THE UNIVERSITY OF TENNESSEE KNOXVILLE

CENTER FOR TRANSPORTATION RESEARCH

Autonomous Truck Mounted Attenuator (ATMA) Pilot

August, 2020

TN TDOT Department of Transportation

Agenda

- Project / system background
- Testing procedures
- I-840 and TIM testing
- Current findings
- Future work

VIDEO

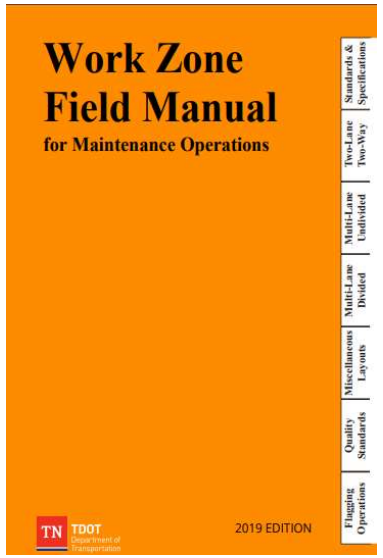
Project Background

Why an ATMA?

- TDOT's goal: Maximize safety in all its work zones to reduce fatalities and injuries,

- Highway workers are routinely being placed at risk driving these trucks "designed to be hit",

- How to consistently keep the required gap distances to the service vehicles? Pavement markings count, range finders…..



Project Background

Objective:

Evaluate performance of ATMA system based on actual testing of the equipment during a demonstration pilot.

Evaluation criteria:

Accuracy, ease of use, applicability to TDOT.

Testing locations:

I-840 – Dickson County

TN Traffic Incident Management Training facility

System Background

System Description

- In operation, the Leader Vehicle (LV) system transmits its position, speed, and heading to the ATMA follower vehicle in a sequential series of Vehicle-to-Vehicle (V2V) “eCrumbs” messages. The ATMA then maneuvers from one eCrumb to the next precisely following the path of the LV at a user-defined vehicle-gap.
- No Wi-Fi, Bluetooth or cellular interface installed on the system.
- The V2V communications system uses a narrowband RF link with frequency hopping technology. The LV and the FLW vehicle have primary and backup transponders, transmitting/receiving the same data on different channels and selecting the best signal for use.
- User Interface to set following distance.
- Absolute GPS data, 15 -18 sattelites.
- The primary navigation system uses a moving-base Real Time Kinematic (RTK) GPS providing centimeter-level accuracy to measure the ATMA position relative to the LV.

- Uses INS (Inertial Navigation System) as backup for RTK (underpasses, heavy foliage, etc)

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Testing Procedures

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Test Scenario	Test Category	Description	Location
3	E-Stop - Emergency Stop	Emergency Stop - Leader Vehicle Internal Button (OCU)	I-840
4	E-Stop - Emergency Stop	Emergency Stop - ATMA Internal Button (OCU)	I-840
5	E-Stop - Emergency Stop	Emergency Stop ATMA External Button	I-840
6	E-Stop - Emergency Stop	Emergency Stop – Leader Independent E-Stop Button (Initiator)	I-840
7	Following Accuracy	Follow Distance Set by User Interface (UI) Panel	I-840
8	Following Accuracy	Following Accuracy on Straight Line	I-840
9	Following Accuracy	Following Accuracy on Slalom Course	I-840
10	Following Accuracy	Lane Change	I-840
11	Typical Applications	Trash Pick-up	I-840
11a	Typical Applications	Herbicide Application	I-840
12	Typical Applications	Pothole Patching	I-840
13	Turning	Turning at I-840	I-840
15	Obstacle Detection	Obstacle Detection - FRONT	I-840
16	Obstacle Detection	Vehicle Intrusion	I-840
22	Other Tests	Speed Test	I-840
24	Other Tests	Braking – Leader Vehicle	I-840
26	Other Tests	Sensitivity to Passing Vehicles	I-840

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Testing Procedures

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Test Scenario	Test Category	Description	Location
23	Other Tests	Bump Test	TDSTC / TIM
27	Other Tests	Leader Reverse	TDSTC / TIM
28	Other Tests	Human vs Machine	TDSTC / TIM
29	Other Tests	Headlights	TDSTC / TIM
30	Other Tests	Cone Detection	TDSTC / TIM
31	Other Tests	Drive Around Loop	TDSTC / TIM
1	System Inspection	Visual Inspection of the System	TDSTC / TIM
2	System Inspection	Inspection of the User Interface (UI) panel	TDSTC / TIM
14	Turning	Minimum Turn Radius	TDSTC / TIM
17	Obstacle Detection	Object Recognition	TDSTC / TIM
18	Communication	Loss of Sensor (Radar, LIDAR, Front Facing Ultrasonic)	TDSTC / TIM
19	Communication	GPS Loss	TDSTC / TIM
20	Communication	Loss of Communication (Single V2V Radio)	TDSTC / TIM
21	Communication	Loss of Communication (Both V2V Radios)	TDSTC / TIM

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I-840 Testing

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TIM Testing

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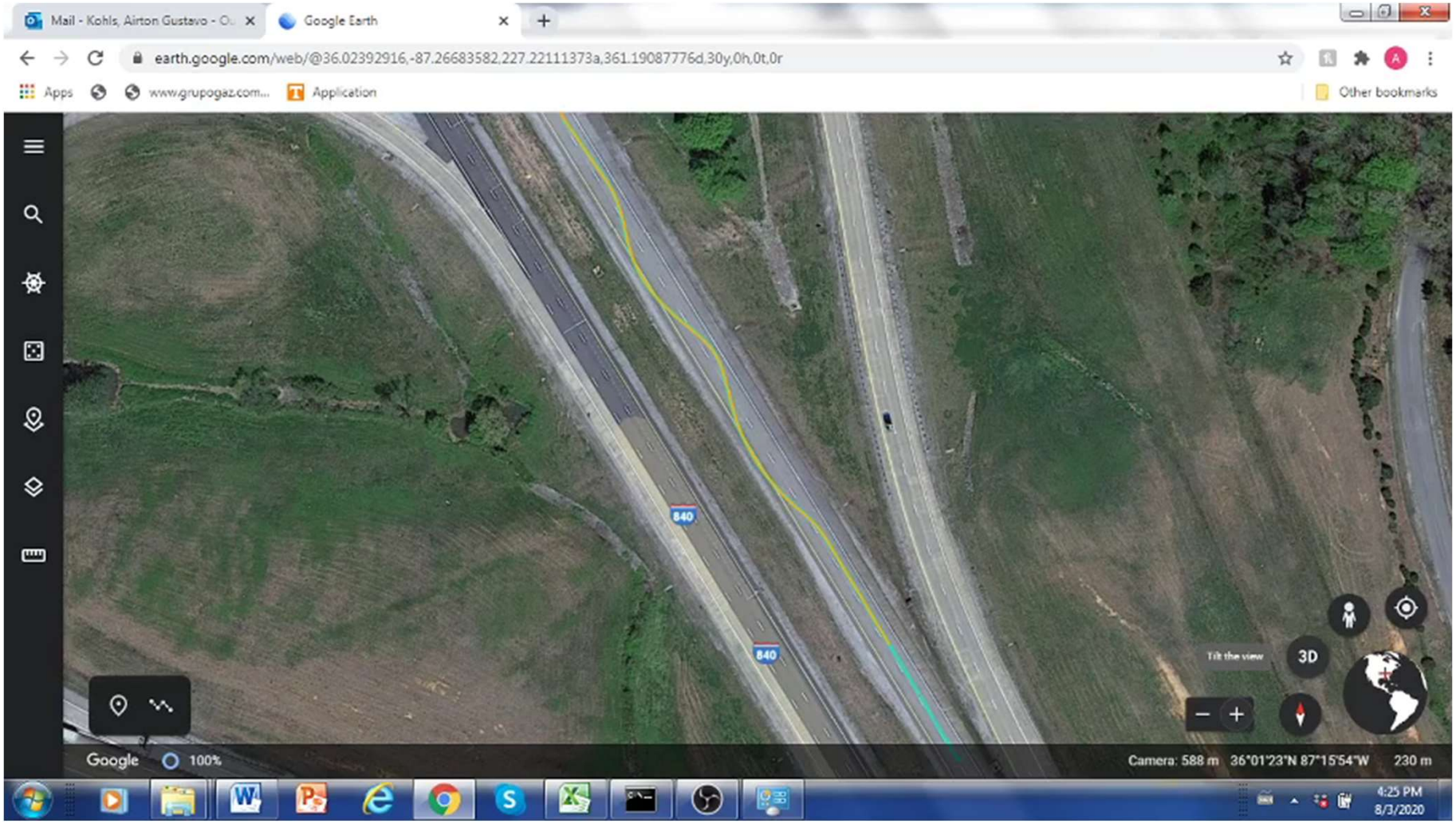
Data Description

.kml files



Current Findings

Layers of redundancy - SAFETY

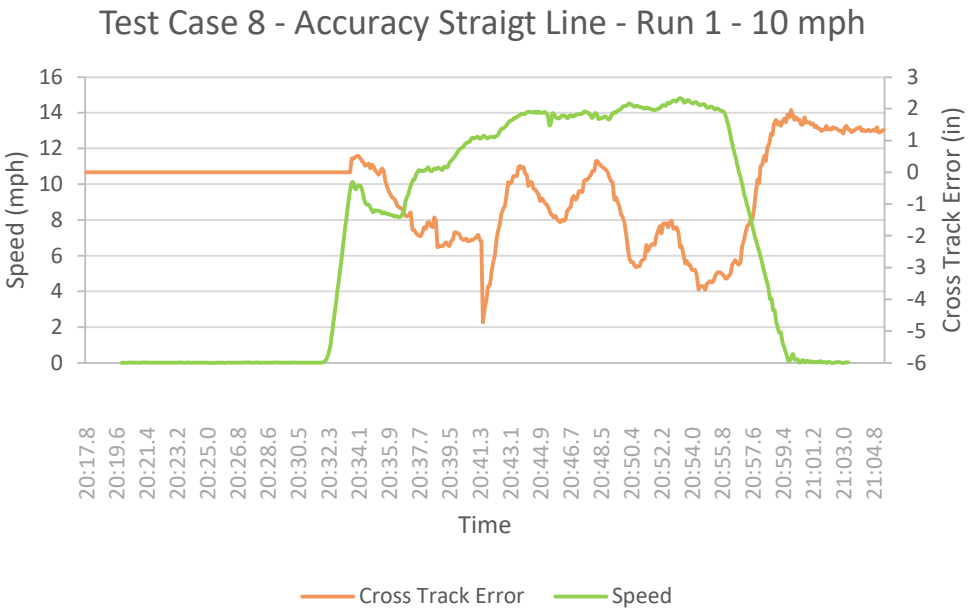
A-stop: internal LDR or loss of communications, object detected, system fault. Stops vehicle, engine is running, can reset FLW.

E-stops: external FLW and internal LDR
Engage brakes and kills the engine

Test Case 4 - A-Stop inside LDR
Gap 100 ft

	Speed - 10mph		Speed - 15 mph	
	RUN 1	RUN 2	RUN 1	Run 2
Stopping Distance:	40'5"	35'5"	75'8"	66'8"
Stopping Time:	4.03 sec	3.68 sec	6.25 sec	5.56 sec

Current Findings



CTE between
-4.72 to 1.96 in

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Current Findings

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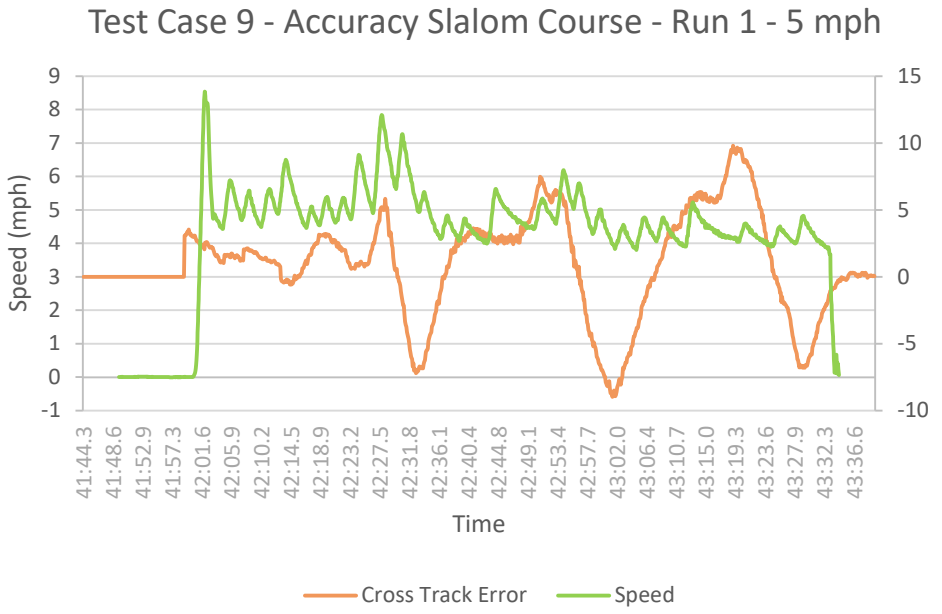
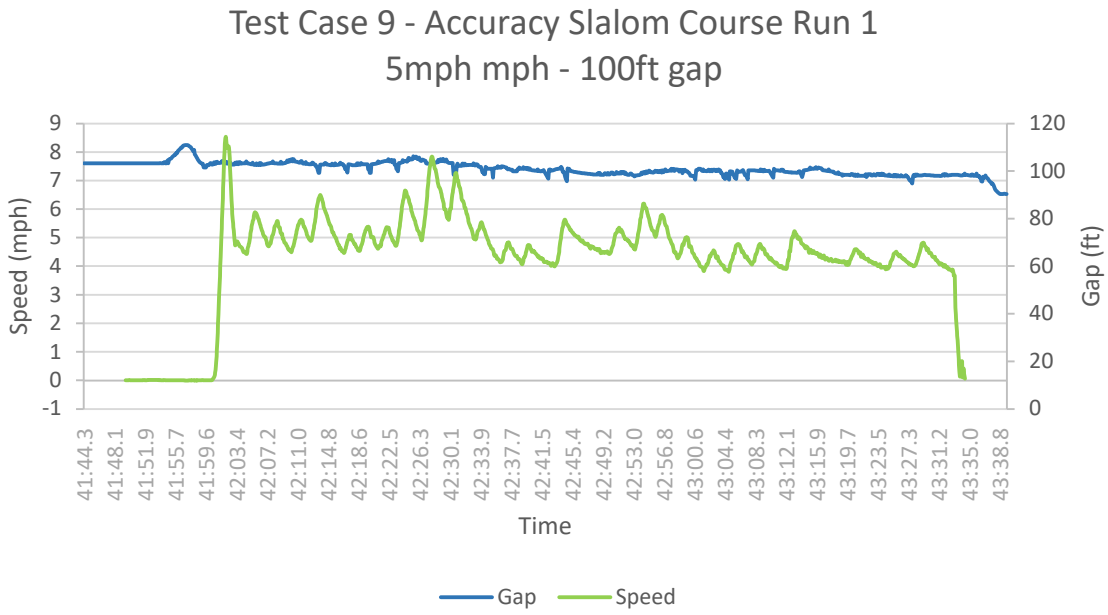


CTE between
-8.97 to 9.80 in



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Current Findings

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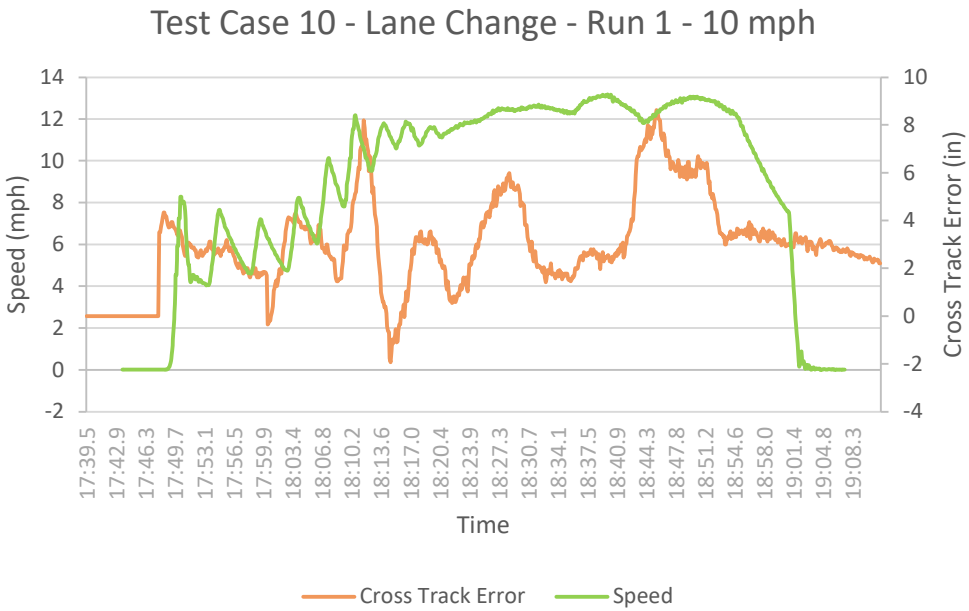


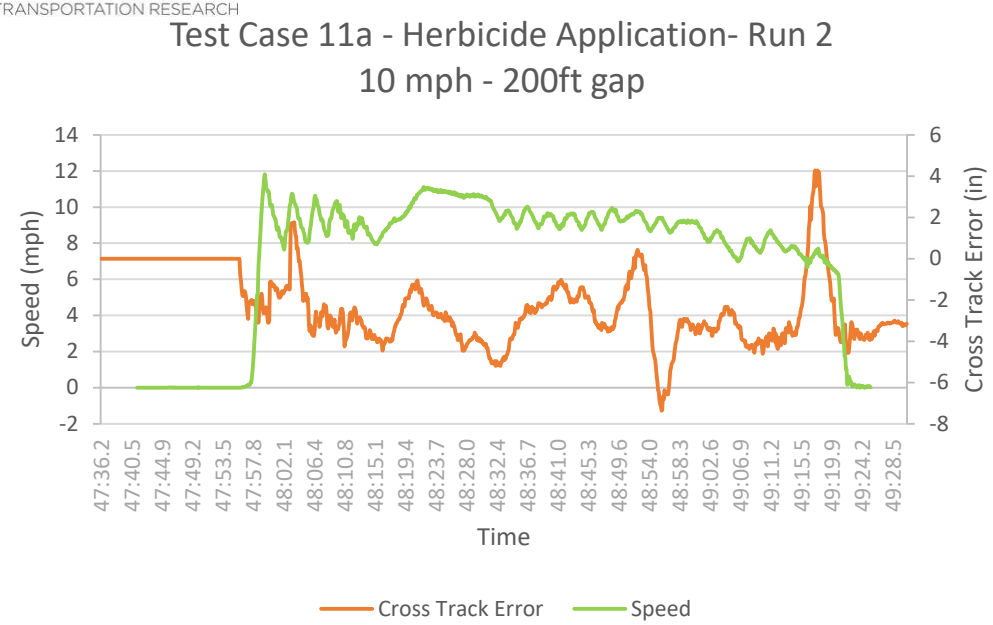
CTE between -1.92 to 8.62 in

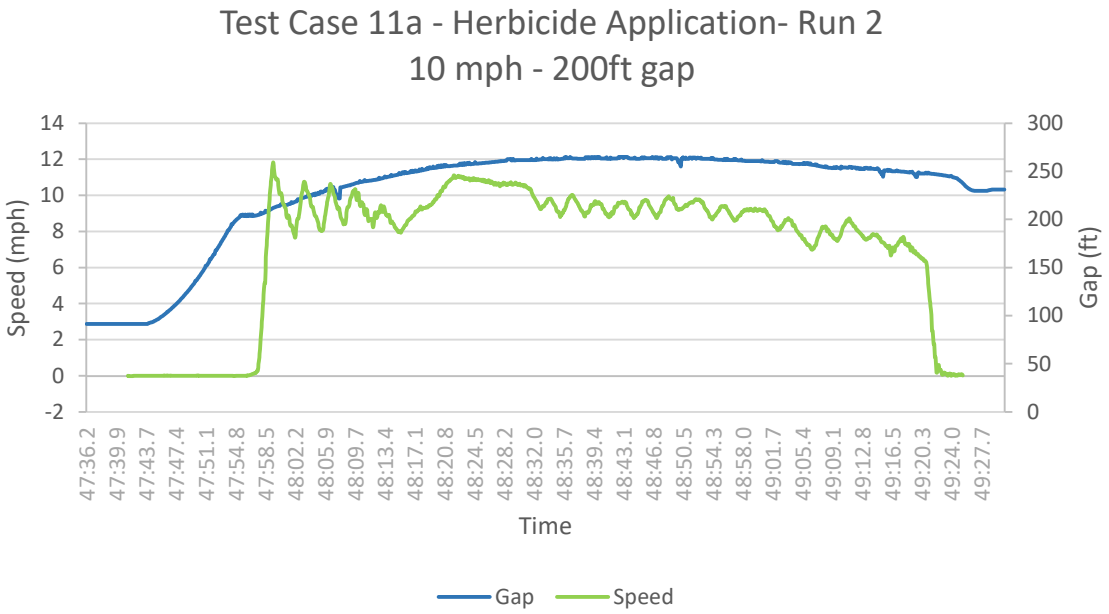
Current Findings

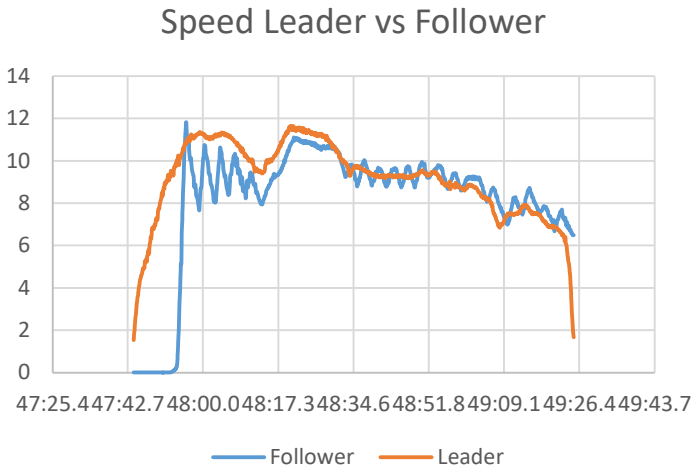
VIDEO

Test Case 11a - Herbicide Application

Current Findings



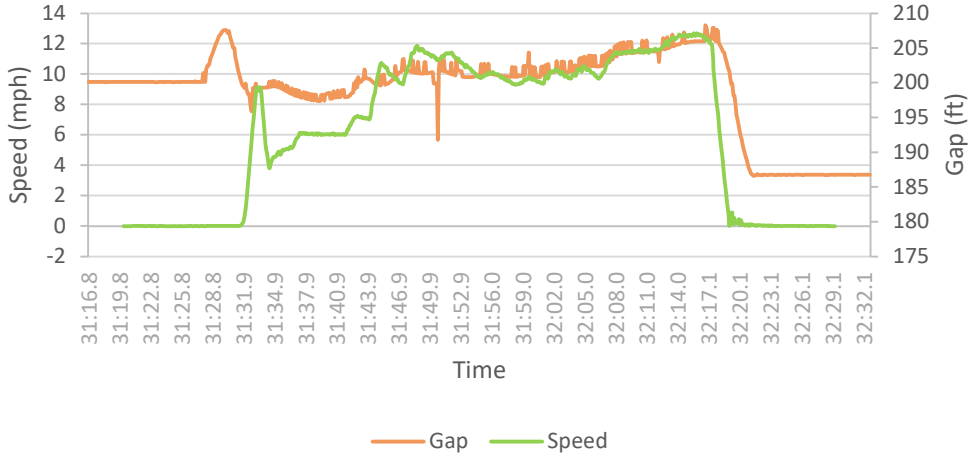




FLW variability? Gear changes,etc

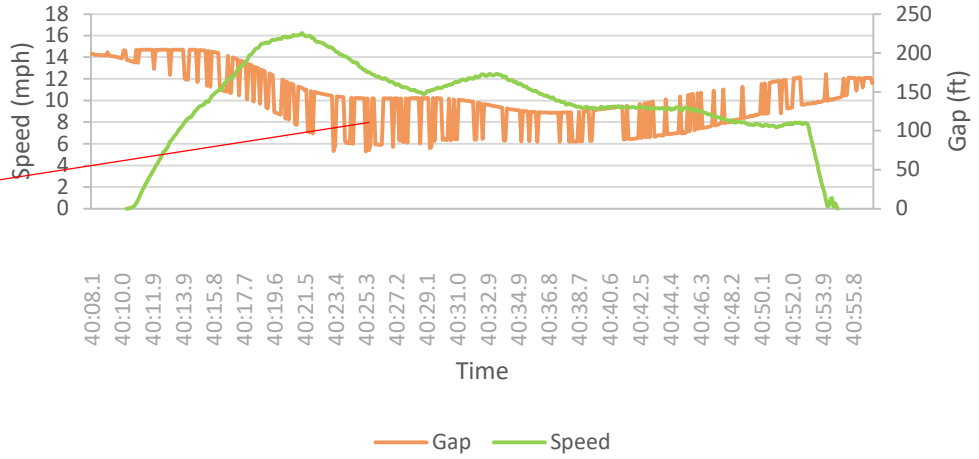
Current Findings

Test Case 28 - Human vs ATMA - Run 2 - **ATMA**
10 mph - Gap 200ft



Time	Speed (mph)	Gap (ft)
40:25.0	12.43	141.8946
40:25.1	12.41	141.829
40:25.2	12.3	141.7962
40:25.3	12.24	73.78519
40:25.4	12.23	141.7634
40:25.5	12.2	75.13032
40:25.6	12.08	84.25094
40:25.7	12.01	141.6649
40:25.8	12.03	141.6321
40:25.9	12.08	82.4137

Test Case 28 - Human vs ATMA - Run 2 - **Human**
10 mph - Gap 200ft



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Current Findings

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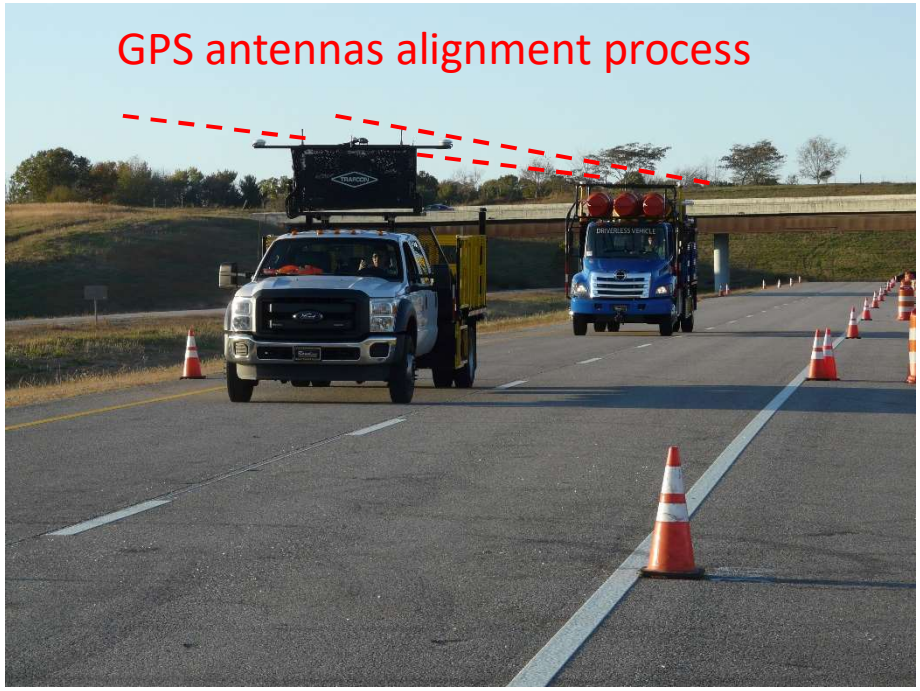
The ATMA gap control is tuned with a configuration value based on customer preference. We can make it really aggressive, which usually is not a good idea for lower speeds, due to constant adjustments of brake and throttle. Or, we can make it relaxed, which takes more time to catch up to get to the correct gap.

Future Work



- Analysis on Ease of Use: plot graphs with IDLE time included

IDLE	Start	32:22.6	09:22.6
	End	41:45.2	
ROLLOUT	Start	41:45.3	00:09.4
	End	41:54.7	
RUN	Start	41:54.8	01:44.8
	End	43:39.6	

- Finish analysis of all case scenarios

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