White Paper

Transforming Rural Mobility in Japan and the World

In collaboration with McKinsey & Company

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Contents

Foreword

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New urban mobility systems are mushrooming across most of the world's urban areas. Mobility-as-a-service (MaaS), autonomous shuttles and micro mobility are attracting the attention of cities, businesses, investors and policy-makers to develop a smarter, more environmentally friendly and more convenient mobility offering for the future. Meanwhile, rural mobility systems, whose economic sustainability is facing severe pressure due to a decrease in demand (the number of passenger miles travelled) and a partial decrease in the supply of transportation, are garnering significantly less attention in public debate from policy-makers and the mobility industry.

While Japan is considered a global leader in providing excellent public transport, the economic sustainability of rural mobility in the country has long been in steady decline. With the exception of its three major metropolitan areas Tokyo, Osaka and Nagoya, bus usage decreased by 36% over the past 20 years.[1] Even more alarming, this trend will continue as the population outside the metropolitan areas is expected to decrease further by up to 20% by 2045.[2]

Japan is not alone in facing rural mobility challenges. While the country's rapid population decline makes it a pioneer in confronting these issues, rural population decline in other G20 countries will be 2.5-times faster in the coming decade compared with the past 10 years.[3] As more countries face similar challenges, more global attention will turn to rural mobility.

The good news is that even in rural areas with currently unsustainable public transportation, the Fourth Industrial Revolution is bringing solutions that operate more economically in areas with lower transport demand that are more resilient against fluctuations in demand and that maintain or even increase current levels of passenger convenience.

On-demand transportation services, such as those enabled by connected, autonomous shuttles, will operate more economically under low and fluctuating levels of demand. Micro-mobility solutions, such as e-bikes for students and tourists and e-wheelchairs for the elderly, can fill the gap for last-mile public transportation. Using these new technology sets will help provide better mobility to rural populations while reducing the need for ongoing government funding in the future.

This White Paper, a collaboration between the World Economic Forum Centre for the Fourth Industrial Revolution Japan and McKinsey & Company, aims to help identify the cities in Japan with the highest need for transformation, to develop a framework to sustainably transform the rural mobility system and to identify the best solutions by city archetype. We hope these solutions can help effectively propel Japan's transformation in regional rural mobility and better serve the mobility needs of its rural population.

Executive summary

Growing concern on rural mobility

Rural Japan's public transportation is unsustainable in many areas due to a declining and increasingly ageing population, as well as financial pressure on city budgets. In about 60% of rail lines in the Chugoku region, revenue covers less than 50% of the cost,[4] with a further decline expected in the next decades. In some areas, cities need to subsidize more than JPY 3,000 (Japanese yen) per rider,[5] while riders pay several hundred yen for a ride.

This issue affects not only Japan but also most developed nations, where rural populations are expected to decrease annually by 0.8% on average through the 2020s, or 2.5 times faster than in the current decade.[6] Several roadblocks prevent local leaders from confidently confronting this issue squarely and transforming the mobility system; they include the lack of an established process to choose the best solutions by gathering the right set of data and simulating possible scenarios, as well as a lack of visibility on best practices globally.

Public Transit Sustainability Index to reveal situation for municipalities

The World Economic Forum developed the Public Transit Sustainability Index in 2019 to support local governments to step up and reform their mobility systems. It provides transparency to remind of the urgency and to highlight key issues needing transformation. Indicators of profitability along rail, bus and taxi modes as well as future demand and supply forecasts provide an objective and forward-looking understanding of the sustainability of the current mobility system.

For example, based on the Index, 74% of cities in Hiroshima Prefecture had mobility systems with low to mid sustainability,[7] reiterating the need for systemic transformation. The result is summarized in the White Paper in five distinct city archetypes requiring different solutions.

Tailored solutions for each city archetype

New mobility solutions, made possible by technological advances collectively known as the Fourth Industrial Revolution, can present new transit solutions before they get stacked, operate more economically with less demand and offer more convenience for users.

For that, local governments need to implement the right mobility solutions that fit each city's condition. The Forum developed DRIVER, a set of six guiding principles for rural mobility reform which, by matching them with a city archetype, can help cities automatically narrow their required directions of transformation.

Lastly, a library of best practice cases presents sustainable mobility blueprints tailored to each city archetype's future needs along various mobility solutions. Examples of a taxi support model and autonomous vehicle shuttles show how best-fitting existing solutions, as well as emerging ones, can improve rural mobility and key conditions for introducing the solution.

Chapter 1: Ageing and declining populations are a risk to rural-mobility sustainability

Japan's declining demand for rural mobility places a serious economic strain on the mobility system. Consider that 85% of the country's rural bus operators are below their break-even point.[8] Across 60% of rail lines in the Chugoku region, revenue covers less than 50% of the operating costs (Figure 1). As this low profitability is a structural problem caused by low population density, pushing rail operators to improve their operating efficiency would not address the core problem. Moreover, a declining population alone could reduce rural transit profitability by another 5-10% by 2040.[9]

Figure 1: Profitability of rural rail lines roughly correlates with population density

Correlation between population density and profitability of rail lines in Chugoku region

Operating profit rate

Population density/habitable area[1]
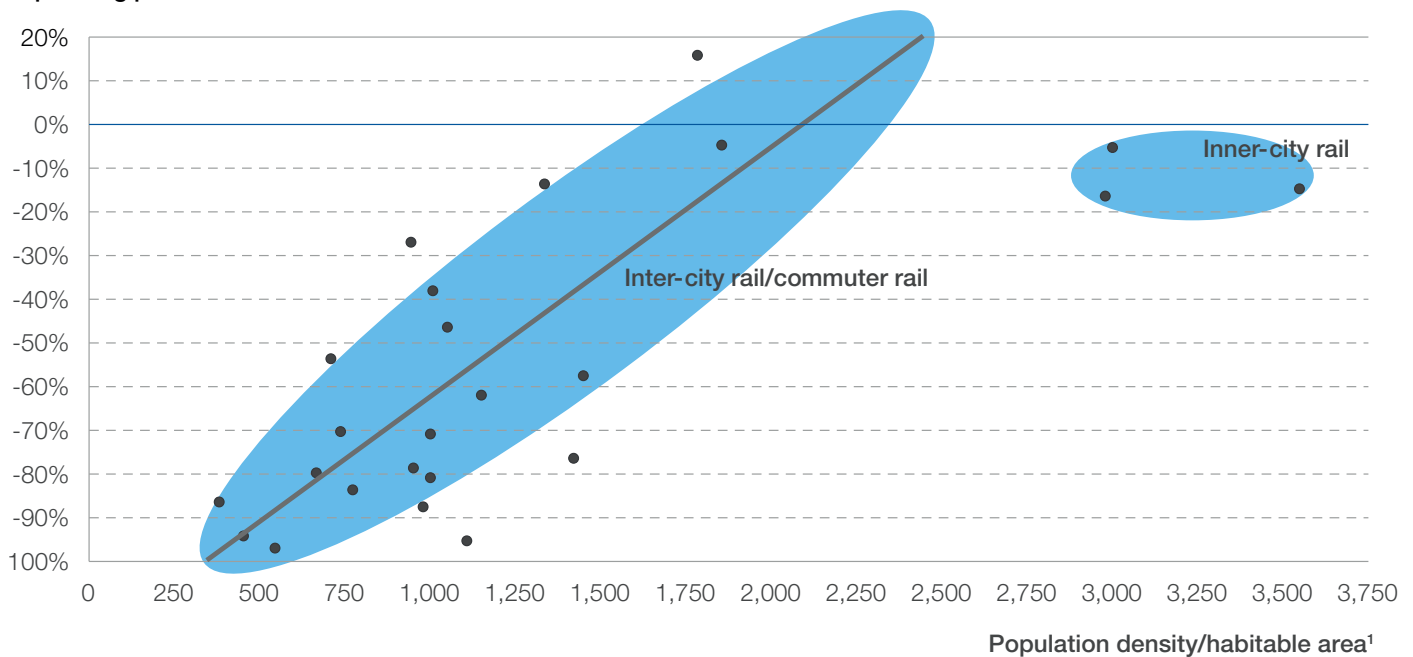
[1] Habitable area = total land size minus forests and ponds/lakes
Sources: Jun Umehara, 5 February 2018, "全国の鉄道「営業係数」大公開" ["Disclosure of 'operation ratio' for rail lines nationwide"], Toyo Keizai; Statistics Bureau of Japan, 2019, "統計でみる市区町村のすがた 2019", ["Statistical Observations of Municipalities 2019"], https://www.stat.go.jp/data/s-sugata/index.html

While Japan has relatively higher rates of sustained population decrease and ageing, these phenomena are also highly relevant for other G20 countries. Many developed nations that subsidize public transit, such as the United States and in Europe, experience even worse profitability. Indeed, on average each transit mode in the United States operates at a deficit. Revenues from commuter buses and trains recover only 52.9% of their operating costs nationwide.[10] Naturally, the situation is worse in rural areas; in the United Kingdom, revenues cover 62% of rail line operating costs in England, 40% in Wales and 30% in Scotland.[11] Budgets for local bus service in non-metropolitan areas have fallen by 55% in the United Kingdom since 2012.[12]

Demographic shifts are worsening the prognosis. The United Nations predicts that in the 2020s, the annual rate of decline in rural populations of G20 nations will increase from about 0.3% to 0.8% per year (Figure 2). This trend suggests that developed countries will need to focus more on rural mobility in the coming decade.

Figure 2: Rural populations in G20 countries are projected to decline

Compound average growth rate of rural population
%/year; G20 countries

		2010 - 2020	2020 - 2030	Delta[1]
Japan		-1.3	-1.6	-0.3
Saudi Arabia		1.0	-0.2	-1.3
Turkey		-0.5	-1.4	-0.8
Russia		-0.4	-1.2	-0.8
South Korea		0.7	-0.1	-0.8
Germany		0	-0.7	-0.7
Australia		0.6	0	-0.6
Canada		0.6	0	-0.6
India		0.6	0.1	-0.5
Mexico		-0.1	-0.6	-0.5
South Africa		-0.2	-0.6	-0.5
Indonesia		-0.3	-0.7	-0.4
Italy		-1.0	-1.3	-0.4
United States		-0.3	-0.7	-0.3
China		-2.3	-2.6	-0.3
France		-0.9	-1.2	-0.3
Argentina		-0.5	-0.8	-0.3
Brazil		-1.1	-1.3	-0.2
United Kingdom		-0.9	-1.1	-0.2
Average		-0.3	-0.8	-0.5
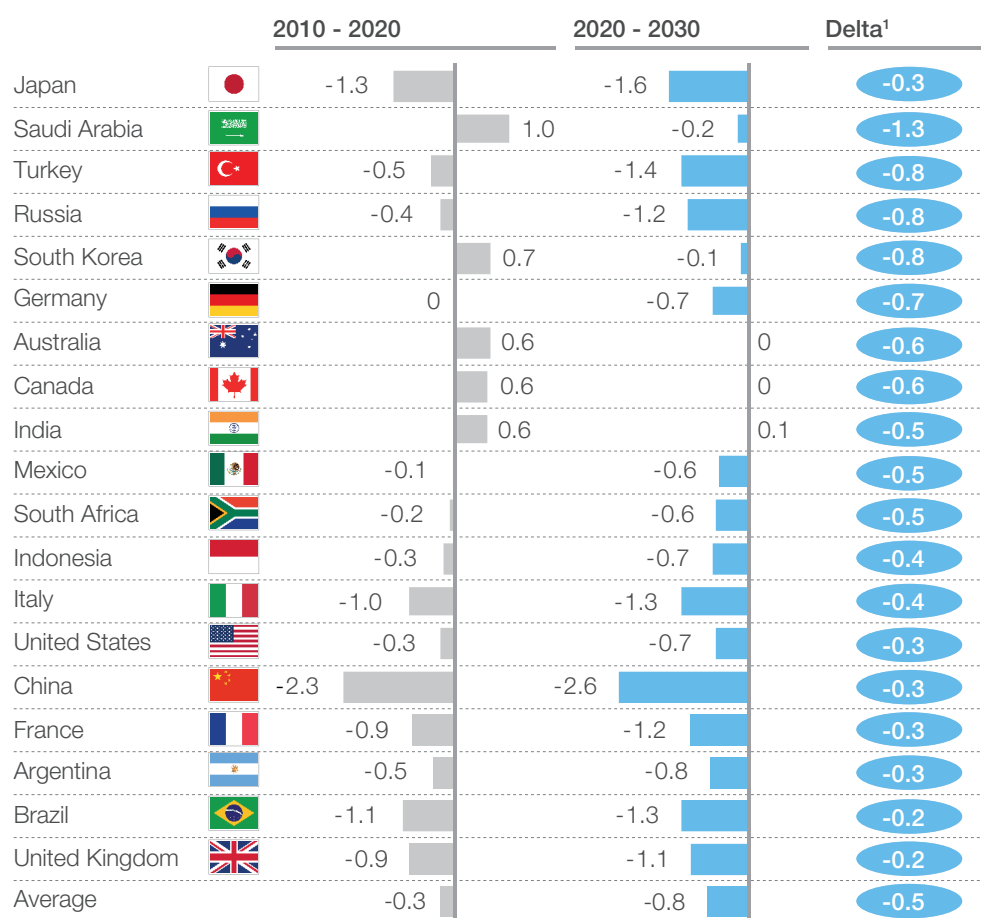
[1] The numbers in the Delta column have been rounded.
Source: Based on information from the United Nations, DESA/Population Division, 2018, "World Urbanization Prospects: The 2018 Revision, Online Edition", https://population.un.org/wup/Download/

While this analysis focuses on rural mobility transformations using Japanese case studies, the findings are globally applicable. Rural and suburban regions with multiple layers of public transit share the same issues, and countries such as South Korea and those in Western Europe can benefit from the recommendations. In the United States and Australia, for example, relevant use cases appear in suburban areas instead of rural ones where the only transportation mode is private cars.

Chapter 2: What the Public Transit Sustainability Index reveals about rural mobility

While most local governments understand the problems related to rural mobility, they have no well-established tools or processes to make informed, objective decisions on building transformation plans.

To identify the most pressing challenges facing mobility, Hiroshima Prefecture was studied as a representative region. First, 23 cities and towns were surveyed there in September 2019, focusing on the challenges of their current mobility systems and the granularity of data to which they have access (Figure 3). As Question 1 of the survey shows, all respondents had a sense of urgency about the state of rural mobility, with 83% indicating the issue was "highly urgent".
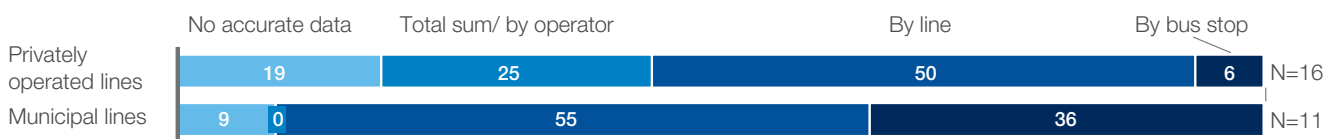
The data suggests, however, that cities have not developed systematic processes to select the optimal solutions – processes such as setting goals for the regions, gathering the right set of the necessary data or simulating solution options. A combined 44% of cities indicated in Question 2 that they have no line-level data for their privately-operated lines, and full bus stop-level data was available in only one municipality. Question 3 of the survey aimed to understand whether practices to support objective decision-making existed, but only one municipality had some form of benchmarking, and 63% of respondents did nothing. While this study focuses on Hiroshima Prefecture, the same situation plays out all over Japan.[13]

Figure 3: Most municipalities surveyed lack data to make evidence-based decisions about rural mobility in Hiroshima

Question 1: Sense of urgency

	Urgent	Highly urgent	
% of responses	17	83	N=18

(No city/town chose neutral/not urgent/not at all)

Question 2: Data granularity of ridership

	No accurate data	Total sum/ by operator	By line	By bus stop	
Privately operated lines	19	25	50	6	N=16
Municipal lines	9	0	55	36	N=11

Question 3: Benchmark with similar cities

	No practice	Exchange information	Data benchmark with nearby cities	
	63	31	6	N=16

Note: Total sum/by operator = total riders for all lines in the municipality/total operators in the municipality.
Source: Authors, "公共交通の利用および支援状況に関するアンケート" [Survey on the use and support of public transit], September 2019 (not published), made in 23 cities and towns in Hiroshima Prefecture (18 responses)

The government's Ministry of Land, Infrastructure, Transport and Tourism (MLIT) council on mobility is considering updating a scheme to design a regional mobility plan,[14] which would be a good trigger to define the required data set and to introduce more up-to-date scenario analyses and benchmarking practices into its mobility plan development processes.

To address these mobility issues in Japan and around the world, the Public Transit Sustainability Index was developed. This new index, using mainly publicly available data, serves as a benchmark for districts to see how sustainable their mobility systems are and offers insight on what they need to do to become – or remain – economically sustainable.

Key indicators of the Public Transit Sustainability Index

The Index provides stakeholders with unbiased data that assists with comparing the current and projected future state of rural transit across five indicators. In addition, the Index provides a meaningful forward-looking perspective, as opposed to other public transit analyses that tend to focus only on the current situation.[15]

The five indicators are divided across two categories: current profitability and future demand and supply. Current profitability looks at the financial performance of core public transit, namely trains, buses and taxis. Future population projections indicate future demand, and drivers' average age represents supply (for more, see sidebars on current profitability metrics and future demand and supply metrics).

Current profitability metrics

Train cost proportion to revenue looks at the profitability of each train line as defined by the train operation ratio, or the cost of earning JPY 100. The cost of maintaining rail infrastructure is significant; in fact, the cost of earning a fixed fare will increase to five- to ten-times the revenue as the population declines.

Bus subsidy shows the subsidy per rider. It includes the subsidy for lines within the city owned by private companies and the cost to outsource municipal bus lines, but not those that run between cities. The subsidy includes contributions from the central, prefectural and municipal government.

Daily taxi income takes a regional view of whether daily drivers' revenue exceeds their estimated daily expense. Because taxis generally do not receive strong government support, it is especially important that independent taxi operators are profitable.

Future demand and supply metrics

Population forecast projects demand. Since the demand for public transit is largely a function of the total population, the proportion of the total population by region in 2025 is compared with that of 2015.

Driver availability indicates the average age of taxi drivers and how it has changed over the past 10 years to forecast the number of drivers. Many areas are already experiencing a shortage of drivers; low salaries and long hours have turned young people off to careers in rural mobility, a critical issue for government leaders to address.

A score of 5 indicates a transit system is sustainable; a score below 2 means a system is in peril.

Indicators and their Index score

Indicator		Description	Scoring method	Explanation for 2 to 3-score threshold
Current profit-ability	**Rail: Cost proportion to revenue (yen)**	- Cost estimation to earn 100 yen by line (operation ratio) - Develop city data by average of lines with stations in the city[1]	5 ◀ 100 4 ◀ 200 3 ◀ 300 2 ◀ 400 1	- JR Hokkaido specified lines "cannot maintain alone" and those lines have a 300-1,000 operation ratio - "N/A" if rail does not exist
	Bus: Subsidy/rider (yen)	- Amount of subsidy from central, prefectural and local government for private bus operators and outsource fee of municipal bus lines, per user (excludes inter-city lines)	5 ◀ 0 4 ◀ 100 3 ◀ 300 2 ◀ 500 1	- Range to have higher subsidy from governments compared to fare from riders
	Taxi: Daily income (multiplier of cost)	- Daily income of taxi per vehicle[2] - Define score by multiplier of estimated cost[3]	5 ◀ 2.0 4 ◀ 1.5 3 ◀ 1.0 2 ◀ 0.8 1	- Taxi usually does not have support within company or from governments, so whether revenue exceeds cost is the key criteria
Future demand/ supply	**Demand: Population forecast (%)**	- Proportion of total population by region in 2025 compared to that of 2015	5 ◀ 100 4 ◀ 95 3 ◀ 90 2 ◀ 85 1	- Regions with a population decrease of more than 1% annually
	Supply: Driver availability (age)	- Average age of taxi drivers in 2025 based on 2016-2017 data and its incremental change in the last 10 years	5 ◀ 50 4 ◀ 55 3 ◀ 60 2 ◀ 65 1	- Regions with high average and rapid increase of driver's age would have large retirement with limited inflow, ending up with total decrease[4]

[1] The weighted average by users is not used to clearly show the impact of lines with very high operation ratios. (The influence of those lines is extremely small in the weighted average by ridership as it has fewer users.)
[2] Data by prefecture for regions without granular data.
[3] Minimum wage used as a basis and cost estimated with the assumption that 73% accounts for labour cost and, within it, 75% is direct labour cost.
[4] Major players put the retirement age at 60 or 65 while the Tokyo Taxi Association puts it at 75 for new owner-driven taxis, which means the majority of drivers above 60 years of age have around 10 years of service remaining.

Sources: Jun Umehara, 5 February 2018, "全国の鉄道「営業係数」大公開" ["Disclosure of 'operation ratio' for rail lines nationwide"], Toyo Keizai; Authors, "公共交通の利用および支援状況に関するアンケート" ["Survey on the use and support of public transit"], September 2019 (not published); Japan Federation of Hire-Taxi Association, 2006, 2007 2016, 2017, "タクシー運転者の賃金・労働時間の現況" ["Current status of wages and working hours for taxi drivers"]; MLIT, Chugoku District Transport Bureau, 2019, "運輸要覧" ["Transportation Handbook"], http://wwwtb.mlit.go.jp/chugoku/content/000040183.pdf.

While robust, the data pool can be enriched going forward by four dimensional levers: depth, width, credibility and availability.

a. **Depth**: Each indicator could benefit from more detail, such as origin-to-destination data by stop, to allow for in-depth analysis of concerned indicators.
b. **Width**: The Index could provide another dimension of perspective with some potential indicators, such as mode share data (especially the percentage by private vehicles), to more accurately capture the size and trend of demand.
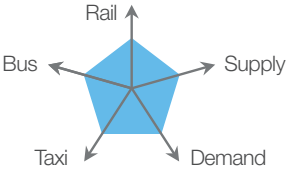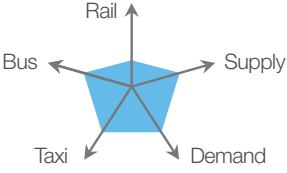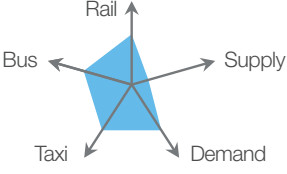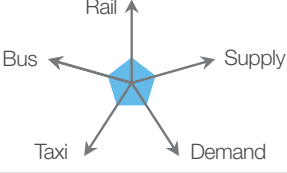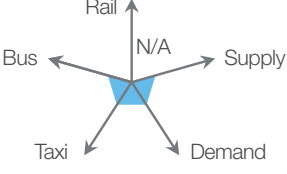c. **Credibility**: Cities need to collect data more consistently and not from a survey of only one to two days, or at least supplement it with other data sources, such as the GPS log from smartphones showing a person's daily journey.
d. **Availability**: Data disclosure could be more inclusive; for instance, taxi revenue data is available in some regions by city and in some only by prefecture, while other regions do not disclose any data.

City archetypes

The World Economic Forum identified five city archetypes that require distinct mobility transformations. Specific challenges identified by using the Public Transit Sustainability Index can indicate the direction each city should take (Figure 4). The size and shape of the polygon in Figure 4 reflects opportunities and challenges for each city archetype. The size of the polygon shows the city transit system's degree of economic sustainability, as classified by its average Index score; an average score of 3 or above is high, 1.5 to 3 is medium, and 1.5 or below is low. The focus is on municipalities that have the highest need for better transit system solutions, demonstrated by transit systems that fall into the medium and low categories.

Figure 4: Cities with transit systems of medium- or low-level sustainability are of immediate interest

Sustainability	Archetype	Index illustration	Characteristics
High	Not a focus area		
Medium	1 Mid-balanced model		– Have modest demand to maintain multilayers of modes, though all services are in tight environment – Further reduced demand and supply is expected
	2 Mid-disproportionate model		– In addition to the characteristics of ①, sustainability of a specific mode, most commonly rail, is especially doubtful
	3 Mid-driver-concern model		– Modest demand is expected now and in the future, but lack of enough drivers may risk continuity of public transit services
Low	4 Low-balanced model		– Sustainability and future forecast is in crucially severe situation – Currently various modes are provided, including rail
	5 Low-without-rail model		– Sustainability and future forecast is in crucially severe situation – Current assets are small and without rail

Source: Authors

A transit system with scores that produce a balanced polygon (such as archetypes 1 and 4) is set as a standard. Conversely, a particularly low-scoring indicator will affect the polygon's dimensions, highlighting the areas ripest for reform. In most cases, cities score the lowest on either rail, which costs the most to maintain (archetype 2: mid-disproportionate model), or supply (archetype 3: mid-driver-concern model). In low-sustainability models, the polygon might not have a dent because the city's other scores are also low, and the biggest differentiating factor becomes whether the city has rail – a relatively rare, exploitable asset for those areas.

This project also reviewed the variation of mobility types and models within Hiroshima Prefecture and noted how each municipality may require a different solution. No municipalities in the prefecture are categorized as mid-disproportionate, but the city archetypes are otherwise evenly distributed. In Hiroshima, 74% of municipalities' transit systems are at medium or low levels of sustainability, reiterating the need for systemic transformation (Figure 5).

Figure 5: Municipal transit systems' scores underline the need for transformation

Distribution of transit systems of cities in Hiroshima Prefecture by sustainability and archetype[1]
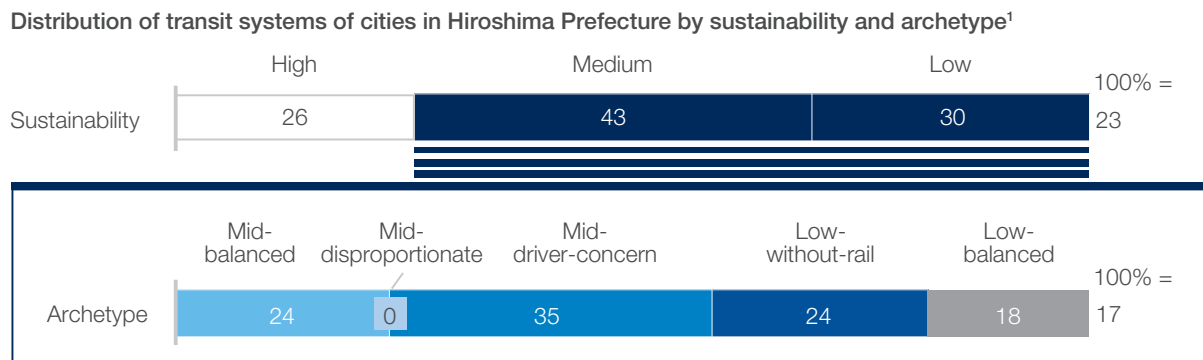
[1] The medium and low levels of sustainability have been rounded: the total is 74%.
Sources: Jun Umehara, 5 February 2018, "全国の鉄道「営業係数」大公開" ["Public release of 'business coefficient' for railways nationwide"], Toyo Keizai; Authors, "公共交通の利用および支援状況に関するアンケート" ["Survey on the use and support of public transit"], September 2019 (not published); Japan Federation of Hire-Taxi Association, 2006, 2007, 2016, 2017, "タクシー運転者の賃金・労働時間の現況" ["Current status of wages and working hours for taxi drivers"]; MLIT, Chugoku District Transport Bureau, 2019, "運輸要覧" ["Transportation Handbook"], http://wwwtb.mlit.go.jp/chugoku/content/000040183.pdf

City-level indicators reflect a wide range of economic sustainability (Figure 6). City A, with scores of at least four out of five for all mode-profitability indicators, is relatively stable. Mid-size cities along the trunk rail line and the Seto Inland Sea, such as City B, indicate that intracity transit like bus or taxi are becoming less sustainable.

The situation is much worse in Cities C and D, both small mountain towns. City C's rail indicator shows that less than 20% of operating costs can be covered by revenue, and each bus ride costs City D more than JPY 3,000 in subsidies. A lack of drivers is another serious concern across the prefecture; the average age of a taxi driver is 63 years, an increase of seven over the past 10 years that shows the failure to recruit a younger generation.

Figure 6: Transit systems across Hiroshima Prefecture have different kinds and levels of risk
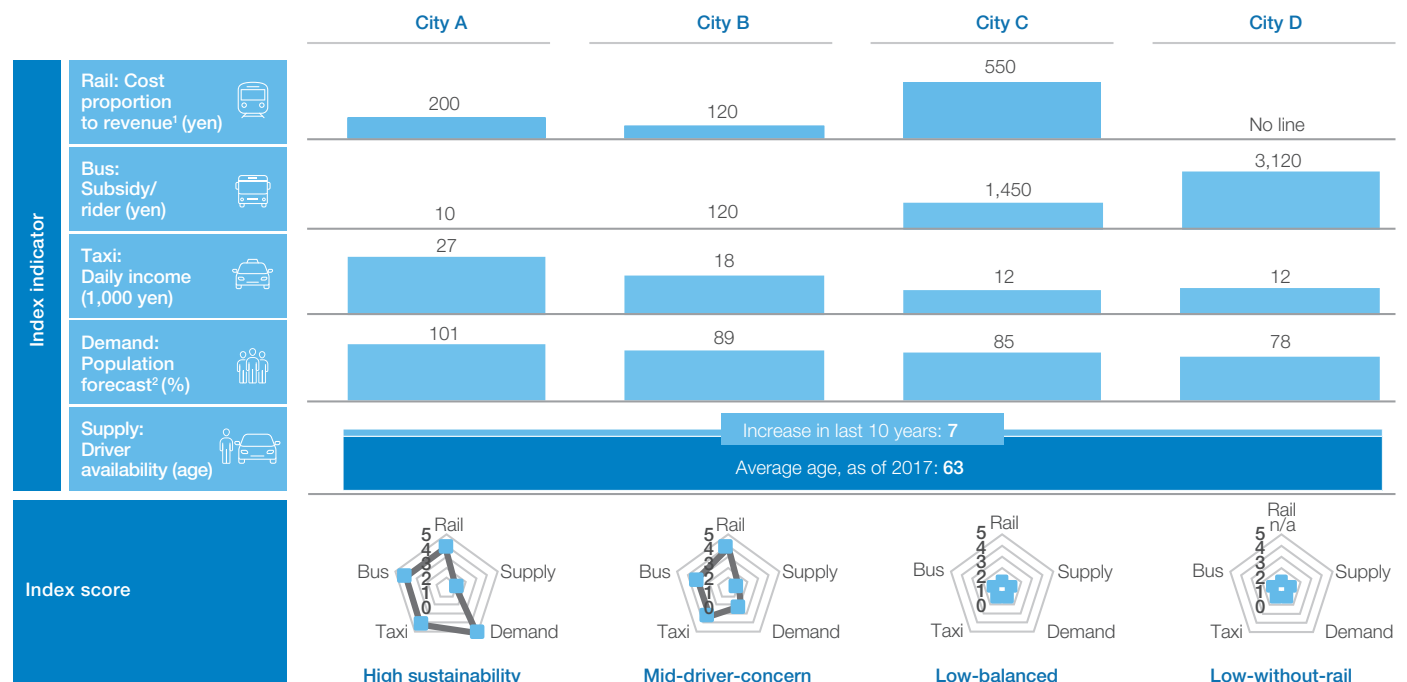
[1] Estimated cost required to earn 100 yen.
[2] The index of forecasted population in 2025 vs population in 2015.
Sources: Jun Umehara, 5 February 2018, "全国の鉄道「営業係数」大公開" ["Public release of 'business coefficient' for railways nationwide"], Toyo Keizai; Authors, "公共交通の利用および支援状況に関するアンケート" ["Survey on the use and support of public transit"], September 2019 (not published); Japan Federation of Hire-Taxi Association, 2006, 2007 2016, 2017, "タクシー運転者の賃金・労働時間の現況" ["Current status of wages and working hours for taxi drivers"]; MLIT, Chugoku District Transport Bureau, 2019, "運輸要覧" ["Transportation Handbook"], http://wwwtb.mlit.go.jp/chugoku/content/000040183.pdf

Chapter 3: DRIVER: A solution framework for rural mobility

Once the challenges of rural mobility are outlined, each city can explore solutions based on their archetype. Through interviews and discussions with experts, city administrators and service providers, six guiding principles called DRIVER were developed for local governments to consider in rural mobility reform. The principles, outlined below, should be prioritized by each city archetype differently:

Dynamic route

Dynamic-route shuttles alter their routes on demand. Origins and destinations can be chosen from predefined stops – or from anywhere a passenger requests a ride – to allow for door-to-door transit. This is especially important in rural areas, which have both a high share of elderly users and low, highly variable demand. Because a walk of several hundred metres can be difficult for some elderly users, flexible transit options that close the last mile empower more users to get around and stay connected to their communities. And, in a low-demand environment with many unused stops, dynamic routes are usually faster and more convenient.

Resident-involved

In regions with structurally unprofitable transit systems and limited funds for transit subsidies, relying solely on private and public transit modes makes it difficult to guarantee accessibility for everyone. Administrators in such regions need to involve resident organizations and non-governmental organizations in transit operations. These organizations can also help solve the shortage of professional drivers. Indeed, volunteer-based ride-hailing services are gradually expanding in transit deserts in Japan under special legislative frameworks.[16]

Intermodal

Integrating payments, reservations and schedule coordination across public transit modes, often with mobility-as-a-service (MaaS) applications, can improve customer experience in rural areas. The low frequency of service highlights the importance of seamless and assured connection between transit modes. As more residents use apps, more information is collected and can be applied to improve connectivity. This data can also help service operators adjust schedules in real time to reduce the wait between connections.

Versatile

Mobility services should consider partnerships with other industries to access a larger profit pool. For example, Choisoko, an on-demand shuttle service in Toyoake, asks for sponsorship from shops and restaurants at bus stops, which helps limit the level of subsidies needed from local governments.[17] Some emerging initiatives demonstrate the visible impact of well-designed mobility systems on residents' health. This social benefit would open a path for accessing larger welfare budgets. Such cross-industry ties can be beneficial for all involved – transit systems, industry and citizens.

Efficient

Before exploring new mobility services, existing services need to be improved and made more efficient, especially with low profitability and downward pressure on declining revenue. For example, instead of maintaining their own call centres, new solutions are emerging, such as outsourcing taxi reservation and dispatching functions to take advantage of economies of scale, and integrating more advanced software to match demand with nearby taxis.

Rightsized

To improve or simply maintain service in the face of decreasing demand, some regions need to select rightsized transportation modes and adjust their mobility mix. Replacing public transit lines involves making difficult decisions, but for some rural areas, it can be the best way to sustain the transit system over the long term. With new technologies and solutions, rightsizing can be an opportunity to provide better service for users for less. One global on-demand service provider, for example, saw that on-demand shuttles acquired two- to three-times more riders on average compared with fixed-route buses, which improved profitability and customer satisfaction. To stabilize a transit system during a transition to a new mobility scheme, continuous contributions from the original operators and commitments from local governments are required.

Applying city archetypes and mobility solutions to improve public transit

In 1995, Musashino, a western suburb of Tokyo, introduced the community bus, a city-funded fixed-route bus service through areas that lacked regular access to existing public transit.[18] The circular route was served by a mini-bus that held about 30 passengers, with a flat fare of JPY 100. The community bus was a success, serving 2.6 million passengers per year and earning a profit of JPY 20 million in 2002.[19]

Many officials from other places visited Musashino, took note and introduced similar programmes in their own cities, but few met with the same success. As part of Greater Tokyo, Musashino had a population of more than 13,000 people per km^2; this population density allowed the system to profit from the JPY 100 flat fare.

This example calls to mind that no one-size-fits-all solution exists and that it is important to understand each city's situation and issues, and to tailor suitable solutions to each community. More than simply applying the principles of DRIVER, correctly prioritizing and adapting the principles to a given city are crucial.

The research evaluated the city archetypes and matched their characteristics to the DRIVER principles to reveal fitting solutions for each rural mobility situation (Figure 7). Two Japanese cities actively seeking new mobility solutions demonstrate the value of solutions meeting key conditions.

Figure 7: Each archetype requires a different solution to transform its rural mobility system

■ Top priority   ▢ Less prioritized

	Priority	Direction of system reform
Mid-balanced (1)	Dynamic route (Top priority); Resident-involved (Less); Intermodal (Top priority); Versatile (Top priority); Efficient (Top priority); Rightsized (Less)	– Improve usability and eventually profitability by cross-modal integration – Diversify revenue source by integrating with other services – Improve operational efficiency
Mid-disproportionate (2)	Dynamic route (Top priority); Resident-involved (Less); Intermodal (Top priority); Versatile (Top priority); Efficient (Top priority); Rightsized (Top priority)	– Redesign mobility system centring on renewal of the concerned mode, while the region is overall healthy – Conduct measures to improve sustainability for ①
Mid-driver-concern (3)	Dynamic route (Less); Resident-involved (Top priority); Intermodal (Less); Versatile (Top priority); Efficient (Top priority); Rightsized (Less)	– Develop efficient operation model with fewer drivers – Diversify driver supply by getting support of residents and autonomous driving – Improve compensation and social status of drivers – Conduct measures to improve sustainability for ①
Low-balanced (4)	Dynamic route (Top priority); Resident-involved (Top priority); Intermodal (Less); Versatile (Top priority); Efficient (Less); Rightsized (Top priority)	– Renew mobility system, especially heavier modes, by unrestrained discussion on the sustainable solution in the long run – Coordinate with existing operators to secure financial and operational support
Low-without-rail (5)	Dynamic route (Top priority); Resident-involved (Top priority); Intermodal (Less); Versatile (Less); Efficient (Less); Rightsized (Top priority)	– Investigate more sustainable solutions by rightsizing modes and involving regional community more – Take advantage of all available vehicles in the region in the long run (e.g. post, nursing)

Source: Authors

The town of Eihei-ji in northwestern mainland Japan is categorized as mid-balanced (archetype 1). It anticipates a population decrease and is seeking new mobility solutions as a participant in a pilot project for the Ministry of Economy, Trade and Industry (METI) Smart Mobility Challenge.[20] Because Eihei-ji is adjacent to the prefecture's capital and already has multiple layers of modestly sustainable public transit modes, reforming the system means, more or less, an upgrade: adding door-to-door on-demand service (dynamic route), introducing an intermodal data platform (intermodal) and integrating transit service with parcel delivery (versatile), echoing solution priority for the mid-balanced archetype in Figure 7.

By contrast, the city of Ube in western Japan has short rail lines that have decreasing ridership, categorizing the city as mid-disproportionate (archetype 2). Ube aims to improve convenience as a core part of its reform by redesigning bus routes and creating a transport hub (intermodal).

However, the city's characteristic initiative is on proactively investigating the possibility of replacing its unprofitable rail lines with a bus rapid transit system (rightsized). The mayor leads this and aims to improve service quality by integrating rapid transit lines with other bus lines, rather than waiting for rail services to deteriorate.
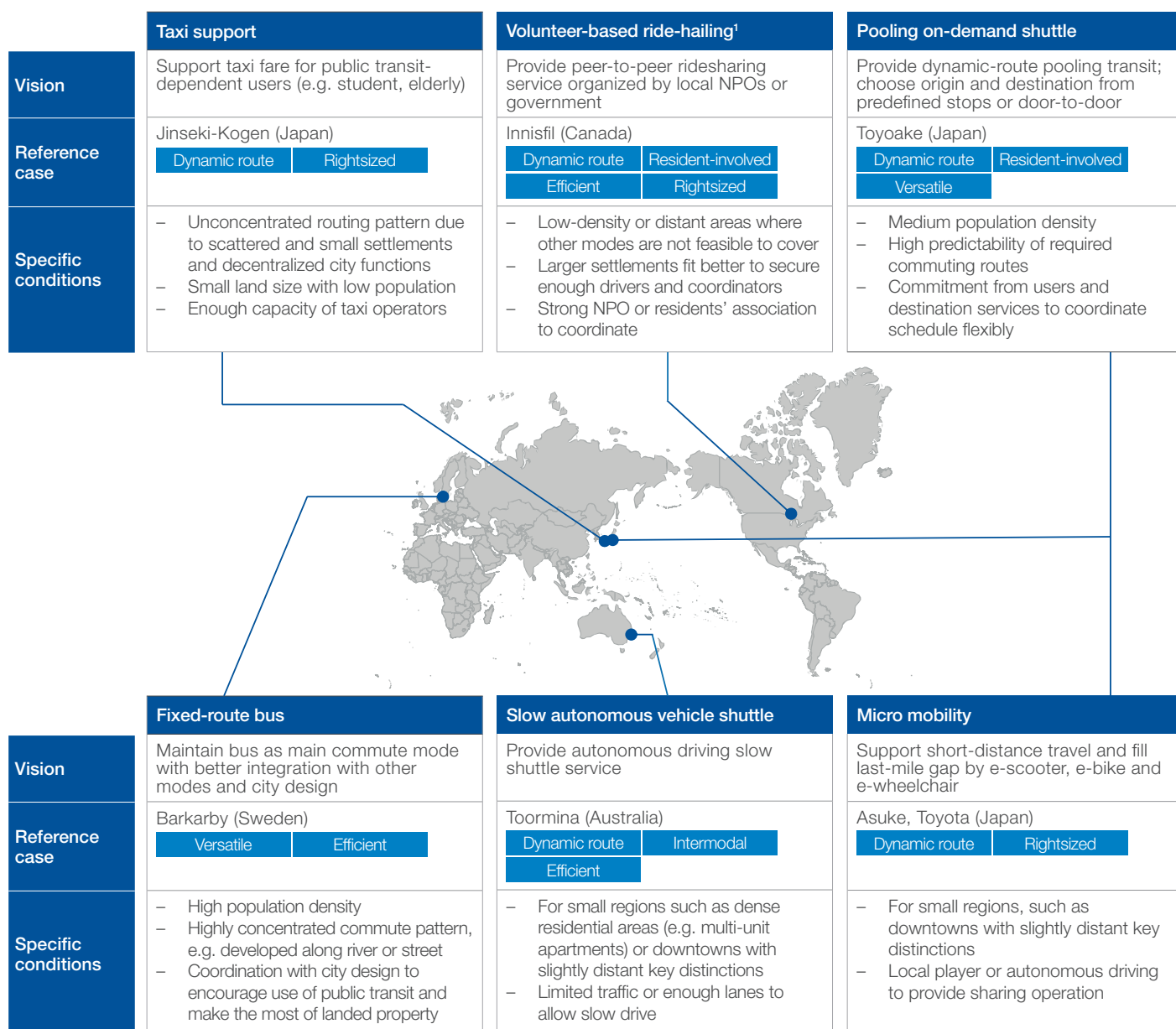
Ube is a rare example of a city that seeks to rightsize its rail system, but in reality rightsizing public transit modes, including rail, may apply to many cities in archetypes 2, 4 and 5. As demographic shifts cause ridership to drop even lower, relying on profit earned in urban areas and on high-speed rail lines to prop up local lines will no longer be feasible for many regions over time. While time and viable options still exist, local government leaders may need to consider whether to fully commit to supporting local lines financially and operationally or to rightsize rail solutions – with operator support.

Chapter 4: Case library for rural areas with transportation needs

To make meaningful improvements to rural mobility systems, leadership must be encouraged to make tough decisions. Government leaders, however, cannot take the first step without the confidence that these changes will provide a brighter future for their region. Furthermore, leaders find it difficult to roll out possible solutions because of roadblocks, including a lack of systematic processes to support efforts and a lack of expertise on a wide range of reference cases. Leaders can take heart, however, from various transport options to choose from, even if their archetype is the challenging low-without-rail model. Cities can use elements from each solution to create a mobility system that best addresses their situation's challenges and needs (Figure 8).

Leaders can refer to many well-functioning existing models and emerging models using new technologies for inspiration and to educate themselves. Case examples offer an in-depth look at the taxi support model to demonstrate that picking the right solutions for the condition of the region still has room to improve the existing system, and to provide an overview of how autonomous driving can flourish in rural mobility through a close look at short-distance applications. Furthermore, those contemplating the future of rural transit must also consider potential solutions that have not yet been tested and could lead to drastic changes.

Figure 8: Cities can choose from various transport elements to augment or build a new rural mobility system

	Taxi support	Volunteer-based ride-hailing[1]	Pooling on-demand shuttle
Vision	Support taxi fare for public transit-dependent users (e.g. student, elderly)	Provide peer-to-peer ridesharing service organized by local NPOs or government	Provide dynamic-route pooling transit; choose origin and destination from predefined stops or door-to-door
Reference case	Jinseki-Kogen (Japan) — Dynamic route, Rightsized	Innisfil (Canada) — Dynamic route, Resident-involved, Efficient, Rightsized	Toyoake (Japan) — Dynamic route, Resident-involved, Versatile
Specific conditions	– Unconcentrated routing pattern due to scattered and small settlements and decentralized city functions – Small land size with low population – Enough capacity of taxi operators	– Low-density or distant areas where other modes are not feasible to cover – Larger settlements fit better to secure enough drivers and coordinators – Strong NPO or residents' association to coordinate	– Medium population density – High predictability of required commuting routes – Commitment from users and destination services to coordinate schedule flexibly

	Fixed-route bus	Slow autonomous vehicle shuttle	Micro mobility
Vision	Maintain bus as main commute mode with better integration with other modes and city design	Provide autonomous driving slow shuttle service	Support short-distance travel and fill last-mile gap by e-scooter, e-bike and e-wheelchair
Reference case	Barkarby (Sweden) — Versatile, Efficient	Toormina (Australia) — Dynamic route, Intermodal, Efficient	Asuke, Toyota (Japan) — Dynamic route, Rightsized
Specific conditions	– High population density – Highly concentrated commute pattern, e.g. developed along river or street – Coordination with city design to encourage use of public transit and make the most of landed property	– For small regions such as dense residential areas (e.g. multi-unit apartments) or downtowns with slightly distant key distinctions – Limited traffic or enough lanes to allow slow drive	– For small regions, such as downtowns with slightly distant key distinctions – Local player or autonomous driving to provide sharing operation

Note: NPO = non-profit organization
1 In Japan, only volunteer-based e-hailing is approved in limited areas, while Innisfil uses Transportation Network Companies.
Sources: Interview with Jinseki-Kogen Town, May 2019; Interviews with operators, September 2019; Uber Blog, "Story of Innisfil", 25 June 2019, https://www.uber.com/en-CA/blog/the-story-of-innisfil/; Chunichi Shimbun, 26 January 2018, "豊田・中山間地域の超小型ＥＶ　高齢者、乗りやすく改造"

Existing solution: Subsidized taxi service

In 2017, the town of Jinseki-Kogen, located in the Hiroshima Prefecture, replaced the fixed-route community bus and on-demand bus services it managed with a taxi-fare subsidy for residents who could not drive, such as the elderly, the disabled and people without a driver's license. The subsidy covered any taxi fare above JPY 600 if the destination was within the town.

A satisfaction rate of 94% from the survey conducted in 2017 proves the improved convenience for users. The cost of the subsidies increased the city's mobility budget slightly, adding JPY 10 million or roughly 10%. Still, a city officer who was interviewed said the move towards subsidies was a "quite positive situation," considering external benefits. One such benefit was that access to alternative transportation for elderly residents meant they could return their driver's license. The number of returned licenses increased sixfold (from 14 in 2016 to 69 in 2017 and 87 in 2018). It would help lower the number of accidents involving elderly drivers, which is of increasing concern for traffic safety in Japan.[21]

In addition, many more people use the taxi service than the former bus line; while the on-demand bus system in 2016 logged 400 monthly rides, in 2017 the taxi service registered 2,500 rides. Increased trips by the elderly are recognized positively, especially because of the impact on their health. The boost from fare support and the resulting increased use of taxis greatly contributed to revitalizing local taxi companies, taking an essential part of rural mobility including school buses and increasing their revenue by 45%.[22]

Other regions can take heed: they can still improve both their customer service and their bottom lines – even in the low-without-rail model (archetype 5) – if they choose the best-fitting solution for their region. Of course, Jinseki-Kogen's solution was well-adapted for its key conditions:

– **Small population and land size**: This system does not gain economies of scale as volume increases, so it would work better for small towns such as Jinseki-Kogen with a population of only 10,000, and the programme would be too costly for larger cities, considering both population and coverage area.
– **Scattered settlements and destinations**: The population of Jinseki-Kogen is spread across the town; key destinations, such as the hospital, city hall or supermarket, are also geographically dispersed. For cities with more concentrated commute patterns, a bus or pooling service is more economically feasible than individual taxi service.
– **Enough taxi capacity**: Jinseki-Kogen has 25 taxis, a relatively high number for the town's size, and the town government supports the recruiting and training of new drivers. A shortage of taxis could easily mean that subsidized taxi service cannot be implemented even if other conditions match.

While not all towns can adopt this system, they can address their challenges by customizing subsidized taxi programmes. They can make up for a taxi driver shortage by, for example, pooling taxi coordination (efficient), or by

including elements of ride-hailing with volunteer drivers (resident-involved). More variation and advanced systems of the subsidized taxi model would be generated.

Emerging solution: Autonomous shuttles

Many pilot projects are using new technologies to meet rural mobility challenges. For example, autonomous driving with an attendant present has been tested in various modes, such as in fixed-route bus in Barkarby, Sweden,[23] and for short-distance slow dynamic-route shuttles in many pilots, including Keitum, Germany;[24] Appelscha, the Netherlands;[25] multiple towns in New South Wales, Australia;[26] and many regions in Japan.[27] These small, self-driving shuttle buses may be used in suburban and rural communities to bring elderly people to nearby destinations or provide last-mile support for riders, especially the elderly.

Marian Grove Retirement Village and Coffs Harbour, both located in suburban areas of New South Wales, lack public transit services. Marian Grove launched a pilot shuttle service called Busbot. The shuttles require no driver intervention, though they have attendants on board ready to switch to manual mode in case of emergency. Users can book the six-seater shuttle by app or phone, and they can choose their pick-up point and destination from pre-fixed stops within 0.1 square kilometre of the retirement village.

Autonomous vehicles (AVs), which are usually cautiously received by users, were rated well in the region after the initial pilot. A user survey conducted at Coffs Harbour after phase 1 of the pilot revealed that 86% of respondents were satisfied and 84% would use such a service again.[28] The pilot has a long way to go, however, before it can be adopted at scale; it does not charge riders a fare, and the business model requires further innovation. One service provider pointed out the need to develop creative solutions to monetize the service and ensure usage. Innovative solutions include coordination with city design; minimized parking space to incentivize the use of public transit and to generate a new source of revenue by efficient use of land; or a scheme to divert spending on a second-car purchase to a subscription fee for public transit services.

As initial insights from slow autonomous shuttle pilot projects unfold, the optimal conditions required to match the solution become clearer:

– **A small area of operation**: The initial implementation of autonomous shuttle services is likely to occur in small areas. Autonomous shuttles currently operate at speeds of 12 to 15 km/h, and an expert who analysed Japanese pilot cases on slow AV shuttles said they cover a maximum area of approximately 4 km and in short enough time to ensure a comfortable ride for the elderly. An AV shuttle model travelling 40-50 km/h is under development, but manufacturers must still address hurdles, such as safety concerns for users of six-seater small, light-weight shuttles.

– **Limited traffic or enough lanes**: Mixed traffic with AVs and traditional cars causes some complexity – not only because it can lead some AV systems to malfunction, but also because human drivers find it difficult to follow the slow pace. In France, a pilot project starting in 2020 will use 7.2 km of dedicated road redesigned from an abandoned railway.[29] This kind of experimental field fits better in the early stage of AV pilots.
– **No heavy snow**: AV shuttles have difficulty operating in some weather conditions, such as in snow-covered areas and during frequent heavy rain, which can prevent AV sensors from functioning properly.

What the future holds

Because the future of mobility is changing rapidly, it is important to imagine how the future mobility system might drastically change rural mobility. For example, in areas where public transit, especially rail, is not sustainable, other infrastructure is expected to face the same issue. But what if it were possible to provide a distributed energy system with electric vehicle-based, on-demand mobility that could act as a mobile battery to balance the supply and demand of a town's energy? Or, what if all vehicles operating in a town, such as for day-care-centre pick-up service, post office, and private cars approved by owners, were integrated in an app and played a part in ride-hailing?

Of course, further investigation is needed to validate the viability and sustainability of a mobility system, but abundant initiatives proceed around the world in different environments. Setting aspirational goals and connecting global reference cases for inspiration can help address some of rural mobility's most pressing issues.

Conclusion: Local governments cannot do it alone

Rural mobility, in a tough situation around the globe, requires urgent attention. While immediate and meaningful action is needed to develop a sustainable rural mobility system, the whole process of transforming rural mobility requires strong leadership from local government in the long run. Though the process might not be straightforward, local leaders need to expand their allies in this effort, across residents and private players (transit operators, mobility service providers and service providers of relevant industries) to realize their mobility and overarching visions. As more local leaders squarely address this issue, more successful cases will begin to appear and develop.

At the same time, private players must become further involved to expand rural mobility systems. While some cases already exist (such as those in slow autonomous shuttles), many future solutions are still in the pilot stage and require further investment and improvement. In isolation, the initial business opportunity of solo pilot projects may be quite small. But as the world's depopulated rural areas spread globally in the coming decade, rural mobility will grow in importance – as will the possibility of developing new solutions. In Japan and around the world, the rural mobility market is wide open and less competitive. And, more importantly, users have a genuine need for it.

The right set of data, gathered and shared across governments and relevant private players, and a well-established process would help improve the quality of decision-making and speed it up. The Public Transit Sustainability Index and city archetype framework make up a toolkit that can support leaders as they begin thinking through their situations and suitable solutions.

The fervent hope is that more players with technology and passion will join the cause to tackle this issue and develop more successful use cases together.

Contributors

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