Route: D

Eliminating Bus Bunching - Building a process, information source, and tool box for improving service

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SUMMARY

The Chicago Transit Authority has improved bus service reliability by 30% using a performance management process and organizational focus on improving the biggest concern for bus customers: waiting too long for the bus. The focused, team approach has helped the agency increase ridership, effective capacity, and customer satisfaction.

LONG WAITS FOR BUSES

The Problem

Customers hate waiting for the bus. Research suggests that customers would be willing to trade one minute waiting for the bus for an extra three minutes riding the bus.[1] The 2006 CTA customer satisfaction survey highlights the three most important issues to resolve for bus customers: "Consistent scheduling of buses", "Knowing what time the next bus arrives", and "On-time performance".

More commonly, customers refer to the problem as "bus bunching". This customer's story sums up the problem on what was voted in the media as the worst route in the system (#8-Halsted): "she grew so disgusted with her No. 8 travels that she eschewed the bus altogether. The final straw: A 55-minute wait for a bus headed southbound as five buses going north passed her by."[2] This is a route with a scheduled headway of 7-10 minutes. This story illustrates the main characteristic of the bus bunching complaint: an extended wait or gap in service. It is often accompanied by what is seen as an inefficient use of resources (operators and equipment) that could be used to eliminate that wait, buses travelling one after another. For the customer, the wait is probably bad enough but seeing multiple buses arriving or passing in the other direction is like salt in a wound. The extended wait could have been eliminated.

Buses bunched together and gaps in service are, unfortunately, the natural state of an unregulated system. Buses spaced evenly apart represent an unstable equilibrium. One external factor can easily put a bus farther behind the one in front and closer to the one behind[3]. Some of the most common external factors include uneven customer loading patterns, street congestion, temporary street blockages, weather conditions, and uneven operating patterns. Once a bus is further behind the one in front (the leader), it must pick up more and more customers, exacerbating the problem. As

[1] Paula Armstrong, Rodrigo Garrido, Juan de Dios Ortúzar (2001). Confidence intervals to bound the value of time. Transportation Research Part E 37 p.143-161

[2] KYRA KYLES (2007, July 3). No. 8 is far from 1st for these bus riders :[RedEye Edition]. Chicago Tribune,p. 4. Retrieved January 24, 2009, from Chicago Tribune database. (Document ID: 1299012621).

[3] For a bus bunching simulation, see www.leatherdale.me.uk/dik/buses.html

the bus gets closer to the bus behind (the follower), the follower picks up and drops off fewer and fewer customers allowing it to close the gap with the bus in front. Now, two buses are traveling together behind an ever-widening gap in service. Other passenger systems, like banks of elevators, exhibit similar bunching behavior. The operating schedule with time points along the route and variable recovery at the terminal attempts to regulate intervals and correct them at the start of the next terminal departure. However, if buses are too far behind schedule, or not able to operate to it, the problem cascades.

The Opportunity

GPS information

The CTA now has both real-time and historical GPS location information for every bus in the system. Armed with this information, the CTA initiated an operations team in the fall of 2007 to eliminate (or dramatically reduce) "bus bunching". Beginning in 2008, the real-time bus tracking system (known as Bus Tracker, www.ctabustracker.com, supplied by Clever Devices) was going to be released in stages for the public. This would help address some of the customer problem of not knowing when the bus will arrive but, if the waits for buses remained long, it would not only continue to drive customers away but also be a disservice to the customer.

Better customer service

The CTA provides about 1 million customer rides on buses every weekday. Every minute that can be saved for customers is more time that they can spend at work, at home, or elsewhere going about their business. This presents a large opportunity to improve the efficiency and quality of life in the Chicago region. Not only that, creating a more reliable bus system should help increase ridership by serving those who would otherwise give up on the system when they need reliable service the most. In other words, a customer may have flexibility in travel times three days a week but not on the other two days. An unreliable system may be sufficient for those flexible days but only a reliable system will be able to meet the customer's requirements for all five days.

PERFORMANCE MANAGEMENT

Acknowledging the Customer Problem

The first step to addressing the problem is to acknowledge the problem exists. While anecdotes from customer complaints and media stories along with customer research help signal that a problem exists, they do not summarize the extent of the problem or present a method for improving it. The historical GPS information provided the evidence that, while riders on some routes may be more vocal, the lack of well-spaced buses was not isolated to a few routes. Armed with this data, the internal team set out on the next step to address the problem.

Defining the Overall Service Quality Measure

The service quality measure must have the following qualities, they should:

- Measure what matters. In this case, customers care most about their wait for the bus.
- Have a clear, consistent, understandable definition. It should be easy for anyone in the organization, from managers to bus operators to planners and support staff to see how the measure is derived and why it matters.
- Present a path toward improvement. The measure should be able to point managers to what should be increased or decreased.
- Be sensitive to changes. When service gets better or worse, the measure should move appropriately to indicate that change.

Measuring what matters

One of the first measures attempted at the CTA to measure bus service quality was to measure the incidence of buses passing a time point within one minute of each other. While this technically measures buses bunched together, it does not address the primary customer concern of the extended wait. Rather than measure the instances of buses close together, the overall bus service quality measure would measure the instances of buses far apart from each other. In many cases the two are related; a large gap between buses leads to several behind it bunching together. The customer complaint of bus bunching occurs because of a large gap in service followed by several buses coming at the same time. It is more important to address the long wait times and overall unreliability of service rather than just bus bunching.

A clear, consistent, understandable definition

A big gap in service is defined as an interval between buses (as measured at a time point) that is greater than either double the scheduled headway or 15 minutes, whichever is greater. This interval is clearly unacceptable and should be reduced. No interval under 15 minutes is ever a big gap, helping expand the focus beyond narrow headway routes, which would show up disproportionally in a strict double headway measure and would not highlight the very negative experiences. This worst-of-the-worst definition also focuses on those really negative customer experiences that disrupt and drastically expand customers' wait time and lead to a lack of reliability.

Several other definitions were considered, including average wait time, excessive wait time, expected wait time, and other headway measures. While the wait time measures are closer to the customer experience across the system, their somewhat complex definitions are difficult to communicate. In a performance management approach, those impacting the measure should be able to understand it. An analysis of average wait time and Big Gaps showed that the two were highly correlated and gave the team confidence that the right measure would be addressed. Every route was ranked based on the number of Big Gaps on the route. Service is roughly designed so that each bus is serving the same amount of customers so a count of those gaps approximates the magnitude of the customers affected. Reassuringly, the #8-Halsted route showed up as the route with the most gaps in service. This route was voted the worst route in the system by the local media[4] and received numerous complaints. It is about 14 miles long and carries 3.5 million customers annually, crossing three college campuses and five rail stations with headways of 6-10 minutes.

Presenting a path toward improvement

The Big Gaps measure emphasizes that closing the gap between two buses spaced very far apart will improve service. When one of the initial measures, a strict bunching measure of two buses travelling within one minute of each other was presented to the Chief Operating Officer, he laughed and said, "If all we want to do is end bus bunching tomorrow, I will issue an order that any bus must not get within three blocks of its leader." This would exacerbate the problem of gaps in service. Not only that, it would not address the core issue causing the unreliable service. The Big Gaps measure showed how service could be improved and would give managers and the rest of the organization a clear target to attack.

Sensitivity to changes

If service improves, Big Gaps should go down. Because a big gap is a dichotomous measure, it does not move as smoothly as an average. There should be enough of them that they will, on average, show trends in service. Initially, there were about 300,000 monthly Big Gaps, representing 8.4% of the system's total intervals between buses. The routes with the highest gaps had measures of 10-20%. This presented a large enough opportunity that was still manageable to address.

Identifying the Key Levers

Supporting measures help show whether progress is being made on the strategies to improve the overall service quality measure. The CTA set out with the goal of creating a handful of supporting measures that directly impacted the overall service quality measure and had clear accountability. These measures would be presented along with the overall measure in the weekly and monthly service quality report. They were easily measurable, had strict accountability, and impacted service. While not comprehensive, they did help provide managers a place to start to improve service. The supporting measures are:

- Relief Violations: Number of on-street reliefs where operators are not present when their bus arrives, causing a delay.
- Runs held: Runs/buses that are not put in service.
- Late at first time point: % of buses that are late to their first stop of the day.
- Scheduled trips recorded: % of the scheduled service that was recorded by the GPS/AVL system. Buses not recorded either were not on the street or had faulty AVL equipment.
- Maintenance Service Delays: In-service delays due to a maintenance-related issue (e.g. engine breakdown).
- Non-maintenance Service Delays: In-service delays due to a non-maintenance equipment issue (e.g. broken window).
- AVAS defects: % of buses at a garage that have AVL equipment not functioning.

The final operational service report is shown in Figure 1.

Figure 1. Service Reliability Report

[4] See note 2

WEEKLY BUS SERVICE REPORT

Confidential (For Internal Use Only)
Week of Sunday, 1/18/2009 - Saturday, 1/24/2009

BUS SERVICE

	Big Gaps	Unscheduled Bunching	Relief Violations	Runs held	% Late 1st Rev Timepoint	Scheduled trips recorded	Mtc SDs	Non-Mtc Equip SDs*	AVAS defects
Systemwide									
1/18/2009	4.4%	2.2%	22	0	9%	94%	511	85	2%
1/11/2009	5.1%	2.8%	19	4	14%	94%	803	120	2%
1/4/2009	4.8%	2.6%	28	1	10%	93%	572	106	1%
12/28/2008	5.1%	1.6%	31	2	11%	N/A	493	106	2%
Change	-0.7%	-0.6%	3	(4)	-5%	0.4%	(292)	(35)	0%
103rd									
1/18/2009	3.8%	1.7%	1	0	9%	95%	36	5	0%
1/11/2009	4.2%	2.3%	2	2	12%	96%	45	5	1%

Additionally, on a monthly basis the individual route performance is reviewed with the key levers that the Scheduling department is responsible for:

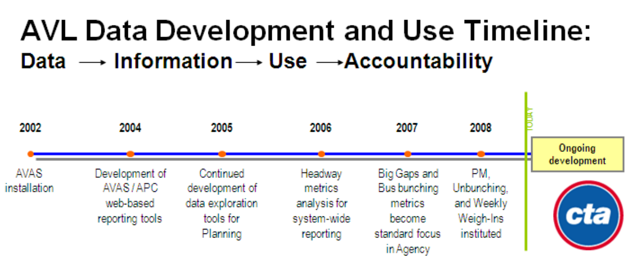
- Short run times: % of trips that are not able to complete their scheduled trip plus recovery time to start their next trip on time (target = 5%)
- Big loads: % of buses with peak passenger loads that meet or exceed capacity

As the analysis and measurement capability developed, supporting measures were added, removed, or adjusted on the service report. Significant changes from week to week or month to month are highlighted in red or green, corresponding to a positive or negative direction.

Creating the Toolbox

As previously described, the first step was to define an outcome measure central to the customer experience, which is essentially "how long do I have to wait for a bus." Technology allowed the CTA to do that in a way that was still in the realm of fiction in 1993 when the federal government formalized agency performance reviews. A brief timeline of the technological developments at the CTA shows the length of time between having measuring capabilities (with the installation of AVL on buses) and using those capabilities for customer-oriented service improvements.

Figure 2. AVL Development



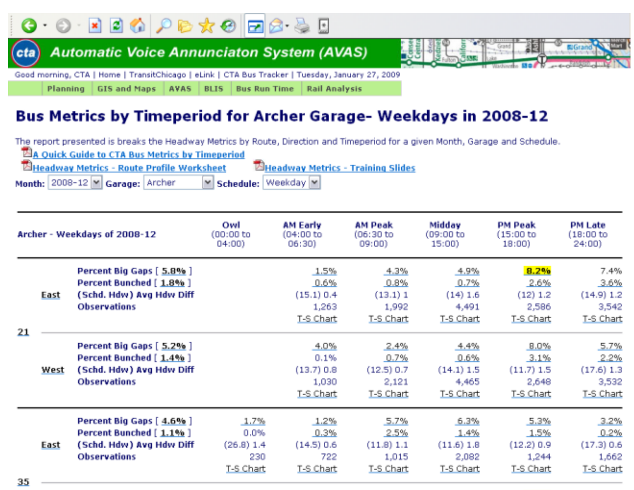
With a working definition of a customer-oriented measure or measures (i.e., Big Gaps and Unscheduled Bunching), the process was begun to create accountability for those measures. Garage and route managers were given responsibility for the performance of their routes.

The next step was to provide tools for analysis so that managers could see what was going on with a lot of detail and try out methods to create even intervals that would make an impact on those measures. Analysis and experimentation were now possible, with an ultimate measure of Big Gaps and Bunching, and a number of subsidiary measures that are seen either as levers to influence the ultimate measures or as focusing mechanisms. The tools can reveal hidden trends and identify outliers.

Two report formats have been key to using intelligent transportation systems (ITS) and data. These are the reports that show (1) Big Gaps/Bunching by time of day and allow the user to click through to more detailed analysis that shows location of problems, and (2) time/space charts (also known as string charts) that allow for review of headways all along the route. No mention can be made of these reports without noting that high praise goes to the information technology developers at the CTA who have done the intensive work of developing databases, pulling out the relevant data and turning it into the reports that managers understand can use. While the initial driver for the data analysis and report development was use by the Scheduling and Planning groups, the move to use by Operations has been well supported.

The information allows a systematic review of the entire system. This gives the CTA more ability to implement their objective approach to improving the system. Rather than focusing on a single incident or complaint, a complete time period and comprehensive view of service is taken. Examples of these reports are shown in Figures 3-5.

Figure 3. AVL Service Reliability by Time Period


cta Automatic Voice Annunciaton System (AVAS)

Good morning, CTA | Home | TransitChicago | eLink | CTA Bus Tracker | Tuesday, January 27, 2009

Planning | GIS and Maps | AVAS | BLIS | Bus Run Time | Rail Analysis

Bus Metrics by Timeperiod for Archer Garage- Weekdays in 2008-12

The report presented is breaks the Headway Metrics by Route, Direction and Timeperiod for a given Month, Garage and Schedule.

A Quick Guide to CTA Bus Metrics by Timeperiod

Headway Metrics - Route Profile Worksheet | Headway Metrics - Training Slides

Month: 2008-12 Garage: Archer Schedule: Weekday

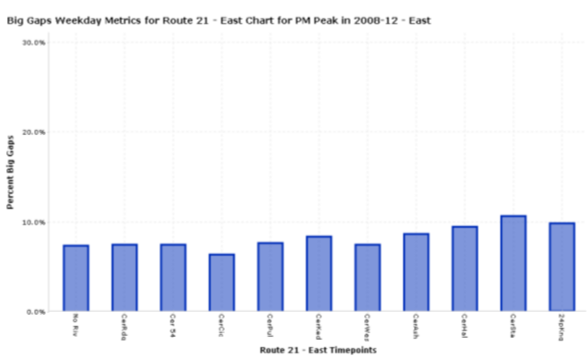
Archer - Weekdays of 2008-12			Owl (00:00 to 04:00)	AM Early (04:00 to 06:30)	AM Peak (06:30 to 09:00)	Midday (09:00 to 15:00)	PM Peak (15:00 to 18:00)	PM Late (18:00 to 24:00)
21	East	Percent Big Gaps [5.8%]		1.5%	4.3%	4.9%	8.2%	7.4%
		Percent Bunched [1.8%]		0.6%	0.8%	0.7%	2.6%	3.6%
		(Schd. Hdw) Avg Hdw Diff		(15.1) 0.4	(13.1) 1	(14) 1.6	(12) 1.2	(14.9) 1.2
		Observations		1,263	1,992	4,491	2,586	3,542
				T-S Chart	T-S Chart	T-S Chart	T-S Chart	T-S Chart
	West	Percent Big Gaps [5.2%]		4.0%	2.4%	4.4%	8.0%	5.7%
		Percent Bunched [1.4%]		0.1%	0.7%	0.6%	3.1%	2.2%
		(Schd. Hdw) Avg Hdw Diff		(13.7) 0.8	(12.5) 0.7	(14.1) 1.5	(11.7) 1.5	(17.6) 1.3
		Observations		1,030	2,121	4,465	2,648	3,532
				T-S Chart	T-S Chart	T-S Chart	T-S Chart	T-S Chart
35	East	Percent Big Gaps [4.6%]	1.7%	1.2%	5.7%	6.3%	5.3%	3.2%
		Percent Bunched [1.1%]	0.0%	0.3%	2.5%	1.4%	1.5%	0.2%
		(Schd. Hdw) Avg Hdw Diff	(26.8) 1.4	(14.5) 0.6	(11.8) 1.1	(11.6) 1.8	(12.2) 0.9	(17.3) 0.6
		Observations	230	722	1,015	2,082	1,244	1,662
			T-S Chart	T-S Chart	T-S Chart	T-S Chart	T-S Chart	T-S Chart
		Percent Big Gaps [5.7%]	0.3%	1.1%	6.1%	7.1%	8.1%	4.4%

The Bus Metrics by Timeperiod report shows the manager the breakdown of percentage of headways that are classified as “Big Gaps” or “Bunched”, by time period. Time periods are broken down into standard time periods:

OWL	0:00 to 4:00
AM Early	4:00 to 6:30
AM Peak	6:30 to 9:00
Midday	9:00 to 15:00
PM Peak	15:00 to 18:00
PM Late	18:00 to 24:00

The report gives a quick heads-up to the manager by highlighting the time periods and direction of travel with the highest percentages of Big Gaps. It is an invaluable starting point for identification of a problem. The manager then has the ability to click through to see either a string chart or a histogram showing in more detail the location of the problem. Further analysis can show whether it is an operator issue or a schedule issue by comparing the performance of several operators on the same route. An example of a histogram showing where the Big Gaps occur, and an example of a Time-Space chart (also known as a string chart), used as the starting point for analysis of a problem (along with other tools) are shown in Figures 4 and 5.

Figure 4. Example of AVL Service Reliability by Location



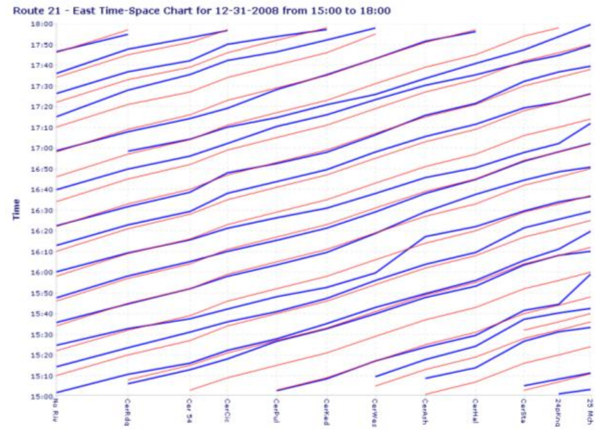


Figure 5. AVL Time-Space Chart

Red lines show scheduled runs and blue lines show actual running time. The string chart allows the manager to see where the gaps or bunching occurs and to identify the operators on each run. A more recent refinement captures more information by combining all the data from string charts for a two-week period and giving the averages for the route for that two-week period.

With this information, a manager can determine when, where, and on whom to focus. Additionally, the information is updated weekly or daily providing quick feedback on the success of initiatives.

Subsidiary measures

In addition to the primary measures, other reports are provided to managers on a monthly basis. Subsidiary measures include:

- List of 30 worst routes for Big Gaps (updated monthly)
- Identification of operators who are late to relief points on the street
- Percentage of buses getting out of the garage on time
- Operators leaving their terminals earlier than scheduled or taking excessive time and leaving late

These measures first focus managers’ attention on the Big Gaps for routes where they are most significant. They then assist the manager in determining potential points of impact for improving service.

Pilot projects

In addition to the primary and subsidiary measures, several pilot projects have been undertaken to test strategies for more even headways. Pilots include:

- Run-for-the-barn. Operators are given only terminal time points and are free to run the route as fast as traffic and safety allows.
- Terminal time keeper. A digital countdown clock located at the terminal to evenly space departures.
- Control Center use of Bus Tracker to advise on-street supervisors, With real-time information available on Bus Tracker, the Control Center monitors certain routes and advises on-street supervisors of headway issues.
- Audio/LED pilot. Direct communication from on-street supervisors to bus operators via audio and visual displays would allow for more frequent headway adjustments. This pilot tried out simple schedule adjustments (move up/move back) to operators using a dashboard mounted device with message lights and audio instructions.

The pilot projects are examples of the experimentation that is being encouraged and measured through the management processes described in the next section. While the pilots have not uncovered any silver bullet for maintaining or restoring service, they do yield clues about when and where certain techniques will work.

PROCESS FOR REVIEW, MEASUREMENT, AND IMPROVEMENT

With the customer-oriented measures in hand, and the toolbox available for analysis and measurement of the effects of intervention, the other critical part of the process was making sure that the word got out about what was expected and how it would be measured. In other words, active engagement in the field was critical. Without a change in culture that emphasizes performance measures as an everyday part of the job, such measures will sit on a shelf to be dusted off once a year. Three nested sets of performance reviews were set in place in the last 18 months to ensure that all levels of management were paying attention to the customer's needs.

Together, these three sets of reviews are occasions for (1) the President to hold Bus Operations accountable for the bus system overall, (2) the head of Bus Operations to hold the garage managers accountable at the eight garages, and (3) the garage managers to hold the route managers accountable for the performance of individual routes. Route managers report to the garage manager and are assigned specific routes to monitor and manage.

Executive performance management meeting (every two months)

The driving force at the CTA is regular weekly Performance Management (PM) meetings where a different department is reviewed each week. These include, for example, Bus Operations, Rail Operations, Facilities Maintenance, etc., each coming up for review about once every two months. These internal performance reviews are led by the President of the CTA and are designed to show progress or lack of progress against clear goals. Adrenaline is high and tolerance for excuses is low.

Unbunching meeting (every month for garage managers)

Layered under the PM meetings is a working group known as the Unbunching meeting that occurs monthly. Here, the eight garage managers compete to try to lead (or at least to stay in the lowest half) in the Big Gaps rankings for their garage. All of the areas that support the garage operations (e.g., maintenance, scheduling, supervision, IT) are present at this meeting to help work through issues and communicate policy changes. Unlike the PM meeting for Bus Operations, which covers a variety of planning and maintenance issues, the Unbunching meeting is focused only on the headway measures of Big Gaps and Unscheduled Bunching, plus the levers that drive those measures. Garage Managers are held to task for making sure that their workforce is performing well. They also present their strategies for improving service reliability on specific routes and solicit support from other parts of the organization.

To support the Unbunching Meeting, the head of Bus Operations meets weekly with a working group of representatives from all of the relevant departments. This operational support group identifies, analyzes, and modifies policies to help field operations improve bus service reliability. For instance, the group oversees pilots, reviews data issues, creates policy changes (such as the relief policy change), and identifies key issues to focus on.

Weekly weigh-ins (weekly for route managers at each garage)

In the Fall of 2008, each garage began having weekly meetings focused explicitly on reducing Big Gaps on the worst performing routes from that garage. Routes on which to concentrate were selected from the list of the 30 worst routes for the system. A format was set up with a white board on which route managers entered data on a weekly basis. While the white board format is a decidedly low-tech way to present sophisticated information, it is highly visible and provides an easy way for a number of people to enter data without having to overcome technological challenges.

Figure 6. Whiteboard in Use at Weekly Weigh-In

The agenda for the Weekly Weigh-In is structured around targeted route performance (i.e., Big Gap and Bunching numbers) and specific Action Items. Each route manager identifies Action Items on which he or she will work in the following week and then reports back on the status of each item the following week. Action Items can be as simple as "Get the construction dumpster moved out of the bus stop zone" or as long range as "Discuss a schedule change for the next pick that will increase the time between time points 2 and 3 and decrease the time between time points 8 and 9."

The Weekly Weigh-Ins emphasize the following:

- Monitoring and feedback about route performance by time of day
- Analysis of route performance using the data tools
- Communication between route managers about what works
- Setting Action Items for the week

The head of Bus Operations has championed the Weekly Weigh-Ins and there has been considerable buy-in by the garages. Part of the process is that periodically the garage managers select a route manager to make a presentation about their route at the larger Unbunching Meeting. This gives visibility and prestige to the process and to the Managers who must present, as well as putting all the other route managers on notice that their time will come. One of the Managers who made such a presentation on Route 22 was honored with the President's Award at a Bus Operations PM session, showing the support of the President for the process as well.

Ownership

Internal ownership of performance measures is essential to their successful use and it must be ownership at an operations level. A national conference in 2000 on performance measures in the transportation sector identified a basic tension between centrally mandated measures and a more bottom-up approach:

> "Setting up the organizational framework for implementing performance measurement can spell the difference between success and failure. The strategic and policy implications, the technical processes, the need for consistency, and the value of champions all seem to imply some degree of central direction. Yet if performance measurement is to become a permanent way of doing business, it must be ingrained in the day-to-day business practices of the entire organization in a manner that is highly decentralized. Finding and instituting the appropriate balance is not easy." [5]

There has been a clear development as the process gained maturity. At first, the managers treated the weekly meetings as driven by central office staff. Fortunately, the flow of the conversation quickly became a dialogue among the transportation managers rather than a one-way reporting to the teacher or manager at the head of the class.

TARGETING IMPROVEMENTS

Root-cause analysis

The first step to improving service system-wide is to analyze the impact of the factors creating deteriorated service. As stated earlier, many factors can contribute to Big Gaps in service. Anecdotal evidence spans the spectrum of possibilities: weather, construction, events, congestion, bicyclists, senior citizens, high-school

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[5] Performance Measures to Improve Transportation Systems and Agency Operations, Report of a Conference, Transportation Research Board (2001) http://onlinepubs.trb.org/Onlinepubs/conf/reports/cp_26.pdf, p.51

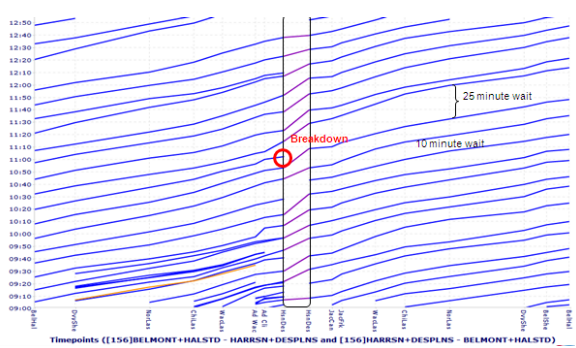
students, trains, scheduling, equipment defects, inter-lining, delivery trucks, traffic lights, supervisors… the list is long. The CTA bus unbunching team set out to quantify the impacts with particular attention paid to those within operational control.

Incident and AVL data

The incident data collected at the CTA Control Center provided a starting point for the potential root-causes that were reported by operators. The number of incidents represents the frequency of the factor and the AVL data can be used to estimate the impact of each incident. For instance, buses blocked by freight trains and buses with equipment defects are both reported to the Control Center. The incident data shows that roughly 10 times the number of buses have equipment defects versus those blocked by trains.

From here, the incident data can be traced back to performance recorded using the AVL system to determine how many Big Gaps each incident creates. Equipment defects create an average of about 11 Big Gaps in service for each incident and trains create about 9. See Figure 7 for a visual example of the impact. The scheduled headway on this route is 10 minutes but a 25-minute gap in service is the result of equipment not being able to continue in service (circled in red). This gap continues for several trips, and a big gap is calculated at every time point the interval is measured (on the X-axis). In this example, there are a total of 15 time points for the route's complete circle, and thus 15 measures of gaps for each trip.

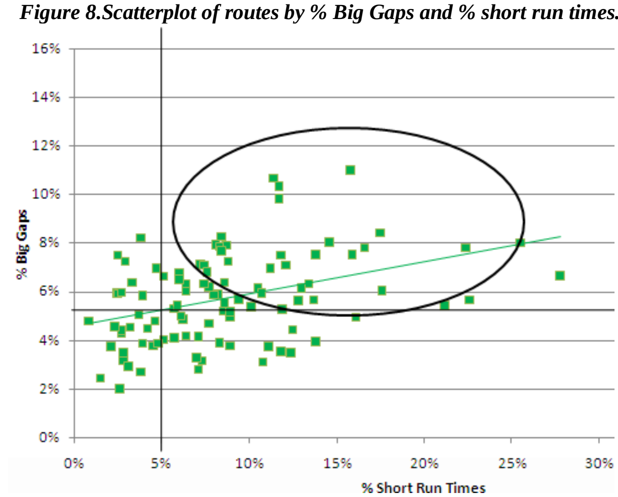
Figure 7. Time-space chart showing equipment breakdown impact



Schedules

Bus schedules should help buses stay evenly spaced while on the route and allow enough time at the end of the route (terminal) to start the next trip on time and evenly spaced. The CTA aims to schedule to a standard so that only 5% of trips would not be able to complete a trip and start the next trip on time (% short run time) or 95% can complete a trip and recover in time to start the next trip as scheduled. Because of the dynamic nature of land development in the service area and changing ridership patterns, a number of routes were not meeting this standard. A linear regression of route service quality (% Big Gaps) versus the scheduling standard (% short run times) shows a clear correlation between scheduling and route performance (Figure 8) and provides an estimate of the impact of updating schedules.

Figure 8.Scatterplot of routes by % Big Gaps and % short run times.



Operating behavior

Operating behavior or variability is tracked using AVL data. Late departures from the garage and operators driving ahead of schedule are two behavioral causes of gaps in service. In these cases, the number of incidents and estimated impact were created using only AVL data. An early terminal departure, for instance, occurs roughly 14,000 times a month but causes only one big gap, on average, per incident. A rough estimate puts this impact at less than 5% of the total Big Gaps.

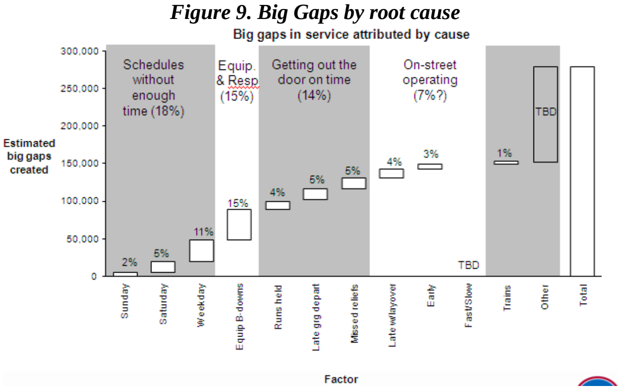
Overall impacts

Overall, much of the service quality impact is within the CTA's operational control. As Figure 9 shows, schedules, equipment, garage departures, and on-street operation are responsible for at least half of the Big Gaps in the system. The impact of schedules without enough recovery time is created by estimating the number of gaps that would be eliminated if all schedules allowed only 5% short run times. The number of standing equipment defects multiplied by the estimate of 11 Big Gaps per incident accounts for 15% of the Big Gaps. "Getting out the door on time" entails leaving the garage on time, making on-time reliefs, and filling each scheduled run.

Together, those add up to about 14% of the Big Gaps. On-street operating makes up the last significant category that was estimated. Late and early terminal departures account for 4% and 3% of the Big Gaps, respectively. The remainder of the variation in operating (after the terminal departure) has yet to be estimated.

This preliminary analysis was sufficient to begin taking action against the biggest causes of gaps in service.

Figure 9. Big Gaps by root cause

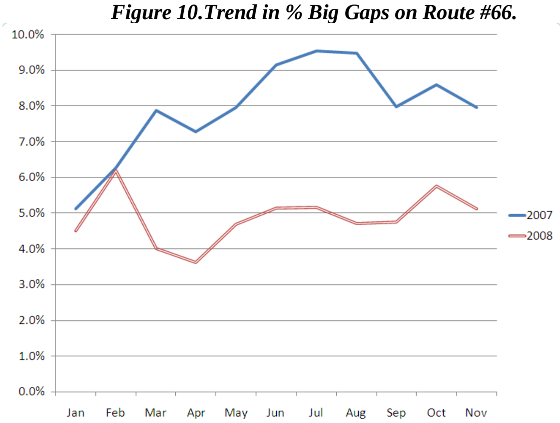


Improvements

Schedules

In 2008, the Planning & Development department systematically addressed the routes with the most opportunity for reliability improvement. Schedules were adjusted to create more recovery time to allow the next trip to begin on time and evenly spaced. Again, a standard of 95% of trips with enough running and recovery time to start on time was used. In the first quarter of 2008, the Scheduling department revised schedules for nearly 50 routes. The schedule changes were almost entirely revenue neutral (unless additional capacity was required) so that increased terminal recovery time resulted in slightly larger headways. Figure 10 shows how a schedule change on one route in January 2008 (#66-Chicago) cut the Big Gaps in half.

Figure 10.Trend in % Big Gaps on Route #66.



Equipment defects

The CTA has historically required the use of buses that are well beyond their useful life because of difficulty securing sustainable funding for equipment. That problem is being addressed as the CTA takes delivery of hundreds of newer buses. Currently, the oldest bus in the system was purchased in 1995 and should be retired within a year.

However, recognizing that equipment defects are always going to occur, the CTA now focuses on service restoration around the incident and on-street repairs that can put a bus back in service more quickly. Service restoration will space forward the following buses and space back the leading buses around a bus that is taken out of service and stop Big Gaps from perpetuating. On-street troubleshooting helps put the equipment back in service more quickly.

On-street operation

With the help of AVL data, the CTA can now better address operators whose behavior may be negatively or positively impacting service quality. The CTA regularly disciplines operators for early or late terminal departures and rewards those who achieve a high level of on-time terminal departures. With increased emphasis on these behaviors, on-time terminal departures have increased from 80% to 87%.

Operational policies have also been re-examined and changed to improve operations. The initial relief policy for instance, would allow operators making an on-street relief to be up to 10 minutes late before they would be subject to a violation. Most routes have headways less than 10 minutes so a relief this late could cause a major service disruption (and nine Big Gaps, on average). Not only that, it would be frustrating to customers forced to wait on the bus for the operator to show up. Once the impact of this policy was analyzed, the CTA changed the policy so that operators were required to be at their relief point on time.

Proactive planning

Many of the impacts on service quality can be predicted, such as construction or high ridership days. With the help of historical data and a close relationship with the City, the CTA can anticipate potential service impacts. For instance, the day before Thanksgiving is often a day with excessive street congestion, early ridership patterns, and absenteeism issues. In 2007, it was the worst service quality day of the fall quarter. In 2008, with the benefit of adjusted service to better meet demand and work schedules for supervisors focused on the key routes and times for that specific day based on historical information, service quality was 50% better than the previous year and appeared as a day with typical service quality.

Route-specific improvements

Each route has its own situational challenges. With the toolbox and processes described earlier, individual managers have been empowered to address situations unique to their routes. For instance, several routes were being impacted by a traffic light that had a 6-second cycle rather than an 18-second cycle. Persistent conversations with the City's Department of Transportation (CDOT) brought about a change to the signal's timing and drastically improved service on the routes affected by it. Often the garage managers have been able to work closely with operators to determine specific schedule changes that would improve service quality. The Scheduling department now systematically takes that input when creating the quarterly schedules.

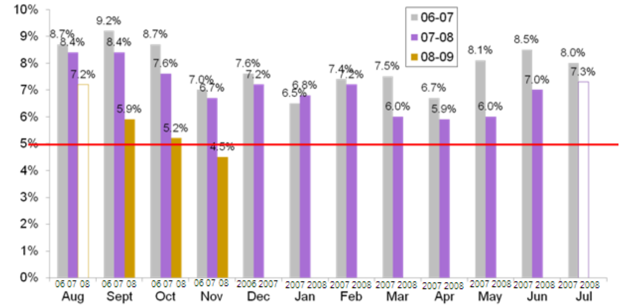
RESULTS

Service reliability

Overall

Overall service reliability, as measured by Big Gaps in service, has improved by over 30%. In November 2007, the system had Big Gaps for 6.7% of all intervals. In November 2008, the system had Big Gaps of 4.5% (Figure 11). This represents the elimination of nearly 100,000 Big Gaps per month. Additional analysis supports an improvement not only in these Big Gaps but also in reducing the variance of all intervals in the system and average wait time.

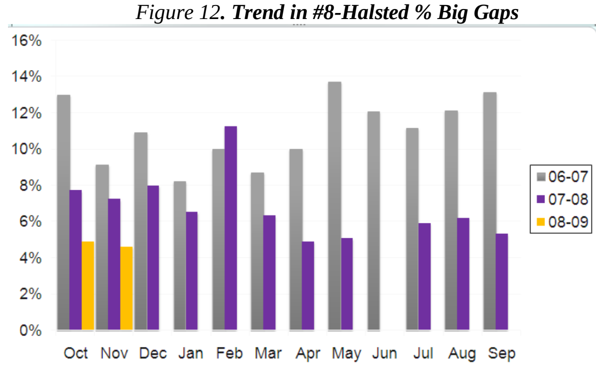
Fjgure 11. Trend in System wide % Big Gaps



Route-specific

The results are even more dramatic for the routes that began with some of the lowest service quality. Big Gaps on the #8-Halsted route improved by 60%, to the point where the route is no longer in the top ten most gapped routes in the system. The combined efforts of improved scheduling and effective management helped deliver improved service quality on this route.

Figure 12. ***Trend in #8-Halsted % Big Gaps***



Ridership

Overall

Bus ridership at the CTA increased by 6.1% in 2008 or 18.9 million rides.[6] While many factors may have contributed to this growth, including increased gas prices and free rides for seniors, it is worth noting that this gain ranks among the highest increases in the country and occurred with no overall increase in system capacity.

Route-specific

[6]http://www.transitchicago.com/assets/1/board_presentations/2009-01_Presidents_Report.pdf

Ridership on the routes with a reliability improvement of 5% or more increased by 12.3% whereas routes with no change in reliability increased ridership by only 2.8%. Figure 13 summarizes ridership and reliability changes for eight routes that received significant schedule adjustments to improve reliability. The #8-Halsted route gained 876,871 annual rides. Capacity was increased to this route to accommodate the increased ridership.

Figure 13. Big Gaps and Ridership Change after Schedule Adjustments.

Route	Big Gaps		Ridership Change
	Before	After	
8	12%	8%	14%
22	17%	10%	13%
66	8%	4%	11%
87	5%	5%	3%
14	11%	6%	13%
36	19%	11%	13%
79	5%	4%	7%
151	15%	9%	12%

Capacity

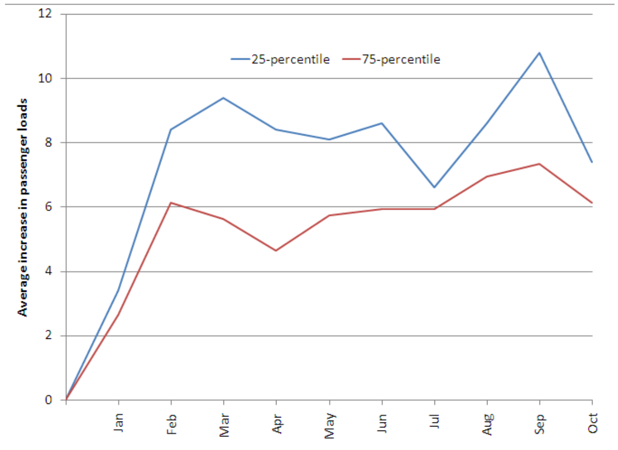
Overall

The 6.1% bus ridership increase at the CTA occurred with little or no increase in overall system capacity. Some capacity was reallocated, adding in one area and subtracting from another. By spacing the buses more evenly, the CTA was able to more effectively use its available capacity. Typically, when buses travel down the street in a bunch, the last bus in the line has underutilized capacity. Most customers crowd into the first bus leaving room on the following buses. Spacing the buses more evenly can increase effective capacity. Additionally, the experience at the CTA supports the hypothesis that increased reliability will result in increased ridership.

Route-specific

An example from one route illustrates how capacity can be better utilized by improving service quality. Figure 14 shows the change in the average passenger load on the 75th percentile of loads and the 25th percentile of loads for the #66 Route by month relative to the 2007 average. Both gain ridership, but the 25th percentile load gains more ridership than the 75th percentile load. Hence, the buses with the most available room were the ones that contributed most to the ridership growth.

Figure 14. Change in average loads for 25thand 75th percentile on #66 route in 2008.



Customer satisfaction

Ad hoc sampling of customer satisfaction shows an increase in satisfaction at the route level although a comprehensive customer satisfaction survey has yet to be completed. On the #8 Halsted bus, for instance, customer satisfaction has increased by nearly 23%, with perceived wait times dropping by 4 minutes (from 16 minutes to 12 minutes). The big gap initiatives helped to improve customer ratings of bus frequency and on-time performance.

ONGOING ISSUES/FUTURE DEVELOPMENTS

Training of users

Managers have widely varying knowledge about the use of computers and data analysis. Training programs that provide more in-depth analysis and more practice in using the available tools would create a higher level playing field for the managers. With more knowledgeable managers on the front lines, the tools could be improved and the levers for affecting the measures could be tested out with greater precision. Ideally, the garage managers would have a number of training opportunities (videos, short programs, individualized instruction) that could be provided for their managers.

Data Display and accessibility

The CTA has experimented with reports that show the data in different formats. For example, the data that appears in a string chart can also be shown in a chart that allows a run to be traced over time. On one hand, people visualize information in different ways and the data can easily be presented in multiple ways. On the other hand, having consistent measures allows comparability across time and personnel. At the beginning of this emphasis on performance measures, simplicity is a definite virtue. As we move along the learning curve, more options can be used in addition to the touchstone measures with which we began.

User confidence in data reliability

For all of the users of the data, the stakes are high. Managers are held accountable for their success or failure in the overall results of Big Gaps and Bunching. Individual operators are held accountable for their performance on a run. As the data is made available to the public, customers and funders will use performance measures to assess whether the level of service is adequate to their demands.

Because of this high importance, those who are being held accountable must have a high degree of confidence in the accuracy and completeness of the data and of the measure itself. Yet as we all know, technology is not perfect and measures may not be well understood. The inevitable glitches that occur may be exaggerated into a generalized "you can't trust the data" mindset.

The best antidote to this kind of mindset is transparency. When problems arise, they must be forthrightly acknowledged and explained. Managers must be encouraged to report potential data problems and care must be taken to respond to their concerns.

Seasonal variations will be better understood after the current managers have worked with the data for several years and when historical reports are readily available for comparisons to be made as part of the analysis.

Maintenance and troubleshooting

The technicians who create the reports have multiple tools at their fingertips to assess whether the data is coming into the system and being analyzed properly. For the uninitiated, a great deal of faith is required and skepticism does creep in. Some simple tools that provide insight into the workings of the system help alleviate the skepticism. For example, two reports that are available to all users are a report on the percentage of buses at a garage where the AVL system is not working properly (typically on the order of 2%) and a report that shows the number of time point records by garage. Reviewing time point records over time can reveal when there is an inconsistency requiring investigation and explanation.

Reliability and ease of use of laptops

So far, the reporting tools and performance measures that we have discussed have been about historical (even if only a week old) data. The AVL data offers the opportunity for real time data to be made available to managers at the garage, supervisors on the street, and controllers at the Control Center. All of these personnel can now view such real time data, but the view is imperfect.

A basic lever that is needed is for supervisors in the field to have reliable access to information about the location of all the buses on their route. Mobile supervisors currently have ruggedized laptops in their vehicles with access to real time information. However, reliability issues have arisen and an assessment is underway as to whether these are man or machine problems and how they can best be resolved. Mobile supervisors also use the laptops to document service restoration activities in the field. In order to continue the data-driven emphasis, their documentation must be comprehensive so that the data derived from that documentation may be used to assess the effects of on-street interventions on service quality.

Control Center resources

The CTA has a centralized Control Center that has access to real time information about the location of buses. Efforts are underway to increase centralized use of real-time information that can provide an end-to-end picture of current bus locations on a route.

Grievances

Managers are concerned about the reliability of the data on which their performance is measured. So also, bus operators are concerned about the reliability of data about operator performance (on-time departures, comparison of run time with peers on the same route) that may be used for employee discipline.

Real Time Exception Reports

On the CTA wish list is an intermediate step that would provide exception reports so that field personnel would know in real time what problems were starting to form. They could then focus their efforts on prevention of a Big Gaps/Bunching problem rather than the harder and less customer-friendly task of restoring service after it has already deteriorated. With additional resources for communication tools, software and training, such reports would eventually be integrated into a system where bus operators themselves would regulate their headway based on information about their location.

Link performance measures to decision-making about resources.

Does a run need more time? Does a route need more frequent buses? Does an operator need more training? These are the kind of decisions embedded informally in the current processes, but decision-making about how to allocate resources may be driven by the squeaky wheel rather than by the data. Current metrics serve well to measure and report results on a current basis. A next step would be for managers in the field to have more explicit understanding of the criteria for how schedule changes get made and how other resources get allocated. This would add structure to the decision-making.

Metrics for customers

The challenges of developing metrics about headway and timeliness of buses that are understandable for transportation professionals are multiplied when we try to extend the use of metrics for customer use. Defining "acceptable headways," for example, can be done in many ways and the CTA is exploring what is the most meaningful as a customer measure.

CONCLUSION

The CTA's experience with performance measures supports the maxim that what gets measured is paid attention. The measures that have been developed are action-forcing for managers, as demonstrated by the changes that occurred in the past year. The measures are validated as being customer-oriented because the biggest changes in ridership are seen on the routes where the most improvement in the Big Gaps measure has occurred. Similarly, customer satisfaction has increased as performance improved.

The comprehensive measures and reporting are possible because each bus is equipped with AVL and because advanced steps have been taken to turn the data into user-friendly information, to train managers in the use of the reports, and to create a culture where performance management is the normal way of doing business. Work continues to make the route performance information more readily accessible, to document the effectiveness of interventions, and to train managers to use available tools systematically and efficiently. Challenges remain in making full use of the data throughout the agency and taking the next step to make meaningful performance measures available for customers.