Literature report on integration of cycling data with non-cycling systems and services

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1. Preface

The Bicycles and ITS (BITS) project is focused on the use of ITS systems in the cycling domain, with the aim to make cycling a more attractive mode of transport. Every ITS system by definition produces data, in the case of BITS cycling data. In the BITS project many of these data are made accessible through the CycleDataHub.

In this report we describe how cycling data are connected to other data types, just like cycling is not just a mode in itself but is integrated in the overall mobility system. For example, as first or last mile solution in a multimodal trip.

The first chapter, written by the province of Antwerp, is about the CycleDataHub and other platforms developed within the BITS project. It also discusses the steps that are being made towards more standardization and the involvement of the BITS project in this.

The second chapter, written by province of Overijssel, covers the availability of cycling data in the National Access Points and the mobility data strategy of the European Commission.

The third chapter, also written by Overijssel, discusses relevant standards for cycling data and MMTIS.

The fourth chapter, written by the university of Oldenburg, covers lessons learned from data analyses, including case studies on the use of cycling data for various purposes, such as analyzing cycling behavior and environmental data. It also discusses privacy and standardisation issues.

The fifth chapter, written by CIE, discusses the linking of cycling (data) with public transportation (data), including the use of shared bikes and the integration of cycling into MaaS and smart city apps.

The sixth chapter, written by the East Riding of Yorkshire Council (ERYC), covers the Social Value Engine. It explains their implementations, the engine and the potential of using it to make investment decisions in cycling infrastructure, using data from surveys.

2. Introduction to the CycleDataHub

2.1. Introduction

The bicycle can safely be called a wonder for mobility and has been defined scientifically as a solution for a number of societal problems. To name but a selection: It has numerous health benefits, it is a key tool in the fight against climate change. It has a considerably smaller spatial footprint compared to cars. It is financially beneficial, and it has a number of social and safety advantages. It is, not restricted to mobility alone but overall, a smart choice.

However, in order for the low-tech bicycle to be integrated in the smart city and the smart region, it must claim its place in the smart world. This is the purpose of BITS: to identify and consolidate the bicycle in this smart technology, to promote its presence, to experiment.

This is why the BITS project has a strong focus on pilots, and more generally on bringing together industry, research and policy makers.

BITS stands for Bicycle and Intelligent Transport Systems. Whatever one understands under intelligent transport system, it is clear that this can involve all types of transport systems (public transport, shared cars/bikes/steps, and privately owned cars, bicycles and other modes, pedestrians, transport over water and air), and can involve all types of intelligent systems. Therefore, the integration of the bicycle in such systems is what we understand in the broadest sense as a means to integrate the bicycle in ITS. It is about integrating the bicycle in 'smart city', 'smart region', 'smart mobility', 'smart ticketing', AI, machine learning, MaaS, bicycles with sensors, bike applications, etc.

2.2. BITS and non-cycling

To identify where bicycles enter the smart realm, we need to recognise the bicycle data formats that are compatible with the smart systems, the broader ITS. The BITS pilot projects (WP3) categorised the different pilots in 4 sets, all with their specific users and specific purposes:

- Category 1: Infra-based ITS,
- Category 2: Bicycle data collection,
- Category 3: Information provision to cyclists
- Category 4: Interactive systems

These and other thematic subdivisions make sense and can be traced back in any of the BITS web deliverables. One can search/filter for formats/licences in the CycleDataHub (CDH), for companies and services in the BITS Directory and for standardised formatted datasets in the bicycle-data.eu website.

2.2.1. CycleDataHub

The CycleDataHub (hence CDH) made an attempt to visualise the current status of what bicycle related data are available, per region, per theme, whether we want to monitor:

- Cycle Use
- Cycle infrastructure
- Environmental/Emissions
- (Personal) health
- Safety
- Bicycle Business Performance

What we have learnt so far from the CDH is that there is a gap between policy and innovation/commerce, that needs to be bridged. This gap exists in both knowledge/experience and in purpose.

Policy makers want to monitor use, infrastructure, safety, health and provide public services to their citizens. At the same time, they are searching to open up data, to make them transparent (these data were paid with tax money), enable the integration of these information sources in any innovative platform/application, in short make the best use of the invested data collection.

Commerce on the other side (together with research and development) create data, create innovation. Whereas mobility policy is the public service for the citizen, the commercial company has clients, it has to collaborate with other companies and public services, but it also wants to protect its investments and products.

Also, the level of technological know-how on the policy, research and commercial parties can be largely divergent, leading to many misunderstandings. On this level, BITS has been a tremendous learning school for all of the stakeholders, especially considering the low-tech basis of the bicycle and most of its promotors.

Perhaps for this reason, it should not come as a surprise that of the 290 datalinks in the CDH, 240 (or 82%) are owned or entered by a government. Also, most of these datalinks are aimed at **monitoring**. Equally, most of these datalinks are bicycle counts. All of the governments are sharing the bicycles counts.

These bicycle movement counts are useful for governments to measure trends in bicycle use and they can also be used to define prioritization for new, wider, better cycle infrastructure. They can even be used to trigger some warning system, in which case the digital connection between bicycle movement and non-cycling modes (a sensitizing/warning system based on either/or number/speed/direction of cyclists on a crossroad) has a direct influence on the cyclists.

An example is the pilot of Aarhus, where a radar detects cyclists coming down at a certain speed and automatically extending the green phase of the traffic light so that the cyclists can still cross at green.

The Schwung app as applied in a pilot in Zwolle is another example of the interaction between cyclists and a non-cycling systems where the cyclists can directly influence the green phase of traffic lights with an activated app in a selected number of Dutch cities/municipalities.

Much the same, using different sensors in a cycle path, a number of traffic research companies now offer cyclist detection systems that use the measured number, speed, and direction of detected bicycles to trigger digital signs, or other safety systems. All of these detecting techniques can therefore be enriched with a warning/sensitizing/informing device (a cycle counter with display, a sign enhanced with led lights, safety systems at cycle or pedestrian crossroad).

These and other datasets, such as shared-bike management systems, bike parking management systems, smart traffic lights and enhanced tracking systems are hardly present in the CDH, for which reason, we have little insight in the data formats, and/or exchange formats of these systems.

The BITS project however does have the BITS Directory that provides a better overview of the businesses and their products.

2.2.2. BITS Directory

The BITS directory has subdivided commercial partners in

- Multimodal Cycling
  - Bike-sharing and other sharing
  - MaaS
  - Multi-modality
- Encouraging Cycling
  - Gamification
  - On-bike Technologies
  - Reporting
  - Rewarding Cyclists
  - Route Planners
  - Safety of Cyclists
  - Smart Locking
  - Smart Parking
  - Traffic management and dynamic routing
- Interactions (B2X)
  - Bike-to-vehicle/to-bike/to-Infrastructure tech
  - Collaborative ITS (C-ITS)
  - Collaborative, Connected and Automated Mobility (CCAM)
  - ISA and speed control
  - Vulnerable Road User ITS (VRUITS)
- Data Processing
  - Big data
  - Counting, measuring, and aggregating
  - EU's National Access Points
  - Privacy/data security
  - Standardisation of data
- Data Analysis
  - Propensity to cycle 'tools'
  - Counting, measuring, and aggregating data (i.e. Dashboards)
  - Cycling industry internal data (i.e. sales)
  - Data for infrastructure
  - Research and market intelligence
- Phase (implemented, pilot, planned, seeking investment, stopped)
- Best Practices
- Target Market
  - B2A (business to administration)
  - B2B (business to business)
  - B2G (business to government)

While the CDH has a high focus on the content, format and European coverage, the BITS Directory provides a quick insight and a tool for tendering in the businesses that provide the services for non-cycling integration. In particular, the topics ‘multimodal’, ‘encouraging’ and ‘interactions’ are focused on the integration of cycling in the wider smart city systems, IoT etc.

2.2.3. Bicycle-data.de

If we want to have an idea on the potential of enriching, and opening up bicycle data, the website bicycle-data.de built by the Very Large Business Applications (VLBA)/ business informatics department of the Carl von Ossietzky University Oldenburg can also be informative. This part of the BITS project has experimented with collecting a large number of datasets and suggesting a number of machine-readable, exchangeable data formats for these datasets. Also, they built a number of dashboards with KPI’s allowing for comparing cities/regions, analysing a city, a graphical presentation and a download of standardised datasets and short URLs. The experimental nature of the exercise makes the data not directly useful for proper analysis, and fine-tuning is certainly needed, the KPI’s however allow for valuable monitoring of bicycle variables per region, per topic: Counting, Parking, Near Accidents and Sniffer Bike, and bicycle app. See 6.3.6 for more information on bicycle-data.de.

2.3. Standardisation

Essential for the inclusion of the cycle data of any format to non-cycling systems is the continued effort and encouragement for standards. In particular, probably because of the availability of a geographical wide spread of datalinks of bicycle counting systems, a special effort was made within the BITS context to encourage the transformation of the different commercial formats of bicycle counts to the DATEX II profile as described on the Dutch website Nationaal Dataportaal Wegverkeer (NDW). A brief investigation in the initiatives towards a common standard for bicycle count was done, whereby the NDW, Fietsberaad Vlaanderen, Fietsberaad Nederland, CROW and the Agency for Roads and Traffic Flanders (AWV) and writer of the Dutch standard Bard de Vries were compared and considered. The Dutch standard was then implemented in the Provinciale fietsbarometer (Province of Antwerp) and for all of the bicycle counts in the bicycle-data.de website from Oldenburg university.

Datalinks forwarding to an API are probably the most readily prepared systems for integration in non-cycling systems. These are designed with that exact purpose, namely to communicate with other computer systems. In this respect, the CDH contains 13 links (from Telraam, Snifferbike, Velopark). Apart from these links, we are aware of other companies and government agencies that provide online platforms and api’s as a service. Non exhaustive, we can name: Eco-counter, Signco (with Metanous), CycleData, Krycer, Geo Square, Hermes Traffic Intelligence, and a number of government agencies, but a simple google search will provide ample examples with combined API and geoservices like GeoJSON, csv, shp, wms, wfs.

3. Relevance of National Access Points and other EU data initiatives for cycling data

The BITS CycleDataHub is an online platform that gives access to various types of cycling data, mainly from authorities within the North Sea Region countries. It is a unique platform, since it is purely focused on cycling. However, many other data initiatives exist across Europe, covering cycling and other modes of transport. This section will describe a number of the most relevant European developments in this field.

3.1. Delegated Regulations on Travel Information Services

In 2013 the European Commission published the first two Delegated Regulations with respect to National Access Points, followed by two other Delegated Regulations in 2015 and 2017 respectively. In 2022 the Delegated Regulation on RTTI was revised. These Delegated Regulations are shown in the table below (source: EU EIP project).

Delegated Regulation	Theme	Common Reference
(EU) No 885/2013	The provision of information services for safe and secure parking places for trucks and commercial vehicles	Safe and secure truck parking (SSTP)
(EU) No 886/2013	Data and procedures for the provision, where possible, of road safety-related minimum universal traffic information free of charge to users	Safety related traffic information (SRTI)
(EU) 2015/962 (EU) 2022/492*	The provision of EU-wide real-time traffic information services	Real-time traffic information (RTTI)
(EU) 2017/1926	The provision of EU-wide multimodal travel information services	Multimodal travel information services (MMTIS)

* applies from 2023 (some part) and 2025

Table 3.1: Commission Delegated Regulations and corresponding ITS Directive priority actions

From the perspective of cycling data, the most relevant Delegated Regulation is the one on Multimodal Travel Information Services (MMTIS). For the future also the revised Delegated Regulation on Real Time Traffic Information is relevant, since in the future it will also be applicable to roads not belonging to the core and comprehensive network, which means that it will also apply to e.g. the urban network, where most of the cycling takes place.

In the first step, the MMTIS defines *static data* uploaded from transport operators and authorities, infrastructure managers, and transport on-demand service providers. In a second step, optionally, *dynamic data* can be made available once the Member States decide to do so.

The **static data** to be exchanged includes (but is not limited to):

- Level 1
  - Local search (origin/destination, access nodes, geometry/layout, points of interest)
  - Trip plans (calendar, mapping day types to calendar dates)
  - Trip plan computation — scheduled modes transport (interchanges, routes/lines, transport operators, timetables, stop facilities access nodes, vehicles, accessibility
  - Stop facilities and accessibility
- Level 2
  - Stop search (transport on demand)
  - Bike sharing stations / Carsharing stations
  - Refuelling /electric charging stations
  - Information services: tariffs, complementary information, trip plans
- Level 3
  - Detailed common standard and special fare query (all scheduled modes)
  - Information on how to book and pay for the services
  - Where how to pay for car parking, public charging stations for electric vehicles, and refuelling points
  - Detailed trip plans
  - Trip plan computation

As for optional **dynamic data**, some examples include:

- Level 1
  - passing times, trip plans, and auxiliary information (disruptions, delays, cancellations)
  - status of access node features (including dynamic platform information, operational lifts/escalators, closed entrances, and exit locations)
- Level 2
  - Passing times (estimated departure and arrival times of services, current road link travel times)
  - Information services (availability of publicly accessible charging stations for electric vehicles and refuelling)
  - Availability check (carsharing availability, bike sharing availability, car parking spaces available (on and off-street), parking tariffs, road toll tariffs)
- Level 3
  - Trip plans (future predicted road link travel times)

3.2 Status of NAP for Multimodal Travel Information Services

In June 2022 the NAPCORE project (www.napcore.eu) has published a report including a description of the current status of implementation of the National Access Point for the provision of Multimodal Travel Information Services, in short 'NAP for MMTIS'. This Delegated Regulation is currently under revision.

	2016	2017	2018	2019	2020	2021
Austria	Planned /2018)	Planned /2018)	Planned	Operational	Operational	Operational
Belgium	-	-	Planned	Planned	Operational	Operational
Bulgaria	-	-	-	-	-	Operational
Croatia	-	-	Planned	Planned	In progress	Operational
Cyprus	Planned (2018)	Planned (2018)	Planned	Operational	Operational	Operational
Czech Republic	-	-	Planned	Planned	Operational	Operational
Denmark	Planned (2019)	Planned (2019)	Planned (2019)	Planned (2020)	Operational	Operational
Estonia	-	-	Planned (2020)	Planned (2020)	Operational	Operational
Finland	Planned (2018)	Planned (2018)	Implementation	Implementation	Operational	Operational
France	-	-	Implementation	Operational	Operational	Operational
Germany	-	-	Planned	Operational	Operational	Operational
Greece	-	Planned	Planned	Planned	Implementation	Operational
Hungary	-	-	Planned	Planned	Planned	Planned
Ireland	Operational	Operational	Operational	Operational	Operational	Operational*
Italy	-	-	-	Planned	Planned (2021)	No answer
Latvia	-	-	Planned	Planned (2022)	Planned (2023)	Operational
Lithuania	-	-	-	Operational	Operational	Operational
Luxembourg	-	-	Planned (2019)	Operational	Operational	Operational*
Malta						Not Operational
Netherlands	-	-	Planned	Planned (2020)	Operational	Operational
Norway	-	Planned (2019)	Planned (2019)	Operational	Operational	Operational
Poland	-	-	-	-	-	No answer
Portugal	-	-	-	-	-	No answer
Romania	-	-	-	-	Planned (2022)	Implementation
Slovakia	-	-	-	-	Planned	Implementation
Slovenia	-	Planned 2020	Planned (2020)	Planned (2020)	Planned (2021)	No answer
Spain	-	-	-	Planned (2020)	Planned (2021)	Operational
Sweden	Planned	Planned	Planned	Planned (2020)	Operational	Operational
Switzerland	-	-	-	-	-	Planned
United Kingdom	-	-	-	-	-	No answer

*Countries that did not answer the survey (No answer) but had an operational NAP in 2020

Table 3.2: Status of NAPs for Delegated Regulation for multimodal travel information services

It can be concluded that there was an increase from one country in 2016, to 20 countries in 2021, regarding the countries that had an operational or implemented (partly operational) NAP, referring to data of the DR (EU) 2017/1926.

In table 3.3 – 3.6 below, the status of each MMTIS NAP (2020) is summarized according to the data categories from the Directive Delegated Regulation for the provision of EU-Wide Multimodal Travel Information Services (EU) 2017/1926 that divides the MMTIS information into several levels of static and dynamic data. This information was collected by the EU EIP project (www.its-platform.eu) in 2020.

In summary, some differences are identified in the adoption of the MMTIS NAPs by the different Member States, such as the following:

- The integration and organization of the datasets on the NAP websites. Some MMTIS NAPs are a website repository with links redirecting to an external entity. Others are focused on a repository of metadata (e.g., Lithuania). Yet, some others are focused on providing a user interactive platform for trip planning.
- European nomenclature harmonization regarding data categories and contents in each MMTIS NAP, with common tags regarding modes of transport and data categories according to the Delegated

Regulation (EU) 2017/1926 for MMTIS, would be helpful in uniformizing the data access.

- The clarification of the end-user of the MTTIS NAPs: data user entities or passengers. Some NAPs are focused on being a repository of links or datasets. Others like Cyprus and Estonia are focused on the final user (i.e., a passenger) providing an interactive platform.
- European legal harmonization regarding licensing data usage. Some countries make a clear division between license and contract. Some ask for a signed agreement; others registering. Such differences might create barriers in the data access.
- Quality of data. It might be difficult to access and estimate the quality of the data since the organisation is the only responsible for making sure that the data corresponds to what is declared in the metadata specification. In order to maintain a high quality of data, NAPs are strongly instructing API connections to adjust any changes in the data.

More detailed information on the multimodal travel information data per country, including cycling data and public transport data, available through the NAPs can be found in the EU EIP NAP 2020 Annual Report. In this report among others the following information on cycling is given:

- General Information on Route/trip Planning
- Bike sharing
- Bike Parking
- Cycling networks
- Public information: operational information
- Public transport: location information
- Public transport: fare and purchase information
- Railway Data
- Road networks & travel times
- Free-floating Vehicles (scooters)

			Data category according to COMMISSION DELEGATED REGULATION (EU) 2017/1926 of May 31 2017	AU	BE	CY	CZ	DK	EE	FI	FR	DE	HU	IE	IT	LT	LU	MT	NL	NO	PL	SE	CH	UK
Static Data	Level 1	Local search (origin/destination)	Address identifiers (building number, street name, postcode)		X		X			X	X						X			X		X	X	X
			Topographic places (city, town, village, suburb, administrative unit)		X		X		X	X	X						X	X		X		X	X	X
			Points of interest (related to transport information) to which people may wish to travel		X				X	X							X	X		X				
		Trip plans	Operational calendar, mapping day types to calendar dates	X	X	X	X		X	X	X	X		X			X	X	X	X	X	X		X
		Location search (access nodes)	Identified access nodes (all scheduled modes)	X	X		X		X	X	X	X		X			X		X	X		X	X	X
			Geometry/map layout structure of access nodes (all scheduled modes)	X	X		X		X	X	X	X		X			X		X	X		X	X	X
		Trip plan computation — scheduled modes transport (interchanges, routes/lines, transport operators, timetables, stop facilities access nodes, vehicles, accessibility)	Connection links where interchanges may be made, default transfer times between modes at interchanges	X	X						X	X		X			X		X	X		X	X	X
			Network topology and routes/lines (topology)	X	X	X	X		X	X	X	X		X			X	X	X	X		X	X	X
			Transport operators	X	X	X			X	X	X	X		X			X	X	X	X	X	X	X	X
			Timetables	X	X	X	X		X	X	X	X		X			X	X	X	X	X	X	X	X
			Planned interchanges between guaranteed scheduled services	X	X		X		X	X	X	X		X				X	X	X	X	X	X	X
			Hours of operation	X	X	X	X		X	X	X	X		X			X	X	X	X	X	X	X	X
			Stop facilities access nodes (including platform information, help desks/information points, ticket booths, lifts/stairs, entrances and exit locations)	X	X		X			X				X			X	X	X	X	X	X	X	X
			Vehicles (low floor; wheelchair accessible.)		X					X				X										X
			Accessibility of access nodes, and paths within an interchange (such as existence of lifts, escalators)	X	X					X				X										X
			Existence of assistance services (such as existence of on-site assistance)																					
		Trip plan computation — road transport (for personal modes)	Road network	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
			Cycle network (segregated cycle lanes, on-road shared with vehicles, on-path shared with pedestrians)		X		X		X		X	X		X			X			X				X
			Pedestrian network and accessibility facilities		X				X		X									X				X

Table 3.3: Summary if the MMTIS NAPs information (Static Data – Level 1) across Europe.

Data category according to COMMISSION DELEGATED REGULATION (EU) 2017/1926 of May 31 2017				AU	BE	CY	CZ	DK	EE	FI	FR	DE	HU	IE	IT	LT	LU	MT	NL	NO	PL	SE	CH	UK
Static Data	Level 2	Location search (demand-responsive modes)	Park & Ride stops		X						X								X					X
			Bike sharing stations		X	X					X			X			X			X				X
			Car-sharing stations		X					X	X			X			X			X				X
			Publicly accessible refuelling stations for petrol, diesel, CNG/LNG, hydrogen powered vehicles, charging stations for electric vehicles		X		X				X			X			X		X					X
			Secure bike parking (such as locked bike garages)																					X
		Information service	Where and how to buy tickets for scheduled modes, demand responsive modes and car parking (all scheduled modes and demand-responsive incl. retail channels, fulfilment methods, payment methods)		X						X							X						X
		Trip plans, auxiliary information, availability check	Basic common standard fares (all scheduled modes): — Fare network data (fare zones/stops and fare stages) — Standard fare structures (point to point including daily and weekly fares, zonal fares, flat fares)		X		X			X	X			X			X	X		X			X	X
			Vehicle facilities such as classes of carriage, on-board Wi-Fi.																					

Table 3.4: Summary if the MMTIS NAPs information (Static Data – Level 2) across Europe.

Data category according to COMMISSION DELEGATED REGULATION (EU) 2017/1926 of May 31 2017				AU	BE	CY	CZ	DK	EE	FI	FR	DE	HU	IE	IT	LT	LU	MT	NL	NO	PL	SE	CH	UK
Static Data	Level 3	Detailed common standard and special fare query (all scheduled modes)	Passenger classes (classes of user such as adult, child, student, veteran, impaired access and qualifying conditions and classes of travel such as 1st, 2nd.)		X		X			X														X
			Common fare products (access rights such as zone/point-to-point including daily and weekly tickets/single/return, eligibility of access, basic usage conditions such as validity period/operator/time of travel/interchanging, standard point to point fares prices for different point to point pairs including daily and weekly fares/zonal fare prices/flat fare prices)							X	X													X
			Special Fare Products: offers with additional special conditions such as promotional fares, group fares, season passes, aggregated products combining different products and add on products such as parking and travel, minimum stay							X														X
			Basic commercial conditions such as refunding/replacing/exchanging/transferring and basic booking conditions such as purchase windows, validity periods, routing restrictions zonal sequence fares, minimum stay.							X	X													X
		Information service (all modes)	How to pay tolls (incl. retail channels, fulfilment methods, payment methods)		X					X										X				
			How to book car sharing, taxis, cycle hire etc. (incl. retail channels, fulfilment methods, payment methods)		X					X														
			Where how to pay for car parking, public charging stations for electric vehicles and refuelling points for CNG/LNG, hydrogen, petrol- and diesel-powered vehicles (incl. retail channels, fulfilment methods, payment methods)		X						X													X
		Detailed trip plans	Detailed cycle network attributes (surface quality, side-by-side cycling, shared surface, on/off road, scenic route, 'walk only', turn or access restrictions (e.g. against flow of traffic)		X		X																	X
			Parameters needed to calculate an environmental factor such as carbon per vehicle type or passenger mile or per distance walked				X																	X
			Parameters such as fuel consumption needed to calculate cost				X																	X
		Trip plan computation	Estimated travel times by day type and time-band by transport mode/combination of transport modes	X	X	X	X												X	X				X

Table 3.5: Summary if the MMTIS NAPs information (Static Data – Level 3) across Europe.

Data category according to COMMISSION DELEGATED REGULATION (EU) 2017/1926 of May 31 2017				AU	BE	CY	CZ	DK	EE	FI	FR	DE	HU	IE	IT	LT	LU	MT	NL	NO	PL	SE	CH	UK
Dynamic Data	Level 1	Passing times, trip plans and auxiliary information	Disruptions (all modes)		X					X	X	X							X			X	X	X
			Real-time status information — delays, cancellations, guaranteed connections monitoring (all modes)	X	X				X	X	X	X					X		X	X		X	X	X
			Status of access node features (including dynamic platform information, operational lifts/escalators, closed entrances and exit locations — all scheduled modes)	X	X					X	X								X	X		X	X	X
	Level 2	Passing times, trip plans and auxiliary information (all modes)	Estimated departure and arrival times of services	X	X				X	X	X	X		X			X		X	X		X	X	X
			Current road link travel times	X	X	X			X	X	X	X	X	X	X	X	X		X	X		X	X	X
			Cycling network closures/diversions		X				X					X			X			X				X
		Information service	Availability of publicly accessible charging stations for electric vehicles and refuelling points for CNG/LNG, hydrogen, petrol- and diesel-powered vehicles								X			X										X
		Availability check	Car-sharing availability, bike sharing availability		X	X					X			X						X				X
			Car parking spaces available (on and off-street), parking tariffs, road toll tariffs		X					X	X			X										X
	Level 3	Trip plans	Future predicted road link travel times	X	X			X	X	X	X	X	X	X					X	X		X	X	X

Table 3.6: Summary if the MMTIS NAPs information (Dynamic Data – Level 1, 2 and 3) across Europe.

3.3. Recent EU actions and policy developments

In the past three years there have been several European Commission policy developments with links to traffic and transport data, and NAPs. Each of the policy areas listed above have individual actions and timescales, but they are interlinked, with underlying themes that aim to tackle climate change and create a sustainable digital future. This section[1] provides an overview of the developments, how these may impact on NAPs; and also how NAPs can contribute to their aims and goals.

3.3.1. New EU Directive on open data and the re-use of public sector information

The EU Directive on open data replaces the 2003 "PSI Directive" Directive 2003/98/EC.

Public bodies hold extensive amounts of data known as public sector information (PSI). The Commission saw a need to address the re-use of public data, supporting the progress towards more freely available public data, and the PSI Directive came into force in 2003. A revision was made in 2013, Directive 2013/37/EU, widening the scope to institutions, museums and archives, limiting fees, putting in place independent compliance supervision, and more emphasis on machine-readable formats.

In 2018 there was a review, public consultation, impact assessment and proposal to revise the directive. Based on these the new Directive EU 2019/1024 on open data and the re-use of public sector information was published in July 2019 and has to be implemented into Member State national law by 16 July 2021.

Member States are encouraged to promote the creation of data based on the principle of 'open by design and by default'. The key changes include:

- **High-value datasets**, dynamic and real-time data, shall be made available via application programming interfaces (APIs) and, where relevant, bulk download
- Limiting the exceptions allowing public bodies to charge more than **marginal costs for the re-use** of their PSI
- Bringing new types of public and publicly funded data into the scope, such as utility, **transport** and research **data**
- More transparency around public-private data arrangements, to create a more level playing field for all market players, promoting the **use of standard licences.**

In the Open Data Directive, a particular focus has been given to high-value datasets, defined as documents whose re-use is associated with important benefits for society and the economy. One of them being mobility.

3.3.2. European Green Deal

In December 2019, the European Commission set out a European Green Deal for the EU and its citizens. The goal of this is to achieve climate neutrality by 2050. The transport sector will play an important role in achieving this target, as it accounts for a quarter of the EU's greenhouse gas emissions. For transport the objective has been set on reducing its emissions by 90% by 2050. In order to achieve the target the Strategy for a Sustainable and Smart Mobility was released on 9 December 2020 and supersedes the 2011 Transport White Paper as the European Commission's vision for transport.

In order to reach the sustainability objectives of the European Green Deal action at EU level, the Commission believes it is necessary to have efficient and strong initiatives that can deliver the needed climate and environmental impacts.

[1] Mainly based on the NAP 2020 Annual Report of the European ITS Platform.

The strategy sets a roadmap and clear policy framework for the sector towards the sustainable and digital transitions. It includes the following objectives:

- increasing the uptake of zero-emission vehicles
- making sustainable alternative solutions available to the public and businesses
- supporting digitalisation and automation
- improving connectivity and access.

The Strategy also includes an action plan with a list of measures that the Commission will take to achieve the objectives of the strategy. From the Roadmap the following areas can be linked to data activities:

- digitalisation - generate business opportunities, innovation, new services and business models
- innovative mobility platforms – data driven, achieved through deeper integration and pooling a variety of different mobility services
- sustainable alternative fuels and associated infrastructure – alternative fuels NAP datasets
- block-chain and common databases – supporting large analytical query workloads

3.3.3. European strategy for data

The Communication on a European strategy for data was published in February 2020, it aims to create a single market for data that will boost Europe's global competitiveness and data laws. The Communication states that common European rules and efficient enforcement mechanisms should ensure that:

- data can flow within the EU and across sectors
- European rules and values, in particular personal data protection, consumer protection legislation and competition law, are fully respected
- the rules for access to and use of data are fair, practical and clear, and there are clear and trustworthy data governance mechanisms in place; there is an open, but assertive approach to international data flows, based on European values.

The actions of the strategy are based on four pillars:

A. A cross-sectoral governance framework for data access and use
B. Enablers: Investments in data and strengthening Europe's capabilities and infrastructures for hosting, processing and using data, interoperability
C. Competences: Empowering individuals, investing in skills and in Small and Medium Enterprises
D. Common European data spaces in strategic sectors and domains of public interest.

The strategy recognises that digitalisation and data play an increasing role in supporting transport sustainability, and points out that several legislative frameworks already contain data-sharing obligations, establishing lists of transport related datasets. The strategy states that wide availability and use of data in public transport systems has the potential to make them more efficient, greener and customer friendly. On smart cities, data use to improve transport systems is also central. These activities are all supported by NAPs.

As noted in pillar D, the strategy will support the establishment of **common European data spaces** to ensure that more data becomes available for use in the economy and society. There will be a **mobility data space**, to further advance intelligent transport systems, including connected cars and other modes of transport. The data space will facilitate access, pooling and sharing of data from existing and future transport and mobility databases.

APPENDIX to the Communication 'A European strategy for data' – Section 3. Common European mobility data space

Digitalisation and data play an increasing role in **supporting transport sustainability**. Several legislative frameworks already contain data-sharing obligations, which establishes a list of datasets (including datasets concerning public transport).

Digital Transport and Logistics Forum is working on a concept of '**federated platforms**' to define what needs to be done at the EU level to facilitate data-sharing/re-use by connecting different public and private platforms.

Networks of **national access points** to make data available exist in the Member States where the data are made available with a view to serving road safety, traffic and multi-modal travel information services, with data generated by the public and the private sector.

Wide availability and use of **data in public transport systems** has the potential to make them **more efficient, green and customer friendly**. Data use to improve transport systems is also a central feature of **smart cities**.

Under the European strategy for data, the European Commission published a proposal for a Regulation on European data governance (Data Governance Act) in November 2020. The Act aims to promote the availability of data for use by increasing trust in data intermediaries and by strengthening data-sharing mechanisms across the EU. The proposal complements the new Open Data Directive and will support existing legislation relating to intelligent transport systems data. The regulation will also support the creation and development of the Common European mobility data space.

4. Standards & common formats

The data mentioned in the delegated regulations mentioned in chapter 3 is to be exchanged through National Access Points (NAP) and via license agreements of data providers, using a defined group of standards/specifications. Regarding MMTIS, the National Access Points are expected to provide information for public transport and other scheduled modes for the comprehensive TEN-T networks, using the NeTEx CEN/TS 16614 standard and subsequent versions, technical documents defined in Regulation (EU) No 454/2011 and subsequent versions, or any machine-readable format fully compatible and interoperable with those standards and technical specifications. As an option for Member States, similar documents shall be produced for dynamic information, and more specifically, those using CEN SIRI CEN/TS 15531 standard.

However, other standards exist for example for cycling, for shared mobility, for parking, etc. This chapter will briefly present the various existing standards, where we have used information from the EU EIP NAP 2020 Annual Report.

4.1. DATEX II standard

DATEX II was developed as a standardised solution to communicate and exchange traffic information among traffic centres, service providers and information broadcasting companies. The usage of DATEX II for data exchange is named in all Delegated Regulations mentioned before, but for the context of this report we focus on RTTI (Real Time Traffic Information) and MMTIS (Multimodal Travel Information Services).
Common and harmonised recommended reference profiles or recommendations are only available as follows (2020):

- Delegated Regulation (EU) 2015/962 – RTTI
  - For dynamic information, several parts of DATEX II have to be taken into account:
    - For real-time event (roadworks, traffic management, …), Situation Publication
    - For real-time messages, VMS Publication
    - For real-time traffic information, Elaborated Data Publication
  - For static data, the INSPIRE Directive (2007/2/EC), has drafted detailed technical documentation of transport network specification which includes many of the static data elements of this Delegated Regulation. Further development in this is required to link the work of INSPIRE.
  - DATEX II is also able to provide historical traffic data, Location of the measurement site, static signal like speed limits,
- Delegated Regulation (EU) 2017/1926 – MMTIS
  - this regulation extends some of the services from Truck Parking, SRTI, RTTI to all the road networks. The provision in DATEX II is possible with dedicated location referencing.

Initial steps have been taken to apply the DATEX II standards/profiles also for data in the cycling domain, such as roadworks, traffic information, counting, etc.

4.2. NeTEx & SIRI standards

NeTEx and SIRI are CEN standards managed by CEN/TC278/WG3/SG9 and CEN/TC278/WG3/SG3.7, a committee of public transport experts from different European countries[2]. These standards are based on the Transmodel[3] framework.

4.2.1. NeTEx

The NeTEx (**Network Timetable Exchange**) standard is a CEN standard (CEN TS 16614-1, 16614-2 and 16614-3) for exchanging public transport data, based on Transmodel (EN 12896-1 to 9), aiming at standardising the way of exchanging data between the information systems involved in public transport. It is based on open technologies (XML, XSD, and UML) and enables service operators and authorities to represent public transport data anywhere in Europe using common formats, standard rules, and uniform protocols.

NeTEx is divided into three parts:

- Part 1: Network topology (CEN TS 16614-1)
- Part 2: Timing information and Scheduled Timetables (CEN TS 16614-2)
- Part 3: Description of the tariffs (CEN TS 16614-3)

Standards are, by their own nature and definition, broad documents that incorporate a very large spectrum of requirements that are beyond local needs and specific implementations. This means that standards' documents are quite large and detailed and somewhat difficult to use for practical applications complying with it. In addition, some local or national specificities can lead to a specific use or a specific codification to be used for certain information or legacy data formats that may be meaningless for all other applications. Finally, in order to use NeTEx, a set of choices needs to be made: some elements proposed by the standards are optional and it must be decided if these items are to be used or not. All of this means, essentially, that the use of profiles is mandatory to adjust the use of a standard to a specific context and a specific use case. The profile may contain information such as:

- details of services
- details of the fixed objects
- details on the options proposed by the standard
- details on optional elements
- precision on the codifications to be used

The NeTEx deliverables comprise of:

(i) a CEN Specification document (in three parts),

(ii) a data model in the standard UML modelling language and

(iii) an accompanying XML schema providing a formal electronic description that can be used by data processing software. Data in NeTEx format is encoded as XML documents that must conform exactly to the schema – standard XML validator tools can check conformance automatically. The schema can also be used to create bindings to different programming languages, automating part of the implementation process for creating software that supports NeTEx formats. Some

[2] http://netex-cen.eu/wp-content/uploads/2015/12/01.NeTEx-Introduction-WhitePaper_1.03.pdf

[3] http://www.transmodel-cen.eu/

examples of XML document encoding different data sets and exchange functions are provided along with the schema.

In effect, documents in NeTEx format are computer files that can be exchanged by a wide variety of protocols (http, ftp, email, portable media, etc). In addition, a SIRI based protocol is specified for use by online web services. The common SIRI framework is used to describe a specific NeTEx/ data service (SIRI-NX) with specialised messages that can be used to request and return messages containing data in NeTEx format, as well as publish/subscribe messages for push distribution. The SIRI-NX responses return a NeTEx XML document that satisfies the request criteria (and also conforms to the NeTEx schema). There is a WSDL binding for this SIRI NeTEx service to make it easy to implement services and service clients as http requests.

A NeTEx service only needs to implement those elements of relevance to its business objectives – extraneous elements present in the binding can be ignored. Parties using NeTEx for a particular purpose will typically define a "PROFILE" to identify the elements that must be present, and the code sets to be used to identify them, for example a Norwegian NeTEx profile has been defined that specifies the use of NeTEx for the exchange of NeTEx data. This profile is now used in the Nordics as a "Nordic profile".

4.2.2. SIRI

SIRI defines a standard for exchanging **dynamic public transport passenger information** data in XML format. SIRI (**Service Interface for Real-time Information**) is divided into five parts:

Part 1 describes the context and the framework including the different organisations involved, public transport vehicle control centres, fleet of public transport vehicles, network information, information provision systems, passenger information services or devices.

Part 2 describes the communication infrastructures and mechanism to exchange real time information.

Part 3 specifies individual application interface of functional modules on real-time tables (production, estimated, at stop, for connection) or on monitoring of vehicles with current position and travel time.

Part 4, named Facility Monitoring, enables the exchange of information on the current status of available facilities.

Part 5 is linked with DATEX II to provide real-time information on situation and incident that appends along the road network and which impacts the journey of the public transport vehicles.

To give some simple examples, SIRI provides:

- real-time departure which could be different from the departure announced in the timetable provided by NeTEx,
- real-time information about the position along the route to an individual vehicle,
- synchronisation between arrival and departure to guarantee the connection, if connections are needed for a journey.

A SIRI-Lite version is also available which is a profile of SIRI to make it simpler to implement and deploy according to the usage of Representational state transfer (REST) than SIRI uses SOAP.

4.3. TAP – TSI standard

A **technical specification for interoperability** (TSI) for **telematics applications for passenger services** (TAP) of the trans-European rail system has been defined by Regulation 454/2011. These specifications are maintained by ERA, European union Agency for Railways[4]. This agency is also responsible of the TAF-TSI which applies to freight transport by rail.

TAP TSI allows the harmonisation/standardisation of procedures, data and messages to be exchanged between the computer systems of the railway companies, of the infrastructure managers and of the tickets vendors in order to provide reliable information to passengers and to issue tickets for a journey on the European Union railway network, in accordance with Regulation n°1371/2007 on rail passengers rights and obligations[5]. TAP – TSI can also be used in the context of urban rail systems.

The Technical Specification for Interoperability on "Telematics Applications for Passengers" (TAP – TSI) prescribes protocols for the data exchange of:

- timetables
- fares / tariffs
- reservations
- information to passengers in station and vehicle area
- train running information, etc.

4.4. Open Journey Planning standard

The **Open Journey Planning** (OJP) API will allow a system to engineer just one interface that it can make available widely (to authorised users or openly as they so choose) rather than having to engineer separate APIs for each bipartite exchange arrangement that may be required with other systems[6]. The principle of the OJP standard is based on a distributed journey planning. Two profiles are possible for a journey planner system:

1. **Active** which receives the request from the traveller with origin and final destinations, analyses the possible routes, requests to each passive journey planner involved in the route calculation, collects and combines the responses from each of them and provides the responses to the traveller who choice his preferred route.
2. **Passive** which receives the request of the active journey planner to calculate routes in its geographical area, transmits the responses to the active journey planner.

The basis of this standard is that the most relevant journey planner to provide the most accurate and updated information is the one which is operating closely to the public transport network.

It limits the data collection and data update at centralised level to avoid risk of delay and big data exchange of unused data.

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[4] https://www.era.europa.eu/

[5] https://ec.europa.eu/transport/modes/rail/interoperability/interoperability/telematic_applications_en

[6] http://www.normes-donnees-tc.org/wp-content/uploads/2017/01/TC_278_WI_00278420_E-RS-170118-final3.pdf

Existing journey planning systems (and probably some that will be developed in the near future) may require their own specific APIs for use with their closest partner systems, where the volume of enquiries is such that efficiency considerations demand a tightly specified API for such clients. The intention of the Open API is to provide an opportunity for just one universal channel to exchange information to lower-volume users – once created then there is little reason not to allow as many users of this API as may wish to use it.

The greatest use of public transport (in terms of the number of passenger journeys) happens in urban areas where frequent and regular services cater for the needs of relatively short-distance journeys. Usage then declines as journey distances get longer – with inter-regional and international journeys comprising the smallest number of public transport journeys.

However, the need for information about PT services is least in areas with frequent and regular services, where passengers quickly get to know about the services they rely on for most of their journeys – and therefore their need to check information systems is relatively infrequent. Longer distance journeys, however, are made less often and for a variety of reasons there is a much greater need to obtain information for such journeys before setting off. So, the need for information is greatest for the very journeys that are made least often. It is difficult to make a business case to provide information systems geared specifically to the needs of the longer-distance travellers, therefore. Instead, it becomes important to find ways of meeting the information needs of those passengers by using information collated and delivered primarily for the much larger group of those making short-distance journeys.

4.5. GTFS & GTFS-RT formats

TriMet in Portland, Oregon, along with Google, was one of the first public agencies to try and tackle the problem of online transit trip planners through the use of open datasets that are shared with the general public (How Google and Portland's TriMet Set the Standard for Open Transit Data in Streetsblog SF)[7]. TriMet worked with Google to format their transit data into an easily maintainable and consumable format that could be imported into Google Maps. This transit data format was originally known as the Google Transit Feed Specification (GTFS). GTFS provide the static information for the public transport network and timetable. As a result of developer innovation, GTFS data is now being used by a variety of third-party software applications for many different purposes, including trip planning, timetable creation, mobile data, data visualisation, accessibility, analysis tools for planning, and real-time information systems. In 2010, the GTFS format name was changed to the **General Transit Feed Specification** to accurately represent its use in many different applications outside of Google products.

Among public transportation data formats, GTFS stands out because it was conceived to meet specific, practical needs in communicating service information to passengers, not as an exhaustive vocabulary for managing operational details. It is designed to be relatively simple to create and read for both people and machines. Even organisations that work with highly detailed data internally using standards like NeTEx, use GTFS as a way to publish data for wider consumption by software developers

[7] https://gtfs.org/gtfs-background

who are more familiar with the Android applications. **GTFS-RT is the real-time data extension** for GTFS. It can be translated in SIRI-Lite.

4.6. GBFS

The General Bikeshare Feed Specification[8], known as GBFS, is the open data standard for shared mobility. GBFS makes real-time data feeds in a uniform format publicly available online, with an emphasis on findability. GBFS is intended to make information publicly available online; therefore information that is personally identifiable is not current and will not become part of the core specification.

GBFS was created in 2014 by Mitch Vars with collaboration from public, private sector and non-profit shared mobility system owners and operators, application developers, and technology vendors. Michael Frumin, Jesse Chan-Norris and others made significant contributions of time and expertise toward the development of v1.0 on behalf of Motivate International LLC (now Lyft). The North American Bikeshare Association's endorsement, support, and hosting was key to its success starting in 2015. In 2019, NABSA chose MobilityData to govern and facilitate the improvement of GBFS. MobilityData hosts a GBFS Resource Center and a public GBFS Slack channel.

GBFS is intended as a specification for real-time, read-only data - any data being written back into individual shared mobility systems are excluded from this spec. The specification has been designed with the following concepts in mind:

- Provide the status of the system at this moment
- Do not provide information whose primary purpose is historical

The data in the specification contained in this document is intended for consumption by clients intending to provide real-time (or semi-real-time) transit advice and is designed as such.

GBFS is an open specification, developed and maintained by the community of producers and consumers of GBFS data. The specification is not fixed or unchangeable. As the shared mobility industry evolves, it is expected that the specification will be extended by the GBFS community to include new features and capabilities over time. To preserve the original vision of GBFS, the following guiding principles should be taken into consideration when proposing extensions to the spec:

- **GBFS is a specification for real-time or semi-real-time, read-only data.** The spec is not intended for historical or archival data such as trip records. The spec is about public information intended for shared mobility users.
- **GBFS is targeted at providing transit information to the shared mobility end user.** Its primary purpose is to power tools for riders that will make shared mobility more accessible to users. GBFS is about public information. Producers and owners of GBFS data should take licensing and discoverability into account when publishing GBFS feeds.
- **Changes to the spec should be backwards-compatible, when possible.** Caution should be taken to avoid making changes to the spec that would render existing feeds invalid.

[8] https://github.com/NABSA/gbfs

- **Speculative features are discouraged.** Each new addition to the spec adds complexity. We want to avoid additions to the spec that do not provide additional value to the shared mobility end user.

There are now over 600 shared mobility systems publishing GBFS worldwide. The list is maintained by the GBFS community.

5. Linking cycling data with public transport – what is needed

5.1. Why and how to better link cycling data and public transport

The understanding of standardization efforts is needed to be able to better integrate data from various modes of transport. Linking cycling and public transport is crucial to achieving intermodality and the behaviour change that is required to decarbonize transport systems. Enabling users to be able to go from their home by bike to their local train station, park, catch a train to the area close to their destination and finish off the last mile of their trip by foot, micromobility option (bike or scooter), or bus is a key requirement for transport systems globally, and enabling cycling at any and every point throughout this chain is mandatory if societies are to decarbonize transit.

Doing so requires the transfers of data between users, local governments, public transit authorities and micromobility operators in a free and flowing manner. By standardizing and creating interoperability between data formats, protocols and specifications, transport stakeholders will be able to align and coordinate their services to user needs. For cycling, this means that priority cycling routes can be identified, enabling public authorities to improve infrastructure, safety and comfort along these roads. It means that upon arrival at a public transport stop (e.g. bus or train stop), the rider knows that secure parking is available, or alternatively, that their bike can be carried on to their train or bus. If this is the case, they are provided with the information specifying ticket costs and location of where the bike needs to be stored during this trip (i.e. in which train compartment must the bike be stored).

Technology and the development of the digital transport ecosystem plays an important role here. A key linkage between cycling data and public transport is via the availability and accessibility of Multimodal Digital Mobility Services (MDMS) and Mobility as a Service (MaaS) platforms. According to the European Commission (EC), MDMS is defined as "systems providing information about, inter alia, the location of transport facilities, schedules, availability and fares, of more than one transport provider, with or without facilities to make reservations, payments or issue tickets" (e.g. route-planners, Mobility as a Service, online ticket vendors, ticket intermediaries)"[9].

However, the current digital services marketplace for mobility is not intuitive enough and lacking in key data for users to adopt. For the EC, "planning and buying tickets for multimodal journeys is much too often much too cumbersome for travellers in the EU"[10]. This is largely put down to fragmented legal and market frameworks that are inhibiting the development and deployment of transport intermodality.

[9] Inception Impact Assessment, *Multimodal Digital Mobility Services*, Ref. Ares(2021)6062336 - 05/10/2021 accessed via https://ec.europa.eu/info/law/better-regulation/have-your-say/initiatives/13133-Multimodal-digital-mobility-services_en

[10] Inception Impact Assessment, *Multimodal Digital Mobility Services*, Ref. Ares(2021)6062336 - 05/10/2021, accessed via https://ec.europa.eu/info/law/better-regulation/have-your-say/initiatives/13133-Multimodal-digital-mobility-services_en

5.2. What needs to be done

Digital mobility services and MaaS platforms promise users access to the information required to effectuate multimodal journeys more efficiently and intuitively. Addressing the challenges that are currently inhibiting progress requires a level of data availability and openness that is currently lacking.

One element that will help resolve these conditions is Fair, Reasonable And Non-Discriminatory (FRAND) access to data. Achieving this will require the following:

a) That all public-facing data is made open. This means that information such as time, schedule, and location of mobility hubs will not be considered as of commercial value, but merely as "raw" data and that the public already has access to it.
b) The creation of trust frameworks between all parties involved in the exchange of data.
c) An industry agreement on the average cost of generating data that is not public-facing, so operators are covered when sharing their data with other transport providers and/or local transport authorities.
d) A reinforced mandate that all public-facing data are collected and published by National Access Points (NAPs), currently already in place but with NAPs struggling to get data listed. This currently exists in France, legislated by the French Mobility Law (the *'Loi d'Orientation des Mobilités* (*LOI n° 2019-1428*; LOM)).
e) Data generated by MDMS on usage/trends/research should also be aggregated and shared back with operators/local authorities as it will inform the evolution of future services.

In addition to the above, a number of on-bike and infrastructural products and services exist that allow for data to be generated for transport authorities to tailor and improve the road system to improve cyclist safety, convenience and comfort and encourage more cycling. These include on-street bike counters that register the number of cyclists that use a given section of cycleway, on-bike sensors that can detect swerves, near misses, road surface or air quality, or simple GPS systems built into helmets, locks or the bike itself that can provide real-time data on journey times and routes.

This non-exhaustive list of cycling technologies illustrate the data sources that are available to local authorities for evidenced based policy making. When combined with a robust public transport network, public authorities can drive behaviour change toward multimodal mobility, combining cycling and public transport. What is crucial however is that the data being generated is standardized. This ensures that all stakeholders are contributing data in a way that is comprehensible and efficient for other parties to understand and use. Where multiple standardized formats, protocols and/or specifications exist, interoperability between these is achieved.

This process of standardization and interoperability helps to ensure a minimum level of technical capacity. According to research by Polis on data from shared micromobility, many local authorities feel they lack the capacity to derive meaningful insights from this data[11]. This is not the case for the private

[11] *Sharing Data for Shared Micromobility*, POLIS, January 2021 – accessed via https://www.polisnetwork.eu/document/sharing-data-from-shared-micromobility/

sector, which perceives that it has the tools and know-how necessary to make use of this data. This "capacity-gap" has a negative effect on both parties, as well as the public interest, where evidence-based decision making must be a priority for future policies.

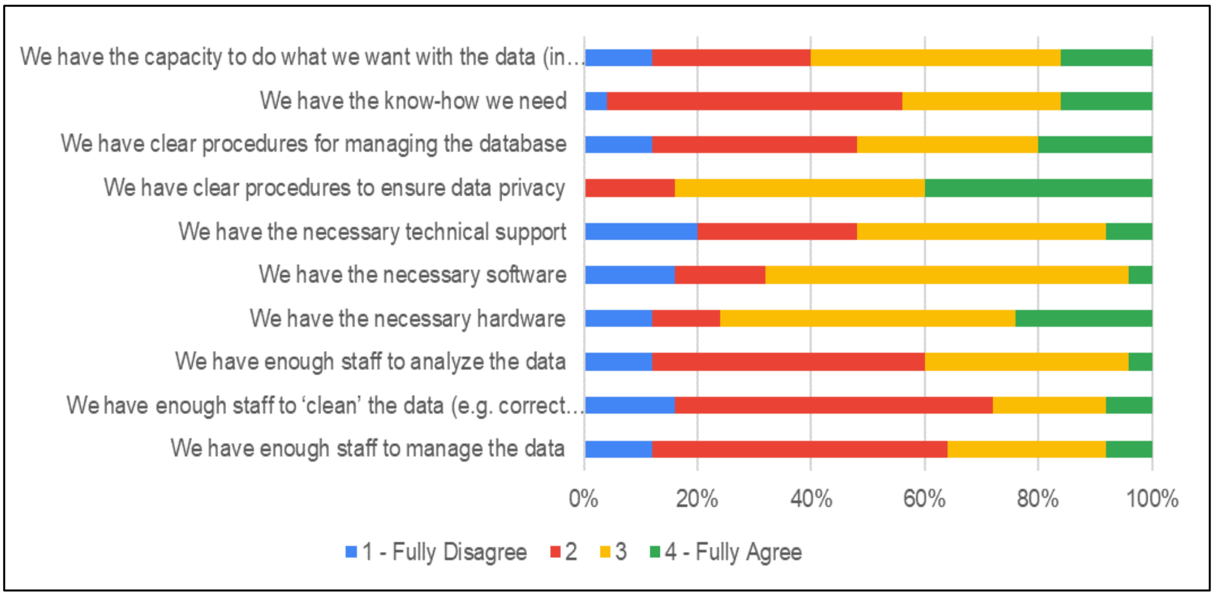

Figure 5.1: Self-assessment of public authorities to work with micromobility data

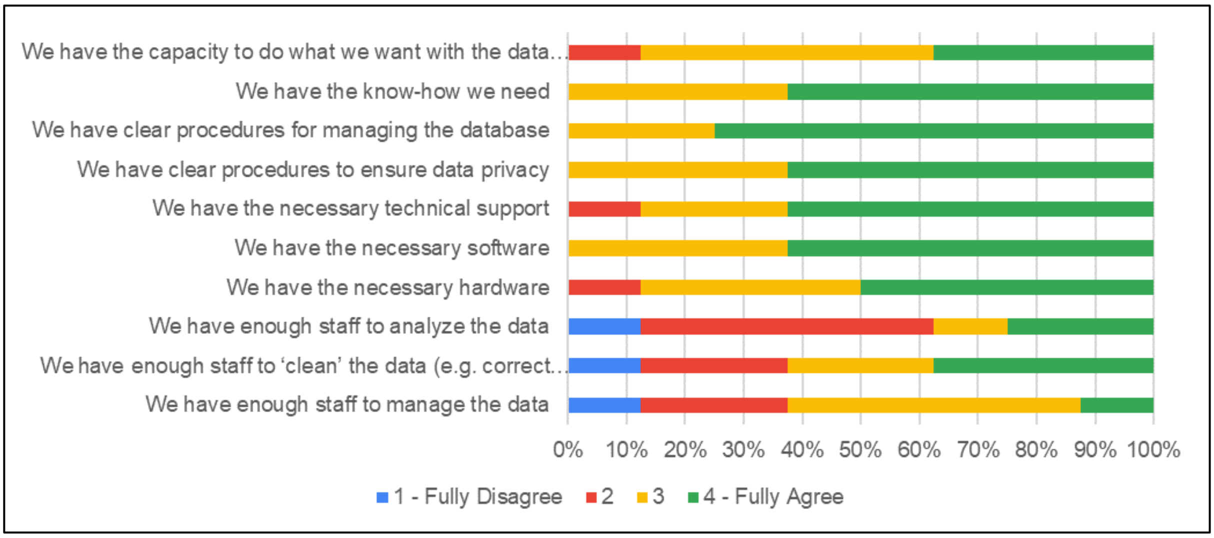

Figure 5.2: Self-assessment of private micromobility operators to work with data

It is therefore crucial to support the uptake and harmonisation of standards. This can be done in the following ways:

a) Financial support to build capacity at every level: operators, local authorities, National Access Points (NAP). All need to understand the standards, the complexity of the quality of data, and how to support their openness and sharing.
b) Financial support to all initiatives working on European-based standards to support their interoperability. Mapping, conversion tools, etc. take a lot of time and resources that are too often not accounted for.
c) Financial support to operators if there is a mandate to implement a new standard. For bike-share operators, it can represent up to 29 months of work. The cost cannot be only on their shoulders to comply with legal mandates, especially with them being SMEs.
d) It could also be a good idea to subsidize Technical Assistance Centres at the NAP level with software developers, data engineers, etc. to support all stakeholders with their projects to comply with existing MMITS and MDMS regulations. This has been implemented by the French NAP with success.

The above provides only a short summary of the work that needs to be done to integrate cycling data within public transport. There is undoubtedly further areas and measures that can be explored to achieve the behavioural shift to more cycling and further integration of cycling into other forms of transport that are necessary to decarbonise global transport systems. With this in mind, the BITS project continues to work with a broad range of stakeholders to develop and consolidate the frameworks and conditions that are required to achieve this.

6. Lessons learnt from data analyses

6.1. Introduction into bicycle data

In this chapter we share some of the experiences that have been gained in the BITS project when it comes to working with cycling data. The data collected within the BITS project shares a common theme of providing information that helps to build more bicycle friendly cities. These data can be divided into two different groups: The first group refers directly to the cycling behaviour. It includes information such as cycling routes, distances, durations, speed, time, breakings, daily and weekly distribution of bicycle traffic. The second group encompasses all information about the cycling environment. It includes cycling infrastructure like the overall surface quality, the identification of street damages like potholes and bicycle parking stations. Furthermore, environmental data, like temperature, air pressure, or particulate matter are part of the cycling environment. Crashes and near crashes belong to both groups, having a specific location in space influenced by the cycling environment. The categorisation and the relationship between the two groups is visualized in Table 6.1.

Cycling behaviour	Cycling Environment
• Cycling routes • Distances • Durations • Speed • Braking • Daily and weekly distribution of bicycle traffic	• Cycling infrastructure o Overall surface quality o Street damages like potholes o Bicycle parking stations • Environmental data o Temperature o Air pressure o Particulate matter
• Location of near crashes • Location of crashes	

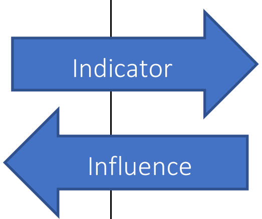

Table 6.1: Categorisation of bicycle data

Data of the first group, can be utilized in an attempt to derive information belonging to the second group, the cycling environment. For example, braking procedures may be used as an indicator for waiting times at traffic lights or for near crashes. The riding behaviour thus can give information about the bicycle infrastructure. The inverse is also possible. Here the influence of environmental factors on cycling behaviour can be investigated. For example, there can be research on the question about the influence of the weather on riding the bike. It is also possible that bicycle data can be evaluated with the help of environmental data.

The number of counted bicycles at different times can be compared with each other by taking the weather conditions into account. If one measurement period encompasses mostly rainy, cold days and the other period has mostly sunny, dry days, this should be considered when the data are compared with each other.

6.2. Data analyses within the project BITS

The aim of the project BITS is to make cities and regions more bicycle friendly. This should lead to a more frequent use of bicycles instead of using other vehicles like cars. Riding a bike has a positive effect on the health of the people who are riding the bike. Moreover, bicycles do not have such high CO_2 emissions like other (motorized) transportation systems. With reference to climate change, CO_2 emissions should be avoided. Cars, who are using a combustion engine, create particulate matter, which has a negative effect on the health of people. This is another reason why bicycles are preferred to cars.

For data analysis the BITS project creates key performance indicators (KPIs) to measure bicycle friendliness. This should help to identify reasonable bicycle infrastructure projects. Policy makers and city planners should then be able to use this information for the development of the bicycle infrastructure. After the implementation of an infrastructure adaption further measurements then can help to evaluate the project (See Figure 6.1).

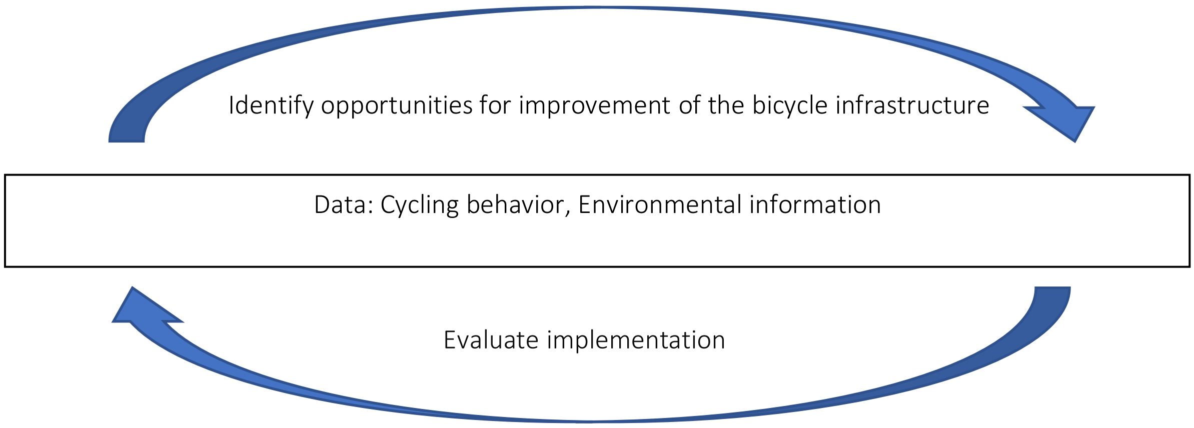

Figure 6.1: Data analysis circle

To get new knowledge, data from different sources must often be compared with each other. This leads to the need that data from different sources must be transformed into a unified standard so that all data have the same scale and calculations can be done on them. Consequently, standardization is another part of the BITS project next to data analysis.

The intention of the data analyses was to get an idea about what can be done with the data that have been collected by the other BITS partners. Furthermore, the analysis has been done to evaluate the BITS implementations. In the following section different data analyses are introduced and the main results are presented. After that, the next section goes deeper into the standardization process, data privacy and GDPR and the lessons learned of the data analysis.

6.3. Projects

6.3.1. Bicycle app data

The company Baron Mobility Service GmbH rent bicycles to companies, who can offer these bikes to their employees. Beside bikes, Baron Mobility also provides a smartphone app that uses gamification features to motivate people to use their bike more often. The bike trips of this app are recorded and are the basis for research that is described in this section.

The recorded data contains the trip ID, GPS coordinates and a timestamp, amongst other information. These data have been used in a master thesis to conduct research on three different research questions. The first research question refers to the bicycle friendliness of cities. The data have been used to calculate KPIs to create a metric for how bicycle friendly a city is. The aim was to make cities comparable with each other regarding bicycle friendliness. The second research question deals with whether it is possible to draw conclusions from the recorded data about the real traffic volume. The data comes from a smartphone app that makes it mobile instead of utilising stationary counting stations that only can measure the traffic at one specific location. Such mobile sensors can give information about a larger region and not just at a specific location. However, this is crowd-sourced data. The data are not collected in a representative way and thus it must be investigated how many participants and how many trips are needed so that the data will infer to the real traffic situation. The third research question refers to near crashes. The riding speed was analysed to identify locations where cyclists often have reduced speeds. Besides traffic lights and intersections, where cyclist must stop, further locations should be identified. The hypothesis is that cyclists have to reduce their speed at dangerous locations. To prevent a crash, cyclists must stop suddenly. When road intersections are not easily manageable, cyclists ride slower. Those locations may also be dangerous, when cyclists do not pay attention. The research targets attempt to identify dangerous locations using smartphone data. With the identification of such dangerous locations the infrastructure can be adapted so that these locations are safer for cyclists in the future and so cyclists have a nicer riding experience.

Figure 6.2: Gamification app for bike trips. Image by Cyclogreen (https://www.ciclogreen.com)

For the first research question, the creation of KPIs to compare cities regarding bicycle friendliness, the following values were computed from the smartphone data for a city:

- Overall average speed, distance and duration
- Average speed, distance and duration per weekday
- Average speed, distance and duration for different weather conditions
- Average duration for a specific distance
- Trips categorized in different speed classes
- Location and frequency of braking processes
- Average duration and location of waiting times
- Location of low-speed spots

The average speed, duration, distance, the number of braking processes and the waiting times have been used to compare the cities with each other and create a city ranking for each category. The result has been compared with other published city rankings. Moreover, the calculated values were compared with values from known bicycle friendly cities. The evaluation of the research is difficult because for the most cities there was only a low number of participants, who used the smartphone app. However, the research describes a possible way for how the bicycle friendliness of cities can be investigated.

For the second research question trips were identified that have passed one of the counting stations in a city. The number of cyclists that have been counted by a station have been compared with the number of trips of the smartphone app that passed the station. First the data were analyzed for a specific day, then for the entire time frame. In the following step, data were compared across the whole city and not just a specific counting station. Only for the city Oldenburg, in which a bit under 1400 trips were recorded, a more representative shape within the distribution of the traffic per hours on a day could be identified. The shapes for each station in Oldenburg vary more but usually show similar shapes, regarding the number of trips and the counted bicycles at a counting station. Figure 6.3 shows the graphs for the different stations. Additionally, it could be attempted to use absolute numbers and to investigate the total traffic at a specific location.

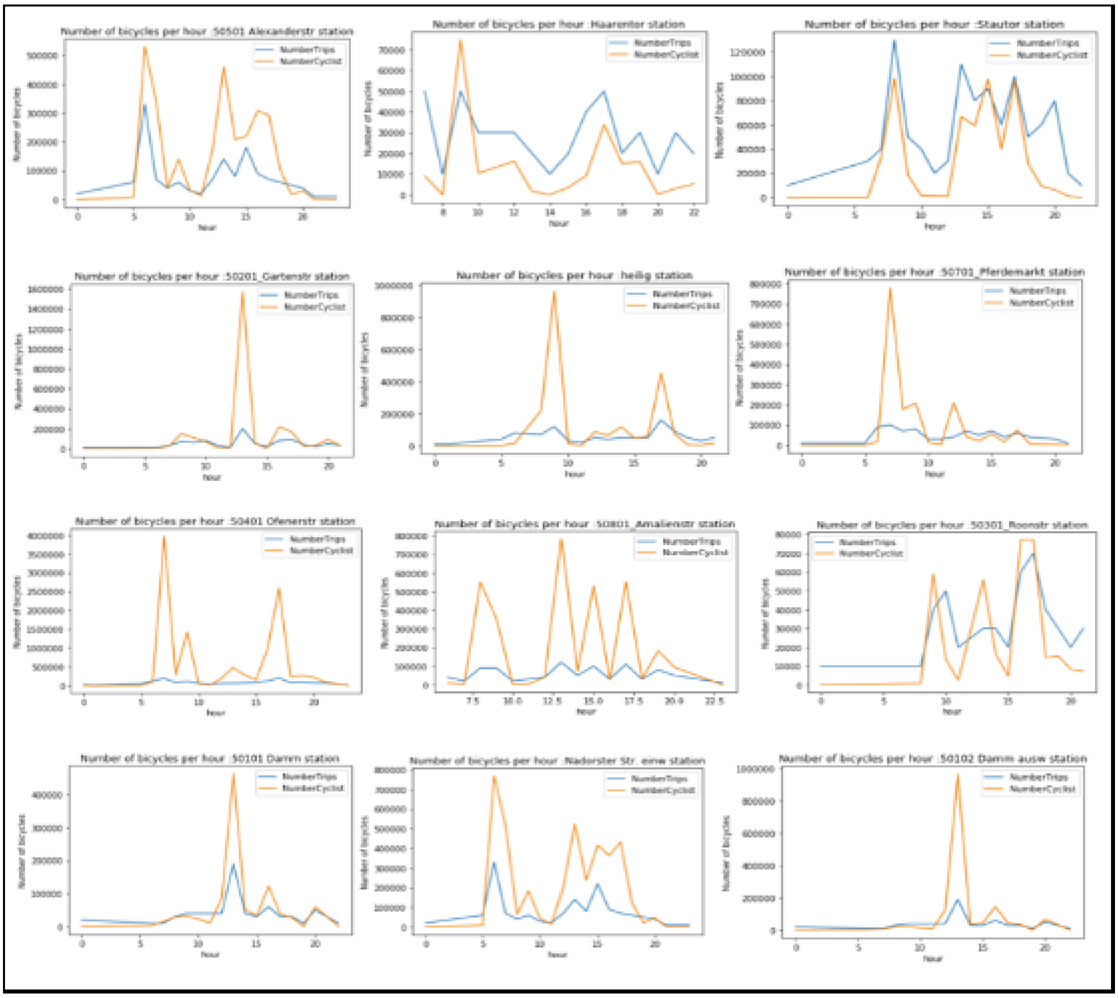

Figure 6.3: Comparison between the number of trips recoded by the smartphone app (blue) and the counted cyclists at a counting station (yellow) over the day. The number of trips is multiplied by 10000 or 100000. Source: Master thesis[12] .

The locations where a crash happened are reported by the police. For the third research question these locations have been investigated. Therefore, the average speed of these locations, has been calculated. For the different accident types the average speeds are different and vary between 11 km/h and 16 km/h. However, the accident type for crossing ways has an average of 14.6 km/h which is near to the average speed of the trips. This is an indicator that those accident types cannot be identified by average values.

The work of the thesis was discussed with city planners. One expert mentioned that braking hotspots and long waiting time locales can be useful information for city planners as they can be an indicator of bad cycling infrastructure.

[12] Title: „Usability of bicycle app data in the context of bicycle-friendly cities" by Firdaous Hebbal. The thesis was written within the BITS project.

To measure bicycle friendliness further parameters are suggested within the thesis, like the number and location of stolen bicycles, or the number, type, and location of accidents.

The paper "Analysis of Bicycle Use in German Cities Based on Smartphone App-generated Data" [13] has been published making use of and showing how such data can be evaluated.

6.3.2. Snifferbike data and route planning

The province of Utrecht has initiated a project in which environmental data have been collected by bicycles. Within a bachelor thesis these data were used to investigate if it is possible that on basis of such data a bicycle route planning application can be implemented that considers the particulate matter on the street. The application should generate routes with the lowest possible fine dust load. The collected data are historical. They do not show the current distribution of particulate matter. It has been investigated if these data can be used for the prediction of the current or future situation of particulate matter in a city. For the prediction the weather data of the predicted period was used to select only those values of particulate matter from the Snifferbike project that were measured under the same weather conditions. Furthermore, a prototype has been implemented for a proof of concept to identify challenges of the technical implementation of such an application. This prototype is visualized in Figure 6.4.

Figure 6.4: Route calculation that considers the distribution of particulate matter.

Key results of the investigation regarding the data are the following:

1. Generally, the values of particulate matter change over the day on weeks days. At the morning there is a peak and in the afternoon a second one. At the noon relatively low values are measured. On weekends the values are more on the same level over the whole day. The distribution over the day corresponds to the traffic density on the street.

[13] Hebbal, F.; Schering, J.; Marx Gómez, J.; Klemp, J. (2022). Analysis of Bicycle Use in German Cities Based on Smartphone App-generated Data. In: 1st International Conference on Technological Advancement in Embedded and Mobile Systems (ICTA-EMoS).

2. There is a low to moderate correlation of temperature and the relative humidity with particulate matter and a very low correlation of air pressure with particulate matter at the weekend. At the weekdays no or very low correlations between these weather parameter and particulate matter exist.
3. The measured values at the weekend are significantly lower than on weekdays.

On basis of these results the application has be implemented the following way. For route generation within the week all measurements at a specific time interval at weekdays are used. To plan a trip at the weekend, all measurements are selected that have been measured at the weekend at similar temperature and humidity.

It is necessary that the data for particulate matter are similar at a specific location under specific weather conditions and at a specific time and day. Only then precise predictions can be done. If the data vary too much under specific conditions at a specific location, then it cannot be estimated precisely how high the values of particulate matter exactly are. The data processing is very slow when a lot of data are processed. The sensors do the measurements at very short time intervals. Consequently, a lot of data are collected for a trip. To prevent very long processing times only data from January to April in 2021 have been used. However, these data were not enough for this kind of analysis because there was too little data at a specific location to draw valid conclusions. This is also demonstrated in Figure 6.4. There are large areas with no color on the map. So, the main technical challenge was the high amount of data that has been generated by the Snifferbikes. For route planning it can be investigated if a set of interpolated maps for specific weather conditions and time frames can be calculated beforehand. Furthermore, artificial intelligence could be used with algorithms being trained beforehand. The execution of the algorithm could then be faster than processing all data on the fly.

6.3.3. Surface analysis

Different administrations in Belgium are using different technologies to measure the bicycle surface quality. This leads to different measurements, and it is not possible to compare the values of the different technologies with each other directly, because the technologies process the data in different ways. For example, the region of Flanders uses the profilometer, whereas the province of Antwerp, that is part of the region of Flanders, uses the Comfortbike. Today, streets must be measured multiple times when measurements from a different technology are needed. This problem should be solved by transforming the measurements into a unified scale. The measurements that are done by the profilometer and by the comfort bike both should be transformed, so that they can be compared with each other.

For the research, three different technologies have been tested on four different street sections in Belgium. These technologies are the profilometer, the Comfortbike and the bike from Drivenby. Each device measured each section twice, so that the reliability of the measurements could be investigated. The surfaces of the street sections are concrete, concrete slaps, concrete tiles and asphalt.

In the first research step the reliability of the measurements are investigated together with possible presentation forms in a graphical visualisation. Each technology computed an aggregated value for every

12.5 meters. For each aggregated value the corresponding GPS coordinates are stored. It is possible to visualize the aggregated values in sequence one after the other. Another possibility is to use the GPS coordinates to calculate the distances from the start point for each aggregated value. We researched which of the two visualisation methods was the most appropriate in terms of getting comparable data. First, each technology has been analysed separately. Then the graphs of the different technologies have been compared with each other one time by plotting the values one after the other and one time by taking the GPS coordinates into account.

Figure 6.5: Measuring technologies. a A profilometer. b Comfortbike. c Drivenby. Images by Belgian Road Research Center.

Regarding the results, the reliability of the profilometer and the bike from Drivenby show quite similar graphs of the same street section. For the Comfortbike reliability exists regarding the distribution of the aggregated value. Concerning the two visualisation forms when only one technology is visualized then it does not make a difference which presentation form is used. However, when different technologies should be visualized in one diagram, then the GPS coordinates should be considered. In Figure 6.6 the measurements of the different devices are shown that have been collected on second test ride of section five. The first graph shows the measurements, when they are visualized in sequence one after the other. The second graph visualizes the measurements by taking the distance to the start point into account.

It has to be added that these are just the first results, and more research has to be done. The research done has been presented at the conference: ”1st International Conference on Technological Advancement in Embedded and Mobile Systems”[14].

[14] Klemp, J.; Marx Gómez, J.; Schering, J. (2022). Analysis of the measurements of cycle path surface quality as collected by three different technologies. In: 1st International Conference on Technological Advancement in Embedded and Mobile Systems (ICTA-EMoS).

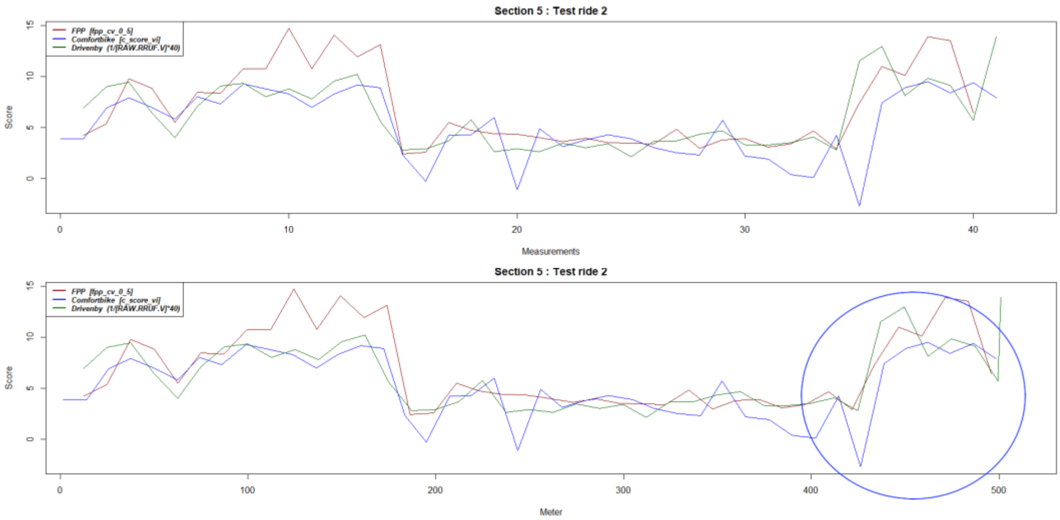

Figure 6.6: Comparison of the measurements between the different devices: Section 5, Test ride 2. a Measurements in sequence. b GPS distance

6.3.4. Near crashes

With the help of a camera the traffic of an intersection has been recorded. Using artificial intelligence, near crashes were then identified. For each near crash the participants (vehicle, cyclist, pedestrian), the direction, the speed, the time difference of the arrival of the participants at the crossing point, as well as the location were saved. Together with the province of Antwerp these data were categorized to identify how critical these interventions are. It has been investigated how the near crashes could be categorized that a realistic picture of the situation can be drawn. The question is how to define critical, high, medium and low risks when the average speed of both participants is taken together with the time difference of the arrival of the participants at the crossing point (dT). Further investigation is needed to see if this computation is an evaluable measurement to define how dangerous a near accident is.

The Wramborg biomechanical survivability thresholds was used to categorize the near crashes. This classification has been created for interventions between vehicles and vulnerable road users (cyclists and pedestrians) and uses both parameters. Bicycle-bicycle or bicycle-pedestrian interventions were not considered. This categorisation has been applied to two recordings of the same intersection that have been made in the years 2019 and 2020. All interventions, including bicycle-bicycle or bicycle-pedestrians, are used here. In Figure 6.7 these diagrams are shown.

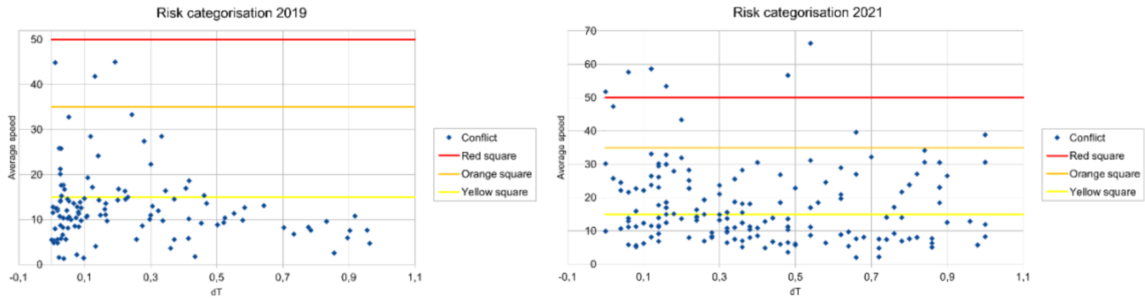

Figure 6.7: Categorization of the near crashes. a 2019. b 2021. Red: Critical Risk. Orange: High Risk. Yellow: Medium Risk.

The categorization cannot represent the shift of the near crashes to higher dT values properly from 2019 to 2021. However, higher safety is given for higher dT values. For bicycle-bicycle and bicycle-pedestrian interventions it must be investigated if it is necessary to adapt this categorization. Research should be done on to what extend the speed and the dT value has an influence on the crash risks that include bicycle-bicycle and bicycle-pedestrian interventions. Then possibly the categorization method must be different for the different types of interventions.

6.3.5. Number of bicycles and weather conditions

For the evaluation of data it is useful to consider additional data to get a better picture of the situation. When the counting data of specific stations have been compared with counting data that have been recorded some time before for example, then it is useful to consider the weather conditions within this evaluation. This is useful because the weather has an influence on how many people are cycling. The information of weather conditions then helps to estimate the degree of impact that weather may have on the number of bicycles at the measurement period. One possible way to get a better picture of the situation in which measurements have been collected, is to develop a visualisation that set weather conditions and counted bicyclists together into one diagram. In Figure 6.8 such two diagrams are visualized. These diagrams help to evaluate the data and provide better understanding.

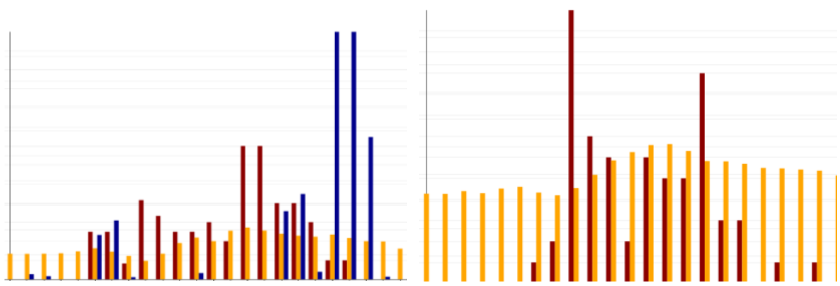

Figure 6.8: Diagrams that contain the weather conditions and the counted bicycles. Hull Road. Measurement periods: 13-23.12.2019 (left), 13-19.12.2020 (right). Red: Average number of bicycles per hour, Yellow: Temperature, Blue: Precipitation. All diagrams have the same scales.

During an interview with people from the administration these diagrams have been discussed. The result was that the administration needs measurable changes. So further processing of the values and the creation of KPIs is needed. As the weather has a big impact on the number of counted bicycles the KPIs need to take the weather conditions into account when the bicycles are counted in a short period. There exists a general number of percentages regarding how much the weather has an impact on the counted bicycles. However, these are just estimates so the real traffic figures can only be approximated. Such diagrams also can be used to conclude if the numbers of bicycles for different time periods can be compared or not. Only when on both measurement periods similar weather conditions exist, can a comparison of the number of bicycles be done.

6.3.6. Bicycle-data website

The bicycle-data platform has been implemented by a student group. With this platform raw data can be parsed into a database and data analysis can be done dynamically by the selection of different parameters. This makes it possible to compare different cities. KPIs from a specific city can be calculated and displayed and different types of data can be visualized in bar charts. Moreover, the raw data can be downloaded and accessed by a Rest-API. Figure 6.9 shows the city comparison page.

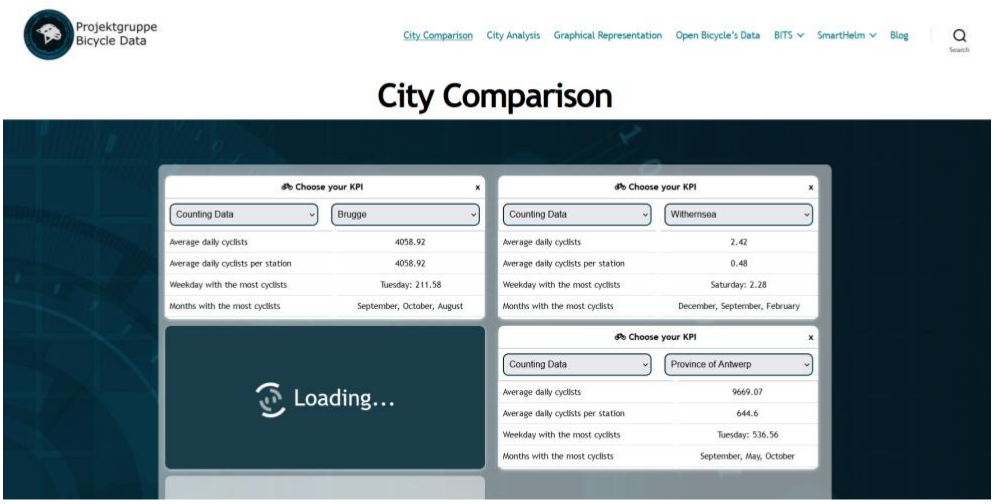

Figure 6.9: Bicycle-data website (https://bicycle-data.de/)

The calculated values were sometimes not well understood. One example is the following question: "Was there light rain 19% of the time? Or does this graph tell me: When it was cold, then we only had .85 cyclists/hour? But how do I then know what type of weather it was during that week?" This follows that for the calculated values further information is needed to understand what they say exactly. A new table is now showing values and explanations that give more information about the values that are used for the calculation. Also, meaningful titles and descriptions are important for the understanding of the data. In Figure 6.10 this new table is shown.

Count per weather classificationv2					
City	Weather classification	Number of measurements	Duration (in sec)	Number of bicycles	Average bicycles (per hour)
Withernsea	Cold	7886	7097400	516	0.6158
Withernsea	Heavy rain	56	50400	6	0.4286
Withernsea	Light rain	508	457200	52	0.4094
Withernsea	Light snow	10	9000	1	0.5
Withernsea	Moderate	2052	1846800	387	0.7544
Withernsea	Rainstorm	1	900	0	null
Withernsea	Stormy	765	688500	78	0.4084
Withernsea	Warm	55	49500	33	2.5385
Withernsea	Windy	3788	3409200	711	0.8484

Figure 6.10: Categorization of the bicycle counting values regarding the weather.

Furthermore, the data must be evaluated on their precision. In light snow only 10 measurements have been done, in rainstorms only one. It is obvious that based on these data the average number of bicycles at this weather could not be concluded. The needed sample size can be calculated using the expected value and the standard derivation. If the sample size is too small, then this could be pointed out in the column "average bicycles".

The portal is accessible under the link www.bicycle-data.de and described in more detail within the paper "The BITS Project – Making cycling data available and comparable on a European scale"[15].

6.4. Standardisation

DATEX II is a European standard for traffic information. The Netherlands uses this standard for bicycle counting data. The data format has the following columns: measurepoint (Id of counting station), start (start of the measurement), end (end of the measurement), bothDirections (total number of counted bicycles), countTo (direction into city), countFrom (direction from city). The student group, who implemented the bicycle-data website, extended this data format with further columns, so that also the weather conditions and information about holidays are stored for each measurement period. This results in four database tables. One stores the measurements and another the information about a station (Figure 6.13). Furthermore, tables are created for the holidays and the weather conditions. The weather conditions are stored for a city at a specific time. In the Figures 6.11 to 6.14 these tables are visualized. The main table that stores the counted bicycles (Figure 6.11) links to further data in the tables: location, holiday and weather.

[15] Schering, J.; Marx Gómez, J. (2022). The BITS Project – Making cycling data available and comparable on a European scale. In: Transportation Research Procedia, Volume 60, pp. 424-431. ISSN 2352-1465. doi.org/10.1016/j.trpro.2021.12.055. (www.sciencedirect.com/science/article/pii/S235214652100956X)

bicycledata.bicycleCount: 17.420.584 Zeilen gesamt (ungefähr), limitiert auf 1.000

id	start	end	holidayID	locationID	weatherID	countTo	countFrom	bothDirections
32.573	2019-06-01 00:00:00	2019-06-01 00:15:00	1	6	2.883	(NULL)	(NULL)	12
32.574	2019-06-01 00:00:00	2019-06-01 00:15:00	1	7	2.883	(NULL)	(NULL)	3
32.575	2019-06-01 00:00:00	2019-06-01 00:15:00	1	8	2.883	(NULL)	(NULL)	2
32.576	2019-06-01 00:00:00	2019-06-01 00:15:00	1	9	2.883	(NULL)	(NULL)	5
32.577	2019-06-01 00:00:00	2019-06-01 00:15:00	1	10	2.883	(NULL)	(NULL)	3

Figure 6.11: Main table that stores the counted bicycles for a specific time interval and links to further data in other tables.

bicycledata.location: 245 Zeilen gesamt (ungefähr)

id	type	country	city	station	latitude	longitude
188	Bicycle-App	Germany	Oldenburg	Bicycle-App	53,1435	8,21427
1	CountStation	Germany	Goettingen	K15 Berliner Straße	51,5369	9,92925
2	CountStation	Germany	Goettingen	K61 Christophorusweg	51,5492	9,93811
3	CountStation	Germany	Goettingen	K51 Nikolausberger Weg	51,5393	9,93878
4	CountStation	Germany	Goettingen	K63 Robert-Koch-Straße	51,5528	9,94006

Figure 6.12: Table that stores the information of each counting station.

bicycledata.weather: 2.925.827 Zeilen gesamt (ungefähr), limitiert auf 1.000

Nächste Zeile Alle Zeilen Sortierung

id	timestamp	country	city	temperature_max	temperature_min	temperature	heatIndex	precipitation	snowDepth	windSpeed	windGust	cloudCover	relativeHumidity	conditions	winddirection	classification
736.783	2015-04-28 22:00:00	Netherlands	Utrecht	11,2	11,2	11,2	(NULL)	0	(NULL)	0	3,1	(NULL)	46,21	Clear	122	Moderate
394.351	2015-04-28 22:15:00	Netherlands	Utrecht	11,3	11,3	11,3	(NULL)	0	(NULL)	0	0	(NULL)	46,21	Clear	86	Moderate
394.352	2015-04-28 22:30:00	Netherlands	Utrecht	11,1	11,1	11,1	(NULL)	0	(NULL)	0	3,1	(NULL)	48,35	Clear	123	Moderate
394.353	2015-04-28 22:45:00	Netherlands	Utrecht	11,3	11,3	11,3	(NULL)	0	(NULL)	0	0	(NULL)	49,24	Clear	86	Moderate
394.354	2015-04-28 23:00:00	Netherlands	Utrecht	11,1	11,1	11,1	(NULL)	0	(NULL)	0	3,1	(NULL)	52,22	Clear	122	Moderate

Figure 6.13: Table that stores the information of the weather conditions.

bicycledata.holiday: 35 Zeilen gesamt (ungefähr)

id	name
1	NoHoliday
2	Pfingstmontag
3	Nieuwjaarsdag
4	Neujahr
5	Allerheiligen

Figure 6.14: Table that stores the holidays.

The location, the weather and the holiday table could not only be referenced by the table that stores the bicycle counting data but by all the other tables with different kinds of measurements, too. These three tables were defined in such a way that they can be part of smartphone generated trip data, parking data, near accidents and data from the Snifferbikes.

It can be differentiated between tables that store some kind of measurements and tables that store additional information for a measurement. Table 6.2 shows both kinds of tables with possible information they could store.

Measurements	Additional information
• Counting stations • Smartphone generated trip data • Parking data • Near accidents[16] • Snifferbike data	• Location information (station, type of technology) • Weather conditions for a city • Holidays

Table 6.2: Differentiation between measurement tables and tables that store additional information.

The process of harmonization of the counting data from different sources and with different data formats and the presented final table structure is described in the paper "A New Research Approach to Harmonize European Bicycle Counting Data from Germany, Belgium and the UK"[17].

6.5. Privacy and GDPR

When data are collected, then you must make sure that the privacy of people is preserved. Otherwise, the people have to be asked for permission and the law regarding the GDPR has to be considered. The anonymizing of crowed sourced tracking data, that include the timestamps and the GPS data, is not a simple task. It only one person, living alone, geographically far away from other people, that then also shortening the beginning of the trip does not help to prevent the identification of the one from who the data have been collected. More complex algorithms must be used to make sure that k-anonymity[18] or other parameter to quantify anonymization are guaranteed for such a case. The GDPR has a focus that the people can decide what data about themselves they want to provide to other people. Perhaps, a possible way could be that the people can define by themselves the parameters in which data should or should not be collected.

Another way to anonymize data is to process the data in that way that they are obfuscated. This can be done by adding random values. A possible use case can be the shifting of GPS coordinates. When the GPS coordinates are shifted, then it is more difficult, to reconstruct a trip. However, multiple trips have to be recorded on the same street and on the same side of the street. Furthermore, other values, that can reveal the trip route, like the timestamp, the tracking id, or specific weather conditions need to be removed or generalized so that k-anonymity is guaranteed. Another possibility to anonymize data is the generalization. For example, timestamps can be categorized to hours and the type of the day (weekday/weekend), so that trips cannot be reconstructed anymore.

[16] Schering, J.; Marx Gómez, J.; Soetens, S.; Verbeek, K.; Singh, A. (2021). How to measure safety risks for cyclists at intersections? In: Halberstadt, J.; Marx Gómez, J.; Greyling, J.; Mufeti, T.K.; Faasch, H. (ed.). Resilience, Entrepreneurship and ICT - Latest Research from Germany, South Africa, Mozambique and Namibia. Cham: Springer Nature Switzerland, pp. 263-278.

[17] Schering, J.; Marx Gómez, J. (2022): A New Research Approach to Harmonize European Bicycle Counting Data from Germany, Belgium and the UK. In: Halberstadt, J. (ed.): YEEES Conference 2021 Proceedings. Cham: Springer Nature Switzerland.

[18] K-anonymity respects the quasi-identifier of a dataset. The unique identifier, that identify a person, are removed from a dataset, but by combining a couple of information it is often still possible to identify the data from a specific person. K-anonymity means that each person cannot be distinguished between at least k-1 other people. All in all, anonymization is difficult, also because it is not known, which information someone has that could be used to identify a person. K-anonymity is in that context an aspired goal and not mathematically proved.

In both cases, the obfuscation and the generalization, the whole dataset has to be known, because it must be ensured that enough values exists so that k-anonymity can be guaranteed. A solution must also be found regarding what needs to be done when not enough data has been collected in a specific region. One way could be, that the original data are stored on a server and the obfuscation or generalization is only done for data that should be made publicly available. Then only data are published for which k-anonymity can be guaranteed. However, this does not target the challenge that much data yet to be anonymized, are still stored on a server. It is always possible that such data can be misused, further distributed, and published. Another thing to note is, that it always must be known how the data have been obfuscated or generalized. Only then the analysis of the data can be done properly.

The question is for what use case the data are needed. Then possibly not needed data can be removed, or even not be collected at all. Another possible way to preserve privacy can be, that calculations with privacy sensitive data, like GPS coordinates, can be done directly on the device of the user. Only the result of these computations is sent to the server. At the University of Twente, there are attempts to investigate the processing of surface quality data directly on the user's device.

Making raw data accessible to the public makes sense when other people can do something with these data. All the described methods for anonymisation lead to the situation that specific types of analysis are not possible anymore. When people can define areas of privacy, then the trips are disrupted and analysis of the length of trips is not possible anymore. If the data are obfuscated, then accurate values do not exist anymore. The data from sensors that identify potholes cannot be processed so well when the location has been obfuscated. When timeseries data are generalized by hours, then the speed cannot be calculated anymore by using the GPS coordinates and the time.

Location	
User's device	Private areas Calculations with sensitive data Random route shortenings
User's device and Server	Obfuscation Generalization

Table 6.3: Tasks to preserve privacy and the location where this happens.

Table 6.3 summarizes tasks to preserve privacy and shows where this is done. A first step of obfuscation and generalization can be done on the user's device and data can be obfuscated or generalized. However, this does not automatically lead to anonymity, as sufficient aggregation with other data is required to ensure k-anonymity. In Table 6.4 a possible way to preserve privacy is described, that combines all tasks that are listed in Table 6.3.

Location	Steps to preserve privacy
User's device	1. Process quality values on the device all X meters on device of the user, measurements in private areas are not made, also a random distance from the beginning of the trip and of the end is not processed. 2. Obfuscation of location (shifting GPS coordinates) and generalization of the time to months and years
Server	1. Publish data only when k-anonymity can be guaranteed

Table 6.4: Listing how privacy can be preserved when surface quality should be measured. This also applies to other use cases, like pothole recognition, identification of trip brakes, measuring weather conditions and air pollution, investigation on cycling behavior or measuring traffic density.

For research such strong anonymization of the data like in Table 6.4 is not useful, when the quality of the measurements should be evaluated, or new computational methods should be investigated. Here the random shortening of the start and the end of the trip routes together with the selection of private spaces, and the aggregation of data from many people could possibly be a compromise to provide privacy sensitive data like GPS tracking data. The generalisation and obfuscation of the data are left out in this case. For investigations on cycling behaviour, where whole trips are needed, the GPS coordinates could possibly be removed. Then no other tasks are needed to ensure privacy. Also, to ask for permission to use the data is another option, so that anonymisation is not needed. Then the GDPR has to be considered and all the user rights (information, deletion, ...) have to be respected. For research there exist less strong regulations, but data are fluent and can easily dispersed. It must be said that the topic of how the data can be processed regarding data privacy and the GDPR was not a big part of the research within the project. For a deeper insight into this topic more publications and research papers must be investigated.

6.6. Conclusion and remarks

6.6.1. Steps in data research process

The different projects that have been done within the BITS project and are presented in the previous sections can be categorized into different steps that have to be done within a data research process.

First, it has to be investigated: what can be done with the data? For what kind of use cases they can be used and what new information can they provide? Section 6.3.1, which presents the analysis of smartphone data, belongs to this step. This research project tries to identify new applications for data which have only been available to us for a short time.

The second step is about a deeper examination of the data itself. It investigates what has to be considered, when specific kind of data should be processed. The main focus lies on the understanding of the data and the data collection process. The three quality criteria for research: validity, reliability and objectivity are important. Data analysis only can lead to correct results if there exist a deep understanding of the data and the data collection process. Only then the data can be analysed in the right way. The results of data analysis can look very good. Nice diagrams, graphs and maps can be created very easily. But that's exactly what makes it so tricky, because if the data is faulty or has been processed incorrectly, then you often can't detect something like that directly from the visualizations. Therefore, for data analysis, from data collection to the processing of the data must always be well known and understood in its entirety. The described project in section 6.3.2, which deals with the possibility to use the measurements of particulate matter from the Snifferbikes to predict the particulate matter concentration for a specific time, and section 6.3.3, that investigated the reliability of the different measurements devices and compared different visualization methods, can be assigned to this step.

The third step is to investigate how the results can be presented in a way that the important results are well presented and the whole presentation is easy to understand. If data are categorized into different groups, then the definition of these categories has to be logical, so that the results will not be distorted. Section 6.3.4, which deals with the categorization of the near crashes is an example where this is relevant. It must be ensured that the labels, titles, legends and explained text describe what the data accurately. When data are only collected by employees, then the data are not representative for the whole society. Crowed sourced data that are collected within a company bike challenge (Baron Mobility Service GmbH provided such data within the BITS project) is an example for that. The data just can say something about the driving behaviour of the group of employees, that collected the data. These data cannot say something about the general behaviour of all the citizens. So, it has to take care that the description of the results are valid. When data are compared with each other, it has to be ensured that they have been collected under similar conditions, or that specific derivations can be made on data, that have been collected on different conditions. The knowledge how the data have been collected and processed is also important in this step. Regarding the visualization. When data is visualized and other data that has an impact on that data is added to that visualization, then the impact of the other data should be readily apparent. Section 6.3.5 deals with that topic. For data that should be dynamically analysable, more must be known about the data. Diagrams or tables, give a well overall overview about the data and can present the main results very easily. However, in order to gain knowledge about a phenomenon, information about data collection and data processing is urgently needed. Diagrams and tables alone are not enough to understand the data and what can be derived from them. Determining which additional data are necessary to comprehend the results, has been investigated with reference to the bicycle-data platform (see section 6.3.6).

Privacy and standardization are steps that are independent from the three steps presented before. They deal with other issues and can be investigated independently from the other steps. When exploring new applications, research must go through all these steps.

6.6.2. Changes in research work

With big data there is a change how data is being analyzed. Now there is access to many data from different data sources that describe different phenomena. All these data can be used to derive new knowledge. With a lot of data there is a need to automize processes. However, at the same time it must be ensured that the data are processed in the right way. When sensor data are defect and always send wrong values, then this has to be recognized by an algorithm. Same applies for sensors that are taken into the house, when the outdoor temperature should be measured or when a sensor does measurements in a car, but the riding speed of bicycles should be measured. Researchers gather lots of data but tend to lose control over the data collection process. So, in research there is now a need to get as much information about the data so that the researcher can use this information as a basis to draw conclusions and derive new knowledge. When different external data should be inserted into a data portal that dynamically processes the data and visualizes the results using tables, or diagrams, then the preprocessing of the data has to be done before.

Either, a researcher does the preprocessing before data are inserted into the data portal, or the data portal does the preprocessing by itself. No matter which way is taken, the user who sees the dynamically created tables and diagrams needs to know further information about the data and the preprocessing. Only then valid conclusions can be made. However, this does not apply if only raw data should be visualized to get an overview of the data. In research usually the researcher does the data processing, calculates the results and draws conclusions on these results. The bicycle-data portal provides the results and the user has to draw the conclusion. So, the last step is being done by a person who knows neither much about the data, nor about the processing of the data. It has to be investigated which kind of information are necessary for a user of such a data portal, who likes to draw conclusions based on the dynamically created tables and diagrams. Within the BITS project a first try has been done (See section 6.3.6). After the needed information has been identified, a general standard must be defined, so that the data providers are able to make these metadata available together with the raw data.

6.6.3. Standardization in IOT and smart services

In Geoinformatics physical objects in the real world are modelled as geo objects. They have a specific location and shape that describe the physical properties. Then they have further properties that are not changeable and other variables that may change over time through specific processes. All objects are entities that have a unique identifier. In programming languages, the processes are defined in methods, that change specific variables of the geo object. Each entity is assigned to a specific geo object class. So, there may exists a geo object class: counting station. The internet of things (IOT) is about real objects that are connected over the internet with each other. They can be modelled like geo objects, because they are physical objects and are located at a specific location in the real world. Figure 6.15 shows an example how a counting station can be modelled.

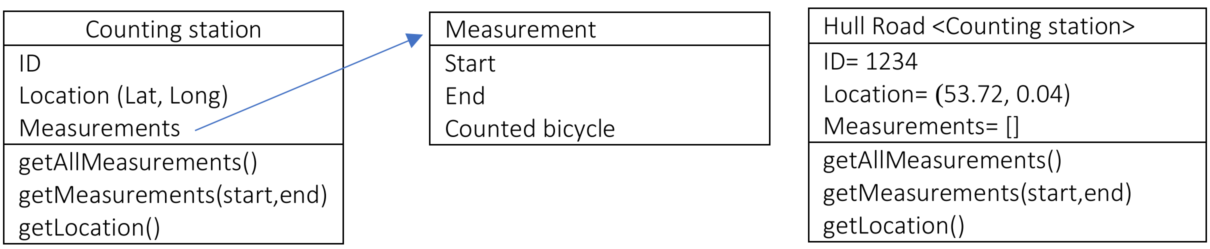

Figure 6.15: Model of a counting station as a geo object. The counting station Hull Road is an entity and an instantiation of the class "counting station".

There is a need for such geo object classes to be standardized. The methods, like getAllMeasurements(), are important for the definition on an API to enable a communication with the IOT.

The open Geospatial Consortium (OGC) is one of the organizations that is creating general standards and APIs on this topic. SensorML is a specification of the OGC that provides a general framework to define physical systems. If this is state of the art, or if in practice other standards are used, that has to be investigated. However, it seems that a generally applicable standard has not yet been established, since data gathered within the project are not all standardized, yet. The companies who provide the physical systems, like the counting stations, need to implement universal standards to provide general access to their systems. Similar stipulations apply to smart services. Although these services do not necessarily have a specific location, the usual structure also applies to them. Sections 3 and 4 present delegated regulations on travel information services, EU initiatives, specific standards and formats that have been developed so far.

6.6.4. Identification of new applications for data

Two different approaches are presented in the following for creating innovations and to answer the question what can be done with the new data we are able to collect today. First, one can have a look at specific tasks that are done today and analyze how these tasks can be made more efficient with the help of the possibilities of the digitalization. Using crowd sourced data to measure surface quality is an example how tasks can be made more efficient, as the streets do not have to be ridden just to measure the surface quality. Also, the attempt to transform data of different devices into one scale is an example of more efficient organization (see section 6.3.3), especially if it is assumed that in the future not only one device will be used to measure the surface quality. The bicycle data platform (section 6.3.6) is a new approach for managing and analyzing data. The challenges that arise with big data need to be met with new data management and data analysis methods. The dynamical creation of tables and diagrams, the harmonized structure of the data within the database as well as the custom download of raw data and a REST-API are steps into that direction.

Alternatively, it can be asked what we want to know. Then we can investigate which information and data is needed to answer this question. This approach is done within the other presented projects. With the smartphone data new knowledge about the bicycle friendliness of cities, the traffic distribution and the location of near crashes should be generated (section 6.3.1). Using the Snifferbike data a new service should be implemented that provides a routing service that considers air quality (section 6.3.2). In section 6.3.4 near crashes should be categorized to analyze dangerous situations at a street crossing. Here also new knowledge should be generated by using cameras and artificial intelligence. The number of bicycles should be evaluated and analyzed by using the weather data, as it is known that the weather influences how many people are using their bikes (section 6.3.5). The linking of the data to the weather data helps in the data analysis of this case.

6.6.5. KPIs, indicators and the dataset

As the BITS project aims to create more bicycle friendly cities the question arises how bicycle friendliness can be measured. It needs universal accepted KPIs to measure bicycle friendliness. Then these KPIs can be captured for each city. Possible KPIs for measuring bicycle friendliness of a city are:

1. Average number of brakes per kilometer.
    a. Requirement: Bicycle trips are well distributed over most of the city
    b. It measures the smoothness of the traffic.
2. Number of crashes with cyclists in relation to the number of inhabitants or distance cycled

    a. It measures the bicycle safety
3. Surface quality of the streets
    a. Requirement: Most of the streets are included
    b. It measures the cycling riding comfort
4. Number of stolen bicycles
    a. Measurement of the bicycle security
5. Air pollution
    a. Requirement: Most of the streets are included
    b. It measures health conditions
6. Representative survey about the usage of the bicycle
    a. Using grades to describe the satisfaction of the cycling conditions
    b. To get a representative average duration of the normal usage of a bicycle per week

These KPIs are objective, reliable and valid and thus fulfill the needs for scientific work. Other kinds of data like the driving speed, the length or the duration of a trip can simply be indicators. In bicycle friendly cities possibly more people ride faster and longer distances. However, also other factors could lead to the fact the people use their bike more intensively. Perhaps the costs for a car are too high, or there is too much traffic, so it is faster to drive with a bike than with a car.

Crowd-sourced data are not directly representative. When enough data have been collected, then subsets of the data could be created. Otherwise just specific groups can be identified, by further details, like age and sex. These groups can then be investigated. It might be interesting how many people are taking part at the company bike challenge in relation to the number of employees. Also, data like driving speed, the length or the duration can be interesting, to analyze. These values can be compared with data from other companies or cities, that are from the same group. The results can then be the basis for more research into the reasons for the differences between companies or cities.

Crowd-sourced data can be used for measuring the environment. The air and surface quality, the weather data, potholes and the traffic flow, measured by waiting times and brakes, are independent from the people, who ride the bike. Here the participants do not need to represent the citizens. All information listed in the right column in Table 6.1 can be collected by crowdsourcing, without any concerns. However, location of near crashes or crashes, need a representative data set, because the cycling behavior depends on the cyclist. Waiting times and brakes are information about the cycling behavior, but in this case the cyclists have little to no influence as this factor is more impacted by the cycling infrastructure.

6.6.6. Linking of data and data processing

Linking the different types of data is usually straightforward, as most measurements save to the location and the time. These values have been used for linking all the data with the weather data. The counting station provided its location. The measurements also store the time. The same applies for the Snifferbike data and the smartphone data, that store the tracking data for a trip. The near crashes and the surface quality data collected just the location data. In this case it was not possible to link the weather data. For all analysis that are related to geoinformation this linking works well. The data can be visualized on a map and geo-informatical methods can be applied. A barrier is that there exist no defined data format and API for each kind of IOT. For counting stations for example there is a need to define a data format and the way to get access to these data that are provided by different counting stations. Then new data from different counting stations can be dynamically requested and inserted into a database. Then dynamic processing and visualizations can be done. General information like the location, ID, name, type and further metadata that applies for all IOT, need to be implemented by all kind of IOTs in the same format. This makes it easier to store and process different kinds of IOTs.

6.6.7. New applications in the field of smart services and IOT

Applications for bicycles can be assigned to the following categories:

1. City information
    - i. Get information about the bicycle in the city
        1. Repair stations
        2. Bicycle routes
        3. Bicycle parking stations
2. Route planning
    - i. Help to define a route that matches specific conditions
        1. Air quality
        2. Main streets / side streets
        3. Shortest distance
        4. Green wave (minimum stopping at traffic lights)
3. On the ride
    - i. Warning about dangerous locations
    - ii. Routing service
4. Smart IOT
    - i. Lightening the path when a cyclist arrives
    - ii. Longer green phase of a traffic light when a cyclist has been identified
    - iii. Bicycle-vehicle communication to prevent crashes
5. Collecting information
    - i. Surface quality
    - ii. Air pollution
6. Gamification
    - i. Motivate people to cycle more often
        1. Smartphone app

A lot of these applications have been tested within the BITS project. For all of them it is useful, that the data are at specific formats and can be accessed on standardized APIs. This makes the implementations much easier. For communication between arbitrary IOT devices such standardization is even necessary.

6.6.8. Outlook

Much happed in the last years in the digitalization of our life. What we can improve, is the general communication between different technologies and services. Therefore, it is necessary to define standards and APIs for each kind of technology. Data formats and APIs for general information need to be implemented by all kind of IOTs. Only, then dynamic communication between devices and services is possible. It must be kept in mind that raw data needs to be pre-processed before the data can be used. With new technologies new data and new information can be generated. It must be investigated, what specific information can measure which kind of phenomena and how specific measurables can be defined to get new knowledge. For research much information about the collection of the data is needed, to derive valuable results. For the dynamic visualization of the data, the user needs more information about the data and the data processing, as they are the one that must interpret the data. Furthermore, the metadata are also important for making use of big data. Regarding the privacy of the user, it is best to compute as much as possible within the user's own device and simply send the calculated results to the server. The user should be able to see the data that will be sent to the server and be able to define private areas in which data should not be collected. Further steps, like obfuscation or generalization to get a more secure anonymization, should be done.

Big data needs different kind of data and data from different sources. Using standardized data formats and APIs helps to implement services on dynamical data. New services can benefit from it.

7. Social value engine in East Riding

We conclude this report with an example from the East Riding of Yorkshire Council (ERYC) on how to combine cycling data with other data to truly have an impact. ERYC are delivering on several pilot implementations as part of the Bicycle and Intelligent Transport Systems (BITS) project including:

- Increasing the number of cyclists in the coastal town of Withernsea and improving their cycle experience with the introduction of a bike library (see below)
- Collecting and using cycling data from bike library users
- Collecting data to establish a baseline for the number of cyclists in the town of Withernsea, which will enable us to gauge if the bike library/ITS scheme is driving an increase, decrease or no change in the number of cyclists
- Sharing bicycle data relating to infrastructure, cycle usage, environment/emissions, personal health, safety, and business performance that anyone can access and use via an open-source platform (www.cycledatahub.eu) that hosts datalinks from the BITS pilot projects.

7.1. Implementations

Implementation 1 - The bicycle library contract was successfully awarded to the Southern Holderness Resource Centre (SHoRes) based in Withernsea via a competitive tendering exercise. The new bicycle library was launched in Withernsea on Friday, 30th July 2021, as part of this 'world first' multi-national partner project, which has given residents the opportunity to borrow a brand-new bicycle for free, as well as to obtain support with bike maintenance, and advice on safe cycling and on improving health and wellbeing.

The bicycles were all fitted with a state-of-the-art trackers, which gather rider statistics and data on carbon savings, popular routes, speed, dwell times, swerving, braking and collisions. The trackers fitted to each bicycle are supplied by See.Sense, an award-winning UK technology and data company that brings technology and people together to enable more people to cycle. The lights enabled cyclists to access a smart phone app that provides data on our journeys and their cycle usage (e.g. distance, calories burned). s.

Implementation 2 - Five traffic counting surveys have been undertaken in December 2019, December 2020, August 2021, December 2021, and August/September 2022. The first survey was carried out to establish a baseline for the number of cyclists in Withernsea in the absence of any data relating to cycle usage in Withernsea. Subsequent surveys were conducted to determine if the bike library pilot was driving any increases or decreases in cycling.

7.2. Social Value Evaluation

As part of the evaluation of the Withernsea bike library pilot we have embedded a social value evaluation process to measure the impact of the pilot on the stakeholders. We are using the Social Value Engine (SVE - https://socialvalueengine.com/) to calculate the total social value generated by our BITS pilots.

The assessment of social value involves identifying the outcomes delivered and selecting financial proxies which can be used to ascribe monetary values to the outcomes. The SVE contains over 300 peer reviewed and externally validated financial proxies from Government and academic sources which provide a strong and justifiable rationale for the validity of all the proxies. The SVE allows us to make a calculation that shows us what impact the project is having on the cyclists, volunteers, and the project team.

Working with the cyclists and SHoRes staff supporting the pilot, an appropriate volume for each of the outcomes claimed is developed. As part of the process, it is important to discount the gross value of each outcome area taking into account deadweight, displacement, attribution and drop off.

The next stage involves identifying the costs associated with the delivery of the service. These should involve indirect costs and in-kind contributions in addition to direct cash costs. Dividing the deflated value of the services delivered by the cost of delivery provides a social return ratio.

To ensure that the social return analysis can be incorporated as part of a broader narrative of impact, each of the outcomes used by the SVE is aligned with the Bristol Accord. This framework is a means of judging the relative sustainability of a settlement or wider territorial unit. It was agreed in 2005 when the UK had the presidency of the EU and it has eight domains which describe the key components of a sustainable place.

A diagram setting out the domains within the Bristol Accord is set out below:

Figure 7.1: Domains within the Bristol Accord.

7.3. Methodology

To evaluate the social value of the BITS project a number of steps are carried out:

1. Development of a Theory of Change
2. Development of an outcomes framework
3. Development of a baseline and end of project survey

7.4. Social Value outcomes

In a forecast of the project, the social value outcomes included:

- Active inclusive and Safe
    - Improved health and wellbeing for residents
    - Reduced in social isolation
    - Improved sense of living in a good place
    - Increased volunteering
- Well Connected
    - Improved access to services
- Environment
    - Carbon reduction through cycling
- Well Served
    - Greater sense of cohesion and cooperation through working collaboratively
- Thriving
    - Skills development for residents and workers
    - Increased employability and work
    - Increase in the creation of micro-business

The social value analysis uses data and information drawn directly from the experience of the bike library users, volunteers and support staff. This intelligence is gathered through participant surveys and case studies. From the case studies, we have selected two quotations from participants which identify some of the benefits they derived from the bike library pilot.

"*I can't believe where I am now. When I first signed up for a bike I wouldn't have dared meet up with groups of people. I didn't really go out that much and only took my dog for a walk. I started out going for short bicycle rides and really had to force myself to leave the house. I still can't get over how much my life has changed; I have made friends with everyone at the South Holderness Resource Centre and am helping other people like me. When I was invited to the presentation day in November (BITS evaluation final workshop event) I had to pinch myself afterwards, I actually talked in front of room full of people I didn't know, to tell them about myself. I have really loved having the bike and it has changed my life for the better.*" – Participant 1

“*I wanted to get fitter and explore the area and hoped I would meet new people by being involved in the workshops. I have found some lovely off road cycle routes and feel fitter. I’ve loved learning bike mechanics and how to index my gears. The bonus is finding employment at the end of it*.” – Participant 2

Thinking about increases or decreases in cycle usage (main target of the BITS project), the feedback from participants can be checked against the counting data that was collected in the town during the project. The results of the counting pilot have been mixed. The initial surveys showed a substantial increase in bicycles on the road throughout 2020, which was supported by a resident survey showing a 10% increase in residents cycling that was undertaken by the Active Withernsea Team in 2020 and 2021. This increase in 2020 was followed by a decline, which the result of several factors including the weather and Covid-19 restrictions on travel and social interaction which were in place in late 2021. Overall, however, the data from the counting surveys evidenced an increase in cycling in the town.

On top of that, this example clearly shows that the effects of cycling are not limited to transportation and that looking beyond cycling domain (or even transport domain), opens up great opportunities.

References

- European ITS Platform: NAP 2020 Annual Report (February 2021)
- NAPCORE: Deliverable 3.2 Report on data availability (June 2022)
- https://github.com/NABSA/gbfs (8 August 2022)

Annex: Overview of National Access Points

Country	Safe and Secure Truck Parking	Safety Related Traffic Information (SRTI)	Real Time Traffic Information (RTTI)	Multimodal Travel Information Services (MMTIS)
Austria	https://mobilitydata.gv.at/	https://mobilitydata.gv.at/	https://mobilitydata.gv.at/	https://mobilitydata.gv.at/
Belgium	www.transportdata.be	www.transportdata.be	www.transportdata.be	www.transportdata.be
Bulgaria	X	X	X	-
Croatia	-	www.promet-info.hr/en/	www.promet-info.hr/en/	www.promet-info.hr/en/
Cyprus	http://www.traffic4cyprus.org.cy/	http://www.traffic4cyprus.org.cy/	http://www.traffic4cyprus.org.cy/	http://www.traffic4cyprus.org.cy/
Czech Republic	https://registr.dopravniinfo.cz/en/	https://registr.dopravniinfo.cz/en/	https://registr.dopravniinfo.cz/en/	https://data.gov.cz/datasets
Denmark	https://du.vd.dk	https://du.vd.dk	https://du.vd.dk	https://du.vd.dk
Estonia	https://www.tarktee.ee/#/en/datex	https://www.tarktee.ee/#/en/datex	https://www.tarktee.ee/#/en/datex	https://www.tarktee.ee/#/en/datex
Finland	X	X	X	X
France	X	X	-	-
Germany	https://service.mdm-portal.de/	https://service.mdm-portal.de/	https://service.mdm-portal.de/	https://service.mdm-portal.de/
Greece	http://data.nap.gov.gr/	http://data.nap.gov.gr/	http://data.nap.gov.gr/	http://data.nap.gov.gr/
Hungary	https://napportal.kozut.hu/	https://napportal.kozut.hu/	https://napportal.kozut.hu/	-
Ireland	-	-	-	-
Italy	-	-	-	-
Latvia	https://lvceli.lv/en/road-network/statistical-data/transport-sector-	https://lvceli.lv/en/road-network/statistical-data/transport-sector-	https://lvceli.lv/en/road-network/statistical-data/transport-sector-	https://lvceli.lv/en/road-network/statistical-data/transport-sector-

Country	Safe and Secure Truck Parking	Safety Related Traffic Information (SRTI)	Real Time Traffic Information (RTTI)	Multimodal Travel Information Services (MMTIS)
	open-data/ , (Road map: https://lvceli.lv/en/sakumlapa-english/#_stavvietas)	open-data/ , (Road map: https://lvceli.lv/en/sakumlapa-english/#_stavvietas)	open-data/ , (Road map: https://lvceli.lv/en/sakumlapa-english/#_stavvietas)	open-data/ , (Road map: https://lvceli.lv/en/sakumlapa-english/#_stavvietas)
Lithuania	-	https://maps.eismoinfo.lt	https://maps.eismoinfo.lt	https://maps.eismoinfo.lt
Luxembourg	-	-	-	-
Malta	-	-	-	-
The Netherlands	Nt.ndw.nu	Nt.ndw.nu	Nt.ndw.nu	nt.ndw.nu
Norway	-	https://transportportal.no/en/	https://transportportal.no/en/	https://transportportal.no/en/
Poland	-	-	-	-
Portugal	-	-	-	-
Romania	https://pna.cestrin.ro	https://pna.cestrin.ro	https://pna.cestrin.ro	https://pna.cestrin.ro
Slovakia	www.odoprave.info, (mobile application https://www.ndsas.sk/i-love-dialnica/mobilna-aplikacia-1)	www.odoprave.info, (mobile application https://www.ndsas.sk/i-love-dialnica/mobilna-aplikacia-1)	www.odoprave.info, (mobile application https://www.ndsas.sk/i-love-dialnica/mobilna-aplikacia-1)	www.odoprave.info, (mobile application https://www.ndsas.sk/i-love-dialnica/mobilna-aplikacia-1)
Slovenia	-	-	-	-
Spain	https://nap.dgt.es/ , (https://www.mitma.es/)	https://nap.dgt.es/, (https://www.mitma.es/)	https://nap.dgt.es/, (https://www.mitma.es/)	https://nap.dgt.es/, (https://www.mitma.es/)
Sweden	Trafficdata.se	Trafficdata.se	Trafficdata.se	Trafficdata.se
Switzerland	-	-	https://opentransportdata.swiss/en/rt-road-traffic-counters/	-
United Kingdom	-	-	-	-