MCube
Munich Cluster for the Future of
Mobility in Metropolitan Regions

MCube Innovation Recommendation 03

The intersection of the future
Why technology is needed for equity in transportation

For sustainable and socially inclusive mobility, we need responsible political decisions. The Munich Cluster for the Future of Mobility (MCube) uses applied and transdisciplinary research to provide a basis for decision-making on the mobility of the future. With the MCube Innovation Recommendations series, we communicate research results and recommendations for action to policy-makers and all interested.

Context

We've all been there: we're travelling by bike or on foot and stand at an intersection for ages before the traffic light turns green and we can finally move on. But how does an intersection actually work? Why do I have to wait even though I'm the only person waiting?

How can technology help us to make intersections smarter and safer for all road users?

In this innovation recommendation, we explain how traffic is controlled in cities, the technologies behind it and how traffic engineering innovations are tested. Given this background knowledge, we show ***what efforts are needed*** in future to develop urban transport systems that are tailored to the needs of all road users.

How does an intersection work?

Intersections are critical points in urban transport networks on which different road users such as vehicles, pedestrians and cyclists meet.

Complex intersections are organised by so-called traffic light systems that connect various technical components with each other:

1. Traffic light
2. Traffic control unit
3. Traffic detector
4. Roadside unit

Traffic lights

The purpose of traffic lights is to indicate to all road users whether they can cross the intersection safely or have to wait so that other traffic flows can pass. When a group of road users crosses the intersection collectively, this is known as a traffic stream. The aim is always to ensure a safe flow of traffic and to avoid accidents by not authorising competing traffic streams at the same time.

Traffic control units

At an intersection, all traffic lights are connected to each other via a traffic control unit. This device guarantees that all traffic lights switch in a coordinated manner. Traffic engineers can use traffic control units to define the logic of the junction – i.e., how long certain traffic streams are allowed to pass the junction, which traffic streams are released together, or which traffic light phases should be switched in sequence. If traffic lights and traffic control units are the only technologies installed in the traffic light system, the defined control logic is repeated with a fixed pattern over and over again.

Traffic detectors

Traffic detectors can be used to transmit live-information about traffic to the traffic control unit. The traffic control unit can then take this information into account in the control logic. This means, for example, that a green light can be turned red early if there are no more vehicles at the corresponding traffic light. Similarly, traffic streams can be released earlier if vehicles are waiting at a traffic light. If an intersection is not controlled according to a fixed pattern but flexibly using live-information from traffic detectors, this is referred to as traffic-actuated control.

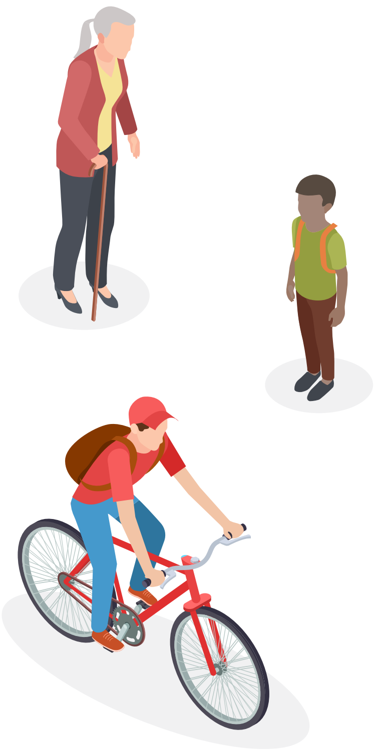
Roadside units

Roadside units are modern telecommunication modules that are connected to the traffic control unit of an intersection. They enable communication between the traffic infrastructure and vehicles that have a similar module. As a counterpart to the roadside unit, modern vehicles have a so-called on-board unit installed, which exchanges data with the roadside unit. This improves the information situation of both individual systems. For example, information about the traffic control logic can be sent to connected vehicles to let drivers know when the light in front of them will turn green.

Especially considering the increasing automation of motorised road traffic, roadside units will play a central role in future-proof traffic engineering systems. If the traffic infrastructure can transmit data directly to automated vehicles, this will help them to navigate safely through complex intersections.

Conversely, automated vehicles can send information (e.g., their position or speed) to the traffic control unit and thus improve their information situation. The traffic control unit can use this information to control the intersection and thus compensate for a lack of traffic detectors.

From car-centred to human-centred transport planning



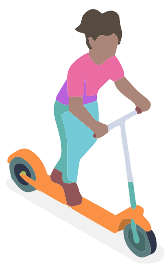
Since the 1950s, the focus in transport planning and engineering has been on car-friendly designs. Today, a large portion of public space is allocated to motorised road traffic, i.e., moving and parked cars. In this mindset, intersections in cities have been equipped with traffic detectors that record motorised road traffic. As a result, cities today are generally well informed about motorised road traffic within the urban area. In addition to the control of intersection, this information is used to monitor traffic, i.e., to recognise accidents or traffic jams, and to inform citizens about them

However, it is not only motorised road users who are on the move in cities: In recent years, we have seen ever-increasing numbers of cyclists and pedestrians. Cities and municipalities are increasingly focused on these modes of transport in their urban and transport planning in order to meet the growing demand. Urban cycle networks have been massively expanded in recent years and footpaths are now much wider than they were a few decades ago.

However, politics is lagging behind when it comes to implementing transport technology:

Nowadays, intersections are usually not (yet) equipped with the necessary technology to adapt traffic control to the needs of pedestrians and cyclists.

For example, traffic detectors in cities are often not able to detect non-motorized road traffic. Commonly, there is a lack of live data on cycling and walking traffic at urban intersections. If this data was available, traffic engineering systems could be better tailored to the needs of these road users.



The imbalance between motorised and non-motorised road users can be illustrated by a simple example: At many intersections, it nowadays is technically possible to extend the green time for a motorized traffic stream. This allows a few cars or even a bus or tram to cross the intersection quickly without having to wait for the next green time. If, on the other hand, an elderly or disabled person takes longer to cross an intersection, this is usually not detected and the green time is not extended accordingly.

How is transport technology tested?

What is traffic engineering?

The discipline of traffic engineering deals with methods and technologies to record, describe and, if necessary, influence traffic flows. In urban areas, a main focus of traffic engineers is to take all road users into equal consideration - especially vulnerable road users such as pedestrians and cyclists

From models to living labs

The top priority in the development of traffic engineering applications is always the road safety of all road users. Especially in urban areas, where a large number of different road users come together, traffic engineering systems have to cope with complex situations. In order to fulfil the high safety requirements in road traffic, traffic engineering innovations generally undergo a multi-stage development process.

1. Data analysis

Relevant data on traffic flows, accidents and other aspects of traffic engineering are analysed. The data can be used to build models that help to better understand traffic.

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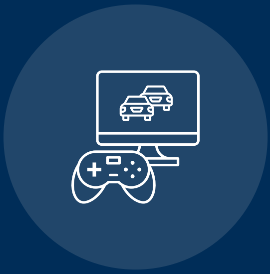

2. Simulation

Real traffic scenarios are digitally recreated in simulations. This way, the effect of traffic engineering innovations on traffic volume, flow and safety can be analysed.

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3. Controlled experiments

Prototypes of traffic engineering innovations are tested outside of regular road traffic. Usually, this takes place on test sites that offer a controlled environment without danger to the public. At the same time, findings from simulations can be tested and validated under realistic conditions.

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4. Living labs

Transport engineering innovations are tested in (spatially & temporally limited) living labs. This makes it possible to test technologies and concepts in real transport environments. Notably, users are now actively involved through feedback or direct interaction with new technologies.

Development of the MCube Test-Intersection for Automated and Connected Driving

As part of the MCube project 'Test-Intersection for Automated and Connected Driving', the TUM Chair of Traffic Engineering and Control, together with the State of Bavaria and Industrieanlagen Betriebsgesellschaft mbH (IABG), has set up a test site to analyse complex urban traffic scenarios. This test site is located on the IABG premises in Ottobrunn (close to the city of Munich), providing a space for controlled experiments that is separate from real road traffic and not subject to road traffic regulations.

The test site is comprised of an asphalt surface on which almost all urban intersection layouts can be recreated using variable infrastructure elements and road markings. It is equipped with the latest traffic technology, including traffic control units, innovative traffic detectors, roadside units and movable traffic lights and traffic light poles. As a result, the test site offers a unique area in which various experiments can be carried out with automated vehicles, particularly in interaction with other road users such as cyclists and pedestrians. Another focus is the testing of new detection technologies to integrate live information about bicycle and pedestrian traffic into urban traffic management and to accurately represent the needs of these road users.

The test site enables reliable and reproducible experimental set-ups. This makes it possible to adjust individual parameters in controlled experiments, while the rest of the test environment provides constant conditions. This comparability is essential in many areas of traffic and mobility research and allows for a precise investigation of various influencing factors, for example on the subjective perception of safety of cyclists and pedestrians.

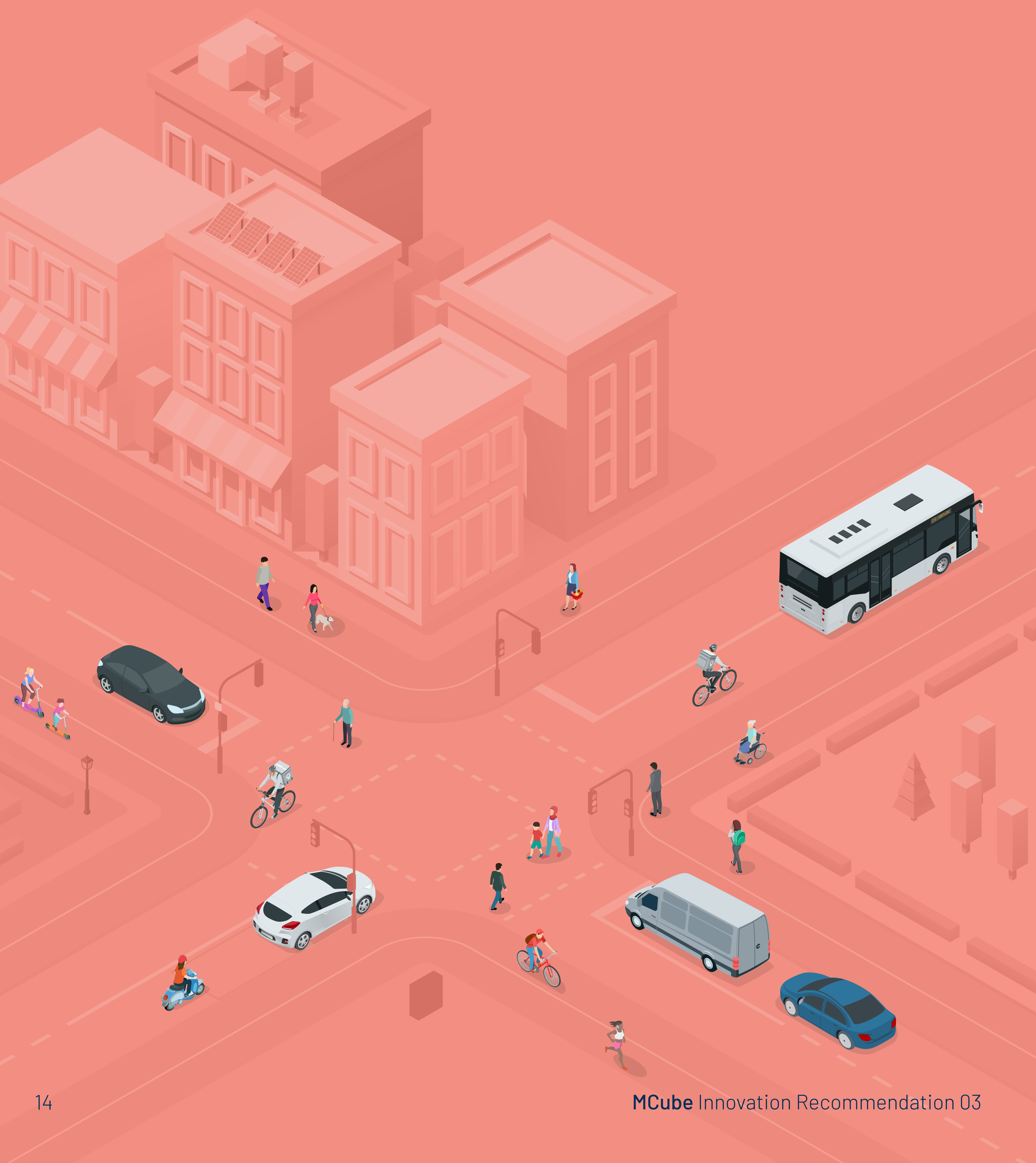
Compared to other test sites, the MCube test site is characterised by its clear focus on urban mobility and complex traffic scenarios with a wide variety of road users.

Innovation Recommendations

Although technologies to create more equity in urban transport are readily available, in practice they are often not yet implemented in cities. Based on the findings of the MCube Test-Intersection project, we have developed three innovation recommendations for decision-makers to promote human-centred transport in cities.

1. **Testing urban scenarios**
2. **Investing in technologies for human-centred transport**
3. **Making data usable – for and from all road users**

1. Testing urban scenarios

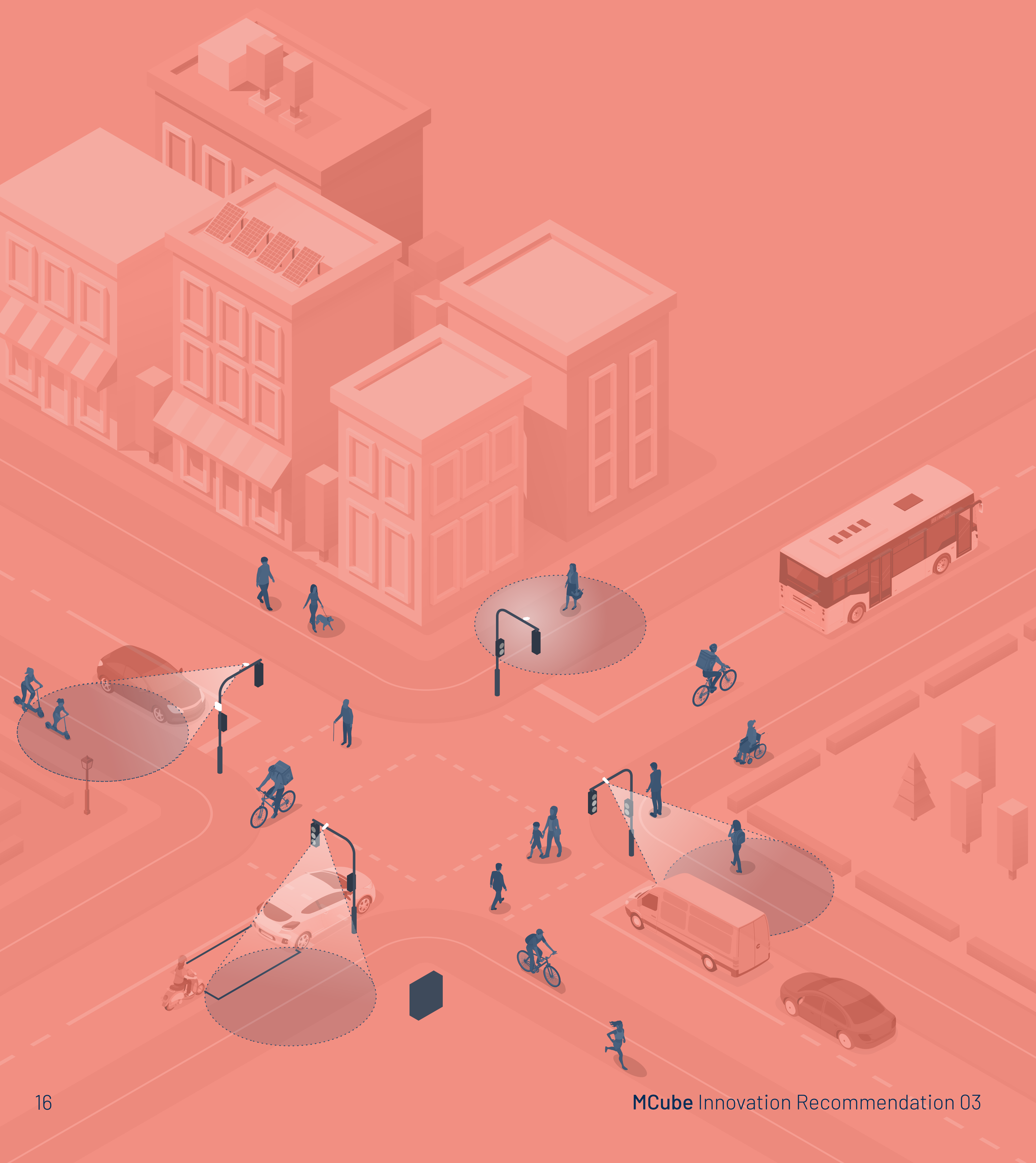


Testing urban transport scenarios is crucial for the development of sustainable transport technologies. Urban scenarios are characterised by their complexity, as they involve many different road users who sometimes behave randomly. Since cyclists and pedestrians are not strictly tied to lanes and their movement speed varies greatly, behaviour patterns are particularly unpredictable. This poses difficult challenges for modern urban transport systems.

New transport engineering applications are one way to tackle these challenges. In spirit of a sustainable mobility transition, they are an important tool to meet the needs of cyclists and pedestrians, as well as particularly vulnerable road users such as wheelchair users or children. Nowadays, scenarios involving road users from these groups are often neglected in the development and testing of transport technology.

We therefore recommend that test fields should be increasingly used to recreate urban scenarios and that particular attention should be paid to the inclusive representation of all road users.

2. Investing in technologies for human-centred transport



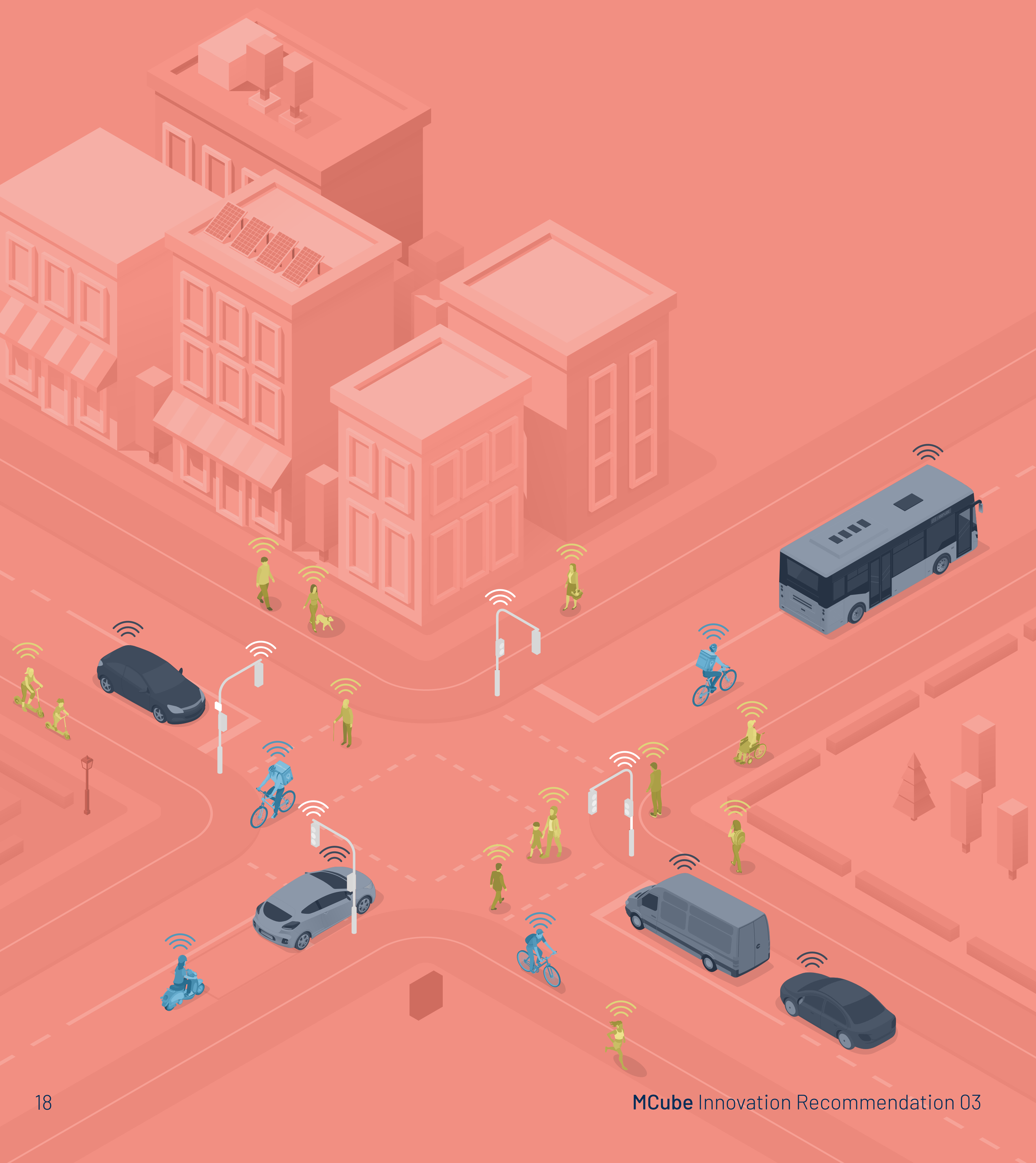
In cities, there is often a lack of live data about bicycle and pedestrian traffic, which is why transport engineering applications in cities cannot respond accurately to the needs of these road users.

To ensure equal participation of all road users in urban areas, the use of appropriate technologies in traffic engineering and control is essential.

A fundamental aspect in promoting equity in traffic is the installation of hardware at intersections. This includes traffic control units, innovative traffic detectors and road side units that are able to collect comprehensive live data on all road users and to use them in traffic engineering applications

The necessary investments must be made available by political decision-makers in order to create the technical prerequisites for true equity in urban traffic. This requires a paradigm shift and political will for human-centred transport.

3. Making data usable – for and from all road users



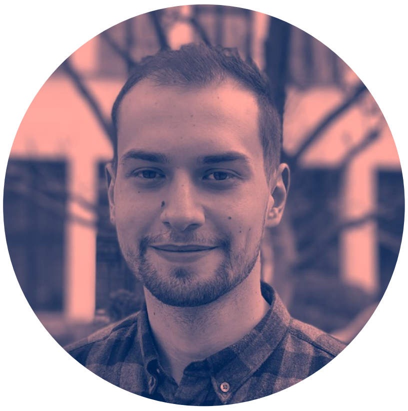
In addition to the data collected directly at intersections by stationary traffic detectors, traffic data collected by road users themselves should be made usable. Modern vehicles are equipped with numerous sensors that record surrounding traffic and can thus support drivers while driving

Automated vehicles in particular have a high number of such sensors and collect large amounts of data, as the vehicle must be able to navigate through complex traffic scenarios without human assistance. However, this data so far has only been used in the vehicle itself and not passed on to the urban transport infrastructure. Another example is traffic data generated by cyclists and pedestrians themselves, e.g., through smartphones or smart watches that can record the position and speed of their users.

The integration of new traffic data sources into urban transport systems can help to provide the missing live data on bicycle and pedestrian traffic. This makes traffic more efficient and safer for all road users.

However, commonly there is no legal framework that regulates the acquisition and utilisation of new traffic data sources.
The im-plementation of such measures requires active political will and commitment. This means that political decision-makers must adopt the appropriate laws and regulations and provide the necessary financial resources. This is the only way to realise comprehensive and equitable traffic management that meets the needs of all road users.

If you want to find out more about the MCube research project Testkreuzung, visit the ***website*** *and subscribe to the* ***MCube newsletter***
The next major milestone is the official opening of the test field including a press event in September 2024.



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MCube - the Munich Cluster for the Future of Mobility in Metropolitan Regions - utilises the unique agglomeration of players in the field of mobility innovation to make Munich a pioneer for sustainable and transformative mobility innovations. The aim of the cluster is to test and research leap innovations in the mobility sector and to develop scalable solutions with a model character for Germany and worldwide.