Planning for Pedestrian Flows in Rail Rapid Transit Stations: Lessons from the State of Current Knowledge and Practice

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Abstract

Decades of research have contributed to the development of standards and models to guide pedestrian-friendly transit station designs, although it is not at all clear from the literature how these tools are collectively used in practice. To address this, we interviewed 15 experts in transit station design. Based on the themes identified in these interviews, we conducted an online census of all 16 transit agencies in North America with rapid rail transit systems with below-grade stations. We found that although standards and codes are most likely to guide design decisions, the three types of tools (published standards, deterministic models, and microsimulation models) are as likely to complement as substitute for one another. We recommend that such analytical models of passenger flow should consider explicitly how practitioners employ them in practice to better link future refinements to the more "pedestrian" world of engineering and design practice.

Introduction

The question of why people choose to travel by private car rather than by public transit is of major concern to transportation planners and transit operators. For some would-be riders reluctant to wade through congested rail transit stations, the answer might be summed up by the words of Yogi Berra: "Nobody goes there anymore. It's too crowded" (Berra 2010, 9).

Good design can alleviate passenger crowding, thereby improving passenger safety, increasing system capacity, and possibly increasing transit ridership. The purpose of this paper is to identify the approaches North American rail transit operators take to analyzing and designing for passenger crowding at below-grade rail transit stations and offer suggestions for more effective utilization of such tools.

The Evolution of Pedestrian Flow Analysis

Beginning in the 1950s, engineers began to develop formulas based on empirical observation to describe pedestrian flows (Hankin and Wright 1958):

$$v = S \times D \qquad (1)$$

where, *v* is pedestrian flow per foot width (p/ft/min), *S* is walking speed (ft/min), and D is pedestrian density (p/ft^2).

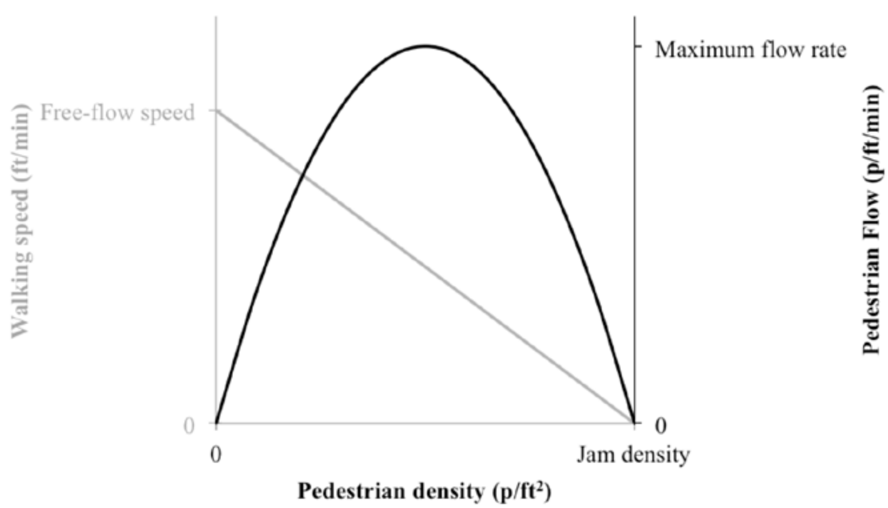
$$v = S / M \qquad (2)$$

where *v* is pedestrian flow per foot width (p/ft/min), *S* is walking speed (ft/min), and *M* is pedestrian space (ft^2/p).

In the half-century since Hankin and Wright's initial work on this topic, other researchers have observed a similar relationship between pedestrian speeds and pedestrian density, although they each observed different maximum pedestrian densities, as summarized in a review and meta-analysis by Weidmann (1992). The most influential of these studies was conducted by John Fruin and incorporated into his highly-cited manual, *Pedestrian Planning and Design* (Fruin 1971).

The simple relationships described by Equations 1 and 2 and illustrated in Figure 1 can be applied to determine the appropriate widths of transit station elements such as passageways, doorways, stairways, and platforms. The current edition of the *Transit Capacity and Quality of Service Manual* (Kittleson & Associates et al. 2003), also referred to as TCRP 100, recommends such a design methodology, where the designer may consider the station area as comprising distinct elements that can be segmented to determine the appropriate sizes for each element, based on anticipated passenger volumes.

FIGURE 1.
Relationship between speed, density, and flow



The deterministic methodology described in TCRP 100 (Kittleson & Associates, Inc et al. 2003) is relatively straightforward to implement—the analysis can be done using simple spreadsheet calculations—and adequately describes pedestrian flows in simple stations under uncongested conditions. However, its applicability to more complex and crowded conditions is more likely problematic.

Beginning in the late 1980s, researchers began to explore the application of increasingly powerful computing technology to simulate the movement of crowds of individual pedestrians without aggregating them into average flows (Gipps and Marksjö 1985). With computers becoming more powerful and widespread, microsimulation became a more feasible way to evaluate pedestrian (and motor vehicle traffic) flows in complex environments and understand crowd dynamics.

Over the past several decades, researchers have developed models to simulate pedestrian movement at the microscopic (or individual pedestrian) level (Gipps and Marksjö 1985; Helbing and Molnár 1995; Blue and Adler 2001; Løvås 1994). These models are the basis for commercially-available pedestrian modeling software packages such as VISSIM (Fellendorf and Vortisch 2010) and Legion (Castle et al. 2011). Although there is a substantial body of literature on solutions to the technical and computational problems associated with accurately portraying the movement of pedestrians (Jia, Yang, and Tang 2009; Ishaque and Noland 2009; Johansson, Helbing, and Shukla 2007; Peacock, Kuligowski, and Averill 2011), very little has been written about whether these increasingly-sophisticated microsimulation models actually are used by transit operators and station designers to inform their design work beyond what is available from deterministic analysis.

Whereas pedestrian flow analysis, whether deterministic and macroscopic or stochastic and microscopic, can guide the design of transit stations, established standards and codes can play a more important role in station design, since they often trump the findings of microscopic or macroscopic models—usually by requiring more space for pedestrians than called for by models of passenger flows (Kittleson & Associates, Inc. et al. 2003). Two sets of standards that are particularly relevant to station design are the Americans with Disabilities Act (ADA) (108th Congress 1990) and the *Standard for Fixed Guideway Transit Systems* published by the National Fire Protection Association, also referred to as NFPA 130 (NFPA 2014).

These standards focusing on the needs of passengers with disabilities and facilitating evacuations under peak conditions frequently determine the size of platforms and other station elements. Nevertheless, such standards typically define only minimums; they do not define maximums, nor do they define all aspects of platforms, queueing areas, and stairs. In such cases, other standards, rules of thumb, deterministic, and micro-simulation models may come into play. Under what circumstances are these models employed? That is the subject of our analysis below.

Research Methodology

To determine whether existing standards and analysis methodologies are adequate for the design of new transit stations, we must first understand how and whether station designers actually use these tools. Specifically, we ask two questions: Does reliance on standards and codes complement or supplant rigorous analysis of pedestrian flows? Is microsimulation a complement to or substitute for deterministic, macroscopic analysis?

To answer these questions, we conducted in-depth, semi-structured interviews with 15 experts in transit station design, including architects, engineers, and transit planners in North America. The experts were identified based on referrals from experienced transit professionals and included consultants as well as agency staff, many of whom had worked in both contexts. Interviews were conducted by telephone, recorded, and transcribed.[1] After compiling the interview transcripts, we carefully reviewed them to identify recurring themes, issues, and considerations in transit station planning for pedestrians.

Based on the themes identified through these expert interviews, we prepared an online survey of planners, designers, engineers, or managers at all 16 transit agencies in the United States and Canada that have below-grade rail transit stations. We contacted representatives from each transit agency by email to invite them to complete the survey. In the event of non-response, we followed up with a telephone call to ask our initial contacts to complete the survey or to identify another person within their agency who would be able to complete it. In most cases, one respondent from each agency completed the survey. At two agencies, New York City Metropolitan Transportation Authority and Bay Area Rapid Transit, two people from each agency completed the survey. Although 18 respondents would be a relatively small sample if we were attempting to generalize about a larger population, this was not the case here, as our survey was something of a census, since every transit operator in the United States and Canada with underground rail transit stations was represented. Since the survey questions (in contrast to our interviews), for the most part, were factual rather than perceptual, responses should—in theory—be consistent among respondents from the same agency. Thus, there would have been only minimal value gained from increasing the sample size to have more respondents from each agency, particularly since the universe of U.S. and Canadian underground heavy-rail operators already was fully represented.

We limited our survey sample to include only those agencies with underground stations, although in all cases these systems operate at- or above-ground stations in their systems as well. As such, the techniques we discuss are applicable to all rail rapid transit stations (those serving systems with fully-controlled tracks), whether the stations are underground, at grade, or elevated. Many regional rail and light rail transit stations are similar to underground rail rapid transit stations, so our findings likely are applicable to such systems as well.

Because the interviews presented primarily the viewpoints of transit station planning and design consultants (since consultants were over-represented among the interviewees and many of the interviewees who currently work for public transit agencies also had experience working as consultants), the survey helped to balance the viewpoints of both consultants and agency staff.

[1] In one instance, the expert was not available for a phone interview and answered the interview questions by email.

The study included seven tasks—(1) determining the number of fare collection machines and gates, (2) selecting locations of fare collection machines and gates, (3) selecting type of fare collection machines and gates, (4) determining the number of vertical circulation (stairs, escalators, elevators) elements, (5) selecting locations for vertical circulation elements, (6) selecting the type of vertical circulation elements, and (7) determining sizes for waiting and walking areas—and survey respondents were asked to select one or more of the following methods or tools they used in the design of the most recent new station with which they were personally involved:

- published standards and codes
- deterministic spreadsheet analysis
- microsimulation software

Respondents also were asked to indicate whether their design interventions were intended to correct for problems observed at other stations in their system, to be consistent with other stations in the system, or to incorporate best practices observed in other transit systems.

Results

Our findings are presented below, first from the expert interviews and then from the transit agency survey. The survey was created based on common themes that emerged from the interviews with all 15 interviewees, even though not all interviewees are directly quoted in the discussion below.

Expert Interviews

We begin first with the relative roles played by published standards, deterministic models, and microsimulation models in the analysis of pedestrian flows at transit stations.

Published Standards

Both consultants and agency staff mentioned the conservative nature of existing standards and codes, noting that adherence to existing standards can render detailed analysis of pedestrian flows moot because the standards often mandate more circulation space than would be called for by an analysis of anticipated passenger volumes. As a staff member at one transit operator put it:

> A lot of that kind of technical work is embedded in standards associated with the design. So, as long as you follow the standards, typically you have enough … entrance capacity to satisfy safety requirements associated with transit stations. So whether you have enough entrances and exits to satisfy the pedestrian flow and circulation space, those are typically handled through the standards we have in place. (Interviewee #1)

Another consultant also explained that station design depends on criteria other than passenger volumes and that when these other criteria are met, the design often will be more than adequate to accommodate anticipated passenger volumes:

> It depends on the volume, but … there should be other factors that are going to govern the size of the facilities. You have to have an agency that understands the minimum of two escalators and then, in some cases, you need to have three in case you have to take one out for maintenance, which you will.… You often will have more capacity just by the fact of redundancy and maintenance requirements that you are going to need for normal operations and normal growth. (Interviewee #2)

This idea of standards serving a dual purpose—for example, that standards intended to allow for emergency evacuation also serve the purpose of ensuring adequate circulation space for comfortable day-to-day passenger flows— also is reflected in the attitudes expressed towards ADA standards. The same consultant said:

> A lot of the things you do for ADA actually help all passengers or a large percentage of passengers, such as people with bikes or luggage or carriages. (Interviewee #2)

In discussing how the practice of transit station design has changed over the years, consultants referred to an increasing reliance on, and stringency of, standards and codes. One referred to the increasing role of ADA standards:

> ADA has changed the way we handle pedestrians over the last 20 years. So we're a lot more cognizant of pedestrian safety and needs of access than we were just 20 years ago. (Interviewee #3)

A second consultant referred to the nearly universal adoption of NFPA 130 (NFPA 2014) as a positive development that improves station safety, although its requirements might be unnecessarily conservative in some cases:

> NFPA 130 is being embraced as the guideline; I don't think just in this country … systems all around the world are following these guidelines, which I think is good—a little bit over-designed, but people will be safe. (Interviewee #4)

On the other hand, some experts expressed concern that the generic, one-size-fits-all nature of some standards can fail to account for station-specific contexts.

Although adherence to standards such as ADA (108th Congress 1990) and NFPA 130 (NFPA 2014) may have added benefits beyond the purposes those standards are intended to serve, they are written to serve particular purposes, and the adoption of standards to meet these purposes may cause the neglect of other goals. One expert mentioned that the lack of a specific standard for passenger comfort might lead to neglect of this consideration or confusion regarding how to address it through station design:

> There tends to be a gap between the fire- and life-safety egress standards that might tell you one thing about what the minimum design safety factor might be and, at the other end of the spectrum, for the comfortable and desirable walking and vertical circulation environment. I think there's still a fair bit of murkiness for what tools are appropriate, what level of analysis is needed. (Interviewee #5)

Deterministic Models

We also asked the experts interviewed about the use of deterministic analyses, which can be done using spreadsheets, and microsimulation analyses, which require specialized software. Such models can be used to determine space needs for passenger movement and queueing and to ensure that designs meet adopted standards or design issues not accounted for in standards.

Some experts mentioned that the methodologies for much of the pedestrian flow analysis for transit stations have changed very little over the past decades. One referenced the continuing relevance of John Fruin's guidelines (Fruin 1971):

> Surprisingly, a lot of what we do right now with pedestrian flow, the basic theory is from John Fruin; his book is called Pedestrian Planning and Design. He was a New York City Port Authority employee; this book was published … in the 70s … and most of the stuff that he has in there are the guidelines that are still used today.… All his guidelines for level of service in pedestrian corridors, stairs, escalators, are still used as a basis. (Interviewee #7)

A major advantage of spreadsheet models is their simplicity and cost-effectiveness compared to microsimulation models. Whereas an agency may need to hire consultants to conduct microsimulation analysis, deterministic models can be created and run in-house. However, one consultant gave an example to emphasize that deterministic models can be adapted to be as complex as circumstances require. If used appropriately, he argued, they can be as informative as microsimulation models:

> We did a bunch of surveys of route choice, and about 95% of people are using the same facilities day in and day out…. So, while the spreadsheet models were more deterministic, if you had enough data from surveys, a transportation transit architect could determine pretty confidently the majority of paths that would be taken through the facility.… You are really designing it and analyzing it for the normal disruptions that occur with enough regularity that you have to plan for, so there are a lot of safety factors built in. (Interviewee #2)

Microsimulation Models

As discussed above, many experts find deterministic spreadsheet analysis of passenger flows to be adequate for many station designs. Some, in fact, were skeptical that sophisticated microsimulation added much value beyond what could be gained through deterministic analysis. A staff member at one agency explained that she saw the value of microsimulation primarily in terms of visualization and communication rather than the analytical insight they offered. According to one consultant, the sophistication of microsimulation modes could even be a disadvantage, when reliance on sophisticated software packages supplants and inhibits analysts' or designers' intuition and expertise:

> There's a couple of new generation models, which, I'm afraid, it's gotten [to be] a little too much of a black box…. I think we've gotten models with some aspects that are very sophisticated, but they also dumb down some other components like the path choice…. Some of the people that are running this model don't know how to interpret this information. So my concern is that

> as the models have become more technically and graphically sophisticated, the people operating them don't really understand what's going on inside them and don't have a good underlying understanding of what the outcome is telling them. So they are just letting the machine … whatever comes out, that's it.… I'm finding [that] the understanding of the fundamental principles in the interpretation of the results is a real problem. (Interviewee #2)

This observation may point to a pattern in which increasingly sophisticated models are now available to analysts who may not have sufficient expertise in basic principles of pedestrian flows and station design to be able to adequately interpret or apply the insights that could be gained from the model. If, as Interviewee #2 suggests, complex and increasingly sophisticated microsimulation models are used primarily, not as analytical tools, but as visualization tools for policymakers and the general public, then agencies may be greatly underutilizing the potential power of these models, and the benefit they do receive may not justify the cost.

A number of experts referred to the high cost of microsimulation models. One consultant explained why microsimulation was not typically used for station retrofits:

> There are very sophisticated pedestrian flow modeling and pedestrian simulation modeling tools that are available, but they're going to be quite costly in the context of a retrofit to a station. (Interviewee #5)

Another consultant further explained that the costs of running a microsimulation model go beyond simply the software license or the consultant fee, and such costs may be justified only in particular situations. In spite of these drawbacks, experts mentioned that microsimulation models allow analysts to test a variety of different designs under a variety of different conditions.

Demand Forecasts

Regardless of which techniques are used to analyze pedestrian flows, the analyst must begin with an accurate assessment of anticipated passenger volumes. One agency staff member explained that a model ultimately is only as good as its input data:

> The bottom line is, the … model is only as good as the information that's being put in there.… The model is as subjective as the … person … saying the data is accurate. And that's somewhat frustrating … if you really need some sort of an objective analysis. (Interviewee #8)

One consultant referred to the fact that inflated ridership forecasts may be used to justify a rail project and emphasized the importance of verifying all assumptions used for ridership forecasts before applying those forecasts to station design:

> Sometime ridership forecasts are high just to justify the pursuit of the project.… But I know when I see some numbers, and the numbers look high, I can tell that's going to be a problem before I run any analysis. So ridership forecasts have to be as exact as possible.… I trust them, but when I see those that are really high I say, "Well, let's get into the numbers a little bit." So it's important—it's important to do it right. (Interviewee #4)

Survey Results

To complement the interviews of the experts, we also conducted a survey of transit operators in the United States and Canada to better understand how transit station passenger queueing and flow design decisions play out in actual practice.

Table 1 lists several design tasks and indicates how commonly standards and codes, deterministic spreadsheet analysis, and microsimulation software are used for each task. Respondents were asked to select all methods that applied to each design task. For some tasks, multiple tools were applied; for others, none of the three tools was applied (for instance, design decisions simply could be made to maintain consistency with other stations). Thus, the row totals in Table 1 do not necessarily sum to 100%.

TABLE 1.

Number of Transit Agencies Reporting Using Various Approaches to Station Design, by Design Task

Design Task	Method or Tool Applied to Design		
	Standards and Codes	*Deterministic Spreadsheet Analysis*	*Microsimulation Software*
Determining number of fare collection machines and gates	9 (60%)	5 (33%)	3 (20%)
Selecting locations of fare collection machines and gates	7 (47%)	2 (13%)	2 (13%)
Selecting type of fare collection machines and gates	4 (27%)	1 (7%)	1 (7%)
Determining number of vertical circulation elements	9 (60%)	3 (20%)	4 (27%)
Selecting locations for vertical circulation elements	11 (73%)	4 (27%)	4 (27%)
Selecting type of vertical circulation elements	10 (67%)	3 (20%)	3 (20%)
Determining sizes for waiting and walking areas	11 (73%)	3 (20%)	4 (27%)
Some aspects of station design	**12 (80%)**	**5 (33%)**	**6 (40%)**

As shown in the bottom row of Table 1, 12 (80%) of the 16 surveyed agencies reported that at least some aspects of the design for the most recently-designed station in their system were based on published standards and codes. One of the 16 respondents skipped the question because (s)he was not personally involved in the design of any recent stations. Of the three remaining agencies reporting that none of their design tasks were based on published standards and codes, two reported using deterministic spreadsheet analysis as a basis for design. One reported not using any type of quantitative analysis as a basis for design, indicating instead that all design tasks were based on consistency with existing stations in the system.

Table 2 shows that use of published standards does not obviate the perceived need for further quantitative analysis using deterministic spreadsheet or microsimulation models. Agencies that use standards and codes as a basis for a design task are about as likely to use microsimulation and/or deterministic analysis for that task as those that do not use standards and codes as a basis—although neither is employed routinely.

TABLE 2.
Number of Transit Agencies Reporting Using Deterministic and Microsimulation Analyses in Addition to Published Standards and Codes for Various Station Design Tasks

Design Task	Deterministic Spreadsheet Analysis	Microsimulation Software Analysis	Both	Neither	Total
When published standards or codes are used					
Determining number of fare collection machines and gates	1	1	1	6	9
Selecting locations of fare collection machines and gates	0	0	1	6	7
Selecting type of fare collection machines and gates	0	1	0	3	4
Determining number of vertical circulation elements	0	1	1	7	9
Selecting locations for vertical circulation elements	0	1	3	7	11
Selecting type of vertical circulation elements	0	0	2	8	10
Determining sizes for waiting and walking areas	1	1	1	8	11
Total	**2**	**5**	**9**	**45**	**61**
Percent	**3%**	**8%**	**15%**	**74%**	**100%**
When published standards or codes are not used					
Determining number of fare collection machines and gates	2	0	1	3	6
Selecting locations of fare collection machines and gates	1	1	0	6	8
Selecting type of fare collection machines and gates	0	0	0	11	11
Determining number of vertical circulation elements	0	0	2	4	6
Selecting locations for vertical circulation elements	1	0	0	3	4
Selecting type of vertical circulation elements	1	0	0	4	5
Determining sizes for waiting and walking areas	0	0	1	3	4
Total	**5**	**1**	**4**	**34**	**44**
Percent	**12%**	**2%**	**9%**	**77%**	**100%**
Regardless of use of standards and codes					
Determining number of fare collection machines and gates	3	1	2	9	15
Selecting locations of fare collection machines and gates	1	1	1	12	15
Selecting type of fare collection machines and gates	0	1	0	14	15
Determining number of vertical circulation elements	0	1	3	11	15
Selecting locations for vertical circulation elements	1	1	3	10	15
Selecting type of vertical circulation elements	1	0	2	12	15
Determining sizes for waiting and walking areas	1	1	2	11	15
Total	**7**	**6**	**13**	**79**	**105**
Percent	**7%**	**6%**	**12%**	**75%**	**100%**

Based on the interviews, in which transit station design experts explained the advantages and disadvantages of microsimulation relative to deterministic analyses, we might expect these two types of analysis to be substitutes for one another. However, Table 2 suggests that this is not the case. For a given design task, agencies are about as likely to use both microsimulation and deterministic analyses than either type of analysis alone. This suggests that microsimulation and deterministic analyses are used as complements as often as substitutes.

Complementarity of Analysis Tools

Ultimately, the question of whether to base a particular analysis task on published standards and codes, deterministic analysis, or microsimulation analysis depends on the questions the analyst seeks to answer. Table 3 lists some potential questions that may be associated with a particular design, as well as the most appropriate analysis tool to answer each question. It also is possible that the size of pedestrian flows and the level of station complexity may influence the choice of analysis tools, with more sophisticated techniques being used for major-volume stations such as major transfer points or stations serving special events.[2] Unfortunately, our survey was not designed to differentiate among station categories, and we cannot confirm this hypothesis.

TABLE 3.
Appropriate Analytical Tools to Answer Particular Questions

Question	Analysis
Does the proposed design meet code requirements?	Analysis described in relevant code
How much space is needed to accommodate at a particular station element (e.g., width of platforms or corridors, number of doorways or fare gates)?	Deterministic spreadsheet analysis
How and where do passenger flows transition from one element to another, and how do individual elements interact with one another?	Microsimulation analysis
How do streams of pedestrians in opposing directions interact with one another?	Microsimulation analysis

Conclusion and Recommendations

The results of our expert interviews and subsequent operator survey suggest that agencies rely primarily on published standards and codes in the design of pedestrian circulation elements in rail rapid transit stations. Moreover, deterministic spreadsheet models and microsimulation models are as likely to complement as to substitute for one another as bases for station design.

Given our focus on how these various approaches are applied in practice, and given the enormous variability in the objectives and constraints of heavy rail station design, it is not possible in this research to answer the question of what approach agencies *ought* to take in analyzing pedestrian flows. We have, however, documented the use of these three distinct approaches in current planning and design practice, as well as the views about their relative merits from interviews of transit station design experts. Our review of the literature, expert interviews, and survey of transit agencies collectively allow us to

[2] Thanks to an anonymous reviewer for making this point.

both draw conclusions about the state of transit station design for passenger queueing and flows and offer some recommendations for best practice.

Short Term

In the short term, agencies can begin each analytical exercise by clearly defining the question that the analysis seeks to address and selecting a modeling or analytical approach that can appropriately answer that question, as suggested in Table 3.

Stations are components of larger systems that interact with and are influenced by both the rail network and the neighborhood surrounding each station. Therefore, an additional short-term practice that can improve pedestrian queuing and flow analysis is to use information about current and anticipated land uses and travel flow patterns adjacent to the station to determine the most common origins and destinations of passenger flows at different times of the day and week and at special events.

Transit operators also can establish processes and systems that encourage coordination and knowledge-sharing among consultants and agency staff, as well as among analysts, planners, and designers. Such coordination can improve the relevance of the analysis by giving analysts a better understanding of the question being asked and empowering them to select the most appropriate tools in response. It also can have designers ask analysts the right questions. To the extent that designers and decision-makers see analysis as a "black box," they are less able to apply the information it provides to their decision-making.

Long Term

In the long term, the literature review, interviews, and survey results suggest that transit agencies occasionally should examine the requirements published in various standards and codes to determine how well they apply to the extant circumstances. In cases in which existing standards are very conservative, such that they result in stations that are consistently over-designed with respect to all other passenger queuing and flow parameters, transit agency staff may choose to either accept the additional margin of safety (and expense) that the codes provide or argue that the standards and codes need not be adhered to (where they are not bound into regulatory code) or that the standards and codes ought to be relaxed in light of changing circumstances (where they are bound into administrative law).

On the other hand, in cases in which existing standards and codes are found to be inadequate with respect to passenger comfort or safety, transit agency staff may choose to codify their own, more demanding standards to ensure that passenger needs and safety will be met consistently.

At present, given the generally conservative requirements of published standards and codes, most agencies do not see a need for, or an added value from, the added cost of sophisticated analysis techniques. As government agencies and professional organizations continue to develop and refine standards and codes, they should do so in ways that encourage the use of available analytical tools to adapt guidelines to the local context, as appropriate. There also may be opportunities to use microsimulation models to verify and refine deterministic models and vice versa, although our research suggests that this is rarely done.

Finally, transit agencies occasionally should reexamine the assumptions that are routinely used for passenger queuing and flow analysis to determine if they continue to adequately describe the characteristics of their riders and particular stations. These assumptions may not change significantly from year to year, but they may drift enough over a decade to require some adjustment. In the end, the choice of particular analytical tools and strategies for accommodating passenger flows should depend on the specific issues that exist at a station and transit system.

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