Smart Transportation for All? A Typology of Recent U.S. Smart Transportation Projects in Midsized Cities

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Greater integration of advanced vehicle technologies is commonly discussed as a component of developing smart cities, potentially leading to a host of benefits. Final impacts of such benefits are uncertain, though, given research that illustrates induced travel by initial adopters of emerging vehicle technologies and services and mixed effects in transit use and active transportation. The locations within cities where interventions of advanced vehicle technologies are envisioned, geographic scope and extent of integration, and the characteristics of these areas are all likely to influence these effects, and these relationships have received limited investigative attention. To address this, we conducted a comprehensive review of proposals submitted by 78 midsized cities in the United States to create a typology that considers (1) the geographic scope of intervention and (2) the degree of integration of connected and automated vehicles, generating five distinct types of projects. Characteristics of the areas within cities identified for intervention are compared to those of their U.S. Metropolitan Statistical Area (MSA). We identified indicators of comprehensive planning efforts as they relate to sustainability and resilience outcomes in each city. Results show that areas identified by cities for advanced vehicle technology interventions differ in important ways from each city's broader population that warrant attention relative to known demographic characteristics and behavior of early adopters of transportation technologies. There is also variation in project motivation and municipal planning indicators across typology classifications. These are essential considerations as smart city–aligned transportation interventions continue to develop. *Key Words: automated vehicle, connected vehicle, smart city, typology.*

先进车辆技术的近一步整合，被普遍认为是发展智慧城市的构成要素，并具有潜力产生大量益处。但有鉴于描绘早期採用新兴车辆技术与服务者所引发的旅次之研究，以及在运输使用和主动运输中的混合效应，此般益处的最终影响却是不确定的。城市中先进车辆技术预期介入的地点、整合的地理范围与程度，以及这些区域的特徵，皆有可能影响上述效应，但这些关系却仅获得有限的研究关注。为了应对此一问题，我们对美国七十八座中型城市所提出的计画进行综合性的回顾，以创造能考量以下面向的类型学：（1）介入的地理范畴，以及（2）连结和自动化车辆的整合程度，并生产五大区别的计画类型。我们将城市中指认进行介入的区域特徵和其于美国大都会统计区（MSA）中的特徵进行比较。我们指认综合规划的指标，它们关乎每个城市的可持续性和回復力结果。研究结果显示，城市为先进车辆技术介入指认的地区，以重要的方式不同于各自城市的广泛人口，因而需要关注已知人口特徵和运输科技早期採用者的行为。该计画动机和市政规划指标，亦在类型学的区分上有所差别。随着与智慧城市紧密合作的运输介入持续发展，这些皆为关键的考量。*关键词：自动化车辆，连结车辆，智慧城市，类型学。*

Una integración más amplia de tecnologías avanzadas para vehículos comúnmente se discute como un componente para el desarrollo de ciudades inteligentes, que potencialmente conducen a una multitud de beneficios. Sin embargo, son inciertos los impactos finales de tales ventajas, dada la investigación que ilustra el viaje inducido por los adoptantes iniciales de tecnologías emergentes y servicios para vehículos, y los efectos mixtos por el uso del tránsito y el transporte activo. Los sitios urbanos donde se prevén intervenciones de tecnologías vehiculares avanzadas, el alcance geográfico y extensión de la integración, y las características de estas áreas, probablemente influirán estos efectos; y estas relaciones han recibido atención

Annals of the American Association of Geographers, 110(2) 2020, pp. 547–558 © 2019 by American Association of Geographers
Initial submission, December 2018; revised submissions, April and May 2019; final acceptance, May 2019
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Published by Taylor & Francis, LLC.

investigativa limitada. Para abocar esta situación, adelantamos una exhaustiva revisión de las propuestas presentadas por 78 ciudades de mediano tamaño en los Estados Unidos, con el propósito de crear una tipología que considere (1) el alcance geográfico de la intervención, y (2) el grado de integración de vehículos conectados y automatizados, generando cinco tipos distintos de proyectos. Luego se compararon las características de las áreas dentro de las ciudades seleccionadas para intervención con las de su Área Estadística Metropolitana americana (MSA). Se identificaron indicadores de los esfuerzos de planificación comprensivos en cuanto se relacionan con sustentabilidad y resultados resilientes en cada ciudad. Los descubrimientos muestran que las áreas identificadas por las ciudades para intervenciones avanzadas de tecnología vehicular difieren de modo importante de la población más grande de cada ciudad que justifique una relativa atención a las características demográficas y comportamentales conocidas de adoptantes pioneros de las tecnologías de transporte. Hay también variación en la motivación del proyecto y los indicadores de planificación municipal a través de las clasificaciones de la tipología. Estas son las consideraciones esenciales en la medida en que las intervenciones al transporte de la ciudad inteligente alineada sigan su proceso de desarrollo. *Palabras clave: ciudad inteligente, tipología, vehículo automatizado, vehículo conectado.*

Smart city initiatives are continuing to develop around the world. Generally, these plans aim to develop sociotechnical systems that rely on investments in information and communications technology (ICT), data sharing strategies, and strong collaborations between agencies and companies that aim to improve the quality of life for urban residents (Hollands 2008; Caragliu, Del Bo, and Nijkamp 2011; Damiani, Kowalczyk, and Parr 2017). Beyond investments in technology and infrastructure, the importance of including human and social capital in smart city development is considered essential to effective creation of sustainable and equitable urban environments (Paskaleva 2011; Schuurman et al. 2012; Angelidou 2014). These efforts are evolving in tandem with those of municipal urban planning agencies. In the past twenty years, comprehensive planning has been profoundly influenced by sustainability and resilience philosophies that emphasize a holistic balance among economic, environmental, and social equity concerns. Many municipalities have created city-wide sustainability or resilience plans intended to provide an overarching framework to guide other planning efforts. Because more traditional comprehensive plans already tend to include economic and environmental components, this sea change in municipal planning has explicitly focused on social equity outcomes when devising planning goals—an essential consideration in smart city planning as well. Meanwhile, transportation systems, particularly those framed as "smart mobility," are receiving more attention as a means to address sustainability and resilience-oriented objectives (Ben Letaifa 2015; Benevolo, Dameri, and D'Auria 2016).

This is an important moment, then, to critically examine how cities are planning to deploy and integrate emerging vehicle technologies as part of smart city planning efforts, given the recent developments in connected and/or automated vehicle (C/AV) technologies. At present, personal vehicle travel and its supporting ecosystem have contributed to well-known issues that stand in opposition to sustainable urban development, leading some to call for a dramatic shift in how transportation systems operate, primarily through greater C/AV integration (e.g., Sperling 2018). It is uncertain, though, that such a shift and its associated projected benefits will be realized, in part due to uncertainties in public use and adoption of these technologies. Indeed, some initial studies of early users of ride-hailing services that closely mirror how people would travel via popularly discussed smart mobility vehicle-based modes suggest that users travel more often and substitute trips previously made by transit, bicycling, or walking (Rayle et al. 2016; Clewlow and Mishra 2017).

As cities strive to meet sustainability and resilience goals in this changing landscape that might include the introduction of C/AVs in some way, understanding the spatial characteristics of projects, potential affected populations, and degree of reliance on C/AVs in future plans is important to consider. Our research, then, uses a recent nationwide set of proposals developed by seventy-eight midsized cities that participated in the U.S. Department of Transportation's (USDOT) Smart City Challenge (USDOT 2016). We primarily consider where within cities projects are proposed and how they propose to integrate C/AVs to construct a typology that explicitly considers the following dimensions: (1) the geographic scope and extent of the intervention proposed and (2) the degree of proposed integration of C/AVs. After classifying projects along these two dimensions, we then consider how the following vary across project type: (1) similarity or dissimilarity of neighborhood characteristics relative to the rest of the U.S. Metropolitan Statistical Area (MSA) that relate to known early transportation technology adopter profiles in the literature, (2) evidence of coordinated municipal sustainability and resilience planning in proposals put forward by the seventy-eight midsized cities, and (3) project equity motivations.

This effort helps to provide a comprehensive insight into how midsized cities across the country are considering introducing new vehicle technologies and services that align with smart city objectives, equity concerns, and sustainability and resilience outcomes.

Background

There is growing optimism that integration of disruptive transportation technologies and services will help address a number of issues in the present-day transportation sector, leading to more sustainable and resilient urban futures, particularly in the vision for a future where shared, automated, electric vehicles are central to urban transportation systems (Fulton, Mason, and Meroux 2017; Sperling 2018). Some expect that such a future could enhance mobility and accessibility for many and reduce total urban vehicle travel, reallocate urban space occupied by parking garages and streets, and lower total emissions from the transportation sector (Greenblatt and Shaheen 2015; Zhang et al. 2015). There is uncertainty, however, about the comprehensive nature of projected benefits (Fagnant and Kockelman 2014; Thomopoulos and Givoni 2015; Wadud, MacKenzie, and Leiby 2016), which are contingent on public consideration, adoption, and wide use of these technologies across diverse populations and urban areas (Cohen, Jones, and Cavoli 2017).

There is also extensive research demonstrating that early adopters of new transportation technologies and services are distinct from the general population in ways that are worth examining in this changing landscape. Early adopters of alternative fuel vehicles (AFVs) tend to be predominantly wealthier, well-educated people living in multicar households with longer commutes, more proenvironmental ideals, and an awareness of how their lifestyle is compatible with changes necessary to adopt an AFV (Sangkapichai and Saphores 2009; Ziegler 2012; Lane et al. 2018). There is more limited understanding of early adopters of C/AVs, because these vehicles and their supporting infrastructure have only begun to be integrated into existing transportation systems. Recent studies, however, have found that stated willingness to adopt and use them tends to be concentrated in the higher income, technologically savvy, male, younger segments of the population who live in denser urban areas (Bansal, Kockelman, and Singh 2016; Hulse, Xie, and Galea 2018). Additionally, initial users of on-demand ride-hailing services—which closely resemble the ways in which people would access future C/AVs on a shared, as-needed basis—are predominantly younger, male, higher educated people living in dense urban areas and, important for longer term sustainability goals, many users substitute trips previously made by transit, biking, or walking while inducing travel (Rayle et al. 2016; Clewlow and Mishra 2017). Taken together, these findings suggest that there are common sociodemographic and socioeconomic characteristics among transportation technology adopters that are essential to consider when recommending new vehicle technologies as a component of smart cities.

At present, though, ride-hailing use nationwide is far from ubiquitous, with much of it concentrated in a few select major urban areas and, important for this research, within certain parts of those cities, leading some to note that introducing new transportation technologies such as C/AVs will face spatial barriers to widespread adoption (Celsor and Millard-Ball 2007; Clewlow 2016; Dias et al. 2017; Litman 2017). This suggests that a geographical assessment of proposed smart city–related transportation interventions is a priority consideration when examining proposed benefits to local populations and municipal sustainability and resilience goals and that attention should be devoted to the kinds of areas being recommended for C/AV integration. Given the rapid market growth in emerging transportation technologies and services, the wide range of uncertain outcomes regarding the introduction of C/AVs and their role in sustainable transportation futures, and the central role that such technologies might play in a number of proposed smart city efforts, this is a crucial area of research focus.

Further confounding the issue is that proposed smart city–related transportation interventions vary in scale, scope, and mode, and there have been only limited efforts to classify them in a generalizable way (Haynes 2018). Typologies have been developed to help clarify municipal operations, governance, citizen services, and scenario planning for developing smart cities (e.g., Batty et al. 2012; Anthopoulos and Fitsilis 2013; Lee and Lee 2014), although these are not focused on the geographic nature of proposed transportation interventions. Nam and Pardo (2011) developed a typology of smart cities along the dimensions of technology, people, and institutions, although transportation is only one component of smart cities considered. These typologies provide a useful framework for constructing one focused on advanced vehicle technologies in smart cities.

Proposal Data

We reviewed all seventy-eight proposals submitted to the USDOT Smart City Challenge in 2015, which included submissions from cities with populations between 200,000 and 850,000 as of the 2010 U.S. Census (USDOT 2016). These data have been made available to the public and represent a comprehensive and recent assessment of how midsized cities across the country are considering transportation-related technological interventions that align with smart city efforts. Each proposal was crafted to align with solicitation requirements that included twelve so-called vision elements, including "connected vehicles" and "urban automation," and cities could elect to address some or all of these elements in their proposals. Although the two aforementioned vision elements certainly helped shape the nature of the submissions as they relate to C/AV integration, cities were free to identify local issues that could be addressed with an intervention, coordinate with municipal planning actors and efforts as they saw fit, and identify locations within their municipal boundaries that warranted an intervention.

Typology Framework

Our typology first considers two primary dimensions: geographic extent and scope of the proposed intervention and degree of integration of C/AVs. This identification of primary themes as the core of the typology is similar in structure to those applied by previous efforts that focused on emerging topics (e.g., Nam and Pardo 2011; Malek, Maine, and McCarthy 2014). The key dimensions of the typology reflect how cities chose to address the following: (1) where within cities transportation-related interventions were planned and (2) how cities considered introducing C/AVs in their proposals. Each of the seventy-eight proposals was then categorized based on its location along these dimensions (Figure 1). For the geographic dimension, we identify the degree to which cities propose to concentrate their interventions in a specific area or disperse them throughout the city. For the vehicle technology dimension, we consider whether or not cities propose to introduce C/AVs into their transportation systems. Using this framework, five distinct classifications of projects emerged: concentrated C/AVs, zones of C/AV integration, mobility hubs, infrastructure first, and transit. The first three include clear plans for C/AV deployment and have a distinct geographic extent and scope of integration, whereas the other two lack one of these criteria.

First, transit projects are those that do not center on the introduction of C/AVs but do identify a clear geographic location for the project. Infrastructure first projects are the reverse case: They are proposed by cities that do not identify a targeted geographic area within the city to include new transportation technologies but instead focus on investment in a distributed, connected, city-wide network of sensors, smart signals, fiber, or other cyberinfrastructure that can eventually support C/AV travel. Generally, these projects are framed as investments in technological capability, and intervention area designations will follow at a later time. We focus next on the three classifications that include C/AV integration and clear geographic specificity.

Concentrated C/AV projects are those that recommend new vehicle technology integration along fixed routes and corridors. Examples included automating existing or planned shuttle or circulator routes, transitioning existing vehicles on dedicated routes into C/AVs, or developing "smart" corridors along clearly identified arterials or highways. Projects with zones of C/AV integration clearly identify an area on a map for C/AV deployment. Within such zones, vehicles would not be restricted only to fixed routes but to flexible travel in the identified area. Proposals in this category often label these zones as demonstration areas or a similar term and favor on-

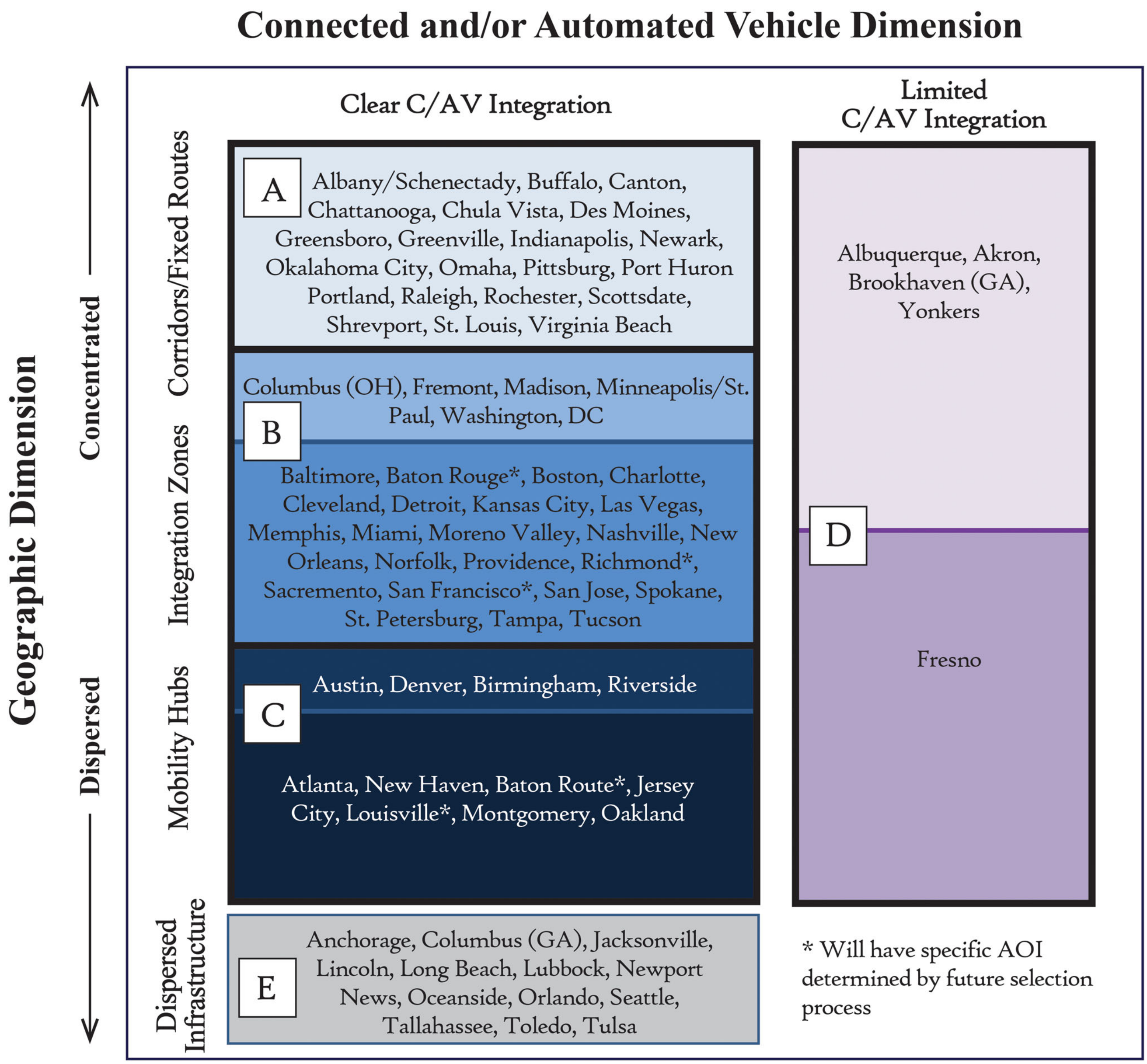

Figure 1. Typology schematic, including list of participating cities. Five classifications on graphic are labeled as (A) concentrated C/AVs, (B) zones of C/AV integration, (C) mobility hubs, (D) transit, and (E) infrastructure first. AV = automated vehicle; C/AV = connected and/or automated vehicles; AOI = area of intervention.

demand C/AV models. Mobility hub projects, whose name comes from a term referenced in Haynes (2018), feature strategic mobility aggregation points located throughout a city. Once at the strategic points, users can access mobility options that could include immediate or future C/AV integration, sometimes on an on-demand, as-needed basis, offering access to locations throughout the city.

In some cases, there were multiple geographic integration types in a city's proposal. These are identified in the transition zones between classifications in Figure 1, although we group projects according to their most geographically dispersed project for the purposes of this study.

Alignment with Local Characteristics

Each proposal included an annotated map that identified specific planned project locations within cities, which we use to classify projects on the geographic dimension of our typology, if applicable. We use the term *area of intervention* (AOI) to describe these locations, for the four project classifications that have them. All AOIs were digitized and stored in a geographic information systems environment. Next, we intersected AOIs with a national-level U.S. Census block group polygon spatial data set to measure the socioeconomic and demographic composition of these areas using American Community Survey (ACS) 2012–2016 five-year estimates (U.S. Census Bureau 2017). An example of an AOI is shown in Figure 2. We then compiled job availability data within each AOI using the U.S. Census's Longitudinal Employer–Household Dynamics (LEHD) data for 2015 (U.S. Census Bureau 2018) and collected daytime populations relative to residential population for each AOI. These are all factors identified in previous literature that are known to relate to transportation technology adoption.

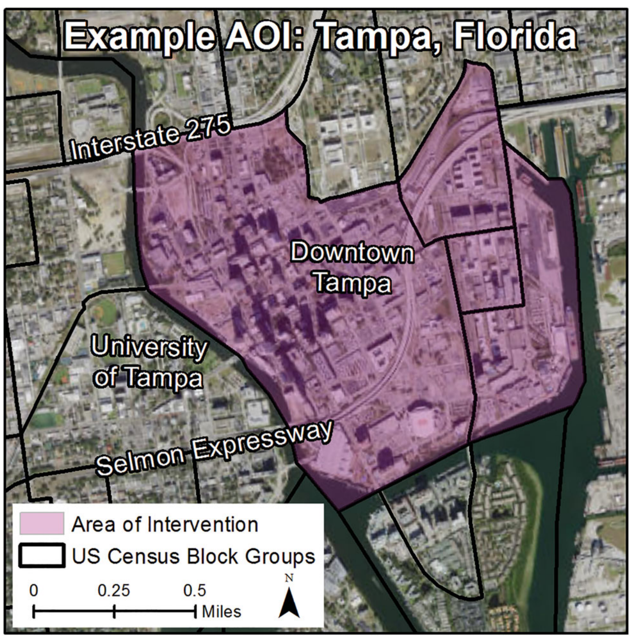

Figure 2. Example AOI designation based on the proposal from Tampa, Florida. AOI = area of intervention.

All metrics were summarized for each AOI (Table 1). AOIs generally included multiple block groups, with an average of twenty per AOI. All metrics were then compared to those of the MSAs in which the project was located. We independently compared AOI metrics to the outlying remainder of the MSA and then conducted difference-of-proportions tests for each characteristic in Table 1 to determine whether the observed percentage in the AOI significantly differed from that of the MSA.

Alignment with Comprehensive Municipal Planning

We then reviewed publicly available planning documents from the same seventy-eight cities that submitted proposals to the USDOT Smart City Challenge, including comprehensive plans, sustainability and resilience plans, or others with a similar city-wide scope and emphasis on sustainability. We also reviewed language within the institutional Web sites hosting these public documents, usually those of municipal planning departments, mayor's offices, or dedicated sustainability offices. Four key planning elements relevant to the aims of smart city efforts as well as sustainability and resilience planning were considered for each city: (1) the existence of a sustainability or resilience plan, (2) the existence of a municipal office of sustainability, (3) the existence of thematic coordination between comprehensive and sustainability plans, and (4) the ongoing use of data indicators in planning, including baselines, targets, and regular public dissemination. In

Table 1. Area of intervention characteristics collected at the U.S. Census block group level

Demographics	Housing	Commuting and vehicle ownership	Employment
% Male	% Owner-occupied units	% Drive alone	% Household income <$50,000/year
% White (non-Hispanic)	% Renter-occupied units	% Carpool	% Household income >$200,000/year
% Age 20–39	% Vacant units	% Transit	% Jobs, workers under age 30
% Age 55+	% Single-family units	% Bike or walk	% Jobs, workers over age 55
% Bachelor's degree or higher	% Multifamily units	% Households with no vehicles	% Jobs with annualized wage <$15,000/year
		% Households with two or more vehicles	% Jobs with annualized wage >$40,000/year

conjunction, we studied the proposals to assess the degree to which city or municipal planning departments were identified as key actors or stakeholders in the submitted proposal, in addition to involvement from metropolitan planning organizations (MPOs) and state transportation agencies. Finally, we identified whether or not a proposal explicitly mentioned providing transportation to a disadvantaged population as a motivating factor for the intervention to assess the relative inclusion of equity. We also considered the extent to which public–private partnerships were involved in the proposal.

Typology Classification Comparisons

Table 2 summarizes proposal-level and AOI characteristics across all five classifications in the typology. Public–private partnerships are most commonly identified in the three project classifications with geographically defined C/AV integration, and these three also have comparatively high rates of MPO involvement in the proposal. Interestingly, as dispersion of project increases, we note a higher percentage of cities that had sustainability and resilience plans at the time of the study. Mobility hub projects most frequently identify providing mobility to a disadvantaged population as a motivating factor, whereas less than half of all other project types do.

Figure 3 independently compares the differences in rates of AOI characteristics relative to that of the MSA by the four typology classifications with a clearly identified geographic intervention area. Generally, residents in AOIs live in areas with comparatively lower rates of driving alone to work and higher rates of

Table 2. Project, planning, and AOI characteristics by typology classification

Factor	Concentrated C/AVs[a]		Zones of C/AV integration[b]		Mobility hubs[c]		Transit[d]		Infrastructure first[e]
Project characteristics									
Public–private	95%		100%		82%		40%		62%
App	100%		100%		100%		100%		85%
Equity motivation	50%		48%		72%		0%		38%
Planning characteristics									
Sustainability or resilience plan	59%		67%		82%		60%		69%
Office of Sustainability or Resilience	68%		89%		64%		20%		77%
Planning indicators	50%		41%		45%		20%		54%
Thematic coordination	27%		48%		36%		40%		15%
Lists MPO	72%		78%		82%		20%		31%
Lists city planning department	18%		30%		18%		40%		15%
AOI metrics									
AOIs	37		55		25		17		—
Block groups	686		1,320		408		207		—
AOI population	954,548		1,744,198		666,231		293,294		—
Downtown AOI	86%		70%		72%		100%		—
University AOI	27%		38%		55%		60%		—
AOI comparison with MSA (%)[f]	<MSA	>MSA	<MSA	>MSA	<MSA	>MSA	<MSA	>MSA	—
Drive alone	70	16	80	11	76	16	71	12	—
Walk or bicycle	8	73	20	67	24	68	24	65	—
Transit use	27	59	18	80	12	76	18	76	—
Two or more vehicles	86	11	87	7	76	12	94	6	—
Age 20–39	22	76	18	69	24	64	6	88	—
Degree (any)	49	46	51	45	44	48	71	29	—
White (non-Hispanic)	78	22	76	22	80	12	65	29	—
Income <$50,000	19	78	15	75	20	72	0	100	—
Jobs >$3,333/month	27	68	29	64	40	48	41	41	—

Notes: C/AVs = connected and/or automated vehicles; MPO = metropolitan planning office; AOI = area of intervention; MSA = Metropolitan Statistical Area.
[a] n = 22.
[b] n = 27.
[c] n = 11.
[d] n = 5.
[e] n = 13.
[f] Remaining percentages within each classification comprised of AOIs that do not significantly differ from MSA metric.

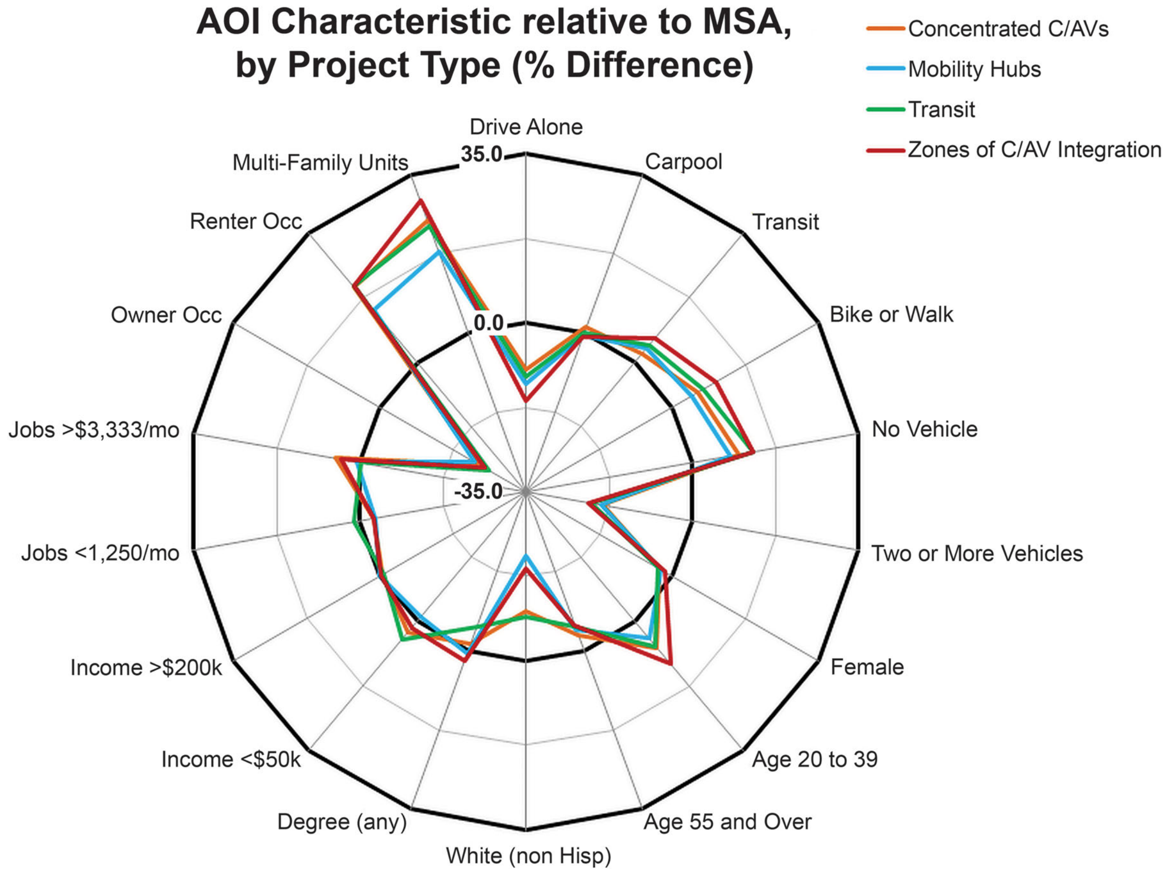

Figure 3. Comparison of AOI characteristic differences relative to MSA value, by project classifications that include geographic specificity. AOI = area of intervention; MSA = Metropolitan Statistical Area; C/AVs = connected and/or automated vehicles.

transit use, bicycling and walking to work, and those who do not own a vehicle. They also are comparatively younger, have higher minority populations, and have higher rates of renter-occupied, multifamily housing units, although these differences are commonly more pronounced in zones of C/AV integration.

Table 2 demonstrates that the majority of AOIs have significantly higher percentages of transit use, walking, and bicycling and lower percentages of driving alone compared to the rest of the MSA, which is essential for considering how C/AVs are deployed in these areas. Concentrated C/AV projects and zones of C/AV integration tended to have AOIs with higher percentages of higher paying jobs compared to the rest of the MSA, which signals an important difference and variation in potential job access compared to mobility hub and transit projects. Meanwhile, relatively concentrated C/AV AOIs tended to have significantly higher proportions of residents making less than $50,000 per year compared to the rest of the MSA, which is notable for considering the mismatch between the employment of local residents and these relatively well-paying jobs. Transit projects had a noticeably different distribution of degree-holders in their populations compared to the other three groups: The majority of these AOIs had significantly lower proportions of their populations without degrees, whereas this was relatively evenly split across AOIs for the other classifications.

Finally, we note that the relative prevalence of AOIs with daytime ratios higher than 2.0 declines as C/AV interventions become more dispersed in the typology (Figure 4). This suggests that more dispersed projects offer potential access to a greater variety of neighborhoods. The relatively high number of AOIs with high daytime population ratios in more concentrated projects indicates that a greater share of those who could interact with the C/AV intervention includes more than just residents, which is a consideration for how benefits accrue to users of these interventions.

Discussion and Conclusions

The typology constructed indicates that the majority of proposals submitted by these seventy-

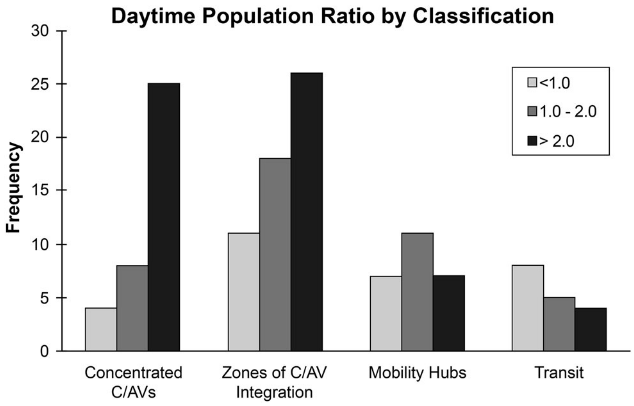

Figure 4. Ratio of daytime area of intervention populations to area of intervention populations, by project classifications that include geographic specificity. C/AVs = connected and/or automated vehicles.

eight midsized cities do recommend introducing C/AVs, although there are differences in geographic concentration. Although we observe variation across typology classifications, AOIs are generally found to be comparatively younger and less wealthy, with a higher share of minority populations, whose residents live in multifamily, renter-occupied units. Residents in these AOIs drive alone to work less often, use transit and active transportation at higher rates than other parts of the city, and own multiple vehicles at lower rates.

These findings carry a number of implications for future smart transportation planning efforts. First, the relative similarity of AOI neighborhood characteristics across proposals is an important finding, because that suggests that these seventy-eight midsized cities are proposing to implement projects in neighborhoods that differ from the rest of the MSA in a consistent manner. Second, given the high focus on C/AV integration, it is worth noting that enhancing access to vehicle travel in these areas that are already less automobile dependent than other areas of the city is unlikely to bring about short-term reductions in vehicle travel in these cities, and therefore in emissions from the transportation sector, without addressing vehicle travel elsewhere in the city. Such counterbalancing efforts do not appear to be directly considered in these projects.

On the other hand, these interventions could allow AOI residents to reach services or higher paying jobs elsewhere through enhanced mobility, and that such access varies by geographic dispersion across the typology warrants attention. Residents in areas that are more reliant on transit and active transportation might be unable to afford personal vehicles at present and would prefer to travel more by automobile. Therefore, to what extent adoption and use of C/AVs by AOI residents occurs should be closely watched in the short-term future as proposals move to reality.

The observed characteristics of residents in AOIs do align with some known characteristics of adopters of new transportation technologies and services in a manner that does not support near-term optimism for sustainable outcomes but also diverges in important ways. Early adopters are known to be wealthier, less racially diverse, and more educated than the profile of residents targeted by these smart city projects. The income component is particularly logical, because personally owned AFVs and C/AVs require a significant personal investment to obtain. On the other hand, there might be opportunities for AOI residents to access these vehicles in the widely proposed shared vehicle ownership model, although it remains uncertain how pervasive such travel would be. It is also unclear from these proposals to what extent subsidies or assistance would be provided to those who might need it to access C/AVs in this manner.

The predominant integration of C/AVs among proposals signals a possible parallel to the reintegration of rail transit in North American urban areas in the 1980s through the 2000s, when initial lines were built in targeted and visible areas, often for economic redevelopment purposes (Lane 2008). The importance of successful demonstration is also seen from early adopters of AFVs, where prior experience is consistently a primary predictive adoption factor (Lane et al. 2018). Targeting initial deployment to areas of a city where early adopters are most likely to use it aligns with diffusion theory's predictions regarding the dissemination of disruptive technologies (Norton and Bass 1987). It is unclear how this will proceed with C/AV introduction, although visible areas already seem to be popular areas for interventions in midsized cities.

Taken together, this could represent an uncertain inflection point in early transportation technology adopter profiles as proposals move to interventions: Different populations than those in the past might comprehensively adopt these emerging technologies and services, or the residents in these areas might not use them to the degree hoped for a variety of reasons. Cities and the academic research community generally cite more long-term societal benefits as motivations for these efforts, but implementation at present appears to depend on a convergence of societal classes toward common technological interactions and capability, currently built on mobile applications. There might be mixed personal technology access or engagement in the AOIs, though, therefore limiting the use and potential benefits to residents. Purposeful development of institutional intelligence and infrastructure efficiency at scale, with perhaps longer term expectations of individual engagement and evolution of networked inhabitants, will be important for future planning efforts.

Given the relatively high daytime resident ratios in more concentrated projects that recommend introducing C/AVs, there is a risk that benefits might accrue to those who work in or travel to these areas instead of residents. Indeed, we observed that public–private partnerships are more commonly observed in these proposals than the explicit inclusion of equity as a motivating factor, which warrants attention. Municipal planning agencies might be motivated by system optimization, which could be improved by inclusion of the private sector and its innovative environment, but there is a risk of friction between longer term or societal benefits and shorter term data monetization and profit-driven motives when private actors are involved, especially if efforts are not tightly aligned with publicly devised comprehensive planning and sustainability goals.

Finally, there are notable differences in percentages of sustainability plans and offices in cities across typology classifications, along with observed alignment of planning elements by regional and municipal agencies. Smart city proposals infrequently mentioned municipal planning agencies as key actors despite the existence of many preexisting municipal plans establishing separate "smart" planning goals. This indicates that there is an opportunity for comprehensive planning deeply informed by sustainability and resilience principles, typically generated by a representational swath of the local community in a transparent public process, to become more tightly coordinated with future smart transportation plans. This disconnect could limit the future ability of a city to align its suite of efforts with longer term sustainability and resilience planning, should such proposals develop in the future.

There are limitations to this study that should be highlighted. The majority of these areas did not translate their reviewed proposal into construction, at least in the state proposed. Second, there was a limitation placed on city sizes for the competition, notably leaving out very large cities, which might have introduced C/AVs in notably different ways. Other characteristics of the AOI could also be considered, along with known interactive effects of the independent metrics identified in this study, which should be considered in future modeling studies. Although the intent was to provide an initial indication of project alignment with key residential characteristics, more detailed information on the types of residents and visitors in these areas would be helpful to consider in certain cities. Further, there might be historical and political reasons why certain cities elected certain intervention types and geographic areas that are not stated in the proposal. These factors are not captured in this analysis and would be an important avenue for future research.

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