ON-FARM TRAFFIC OPTIMIZATION FOR INCREASED EFFICIENCY

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Introduction

Management of vehicle fleets is a complex task. Interactions between a harvesting machine, transport vehicles, and a storage site provides the opportunity for introduction of inefficiencies in the harvest process. These inefficiencies translate to an increased cost of harvest. at best. and possibly a reduction in feed quality. Even when ignoring uncontrollable aspects of machinery, such as break-downs, there still exists idle time during the harvest process that can be minimized to improve harvest efficiency. In 2015 the entire forage harvest process on a commercial dairy was recorded using low-cost GPS data loggers. Controller Area Network (CAN) data were also collected on machines that had the data available. Machine working states were defined based on the GPS and CAN data to determine the time each machine spent doing a certain task. Idle time was defined for the harvesting equipment during alfalfa and corn harvest for silage production.

The equipment involved in this harvest operation was two self-propelled forage harvesters (SPFH), 10 straight trucks and 2 tractor-trailers. During the 2015 growing season, data were collected on these machines for 1600 acres of alfalfa (*Medicago sativa*) and over 2000 acres of corn (*Zea mays*). Machine working states for the SPFH were defined by the rules shown in Table 1 and working states for the transport vehicles are shown in Table 2.

The working states and the relationship between the vehicles provided sufficient information to determine the working time and idle time within a field (Fig. 1). Times when the SPFH was working are highlighted in green, travel time is highlighted in blue, idle time are marked as red, and metal detection (delay time) is highlighted as yellow within the figure. Most idle locations marked in the image are less than one minute-long while a “break” idle time (lunch during the working day) lasted over 75 minutes.

Table 1. Machine working state definitions for a self-propelled forage harvester equipped with a controller area network.

State	Identification
Working	Feedroll Speed > 0, Cutterhead Speed >0, Vehicle Speed > 0
Travelling	Feedroll Speed = 0, Cutterhead Speed =0, Vehicle Speed > 0
Idle	Vehicle Speed = 0, but not due to Delayed or NP event
Delayed	Metal Detection = 1
Non-Productive	Any known idle times not related to Idle or Delayed

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Table 2. Machine working state definitions for transport vehicles based on GPS data and SPFH working state.

State	Identification
Working	SPFH is working, Vehicle Speed > 0, Closest Truck to SPFH
Travelling	Vehicle Speed > 0, Not the Closest Truck to SPFH
Unloading	Within Geofence at Unloading Zone
Idle	Vehicle Speed = 0, Not Working/Travelling/Unloading/NP
Non-Productive	Any known idle times not related to Idle or Delayed

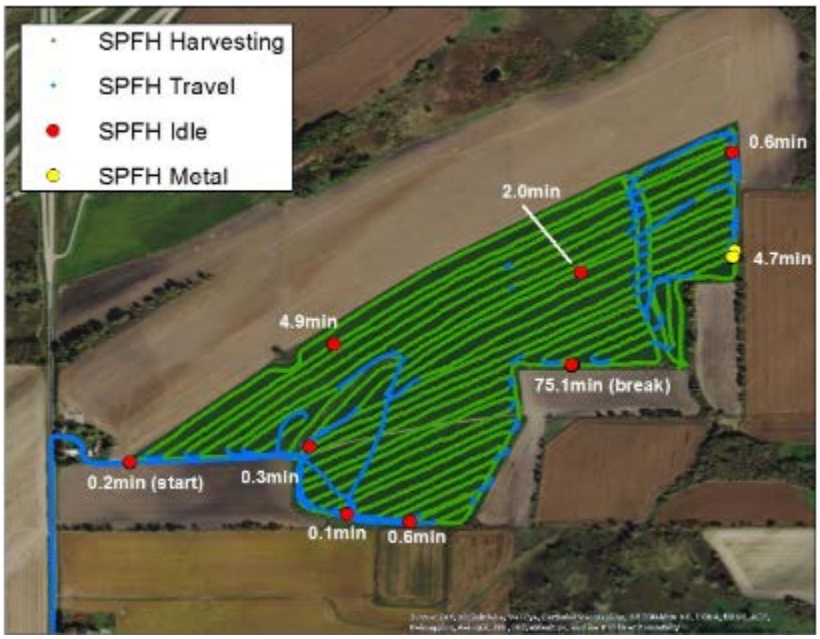

Figure 1. Alfalfa haylage field harvest during 2015. Idle locations and times are highlighted in red during the harvest operation.

Tables 3 and 4 show the harvest efficiency of this operation during haylage harvest and corn silage harvest in 2015. In general, corn silage production was much more efficient than haylage production owing to reductions in travel time, elimination of delay time due to metal detection, and decreased idle time. The harvester was working 54.0% of the operating time during haylage production while during corn silage production it was working 80.1% of the time. Idle time was reduced during corn silage production, by 3%, due to every transport vehicle being in service. Haylage production had a reduced transport vehicle fleet due to the other operation required on the farm like planting other crops.

Table 3. Harvest efficiency for haylage production at a commercial dairy in 2015.

	Minimum	Average	Maximum	Std. deviation
Operation	2.3 h	7.7 h	10.6 h	2.8 h
Harvest	40.0%	54.0%	68.9%	9.6%
Travel	21.7%	29.1%	40.6%	7.1%
Delay	0.4%	1.5%	4.1%	1.4%
Idle	6.1%	15.0%	22.6%	4.9%

Table 4. Harvest efficiency for corn silage production at a commercial dairy in 2015.

	Minimum	Average	Maximum	Std. deviation
Operation	8.2 h	11.9 h	12.8 h	2.2 h
Harvest	65.5%	80.1%	84.9%	7.3%
Travel	4.2%	8.2%	15.6%	4.1%
Delay	0.0%	0.0%	0.0%	0.0%
Idle	5.5%	12.2%	21.9%	5.4%

Minimization of idle time in the forage harvest process helps optimize harvest efficiency. Utilizing sufficient transport vehicles will reduce the time the SPFH is idle. Reductions in non-productive travel time will also produce gains in harvest efficiency.