D3.1 Pre-Deployment Setup Report for Maximum Speed Validation

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1 Introduction

This deliverable builds on two complementary activities aimed at understanding and strengthening validation practices within the Maximum Speed Limit data ecosystem. First, a survey was issued to assess the status of each Pre-Deployment Validation (PDV) location, providing an overview of existing capabilities, processes, and maturity levels. Second, a review of validation methodologies applied in recent projects was conducted to identify proven approaches and lessons learned.

Based on these inputs, the project analyses the data chain architecture implemented in each PDV to clarify stakeholder roles, responsibilities, and interactions. This role mapping enables the identification of a generic data chain model, which serves as a reference for understanding the current operational landscape and its potential vulnerabilities.

Using this foundation, the deliverable derives applicable validation methodologies suited to the present setups. This work forms Version 1 of the deliverable (draft planned by the end of March 2026), subject to positive alignment with the validation PDVs.

In Version 2, the analysis will be extended to identify gaps and propose countermeasures for each PDV to strengthen data quality and reliability, also taken into account the outcome of WP5 on the 'feedback loop'.

Finally, the deliverable will provide recommendations for EU-wide scaling, including best practices and a call to develop the missing infrastructure necessary to support a robust, trusted, and harmonised validation framework.

2 PDV Information

2.1 General Information

Table 1 presents an overview of the Pre-Deployment Validation (PDV) sites involved in Task 3.1, detailing their geographic location, contribution to preparing this deliverable, and the associated partners. This list of partners (per agreement) is not exhaustive and is expected to be complemented by organisations that support the respective PDVs in the time to come.

PDV Locations	Road Types	Survey	1-on-1 interview	SPOC	Email SPOC	Partners
City of Amsterdam (NL)	Urban node Amsterdam	Done	Done	Leon Zegers	l.zegers@amsterdam.nl	Amsterdam, NDW, HERE, ERTICO
City of Helmond (NL)	Urban node, regional	Done	Done	Martin de Vries	martin.devries@helmond.nl	Helmond, NDW
City of Gothenburg (SE)	Urban node Gothenburg	Done	Done	Anna Forsell	anna.forsell@trafikverket.se	STA, Gothenborg, HERE, ERTICO

Interurban roads Spain (ES)	Spanish interurban roads (except for Catalonia and the Basque Country)	Done	Done	Montserrat Estaca Gómez	mestaca@dgt.es	DGT, HERE, (CTAG?)
Nicosia District (CY)	National, Regional	Done	Done	Rodolfo Gomes da Silva	gomes-da-silva.rodolfo-leonel@ucy.ac.cy	Public Works Department, Service Provider ERTICO
Motorways & Secondary roads (625 km) and secondary road network - G1 G2 R1 (SI)	National, Regional	Done	Done	Jure Dolenc	jure.dolenc@appia.si	SI-MIS, HERE, ERTICO
Mediterranean region (FR)	National, Regional, Urban node	Done	Pending	Jean-Philippe Mechin	jean-philippe.mechin@cerema.fr	Metropole Nice Côte d'Azur , Council of Departement of Hérault, National Road directorate of Mediterranee, SP (?), ERTICO
Palaio Faliro - Athens (GR)	Urban Node Athens	-	Pending	Konstantinos Chardavellas	k.chardavellas@hotmail.com	Municipality of Palaio Faliro, NAP, SPs, prof. drivers, traffic org.

Table 1: General MSL PDV information for Task T3.1

2.2 Stakeholders per PDV

To understand the roles and responsibilities per PDV, we have used the RASCI method to establish clarity and efficiency in project execution. This exercise eliminates ambiguity by ensuring every task has a clear individual Responsible for execution and a single Accountable party ultimately answerable for the outcome, while Support roles provide assistance, consulted parties offered input before key decisions, and Informed stakeholders receive regular updates. This structured approach prevents gaps and overlaps in work, streamlines decision-making, and enhances communication, ensuring all team members and stakeholders understand their expected contributions. See Table 2.

	Responsible	Accountable	Supportive	Consulted	Informed
City of Amsterdam					
City of Helmond					
City of Goteborg					
Interurban roads Spain (Spain)					
Nicosia District Cyprus					
Motorways & Secondary roads Slovenia					
Mediterranean region – France					
Palaio Faliro - Athens - Greece					

Table 2: Identified RASCI roles and responsibilities

2.3 Report methodology

The preparation of deliverable D3.1 followed a structured methodology built around a series of coordinated activities that also lay the groundwork for the follow-up deliverable D3.4 (due at M21). The process began with the kick-off of Working Group 3 in November 2026, followed by a dedicated Task 3.1 kick-off in January 2026. To gather foundational input, a survey was launched in the same month, complemented by a joint T3.1 team meeting and a Public Private Tactical Group (PPTG) meeting held in Utrecht. Subsequent activities included one-on-one meetings between task leaders and PDV site representatives in March 2026, as well as three joint team task meetings conducted online during the same period. This phased approach ensured continuous alignment across partners and PDV sites, enabling the systematic collection of input that informed both the analysis presented in D3.1 and the preparatory groundwork for D3.4.

2.4 The de-facto situation - Surveys

A survey was launched to better understand the actual situation in every of the PDV. The survey is published below as ANNEX 1. The individual responses are available on the TISGRADE Sharepoint site. The survey is divided into two parts:

- Part 1: General questions about your PDV site, current status, high-level data processes, initial quality and validation approaches, technical environment, and expectations for tasks 3.1
- Part 2: Detailed questions focusing on your MSL data definitions, attributes, data delivery, metadata, current validation workflows, feedback procedures, and identification of any missing tools or elements.

Through this survey, the task aims to identify common content, procedures, and tools, and to pinpoint gaps to better understand the PDVs needs. These insights are essential for properly preparing the Pre-Deployment Validation phase and for optimizing and harmonizing the RTTI data validation process.

2.5 Comparison of all PDVs

Based on the survey responses, a high-level overview was compiled for all PDVs except for Greece, as presented in Table 3. This overview addresses the following aspects: coverage of Maximum Speed Limits (MSL), completeness, primary source of MSL data, initial validation approaches, MSL update frequency, feedback from Service Providers (SP), key gaps observed, MSL data model in place, standards adopted, assessment of technical maturity in handling MSL data, awareness of EU directives and legal obligations, and key improvement needs.

The analysis revealed a number of gaps, which are described in detail and summarised in Table 4. These relate to a lack of automated validation, fragmented governance, missing feedback loops, inconsistencies in data, incomplete coverage, shortcomings in metadata and quality metrics, and technical heterogeneity across PDVs.

Aspect	Cyprus	France	Amsterdam	Helmond	Sweden Gothenburg	Slovenia	Spain
MSL coverage	Partial (PWD roads)	Partial; national roads available	Yes, but incomplete	Not structurally managed	Full national coverage	Highways & state roads	State interurban roads
Data completeness issues	Needs updates	Missing beyond national roads	Data quality & gaps	Database outdated	Missing temporary & dynamic limits	No linear data for some roads	
Primary data source	Crowd-sourced (Mapillary)	Traffic regulation orders & authorities	To be defined	Past inventories, ad hoc input	Traffic orders (STFS)	Official signalisation database	Contractors → INCA → Ministry
Validation approach	Manual checks	Patrol checks & legal validation	Pilot phase	Mostly none	Automated + manual	No formal validation	Automated + expert review
Quality metrics used	None	Not standardized	To be defined	None	ISO 19157, internal metrics	None	
Update frequency	On request	Varies by authority	To be defined	Ad hoc	Daily	Major changes only	Weekly
Feedback mechanisms	None	Limited, sometimes overwhelming	Planned	None	User feedback & provider dialogue	None	TomTom-HERE, Geojunxion
Key gaps	No validation tools	Fragmented processes	No city-wide validation	Missing processes & roles	Lack of sign location data	No feedback loop	Missing tools, fragmented data, no FCD validation, missing polylines
Data model	Point (coordinates)	Legal & linear referencing	To be defined	Both point & linear	Linear (traffic order-based)	Both	Point signs → linear segments
Standards & formats	DatexII → TN-ITS planned	CSV, INSPIRE, DatexII	Unknown	NAP-managed	INSPIRE, TN-ITS, APIs	TN-ITS	NAP (file download) Inspire and TN-ITS
Technical maturity	Low	Medium (varies)	Low–medium	Low	High	Medium	Medium

Table 3: Overview of PDV characteristics derived from the surveys

Gap Category	Observed Across Sites	Most Affected Sites
Lack of automated validation	Manual or absent validation workflows	Cyprus, Helmond, Slovenia, Amsterdam, Spain
Fragmented governance	Unclear roles between authorities and NAPs	France, Amsterdam, Helmond, Spain
Missing feedback loops	No structured SP/end-user feedback	Cyprus, Helmond, Slovenia, Spain
Data inconsistencies	Differences between legal orders, databases, and signs	Sweden, France, Helmond, Spain
Incomplete coverage	Missing local roads, temporary limits, or dynamic speeds	France, Slovenia, Sweden, Spain
Metadata & quality metrics gaps	Limited quality indicators	Cyprus, Slovenia, Helmond, Spain
Technical heterogeneity	Mixed standards and maturity levels	All sites except Sweden

Table 4: Identified gaps and affected PDVs

2.6 PDV operational landscape

Below, Figure 1: Structured approach to capture the PDV operational landscape presents a structured framework that was used to capture the operational landscape of each PDV site. This "footprint" approach provides a systematic way to characterise and compare PDVs across multiple dimensions relevant to their handling of MSL (Maximum Speed Limit) data. The framework is organised into the following key dimensions:

- Organisations involved — Identifies the types of stakeholders engaged in each PDV, ranging from national road authorities, ministries, and regional authorities to municipalities, legal agencies, police, and third parties. This dimension highlights the institutional ecosystem in which each PDV operates.
- Data sources — Captures the origin of MSL-related data, including existing MSL databases, field surveys, third-party data, active and passive community feedback (e.g., floating car data), service provider feedback, and traffic regulation orders. This illustrates the diversity of input feeding into the PDV.
- Core MSL database — Indicates the underlying data infrastructure, such as GIS-based MSL repositories, traffic sign databases, or INSPIRE-compliant systems. This reflects the foundational data assets used.
- Validation triggers — Describes the events or conditions that initiate validation activities, such as ad-hoc validation, scheduled resurveys, receipt of new legal orders, or community feedback.
- Validation metrics — Specifies the standards or approaches used to assess data quality, including TISA 5-star rating, ISO 19157-1:2023, bespoke metrics, algorithmic tools (e.g., GIS/FME), and TN-ITS message compliance.
- Validation steps / methods — Outlines the procedures applied during validation, such as ad-hoc checks, scheduled resurveys, logic-based tools at data entry, manual sampling, algorithms, and compliance testing.
- Validation publication — Describes how validated data is made available, whether through source validation, data entry logic tools, manual sampling, algorithmic processing, or TN-ITS API and file downloads.
- Access point — Identifies the channels through which validated data is accessed, such as TN-ITS API or web page, and other options including INSPIRE endpoints.

- PDVs populated this framework by colour-coding: Green for elements currently applicable to their operations. Orange for elements planned to be explored or implemented during the project.

This visual representation enables a comparative overview of each PDV's current state, maturity level, and intended evolution across technical, organisational, and procedural dimensions. It serves as both a diagnostic tool and a roadmap for alignment and capability development within the project.

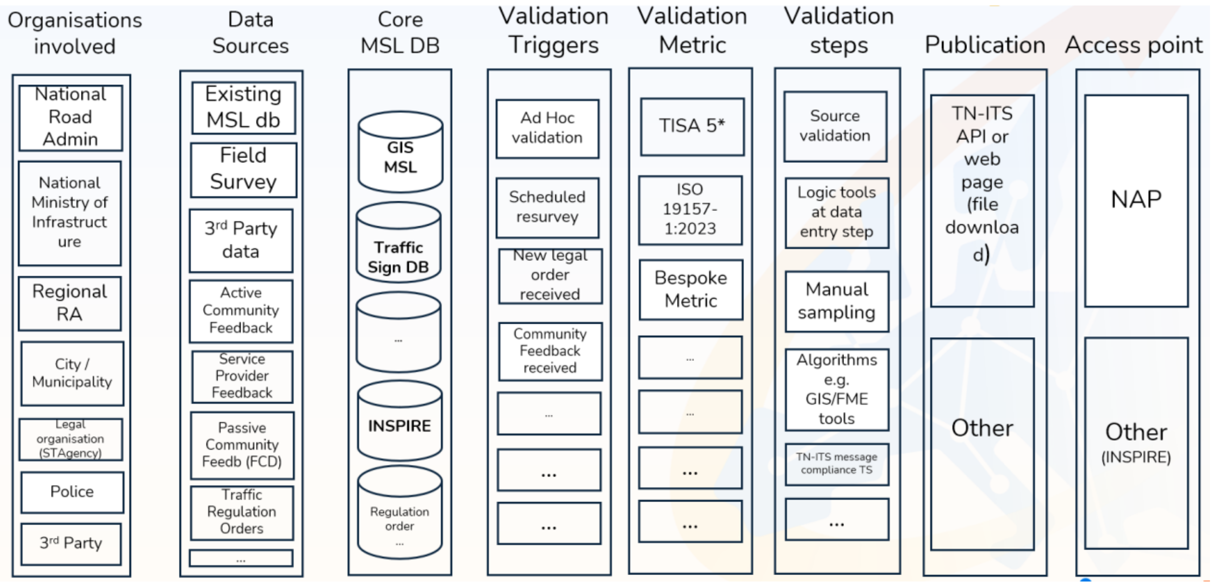

Figure 1: Structured approach to capture the PDV operational landscape

3 Precedent Practices

This chapter elaborates on a selection of five relevant projects and reports that inform the definition of validation methodologies for static road data, including MSL (Maximum Speed Limit) data. A more detailed overview can be found in Annex 1 of this document. The key sources available and examined are as follows:

3.1 EU-EIP Sub Activity 4.7: Provision of updates of ITS spatial road data

Public road authorities, including national administrations, regional and local bodies, and coordinating entities, serve as the legal data owners and manage authentic databases such as Digiroad and Wegendatabank. The production of TN-ITS data follows a five-step technical process—change detection, filtering and mapping, location referencing (primarily using OpenLR), standardized formatting into XML/GML, and publication via a REST API or National Access Point. Data quality is managed through the data provider's responsibility, validation via feedback loops from map providers like TomTom and HERE, and prerequisites such as adequate ICT systems and maintenance procedures. However, risks to quality include potential inconsistencies in interpreting traffic sign data across authorities and variable completeness of digital attributes, which may affect compliance with TN-ITS specifications.

- Source: EU-EIP SA4.7 (2018): EU-EIP-SA47-Deliverable 2-SA 4.7-Final.pdf

3.2 TN-ITS GO project

The TN-ITS GO service pilots are built on a four-layer high-level architecture that enables the exchange of road network updates from public authorities to map providers. Data owners include national road administrations (e.g., Rijkswaterstaat), ministries of transport, and regional authorities, who manage primary road databases, traffic sign registries, and dedicated TN-ITS intermediate databases. The core production process involves change detection, data mapping to harmonized specifications (CEN/TS 17268), location referencing (e.g., OpenLR or GML), and publication of XML update sets via a National Access Point or web portal. A feedback loop is also integrated into the architecture, allowing map providers like TomTom and HERE to report errors or inconsistencies, which authorities then use to improve their source data quality.

- Source: TN-ITS GO (2021): D2.3 Data store maintenance and TN-ITS roll out (available at: https://tn-its.eu/wp-content/uploads/2024/01/D-2.3-Data-store-maintanance-and-TN-ITS-service-roll-out.pdf)

3.3 ISA FIT - Helmond, Netherlands

The TN-ITS service pilots, as described in the ISA-FIT document, employ a continuous data chain architecture that bridges authoritative road data changes with end-user applications like Intelligent Speed Assistance (ISA). Data ownership lies primarily with national and regional road authorities (e.g., Rijkswaterstaat), National Access Point operators such as the National Data Warehouse, and local cities like Helmond, supported by databases including national road networks (NWB), road properties registries (WKD), and NAP portals. The production process involves change detection, internal GIS updates, data mapping to the TN-ITS format, conversion to CEN/TS 17268 standard (XML/GML), and publication via a National Access Point for map providers like TomTom and HERE to ingest and normalize. Validation of data quality rests on authoritative trust in official government databases, technical heuristics to fill missing segments, source verification by production teams, vehicle-based feedback loops to detect map-sign mismatches, and provider normalization before end-user delivery. Collectively, these layers ensure that speed limit and traffic regulation data are authoritative, reliably processed, and continuously improved through real-world observations.

- Source: ISA-FIT (2022): DEL-22043-D02-Results on functional evaluation and user aspects-ISA-FIT-pages-1,33-39.pdf

3.4 NAPCORE Milestone M4.2.7

Public road authorities, including national administrations, regional and local bodies, and NAP operators acting as trusted intermediaries, remain the primary data owners with clear data sovereignty and provenance requirements. These authorities maintain authoritative, government-maintained systems such as national road network databases, traffic regulation registries, asset management systems, and intermediate TN-ITS staging databases that serve as the single source of truth. The harmonised production chain for qualitative TN-ITS data involves change detection, data extraction and mapping to standard code lists, location referencing (e.g., OpenLR), transformation to XML/GML per CEN/TS 17268, publication via NAPs or APIs, and feedback ingestion from users. The structured quality management framework includes defined quality dimensions (accuracy, completeness, consistency, timeliness, integrity), provenance metadata, feedback loops, cross-border semantic checks, and risk-based validation for safety-critical use cases like ISA. Trust is conceptualised as a multi-layer construct grounded in authoritative provenance, transparent and auditable processes, measurable quality indicators, secure NAP-based distribution, and cooperative feedback loops that collectively ensure fitness for purpose in digital mobility services.

- Source: NAPCORE (2024): M4.2.7 Guide for ensuring the deployment of Trust, Quality, Integrity, Security, and Sovereignty of TN-ITS data — Concepts of data chain evaluation tools (update) (available at: https://www.napcore.eu/documents/M4.2.7_Final_version.pdf) and M3.8 Quality frameworks (available at: https://napcore.eu/quality/)

3.5 NAPCORE WG3.1 Quality Frameworks

The quality framework assigns data quality responsibility to clearly identified and accountable data owners, including national road administrations, regional and local authorities, and public agencies managing specific datasets such as traffic signs and restrictions. These owners rely on authoritative source systems as a single source of truth, encompassing road network and topology databases, traffic regulation registries, asset management systems, event databases, and intermediate staging databases for harmonization and version control. The production chain embeds quality checkpoints throughout—from data collection and change detection through harmonisation, validation and enrichment, publication via a National Access Point, and finally monitoring with feedback integration. Structured validation methods employ quality dimensions such as accuracy, completeness, consistency, timeliness, integrity, and availability for services. Validation techniques include automated validation rules, cross-dataset consistency checks, metadata-based reporting, audits, quality monitoring dashboards, feedback loops from service providers and users, and fitness-for-purpose assessment. Quality validation is measurable, continuous, and use-case driven, with quality evaluated against specific service needs such as navigation versus automated driving.

4 Key observations

4.1 Overview

4.1.1 Harmonisation needs

Table 5 outlines the key harmonisation needs across eight test sites, specifying the required actions and their expected impacts for each area. For instance, defining roles between road authorities, NAPs, and SPs within the governance model is expected to yield clear accountability and faster updates, while introducing automated checks in the validation framework aims to improve data reliability. Additional actions—such as establishing feedback loops, integrating sign data, aligning standards, defining metadata and KPIs, and investing in capacity building—are each tied to specific outcomes like continuous data improvement, reduced discrepancies, cross-border interoperability, comparable performance monitoring, and faster maturity across sites.

Harmonisation Area	Required Actions	Expected Impact
Governance model	Define roles between road authorities, NAPs, and SPs	Clear accountability & faster updates
Validation framework	Introduce automated checks and shared quality metrics	Improved data reliability
Feedback mechanisms	Establish SP → NAP → authority feedback loops	Continuous data improvement
Sign data integration	Link traffic orders, digital data, and physical signs	Reduced discrepancies
Standards alignment	Promote TN-ITS, machine-readable regulations	Cross-border interoperability
Metadata & KPIs	Define common quality indicators and dashboards	Comparable performance monitoring
Capacity building	Training & best practice exchange	Faster maturity across sites

Table 5: Harmonisation area, actions and impact

4.1.2 Qualification

The qualification tables assess the readiness of each PDV against four critical building blocks of a trustworthy MSL data ecosystem:

- **Authoritative ownership and responsibility** – ensures that data originates from legally mandated authorities with clear accountability and provenance.

- **Controlled government-maintained database** – evaluates whether a stable, authoritative system exists as a single source of truth.
- **Harmonised TN-ITS production** – assesses the existence of a standardised, end-to-end data transformation and publication pipeline aligned with TN-ITS specifications.
- **Quality management embedded in the lifecycle** – verifies whether validation, monitoring, feedback loops, and quality metrics are systematically integrated.

These dimensions reflect the core principles identified in precedent practices (e.g. TN-ITS GO, NAPCORE) and the gaps observed across PDVs. The qualification status (Fully: green / Partially: yellow / Does not yet qualify: orange) indicates the maturity level of each PDV in delivering reliable, scalable, and interoperable MSL data for safety-critical use cases such as ISA.

PDV Site	Qualification Status	Remark	Status
Sweden (Gothenburg)	Fully qualifies	Clear legal chain: traffic orders → STA → NVDB → NAP. Authorities remain owners; NAP distributes. Strong provenance and legal basis.	
France (Mediterranean)	Qualifies (with fragmentation)	Traffic regulation orders are legally binding and issued by competent authorities. Ownership is clear but fragmented across levels.	
Slovenia	Qualifies	Official signalisation database and national operators maintain authoritative data; TN-ITS published via NAP without transfer of ownership.	
Cyprus	Partially qualifies	PWD is authoritative owner, but reliance on crowd-sourced data and lack of validation weakens provenance and trust chain.	
Helmond	Partially qualifies	Municipality is authoritative owner, but ad-hoc processes and unclear validation responsibilities weaken accountability and provenance.	
Spain	Partially qualifies	National authority (DGT) and contractors manage data, but the chain from legal traffic orders to digital datasets is not fully transparent or consistently governed. Fragmentation between actors and reliance on intermediate processing (e.g. INCA) weakens clarity of responsibility and provenance.	
Amsterdam	Does not yet qualify	Governance and workflows are still being defined; authoritative ownership and data provenance chain not operational.	

Table 6: Authoritative ownership and responsibility per PDV site

PDV Site	Qualification Status	Evidence & Rationale	Status
Sweden (Gothenburg)	Fully qualifies	NVDB (national road DB), STFS (traffic regulation registry), TNE editor workflows, daily updates, versioning. NAP distributes data without replacing source systems.	
France (Mediterranean)	Partially qualifies	National datasets and INSPIRE road data exist, but fragmentation across authorities and lack of unified registries limit a single source of truth.	
Slovenia	Partially qualifies	Official signalisation DB and National Traffic GIS exist; however, lack of validation workflows and incomplete linear data weaken synchronisation.	
Helmond	Partially qualifies	National database (NWB via NDW) exists, but municipal processes are ad hoc and updates are delayed, weakening reliability as a single source of truth.	
Spain	Partially qualifies	Government-backed systems and NAP infrastructure exist, but the database is not fully harmonised or complete. Data originates from contractors and is transformed before reaching authorities, leading to inconsistencies, missing attributes (e.g. polylines), and lack of a clearly defined single source of truth.	
Cyprus	Does not yet qualify	No comprehensive government-maintained database; reliance on crowd-sourced imagery and manual checks undermines authoritative control.	
Amsterdam	Does not yet qualify	Government database integration and workflows are still under development; no established authoritative ecosystem yet.	

Table 7: Controlled government-maintained database per PDV site TN-ITS production

PDV Site	Qualification Status	Evidence & Rationale	Status
Sweden (Gothenburg)	Fully qualifies	End-to-end chain: STFS orders → NVDB → TN-ITS with OpenLR → NAP/API → SP consumption. Automated validations and daily updates support harmonisation.	
Slovenia	Partially qualifies	TN-ITS publication exists and OpenLR used; however, validation, feedback loops, and full pipeline automation are missing.	
France (Mediterranean)	Partially qualifies	Legal and data foundations exist; movement toward Datex II/TN-ITS, but fragmented processes and incomplete transformation workflows limit harmonisation.	
Spain	Partially qualifies	TN-ITS and INSPIRE formats are supported via the NAP, but the production chain is not fully standardised or automated. Gaps remain in validation workflows, linear referencing, and integration of feedback loops (e.g. FCD), limiting full harmonisation.	
Cyprus	Does not yet qualify	TN-ITS planned but not operational; reliance on crowd-sourced data and manual validation prevents a harmonised pipeline.	
Helmond	Does not yet qualify	No structured TN-ITS production workflow; processes ad hoc and transformation chain not defined.	
Amsterdam	Does not yet qualify	TN-ITS pipeline still under design; data model, mapping, and workflows not yet established.	

Table 8: Harmonised TN-ITS production per PDV site

PDV Site	Qualification Status	Evidence & Rationale	Status
Sweden (Gothenburg)	Fully qualifies	Automated validations (FME scripts), manual external quality control, versioned NVDB updates, metadata publication, dashboards and reports. Quality embedded across lifecycle.	
France (Mediterranean)	Partially qualifies	Patrol checks and legal validation exist, but lack of harmonised metrics, automation, and dashboards limits lifecycle integration.	
Slovenia	Does not yet qualify	No formal validation workflow, limited quality controls, and absence of monitoring or quality metadata.	
Cyprus	Does not yet qualify	Manual checks only, no metrics, automation, or feedback mechanisms; quality not embedded in lifecycle.	
Helmond	Does not yet qualify	Ad hoc visual checks, no structured validation, versioning, or quality monitoring.	
Amsterdam	Does not yet qualify	Quality processes still under development; validation, metrics, and governance not yet defined.	
Spain	Does not yet qualify	Some automated and expert-based validation exists, but quality management is not systematically embedded. Missing feedback loops, lack of consistent quality metrics, incomplete metadata, and absence of continuous monitoring prevent full lifecycle integration.	

Table 9: Quality Management Embedded Throughout the Lifecycle

5 Validation Framework for Maximum Speed Limit (MSL)

Framework Overview

This Validation Framework defines how static Maximum Speed Limit (MSL) data will be validated across the TISGRADE ecosystem. It reconciles three potentially conflicting sources—legal traffic orders, digital databases, and physical signage—through a continuous, end-to-end validation process. As such, the framework recognizes that a flawless "Single Source of Truth" does not exist.

The framework is modular to accommodate varying maturity levels across PDVs and emphasizes authoritative provenance, harmonized validation rules, and feedback-driven improvements. The goal is a scalable, auditable, and trust-enhancing validation cycle that supports safe and compliant digital mobility services across Europe.

5.1 Scope and boundaries

- In-scope: digital speed limit data (MSL) used by map providers, vehicle systems, and mobility services within ITS and related EU regulations. Road authorities and researchers may use the data for asset management, planning, simulations, etc.; data elements include speed values, sign locations, regulatory references, provenance, timestamps, and responsible authorities.

- Out-of-scope: non-MSL road attributes (e.g., traffic restrictions, road markings) unless used to support MSL validation; data already harmonized under non-EU standards without cross-border alignment.
- Core principle: end-to-end traceability, auditable lineage, and change management across the data lifecycle.

5.2 Roles & Responsibilities

Here, we establish a governance framework for MSL data validation, building on a RASCI model that clarifies responsibilities and decision rights. It introduces an Escalation & Audit Body and enumerates governance artifacts (e.g., matrices, change control, audit trails) to enable cross-PDV alignment and traceability.

The roles are defined according the RTTI delegated regulation EU 2022-670.

Role	Responsibility in Validation
Data provider	Provides the original source of data
Road Authority (Regulator) (data user)	Accountable for source data accuracy; performs internal validation, Accountable for the publication of the data, accountable to ensure the relationship with the data provider, accountable to publish the authentic link to the data on the NAP.
NAP Operator	Some of the NAPS can hosts validated datasets; It hosts the references to the data and the related meta data descriptions, improves the trust by the applied compliance rules and certification of the data user and data provider.
Service Provider (Map Provider)	Provides feedback on data inconsistencies; performs normalization, and may run consumer-facing validation checks
Vehicle / End-User	Generates observations (camera-map deviations, ISA interactions, user reports) that trigger validation actions
Coordinating Body (PDV manager in the context of this project)	Defines, executes and reports harmonized validation of data, their validation methods results and applies quality metrics, in a cross-PDV alignment
National /competence body	Root of trust for the compliance rules, monitors the NAP info and audits the published data sets. It has the right to revoke the data sets.

Table 10: Roles and responsibilities

5.3 Validation Building Blocks

The table below presents a five-block validation framework for Maximum Speed Limit (MSL) data, where each block addresses a distinct layer of quality assurance. B1 and B2 establish the foundation by ensuring source data is authoritative and consistent with legal orders and physical signage, while B3 introduces external feedback loops from map providers, vehicles, and road users to continuously identify discrepancies. Finally, B4 and B5 automate technical validation—including change detection, logical consistency, format compliance, and publication checks—to ensure that only standardized, reliable MSL data is distributed via National Access Points or APIs.

No.	Block	Responsibilities & Methods
B1	Source Authority Validation	**Responsibility:** • data user (road authority) with its data provider **Trigger:** Repetitive **Approach:** • Automated schema and range checks at data entry • Cross-dataset consistency checks (e.g., legal order vs. database) • Provenance metadata to verify authority and update history
B2	Cross-Referencing Validation	**Responsibility:** • Joint co-operation: data user (road authority) with its data provider with service providers (Feedback loop) Trigger: • New legal decision, scheduled resurvey, or reported discrepancy Methods: • Compare digital database against physical signage (field patrols, surveys) • Compare legal traffic orders against database entries • Use reference network models (e.g., OpenLR, linear referencing)
B3	Feedback-Driven Validation	**Responsibility:** • Joint co-operation: data user(road authority) with its data provider with service proviers (Feedback loop) **Trigger:** repetitive, feedback itself **Sources:** • Combined from Map service providers (reporting integration errors, statistical analysis • Vehicle-based observations (camera-map deviations, ISA system overrides) • Road users and field staff (crowdsourced reports) • Police reports

		• ... **Approach:** • Observations serve as "leads" → authority verifies → corrects source if needed
B4	Automated Validation	**Responsibility:** • Joint co-operation: data user (road authority) with its data provider with service providers (Feedback loop) **Trigger:** feedback itself **Approach:** • Change detection algorithms (identify deltas in source databases) • Logic-based validation (e.g., speed limit cannot increase from 50 to 120 km/h without a motorway segment) • Format validation (XML/GML schema compliance with CEN/TS 17268) • Location referencing validation (OpenLR decoding test)
B5	Publication Validation	**Responsibility:** Data user (Authority) **Triggers:** A change in the MSL attribute, a release of a data set. **Approach** Checks at NAP/API level: • Metadata completeness (provenance, timestamp, responsible authority) • TN-ITS message compliance (per DATEX II Part 14 standard under governance the TN-ITS alliance. • Location reference verification

Table 11: Five validation building blocks

5.4 Maturity Levels for MSL Validation

Based on the 1-on-1 discussions, the framework defines progressive maturity levels:

Level	Description
1 - Manual	Ad-hoc checks, no formal validation, missing feedback loops
2 - Reactive	Validation triggered by complaints or obvious errors
3 - Systematic	Automated checks at data entry; scheduled validation activities
4 - Continuous	Real-time change detection; feedback loops integrated; cross-referencing automated
5 - Predictive	AI/ML used to flag potential inconsistencies before publication

Table 12: Maturity levels in MSL validation

PDV Maturity Targets: For safety-critical applications (e.g., ISA), minimum Level 3-see further) is required with explicit runbooks and KPI-driven remediation (

5.5 Validation Triggers

Validation triggers indicate when validation work should start, tying regulatory updates, data changes, and external observations to the execution of the PDV pipeline. They ensure that new or altered speed-limit data, updated traffic orders, or detected inconsistencies are promptly validated and reconciled. To support structured planning and execution, the framework distinguishes four trigger types: Scheduled, Event-driven, Feedback-driven, and Ad-hoc. The following table provides representative examples for each trigger type, see table below.

Trigger Type	Examples
Scheduled	Daily, weekly, or monthly automated checks; periodic resurveys
Event-driven	New traffic regulation order, road design completion, new aerial imagery
Feedback-driven	Service provider error report, vehicle observation, user complaint
Ad-hoc	Patrol observation, police report, known high-risk location

Table 13: Triggers to initiate the validation

5.6 Validation Workflow

Step 1: Change Detection **(e.g. a new regulation or, a result of an accepted feedback)**
↓
Step 2: Internal Validation (authority) — schema, logic, range checks
↓
Step 3: Cross-Referencing — legal order vs. database vs. physical sign
↓
Step 4: Harmonisation & Mapping to TN-ITS specifications
↓
Step 5: Location Referencing validation (OpenLR / linear referencing)
↓
Step 6: Format Conversion validation (XML/GML, CEN/TS 17268)
↓
Step 7: Publication via NAP/API with quality metadata
↓
Step 8: Feedback Ingestion — monitor SP reports & vehicle observations
↓
Step 9: Source Correction — authority updates master database
↓
(Return to Step 1)

5.7 Quality dimensions and levels, TISA 5-Star, KPIs, Acceptance Criteria

5.7.1 Applied quality dimensions and levels

Based on NAPCORE M4.2.7 and WG3.1, the proposed framework adopts six measurable quality dimensions:

Dimension	Definition for MSL Data
Accuracy	Speed limit value matches physical sign and legal order
Completeness	All road segments have an assigned speed limit
Consistency	No contradictions between databases, signs, and legal orders
Timeliness	Updates reflect real-world changes within defined latency
Integrity	Data has not been corrupted or altered without authorization
Availability	MSL data is accessible via NAPs or APIs when needed

Table 14: Quality dimensions for MSL validation

The proposed validation framework supports progressive alignment with the TISA RTTI 5-Star Rating Standard by systematically improving key data quality dimensions, including accuracy, completeness, timeliness, consistency, and compliance with established formats. Lower maturity levels (1-2 stars) reflect limited data quality and partial usability, while 3 stars represent the minimum acceptable level for service provider integration. Higher levels (4-5 stars) correspond to increasingly reliable, complete, and timely data with greater granularity and consistency. The framework's validation blocks–covering source verification, cross-checking, feedback integration, and automated controls–enable continuous quality improvement, supporting data providers in achieving higher rating levels and ensuring fitness for safety-critical use cases such as Intelligent Speed Assistance.

5.7.2 Key Performance Indicators (KPIs) for Validation

In the table below, a number of KPIs are suggested for the validation of MSL in the PDVs.

KPI	Measurement
Detection rate	% of actual MSL changes captured within update cycle
False positive rate	% of reported changes that are invalid
Time-to-validate	Average time from change detection to publication
Feedback resolution time	Average time from SP report to source correction
Completeness score	% of road network with validated MSL data
Consistency score	% agreement between database, legal order, and physical sign

Table 15: KPI and measurement descriptions

5.7.3 Acceptance criteria

Acceptance criteria define the measurable targets for PDV pipelines and set expectations for performance within each reporting period. They require that KPIs are met, validation maintains a complete provenance chain with documented change history and rationale, and every (TN-ITS/MSL) publication includes quality and provenance metadata:

- PDV validation activities meet target KPIs per reporting period
- Validation is auditable with complete provenance chain (change history + rationale)
- All published TN-ITS updates include quality/provenance metadata

5.7.4 Sampling & cadence

Sampling and cadence specify how validation samples are selected and how often validation activities occur to support statistically meaningful ground-truth comparisons. They also require automated dashboards for continuous monitoring and periodic reassessment.

- PDVs define sampling sizes and confidence levels for “the PDV identified ground-truth” comparisons
- PDVs establish (automated) dashboards for continuous monitoring and periodic evaluations

5.8 Implementation Recommendations for PDVs

From the document's gap analysis (Table 4), the framework recommends:

Gap	Recommended Validation Action
Lack of automated validation	Implement schema checks + logic-based validation at data entry
Fragmented governance	Assign clear RASCI roles for each validation step
Missing feedback loops	Establish SP → NAP → Authority feedback mechanism (WG5)
Data inconsistencies	Run cross-dataset consistency checks (legal vs. database vs. signs)
Incomplete coverage	Use technical heuristics to flag missing segments as 'unknown'
No quality metrics	Adopt the 6 quality dimensions with automated reporting
TN-ITS (DATEX II part 14) readiness	For the sites that already have the service: Provide the overview how TN-ITS services are improved For the sites that do not have the service: please assess what it should cost to deploy the TN-ITS service.

5.9 Summary

This chapter presents a structured, modular data quality and validation framework for Maximum Speed Limit (MSL) data, aligned with European RTTI requirements. It combines authoritative source validation, cross-referencing of legal, digital, and physical data, and continuous feedback integration from service providers and end users. Supported by automated and manual validation mechanisms, the framework ensures traceability, consistency, and continuous improvement across the data lifecycle. By embedding measurable quality dimensions and supporting progressive maturity towards the TISA 5-Star Rating Standard, it provides a scalable and auditable approach to enhance data reliability, foster trust among stakeholders, and support safety-critical applications such as Intelligent Speed Assistance

PDV VALIDATION FRAMEWORK

APPLIED QUALITY DIMENSIONS: Accuracy | Completeness | Consistency |

Timeliness | Integrity | Availability

APPLIED VALIDATION BUILDING BLOCKS

B1: Source

B2: Cross

B3: Feedback

B4: Automated Driven

B5: Publication

APPLIED TRIGGERS: Scheduled | Event-driven | Feedback-driven | Ad-hoc

APPLIED KPI's and their value.

Observed MATURITY at the beginning of the project

Manual → Reactive → Systematic → Continuous → Pred.

Observed MATURITY at the Phase 1 of the validation

Manual → Reactive → Systematic → Continuous → Pred.

Observed MATURITY at the Phase 2 of the validation

Manual → Reactive → Systematic → Continuous → Pred.

Figure 2: Summary of the MSL validation framework

6 Validation and improvement implementation (Phase1)

6.1 Validation PDV Sweden

In Gothenburg, speed limit validation already benefits from a mature national ecosystem, yet practical improvements can be implemented immediately to address known gaps, particularly discrepancies between traffic orders, digital records, and physical signage. These actions build on existing processes without requiring major system changes.

The first step is to compare speed limit data in NVDB (official authority data) with data from service provider (HERE speed limit data). Selected areas could be specified.

Secondly, the output (i.e. the differences between the two datasets) will be analysed and categorized to help structure and better understand the source of error. Based on previous experiences and quality testing, some assumptions about the types of errors that might occur have already been made. However, the aim is to gain understanding of how to categorize these issues, streamline the error-handling process, and ensure that corrections can be routed more efficiently to the appropriate party responsible for the error.

Third, the legally binding traffic orders in STFS should remain the authoritative reference, and the output comparison will use the data in STFS as the main verification.

Finally, the source of the error will be corrected if possible (could be in STFS, sign, NVDB or HERE DB) and systematic errors should be addressed.

The test is intended to establish a baseline that can be used to create a more efficient and continuous feedback loop (T5.3).

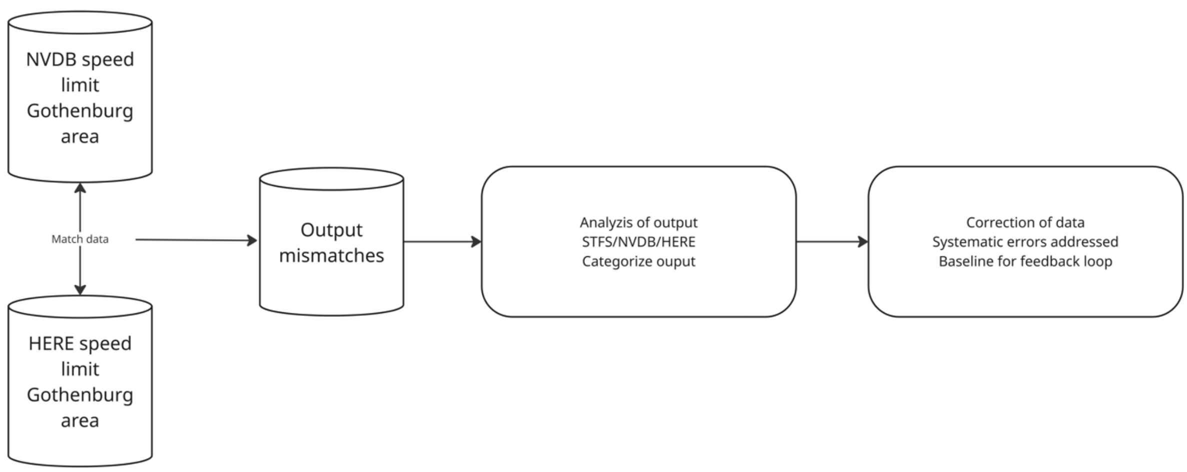

Figure 3: Initial high-level idea of the PDV. To be devolved during the PDV

6.2 PDV - France

In the Mediterranean PDV site, speed limit validation must be achievable within current constraints, including fragmented responsibilities, limited digitisation of traffic regulation orders, and the absence of unified registries. Despite these limitations, practical validation can be implemented immediately through targeted, low-overhead measures.

First, validation efforts should prioritise high-risk and high-impact road segments, such as motorways, primary corridors, school zones, and areas affected by recent road works. Focusing on these locations maximises safety benefits while avoiding the need for full network coverage.

Second, traffic regulation orders should be used as the authoritative reference. Even when not machine-readable, a manual comparison between recent orders, installed signs, and existing database entries can identify discrepancies and confirm legal accuracy.

Third, routine patrols conducted by road operators can be leveraged for opportunistic validation. Patrol teams can flag inconsistencies observed during normal operations, eliminating the need for additional field campaigns. These observations should be recorded systematically.

Fourth, a simple discrepancy log—such as a shared spreadsheet or ticketing tool—should be established to capture location, observed speed limit, expected value, date, and reporter. This creates traceability, supports prioritisation, and provides an audit trail without requiring new IT systems.

Finally, all new or modified speed limits should undergo a basic three-step verification before publication: confirm the traffic order, confirm sign installation, and confirm database update. This prevents the introduction of new inconsistencies while legacy issues are gradually addressed

6.3 Validation Slovenian PDV

In Slovenia, practical validation of speed limits must be implemented within current constraints, including limited validation workflows, incomplete linear data for some roads, and the absence of structured feedback mechanisms. Despite these limitations, immediate improvements are feasible by leveraging existing national databases and operational practices.

First, validation should prioritise highways, motorways, and high-risk segments such as tunnels, interchanges, and sections with dynamic speed limits. Focusing on these areas maximises safety impact while keeping validation efforts manageable.

Second, the official traffic signalisation database should be used as the authoritative reference. A targeted comparison between this database, published TN-ITS data, and field observations can identify inconsistencies in speed values, sign locations, or linear referencing.

Third, routine maintenance activities by road operators (e.g. DARS and DRSI) can be used for opportunistic validation. Field teams can report discrepancies observed during inspections or works, enabling continuous verification without additional field campaigns.

Fourth, a simple discrepancy log should be introduced to record location, observed speed limit, expected value, date, and source. Even a basic shared file improves traceability, supports prioritisation, and creates an audit trail for corrections.

Finally, updates to speed limits should undergo a basic verification before publication: confirm the legal decision or operational instruction, confirm sign installation or VMS configuration, and confirm correct encoding in the National Traffic GIS and TN-ITS output. This prevents new inconsistencies while legacy issues are gradually resolved.

6.4 Validation Cyprus PDV

In Cyprus, practical validation of speed limits must be implemented within current constraints, including reliance on crowd-sourced imagery, manual checks, limited-service provider engagement, and the absence of automated validation tools. Despite these limitations, immediate improvements are possible by strengthening the use of authoritative sources and structuring existing practices.

First, validation efforts should prioritise major roads and high-risk locations, such as urban arterials, school zones, and recently modified sections. Concentrating on these areas improves safety and data reliability without requiring full network coverage.

Second, the Public Works Department (PWD) should use official traffic decisions and approved speed limits as the authoritative reference. A targeted manual comparison between these decisions, Mapillary observations, and the current dataset can identify outdated or inconsistent records and improve baseline accuracy.

Third, routine activities by road maintenance teams and contractors can be leveraged for opportunistic validation. Field staff can report discrepancies observed during inspections or works, enabling continuous verification without dedicated survey campaigns.

Fourth, a simple discrepancy log should be introduced to capture location, observed speed limit, expected value, date, and source (e.g. Mapillary, field staff). Even a basic shared spreadsheet improves traceability, supports prioritisation, and creates an audit trail for corrections.

Finally, any speed limit update should undergo a basic verification before publication: confirm the official decision, confirm sign installation, and confirm correct entry in the dataset and NAP. This prevents new inconsistencies while legacy issues are gradually addressed.

6.5 The Netherlands PDV's (Helmond, Amsterdam and NDW)

This chapter describes the PDVs in Helmond and Amsterdam. We start with some **overall** remarks. Then the specific activities for **Helmond, Amsterdam** and **NDW** are described.

6.5.1 Overall

Key principles in the PDVs in the Netherlands are:

- The PDV locations in the Netherlands are Helmond and Amsterdam. NDW plays an important role in these PDVs as part of the ecosystem.
- Execution of the PDVs is carried out in close cooperation with the Dutch project ARAMIS and 'Koplopersaanpak' a.k.a. KLA.
- During execution we work with a plan–do–check–act cycle, which we will link to the delivery of the relevant ARAMIS deliverables.
- In accordance with the TISGRADE WG3 Project Plan, we distinguish the following types of validation:
    a. Preventive validation (automatic rule checks, intake checks)
    b. Operational monitoring (active status checks, spatial and temporal validation)
    c. Structural analysis (KPI monitoring, root cause analysis, process optimization)
- For preventive evaluation, we use level three of the TISA 5-star rating specification for the objectively determinable criteria.
- For those criteria that require "ground truth", we will rely on operational monitoring and merging of different data sources to determine the probability at data-item level and include it in the data feed.
- For structural analysis, a connection will be made with the dashboarding from ARAMIS for mandates and prohibitions (including speed limits). Determining the KPIs will initially be done manually at the start of the PDVs, but during the one-year PDV period this will transition to automated KPI determination.
- To determine improvements during the PDV period, a baseline measurement will be carried out at the start.

This PDV consists of a cooperation between the Dutch NAP (NDW) and the two cities Amsterdam and Helmond. The reason for this cooperation is that the two cities on the one side are connected to the NAP, which in its turn will provide the Service Providers with the relevant and validated data. On the other side the two cities will share some of the solutions created in the Task 3.1.

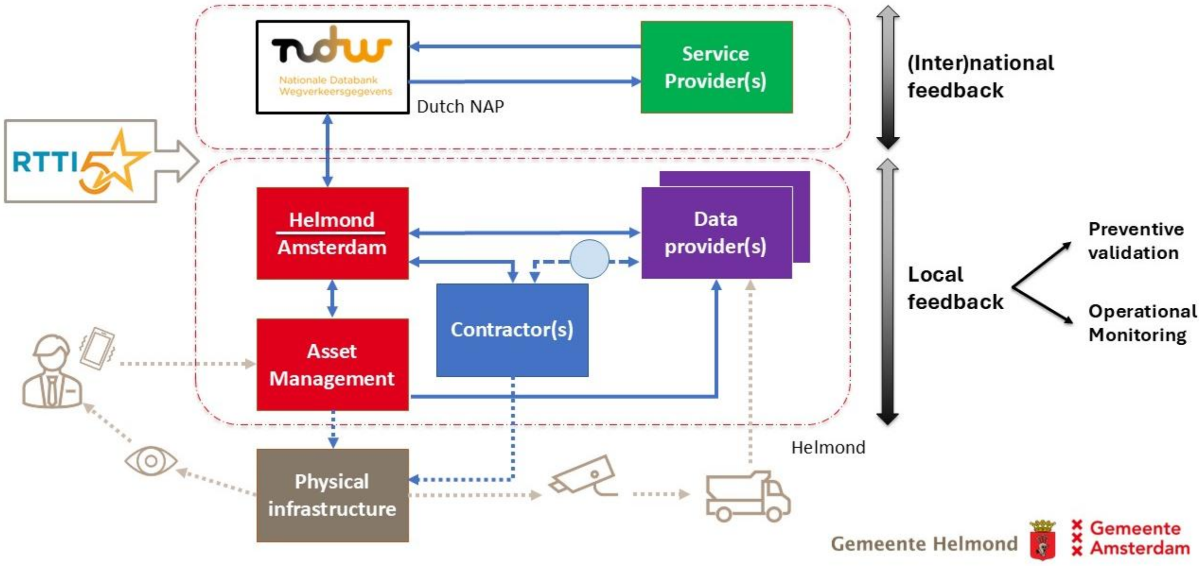

Figure 4: Helmond PDV: high-level MSL eco system

Preventive validation (automatic rule checks, intake checks)

- Creating a (new) ground truth by uploading 360 images into a platform, named Panoramax, that will automatically recognize signs and label them according to the Dutch regulations (RVV). The validated data will be uploaded to the national road database (NWB) with GEORGE (user interface tool).
- On a yearly basis the 360 images will be updated and thereby the NWB data. This is named "the long feedback loop".
- The NDW Data Quality team is currently conducting a study on the current data quality in relation to the TISA 5-star rating. Based on the outcomes of this study, concrete actions for preventive validation will be formulated.

In addition, several aspects of the current end-to-end process can be improved:

- Ability to specify an effective date for new speed limits in George.
- Link speed limits in WKD with corresponding traffic decrees.
- Indicate discrepancies between OSM and NWB based on daily comparisons.
- Increase publication frequency of maximum speed limits to at least daily (instead of monthly).
- Publication should also include advance announcements of upcoming speed-limit changes.
- Add to the traffic-decree dashboard the traffic-decree mutations in WKD maximum speed that contain a traffic-decree reference.
- RWS should adjust the default value placed in the reliability column for road sections automatically assigned a default speed. Instead of 50%, use 49%, so users

can be alerted to changes (more info on the reliability column, see the attribute 'Betrouwbaarheid' description in https://docs.ndw.nu/en/handleidingen/wkd/wkd_maxsnelheden/).

- In George, apply different visualisation for road sections where (a) NWB and OSM differ, and (b) road sections with automatically generated speed limits (reliability 49%), so users can validate and mark them as "validated" in George.

Operational monitoring (active status checks, spatial and temporal validation)

- Validation of the data in NWB against OpenStreetMap (OSM). This will lead to updating the data in GEORGE and/or in OSM. The validation will be executed every [x] [days/weeks/months]. This is named a "short feedback loop".
- Only Helmond: creating another short feedback loop by equipping 23 garbage vehicles with cameras. A subset of the signs is automatically recognized and validated against the ground truth. This is also considered as a "short feedback loop".
- NDW will provide the OSM-GEORGE validation to the road authorities via digital tooling in GEORGE.
- Create a dashboard showing compliancy between traffic regulation order and maximum speed.

Structural analysis (KPI monitoring, root cause analysis, process optimization)

We will investigate the following ways of structural analysis:

- Transition from manual KPI determination to automated KPI determination
- Development of root-cause analysis and improvement of the source data
- Development of a dashboard for mandates and prohibitions. This dashboard focuses on rules and restrictions, including speed limits. It therefore aligns with the scope of both TISGRADE and ARAMIS (deliverable A2). In building this dashboard, we will leverage the knowledge and experience gained during the development of the roadworks dashboard (ARAMIS deliverable B5, MVP delivery in Q2 2026)

6.6 Validation Spanish PDV

The Spanish PDV focuses on interurban roads, where data is managed through a multi-actor chain involving contractors, intermediate systems (e.g. INCA), and the national authority (DGT). The current validation approach combines automated checks during data processing with expert-based review. While this provides a basic level of quality assurance, validation is not yet fully embedded across the entire data lifecycle.

Several challenges affect the robustness of the validation framework. These include fragmented governance, limited traceability between legal traffic orders and digital datasets, and the absence of a clearly defined single source of truth. In addition, incomplete data models—particularly the lack of consistent linear referencing—reduce the effectiveness of cross-checking and network-wide validation. Feedback from service providers exists but is not systematically integrated, and the use of quality metrics and metadata remains limited.

To improve validation maturity, Spain should implement end-to-end validation workflows aligned with the defined building blocks, strengthen governance and traceability, and harmonise data models. Furthermore, integrating structured feedback loops and adopting standardised KPIs will enable continuous monitoring and improvement, supporting a more scalable, transparent, and reliable validation framework.

6.7 Service Providers

6.7.1 Be-Mobile

Within the framework of TISGRADE, the TISA RTTI 5-Star Rating Specification is chosen as a working example methodology for validating MSL data feeds. The 5-Star Rating can serve as a KPI framework for assessing the quality of these data sources and forms an important component of the validation approach described in D3.2/D3.3, where a structured self-assessment methodology of the 5-Star rating is provided in the Annex.

This methodology translates the TISA 5-Star Rating Specification into a clear and operational procedure for PDVs for the evaluation of maximum speed limit restriction data (as well as road works and road/lane closures). It:

- Specifies the calculation type for all relevant criteria (real-time desk analysis, historical desk analysis or ground truth analysis)
- Gives a detailed procedure for calculating the ground truth criteria

In the first phase, the methodology is demonstrated in a worksheet self-evaluation file. A designated member of the PDV team can apply the methodology and complete the file for each relevant dataset/feed containing speed limit restriction information. Based on the entered values, the file will automatically generate a 5-Star Rating per source.

Data requirements for a 5-Star rating

The historical desk analysis part of any valid 5-Star Rating evaluation requires a database with a sufficient number of historical feed updates, as they were originally published by the source.

Additionally, the ground truth validation part requires ground truth data: verified real-world reflecting the actual conditions on the road network, from which speed limit information can be extracted. Good examples are Road User Feedback (RUF) data and FCD. Only by comparing published speed limit data with reliable ground truth over a predefined number of historical events can accuracy, timeliness, completeness, and consistency be objectively assessed.

The execution methodology therefore specifies the minimum number of events of the historical database and the minimum characteristics of the ground truth dataset needed to perform a reliable 5-Star rating.

Future Automation of the 5-Star Rating

At a later stage of the project, the experience gained from testing the 5-Star rating methodology will be used to select a final approach, which will then be automated and implemented in a dedicated tool, among other uses for speed limit restriction validation. This tool will ensure scalable validation across multiple sources and will:

- Accept datasets in TN-ITS, DATEX I, DATEX II V2, and DATEX II V3, Shapefiles, WMS, WGS, ...formats containing speed limit information
- Process both source data and ground truth data
- Automatically calculate attribute-level KPI's for speed limit restrictions
- Generate a 5-Star Rating per data source

This automation will support the continuous evaluation of dynamic speed limit data quality by enabling faster execution through reduced manual effort and ensure consistent criteria calculation over periodic re-evaluations.

6.7.2 HERE

HERE's role focuses on comparative validation, structured feedback, and identification of systemic data quality issues, while respecting intellectual property constraints and existing data governance models.

For Task 3.1 PDVs, HERE proposes a comparative validation workflow in which authoritative speed limit data provided by road authorities is compared against HERE's internal speed limit representation for the same geographic scope. This comparison is used to identify potential discrepancies in speed values, spatial extents, update timing, or interpretation of regulations. The objective is not to establish a new ground truth, but to highlight inconsistencies and improvement opportunities within the existing data chain.

HERE provides feedback to PDVs in a structured and actionable format, for example by indicating the location of a potential issue, the category of discrepancy (e.g. value mismatch, missing update, inconsistency), and a confidence indication. Depending on PDV maturity and agreed constraints, feedback can be binary or categorical, rather than value-by-value data exchange. The validation of discrepancies against traffic orders and field reality remains the responsibility of the road authority.

Finally, HERE recommends that PDVs with frequent updates apply a lightweight preventive validation step before publication, confirming alignment between traffic orders, physical signage, and digital encoding. The experiences and lessons learned from these PDVs will feed into the design of scalable feedback-loop mechanisms in subsequent TISGRADE tasks.

This approach represents an initial validation concept from the HERE perspective and will be further refined during the project based on PDV experience and cross site learnings.

7 Evaluation of validation and data Quality Improvement

To be addressed in phase 2 of the validation task. The following chapters are for discussion.

7.1 Validation Maturity

7.2 KPI and 5* impact

7.3 Use and value of external sources

7.4 Service provider uptake validation

7.5 Workload and technical sustainability

7.6 Standardised evaluation matrix

8 Conclusions and next steps

This deliverable establishes a common validation and data quality framework for Maximum Speed Limit (MSL) data across PDVs, aligned with RTTI requirements and supporting progression towards the TISA 5-Star Rating Standard. It highlights key gaps in current practices, including limited automation, fragmented governance, and missing feedback loops. The proposed framework provides a scalable, auditable approach to improve data reliability through continuous validation and stakeholder collaboration. Next steps include implementing the framework within each PDV, defining measurable KPIs, integrating feedback mechanisms, and further refining the approach in D3.4 to support harmonisation and EU-wide deployment to be addressed in phase 2 of the validation task.

9 ANNEX 1: Precedent Practices

9.1 EU-EIP Sub Activity 4.7: Provision of updates of ITS spatial road data

The data owners are typically public road authorities who hold legal responsibility for the maintenance and regulation of the physical road network. These include:

- National Road Administrations: Such as the Finnish Transport Agency (FTA), Transport Infrastructure Ireland (TII), and the National Institute of Geographic and Forest Information (IGN) in France.
- Regional and Local Authorities: In Flanders, the Department of Mobility and Public Works (MOW) manages data for regional roads, while in the UK and Ireland, Local Highways Authorities (LHAs) are crucial for data regarding local roads and Traffic Regulation Orders (TROs).
- Coordinating Bodies: Organisations like GeoPlace in the UK assist in coordinating data from multiple local authorities into a unified national view.

Relevant Databases

- Authorities manage internal databases that serve as the "authentic" source for road attributes and geometry. Key systems identified in the pilots include:
- National Road Databases: Examples include Digiroad in Finland, which utilizes the OTH system for attributes and VVH for geometry, and the BDUni in France.
- Infrastructure and Pavement Registries: The Wegendatabank in Flanders stores road characteristics and traffic sign data, while Ireland uses the MapRoad PMS, a cloud-based Pavement Management System shared by local authorities.
- Reference Network Models: Many pilots link their data to high-accuracy spatial models, such as OS MasterMap Highways Network in the UK or Ordnance Survey Ireland Prime2.

Processes to Produce TN-ITS Data

The production of TN-ITS data involves a sequence of technical processes that transform raw administrative or GIS data into standardised update messages.

1. Change Detection (Extraction): Systems monitor internal databases to identify "deltas" or changes (additions, modifications, or removals) that occurred over a specific timeframe, such as the last 24 hours. In Finland, Jenkins automation is used to trigger this daily extraction.
2. Data Filtering and Mapping: Internal data formats (e.g., JSON, Excel, or SQL) are filtered for TN-ITS relevance and mapped to the conceptual ROSATTE/TN-ITS specification. This includes translating national traffic sign codes into standardised safety feature types.

3. Location Referencing: To ensure map providers can accurately place updates, the architecture applies dynamic location referencing, primarily OpenLR, which encodes the location into a compact binary string. Some pilots also include INSPIRE linear referencing as a redundant, authoritative link to national networks.
4. Standardised Formatting (Conversion): The mapped data is converted into standardised XML/GML files that strictly follow the TN-ITS schema. Coordinate systems are typically converted from national formats to WGS84.
5. Publication and Distribution: The resulting update sets are published via a public REST API or hosted on a National Access Point (NAP). This allows data users like TomTom and HERE to query and download the latest update sets automatically.

According to the sources, static road data is typically published by road operator authorities and is "by nature trusted and from an accepted quality level (tbd)". This signifies that because the data originates from the public authorities responsible for the road network, it is considered an authoritative and efficient source.

Beyond this general status of trust, the sources describe several common pillars and statements regarding how **quality validation is managed** across the pilots:

1. Responsibility of the Data Provider

A common principle across the implementation results is that the accuracy of the information remains the responsibility of the individual data providers (authorities). For instance, in the Spanish pilot, the system processes existing information, and if errors or inconsistencies are detected, they are reported back to the competent authority to make the necessary modifications.

2. Validation through Feedback Loops

The TN-ITS exchange framework explicitly includes "quality control and feedback" as a core component of its data chain.

- Standardised Processes: CEN has developed requirements to standardise the feedback process across all involved European countries.
- User Feedback: Data users, such as map providers (TomTom and HERE), provide feedback on errors or inconsistencies they find when integrating the data, which authorities then use to improve source data quality.

3. Prerequisites for Quality Supply Chains

The sources state that establishing a "quality-ensured supply chain" for safety-related attributes (like speed limits) requires two main prerequisites at the authority level:

- Adequate ICT/GIS systems and databases.

- Established procedures for data maintenance and quality within the road authorities themselves.

4. Identified Risks to Data Quality

The sources also offer a common perspective on the challenges of maintaining quality, noting that there is a risk of inconsistency because different authorities may interpret traffic sign data in different ways. Additionally, the completeness of digital attributes at the source can vary, which may affect compliance with the harmonised TN-ITS specifications.

9.2 TN-ITS GO project

The high-level architecture of the TN-ITS service pilots is designed to create a seamless data chain for exchanging road network spatial data updates between public authorities and map providers. This architecture typically consists of four main layers: source data maintenance by authorities, data extraction and conversion processes, publication through a central service, and consumption by data users.

Data Owners and Authorities

The data owners are primarily national or regional road authorities responsible for the maintenance and management of the road network. These include:

- National Road Administrations: Such as Rijkswaterstaat (Netherlands), Hungarian Public Road (Hungary), and Infrastruturas de Portugal (Portugal).
- Ministries of Transport: For example, the Ministry of Infrastructure (Slovenia) or the Ministry of Infrastructure, Transport and Network (Greece).
- Regional Authorities: In countries like Spain, data is also sourced from regional road authorities and the Ministry of the Interior (DGT).

Relevant Databases

Authorities manage several types of internal databases that serve as the foundation for the TN-ITS service:

- Primary Road Databases: These store technical characteristics of the road network, such as geometry, road width, and road classification (e.g., the NWB in the Netherlands or the BCP in Slovenia).
- GIS and Traffic Sign Registries: Dedicated databases for georeferenced objects, specifically focusing on traffic signs for speed limits, weight, and height restrictions (e.g., the Traffic Sign Registry in Hungary or WEPS in Slovenia).
- TN-ITS Intermediate Databases: Many pilots (such as Cyprus and Portugal) implement a dedicated intermediate database that automatically logs changes triggered from the main spatial databases to facilitate the update process.

Processes to Produce TN-ITS Data

The core of the architecture involves a series of processes that transform static road data into standardised update messages.

1. Data Retrieval and Change Detection: Processes monitor the source databases to identify "deltas" or changes in road attributes (such as a speed limit modification) compared to previous versions.
2. Data Mapping and Translation: Source data, often in national formats or Excel files, is mapped to the harmonised TN-ITS specification (CEN/TS 17268). This involves converting internal sign codes into standardised formats like EN ISO 14823.
3. Location Referencing: Standardised spatial referencing methods, such as OpenLR, GML, or linear referencing, are applied to ensure that map providers can accurately place the updates on their own digital maps.
4. Publication and Exportation: The translated data is packaged into XML update sets and published through a download service. This is typically hosted on a National Access Point (NAP) or a dedicated web portal for map providers like TomTom and HERE to consume.
5. Feedback Loop: A process is often included to receive and integrate feedback from data users regarding errors or inconsistencies, allowing authorities to improve source data quality.

9.3 ISA FIT - Helmond, Netherlands

The high-level architecture of the TN-ITS service pilots, as described in the ISA-FIT document, is structured as a continuous data chain that bridges the gap between authoritative road data changes and end-user applications like Intelligent Speed Assistance (ISA). This architecture facilitates the exchange of static road data updates—specifically speed restrictions, warnings, and traffic regulations—between public authorities and map service providers.

Data Owners and Authorities

The primary data owners are national and regional governments and road authorities, as they hold the legal responsibility for the physical road network and the regulations applied to it. Key entities identified include:

- National Road Authorities: Such as Rijkswaterstaat (RWS) in the Netherlands, which provides the authoritative speed data used in the pilots.
- National Access Point (NAP) Operators: Entities like the National Data Warehouse (NDW) in the Netherlands, which host and provide access to the data.
- Local Authorities: Cities (such as Helmond) that participate in analysing events and verifying data accuracy.

Relevant Databases

The architecture relies on several tiers of databases to manage and synchronize road information:

- National Road Databases: For example, the Nationale Wegenbestand (NWB), which provides the geographic representation of the road network.
- Road Properties Databases: Specific registries like the Wegkenmerkendatabase (WKD) in the Netherlands, which store speed restrictions and other attributes linked to the road geography.
- Base/Reference Registrations: Internal systems like the Basisbestand Netwerken (BN) that incorporate changes from various sources like road designs and aerial photography.
- NAP Portals: Centralised platforms (NAPs) where TN-ITS datasets are published for commercial consumption.

Processes to Produce TN-ITS Data

The production of TN-ITS data involves a sequence of capturing, processing, and publishing road attribute changes:

1. Change Detection: Real-world changes are identified using aerial photographs, road designs, and reference registrations.
2. Internal Database Update: Detected changes are incorporated into internal GIS applications (such as the OHx suite) on a daily basis.
3. Data Extraction and Mapping: Authorities identify relevant road segments and attributes from their internal collections and map them to the TN-ITS data format.
4. Format Conversion: Data is converted into the CEN/TS 17268 standard, representing changes as point features (e.g., traffic signs) or linear features (e.g., speed limit segments).
5. Publication: The resulting update sets (XML/GML) are synchronised (typically monthly or daily) and made available via a download service on a National Access Point.
6. Ingestion and Normalisation: Map providers (like TomTom and HERE) download the data, perform their own validation and normalisation, and publish it to end-users.

Validation of TN-ITS Data Quality

The ISA-FIT document outlines several layers of quality validation to ensure the reliability of speed limit data:

- Authoritative Trust: The architecture shifts from open-source data (like OpenStreetMap) to official government reference databases specifically to ensure the use of authoritative data, which avoids uncertainty regarding maintenance processes.
- Technical Heuristics: Algorithms are used to complement speed restrictions on shorter road segments where data might be missing, although some segments may still be marked with an 'unknown' value.

- Source Verification: Change reports submitted by individuals or authorities are verified by a production team before being processed into the source database.
- Vehicle-Based Feedback Loops: Modern architectures include a feedback mechanism where vehicles detect observations (such as camera-map deviations or system overrides) and send them to the cloud. These observations serve as "leads" for authorities to verify if a physical sign is missing or incorrect in the database.
- Provider Normalisation: Before the data reaches the end-user, map and service providers perform independent validation and ingestion checks to maintain the high quality of their commercial products.

9.4 NAPCORE Milestone M4.2.7

9.4.1 Data owners and responsible authorities

M4.2.7 confirms that public road authorities remain the primary authoritative data owners. These include:

- National road administrations and transport ministries responsible for motorways and national networks.
- Regional and local authorities managing secondary and urban roads and traffic regulations.
- NAP operators acting as trusted intermediaries that publish and provide access to datasets while preserving authority ownership.

The document emphasises data sovereignty and provenance, requiring clear identification of the responsible authority for each dataset.

9.4.2 Relevant databases used

The report highlights reliance on authoritative, government-maintained systems, such as:

- National road network databases (geometry, topology, classification).
- Traffic regulation and sign registries (e.g., speed limits, restrictions).
- Asset and infrastructure management systems (pavement, signage, road works).
- Intermediate TN-ITS staging databases used to manage updates and versioning.

These systems form the single source of truth, with NAPs providing discovery metadata rather than replacing source databases.

9.4.3 Process to produce qualitative TN–ITS data

M4.2.7 describes a harmonised production chain:

- Change detection in authoritative systems (design updates, surveys, aerial imagery, reports).
- Data extraction and mapping to TN-ITS concepts and code lists.

- Location referencing using standard methods (e.g., OpenLR, linear referencing).
- Transformation and validation into standard formats (XML/GML, CEN/TS 17268).
- Publication via NAPs/APIs with metadata describing quality and provenance.
- Feedback ingestion from data users and service providers.

9.4.4 Validation and data quality methodologies

M4.2.7 promotes a structured quality management framework including:

- Defined quality dimensions: accuracy, completeness, consistency, timeliness, and integrity.
- Provenance metadata to verify authority and update history.
- Feedback loops from map providers, users, and automated systems.
- Cross-border semantic checks to detect inconsistencies in interpretation.
- Risk-based validation aligned with safety-critical use cases (e.g., ISA).

The aspect of trust was explicitly researched in this document as a summary:

In NAPCORE M4.2.7, trust is a structured, multi-layer concept that ensures TN-ITS road data can be reliably used across borders and in safety-critical applications. It is grounded in authoritative provenance, meaning data originates from legally responsible public authorities and includes verifiable metadata on ownership and maintenance. Trust is reinforced through transparent, auditable processes that document how data is collected, transformed, and distributed. Measurable quality indicators—such as accuracy, completeness, timeliness, consistency, and integrity—provide evidence of reliability. Secure distribution via National Access Points preserves data integrity, while cooperative feedback loops and risk-based validation continuously strengthen trust and ensure fitness for purpose in digital mobility services.

9.5 NAPCORE WG3.1 Quality Frameworks

Data owners and responsible authorities

The quality framework confirms that data providers remain responsible for data quality, typically:

- National road administrations and transport ministries.
- Regional and local authorities managing local networks and regulations.
- Public agencies or delegated operators maintaining specific datasets (e.g., traffic signs, restrictions).

The repository stresses clear responsibility allocation and documentation of roles, ensuring accountability for quality and updates.

Key insight: Quality management begins with clearly identified, accountable data owners.

9.5.1 Relevant databases (authoritative sources)

The quality materials emphasize the use of authoritative, maintained source systems, including:

- Road network and topology databases.
- Traffic regulation and restriction registries.
- Asset management systems (signage, infrastructure).
- Event and road works databases.
- Intermediate staging databases used for harmonization and version control.

They highlight the importance of a single source of truth and consistent synchronisation between systems.

Trustworthy quality depends on controlled, authoritative source systems.

9.5.2 Processes to produce TN-ITS data

The repository aligns with the TN-ITS production chain but emphasises quality checkpoints:

Typical process with quality controls:

- Data collection & maintenance
- Surveys, design updates, sensors, and administrative decisions.
- Change detection & versioning
- Identification of updates and maintenance of history.
- Data harmonisation & mapping
- Alignment with TN-ITS specifications and code lists.
- Validation & enrichment
- Automated checks (format, logic, completeness) and manual review.
- Publication via NAP
  Distribution with metadata describing quality and lineage.
- Monitoring & feedback integration
  Continuous improvement through user/provider feedback.

Quality is embedded throughout the production chain, not only at publication.

9.5.3 Quality validation methods

The NAPCORE quality framework promotes structured validation using:

- Quality dimensions
- Accuracy
- Completeness
- Consistency
- Timeliness

- Integrity
- Availability (for services)

Validation techniques:

- Automated validation rules (schema, logic, range checks)
- Cross-dataset consistency checks
- Metadata-based quality reporting
- Audits and quality monitoring dashboards
- Feedback loops from service providers and users
- Fitness-for-purpose assessment

Quality is evaluated against service needs (e.g., navigation vs. automated driving).

Quality validation is measurable, continuous, and use-case driven.

10 ANNEX 2: Validation Plan per PDV

This validation plan for Maximum Speed Limit (MSL) data is designed for the TISGRADE Pre-Deployment Validation (PDV) locations. It integrates the technical requirements of Deliverable 3.1, the strategic alignment from Joint Call No. 3, and the specific "footprint" and RASCI frameworks provided in the sources.

10.1 Start Phase: PDV Context, Availability, and Feedback Definition

Before operational validation begins, each PDV must document its organizational and technical environment to ensure transparency and data sovereignty.

- PDV Description: Specify geographic location (e.g., urban node, interurban roads) and road types covered (national, regional, or local).
- Responsibilities (RASCI Model): Define who is Responsible for execution, Accountable for outcomes, and who serves in Supportive, Consulted, or Informed roles for validation tasks. (cfr table 2)
- Footprint (Ecosystem): Describe the site's operational landscape across various dimensions. A template is provided for this in D3.1. fig 1
    - Organisations: Involved stakeholders (ministries, municipalities, police, etc.).
    - Data Sources: Origins of MSL data (legal orders, field surveys, existing databases).
    - Core MSL Database: Underlying infrastructure (GIS, traffic sign registries, etc.).
    - Validation Access Points: Channels for accessing validated data (NAPs, APIs).
- Timing Plan: Align with project milestones, such as the transition from Version 1 (initial setup) to Version 2 (incorporating feedback loops).

10.2 Phase One: Baseline Validation and Advanced In-Situ Evaluation

This phase focuses on strengthening the data chain, yet without a feedback loop from service providers operational. It relies on authoritative and acquired sources and internal technical checks.

- Quality Criteria (Dimensions): Use the six core dimensions to evaluate MSL data: Accuracy, Completeness, Consistency, Timeliness, Integrity, and Availability.
- Self-Assessment of Maturity: Sites should aim for at least Level 3 (Systematic), where automated checks are performed at data entry and validation activities are scheduled.
- Validation Triggers:
    - Scheduled: Daily or weekly automated checks.
    - Event-driven: New traffic regulation orders or completion of road designs.
    - Ad-hoc: Patrol observations or police reports.

- Key Performance Indicators (KPIs), e.g:
    - Detection Rate: % of actual MSL changes captured.
    - Completeness Score: % of road network with validated data.
    - Consistency Score: % agreement between legal orders, databases, and physical signs.

    Report these figures as an impact assessment.
- Sampling & Cadence: Define sample sizes and confidence levels for comparing digital records against the "ground truth" (physical signs).
- Acceptance Criteria: Validation must be auditable with a complete provenance chain, and all published updates must meet target KPIs and include quality metadata.
- Methods (Building Blocks):
    - B1 (Source Authority): Automated schema and range checks at data entry.
    - B2 (Cross-Referencing): Comparing digital databases against physical signage and legal orders.
    - B4 & B5 (Automation/Publication): Logic-based checks (e.g., speed limit range logic) and format validation (CEN/TS 17268).
- TN-ITS readiness: please report on your TN-ITS readiness as per chapter 6.8
- Final summary: Use the overview of chapter 6.9 to present your PDV actions used.

10.3 Phase Two: Operational Feedback-Loop Validation (draft for discussion)

Phase 2 expands the plan to include a continuous cycle where external observations from service providers (SPs) and road users inform data corrections.

- Feedback Mechanism (Building Block B3): Integrate observations from map providers (e.g., TomTom, HERE), vehicle-based camera detections, and user reports as "leads" for authority verification.
- Advanced Quality Targets (TISA 5-Star):
    - 4 Stars: Integration of feedback loops to improve timeliness.
    - 5 Stars: Full cross-referencing with legal orders combined with vehicle-based validation.
- Additional KPIs:
    - Feedback Resolution Time: Average time from an SP report to a corrected source in the master database.
    - False Positive Rate: % of reported changes from external sources that are found to be invalid upon verification.

- Target Maturity Level: Move toward Level 4 (Continuous), where real-time change detection and feedback loops are fully integrated into the operational workflow.
- Updated Workflow: The end-to-end process now concludes with Step 8 (Feedback Ingestion) and Step 9 (Source Correction), which then restarts the change detection cycle.

This phase begins once a structural, electronic data exchange with service providers is active.

10.3.1 Structural Feedback Integration

- Closed-Loop Exchange: Transition to a system where SPs (e.g., HERE, TomTom) report errors found during data ingestion directly to the authority.
- Vehicle-Based "Leads": Leverage modern vehicles that detect camera-map deviations to provide authorities with specific locations needing verification.
- Floating Car Data (FCD) Sanity Checks: Use FCD to identify segments where driving speeds significantly differ from the registered limit, triggering an investigation.

10.3.2 Automated Quality Management

- TISA 5-Star Automation: Deploy a dedicated tool to accept DATEX II feeds, automatically calculate quality criteria, and generate continuous 5-Star Ratings.
- AI-Driven Verification: Scale city-wide automated sign recognition to continuously compare physical road infrastructure with the digital database.
- Auditability: Maintain provenance metadata and auditable update histories to ensure data sovereignty and cross-border trust.

11 Document history table

Date	Version	Status	Author	Description
10-04-2026	1.0	Delivered	Stephen T'Siobbel Frank Daems	Validation of Maximum Speed limits in TISGrade Pre-Deployment Validation Sites
-	-	-	-	-

12 References

12.1 Figures and tables

Figures

Tables

12.2 References

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