The evolution of the Road Weather Station: Winter Monitoring to Future Mobility

Vaisala, Petteri Leppänen

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RWIS and Winter Maintenance operations - The benefits are clear.

Summary of Benefit–Cost Analysis

Case Study State	Winter Season	Winter maintenance Cost ($ 000s)	Benefits ($ 000s)	Weather Information Costs ($ 000s)	Benefit-Cost Ratio	Benefits/ Maintenance Costs (%)
Iowa	2006–07	14,634	814	448	1.8	5.6
Nevada	2006–07	8,924	576	181	3.2	6.5
Michigan	2007–08	31,530	272	7.4	36.7	0.9

Cost Benefits of Weather Information for Winter Road Maintenance

Final Report
April 2009

Sponsored by:
Aurora Program

Administered by:
Iowa Department of Transportation

MONTANA STATE UNIVERSITY College of ENGINEERING

TABLE 1	EPA (1976)	TISA (1976)	TRB (1991)	Hanbali (1994)	Sakshaug et al (1995)	Fraser et al (1998)	Thornes (2000)
	United States	United States	United States	New York, Illionois, Wiscon.	Norway	N. Ireland	United Kingdo
BENEFITS							
1. Reduce Traffic Accidents	No	Yes	No	Yes	Yes	Yes	£630m
2. Reduce Traffic Delays	No	Yes	No	Yes	Yes	Yes	£1,500m
3. Emergency Response	No	Yes	No	No	No	No	£235m
4. Fuel Economy	No	Yes	No	Yes	No	No	£16m
Total		$18,400m					£2,381m
COSTS							
1. Vehicle Corrosion	$2,000m	$643m	$3,500m	No	No	No	£150m
2. Bridge/Road Corrosion	$500m	$160m	$225m	No	No	No	£5m
3. Street Furniture Corrosion	$10m	$2m	$100m	No	No	No	£2m
4. Water Contamination	$150m	$10m	$10m	No	No	No	£1m
5. Vegetation & Soil Damage	$50m	Zero	n.a.	No	No	No	£2m
6. Cost of Salt Spreading	$200m	$200m	£1,500m	Yes	No	£5m	£140m
Total	$2,910	$1,015m	$5,335m				£300m
Benefit/Cost Ratio		18 to 1		6.5 to 1 - 2 to 1			8 to 1

Table 1 A comparison of International winter maintenance Benefit/Cost studies

Table 1 shows a comparison of benefit/cost studies across the world. Values range from 2:1 to 18:1 but it is likely that a ratio of 8:1 is typical for UK

PERFORMANCE AUDIT METHOD FOR WINTER MAINTENANCE

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2002

THE USE OF PERFORMANCE INDICES AND THE ADVANCEMENT IN THEIR DEVELOPMENT FOR IMPROVED ACCOUNTABILITY

D. Johns & P. Bridge
Vaisala

SIRWEC 2016

Assumption 1 hour Grip below 0.6 = 1 hour delay	Estimated economic loss	Estimated saving over do nothing	Cost to benefit ratio
No treatment	338,240,000		
Assuming national daytime only treatement (44%)	148,825,600	189,414,400	**13.5**
24 hour treatment (8%)	27,059,200	311,180,800	**22.2**

…quantify the cost-effectiveness of RWIS. Results show that after the implementation of the two RWIS stations, 41.91% and 26.15% of inclement weather collisions have been reduced. The benefit-to-cost ratio (BCR) for these stations is 39.97 and 9.83 respectively, indicating RWIS is an economically viable countermeasure and hence the transportation agencies can be more confident while allocating funds for its implementation.

Safety Effects of Road Weather Information System (RWIS) - A Cost-Benefit Analysis

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TRB 2021

Even at site specific level

Case study: Colorado DOT

- **Weather related hazard**
- Plowed snow accumulated on a blind curve on a busy highway just outside of Aspen, Colorado.
- Snow would melt during the day and refreeze after road became shaded later in the day.
- CDOT noticed numerous crashes were occurring at this curve despite generally good driving conditions
- They concluded that drivers were traveling at a higher rate of speed in good conditions, and were not prepared for the refreezing snow and ice conditions once they entered the turn.
- **Solution**:
- Station installed with remote sensor at curve location. Sign located well before curve to advise drivers of hazard ahead

- **Results**
  - 80% reduction in accidents
  - Before system average of 15 accidents per year
  - After ~ 3 accidents
  - Approximately 12 accidents saved every year
  - Assuming 2 serious and 10 slight injury accidents
  - **Saving of (2x$216k)+(10x$80k) = $1.232M per annum**
- **Estimated 15:1 return of investment in 1 year**

Case study: A725 South Lanarkshire

- **Weather Related Hazard**
- Build up of water on the road surface led to numerous accidents at one point on the A725
- Vehicles were travelling too fast for the conditions and loosing grip at the location
- A fatal accident occurred at the site in September 2012

Solution

Site installed in November 2012 with remote sensor measuring water film thickness with link to Variable Message Sign to slow vehicles down as they approach the risk area

- **Results**
- In the 4 years **before** the system there were
  - 8 slight accidents
  - 2 serious
  - 1 fatal
- **After** the system over 3 years
  - 4 slight accidents only
- 1/3 reduction in slight accidents (2 per year) equates to approx. (2 x £23k) = £46k
- 1.5 serious (1 every 2 years) = (1.5 x £220k) = £330k
- 0.75 fatal (1 every 4 years) = (0.75 x £1.9M) = £1,425k

Total Saving £1.8M over 3 years

Case study: Oregon DOT

- **Weather related hazard**
- Wet or icy conditions on curved ramps were causing drivers to lose grip and slide off the road.
- High rates of on/off traffic on interchanges throughout the corridor were especially troublesome during wet or icy conditions.
- Oregon DOT was aware of the numerous crashes, especially on the curved ramps during adverse weather.
- They concluded that drivers were traveling too fast for conditions and were not prepared for the loss of grip on the wet or icy ramps.
- **Solution**:
- Stations installed with remote sensor at ramp locations and along corridor. Signs located before ramps and within corridor to advise drivers of conditions and reduced speeds.

- **Results**
  - Ramps crashes dropped from 29 to 14, a 48% reduction
  - Serious injury crashes dropped from 5 to 2
  - Assuming eliminating 2 serious and 10 rear-end/side swipe accidents per year
  - **Project Benefit of $881K per year**
- **Estimated 17:1 return of investment over 5 years**

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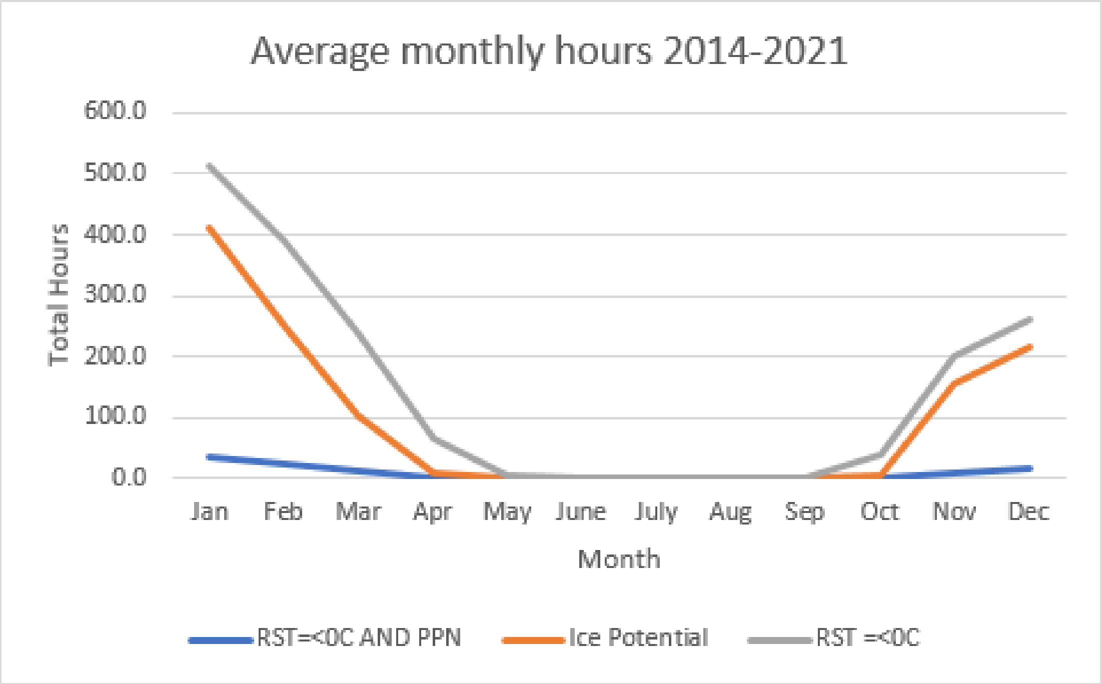
RWIS data allows an evidenced based approach

- Monthly data 2014-2021 Sagan, Sweden
- Analysis shows clearly that relying on temperature alone to make treatment decisions will significantly overestimate the problem
- Whilst just treating when RST is below zero AND there is precipitation falling will significantly underestimate the need for treatment
- Baseline can be determined by RST below zero and surface state NOT DRY = Ice potential
- These measures can then be utilised as a simple KPI to understand the effectiveness of the treatment regime



		Number of hours	Actual Deviation (hours)	Percentage Deviation
1	Baseline (Ice Potential)	1148.4		
2	RST only	1705.8	557.4	49%
3	RST and precip	93.3	-1055.1	-92%

1 *Number of hours where Ice could have formed whether treated succesfully or not*
2 *Number of hours where road surface was at or below freezing point*
3 *Number of hours where surface temperature was at or below freezing point and there was some form of precipitation at the same time*

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RWIS into the future
The transportation transformation

Today

- Human driver has full responsibility for all decisions.
- Information is gained visually from outside the vehicle or from radio

Near future / Now?

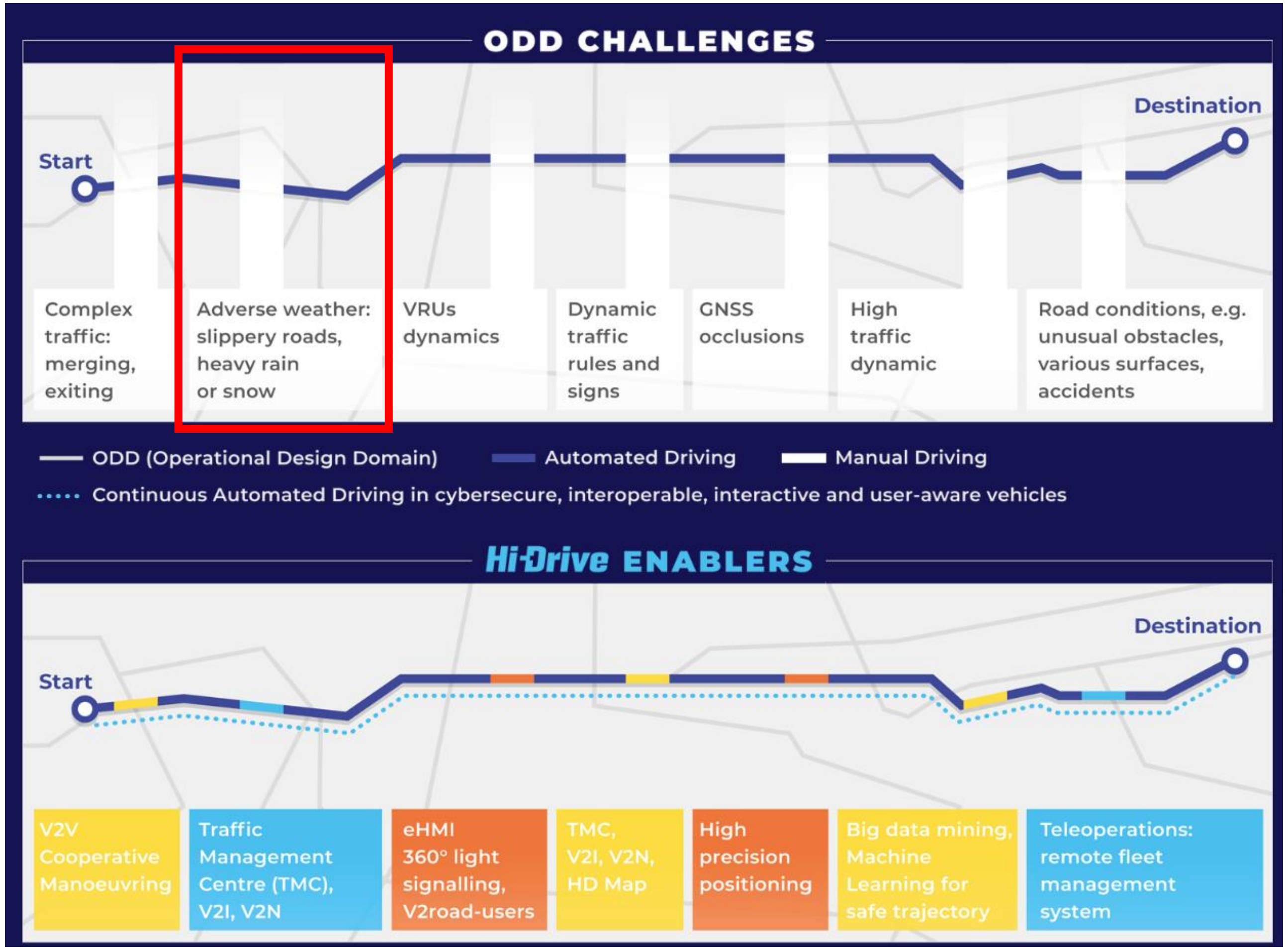
- Human driver has full responsibility for all decisions.
- Information is gained from in vehicle applications and mobile phone apps
- Data gets into vehicles from other vehicles, internet or roadside broadcasts

The future goal

- Driving is increasingly automated with vehicle relying on sensors for situational awareness
- Additional information comes into vehicle from other connected vehicles, internet and roadside infrastructure

As connectivity and automation become common place the need for external information to underpin safe operations will increase.

Future Mobility needs weather information



- As vehicles start to rely more on their sensors weather starts to play a critical role in how and when they can operate in automated modes
- Like the human driver poor visibility affects the vehicles ability to "see" properly and can mean that they will need to drop out of auto-pilot back to manual driving
- Critical to safety will be accurate and timely observations

PROJECT FACTS

Budget € 60 million | Funding € 30 million | Consortium 53 partners | Involvement 13 countries | Timeline July 2021 – June 2025 | Project coordinator Aria Etemad, Volkswagen Group Innovation, aria.etemad@volkswagen.de | LinkedIn company/hi-drive | Twitter @_HiDrive_ | www.hi-drive.eu

Hi-Drive Designing Automation

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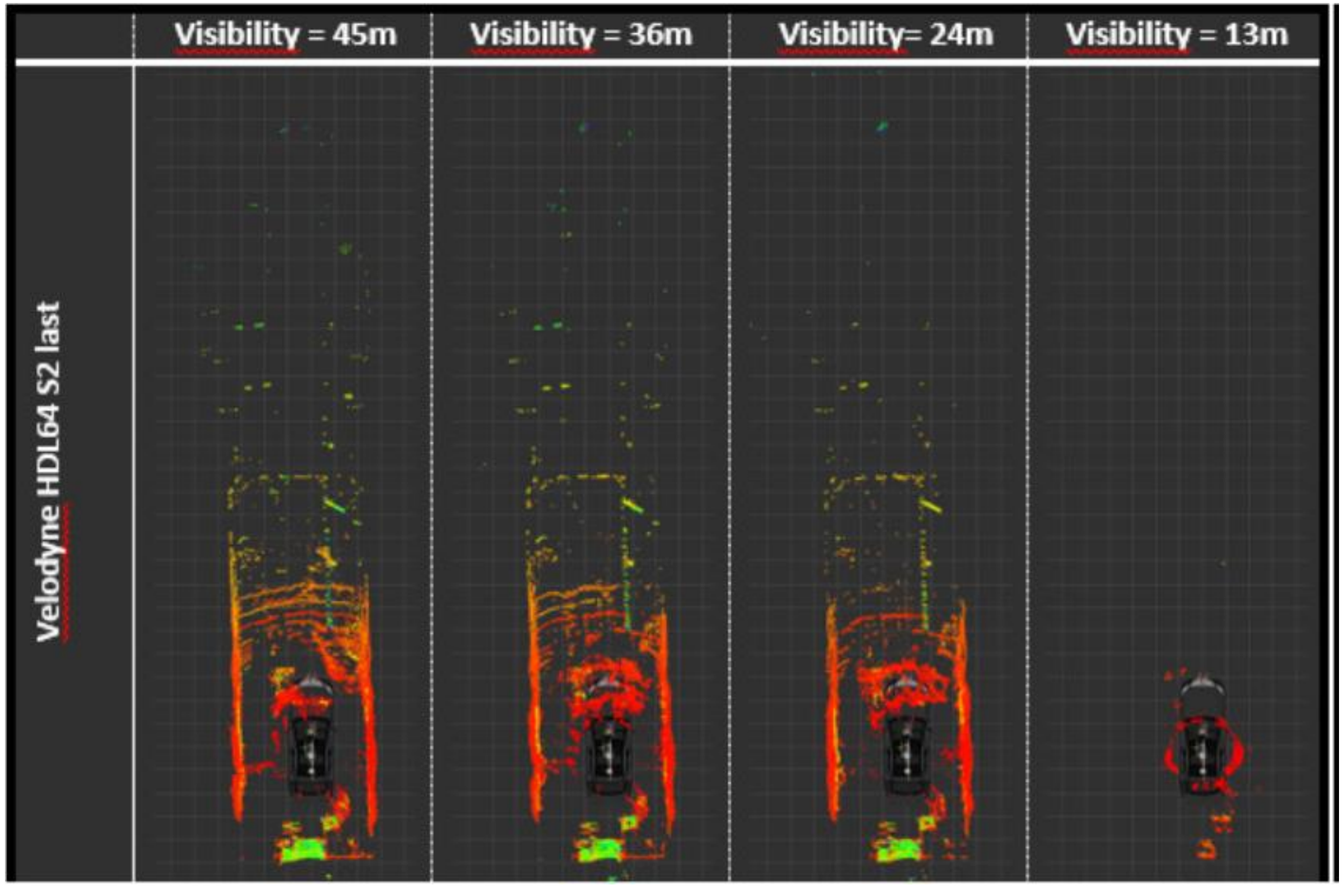
Weather impacts on vehicle sensing

- Many sensors are affected to lesser or greater degree by weather
- Precipitation is particles of differing size and densities moving in the field of view effectively obstructing the target
- To enable sensing in all conditions then multiple methods need to be deployed and fused by each vehicle (E.g. Lidar, Radar, Computer Vision etc)
- RWIS can play a major part in assisting situational awareness



Source, DENSE: Environment perception in bad weather - first results; Werner Rittera, Mario Bijelica, Tobias Grubera, Matti Kutilab and Hanno Holzhüterc

4 key areas of concern for automated driving

Atmospheric derived obscuration

- Particles in the air within the field of sensing that can be caused by meteorological factors such as fog or heavy rain or snow. Also, will include obscuration through smoke or dust.

Road weather surface condition

- Any weather-related contaminant on the road surface from thin films of water, ice or snow through to standing water or snow drift

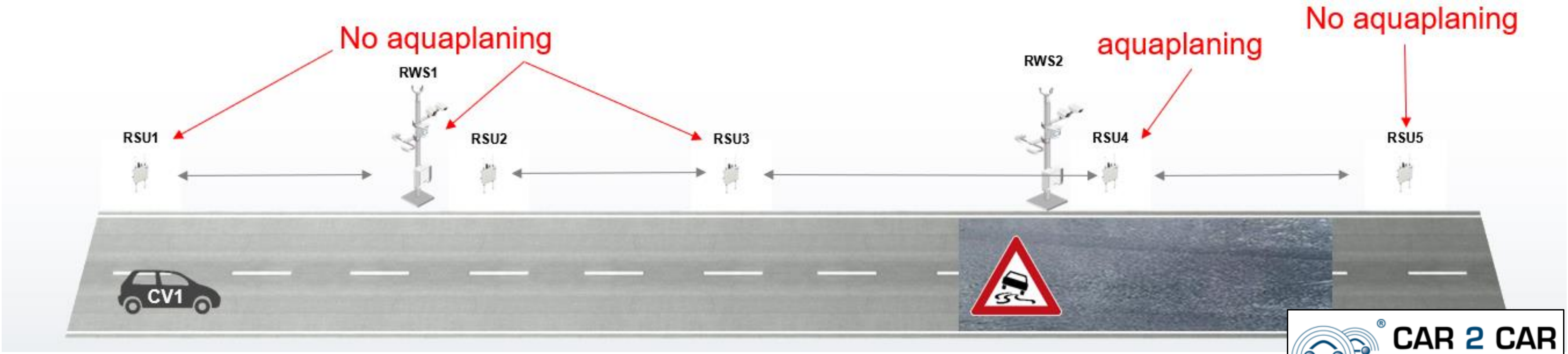
Secondary weather phenomena

- Spray being created by traffic passing through standing water, sun reflection off wet or icy surfaces

Landscape alteration

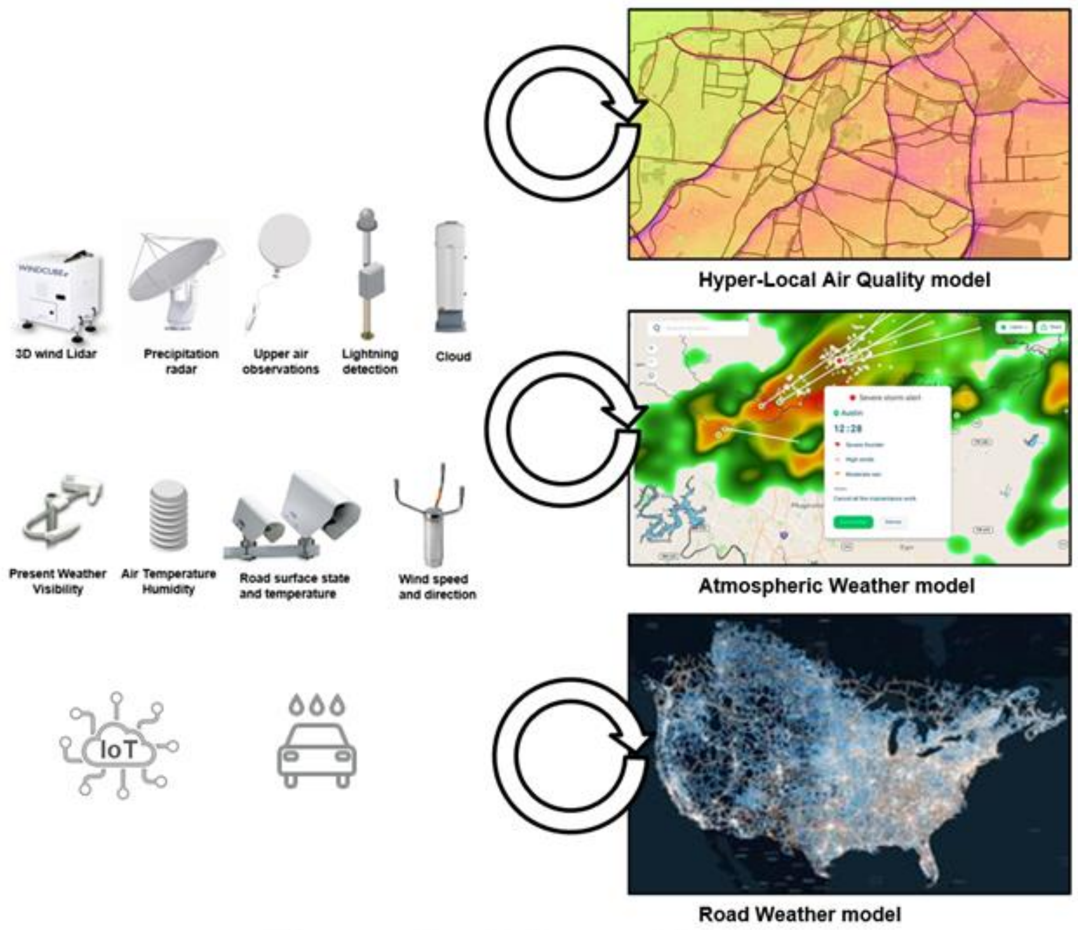
- Wet objects changing luminosity or refractive properties, snow covered objects effectively moving position, road markings covered in snow

Direct I2V communications



1. Weather detected by static observation network
2. Data passed to numerous Road-Side Units (RSU's)
3. Real time observations offered to all connected vehicles approaching hazard area
4. Each vehicle makes its own decision on action or no action depending on its own requirements
5. RWIS always reporting ➔ constant situational awareness

Hybrid cloud and infrastructure weather



Observation Enhanced Modelling

Summary

- RWIS have proved their worth over the years with respect to winter maintenance activities
- This will always be required as underpins an efficiently operating transport network
- However, as technology marches on, the road weather station will increasingly have another supporting role to play
- Sensing technology on vehicles is vulnerable to severe weather and to maintain safety, high accuracy and high availability of observation is required.
- This will allow vehicles to operate in safety, whilst helping to realise the goals of Vision Zero through applied technology in ever more sophisticated vehicles

Thank you!

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