levitate

Definition of Quantified Policy Goals

Deliverable D4.1 – WP4 –

Definition of Quantified Policy Goals

Work Package 4, Deliverable D4.1

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Executive Summary

This deliverable describes the process and result of defining quantified policy goals within the LEVITATE project. These policy goals will be further used for the identification of desirable visions and for the backcasting approach. Along with the goals, indicators are defined that allow precise measurement and monitoring of the progress over time.

Analysing and comparing existing approaches, initiatives and strategies, we find in principle agreement on high-level goals and their organisation into "dimensions" (like Safety, Economic, Society and Environment). Our analysis considers various organisational and geographical levels, viz., (a) looking at the sustainable development goals (United Nations), (b) the Sustainable Urban Mobility Indicators (SUMI) developed as part of an EU project with the same name, the smart city index from the Smart Cities Council (which is a global initiative), and finally (c) the smart city strategies and urban development plans for the two cities Vienna and Greater Manchester. On the detailed level, our analysis also reveals that indicators are not always well defined, and they allow some variance in their measurement.

The next step is to analyse the selection criteria for goals and indicators, out of the huge variety which has already been proposed, in more detail. We propose to classify the goals to be further considered in LEVITATE according to four dimensions: Safety, Society, Environment and Economy. From that highest level, more specific goals, objectives and targets (based on corresponding indicators) can be defined.

Goals have to be specific to the scope of the LEVITATE project which means that connected and automated transport systems (CATS) have some potential to contribute towards them. This defines the relationship between this deliverable and D3.1 that identifies the main impact areas of CATS. Further criteria like measurability and comparability, as well as completeness and interdependency are also discussed – guiding the further goal selection process.

The final proposed set of policy goals and indicators presented in this deliverable was achieved in a multi-step process; based on existing approaches and applying the above-mentioned selection criteria, an exemplary preliminary list was generated together with experts from the City of Vienna. Strong focus in this phase was on keeping the set compact, yet reflecting the long term vision of the city, and preferring indicators where measurement data are already available today. This preliminary list served as input for an online survey, where members of the Stakeholders Reference Group (experts from different sectors and organisation types of different European cities and regions) were invited to prioritise the goals and indicators and propose additional ones.

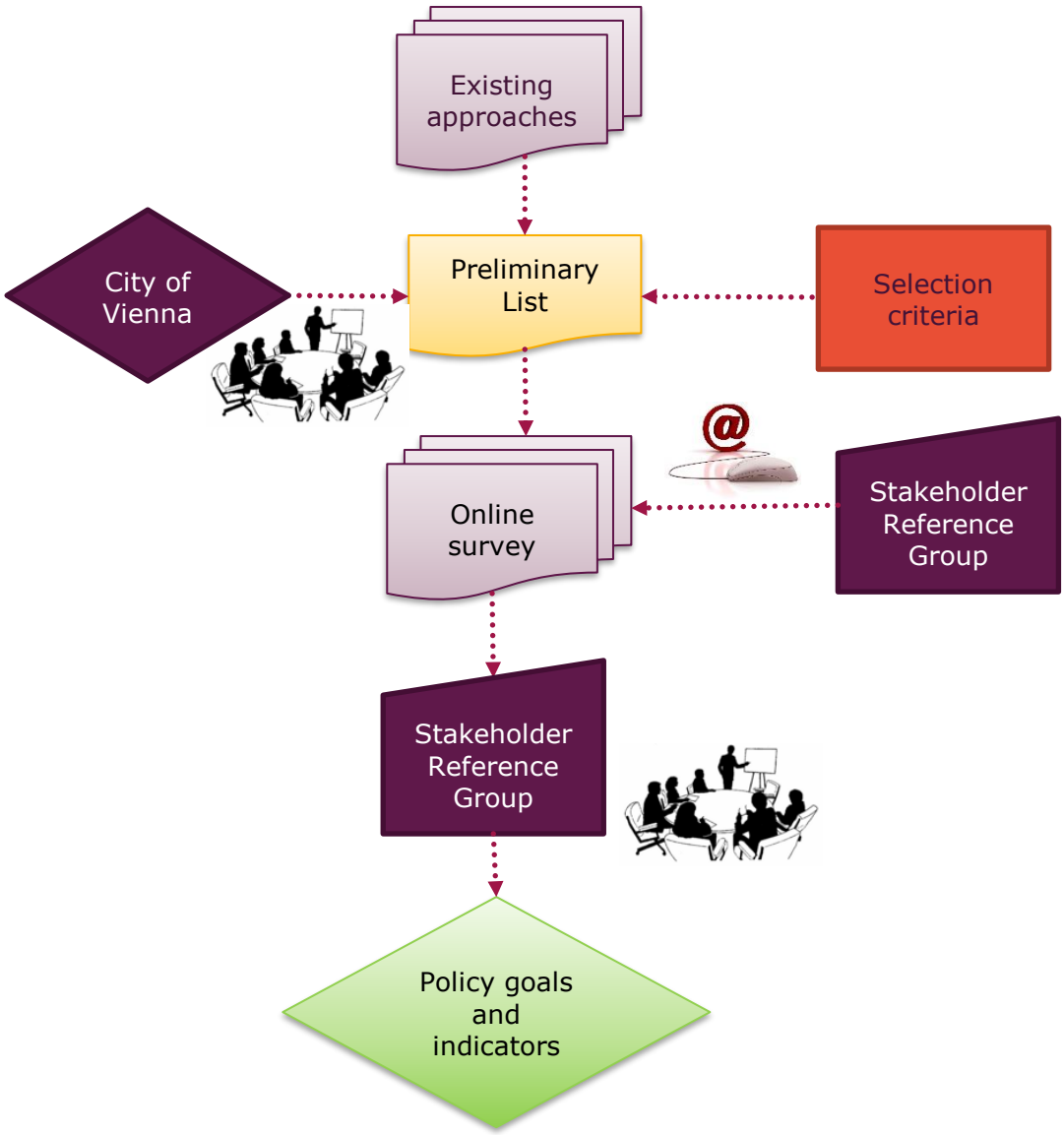

Figure S.1 Identification of policy goals and indicators

The main expert validation took place at the LEVITATE Stakeholder Reference Group Workshop in Gothenborg on 28th May 2019, where dependencies and possible conflicts across the four dimensions were also discussed. After final consultations with experts from the City of Vienna, considering the additional proposals from the workshop, the following policy goals and indicators were proposed (see Table S.1). The list is organised along the four chosen dimensions, indicated by colours, where shades are used to reflect overlaps between two dimensions.

Table S.1 Consolidated proposed goals and indicators for LEVITATE

Dimension	Policy Goal	Indicator
Safety	Protection of Human Life	Number of injured per million inhabitants (per year)
		Number of fatalities per million inhabitants (per year)
	Perceived Safety	Standardised survey: subjective rating of (overall) safety
	Cyber Security	Number of successful attacks per million trips completed
		Number of vulnerabilities found (fixed) (per year)
Society	Reachability	Average travel time per day (dispersion; goal: equal distribution)
		Number of opportunities per 30 minutes per mode of transport
	Use of Public Space	Lane space per person
		Pedestrian/cycling space per person
	Inclusion	Distance to nearest publicly accessible transport stop (including MaaS)
		Affordability/discounts
		Barrier free accessibility
		Quality of access restrictions/scoring
	Satisfaction	Satisfaction with active transport infrastructure in neighbourhood (walking and/or cycling)
		Satisfaction public transport in neighbourhood
Environment	Low Noise Levels	Standardised survey: subjective rating of main sources of disturbing noise
	Clean Air	Emissions directly measurable: SO2, PM2,5, PM10, NO2, NO, NOx, CO, O3
	Efficient Settlement Structures	Building volume per square kilometre (total and per built-up area)
		Population density (Eurostat)
	Sustainable Behaviour	Rate of energy consumption per person (total)
		Rate of energy consumption per person (transport related)
Economy	Prosperity	Taxable income in relation to purchasing power
	Fair Distribution	GINI index

1 Introduction

1.1 Levitate

Societal **Lev**el **I**mpacts of Connec**t**ed and **A**utoma**t**ed Vehicl**e**s (Levitate) is a European Commission supported Horizon 2020 project with the objective to prepare a new impact assessment framework to enable policymakers to manage the introduction of connected and automated transport systems, maximise the benefits and utilise the technologies to achieve societal objectives.

Specifically Levitate has four key objectives:

1. To incorporate the methods within a **new web-based policy support tool** to enable city and other authorities to forecast impacts of connected and automated transport systems (CATS) on urban areas. The methods developed within Levitate will be available within a toolbox allowing the impact of measures to be assessed individually. A Decision Support System will enable users to apply backcasting methods to identify the sequences of CATS measures that will result in their desired policy objectives.
2. To develop a range of **forecasting and backcasting** scenarios and baseline conditions relating to the deployment of one or more mobility technologies that will be used as the basis of impact assessments and forecasts. These will cover three primary use cases – automated urban shuttle, passenger cars and freight services.
3. To establish **a multi-disciplinary methodology** to assess the short, medium and long-term impacts of CATS on mobility, safety, environment, society and other impact areas. Several quantitative indicators will be identified for each impact type.
4. To apply the methods and **forecast the impact of CATS** over the short, medium and long-term for a range of use cases, operational design domains and environments and an **extensive range of mobility, environmental, safety, economic and societal indicators**. A series of case studies will be conducted to validate the methodologies and to demonstrate the system.

1.2 Work Package 4 and Deliverable 4.1 within Levitate

The objective of work package 4 is to develop target scenarios and feasible paths to reach them with interventions concerning automated vehicles. The main steps are:

- Research of national/European policy goals in the impact dimensions.
- Definition and description of goals and visions[1] of cities and other stakeholders for short, medium and long-term.
- Applying the results on impacts from WP3 and data available from the cities to define targets.

[1] The term „visions" is used here instead of the term „scenarios" that has been used in the project proposal. Refer also to relevant part of terminology agreed in the project, given in the Appendix (Used Terminology).

- Using backcasting methodologies to define feasible paths to reach the stakeholders' goals with special consideration to automated vehicles.
- Definition of forecasting scenarios and desired outputs for the consolidation of the different use-cases.

Deliverable 4.1 contributes mainly to the second Levitate objective, by setting the ground for further vision development in WP4 through analysis and proposal of high-level policy goals, accompanied by quantified indicators (key performance indicators – KPIs) which can be used for evaluating the path towards higher level goals.

This document summarises the preparations for defining desirable visions (Deliverable 4.2). The activities documented in this deliverable include a review of sustainable development goals on different policy levels (global/European, city level) to extract common goal categories and mobility related targets (Chapter 2), a systematic discussion of aspects that should be considered for the selection of goals and indicators in the LEVITATE context (Chapter 3), and a description of selected goals and related indicators which have been discussed and approved by the LEVITATE Stakeholder Reference Group in the course of the first LEVITATE Workshop in Gothenburg on 28th May 2019 (Chapter 4). This selection of most important goals and corresponding indicators serves as a basis for the definition of desirable futures for the backcasting approach.

Additionally, this step is strongly interlinked with impacts of CATS as identified in WP3. Some of the most commonly used indicators in relation to mobility (and specifically automated mobility) are listed and described in Deliverable 3.1. They are included in our approach and systematically further developed in chapter 3 and 4 of this deliverable.

2 Existing Approaches for Specification of Policy Goals

2.1 Background and Basic Scope

The goal of this chapter is to collect relevant inputs for the specification of quantified policy goals that can be used in LEVITATE, by exploring already existing approaches, frameworks and strategies on different levels – in organisational as well as geographic terms, from UN global level to local city strategies. Note that this list is by no means exhaustive, rather we try to define the basis for the selection of policy goals that will be used to define desirable future visions for city developments.

The scope for this initial step includes approaches for identifying and specifying development goals on different policy levels. Several examples can be found in the context of Smart City concepts (e.g. Smart City Wheel, Figure 1), which have been developed to tackle the full potential of using different urban data sources to manage assets and resources efficiently. Hence, these approaches provide a helpful framework for identifying and specifying urban policy goals. However, these concepts are not globally standardised. In this step, several different measurements are explored for extracting relevant goals and indicators in the LEVITATE context.

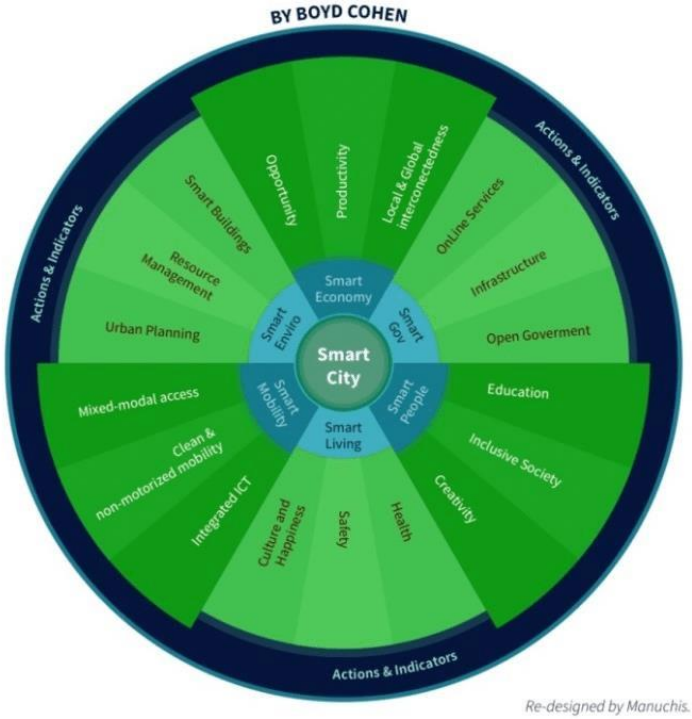

Figure 1 Smart City Wheel developed by Boyd Cohen [1]

2.2 Sustainable Development Goals

On the global level, the United Nations have developed a definition of sustainable development goals (SDG). As explained on the corresponding web site [2] these high-level and generic goals can be understood as follows:

The Sustainable Development Goals are the blueprint by the United Nations to achieve a better and more sustainable future for all. They address the global challenges we face, including those related to poverty, inequality, climate, environmental degradation, prosperity, and peace and justice. The goals interconnect and in order to leave no one behind, it is important that we achieve each goal and target by 2030.

Each of the 17 high-level goals is further refined into a subset of more specific targets with specified time frame – each of them characterised by at least one quantified indicator (for details refer to [3]).

In the context of LEVITATE it won't be feasible to address the *whole* set of these goals – nor can all goals be considered as relevant for mobility or connected and automated transport systems (CATS) – but several of the specified goals and targets can immediately be identified as having a close relationship to the scope of LEVITATE. This includes the following (where high-level goal, target(s) and corresponding indicators are listed below): [2]

- Goal 3. Ensure healthy lives and promote well-being for all at all ages
    - 3.6 By 2020, halve the number of global deaths and injuries from road traffic accidents
        - 3.6.1 Death rate due to road traffic injuries

- Goal 9. Build resilient infrastructure, promote inclusive and sustainable industrialisation and foster innovation
    - 9.1 Develop quality, reliable, sustainable and resilient infrastructure, including regional and trans-border infrastructure, to support economic development and human well-being, with a focus on affordable and equitable access for all
        - 9.1.1 Proportion of the rural population who live within 2 km of an all-season road
        - 9.1.2 Passenger and freight volumes, by mode of transport

- Goal 11. Make cities and human settlements inclusive, safe, resilient and sustainable
    - 11.2 By 2030, provide access to safe, affordable, accessible and sustainable transport systems for all, improving road safety, notably by expanding public transport, with special attention to the needs of those in vulnerable situations, women, children, persons with disabilities and older persons
        - 11.2.1 Proportion of population that has convenient access to public transport, by sex, age and persons with disabilities
    - 11.6 By 2030, reduce the adverse per capita environmental impact of cities, including by paying special attention to air quality and municipal and other waste management

[2] Targets are related to the Agenda 2030, which takes 1990 as basis year.

        - 11.6.1 Proportion of urban solid waste regularly collected and with adequate final discharge out of total urban solid waste generated, by cities
        - 11.6.2 Annual mean levels of fine particulate matter (e.g. PM2.5 and PM10) in cities (population weighted)
    - 11.7 By 2030, provide universal access to safe, inclusive and accessible, green and public spaces, particularly for women and children, older persons and persons with disabilities
        - 11.7.1 Average share of the built-up area of cities that is open space for public use for all, by sex, age and persons with disabilities
        - 11.7.2 Proportion of persons victim of physical or sexual harassment, by sex, age, disability status and place of occurrence, in the previous 12 months
    - 11.a Support positive economic, social and environmental links between urban, peri-urban and rural areas by strengthening national and regional development planning
        - 11.a.1 Proportion of population living in cities that implement urban and regional development plans integrating population projections and resource needs, by size of city

It should also be mentioned here that all the available data corresponding to these SDG indicators are available online in the Global SDG Indicators Database (refer to [4]) for years 2000 – 2013 and for 225 geographical areas.

2.3 SUMP / SUMI (EU Reference Frameworks)

The Sustainable Urban Mobility Indicators (SUMI) [5] were developed as part of an EU project (service contract MOVE/B4/2017-358 for the European Commission's Directorate-General for Mobility and Transport providing technical support related to sustainable urban mobility indicators) to create a unique global framework to support integrated multimodal and fact-based planning of urban sustainable mobility (supported by the World Business Council for Sustainable Development). The indicators are split into four dimensions defined as

- G – Global Environment:
    - *Global environment (G) refers to the global scale, i.e. mobility impacts that occur far beyond the city limits, and is focused on long-term environmental aspects (such as climate change)*
- Q Quality of life:
    - *Quality of life (Q) refers to the city or local scale and the short-term (direct impacts) on social aspects of urban life (such as health or fatalities and security).*
- E Economic Success:
    - *Economic success (E) refers to the economic aspects at the city scale (such as public finance related to mobility).*
- S Mobility System:
    - *Apart from external inputs (resources and materials) and outputs (impacts) of the mobility system (with the three abovementioned sustainability dimensions) a fourth category of indicators refers to the performance of the mobility system (S) itself. This performance might*

have consequences for the input or output of the mobility system on all three sustainability dimensions.

The indicators selected can be seen in Table 1. Since the assignment to the dimensions is not always unique, primary and secondary dimensions are specified.

Table 1 The 19 SUMI split into the four dimensions Global Environment (E), Quality of Life (Q), Economic Success (E), and Mobility System Performance (S).

Set of 19 Indicators for the Sustainability of Urban Mobility	Short Names of Indicators	Dimen-sions		Data Input
		Prim	Sec	
Affordability of public transport for the poorest people	Affordability	S	Q	Exist
Accessibility for mobility impaired groups	Accessibility for impaired	S	Q	Survey
Air polluting emissions	Air pollution	Q		Calc
Noise hindrance	Noise hindrance	Q		Measure
Traffic safety	Safety	Q		Exist
Access to mobility services	Access	Q		Analysis
Quality of public area	Public area	Q		Survey
Functional diversity	Functional diversity	Q	E	Analysis
Commuting travel time	Travel time	Q	E	Survey
Economic opportunity	Economic Opportunity	Q	E	Survey
Net public finance	Public finance	E		Exist
Mobility space usage	Space usage	G	E	Analysis
Emissions of greenhouse gases (GHG)	GHG	G		Calc
Congestion and delays	Congestion	G	S	Measure
Energy efficiency	Energy efficiency	G	S	Calc
Opportunity for active mobility	Active mobility	G	S	Analysis
Intermodal integration	Intermodal integration	S		Survey
Comfort and pleasure	Comfort and pleasure	S	Q	Survey
Security	Security	S	Q	Survey

The indicators were chosen such that they fulfil the following criteria (from SUMI Methodology)

- ***Fairness****: including both positive effects of mobility (e.g. accessibility) and negative impacts (e.g. noise hindrance).*
- ***Completeness****: the set of indicators has to measure all relevant aspects for evaluation of the sustainability of the urban mobility.*
- ***Technology neutral****: not favouring one technology over another, existing or to come.*
- ***Mode neutral****: not favouring any mobility mode*

Furthermore, the parameters are chosen such that they can be easily attained and are measurable. The data for the indicators comes either from direct measurements, existing data or is collected using surveys (see Table 1). A methodology was developed to

calculate parameters on a 0 to 10 scale for all 19 indicators (10 being the best attainable score within the present state of the art of technology).
The methodologies for the indicator calculations include:

- Using data from existing data-bases for indicators like affordability (household budget and public transport costs) and traffic safety (fatalities)
- Measurements for indicators like noise hindrance (measurements at 50 points in cities)
- Surveys for indicators like analysis of accessibility (survey amongst 65+, people with (registered) visual disabilities or reduced mobility, pregnant women) or intermodal integration (survey amongst users and non-users of intermodal connections)
- Analysis of data-sources for indicators like functional diversity (analysis of Map data with GIS for diversity of land usage) or access (GIS analysis of spatial data)
- Calculation from mobility simulation results for GHG and pollution

The results can be analysed using graphical representations (see Figure 2) to see the general importance and level of the different indicators in urban area.

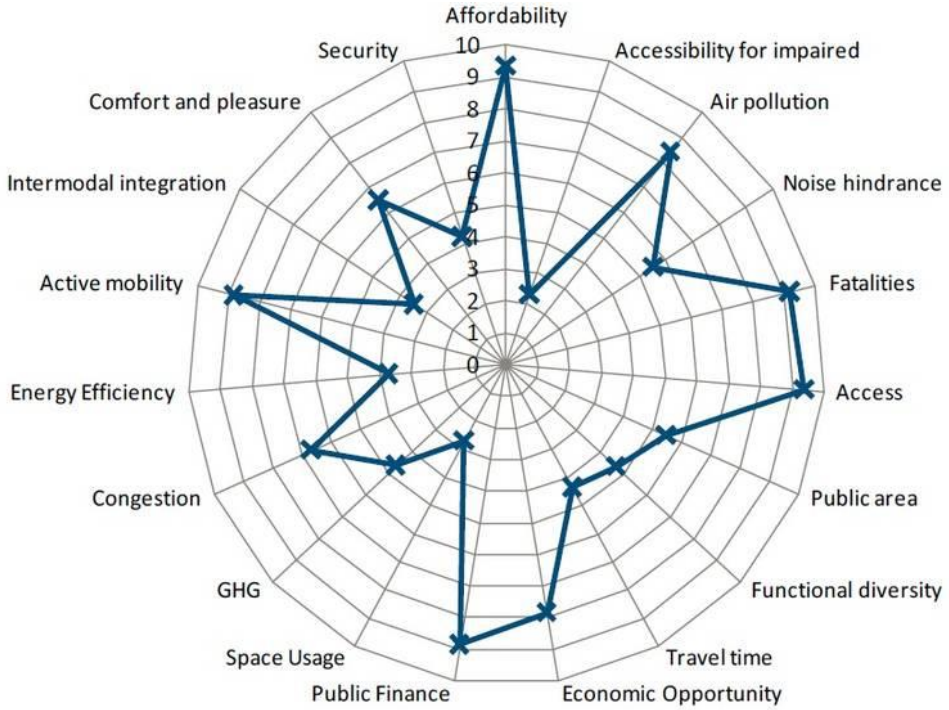

Figure 2 Graphical representation of the SUMI.

2.4 Smart Cities Council

The Smart Cities Council [6] is a global initiative claiming to represent the world's leading smart cities network. Their vision is a world where digital technology and intelligent design have been harnessed to create smart, sustainable cities with high-quality living and high-quality jobs.

The Smart Cities Council promotes cities that embody three core values:

- **Livability:** Cities that provide clean, healthy living conditions without pollution and congestion. With a digital infrastructure that makes city services instantly and conveniently available anytime, anywhere.
- **Workability:** Cities that provide the enabling infrastructure — energy, connectivity, computing, essential services — to compete globally for high-quality jobs.
- **Sustainability:** Cities that provide services without stealing from future generations.

As part of their support activities and smart city tools they have also provided a structured list of dimensions, working areas and quantified indicators that has been used to calculate a smart city index and create a ranking of smart cities worldwide.

The indicators collected to calculate this smart city index can be found in Table 3.Table 2. Many of these indicators can also be found in the Smart City Strategies of different cities.

Table 2 Indicators and Description connected to the policy goal smart city according to [6]

Dimension	**Working Area**	**Indicator**	**Description**
Environment	Smart Buildings	Sustainability -certified Buildings	Number of LEED or BREAM sustainability certified buildings in the city (Note: if your city uses another standard please indicate)
			% of commercial and industrial buildings with smart meters
			% of commercial buildings with a building automation system
		Smart homes	% of homes (multi-family & single-family) w/ smart meters
	Resources Management	Energy	% of total energy derived from renewable sources (ISO 37120: 7.4)
			Total residential energy use per capita (in kWh/yr) (ISO 37120: 7.1)
			% of municipal grid meeting all of following requirements for smart grid (1. 2-way communication; 2.) Automated control systems for addressing system outages 3.) real-time information for customers; 4.) Permits distributed

Dimension	Working Area	Indicator	Description
			generation; 5.) Supports net metering
		Carbon Footprint	Greenhouse gas emissions measured in tonnes per capita (ISO 37120: 8.3)
		Air quality	Fine Particular matter 2.5 concentration (µg/m3) (ISO 37120: 8.1)
		Waste Generation	% of city's solid waste that is recycled (ISO 37120: 16.2)
			Total collected municipal solid waste city per capita (in kg) (ISO 37120: 16.3)
		Water consumption	% of commercial buildings with smart water meters
			Total water consumption per capita (litres/day) (ISO 37120: 21.5)
	Sustainable Urban Planning	Climate resilience planning	Does your city have a public climate resilience strategy/plan in place? (Y/N) If yes provide link.
		Density	Population weighted density (average densities of the separate census tracts that make up a metro)
		Green Space per capita	Green areas per 100,000 (in m2) (ISO 37120: 19.1)
Mobility	Efficient Transport	Clean-energy Transport	Kilometres of bicycle paths and lanes per 100,000 (ISO 37120: 18.7)
			# of shared bicycles per capita
			# of shared vehicles per capita
			# of EV charging stations within the city
	Multi-modal Access	Public Transport	Annual # of public transport trips per capita (ISO 37120: 18.3)
			% non-motorized transport trips of total transport
			Integrated fare system for public transport

Dimension	Working Area	Indicator	Description
	Technology Infrastructure	Smart cards	% of total revenue from public transit obtained via unified smart card systems
		Access to Real-time Information	Presence of demand-based pricing (e.g. congestion pricing, variably priced toll lanes, variably priced parking spaces). Y/N
			% of traffic lights connected to real-time traffic management system
			# of public transit services that offer real time information to the public: 1 point for each transit category up to 5 total points (bus, regional train, metro, rapid transit system (e.g. BRT, tram), and sharing modes (e.g. bike sharing, carsharing)
			Availability of multi-modal transit app with at least 3 services integrated (Y/N)
Government	Online Services	Online Procedures	% of government services that can be accessed by citizens via web or mobile phone
		Electronic Benefits Payments	Existence of electronic benefit payments (e.g. social security) to citizens (Y/N)
	Infrastructure	WiFi Coverage	Number of WiFi hotspots per km2
		Broadband Coverage	% of commercial and residential users with internet download speeds of at least 2 Mbit/s
			% of commercial and residential users with internet download speeds of at least 1 gigabit/s
		Sensor Coverage	# of infrastructure components with installed sensors 1 point for each: traffic, public transit demand, parking, air quality, waste, H2O, public lighting

Dimension	Working Area	Indicator	Description
		Integrated Health + Safety Operations	# of services integrated in a singular operations center leveraging real-time data. 1 point for each: ambulance, emergency/disaster response, fire, police, weather, transit, air quality
	Open Government	Open Data	Open data use
		Open Apps	# of mobile apps available (iPhone) based on open data
		Privacy	Existence of official citywide privacy policy to protect confidential citizen data
Economy	Entrepreneurship & Innovation	New Startups	Number of new opportunity-based startups/year
		R + D	% GDP invested in R&D in private sector
		Employment Levels	% of persons in full-time employment (ISO 37120: 5.4)
		Innovation	Innovation cities index
	Productivity	GRP per Capita	Gross Regional Product per capita (in US$, except in EU, in Euros)
	Local and Global Connection	Exports	% of GRP based on technology exports
		International Events Hold	Number of international congresses and fairs attendees.
People	Inclusion	Internet-connected Households	% of Internet-connected households
		Smart Phone Penetration	% of residents with smartphone access
		Civil Engagement	# of civil engagement activities offered by the municipality last year
			Voter participation in last municipal election (% of eligible voters) (ISO 37120: 11.1)
	Education	Secondary Education	% of students completing secondary education (ISO 37120: 6.3)
		University Graduates	Number of higher education degrees per 100,000 inhabitants (ISO 37120: 6.7)

Dimension	Working Area	Indicator	Description
	Creativity	Foreign-born immigrants	% of population born in a foreign country
		Urban Living Lab	# of officially registered ENOLL living labs
		Creative Industry Jobs	Percentage of labour force (LF) engaged in creative industries
Living	Culture and Well-being	Life Conditions	Percentage of inhabitants with housing deficiency in any of the following 5 areas (potable water, sanitation, overcrowding, deficient material quality, or lacking electricity)
		Gini Index	Gini coefficient of inequality
		Quality of life ranking	Mercer ranking in most recent quality of life survey
		Investment in Culture	% of municipal budget allocated to culture
	Safety	Crime	Violent crime rate per 100,000 population (ISO 37120: 14.5)
		Smart Crime Prevention	# technologies in use to assist with crime prevention, 1 point for each of the following: livestreaming video cameras, taxi apps, predictive crime software technologies
	Health	Single Health History	% of residents w/ single, unified health histories facilitating patient and health provider access to complete medical records
		Life Expectancy	Average life expectancy (ISO 37120: 12.1)

Table 3 Indicators and description connected to the policy goal smart city according to [6]

2.5 Local City Strategies

So far there is no common European standard approach for defining goals and indicators for further development into smart cities that has been widely adopted and can be used for easy comparison between cities. Nevertheless, we complete this chapter by evaluation of two examples of existing city strategies, in terms of high-level goals and possible indicators with specific focus on transport related developments.

2.5.1 City of Vienna Strategy

The Viennese Urban Mobility Plan, under the "STEP 2025 Urban Development Plan" [7] sets out the goals of the City of Vienna for a viable transport system of the future. In the section "Objectives and indicators" the following goals and corresponding impact targets are stated:

- Fair – Street space is allocated fairly to a variety of users and sustainable mobility must remain affordable for all.
    - Impact Target: the total sum of spaces for cycling, walking and public transport in all conversion and urban renewal projects is rising.
- Healthy – The share of active mobility in every-day life increases; accident-related personal injuries decline.
    - Impact Target: the share of people in the Viennese population who are actively in motion for 30 minutes daily as they run their daily errands is to rise from 23% in 2013 to 30% in 2025. The number of traffic casualties and persons injured in traffic accidents declines further.
- Compact – Distances covered between work, home, errands and leisure time activities are as short as possible.
    - Impact Target: the share of trips done on foot or by bike to shop for supplies or accompany someone as well as distances covered for leisure time activities will increase from 38.8% in 2013 to 45% in 2025.
- Eco-Friendly – Mobility causes as little pollution as possible, the share of eco-mobility in the trips made in Vienna and its environs is rising. The relative change in the modal shift will be largest in bicycle traffic. In absolute figures, the largest increase in the number of trips will be attributable to public transport.
    - Impact Target: modal split changes for the Viennese will be reflected in a move away from 72%:28% in 2013 to 80% of eco-mobility and 20% of car traffic by 2025. Traffic in Vienna will shift to a modal split with a much large share of eco-mobility.
- Robust – Mobility is as reliable and crisis-proof as possible. Mobility should be possible without necessarily owning a means of transport.
    - Impact Target: the CO2 emissions caused by transport in the Vienna road network (according to the EMIKAT definition) will decline by about 20%, from roughly 2.1 million tons/year in 2010 to about 1.7 million tons/year in 2025. The public transport system remains very reliable. Bicycle availability rises, for example by 2025 80% of all households should have a bike at their disposal and 40% of the population should be able to reach a bike sharing station within a maximum reach of 300 meters. By 2025, 50% of the population should have a car sharing location within a maximum distance of 500 meters from their homes.
- Efficient – Resources are used in a more efficient way, helped by innovative technologies and processes.
    - Impact Target: absolute final energy consumption of the Vienna transport system (according to the EMIKAT definition) will decline by about 20% to around 7.3 TWh by 2025, compared with roughly 9.1 TWh in 2010.

Further, a series of quantitative indicators have been defined (along with qualitative or even quantitative goals for development until 2025) for following areas:

- Mobility behaviour
- Mobility services, reachability and availability of vehicles

- Transport demand, speeds and traffic safety
- Energy and environment

For a detailed list of these indicators please refer to the Appendix.

One example, modal split of traffic in Vienna, is illustrated in Figure 3, showing recent development along with target for 2025.

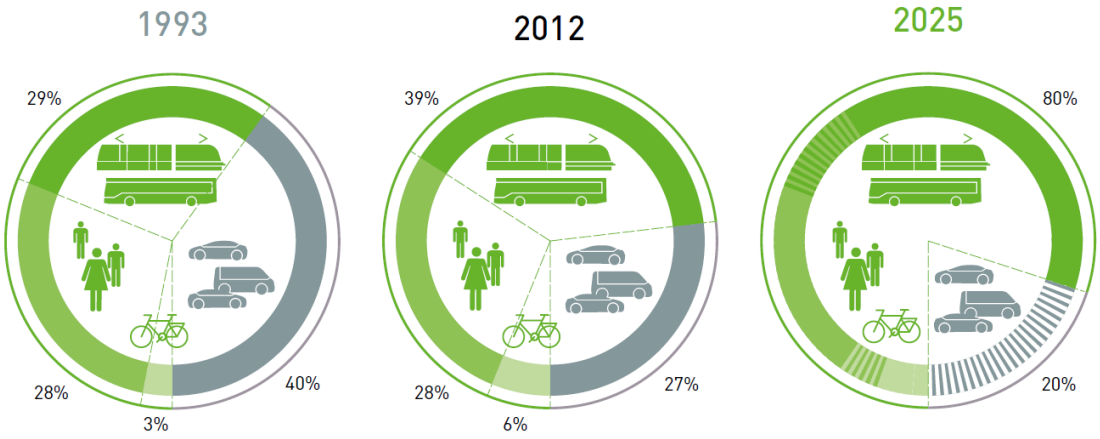

Figure 3 Modal Split in Vienna – recent development and target for 2025, taken from [7]

2.5.2 Greater Manchester Transport Strategy

The Greater Manchester Transport Strategy 2040 [8] follows the vision "*World class connections that support long-term, sustainable economic growth and access to opportunity for all*".

The strategy comprises seven core principles, each of which shall be applied across their transport network:

- **Integrated** – allow customers to move seamlessly between modes and services
- **Inclusive** – provide accessible and affordable transport
- **Healthy** – promote walking and cycling for local trips
- **Environmentally responsible** – deliver lower emissions, better quality environment
- **Reliable** – give customers confidence in journey times
- **Safe and secure** – reduce road accidents and deaths
- **Well maintained and resilien**t – able to withstand unexpected events and weather conditions

They have also identified a number of challenges in achieving their vision, and for each of these challenges there is a particular outcome that they would like to see. The approach is to measure the extent to which they are achieving these outcomes through a set of key performance indicators. These challenges, outcomes and indicators are summarised in Table 4. At present stage, however, it is not yet clear how each of these indicators can and will be measured precisely.

Table 4 Greater Manchester: KPIs for Transport Strategy 2040

Vision	Challenge (from Part 1)	Desired Outcome	KPI
Supporting sustainable economic growth	Growth could result in increased congestion	Reduced congestion	Journey speed by mode
	Growing economy requires access to wide pool of labour	Better access to skills & markets	Sustainable transport catchment population of the Regional Centre & other major employment locations
	Businesses require reliable journey times for deliveries and workers	More reliable journey times	Journey reliability by mode
	Networks need to cope with adverse weather, ageing infrastructure and increased demand	Resilient and well maintained network	Satisfaction with road maintenance
	Developing a transport system that compares well to that of leading European cities	People see GM as a good place to visit & invest	Perceptions of GM as a place to live, visit, do business
Improving quality of life	Good access is needed to jobs and training so that transport is not a barrier to opportunity.	Better access to jobs/training	Sustainable transport catchment population for key locations - employment / colleges
	Centralisation of services and changes in retailing can make it harder for some people to access education, healthcare, shopping etc	Better access to services	Sustainable transport catchment population for key locations -town centres/hospitals
	Encouraging people to improve their health through greater levels of activity	More people travelling actively	No. of walking & cycling trips

Vision	Challenge (from Part 1)	Desired Outcome	KPI
	Reducing the number of serious casualties on the roads and the amount of crime and anti-social behaviour on the transport network.	Improved safety and personal security	KSIs split by vulnerable groups, Perception of personal security by mode
Protecting the environment	Increasing the use of sustainable transport to reduce the negative impacts of car use.	More people travelling by non- car modes	Mode split Traffic growth levels
	Economic and population growth will increase the demand for travel, and increase harmful emissions	Reduced emissions of CO_2, NO_2	CO_2 emissions, NO_2 emissions
	Making the best use of existing infrastructure to help reduce environmental impacts.	Accessible locations prioritised for new development	% of new homes having >level 4 accessibility to the public transport network[8]
	Protecting the natural and built environment from the impacts of transport.	Infrastructure designed and maintained to minimise environmental impact	N/A – assurance is via approved Project Management Procedures

2.6 Comparison of Approaches and Strategies

Two example city strategies have been discussed in this chapter, after starting with higher level and generic initiatives and frameworks.

The evaluation of high-level goals, targets and specific indicators has shown that there seems to be general consensus on high-level goals (like environment, health, safety, society / quality of live and economy). Also, the specific targets can be mapped well to cross-regional and higher-level initiatives – no inconsistencies or major discrepancies between the stated strategies and goals have been identified. Furthermore, both cities define their goals for the mobility and transport sector and hence do not actively distinguish between passenger and freight transport. Goals such as travel time, environmental impact and modal shift are defined on a general level. In the project, we will be more specific later when considering the actual use cases.

On highest level, the goals might be structured according to three groups ("dimensions") that have been frequently used in sustainable development and adopted by several organisations: Economic, Social and Environment. This approach of considering three types of "bottom lines" (i.e. parameters that should be optimised) has also become known as *Triple bottom line* (TBL) concept.

Turning to the lower level, however, it can be found that objectives, targets and indicators are not always easily comparable, for example due to

- Inconsistent, missing or imprecise specification - what and how to measure
- Different timescales for reaching certain targets (e.g., from 2020 up to 2050)
- Different or missing specification of reference points (e.g., reduction by 50%, compared to which reference date?)

Hence, while the general goal dimensions are largely similar, it is difficult to directly compare the development of two cities. Even for commonly used frameworks like the SUMI, a detailed comparison of city development performance is somewhat limited, as the indicators are not always defined precisely and allow some variance in their measurement. However, the sets of indicators are certainly useful for monitoring the progress of an urban development of a city over time if measured consistently in regular intervals.

3 Selection Process and Criteria for Defining Policy Goals in LEVITATE

3.1 Goal Dimensions & Used Framework

For selecting relevant goals and indicators in the LEVITATE context, we define a set of *goal dimensions*. Such a goal dimension, in an extremely simplified view, might be imagined as being represented by just one (summary) parameter that shall be optimised.

In principle it should be possible to assign each selected goal to one (main) dimension. It is also clear, however, that goals of different dimensions are inter-independent; in some cases, they might support each other, in other cases they might be conflicting.

The proposed four dimensions of policy goals to be considered are:

- Environment
- Economy
- Society
- Safety

Note that this proposal extends the 'triple bottom line' (TBL) concept (as discussed in section 2.6) by adding "Safety" as a fourth dimension, due to its obvious outstanding relevance for the introduction of CATS and aligned with the general focus of LEVITATE. Safety can also be considered as a high-level concern that goes far beyond the transport domain itself.

Note further that Mobility – which is often used in a Smart Cities context and might also be used to classify CATS impacts and goals – has not been considered here as a valid dimension, as it reflects the transport system itself rather than the higher-level goals that extend far outside the transport domain. Goals and indicators belonging to such a category like Mobility might be easily mapped to one or more of the dimensions above, e.g. "Reachability / Travel Time" can be mapped to dimension "Society" and "Economy".

Regarding a possible framework for definition of relevant high-level goals, refining them into (lower level and more specific / shorter-term) objectives and finally targets with quantified indicators, a detailed guideline (in particular for taking a transport systems perspective) can be found on [9].

Goals are statements that describe the fundamental economic, social and environmental outcomes that a jurisdiction is aiming to achieve through its activities across all sectors. They are therefore not transport specific – they sit above transport. Goals draw on whole of government strategic plans and vision documents and occur at the highest level of planning. Even if goals are typically developed without regard to the transport system, it is important to identify and select goals here that transport has some potential to contribute towards. There is little point in selecting a goal that is completely unrelated to the transport system.

Objectives should be chosen or developed with the intention of generating measurable targets/KPIs to monitor their performance. This means that objectives should have some measurable aspect, even where they are expressed in very broad terms.

A key performance indicator (KPI) is a measure that enables monitoring of performance in terms of progress towards a specific, defined objective. A target is the desired level of performance for a specific performance indicator. Performance indicators and targets are mechanisms to operationalise objectives. Performance can be measured from several different perspectives, as illustrated in
Figure 4 below: Process, inputs, outputs and outcomes.

It is obvious that the last category of KPIs is the one that has the closest link to the high-level goal. Outcomes are better indicators of the effectiveness of an activity. Outputs usually measure the level of activity and not its end result, but outcomes are often more difficult to measure than outputs.

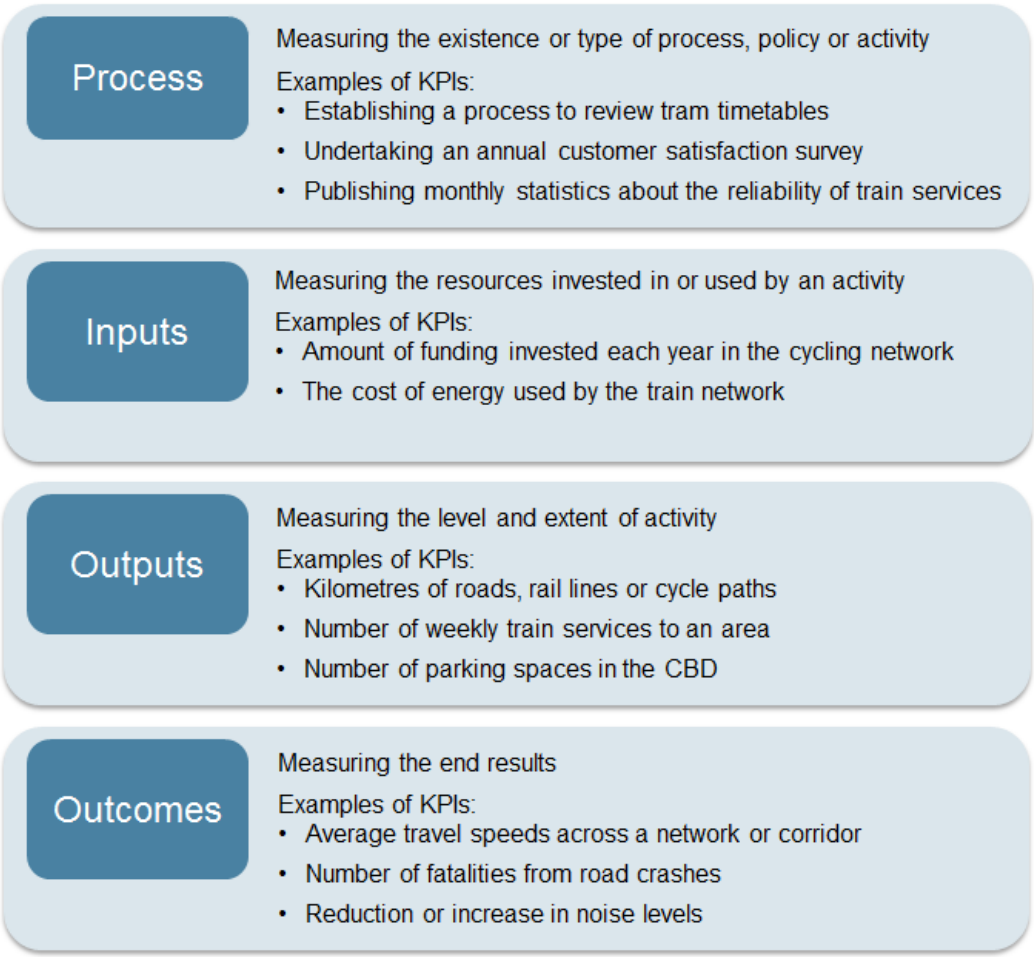

Figure 4 Different aspects for target / KPI definition, with examples for transport systems (taken from [9])

The following picture (Figure 5) illustrates the (simplified) relationship between identification of CATS impacts in WP3 and the definition of policy goals in WP4 where we follow the logically opposite approach – starting from high level visions of the (distant) future.

Given the dynamics of urban development, it is likely that detailed targets / KPIs which are defined now might be subject to change over time, while the corresponding high-level goal stays unchanged. It might turn out, for example, that one indicator that has been selected as KPI does not allow comprehensive assessment or is no longer relevant within that goal dimension, and that it is therefore recommended to substitute it by another KPI.

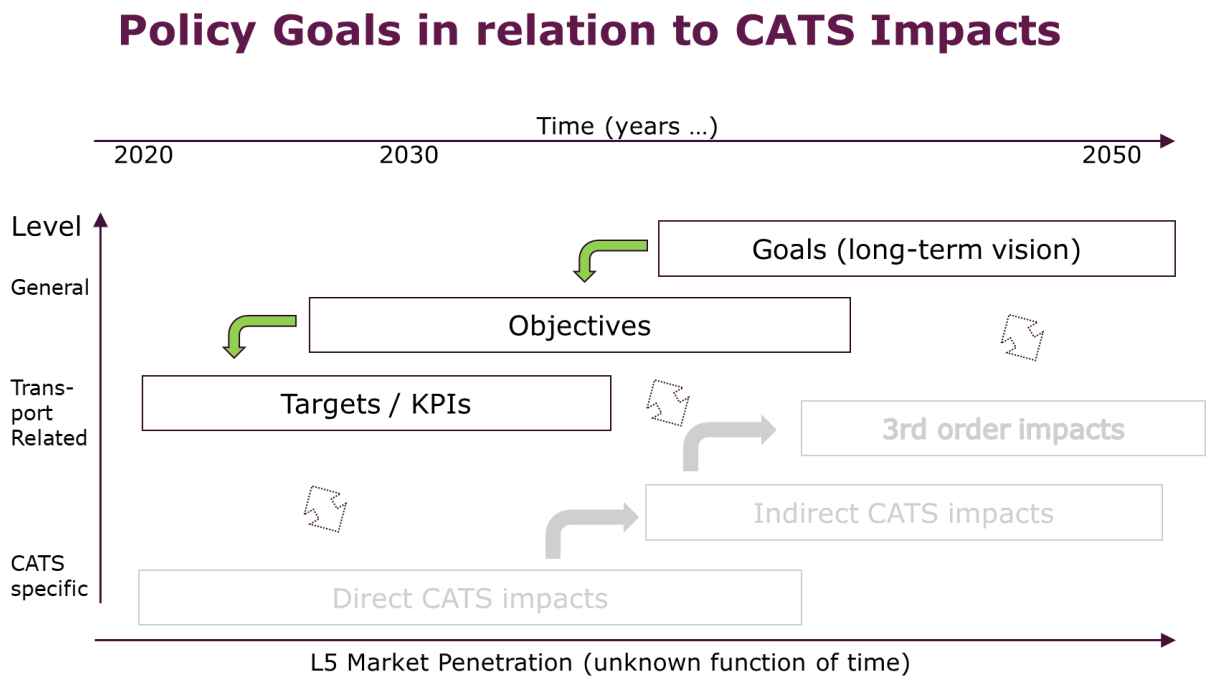

Figure 5 Schematic illustration of approach taken for definition of goals and indicators

3.2 Specific for CATS – Connection to Impacts

As stated before, the goals, objectives and targets should be defined in such a way that CATS can contribute towards them. The selection of dimensions presented in the previous section already narrows down the overall scope of policy goals to a certain extent, compared to more generic approaches like the UN SDG. Still it is evident, that for each of the four dimensions only a subset of goals and objectives is feasible to be addressed in LEVITATE, even if we consider higher order impacts of CATS.

In general, we propose to align the selected goals, objectives and targets/KPIs on each level with the (preliminary) CATS impact areas identified in WP3 (mainly the wider impacts due to their reach beyond the transport system). This alignment will be achieved in an iterative process. Within each iteration, a selected set of goals, objectives and indicators will be presented to stakeholders to revise according its relevance for CATS and then prioritised for analyses.

As a first step for assessing a certain set of goals and indicators we apply a kind of *qualitative correlation matrix* that is comparing a certain set of goals/indicators (rows) against a set of expected CATS impacts (columns). At this stage, the relevance of goals/indicators for CATS is more important than the sign and precise strength of the correlation given by the matrix. This pairwise evaluation of relevance is achieved by expert assessment.

This approach is illustrated in Figure 6 by evaluating the Smart City Index Master Indicators (rows) against the wider impacts identified in [10] (columns), where the supposed existence of correlation is indicated by dark (in case of strong connection) or light green.

The following interpretations are possible for the resulting correlation matrix:

1. Rows with one or more matches (dark or light green cells) are relevant goals/indicators (for example Carbon Footprint/Air Quality).
2. Rows with no matches
    a. Either are not sufficiently relevant indicators with respect to CATS (for example Smart Buildings indicators, water consumption), or
    b. Indicate that the impacts identified so far (columns) might not yet be complete (for example Access to real-time information / Presence of demand-based pricing, highlighted in yellow).
3. Columns (Impacts) with one or more matches (dark or light green cells) indicate that this impact area is already covered with corresponding indicators (for example Air pollution).
4. Columns with no matches indicate that the set of goals (indicators) might not yet be complete in order to cover all significant CATS impacts (for example noise pollution).

Dimension	Working Area	Indicator	Relevance for CATS Impacts	Wider impacts identified in Deliverable D3.1											
				Propulsion energy Energy efficiency Vehicle emissions	Air pollution	Noise pollution	Geographic accessibility	Commuting distances	Inequality in transport	Land use	Public finances	Employment	Trust in technology	Road safety	Public health
Environment	Smart Buildings	Sustainability-certified Buildings													
		Smart homes													
	Resources Management	Energy													
		Carbon Footprint													
		Air qualty													
		Waste Generation													
		Water consumption													
	Sustainable Urban Planning	Climate resilience planning													
		Density													
		Green Space per capita													
Mobility	Efficient Transport	Clean-energy Transport													
	Multi-modal Access	Public Transport													
	Technology Infrastructure	Smart cards													
		Access to real-time information													
Government	Online services	Online Procedures													
		Electronic Benefits Payments													
	Infrastructure	WiFi Coverage													
		Broadband coverage													
		Sensor Coverage													
		Integrated health + safety operations													
	Open Government	Open Data													
		Open Apps													
		Privacy													
Economy	Entrepreneurship & Innovation	New startups													
		R + D													
		Employment levels													
		Innovation													
	Productivity	GRP per capita													
	Local and Global Conexion	Exports													
		International Events Hold													
People	Inclusion	Internet-connected Households													
		Smart phone penetration													
		Civic engagement													
	Education	Secondary Education													
		University Graduates													
	Creativity	Foreign-born immigrants													
		Urban Living Lab													
		Creative Industry Jobs													
Living	Culture and Well-being	Life Conditions													
		Gini Index													
		Quality of life ranking													
		Investment in Culture													
	Safety	Crime													
		Smart Crime Prevention													
	Health	Single health history													
		Life Expectancy													

Figure 6 Illustration of evaluating a set of indicators against the expected CATS impacts

Of course, such conclusions can be extended to goals/indicators and impacts where only a weak connection has been identified.

The output of this process is a basis for a (next) iteration of validation by experts and corresponding refinement of goals and indicators.

3.3 Measurability & Comparability of Indicators

The evaluation of several existing approaches and lists of indicators has shown that there is a wide range of how precisely they are defined and to which degree they have been quantified.

Indicators should be measurable, whether they are quantitative or qualitative in nature (where for the latter this typically means to transform them into a numerical scale). Physical quantities or dimensionless numbers are directly measurable; indicators like access to a certain mode of transport can be measured simply by observation once "access" is defined (e.g. available within 1 km distance from home). Often, a scale or index needs to be created to measure a qualitative variable in quantitative terms. For example, satisfaction might be measured by evaluating response to a set of objective questions.

Regarding comparability of indicators (e.g. between different regions or cities, but also for monitoring development over time), we should be aware of the following aspects:

- A precise definition on how to measure the indicator (as described above) is an obvious precondition.
- Indicators between cities or regions can only be compared if they
    - Either express quantities that have the same scale across regions of different size (e.g. distance to nearest accessible public transport stop),
    - Or are formulated as suitable ratio (e.g. number of casualties per year and per 100,000 residents)
- In particular, when evaluating already available data from different regions (or time periods), it might be challenging to map these to the precise definition of the desired indicator. For the areas considered here, we need to be aware that there are a lot of pre-existing indicators currently in use by several entities.
- Targets and KPIs sometimes are expressed in trends over time (for example, 'a 15% reduction in pedestrian fatalities over the next five years') or in comparisons with other jurisdictions (for example, 'reduce crashes on country roads to below the national average') – which adds another level of complexity for comparability.

However, as indicators are not necessarily required to be comparable between cities but can serve as assessing the progress of transformation of a single city over time, comparability *between cities* is not a criterion.

Related to measurability and comparability, we can also formulate another requirement: *Simplicity*. Indicators should be directly and readily measurable without more complex analysis. This is because the collection, management, and analysis of data is usually resource intensive.

The measurability of indicators has also been assessed in the LEVITATE Stakeholder Reference Group Workshop, for presentation of results refer to section 4.2.

3.4 Completeness & Independency of Indicators

Finally, it should be assessed how well the selected indicators represent the relevant target space of LEVITATE. By selecting a (small) set of KPIs for representing "a possible

future", we perform a drastic simplification, reducing the number of dimensions of the criterion space from (unknown) large number to a (manageable) very small number (as an extreme to 4 – which is the number of "goal dimensions" introduced in section 3.1).

This step of validation has been performed based on the previously identified goals and indicators in collaboration with experts from the planning department of the Vienna City administration to check the proposed goals and indicators against the aforementioned criteria (relevance for CATS, measurability, comparability, simplicity) to achieve dimensionality reduction based on qualitative expert input.

For the considerations within this deliverable, we define the key aspects as

1. *Completeness* – does the set of selected KPIs ("features") describe the future vision reasonably well, or are there any important aspects not covered?
2. *Independency* – are the selected KPIs ("features") sufficiently independent from each other, or is there high redundancy of several parameters?

On a qualitative level, consideration of these two aspects has been integrated into the approach already outlined in section 3.2. Possible CATS impacts, which do not match any of the already identified goals, indicate that this list might not yet be complete. Multiple matches, on the other hand, indicate that there might be a strong redundancy between the corresponding goals.

A further significant contribution to the evaluation of completeness and interdependency of goals and indicators has come as result of the LEVITATE Stakeholder Reference Group Workshop. For each of the four dimensions, additional goals and corresponding indicators have been proposed. In a final common discussion of results, also the interdependencies between goals (belonging to different dimensions) have been analysed, distinguishing between the case where goals are supporting each other (positive impact), and where they are conflicting (negative impact). For presentation of results refer to section 4.2.

3.5 Summary of Aspects Considered in Selection Process

In this chapter we have focused on the requirements and methodologies for the selection of policy goals that are relevant for LEVITATE. The documentation of this process, of used framework and of the key selection criteria has been separated from documenting the actual results (i.e. the output of this process) which will be given in the next chapter.

As a summary, we are considering following aspects for selection of relevant policy goals:

- Organisation of goals into a small set of dimensions (highest-level goals) – ensuring the relevance for subsequent vision development in WP4
- Breaking down high-level goals (long-term visions) into objectives, targets and finally assign them KPIs, preferably focusing on outcome
- Correlation of CATS impacts to KPIs – how far can a KPI be influenced by CATS
- Practicality of indicators – how easily can they be measured and compared
- Completeness and independency of goals and indicators

All these aspects have been considered in an iterative process, containing the following main steps (illustrated in Figure 7):

- Consultations with experts from the planning department of the Vienna City administration, leading to a preliminary list
- Expert validation in a pre-workshop online survey
- LEVITATE Stakeholder Reference Group Workshop

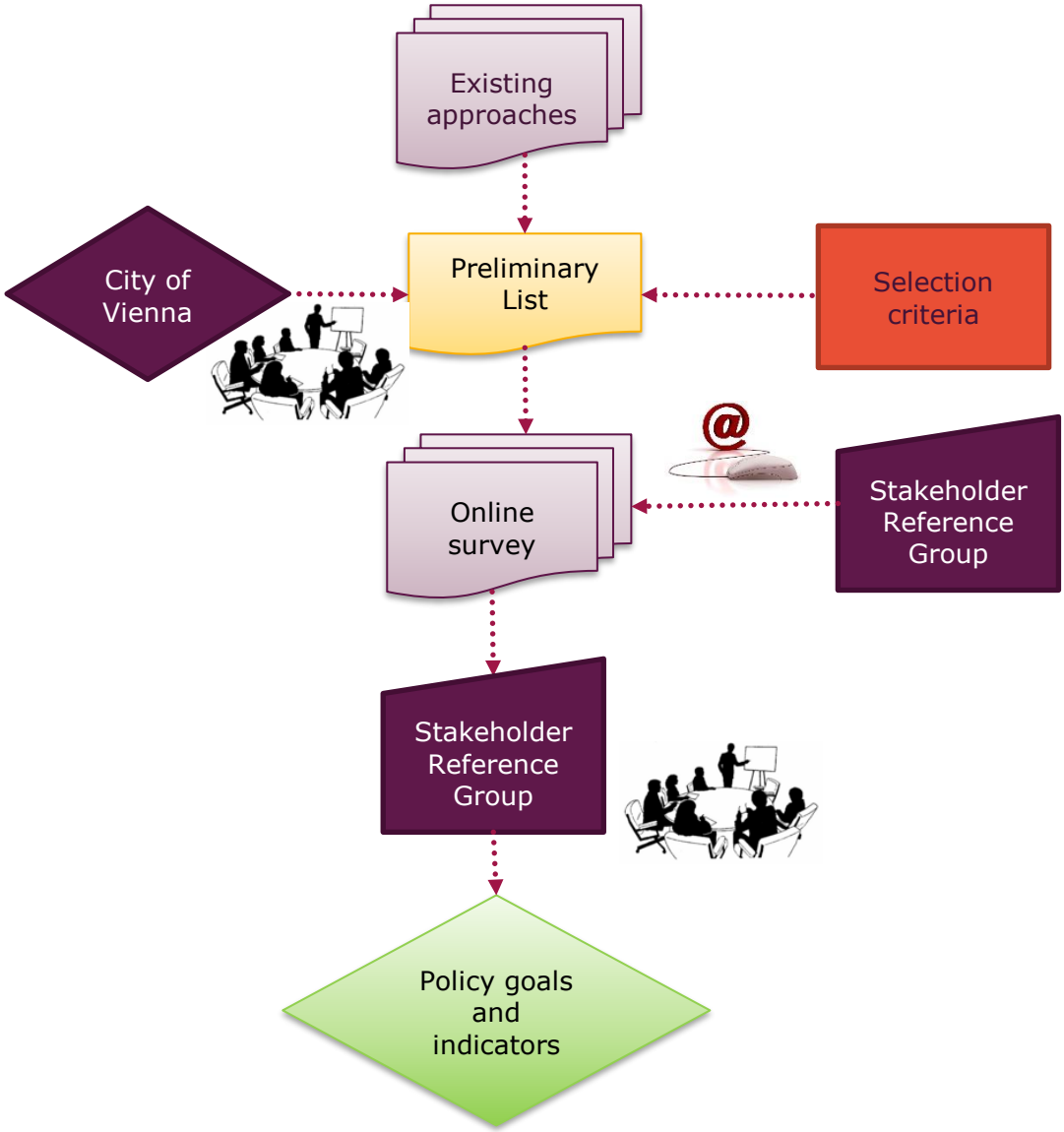

Figure 7 Identification of policy goals and indicators

As a final note, it should be pointed out that at the current stage of the project we have not arrived at an exhaustive conclusion on *all* aspects mentioned above for the proposed goals and indicators, nor at the *one and only* set of goals and indicators to be considered in LEVITATE. Rather, the results presented in the next chapter represent the current state after the mentioned iterations of expert validation; this consolidated list should be

good enough to serve as a base for the further tasks in WP4 and the other LEVITATE work packages. Regarding the use cases considered in LEVITATE (automated urban transport, passenger cars, and freight transport and logistics), more specific policy objectives, targets and indicators might be required in addition to the higher level goals and indicators proposed in this deliverable.

4 Quantified Policy Goals for LEVITATE

4.1 Preliminary List of Proposed Goals and Indicators

Based on the analysis of existing approaches in definition of high-level goals and derivation of objectives, targets and suitable indicators in chapter 2, and the selection criteria in the context of LEVITATE as outlined in chapter 3, a preliminary structured list of goals and indicators has been proposed. Decisions for arriving at this list can be summarised as follows:

- The goals, working areas and indicators have been selected out of the existing approaches that have been analysed in chapter 2.
- Selection has been mainly driven by the relevance for CATS (i.e. priorisation of goals that are likely to be influenced by the CATS impacts analysed in LEVITATE).
- The organisation of goals (and working areas) has been guided by considering four dimensions – Safety, Environment, Economy and Society – where certain areas might be assigned to more than one dimension.
- The number of recommended indicators has been chosen as small as possible with respect to the project goals.
- Measurability and comparability of the proposed indicators has been aligned with expert input from the City of Vienna.

The following table (Table 5) summarises the proposed goal areas and corresponding indicators, along with intended outcome (which behaviour of this indicator – increase or decrease – is desired). The colouring indicates the assignment to the four dimensions, where a certain degree of overlapping can be observed and is indicated by shades, e.g. Energy consumption can be assigned to Economy in addition to Environment, Reachability and Public Space have relevance for Economy in addition to Society.

Table 5 Proposed goal areas, indicators and intended outcome

Dimension	Goal Area	Indicator	Intended outcome
Safety	Accidents	Number of injured per million inhabitants	
		Number of fatalities per million inhabitants	
Environment	Emissions	SO2, PM2,5, PM10, NO2, NO, NOx, CO, O3	
	Urban Sprawl / Density	Building volume per square kilometre (total and per built-up area)	[3]
		Population density (Eurostat)	[4]

[3] Depending on local conditions, different intended outcomes have to be considered here.
[4] Depending on local conditions, different intended outcomes have to be considered here.

Dimension	Goal Area	Indicator	Intended outcome
	Energy Consumption	Rate of energy consumption per person (total)	
		Rate of energy consumption per person (transport related)	
Economy	Prosperity	Taxable income in relation to purchasing power	
Society	Reachability	Average travel time per day	equally distributed
		Number of opportunities per 30 minutes per mode of transport	
	Public Space	Lane space per person	
		Pedestrian/cycling space per person	
	Inclusion	Distance to nearest publicly accessible transport stop (including MaaS)	
		Affordability/discounts	
		Barrier free accessibility	
		Quality of access restrictions/scoring	
	Transport System Satisfaction	Satisfaction with active transport infrastructure in neighbourhood (walking and/or cycling)	
		Satisfaction public transport in neighbourhood	

4.2 Expert Validation of Goals and Indicators

As part of the first LEVITATE Stakeholder Reference Group Workshop, which was held in Gothenburg, Sweden, on 28th May 2019 [5], experts from different sectors were involved to discuss and adopt the list of goals and indicators and to disclose potential synergies and conflicts regarding efforts to achieve specific goals in the four selected dimensions environment, society, economy and safety. Expert input was collected in two phases: (1) through a pre-workshop online survey, and (2) in the course of group and plenary discussions during the workshop. The group participating in the workshop included mainly representatives from municipalities and government bodies, but also industry, transport operation and management, policy, and research.

The online survey was sent to all registered participants prior to the workshop to obtain a general assessment of the proposed indicators and to allow using the survey results as an impulse for inspiring discussions during the workshop. In the survey, participants were asked to rank the four goal dimensions regarding their importance in the local

[5] For details refer to https://levitate-project.eu/2019/06/11/what-do-policy-makers-want-to-know-about-the-impact-of-connected-automated-vehicles/

strategic development of their region. For each of the proposed indicators for the development of a livable city, respondents were asked to indicate

- whether the indicator is monitored (regularly measured) in their city, and
- whether there are related specific goals (values) defined for the
    - short (appr. 5-10 years),
    - medium (appr. 15-20 years) or
    - long term (appr. 25-30 years).

In addition, respondents were asked to suggest other relevant indicators.

Visualisations of the evaluated results of this survey, grouped by type of organisation, are given in the Appendix. Even if the number of survey participants was not large enough to draw reliable conclusions, a few trends could be observed, like:

- Safety related goals were considered most important from governmental organisations.
- Economy related goals were considered most important from industrial organisations, whereas society related goals were considered least important by this group.
- From indicators currently being measured, governmental organisations rather focus on accident rates (Safety) and emissions (Environment). Municipalities have a slightly broader scope of indicators, measuring indicators that they can potentially influence.

There were also a few additional inputs on other relevant indicators:

- Public transport: reliability, punctuality, connection security, modal split (main dimensions: Society, Economy)
- Affordability of accommodation rental in cities (main dimensions: Society, Economy)
- Number of cyclists (main dimensions: Society, Environment)
- Noise, traffic jams, resilience capacity - for example, ability to anticipate heat waves (main dimensions: Environment, Economy)

Further, several additional inputs have been received on the question on "other specific goals you have defined for a certain time period", partly referring to the particular Smart City strategies. Amongst these inputs are:

- SUMP, climate Action plan and Clean Air Management Plan etc.
- Modal split goals: e.g., "to have 80% of people moving around by walking, cycling or public transport by 2041, up from 64% now"
- More cleaner vehicles in the total fleet size, introduction of pollution zones, bicycle facilities (lanes and parking)
- a carbon neutral city in 2050 - ban on diesel vehicles in 2024 and gasoline vehicles in 2030
- Zero emission zone for city logistics in 2025

In the workshop, the main purpose of involving stakeholders was to generally receive constructive feedback to the proposed goals and indicators and to specifically identify conditions and indicators for reaching one of the four specific goal dimensions: Environment / Society / Economy / Safety. To inspire the discussions and explain the scope of related areas, a short impulse talk was given describing two "extreme" future scenarios and the role of CATS therein. The examples were drawn from related futures scenario studies [11] [12] [13] and refer to a market/tech development with high usage of CATS resulting in increasing travel distances and traffic volumes and a

policy/regulated development with limited application of CATS and local lifestyles mainly due to environmental reasons.

Following this impulse presentation, the participants were randomly allocated to four discussion groups. Each of the groups was to focus on one specific goal dimension. Participants were asked to imagine a future, in which one specific goal dimension is fully achieved and to identify the concrete details of such a future: how would such a world look like, what would be needed to optimise, how progress could be measured, and what could be drawbacks in relation to other dimensions.

Subsequently they were invited to discuss the main achievements regarding an ideal development in this dimension, potential conflicts with other goal dimensions and the most relevant indicators for measuring the progress in this goal dimension (where both the importance and the measurability of the indicators were rated by the experts). The discussion was facilitated by an illustration of goal dimensions and related CATS-induced impacts (Figure 8) [6] and the list of indicators resulting from the survey.
After the separated group discussion, the results were consolidated in a plenary setting to identify the most relevant synergies and conflicts between different goals within the four dimensions and to rank the goals and indicators regarding the selection criteria from the perspective of the stakeholders.

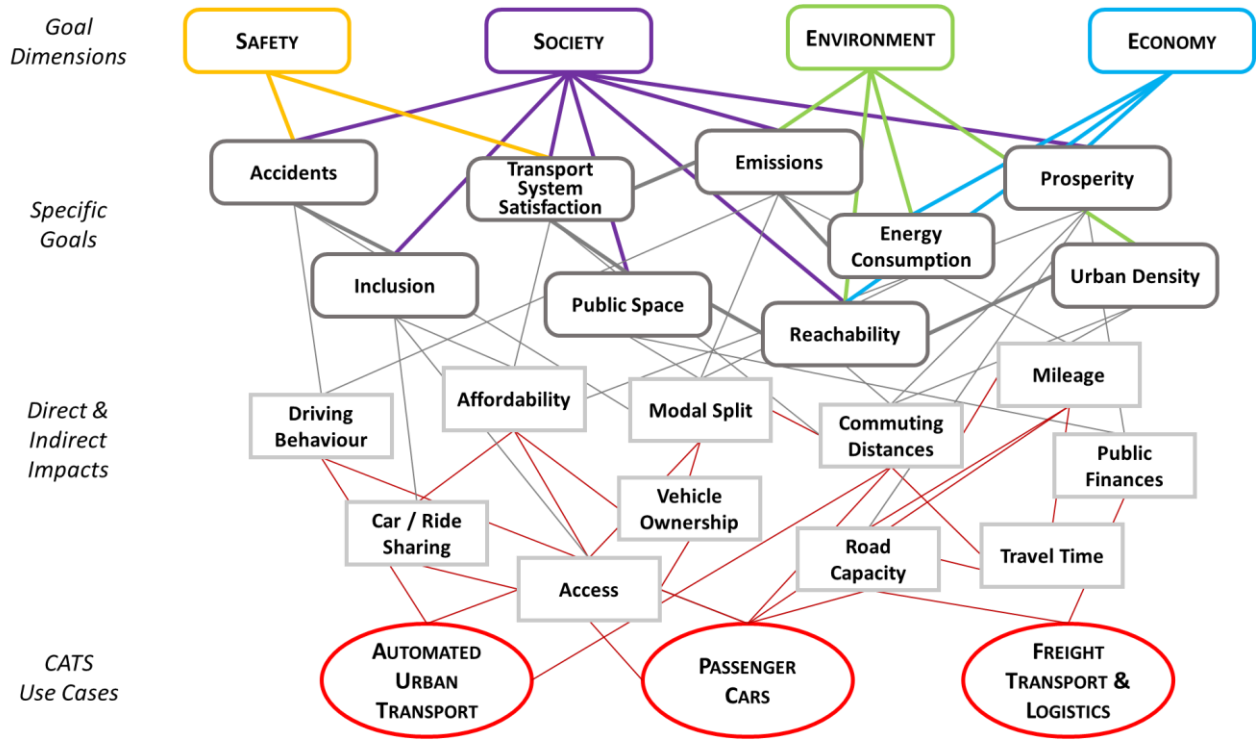

Figure 8 Goal dimensions and impacts of CATS

[6] Note that this repesentation that has been used during the workshop is not fully consistent with the latest classification of impacts in [10] which distinguishes between direct, systemic and wider impacts.

Following main results from the four separate group discussions can be mentioned:

- *Safety* – additional important goals and indicators:
  - *Perceived* safety – measured by surveys
  - Cyber-Security/Safety – no misuse of CATS, number of cyber-security breaches
- *Economy*: The main conclusion in this group was that the goals and indicators are overlapping with the other goal dimensions and optimising them also leads to a "perfect economy" – without major conflicts (this was not seen in such an optimistic way by the other groups). Input on additional important goals and indicators:
  - External costs (lowering these will have a significant positive impact on the economy, but there is also strong overlap with other dimensions)
  - Safety aspects (number of accidents/fatalities, overlap with *Safety*)
  - Environment and health aspects (greenspace/active mobility, overlap with *Environment*)
- *Environment* – additional important goals and indicators:
  - Sustainable mindset & perception – measured by surveys and/or (better) behaviour (use of material, energy, …)
  - Spatial reachability (overlap with *Society*, and goals already considered)
  - Flexible & adaptive systems (use of material, system utilisation)
- *Society* – additional important goals and indicators (note that several inputs from this group overlap with other goal dimensions):
  - Equity (GINI index) (overlap with *Economy*)
  - Employment rate (overlap with *Economy*)
  - Noise (overlap with *Environment*)
  - Happiness/Satisfaction – measured by surveys
  - Cyber-Security (overlap with *Safety*)

In the final plenary discussion on synergies and conflicts between different goals within the four dimensions, a diagram was generated (refer to Figure 9) where green arrows indicate positive impact on (synergies with) other goal dimensions and red arrows indicate negative impact on (conflicts with) other goal dimensions. Note, however, that this illustration just represents a snapshot of the discussion process during the workshop and should not be considered as final or complete.

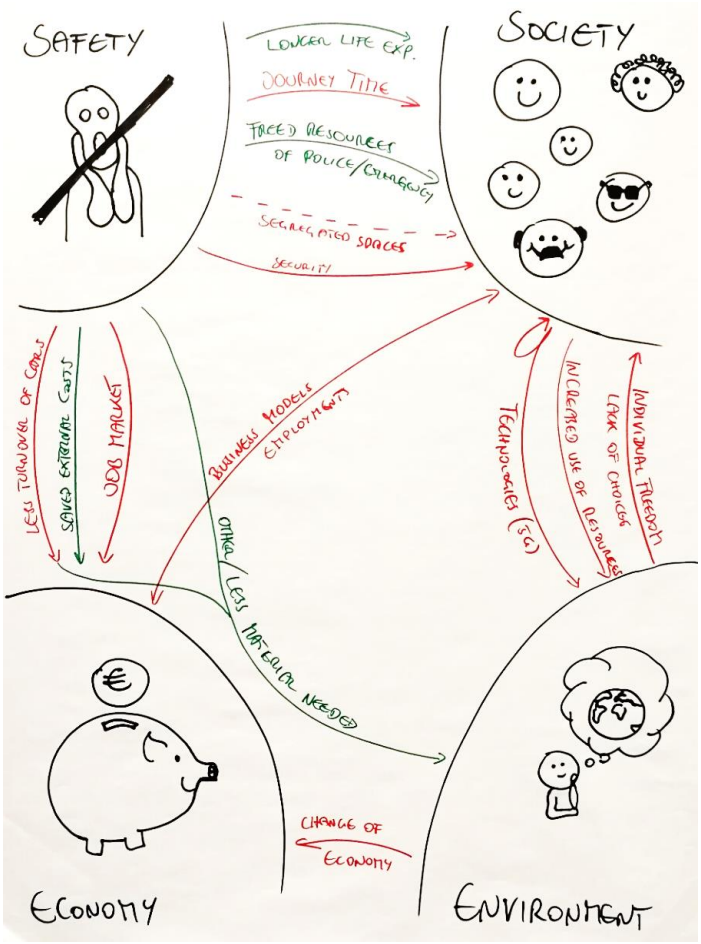

Figure 9: Diagram illustrating the synergies and conflicts between different goals

4.3 Consolidated List of Goals and Indicators

In a final post-workshop iteration with the experts from the City of Vienna the additional inputs from the workshop were reviewed, with the intention to arrive at a consolidated view on the goals and indicators to consider in LEVITATE. A general consideration for this final selection was at one hand the limitation to indicators relevant for CATS, and on the other hand revisiting of the dependency and redundancy of proposed indicators (also across dimensions). This led to following conclusions:

- The *Safety* dimension is a bit more specific than the others (and has been included due to the focus of the LEVITATE project). Closest overlap is seen with Society dimension. The goals *Perceived Safety* and *Cyber-Security* (according to

workshop inputs) are included here – in addition to the (previously proposed) central goal of *Protection of human life*.

- For the Society dimension, the already previously proposed goals of *Reachability*, *Use of public space*, *Inclusion* and *Satisfaction* are considered as sufficient. Additional inputs from the workshop have been partly considered for the other dimensions, and goals like "Happiness" are seen as too generic goals which are influenced mainly by external factors not related to CATS, thus, the impact of CATS to a general level of happiness is hard to extract.
- For the *Environment* dimension, we have added the goal *Low noise levels* (where subjective rating is considered more important than objective measurements – there is clear overlap with the Society dimension). The other goals, with already previously proposed indicators, are *Clean air*, *Efficient settlement structures* and *Sustainable behaviour*. For the last goal, measurable indicators related to behaviour (like energy consumption) are considered more relevant than indicators which are just based on surveys on attitudes or reported behaviour. Indicators like use of material have not considered so far because it is not sufficiently clear how to measure them. Still, as material consumption has been considered as highly relevant, such an indicator should be included in case reliable measurement methods are developed.
- Finally, the *Economy* dimension has been reduced to two main sub-dimensions (goals): the creation of value (*Prosperity*) and its *Fair distribution*. Other proposed indicators like employment rate are implicitly covered by the former (even if employment might be more directly impacted by CATS). Minimising external costs was not in all cases seen as a relevant goal by itself, but some goals in other dimensions (e.g. avoiding accidents) would definitely result in reduction of external costs.

A ranking (priorisation) of these finally proposed goals has not been considered as useful at this stage. As mentioned earlier, such priorisation might be needed later, when defining specific visions and analysing conflicting goals in more detail.

The following table (Table 6) summarises the proposed goals and indicators, updated after the results of the pre-workshop survey and the discussions at the workshop, and after final alignment with the experts from City of Vienna. One column has been added to this table – Measurability: how easy is it do get the corresponding data? For some indicators the data might already be available, for others it is not even entirely clear *how* to measure them.

Table 6 Consolidated proposed goal areas and indicators, with comment on measurability

Dimension	Goal	Indicator	Measurability
Safety	Protection of Human Life	Number of injured per million inhabitants (per year)	+++ (already measured)
		Number of fatalities per million inhabitants (per year)	+++ (already measured)
	Perceived Safety	Standardised survey: subjective rating of (overall) safety	++ (already measured)
	Cyber Security	Number of successful attacks per million trips completed	? (measurability unclear)
		Number of vulnerabilities found (fixed?) (per year)	? (measurability unclear)
Society	Reachability	Average travel time per day (dispersion; goal: equal distribution)	+
		Number of opportunities per 30 minutes per mode of transport	? (precise definition required)
	Use of Public Space	Lane space per person	+
		Pedestrian/cycling space per person	+
	Inclusion	Distance to nearest publicly accessible transport stop (including MaaS)	**+**
		Affordability/discounts: to which degree are transport services used by low-income groups	+
		Barrier free accessibility: to which degree are transport services used by socially disadvantaged and vulnerable groups, including people with disabilities	+
		Quality of access restrictions/scoring	+ (qualitative ind.)
	Satisfaction	Satisfaction with active transport infrastructure in neighbourhood (walking and/or cycling)	+
		Satisfaction public transport in neighbourhood	+
Environment	Low Noise Levels	Standardised survey: subjective rating of main sources of disturbing noise	+
	Clean Air	Emissions directly measurable: SO2, PM2,5, PM10, NO2, NO, NOx, CO, O3	+++
	Efficient Settlement Structures	Building volume per square kilometre (total and per built-up area)	+
		Population density (Eurostat)	+++
	Sustainable Behaviour	Rate of energy consumption per person (total)	+++
		Rate of energy consumption per person (transport related)	+
Economy	Prosperity	Taxable income in relation to purchasing power	+++
	Fair Distribution	GINI index	+++

Finally, we can compare this consolidated list of policy goals against the wider impacts of CATS identified in [10], as we already have proposed in section 3.2. Again, supposed existence of correlation is indicated by dark (in case of strong connection) or light green. This approach is shown in Figure 10.

Dimension	Working Area	Relevance for CATS Impacts	Wider impacts identified in Deliverable D3.1											
			Propulsion energy Energy efficiency Vehicle emissions	Air pollution	Noise pollution	Geographic accessibility	Commuting distances	Inequality in transport	Land use	Public finances	Employment	Trust in technology	Road safety	Public health
Safety	Protection of Human Life													
	Perceived Safety													
	Cyber Security													
Society	Reachability													
	Use of public space													
	Inclusion													
	Satisfaction													
Environment	Low noise levels													
	Clean air													
	Efficient settlement structures													
	Sustainable behaviour													
Economy	Prosperity													
	Fair distribution													

Figure 10: Illustrating the correlation of consolidated list of policy goals with the expected CATS impacts

5 Conclusion and Outlook

After analysing existing initiatives, frameworks and strategies for definition of (transport and smart city related) policy goals and corresponding indicators, and discussing the selection process for LEVITATE in detail, we arrived at a proposal of relevant policy goals / indicators to be further considered in the project. This selection process has been iterative, starting with expert input from the City of Vienna that was considered for a pre-workshop survey, and finally consolidated after the LEVITATE Stakeholder Reference Group Workshop.

At this stage we have defined a basic set of goals and indicators, in the space spanned by the four dimensions Safety, Environment, Economy and Society. This set should be relevant for CATS (i.e. matching to the CATS impacts identified in WP3), aligned with City strategies, practicable in terms of measurability and comparability, and finally a suitable representation of the relevant target space of LEVITATE, (near to) complete, without too many redundancies.

The next key activity in WP4 will be the definition of desirable visions based on multi-criteria analysis. To evaluate different visions both single impacts, but also the inter-connections and correlations of different factors will have to be investigated.

Based on the preliminary discussion in this deliverable in section 3.4, performing a more quantitative analysis of interdependency between considered KPIs could involve a statistical evaluation of existing time series of data available, calculating the covariance matrix of considered key indicators. A related approach in the context of SDG is applied in a World Bank paper [14].

It is also clear, however, that correlation (linkages) between values of several KPIs does not yet infer any causal relationship. A correlation between two variables is not a sufficient condition to establish a causal relationship (in either direction). Deriving causal (directed) networks from correlation between data, is subject to ongoing research in a wide field of domains. We assume that analysing causal relationships between indicators are out of project scope.

As a final note, causal relationships will obviously become relevant in LEVITATE when analysing the impact of CATS and the effect of possible interventions (along with rebound effects). This will be an important aspect for the subsequent tasks in WP4.

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Appendix

City of Vienna – Example indicators

On the following pages, tables extracted from [7] are copied, following the overview given in section 2.5.1.

The explanation below is provided in the forefront of listing the indicators.

> An ever increasing number of data is analysed to observe the development of mobility and traffic in Vienna. The indicators thus obtained are important reference values to examine the effectiveness of measures and identify areas where steps need to be taken. The indicators in the following tables are monitored continuously. Wherever available, figures from previous years are stated. Due to the diversity of sources, it is not possible to use one single reference year. In some cases, several statistical series started only recently or comparisons are not possible due to changes in the collection method so that it does not make sense to state a historical value.

MOBILITY BEHAVIOUR

Indicator	Definition	Historical value	Most recent value available	Development sought by 2025
Active mobility	Share of those persons in the Viennese population who are in motion for at least 30 minutes a day in the course		2013: 23%[12]	30%
Trips to get supplies, accompany someone or spend leisure time	of Modal split share of bike and walking to cover the distances for "getting supplies", "spending leisure time", "taking someone to a destination or collecting someone from a place"[12]	2010: 37.4%	2013: 38.8%	45%
Car use	Percentage of the population using a car several times a week	2003: 42%[4]	2013: 42%[6]	👁
	Utilisation of car capacity in persons	2009: 1.3[15] 2011: 1.38[10]	2013: 1.28[11]	↗
Average distances covered [km]	Average distances the Viennese cover in Vienna [km]	2001: 5.1 km[14] 2006: 5.4 km[14]	2013: 4.1 km[11]	↘
	Share of errands which Viennese population does on foot within walking distances (1 km)	2006: 29.0%[14]	2013: 25.0%[11]	↗
Average distances covered by car	Average distances which Viennese population covers by car within V enna [km] (2009: self-appraisal, 2013: calculation by route planner)	2009: 7.6 km[15]	2013: 5.4 km[11] (Änderung der Erhebungsmethode)	👁
Modal split in passenger transport	Modal split for the Viennese population, referring to the number of trips (eco-mobility:MIT)	1999: 64:36[11]	2013: 73:27[11]	80:20
Modal split in passenger transport at city limits	Modal split of destination traffic at city limits towards centre between 6 and 9 am total cordon (Eco-mobility MIT)[13]	1995/96: 33.2:66.8	2008/09/10: 31.8:68.2	👁
Share of walking and cycling in modal split	Modal split walki g summer half-year (April-October)		2013: 27.7%[11]	↗
	Modal split walking winter half-year (November-March)		2013: 25.8%[11]	↗
	Modal split cycling summer half-year (April-October)		2013: 10.1%[11]	↗
	Modal split cycling w nter half-year (November-March)		2013: 0.5%[11]	↗
Multimodality	Percentage of populatio using at least two modes of transport within a week		2013: 52%[11]	↗
Modes of transport on way to school	Tendency among 6-10 year olds who walk, cyc e or travel on public transpor [12]		2013: 79.7%	↗
	Percentages of 6-14 year olds who walk, cycle or travel on public transport[12]		2013: 87.4%	↗

Legend	
👁	I dicator for the purpose of further monitoring, it is not useful to make a statement about development sought
→	Future development sought: Maintain level (for indicators which are already excellent)
↗ or ↘	Future indicator development sought: rise or decline
[Figure]	Quantitatively defined target values

MOBILITY SERVICES, REACHABILITY AND AVAILABILITY OF VEHICLES

Indicator	Definition	Historical value	Most recent value available	Development sought by 2025
Satisfaction with transport in Vienna	Satisfaction with public transport (school marks 1-5, 1 being best mark)	2003: 1.89[4]	2013: 1.70[6]	↗
	Satisfaction with pavements and footways for pedestrians (school marks 1-5)	2008: 1.93[4]	2013: 1.74[6]	↗
	Satisfaction with cycling path network (school marks 1-5)	2003: 2.29[4]	2013: 2.29[6]	↗
	Satisfaction with car traffic (school marks 1-5)	2003: 3.27[4]	2013: 3.02[6]	↗
Public transport passes	Percentage of the Viennese in the total population holding a Wiener Linien annual season ticket[2]	2005: 19%	2013: 31%	↗
Public transport services	Operating performance of Wiener Linien, total capacity (places including seats and standees) in mill. km[18]	2010: 17,444.4	2012:18,390.3	👁
Public transport reliability	Percentage of seat and standee place kilometres which Wiener Linien failed to operate[23]		2014: 0.3%	→
Access to public transport stops	Percentage of the population with an underground/suburban train stop located 500 m or less from home or another public transport stop 300 m or less from home[20]		2013: 97.3%	→
Bicycle availability	Percentage of households with at least one bicycle[11]	2003: 58%	2013: 69%	80%
Bike sharing station availability	Percentage of the population with bike sharing stations located 300 m or less from home[20]		2013: 24.6%	40%
Car sharing location availability	Percentage of the population with car sharing services located 500 m or less from home[20]		2013: 38.5%	50%
Degree of motorisation	Passenger cars per 1,000 inhabitants[16]	2001: 416	2014: 386	↘
	Motorcycles per 1,000 inhabitants[16]		2014: 46.7	👁
Reachability of primary schools	Percentage of primary school pupils able to find a place in school located 1,500 m or less from their home[20]	2011/12: 93.6%	2013/14: 95.7%	👁

TRANSPORT DEMAND, SPEEDS AND TRAFFIC SAFETY

Indicator	Definition	Historical value	Most recent value available	Development sought by 2025
Wiener Linien public transport passengers	Passenger numbers on Wiener L nien per year[18]	2001: 729 5 Mio.	2013: 900.1 Mio.	↗
Average speed of public transport	Average travel speed of tram, rush hours		2013: 15.0 km/h[18]	↗
	Average travel speed of tram, evening hours		2013: 16.3 km/h[18]	↗
	Average travel speed of bus, rush hours		2012: 17.1 km/h[18]	↗
	Average travel speed of bus, evening hours		2012: 20.1 km/h[18]	↗
Transport at city limits	Destination traffic (public transport and MIT) at city limits heading for Vienna between 6 and 9 am[13]	1996 134,700	2010: 153,150	👁
Motorised traffic density; census profiles	Changes in mean weighted traffic de sities (number of motor vehicles) on main streets A+B (counting stations of Vienna Traffic Census, every 5 years)[3]	2000-2005: +3.7%	2005-2010: -5.5%	↘
	Changes in mean weighted traffic dens ties (number of motor vehicles) on main streets A+B (perma ent counting stations, annual)[1]		2008-2012: -4.6%	↘
	Changes in mean weighted traffic densities (number of motor vehicles) on main streets A+B a city limits (counting stations of Vienna Traffic Census, every 5 years)[3]	2000 2005: +10.1%	2005-2010: -5.9%	↘
	Changes in mean weighted traffic densities (number of motor vehicles) on main streets A+B within inner city area (permanent counting stations, annual)[1]		2008-2012: -3.7%	↘
	Changes in mean weighted traffic densities (number of motor vehicles) on main streets A+B crossing Danube river (permanent counting stations, annual)[1]		2008-2012: -6.2%	↘
	Changes in mean weighted truck traffic densities (number of trucks) on main streets A+B (permanent counting statio s, annual)[1]		2008-2012: -13.4%	↘
Bicycle census profiles	Mean density of bicycle traffic at 8 permanent counting stations throughout year[9]	2003: 8,492	2013: 10,627	↗
	Mean density of bicycle traffic at 8 permanent counting stations during cycling season[9]	2003: 11,661	2013: 14,.734	↗
Accidents	Number of traffic casualties per year[17]	2005: 34	2013: 17	↘
	Number of persons injured in traffic accidents per year[17]	2005: 7,120	2013: 6,979	↘

ENERGY AND ENVIRONMENT

Indicator	Definition	Historical value	Most recent value available	Development sought by 2025
Energy consumption	Final energy consumption of the transport sector in Vienna per year, adjusted for EMIKAT calculation [GWh][21]	1999: 7,474 2005: 8,764 2010: 9,094 2011: 8,744	2012: 8,647 GWh	7.300 (rd.-20% ggü 2010)
	Energy used by Wiener Linien for operating public transport	2010: 625 GWh	2013: 594 GWh	👁
Renewable energy	Share of renewables in transport energy resources [24]	2005: 0.58% 2010: 5.95%	2012: 6.18%	↗
Alternative propulsion systems	Share of passenger cars with alternative propulsion systems (electric, LNG, hybrid) licensed in Vienna[16]	2008: 0.15%	2013: 0.52%	↗
CO_2 emissions	Traffic-related CO_2 emissions in Vienna, according to EMIKAT[22]	1999: 1,871 kt 2005: 2,219 kt 2010: 2,141 kt 2011: 2,072 kt	2012: 2,062 kt	1.700 (rd.-20% ggü 2010)
Traffic noise	Traffic noise nuisance in close surroundings of home (cumulative, marks 3-5)[6]		2013:29%	↘
PM10 concentration	PM10 limit values exceeded: Number of days when limit value was exceeded (daily mean value >50 g/m³) p.a. (mean value from 13 measuring stations)[7]	2006: 53	2013: 26	↘
	PM10 annual mean value mean value from 13 measuring stations[7]	2006: 32 µg/m³	2013: 25 µg/m³	↘
NO_2 concentration	NO_2 limit values exceeded: Number of half hours when limit value was exceeded (>200 g/m³) p.a (measuring station at Hietzinger Kai)[7]	2006: 59	2013: 0	→
	NO_2 annual mean value mean value (measuring station at Hietzinger Kai)[7]	2002: 57 2006: 74	2013: 51 µg/m³	↘

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(22) Vienna Emission Cadastre (emikat.at), managed by MA 22, data provided by Chief Executive Office, climate protection coordination
(23) Informatio from Wiener Linien, August 2014
(24) Calculations of MA 20 – Energy Planning, based on the energy balance sheet by Statistics Austria

Evaluation of pre-workshop survey

In the following, the results of the pre-workshop online survey (as described in section 4.2) are presented in some more detail.

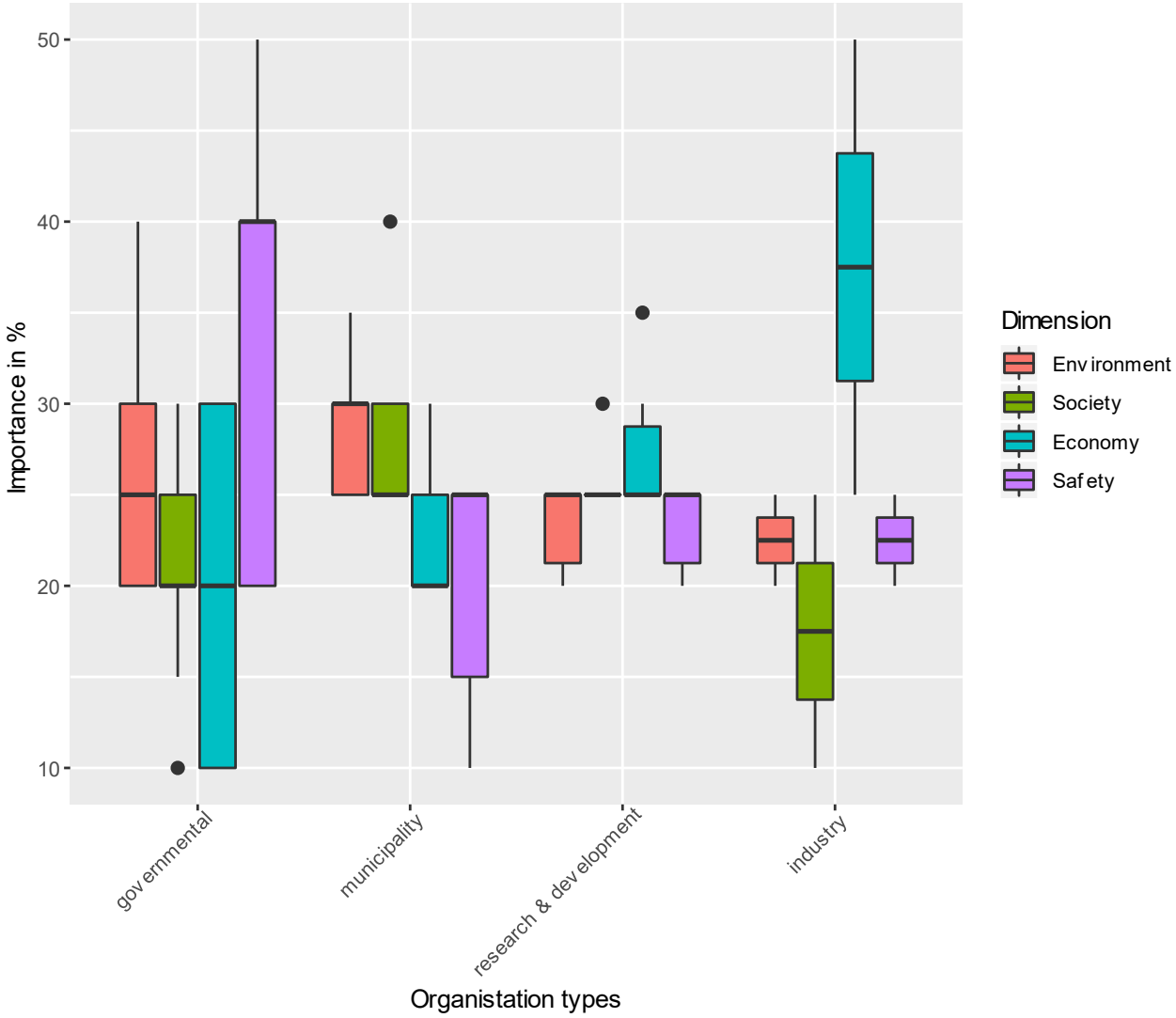

Figure 11 Boxplot of the different goal dimensions by Organisation type.

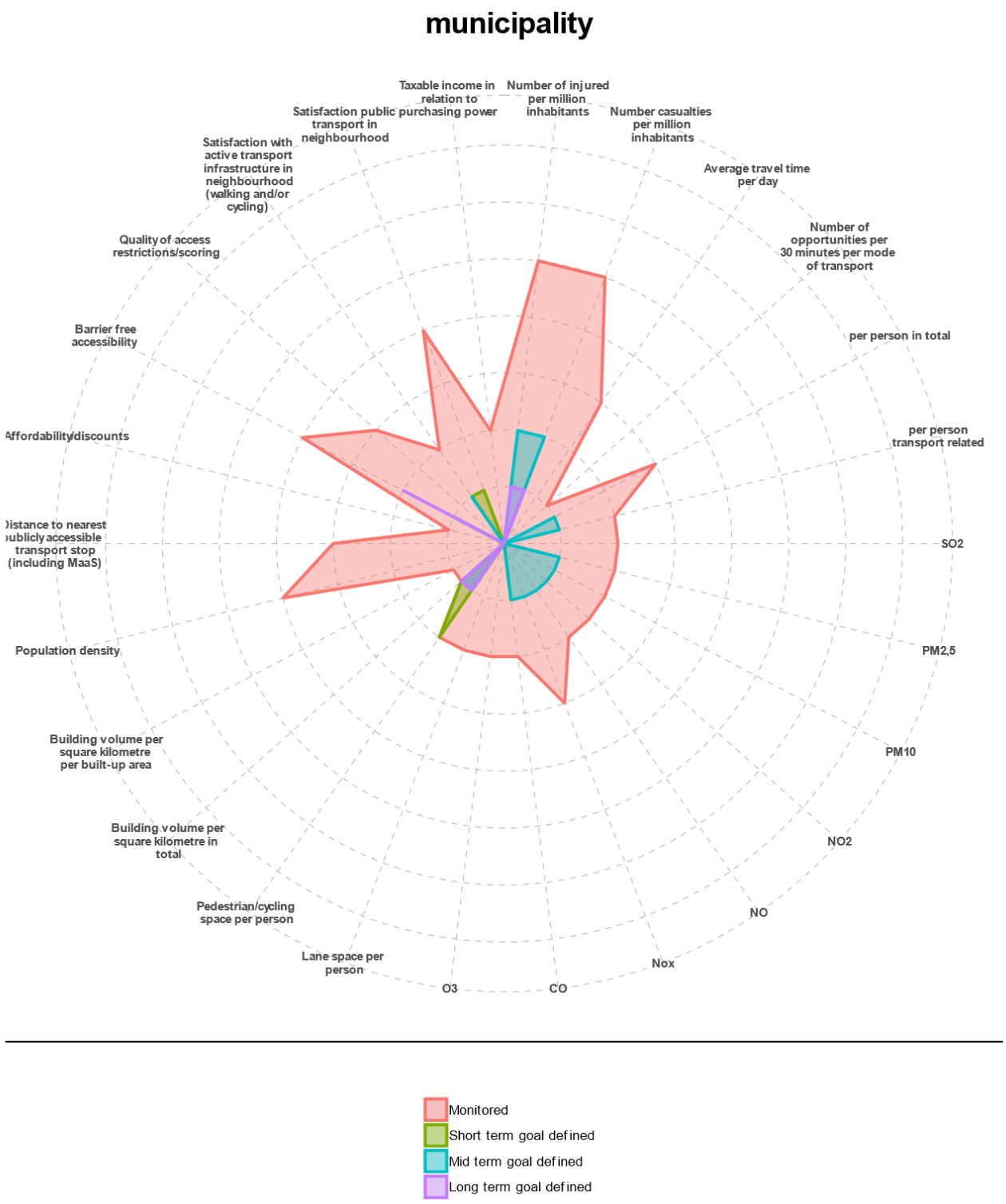

Figure 12 Spider Graph showing by how many municipalities the indicators are currently measured and how many of them have short-, medium- and long-term goals for each indicator

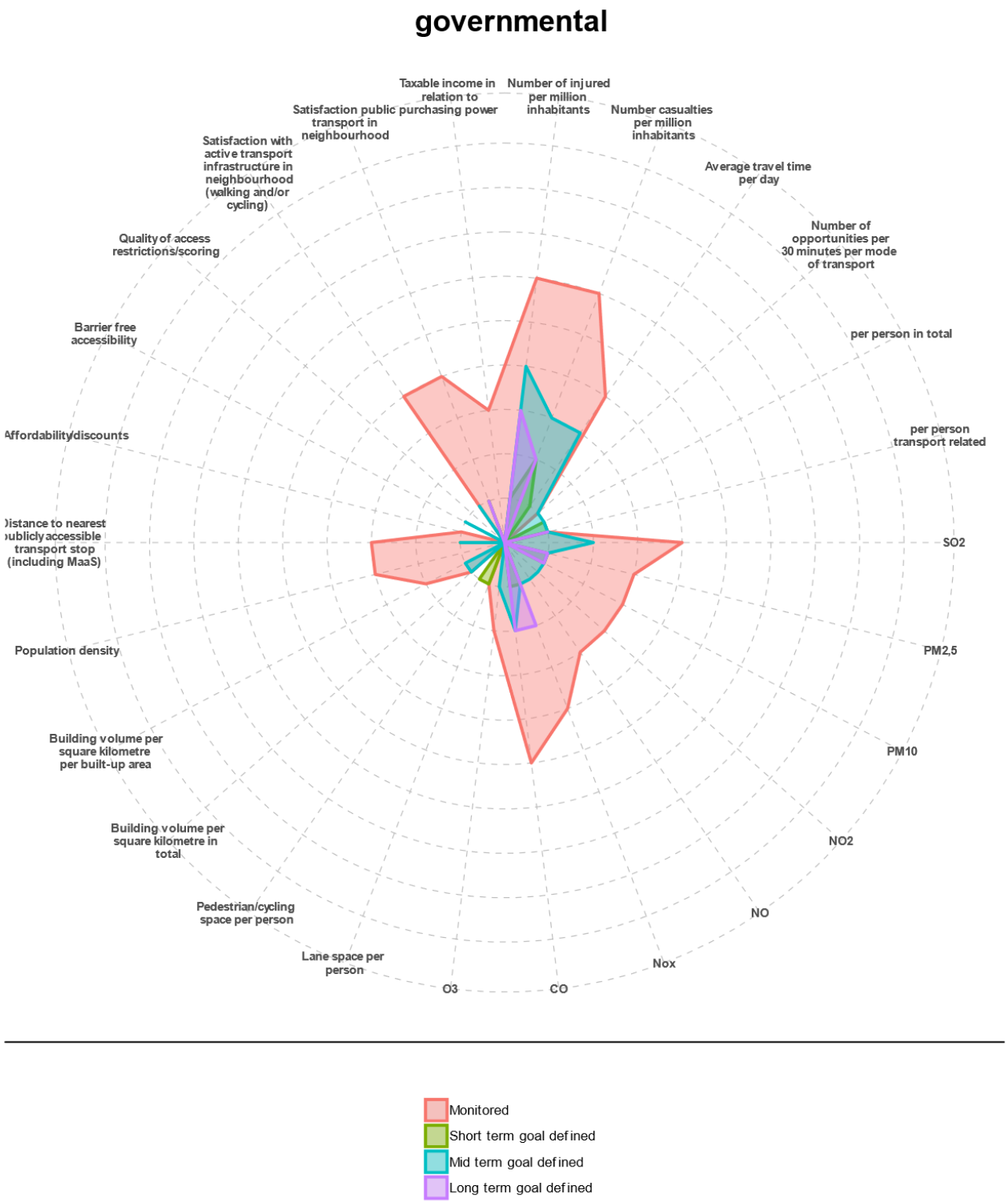

Figure 13 Spider Graph showing by how many governmental organisations the indicators are currently measured and how many of them have short-, medium- and long-term goals for each indicator

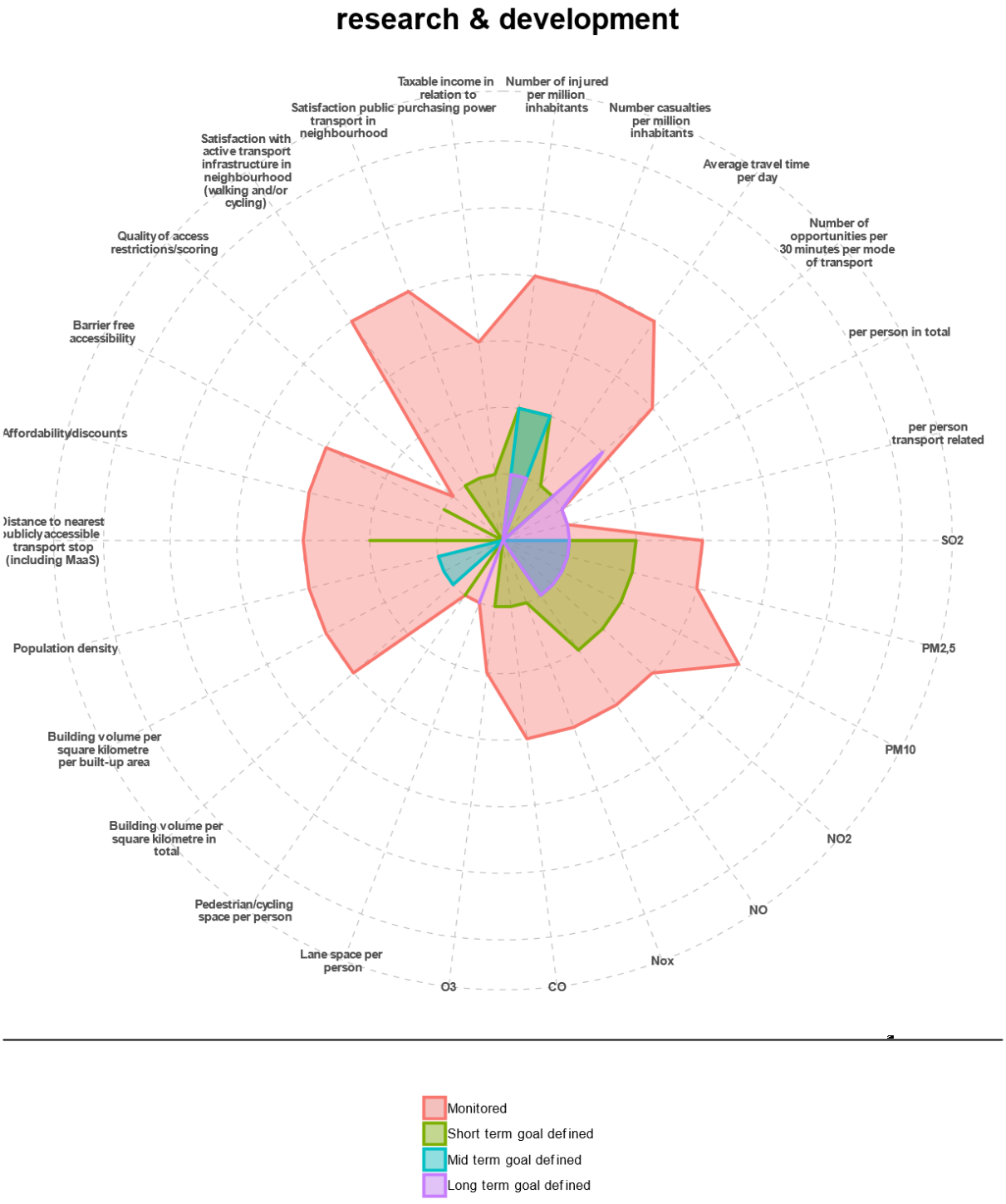

Figure 14 Spider Graph showing by how many research & development organisations the indicators are currently measured and how many of them have short-, medium- and long-term goals for each indicator

Used Terminology

Following definitions that have been discussed in LEVITATE across the work packages are relevant for this deliverable; these are the terms that are proposed to be used throughout the project:

Term	Description	Examples
Impact categorisation	In order to simplify the categorisation of CATS impacts, two main categories are identified: (1) Direct impacts: impacts that are produced directly from the introduction of CATS on the transport system such as vehicle design and driving behaviour (2) Indirect impacts: impacts that are a by-product of the direct impacts of CATS. For example, driving behaviour will affect road user interaction and therefore road safety which is an indirect impact.	
Policy	Definition: A set of ideas or a plan of what to do in the future in particular situations that has been agreed to officially by a group of people, a business organisation, a government or a political party.	Environmentally friendly, social equity, increase in health, livability
Policy goals / Policy objectives	Definition: A single target within the whole policy (should be SMART) Should be third order impacts, which are wider impacts e.g. societal and are usually not directly transport related.	One of the European 20-20-20 Targets: The 2020 energy goals are to have a 20% (or even 30%) reduction in CO2 emissions compared to 1990 levels.
Policy interventions / measures	Definition: An intervention is an action undertaken by a policy-maker to achieve a desired objective. Interventions may include educational programs, new or stronger regulations, technology and infrastructure improvements, a promotion campaign.	Introduction of a city toll, conversion of driver license training, dedicated lanes for automated vehicles
Vision	Definition: Description of a future situation defined by a bundle of vision characteristics and dedicated at a specific point in time	The case of Vienna (modal share, mobility demand, penetration rate of automated vehicles of level x, …)

Vision characteristic	Definition: An indicator representing a policy goal that has to be achieved at a certain time. A single target within the vision in the level of first and second order impacts (which occur in the transport system, on a trip-by-trip basis / which involve system-wide changes in the transport system)	Penetration rate of automated vehicles of level x, population density, number of near miss / collisions, Number of accidental deaths, particulate pollution, noise, public green space.
Transformation Path	Definition: A postulated sequence or development of policy interventions / measures (and external events/measures/conditions) driving from a vision 'A' at time 'X' (which can be the current situation) to a vision 'B' at time Y	Situation now in Vienna (modal share, mobility demand, penetration rate of automated vehicles of level x, …), measures: campaign in 2020, funding for dedicated research in 2025, restricted access to freight in 2025, city toll in 2028; situation in 2030: (specified modal shift, expected mobility demand, penetration rate of automated vehicles of level x, …)