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# Rationalization of applications planning and scheduling for mobile working machines

Agricultural value-added processes are regarded isolated. There is no integrated view on the current value chain with its material, information and financial flows. This leads to unique optima, which in sum are lower than a global optimization of the whole value chain. Therefore, the goal should be an efficient resource allocation along the whole supply chain. The „MaisApp", introduced here, can be used as a manufacturer independent instrument in order to improve the applications control of modern and capital-intensive machines.

**Keywords**
Supply chains, applications planning, scheduling, job processing, smartphone

**Abstract**
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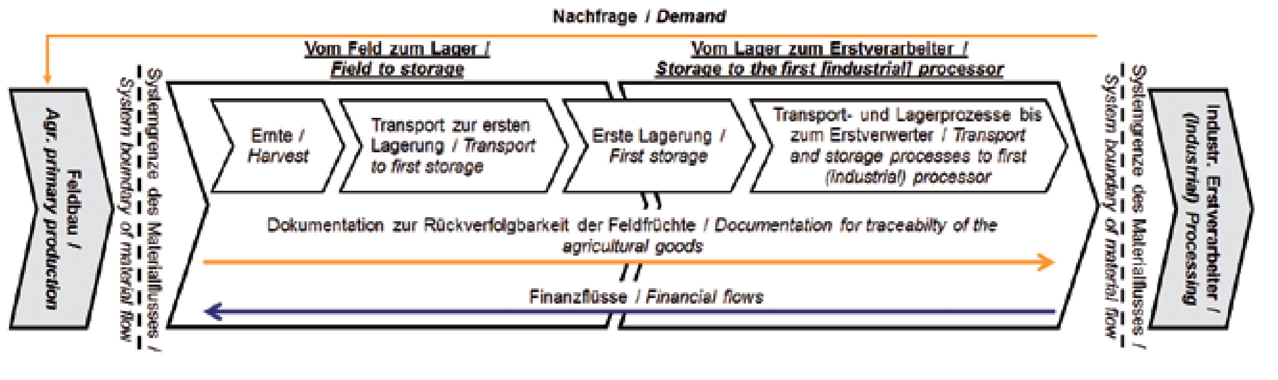
The University of Applied Science Osnabrück is developing practice-oriented approaches to procure technical and organizational improvements in the agricultural value chain. This is done in the framework of the research project "Decision strategies and communication structures for cooperating mobile machines" (KOMOBAR) promoted by the working group AGiP (Arbeitsgruppe innovative Projekte). The research focus KOMOBAR is divided into three sub-projects with different technical emphases. The sub-project "Logistic" analyses the operative logistic processes and deals with the development of new business and cooperation models using an economic point of view. In doing so, it can revert to the results of the sub-project "IT/Technology" which develops and implements technical solutions such as self-organized distributed communication platforms as well as self-configuring and optimizing communication-gateways. The sub-project "User-orientation" ensures the transferability of the generated solutions into the agricultural practice. With this interdisciplinary approach, new perspectives that are contributing to the development of holistic solutions are found. KOMOBAR focuses on agriculture. The starting point is the interface between the agricultural primary production and the (industrial) processing. Actors who are involved in these production steps are regarded by KOMOBAR as parts of an integrated supply chain with material, information and financial flows whose overall performance shall be optimized (**Figure 1**).

The supply chain has been divided into two sub-processes to provide a better limitation of the different problems. The sub-process "Field to storage" addresses the harvest in the narrower sense. It starts with the planning of the harvest and ends, from an organizational point of view, with the first planned storage of the harvested goods within the material

Fig. 1




*Detail of the value chain within the scope of KOMOBAR* flow [1]. This is intentionally interrupted with the aim of decoupling the preceding and subsequent process steps [2]. The requirements for the transaction of the work process that are explained above are already in the focus in this sub-process. So far, the planning of the order sequence of contractors, as well as the corresponding disposition of machines and operators, is done only with rudimentary assistance from IT systems. The transferability of well-established industrial solutions such as production planning and scheduling systems [3; 4; 5; 6; 7] to the agriculture is not necessarily available. This is due to specific constraints such as the weather dependency, the especially strong peak load at specific times or the quantitative asychronism between harvest, treatment and processing. Therefore, a decision support system is developed within the scope of KOMOBAR, making the exemplarily named constraints operable and improving the applications planning and scheduling for task dispatchers at contractors. Using a wide range of methods such as qualitative cross-sectional analysis or experiments, all persons involved in the scheduling as well as their strategies and requirements that are relevant for the planning are identified. Likewise, all persons involved in the field of the operations management and their decision-making structures, as well as all relevant constraints, have to be identified and classified. These can differ for example when regarding the time of occurrence (during the planning and/or scheduling), the duration or the expected effects on the order processing and may require different counteractions.

The second sub-process of the supply chain addresses the transport from the first storage to the first (industrial) processor. In contrast to the aforementioned sub-process, the economical demands on the job processing in this area in practice are emerging more slowly. A first step is for KOMOBAR to record and display the actual process. Based upon the process mapping, the possibility of employing specialized logistic service providers is tested. Problems arise when highly variable transport volumes, due to different harvest requirements, have to be handled together with fluctuating freight capacities that have to be generated.

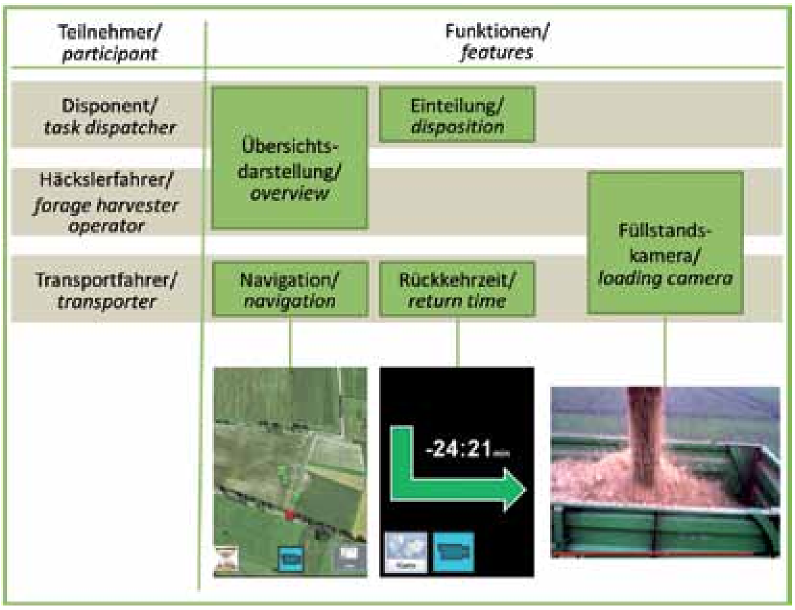
Apart from the two sub-processes forming the operative job processing, the aspects that are encroaching upon the whole supply chain are regarded separately. Examples are the influence of the (end customer) demand, the documentation and the traceability and processing of the financial flows.

## First application solution “MaisApp”

The “MaisApp” is an assistance system steering the operation of forage harvester convoys and giving all involved operators process information in an uncomplicated way. As described here in the tested stage of development of the “MaisApp”, an optimal scheduling of the harvest is guaranteed. Disturbances, e. g. a lack of transporters, are quickly identified by using contextual information and can be dealt with. The principles for the development of the “MaisApp” are geared to the following theses which are derived from observational studies:

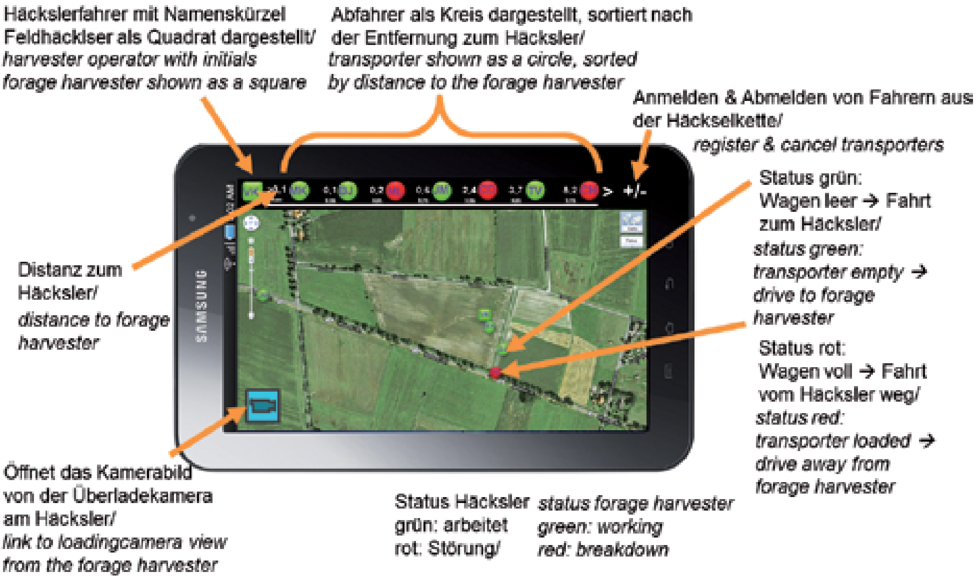
- The smartphone technology is the perfect hardware basis as it is inexpensive and independent from the manufacturer. Due to its popularity there are virtually no extra costs.
- It is important to focus on the essential functionalities. If any goal conflicts concerning this matter evolve, they shall be solved by reducing the range of functions.
- The consumer acceptance increases if there are no direct instructions for the scheduling of the process chain. The operators make their own decisions, whilst being supported by contextual information.

Fig. 2




*Schematic diagram of the „MaisApp“*

Fig. 3




*„MaisApp" overview for the forage harvester operator*

Considering the harvesting principles, a prototype of the "MaisApp" was developed and tested during the harvest 2011. A schematic diagram of the functions can be found in **Figure 2**. The conceptual and technical implementation can be summarized as follows:

- The "MaisApp" is a web-based application running on every system software (iOs, Android, Windows mobile,...).
- There are three user types (forage harvester operator, transporter, task dispatcher), each of whom are assigned an own user interface. The user type is recognized when logging in.
- The range of functions was reduced to the navigation, the information about the filling level of the forage harvester using a WLAN camera and the return time of the transporter to the forage harvester.

**Figure 3** shows a user interface for the forage harvester operator. Apart from the task dispatcher, the forage harvester operator can also decide about the forage harvester convoy and add or remove transporters during the day of harvest (header). All participants of the forage harvest convoy are listed and sorted according to their distance from the forage harvester. The transporters are represented by circles and the forage harvester by a square containing the operator's initials. The color of the icons gives information about the status of the vehicles and is entered via the user interfaces of the operators. In case of a breakdown or for the purpose of information exchange, a mobile phone connection to the corresponding operator can be arranged by touching the icon.

In the "MaisApp" it is possible to select a camera view via another visualization interface. This transmits the view of a camera attached to the discharge spout of the forage harvester (**Figure 4**). This image is sent to all logged-in users via WLAN. For this purpose, a WLAN router is installed on the forage harvester and connected to the camera. In addition to the WLAN exchange, the images are sent to a server via GSM. Vehicles in the direct WLAN range use an ad-hoc communication whilst those beyond the WLAN range use the GSM connection. In the field test ad-hoc connections to the WLAN have been possible for distances of 300 m and more.

Additionally, the transporters can select the display of the return time. This is approximated by using the actual and the last loading times of all transport units in the forage harvester convoy. The loading times were investigated in the harvest 2011 by entering the time at the beginning and the end of the loading on the touch-screen. The same applies for the arrival at the place of unloading.

Abb. 4

*The real time picture of the WLAN camera provided to the whole forage harvester convoy*

## Conclusions

Based on the findings of the corn harvest 2011, the "MaisApp" is to be further developed for the coming season.

- Adaptation of the color code according to the time allotment of the Kuratoriums für Technik und Bauwesen in der Landwirtschaft (KTBL) with regard to process times [8]
- Automatic status recognition of all vehicles, amongst others by a constant analysis of the GPS positions
- Integration of a message system for the easy submitting of standard messages

With regard to the outlined approach to develop a decision support system for task dispatchers at contractors, the described "MaisApp" is an instrument for the scheduling of the work machine. This has to be supplemented by others and should be extended by a preceding applications planning component. The development is based on the modeling/simulation of different harvest scenarios. In these, different constraints are regarded which are to deal with either in the scope of the applications planning or the scheduling.

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## Other tips

AGIP research main focus