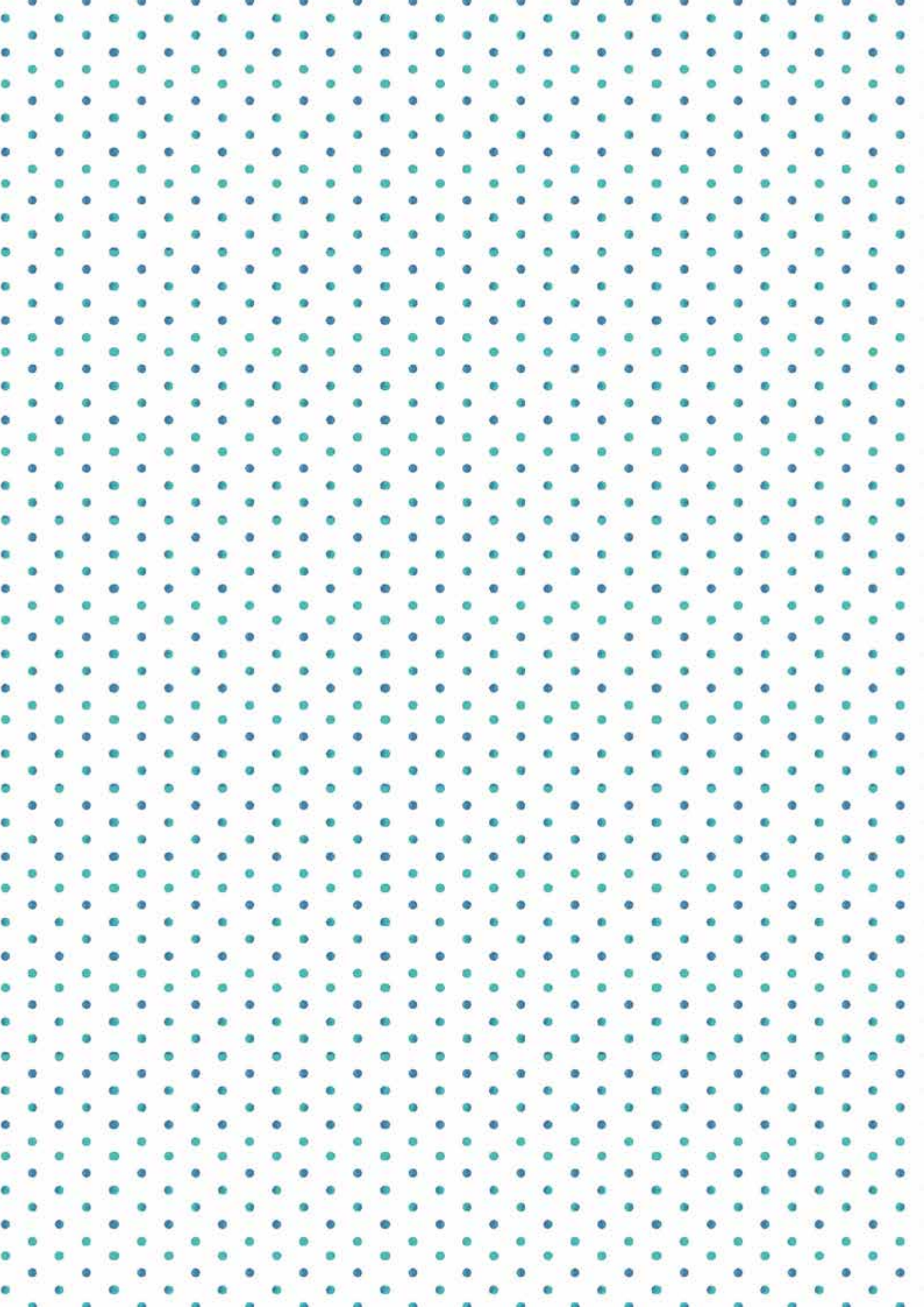


Walking, Cycling and Congestion

Implementer's Guide
to Using the FLOW
Tools for Multimodal
Assessments



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AT A GLANCE

FLOW is a European Commission research and innovation project focusing on the congestion reduction benefits of walking and cycling. The project addressed the specific challenge of helping cities better assess the transport impacts of walking and cycling improvement projects so the full benefits of such projects in reducing congestion could be understood.

FLOW began by researching existing definitions of congestion, technical methods for assessing congestion and transport quality in general, and the process used to perform these assessments (transport impact assessment). The research confirmed FLOW's hypothesis that standard transport analysis tools systematically underestimate the transport benefits of walking and cycling improvements.

FLOW used these research findings to create five multimodal calculation procedures for assessing traffic engineering impacts, a comprehensive impact assessment tool and recommendations for improving transport modelling software. In all cases the emphasis was on creating tools that better account for the impacts of walking and cycling improvements.

In order to test these tools, FLOW's six partner cities used them to perform detailed analyses of proposed walking and/or cycling improvement projects. A total of 9 Exchange and 23 Follower Cities were trained in using the new tools and have started using them in the planning process. The partner and follower cities actively participated in the process of developing and refining the FLOW tools.

The key results of the FLOW project are the tools and calculations described in this document, the experience of the six FLOW partner cities who modelled and tested and reflected on the tools, and a set of recommendations for urban transport policy, multimodal transport assessment techniques, and research resulting from the collective work and learning which took place within the project's three-year lifespan.

Organisation of this Guide

This document presents an implementer's guide to using the approach developed by FLOW to better assess the congestion reduction benefits of walking and cycling projects. It explains how to use the FLOW multimodal calculation procedures and FLOW Impact Assessment Tool.

Chapters 1 and 2 were written for decision makers, transport planners and engineers and those interested in urban transport policy. These chapters provide context and background and describe how the tools were developed.

Chapter 1 introduces the FLOW project and offers some recommendations for improving transport assessment techniques. Chapter 2 presents a basic background on transport analysis tools, the transport impact assessment process and transport software models (while planners and engineers may find some of the explanations in sections 2.2 and 2.3 "basic", they will be helpful for those without such a technical background).

Chapters 3 and 4 are the technical chapters, providing step-by-step instructions on how to use the tools and calculations developed in FLOW. The intended audience is transport planners and engineers who want to use the tools.

Chapter 5 contains references and resources.

ABOUT FLOW

FLOW sees a need for a paradigm shift wherein non-motorised transport (often seen from a transport policy perspective simply as a nice “extra”) is placed on an equal footing with motorised modes with regard to urban congestion. To do this, FLOW is creating a link between (currently poorly-connected) walking and cycling and congestion by developing a user-friendly methodology for evaluating the ability of walking and cycling measures to reduce congestion. FLOW has developed assessment tools to allow cities to evaluate the effects of walking and cycling measures on congestion.

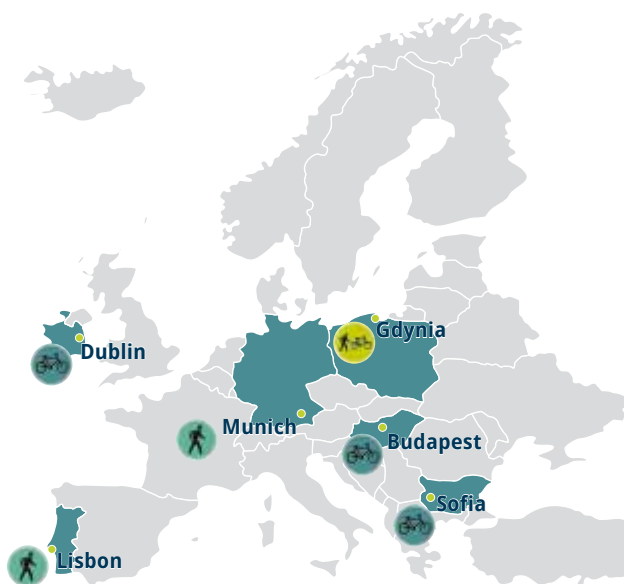
Our aim is for such tools to become the standard for assessing the impact of walking and cycling measures on congestion. The tools include a congestion impact assessment (including socio-economic impact, an assessment of soft measures,

congestion evaluation based on KPIs and a cost benefit analysis) and traffic modelling. Current modelling software has been calibrated and customised in FLOW partner cities to analyse the relationship of cyclist and pedestrian movements to congestion. The modelling and impact assessment will identify the congestion reducing effect of walking and cycling measures. FLOW partner cities have developed implementation scenarios and action plans for adding or up-scaling measures that are shown to reduce congestion.

FLOW targets three distinct audiences, with materials and messaging for each. Cities will learn about the value and use of new transport modelling tools, businesses will be made aware of the potential market in congestion busting products and services

and decision makers will be provided with facts to argue for putting walking and cycling on equal footing with other modes of transport. FLOW is meeting the challenge of “significantly reducing urban road congestion and improving the financial and environmental sustainability of urban transport” by improving the understanding of walking and cycling measures that have potential to reduce urban congestion.

The communication work in the project disseminates FLOW outcomes and outputs to a wider group of cities and regions as well as other urban transport stakeholders across Europe through a set of supporting communication products and networking tools. The project has developed a set of targeted dissemination activities including e-newsletters, a website, social media campaigns, including the FLOW “Quick Facts for Cities” for decision makers and this “Implementer’s Guide” on tools and measures for tackling congestion through walking and cycling.



1

Why walking and cycling and congestion?

FLOW, a European Commission research and innovation project running from 2015-2018, improved techniques for assessing the congestion reduction benefits of walking and cycling.



The FLOW project addressed the challenge of: “Assessing how the role of walking and cycling in the urban modal split can be increased, for example through awareness-raising activities, financial/tax incentives, allocation of infrastructure space, planning approaches/provisions, service concepts, intermodal links, and human-centred environments.” (EC 2013)

FLOW focused on improving **planning approaches** to better understand the transport impacts of walking and cycling, and thereby help increase the mode split of walking and cycling in urban transport.

1.1. PLANNING APPROACHES FOR URBAN TRANSPORT

Cities use a variety of planning approaches to evaluate urban transport improvements. These approaches consist of well-established traffic engineering techniques, assessment tools, and transport models.

FLOW began with the hypothesis that these standard transport analysis techniques, tools and models systematically underestimate and/or ignore the potential contribution of walking and cycling projects to improve transport conditions and reduce traffic congestion.

The inability to accurately estimate the transport benefits of walking and cycling projects has made it difficult to increase the mode share for walking and cycling because:

1. Decision-makers dismiss walking and cycling improvement projects as possible solutions for reducing congestion;
2. Planners have difficulty countering those who argue, for example, that adding a cycling lane will worsen traffic congestion;
3. City residents often do not see walking and cycling projects as useful transport measures, but rather as urban amenities or recreation facilities.

In short, the inability to accurately analyse the transport benefits of walking and cycling has prevented many urban walking and cycling projects from being implemented, thereby reducing the number of people walking and cycling. This has deprived cities of an effective means for reducing congestion.

MORE WORK NEEDS

TO BE DONE BOTH IN TERMS OF IMPROVING METHODOLOGIES AND DEVELOPING A MORE BALANCED APPROACH TO TRANSPORT SYSTEM DECISION-MAKING.

THE INABILITY TO ACCURATELY ANALYSE

THE TRANSPORT BENEFITS OF WALKING AND CYCLING HAS PREVENTED MANY URBAN WALKING AND CYCLING PROJECTS FROM BEING IMPLEMENTED, REDUCING THE NUMBER OF PEOPLE WALKING AND CYCLING AND DEPRIVING CITIES OF AN EFFECTIVE MEANS FOR REDUCING CONGESTION.

The FLOW project addressed this problem by developing new planning approaches for urban transport. These included:

- a set of modifications to existing transport models (chapter 2.4.3)
- the FLOW multimodal calculation procedures (five calculations for evaluating the transport impact of improvement projects) (chapter 3)
- the FLOW Impact Assessment Tool (an urban planning tool for assessing the overall impacts of transport improvement projects) (chapter 4)

In developing these new planning approaches, FLOW focused on congestion, consistent with the EC's research goal of "Significantly reducing urban road congestion" (EC 2013).

The process began by asking: What is congestion and how can it be measured? Next it asked: How do cities evaluate the congestion impacts of transport improvements?

The rest of chapter 1 briefly outlines what FLOW learned from asking these questions and how the project used this knowledge to build a foundation for developing its planning approaches. This process used literature review, expert surveys, working sessions with invited experts, and detailed discussion in project consortium meetings (a broad cross-section of stakeholders ranging from local administrations to walking and cycling experts to transport modellers).

1.2. WHAT IS CONGESTION AND HOW CAN IT BE MEASURED?

Everyone knows what congestion is.

Well, yes, sort of. But understanding: "Sorry I'm late. The roads were congested," is neither scientific nor satisfactory for technical analysis.

Scientific literature approaches the issue of defining congestion by 1) developing a quantitative method for assessing the operational quality of a transport facility or service; and 2) setting a quality level below which the transport facility is said to be "congested".

A wide variety of indicators are used to quantitatively assess the operational quality of a transport facility or service including **travel time**, **vehicle density**, and **reliability**. Many of the most commonly used indicators are described in the **FLOW Multimodal Analysis Methodology**.

Traffic engineers have developed standardised tools for calculating these indicators and recommendations for using them. The starting point for FLOW was to investigate these existing tools and the general concept of congestion.

FLOW took a fresh look at quality indicators for transport systems and at the tools used to calculate them. The objective was to develop a multimodal definition of congestion and to improve the tools and processes used to measure congestion. This process led to several key findings:

- **Congestion is difficult to define** – there are many transport system quality indicators that can be used to define congestion, but none fully met FLOW's objectives of (1) being multimodal, (2) considering both demand and supply, (3) providing flexibility for specific local circumstances, and (4) including user perspectives.
- **Congestion is a matter of perspective** – Two situations with the same quantitative level of congestion could be viewed very differently. For example, a congested motorway makes motorists unhappy, while a busy (congested) pedestrian zone may make shopkeepers happy. Or, as expressed in the famous (at least for urban planners) quote: "The only thing worse than congestion is no congestion".
- **Increasing capacity can increase congestion** – Increasing capacity is the most common solution proposed for congestion: just add extra lanes. But, when a congested road is widened, it attracts more motorists (who switch from other modes, change their travel times, or move to new housing developments in areas surrounding the motorway) and soon becomes congested again. The additional traffic is called induced traffic.
- **Decreasing capacity does not have to increase congestion** – More surprising than induced traffic is the case of traffic evaporation, a situation that can occur when capacity is reduced (e.g., a motorway is removed). Here people change their travel patterns to avoid the roads leading to/from the capacity reduction, thus reducing congestion on those roads.¹
- **People accept recurrent congestion** – It is never fun to be caught in congestion, but people choose to drive despite the fact that congestion is often foreseeable (e.g., during commute hours). Although many people argue they have no alternative to driving, this indicates a certain level of acceptance of congestion.
- **Congestion is not the best indicator of transport system performance** – Congestion is only one indicator of transport network quality. Other indicators such as accessibility by multiple modes of transport, air quality, or average travel time may provide a better picture of a city's transport situation. Combining several measures (including congestion) offers a balanced approach.
- **Eliminating congestion is not a requirement for liveability and economic success** – All the world's most liveable and economically prosperous cities have congestion because congestion is an indication that many people want to be there. Eliminating congestion by building motorways or widening roads can destroy the very qualities that attract people to a city. (Levinson, 2016)

¹ The scientifically proven phenomenon around induced traffic and traffic evaporation is called Braess' Paradox. Its details are beyond the scope of this guide.

- **Congestion is an economic problem** – The economic theory of congestion acknowledges that any resource that is under-priced will be over-consumed. Congestion occurs when driving is under-priced, meaning more people drive. Recognising the economic basis of congestion, cities like London, Stockholm, Milan and Singapore have used pricing as a strategy to manage congestion (Lehe, 2017).

As these findings make clear, congestion is complicated to define and to measure. As no standard definition of congestion existed, FLOW developed the following definition:

Congestion is a state of traffic involving all modes on a multimodal transport network (e.g. road, cycle facilities, pavements, bus lane) characterised by high densities and overused infrastructure compared to an acceptable state across all modes against previously-agreed targets and thereby leads to (perceived or actual) delay.

This definition meets FLOW's four objectives of 1) being multimodal, 2) considering supply and demand, 3) allowing local flexibility, and 4) considering user perspective. The definition also points toward the specific indicators recommended for assessing transport system quality: **density** and **delay**. This leads to another question:

1.3. HOW DO CITIES EVALUATE THE CONGESTION IMPACTS OF TRANSPORT IMPROVEMENTS?

Cities use a variety of transport analysis techniques, tools and models to evaluate the benefits and impacts of changes to the transport network, new development plans and/or new policies. These analysis methods are used in a process called transport impact assessment. A transport impact assessment study compares conditions on the transport network "before" and "after" a specified change is made.

FLOW investigated transport analysis techniques and the process of transport impact assessment in its effort to develop new planning approaches for improving consideration of walking and cycling in reducing congestion. The main findings of this investigation were:

- **Tools and models used to calculate transport quality indicators have limitations** – Like most analysis methods and software models, transport analysis tools and models include assumptions and simplifications. It is important for transport planners to understand these limitations to effectively apply tools and models in the transport impact assessment process.

- **Many transport assessment tools and models do not adequately consider the transport impacts of walking and cycling** – The investigation confirmed FLOW's hypothesis that standard transport analysis techniques, tools and models systematically underestimate and/or ignore, the potential contribution of walking and cycling to transport system performance. Several examples of these limitations are outlined in Chapter 2.
- **More data is needed** – A fundamental problem faced by all cities is insufficient data on walking and cycling. This lack of data leads to a vicious circle: cities do not (and, in some cases cannot) accurately measure walking and cycling activity, so they cannot demonstrate that improving walking and cycling facilities will improve transport conditions and/or help reduce congestion. Interestingly, the recent development of small and inexpensive sensors provides an excellent opportunity for improving data collection, although cities are only now beginning to take advantage of this new technology.
- **Outputs of transport tools and models must be communicated clearly** – It is important for transport planners to communicate both the assumptions and the outputs of transport analyses clearly and transparently to help build and maintain trust between city staff, decision-makers and the general public. This is especially true where induced traffic or traffic evaporation leads to outputs that are counter-intuitive and surprising for non-professionals. The complexity of many transport analysis techniques and models makes this challenging but resources such as **Transport Modelling for a Complete Beginner** (Hollander, 2016) are available to help.

These investigation results were used to help develop 1) recommendations for improving the analysis of transport improvements and 2) specific tools and techniques for addressing the limitations of current approaches for analysing the impacts of walking and cycling on transport network performance. These tools and techniques included a set of transport modelling software improvements (see chapter 2.4.3), the FLOW multimodal calculation procedures (see chapter 3) and the FLOW Impact Assessment Tool (see chapter 4).

Section 2.2 summarises the most important findings from FLOW's investigation of congestion and transport system quality indicator assessment techniques.



MORE WORK NEEDS

TO BE DONE BOTH IN TERMS OF
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DEVELOPING A MORE BALANCED
APPROACH TO TRANSPORT SYSTEM
DECISION-MAKING.

1.4. TRANSPORT ASSESSMENT RECOMMENDATIONS

The investigation results confirmed FLOW's initial hypothesis: standard transport analysis techniques, tools and models are limited in their ability to assess the potential contribution of walking and cycling projects to improving transport conditions and reducing traffic congestion. Furthermore, congestion is puzzling. At first glance, it seems easy to define and understand but it is, in fact, complex and sometimes surprising. Its perceived simplicity means "eliminating" motor vehicle congestion is often prioritised over multimodal approaches that seek to manage congestion by creating alternatives to individual car travel.

As described in this and the following chapter, the FLOW project made and tested modifications to transport analysis techniques, tools, and models designed to improve their ability to consider the impacts of walking and cycling. However, the project also found that additional work is needed both in terms of improving methodologies and in developing a more balanced approach to transport system decision-making.

FLOW's specific recommendations regarding transport impact assessment are:

1. Improve transport analysis techniques, tools and modelling software to better describe multimodal transport system performance and to ensure that walking and cycling are placed on an equal footing with motorised modes in the analysis of transport system performance (including congestion reduction). This includes developing techniques to assess new types of transport/urban infrastructure such as shared space, pedestrian zones, pedestrian priority streets and cycle highways.
2. Shift the focus from "solving" congestion to "managing" congestion. Due to induced traffic, it is very difficult to eliminate congestion. Furthermore, because it indicates people are attracted to an area, congestion often results from a place being attractive (successful). Therefore, cities would be advised to manage congestion by creating a range of options and human-centred environments that encourage walking and cycling, so as not to destroy the very qualities that led to the congestion.

Achieving these recommendations will require boldness on the part of local administrations, more research, and a major effort to increase public awareness. Indeed, the complexity of transport analysis, modelling, and congestion has created a barrier to public understanding, making it ever more important to develop transparent and clear approaches for transport planning.

2

Transport Impact Assessment and Modelling

This chapter presents a context for understanding the planning approaches developed in FLOW. It briefly introduces the topics of transport impact assessment, traffic engineering techniques for assessing transport system performance and transport modelling. It begins by briefly highlighting the urban transport (as opposed to health, environmental or other) benefits of walking and cycling.



2.1. VALUE OF WALKING AND CYCLING IN URBAN TRANSPORT

The congestion reduction potential of walking and cycling is often overlooked. One reason is that automobiles and motorways were viewed as the future when transport analysis techniques and models were initially created. Indeed, many of these techniques were developed specifically to assist in the planning and design of new roads and motorways. Walking and cycling were viewed as old fashioned or only relevant for those who could not afford cars, so it was not seen as necessary to fully include them as modes of transport in transport analysis and modelling.

Moreover, as motorised traffic grew, many people forgot the practical transport function that walking and cycling play in urban transport. In a sense pedestrians and cyclists became invisible (perhaps due partly to their small size compared to automobiles). Some began regarding walking and cycling as recreational activities with little connection to purposeful urban travel.

In fact, walking and cycling play a key role in urban transport. Consider that walking is an essential part of almost every journey regardless of mode (bus riders walk to the bus stop, drivers walk to their cars, and people walk on errands in city centres). And cycling mode shares for commuters in many cities are significant (e.g., over 40% in Amsterdam and Copenhagen).

The perception of walking and cycling as key modes of urban transport has increasing rapidly in recent years. Consequently, transport planners and engineers are improving analysis techniques to more accurately assess their impacts. FLOW has contributed to this effort by developing new tools and recommendations for better assessing the transportation impacts of walking and cycling. These tools will help increase the awareness of walking and cycling as efficient and cost-effective forms of urban transport, in addition to their significant environmental and health benefits.

2.2. WHAT IS A TRANSPORT IMPACT ASSESSMENT?

A transport impact assessment is a study performed to evaluate the impacts (both positive and negative) of changes to the transport network, new development plans and/or new policies. For example, a city wants to know the transport impact of adding a new traffic lane to a road (increased transport supply) or building a new apartment complex (increased transport demand).

While specific methods used to prepare a transport impact assessment vary, they all follow the same general approach:

1. Define the proposed change (e.g., new cycle lane) in as much detail as possible;
2. Determine the spatial area to be studied (a large change will have a large study area);
3. Determine what types of technical analysis (e.g., traffic engineering methods, transport modelling, multi-criteria impact assessment) will be used to assess the impacts of the change on transport system performance.
4. Collect data needed to complete the technical analyses;
5. Perform technical analyses and present results;
6. Make decision regarding the proposed change.

For example, assume a city is considering building a new cycle path by reallocating space from motorised traffic. The proposed cycle path would be defined in detail (e.g., where does it start/end). The study area would be defined as the transport network adjoining the cycle path. The technical analyses would assess the transport system performance of the local network, focusing on questions such as how many new cyclists could be attracted by the new cycle path, how it would improve safety, and what impact it would have on other modes.

If the cycle path were expected to draw users from a wide corridor, the study area would be larger than for a local cycle path, and the analysis would include more extensive transport modelling. If the project were expected to have a significant impact, say a city-wide cycle network, the study area could include the entire metropolitan area and the analysis would include more comprehensive transport demand modelling (considering long term changes to economic, environmental and social conditions).

In all cases, data would be collected, analysed, assessed and presented, and decision-makers would use the information to determine how to best design the project and, ultimately, whether or not to build the cycle network.

The FLOW project focused on the analysis techniques used to assess transport impacts for all types of transport improvement projects. It asked: **Do these techniques accurately evaluate the congestion-reducing benefits of walking and cycling improvement projects?** The project investigated three types of analysis technique:

1. Traffic engineering techniques for assessing transport system performance;
2. Transport modelling; and,
3. Comprehensive impact assessment.

FLOW found that all three types of analysis techniques could be improved to better consider walking and cycling. Some of the main findings are outlined in sections 2.3, 2.4 and 2.5. After assessing the techniques, FLOW developed planning approaches for improving the analysis of walking and cycling transport impacts. These approaches were changes to transport software models (see chapter 2.4.3) the FLOW multimodal calculation procedure (see chapter 3) and the FLOW Impact Assessment Tool for comprehensive impact assessment (see chapter 4).

2.3. TRAFFIC ENGINEERING TECHNIQUES

Traffic engineering techniques use mathematical formulae to assess the performance of individual transport network elements (e.g., junctions), sets of elements (e.g., corridors), and services (e.g., public transport service).

Many government authorities and professional organisations have developed and recommended the use of specific traffic engineering techniques. For example, some cities require the use of specified traffic engineering techniques in transport impact assessment studies performed within their jurisdictions.

Traffic engineering techniques are fully described in standard engineering handbooks including the German Highway Capacity Manual (FGSV 2015) and the US Highway Capacity Manual (TRB 2010). These handbooks contain detailed instructions and information regarding the evaluation of transport system performance for all modes of transport and on all types of transport facilities.

This section presents a high-level summary of several basic traffic engineering techniques. Readers should consult the highway capacity manuals and other standard traffic engineering references for more detailed information.

There are three basic approaches for evaluating transport system performance. They can be categorised in terms of their quality indicators:

1. Physical qualities: for example, **volume to capacity ratios** and **vehicle density** (see 2.3.1);
2. Time: for example, **delay** and **reliability** (see 2.3.2); and
3. Area-wide indicators: for example, **vehicle kilometres travelled** and **amount of pollution generated** (see 2.3.3).

Some indicators are derived from one or more of these primary types of indicator. For example, the familiar indicator level of service (LOS) can be derived from physical qualities or time. The following sections briefly describe example indicators for each category.

2.3.1. Physical Indicators of Transport System Performance

Physical indicators of transport system performance are the easiest to understand because they are based on visible characteristics and conceptually simple techniques.

The most intuitive physical analysis technique compares the **transport demand** (for example, the number of people, cars or bicycles) to the **transport facility capacity** (i.e., how many people, cars, bicycles, etc. can use the transport facility effectively). The demand 'V' is divided by the capacity 'C' to generate a **volume to capacity (V/C) ratio**.

For example, the number of automobiles using a roadway segment is compared to the capacity of the roadway segment. The transport facility capacity is determined by research (for example the capacity of a roadway lane is estimated to be 1800

automobile equivalents per hour). If the demand on such a segment is 900 vehicles per hour, the volume to capacity ratio is 900 divided by 1800 or 0.50.

Density is another physical indicator for evaluating transport system performance. Density is the number of persons or vehicles using a given amount of space (e.g., 2 persons per m², 500 cars per kilometre lane). Density more closely accounts for the behaviour of transport participants (e.g., drivers) than V/C ratios and therefore provides a more accurate description of transport system performance. While density can be measured physically, it is generally estimated using transport models. Density is recommended by many standard traffic engineering references as an indicator for evaluating transport system quality. The FLOW multimodal calculation procedures use density as one of its key performance indicators.

While physical indicators of transport system quality are easy to understand, they have two key problems. First, it is difficult to estimate future demand because most transport system changes have impacts beyond their immediate area. Therefore, transport models are needed.

Second, the transport system performance depends on the interaction of users, for example, the behaviour of drivers in automobiles travelling on a road (speed, following distance, overtaking possibilities, etc.). Thus, in the V/C ratio example above, adding a lane to a road does not add 1,800 vehicles per hour to the capacity; it adds less because motorists would behave differently with the second lane (e.g., some capacity would be used by vehicles shifting between lanes).

Most of the existing research regarding the interaction of users on transport facilities focuses on motor vehicles. Research is needed to fully understand the interaction of pedestrians and cyclists on transport facilities, both in situations when they are using separated facilities (e.g., a sidewalk or cycle lane), and especially when they are sharing the same physical space with other modes (e.g., bicycles in a roadway lane). Today many traffic engineering techniques rely on simple rules of thumb in these situations; for example, bicycles are treated as half an automobile. This research should help improve the ability to evaluate the transport benefits of walking and cycling improvements.

2.3.2. Time-Based Indicators of Transport System Performance

Time-based indicators of transport system performance use time measurements to assess the quality of transport system performance (e.g., travel time between origin and destination).

Time-based indicators have the advantage that actual measurements (e.g. how long it takes to walk from A to B) can be made easily, and these measurements include interactions with other modes of transport (e.g., interaction between pedestrians on the sidewalks between point A and point B). Furthermore, the development of inexpensive sensors has improved the ability to collect time data for all transport modes. As with all indicators, estimating future travel times requires the use of transport models.

The FLOW multimodal calculation procedures use delay as a time-based key performance indicator and defines delay as the difference between the minimum travel time and the actual travel time.

There are several problems with using delay that particularly affect walking and cycling. First, many standard traffic engineering techniques are based on evaluating automobile-oriented infrastructure and behaviour. For example, pedestrians are delayed in many uncounted ways far beyond the time they wait to cross the street at a standard 4-arm junction (see figure 1). These include delays caused by the lack of a formal crossing facility (waiting for a gap in traffic or making a large detour), crossings not located on the desire line (e.g., staggered crossing layouts), and grade-separated facilities (bridges or underpasses) where, since the pedestrian is always moving, no delay is measured although walking is significantly discouraged (see figure 2).

Figure 1: Standard 4-arm junction

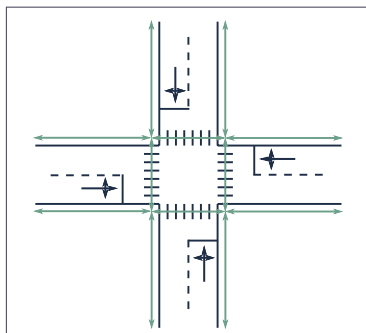
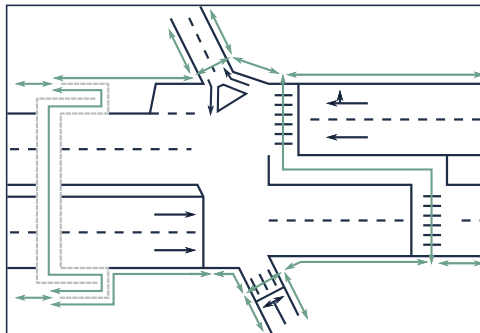


Figure 2: Actual crossing distances for pedestrians at a non-standard junction



Another problem with delay is the choice of minimum travel time as a comparison point. Using the concept of acceptable time rather than minimum time has the advantage of including user perception and choice. A good example is a cyclist who chooses a slightly longer route because she feels it is safer or a walker who accepts a slightly longer travel time to travel along a pleasant route. Using acceptable travel time provides a fuller description of transport network quality, but there is insufficient research on how to estimate and calculate acceptable travel times, especially for walking and cycling. Developing a better understanding of acceptable time is an excellent subject for further research.

2.3.3. Area-Wide Indicators of Transport System Performance

Area-wide indicators of transport system performance describe total or average transport data for a designated geographic area (e.g., a city or region). These indicators include **vehicle kilometres travelled**, **accessibility** (often measured in terms of travel times) and **environmental impacts** (air pollution). These indicators are almost always outputs of transport models and are generally applied on a network or regional basis (e.g., the number of vehicle kilometres travelled in the city under future scenario 1 is expected to be 3% higher than under scenario 2).

The FLOW Impact Assessment Tool uses several area-wide indicators to develop an overall assessment of a transport improvement project (see chapter 4).

2.3.4. Level-of-Service

Level-of-service (LOS) is a qualitative transport performance measure based on quantitative methods such as the physical and time-based indicators described above.

SINCE THE ANALYSIS

TECHNIQUES FOR DIFFERENT MODES USE VERY DIFFERENT METHODS, THERE IS LIMITED COMPARABILITY BETWEEN THE ACTUAL QUALITY OF SERVICE EXPERIENCED BY PEOPLE USING DIFFERENT MODES, EVEN WHEN BOTH HAVE THE SAME LOS.

LOS provides a more descriptive way of presenting numerical results of transport evaluation techniques to non-technical audiences.

LOS is based on the American academic grading scale where “A” equals excellent and “F” equals failure. The analyst first calculates a numerical value for transport facility quality then uses that value to determine LOS. For example, a planner calculates a volume to capacity (V/C) ratio of 0.47 at a junction. Next the planner looks in a table of values and sees that for a V/C ratio of 0.47, the LOS would be “A” (excellent).

Level-of-service makes it possible for planners to say, “under scenario one LOS would be ‘A’ and under scenario two LOS would be ‘C’ so scenario one is better”. The grading scale makes it easier for decision-makers to understand transport system quality, but does not accurately describe conditions for users (e.g., facilities with V/C ratios of 0.71 and 0.79 would be experienced quite differently by users, but have the same LOS).

The simplicity of LOS has led to the development of analysis techniques for describing service quality for all modes of transport. In other words, it is possible to estimate the LOS of a stairway, cycle lane or public transport route. Since the analysis techniques for different modes use very different methods (e.g., delay for road segments, amount of space per person in a public transport vehicle), there is limited comparability between the actual quality of service experienced by someone using one mode and someone using another mode when both have the same LOS. (In other words, a driver experiencing LOS D has a different experience than a bus passenger experiencing LOS D.)

Since LOS is calculated differently for different modes of transport it is difficult to develop a single LOS for a transport facility that describes a truly multimodal LOS. The FLOW multimodal calculation procedures use a utility-point approach to address this problem.

2.3.5. FLOW Multimodal Analysis Methodology of Urban Road Transport Network Performance

The FLOW Multimodal Analysis Methodology of Urban Road Transport Network Performance describes the process and results of FLOW’s analysis of transport system performance methods and their application to urban congestion. The document also presents FLOW’s multimodal calculation procedures for calculating the recommended key performance indicators: density, delay and LOS. Chapter 3 of this document presents a detailed description of how to calculate these KPIs and the FLOW-developed multimodal performance index (MPI).

2.4. TRANSPORT MODELLING

Transport models are used to estimate future conditions on transport networks. This section outlines the two main types of models, several modelling problems that particularly affect walking and cycling and improvements to transport models developed in FLOW.

2.4.1. Types of Transport Models

Macroscopic Models

Macroscopic models estimate transport demand for large areas (e.g., cities, regions, nations) (see figure 3) based on socio-economic data. They generally follow the four-stage approach:

- (1) **Trip generation** (how many trips will be made?) – split the area into zones and use zone-specific socio-economic data to predict transport demand to/from the zone in person-trips;
- (2) **Trip distribution** (where will people travel to and from?) – predict zone-to-zone person-trip transport flows using the socio-economic data;
- (3) **Mode split** (which transport mode will they use?) – predict which mode of transport (driving, public transport, walking, cycling, etc.) people will use for each trip;
- (4) **Trip assignment** (which routes will they take?) – predict which specific route (roadways, public transport routes, cycle routes, sidewalks, or combination) persons will use for their trip.

Figure 3: Image of a complete network from a macroscopic model.



Each step in the model contains sub-models and numerical techniques designed to forecast human behaviour. These techniques are often complex and require a great deal of data to calibrate properly. While transport models have been significantly improved since the first models were developed in the 1950s, they are still based on many assumptions and simplifications that require more research to improve.

Transport models were originally developed to evaluate major urban transport improvement projects (e.g., new motorways or rapid transit lines). It is only recently

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that they have been used to consider finer grained zonal structures and smaller scale transport systems (e.g., walking and cycling). Many of the same sub-models **should** apply to these situations (e.g., choosing which cycle route to take should be like a driver choosing which roads to use) but exactly how the models need to be adjusted remains a subject of research. An important FLOW objective was to contribute to this research by improving the ability of models to forecast the transport impacts of walking and cycling.

The outputs of macroscopic models are area-wide indicators such as accessibility indicators, person kilometres travelled, travel times, pollution generated, and transport costs. Their main function is analysing transport conditions at the system or network level (e.g., citywide vehicle kilometres travelled).

Microscopic Models

Microscopic assignment models analyse the performance of individual transport facilities (e.g., junctions, roadway segments, cycle lanes, sidewalks) at a detailed level (see figure 4). They are generally used to analyse transport conditions on a set of facilities in a small to medium sized area.

Figure 4: Image from a microscopic model simulation of a junction.
Image courtesy of COWI A/S



Microscopic assignment models use locally collected data or results from steps 1-3 of a macroscopic model to assign traffic flows (for all modes) to specific transport infrastructure. They use these flows to evaluate the transport performance of individual transport facilities using transport engineering methodologies (such as those outlined in chapter 2.3 above). They also estimate area-wide indicators to assess overall transport system performance in the study area (e.g., pollution generated).

Microscopic models are subject to some of the same caveats regarding complexity and need for more research (especially for walking and cycling) as macroscopic models.

2.4.2. Limitations of Transport Modelling in the Evaluation of Walking and Cycling

Although today's models are effective tools, all transport analysis techniques and models are simplifications and therefore cannot precisely forecast future conditions in the real world. This section briefly outlines several aspects of transport modelling that are particularly problematic for the evaluation of walking and cycling improvement measures.

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THE REAL WORLD.

Complexity of walking and cycling

The behaviour of motor vehicle traffic on roads is relatively homogeneous. Automobiles generally stay in their lanes and move forward in the same direction at similar speeds. Even under these conditions, the precise behaviour of motor vehicles in traffic is not fully understood.

Pedestrians and cyclists, on the other hand, have much more freedom of movement and relative heterogeneity. This is especially true in large multi-user areas such as shared space or pedestrian districts. Therefore, much more research is needed on the behaviour of pedestrians and cyclists in these areas and in mixed use infrastructure (e.g., combined walking and cycling paths). This research should be used to refine models to better evaluate the transport impacts of projects such as shared space.

As part of the FLOW project the PTV Vissim/Viswalk model was improved to better model shared space. For more information on FLOW's model improvements please see section 2.4.3 below.

Estimating the costs of walking and cycling

One of the basic assumptions in traditional transport modelling is that humans behave as rational economic actors. This means they choose the least costly route to make a given trip.

Perceived costs are calculated based on financial costs (cost per kilometre to operate a car, public transport fare), costs based on travel time (calculated by applying a standard cost per hour to the travel time) and sometimes additional "penalties" to reflect user preferences (e.g. time penalties for interchange as compared to direct services). This method is reasonable for comparing an automobile trip to a public transport trip. But how well does it work for walking and cycling?

A good example is safety. People rarely consider safety when making travel decisions as car drivers because there is a certain common level of safety (everyone is in large metal boxes), but safety is an important consideration when walking or cycling. Experience in many cities has shown that the cycling mode share increases significantly when safe **networks** are created – one unsafe segment on a route makes the journey impossible for some. In Seville the number of cyclists increased from 6,000 to 70,000 when a coordinated network of cycle lanes was opened. (Walker, 2015)

People walking and cycling also consider environmental quality (not important for most people travelling in soundproof, air-conditioned metal boxes), gradients and how scenic or enjoyable the route is when making travel decisions.

A simple model based exclusively on travel time and cost does not consider these factors. This means models will very likely underestimate the benefits of, for example, a small improvement that completes a safe cycling network. It is possible to improve models to better consider these non-time and cost factors, although this increases complexity. Newer activity-based models are also able to better consider some of these factors.

A KEY PROBLEM

WITH CALIBRATION IS THAT IT MEANS THE MODEL IS BEST SUITED FOR ANALYSING SCENARIOS THAT ARE SIMILAR TO EXISTING CONDITIONS AND LESS ACCURATE FOR ESTIMATING THE IMPACT OF INTRODUCING A COMPREHENSIVE NETWORK OF CYCLE LANES WHERE NONE EXISTED BEFORE.

Estimating the impact of major changes

All models work best when they are forecasting the impacts of incremental (small) changes. As the degree of change increases, the accuracy of models decreases. This occurs because models cannot consider everything for intellectual ('we don't know') and practical ('we can't calculate such a complex relationship efficiently') reasons.

To ensure that models match reality as closely as practical they are "calibrated" based on local traffic conditions. Calibration consists of creating a transport model for an area, then running the model and comparing the results to real data. For example, comparing the traffic volumes predicted by the model for ten locations to the actual traffic volumes at those locations. The model is then adjusted until the predicted volumes are within a specified relation to the actual volumes (e.g., predicted volumes are +/- 5% of measured volumes).

A key problem with calibration (beyond the large amount of data and detailed understanding of model processes needed) is that it means the model is best suited for analysing scenarios, transport improvements or policies, that are similar to existing conditions. The model can adequately estimate the impact of an additional motorway lane, but it would be less accurate for estimating the impact of introducing a comprehensive network of cycle lanes where there had been no cycle lanes before.

The calibration process is particularly difficult for walking and cycling improvements because, in many cases, the baseline for walking and cycling starts at a relatively low level, so models will not be able to forecast the benefits of a large change such as creation of a pedestrian district or network of safe cycle paths. Adding to the problem is the lack of detailed quantitative data available on walking and cycling that can be used in the calibration process.

Induced traffic

Induced traffic is new traffic that is attracted to a transport facility after it is improved. Before the transport facility was improved, this traffic used a different route or transport mode, travelled at a different time, or didn't travel at all. In other words, it is new traffic attracted to the improved route. In economic terms, induced traffic is attracted by reducing the cost of travel on the improved route.

Induced traffic is a major reason why many road improvement projects sold to decision-makers as "solutions" to the congestion problem don't, in fact, eliminate the congestion. These include roadway widening projects where congestion remains the same or becomes even worse after the widening, such as the M25 in the UK.

Transport models can forecast induced traffic but this requires refinements including the use of elasticities to estimate the propensity for people to change their mobility behaviour based on the qualities of the improved transport facility. Furthermore, many assumptions are needed to fully consider broader changes, such as business location decisions, that affect induced travel demand.

The complexity of these model refinements means they may not be made and/or the full implications of induced traffic not explained to decision-makers. Decision

makers then follow the intuitive approach that adding more road space will reduce congestion. They do not consider alternative types of improvements, such as creating a safe cycling network or pedestrian zone, because they are convinced (by the model) that congestion can be eliminated.

Traffic evaporation

The flip side of induced traffic is traffic evaporation. Traffic evaporation refers to the traffic that disappears if transport supply is reduced. This is shown most clearly in urban motorway removal projects (e.g., Seoul, San Francisco, Portland) where motorways have been removed without drastically increasing congestion. In this case, the price (in time) of driving is increased, so people switch to other routes, or use other modes of transport. Congestion on the transport facility remains about the same even after the facility's capacity is reduced (<http://freakonomics.com>).

Current transport models are not capable of predicting traffic evaporation because there is insufficient data for developing model elasticities. This is problematic for evaluating the impacts of walking and cycling improvements because it means models overestimate the congestion impacts of many walking and cycling improvements. For example, if a road is narrowed to add a cycle lane or traffic signal timing is changed to reduce delays for pedestrians, the model might not recognise that these changes could reduce motorised traffic demand by encouraging travellers to use other routes, switch modes, travel at other times, or make other changes to their travel behaviour.

Many walking and cycling projects have reduced road space without leading to the increased congestion feared by opponents. The FLOW **Quick Facts for Cities** and the six FLOW city case studies provide good examples.

Model complexity

As the above discussion shows, transport modelling is complex. It is important that planners understand the simplifications and assumptions made in modelling so they can fully understand model results and clearly communicate them to decision-makers and the public. This is especially important when analysing the impacts of walking and cycling improvement projects because, as outlined above, transport models were not originally designed to include these modes of transport and many models still do not accurately account for walking and cycling behaviour.

2.4.3. FLOW Project Transport Model Improvements

Transport models are being continuously improved through research and development in academics and industry. The FLOW project has contributed to this research and has developed several techniques for improving the quality of transport modelling. These modelling improvements are:

- Microscopic modelling – Enhanced modelling of conflict zones between cars and pedestrians, behaviour parameters, new mobility patterns, the interaction between bikes and pedestrians and shared space

IT IS IMPORTANT

THAT PLANNERS UNDERSTAND
THE SIMPLIFICATIONS AND
ASSUMPTIONS MADE IN
MODELLING SO THEY CAN FULLY
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AND CLEARLY COMMUNICATE
THEM TO DECISION-MAKERS AND
THE PUBLIC.



- Macroscopic modelling – Path-level attributes in stochastic assignment of bicycles (e.g. slope, level of vehicle traffic), a modelling platform for combination of two path legs (can be used for walk & ride or bike & ride) and an enhanced representation of mobility sharing in PT assignment (for bike share)

These improvements were implemented in the PTV Visum (macroscopic) and PTV Vissim/Viswalk (microscopic) models and tested in the FLOW partner cities.

2.5.FLOW MULTIMODAL CALCULATION PROCEDURES AND FLOW IMPACT ASSESSMENT TOOL

The FLOW multimodal calculation procedures are specific traffic engineering techniques designed to better assess the transport system performance impacts of walking and cycling improvements. These tools – and step-by-step instruction on using them – are described in Chapter 3.

The FLOW Impact Assessment Tool is a technique for evaluating the mobility, environmental, societal and financial impacts of transport improvements. The tool recognises that transport should not be the only consideration when decisions are made about improving the transport system. The FLOW Impact Assessment Tool is described in Chapter 4.

3

FLOW Multimodal Calculation Procedures

This chapter summarises the FLOW multimodal calculation procedures and describes how to use them to evaluate the transport impacts of improvement projects. For more detailed information please see the FLOW Multimodal Analysis Methodology of Urban Road Transport Network Performance. The spreadsheets required for the following calculations are available at www.h2020-flow.eu/resources/publications.



3.1. OBJECTIVE AND RESULTS

The FLOW multimodal calculation procedures were developed to provide an analysis technique that better accounts for the transport impacts of walking and cycling improvements than the standard practices currently used.

The FLOW multimodal calculation procedures were developed by: first, investigating existing indicators used to evaluate transport facility quality (especially those used to identify congestion); second, examining the transport engineering methodologies used to calculate those quality indicators; and, third, developing an approach for modifying those methodologies to more accurately evaluate walking and cycling improvements.

The key performance indicators (KPIs) used to evaluate transport facility quality are **density**, **delay**, and **level of service**. The transport engineering techniques used to calculate these indicators are well known and generally acceptable for evaluating the transport impacts of walking and cycling improvements.

However, a key problem with standard transport engineering techniques is that they are unable to combine mode-specific results into a usable multimodal assessment of quality. For example, the technique used to evaluate pedestrian delay works well, but these results are difficult to integrate with vehicle-based delay to obtain a complete multimodal assessment of transport system performance. One aspect of this problem is that most techniques are based on vehicles rather than people; this means that a transit vehicle with 50 people is treated the same way as a car with one person.

The FLOW multimodal calculation procedures have been developed to address this problem by creating a multimodal performance index (MPI) for three key performance indicators: delay, density and level-of-service. These indicators are defined as:

- Delay: the additional travel time experienced by a user compared to the minimum travel time.
- Density: the number of persons or vehicles using a given space.
- Level of Service (LOS): a qualitative indicator of the service experienced by users.

The FLOW multimodal calculation procedures approach the problem of multimodal facility analysis by (1) modifying the technique proposed for estimating KPIs to be based on the unit of persons rather than vehicles; (2) using a utility points-based approach to calculate multimodal LOS; and (3) creating a multimodal performance index (MPI) that calculates a weighted average of the mode specific KPI values. The specific tools for calculating these indicators are presented below.

The spreadsheet needed for all of the calculations described below can be found at: www.h2020-flow.eu.

A KEY PROBLEM

WITH STANDARD TRANSPORT ENGINEERING TECHNIQUES IS THAT THEY ARE UNABLE TO COMBINE MODE-SPECIFIC RESULTS INTO A USABLE MULTIMODAL ASSESSMENT OF QUALITY.

3.2. USING THE FLOW MULTIMODAL CALCULATION PROCEDURES – OVERVIEW

The FLOW multimodal calculation procedures are designed to evaluate the impacts of transport improvements on the multimodal transport system. For example, they can be used by planners who want to analyse the impact of adding a new cycle lane to a street by removing a vehicle lane.

The FLOW Multimodal Transport Calculation Procedure consists of the following four-step process:

- 1) Determine Assessment Level
- 2) Set Improvement Priority
- 3) Calculate Key Performance Indicator (KPI) using FLOW multimodal calculation procedures
- 4) Calculate Multimodal Performance Index (MPI) using FLOW multimodal calculation procedures

These steps are outlined below.

THE FLOW MULTIMODAL CALCULATION PROCEDURES

ARE DESIGNED TO EVALUATE THE IMPACTS OF TRANSPORT IMPROVEMENTS ON THE MULTIMODAL TRANSPORT SYSTEM. FOR EXAMPLE, THEY CAN BE USED BY PLANNERS WHO WANT TO ANALYSE THE IMPACT OF ADDING A NEW CYCLE LANE TO A STREET BY REMOVING A VEHICLE LANE.

Step 1 – Determine Assessment Level

The assessment level describes the transport facilities that will be evaluated in the transport impact assessment. This choice depends directly on the type of improvement being implemented. In the FLOW multimodal calculation procedures, there are three main options: junction, segment, or corridor. If the improvement is being made to a junction, the methodology for junctions is used, and so forth.

Step 2 – Set Improvement Priority

Step 2 is optional. It consists of applying a priority factor (weighting factor) in the calculations to favour a specified type of transport improvement in the calculation process. For example, a city may have a policy to increase its cycling mode share to 10%. This city may then choose to apply a priority factor to cycling improvements.

The advantage of using a priority factor is that all types of proposed improvements can be evaluated using a transparent process adapted to local circumstances. Using a priority factor would replace the current situation where a cycling improvement and

motor vehicle improvement were evaluated using the same methodology, the motor vehicle project was shown to be better, but decision-makers chose the cycling project because the city policy was to support cycling. The FLOW approach with priority setting would say if the cycling improvement, with the priority factor, was better than the car project it would be implemented, but if the priority factor was not enough, the motor vehicle project would be implemented.

Whether or not to use the priority factor is a question that each city can decide individually. The FLOW multimodal calculation procedures can be used with or without the factor. However, if a city decides to use a priority factor, the factor should be determined in an open and transparent process. Furthermore, when priority factors are used, care should be taken when benchmarking projects in different cities.

Step 3 – Calculate Key Performance Indicator (KPI)

Step 3 consists of calculating the key performance indicators for each mode expressed in the same indicator (i.e., density, delay or LOS). The KPI is calculated using the appropriate FLOW multimodal calculation procedure.

There are two approaches for obtaining the data needed to estimate the performance indicators: using a model or manually. The advantages of modelling are that it can estimate changes in traffic (motor vehicle, pedestrian and cyclist) on individual facilities caused by the improvement (see discussion in Chapter 2) and that the performance measure of interest (e.g., delay) is normally available as a direct model output.

If a model is not available, there are manual methods available based on measuring existing conditions and making projections of future conditions. These methods are described in standard transport references (e.g. German or US highway capacity manuals).

The specific methods developed by FLOW for calculating KPIs are described starting in Section 3.4.

Step 4 – Calculate Multimodal Performance Index (MPI)

Step 4 consists of aggregating the key performance indicators for delay and LOS from the assessment level (junction, road segment, or corridor) for all modes into a multimodal performance index (MPI).

The MPI provides a multimodal assessment of transport network quality using delay or LOS for the selected transport facility. The MPI is calculated by converting the facility delay or LOS into a person-based delay or LOS. This conversion is needed because the KPIs calculated in Step 3 are based on vehicles for automobiles and public transport. (The KPIs calculated in Step 3 for pedestrians and bicyclists are already based on persons.)

The specific methods developed by FLOW for calculating MPIs are described starting in Section 3.4.

THE FLOW APPROACH

WITH PRIORITY SETTING
WOULD SAY IF THE CYCLING
IMPROVEMENT, WITH THE
PRIORITY FACTOR, WAS BETTER
THAN THE CAR PROJECT IT
WOULD BE IMPLEMENTED,
BUT IF THE PRIORITY FACTOR
WAS NOT ENOUGH, THE MOTOR
VEHICLE PROJECT WOULD BE
IMPLEMENTED.

3.3. ASSESSMENT TYPE AND KEY PERFORMANCE INDICATOR CALCULATION

FLOW has developed multimodal calculation procedures to evaluate the following five KPI – facility type combinations:

1. Junction delay
2. Junction LOS (based on delay and utility points)
3. Road segment density
4. Road segment LOS (based on density and utility points)
5. Corridor delay

FLOW has not developed a tool for evaluating LOS for corridors but recommends presenting the LOS for all transport facilities along the corridor graphically. This approach provides a more descriptive presentation of transport conditions.

The following sections describe how to use the FLOW multimodal calculation procedures for each KPI – facility type combination. Each section starts by calculating the key performance indicator (KPI), then calculating the multimodal performance index (MPI).

The descriptions are based on examples. The data sources and calculations in the examples are described first and then spreadsheet tables are presented that summarise the calculation process. Spreadsheet-based versions of the FLOW multimodal transport analysis tools described in this chapter are available at www.h2020-flow.eu.

3.4. FLOW MULTIMODAL CALCULATION PROCEDURE: JUNCTION DELAY

Delay is defined as the difference between the actual travel time and the minimum travel time (free flow conditions).

The delay value for a junction is a sum of the delays for all transport modes and all movements (e.g., turning right, going through, and turning left) on all arms of the junction. This means that a typical four-armed junction will have a total of 44 delay values (11 for each arm: 3 possible movements for cars, public transport, and bicycles; 2 possible movements for pedestrians – persons crossing the junction from both sides of the considered arm).

Delay values for all transport modes and movements can be obtained as output from a microscopic transport model or measured in the field using techniques from standard transport references (e.g., the German or US highway capacity manuals).

Table 3-1: Delay at Junction

| Delay at Junction | | | Input | | | Result of delay calculation | Result of transformation | Result of aggregation | |
|-----------------------------|-------|------------|-----------------|------------------------------------|----------------------------------|---|----------------------------|-----------------------------|----------------------------------|
| Transport Mode and Movement | | | Priority factor | Vehicle occupancy ratio (pers/veh) | Traffic volume (veh/h/ln; ped/h) | Mean delay per mode (s/pers/turn. mov.) | Traffic volume (pers/h/ln) | Mean delay per arm (s/pers) | Mean delay per junction (s/pers) |
| 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |
| Junction Arm 1 | Car | right | 1 | 1.2 | 108 | 24 | 130 | 55 | |
| | | through | | | 15 | 51 | 18 | | |
| | | left | | | 122 | 51 | 146 | | |
| | Bus | right | 1 | 40 | 0 | 0 | 0 | | |
| | | through | | | 0 | 0 | 0 | | |
| | | left | | | 0 | 0 | 0 | | |
| | Cycle | right | 1 | 1 | 28 | 24 | 28 | | |
| | | through | | | 242 | 51 | 242 | | |
| | | left | | | 34 | 51 | 34 | | |
| | Walk | crossing 1 | 3 | 1 | 512 | 58 | 512 | | |
| | | crossing 2 | | | 178 | 58 | 178 | | |
| Junction Arm 2 | Car | right | 1 | 1.2 | 138 | 45 | 166 | 47 | |
| | | through | | | 45 | 33 | 54 | | |
| | | left | | | 52 | 44 | 62 | | |
| | Bus | right | 1 | 40 | 0 | 0 | 0 | | |
| | | through | | | 6 | 33 | 240 | | |
| | | left | | | 0 | 0 | 0 | | |
| | Cycle | right | 1 | 1 | 18 | 45 | 18 | | |
| | | through | | | 45 | 33 | 45 | | |
| | | left | | | 9 | 44 | 9 | | |
| | Walk | crossing 1 | 3 | 1 | 152 | 65 | 152 | | |
| | | crossing 2 | | | 243 | 44 | 243 | | |
| Junction Arm 3 | Car | right | 1 | 1.2 | 38 | 41 | 46 | 57 | |
| | | through | | | 24 | 41 | 29 | | |
| | | left | | | 68 | 41 | 82 | | |
| | Bus | right | 1 | 40 | 0 | 0 | 0 | | |
| | | through | | | 0 | 0 | 0 | | |
| | | left | | | 0 | 0 | 0 | | |
| | Cycle | right | 1 | 1 | 4 | 41 | 4 | | |
| | | through | | | 84 | 41 | 84 | | |
| | | left | | | 13 | 41 | 13 | | |
| | Walk | crossing 1 | 3 | 1 | 170 | 58 | 170 | | |
| | | crossing 2 | | | 768 | 58 | 768 | | |
| Junction Arm 4 | Car | right | 1 | 1.2 | 65 | 13 | 78 | 39 | |
| | | through | | | 24 | 13 | 29 | | |
| | | left | | | 71 | 24 | 85 | | |
| | Bus | right | 1 | 40 | 0 | 0 | 0 | | |
| | | through | | | 6 | 13 | 240 | | |
| | | left | | | 0 | 0 | 0 | | |
| | Cycle | right | 1 | 1 | 12 | 13 | 12 | | |
| | | through | | | 87 | 13 | 87 | | |
| | | left | | | 43 | 24 | 43 | | |
| | Walk | crossing 1 | 3 | 1 | 186 | 44 | 186 | | |
| | | crossing 2 | | | 134 | 65 | 134 | | |

Column details and descriptions

- 4 Priority factor
In this example, pedestrians have been given the highest priority (3) over the other modes (all 1).
- 5 Vehicle occupancy ratio
Standard ratios can be used or you may use your own junction-specific values (this is especially important for PT as occupancy differs substantially between cities and routes).
- 6 Traffic volumes for all modes and movements by junction arm
These values should be "decisive", i.e. the volume in the lane with the higher volume, if there are multiple lanes. Volumes can be taken from microscopic model outputs or measured and calculated manually.
- 7 Mean delay value for each mode, junction movement and arm
This is a direct output from a microscopic transport model. Manual calculation methods are also available.
- 8 Traffic volume per arm
This is the result of transforming traffic volumes from vehicle-based figures to person-based figures. Volume of vehicles (Column 6) x vehicle occupancy ratio (Column 5) = traffic volume in persons. The priority factor (Column 4) is also applied in this calculation. In this case:
arm 1 car right turns: 108 vehicles/hr x 1.2 persons/vehicle x 1 (priority) = 130 persons/hr
arm 1 ped 1: 512 peds/hr x 1 person/ped x 3 (priority) = 1,536 persons/hr
- 9 Mean delay for all modes and junction movements for each junction arm
This is calculated in two steps.
Step 1 Calculate the total delay for each junction movement and mode for the junction arm (including priority factors). In this case: Arm 1 car right turns: 130 person/hr x 24 sec/person x 1 = 3,120 sec
Arm 1 ped 1: 512 peds/hr x 58 sec/person x 3 = 89,088 sec
Step 2 Add together all 11 delays (calculated with priority factor for each movement, mode and arm) and divide by the number of persons (calculated with the priority factor). In this case: Arm 1: 146,292 sec delay ÷ 2,668 persons = 54.83 sec/person
- 10 Mean delay for the whole junction
This is calculated in three steps:
Step 1 sum delays by movement, mode and approach calculated in step 1 of column 9. For example:
Arm 1: 146,292 sec delay
Arm 2: 84,307 sec delay
Arm 3: 173,790 sec delay
Arm 4: 59,552 sec delay
Total for all arms: 463,941 sec delay
Step 2 sum the traffic volumes calculated in column 8 for all modes, junction movements and approaches for a total traffic volume for the junction. (these volumes are in persons and have been calculated using the priority factor set by the city.)
Step 3 To get the overall junction delay, divide the total delay calculated in Step 1 by the total traffic volume calculated in Step 2. For example: Total junction delay all arms: 463,941 sec
Total junction volume all arms: 9,053 persons
Overall junction delay: 51.24sec delay per junction user

3.5.FLOW MULTIMODAL CALCULATION PROCEDURE: JUNCTION LEVEL-OF-SERVICE (LOS)

The FLOW multimodal calculation procedure calculates level-of-service for junctions based on delay.

The first step, therefore, is to calculate junction delay. This is done using the technique described in Section 3.4 above.

Next, a table is used to assign a LOS value to numerical values of delay calculated as described in Section 3.4 (above). Table 3-2 presents the Junction LOS Table from the German Highway Capacity Manual (FGSV 2015).

Table 3-2: Level-of-Service values for signalised junctions (Source: FGSV 2015).

| LOS | Automobile | Public Transport | Cycle | Pedestrian |
|-----|--------------------------|--------------------------|-----------------------------|--------------------------------|
| | mean delay (sec/vehicle) | mean delay (sec/vehicle) | maximum delay (sec/bicycle) | maximum delay (sec/pedestrian) |
| A | ≤20 | ≤5 | ≤30 | ≤30 |
| B | ≤35 | ≤15 | ≤40 | ≤40 |
| C | ≤50 | ≤25 | ≤55 | ≤55 |
| D | ≤70 | ≤40 | ≤70 | ≤70 |
| E | >70 | ≤60 | ≤85 | ≤85 |
| F | | >60 | >85 | >85 |

The table below describes how to calculate the junction LOS (KPI) and multimodal performance (MPI) for a typical four arm junction. For simplicity's sake, the same example values used to calculate the junction delay (on page 35) are used in this example.

Table 3-3: Level-of-Service at a Junction

| LOS at Junction | | | Input | | | | Result of LOS calculation | Result of transformation | | Result of aggregation | |
|-----------------------------|-------|------------|-----------------|------------------------------------|----------------------------------|---------------------------------------|---------------------------|--------------------------|--------------------------|-----------------------|----------|
| Transport Mode and Movement | | | Priority factor | Vehicle occupancy ratio (pers/veh) | Traffic volume (veh/h/ln; ped/h) | Mean delay per mode (s/per/turn move) | LOS | Utility Points | Traffic Volume (pers/hr) | Mean utility | Mean LOS |
| 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 |
| Junction Arm 1 | Car | right | 1 | 1.2 | 108 | 24 | B | 90 | 130 | 59 | D |
| | | through | | | 15 | 51 | D | 50 | 18 | | |
| | | left | | | 122 | 51 | D | 50 | 146 | | |
| | Bus | right | 1 | 40 | 0 | 0 | | | | | |
| | | through | | | 0 | 0 | | | | | |
| | | left | | | 0 | 0 | | | | | |
| | Cycle | right | 1 | 1 | 28 | 24 | A | 110 | 28 | | |
| | | through | | | 242 | 51 | C | 70 | 242 | | |
| | | left | | | 34 | 51 | C | 70 | 34 | | |
| | Walk | crossing 1 | 3 | 1 | 512 | 58 | D | 50 | 512 | | |
| | | crossing 2 | | | 178 | 58 | D | 50 | 178 | | |
| Junction Arm 2 | Car | right | 1 | 1.2 | 138 | 45 | C | 70 | 166 | | |
| | | through | | | 45 | 33 | B | 90 | 54 | | |
| | | left | | | 52 | 44 | C | 70 | 62 | | |
| | Bus | right | 1 | 40 | 0 | 0 | | | | | |
| | | through | | | 6 | 33 | D | 50 | 240 | | |
| | | left | | | 0 | 0 | | | | | |
| | Cycle | right | 1 | 1 | 18 | 45 | C | 70 | 18 | | |
| | | through | | | 45 | 33 | B | 90 | 45 | | |
| | | left | | | 9 | 44 | C | 70 | 9 | | |
| | Walk | crossing 1 | 3 | 1 | 152 | 65 | D | 50 | 152 | | |
| | | crossing 2 | | | 243 | 44 | C | 70 | 243 | | |
| Junction Arm 3 | Car | right | 1 | 1.2 | 38 | 41 | C | 70 | 46 | | |
| | | through | | | 24 | 41 | C | 70 | 29 | | |
| | | left | | | 68 | 41 | C | 70 | 82 | | |
| | Bus | right | 1 | 40 | 0 | 0 | | | | | |
| | | through | | | 0 | 0 | | | | | |
| | | left | | | 0 | 0 | | | | | |
| | Cycle | right | 1 | 1 | 4 | 41 | C | 70 | 4 | | |
| | | through | | | 84 | 41 | C | 70 | 84 | | |
| | | left | | | 13 | 41 | C | 70 | 13 | | |
| | Walk | crossing 1 | 3 | 1 | 170 | 58 | D | 50 | 170 | | |
| | | crossing 2 | | | 768 | 58 | D | 50 | 768 | | |
| Junction Arm 4 | Car | right | 1 | 1.2 | 65 | 13 | A | 110 | 78 | | |
| | | through | | | 24 | 13 | A | 110 | 29 | | |
| | | left | | | 71 | 24 | B | 90 | 85 | | |
| | Bus | right | 1 | 40 | 0 | 0 | | | | | |
| | | through | | | 6 | 13 | B | 90 | 240 | | |
| | | left | | | 0 | 0 | | | | | |
| | Cycle | right | 1 | 1 | 12 | 13 | A | 110 | 12 | | |
| | | through | | | 87 | 13 | A | 110 | 87 | | |
| | | left | | | 43 | 24 | A | 110 | 43 | | |
| | Walk | crossing 1 | 3 | 1 | 186 | 44 | C | 70 | 186 | | |
| | | crossing 2 | | | 134 | 65 | D | 50 | 134 | | |

Column details and descriptions

- 4 Priority factor for each mode of transport
In this example, pedestrians are given the highest priority.
- 5 Vehicle occupancy ratio in persons per vehicle
Standard ratios can be used or you may use your own junction-specific values (this is especially important for PT as occupancy differs substantially between cities and routes).
- 6 Decisive traffic volumes for all modes and movements by junction arm
Traffic volumes for all modes and movements by junction arm should be "decisive", i.e. the volume in the lane with the higher volume, if more than one lane. Volumes can be taken from microscopic model outputs or measured and calculated manually.
- 7 Mean delay (KPI) for each mode, junction movement and arm
- 8 Level of service for each mode, junction movement and arm
This is determined by comparing the appropriate delay value (for the mode, junction movement and arm) to the values in the standard Level of Service Table (page 36).
- 9 LOS utility points
Utility points provide a uniform basis for comparing LOS across modes (see: FLOW Multimodal Analysis Methodology of Urban Road Transport Network Performance, Section 3.3.3). Utility points are simply a numerical value given to each LOS. These values are shown in the (standard) Level of Service Utility Points Table on page 41. The utility point values here are based on LOS (Column 7). For example: arm 1 – car – right turns: LOS B = 90 utility points
- 10 Traffic volume adjusted for vehicle occupancy
This is a multiplication of Columns 5 and 6. For example: arm 1 – car – right turns: 108 vehicles/hr x 1.2 persons/vehicle = 130 persons/hr
- 11 Mean utility points for a junction
This represents the overall junction LOS for all modes of transport. It is calculated in 3 steps:
Step 1) Multiply utility point values for all modes, junction movements and junction arms. For example: arm 1 – car – right turns: 90 utility pts/person x 130 person/hr (adjusted for vehicle occupancy in Column 9) x 1 (car priority factor) = 11,700 utility pts
Repeat for all 44 possible junction movements.
Step 2) Multiply total adjusted volumes for all modes, junction movements and junction arms (adjusted for vehicle occupancy and priority): arm 1 – pedestrian 1: 512 peds/hr (column 6) x 3 (ped priority) = 1,536 persons/hr
Repeat for all 44 possible junction movements.
Step 3a) Add together all 44 utility point values for each mode, junction movement, and junction arm (from Step 1)
Step 3b) Add together all adjusted volumes for each mode, junction movement and junction arm (from Step 2)
Step 3c) The mean utility point value equals total junction utility points value (Step 3a) divided by total junction adjusted volume (Step 3b)
Total junction utility points all arms: 463,941
Total junction volume all arms: 9,053
Mean junction utility points: 58.87
- 12 Overall junction level of service
The mean junction utility points value (Column 10) is used to directly estimate the overall junction LOS by comparing it to the values presented in the (standard) table of Level of Service Values for Signalised Junctions on page 36. In this example, the utility point value of 58.87 translates to junction LOS D.

3.6.FLOW MULTIMODAL CALCULATION PROCEDURE: ROAD SEGMENT DENSITY

Density is defined as the number of vehicles (cars, public transport vehicles or bicycles) or persons, occupying a given area. In the case of vehicles, it is generally defined in terms of kilometres of lane (e.g., 850 vehicles per lane-kilometre). For pedestrians it is usually defined in terms of actual space (e.g., 2 persons per square metre).

Both the German and US highway capacity manuals recommend the use of density as an indicator for determining transport network performance (FGSV 2015, TRB 2010).

Table 3-5: Density on a Roadway Segment

| Density on Road Segment | Inputs | | | Result of Density Calculation |
|-------------------------|-----------------|----------------|----------------------|-------------------------------|
| 1 | 2 | 3 | 4 | 5 |
| Mode | Priority Factor | Traffic Volume | Average Travel Speed | Density |
| Automobile | 1 | 125 | 23 | 5 |
| Bicycle | 1 | 200 | 12 | 17 |
| Pedestrian | 2 | 1850 | 4 | 880 |

Column details and descriptions

- ② Priority factor for each mode of transport
In this example, pedestrians are given the highest priority.
- ③ Traffic volume in units relevant to each mode
Vehicles/hr/lane for cars and bicycles, and pedestrians per hour
- ④ Average travel speed for each mode
These values are either measured in the field or are outputs from a model. A walking speed of 4 km/h is assumed.
- ⑤ Results of the density calculation
The density is the traffic volume divided by the average travel speed. For pedestrian density, the traffic volume is multiplied by the priority factor to obtain an adjusted traffic volume. This adjusted traffic volume is divided by the effective sidewalk width to obtain the density. In this case:
Pedestrian density: $1850 \text{ peds/hr} \times 2 \text{ (priority factor)} \div 1.05 \text{m effective width} \div 4 \text{ km/h} = 880 \text{ persons/m effective width/km}$

3.7.FLOW MULTIMODAL CALCULATION PROCEDURE: ROAD SEGMENT LOS

Road segment level-of-service is calculated based on several different variables depending on the transport mode. More specifically:

1. Automobiles: vehicle density (e.g., number of cars on one-kilometre lane of a roadway).
2. Public Transport: public transport speed index, this represents a comparison between the speed of automobiles and public transport vehicles (e.g., if public transport vehicles travel at a speed of 20 km/hr and private vehicles travel at 30 km/hr then the speed index is 0.66 (i.e., 20 km/hr /30 km/hr). For more information please see Chapter 7 of the German Highway Capacity Manual (FGSV 2015).
3. Cycles: disturbance rate, this is calculated based on the average number of disturbances encountered by cyclists per kilometre based on the width of the cycling facility and the number of encounters. For more information please see Chapter 8 of the German Highway Capacity Manual (FGSV 2015).
4. Pedestrians: pedestrian density (e.g., number of persons per square metre of sidewalk space).

A table is used to assign a LOS value to the appropriate variables for each transport mode. Table 3-6 presents the Roadway Segment LOS Table from the German Highway Capacity Manual (FGSV 2015).

Table 3-6: Level-of-Service values for road segments (Source: FGSV 2015).

| LOS | Automobile | Public Transport | Cycle | Pedestrian |
|-----|-----------------------|---------------------------|--|--|
| | density (vehicles/km) | PT travel speed index (-) | cycle disturbance rate DR unidirectional traffic (disturbances/cycle/km) | pedestrian density (persons/m ²) |
| A | ≤7 | ≥0,95 | <1 | ≤0,10 |
| B | ≤14 | ≥0,90 | <3 | ≤0,25 |
| C | ≤23 | ≥0,80 | <5 | ≤0,60 |
| D | ≤34 | ≥0,65 | <10 | ≤1,30 |
| E | ≤45 | ≥0,50 | >10 | ≤1,90 |
| F | >45 | <0,50 | - | >1,90 |

Column details and descriptions

- 4 Traffic volumes for each mode
This is gathered via field measurements or from model outputs.
- 5 Level of service indicator value for each mode
For cars and pedestrians, the indicator value is density. The figure can be either a model output or calculated as shown in Section 3.6 on page 38). For bicycles, the indicator is disturbance rate (DR) (see Chapter 8 of the German Highway Capacity Manual for calculation). For public transport, the indicator is travel speed index (see Chapter 7 of the German Highway Capacity Manual for calculation).
- 6 Level of service for each mode operating on the roadway segment
These values are determined by comparing the LOS indicator value for each mode to the values shown in the (standard) Level of Service Values for Road Segments Table on page 39. In this example:
Car: 19 vehicles/hr = LOS C
Bicycle: Disturbance Rate: 4 = LOS C
Pedestrians: 0.26 persons/m2 = LOS C
- 7 LOS utility points for each mode on the roadway segment
Utility points provide a uniform basis for comparing LOS across modes. Utility points are simply a numerical value given to each LOS. The values are taken from the (standard) Level-of-Service Utility Points Table on page 41 based on the LOS in Column 6. In this example, car LOS C (calculated based on density) = 70 utility points
- 8 Traffic volume adjusted for vehicle occupancy
This is a multiplication of Columns 3 and 4. For example, car: 1,710 vehicles/hr x 1.2 persons/vehicle = 2,052 persons/hr
- 9 Mean utility points for the roadway segment
This represents the multimodal LOS for the roadway segment. It is calculated in three steps.
Step 1) Calculate the total utility points for all modes on the roadway segment by multiplying the utility points for each mode by the traffic volume (adjusted for vehicle occupancy as calculated in Column 8) and priority factor (in this case, 1 for all modes). Here,
Car: 2,052 person/hr x 70 utility pts/person x 1 = 143,640 utility pts
Bicycle: 20 person/hr x 70 utility pts/person x 1 = 1,400 utility pts
Pedestrian: 1,300 person/hr x 70 utility pts/person x 1 = 91,000 utility pts
Add these three values to obtain the total roadway segment utility points:
143,640 + 1,400 + 91,000 = 236,040 roadway segment utility points
Step 2) multiply the total priority adjusted volumes for all modes on the roadway segment by the priority factors to obtain the priority adjusted volume. In this case:
Car: 2,052 person/hr x 1 = 2,052
Bicycle: 20 person/hr x 1 = 20
Pedestrian: 1,300 person/hr x 1 = 1,300
Add these three values to obtain the total priority adjusted roadway segment volume:
2,052 + 20 + 1,300 = 3,372 persons/hr
Step 3) calculate the mean (multimodal) roadway segment utility point value by dividing the total roadway segment utility points by the total roadway segment priority adjusted volume. here, 236,040 total roadway segment utility points ÷ 3,372 persons/hr = 70.12 utility pts
- 10 Overall roadway segment level of service
The mean roadway utility points (Column 9) can be used directly to estimate the multimodal roadway segment LOS based on the values presented in the (standard) Level-of-Service Utility Points Table on page 41. In this example, the roadway segment operates at LOS C

Table 3-7: Roadway Segment Level-of-Service

| | Input | | | LOS indicator | LOS Value | | | MPI | |
|----------------|---------------------|------------------------------------|-------------------------------|---------------------------------------|-----------|-----------------------|-------------------------|------------------|----------|
| 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |
| transport mode | priority factor (-) | vehicle occupancy ratio (pers/veh) | traffic volume (veh/h, ped/h) | density Dist. Rate pedestrian density | LOS | utility points UP (-) | traffic volume (pers/h) | mean utility (-) | mean LOS |
| automobile | 1 | 1.2 | 1710 | 19 | C | 70 | 2052 | 70 | C |
| cycle | 1 | 1 | 20 | 4 | C | 70 | 20 | | |
| pedestrian | 1 | 1 | 1300 | 0.26 | C | 70 | 1300 | | |

3.8.FLOW MULTIMODAL CALCULATION PROCEDURE: CORRIDOR DELAY

Delay is defined as the difference between the actual travel time and the minimum travel time (free flow conditions).

The delay value for a corridor is the sum of the delays experienced for all users of all transport modes using the corridor.

Traffic volumes and delay values for all transport modes can be obtained as output from a microscopic or macroscopic transport model. These values can also be obtained via field measurements following procedures described in standard highway capacity manuals.

Table 3-8: Corridor Delay

| Input | | | | Result of delay calculation | | | | MPI |
|------------------|-----------------|------------------------------------|--------------------------------------|--|---|--|-------------------------|----------------------|
| 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 |
| transport mode | priority factor | vehicle occupancy ratio (pers/veh) | decisive traffic vol. (veh/h; ped/h) | actual travel time (s/ pers/ln, s/ pers) | minimum travel time (s/ pers/ln, s/ pers) | mean total delay per mode (s/ pers/ln) | traffic volume (pers/h) | mean delay (s/ pers) |
| car | 1 | 1.2 | 2,000 | 545 | 217 | 328 | 2,400 | 85 |
| public transport | 1 | - | 11,000 | 639 | 603 | 36 | 11,000 | |
| cycle | 1 | 1 | 300 | 850 | 723 | 127 | 300 | |
| pedestrian | 1 | 1 | 1,500 | | | 45 | 1,500 | |

Column details and descriptions

- 5 Actual travel time experienced by the average user of each mode travelling on the corridor
This is obtained from model results or field calculations.
- 7 Mean delay for each mode on the corridor
Calculate this by subtracting the minimum travel time (Column 6) from the actual travel time (Column 5). Here: Mean total delay: Bicycle: 850 sec- 723 sec = 127 sec
- 8 Traffic volume adjusted for vehicle occupancy
This is a multiplication of Columns 3 and 4:
Car: 2,000 vehicles/hr x 1.2 persons/vehicle = 2,400 persons/hr
- 9 Mean delay for all modes on the corridor
This is calculated in three steps:
Step 1) Calculate the total delay values for all modes on the corridor by multiplying the traffic volume for each mode (adjusted for vehicle occupancy, see Column 8) by the average delay for that mode and the priority factor (here 1 for all modes). In this case,
Car: 2,400 person/hr x 328 sec/person x 1 = 787,200 sec/hr
PT: 11,000 person/hr x 36 sec/person x 1 = 396,000 sec/hr
Bicycle: 300 person/hr x 127 sec/person x 1 = 38,100 sec/hr
Pedestrian: 1,500 person/hr x 45 sec/person x 1 = 67,500 sec/hr
These four values are summed to obtain the total corridor delay:
787,200 + 396,000 + 38,100 + 67,500 = 1,288,800 sec/hr
Step 2) Multiply the total adjusted volume values for all modes on the roadway segment by the priority factors to obtain the priority-adjusted volume. In this case:
Car: 2,400 person/hr x 1 = 2,400
PT: 11,000 person/hr x 1 = 11,000
Bicycle: 300 person/hr x 1 = 300
Pedestrian: 1,500 person/hr x 1 = 1,500
These values are summed to obtain the total priority adjusted volume:
2,400 + 11,000 + 300 + 1,500 = 15,200 persons/hr
Step 3) Calculate the mean delay for all modes on the corridor by dividing the total corridor delay by the total priority-adjusted volume. In this case,
Total corridor delay: 1,288,800 sec/hr ÷ 15,200 persons/hr = 84.8 sec/person

3.9.FLOW MULTIMODAL CALCULATION PROCEDURES

Sections 3.4 through 3.8 presented detailed descriptions of how to use the FLOW multimodal calculation procedures. These calculations and the methodology used to develop them are described in detail in the **FLOW Multimodal Analysis Methodology of Urban Road Transport Network Performance** (available at www.h2020-flow.eu/resources/publications).

The next chapter describes the second main tool developed as part of the project, the FLOW Impact Assessment Tool.

Reference table

Table 3-4: Level-of-Service Utility Points

| LOS | Utility Points |
|-----|----------------|
| A | 110 |
| B | 90 |
| C | 70 |
| D | 50 |
| E | 30 |
| F | 10 |



4

FLOW Impact Assessment Tool

This chapter describes how to use the FLOW Impact Assessment Tool. For more detailed information about the tool and its development please see: FLOW Impact Assessment Tool Guidelines. The spreadsheet-based tool is available at www.h2020-flow.eu/resources/publications/.



4.1. INTRODUCTION

The FLOW Impact Assessment Tool is a holistic technique for evaluating transport improvements. It is designed to provide decision-makers with more information about a transport improvement project's impacts and benefits than simply facility-based multimodal transport analysis (i.e., the methods described in Chapter 3 above).

In addition to facility-based transport analysis, the FLOW Impact Assessment Tool considers mobility, environmental, societal, and economic impacts. The tool recognises that transport is not the only consideration when decisions are made about improving the transport system.

Sections 4.1 through 4.4 below summarise the FLOW Impact Assessment Tool spreadsheet and how it was developed. The tool and the methodology used to develop it are described in detail in the FLOW Impact Assessment Tool Guidelines.

The FLOW Impact Assessment Tool (described in this chapter) and the FLOW multimodal calculation procedures (Chapter 3) are designed to be used together to provide a clear understanding of the benefits and costs of transport improvement projects, and especially to help evaluate the congestion reduction benefits of walking and cycling projects.

The Impact Assessment Tool was developed by surveying existing evaluation techniques from FLOW partner cities and conducting a literature review. Results of this research were used to develop a spreadsheet-based method for analysing transport improvements.

The FLOW Impact Assessment Tool spreadsheet evaluates transport system improvements by comparing data from “before” the transport improvement is implemented (ex-ante) to data from “after” the transport improvement is implemented (ex-post). More simply:

$$\begin{array}{rcl}
 & \text{Data with the proposed improvement (i.e., after)} & \\
 - & \text{Data without the proposed improvement (i.e., before)} & \\
 \hline
 = & \text{Impact of the transport improvement} &
 \end{array}$$

The user enters the with data and without data obtained from a transport model and/or measurements obtained from another source (e.g., traffic counts, analysis results, etc.) into the spreadsheet, and the spreadsheet calculates the impact of the proposed transport system change (e.g., a new cycle lane).

Note that the value calculated for the impact could be positive or negative and that, depending on the indicator being considered, a negative value could be better than a positive value. For example if the tonnes of CO² generated after the project is lower than before the project, the impact will be a negative number which is good (less CO² is generated).

The spreadsheet calculates transport impacts using factors based on country-specific and EU-wide default values. It is possible for users to adjust some of these values to better account for local conditions. For more details on the spreadsheet calculation methods (i.e., formulas), default values and factors please see FLOW Impact Assessment Tool Guidelines.

THE FLOW

IMPACT ASSESSMENT TOOL
RECOGNISES THAT TRANSPORT
IS NOT THE ONLY CONSIDERATION
WHEN DECISIONS ARE MADE
ABOUT IMPROVING THE
TRANSPORT SYSTEM.

Note that the FLOW Impact Assessment Tool requires users to enter both the “with” and “without” cases; then it calculates the impact of the transport improvement.

4.2. TARGET SYSTEM AND INDICATORS

The FLOW Impact Assessment Tool considers the mobility, environmental, societal and economic impacts of transport system improvements. The specific impacts considered are called the target system and the indicators are data used to assess these targets. The target system and indicators are listed in Table 4-1. The indicators listed in the table are outlined in section 4.4 below.

Table 4-1: FLOW Impact Assessment Tool target system and indicators.

| Target System | Scope | Indicators | Units |
|-----------------------|---------------------------------------|---------------------------------------|------------------------|
| Transport Performance | Travel time related | Total travel time | Euros / Year |
| Public Financing | Costs of new infrastructure | Investment costs | Euros / Year (annuity) |
| | | Operating and maintenance costs | Euros / Year |
| Environment | GHG emissions and local air pollution | Total direct CO ₂ emission | Tonnes / Year |
| | | Total direct NO _x emission | Tonnes / Year |
| | | Total direct PM emission | Tonnes / Year |
| | Land consumption | Sealed surface | Qualitative assessment |
| Society | Traffic safety | Fatalities | Number / Year |
| | | Serious injuries | Number / Year |
| | Health | Health Impacts | Reduced deaths / Year |
| | Increased access | Accessibility | Qualitative assessment |
| | Social interaction | Separation effect | Qualitative assessment |
| Economic | Vehicle operation | Vehicle operating costs | Euros / Year |
| | Energy consumption | Total final energy consumption | kWh / Year |
| | Attractiveness (monetary) | Commercial rents | Euros / Year |
| | | Residential rents | Euros / Year |

While this list of indicators is relatively straightforward, collecting the data needed to calibrate the transport model (assuming one is used) and to perform the supplemental analyses required to estimate the indicators can be challenging.

THE FLOW
IMPACT ASSESSMENT TOOL
CONSIDERS THE MOBILITY,
ENVIRONMENTAL, SOCIETAL
AND ECONOMIC IMPACTS
OF TRANSPORT SYSTEM
IMPROVEMENTS.

4.3. TYPES OF IMPACT ASSESSMENT

The FLOW Impact Assessment Tool's target system considers a wide range of quantitative and qualitative indicators. The question for decision-makers is: How can these indicators be used to make a decision if they all are expressed in different units (e.g., €/year, tonnes, etc.)? For example, which is better: an improvement that costs €200,000 and generates 200 tonnes of CO₂, or a project that costs €100,000 and generates 500 tonnes CO₂?

The FLOW Impact Assessment Tool calculates four commonly used methods for comparing improvement projects whose impacts are described by indicators expressed in different units. The spreadsheet calculates results for all four methods; cities can use whichever method, or combination of methods, they prefer to assist in the decision-making process.

FLOW recommends that cities consider the results of all four methods when they make decisions regarding changes to the transport system. This provides a much rounder and more complete picture of the impact expected by the change.

The FLOW Impact Assessment Tool provides results for the following comparison methods:

- **Multi-criteria analysis (MCA)** – in a MCA all indicators are considered individually (this enables decision-makers to express explicit priorities: for example, in the example described above, a city decides it is worth spending €100,000 to reduce CO₂ by 300 tonnes. Tab 12 of the FLOW Impact Assessment Tool spreadsheet lists the values for all indicators. (The FLOW Impact Assessment Tool spreadsheet is described in more detail in Section 4.4.)
- **Weighted benefit analysis (WBA)** – in a WBA single indicators are transformed into a common measurement system (utility points) and the utility points are weighted based on the priorities of the decision-makers. The weighted utility points are then summed to provide a single value for the improvement project's impact.

Tab 13 of the FLOW Impact Assessment Tool spreadsheet summarises the weighted benefit analysis for the improvement project being assessed. The FLOW Impact Assessment Tool spreadsheet uses a linear utility point approach to perform the weighted benefit analysis.

To perform this analysis, spreadsheet users must simply enter an upper limit (best case) and a lower limit (worst case) for the selected indicator, and weighting factors for all indicators, on Tab 13 of the spreadsheet. The spreadsheet then automatically calculates the WBA. For more details on this process please see the FLOW Impact Assessment Tool Guidelines.

WHICH IS BETTER:

AN IMPROVEMENT THAT COSTS €200,000 AND GENERATES 200 TONNES OF CO₂, OR A PROJECT THAT COSTS €100,000 AND GENERATES 500 TONNES CO₂?

- **Cost-benefit analysis (CBA)** – in a CBA all the indicators are described in terms of their costs (e.g., the costs to society of transport fatalities). This provides the analyst with a single monetary value for the improvement project. Cost benefit analysis is complex because, while there are default values for the monetary value of many indicators, it is extremely difficult to fully determine these costs because they depend on questions such as estimating the value of a human life. The FLOW Impact Assessment Tool provides country-specific default values based on European and other research (these can be replaced with local values when appropriate). Tab 14 of the FLOW Impact Assessment Tool spreadsheet summarises the cost benefit analysis.
- **Qualitative appraisal** – in many cases there are indicators that cannot be easily expressed in numerical terms and must be analysed qualitatively. In the FLOW project three indicators were analysed qualitatively: sealed surface area (amount of pavement), accessibility (increased access to amenities via walking and cycling), and separation effect (to account for social interaction). In a qualitative appraisal, a limited set of numerical values is used to describe the magnitude of the indicator's change.

Tab 15 of the FLOW Impact Assessment Tool spreadsheet enables users to qualitatively assess the impacts of these three indicators using a 5-point scale from +2 (most positive impact) to -2 (most negative impact) with 0 for no impact. The spreadsheet also enables users to assign a weighting (priority) for each of these three indicators.

The FLOW Impact Assessment Tool spreadsheet summarises the results of the cost benefit analysis, weighted benefit analysis and qualitative evaluation on spreadsheet Tab 16.

4.4. USING THE FLOW IMPACT ASSESSMENT TOOL – SPREADSHEET INSTRUCTIONS

The FLOW Impact Assessment Tool is embedded in a Microsoft Excel spreadsheet. Users enter data into the spreadsheet and the spreadsheet calculates values for the target system indicators and the four types of impact assessment described in Section 4.3.

The spreadsheet is designed to compare two cases: a “with” improvement project alternative and a “without” improvement project alternative. Users enter transport

data for the two cases and financial data about the improvement project into the appropriate spreadsheet tabs.

This section summarises the spreadsheet and describes how to use it. For more details please see the FLOW Impact Assessment Tool Guidelines. The spreadsheet is available at www.h2020-flow.eu.

Spreadsheet Organisation

The FLOW Impact Assessment Tool spreadsheet consists of 16 tabs. These tabs are summarised in Table 4-2. Each tab is described in more detail in the following sections. These instructions are best understood when the reader has the spreadsheet open on their computer and can view each tab as it is described.

The titles below generally include the words: “Required” or “Optional”. Optional means default values are used in the calculations. “Required” means that if the user wants this information to be included in the calculation, they must enter data. In some cases, the users may not have data (e.g., Tab 5: commercial and residential attractiveness). If this is the case the section can be left blank, which means this calculation will not be done.

Cover Page and Target System – Tabs 1 and 2

These tabs present general information about the FLOW project and spreadsheet. The Legend on Tab 1 describes the colour coding used throughout the spreadsheet. This is helpful for understanding where (which cells) users need to input data.

Project Description – Tab 3 – User Input Required

Users enter general information about the improvement project and location into the cells on spreadsheet Tab 3. Most of the information is self-explanatory except:

- **Country** – The country can be selected from a drop-down list. It is used by the spreadsheet to select appropriate default values for the calculations. While the default values come from European statistics (for details please see FLOW Impact Assessment Guidelines), they can be changed by the user if appropriate.
- **Assessment period** – the assessment period is the user-selected time period under consideration (generally peak hour or day). It is chosen based on the type of transport data the user has available for the analysis.

WHILE THE DEFAULT VALUES

COME FROM EUROPEAN
STATISTICS, THEY CAN BE
CHANGED BY THE USER IF
APPROPRIATE.

Table 4-2: FLOW Impact Assessment Tool spreadsheet summary of Tabs.

| Spread-sheet Tab | Title | Description |
|------------------|-------------------------------|---|
| 1 | Cover page | Short summary of the FLOW project and legend for understanding spreadsheet cell contents (i.e., which are input data, which are calculated, etc.). |
| 2 | Target system | Illustration of FLOW Impact Assessment target system. |
| 3 | Project description | General information about the proposed improvement project and location. |
| 4 | Traffic data – INPUT | Transport data (e.g., traffic volume by mode, travel time data, accident data, etc.) to be input by user. |
| 5 | Monetary values - INPUT | Financial data (e.g., improvement project costs, economic data) to be input by user. |
| 6 | Conversion factors | Default factors used to convert user input data into FLOW target system indicators (e.g., factor to convert automobile travel time into CO ² emissions, etc.). |
| 7 | Public financing | Indicators calculated by spreadsheet. |
| 8 | Transport network performance | |
| 9 | Environment | |
| 10 | Society | |
| 11 | Private business | |
| 12 | Multi-Criteria Analysis | Overview of results for specified analysis type. |
| 13 | Weighted Benefit Analysis | |
| 14 | Cost Benefit Analysis | |
| 15 | Qualitative Appraisal | |
| 16 | Summary Impact Assessment | |

Traffic Data – Tab 4 – User Input Required

Users enter traffic data for the “without improvement project” and “with improvement project” cases into the cells on spreadsheet Tab 4. Data must be entered in the cells shaded dark yellow. Data can be entered in the cells shaded light blue (optionally). No data is needed for the light brown cells.

Optimally the data entered in this tab should come from a transport model, but it is possible to develop the data from field measurements using standard traffic engineering methods described in highway capacity manuals. This section summarises the data requirements.

Traffic Data - Required

- **Travel Time (1)** – Enter the total travel time (vehicle hours or person hours) during the assessment period for each transport mode.

- **Travel Time (2)** – Enter the total time (tonne hours) during the assessment period. This data is required for commercial transport only (note: LCV = light commercial vehicle, HGV = heavy goods vehicle).
- **Vehicle Operating Costs** – Enter the distance travelled (vehicle kilometres) during the assessment period for each transport mode.
- **Direct Emissions Final Energy Consumption** – Enter the share of vehicle distance travelled (percent) in which vehicles operate under: (1) free flow traffic, (2) heavy traffic, (3) saturated traffic, and (4) stop-and-go traffic conditions, during the assessment period into the appropriate row. This data is only needed for motorised transport modes. This data should sum to 100%.

Traffic Data - Optional

Users can enter data into these fields; otherwise the default values shown on the spreadsheet will be used in the calculations.

- **Assessment Period** – Enter the assessment period (peak hour or day).
- **Factor: Period to Day** – Enter the factor to be used for converting the user selected assessment period data into daily data. If the user selected period is “peak hour” then this factor will vary between 8 and 14 (the default value is 8); if the user selected period is “day” then the factor is 1 (i.e. no adjustment is needed).
- **Factor: Day to Year** – Enter the factor to be used for converting daily traffic values to yearly traffic values. The default for this factor is 250 to account for differences between weekday and weekend traffic.
- **Trip Purpose** – Enter the share of vehicle distance travelled (percent) for the trip purposes: (1) work trips (trip undertaken for work purposes), (2) commute trips (home-work, home-education), and (3) other trips (e.g., leisure, shopping) into the appropriate row for each transport mode. This data should sum to 100% (for each column of three cells). For example, the default values for motorised private transport are 10% work, 70% commute, and 20% other = 100%.
- **Vehicle Occupancy** – Enter the vehicle occupancy rates in persons per vehicle for (1) work trips, (2) commute trips, and (3) other trips into the appropriate row for each transport mode.

Accident Data - Required

Users need to enter accident data in this section. A transport system safety analysis should be performed to estimate how the proposed improvement project will change the number of accidents.

- **Fatalities** – Enter the number of persons killed per year for all modes of transport (this is often an average over some number of years to account for the variation).

- **Severe Injuries** – Enter the number of severe injuries per year for all modes of transport.
- **Light injuries** – Enter the number of light injuries per year for all modes of transport.

Health Benefit Data - Required

Users need to enter activity data into this section to estimate the health benefits of active transport modes (which the spreadsheet calculates based on the World Health Organisation's HEAT method).

- **Duration of daily walking or cycling activity** – Enter the average number of minutes spent walking and cycling per day by an average person for both the “with proposed transport improvement” and “without improvement” cases.
- **Number of days activity is carried out** – Enter the number of days per year in which the average person performs this physical activity.
- **Travel demand** – Enter the number of persons carrying out this physical activity.

Energy Data - Optional

Users can enter data into these fields, otherwise default values will be used in the calculations.

- **Share of Engine Type** – Enter the share of automobiles using petrol and diesel engines for both the “with proposed transport improvement” and “without improvement” cases. The share of petrol versus diesel varies significantly between countries and even regions; therefore, users should enter national or regional data whenever possible. The shares should sum to 100% for each case. The default values are 70% petrol and 30% diesel.

Monetary and Cost Data – Tab 5 – User Input Required

Users enter monetary and cost data into the cells on spreadsheet Tab 5. The spreadsheet is based on 2015 data and therefore all monetary costs must be expressed in 2015 euros.

Data must be entered in the cells shaded dark yellow. Data can optionally be entered in the cells shaded light blue. No data is needed for the cells shaded brick red, this data is filled in automatically based on the country (selected by the user on Tab 3).

The data for this section will come from the transport improvement project planning process, local economic statistics, and the city's standard investment planning system (e.g., interest rate).

Improvement Project Investment Costs – Required & Optional

- **Interest Rate / Discount Rate** – (Optional) Enter the interest rate (percent) for the reference year to be used in calculating the project's financial information. The default rate is 3%.
- **Cost Components** – (Required) Enter the cost (euros) for each component of the project expressed in 2015 euros. Enter the full costs (i.e., including any taxes etc.).

The component “construction and planning” includes the full cost of building the basic improvement; the component “civil structures” includes the full cost of building any major structures required for the improvement (e.g., a bridge). These components are separated because they will normally have different life cycles.

- **Life Cycle** – (Optional) Enter the life cycle (i.e., how long the component will last until it needs to be replaced) for each component. The default life cycles are shown on the spreadsheet.

Improvement Project Operating and Maintenance Costs – Required

- **Cost per Year** – Enter the annual operating and maintenance costs (€/year in 2015 euros).

Commercial and Residential Attractiveness – Required

This section is used to enter data about the increased economic attractiveness created by the transport improvement project. The data for this section comes from local economic data, estimates of affected properties, and the PERS Audit (a method for quantifying the economic benefits of pedestrian improvements developed by the Transport Research Laboratory (TRL 2014)). The PERS method was developed and tested for pedestrian projects, and therefore the FLOW Impact Assessment Tool only applies it for pedestrian projects. However, it could clearly be extended to cycling and shared-space projects; this would be an excellent topic for further research.

- **Commercial Rental Cost** – Enter the annual rental cost for commercial property in euros per m² per year (current prices expressed in 2015 euros).
- **Affected Space** – Enter total amount of commercial property affected by the pedestrian transport project (m² floor space).
- **PERS Audit Improvement Score** – Enter the quantified improvement in pedestrian environmental quality from PERS audits (weighted change in score).
- **Residential Rental Cost** – Enter the average monthly rental cost for apartments in euros per month (current prices expressed in 2015 euros).
- **Affected Units** – Enter total number of residential units affected by the pedestrian transport project (number).

THE PERS METHOD

WAS DEVELOPED AND TESTED FOR PEDESTRIAN PROJECTS, AND THEREFORE THE FLOW IMPACT ASSESSMENT TOOL ONLY APPLIES IT FOR PEDESTRIAN PROJECTS. HOWEVER, IT COULD CLEARLY BE EXTENDED TO CYCLING AND SHARED-SPACE PROJECTS; THIS WOULD BE AN EXCELLENT TOPIC FOR FURTHER RESEARCH.

THE METHOD

ALSO ENABLES USERS TO WEIGHT EACH INDICATOR BASED ON LOCAL PRIORITIES. FOR EXAMPLE, TRAFFIC SAFETY COULD BE RATED TWICE AS IMPORTANT AS ALL OTHER INDICATORS.

Country Specific Default Values

The rest of this spreadsheet tab summarises the monetary default values for the user-selected country (from Tab 3). No input is required from users.

Conversion Factors – Tab 6

FLOW Impact Assessment Tool spreadsheet tab 6 presents the default conversion factors used to calculate several of the target system indicators. No user input is required, although users can enter local data to replace the default factors if desired and appropriate.

Indicators Calculated by Spreadsheet – Tabs 7 – 11

FLOW Impact Assessment Tool spreadsheet tabs 7 to 11 present the target system indicators as calculated by the spreadsheet using the data input by users and default values outlined above.

These tabs present the calculations. There is no need for users to enter any data.

Analysis Results – Tabs 12 - 15

FLOW Impact Assessment Tool spreadsheet tabs 12 to 15 present the results of the four different types of analysis recommended by the FLOW project (see Section 4.3 above). Tab 16 summarises the overall assessment results. This section describes each of the tabs and any additional user entered data necessary.

Multi-criteria Analysis (MCA) – Tab 12

Tab 12 presents results of the multi-criteria analysis. This consists of the 17 FLOW Target System indicators in their own units.

Weighted Benefit Analysis (WBA) – Tab 13

Tab 13 presents results of the weighted benefit analysis. The FLOW Impact Assessment Tool spreadsheet assumes a uniform linear utility point scale. This requires users to set a lower and upper boundary for the range of possible indicator values – for each indicator. To perform this analysis, users must input the following data:

- **Lower Boundary** – Enter the lowest value for the selected indicator in the column marked lower boundary. This will be assigned a value of -100 utility points.
- **Upper Boundary** – Enter the highest value for the selected indicator in the column marked upper boundary. This will be assigned a value of +100 basis points.

The method also enables users to weight each indicator based on local priorities. For example, traffic safety could be rated twice as important as all other indicators. To perform this weighting, users must input the following data:

- **Weighting Factor** – Enter the relative importance of each indicator in the column marked weighting factor. Enter “1” in all the cells where there is no priority weighting.

The sum of the benefits line at the bottom of the spreadsheet tab presents a single value for the benefit of the proposed transport improvement project based on the local priorities expressed in the weighting factor.

Cost Benefit Analysis (CBA) – Tab 14

Tab 14 presents results of the cost benefit analysis. In this analysis all the indicators are expressed in terms of annual monetary costs. These costs are automatically calculated in the spreadsheet based on user input data and default values (from Tab 5). The top portion summarises the results. The bottom portion summarises the costs and benefits for each indicator.

Qualitative Evaluation – Tab 15

Tab 15 is used to complete a qualitative evaluation of three FLOW Target System indicators: land consumption, increased access, and social interaction. These three indicators are defined as follows:

- **Land consumption** – the amount of additional sealed surface used by the transport improvement (could be a negative value if the improvement reduces sealed surface);
- **Accessibility** – the increased access of non-motorised residents to amenities (e.g., jobs);
- **Separation effect** – the increased social interaction due to walking and cycling improvements;

To perform the qualitative analysis, users must input the following data into the spreadsheet:

- **Qualitative Evaluation** – Enter the user’s assessment of how the value of the given indicator changes with implementation of the transport improvement project (+2 for great positive impact, +1 for positive impact, 0 for no relevant impact, -1 for negative impact, and -2 for great negative impact).
- **Weighting Factor** – Enter the relative importance of each indicator. Enter “1” in all the cells where there is no priority weighting.

These results are used in preparing the overall assessment.

Overall Assessment – Tab 16

Tab 16 presents the overall assessment results. It summarises the project description and then presents the results of the cost benefit analysis, weighted benefits analysis, and qualitative analysis on a single page.



5

FLOW Recommendations

Research projects often discover unexpected paths along their journey. FLOW was no exception. Early in the process, project participants realised that focussing exclusively on improving the ability of standardised transport analysis techniques to consider walking and cycling was insufficient. These techniques needed to be reviewed in a broader context.



The participants also found that a focus purely on reducing congestion was misplaced. Recent research findings on induced traffic, on disappearing traffic and on the effectiveness of managing congestion – among other topics – call into question the ability and benefit of trying to eliminate congestion.

A summary of FLOW's general recommendations is presented below. Detailed audience-specific recommendations can be found in Appendix 1.

1. Fully consider walking and cycling when developing plans and policies to improve transport system performance as well as through the impact analysis and implementation processes.

Many transport policies do not recognise the full benefits of walking and cycling on improving transport system performance. In the worst case, walking and cycling are considered recreational activities without transport relevance. Governments at all levels must introduce policies that recognise walking and cycling as means to improve urban transport system performance and liveability and must support their implementation.

Transport impact analysis plays an important role in decision making on new transport improvements and development schemes. However, these analyses are often performed using techniques and models that do not fully consider all modes (e.g., walking and cycling). Decision makers should require that multimodal analysis techniques and models be used for all transport impact analyses. Local authority staff should include the requirement for multimodal analysis in their calls for tender and other stakeholders should petition elected representatives to call for multimodal analysis. Transport planning consultants should inform their clients about the importance of multimodal analysis and use it in all analyses.

2. Improve existing transport analysis techniques and models to include all modes and to account for the interaction between modes.

Transport analysis techniques and models must be significantly improved to place walking and cycling on an equal footing with motorised modes. Especially important will be developing methods for assessing new types of transport infrastructure – such as shared space, pedestrian districts and cycle highways – that fully consider recent transport research on topics such as induced demand and disappearing traffic. All stakeholders should support research targeted at improving existing transport analysis techniques and models and at developing new approaches.

3. Improve communication about multimodal transport analysis and increase transparency in the transport planning process.

New transport infrastructure or land development projects can have very significant impacts on an area's liveability, but the transport analysis techniques and modelling used in the decision-making process are very complex and the planning approval process is often unclear. Local authorities, transport consultants and researchers need to improve communication strategies to better explain analysis techniques and the planning process so that they are easily understandable by the general public.

4. Improve data collection for walking and cycling to better understand the movements of these modes. Refer to the recommendations of the European Cyclists' Federation and Walk21 and to results from the FLOW data workshop (on the FLOW website).

Data is necessary to better understand transport behaviour, to give input for assessment tools and to develop better transport models. Unfortunately, few authorities – at any level of government – collect sufficient data on walking and cycling, making it difficult to fully consider these modes in the transport planning process. There are excellent standards for collecting walking and cycling data, and new technologies (e.g., activity trackers) are making data collection easier. All government authorities must collect the data required to fully assess the effect of walking and cycling on congestion and on the urban environment as a whole.

5. Place transport system performance (including congestion) within the larger context of urban liveability, economic viability, safety and health (not above it).

The quality of transport service is one of many factors that combine to make a place liveable, economically successful, competitive, sustainable and healthy. But decision making often focusses exclusively on transport considerations (and mainly congestion). Taking a multi-disciplinary approach to transport decision making is critical to supporting an equitable and sustainable future for all.

Adopting a broader view of transport decision making also helps cities recognise how to shift current strategies, such as “eliminating” congestion, into more balanced (and feasible) strategies such as “managing” congestion or increasing overall capacity. This shift in perspective provides decision makers with a much broader palette of options to work with when planning their cities.

5.1. FLOW DETAILED RECOMMENDATIONS

| LOCAL | |
|---|--|
| Recommendations for practitioners in local authorities: | |
| LOCAL PRACTITIONERS | 1. Ensure that the content and language of your policies and guidelines on urban traffic management reflect a multimodal perspective of urban road network performance. |
| | 2. Ensure that multimodality and modal equity are applied at all stages by: i) having in your procedures and guidelines an impact assessment framework that includes multimodal transport benefits and significant non-transport benefits (e.g. health), ii) including in your terms of reference for procurement a requirement for services to include a multimodal impact assessment using good practice tools and techniques and iii) reviewing project performance after implementation with a multimodal impact assessment. |
| | 3. Within the context of your sustainable urban mobility planning, actively seek opportunities to improve network efficiency and city-wide accessibility through measures to improve conditions for safe and attractive walking and cycling. |
| | 4. Review your priorities when considering new transport schemes to avoid a disconnect between agreed-upon objectives (e.g. prioritise walking and cycling) and what is done in practice. |
| | 5. Proactively address the walking and cycling data gap by reviewing existing data collection standards and processes to ensure that you can answer basic questions about walking and cycling activity such as volumes, mode choice behaviour, safety, infrastructure location and condition, etc. |
| | 6. Have in-house understanding of how models work. Either develop in-house competency to carry out multimodal transport modelling or acquire the skills to write planning and modelling specifications that fully consider walking and cycling and to interpret analysis findings for decision makers. |
| | 7. Educate decision makers and stakeholders to take a broader view of the transport problem. For example, reformulate questions on how to solve congestion to how to manage congestion and/or increase corridor capacity. |

| LOCAL | |
|--|--|
| Recommendations for local decision makers: | |
| LOCAL DECISION MAKERS | 1. Require up-to-date data on walking and cycling. Local authority staff need strong political backing to address the data issue. Decision makers must provide leadership in relation to collecting data and gathering evidence in their communities. |
| | 2. Shape the impact assessment framework by working with your staff to specify the assessment criteria for transport schemes at the beginning of projects. Ask for a balanced multimodal assessment that includes all the criteria that are important to the community (economic, social and environmental as well as transport) and about the impact of transport schemes on all modes. |
| | 3. Support the ongoing training of your staff so that they understand the multimodal perspective and the need to assess all modes equally. |

| NATIONAL | |
|--------------------------------------|--|
| Recommendations for national actors: | |
| | 1. Ensure that the content and language of your policies and guidelines on urban traffic management reflect a multimodal perspective on urban road network performance. Incorporate the concept of multimodality and mode equity into standards and guidelines for local implementation and offer incentives to cities that adopt these standards. |
| | 2. Issue policy recommendations to local authorities that recognise the role of walking and cycling in reducing congestion/improving road network performance. |
| | 3. In collaboration with local authorities, adopt guidelines to improve data collection and analysis for walking and cycling. |
| | 4. Establish consistent mechanisms for evaluating project proposals that prioritise sustainable modes of transport, taking into account the movement of people (not vehicles). Include in your policy framework a requirement for the multimodal evaluation of mobility benefits for all transport schemes as part of any project appraisal. |
| | 5. Provide financial support to local authorities which apply a multimodal approach to transport system decision-making that places transport into the larger context of urban life, the environment, health and the economy. |

| EUROPEAN UNION | |
|--------------------------------|---|
| Recommendations for EU actors: | |
| | 1. Ensure that the content and language of your guidelines on urban traffic management reflect a multimodal perspective on urban road network performance. Establish consistent mechanisms for evaluating project proposals that require the prioritisation of sustainable modes of transport, taking into account the movement of people (not vehicles). |
| | 2. Create a European Walking Strategy as a framework in which cities can plan walkable communicates and incorporate the principles of multimodality and equity among transport modes into the EU Cycling Strategy and into all EU transport strategies. |
| | 3. Establish guidelines for standardised data collection methods for walking and cycling as modes of urban transport. Make funding available to develop the guidelines, for pilot schemes and for consultation with the local and national level. |
| | 4. Require cities to use multimodal assessments of transport system quality in their SUMP measure appraisals. |
| | 5. Provide financial support to local authorities which apply an approach to transport system decision-making that integrates transport into the larger context of urban life, the environment, health and the economy. |

| TRANSPORT CONSULTANCIES (AND THEIR PROFESSIONAL BODIES) | |
|--|--|
| Recommendations for transport consultancies and their professional bodies: | |
| | 1. Develop competencies to add multimodal evaluation of mobility benefits for transport projects and the modelling and assessment of walking and cycling to your service offering. As European transport consultancies, also tailor and market such services to international markets. |
| | 2. Ensure that the content and language of training materials and professional standards reflect the principles of multimodal assessment and mode equity so that they become the norm rather than the exception in transport planning practice. |
| | 3. Work with modelling software providers to improve walking and cycling in modelling tools: both demand and mode choice modelling (macroscopic) and behavioural modelling of interactions (microscopic). |
| | 4. Educate clients (i.e., decision makers and local authority staff) about the importance of fully considering walking and cycling in transport impact analyses and inform them about improved techniques and modelling of walking and cycling. |
| | 5. Develop a voluntary charter of technical proficiency, transparency and ethics for those who offer services in transport modelling and appraisal and hold those to account who fail to uphold technical and ethical standards. |

MODEL DEVELOPERS AND RESEARCHERS

Recommendations for model developers and researchers:

1. Carry out further research into the phenomena of induced and disappearing traffic that result from the introduction and removal of infrastructure to provide guidance for strategic transport modelling.
2. Improve the understanding of the behaviour of pedestrians and cyclists – taking into account differences from country to country – and how to code these into a model accordingly.
3. Carry out microsimulation transport modelling research on the interaction of cyclists and vehicles in shared lanes and on pedestrian behaviour in crowded street conditions. Improve the overall modelling of shared spaces.
4. Develop more meaningful input variables and technical indicators for a calculating level-of-service index for urban cycling and walking.
5. Develop a multimodal delay and/or level-of-service indicator for shared facilities (bicycles and motor vehicles on shared lanes or bicycles and pedestrians on shared paths), including behavioural research to understand modal inter-relations in capacity concepts.
6. Help to improve our understanding of “acceptable” or “expected” travel times for all transport modes in an urban context with a view to defining a multimodal reference condition against which to measure delay in cities.

MESSAGES FOR INFLUENCERS AT ALL LEVELS

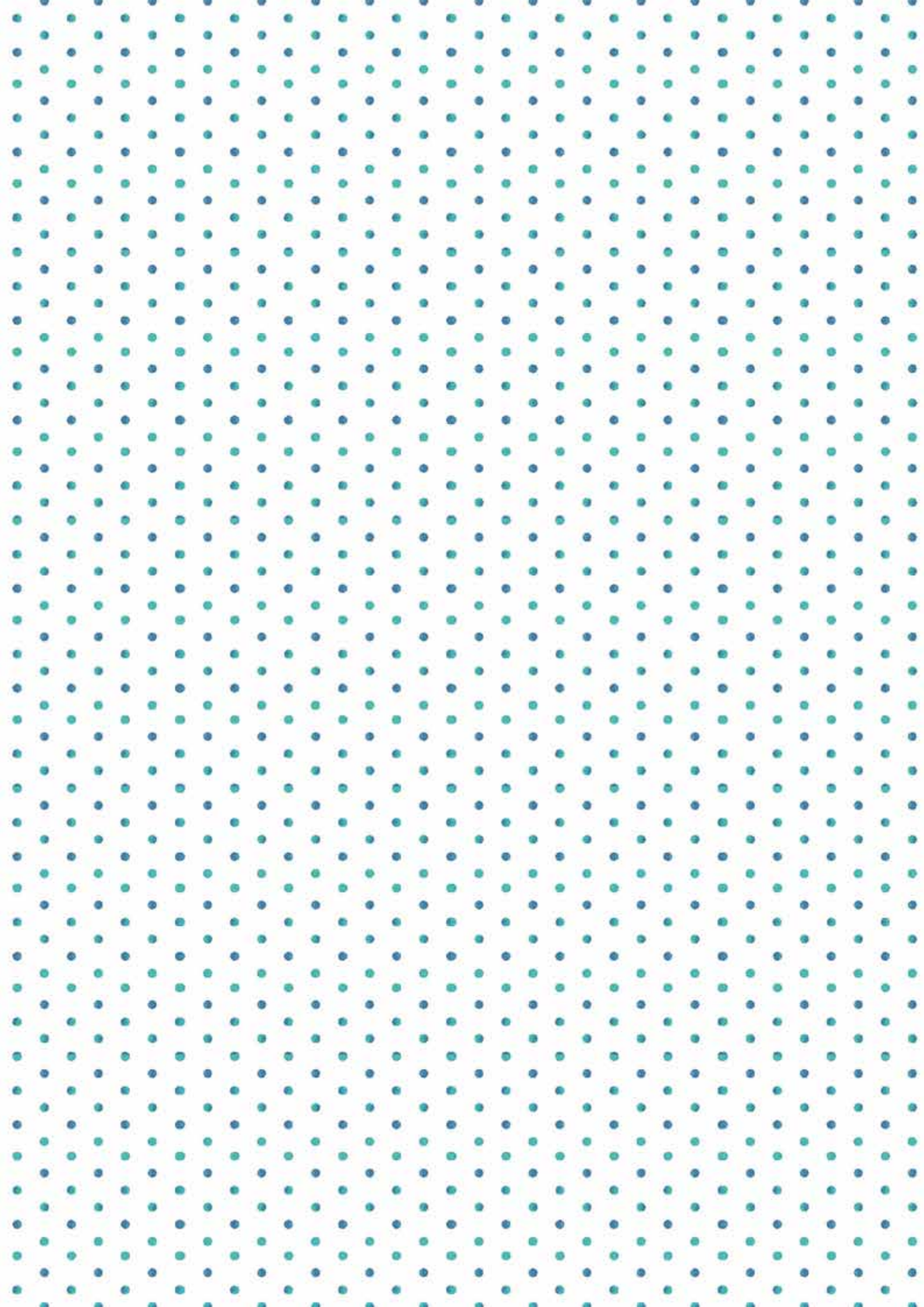
1. Educate decision makers and stakeholders to take a broader view of transport problems. For example, reformulate questions on how to “solve” congestion to how to manage congestion and/or increase corridor capacity.
2. Actively promote a multimodal approach, knowing that efficient public transport is a significant contribution to congestion management. Discourage competition between cycling, walking and public transport.
3. Promote the message: if implemented well, walking and cycling can help reduce urban congestion. Good examples can be found in the FLOW Quick Facts for Cities.
4. Add congestion management to the already-long list of benefits of walking and cycling, when you’re selling the idea to decision makers.
5. Share the message that creating space for more cars in cities is a short-term solution. In such a scenario, urban growth will lead to more cars until the available space is full. Only more efficient use of space (walking and cycling) will make a city liveable and ready for future growth.

6

References and Resources

FLOW Deliverables and Resources (working papers)

All FLOW deliverables and resources are available for download at
www.h2020-flow.eu.



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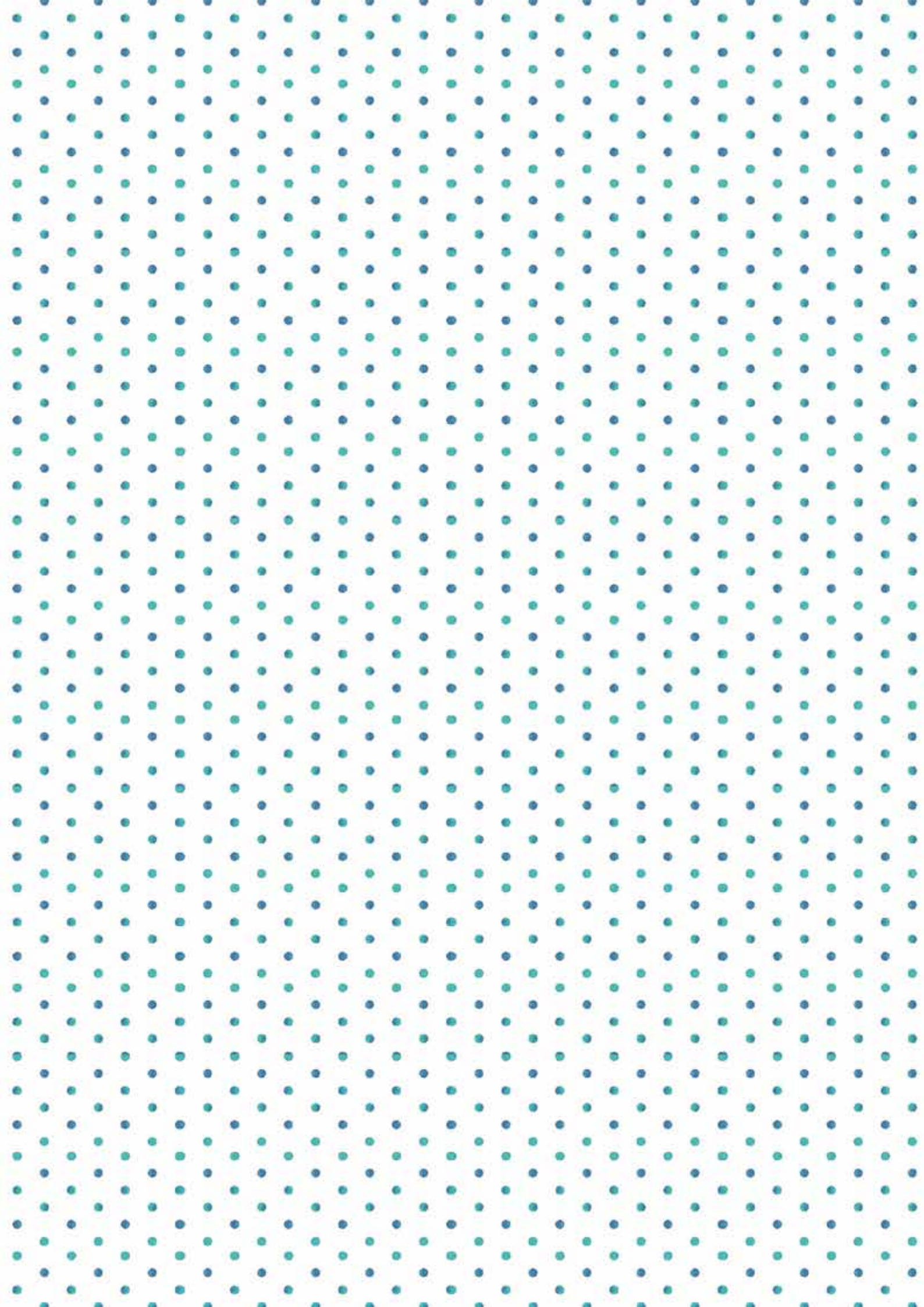
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FLOW is a CIVITAS Horizon 2020 project, running from May 2015 to April 2018. FLOW has developed a multimodal analysis methodology to assess the impact of walking and cycling measures on transport network performance and congestion. FLOW's ideas are being tested in its partner cities of Budapest, Dublin, Gdynia, Lisbon, Munich and Sofia.
www.h2020-flow.eu

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