D6.2.5

Identification of specifications according to use-cases

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LIST OF ABBREVIATIONS

Acronym	**Description**
API	Application Programming Interface
DB	Data Base
ETA	Estimated Time of Arrival
ETD	Estimated Time of Delivery
FCD	Floating Car Data
GA	Grant Agreement
GPS	Global Positioning System
ICT	Information and Communication Technologies
ITS	Intelligent Transportation Systems
JSON	JavaScript Object Notation
LoS	Level of Service
ML	Machine Learning
PCS	Port Community System
POI	Point of Interest
REST	Representational State Transfer
RTTI	Real Time Traffic Information
TM	Traffic Management
TM2.0	Traffic Management 2.0
TMC	Traffic Management Centre
TOS	Terminal Operating System
T&L	Transport and Logistics
V2X	Vehicle To Anything

VMS	Virtual Message Signs
XML	Extended Mark-up Language

CONTRACTUAL REFERENCES

FENIX stands for “A European **FE**derated **N**etwork of **I**nformation e**X**change in Logistics”. FENIX is an action 2018-EU-TM-0077-S under the Grant Agreement number INEA/CEF/TRAN/M2018/1793401 and the project duration is 36 months, effective from 01 April 2019 until 31 March 2022. It is a contract with the Innovation and Networks Executive Agency (INEA) under the powers delegated by the European Commission.

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1 INTRODUCTION

1.1 Purpose of the document

The work performed in task A6.2 aims to implement measures for the reduction of congestion, fostering safety, and improving the level of service on the FENIX network. The FENIX network includes logistics operations and goods transportation, and the overall objective is to:

- Improve information and data sharing in a cross-domain urban/interurban environment
- Improve cross-border and multimodal cooperation
- Foster interoperability

As stated in the FENIX GA, sub-activity A6.2 will be completed in 2 phases: a first one dedicated to the specification of the TM2.0 services in FENIX and a second phase dedicated to implementation, deployment, and impact validation of the deployed services. The first phase includes the identification of scenarios for coordination of multimodal traffic management (TM) plans at cross-border and urban/interurban integration. This has allowed the definition of measures to minimise perceived discontinuity in quality of information for traffic management services, the identification of needs for data exchange and the identification of the information system requirements. The first phase is being concluded with the specification of the TM2.0 services and the description of the system architecture for Transport & Logistics (T&L) services (D6.2.5).

The present document starts by describing the identified data processes, based on the TM2.0 scenarios defined in deliverable D6.2.4[1] (Chapter 3). Chapter 4 is focusing on providing a general technical specification of each data process, presenting a problem statement, a description of the objective, steps, input, and output data. Chapter 5 presents the comprehensive blueprint for the TM2.0 services, related to data exchange and describes the system architecture for T&L services. Finally, Chapter 6 concludes the document and provides a description of the next steps.

1.2 Connection to other deliverables

The work contained within the various deliverables of A6.2 is interconnected, as shown in the following image.

[1] FENIX Deliverable D6.2.4: *Definition of information system requirements*

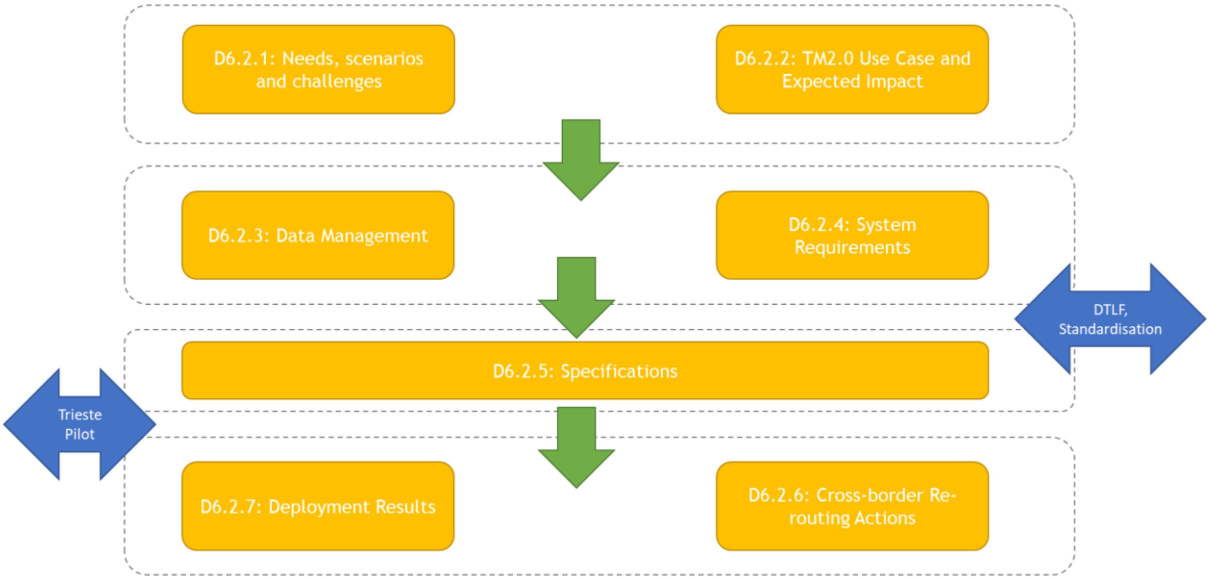

Figure 1: Interaction of subtasks in Activity A6.2

This deliverable has received inputs from D6.2.2, D6.2.3[2] and D6.2.4, which respectively describe the TM2.0 use cases, the relevant data needs, and the overall system requirements.

The document will provide inputs to D6.2.6 and D6.2.7, which concerns the presentation of the results of the deployment activities performed at the pilots, and the results of the study for re-routing cross border actions and corridors services.

1.3 Methodology

For the work performed in this deliverable the following process was followed:

1. By analysing the already defined specific TM2.0 services, scenarios and experiences, described in D6.2.2 & D6.2.4, relevant cooperative data processes are identified. By cooperative, we mean data processes that involve several data sources and/or stakeholders.
2. Each data process is analysed and specified, describing either the correlation analysis, aggregations or exchange required; the analysis also describes the data inputs-outputs.
3. Using this bottom-up approach, a comprehensive blueprint for the TM2.0 services is presented. The blueprint provides the association between the data processes and the TM2.0 services and scenarios.

[2] Deliverable 6.2.2: *Demonstrating and evidencing the added value of Traffic Management 2.0 featuring new services dedicated to the optimization of transport and logistics processes* and Deliverable 6.2.3: *Definition of data exchange needs and requirements*

4. The proposed system architecture for the provision of T&L services is presented.

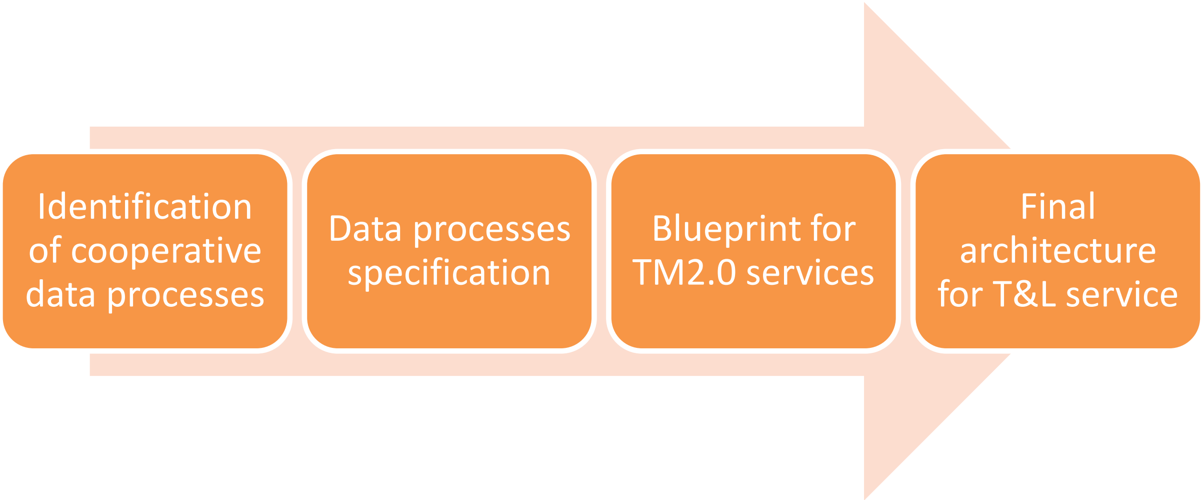

Figure 2 Methodology for D6.2.5

2 EXECUTIVE SUMMARY

Improved road transportation performance for freight movement, through the implementation of efficient Traffic Management schemes, has the potential to increase efficiency all along the supply chain, and thus increase the transport efficiency of manufacturers, distributors, and retailers.

The goal of FENIX A6.2 is to extend the TM2.0 concept to include Freight Transport stakeholders in the traffic management loop, using the existing infrastructure to share data and improve the overall coordination among all the actors involved in the logistics chain.

Analysing operational data in real-time, numerous services can be developed to positively influence the utilisation of the infrastructure and resources. The information provided can be used to improve multimodal, urban-interurban and cross-border logistics operations. This will help increase the flexibility and resilience of the system, as well as the service quality, and it will ultimately help reduce greenhouse gas emissions, fuel consumption, idle times, revenue losses and delivery times.

Starting from the TM2.0 services and scenarios identified in the previous reports of A6.2[3], the present document, deliverable D6.2.5, first specifies the data processes that will be followed to provide the TM2.0 services at the relevant pilot sites. These data processes are defined either in the form of correlation analysis (i.e., multiple data types provide a new data type), or in the form of data aggregation (i.e., multiple data sources are integrated and provide an aggregated output) or data exchange (i.e., same data types are exchanged between different stakeholders to support a traffic management procedure).

Based on the data processes' analysis, a TM2.0 blueprint and a high-level system architecture will be defined, to support cooperation between stakeholders in the Traffic Management, Transport and Logistics sectors.

[3] Enhanced traffic management in L&T corridor information systems services

3 Definition of Data Processes according to TM2.0 Scenarios

The implementation of TM2.0 scenarios requires several data types, which need to be aggregated, correlated and/or exchanged to produce meaningful results leading to the scenario successful execution. In Table 1, these data processes are associated with the TM2.0 scenarios that have been identified in deliverable D6.2.4.

Table 1: How the TM2.0 scenarios are associated with necessary data and data processes

A/A	Type of scenario	Scenario name	Description	Data process name	Input	Output	
						Trigger	Traffic measure
1	Multimodal	Network optimization based on intermodal data exchange	Within this scenario, the scheduled ships' arrival times and the suggested time for the truck arrival at the terminal are shared with the mobility agency/Traffic Management Centre. Strategies are actuated to optimally distribute the freight traffic across the road network near the port area, by using all the available infrastructure (e.g., parking, buffer zones, rest area, secondary roads, etc.) Re-routing options are provided to truck drivers, considering both traffic conditions and port information. Arrival times at terminal are therefore optimised, avoiding peaks, and reducing queues at gates.	Correlation of scheduled cargo ship arrivals, scheduled truck arrivals and real time road traffic data	Scheduled ship arrival times Reserved (scheduled) truck arrival times Historical traffic data Real time parking / buffer zone availability Real time traffic conditions	Forecast congestion around Terminal	Parking suggestions Re-routing suggestions
2			Within this scenario the real time, actual ferry boat arrivals are shared with the mobility agency/Traffic	Correlation between real time ferry boats arrivals	Historical ferry boat arrival time stamps, vehicle	Forecast congestion around	Re-routing suggestions

A/A	Type of scenario	Scenario name	Description	Data process name	Input	Output	
						Trigger	**Traffic measure**
			Management Centre. In this case the System implements Traffic Management Strategies based on a network of virtual VMS which are addressing the Business users identified. The Traffic Management Strategies (virtual VMS content and position) are available to Traffic Management Operators and Infrastructure Authorities.	and road traffic	capacity, and actual number of vehicles per trip Historical traffic data Real time Ferry boat arrivals Real time road traffic	terminal	Traffic light control
3	Multimodal	Traffic anomaly forecast at Port gates and surrounding roads (Proactive)	The predictive model is used to identify traffic patterns in the long run and potential traffic anomalies forecasts in the short run. These will be communicated via email to Fleet Managers.	Correlation between container terminal Gate, truck traffic and road traffic	Historical Gate's traffic flow Historical traffic data	Forecasted traffic congestion	Dashboard
4	Multimodal	Real time Traffic anomaly at Port gates and surrounding roads	Within this scenario the real time situation at the Port's gate is monitored in real time	Gate traffic data monitoring	Real time Gate's traffic flow	Real time traffic congestion at the roads leading to the	Real time traffic information

A/A	Type of scenario	Scenario name	Description	Data process name	Input	Output	
						Trigger	Traffic measure
						Gates	
5	Multimodal	Multimodal Estimated Time of Arrival (ETA) for cargo optimization	Within this scenario, cargo transport to logistics hubs is optimised by providing ETA in a single point of visualization (dashboard) of all the transport modes related to the transport. This includes truck, train, vessel/barge, and ship. ETA is key information for operation planning at strategic points of corridors. Through the ability of several data sources, accurate and significant volume of ETA is delivered through a multi-sources ETA collector and calculator to provide to terminal operators a clear visibility of in-going and out-going flows of cargo.	Traffic data aggregation Vessel arrivals/departures	Truck estimated or actual arrivals and departures Vessel arrivals and departures		Dashboard
6	Urban – Interurban	Collaborative Traffic Management Strategies	Within this scenario, a truck driver is informed of traffic events occurring on the highway and an alternative route, appropriate for heavy goods vehicles – thus avoiding roads where trucks are prohibited, is proposed, if needed, to	Traffic data aggregation	Real time traffic incidents Traffic Management Plans	Real time traffic incidents	Real time traffic information Re-routing suggestions Parking

A/A	Type of scenario	Scenario name	Description	Data process name	Input	Output	
						Trigger	Traffic measure
			shorten time of arrival. Traffic Management plans and strategies coming from the traffic operators are shared with the freight operators and truck drivers to support a better trip planning and to improve the decision-making process.		Traffic Management strategies Parking information		suggestions
7	Urban – Interurban	Floating Car Data (FCD) aggregation	Within this scenario, FCD coming from the logistics fleets (using the mobile app) is integrated for a more precise travel time estimation on highways. More specifically, average speeds are calculated for each network link. These speeds are used to improve the standard network and thus calculate more realistic travel times. The combination of real-time traffic information and forecast capabilities enables the road operator to derive measures to mitigate congestion, manage traffic more efficiently and enhance the Traffic information	FCD aggregation	GPS coordinates	Average speeds at road links (real time and historical)	

A/A	Type of scenario	Scenario name	Description	Data process name	Input	Output	
						Trigger	Traffic measure
			services. Indeed, if enough data are present, traffic planners can analyse capacity bottlenecks in road networks: for example, hot spots, where congestions occur regularly, can be identified and targeted measures to mitigate congestions initiated.				
8	Urban – Interurban	Points of interest Notification	Provision of information that allows drivers to reduce fuel consumption or that allows them to plan their route knowing where to stop to fill up with the most cost-effective fuel. Information provided includes presence of repair services, truck stops, rest stops, and service stations affiliated with the logistics operator. It helps them make informed decisions about the best route to take.	POIs aggregation	POIs information		POIs notifications
9	Cross - border	Cross border collaborative traffic management	Within this scenario, Traffic Management plans and strategies coming from the traffic operators of two neighbouring countries are	Cross-border traffic data exchange	Traffic management plans Traffic	Traffic incidents	Traffic management strategies (re-routing

A/A	Type of scenario	Scenario name	Description	Data process name	Input	Output	
						Trigger	Traffic measure
			exchanged and decisions shared with freight operators and truck drivers. More specifically, a predefined allocation of rerouting measures to a specific situation (such as incidents, heavy congestion, planned events (road works), environmental issues) is set and shared, in order to control and guide freight traffic flows as well as to inform truck drivers pre- and on-trip and provide a consistent and timely service to the truck drivers.		management strategies (re-routing measures) vs specific conditions Real time traffic conditions		measures) vs specific conditions

4 Data Processes Specifications

The data processes identified in the previous section are either data aggregations/collection processes, data correlation processes or data exchange processes. In Table 2, they are presented and clustered per process type. The processes are then detailed in the following chapters**.**

Table 2: General presentation of data processes

Data process type	**Data process name**
Data aggregation and collection	Gate traffic data monitoring
	Floating car data aggregation
	Traffic data aggregation
	POIs aggregation
Data correlation	Correlation between real time ferry boat arrivals and road traffic
	Correlation between scheduled cargo ship arrivals, scheduled truck arrivals and road traffic
	Correlation between Port Gate traffic and road traffic
Data exchange	Cross border traffic data exchange

4.1 Data aggregation and collection processes

4.1.1 Gate traffic data monitoring

4.1.1.1 Problem statement

The trucks accumulated at the Port's Gates, especially during peak time, may result in long queues, which in turn may have a negative impact on the efficiency of the neighbouring road network. For this reason, the gate traffic, in terms of flows, delays and queues should be monitored on a regular basis both for real-time as well as planning reasons.

4.1.1.2 Data process description

The Port Operators may have implemented access control systems that are monitoring in real time the trucks coming in and out of the Port area. The access control systems collect and aggregate incoming and outgoing truck data. One type of data collected is the number of trucks getting in and out of the Port Gates per volume of time. These data are aggregated to provide information on Gate traffic capacity and, as a result, indication of queues and delays.

4.1.1.3 Description of input data

The input data consists of the following data types:

- Individual truck entrances and exits with date/time stamps.
- Indication of whether the truck should follow a specific entrance or exit lane (for example, the truck needs to go through Customs or not).

4.1.1.4 Description of output data

The output data is trucks flow. The process should dynamically quantify the trucks waiting at the custom gates by forecasting or measuring in real time the truck arrivals at the port's gates.

4.1.2 Floating Car Data (FCD) aggregation

4.1.2.1 Problem statement

Traffic congestion can have a serious impact on logistics operations, influencing arrival times at port or last mile deliveries. Real time data, obtained from GPS equipped vehicles, can be integrated with the more traditional data collection methods (e.g. Magnetic loops, road tube counters, piezo sensors, radars, etc.) to achieve a better traffic corridor control and management. In particular, the objective is to:

- Optimise the travel times predictability for trucks,
- Optimise Traffic Network and identify hot spot (detecting congested areas in the network).

Combination of real-time traffic information and forecast capabilities enables the road operator to derive measures to mitigate congestion, manage traffic more efficiently and enhance the Traffic Information Services. Indeed, if enough data is present, traffic planners can analyse capacity bottlenecks in road networks: for example, hot spots, where congestions occur regularly, can be identified and targeted with measures to mitigate congestions initiated.

4.1.2.2 Data process description

Objective: integrating Floating Car Data (FCD) coming from logistics fleets to obtain a more precise travel time estimation on highways and to develop an algorithm to detect the traffic congestion information on the highway and state road around the port area.

- Step 1: Definition of the road network of interest & x time
- Step 2: Data pre-processing
- Step 3: Map matching
- Step 4: Travel speed estimation
- Step 5: Traffic congestion classification
- Step 6: Integration with other traditional congestion detection methods

Road network definition

The affected road network could be divided into many areas depending on the proximity to the Port gates and the accessibility to major roads.

Data pre-processing

The incoming data is pre-processed in order to be filtered against "statistical noise" such as incomplete or wrongly configured data sets.

Map matching

The vehicle position data is filtered to be reliably associated to the road network links.

Travel speed estimation

Average speeds will be calculated for each network link. These speeds will be used to improve the standard network and thus calculate more realistic travel times.

Traffic congestion classification

The travel speeds are measured against free flow speeds that have been derived from previous analysis of the road network. Based on the deviation of the actual speeds vs the free flow various levels of service are defined by the system.

Integration with other traditional congestion detection methods

The Floating Car Data may be integrated with other traffic data through fusion techniques in order to provide a more reliable end result.

4.1.2.3 Description of input data

Input data consists mainly of speed and position information associated with time to which they refer. These raw data are defined from the PVT (position, velocity, time) information made available in the standard NMEA 0183 from GPS receivers. The OBU, to reduce transmission costs (GPRS), send only part of the data produced by GPS: PVT data, the direction, and the index of precision HDOP. The basic data obtained from GPS are integrated with the information that the OBU can calculate or retrieve by further on-board measurement systems (odometer) recorded upon the acquisition of GPS position. The data may refer to the FCD data from private vehicles (cars), fleet generated by means of public transport (bus) and commercial fleets.

The type of vehicles is distinguished by the attribute vehicle type, this makes it possible to treat data for homogeneous classes (e.g. private transport, freight, and public transport).

Table 3: FCD detailed data types

Data Type	Details
Veh	Anonymous vehicle ID
Timestamp	Time with reference to the GMT
Lat	Latitude WGS84
Lng	Longitude WGS84
Alt	Altitude
Heading	Direction respect to the geographic north
Speed	Instantaneous Speed km/h
Hdop	Precision factor
Event	Triggering event (e.g., sampling, keyOn, keyOff, door opening etc.)
Tracking_distance	Odometric distance respect to the previous measure [m]
Global_distance	Total odometric distance [m]
Tracking_type	Type of Sampling: time, space, mixed
Vehicle_type	Vehicle type: car, truck, bus, tram etc.
Vehicle_information	Various parameters: engine type, kW, class etc.

4.1.2.4 Description of output data

Output data are Travel Time (TT) estimation and travel Origin Destination (OD) data.

TT information consists of compiled and aggregated data. A travel time on an arc of the reference graph will be communicated instead of the single location of a vehicle.

There are two different TT data / speed: The first is an effective "measure", characterized by three fundamental parameters of the statistics distribution (mean, standard deviation, and number of samples). The second is “estimation" based on the proprietary methodology of the fleet owner characterized by a value "Estimated" and a quality indicator of the estimate.

Table 4: Data for TT calculation

Data Type	Details
LCD 1	Location reference code of start location
LCD 2	Location reference code of end location
start_time	Starting time to which data are reported
stop_time	End time to which data are reported
Time	Average travel time [s]
Speed	Instantaneous Speed km/h
n_vehicles	Number of vehicles that contributed to the calculation
std_dev	Standard deviation of the sample distribution
Accuracy	Shows, in percentage, the validity of the data.
estimated_ speed	Estimate of the speed [km/h]
q_idx	quality index of the estimate (1 = min, max = 5)

Travel OD information is the number of trips for each origin-destination pair defined within the OD matrix.

4.1.3 Traffic data aggregation

4.1.3.1 Problem statement

Real-time accurate traffic data collection and aggregation can generate reliable traffic insights within a pre-defined period and area, enabling transportation systems to monitor and manage operations, maximizing safety and efficiency.

Final objective is to:

- Optimise the travel times predictability for trucks
- Optimise Traffic Network and identify hot spot

- Generate more tailored traffic management plans and strategies.

4.1.3.2 Data process description

Objective: Collect and aggregate traffic data from multiple sources to control and manage (freight) traffic as well as to inform drivers pre- and on-trip and provide a consistent and timely service.

- Step 1: Definition of the road network of interest
- Step 2: Identification of data sources
- Step 3: Data collection
- Step 4: Data fusion and processing

Road network definition

The road network should be divided into road sections to allow for a better monitoring of the area.

Data sources identification

Road operators can perform better interpretation of the observed traffic conditions by considering various data sources across different data providers. Data sources can include, but are not limited to:

- Inductive loop detectors: they detect vehicles movement, presence, count, and occupancy.
- Magnetic sensors: they detect vehicles movement and presence.
- Cameras: they detect vehicles across several lanes, allow for vehicles classification, flow rate, occupancy, density, speed, and queue length.
- Radar: it detects vehicles, measures speed, and detects movement direction.
- Infrared: It can measure speed, vehicle volume, and lane occupancy.
- Ultrasonic: it allows to detect vehicles presence and occupancy.
- GPS: it provides information on vehicles location (coordinates), speed and direction.
- Bluetooth: It detects traffic streams.
- Cell phone tracking: it provides geographic location.
- Weather station: it allows to gather meteorological data, including weather, temperature, and wind speed.
- Etc.

Data collection

Sensors/data sources create a raw input signal in various formats, which then needs to be collected, and filtered into meaningful features before being used to take decisions for better traffic management. An incomplete and inaccurate data collection phase can affect estimation and forecast results.

Data fusion and processing

Different methodologies exist to process collected data to forecast and provide real-time travel and event information. These methodologies depend amongst others on the data fusion and processing system used, and traffic model applied.

In general, processing and performing data fusion for data coming from multiple sources increases prediction accuracy of the models, and decreases the uncertainty present in individual source data, leading to a better interpretation of the observed situation.

The choice of the method depends on different variables, most importantly the available data and final application. Operational constraints and flexibility should also be considered, as well as functional growth since algorithms must accommodate increased functionality as the system evolves through time.

The main data fusion algorithms that can be used to support ITS applications or strategies are:

- Artificial neural network
- Bayesian inference
- Dempster-Shafer
- Inference rules
- Weighted mean
- Fuzzy logic
- Kalman filter & extended Kalman filter
- k-means algorithm
- Kernel estimator
- Particle filter
- Unscented Kalman filter

Once chosen, the models need to be trained and tested for evaluation.

4.1.3.3 Description of input data

Many input data need to be considered and processed to estimate and predict traffic conditions. A non-completely exhaustive list is provided in the following table.

Table 5: List of data for traffic conditions evaluation

Data variable	**Details**

Vehicle	Anonymous vehicle ID
Vehicle Class	Vehicle classification
Volume	Total number of vehicles on the road as observed over a period
Speed	Distance a vehicle travelled in time units
Distance	Distance of the path
GPS	Vehicle's locations
Occupancy	Extent of the road the vehicles occupy at location (aggregated)
Flow	Flow of vehicles on the road section at x-minute interval (aggregated)
Lanes	Number of lanes on the road section
Entrance Ramp	Number of entrance ramps on the road section
Exit Ramps	Number of exit ramps on the road section
Time	Time of the day
Day	Day of the week
Accident	Time, geographical location, and severity of the accident
Road works	Start time, end time, geographical location, and severity
Other events	Start time, end time, location, and type of events
Weather	Weather conditions (e.g., Cloudy, light fog, fog, light rain, heavy rain, snow, thunderstorm, etc.)
Temperature	Temperature (Celsius)
Wind	Wind speed

4.1.3.4 Description of output data

Output data are:

- Travel-time (TT) estimation and prediction
- Origin-destination (OD) estimation
- Traffic flow forecasting: fundamental to understand road capacity and traffic congestion.

Short-term (5/10 min ahead) and long-term predictions (1 hour ahead) can be generated. This information is an essential measurement for travel navigation decisions.

- *Traffic management and incident detection*: this is the timely detection of unscheduled incidents, with automatic detection mechanisms from data derived from the road infrastructure. Incidents are those that result in stopped vehicles (e.g., breakdown, out of fuel, or accident), rapid detection of these situations and early removal of the offending vehicles is most critical, to allow quick reconfiguration of the area.

4.1.4 POIs aggregation

4.1.4.1 Problem statement

Truck drivers require also other information when travelling, such as repair services, truck stops, rest stops, service stations affiliated with the logistics operator, secure parking lots, and so on. This information, collectively called Points of Interest (POIs), can help them make informed decisions about the best route to take, depending on their needs. The impact will be:

- Improved comfort for truck drivers
- Safer and more secure trip
- Reduced fuel consumptions/ fuel savings

4.1.4.2 Data process description

This data process includes collection of POIs from various sources to be presented to the truck drivers or fleet managers in a homogeneous way. The data aggregation is based on digital sources or manual collection and insertion of POI data into DBs.

4.1.4.3 Description of input data

Input data in POIs data consists at least of location (latitude and longitude, according to WGS84) and POI type. Optionally, the POI data may also include static content (details about the services provided at this point of interest) and/or dynamic content related.

The following table shows possible data types and related information.

Table 6: Additional POI data details

Data type	Static information	Dynamic content
Safe and secure parking areas	Location, Security level,	Availability

Data type	Static information	Dynamic content
	services provided, tariffs	
Other parking or rest areas	Location, services provided	
Fuel stations	Location, services provided	Fuel costs
Repair stores	Location, type	

4.1.4.4 Description of output data

The output data are the input data in a homogenised manner.

4.2 Data correlation processes

4.2.1 Correlation between real time ferry boats arrivals and road traffic

4.2.1.1 Problem statement

Estimate the impact of the ferry boat traffic on road traffic congestion

1. Ferry boat arrivals at the Port at time (t) , which disembark a big number of vehicles, could have a traffic impact on the road network close to the port at time (t+x), where (x) could be the vehicles' average times to; a) get off the ferry and b) travel from Port gate to the road network affected.
2. Ferry boat departures from the Port at time(t), which embark a big number of vehicles, could have a traffic impact on the road network close to the port at time (t-x), where (x)could be the vehicles' average times to; a) travel from the road network affected to the Port gate and b) get on the ferry.

4.2.1.2 Data process description

Dynamic Forecasting Methodology

Objective: develop a ML algorithm that forecasts the fluctuation on average vehicle speeds and/or number of vehicles per hour (traffic flow) at the affected road network for the next x minutes (time window) given the actual berth of Ferries and the expected number of vehicles disembarking from them at the port.

- Step 1: Define the affected road network & x time
- Step 2: Specify the historical input data for modelling process

- Step 3: Perform the correlation analysis
- Step 4: Specify the real time input data
- Step 5: Define the output forecasted data

Affected Road network

The affected road network could be divided into many areas depending on the proximity to the Port gates and the accessibility to major roads.

Required historical input data for modelling process

There are two major historical data types collected and analysed:

- Historical ferry boat traffic data
- Historical road traffic data

Regarding the first major data type (ferry boat traffic) the following elements should be collected:

- Name of the vessel
- Actual date/time of arrival or departure at the Port
- Number of vehicles carried by vessel

Regarding the second major data type (road traffic) the following elements should be collected:

- Speed information per road link per 5-minutes intervals (average speeds)
- Number of vehicles information per measurement point per 5-minutes intervals (traffic flows)
- Accidents / Road works: date/time, duration, severity
- Weather conditions

Correlation analysis

The working assumption is:

The number of total vehicles is considered an additional burden to “normal” road traffic and is expected to have an impact at time t+x (as specified in previous sections). The impact is congestion leading to lower speeds than normal speeds and more road vehicles than normal traffic flow.

The correlation analysis will prove this assumption and provide the level of speed decrease (in terms of % to the normal average speed or to the free flow speed) and traffic flow increase (in terms of number of additional vehicles).

4.2.1.3 Description of Input data

For the real time operations, we should develop two static DBs with the following data:

- First DB: Name of vessel and a) expected number of road vehicles embarking at the Port on this vessel per typical day type (weekdays and Weekends), and b) expected number of road vehicles disembarking at the Port on this vessel per typical day type (weekdays and Weekends),
- Second DB: Scheduled departures.

The above-mentioned task should be based on historical DB.

There should be the following real time data provided by external sources via APIs.

Table 7: Real time data required for correlation between ferry boat arrivals and road traffic

Data type	Details
Ferry boat berthing	Notice of berthing with time stamp. The data should contain vessel name
Speeds	Speeds at selected road links at 5 minutes intervals
Traffic flows	Number of vehicles at measurement points at 5 minutes intervals

4.2.1.4 Description of output data

The output will be 15 – 30 minutes forecast of speeds at selected road links of affected areas.

The forecasted output information will be used to activate Traffic Management measures.

4.2.2 Correlation of scheduled cargo ship arrivals, scheduled truck arrivals and road traffic data

4.2.2.1 Problem statement

High demand for cargo shipments by road vehicles will have an impact on the traffic congestion at the roads close to the port. This can be evaluated via two methods:

- By analysing the scheduled cargo ship arrivals versus the expected flow of trucks to collect cargo goods from the ships
- By analysing the scheduled truck arrivals at the port, if a digital gate appointment service would exist

4.2.2.2 Data process description

Dynamic Forecasting Methodology

Objective: develop a ML algorithm that forecasts the fluctuation on average vehicle speeds at the affected road network for the next x minutes (time window) given the expected number of vehicles entering or exiting the port.

- Step 1: Define the affected road network
- Step 2: Specify the historical input data for modelling process
- Step 3: Perform the correlation analysis
- Step 4: Specify the input data
- Step 5: Define the output forecasted data

Affected Road network

The affected road network could be divided into many areas depending on the proximity to the port gates and the accessibility to major roads.

Required historical input data for modelling process

There are two major historical data types collected and analysed:

- Historical cargo ships arrivals
- Historical port gate traffic data
- Historical road traffic data

Regarding the first major data type (cargo ships arrivals) the following elements should be collected:

- Berth of cargo ships
- Actual date/time of arrival at the port

Regarding the second major data type (port gate traffic) the following elements should be collected:

- Number of trucks entering or exiting
- Actual date/time of arrival or departure at the port

Regarding the third major data type (road traffic) the following elements should be collected:

- Speed information per road link per 5 minutes intervals (average speeds)
- Number of vehicles information per measurement point per 5 minutes intervals (traffic flows)
- Accidents/road works, date/time, duration, severity
- Weather conditions

Correlation analysis

The main objective is to develop an ML algorithm to dynamically forecast vehicle travel speeds considering the expected number of trucks at the gates. The estimated or actual expected number of trucks will allow the algorithm to estimate speed forecast for the defined road network.

In the first case of estimating the number of trucks, a model will be developed that calculates the time of truck arrival and average number of trucks per cargo ship. In this case the cargo ships will generate traffic after some time.

In the second case of knowing the actual number of trucks expected based on the gate appointment system, no model will be developed.

The correlation analysis will prove this assumption and provide the level of speed decrease (in terms of % to the normal average speed or to the free flow speed).

4.2.2.3 Description of input data

Depending on the method engaged, the input data will be either the estimated number of trucks according to the algorithm developed or the expected number of trucks according to the gate appointment system at the port gates, and real time data of vehicle speeds at affected road network.

4.2.2.4 Description of output data

The output will be a forecast of speeds at selected road links of affected areas.

4.2.3 Correlation between container terminal Gate truck traffic and road traffic

4.2.3.1 Problem statement

Truck queues at the port gates could potentially have an impact on the traffic at the roads close to the port. In fact, stationary trucks would block road lanes which would be otherwise used by ordinary traffic.

Besides this problem, which would be more evident at high peak times, a high proportion of trucks compared to normal traffic, at the roads leading to the port, may have an impact on road network efficiency (speeds and level of service). This impact on efficiency could be forecasted dynamically considering the dynamic truck queue at the port gates.

4.2.3.2 Data process description

Dynamic Forecasting Methodology

Objective: develop a ML algorithm that forecasts the fluctuation on average vehicle speeds at the affected road network for the next x minutes (time window) given the actual number of vehicles entering or exiting the port.

- Step 1: Define the affected road network & x time
- Step 2: Specify the historical input data for modelling process
- Step 3: Perform the correlation analysis
- Step 4: Specify the input data
- Step 5: Define the output forecasted data

Affected Road network

The affected road network could be divided into many areas depending on the proximity to the port gates and the accessibility to major roads.

Required historical input data for modelling process

There are two major historical data types collected and analysed:

- Historical port gate traffic data
- Historical road traffic data

Regarding the first major data type (port gate traffic) the following elements should be collected:

- Number of trucks entering or exiting
- Actual date/time of arrival or departure at the port

Regarding the second major data type (road traffic) the following elements should be collected:

- Speed information per road link per 5 minutes intervals (average speeds)
- Number of vehicles information per measurement point per 5 minutes intervals (traffic flows)
- Accidents /road works, date/time, duration, severity
- Weather conditions

Correlation analysis

The main objective is to develop an ML algorithm to dynamically forecast vehicle travel speeds considering the forecasted number of trucks at the gates. The number of trucks of previous time slot will generate an estimation of trucks to be expected at the gates for the next time slot. This forecast will allow the algorithm to estimate speed forecast for the defined road network.

The correlation analysis will prove this assumption and provide the level of speed decrease (in terms of % to the normal average speed or to the free flow speed).

4.2.3.3 Description of input data

The input data will be real time or nearly real time number of trucks at the port gates, and real time data of vehicle speeds at affected road network.

4.2.3.4 Description of output data

The output will be the forecast of speeds at selected road links of affected areas.

The forecasted output information will be used to activate traffic management measures.

4.3 Data exchange processes

4.3.1 Cross-border traffic data exchange

4.3.1.1 Problem statement

Local bottlenecks are usually addressed by traffic management services, with the aim of preventing traffic flow breakdown and increasing road safety. When dealing with long distance transport, decisions should be taken also considering neighbouring countries, to reach maximum network optimisation level.

Traffic Management plans and strategies coming from the traffic operators of two neighbouring countries (e.g., Italy/Austria, Italy/ Slovakia) should be exchanged and decisions shared with freight operators and truck drivers. Sharing this information can both support a better trip planning and improve the decision-making process of the parties involved.

4.3.1.2 Data process description

Objective: Agree on and share a predefined allocation of rerouting measures to a specific situation (such as incidents, heavy congestion, planned events (road works), environmental issues) to be shared among the traffic management operators, traffic police and other necessary parties, to control and guide (freight) traffic flows as well as to inform drivers pre- and on-trip and provide a consistent and timely service.

- Step 1: Definition of the road network of interest
- Step 2: Variables assessment for each road section considered
- Step 3: Definition of re-routing measures for each road section under consideration
- Step 4: Communication procedures and data sharing

Road network definition

The road network of interest should be divided into many road sections, to better manage the rerouting measures in case of planned or unplanned events.

Variable's assessment

For each road section considered (highway or state roads, and alternative paths), different variables need to be considered and assessed:

- Data flows for incoming traffic
- Traffic reopening scheduling (for at least one lane)
- Distance between roadblock and access point for emergency vehicles
- Time window of the unplanned or planned event
- Other concurrent events (e.g. accidents, road works, special events, etc.)

Re-routing measures definition

Alternative routes are analysed and selected.

The re-routing measures also include congestion thresholds, average number of re-routing vehicles and duration of re-routing action.

Communication procedures and data sharing

To enable interoperability between all involved parties, interfaces and information structure need to be specified and agreed on beforehand. This is key to guarantee continuity of services and cross-border traffic management cooperation.

For instance, in case of forecast and real time event information exchange between two or more different organisations (data providers and service providers), road operators can agree to use the corresponding DATEXII profiles.

4.3.1.3 Description of input data

Input data include the following

Table 8: Input data for re-routing calculation

Data type	**Details**
MAP	Map of the road area
Position	Location code and estimated spatial dimension
Incident	Type, cause
Data flows	Data flows for incoming traffic

Impact	Estimated impact on traffic situation
Date	Start and estimated end date
Time	Start and estimated end time
Source	information source
Means	Means of information provision

4.3.1.4 Description of output data

The output data mainly consists of re-routing options, including a set of measures and actions aimed at planning and coordinating optimal traffic flow management. Type of event, specific road, traffic, and environmental conditions are all taken into considerations.

5 TM2.0 Blueprint

5.1 Overall approach

This chapter specifies a TM2.0 blueprint. This aims at defining the relation between the data processes and the TM2.0 output (i.e. TM2.0 services), which shall lead to:

- Road Network optimization
- Synchronized and coordinated multimodal logistic operations

The TM2.0 services are the actual Traffic Management output, which lead to the implementation of the identified TM2.0 scenarios.

For this purpose, a service architecture is developed, and a high-level view presented in the next section. The service architecture describes the software modules that will comprise a complete TM2.0 system for T&L services. The core of the system are those sub-systems that collect, aggregate, fuse, and analyse the data which are generated by multiple sources.

Figure 3 shows this overall approach.

Figure 3: From data to TM2.0 scenarios implementation

5.2 Service architecture for T&L services

This section highlights the key aspects that should be placed at the core of the TM2.0 Service Architecture. The following schema (Figure 4) describes a possible service architecture that would accommodate the overall TM2.0 concept.

Overall, the TM2.0 Service Architecture has the following layers:

The *acquisition layer* gathers data and information from different data sources: from traffic management centres and fleet management systems to other service providers and user applications. This is the layer connected to the FENIX federated platform and the National Access Point (NAP) – being here the CCISS in the specific case of the Italian, Trieste pilot site.

Different types of data can be retrieved: aggregated FCD, events, traffic flows etc, which are collected and normalised.

The *geospatial layer* deals with geo-referencing. It allows to visualise events and conditions as they happen in specific places and how they may change over time (geospatial analytics).

The *descriptive layer* performs data validation and fusion, also providing awareness and an understanding of historic trends.

The *predictive layer* instead performs data short, mid-term forecasts and correlation analyses between the various data sets. It helps to gain deeper insights into possible future events, probable impacts of programs and policies, potential citizen, or business reaction to new initiatives, as well as measure the efficacy and quality of services delivered and of the test scenarios.

Those layers together comprise of the modules performing the data processes described in the previous section.

The *prescriptive layer* suggests the optimal path to achieve desired outcomes, i.e. T.M. 2.0 actions. It has different features: smoothing network flow, pro-active incident, and corridor management (strategy manager), real-time holistic information, collaborative travel management.

Finally, through the business Intelligence layer it is possible to generate reports and evaluate technical and performance KPIs.

Figure 4 represents these layers.

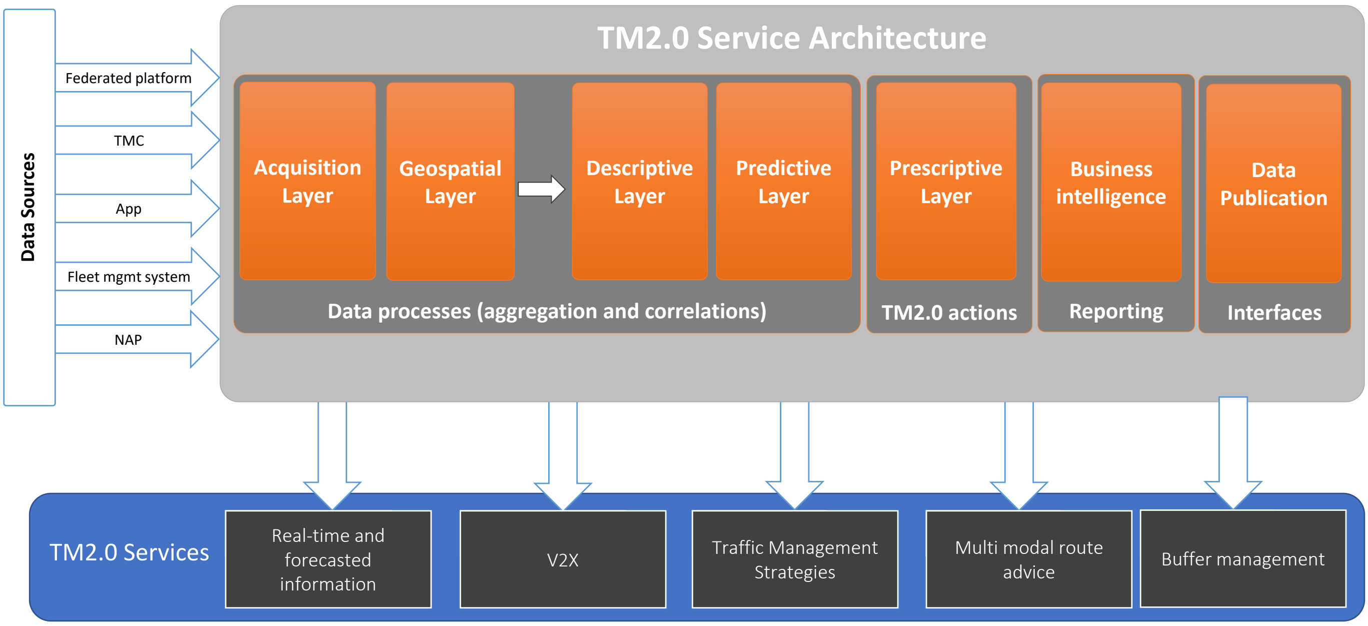

Figure 4: TM2.0 Service architecture

5.3 Data Processes and TM2.0 services

In this chapter, the data processes are associated with the TM2.0 services that have been identified in previous deliverable D6.2.2.

The implementation of each service requires several data types to be aggregated and correlated or exchanged. The following table shows which data processes defined in Chapter 3 could be used to deliver the TM2.0 services.

Table 9: How the TM2.0 services are associated with the data processes identified

Service name	**Relevant data processes**							
	Gate traffic data aggregation	*Traffic data aggregation*	*FCD aggregation*	*POIs aggregation*	*Correlation between ferry boat arrivals and road traffic*	*Correlation of scheduled cargo ships, trucks, and road traffic*	*Correlation between gate traffic and road traffic*	*Cross border traffic data exchange*
Traffic Information forecast	X	X	X		X	X	X	
Traffic Management Plans		X						X
Travel time information		X	X		X	X	X	
Traffic events information		X						X
Traffic management strategies		X	X		X	X	X	X

Service name	Relevant data processes							
	Gate traffic data aggregation	*Traffic data aggregation*	*FCD aggregation*	*POIs aggregation*	*Correlation between ferry boat arrivals and road traffic*	*Correlation of scheduled cargo ships, trucks, and road traffic*	*Correlation between gate traffic and road traffic*	*Cross border traffic data exchange*
V2X services	X	X	X	X	X	X	X	X
FCD aggregation			X					
Multi modal route advice	X				X	X	X	
Buffer zone management	X	X	X	X		X	X	

6 CONCLUSION AND NEXT STEPS

The present work contains a specification of the several data processes necessary for the provision of the TM2.0 services identified as relevant for the optimization of transport and logistic processes in the framework of the FENIX A6.2 activity.

Deliverable 6.2.5 work focuses on data processes as these are significantly important for the successful delivery of the TM2.0 scenarios already described in the previous A6.2 deliverables, for two key reasons:

1. The data processes are complex due to the multimodal and multi-stakeholder nature of the T&L business that FENIX is dealing with. They involve multiple data sources, and they need the engagement of various organisations with different objectives and modes of operation.
2. They are scientifically challenging as they require effort to collect, aggregate, filter, validate and then correlate with other data types.

D6.2.5 work starts by analysing the TM2.0 scenarios, which are applied at the FENIX pilot sites with traffic management use cases (i.e., Italian, Trieste pilot site, the French, and the Greek pilots).

The data processes are categorised depending on the work to be performed into three groups:

1. Data collection & aggregation: data are collected from a single or multiple sources and processed to provide a meaningful data output
2. Data correlation: different data types are combined to provide a new result
3. Data exchange: data collected from at least two different organisations are exchanged to provide homogeneous traffic management actions at a wider area, for example cross border traffic data exchange between two Traffic Management centres of two different countries

Each data process is then analysed to specify the following elements:

- Problem that the data process needs to solve
- Description of the process
- Input data required
- Output data delivered

The final output is the TM2.0 blueprint: how the collected data are processed to deliver the TM2.0 services, for implementing the TM2.0 scenarios. The blueprint includes:

- A service architecture specifically tailored to the needs of the T&L operations.
- A matrix between the data processes and the TM2.0 services; this will help map the input data with the output results of the TM2.0 service architecture.

This deliverable concludes the first phase of activity A6.2.

In the next phase the focus will be on the one hand; the implementation, deployment, and evaluation of the TM2.0 service architecture (D6.2.6), and on the other; presentation of the results of the study for re-routing cross border actions and corridors services (D6.2.7).