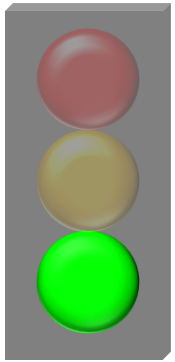
SUMITOMO ELECTRIC
Connect with Innovation

Intelligent Traffic Signal Management using Probe Data



Information Network R & D Center

Sumitomo Electric Industries, Ltd.

Date: September, 2022

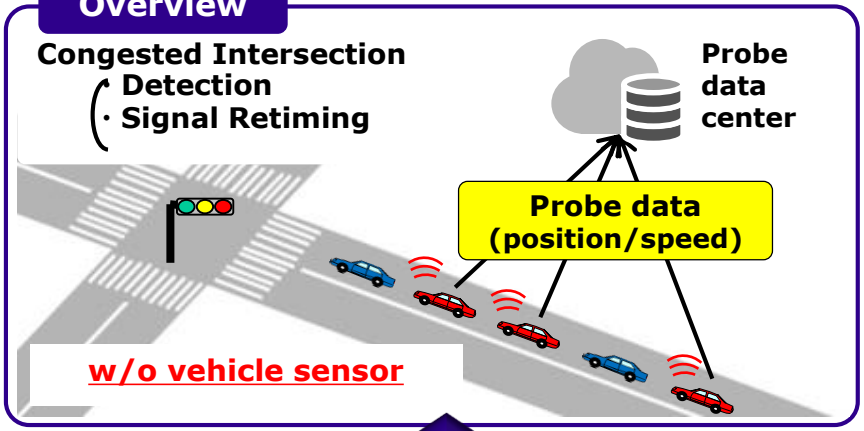
SUMITOMO ELECTRIC GROUP

Intelligent Traffic Management using Probe Data

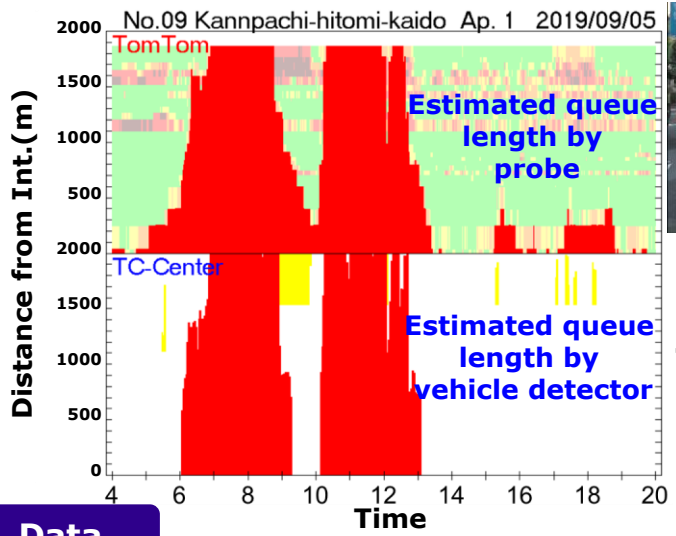
We are expecting that probe based data will become key resource for traffic signal control. And it will relieve from the detector equipment and maintenance.

Overview

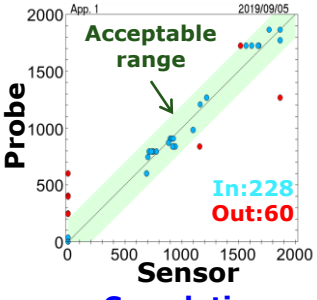
Congested Intersection
- Detection
- Signal Retiming



Comparison



Kanpachi-hitomi-kaido Int.



Correlation

Data

- TOMTOM probe-based analysis data
  - TomTom and SEI have been in partnership since 2019.
  - TomTom's data is provided worldwide, include the entire U.S.

Intelligent Traffic Management using Probe Data

What can we do using probe based data?

The acquisition information : Congestion length, Travel time ⇨ Delay time

Signalized intersection analysis

Case in Japan

Case in USA 1)

Signal timing data resetting

New algorithm

Trial test 2)

Degree of saturation

$$D=\frac{q*c}{s_f*g}$$

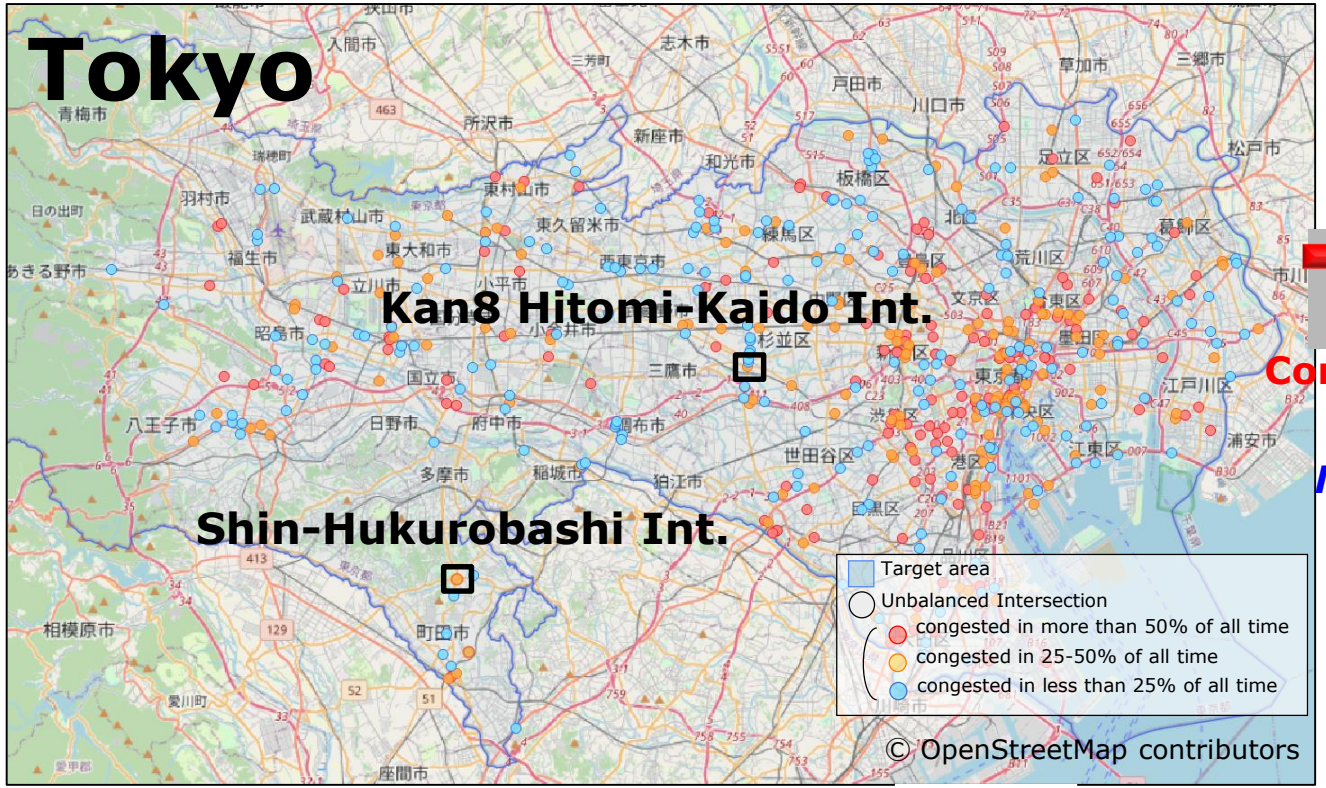
q : Traffic volume (vehicle/sec.)
c : Cycle length (sec.)
s_f : Saturation flow rate (vehicle/sec.)
g : Effective green time (sec.)

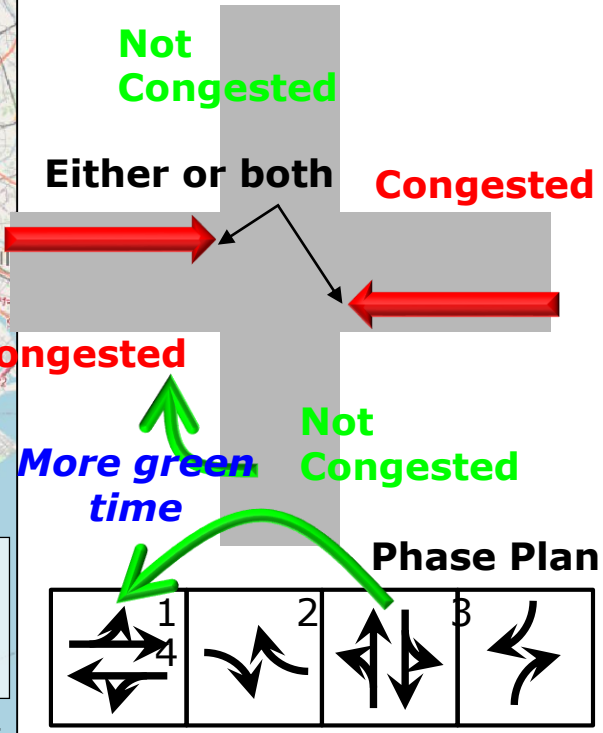
The new algorithm can calculate "D" even if detectors were not set at signalized intersection.

1) TS16 : Managing Congestion , Sep.20th 03:00-04:30 PM, Room 402B
2) TS34 : How Technology Impacts Transportation I, Sep.21st 08:00-09:30 AM, Room 402A

Signalized intersection analysis (Case in Japan)

Sorting out unbalanced congestion intersections





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New Method Development

Indexes such as "Degree of saturation", "TOSI" can be obtained from probe data even if vehicle detectors are not installed at intersection.

Newell mentioned average delay time per vehicle (w) can be obtained the formula as follows;

$$w = 0.5(1-g/c)^2 * c/(1-q/s_f)$$

Newell, Gordon F : Theory of highway traffic signals, ITS Reports 1989(07), Jan.1989

$$w = 0.5(1-g/c)^2 * c/(1-q/s_f)$$
$$= 0.5(c-g)^2/((1-q/s_f)c)$$
$$= 0.5(c-g)^2 s_f/((s_f-q)c)$$
$$2w(s_f-q)c = (c-g)^2 s_f$$
$$2ws_fc-2wqc = (c-g)^2 s_f$$
$$2wqc = 2ws_fc-(c-g)^2 s_f$$
$$q = \{1-(c-g)^2/(2wc)\}s_f$$

This formula can be modified to q =.

$$q = \{1-(c-g)^2/(2wc)\}s_f \quad \{\text{Under-saturation}\}$$

Extension of the theory for over saturation

$$q = \{1-(c-g)/c\}s_f, \quad v_q = [\{w-(c-g)/2\}/(c-g)]*\{1-(c-g)/c\}s_f \quad \{\text{Over-saturation}\}$$

q : Traffic volume (vehicle/sec.)
c : Cycle length (sec.)
g : Effective green time (sec.)
s_f : Saturation flow rate (vehicle/sec.)
v_q : Vehicles in queue

s_f can not be taken from probe data, however!!

*This technique is protected by U.S.patent 11,263,900.

Degree of saturation

$$D = \frac{q*c}{s_f*g} = \frac{\{1-(c-g)^2/(2wc)\}s_f c}{s_f*g}$$

The temporal oversaturation severity index (TOSI)

$$TOSI = \frac{L/J \times H}{g} = \frac{L/J}{s_f \times g} = \frac{[\{w-(c-g)/2\}/(c-g)]*\{1-(c-g)/c\}s_f}{s_f \times g}$$

L : Minimum residual queue length (feet)
J : Headway under congested traffic conditions (feet)
L/J : Vehicles in queue
H : Saturation discharge headway (sec.)
$H=1/s_f$

https://link.springer.com/article/10.1007/s13177-021-00292-z#author-information
Published: 31 January 2022
Traffic Signal Control Parameter Calculation Using Probe Data

Intelligent Traffic Management using Probe Data

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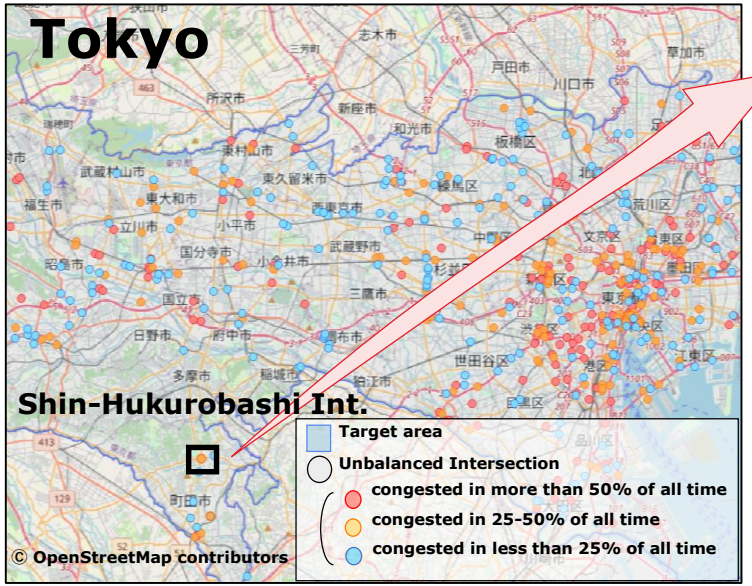
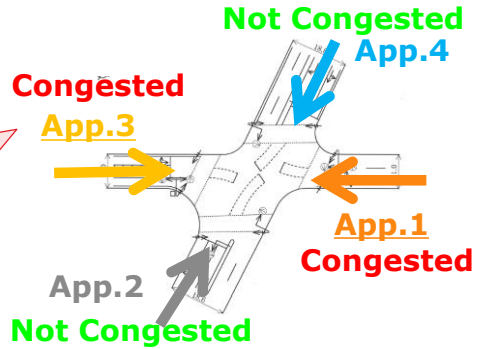
Use Case in Tokyo, Japan

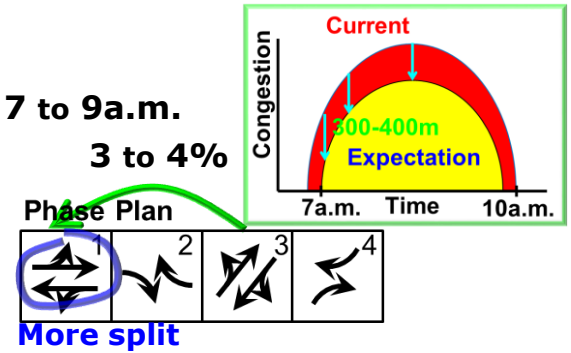
The new methods were implemented at the intersections in Tokyo. And the results proved the effectiveness of the methods.

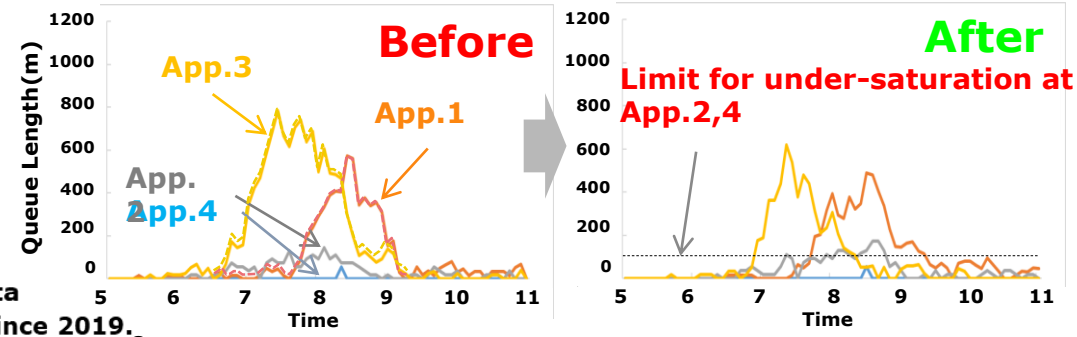
- **Probe-based detection of "Unbalanced Intersections"**



- **Probe-based signal parameter retiming**







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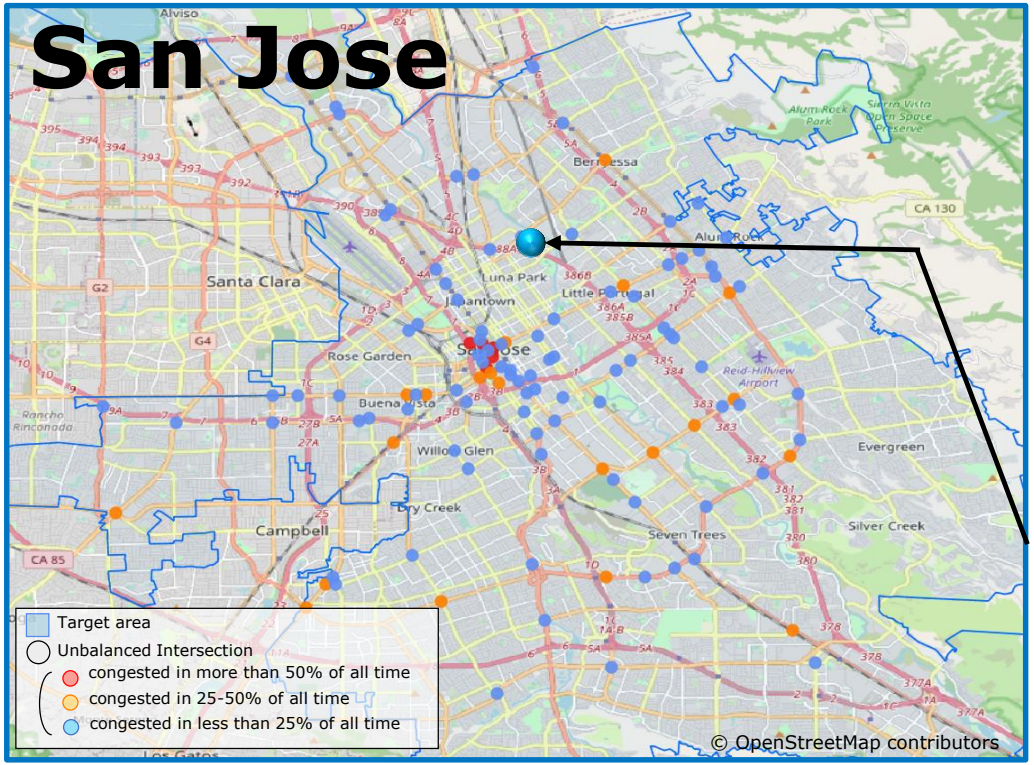
Signalized intersection analysis (Case in USA)

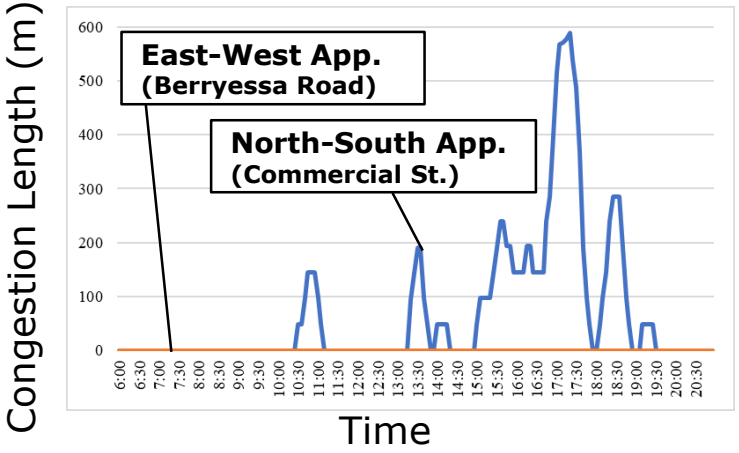
Sorting out unbalanced congestion intersections



* Period:
  1 - 5, Aug., 2022

* Unbalanced Intersections:
  116 / 1052 (about 11%)

Ex) 1 Aug., 2022



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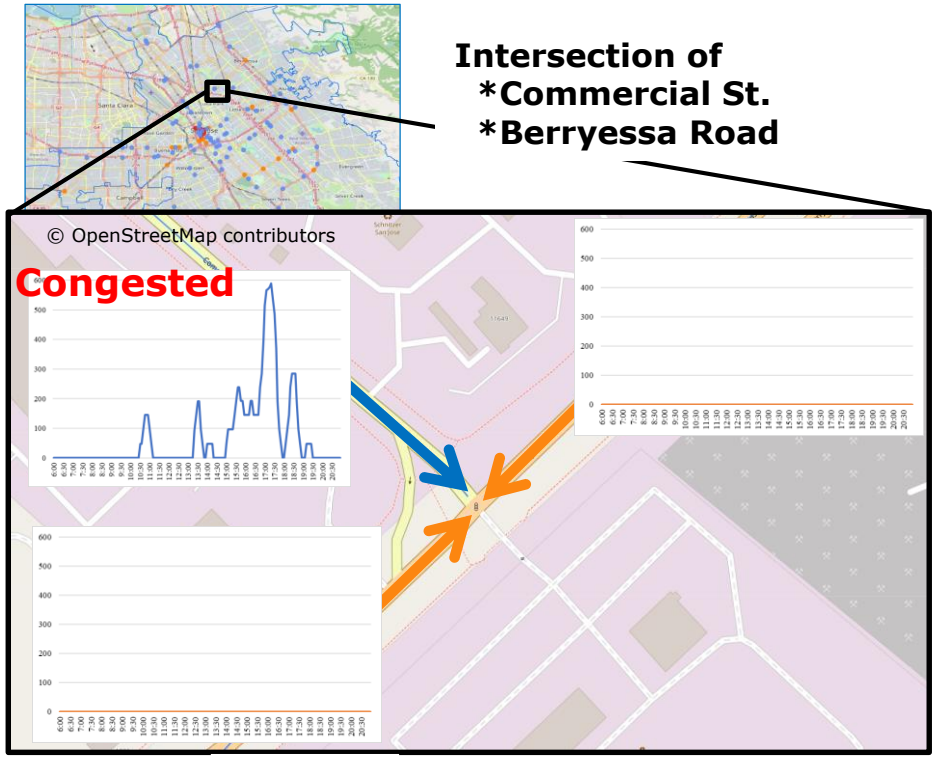

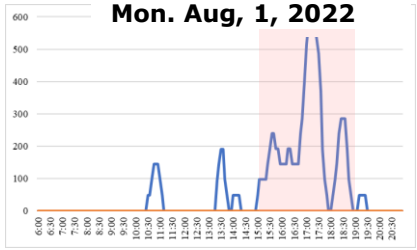

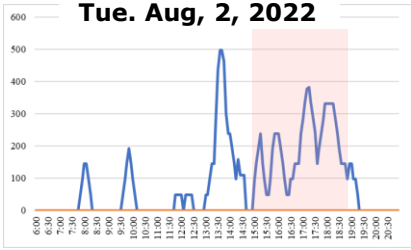

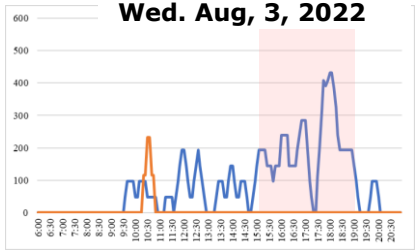

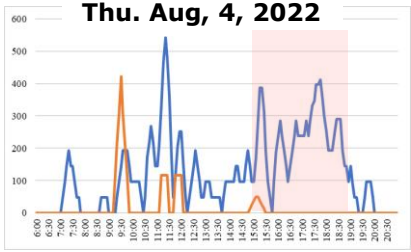

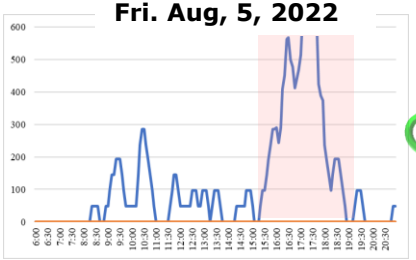

Room for signal retiming in the evening peak hours every weekday

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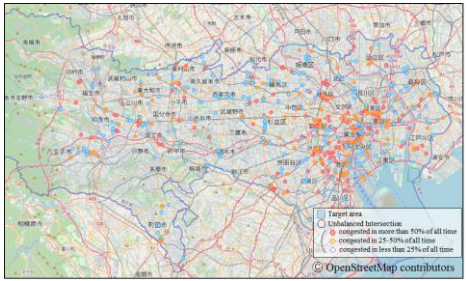
Work flow for making safe and smooth traffic flow with probe data analysis

Probe data (Current) → **Sorting out unbalanced congestion intersections**

Current signal control stats → **Analysis and Signal time data calculation**

Probe data (after) → **Effect inspection**



If $w \leq (c-g)/2$ Under-saturation

$q=\{1-(c-g)^2/(2wc)\}\ s_f$

New algorithm

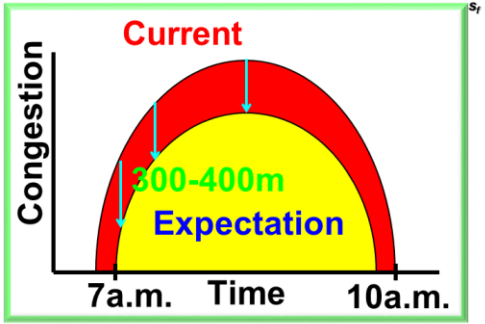
$L_r = \frac{q+k*v_q}{s_f}$

If $r/2<w$ Over-saturation

$q=(1-(c-g)/c)s_f$

$v_q=[\{w-(c-g)/2\}/(c-g)]*\{1-(c-g)/c\}s_f$

k : Usage ration of j
V_q : Vehicles in queue (veh./sec.)
c : Cycle length (sec.)
g : Effective green time (sec.)
s_f : Saturation flow rate (vehicle/sec.)



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