

Ultra-compact electric car sharing for last-mile mobility

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This case study discusses Toyota Motor Corporation's demonstration project on car-sharing using ultra-compact electric vehicles to overcome the last mile challenge for public transportation. Public transportation systems such as subways, light rail and bus rapid transit, typically have stations every one-mile or so. Access to these stations beyond an easy walking distance is known as the last-mile challenge. Toyota Motor's project evaluated how coordinated sharing of ultra-compact electric vehicles can be used to address the last-mile challenge while also lowering emissions as well as reducing any potential negative impact on the electricity grid.

This project dubbed "One Mile Mobility" was part of the Toyota Smart Community project, one of the four smart community projects funded by the Japanese government, in collaboration with the private sector. This project was active from FY2012 through FY2014. The budget for the One Mile Mobility system was JPY 3bn (\$2.58m). It was part of a larger experiment on integrated traffic data management system (TDMS) and energy data management system (EDMS).

THE CHALLENGE

According to the United Nations' Intergovernmental Panel on Climate Change (IPCC), greenhouse gas (GHG) emissions from the transport sector in 2010 had already reached 7 GtCO₂eq ie, 23% of global energy-related CO₂ emissions (Reference 1). GHG emissions from the transport sector have more than doubled since 1970, outpacing the growth rate of all other energy end-user sectors, with 80% of this increase coming from road vehicles. In 2014, IPCC projected that without "aggressive and sustained mitigation policies" GHG emissions from the transport sector could reach 12 GtCO₂eq by 2050. Increasing utilisation of public transportation can reduce GHG emission growth by reducing private passenger vehicle usage. However to increase utilisation of public transportation, an efficient and emissions-free approach to the last-mile challenge is needed. For this project Toyota evaluated whether coordinated car-sharing using ultra-compact electric vehicles can be the solution. Additionally, to avoid increasing peak-demand as a result of electric vehicle charging, it tested integration of the local Traffic Data

Management System (TDMS) with the utility's Energy Data Management System (EDMS) to ensure coordinated charging of the electric vehicles.

WHAT THEY DID

Figure 1 shows the basic system configuration of the Toyota Motor demonstration project. For this project, Toyota used about 100 units of the two-seater Toyota COMS (Figure 2) as well as the one-seater¹ Toyota i-Road (Figure 3). These electric vehicles have a range of 50km per full charge. The One Mile Mobility Management System was linked to both the Traffic Data Management System as well as the Energy Data Management System to offer trip options based on commute distance, time and associated GHG emissions.

Users of the system could book the ultra-compact vehicles via a smart phone app as well as a web portal. Registered users also could receive reward points via third parties.

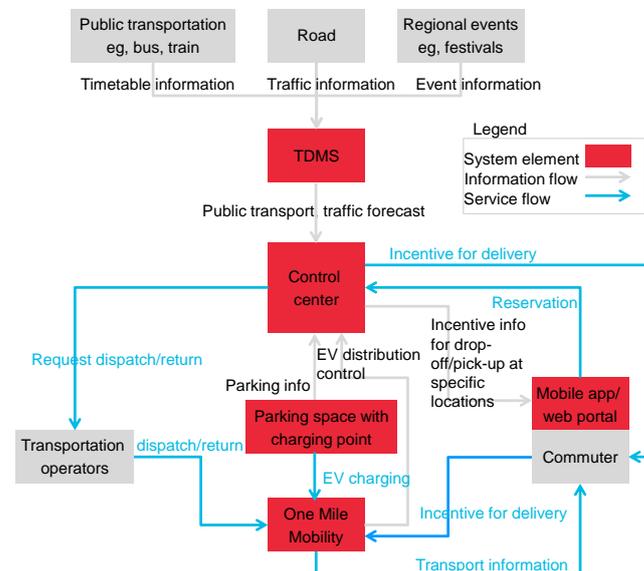


Figure 1: Toyota's one mile mobility system
Source: Toyota Motor, Mitsubishi UFJ Research Consulting.
Note: TDMS stands for traffic data management system.

¹ Toyota i-Road models used in Europe are two-seaters.

TDMS collects real-time data on traffic flow, parking area vacancies, and bus/train itineraries as well as passenger flows. It also collects information on the weather as well as local events such as festivals. Based on this information, it predicts transportation demand and supply for the near future and then coordinates pick-up/drop-off for the ultra-compact electric vehicles as well as their charging schedule.



Figure 2: Toyota COMS
Source: Bloomberg

Based on TDMS's prediction as well as existing reservations of the ultra-compact electric vehicles, the One Mile Mobility Management System assigns the appropriate amount of ultra-compact electric vehicles to each designated parking area. The vehicles are dispatched to their optimum location by third-party delivery companies, as well as via offering incentives to users to drop-off (or pick-up) from specific locations.



Figure 3: Toyota i-ROAD
Source: Bloomberg

OUTCOME

In the Toyota city experiment, more than 3,000 users signed up for the service, and Toyota was able to confirm the performance of the system as planned. Based on data shared by Toyota, Mitsubishi UFJ Research and Consulting has performed preliminary economic analysis on the results of the experiment for the most popular daily commuting route during the experiment. For this route, if the commuter uses a local train and the car sharing option, the cost for each single-trip is JPY 590 (\$5.06²) based on the train ticket cost of JPY 330 and JPY 260 usage fee for the ultra-compact electric vehicle. If the user chooses to drive his own car, the cost is JPY 580 (\$4.97) per usage³. While there is a slight cost difference, Toyota expects commuters relying on the One Mile Mobility system to have a better user experience as a result of the smaller size of the vehicle being better suited for a congested urban environment, as well as the availability of pre-assigned parking.

Beyond, ease of use benefits, there are clear benefits in GHG emissions reduction. Mitsubishi UFJ Research and Consulting estimated that if it would be possible to expand this scheme to serve 10% of Japan's 86m commuters, it would be possible to reduce 340,000 tonnes of emissions, equal to 10% of the Japanese government's emission reduction target for the transport sector.

Is the outcome replicable?

Toyota Motor has already started similar projects elsewhere in Japan as well as in France.

Grenoble: In September 2014, in coordination with City of Grenoble as well as French utility EDF (and its affiliate Sodetrel), and local car-sharing operator Cité lib, Toyota launched a similar three-year project in Grenoble. The project named "Cité lib by Ha:mo" involves 35 three-wheel Toyota i-ROAD and 35 four-wheel Toyota Auto Body COMS distributed across 27 stations throughout the city. The service has a simple pricing structure dubbed "3, 2, 1 euros" for respectively, the first, second and third 15-minutes of usage. It also includes discounts for users who subscribe to annual passes for the local transportation system.

² Exchange rate used is JPY 116.6/USD

³ Assuming a vehicle cost of JPY 1,650,000 (depreciation of nine years), vehicle tax of JPY 34,500/year, insurance cost of JPY 30,000/year, gasoline cost of JPY 138/litre (November 2013 local value), gas mileage of 20km/litre, parking fees of JPY 5,770/month (November 2013 local value), vehicle annual distance travel of 9,120 km.

Tokyo: In February 2015, Toyota in collaboration with parking operator, Park24 announced a six-month trial of the One Mile Mobility system using 5 i-Road electric vehicles in the business district of Tokyo around Yurakucho station. Later it expanded the trial to include 25 COMS vehicles, and extended the trial period to the end of March 2016. The fee structure for this trial is also very simple: JPY 412 (\$3.53) per 15 minutes of usage for the i-Road and JPY 206 (\$1.77) per 15 minutes for the COMS.

Okinawa: In October 2015, Toyota announced the launch of the One Mile Mobility system in Motobu Peninsula of Okinawa Island. Motobu Peninsula is the location of many of Okinawa Island's tourist attractions eg, the Churaumi Aquarium, and the UNESCO World Heritage-listed Nakijin Castle Ruins. For this trial, Toyota is collaborating with travel agency JTB as well as six local hotels and tourism entities, to offer 30 COMS vehicles to tourists.

Toyota's rapid deployment of the One Mile Mobility system suggests it has confidence in the potential of the system. The experience of other integrated electric vehicle car sharing projects eg, the [Bluecar service](#) in Paris developed by the Bolloré Group, provides good supporting evidence that Toyota's confidence is well-placed.

FUTURE PLANS

Figure 4 shows the potential future operating scheme of the One Mile Mobility system based on Toyota's experience thus far. The One Mile Mobility operator procures equipment and services from the various players shown in Figure 4 to provide the ultra-compact electric car-sharing to commuters. The OMM operator would be collecting fees from commuters who use the system as well as the local municipality that would benefit from lower congestion and better air quality and hence, enhanced economic activity.

The OMM operator's costs would include user incentives for cooperation with drop-off/pick-up incentives, vehicle delivery costs, control system operating costs, communication costs and initial costs to procure the electric vehicles as well as construct the charging infrastructure. The OMM operator would be able to generate additional revenues or cost savings via coordination with the local utility, public transport operator as well as local retail businesses. For example it can reduce its electric vehicle charging costs and potentially generate revenue by utilising its charging infrastructure as part of a demand response scheme in coordination with the local utility. It can also generate revenues from local businesses by enabling advertisements on the mobile app for the service as well as via its parking locations.

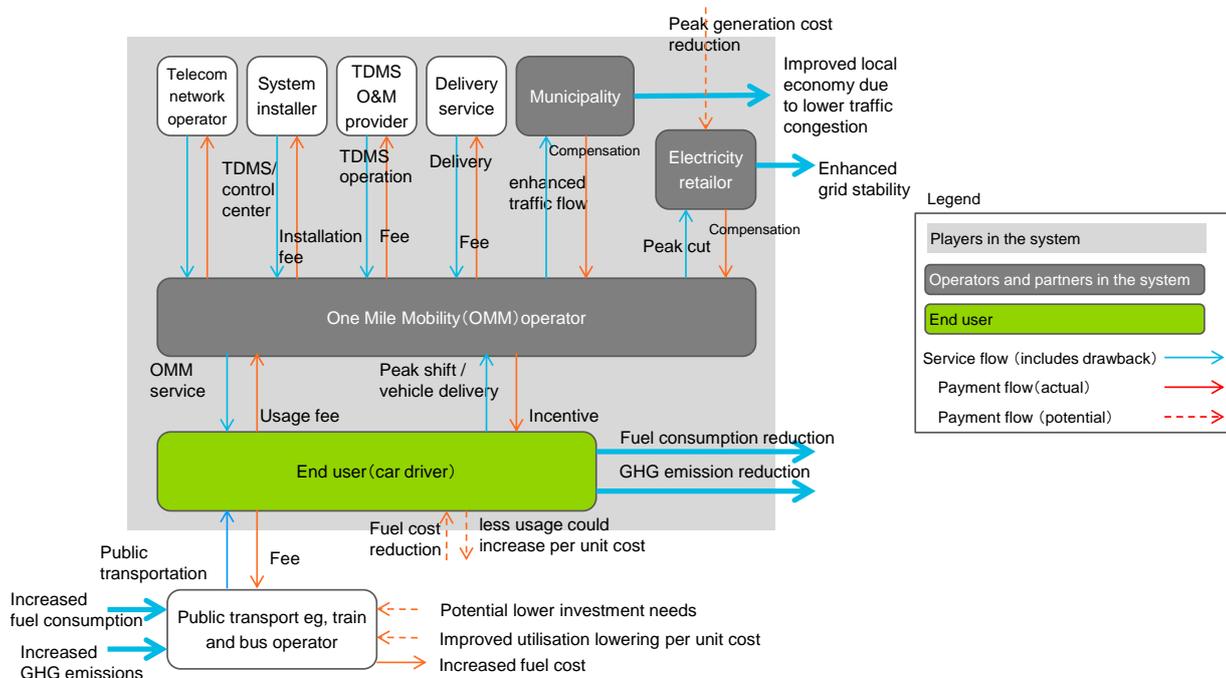


Figure 4: One Mile Mobility operation scheme
 Source: Toyota Motor, Mitsubishi UFJ Research & Consulting

Which locations are suited for the system?

In Japan, the City and Regional Development Bureau of the Ministry of Land, Infrastructure, Transport and Tourism (MLIT) designated urban areas and tourist spots as targets for the One Mile Mobility scheme back in 2010 (Reference 2). Below is an examination of specific types of locations that could benefit from this system.

Urban centres with severe traffic congestion: In urban areas where traffic is congested, implementation of this system could help alleviate congestion. In Japan, MLIT analysis (Reference 3) has shown 93.7% of passenger vehicle car travel is under 30 km. The average occupancy of passenger vehicles is 1.30 persons. As such, two-seater ultra-compact electric vehicles with a range of 50km, could address the needs of majority of commuters. The combination of the ultra-compact size of these electric vehicles, and coordination with public transportation infrastructure, would reduce traffic congestion.

Suburban areas: Suburbanisation, particularly relocation of commercial centres to the suburbs is an ever increasing trend. Suburbanisation tends to result in higher rates of single-occupancy vehicles. Providing public transportation in suburbs also tends to be rather costly. By implementing the One Mile Mobility system in the suburbs, it could be possible to reduce single-occupancy vehicles and enhance utilisation of public transportation hence lowering its costs.

Public transit deserts: there are many regions around the world, for example newer urban developments in Tokyo Bay area, and San Antonio Texas, where public transportation infrastructure is either non-existent or not sufficient relative to demand. In many developed as well as developing economies, local and central governments have not been able to devote sufficient funding to public infrastructure particular since the aftermath of the 2007-08 financial crisis. Deployment of the one mile mobility system in these regions can be a more cost effective way to overcome the lack of sufficient public transportation.

Tourist spots: by their nature, tourist destinations are congested. Many tourist destinations can be ecologically sensitive or have narrow roads that are not suited for conventional vehicles. Deploying the One Mile Mobility system across these sites could overcome these challenges. The convenience of not having to return the vehicles to the same location would also benefit the tourists.

How would the economics improve?

The expenses for the One Mile Mobility system are vehicle costs (vehicle procurement and maintenance costs), system costs (control system procurement and maintenance costs), station costs (station equipment/facility depreciation, maintenance costs and property leasing costs), operating costs (labour costs for supervisors, call centre staff, maintenance and assign/return staff, etc.). Revenues would be the fees paid by commuters as well as any additional services that can be provided based on agreements with local municipalities, utilities, public transport operators and other local businesses. While the equipment costs are expected to be relatively similar across different locations, other expenses and revenues would widely vary by location. Based on data shared by Toyota, Mitsubishi UFJ Research and Consulting has done some preliminary analysis on economics of the system. Placing a fleet of 100 vehicles with 200 parking spaces in one city is unlikely to be economical. However, if the system is expanded to five cities within the same region with a fleet of 600 vehicles across 300 parking spaces, the deployment would likely be economical. With 600 vehicles across 300 parking areas over five neighbouring cities, the payback period would be approximately six years.

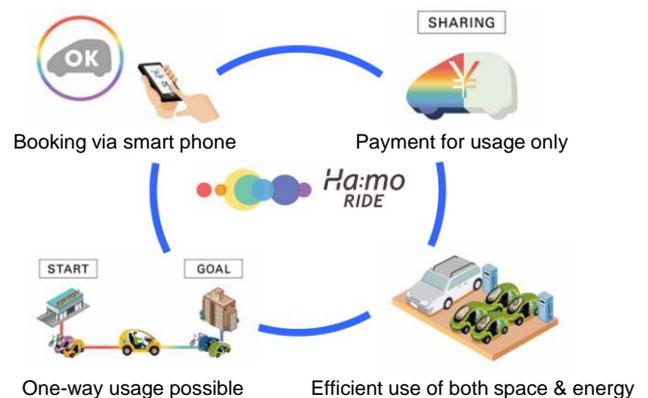


Figure 5. Toyota's Ha:mo ride sharing concept.
Source: Toyota Motor

FINAL THOUGHTS

The One Mile Mobility system (Figure 5) can reduce congestion as well as GHG emissions, thus contributing to the quality of life in the region of its deployment. The integration of the local Traffic Data Management System as well as the Energy Data Management System also offers clear benefits to both the electricity grid as well as the local transportation infrastructure. Toyota is currently evaluating which domestic and international markets would be best suited for commercial deployment of the system post 2020. It

is considering regions that suffer from air pollution such as urban centres in India and South East Asia. Countries with aging populations such as Japan could also benefit. As for the economics of the system, the global shift towards connected vehicles and auto-pilot technology is expected to enable cost reductions that would benefit the One Mile Mobility system. Future adoption will also depend on consumer acceptance and localised practical challenges.

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