Criteria for closing mountain passes based on friction measurement and crosswind

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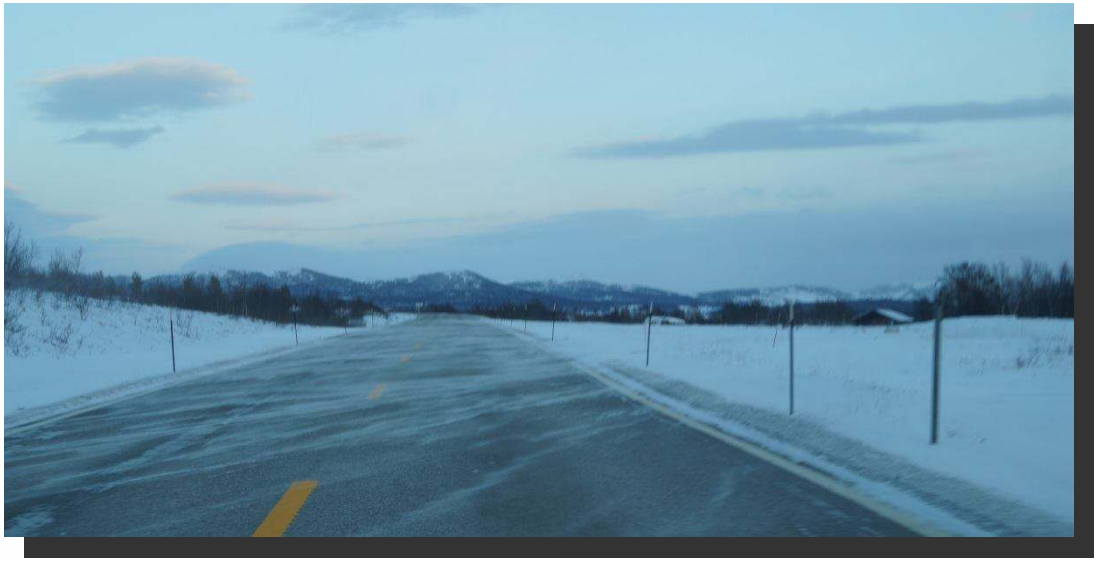


1. Background - The bus accident

- A coach (double decker) was heading south from Trondheim to Oslo.
- When reaching Dovrefjell there was strong wind combined with ice covered roads.
- The bus lost grip and went into the ditch.
- 30 persons injured, 4 of them seriously.

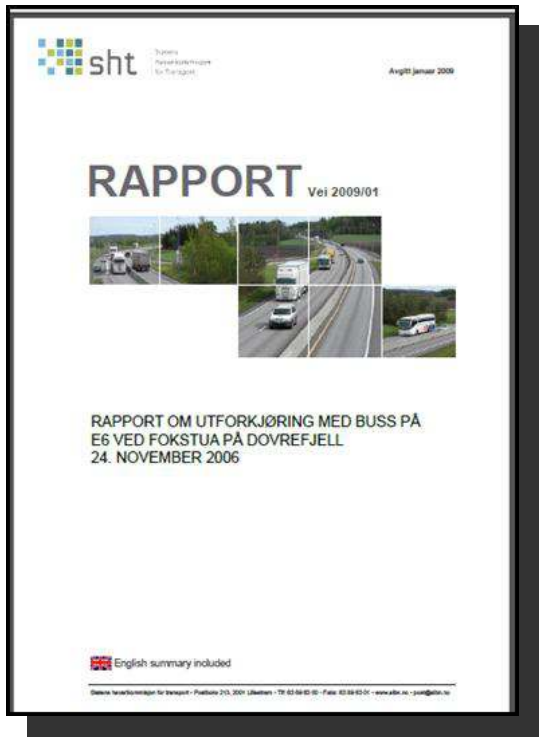
Source: AIBN

1. Background - The bus accident

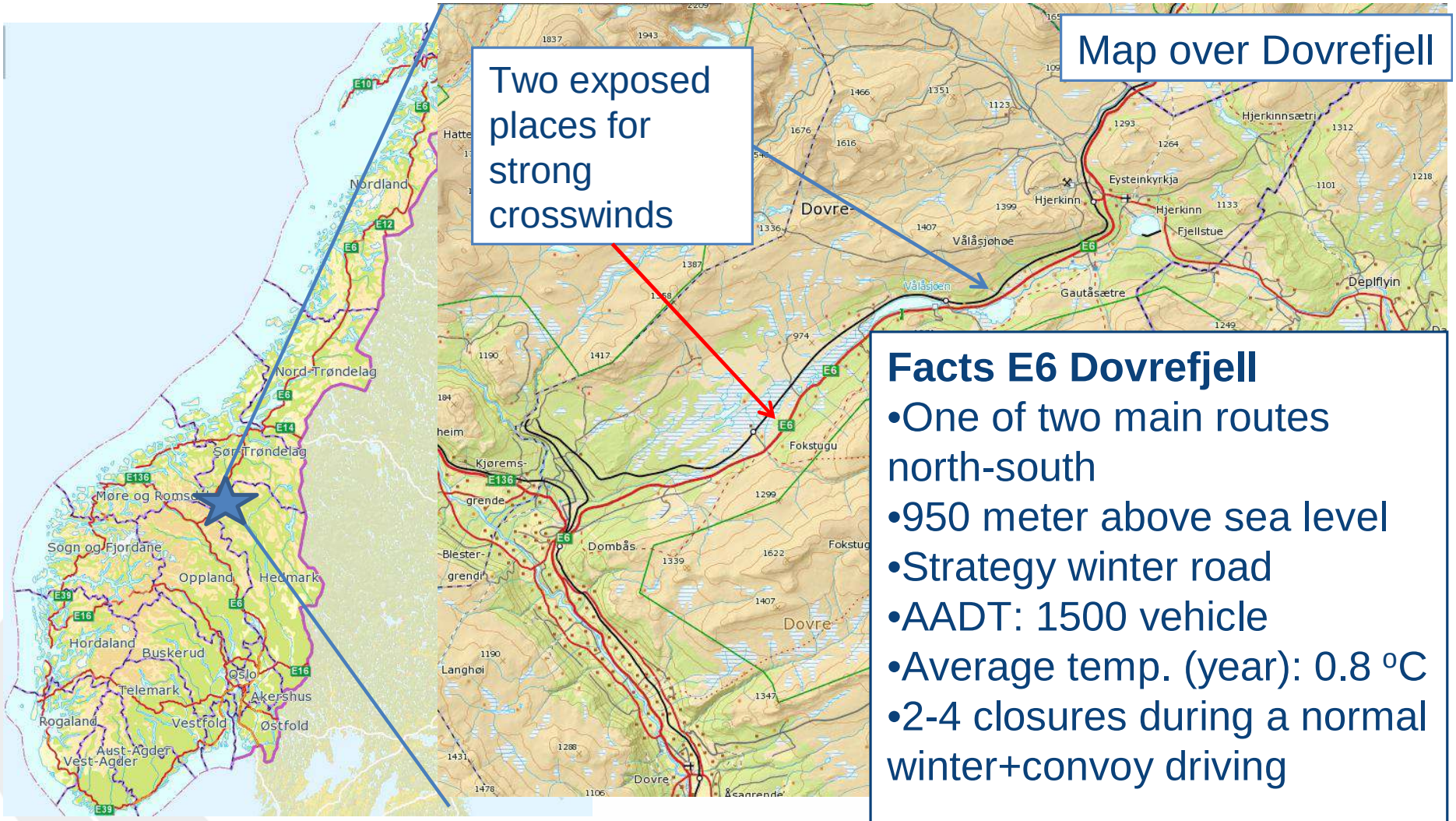
The Accident Investigation Board Norway (AIBN) made a report and had several safety recomendations:

1.Better information system for the road users.
2.Clearer directives for management and closing of roads.
3.Methods for increasing friction under conditions with strong wind.

The contractor «Mesta» was also interested in a tool helping him to take the right decisions.



1. Background - The mountain pass Dovrefjell



Facts E6 Dovrefjell

- One of two main routes north-south
- 950 meter above sea level
- Strategy winter road
- AADT: 1500 vehicle
- Average temp. (year): 0.8 °C
- 2-4 closures during a normal winter+convoy driving

1. Background - The mountain pass Dovrefjell

3. Description of the project - Instrumentation

3 weather stations:

- Temperature
- Wind
- Precipitation
- Road surface state sensors

Friction is measured frequently by the contractor. Road condition monitor mounted on the snow plough.

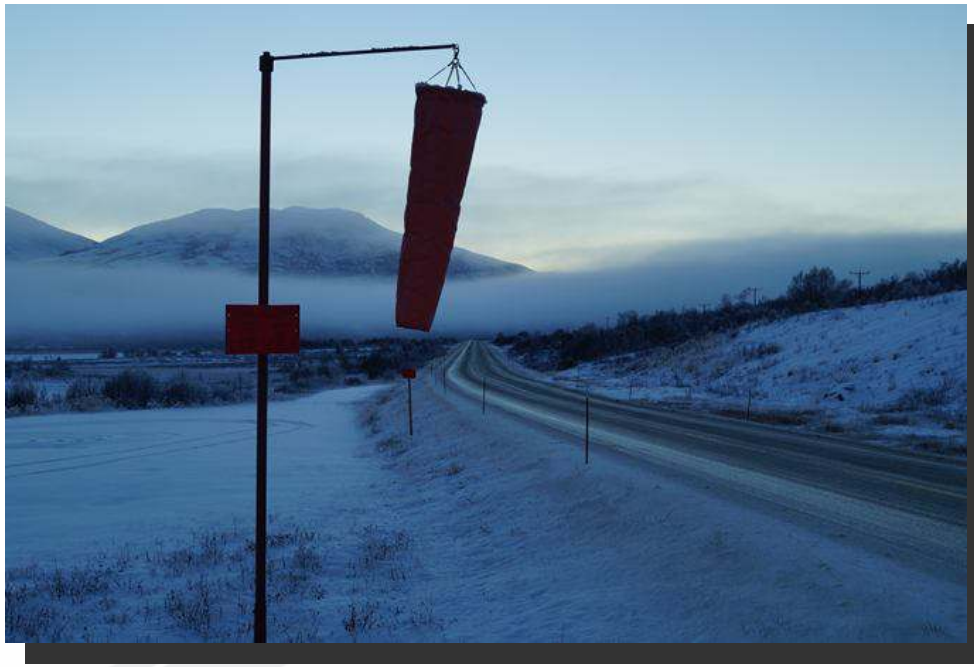
Friction device: ViaFricition

Road condition monitor: Teconer

3. Description of the project - Instrumentation

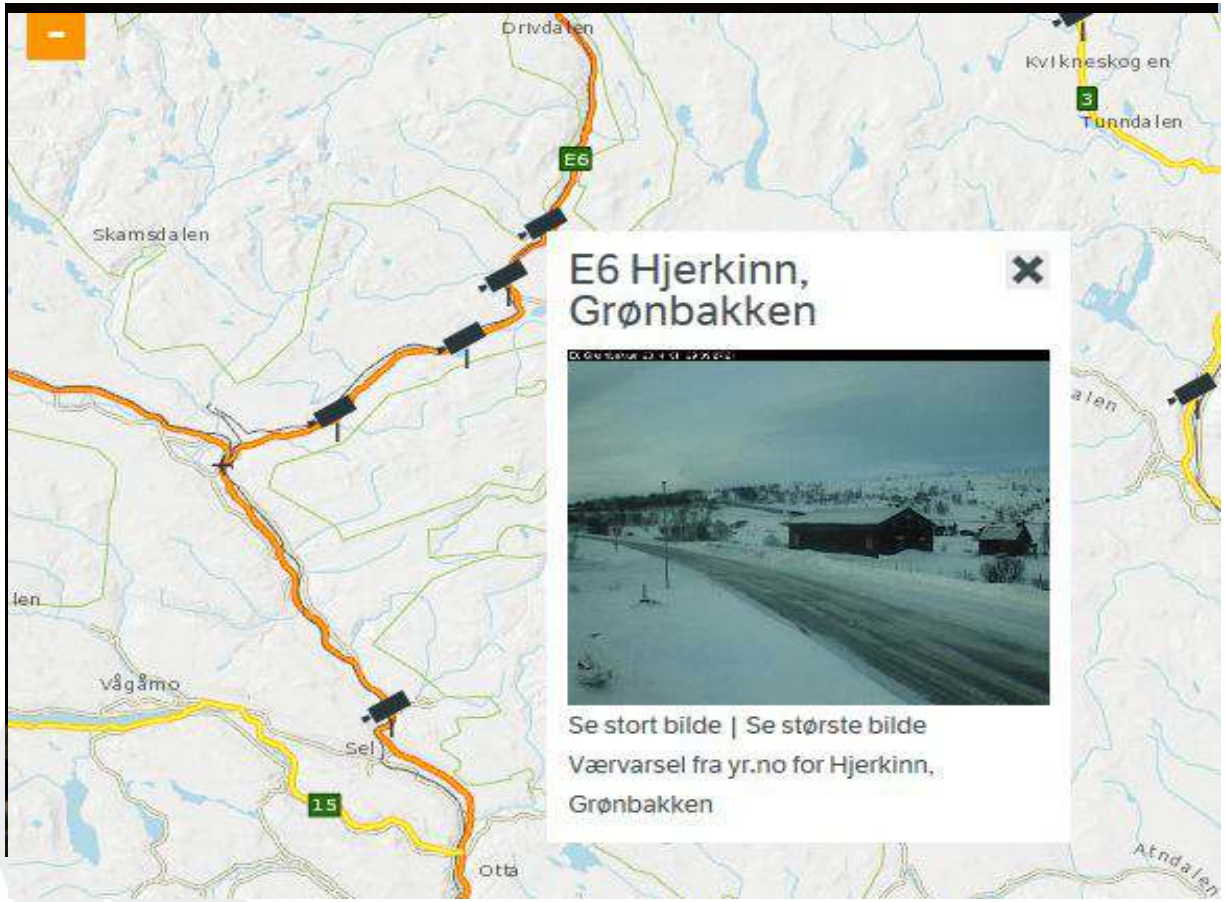
One wheather station was destroyed by a truck in the beginning of january this year.

2. Description of the project - Instrumentation



Visibility: Home-made signpost are installed so the operator can consider the visibility through the webcameras.

3. Preliminary results – Better information to the road users



- 5 Variable signposts
- 4 online webcameras
- SMS-warning (need subscription)

3. Preliminary results - Guidelines for introducing convoy driving or closure

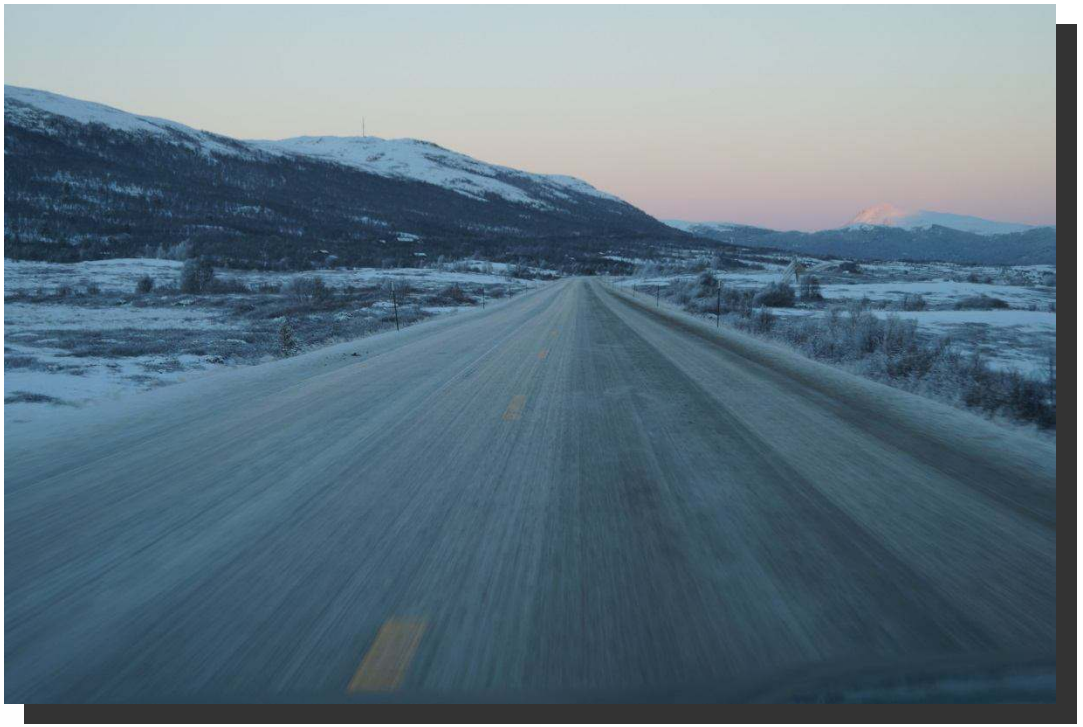
We have created a spreadsheet / mobile app for helping the contractor:

Input:

- Visibility
- Friction
- Wind

Output:

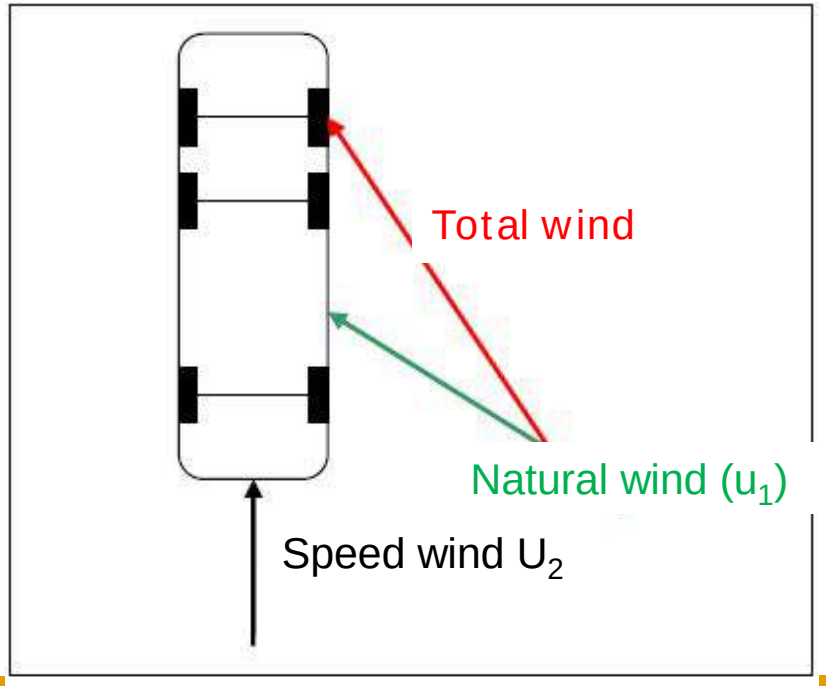
- Recommended speed limit
- Convoy driving
- Closed road



3. Preliminary results - Guidelines for introducing convoy driving or closure

- Different vehicle types have different aerodynamic properties and some are more vulnerable for crosswinds.
- The app take this into account and give recomended speed limit based on the «worst case vehicle».
- Low speed is one measure when the wind is strong.

Total wind force (u) = Natural wind (u_1) + wind because of the speed (u_2)



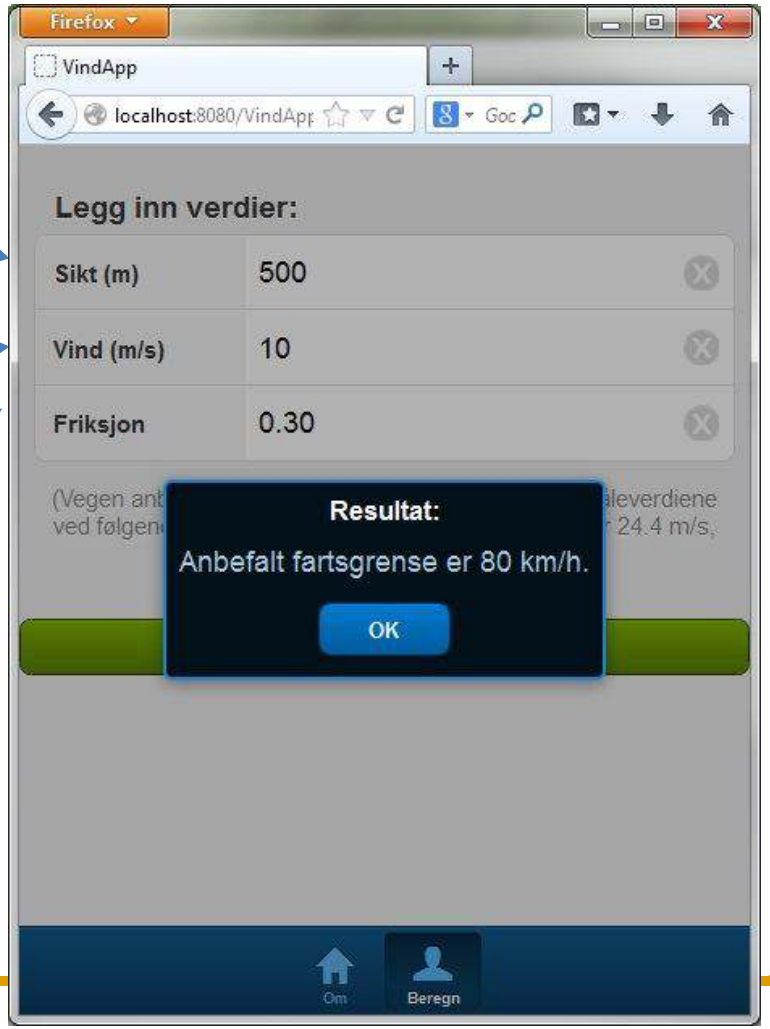
3. Preliminary results - Guidelines for introducing convoy driving or closure

Tool for estimating the road status:

Visibility (m)

Wind (m/s)

Friction



Result: Open road with recommended speed limit of 80 km/h.

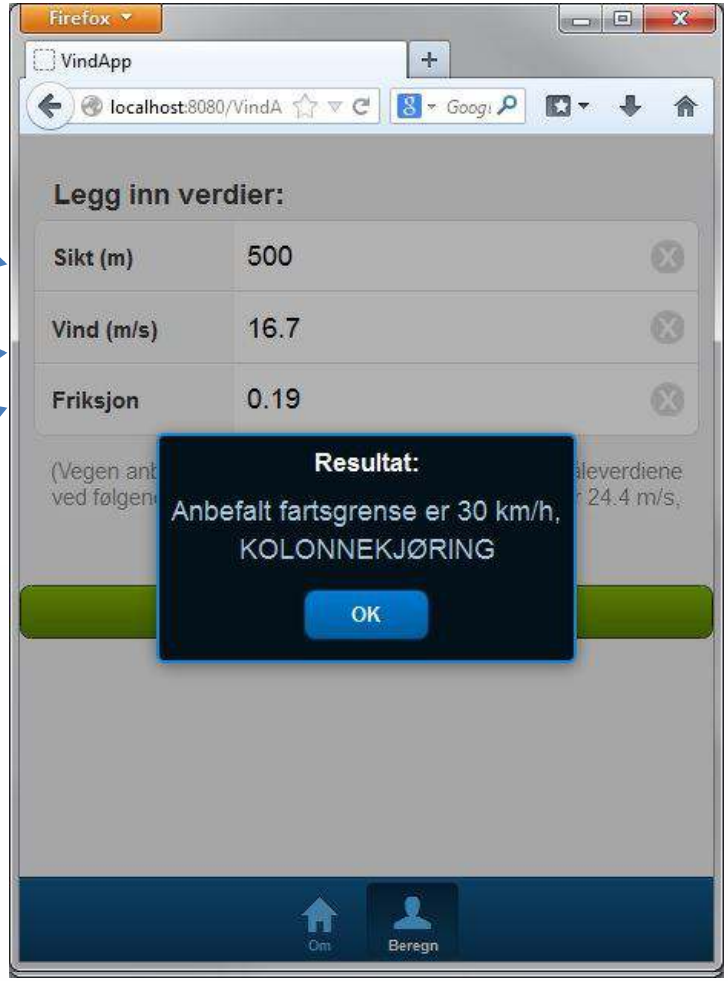
3. Preliminary results - Guidelines for introducing convoy driving or closure

Tool for estimating the road status:

Visibility (m)

Wind (m/s)

Friction



Result: Convoy driving with recommended speed limit of 30 km/h.

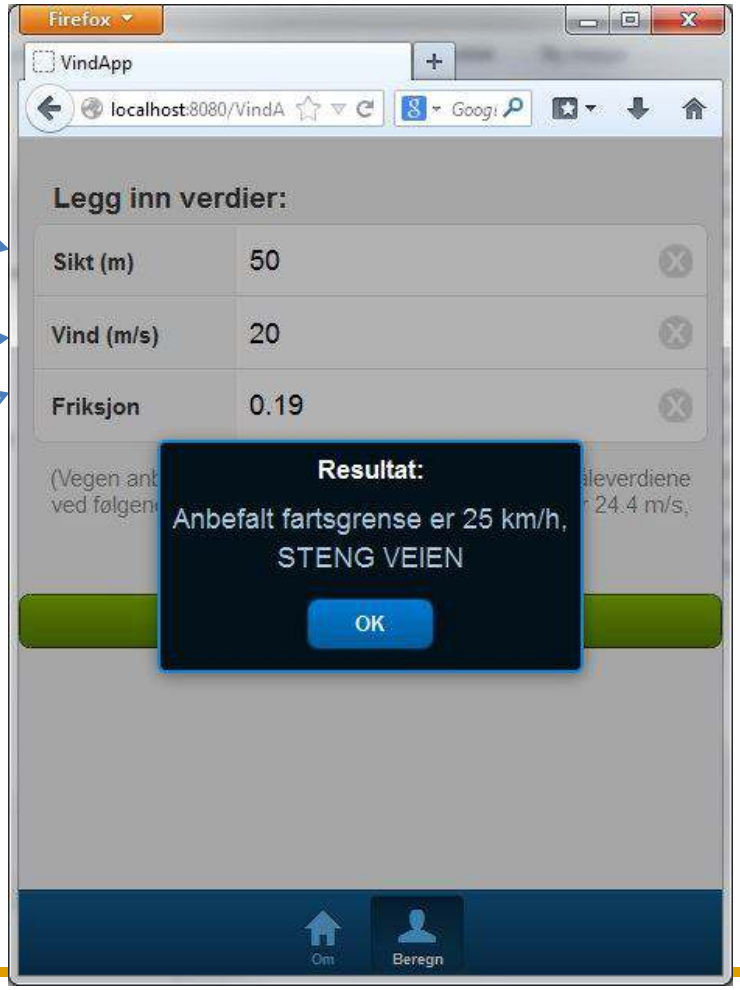
3. Preliminary results - Guidelines for introducing convoy driving or closure

Tool for estimating the road status:

Visibility (m)

Wind (m/s)

Friction



Result: The road is closed

3. Preliminary results - Guidelines for introducing convoy driving or closure

Convoy driving:

- Can be introduced when the driving conditions are difficult. (e.x wind, snow drifting, narrow road)
- The snow clearing crew can exclude vehicles.
- Maximum number of vehicles and people.
- One snow plough in front and one escort car at the end. Max speed 40 km/h.

Photo: Geir Brekke, NPRA

3. Preliminary results - Actions to increase the friction

How to increase the friction when the wind is strong and you have a slippery road?

- **Problem:** The sand particles will just go away with the wind when the wind is strong.
- Preventive sanding can be done with use of the warm-wetted sanding method.
- Old warm-wetted spreaders with towed spreader will probably be better when the wind is strong.

Photo: *Old warm wetted spreader with the possibility to change from disc to towed spreader. Photo by Torgeir Vaa, NPRA*

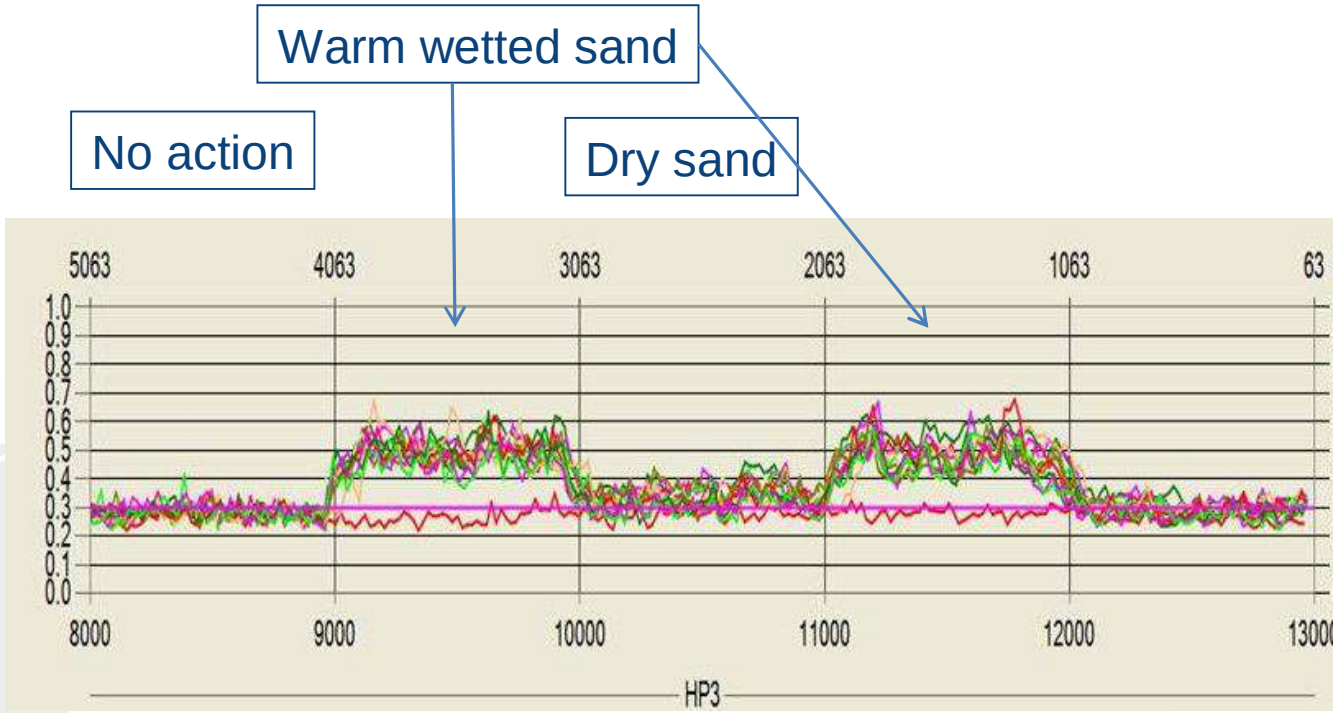
3. Preliminary results - Actions to increase the friction

Examples of use of warm wetted sand on Dovrefjell

3. Preliminary results – Actions to increase the friction

Examples of use of warm wetted sand

Testing the friction contribution:



3. Preliminary results – Another preventive action

The snow in the trench are cleared by a snowplow to prepare for the next storm

4. Further work

- Adjust and improve the mobile app based on the actual closures.
- Consider the possibility to have road lightning on the most difficult section.
- Consider the possibility to have recommended speed limit when the driving conditions are difficult.

Photo: Road lightning at Haukelifjell. Photo: Harald Norem, NPRA

Thank you for your attention!