Geomatics for Mobility Management

A comprehensive database model for Mobility Management

Introduction

Research context

Mobility Management

Strategies and policies to reduce or redistribute travel demand in time and space

Wide range of tasks and data

Traffic monitoring

Traffic enforcement

Private/Public info-mobility

Objective

Reduce the impact of transport (congestion, pollution, security)

Introduction

Motivation

Urban transport has a large impact on the socio economic growth and in general on the quality of life of citizens.

SUSTAINABLE TRANSPORT

Concept promoted by the European Commission

Mobility management is a key factor
to provide integrated and real-time information

Data integration as key strategy
Better managing to better inform

SPATIAL INTEGRATION

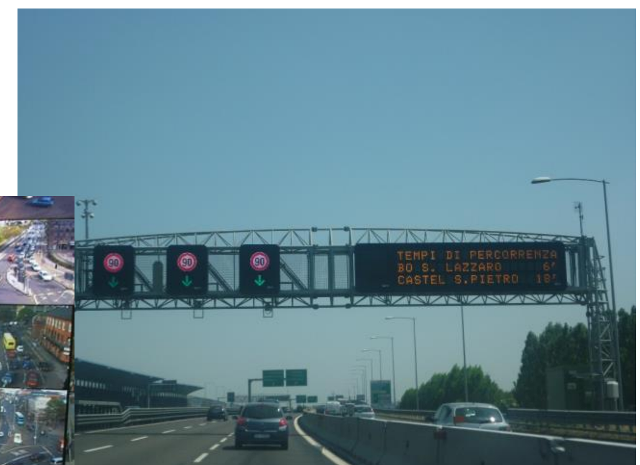
GIS as a solution to integrate the separated and vertical vision in a **spatial** and **horizontal** ones

Intelligent Transport Systems

Core technology for Mobility Management

Hardware and software applications for transport data management, devoted in particular with **real-time** data

- AD HOC systems → one system one task
- Data and information produced are difficult to reuse



Introduction

Research issues

Mobility management companies

Wide variety of structures and tasks, inside and between countries:

- Private companies, public companies, public private partnerships
- Managing only private traffic, public transport or both, differences in information systems…
    - Overlays in duties and areas of responsibility

5T case study in Turin

Public private partnership, need of interaction with others mobility management companies, duties variety over time, general separation between ITS systems…

Traffic Operation Centre interfaces:

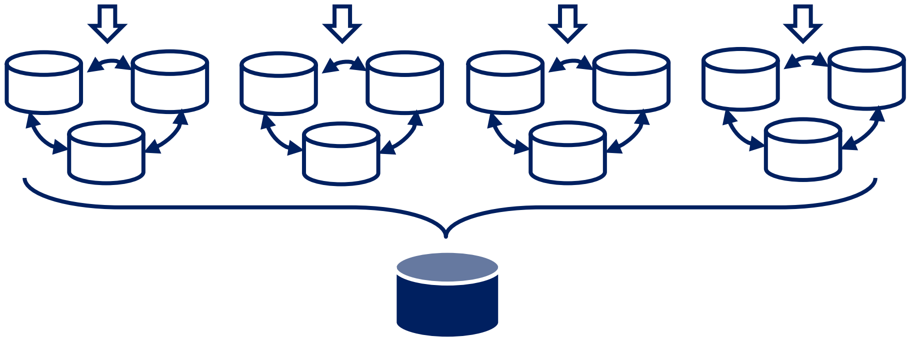
- VIDA & MOVIDA
- UTC platform
- FCD aggregator
- SCRIBA platform
- DATEX node
- ….

Introduction

Objective and research questions

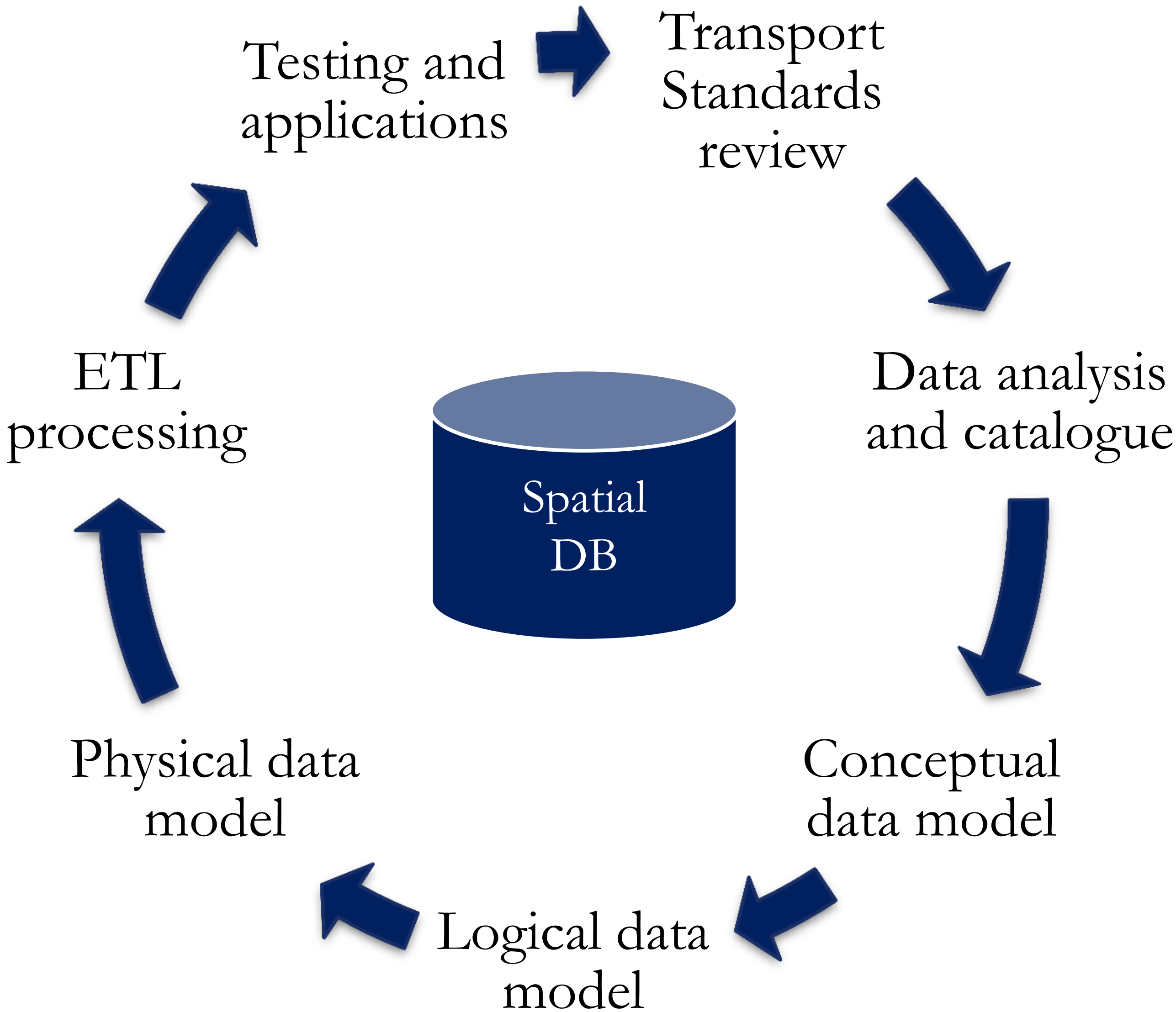
Design a comprehensive spatial data model for mobility management

as base for multi-thematic analysis
and as a tool for decision support system



- It is possible to build a spatial data model independent by used ITS technologies? It can be reusable by different companies?
- Can the transition between ITS and GIS be automated?
- How a comprehensive spatial data model can enable transport data integration?

Methodology



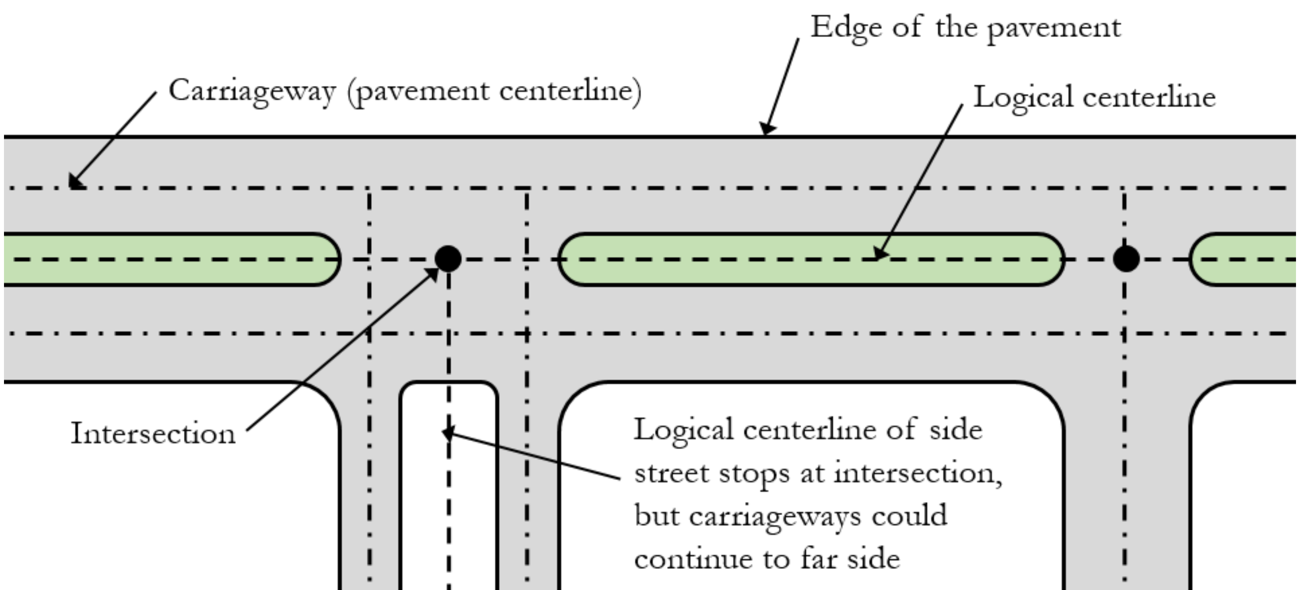
Mobility data issues

The network data

In transport management approach the network infrastructure defines the transport supply

Graph model is the most used way to represent transport supply as it allows to solve most common network and routing problems.

- *Node* represents an object of interest
- *Link* represents a relationship between two nodes
- *Path* is an alternating sequence of nodes and links
- *Cost* is a numeric attribute associated with links or nodes



Mobility data issues

The network data

Multiple sources of network data

OPEN DATA

OpenStreetMap

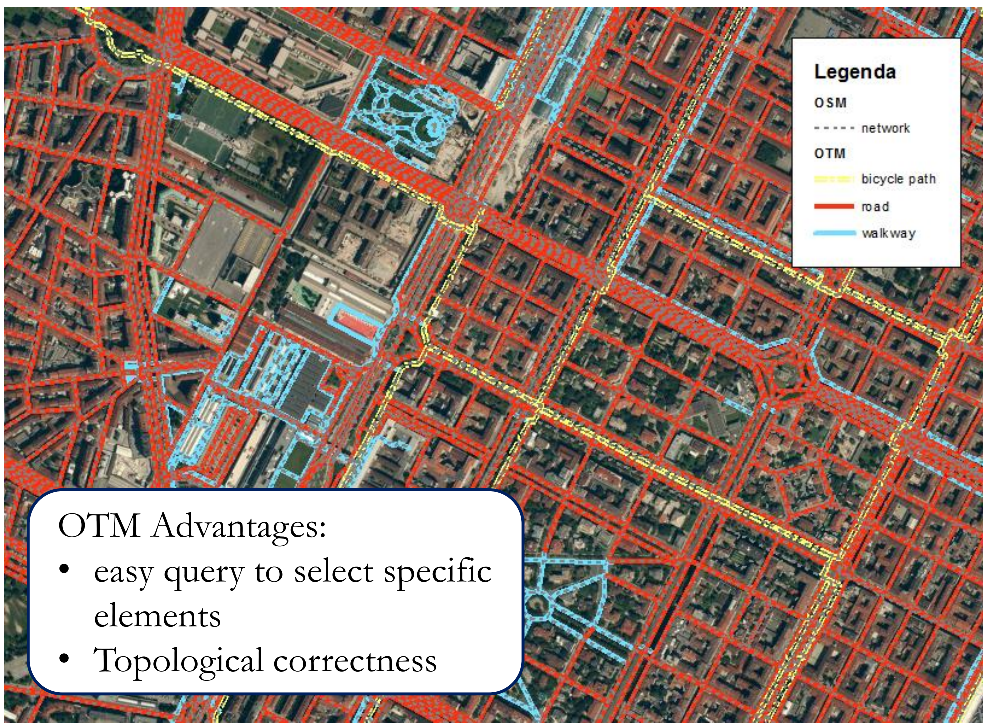
OpenTransportMap

COMMERCIAL AND CUSTOM DATA

Navstreets Streets dataset (Here/Navteq)

Custom Arcs and Path of 5T

OTM vs OSM



OTM Advantages:
- easy query to select specific elements
- Topological correctness

Navstreets Streets

Mobility data issues

The network data

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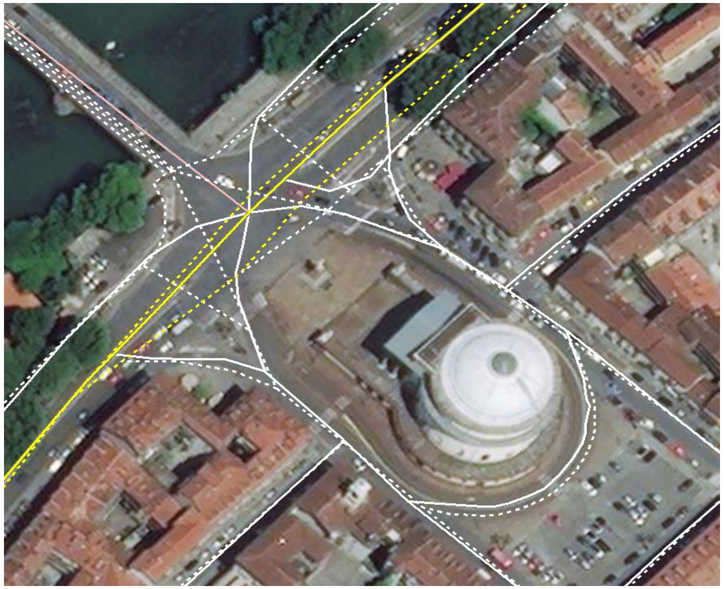
Navstreets Streets vs OTM

Differences in LOGICAL REPRESENTATION

Multiples or single centerline
when there are more lanes



Differences in
INTERSECTION representation

Mobility data issues

The network data

Multiple sources of network data

OPEN DATA

OpenStreetMap

OpenTransportMap

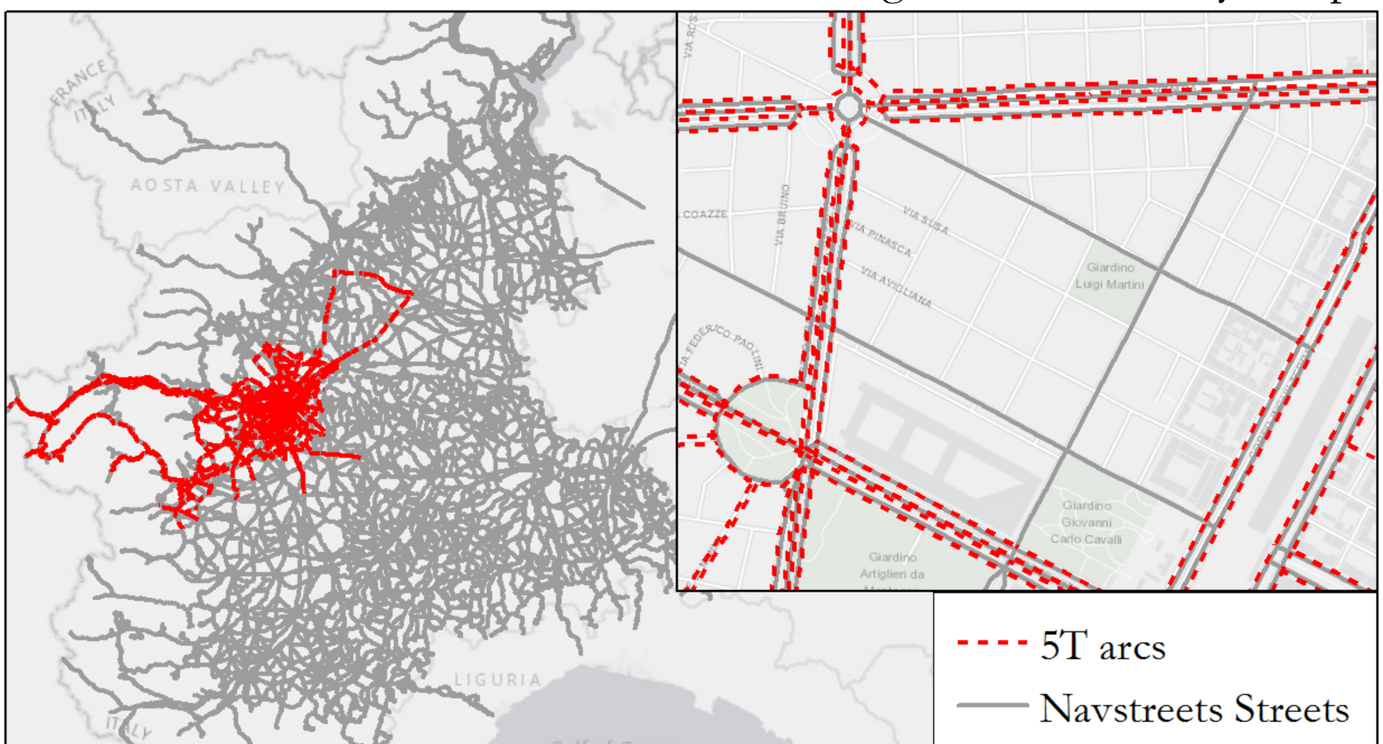
COMMERCIAL AND CUSTOM DATA

Navstreets Streets dataset (Here/Navteq)

Custom Arcs and Path of 5T

Navstreets Streets vs 5T arcs and paths

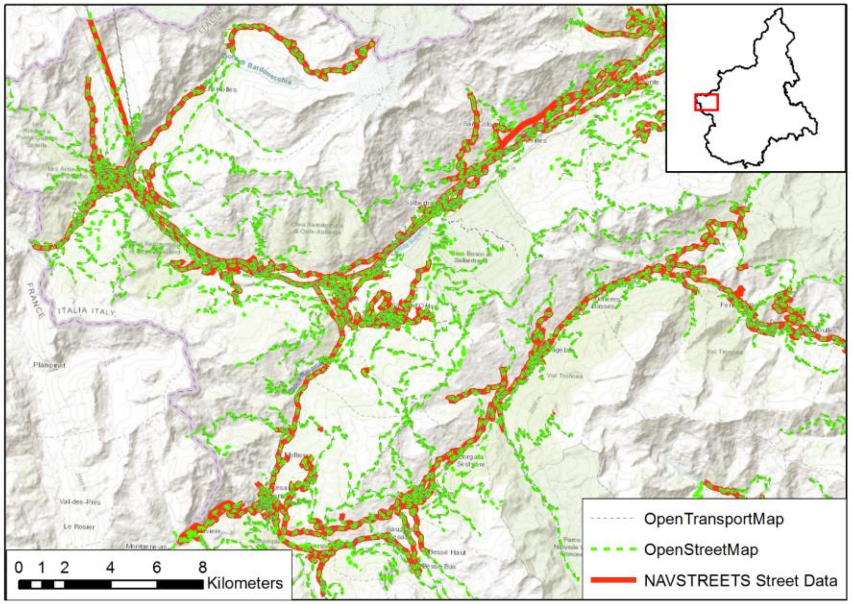
Differences in LOGICAL REPRESENTATION, geometric accuracy and precision



Mobility data issues

Network data comparison

OpenStreetMap – OpenTransportMap – Navstreets Streets



Evaluate differences in:
- Spatial completeness
- Attribute completeness and accuracy
- Topology

Refined dataset in order to find a 1:1 correspondence between features:
- Selection in 5/10/30 m range
- Map matching between attributes

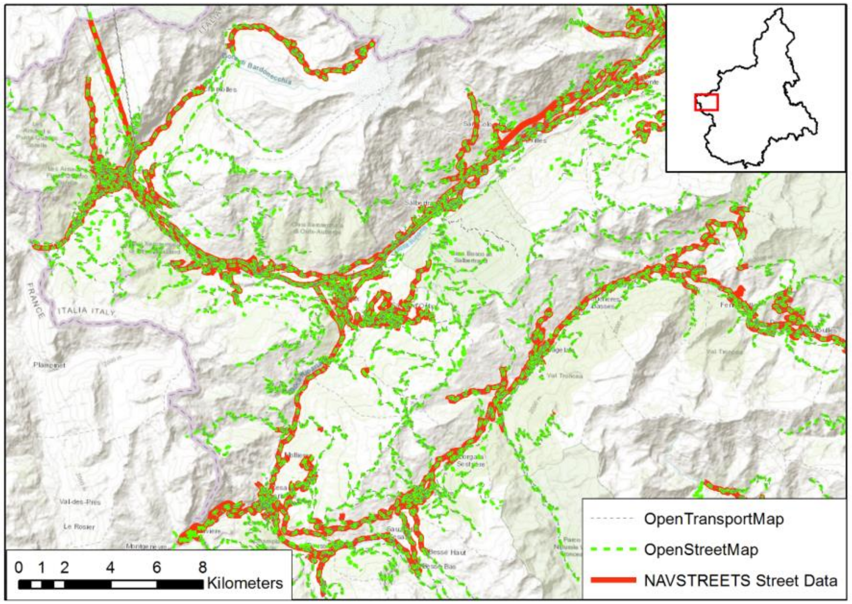
Spatial completeness

		NAVSTREETS Street Data	OpenStreetMap	OpenTransportMap
Piedmont - all	Total Kms	58.924,85	101.324,40	128.300,77
	Features count	462.875	306.465	702.501
Piedmont - car traversable	Total Kms	48.935,19	82.051,99	105.459,93
	N° of features	406.291	255.984	609.952

Mobility data issues

Network data comparison

OpenStreetMap – OpenTransportMap – Navstreets Streets



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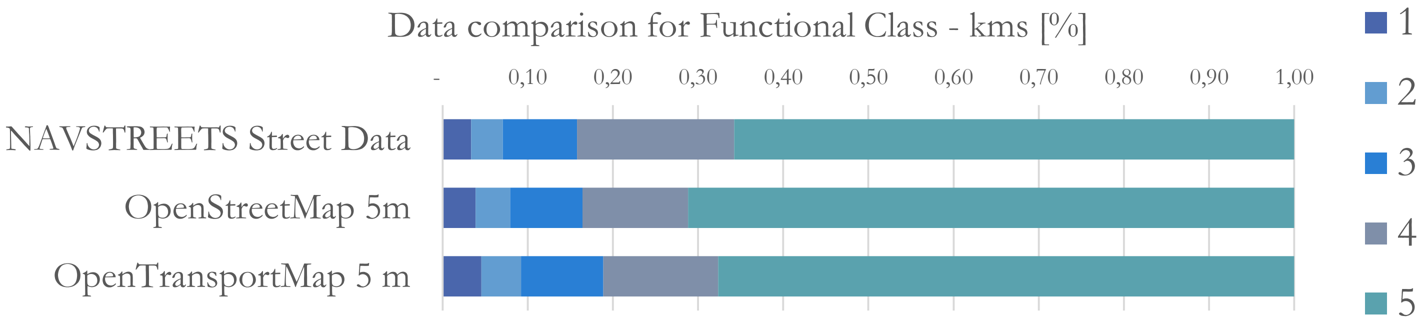
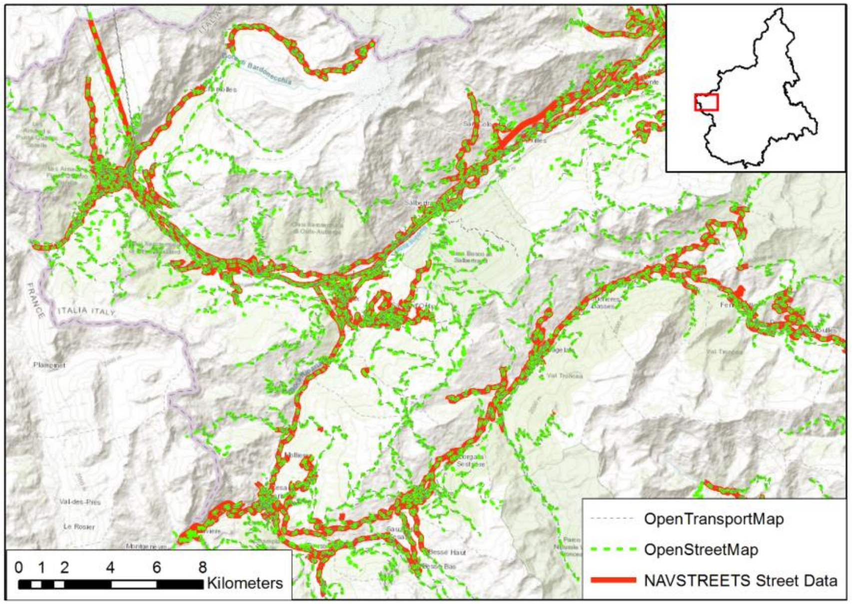
Attribute completeness – functional class



Mobility data issues

Network data comparison

OpenStreetMap – OpenTransportMap – Navstreets Streets



Evaluate differences in:

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Refined dataset in order to find a 1:1 correspondence between features:

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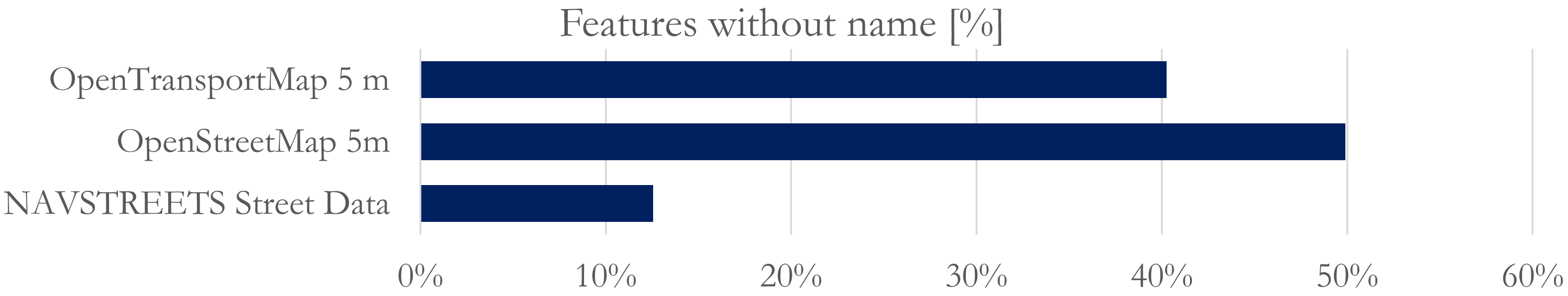
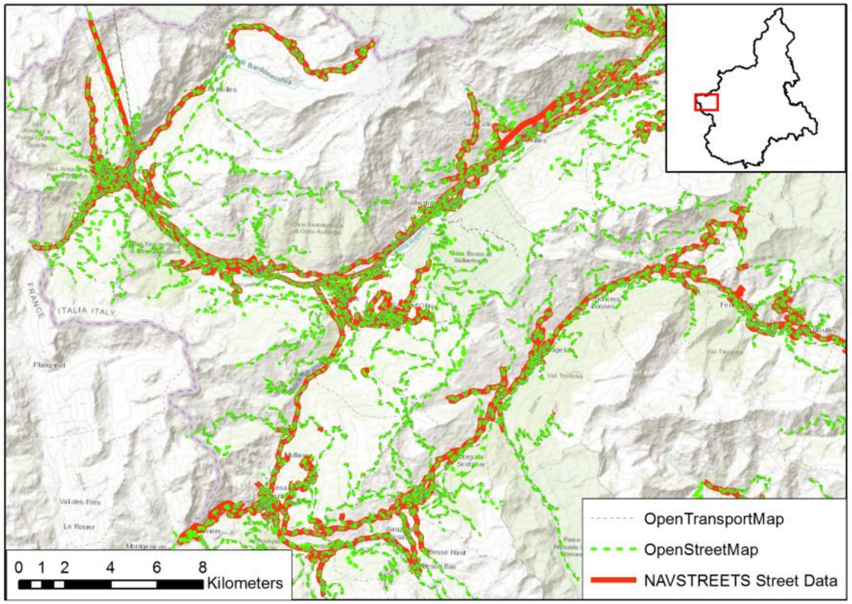
Attribute completeness – road name



Mobility data issues

Network data comparison

OpenStreetMap – OpenTransportMap – Navstreets Streets



Evaluate differences in:
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Refined dataset in order to find a 1:1 correspondence between features:
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Topology

	Feature Mean Length	N° of Features	Must Not Self-overlap	Must not Self-intersect
NAVSTREETS Street Data	0,127	406.291	0	0
OpenStreetMap	0,331	255.984	44	74
OpenTransportMap	0,183	609.952	5	15
OpenStreetMap - FeatureToLine	**0,170**	**481.524**	**0**	**0**

Mobility data issues

Network data comparison

OpenStreetMap – OpenTransportMap – Navstreets Streets

Open data:

- Complete from a spatial point of view
- Presence of topology errors
  - Correction requires time and manual effort
- Problems in attribute completeness and reliability:
  - Wrong or missing hierarchy level
  - Missing road names, misspelling errors

Commercial data:

- High reliability even if at high cost

OpenTransportMap can be considered a valid source for some basic mobility management tasks.

Commercial dataset represent the most appropriate solution for advanced mobility management tasks.

Mobility data issues

Ancillary elements of transport network

Traffic detectors

- Fixed traffic detectors (Induction loops, Microwave sensors, Ultrasound sensors, Doppler Radar, Wireless magnetic field)
- Urban Traffic Control (UTC) system (loops + stations + traffic lights)
- Cameras
- Floating Car Data (FCD)

Informative panels

- Fixed/mobile
- Specific purposes (VMS-T, VMS-Z, VMS-P, VIA)

Points of interest and other objects

- Bollards
- Restricted Access Area Gates
- Autovelox
- Parking areas
- Public Transport Stops, Stations and Depots, bike and car sharing stations
- Weather Stations

Mobility data issues
Traffic measures and events

Dynamic and real-time data

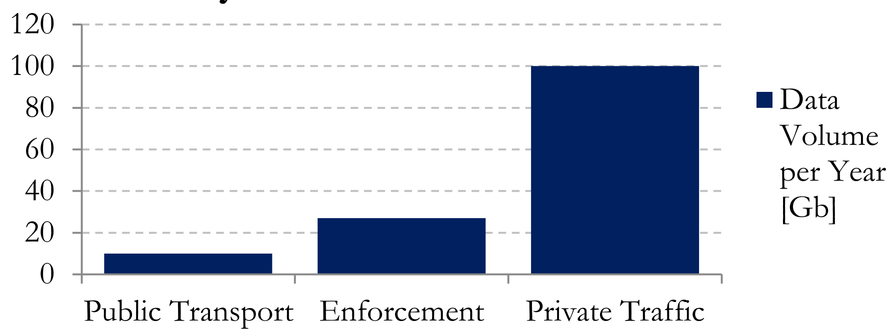
Raw measures

Flow, speed, vehicles count, travel time, vehicle positions
Temporal range: 1/5/15 minutes
Sources: fixed detectors (loops and cameras)and FCD

Aggregated measures

Mean Flow, Mean speed, Mean Travel Time, Level of Service – realtime and forecasted
Temporal range: 5/15/30/45/60 minutes
Sources: Regional and Metropolitan Supervisor software

Yearly data volume in 5T

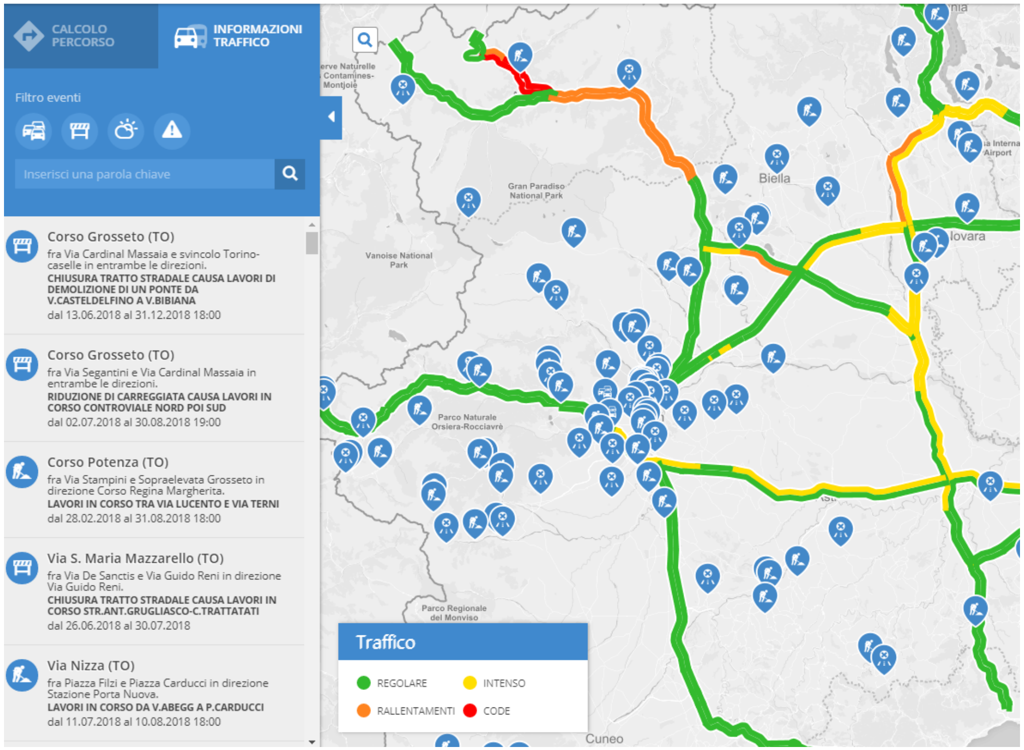


Mobility data issues

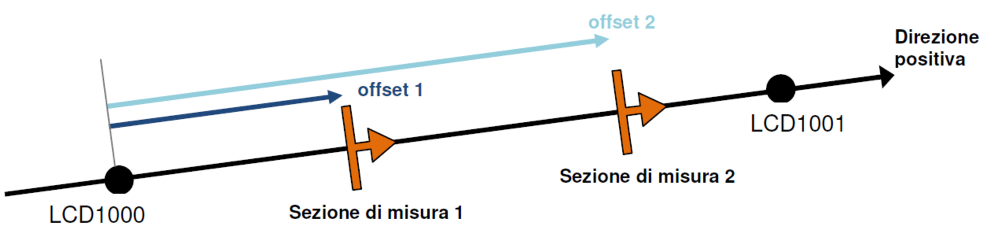
Traffic measures and events

Traffic events

Muoversi in Piemonte



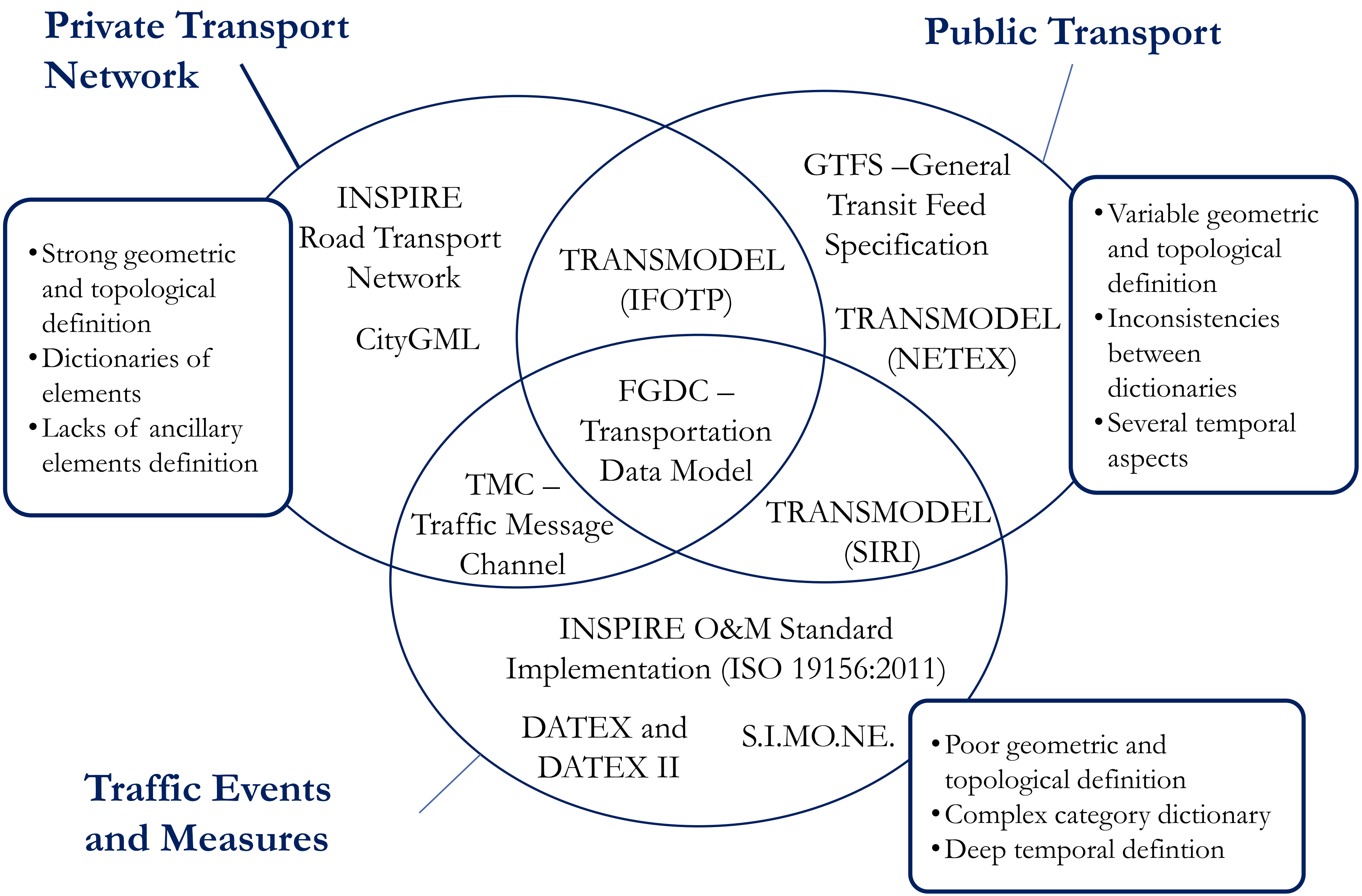
- Protocols for information exchange between agencies;
- XML encoding format;
- Complex system of categorization;



Linear referencing techniques for the correct positioning of an event.

Transport Standards

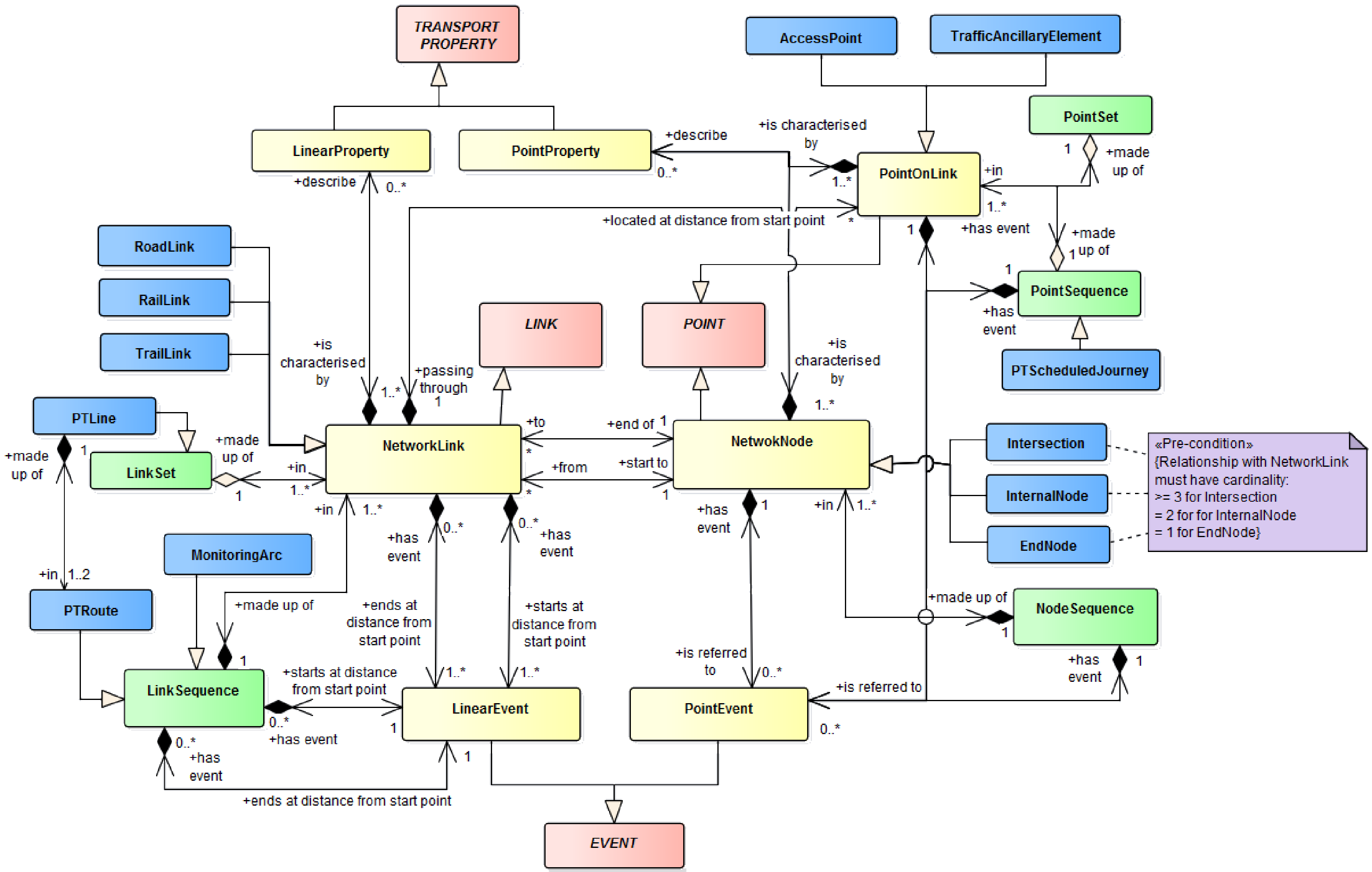
Description and comparison



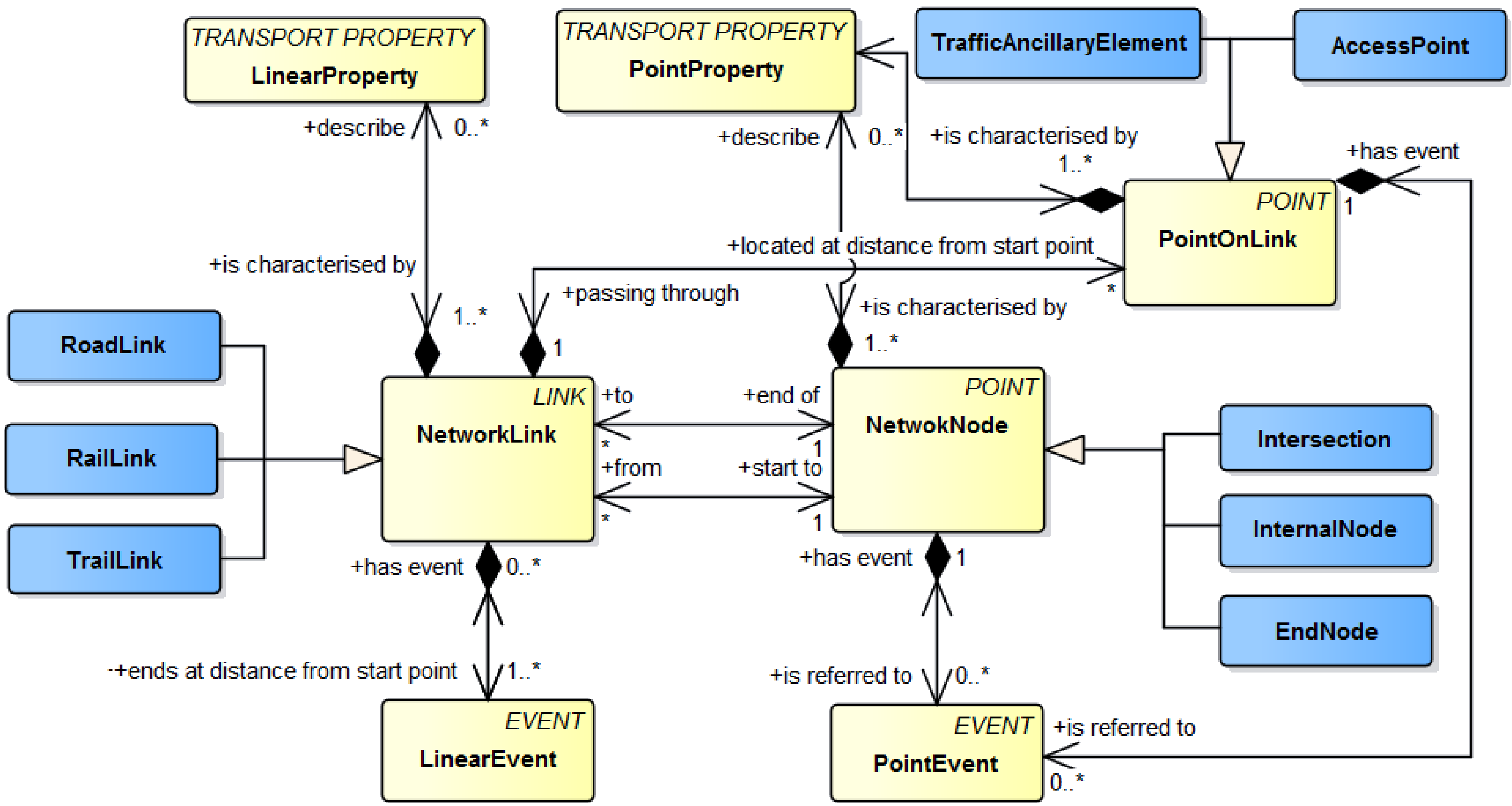
Data modelling

The conceptual data model

Overview



Main elements



Data pre-processing and ETL

Road Network

Direction of flow pre-processing

↓

Navstreets Streets 2016

↑

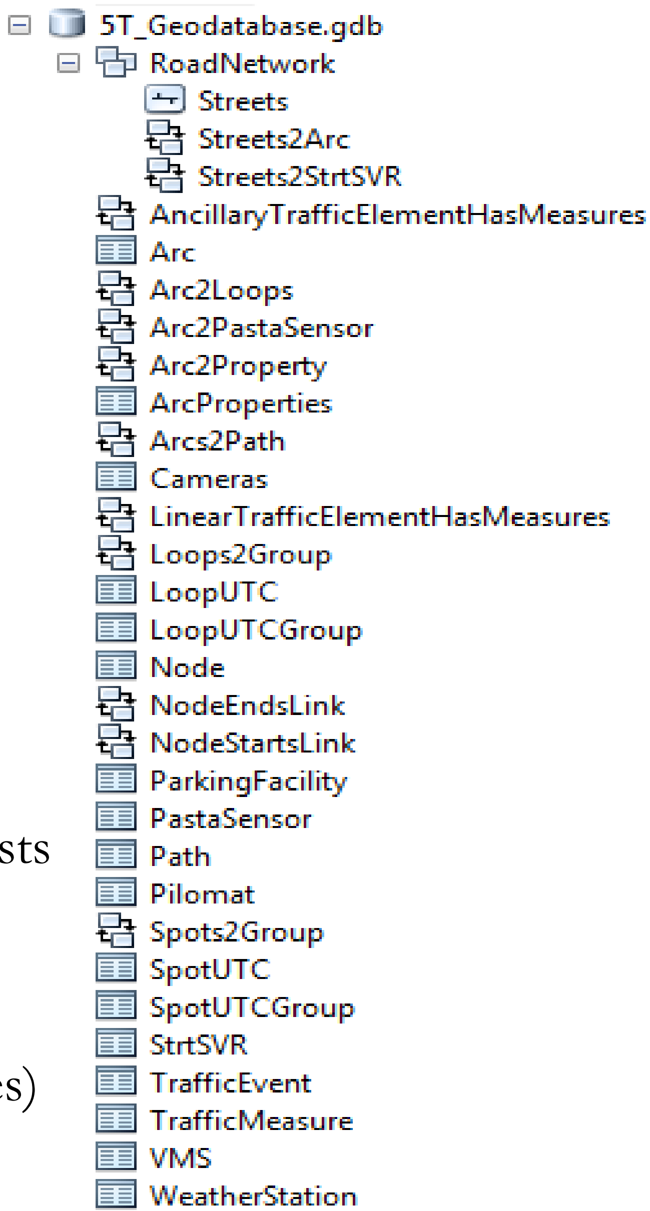
LinkSVR → Conflation processing ← 5TArcs

Ancillary Traffic Elements

- Composite primary key creation
- Attribute matching between values and code lists
- Linear referencing with ArcGIS

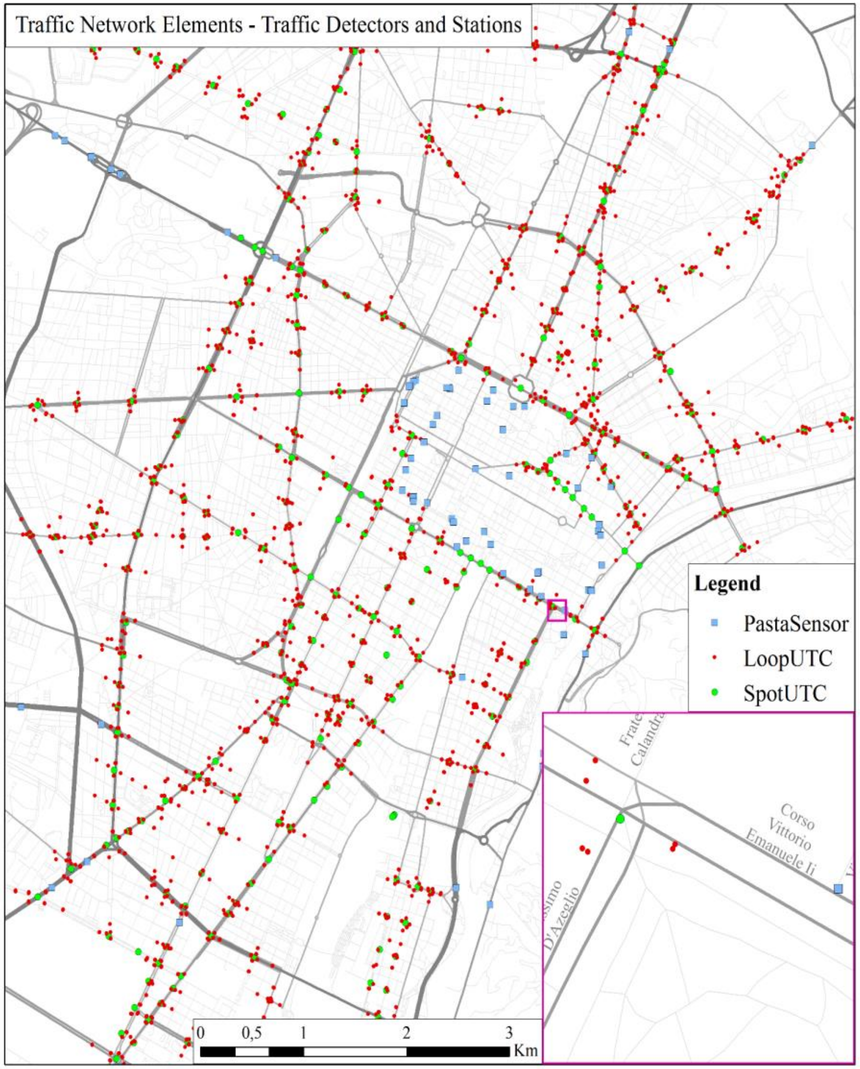
Measures and Traffic Events

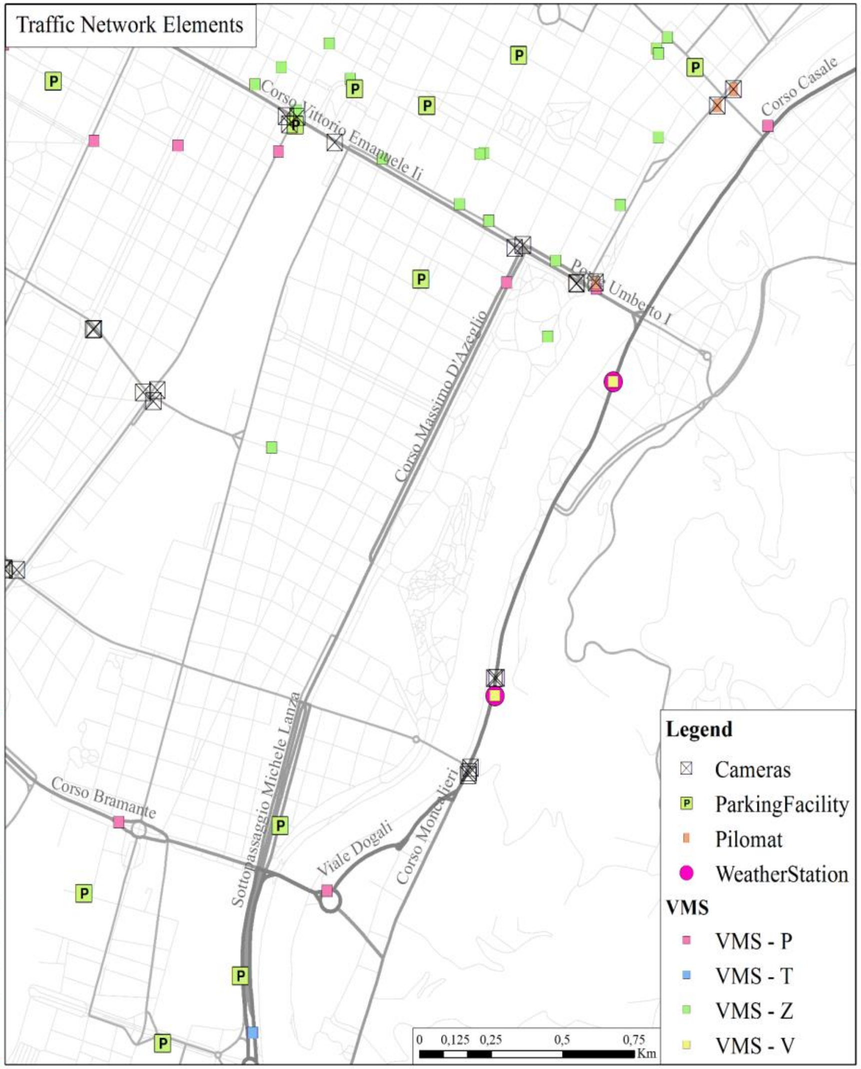
- Measures extraction scripts ("group by" queries)
- ArcGIS custom script for traffic events linear referencing on TCM locations



Applications
Elements visualisation

Visualisation and queries of fixed ancillary traffic elements

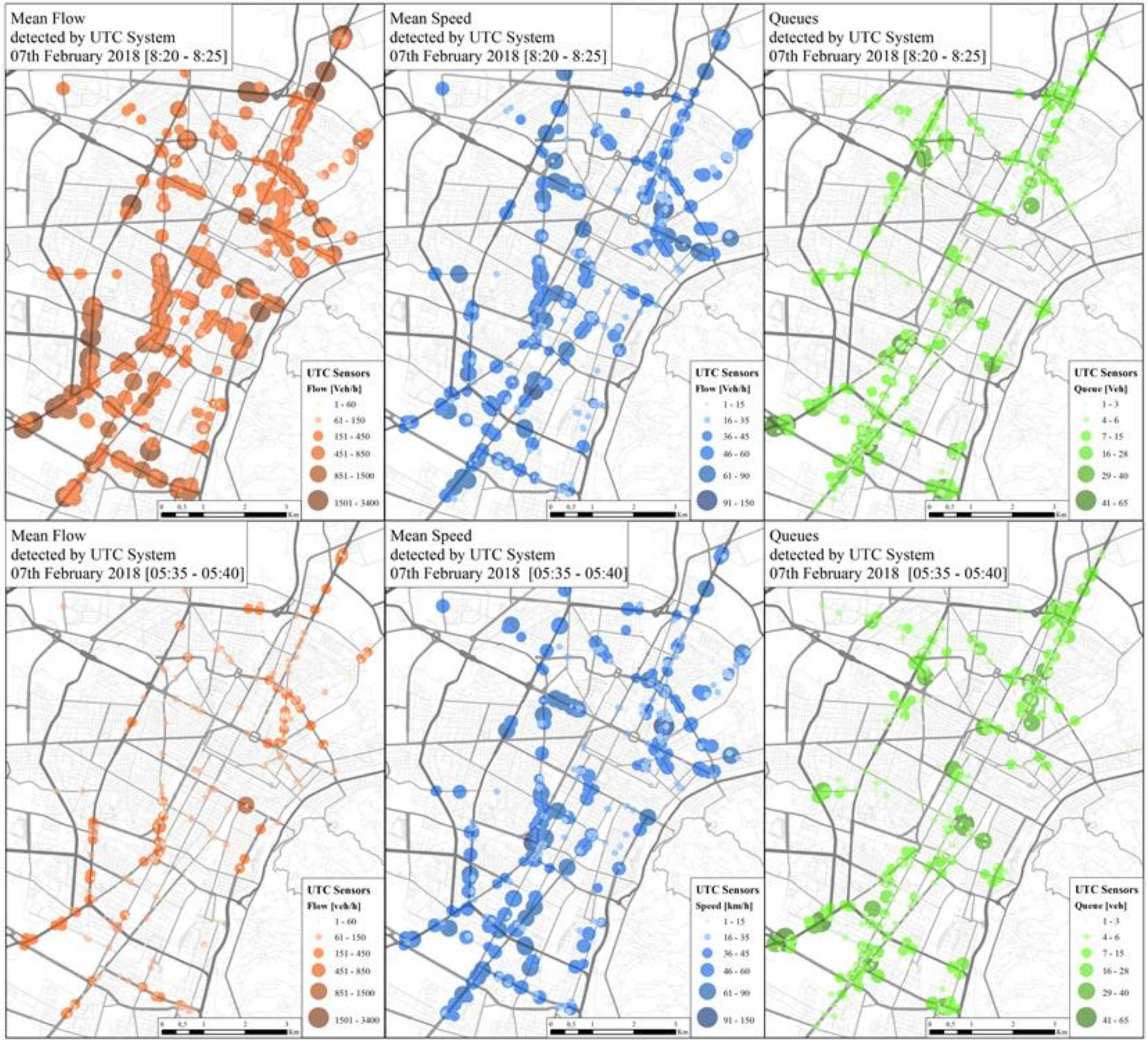




Applications

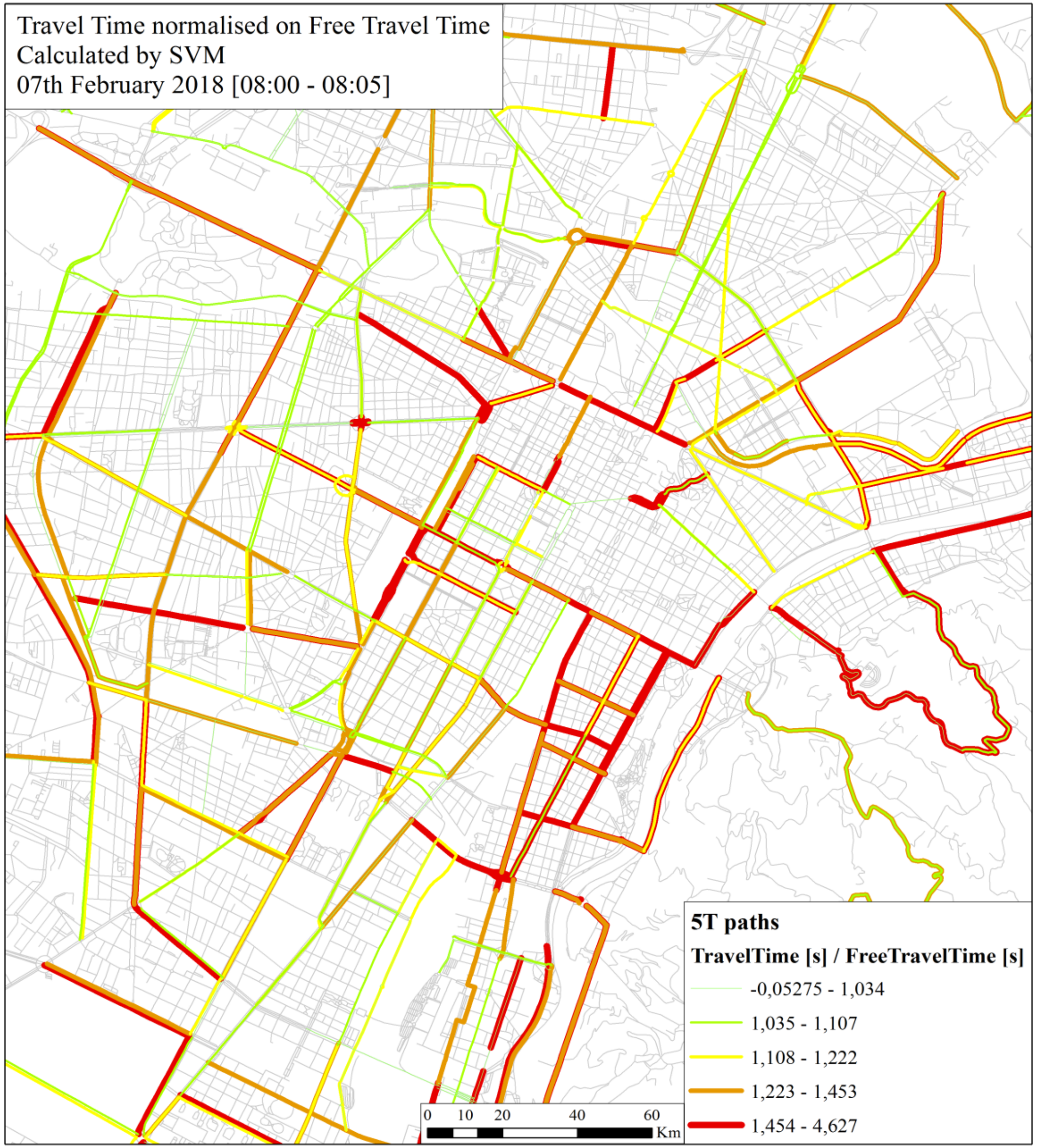
Measures visualisation

UTC measures at peak and non-peak hour (flow, speed, queues)



Applications

Measures visualisation

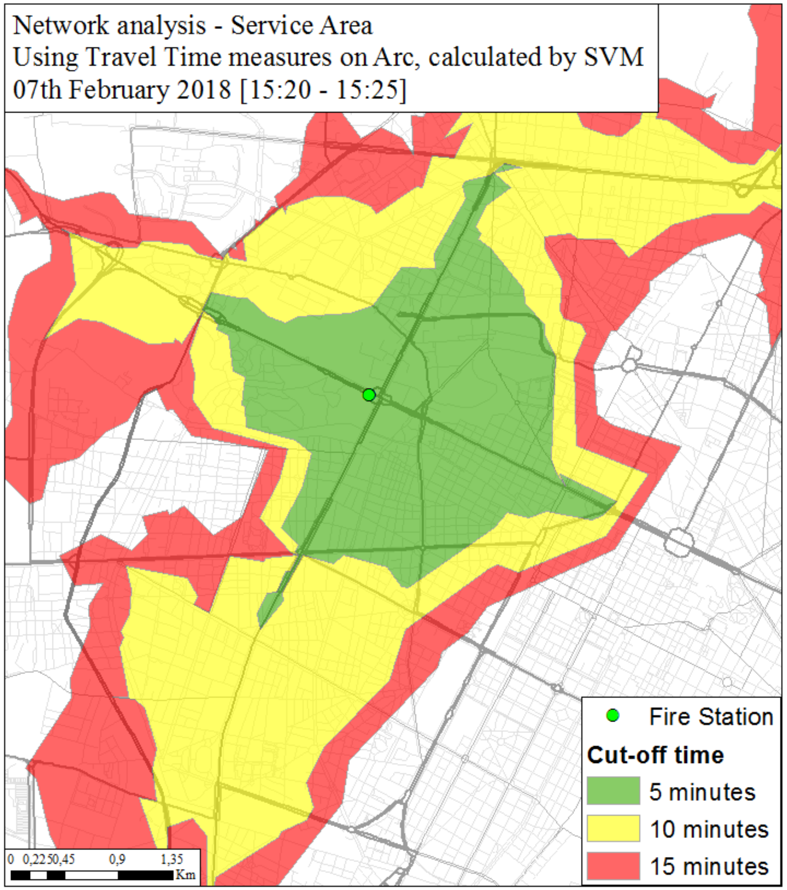


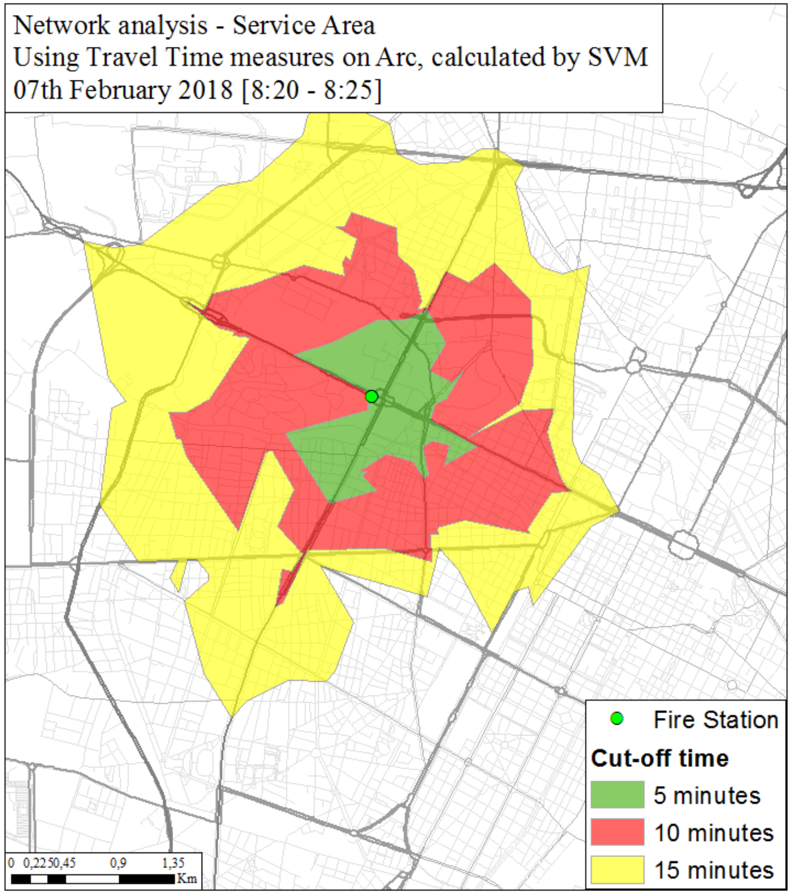
Measures from Metropolitan Supervisor, travel time normalised at peak hour

Applications

Network analysis with real impedances

Service areas at peak and non-peak hour

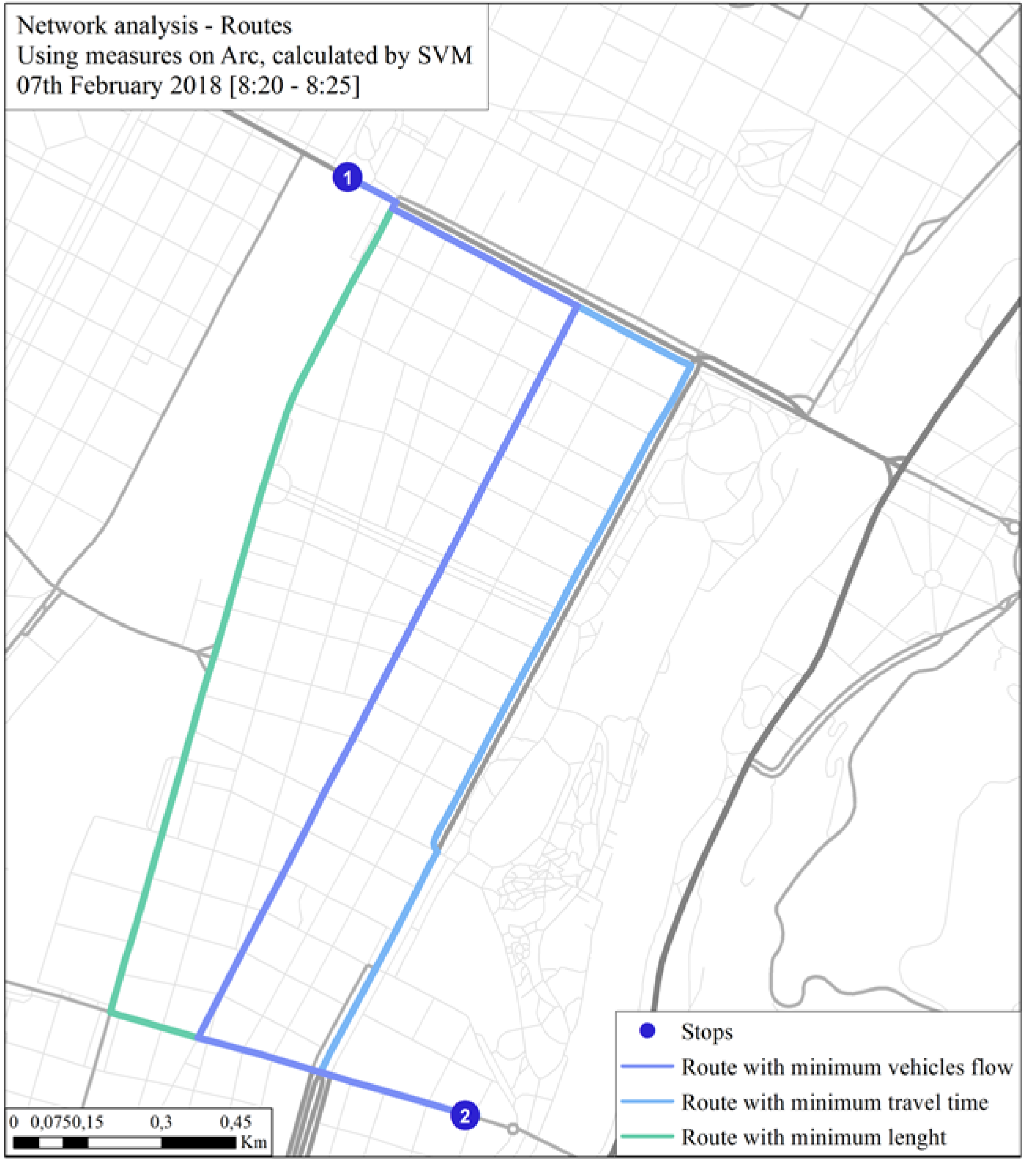




Applications

Network analysis with real impedances

Best route calculation using different types of impedances (flows, travel time, length)



Applications

Traffic events visualisation – a case study

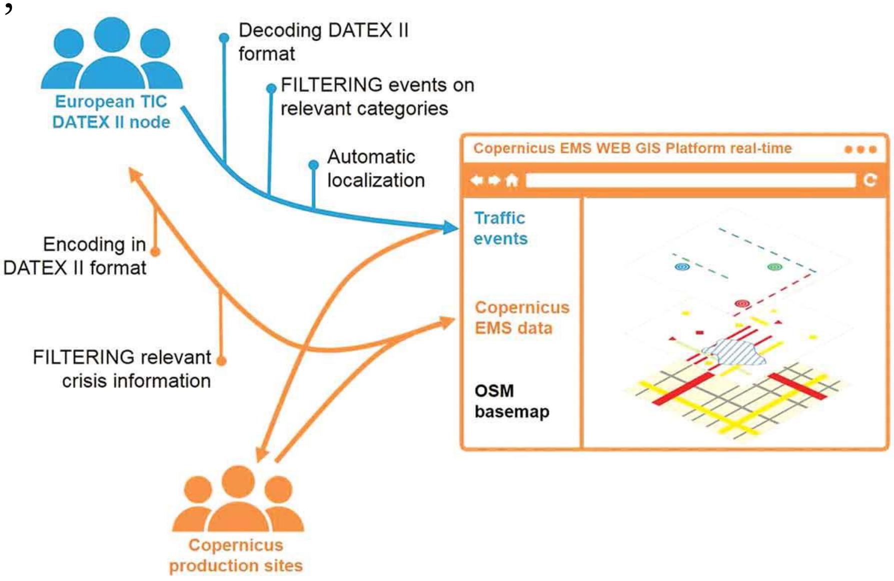
TMC traffic events for Emergency Mapping

CASE STUDY – Piedmont floods November 2016

Goal: integrate TMC info in routinary emergency mapping services

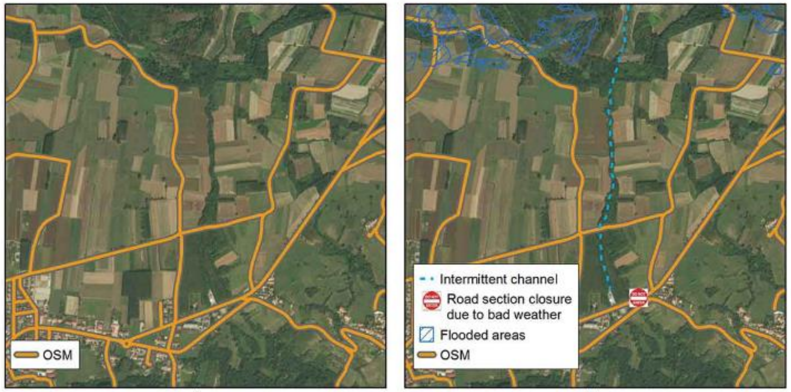
Workflow:

- 3 different sources (WordPress page, ISTA/mistic, ISTD/tcm_sistema);
- Filtering on temporal window [22/11/2016 – 02/12/2016];
- Filtering on event category;
- Materialisation of ISTA/mistic events from TMC reference to Navstreets Streets network + Parsing of WP pages versions & materialization on Navstreets Streets ;
- Confrontation between EMS damage detection and traffic events with and without a time window (Scenarios);
- Evalution of traffic events utility in both scenarios.



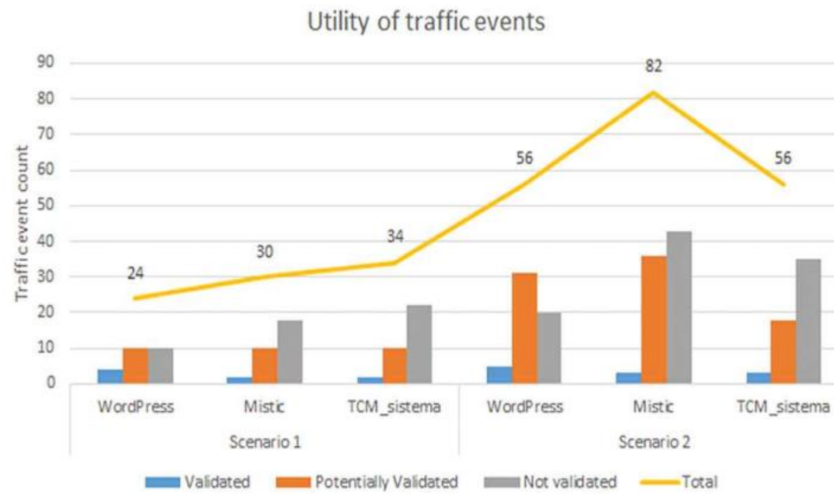
Applications

Traffic events visualisation – a case study



a) b)

→ Enhancement of reference data



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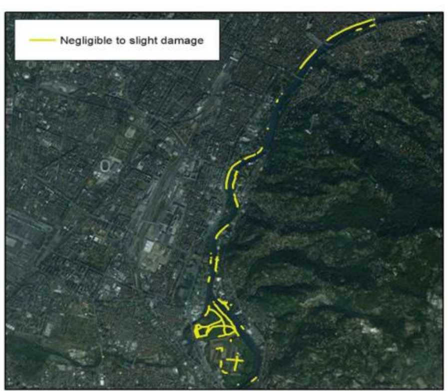
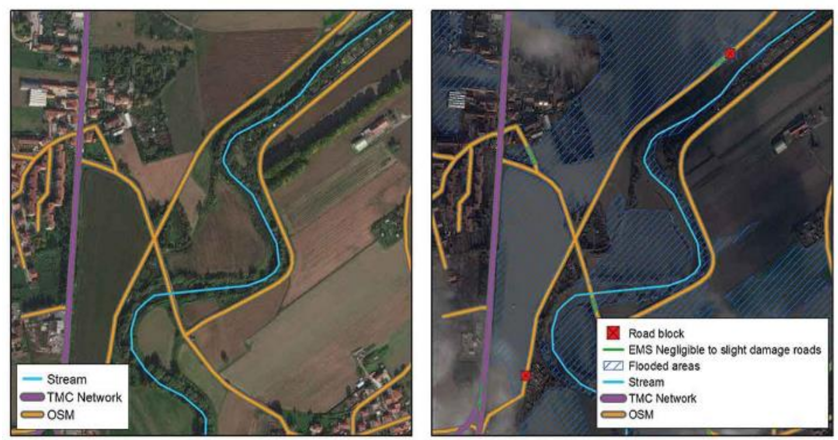


→ Damages outside TMC



a) b)

→ New road blocks

Applications

Traffic events visualisation – a case study

TMC traffic events for Emergency Mapping

Considerations on the case study - Piedmont floods November 2016

- TMC events pertaining to several km of roads: not best condition to identify spot damages. Very limited number of point events
- TMC only operational on "major" network → extend it to small rural/mountain roads (openLR?, WGS84 coordinates?)
- several TMC events pertaining the same road, not only in different mechanisms (WP, ISTD, Mistic) but also within the same mechanism → duplicated "alerts"
- DATEX II solves several issues:
    - Event categories improvement
    - Possibility to provide point coordinates and openLR referencing
- TMC for pre-alerting-imagery triggering?
- Integration TMC-OSM: the German case, impact on crowdsourcing, etc.

Conclusions

Results

Comprehensive spatial data model

- A concrete proposal of dictionary and relationships for ancillary traffic data (generally poor in transport standards)
- Good basis for reports and analysis, not suitable for operational activities

Data and model reuse

- Possibility to reuse a various types of measures and events and good performance thanks to ad hoc queries extraction and measure aggregations
- Logical data model can be adapted for other agencies and other DBMS (technology independent)
- Physical data model and ETL script highly dependent from the ITS technology

ITS to desktop GIS data transition

The process cannot be automated and reused in different contexts, but good practices and general procedures can be defined

Conclusions

Further developments

Prin further developments

Data models will be operational deployed for different goals related to operational services:

1. Extensive harvesting (and possible survey) of all the Piedmont Region bus stops with the aim to build-up a comprehensive geodatabase needed for public transportation service clearing;
2. Definition of all Piedmont Region public transportation routes (linked to bus stops) for regional routing and infomobility services deployment;
3. Extensive harvesting (and possible survey) of all Piedmont Region cycling routes for the full management of sustainable mobility and infomobility delivering;
4. Implementation of an operational data model based on radio base analytics both in static and dynamic modes to define and update already available origin-destination matrix

Conclusions

Further developments

Additional elements for spatial data model

- Operational and management aspects of ancillary traffic elements (status, connection types, diagnostics, IP…)
- Real time and complex type data (as cameras outputs, VMS messages…)
- Integration of travel demand (O/D matrix)
- Most sophisticated network analysis as "what if" scenarios
- Specification of public transport components and measures (defined only at conceptual level)
- Integration of slow and sharing mobility elements (bicycles paths, bike and car sharing stations)
- Adoption of DATEX II dictionary and OpenLR location system for traffic events

Prin further developments

Data models will be operational deployed for different goals related to operational services:

1. Massive harvesting and possible survey to implement a Piedmont Region bus stops GeoDB needed for public transportation service clearing and for infomobility dispatch;
2. Setting-up of a Piedmont Region bus routes GeoDB (to be linked with the bus stops one) for public transportation regional routing;
3. Massive harvesting and possible survey to implement a Piedmont Region cycling routes GeoDB for sustainable mobility and infomobility purposes;

Prin further developments

4. Implementation of an operational data model based on radio base analytics both in static and dynamic modes to define and update already available origin-destination matrix;
5. Setting-up of an homogeneous National road graph (at a different map scale) in collaboration with MIT to be used for traffic monitoring, assets inventory, meteo application, etc. (accordingly to the recent "Smart road" act);
6. Definition of navigable road graphs (both 2D and 3D) for connected cars and autonomous driving applications.