NOKIAN HEAVY TYRES' ADVANCED SMART TIRE SOLUTIONS FOR AGRICULTURE, FORESTRY, AND ROAD TRAFFIC

NHT KEY FINDINGS IN LEVITOI PROJECT

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THE NEW WINDS OF WORK MACHINE TECHNOLOGY - CLOSING WEBINAR OF THE LEVITOI PROJECT, DECEMBER 12, 2024

NOKIAN TYRES AT A GLANCE

NOKIAN TYRES DEVELOPS AND MANUFACTURES PREMIUM TIRES FOR PEOPLE WHO VALUE SAFETY, SUSTAINABILITY, AND PREDICTABILITY

- #1 in premium tires in the Nordics
- Clear strategy to reach EUR 2 billion net sales by 2027
- Solid balance sheet to facilitate strategy execution
- Listed on Nasdaq Helsinki

2023

NET SALES
1,174
EUR MILLION

3,400
PROFESSIONALS

PRODUCTS SOLD IN
55
COUNTRIES

NET SALES[1] BY BUSINESS UNIT, %

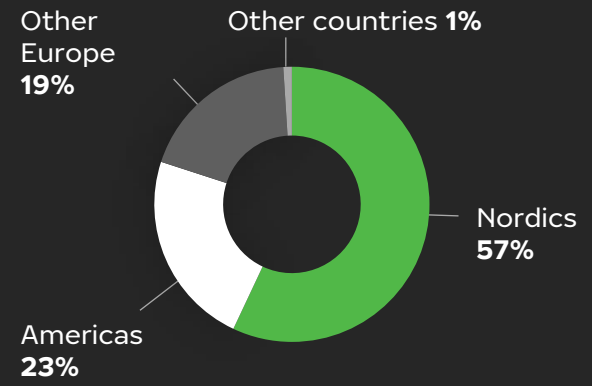
BALANCED MANUFACTURING FOOTPRINT

FINLAND
Capacity expansion finalized in 2023

ROMANIA
First tires in H2/2024, commercial production starts in 2025

US
Ramp-up to be finalized in H1/2024

NET SALES BY GEOGRAPHICAL AREA, %



[1] From external customers

INTUITU™

Tire Mounted Sensor (TMS)

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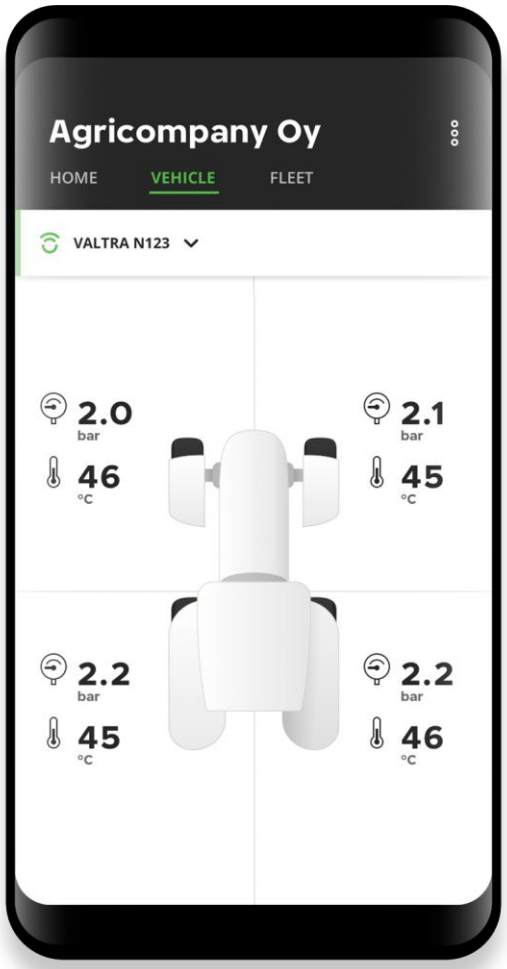
INTUITU™ AVAILABLE TODAY

TIRE PRESSURE

TIRE TEMPERATURE

USER-DEFINABLE ALERTS

WORKS OFFLINE



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FROM TPMS TOWARDS INTELLIGENT TIRE

	Indirect TPMS	Direct TPMS	Tire Mounted Sensor (TMS)	Tire ADS
Typical features	Pressure change detection using vehicle's ABS sensors	Pressure and temperature measurement	Tire ID, tire type, pressure, temperature, tread wear, load.	Tire ID, tire type, pressure, temperature, tread wear, load, aqua planning, slippage, pumping, forces, continuous road condition and friction measurement
Sensors	Vehicle's ABS	Pressure and temperature sensors	Accelometer or strain sensor, pressure and temperature sensors	Accelometer or strain sensor, pressure and temperature sensors
+/-	Simplicity for consumers. No additional sensors on tires/wheels. No absolute pressure value. Can be slow to detect pressure changes. Frequent false alarms possible.	Faster and more accurate than Indirect TPMS. Absolute measurement for pressure and temperature	Enables more advanced use cases than TPMS. More complex and more expensive.	Enables more advanced use cases than TMS. More complex and more expensive. Requires energy harvesting solution to support continuous measurement.
Assembly	N/A	Valve, rim, or tire mount	Tire mount	Tire mount
Energy source	N/A	Battery	Battery	Energy harvesting
Communication method	N/A	BLE, 315 MHz or 433 MHz radio. BLE typically made with separate gateway HW.	Bluetooth Low Energy (BLE)	Bluetooth Low Energy (BLE)

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KEY FINDINGS

NHT KEY FINDINGS IN LEVITOI PROJECT

Radial tire research did proceed as planned, crossply tire results poor

Tire structure	Technology demonstration	Ground characteristics recognition	Load measurement
Crossply tire	Case 1: Seed drill tire	Not promising	Not promising
Crossply tire	Case 2: Forestry machine tire	Obstacles only	Not promising
Radial tire	Case 3: Truck tire	Promising results in road load capasity recognition. Further research is needed.	Not in scope
Radial tire	Case 4: Tractor tire	Promising results in basic soil recognition. Further research is needed.	**Very promising results in load measurement. Potential R&D project to follow.**

NHT will continue Levitoi project until 31.12.2025 in order to finalize reseach on load measurement algoritm.

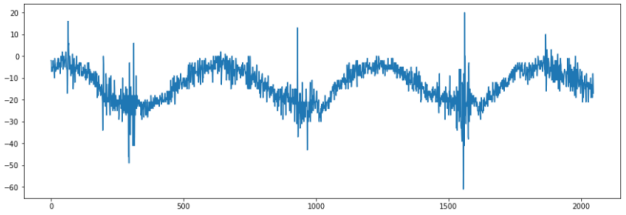
Confidential

CASE 1:
SEED DRILL CROSSPLY TIRE

RESULT: SENSOR ATTACHED TO CROSSPLY TIRE DOES NOT DELIVER PROMISING SIGNAL

Signal is different to radial tire

- It was difficult to calculate contact patch from this data
  - Noisy peaks were quite common in this data
  - The data was quite unstable and easily observable peaks were not often present in the data
  - Calculated frequency from the data changed and this may have also affected the filtered signal



Crossply structure as challenge

- Crossply tire structure is much stiffer than radial structure. This means that deflections in crossply tire are smaller and may also differ in shape from radial tire.
- Missing of typical phenomens seen in signal in radial are probably based on this structural difference.
- Similar results were obtained from forestry tires.
- These results lead NHT to focus on radial tires.
- Further research was made on obstacle recognition.

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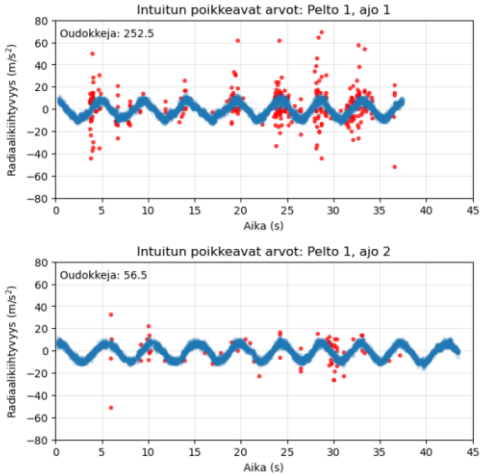
CASE 2: FORESTRY MACHINE CROSS PLY TIRE

RESULTS: SENSOR IN CROSSPLY TIRES CAN RECOGNIZE OBSTABLES

Forestry tire testing

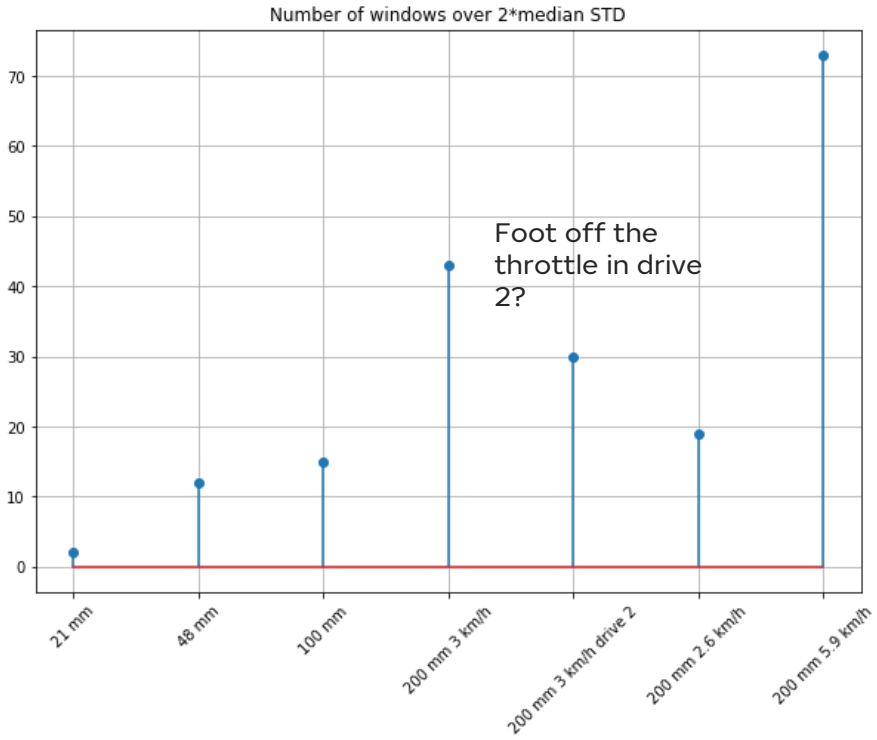
- Initial data-analysis of cross-ply tires didn't reveal similar easy-to-find correlation between tire and ground as radial tires
- More in depth analysis has revealed somewhat promising outliers (in Finnish: oudokki) which seem to correlate with ground characteristics

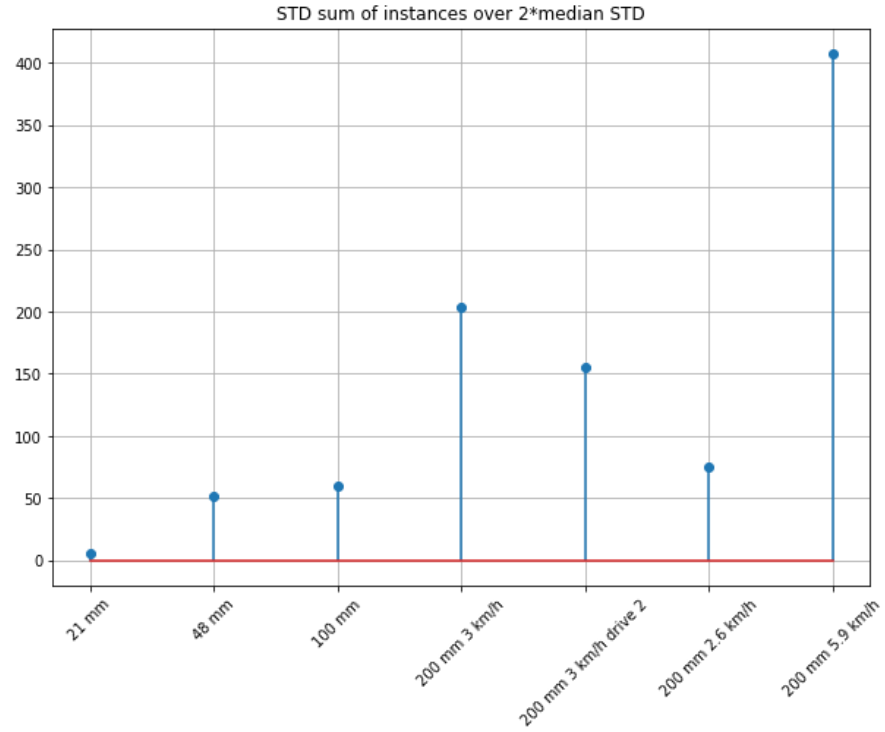


Obstacle testing

COMPARISON OF STD INCREASE

- There is a clear increase in the intensity of the STD increase with increasing obstacle size and increasing velocity





The higher intensity for the highest velocity is visible as there are both more increased STD windows but also the values are higher (difference to 2nd highest is larger than when comparing window number)

CASE 3:
TRUCK RADIAL TIRE

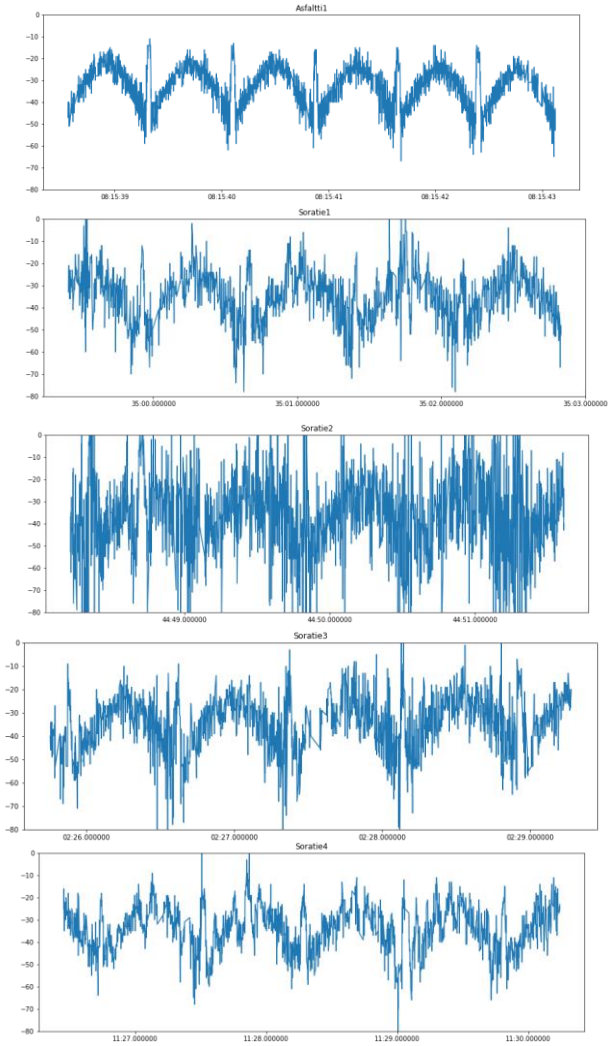
RESULT: PROMISING RESULTS, FURTHER RESEARCH IS NEEDED

- Asphalt road and very soft gravel road can be identified with good accuracy
- Direct correlation between road load capasity and sensor signal is difficult to show
  - One reason are the point measurements of load capasity
- Need is for continuous load measurement on gravel roads

COMPARISON OF TIRE DATA AND LOAD CAPACITY

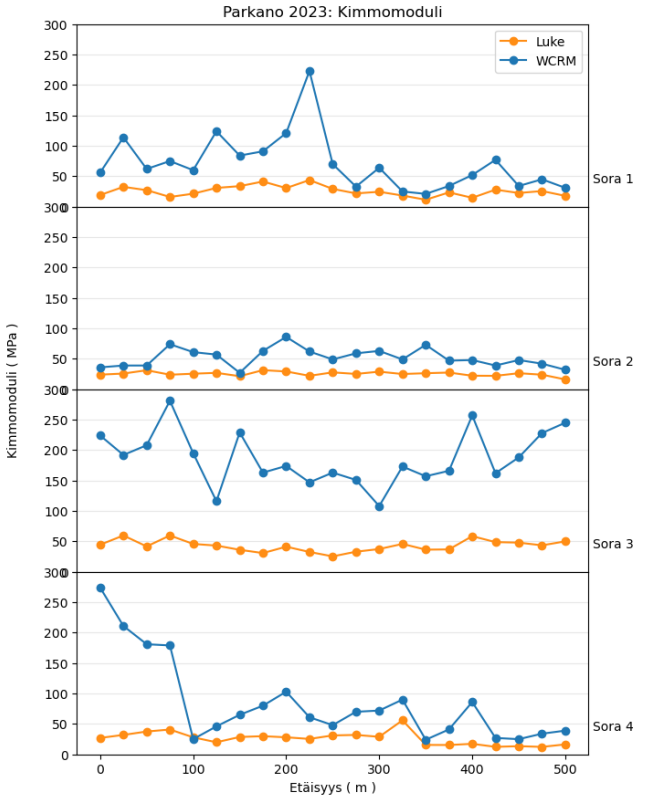
Acceleration measurements

- Asphalt clearly stands out from gravel roads.
- On gravel roads, the vibration during the tire's rotation seems to increase as the road's drivability deteriorates



Deflectometer measurements

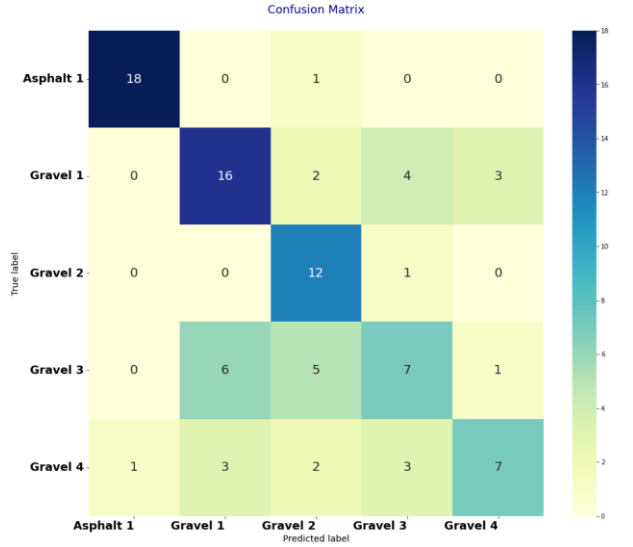
- The results of the road's elastic modulus measurements depend on the method used.
- The correlation with measurements taken using the Zorn ZFG 3000 looks promising.
- On the other hand, a similar correlation was not found with measurements taken using the KUAB FWD 50.

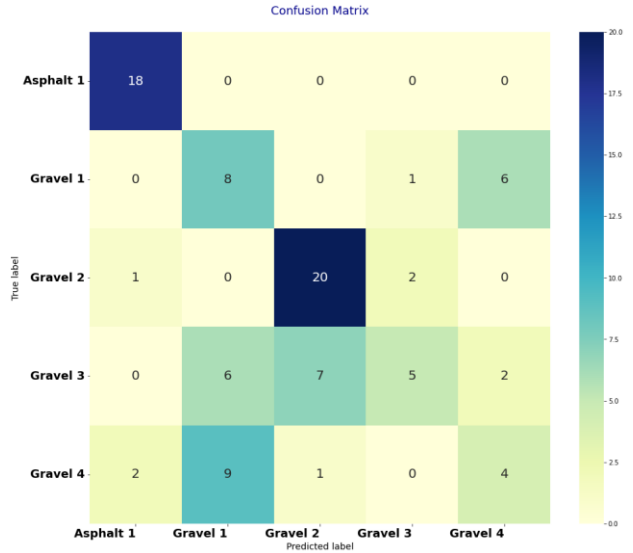


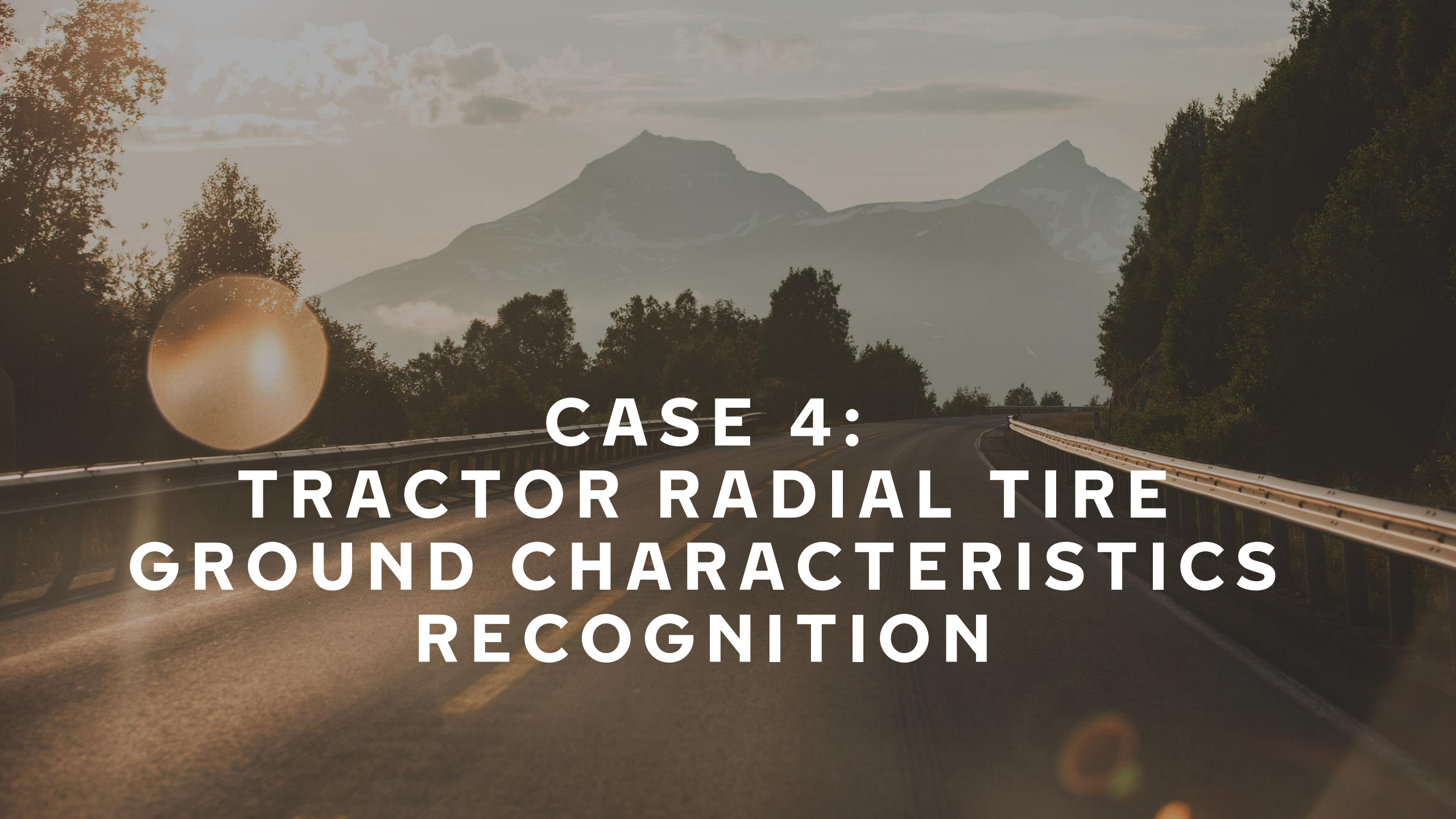
CONVOLUTIONAL NEURAL NETWORK (CNN)

Testing CNN for classification

- Gravel road 2 was classified correctly more often than the other gravel roads
- Asphalt data was also classified quite reliably by different neural network models







CASE 4: TRACTOR RADIAL TIRE GROUND CHARACTERISTICS RECOGNITION

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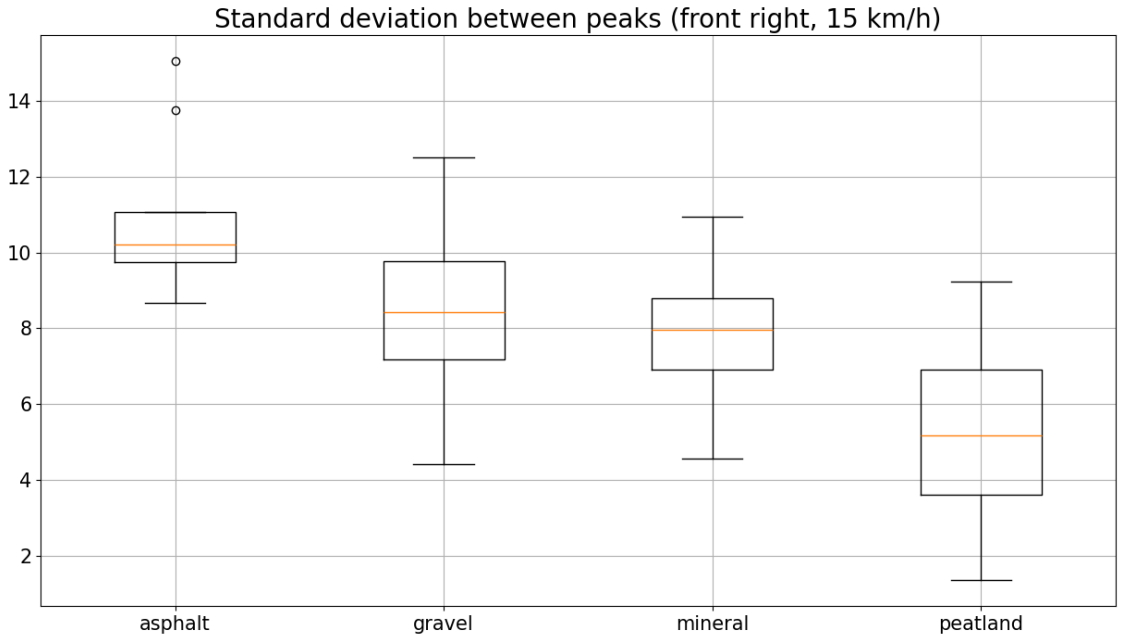
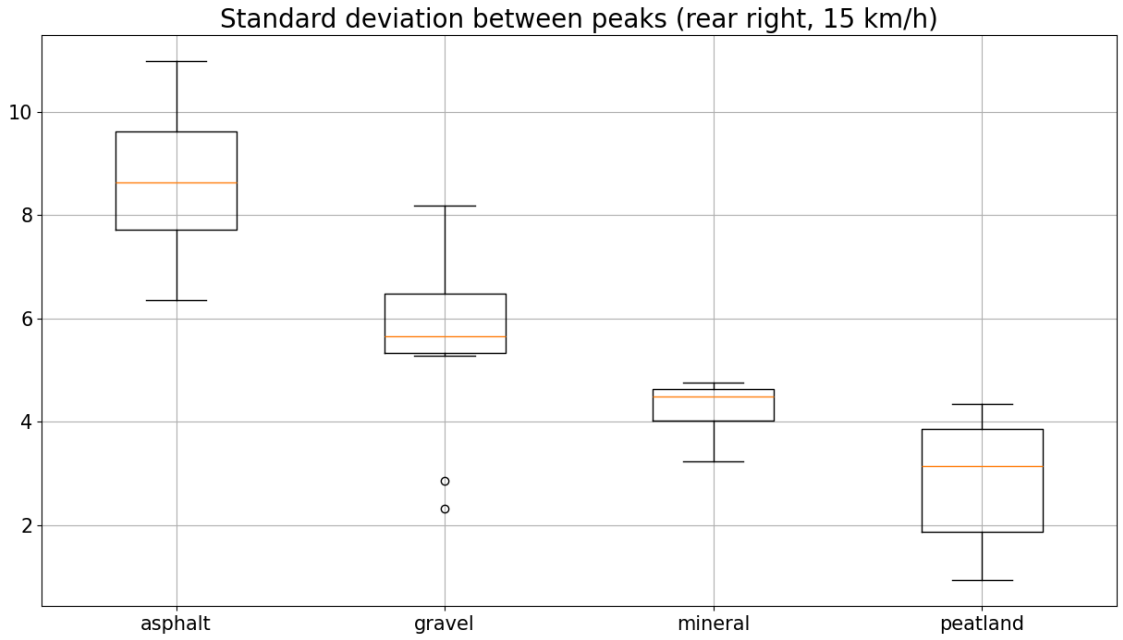
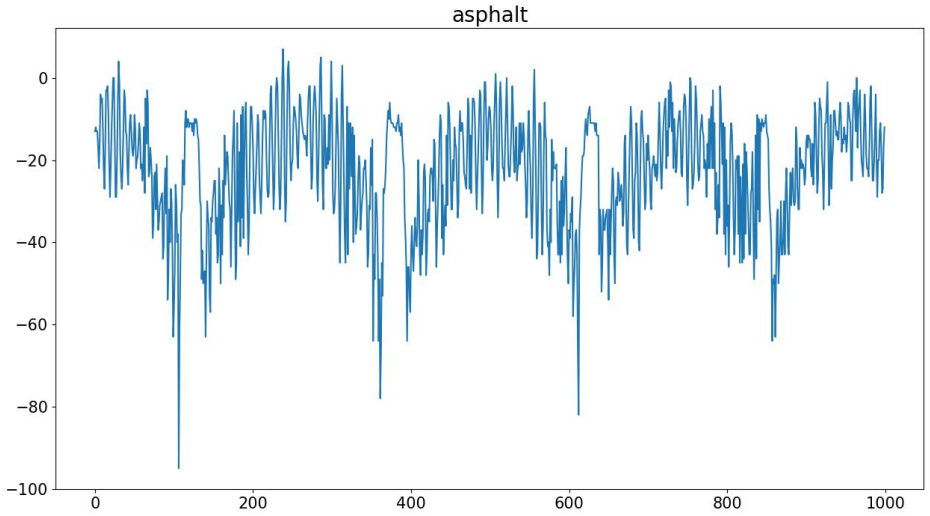
RESULT: PROMISING CORRELATION, FURTHER RESEARCH IS NEEDED

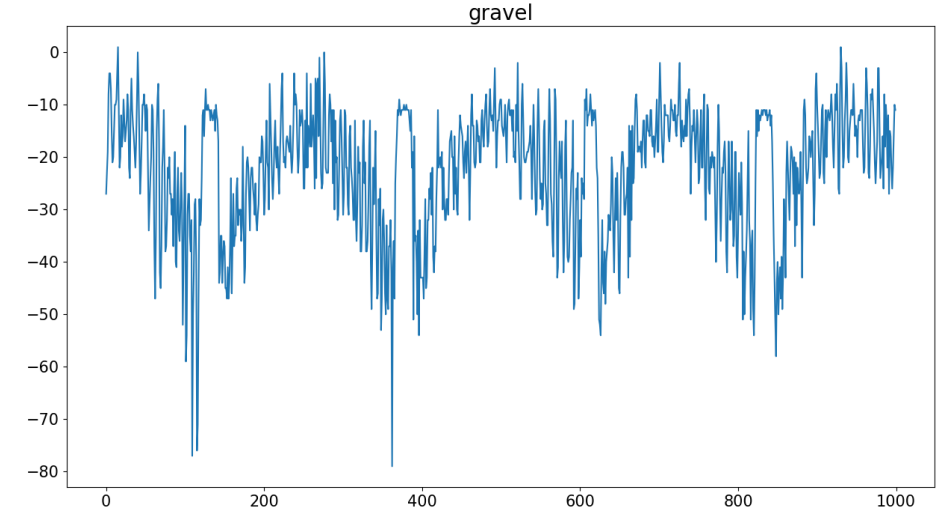
Standard deviation decreases as the toughness of the road decreases

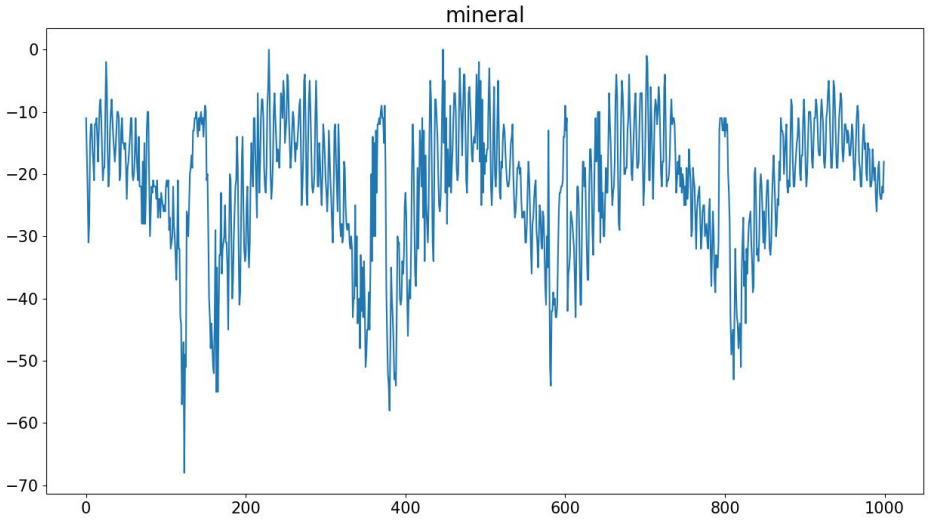


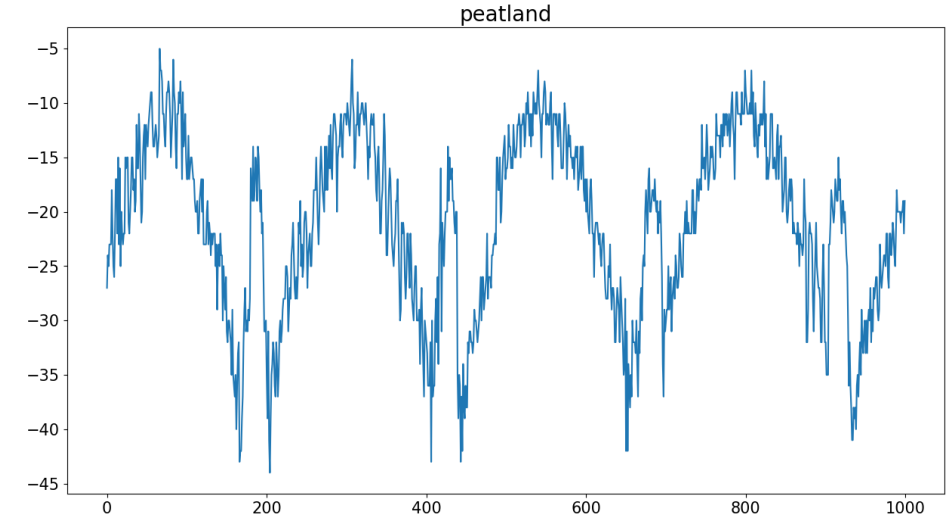


THE EFFECT OF THE SURFACE ON ACCELERATION DATA FOR A TRACTOR TIRE



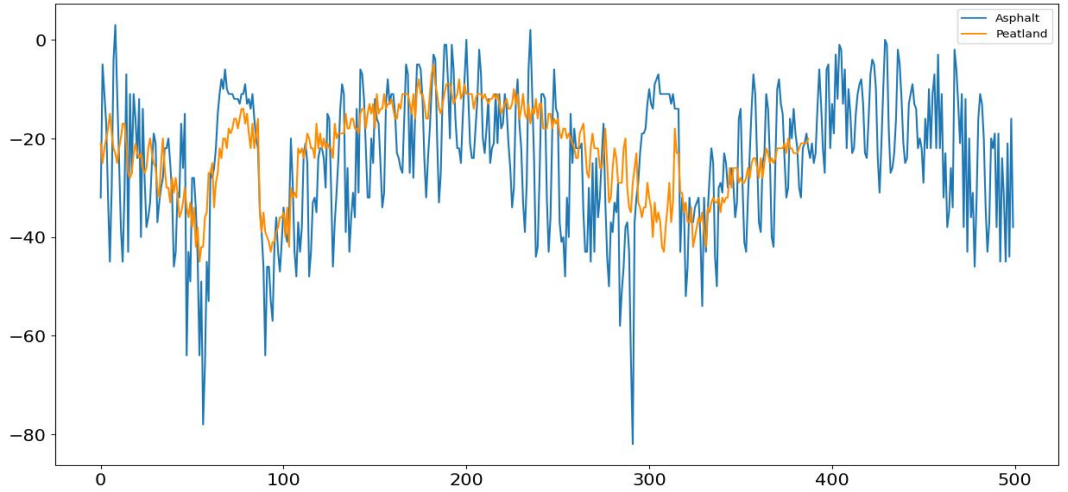


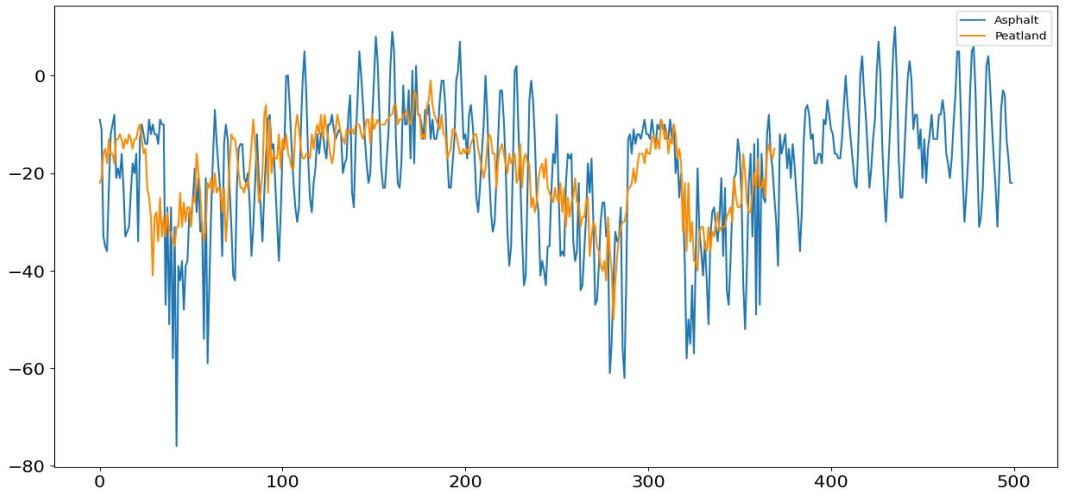


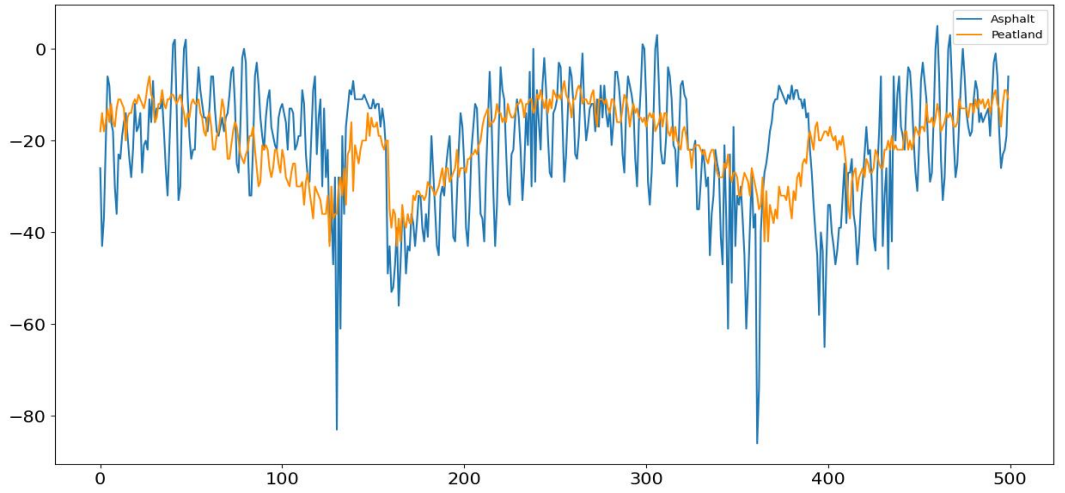


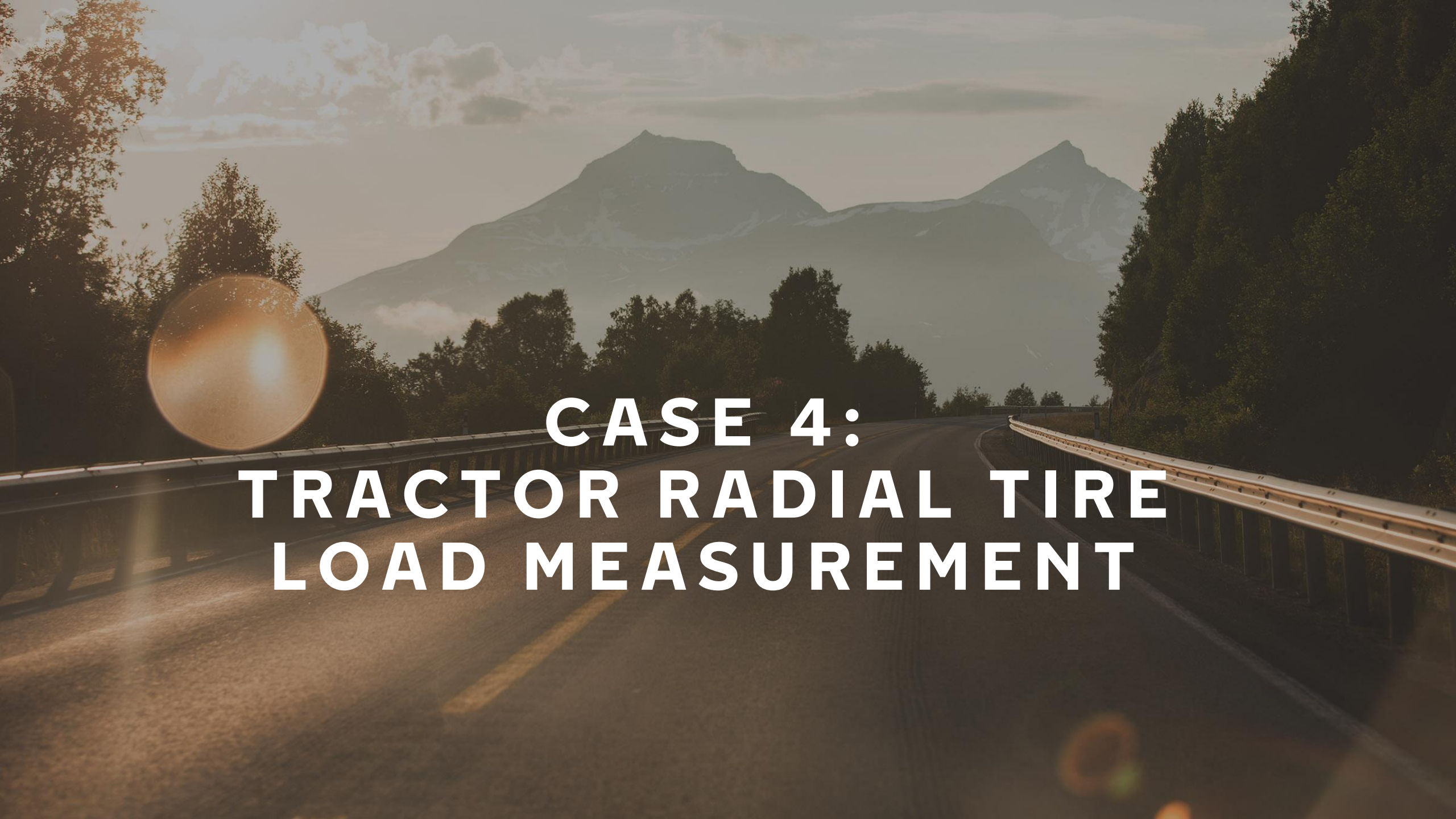
THE SHAPE OF ROAD CONTACT ON DIFFERENT SURFACES

- The leading edge of surface contact is rounder on peat soil than on asphalt.



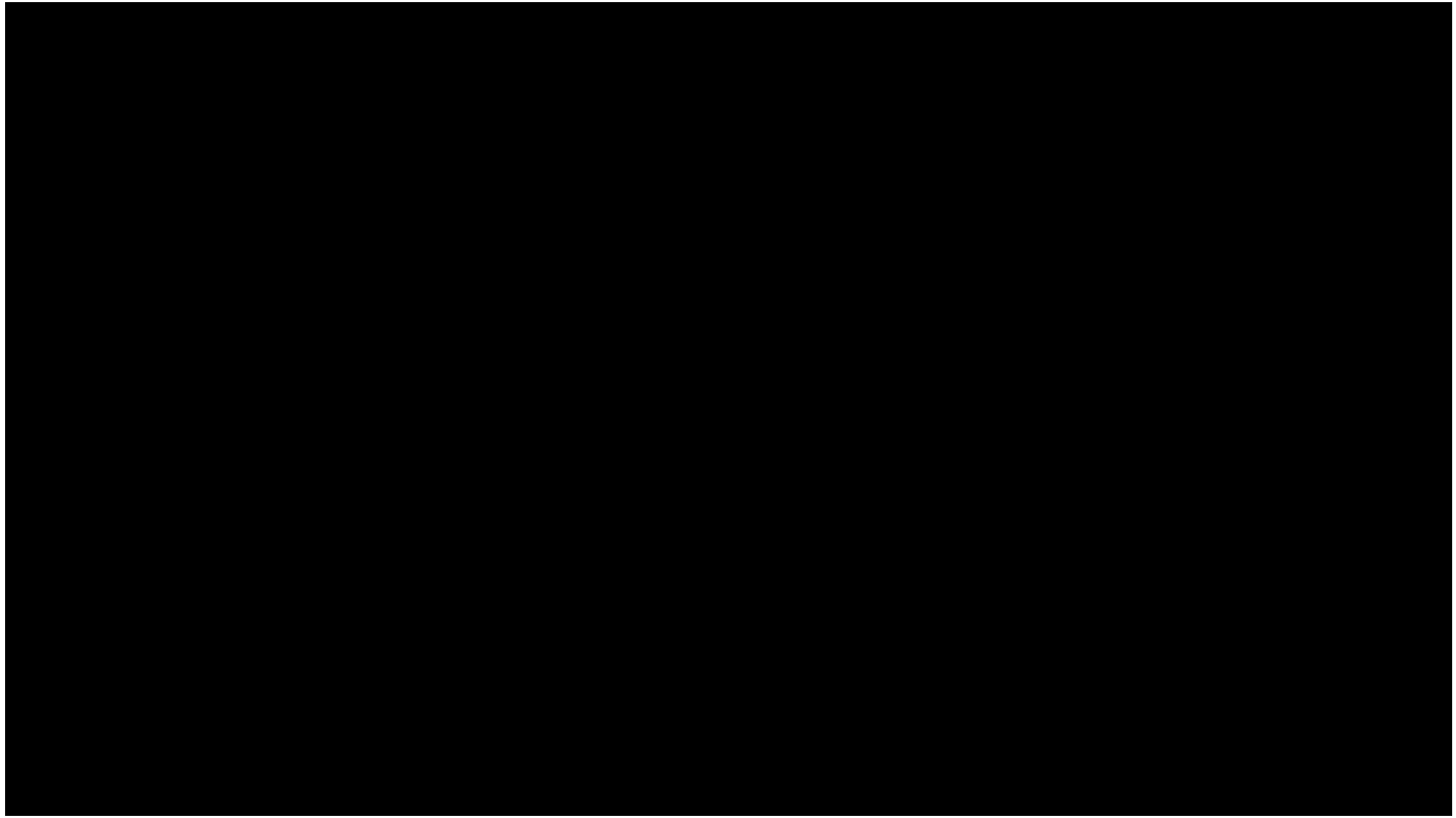






CASE 4: TRACTOR RADIAL TIRE LOAD MEASUREMENT

LOAD SENSING DEMO



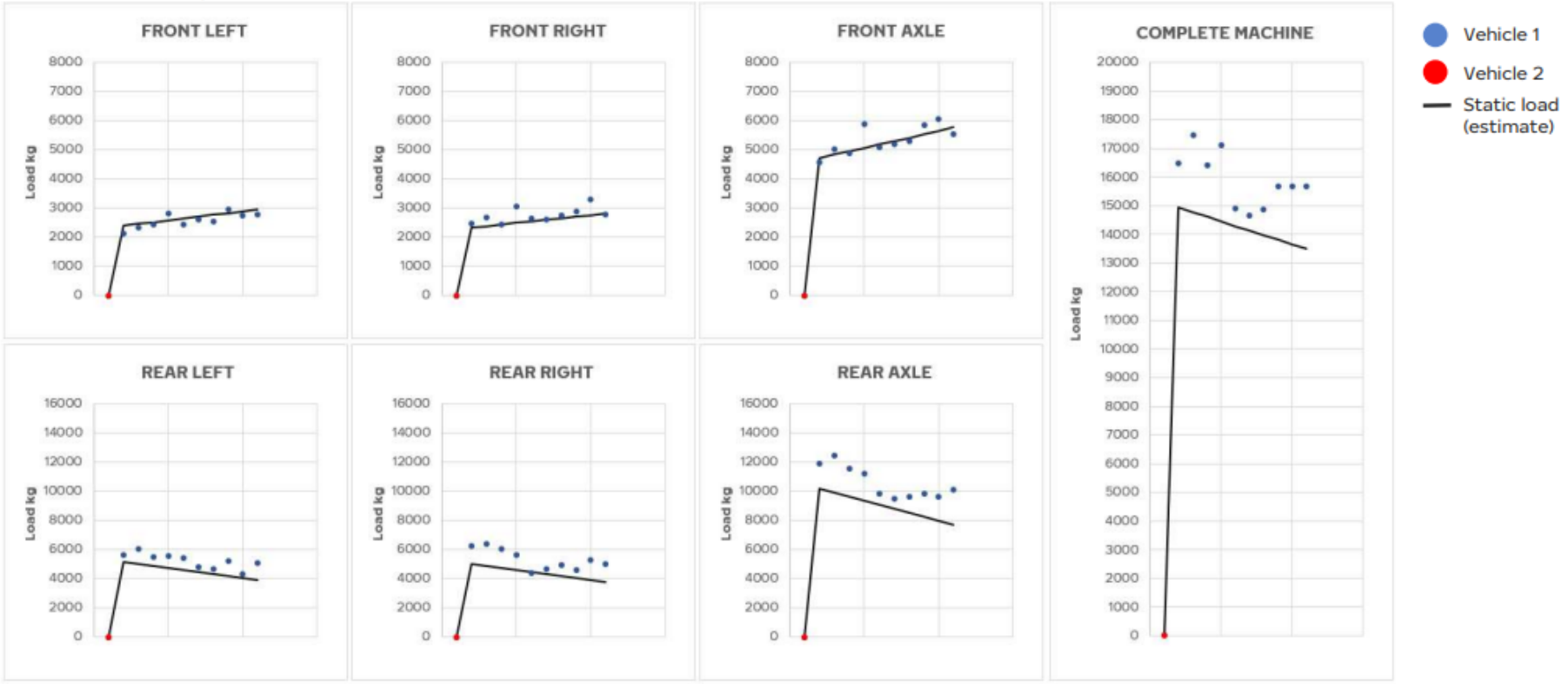
RESULT: GOOD REPEATABILITY AND ACCURACY

Reseach continues on algoritm

High hopes on R&D project start in 2025

HARD SOIL | 1.6 BAR | 25 KM/H

Sensor SW: contact_patch_dec2023-20240214-36541 | Load matrices 04052024_0311



FIELD OPERATION DEMONSTRATION

Results can be utilized for e.g. inflation pressure optimization

FRONT TIRES COULD HAVE 0.8 BAR, NOT 1.6 BAR

LOAD CAPACITY FOR TRACTOR, KG

Pressure (kPa)	Speed (km/h)													
	0	5	10	15	20	25	30	35	40	50	55	60	65	70
60	6440	3470	3080	2940	2910	2885	2855	2830	2800	2800	2800	2800	2800	2550
80	7475	4030	3575	3415	3380	3350	3315	3285	3250	3250	3250	3250	3250	2960
100	8625	4650	4125	3940	3900	3865	3825	3790	3750	3750	3750	3750	3750	3415
120	9775	5270	4675	4465	4420	4380	4335	4295	4250	4250	4250	4250	4250	3870
140	10925	5890	5225	4990	4940	4895	4845	4800	4750	4750	4750	4750	4750	4325
160	11845	6385	5665	5410	5355	5305	5255	5200	5150	5150	5150	5150	5150	4685
180	12535	6760	5995	5725	5670	5615	5560	5505	5450	5450	5450	5450	5450	4960
200	12880	6945	6160	5880	5825	5770	5710	5655	5600	5600	5600	5600	5600	5095

Increase the inflation pressure by 40 kPa (0,4 bar , 7 psi) for : Extensive road driving and use on slopes with inclination more than 20%. Do not exceed maximum pressure. In dual formation the load capacity is 0,88 x single tire load capacity per tire. For high torque field application use 30km/h line. 60kPa (0,6 bar , 9 psi) low torque application only.

https://products.nokiantyres.com/en/system/certificate-pdf/?id=T445769&pdf=1&units

THANK YOU!

For further information, please contact
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