DOOR-TO-DOWNTOWN

HOW BOULDER, COLORADO, TESTED THE FUTURE OF MOBILITY

BY EDWARD KLOCK-MCCOOK, ROBERT MCINTOSH

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ABOUT US

ABOUT ROCKY MOUNTAIN INSTITUTE

Rocky Mountain Institute (RMI)—an independent nonprofit founded in 1982—transforms global energy use to create a clean, prosperous, and secure low-carbon future. It engages businesses, communities, institutions, and entrepreneurs to accelerate the adoption of market-based solutions that cost-effectively shift from fossil fuels to efficiency and renewables. RMI has offices in Basalt and Boulder, Colorado; New York City; Washington, D.C.; and Beijing.

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"I used d2d with my family to go out to dinner around the holidays. It was my first time using rideshare and I couldn't believe how easy it was!" - David Harwi

EX EXECUTIVE SUMMARY

EXECUTIVE SUMMARY

Boulder, Colorado, like many cities around the United States, faces a growing challenge. Urbanization has revitalized city centers, but it comes with a price—increased difficulty accessing the very amenities that are driving the urban renaissance. At the same time, building more infrastructure (e.g., parking and roads) is expensive, consumes real estate that could be put to better use, and ultimately only induces more demand. What's more, new infrastructure could well become a stranded asset in the near future as the coming mobility revolution portends that the age of cities built to support personal vehicles is coming to an end.

Because of these myriad factors, Boulder chose to take a bold step toward the future and improve access to downtown by adding to the "menu of mobility options" without building a single parking space or adding a single lane-mile. Door-to-Downtown, or d2d, as it was popularly known in the community, was created as a true public-private partnership and offered local residents the opportunity to travel to and from downtown using door-to-door mobility services at a price that was competitive with driving and parking their personal vehicles. This price point is important because, according to recent research by Rocky Mountain Institute, door-to-door service prices will fall over the next several years and become much more competitive with private vehicle use. As a result, Boulder tested the demand and effectiveness of tomorrow's mobility system, today.

Over the course of the 11-week program, registrants totaled more than 6 percent of Boulder's adult population, and nearly 2,500 inbound trips were taken. Although the pilot operated seven days per week, the trips were concentrated on Friday, with an average of 60 trips—the very day when parking is often the most challenging in downtown Boulder. An average of 1.8 passengers were in each vehicle, and customers rated d2d's ease of use at 4.5 out of 5 compared with driving and parking themselves. Passengers spent an average of $87 per person while downtown.

This initial pilot was designed to target downtown retail and restaurant patrons using a streamlined rapid-prototype approach. The lessons learned will be invaluable when designing future mobility programs that aim to serve ever-larger customer segments. For example, opportunities exist for downtown commuting as well as commuting and retail passengers in other areas of Boulder. Additionally, electric vehicles could be integrated into the system, and they could possibly even be powered by locally generated renewable energy.

The future of mobility is just around the corner, and d2d is an excellent example of how communities can prepare for that future today, while avoiding expensive investments that may well be outdated long before the end of their useful life. As urban cores continue to attract businesses, residents, and visitors, access will be an increasing challenge. Finding innovative solutions that preserve the very amenities driving that vitality will create a virtuous cycle and drive economic vitality for decades to come.

TESTING MOBILITY AS A SERVICE

01 MOBILITY IS RIPE FOR DISRUPTION

MOBILITY IS RIPE FOR DISRUPTION

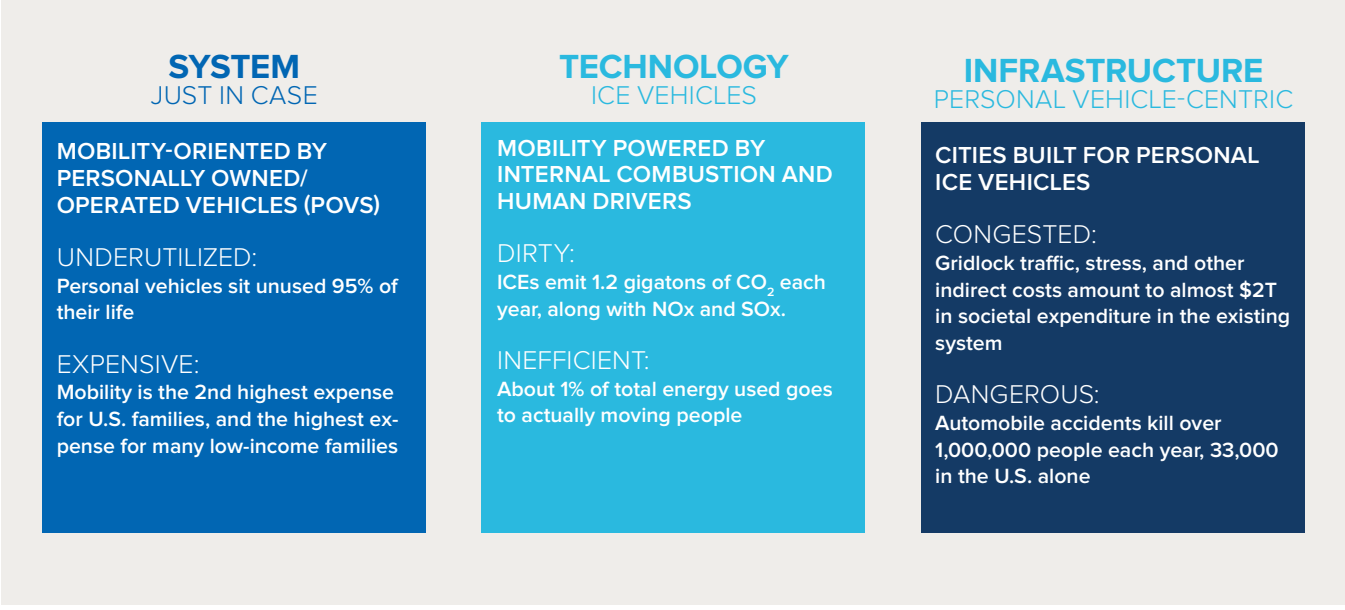
The current mobility paradigm is inefficient, costly, and a hazard to health and the environment. Today's mobility system (see Figure 1) is built on personal vehicles that are available to their owners "just in case." Privately owned, individually driven, internal combustion engine (ICE) vehicles sit unused 95 percent of the time,[1] cost their owners over $1 trillion annually,[2] and account for 16 percent of all emissions in the U.S.[3] The fully burdened cost of these vehicles amounts to a staggering $3 trillion per year when including road construction, maintenance, injuries and fatalities, lost productivity (i.e., sitting in traffic), public land lost to parking, and pollution.[4]

When Americans do drive, most trips are made with one person in the vehicle even though vehicles are usually designed to fit five occupants. American cities and suburbs have been designed and built around personal vehicles for a century, but as city populations increase, so do pollution, traffic congestion, and pressure on infrastructure.

The status quo of personal vehicle ownership is expensive. The average American drives a vehicle approximately 11,400 miles per year,[5] leading to an annual cost of approximately $6,612 ($0.58/mile[6]) to own and operate an average light-duty vehicle—the second-largest expense for a typical American family.[7] Low-income Americans often spend over 15 percent of their earnings on transportation.[8] What is more, personally driven automobiles are a veritable public health crisis, killing approximately 33,000 people each year in the U.S. alone;[9] 95 percent of fatal accidents are due to human error. This is not counting the deaths and health issues from the sulfur oxides and nitrogen oxides emitted by fossil fuel-powered vehicles.

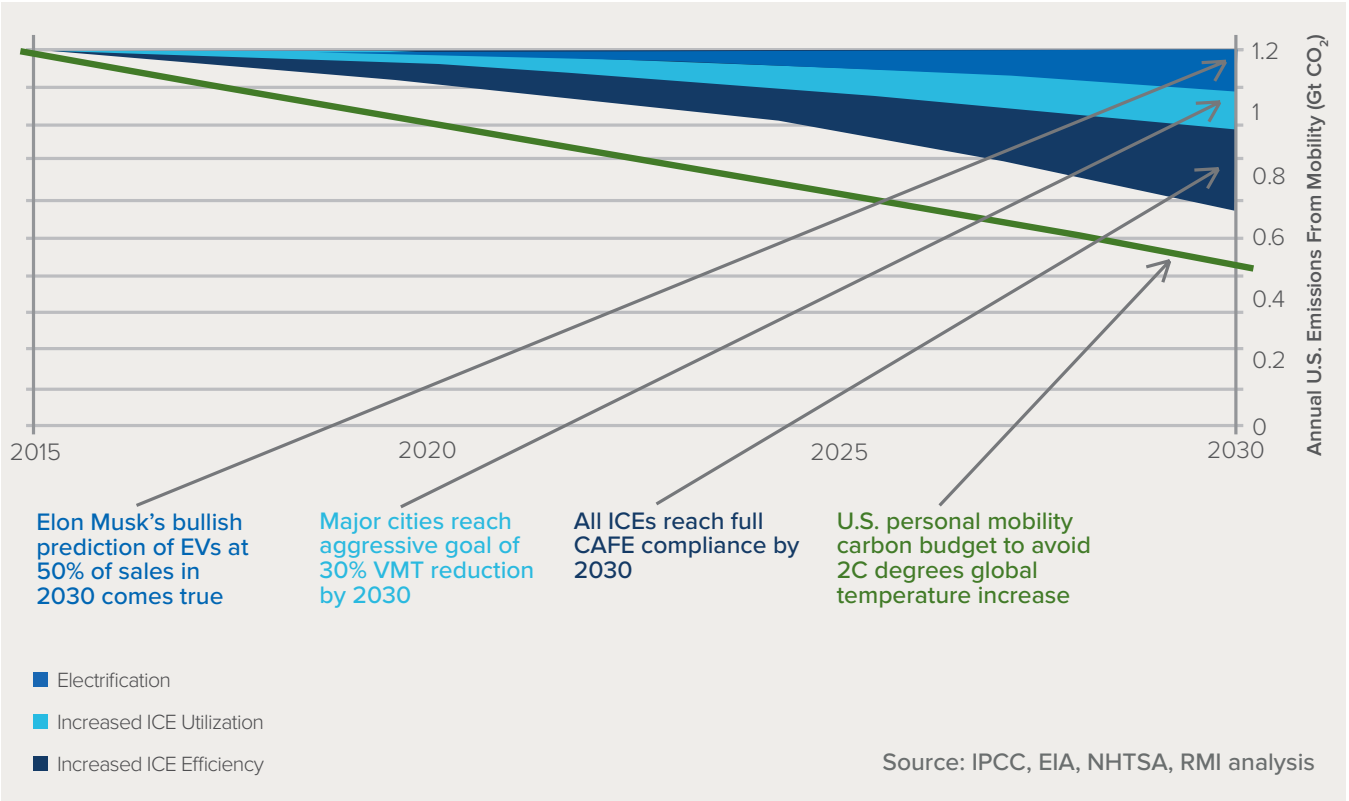
If these individual impacts were not severe enough, personal vehicles are also a major contributor to the global challenge of climate change. At our current pace, we will exceed the upper limit of carbon emissions allowed for personal mobility in order to avoid two centigrade degrees of global

FIGURE 1:
INEFFICIENCY OF THE CURRENT MOBILITY SYSTEM



average temperature increase—a target that the Intergovernmental Panel on Climate Change maintains is critical to avoid severe impacts of climate change and a goal that the U.S. recently pledged to uphold at the 2015 Paris Climate Conference. Even if the U.S. undertakes aggressive efficiency improvements in Corporate Average Fuel Economy (CAFE) standards, electrification, and vehicle miles traveled (VMT) reduction measures, the current paradigm in the U.S. cannot meet the emissions reduction required to mitigate climate change (see Figure 2). More drastic action is needed.

FIGURE 2:
IMPROVEMENTS IN THE CURRENT MOBILITY PARADIGM FAIL TO MEET CARBON REDUCTION GOALS



Source: IPCC, EIA, NHTSA, RMI analysis

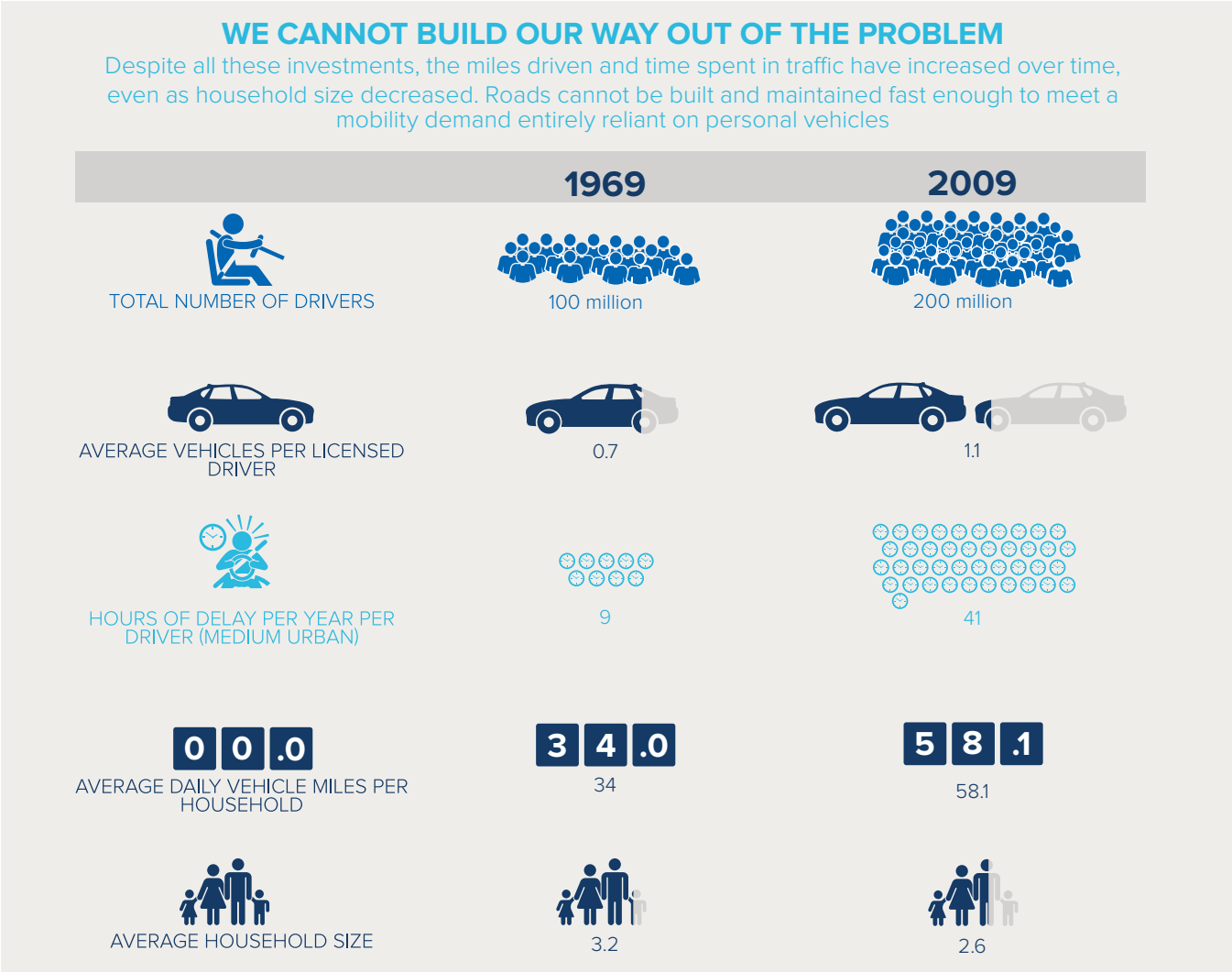
INVESTMENTS IN THE SYSTEM

Over the course of the 20th century, the U.S. has invested in a vast network devoted to the personal automobile. This has included:

- 4 million miles of local roads and 48,000 miles of interstate highways at a total cost of $8.2 trillion
- 800 million parking spaces at an estimated cost of $4.8 trillion
- 168,000 fuel stations

Every year, the U.S. spends $160 billion maintaining these systems, although much more is actually required. Current assessments indicate that $2 trillion to $4 trillion in upgrades and replacements are needed just to bring the U.S. transportation system up to minimum safety and quality standards.[10] Even as this vast system falls apart and the costs increase to unsustainable levels, the amount of miles driven per year and the time spent in traffic continues to rise (see Figure 3).

FIGURE 3:
PERSONAL VEHICLE DATA 1969–2009



The system cannot be improved fast enough to keep up with mobility demand. The only way to meet this demand is by changing to a new paradigm.

DISRUPTION IS NIGH

Although personal mobility has been slow to evolve for many reasons—trillions of dollars in existing infrastructure and entrenched behavior at the top of the list—rapid changes in society and technology are setting the stage for rapid, inevitable disruption to personal mobility as we know it today (see Figure 4).

FIGURE 4:
KEY SOCIAL AND TECHNOLOGICAL TRENDS

SOCIAL CHANGE

RISE OF THE SHARING ECONOMY

SOCIAL MEDIA UBIQUITY

URBAN POPULATION GROWTH

FLAT PER CAPITA VMT & DEFERRED VEHICLE OWNERSHIP

DISRUPTIVE TECHNOLOGY

EXPLOSION OF DATA PROCESSING AND CAPABILITY

SELF-DRIVING VEHICLES

BATTERY & SENSOR COSTS DROPPING

SMARTPHONES

SOCIETAL PRESSURE

MANY CITIES, STATES, AND THE FEDERAL GOVERNMENT ENACTING AGGRESSIVE CO_2 REDUCTION GOALS

SOME CITIES ARE ENACTING FOSSIL-FUELED TRIP REDUCTION GOALS AND PROGRAMS

airbnb

swap.com ONLINE CONSIGNMENT

ZOPA

NETFLIX

BCycle

Zilok

zipcar

couchsurfing

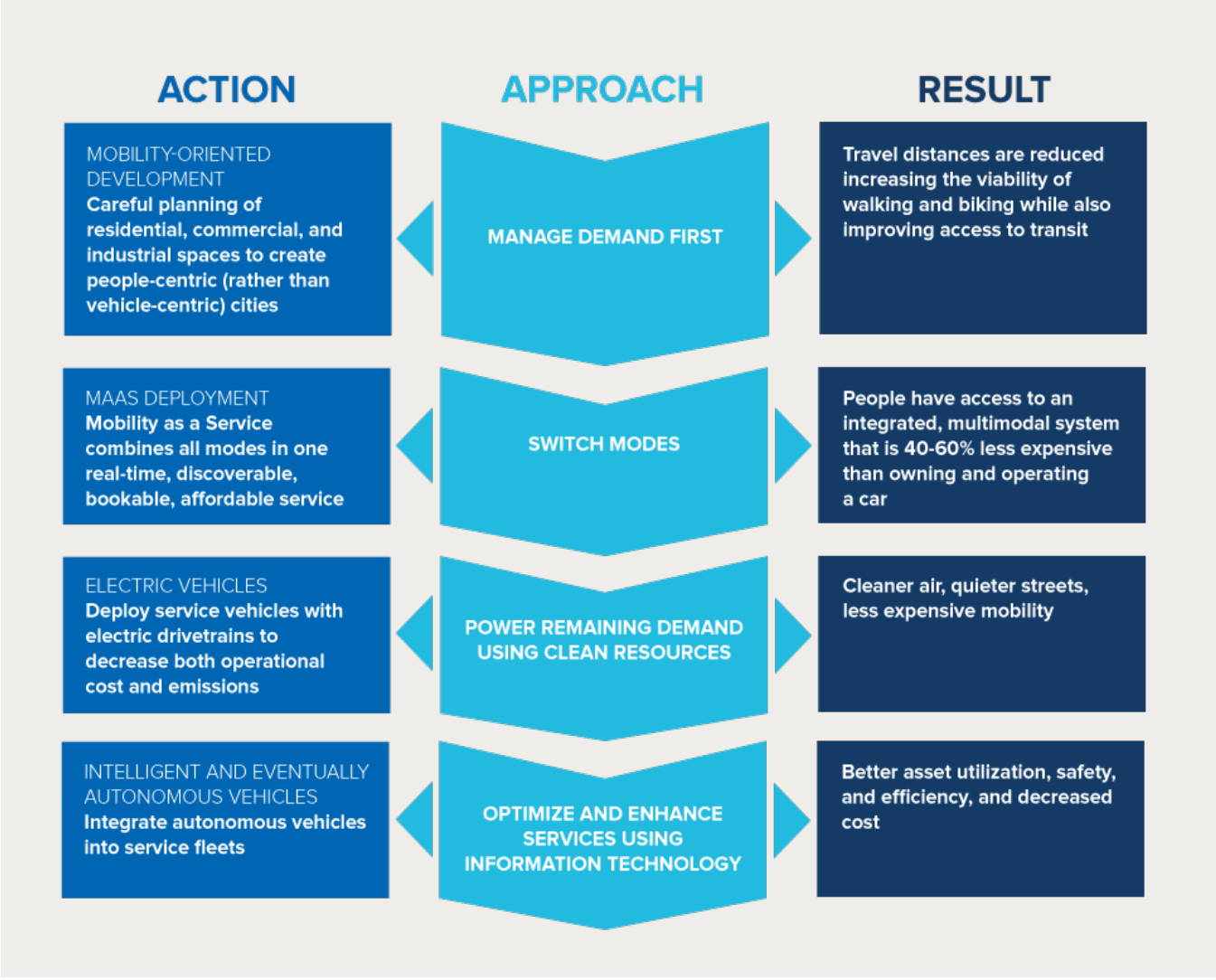
BookMooch New life for Old books

Bla Bla Car

Google Self-Driving Car, image courtesy of smoothgroover22

These rapid changes have opened the door to three principal opportunities: Mobility as a Service (MaaS); electric, autonomous vehicles (EAVs); and mobility-oriented development (MOD). These three pillars operate synergistically to reduce cost, improve safety, and decrease emissions and pressure on infrastructure (Figure 5).

FIGURE 5:
THE FUTURE OF PERSONAL MOBILITY

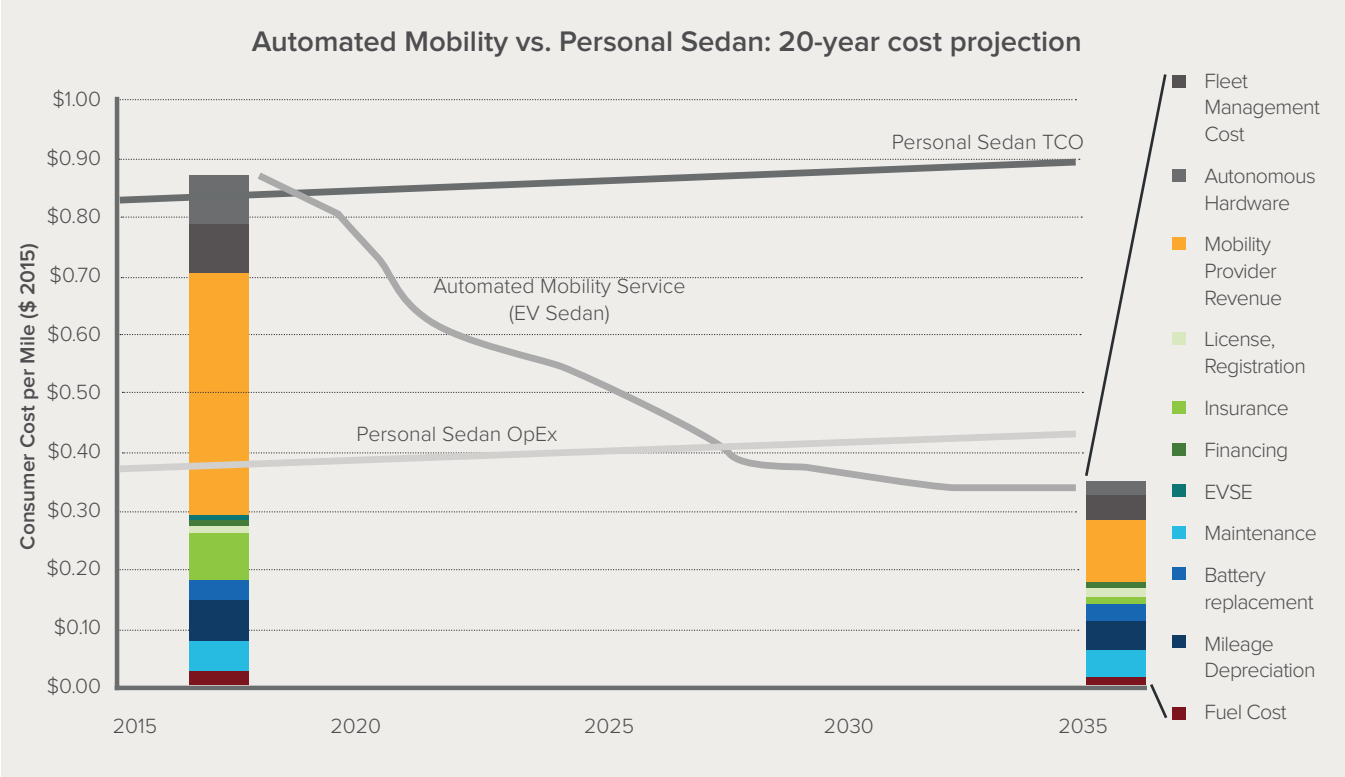


MOBILITY AS A SERVICE (MAAS):

Rather than customers owning a personal vehicle that sits unused 95 percent of the time, transportation can be provided on an as-needed basis by fleets of shared vehicles that pick up and deliver customers on demand. This shifts from "just in case" vehicle ownership to "just in time" service delivery.

As noted earlier, the total cost of ownership for personal vehicles is $0.58/mile on average. By contrast, a fleet of electric, autonomous service vehicles could provide ubiquitous service within a city, with less than one-minute wait times, for $0.35/mile or lower by 2035 (see Figure 6). The savings will be even greater when sharing a ride with other customers. This would represent an average individual savings of $3,200 per year (assuming 11,400 miles per year for the average person). This amounts to a nearly $1 trillion per year opportunity in the United States and is why industry giants and startups alike are pushing hard to achieve this outcome.

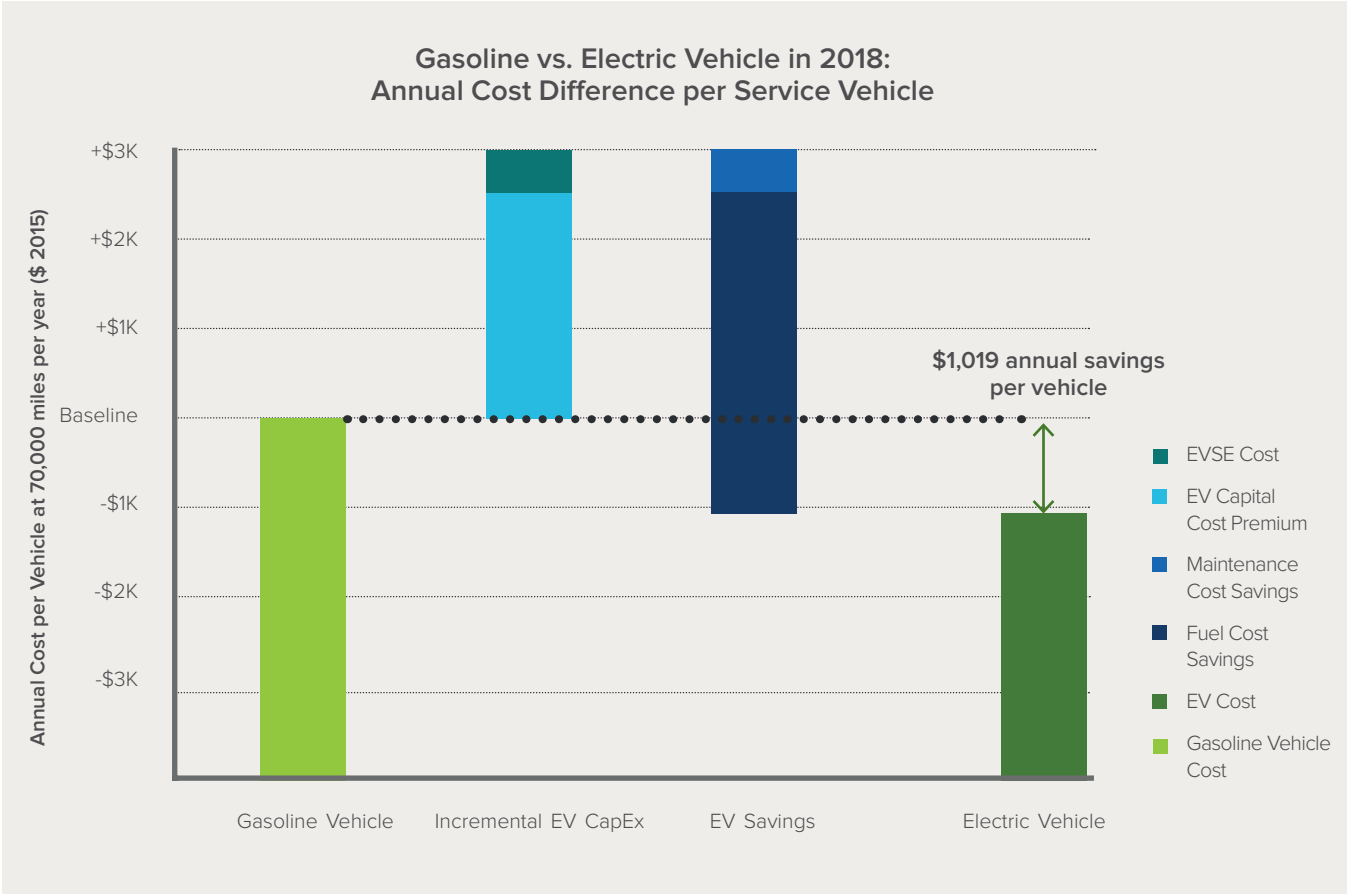
FIGURE 6:
AUTOMATED MOBILITY COSTS OVER TIME (FROM RMI'S PEAK CAR OWNERSHIP REPORT)



ELECTRIC VEHICLES (EVS):

The electrification of vehicle or person miles traveled is critical to reducing emissions from mobility, whether the vehicles are personally owned or part of a fleet. To date, one of the primary challenges to widespread personal EV adoption has been the extremely long payback due to an EV's up-front cost premium versus an equivalent ICE vehicle. However, vehicles used for mobility services drive three to six times as many miles per year compared with a typical car for individual purposes.[11] As a result, service EVs accrue operational savings due to lower fuel and maintenance costs three to six times as quickly, offsetting the higher up-front cost. In fact, the savings accrue so quickly that the average taxi driver would make $1,019 more per year driving a $70,000 Tesla Model S than he or she would driving a Honda Accord (see Figure 7).[12] As a result, a fleet operator will have an explicit financial incentive to deploy EVs, regardless of climate or environmental priorities.

FIGURE 7:
GASOLINE VS. ELECTRIC SERVICE VEHICLE COSTS (FROM RMI'S PEAK CAR OWNERSHIP REPORT)



The degree to which EVs reduce CO_2 emissions is a function of the carbon intensity of the electricity they are using. An EV can be worse than a hybrid vehicle in a coal-heavy electricity system. However, as more renewables are added to the grid, EVs will become a far better option, approaching zero emissions at 100 percent renewable penetration.[i] In addition, local air quality is immediately improved because EVs have zero tailpipe emissions.

AUTONOMOUS VEHICLES (AVS):

The second technological hurdle facing widespread personal EV adoption is autonomous vehicles. Autonomous vehicle technology is already being deployed in many modern vehicles, and companies like Apple, GM, Google, Tesla, and Uber already test fully autonomous vehicles on public roads. It is likely that fully autonomous vehicles (capable of navigating from one destination to another without human control at any point) will be commercially available as soon as 2020.[13]

Autonomous vehicles offer the potential to dramatically lower the cost of mobility services while virtually eliminating accidents due to human error, the cause of 95 percent of traffic fatalities. AVs will also add value by recovering lost time that drivers currently dedicate to actively driving. On average, personal vehicle drivers in the United States spend almost one hour and 45 minutes per day driving.[14] Recovering this time so that people can pursue productive or leisure activities will be a massive gain for society.

Autonomous vehicles will have far greater utilization than the 5 percent of the time that personal vehicles are used, resulting in more mileage per year per vehicle. This is ideal for service vehicles, which are frequently already driven continuously for 16 or more hours per day. At this high mileage (many estimates indicate that autonomous service vehicles could easily drive 80,000 miles per year or more), vehicle electrification becomes necessary in order to keep costs low for fuel and maintenance, which in turn overcomes the higher initial cost of an electric vehicle. Depending on the difference in initial cost—a Tesla S is more expensive than a Nissan Leaf—and the mileage per year, the initial cost can be paid back after as little as 30,000 miles of lower fuel and maintenance costs. Additionally, because fewer vehicles are needed to accomplish the same job, congestion and parking demand will decrease dramatically. Research shows that a fully autonomous system can deliver the same level of service as today with 80 to 90 percent fewer vehicles.[15]

Rocky Mountain Institute's *Peak Car Ownership* report details the current and future growth of autonomous vehicle technology and the deployment of AVs as service vehicles.

[i] A Prius hybrid has emissions of 185 grams CO_2 per mile (fueleconomy.gov). An electric vehicle consumes 0.34 kWh of electricity per mile, on average. On Boulder's current grid with emissions of 860 grams CO_2 per kWh, this implies an embedded CO_2 cost of 325 grams per mile for an electric vehicle (with 90% battery charging efficiency). An average gasoline vehicle produces 411 grams CO_2 per mile.

MOBILITY-ORIENTED DEVELOPMENT:

Creating infrastructure and policy to benefit or encourage a particular transportation paradigm is nothing new. As noted earlier, the U.S. has spent trillions of dollars on personal vehicle infrastructure in the 20th century and developed regulations and policy for this system at the national, state, and local levels. Without this vast network of support in place, the market for personal vehicles may never have grown the way it did. As electric, autonomous Mobility as a Service (eaMaaS) advances, it will need similar support to survive and thrive.

The most obvious of these is the charging network for electric vehicles, which will expand to become more ubiquitous and rapid. However, roadways will also need to be adjusted for automated vehicle-only lanes. With a major reduction in space dedicated to parking idle vehicles, housing, commercial, and industrial space can be more people-centric, thus reducing the distances required for commuting, shopping, and recreation. This will make walking and biking more practical, and provide easier access to public transit. At the same time, pick-up and drop-off facilities will become very important.

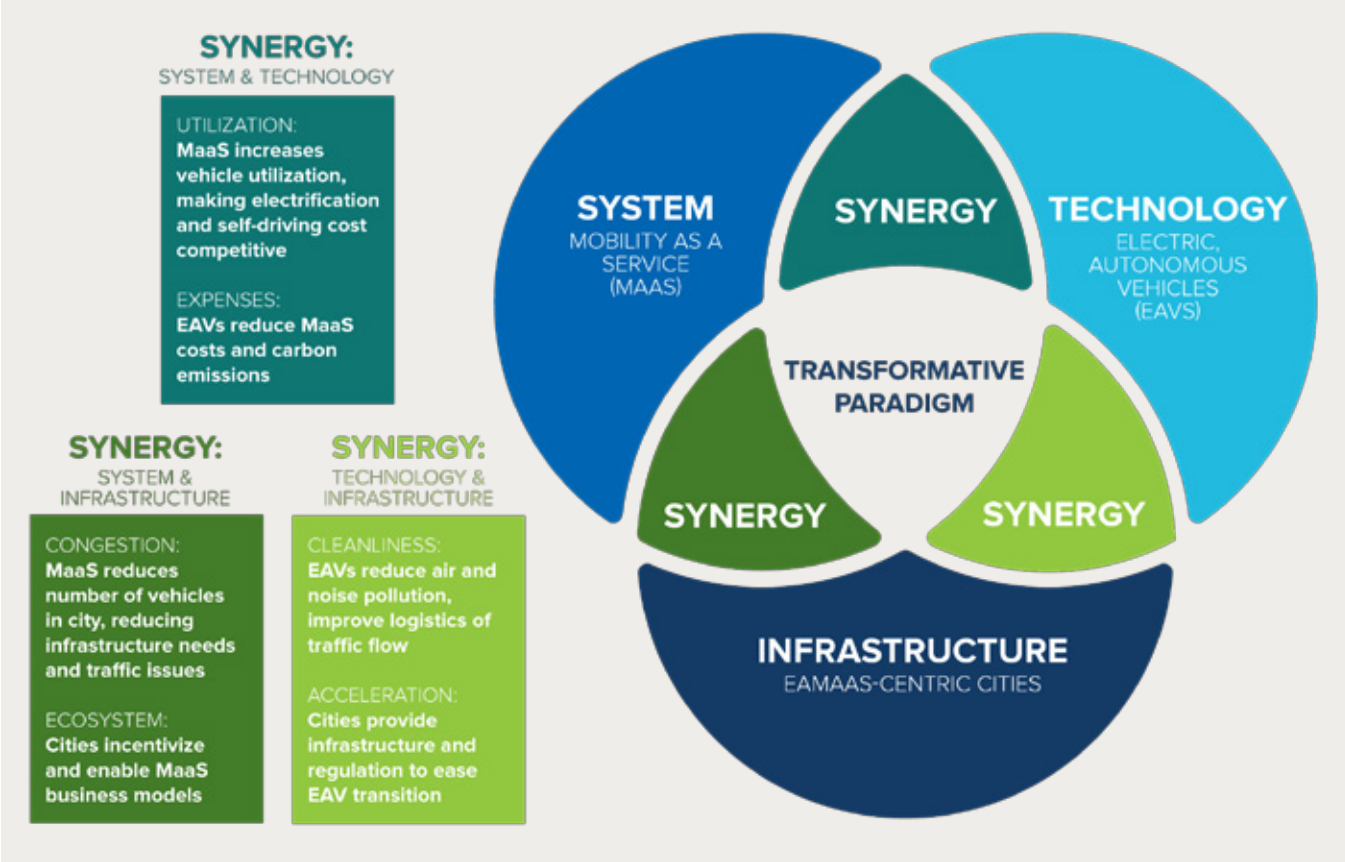
AUTONOMOUS VEHICLES AND PUBLIC TRANSIT

It is also important to point out that autonomous vehicles and public transit are symbiotic and part of the same system. For a variety of reasons, people tend to think in a binary way about these issues. Specifically, autonomous vehicles are thought of as small cars, often privately owned, and certainly door-to-door. Conversely, public transit is thought of as large vehicles often moving on scheduled routes. But this is a false distinction. Autonomous technology is not limited to small vehicles and public transit is not limited to large, fixed-route service. An efficient system dispatches the right vehicle for the right job. An empty 50-foot bus is no more efficient (in terms of pollution, throughput, congestion, or cost) than an endless stream of singly occupied vehicles all going the same place. The real opportunity—and challenge—lies in breaking down these mental models and reimagining how the system can provide cost-effective and convenient service for everyone.

SYNERGIES AMONG ELEMENTS

The strength of MaaS, EAVs, and mobility-oriented development lies not just in their individual benefits but also in their synergistic possibilities. Figure 8 shows how each component supports the others.

FIGURE 8:
SYNERGISTIC FUTURE MOBILITY PARADIGM



02 BOULDER TODAY AND TOMORROW

Image courtesy of Pedro Szekely

BOULDER TODAY AND TOMORROW

BOULDER'S ADMIRABLE TRANSPORTATION GOALS

As a mobility-friendly city, public transit's mode share in Boulder, Colo., is more than twice the national average, and the mode shares of bicycles and pedestrians are higher than most cities in the U.S. Nevertheless, Boulder has committed to reducing the mode share of single occupant vehicles (SOVs) as one of the key ways to improve system efficiency, reduce energy consumption, and reduce carbon emissions while also balancing social and economic sustainability goals. As shown in Table 1, by 2035 Boulder plans to reduce SOV mode share from 36 percent to 20 percent of all trips for residents (a 45 percent reduction) and from 80 percent to 60 percent for nonresident employees (a 25 percent reduction).

Some additional goals in the Transportation Master Plan (TMP) include:[16]

- **Vehicle Miles Traveled (VMT):** Reduce VMT in Boulder Valley 20 percent by 2035
- **Emissions:** Achieve a 16 percent reduction in GHG emissions; continue reductions in mobile source emissions of other air pollutants
- **Economic Feasibility:** Expand fiscally viable transportation options for all Boulder residents and employees, including older adults and people with disabilities
- **Commuting Services:** Increase transportation alternatives commensurate with the rate of employee growth
- **Others:** Reduce daily VMT per capita; improve safety

Electric and eventually electric, autonomous Mobility as a Service has the potential to address many of the TMP goals noted above, and to address the concerns of downtown stakeholders specifically. In particular, eaMaaS will help advance five TMP themes as follows.

- **Complete Streets:** eaMaaS will make streets safer for pedestrians and cyclists because autonomous vehicles will drastically reduce accidents due to human error
- **Regional Travel:** eaMaaS will provide first- and last-mile connections to Regional Transportation District (RTD) regional routes
- **Transportation Demand Management:** eaMaaS will give people better options to decrease reliance on individually owned vehicles
- **Funding:** eaMaaS will lower infrastructure costs by decreasing the overall number of cars
- **Integration with Sustainability Initiatives:** High-mileage fleet vehicles will likely be electric because of significant operational cost savings

TABLE 1:
MODE-SHARE GOALS FOR THE CITY OF BOULDER[17]

	THIS IS THE MODE SHARE THAT WE HAVE TODAY		THESE ARE THE 2020 TARGETS ESTABLISHED FOR RESIDENT TRIPS IN THE PREVIOUS TMP	THESE ARE THE NEW TARGETS WE ARE PROPOSING FOR THE 2035 TMP	
	Resident Trips	Non-Resident Trips		Resident Trips	Non-Resident Trips
PED	20%	10%	24%	25%	0%
BIKE	19%	1%	15%	30%	2%
TRANSIT	5%	9%	7%	10%	12%
SOV	36%	80%	25%	20%	60%
MOV	20%	10%	29%	15%	26%

DOWNTOWN BOULDER'S INFRASTRUCTURE CHALLENGES

Boulder has a vibrant economy but is challenged by increased congestion and a rising demand for parking. Parking and congestion in downtown Boulder (sometimes referred to as the Business Improvement District or Central Area General Improvement District [CAGID]) has become a particular challenge, driven by its attractiveness and a combination of employees, visitors, and residents often relying on SOVs for transportation. Despite an already excellent menu of options, including EcoPasses for all full-time employees, enhanced bike lanes, and parking programs, parking demand and congestion are on the rise.[ii]

Between visitors, residents (as customers), and employees, an estimated 27,000 trips are made to downtown Boulder each day.[18] There is approximately a 50/50 split between residents (living within five miles) and visitors (outside that area), with SOVs accounting for 36 percent and 80 percent of trips, respectively. Given that split, an estimated 15,000 SOV trips, are made to Boulder per day. Since Boulder has approximately 6,800 parking spaces available,[19] parking becomes tight at certain times of day.

According to 2014 surveys, 50 percent of downtown Boulder employees live within five miles of Boulder, and 29 percent of those employees use SOVs to get to work. Thus, of downtown Boulder's 9,000 employees (expected to grow to 12,800 by 2035), approximately 1,300 employees living within five miles of downtown Boulder use SOVs to get to work every day and occupy Boulder's limited stock of parking spaces.

In 2014, 40 percent of the downtown Boulder customers were full-time residents of Boulder, and 36 percent of Boulder residents used SOVs for transport around Boulder. Thus, given estimates that Boulder residents visit downtown Boulder 11,000 times per day on average,[20] there are approximately 4,000 SOV trips to downtown Boulder per day, further increasing congestion and requiring parking.

A primary complaint among residents in the downtown Boulder area is that visitors and employees in the area occupy parking spaces on residential streets. The neighborhood parking permit programs were created to manage this demand, but despite their success, commuters parking on neighborhood streets remains a challenge as demand increases. Although a few years ago it was relatively easy to obtain a permit to park downtown, today the waiting list for a permit is 1,800 people long. The increasing number of employees and visitors to downtown is likely to drive increased parking in residential areas, to the consternation of residents.

Though new commercial real estate is available in downtown Boulder, some is now unoccupied because employers are unwilling to move in when parking permits and spaces are not available for their employees. Unoccupied commercial space is a lost opportunity for tax revenue and job creation. As of late 2016, an estimated 80,000–100,000 square feet of commercial space was not leased due in part to parking issues.[21] Creating alternatives to personal vehicle use can reduce parking demand and improve the desirability of this commercial space.

[ii] EcoPass is an annual employer-sponsored pass providing employees unlimited rides on the Regional Transportation District's system. All downtown Boulder employees are eligible for a free EcoPass through CAGID.

DOWNTOWN BOULDER'S CHALLENGES TO GROW IN THE FUTURE

Under the projected build-out of downtown Boulder through 2035, the number of total employees is expected to increase 43 percent from 8,956 to 12,803. Similarly, the amount of downtown commercial space is expected to increase 39 percent and the number of residential units to increase by 67 percent.[22] With parking facilities already near capacity during afternoons, increased development will require additional parking structures and/or result in increased encroachment into residential neighborhoods, both of which have economic and public-perception costs. According to Fox, Tuttle, Hernandez, approximately 2,700 additional parking space equivalents will be required to support the planned build-out of downtown Boulder. Given this, it is necessary to decrease the demand for SOV parking in Boulder. Alternative ways must be created to satisfy the mobility needs of the population of employees, residents, and visitors.

Constructing 2,700 additional parking spaces (structures only, as on-street parking is saturated) would require an investment of $54 million.[iii] As eaMaaS becomes more prevalent, these investments could become stranded assets. Instead, Boulder could invest in accelerating the future of mobility. Door-to-Downtown (d2d) represents a bold first step in that direction.

[iii] RMI calculation is based on an assumption that 2,700 spaces are needed by 2035 at a cost of $20,000 per parking structure space. Spaces in parking structures range from $15,000 to $70,000 depending on a number of factors.

03 INNOVATIVE ACCESS TO DOWNTOWN BOULDER

INNOVATIVE ACCESS TO DOWNTOWN BOULDER

The City of Boulder, the Downtown Boulder Partnership (DBP), and local business owners recognize that downtown Boulder is faced with a paradoxical challenge. Residents, customers, and employers presently feel the constraint on downtown parking like never before. This results in some people no longer visiting downtown. At the same time, city planners also understand that building more parking is costly, and that it would likely become obsolete well before any reasonable amortization period on such a large capital investment. Further, the space that would be used for parking could be used for higher-value uses such as retail, office space, affordable housing, etc. Out of this common understanding, a project team was created, as shown in Figure 9, to quickly test innovative approaches to improve access to downtown Boulder.

FIGURE 9:
PROJECT TEAM STRUCTURE

The central project team for the pilot was composed of the City of Boulder's Department of Community Vitality, the Downtown Boulder Partnership, Rocky Mountain Institute, and Commutifi. Final decision-making authority lay with the Department of Community Vitality.

The specific goals agreed to by the partners are outlined in Table 2. In addition to high-level goals, it was important to develop a set of metrics against which the performance of the pilot could be measured. The metrics agreed to for the pilot are shown in Table 3. Section 5 details the performance of the pilot against these metrics. It is also important to note that this pilot was meant to test a specific hypothesis: If MaaS cost the same as driving and parking, people will use the service instead of driving their cars. Follow-on projects can and should incorporate a focus on other aspects of MaaS, for example, reduced congestion/VMT or reduced CO_2 emissions.

TABLE 2:
OVERARCHING PROJECT GOALS

Enhance commuters' and customers' accessibility to downtown Boulder
Improve economic vitality in downtown Boulder through improved experience for visitors and improved access for employees
Reduce parking demand
Reduce vehicle miles traveled (VMT)
Reduce carbon intensity of traveling to downtown Boulder
Use the pilot program in downtown Boulder as a model for other areas of the city

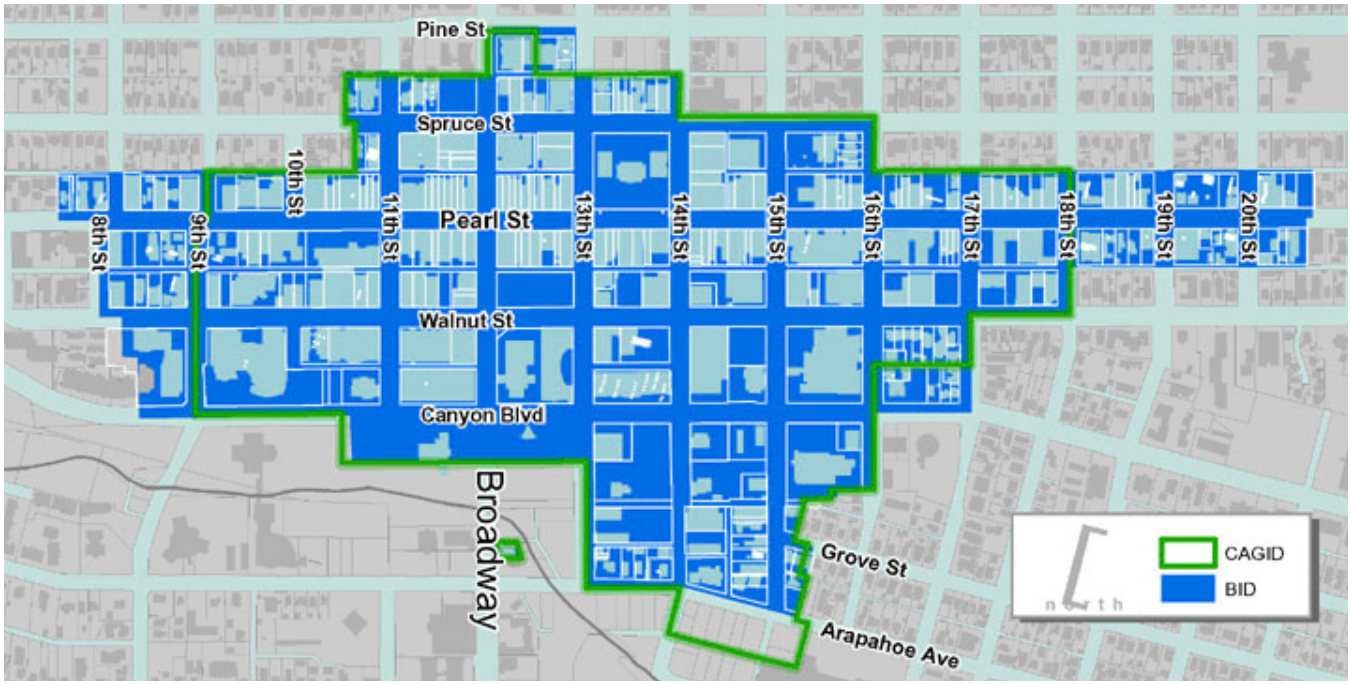
TABLE 3:
METRICS FOR SUCCESS

Mode share (in particular SOV share)
Number of users/repeat users
VMT
Parking demand
Carbon emissions reduction
Ease of use
Improved perception of parking availability for consumers

BOULDER CENTRAL AREA GENERAL IMPROVEMENT DISTRICT (CAGID)

CAGID and the City of Boulder's Department of Community Vitality are responsible for providing parking and access to downtown, as defined on the map shown in Figure 10. Funding for these operations comes from parking and property tax revenue within the district. Funds can only be expended to explicitly advance parking and access within the district. Because the Department of Community Vitality was the primary champion and funder of this pilot program, the pilot had to focus on providing access to downtown. Therefore, the scope was limited up front to downtown commuters and patrons of downtown shops and restaurants. Nevertheless, the entire team recognized the opportunity to take lessons learned from the pilot and apply them to other parts of Boulder or the city as a whole.

FIGURE 10:
MAP OF THE BOULDER CENTRAL AREA GENERAL IMPROVEMENT DISTRICT



EVALUATING MULTIPLE PILOT APPROACHES

At the start of the program, Rocky Mountain Institute (RMI) conducted comprehensive research so that the team could understand the challenges, opportunities, potential impact, and cost associated with various possible approaches. Using the results of this research, the team developed a menu of service models and analyzed them against the goals and metrics outlined above as well as the cost and risk of implementation. Table 4 summarizes these service models.

TABLE 4:
CANDIDATE SERVICE MODELS

SERVICE	DESCRIPTION	COST STRUCTURE	CUSTOMERS
Shuttle service to and from satellite lots	Shuttle service moves car commuters to and from parking lots on the periphery of the city into downtown Boulder, encouraging commuters not to bring cars into downtown	Fixed	Employees
Subsidized transportation service provider trips to downtown	Create subsidized trips through transportation service providers to bring residents and local commuters into downtown without using SOVs	Variable	Visitors, locals, employees
Merchant-validated transportation service provider rides from downtown	Restaurants and shops provide subsidized transportation service to customers meeting minimum spending requirements	Variable	Visitors, locals
Valet services within CAGID	Merchants and city subsidize centralized valet services for customers to increase utilization of parking garages during evenings	Variable	Visitors, locals
Electric vehicles for transportation service providers	City provides support through guaranteed loans, subsidies, or partnerships with companies to provide electric vehicles for transportation services	Fixed	Visitors, locals
Parking right-pricing	City tunes the price for on-street and garage parking so that supply more closely matches demand, resulting in better parking availability and fewer cars circulating in search of parking	Variable	Visitors, locals

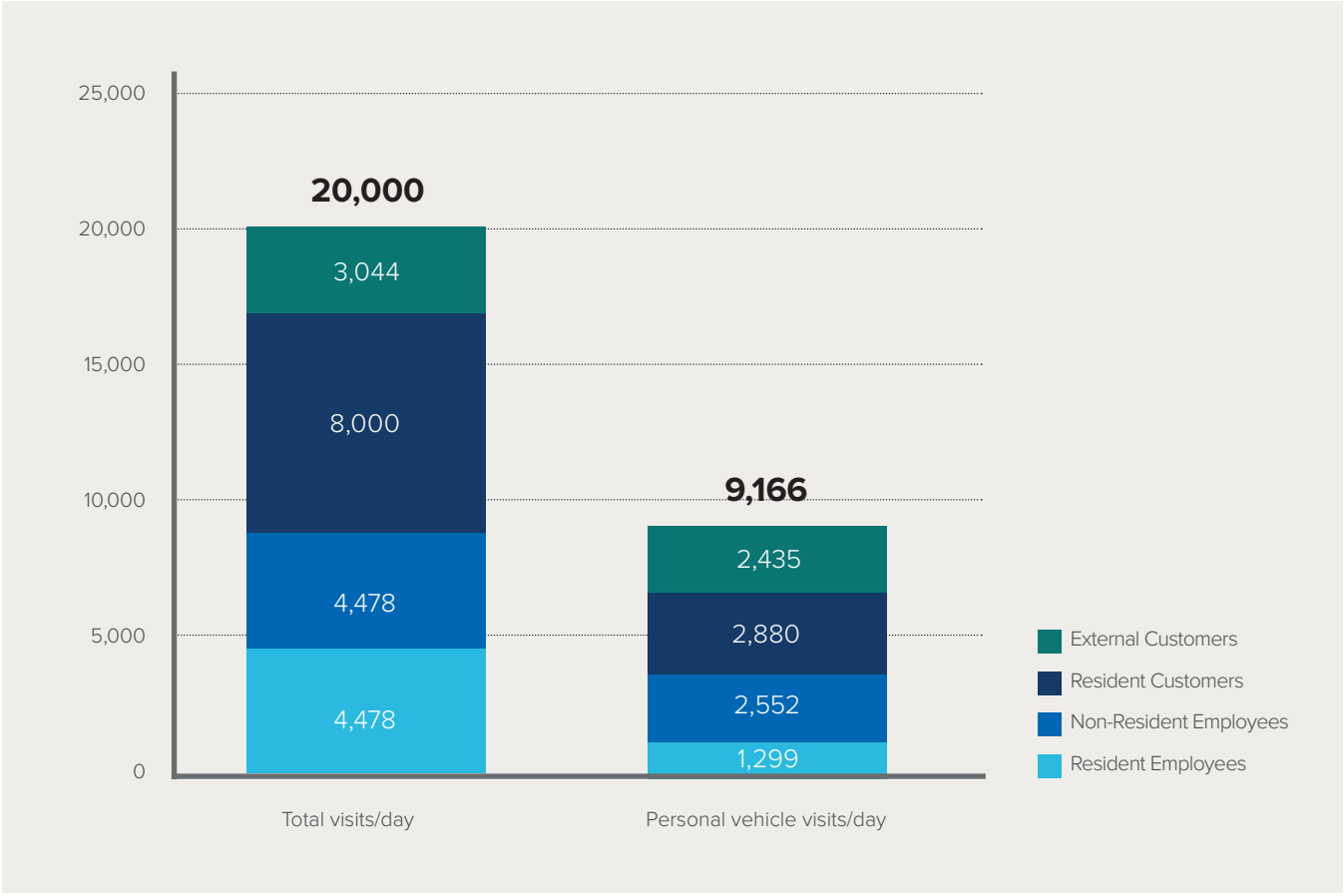
People coming into downtown Boulder can be broken down into one of four groups: 1) customers who reside outside of Boulder; 2) customers who reside within Boulder; 3) employees who reside outside of Boulder; and 4) employees who reside within Boulder. Each of these groups has different transportation needs and challenges, different trip lengths, and a different number of members. Because of these differences, providing an alternative means to reach downtown requires a distinctive approach, and has a unique cost and opportunity relative to the metrics outlined above. Figure 11 shows the total visits and SOV visits per day by each of these groups.

The project team decided to focus this pilot on customers (both local residents and nonresident visitors) coming into downtown because they are a large pool of SOV travelers and such a focus would mitigate the risk of exceeding the budget because of the lower anticipated adoption rate for customers compared with employees.

The initial analysis indicated that the three services with the greatest potential impact were:

1. City-subsidized shuttle service to and from satellite lots

FIGURE 11:
VISITS TO DOWNTOWN BOULDER PER DAY

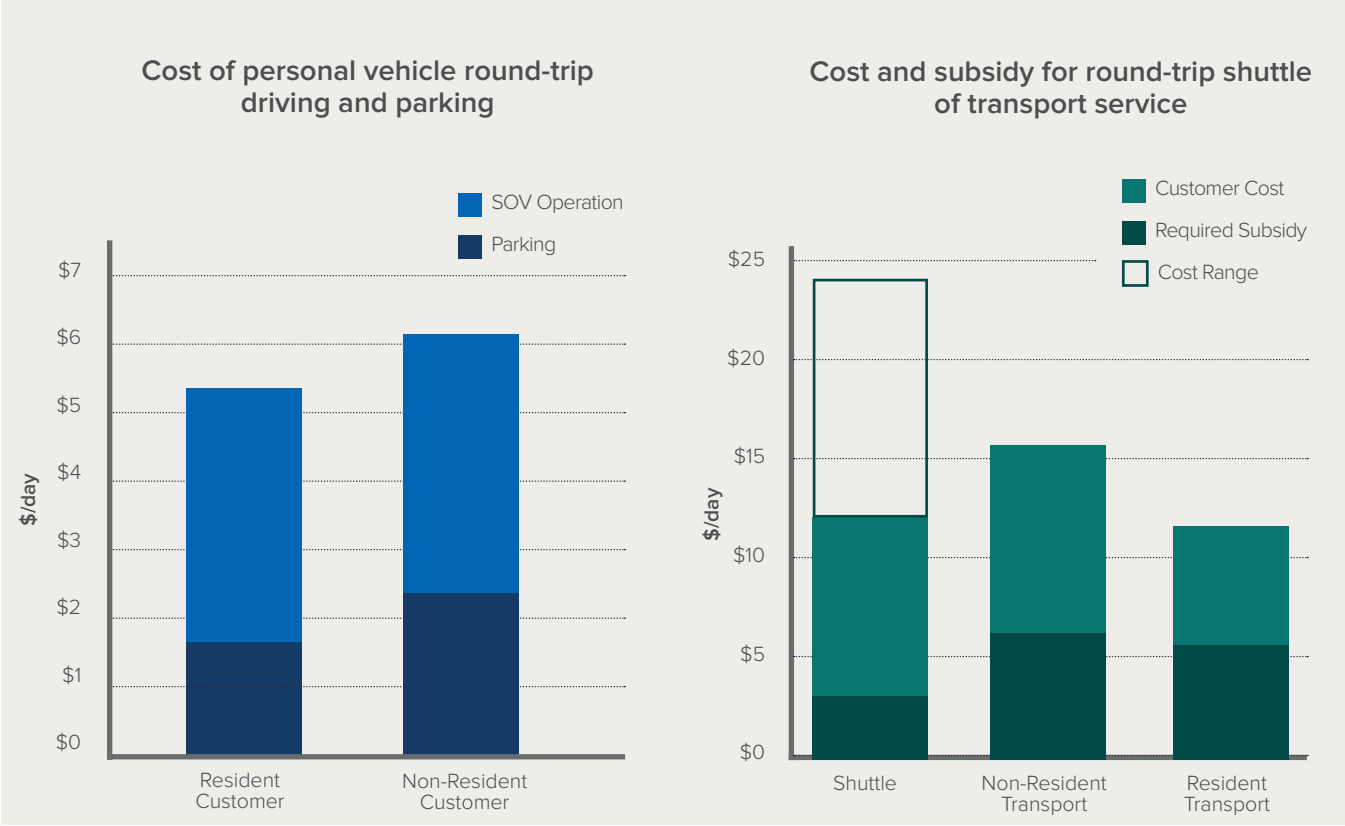


2. City-subsidized transportation-service-provider rides to downtown
3. Merchant-validated transportation-service-provider rides from downtown

These options could target large groups bringing personal vehicles into downtown. Originally, a six-month pilot was planned with costs calculated on a monthly basis. Options 2 and 3 were merged into a larger transportation service provider pilot, as it became clear both could be pursued simultaneously and were symbiotic.

To the extent possible, the consumer's cost for each of these services was intended to be equivalent to driving to and parking in downtown Boulder. There are two reasons for this: 1) it is easier to encourage behavior change if people do not have to pay a premium; and 2) the coming paradigm shift in personal mobility promises to provide ubiquitous, door-to-door service for a cost equal to that of driving and parking as soon as 2020.[23] Therefore, one of the goals of the pilot was to test, in the real world, what demand looks like for a service that is equal in cost to driving and parking. As a result, the City subsidy for each different model was calculated based on the difference between the actual cost of that service in 2016 and the consumer's cost of driving and parking his or her vehicle in downtown Boulder. Figure 12 shows this cost comparison.

FIGURE 12:
COST OF DRIVING PLUS PARKING VS. SERVICE OPTIONS



THE IMPORTANCE OF FIXED- VS. VARIABLE-COST APPROACHES

Because of the uncertainty involved with these cutting-edge approaches, it was important to mitigate risk. One of the biggest risks associated with this program was the uncertainty of how many people would use the service. In general, fixed-cost services like vans and buses are more cost-effective at higher ridership levels, whereas services that charge on a per-ride basis are more cost-effective for lower levels of ridership. If the chosen service model has mostly fixed costs, there's a distinct possibility that the cost per rider delivered could be prohibitive if ridership is low. There are several examples from around the United States where this has happened. An approach that uses a variable cost that scales with ridership alleviates this risk.

Of course, if ridership is greater than expected, the budget could be quickly exceeded. Two things were done to mitigate this risk. The first was understanding at which ridership levels it makes financial sense to switch to larger, contracted vehicles. Since the pilot was closely monitored, if ridership levels threatened to exceed this threshold, the team would be able to pivot toward larger vehicles on a fixed contract. Second, a safety switch was built into the program that capped the City's subsidy expenditure and allowed the pilot to stop if the subsidy was exhausted.

Detailed analysis by RMI determined the following for programs accommodating both downtown Boulder customers and commuters:

Shuttle Service

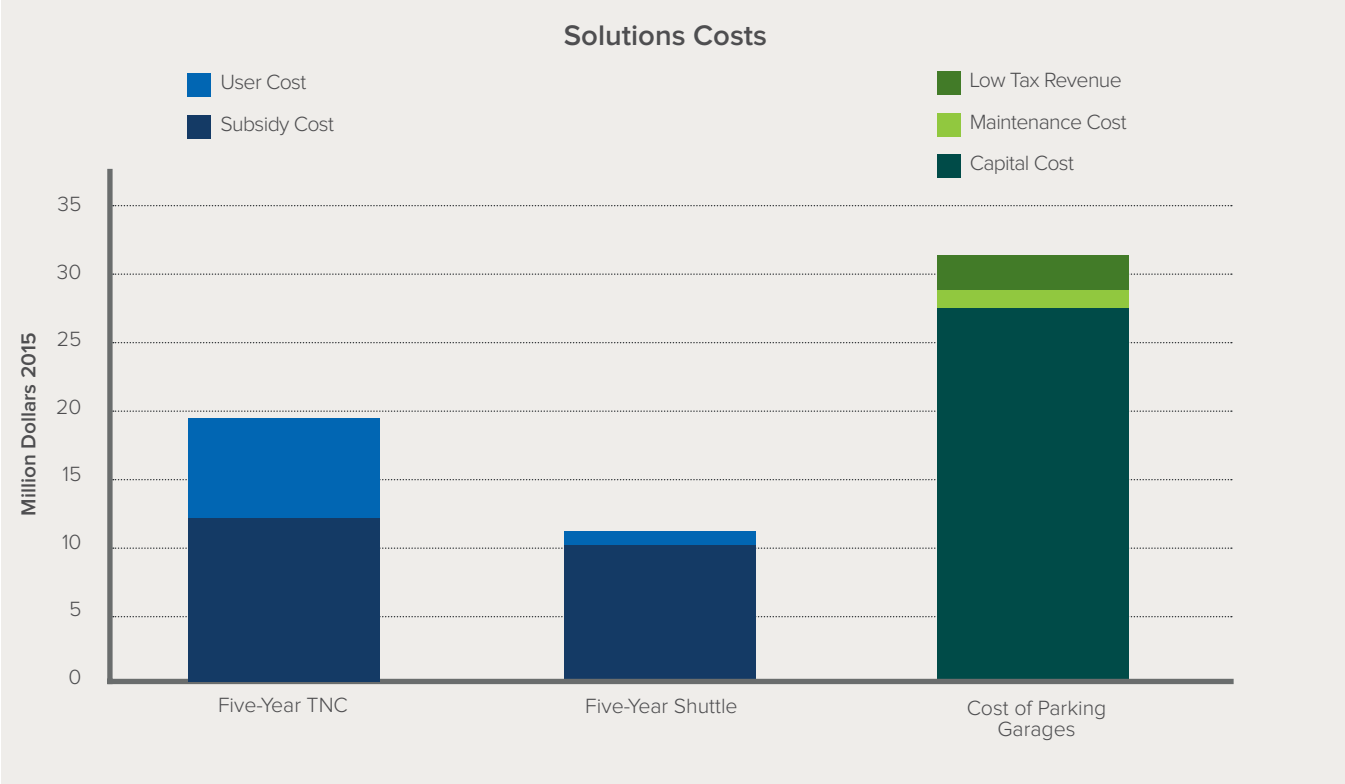
- Over a six-month pilot, costs for a shuttle service are fixed. Six shuttles (to meet continual demand from two external parking lots) will cost $1,117,000 regardless of ridership
- The model planned on a cost to the customer of $1.50/ride, with the remaining cost covered by the City

Transportation Service

- The cost of a six-month pilot with a transportation service provider (TSP) depends on uptake by customers and the subsidy offered by the City. With a 50 percent subsidy, the cost could be as low as $588,000 for 10 percent adoption by current customer and commuter personal vehicle users and up to $1,565,000 for adoption by 30 percent of personal vehicle users
- Changes to the subsidy affect ridership and the amount paid by the City

The above costs, although seemingly expensive, are in fact low when compared to the cost of building additional parking. Figure 13 shows the cost comparison between the TSP-based service and building the amount of parking required to meet Boulder's expected parking demand growth in 2035. Furthermore, because the cost of mobility services is going to fall dramatically in the next five years, the subsidy required to make mobility services competitive with driving and parking will decrease in lockstep. As a result, the City could invest less money while improving access to downtown and allowing space that would otherwise be used for parking to be developed for higher-value uses.

FIGURE 13:
COST OVER FIVE YEARS OF MOBILITY SERVICES VS. NEW PARKING[IV]



[iv] 2,700 parking spaces needed by 2035 at a cost of $20,000 per space (parking structure, as street parking is filled). Lost tax income averages at $5.80/sq. ft. for commercial space, with 675,000 sq. ft. lost to parking by 2035. Parking garage maintenance is $300 per space per year. Parking garage costs are only for expansions by 2022.

FINAL PILOT APPROACH

The project team conducted a rigorous, iterative design process, taking into account input from the entire advisory team, to settle on the final approach: Door-to-Downtown, or d2d, as it became known in Boulder. Retail and restaurant customers were the targeted audience since they drive economic vitality while not prematurely exhausting the budget. Time-of-day limits were set to correspond to the operating hours of downtown retailers and restaurants.

The discount provided to the customer was designed to achieve two things: 1) to lower the cost of a TSP ride to downtown to compete with driving and parking for the average Boulder resident by providing a $5-per-ride discount; and 2) to provide enough trips to allow people to become comfortable and habituated to using mobility services. This would also allow the advisory team to study patterns of repeat ridership. As a result, individuals were provided with discounts on five inbound trips.

The City provided a $4-per-ride subsidy for inbound rides that was matched by an additional $1 discount from the TSPs. Additionally, the City was paid a fee by the TSPs for each new customer who registered and took his or her first ride. To be eligible for the discount, the inbound rides could begin anywhere but had to end within downtown Boulder. This was a key enabler as it permitted CAGID funds to be used for the pilot.

In parallel, but independent from the City, Downtown Boulder Partnership, RMI, and Commutifi developed a program that enabled interested downtown merchants to provide their customers with a $5 discount for their ride home with a minimum purchase of $50.

The pilot utilized transportation network companies (TNCs) and taxis because they charge on a per-ride basis, instead of larger, contracted shuttles. This approach would help mitigate the risk of low initial ridership. Given that the pilot would only run for five weeks, with an option for six additional weeks, it was unlikely that ridership would grow quickly enough to justify the investment in a contracted shuttle service, even though the potential size of the market could mean it would be a more cost-effective approach in the long term.

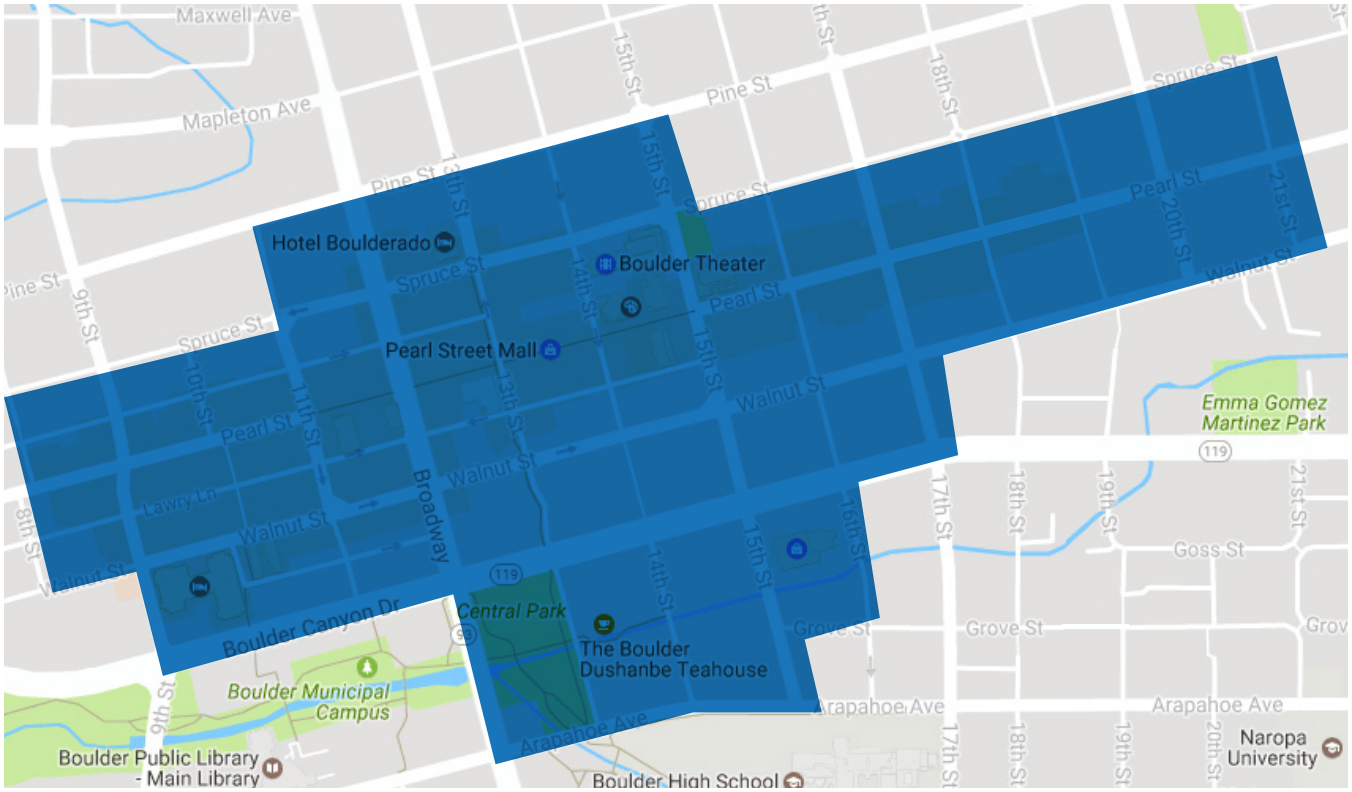
For this initial pilot, the team elected not to require pooling of rides (e.g., UberPOOL or Lyft Line, where riders traveling along a similar path are matched together to share a car) because the goal was to make the barrier to new customers as low as possible given the behavior change required. Requiring pooled rides is a recommended addition to a future expansion.

In order to streamline the user experience (described in detail below), passenger discounts would be distributed to their smartphones via Commutifi.

The basic pilot structure is below:

- **Duration:** November 25, 2016–January 1, 2017, with option to extend to February 14, 2017 (this option was exercised)
- **Timing:** 11:00 a.m.–9:00 p.m. (focus on bringing retail and restaurant customers to downtown)
- **Coupon Amount and Limits:** $5 off five rides into downtown CAGID area
  - Transport service providers pay $1 of discount, city pays $4 of discount
  - No limit on the number of merchant-discounted rides from downtown
  - Subsidy budget of $22,400
- **Geofence Limits:** The destination for inbound rides is limited to CAGID in downtown Boulder (see Figure 14 on the next page)
- **City Bonuses:** Participating transportation service providers pay the City a fee for each new user who registers through d2d and takes his or her first ride
- **Distribution Method:** Commutifi sends digital coupons directly to customers' smartphones

FIGURE 14:
D2D SERVICE MAP



SECURING TRANSPORTATION SERVICE PROVIDERS

A critical facet of the pilot program was to open participation to all providers who could meet the requirements outlined above. This had several benefits, including avoiding the time and cost associated with a formal RFP, fostering beneficial competition, and providing diverse service options to the community.

CUSTOMER EXPERIENCE

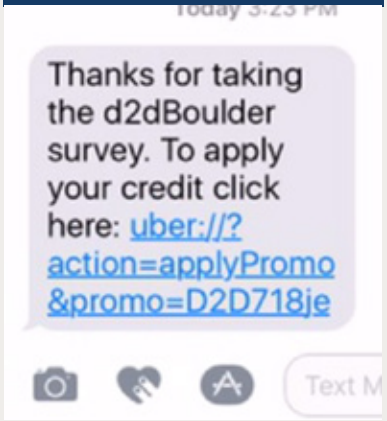
The d2d user experience was smartphone based, as shown in detail in Figure 15 on the next page. Commutifi delivered coupons after customers completed the initial survey and registration process, and sent follow-up surveys to users at later points in the pilot.

FIGURE 15:
CUSTOMER SIGNUP AND USAGE

STEP 1: SURVEY

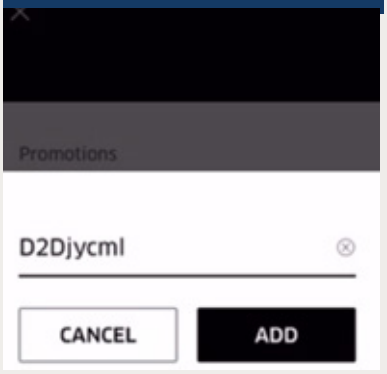
Survey to be completed by user d2dboulder.com

STEP 2: COUPON



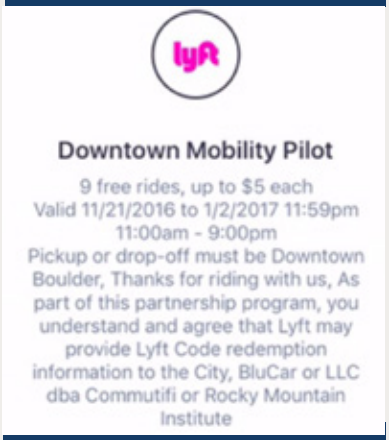
Coupon is sent to user's phone

STEP 3: DELIVERY



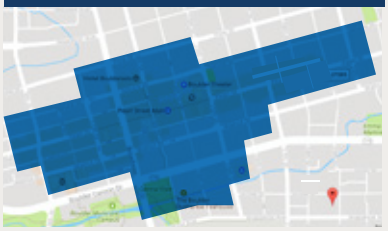
Users click on link and coupon opens their application or asks them to sign up

STEP 4: CREDIT



Credit is applied

STEP 5: JOURNEY



User rides to CAGID area in downtown Boulder

STEP 6: SURVEY

Follow-up survey is sent to user's phone later

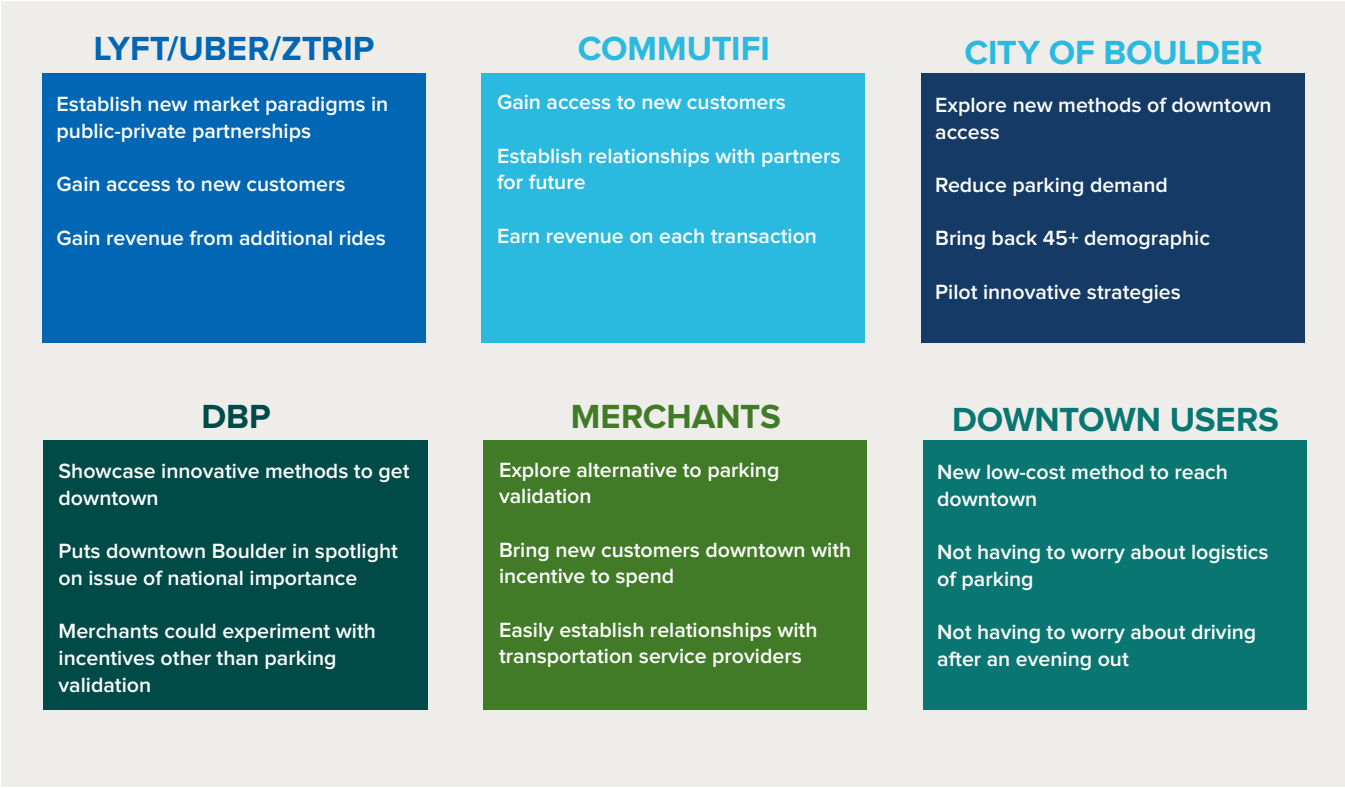
PUBLIC-PRIVATE PARTNERSHIP

The success of d2d is due, in no small part, to the shared value that enabled a robust public-private partnership (P3). As shown in Figure 16, the City, DBP, service providers, and merchants all derived value from the pilot. As a result, all parties were willing to make substantive contributions of both human and financial resources. The result was a robust and compelling offering to the customer that distributed the costs such that all parties felt justified in making the investment.

As noted below, participation in this program was open to any transportation service provider that could and would meet the requirements laid out by the team. The new integrated approach required flexibility on these requirements to secure the desired diversity of services. The resulting compromises entailed greater consideration in one area in lieu of precise compliance with a requirement. However, in all cases, the compromises created a net positive for the City and for customers.

Ultimately, Lyft, Uber, and zTrip partnered on d2d to provide the actual transportation. Each provided a $1 discount to match the City's $4 subsidy, giving the passenger a final discount of $5. In addition, these partners helped with marketing d2d both through

FIGURE 16:
VALUE PROPOSITION



their email lists and with ambassadors on Pearl Street, downtown Boulder's main retail street. zTrip also provided wheelchair accessible rides for customers with disabilities (discussed in further detail below).

Merchants received value from the marketing campaign and customers potentially targeting their businesses because of the return-trip discount. DBP was able to recruit 19 merchants to participate by offering a $5 discount for the return trip if the customer spent $50 or more. This discount was distributed via Commutifi's platform using the customer's cell phone number. The $5 cost to the merchant was similar to what many already pay for parking validation for their customers. By bringing local merchants into d2d, customers could receive a discount on their return trip without any cost to the City. Local merchants participating in the program included:

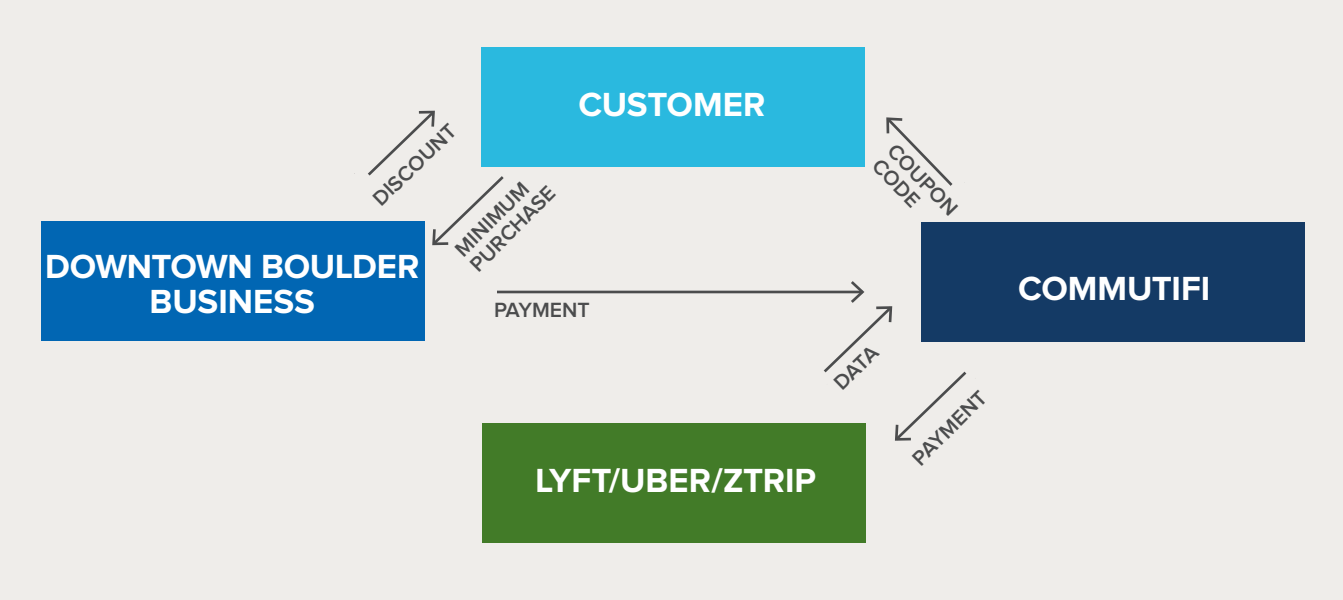
- Arcana Restaurant
- Art Source International Inc.
- Bliss
- Bodywork Bistro
- Boulder Book Store
- Hurdle's Jewelry
- Liquor Mart
- Pasta Jay's
- Patagonia, Inc.
- Paul Morrison Colours Ltd.
- Pedestrian Shops
- Ramble on Pearl
- Rio Grande Mexican Restaurant
- SALT the Bistro
- Savory Spice
- Weekends
- West Flanders Brewing Company
- Wild Standard
- Zeal

COMMUTIFI CONNECTED TRANSPORTATION SERVICE PROVIDERS, PASSENGERS, AND MERCHANTS

Commutifi, the platform upon which d2d was built, was key to enabling multiple providers to participate in a way that was seamless to the end user. The TSPs provided digital coupons to Commutifi before the public start of the pilot. When users registered through the survey, selected their transportation service of choice, and provided their cell phone number, Commutifi would automatically and instantly send the user a text message. This text message contained the appropriate coupon and "deep linking" into Uber's and Lyft's applications. Deep linking provides application interoperability between a native app or Web view and the native TSP application. Deep links are simply URLs that reference the TSP app and support query parameters to affect the TSP app's behavior once launched. When the user clicked on this link in the text message, the coupon was automatically loaded into the correct application and instantly provided the discount. Commutifi's system also prevented people from attempting to register more than once and/or with multiple providers.

For merchant-validated return trips, Commutifi created an open market that enabled the merchants to easily participate in d2d. When a merchant validated a customer's return trip, Commutifi provided a coupon code directly to the customer and billed the merchant for the code. In doing so, merchants did not have to set up arrangements with multiple transportation service providers. The Commutifi platform also gave business owners real-time visibility on the validations issued by their employees. Figure 17 shows the mechanics of how payments and coupons flowed for the return trip.

FIGURE 17:
RETURN-TRIP COUPON AND PAYMENT FLOWS



EQUAL ACCESS

The Americans with Disabilities Act (ADA) requires that equal access be provided to customers with disabilities. zTrip, which has handicapped-accessible vehicles operating regularly in Boulder, agreed to add this service to the program.

Additionally, Title VI of the Civil Rights Act requires equal access regardless of economic status, meaning that d2d has to be accessible to those without a smartphone. To overcome this challenge, zTrip, which has a telephone-based dispatch system, provided a means for people without a smartphone to access the d2d program. Those in need of a wheelchair-accessible vehicle made their request through the same phone system.

PERFORMANCE MONITORING

The team closely tracked the performance of the pilot. Commutifi, Lyft, Uber, and zTrip reported weekly on registrations, ridership, and other metrics. This data was anonymized in order to meet confidentiality requirements, but allowed the constant measurement of key success metrics:

- Budget vs. actual
- Mode share (in particular personal vehicle share)
- Number of users and repeat usage
- Riders per day
- Parking demand
- Ease of use

Measuring these metrics was key to ensuring d2d was meeting CAGID goals of increasing downtown access for customers and alleviating parking pressure. It also provided the opportunity for midcourse correction, if needed, as well as ensuring that the subsidy did not exceed the budget.

CUSTOMER DEMOGRAPHICS, SATISFACTION, AND FEEDBACK CAPTURED THROUGH SURVEYS

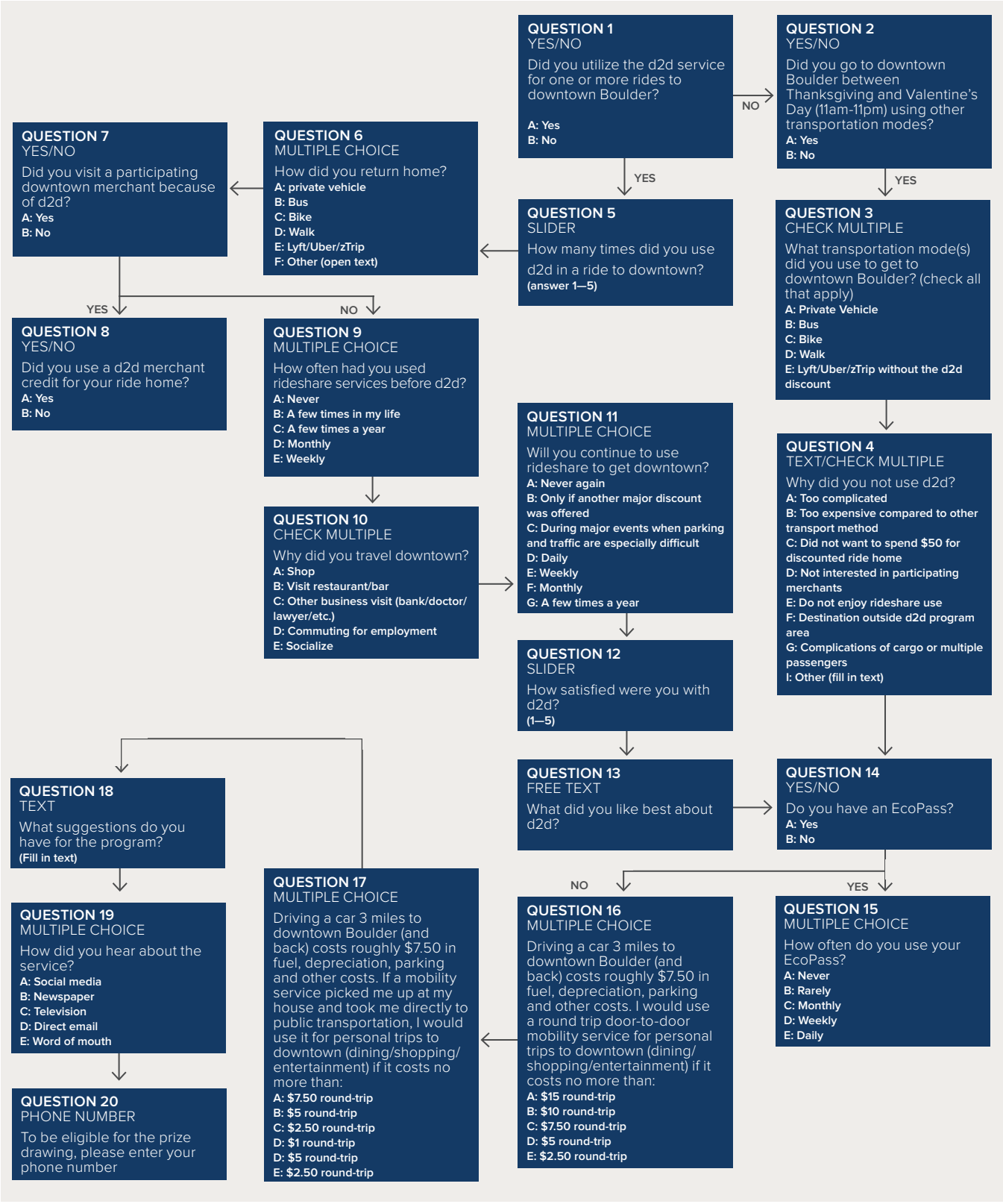
The team gave three surveys to d2d users over the course of the pilot. Users were required to submit the initial survey in order to receive the discount. This survey was made as streamlined as possible in order to minimize the transactional friction and get the largest possible customer pool. The midstream survey, sent December 28, 2016, to d2d registrants, explored user satisfaction with and utilization of d2d. Users had to respond to this survey to receive an extension on the discount through February 14, 2017. The final survey, sent February 15, 2017, to registrants, asked lingering questions and explored users' interest in future MaaS offerings. In exchange for responding to this survey, customers were entered into a drawing for Lyft and Uber discounts and Downtown Boulder gift cards. The details of the first and second surveys are shown in Table 5. The details of the final survey are shown in Figure 18.

The survey results helped the team understand, almost in real time, who was using the service, how they were using it, and why. Additionally, the data revealed important insights that will help improve any future efforts to expand and enhance this program. The results from these surveys and lessons learned are discussed in sections 5 and 6, respectively.

TABLE 5:
SURVEY QUESTIONS

QUESTION	FIRST SURVEY	SECOND SURVEY
1	What is your age in years?	How did you hear about d2d?
2	What is your home zip code?	Have you used d2d yet?
3	How many times did you visit downtown Boulder in the last two months?	Why have you not used the d2d program yet? (if #2 = no)
4	How would you usually travel to downtown Boulder?	How much did you individually spend on your visit to downtown after taking the d2d? (if #2 = yes)
5	What is your reason for using the d2d service?	Compared to how you usually get downtown, how easy was the d2d service to use?
6	What do you plan to do while you are downtown?	On average when you used d2d, how many were in your party (including yourself)?
7	Which rideshare partner would you like to receive your credits on?	What services did you use while downtown?

FIGURE 18:
FINAL D2D CUSTOMER SURVEY



04 MARKETING D2D

MARKETING D2D

The marketing campaign was a coordinated effort that included news coverage, digital direct mail, Facebook ads, online billboards, newsletter mentions, print ads, tweets, and blog posts. The details are shown in Table 6 and Figure 19.

TABLE 6: PART 1
MARKETING CAMPAIGN

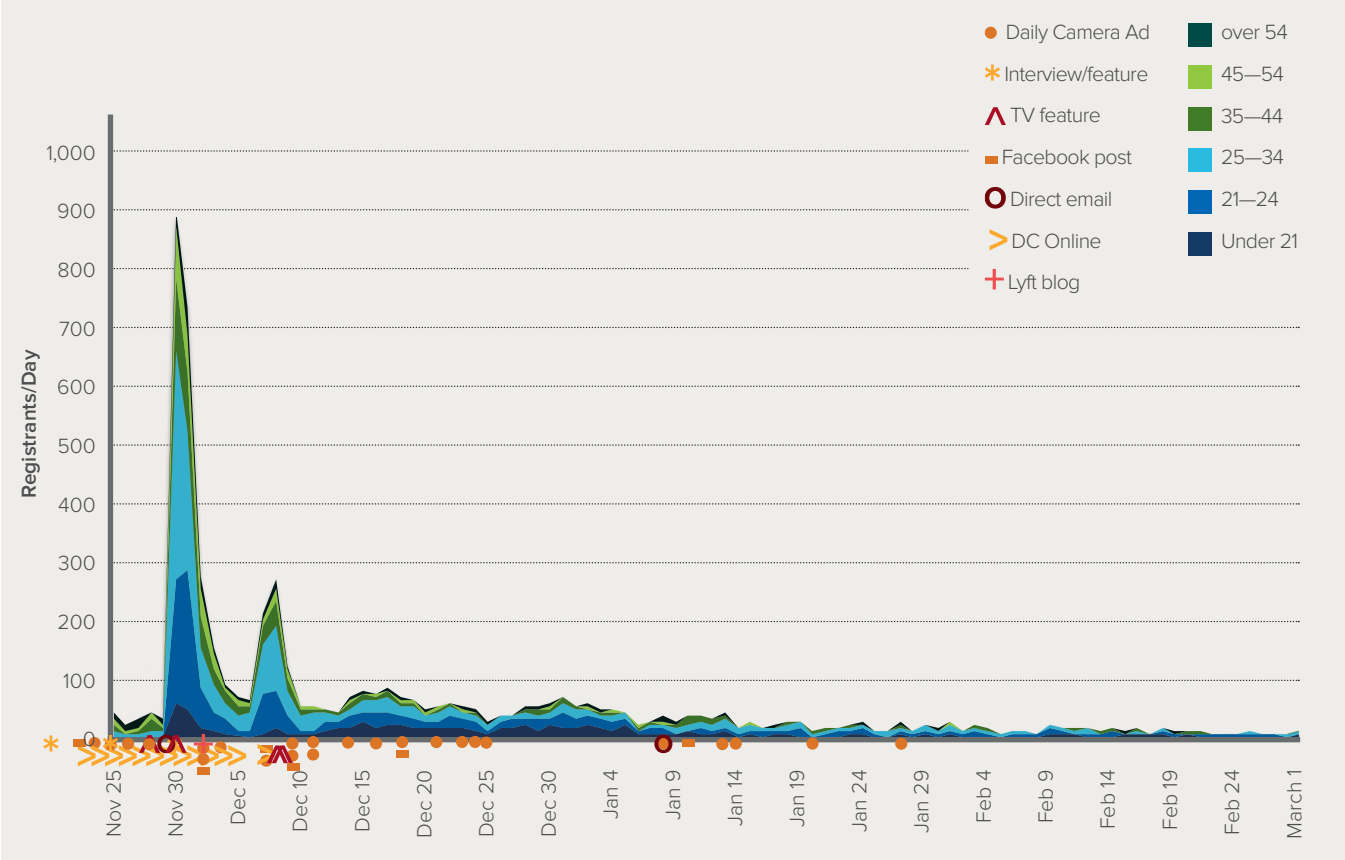
DATE	MARKETING EFFORT
November 19	Daily Camera editorial
November 23	Daily Camera 4C X 10 ad
November 23	DailyCamera.com – sliding billboard
November 23—December 5	DailyCamera.com – super big box ad
November 23	Daily Camera Facebook post
November 24	Daily Camera strip ad
November 25	Daily Camera strip ad
November 25	Inside Boulder interview
November 26	Daily Camera spadea (wrap) – Small Business Saturday
November 27	Fox News (KDVR) mention
November 27	Daily Camera 4C X 10 ad
November 29	Digital direct mail – 100,000 email addresses
November 30	Daily Camera blurb
November 30	Channel 7 (KMGH) mention
December 1	DailyCamera.com – sliding billboard
December 2	Lyft blog post
December 2	Daily Camera impact note (Post It)
December 2	Daily Camera Friday Magazine ad
December 2	Daily Camera Facebook post
December 4	Daily Camera 4C X 10 ad
December 7	Boulder Now Facebook Post
December 7	Daily Camera 1/2 page ad
December 7	DailyCamera.com – sliding billboard
December 8	9 News (KUSA) mention

TABLE 6: PART 2
MARKETING CAMPAIGN

DATE	MARKETING EFFORT
December 9	Colorado & Company (KUSA) interview
December 9	Daily Camera Friday Magazine ad
December 9	Daily Camera Facebook post
December 11	Daily Camera impact note (Post It)
December 11	Daily Camera 4C X 10 ad
December 14	Daily Camera 1/2 page ad
December 16	Daily Camera Friday Magazine ad
December 18	Daily Camera 4C X 10 ad
December 18	Daily Camera Facebook post
December 21	Daily Camera 1/2 page ad
December 23	Daily Camera Friday Magazine ad
December 24	Daily Camera Friday Magazine ad
December 25	Daily Camera 4C X 10 ad
January 8	Daily Camera full-page ad
January 8	Digital Direct Mail – 50,000 email addresses
January 10	Daily Camera Facebook post
January 13	Daily Camera Friday Magazine ad
January 14	Daily Camera Facebook post
January 20	Daily Camera Friday Magazine ad
January 27	Daily Camera Friday Magazine ad

MARKETING EFFECTIVENESS

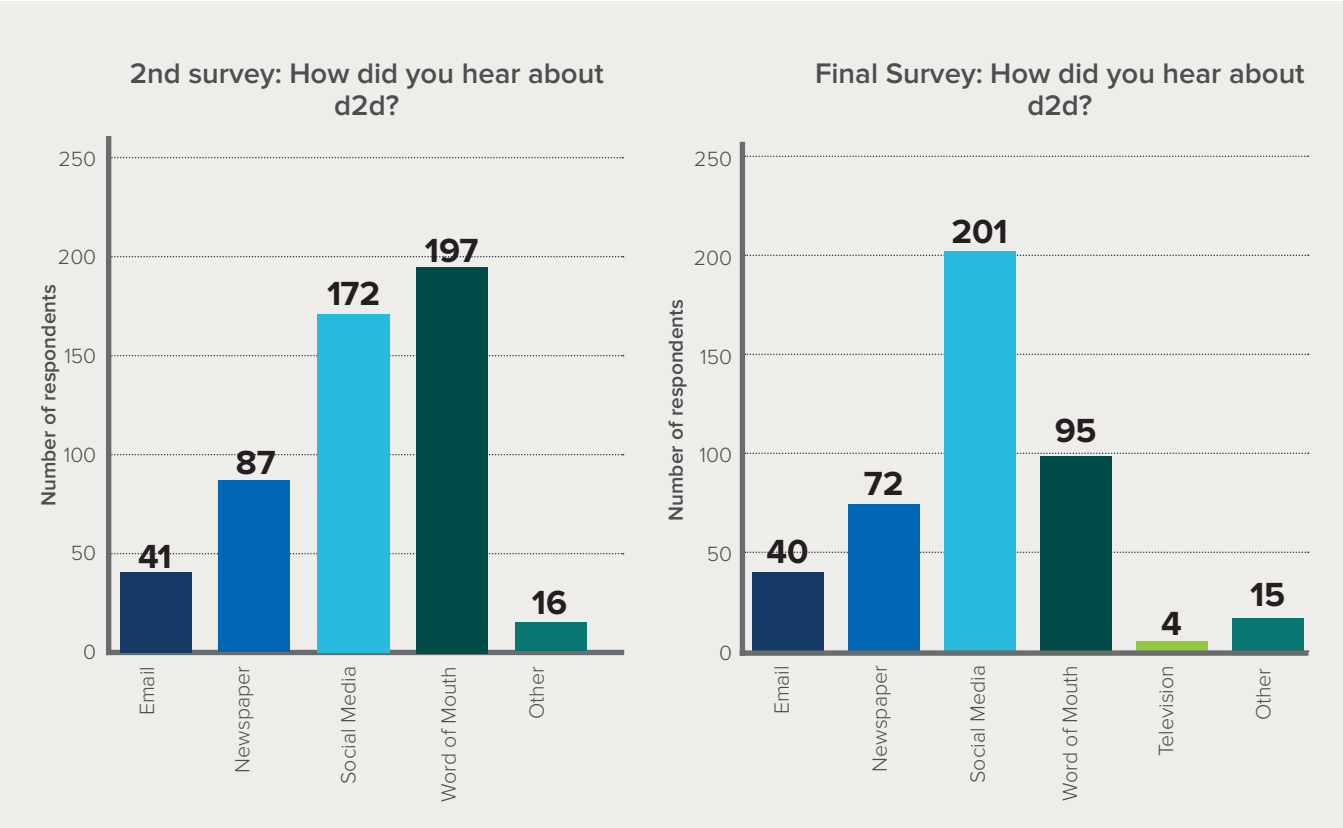
FIGURE 19:
REGISTRATIONS BY DEMOGRAPHIC VS. MARKETING ACTIONS



It is difficult to measure the exact effect of each advertising method on registrations because many different methods were deployed concurrently or spaced closely together. However, the biggest jumps came after the Facebook advertisements and the digital direct mail events. In particular, the digital direct mail had by far the largest jump in registration for the 45+ demographic—a success worth noting given that this was the priority demographic targeted by the program.

As shown in Figure 20, respondents to the second and final surveys indicated that the two most common ways they learned of d2d were social media posts and word of mouth. However, since neither of these surveys included age-related questions, the effectiveness of each advertising method cannot be correlated with age.

FIGURE 20:
HOW REGISTRANTS LEARNED OF D2D



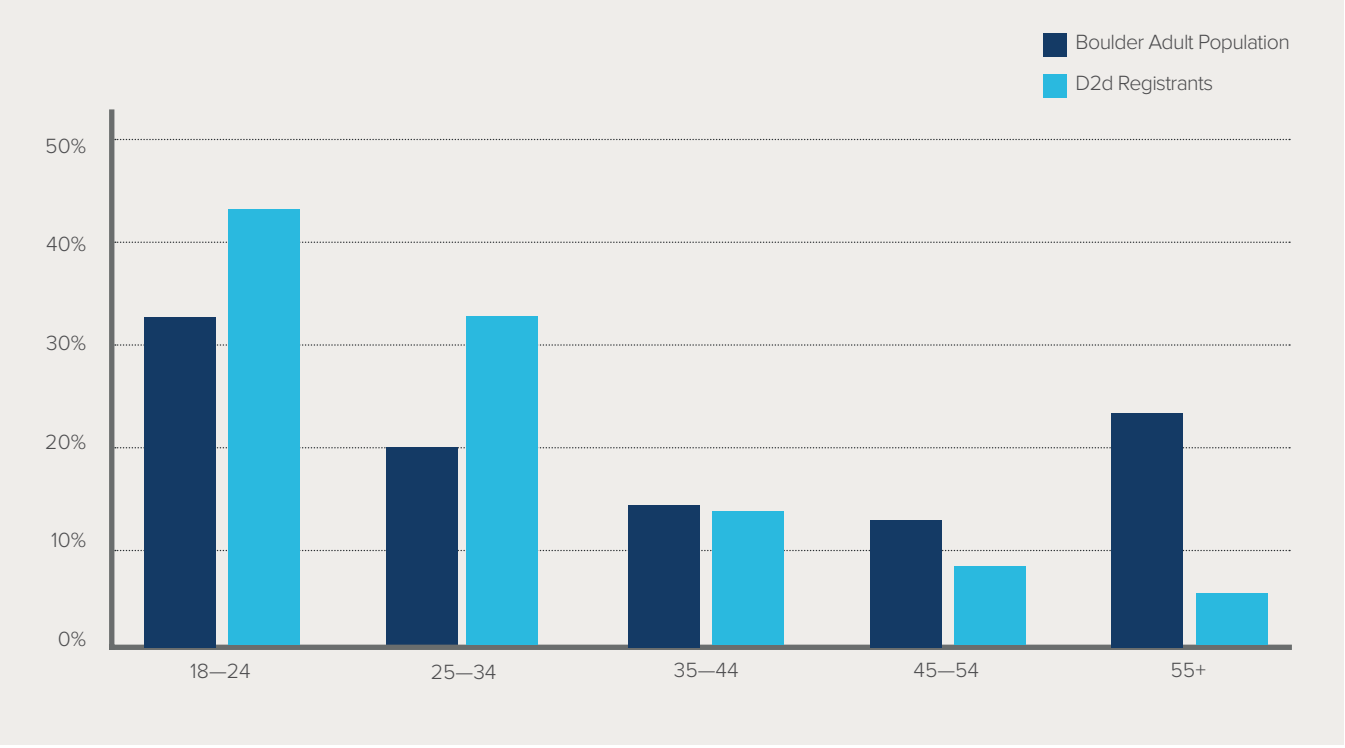
05 D2D RESULTS

D2D RESULTS

REGISTRATION

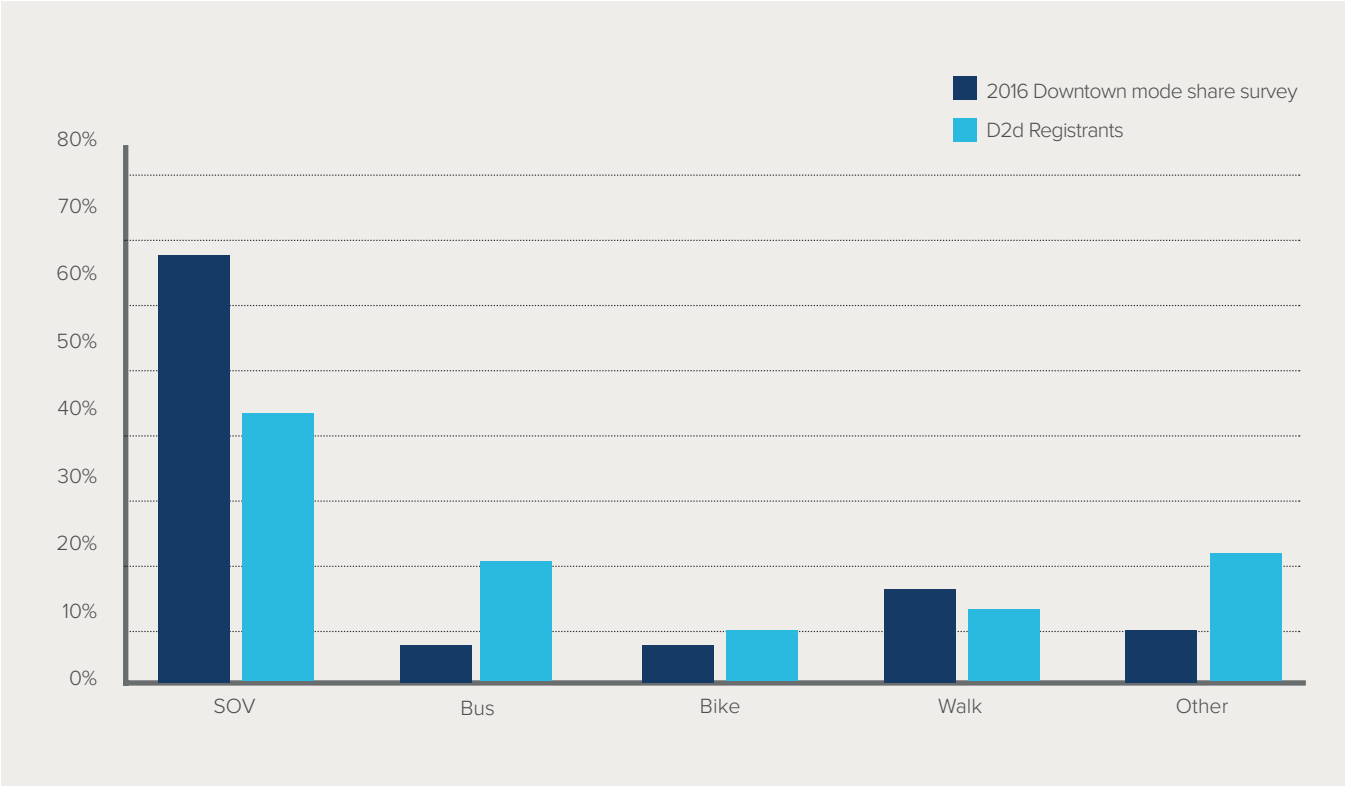
At the conclusion of the program, 5,400 participants had registered for d2d. The ages of registrants are shown in Figure 21. As noted previously, one of the goals of the program was to attract the 45+ demographic. It proved challenging to convert that cohort into active users. Nevertheless, because parking demand was reduced due to participation by other age groups, the availability of parking for those who still preferred to drive was improved. Additionally, traditional assumptions about the younger demographics, namely that they do not spend very much downtown, may no longer be true. The data suggests that d2d riders spent a healthy amount while downtown. The younger demographic are benefiting from the surge in tech jobs in Boulder, giving them more disposable income.

FIGURE 21:
AGE DISTRIBUTION OF D2D REGISTRANTS VS. BOULDER ADULT POPULATION



When asked how they would usually travel to downtown (Figure 22), 42 percent of registrants reported that they would have come by single-occupant vehicle, which is lower than the percentage of SOV visitors reported in the Boulder Downtown User Survey from summer 2016. (Note: This is the only available information on mode-shares specifically for downtown.) A combined 38 percent reported that they would have taken the bus, biked, or walked. However, d2d occurred during December 2016 and January 2017, which were very cold and snowy. Many users reported in the final survey that they found great appeal in d2d because they did not have to wait in the cold for a bus or bike in snowy conditions. Additionally, the downtown user survey is conducted in the summer, meaning it is likely the high point of non-SOV access to downtown. For both of these reasons, it is not a completely equivalent comparison. Nevertheless, refinements could be made to any future program to more precisely target users who would otherwise take an SOV.

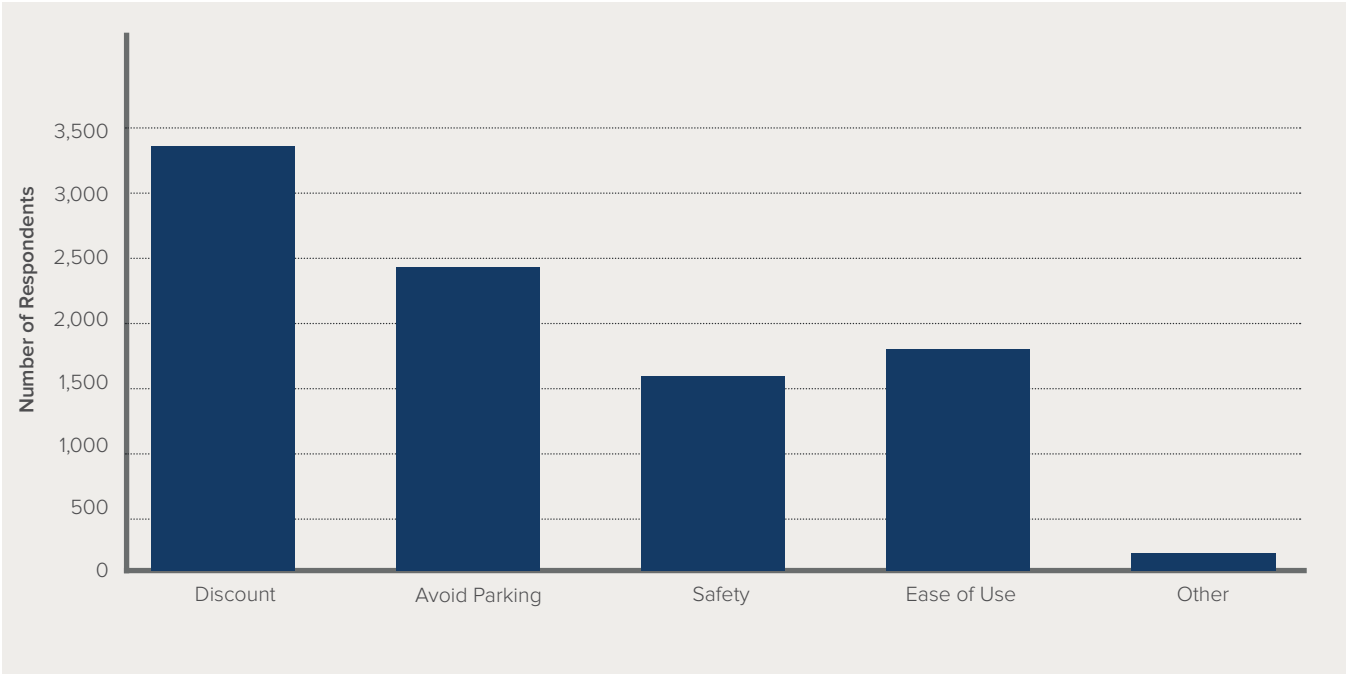
FIGURE 22:
MODE SHARE: D2D VS. DOWNTOWN USER SURVEY



The first survey asked why registrants chose to use d2d (Figure 23). Not surprisingly, the most common answer was the $5 off five rides. However, the second most common answer was to avoid parking (respondents could choose multiple answers).

The “other” category offered a wide variety of answers, the most popular being some variation on “to avoid cold weather.” Thus it would be interesting to see whether d2d would attract the same group of users during summer, when walking, biking, and taking public transit are much easier and more appealing. However, the second most popular answer in the “other” category was related to allowing users to avoid driving or otherwise navigating their way home after imbibing an intoxicant. This ties well with the ancillary benefits of MaaS, which helps avoid accidents caused by human errors—including intoxication.

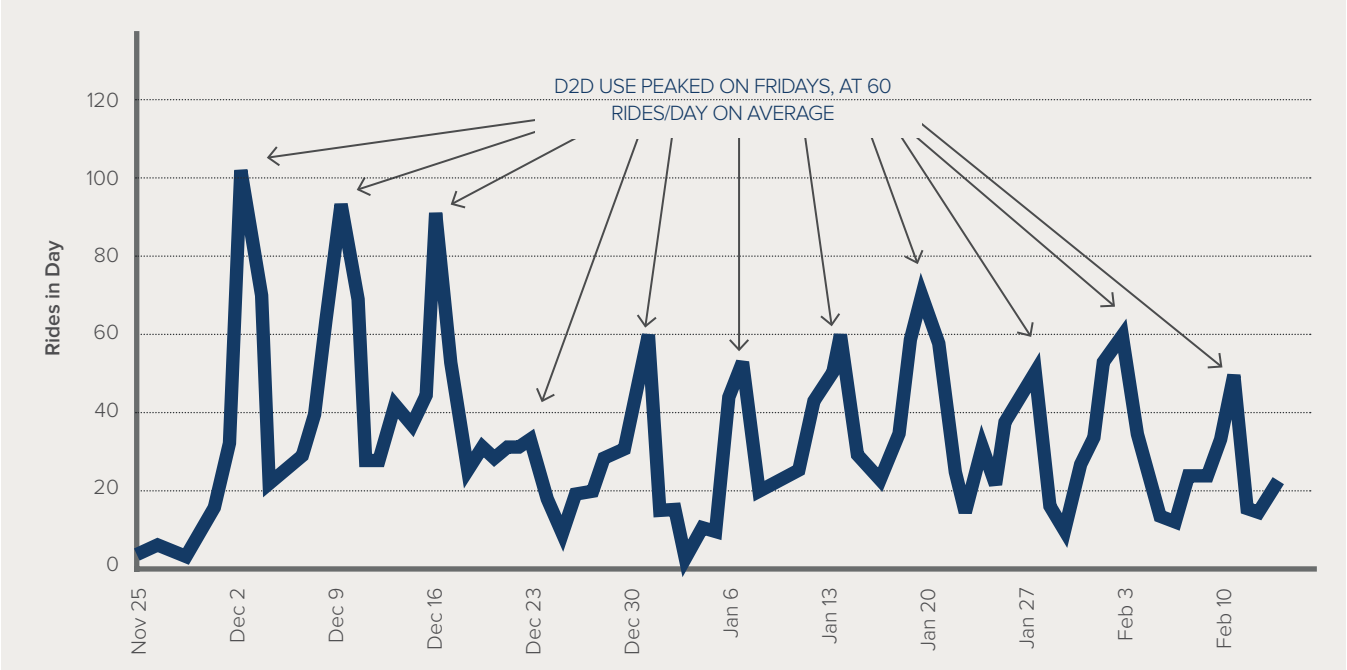
FIGURE 23:
REASONS FOR USING D2D



TRIPS TAKEN

Over the course of the project, registered users took 2,477 trips by Lyft, Uber, and zTrip combined. At a cost to the City of $4/ride, this should equate to $9,908. However, the actual number was $9,802, as a few trips did not use the whole $5 subsidy. Thus the total cost was well under the subsidy budget of $22,400. Trips per day for the entire pilot are shown in Figure 24. With an average of 60 trips per day, Friday consistently had the largest number of trips (Saturday came in second at 54 trips per day on average).[v] This indicates that d2d had the largest impact precisely on the day when finding parking is the biggest challenge.

FIGURE 24:
NUMBER OF RIDES OVER TIME

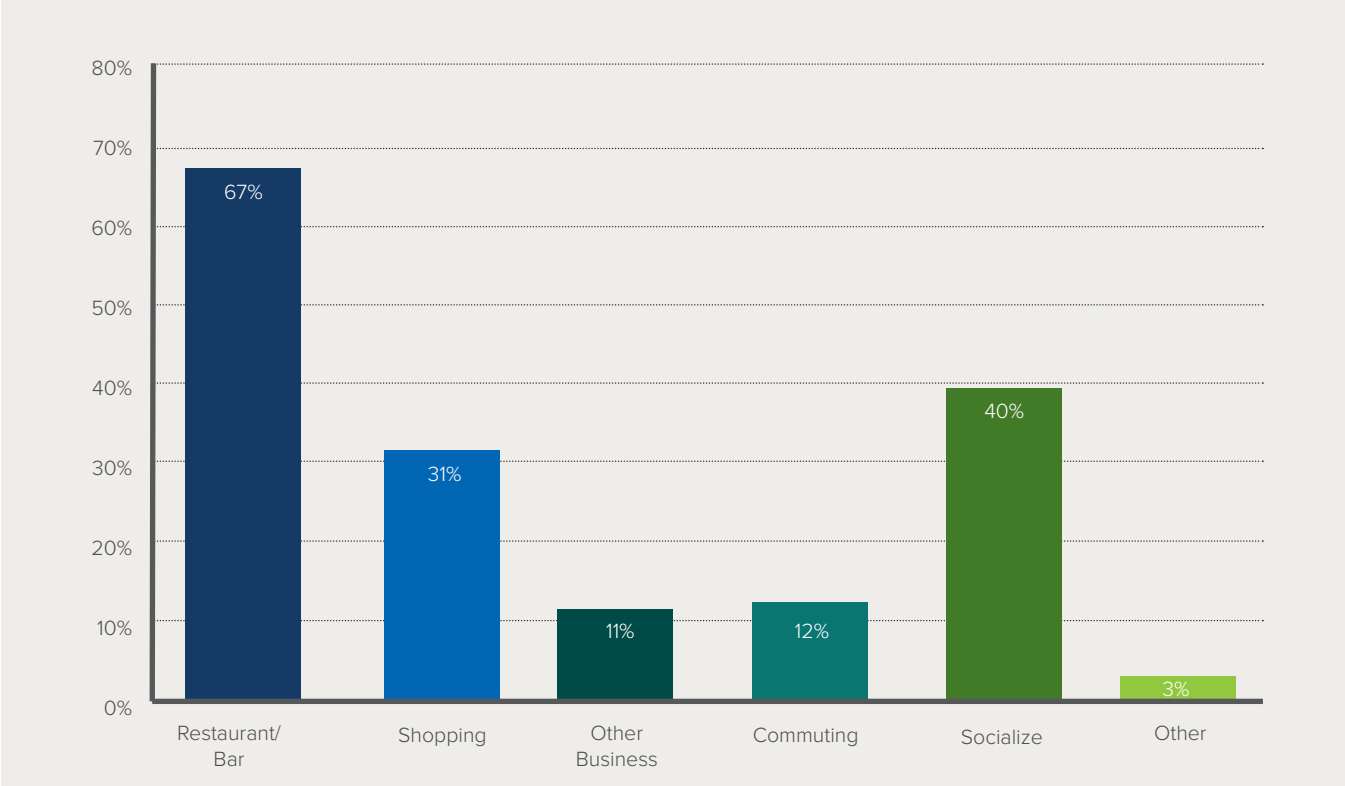


[v] These results exclude Christmas weekend, which is an outlier and not representative of a typical weekend.

ECONOMIC IMPACT

According to the survey data, restaurants and bars were the most common destination among d2d users. Figure 25 shows the overall distribution in d2d user destinations. It is important to note that multiple selections were permitted when answering this question. This data indicates that the pilot was successful in reaching its target audience.

FIGURE 25:
D2D REPORTED USER DESTINATIONS IN DOWNTOWN (FINAL SURVEY)



According to the second survey, d2d users spent an average $87 per person while downtown. Given that there were 2,477 trips taken, at least $215,499 was spent downtown by d2d users. This is a conservative figure because there were an average of 1.8 people per trip. Given that the City sales tax is 3.86 percent and the food service tax is 4.01 percent, d2d users provided at least $8,318 to the general fund. This accounts for 85 percent of the subsidy cost, assuming only one person out of the 1.8 people per trip spent $87. If the assumption is that 1.8 people each spent $87, the revenue is even higher, as summarized in Figure 26. It is worth noting that many of the customers may have come to downtown anyway, by other means

WHERE D2D USERS CAME FROM

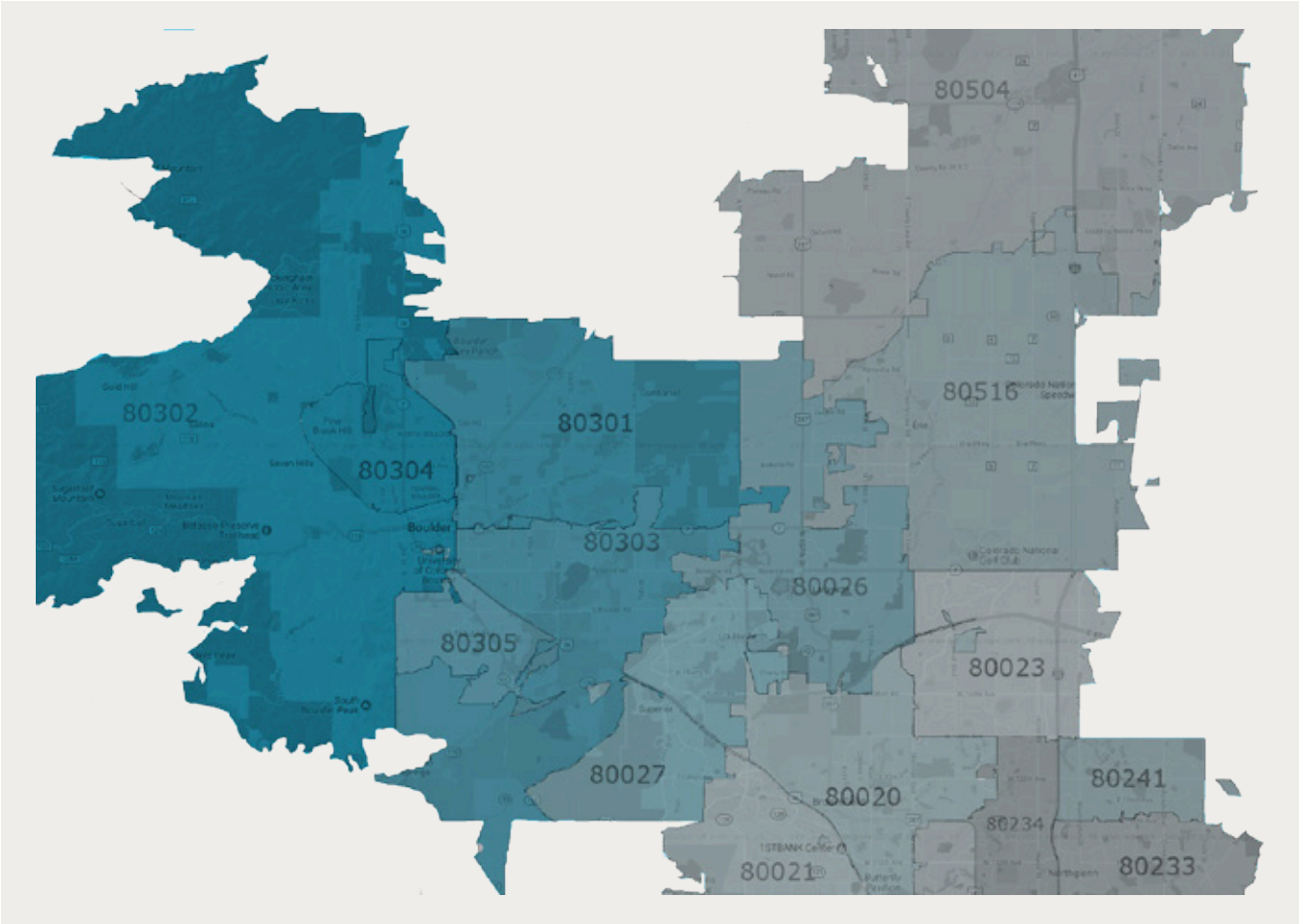
Most d2d trips were from Boulder zip codes, with the average distance 5.2 miles from downtown Boulder (measured from middle of a zip code to the Pearl Street Mall). More exact locations were not possible because of the need to protect users' privacy. The overall distribution of inbound trip origins is shown in Figure 27 on the next page.

FIGURE 26:
RETURN ON INVESTMENT OF THE PILOT SUBSIDY

TRIPS TAKEN	2,477
PEOPLE PER TRIP	1.8
AMOUNT SPENT DOWNTOWN PER PERSON	$87
TOTAL SPENT DOWNTOWN	$215,500–$387,900
SALES TAX REVENUE	$8,318–$14,972

COST OF SUBSIDY: $9,802
COST OF MARKETING: $20,700

FIGURE 27:
GEOGRAPHIC DISTRIBUTION OF INBOUND TRIP ORIGINS



ZIP CODE	AMOUNT OF RIDES
80302	719
80304	695
80301	425
80303	302
80305	212
80027	46
80026	16

ZIP CODE	AMOUNT OF RIDES
80310	12
80020	5
80202	4
80249	4
80214	3
80516	3
80004	2

ZIP CODE	AMOUNT OF RIDES
80021	2
80309	2
80003	1
80023	1
80031	1
80203	1
80211	1

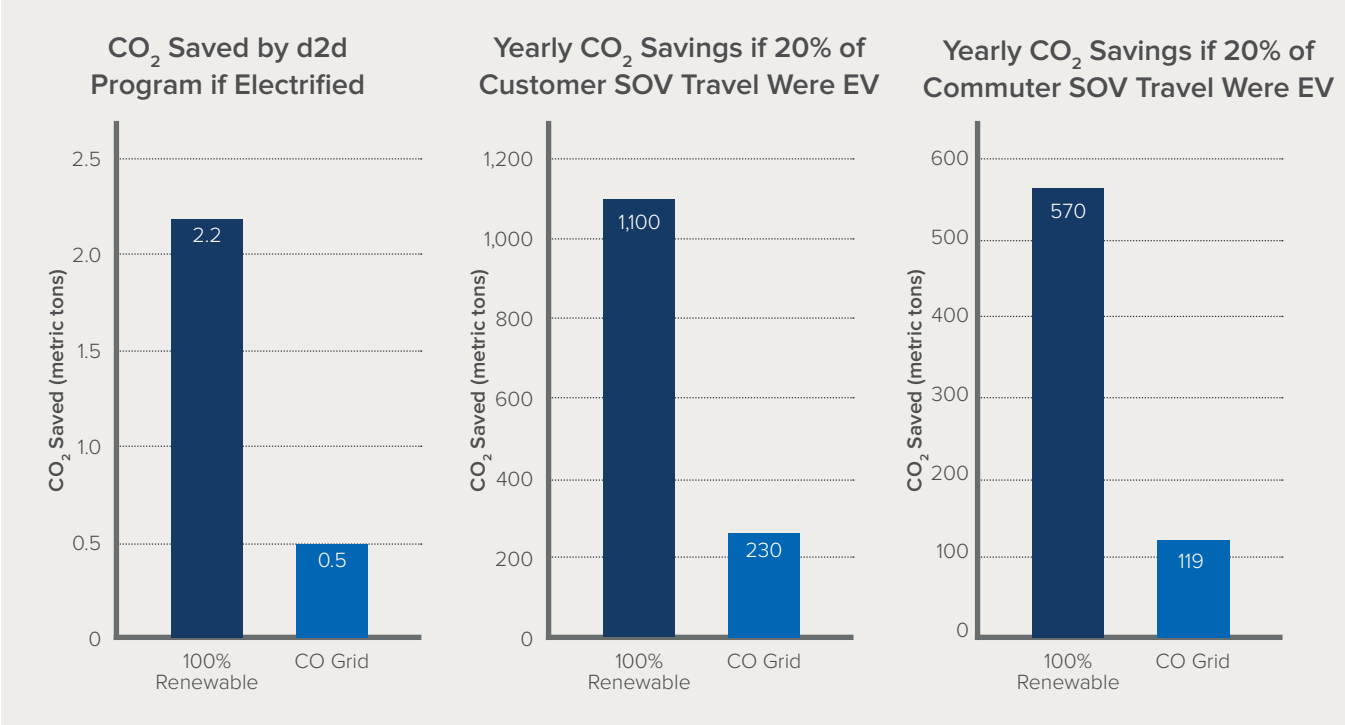
ZIP CODE	AMOUNT OF RIDES
80220	1
80223	1
80234	1
80246	1
80504	1

IMPACT ON CO_2

While d2d did not reduce emissions, the potential impact of electric vehicles can be calculated based on the results from d2d. Given our knowledge of a total of 2,477 rides with an average distance driven of 5.2 miles, d2d displaced an estimated 12,880 miles that would have been covered through other means. Since the initial survey reported that 42 percent of users would have otherwise taken a personal vehicle (and there is no other means of measuring what specific users would have taken on a particular trip), the program saved approximately 5,410 personal vehicle miles (this is likely conservative, as most users making longer trips in winter would have taken a personal vehicle). However, this should not be confused with a VMT reduction—the miles were still traveled by a vehicle, even if it was a transportation service vehicle.

The average emissions per personal vehicle mile is 411 grams CO_2 (nationwide, not for Boulder). Figure 28 shows the CO_2 that would be saved if these vehicles were electrified in the future—on both a 100 percent renewable grid and Boulder's current electric grid, which creates 325 grams of CO_2 per mile (assuming 0.34 kWh/mile for an electric vehicle). Figure 28 also shows the potential emissions reduction of electric MaaS with 20 percent adoption of each group (customers and commuters)—a bold but achievable 2020 goal if action is taken now. This reduction would be a meaningful first toward the City's stated goal of reducing transportation emissions 16 percent by 2050.

FIGURE 28:
POTENTIAL CO_2 REDUCTION FROM ELECTRIC VEHICLES



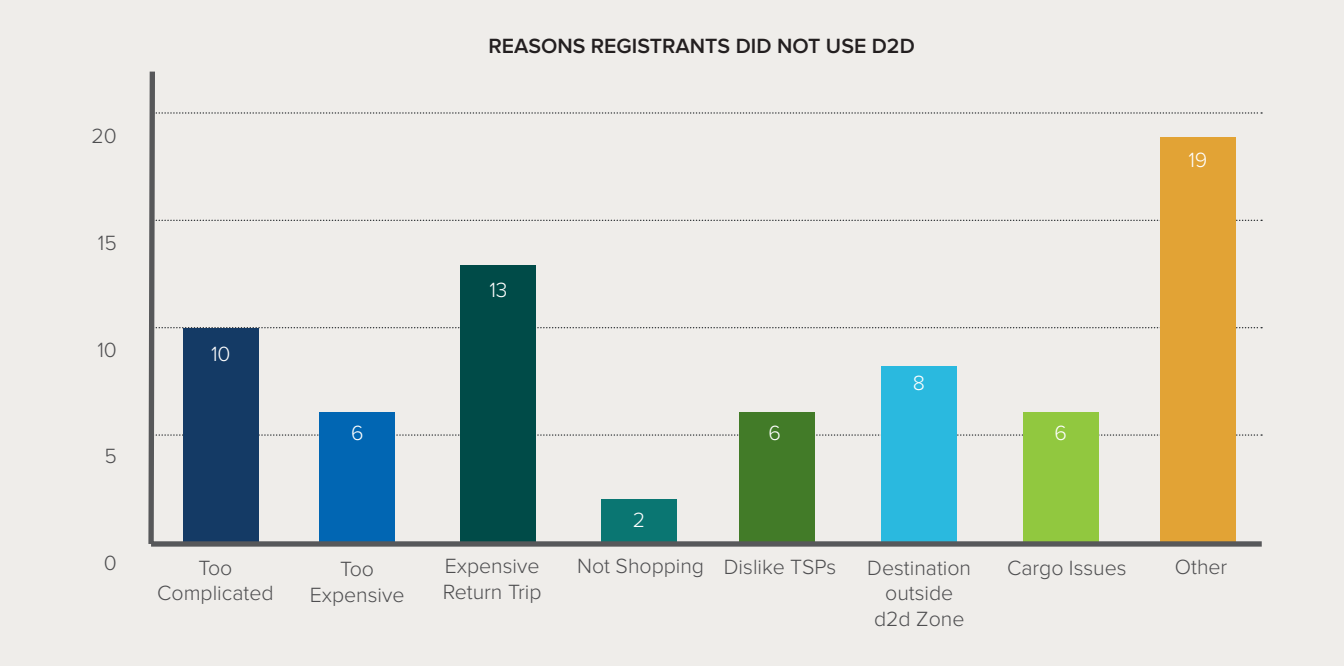
IMPACT ON PARKING

Forty-two percent of survey respondents said they would have taken a personal vehicle without d2d. Therefore, we can estimate that 1,040 personal vehicles did not park in downtown as a result of the pilot. This avoided parking demand was concentrated on Friday nights, when an average of 25 SOVs did not park. Friday night is one of the most challenging times for parking in downtown as the workforce overlaps with weekend shoppers and diners. The pilot has clearly demonstrated potential to alleviate parking demand if scaled appropriately.

WHY PEOPLE DID NOT USE D2D

The final survey asked d2d registrants if they had used the service and if not, why? The responses (seen in Figure 29) varied considerably, but the three most common were that the merchant purchases required to earn a return trip were too much, the service was too complicated, or that they had simply forgotten (the majority of the "other" responses). This indicates that the service must be absolutely foolproof, that it must find ways to remind users of its existence (particularly if they are traveling to downtown Boulder), and that methods must be found to provide users an affordable return trip.

FIGURE 29:
REASONS REGISTRANTS DID NOT USE D2D



06 LESSONS LEARNED

Image courtesy of Pedro Szekely

LESSONS LEARNED

REQUEST FOR PROPOSALS VS. OPEN FIELD

Procurement processes can cause pilot startup time to be lengthy. This is a challenge familiar to civil servants the world over. Nevertheless, those procurement processes exist to ensure a level playing field and that the City pays a fair price for quality services. In order to streamline the process and make sure d2d got off the ground while it was still relevant, the team worked with stakeholders to create a set of requirements that ensured the pilot would function as desired and that all parties received value from it. Instead of a competitive request for proposals (RFP) with a single provider selected at the end, we invited any transportation provider that could meet the requirements to participate in the pilot. This open-market approach not only enabled rapid deployment but also provided a diverse set of services for the public and healthy competition.

Commutifi helped to overcome one of the potential problems of having an open market, namely having to interface with multiple providers' systems. The Commutifi platform formed the common link between the City, TSPs, merchants, and customers. This was a key enabler to the open-market approach.

CONTRACTING AND DATA SHARING

One of the biggest hurdles for a pilot of this type is setting up the agreements for providing services and sharing data. TSPs are rightly concerned about protecting their customers' privacy and yet the performance of a pilot must be evaluated. Second, city governments are subject to open-records laws, meaning that any sensitive data received by the City could easily end up in the public domain. This creates an inherent tension and can be an insurmountable hurdle.

The d2d program had two important distinctions that ultimately led to success. The first was that the City of Boulder and DBP provided significant value to the program in the form of a robust subsidy and marketing strategy, making the pilot compelling to the TSPs. Second, RMI and Commutifi were able to act as the data repository by aggregating and analyzing the data prior to delivery to the City. Both Commutifi and RMI signed agreements with the TSPs that detailed the data to be shared and the care with which it had to be handled. In no case was sensitive data provided to the City, which alleviated concerns about that data ending up in the public space. All of the meaningful results, relative to pilot performance, were teased out by RMI and are presented in this report.

However, despite these steps, the project required a lot of work from all parties to agree to the necessary data and metrics to judge the pilot's performance. Adequate time should always be allowed to come to agreement on difficult issues such as data sharing, and that agreement should be as specific and detailed as possible about the data to be shared, when it will be shared, and for what purposes it may be used.

MARKETING

The Downtown Boulder Partnership led the marketing effort for d2d. It dedicated $20,700 to advertising and design/production in addition to significant time and effort by its senior leadership to help ensure a successful pilot. Its efforts proved hugely successful as d2d ultimately attracted 5,400 registrants.

Some important lessons emerged from the marketing efforts. The first was that social media and word of mouth were the most effective means of promoting this type of pilot, at least in the Boulder context. As shown in Figure 20 above, these two approaches were the most common way people learned of the pilot. The team believes that robust social media advertising in the early days of the pilot led to the notable word-of-mouth success. In terms of people registered in such a short time, it's clear that the marketing efforts of d2d were successful when compared to other mobility pilot projects around the country.

The second important lesson was that reaching the 45+ year-old demographic and convincing them to participate was a challenge. Of course, this was anticipated and much of the marketing effort went toward reaching this group, including several different types of print ads in the *Daily Camera*, ads placed directly on the *Daily Camera* website, and direct outreach to local groups and communities in the target demographic. Despite these concerted efforts, as shown in Figure 21, d2d recruitment lagged in the 45+ age group relative to the Boulder population as a whole.

A third lesson was that future efforts could go after the age groups that were most receptive, which would likely result in fewer marketing dollars spent per registered user. If SOV trips to downtown are avoided, regardless of the drivers' ages, parking is liberated for everyone, and those who are not as likely to use a mobility service can take advantage of more readily available parking.

VMT REDUCTION

At the outset, VMT reduction was considered in the design of d2d due to its positive effects on congestion and pollution. However, the project team strategically elected not to require pooling because the belief was that this pilot was already asking for a significant behavior change and requiring that people ride with strangers would be a step too far at this juncture.[vi] This was expected to be an especially difficult adaptation for the targeted 45+ year old demographic. Because pooling was not required, parking demand in downtown was reduced but VMT likely was not—though accurately quantifying VMT in this case is very difficult. Future programs could require carpooling or incorporate shuttle elements that would reduce VMT.

Image courtesy of Pedro Szekely

[vi] "Pooling" in this context means that after the initial passenger is picked up, the TSP's software finds another person traveling along a similar route and adds that person to the vehicle.

07 NEXT STEPS TOWARD THE FUTURE OF MOBILITY FOR BOULDER

NEXT STEPS TOWARD THE FUTURE OF MOBILITY FOR BOULDER

TRANSPORTATION SERVICE CREDITS AS PART OF ECOPASS

One of the biggest hurdles to people choosing public transportation, walking, or biking on a given day—and especially choosing to give up a car completely—is the "just in case" situation. Anything from the unexpected afternoon thunderstorm to a child getting sick at school to an unexpected off-site meeting creates a very high barrier for people to not use their car. Another common issue is the need to carry cargo of some kind, such as groceries or work materials.

An effective way to lower these barriers could be to include TNC/taxi credits as part of Boulder's EcoPass program. This would help users of EcoPass feel more comfortable about taking a bus, walking, or riding their bike if they knew that during an unforeseen event they could access a discounted or free ride from a transportation service provider. Bringing the EcoPass closer to true Mobility as a Service might make it possible for users to abandon their cars, either for the day or, hopefully, altogether. The return on investment with this approach could be significant.

Theory: For a significant group of people, an alternative mode of transportation would work most of the time, but they need a solution that works 100 percent of the time. By providing credits for on-demand, short-wait-time, door-to-door service, those people would have a 100 percent solution.
Pilot: Test this theory by offering TNC/taxi credits as part of the EcoPass, possibly for the downtown EcoPass or with a group of employers.

TRANSPORTATION SERVICE PROVIDER INTEGRATION WITH FLATIRON FLYER

The Flatiron Flyer offers a compelling service between Boulder and Denver. The buses are generally full in both directions—morning, noon, and night. They also are able to bypass most of the congestion on U.S. 36 and I-25 because of the priority lanes, offering significant value to passengers. However, the service, by its very nature, does not pick up or drop off people close to their destinations unless they happen to be going somewhere near the route in and out of Boulder. As a result, it can often take longer to travel to or from the Flatiron Flyer than it does to travel between Denver and Boulder.

However, this challenge also represents a major opportunity. Linking the Flatiron Flyer with TSPs to solve that first- and last-mile problem could greatly increase the effectiveness of the service, and because it would be displacing longer trips, it would have a much greater impact on decreasing VMT and pollution. The Table Mesa station stands out as one possible integration point. This is a major hub on the southern edge of town. Trips between Table Mesa and Denver's Union Station take only 26 minutes, even at rush hour. Boulder Junction, in central Boulder, could be another integration point as RTD service scales up with build-out of the development.

The design of an integrated service could be intelligent, right sizing the vehicles for the level of demand. TNCs represent only one possible solution. If large demand were generated in the Flatirons Office Park, for example, a dynamically routed shuttle could be most cost-effective. Ultimately, all of these vehicles could be electrified, as discussed below. The advantage of this approach is that the total VMT/CO_2 avoided is derived from the entire avoided trip—presumably longer than a local trip—while leveraging an existing resource and only "filling the gap."

Theory: More people would use regional transit, like the Flatiron Flyer, if they had a better first- and last-mile connection in Boulder
Pilot: Test this theory by offering a subsidized, door-to-door, dynamically routed service from a major transit hub.

SATELLITE PARKING WITH SHUTTLES

Another possible approach to alleviate parking demand and traffic downtown is to set up satellite parking lots outside of the city for commuters, and then provide discounted or free dynamically routed shuttle service directly into downtown. This would reduce the demand for parking—eliminating the necessity to convert prime real estate into parking lots—and free up parking for downtown customers. For every commuter that would have parked downtown all day, a parking space would be liberated for multiple customers, who only visit for a few hours. VMT would also be reduced as a function of the location of the satellite lots and the load factor on the shuttles. This program would have to be carefully designed to create demand because of the major investment required.

Theory: People would like to avoid the cost and hassle of parking in downtown if they had a convenient alternative.
Pilot: Identify the biggest opportunities in terms of a regional commuting route that is not well served by transit and test an approach that uses satellite parking and shuttle services.

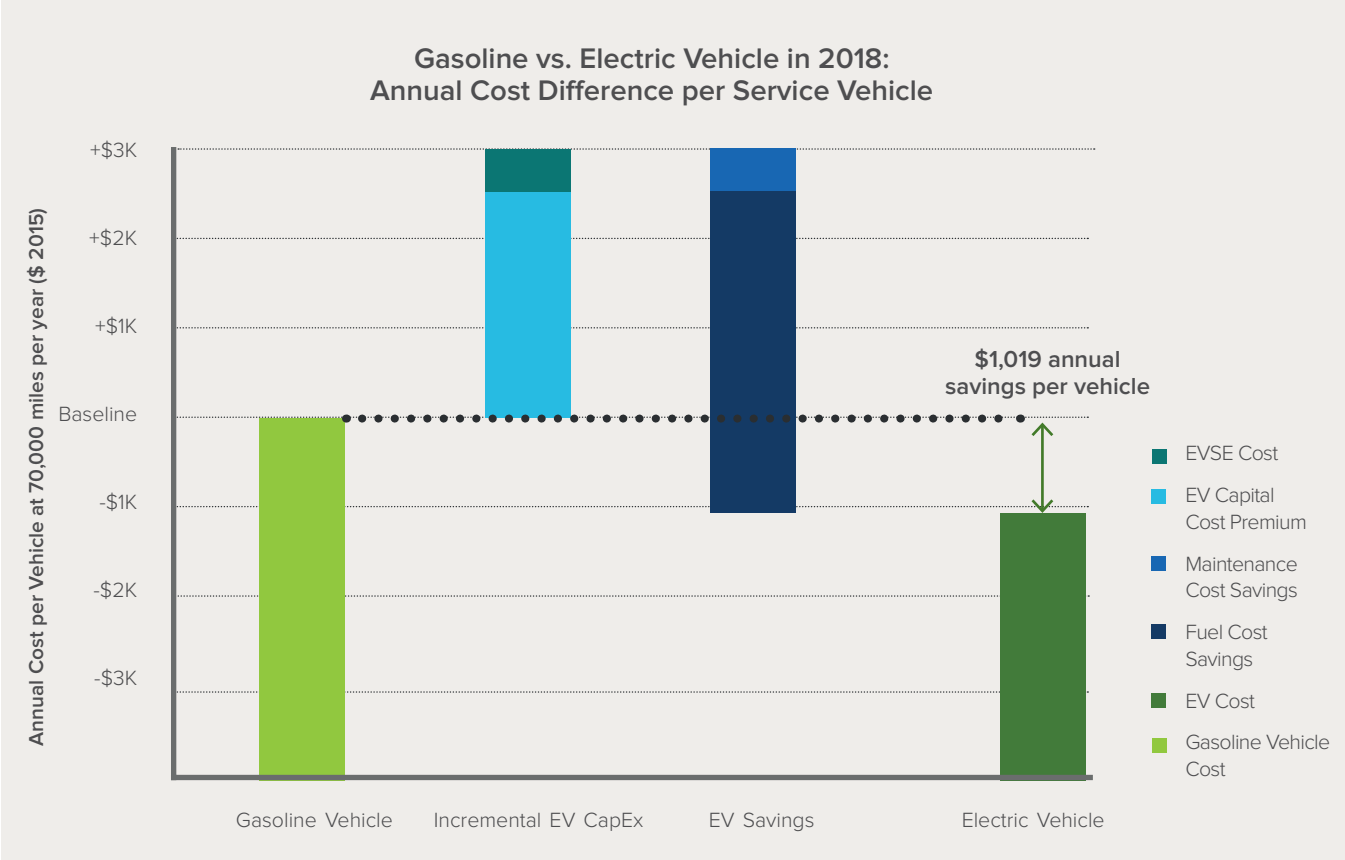
ELECTRIC VEHICLES FOR TRANSPORTATION SERVICES

Reducing CO_2 emissions is a community priority in Boulder, and EVs have excellent potential to reduce emissions associated with mobility. Even on the electrical grid in Colorado today, which is fueled largely by coal, EVs emit less CO_2 than an internal combustion engine (ICE) vehicle. But importantly, as the grid integrates more renewables, the CO_2 from EVs will decrease as well. Additionally, EVs improve local air quality because they emit no NOx or SOx, the ingredients for smog and ground-level ozone. They also hold the potential to actually help the grid transition to a high percentage of renewables by being able to even out the load curve associated with solar production at midday and wind production at night.

Although EVs were strategically left out of the d2d pilot, they represent an opportunity going forward to help Boulder meet its CO_2 reduction goals.

EVs for personal vehicles face familiar headwinds. The higher initial cost and three- to five-year payback are barriers many are not willing to cross. However, professional drivers travel three to five times as many miles per year as the average person. Because of the lower fuel and maintenance costs of EVs, they are a terrific opportunity for fleets, not just for environmental reasons but also for economic reasons. The lower operating cost of an electric vehicle (Figure 30 on the next page) equates to $1,019 savings just in the first year if it is driven 70,000 miles—not a difficult task for a service vehicle.

FIGURE 30:
EV COST SAVINGS AT 70,000 MILES PER YEAR



Even so, many transportation service drivers do not use electric vehicles because the higher up-front cost and charging logistics are intimidating. If the City of Boulder were to invest in providing these drivers with easy access to electric vehicles, perhaps rented on a per-mile basis and with easy access to charging infrastructure, then CO_2 emissions associated with these services would drop immediately. With new affordable, long-range EVs coming on the market, this approach is made easier.

Theory: EVs make compelling high-mileage fleet vehicles because of dramatically lower operating costs.

Pilot: To date, this has not been tested at any scale in the real world. Help to launch a fleet of EV service vehicles, either for TNC drivers, taxi drivers, or a dedicated operator. Real-world data showing the cost savings of these vehicles would be a very powerful tool for convincing fleet operators to electrify.

08 BOULDER ADVANCES TOWARD A GLOBAL VISION

Image courtesy of Pedro Szekely

BOULDER ADVANCES TOWARD A GLOBAL VISION

Emerging technologies and societal trends are creating an opportunity for a new mobility future in which electrified (and eventually self-driving) vehicles operate within transit-friendly, walkable, and bikeable metropolitan areas. Boulder's work on pilots such as d2d accelerates the city toward reaching that future rapidly and with a better understanding of how best to meet citizen and commercial needs at the same time. In contrast to the current just-in-case transportation system, mobility becomes a service, available when and where it is needed. This allows fewer vehicles to do the same job at lower cost to consumers, who no longer have to pay (capital, insurance, maintenance, and parking) for vehicles that sit idle 95 percent of the time. This is a massive economic opportunity for consumers, businesses, and municipalities.

The sharing economy is on the rise, and broad swaths of industries are switching to business models that make services available on demand. Personal mobility is certainly not immune to this disruption. This transformation, already under way, is made possible by rapidly expanding data storage and processing capabilities, major advancements in electric vehicle technology—especially falling battery costs—and fully autonomous, driverless cars rapidly becoming a commercial reality. These key societal trends and technology developments are enabling a radical mobility paradigm shift. As countries in the developing world build infrastructure, they are moving toward these new technologies and systems, leapfrogging the traditional, expensive Western transport paradigm. Boulder has the potential to be at the head of this global transportation revolution, being a leader when much of the United States is still trying to catch up.

Electric, automated Mobility as a Service is a long-term goal. The technology is still developing, but it is coming quickly. Boulder is preparing for a future where the reality has shifted. EaMaaS offers all of the benefits of personal vehicles without any of the hassle, by providing the best service for the trip at hand—whether that be a shuttle link to a bus for the daily commute or a door-to-door ride for an unexpected trip to the doctor. Moreover, unlike personal vehicles, shared driverless cars can be seamlessly integrated with a wide array of multimodal transit options, including walking, biking, and mass transit in particular—creating one uninterrupted experience that gives users flexibility to meet their preferences and needs from moment to moment. Finally, the design of cities will simultaneously evolve in a virtuous cycle as the new mobility paradigm both enables and benefits from cities that are no longer built around personal vehicles.

EAMAAS WOULD OFFER SEVERAL MAJOR BENEFITS TO CONSUMERS:

- **Convenience:** MaaS means no need to worry about the hassles of car ownership like maintenance, parking, and the possibility of a breakdown.
- **Saved Time:** In the U.S., the average person spends 101 minutes per day driving—roughly 600 hours per year.[24] That's valuable time that can be unlocked if drivers become passengers of a mobility service. Valued at minimum wage, that is $4,500/year.
- **Safety:** In the U.S., more than 33,000 people die annually from car crashes, yet 95 percent of accidents are caused by avoidable driver error.[25] Driverless cars could eliminate the vast majority of these accidents and thus provide a much safer ride than a traditional personal vehicle.
- **Flexibility:** By purchasing Mobility as a Service rather than as an asset, users can choose the mode of transportation that fits their needs at any given time. Driverless cars can easily link up with mass transit, walking, or biking.
- **Savings:** A highly utilized and cost-optimized fleet of driverless vehicles will form a critical link in eaMaaS, and the result for consumers will be a mobility option that's vastly cheaper and more effective than underutilized personal vehicles. The potential savings is thousands of dollars per year, per person.

The crux of this paradigm shift is a fleet of electric, autonomous vehicles that—together with other transport modes—offer Mobility as a Service. In order to reach this next evolution in personal mobility, it is necessary to develop the three principal areas—electric, autonomous vehicles; Mobility as a Service; and mobility-oriented development. With the d2d program, Boulder has made an important step toward the future of mobility. Future projects can explore other crucial steps or synergies between these critical components. The future is coming. Boulder can lead the way.

Image courtesy of Pedro Szekely

GA

GLOSSARY OF ACRONYMS

GLOSSARY OF ACRONYMS

ADA	Americans with Disabilities Act
AV	Autonomous vehicle
BID	Business Improvement District
CAFE	Corporate Average Fuel Economy Standards
CAGID	Boulder Central Area General Improvement District
DBP	Downtown Boulder Partnership
eaMaaS	Electric, autonomous Mobility as a Service
EAV	Electric, autonomous vehicle
EV	Electric vehicle
ICE	Internal combustion engine
MaaS	Mobility as a Service
MOD	Mobility-oriented development
MOV	Multiple-occupancy vehicle
P3	Public-private partnership
RTD	Regional Transportation District
SOV	Single-occupant vehicle
TMP	Transportation Master Plan
TNC	Transportation network company
TSP	Transportation service provider
VMT	Vehicle miles traveled

EN

ENDNOTES

Image courtesy of F. Delventhal

ENDNOTES

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