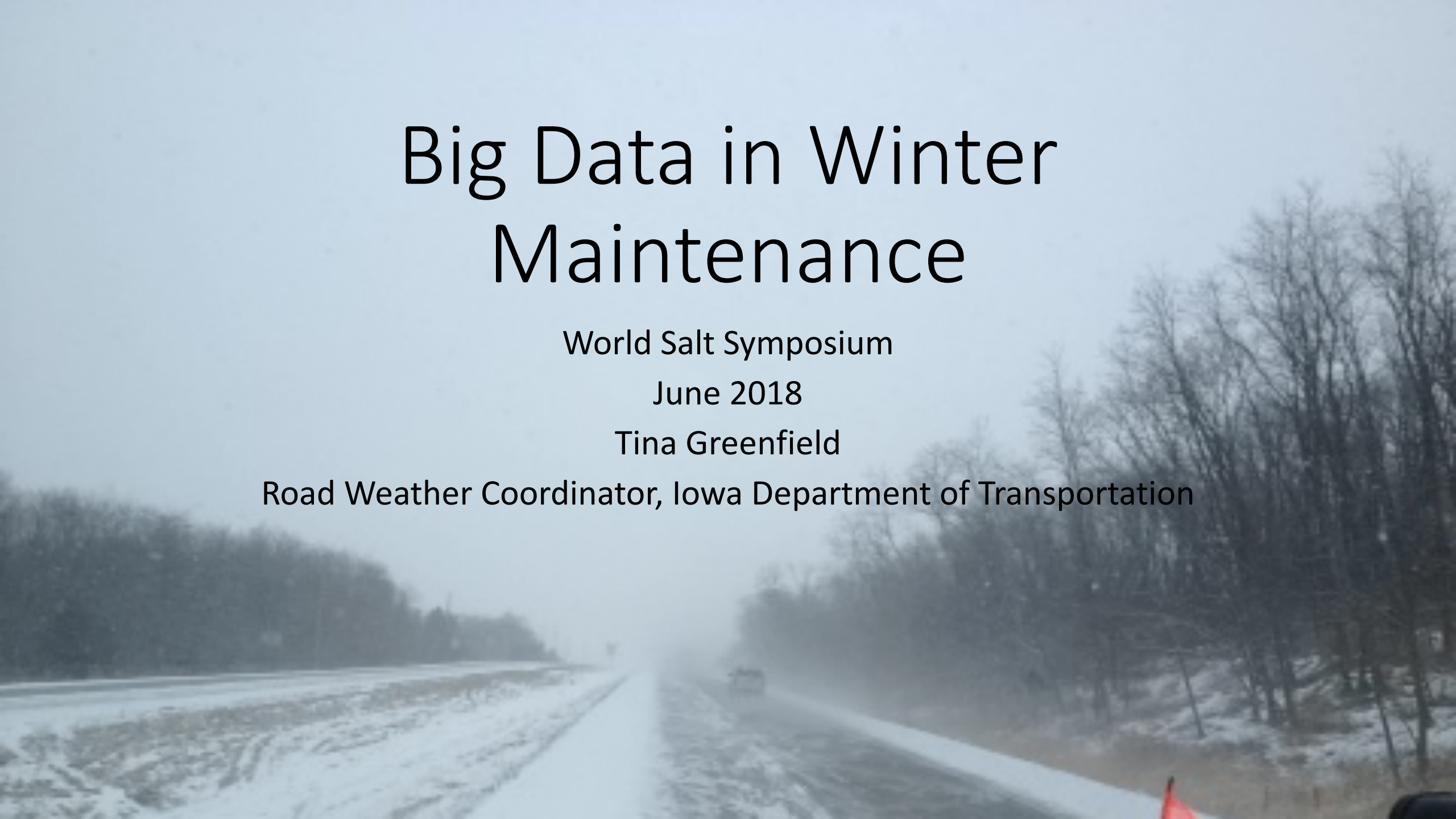
Big Data in Winter Maintenance

World Salt Symposium

June 2018

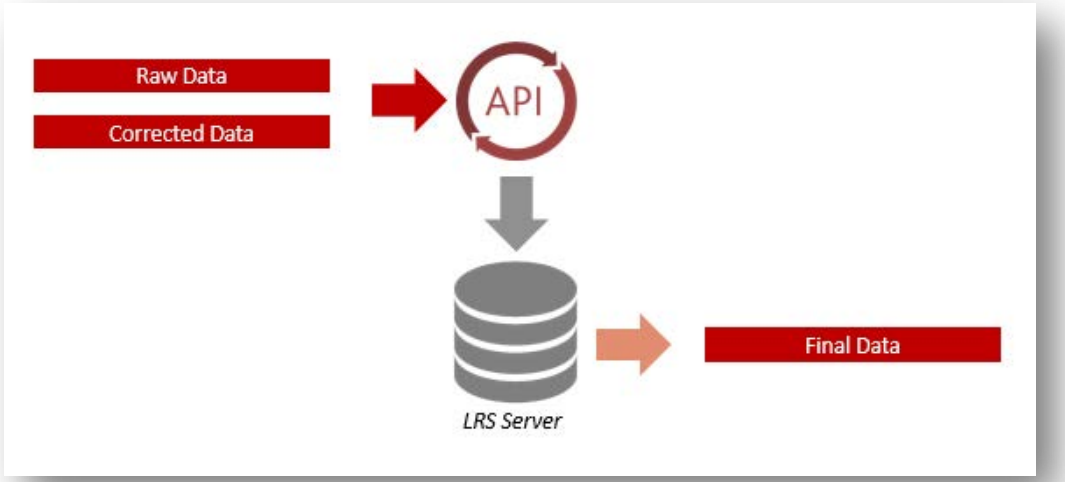
Tina Greenfield

Road Weather Coordinator, Iowa Department of Transportation



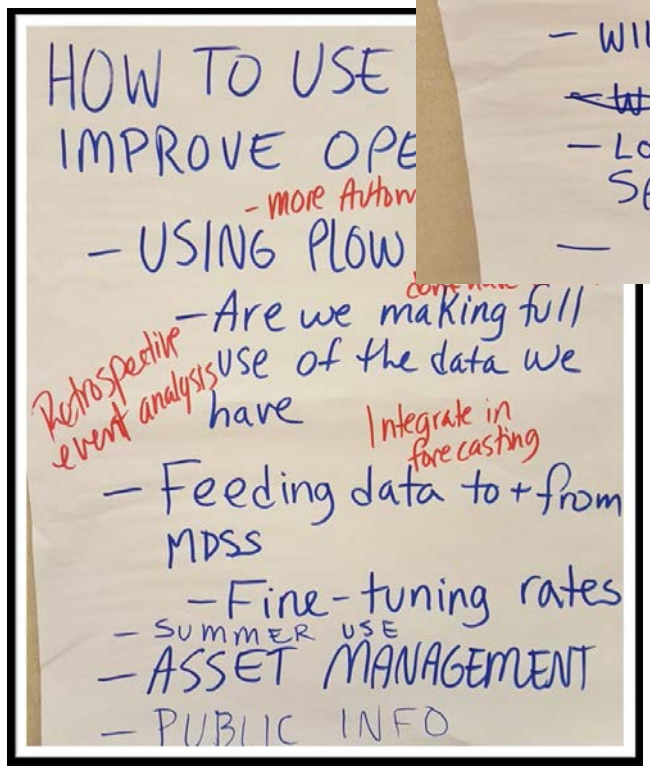
Big Data

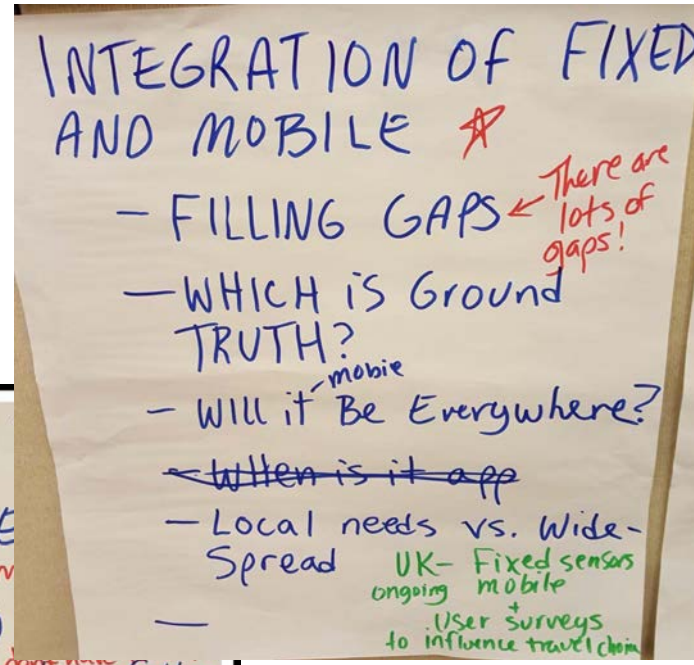
- Extremely large data sets that may be analyzed computationally to reveal patterns, trends, and associations
- Winter maintenance is a complex process with lots of variables, inputs, and varied outcomes



Worldwide Interest – and Bewilderment in Big Data

- Mobile data collection – imagery, sensors, controllers, and vehicle state data
- Crowd-sourced road condition information – using driver speeds or citizen reports to gauge road conditions or operations performance
- In-cab considerations: informed and connected vs. distracted and data-overloaded
- Sharing maintenance data with the public and researchers



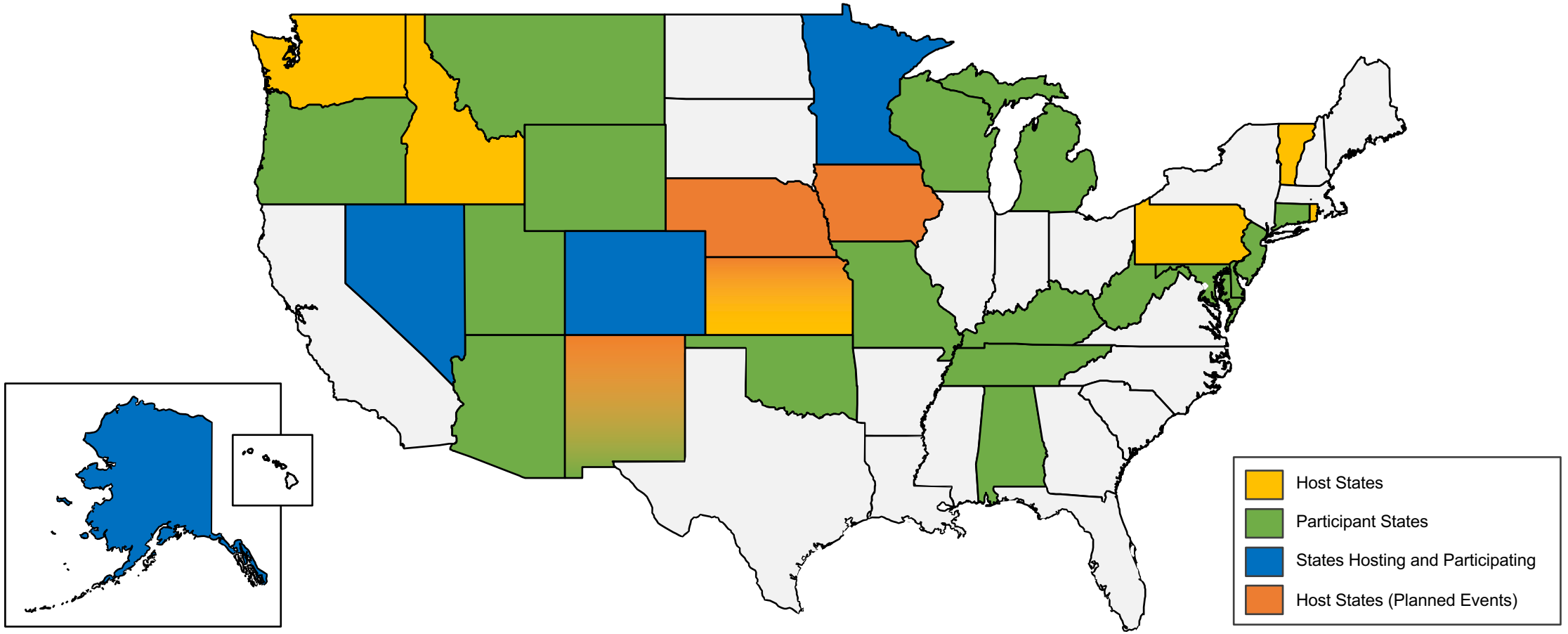


Federal Initiatives

- **Cost-Efficient Operation.** Employing sensors on existing fleets is a relatively low-cost method of gathering road weather observations that can support numerous maintenance, traffic, and performance management strategies.
- **Proactive Management.** Vehicle-based technologies provide agencies with the information needed to proactively manage roadway systems before the negative impacts of road weather occur.
- **Improved Safety, Mobility, and Economy.** Connected vehicles technologies, advanced weather prediction and targeted decision support enable operators to more effectively maintain a high level of service on roads, which decreases crashes and keeps traffic moving smoothly.

State Involvement:

WSR Workshops, Peer Exchanges, and Demo Site Visits



Recent Federal “Weather Savvy Roads” Events

WORKSHOPS

- Pathfinder in MN (Sept 2017)
- Pathfinder in ID (Oct 2017)
- Pathfinder in AK (Jan 2018)
- Pathfinder in KS (Part I) (Jan 2018)
- WSR in VT (May 2018)
- Pathfinder in WA (Mar 2018)
- Pathfinder in PA – (Apr 2018)
- *Pathfinder in NE (Jun 2018)*
- *Pathfinder in KS (Part II) (Oct 2018)*
- *IMO in NM (TBD)*

DEMO SITES AND PEER EXCHANGES

- IMO and Pikalert in CO (Nov 2017)
- IMO in NV (Dec 2017)
- IMO in MN (Mar 2018)
- IMO in Rhode Island (Apr 2018)
- *IMO in Iowa (Aug 2018)*

SUMMITS

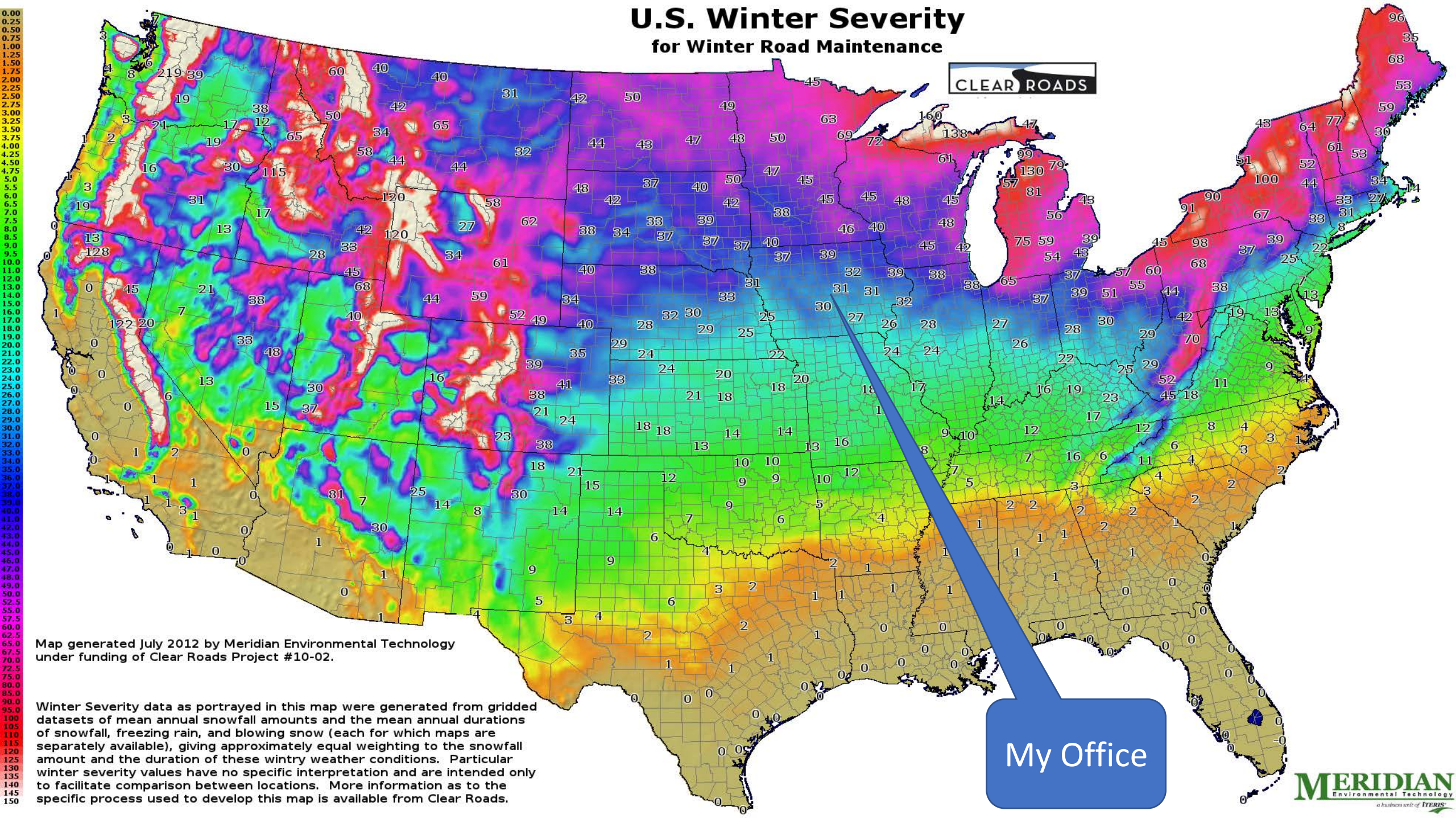
- *Pathfinder Summit (Salt Lake City) – June 2018*

A Bit About Iowa DOT

- 101 garages
- 900 snow plows
- 1,000 permanent drivers
- 462 seasonal part-time drivers
- 9,480 centerline miles
- 24,200 total lane miles
- 3 different winter service level classifications (officially), 6 in winter operations
- $40M annual winter maintenance budget

U.S. Winter Severity

for Winter Road Maintenance



Map generated July 2012 by Meridian Environmental Technology under funding of Clear Roads Project #10-02.

Winter Severity data as portrayed in this map were generated from gridded datasets of mean annual snowfall amounts and the mean annual durations of snowfall, freezing rain, and blowing snow (each for which maps are separately available), giving approximately equal weighting to the snowfall amount and the duration of these wintry weather conditions. Particular winter severity values have no specific interpretation and are intended only to facilitate comparison between locations. More information as to the specific process used to develop this map is available from Clear Roads.

MERIDIAN Environmental Technology
a business unit of ITERIS

Winter Materials

- Salt is our primary anti-icer, pre-wet, and deicer
- We use lots of brine. About 20M gallons annually
- ~42,000 gallons Calcium Chloride as brine mix-in when needed
- ~20,000 tons sand

Our Steps into “Big Data”

- Purpose was to understand & visualize
  - Fleet Movement
  - Material Usage
- Provide
  - Tools for managers to direct fleet
  - Less paperwork for drivers
  - Public a better winter driving experience
- Turn plow data into information we could use to become more efficient
- Access to raw data for custom reporting

Timeline

- 2010 RFP
- Trial deployment 2011-2012
- Full deployment 2012-2013
- Debut of the ‘Plow Cam’ 2013-2014

iPhone Plow Cams

What

- iPhones with suction-cup windshield mounts
- Custom app snaps a photo of road every 10 minutes if truck is moving

Why

- A picture is very informative
- Road condition monitoring for managers and public

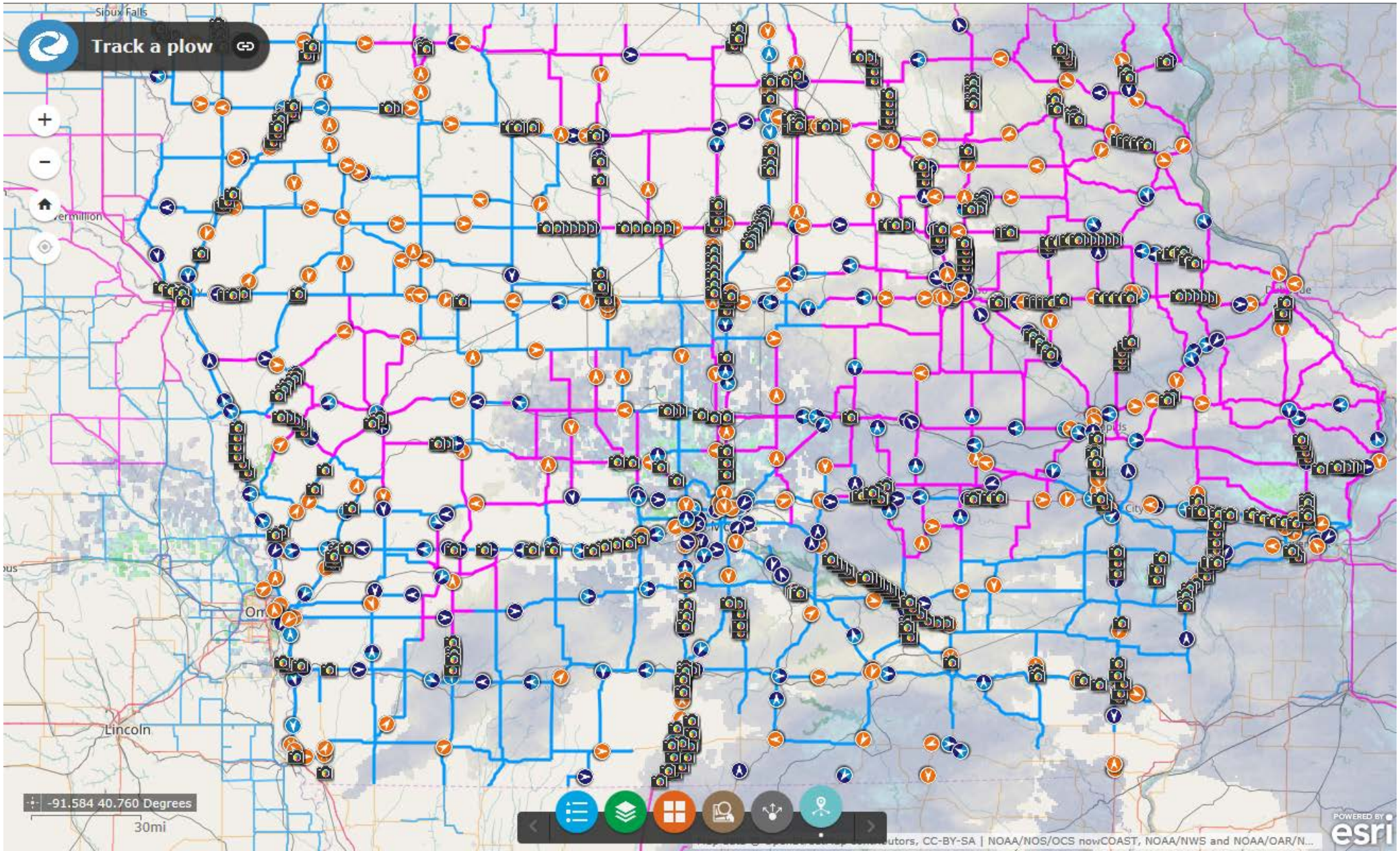
How

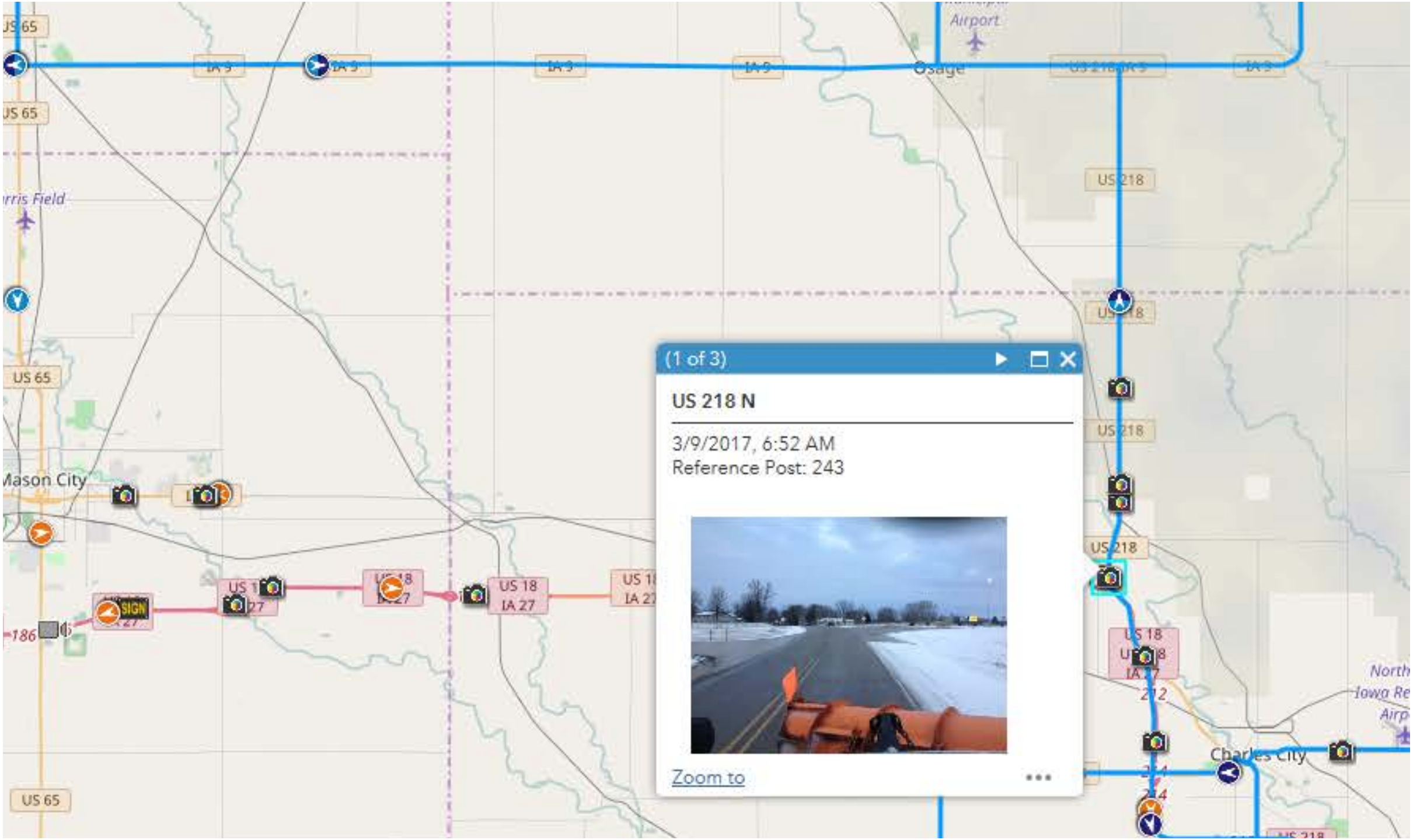
- Phone sends picture and GPS coordinates to server
- Photo posted on website map with location


MOTOROLA


Sioux Falls
Council Bluffs
STAY BACK
50 FEET

http://trackaplow.iowadot.gov




(1 of 3)
US 218 N
3/9/2017, 6:52 AM
Reference Post: 243
Zoom to
Mason City
Osage
Charles City
US 65
US 218
US 18
IA 27
SIGN

Positive Public Response

- Communications staff used images and plow counts extensively
- Fewer calls from public and law enforcement “wondering if we were out”

What We Learned

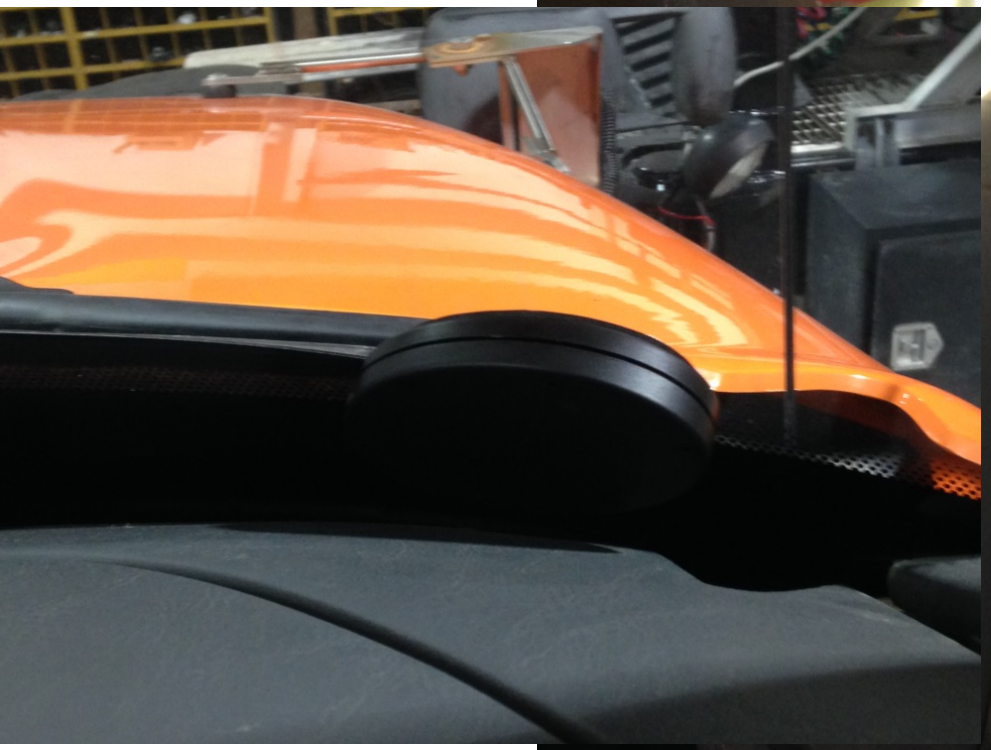
- It is much easier to collect data than it is to provide good information
  - Had to learn the hard way what data we *really* need – and for what purpose
  - Must try to fill gaps or summaries won't be accurate
- Plow photos are much more useful than we thought at first
- Careful and proactive communication with public seems to really help
  - How much to communicate is always under debate!
- It is an iterative process
- We needed more engine data
- Need easier/deeper automated reporting capabilities

Timeline

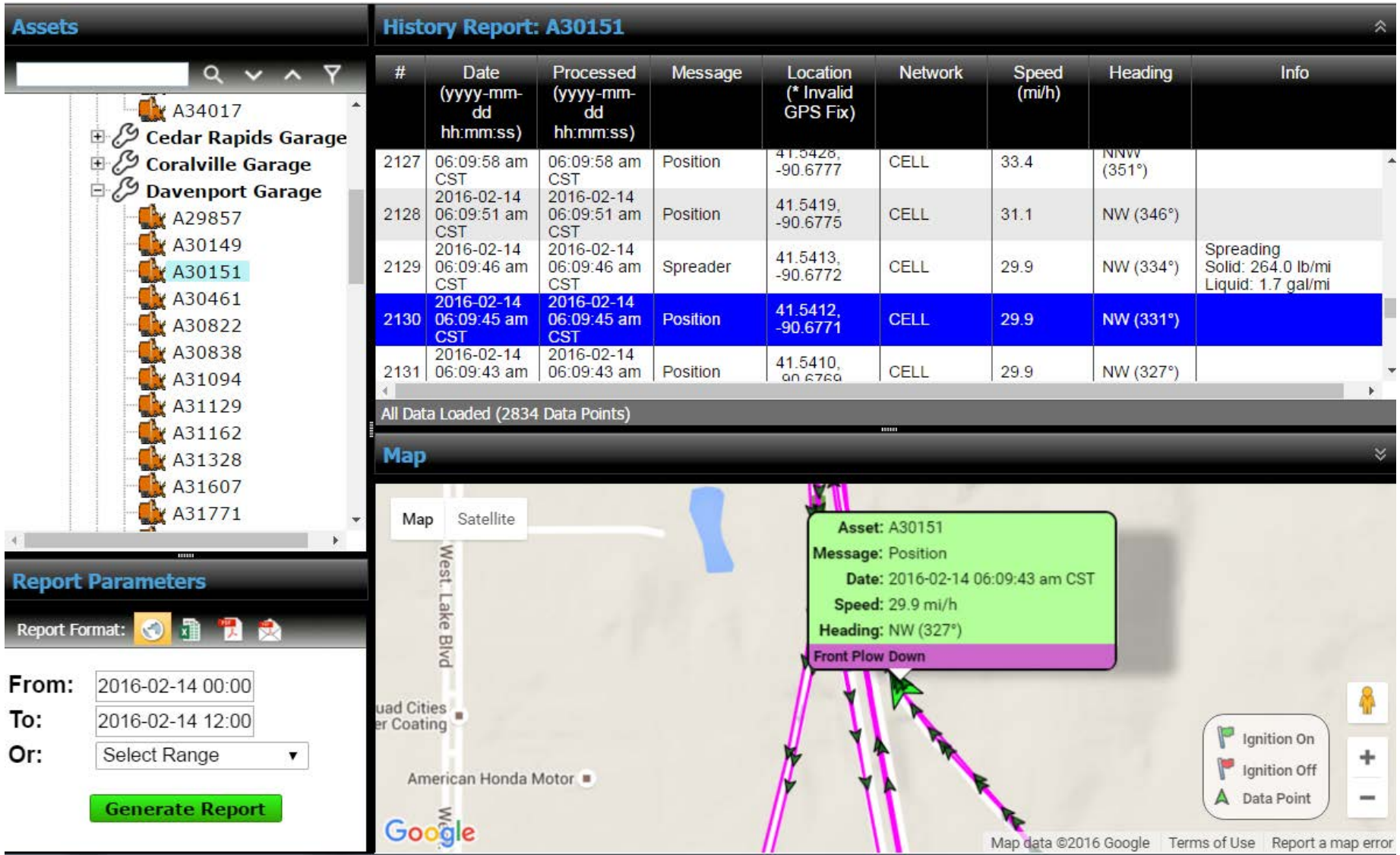
- 2010 RFP
- Trial deployment 2011-2012
- Full deployment 2012-2013
- Debut of the ‘Plow Cam’ 2013-2014
- Second generation AVL 2015-2016
- Second generation Plow Cam 2017

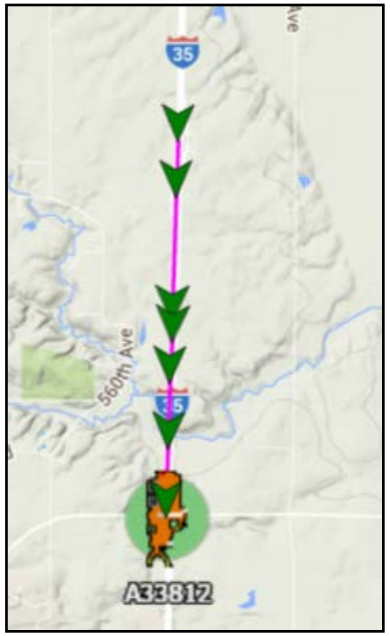
Current System

- Every 10 seconds
  - Cumulative material
  - Spreader status outputs
  - Truck position, heading, speed, and engine alerts
- In-truck WiFi
- Remote connection to truck’s engine diagnostics
- Hosted website
  - Reports
  - Live maps
  - Asset information
- New Axis IP camera instead of iPhones

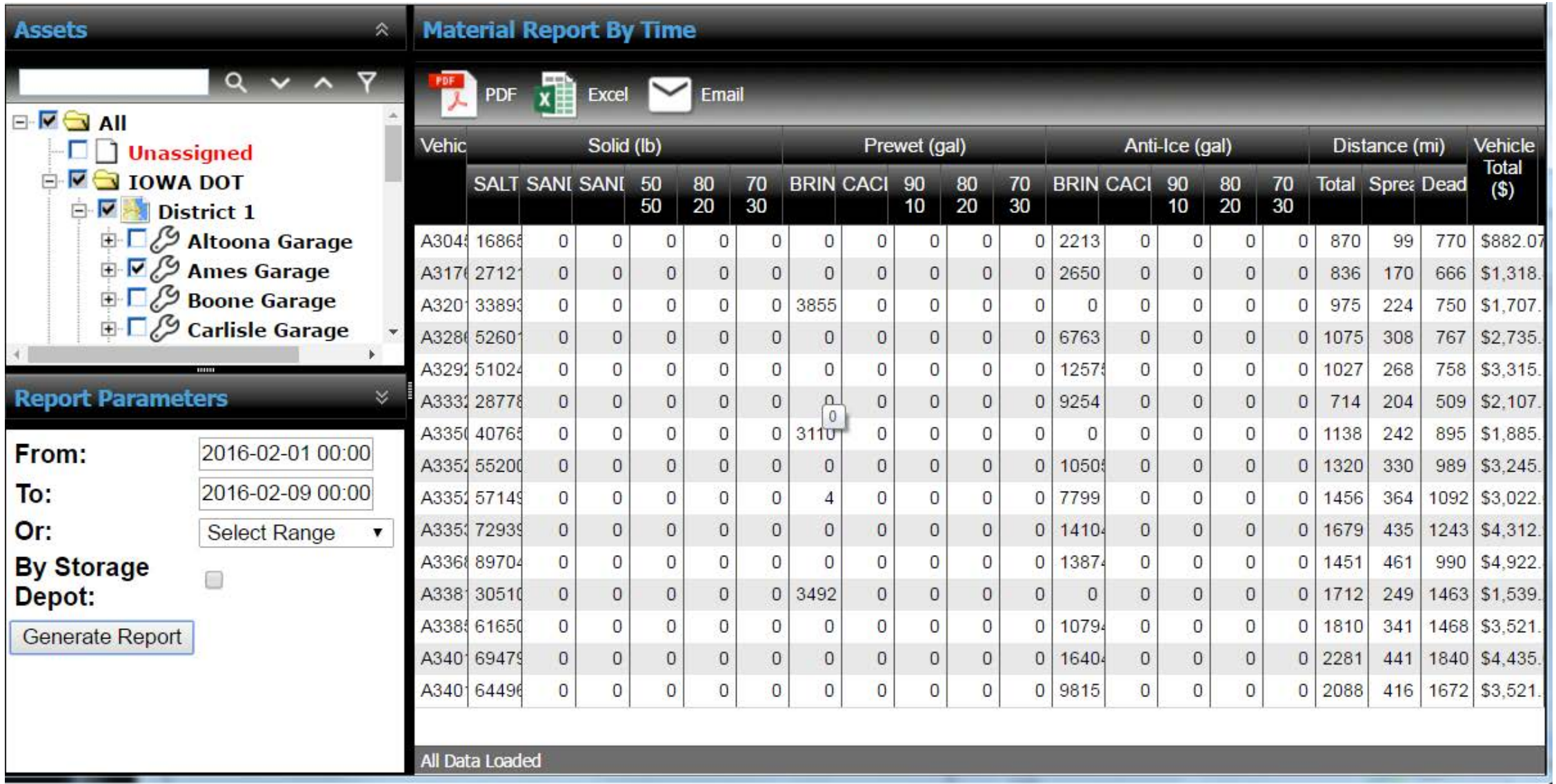


Current and Historical Paths

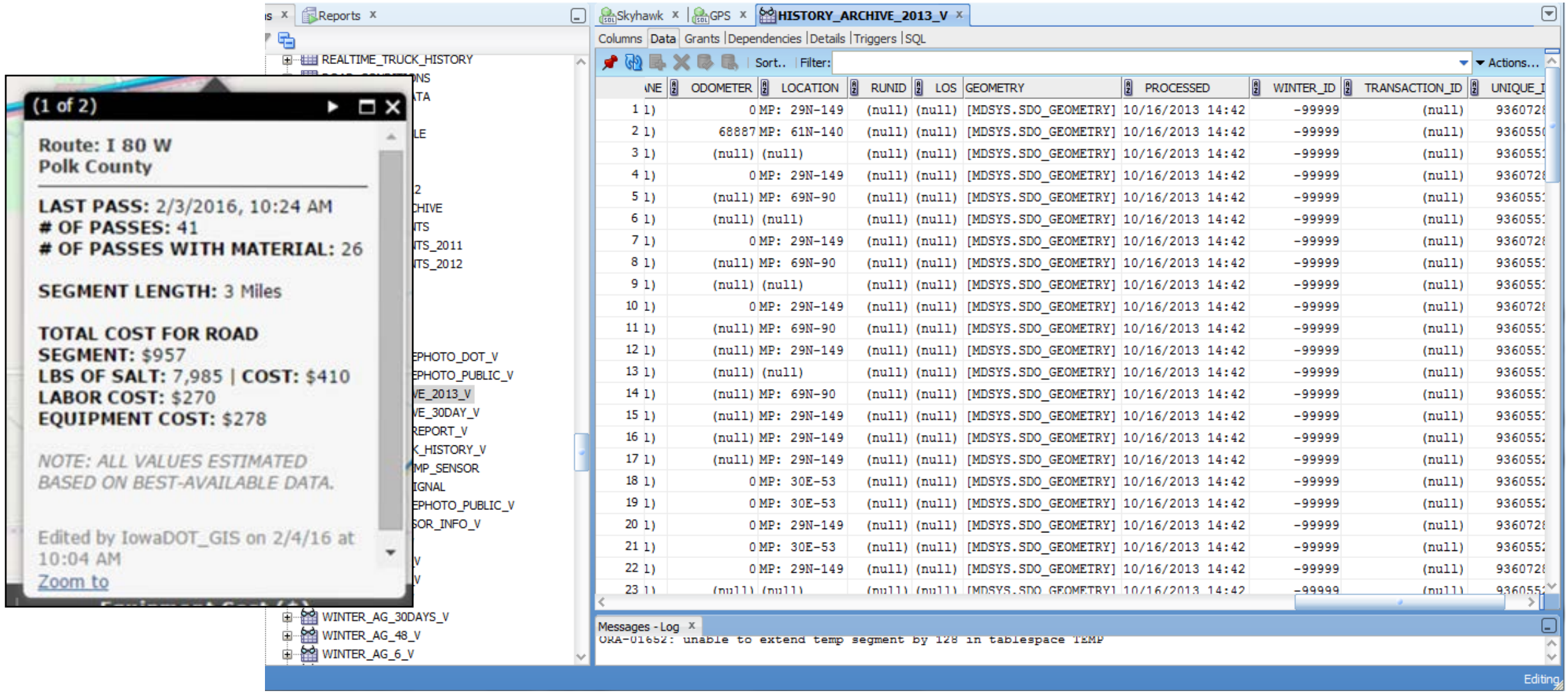




Reports and Summaries



What Do We Do With All This Data??

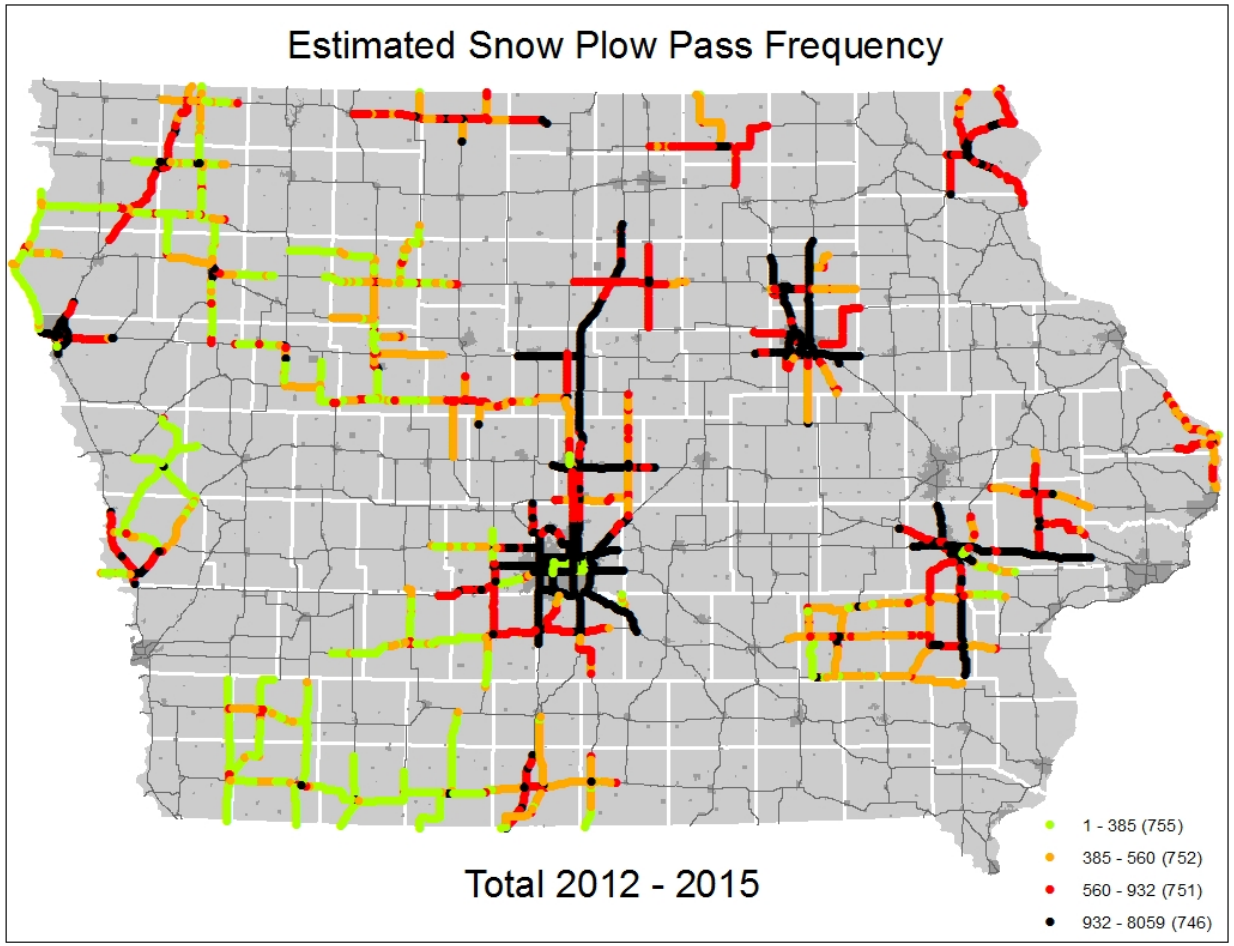


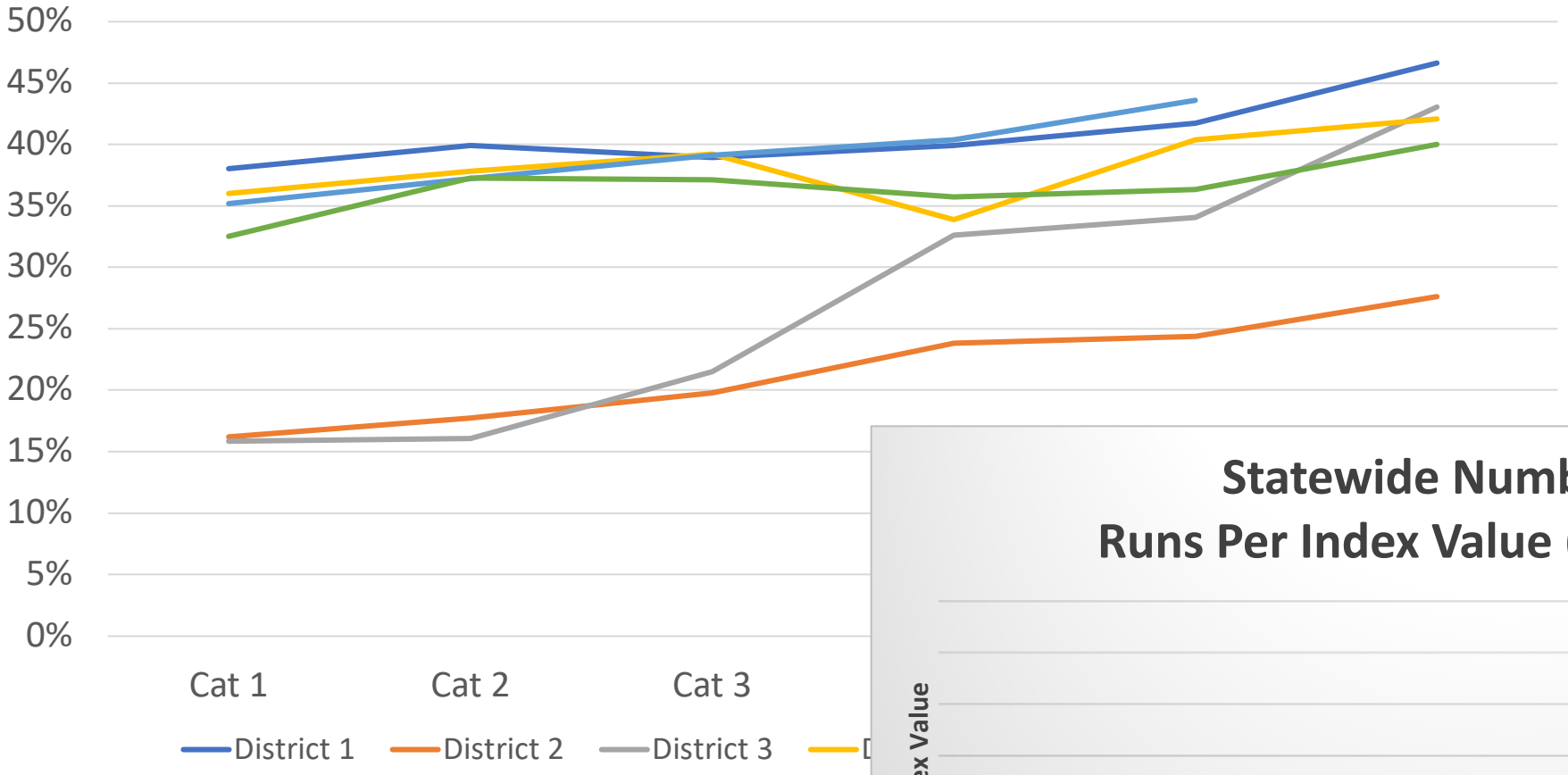
Data for Management Decisions

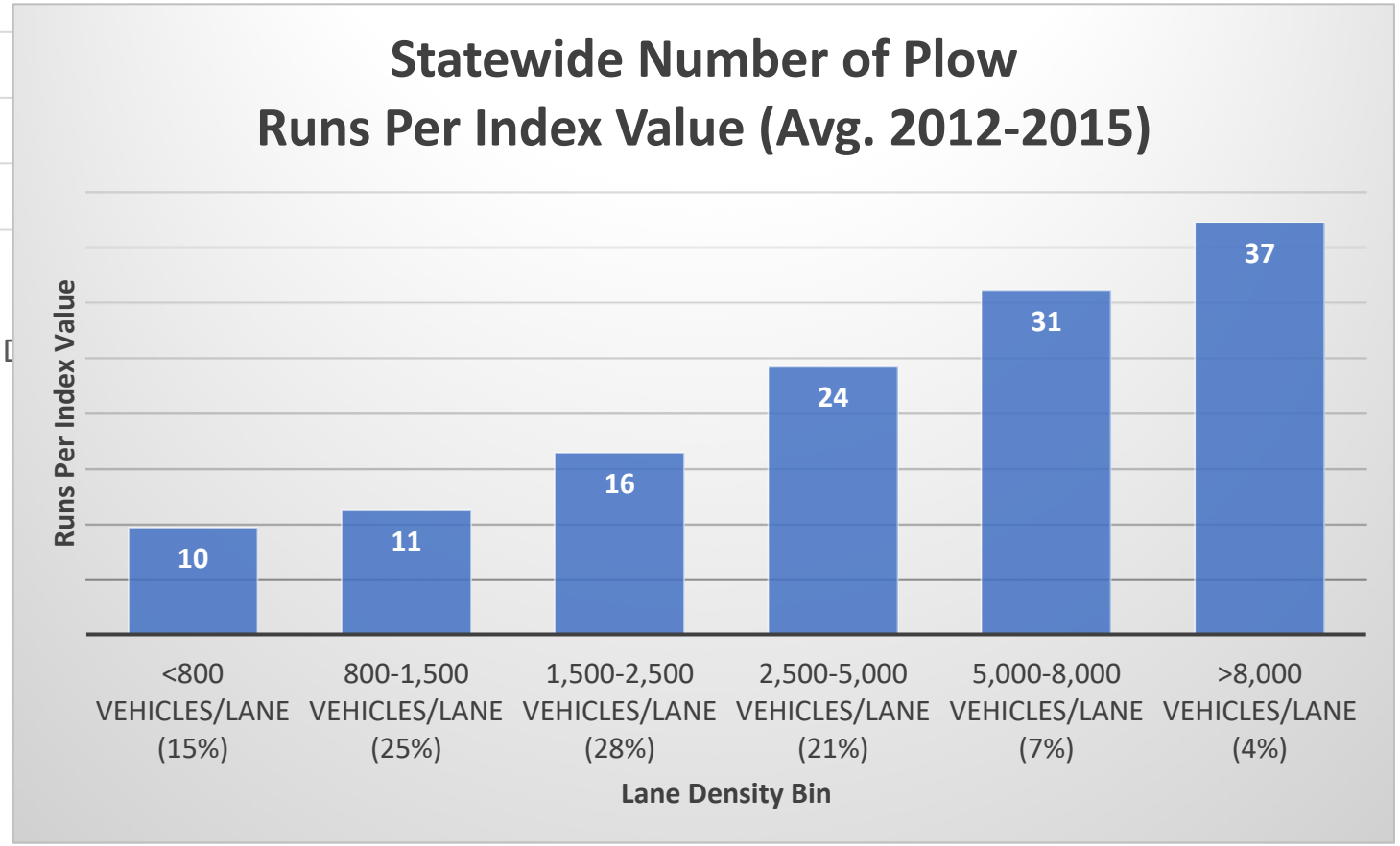
- In recent years, the department has been faced with reduced staff budgets
- How do we reprioritize when we can’t re-hire plowing positions after a vacancy?
  - Could we make it up by reduced LOS on low volume roads?
  - Less nighttime plowing?
  - What impact does a loss of X drivers make on our plow pass frequency?

Modeling Operations and Alternatives -- Understanding Current Operations

- Study 36 garages using GPS/AVL records (InTrans)
- Aggregate records that look like spreading/plowing and count up passes by milepost
- Factor out weather severity
- Bin the records by AADT class, costcenters, districts




50%
45%
40%
35%
30%
25%
20%
15%
10%
5%
0%
Cat 1
Cat 2
Cat 3
District 1
District 2
District 3

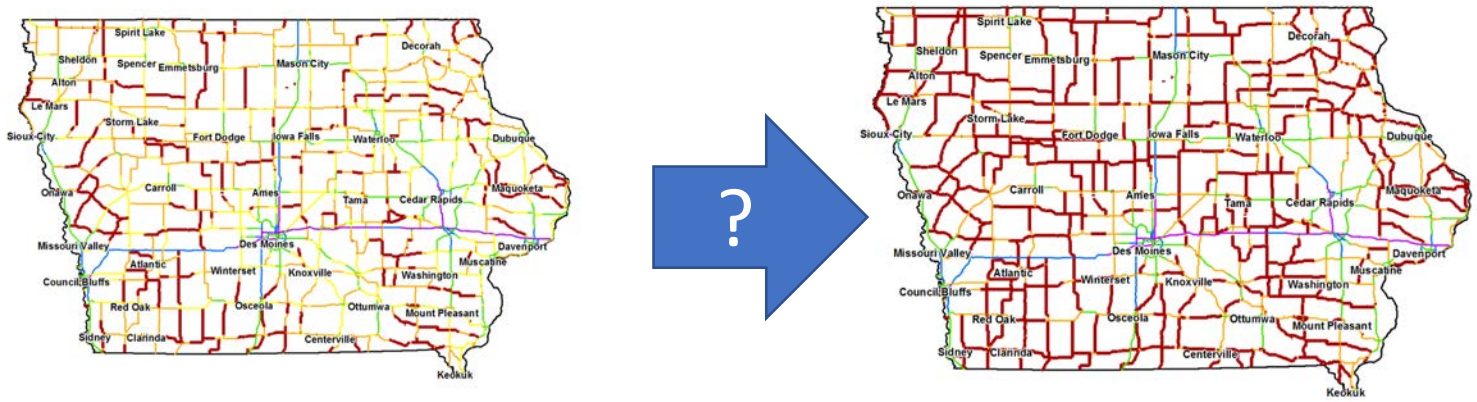

Statewide Number of Plow Runs Per Index Value (Avg. 2012-2015)
Runs Per Index Value
10
11
16
24
31
37
<800 VEHICLES/LANE (15%)
800-1,500 VEHICLES/LANE (25%)
1,500-2,500 VEHICLES/LANE (28%)
2,500-5,000 VEHICLES/LANE (21%)
5,000-8,000 VEHICLES/LANE (7%)
>8,000 VEHICLES/LANE (4%)
Lane Density Bin

Outcome

- Based on this information, we could calculate average number of plow passes per day on a 24 hour storm
- Form baseline for modeling potential changes to plow pass frequency
  - Low volume roads were already much less plowed than high volume roads
  - Trimming service to low volume roads had a limit to the savings that could be achieved
  - Low volume roads were already also less-serviced at night
  - Depending on budget scenarios, cuts would eventually have to impact higher volumes

Outcome

- Once baselines were set, we can now estimate what impact various staff losses would have
- Run various scenarios to illustrate potential ways to compensate for the same loss
- Communicate the impacts to decision-makers more effectively



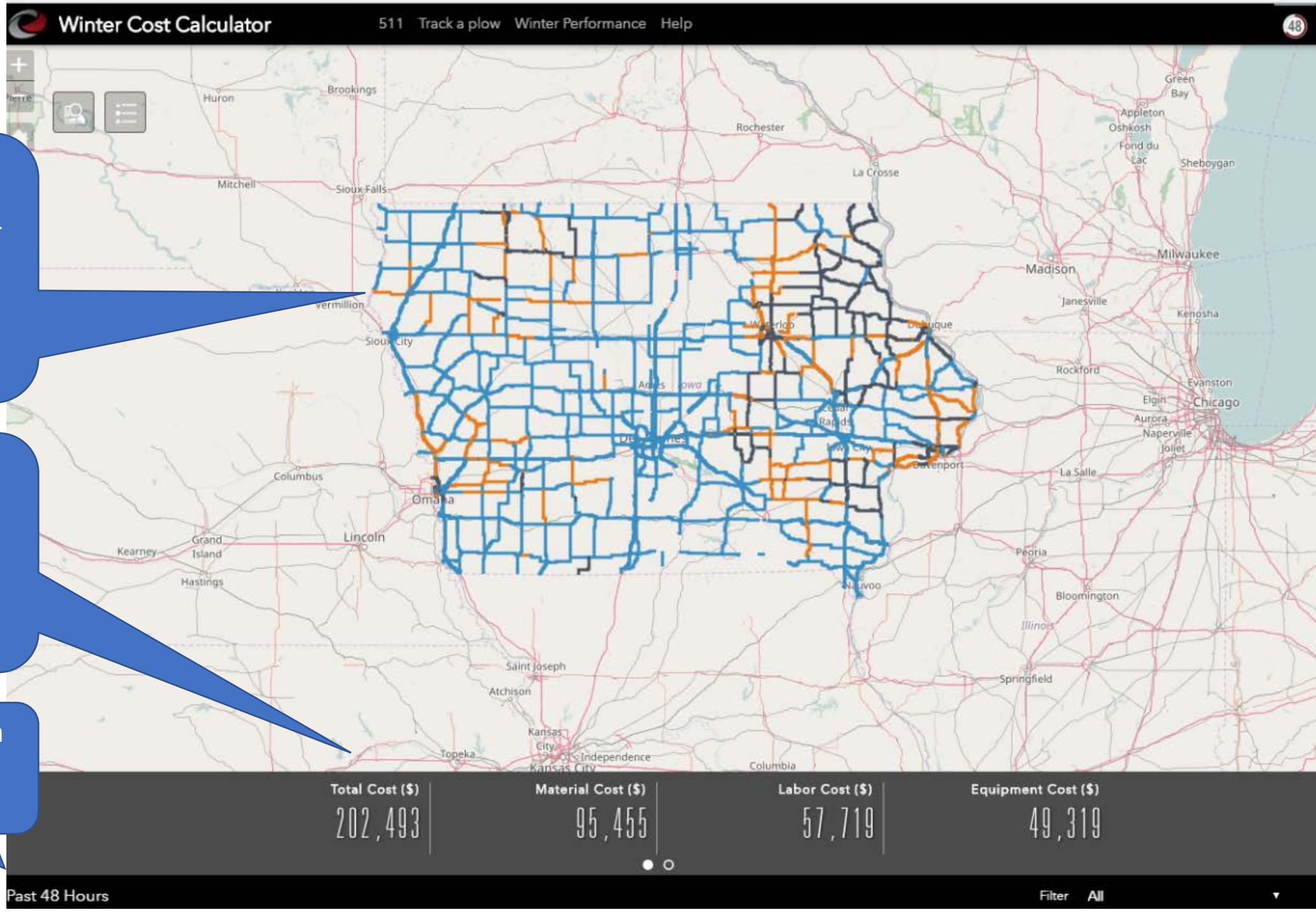
Winter Cost Calculator

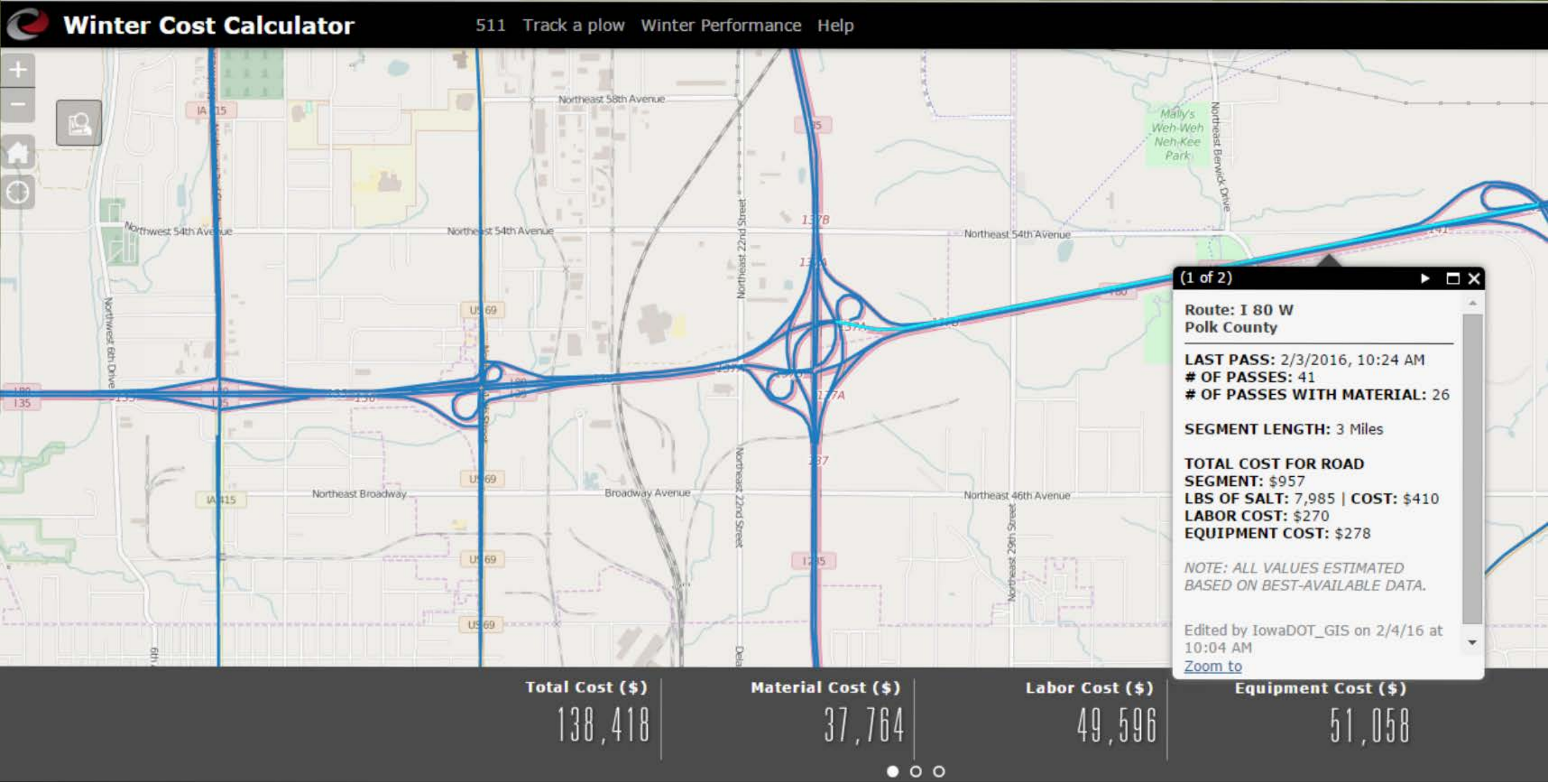
- FME reads oracle spatial segment data
- Applies average commodity costs to labor, salt, brine, and equipment hours
- FME pushes data to a feature service in ArcGIS Online
- Use a stock ArcGIS Online template to pull data and display on a map
- http://wintercostcalculator.iowadot.us

Color themes for low/moderate/ high use

Costs/totals for the area of map within view

Public app uses a rolling 48-hour total





http://wintercostcalculator.iowadot.us

Salt/labor management dashboard

What

- Produces ‘expected’ salt/labor use for each area for each day
- Compares ‘expected’ vs. ‘use’

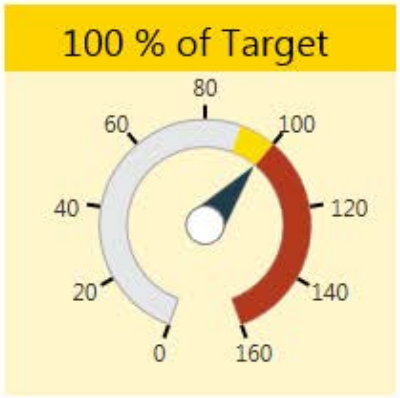
Why

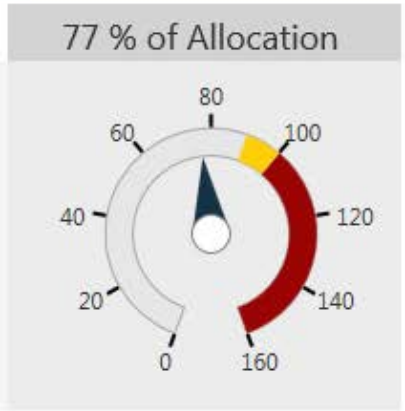
- Shows how well we adhere to our use guidelines for each unique storm and location

How

- Uses detailed observed weather data
- Uses each garages’ responsibility info. – lane miles and service level
- Computes expected use according to guidelines

- In use for 6 years
- Web-based
- Updates daily





Freezing Rain Hours: 4,395

Heavy Snow Hours: 2,921

Medium Snow Hours: 8,378

Light Snow Hours: 4,218

Blowing Snow Hours: 6,864

Frost, Refreeze, Sleet Hours: 5,785

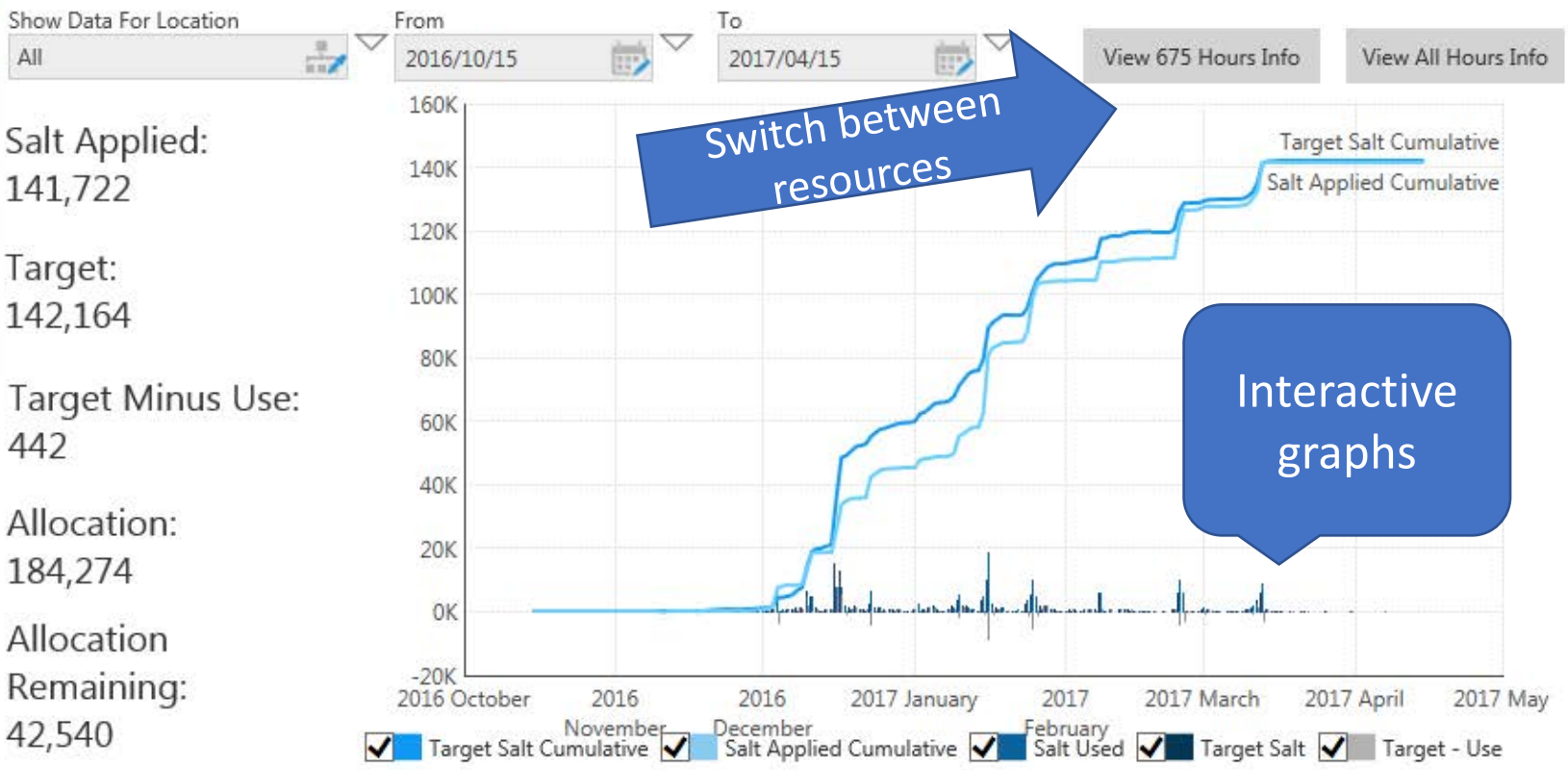
Salt Applied: 141,722

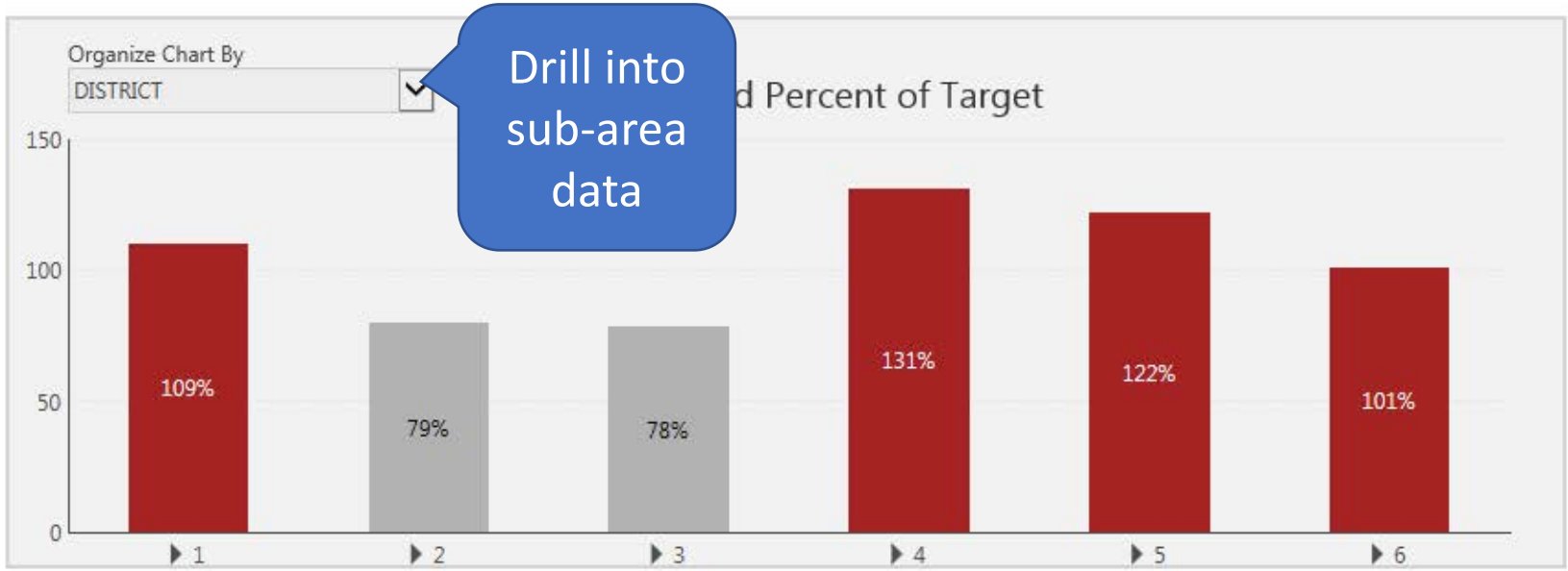
Target: 142,164

Target Minus Use: 442

Allocation: 184,274

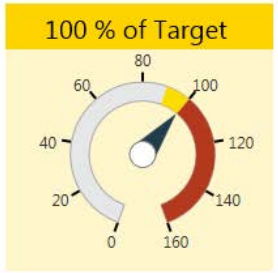
Allocation Remaining: 42,540

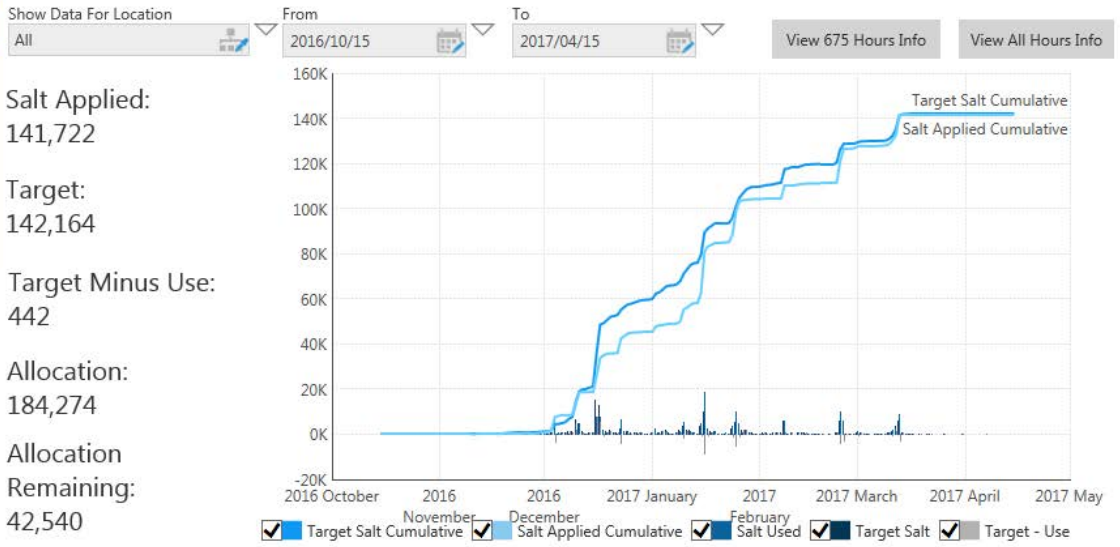




What Does This Mean For people?

- Targets provide a benchmark
- Visual way to compare
  - Across time or location
  - Outliers become obvious
    - Simple reporting errors
    - Unusual use
- New data daily
  - Catch potential problems early





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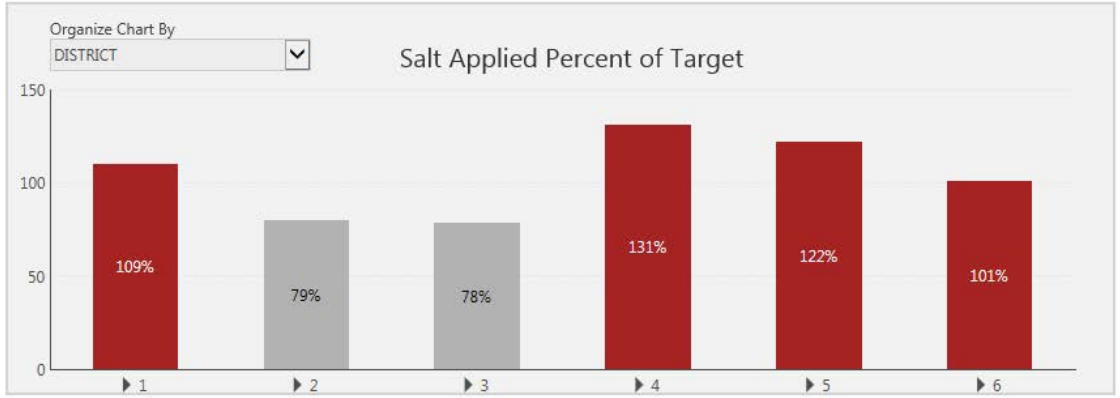
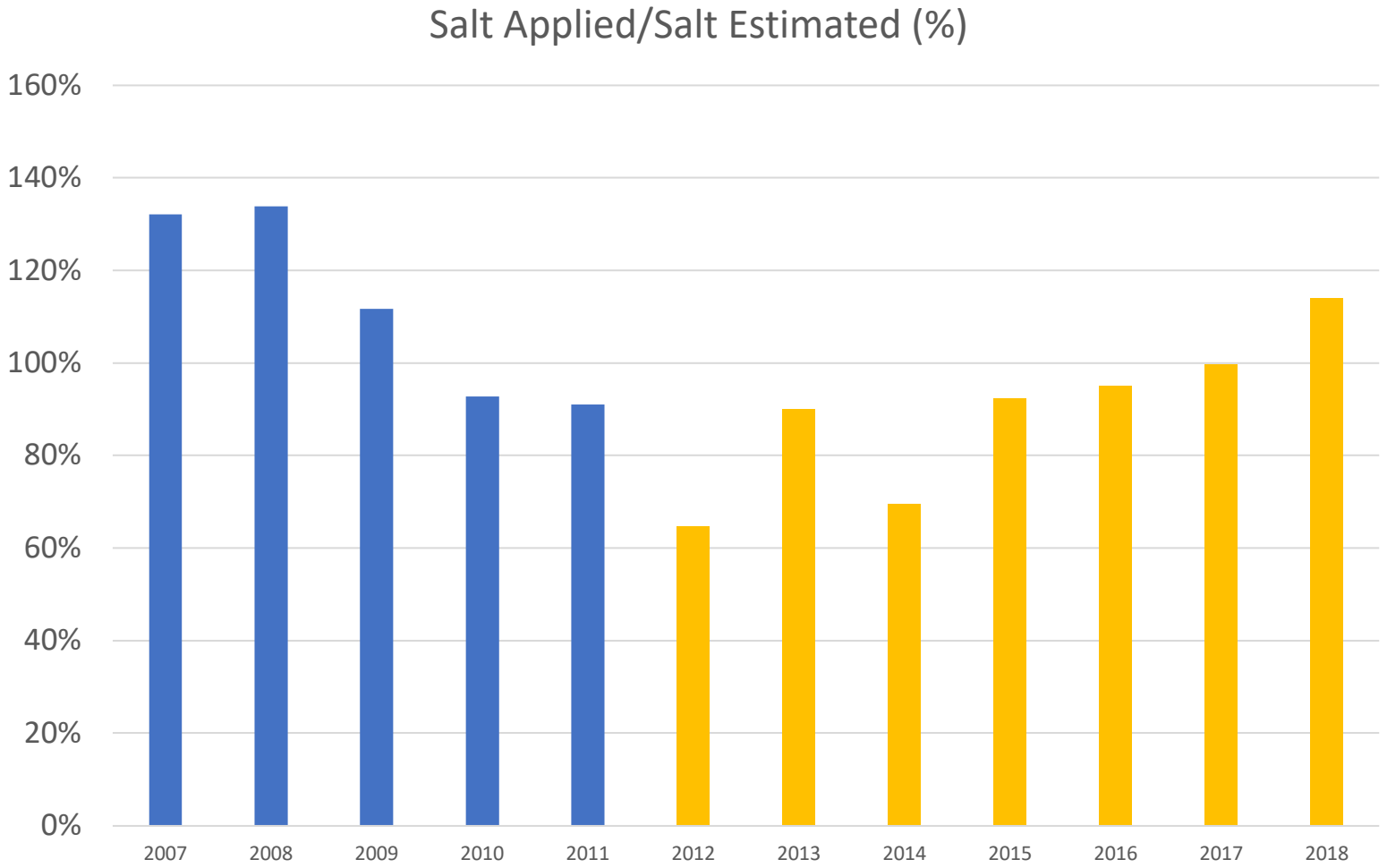


How We Have Changed



2007-2011
(pre dashboard) value of tons over estimated:

$1.6 M per year

2012-2018
(after dashboard) value of tons under estimated:

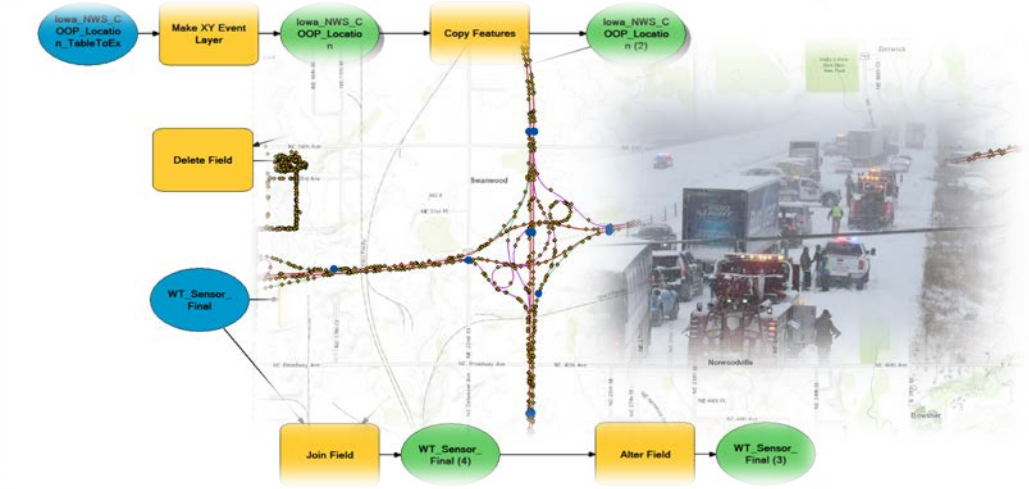
$1.3M per year

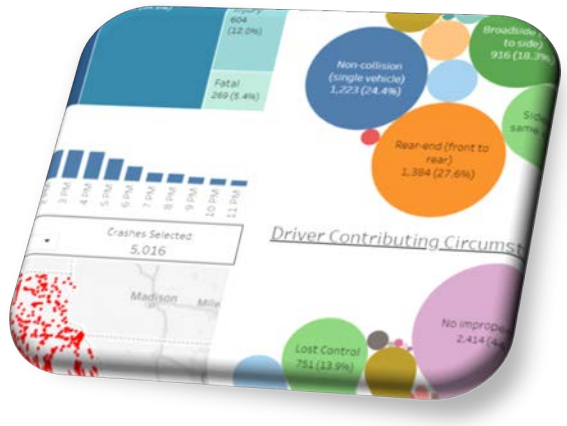
Work Underway

- Automated winter road condition reporting
  - Can road conditions be deduced via traffic speeds, weather observations, and AVL data?
  - Provide more detailed or faster updates on public road condition expectations
  - Under contract with SAS
  - Prototype this next winter?

Visualizing Maintenance Impacts

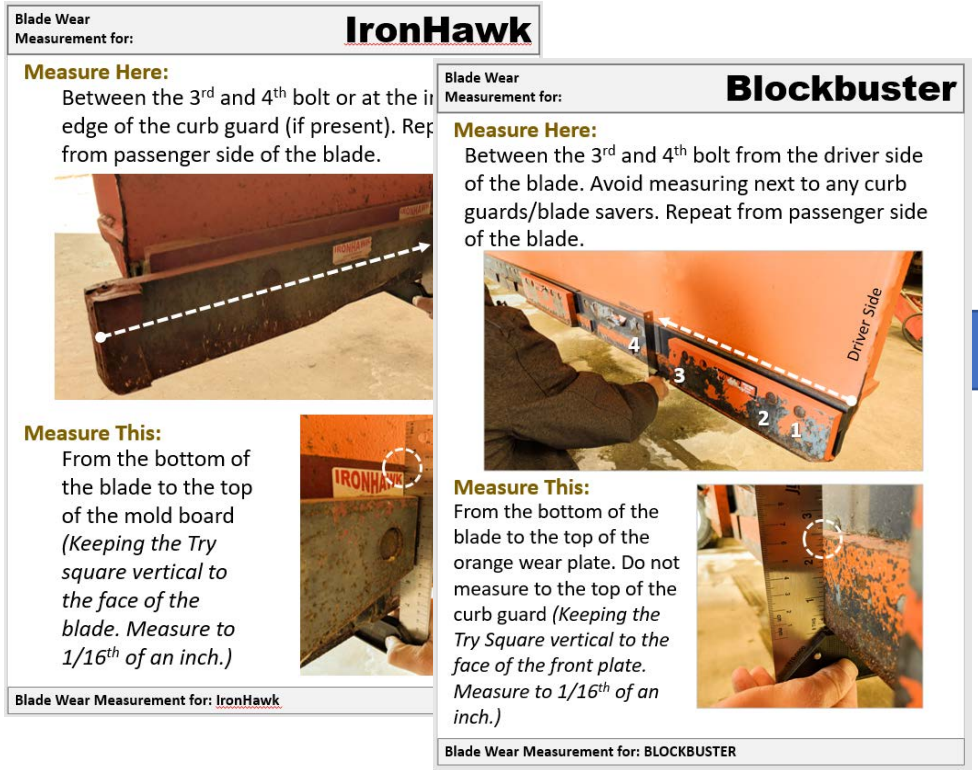
- Provide a better understanding of the impact of winter maintenance on mobility and safety in user-defined time periods and locations

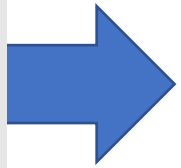




Plow Blade Wear Analysis

- Conduct an analysis to understand plow blade performance based on experienced wear



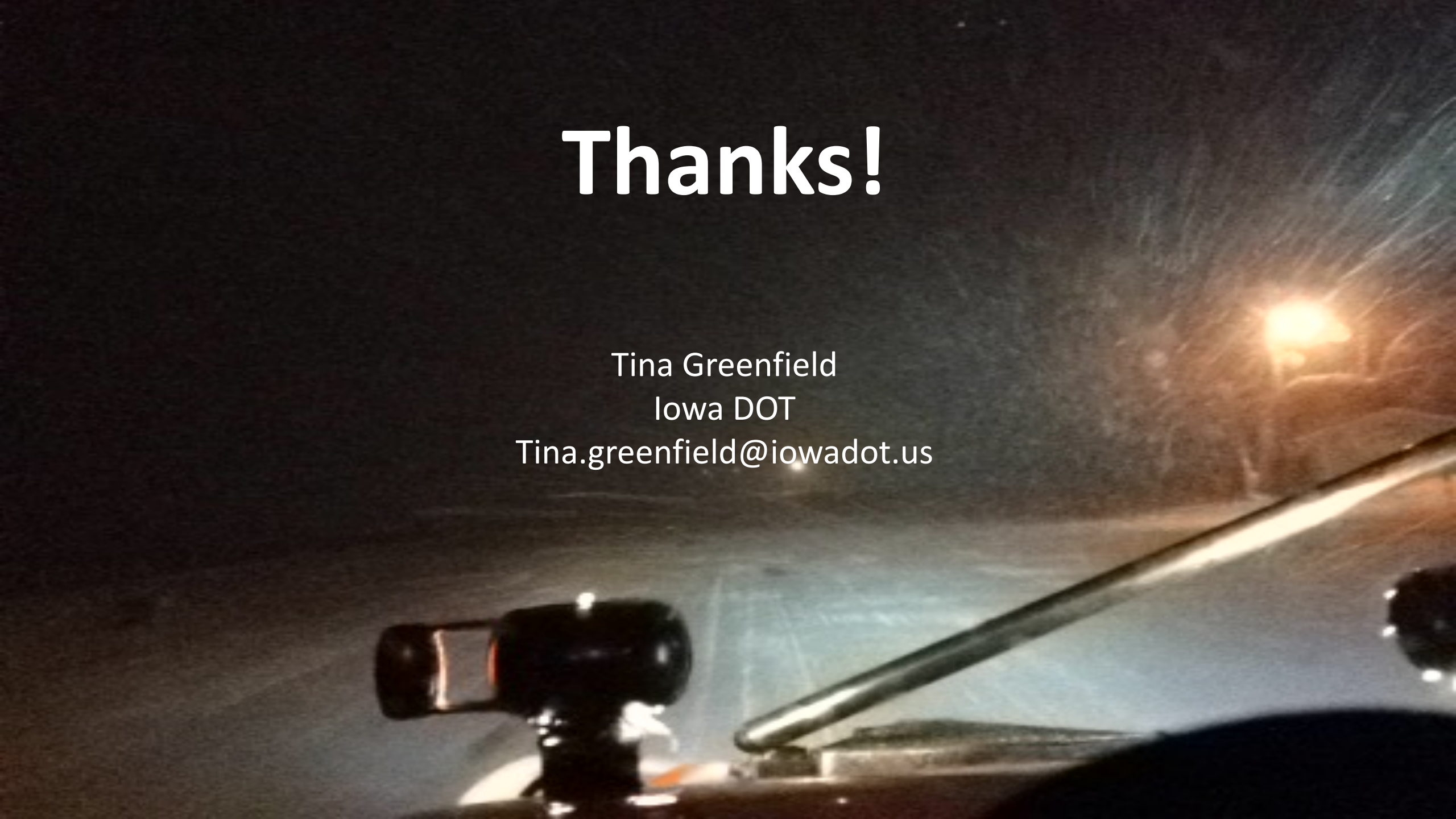


Status as of:				3/5/2018	
Truck	District	Garage	Status	Num. Measurements	Comments
A32084	1	Altoona		6	
A33993	1	Altoona		6	Replaced
A34018	1	Ames		4	
A33524	1	Ames		6	
A33812	1	Ames		2	
A33683	1	Ames	No measurements to date	0	
A33855	1	Boone		6	
A33976	1	DSM North		13	Replaced
A34379	1	Grinnell		8	
A33313	1	Jefferson	No measurements to date	0	Damaged in Crash
A34400	1	Jefferson	No measurements to date	0	
A32919	1	Williams		4	
A33527	1	Williams		4	
A32064	2	Decorah		10	
A31119	2	New Hampton		31	
A32910	3	Rockwell City		12	
A30131	3	Sioux City Leeds		2	
A29043	3	Sioux City Leeds		4	
A32072	3	Spirit Lake		11	
A32903	4	Adair		10	
A33974	4	Missouri Valley		8	Replaced
A33679	4	Neola		8	
A31315	4	Pacific Junction		13	
A30827	5	Albia		6	Replaced
A31136	5	Albia		3	
A34353	5	Martensdale	No measurements to date	0	
A30459	5	Ottumwa		10	
A34365	6	Cedar Rapids		13	
A30832	6	Cedar Rapids		15	
A33537	6	Cedar Rapids		11	
A32851	6	Newhall		5	Replaced
A33315	6	DeWitt		20	Damage Photos
A32861	6	DeWitt		19	Damage Photos
A33659	6	Independence	No measurements to date	0	
A31374	6	Newhall	No measurements to date	0	
A34374	6	Tipton	No measurements to date	0	
A32896	6	Williamsburg	No measurements to date	0	
A33535	6	Williamsburg	No measurements to date	0	

This project is based on receiving blade measurement data after each event.


We’re just at
the very
beginning


But at the end
of my
presentation



Thanks!

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