

## Motivation

Roadworks are unavoidable for the maintenance and expansion of public infrastructure; at the same time, they are an obstacle to mobility. Transport authorities have the task of ensuring a smooth flow of traffic despite road works. Traffic-relevant roadworks must be identified and made available as information so that everyone can coordinate and the interested public can be informed.

With up-to-date and target group-adapted information about road works, road users such as ambulances, fire brigades, logistics companies and individual traffic can be intelligently guided around road works, thus optimising the traffic situation. In this way, the search traffic can be minimised, traffic jams can be avoided and the associated pollution can be reduced.

In the current discussion on digital traffic management, the task of providing road works information tailored to the various stakeholders and in real time is viewed very positively. In this paper, we first focus on the situation in the Free and Hanseatic City of Hamburg, with an outlook on how a solution could be transferred to other municipalities.

## Background

The various interested stakeholders such as emergency services, logistics and individual traffic often have a very different understanding of road works. This includes the nature and extent of the characteristics of road works and which of them are of interest to whom. For example:

- Rescue and emergency vehicles are interested in whether roadworks are generally passable; if necessary, using blue light and driving against a one-way road. This information must be up-to-date and accurate in order to avoid delays in an emergency.
- Logistics companies plan delivery routes in the long term, e.g. for supermarket deliveries about six months in advance. They want early information if a delivery route is disrupted due to roadworks.
- Car sharing services such as MOIA or IOKI need daily updates on road works that could affect their service. As additional information on road works, they need the exact dimensions and traffic routing around a road work in order to relocate possible pick-up and drop-off points. This also applies to the subordinate road network.
- Individual road users want to avoid road blocks and traffic jams and be intelligently rerouted by their GPS.

Depending on the perspective and task of the actors, different roadwork information is relevant at different points in time. This information must be quality-assured and compared with reality in order to avoid faulty routing. Today, this task is mainly done manually, which is very time-consuming and error-prone. What is missing so far is a solution for automated, area-wide recording, quality assurance and publication of road works.

## Challenge

Despite the digitization strategy of many cities, the flow of information about current road works to the public is in need of improvement. We summarize the main current problems for the provision and dissemination of valid road work data as follows:

1. **Manual road works recording and maintenance:** For intelligent routing taking road works into account, these must be recorded and published with their exact geometry and the associated traffic routing (full closure, one-way road, etc.). Today, this information is recorded manually by clerks in Hamburg. These clerks enter road works selectively, according to the impact of a road work on traffic. The necessary resources are often lacking for the recording and maintenance of short-term road works and those on secondary roads.
2. **Deviation between planning data and real situation:** due to e.g. weather situations such as heavy rain or snow, the start of construction can be delayed in practice and thus deviate from the planned start date of an official permit. In such cases, the published planning data on road works do not match reality. Drivers are thus diverted in the wrong way or in an unnecessarily complicated way.
3. **Manufacturer-independent routing:** from a city's point of view, the issue of mobility and road works affects all people working and living in a city. In order for all these people to be informed about road works in a manufacturer-independent way, neutral data formats and platforms for the exchange of road works information must be found, which all manufacturers can access equally.

According to our research, the situation can be summarized as follows: The lack of information about current road works leads in everyday life in all larger municipalities to unnecessary search traffic, causes congestion and thus increases pollution.

The current process for publishing road works is shown in Figure 1. Road works are registered at road work authorities, coordinated with other road works and handed over to road traffic authorities for assessment with regard to traffic safety and order. The traffic authorities publish traffic-relevant road works in platforms such as MDM or TIC. What constitutes traffic-relevant road works is decided individually by each traffic authority. In Hamburg, for example, only road works on major roads are published. Since not all road works are published on platforms such as MDM or TIC, navigation providers use other sources such as websites to obtain additional information about road works.

# Publication of Road Works

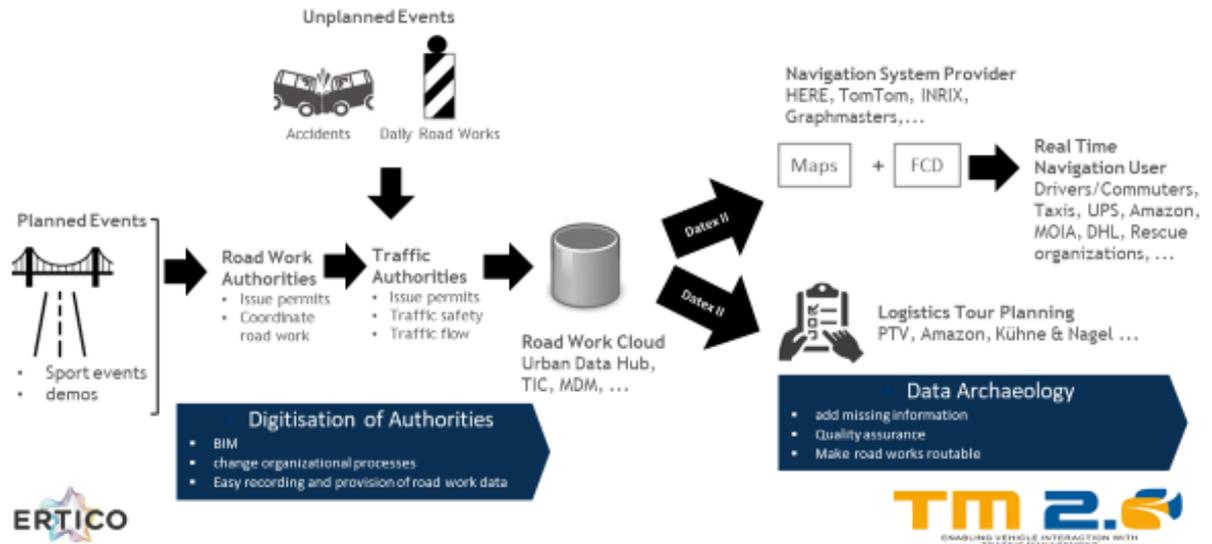


Figure 1: Procedure for publishing roadworks

While many long-term road works on motorways and main roads in Hamburg are recorded and published, this information is largely missing for short-term road works, for urban secondary roads and for current plan changes. On the busy motorways and main roads, even short-term measures can cause widespread congestion. The secondary roads, on the other hand, are essential for last-mile logistics with participants such as taxis, emergency services, parcel services, delivery services and new mobility providers such as MOIA or IOKI. In addition, the secondary roads in urban traffic often serve as alternative routes for road works and closures on main roads.

## Solution approach

At the core of the solution approach is the idea of building a digital twin for road works. This idea has been pursued in practice for several years from two directions: to the left and to the right of the road works cloud-platform (see figure 1).

- **Approaches to the right of the roadworks platform:** these take the incomplete and partly quality-assured roadworks in the platform as a given and try to supplement the missing information with real-time data such as FCD, roadworks apps, published information on websites, etc.
- **Approaches left of the roadworks platform:** aim to improve the scope and quality of roadworks before publication. For this purpose, organizational processes in authorities must be adapted and digital tools for recording and providing roadworks must be introduced.

Our goal is to automate and thus significantly simplify the digital recording and provision of road works on the left-hand side of the road work cloud-platform through technological

developments. To this end, organizational processes in public authorities must be adapted in a minimally invasive manner. The real-time data on the right side of the road work cloud-platform can improve quality assurance in a feedback process:

- **GeoNetBake:** since 2019, the Hamburg State Agency for Roads, Bridges and Waterways (LSBG) has been developing an electronic IoT beacon together with the company ABOUT GmbH. This captures the outlines of road works with centimeter precision and makes this information available digitally. What the GeoNetBake does not record, however, is the actual traffic routing in the area of the roadworks, e.g. whether it is a full closure, one-way street or lane narrowing. However, this information is elementary for routing in the navigation system.
- **Floating Car Data (FCD):** Companies such as Google, HERE, TomTom or Inrix record the traffic situation in cities by inferring the overall traffic situation from movement data of individual vehicles. Statistics on traffic movements on individual roads can help to identify deviations from regular traffic. If suddenly no vehicles are travelling in a certain direction on a particular day, even though vehicles were still on the road on the previous days, this indicates a closure due to road works. In combination with GeoNetBake, this closure can be additionally validated.
- **Drones:** Current developments in the drone environment can provide additional support in recording the roadworks situation from the air. Drones can survey roadworks areas, record traffic situations and help to assess roadworks road safety from the air.
- **Other IoT Sensors:** Movement data from local public transport, refuse collection vehicles and other road users, in addition to FC data from individual providers, can help to improve the information situation regarding roadworks on seldom-used secondary roads in particular.
- **Feedback from drivers:** in addition to the automated approaches mentioned above, feedback from drivers can also be collected via an app and compared with the automatically collected information.
- **Prioritised site inspection:** when drivers, FCD data or other sources report roadworks that deviate from the original planning or approval of the authorities, messages can be generated to the urban site inspectors. Equipped with a mobile application, inspectors can receive reports in real time, walk the associated roadworks on site and, if necessary, fill in missing roadworks information directly. Frequently reported roadworks could be given priority. The roadworks information added on site can be forwarded directly to the routing companies and taken into account in the drivers' navigation systems.

Considered individually, the solutions above do not offer the required level of detail and quality for roadworks for the actors and use cases under consideration. However, a sensible combination of the solutions above can create an up-to-date, precise and quality-assured digital twin of all road works in a city. The data of the digital twin can be made available to the public and used, for example, in navigation systems for efficient routing. The mobility data

marketplace (MDM), for example, could be used as a platform. In the future, this information can also be used for strategic routing for autonomous driving. With current roadwork information and traffic data, autonomous vehicles can independently calculate a locally optimized route without constantly ending up in road blocks.

In a pilot project led by the LSBG, the challenges described should be consolidated and a concept and pilot system for the provision of application-oriented road work data should be developed. The project should involve the various stakeholders in an exemplary manner in order to develop the interests and concrete use cases. In the outlook, the project should outline a strategy for the gradual transfer of the solution approaches to other municipalities.

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