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Author(s):	Tuomo Eloranta (ERTICO), Paul Kompfner (ERTICO), Michele Manzato (Mizar Mediaservice), Katia Van Hemelrijck (TRITEL), Didier Danflous (CETE-med)
Project manager:	Paul Kompfner (ERTICO) Tel: +32 2 400 07 32, fax: +32 2 400 07 01 E-mail: p.kompfner@mail.ertico.com
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Other author(s):	Paul Kompfner (ERTICO), Michele Manzato (Mizar Mediaservice), Katia Van Hemelrijck (TRITEL), Didier Danflous (CETE-med)
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1 Executive Summary

1.1 Setting the scene

European transport information is characterised by its local or restricted qualities. In order to develop systems that have wider regional, national and pan-European potential, it is first necessary to develop common specifications and standards for sharing and exchanging transport data. Earlier Framework programmes have successfully developed standards for individual transport modes.

The opportunity now exists to extend these standards to operate in a multi-modal transport environment, laying the foundation for the development of more comprehensive transport information systems and the achievement of significant improvements to the availability and accuracy of transport information across Europe. They will also underpin better co-ordination and improved operating efficiency on the part of transport operators and administrations. Also, common and sharing and exchange specifications are a key enabling factor for service interoperability and customer roaming.

1.2 Approach

TRIDENT's intention has been to develop specifications and software modules, which would enable the sharing and exchange of real-time multimodal traffic and traveller information through the whole TTI content chain. Intentionally, two different paths to achieve this goal were selected: One based on the "messaging approach" (EDI, DATEX) and the other one based on the use of more modern object-oriented technologies.

The aim of the EDI approach is to offer existing DATEX users a way to exchange a larger variety of content using their existing DATEX nodes as well as provide a first step of the migration path towards the OO technologies.

The aim of the OO approach is to offer new actors means to exchange the whole range of traffic and traveller information using modern technologies, yet fully taking advantage of the high level of know-how obtained in developing the DATEX (road traffic information exchange) and TransModel (Public Transport reference model) standards.

After the development of the draft specifications, a five test site validation and demonstration of applications based on the specifications was planned.

1.3 Results and achievements

TRIDENT reached its goals and produced two sets of specifications, implemented them at 4 test sites in Europe and produced the final specifications.

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TRIDENT built and operated four different test sites: West Yorkshire, Rome, Paris and Flanders. All of the applications have proven successful, and continue to operate after the end of the project. West Yorkshire and Paris applications are already enlarging from the original demonstration sites to other areas and transportation modes, Flanders is used for assessing supply of public transport in altered demand situations and Rome is considering adding tourism information to the existing TRIDENT application.

Since the production of the first full draft of the OO specifications took a lot longer than expected, a recurring update procedure for the OO specifications was adopted, for as long as the specifications were at least to a small level acceptable by all the demonstration sites. This approach was chosen as it was realised that sites would run into enormous problems had they use the previous version of the specifications.

The final specifications and modules have been already released to more than 40 different organisations and companies in both Europe and overseas for evaluation purposes.

1.4 Conclusions and Plans for the Future

In a summary, TRIDENT has achieved all the goals it aimed to achieve, and perhaps even more. First specifications for multimodal information have been produced, tested, trialled and modified according to the results from the trials.

Each of the current TRIDENT partners has interest in taking the TRIDENT demonstration sites a further by extending the geographic and modal coverage and to use TRIDENT interfaces to feed information to various end-user platforms.

Specifications have been submitted to the CEN TC 278 working groups WP3, 4 and 8. It has been recognised that the TRIDENT specifications will end up being a key European standard on multimodal information exchange.

A major success for the project dissemination activities was a TRIDENT Forum and Seminar in London. Close to 100 delegates participated in the event. A major outcome of the event was that a post-project platform to support the TRIDENT specifications after TRIDENT was seen necessary. This platform would act as a catalyst for the development and convergence of different developments into a pan-European solution. The supporting (TriEx) forum is targeted to kick off in Q1/2003 and co-ordinated by ERTICO.

1.5 Contact Point

All the key TRIDENT results are available as public documents via the TRIDENT web site http://www.ertico.com/trident/. The website continues to be supported after the project and will contain the key project deliverables as well as the latest news on the continuation of TRIDENT activities after the end of the project. Activities of the future Forum are listed on http://www.ertico.com/triex/.

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2 Project outline

2.1 Background

TRIDENT is a 5th Framework Programme EU project that focuses on the exchange and sharing of multi-modal Travel and Traffic information.

As for past experiences in single mode developments, the project expectation is to favour and/or accelerate the development of telematic networks and to enable a more rapid diffusion of ITS services. A major output of the project is the development of specifications for systems architectures in the multimodal travel domain.

Many systems designed for exchanging data related to travel and traffic have already been developed in the past, either as proprietary solutions or as national or international standards. Among the international standards is DATEX, of which TRIDENT can be considered the conceptual and technological evolution. In fact, inspiration for TRIDENT came principally by those problems recognised in the deployment process of DATEX, and by the acknowledgement of the growing needs in the market of traffic and travel data.

2.2 Project objectives

The objective of TRIDENT is to support multimodal travel services by establishing the common and reusable mechanisms required for sharing and exchanging data between transport operators (content owners) of different modes (bus/tram/metro, rail, road). It also investigates and proposes solutions for well known organisational and strategic issues hampering travel intermodality. Project proposes new standards as well as recommends supporting the implementation of systems based on the project's results. Rapid progress is anticipated on the specifications supporting an EDI approach, enhancing results from the 4FP (extensions of data dictionnaries and location referencing rules, new messages for public transport delays, cancellations and schedules..).The main focus of the project is on the development of common specifications supporting object oriented approach. Attention goes to object oriented exchange (JAVA/CORBA) and database access techniques (CGI scripts, federated homogeneous/heterogeneous databases).

TRIDENT has developed specifications in two approaches following two parallel streams: the EDI approach and the Object-oriented approach.

- **EDI approach:** The EDI approach extends the DATEX specifications with new messages that allow the exchange of some public transport data: public transport timetables, public transport delays and cancellations, trip times. The final version of the TRIDENT EDI approach specifications is described in TRIDENT deliverable D3.6.

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- **Object-oriented approach:** The Object-oriented approach aims to design a new data exchange mechanism, which supports multimodality, state-of-the-art technologies and more open architectures and networks. The Object-oriented approach is described in TRIDENT deliverable D3.7.

2.3 Role of key organisations

TRIDENT consortium consists of mainly two types of organisations

Category	***Participants***	***Key Roles***
Transport operators, authorities and agencies	ATAC (I) STA (I) De Lijn (B) MVG (B) METRO (UK) RATP (F)	a) Definition of key user needs on information exchange specifications and applications b) Trialling and validation of developed applications c) Analysis of potential benefits of the developed specifications and modules d) Definition of key non-technical obstacles for information exchange
Application developers and providers	Mizar MediaService (I) TRITEL (B) MVA (UK) CETE-Med (F) DRYADE (F) (Subcontractor)	a) Development of draft and final specifications for multimodal information exchange b) Development and validation of information exchange applications c) Analysis of technical benefits od the developed specifications and modules d) Analysis of potential market for the developed solutions

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3 Methodolgy and approach

3.1 Technical development

3.1.1 EDI approach

An EDI (Electronic Data Exchange) approach is further developed by creating a new key message for Public Transport and adding a new Location Referencing method to the specifications, and by extending the DATEX Data Dictionary 3.1a. It was decided in WP3 that TRIDENT would develop new EDI specifications for following data types:

- Public transport delays
- Public transport cancellations
- Public transport travel times

Within the scope of the EDI specifications the following Public Transport (PT) information can be exchanged:

- Point Timetables;
- Line/Route Timetables;
- Individual Itineraries;
- Vehicle status and delays;
- Travel times between two locations (via a third one, if necessary to decide between two or more routes between the same points).

Point Timetables give Public Transport timings at a particular point location, a *PT Stop point* (eg. at bus stop, etc.). Each Point Timetable can provide information relating to a set of V*ehicle Journeys* relating to the PT Stop point. Each Vehicle Journey can contain information relating to the *timetabled, expected or recorded arrival and departure times* at the PT Stop point. Furthermore for each Vehicle Journey information can be provided on its *journey pattern origi*n, *journey pattern destination* and *journey pattern intermediate stop point*s, its *line* and information relating to attributes of the Vehicle Journey. If all Vehicle Journeys referred to share the same *journey pattern* and/or *line* this information can be given once for all Vehicle Journeys.

Line/Route Timetables give Public Transport timings for multiple points (PT stop points) along the whole (or part) of a *line* or *rout*e. Each Line/Route Timetable can provide information relating to a set of *Vehicle Journeys* relating to the identified PT stop points. Each Vehicle Journey can contain information relating to the *timetabled, expected or recorded*

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arrival and departure times at each identified PT Stop point. Furthermore for each Vehicle Journey information can be provided on its *Journey pattern origi*n, *Journey pattern destination* and *Journey pattern intermediate stop points* and information relating attributes of the Vehicle Journey. Alternatively if all Vehicle Journeys referred to share the same *journey pattern* and/or *line* this information can be provided once for all Vehicle Journeys.

Individual Itineraries give information relating to one or more Vehicle Journeys and connections relating to the planned or actual progress of a traveller through the network. These Vehicle Journeys, connections and other links are identified as *Trip Segment*s. Trip Segments may include *NonPTAccessLin*k, *PTAccessLin*k, a *Rid*e, *ConnectionLink* and a *Wai*t.

Vehicle status and delays gives information on status and timing delays of one or more related Vehicle Journeys. For an individual Vehicle Journey information on status and delays can be given for the journey as a whole or for one or more points (PT Stops) along the *line* or *rout*e. Each Vehicle Journey can contain information relating to the *timetable*d, *expected* or *recorded arrival and departure times* or *arrival and departure delays* at each identified PT stop point. Furthermore for each Vehicle Journey information can be provided on its *Journey pattern origi*n, *Journey pattern destination* and *Journey pattern intermediate stop points* and information relating to the status and conditions of the Vehicle Journey. The provision of status and delay information for an individual Vehicle Journey cannot be given for the journey as a whole and for one or more points (PT stop points) along the line or route concurrently. If all Vehicle Journeys referred to share the same *journey pattern* and/or *line* this information can be provided once for all Vehicle Journeys. Information on status and delays for multiple related Vehicle Journeys can be given. This information shall be provided for all Vehicle Journeys on the whole (or part) of a line or route or at specific PT Stops, within the specified valid period. The provision of status and delay information for multiple Vehicle Journey cannot be given for the journey as a whole and specific PT Stops along the line or route concurrently. If all Vehicle Journeys referred to share the same *journey pattern* and/or *line* this information can be provided once for all Vehicle Journeys.

Public Transport travel times between two locations (via intermediate locations, if necessary to decide between two or more routes between the same points). Travel time can be provided in two ways:

- Travel times between two locations (via intermediate locations), which are not specifically related to a specific individual vehicle journey. This is presented as a travel time over one or more links, and can be provided with a period of validity;
- Travel times between two locations (via intermediate locations), which are related to a specific individual vehicle journey. This is presented a travel time for a specific vehicle journey over one or more links;

3.1.2 Object Oriented (OO) approach

System Architecture

A first issue that became evident in the implementation of DATEX systems was that connections between different parties and organisations were hard to set up, maintain and

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operate – and thus expensive and time-consuming with respect to the rest of the system. TRIDENT addresses this issue by relying on the Internet that nowadays can connect almost every computer on Earth, with rather inexpensive links.

TRIDENT defines a distributed object-oriented architecture in order to allow TRIDENT systems to communicate. The architecture enables 'client-server' style interaction, which is someway more interactive than the "messaging" approaches (such as EDI). Any TRIDENT system can act as a "client", a "supplier" or both "client" and "supplier".

Every client system must be assigned appropriate security credentials in order to access information on a supplier system. Basically, the operator of a TRIDENT Supplier system will assign separate usernames and passwords to each client. Each time a client connects it will communicate both username and password. This way the suppliers will be able to:

- Reject requests coming from non-authorised clients;
- Selectively limit the scope of the accessible information by different providers. I.e., a trusted client can be given full access to information, while an almost anonymous client will be able to access only part of it.
- Track information requests and downloads from authorised clients;

System functions

In DATEX basic system functions were implemented in a "messaging" approach. DATEX, in fact, makes use of EDIFACT for packaging information and FTP as transport layer. These technologies are well consolidated and have been around for a long time, but they suffer of a number of known problems and limitations. For many applications a client/server paradigm would be more flexible and more practical.

With the TRIDENT OO Specifications, information can be exchanged either "on demand" or "on occurrence". When exchanged on-demand, the client explicitly asks for information to the supplier: if the supplier has it, then the requested information is returned immediately. A typical request on-demand is the request of a specific Public Transport network: a response with the structure of the network is delivered at once, just after the request is submitted.

When exchanged on occurrence, the client initially establishes a "subscription" on the supplier that states which information is requested and when it should be delivered. Then, when the conditions expressed in the request are met, the supplier delivers the information to the supplier. A typical example of this are Road Traffic events: normally a client will tell the supplier which events are of interest to him and which roads/areas they will affect; then, when matching events are detected, they are delivered to the client.

Multimodality

Most of the existing developments are specific to one transport mode – DATEX, for example, was specially conceived for Road Traffic data exchange between TICs/TCCs either for internal management purposes and/or to provide information to end users. For the same reasons, nowadays Public Transport Operators also need to exchange information on the Public Transport Service, at least as much as TICs do. Some solutions were developed in the

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past few years (see, as an example, the TransXchange UK standard, which is specifically designed for bus registrations) however all are application-specific.

The following families of information can be exchanged (within the current version of the TRIDENT specifications):

- Road traffic data (traffic measurements)
- Situations and events, in the road traffic and public transport domain
- Trip times
- Itineraries
- Public transport network descriptions
- Public transport static timetables
- Public transport status

New state-of-the art technologies

Several distributed data exchange technologies have been designed and developed during the past few years and have been effectively applied to many different IT fields. Many of these object-oriented programming technologies have reached the status of a standard: notably, Java and CORBA. Ten years ago, when the development of DATEX started, these technologies were not existing. When we reconsidered the design of a new data exchange system we recognised the benefits that the adoption of these technologies would bring.

3.1.3 Explanations for changes to original approach

Apart from the changes to the demonstration sites activities, the project followed the original approach to a satisfactory level. All original high-level objectives were met, and the development that took place, had been proven successful.

Moving more towards the Object Oriented Methodologies

The most fundamental changes in balancing between the efforts put into different areas on the project was the clear direction of moving more away form the EDI approach and supporting more the OO approach. A very high market demand for the OO specifications and at the same time diminishing demand for the EDI specifications led to the transition of efforts from EDI to OO specifications development. The EDI solutions were still however produced, and they provide the functionality required by the project. OO specifications, on the other hand, are more advanced than originally intended to be, and have therefore enjoyed enormous success also outside the project consortium.

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3.2 Evaluation results

While TRIDENT focused on the development of common multi modal data exchange standards both for the EDI an OO approach, the long term objective is to facilitate the use of these standards to significantly improve the availability and quality of information about private transport and public transport services in Europe.

WP5 – Assessment and Evaluation of the TRIDENT project both covers the technical assessment of the deployment of the common specifications and modules at the test sites and the evaluation of their impact on multimodal services and applications.

The operational performance of the common specifications for both approaches has been assessed and the enabling or quality enhancing effects of the proposed mechanisms has been evaluated.

The TRIDENT OO specifications support multi modal travel ITS services by allowing a multi modal data exchange and sharing.

The TRIDENT specifications reduce development costs, offer better quality of information provision, enhance the quality of multi modal services, improve access to information on transport, reduce communication times, facilitate access to the information.

TRIDENT specifications for data exchange and sharing lead to services with improved quality, extent and availability of transport information available to the citizen, extend the choice available to travellers, improve the efficiency of European transport networks.

The validation work focused on the validation of the TRIDENT common specifications through tests at the sites.

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4 Results and achievements

4.1 TRIDENT specifications

4.1.1 EDI specifications

The EDI specifications are an extension the European Pre-Standard :

ENV 13777:2000	**DATEX specifications for data exchange between traffic and travel information centres (version 1.2.a)**

The TRIDENT project has created a new TRAPTI message to accompany the road traffic oriented DATEX specifications. The functionality of the DATEX specifications itself have been left fully unmodified, with the only addition being the new TRAPTI message and its accompanying definitions in the Data Dictionary.

4.1.2 OO Specifications

The TRIDENT Object-oriented specifications are a single, complete set of specifications. However, they have been divided into several different modules in order to:

- Ease the readability of the different parts;
- Provide an easy way to extend single documents without having to update the others;
- Make it easy to pick only what is needed out of the specifications.

The specifications are divided into the following parts:

- D3.7/1 – Introduction
- D3.7/2 – System Specifications and System Architecture
- D3.7/3 – Logical Data Model
- D3.7/4 – XML Schema
- D3.7/Annex A – Data Dictionary (*)
- D3.7/Annex B – Location Referencing (*)
- D3.7/Annex C – Appendices

Those parts marked (*) are common with the EDI and Object-oriented specifications

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D3.7/1 – Introduction

This gives:

- An overall introduction to the TRIDENT project;
- An overview of the TRIDENT Object Oriented specifications suite;
- A brief introduction to the Object Oriented technologies that have been used in the specifications.

D3.7/2 - System specifications and system architecture

This section defines the TRIDENT system specifications. It is divided into several parts:

- Describes the different "use-cases" that are allowed by the TRIDENT OBJECT-ORIENTED specifications are described. An Use-case is an UML modelling paradigm which describes an operative scenario where a number of "actors" are at work and can perform only a set of well-defined operations.
- Defines the system interfaces that 'peers' can implement in order to exchange information, using UML class diagrams. These interfaces are very generic and are not explicitly limited to exchange Travel and Traffic information only. Generic "requests" and "responses" are taken into account. The interfaces support both single requests ("pull" functions) and registered requests ("push" functions);
- Describe the inner behaviour of the basic operations of system interfaces in term of UML sequence diagrams.
- Describe the structures that allow the exchange of Travel and Traffic information. These structures are intended to encapsulate objects that are instances of the classes defined in the Logical Data Model in order for them to be delivered 'over the wire'.

D3.7/3 – Logical Data Model

This document provides an Object Oriented Data Model that defines how a set of Travel and Traffic Information can be organised into a well-defined logical structure. The Data Model aims to be coherent in integrating Road Traffic, Public Transport and some inter-modal facilities in a common, integrated approach. As far as we know, this is the first attempt in this direction.

The Logical Data Model is described as a set of UML diagrams. The structure of the Logical Data Model is the result of coherent union of existing data models in the Road Traffic domain (mainly DATEX) and in Public Transport domain (TRANSMODEL). Also, a large part of the data model is the result of original work within the TRIDENT task force.

A lot of effort was put in making the Object Oriented Data Model a self-contained model that can be easily drawn out of the specifications. Implementers are encouraged to keep this Data Model as a reference model for the representation of Travel and Traffic information.

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D3.7/4 – XML Schema

TRIDENT recognises the importance of XML since it is rapidly becoming the de-facto standard for sharing and exchanging structured data. Thus, this document contains the reference implementation of the OBJECT-ORIENTED Logical Data Model for XML, described in term of an XML schema.

Also, as XML is a real software language, this document proposes an implementation of the logical data model described in D3.7/3 in a real programming language. Thus it addresses most of the issues that may arise in the implementation of the specifications in any other programming language.

D3.7 Annex A – Data dictionary

Annex A describes the classes, class attributes and enumerated values used through the whole specifications. At the current state of development, a single data dictionary was produced for both the EDI and the Object Oriented approach. The data dictionary is thereby a mix of the two approaches.

As for the Logical Data Model, the content and the organisation of the data dictionary owes much to DATEX and to TRANSMODEL. Since many objects in the Data Model are brand new appropriate new definitions are supplied.

D3.7 Annex B – Location referencing

A key issue in the exchange of Travel and Traffic information is the actual way geographic locations are described and coded, that is Location Referencing. Due to the variety of location referencing methods developed and currently in use, especially in the ITS domain (text names, ALERT-C codes, proprietary codes, coordinates, …) and to the different requisites that these methods have in different contexts (e.g. Road Traffic and Public Transport) this issue proved to be one of the most challenging in TRIDENT.

Annex B, also a common document between the EDI and the Object-oriented approach, describes the TRIDENT proposal for location referencing. In order to guarantee compatibility with existing systems a wide number of commonly used location-referencing methods have been retained and are supported by TRIDENT. Besides, an extended ILOC referencing method, ILOC+, has been devised in order to provide a means of coding another wide range of locations: PT points (stops, access points, …), addresses, areas, proprietary codes, …

D3.7 Annex C – Appendices

Annex C contains the complete bibliography and glossary of D3.7.

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4.2 Prototypes

4.2.1 EDI Prototype

A DATEX node can be considered as a black box able to send/ receive data streams to/from other DATEX nodes.

The DATEX/EDI approach solution implies some fixed architectural choices at different levels but always in terms of interconnection between nodes. As an example, FTP (File Transfer Protocol) data exchange of DATEX messages implies that any DATEX node has to implement such a protocol; EDI solution needs a standard EDIFACT converter, etc.

With respect to the system architecture, a DATEX node can be simplified in the following layers:

- Communication layer
- Application layer
- Database layer
- User interface

The implementation of the TRIDENT prototype impacts on each of these layers. This is independent from the hardware/software platform.

Communication layer

As a preliminary requirement, if we consider a PT company as an external content provider whose information is conveyed by a TRAPTI message, we need to consider in the implementation a software able to convert the PT information in DATEX situations.

Note: due to the difficulties to convert PT information (normally coded in abstract coding mode) in DATEX situations, the software should be able to keep trace of both information source and DATEX situation.

In the TRIDENT TRAPTI prototype this ‘conversion’ software is outside of the scope of the prototype. Within the scope of the project the EDIFACT converter has to be ad-hoc configured to encode/decode the EDIFACT TRAPTI message.

Generally, DATEX implementations in the EU adopt not-standard commercial EDIFACT software products: they are custom solution expressly built for the particular implementation. This makes the configuration of a new EDIFACT message much more difficult than it would be with a commercial converter.

Application layer

With respect to the Kernel DATEX functions (updates, deletes, cancellation…) the software prototype has to be adapted to the new Data Model. In other terms, TRAVIN/TRAINS implementations have to be modified in order to include the new TRAPTI message functionalities.

Data Base layer

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The DATEX Data Model has to be integrated with the new TRAPTI Data Model, in order to be able to store the PT information received.

Relational databases provide functionalities that helps implementers to easily create and manage the new structure of the extended DATEX database.

User interface

Strictly speaking, the User Interface is out of the scope both of the DATEX Node and of the TRIDENT TRAPTI prototype. However, in order to be able to test the TRAPTI prototype it is necessary to include in the TRIDENT EDI developments a UI able to show the information received, at least in text format.

4.2.2 OO Prototypes

One important part of the TRIDENT project is, as stated in the TRIDENT Technical Annex, the development of "common prototypes (reusable modules) based on the common specifications for deployment at sites". Both EDI and OO prototypes were foreseen: this document concentrates on Object-Oriented prototypes.

With regard to the Object-Oriented prototypes the Technical Annex foresaw the development of "tools that enable to access available data by acting as external clients using new techniques/technologies such as CORBA, API, DCOM, XML".

Soon after the beginning of the project it was recognised that the scope of the common prototypes was much broader than those intended in the Technical Annex. We realised that the prototypes were not only "internal development tools" but could be seen as key tools for the rapid establishment of a widespread "TRIDENT Network" of entities interested in the exchange multimodal travel and traffic information. Thus, we resolved to develop prototypes that should be made freely available to anybody on the project's website and could be used potentially anywhere as an aid to the establishment of a TRIDENT node.

On the other side, throughout the evolution of the project we soon realised the role that each of the technologies above played in the big picture. We recognised the XML as the de-facto standard for information interchange over the Internet, and we resolved to code any information exchange between TRIDENT nodes as XML streams.

Also, it was decided to use the UML formalism to describe the system, the system interfaces and the structure of data, in order to:

a) make use of a standardised formalism for the design of system architecture; and

b) keep a sufficient generality on what was developed, and not to be tied to a particular distributed Object-Oriented technology.

This way it would be possible to implement a TRIDENT node potentially in any distributed Object Oriented technology, and still be compatible with any other TRIDENT node, as XML is the real common denominator to any node. This is summarised in Figure 1 (taken from D3.3/2).

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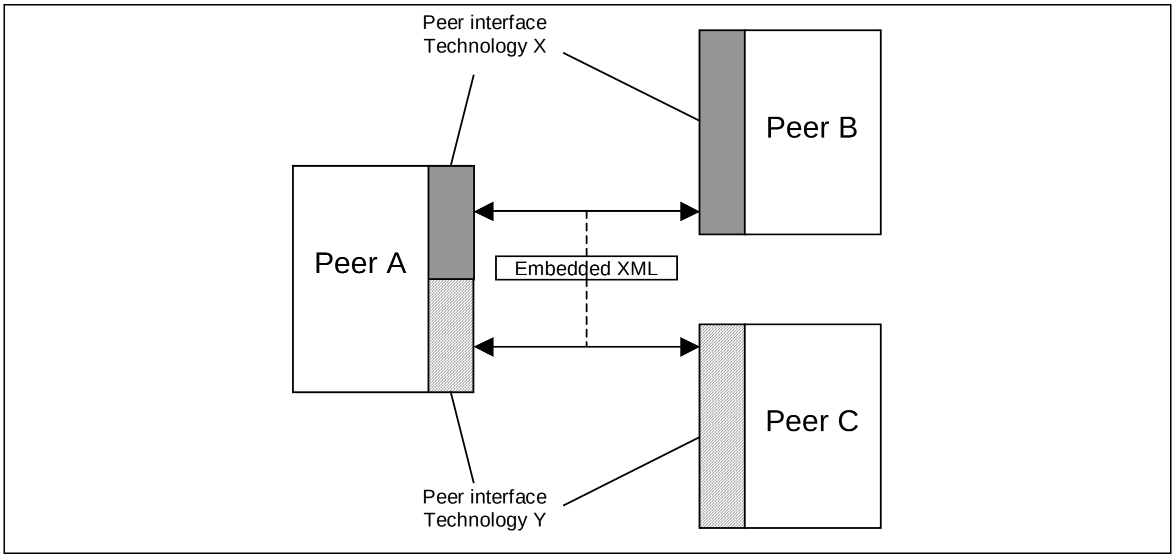

Figure 1. *Interfaces between peers.*

Due to these interim adaptations to the initial idea of the Common Prototypes we actually ended up with a much more significant product: the Common Access Modules.

These common modules are actually the source code of the interfaces between different peers. Since the core system specifications are defined in UML, implementation into a target OO language or architecture performed by different people on different systems is prone to allow differences and inconsistencies between the systems. The Common Access Modules are the reference implementation of the specifications that ensures interoperability, at least at the interface level.

The Common Access Modules constrain different TRIDENT systems to present homogeneous and consistent interfaces. However, they do not guarantee uniformity in the semantics or operational behaviour. In principle it would have been possible to add some "intelligence" to the modules, but this would result in much less flexible modules and would have put further constraints and specifications on the systems. In the end we decided to leave all the internal details beyond the interface to the implementers.

4.3 Demonstration Applications

4.3.1 Flanders test site

The objective of the Belgian (Flemish) site is to support a service for door to door travel advice on request for both private and public transport in Flanders, by linking and connecting servers and databases of different transport mode operators, based on the TRIDENT results for the object oriented approach.

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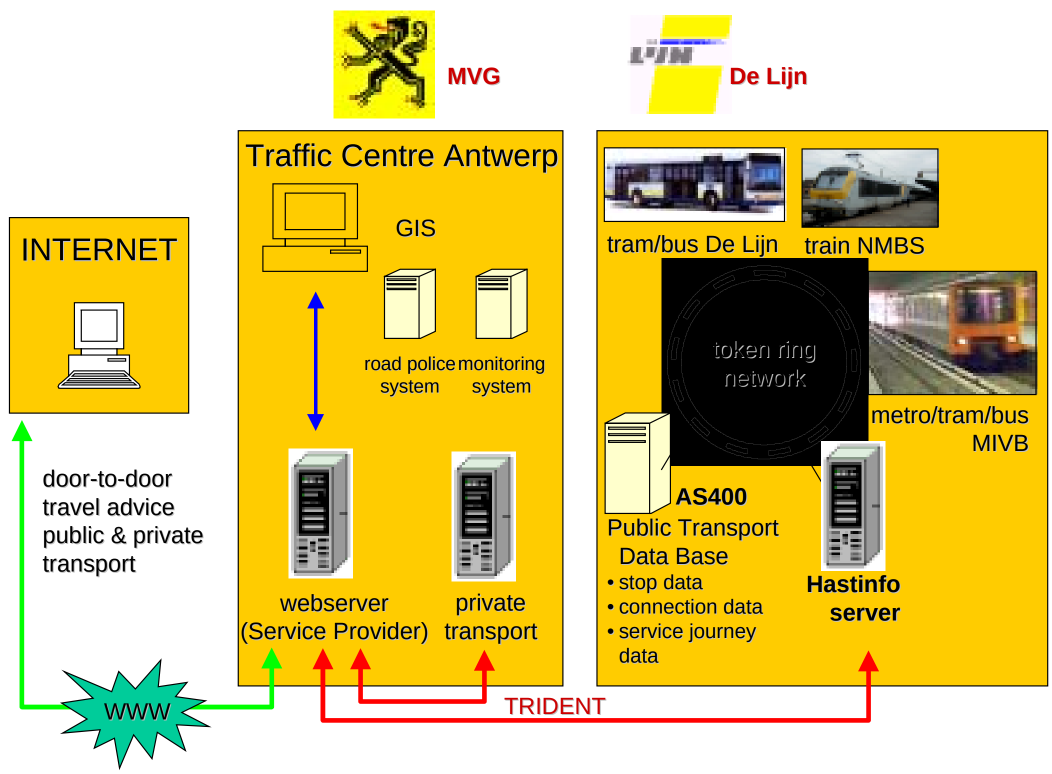
The participating operators are the Flemish Ministry (Ministerie van de Vlaamse Gemeenschap - MVG) and the public transport organisation De Lijn (responsible for urban and interurban public transportation in Flanders by means of buses and trams).

The Flemish Ministry will build a multi-modal Web server in the Flemish Traffic Centre in Antwerp that can deliver door-to-door travel information on request (car, bus, tram or train). Requests by service users for this door to door information will be done via an Internet site (HTML), which will be developed using advanced Internet technologies like XML (eXtensible Mark-up Language) and JAVA.

The server in the Flemish Traffic Centre will communicate with the server in the Public Transport Company, De Lijn, in Mechelen to obtain public transport journey information (including information on trains from the Belgian Railway operator NMBS / SNCB and information on metros, trams and buses from the Brussels transportation company MIVB/STIB).



4.3.2 Paris test site

The objective of the Paris site is to provide a tool to capture and disseminate information concerning real time event (Situation, SituationElement and PTIncident according to TRIDENT's terminology) and the corresponding status (PTStatus and related objects) on the

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PT network. Basic information on the network topology has also to be provided in order to link the events to the network. Its name is SIPRE 2.

The dissemination of information takes place between SIPRE 2 and any other internal RATP system needing Event and PT Status description. Among others, these systems will be:

- PiviPro for RATP call centre,
- PiviWeb for web information,
- Videotext (Minitel) system,
- Paris-Trafic (SMS dissemination)

Later SIPRE will probably be interconnected with other systems like SIEL (information on station for RER) and ALTAIR (on station information for buses).

The system has to be a multimodal system providing information on any public transport in PARIS and its suburb: RATP buses, independent buses (OPTILE), Métro, RER, TRAM, SNCF.

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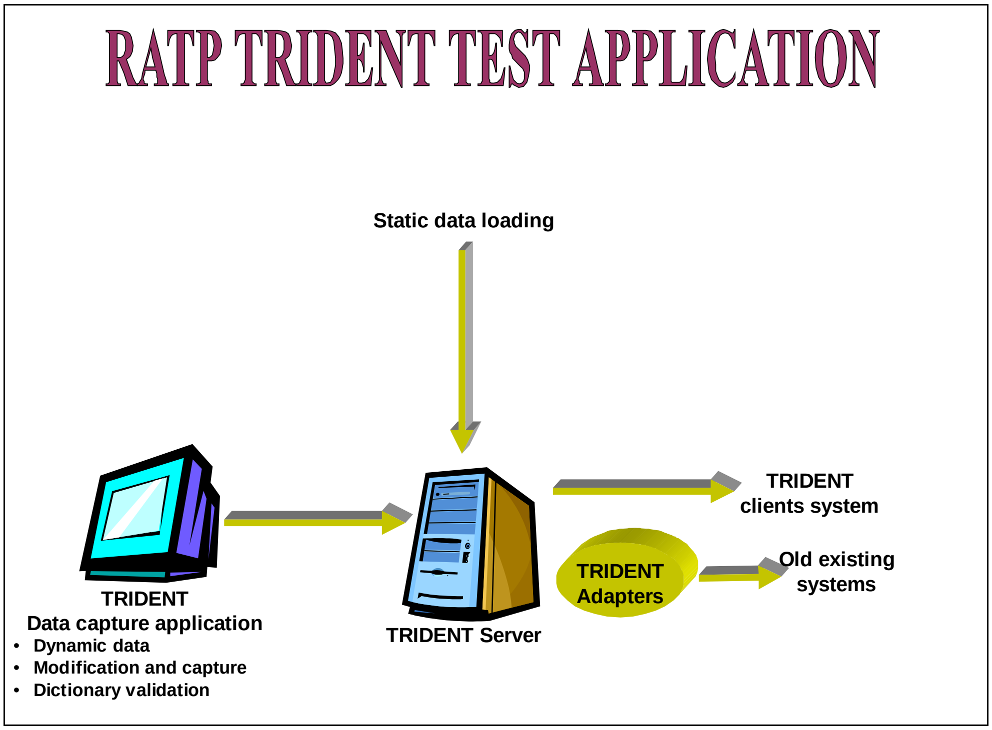
Figure 2: The RATP TRIDENT Test Application



One important point about SIPRE 2 is that it is a real operational system, and not only a TRIDENT prototype. This means that TRIDENT will be used for years by RATP.

As indicated by its name, SIPRE 2 comes after SIPRE 1. SIPRE 1 is a very simple system, although allowing capture and dissemination of events and status of the PT network. But it has important gaps, of which the larger ones are:

- It is not an open system, and it is quite difficult to make it evolve,
- It is a single user system,
- It uses a proprietary format (through “ftp”) for data dissemination,
- Data are not well structured, and most of the information is hold in a human built text field.

TRIDENT seems to be the best solution to provide an answer to these problems. TRIDENT will, moreover, open SIPRE to exchange with other operators (SNCF, OPTILE,…), and may become a common data exchange format between all passenger information systems (internal and external).

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4.3.3 West Yorkshire test site

In West Yorkshire the TRIDENT specifications are used to support the introduction of real time multi-modal public transport information using object oriented technologies. In particular they are being used to provide integrated real time information for bus-rail links in the Denby Dale area linking real time bus information with similar information for trains. Information on delays and cancellations from train operators is shared with Metro and combined with real time bus information held by Metro's own systems. This forms the basis of a real time enquiry system capable of providing information for multi-modal journeys involving both bus and train.

Real time information for both buses and trains is displayed on a single screen at locations such as Denby Dale and made available to the public initially via Metro's telephone enquiry line. The availability of multi-modal real time information allows the passenger to make a more informed travel choice especially on occasions where there are disruptions to the service.

It is anticipated that the system will be extended to cover West Yorkshire and form the basis of exchanging data with other systems in neighbouring authorities facilitating cross boundary service enquiries. In the future other modes such as tram and road traffic may be included with other retail channels being introduced to disseminate information more widely than via the call centre.

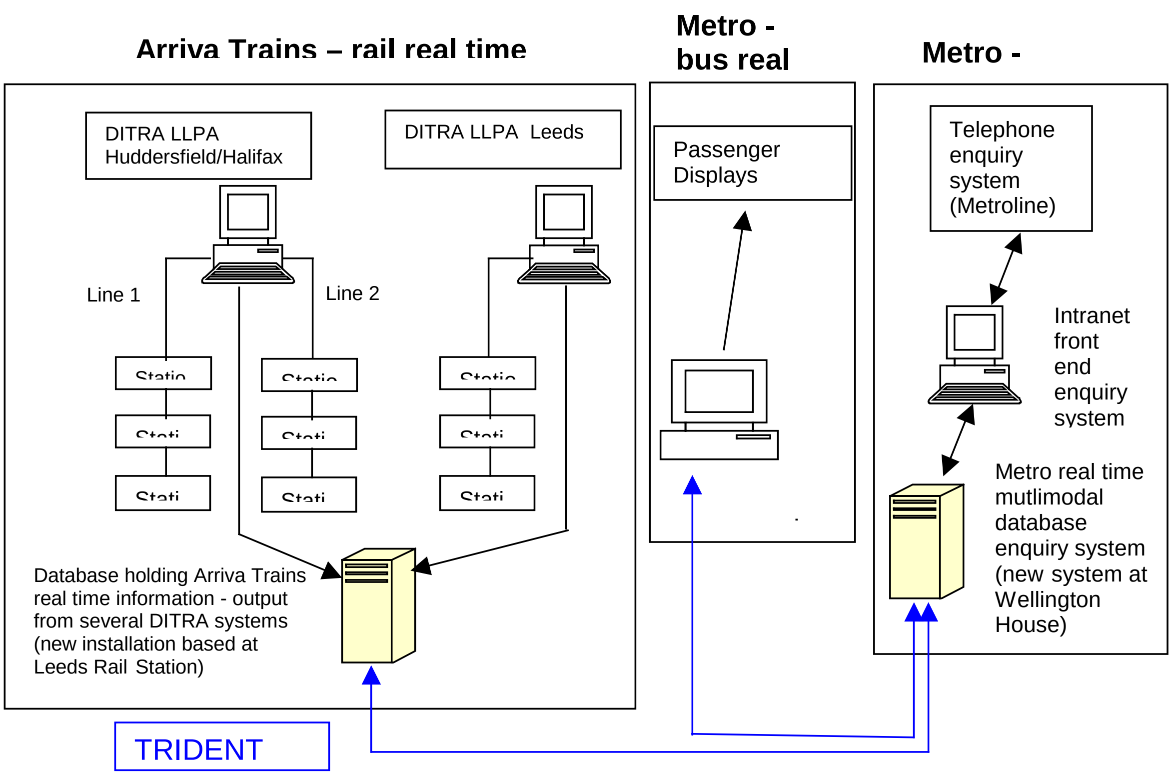

Figure 1 – Diagrammatic Representation of the West Yorkshire Dynamic Test Site

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4.3.4 Rome test site

The two approaches (EDI and OO) will be tested on the Italian site in different laboratory areas in urban context (Rome and Turin) to test the compatibility, reliability of the EDI-DATEX and OO different approaches and to determine the applicability in such context of the two approaches.

The realisation of a new service through the OO approach in which users can receive combined information, originated from two different transport sectors, in a simple and useful way is an important added value expected by the project with the general objective of improving mobility through a better knowledge of transport situations and facilities.

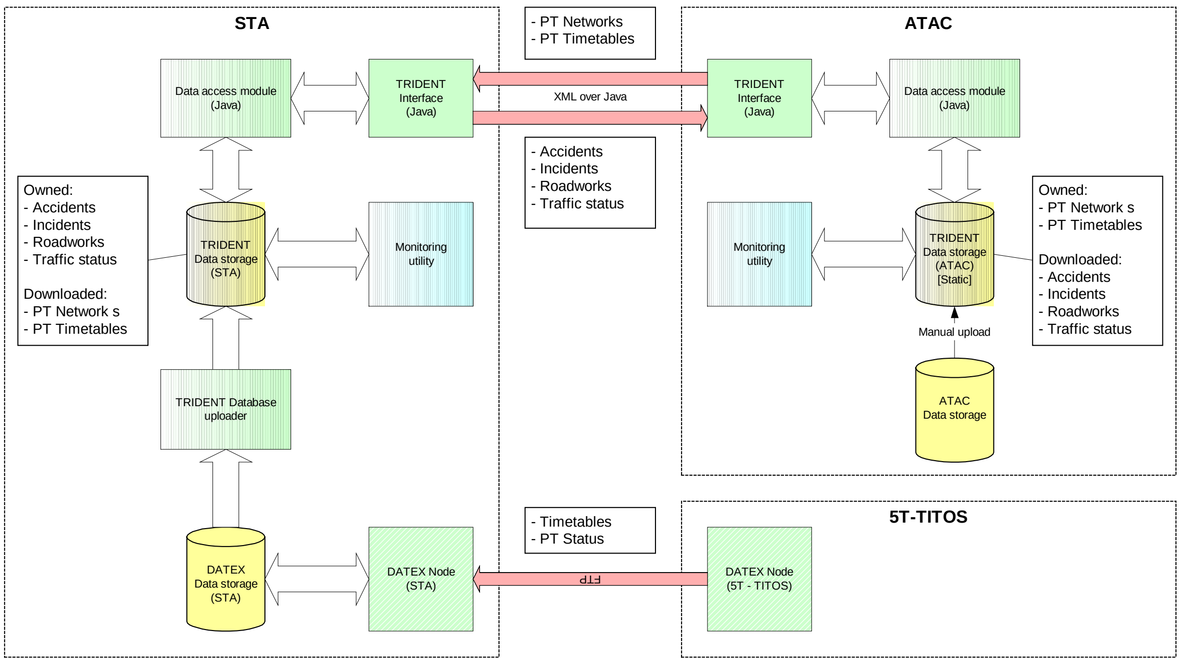

Figure 2.3.1 – The TRIDENT architecture in the Italian site

The final scope of Rome is in having a system able in linking and connecting info-servers and databases of different transport mode operators in order to support planned door to door travel information services in the area, with possible extension to tourism and leisure.

In the diagram, the cumulative situation of the trails among the three organisations is evidenced as well as areas that will be addressed by TRIDENT.

The introduction of new messages on top of a DATEX-Net client-server system architecture between STA and 5T TIC (in particular messages for delays, cancellations and schedule in public transport). STA is the mobility agency for the city of Rome. Its Traffic Control Centre manages about 200 km of primary roads inside the city as well as 60 CCTV camera network, 48 VMS network and the access control system to the historical centre. All this data and the integrated information coming from them are managed by a Datex standard TIC. The necessary future integration of this data with those coming from the Public Transport operators for the provision of a complete information service to the stakeholders and to the

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citizens, makes necessary the testing of data exchange protocols and the evaluation of new systems.

5T Company has already developed a server infrastructure capable of accessing mobility information (private and public transport static and dynamic info, general info on Turin services). This server has already a standard DATEX interface to allow client-server exchange of mobility transport data. In the context of the 5T plans, this infrastructure will be powered and enhanced in order to support the above described services in the EDI test.

The participating operators for the Italian OO test site are STA, ATAC and 5T Company, who have implemented TRIDENT-interfaces to create the information backbone required for a multimodal door-to-door journey planner demonstration service system. This TRIDENT system is intended for service providers who will build applications on top of the exchanged / shared data. The consultancy office MIZAR MEDIASERVICE, who made part of the TRIDENT specifications, will be the service provider for the TRIDENT demo. The role or added value of the TRIDENT application in Italian lies in the fact that all the available data can be exchanged between STA and ATAC via XML requests. Thus ATAC and STA will test the OO approach: the objective of this test is to realise a new service in which users can receive combined information, originated from two different transport sectors, in a simple and useful way.

4.4 Standardisation

4.4.1 TRIDENT CEN TC 278 submissions

The TRIDENT draft and final standards have been submitted officially to CEN TC 278 working groups 3, 4 and 8. Various presentations preceding the submission have been given on TC 278 technical meetings by the specification developers. TRIDENT has also given considerable amount of feedback to a new work item on CEN TC 278 WG3 for “Dynamic Public Transport Architecture”, where TRIDENT is seen as a cornerstone achievement and a major input to the standardisation activities.

4.4.2 Working with TPEG

TRIDENT developers have also given related feedback to the standardisation activities carried out by the TPEG protocol developers. The main issue seen necessary to be made coherent is the location referencing. The post-TRIDENT project activities will also aim in closer collaboration with the TPEG community, and EBU has already given indication of interest to collaborate in future development and converging actions.

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4.4.3 Working with DATEX

Both the specifications rely heavily on the work already carried out in DATEX. Therefore, a close liaison with the DATEX community was established from the beginning of the project. Many of the key partners (CETE-Méd, TRITEL, Mizar, MVA) were already essential partners in the DATEX programme, which helped the information flow between the initiatives.

At the end of the project, the final OO specifications were also officially submitted to the DATEX technical committee for evaluation purposes to see, how the DATEX could migrate towards the OO approach taken in TRIDENT. The post-TRIDENT project activities will also aim in closer collaboration with the DATEX community.

4.4.4 Working with EDIFACT

The draft and final specifications have been unofficially presented to the EDIFACT Transport Committee. However, as even the underlying DATEX specifications and messages have not officially been standardised for EDIFACT, the TRIDENT additions remain “for information only” to the EDIFACT. It was suggested by the end of the project, that the DATEX TC would pursue further standardisation on the EDIFACT wrapped TTI messaging.

4.5 Models, guidelines, methodologies

TRIDENT’s main effort has been in producing a set of specifications to be used for multimodal Traffic and Travel Information exchange on a European level. The project has not implicitly specified issues like model contracts for information exchange, guidelines for implementing the specifications and guidelines for agreements between the actors. These have been recognised as key issues within the project, and some recommendations have been given in a “Final Recommendations to Overcome Non-Technical Obstacles” –deliverable.

These issues on a larger scale have been proposed to be handled further on either a TRIDENT spin-off Forum or a large-scale TTI activity on the 6th Framework programme, taking into account e.g. the EC recommendation on the availability of public TTI for private services.

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5 Deliverables

The following table presents all deliverables produced and delivered by the project with the corresponding web link when publicly available.

Table 1: TRIDENT deliverables and corresponding website links (for public documents)

Deliverable number and title		***Dissemination level***	***Electronic reference***
D1.1	Project Summary Presentation	Public	**N/A** **(Information available at www.cordis.lu)**
D1.2	Final Report	Public	**N/A** **(This Document)**
The present report.			
D2.1	Characteristics and benefits of state of the art data sharing and exchange technologies	Public	http://www.ertico.com/activiti/projects/Doc_Library/Trident/2_d21v50.pdf
D2.2	Draft User Needs and Communication Scenarios	Public (superseded by D2.5)	**N/A** **(superseded)**
D2.3	Draft Recommendations to Overcome Non-technical Obstacles	Public (superseded by D5.5)	**N/A** **(superseded)**
D2.4	Results of the User Forum	Public	http://www.ertico.com/activiti/projects/Doc_Library/Trident/2_d24v20.pdf

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Deliverable number and title		***Dissemination level***	***Electronic reference***
D2.5	Final User Needs and Communication Scenarios	Public	http://www.ertico.com/activiti/projects/Doc_Library/Trident/2_d2.5.pdf
D3.1	Draft Specifications for the EDI Approach	Public (superseded by D3.6)	**N/A** **(superseded)**
D3.2	Results of Technical Workshop on use of New Technologies	Public	http://www.ertico.com/activiti/projects/Doc_Library/Trident/2_D3-2_v2-1.pdf
D3.3	Draft Specifications for the Object Oriented Approach	Public (superseded by D3.7)	**N/A** **(superseded)**
D3.4	Prototypes for the EDI Approach	Public	http://www.ertico.com/activiti/projects/Doc_Library/Trident/2_d34.pdf
D3.5	Prototypes for the Object Oriented Approach	Public	http://www.ertico.com/activiti/projects/Doc_Library/Trident/2_d35.pdf
D3.6	Final Specifications for the EDI Approach	Public	http://www.ertico.com/activiti/projects/Doc_Library/Trident/2_D36agr.doc
D3.7	Final Specifications for the Object Oriented Approach	Public	http://www.ertico.com/activiti/projects/Doc_Library/Trident/2_D37agr.zip

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Deliverable number and title		***Dissemination level***	***Electronic reference***
D4.1	Site Validation Plans	Public	http://www.ertico.com/activiti/projects/Doc_Library/Trident/2_D41v30.zip
D4.2/3	Site Implementation Results	Public	http://www.ertico.com/activiti/projects/Doc_Library/Trident/2_d423.pdf
D5.1	Project Evaluation Guidelines	Public	http://www.ertico.com/activiti/projects/Doc_Library/Trident/2_d51v14.pdf
D5.2/3	Validation results of the demonstration sites	Public	http://www.ertico.com/activiti/projects/Doc_Library/Trident/2_d523.pdf
D5.4	Results of the User Forum	Public	http://www.ertico.com/activiti/projects/Doc_Library/Trident/2_d5_4.pdf
D5.5	Final Recommendations to Overcome Non-technical Obstacles	Public	http://www.ertico.com/activiti/projects/Doc_Library/Trident/2_d55.pdf
D6.1	Dissemination and Use Plan	Public	http://www.ertico.com/activiti/projects/Doc_Library/Trident/2_d61v40.pdf
D6.2	Draft Technology Implementation Plan	Restricted to Project Partners	**N/A (Confidential)**
D6.3	Final Technology Implementation Plan	Restricted to Project Partners	**N/A (Confidential)**

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6 Conclusions and Outlook

6.1 Technical feasibility of the solutions

The specifications have proven to be a workable solution on four very different test sites and test applications in different European countries. They offer technical benefits not available using previously developed solutions. Together with the state-of-the art object-oriented technologies and support for Internet based communications platform they offer a very effective backbone solution for pan-European multimodal real-time information exchange.

The object oriented data model and the accompanying XML schemas have made the data content easier to understand and implement than on the previous developments (e.g. DATEX). And as the solution is based on existing standards (DATEX, TransModel),

However, as the specifications have only been tested for a rather short period of time with small-scale demonstration applications, their full technical viability and extendibility is yet to be proven.

6.2 Economical viability of the solution

6.2.1 The EDI solution

The EDI solution is targeted at authorities and other organisations that have already implemented DATEX for their TTI exchange. The new TRAPTI message can be added to the existing DATEX node at a fairly modest investment.

However, as none of the project participants any longer had any specific interest in EDI developments, the developed EDI solution has been publicly released, and informally presented to both EDIFACT and CEN for potential future activities.

Generally, an EDI based TTI exchange solution has not been able to gather large support outside the public authorities sector (e.g. DATEX), and TRIDENT did not seem to make an exception to this rule.

The downside of a DATEX-like solution is, it is quite unknown outside the small public road authority sector (and some commercial motorway operators), which usually has very little interest in public transport information. As the main use of TRIDENT is to provide multimodal information to upper levels of the information chain, it is usually more economically viable for the supplier of the road traffic information to adapt to the needs of the rest of the content chain than to try to adapt the needs of the content chain to the needs of the single actor. Especially as something like a DATEX message on road traffic information can

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almost seamlessly be transferred into a TRIDENT OO message with rather similar content on very small investment on a “DATEX->TRIDENT OO” translator.

6.2.2 The OO solution

The OO solution has seen a substantial experimental and even commercial take-up during the lifespan of the project as well as afterwards. As a singular commercial solution does not exist for TRIDENT, but it is more a “building block” for future commercial products, no actual figures can be given on the financial viability of the solution.

However, a large number of organisations, especially in UK, have shown a high interest and belief in a TRIDENT-like solution. The suppliers of commercial solutions in TRIDENT (especially MVA and MIZAR MEDIA SERVICE) have shown interest in continuing to support TRIDENT specifications after the life of the project, on their own expenses. This alone is evidence of the commercial viability of the solution. On top of this, there are many organisations around the world, mostly middleware suppliers, outside the project consortium who have requested a copy of the TRIDENT specifications for evaluation purposes.

Country	Number of UAs
France	8
UK	10
Belgium	7
Finland	5
Sweden	4
Germany	8
Netherlands	2
USA	2
Austria	1
Denmark	3
Norway	1
Switzerland	1
Spain	2
Canada	1
New Zealand	1
EC	1
Grand Total	**57**

Table: Number of TRIDENT Final Specification User Agreements Signed by different organisations

The further take-up of a harmonised TRIDENT-based solution however requires a clear commitment from the specification user community to work together on the development activities. By the end of the project, a supporting forum was planned to be established, and a first launching meeting is planned for February 2003. The intention of the open self-funded forum is to act as a guardian for the specifications and guarantee, that any development within the TRIDENT specifications is applicable on European level, and also properly disseminated to the ever-growing user community.

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6.3 Future developments

TRIDENT project has recognised two clear development paths for the activities of TRIDENT and also other issues recognised during the lifespan of the TRIDENT project.

First of all, **there is a clear need for a supporting organisation for the TRIDENT OO Specification development.** For this, ERTICO is planning to launch a TriEx –forum to build a technical group for supporting the specifications. Clearly recognised activities would be handled within the self-funding organisation, where the developers would, with their own resources, jointly develop and maintain these specifications. The interest for such a forum has already been expressed by several participants of TRIDENT as well as the TRIDENT Specification User Community.

Secondly, this before mentioned forum requires a **higher level supporting structure to give support on the general issues in information exchange** (e.g. long-term visions on convergence between multiple approaches), and the more organisational and political issues. ERTICO intends to use the same TriEx forum as a platform to create a “TTI Exchange High Level Group”.

Thirdly, **there clearly is still innovation for research and development in the TTI sector in Europe.** This is to be proposed as an Integrated Project for the 6^{th} Framework Programme. Need for development would especially be recognised in creating a solid pan-European networking and marketplace structure for Traffic and Traveller Information. Especially issues like

- Enhancement towards tourism information and reservation / payment services
- **Singular** multimodal location referencing method applicable for multiple end-user services
- On-line agreements between actors
- The **business models** for TTI services
- **Aggregation of content,** eg. Creating travel times from floating car and vehicle count/speed (“loop data”) sources
- Making information more easily accessible and available on-line independent of media channel, end-user terminal and user preferences

are currently missing from all the TTI exchange developments, and do clearly need a pan-European approach. An initiative has been put forward by ERTICO and it has already gained a huge interest in the field, from public authorities, service providers, software vendors and research institutes throughout Europe.

In conclusion, TRIDENT has been achieved a foothold in Europe on TTI information exchange. However, the field is very scattered with a huge number of overlapping solutions with no clear interfacing technologies between any of them (e.g. TRIDENT can act as a backbone solution for information exchange, but there is no guide on how to translate TRIDENT message into a TPEG or TMC message). A harmonising activity to take all the activities into conclusion is intended to be done within a TriEx forum. Making all the information available technically via a singular networking is another issue, and this is to be supported by a potential large-scale FP6 activity.

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7 Project Data and Contact Details

Project Data

Contract: IST-1999-10076 - TRIDENT
Starting date : 01-Jan-2000 **Duration :** 33 months
Total Cost : 3,462,592 EURO **EC Contribution :** 1,477,588EUR
Project URL : http://www.ertico.com/trident/

Project Participants

Principal Contractors	**Country**	**Role**
European Road Transport Telematics Implementation Coordination Organisation S.C.R.L.	B	CO
B+S Ingenieur AG	CH	CR
Centre d'Etudes Techniques de l'Equipement-Méditerranée	F	CR
Vlaamse Vervoermaatschappij DE LIJN	B	CR
MVA Limited	UK	CR
Régie Autonome des Transports Parisiens	F	CR
Societa Trasporti Automobilistici S.p.A.	I	CR
Transport Infrastructure & Telematics NV	B	CR
Mizar Mediaservice S.r.L.	I	CR
Agenzia per I Trasporti Autoferrotramviari del Commune di Roma	I	CR
Assisting Contractors	**Country**	**Role**
Ministerie van de Vlaamse Gemeenschap	B	AC
La Poste Suisse Car Postal	CH	AC
Sponsor	**Country**	**Role**
ASTRA – Swiss Federal Roads Office	CH	Spons or

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Contact Details

Project Coordinator

Name :	Paul Kompfner
Organisation :	ERTICO - European Road Transport Telematics Implementation Coordination Organisation S.C.R.L.
Address :	Avenue Louise, 326
	1050 Brussels
	Belgium
Tel :	+32 2 400 07 32
Fax :	+32 2 400 0 7 01
e-mail :	tridentertico@mail.ertico.com

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