The SOILAssist Sensor System

Dynamic Changes of Wheel Load and Mean Contact Area Pressure during Ploughing and Sugar Beet Harvest

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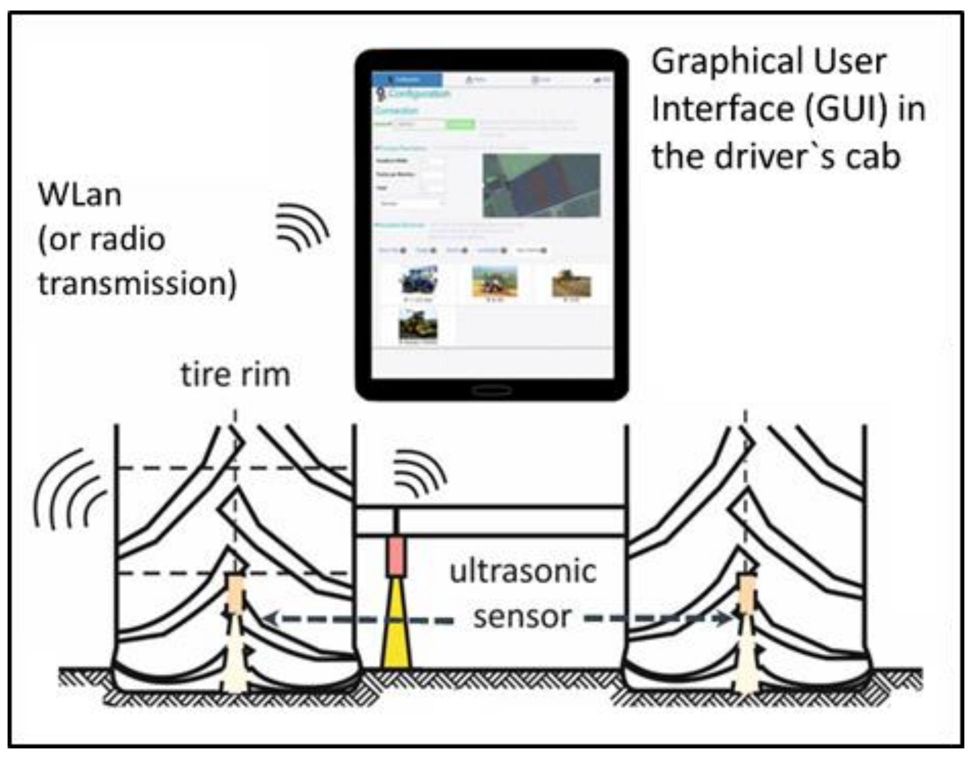
Background and Aim

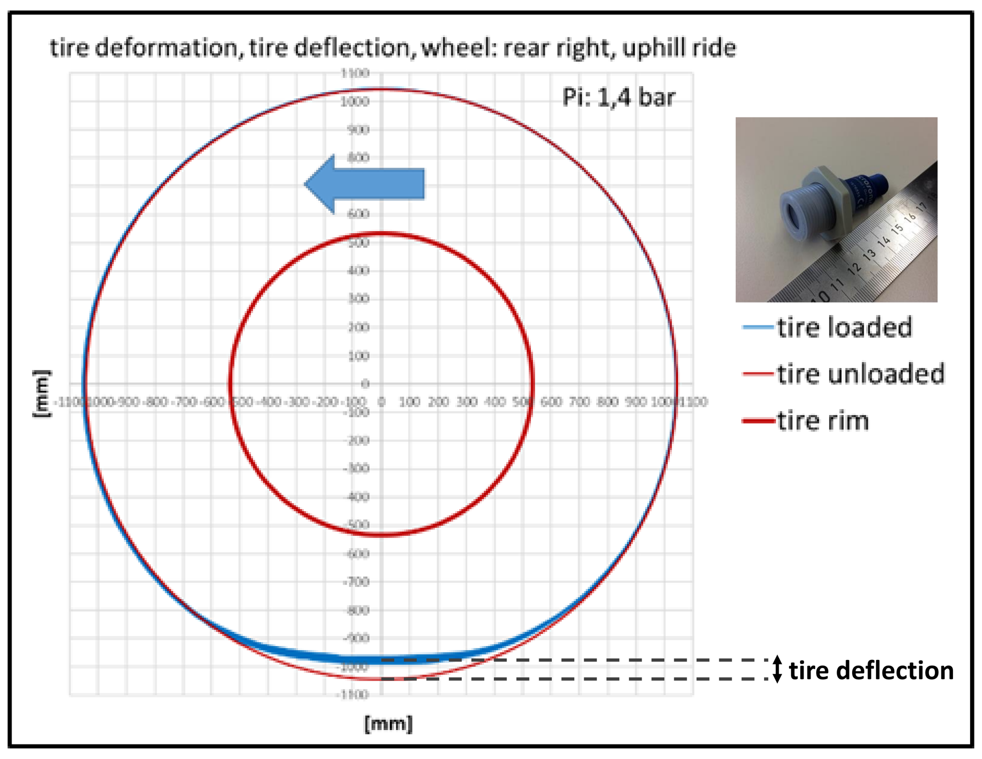
Sizes and masses of agricultural machinery increased steadily over the past years and decades. Especially under moist soil conditions, high wheel loads of agricultural machinery and repeated wheel passages can cause soil deformation, harmful soil structure damages, and persistent subsoil compaction. Wheel load and contact area pressure are often assumed to be static. Usually wheel load and contact area (and contact area pressure) are determined by static weighing (e.g. portable scales) and static measurement of the contact area (soil-tire). In practice, both are highly dynamic and change continuously e.g. during harvest.

The aim was to develop a sensor system to determine dynamic wheel load and mean contact area pressure during field traffic.

The SOILAssist Sensor System



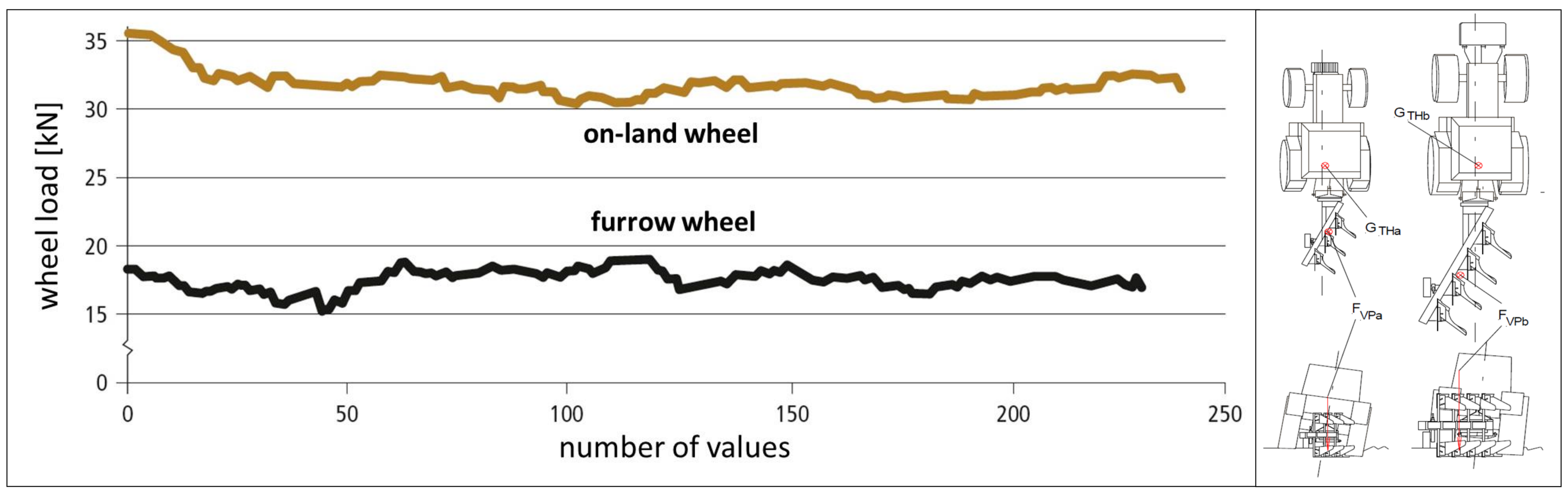
Ultrasonic sensors in the tire rim and under the axles



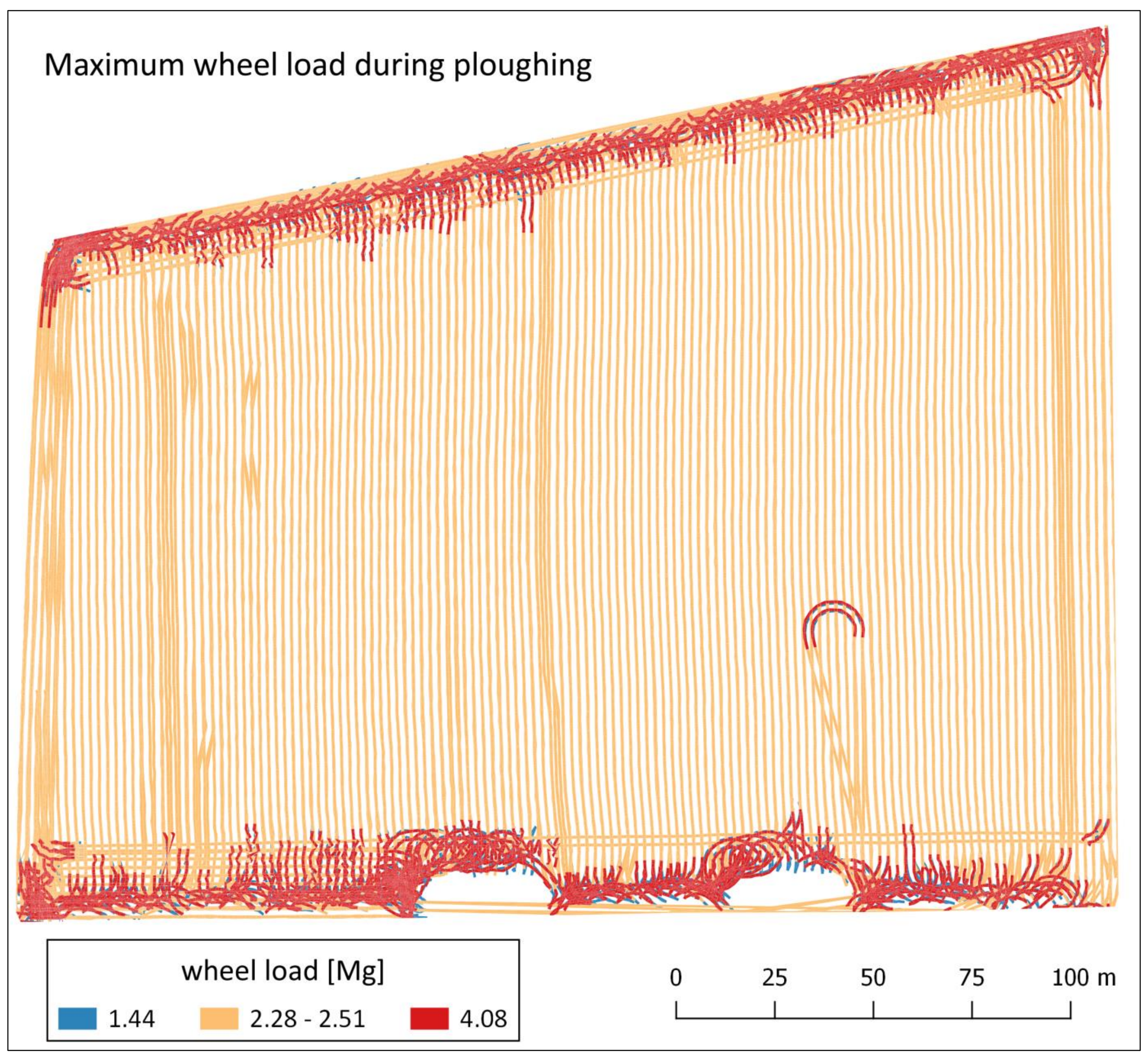
Tire deflection of a Michelin 710/70 R 32 tire during field traffic

Results during Ploughing

First results of sensor measurements during ploughing showed that the load distribution between onland-wheel and furrow wheel of the pulling tractor highly depends on the working width of the plough. For ploughs with ≥ 4 plough blades, the maximum wheel load is on the on-land wheel (60:40), for ploughs with ≤ 3 plough blades the opposite is true (40:60).



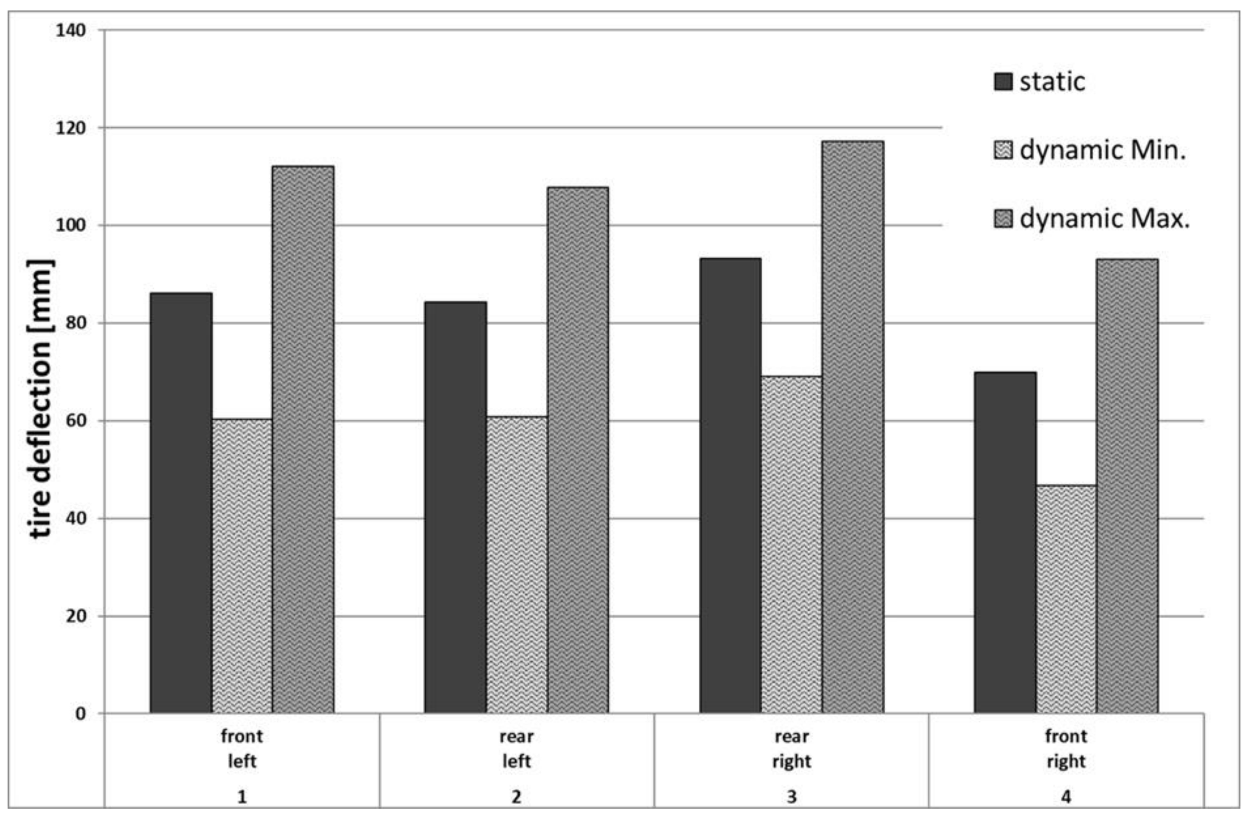
Load distribution between on-land wheel and furrow wheel during ploughing with a 4-blade plough



Spatial distribution of maximum wheel load during ploughing after sugar beet harvest (Augustin et al. 2019)

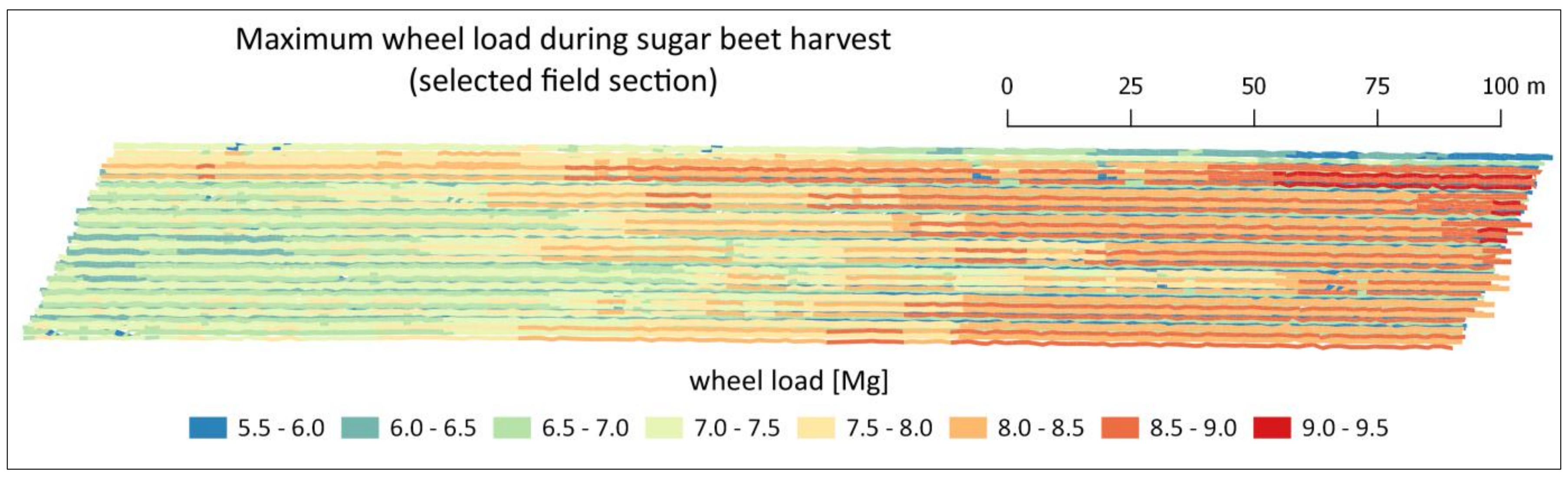
From the soil compaction point of view, it is not only the load distribution during ploughing, but the maximum wheel load at the headlands. The wheel load of the rear wheels of the tractor can be up to 45% higher (approx. 1.5 - 1.8 Mg) when the plough is lifted at the headlands compared to the wheel loads during ploughing.

Results during Sugar Beet Harvest



Static and dynamic tire deflections during sugar beet harvest with full bunker

In addition to the dynamic wheel loads, the spatial distribution of the maximum wheel load in the field plays a decisive role when considering soil compaction processes on field or regional scale. The maximum wheel load during sugar beet harvest was determined with the Field Traffic Model (FiTraM) by Augustin et al. (2019). With the results of the sensor system, spatial differences in wheel load, wheel load distribution, bunker filling, and yield can be derived for the entire field or several fields.



Spatial distribution of maximum wheel load during sugar beet harvest

The comparison of static weighing with portable scales and dynamic weighing with the sensor system during harvest showed, that the dynamic wheel load can be up to 33% (26 – 33%) higher (or lower) than the static wheel load for a short time. The corresponding dynamic mean contact area pressure can be up to 20% higher (16 – 20%) than the static values for a short time.

Conclusions

Dynamic wheel load and contact area pressure can be significantly higher than the static values, even for a short time. In addition, their spatial distribution in the field in combination with the number of wheel passes plays a decisive role when considering soil compaction processes on field or regional scale. This is a prerequisite for a more precise understanding of soil compaction processes in agriculture.

SOILAssist is part of the German research program 'BonaRes'

This project is supported by BMBF BonaRes (grant no. 031A563A / 031B0684A)

SPONSORED BY THE Federal Ministry of Education and Research

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