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Luxembourg Parking Strategy Data Collection Guidance

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What gets measured gets managed. This requires comprehensive, consistent and integrated data.

Summary

The Grand Duchy of Luxembourg is developing a National Parking Strategy to guide the country's parking policy and planning decisions. This report identifies data needs to support that Strategy. It reviews various parking planning documents and their data needs. It identifies the data required for various parking policy and planning analysis, and research purposes. It recommends specific actions for efficiently collecting comprehensive, consistent and integrated parking-related data.

Contents

Introduction

Like most economically successful countries, the Grand Duchy of Luxembourg experiences traffic and parking problems. To address these, the Ministry of Sustainable Development and Infrastructures (MDDI) recently published *Modu 2.0,* a sustainable mobility strategy. It includes plans to create a national Parking Strategy. Implementing this Parking Strategy will require various types of data for policy analysis, planning and research. This report identifies specific data needs. This provides guidance for Phase 2 (data collection) and Phase 3 (strategy development) of the Strategy's development.

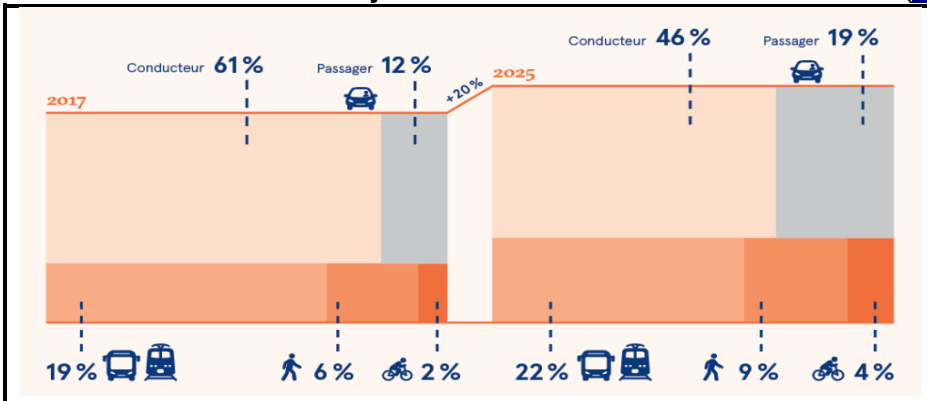
This is a unique and useful project. Although some cities and regions have parking strategies, this is the first developed at a national level. Parking policy and planning decisions have many economic, social and environmental impacts. Many current parking policies and planning practices contradict strategic objectives, such as reducing traffic congestion, accidents, pollution emissions, and support more sustainable urban development. A Parking Strategy can help ensure that parking policies support strategic objectives, as indicated in Exhibits 1 and 2.

Exhibit 1 **Parking Policy Impacts on MDDI Strategic Objectives** (www.modu2.lu)

Strategic Objective	Supportive Parking Policies
Shift travel from automobiles to more resource-efficient modes (walking, bicycling, ridesharing and transit).	Reducing parking subsidies and efficient parking pricing are very effective at shifting modes.
Promoting carsharing in urban areas.	Reduced and unbundled private parking, and designed carshare spaces support carsharing.
Improve traffic safety and security on sidewalks, bikelanes and roads.	More efficient management can free up space for wider sidewalks, bike- and bus-lanes, and traffic calming.
Reduce the volume of soil that must be evacuated from building sites.	More efficient management can reduce the number of underground parking spaces needed in each building.
Improve motorists convenience	Improve parking information and management so motorists can more easily find a parking space.
Reduce traffic congestion while accommodating 20% commute trip growth by 2025, as illustrated below.	Efficient parking pricing and management to encourage mode shifts. Reduce parking supply to allow more compact development which supports efficient modes.

Appropriate parking policies can help achieve many of Luxembourg's strategic planning goals.

Exhibit 2 **Modu 2.0 Objective 1: Home to Work Mode Shares** (www.modu2.lu)



A Modu 2.0 objective is to reduce traffic congestion while accommodating 20% growth in total commute trips between 2017 and 2025. Achieving this will require parking policies that encourage travellers to use non-auto travel modes, and

	supports more compact development.

Many jurisdictions, particularly growing cities, are applying a new parking paradigm (Economist 2017; Litman 2017). The old paradigm assumed that parking should be abundant and inexpensive; the new paradigm favors more efficient management of parking resources. Luxembourg is currently implementing many new paradigm strategies, including reduced and more specific parking requirements for development, more efficient parking regulations and fees, plus various strategies to encourage shifts from driving to more resource-efficient travel modes, particularly for commuting.

The new parking paradigm significantly expands the range of impacts and options considered in parking planning, and so expands data needs. For example, the old paradigm used relatively simple formulas to determine the minimum number of parking spaces that should be built in a particular building: the same parking ratios were applied to all buildings of a particular type. The new paradigm uses more complex models which account for various demographic, geographic, economic and management factors. Such planning requires more comprehensive and integrated data sets.

To illustrate this requirement Exhibit 3 identifies the data needed to answer typical parking planning questions. These data must be comprehensive, consistent and integrated. For example, parking supply and utilization data should be disaggregated by vehicle and facility types, and location, with information about ownership, regulations and pricing, and collected at various times. Some of this information is already collected, but in practice it is often inconsistent, with varying definitions and collection methods, making it difficult to integrate the information for planning, analysis and research purposes.

Exhibit 3 Data Needed to Answer Various Parking Planning Questions

Planning Questions	Data Needs
When and where are parking facilities congested (motorists have difficulty finding an unoccupied space)?	Parking facility occupancy and utilization.
How many parking spaces are needed in a particular building or area?	Current and future vehicle ownership and trip generation. Area walkability.
Is it possible to share parking facilities?	Nearby parking supply, ownership and utilization. Local walking conditions.
What parking management strategies are most effective?	Detailed information on parking and travel demands, and how demographic, geographic, economic and management factors can affect those demands.
How much should businesses and governments spend on parking management programs?	Parking facility costs. Parking management program costs and benefits, including co-benefits beyond parking facility cost savings.
How well do parking programs perform?	Parking facility and program costs, parking facility occupancy and utilization rates, user satisfaction and complaints, local business activity.

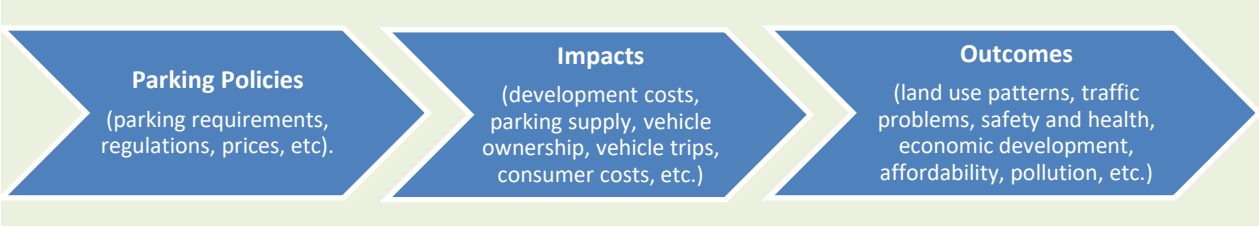
Various parking planning questions require various types of data. It is important to anticipate data needs so they can be collected efficiently.

This report provides guidance for comprehensive, consistent and integrated data needed for parking planning in Luxembourg.

Parking Policy Impacts

Parking policies decisions have many impacts; they can affect vehicle ownership and travel, consumer costs and development patterns, which have various economic, social and environmental outcomes. For example, parking requirements can increase development costs, particularly in areas with high land values, which encourages sprawl over urban infill. Convenient and inexpensive parking increases vehicle ownership and use, which increases traffic and pollution problems. Efficient parking regulations and pricing can ensure that parking spaces are always available to high-value uses, such as delivery vehicles, passenger pick-up/drop-off, and customers, which supports economic development. Exhibit 4 illustrates parking policy impacts and outcomes. It is important to understand these relationships so parking policies can be aligned with strategic planning goals.

Exhibit 4 **Parking Policy Impacts and Outcomes**



Parking policies can have various impacts and outcomes.

In recent years parking planning has expanded to consider a wider range of impacts, objectives and solutions. For example, parking facilities are now recognized as a major development costs, particularly in areas with high land values, and therefore a constraint on affordable urban infill, so planners want accurate information on parking facility costs, and the effectiveness of management strategies that reduce the number of parking spaces needed to serve urban destinations. In addition, inexpensive parking is now recognized as an incentive that increases vehicle ownership and use, which exacerbates traffic problems, so planners want information on the effectiveness of management strategies that reduce both parking and traffic problems.

The table below summarizes how parking planning priorities have expanded over time, and the expanding scope of data needed.

Exhibit 5 **Parking Planning Priorities and Data Needs**

Time Period	Parking Planning Priorities	Data Needs
1950+	Increase parking supply to reduce parking congestion. Improve facility design to maximize motorist convenience and safety.	Parking supply. Parking demands. Facility design. Improve parking facility operational practices.
1970+	Local environmental impacts. Reduce impervious surface and unattractive design.	Facility design and operational practices.
2000+	More efficient traffic and parking management. Consistency with strategic planning objectives.	Factors that affect parking demands. Regulations and pricing. Parking facility costs. Quality of travel and parking options.

Parking planning priorities and data needs have expanded over time.

Exhibit 6 lists various strategic planning objectives, related parking policy impacts, and data needs for understanding these impacts. This illustrates the types of data needed for various policy and planning analyses.

Exhibit 6 Planning Objectives Parking Data Needs

Planning Objective	Parking Policy Impacts	Data Needs
Cost-effective development	Parking regulations tend to increase development costs.	Parking facility costs. On-site parking demands. Car ownership and use. Opportunities for more efficient management, such as sharing with nearby developments or shifting travel to non-auto modes.
More compact and mixed urban development	Policies that support efficient parking management, which reduces parking supply requirements, allow more compact and mixed development.	
Efficient roadway design	On-street parking displaces other possible uses of road rights-of-way such as bus-lanes, bike-lanes, wider sidewalks and landscaping.	Current on-street parking supply, regulations and pricing. Parking demands. Opportunities for more efficient management.
Maximize motorists convenience and satisfaction	Policies can affect parking supply, prices, and user information, and therefore users' convenience.	Parking supply, regulations, prices, availability/occupancy and user information. User satisfaction.
Support economic development	Parking can ensure convenient access, particularly for high-value trips (deliveries, passenger pick-up/drop –off, customers, etc.).	Parking demands, particularly for high-value trips. Parking supply and availability. Opportunities for more efficient management.
Reduce traffic problems (congestion, accidents and pollution emissions)	Abundant and cheap parking encourages automobile ownership and use.	Travel demands. Ability to shift travel to non-auto modes.
Reduce parking facility environmental impacts	More efficient management can reduce impervious surface area, soil disposal, habitat loss, and stormwater management costs.	Parking supply and type (surface, structured or underground), portion of land paved for roads and parking, and design quality (e.g., landscaping).
Improve our understanding of parking policy impacts and evaluate performance	Research is needed to help understand relationships, such as how changes in prices or service quality affect parking demands.	Various standardized data that can be used to measure trends and relationships, compare different areas, and track trends.

This table indicates how parking policies affect various planning objectives, and types of data needed to understand these impacts in order to optimize policies.

Literature Review

There is increasing interest among policy makers and planning professionals concerning parking planning issues. Earlier analysis primarily concerned with parking facility design to maximize motorists' convenience and aesthetics, efficient operations of parking services, and how to determine the minimum number of parking spaces needed in a particular location. This required data on vehicle size and mix (such as the portion of small, medium and large vehicles), and methods for measuring parking demands (also called *parking generation*) for various land uses and geographic locations.

During the last two decades a growing body of literature has examined ways to more efficiently manage parking through sharing, efficient pricing and other transportation demand management strategies. This requires more detailed data on parking demands, such as how peak demand variations between different land use types allow sharing, how prices and geographic location affect parking demands, and the effectiveness of various parking management strategies. In recent years there have been growing concerns about the effects that parking policy and planning decisions can have on development patterns, affordability, travel activity, and environmental qualities; understanding these relationships requires detailed and integrated data related to parking supply and price, parking facility costs, land use patterns, economic development, housing affordability, travel activity, consumer demands, and location preferences, to name a few examples.

Below are examples of parking planning documents and the data they use.

Document	Data Needs
Paul Barter (2016), *On-Street Parking Management: An International Tool-kit*, Sustainable Urban Transportation Technical Document #14, GIZ and SUTP (www.sutp.org); at https://bit.ly/2JyHJt7.	Parking supply, design, regulation and price, demands, utilization, user and business concerns, local business activity, user information and satisfaction.
Mark Childs (1999), *Parking Spaces: A Design, Implementation and Use Manual for Architects, Planners, and Engineers*, McGraw Hill (www.mcgraw-hill.com).	Parking facility size and design.
CROW, the Dutch Knowledge Platform for Transport, *Parking Figures 2018*, Infrastructure and Public Space (www.crow.nl/english-summary).	Parking supply, regulations, price and demand by location and land use type.
William J. Gribb (2015), "3-D Residential Land Use and Downtown Parking: An Analysis of Demand Index," *CityScape*, Vol. 17, No. 1, pp. 71-84; at https://bit.ly/2QV0iHd.	Geocoded parking supply, demand, utilization, parking requirements, and building development.
ITE (2010), *Parking Generation*, Institute of Transportation Engineers (www.ite.org).	Parking supply, demand and occupancy rates by land use type.
ITE (2016), "Planning for Parking," *Transportation Planning Handbook*, Fourth Edition, Institute of Transportation Engineers (www.ite.org).	Parking supply, design, regulations, price, demand, turnover, utilization, development patterns, construction and operating costs, pricing and revenues, enforcement practices and management opportunities.
John D. Edwards (2006), "The Main Street Parking Initiative," *ITE Journal*, Vol. 76, No. 11 (www.ite.org), November 2006, pp. 30-38; at http://bit.ly/2c4ADuj.	Area-wide parking supply, demand and occupancy, facility design, opportunities for more efficient management, and local economic impacts.

Document	Data Needs
King County (2011), *Right Size Parking Project and Calculator* (http://metro.kingcounty.gov); at https://bit.ly/2v0vUmZ.	Parking supply and demand with demographic, geographic, economic and management factors for specific buildings.
Michael Kodransky and Gabrielle Hermann (2011), *Europe's Parking U-Turn: From Accommodation to Regulation*, Institute for Transportation and Development Policy (www.itdp.org); at https://bit.ly/2Ib95Ei.	Regulations, prices, and management practices.
Todd Litman (2016), *Parking Management Best Practices*, American Planning Association Press. Also see *Parking Management: Strategies, Evaluation and Planning*, Victoria Transport Policy Institute (www.vtpi.org); at www.vtpi.org/park_man.pdf.	Parking supply, demand, regulations and prices, construction and operating costs, opportunities for sharing and other management strategies.
Michael Manville and Jonathan Williams (2011), *The Price Doesn't Matter if You Don't Have to Pay: Legal Exemption as an Obstacle to Congestion Pricing*, UCLA Institute of Transportation Studies.	Parking supply, demand, regulations, prices, exemptions and enforcement.
Wesley E. Marshall and Norman W. Garrick (2006), "Parking at Mixed-Use Centers in Small Cities," *Transportation Research Record 1977*, Transportation Research Board (www.trb.org).	Parking supply and occupancy by location measured using field surveys.
G. Mingardo and J. Meerkerk (2012), "Is Parking Supply Related to Turnover of Shopping Areas? The Case of the Netherlands, *Journal of Retailing and Consumer Services*, Vol. 19/2, March, pp 195-201; at https://bit.ly/2rXBzXm.	Commercial area parking supply, parking regulations and prices, availability, duration, user type (delivery, customer and employee vehicles), local geographic and economic conditions, and local business activity.
MTC (2007), *Reforming Parking Policies to Support Smart Growth*, Metropolitan Transportation Commission (http://mtc.ca.gov/sites/default/files/Toolbox-Handbook.pdf).	Parking supply, demand, occupancy, regulations and price, geographic conditions, non-auto mode quality (walking, transit, and carsharing), tax and fee revenues.
Ruth Steiner, et al. (2012), *Impact of Parking Supply and Demand Management on Central Business District Traffic Congestion, Transit Performance and Sustainable Land Use*, Florida DOT Research Center (www.dot.state.fl.us/research-center).	Parking supply and demand, vehicle traffic, transit ridership, and land use development.
Sophie Tyler, et al. (2012), *The Relevance of Parking in the Success of Urban Centres, A Review*, London Councils (www.londoncouncils.gov.uk); at https://bit.ly/19vMxck.	Parking supply and demand, vehicle traffic, land development, local economic activity.
Rick Williams (2013), *Parking Made Easy: A Guide to Managing Parking in Your Community*, Oregon Transportation and Growth Management (www.oregon.gov/LCD); at https://bit.ly/2yHzLpC.	Local parking supply and demand; occupancy, turnover and utilization, user convenience and satisfaction, construction and operating costs, enforcement practices, local development patterns, and local travel options and patterns.

This table identifies the types of parking data reported and analyzed in various parking planning documents.

This indicates that parking planning analyses require diverse and integrated data.

Examples of Parking Data Collection and Use

Regional Parking Supply and Cost Analysis

Various studies use GIS and aerial images to count the total number of parking spaces in an area, and in some cases estimate their economic costs. For example, Eric Scharnhorst (2018) "Quantified Parking: Comprehensive Parking Inventories for Five U.S. Cities," developed comprehensive parking inventories for the cities of New York, Philadelphia, Seattle, Des Moines, and Jackson, Wyoming. The results indicate that these urban regions have significantly more parking spaces than homes, vehicles or people. The study found a greater portion of surface parking where land is less expensive and a greater portion of structured parking where land is more costly. In a seeming paradox, the number of parking spaces per hectare tends to increase where it is less visible.

Using local land prices and typical construction costs the study estimated parking facility replacement costs in each city. Seattle's 1.6 million parking spaces are valued at $35.8 billion, approximately $118,000 per household. Jackson is home to over 100,000 parking spaces that would cost $711 million to replace, or $192,000 per household. The per-household share of the parking inventory in Des Moines and Philadelphia is $77,000 and $30,000 respectively.

The study found inconsistencies in the cities' data definitions and collection methods. On-street parking data were only available from the transportation department of just one city, Seattle. New York street parking analysis required integrating street and signage data, which required computer programming and database architecture skills. For the other three cities, on-street parking inventories were derived from the geometries of street line work. Parcel data was publicly available for all five cities, but each tax assessor recorded parking differently, making off-street structured parking inventories a custom job for each city. Almost all of the off-street surface parking data came from satellite or aerial imagery, yet these data differed in resolution and kind for each city. Despite these inconsistencies, the method used to build parking inventories may be transferable to generating parking inventories in other cities.

Parking Apps (www.eltis.org/discover/news/data-us-apps-you-netherlands-0)

The City of Amsterdam places available data on traffic and mobility at the disposal of residents and other interested parties free of charge, in order to optimize its services and create innovative mobility products. The slogan 'we have the data, you the apps' points out the aim of the project: to offer the opportunity for developers of applications and route planners to create new products or upgrade existing ones, such as apps with practical multimodal information, for the City.

The city makes diverse data available including information on parking options, such as parking places, prices and schedules. Touring car companies can check their proper parking places, the obligatory city route, hop off/hop on stops and the maximum passing heights. There is also real time information on public transport and the location of secure bike parking places. Some online information, such as parking tariffs and the location of loading blocks for electric vehicles is regularly updated.

Safe and Secure Truck Parking (https://ec.europa.eu/transport/themes/its/road/action_plan/intelligent-truck-parking_en)

Secure parking places for trucks and commercial vehicles has been listed as a top priority in the European Union's ITS Action Plan and the ITS Directive 2010/40/EU. European truck drivers need appropriate information on safe and secure parking places. They often have insufficient number of parking facilities and therefore park in non-secured zones or unsafe locations. Existing capacity needs to

be optimised by digital information on for instance the location, equipment and facilities of existing parking areas. Specifications have been adopted by the Commission (delegated Regulation (EU) N°. 885/2013) on 15 May 2013 to facilitate the exchange of data and to ensure EU-wide accessible information providing an up-to-date inventory of safe and secure parking spaces for trucks along the main European transport corridors to enable the provision of services.

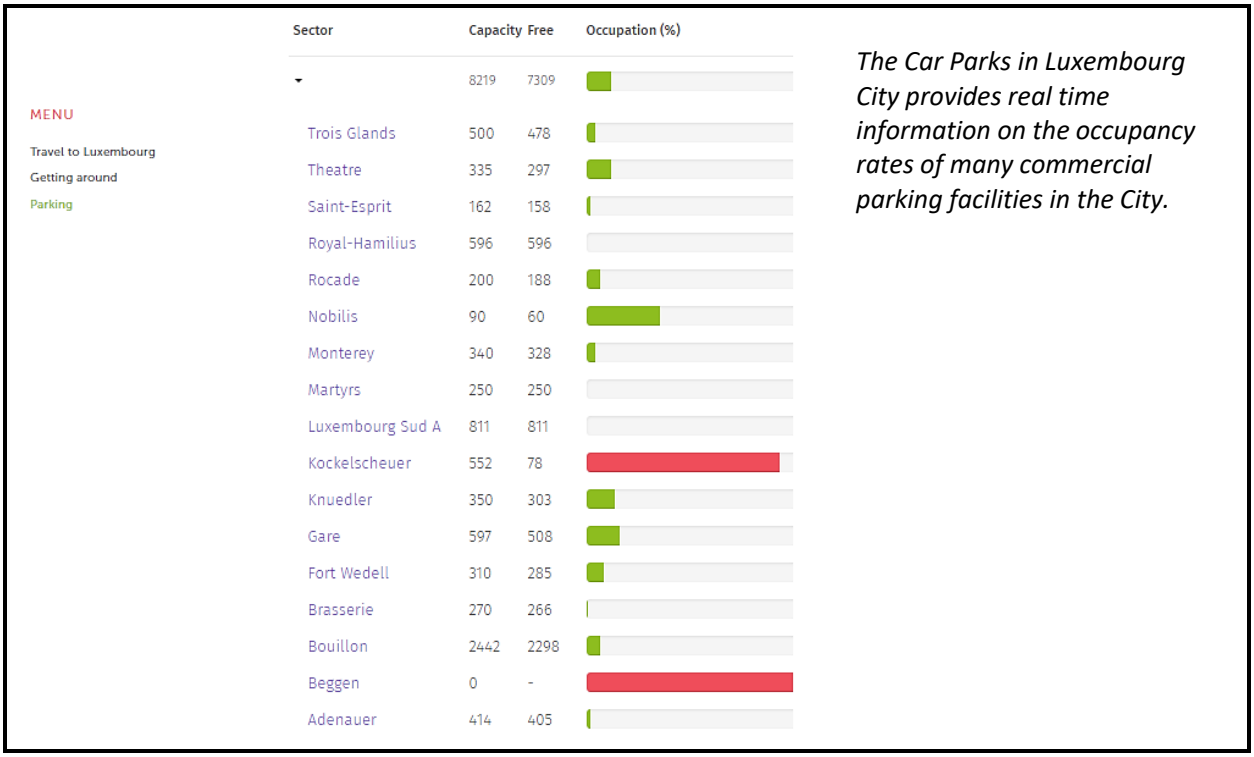
City Traffic Data (www.eltis.org/discover/news/city-collecting-traffic-data-support-sump-italy)

Molfetta, on Italy's Adriatic coast, is working with a private company to gather traffic data to inform the city's development of a Sustainable Urban Mobility Plan (SUMP). The company is recording the traffic flow on the city's road network, counting cars, buses and bicycles. This data will be compared with accident and pollution statistics, and supplemented by interviews carried out on public transport.

Aiming to create a traffic model of the city which is as complete as possible, Molfetta hopes to be able to simulate the effects of different measures to resolve certain problems. Data will be gathered on the city's parking facilities as well as on road use. The next steps will be to analyze the data to feed into a draft SUMP that will define the city's objectives and the strategies that will be used to achieve their outcomes. This draft will then be shared with stakeholders and the public for feedback.

Luxembourg City Parking Options (www.luxembourg-city.com/en/plan-your-stay/traveller-information/car-parks)

The *Car Parks in Luxembourg City* app provides real-time information on parking availability at various commercial parking lots around the city.



The Car Parks in Luxembourg City provides real time information on the occupancy rates of many commercial parking facilities in the City.

CROW, the Dutch Knowledge Platform

CROW, the Dutch Knowledge Platform for Transport, Infrastructure and Public Space (www.crow.nl/english-summary) publishes various parking planning and management resources (www.crow.nl/thema-s/parkeren), including new parking demand values and a parking demand tool (a software program) that municipal governments can use to establish parking standards for new developments: in suburban areas these value are used as minimum, and in central city areas they are often used as maximums (Mingardo 2016).

Dortmund Bids to Use 'Hidden' Parking Spaces (https://bit.ly/2XB7ahc)

Dortmund, Germany plans to tap unused private parking spaces to cut congestion and pollution and boost electric mobility. It hopes to use Federal *PuLS* (Parking & Shopping in the City) funding to put electric vehicle charging infrastructure in private parking areas and make it publicly available via a sharing platform. Research has suggested that as much as 30% of a city's traffic is people looking for somewhere to park. A study by Dortmund's planning office found that many residents' backyard parking spaces and garages are often unused during the day when residents drive to work. This project will require data on parking demands, including demand for electric vehicle recharging, private parking supply, and user information technologies.

Types of Parking-Related Information

This section describes various types of parking-related information.

Exhibit 7a Parking Supply Inventories

Definition	Number and type of parking spaces in an area.
Uses	Parking policy and planning analysis, economic analysis and parking management.
Categories	Type (surface, structured, underground, on-street), design, ownership (public, private), location, regulations, prices and amenities (security, electric vehicle charging stations, etc.).
Collection methods	Special surveys, property records, and remote sensing (aerial and satellite photos).
Current practices	Local governments often commission parking supply inventories, but the results are often incomplete, for example, including public but not private parking, retail but not residential, and lacking key information such as size, price and amenities. The city of Luxembourg has an inventory of municipal off-street parking spaces but not of their on-street parking places. More complete inventories exist for some areas, such as Esch, Belval and Dudelange. The MOB has a geocoded database of all de Park and Ride spaces, which totals about 18,000 spaces.
Recommended Improvements	Local governments should collect comprehensive parking supply information suitable for including in property assessment databases and geographic information systems. This should include all types of parking, and all significant location, ownership, design, prices and attributes.
Key References	Barter (2016); Chester, et al. (2015); CROW 2018; ITE 210 and 2016; Scharnhorst (2018)
Recommended Actions	Establish national parking inventory standards to ensure that the data are consistent and compatible. This should define data categories, collection methods and database formats.

Exhibit 7b Parking Demands (also called "Parking Generation")

Definition	Models that predict the number vehicles that will need to park at a particular time and location, and factors that affect those demands.
Uses	Parking policy and planning analysis, project evaluation, parking management planning.
Categories	Facility type (on- and off-street), land use type (residential, retail, commercial), user type (delivery, commuter, customer, residential), vehicle type (car, bus, truck, taxi), location and time.
Collection methods	Census and government vehicle registration data, regional travel surveys, special surveys and studies, and generic (not city specific) vehicle trip generation and parking generation models.
Current practices	Most jurisdictions have traffic models that predict the number of and types of trips that will be generated to and from specific locations, and therefore parking demands. Census and travel surveys measure the number of vehicles owned by various types of households (considering age, income, employment, location, etc.) which can be used to predict parking demands. The Institute of Transportation Engineer's *Parking Generation* reports and software provide generic estimates of parking demands for various land use categories. CROW, the Dutch Knowledge Platform for Transport, Infrastructure and Public Space, publishes parking data and a demand model for The Netherlands. The Luxembourg government has vehicle ownership data, and a general travel survey (Luxmobil) was performed in 2017.
Recommended Improvements	Consult with stakeholders (planners, transport engineers, etc.) to evaluate current parking generation modelling practices in Luxembourg, and ways to improve it, including targeted studies needed to develop more accurate parking generation models that account for additional factors, such as effects that demographic shifts, non-auto travel improvements, and financial incentives would have on parking demands.
Key References	CROW 2018; Gribb 2015; ITE 2010 and 2016;
Recommended Actions	MDDI commission development of parking demand models, similar to those produced by ITE and CROW, that can predict vehicle ownership and trips, and therefore parking demands, accounting for demographic, geographic, economic and management factors.

Exhibit 7c Land Use Development Affecting Parking Supply and Demands

Definition	Data on current and future land use development (houses, employment, retail activity), and therefore parking supply and demands in specific areas.
Uses	Parking policy and planning analysis, transport and parking facility project evaluation, parking management planning.
Categories	Land use type (residential, retail, commercial), location, density, mix, parking supply and management practices.
Collection methods	Planning documents, real estate market projections, and building applications.
Current practices	All jurisdictions have GIS databases with current land use information, and plans (PAGs) which predict future development. Luxembourg's four sectorial plans (Transport, Zone of Economic Activity, Landscape and Housing) provide national development information. However, there is no comprehensive analysis of their parking demands.
Recommended Improvements	GIS databases should include parking data. Analysis of future developments should consider opportunities for sharing parking facilities and encouraging non-auto travel.
Key References	Regional development plans. Rye 2010; Steiner, et al. 2012; Willson 2015
Recommended Actions	Develop high and low estimate of parking needs for local area. High values will typically reflect current parking supply practices, low values will reflect the parking supply that will be required if cost-effective parking management strategies are implemented.

Exhibit 7d Trends Affecting Future Parking Demands

Definition	Develop projections of demographic, land use development, economic, and transport trends that may affect future parking supply and demands, and planning needs.
Uses	Parking policy and planning analysis, minimum parking requirements, parking facility project evaluation, parking management planning
Categories	Demographic (population growth and type), land use development (building type, density and mix), economic (business activity, employment and incomes) and transport (quality of travel options, pricing, new technologies) trends are likely to affect future parking demands.
Collection methods	Demographic and economic projections. Vehicle ownership data, travel surveys, trip generation studies and special studies.
Current practices	Most jurisdictions commission travel surveys and have travel models which are used to predict future trip generation rates in specific areas, and travel volumes on specific corridors. These models consider various factors that are likely to affect future travel demands. Luxembourg has a national travel demand model based on the PTV Visum platform.
Recommended Improvements	Improve travel models to better predict the effects of travel and parking management strategies such as improved travel options, road and parking pricing, and mobility management.
Key References	National demographic and economic growth projections. Nourinejad, Sina and Roorda 2018.
Recommended Actions	Support transport model improvements to more accurately predict how demographic, development, economic and transport factors will affect future parking demands.

Exhibit 7e Parking Facility Occupancy, Availability and Utilization Rates

Definition	Number of parking spaces occupied at specific locations and times, frequency that motorists have difficulty finding suitable parking spaces, and frequently spaces are occupied.
Uses	Parking policy and planning analysis, parking problem identification, evaluating facility efficiency, parking management planning.
Categories	Facility type (on- and off-street), land use type (residential, retail, commercial), user type, vehicle type (car, electric car, bus, truck), location, time.
Collection methods	Field surveys, automated systems (embedded sensors, cameras, and entrance-exit counts), remote sensing (aerial and satellite images).
Current practices	Most jurisdictions occasionally commission parking occupancy surveys in commercial areas to identify parking problems. The MDDI performs annual occupancy surveys at Park and Ride lots. Some car parks in Luxembourg City have real-time occupancy but many of these are privately owned so the results are not available to planners.
Recommended Improvements	Commission regular parking occupancy services. Where possible, implement automated parking occupancy reporting systems, such as in-pavement sensors or cameras. Encourage or require private parking operators to supply these data in standardized formats.
Key References	https://data.public.lu/en/datasets/mobilite-circulation-et-parkings
Recommended Actions	Establish national standards for parking occupancy data collection using field surveys, automated systems and remote sensing. Encourage or require businesses and local governments to collect these data and make them available for planning purposes.

Exhibit 7f User Parking Availability and Price Information

Definition	Information for users on parking availability and prices.
Uses	Allows motorists to easily find parking spaces that meet their needs.
Categories	Current (real time) and future parking space availability, price, and amenities (secure parking for freight trucks and electric vehicle charging stations).
Collection methods	Sensors or cameras which provide real-time information on parking space occupancy, with information on attributes such as price, size, security and amenities.
Current practices	Some commercial parking facilities (parking rented to the public) have real-time occupancy and price information on signs, websites and apps, but this information is not comprehensive. The *Car Parking in Luxembourg City* website provides real time information on current occupancy rates of major off-street parking lots. Other websites provide information on electric vehicle charging stations (https://chargy.lu/en) and carshare parking (www.zipcar.com).
Recommended Improvements	Develop automated and standardized availability and price information for public parking facilities, and make this information available for websites and apps. Include on- and off-street, municipal and private, price and availability, and special needs parking (disability, electric vehicle charging, large vehicle, long-term, etc.) Encourage or require private operators to supply data in standardized formats.
Key References	https://data.public.lu/en/datasets/mobilite-circulation-et-parkings.

Research questions	Develop a plan for expanding official websites and apps to include more parking information, including more types of parking facilities and information.

Exhibit 7g Parking Facility Costs

Definition	The full costs of building and operating parking facilities suitable for planning and economic evaluation.
Uses	Parking policy and planning analysis, project evaluation, and program evaluation, for example, to account for the savings provided by parking management and TDM strategies.
Categories	Cost category (land, construction, operation, and environmental impacts), type (surface, structured, underground, on-street), and location.
Collection methods	Special surveys and studies, accessor analysis, and industry reports.
Current practices	Parking facility costs are generally estimated from building and parking industry sources, and special studies. Due to a lack of standard parking facility cost data, these costs, and the savings from reduced automobile travel, are often overlooked in the economic evaluations of parking management, TDM and non-auto mode improvement programs.
Recommended Improvements	Commission special studies that estimate costs of various types of parking facilities.
Key References	Auchincloss (2014); Carl Walker 2016; Chester, et al. 2015; Cudney 2013; Scharnhorst 2018; Woudsma, Litman, and Weisbrod 2006.
Recommended Actions	Commission studies that estimate the costs of various types of parking facilities. Collect information on parking facility land, construction, operations and environmental costs.

Exhibit 7h Parking Facilities Prices, Revenues and Cost Recovery

Definition	Prices charged for parking facility use, revenues generated, and portion of costs paid by users.
Uses	Parking policy and planning analysis, social equity analysis, project economic evaluation, and parking management planning.
Categories	Facility type (on- and off-street), ownership (public or private), land use (residential, retail, commercial), user type (delivery, commuter, customer, visitor, residential), vehicle type (car, bus, truck), location, time.
Collection methods	Special surveys, commercial parking company tax reports.
Current practices	Parking price information is generally available, but revenues and cost recovery information are often considered proprietary and so are not generally reported. Park and Ride parking is free, and little information is available on government parking facility revenues.
Recommended Improvements	Impose revenue reporting requirements on commercial parking operators.
Key References	Auchincloss (2014); Gabbe and Pierce 2016; Pierce and Shoup 2013; San Francisco 2009; Shoup 2005; SFPark 2012; Spears, Boarnet and Handy 2014;

Research questions	Incorporate price information into parking inventories. Established standards for parking revenue data reporting by private operators and municipal governments.

Exhibit 7i Problems, User Satisfaction and Complaints

Definition	The degree that users experience parking problems and are satisfied with their parking experience.
Uses	Parking problem identification, policy and planning analysis, parking management planning.
Categories	Types of problems (inadequate supply, excessive prices, inadequate user information, payment difficulties, unclean, unsafe, etc.), user type (delivery, commuter, customer, visitor, residential), location, time.
Collection methods	User surveys, complaints, and violations.
Current practices	Most government and commercial parking organizations track complaints and compliance, and some perform user satisfaction surveys.
Recommended Improvements	Include indications of user satisfaction, complaints, compliance, and possible improvements in parking program evaluation.
Key References	Childs 1999; Rye 2010; Steiner, et al. 2012; Tyler, et al. 2012; Willson 2015.
Recommended Actions	Commission parking user satisfaction surveys. Incorporate questions concerning parking user satisfaction into travel and consumer surveys. Establish ways for users to report parking problems to local governments.

Exhibit 7j Parking Performance Evaluation

Definition	Standardized data for evaluating policies and programs. This should reflect indicators that are *meaningful* (the information is useful for identifying problems and evaluating progress toward goals) and *measurable* (data are reliable, consistent and obtainable).
Uses	Program evaluation, problem identification, comparisons and trend analysis.
Categories	Parking occupancy, travel trends (reductions in auto trips and mode share), program cost-efficiency (program costs relative to cost savings), local economic activity, and user satisfaction.
Collection methods	Various methods for different types of data including field surveys and automated data collection, travel surveys and counts, economic evaluation studies, user surveys and complaints.
Current practices	Parking management programs have not been widely implemented in Luxembourg. Some transportation programs have performance indicators, but they are not standardized.
Recommended Improvements	Identify various policy and program performance indicators, including inputs (costs), outputs (changes in parking supply and travel activity) and outcomes (impacts on ultimate goals such as development and employment, parking and traffic congestion, user costs, and user satisfaction).
Key References	Ison and Mulley 2014; Manville and Shoup 2005; McCahill and Garrick 2014;

Recommended Actions	Develop standard parking and transportation management performance indicators related to their benefits, costs, travel impacts, and user satisfaction.

Parking Data Recommendations

This section provides recommendations for data sets to support Luxembourg's Parking Strategy.

Parking Supply

MDDI should establish standards for comprehensive, consistent and integrated data on parking supply, which can be incorporated into local, regional or national databases. This information can be collected during assessment surveys and incorporated in property record databases. The database should indicate parking facility type (surface, structured, underground, on-street), ownership (public, private, commercial), design (size of spaces), location, regulations, prices, and amenities (security, electric vehicle charging stations, etc.). This information should be suitable for GIS mapping.

Parking Demands

Luxembourg's general travel survey (Luxmobil) and travel demand models should be improved to predict vehicle ownership and trip generation in specific locations and times, taking into account land use development, demographic, economic and transport trends. This information should be used to predict parking demands for various types of trips (delivery, commuter, customer, and residential), vehicle types (car, bus, freight truck, taxi, and electric vehicles) at specific locations and times.

These models should be augmented with targeted research concerning how various geographic, demographic, economic and management factors affect parking demands in Luxembourg, for example, how vehicle ownership and parking facility occupancy rates vary by affected people's income and age, proximity to local services, walkability and public transit access, and price. The CROW Parking Demand Model could serve as a model.

MDDI could commission targeted studies that investigate how demographic (population growth and type), land use development (building type, density and mix), economic (business activity, employment and incomes) and transport (quality of travel options, pricing, new technologies) trends are likely to affect future transport and parking demands.

Parking Facility Occupancy, Availability and Utilization Rates

MDDI should establish national standards for parking occupancy data collection using field surveys, automated systems (embedded sensors, cameras, and entrance-exit counts), remote sensing (aerial and satellite images). Encourage or require businesses and local governments to collect these data and make them available for planning purposes. This information should reflect locations, times and vehicle types. It should be structured to help identify where and when parking facilities exceed maximum occupancy targets (85% for high-turnover uses such as delivery vehicles, passenger drop-off/pick-up, and quick errands, and 95% for longer-term uses such as commuting, park-and-ride and residential parking), including analysis of specific users such as freight truck, taxi or electric vehicles. This information should be structured so it can be used to provide comprehensive and current parking availability and price information to users on maps, websites and apps.

Parking Facility Costs

MDDI should commission studies of current and future parking facility costs (land, construction, operations and environmental damages), prices, revenues and cost recovery, categorized by type (surface, structured, underground, on-street), ownership (public, private, commercial), design (size of spaces), location and amenities (electric vehicle charging stations, etc.). This information should be regularly updated.

Problems, User Satisfaction and Complaints

Commission surveys to identify parking problems, user satisfaction and complaints. Incorporate questions concerning parking user satisfaction into travel and consumer surveys. Establish ways for users to report parking problems to local governments. Work with local organization to perform user satisfaction surveys in specific areas, such as commercial districts.

Parking Performance Evaluation

MDDI should work with other organizations (other government agencies and professional organizations) should establish standard transportation and parking program performance indicators. These should include indicators that are useful for problem identification, planning analysis and performance evaluation. The following are examples of parking-related performance indicators.

- **Parking program costs and cost recovery.** Information on the costs of providing parking facilities and operating parking management programs, revenues and cost recovery, suitable for analyzing cost-efficiency (costs per space or user) and comparisons between different times and locations.
- **Facility and service quality.** Quality of parking facilities (convenient, clean, attractive and safe), user information (available, understandable and accurate), and services (friendly and responsive).
- **Parking facility availability and occupancy.** Data on the frequency with which motorists have difficulty finding suitable parking spaces, and the portion of parking spaces occupied at various times and locations, suitable for efficiency analysis.
- **Planning consistency.** Degree that parking policies and programs support strategic planning objectives including maximizing local economic development (more businesses, employees and residents), reducing traffic problems, and environmental protection.
- **Use satisfaction, complaints and compliance.** Municipal governments or other local parking planning organizations should perform regular user satisfaction surveys, and track parking program complains and compliance. This information should indicate, as much as possible, user type (commercial vehicle, commuter, customer, visitor, resident), parking facility type and location (on-street, off-street and commercial), and type of problem.

Performance data should be regularly (at least annually) reported.

As much as possible this information should use standardized definitions and categories so it is compatible with data collected in other jurisdictions and organizations. For example, vehicle categories (motorcycle, car, van, bus, freight truck) should be consistent with those used by the EuroStats and other international agencies. If possible, parking pricing data should be defined and collected to be consistent with Colliers International Parking Rate Surveys.

Much of this data should be geocoded for analysis and mapping purposes. Parking facilities serve an area within convenient walking distance, which generally ranges from 50 meters, for deliveries, people with disabilities, and quick errands, up to about 1,000 meters for lower-income commuters and special event attendees, who may walk up to 10 minutes to minimize their parking costs. As a result, parking data must generally be provided at a fine geographic scale.

Exhibit 6 summarizes recommended data collection types, their categories and collection methods.

Exhibit 6 **Parking-Related Information Needs**

Data Type	Categories	Recommended Actions
Parking supply	Type, ownership, location, regulations, prices and amenities.	Establish national parking inventory standards.
Parking demands	Facility type, land use type, user type, vehicle type, location, time, for current and future conditions.	Commission development of models that can predict parking demands in a particular situation.
Land use development	Land use type, location, parking supply and management practices.	Develop high and low parking needs estimates in local development plans.
Trends affecting parking demands	Demographic, land use development, economic and transport trends that may affect future parking demands.	Support transport model improvements to more accurately predict how demographic, development, economic and transport factors will affect future parking demands.
Parking facility occupancy, availability and utilization	Facility type, land use type, user type, vehicle type, location, time.	Established parking occupancy data collection standards. Encourage or require businesses and local governments to collect these data and make them available for planning purposes.
User parking availability and price information	Current and future parking space availability, price, and amenities.	Develop a plan for expanding official websites and apps to include more parking information.
Parking facility costs	Cost category, type, and location.	Commission studies that estimate parking facility costs.
Parking facilities prices, revenues and cost recovery	Facility type, ownership, land use, user type, vehicle type, location, time	Special surveys, commercial parking company tax reports.
Problems, user satisfaction and complaints	Types of problems, user type, location, time.	Commission parking user satisfaction surveys. Incorporate parking user satisfaction questions into travel and consumer surveys. Establish ways to report parking problems to local governments.
Parking performance evaluation	Parking occupancy, travel trends, program cost-efficiency, local economic activity, and user satisfaction.	Develop standard parking and transportation management performance indicators related to their benefits, costs, travel impacts, and user satisfaction.

This table summarizes parking-related data times, their current availability, and possible improvements.

Conclusions

The Grand-Duchy of Luxembourg is developing a national parking strategy that will help align parking planning decisions with strategic planning goals. A key first step is to identify the data needed for parking policy and planning analysis, and research purposes. This report identifies those needs and provides specific recommendations for collecting these data.

Because parking planning decisions can have diverse impacts, their evaluation requires diverse data including current and future parking supply, demand, occupancy, costs, prices, user satisfaction, and program performance. Much of these data are currently collected, but often in ways that incomplete, incompatible or difficult to use. Standardizing data definitions, collection methods and data management can minimize the costs and maximize the utility of this information. Since parking is part of the transportation system and affects land use development, these data should be integrated with transport and land use development data sets.

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