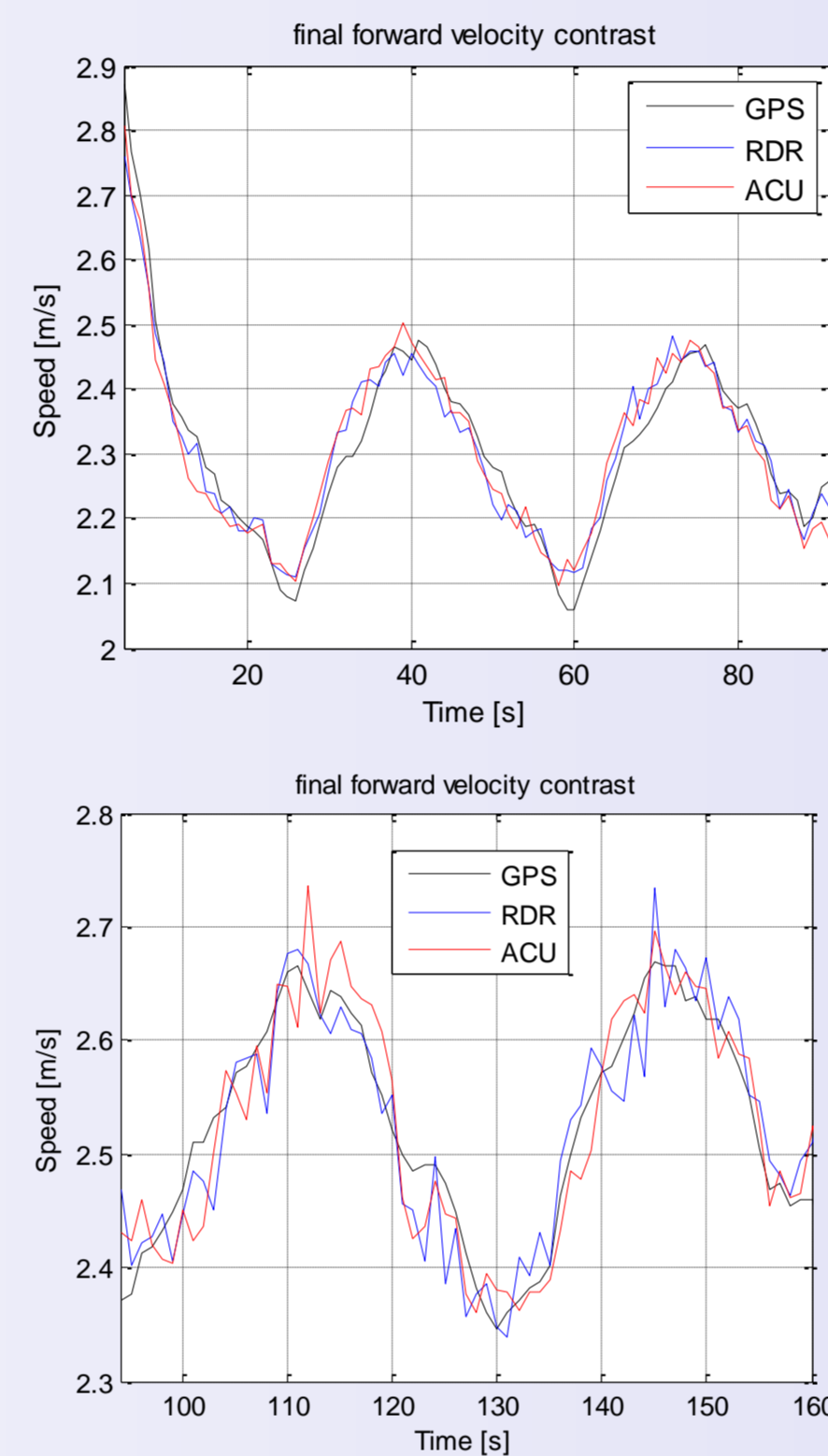
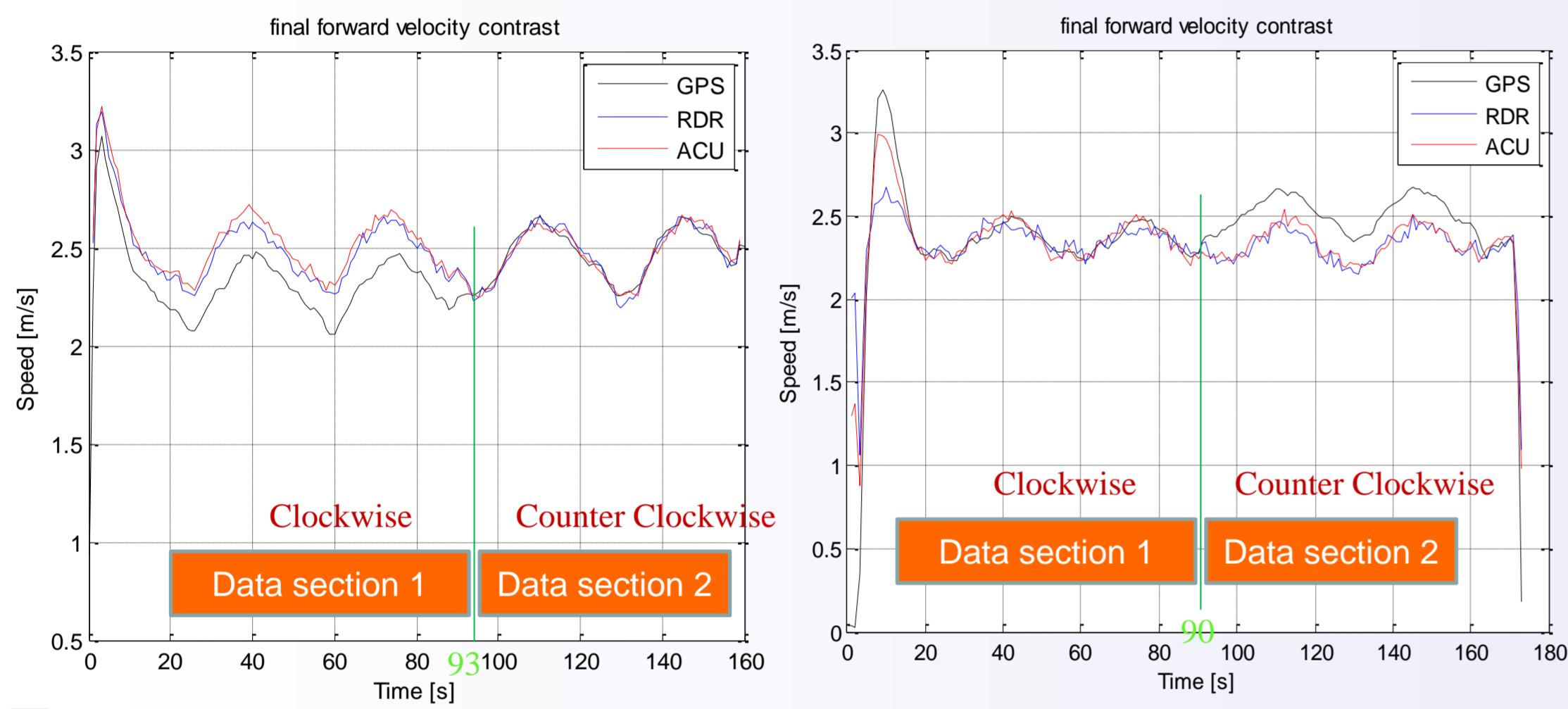
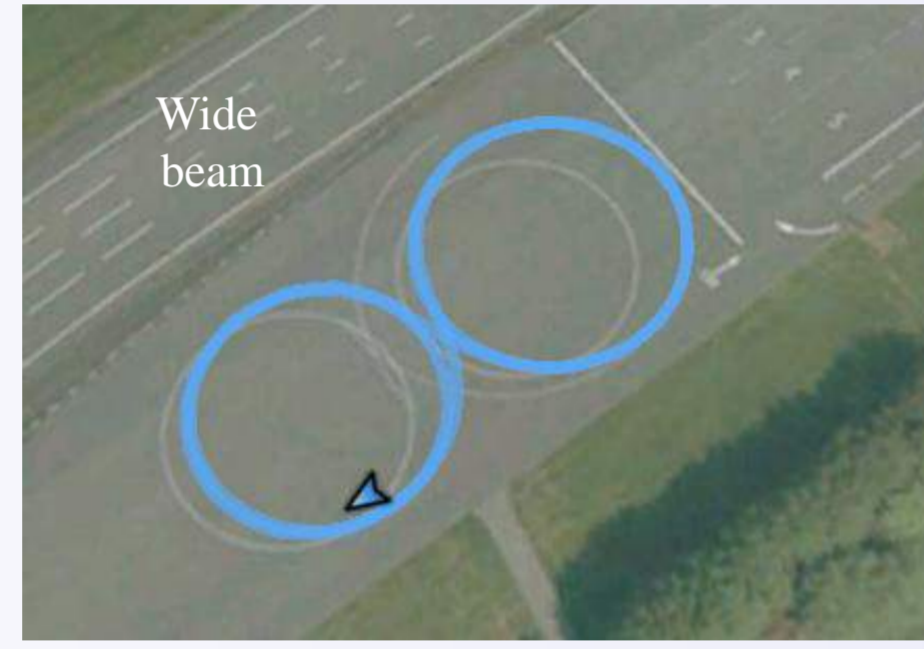
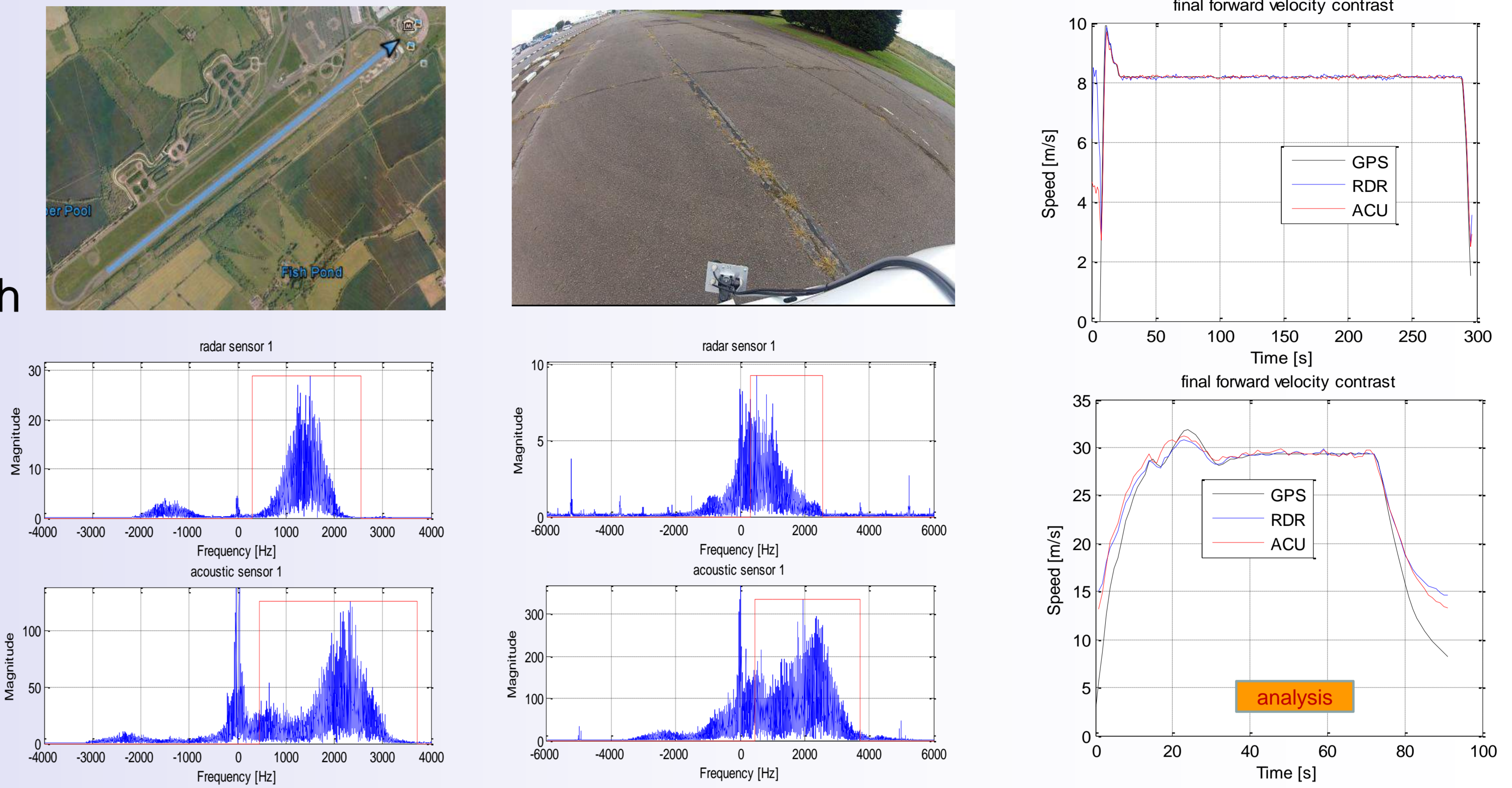


## I. On Road Test-Straight Line

### • Testing conditions

- Sensor type: Radar & Acoustic
- Beam type: Narrow beam & Wide beam
- Speed: 5mph, 10mph, 20mph, 30mph, 40mph, 70mph

Relative error	Sensor Type	5 mph	10 mph	20 mph	30 mph	40 mph	70 mph
Narrow beam	Radar	/	0.5%	0.4%	0.3%	0.3%	0.2%
	Acoustic	/	0.6%	0.3%	0.2%	0.3%	1.0%
Wide beam	Radar	1.3%	1.4%	0.9%	/	0.5%	0.4%
	Acoustic	0.8%	1.0%	0.8%	/	0.5%	0.6%



## II. On Road Test-Circle

### • Testing conditions

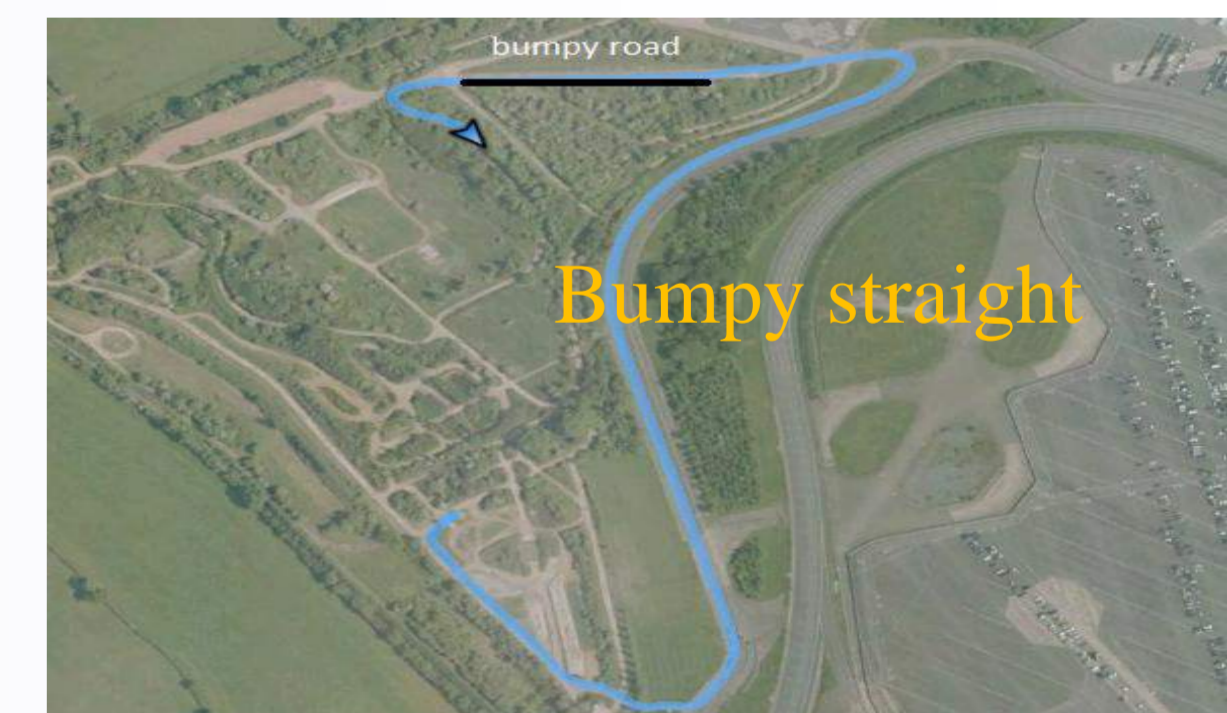
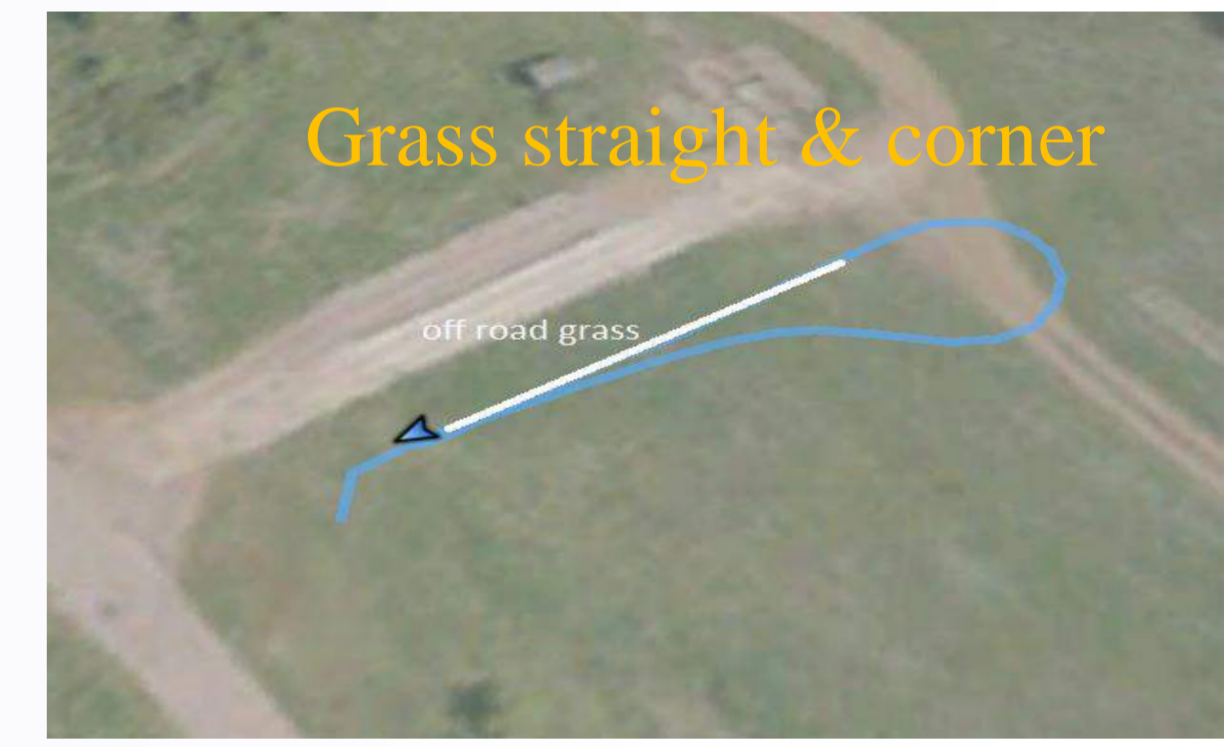
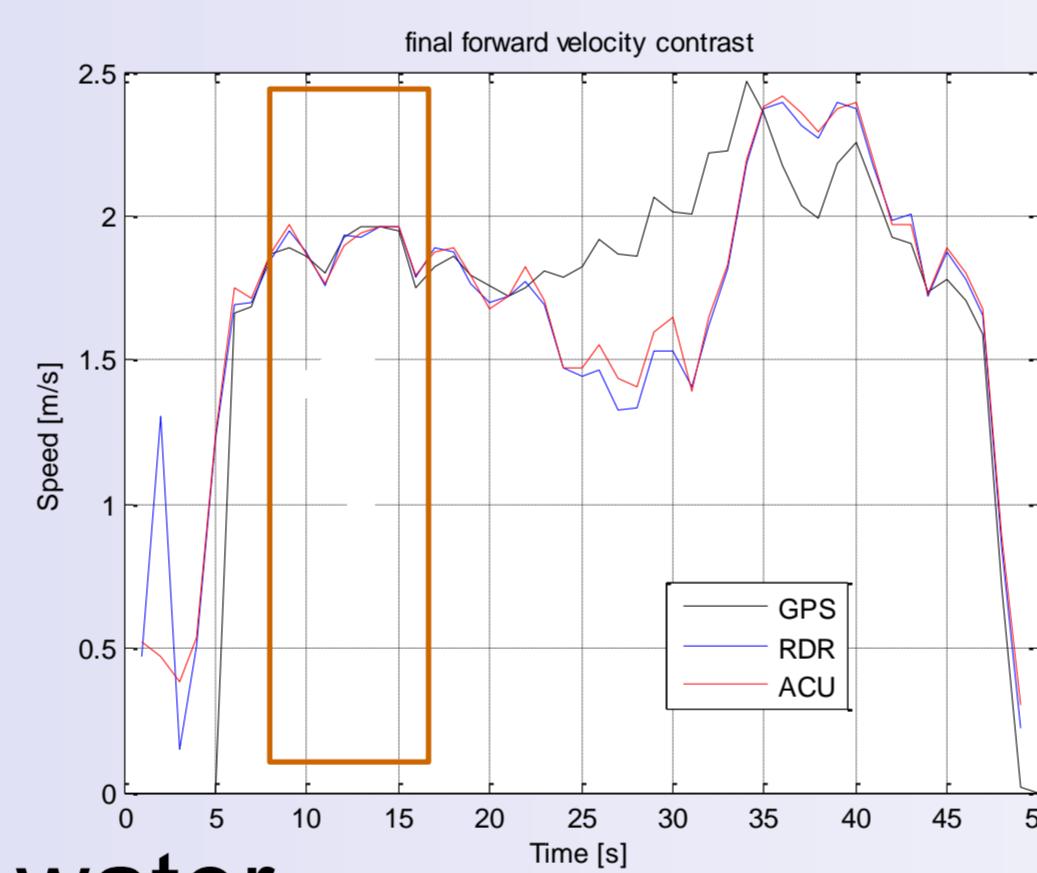
- Sensor type: Radar & Acoustic
- Beam type: Narrow beam & Wide beam
- Speed: 5mph, 15mph

Relative error	sensor type	5mph	15mph
Narrow beam	Radar	1.3%	0.7%
	Acoustic	1.5%	1.2%
Wide beam	Radar	1.7%	1.0%
	Acoustic	1.2%	1.7%

## III. Off road result

### • Testing conditions

- Sensor type: Radar & Acoustic
- Beam type: Narrow beam & Wide beam
- Speed: low speed around 5mph-10mph
- Road conditions: off road, bumpy, gravel, grass, water



Road condition worse →

Average Relative error	sensor type	On road 10mph	gravel 9.4mph	grass 4.5mph	Bumpy 5.5mph	Off road 5.5mph	water 3.5mph
Narrow beam	Radar	0.5%	/	1.6%	1.5%	3.4%	5.1%
	Acoustic	0.6%	/	1.5%	1.2%	3.3%	3.7%
Wide beam	Radar	1.4%	1.9%	1.9%	/	6%	/
	Acoustic	1.0%	1.2%	1.3%	/	2.9%	/

## IV. Summary

- **Hardware:** Constructed multi-sensor test bed
- **Experiment:** Completed trials on various surfaces with various speeds and trajectories
- **Algorithm:** Envelope Detection, Mass centre method, Kalman filter, Multi-Sensor fusion
- **Data Analysis Result:** In general expect the precision of speed estimation to be between **0.5%~5%** from both radar and acoustic sensors for all tested surfaces, trajectories and speeds