HARMONIZING TRAFFIC INFORMATION BENCHMARKS

North American Traffic Working Group

Data Quality 2010

About NATWG

ITS AMERICA

The North American Traffic Working Group (NATWG) works collaboratively to define, accept and advocate for the unique needs of North America traffic information services. NATWG seeks to develop a coordinated, proactive market driven implementation of traffic and travel information services and products by both influencing international standards efforts and coordinating the development of non-competitive commercial agreements.

Members sampling:

SIRIUS SATELLITE RADIO | XM

INRIX

california center for innovative transportation
UNIVERSITY OF CALIFORNIA, BERKELEY

BMW

NAVTEQ

Texas Transportation Institute

Total Traffic Network

TRAFFICAST

Traffic Information Quality

- Traffic information has become abundant but quality remains seldom monitored
  - End users are relatively clueless about information quality
  - Margins of error are not well understood and used in practice
- There are no widespread metrics or evaluation procedures to measure data quality
  - Each customer (e.g. car manufacturer, DOT…) conducts its own benchmark
  - Evaluation results cannot be readily compared

Postulate:

- Harmonized benchmarking methods would benefit both suppliers and customers
  - Improve consistency and fairness of evaluations
  - Lower overall costs by eliminating duplication of efforts
  - Better recognize true value-added and pull quality upward

NATWG's Data Quality Efforts

- Objective: agree on and publish guidelines on how to measure and report traffic information quality

- Process to date:
  - January-June 2009: Committee-level discussions
    - Each provider disclosed its data evaluation procedures
    - Concluded with synthesis at ITS America's annual conference
  - July-December 2009: Task force
    - Starting point: single floating car as ground truth collector
    - Developed draft guidelines that include procedures and metrics

Presentation Goals

- Present NATWG's product to date
  - Guiding principles and process
  - Premises of the guidelines
  - Content and organization of the document at a glance
  - Gaps, voluntary omissions and next steps
- Recruit stakeholders
  - Obtain further process buy-in and legitimacy
  - Collect feedback on content to move forward
  - Identify early adopters

Task Force

- Current Members:
  - J.D. Margulici, California Center for Innovative Transportation
  - Matt Lindsay, NAVTEQ
  - Kevin Lu, Telcordia
  - Chris Scofield, INRIX
  - Shawn Turner, Texas Transportation Institute
  - Billy Bachman, GeoStats
- Ex-Officio Member:
  - David McNamara, AutoTech Insider

Data Quality Measurements: Basic Premises

- Customers
  - Auto OEMs, PND manufacturers, data distributors, DOTs…
- Benchmarking purposes
  - Quality assurance, data validation
  - Comparison between providers, markets, traffic conditions…
- What gets assessed?
  - Incident / traffic event messages
  - Instantaneous flow data, i.e. speed-colored maps
  - Travel times
- What gets measured?
  - Timeliness [how fast conditions are transmitted]
  - Accuracy [degree of fit with a trusted source ('ground truth')]
  - User satisfaction [ultimate perception by the end user]

Different Flavors of 'Data Quality'

- FHWA metrics:

accuracy, validity, coverage, timeliness, completeness, accessibility

  - Accuracy
    - Most straightforward
  - Coverage
    - More difficult to articulate – only relevant with regards to a given level of accuracy
  - Timeliness
    - Seems more of an internal / SLA issue
  - Accessibility
    - Notion of usefulness / perception by end-user
    - Essential business feature, but ancillary to benchmarking

- NATWG Guidelines will initially focus on information accuracy

Measuring Information Accuracy

- Collect 'ground truth' traffic data
  - Define a set of technology and procedures
  - Key issue is level of confidence / statistical significance

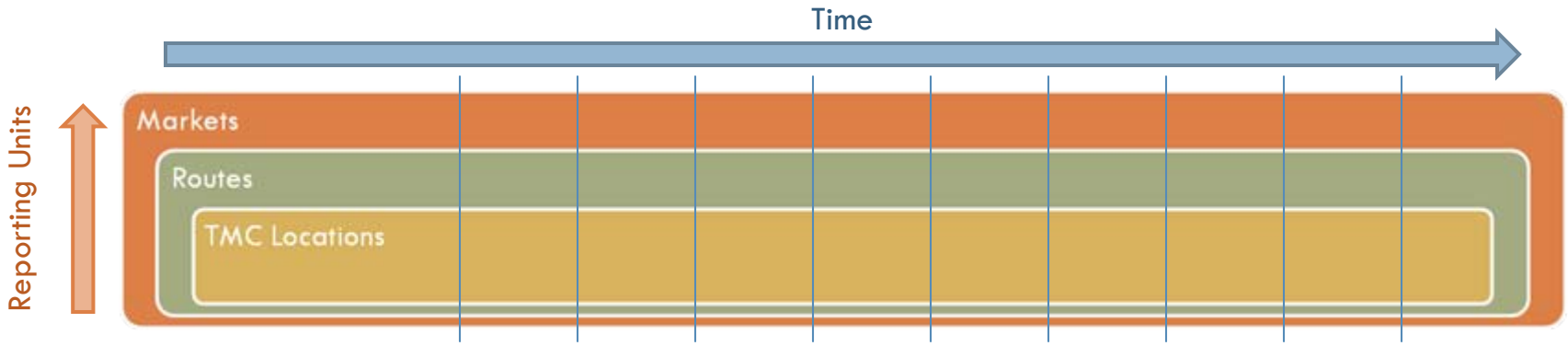
- Compare a traffic information source against ground truth
  - Requires metrics that are ideally:
    - Formally defined and easy to compute (no exceptions / fringe cases)
    - Relevant to the end-user experience
    - Easy to interpret
    - Good balance of synthetic vs. exhaustive (i.e. tells the story concisely)
    - Normalized and scalable (i.e. independent from route length, sample size, etc.)

NATWG Guidelines: General Considerations

- Focus on speed information
  - MPH value on a given segment at a given time
  - Median travel time along a route
  - Qualitative description such as ‘free flow’ or ‘heavy congestion’
- Guidelines, not standard (yet)
  - Leaves room to interpretation, balances principles with formal rules
  - Most important is transparency in assumptions, methods and results
- Insistence on meaningful tests
  - Reporting units (routes / time of day) must be homogeneous
  - Information quality matters most when roads are congested

NATWG Guidelines: Additional Considerations

- Guidelines developed for freeway environment primarily
  - Extension to signalized arterials possible
- Ground truth collection
  - Either floating cars or reidentification technology
  - To date, guidelines developed for a single floating car run
- Reporting units
  - By default, the most granular reporting unit is TMC location code
  - However the guidelines will work with any segment definition



NATWG Guidelines: Overview

- Preamble

1. General Considerations
2. Route Selection
3. Test Equipment
4. Driving Behavior
5. Data Logs Processing
6. Traffic Content Processing
7. Speed Comparison
8. Travel Time Comparison
9. Congestion Level Comparison

Speed Comparison

- For each TMC, we can compute the speed differential between the Ground Truth speed (V^{GT}) and the Traffic Information Service speed (V^{TIS})
- Differentials are aggregated across route TMCs, producing a single score
- We recommend using the Root Mean Squared Error (RMSE) aggregation:

$$\text{RMSE} = \sqrt{\frac{1}{n}\sum_{i=1}^{n}\left(V_i^{GT} - V_i^{TIS}\right)^2}$$

- Consider the following example:

TMC Code	Description	GT Speed	TIS Speed	Squared Difference
105N04414	I-80 / I-580 Merge to I-80 x Gilman-University	70.9	55.0	254.2
105N04413	I-80 x Gilman-University to I-80 x University	72.5	65.0	56.4
105N04412	I-80 x University to I-80 x Ashby	50.3	55.0	22.3
105N04411	I-80 x Ashby to I-80 x Powell	36.1	32.0	16.5
105P18840	I-80 x Powell to McArthur Maze	41.7	48.0	39.1
105N04409	McArthur Maze to I-80 / I-580 Merge	12.4	20.0	57.9
105N04408	I-80 / I-580 Merge to I-80 / I-880 Merge	19.6	21.0	1.8
105N04407	I-80 / I-880 Merge to Bay Bridge Toll Booths	8.9	17.0	65.5
105N04406	Bay Bridge Toll Booths to Bay Bridge East End	46.2	45.0	1.5
105N04405	Bay Bridge East End to Yerba Buena Island	45.6	58.7	171.9
105N04404	Yerba Buean Island to Bay Bridge West Span	41.7	33.0	75.6
105N04403	Bay Bridge West Span to I-80 x Embarcadero	29.2	37.5	68.8
105N04402	I-80 x Embarcadero to I-80 x Harrison	37.9	34.0	15.3
105N04401	I-80 x Harrison to I-80 x 5th Street	51.9	45.0	47.2
105N04400	I-80 x 5th Street to I-80 x 7th Street	54.4	55.0	0.4
			RMSE	7.72

Travel Times Comparison (Components)

- For each road element considered, four basic elements are calculated:
  - *L* - The length in miles of the cumulative distance between each GPS point on the segment
  - T^{ACT} - The actual travel time of the test vehicle.
  - T^{REF} - The reference speed travel time estimate of the vehicle.
  - T^{TIS}- The estimate of travel time using data from the Traffic Information Service are calculated.
- For example, three sections of a 60 MPH limit freeway might yield the following:

ID	Length (Miles) *L*	Entry Time	Exit Time	Actual Travel Time (Seconds) T^{ACT}	Reference Speed Travel Time (Seconds) T^{REF}	TIS Estimated Travel Time (Seconds) T^{TIS}	
1	1	07:00:00	07:01:12	72	60	84	← *TIS Too Slow*
2	2	07:01:13	07:05:13	240	120	180	← *TIS Too Fast*
3	0.5	07:05:14	07:05:59	45	30	65	← *TIS Too Slow*

- From these elements, deltas between T^{ACT} and each of T^{REF} (D^{REF})and T^{TIS} (D^{TIS}) are calculated as relative and absolute values and harmonized by length (E^{REF}, E^{TIS}), where the delta is the est. travel time minus the actual travel time in each case e.g.:
  - $D^{REF} = T^{REF} - T^{ACT}$ and $D^{TIS} = T^{TIS} - T^{ACT}$
  - $E^{REF} = D^{REF}/L$ and $E^{TIS} = D^{TIS}/L$

This creates a relative and absolute metric for each segment equivalent to seconds per mile (SPM) of error for each of T^{REF} and T^{TIS} compared to T^{ACT}.

Travel Times Comparison (Metrics)

- In this fashion, the performance of traffic information can be compared in a normalized fashion to create a metric of the value of the traffic information in the context of the amount of travel time lost due to the vehicles reduced speed where 'Improvement' (I) is defined as:
  - $I = ABS\ E^{REF} - ABS\ E^{TIS}$
- We can further calculate a second value of improvement (I^{PC})as a percentage of the total absolute error of the reference speed estimate removed using the total TIS estimate for the entire route – e.g.:
  - $I^{PC} = I/ABS\ E^{REF}$

ID	L	T^{ACT}	T^{REF}	T^{TIS}	D^{REF}	D^{TIS}	ABS D^{REF}	ABS D^{TIS}	E^{REF}	E^{TIS}	ABS E^{REF}	ABS E^{TIS}	I	I^{PC}	
1	1	72	60	84	-12	12	12	12	-12	12	12	12	0	0.00	*Net tie*
2	2	240	120	180	-120	-60	120	60	-60	-30	60	30	30	0.50	*Net Improvement*
3	0.5	45	30	65	-15	20	15	20	-15	20	30	40	-10	-0.33	*Net Degradation*
R1	3.5	357	210	229	-147	-28	147	28	-42	8	42	8	34	0.81	*Route Net Improvement*

Sum of Individual (L and T) components are then Processed using the same logic to create route based units.
Sum of route based units can be further aggregated within road class to give city wide score.

Travel Times Comparison (Aggregation)

- Another useful metric that can be derived from this numbers is the performance of both the reference speed estimates and the TIS estimates of travel time to the actual travel time observed, where:
  - $P^{REF} = 1-(ABS\ D^{REF} / T^{ACT})$
- These metrics provide the context for the amount of congestion observed in the test and the impact of the improvement in performance in the context of the total actual drive time. These metrics as all travel time metrics tend to provide more clarity when aggregated at the route level.
- In our sample, the P^{REF} values vary from 50% to 84% accuracy of travel time prediction and average only 59% accuracy for the whole route. P^{TIS} also varies from 56% to 84%, but in the context of the route, the travel time estimate using the traffic data is 92% accurate.

ID	T^{ACT}	ABS D^{REF}	ABS D^{TIS}	P^{REF}	P^{TIS}
1	72	12	12	0.84	0.84
2	240	120	60	0.5	0.75
3	45	15	20	0.66	0.56
R1	357	147	28	0.59	0.92

Congestion Levels and Speed Tolerance

- Speeds can be put into 'levels' corresponding to degree of congestion. For example:

Speed Levels (% of Reference Speed)	Speed Level Boundaries (Ref Speed = 50)	Speed Level Boundaries (Ref Speed = 65)	Congestion Level	Level Index
92+%	46+	60+	Green	4
62-92%	31-46	40-60	Yellow	3
31-62%	16-31	20-40	Red	2
0-31%	0-16	0-20	Black	1

- The floating car speed and the speed reported by a traffic information source may stand across a speed boundary while being very close

- Penalizing the traffic information provider for a wrong level estimate in such a situation is neither fair nor desirable. This effect is minimized with a speed tolerance threshold θ :

$$if\ |V^{GT} - V^{TIS}| < \theta\ then\ L^{GT} = L^{TIS}\ otherwise\ L^{GT} \neq L^{TIS}$$

Congestion Levels: An Example

- An error count can be computed reflecting the frequency that the GT and TIS speeds correspond to different levels

- Using our example:

TMC Code	Description	GT Speed	TIS Speed	GT Level	TIS Level	GT Level with Threshold	Difference
105N04414	I-80 / I-580 Merge to I-80 x Gilman-University	70.9	55.0	4	3	4	1
105N04413	I-80 x Gilman-University to I-80 x University	72.5	65.0	4	4	4	0
105N04412	I-80 x University to I-80 x Ashby	50.3	55.0	3	3	3	0
105N04411	I-80 x Ashby to I-80 x Powell	36.1	32.0	2	2	2	0
105P18840	I-80 x Powell to McArthur Maze	41.7	48.0	3	3	3	0
105N04409	McArthur Maze to I-80 / I-580 Merge	12.4	20.0	1	1	1	0
105N04408	I-80 / I-580 Merge to I-80 / I-880 Merge	19.6	21.0	1	2	2	0
105N04407	I-80 / I-880 Merge to Bay Bridge Toll Booths	8.9	17.0	1	2	1	1
105N04406	Bay Bridge Toll Booths to Bay Bridge East End	46.2	45.0	4	3	3	0
105N04405	Bay Bridge East End to Yerba Buena Island	45.6	58.7	3	4	3	1
105N04404	Yerba Buean Island to Bay Bridge West Span	41.7	33.0	3	3	3	0
105N04403	Bay Bridge West Span to I-80 x Embarcadero	29.2	37.5	2	3	2	1
105N04402	I-80 x Embarcadero to I-80 x Harrison	37.9	34.0	2	2	2	0
105N04401	I-80 x Harrison to I-80 x 5th Street	51.9	45.0	3	3	3	0
105N04400	I-80 x 5th Street to I-80 x 7th Street	54.4	55.0	3	3	3	0
						Error Count	4

Further Considerations

- Metrics are not fully formalized yet
  - Need to rub against real world data
  - Need buy-in from more stakeholders
- Ground-truth data collection needs revisiting
  - Make determination on adequate sampling
  - Examine alternatives to floating cars
- The testing methodology needs to scale up
  - From a given route to an entire metropolitan market

Implications

- Expand task force
  - Recruit new members who can weigh in on final decisions
  - Generate additional legitimacy
- Need partners to try out the guidelines
  - Use metrics with existing / ongoing validation data
- Need additional technical investigations
  - Fine-tuning of metrics and their parameters
  - Study sample size issues
  - Good news: pooled fund study can provide match

Pooled Fund Study TPF-5(200)

- Objective:
  - Standard test procedure to evaluate the quality of travel time data services
  - Consistent evaluation results
  - Fair comparisons between data services
- Public agency clients, public and private stakeholders
- Sponsors:
  - VA lead state
  - Also AL, CA, FHWA, MD, MI, PA
- Contractors:
  - VTRC, UVA, TTI
- August 2009 to April 2011
- See http://www.pooledfund.org

Thank you!

Q&A

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