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Vehicle Data Collection for Predicting Driving Behavior on Interchanges

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Objective of the Study

- Evaluate the consistency of the results for two vehicle data collection methods on interchange ramps; namely
  - floating vehicle data collection via smartphone apps and
  - direct field measurements.
- Assess the reliability of such data collection environments in terms of their accuracy to record various driving behaviors, with special emphasis on ramps with varying curvature.
- Correlation of the results obtained from the application of the above two methods.
- Investigation between the speed differences in daytime and nighttime conditions in respect to the horizontal radius of each curve.
- Investigation between the speed differences in weather conditions i.e. heavy rain, normal rain, wet pavement and dry pavement conditions.

Data Collection

Reverse Trumpet Interchange Type was selected in a suburban area

Traffic composition: Mixed, with increased commercial trucks

- 10% motorcycles
- 72% Passenger Cars
- 18% Heavy Trucks

Automatic Traffic Counters was placed in 4 locations

Duration of the measurements was three consecutive days taking 24-hour data between 6th and 8th of July 2018)

Data Collection

Geometrical characteristics of the study interchange at measurement spots

Measurement spot	Curve radius	Road gradient	Superelevation
ATC-1	110 m	-1.57 %	2.00 %
ATC-2a	65 m	2.48 %	2.00 %
ATC-2b	30 m	-3.80 %	3.50 %
ATC-3 (Pir)	220 m	-4.00 %	-2.00 %
ATC-3 (Kor)	220 m	4.00 %	2.00 %

ATC: MetroCount MC5600

Data Collection

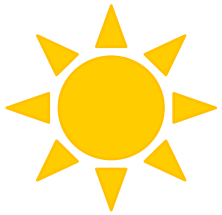
Traffic volume

- The Average Daily Traffic (ADT) counted in direction to Piraeus is 4.500 vehicles while the ADT counted in the direction to Korinthos was three times higher (13.000 vehicles).
- This finding further strengthens the assumption that this reverse type interchange is potentially dangerous, since the higher volume traffic is occurring on the loop of the interchange with the radius of 30m.

Data Analysis - Speed data processing

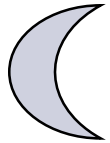
Free flow conditions

Only measurements with a headway greater than 6 seconds were utilized



Day-time

Data measured from 06:00 to 21:00 were considered day-time



Night-time

Data measured from 21:00 to 06:00 were considered night-time

Data Analysis - Speed data processing

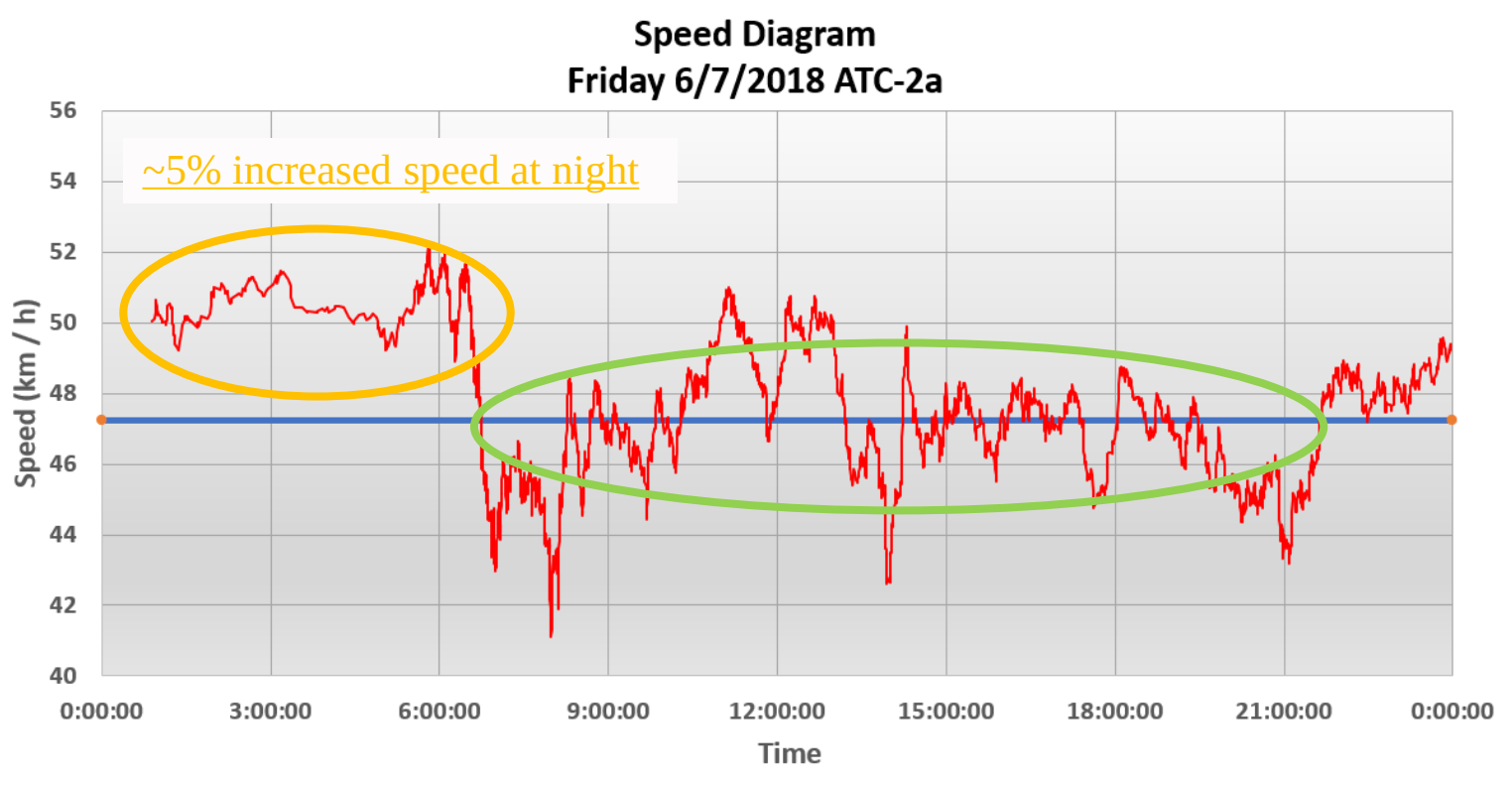
Workflow of analysis

- Raw data collected determined the traffic volume at each ramp.
- Free-flow data were gathered to determine the operating speed (85^{th} percentile speed).
- The average speed (50^{th} percentile speed) was determined for daytime and nighttime.
- The calculated operating speed was correlated to different weather conditions.

Data Analysis - Speed data processing

Speed change during all day (24-hour) was investigated

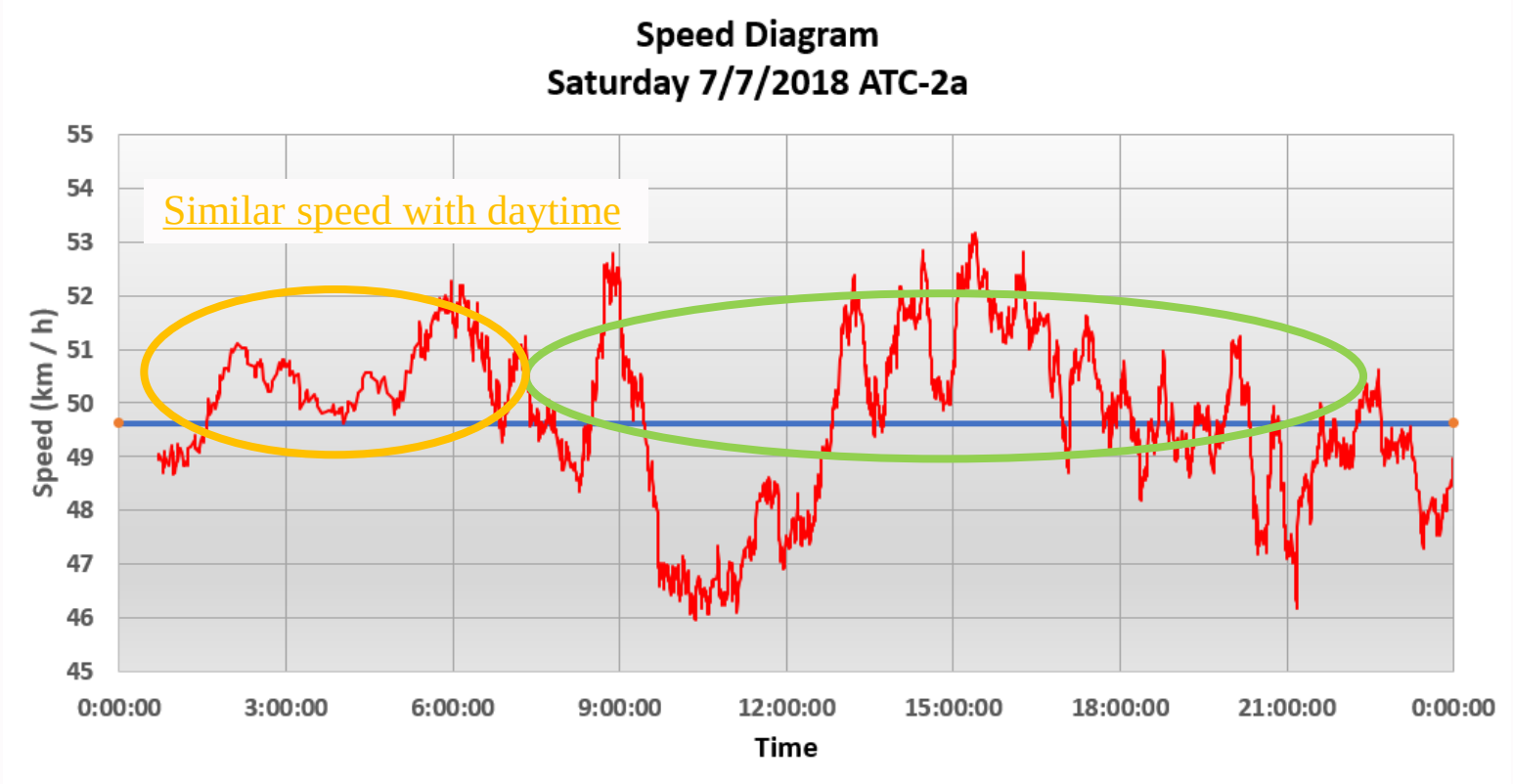
- Speed increase was observed during nighttime almost in all cases during Friday (working day).



Data Analysis - Speed data processing

Speed change during all day (24-hour) was investigated

- Speed increase was observed during nighttime almost in all cases during Friday (working day).
- On the other hand, during Saturday (half day) and Sunday (rest day) similar speed between daytime and nighttime was observed in many cases while in some cases a slight decrease on speed was found in nighttime in respect to daytime.



Data Analysis - Speed data processing

Daytime and nighttime average speed

- The measurements of the interchange loop (R=30m) shows a 11.4% increased speed at nighttime, while a reduction of 1% to 1.6% found on larger radius (65m and 110m respectively). This high difference between daytime and nighttime founded on the loop is probably due to very high traffic volume of the present ramp:

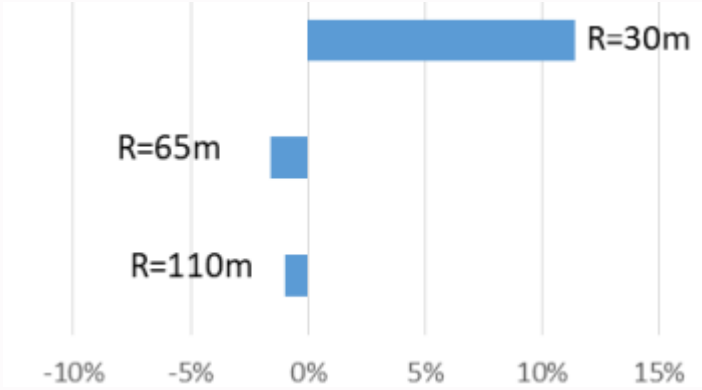
  R=30m

  - 1.200 vehicles per hour in daytime, **Level of Service D**
  - 200 vehicles per hour in nighttime, Level of Service A

  R=65m and R=110m

  - 300 vehicles per hour in daytime, Level of Service A
  - 100 vehicles per hour in nighttime, Level of Service A

50th percentile speed (km/h)			
Measurement spot	**V_{50} day**	**V_{50} night**	**Difference**
ATC-1 (R=110 m)	57.22	56.66	-1.0 %
ATC-2a (R=65 m)	48.98	48.20	-1.6 %
ATC-2b (R=30 m)	30.39	33.84	+11.4 %

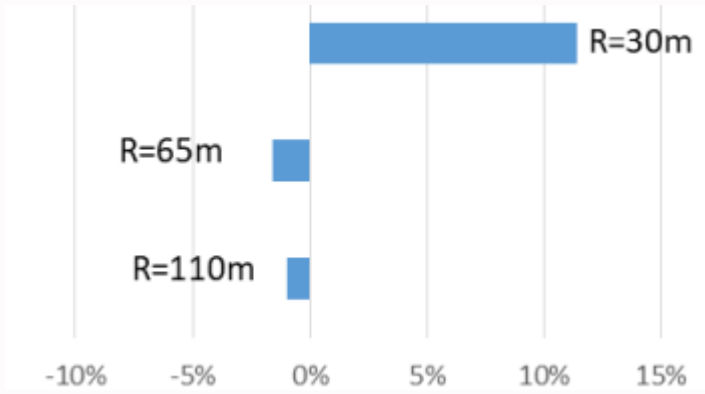


Data Analysis - Speed data processing

Day and night average speed

- According to GPS data collection study (de Jong, 2017) there is a speed reduction of 3% during nighttime, however this reduction is not related to the geometry of the ramp.
- According to direct field measurements from the present research there is a speed reduction of 1% ~ 1.6% during nighttime for radius of 65m and 110m, similar to GPS data collection study.
- The 11.4% speed reduction on the loop ramp (30m) could be possible due to very high hourly traffic and the reduced Level of Service during daytime and therefore could not be considered.
- The measured data on the present study didn't show any correlation between curve radius and speed reduction for daytime and nighttime.

Average speed (km/h)			
Measurement spot	**V_{50} day**	**V_{50} night**	**Difference**
ATC-1 (R=110 m)	57.22	56.66	-1.0 %
ATC-2a (R=65 m)	48.98	48.20	-1.6 %
ATC-2b (R=30 m)	30.39	33.84	+11.4 %



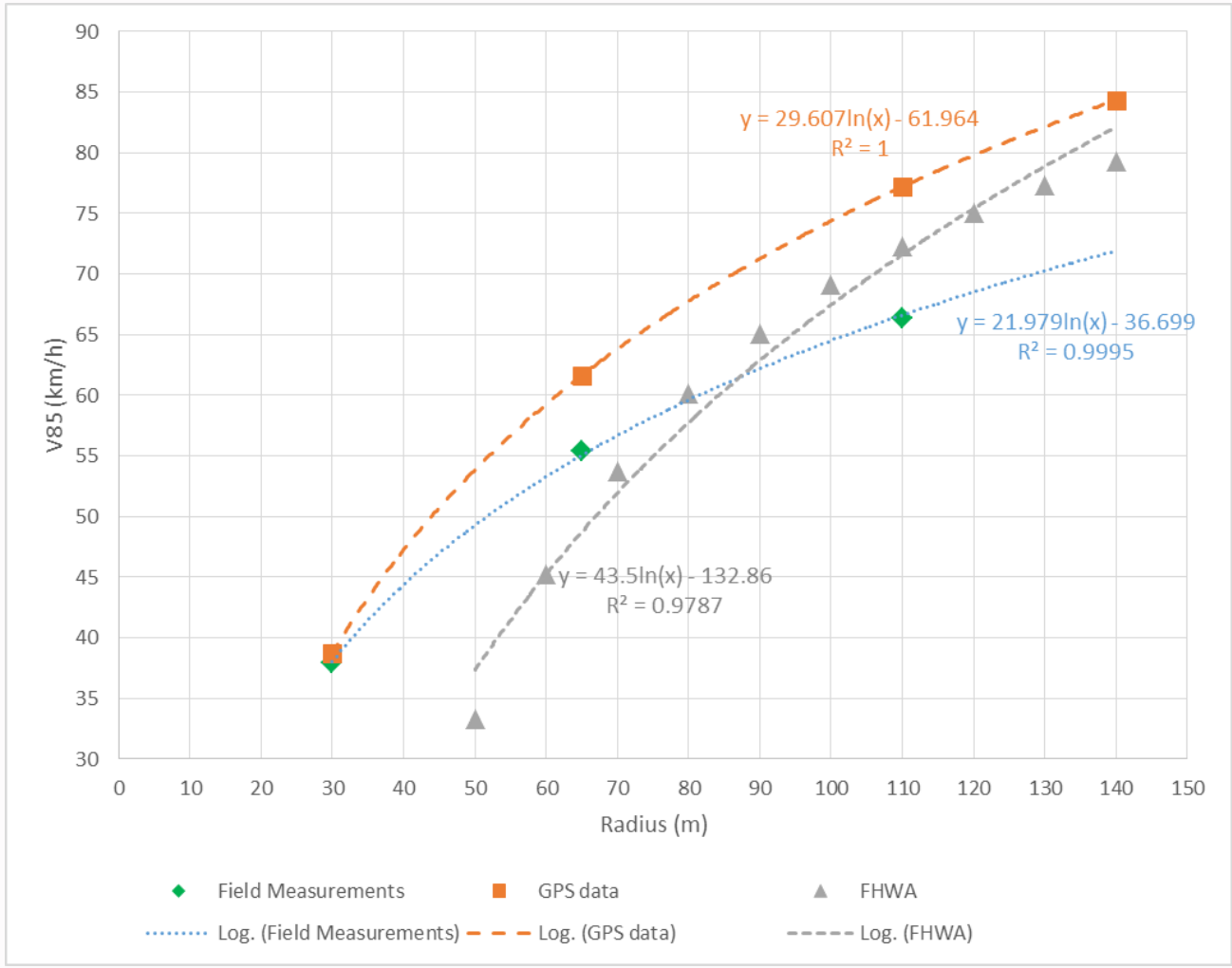
Data Analysis - Speed data processing

Operating speed

- The measurements from ATC-3 position (radius 220m) was ignored due to traffic signalized intersection nearby.
- The operating speed measured for the rest curves summarized:

Operating speed (km/h)				
Measurement spot	**6/7/2018**	**7/7/2018**	**8/7/2018**	**Average**
ATC-1 (R=110 m)	64.43	68.84	65.94	66.40
ATC-2a (R=65 m)	54.78	56.51	54.93	55.41
ATC-2b (R=30 m)	37.24	38.53	37.97	37.91

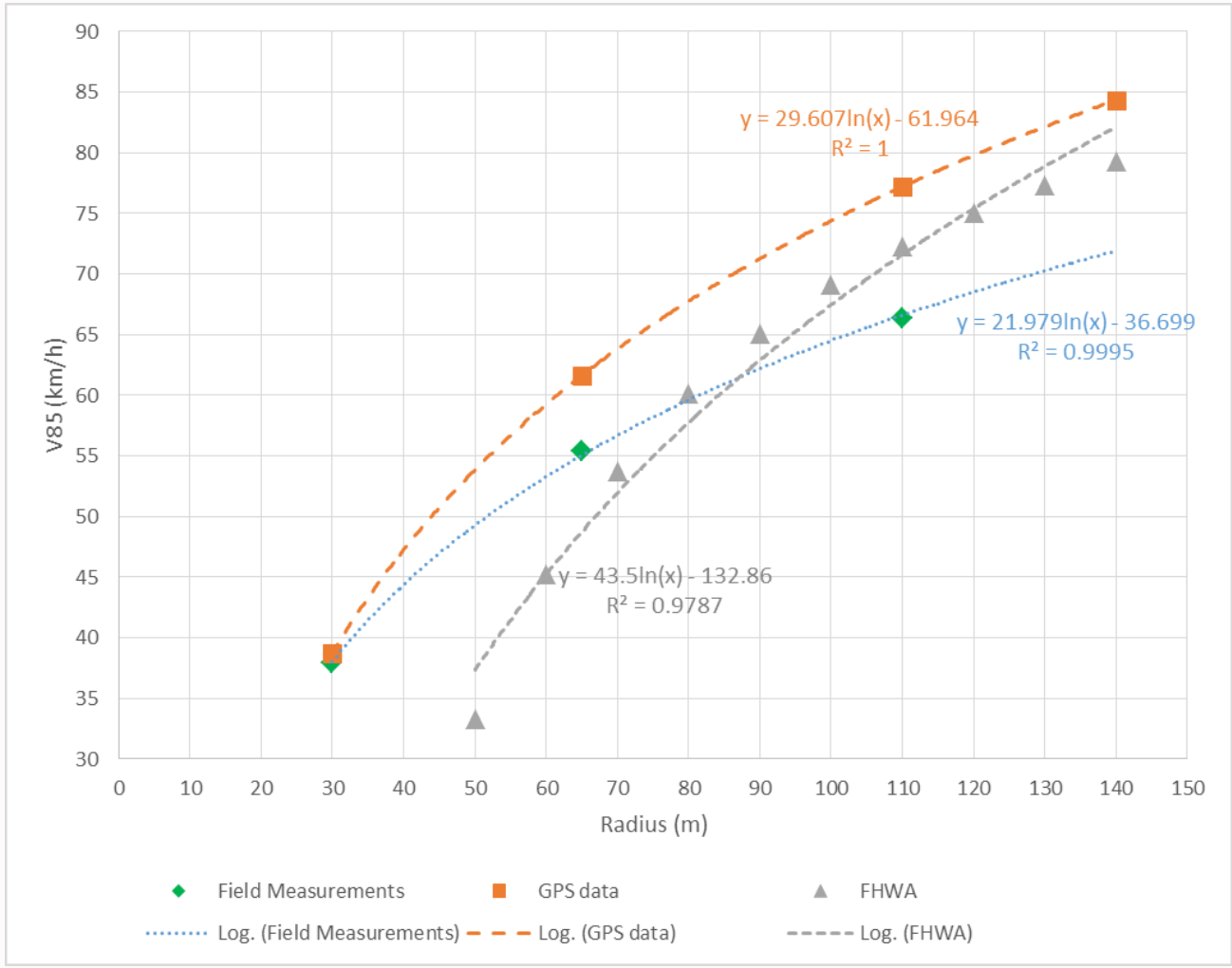
- The calculated operating speed was graphed and compared to the findings of the GPS data collection method (de Jong, 2017)



Data Analysis - Speed data processing

Operating speed findings

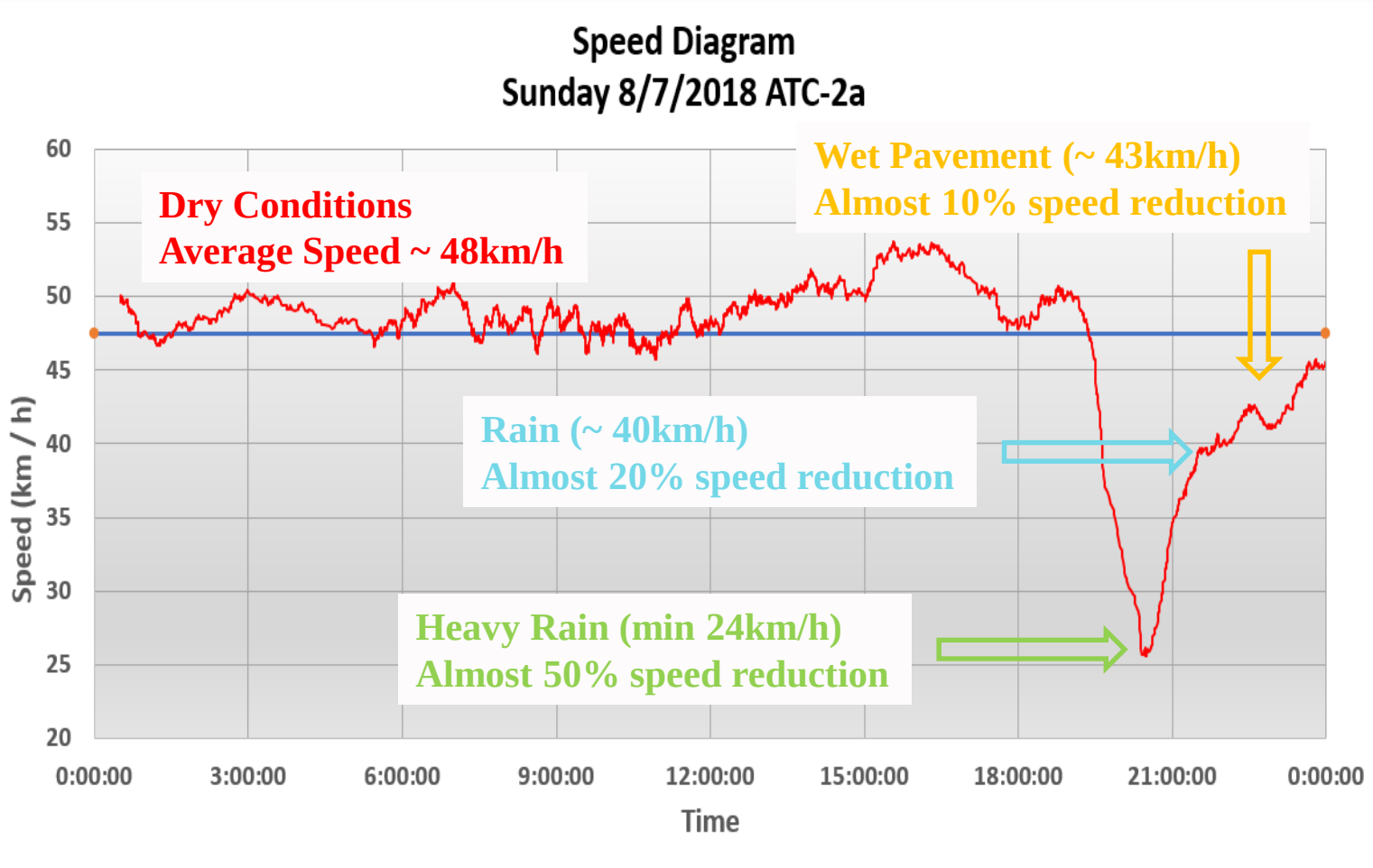
- The operating speed suggested by the FHWA is slightly correlate to the findings of measurement methods.
- The on-site measurements follow a similar pattern with the GPS measurements for radii smaller than 50m, while they deviate for larger radii. This is probably caused by the small superelevation rate 2% at the interchange curves in the present study compared to 6% found in the GPS data study.



Data Analysis - Speed data processing

Speed variation in respect to weather conditions was investigated

- Meteorological data were collected and there was a sudden rainfall on Sunday.
- The weather conditions was classified in 4 categories
  - Dry Pavement (before 19:20)
  - Wet Pavement (after 22:20)
  - Normal Rain (20:20 – 22:20)
  - Heavy Rain (19:20 – 20:20)

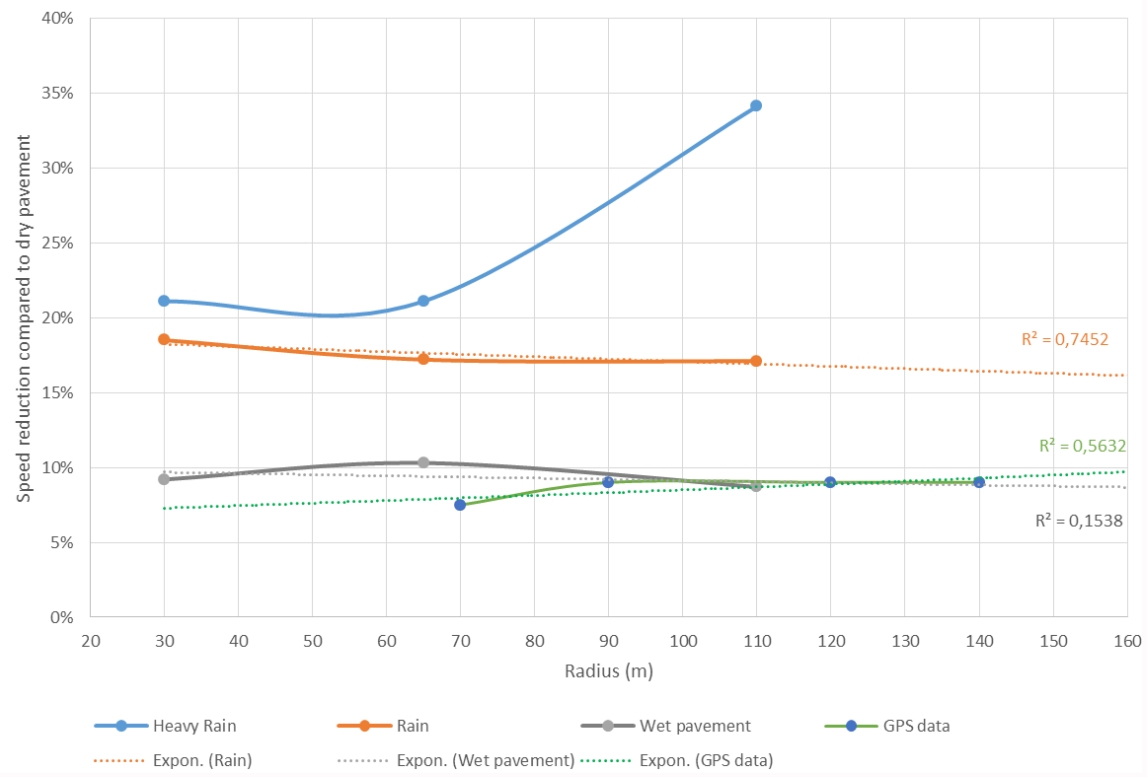


Data Analysis - Speed data processing

Speed variation in respect to weather conditions

- The Operating speed depending on the weather conditions is following:
  - A sudden speed decrease in heavy rain period between 22% ~ 34% (max 50% instantly).
  - A slight lower reduction in normal rain conditions between 16% ~ 18%
  - A reduction around 10% in wet pavement conditions.

85th percentile speed (km/h)				
Measurement spot	**Dry**	**Heavy Rain**	**Light Rain**	**Wet Pavement**
ATC-1 (R=110 m)	64.55	42.57	53.48	58.91
ATC-2a (R=65 m)	54.15	42.75	44.83	48.75
ATC-2b (R=30 m)	38.94	30.71	31.75	35.36
ATC-3 Kor (R=220 m)	59.72	47.50	51.36	56.36
ATC-3 Pir (R=220 m)	59.04	47.73	52.30	56.82



- In GPS data method (de Jong, 2017) a decrease between 3%-8% was found while the speed reduction counted in field measurements was around 10%.

Conclusions

1. The operating speed measured with the two methods is similar for smaller horizontal radii, while for higher radii values GPS data collection method shows an increased speed in respect to field measurements method.
2. Both methods concluded that the speed reduction between daytime and nighttime could not be defined related to the geometric design of the interchange ramps.
3. On the other hand, a similar speed reduction in nighttime between 1% to 3% is founded in both methods.
4. Both methods suggest an operating speed reduction during rainfall. In the GPS data collection method, this reduction was in the range of 3% ~ 8% compared to the present study where the measured speed reduction is around 10% in wet pavement conditions, around 16% ~ 18% on normal rain conditions and 22% ~ 34% on heavy rain conditions.

Subject for further research

- More data collection for similar interchange branches in a wider range of horizontal curves and traffic volumes could be made.
- More data collection for other interchange types rather trumpet, such as diamond, cloverleaf etc.
- Additional speed measurements in different weather conditions including:
  - Heavy rain conditions
  - Normal rain conditions
  - Wet and dry pavement conditions
- Additional analysis for heavy vehicles and motorcycles and correlation with the results of passenger cars, taking also into account the traffic composition could be investigated.

Thank You
for your attention!