"Real-Time" Ridesharing – The Opportunities and Challenges of Utilizing Mobile Phone Technology to Improve Rideshare Services

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ABSTRACT

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In recent years, an innovative ridesharing service relying heavily on advanced mobile phone technologies known as "real-time" ridesharing, or "dynamic" ridesharing has gained in popularity. Traditionally, rideshare arrangements between two or more unrelated individuals for

- 45 commuting purposes have been relatively inflexible, long-term arrangements. "Real-time" ridesharing attempts to provide added flexibility to rideshare arrangements by allowing drivers and passengers to arrange occasional shared rides ahead of time or on short notice. The addition of this service innovation presents a number of opportunities to overcome existing rideshare challenges.
- 50 The paper begins with a definition of "real-time" ridesharing and follows with a comprehensive categorization of the challenges hindering greater rideshare participation. The information gathered suggests that rather than being a single challenge to be overcome, the 'rideshare challenge' is a series of economic, behavioral, institutional and technological obstacles to be addressed. The potential opportunities, and obstacles, created by "real-time"
- 55 innovations are then highlighted. The paper concludes with several recommended 'next steps' to further understand how rideshare participants use "real-time" services, focusing specifically on the need for multiple, comprehensive "real-time" rideshare trials.

This study provides an important foundation upon which further "real-time" ridesharing research can take place. By identifying and categorizing existing rideshare challenges, and by outlining how "real-time" ridesharing addresses and exacerbates these challenges, this study highlights where opportunities in technology-based ridesharing exist, and where important issues remain.

INTRODUCTION

The purported benefits from increased ridesharing are substantial. A successful rideshare scheme could, from a societal perspective, reduce fuel consumption and emissions, reduce congestion during peak travel periods, reduce parking costs for travelers and employers, provide a reliable alternate mode for travelers, and promote greater equity in transportation by ensuring that mobility is maintained for lower income travelers. For commuters, major rideshare benefits include travel time savings, cost savings (namely fuel and parking) and increased mode choices.

- For employers, reduction in the cost of providing parking and improvements in worker productivity brought about by less stressful commutes are two of the primary potential benefits. Yet even with such a substantial number of benefits to a variety of transportation stakeholders, interest in ridesharing among travelers has remained relatively low. While ridesharing as a journey-to-work mode has remained relatively stable for the past five years (10-11%) (*I*), the
- 75 fact remains that it is still half as popular as it was in 1970 (20.4%) (2). In recent years, an innovative rideshare service relying heavily on mobile phone technologies known as "real-time" ridesharing, or "dynamic" ridesharing has gained in popularity. Traditionally, rideshare arrangements between two or more unrelated individuals for commuting purposes have been relatively inflexible, long-term arrangements. The increasing
- 80 complexity of work and social schedules and the related increase in vehicle trip complexity, such as trip chaining, is assumed to have made this type of commuting arrangement less desirable. Real-time ridesharing attempts to provide added flexibility to rideshare arrangements by allowing drivers and passengers to arrange occasional shared rides ahead of time or on short notice. The addition of this service innovation presents a number of opportunities to overcome existing rideshare challenges, but also exacerbates certain rideshare challenges.
 - The paper begins with a definition of "real-time" rideshare enabling of the challenges in a comprehensive categorization of the challenges hindering greater rideshare participation. The potential opportunities, and obstacles, created by "real-time" innovations are then highlighted. The paper concludes with several recommended 'next steps' to further understand how rideshare
- 90 participants use "real-time" services, focusing specifically on the need for multiple, comprehensive "real-time" rideshare trials.

DEFINING & DESCRIBING "REAL-TIME RIDESHARING"

"Real-time" ridesharing has been defined in a variety of ways. One of the first formal definitions proposed for "real-time" ridesharing was developed in preparation for a trial in Sacramento, CA

- 95 in 1994 (3). The team behind that trial defined "real-time" ridesharing as "a one-time rideshare match obtained for a one-way trip either the same day or the evening before" (3). Several years later, researchers developing a similar trial in Seattle proposed that "dynamic ridesharing" be defined as "two or more people sharing a single trip, without regard to previous arrangements or history among the individuals involved...a dynamic ridesharing system must be able to match
- 100 random trip requests at any time" (4). A more recent definition proposed by 'dynamicridesharing.org' suggests that "dynamic ridesharing" is "a system that facilitates the ability of drivers and passengers to make one-time ride matches close to their departure time, with sufficient convenience and flexibility to be used on a daily basis" (5). Note that all three of the definitions emphasize the occasional nature of these arrangements, using the term "one-time"
- 105 trips. The other main characteristic of all three of these definitions is the amount of advanced notice required for the arrangement of trips with the Sacramento definition recommending the

"same day or the evening before" a trip, the Seattle definition recommending "at any time", and the 'dynamicridesharing.org' definition recommending "close to [participants] departure time". In general, "real-time" ridesharing implies that little advanced notice is needed when attempting to establish a shared trip.

For the purposes of the study presented in this paper, "real-time" ridesharing is defined as:

"A single, or recurring rideshare trip with no fixed schedule, organized on a one time basis, with matching of participants occurring as little as a few minutes
 before departure or as far in advance as the evening before a trip is scheduled to take place".

In addition to the proposed definition, the use of the term "real-time" ridesharing may refer to the package of technologies and features that are typically used to enable this type of service.

"Real-time" services tend to rely on a similar set of technologies and share similar features. The underlying technological requirements often include:

- 125 (1) <u>Smart Phones</u> Many service designs rely on the recent proliferation of smart phones in the market place. The firms developing the underlying software for "real-time" ridesharing have focused their efforts on platforms with easy-to-use, attractive user interfaces such as Apple's iPhone software and Google's Android platform.
- 130 (2) <u>Constant Network Connectivity</u> The need to communicate ride requests and accept offers on short notice requires that one be constantly connected to the network. Many smart phones are now offering (or require) unlimited data plans with new smart phone contracts, facilitating constant network connectivity.
- (3) <u>GPS Functionality</u> The use of Global Positioning System (GPS) functionality has been incorporated into many applications so that they become "location aware". In other words, participants seeking a ride do not need to key in their current location because the GPS built into their smart phone knows where they are located and communicates this information automatically when trips are logged. This is often marketed as a time saving feature.
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(4) <u>Ride Matching Algorithm</u> – All of the underlying systems use some form of algorithm to match riders and passengers. Some of the algorithms do so based only on origin and destination, while some of the newer algorithms match drivers and passengers based on the commonality of their travel route.

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(5) <u>Data Repository</u> – All "real-time" systems (and Internet-connected rideshare systems in general) have a data repository where rideshare information is stored. The types of data stored might include a current list of ride requests and offers, individual participant profiles and summary statistics on participation.

Many (but not all) "real-time" rideshare services incorporate additional features such as:

155 (6) <u>Stored User Profiles</u> – Providers will allow users to create and save information profiles. Personal information such as name, employer, home and work locations, popular origindestination (OD) pairs with the user's preferred route, and a photo are common. Some systems require a photo of the driver's vehicle and license number be provided. Stored profiles require more participant time on the front end, but make future ride requests much less time consuming.

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(7) <u>Social Network Integration</u> – Because of the propensity of individuals to share rides with people they know or share common characteristics with, some providers have linked their services to existing social networks in an effort to improve successful matches. For some, this has meant incorporating their services with online networks such as 'Facebook'. In these cases,

- 165 only friends within a given individual's immediate Facebook network will be considered when searching for ride matches. For other providers, 'social network integration' has focused on offering services to a specific organization or institution. In these cases, only co-workers at the same organization are considered as potential partners.
- 170 (8) <u>Participant Evaluation</u> "Real-time" services may allow participants to rate each other, much like the online auction service 'eBay'. After a ride has been completed successfully, both the passenger and driver are asked to rate each other. The idea behind this feature is that it allows future users to evaluate potential partners quickly, based on others past experiences. The theory is that those with higher ratings are likely to be preferable shared ride partners.
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(9) <u>Automated Financial Transactions</u> – "Real-time" services may allow for financial transactions between participants. Some allow participants to name their own price, while others recommend a value based on standard Internal Revenue Service (IRS) vehicle cost estimates. Some providers facilitate automatic transactions through the use of online payment systems such

180 as PayPal. Other providers simply calculate the recommended shared cost and allow drivers and passengers to negotiate and agree on a final amount and payment method.

(10) <u>Incentives and Loyalty Rewards Linked to Participation</u> – "Real-time" providers may offer incentives or loyalty rewards based on a given individual's level of participation, much like

185 airline loyalty programs. Those that participate more frequently earn more points or rewards. Providers hope that by providing incentives, existing participants will be encouraged to post rides more frequently, and new participants will be encouraged to join their service.

"Real-time" ridesharing capitalizes on advancements in mobile phone technologies and
 allows participants to organize shared rides on short notice from virtually any location with
 cellular coverage.

THE 'RIDESHARE CHALLENGE' FROM MULTIPLE PERSPECTIVES

As part of this study, the existing challenges associated with ridesharing are first identified and subsequently categorized. Interviews were conducted with fifteen rideshare stakeholders

195 including private sector rideshare service providers, public sector service providers and several large organizations. The purpose of these interviews was to allow leaders in the provision of rideshare services to describe what they perceived as the largest rideshare challenges to be

overcome. These interviews informed the organization of the "Real-Time Rides" workshop, a two-day event held at MIT that many of the interviewees subsequently attended. The workshop

- 200 brought together approximately 40 participants from five countries. The goals of the workshop included encouraging greater collaboration and information sharing among stakeholders, discussing roles for the academic community investigating strategies that could lead to greater rideshare participation, and establishing a long-term dialogue among stakeholders to discuss new innovations and ongoing challenges.
- 205 The information gathered from the interviews, workshop, and published materials suggests that rather than being a single challenge to be overcome, the 'rideshare challenge' is actually a series of economic, behavioral, institutional and technological obstacles to be addressed. These challenges are summarized and discussed in detail.

Economic Challenges

- 210 The economic challenges associated with ridesharing can be broken into two distinct categories: the economic barriers associated with ridesharing specifically, and the favorable economics of other modes, particularly single-occupant vehicle (SOV) travel. The former are largely inefficiencies or market frictions that are specific to ridesharing, whereas the latter are economic phenomena that benefit other modes of transportation, thereby making ridesharing less desirable.
- 215 The first two challenges discussed are rideshare-specific; the third and fourth economic challenges highlighted are best described as favorable economics for other transport modes.

Imperfect Information

Ridesharing suffers from a variety of instances of imperfect information. At the most basic level, drivers and passengers willing to share rides may not have any way of identifying one another. This challenge has been largely addressed through the development of increasingly sophisticated

- 220 This challenge has been largely addressed through the development of increasingly sophisticated ride matching systems. However, imperfect information inefficiencies exist elsewhere. Even if drivers and passengers can be successfully matched, little is known about each individual. What is the driver's driving history? Do either the driver or passenger have a criminal record? Does either the driver or passenger smoke? These information gaps can be important in determining
- 225 ones likelihood of sharing a ride. Imperfect information can also affect those that do not currently share rides. If a particular driver had not seriously considered sharing rides, but was informed one day that four employees at his organization live in his neighborhood and commute at approximately the same times as he does on a consistent basis, might that encourage him to consider ridesharing for future trips? What if the same driver was presented with the cost and
- 230 travel times for all commuting options including transit and ridesharing? Would that encourage a change in travel behavior? The imperfect information challenge is closely associated with some of the social/behavioral and technological rideshare challenges outlined below.

High Transaction Costs

High transaction costs are another feature common to many traditional rideshare arrangements.
These costs generally take two forms; the time needed to establish a rideshare arrangement, and the additional time needed to pick up and drop off passengers. The amount of effort needed to establish a rideshare arrangement is not insignificant. The creation of a user profile, the search for appropriate matches in a database and the calls and/or e-mails to share information and establish a schedule can be time consuming, particularly if the length of time one plans on

sharing rides is unknown. If the expectation is that the rideshare arrangement will be frequent

and long lasting (perhaps multiple shared rides per week for six months or longer), this initial transaction cost may be deemed reasonable. If, however, a participant is only interested in occasional or short-term rideshare opportunities, the initial transaction cost may be seen as too onerous. Given the complexity of daily schedules and the fact that schedules have significant

- intra-week variability, occasional rideshare arrangements are probably more suitable for many 245 people these days, and as such transaction costs need to be reduced to make these types of arrangements desirable. The second form of transaction cost is the time needed to deviate and/or wait for passengers as they are picked up and dropped off. Several studies have shown that the majority of drivers are unwilling to incur more than a 5-10 minute delay in order to pick up and
- drop off passengers (6)(7), suggesting this is a significant factor in one's perception of rideshare 250 convenience.

Subsidies Favoring Other Transport Modes

While ridesharing suffers from various economic inefficiencies, other modes and particularly private vehicle ownership, continues to capitalize on rather favorable economic distortions, namely subsidies for specific modes of transportation. Subsidies for employee parking, transit, vanpooling and most recently cycling have created a distinct disincentive to share rides. While the federal government has largely been responsible for creating these economic distortions and has shown no interest in eliminating them, many employers and employees benefit from the

subsidies, making them even more difficult to eliminate. By allowing employers to offer employer-paid parking and pre-tax transit to employees, these firms avoid paying corporate tax 260 on those benefits.

Decreasing Costs of Vehicle Ownership

The average cost of vehicle ownership has generally followed a downward trend historically. The Comerica Auto Affordability Index, plotted in Figure #1, measures the number of weeks of family income needed to purchase a new vehicle. While the index has been as high as 30 weeks 265 of family income in 1995, it has since decreased to an all-time low of less than 22 weeks of income in 2009 (8). It should be noted that this chart is only concerned with the average purchase price of new vehicles; it does not include variable costs such as gasoline or insurance, and it does not include the costs of buying a lower-priced, used vehicle instead of a new one. Nevertheless,

- 270 it highlights the decreasing cost of auto ownership. Data from the Consumer Expenditure Survey (CES) confirms that auto expenditures as a percentage of household income has also decreased over time. Between 1990 and 2008, the percentage of pre-tax income spent on private transportation decreased from 15.1% to 12.7% (9). Both of these trends demonstrate that private auto ownership has become less costly over time, in absolute terms and as a percentage of
- household expenditures. 275



280 FIGURE #1: Comerica Bank Auto Affordability Index, 2009

Social / Behavioral Challenges

The rideshare challenge can also be characterized as a set of social & behavioral obstacles to be overcome. It should be emphasized that the social and behavioral challenges presented here are rational human concerns, but challenges that can be overcome with sufficient safeguards,

etiquette and incentives.

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"Stranger Danger"

It's not uncommon for Hollywood to portray hitchhiking as a common activity, but unfortunately ridesharing between unknown travelers represents but a small portion of the shared rides that take place. Surveys have suggested that as little as 3% to 10% of shared rides occur between unknown passengers, with the rest occurring between family members, co-workers and neighbors (6)(7)(10). These statistics clearly reflect the phenomenon of "Stranger Danger", whereby drivers and passengers show little interest in sharing rides with strangers because of personal safety concerns.

Power Mismatch and the Need for Mutual Dependency

- 295 The power dynamics in traditional, long-term rideshare arrangements is worth considering. Drivers typically have greater power to dictate departure time and behavior in the vehicle. Passengers essentially give up their power to participate in the arrangement in exchange for some benefit (cost savings from leaving a vehicle at home, typically). This power mismatch and the perception of unequal distribution of benefits would suggest that traditional arrangements should
- 300 not be sustainable. In reality, this 'power' mismatch is often overcome by having drivers and passengers alternate driving responsibilities from one day to the next. In effect, drivers and passengers share the power mismatch burden, and share in the benefits of the arrangement. In casual carpool arrangements, the driver retains the power to leave when they want, but relies on passengers to gain access to the faster moving high occupancy vehicle (HOV) lanes, or to avoid which table. The atmeture of the arrange and the power is such that both metrics have the next.
- 305 vehicle tolls. The structure of the casual carpool system is such that both parties have the power

to make the arrangement succeed or fail. Drivers capture travel time benefits while maintaining their freedom to travel when they choose. Passengers capture travel time and cost reduction benefits, but give up some freedom in the process. In both traditional and casual carpool arrangements, it is the mutual dependency and mutual benefit between drivers and passengers

310 that allows ridesharing to be sustained over the long term. In occasional rideshare arrangements, the challenge is in identifying opportunities where this mutual dependency exists, and where the power mismatch can be overcome.

Reliability of Service

One of the largest behavioral challenges to be overcome is the perception of low reliability in 315 rideshare arrangements. In a typical commuting rideshare arrangement, passengers agree to share rides with a single driver for a period of time, in many cases several months. The driver and passenger agree to a schedule and make small modifications as needed. However, if the driver has an unexpected appointment or emergency, the passenger may be left with no rideshare options for the return journey, a situation that is unacceptable to many commuters. Poor

320 perceptions of reliability are not just isolated to passengers. Drivers that are required to wait for a passenger or modify their schedule substantially to accommodate passengers may have poor reliability perceptions as well.

Schedule Flexibility

- The lack of schedule flexibility has been one of the longest running challenges in rideshare arrangements. For rideshare arrangements to last for a reasonable period of time, drivers and passengers often agree to a relatively fixed schedule including arrival and departure times, agreed upon meeting locations and driving responsibilities. This type of arrangement does not allow for much flexibility. Variable work and social schedules can make fixed rideshare arrangements difficult to maintain. It is interesting to note that increased flexibility and increased reliability in rideshare arrangements often compete against one another.
 - Consistency of Expectations (Vehicle Type & Behavior)

Once drivers and passengers have been sharing rides for a period of weeks or months, they grow accustomed to the routine. The type of vehicle, the condition that it's in, the habits of the driver and passenger, the radio station selected, all of these become familiar features or expectations of

- 335 the trip. This consistency of service is similar to transit in many regards. Transit passengers have a good sense of the type of vehicle that will pick them up, the condition that it will be in, the destination they'll be dropped off at, the behavior of the transit operator and the behavior of fellow passengers. Much of this consistency is due to standardization (of vehicles and driver training), the provision of information (route maps and schedules) and social cues relating to
- 340 appropriate behavior. One-time or short-term ridesharing arrangements make it difficult for travelers to establish consistent expectations of their commuting trip, and may explain some unwillingness to participate in occasional rideshare arrangements.

Institutional Challenges

The institutional dynamics of ridesharing are not frequently discussed, but do impact the mode's attractiveness in a substantial way. The majority of the institutional challenges can be distilled down to a question of what are appropriate roles for the private and public sectors in encouraging ridesharing, and which stakeholders are in the best position to capture value and share it with rideshare participants.

Insufficient Institutional Collaboration

- 350 This challenge lies in encouraging each of these stakeholder groups to collaborate with one another and take action in those areas in which they have an advantage. For example, private firms that specialize in the development of rideshare matching software and travel management solutions have a key role in reducing transaction costs and providing better information for travelers. Large employers often have the ability to influence travel behavior through the
- 355 modification of parking prices or by providing benefits for those that choose commuting alternatives. State agencies have a critical role in creating incentives for ridesharing, such as HOV lanes, and developing effective policies to support ridesharing, such as modifications to taxi regulations. The federal government could play a strong role in promoting ridesharing by leveling the playing field and allowing rideshare participants to claim the pre-tax transportation
- 360 fringe benefits that are available to transit and vanpool participants. Given conflicting goals, resources, power and perceived public mandates it can be difficult for all of these institutional stakeholders to reach a consensus on their respective roles.

Business and Revenue Model

- A distinct challenge from the private rideshare service provider's perspective is how best to 365 generate revenues from a rideshare arrangement. Generally, we have seen providers use four general approaches to revenue generation; offering matching services free of charge while relying on advertisement/marketing revenue, capturing a percentage of transaction value as it is transferred between passengers and drivers, the development of customized commuter information portals for employers/institutions, and the development of rideshare services for
- 370 public agencies. Each of these revenue models have been used with varying levels of success, suggesting there is no single model that is ideal.

Service Competition within a Market

In many geographic areas, public and private sector providers compete against one another (competition in the market). In some cases, this has led to tension between the two stakeholder groups and ultimately to the creation of multiple, unconnected databases that provide little value to potential rideshare participants. However, competition between providers can be beneficial. For example, competition between firms offering competing ride-matching systems may yield a lower-cost system or one customized to local situations in a given market (competition for the market). With high initial development costs and the need for substantial participation ("critical

- 380 mass") before sustainable levels of matched rides are reached, there is a strong argument for having a single ride-matching system in a given market. If competition within markets were encouraged, it is conceivable that multiple, non-connected ride-matching services would exist with no single service having sufficient participants to reach a critical mass. This feature of rideshare service delivery should be balanced against the previously described phenomenon of
- 385 "Stranger Danger", in which rideshare participants are more likely to travel with people they know and trust. "Stranger Danger" suggests that numerous, small-scale ride-matching systems based on social networks may yield higher match rates. Ideally, services would compete for a particular market (a large organization, for example), but these individual services would be

connected in such a way that participants could search for rides outside of their existing socialnetwork, and hence across provider platforms.

Technological Challenges

The technological challenges associated with ridesharing have been the focus of many previous rideshare efforts (Bellevue 'Smart Traveler', Los Angeles 'Smart Traveler'), however the substantial advances that have been made have not translated into increases in participation. It is

395 becoming increasingly clear that technological advances must be paired with solutions that address the previously described economic, social and institutional challenges if rideshare participation is expected to increase.

Measurement of Successful Rideshare Trips

- If participants are to be rewarded for undertaking a rideshare trip, or if public agencies and employers are attempting to determine the effectiveness of their rideshare initiatives, there must be a method of measuring successful rideshare trips. Many current systems rely on the honor system to measure rideshare participation. When incentives are small, or when investment has been minimal, the lack of measurement and potential overstatement of successful trips may be an acceptable trade-off. However, when incentives are substantial or investment in rideshare
- 405 initiatives is high, measurement becomes much more important as a way of measuring success and justifying the resources expended. If future rideshare initiatives are expected to see increased levels of discretionary investment and rely more heavily on incentive-based approaches, measurement of trips will be essential feature of ride matching services.

Establishing a Common Rideshare Data Specification

- 410 A large technological challenge to be addressed is the creation of a common data specification for storing or transmitting rideshare information. Addressing this technological challenge accomplishes very little in and of itself; however, it is a necessary preliminary step towards integrated, multi-modal travel information and the formation of rideshare trips from multiple databases.
- 415 A recent study has highlighted the multi-modal nature of commuting. Block-Schachter (11) found that approximately 30% of MIT community members use multiple modes of transportation in a single week. The critical issue is one of choice; when commuters are given transport choices, they will alter their behavior day to day to meet their changing circumstances. As such, the integration of rideshare options with information on other modes of travel in a
- 420 single commuting information source is an important step towards encouraging greater multimodal behavior, including greater rideshare participation.

The development of a common data specification for ridesharing would enable the aggregation of multiple rideshare databases. Currently, many rideshare matching services seek to attract as many participants as possible to increase the probability of matching up a driver and passenger. However, most services can only search for matches within their own system. With a

425 passenger. However, most services can only search for matches within their own system. With a common data specification, multiple provider databases could be searched simultaneously, potentially leading to higher overall number of matches and successful rideshare trips.

"REAL-TIME" RIDESHARING – OPPORTUNITIES & CHALLENGES

"Real-time" rideshare services have the ability to address a number of the challenges identifiedabove, but it also exacerbates other challenges. The use of "real-time" technologies should be

viewed as a 'necessary, but not sufficient' solution to some of ridesharing's biggest challenges. In specific terms, "real-time" ridesharing extends the range of existing options available to travelers and complements other changes in rideshare service provision.

Benefits of "Real-Time" Ridesharing

435 The benefits of "real-time" ridesharing are numerous, and begin to address a number of the challenges outlined in the previous section. The most substantial benefit is an expansion in the types of trip that are suitable for ridesharing. This added flexibility is a distinct advantage for rideshare participants.

Expansion of Trip Types Suitable for Ridesharing

- 440 Traditional rideshare arrangements often involve recurring trips that are relatively fixed in terms of schedule, take place for months at a time and are generally agreed to a day or two ahead of time. In contrast, "real-time" services are often marketed as allowing users to find single trips on very short notice, perhaps as little as 30 minutes ahead of time. This raises an important question about the desirability of these 'immediate' trips. Is this type of rideshare offering perceived as
- 445 valuable to potential participants? A study found that of sixty focus group participants, less than a handful were interested in arranging "last minute" rides (12). They felt that these "instant" trips would be difficult to arrange or simply would not work. Rather, participants were interested in arranging rides on a part time or occasional basis with notification of potential trips in advance, such as the evening before their commute to work. Deakin, Frick & Shively used the term
- 450 "reliable flexibility" to describe this participant need (12). Based on this important insight, "realtime" ridesharing services could cater to three unique types of rideshare trip; immediate trips, occasional trips and traditional, long-term rideshare trips.

Immediate trips, where a passenger seeks a ride on very short notice, might be undertaken when they have found themselves with few transport alternatives. Perhaps the passenger has missed a transit trip or their original rideshare opportunity fell through at the last minute.

Occasional rideshare trips are likely to occur among commuters that would like to share rides, but have social schedules that change week to week, or work inconsistent hours. In these situations, participants would prefer to establish rideshare arrangements on a day-by-day, or ride-by-ride basis. Ideally, a "real-time" service would send a note to all participants that have

- 460 identified themselves as looking for occasional rideshare trips at an established point, say 5pm weekday evenings. Participants would have several hours to confirm their desire to share a ride and their desired travel time. At a certain point, say 7pm, no further ride requests would be accepted for the following morning and matching would take place immediately. Several minutes after 7pm, participants that could not be matched would be notified and alternate travel
- 465 options would be outlined. For those participants that could be matched, the personal details of the appropriate travel partner would be sent and both participants would have a short period of time to review the personal details of their partner and confirm their intention to ride with that individual. A similar process would take place around midday for the evening commuting trip. These occasional arrangements provide participants with greater schedule flexibility than
- 470 traditional ridesharing while providing greater reliability than immediate rideshare opportunities. Traditional rideshare arrangements, whereby drivers and passengers with similar and rather fixed schedules agree to share rides for a longer period of time, can also be provided by "real-time" rideshare services. In these instances, the importance of the personal characteristics of the driver and passenger are more important than the speed of matching.

475 Decreases Transaction Costs

Rideshare services, specifically those with smart phone functionality that actively contact participants with potential matches, can significantly reduce the amount of time needed to establish a rideshare arrangement. The automatic accessing of profile information remotely, including a participant's current location, minimizes the amount of direct user input needed.

480 Decreasing these "transaction costs" (time needed to establish a rideshare trip) sometimes comes at the expense of a rigorous review of the profiles of potential rideshare partners. Some providers have attempted to overcome this perceived drawback by providing participant ratings that allow users to quickly determine how previous partners have perceived riding with a given person.

Improves Information Availability for Traveler Decision Making

485 Some "real-time" rideshare services integrate information from other modes of transportation in addition to rideshare options. In the event that a rideshare match cannot be established, transit or shuttle bus information can be provided to users allowing them to make more informed travel decisions.

Reduces "Stranger Danger" Concerns

- 490 While some features of "real-time" rideshare services may actually increase "stranger danger" concerns (such as the automatic matching of drivers and passengers), many services have incorporated features that reduce "stranger danger". Many services work on mobile devices with GPS that theoretically should be able to track each participant's position throughout a rideshare trip. If a participant agreed to share this type of information with a rideshare provider, it could be
- 495 used to track participants and ensure that the agreed upon journey is taking place, and it could be used to validate that a successful shared ride was undertaken for those journeys where a financial transaction was agreed to, or where incentives are being disbursed. If this feature is coupled with 'social network' features (such as only allowing shared rides between employees within the same firm), 'stranger danger' concerns can be further mitigated.

500 Drawbacks of "Real-Time Ridesharing

The drawbacks of "real-time" ridesharing are trade-offs that participants need to consider. While "real-time" innovations can offer greater flexibility and can provide valuable travel data, users have to balance that with reductions in travel reliability and a loss of privacy.

Flexibility vs. Reliability Trade-Off

- 505 A large trade-off involved in the use of "real-time" ridesharing is the loss of trip reliability in exchange for trip flexibility. However, the degree to which these two features are traded-off depends on the type of rideshare trip being sought. While traditional rideshare opportunities suffer from a lack of flexibility, they are quite reliable. On the opposite end of the spectrum, immediate rideshare trips are very flexible, but provide little service reliability. Occasional trips,
- 510 where matching takes place sufficiently far in advance of the start of the trip to allow for alternate travel arrangements to be made, tends to offer a balance between flexibility and reliability.

Valuable Travel Data vs. Loss of Privacy

"Real-time" rideshare services operating on smart phones with integrated GPS have the ability to generate much more valuable data than simple rideshare trip confirmation. If data were to be collected throughout the day, detailed travel patterns including the prevalence of trip chaining could be determined. From an urban planning and transport modeling perspective, this information could be used to supplement periodic travel diaries and improve the input data used in urban modeling endeavors. With a sufficiently large number of these devices collecting data,

520 traffic patterns and congestion information could be inferred. This information could be quite valuable to public agencies or rideshare providers themselves, however all of these examples of data collection involve a loss of personal privacy for the user of the smart phone. A fundamental challenge with future use of "real-time" rideshare services will be balancing the use of technology for innovative data gathering, while ensuring that personal privacy is respected.

525 DISCUSSION AND RECOMMENDED 'NEXT STEPS' IN THE EVALUATION OF "REAL-TIME" SERVICES

Having laid out a general series of challenges facing ridesharing, and having discussed the potential benefits and drawbacks of "real-time" innovations, the paper concludes with a discussion of recommended next steps in the evaluation of "real-time" services. While research

- 530 into the potential of "real-time" ridesharing has increased in recent years, much of it has been based on stated-preference surveys, interviews and focus groups. There is a strong need for further research into how participants actually use and react to "real-time" services. Are there certain trip types that are more conducive to "real-time" ridesharing (commuting vs. recreational vs. inter-city)? Do different geographic locations use "real-time" services differently? Are certain
- 535 business models, or institutional designs, more appropriate for "real-time" ridesharing? What features of "real-time" services are most important to users? Many of these questions are best answered through the design and implementation of a comprehensive series of trials in multiple locations throughout North America.

Throughout the 1990's and early 2000's, a handful of technology-enabled rideshare trials 540 were funded, beginning with the Bellevue 'Smart Traveler' demonstration in 1993. Unfortunately, the results from many of them did not live up to their expectations. With this in mind, the value of further rideshare trials might be questioned. However, there are good reasons to believe that there is potential value in further rideshare trials. For one, the technology in use today is much more advanced and much more user-friendly than anything used in the previous

- 545 trials. Second, some very important lessons were learned from the previous trials. Those that neglected targeted marketing and the provision of incentives tended to perform rather poorly, and those that focused on large employers tended to perform better than average. Trials that incorporate these 'lessons learned' in combination with advanced technology have particular promise of success. Several upcoming rideshare trials are beginning to incorporate some of these
- 550 'lessons learned' and should reveal interesting insights into the viability of "real-time" ridesharing.

The European Commission OPTI-TRANS trial (13) has recently completed the design stage and is proceeding with implementation. While "real-time" rideshare features are only a small portion of this trial's design, its multi-modal design is important and may provide greater

- 555 insight into personal travel decision-making when relevant, real-time information is provided. The trial aims to create a personal traveler navigation system that is accessible from a mobile device. The system will link multiple sources of public and private transportation data into one application, and will provide travelers with a recommendation as to which mode of travel is most suitable for their needs. Information from local transit services (bus, metro, tram & rail) in
- 560 Madrid, Spain will be integrated with current rideshare opportunities, taxi availability, cycling

opportunities and walking. The trial design is comprehensive and includes focus groups, surveys and orientation sessions to solicit as much user feedback as possible (13).

A second rideshare trial has recently been approved and funded by the Washington State Dept. of Transportation (WSDOT) to demonstrate "real-time" ridesharing in the SR 520 corridor in the greater Seattle region (14). The six-month trial, beginning Fall 2010, is recruiting 1,000 565 participants (250 drivers, 750 passengers) and hopes to reduce 30,000 trips over the life of the trial (~20 rides/driver/month). Marketing and recruitment is focusing on major employers and Transportation Management Associations (TMAs) in the corridor. The trial incorporates numerous safety features (including driver record, criminal history, and sex offender registry

570 checks) and will provide incentives to both drivers and passengers for the length of the trial (14). This trial shows great promise in that it incorporates advanced "real-time" technologies, it targets large employers and it provides incentives to participants throughout the trial period. All of these features are believed to increase the potential success of a "real-time" trial, as the following discussion will highlight.

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The findings presented in this paper suggest that the success of "real-time" ridesharing can be improved if rideshare initiatives, including future trials, include the following features.

(1) Target Large Employers: Targeting large employers offers numerous advantages. First, some 580 studies have demonstrated that the vast majority of shared rides take place between family members, co-workers and neighbors (2)(6)(7)(10)(15), because of the common social connection, or 'social network'. The targeting of large employers naturally overcomes some of the 'stranger danger' fears associated with ridesharing because employees share a common social connection and the threat of employment repercussions (such as termination) discourages undesirable behavior. Second, the journey-to-work is generally a commuting trip that takes place 585 during peak periods when congestion is high. The targeting of SOV commuting trips offers the greatest congestion reduction potential. Third, from a matching standpoint, targeting large employers where all drivers and passengers share a common OD simplifies the matching process and increases match rates by changing the typical 'many-to-many' matching process to a 'many-590

to-one' process.

(2) Integration of Travel Information from Multiple Modes: The complexity of personal schedules and trips is such that future rideshare participants are unlikely to rely exclusively on a single mode, ridesharing or otherwise. As such, the provision of integrated, real-time, multimodal information allows participants to make informed travel choices. The integration of transit information with rideshare opportunities would be particularly appropriate, as these two modes tend to complement one another in existing successful rideshare arrangements (such as the 'casual carpools' in the San Francisco-area, and the 'slug-lines' in the Washington, DC-area).

- 600 (3) Comprehensive Participant Engagement: The challenges outlined earlier in this paper reinforce the fact that the 'rideshare challenge' is as much about human preferences as it is about the need for improved technology. As such, future initiatives should place as much emphasis on participant engagement efforts, such personal travel planning and the provision of rideshare incentives, as it does on advanced technologies. Preliminary research efforts suggest that the
- provision of personalized travel information can influence travel behavior and reduce SOV trips 605 by 10% or more (16)(17). Incentives have long been a successful mechanism to encourage

ridesharing and are likely to remain important for the foreseeable future. Participant engagement and incentives tend to be the most expensive components of a rideshare initiative, however designers should resist the urge to eliminate these features, as they are likely to increase the everall level of rideshare participation

610 overall level of rideshare participation.

This study has provided an important foundation upon which further "real-time" ridesharing research can take place. A variety of challenges facing ridesharing were identified and carefully categorized. The opportunities presented by "real-time" technologies and service innovations were described along with the specific challenges that they address. The study also

615 identified remaining issues, or drawbacks, that will need to be addressed with "real-time" ridesharing going forward. Finally, based on the opportunities and drawbacks identified, this study outlined important rideshare service characteristics and features that should be incorporated into upcoming rideshare trials to increase their potential for success.

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Errors, omissions or issues with the accuracy of the analysis are the responsibility of the authors.

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