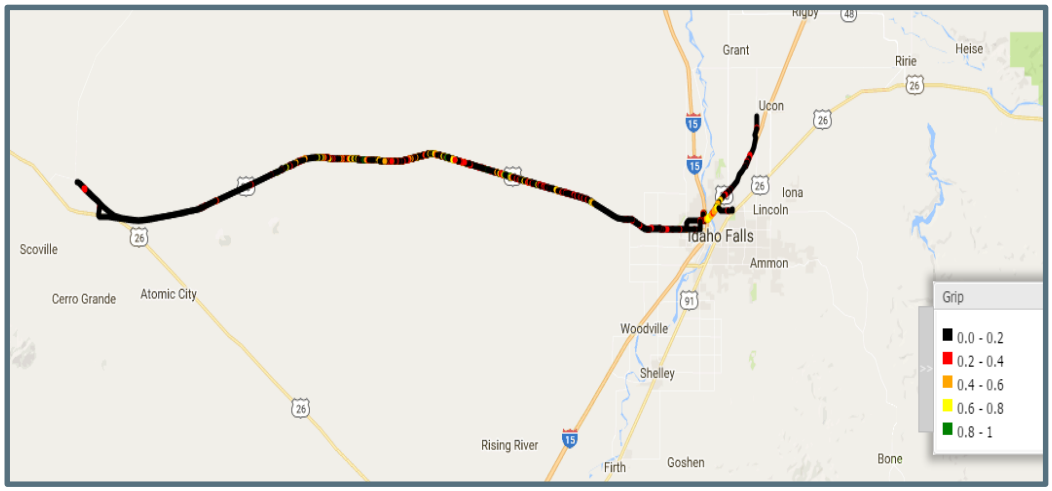
Current INL Bus and Route Support



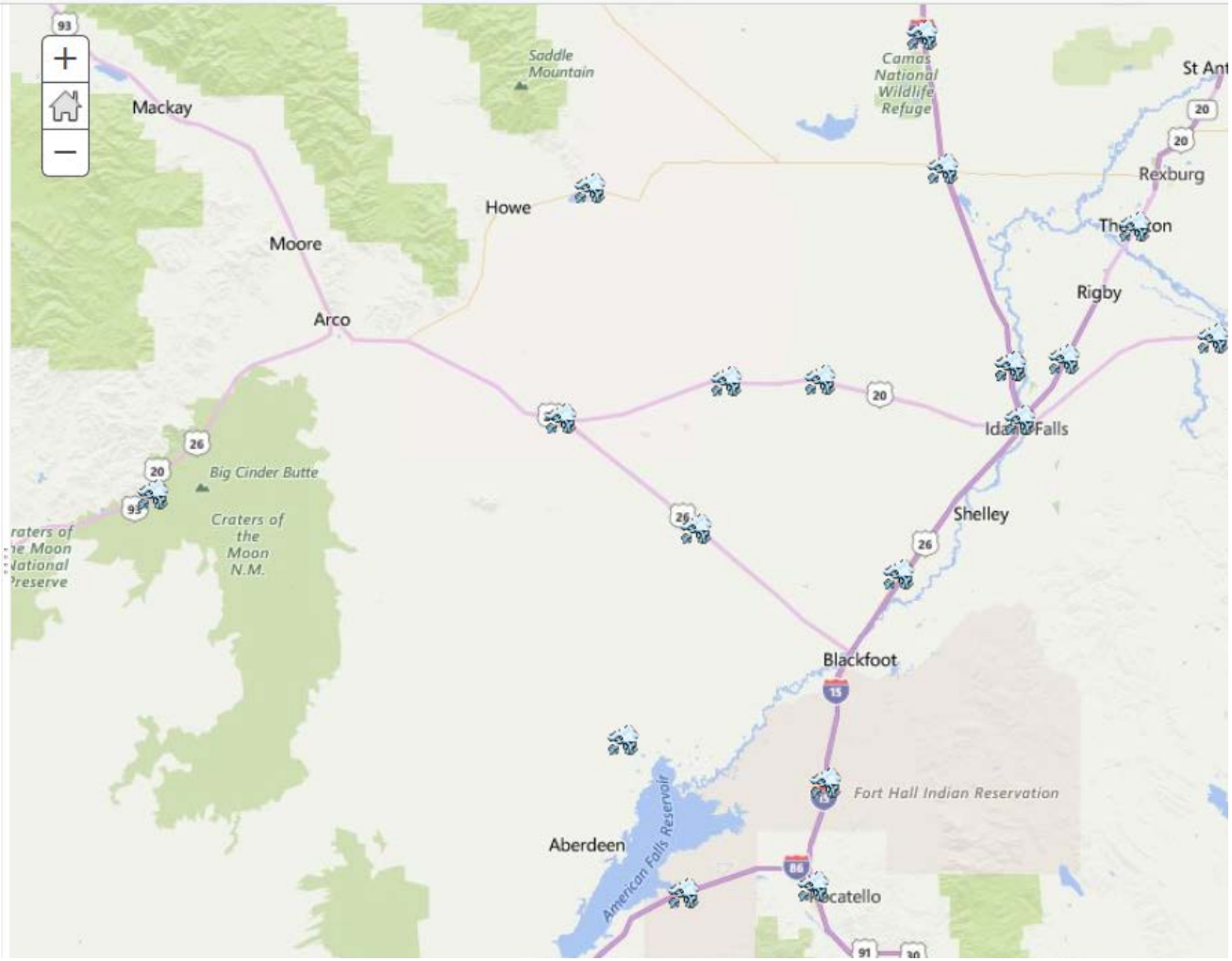


INL Road Scout

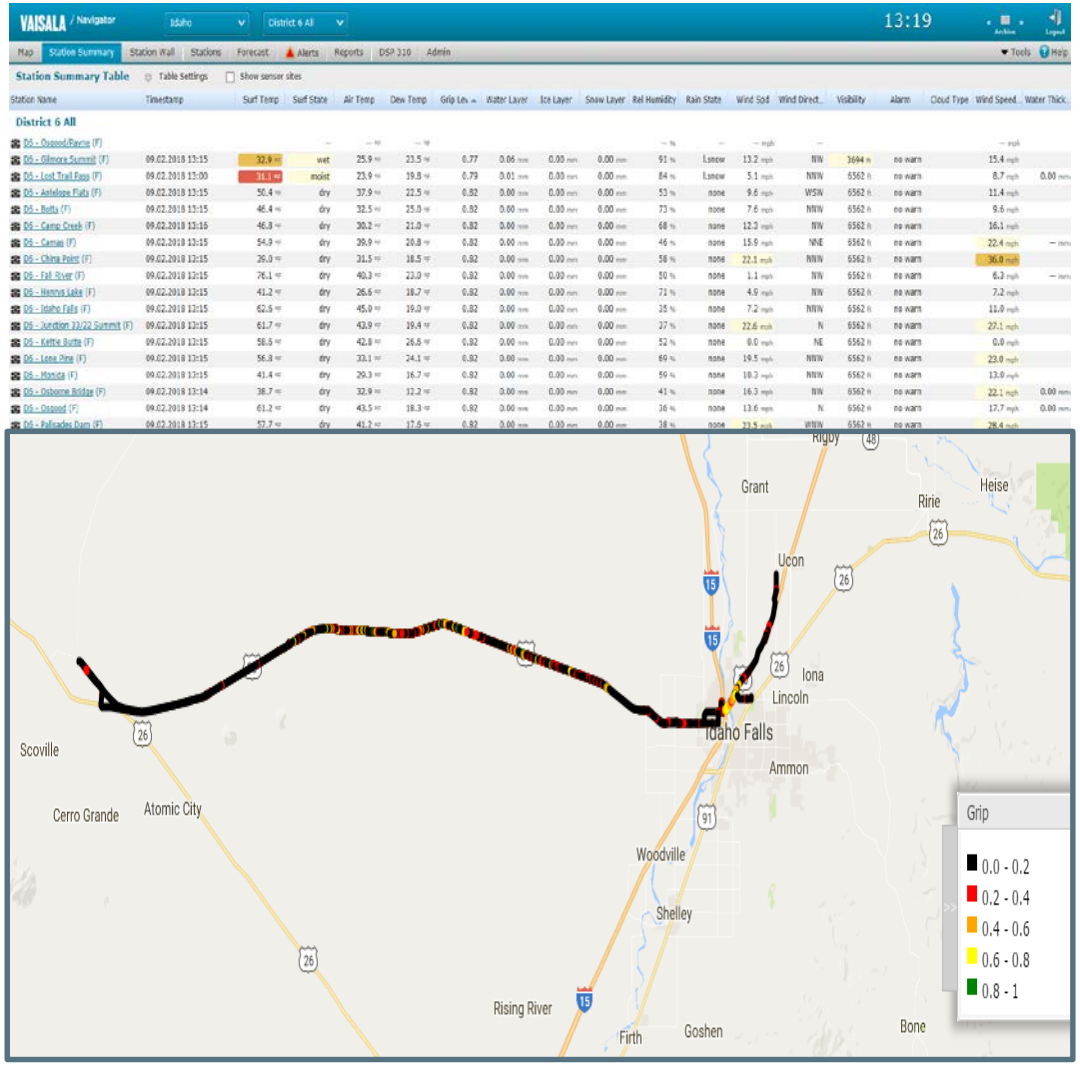
- Road Scouts are on the road by 3 a.m. to report road conditions to management.
- 4 Road Scout trucks have the Vaisala mobile systems mounted on the vehicle
- Go / No-Go, delay, or re-route decisions based on capability of a professional driver in 40,000 GVW bus, input from ITD plow supervisors, and weather forecast.



RWIS Sites on INL Bus Routes



Data Comparison



Summary of Weather-related Road Closures Due From 2008-2017

DATE/TIME CLOSED	DATE/TIME OPENED	DISTRICT	ROUTE	MILEPOST	CAUSE
12/29/2007 12:08	12/29/2007 13:26	6	SH-33	0-32.5	DRIFTING SNOW REDUCED VISIBILITY
1/21/2008 0:51	1/21/2008 6:08	6	I-15	135-167	DRIFTING SNOW REDUCED VISIBILITY
1/28/2008 6:19	1/28/2008 23:31	6	US-20	257-305	DRIFTING SNOW REDUCED VISIBILITY
1/29/2008 13:23	1/30/2008 11:52	6	US-20	263-305	DRIFTING SNOW REDUCED VISIBILITY
1/31/2008 13:50	2/1/2008 13:50	6	US-20	263-305	DRIFTING SNOW REDUCED VISIBILITY
2/7/2008 5:43	2/10/2008 2:13	6	US-20	256-305	DRIFTING SNOW REDUCED VISIBILITY
[illegible]	[illegible]	[illegible]	US-26	272-300	[illegible]

68

*total weather-related incidents**

↓

51

unique events

↓

39

events due to
wind/dust/snow/water

↓

10

between 2014-2017

*Data provided for I-15, US-20, US-26, SH-33.

IBM Developed Model Provides Predictive Insights

Project Overview

1 Inclement/ unpredictable weather, resulting in road delays and closures, presents challenges for INL's bus operations team.

2 This disrupts business operations, creates unnecessary operational costs and increases the risk of accidents to employees.

3 IBM created an interactive visual dashboard which consolidates disparate data, machine-learning models to deliver recommendations for route optimization.

Data and Analytics

300+ Miles of Road

POIs/ mile markers/ road segments for 4 major freeways and highways

7.6M+ Data Points

3.5+ GB data volume,
6 disparate data sources

90 Weather Variables

55 raw and 35 derived variables analyzed across the entire proof-of-concept

2 Derived Indices

Black Ice Index, Snow Drift Index

Leading Edge Technology

Watson Visual Recognition,
Natural Language Processing
Machine Learning Models

Dashboard Insights

Features and Capabilities:

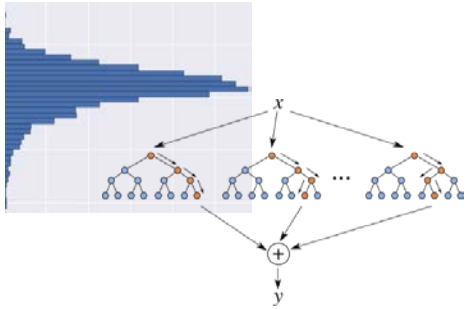
- **Control Center:** Allows discovery of real-time weather and road alerts along bus routes and INL POIs.
- **Interactive Map:** Visualizes future delays and road closures at mile marker and road segment level.
- **Road Analytics:** Predictive analytics provide 48-hour forecasts and hourly delay predictions for top weather KPIs.
- **Traffic Cameras:** Watson Image Recognition helps understand real-time road conditions.

Advanced Model Built on High-resolution Weather and ZONAR Driving Data to Predict Route Travel Time and Road Conditions

Determination of key weather data for each route-area → **Integration of ZONAR data** → **Generation of Regression model** → **Insights delivered through a browser-based platform**

Precipitation
Windspeed
Temperature
…

Speed
Nearest RWIS location



Multiple weather parameters with potential to predict speeds are determined
Weather data from nearby sensors are used to give precise local estimates

ZONAR provided bus route data is combined with weather data in order to predict expected speed relative to normal

Random Forest Regression models are tested and parametrized in order to determine the best model form and fit to optimally estimate speed

Insights delivered through a hosted IBM dashboard

The Route Travel Time Forecast Model Produces Outputs at the Mile Marker and Hourly Level

Select top predictor weather variables for forecast model → **Statistically Infer Weather Variables to Reduction in Bus Speeds** → **Validate and Predict**

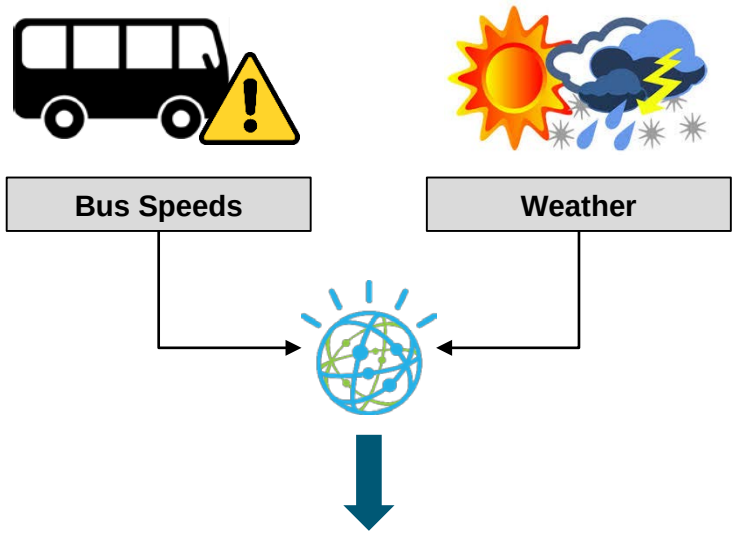
WX variables collected from RWIS Stations

- Temperature
- Wind Speed/Direction
- Precipitation
- Pressure
- Humidity

\+

35 additional derived weather variables

- Snow Drift Index
- Black Ice Index
- 1-24 hr Snow Accumulation
- 1-24 hr Avg Temperature
- Solar Angle



Pearson Correlation of predicted to observed bus speeds

$\rho = 0.56$

Generate forecasts every hour at every mile marker

The Weather Company
An IBM Business

predict

3/2/2018 13:30 I-15 Mile 208

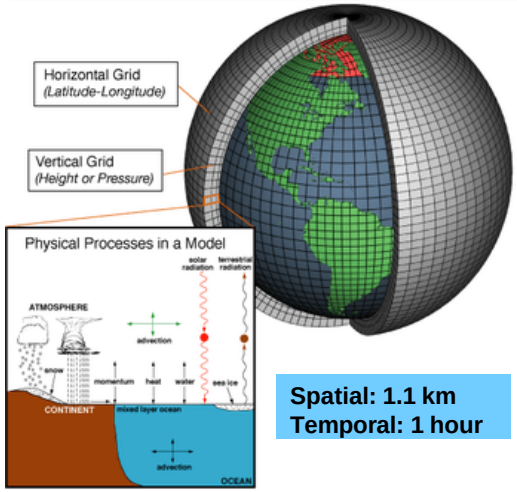
43 mph

State-of-The-Art Weather Modeling to Predict Probability of Road Closures

Hi-Resolution Ensemble of 161 Numerical Weather Prediction Models

Deriving Factors Relating to Road Closures

Calculate Probability of Road closure at each Mile Marker

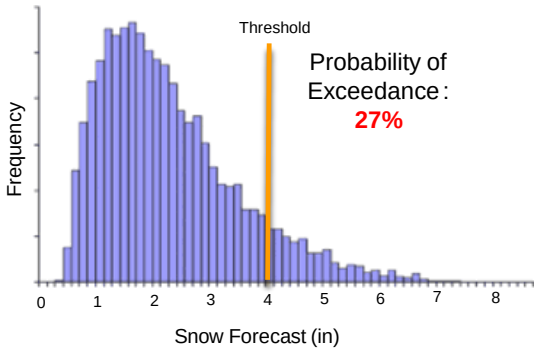


Spatial: 1.1 km
Temporal: 1 hour

$$\left(\nabla^2\omega + \frac{f_0^2}{\sigma}\frac{\partial^2\omega^2}{\partial p^2}\right) = 0$$

$$\nabla^2\omega = -\frac{f_0^2}{\sigma}\frac{\partial^2\omega^2}{\partial p^2} = -\frac{f_0^2}{\sigma}\frac{\partial\left(-DIV_h\right)}{\partial p}$$

- Snow Accumulation



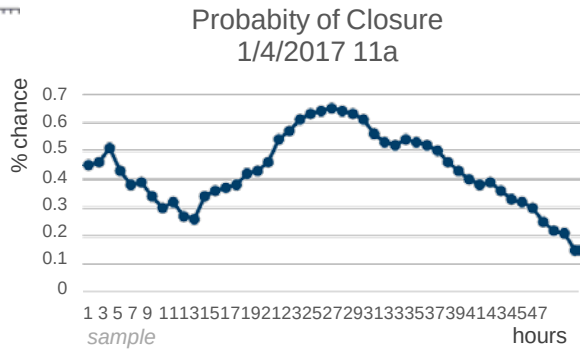
- Snow Drift Index (SDI)

$$SDI = 2 * \frac{(Snow_{qpf*}WS^2)}{(1710 + 13.6 * T_c} * \sin\theta$$

- A SDI of 1 equates to a ground blizzard

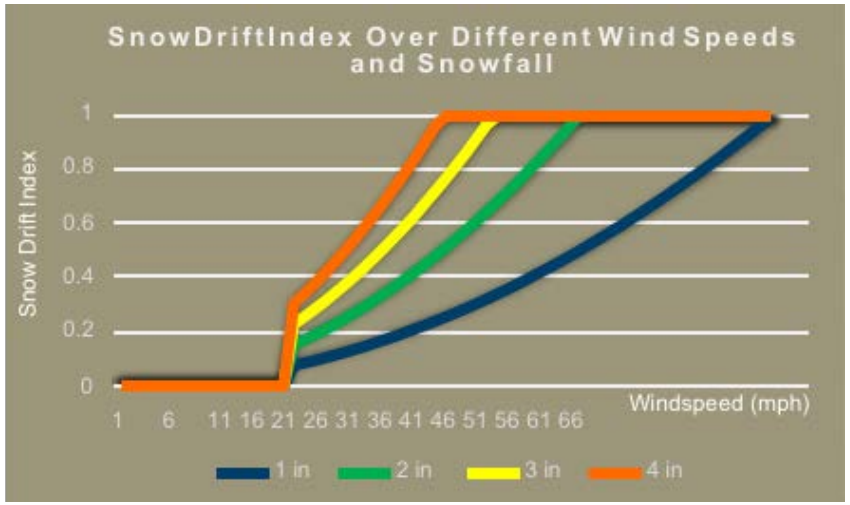
- Snow Accumulation
- Wind Speed
- Wind Direction
- Road Direction
- Temperature

Calculated every mile



Weather-derived Travel Indices

SNOW DRIFT INDEX



- Ground Blizzard approximately 1 on the Snow Drift Index
- Severe driving conditions >= 0.5
- Minimum WindSpeed (WS) of 18 mph to initiate blowing conditions
- Need temperatures below 40F to cause blowing and drifting

BLACK ICE INDEX

- Combines freezing rain and freezing fog
- Takes into account 4 variables

Ice Accumulation

Road Temperatures

Fog Development

Solar Radiation

- If ice is predicted to occur, algorithm throws a flag at every mile marker

Image Classification on ITD Traffic Camera Video

Powered by IBM **Watson**

Over 1,000 images between January 9th – March 13th 2017 were trained using Watson Image Recognition for the Telegraph Hill Camera to classify road conditions (dry with no snow, dry with snow, partial coverage, total coverage, etc.)

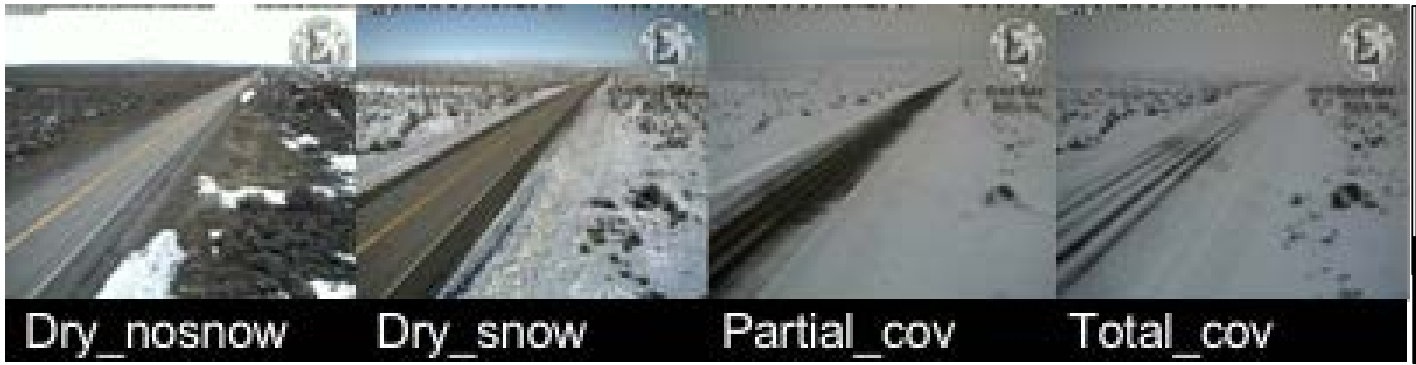
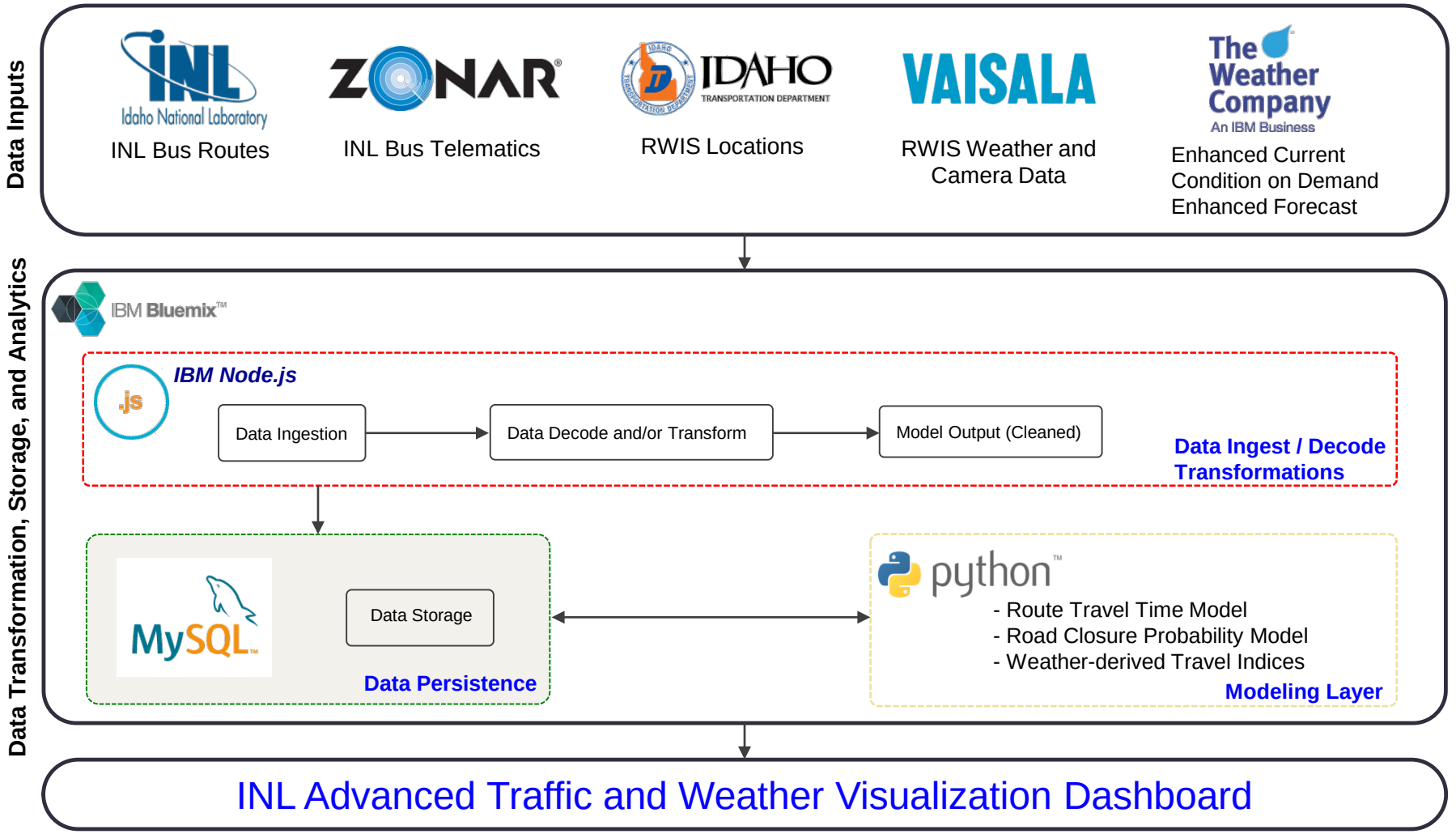


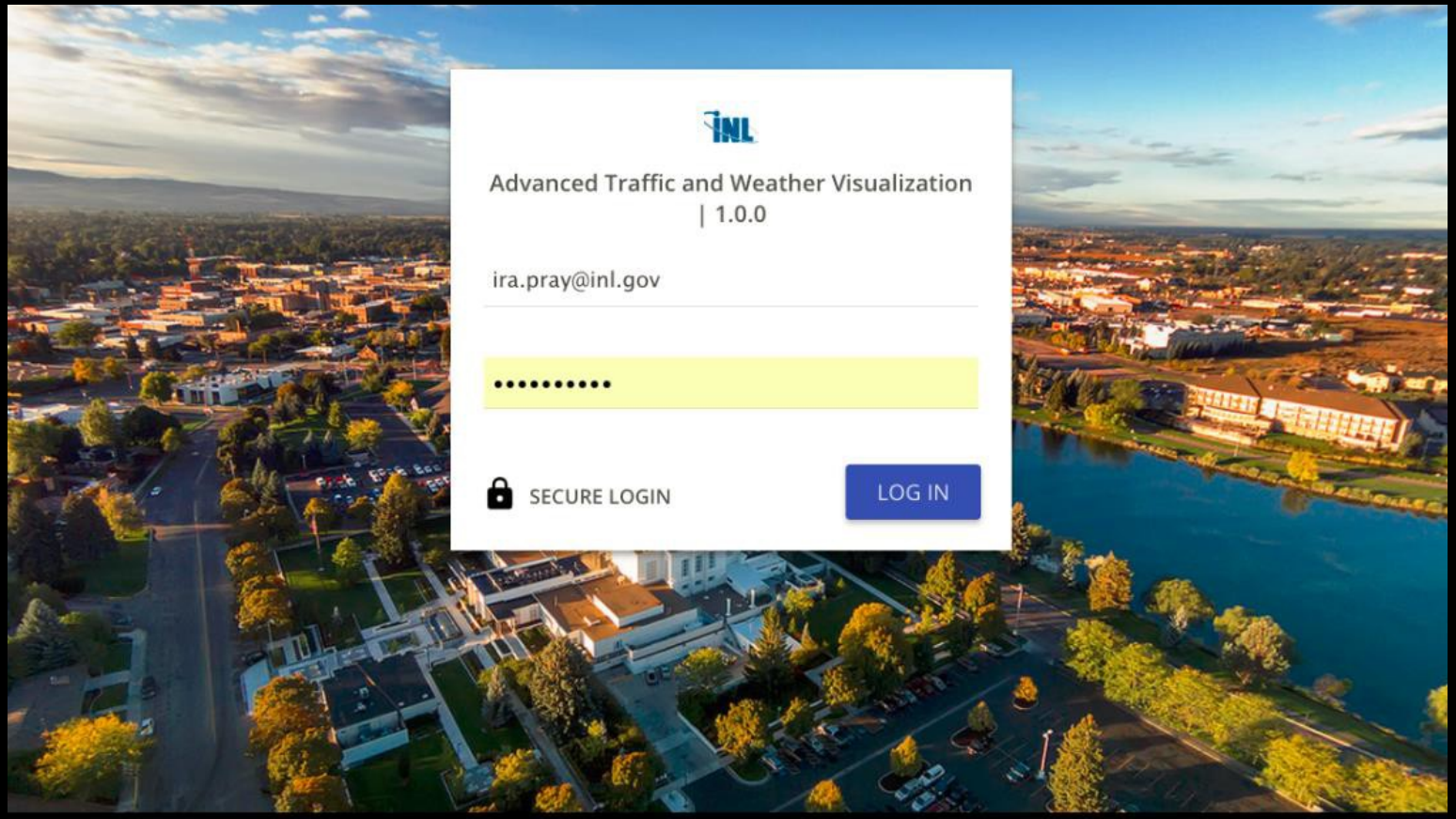
Image Classification Methodology

1. Prepare training data and sort training set into pre-defined classes (“dry”, “snow/ precip”, etc.)
2. Upload training data into Watson Image Recognition API to train a new classifier
3. Based on classes identified, a classifier set is trained which can be used to run novel images
4. Test images - images will be sorted into classes with scores ranging from 0 (no correlation) to 1 (max correlation)

Total_cov
“0.993”

INL Advanced Traffic and Weather Dashboard Solution Overview





Data and insights presented are a combination of live & historical elements. Future iterations could incorporate a full live environment.
The prototype and insights shown here are meant as a proof of concept in this phase, and should not be used in production.

Summary View

Idaho National Laboratory

Wednesday March 8, 2017 10:58:32 AM Reid Mechanick

Summary
Map
Road Analysis
ITD Cameras

PROTOTYPE

IBM

Current Weather

Sunny
31 °F

Visibility: 9 mi.
Precipitation: 0.0"

1100 WEST

Hourly Forecast

9 AM	10 AM	11 AM	0 AM	1 PM	2 PM	3 PM	4 PM	5 PM	6 PM	7 PM	8 PM
31°F	**33°F**	**36°F**	**38°F**	**41°F**	**42°F**	**43°F**	**43°F**	**41°F**	**40°F**	**38°F**	**38°F**
7 mi.	7 mi.	6 mi.	7 mi.	8 mi.	9 mi.	9 mi.	9 mi.	9 mi.	8 mi.	8 mi.	7 mi.
0.0"	0.0"	0.0"	0.0"	0.0"	0.0"	0.0"	0.0"	0.0"	0.0"	0.0"	0.0"

Key Alerts 6 Hour View

Black Ice	Snow Drift	Traffic
6 +20%	0	4 -50%

Temperature	Rain	Snow
0	0	0

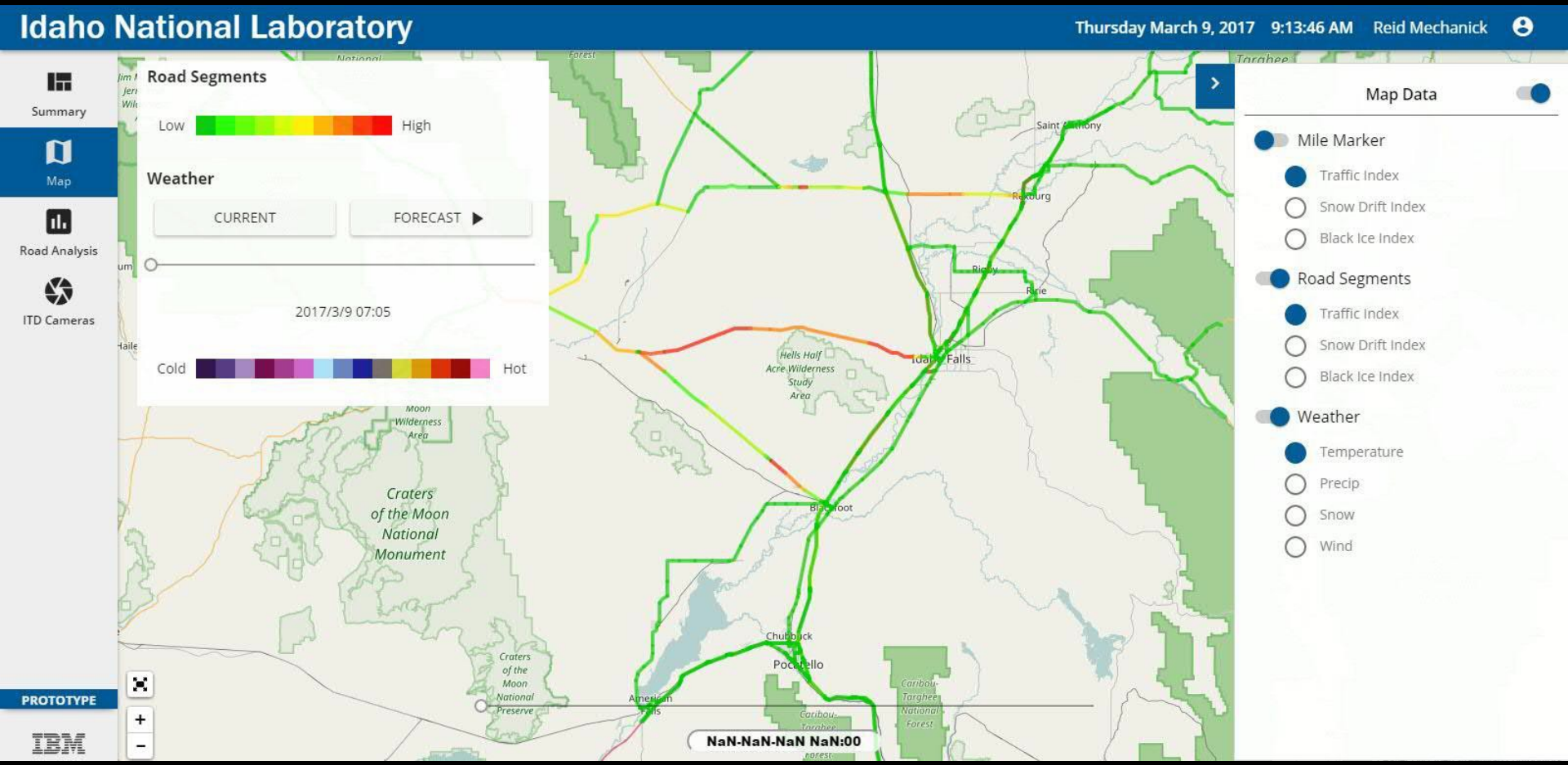
Upcoming POI Alerts

Black Ice Alert Howe Junction	0.35
Black Ice Alert Howe Junction	0.49
Traffic Alert Atomic City	0.89
Traffic Alert Atomic City	0.79
Traffic Alert Atomic City	0.62

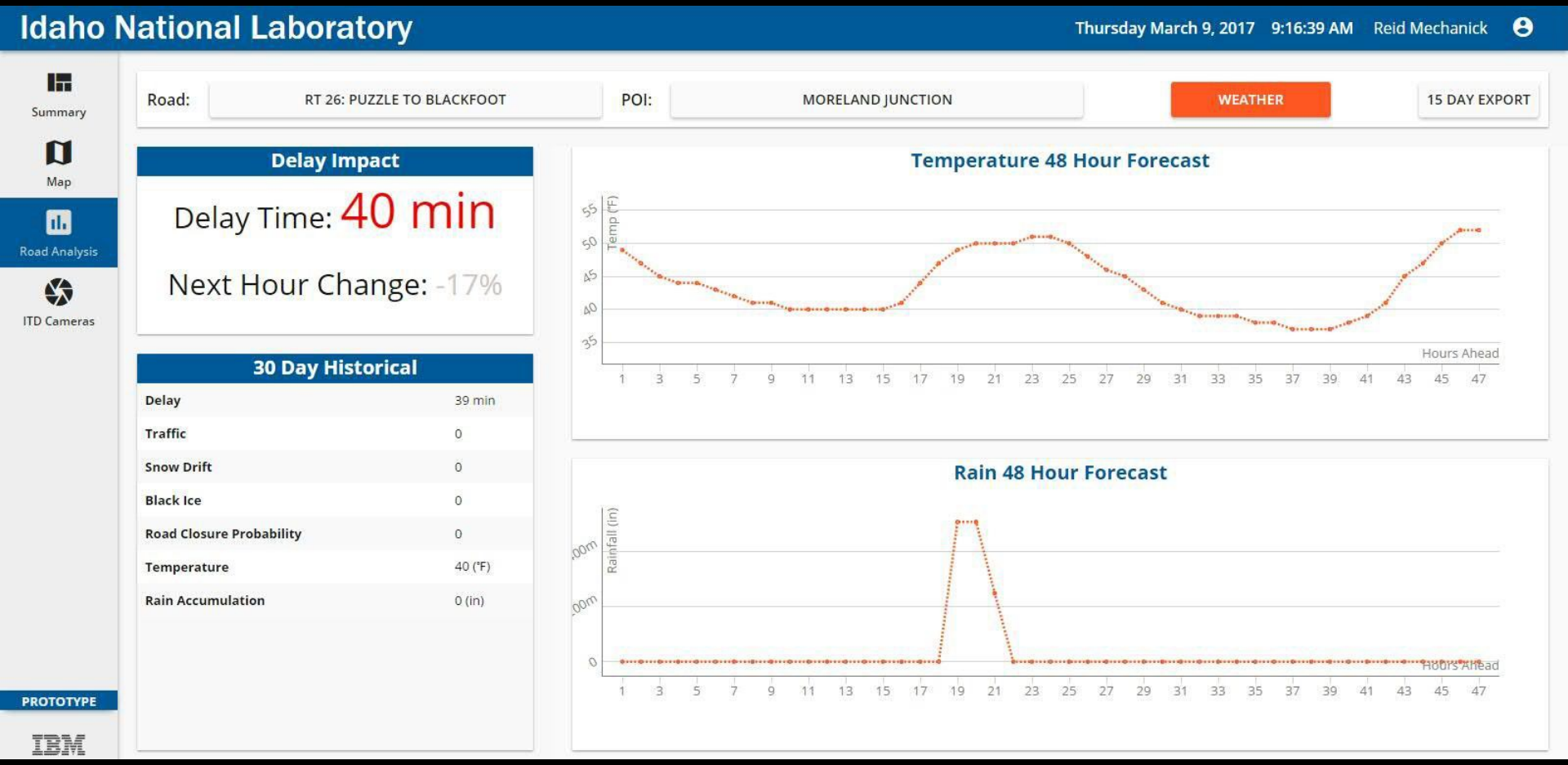
Traffic Flow

VIEW ALL

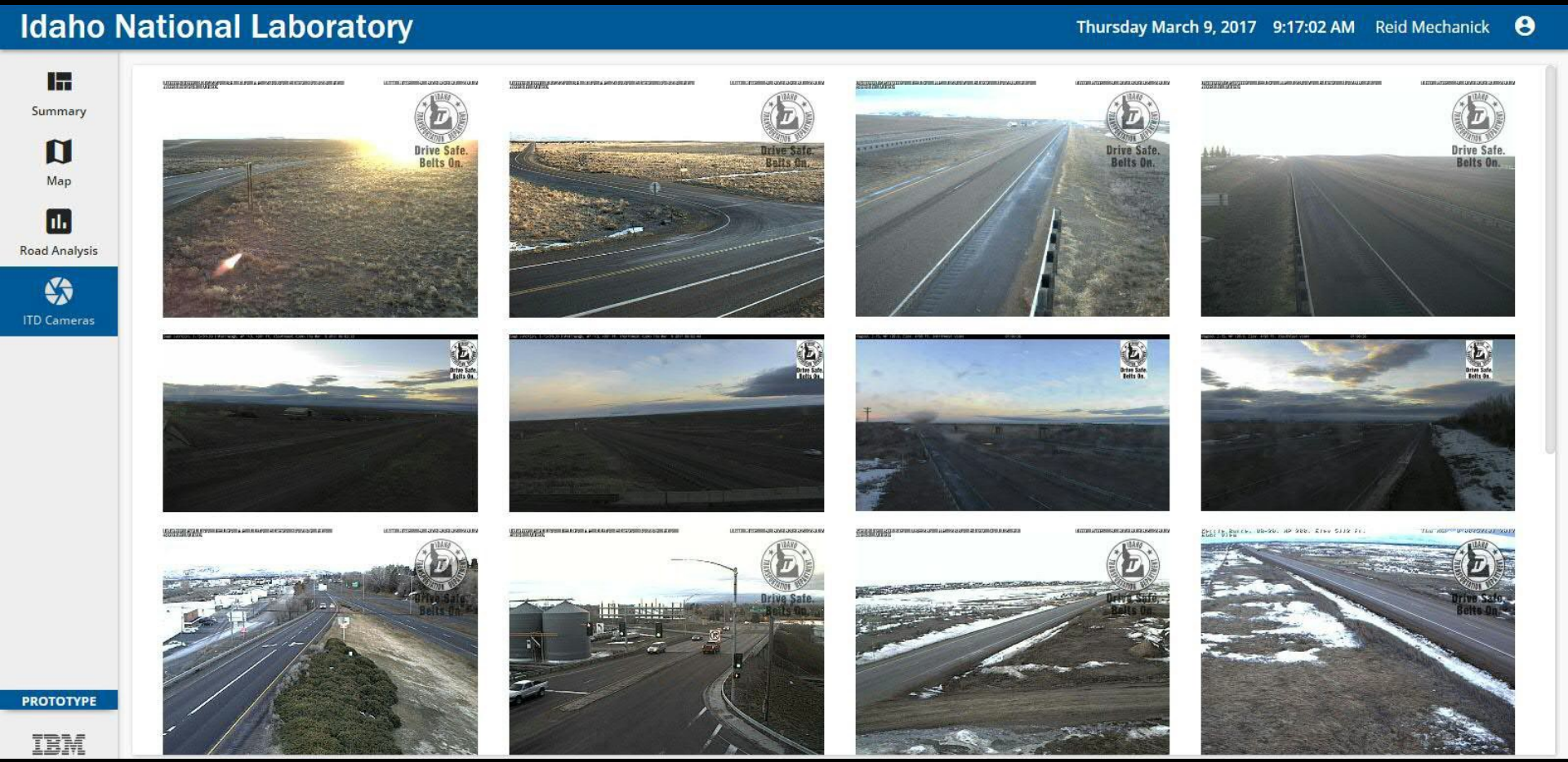
Map View


Idaho National Laboratory
Thursday March 9, 2017 9:13:46 AM Reid Mechanick
Summary
Map
Road Analysis
ITD Cameras
PROTOTYPE
IBM
Road Segments
Low
High
Weather
CURRENT
FORECAST
2017/3/9 07:05
Cold
Hot
Craters of the Moon National Monument
Craters of the Moon National Preserve
Hells Half Acre Wilderness Study Area
Moon Wilderness Area
Idaho Falls
Pocatello
Chubbuck
Blackfoot
Rexburg
Rigby
Ririe
Saint Anthony
Caribou-Targhee National Forest
NaN-NaN-NaN NaN:00
Map Data
Mile Marker
Traffic Index
Snow Drift Index
Black Ice Index
Road Segments
Traffic Index
Snow Drift Index
Black Ice Index
Weather
Temperature
Precip
Snow
Wind

Road Data and Analytics View



ITD Traffic Cameras

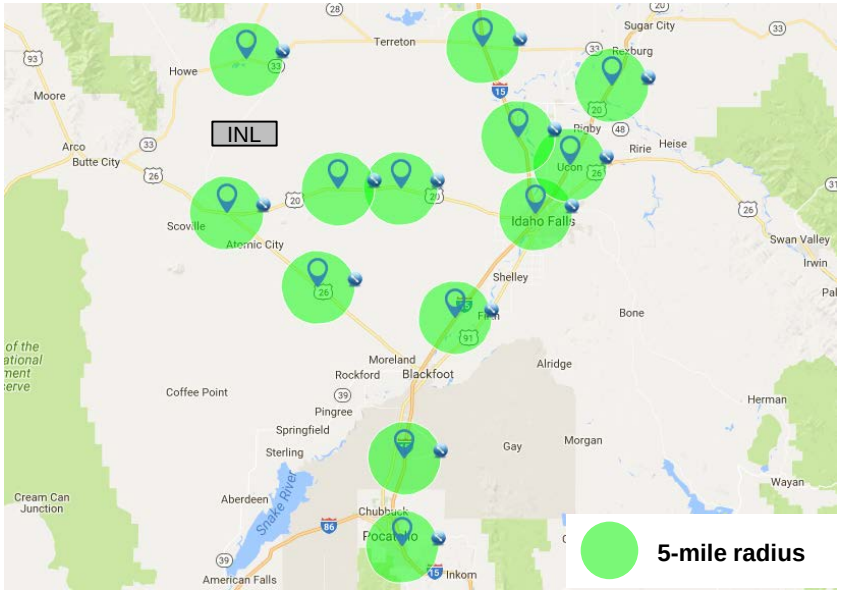


ITD Dashboard Camera Project

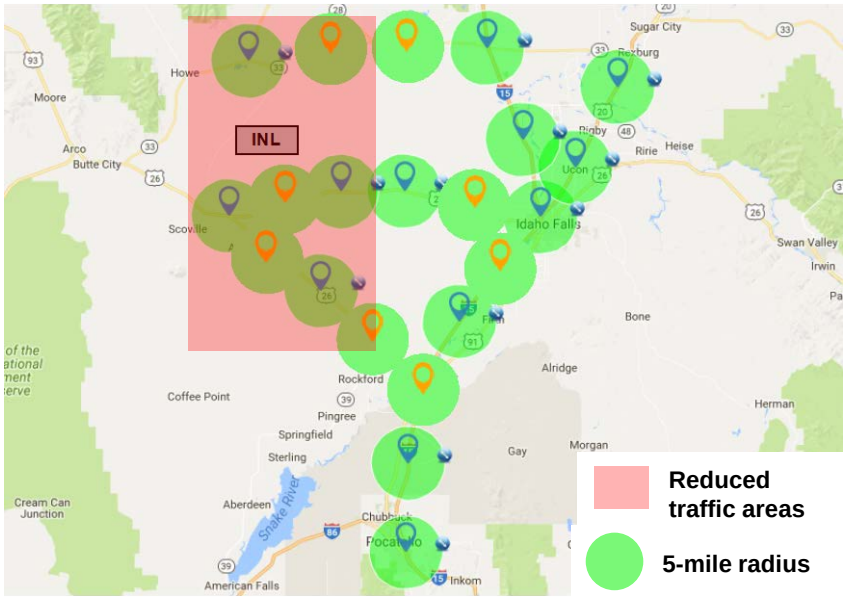
- INL and ITD are partnering on a dashboard camera pilot project
  - 2 ITD snowplows, 1 INL coach, 1 INL scout vehicle
  - Each vehicle has 1 forward facing camera, a DVR, a GPS receiver, and a cellular modem
  - Snapshot Images and location data is uploaded to Nova (service provider), then transferred via an API to ITD's 511 Traveler Information websites
  - Snapshots are filtered by elapsed time and vehicle movement
  - Images are posted for a maximum of 2 hours and overwritten with more recent images collected over the highway segments
  - Snapshots could be integrated into the video analytics feature of Watson

ITD Dashboard Camera Project

The current network of RWIS stations does not provide sufficient coverage along INL's bus routes



Coverage from the existing network of weather stations along INL bus routes.



Supplementing the current network with additional personal weather stations will provide more sufficient coverage

Additional weather stations will provide increased accuracy and higher granularity, allowing for improved hyper-local forecasting

Adding additional weather stations will provide:

- Increased accuracy in weather and conditions at key locations and Points of Interest (POIs) along bus routes
- Higher resolution weather data for training analytical models which will produce more reliable and robust forecast models
- Data collected can be integrated with ITD and visible to the public

Thank you, additional information contacts

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