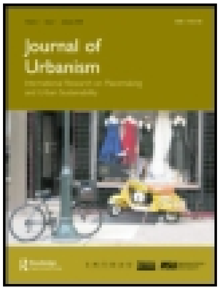

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Understanding the impacts of integrating New Urbanist neighborhood and street design ideals with conventional traffic engineering standards: the case of Stapleton

Wesley E. Marshall[a]
[a] Department of Civil Engineering, University of Colorado Denver, CO, USA
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Understanding the impacts of integrating New Urbanist neighborhood and street design ideals with conventional traffic engineering standards: the case of Stapleton

Wesley E. Marshall*

Department of Civil Engineering, University of Colorado Denver, CO, USA

This research considers the implications of building places that possess many of the qualities that make New Urbanism so desirable but also marginalizing them with other qualities that prioritize automobility to meet the demands of conventional traffic engineering standards. By examining the existing built environment of Stapleton – a New Urbanist development in Denver, Colorado – in terms of street network characteristics, street designs, and intersection designs, I investigate the inconsistencies of the resulting built environment with respect to the latest research and state-of-the-practice New Urbanism design ideals. The outcomes are then considered in terms of how people actually use the transportation system by way of vehicle speed studies and travel diaries. The trends suggest that mixing New Urbanist neighborhood and street design characteristics with conventional traffic engineering standards results in travel behaviors more consistent with conventional auto-oriented developments.

Keywords: New Urbanism; street design; street networks; vehicle speeds; mode choice; AASHTO

Introduction

There will never be a single, cookie-cutter approach to designing a transportation system supportive of New Urbanism ideals; however, there are a number of underlying principles subscribed to by a majority of New Urbanists. These tenets typically include narrow street cross-sections supported by a compact and connected street network (CNU 2000, 2012). While such designs must be coordinated with a multitude of other urban elements – such as mixed-use zoning, supportive transit, and good placemaking – to truly achieve the sought-after transportation behavior benefits, the reality is that most New Urbanist designers face an uphill battle simply trying to attain the fundamental street and street-network designs. One issue is that there is usually no single core antagonist in this struggle, as conflicts are often found at the local level as well as at the regional and federal levels, in publications such as *A Policy on Geometric Design of Highways and Streets* by the American Association of State Highway and Transportation Officials (AASHTO 2004). This speaks to the systematic nature of the problems that many planners and designers face, even in situations where the priorities are seemingly aligned with those supported by New Urbanists.

In an effort to actually get things built, most New Urbanist design teams find that they need to compromise, and in effect, merge what the designer views as the ideal solution with more conventional traffic engineering elements. The problem with this is that the

*Email: wesley.marshall@ucdenver.edu

resulting transportation designs often become a hybrid mix of various influences. The bigger problem is the inherent disconnect between these influences. In other words, what happens when we make such compromises and build places that possess many of the qualities that make New Urbanism so desirable but also marginalize them with other qualities that prioritize automobility? More specifically, what are the resulting travel behaviors, and perhaps more importantly, the safety implications? Improving our understanding of these complex issues is vital, not only to achieving the anticipated benefits of New Urbanism, but also to sustaining the market success of New Urbanism. Failure on deliver on some key performance measures, such as those related to travel behaviors and road safety, could relegate New Urbanism, and smart growth efforts in general, toward niche markets as opposed to a better overall vision for a safer and more sustainable society.

This research delves into the design realities of Stapleton, a New Urbanist development in Denver, Colorado, that faced these exact hurdles, by examining the existing built environment – with respect to street network characteristics, street designs, and intersection designs – and investigating the inconsistencies of those designs with respect the latest research and state-of-the-practice New Urbanist thinking. The results are then considered in terms of how people are actually using the system, by way of vehicle speed studies and travel diaries.

Literature review

Critical of the conventional sprawling development common in the second half of the twentieth century, the New Urbanist movement, beginning in the early 1980s, sought to create places reminiscent of more traditional communities (CNU 2000). The main aspects of New Urbanist design include:

- Livable streets arranged in compact and walkable blocks.
- A range of housing choices serving a diverse range of ages and income levels.
- Schools, stores, restaurants, and other destinations accessible by walking, bicycling, or transit.
- A human-scaled public realm where buildings define and enliven streets and other public spaces (CNU 2000).

The premise behind New Urbanism is that such a combination of neighborhood design elements would lead to better and more sustainable places to live, work, and play. While academic research investigating these claims was not commonplace until the 2000s, classic books by influential thinkers such as Jane Jacobs (1961) and Lewis Mumford (1961) make similar arguments about neighborhoods and the built environment having the potential to influence behaviors. Academic research into such effects began with smaller-scale studies of streetscapes and social interaction (Appleyard and Lintell 1972) and graduated to transportation-related behaviors in the 1990s (Handy 1992, 1996a, 1996b; Cervero and Gorham 1995; Cervero and Radisch 1996). Much of this early built-environment research focused on older, traditional neighborhoods as a proxy for actual New Urbanist communities (Handy 1992, 1996b; Cervero and Radisch 1996; Crane and Crepeau 1998; Greenwald 2003; Nasar 2003). While perhaps useful for establishing the potential for New Urbanist communities, this limitation could fail to properly capture the extent of the differences between older, traditional neighborhoods and New Urbanist communities that influence behavior.

In terms of research specific to New Urbanism, the work is relatively scarce (Handy 2006). Most of the early studies were qualitative and focused on walking behavior as well as the related issue of increased social interactions (Plas and Lewis 1996; Langdon 1997; Kim 2000). These studies tended to find somewhat higher walking and social interaction rates in the New Urbanist neighborhoods, results that were typically confirmed by the similar but more quantitative studies that followed (Lund 2003; Dill 2006; Toit et al. 2007). The research also suggests that these additional non-motorized trips may not be completely substituting for driving trips. Some researchers have found less driving associated with New Urbanism (Rodríguez et al. 2006), while others have found that residents of New Urbanist communities drive just as much as those living in more conventional suburban developments (Falconer, Newman, and Giles-Corti 2010). The true effectiveness of New Urbanism remains the subject of intense debate (Gordon and Richardson 1997; Fainstein 2000; Ellis 2002; Grant 2006).

Despite these somewhat mixed results, the consensus of the more general travel behavior research – which is focused more upon understanding isolated variables as opposed to the synergistic combination of elements espoused by New Urbanists – is that these individual ingredients tend to be associated with an in increase walking and, to a lesser extent, a decrease in driving (Handy 2006). For example, Ewing and Cervero's (2010) meta-analysis examined over 200 studies quantitatively relating elements of the built environment to travel behavior. This seminal study highlights the fact that an abundance of diverse factors influences travel behaviors. With respect to walking, outcomes have been shown to be associated with the availability of pedestrian facilities (Kitamura, Mokhtarian, and Laidet 1997; Hess et al. 1999), street network design (Marshall and Garrick 2010a), density (Frank and Pivo 1995), accessibility (Levinson and Krizek 2005), and local amenities (Handy 1992; Manaugh and El-Geneidy 2011). The next section describes the research related to the transportation design elements under investigation in this study: street networks, street widths, and curb radii.

Design elements: street networks, street widths, and curb radii

Over the course of the last hundred years, street networks have evolved from fairly compact and connected toward sparser, more dendritic designs (Southworth and Ben-Joseph 1997; Ben-Joseph 2005; Talen 2012). While the overall Denver region has not been an exception to this trend, much of the actual city of Denver is an orthogonal grid. In terms of travel behaviors, the main topic of the previous section, the growing body of research supports the New Urbanist notion that blocks should be compact and walkable because such fine-grained street networks tend to result in fewer vehicle miles traveled and additional active transportation (Marshall and Garrick 2010a, 2012). This research strand also suggests that these networks are safer for all road users (Marshall and Garrick 2011b); in particular, accident severity is drastically reduced, which suggests that such networks promote lower vehicular speeds (Marshall and Garrick 2010b, 2011a).

Studies linking vehicle speeds to street design elements have been fairly common (Martens, Comte, and Kaptein 1997; Swift, Painter, and Goldstein 2006; Gattis and Watts 1999; Gattis 2000; Fitzpatrick et al. 2001; Naderi, Kweon, and Maghelal 2008; Ivan, Garrick, and Hansen 2009). From the early work investigating the perceived width of the roadway with respect to vehicle speeds (Smith and Appleyard 1981) to studies that attempt to isolate the statistical impact of the individual elements (Ivan, Garrick, and Hansen 2009), "observation has shown the situation which promotes the highest speeds on residential streets is a wide street with low parking density, low traffic volumes, and long headways between vehicles" (Daisa and Peers 1997). These issues could be of particular concern on streets in Stapleton that, for example, provide on-street parking near housing units with off-street parking available. In terms of street width as a specific factor, the research collectively finds that wider streets result in higher speeds (Daisa and Peers 1997; Martens, Comte, and Kaptein 1997; Ivan, Garrick, and Hansen 2009). Despite the size of the effect being up for debate (Gattis and Watts 1999; Gattis 2000), research suggests associated negative safety implications for wider streets. In his 1999 report on traffic calming, Ewing states that "relative to wide streets, narrow streets may calm traffic. … Drivers also seem to behave less aggressively on narrow streets, running fewer traffic signals, for example." A Colorado-based study supports this idea with safety data (Swift, Painter, and Goldstein 2006). Relating street width to travel behaviors, the results of another study suggest higher pedestrian volumes on narrower streets than on wide streets (Ewing 1999). With respect to New Urbanist design ideals regarding narrower streets (ITE and CNU 2010) and the associated New Urbanist goals found in the charter (CNU 2000), the existing literature upholds this connection. Related to vehicle speed and street design, large curb radii at intersections have also been shown to be associated with higher speeds (Tarawneh, Rifaey, and McCoy 1998; LaPlante and McCann 2008).

The subsequent work in this article represents a step forward beyond the general New Urbanist academic literature by better assessing the design of a specific New Urbanist neighborhood in terms of which elements actually meet New Urbanist standards and which are more representative of conventional traffic engineering standards. Given that most studies of New Urbanism tend to compare the travel behaviors of those living in New Urbanist communities (or those living in traditional neighborhoods that exhibit qualities associated with New Urbanism) to those in suburban developments, without making such distinctions, it is not surprising that the results have been mixed. New Urbanism has always called for a combination of design elements to be effective (CNU 2000; Lund 2003). So, without fully understanding the intricacies of the designs, it would be easy – and misguided – to label a New Urbanist community that is not living up to its projected travel behavior outcomes a failure. New Urbanism may not be failing in these places; there may be underlying symptoms distinct from New Urbanist ideals. Accordingly, expanding beyond the myopic assumption that all New Urbanism can be judged uniformly is both necessary and timely.

Study background

The plan for Stapleton

This research was based on the Stapleton development in Denver, Colorado. Since 1929, Stapleton had served as the region's primary airport, before being decommissioned in 1995 upon the opening of Denver International Airport. Five years prior to the decommissioning, a nonprofit group called the Stapleton Redevelopment Association was formed with the goal of creating a plan for redevelopment. After an official partnership agreement with the city of Denver in 1993, the group conducted extensive community outreach, including over one hundred meetings. Two years later, they produced a document – ironically referred to as the "Green Book" (Stapleton Redevelopment Foundation 1995) – that set forth a New Urbanism–based redevelopment plan for the 4700 acres of land.

New Urbanism is guided by the principles laid out in the *Charter of the New Urbanism* (CNU 2000). The charter sets forth 27 principles intended to guide policy and urban design practices. Beyond the main transportation thrusts of the charter, the CNU has more recently been involved with two other published documents: *Sustainable Street Network Principles* (CNU 2012) and *Designing Walkable Urban Thoroughfares: A Context Sensitive Approach* (ITE and CNU 2010). These documents are relevant to this study, despite not being published until more recently, because they express the design ideals that have long been practiced by New Urbanists.

Sustainable Street Network Principles identifies the New Urbanist ideals regarding the fundamental characteristics of good street network design. While not prescribing any specific pattern, the document highlights themes such as maximizing connectivity, spacing major streets properly, and keeping all streets safe and walkable. Similar views are espoused in a prior book by Peter Calthorpe (1997), the hired master planner for Stapleton. The ITE/CNU document reviews similar street network principles but also speaks to individual street design elements and the need to integrate streets within the framework of the associated context zones. Rather than relying on the functional classification system, which disaggregates the streets into arterials, collectors, and local streets, New Urbanists typically advocate for the context-zone approach, which is intended to better facilitate design criteria that are responsive to the surrounding contexts (ITE and CNU 2010). One of the first compromises that the designers of Stapleton had to make with the city was to adhere to functional classification designations, as opposed to following what the context-zone framework would stipulate (Peter Calthorpe, personal communication, 2012).

The functional classification system has been criticized by a number of researchers as (1) being overly simplistic and rigid in terms of limiting the base functionality of streets (in terms of access versus mobility) and (2) not recognizing critical issues such as differences in land use, pedestrians, bicyclists, transit, and placemaking (Garrick and Kuhnimhof 2000; Jacobs, MacDonald, and Rofe 2002; Greenberg and Dock 2003; Aurbach 2012). These are all issues that the context-zone approach explicitly considers (ITE and CNU 2010).

The Stapleton Green Book itself also established a set of community objectives. For instance, in terms of a general approach to transportation and land use, the document states:

> Land use planning and community design stress compact, mixed use communities that are walkable and transit-oriented. These characteristics can reduce automobile dependence and emissions. … Transportation technologies emphasize bus and rail transit, bicycling, walking, and alternative fuels for vehicles.

The guiding principles for Stapleton addressed common sustainability realms such as environmental responsibility, social equity, and economic opportunity in addition to physical design, transportation systems and corridors, and city street grid and urban development patterns. Under each heading are listed several principles intended to guide decision-makers in the implementation of the overall plan. For example, the first principle listed under city street grid and urban development patterns is: "Extend the surrounding street and block configuration into the southeast and southwest of the site as an extension of the city."

The plan was to provide for a "variety of mobility options beyond the automobile including walking, bus, bicycling, rail transit (along the Smith Road corridor) and the use of telecommunications to substitute for the need for travel", with the explicit performance goal of reducing automobile reliance and vehicle miles traveled. In other words, the intent was to prioritize accessibility, transit, walking, and biking over mobility and driving.

A master developer, Forest City, was selected in 2001, and by late 2002, the first residents began calling Stapleton home, amidst heavy construction. A decade later, Stapleton has over 14,000 residents, several schools, a town center, and hundreds of acres of open space, as well as commercial, retail, and office space. Full build-out is anticipated to include over 30,000 residents and 35,000 workers.

The current incarnation of Stapleton's transportation system

The street network

According to Stapleton's Green Book, as well as New Urbanist literature on the subject, one of the primary goals of the Stapleton development was to connect to the existing gridded Denver street network. Figure 1 depicts the historical concept of the original 1920s street grid expansion plan for Denver and illustrates the mindset that the development plan had in place for connecting Stapleton back to the historic street grid. As described in the literature review, compact and connected street network designs have their benefits.

Street network compactness is typically defined by metrics such as intersection density and block length (Handy, Paterson, and Butler 2003; Marshall and Garrick 2012). Due to the sheer volume of parks and open space in Stapleton, such street network measures are relatively difficult to determine objectively. Average scores for the Stapleton street network demonstrate intersection densities approaching 200 intersections per square mile (77 intersections per square kilometer) and a mean block size of approximately 400 feet (122 m). While not as compact as well-known gridded networks such as Portland, the numbers are comparable to a highly walkable and bikable city such as Berkeley, California. Stapleton's street network, however, is not particularly representative of the orthogonal Berkeley grid, nor those found in the neighborhoods surrounding Stapleton. Figure 2 depicts the portion of Stapleton south of Interstate 70, the Park Hill neighborhood to the west, and the city of Aurora to the south. Figure 3 highlights the Stapleton network in terms of functional

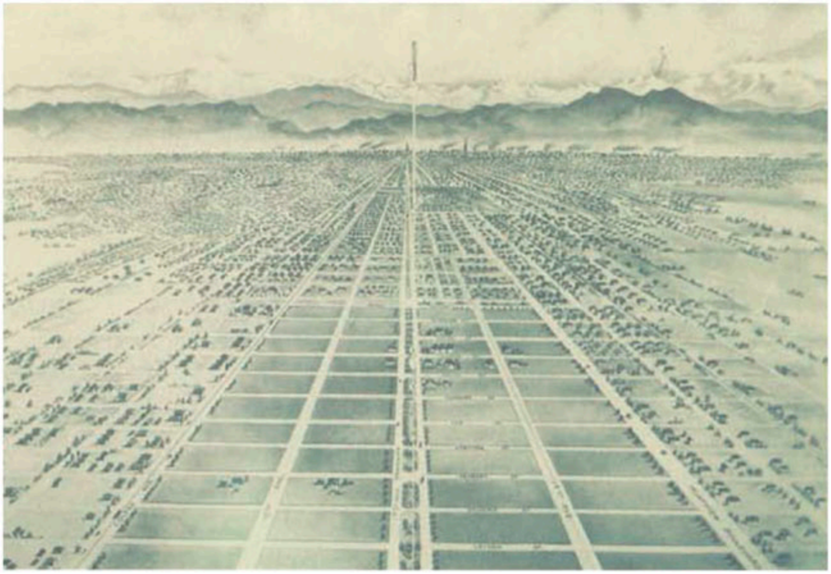

Figure 1. Circa 1920s depiction of Denver street grid expansion toward Stapleton.
Source: Stapleton Redevelopment Foundation 1995. Stapleton Development Plan. Denver, CO: City and County of Denver.

Figure 2. South Stapleton's street network with respect to the surrounding fully gridded neighborhoods.

classification, with the areas shown representing the area outlined in yellow in Figure 2. Note the subset of curvilinear streets mixed amongst the rectilinear network that is a result of the open space created by the greenways and parks; while these greenways and parks limit connectivity and direct routes for vehicles, they also provide additional connectivity and more direct routes for pedestrians and bicyclists. Due to such issues, street connectivity is decidedly more difficult to interpret than network compactness.

Street connectivity is most typically measured by the link-to-node ratio or the connected-node ratio (Handy, Paterson, and Butler 2003; Marshall and Garrick 2012), both of which attempt to quantify the relative connectivity of different network designs. What such metrics fail to detect are differences between local neighborhood street connectivity and citywide street connectivity. In other words, street connectivity internal to the development is treated similarly to an external connection. Figure 4 illustrates a few examples of gridded networks that are fundamentally different in terms of functionality, but in terms of metrics such as the link-to-node ratio or the connected-node ratio, the first two networks depicted in Figure 4 would have comparable numbers.

Stapleton does not exhibit full connectivity; rather, Stapleton can be better represented by the second image in Figure 4, that of the network with high neighborhood connectivity and low citywide connectivity. While a handful of streets connect Stapleton to the surrounding neighborhoods to the east and south, there are very few streets connecting one end of Stapleton to the other. Martin Luther King, Jr., Boulevard (MLK) is the only one that provides east–west connectivity, while Central Park Boulevard (CPB) provides for the

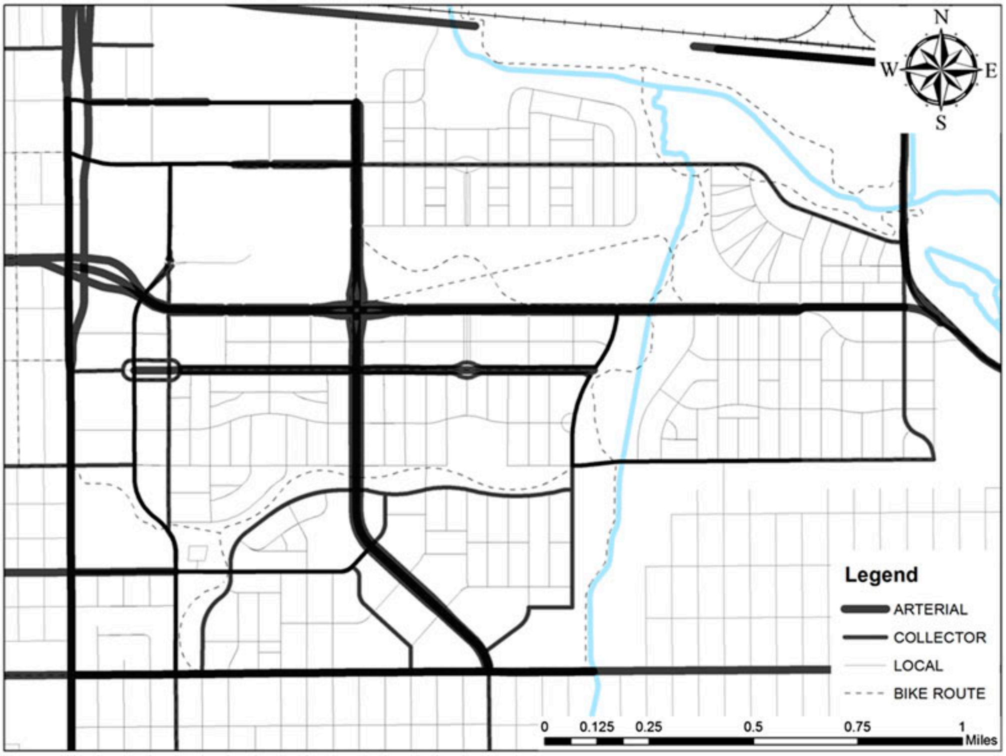

Figure 3. Close-up of Stapleton's street (2013).

Figure 4. Gridded street network typologies. Adapted from Marshall (2005).

main north–south movement (the Syracuse Street and Roslyn Street one-way couplet supports Central Park Boulevard with north–south travel but only reaches as far north as East 35th Avenue). Such strategies help limit the through movement of vehicle traffic on residential streets; the disadvantage is that almost all cars must find their way to a small number of individual streets. Thus, the hierarchical nature of the Stapleton street network is more representative of the functional classification system's dendritic typology than what might be associated with the New Urbanist street network ideals described previously (Marshall and Garrick 2009; CNU 2012).

Street designs

CPB and MLK are defined as urban arterials by the City of Denver (based upon AASHTO's functional classification system). Such arterials are intended for high traffic volumes and longer trip length, with service to adjacent land uses secondary to mobility (AASHTO 2004). The design of CPB is best described as a parkway, with two lanes of through movement separated by a 50-foot-wide (15.2 m) raised median. Each direction also includes a bike lane and a parking lane, as well as turn lanes at collector and arterial intersections. MLK primarily has two travel lanes in each direction (one segment within Stapleton has three in each direction), with on-street parking along certain stretches but no bike lanes. As a New Urbanist community, Stapleton falls on the larger end of the spectrum; thus, while most examples of New Urbanism are able to locate arterial roads on the periphery, these arterials run right through the heart of Stapleton. Figure 5 depicts CPB and MLK. The speed limit on CPB is 30 mph (48.3 km/h); the speed limit on MLK is primarily 35 mph (56.3 km/h), but it includes a new stretch marked as 30 mph near the future town center on the eastern edge of Stapleton.

While current traffic volumes do not warrant the capacity appropriated on these arterials, both were designed with future traffic demands in mind, as forecasted by the Denver Regional Council of Governments' 30-year regional travel demand model. Future demands on CPB are predicted to be over 30,000 vehicles per day, even though current volumes are approximately 12,000 vehicles per day. This design reflects a self-fulfilling "predict and provide" mentality where the current streets must be able to accommodate some future level of traffic demand, in direct contrast to New Urbanist ideals (Dankosky et al. 2010).

New Urbanists have long used narrow streets to restrict travel speeds, and research continues to support the hypothesis that such streets are not only slower (Swift, Painter, and Goldstein 2006; Hansen et al. 2007) but also safer (Noland 2000; Dumbaugh 2006). Many municipalities attempting to control vehicle speeds on local streets encourage narrower cross-sections with parking on both sides (Neighborhood Streets Project 2000). Local streets in Stapleton are generally designed for two-way traffic with on-street parking on both sides of the street. Such a cross-section, according to the City of Denver's regulations, requires a minimum of 30 feet (9.1 m) of width – 32 feet (9.8 m) on streets with three underground utilities – although some local streets in Stapleton are as wide as 38 feet (11.6 m). Similar collector streets would require a minimum curb-to-curb width of 38 feet, which is only 2 feet wider than what the ITE-CNU manual would recommend. Figure 6 depicts these cross-sections.

The context-zone approach, as recommended by the ITE-CNU manual, states the importance of considering, for example, the needs of the adjacent land uses when designing on-street parking. In the case of Beeler Street, a 38-foot-wide collector with a natural area on one side of the street and residential uses with required off-street parking on the other, the street typically has very low parking occupancy, and thus, excessive street space. This is not uncommon in Stapleton because most dwelling units possess at least one, if not two, off-street parking spaces. Infrequently occupied on-street parking has been shown by various researchers to be associated with higher vehicle speeds as well as higher crash rates; a curb-to-curb width closer to 24 feet seems to have the lowest crash rates in urban areas (Daisa and Peers 1997; Swift, Painter, and Goldstein 2006; Dumbaugh 2006; Marshall, Garrick, and Hansen 2008).

City of Denver regulations, based upon AASHTO guidelines, also specify a minimum 30-foot (9.1 m) curb radius at all arterial road intersections. While larger radii are linked to

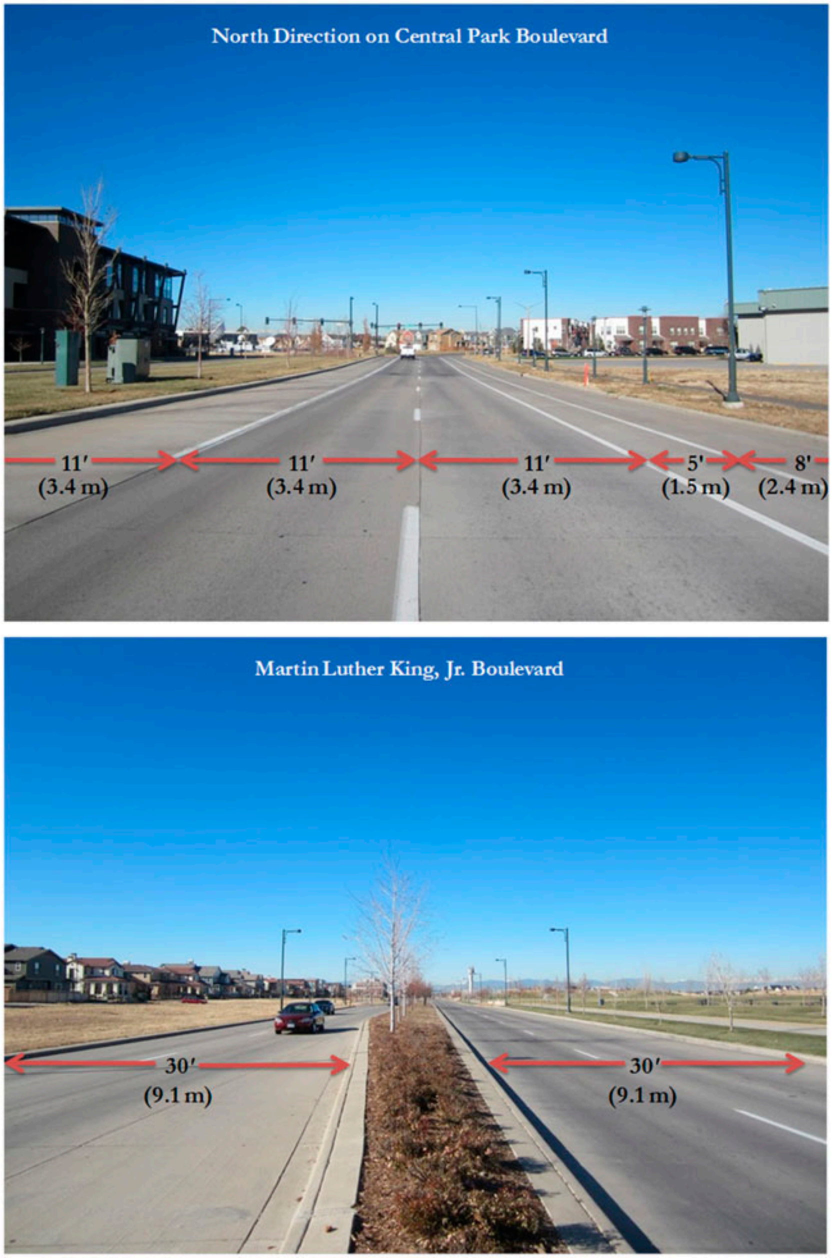

Figure 5. Stapleton's urban arterials.

an increase in vehicle speeds (AASHTO 2004) and an increase in pedestrian crossing distances (Sacramento Transportation and Air Quality Collaborative 2012), the larger issue is that engineers have no flexibility to use a smaller radius in situations where the arterial crosses a local street or, more critically, where on-street parking and/or bike lanes – in this case 8 feet (2.4 m) and 5 feet (1.5 m) wide, respectively – increase the effective turning radius. Figure 7 depicts an intersection along CPB where the effective radius is more than

Figure 6. Stapleton's local streets.

70 feet (21.2 m), even though the actual curb radius is 30 feet (9.1 m). Generally, a curb radius of 30 feet or more results in a "free-right" turn condition for passenger cars (Chellman 2000). An effective turning radius of 70 feet or more extends this "free-right" condition to larger vehicles and leads to an increase in vehicle speeds for smaller vehicles. The ITE-CNU manual stipulates curb turn radii of 10–30 feet for walkable thoroughfares

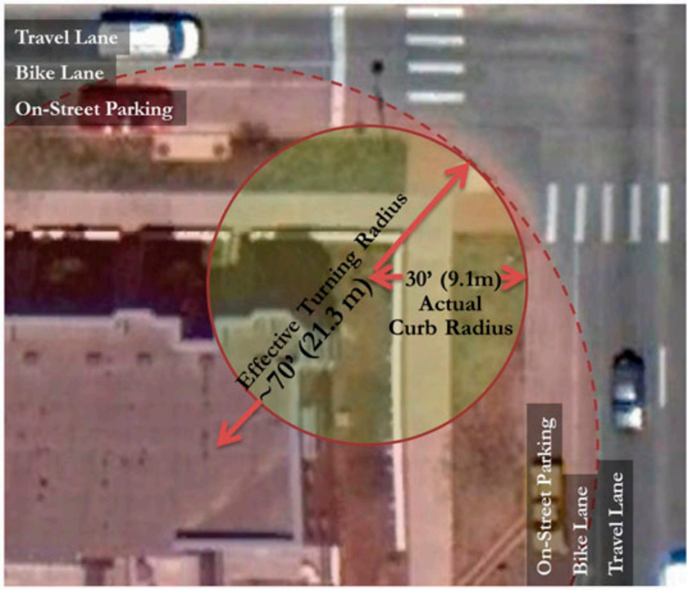

Figure 7. Required 30-foot (9.1 m) curb radius versus effective 70-foot (21.3 m) turning radius.

and 30–75 feet for vehicle-oriented thoroughfares (ITE and CNU 2010). Design guidelines from England deem "large curb radii" as anything larger than 23 feet (7.0 m) (Chellman 2000). Thus, the problem is not simply failing to properly consider the effective turning radius; the initial design value of a 30-foot curb radius is already excessively large.

The logic behind vehicle-oriented turn radii is to make sure that vehicles can turn quickly enough in their own lanes not to impede through traffic. Rather than ensuring in-lane turning, smaller curb radii encourage slower vehicle speeds and provide shorter pedestrian crossing distances. Well-informed design guidelines from the United States recommend designing curb radii to be as small as possible, typically 6 feet (1.8 m) to 15 feet (4.6 m) (FHWA 2006; Tumlin 2012).

Results

Vehicle speeds

The Stapleton Master Community Association collected vehicle speeds on streets throughout Stapleton with tube counters between 2007 and 2009. Table 1 displays the collected speeds for 11 representative street segments, which includes 4 arterial segments, 4 collector segments, and 3 local segments. Figure 8 depicts the street segments studied and identifies the percent of cars over the speed limit for each segment. In total, the data represent over 136,600 individual vehicle speed recordings that were collected across multiple 24-hour periods for each segment (speed data for each segment was typically collected for between 2 and 10 days, depending upon volumes). For that reason, the data represent not only free-flow traffic speeds but also vehicles slowing down for turning movements, congestion, parking, or any number of other reasons.

The first set of results shown in Table 1 are for MLK and CPB, arterials with posted speeds of 35 mph (56.3 km/h) and 30 mph (48.3 km/h), respectively. Despite the fact that the speed data included vehicles slowing for turns and so on, drivers were still over the

Table 1. Stapleton vehicle speed studies.

Arterials

Name: Martin Luther King Jr. Boulevard — Facility Type: Arterial
Description: 2-ways; 4 through lanes; parking one side — Posted Speed: 35 mph/56.3 kph
Curb-to-Curb: 30' (9.1 m) — % Over Limit: 18.1%

Speed (mph)	1-20	20-30	30-40	40-50	50-60	60-70	70+
Speed (kph)	1.6-32.2	32.2-48.3	48.3-64.4	64.4-80.5	80.5-96.6	96.6+	112.7+
Volume	1,406	3,079	5,749	686	24	1	2
% of Total	12.8%	28.1%	52.5%	6.3%	0.2%	0.0%	0.0%

Name: Central Park Boulevard — Facility Type: Arterial
Description: 2-ways; 4 through lanes; parking & bike lane both sides — Posted Speed: 30 mph/48.3 kph
Curb-to-Curb: 35' (10.7 m) in each direction (separated by median) — % Over Limit: 21.8%

Speed (mph)	1-20	20-30	30-40	40-50	50-60	60-70	70+
Speed (kph)	1.6-32.2	32.2-48.3	48.3-64.4	64.4-80.5	80.5-96.6	96.6+	112.7+
Volume	6,388	15,938	6,018	180	9	0	0
% of Total	22.4%	55.9%	21.1%	0.6%	0.0%	0.0%	0.0%

Name: 23rd Ave *(36' section)* — Facility Type: Arterial
Description: 2-ways; 2 through lanes; parking both sides — Posted Speed: 25 mph/40.2 kph
Curb-to-Curb: 36' (11.0 m) — % Over Limit: 19.2%

Speed (mph)	1-20	20-30	30-40	40-50	50-60	60-70	70+
Speed (kph)	1.6-32.2	32.2-48.3	48.3-64.4	64.4-80.5	80.5-96.6	96.6+	112.7+
Volume	2,508	7,258	779	10	0	0	0
% of Total	23.8%	68.8%	7.4%	0.1%	0.0%	0.0%	0.0%

Name: 23rd Ave *(40' section)* — Facility Type: Arterial
Description: 2-ways; 2 through lanes; parking both sides — Posted Speed: 25 mph/40.2 kph
Curb-to-Curb: 40' (12.2 m) — % Over Limit: 28.2%

Speed (mph)	1-20	20-30	30-40	40-50	50-60	60-70	70+
Speed (kph)	1.6-32.2	32.2-48.3	48.3-64.4	64.4-80.5	80.5-96.6	96.6+	112.7+
Volume	2,146	5,669	1,053	20	2	1	0
% of Total	24.1%	63.8%	11.8%	0.2%	0.0%	0.0%	0.0%

Collectors

Name: Beeler Street — Facility Type: Collector
Description: 2-ways; 2 through lanes; parking both sides — Posted Speed: 25 mph/40.2 kph
Curb-to-Curb: 38' (11.6 m) — % Over Limit: 63.9%

Speed (mph)	1-20	20-30	30-40	40-50	50-60	60-70	70+
Speed (kph)	1.6-32.2	32.2-48.3	48.3-64.4	64.4-80.5	80.5-96.6	96.6+	112.7+
Volume	780	3,619	2,235	40	2	0	0
% of Total	11.7%	54.2%	33.5%	0.6%	0.0%	0.0%	0.0%

Name: 26th Ave — Facility Type: Collector
Description: 2-ways; 2 through lanes; parking one side — Posted Speed: 25 mph/40.2 kph
Curb-to-Curb: 30' (9.1 m) — % Over Limit: 45.9%

Speed (mph)	1-20	20-30	30-40	40-50	50-60	60-70	70+
Speed (kph)	1.6-32.2	32.2-48.3	48.3-64.4	64.4-80.5	80.5-96.6	96.6+	112.7+
Volume	3,578	19,062	7,045	176	6	0	0
% of Total	12.0%	63.8%	23.6%	0.6%	0.0%	0.0%	0.0%

Name: Syracuse Street — Facility Type: Collector
Description: 1-way; 2 through lanes; parking both sides; bike lane — Posted Speed: 30 mph/48.3 kph
Curb-to-Curb: 43' (13.1 m) — % Over Limit: 44.1%

Speed (mph)	1-20	20-30	30-40	40-50	50-60	60-70	70+
Speed (kph)	1.6-32.2	32.2-48.3	48.3-64.4	64.4-80.5	80.5-96.6	96.6+	112.7+
Volume	328	3,668	3,103	43	2	0	0
% of Total	4.6%	51.3%	43.4%	0.6%	0.0%	0.0%	0.0%

Name: 35th Ave — Facility Type: Collector
Description: 2-ways; 2 through lanes; parking & bike lane both sides — Posted Speed: 25 mph/40.2 kph
Curb-to-Curb: 25' (7.6 m) in each direction (separated by median) — % Over Limit: 24.9%

Speed (mph)	1-20	20-30	30-40	40-50	50-60	60-70	70+
Speed (kph)	1.6-32.2	32.2-48.3	48.3-64.4	64.4-80.5	80.5-96.6	96.6+	112.7+
Volume	938	1,933	406	9	0	0	0
% of Total	28.5%	58.8%	12.4%	0.3%	0.0%	0.0%	0.0%

Locals

Name: Willow Street — Facility Type: Local
Description: 2-ways; 2 through lanes; parking both sides — Posted Speed: 25 mph/40.2 kph
Curb-to-Curb: 30' (9.1 m) — % Over Limit: 3.2%

Speed (mph)	1-20	20-30	30-40	40-50	50-60	60-70	70+
Speed (kph)	1.6-32.2	32.2-48.3	48.3-64.4	64.4-80.5	80.5-96.6	96.6+	112.7+
Volume	5,136	1,056	46	0	0	0	0
% of Total	82.3%	16.9%	0.7%	0.0%	0.0%	0.0%	0.0%

Name: Fulton Street — Facility Type: Local
Description: 2-ways; 2 through lanes; parking both sides — Posted Speed: 25 mph/40.2 kph
Curb-to-Curb: 38' (11.6 m) — % Over Limit: 18.0%

Speed (mph)	1-20	20-30	30-40	40-50	50-60	60-70	70+
Speed (kph)	1.6-32.2	32.2-48.3	48.3-64.4	64.4-80.5	80.5-96.6	96.6+	112.7+
Volume	435	653	81	0	0	0	0
% of Total	37.2%	55.9%	6.9%	0.0%	0.0%	0.0%	0.0%

Name: Havana Street — Facility Type: Local
Description: 1-way; 2 through lanes; parking both sides; bike lane — Posted Speed: 25 mph/40.2 kph
Curb-to-Curb: 40' (12.2 m) — % Over Limit: 29.9%

Speed (mph)	1-20	20-30	30-40	40-50	50-60	60-70	70+
Speed (kph)	1.6-32.2	32.2-48.3	48.3-64.4	64.4-80.5	80.5-96.6	96.6+	112.7+
Volume	8,295	11,411	3,504	85	0	0	0
% of Total	35.6%	49.0%	15.0%	0.4%	0.0%	0.0%	0.0%

speed limit in over 18% of cases on MLK and almost 22% of cases on CPB. Drivers were found exceeding 50 mph (80.5 km/h) on both roads, and multiple vehicles were also found to have exceeded 70 mph (112.7 km/h) on a 35 mph stretch of MLK. As described earlier, both roads are currently under capacity thanks to being designed with 2030 traffic volumes in mind; this conventional traffic engineering mindset probably contributes to the high speeds and to these roads becoming barriers between several neighborhoods within Stapleton (Barr 2011).

The other arterial investigated was 23rd Avenue, a primarily residential street that transitions from a 36-foot cross-section to a 40-foot cross-section. In the 36-foot case, approximately 19% of vehicles were exceeding the 25 mph limit, and in the 40-foot case, over 28% of vehicles were. The highest speeds seen on this stretch of 23rd Avenue, where the speed limit is 25 mph, were over 50 mph.

The next four examples in Table 1 are collector streets, primarily along residential stretches, with posted speed limits of 25 mph on all but Syracuse Street, which is marked as 30 mph. Beeler Street varies in terms of width and on-street parking, but the stretch where speeds were collected is a 38-foot (11.6 m) cross-section with on-street parking on both sides. Over 63% of drivers exceeded the speed limit on Beeler, with some vehicles surpassing 50 mph. Similar results were found along 26th Avenue, which is a 30-foot (9.1 m) cross-section with two-way traffic but only one parking lane. A raised median divides 35th Avenue, varying in width from as little as 4 feet to over 150 feet. As a result, it

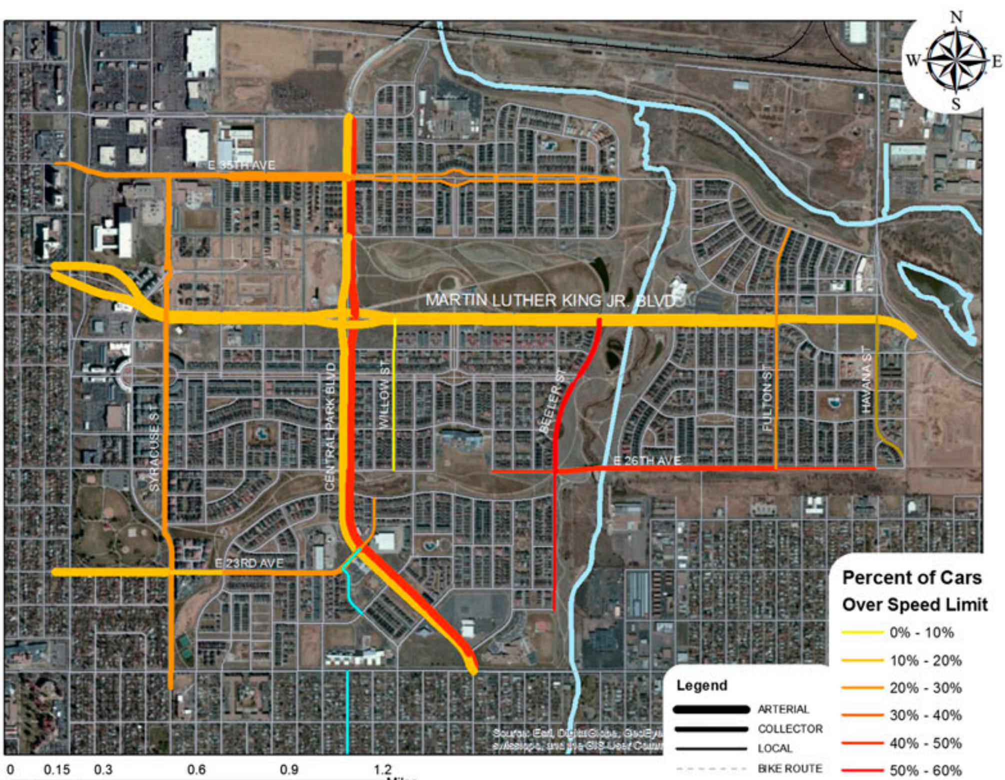

Figure 8. Stapleton speed study: percent of cars over the speed limit.

functions akin to a pair of one-way streets. The curb-to-curb width in each direction is 25 feet (7.6 m), which includes one travel lane, a parking lane, and a bike lane. Almost 25% of vehicles on 35th Avenue exceeded the 25 mph speed limit. Syracuse Street is a one-way paired with Roslyn Street. With two lanes of through traffic on each street, the segments also include parking on both sides and a bike lane, for a total curb-to-curb width of 45 feet (13.1 m). Despite relatively high on-street parking occupancy as compared to other streets within Stapleton (due to a high number of apartment complexes in close proximity), over 44% of vehicles exceeded the 30 mph speed limit, and many cars traveling over 50 mph were observed.

The other three examples represent local streets along residential stretches, all with posted speed limits of 25 mph. The portion of Havana Street where the data were collected is designed similarly to the collector Syracuse Street but fits the same traveled-way elements (two through lanes, a bike lane, and on-street parking on both sides) into a cross-section 5 feet narrower. With a posted speed of 25 mph, as opposed to the 30 mph speed limit on Syracuse, approximately 30% of drivers exceed the limit. The other two local streets both have two-way traffic and on-street parking on both sides. Fulton Street does this with a 38-foot (11.6 m) curb-to-curb distance, while Willow Street is only 30 feet (9.1 m) wide. On Fulton Street, 18% of drivers exceed the speed limit, while only 3% do on much narrower Willow Street.

Studies by other researchers suggest that a pedestrian hit by a vehicle at 20 mph (32.2 km/h) has a 5% risk of fatality; at 30 mph (48.3 km/h), a 45% risk; and at 40 mph (64.4 km/h), an 85% risk (Leaf and Preusser 1999). Not surprisingly, vehicle speeds have been shown to be significant not only in terms of road safety but also in terms of the perception of safety – both of which are extremely important in terms of user behavior and mode-choice decisions.

Mode choice

The 2009-2010 Front Range Travel Survey (FRTS) is an in-depth household travel survey conducted decennially through the efforts of the four Metropolitan Planning Organizations (MPOs) along Colorado's Front Range in cooperation with the state DOT, the regional transit provider, and Federal Highway Administration. With approximately 12,000 households across the Denver metropolitan area involved, it is the most comprehensive source of travel data available for the region. Figure 9 depicts a spatially interpolated raster image highlighting the probability that an individual walks or bikes to work based upon their residence location. In this image, the darker the color, the more likely it is that a resident of that neighborhood uses active transportation.

In terms of expectations, regional trends and the existing literature both suggest that driving would be the prevalent mode of journey to work in Stapleton. The 2010 American Community Survey estimates that 3.9% of Denver workers walk to work, 2.2% commute by bicycle, and 6.2% take transit to work (ACS 2010). In terms of both walking and transit, the FRTS-reported work-mode shares for Stapleton lag behind this estimate for the City of Denver, with 97.7% of residents driving to work in Stapleton (or 92.0% driving when considering all trips, as displayed in Table 2).

As part of the FRTS, the City and County of Denver funded an oversampling of selected mixed-use neighborhoods. In addition to Stapleton, the oversampling included Lowry, another New Urbanist neighborhood, as well as three older, more established neighborhoods: Cherry Creek, East Colfax, and the Highlands. Because mode choice can be so contextually specific, I compare the Stapleton results with these other Denver-area

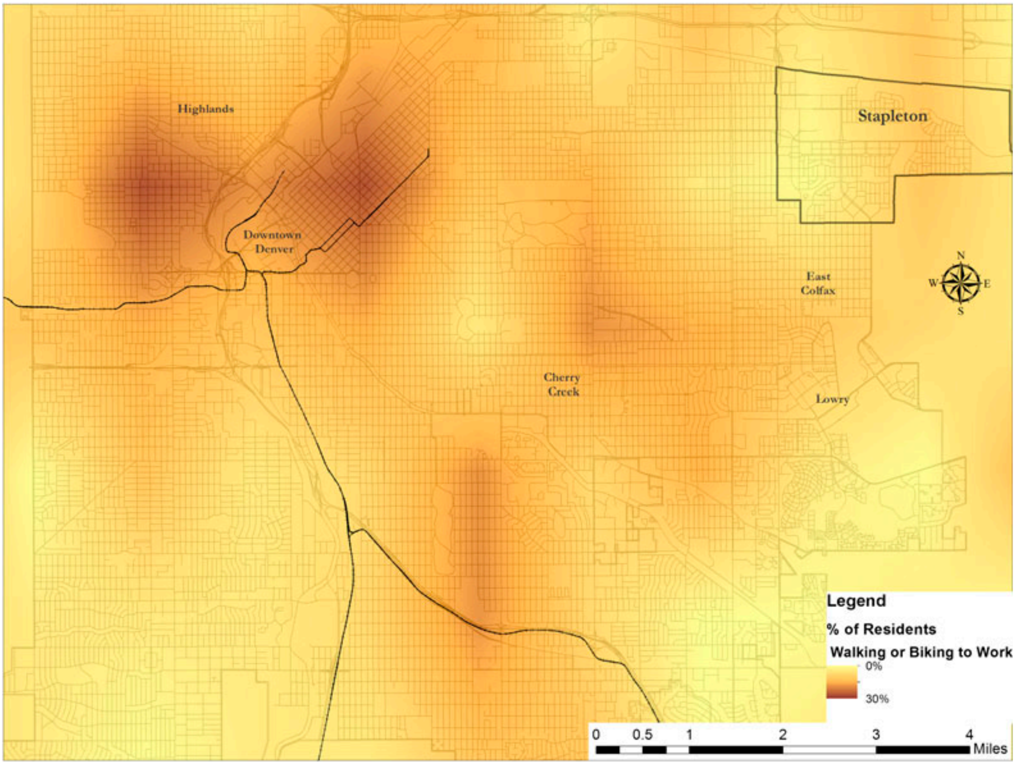

Figure 9. Front Range Travel Survey journey-to-work mode choice results.

neighborhoods (also indicated in Figure 9). The benefit of comparing Stapleton with such peer neighborhoods is to provide additional context for the travel behavior results. For example, the non-driving travel mode shares for a community might be considered successful in a completely auto-dependent region; the same numbers might be considered a failure in a place like the Netherlands. Table 2 further details the results of the FRTS, combining both work and non-work travel, as well as data on other factors relevant to mode choice.

Overall, both Stapleton and Lowry, the two New Urbanist communities studied, are lagging behind all three of the older urban neighborhoods in terms of walking, biking, and transit mode shares. While it is expected that transit usage for Stapleton residents will increase once the commuter-line rail between the central business district and the new airport is completed in 2016, the high reliance on driving and the associated walking and biking mode shares for Stapleton are still somewhat unexpected. However, as discussed previously, travel can be influenced by a number of mitigating factors (Heinen, van Wee, and Maat 2010). For instance, the two New Urbanist communities are located slightly further from the central business district than the older urban peer neighborhoods. Based upon that finding, the hypothesis might be that residents of Stapleton and Lowry travel greater distances to work than those in the older urban communities; however, there is no statistically significant difference in distance traveled to work of residents across the five study neighborhoods (based upon a *t*-test at 95% C.I.). Residents of the Highlands and Stapleton average just over 6.6 miles (10.6 km), while Cherry Creek, East Colfax, and

Table 2. Front Range Travel Survey journey-to-work mode choice results.

		New Urbanist		Traditional Urban Neighborhoods		
		Stapleton	Lowry	Highlands	East Colfax	Cherry Creek
General US Census Data	Total Population	13,948	8,000	8,429	10,191	6,905
	% Population Under 18	25.20%	25.00%	15.40%	25.50%	17.40%
	# Housing Units	4,338	4,066	4,683	4,618	3,519
	Average HH Income	$41,600	$69,034	$39,568	$37,010	$109,786
	% Population non-Latino White	69.70%	73.80%	57.40%	32.40%	92.1
	African American	10%	9.80%	1.90%	24.30%	0.40%
	Latino	12.90%	9.90%	37.30%	27.70%	4.30%
	Native American	0.60%	0.30%	0.60%	0.80%	0.10%
	Asian/Pacific Islander	3.70%	3.40%	1.40%	11.30%	1.70%
Front Range Travel Survey Data (all trips)	**% Walk**	2.3%	7.4%	11.7%	12.6%	16.7%
	% Bike	2.3%	0.0%	3.4%	12.6%	3.2%
	% Bus	3.4%	1.9%	6.9%	8.4%	4.8%
	% Light Rail	0.0%	0.0%	0.7%	70.0%	3.2%
	% Drive	92.0%	90.7%	77.2%	65.7%	72.2%
	Household Size	3.27	2.93	2.64	1.97	2.36
	Tenure (years)	3.32	3.62	4.13	3.62	4.23
	Average Age	46.90	49.90	48.70	50.50	55.80
	Distance to Work (miles)	6.69	5.60	6.63	5.30	5.35
	Daily Household Trips	12.58	11.46	11.50	8.87	10.69
	Household Vehicles	1.93	2.03	2.05	1.72	2.19
	Household Bikes	2.93	2.01	2.07	1.44	2.36
	Free Parking at Work (0, 1)	0.75	0.79	0.80	0.72	0.80
	Transit Pass (0, 1)	0.10	0.13	0.16	0.17	0.13
Additional Information	Approximate Distance to CBD (miles)	4.5 - 7.0	5.0 - 8.0	1.0 - 3.5	0.5 - 2.5	2.0 - 4.5
	Intersection Density (per sq. mile)	155	131	159	125	182
	Average Block Length (ft)	404	440	436	499	390
	Walkscore (out of 100)	29	42	77	89	86
	Transit Score	44	40	63	80	49
	Average # Transfers to reach CBD	2	2	0 - 1	0 - 1	2

Lowry are all in the 5.3–5.6-mile (8.5–9.0 km) range. Since distance to work does not adequately explain the differences in travel behavior outcomes, it would not be particularly surprising to find that residents of the New Urbanist communities are working in areas outside of the central business district, and thus have greater access to free parking at work, which could also contribute to greater driving mode shares. Interestingly, this hypothesis is also false, with access to free parking at work not being statistically different for residents surveyed in these five neighborhoods.

Since regional accessibility and parking are not shedding much light on why Stapleton residents drive at a higher rate than the comparison neighborhoods, other factors that might mitigate our expectations for the built environment of Stapleton to influence mode choice relate to socio-demographic and socio-economic differences. In terms of age of survey respondents, only Cherry Creek differs significantly from the other four neighborhoods, trending slightly higher. Income is a factor typically associated with increased overall travel (Winters et al. 2010) and decreased bicycling (Xing, Handy, and Mokhtarian 2010). Household income is highest for Cherry Creek, the old urban neighborhood furthest from downtown, followed by Lowry, the other New Urbanist neighborhood. Income for Stapleton is also statistically significantly higher than for the other two older urban neighborhoods, but the income levels for these three neighborhoods still appear reasonably comparable.

While commute distances, availability of free parking, socio-demographics, and socio-economic differences are not particularly illuminating in terms of explaining the mode-share outcomes, site visits to these neighborhoods suggest another possible factor: the character of the mixed-use areas. For instance, the majority of the commercial, retail, and restaurant uses for Stapleton and Lowry are concentrated in certain zones (such as within their respective town centers), which contrasts with the three older urban neighborhoods, where such land uses tend to proliferate beyond the major commercial zones. The older neighborhoods also tend to possess a more diverse and eclectic mix, while Stapleton and Lowry tend toward a higher percentage of national chains and franchises. Given the existing data, it is difficult to point to these qualitative land-use dissimilarities as explanatory; however, they perhaps tell a part of the Stapleton story that contributes to the travel behavior differences among these neighborhoods.

Given the inability to attribute the relatively high driving and low walking and bicycling for Stapleton to specific mitigating factors, it seems fair to consider saying the following at this point in the development of Stapleton: (1) the results are indeed discouraging; (2) there is room for improvement; and (3) more needs to be done to better accommodate and promote walking, biking, and transit trips.

Discussion

In an interview with the author in 2012, Peter Park, planning director for the City and County of Denver from 2003 to 2011, stated that one of the largest obstacles that Stapleton would have to overcome in the future was the impermanence of any New Urbanist reforms in the city's traffic engineering regulations. In other words, Park stated that it was not uncommon for developers to receive variances on a project-by-project basis allowing them to design a road with, for instance, a smaller curb turn radius than the city's regulations stipulate. From Park's perspective, the problems with such a variance were two-fold: (1) any future changes to the road would come under the scrutiny of the city's standards once again, but without the voice of the New Urbanist designers; and (2) such provisional variances cannot have any sort of systematic effect. In contrast, a city that embraces the New Urbanist ideals and changes its laws to reflect such standards would not have to withstand potential design compromises and thus have a better probability at enduring success.

This sustainability concern of New Urbanist designs that Park underscores surfaced with some of the recent alterations to Stapleton's transportation system. In December 2010, a near-term pregnant woman was run over in a hit-and-run crash at a stop-controlled intersection along CPB near 29th Avenue. The woman survived, but tragically, the baby did not. Although there were significant resident concerns regarding traffic safety prior to this incident, this heartbreaking event sparked a number of stakeholders toward trying to improve the many problematic streets in Stapleton that seem to be inherently designed for high speeds. But rather than address some of the systematic issues described in this article, the city of Denver stated that the intersection did not meet city standards and reviewed three traffic-control options for replacing the stop signs at the intersection where the crash occurred:

- Installing a traffic signal.
- Installing a two-lane modern roundabout.
- Closing the median on CPB across 29th Avenue.

Given this limited subset of alternatives, the City determined that a traffic signal was the only viable option. A two-lane roundabout was too costly, given right-of-way requirements; reducing the road to one lane was deemed out of the question, given future traffic projections; and closing the median on CPB would impact traffic on parallel routes, particularly given the fact that the median across 26th Avenue was previously closed in an effort to limit high-speed through traffic on that residential street. Once residents learned that the city of Denver was proceeding with the traffic-signal option, a community group organized a petition and received over 400 signatures asking the city to hold off on the traffic signal until a broader safety analysis could be conducted (Houtsma 2011).

Given the current configuration and the known speed issues along CPB, the research suggests that a traffic signal in a location that was likely to be green most of the time would promote higher vehicle speeds, transform these streets into greater neighborhood barriers, and could result in less safe conditions. The traffic-calming literature indicates that traffic signals do not help control speed; rather, they can lead to an increase in mid-block speeds as drivers try to make up for lost time (Ewing 1999). In a safety study of stop signs that were converted to traffic signals in New York City following political pressure, crashes rose by 65% (Sandler et al. 1989). Moreover, in answering the question "Does a traffic signal control speed?" the New York City Department of Transportation website states (see also Kazis 2011):

> No. In some areas where speeding is a problem, residents believe that a traffic signal is needed to address the speeding problem. In fact, traffic signals sometimes result in greater speeds as drivers accelerate to try to get through the signal before it turns red.

Prior to the public meeting, the City of Denver initiated construction of the traffic signal, a \$100,000 project, by tearing out the 50-foot-by-50-foot (15.2 m by 15.2 m) landscaped median. The stance of the city was that their engineers had exhausted all available options and that a traffic signal was the only feasible one given the traffic demand warrants, which were erroneously described as "required by federal standards" (Public Meeting 2011).

Rather than taking a systematic look at solving the transportation issues through network and street designs that help regulate speeds, the city focused on Band-Aid solutions – such as promising better police enforcement – that ignored the roots of these problem. One officer at a public meeting described CPB as a "smooth, flat, wide-open thoroughfare perfect for speeding, which is why they patrol it as much as they can" despite the fact that Denver currently only has seven officers dedicated to such duties across the entire city (Public Meeting 2011). Another response to some of the problematic streets in Stapleton was the decision of Denver Public Schools to provide buses for students that have to cross CPB, even though they do not meet the minimum distance typically required to be eligible for a bus (Barr 2011). In an interview on Colorado Public Radio, one Stapleton mother

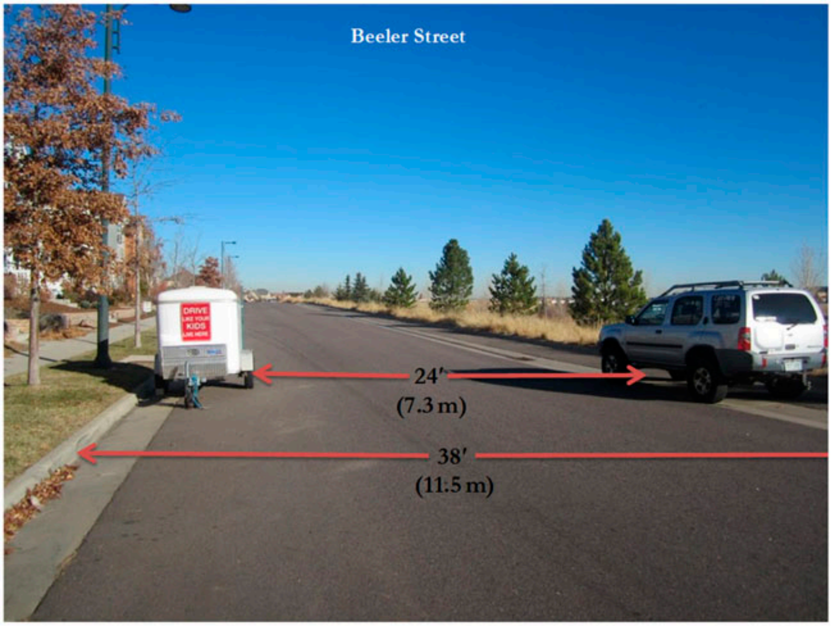

Figure 10. Ad hoc traffic calming along Beeler Street.

reported that she walks her children “about eight blocks to the east to catch the bus” even though “the school is eight blocks west” (Barr 2011). If such a case exists in any New Urbanist community, then it is impossible to declare that place a success.

Conclusion

So, what can we learn from Stapleton? To begin with, Stapleton serves as a reminder that the transportation design ideals of a New Urbanist community can be compromised by conventional traffic engineering standards (Calthorpe 2012). As a result, Stapleton does not exhibit all of the qualities documented in the New Urbanist literature with respect to street network and street design, despite its picturesque New Urban appearance. The products of this combination, with respect to Stapleton’s current incarnation, are: (1) higher-than-desired vehicle speeds on streets of every type; and (2) higher driving mode shares and less walking, biking, and transit use than peer neighborhoods in the region.

To say that Stapleton is not a significant accomplishment over conventional suburban development would be overly critical; however, Stapleton certainly has room for improvement. While research suggests that there are design solutions that would address both the needs of the community and continue to serve regional mobility in a situation such as Stapleton, the difficulty is that such changes are difficult to implement, both politically and economically, after a community has already been built. The economic issues essentially relate to the cost of such wholesale changes, while the political issues refer to both the economic issues as well as, for example, the typical objections faced when trying to add a through connection to a heretofore unconnected street. While not impossible, trying to fix such design compromises after the fact can be problematic.

Hence, one lesson to be learned from this evaluation of Stapleton is that every effort should be made to implement New Urbanist–informed designs in the initial incarnation of a new community. With respect to multi-phase projects and good design standing the test of time, another lesson derived from this research is the importance of codifying the work, as opposed to obtaining an occasional regulations variance. A third take-home has to do with trying to implement New Urbanism via conventional planning approaches. In this case, the system was designed using the functional classification system in conjunction with a "predict and provide" approach rather than the context-zone approach recommended by the ITE-CNU manual, which would probably facilitate a built environment more in tune with New Urbanist ideals.

New Urbanism seems to require an amalgamation of factors working together to achieve the anticipated transportation and transportation-behavior benefits. Systematic network-level and street-design issues are difficult to overcome, which leaves many communities applying Band-Aid solutions. To really put a community such as Stapleton back on the path toward realizing the original vision set out for it of a convenient, safe, and comfortable transportation system for all road users, there needs to be a shift in the mindset of the many interest groups involved in such projects. To paraphrase Dan Burden's assessment of Stapleton's predicament: we need to focus more on community building, rather than capacity building (personal communication, 2011). Focusing on community goals, such as those set forth in the original Stapleton vision and the associated New Urbanist documentation, and looking for ways to better understand the disconnects between New Urbanist transportation design ideals and conventional engineering solutions – and the insidious implications of those disconnects – will go a long way toward ridding ourselves of the unsafe streets that are beginning to permeate not just Stapleton but other large-scale New Urbanist developments as well. On the other hand, we could also follow the tactical urbanism lead of one Stapleton resident (see Figure 10), who persistently reduces the effective width of Beeler Street, where more than 63% of drivers are speeding, from 38 feet (11.6 m) to 24 feet (7.3 m) by parking his truck on one side of the street – almost 4 feet (1.2 m) from the curb – and on the other side, a trailer with a sign that reads: "Drive like your kids live here."

Notes on contributor

Dr. Wesley E. Marshall is an assistant professor of civil engineering and affiliate faculty in urban and regional planning at the University of Colorado Denver, program director of the University Transportation Center through the Mountain Plains Consortium, and co-director of the Active Communities/Transportation (ACT) research group. He received his professional engineering license in 2003 and focuses on transportation teaching and research dedicated to creating more livable and sustainable urban infrastructures, particularly in terms of road safety, active transportation, and transit. Other recent teaching and research topics include transportation planning and land-use modeling, parking, health, and street networks. Having spent time in the private sector with Sasaki Associates and Clough, Harbour & Associates, he has been working on planning and site-design issues related to civil and transportation engineering for the last 15 years. A native of Watertown, Massachusetts, Dr Marshall is a graduate of the University of Virginia and the University of Connecticut, a recipient of the Dwight David Eisenhower Transportation Fellowship, and winner of the Transportation Research Board's Charley V. Wootan Award for outstanding paper in the field of policy and organization.

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