INTREST + EUROMAP: Intermodal Digital Network Models for Europe

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SUMMARY

Until now European Digital Network Databases usually cover just one mode of transport, refer only to a specific area or are merely suitable for information issues. A new concept of an integrated data model will be presented which offers an open and consistent platform of network data for multi-modal and inter-modal transport applications. The network data can be used for applications in the field of transport planning, travel information and operational planning. Different data sources, e.g. digitised road networks from commercial navigation systems and public transport passenger information systems are integrated to provide a basis for uni-modal and inter-modal routing purposes.

1 REQUIREMENTS AND EXAMPLES FOR EUROPEAN DIGITAL NETWORK MODELS

High quality and up-to-date digital content is the key to high quality transport, traffic and mobility applications and services for public and commercial as well as private purposes. Typically, data pools such as hotel registers, yellow pages or digital road maps by the major commercial providers can only reach limited completeness and relevance on local level. Centralised content acquisition by commercial providers is costly and can often not yield sufficient quality and detail due to the lack of local knowledge. At the same time, different actors are working on a local as well as application-specific level. They acquire and process transport-related digital data, e.g. for transport planning, traffic management and tourist information.

These data pools cannot be easily accessed and combined, due to different map bases and referencing techniques as well as different data formats and quality standards. Furthermore these data pools usually only have local to regional coverage. The separation of digital map content is also visible in the area of public transport information, which is not integrated with road transport. Intermodal applications and information services therefore require particular effort with regard to digital map maintenance and integrated services.

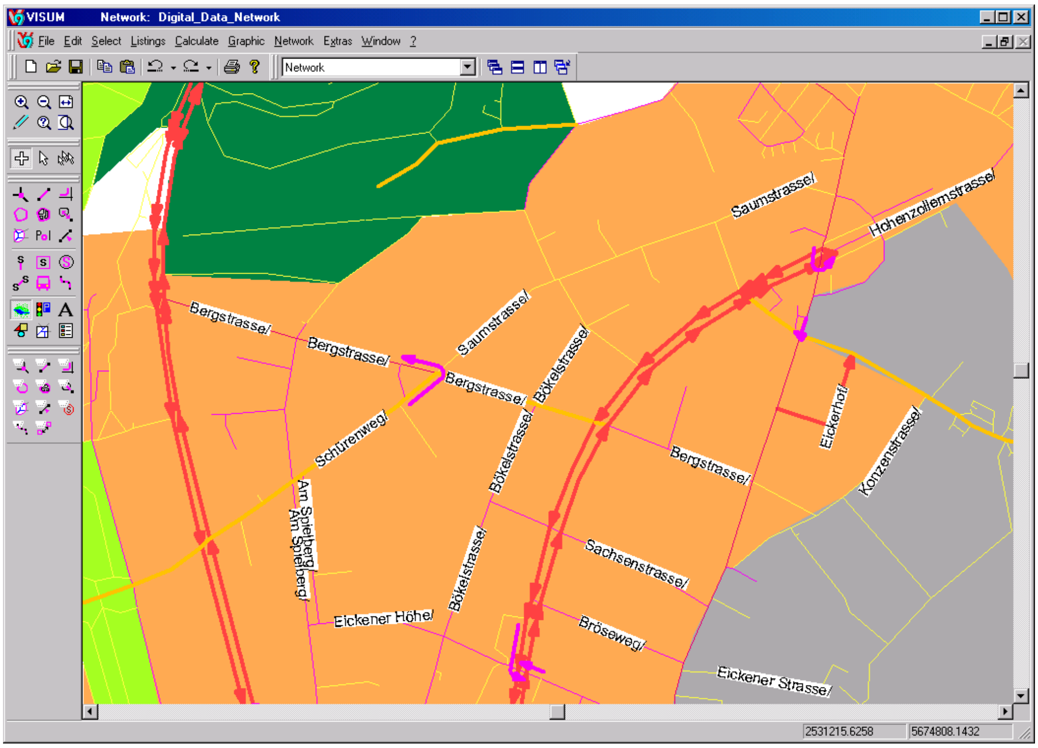

Figure 12: Transport network derived from commercial European digital data source including one-ways (red links) and turning prohibitions (violet links)

PTV and DDS provide these data in easy to handle formats like ATF or Shape File, which are easier to handle than GDF data description. If street and public transport networks should be covered by one common system, a significant extension of base data model and its format is needed. GDF e.g. doesn't cover the field of public transport or more general spoken timetable or headway based line services.

For different applications relevant data sources are offered for European networks on a highly detailed level as well as based on the major network only. In general link networks are updated and extended regularly. Additional spatial information layers such as settled areas, industrial areas are provided without as much precision.

Link network data is offered as pure network data including link information only. Applying advanced conversion methods simple networks without any routing restrictions and attributes can be derived to generate the minimum requirement for routing networks –

links and nodes. More comprehensive data sources include additional routing information and network attributes such as turning prohibitions, link types and one ways (see Figure 12).

One essential task is data integration of different spatial data sources. Two main aspects have to be considered: spatial (coordinates) and data (attributes) integration. A first step can be done within GIS programmes. They handle objects such as points, polylines and polygons within a spatial framework. Coordinates are defined based on projections or depictions. Objects are described by attributes within databases and coordinates. External objects with yet no spatial context (e.g. petrol or railway stations) have to be geo-referenced (e.g. based on street name and house number or GPS-data) to be included in the complete data framework.

Coordinates of different digital data sources can be transformed into one common system to get a spatial data integration. No depiction system can be called the best system for a European network display. As a conciliating system e.g. a “Lambert conformal conical” system, using two standard parallels, can be applied.

European networks can be generated for individual transport (e.g. water, road and road network) as well as for public transport (e.g. rail, bus, air transport). Many aspects of a transport or traffic model cannot be described within a GIS data model (e.g. turnings at a node, directed links attributes, time profiles). Therefore further specialised programme systems are needed. A newly developed data model for *ptv vision* describes the different requirements for individual and public transport networks.

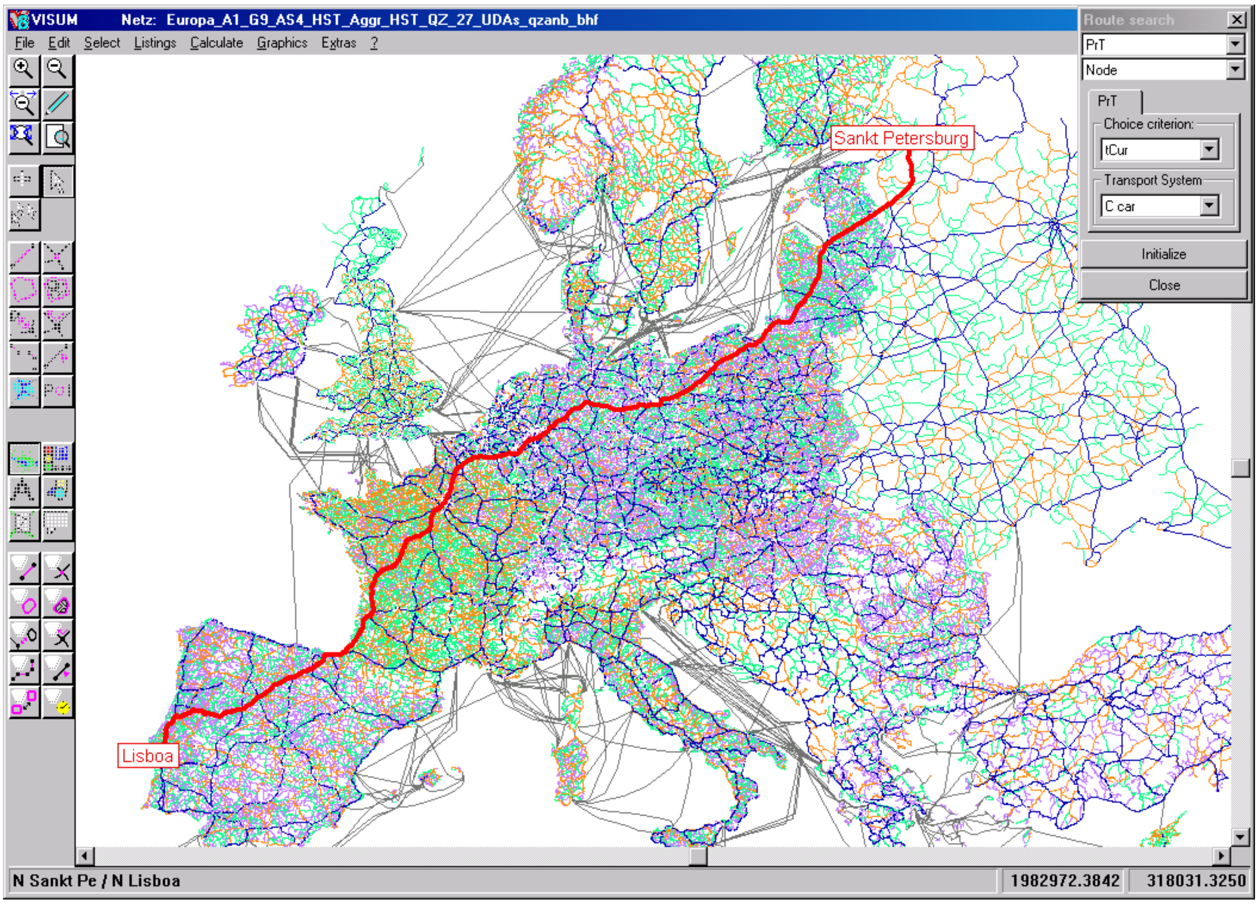

Figure 13: Route search in European road network: St. Petersburg -> Lisbon

Navigation network data is widely used in road routing systems. The fitting and consistency of different sources has an important role. “Holes” in the link network are highly disabling to these systems for European-wide route guidance calculations. The European road network as displayed in Figure 13 contains 173.000 nodes, 506.000 links and more then 1.6 Mio turnings. A route search between e.g. St. Petersburg/Russia and Lisbon/ Portugal takes a few seconds within ptv transportation/VISUM using a standard PC. This transport network is based on DDS/PTV European network data. The first major 4 link categories are considered (4 of 7 categories).

The generation of a public transport network needs more input data then a road network. The road network can be used an initial network e.g. for bus networks. Rail, water or air bound networks have to be generated separately. Some more specific public transport elements have to be added as well: stops, line routes with its time profiles, timetable information. Figure 14 shows a European railway network with more than 64.000 stations plus several 1.000 turning junctions, nearly 150.000 rail links and approximately 330.000 turnings.

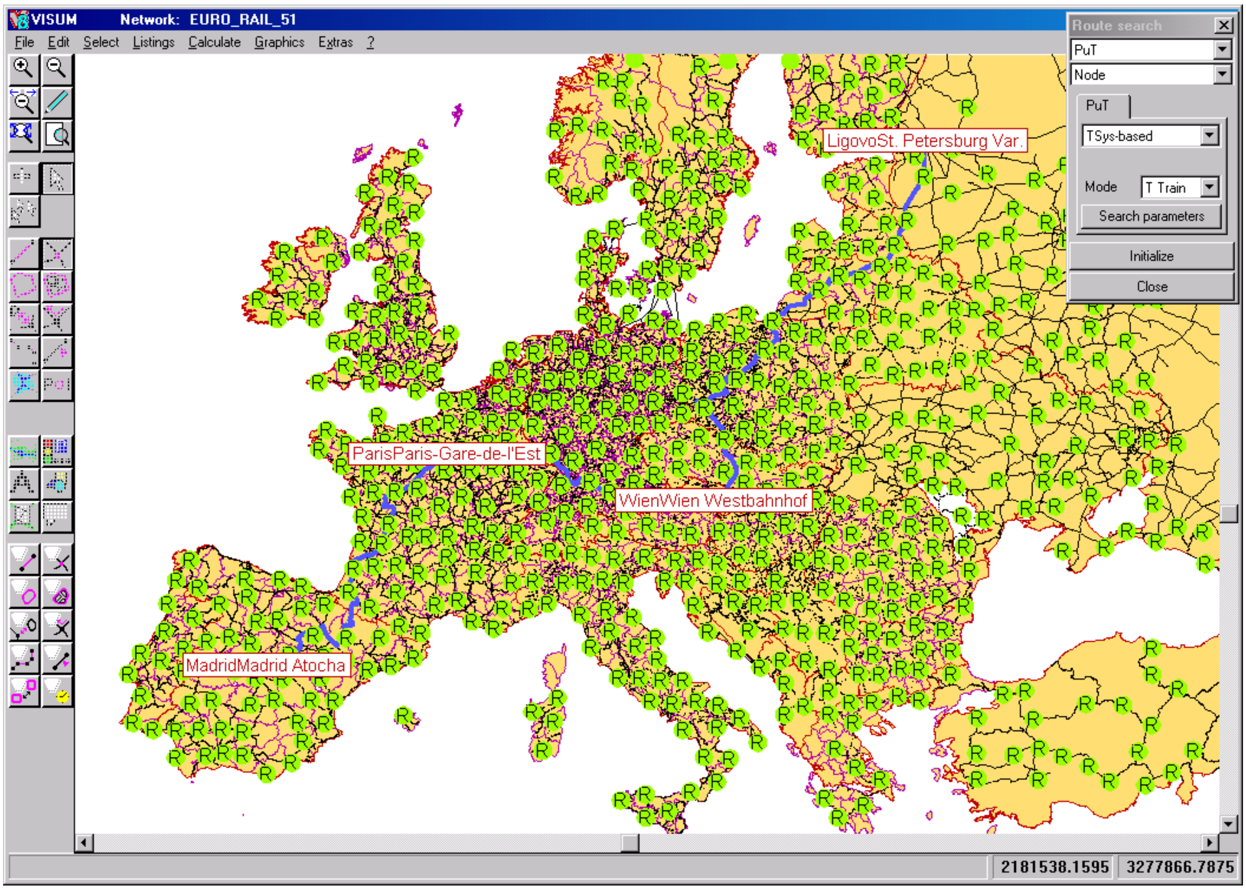

Figure 14: Route search in European rail network derived from digital data sources (R: station)

As soon as line-routes and timetable information are included, the modelled transport system offers all functions for a public transport passenger information system.

Integrated information systems based on digital maps are needed for easier data access and minimisation of parallel non-connected databases. These can have huge advantages for the system operators as well as for the users. Only one database has to be managed (e.g. reduced cost for system extensions) and only one database has to be consulted by the users, offering many different spatial data. A good example for such a highly integrated spatial database is developed within INTREST for the whole state of Bavaria.

2 INTREST – DATA INTEGRATION

The INTREST project develops and demonstrates the technical infrastructure as well as the commercial and organisational framework for a central, inter-modal referencing platform for transport-related digital data in Bavaria. Local and application data and data specific to different applications, which are collected and maintained by public and private entities, are combined in a central data pool where they are referenced to a digital map and marketed to third parties. Two transport software providers, PTV Planung Transport Verkehr AG, Karlsruhe and Mentz Datenverarbeitung GmbH (mdv), Munich have been charged with the conception and development of the system, which is scheduled to operate in 2004.

2.1 Objectives of Interest

As part of the Bavarian mobility 21 initiative, the INTREST-project develops the technical infrastructure as well as the commercial and organisational framework to overcome this situation in Bavaria. Central objectives for the Bavarian state (Board of building and public works, Bavarian Ministry of Interior Affairs) for the project are

- *Improved access and exchange of transport-related digital map data* and corresponding content areas for public and private entities in Bavaria by establishing an integrated geo-referencing system and digital map data pool which is shared and maintained by the INTREST partner network,
- *Improved quality and completeness* of transport-related digital map content for Bavaria: diverse, decentralised INTREST partners with local and application-specific knowledge ensure the content supply. Central to INTREST is a comprehensive digital vector map, which integrates public and private transport modes in a network model,
- *Open and extendable system architecture and content catalogue* in order to integrate diverse applications and services; the INTREST object model and the INTREST interface are public,
- *Maximum synergies with commercial digital maps:* With a commercially available digital (vector) map as base supply in INTREST, initial content layers and their regular updates are ensured. No redundant collection of digital map data occurs. If necessary, digital map data with coverage outside Bavaria can be easily joined,

- *Establishment of a dynamic, inter-modal trip information system* on the Internet as showcase for data pool,
- *Development of organisational and commercial terms* for the continuous operation of INTREST by a private operator after the end of the project.

In the longer term, the INTREST referencing system and data pool shall

Facilitate and improve digital map applications and services of the different Bavarian state authorities with regard to transport planning, infrastructure operation and information services. Examples are applications such as road accident evaluation, road construction management systems, or road management systems and their related information services;

Create an improved inter-modal transport content base and subsequent services, which help to achieve a more balanced modal split in passenger transportation; stimulate new IT applications and services by third parties through high quality and low cost local digital map content.

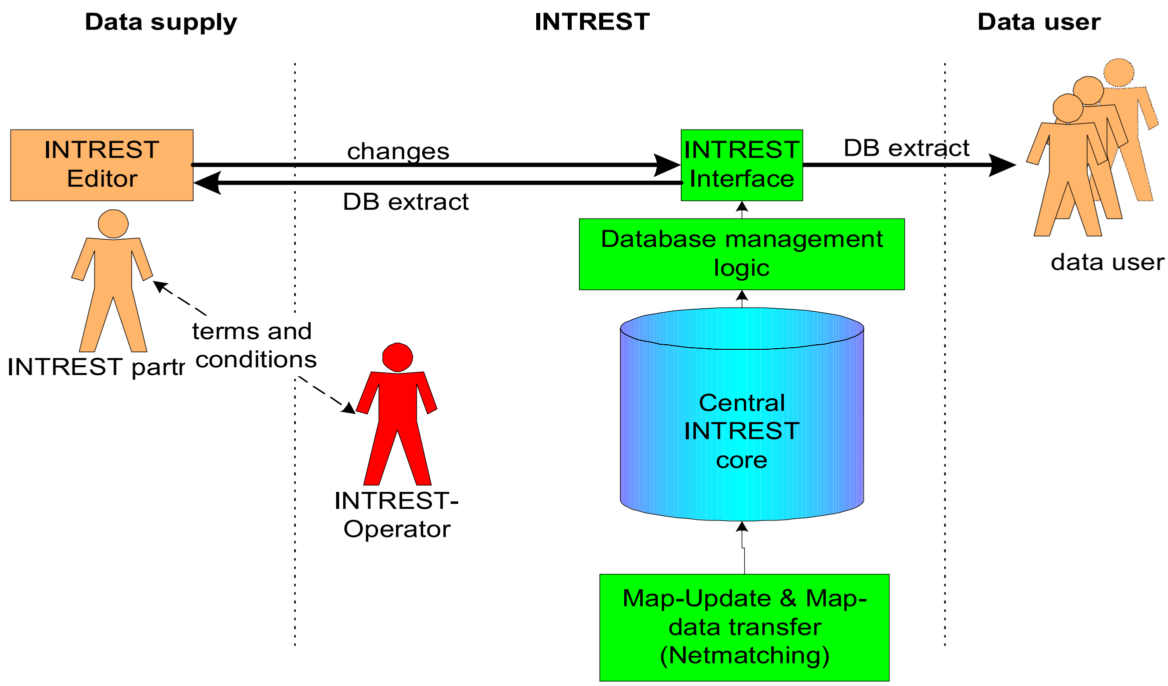

Figure 15: Principle workflow of INTREST

2.2 Use cases and scenarios

The main use cases for the INTREST system are described, together with the concrete scenarios, where they are applied. The scenarios reflect activities of pilot INTREST partners, which will use and test the INTREST system during the test operation phase.

Obtaining data from INTREST

The INTREST customer has to register with the INTREST operator and agree on the general commercial terms of INTREST (incl. licences, see below). With a web browser application, the customer can customise the content for extraction from INTREST, with regard to the object layer and geo-graphical coverage. The data are then extracted and stored. The customer then receives a link to download the data in the standard INTREST format.

> *Example 1:* The Bavarian traffic management centre is an INTREST partner and regularly references its detection units and other data in INTREST. A telematic service provider wants to use additional dynamic information layers from the Bavarian traffic management centre in order to upgrade his own information base. For this purpose, the service provider needs the stationary detection units on the motorways including their geo-references. Instead of re-entering and referencing the data, he purchases the detector data including the reference to the commercial map database from INTREST.

Entering and maintaining data in INTREST

Entities supplying INTREST become INTREST partners and have access to the data pool at preferential terms. Initially, the operator agrees the extent of the data supply with the partner, in terms of coverage, content layer and update frequency. Usually, the partner will communicate with the INTREST server via a web-browser interface in order to obtain a data base extract for editing. If no other editing restrictions (e.g. from another editing partner) exist, he locks this content layer for other editors and receives the data in the standard INTREST format via download. The data entry is then handled off-line via an INTREST editor or a compatible editing application. Having completed the editing, he will login on the server via the browser interface, upload the changes and free the lock. The server checks the data and integrates them into the data pool or rejects them. The user is informed about the result and the user account is credited with the value of the data delivered to the server.

> *Example 2:* A large public transport provider supplies INTREST with data on public transport lines (sub-way, tramway), cycle paths and pedestrian paths. He enters this information to make it available in information services using INTREST

data. The public transport provider becomes INTREST partner and has the rights to change those content layers in his area of operation.

Example 3: The authorities of a large Bavarian city together with the public transport provider wish to enrich the digital map content available for their information service on the Internet. They therefore will make use of the editing possibilities and enter points of interest (POI) with regards to public places as well as tourist information.

Updating the digital map in INTREST

The underlying commercial digital map is regularly updated in INTREST, in order to maintain the compatibility with the current commercial map coverage and in order to benefit from the updated map content. Since the editing operations might have altered the original topological content of the INTREST map (e.g. inserted a new link), the two maps need to be matched, i.e. links in the INTREST map have to be mapped to links of the new commercial map update to identify the differences. The INTREST map is then enriched by those changes, new in the commercial database. All geo-references by other data objects to the INTREST network are then updated to the new enriched network base. This complex process is done at least once a year.

Integrating data from foreign map databases

Certain content layers in foreign digital map databases can be useful to the INTREST data pool though their transfer cannot be handled via an editing tool. This way of data transfer into the INTREST database is important, since it allows existing databases to be tapped with their own referencing and digital map. It also allows the transfer of INTREST data to external network references in foreign databases. In such a case, a net-matching process between the foreign map base and INTREST is performed. In an offline process, corresponding links in both networks are identified. After an automatic identification of corresponding links, a remainder of links, which could not be matched automatically, needs to be treated manually via an editor. With the resulting set of corresponding network links, attributes and objects in the foreign database can then be transferred to the corresponding object or reference in the INTREST database. Such a process cannot be handled by the INTREST partner supplying data via the INTREST interface, but requires the special intervention of the system operator.

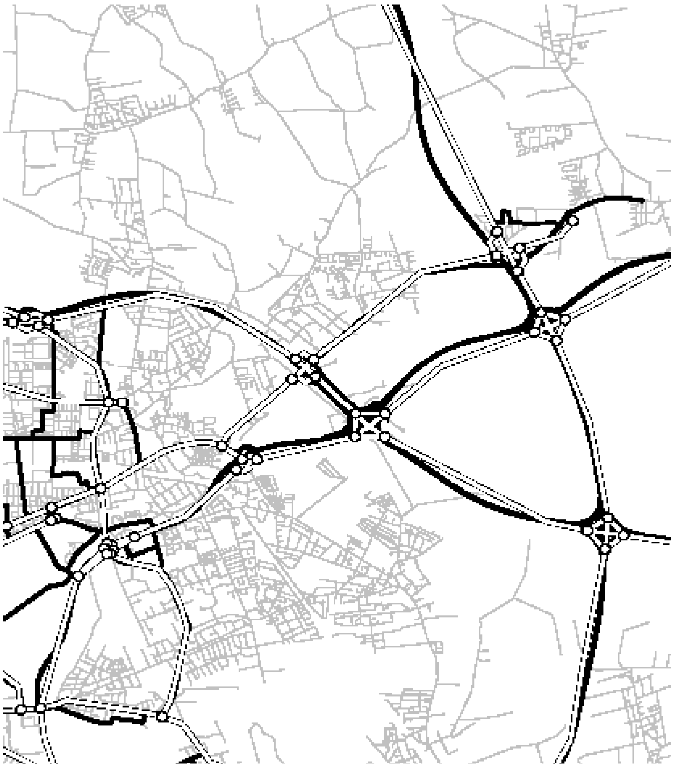

Figure 5: Example of two digital networks which are matched against each other

Example 3: The Bavarian traffic management centre integrates certain (static) base objects in INTREST to which dynamic information layers refer to: this includes stationary traffic detection units, 'LOS'- links (links to which a calculated Level of Service refers to) etc. The traffic management centre plans to update its digital map regularly through INTREST including the references for its own specific objects. With regards to the linear objects, a net matching with the INTREST map has to be made. (see figure 5)

Example 4: The Bavarian road authorities have built up the Bavarian Road Information System (BaySIS) for planning and running their operations. BaySIS uses their own digital network and maintains information such as road width, number of lanes, road kilometre counter in this system. With the help of a net matching such information can be transferred towards the corresponding INTREST objects.

2.3 Integrated digital map data model for inter-modal traffic information services

The digital map model that was developed for INTREST is geared to support the broad content requirements of inter-modal, dynamic traffic information systems. It also reflects the first INTREST partners and customers that wish to enter and to use the data pool. Of course, the current object content is useful for many other applications as well. With new requirements from further applications, new data objects and extensions can be added to the INTREST data model.

The data model contains the typical network and map objects from commercial digital map data providers (node-link topology, geometry, background layers, streets, addresses, points of interest), which have been adapted and enriched to the purposes of INTREST. Particular attention has been given to the modelling of public transport lines as well as non-motorised modes (by foot and or bicycle). Data objects for better coverage of administrative regions, specific public transport objects (a hierarchical model for transfer points between modes), traffic objects (like detectors, road construction, or traffic signs) and the representation of weather information have been added.

These objects are modelled and maintained in INTREST to the extent at which the content is interesting to more than one specific application and user. This avoids handling and maintaining too differentiated objects and content in a central database for general use. Additionally, specific information remains with the original data holder, who can save the INTREST Object-ID and network reference in case other INTREST partners wish to link this specific content to the core INTREST content (see figure 6**Fehler! Verweisquelle konnte nicht gefunden werden.**).

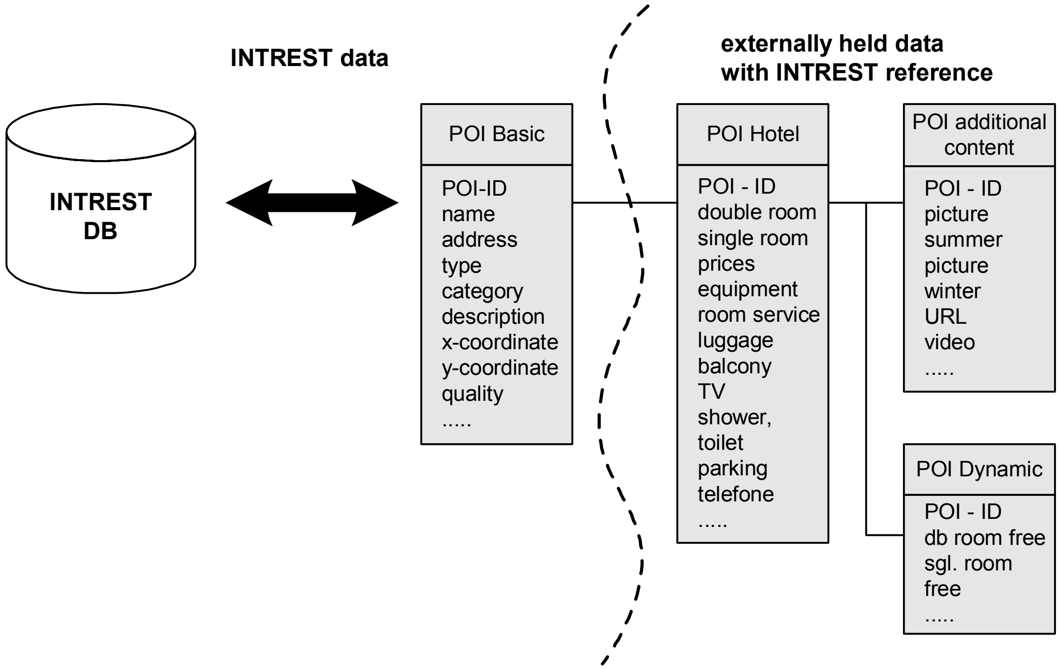

Figure 6: INTREST internal data object and corresponding object details with the data supplier (example: point of interest)

Dynamic content itself (e.g. current detection values) and the public transport schedule is not included in the data model but held in adjacent databases which use INTREST references to the respective static objects (e.g. the detection unit). To some of these objects, INTREST offers an object model as a recommendation.

2.4 Commercial view on INTREST

INTREST & EUROMAP have a particular position in the value-added-chain for digital map content since it aims at a content enrichment of commercially available map material through local sources and knowledge. This content is difficult to market on its own since it typically has a limited regional coverage, is not comprehensive enough on its own and since costs for processing the data for sales and marketing outweigh the benefits of the limited content by far. In this context, INTREST offers three basic functions to INTREST partners feeding content into INTREST:

- The referencing to a common (commercial) map;
- The compilation of separate data pools and suppliers into one database thereby creating a larger, more comprehensive content base;
- The brokering of the acquired data (together with the underlying commercial map);

In this way, INTREST can create a market for focused and small-scale content providers for which INTREST offers a central marketing and outlet of data. Such a sales perspective to third parties, while attractive in principle, will only work if INTREST has gained sufficient popularity, i.e. supplying partners and hence the INTREST specific content have reached a certain, critical level.

INTREST also offers partners the possibility to edit and enrich a (commercially available) digital map in their specific area and customise it to *their own specific purposes* on a continuous basis. Users of proprietary and self-maintained maps might eventually adopt the INTREST solution and replace their own isolated map maintenance through INTREST.

It is this latter motivation, which brings content owners without own marketing activities to collaborate with INTREST during the starting phase. Typical pioneer users of INTREST, which have already indicated their interest are municipalities, public transport providers as well as public authorities involved in road management activities.

For the operation of the data pool, data entry and data use need to be valued, otherwise data suppliers cannot be credited on the level of their contribution to the INTREST data pool. This is done through an internal user account, which records data entry and data extraction. The data entry is valued in an internal INTREST currency according to number, type and entry type (update/delete or insert). Similarly, data extracted are valued and debited to the users account. As long as the INTREST operator makes no commercial turnover of data, no money can be fed back to the data suppliers. As soon as data sales occur, the data suppliers can be rewarded according to their overall contribution to the whole INTREST data pool. No specific tracking of supply and sales of specific data (e.g. one specific hotel information) are envisaged so far.

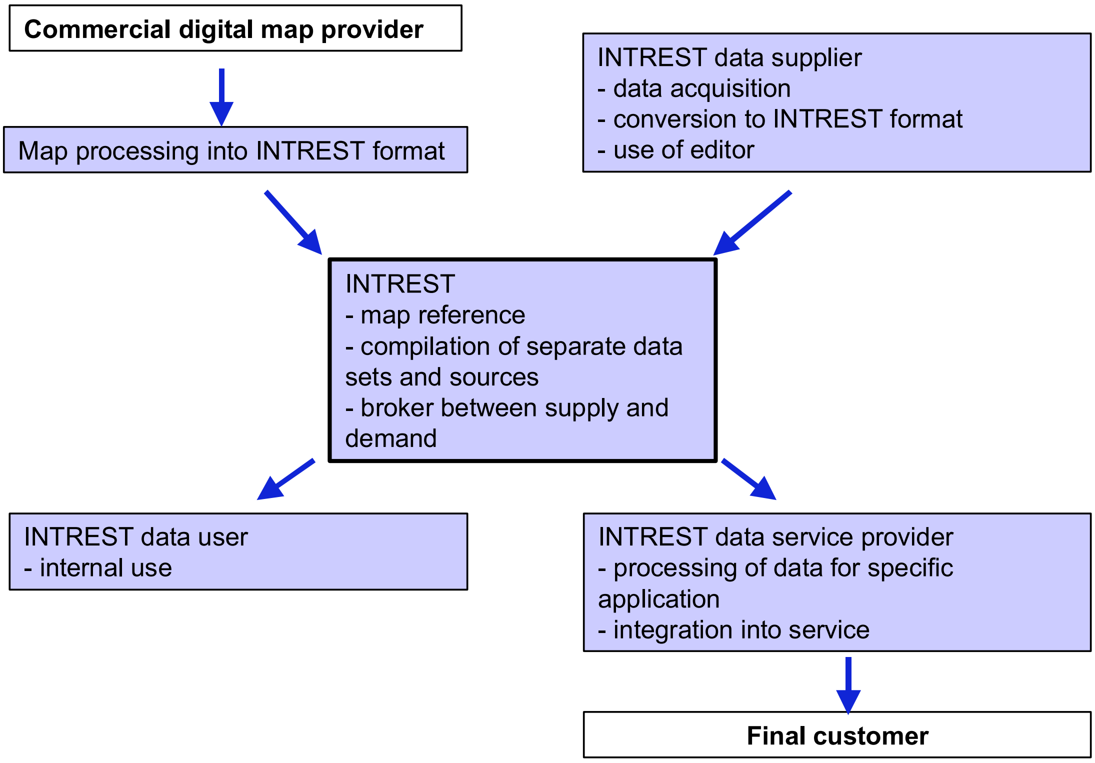

Figure 7: INTREST in the value-chain for digital map content

Obligatory to the use of INTREST data is the possession of the digital map licence of the supplying digital map provider. In the INTREST-project a licensing arrangement regarding transport-related usage has been negotiated and concluded between the Bavarian state and a major digital map provider. It offers preferential terms to INTREST partner supplying data to the pool. In order to motivate and push participation, the Bavarian state covers licence cost for its transport-related authorities and the major public transport providers with regards to desk top applications. Data use for Internet services or print media are ruled by separate arrangements.

3 TECHNICAL ASPECTS OF THE EUROMAP DATAMODEL

Based on the ideas of INTREST a similar project is being developed on a European level. The required data is available. It has to be collected and integrated within a core system e.g. like *ptv vision* and VISUM. The first results are shown in figures 2 and 3. While the main purpose of INREST is the improvement of the inter-modal passenger information the objective of PTV is to provide a comprehensive data model covering the requirements of road and public transport planning on strategical and operational levels simultaneously in one application.

A core system integrating data from various sources needs to be an open system with several interfaces for exchanging the data. This includes the ability to read and write several common data formats.

Starting to build up a new network the interfaces play a central role. Compared to a decade ago major projects no longer involve manual digitising of the core network, but will rather rely on already processed data. Especially data that is used for navigation systems for cars has proven to be very convenient. These navigation networks are not only very precise and have a high resolution, but are even updated regularly.

The data model is the base of any software application as:

- it defines all objects and there interrelationships,
- it determines the level of detail of the model,
- it limits or extends the possibilities of the applications.

For the integration of the product *ptv vision* into a consistent software package several adjustments were essential. Additionally the alignment with external data supplier and software producers made modifications necessary:

One example for an extension of the data model is an improved stop model for public transport. It introduces new levels of modelling with stop points being the smallest entity. Stop point describe locations where public transport vehicles stop for passenger transfers. Stop points are located within stop areas representing platforms, bus bays or station buildings. One ore more stop areas are aggregated to a stop (see figure 8).

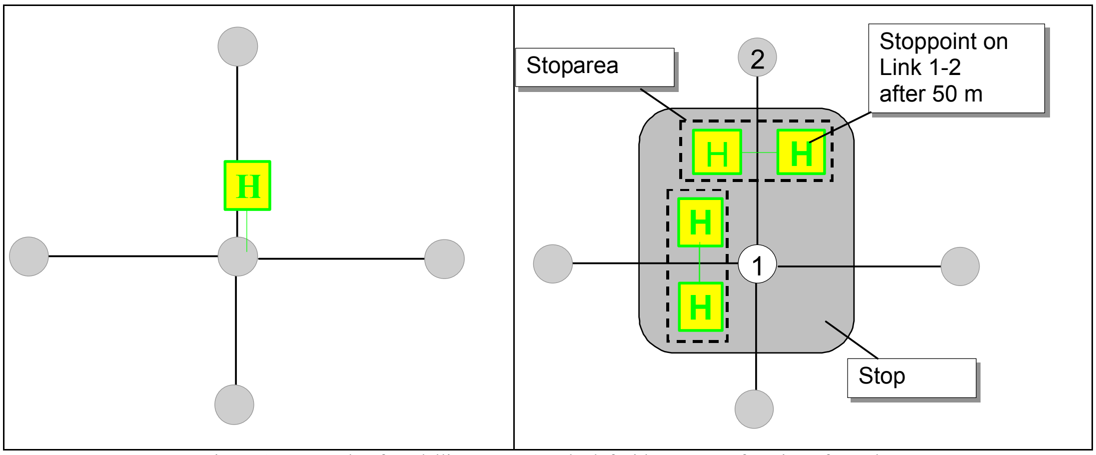

Figure 8: Example of modelling a stop: on the left side a stop as function of a node,
on the right stop points along a links united to stop areas and the stop itself.

This data model enables a much more detailed modelling of a stop (e.g. a railway station with different platforms) and thus supports additional types of information and evaluations. Such an extended model opens up new possibilities:

- a improved interaction between macro- and microscopic simulation,
- an intensive use of navigation networks,
- a linking-up with passenger information systems,
- navigation systems can be provided with dynamic traffic flow data and current travel times,
- passenger information systems can consider specific customer input (e.g. transfer with wheelchairs),
- vehicle data is analysed to calculate possible delays.

The core system is consequently not only a network editor and calculating tool, but also the core data framework, which is structuring, processing and improving information.

4 ACKNOWLEDGMENT

The reported developments in INTEREST and EUROMAP wouldn't be possible without the help of numerous colleagues namely Klaus Nökel, Steffen Wekeck, Thomas Friderich, Markus Friedrich, Michael Landwehr and Axel Gußmann.

5 CONCLUSION

The objectives of EUROMAP and Interest are to provide a wide and comprehensive access to high resolution navigation data for transportation planning and information purposes for reasonable costs. EUROMAP can build the backbone of a transportation data warehouse which allows to store and process multiple data in a consistent manner. The data platform is open, well documented and system interfaces to relational databases and standard GIS systems are supported. INTEREST is still under development. It is planned to publish in 2004 a white book which describes in detail the technical approach and the data model.