Cornelia Weltzien, Fabian Graefe and Hans-Heinrich Harms, Brunswick

An Assistance System for Overloading

Results from Two Years of Research

In order to exploit the potential for automating the overloading process, an assistance system for overloading agricultural goods (ASÜL) was developed at the Technical University in Brunswick, within the framework of a DFG-funded project (German Research Society). During the two year project, tests were conducted to determine to what extent ASÜL allows automatic overloading. The main focus was first on developing strategies for automatically filling the transport unit. Subsequently, workload reduction for the driver was evaluated by ASÜL, as well as the system's ability to guide the flow of the chopped material.

Dipl.-Ing. (FH) Cornelia Weltzien is scientific employee at the Institute for Agricultural Engineering and Fluid Power, TU Braunschweig (Head: Prof. Dr.-Ing. Dr. h.c. H.-H. Harms), Langer Kamp 19a, 38106 Braunschweig; e-mail: *c.weltzien@tu-bs.de*
Dipl.-Ing. Fabian Graefe is scientific employee at the Institute for Control Engineering, TU Braunschweig (Head: Prof. Dr. W. Schumacher), Hans-Sommer Strasse 66, 38106 Braunschweig;
e-mail: *Graefe@ifr.ing.tu-bs.de*

The research Project was funded by the German Research Society (DFG) and supported by the company CLAAS, which supplied a self-propelled harvester. The development of the GPS system was executed in a co-operation with the company Geo++.

Keywords
Overloading, loading process control, more driver comfort

High attention and concentration by the operators is required during the overloading process. These demands increase at higher working speeds with higher-capacity machines and with larger transport units. For this reason the Institute for Agricultural Engineering and Fluid Power, in cooperation with the Institute for Control Engineering, has developed an assistance system for overloading agrcicultural goods (ASÜL). The ASÜL determines the relative position between the harvester and the transport unit (*Fig. 1*). Taking the relative position as input value, the system calculates the target point for the stream of chopped material. A loading process control is constantly moving the target point position within the trailer in order to ensure even loading, thus the transport volume can be utilised to full capacity. A driver guidance system indicates the ideal relative position for the transport unit. The operator has to adapt the position of the transport unit by driving slower or faster [1, 2, 3].

Material and Methods

Field tests were carried out with the ASÜL for harvesting grass and maize for silage production. The aim was to prove the functionality of the ASÜL and to develop a loading strategy. During the first year of field tests the focus was on the accuracy of reaching the target point, the reduction of losses and optimal utilisation of the transport capacity. The second year the focus was on the reduction of the workload for the operators, for which the most promising loading strategy was selected.

Three experiments were carried out during each test series. First, the filling was executed manually and the tractor driver had sole control of the loading. The automatic was turned off and the operator of the harvester was not to assist by any means.

This was followed up by a test with the automatic turned on, but without any loading strategy running. The chute was aimed at a single target point in the trailer. During this test the relative position of the transport unit was varied in order to determine the dynamics of the chute control.

Finally the quality of the the automatic loading control with the fully functional ASÜL was tested. The criteria for this test were the even distribution of the material and the optimal utilisation of the transport capacity.

Results

The functionality of the ASÜL was proved under field conditions. The GPS technology, which is utilised for the determination of the relative position, is dependant on environmental conditions. Shading caused by trees led to signal loss during the field tests. The relativ accuracy of the GPS system is within a centimetre range.

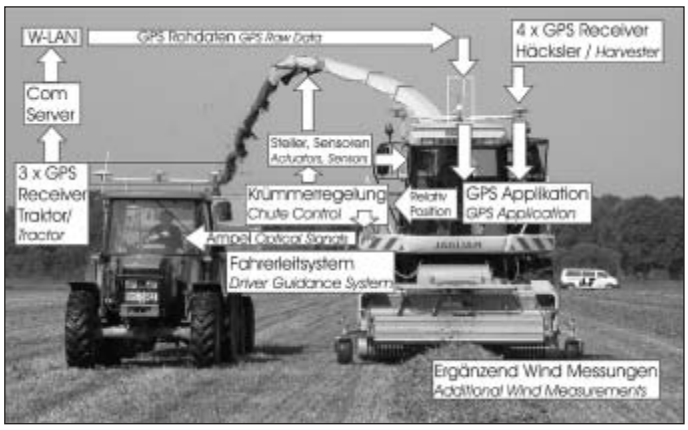

Fig. 1: Set-up of the assistance system for overloading agricultural goods (ASÜL)

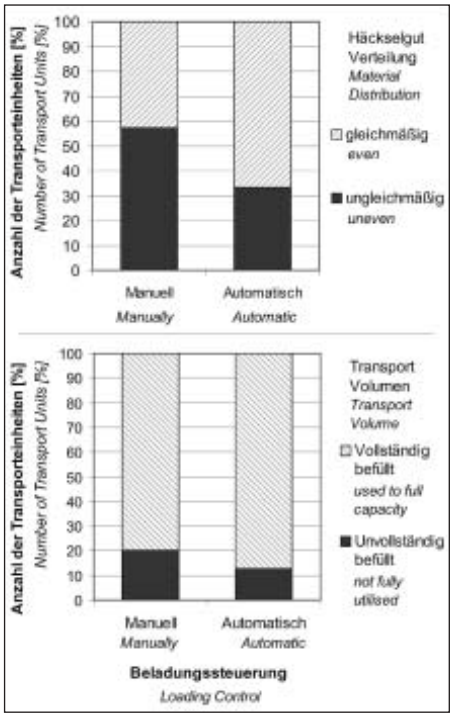

Fig. 2: Filling of the transport units; above: distribution of the material flow, below: utilisation of loading volume capacity

The ASÜL can be applied while driving parallel, in straight lines or curves, and even during the turning at the headlands. The aiming accuracy of the system depends on the distance from the target. The mean and maximum working range during the tests was a radius of 9 m and 14 m, respectively and the errors of the target points were 0.3 m and 0.5 m respectively. To ensure that the stream of material lands on the trailer, it is advisable not to aim too close to the trailer side panels.

With only negligible losses the transport capacity can be utilised better with the ASÜL than without. Due to the fact that the material is distributed more evenly with the automatic filling, the average of all trailers shows higher loads (*Fig. 2*). However, the results vary to such an extent between the individual trailers that this only shows a trend as the results are not statistically reliable.

Driver Convenience

The standardised NASA-TLX questionnaire has been used to determine the workload of the tractor driver [4, 5, 6]. A reduction of the workload could clearly be shown (*Fig. 3*). The danger of missing the smaller transport unit is greater than when loading larger trailers and thus increasing the workload. Untrained drivers tend to be more stressed by the task of driving the tractor parallel to the harvester than by the task of controlling the loading process itself. Although the system alleviates the driver's burden, he is only guided by the system and still has to drive. Therefore the reduction of the workload is greater for the skilled than for the untrained driver.

Demand and Benefit

A survey of contractors showed a strong interest in an assistance system for overloading. The main incentive would be an increase in harvesting capacity, which would go hand in hand with the increased convenience for the drivers. Contractors would be willing to invest between 1000 € and 8000 € for such a system.

So far there is no reliable data available concerning the price of such a system. For the feasibility analysis the maximum of what the contractors were willing to spend was used as an estimated price. Because of the reduced workload, the working speed can be increased [7]. Assuming an increase of 0.25 km/h in average working speed and an annual chopping capacity of 1300 ha, the system could amortise itself in less than six years.

Conclusions

During field tests the functionality of the ASÜL as well as the reduction of the workload for the drivers could be proven. Contractors showed a strong interest in the system, the main benefit of which is expected to be the higher working speeds resulting from increased driver comfort.

The ASÜL can already aid in relieving the driver's burden, however, the degree of workload reduction depends on the loading strategy selected. In order to further reduce the stress on the driver the overloading process has to be automated completely. In order to achieve this goal, the loading of the transport unit has to be controlled in accordance with the filling level. The next step is the integration of a filling level sensor into the ASÜL. At this point of time a filling level detection system FILLED is being developed at the TU-Braunschweig [8]. Furthermore alternative sensor concepts have to be tested to determine filling levels and relative positions. Another approach could be the development of an overloading control system based on software models of the filling process.

Literature

[1] *Wallmann, G., und H.-H. Harms*: Assistenzsystem zur Überladung landwirtschaftlicher Güter. Landtechnik 57 (2002), H. 6, S. 352-353

[2] *Weltzien, C., F. Graefe, I. Bönig und H.-H. Harms*: Automatisierung des Überladevorganges am Feldhäcksler. Landtechnik 59 (2004), H. 4, S. 260 - 261

[3] *Weltzien, C., F. Graefe, I. Bönig und N. Diekhans*: Automatisierte Überladung bei selbstfahrenden Feldhäckslern. Tagungsband 62. VDI-MEG Jahrestagung Landtechnik, 7. und 8.10. 2004, Dresden, VDI-Berichte Nr. 1855, 2004, S.123 - 130. ISBN 3-18-091855-1

[4] ISO 17287:2003, Deutsche Fassung EN 17287:2003. Ergonomische Aspekte von Fahrerinformations- und Assistenzsystemen. Verfahren zur Bewertung der Gebrauchstauglichkeit beim Führen eines Kraftfahrzeuges

[5] *Hart, S.G., and L.E. Staveland*: Development of NASA-TLX (Task Load Index): Results of empirical and theoretical research. In: Hancock, P.A.; Meshkati, N. (Hrg.), Human Mental Workload. Elsevier Science Publishers B.V., North-Holland, 1988, pp. 139-183

[6] *Vejvoda, M., A. Samel, H. Maaß, N. Luks, A. Linke-Hommes, M. Schulze, L. Mawet und H. Hinninghofen*: Untersuchungen zur Beanspruchung des Kabinenpersonals auf transmeridianen Strecken. DLR-Forschungsbericht ISRN, DLR-FB-2000-32, 2000, S.14-16, Abrufbar unter: http://www.dlr.de/me/publikationen/abstracts/fbkabine2000-32b_ge.pdf

[7] *Feiffer, A.*: Lenkhilfen sind echte Hilfen. Lohnunternehmen, 60 (2005), H. 7, S. 26 - 20

[8] *Graefe, F., C. Weltzien, W. Schumacher und H.-H. Harms*: Füllstandsermittlung zur automatisierten Überladung bei selbstfahrenden Feldhäckslern. Beitrag im Tagungsband 63. VDI-MEG Jahrestagung Landtechnik, 4. und 5. 11. 2005, Hannover, VDI-Berichte, 2005

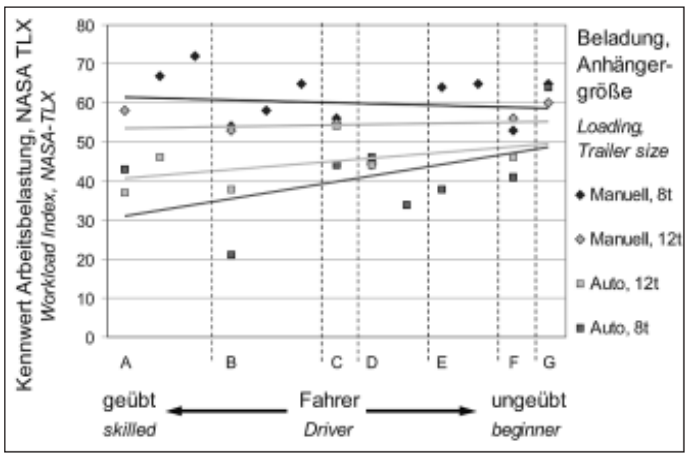

Fig. 3: Subjective assessment of tractor driver's work load according to NASA-TLX procedure; an increasing index indicates a higher work load