A Convergence of Public-Private Benefits in Denver: Surveys and Analyses to Inform Urban Mobility-, Energy-, Infrastructure- and Behavior-Related Innovation

Preprint

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A convergence of public-private benefits in denver: surveys and analyses to inform urban mobility-, energy-, infrastructure- and behavior- innovation

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Abstract

Cities, public transit agencies, and new private ride hailing services seek to understand emerging traveler dynamics, the shifting demographics of urban travelers,and new energy-efficient mobility opportunities. This includes exploring how new infrastructure investments, public and private mobility services, and smart-phone mobility apps are reshaping behaviors, demands (e.g. mobility-on-demand services), travel experiences and energy-efficient urban travel preferences. Currently, cities and metropolitan regions are providing and experimenting with many new mobility options, technologies, and personalized information services at the intersection of urban mobility, energy, and infrastructure systems (e.g., new commuter rail). To date, technology alone has not been able to crack the nut of "creating faster trip times, less congestion, safer streets, and cleaner air for its citizens through fewer cars on the road". This paper focuses on this gap by offering new concepts and potential for integrated approaches. Accommodating more vehicles miles traveled in cities, without increases in person miles traveled (PMT), could be costly, generating: 1) tremendous demands for new infrastructure, land, road space, materials, and energy; 2) higher traffic fatality risks; and 3) worsening air quality. Therefore, this study focuses on reducing single occupancy vehicle use by enhancing integrated mobility, helping transit and ridehailing increase occupancy in ways that also reduce energy use, and improve quality of life for urban travelers and communities. This study focuses on a survey of urban travelers in Denver, as a representative case study for metropolitan regions experiencing rapid growth, ageing populations, increased urban sprawl, traffic-related delays, and inefficient energy use per PMT.

KEYWORDS: Travel Behavior Motivations, Smart Technology, and Infrastructure

Background

In the United States, more than 28% of energy use comes from the transportation sector, and since the 1880s (when the internal combustion engine automobile was patented), there have been few times in history where annual vehicle miles traveled in the United States has not continuously increased. This trend includes a couple years during World War II, during the 1970s fuel crises, and in recent years from 2005 to 2013. While total vehicle miles traveled (VMT) in the United States has been hovering around 3 trillion miles from 2012 to 2015, VMT per capita has started dropping nationally and for the Denver region (Fig. 1).

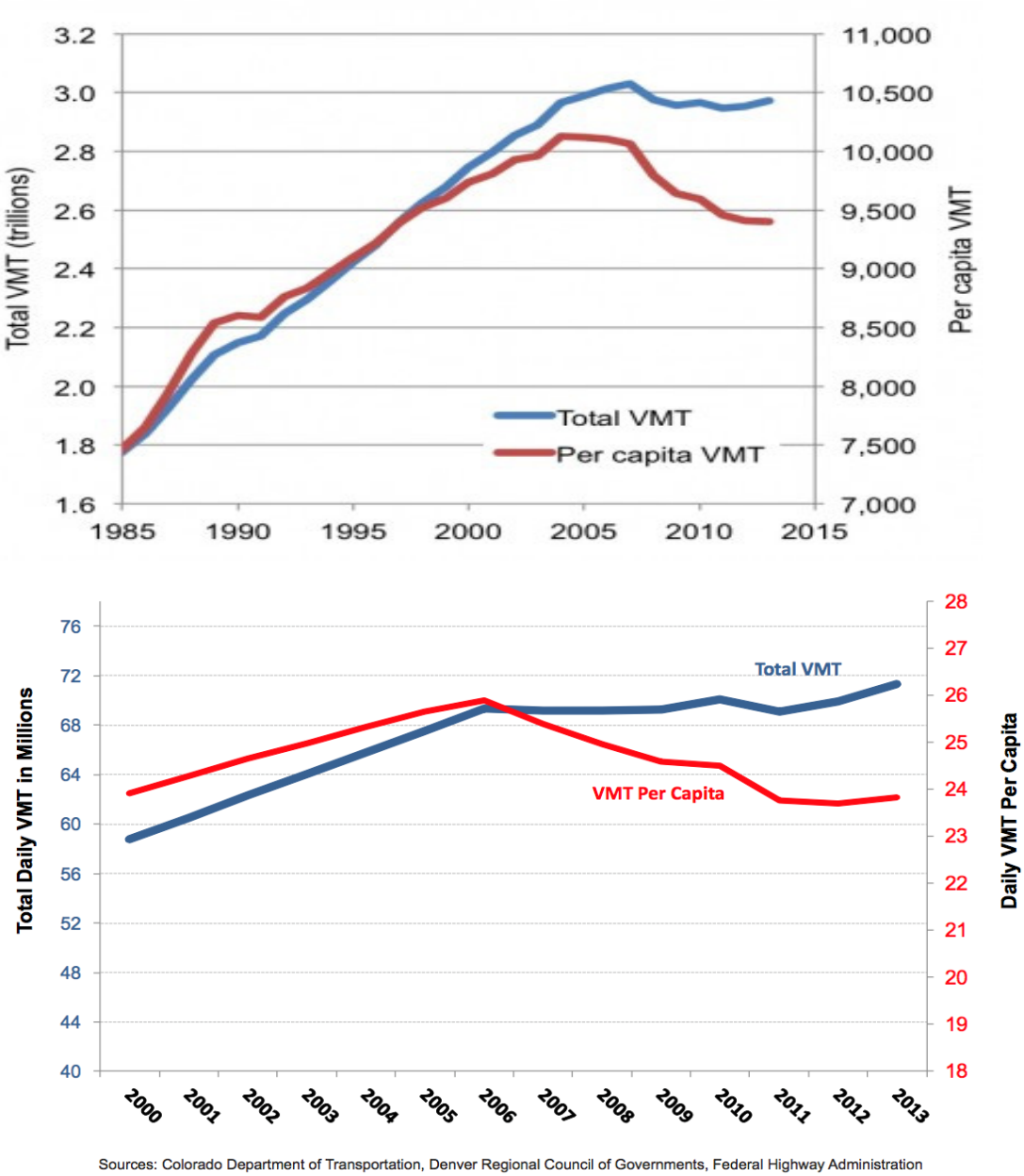

Figure 1: VMT Trends for the U.S. (top) and Denver (bottom) (Weekday VMT) through 2013

At the same time, the Denver region has experienced a sharp increase in air travel (Denver International Airport saw 55 million passengers a year in 2015, up from 35 million in 2012) and total VMT is continuing to increase. Despite greenhouse gas (GHG) reduction gains due to renewable portfolio standards, shifts from coal to natural gas, energy efficiency upgrades, and other building sector actions; Denver GHG emissions have remained similar in 2010 to 2013 - potentially due to increasing transport sector GHG emissions over the past five years (from 2009 through 2013) and population growth. While the City and County of Denver has been adding population (60,000 total residents in the past five years), preliminary analyses of data from the Regional Transportation District (RTD) demonstrates Denver local annual transit boardings have decreased (from ~49 million in 2010 to ~46.5 million in 2015) (RTD, 2016; City of Denver, 2016); see Fig 2.

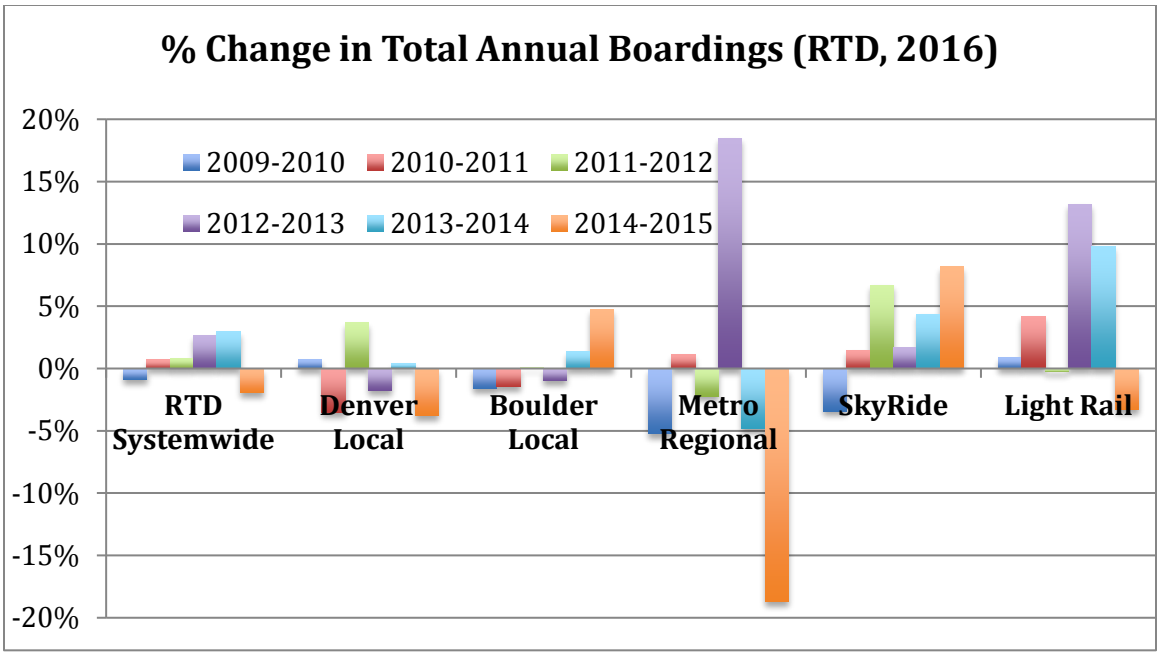

Figure 2: Regional Transportation District (RTD) – Data from Denver's Transit Agency

With Denver transport-related energy use and emissions high and rising (according to latest estimates), and with public transit uptake minimal in recent years, key questions arise and motivate exploration of a hypothesis that new integrated mobility options / incentives could be critical to reducing emissions, pollution, and congestion, while making mobility easier, increasing transit ridership, and improving quality of life. By contrast, estimates suggest almost a doubling in TNC drivers in the Denver metro from 2012-2014. Figures 3 and 4 compares some of these TNC shifts over this period for selected cities and nationally (Arellano, 2016; Hathaway & Muro, 2016).

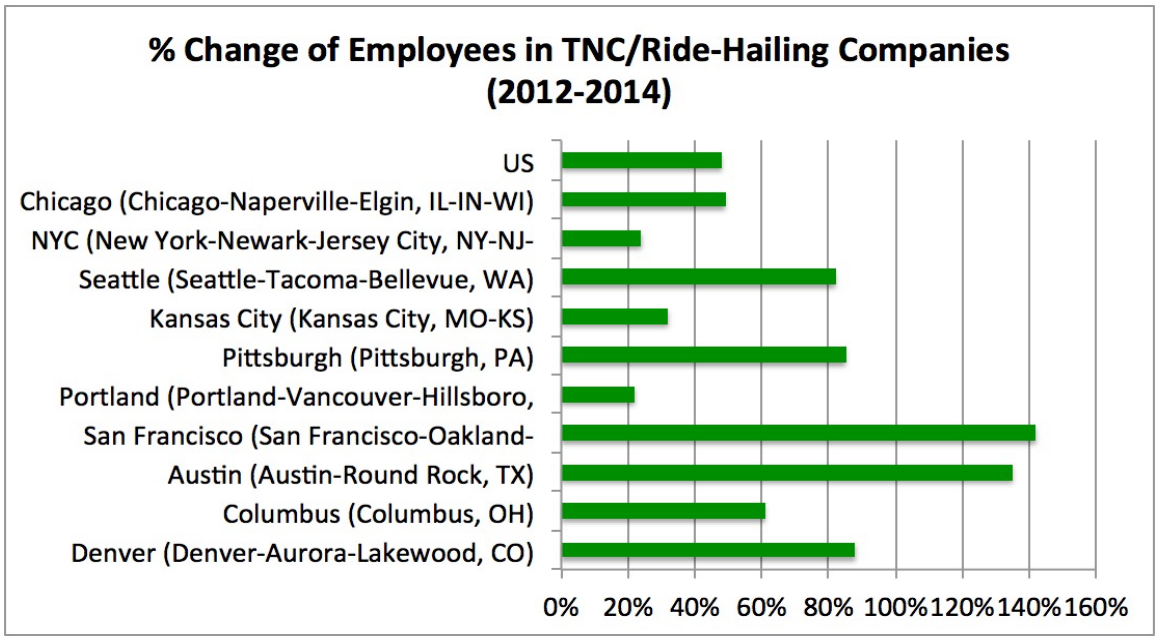

Figure 3. Denver metro area as % increase in number of employees in TNC companies

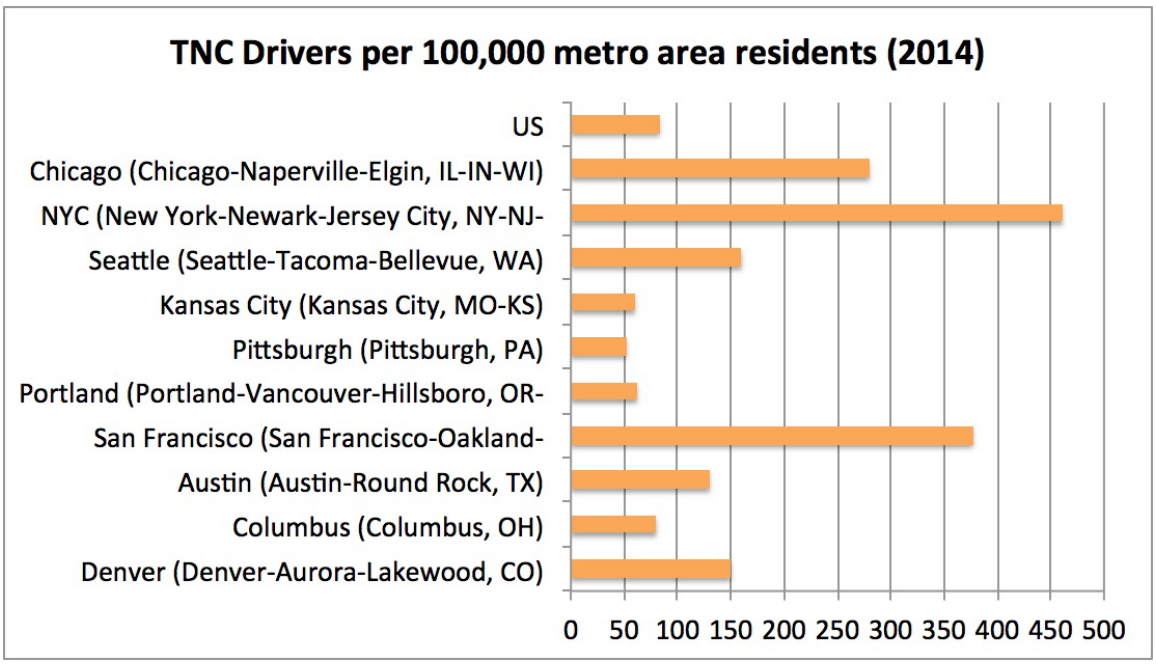

Figure 4. Initial benchmarking of Denver TNC drivers per 100,000 metro area residents

The results of this study will aim to inform efforts in strategic locations on mobility systems integration and sustainable urban mobility, that can help address the 32% of total GHG emissions from transport sector in Denver, including 15% from gasoline vehicles, 7% from air travel, 6% from fuel production, and 4% from diesel vehicles. New technologies, plans, policies, and behaviors that help to increase occupancy in TNCs, transit, and other commuting modes are all potentially critical to smart, low-carbon mobility systems and related urban ICT service upgrades, to be explored via this study.

Infrastructure Investment: Do futures of transit, TNCs, and mobility apps align?

This study primarily focuses on the new University of Colorado 'A' line commuter rail route and the uptake by new travelers, as connecting Denver International Airport and Downtown Union Station. This line received nearly $1.5 billion in public and private investment. Based on the timing of opening in April 2016, this study was conducted in the months following, to understand the uptake of a new and alternative travel-mode choice for urban travellers (including the motivators for using transit and on-demand services). This study also explores intelligent mobility information to inform travel, and enablers and barriers to traveller adoption (including business/vacation travelers and residents) of new infrastructure. Initial data are collected to address the emerging topic of integration of ridehailing and transit services, and demographics currently participating.

Study Rationale

To date, technology alone has not been able to crack the nut of "creating faster trip times, less congestion, safer streets, and cleaner air for its citizens through fewer cars on the road" (Bliss, 2017). This paper focuses on this gap, and the potential for improving the alignment of public-private actors to help shape integrated mobility with TNCs and enhanced transit investments. By combining uses of new technology and infrastructure with new human-centered data, this study explores motivations that may shape synergies in ride-hailing with new transit infrastructure.

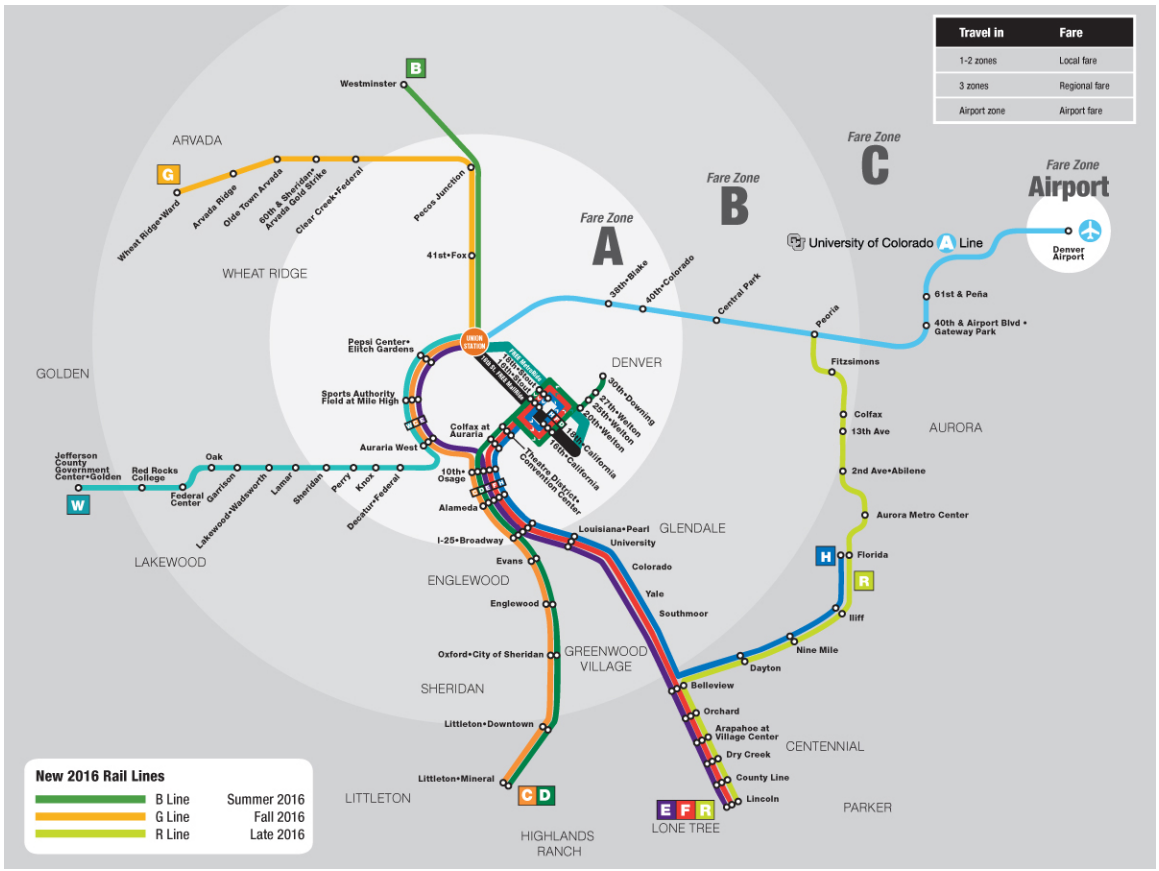

Figure 5: RTD system map of new 2016 rail lines

New emerging research on trends in ridehailing, transportation network companies (TNCs), and app-based ride services (Schaller, 2017) for New York and the energy impacts of automated vehicles nationally (Brown, Gonder, and Repac, 2014) exemplifies the important challenge and opportunity of gaining increased observability of new travel choices in cities. Furthermore, understanding who has access to TNCs, as demonstrated by surveys in the Greater Seattle region (Hughes and Mackenzie, 2016) also point to important new lines of inquiry. To date, few studies have made efforts to capture initial locations, demographics, and ridehailing-transit integration options as public-private partnerships. While more general studies on public-private partnerships have highlighted one key success factor as ensuring stable and enduring relations over 10 years (Terrien et al. 2016; Osei-Kyei and Chan, 2015), most PPPs for TNCs with transit remain nascent. In this study, the authors hypothesize that Denver companies, TNCs and transit services could find mutually beneficial alignment that saves money for employee air travel (now that a new downtown-to-airport rail line has been established), with reimbursement costs lowered and significant benefits for travelers through a reduced need for reimbursements for parking and taxis, and easier receipt submissions using auto-emailed TNC receipts or company credit cards/TNC accounts. Complementing this vision on exploring transitions, three specific motivating factors for the initial data collected in this study include:

1) Exploring how travelers and commuters using transit corridors could have first and last mile connectivity challenges, due to traveling on very new transit lines;
2) Opportunities via new public-private partnership (PPP) of transit agencies with TNC ride-hailing services;
3) By increasing higher occupancy transit and ridesharing to and from the airport, regional companies can find ways to save money and meet sustainability goals.

Using an initial Denver travel and stated preferences survey (n=104), this paper helps to provide new information on current and the potential for new behaviors and preferences, that may motivate increased adoption of transit, and hybrid uses of ride-hailing services (e.g. Uber, Lyft, employee shuttles) with transit. The preliminary results aim to inform larger studies on the future design of public and private automated and shared vehicle fleets, in ways that may optimize co-benefits among employers, employees, transit agencies, ride-hailing services, transportation/city-regional authorities, and city residents.

Through focus groups and meetings of Lyft and the transit agency (RTD) in Denver, with National Renewable Energy Laboratory (NREL) smart mobility researchers, new concepts and survey questions are being explored as follow up to an initial City of Centennial (Denver suburb) first/last mile, on-demand, mobile-based public-private partnership (PPP) pilot to enhance services, ridership, and affordability. Useful lessons and remaining gaps in knowledge have been identified regarding the uptake, scalability and replicability of a joint RTD and Lyft program around the larger region. For example, the following survey questions have emerged from initial discussions:

- What are the most synergistic opportunities and regional locations for interactions between public transit and transport network companies that may improve quality of life for all urban residents while also reducing costs/energy use?

- Where are the key urban areas for highest mutual benefit between connectivity of transit, ridesharing, and businesses though new PPPs?

- What business models for PPPs and mobility apps are most effective to help improve quality of life and convenience, and reduce costs, congestion, and energy use?

This area of inquiry is timely, especially as another PPP is also now emerging between Uber and the transit fleet in the City of Lone Tree, which is focused on having the transit fleet run on the Uber app service. The aim of initial data collection and survey efforts offers are to being to develop new useful datasets to expand on an initial PPP pilot to other areas of Denver that may have high potential. Although not yet the emphasis in this paper, insights gathered on a short to longer term, phased study approach may emerge from initial data collection efforts:

- Short-term: An opportunity for transit agencies to save on costs by partnering with TNCs to better serve paratransit/disabled community. The present practice is expensive, and delivers less than optimal service. This presents a hypothesis: a cooperative Lyft/RTD pilot will save the transit agency money, enhance paratransit service, and expand the Lyft-RTD partnering role in Denver.

- Mid-term: Connecting businesses and their employees with Lyft to transit, including access to new lines. This could be specifically for air travel commutes to save money on business trips now that the A line is open and running. By considering strategic locations and collecting preliminary data, initial analytical insights can inform future conversations between RTD and Lyft that address both their interests/questions for future survey design, which extends beyond an initial 100 travelers.

- Long-term: Developing evidence to design/promote shared use automated vehicles/ridesharing “routes” as replacing transit and/or enhancing transit (through coordination with Lyft) along existing/new routes. For example, analyses could be conducted that help transit agencies identify where 'to exit' in locations where transit load factors are too low to justify operating transit vehicles (such as the two persons-per-bus all-day phenomena in the Littleton, as RTD has identified) and instead, to concentrate public transit services elsewhere while encouraging or even subsidizing ridehailing or other supportive private mobility services (and apps) to step in to support.

Although these challenges and opportunities are critical and offer the rationale for this study, the design of objectives are narrower in scope, based on engaging with RTD and Lyft. The study objectives, city context, and preliminary analytical insights are described next.

Study Objectives

Although the differences in travel behaviors and preferences within cities have been explored across multiple cities, and similar efforts have been made at the national level, few studies unpacks the uptake of new services and how initial experiences shape satisfaction levels and preferences for improvements, considering a diverse array of residents and visitors within and across the Denver metropolitan area (estimated population of 2.8 million).
The organization of the rest of this paper is as follows. First, we describe the case study area, transit corridor, and target study populations. We then develop methods to explore survey results, and discuss key findings regarding the uptake of emerging mobility options enabled by new infrastructure and information services. The analyses help to provide initial baseline understanding for the potential aligning of incentives and programs between public-private actors to realize co-benefits for smart urban mobility.

Case study context

Between 2010 and 2035, the metropolitan region's population is expected to increase almost 50 percent, from almost 3 million to more than 4 million people. In integrating energy, transportation, and urban infrastructure engineering and planning, multiple issues compete for prominence in enhancing urban mobility-, energy- and urban infrastructure-related services innovation in which the city and metro region is investing.

For example, in the past three decades, no metro area in the United States has invested as quickly in rail infrastructure than Denver. To inform a broader perspective of traveler priorities using these new services, a survey was conducted among over 100 travelers. The survey explored the state of local conditions, the challenges citizens face, and the ways in which differences in local conditions (socio-institutional, infrastructure, and health-related) demonstrate inequities and influence how citizens perceive risks and rank priorities for the future design and implementation of local planning, policy, and community-based efforts.

Methods for Developing Initial Analytical Insights

For this study, over 100 household surveys were conducted from June to September 2016, with local research partners providing supplementary data and guidance for survey design. Over 10 types of priorities for change are identified and explored based on multiple spatial and human factors. The timing of this survey was designed so that weather was less of an issue (summer months).

Although transportation disruptions of ridehailing and shared mobility are emerging, and a future of connected and automated vehicles is on the horizon, the emerging array of choices for urban populations are still not well understood, especially within the context of understanding new opportunities for combining new choices with existing and new transit infrastructure investments. In essence, this study explores how differences in socio-demographic, travel profiles, and use of ICT may influence energy-efficient travel behaviors of transit riders, relative to those who are driving, often in single-occupancy vehicles (SOVs). More specifically, this study explores how differences in and among urban travelers and the future integration of public and private solutions within and across Denver could shape the uptake of emerging mobility options enabled by new infrastructure and information services.

Highlights and steps for developing initial analytical insights from results are given below:

- A smart mobility survey in Denver was conducted among 100 travelers

- Questions are asked that explore 1) the uptake of new infrastructure and information services, 2) upgrade priorities, and 3) alternatives to the present mobility choice made.
- We identify primary reasons for choosing travel mode such as convenience, cost, time, lack of a car, and identify key travel priorities categorized in the "GoDenver" app as sooner, cheaper, greener, or healthier.
- Variations in age, satisfaction levels, priorities, and a focus on key locations can inform mobility service integration and future automated vehicle routes.

5. Results

The tables below summarize survey findings in terms of frequency of survey responses. Key findings include that there has been limited uptake of new smart phone applications to date, yet if prompted to use the personalized app for travel decisions, **time and costs outweigh all other factors.** When specifically asked why they chose their primary mode, travelers cited convenience as a primary motivator for their travel behavior and decision.

Table 1 Variables in survey dataset for assessing local traveler profiles

Class of Variables	Independent variable	Categories	Frequency
Demographic	Gender	Male	50 (48.1%)
		Female	52 (50.0%)
		Other / Prefer Not to Answer	2 (1.9%)
	Age	<40	55 (52.8%)
		>40	45 (43.2%)
		Prefer Not to Answer	4 (3.8%)
	Colorado resident	Yes	80 (76.9%)
		No	24 (23.1%)
	Colorado visitor	Yes	22 (21.2%)
		No	82 (78.8%)
Traveler Profile	Traveling for work	Yes	61 (58.7%)
		No	43 (41.3%)
	Traveling for pleasure	Yes	43 (41.3%)
		No	61 (58.7%)
	Ordinarily drives and does not take transit	Yes	11 (10.6%)
		No	92 (88.5%)
		Uses Access-A-Ride	1 (1.0%)
Airport-Related	Employed at airport (targeted sample)	Yes	34 (32.7%)
		No	70 (67.3%)
	No. of trips to airport in previous 60 days	>2	56 (53.8%)
		<2	47 (45.2%)
		No Reply	1 (1.0%)
Use of ICT	Have a smart phone	Yes	82 (78.8%)
		No	9 (8.7%)
		No Reply	13 (12.5%)

Have used the GoDenver mobility app	Yes	0 (0.0%)
	No	101 (97.1%)
	No Reply	3 (2.9%)
If to use app, will improve travel experience	Yes	72 (69.2%)
	No	17 (16.3%)
	No Reply	15 (14.5%)

Below tables offer variables in survey dataset for identifying priorities (as dependent variable).

Table 2 Satisfaction Levels (as dependent variable): How satisfied are you with the experience on this trip?

Dependent Variables	Frequency (n=104)
Very dissatisfied	3 (2.9%)
Somewhat dissatisfied	7 (6.7%)
Neutral	15 (14.4%)
Somewhat satisfied	24 (23.1%)
Very satisfied	54 (51.9%)
No Reply	1 (1.0%)

Table 3 Priorities (as dependent variable): What might improve your experience?

Dependent Variables (in order of importance to surveyed travelers)	Frequency (n=104)
Device charging outlets on transit	75 (72.1%)
Access to wifi / internet on transit	72 (69.2%)
Express route	69 (66.3%)
Other: please specify	68 (65.3%)
Access to a bathroom closer to transit station	62 (59.6%)
Weather protection / shelters	51 (49.0%)
Alternative payment systems	49 (47.1%)
Public drinking water availability	46 (44.2%)
Access to a bathroom on-board transit	43 (41.3%)
More space for bags / luggage on transit	32 (30.8%)
Cleaner facilities	29 (28.2%)
Availability of food and beverage for purchase on board	29 (27.9%)
Ability to carry bikes more easily	27 (26.0%)

Table 4: GoDenver App: Which information in the app would be most important to you for your daily travel?

Dependent Variables (in order of importance to surveyed travelers)	Independent variable
Sooner	32 (30.8%)
Cheaper	26 (25.0%)
Healthier	3 (2.9%)

Greener	2 (1.9%)
No reply	41 (39.4%)

Table 5 Motivations and Priorities: Why primary mode was selected?

Class of Variables	Independent variable
Convenience	37 (35.6%)
Costs	26 (25.0%)
Time	15 (14.4%)
Environmental	6 (5.8%)
No car	6 (5.8%)
Other	5 (4.8%)
Traffic	3 (2.9%)
Lack of /Availability of parking	2 (1.9%)
Own a free EcoPass	1 (1.0%)
Health	1 (1.0%)
Ability to work or multitask	1 (1.0%)
Social influence	1 (1.0%)

Table 6 Primary Alternatives to Current Mode Choice

Class of Variables	Independent variable
Walk	1 (1.0%)
Ride with someone else	25 (24.0%)
Taxi	3 (2.9%)
Bus	19 (18.3%)
Driven myself	31 (29.8%)
Bicycle	1 (1.0%)
Uber	11 (10.6%)
Lyft	2 (1.9%)
Airport shuttle	5 (4.8%)
Other	3 (2.9%)
Would not have made the trip	2 (1.9%)

When given the opportunity to share specific comments on motivations, some survey respondents chose to share more. The following set of responses offers a sub-sample of interesting responses provided:

- Less traffic and I have a free EcoPass for the whole year
- I don't have a car and I don't want to pay for Uber/Lyft every day
- I don't want to drive and be stressed coming to work trying to drive
- $9 train for full day; used to pay $19 for bus each day (before train, it was not good; now better)
- Cheaper than parking and my company pays for my transit pass
- Costs (in terms of maintenance of car comes to mind; I also don't want to drive in traffic and was just curious to check this option out)

- Don’t have to waste gas, the ride is short, no traffic and its faster
- I don’t like public transportation and waiting for the bus
- Unreliable. Public transport should be very reliable but it’s not.
- My car is messed up so I have to take the train
- Only way to get out here for me is transit –

Figure 6. Word collage of selected survey responses.

Figures 7, 8, and 9 summarize results in terms of, respectively, average travel time, use of TNCs, and use of TNCs with transit for route of their most recent trip (when survey was conducted).

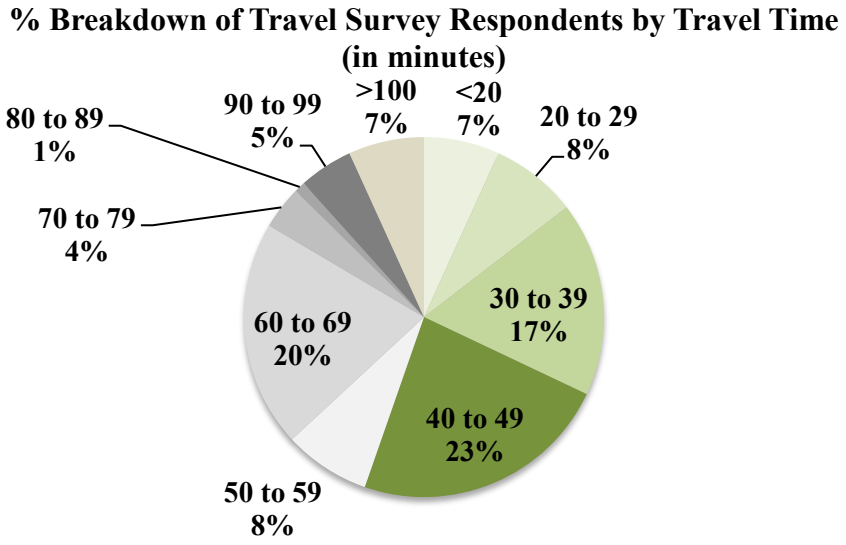

Figure 7. Survey responses on travel time (in minutes)

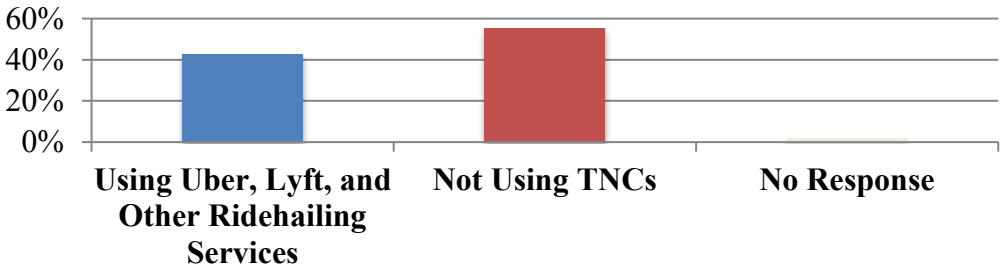

Figure 8. Survey responses on use of TNCs (n=104)

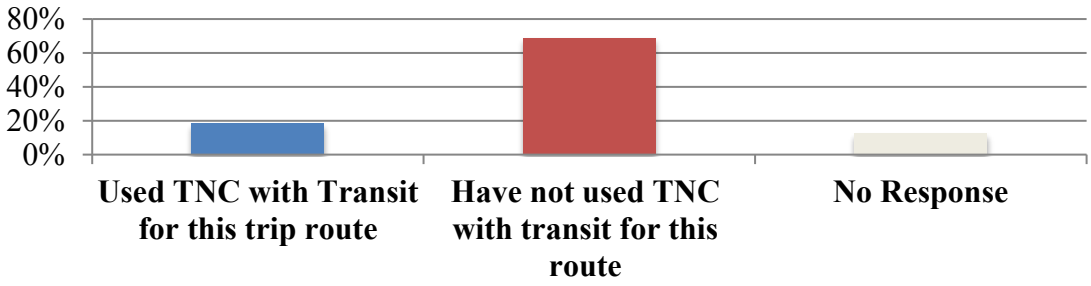

Figure 9. Survey responses on the use of TNCs and transit for this trip route (n=104)

Discussion

The results demonstrate the importance of travel time and convenience (e.g. as the response of sooner in the GoDenver app), and interest in device charging outlets on transit as an amenity. The potential for substitution of vehicle-based alternatives could represent potential for reduced traffic congestion and energy use, yet would likely have to be time-competitive for at least a third of all travelers surveyed. Although human factors are complex and any assessment of traveler profiles is far from all encompassing, we explore how human factors (demographic / traveler profiles, employment destinations, use of ICT) could shape satisfaction levels, priorities, and primary travel alternatives. A key finding is that time, costs and convenience are key motivators.

Next versions of these analyses will focus on the need to further examine these associations and new travel mode integration uptake based on determinants of types of traveler profiles. To date, few studies have explained the determinants or socio-demographic breakdowns for satisfaction levels, improvement priorities, and travel mode motivations and how they may vary by citizen populations and origin-destination pairs within the city. Knowledge in this area may help to understand why certain issues rank higher in competing for prominence in traveler decisions and for subpopulations by age, gender, residence, and use of information and communication technology (ICT) such as smart phones and associated mobility applications under development.

Conclusions

This case study demonstrates the importance of obtaining and using new knowledge to improve service delivery while understanding perceptions and priorities for change. Future research building on the baseline data collected, could be developed in three ways:

a) Creating opportunities for integrative assessment of new ridehailing, transit infrastructure and mobility application services as early proxies of future use of connected automated vehicles synergistic with shared mobility and transit.
b) Exploring implications of service-user behaviors and preferences, for future planning and policy agenda setting efforts that are cognizant of and recognize key urban traveler experiences and aspirations for diverse subpopulations.
c) Exploring energy, cost, and traffic displacement impacts of shifts toward public systems from increasing trips made in single-occupancy private vehicles.

Spatial analyses using origin-destination aspects of survey data, and examining the use of PPPs for urban mobility (e.g. travel by transit and Uber/Lyft), may offer new understandings for new place-based shared mobility and transit synergies. Future methods can be developed to create new knowledge on the questions: ‘To what extent do differences in urban travelers shape their priorities?’ and ‘Who (by traveler profiles, destinations, and ICT uptake) cares about what priorities?’ Based on the results and new phenomena of ridehailing and mobility apps, having on-demand mobility augment transit infrastructure (e.g. new downtown-airport or downtown-west corridors) to save time, money, and increase convenience may remain important lines of inquiry.

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