

Steps towards the infrastructure of ETIS from a user's point of view

- The way towards an operational ETIS using synergies between 4th FP outcomes -

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- Abstract** The goal of ETIS is to support policy-makers during the whole process of “Policy Scenario” formulation through to making the actual decision. Outcomes from the BRIDGES project are usable for the implementation of ETIS. The outcomes from BRIDGES can be used to guarantee homogeneous data, data structures, information contained in the data, software and software structures. The main concepts are a number of guides which serve as directories of available data (Digital Data-sources Guide - DDG), models (Digital Models Guide - DMG) and compatibility between both and between the models (Digital Models / data Compatibility Guide - DMCG), software to glue applications together that weren't initially developed to communicate with each other (Network Information System – NIS), a homogenous data (information) exchange format (Generalised Transportation-data Format – GTF and GIS-GTF) and a user-friendly interface (Decision Support System – DSS). Together, these components can be composed to be the foundation of ETIS. With further development, of a generic language for accessing models and retrieving results (Transportation-data Interchange Protocol – TIP), DMG, DMCG, further enhancement of the DDG, GTF, DSS and development of a single access point to all the functionality through a Web-Interface (i.e. Web-page / site for the Internet) an operational ETIS can be implemented. The ETIS structures were conceived to be “self-cultivating”, i.e. only minimal effort from outside (e.g. the European Community) will be needed to maintain ETIS and for ETIS to prosper and grow. The “ETIS club” will make sure of this without having to explicitly make the effort, because of the “invisible hand” of fair regulations, quality controls and market competition.
- Keywords** ETIS, club, BRIDGES, implementation, models, software, data, homogenous, communicate, accessing, retrieving, source, guide, compatibility, decision, European, Commission, EC, GTF, TIP, DDG, DMG, DMCG, NIS, DSS.

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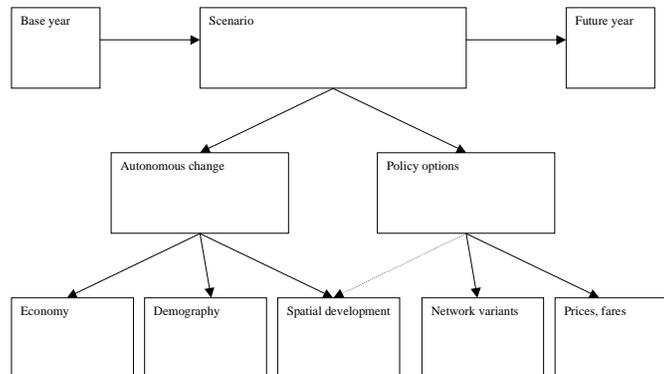
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1. CURRENT SITUATION & PROBLEMS

This chapter briefly describes the well known interdependency between the elements of policy scenarios a decision maker wants to analyse. Queries reflect the user's request to a model and finding the data pool which has to be accessed. They also identify the basic problem decision makers are faced when they want to validate different analyses leading into the problem of incompatibility of results.



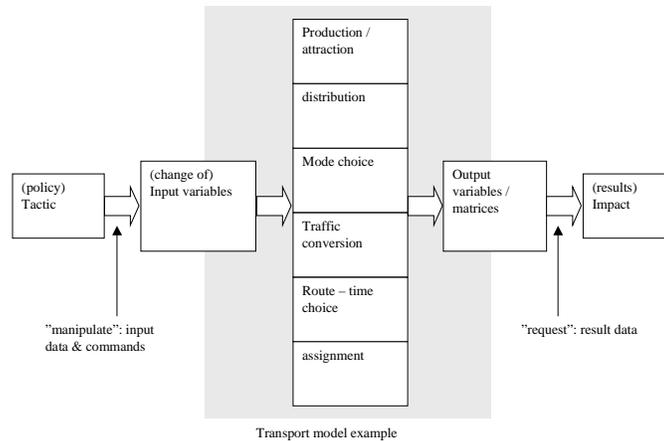
Source: APAS#22 - Transport strategic modelling

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Fig. 1. *Policy Scenario & Queries according to APAS¹*

The goal of ETIS is to support policy-makers during the whole process of “Policy Scenario” formulation through to making the actual decision. Fig. 1 depicts the usual inputs that define “Policy Scenarios”, like economic, demographic and spatial developments as well as network changes and changes in prices and fares for the use of transport supply. This is the level at which decision-makers operate therefore this should be the domain from which the User Interface (UI) of ETIS is derived from. In this way, the users (decision-makers) won't need to think in different categories other than the ones that are known and common to the user. This is a major problem nowadays, because the systems to support the decision-maker require that the decision-maker thinks in different categories other than the ones he is used to.

¹ "Transport strategic modelling", Transport Research - APAS, 22, European Commission – Directorate General VII - Transport



Transport model example

Source: APAS# 22 - Transport strategic modelling

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Fig. 2. Queries & Models

The usual workflow currently, is depicted in *Fig. 2*. The policy to be analysed using models is “translated” into model specific commands such that the concrete model, that is chosen by the user “by hand” and without support, is run and produces results – that are “hopefully” the results required for the user to make an objective decision for the problem at hand.

Despite the initial problem to formulate policy scenarios, it is even harder to translate them into queries which can be understood by the addressed models. This is mainly due to fact that different models need different queries because of the inhomogeneous structure of the underlying data model and theory of the used model. Furthermore there is the problem to link the data with the models in a way that is usable by the models.

Currently, the structure of the numerous software applications and databases is inhomogeneous and largely incompatible with each other. Which, very frequently, leads to the problem (- rather the impossibility) of comparing results from scenarios based on different software applications and databases.

The basic problem of trying to compare results from different software applications and databases lies in the fact that the underlying data-models (DM) for the software applications and databases are incompatible or only made compatible with extreme difficulty and loss of information. This is because the informational units used by the data-models are to “large”, meaning one unit contains too much information.

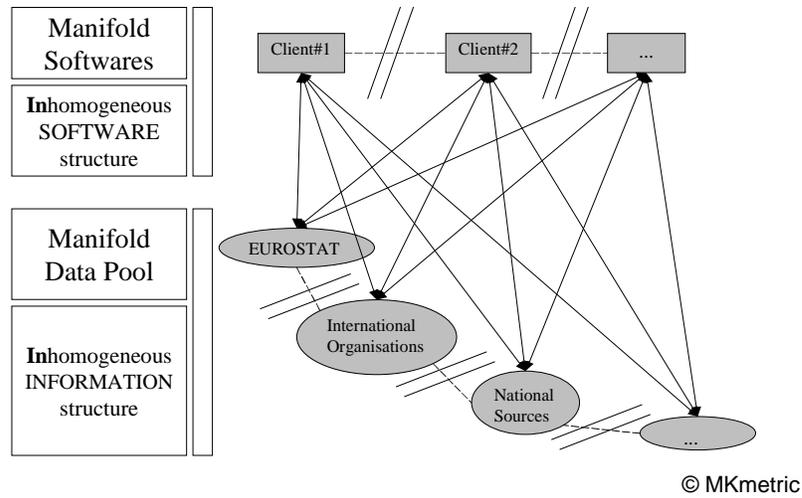


Fig. 3. Current Data Pool

Therefore it is virtually impossible to manage the task of matching informational units contained in different databases without loss of information.

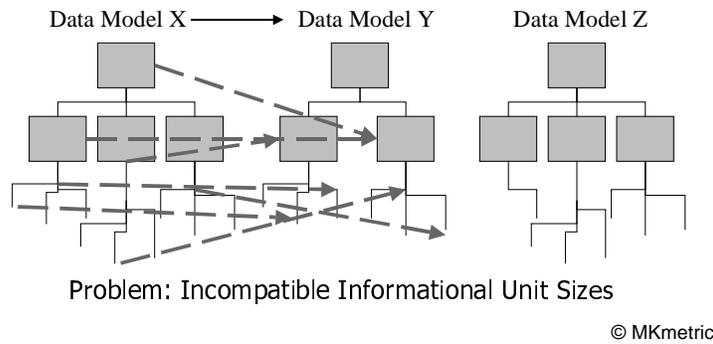
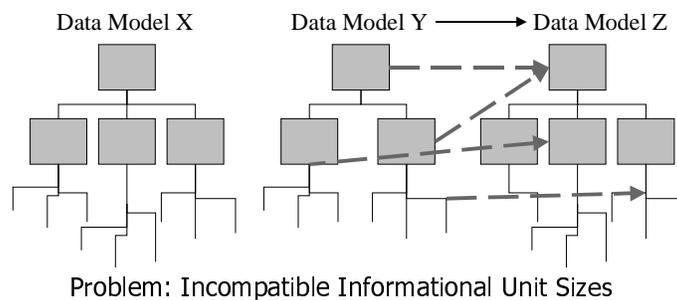


Fig. 4. Matching Data Models Step 1

If more than one matching of informational units in different databases is required, there is a loss of information, in each step of transformation. Which very often (almost in all cases) leads to the fact, that the output of all the transformations won't contain all expected relevant information.



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Fig. 5. Matching Data Models Step 2

Therefore decision makers are always faced with the problem of the incompatibility of results when taking a decision.

2. ETIS VISION & CONCEPT

Starting from the ETIS vision where any user (all over the EC) can access data, models, analyses and GIS tools within his workspace through a user-friendly and guiding interface, the discussion about the necessary concrete developments will be done step by step laying out an adequate and ideal ETIS concept.

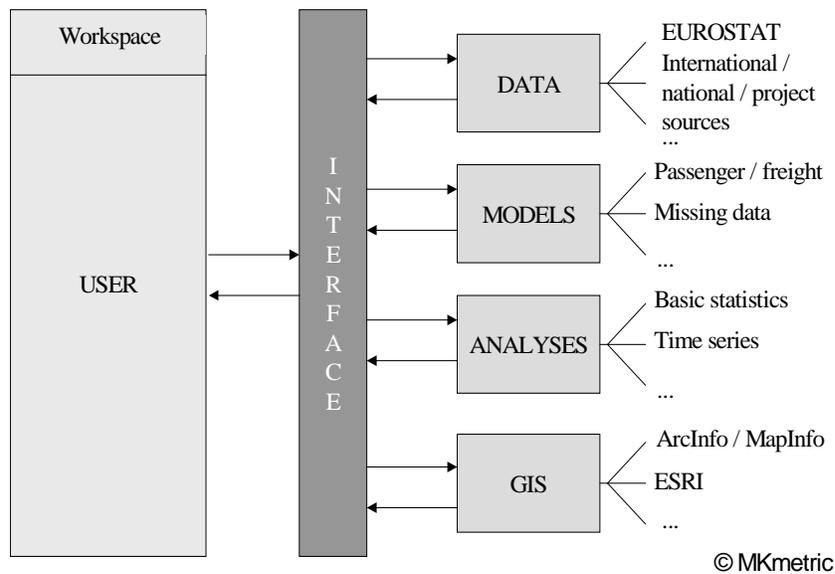


Fig. 6. ETIS Vision

So the first step is to increase the technical accessibility to data in an automatic manner as stated in chapter 1. The aim is to keep the plurality models, data and all other tools but to ensure that information can be exchanged without any loss of content. Within ETIS the structure of numerous software applications and databases have to be accessible in a homogeneous and compatible fashion based on a uniquely identifiable “Generalised Transportation-data Format” (GTF). A set of GTF translators will ensure that full information exchange is possible and provide a single access point to all models, data, analyses and GIS tools.

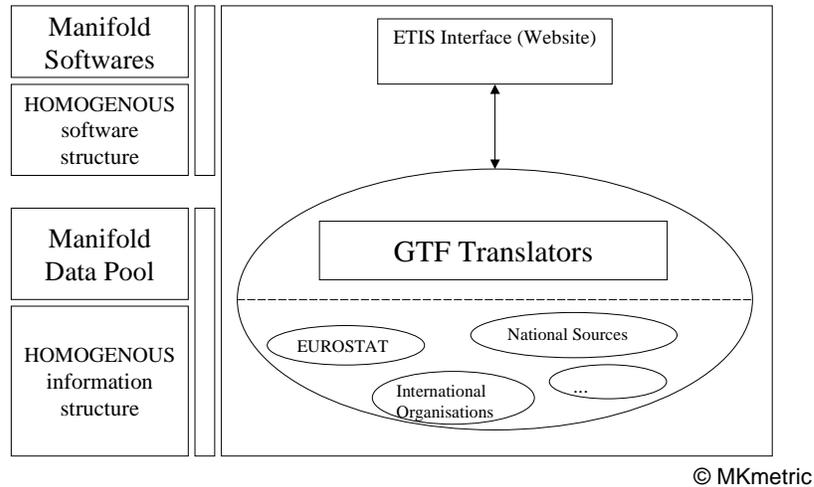
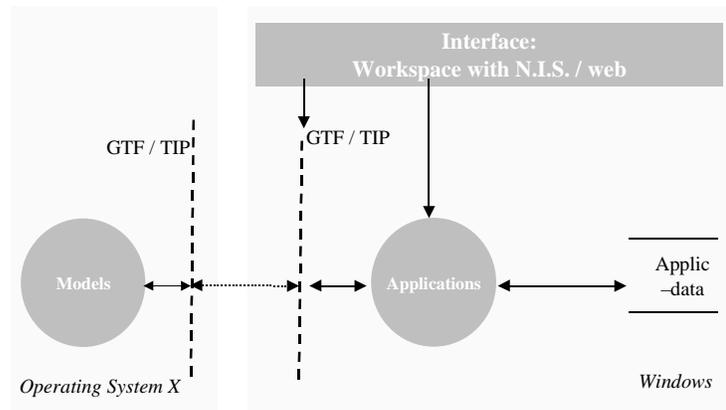


Fig. 7. ETIS / GTF Data Pool

Following the ETIS vision and considering all the problems described in chapter 1, the structure of ETIS should be the following:

- Instead of having disparate and manifold software applications and databases, ETIS should contain all necessary elements and provide one single access point – through its interface
- Instead of having incompatible proprietary formats and informational contents, a “Generalised Transportation-data Format” (GTF) should be used throughout the whole system, by providing translators to / from the proprietary formats to GTF. GTF consists of a generalised data-model (GTF-DM), a standard exchange format (GTF-GESMES) and a generic language for accessing models and retrieving results (“Transportation-data Interchange Protocol” – TIP)
- The interface of ETIS should provide a support system to aid the user in formulating policy scenarios in the way that the system can decide which database(s) and model(s) should be used to compute the results or if the users wish to take these choices themselves, to aide the users to find the relevant data sources and model providers – this is a “Decision Support System” = DSS.



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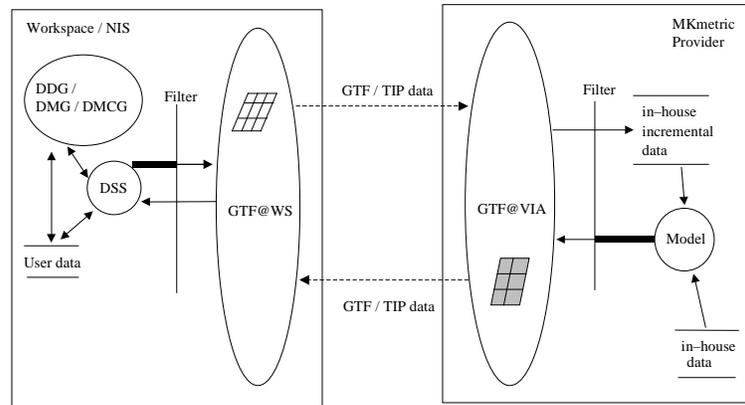
Fig. 8. ETIS Structure Overview

And lastly, everybody and everything that is involved in ETIS is called the “ETIS club”.

In a bit more detail, the required ETIS structure has the main components and the following infrastructure:

- a software to enable communication between applications that aren't initially able to communicate with each other (NIS – Network Information System)
- a DSS (Decision Support System) to assist the user in formulating and running the queries to solve the policy questions
- a DDG (Digital Data sources Guide), a DMG (Digital Model Guide) and a DMCG (Digital Model/data Compatibility Guide) are needed for the DSS operate
- a TIP (Transportation-data Interchange Protocol) to run models using a “generic language”
- a GTF translator for each model that is to be accessed by the system
- and relevant databases in GTF for input to the models

A filter should be used to make sure only absolutely necessary data will be transmitted to model providers (- in order to decrease the necessary bandwidth). Also, it should be required to transfer either only incremental data or only complete data, depending on which one has the lesser amount of data. Fig. 9 depicts these concepts.



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Fig. 9. ETIS Concept

As many ETIS structure details are mentioned in the ETIS concept, the following chapters will shed a light on these “infra”-structure elements.

3. INFRASTRUCTURE FOR ETIS

In this chapter we want to explain the basic infrastructure details necessary for the ETIS concept depicted in *Fig. 9*. Therefore you'll find the principles of how the communication, automation, user interface and guides support ETIS, in this chapter. Some of the supporting features are already worked in out in quite some detail within the BRIDGES² research project of the 4th FP of the EC. It should also be stated that these infrastructure elements have been (and still are) implemented and tested at the EC-DGVII, EUROSTAT and European Investment Bank (EIB).

3.1. Supporting Model Communication

GTF - the "Generalised Transportation-data Format" – is a data-model and exchange format specification. Software applications that implement this specification for a specific model are called "GTF Translators".

The data-model underlying GTF is generic and atomic. This means, that the information units in the GTF-DM are small – reduced to the absolute minimum of one bit of information. This DM was specifically developed to support the informational contents of as many models as possible, i.e. the units are "atomic". Therefore the DM was based on the information that is needed in the exchange between models and not based on any DM of any specific model(s), i.e. GTF is generic.

With GTF, a homogeneous view on a specific data-model of a transport model can be defined. Thus, GTF can be used as mediator format while transforming one data-model of the output of a model to another.

GTF thus also reduces the amount of required translators from $n*(n-1)$ to n (for each translation direction).

² "BRIDGES – Building Bridges between Digital Transport Databases, GIS applications and Transport Models, to develop ETIS software structure", 4th FP

1. Model requirements:

GTF = Generalised Transportation data Format

- EDI format to exchange transportation modelling information
- not to impose formats or contents constraints on modellers exchanging data
- not specifically for GIS

GTF specifies building blocks (entities)
GTF is a general structure of the information transport models use

Principles:

- not too many basic building blocks (generic entities)
- generalised enough for (mainly) modelling information and (also) other information
- derived from economic theory: supply / demand / market

- GTF = Exchange of Data (homogenous & generic)

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Fig. 10. Supporting Model Communication 1

Subsequently, GTF can be used for exchanging data between models.

1. Model requirement:

GTF = Generalised Transportation data Format

GTF is an EDI format to exchange transportation modelling information

- a. between transportation models
- b. between transportation models & other applications

GTF is NOT to impose formats or contents constraints on modellers exchanging data

GTF specifies building blocks (entities) which can be used to describe & exchange data used by transportation models.

I.e. GTF gives a general structure of the information transport models use in order to be able to exchange this information.

Principles guiding the design of the GTF data model:

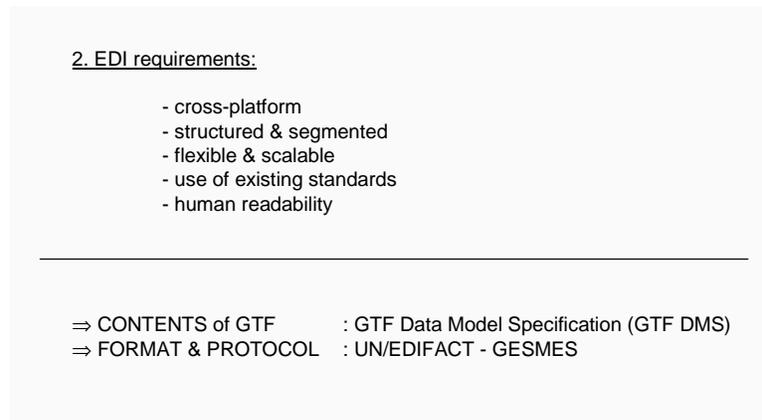
- not too many basic building blocks (generic entities)

BUT the possibility to cast complex information into such structures (or combinations of these)

- generalised enough to encompass (**mainly**) modelling information, e.g. socio-economic data, (and **also** encompass other information like simple graphical data or GIS information).

- derived from **economic theory: supply / demand / market**

because of the nature of the information to be exchanged. I.e. transportation information like socio-economic data is very much correlated with economic concepts and terminology



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Fig. 11. Supporting Model Communication 2

2. EDI requirements due to ETIS structure and GTF:

- cross-platform = PC - Windows / UNIX -> ASCII
- structured & segmented = for minimal redundancy and reduction of complexity
- ⇒ divide & conquer
 - flexible & scalable = to adapt to (user / workspace) requirements
 - use of standards = so that people use it
 - human readability = if problems arise it is always a better thing to have data readable by humans, directly
- ⇒ ASCII
- ⇒ CONTENTS of GTF is specified in the GTF data model which gives the structure of the entities
- ⇒ FORMAT & PROTOCOL for transmitting GTF files : UN/EDIFACT - GESMES specification STANDARD

3.1.1. Matching Data Models using GTF

As described before, the informational units of the GTF-DM are “atomic”. Therefore the informational units (- the data) of any other DM (DM-X) can be decomposed according to the GTF-DM.

For example, an information unit, say “Time” is “50”, of some data-model DM-X of “Flows”, is a non atomic information because one can’t know whether there is much implicit information or not, without having the exact definition of the data-model (and thus the exact definition of the attribute “Time”). “Time” might be an aggregated value meaning the “Total travel time”. This, too, is aggregated and could mean f.i. the sum of access /

egress, taxiing time, flight time, etc. Already this example shows that implicit information can be numerous.

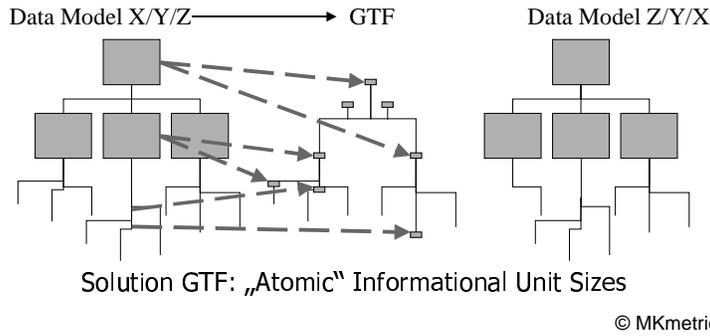


Fig. 12. Matching Data Models using GTF Step 1

To avoid this confusion, the GTF data-model offers containers of “atomic” information which must be used to describe aggregated information as in the example above.

In the GTF-DM, all pieces of information that qualify a piece of data are kept in separate entity instances which are linked through relationships to the entity instance containing the piece of raw data. In the case of the example, this means, that “access/egress”, “flight time”, “total time” etc. are qualifiers (“flags”) attached to the raw data “50”.

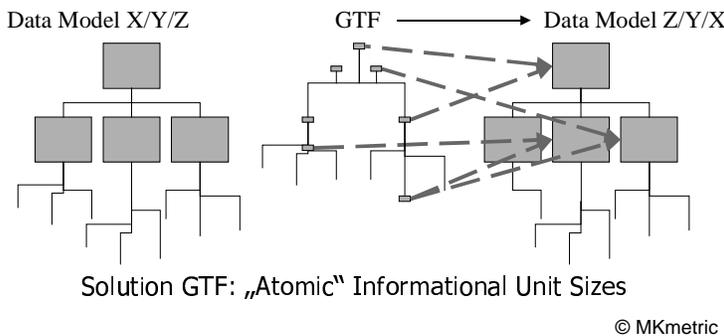


Fig. 13. Matching Data Models using GTF Step 2

Following the example in the previous Fig. 12, the decomposed information (DM-X) can be built together differently than the original DM using the GTF informational units, creating the data according to a different DM (DM-Z).

I.e. the assembling of aggregated information units from the GTF-DM units can be done in analogy of decomposing aggregated information units into GTF-DM units. It’s just the reverse principle.

The next sections will describe in more detail the GTF-DM.

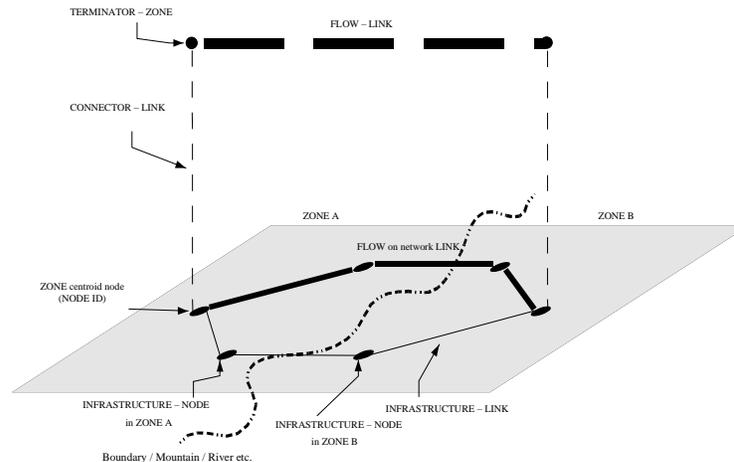
3.1.2. GTF Data Model Overview

The basic information captured in the GTF-DM are:

- the infrastructure elements of networks: NODE, INFRASTRUCTURE-LINK etc.
- the zonal elements needed for flow assignment: ZONE, FLOW and CONNECTOR-LINK

These types of basic information are further sub-divided in the GTF-DM until the level of detail required (one bit) is reached. Also, all entities of the GTF-DM have a "GIS" part and a "TYPE" part. The "GIS"-part is used to capture graphical information, e.g. co-ordinates, vertices attached to LINKs etc. The "TYPE" part contains the information relevant to models, e.g. INFRASTRUCTURE-LINK and FLOW-LINK.

Many usual elements found in the inputs used by models, e.g. node, link, are generalised in the GTF-DM, e.g. a LINK is a connection between two TERMINATORS, a TERMINATOR is a starting point or ending point of a LINK, a LINK can be an INFRASTRUCTURE-LINK, a FLOW-LINK or a CONNECTOR-LINK etc., to provide atomic informational units.



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Fig. 14. GTF Data Model Overview

A brief overview covering the GTF entities and relationships is depicted in Fig. 15. For further information concerning details we refer to deliverable D3 of the BRIDGES project.

The overview shows the main entities and relationships in the GTF-DM.

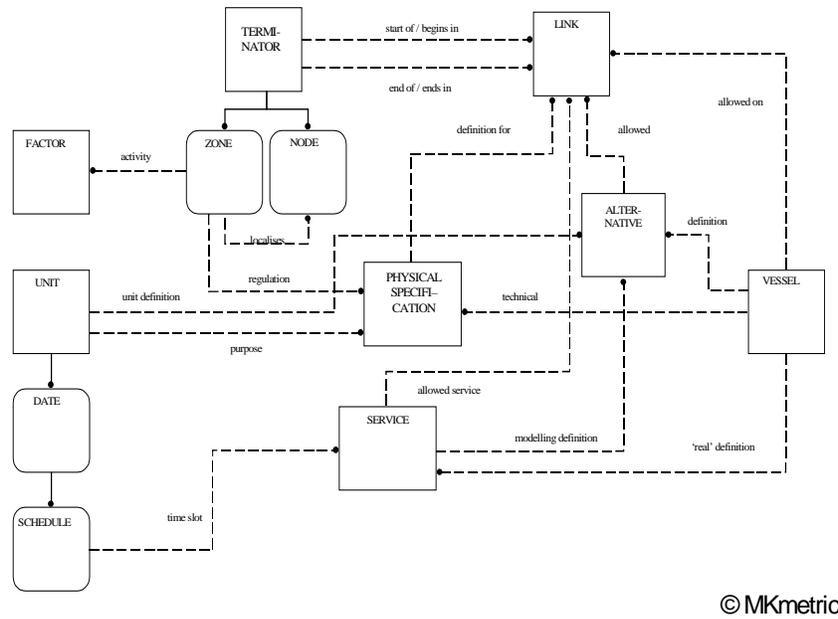


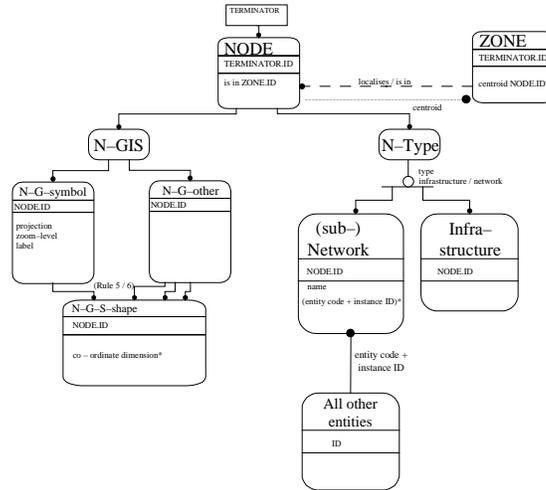
Fig. 15. GTF Data Model Entity-Relationship Overview

To explain the principles of the data model structures as an example, the informational unit “NODE” structure as depicted in Fig. 16:

- all NODEs have “TYPE” information and (optionally) “GIS” information associated to them
- The “GIS” information of a NODE are, e.g.:
 - “SYMBOL”: definition of the symbol to use when displaying the NODE. This entity has a relationship to a “SHAPE” entity which captures the co-ordinates defining the “SHAPE”.
- The “TYPE” information of a NODE are:
 - “INFRASTRUCTURE”, defining the NODE as a network infrastructure node without further structure
 - “(sub-) NETWORK”, defining the NODE as a sub-network, which itself is a grouping of (possibly) all other entities in the GTF-DM. This means, different levels of detail are possible for a network.

All NODEs have a relationship to a ZONE (- the name of the relationship is “is in”), defining the ZONE in which a NODE is contained. (All ZONES have relationships to NODEs (- the name of the relationship is “localises”) defining the connector NODEs which connect the a ZONE to the network).

A NODE is a child of TERMINATOR (like ZONE). But the function of NODEs is to represent (in combination with LINKs) the graphical and modelling topology of networks.



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Fig. 16. GTF Example: Node

N-GIS (=TERMINATOR-NODE-GIS) is the container of graphical node information like projection, zoom-level of the co-ordinates associated with NODE in the entity N-G-S-shape (=TERMINATOR-NODE-GIS-SYMBOL-SHAPE). N-G-S-shape is a container of lists of co-ordinates describing the shape of a symbol used to display NODEs.

Nodes can be associated with ZONES.

The function of a NODE as an element in the topology description of a supply side model makes a NODE of type “INFRASTRUCTURE”. If the NODE is used as an aggregation container of other entities, then the NODE is of type “(sub-)NETWORK”. And one uses this kind of NODE to “zoom in” and to “zoom out” of a NODE in order to see its internal structure.

The English definition (in a computer science context) is:

zoom:

<graphics> To show a smaller area of an image at a higher magnification ("zoom in") or a larger area at a lower magnification ("zoom out"), as though using a zoom lens on a camera.

In the context of this specification the definition above is enriched by the concept of “zooming in” to show further **topological** detail (not only graphical detail) associated with the NODE. But the basic idea of showing more detail or hiding it stays the same.

The further detail a (sub-)NETWORK can associate with a NODE is, that the NODE is made up of other entities, e.g. a group of NODEs and LINKs that describes a railway station, an airport or generally terminals and their access and egress points as well as their ‘turns’ and ‘changes’ between LINKs (or LINKs of different modes!).

The entity ID's of all entities that a NETWORK instance comprises are migrated to that instance the NETWORK entity, such that the NETWORK instance becomes the grouping of all the entity instances that make up a specific (sub-)NETWORK.

Excourse "Information needed by Models"

The transport data that is covered is primarily that which is used in strategic transport models. Thus it covers interurban, regional or international travel on all transport modes for both passengers and freight. It does not cover detailed local traffic issues, such as the representation of road junction geometry.

In order to manage data, we must understand its basic characteristics. Data can be thought of as a symbolic representation of facts with meanings. A single meaning can be applied to many different facts. For example, the meaning "product name" could be applied to numerous combinations of alphabetic characters. A fact without a meaning is of no value. However a fact with the wrong meaning can be disastrous, as has been found by some international firms who realised that their standard product name had unfortunate connotations in the local language where they were marketing. Therefore, the focus of data management must be on the meaning associated with data.

Information can be defined as an aggregation of data for a specific purpose or within a specific context. Thus, the strategy to manage the information resource must focus on managing the meanings applied to facts, rather than attempting to control or limit the creation of information.

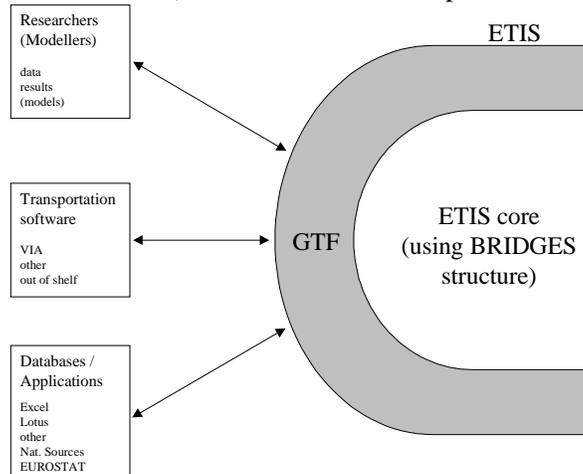
For further details we refer to the paper "Data needs for modelling" presented at the CONCERTO workshop 22/23 Oct. 1998, Brussels. In this paper the tasks, policy & modelling needs:

- 1 Policy needs and modelling
 2. Queries and data needs for modelling
 - 2.1. Generation
 - 2.2. Distribution
 - 2.3 Mode choice
 - 2.4. Assignment
 - 2.5. Interdependency of the modelling steps
 - 2.6. Other models
 - 2.7. Supply side
 3. Resume
- are discussed.

3.1.3. ETIS External Interface

Once ETIS is up and running, a further enhancement is already envisaged:

- all GTF Translators can be linked together (and new translators can be written) to provide a homogenous I/O interface between the core of the system and the outside (external data & model providers etc.).



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Fig. 17. GTF ETIS External Interface

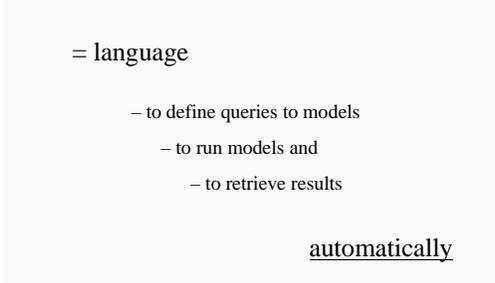
To drive forward the automation process other supporting links have to be developed.

3.2. Supporting Automation

In order to be able to run, models generically a “language” for this purpose will be defined. This “language” will be incorporated into the GTF exchange format. It will allow to run models and retrieve the requested results automatically, without having to contact a model provider personally by defining a project to compute the results.

This will allow ETIS an effective use of external and internal models.

- TIP = Transportation-data Interchange Protocol



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Fig. 18. Supporting Automation

Figures 10 - 17 established the specification for a "Generalised Transportation–data Format". Now a specification concerning the available commands to a user's workspace is required. These commands will be attached to a GTF file and will enable a model provider to process the GTF data file so that the requested answers are computed. This is necessary, because a GTF data file alone doesn't contain any information on what shall be done with the data. This is where TIP is necessary. TIP is a generalisation of "usual" commands (queries) to a transportation model. The development of TIP is based on the classic four step transportation model: generation, distribution, modal split and assignment. Within these four stages, a number of commands (independent of the actual model or the model's philosophy) can be issued to the model in order to produce intermediate data or final model results. These results can then be filtered through a filter defined in a TIP command file that is attached to a GTF data file. The filter extracts the data relevant to the user's query out of the model results and notifies the user's workspace that the requested results are available at the model provider.

3.2.1. Classification of possible queries

The categories of possible (transportation–)information exchange are:

- pricing policies
- regulatory policies
- investment policies
- co–operation of models

The following types (per category) are feasible – also ensuring that meaningful results could be produced:

modification of model input

input modification, e.g.

- proportional modification of a variable's value on a whole network or a specific sub–set (for pricing policies, regulatory policies)
- modifications of networks (for investment policies)

output queries, e.g.

- modal split effects (e.g. high speed train vs. air; alternative i vs. alternative j)
- generation and distribution effects on airport choice results

communication between models

- Model provider A → MKmetric: output of model A (passenger movements or OD–flow matrix) as input to VIA
- MKmetric → Model provider A: output of VIA (modal split matrix) VIA as input to model A

In respect to scenario definitions and future projections the described options fit into the following framework (please refer to "TRANSPORT RESEARCH APAS – Transport strategic modelling" for further information):

Please refer to Fig. 1.

For each of the components in the last level of the hierarchy two commands must be available:

Input modification:

1. explicit change of variable values, e.g. variable $X = 100$
2. functional change of variable values, e.g. variable $X = (\text{variable } Y * 2) + \text{variable } Z$

(all mathematical standard operators and functions are allowed for manipulation, e.g. $\log()$, $\sin()$, $+$, $-$, $*$, $/$, $\exp()$ etc.)

Output query:

3. output matrix to be calculated, e.g. modal split for all available modes, assigned road network – Germany
4. definition of extracted variables, e.g. modal split of mode road and air, travel-time on link 1152, travel-time of shortest path between zone 51 and zone 894

The variables available in 1., 2. and 4. are the attributes of entity instances defined in the GTF data model, e.g. PHYSICAL_SPECIFICATION (of LINK 34254) – flow.

3.2.2. TIP commands

The commands needed are split into two categories:

- manipulation of variables (selecting & setting / updating)
- creating, requesting matrices (selecting & calculating)

These categories are based on the usual structure of transport models:

(See Fig. 2.)

The variables available for manipulation are those defined in the GTF data model, e.g. "entity FACTOR – INSTANCE 34923 – Population Class 79" for a *single* manipulation or "entity FACTOR – Population Class 79" for manipulation of *all* instances. The semantics for the manipulation commands is based on SQL, because the manipulation of GTF variables is a manipulation of relational data. **The manipulation commands** (i.e. manipulation of model input data) **always refer to data already located at the model provider.** (To manipulate data located in the GTF file doesn't make sense, as the result of the manipulation can be computed beforehand, at the user's site.) The commands have the following syntax:

```
UPDATE <entity>.<ALL|SINGLE> SET <variable>=<value>
UPDATE <entity>.<ALL|SINGLE> SET <variable>=<function>
UPDATE <matrix>
```

Where 'function' is a mathematical function of any variables in the GTF data already at the model provider.

A user can either modify single data elements (e.g. travel-time on link between node 42873 and node 42192 multiplied by 1.2) or lists of data elements (e.g. all the travel-times in a network multiplied by 1.1).

<matrix> is one of those specified in the following paragraph.

The requests for calculation are related to the usual phases that a transportation model comprises: generation (production / attraction), distribution, mode choice (modal split), traffic conversion, route choice and assignment (see Fig. 2). The request commands (i.e. model output data) are introduced by the keyword "CREATE"

Command syntax: "CREATE <matrix> {MODE|PURPOSE|SEGMENT|PRODUCT}"

Followed by the these keywords:

KEYWORD	Computed / Resulting Matrix contents
GENERATION	Matrix: ZONE (x PURPOSE or SEGMENT / PRODUCT) Cell contents: ZONE number of TRIPS or amount of FREIGHT
PRODUCTION/ ACTTRACTION	Matrix: ZONE x ZONE (x PURPOSE or SEGMENT/ PRODUCT) Cell contents: number of TRIPS or amount of FREIGHT
DISTRIBUTION	Matrix: ZONE x ZONE (x PURPOSE or SEGMENT/ PRODUCT) Cell contents: number of TRIPS or amount of FREIGHT
MODAL SPLIT	Matrix: ZONE x ZONE x MODE (x PURPOSE or SEGMENT/ PRODUCT) Cell contents: amount of FLOW / PERCENTAGE (trips / tons)
TRAFFIC CONVERSION	Matrix: ZONE x ZONE x MODE (x PURPOSE or SEGMENT/ PRODUCT) Cell contents: number of VEHICLES
ASSIGNMENT	(loaded) network: NODE x NODE Cell contents: LINK attribute(s)

The keyword defines which output matrix shall be computed and transmitted (after filtering) back to the user. The specification of MODE, PURPOSE, SEGMENT / PRODUCT is optional. If one is specified it must follow the keywords preceding, e.g. "CREATE DISTRIBUTION BUSINESS".

The output filter is defined with

```
FILTER <matrix> <variable 1> ... <variable N>
```

The meaning of this line is: "Filter from the output matrix <matrix> the variables <variable 1> through <variable N>". Where <variable> is the fully-qualified name of an entity attribute.

3.3. Supporting Interface

This chapter will specify in a little more detail the elements needed to the ETIS user interface.

- DSS = Matching "policy queries" to ETIS core functionality
 - Getting transport model results specifically requested by the user
 - Database utilities to establish queries and prepare reports, tables, graphs and maps
 - An expert system shell to focus into desired model characteristics
 - Comparative answers to alternative scenarios/ options
 - Evaluation with a multi-criteria assessment tool
 - A GIS tool
 - Facilities for parsing, storing, and executing model templates
 - An interface that can be customised according to user needs
- Web-interface = main (only) access point to functionality for the user

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Fig. 19. Supporting Interface

The main elements are a Decision Support System and a web interface.

3.3.1. Decision Support System - DSS

A Decision-Support System (DSS) has been developed as part of the BRIDGES research project. It provides a set of tools that facilitate navigation of the European Transport Information System (ETIS) according to specific needs of a user.

DSS allows to select or formulate questions, transforms them into a series of calls to transport models and databases, and displays the results through its own routines (as reports, tables, graphs, maps) or through other ETIS modules.

The DSS can be used also as an independent module, since it has its own expert system shell, a multi-criteria assessment, database management capabilities, and GIS utilities.

The options available to DSS users include:

- Getting transport model results specifically requested by the user

- Database utilities to establish queries and prepare reports, tables, graphs and maps
- An expert system shell to focus into desired model characteristics
- Comparative answers to alternative scenarios/ options
- Evaluation with a multi-criteria assessment tool
- A GIS tool
- Facilities for parsing, storing, and executing model templates
- An interface that can be customised according to user needs

Modellers can make part of their models' functionality available to outside users by preparing DSS Templates. A template is an ASCII file that contains descriptions with keywords used by the DSS in order to parse, analyse and store the defined methods. For each specific user question the modeller prepares a method, which can be registered in the DSS database. Examples using MKmetric's VIA model results have been prepared to demonstrate the template concept.

The two main elements of the DSS are:

Activity: Decision-Support System

A key element of the ETIS Core Interface (CI) is its user friendliness. The DSS for making queries and interpreting results will enjoy similar user-friendly characteristics. It will be programmed as an independent application properly linked to ETIS Core Interface and other ETIS elements. The own CI programming language and functions will be tested (when ready) to facilitate the best possible integration of DSS into ETIS structure. DSS menus will allow the user to formulate specific questions and information requests to ETIS system, and transform them into a series of calls to transport models and/or databases.

The DSS will facilitate the following options:

- (1) *Initiation of transport models more appropriate to the functionality requested by the user;*
- (2) *Database utilities to establish queries, updating, obtaining reports, etc;*
- (3) *Establishment of expert rules to estimate missing data;*
- (4) *Comparative answers to user questions relating to alternative scenarios/options; and*
- (5) *Evaluation of model results according to multi-criteria models (e.g., should I recommend this road to be build this way?).*

The DSS will be a combination of a database manager and an expert system. Options (1), (3) and (5) will be provided through an expert system module that will know, depending on the question, which model data to use, how to fill in data gaps, and what kinds of results to display to the user.

Activity - Expert System (ES)

The main task of the Expert System (ES) is to analyse user's queries, decompose them into sub-queries for passing to other modules, and combine results into a meaningful form for the user to understand. In doing so the ES will apply default values, educated guesses and qualitative criteria to fill in any missing data required for running other modules.

The ES will be part of the DSS and thus, will be accessible through ETIS Core Interface, or directly by its own user-friendly interface.

The ES will have the following layers: (1) Query Manager that interprets user queries, (2) an ETIS guided navigator that calls the appropriate modules and/or inspects the corresponding parts of its knowledge base, (3) a Default Manager that applies rules in order to find realistic assumptions for missing data, (4) an Evaluator that assembles results from the diverse sources above mentioned to be used in a multi-criteria model.

3.3.2. Web interface for the User Interface of ETIS

The Usability-gap of current user interfaces (UI) and an optimal UI requires re-thinking and re-designing of a central access point to the functionality that a user wants, therefore the following is needed (rather planned): Transparency, friendliness, interactivity; Exact definition of the UI (user interface) and definition of the best implementation strategy – local application or web-browser based with Applets contacting a (possibly distributed) server or the external resources (data, models) ?.

3.4. Supporting Guides

The ETIS supporting software system will need some guidance to be able to optimally aid a user in finding and using the necessary data and model to solve the user's queries.

- DDG = Digital Data-sources Guide
 - Directory of links / references to sources of data

- DMG = Digital Models Guide
 - Directory of references to models & specifications (I/O, regionalisation, etc.) of models

- DMCG = Digital Models/data Compatibility Guide
 - Specification "matrix" of compatibility of data from DDG and models from DMG

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Fig. 20. Supporting Guides

3.4.1. Digital Data sources Guide - DDG

The Digital Data Guide (called DDG) was implemented in BRIDGES. Its general objective is to provide the European deciders with a comprehensive view of the transport data available in Europe, with a focus on digital data (databases and GIS).

Special attention has been paid to the fact that this tool must be coherent with the other components of BRIDGES, particularly the «DSS».

The DDG is an interactive guide of the existing (and emerging) digital information products dealing with transport with European interest. This guide should be easily updateable. It will be multi-entries, describing in detail source references, formats and metadata (including confidentiality and cost). Particular attention will be paid to information networks involving several partners, such as World span.

It was co-ordinated with INFOSTAT, MESUDEMO, OD/ESTIM, COMMUTE and ASSEMBLING regarding the information requirements by various user's profiles and maintenance of the system.

The objective of the DDG is the assessment of present and future data sources availability, including accessibility criteria (format, cost, confidentiality, software, acquisition). The DDG does not contain data itself, but accurate source references.

Under a user-friendly environment, the DDG will guide the user through a multi-entries tool describing: references/sources, formats and any other key relevant parameter needed to evaluate the interest and the value of each European source of information. It will be linked to the Decision-Support System.

The DDG will be closely related to European user's needs and purposes. In this context, contacts with Eurostat, Gisco, DGVII and Infostat will be assured.

3.4.2. Digital Model Guide - DMG

The DMG - the Digital Model Guide, which is analogous to the DDG but focuses specifically on models - in a much more detailed manner than in the DDG. The DMG would include detailed information about models, their requirements and their scope etc. With this the user could chose much more appropriate models for his query.

3.4.3. Digital Model / data Compatibility Guide - DMCG

The DMCG – Digital Model / data Compatibility Guide - which would state which data and models are compatible and to what degree, something which can't be done using only the DDG and the DMG. This would allow the system (actually the DSS) not only to guide the user to the data and the model, but to present a list of models & data fitting best to the query. A user could concentrate on finding data & models that answer his question precisely thus only using minimal data and model resources.

3.5. Supporting Software Communication

Ongoing research and development in the G.I.S sector is moving towards major openness, scalability and Internet compatibility, as well as towards major user friendliness for Desktop Mapping options. On the other hand, commercial transport models enjoying G.I.S. options are emerging (such as TransCad by Caliper) and GIS app. well linked to sophisticated DBS app. with utilities able to read any kind of data format (such as Geomedia). Database managers, through ODBC and further Internet JDBC extension, are in process of achieving data format exchange and, to some extent, query message communication through SQL protocols.

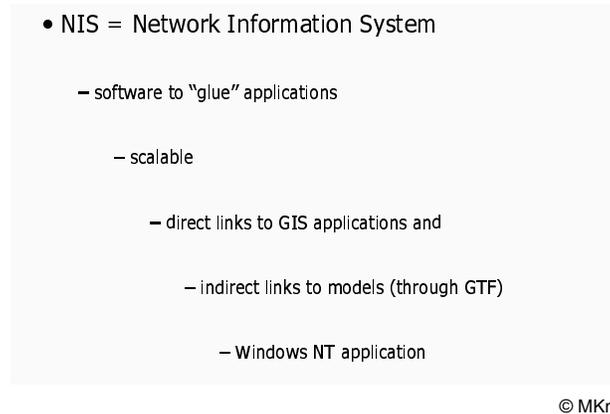


Fig. 21. Supporting Software Communication

Network information System - NIS

Generally speaking, since software users become more software demanding, there is a natural move towards open systems and public formats. No single application can solve optimally all requirements, and well linked open platforms of CAD, DBS, GIS, DM and Transport Models are needed to carry on specialised works with enough productivity. Already existing closed and universal applications with proprietary data formats will tend to be substituted by a more or less large list of specialised intercommunicated applications (or even simple software components, stand-alone routines and controls) open to share data with other applications and to be driven externally, exchanging command messages.

In conclusion, the transport planning and management sector ideally requires a specific combination of CAD, GIS, DBM and DM Desktop Mapping open in order to support information systems in a proper manner. BRIDGES Core N.I.S. Utilities are defined in this frame.

CAD app. (such as AutoCAD or Microstation) facilitate the digitalisation of physical networks and reference environmental and territorial elements, with additional G.I.S. oriented routines (programmed of AutoLisp or UCM-DML, or in general in Visual Basic, or just assembled into G.I.S. sister applications such as Geographics-Microstation) simple graph databases can be supported.

G.I.S. more sophisticated applications (such as ArcInfo or MGE) have specialised network-modules with many graph-oriented routines (despite incomplete and in many cases sub-optimal). They provide with complex geographic routines for projection change and adjustment, zone intersection, super-imposition etc. as well as raster (such as satellite images, scanners) integrated processing.

DM applications (such as MapInfo, ArcView) enjoy basic G.I.S. options and provide easy graphic display of data and results. They tend to be open to external applications, such as Microsoft Excel or Access, where data and basic calculations can be more properly handled, or to complementary G.I.S. app.

DBM (such as Access, Dbase, Oracle...) are always needed to store and manage increasingly large data sets coming from many different sources. Neither CAD plus G.I.S. routines, nor G.I.S. or DM application are optimal for managing large databases.

Transport Models will tend to decentralise CAD, GIS, DBS and DM utilities to external app., focusing instead on highly sophisticated modelling routines and algorithms. Even some mathematical conventional processes in most cases will be handled by mathematical packages (such as Mathematica and others) or components. (I.e. links to GTF)

Conclusion:

BRIDGES research should be followed by ETIS research in these complementary directions:

One the one hand it defines an specific format for storing and transferring transport topologies (GTF), which integrates elements from CAD formats (DXF, DGN...), GIS formats (...), DBS (MDB, DBS...) and DM (SHP, MAP-TAB...) in a transport-oriented manner.

On the other hand, specific routines and utilities devoted to manage network-oriented databases (and importing/exporting to GTF) are being developed within BRIDGES Core. Similarly to GTF, these routines extend, in a transport-oriented direction, CAD, GIS, DBS and DM routines.

A user-interface able to manage transport graphs with high productivity (and integrate external applications) will be developed.

4. INITIAL IMPLEMENTATION & FUTURE OF ETIS

In this chapter we want to outline a path to put ETIS into action. Starting from an initial implementation we point out the future potential and wide spread ramifications of ETIS. Finally, we shed some light on the technical network issues.

To start-up ETIS we suggest an initial implementation in a pre-selected environment. Here we can deal with and solve specific problems so that ETIS can become the best chance to grow in an open environment with qualified access. Like in the BRIDGES project we suggest EC-DGVII, EUROSTAT and EIB as initial users (and final customers) of ETIS, i.e. the ETIS club.

As soon as ETIS is working properly other EC-DGs and the ministries & public institutions of the EC member states should join the ETIS club and can be used as multipliers. Again some time will be needed to endorse all new requirements and ideas, but as ETIS is conceptually flexible this process will happen fast. Finally, any user and provider can join the well established ETIS club and an independent institute should take over the task of operating ETIS.

- ETIS club =
 - Users +
 - Software-providers +
 - Data-providers +
 - Model-providers

- Steps:
 - **Initially:** use of **4th FP outcomes** and data / models available at the Commission
 - **Later:** use of **5th FP outcomes**

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Fig. 22. Initial Implementation of ETIS

Below we summarise the development sequence of ETIS and the 'club' (= people using ETIS):

1. (Default) step: usage of
 - consortium partners' modelling software
 - free application executables
 - models • GIS • EUROSTAT

and the further development steps of models, data, networks and software can proceed as follows:

2. step: **tasks funded by the EC at 100%.**
3. step: **tasks funded by the EC at 50%.**
4. step: **as parts of future EC tasks and projects.**
5. step: **tasks contracted by the member states endowed by then (past, present, future projects, data etc.).**
6. step: **all qualified users and providers on a free basis from the outside market.**

To ensure the future of ETIS it shall not be a closed subsidised entity. Moreover, it is essential to ensure self-cultivating structures open to any kind of user, data, model, analysis and GIS tool provider. Of course one should take the chance from the beginning to establish qualified access rules, e.g. by a scientific committee, to ensure a high level of service, science, transparency and validated work. The access to ETIS should not be a matter of the entrance fee or user charges it should rather be the quality provided and the reputation & seriousness of users and providers.

Therefor ETIS should be established as a virtual market place where decision makers represent the demand side and service (data, model etc.) providers the supply side. It should be run by an independent institution, which is neither in conflict with politics nor has any commercial interests. If it appears that profit will be made then there should be the guarantee that the institute will finance EC-wide surveys or other data collection, harmonisation or homogenisation & ensuring compatibility tasks (to support the self-cultivating activities). In addition, one will have to ensure that the administrative tasks are as low as possible by freezing the budget and that a maximum of services the institute needs to run and maintain ETIS (-maintenance of the infrastructure elements, security, quality aspects and accounting procedures, electronic accessibility etc.) is contracted externally by market prices.

Standard maintenance topics will have to address the ongoing upkeep of the technical network aspects of ETIS like the servicing of all the servers and the permanent availability of the system, the regular checking that all members of the ETIS club continually fulfil the quality requirements and standards, keeping the list of members up to date, dealing with surprising events like fire, water outbreaks and all unforeseeable other events, the accounting of the usage of external provider (or internal services between the DGs) services and reimbursement of utilised resources and lastly constant implementation of the security levels needed by different users and providers.

Further maintenance topics will have to deal with updating and improving the guides (DDG, DMG and DMCG), enhancing and detailing

GTF, adapting the exchange format of GTF from GESMES to other formats like XML and last but not least increasing the user friendliness of the user interface by implementing the access to all functionality of ETIS through a web interface, i.e. a web site (- for example by programming Java Applets that connect to the nearest ETIS server and run the necessary transactions).

These are by no means complete lists, but they already show the level of detail to be dealt with on an operational basis once ETIS is up and running.

- ETIS as „market place“
 - new providers (models/data) could use ETIS web-site to apply to ETIS club
 - ETIS club will increase fair competition between providers
 - ETIS users will have greater transparency of quality / costs of providers
 - ETIS ensures a qualified market access

- Research boost due to ETIS
 - Due to easy and consistent data / formats and access
 - Transparency of models / data in ETIS club

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Fig. 23. Self-Cultivating ETIS Structures

Implications / ramifications of GTF, BRIDGES and ETIS

The impact of the ETIS research and resulting bridging software will have many ensuing scientific & commercial and practical ramifications:

1. the compatibility between application specific files resulting from ETIS will allow users to stay in their known environments (workspaces) and use new software without wasting time having to learn the new software usage for importing / exporting. This will be done by bridging software and the GTF translators.

2. people dealing with problems appearing in different working areas can exchange information, e.g. analysing side effects when changing from a higher to a lower aggregation level

3. synergetic effects can result from the possibility of transferring knowledge between systems and points of view

4. the number of software, data, model licenses that will have to be purchased will decrease because of the centralised way the software and databases can be accessed using ETIS

5. a user can pre-select scenarios and identify those which really are relevant to his problem and then can be worked out in detail by human experts (consultants)

6. ETIS will give a boost to the availability of data in Europe; easy access to data will become as obvious in Europe as it already is in the United States of America

7. it will be possible to compare different models' results (and their quality) as they can be used on the same data(-base)

8. model users won't always have to (re-)create their own databases over and over again like in the past, but will have access to standard data(-bases)

9. data(-bases) will gain in quality as time passes, because the data providers will have an incentive to update their databases regularly and properly, since only the "good" databases will be used and in addition good databases work out by master or ph.d. students can be made accessible

10. data providers, consultants and software developers will want to join the ETIS-'club, because it is a great way of making oneself known to the public (or the ETIS community) and therefore being a good selling platform (something like an open and free market)

11. countries which don't have a transport planning system can have access to the existing transport knowledge and use whatever suits their needs, i.e. they will have the possibility of planning transport infrastructures, something not done up to now

12. the fast pace at which telecommunication and telematics are developing in respect to the pace at which models are developing, suggests that within a few years users will be able to use even remote (call-in) models interactively

13. since the GTF specification belongs to the EC, it will have the possibility to ensure the technical quality, i.e. that the service providers linked to ETIS meet some standard hardware or availability requirements etc., or model quality, i.e. that the model providers ensure some standard of quality of their models and results resulting in a high performance (= speed, requested detail, ease-of-use, availability of an e-mail complaints box etc.), because only the requested results are transferred in the appropriate detail. The quality of the data could be ensured by EUROSTAT or national public services like national statistical offices.

14. a standard for transport projects can be defined by databases, models and comparative result representation for any user-group, so the results of different projects can be compared

15. researchers from different countries can work on the same database and exchange knowledge about their findings

16. some ETIS' links might become obsolete, as application developers open their system to import and export their application's data or directly use the GTF specification, but most ETIS components, e.g. the 'Decision Support System' (DSS), GTF etc., won't become obsolete, because the application developers just will provide simple import / export routines, without the power and general applicability of ETIS' components

17. once GTF and ETIS are in place and in use, user's needs will make GTF grow to accommodate the new requirements

18. specific confidential workspaces can, will and have to be defined to also ensure different security levels, once ETIS gets opened up

19. users will request new models or combination of models, which previously could have been denied by the consultants, because of lack of transparency on the supply-side of the business

20. transport companies will be able to find new market niches to supply with their service(s)

21. to ensure a high level of technical and model quality the institution running ETIS could open an e-mail complaints box for the users, reporting difficulties accessing or using some service provider etc. or other problems, which could be monitored, resulting in formal complaints to the service providers to raise their standard of quality

22. with the control over ETIS by an independent institution one can ensure that new service providers will first have to be able to cope with test-suits, before allowing their complete entrance to ETIS, ensuring a high quality level of service (enough help support for their services, validation of their data / results and models etc.) through ETIS

23. with the possibilities of automation using TIP a very important (and main) aspect of the user-friendliness of the system can be developed, as with the automation using TIP, the system can relieve the user from many tedious and unnecessary (from the user's point of view) tasks.

24. users and providers subscribing to / entering the ETIS club will have to pass quality (qualifier) procedures. These can later also be used for maintenance duties like the updates of guides, queries, GTF / TIP etc. The same holds for users and providers which are already in the club as they will be interested in updating their services and to include new queries or demands into the DSS

25. all these effects will have a vigorous impact on research in this and other fields

These are just some interdependencies one can think of. Of course there will be many more.

Fig. 24 depicts the vision of ETIS as a system that allows users from anywhere (at least the whole of Europe) to access ETIS and to make productive work over the Internet.

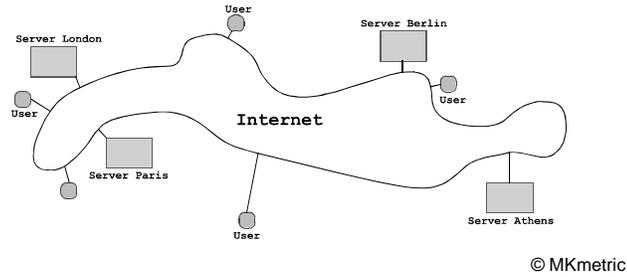
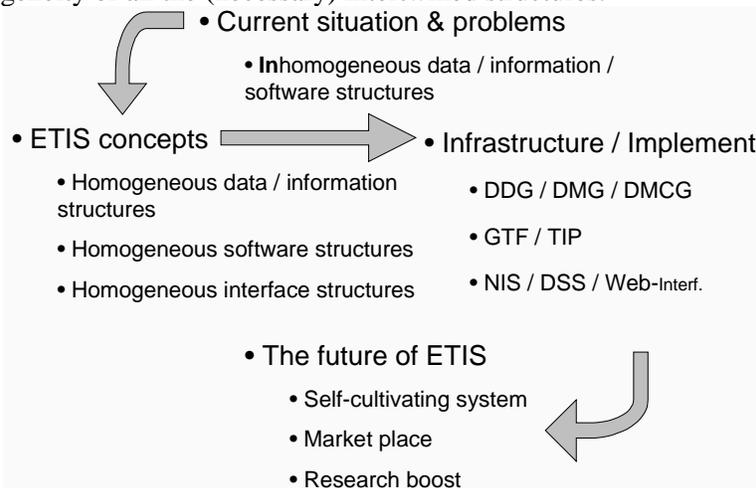


Fig. 24. ETIS club Intra- / Internet Structure

It would exceed the focus of this paper to start the discussion of what kind of technical network should be used, how the servers have to be structured or whether it makes sense to follow a centralised or de-centralised strategy. But as the points raised show, we already thought of this so that we just want to state at this point that we recommend a high-speed backbone network with decentralised server architecture and a central backup, security and accounting system.

5. CONCLUSION / SUMMARY

The goal of ETIS is to support policy-makers during the whole process of “Policy Scenario” formulation through to making the actual decision. To be able to do this, the decision maker nowadays has many obstacles to overcome because the data, the data structures, the information contained in the data and last but not least the software and software structures are mostly (mainly) in-homogeneous and the formats proprietary. This makes the task of finding sound (and comparable) information to base a decision on and the comparison of such information (e.g. scenario results from models) nearly impossible due to the virtual impossibility of exchanging data / information from one model / software to another and the already mentioned in-homogeneity of all the (necessary) intertwined structures.



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Fig. 25. Summary

In order to develop a system to support a decision maker in a user-friendly way the concept of ETIS were developed which will guarantee homogeneous data, data structures, information contained in the data and software and software structures.

The main concept is a number of guides which serve as directories of available data, models and compatibility between both and between the models, software to glue applications together that weren't initially developed to communicate with each other, a homogeneous data (information) exchange format and a user-friendly interface. Together, these components “are” ETIS.

The ETIS structures were conceived to be “self-cultivating”, i.e. only minimal effort from outside (e.g. the European Community) will be needed to maintain ETIS and for ETIS to prosper and grow. The “ETIS club” will make sure of this without having to explicitly make the effort, because of the “invisible hand” of fair regulations, quality controls and market competition.

As ETIS is still under development and a major task with wide spread influence any comments or suggestions are very welcome. Please make use of our email and let us all together make the ETIS vision an operational reality in the century of communication and the information highway.