Hazard Warnings

Whitepaper

December 2023

Scope

This white paper describes the Hazard Warnings service offered by TomTom. It details the technical interfaces between the involved components, such as end-user devices and TomTom Hazard Warnings. All examples provided in this document are informative and may not be complete.

Introduction to TomTom Hazard Warnings

TomTom Hazard Warnings is a low-latency warning service for end-user devices and customer backends. The warnings published by the service are safety-related and inform end-users of potentially dangerous traffic, road, and weather conditions.

The hazard warnings help drivers anticipate the journey ahead. Based on GPS probe data and enriched with government feeds, community input, car sensors, and other third-party data, the warnings can be displayed through in-vehicle navigation devices or transmitted to advanced driver assistance systems (ADAS). This enables the latter to adjust speed or adapt functionality as necessary.

TomTom Hazard Warnings provides alerts on safety-critical incidents in the following categories:

- Traffic hazards
- Road hazards
- Weather hazards

Hazard types

TomTom Hazard Warnings covers several different types of hazards. This list is expected to expand over the coming months. TomTom is considering adding more types of hazards and general warnings to its service. TomTom will inform customers about new additions before their launch.

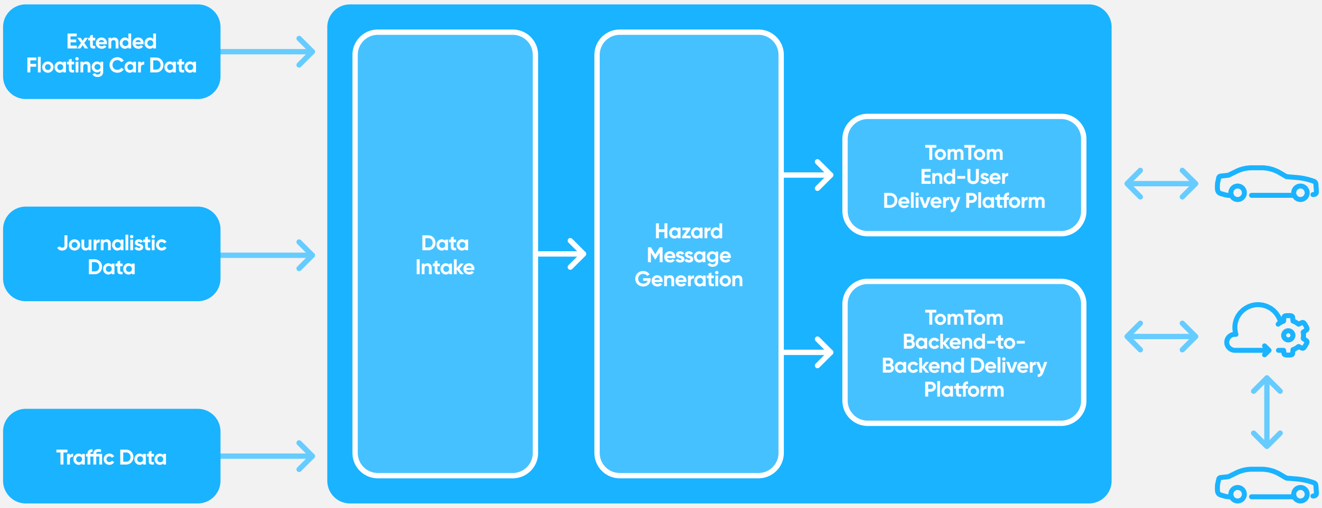
Hazard category	Hazard type	Hazard description
Traffic	Accident	Accidents are dangerous situations, mainly if they have just occurred. Conditions like this are usually unclear, and drivers must navigate cautiously as they get near the location or want to assist.
Traffic	Broken Down Vehicle	Breakdowns can cause vehicles to suddenly stop, roll out, or get stuck between lanes, creating potential obstacles for other drivers. Additionally, the passengers of the broken-down vehicle may exit the car, requiring other drivers to proceed with caution.
Traffic	Emergency Vehicle Approaching	Emergency Vehicle Approaching (EVA) indicates vehicles with priority on the road. Drivers must let them pass.
Traffic	Jam Tails	Jam tails occur at the end of traffic jams. If a jam tail is located behind a curve or hill, it can pose a significant danger to approaching vehicles. To avoid sharp braking or potential accidents, drivers should adapt their driving behavior accordingly.
Traffic	Wrong Way Driver	Wrong way drivers refer to vehicles driving in the wrong way against the legal traffic flow of the road.
Road	Bad Road Conditions	Bad road conditions can include potholes, shoulder drop-offs, cracks, and uneven surfaces. These require drivers to reduce speed and navigate carefully.
Road	Objects on Road	Any kind of object on the road (e.g. animals, people, or fallen vehicle loads) is a potential obstacle. Drivers need to be aware of these and drive carefully when approaching the location.
Road	Roadworks	Roadworks are construction sites for roadway maintenance. They usually come with speed restrictions, barriers, and lane changes.
Weather	Reduced Visibility	Severe weather conditions (e.g., heavy rain or fog) can dramatically reduce visibility. Drivers must limit their speed and pay close attention to surrounding vehicles.
Weather	Slippery Road	Slippery road conditions are mainly caused by bad weather but also abnormal liquids (e.g., oil) on the road surface. Such conditions can cause vehicles to behave unpredictably.
Weather	Strong Winds	Unexpected strong winds (e.g., cross winds) may cause the vehicle to move in an unwanted direction.
Generic	Generic	All other kinds of hazards that the proposed scheme cannot cover.

Hazard Warnings platform

TomTom Hazard Warnings consist of components that ensure a low-latency and high-quality delivery of hazard messages. A high-level overview is provided in Figure 1.

The service receives information from multiple sources and normalizes the data, which is then analyzed, aggregated, verified, and validated. TomTom Hazard Warnings uses this information to quickly deliver an up-to-date set of hazard messages to all connected customers.

Figure 1: TomTom Hazard Warnings platform



Hazard Warnings Delivery

We currently support multiple delivery mechanisms. The communication between all actors uses standard internet protocols.

To guarantee the highest level of data security across all access points, we utilize robust authorization and authentication mechanisms.

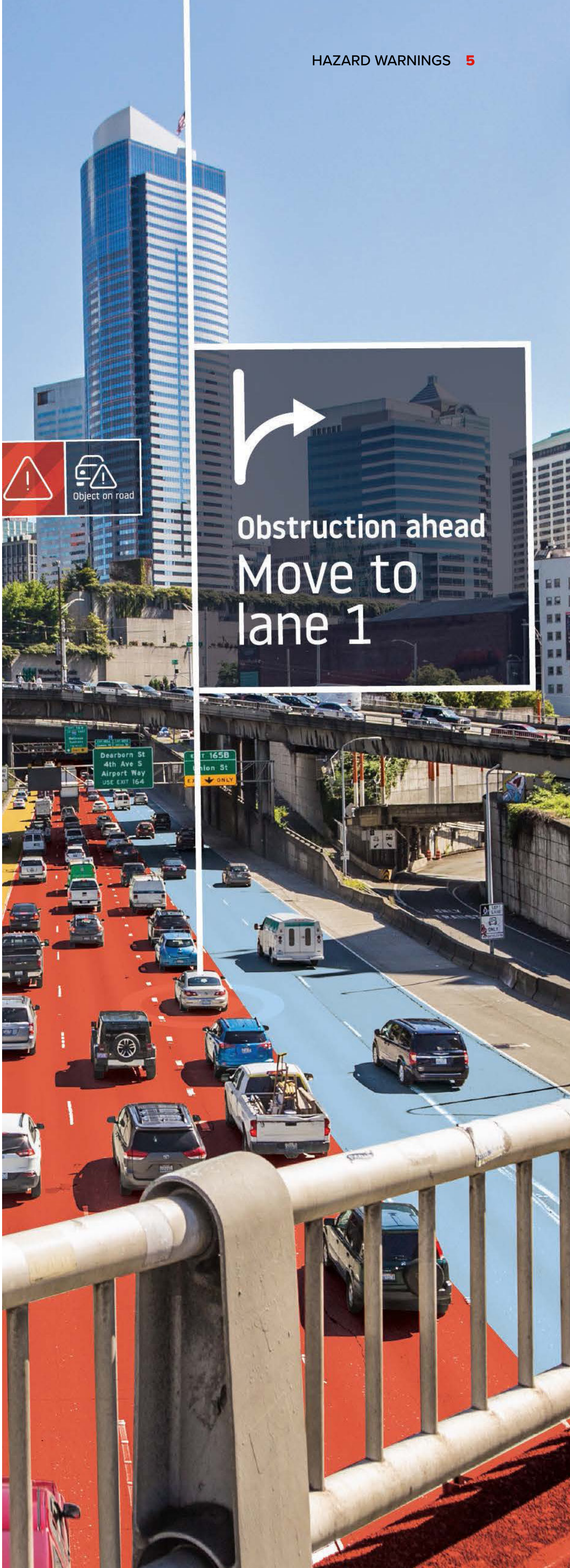
To ensure a round-trip latency of under 5 seconds, we use push technology to notify our customers about safety-critical events.

End-User delivery

The client (or end-user) usually uses a device, like a head unit, to connect to our service. The service follows the publish/subscribe model and uses the MQTT standard. This delivery method is suitable for in-car integration use cases.

Backend-to-Backend delivery

The client (or backend) uses their backend service to access big chunks of hazard data. Hazard messages are grouped into regions like countries. The service follows a publish/subscribe model and uses the Kafka protocol. The client distributes the events within their fleet themselves.



End-User Delivery

Introduction

TomTom Hazard Warnings end-user delivery uses a topic-based and publish-subscribe model to deliver safety-critical hazard warnings to customers with a round-trip latency of under 5 seconds. MQTT is the transport protocol used for our Hazard events.

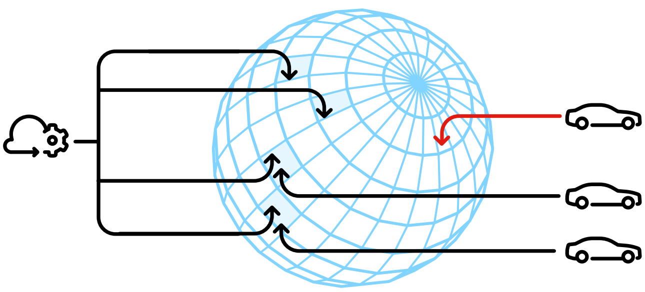
Distribution

Hazardous events happening on the globe are grouped into cells based on the Morton tiling scheme (see Appendix). Depending on the tile level, the size of the grid cell varies. Due to this approach, we limit the volume of the transmitted data. The Client device calculates the Morton tile depending on its current position and uses the tile ID as part of the request. Our clients can benefit from high flexibility thanks to the multiple tile levels.

MQTT

MQTT is a client-server publish/subscribe messaging transport protocol. It was designed to be lightweight, open, simple, and easy to implement. The protocol runs over TCP/IP or other network protocols that provide ordered, lossless, bi-directional connections.

Figure 2: TomTom Hazard End-User Delivery



Topic subscription

Hazard messages (as part of MQTT messages) are organized into so-called topics. The topics follow a hierarchical structure, like a file system, using the forward slash (/) as a separator. Each entry in the topic path acts as a filter for the underlying data. TomTom Hazard Warnings allows geographical filtering and the ability to select messages by their type.

The end-user delivery service offers the following topic structure:

> *<messageType>/<api_version>/<mortonCode level 10>/<mortonCode level 11>/ <mortonCode level 12>/ <mortonCode level 13>/<hazard type>/#*

The topic structure allows the client to select and filter the hazard messages according to the geographic location and the hazard types. The strings in the topic structure are case-sensitive.

Table 1: Definition of the subscription values

Topic entry	Default	Description
Message type	h5s	Identifier for hazard messages
Api Version	v1	An identifier of the schema version of the content, breaking changes will be reflected in changed Content API versions, current value “v1”
Morton code level 10		Morton code for level 10
Morton code level 11		Morton code for level 11
Morton code level 12		Morton code for level 12
Morton code level 13		Morton code for level 13
Hazard type		Selected hazard type like “broken_down_vehicle”
#		Mandatory wildcard to retrieve all available messages under the topic defined by above parameters.

Backend-to-Backend Delivery

Introduction

TomTom Hazard Warnings for the backend-to-backend use case are delivered via its dedicated platform. This uses Apache Kafka to stream hazard events to the customer backend. Events are provided via a topic-based, publish-subscribe model and will be encoded into Protocol Buffers (see[1]). Detailed information about the connection process will be shared via a dedicated backend-to-backend platform specification.

Distribution

Hazardous events are grouped into areas of interest or named regions. A region can be an entire country like Japan or a city like Berlin. The customer is responsible for distributing the Hazard Events to relevant clients in the requested area.

Apache Kafka

To ensure a round-trip latency of less than 5 seconds, we use push technology to notify our customers about safety-critical events. As the technology for the backend-to-backend use case, we use Apache Kafka as the stream processing platform. Our Hazard Warnings service acts as a producer and publishes streams of hazard events. The client backend acts as a consumer and subscribes to the hazard topics to process them.

Topic Subscription

After a successful connection to the TomTom backend-to-backend delivery platform, Hazard Warning events are available by subscription to the topics, in the format:

> *<type_of_message>.<api_version>.<region>.<hazard_type>*

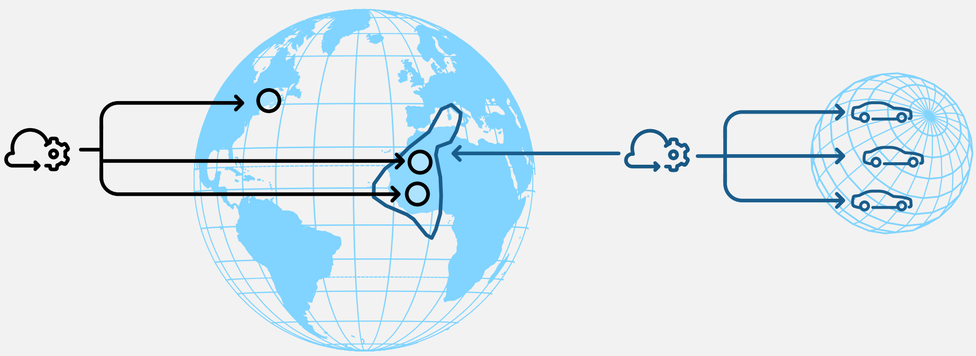
Table 2: definition of the subscription values

Type of message	Hazards
Api Version	With a schema version identifier of the content, breaking changes will be reflected in the changed Content API versions, current value "v1."
Region	The identifier of a regional partition of the content can be a country code or city name. It will be shared with customers for individual access.
Hazard type	One of our supported hazard types mentioned above. E.g. SLIPPERY_ROAD or REDUCED_VISIBILITY.

Data Format

Hazard events are encoded in Protocol Buffers, a language-and platform-neutral mechanism to serialize structured data. The content is structurally described in the form of Protocol Buffers schema file. This schema features two primary elements: a metadata section and a message section. The metadata mainly details the creation and expiration time of the hazard event. The message component contains hazard-specific information like location and information regarding severity. TomTom will provide a detailed schema description.

Figure 3: TomTom Hazard Backend-to-Backend delivery



1. Protocol Buffers," [Online]. Available: http://www.protobuf.dev

Location Referencing

Location references are used to exchange spatial location information within digital maps. Such references describe “where” something is on Earth. Hazard messages consist of “what” happens and the “where” information. “What” is, for example, the hazard type, e.g., an accident or strong winds. “Where” relates to the location (on Earth). Location referencing can happen in many ways and for hazard messages, the location referencing method needs to be processed quickly by digital systems and offer highly accurate locations. The method must also overcome differences in digital maps.

TomTom Hazard Warnings uses geo-coordinates and OpenLR™ as location referencing methods. Both methods support the usage of location references for points, linear stretches, and areas.

Geo-coordinates

Geo-coordinates are the simplest way to address a location. They consist of longitude and latitude values represented in an ellipsoid model of the Earth. The model used for TomTom Hazard Warnings is WGS84.[2]

A single coordinate represents a single point; an ordered sequence of coordinates represents either a path or an area, depending on the agreement to connect the last coordinate with the first one.

OpenLR™

OpenLR™ is an open-source location referencing method developed by TomTom. It offers point, linear, and area locations of different hazard types. The method has been standardized and adopted by OEMs and their suppliers. The central concept for linear locations is based on location referencing points along the location and shortest-paths calculation between these location referencing points.[3]

Figure 4: Example of a point location

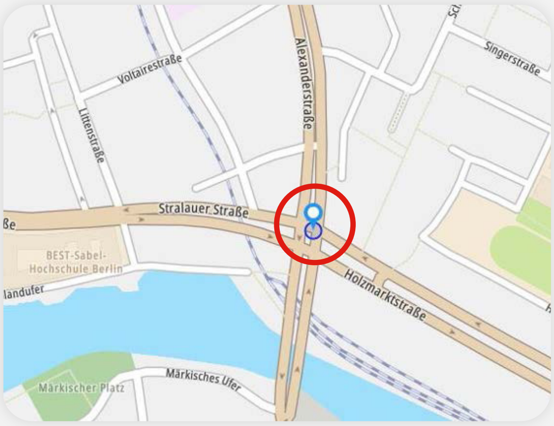


Figure 5: Example of a linear location

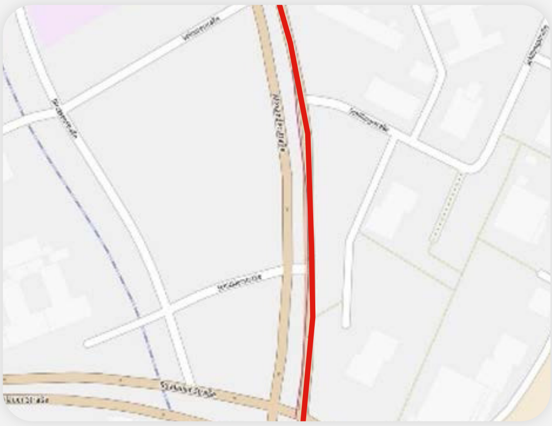


Figure 6: Example of an area location

2. ICAO, “WGS-84,” [Online]. Available: https://gis.icao.int/eganp/webpdf/REF08-Doc9674.pdf

3. OpenLR Association,” [Online]. Available: http://www.openlr.org/. Note: Please see the link for further details, specifications, and links to code samples.

Appendix

Morton Codes

In the end-user delivery use case, the client application focuses on smaller areas of interest to avoid significant overhead or filtering relevant data on the client side.

To support this use case, we split the world into smaller tiles (also known as cells or regions). This allows for smaller data per tile and localized information sent to clients. Morton codes are an excellent option for splitting the world logically into cells. Such codes work with simple geo-coordinates (latitude and longitude in WGS84) and form hierarchical grids of cells. Another benefit of Morton codes is that they assign a unique ID to each cell, which can be easily calculated from its geo-coordinates.

The size of the grid cells depends on the level. The bigger the level, the smaller the cells. The cells are not square, and the different edges (in the direction of latitude and longitude) have different lengths. The length of a degree of latitude varies due to the Earth's curvature.

Average sizes for selected levels are shown in Table 3, with examples for The Netherlands (NLD).

Table 3: Cell dimensions depending on the Morton level

Level	Avg. length latitude (meters)	Avg. length longitude (meters)	Country
2	19,422	38,880	NLD
3	9,711	19,440	NLD
4	4,855	9,720	NLD
5	2,427	4,860	NLD

The Netherlands coverage for the Morton levels 10 – 13 is shown in the following figures.

Figure 7: Morton tiles, level 10, NLD

Figure 8: Morton tiles, level 11, NLD

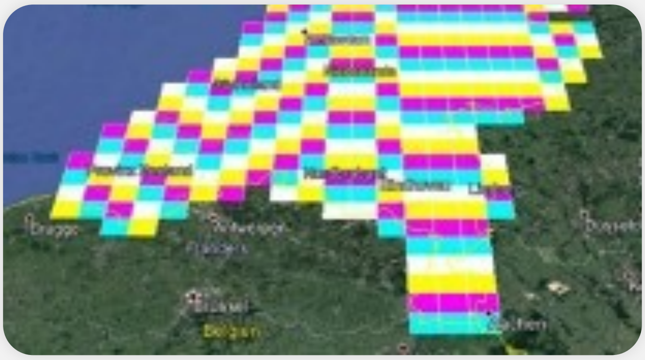


Figure 9: Morton tiles, level 12, NLD

Figure 10: Morton tiles, level 13, NLD

Summary

TomTom Hazard Warnings combines the coverage of a wide array of hazard types with low-latency and high-quality hazard message delivery. It can be easily integrated with both end-user navigation devices and advanced driver assistance systems. By notifying both drivers and automated vehicles about potential hazards ahead of time, TomTom Hazard Warnings helps road users better anticipate risks and navigate safely.

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