TISA
Traveller Information Services Association

Functional Road Classifications (FRC)

An Introduction

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TISA Vision, Mission and Purpose

Our Vision – A world where traffic and travel information is 100% correct, 100% of the time on all roads

Our Mission – To lead the development of trusted traffic & travel standards and harmonized services for our members.

Our Purpose – Ensure travel is safe, efficient and sustainable for everyone, everywhere

TISA Value Proposition

For all public and private stakeholders in the Intelligent Transport System (ITS) value chain …

Who want to ensure travel is safe, efficient and sustainable for everyone, everywhere

Our membership driven association connects all stakeholders to develop and maintain the standards, software and tooling in traffic & travel information and data quality accreditation

That by using TISA standards provides **seamless traffic and travel services** ensures interoperability worldwide & reduces costs for your organisation;

Allows you **to shape TISA standards** to your own user cases and needs;

Offers **new business opportunities** and the opportunity to facilitate networking with other organisations sharing the same goals;

Gives your organisation access to the **latest developments on all ITS standards** in a one-stop shop;

Supports your **preparation & compliance** to global ITS domain regulations

The TISA Global Membership

Our Value Proposition is for all public and private stakeholders in the Intelligent Transport System (ITS) value chain who want to ensure travel is safe, efficient and sustainable for everyone, everywhere. TISA Members include ITS Service and Solution Providers, User Device Manufacturers, Public Sector Stakeholders and Vehicle Manufacturers.

Functional Road Classification (FRC)

An Introduction

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1 INTRODUCTION

Transportation systems rely on well-structured and efficient roadway networks to support the movement of people and goods. The broad use of digital mapping technologies in navigation, logistics, and infrastructure management led to an increased importance of standardizing the way roads are categorized. Functional road classifications (FRCs) provide systematic methods for organizing roadways based on the type of service they offer within the broader network. By segmenting roads according to their role — whether facilitating high-speed, long-distance travel, or enabling access to local destinations — FRCs support map-related processes such as route planning algorithms, traffic management, or urban development strategies.

In digital maps, FRCs serve as foundational attributes that inform how routing engines determine optimal paths, how spatial databases are organized, and how authorities allocate resources for maintenance and upgrades. A clear understanding of FRC principles is therefore essential not only for transportation specialists and urban planners but also for technology developers and policymakers who utilize digital maps in their workflows. This document provides an overview of the most frequently used FRC frameworks, emphasizing their purpose, hierarchical structure, and significance within digital mapping systems.

Functional Road Classification (FRC) is a systematic method used to categorize roads, streets, and highways based on the role or function they serve within the overall transportation network. This classification helps planners, engineers, and policymakers understand and manage the flow of traffic, prioritize investments, and design roads to meet both mobility and access needs.

1.1 Scope of this document

This document introduces the foundational principles underlying Functional Road Classifications (FRCs) as they are applied in digital mapping systems. It aims to provide explanations of the core concepts and illustrate common challenges encountered in the application and interpretation of FRCs. The focus remains on standard or representative cases, which constitute the majority of real-world applications. With this scope, the document ensures that readers obtain a broad overview of FRC fundamentals and practical strategies for standard implementations. More complex cases or non-standard applications will be treated in a separate document to be published later.

The document is tailored to readers with a scientific or technical background, providing accessible explanations without going too deep into technical specifications, mathematical formulas or code examples.

Please note that this document does not aim to provide any practical recommendations or implementation guidelines for the concepts covered herein. Excluded are also methods for digital map production and updating.

1.2 Core principles of Functional Road Classification systems

The primary purpose of functional classification is to define the role that each roadway segment plays in serving travel needs-ranging from facilitating long-distance travel to providing direct access to properties. The functional classification of roadways is fundamentally structured around the two principal objectives of **Mobility** and **Access**. Each objective encapsulates a distinct but complementary aspect of transportation network design and operation.

Mobility	Mobility refers to the capacity of a roadway to facilitate the efficient, rapid, and uninterrupted movement of vehicles and individuals, often over extended distances. Roads designed with a dominant emphasis on mobility, such as principal arterials, are characterized by limited intersections, few access points, and higher travel speeds. Their core function is to move high volumes of traffic between major origins and destinations—such as cities, industrial zones, and regional centres. The physical and regulatory design of these roads prioritizes through-traffic, streamlining flows and minimizing delays caused by turning movements, access to adjacent properties, or localized interruptions. In digital mapping, mobility-prioritized roads are integral to route optimization for long-haul or cross-regional navigation, ensuring that travellers experience minimal travel time and maximum network efficiency.
Access	Access describes the ease with which vehicles and pedestrians can enter or exit the roadway network, particularly in relation to adjacent land uses — such as residences, businesses, and institutions. Roads functioning primarily as access providers, such as local streets and service roads, are characterized by plentiful entry and exit points, lower travel speeds, and frequent intersections. The overarching purpose here is to afford direct, convenient connectivity between the transportation system and the specific destinations it serves. Rather than maximizing flow efficiency, the design of access-oriented roads aims to accommodate diverse traffic movements, including short trips, deliveries, and on- and off-street parking manoeuvres. Within digital mapping contexts, accurate representation of access-oriented segments is crucial for navigation solutions requiring precise endpoint routing and property-level address resolution.

Table 1: Core principles of FRC systems

In summary, the mobility-access spectrum is intrinsic to functional road classification: at one end, arterials and highways optimize system-wide movement, while at the other, local and collector roads serve site-specific access needs. Striking an appropriate balance between these objectives within the network — and transparently encoding this balance in digital maps — is essential for effective transportation planning, operations, and user experience.

> Within FRC frameworks, each road is assigned a class that reflects a balance between two objectives: *Mobility* and *Access*. *Mobility* generally refers to road capacity and traffic volumes, whereas *Access* describes for which types of vehicles a given road is foreseen.

1.3 Basic types of road

In the context of functional road classification (FRC), the three principal road types are *arterial roads*, *collector roads*, and *local roads*. Each serves a distinct transportation role by balancing the competing objectives of mobility (efficient movement of traffic) and access (ease of reaching adjacent properties). Below, each class is described in detail, along with illustrative examples.

1.3.1 Arterial Roads

Arterial roads form the backbone of the transportation network within urban and regional contexts. Their primary function is to provide high-capacity, efficient routes for the movement of large volumes of traffic, often across significant distances or between major centres of activity (such as city districts, commercial hubs, or industrial zones). These roads are characterized by multiple lanes, higher speed limits, and limited direct property access to optimize flow and minimize delays. Arterials often include both major (principal) and minor categories, with the former including highways, expressways, or freeways.

Key features:

- high traffic volume and capacity
- higher speed limits compared to other road types
- limited direct access, i.e. access control measures such as medians or restricted intersections are common
- serve as main routes for commuting and logistics
- support public transportation corridors

Examples:

- principal arterial: autobahns, interstates, or city bypass roads
- major arterial: the 'B' federal highways in Germany or U.S. state highways
- urban arterial: a multi-lane avenue connecting downtown to the suburbs

Figure 1: Example for an arterial road

1.3.2 Collector Roads

Collector roads serve an intermediary function, channelling traffic between local streets and arterial roads. Their design balances mobility and accessibility, allowing significant property access and moderate travel speeds while still facilitating the efficient distribution of traffic to broader network routes. Collectors may take the form of wide boulevards, feeder streets in suburban developments, or key community corridors. They often connect residential areas, small commercial centres, and institutional land uses to major traffic arteries.

Key features:

- moderate traffic volumes and capacities
- moderate speed limits, typically lower than arterials but higher than local roads
- frequent intersections, including roundabouts and stop or signal controls
- designed for a mix of property access and through movement
- often serve as routes for local public transportation

Examples:

- a residential boulevard linking several neighbourhoods to a town centre.
- a feeder road collecting traffic from local streets and directing it toward a major arterial.
- community roads providing access to facilities like schools, parks, or minor shopping centres.

Figure 2: Example of a collector road

1.3.3 Local Roads

Local roads, also referred to as streets, serve the primary function of providing direct access to dwellings, businesses, and other properties. They offer the highest level of accessibility within the road network but are not intended to accommodate through-traffic over long distances. Local roads typically have low speed limits, lower volumes of traffic, and minimal connectivity beyond their local area. They often include residential streets, cul-de-sacs, alleys, and access roads in both urban and rural settings.

Key features:

- lowest traffic volumes and speeds
- numerous access points — driveways, parking lots, entrances
- prioritize access over mobility, discouraging non-local through-traffic
- frequently comprise the majority of the length in a road network

Figure 3: Example of a local road

Examples:

- a residential street in a subdivision
- a cul-de-sac serving a small cluster of homes
- an alleyway providing rear access to urban properties

Summary

- **Arterial roads** provide high-capacity, efficient movement between major destinations, prioritizing mobility over access.
- **Collector roads** distribute traffic between local and arterial roads, balancing both objectives.
- **Local roads** offer direct property access with low traffic volumes, prioritizing access over mobility.

This hierarchical structure allows transportation systems and digital maps to support a wide range of travel needs, from long-distance commuting to local circulation, while facilitating systematic planning, modelling, and navigation.

1.4 Purpose and Applications of FRCs

Functional classification is used for:

- transportation planning and funding
- roadway design standards
- access management
- system performance monitoring
- routing
- location referencing
- map matching
- map display
- traffic safety

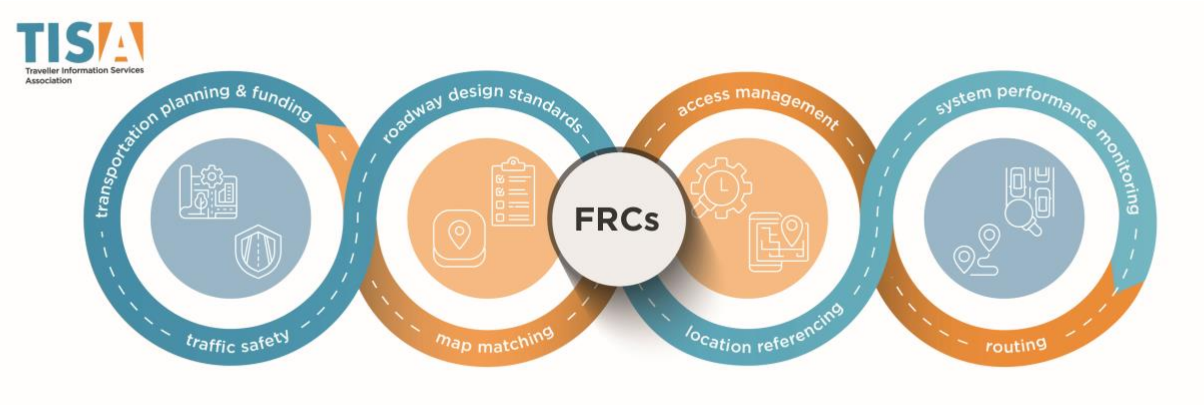


Figure 4: Purpose and application of FRCs

Each application is explained in detail in the following sections.

1.4.1 Transportation planning and funding

Functional road classifications (FRCs) play a critical role in both transportation planning and the allocation of funding for network development and maintenance. The systematic categorization of roads according to their functional role—primarily based on mobility and access—enables a rational and transparent framework for infrastructure management at municipal, regional, and national levels.

In the context of transportation planning, FRCs provide the foundational logic for designing balanced and efficient networks. Planners use these classifications to structure road hierarchies, ensuring logical progression from local access to regional and national routes. This organization helps to:

- Direct long-distance and heavy traffic onto arterials, reducing congestion and wear on roads with lower capacity or more sensitive environments.
- Allocate right-of-way and design standards that are commensurate with the intended function of each roadway, paramount for optimizing safety, traffic flow, and urban integration.
- Guide zoning and land-use decisions, since high-mobility arterials are less suited for frequent property access while local roads facilitate finer-grained connectivity to homes and businesses.

From the perspective of funding, FRCs serve as an objective basis for prioritizing resource distribution. They help align financial investment with the broader societal value and functional importance of roadway segments. For example:

- High-priority FRC categories, such as principal arterials and major collectors, often receive greater funding for upgrades, routine maintenance, and technological enhancements due to their strategic significance for mobility, commerce, and emergency response.
- Funding formulas at the national or sub-national level routinely incorporate FRC designations to ensure transparent alignment with policy goals, such as economic development, environmental sustainability, and equitable mobility.
- In public grant programs and international initiatives—such as those supported by the European Union or federal agencies—eligible roads are frequently defined by their FRC. This ensures that subsidized investment achieves maximal network or societal benefit.

Moreover, FRCs foster interoperability and data compatibility across digital mapping platforms and governmental agencies, allowing for coordinated investments and evidence-based project selection. By classifying roads according to their function, authorities can monitor system performance, forecast future demand, and adapt funding strategies as travel patterns evolve.

In summary, the purpose and application of FRCs in transportation planning and funding are twofold: they provide a logical basis for network design, supporting efficient movement and access; and they underpin fair, strategic allocation of resources, ensuring that investments align with the relative importance and service function of each roadway segment. This holistic approach enhances system resilience, cost-effectiveness, and the societal value derived from transportation infrastructure.

1.4.2 Roadway design standards

Functional road classifications (FRCs) are central to establishing consistent, rational roadway design standards across cities, regions, and entire countries. The primary objective is to ensure that the geometric, structural, and operational features of each roadway segment are precisely matched to its intended function within the broader transportation network. This approach minimizes resource waste, enhances safety, and improves network performance.

Within the context of roadway design, FRCs define the expected role of each road—whether maximizing mobility, enhancing access, or providing an optimal balance. Design standards are developed accordingly, covering factors such as lane width, shoulder type, sight distance, intersection design, permissible access points, signage, and pedestrian and cycling accommodations.

For arterial roads, which are designed to support high-speed and high-volume movement over longer distances, design standards typically prescribe wider lanes, gentle horizontal and vertical curvature, limited direct property access, and advanced traffic control technologies. Features such as grade separation at critical intersections, wide medians, and accommodations for heavy vehicle loads are common. The intention is to facilitate efficient through-traffic, minimize delays, and maintain a high level of operational safety.

Collector roads, acting as intermediaries between arterials and local streets, have design standards that reflect their dual role in balancing access and mobility. These specifications might include moderate lane widths, more permissive intersection spacing, and design speeds lower than those of arterials. Provisions for direct property access are more flexible but still controlled to ensure efficient flow. Pedestrian crossings and traffic calming measures are often included as standard.

Local roads are primarily intended for direct property access and low-speed travel within neighbourhoods. Their design standards emphasize frequent access points, narrower lanes, minimal curb radii to encourage slower vehicle speeds, and an increased focus on pedestrian and cycling facilities. Design speeds and sight distances are minimized, reflecting the expectation of mixed traffic with frequent stopping and turning movements.

The use of FRCs in setting these standards provides several advantages:

- **Standardization**: FRCs ensure that roads with similar functions are built and maintained to common specifications, facilitating predictability and ease of use for all network users.
- **Safety**: Roads designed according to their functional category help prevent mismatches between expected and actual vehicle speeds or movement patterns, thus reducing accident risk.
- **Cost-effectiveness**: Applying appropriately tailored design standards ensures that resources are invested where they yield the greatest impact, avoiding excessive expenditure on roads with modest traffic or accessibility demands.
- **Regulatory clarity**: Planners, engineers, and contractors benefit from clear guidance when interpreting design manuals, enabling more efficient design and review processes, especially when projects span multiple jurisdictions.

In summary, FRCs provide a rigorous, function-based framework for the development and implementation of roadway design standards. This alignment ensures that each road segment safely and efficiently fulfils its role—whether as a conduit for rapid mobility, a channel for distributing traffic, or a means of providing direct local access—ultimately supporting a cohesive, high-performance transportation network.

1.4.3 Access management

Functional road classifications (FRCs) provide a foundational framework for access management within transportation networks by systematically matching the level of property access allowed to the function assigned to each road segment. Access management refers to the regulation and design of entry and exit points—driveways, intersections, and other connections—to and from roadway facilities. The interplay between FRCs and access management ensures that individual roads or streets can perform their intended service roles—either prioritizing uninterrupted mobility or providing frequent opportunities for access—effectively and safely.

The primary purpose of integrating FRCs into access management is to resolve the inherent conflict between the needs for vehicular mobility and property accessibility. Roads serving primarily as mobility corridors (such as arterials) are designed to minimize disruptions from turning and crossing manoeuvres and therefore benefit from strict access control. In contrast, roads classified for access (such as local streets) are intentionally structured to support more frequent entry and exit movements, accepting lower speeds and volumes to facilitate the needs of abutting land uses.

Key applications of FRCs in access management include:

- Access Spacing and Control: Roadways with higher functional classifications (arterials and expressways) impose more restrictive access management standards. This means fewer driveways, greater distances between access points, and extensive use of medians or other controls to maintain traffic flow. Lower-classification roads (collectors and locals) allow greater density of access points, supporting the goal of serving adjacent properties and local traffic movements.
- Intersection and Driveway Design: FRCs dictate the requirements for the type, location, and geometric design of intersections and driveways. Arterials may require signalized intersections or roundabouts with restricted movements, while local roads often support minor, unsignalized intersections with direct property access.
- Network Functionality Preservation: Proper application of FRC-based access management practices preserves the hierarchy and intended operational roles within the road network. By tailoring access policies to road classification, authorities can protect investment in high-capacity corridors, reduce congestion, and decrease crash risk due to conflicts between high-speed through traffic and local turning movements.
- Planning and Regulatory Consistency: FRCs provide a uniform basis for developing and applying land use and access regulations. This ensures that adjoining developments are designed with appropriate setbacks, driveway locations, and internal circulation systems that complement the classification and design of the adjacent roadway.
- Retrofit and Remediation: In instances where prior development or design decisions do not align with the functional classification, FRCs guide retrofit measures—such as driveway consolidation or installation of medians—to restore the desired functional performance of the road segment.

Through these mechanisms, FRCs enable road authorities and planners to achieve a coherent and safe transportation network, reducing conflicts, enhancing capacity, supporting economic and land use goals, and efficiently allocating public resources. Ultimately, the pairing of functional classification with systematic access management preserves both network mobility and property access within a logical, predictable, and sustainable framework.

1.4.4 System performance monitoring

Functional road classifications (FRCs) are essential instruments in system performance management for transportation networks. Their primary purpose in this context is to provide a consistent framework for evaluating, benchmarking, and improving the operational effectiveness of roadway systems.

FRCs enable transport agencies to systematically segment the road network according to function, which is critical for setting tailored performance expectations and monitoring outcomes. Performance metrics—such as roadway condition, capacity utilization, congestion levels, crash rates, and travel times—are analysed and compared within similar functional classes rather than indiscriminately across the entire network. This differentiation ensures that benchmarks are realistic and relevant to each road type, acknowledging, for example, that principal arterials are expected to sustain higher traffic loads and performance levels than local roads.

In practice, FRCs are applied in several aspects of system performance management:

- Condition and Performance Monitoring: Using FRCs, agencies collect and report network condition data (e.g., pavement quality, bridge integrity) and operational indicators (e.g., average speeds, delays) in a stratified manner. National frameworks, such as the Highway Performance Monitoring System (HPMS) in the United States, require states to submit detailed data—organized by functional class—that underpin federal performance assessments and funding apportionment.
- Target Setting and Benchmarking: Agencies establish performance targets for roadway maintenance, safety, and mobility based on the functional role of each segment. Higher priority classes, such as principal arterials, often have more stringent targets for condition and reliability. This supports a performance-based approach to infrastructure management and investment.
- Program and Project Prioritization: In resource-constrained environments, FRCs guide the prioritization of improvement programs by focusing attention on the most critical links in the network. This ensures that strategic upgrades, preservation activities, and safety improvements are directed where they will have the greatest systemic impact.
- Asset Management: The classification framework supports data-driven asset management, enabling agencies to allocate preservation resources in proportion to the functional importance and usage intensity of roadways. Investment decisions are thus better aligned with actual service expectations and long-term system performance.
- Safety and Operations Analysis: Crash rates, operational incidents, and traffic management strategies are evaluated with respect to functional classification, enabling targeted interventions and policy refinements that are sensitive to the specific challenges and usage patterns of each road type.

Through these mechanisms, FRCs facilitate a structured, objective approach to performance monitoring and system management, allowing for transparent reporting, informed decision-making, and a clear linkage between roadway function and public performance expectations. This clarity promotes accountability and continuous improvement across all tiers of government and agency operations involved in roadway system stewardship.

1.4.5 Routing

Functional road classifications (FRCs) are essential for the structure and efficiency of routing in digital navigation systems. Their primary purpose in this context is to inform routing algorithms about the relative importance and intended function of each road segment, enabling the calculation of optimal routes that respect both mobility priorities and local access needs.

By embedding FRC information in digital map databases, road networks are organized hierarchically into arterial, collector, and local roads, reflecting their capacity, speed, and connectivity levels. Routing algorithms utilize this hierarchy to accelerate search processes and prioritize travel on roads appropriate for each trip's purpose. For instance, long-distance or through-traffic is typically routed along higher-class arterials to minimize travel time and reduce congestion on local streets, while routing toward the final destination leverages collector and local roads to provide precise access.

The applications of FRCs for routing include:

- Efficient Route Calculation: FRCs allow navigation systems to quickly exclude unsuitable road segments for through-traffic, focusing search efforts on high-capacity arteries for most of a journey. This hierarchical approach significantly reduces computational complexity, which is especially advantageous in large-scale networks.
- Context-Sensitive Routing: FRCs provide a structured basis for adjusting route preferences according to trip characteristics. Algorithms can favour arterial routes for long trips while prioritizing access routes for local deliveries or neighbourhood navigation. This adaptability supports both user preferences and traffic management policies.
- Prevention of Traffic Spillover: By design, FRC-informed routing discourages the inappropriate use of local roads by through-traffic, which enhances residential liveability, improves road safety, and preserves the intended operational function of each segment. Studies have shown that more sustainable and community-friendly routing can be achieved when route planners leverage local FRC implementations.
- Support for Real-Time and Dynamic Routing: The integration of FRCs with real-time data (e.g., congestion, incidents) enables dynamic adjustment of routes while still respecting the logical network hierarchy. This prevents algorithms from exploiting minor roads in ways that degrade system performance or cause negative externalities.
- Basis for Policy Implementation: Authorities can use FRCs within routing engines to enforce policy goals, such as restricting heavy vehicles from low-class roads or favouring designated corridors for freight traffic.

In summary, FRCs are vital data structures underlying modern routing systems. They ensure that calculated routes align with the planned function of each road, balance network performance with local quality of life, and support adaptive, scalable, and sustainable navigation solutions in digital maps.

1.4.6 Location referencing, Map matching & Map display

Functional road classifications (FRCs) play a pivotal role in both location referencing and map matching within digital mapping and navigation systems. Their integration into these processes enables the precise identification of positions along the road network and enhances the reliability of matching observed positional data (such as from GPS) to the correct road segments in a digital map.

Location referencing

Location referencing is the method of specifying precise locations or road segments within a network, independent of address or coordinate systems. FRCs provide a standardized hierarchical structure that underpins these references. By assigning a functional classification to every segment, digital maps can encode locations not just as geographic coordinates, but in relation to the road hierarchy—for example, "on a principal arterial road between two collectors." This approach supports several critical applications:

- Unambiguous Identification: FRCs ensure that location references are robust against network changes (e.g., new construction or reclassification), because they tie references to road function as well as geometry.
- Interoperability: Many map data exchange standards (e.g., OpenLR) use FRCs to encode routes, enabling different navigation systems to interpret and decode location references consistently.
- Efficient Data Management: Storing and sharing spatial events (such as incidents or maintenance) relative to functionally classified roads allows for targeted responses, streamlined reporting, and integration across agencies or platforms.

Map matching

Map matching is the process of aligning observed position data (e.g., a sequence of GPS fixes) to the most plausible path on a digital road network. FRCs significantly enhance this process at several stages:

- Candidate Reduction: When multiple nearby segments could plausibly match an observation, FRCs help restrict consideration to likely functional classes, e.g., ignoring minor streets when a user is known to be on a highway.
- Heuristic Weighting: Map matching algorithms utilize FRCs to assign higher likelihood to certain road types, reflecting expectations about travel behaviour. For example, rapid and straight carriageways are more likely on arterials than on locals.
- Error Correction: FRCs support the correction of mismatches by informing algorithms about logical connectivity, enabling recovery from GPS errors or map ambiguities by considering road hierarchy.
- Advanced Techniques: Recent map matching models—such as those employing Hidden Markov Models—can use FRCs as factors in probability calculations, improving matching accuracy, especially in complex, multilevel, or urban road networks.

Overall, the systematic application of FRCs in location referencing and map matching ensures that digital maps remain accurate, navigable, and resilient to changes in the physical and digital environment. This underpins reliable turn-by-turn navigation, accurate reporting of events or incidents, and efficient operations for services ranging from emergency response to logistics planning.

Map display

The FRC-classification is used for map display purposes. Depending on the zoom level, in the applications of most providers the map shows a different level of detail. The FRC ensures that on higher zoom levels (zoom out) only the most important roads are shown, and that more detail will appear when zooming in.

1.4.7 Traffic safety

Functional road classifications (FRCs) serve a crucial role in enhancing traffic safety by systematically organizing road networks according to the primary function of each segment. This classification provides a foundational framework for designing and managing roads in a manner that minimizes conflicts, reduces crash risks, and supports safe movement for all users.

The core safety benefit of FRCs lies in their ability to clearly differentiate between road segments intended for high-speed, long-distance travel (such as arterial roads) and those intended primarily for local access (such as local streets). When roads are classified and designed according to function, safety interventions and design standards can be tailored more precisely to anticipated traffic volumes, speeds, and use patterns. For example, arterial roads are planned with restricted access, median barriers, and higher visibility requirements, which collectively reduce the likelihood of severe collisions. In contrast, local roads accommodate frequent driveways, lower speeds, and higher pedestrian activity, necessitating features such as traffic calming measures and enhanced crosswalks.

FRCs also inform the implementation of speed limits, access spacing, intersection design, and signal control. Arterials typically feature higher design speeds and limited access points, minimizing the opportunities for conflict between through traffic and local movements. This systematic limitation of access on roads designated for mobility helps reduce collision rates linked to turning movements and driveways, thereby decreasing crash severity and frequency. Collectors, which balance mobility and access, require careful intersection and driveway design to ensure safe integration of local and through traffic flows. Local roads, meanwhile, prioritize safety for residents and non-motorized users through lower speeds and physical measures that discourage through traffic.

Performance monitoring and crash analysis are further facilitated by FRCs, as safety outcomes can be benchmarked and interventions prioritized based on roadway function. Agencies can evaluate crash rates by road class, identify overrepresented risk factors, and target infrastructure improvements where the benefit to safety is greatest.

Empirical studies and international guidance underscore that robust application of FRC-based design and management principles leads to significant reductions in accident rates and injury severity. When the classification of roads is synchronized with their design, operation, and management, the overall negative impact of traffic incidents is mitigated, and road user safety is enhanced throughout the network.

In summary, the purpose and application of FRCs in traffic safety are to create a coherent, predictable environment where each road’s operational role is supported by appropriate safety features, regulatory controls, and infrastructure investments. This targeted approach reduces conflicts, controls speeds, and ultimately contributes to safer transportation systems for all users.

1.5 FRCs for routing

Road networks can be classified using various schemes and attributes tailored to specific use cases such as routing, display, and speed restrictions. In the context of routing, the Functional Road Classification (FRC) indicates the relative importance of different road types within a broader network, particularly for motorized vehicle usage.

Routing algorithms utilize FRC to establish logical connections between a starting point and a destination by prioritizing higher road classes as the distance from the start or destination increases. By excluding lower road classes, these algorithms efficiently reduce the number of possible routes between two points, resulting in logical routes that can be computed quickly.

Note that in this document we approach the routing classes as a generic form of classification. A more detailed view on the different types of road classifications, their use cases and application in different map providers is available in the A1 document.

1.6 FRCs for Map Matching

Map matching is the process of aligning observed positions—such as those acquired from GPS or other sensors—to the most probable path on a digital road network. Functional road classifications (FRCs) are an integral part of this process, especially within standardized and interoperable location referencing methods such as Open Location Referencing (OpenLR) and ISO 17572-3.

FRCs categorize each road segment by its functional importance—for example, distinguishing a motorway from a secondary or local street. In map matching, appropriately leveraging FRC information allows algorithms to filter, prioritize, and score candidate matches for a given location observation. As a result, the system can avoid implausible, low-class roads when high-level roads are expected, or resolve ambiguities when multiple network segments are geometrically proximate.

Within the context of OpenLR, a widely used open-source dynamic location referencing method, FRCs are explicitly encoded as part of each Location Reference Point (LRP) and along the referenced path. The map-matching process typically involves the following steps:

- Candidate selection: For each LRP, the algorithm identifies potential road segments near the coordinate. Each LRP contains the anticipated FRC, assisting in the elimination of mismatched functional classes at an early stage.
- Scoring and selection: Candidate road segments are scored by their proximity to the LRP's geographic position and their alignment with the FRC value. Segments with incompatible FRCs (e.g., a motorway segment expected, but only a local street found) are either penalized or excluded1.
- Path construction: The matched LRPs are connected, and routing algorithms often utilize the lowest FRC between consecutive points (as specified in OpenLR) to ensure that the path follows the expected road hierarchy rather than detouring onto lower-class roads.
- Map independence: FRCs help retain consistency between different digital map providers, who may represent the physical layout and identifiers of roads differently. By abstracting to functional class, OpenLR and similar methods maintain interoperability and robustness in cross-map referencing.

Map matching uses FRCs to accurately align GPS positions with the correct roads, helping algorithms prioritize likely matches, filter out implausible roads, and maintain consistent, interoperable referencing—especially in standards like OpenLR—by scoring candidate road segments based on both location and functional importance.

1.7 FRCs for Location Referencing

Location referencing is a foundational concept in intelligent transport systems (ITS), enabling the exchange of spatial information—such as traffic events, route segments, or points of interest—between systems that may use different digital maps. To ensure interoperability, location references must be interpretable regardless of the underlying map provider, geometry, or data model.

1.7.1 Types of Location Referencing

Two main approaches exist: **pre-coded location referencing** and **dynamic referencing**.

Pre-coded referencing, such as used in **RDS-TMC (ISO 14819-3)**, relies on predefined location tables. Each location is assigned a unique identifier, which is referenced in messages. This method is compact and efficient but limited in flexibility. Only locations present in a pre-agreed table and appropriately tagged in a digital map can be referenced. Location table updates require coordination between table-owners, map providers, content and service providers, and receiver manufacturers. This makes it not suitable for dynamic or ad-hoc location encoding.

Dynamic location referencing, by contrast, allows any location to be encoded on-the-fly using geometric and semantic attributes, including FRC. This approach is map-agnostic and supports real-time applications such as traffic incident reporting, navigation, and routing. Experience has shown that relying solely on coordinates does not ensure reliable matching of location references across different maps. Two notable methods in this category are **DLR1**, as defined in **ISO 17572-3**, and **OpenLR™**, a widely adopted open-source protocol documented in a public white paper. While technically distinct, OpenLR is conceptually similar to DLR1 and aligns closely with its principles.

FRCs only play a role in Dynamic Location Referencing Methods, as explained below.

1.7.2 The role of FRC in Dynamic Location Referencing

Dynamic referencing methods describe locations using a combination of spatial coordinates and descriptive attributes such as direction, form of way, and **Functional Road Class (FRC)**. These attributes collectively define the expected characteristics of the road segment, allowing the receiving system to match the location reference to its own map—even if the geometry or naming differs.

Among these attributes, **FRC plays a central role**. It categorizes roads based on their functional importance—ranging from motorways and principal arterials to local streets. This classification reflects the road's role in the transport network, such as supporting long-distance travel or providing local access.

FRC as a guiding attribute

In dynamic referencing, FRC serves as a **guiding attribute** that helps the receiving system identify the correct road segment. When decoding a location reference, the system uses the FRC to filter and prioritize candidate segments. For example, if the reference indicates a high-class arterial road, segments with lower FRCs can be excluded from consideration. This improves matching accuracy and reduces ambiguity, especially in dense or complex road networks.

In both OpenLR and ISO 17572-3-compliant systems, the use of FRC ensures that road segments of appropriate functional significance are selected. This contributes to robust, accurate, and interoperable matching between observed locations and digital road networks.

Efficiency and Interoperability

FRC also contributes to the **efficiency** of the matching process. By narrowing the search space to segments of the expected functional class, algorithms can reduce computational overhead and improve response times. This is particularly valuable in real-time applications, such as dynamic routing or traffic incident detection.

Moreover, FRC enhances **interoperability** between systems using different maps. Because it abstracts the road's role rather than relying on proprietary identifiers, FRC enables consistent interpretation of location references—even when the underlying map geometry or naming conventions differ. This makes dynamic referencing suitable for cross-provider, cross-border, and cross-platform data exchange.

Matching Challenges and Subjectivity of FRC

Despite its utility, FRC classification is inherently **subjective**. Different map providers may assign different FRCs to the same physical road based on their own criteria—such as traffic volume, connectivity, administrative designation, or regional planning standards. For instance, a road classified as a "collector" in one map might be labeled "local" in another, depending on the provider's interpretation of its role.

This subjectivity introduces challenges in dynamic referencing. If the encoded FRC does not align with the receiver's map, the matching algorithm may discard valid segments or select incorrect ones. This can lead to mismatches, degraded routing performance, or misinterpretation of traffic events.

To mitigate these issues, systems often apply **tolerance thresholds** or **fallback strategies** during decoding. For example, a receiver may accept segments with adjacent FRC levels if no exact match is found. While this improves robustness, it also introduces complexity and potential ambiguity. The trade-off between strict matching and flexible interpretation must be carefully managed to ensure reliable interoperability.

Summary

Functional Road Class is a foundational element in dynamic location referencing. It enables accurate, efficient, and interoperable matching of location references across diverse digital maps. By capturing the functional significance of road segments, FRC supports robust location encoding and decoding—even in the face of geometric discrepancies or naming inconsistencies.

However, the subjective nature of FRC classification requires careful handling. Differences in interpretation between map providers can affect matching outcomes, and systems must be designed to accommodate such variation without compromising reliability.

1.8 FRCs for Transportation Planning and Policy Making

Functional road classifications (FRCs) are instrumental for policy making and transportation planning, providing a standardized framework that supports the development, regulation, and management of transportation networks across administrative and technical domains. Their use is particularly relevant in aligning network infrastructure with policy objectives and fulfilling regulatory requirements at national and European levels, notably within the context of the European INSPIRE directive.

1.8.1 FRCs in Policy Making and Transportation Planning

In policy making, FRCs serve as a reference system that enables authorities to translate broad mobility policy goals—such as increasing accessibility, reducing congestion, enhancing safety, or optimizing modal shift—into actionable network strategies. By categorizing roadways according to their functional importance and role (e.g., arterial, collector, local), FRCs make it possible to:

- Prioritize investment decisions and maintenance budgets, ensuring that resources are allocated efficiently to support critical corridors and optimize societal benefit.
- Establish regulations such as access restrictions, vehicle type limitations, environmental zones, or speed management policies that are precisely targeted to the functional class of each road.
- Support land use planning and urban development by informing zoning regulations and aligning major development areas with appropriate network capacities and accessibility levels.
- Facilitate risk assessment and resilience planning by identifying infrastructure criticality (e.g., prioritizing arterial roads for emergency evacuation routes or disaster recovery).
- Enable evidence-based monitoring and evaluation of network performance at each level of service, guiding adaptive policy adjustments.

In transportation planning, FRCs are central to modelling network behaviour, scenario analysis, and the design of integrated transport systems. They assist planners in balancing network connectivity, operational efficiency, local access needs, and regional mobility. This systematic approach ensures that planned enhancements or expansions conform to both current functional needs and anticipated future demand, promoting interoperability across local, regional, and national frameworks.

1.8.2 FRCs and the European INSPIRE Directive

The INSPIRE (Infrastructure for Spatial Information in the European Community) directive establishes a legal framework to create a harmonized, interoperable spatial data infrastructure across EU member states, facilitating environmental and territorial policy implementation.
Within INSPIRE, thematic data specifications for Transport Networks require the consistent encoding of road attributes, including functional road classification, to ensure that infrastructure is described uniformly across national boundaries. FRCs, as structured attributes, provide:

- Semantic interoperability: The FRC schema defined in INSPIRE aligns with widely used national and international classification systems, allowing traffic, planning, and environmental datasets from multiple countries to be integrated and compared seamlessly.
- Cross-border policy support: By enabling comparable and compatible network characterization, FRCs under INSPIRE support trans-European initiatives—such as the TEN-T (Trans-European Transport Network)—and facilitate the assessment of cross-border mobility, freight corridors, and cross-jurisdictional environmental impact analysis.
- Efficient data sharing and decision support: Governmental entities and the public can access harmonized spatial datasets for transportation planning, investment programming, and strategic environmental assessment. This fosters transparent, data-driven policy making that is responsive to European objectives (e.g., decarbonization, modal integration, spatial equity).

In summary, FRCs provide the technical backbone necessary for translating transportation policy into practical planning and regulatory action. Their role is codified and extended in Europe by the INSPIRE directive, which mandates standardized, interoperable classification of road networks as a prerequisite for coordinated, transnational policy and environmentally sustainable transport planning. This dual-level approach ensures that all stakeholders—from national governments to regional planners—operate with a shared understanding of network structure and function, enhancing policy efficacy and infrastructure resilience.

The INSPIRE Directive (Infrastructure for Spatial Information in the European Community) is a European Union legal framework, established by Directive 2007/2/EC of the European Parliament and of the Council of 14 March 2007. It aims to create a harmonized spatial data infrastructure across the European Union to support environmental policies and any activities likely to impact the environment. INSPIRE specifies common standards for documenting, sharing, and disseminating spatial datasets through technical implementing rules. Its scope covers 34 thematic areas, including transport networks, and requires public bodies in EU Member States to provide interoperable, accessible spatial data (1, 2, 3).

For official documentation, legal texts, and technical guidelines, you may refer to:

- The official INSPIRE legislation page of the European Commission, which provides background, legislative details, and an overview of implementing rules and themes.
- The full text of Directive 2007/2/EC, available via EUR-Lex, the European Union's legal database3.
- National portals (such as Ireland's and Belgium's) and the European Geoportal, offering insights on implementation and access to certified datasets.
- Technical guidelines, especially concerning the Transport Networks data theme, are available from the European Commission's INSPIRE knowledge base and working group documents.

These references ensure authoritative and up-to-date information on the INSPIRE Directive, its intended purpose, geographical scope, and implementation methodology within the EU.

1. https://knowledge-base.inspire.ec.europa.eu/legislation/inspire-directive_en
2. https://gov.ie/en/department-of-climate-energy-and-the-environment/publications/inspire-directive/
3. https://eur-lex.europa.eu/eli/dir/2007/2/oj/eng

2 OVERVIEW OF COMMONLY USED FRC

OpenStreetMap's functional classification is community-driven and flexible, while commercial platforms like TomTom and HERE employ rigid hierarchies for analytics. Google prioritizes visual detail over formal classification. These differences reflect varying priorities: OSM emphasizes openness, commercial providers focus on routing efficiency, and Google enhances user experience through map rendering.

Platform	Classification System	Key Characteristics	Granularity	Example Classes
Open Street Map	highway=* tags	Community-driven, function/ importance-based	7–9 tiers	motorway, trunk, primary, secondary, tertiary, residential, service
TomTom	Functional Road Class (FRC 0–7)	Hierarchical design for traffic analytics	9 tiers	FRC 0 (motorways), FRC 3 (arterials), FRC 8 (dead-end roads)
HERE	Functional Class 1–5	Simplified hierarchy for routing efficiency	5 tiers	Class 1 (highways), Class 5 (local roads)
Google Maps	Functional Roads Class, represented as road priorities	Hierarchical design for routing, navigation, and visual rendering	9 tiers	Controlled Access roads, primary highway, secondary road, Arterial, local, terminal

Table 2: Overview for FRCs used by different map providers

2.1 Key differences of digital maps

2.1.1 Purpose and Design

Community-driven digital maps: OpenStreetMap (OSM)

OpenStreetMap (OSM) is an open-source, community-driven global mapping project designed to provide free and editable geographic data. Its principal purpose is to democratize access to high-quality map data, allowing anyone to use, modify, and share both the maps and the underlying geospatial information. This initiative arose due to restrictions on proprietary mapping data and aims to provide an alternative that supports innovation, humanitarian efforts, and research.

OSM's design is fundamentally collaborative: volunteers around the world collect data through GPS traces, surveys, aerial imagery, and import from open data sources. Geographic entities—such as roads, buildings, and natural features—are encoded using a system of nodes, ways, and relations. Contributors annotate features with standardized tags, supporting both human and programmatic interpretation. The map is constantly evolving, with edits and updates occurring in near real-time through user-friendly web and desktop editing tools. All data is shared under the Open Database License, ensuring transparent and wide-ranging applicability across applications, including navigation, disaster response, academic research, and urban planning.

Commercial digital maps: TomTom, HERE and Google Maps

TomTom, HERE and Google Maps are commercial providers of digital map data and advanced location-based services, each leveraging distinct strategies and technologies to meet the complex demands of mobility, navigation, and automotive sectors.

- **TomTom** focuses on creating highly detailed, multi-layered maps tailored for various applications, from everyday navigation to advanced driver assistance systems (ADAS) and automated driving. The Orbis Maps platform exemplifies this approach, packaging data into specialized layers for search, routing, lane-level guidance, and analytics. TomTom integrates proprietary data collection, live sensor data from connected devices, and open collaboration efforts, enabling rapid, consistent updates and global scalability. The design emphasizes modularity, allowing industry partners to build custom solutions on top of granular, validated map layers—minimizing integration complexity and supporting emerging automotive and smart city needs.
- **HERE Technologies** develops a unified, highly accurate map and location platform widely adopted by automakers, governments, and logistics providers. Their design philosophy centres on building a digital twin of reality, incorporating multi-sensor data, AI, and crowdsourcing to deliver up-to-date, centimetre-level maps. HERE augments core maps with dynamic data layers—like road infrastructure, rules, and 3D landmarks—making its platform adaptable for navigation, autonomous vehicle localization, fleet management, and analytics. The architecture supports private data overlays, ensuring users can securely enrich the base map with proprietary content, and enables standardized integration with external systems.
- **Google Maps** is a comprehensive mapping platform and geospatial service that supports both high-volume consumer applications and specialized enterprise-grade services. Its principal purpose is to make geographic information universally accessible and useful, delivering detailed digital maps, satellite imagery, real-time traffic data, and location-based services serving both end-users and professional developers through web, mobile, and API interfaces. The platform's utility is built upon a high-performance infrastructure that processes data from a diverse array of inputs, including satellite imagery, Google Street View sensors, sourced datasets, and vehicle fleet data. Crowdsourcing continues to play a significant role, with user feedback and contributions improving place details, addressing errors, and enhancing local coverage.

  The system employs sophisticated algorithms for geocoding, route calculation, and dynamic rendering, enabling real-time updates and accurate route planning across multiple transportation modes (driving, walking, cycling, transit). Recent advancements in Gemini models have further enhanced the platform's ability to process complex geospatial data. In end user applications, this enables conversational discovery, personalized recommendations and immersive navigation, which uses AI to analyze billions of Street View and aerial images to provide a 3D spatial understanding of the route. This includes precise visualizations of lanes, crosswalks, and road constraints that assist in complex driving maneuvers.

  Its architecture, distributed servers, and tile-based rendering system ensure seamless scalability and responsiveness for billions of users and modern enterprise use cases. This approach balances the accessibility of a global consumer tool with the technical rigor of an industrial-grade mapping service. While the consumer interface prioritizes usability and local discovery, the underlying geospatial engine is optimized for the precision, modularity, and reliability standards expected by automotive and logistics partners.

In summary, while OSM is designed for maximum openness and democratization of mapping data, TomTom and HERE emphasize commercial precision, layered modular design, and real-time intelligence tailored to enterprise and automotive partners. Google Maps bridges consumer accessibility with industrial-scale geospatial infrastructure, providing a feature-rich experience built upon continuous global data integration, matching the commercial precision and real-time intelligence tailored to enterprise partners.

2.1.2 FRC granularity

OpenStreetMap (OSM), TomTom, HERE and Google Maps employ different functional road classification (FRC) levels because of their distinct data models, organizational goals, user communities, and technical requirements.

OpenStreetMap's FRC levels result from its open, volunteer-driven model. Contributors worldwide assign road classes using flexible tagging conventions that reflect local understanding and practices. This approach yields highly detailed and adaptive classifications in some areas, but it also leads to regional variation and occasional inconsistencies, as there is no enforced global standard or centralized oversight.

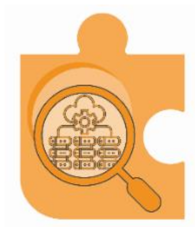
TomTom and HERE, as commercial entities, adhere to international standards (such as ISO 17572-3 or FHWA guidelines) for their classification schemas. Their business models require consistency, precision, and completeness to support professional applications, including automotive navigation, regulatory reporting, and advanced driver assistance. They maintain centralized control and systematic data collection—using proprietary sensors, official data, and algorithmic validation—which ensures their FRC levels are uniformly applied globally and quickly updated in response to road network changes.

Google Maps maintains a proprietary classification schema, developed from automated analysis of massive, diverse data sources (such as satellite imagery, Street View, and governmental records). Its FRC levels are optimized for consumer usability, context-sensitive routing, and rapid global updates, prioritizing real-time functionality and broad accessibility over strict adherence to public standards. The schema is centrally managed, facilitating consistency but making the underlying logic less transparent.

In summary, differences in FRC levels arise from each provider's distinctive approach to data governance, intended application domains, technical update methods, and the balance between local adaptation and global standardization. These variations ensure that each platform meets the needs of its primary user base—whether those are local mappers, automotive OEMs, traffic analysts, or everyday consumers—while reflecting the trade-offs between openness, consistency, and rapid innovation.

- TomTom uses 8 FRC levels, including distinctions like FRC 7 (alleys, park roads)
- OSM uses 7 main classes, with subcategories (e.g., *_link for ramps)
- HERE uses 5 FRC tiers, emphasizing major highways to local roads
- Google uses 9 FRC ties, bridging consumer accessibility and industrial precision

2.1.3 Data Sources



The data sources used by OpenStreetMap, commercial platforms like TomTom, HERE and Google Maps, differ in their methods, scope, and integration practices. Below is an overview for each:

Community-driven digital maps: OpenStreetMap (OSM)

OpenStreetMap relies on an open, community-driven approach to data collection, using a broad range of sources:

- ground surveys: Contributors collect geospatial data directly using GPS devices, smartphones, and traditional methods (field mapping, annotating paper maps)
- aerial and satellite imagery: Volunteers trace roads, buildings, and features from freely licensed or open-access imagery

- public domain and open government data: Data imports include out-of-copyright maps, public records, and open data from national or local authorities, provided the license matches OSM's requirements
- corporate fleet data and apps: Companies and organizations (such as logistics fleets or Amazon delivery vehicles) may contribute GPS traces, and users update POIs and road attributes using dedicated applications
- crowdsourcing events: Mapping parties, humanitarian projects, and local community initiatives further expand and refine the map

Commercial digital maps: TomTom, HERE and Google Maps

These companies employ systematic, technology-driven methods to collect and curate high-quality, up-to-date data. Examples for such data collection, integration and validation methods are:

- Satellite and aerial imagery: continuous updates from commercial satellites and aerial sensors provide foundation layers
- Sensor-derived observations: data from connected vehicles, automotive OEMs, sensors, and telematics devices
- Mobile mapping vehicles: vehicle (e.g. TomTom's MoMa cars or Google Maps Streetview cars) collect panoramic imagery, LiDAR, and high-precision GPS tracks
- Partnerships: incorporates open data (e.g., from OSM), third-party partners, or government sources
- Third-party and governmental data: integrating public authorities' data sources, including administrative datasets and public records
- User and community contributions: locally sourced updates and feedback mechanisms
- Automated and manual validation: AI-driven integration, proprietary quality assurance routines, and partnerships with both car manufacturers and tech companies
- Real-time GPS probe data: aggregating anonymized location information from hundreds of millions of vehicles (including fleets, delivery vans, and consumer cars), smartphones, and telematics.
- Traffic sensors and cameras: combining data from road sensors, public agencies, and local authorities
- Real-time user-contributed data: aggregating anonymous location information and traffic data from billions of smartphone users, providing live traffic updates and error correction
- APIs for external data: businesses and local governments can upload maps and new locations directly map makers via custom tools
- OSM is community-driven, drawing from direct surveys, open data, imagery, and local/corporate contributors.
- Commercial map makers, such as TomTom, HERE or Google Maps rely on a blend of satellite/aerial imagery, proprietary sensor networks, vehicle fleets, public and partner data, systematic validation. They also integrate open data and user feedback.

2.1.4 Application in Routing

Functional Road Classifications (FRCs) are fundamental to routing algorithms in all major digital map platforms, but their assignment, integration, and influence on routing behaviours differ substantially among OpenStreetMap (OSM), TomTom, HERE and Google Maps due to variations in schema transparency, data model granularity, and primary use cases.

OpenStreetMap (OSM)

OSM's routing systems (e.g., OSRM, GraphHopper, Valhalla) rely on community-assigned FRCs, encoded using tags such as highway=primary, secondary, tertiary, and so forth. The routing engine interprets these tags to prioritize higher-order roads (e.g., for long-distance or faster routes) and to discourage unnecessary use of local ways for through-traffic. Given OSM's open data structure, users and developers can explicitly tune how FRCs affect route priority, speed assumptions, and avoidance behaviours. However, regional inconsistencies or gaps in classification (due to community contributions) can lead to variability in route quality, especially in less-mapped areas. Advanced profiles can customize FRC weighting—for example, prioritizing cycleways for bicycle routing or footpaths for pedestrian navigation.

TomTom

TomTom applies a highly standardized, globally consistent FRC hierarchy, closely tied to international definitions. Their proprietary routing engines leverage this structure to optimize route selection based on trip purpose, vehicle type, and traffic regulations. FRCs allow the engine to efficiently exclude lower-class roads for long-distance or freight routing, ensuring robust avoidance of residential streets except for destination access. This approach supports advanced features—such as lane guidance and ADAS—by confidently applying regulatory and legal constraints linked to FRC categories.

HERE Technologies

HERE uses a very similar approach to TomTom, with FRCs integrated into the network as an essential attribute for route selection, traffic-based detouring, and restriction enforcement. HERE's routing algorithms treat FRCs as both a filtering and weighting mechanism; arterials are heavily favoured for interurban routing, while local streets are relegated to first/last mile legs. The precision and uniformity of HERE's FRC dataset enable fine-tuned route recommendations and underpin specialized profiles for logistics, emergency response, or congestion avoidance. HERE further incorporates dynamic data (real-time closures, events) on top of FRC-based hierarchy to enhance routing decisions.

Google Maps

Google Maps maintains a proprietary FRC schema integrated with a sophisticated, data-driven routing engine. Google's system automatically leverages FRCs to select faster, more suitable roads for through-routes while relegating local streets or minor roads for destination approach or context-specific situations. The relative importance of FRCs in routing is dynamically adjusted by Google's real-time traffic and machine learning models, which may override pure FRC hierarchy where historical or current data suggest better alternatives. The nature of Google's system means that users, while having visibility into the FRC-based aspects, do not have direct control over the impact of FRCs on functionality such as routing. The practical result is a consistent avoidance of inappropriate through-traffic on minor roads and highly adaptive route selection.

Comparative Summary

- OSM allows for customizable, transparent FRC routing, but may suffer from local variation in FRC assignment.
- TomTom and HERE offer rigorous, globally standardized FRC-based routing, supporting advanced automotive and regulatory requirements.
- Google Maps uses a proprietary hierarchy: FRCs underpin basic route structure but are dynamically weighted by real-time data and automated optimization, resulting in adaptive but non-transparent routing choices.

Thus, while all platforms use FRCs to ensure route efficiency, legality, and user appropriateness, their methodologies differ in consistency, configurability, and transparency, impacting integration and trust in predicted route behaviour.

2.2 Outlook

Detailed information for digital maps of commercial map makers and their FRC systems

The next version of this document will present a comparative overview of how digital mapping platforms from commercial map makers implement Functional Road Classification (FRC) systems. These systems are essential for organizing roads by their functional importance and role within transportation networks, directly impacting routing, map rendering, and the interpretation of traffic data. OpenStreetMap classifies roads using a seven-level "highway" tag system, which ranges from motorway—the top tier demanding specific construction standards—to residential roads, at the lowest end of the hierarchy. This system, drawn from British practice, requires local judgment to maintain network integrity and avoid isolated high-class roads surrounded by lower classes.

TomTom takes a different approach, employing a nine-level FRC scheme. Each FRC value—from 0 (Motorways) to 8 (Other Roads)—identifies road segments based on their service character and the role they play in efficiently channelling traffic through the network.

HERE Technologies organizes road segments into five functional classes, from major expressways and highways to local residential and rural roads. Here, FRCs are crucial for routing optimization and map display, with higher-class roads favoured for long-distance trips and lower-class roads restricted mostly to local access or route endpoints.

Google Maps applies tiers of classifications ranging from Controlled Access roads to Arterials, and local roads. These are determined by the road's connectivity, speed limits, the number of lanes, and volumes of traffic, along with land use and development patterns. Influenced by both federal and local standards, Google's road classification system shapes routing choices and how map layers visualize streets, promoting arterial roads for efficient travel and using local roads to connect local zones with main arteries. The classification in Google Maps is subject to updates whenever roads are re-designated according to evolving regional guidelines and authoritative sources.