Forage Harvest Process Logistics Assessment

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Have you ever viewed your forage harvest operation from the standpoint of logistics? Google defines logistics as "The detailed coordination of a complex operation involving many people, facilities, or supplies." This definition describes the forage harvest process well when considering harvest of haylage and/or corn silage. Machinery involved with forage harvest include mowers, rakes or mergers, a forage harvester (self-propelled or pull-type), transport vehicles (straight truck, tractor trailer, or forage carts), and packing tractors. There is also the consideration of the locations of all this machinery in the field and the storage facility and relative distances between them. Considering the harvest system in terms of logistics, there are several inefficiencies that occur, adding cost to the process. Researchers at the University of Wisconsin-Madison are working toward quantifying these inefficiencies and identifying methods to eliminate them in order to optimize the forage harvest process.

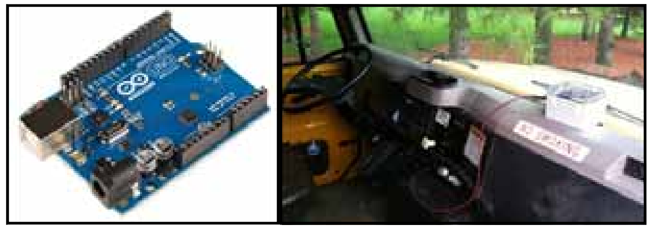

Figure 1. Arduino® open-source micro-controller board (left) and Arduino® GPS data logger system installed in forage transport vehicle.

Figure 2. Vector™ CAN Case XL and Vector™ CAN GPS data logging system (left) and Vector™ system installed on a self-propelled forage harvester.

A single farm operation was considered for this study involving 2 30´ mergers, 2 self-propelled forage harvesters, 10 straight truck forage boxes, and 2 tractor-trailer forage boxes. Data were collected on 4,050 acres spanning rye harvest, 4 cuttings of alfalfa, and corn silage harvest. Global Positioning System (GPS) data were collected on all vehicles involved in the harvest process. This provided location (latitude and longitude), speed, heading/direction, and accurate time. An open-source micro-controller platform (Arduin®) was used in conjunction with a GPS antenna and SD™ card shield for data storage (Figure 1). This system collected GPS data once per second.

On the self-propelled forage harvesters, Controller Area Network (CAN) data were also collected. This provided information such as engine speed, fuel consumption, Power Take-Off (PTO) state, etc. Vector™ CAN Case XL data loggers and Vector™ CAN GPS (Figure 2) peripherals were used to collect the machine data and location data on the self-propelled forage harvesters. GPS data from this system were logged in at once-per-second intervals while CAN data were logged every time a message was produced. The structure of a CAN system prioritizes messages so important fault codes take precedence over standard messages, making timed message transmission impractical. These messages were logged on arrival and associated with accurate time information provided by the GPS system.

Coupling GPS location data on all the machines with CAN and GPS data from the self-propelled harvesters allowed for algorithm defining machine working states to be developed. These states include working (merging, harvesting, or being loaded), idle (waiting, malfunction time, etc.), transport time (hauling to the bunker, field transitions, etc.), and unloading time for trucks and tractor-trailers. Once the times for all of these tasks are known a model can be developed including distance from the field to the bunker, travel speed/loading times for transport vehicles, and transport vehicles required to harvest a particular field.

Practical application of the research results include a calculation tool for farmers and custom operators optimizing resource allocation. For example, by identifying a specific harvester, truck volume, and field location in relation to bunker location, the model could calculate the minimum number of trucks needed to harvest that particular field. If the calculation shows 4 trucks are needed to keep material away from the forage harvester and headed to the bunker, a farmer might allocate 5 to the job just to be sure, but not 6 or 7 trucks with excessive idle time. Furthermore, a telematics system for improved communication between harvester, transport vehicles, and packing tractors could be developed providing optimized return routes for the trucks to most efficiently get back to the forage harvester for loading, thus reducing idle time.

Figure 3 shows the travel paths of mergers, forage harvesters, and transport vehicles in one 60 acre field during a forage harvest operation. The travel paths for mergers and forage harvesters are set for north/south travel, but the transport vehicles followed any path most efficiently pairing them with the chopper again. What impact might this have on soil compaction? Imagine if a new telematics system could provide light-bar type guidance for transport vehicle operators so their travel within the field was limited to specific tram lines. Soil compaction would be limited to those tram lines except for the instances where the truck was alongside the chopper being loaded. Compaction within this field could be greatly reduced, thus, increasing yield and soil health in the process.

Figure 3. GPS located travel paths of all vehicles involved in a forage harvest process.

The machine path control and logistics optimization study at the University of Wisconsin-Madison is providing interesting data for increasing efficiency of the forage harvest process while minimizing the impact of soil compaction within forage fields. The key to optimization is providing improved communication between harvesters and transport vehicles, minimizing travel time and maintaining tram lines within the field for optimal harvest. Having this system in place would ultimately reduce harvest time and maintain soil health, thus, maximizing profit for farmers and custom harvesters.