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White Paper

Shared, Electric and Automated Mobility (SEAM) Governance Framework

Prototype for North America and Europe

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Preface

This White Paper offers a prototype framework for integrated shared, electric and automated mobility (SEAM) governance. It is comprised of a short introduction to a project idea, the rationale for the project structure and ideas for a customized governance framework.

The SEAM Governance Framework Prototype has four phases: (i) governance **work principles** outlining essential approaches to be considered by developers of SEAM governance; (ii) **governance visions**, including objectives that the authors believe should be embedded in SEAM governance development goals; (iii) **governance instrumentation** stock, where creative and exhaustive tools for public- and private-sector actors are presented by type and priority ("SEAM rank"); and (iv) **policy evaluation** tips and tools, which highlight issues that typically impede the evaluation of governance instruments and present evaluation models. These tools can be made available for engaged cities to use as part of the pilot process.

Executive summary

Shared, electric and automated mobility (SEAM) should be viewed as complementary features of an urban passenger mobility system of the near future. As such, these three features should be advanced through a governance approach that combines policies through a constructive stakeholder process.

The SEAM Governance Framework Prototype suggested in this White Paper advocates for a four-step approach that can be led by a city:

1. **Establish work principles**

The key work principles are:

- Encourage an inclusive environment for public- and private-sector stakeholders as well as community collaboration on the design, evaluation and modification of policies
- Create a cultural, institutional and cognitive environment for dynamic governance and the establishment of a common language
- Establish operational guidelines for evaluating success and managing risks
- Form efficient, transparent and authoritative governance mechanisms

2. **Set vision and goals**

The ultimate vision is for an inclusive and sustainable mobility system, which improves urban quality of life for all. The goals could include good urban space and mobility integrations, shared-ride mobility (by occupancy-commute), zero-emissions mobility, electrified and shared automated vehicles (first as community-inspired pilots) and dynamic governance.

3. **Package policy instruments**

The policy library is divided into "cost" and "price" levers. Under each of these, policies are divided into those overseen by the public-sector, private-sector and joint public-and private-sector leaders.

4. **Form a reliable policy evaluation mechanism**

Given the abrupt nature of current urban mobility trends, the evaluation of urban mobility policy is best when based on real-world data and done periodically.

1. Introduction

This section outlines the shared, electric and automated mobility (SEAM)[1] governance project goal, approach and process.

Project collaborators

Assembled by the World Economic Forum Centre for the Fourth Industrial Revolution Autonomous and Urban Mobility (AUM) project team, the Global New Mobility Coalition will be formed in the fall of 2019. The Coalition seeks to advance an informed awareness and to co-develop policies that demonstrate and capitalize on the significant long-term environmental benefits of shared, electric and automated mobility technologies, and support their piloting in real-world applicants today.

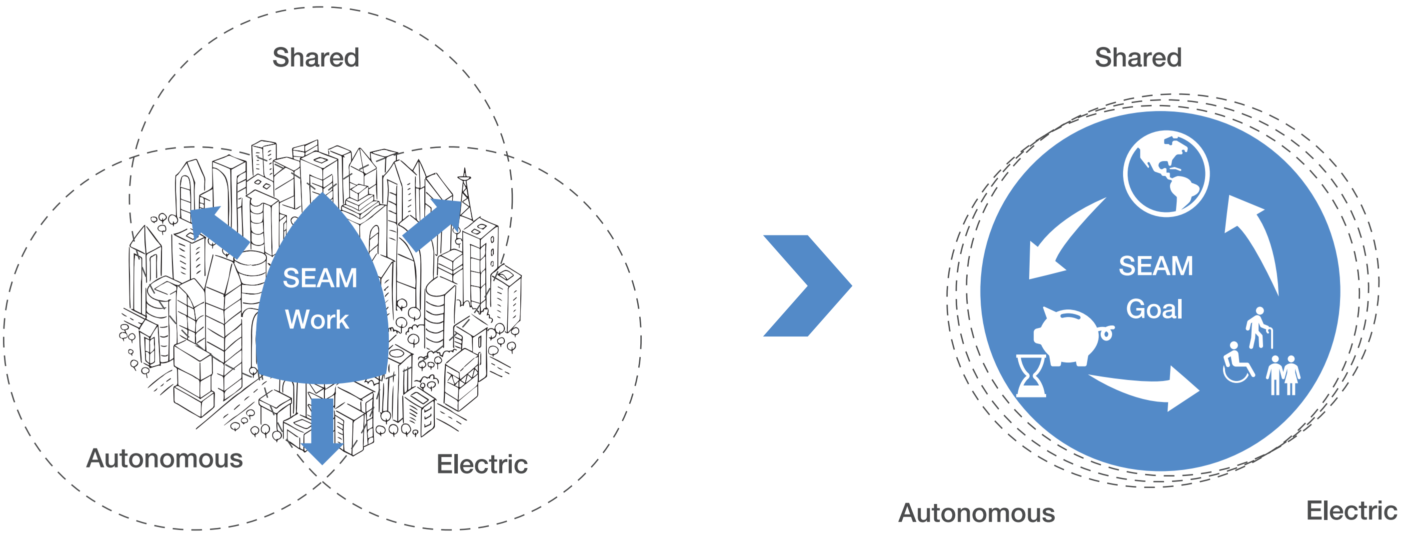
SEAM Governance Framework Prototype goal

The project goal is to ensure that new mobility governance adopts an integrated approach to SEAM to primarily advance positive environmental outcomes (Figure 1). Its near-term objective is to explore pathways for achieving this goal through urban pilots by plugging into local sustainability goals (socio-economic, environmental) and guiding the tailoring of comprehensive governance instrumentation packages to local contexts.

In AUM work, shared mobility refers to high-occupancy rides rather than to shared travel models (vehicles, bikes, scooters).[2] Electrification of vehicles is a means to a zero-tailpipe emissions goal, and therefore other technologies towards that end are meant to be included in this simple term (e.g. fuel cell vehicles).[3] Automated or autonomous[4] mobility refers to high automation, namely when all tasks can be handled by the vehicle system without human intervention though in a limited environment (geofenced), and to full automation, when an automated system can handle all roadway conditions and environments.[5]

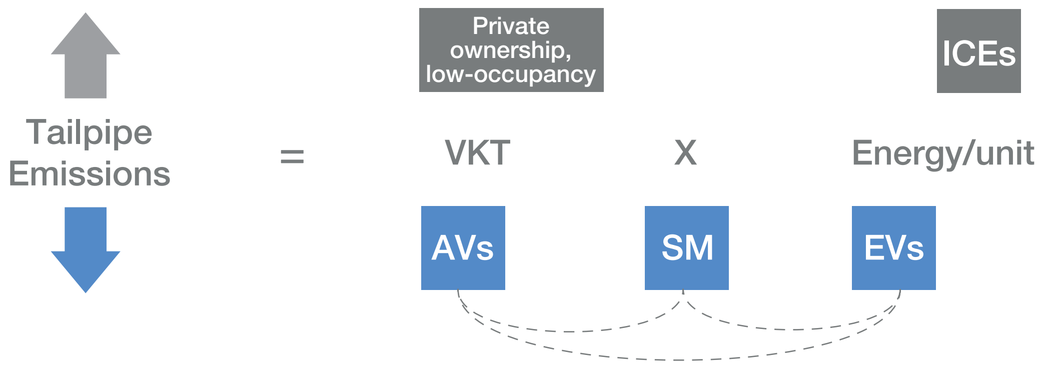
Shared, zero-emission and automated solutions are complementary and enhance each other's benefits.[6] Research to date has considered the potential for reduced emissions from shared, electric and automated mobility given their individual and joint impacts on energy consumption (fuel economy, fuel type, occupancy per vehicle, road load or congestion) and cumulative vehicle distance travelled (travel behaviour). While emission reduction estimates vary (see Appendix I), "many experts believe that a fleet of right-sized, shared, fully autonomous, electric-drive vehicles integrated into the transportation network could be a key to reaching transportation decarbonization goals".[7] Assessing local environmental impact scenarios from SEAM through a local lens provides value (Figure 2).

Figure 1: SEAM governance goal



Source: Authors

Figure 2: SEAM air quality and climate benefits – 45-95% reduction in emissions if combined right



Note: VKT = vehicle kilometres travelled; ICE = internal combustion engine; AV = automated vehicle; SM = shared mobility; EV = electric vehicle
Source: Authors

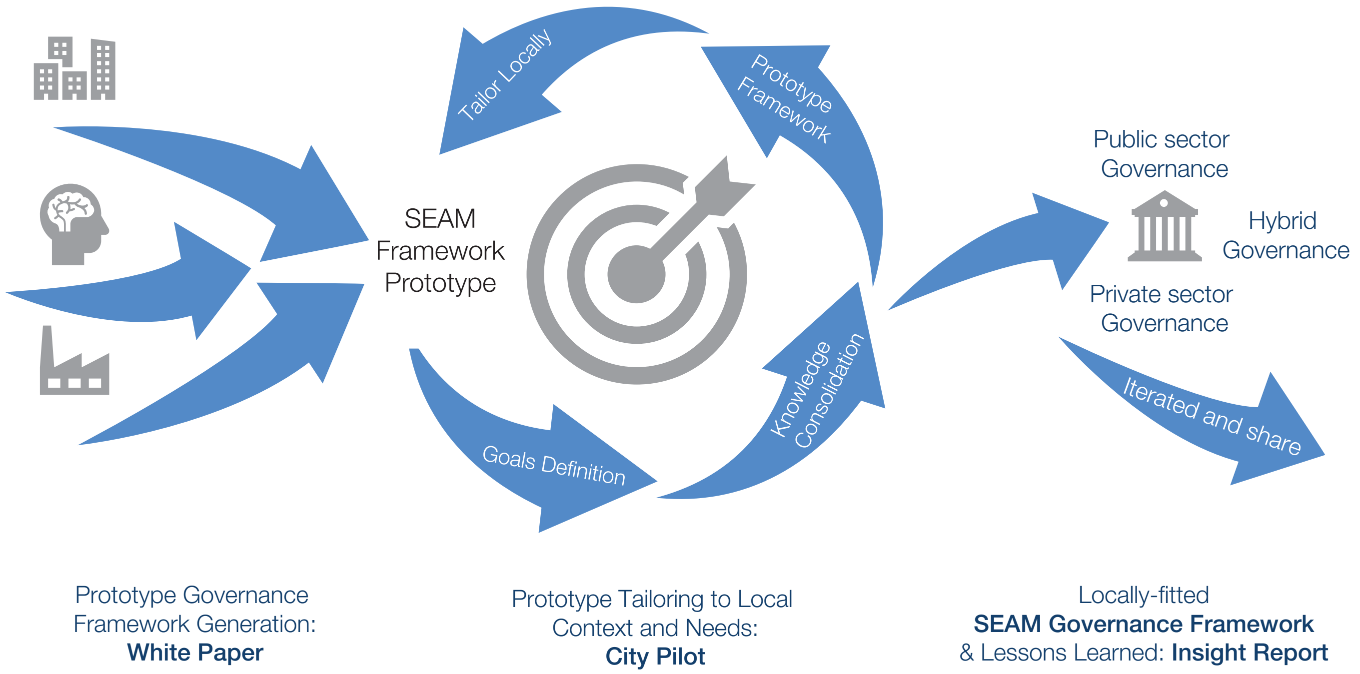
To facilitate the environmental and sustainable benefits of SEAM, the AUM community refined four tools: work principles; a vision and goals; a policy library; and policy evaluation models. It further brings together a diverse and engaged community of subject matter experts from companies, academia, think tanks and NGOs.

The community's desire is to work with individual cities to customize the framework proposed here for their unique needs for capitalizing on SEAM for positive environmental benefits.

SEAM Governance Framework Prototype: approach and process

The AUM team assembled a community to develop the SEAM Governance Framework. The intention was to invite pilot cities to experiment with and adjust the Framework Prototype according to their needs and governance context (Figure 3). Therefore, this prototype is not intended to be adopted as is, but rather to stimulate and guide local governance discussion, and to tailor approaches and instrumentation to local best practices. Such processes, when available, would ideally be recorded, iterated and shared with key public- and private-sector leaders from other municipalities.

Figure 3: SEAM governance project process

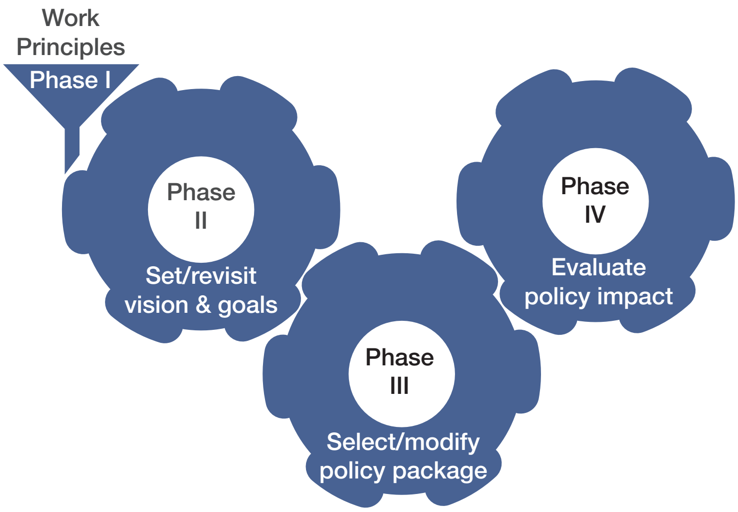


Source: Authors

2. SEAM Governance Framework prototype

The co-designed SEAM Governance Framework has four phases (Figure 4). It provides high-level and long-term insights for devising governance work principles and guidelines for crafting governance visions and subsequent goals and objectives. It also provides actionable short-term recommended SEAM governance instruments (policy library) and evaluation tools. The Framework is meant to be tailored to interested and suitable cities through a pilot engagement process.

Figure 4: SEAM Governance Framework phases



Source: Authors

Each of the chapters is built on AUM community efforts (see the reference list in Appendix II) curated by the World Economic Forum Centre for the Fourth Industrial Revolution. Chapters include relevant case studies and suggested readings.

2.1 Phase I: Governance work principles

The pilot city should develop a steering document that outlines SEAM governance work principles, or review existing documentation, while considering the following work principles:

- **Engage with external stakeholders**, existing and potential, including the private sector, academia and civil society communities (see Case Study 1).
- **Engage with internal stakeholders and seek cross-ministerial participation** to enable action that builds on multiple perspectives and experiences. This should include but not be limited to legal, financing, monitoring and enforcing entities (see Case Study 2).
- **Create an environment for dynamic governance** that can be fitted to changing cultural, institutional and cognitive conditions, and acknowledge that no current framework will be perfect.
- **Form a clear terminology handbook** to smooth communications between involved actors and to revisit the typology periodically (see Case Study 3).
- **Establish performance indexes and risk management guidelines** in advance, using levels of importance and likelihood and aligning on how predicated technical, organizational and operable issues should be addressed, noting points of escalation (see Case Study 4).
- **Form efficient, transparent and authoritative management, evaluation and enforcement capacities** as well as work mechanisms (see Case Study 5).
- **Ensure good governance,** which seeks to minimize regulatory patchwork. Tread lightly around the use of pre-emption and proactively pursue continuous improvement based on timely real-world governance impact evaluation (see Case Study 6).

Case Study 1: Rethinking mobility requires a truly participatory effort (Ford Motor Company's Greenfield Labs)

"With a new perspective on mobility must come a new set of design principles for street stewardship, street design, and mobility creation. Ford created the National Street Service to ensure that new technologies and services it creates help carry streets forward to a future that puts people at the center of this vital public space. Ford hopes that these design principles can become a touchstone for all people building the streets of the future."

From "Principles for the Living Street of Tomorrow", *Living Streets*, https://www.ourlivingstreets.com/

Case Study 2: Hybrid instrumentation calls for hybrid governance (Innovation Center for Energy and Transportation)

"The adoption of the ZEV-credits in China can set an example for the importance of cross-institutional agreement for forging a mandate that is enforceable and manageable: It was only after five ministries have jointly agreed to pursue a ZEV credits mandate, that the mandate could have been adopted and signalled to the industry that there are governing capacities, and that the game is on."

– An Feng, Founder and Chief Executive Officer, Innovation Center for Energy and Transportation (iCET), China

Learn more at: Ben Dror, M. and Feng, A., "Government policy and regulatory framework for passenger NEVs in China", *forum*, Issue 112, March 2018, p. 38, https://www.oxfordenergy.org/wpcms/wp-content/uploads/2018/04/OEF-112.pdf

Case Study 3: Standard taxonomy and definitions (University of California, Berkeley; SAE International)

A consequence of the ever-growing and -evolving landscape of shared mobility is the lack of standardized terms and definitions. The shared and digital mobility industry is challenged with discrepancies in use and definition of terms, which often create ambiguity and confusion for policy-makers, regulatory agencies and the broader public. *Taxonomy and Definitions for Terms Related to Shared Mobility and Enabling Technologies* – J3163™ is aimed at tackling this problem, and it is planned to be revisited periodically. The current standard organizes taxonomy into six categories: travel modes (e.g. car-sharing and bike-sharing), mobility applications (e.g. mobility tracker apps), service models (e.g. peer-to-peer service model), operational models (e.g. station-based round trip), business models (e.g. business-to-business roundtrip) and deprecated terms (e.g. ride-sharing).

Read more at: SAE International, *Taxonomy and Definitions for Terms Related to Shared Mobility and Enabling Technologies J3163_201809*, https://www.sae.org/standards/content/j3163_201809/

Case Study 4: Drones and Tomorrow's Airspace (World Economic Forum Centre for the Fourth Industrial Revolution)

The Advanced Drone Operations Toolkit provides a modular approach for governments to enable societally important and safe drone projects. Each recommendation is based on lessons learned from the latest successful pilot projects in Switzerland, Rwanda and Malawi – saving lives and creating new forms of aerial logistics. Among its findings are the benefits of a performance-based regulation (PBR) model: governments around the world are struggling to balance efficient oversight over innovative mobility solutions with the dynamism of rapidly evolving socio-technologies. PBRs are regulations based on dynamic risk mitigation that allow authorities to respond quickly to new types of mobility options by identifying and managing their potential risks.

In the context of road mobility, and given the rapid socio-technological development, the success of dynamic performance-based safety governance in the commercial use of new solutions can support a smooth transition to SEAM.

Read more at: *Advanced Drone Operations Toolkit: Accelerating the Drone Revolution*, Insight Report, World Economic Forum, December 2018, http://www3.weforum.org/docs/WEF_Advanced_Drone_Operations_Toolkit.pdf

Case Study 5: Agile cities – Preparing for the Fourth Industrial Revolution
(World Economic Forum)

According to *Agile Cities: Preparing for the Fourth Industrial Revolution*, a report by the World Economic Forum Global Future Council on Cities and Urbanization, "After years of building up both infrastructure and processes, cities must now break down silos and invite innovation in order to fully benefit from the opportunities and meet the changes facing their populations.

The need to be agile – to quickly adapt to changing needs – cuts across all areas of urban infrastructure and processes. The guidelines and metrics provided in this report draw attention to three levels on which cities have experimented with innovation and found new solutions:

– 'Physical' components – how current infrastructure can be adapted to new needs and uses without outsized investment, long planning processes or inconvenience to citizens.

– 'Digital' elements – how new technologies can be harnessed to better understand trends and citizens' needs, as well as provide insight on current urban infrastructure and services and optimize their benefits.

– 'Environmental' factors – how the environmental effects of urban activity can be mitigated through innovative applications in both the physical and digital spheres."

Read more at: *Agile Cities: Preparing for the Fourth Industrial Revolution*, World Economic Forum, September 2018, http://www3.weforum.org/docs/WP_Global_Future_Council_Cities_Urbanization_report_2018.pdf

Case Study 6: Privacy-aware open data exchanges to encourage operator participation (New York University)

"Open data exchanges are critical for supporting data-driven innovations in 'living lab' ecosystems. Open data exchanges are also important for public agencies to provide decision support for their public services, which are becoming increasingly multistakeholder, interoperable and information-centric. A city-operated MaaS [mobility as a service] can involve multiple partners: multiple transit operators, a smart grid provider, a fare manager, a mobile app provider, among others. This concept of data-driven innovations of 'living lab' ecosystems will only succeed if operators are willing to share some aspect of their operational data with public agencies and researchers. Mechanisms for generating synthetic data have been developed to make such data sharing possible while minimizing the risk of adversarial espionage. The mechanism is tested with shared taxi route data simulated from a study of the Long Island Railroad."

– Joseph Chow, Deputy Director, Connected Cities with Smart Transportation (C2SMART), University Transportation Center, New York University, USA

Learn more at: He, B. and Chow, J., "Optimal privacy control for transport network data sharing", Conference Paper, 23rd International Symposium on Transportation and Traffic Theory, Lausanne, Switzerland, July 2019 (not yet published)

Case Study 7: Shared mobility principles for liveable cities around the globe (New Urban Mobility alliance)

Initiated by Robin Chase, a transportation entrepreneur and co-founder of Zipcar, "the Shared Mobility Principles for Livable Cities were launched at the 2017 Ecomobility World Festival in Kaohsiung, Taiwan, where they were reflected in ICLEI's [Local Governments for Sustainability] Kaohsiung Strategies for the Future of Urban Mobility", according to the *Shared Mobility Principles for Livable Cities* website. The Principles already have over 170 signatures and are now curated by the New Urban Mobility alliance (NUMO), a dedicated global non-governmental organization (NGO). Its website states that the alliance "channels tech-based disruptions in urban transport to create joyful cities where sustainable and just mobility is the new normal."

The Shared Mobility Principles for Livable Cities website goes on to state that signatories to the Principles "encourage all stakeholders – cities, NGOs, academic institutions and companies – to seek creative uses of the principles."

Learn more at: Shared Mobility Principles for Livable Cities, https://www.sharedmobilityprinciples.org/

Case Study 8: Community-based mobility and infrastructure for short-term EV adoption (Envoy)

Community-based mobility requires dissecting socio-economic factors for various demographics to understand community needs and how to best apply private and public funds to meet these needs. For example, Envoy, a provider of on-demand shared electric vehicles (EVs), deployed EVs in three types of communities:

1. Market rate residential city communities: Adoption of service was spurred by users being conscious of their environmental footprint and of the costs (offsetting the costs of owning a vehicle, such as lease, loan, insurance and parking expenses). Vehicles are used primarily for errands and short-distance trips within the city. The communities and the mobility service are privately funded. Infrastructure is privately and publicly funded, with public funding coming from utility rebates.
2. Universities: Adoption of service was driven by users being extremely cost-conscious (students with a limited budget). Uses are primarily for errands and weekend trips (daily rentals). The communities and mobility service can be either privately or publicly funded. Infrastructure is privately and publicly funded, with public funding coming from utility rebates.
3. Low-income/disadvantaged communities: Adoption of services was driven by education and outreach, as users are generally not familiar with and scared to use new technology. Once adoption occurs, uses are for solving first/last mile commutes and for addressing the issue of food deserts (i.e. regions where residents lack access to healthy, affordable food) as well as the effect of regentrification on access to transportation for this demographic. The communities and mobility service are publicly funded, as is the infrastructure (via grants and utility rebates). The communities rely on public funding assistance for their transportation budget, and cities and counties need to ensure any form of public transport payment and system is technologically capable of integrating with other modes of mobility.

2.2 Phase II: Governance vision and goals

The pilot city should create a steering document that outlines the city's vision and goals regarding SEAM, or should review its existing documentation (plans and processes) while considering the following vision and goals:

- **Cities and mobility** are interconnected and should be planned together. Good urban space and mobility integrations prioritize and empower interaction among people in an efficient, equitable and inclusive manner (see Case Study 7).

- **Shared mobility** (referred to exclusively as ride-sharing in this paper) has been recognized as a key enabler for sustainability via reduced emissions and should therefore be prioritized (see Case Study 8).

- **Zero-emissions mobility** is technically available and projected to improve the sustainability of transportation systems via reduced carbon and other emissions and reduced public-health degradation, and should therefore be prioritized**.**

- **Automated mobility** is projected to enhance shared mobility and be enhanced by electric mobility. Given its nascent stage and the need to test and tailor it to local contexts, automated mobility should be pursued in urban areas through shared fleets and encouraged to be electric and high occupancy.

While SEAM governance is focused on positive environmental outcomes, the following impacts of mobility on sustainability and the contrasting approaches to mobility were consolidated as useful reference when reviewing existing vision and goals for mobility or setting new ones:

Mobility's impact on sustainability[8]

Economic	Societal	Environmental
Traffic congestion	Inequity of impacts	Air and water pollution
Mobility barriers	Mobility disadvantaged	Habitat loss
Accident damages	Human health impacts	Hydrologic impacts
Facility costs	unity interaction	Depletion of non-renewable resources
Consumer costs	Community liveability	
Depletion of non-renewable resources	Aesthetics	

Source: Authors in collaboration with Framework contributors

Contrasting approaches to mobility[9]

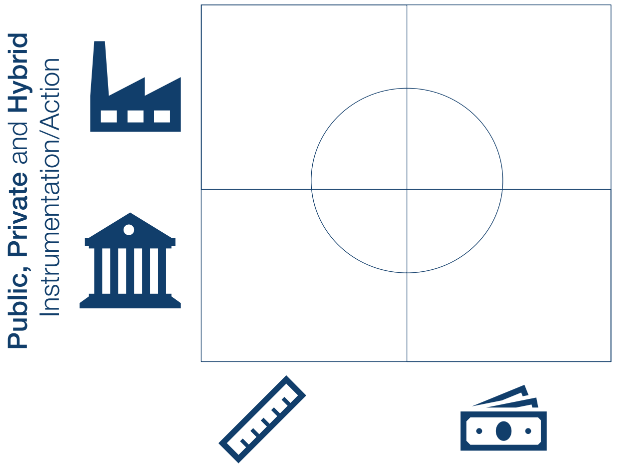
Conventional transportation approach	Sustainable transportation approach
Mobility	Accessibility
Traffic focus, motorized with emphasis on automobile	People focus, vehicle and foot (not only motorized)
Large in scale	Local in scale
Street as a road, physical dimensions	Street as a space with social and environmental dimensions
Forecasting traffic	Visioning on cities
Modelling approach	Scenario development and modelling
Economic evaluation	Multi-criteria evaluation (including social, environmental)
Travel as derived demand	Travel as a valued activity and derived demand
Demand based (speeding up traffic)	Management based (slowing movement down)
Minimizing travel time	Reasonable travel time, travel time reliability
Segregating people and traffic	Integration of people and clean traffic

Source: Authors in collaboration with Framework contributors

2.3 Phase III: Governance instrumentation guide

The use of two governance levers – space and cost – is recommended when considering SEAM governance instrumentation (Figure 5). By listing both in-use and potential policies in a matrix under each of these groupings or "buckets", it will likely be simpler to identify a package of policies suitable for the city for the short, medium and long term.

Figure 5: Suggested SEAM governance instrumentation buckets–space and cost



Source: Authors

It is recommended not only to package policy instruments to offset undesired side-effects and eliminate loopholes, but also to adopt a dynamic approach that allows for real-world data evaluation-based policy modification. The reason for this is that, given socio-technical transitions in urban mobility, governance instrumentation is likely to evolve as well.

Each of the following sections focuses on one of the two levers and includes a policy library comprising quick snapshots of real-world case studies provided by stakeholders, as well as overviews of governance tools and action. A summary of governance instruments, showing categories and subcategories, follows:

Mobility governance instruments in the transport sector

Instrument category	Subcategories
Regulation	Regulations, standards
Economic	Tax, fees/charges, subsidies, incentives, grants
Hybrid	Cap and trade, set and trade
Information	Labelling, public shaming

Note: "cap" = maximal provision; "set" = minimal requirements
Source: Authors in collaboration with Framework contributors

Each of the tables listing governance instruments and presented below should include a column with SEAM ranks from 1 (highest) to 5 (lowest). To constructively determine the SEAM rank, collective intelligence should be used via an interactive workshop that includes an anonymous ranking allocation. In addition, repeating the SEAM rank attribution locally through an imputation process that includes local stakeholders is strongly recommended.

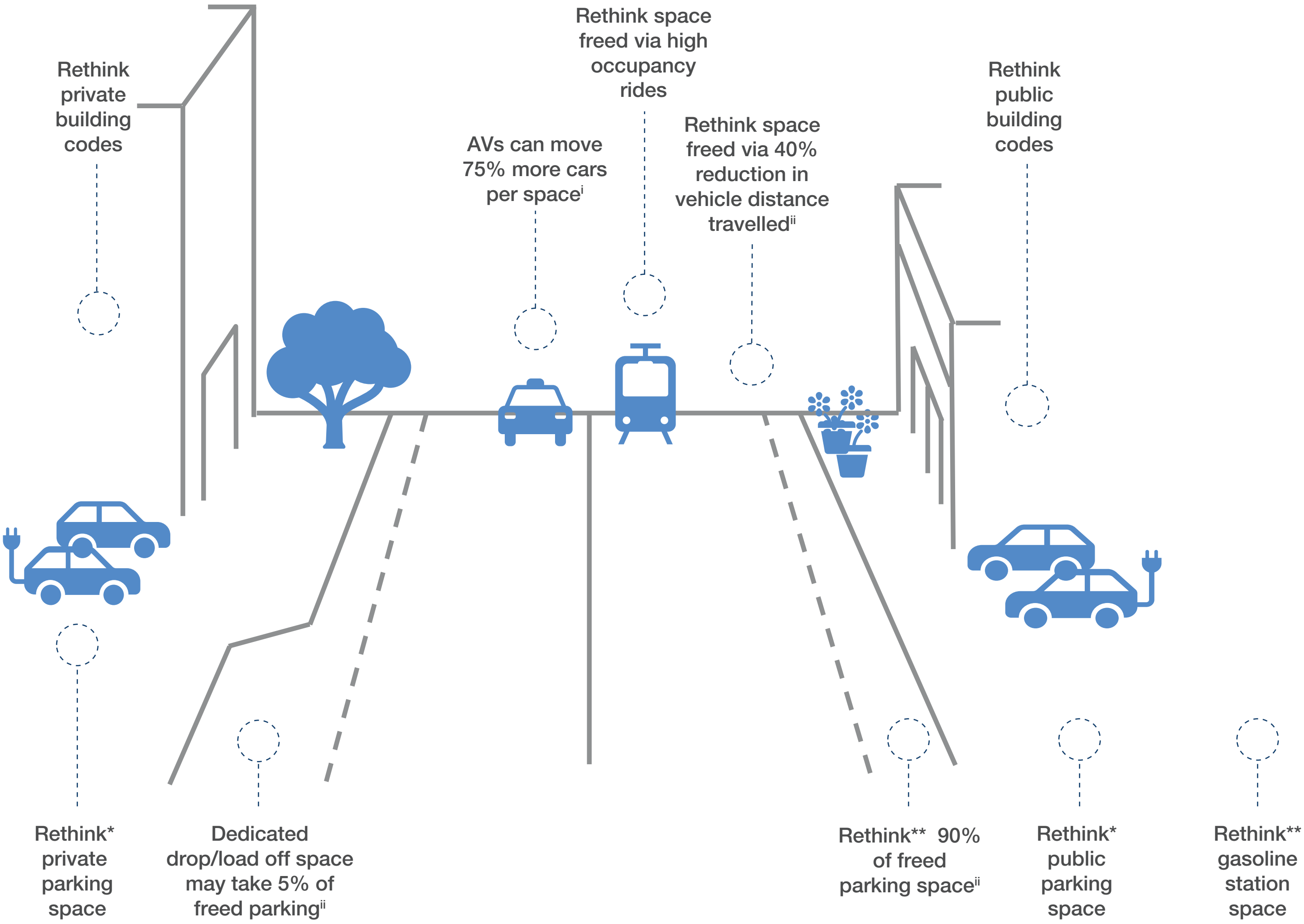
2.3.1 Preferential and flexible space allocation for SEAM

A basic governance-dependent lever is the value of space, typically determined by the allocation of space for particular needs and with a vision in mind (Figure 6). As a finite resource, space is commoditized through allocation and its value is indirectly (though often significantly) affected.

The growing number of vehicles, miles travelled and emerging transport modes have put pressure on available space and feed conflicts over space allocation. Studies show that serving existing road-space demand based on peak-hour traffic volume deepens path dependency, such as using private vehicles for daily trips, as a result of forging more sustainable mobility behaviour, such as shared rides and active mobility like biking.[10] Space allocation also plays a key role in changing demand by deprovisioning parking and improving seamlessness of intramodality. Ample studies have demonstrated that the supply of parking space creates distance between places, decreases the opportunity for non-motorized access and increases the demand for motorized access.[11]

Figure 6: Space allocation–inclusive and allowing for dynamism

(Possible allocations shown are not exhaustive)



* Rethink parking: drop-off/load-on; Prioritize space for shared electric (autonomous) modes, etc.
** Rethink curb-space: active/micro mobility, high occupancy, green space, etc.

Source: Authors; [i] "Advice On Automated and Zero Emissions Vehicles Infrastructure", *Infrastructure Victoria*, October 2018; [ii] "Transition to Shared Mobility: How large cities can deliver inclusive transport services", *International Transport Forum Policy Papers*, No 33

Finally, new approaches to solving congestion attempt to leapfrog unsustainable commuting patterns to engineer short-lived solutions.[12] The following factors are typically considered when advancing notions of being agile, holistic and inclusive in governing "space":

- Access to people of all physical and mental needs, including baby carriages and active mobility modes, such as bikes
- Shifting space purposes according to needs (e.g. rush hour, weekend)
- Use of flexible rather than fixed signage/marking (e.g. paint)

The following table summarizes the types of action required by the listed governance tools. This is useful for understanding the level of complexity and cross-ministerial involvement.

Types of mobility governance action required

Action type	Comments
Space (infrastructure) development	Requires space development; may include construction, utilities, etc.
Space (infrastructure) management	Requires space management; may include digitization, signage, financing
Mode (vehicle) management	Tackles mode diversity; likely to require fewer resources than the types of infrastructure action, but is more politically loaded. *Note: mode development is excluded because it is unlikely to be feasible under city governance provisions.*

Source: Authors in collaboration with Framework contributors

Library of public-sector space lever policies

Category	Subcategory	Type of action	Action
Regulatory	*Parking, road and curb-space permits*	*Space development*	*Streamline permitting to expedite charging infrastructure for SE(A)M vehicles*
		Space management	*Expand high-occupancy vehicle (HOV) lanes and permit access to high-occupancy SE(A)M vehicles*
			Grant access to urban transit origin and destination points for SE(A)M vehicles
			Convert parking and curb-space access permits to SEAM drop-off and pick-up only
			Provide access to public charging infrastructure for SE(A) M applications (incl. fast charging)
		Mode management	*Limit registration and impose operational caps on non-SEAM vehicles (e.g. cap number of shared vehicles that are not electric)*
	Building permits	*Space management*	*Adopt SEAM-ready building codes to ensure that both residential and non-residential space prioritizes SEAM*
	Road-use limitations		*Set us zero and low emission zones, restrict non-SEAM vehicles in sensitive areas (e.g. schools)*
Economic	*Research grants*	*Space management*	*Fund research that advances understanding of space allocation issues*
	Subsidies	*Space development*	*Subsidize space conversion from non-SE(A)M to SE(A)M use, including charging infrastructure, drop-off, etc.*[13]
	Funds		*Fund conversion of non-SE(A)M space to SE(A)M-ready, including charging infrastructure and load, drop-off and other spaces that effectively cater exclusively to SE(A)M needs*
Information	*Information disclosure*	*Space management*	*Disclose information about space-related governance online and through advocacy groups in a timely manner to ensure transparency and inclusiveness*
			Track and disclose rate of adherence to regulation by location, company and usage type as a public reputation (rewarding and shaming) tool
Hybrid	*Cap and trade*	*Space development*	*Create cap and trade schemes that increase the percentage of private parking space that qualifies for and is dedicated to SE(A)M*

Note: The "(A)" in "SE(A)M" implies the emphasis is less on the future-oriented "automated" goal and more on the immediate targets of "shared" and "electric".
Source: Authors in collaboration with Framework contributors; Action (or governance instrumentations listed here) would ideally be ranked through a dedicated multistakeholder exercise.

Library of private-sector space lever policies

Category	Subcategory	Type of action	Action
Regulatory	Parking, road and curb-space allocation	Space management	Restrict non-SE(A)M or priority SE(A)M parking, drop-off and pick-up spaces on corporate premises
	Road-use limitations (in-app)		Limit the use of specific roads on route-optimization applications used by non-SEAM vehicles to limit spillover of travel's negative effects into sensitive areas (e.g. schools)
	Building permits	Space development	Adopt SE(A)M-ready codes to ensure both residential and non-residential space is prioritizing SE(A)M, particularly on account of parking space for privately-owned cars; then, shift to economic instrumentation for developing space accordingly
Economic	Fund research	Space management	Fund research that can advance understanding of space allocation issues on corporate premises and employee households
	Fund development	Space development	Fund conversion of non-SE(A)M space to SE(A)M-ready, including charging infrastructure and load, drop-off and other spaces that effectively cater exclusively to SE(A)M needs
	Subsidizing development		Allocate space or discounted services, among others, and operators of charging
Information	SEAM services	Mode management	Applicable for mobility service companies: add app features that better serve SE(A)M users, such as battery status along the ride, charging/swapping options along the road, designated pick-up and drop-off locations, and intermodal options for first/last mile
	Information disclosure	Space management	Disclose information about space-related governance online and through advocacy groups in a timely manner to ensure transparency and inclusiveness
Hybrid	Set/Cap and trade	Space development	Applicable for large corporations: set bottom (minimal requirements) or create cap (maximal provision) and trade schemes that increase the percentage of private parking space that qualifies and is dedicated to SEAM across the corporation

Note: The "(A)" in "SE(A)M" implies the emphasis is less on the future-oriented "automated" goal and more on the immediate targets of "shared" and "electric".
Source: Authors in collaboration with Framework contributors; Action (or governance instrumentations listed here) would ideally be ranked through a dedicated multistakeholder exercise.

Library of public- and private-sector (hybrid) space lever policies

Category	Subcategory	Type of action	Action
Economic	*Research and development*	*Mode management*	*Co-fund SE(A)M research about space and mode conversation trends and identify challenges*
	Co-fund (subsidize)	*Space management*	*Subsidize space conversion from non-SE(A)M to SE(A)M use*
Information	*Information access*		*Develop public-private consensus around typology and revisit definitions periodically to accommodate for new socio-technological transitions*
	Information disclosure		*Form partnership with shared, electric and automated companies, making it easier to identify and overcome barriers, identify optimal solutions and share the cost of their development and deployment*
	Information disclosure		*Make consolidated and transparent information about space-related governance available online in a timely manner; the public and private sectors should disclose governance efforts as a useful way of increasing awareness and advancing consensus*
Hybrid	*Set/Cap and trade*	*Space development*	*Set bottom (minimal requirements) and co-create cap (maximal provision) trade schemes that increase the percentage of private parking space that qualifies and is dedicated to SE(A)M across a defined group of companies*

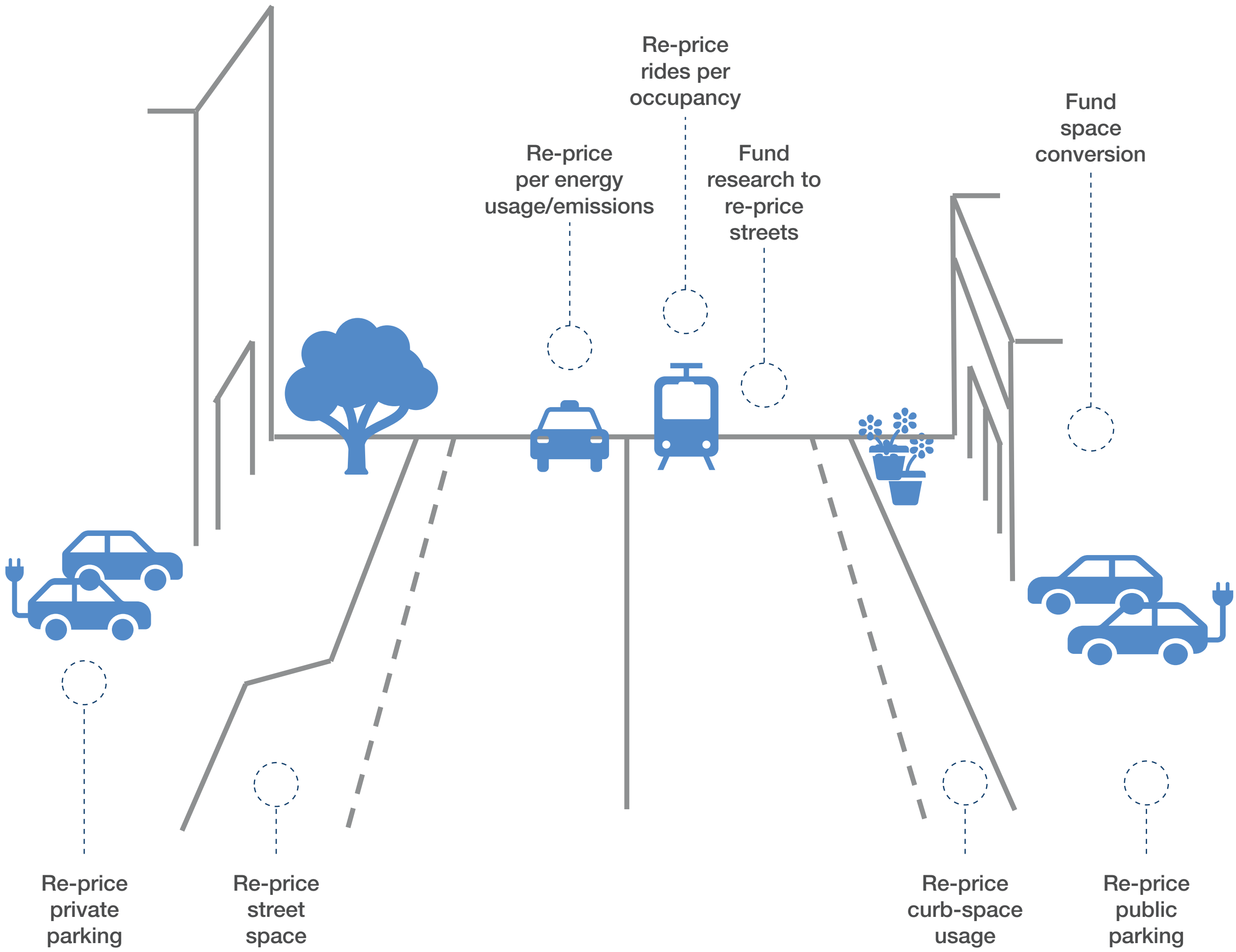
Note: The "(A)" in "SE(A)M" implies the emphasis is less on the future-oriented "automated" goal and more on the immediate targets of "shared" and "electric".
Source: Authors in collaboration with Framework contributors; Action (or governance instrumentations listed here) would ideally be ranked through a dedicated multistakeholder exercise.

2.3.2 Integrated preferential flexible cost determination for SEAM

Another basic governance lever is the determination of cost, directly and indirectly. Over the past two decades, economic geography and geo-economics have revealed that significant environmental effects – degraded air quality, intensified climate change, land and water contamination from manufacturing, supply-chain, and in-use and after-life processes – are disregarded in traditional ways of determining travel cost. Mobility's negative effects on society, including mobility "deserts" leading to the segregation of entire communities as well as to nutritional, educational, financial and other socio-economic inequality, have also received headlines. The list of externalities of mobility is long and is not intended to be covered exhaustively here. Determining the cost of existing and potential urban mobility should account for externalities and be aligned with a vision as well as short- and long-term goals (Figure 7).

Figure 7: Determining costs of existing and potential urban mobility

(Cost determinations shown are not exhaustive)



Source: Authors

Recognizing that significant externalities exist in current mobility systems, this section aims to highlight the importance of redesigning cost structures in an inclusive, balanced and holistic manner. The tables below list governing tools for restructuring some of mobility's costs.

Library of public-sector cost lever policies

Category	Subcategory	Action
Regulatory	*Cost regulation*	*Set a cap on SE(A)M ride cost for the commuter – possibly on certain hours of the day and for types of commuters*
Economic	*Tax exemption*	*Exempt SE(A)M from registration and licensing tax (partially or in full)*
	Road surcharge/ subsidy	*Expand the use of tolls and congestion/road pricing and provide reduced fees for SE(A)M, and/or increase fees for non-SE(A)M modes*
	Parking surcharge/ subsidy	*Reduce parking fees for SE(A)M*
	Mode supply surcharge	*Subsidize preferentially for SE(A)M manufacturing (if governed locally) and sales*
Information	*Information disclosure*	*Disclose SE(A)M cost governance to the public (e.g. online) in a comparable manner*
		Disclose SE(A)M and non-SE(A)M actual costs to the public (e.g. online) in a comparable manner
		Disclose information about how SE(A)M governance funds are used, preferably towards the removal of barriers and challenges of SE(A)M mobility related to supply, demand and management to help gradually reduce the need for funds

Note: The "(A)" in "SE(A)M" implies the emphasis is less on the future-oriented "automated" goal and more on the immediate targets of "shared" and "electric".
Source: Authors in collaboration with Framework contributors; Action (or governance instrumentations listed here) would ideally be ranked through a dedicated multistakeholder exercise.

Library of private-sector cost lever policies

Category	Subcategory	Action
Regulatory	*Corporate benefits*	*Offer mobility budgets for SEAM and variants as an alternative to traditional corporate personal car lease*
	Corporate agreements	*Form partnerships with companies offering SE(A)M services (charging, automation, shared rides) to enable tailored and discounted services*
Economic	*Subsidies*	*Subsidize SE(A)M usage fees to employees (e.g. charging, ride-sharing)*
	Rewards	*Set token benefits (e.g. shares, vouchers, reimbursement)*
	Subsidies	*Subsidize the transition to SE(A)M (applicable for mobility service companies); for example, EVs for ride-hailing*
Information	*Gamification**	*Create corporate "sustainability tokens" for rewarding employees that use SE(A)M; then, consider enacting economic instrumentation to allow for redemption (or maintain an in-kind value, such as credentials)*
	Information disclosure	*Disclose information about SE(A)M usage costs versus non-SE(A)M costs to employees*
Hybrid	*Set and trade*	*Set bottom (minimal targets) and trade schemes that increase the percentage of SE(A)M use*

* Gamification is defined here as "game design elements in non-game contexts"[14]
Note: The "(A)" in "SE(A)M" implies the emphasis is less on the future-oriented "automated" goal and more on the immediate targets of "shared" and "electric".
Source: Authors in collaboration with Framework contributors; Action (or governance instrumentations listed here) would ideally be ranked through a dedicated multistakeholder exercise.

Library of public- and private-sector (hybrid) cost lever policies

Category	Subcategory	Action
Economic	*Subsidies*	*Form partnership that enables tax exemption for employee income used towards SE(A)M mobility usage*
	Rewards	*Co-subsidize programmes that encourage employees to use SE(A)M*

Note: The “(A)” in “SE(A)M” implies the emphasis is less on the future-oriented “automated” goal and more on the immediate targets of “shared” and “electric”.
Source: Authors in collaboration with Framework contributors; Action (or governance instrumentations listed here) would ideally be ranked through a dedicated multistakeholder exercise.

2.4 Phase IV: Reliable policy evaluation for SEAM

The method of evaluation should be developed In tandem with the design of governance instruments. The two are best treated as complementary during the implementation of governance instrumentation.[15]

Time is the main factor when deciding on investment in mobility. Time-value, however, is likely to differ between commuters and along each commuter's day as it unfolds, affected by changing levels of productivity and digital access to work, services and recreation.[16] Furthermore, no silver bullets exist: different cities[17] and companies experimenting with the SEAM governance recommendations will prioritize governance instrumentation differently and assess the effect using different factors that are more relevant to their particular context.

Research shows that SEAM solutions are both individually and collectively capable of advancing sustainability. Even without shifting to the electric-powered train, automating the internal combustion engine vehicle was instrumental in substantially reducing energy consumption and carbon emissions.[18] And even without automation, shared mobility (ride-sharing) delivers sustainability in the form of socio-economic and environmental benefits.[19]

While SEAM is meant to advance the delivery of urban sustainability (maximize socio-economic and environmental benefits), an array of governance evaluation tools in this section can assist interested pilot cities and are made available by the following AUM community members: the International Transport Forum (ITF), the National Renewable Energy Laboratory (NREL) and the Innovation Center for Energy and Transportation (iCET).

Useful reference information is consolidated below on the following:

- Preparation for policy evaluation
- Uncertainties in mobility policy evaluation
- Factors related to mobility policy instruments' efficiency and feasibility

Preparing for policy evaluation

Steps to consider*	Data-related considerations[20]
Data specifications	**Data sample size**: Can the involved company provide a data sample size sufficient for the policy evaluation?
Data sources and technical support for extraction, cleansing and analysing	**Data tampering**: Are all access points to the data known and manageable?
Risk management (identify potential issues, their level of impact and likelihood; set up a response plan)	**Data reliability**: Can raw data from the involved company be reliably extracted while still being specific enough for the policy evaluation?

* Setting an evaluation process is likely to be contingent on the selected tool.[21]
Source: Authors in collaboration with Framework contributors

Evaluation models from three AUM community members address carbon emissions, transport emissions and EV deployment options:

Carbon emissions model (ITF)

According to the ITF website, "the urban transport model analyses mobility in all the 1,667 cities with 300,000 inhabitants or more … The model simulates the evolution of variables that shape transport demand in cities, such as land use, availability of roads, quantity and quality of public transport before analysing the impact of these variables of transport demand and mode choice. The model derives levels of transport activity and mode shares in different policy scenarios, e.g. for policies that favour public transport or for declining fuel prices. It is calibrated on a dataset resulting from an extensive collection from various institutions and covering all the main regions of the world."

The model was recently upgraded to include a series of disruptive technologies, business models and services, including automated/autonomous driving, shared mobility and electrification of urban and non-urban passenger transport.

Find out more at: "The ITF Modelling Framework", International Transport Forum, https://www.itf-oecd.org/itf-modelling-framework

Transport emissions model (iCET)

The model, China Urban Transportation Emissions Calculator (CUTEC), is meant to support urban transport decision-making by comparing the effects of policy on local air quality and carbon emissions, as well as other related effects such as congestion. CUTEC is designed to be open source: it is a Microsoft Office spreadsheet tool that helps to gain insights into the entire design and calculation process. Adaptable to local conditions and requirements, it is also free of charge.

Register at http://www.icet.org.cn/english/registration2.asp?rid=91 to consult the model

Automotive Deployment Options Projection Tool (NREL)

According to the NREL website, "the Automotive Deployment Options Projection Tool (ADOPT), [developed by NREL], is a light-duty vehicle consumer choice and stock model. ADOPT estimates vehicle technology improvement impacts on future U.S. light-duty vehicle sales, energy use, and emissions.

ADOPT provides consumer choice estimates based on questions like:

- How much impact do lower battery prices have on electric vehicle sales?
- How quickly would the market adopt a co-optimized engine/fuel combination that achieves a 10% efficiency improvement?
- How do fuel prices impact the electric vehicle/plug-in hybrid electric vehicle sales mix?
- How does vehicle lightweighting impact powertrain sales?"

Learn more at: "ADOPT: Automotive Deployment Options Projection Tool", Transportation Research, NREL, https://www.nrel.gov/transportation/adopt.html

Uncertainties in mobility policy evaluation[22]

Class of uncertainty	Specification of uncertainty	Source of uncertainty	Severity
System boundaries	*Unclear problem definition** Fragmented or wrong view of the problem and of casualties	– Lack of knowledge – Desire to keep things simple – Inherent complexity of transport system and subsystems, and relations with other systems	Medium
Future external inputs (beyond control)	*Changing needs and attitudes in driving and travel behaviour** Influence of the legal system (liability) Future urban sprawl *Future technology** *Future culture**	– Long-term nature of implementing technology – Inherent poor predictability of most of these factors in the long term	High
System performance and responses	Effect of technology on traffic safety, emissions and efficiency Interface of technology with other transport goals Type and time of indirect impact (for example, in residential area)	– Poorly known key relations and mechanisms determining system behaviour due to lack of research with an integrated approach and focus on causality; lack of clear specifications of the structure of technology in practice	High
Valuation of policy outputs	No clear vision on which core values can be respected Shifting values and standards in judging policy impact	– Policy-makers' lack of sufficient knowledge – Possible disaster that works as a catalyst – Long-term nature of implementing technology	Medium

* Specifications highlighted in italic mark uncertainties that could be better understood by using real-world data.
Source: Authors in collaboration with Framework contributors

Mobility policy instruments' efficiency and feasibility factors

Instrument	Criteria			
	Environmental effectiveness	*Cost-effectiveness*	*Distributional considerations*	*Institutional feasibility*
Regulations and standards	Emission levels set directly, though subject to exceptions; depends on deferrals and compliance	Depends on design; uniform application often leads to higher overall compliance costs	Depends on a level playing field; small/ new actors may be disadvantaged	Depends on technical capacity; popular with regulators in countries with weak functioning markets
Taxes and charges	Depends on ability to set tax at a level that induces behavioural change	Better with broad application; higher administrative costs where institutions are weak	Regressive; can be improved with revenue recycling	Often politically unpopular; may be difficult to enforce with underdeveloped institutions
Tradable permits	Depends on emissions caps, participation and compliance	Decreases with limited participation and fewer sectors	Depends on initial permit allocation; may pose difficulties for small emitters	Requires well-functioning markets and complementary institutions
Voluntary agreements	Depends on programme design, including clear targets, a baseline scenario, third-party involvement in design and review, and monitoring provisions	Depends on flexibility and extent of government incentives, rewards and penalties	Benefits accrue only to participants	Often politically popular; requires a significant number of administrative staff
Subsidies and other incentives	Depends on programme design; less certain than regulations/ standards	Depends on level and programme design; can be market-distorting	Benefits selected participants (possibly some that do not need it)	Popular with recipients; potential resistance from vested interests, and can be difficult to phase out
Research and development	Depends on consistent funding, when technologies are developed, and on policies for diffusion; may have high benefits in the long term	Depends on programme design and the degree of risk	Initially benefits selected participants; potentially easy for funds to be misallocated	Requires many separate decisions; depends on research capacity and long-term funding
Information policies	Depends on how consumers use the information; most effective in combination with other policies	Potentially low cost, but depends on programme design	May be less effective for groups (e.g. low-income) that lack access to information	Depends on cooperation from special interest groups

Source: Authors in collaboration with Framework contributors

3. Summary

This White Paper aims to illuminate best practices in the development of shared, electric and automated mobility (SEAM) governance. The SEAM Governance Framework offered here is not an end but rather the means to one: the authors wish to hone the suggested Framework together with pilot cities.

The Framework will serve as a reference when creating a tailored framework for each pilot city and will comprise long- and short-term action. First, it will create a long-term SEAM vision (or revisit the existing one) as well as work principles for delivering on that vision. Second, the selected local governance instruments will be packaged, and evaluation tools will be tailored in a manner best suited for the pilot city's local context in the short term.

The SEAM Governance Framework Prototype authors and contributors anticipate an iteration of its tailoring to local cities will be useful in identifying and possibly addressing some barriers to commercializing SEAM. Lessons from pilot processes can be useful in accelerating and scaling SEAM development elsewhere.

Glossary

Mobility governance: The processes of governing, including private-sector decision-making and public-sector policy-making.

Pilot: Experimentation with governance in the private or public sector (or both), including but not limited to training for articulating the White Paper's core content to entities governing mobility, to workshops for tailoring the paper's core content to local contexts, and to the design of local governance instrumentation packages and/or evaluation methods based on key issues presented in the paper.

Framework: A structured and deliberate approach to governance that is well thought through, transparent and explainable.

Shared(-ride) mobility: High-occupancy rides that maximize the space within a travel mode while adhering to safety, rather than shared models of travel (vehicles, bikes, scooters).

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The World Economic Forum Centre for the Fourth Industrial Revolution Autonomous and Urban Mobility portfolio is a global, multi-industry, multistakeholder endeavour aimed at co-designing and co-creating governance frameworks and tools. The SEAM Governance Framework Prototype paper is based on numerous discussions, workshops, research and the combined effort of all those involved. The opinions expressed herein may not necessarily correspond to that of each constituent engaged in the project.

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Appendix I

Potential environmental impacts of new mobility

Study	New mobility category	Metric	Effect	Notes
Brown et al. (2014)	Fully autonomous, semi-autonomous	Platooning	–10% energy use	Analysis of the possible energy implications of autonomous vehicles, including an estimation of individual factors.
		Efficient driving	–15% energy use	
		Efficient routing	–5% energy use	
		Travel by underserved	+40% energy use	
		Efficient driving (additional)	–30% energy use	
		Faster travel	+30% energy use	
		More travel	+50% energy use	
		Light-weighting and size optimization	–50% energy use	
		Less time searching for parking	–4% energy use	
		Higher occupancy	–12% energy use	
		Electrification	–75% energy use	
		Net outcome	–95% to +173% energy use	
Wadud et al. (2016)	Fully autonomous, semi-autonomous	Platooning	–25% to –5% energy use	An analysis of the possible energy and environmental implications of autonomous vehicles estimated by mechanism. The authors evaluate four potential future scenarios of autonomous vehicle deployment and provide policy recommendations for an optimal outcome.
		Eco-driving	–20% to 0% energy use	
		Congestion mitigation	–5% to 0% energy use	
		De-emphasized performance	–25% to –5% energy use	
		Improved crash avoidance	–25% to –5% energy use	
		Vehicle right-sizing	–45% to –20% energy use	
		Higher highway speeds	+5% to +25% energy use	
		Increased features	0% to +10% energy use	
		Travel cost reduction	+5% to +60% energy use	
		New user groups	+5% to +15% energy use	
		Changed mobility services	-20% to 0% energy use	
		Net outcome	–45% to +105% energy use	

Study	New mobility category	Metric	Effect	Notes
Greenblatt and Saxena (2015)	Fully autonomous, ridesourcing/ e-hailing,shared ridesourcing/e-hailing	Shared, electric, right-sized, autonomous vehicles	–87% to –94% reduced GHG/ mi	An analysis of the maximum potential energy consumption and GHG reduction from the optimal utilization of fully autonomous, shared, electric, right-sized taxis.
Fagnant (2014)	Fully autonomous, ridesourcing/e-hailing, shared ridesourcing/e-hailing	Vehicles removed	11 conventional vehicles per shared autonomous vehicle	A model of that considers the potential benefits of replacing current vehicle usage and travel with shared autonomous
		Increased travel	11% more travel	
		Energy and emissions implications	–12% energy use; –5.6% GHG; –19% SO_2; –34% CO; –18% NO_x; –49% VOC; –6.5% PM_{10}	
Lammert and Gonder (2014)	Semi-autonomous	Fuel savings of platooning tractor trailers	Fuel savings of 6.4%	Summary results from the realworld testing of semi-autonomous tractor trailers
Martin, Shaheen, and Lidicker (2010)	Round-trip carsharing	Fuel economy	Increase by 10 MPG from fleet turnover	Analysis of how carsharing influences user vehicle ownership rates based on consumer survey in North America.
		Vehicle ownership	Per household rates fell from 0.47 to 0.24	
		Vehicles removed	1 carshare vehicle removes 9–13 vehicles	
Martin and Shaheen (2011)	Round-trip carsharing	Vehicle miles traveled (VMT)	Reduced by 27%	Evaluation of GHG emission reduction impacts from round-trip carsharing in North America based on consumer survey.
		GHG emissions	Average household reduction of 0.58-0.84 tons of GHG/year	
Namazu and Dowlatabadi (2015)	One-way carsharing	GHG emissions	Mode shifting reduced emissions 42%–54%	Study of the GHG emission implications of carsharing on various types of households and their characteristics in Vancouver, Canada.
			New fleet reduced emissions 19%–20%	
			Right sizing reduced emissions 31%–34%	
Martin and Shaheen (2016)	One-way carsharing	GHG emissions	Reduced by 4%–18%	Analysis conducted across five U.S. cities to study the impacts of car2go. Includes data from car2go as well as consumer survey and activity data.
		VMT	Reduced by 6%–16%	
		Vehicle ownership	Removed 7–11 vehicles per carshare vehicle	
Shaheen (expected in 2017)	Ridesourcing/e-hailing	Currently unavailable	Currently unavailable	Currently unavailable

Source: Slowik, P. and Kamakaté, F., "New Mobility: Today's Technology and Policy Landscape", International Council on Clean Transportation, White Paper, Table 2, July 2017, https://www.theicct.org/sites/default/files/publications/New-mobility-landscape_ICCT-white-paper_27072017_vF.pdf.

Appendix II

Reference list

Organization	Reference
University of California, Davis (USA)	Global New Mobility Coalition Meeting: Climate Policy Tools for the 3 Revolutions Federal, State, and Local Governance of Automated Vehicles: Issue Paper, December 2018 Three revolutions in urban transportation: How to achieve the full potential of vehicle electrification, automation, and shared mobility in urban transportation systems around the world by 2050, 2017
International Council on Clean Transportation	When does electrifying shared mobility make economic sense? Working Paper 2019-01 Emerging policy approaches to electrify ride-hailing in the United States: Briefing, January 2019
Shared Mobility Principles for Livable Cities	Shared Mobility Principles for Livable Cities
New Urban Mobility alliance (USA)	NUMO Presentation at GNMC meeting, 14 November 2018
National Association of City Transportation Officials (USA)	Blueprint for Autonomous Urbanism: Module 1/Fall 2017, Designing Cities Edition City Data Sharing Principles: Integrating New Technologies into City Streets, January 2017
Greenfield Labs, Ford Motor Company (USA)	Principles for Living Street of Tomorrow
BMW (Germany)	Mobility 2050. Region of Munich – Creating a Common Vision for Sustainable Development in an Unique Public Private Cooperation, 2014* BMW Presentation at GNMC meeting, 14 November 2018: BMW Group Center of Competence, Urban Mobility
World Resources Institute (Washington DC)	Transport Emissions Social Cost Assessment: Methodology Guide, 2016
Innovation Center for Energy and Transportation (China)	China Urban Transport Emission Calculator (CUTEC) ICET Report, 2016
World Economic Forum Centre for the Fourth Industrial Revolution (San Francisco, USA)	GNMC workshop summary, 14 November 2018* Advanced Drone Operations Toolkit: Accelerating the Drone Revolution, December 2018 Agile Cities: Preparing for the Fourth Industrial Revolution, September 2018

* To register to access the document, contact: Sandra.Caballero@weforum.org

Source: Authors

Endnotes

1 Other acronyms are used elsewhere (e.g. ACES for "autonomous, connected, electric and shared"); SEAM, however, is meant to emphasize the importance of "shared" and "electric" rides and therefore places these two prior to "automated".

2 Literature offers new mobility typology, including mobility as a service, mobility on demand, ride-sharing, ride-sourcing/e-hailing and car-sharing. For example, see SAE International, "Shared Mobility", https://www.sae.org/binaries/content/assets/cm/content/topics/shared-mobility/summary-of-j3163.pdf; and Shaheen, S. "Mobility on Demand (MOD) and Mobility as a Service (MaaS) How Are They Similar and Different?", *Move Forward*, 7 March 2019, https://www.move-forward.com/mobility-on-demand-mod-and-mobility-as-a-service-maas-how-are-they-similar-and-different/.

3 Studies clearly attest to the challenge of constraining vehicle emissions, even when policies are driving down regulated emission levels; see, for example, Bernard, Y., Tietge, U. German, J. and Muncrief, R. *Determination of real-world emissions from passenger vehicles using remote sensing data*, International Council on Clean Transportation (ICCT), June 2018, https://www.theicct.org/publications/real-world-emissions-using-remote-sensing-data, https://www.theicct.org/publications/laboratory-road-2018-update. Therefore, an important distinction is made between transitional zero-emission vehicles and zero-emission vehicles (ZEVs), noted by the California Air Resources Board, for example in the ZEV Credits mandate; see California Air Resources Board, "Zero-Emission Vehicle Standards for 2018 and Subsequent Model Year Passenger Cars, Light-Duty Trucks, and Medium-Duty Vehicles", https://www.arb.ca.gov/msprog/zevprog/zevregs/1962.2_clean.pdf.

4 Automated vehicles do not operate in full autonomy but rather are communicating with an array of information sources on the road, in other vehicles, in-vehicle and with a control centre.

5 In accordance with SAE International taxonomy; see SAE International, "Taxonomy and Definitions for Terms Related to Driving Automation Systems for On-Road Motor Vehicles", 15 June 2018 (revised), https://www.sae.org/standards/content/j3016_201806/.

6 Furthermore, a series of recent studies by the ICCT indicate that "based on underlying economics, ride-hailing vehicles are ripe for electrification. Because of their greater annual mileage, typical full-time ride-hailing drivers have fuel savings that accrue 2 to 3 times faster when they buy more fuel-efficient vehicles. In addition, because ride-hailing and taxi fleets approach vehicles from a commercial perspective, this could help make economic metrics regarding fuel savings and payback period more compelling than for typical private vehicle owners. Even without purchasing incentives, BEVs [battery-electric vehicles] will become the most economically attractive technology for ride-hailing operations in the 2023-2025 time frame". See Pavlenko, N., Slowik, P. and Lutsey, N. *When does electrifying shared mobility make economic sense?*, Working Paper 2019-01, ICCT, 8 January 2019, https://www.theicct.org/publications/shared-mobility-economic-sense; Slowik, P., Pavlenko, N. and Lutsey, N. "Emerging policy approaches to electrify ride-hailing in the United States", Briefing, ICCT, 8 January 2019, https://www.theicct.org/publications/policy-briefing-electrify-ridehailing.

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17 More about city typologies can be found at: Urban Typologies, "Data-driven city classification – 13 Typologies, 331 Cities", http://web.mit.edu/afs/athena.mit.edu/org/i/its-lab/www/dashboard/new%20dashboard/index.html.

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