

New Transit Performance Measures and LOS Criteria for Link-level Assessment

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ABSTRACT

The focus of this research is to assess link-level transit performance measures from the operators' perspective. Data captured through Automatic Vehicle Location (AVL) units installed on Charlotte Area Transit System (CATS) buses for 2012 was used to develop query tools and compute link-level transit system performance measures, conduct analysis, and derive meaningful interpretations. The query tools developed computed measures by comparing actual bus travel time along selected links (between two consecutive fixed bus stops) with the scheduled travel time along the same link for each run in a year. Actual delay time and early arrivals as well as percentage of delays and early arrivals were computed to assist in the assessment. New level-of-service (LOS) criteria, to indicate link-level transit system performance, based on percentage-based measure are proposed. The analysis was conducted by time-of-the-day and day-type. Findings from the research indicate that percentage-based performance measures would be more reliable than fixed range-based measures (delay or difference in travel time) for planning and assessment of operational performance by transit agencies.

INTRODUCTION

- Public transportation helps reduce road congestion and travel time, thereby, reducing energy consumption and air pollution.
- The performance of transit system plays a vital role for over 90 percent of public transportation users who do not own a car and have to rely on public transportation.
- According to the Federal Highway Administration (FHWA), 50 percent of transit system users were travelling to or from work, 12 percent to or from college or school, and 4 percent to access medical services.
- These statistics show that the reliability of transit system is important for at least 66 percent of users who need to know their expected travel time to a given destination, to be on time.
- Travel time reliability, on-time performance, delay, safety, security, comfort, convenience, frequency, hours of service, service coverage, transfer time, and passenger environment are some of the transit performance measures.
- In this research, the reliability of link-level (scheduled) travel times is evaluated to assess the transit system performance.

BACKGROUND

- The level of variability between the expected travel time (scheduled, average or median travel time) and the actual travel time is travel time reliability.
- Researchers in the past have proposed various concepts of transportation reliability such as connectivity reliability, capacity reliability, encountered reliability, performance reliability, flow decrement reliability, mode choice reliability, and travel time reliability (Wakabayashi, 2008).
- Seberi et al. (2013) proposed and used stop-level reliability measures using empirical data from archived Bus Dispatch System (BDS) data in Portland, Oregon to evaluate and prioritize stops for operational improvement purposes such as bus holdings or schedule adjustments.

METHODOLOGY

- AVL data collected at fixed bus stops during 2012 was used for research.
- Data was categorized based on the direction (inbound, outbound), segment (between two consecutive fixed bus stops), day-type (weekday or weekend), and time-of-the-day.
- Travel times (between two fixed bus stops), actual travel times (summation of actual dwell time and actual travel time), and scheduled travel times (summation of scheduled dwell time and scheduled travel time) for each segment were computed.
- The transit performance for each route was evaluated by comparing actual travel times with scheduled travel times on each segment between the fixed bus stops.
- To evaluate severity of delays or early arrivals, five different ranges of percentage-based on-time performance measures are proposed instead of fixed range-based on-time performance measures.

Fixed range-based on-time performance measures (Existing - TCQSM)

$$-\delta \geq [\text{scheduled travel time} - \text{actual travel time}] \leq +\delta$$

where, $\delta = (1 \text{ min}, 2 \text{ min}, 3 \text{ min}, 4 \text{ min}, \& 5 \text{ min})$

Percentage-based on-time performance measures (Proposed)

$$-\delta (\text{aveTT}) \geq [\text{scheduled travel time} - \text{actual travel time}] \leq +\delta (\text{aveTT})$$

TABLE 1 Proposed LOS Criteria

LOS	Range
A	If at least 50% of times, (STT-ATT) is within $\pm 5\%$ of average TT
B	If at least 50% of times, (STT-ATT) is within $\pm 10\%$ of average TT
C	If at least 50% of times, (STT-ATT) is within $\pm 15\%$ of average TT
D	If at least 50% of times, (STT-ATT) is within $\pm 20\%$ of average TT
E	If at least 50% of times, (STT-ATT) is within $\pm 25\%$ of average TT
F	If 50% of times, (STT-ATT) is not within $\pm 25\%$ of average TT

*Note: TT is travel time, ATT is summation of actual dwell time & actual travel time and STT is summation of scheduled dwell time & scheduled travel time.

CASE STUDY

- Transit bus Route 11 in the Charlotte metropolitan area, which runs between Transit City Center and the University of North Carolina at Charlotte, was considered as the case study.
- The total number of fixed bus stops for inbound and outbound directions is 6; including bus start point and end point.

TABLE 2 Summary of Weekday Travel Times for Route 11, Segment 1, Inbound Direction for the Year 2012 based on Time-of-the-day

Time Period	Sample Size	Actual Travel Time (sec)			Scheduled Travel Time (sec)		
		Minimum	Average	Maximum	Minimum	Average	Maximum
9-Jul	1,296	612	1,216	2,748	660	1,022	2,460
11-Sep	1,272	556	969	1,827	780	987	2,400
13-Nov	1,269	616	974	1,996	720	868	1,920
13-15	1,316	584	1,517	3,094	720	1,425	1,920
15-17	1,188	610	1,621	3,119	780	1,562	1,920
17-19	1,053	576	1,160	3,071	840	1,368	3,540
19-7	3,861	430	1,038	3,636	720	955	1,800

Figure 1 Route 11 with Fixed Bus-stops - Inbound (left) and Outbound (right)

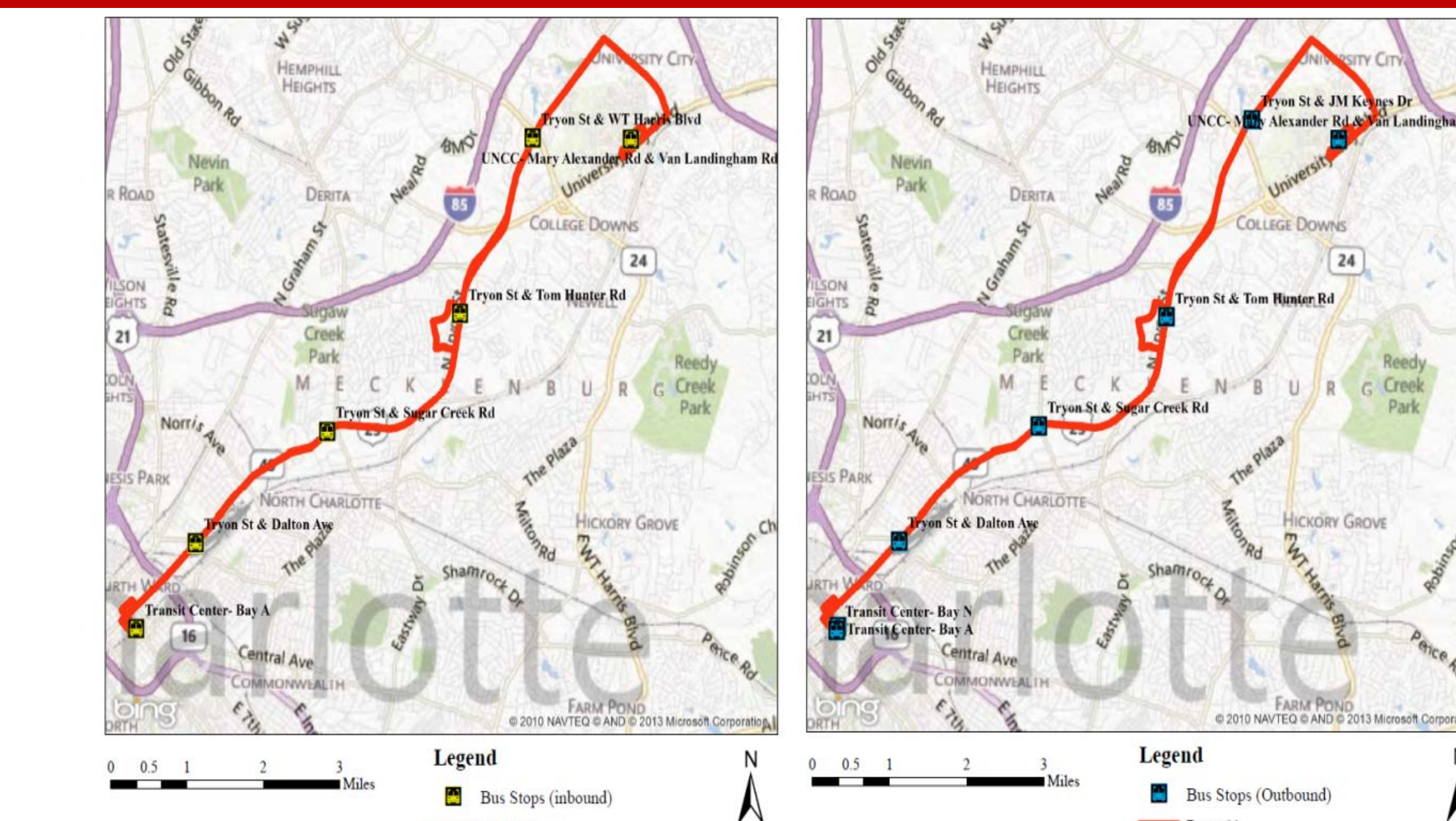


TABLE 3 Fixed-range based On-time Performance Measure for Route 11, Segment 1, Inbound Direction based on Time-of-the-day

Segment	TOD	Fixed-range based On-time Performance Measure (%)				
		1 min	2 min	3 min	4 min	5 min
1	AM Peak	19.10	35.20	48.60	60.60	69.00
	Mid-Day	20.90	44.10	60.90	76.20	84.90
	PM Peak	11.00	18.70	28.00	38.30	48.10
2	AM Peak	18.60	41.70	71.00	85.70	98.00
	Mid-Day	35.60	69.10	92.30	98.70	99.70
	PM Peak	44.10	81.50	90.50	97.40	98.40
3	AM Peak	41.60	70.20	86.40	95.10	98.30
	Mid-Day	39.00	66.60	83.70	92.30	96.50
	PM Peak	38.60	68.60	87.00	93.90	97.40
4	AM Peak	52.60	86.50	97.40	99.20	99.50
	Mid-Day	45.10	80.50	94.90	98.00	99.10
	PM Peak	18.10	43.30	65.90	89.90	99.10
5	AM Peak	41.80	77.80	91.40	95.60	97.20
	Mid-Day	34.50	64.30	86.10	95.00	97.70
	PM Peak	29.80	59.30	81.00	93.40	96.80

TABLE 4 Percentage-based On-time Performance Measure for Route 11, Segment 1, Inbound Direction based on Time-of-the-day

Segment	TOD	New On-time Performance Measure (%)				
		5%	10%	15%	20%	25%
1	AM Peak	19.10	35.60	48.80	60.90	69.50
	Mid-Day	18.00	35.10	53.00	64.80	76.80
	PM Peak	10.60	18.30	27.10	36.40	46.80
2	AM Peak	6.70	13.50	18.90	26.30	33.50
	Mid-Day	15.90	29.90	43.40	58.30	71.30
	PM Peak	12.20	36.70	66.10	79.90	82.50
3	AM Peak	14.60	32.60	50.90	62.70	71.40
	Mid-Day	15.80	32.80	47.60	59.00	67.70
	PM Peak	16.50	33.00	47.50	60.90	69.70
4	AM Peak	20.60	40.80	57.00	73.20	84.20
	Mid-Day	16.50	33.00	49.70	64.10	76.60
	PM Peak	6.00	12.10	21.10	29.20	39.30
5	AM Peak	24.70	40.60	61.20	76.40	84.20
	Mid-Day	17.70	33.60	49.00	63.40	75.60
	PM Peak	13.30	26.50	41.60	54.80	66.30

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TABLE 5 LOS based on Percentage-based On-time Performance measure

Segment	Time Period	LOS
1	AM Peak	D
	Mid-day	C
	PM Peak	F
2	AM Peak	F
	Mid-day	D
	PM Peak	C
3	AM Peak	C
	Mid-day	D
	PM Peak	D
4	AM Peak	C
	Mid-day	D
	PM Peak	F
5	AM Peak	C
	Mid-day	D
	PM Peak	D



TABLE 6 Comparison of On-time Performance Measures for Route 11, Segment 1, Inbound Direction

Range-Based On-time Performance Measures	Standard Deviation	
	Inbound	Outbound
STT ± 1 Minutes	13.49	21.27
STT ± 2 Minutes	19.12	32.01
STT ± 3 Minutes	18.47	33.25
STT ± 4 Minutes	15.82	33.38
STT ± 5 Minutes	13.05	31.67
Percentage-Based On-time Performance Measures	Inbound	
	Inbound	Outbound
STT $\pm 5\%$ of Average TT	4.86	9.45
STT $\pm 10\%$ of Average TT	8.74	16.8
STT $\pm 15\%$ of Average TT	12.01	22.57
STT $\pm 20\%$ of Average TT	13.98	26.61
STT $\pm 25\%$ of Average TT	14.33	28.61

CONCLUSIONS & SCOPE FOR FUTURE WORK

- Arrival of a bus at a bus-stop has a strong correlation with travel time along the previous links and delays incurred at the previous bus-stops.
- As fixed-time based performance measures does not consider the effect of length and other traffic characteristics of the segment, this research recommends using the percentage of times the actual travel times and scheduled travel times differ between bus-stops for use in assessing transit system performance.
- The proposed percentage-based performance measures and LOS criteria are observed to be more reliable than fixed range-based measures. It can be further explored and used by agencies as a measure for planning and assessment of link-level operational performance.
- Incorporating tolerance levels in evaluating LOS measures based on riders/passengers perspective merits an investigation.

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