ConnectSmart: Connecting Transportation System Management Operations and Active Demand Management

Response to
USDOT #DTFH6116RA00012

Table of Contents

Project Description

1. Introduction 1

2. Entity Description 3

3. Geographic Area 4

4. Real World Issues & Challenges 4

5. Transportation Systems and Services 5

5.1 Active Demand Management Systems and Services 6

(a) Mobility Option Discovery – Shift Departure Time, and Route 7

(b) Mobility Option Discovery - Social Carpooling 8

(c) Mobility Option Discovery – Ridesharing 8

(d) Mobility Option Discovery – Electric Bike Sharing 9

(e) Mobility Option Discovery – Transit and Augmented Mobility 10

(f) Mobility Option Engagement – Integrated Services 10

5.2 TSM&O Strategies and Adaptive-Integrated Corridor Management 11

6. Scope of Work Plan 12

6.1 Year One - System Integration Planning and Pilot Program Jump-start 13

6.2 Year Two - Pilot, Learning and Testing 14

6.3 Year Three - Optimization and Refinement 15

6.4 Data Sharing and Documentation 17

7. Deliverables 17

8. Deployment Challenges 18

9. Quantifiable System Performance Improvements 18

10. Vision, Goals, and Objectives 20

11. Plan of Partnership 20

12. Leveraging Existing Advanced Transportation Technology Investments 21

13. Schedule 22

14. Leveraging the ITS Program 22

15. Project Management and Key Personnel 23

16. Primary Point of Contact 24

17. Funding Breakdown 24

List of Figures

Figure 1: Proposed ConnectSmart Framework 1
Figure 2: Energy Corridor and Downtown District 4
Figure 3: TSM&O, TCC, and A-ICM and ADM Integrated Framework 6
Figure 4: B=MAT Model 7
Figure 5: Metropia App Screenshots 7
Figure 6: Metropia DUO Social Carpooling 8
Figure 7: Metropia App Mobility Options 10
Figure 8: Mobility Options Discovery and Engagement in the ConnectSmart Project 11
Figure 9: System Engineering V Diagram (Years 1 and 2) and CCSC Diagram (Years 3) 12
Figure 10: Connect Smart Team Organizational Chart 21

List of Tables

Table 1: ConnectSmart Project Accomplishes USDOT Visions and Goals 2
Table 2: How ConnectSmart Aligns with USDOT Emphasis Areas 3
Table 3: Houston Region Transportation Issues and Challenges 5
Table 4: Typical Work Day Scenario for Pedal Bike versus ebike 9
Table 5: Deliverable Table 17
Table 6: Performance Metrics 19
Table 7: ConnectSmart Project Schedule 22
Table 8: Budget Summary 24
Table 9: Budget Breakdown by Task Groups 25

Project Description

1. Introduction

This application proposal presents the ConnectSmart project to deploy an advanced technology platform that integrates Transportation Systems Management & Operations (TSM&O) and Active Demand Management (ADM) with multi-modal demand/mobility management. The project aims to establish a model technology deployment site that enhances the safety, reliability, and efficiency of Houston's regional transportation system, significantly reduces congestion, and maintain quality of life and economic vitality.

The ConnectSmart team is built on a strong public-private-professor partnership (P4) that provides the foundation for a long-term and financially sustainable project. The team brings together relevant expertise, mission-aligned coordinating organizations, and consists of Houston regional agencies, leading private mobility service providers, and renowned academic/research institutions ready to deliver an ADM and TSM&O based solution to meet the Houston's region regional congestion mitigation and air quality attainment goals.

Central to the ConnectSmart platform are two core intents:

1) Disperse demand spatially, temporally, and across a wide range of mobility options through ADM strategies that change the behavior of commuters by influencing their decisions towards adopting more efficient mobility options such as leaving at a less congested time, taking a less congested route, share rides, and utilize public transit.
2) Reduce congestion by enhancing TSM&O effectiveness through data sharing of massive amounts of mobility data among regional agencies and by improving TSM&O analytics capabilities to directly achieve safety, system performance improvements and enable real-time operational interventions.

The proposed ConnectSmart framework for setting up and maintaining a model technology deployment site that will benefit Houston and can be readily be replicated by other jurisdictions is illustrated in Figure 1. It features the deployment of market-ready and proven innovations in mobility technology and traveler engagement, employs data sharing among mobility technology and service providers and all team members and enables "big data" analytics for the agency partners.

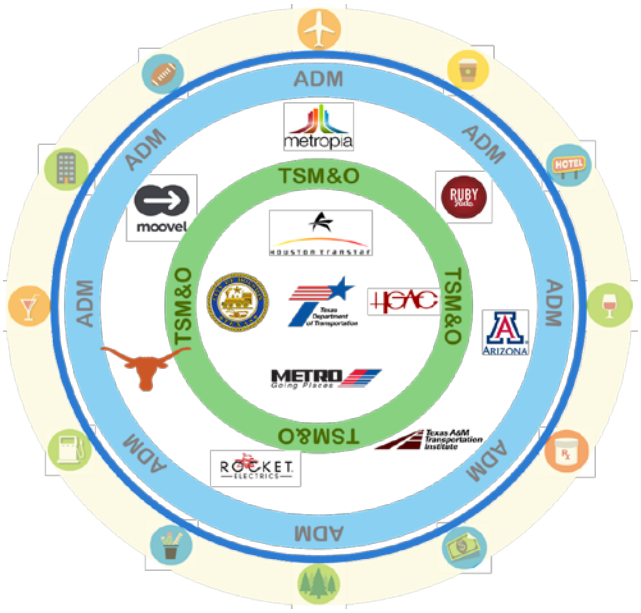

Figure 1: Proposed ConnectSmart Framework

At the core of the framework (center ring) are the public partners (Houston regional agencies) who drive the project's system objectives and who are supported by the private- and professor/academic-sector partners (the middle ring) who are able to influence optimal travel decisions through ADM strategies and technologies (the outer ring) and enhance the TSM&O effectiveness for the agency partners through data sharing and analytics provisioning.

The ConnectSmart model platform will integrate various mobility technologies and data sources to provide predictive multi-/inter-modal travel time, cost, and reliability information. In turn, this predictive and multi-faceted information can be delivered to the travelers via a single tool that:

1) Gives drivers the information and incentivizes them to make better mobility decisions
2) Gives Agency partners access to collected, aggregated and anonymous user data and control of how the data is used to drive specific outcomes
3) Has the ability to ultimately connect demand and supply by feeding in demand information into supply optimization (signal control)
4) Shares live data to travelers using the best communication methods (through mobile app's, Direct Messaging, Websites, or DMS, etc.)

This model platform will enhance TSM&O capability and capacity for ConnectSmart regional transportation agencies.

Finally, the ConnectSmart project aligns with the following USDOT Visions and Goals, as summarized in Table 1.

Table 1: ConnectSmart Project Accomplishes USDOT Visions and Goals

ConnectSmart	USDOT Visions and Goals
●●●	Reduced costs and improved return on investments, including through the enhanced use of existing transportation capacity.
●●●●	Delivery of environmental benefits to alleviate congestion and streamline traffic flow.
●●●	Measurement and improvement of the operational performance of the applicable transportation networks.
●●	Reduction in the number and severity of traffic crashes and an increase in driver, passenger, and pedestrian safety.
●●●●	Collection, dissemination, and use of real-time transportation-related information to improve mobility, reduce congestion, and provide for more efficient and accessible transportation, including access to safe, reliable, and affordable connections to employment, education, healthcare, freight facilities, and other services.
●●●●	Delivery of economic benefits by reducing delays, improving system performance and throughput and providing for the efficient and reliable movement of people, goods, and services.
●●●●	Integration of advanced technologies into transportation system management and operations.
●●●●	Demonstration, quantification, and evaluation of the impact of these advanced technologies, strategies, and applications towards improved safety, efficiency, and sustainable movement of people and goods.
●●●	Reproducibility of successful systems and services for technology and knowledge transfer to other locations facing similar challenges.

Additionally, the ConnectSmart project specifically aligns with the goals and objectives of the following USDOT emphasis areas outlined in Table 2.

Table 2: How ConnectSmart Aligns with USDOT Emphasis Areas

Emphasis Area	ConnectSmart Alignment
Transportation elements associated with Smart Cities	Applies advanced technology to connect transportation assets into a single interactive network that allows communities to reduce congestion, support efficient goods movements, provide multimodal choices, keep travelers and freight logistics safe, reduce fuel consumption, protect the environment, respond to climate change, connect underserved communities, and support economic vitality.
Unified fare collection and payment system across transportation modes and jurisdictions	Leverages an ongoing electronic transit ticketing platform and allows payment across multiple apps to reach out to a broader commuting public.
Multimodal Integrated Corridor Management (ICM)	Enhances the agency capabilities to manage corridors as an "integrated system" rather than on an "asset-by-asset" basis through the ConnectSmart ADM and TSM&O elements. When multiple corridors experience congestion over common temporal timeframes an integrated solution incorporating innovative operational strategies that optimize available capacity in the existing infrastructure while managing demand growth, demand shifts and demand spikes associated with scheduled or unscheduled events may be required.
Dynamic ridesharing	Reduces the number of single passenger commuting trips beyond current business and recreational trips served by Transportation Network Companies and expands the existing ridesharing service network by incorporating several innovations: subscription-based ridesharing services, shared electric bike services, social carpooling, and a multi-modal mobility discovery and engagement platform.

2. Entity Description

The Texas Department of Transportation (TxDOT) is the eligible and prime entity applying for this solicitation advertised by the U.S. Department of Transportation. Throughout its 100-year history, TxDOT has administered federal highway construction and maintenance and is known as a national transportation leader and steward of a diverse transportation network serving more than 26 million Texans (40 million by the year 2035) and that helps fuel a vibrant state economy. Population and job growth will bring more congestion to urban areas, in particular the Houston Metro area, consequently increasing the stress on roads. These demands continue to increase faster than the roadway capacity needed to handle this growth. In addition to population growth, the aging population is another challenge, which affects highway design, driver safety, and an increased demand for public transportation.

Particularly, TxDOT Houston District will be the prime entity for carrying out this project's proposed deployment and will coordinate very closely with other Houston regional transportation agencies. TxDOT Houston District plans, designs, builds, operates, and maintains the state's transportation system in the six-county region. This equates to a population of 5.8 million, over 10 thousand lane miles, and over 81 million daily vehicle miles traveled. TxDOT is a member of the Houston TranStar (the local transportation and emergency management center) - a unique partnership that also includes City of Houston, Harris County, and METRO who share and exchange information to keep travelers informed and safe in the fourth most populated city in the United States.

As such, TxDOT will work closely with TranStar and the other member partners on ConnectSmart project; this brings many tangible benefits to the project. TxDOT will manage the project by assigning a group of TxDOT staff as the program managers and will provide support regarding the various TranStar collected datasets as well as establish connections with TranStar partners and their respective datasets. TxDOT staff will also provide oversight of the project's invoicing by the ConnectSmart team members.

3. Geographic Area

The Houston region has some of the most congested corridors in Texas, if not the nation, and identifying the causes of congestion is an important consideration. Houston's current transportation system includes more than 25,000 miles of total roadway, with more than 173 million vehicle miles traveled (VMT) daily in 2015. The majority of the major roadway system is arterial streets. Freeways, including Interstates and other limited-access roads, make up around 10% of the roadway system but handle more than 40% of daily traffic. Conversely, local roads (or collectors) comprise almost a quarter of the system but serve only 7% of daily traffic—mainly at the origin and destination points. Approximately 180 miles of tollways are located in the region, handling about 8% of daily traffic - an opportunity for future growth in terms of their regional percentage share. Approximately 100 total miles of Managed/HOT lanes and around 200 miles of Managed/HOV lanes are available on four major regional freeways and account for approximately 900,000 VMTs traveled or 1% of travel during peak-period, or rush hour-like, conditions.

The Metropolitan Transit Authority of Harris County (METRO) provides public transportation to the Houston region. It operates bus, light rail, bus rapid transit, and paratransit services to Harris and Fort Bend Counties, servicing a total of 15 cities. Recently, METRO redesigned its local service in favor of a high-frequency, high-demand bus network. As a result, all local bus routes (more than 80 local bus routes) run 7 days a week. In addition, 30 routes are associated with 26 park-and-ride locations within the region.

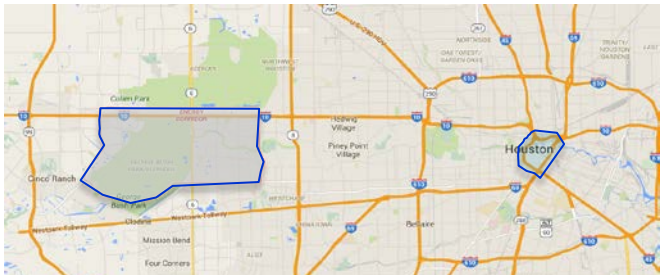

Figure 2: Energy Corridor and Downtown District

Our plans are to deploy the ConnectSmart platform in the entire region, but will initiate deployment within two corridors/sub-areas first: the Energy Corridor and the Downtown District. The Energy Corridor is loosely bound just north of Interstate 10 (the Katy Freeway) and The Westpark Tollway Drive to the south and extends from Kirkwood Road to the east and Barker Cypress to the west. The area is defined by many energy industry-related companies, such as BP America, Citgo, ConocoPhillips, ExxonMobil and Shell Oil Company. Over 26,000 acres (40.6 square miles) of the urban park area, the largest outside the National Park System, borders The Energy Corridor. Two parks adjacent to the district include George Bush Park and Bear Creek Pioneers Park. Many energy corridor employees live within the 15-mile radius, making them great candidates for the proposed ADM concept.

4. Real World Issues & Challenges

Houston is among the largest and fastest-growing metro regions in the U.S. and is facing many real world issues and challenges which can and will be addressed through the deployment of the ConnectSmart project. Table 3 introduces these issues, their associated challenges and demonstrates how the ConnectSmart project will contribute to their resolve.

Table 3: Houston Region Transportation Issues and Challenges

Issues	Challenges	ConnectSmart Deployment Impact
Houston ranks 6th in traffic congestion in urban areas and is regularly under weather-related disruptions (Source: Texas A&M Transportation Institute (TTI) Urban Mobility Report, 2015).	Over 80% of Houston area commuters travel to work alone and weather related massive roadway closures have severely impacted the regional economics.	System efficiency and robustness is maximized by reducing vehicle trips and increasing person-trip capacity.
Houston is widespread, covering over 100,000 square miles, and has multiple business and economic service centers located throughout the region.	Servicing the mobility needs in such an expansive region requires new investments and strategies.	Capacity is expanded by leveraging technology and providing innovative mobility options to users to meet commuting needs.
The Houston-Galveston-Brazoria (HGB) area was designated "nonattainment" and classified "marginal" under the 2008 eight-hour Ozone (O3) National Ambient Air Quality Standard.	Vehicle emissions reduction presents a major challenge and priority for overcoming this designation and classification.	Reduce vehicle emissions by enabling travelers to make better trip decisions, thus reducing CO_2 emissions and energy consumption
The Port of Houston (PHA) surpassed 2 million twenty-foot equivalent units (TEU) for the first time ever, setting a container throughput record for U.S.	Eighty-two percent of the goods in the Houston region are carried by trucks, placing a strain on the infrastructure.	Reduce truck delays by providing reliable routes for trucks, thus maintaining regional economic vitality.

By providing a smarter, optimized, and safer transportation network through the deployment of ConnectSmart, TxDOT will:

- Maximize the current system's capacity without incurring the expenses of added capacity.
- Provide for more economic opportunities.
- Better manage congestion and incidents in the Houston region.
- Increase efficiency of goods movement allowing for maintaining and building of Houston's status as an international trading hub.
- Enhance mobility access for all by offering more transportation choices that can reduce transportation costs and travel time and add to Houston's quality of life.

5. Transportation Systems and Services

The transportation systems, technologies, and mobility service programs offered through the ConnectSmart project, align under two key pillars for addressing regional congestion from a supply-and-demand perspective: Active Demand Management (ADM) and Transportation Systems Management & Operations (TSM&O).

As shown in Figure 3, The ADM strategy consists of a mobile App platform powered by the Metropia metro mobility App (with Moovel integration) and complemented with various regional existing Advanced Traveler Information Systems (ATIS) that centralizes a

comprehensive supply of mobility option programs and services. Mobility options like departure times, route, ridesharing, e-biking are included in the overall program and service offering. Gamification and incentives are tested and piloted to trigger and anchor positive behavior change and reward wise decision-making. The data collected through the respective mobility programs and services will be aggregated and shared in a ConnectSmart Data Hub (CSDHub) to calculate the Total Capacity (TC) of the entire multi-modal system with the goal to provide TSM&O effectiveness and efficiency through system/user data and analytics. The TSM&O strategy is enhanced by an innovative Total Capacity Coordination (TCC) enabled *Adaptive-Integrated Corridor Management (A-ICM)* approach based on the TC concept (for more details see Section 5.2) in order to not only deliver personalized optimal mobility options but also to dynamically increase person-trip capacity due to unforeseen system disruption to a certain mode, making the system more robust and adaptive against incident or disastrous events.

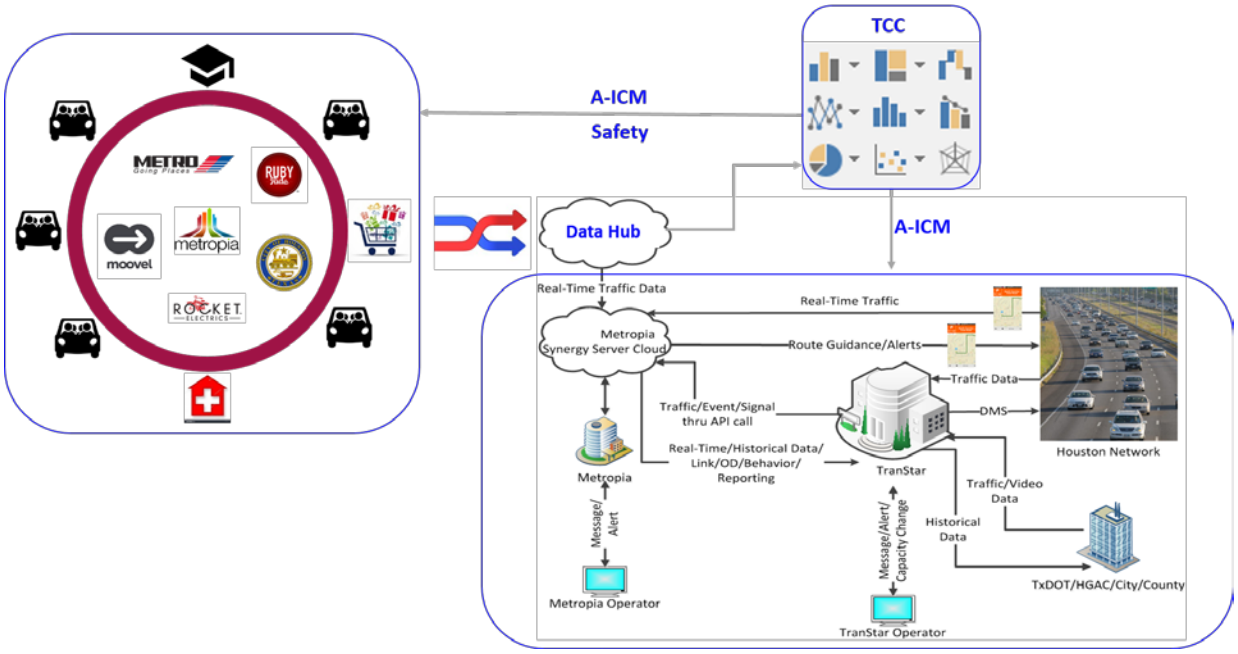

Figure 3: TSM&O, TCC, and A-ICM and ADM Integrated Framework

The ConnectSmart transportation system allows Houston regional transportation agencies to proactively manage and influence its traffic network/conditions. Examples of proactive management are pre-trip and en-route information provided directly to travelers' mobile smartphone devices or posted on DMS. If a traveler reroutes due to en-route information, the App will capture travelers' real-time routing decisions. Further, the App-based platform will relay arterial traffic flows and approach delay information that could then be used to adjust or optimize traffic signals.

This section describes the services, products, and systems of both and how by working together, they will create the foundation for a more reliable, efficient, and sustainable transportation system for the Houston region.

5.1 Active Demand Management Systems and Services

The ADM programs and services offered through ConnectSmart are based on the concepts of mobility option ***discovery*** and mobility option ***engagement***.

Prior research and studies concluded that humans are influenced by their habitual behavior. Once a habit is formed, it takes a great deal to trigger a new behavior. According to the Motivation Theory by Prof BJ Fogg at Stanford University shown in Figure 4[1], if we can make things easy to do then there is a better chance for both high and low motivated commuters to trigger a behavior change. Therefore, making an array of mobility options available to commuters through **Mobility Options Discovery** becomes the first behavior tenet of the ConnectSmart project.

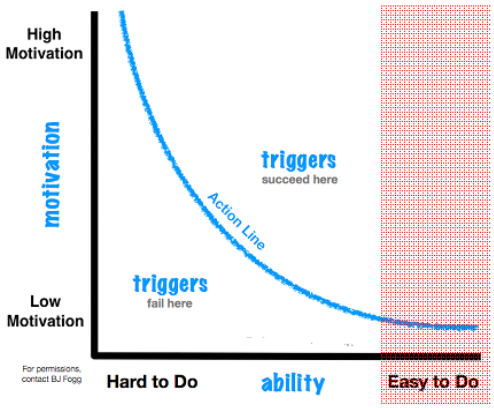

Figure 4: B=MAT Model

However, making the mobility options available to commuters does not mean we should take it for granted that the commuters will change their behavior immediately or at all (otherwise, Google Map with the multi-modal information would have created a massive alternate mode adoption since the multi-modal functionality inception years ago). What is missing is actively presenting the mobility options to commuters and engaging them through appropriate means (e.g. gamification and incentives) to trigger desired behavior changes. As such, **Mobility Option Engagement** becomes the second ConnectSmart behavior tenet.

Below, five mobility options are presented to be <u>discovered and actively delivered</u> to users, followed by engagement strategies to trigger and anchor the behavior change.

(a) Mobility Option Discovery – Shift Departure Time, and Route

According to the US Census American Community Survey 2011 data[2], 85% of the commuting public either drive alone or carpool. These commuters who drive have the option to choose a less congested time to leave and the least congested routes. If those with flexible schedules could leave at a less congested time and take a less congested route, then congestion could be effectively reduced[3]. The Metropia mobile App facilitates the shifting of departure time and route by providing drivers the pertinent predictive travel time and associated rewards (Metropia points). Once the user leaves at a pre-committed time and takes a pre-committed route, he/she would be awarded with the points and with resultant CO2 and travel time savings will instantly appear on the App screen upon arrival. During the ConnectSmart project, the Metropia app (currently deployed in Tucson, AZ, Austin, TX, El Paso, TX, and New York City) will be promoted to the general traveling public in the entire Houston region.

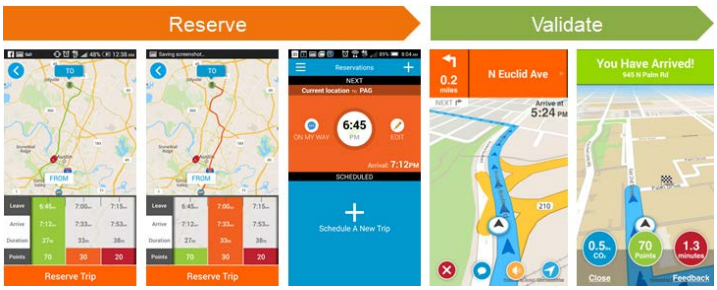

Figure 5: Metropia App Screenshots

[1] http://behaviormodel.org.
[2] https://www.census.gov/programs-surveys/acs/.
[3] Currie, G. (2011). Free Fare Incentives to Shift Rail Demand Peaks--Medium-term Impacts. TRB Annual Meeting.
Hu, X., Y.-C. Chiu and J. Shelton (2016). "Development of a Behaviorally Induced System Optimal Travel Demand Management System." Journal of Intelligent Transportation Systems (just-accepted).
Lee, C., P. Winters, et al (2013). Improving the Cost Effectiveness of Financial Incentives in Managing Travel Demand Management (TDM).
Merugu, D., et al (2009). An incentive mechanism for decongesting the roads: A pilot program in Bangalore. Proc. of ACM Workshop.
Zheng, H., E. Nava, and Y.-C. Chiu (2011). Evaluating Active Traffic and Demand Management Strategies for Congested Tourism Traffic Corridor. IEEE Intelligent Transportation Systems Conference, Washington, D.C., IEEE.

(b) Mobility Option Discovery - Social Carpooling

ConnectSmart will offer a carpooling mobility option based on the concept of Social Carpooling, i.e.; opportunities to fill empty seats are found within the existing social network such as traveling with coworkers, being affiliated with the same religious group, sports team, schools, etc. The existing social structure alleviates the mental barrier and security concerns for carpooling with strangers. Metropia's social carpooling feature, "DUO" (Driving Up Occupancy) matches drivers and riders as carpoolers once they are inside a vehicle and does not require pre-matching nor cash payments but rather offers incentives to spur drivers and riders to carpool on a daily basis or on a special occasion. DUO riders and drivers receive points which they can redeem for rewards. During the ConnectSmart project, we propose to initially focus on promoting DUO to employers and then gradually promote DUO to various school districts to promote carpooling for various school activities. Finally, the DUO feature will be promoted as one of the optimal mobility options for group travel activities. DUO is currently being used where Metropia is currently deployed and has been used for group travel activities associated with the Roads and Streets Conference in Tucson, AZ in Spring 2016 and with several large events in Austin, TX.

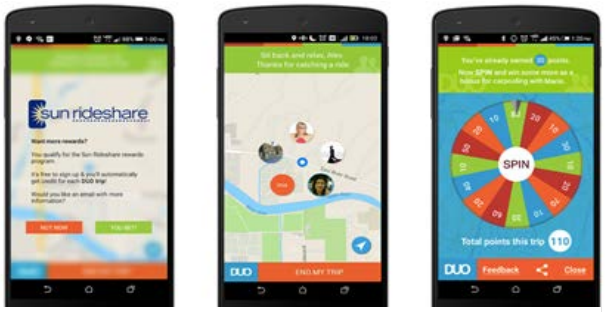

Figure 6: Metropia DUO Social Carpooling

(c) Mobility Option Discovery – Ridesharing

Although Transportation Network Companies (TNCs), including ridesharing services like Uber or Lyft, are steadily gaining in popularity, it is important to recognize that these types of services may reduce car ownership but not necessarily Vehicle-Mile-Travelled (VMT) unless they are carpooled trips. For-hire TNC and ridesharing drivers are not commuters but full-time or part-time drivers who drive for primary or supplementary incomes. According to our own survey of 30+ rideshare drivers across five different cities, these for-hire vehicles run at about 50% utilization on average with the majority of passengers being business travelers or bar/restaurant goers, only few are commuters. Except among high-income individuals, for-hire ridesharing is still cost-prohibitive as a viable commuting solution, thereby preventing it from being a truly viable first-/last-mile solution for transit unless subsidized[4]. The key elements for the ride-sharing services to achieve congestion mitigation goals are: (1) a higher utilization and occupancy (e.g. reduced VMT), and (2) a lower cost and user fee (e.g. viable for commuting or first-/last-mile for transit).

There is a significant amount of daily trips that currently fall through the cracks - too short (and thereby too expensive) for TNC's, too local for fixed-route public transit, and too far to walk. These are the trips that make car ownership mandatory, not optional, in the low-density cities such as Houston. The strategy for the ConnectSmart project in accomplishing both goals is to propose a subscription-based ridesharing service that allows subscribers to request rides in both pre-planned and on-demand manners. The subscriber pays a monthly fee for a certain number of trips in the form of credits. Credits for recurring and pre-scheduled trips (e.g. monthly doctor appointments, daily school trips, etc.) would be lower than the last-minute on-demand / hailed

[4] In most cities ridesharing services have a minimal charge around five dollars per trip.

trips. This system would allow service operators to maximize vehicle fleet utilization via optimal scheduling, ride-matching, and vehicle routing, thereby lowering the operating cost and user fee.

RubyRide is the leading subscription-based ridesharing service provider offering several different service options. Currently operating in Phoenix, AZ, RubyRide is planning operations in Tucson, AZ, and Pittsburgh, PA, and its services include:

- Fixed-rate subscription service, with flat monthly pricing, and service limited by zone, rather than time in the car. This service is targeting short trips and the first-mile/last-mile trip in an economic, reliable, and friendly way.
- Corporate sponsored/subsidized transportation service to provide reliable and dynamic services for large organizations such as corporations, universities, health-care providers. The flexible cost structure allows company/sponsors to pay for part of the trip cost and further cut down the cost for the users. This service is ideal for employer-based shared-ride commute solutions.

During the ConnectSmart, the subscription based ride-sharing service will be integrated with the social carpooling service (DUO) in order to sufficiently meet the demand surge during peak hours, without degrading the fleet utilization and efficiency.

(d) Mobility Option Discovery – Electric Bike Sharing

The ConnectSmart project will enable the nation's first full system ebike deployment with Houston-based employers. Electric bike (ebike) share programs are beginning to flourish outside the US, but their adoption is lagging significantly in the US due to culture, technology, and infrastructure barriers.

An ebike is just like a regular bike, except it has a small battery and nearly silent electric motor that allows the user to go faster and further than would normally be possible. The availability of an ebike expands the user base to people who may not feel physically capable of cycling otherwise. They allow riding up hills, in regular clothing, and for distances very comfortably—making them perfect for corporate users. Table 4 shows the differences between riding a normal pedal bike versus an electric bike represents a typical work day scenario.

Table 4: Typical Work Day Scenario for Pedal Bike versus ebike

	Regular Pedal Bikes	Rocket Electrics ebikes
Practical one-way trip range	1 mile	7 miles
Practical area coverage in one ride	4 sq. miles	150 sq. miles
Typical operating speed	< 10mph	15-20 mph
Physical effort required	strenuous	minimal
Appropriate for use in business attire	no	yes
Comfortable use in hot weather	no	yes
Comfortable use up hills	no	yes

Through ConnectSmart, Rocket Electrics ebikes, currently operating in Austin, Texas, will introduce the Rocket Electrics ebike Pool to Houston. Vastly different from other bike sharing programs, this program leverages the capabilities of an ebike so that users can choose the amount of physical exertion they expend, enabling them to go further with less sweat equity with just a fraction of the effort required in comparison to using a traditional pedal bike. Rocket ebike Pools are designed for the exclusive use of employees of a company or government agency with ebikes

being securely stationed at a participating company or organization's property, rather than on a public right of way. Once employees are trained on the use of the system, ebikes can be checked out by participating employees at any time. The employee goes to a secure area where the ebikes are stored, selects a key to unlock a particular ebike, and can use it to go to lunch, to run an errand, and if they live within 7 miles of the office even to commute home. Rocket Electrics proprietary key fob system tracks which bikes are out and with which employee. Rocket Electrics maintenance staff will keep the fleet in tip-top shape so that all electric bikes are ready to ride at all time. The scalable system is stored on site, so users do not have to walk around outside to locate a bike or worry about the general public's use of a bike.

(e) Mobility Option Discovery – Transit and Augmented Mobility

ConnectSmart also features integration with Moovel's RideTap. RideTap is a mobility option integration software development kit (SDK) that allows multiple ride providers (transit agencies, car-sharing, ridesharing, etc.) to be "deep-linked" so that any App that embeds the RideTap SDK can present a wide number of mobility options to the users. Moovel is currently developing the transit ticketing and payment process for Houston METRO and therefore there will be an immediate benefit to Houston METRO. We propose to link with RideTap from Metropia App and through the RideTap integration, Metropia App users have convenient access and payment options to other existing Houston area mobility options like Car2Go, ZipCar, and METRO. RubyRide and ebike options will also be prepared and automated to be integrated in the same manner.

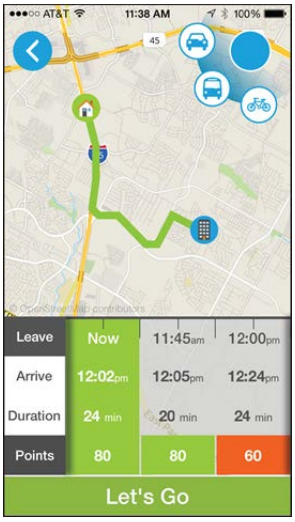

Figure 7: Metropia App Mobility Options

(f) Mobility Option Engagement – Integrated Services

All of the aforementioned innovative mobility discovery options will be integrated into the Metropia App via RideTap SDK, helping commuters to both discover and engage in innovative mobility options. The following scenarios illustrate how this integrated mobility option will function:

- Users can request a ride with Metropia DUO or RubyRide though Metropia. This option combines ridesharing with social carpooling, engages users with gamification, and increases the occupancy, efficiency, and demand of the mobility option service at a lower cost.
- Users can check out a Rocket ebike at an employer or designated location. Once a user taps on the bike option (see the upper right-hand corner of the Metropia App screenshot illustrated by Figure 6), the available ebike locations will appear on a subsequent screen and the user can scan the QR code on the bike as part of the checkout and rental payment process.
- Users can request the delivery or pickup of an ebike from the shop or employer to the house via the RubyRide service so that a user can have flexible mode options throughout the day.
- Users can secure transit and other commonly available car-sharing services like Car2Go available in the Houston region through the Metropia app. These services will also be seamlessly integrated and made available to users via the RideTap SDK functionality.

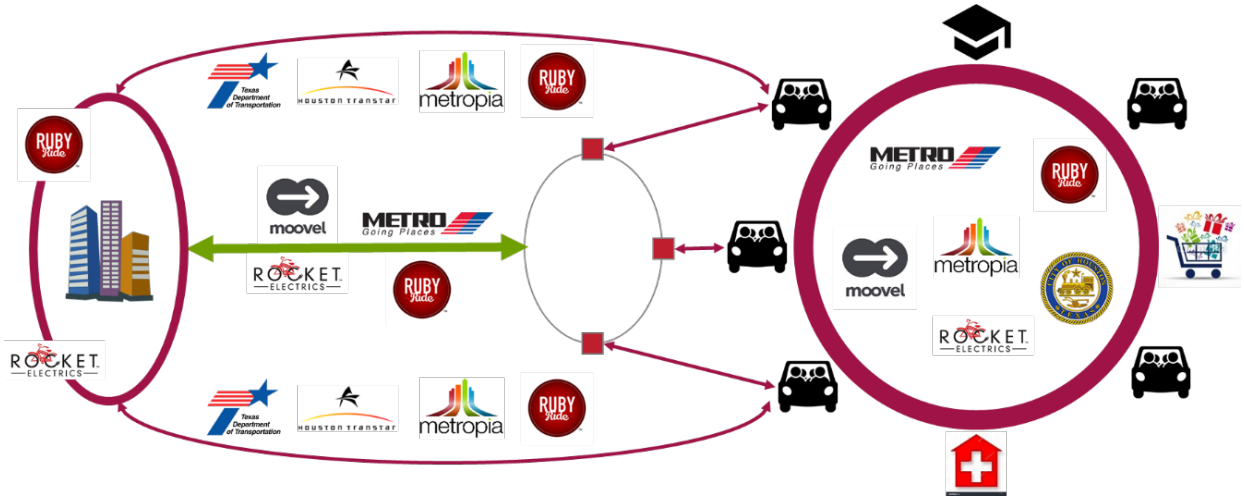

Figure 8: Mobility Options Discovery and Engagement in the ConnectSmart Project

As shown in Figure 8, the integrated mobility options/services form a service network for "city circulation" type of trips such as child's school, grocery shopping, doctor appointments, etc., and can be consolidated/pooled with RubyRide types of services. This would help reduce many single/low occupancy vehicle trips in the city and increase accessibility to transportation by certain groups (e.g. senior citizens, shift workers who work late when transit no longer runs). Further, the Metropia DUO carpooling service would also work seamlessly with RubyRide to supplement or provide additional capacity to accommodate possible demand surge during rush hour which exceeds RubyRide's fleet capacity. RubyRide combined DUO could also be a good solution to solve the first-/last-mile challenges for Houston METRO, provide an improved accessibility to the fixed route transit system.

5.2 TSM&O Strategies and Adaptive-Integrated Corridor Management

The foundation of the ConnectSmart TSM&O strategies is the ***Total Capacity (TC)*** concept that defines the entire transportation system capacity as a combination of all capacities (person trips) provided by all fixed facilities and mobility services. Apart from the traditional traffic engineering definition, including *mobility services* in the total capacity definition allows us to plan and operate capacity in terms of person trips, rather than vehicle trips.

The distinction could be better understood when one particular facility/service is under disruption and through the proposed ***Adaptive-Integrated Corridor Management (A-ICM)*** approach, other types of service capacities can be mobilized or elevated in real-time/quasi-real-time in order to compensate for the disrupted capacity. The total vehicle trips capacity may be reduced due to the disruption but not the person trip capacity. This A-ICM approach allows the system to robustly absorb the temporary "shock" caused by the disruption without significantly reducing the person trip capacity. For example, if there is a scheduled metro system temporary shut-down for maintenance, the A-ICM strategy will estimate the impact and determines the best course of actions including activating carpooling/ridesharing campaigns to encourage more drive-alone drivers to help out by giving rides to potentially stranded metro riders. The increased capacity brought forth by the carpooling activities compensates for the reduced transit capacity.

Total Capacity Coordination (TCC) is enabled by the data-sharing among the private and public partners providing mobility option services through ConnectSmart as well as the big-data analytic platform that utilizes and mines the massive amount of traffic and behavior data shared

by the project team. Specifically, this project will leverage the big data infrastructure offered and shared by the public-private partners to rapidly deploy:

ConnectSmart Data Hub (CSDHub) – A cloud-base big-data SQL, no-SQL, and graph database data management system that enables efficient data storage, query, and mining. To enable TCC, all freeway/arterials capacity conditions (shared by TranStar), transit operating conditions (shared by METRO), Metropia users (shared by Metropia), RubyRide fleets (shared by RubyRide), and ebike fleet (shared by Rocket E), and Car2Go and ZipCar (shared by Moovel) operations will be tracked in real-time. This data infrastructure will be developed by Metropia, with additional resources provided by TTI, UT-Austin, and the University of Arizona (UA).

TCC - a set of sophisticated statistical, optimization, and network flow algorithms to decide on network capacity adjustment based on real-time network conditions. TCC starts from inventorying all the hard and soft capacities and estimate the feasible marginal capacity increase should the service capacity needs to be increased. This effort will be led by Metropia and supported by UT-Austin, UA, and TTI.

A-ICM - an operating process to determine the existing capability and to help system operators to determine strategies to optimize additional capacity, Once the A-ICM strategy is determined and deployed, delivered personalized traveler information include network conditions and recommended optimal mobility options that are highly correlated to individual's travel activity patterns and contexts. For example, if during a flood event a certain highway is not traversable, the A-ICM capability will interface with the CSDHub and TCC to dynamically recommend optimal mobility options for users who are not impacted by the flood event. The A-ICM component will be a joint effort between Metropia, University of Arizona, and TTI.

6. Scope of Work Plan

The entire ConnectSmart project will be deployed by following the ITS system engineering process recommended by FHWA. In the first two years, the ConnectSmart system development process will specifically follow the "V" diagram of the system engineering (SE) process (see Figure 9). Due to the ADM emphasis of this project, Year 3 will follow the custom centered system cycle (CCSC) diagram (see Figure 9). The CCSC focuses on increasing customer lifetime value through various custom acquisition and retention strategies and learning and optimizing the product/service offering in a cyclic manner. We anticipate each CCSC cycle will take approximately six months.

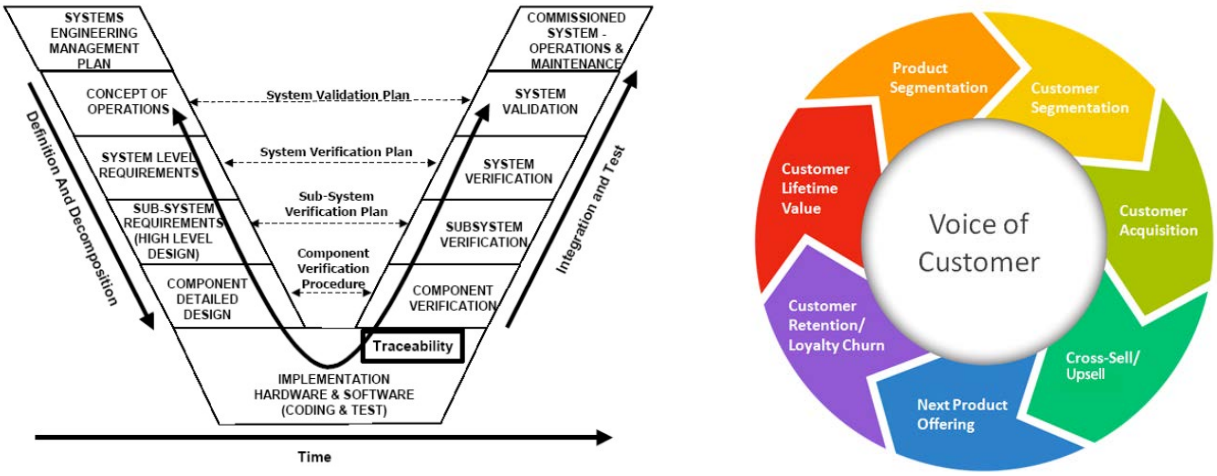

Figure 9: System Engineering V Diagram (Years 1 and 2) and CCSC Diagram (Years 3)

6.1 Year One - System Integration Planning and Pilot Program Jump-start

Generally, the Year One tasks focus on the left-side of V diagram. About half of the right-side of the V diagram will be started in Year One and continue to Year Two.

Task ID (L: Lead, S: Support)	Year One - Task Descriptions
TD1-1 L: TxDOT/Metropia, S: All	Conduct a kick- off meeting with DOT at an agreed location. ***Milestone**: Kick-Off Meeting within 4 weeks of Award*
TD1-2 L: TxDOT/Metropia, S: All	Monthly progress report to document activities performed, anticipated activities, and any change to schedule or anticipated issues.
MP1-1 L: Metropia, S: All	ConOps document development (ADM, TSM&O, and A-ICM). This task is in compliance with the system engineering process. We will combine all the existing system architecture documents and clearly defined the ConOps to enhance the regional ITS architecture. ***Deliverable**: ConOps document.*
MP1-2 L: Metropia, S: All	High-level and detailed system design of CSDHub, TCC, and A-ICM use case documentations. ***Deliverables**: Complete system design document.*
MP1-3 L: Metropia	Metropia system alpha and beta testing. ***Deliverables**: Testing report to be included in monthly report.*
MP1-4 L: Metropia, S: Moovel	Metropia-Moovel RideTap Integration and multi-modal offering. ***Milestone**: Launch a Metropia App with RideTap integration.*
MP1-5 L: Metropia	Launch education outreach and engagement activities.
MP1-6 L: Metropia, S: All Univs. TranStar	Start CSDHub, TCC and A-ICM development, and start TranStar integration, including all performance measures and visualization capabilities.
RE1-1 L: Rocket E, S: UCI	ConOps document development ***Deliverables**: ConOps documents.*
RE1-2 L: Rocket E, S: Metropia, agencies, UCI	Pilot area survey and employer partner recruitment ***Deliverables**: Pilot plan including which employers to participate and the general plan for the pilot program*
RE1-3 L: Rocket E, S: UCI	Site survey of partner locations and on-site employee promotion, recruit, and coaching
RE1-4 L: Rocket E	System preparation and service launch ***Milestone**: Program launch*
RE1-5 L: Rocket E	Interactivity with users to promote best practices and make adjustments through user surveys and performance monitoring ***Deliverables**: Program progress updates and lessons learned memo to be included in the monthly report.*
RE1-6 L: Rocket E, S: Metropia	Data sharing to CSDHub ***Milestone**: Data integrated into CSDHub*
RR1-1 L: RubyRide, S: Metropia	ConOps document development ***Deliverables**: ConOps document.*

Task ID (L: Lead, S: Support)	Year One - Task Descriptions
RR1-2 L: RubyRide, S: Metropia	First Pilot service area finalization, detailed growth plan in place. ***Deliverables****: Pilot plan including which employers to participate and the general plan for the pilot program.*
RR1-3 L: RubyRide, S: CTR	Service readiness preparation
RR1-4 L: RubyRide, S: Metropia	Education and engagement to inform and encourage participation. ***Milestone****: Soft launch, pilot starts*
RR1-5 L: RubyRide, S: Metropia	Data sharing to CSDHub ***Milestone****: Data integrated into CSDHub*
MP1-7 L: Metropia, S: All	Performance monitoring, documentation, and reporting ***Deliverables****: Annual report and meeting on project progress and performance evaluation for all proposed systems/services.*
MP1-8 L: Metropia, S: All	***Milestone****: Year One annual progress review meeting with stakeholder, USDOT, and the advisory panel.*
TD1-3 L: TxDOT/Metropia S: All	An Annual Report to the Secretary describing the deployment and operational cots compared to the benefits and savings, and how the project has met the original expectations proposed in the plan.

6.2 Year Two - Pilot, Learning and Testing

Generally, the first half of Year Two tasks focus on completing the right side of the V diagram, emphasizing on the continual testing, verification and refinement of the ADM services, data sharing, and TSM&O, and TCC components. It is our aim that the entire ConnectSmart system supporting TSM&O, ADM, TCC, and A-ICM will be 90%+ in field operations/testing by the end of Year Two.

Task ID	Year Two - Task Descriptions
TD2-1 L: TxDOT/Metropia, S: All	Monthly progress report to document activities performed, anticipated activities, and any change to schedule or anticipated issues.
MP2-1 L: Metropia, Support: All	Finalize Evaluation of ConnectSmart Year One performance. ***Deliverable****s: Final Year One performance report to be included in the annual report.*
MP2-2 L: Metropia Support: Moovel	Metropia-Moovel RideTap Integration and multi-modal offering to users. Outreach activities to observe the adoption and user behavior.
MP2-3 L: Metropia, S: All Univs. TranStar	Finish CSDHub, TCC, and A-ICM developments, and complete TranStar integration, including all performance measures and visualization capabilities. System verification and testing. *Deliverable: Testing Report.*
RE2-1 L: Rocket E, S: Metropia	Finalize Evaluation of Year one progress and realignment of targets ***Deliverables****: Final Year One performance report to be included in the annual report.*
RE2-2 L: Rocket E, S: Metropia	Survey partners to identify purpose-built ebikes. ***Deliverables****: Survey, finding, and next planning report to be included in the annual report.*

Task ID	Year Two - Task Descriptions
RE2-3 L: Rocket E	Recruit additional partners.
RE2-4 L: Rocket E	Scale fleet based on feedback with additional ebikes. ***Milestone**: Expanded rollouts.*
RE2-5 L: Rocket E	User survey and performance monitoring.
RE2-6 L: Rocket E, S: Metropia	Data sharing to Data Hub; Outreach and engagement to grow user-base ***Milestone**: Continual data integration and analytics.*
RR2-1 L: RubyRide, S: Metropia	Finalize Evaluation of Year one progress and realignment of targets. ***Deliverables**: Final Year One performance report to be included in the annual report.*
RR2-2 L: RubyRide, S: Metropia	Second and 3rd pilot area growth initiation. ***Milestone**: rollout to the 2nd and 3rd pilot areas.*
RR2-3 L: RubyRide, S: CTR	Dynamic rideshare and sponsored services launch. ***Milestone**: dynamic ridesharing launch.*
RR2-4 L: RubyRide, S: Metropia	Enhanced data capture and sharing targets complete. ***Milestone**: Data sharing to CSDHub.*
MP2-4 L: Metropia, S: All	Performance monitoring, documentation, and reporting ***Deliverables**: Annual report and meeting on project progress and performance evaluation for all proposed systems/services.*
MP2-5 L: Metropia, S: All	***Milestone**: Year Two annual progress review meeting with stakeholder, USDOT, and the advisory panel*
TD2-2 L: TxDOT/Metropia S: All	An Annual Report to the Secretary describing the deployment and operational cots compared to the benefits and savings, and how the project has met the original expectations proposed in the plan.

6.3 Year Three - Optimization and Refinement

Year Three focuses on the field operation of TCC and A-ICM. Defined use cases will be deployed and tested and documented. The ADM aspect will focus on the customer center system cycle (CCSC) to continually improve the refine the service provisioning. Further various ADM and user education and engagement campaigns will be deployed and tested to trigger positive behavior change toward more congestion-alleviating travel choices.

Task ID	Year Three - Task Descriptions
TD3-1 L: TxDOT/Metropia, S: All	Monthly progress report to document activities performed, anticipated activities, and any change to schedule or anticipated issues.
MP3-1 L: Metropia, S: All	Finalize Evaluation of ConnectSmart Year Two performance. ***Deliverable**s: Year Two performance report.*
MP3-2 L: Metropia, S: All	Active Demand Management behavior change plan. ***Deliverable**s: ADM behavior change plan.*
MP3-3 L: Metropia, S: Moovel	Metropia-Moovel RideTap Integration and multi-modal offering to users. Outreach activities to observe the adoption and user behavior. ***Deliverables**: User adoption report to be included in the monthly report.*

Task ID	Year Three - Task Descriptions
MP3-4 L: Metropia, S: All Univs. TranStar	Full field operations of the CSDHub, TCC, and A-ICM progress, and TranStar integration, including all performance measures and visualization capabilities. System verification and testing. ***Deliverable**s: Field operations report to be included in the monthly report.*
MP3-5 L: Metropia, S: All	ADM strategy deployment. ***Deliverables**: Final system verification and testing report to be included in the monthly report.*
RE3-1 L: Rocket E, S: Metropia	Evaluation of partner program using cumulative data from all years. ***Deliverable**s: Year Two performance report to be included in the Annual Report.*
RE3-2 L: Rocket E, S: Metropia	Continual surveying partners to identify purpose-built ebikes. ***Deliverables**: Survey, finding, and next planning report to be included in the appropriate monthly report.*
RE3-3 L: Rocket E	Recruit additional partners
RE3-4 L: Rocket E	Scale/refresh ebike fleet as requested; Education outreach and engagement to grow user-base. ***Milestone**: Expanded rollouts.*
RE3-5 L: Rocket E	User survey and performance monitoring.
RE3-6 L: Rocket E, S: Metropia	Data sharing to Data Hub. ***Milestone**: Continual data integration and analytics.*
RR3-1 L: RubyRide, S: Metropia	Finalize Evaluation of Year Two progress and realignment of targets. ***Deliverable**s: Final Year Two performance report to be included in the annual report.*
RR3-2 L: RubyRide, S: Metropia	Extend partnerships and Community engagement efforts. ***Milestone**: Rollout to additional pilot areas.*
RR3-3 L: RubyRide, S: CTR	Dynamic ridesharing and sponsored services launch. ***Milestone**: Dynamic ridesharing launch.*
RR3-4 L: RubyRide, S: Metropia	Deploy mature Zone-based service model and dynamic subscriptions. ***Milestone**: Zone-based service and dynamic subscriptions rollout.*
MP3-6 L: Metropia, S: All	Performance monitoring, documentation, and reporting ***Deliverables**: Annual report and meeting on project progress and performance evaluation for all proposed systems/services.*
MP3-7 L: Metropia, E: All	***Milestone**: Year Three annual progress review meeting with stakeholder, USDOT, and the advisory panel.*
TD2-2 L: TxDOT/Metropia S: All	An Annual Report to the Secretary describing the deployment and operational cots compared to the benefits and savings, and how the project has met the original expectations proposed in the plan.

6.4 Data Sharing and Documentation

The ConnectSmart team members are committed to anonymized but comprehensive and transparent data sharing among team members by populating the CSDHub in order to achieve the optimal outcomes for ADM and TSM&O. The shared data include:

- Subscription data – detailed subscription data by geographic areas (go down to parcel level). Purpose: program performance evaluation.
- Usage data – detailed service usage data. Purpose: program performance evaluation.
- Trip data - characteristics of trips or daily activity tours. Purpose: travel pattern analysis.
- Traffic data – anonymized GPS traces. Purpose: traffic condition monitoring and trend analysis, corridor travel time and reliability analysis, departure diurnal curves analysis and mode-specific performance evaluation.
- Utilization and occupancy data by mode, time, and facilities. Purpose: operational effectiveness and efficiency of the program.
- User Survey data - customer satisfaction toward the program. Purpose: program evaluation.
- User behavior data - behavior change before and after enrolling into the program. Purpose: program evaluation.
- Gamification data - how users respond to incentives, gamification, and campaigns. Purpose: program evaluation.

7. Deliverables

Table 5 summarizes the planned deliverables to the USDOT. The deliverables with task ID are associated with respective tasks listed in Section 6.

Table 5: Deliverable Table

Deliverables	Approximate Due Date	Section 508
Kick-off Meeting - Conduct a kick-off meeting with DOT at mutually-agreed-upon location.	Within four weeks after award.	No
Monthly Progress Reports – submit progress reports to document activities performed, anticipated activities, and any changes to schedule or anticipated issues.	Monthly	No
Annual review meetings with USDOT Advisory Panel to review the deployment progress, performance metrics, lessons learned, and future activity planning.	Last month of each year.	No
Annual reports to the Secretary – submit a report describing the deployment and operational costs compared to the benefits and savings, and how the project has met the original expectations projected in the deployment plan.	Annually beginning one year after award	Yes
MP1-1D: ConOps document for ADM, TSM&O, TCC, and A-ICM.	One month after completion of MP1-1.	No
MP1-2D: A technical report of concept of TCC and A-ICM concept and strategies and how A-ICM can be applied to other cities.	One month after completion of MP1-2.	No
RE1-1D: ConOps document for Rocket Electrics ebikes.	One month after completion of RE1-1.	No

Deliverables	Approximate Due Date	Section 508
RE1-2D: ebikes pilot plan including which employers to participate and the general plan for the pilot program.	One month after completion of RE1-2.	No
RR1-1D: ConOps document for RubyRide service.	One month after completion of RR1-1.	No
RR1-2D: RubyRide pilot plan including which employers to participate and the general plan for the pilot program.	One month after completion of RR1-2.	No
MP2-3D: CSDHub, TCC, A-ICM final system verification, and testing report.	One month after completion of MP2-3.	No
MP3-2D: ADM behavior change plan.	One month after completion of MP3-2.	No

8. Deployment Challenges

There are no known regulatory or legislative challenges to implementing the project. As the Prime recipient, TxDOT will contract with the other public and private sector partners in accordance with its normal contracting practices to move toward efficient implementation. TxDOT will provide oversight of the project and sub-partners. TxDOT also welcomes FHWA's oversight of the project. TxDOT will provide continuous quality assurance and quality control throughout the life of the project.

9. Quantifiable System Performance Improvements

The ConnectSmart team proposes a set of comprehensive quantifiable performance metrics to measure the success of this project. Performance is evaluated according to project partners and commuters with each having a set of criteria with targeted outcomes. Because in the ConnectSmart project the program partners are experienced transportation system management agencies and technology innovators with sufficient marketing deployment experiences, these targeted outcomes are deemed feasible based on the past experience and domain knowledge.

- Commuters: The evaluation focuses on travel time saving, route prediction accuracy and satisfaction.
- Agency: The evaluation focus is on travel time saving for both ADM program users and non-users[5] of the ConnectSmart platform and more importantly the vehicle trips reduction rate. Here, we highlight that the taxi-hailing or for-hire type of TNC service does not necessarily reduce vehicle trips because TNC drivers are not commuters but full-time or part-time drivers. In this case, the greater benefit would be to also encourage TNC users to carpool.
- Mobility Option Programs: Each of the ConnectSmart mobility option programs will have respective evaluation criteria:
  - The Metropia and Moovel multi-modal ADM program is evaluated by travel time savings, route prediction accuracy and more importantly how many program users start to explore and use non-drive-alone option through the discovery and engagement

[5] The behavior change of the users can also benefit the travel time of non-users, leading toward to system optimal (SO).

strategies. The Net Promoter Score (NPS) is a final industry standard evaluation criteria.[6]

- The E-bike Program is evaluated by # of trips and service utilization per employer and the NPS
- The RubyRide program is also evaluated by NPS, plus the vehicle trip reduction rate, fleet utilization, and customer values.

Table 6: Performance Metrics

Program Partners	Criteria	Targeted Outcomes (permitted deviation)
Commuters	• Average travel time-saving • Average routing prediction accuracy • Net Promoter Score • * Avg. CO2 saving • * Avg. Fuel saving	• 10% (<5%) • 15% prediction error (>5%) • 20+ • Observational, no target • Observational, no target
Agency	• # of program users • Avg. travel time saving for users and non-users • Avg. routing prediction accuracy for all users • Vehicle trips reduction rate • Total travel time saving for the entire region/yr. • *Dynamic capacity increase (A-ICM)	• 50,000 (< 20%) • 15% (<5%) • 15% prediction error (>5%) • 10% • 10M minutes • 10% users per event
Employers	• *# of participating employers • *# of active users by employee • *Avg. Travel time saving by employer • *Avg. Routing prediction accuracy by employer • *Avg. User experience satisfaction by employer	• Observational, no target • Observational, no target • 15% (<5%) • 15% prediction error (>5%) • >5 out of 10-point scale
Metropia/ Moovel	• Net Promoter Score[7] • Average travel time-saving • Average routing prediction accuracy • Multi-modal engagement	• 20+ • 10% (<5%) • 15% prediction error (>5%) • >5 out of 10-point scale
ebike	• Net Promoter Score • **Average ebike trips per employer, per day. • **Per site population based utilization • **Changes in ebike use and adoption • Vehicle trips reduction rate	• 20+ • (3+, 1+, < 1) • (50%+, 25%+, 10%+) • (10%+ 0%+ -1%-) • 10%
RubyRide	• Net Promoter Score • Vehicle trip reduction rate • Fleet utilization rate • Customer value compared to owning a vehicle	• 20+ • 10% • 50% • $1,000/yr.

* Observational only, not used for evaluation
** (very successful, successful, marginal)

[6] The Net Promoter Score (NPS) is an industry standard widely used to gauge the loyalty of a firm's customer relationships based on the satisfaction of the product/service. The higher the score is the more likely the happy user is likely to promote the service/product to others.

[7] Net Promoter Score (NPS) is a management tool widely used to gauge the loyalty of a firm's customer relationships. https://en.wikipedia.org/wiki/Net_Promoter

10. Vision, Goals, and Objectives

The ConnectSmart project vision is to deliver a solution that meets the Houston's region congestion mitigation and air quality attainment goals, while engaging system users to change their behavior and dynamically managed system capacity along the traveler's trip chain.

The overarching goal of the ConnectSmart project is to pilot and demonstrate smart and connected transportation system in the Houston region by (1) introducing advanced transportation technologies through a platform that enables users to dynamically discover mobility options and engages them in positive behavior changes, and (2) enabling multi-sourced big data analytics and behavior economics strategies and thereby manages demand and increases access to essential services and other destinations.

Meeting the project vision and goal requires carrying out a set of clear objectives each with their respective, associated benefits:

- Improve return on investments through the enhanced use of the existing transportation system capacity.
- Improve air quality in the nonattainment Houston-Galveston-Brazoria (HGB) region through vehicle emissions reduction.
- Enhance TSM&O effectiveness and efficiency through more system/user data and analytics to enable Houston regional transportation agencies to proactively measure, manage, and influence its traffic network/conditions and capacity.
- Provide real-time and predictive future roadway segment traveler information for both recurrent and non-recurrent traffic conditions, including particularly major disastrous-related system disruptions; thereby, positively impacting the economy by improving the reliable movement of commuters, goods, and services.
- Introduce emerging multi-modal mobility options to travelers to better utilize corridor/system capacities and increase access to mobility services by all.
- Increase regional transportation agencies' understanding of traveler responses to information and mobility options and use of travel behavior data to improvement operational planning decisions.
- Utilize integrated information to allow transportation agencies to prioritize infrastructure growth and maintenance decisions to ensure a state of good repair.
- Enhance and strengthen working partnerships among Houston regional transportation agencies through the shared big-data analytics and creating the infrastructure to promote vehicle-to-vehicle, vehicle-to-infrastructure and autonomous vehicle deployment.

11. Plan of Partnership

The Houston region is well known for piloting and deploying cutting-edge traffic management strategies since the establishment of TranStar in 1993. This ConnectSmart project marks another visionary collaboration among transportation agencies, emerging technologies, and innovations in order to effectively cope with the worsening congestion due to both growing population and prosperous economy. Agency support letters are included in the attached Supplemental Document.

Major regional transportation agencies continue their legendary collaboration by both sharing data and participating in various mobility initiatives set forth in this project. TranStar will be the primary entity for CSDHub data integration and A-ICM implementation. Four major task areas will be researched as implemented via joint collaborations among four companies – Metropia, Moovel, RubyRide, and Rocket Electrics, and three research institutions – the University of

Texas at Austin, Texas Transportation Institute, and the University of Arizona. It is noteworthy that the ConnectSmart team recognizes that future opportunities may exist to partner with additional external partners during the performance period. The team remains open-minded in engaging further in-kind partnership to enhance the outcomes for this project.

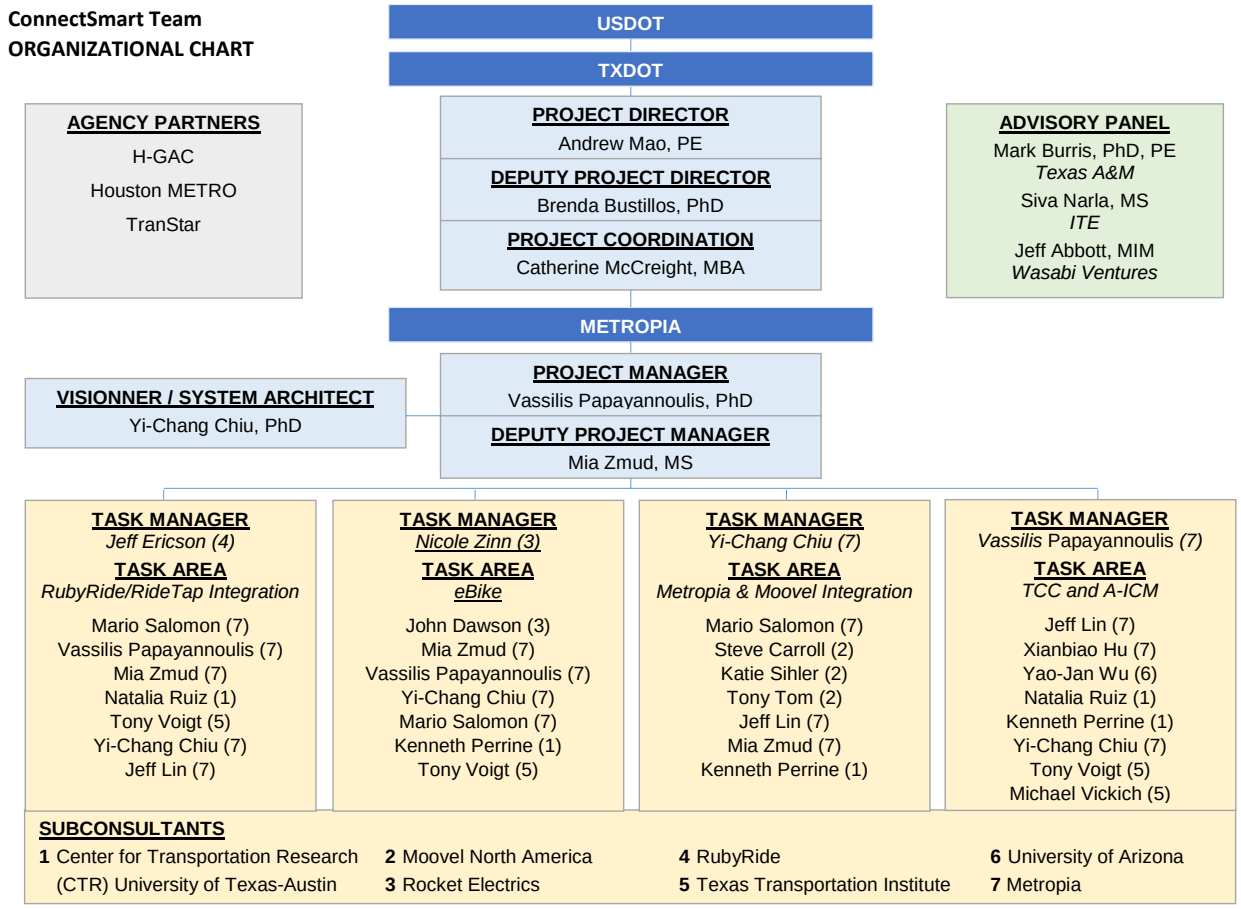

Figure 10: Connect Smart Team Organizational Chart

12. Leveraging Existing Advanced Transportation Technology Investments

The ConnectSmart program will enhance several systems currently in place in the Houston region by supplementing their data collection methods with data collected via the Metropia system. Systems foreseen as benefiting from this program are: Bluetooth traffic data collection, carpooling program, alternative modes of travel, incident towing programs, and overall travel demand management for the region. Highlights of the benefits include:

- Collected Bluetooth traffic data would be supplemented by real-time, second-by-second GPS points/traces collected through the Metropia App.
- The Metropia App will aid the current carpooling reward program in the region (NuRide) by eliminating the cumbersome process of self-reporting by seamlessly and directly reporting carpooling activity from the App to the carpooling program database without user intervention.
- Based on the traveler's route, the Metropia App will perform a thorough search of alternative mobility options as well as their supporting components and provide detailed step-by-step instructions on fares, stops, routes, transfer points, and travel times.

- TxDOT has funded SafeClear, a multiyear program to better manage incidents in the region. Metropia App will integrate available data with a new component that allows travelers to directly send an "SOS" alert letting TranStar/tow truck driver know of a stall or incident to allow for faster response rates.

Finally, Houston's travel demand management as a whole will be enhanced by the data collection of the Metropia App utilizing the GPS trajectories along the trip chain.

13. Schedule

The overall schedule for major task groups is summarized in Table 7. As discussed in Sections 6.1 to 6.3, Year One focuses on planning, design and starting integration for TSM&O related tasks and ADM mobility services will be launched by the end of Year One. Year Two focuses on the piloting of the ADM mobility services and testing of the CSDHub, TCC, and A-ICM functionalities. In Year Three, all systems will be fully functional and under continual improvement and optimization. Performance monitoring, reporting, and documentation will be conducted regularly and reported and shared with USDOT and the Advisory Panel. The annual review meetings allow the USDOT and the Advisory Panel members to provide feedback and comments to guide the subsequent year's activities.

Table 7: ConnectSmart Project Schedule

		Year 1				Year 2				Year 3			
		Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4
MP1-1 and 1-2	System design and planning	■											
MP1-3 and 1-4	Metropia system alpha and beta testing, RideTap integration	■	■	■									
MP1-5	Market Launch				■								
MP1-6	CSDHub, TCC and A-ICM capability implementation		■	■	■	■	■						
RE1-1	Conops, design, planning, and initial pilot sites recruits	■											
RE1-2 to 1-5	Pilot planning and implementation	■	■	■	■								
RE1-6	Data sharing				■								
RR1-1	Conops, design, planning, and initial pilot sites recruits	■											
RR1-2 to 1-4	First Pilot service area finalization, detailed growth plan in place.		■	■	■								
RR1-5	Data sharing to CSDHub				■								
MP1-7	Performance monitoring, documentation, and reporting				■								
MP1-8	***Milestone** : Year One annual progress review meeting with stakeholder,*				■								
MP2-1	Year One evaluation					■							
MP2-2	Metropia-Moovel RideTap Integration and multi-modal offering					■							
MP2-3	Finish CSDHub, TCC, and A-ICM developments, and TranStar initegration					■	■	■	■				
RE2-1 to 2-4	Feedback, adjust and optimize, additional pilots, integrated ADM services					■	■	■	■				
RE2-5	User survey and performance monitoring.								■				
RE2-6	Data sharing to Data Hub								■				
RR2-1 to 2-2	Feedback, adjust and optimize, additional pilots, integrated ADM services					■	■	■	■				
RR2-3	Dynamic RideShare and sponsored services launch.						■	■	■				
RR2-4	Enhanced data capture and sharing targets complete.								■				
MP2-4	Performance monitoring, documentation, and reporting								■				
MP2-5	**Milestone**: Year Two annual progress review meeting with stakeholder, US-								■				
MP3-1 to 3-5	Region-wide deployment and user ramps up, optimization and refinement									■	■	■	■
RE3-1	Feedback, adjust and optimize, additional pilots, integrated ADM services									■			
RE3-2 to 3-5	Continual surveying partners to identify purpose-built ebikes. Deliverables:									■	■	■	■
RE3-6	Data sharing to Data Hub.												■
RR3-1	Feedback, adjust and optimize, additional pilots, integrated ADM services									■	■	■	■
RR3-2 to 3-4	Extend partnerships and Community engagement efforts.									■	■	■	■
MP3-6	Performance monitoring, documentation, and reporting												■
MP3-7	***Milestone** : Year Three annual progress review*												■

14. Leveraging the ITS Program

TranStar collects travel information and monitors the system utilizing toll tag readers, Bluetooth readers, and other devices. This information provides information on traffic incidents and planned construction, giving location, travel direction, and nature of the incident or activity on its

275 system-wide permanent roadside DMS. Furthermore, TranStar monitors traffic incidents with more than 900 regional Closed Circuit Television Camera (CCTVs).

ConnectSmart will enhance the above-mentioned systems by providing TSM&O effectiveness and efficiency through more system/user data and analytics, allowing TranStar to proactively manage and influence its traffic network/conditions. ConnectSmart analytics and predictive algorithms would (1) permit for a more reliable travel time prediction during recurring and non-recurring events that would be disseminated as pre-trip and/or en-route information directly to travelers or posted on the 275 system DMS, (2) relay arterial traffic flows and approach delay information that could then be used to adjust or optimize traffic signals, and (3) alert travelers of incidents on the network via a verified CCTV mechanism. Finally, ConnectSmart would integrate the SafeClear towing service directly into its App, allowing for a faster tow request as travelers can directly request a tow from the App as soon as they experience an issue on the traffic network.

The City of Houston manages 2,450 traffic signals, 1,600 school flashers, and a total of 650 Bluetooth station readers and installed a communications system that collects arterial data including travel time, speed, traffic, and volumes using Bluetooth technology (602 Bluetooth station). Harris County also installed Bluetooth devices at the majority of its traffic signals. These two systems provide a network of data that covers most of the principal and major arterials and provide a unique opportunity to investigate interactions between the freeway and arterial network. ConnectSmart would enhance these systems by (1) supplementing the Bluetooth collected data with the GPS collected traffic data via the App, (2) incorporating school zones within analytics to avoid these areas if a faster route is available or alert travelers of their approach to such areas and their reduced speed limit, and (3) informing traffic signals of delays encountered at intersections.

Staffing Description

15. Project Management and Key Personnel

This ConnectSmart will be directed by Andrew Mao, Director of Planning of the Texas Department of Transportation Houston District. Mr. Mao will be supported by his key staff, Dr. Brenda Bustillos and Catherine McCreight for overall task execution and project management. Dr. Vassilis Papayannoulis will be the Project Manager, supported by Ms. Mia Zmud who will serve as a Deputy Project Manager. For agency/firm bios and key personnel resumes, please see the attached Supplemental Document.

Name	Agency	Role
Andrew Mao, PE	TxDOT	Project Director: overall project progress & quality
Brenda Bustillos, PhD	TxDOT	Deputy Project Director: Assists in project oversight
Catherine McCreight, MBA	TxDOT	Leads project coordination
Vassilis Papayannoulis, PhD	Metropia	Project Manager
Mia Zmud	Metropia	Deputy Project Manager. Metropia ADM Lead
Yi-Chang Chiu, PhD	Metropia/UA	Visioneer and System Architect/Co-PI Univ. of AZ
Steve Carroll	Moovel	Moovel Lead: leads RideTap provisioning

Name	Agency	Role
Jeff Ericson	RubyRide	Task Lead: leads RubyRide service deployment
John Dawson	Rocket Electrics	Rocket Electrics Lead: ebike service deployment
Nicole Zinn	Rocket Electrics	Task Lead: leads ebike service deployment
Natalia Ruiz, PhD	CTR UT-Austin	CTR Lead: leads transit service analysis and new strategy deployments
Kenneth Perrine	CTR UT-Austin	CTR Lead
Tony Voigt	TTI	TTI Lead: System integration
Yao-Jan Wu, PhD	Univ. of AZ	Leads network performance measures & visualization
Mark Burris, PhD	Mark Burris	Advisory Panel – casual carpooling
Siva Narla	AVS, LLC	Advisory Panel – TSM&O technology
Jeff Abbott	Wasabi Ventures	Advisory Panel – Venture

16. Primary Point of Contact

Andrew C. Mao, PE
Director of Advance Transportation Planning, TxDOT Houston District
Tel: 713-802-5301, Email: andrew.mao@txdot.gov
Address: 7600 Washington Ave, Houston, TX 77007

Funding Description

17. Funding Breakdown

As shown in Table 8, the total budget of this project is proposed at $17,878,124 with 50% requested from USDOT and the other 50% fully matched by the ConnectSmart team members. All the ConnectSmart team members have committed varying levels of matching (details are included in the attached supplemental document) but **TxDOT is committed to providing the dollar for dollar cash match (50/50) to meet the matching requirement should any of the program income related match fall short during the performance period.**

Table 8: Budget Summary

Team Member	Funding						Total - Fed	Total - Local	Total Program
	Y1- Federal	Y1 - Local	Y2- Federal	Y2- Local	Y3- Federal	Y3 - Local			
TxDOT	$400,000	$1,383,365	$400,000	$850,000	$400,000	$438,960	$1,200,000	$2,672,325	**$3,872,325**
Metropia	$1,287,779	$514,798	$1,046,707	$532,882	$1,071,264	$585,115	$3,405,750	$1,632,795	**$5,038,545**
Moovel	$0	$100,000	$0	$100,000	$0	$100,000	$0	$300,000	**$300,000**
RubyRide	$800,000	$800,000	$514,727	$514,727	$200,000	$200,000	$1,514,727	$1,514,727	**$3,029,454**
Rocket Electrics	$382,800	$72,182	$495,238	$352,381	$489,753	$943,228	$1,367,791	$1,367,791	**$2,735,582**
CTR (UT-Austin)	$81,109	$81,343	$83,713	$83,784	$85,971	$86,297	$250,794	$251,424	**$502,218**
TTI	$200,000	$200,000	$200,000	$200,000	$200,000	$200,000	$600,000	$600,000	**$1,200,000**
Univ of Arizona	$200,000	$200,000	$200,000	$200,000	$200,000	$200,000	$600,000	$600,000	**$1,200,000**
Subtotal/Year	**$3,351,688**	**$3,351,688**	**$2,940,385**	**$2,833,773**	**$2,646,988**	**$2,753,600**	**$8,939,062**	**$8,939,062**	**$17,878,124**

Table 9 shows the budget breakdown by tasks groups.

Table 9: Budget Breakdown by Task Groups

Year One - Task Descriptions		
MP1-1 to 1-6	System design, setup, configuration, field testing, RideTap, CSDHub design, TCC, and A-ICM ConOps and integration design and initial implementation.	$3,333,734
RE1-1 to 1-6	ConOps, design, planning, and initial pilot sites recruits.	$1,872,158
RR1-1 to 1-5	ConOps, design, planning, and initial pilot sites recruits.	$809,193
MP1-7	Performance monitoring, documentation, and reporting.	$543,452
MP1-8	Milestone: Year One annual progress review meeting with stakeholder, USDOT, and the advisory panel.	$144,841
Year Two - Task Descriptions		
MP2-1 to 2-3	Region-wide deployment and user ramp-up, optimization and refinement, A-ICM pilot testing and CSDHub operations, multiple-modal discovery and engagement.	$2,448,194
RE2-1 to 2-6	Feedback, adjust and optimize, additional pilots, integrated ADM services.	$1,154,832
RR2-1 to 2-4	Feedback, adjust and optimize, additional pilots, integrated ADM services.	$1,625,146
MP2-4	Performance monitoring, documentation, and reporting.	$449,362
MP2-5	Milestone: Year Two annual progress review meeting with stakeholder, USDOT, and the advisory panel.	$96,626
Year Three - Task Descriptions		
MP3-1 to 3-5	Region-wide deployment and user ramp-up, optimization and refinement, Further TranStar integration with A-ICM procedure, multiple-modal discovery, and engagement outreach expansion. Final performance assessment.	$2,419,036
RE3-1 to 3-6	Feedback, adjust and optimize, additional pilots, integrated ADM services.	$1,883,468
RR3-1 to 3-4	Feedback, adjust and optimize, additional pilots, integrated ADM services.	$544,550
MP3-6	Performance monitoring, documentation, and reporting.	$437,437
MP3-7	Milestone: Year Three annual progress review meeting with stakeholder, USDOT, and the advisory panel.	$116,096
	Total	$17,878,124

For cost-share commitment letters and detailed budgets, please see the attached Supplemental Document.

Answers to the Organizational Information questions are included in the attached Organizational Information Document.