How Crowded is Crowded?

A Practitioner’s Tool to Assessing Rail Congestion

Wendy Jia
Washington Metropolitan Area Transit Authority
wjia@wmata.com
202-962-6474

Melissa Chow
Washington Metropolitan Area Transit Authority
mchow@wmata.com
202-962-1575

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ABSTRACT

Passenger crowding on rail transit systems impacts passenger experience and ridership growth and often reflects the lack of infrastructure capacity to meet travel demand. Operators and policy makers recognize the importance of crowding issues and develop policies and measures to monitor and assess the levels of crowding. Despite the importance of monitoring crowding, most systems rely on the traditional approach of data collection – manually collecting and monitoring passenger crowding conditions. The advancement of transit technology for assessing crowding is still in the developmental and testing stages, and is not ready for systemwide deployment on a recurring basis. This paper explores an application created to estimate passenger crowding through measuring passenger loads on a link level – between any pair of stations in any direction of travel. The paper discusses the approach of automating passenger load estimates with readily available faregate transaction data, documents the methodology and development of the application, proposes different uses of the application in the rail transit operating and planning environments, and identifies potential improvements. In the case of the Washington Metropolitan Area Transit Authority (WMATA/Metro), the documented application not only assists in Metro’s operations planning and long range planning, but also sets a practical example on how to take advantage of its fare transaction data and turn it into a powerful tool to track variations of passenger loads on the lines and within stations for any given time period.

INTRODUCTION

Rail transit, commonly known as “Metro” or “Subway” in many cities, has exerted great influence on the urban landscape, development patterns, mobility, and the quality of life. In the large metropolitan regions where major investments in rail transit were made, T. Litman found that rail systems have significantly higher per capita transit ridership and lower per capita private vehicle ownership and mileage than otherwise comparable cities with less or no rail transit services (1). In the US, rail transit ridership increased at 2.1% annually between 1990 and 2011 compared to all transit ridership at 0.8% annually (2).

The growth of rail ridership demand over time, while successfully bringing in higher cost recovery and higher utilization of system capacity, would eventually approach or exceed the design capacity during peak travel periods or special events, and result in passenger crowding. Passenger crowding, on any public transport system, is considered to negatively affect passenger travel experience, delay travel times, degrade operational efficiency, and even generate potential safety hazards under circumstances such as “sardined” railcars and platforms. Therefore, assessing the level of passenger crowding is critical for rail transit systems, not only to understand customer experience, but also to identify causes and develop corresponding strategies to manage or relieve congestion.

The foundation to monitoring passenger crowding is the ability to estimate the number of passengers, also referred to as passenger loads, on the train and/or the railcar over a defined time period. Other measures are either derived upon, or related to, the total number of passengers, such as passenger per square feet or percentage of standees. However, under current operations and fleet configurations, there is no easy way to systematically estimate and monitor passenger
loads at critical locations, not to mention across the system. One common practice is to dispatch trained personnel to selected locations and manually count passenger loads on railcars.

The advancement of technology, such as Wi-Fi and Bluetooth, is still nascent for passenger flow monitoring and counting, and is not ready for systematic or consistent deployment – at least for the larger rail transit systems that carry high ridership and provide multiple travel paths. The newest generation of rail cars are equipped with a load weight function which may lead to a passenger load count approach down the road. In contrast, bus systems have made great progress with the development of on-board automatic passenger counting (APC) systems, which nowadays capture bus passenger loads at a fairly high level of accuracy.

While the progress of transit technology will eventually bring in effective innovations to the monitoring and measuring of passenger loads down the road, agencies still need practical solutions to monitor and predict passenger loads in the future. Other approaches have been explored to assess passenger loads and crowding to supplement the manual counts and to provide an alternative method for system planning. The purpose of this paper is to discuss a different approach in exploring the automation of passenger load estimates by using readily available transit data, documenting the methodology and functions of the application, and discussing its applicability and potential improvements for the future.

LITERATURE REVIEW

Most of the published research on passenger crowding on public transport systems focuses on the impacts of the crowding, crowding measures taken, who’s creating the crowding measures, case studies of crowding, and the benefits of monitoring passenger crowding. Through a variety of white papers, transportation research reports, and practitioners’ papers, these issues are recognized as significant towards understanding passenger crowding.

Impacts of Passenger Crowding

Crowding on public transport is important to study. Overcrowding on public transport can affect business (including employment) and tourism, at the very least (3). More specifically it can lead to platform delays, crowding on platforms, the inability to board, stress, and passenger discomfort (due to overcrowding)(4,5). Additionally, crowding is often considered a key service attribute – how customers judge the public transit system – along with other factors such as travel time and reliability(6). These detailed effects have a time cost associated with them, which can be evidence as to why creating ways to assess the crowding can be beneficial.

Measures to Track Passenger Crowding

Given the above stated reasons on the importance of understanding the potential impacts of crowding, measures have been created to track crowding levels. The key to passenger crowding monitoring is to obtain ways to estimate passenger load measures, often chosen to fit with individual systems, on a train or railcar during commuting hours, when the system is operating at high capacity to carry the peak demand of the day.
Published guidelines

In the US, the Transit Capacity and Quality of Service Manual (TCQSM) provides guidance and reference for measuring passenger crowding. It contains official definitions of station capacity, pedestrian levels of service (LOS), line capacity, and how to determine person capacity. However, even in the TCQSM, it acknowledges the difficulty of measuring passenger crowding consistently as car models and seat configurations vary too much (7).

The published guidelines in the TCQSM define rail transit capacities and establish thresholds to measure passenger crowding:

- Line capacity is the maximum number of trains that can be operated on a segment of track per time period (usually one hour) (8).
- Person capacity is the maximum number of people that can be on board a train on a segment of track per time period (usually one hour) (9).
- Station design capacity is calculated by passenger demand during peak travel periods, demand during special events, and demand during emergency situations (10).
- Pedestrian LOS is determined by the amount of standing space, the perceived comfort and safety, and the maneuverability in the pedestrian circulation area of a station. LOS is graded from A-F where A is equal to unimpeded movements and F is equal to seriously constrained movements. Maximum pedestrian capacity is usually LOS E or F but typically stations are not designed for maximum capacity so as to be more comfortable to passengers (11).

Variations in measurements

Aside from the TCQSM, which provides definitions and general guidelines, most agencies seem to set their own measures. Moreover, many agencies lack the ability to automatically track capacity, especially within stations, and do not necessarily report on capacity/crowding on a regular basis. Also, many agencies rely purely on manual counts. Essentially, capacity related data collection is different everywhere, with varying degrees of capacity related monitoring.

As a result, crowding measures vary greatly among cities, systems, and countries, and even within city systems to fit into the existing rail infrastructure and rail fleet. Some of the measurements that are used include:

- Passengers in excess of capacity (PIXC)
- Passengers per square foot
- Passengers per square meter
- Passengers per car (PPC)
- Optimal passenger capacity
- Standees per square foot
- Standees per square meter
- Passengers per seat
- Average passenger load as a percentage of train capacity

For example, New York City Transit (NYCT) uses measures of optimal passenger capacity and average passenger load as a percentage of train capacity while allowing varying thresholds.
within the system. In the early 90s, when NYCT used optimal passenger capacity as a measure, it defined the passenger capacity of the Interborough Rapid Transit system (IRT) at 110 passengers per car, and the Independent Subway System (IND) at 145 passengers per car (12). Both of these systems are a part of the New York City Transit Authority’s subway system. The IND has wider bodied and longer train cars, hence the larger capacity.

In 2007, NYCT was reported by the New York Times as being packed beyond capacity. The measurement substantiating the findings was the average passenger load as percentage of train capacity. The Lexington Avenue lines and the Seventh Avenue lines were both near, at, or beyond capacity – especially the Lexington Avenue lines, where all three lines (4,5,6 Trains) were above 100% during peak periods. Unfortunately for both Lexington Avenue and Seventh Avenue, those trains were already running at capacity. Hence, there was no more room to run additional trains. Also, as a result, they tended to be less on time as well (13). Additionally the Lexington Avenue and Seventh Avenue lines use the narrower bodied trains (IRT) so the capacity is less to begin with.

London Underground, on the other hand, uses the measure of passengers in excess of capacity (14), which can also be expressed in a percentage too (15). However London Overground does not apply the same measure, indicating that measures vary depending on mode (16).

Between the US and most other countries, differences can be found between measurement systems – metric vs. imperial systems/US customary units. In the US, crowding may be measured by standees per square foot as opposed to most other countries where they would be measured by standees per square meter. However, not every system measures this way either. Sometimes it may be passengers/seat in the US (17).

**Empirical studies**

There has been a lot of research relating to case studies of crowding. However, given the crowding variations, most case studies are independent and solely for the benefit of the agency or city that’s commissioning the study. This may be due to individualized and unique situations within each city or agency. London Underground, for example, has measures to deal with congestion at stations (18). In New York City, to study one aspect of crowding, they studied passenger seating and standing behavior and suggested improved layouts to ease crowding near doors as a result (19). Similarly, the Chicago Transit Authority (CTA) also studied seating and passenger flow to see if it could ease capacity/crowding issues that CTA was facing on board its trains. In their case there was no evidence that longitudinal seating would help but removing stanchions and weather panels near the doors helped with passenger flow (20). On a broader scale, in the 2005 railcar capacity analysis, the Washington Metropolitan Area Transit Authority (WMATA, also known as Metro) analyzed rail car capacities previously with goals of 1) improving passenger flow, 2) increasing capacity of rail cars, 3) improving ridership quality for the standing and the seated, and 4) improving the accessibility of the disabled. The analysis ultimately recommended that they remove obstacles that block passenger movement, reconfigure seats longitudinally, increase the number of hand rails, and test everything in the second phase of the study. Also, they noted that the existing configuration gave each passenger 3.0 square feet
per passenger (21). Ultimately however, longitudinally seats were not executed due to safety reasons (22).

The above examples were empirical cases on how to ease crowding. However, there have been fewer case studies about crowding in general with actual numbers related to crowding. In the New York City Department of Transportation report “Reducing Subway Overcrowding at the Manhattan CBD Cordons – Volume 1: The Queens Cordon” (1992), there were some figures generated on overload percentages. For example, the average subway from Queens into the Manhattan CBD were overloaded by 10% and that 1/3 of these trains were overloaded by at least 20% (23). It also came up with three options for increasing subway capacity: 1) running longer trains, 2) building new connections, and 3) building new subway lines (24). Also, as mentioned earlier, in 2007, NYCT was looking for long term solutions to ease crowding on its lines, where several of the lines were already beyond capacity.

**Summary of Literature Review**

As stated earlier, in general there is a dearth of case studies for crowding that are relevant to specific studies as research has been so scattered. Yet at the same time, crowding is clearly a significant issue around the world in transit. Hence, even though research is scattered and specific to locales, there are definitely benefits to measuring and monitoring passenger crowding and identifying operational and infrastructure solutions henceforth.

Crowding can influence passenger behavior – it may affect the passenger’s decision whether and when to take the trip. Other factors also come into play, depending on where the passenger lives – in a suburban or urban setting, the length of the trip, the layout of the transit vehicle, as well as if the passenger is used to the crowding. Furthermore, there is uncertainty as to what levels of crowding the passenger might face (25). All of the researches and cases of said variables are potentially worth monitoring. Additionally, monitoring can help in cost/benefit analyses, which ultimately could be worthwhile for incorporation into public policy relating to transportation and health and safety (26).

**METHODOLOGY AND DEVELOPMENT**

The initial concept for developing an application to estimate passenger loads over WMATA’s rail network came in the late 2000s, building upon the two rail ridership data opportunities that became available then. In the mid-2000s, Metro migrated the detailed fare transaction data into an Oracle database, allowing users to easily access and query data from a standard desktop computer. This fare transaction data was further broken down by fare media, service type, origin and destination, along with other categories. Around the same time, planners developed a rail transit demand forecasting model with elaborated Metrorail network coding details, which enabled them to create a better fit of the base year and future year rail trip forecasts.

**Origin-Destination (OD) Data**

Metro’s fare system requires riders to tap in at the entry faregate and tap out at the exit faregate, using either SmarTrip or magnetic cards, which are coded with unique identification numbers.
Metro is able to process the faregate transactions into an origin and destination table format that is made up of the existing 86 stations, or 112 mezzanines, at intervals of 30 minutes, 60 minutes, or other defined time intervals.

TABLE 1: Sample Faregate Transaction in OD

<table>
<thead>
<tr>
<th>Orig</th>
<th>Dest</th>
<th>Anacostia, N</th>
<th>Anacostia, S</th>
<th>Woodley Park-Zoo</th>
</tr>
</thead>
<tbody>
<tr>
<td>Addison Road</td>
<td>Addison Road</td>
<td>0</td>
<td>7</td>
<td>2</td>
</tr>
<tr>
<td>Anacostia, N</td>
<td>Anacostia, N</td>
<td>2</td>
<td>0</td>
<td>3</td>
</tr>
<tr>
<td>Anacostia, S</td>
<td>Anacostia, S</td>
<td>7</td>
<td>9</td>
<td>0</td>
</tr>
<tr>
<td>Woodley Park-Zoo</td>
<td>Woodley Park-Zoo</td>
<td>2</td>
<td>8</td>
<td>1</td>
</tr>
</tbody>
</table>

Travel Demand Forecasting Refinements

Metro currently carries 1.2 million daily transit trips on Metrorail and Metrobus, and is ranked the second largest rail transit system and the sixth largest bus system in the US, in terms of ridership. In the mid-2000s, planners explored ways to refine the regional travel demand forecasting model to improve the modelled network and transit access, and to forecast rail ridership in the Washington, DC region. This resulted in a refined forecasting model uniquely built for the Metro system, which separated transit access by mode—walking, bus, commuter rail, and park-and-ride—and used the rail passenger survey data to split and update access modes by station.

The timing of the OD data and a refined transit forecasting model led to the conception of developing a tool to integrate both of them into an application. This integration introduced an exploratory way to generate passenger trip estimates on a link level—trips between any pair of adjacent stations in the direction of travel.

Application Development

To date, the passenger load estimation tool has gone through three phases of development and refinements. The initial phase was in 2008, when the first attempt was made to link the OD data and the travel forecasting model. At that time, the model’s rail network was micro-coded to include mode-based access links to mezzanines, connection links between mezzanines and platform levels, and transfer links between Metrorail lines. Using CUBE, a software that has transportation modeling capabilities, path assignments were carried out and rail trips were estimated in this first-stage application. However, the new tool at that time was only capable of developing trip estimates for the AM/PM peak hours and for the entire day, using the time periods defined in the regional forecasting model. Additionally, the GIS mapping interface was rudimentary and far from being user-friendly.

The second effort focused on improving the user-friendliness of the application and the GIS interface. It also added functions to allow users to introduce changes to the rail system operating plan—a useful function for developing and accessing future system changes.
The most recent update allowed for the application to run independently of CUBE on any desktop computer. It also expanded the analysis time period from the defined peak hours to any 30-minute period throughout the day, created detailed analyses reports, and built a direct interface with the GIS software. To assist in the validation of the update, field data collection was conducted for the critical rail links across the system in the peak hours, especially those where multiple lines operate and/or interchange. The collected passenger trips on the selected links were then validated against the initial application output and used to adjust the application, similar to what is typically done in the travel demand forecasting.

FUNCTIONS AND APPLICABILITY

The passenger load estimation application has been used to support and provide input for a variety of planning studies on rail fleet expansion and station capacity improvements, as well as supplement current passenger load data collection. For a large transit system that offers many travel routes and internal transfer options, real passenger behavior on routing choices is far more complicated on a daily basis, influenced by personal preference of stations and routes as well as operating conditions. The following section discusses its planning functions and applicability.

A Mini Metrorail Travel Demand Forecasts and Investment Analysis

As aforementioned, the regional travel demand forecasting model is built for multimodal analyses for a metropolitan region that consists of highways, rail transit, bus transit, and other modes. Thus, it is neither possible nor practical for it to be refined to mimic operating conditions within a rail network, with scheduling and routing variations from hour to hour, or for it to respond to the fluctuations of travel demand and travel patterns. Separating the rail network from the regional model allows planners and modelers to build several of the current and future rail networks and operating plans, and generate link-level forecasts to inform them of potential crowding conditions on the planning horizon.

Metro is looking to invest in rail fleet expansion to accommodate growing ridership demand and changing travel patterns. Planners face many questions, such as:

- What will the system’s heavy load rail segments look like in the next five, ten, or even 30 years given the known land use forecasts generated by the Metropolitan Planning Organization and local jurisdictions? Will the system anticipate new high demand segments?
• What level of expansion in terms of railcars and supporting infrastructure will be needed to meet the anticipated heavy loads of passengers on the system? How many railcars are to be funded and where should they be distributed among the lines within the system?

• In anticipation of continuing urban growth and varying paces of land use development across sub-areas of the region, will the high demand segments change over time and by how much? What level of railcar investment will meet the anticipated future demand while maintaining or even reducing peak crowding on the train?

Based on the link-based forecasts of passenger loads during the peak periods, planners can conduct scenario analyses of peak railcar crowding, whether it is for determining the number of railcars to be purchased, or for modifications to the proposed operating plans, and even for potentially long-term changes to the future rail network.

**FIGURE 2: Railcar expansion scenario analysis (8am -9am)**

<table>
<thead>
<tr>
<th>100% 8 Cars</th>
<th>Red</th>
<th>Orange/Silver</th>
<th>Green</th>
<th>Blue</th>
<th>Yellow</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gallery WB</td>
<td><img src="image1" alt="Gallery WB Red" /></td>
<td><img src="image2" alt="Gallery WB Orange/Silver" /></td>
<td><img src="image3" alt="Gallery WB Green" /></td>
<td><img src="image4" alt="Gallery WB Blue" /></td>
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<td>Courthouse EB</td>
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<td><img src="image9" alt="Courthouse EB Blue" /></td>
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<td><img src="image14" alt="Waterfront NB Blue" /></td>
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<td><img src="image22" alt="Pentagon NB Orange/Silver" /></td>
<td><img src="image23" alt="Pentagon NB Green" /></td>
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<table>
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<th>50% 8 Cars</th>
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<th>Orange/Silver</th>
<th>Green</th>
<th>Blue</th>
<th>Yellow</th>
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<tr>
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<td><img src="image27" alt="Gallery WB Orange/Silver" /></td>
<td><img src="image28" alt="Gallery WB Green" /></td>
<td><img src="image29" alt="Gallery WB Blue" /></td>
<td><img src="image30" alt="Gallery WB Yellow" /></td>
</tr>
<tr>
<td>Courthouse EB</td>
<td><img src="image31" alt="Courthouse EB Red" /></td>
<td><img src="image32" alt="Courthouse EB Orange/Silver" /></td>
<td><img src="image33" alt="Courthouse EB Green" /></td>
<td><img src="image34" alt="Courthouse EB Blue" /></td>
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</tr>
<tr>
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<td><img src="image37" alt="Waterfront NB Orange/Silver" /></td>
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<td><img src="image47" alt="Pentagon NB Orange/Silver" /></td>
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<td><img src="image49" alt="Pentagon NB Blue" /></td>
<td><img src="image50" alt="Pentagon NB Yellow" /></td>
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</tbody>
</table>

**Figure 2** illustrates the need for railcar expansion to support demand growth in the next 15 years through a scenario analysis. With the currently funded 50% 8-car consists, all heavy load segments will be in congested conditions or worse. However, if Metro could operate all 8-car consists, many links would meet the current service standards. Beyond 2030 the rail link forecasts clearly inform that major infrastructure expansion would be needed to fundamentally increase the system’s line capacity, should land use continue to grow as planned.

**Assessment of Station Demand and Congestion**

After more than 35 years of strong ridership growth, Metro is facing the challenge of ridership demand approaching or exceeding the design capacity, in particular, within the system’s core that covers the Central Business District and the National Mall within Washington, DC and inner areas of the City of Alexandria and Arlington County. This same congestion is also observed in the growing suburban areas, such as terminal stations during the peak hours due to the single-directional peaking patterns of suburban commuters.
In 2008, Metro started an innovative approach that combines engineering design, architectural improvements and dynamic congestion analysis to tackle congested conditions at these stations and to identify operational and engineering solutions for capacity expansion. One key element of the effort is the in-depth understanding of many pedestrian flows within a single station. At some core transfer stations, which host as many as four lines today and have multiple escalators, stairs and connected mezzanines, it is impossible to use manual data collection as a way of identifying locations associated with transfer congestion during peak periods and special events.

The application offers the most practical way to provide estimates of internal station movements over many paths. At the L’Enfant station, there are many potential transfer paths, each carrying varying volumes of riders, as shown in the pink area of Figure 3.

FIGURE 3: Station congestion identification

<table>
<thead>
<tr>
<th>Origin to Destination (8-9am)</th>
<th>Total</th>
<th>N Mezzanine</th>
<th>SE Mezzanine</th>
<th>SW Mezzanine</th>
<th>Blue / Org EB</th>
<th>Blue / Org WB</th>
<th>Green SB</th>
<th>Green NB</th>
<th>Yellow NB</th>
<th>Yellow SB</th>
</tr>
</thead>
<tbody>
<tr>
<td>N Mezzanine</td>
<td>595</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>40</td>
<td>234</td>
<td>93</td>
<td>30</td>
<td>126</td>
<td>73</td>
</tr>
<tr>
<td>SE Mezzanine</td>
<td>207</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>28</td>
<td>82</td>
<td>22</td>
<td>9</td>
<td>47</td>
<td>18</td>
</tr>
<tr>
<td>SW Mezzanine</td>
<td>186</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>11</td>
<td>95</td>
<td>4</td>
<td>13</td>
<td>49</td>
<td>13</td>
</tr>
<tr>
<td>Blue / Org EB</td>
<td>1,144</td>
<td>256</td>
<td>368</td>
<td>147</td>
<td>0</td>
<td>269</td>
<td>3</td>
<td>88</td>
<td>12</td>
<td></td>
</tr>
<tr>
<td>Blue / Org WB</td>
<td>2,262</td>
<td>202</td>
<td>365</td>
<td>60</td>
<td>0</td>
<td>211</td>
<td>345</td>
<td>526</td>
<td>545</td>
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</tr>
<tr>
<td>Green SB</td>
<td>2,126</td>
<td>574</td>
<td>579</td>
<td>110</td>
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<td>207</td>
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<tr>
<td>Green NB</td>
<td>3,262</td>
<td>298</td>
<td>227</td>
<td>70</td>
<td>924</td>
<td>425</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>447</td>
</tr>
<tr>
<td>Yellow NB</td>
<td>2,772</td>
<td>586</td>
<td>436</td>
<td>139</td>
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<td>349</td>
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<tr>
<td>Yellow SB</td>
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<td>265</td>
<td>55</td>
<td>47</td>
<td>6</td>
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</tr>
</tbody>
</table>

The tool, with its detailed intra-station network that maps out connections—between upper and lower platforms, between platforms and mezzanines, and between mezzanines and streets—allows for the assignment of demand to the individual paths. Such demand is then matched with the design capacity of vertical circulations, including escalators, stairs, elevators, and horizontal circulations (i.e. faregates and vending machines), and generates ratios of volume (demand) over capacity as indicators of level-of-service and congestion.

When passenger flow estimates are fed into a pedestrian simulation model, planners can visually identify the hot spots and causes, and quantify the level of congestion. As shown in the same L’Enfant station case, the estimated high transfer demand—between passengers exiting the northbound train and then heading down to the lower platform—is clearly identified by hot spots along the transfer paths, as shown in red. As a result, planners and engineers are able to start developing short-term congestion relief solutions and mid-term capacity expansion alternatives, from reversing escalator movements to adding new vertical circulations at hot spots to building intra-and inter-station pedestrian connectors to bypass the hot spots.

Estimates of Current Passenger Loads

The passenger load estimation application has been used to support or provide input for a variety of planning studies for rail fleet expansion, station capacity improvements, as well as for
strategic planning. For day-to-day operational use, this application can be used to supplement the current manual counts. However, further integration of real-time operational data and better validation of passenger counts at transfer stations are needed.

While the estimates use OD data of the current rail operations as the input, its output is considered an approximation of passenger loads based on the scheduled operations, and not the real-time passenger loads and crowding. The application, similar to most travel demand forecasting tools, builds upon the scheduled rail service and throughput, not the real-time rail throughput.

For any large system with frequent service and aging infrastructure, train throughput and on-time performance have slight variations on an hourly basis. Other operating events also affect the scheduled throughput. For example, door failures and other incidents on the rail system often cause a ripple effect on the system, and create temporary surges in train crowding at the moment of service restoration, thus making it deviate from the scheduled service or throughput. Currently, planners are looking into ways to convert real-time train operations data into a database which could open up the possibility of using actual rail service and railcar throughput as one of the inputs. This would generate a more realistic approximation of passenger loads.

For a large rail transit system with travel path choices and internal transfer opportunities, rider behavior is not as simple as what is assumed in traditional travel demand forecasts. Unlike the travel demand forecasting model, in the real world, travel time is not the sole determining factor of a passenger’s route choice. Many personal preferences influence travel behavior. For example, it is observed that a good percentage of riders opt for a one-seat ride with a longer travel time and avoid a faster path that requires a transfer. However, this user preference may change once the levels of service over two or three travel paths are significantly differentiated. Also, users may prefer using certain stations over others that tend to be more crowded. Often, the passenger crowding inside the arriving train will deter passengers on the platform and push them to the next train or a less preferred path. As such, data about passenger preferences and transfer patterns would allow the application to better simulate travel behavior, and estimate loads at the critical transfer points.

CONCLUSIONS

Estimating rail passenger loads informs agencies of potential passenger crowding and identifies the timing and locations of peak travel demand. It is recognized that there is a lack of research on the impact of passenger crowding and measures of passenger crowding. Additionally, there is little practical guidance on how to develop passenger crowding assessments across the system, nor is there readily available technology to provide convenient and reliable data on passenger loads or crowding. While each system may develop passenger loads and crowding measures that fit into the individual fleet and infrastructure capacity, the documented approach to a passenger load estimation application presents a tool that can be used by planners and engineers to monitor, assess, and forecast peak passenger volumes and locations of high demand.
The application developed by WMATA not only assists in its operations and planning, but also sets a practical example on how to take advantage of its fare transaction data and turn it into a powerful tool to track variations of passenger trips on the lines and within stations for any given time period. Utilizing system generated data and a detailed transit network, this application has assisted multiple planning studies and analyses, enabling rail transit practitioners to identify bottlenecks or demand-supply imbalances and develop short-term operational adjustments as well as long-term fleet and facility capital investments. The integration of data, the rail network, and GIS mapping into one suite creates an easy-to-use tool. In the near future, integration of actual train operational data and validation of passenger travel choices and preferences would enhance the application’s potential for providing actual conditions-based estimates of passenger loads and crowding measures.
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Disclaimer

This paper expresses the authors’ view and experience. However, it does not purport to represent the views or policies of the agency.

References


