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Evaluating left turn saturation flow rate at signalized intersections by applying Floating Car Data (FCD) Technology

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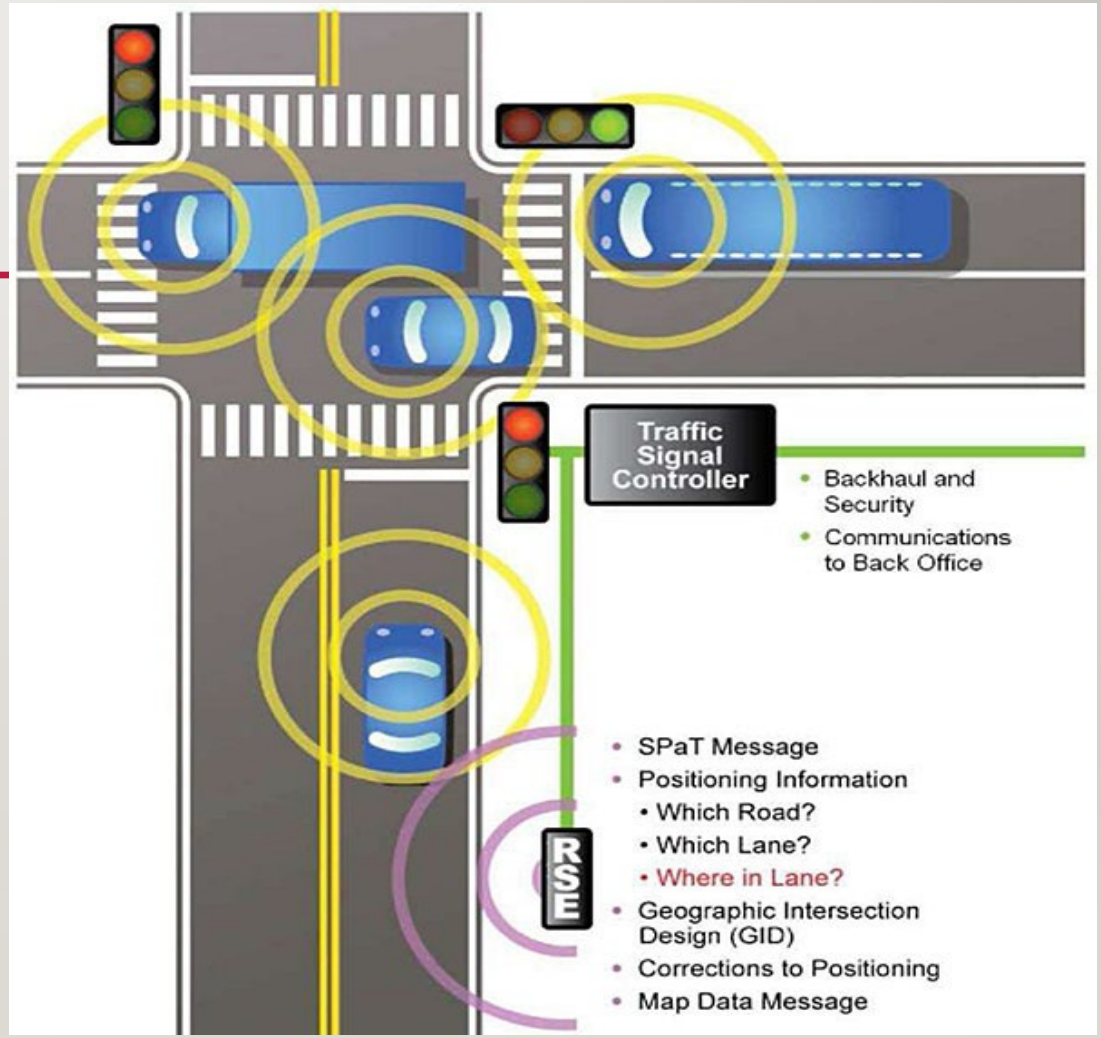
SATURATION FLOW RATE

Saturation flow rate is defined as the equivalent maximum hourly rate at which vehicles can traverse a lane or intersection approach under prevailing traffic and roadway conditions assuming the full availability of green signal time and no lost times [Source: Highway Capacity Manual (HCM),2010]

AN INNOVATIVE APPROACH TO APPLY IN SATURATION FLOW RATE ESTIMATION !

A newly developed GPS based technique called **Floating Car Data (FCD)** obtains information on speed and spacing between the vehicles focusing on left turn movement at signals.



FCD SHOWS PROMISE FOR SUPPORTING REAL-TIME OPERATIONS AND PROVIDE EFFICIENT LEFT TURN PLANS!

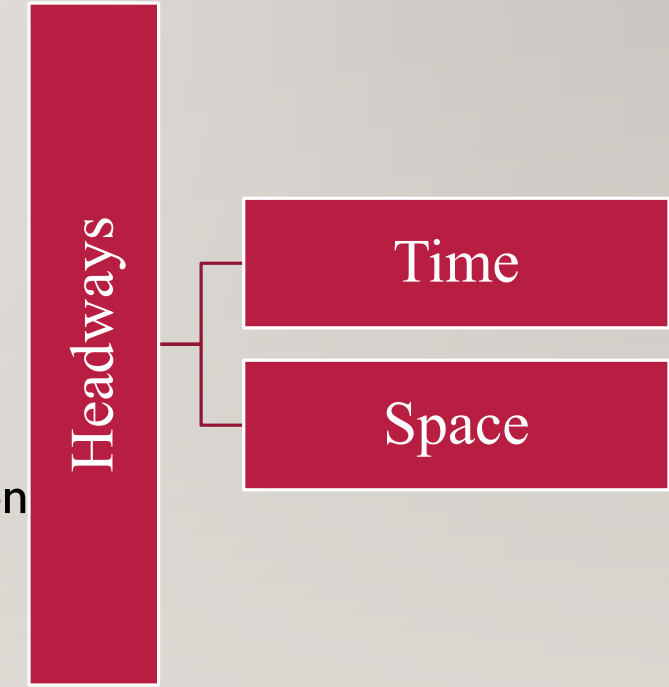
System is based on the acquisition of the sequence of positions and velocities of the instrumented vehicles.

Since spacing between cars in left turn movement is a primary factor to determine the flow rate, FCD can show an effective method .

Moreover this technique is applicable to detect the heavy duty vehicles (freights) from all the types.

HEADWAYS

- Time headways are very important parameters in determining saturation flow rate.
- By observing each turning vehicle's (including freights) travel time from a point to another point , time headways are calculated.
- FCD can be applied to collect data on both time and space headways from the left turning vehicles.
- Space headways are considered as one of the independent parameters for saturation flow rate estimation.



Time Headway:

the elapsed time between the arrival of pairs of vehicles at a common observation point is defined as the time headway and is expressed in seconds.

CONVENTIONAL FIELD METHOD

- Average headway=(Tn-T4)/(N-4)
- Tn= total time for N vehicles
- T4= time for the rear axle of the fourth vehicle entering the intersection
- N=total number of vehicles entering the intersection

CURRENT RESEARCH APPROACH

- Average headway, $h = \frac{h_1 + h2 + \cdots + h_{n-1}}{n-1}$
- Where n= total number of left turning vehicles during the green time
- $h_1, h_2, .., h_{n-1}$= average time headway between the vehicles

MOTIVATION

This research is planned to

- provide a new concept and challenges by applying FCD to detect the types of vehicles using spacing and time headway trajectories
- apply to the locations where other traffic monitoring systems are not available
- contribute travel time comparison between general (non-equipped) and smart cars (equipped with GPS) during congestion period

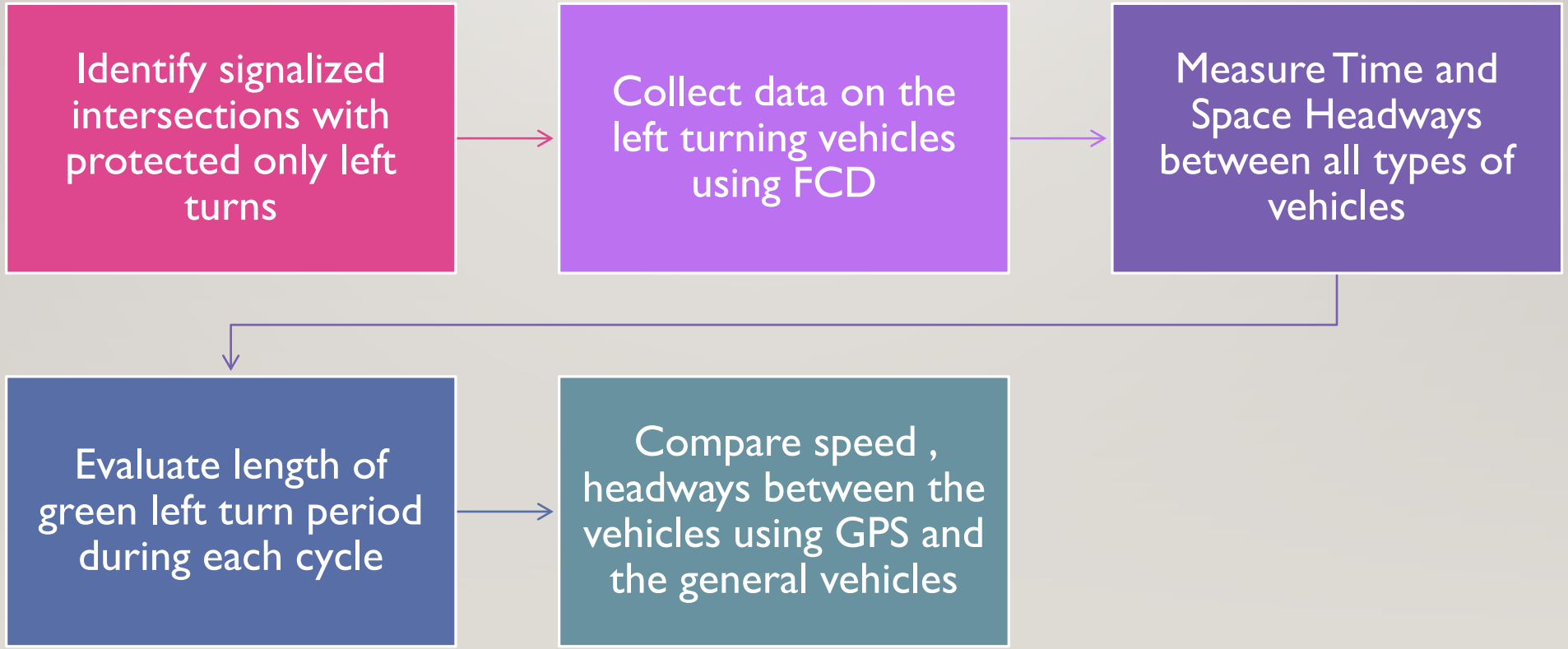
RESEARCH OBJECTIVE

Detect	Detect the small, large and freight vehicles and isolate them estimating space and time headway.
Develop	Saturation flow rate can be determined by establishing a mathematical model
Analyze	Analyze the overall capacity of signalized intersection and level of service by integrating left turning travel time into the capacity estimation.

THE COMBINED COLLECTED DATA TOGETHER…..

- develop a powerful model,
- gives qualified and real-time information for the mobility of persons.
- provides reliable saturation level of the road network and travel times.

PROPOSED WORKFLOW CHART



METHODOLOGY

- Data:

Data on number of left turning vehicles/freights, spacing, time headways and speed can be collected for both instrumented and non instrumented vehicles.

- Model:

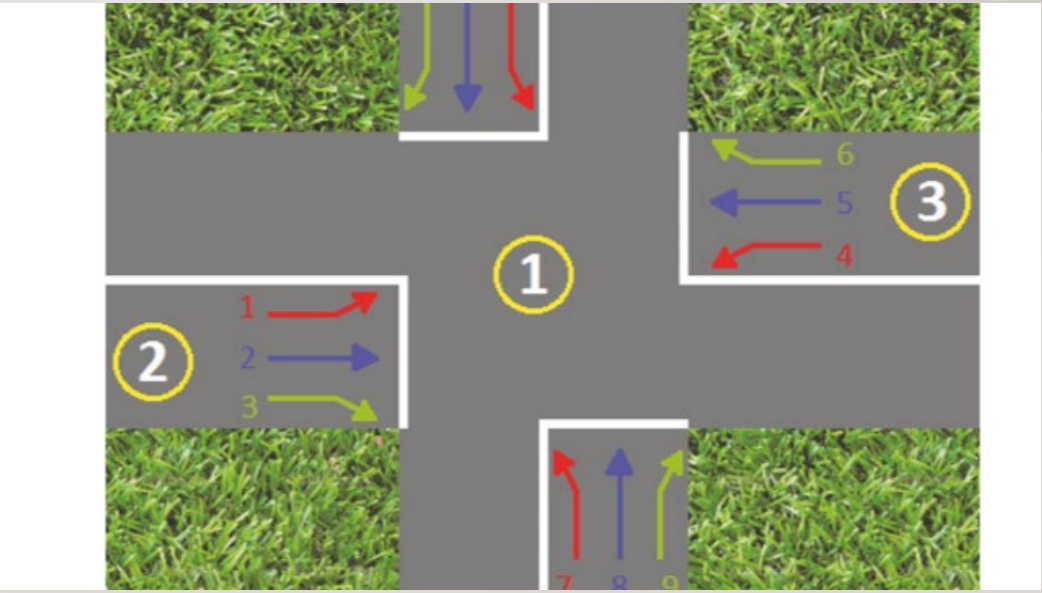
Using vehicular speed, time headway and spacing between the left turning vehicles as major input variables a mathematical model for saturation flow rate can be developed

The developed model can apprehend the sensitivity of car following behavior of roadway users incorporating FCD technique

Discrete Probabilistic approach of traffic flow will be the base of the model.

ANALYSIS

- Validation of model
- Use Simulation
- Compare output for different left turn protections



STATISTICAL DATA ANALYSIS

Protected only left turn:

$$S = f(W,v,h,s)$$

where S=left turning saturation flow rate

W= Total width of opposing lanes

v= left turning average speed

h= average time headway

s= average spacing between vehicles

PRESENCE OF HEAVY VEHICLES

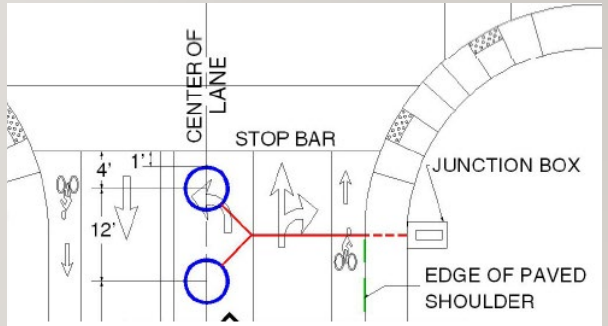
The percentage of heavy vehicles in the traffic stream influences on the saturation flow rate!

Due to slower maneuverability~ affecting the saturation flow rate. Part of the study is focused on traffic composition in the connected vehicles environment to estimate the saturation flow rate effectively at different penetration levels.

CHALLENGE

Advantages of using FCD over loop detector data:

- Inexpensive
- New algorithms for researchers and engineers
- Offer best left turn phasing (efficiency)



(a) Schematic design of loop detector design

(b) Physical representation of loop detectors

DYNAMIC CHANGES IN TRAFFIC STREAM!!!

The proposed method has the potential to be used in adaptive signal control systems for dynamically estimating the saturation flow rate to respond to unanticipated changes in the traffic caused by road incidents such as temporary lane blockages, accidents, adverse weather conditions, etc. and does not require the disposition of traffic sensors such as loop detectors.

CONCLUSION

The challenge was to develop a simplified and economical integrated mathematical model for estimating the saturation flow rate using FCD.

The linear (probabilistic) regression method is the best choice for developing the saturation flow rate model.

Limitations :

- Currently permitted only and protected/permitted types of left turns could not be taken under consideration.

THANK YOU…