A DATA MODEL
FOR THE INTEGRATED TRANSPORTATION SYSTEM

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Abstract: Transportation systems are indispensable for all the countries around the world. The main concerns of transportation systems are safety, efficiency and reliability. To fulfill those concerns, it is necessary to integrate into one overarching transportation information system. Integrated Transportation System (ITS) was proposed as a future transportation information system and proposed the three layers object model (3LOM) as an architecture of ITS. In 3LOM, the middle layer consists of a data management system. In order to implement the data management system of the middle layer, it is crucial to design an integrated database structure. This paper proposes a four-layer database model of ITS and discusses how to integrate different types of transportation system. The four-layer model includes a general map database, a general transportation system database, a schedule based and non-schedule based transportation system database, and a specific transportation system database.

Key Words: database design, layer model, integrated transportation system.

1. INTRODUCTION

Transportation systems are indispensable for all the countries around the world to support various activities of our societies. Currently, there are various transportation systems and they are controlled and managed separately by different control systems, for example, rail and road traffic each uses differing systems of control. Within the context of highway management and en-route navigation, these are separate systems again. However, they manage related transport system components and as such it appears reasonable that they should ‘co-operate’ more closely, particularly during times of war, civil unrest, and natural disaster. To achieve such integration of transport management, it is necessary to integrate their management into one overarching transportation information system and accelerate the collaboration among different types of transport organizations.

H. Ikeda and N. Vogiatzis et al (2003) proposed an Integrated Transportation System (ITS) as a component of a future transportation information system. The purpose of ITS is to improve the performance of transportation safety, efficiency and environment protection by managing and controlling any kind of transport resource and activity. A three-layer object model (3LOM) (H. Ikeda, N. Vogiatzis, et al, 2004) proposed the ITS architecture that consists of a front-end component in the bottom layer, a data management system in the middle layer, a
knowledge management system in the top layer and independent control centers. Among these, the middle layer takes the role of storing, managing, retrieving and manipulating data to support other layers. In order to implement the data management system of the middle layer, it is crucial to design an integrated database structure which must cover any kind of resource and activity of ITS.

This paper proposes a four-layer model of database layer in ITS and discusses how to integrate different types of transportation system. We design of physical allocation of base relation as implementation of the layered database. The paper consists of the data structure of a general map, a general transportation system, a schedule based transportation system, a non-schedule based transportation system, and a railway transportation system.

2. INTEGRATED TRANSPORTATION SYSTEM (ITS)

2.1. Integrate different type of transportation systems.
In Vogiatzis et al (2003), a new type of integrated traffic management/traffic micro-simulation system was proposed. It was called Integrated Transportation System or ITS. Specifically, ITS began as a decision support system which has now grown in concept to become an intelligent, self-sustaining traffic/transport network management system. It does so by conceptually integrating the three main elements of traffic networks; 1) the users of the network (drivers, pedestrians, etc); 2) the traffic engineer who physically manages the network; and 3) the traffic management system. It does so by developing the idea of each vehicle in the network being ‘connected’ to the system, in which case there is no longer a need for the traffic signaling system to be interested in movement of vehicles between intersections, rather the movement of vehicles between ‘Locations’.

The purpose of ITS is to improve the performance of transportation safety, efficiency and environment protection by managing and controlling any kind of transport resource and activity. Figure 1 indicates three layers of the system-3LOM as an architecture design of ITS, including: local units in the bottom layer, individual and Statistical Data Systems (DBS) in the middle layer and Knowledgebase System (KS) in the top layer and an independent Central Control system (CCs) for some specified purposes. The lowest layer manages specific controllers in locations of intersection, acquires data from those locations and controls the environment. Data is acquired by a local unit called front-end components; data is then transmitted to the data management system or related to control centers. Some data is used specifically for the control of individual locations whereas other data is locally summarized and then transmitted to the middle layer. The DBS in the middle layer also manages data from individual controller and system-wide data for the purpose of resource management, analysis and transport facilities planning. The data in the middle layer are...
used for establishing new knowledge rules, supporting activities of managing transport office, registration of vehicles, the administrating of roads, etc.

In the top layer, KS manages the control/behavioral rules associated with the environment such as intersections, facilities and appropriate rules for conditions such as accident wardens, traffic congestion etc. Finally, control centers are established for specific purposes such as a fire control, highway monitoring, road traffic monitoring etc. Each control center connects to the related local units to get appropriate data for its control mechanism.

2.2. Role of Database Design for Transportation System

General purposes and activities of various types of transportation system are similar and cooperated with each others. Basically, there are four types of resource, physical resource, human resource, financial resource and information resource and, transportation systems generally utilize large amount of those resources. These factors are the most common characteristics among different types of transportation system and, some resources can be shared among different transport organizations. Therefore, transportation resource management systems play a crucial role to improve the safety, efficiency and effectiveness. The key performance criteria of these systems must satisfy the maintenance, sharing, planning and analysis of the resources which are relevant with any transportation system. Moreover, there are many different transport activities, such as driver activities, vehicle movement and, therefore, recording and retrieving the information of those kinds of activity can support, for example, the analysis of transportation system status, planning for future activities and controlling real time transport operations. In order to achieve a well-managed environment and the control of the huge amount of transport resources and various types of activities, a well-organized information system is essential the development of a new type of transport control system.

A database is buttress of any kind of information system. It is an organized collection of data and this technology is used to store data in a computer in a systematic way to get great data integrity, obtain the data integration, acquire data security, reduce data redundancy and assist for the great retrieval of information to the users by using the effective transaction systems. A database facilitates the development of transaction programs of information system. This fact is also very important for the automation of transportation management and control systems. Furthermore, giving the effective information to the related control center can increase the performance of transport control systems such as safety, efficiency and reliability. According to the above factors, designing a database structure for transportation systems plays an important role for future transportation information system.

There are many who have proposed data structures in transportation data management field. However, those data management systems are focused on specific purposes/issues and the integration of different types of transportation systems has been received little or no attention. In 2004, Friedrice M. introduced an extending transportation planning models by adopting an operational transit planning scheme instead of strategic modeling. This model proposed ER diagram for data model describing a public transport line with geographic routes, time profile and service trips, including the data objects such as stop points, running days, line routes, time tables, etc. However, in reality, in order to perform the operational planning, relevant organizations require regular information from transport objects such as signaling systems (e.g. signal timing) to estimate the necessary requirements associated with issues such as the running time of operations. This kind of information is strongly localized (such as road intersections, railway level crossings, etc). Furthermore, a driver-vehicle unit which was may
have planned to start a ‘trip’ at some time in the future, made the system aware of this plan of action and then finds that the vehicle itself has mechanical failures or is in need of service and thus the trip is either postponed or altered at the last minute. To treat these kinds of issues, relevant organizations require information such as the location of replacement vehicles, condition of replacement vehicles, usage of replacement vehicles (in the case of public or pooled vehicles) and etc. Therefore, a data structure should have relationship between locality information and vehicle information. Beside this proposal, Schlenoff et al. has developed an on-road driving database that accurately conveys the appropriate information about road networks for planning systems. In this database, the structure and features of the road network are captured in a six level decomposition hierarchy. This six level hierarchy was chosen for the on-road driving database to allow for the efficient representation of the road network at various levels of abstraction. This data structure is very important for road network information, however, it can only support for the road. In fact, transportation related organizations require information for other types of locations such as parking areas, hospitals, fire stations, fuel stations, etc.

3. DATABASE DESIGN OF INTEGRATED TRANSPORTATION SYSTEM

In previous section, we have discussed about the important role of database design for transportation systems. Our target is to integrate different types of transportation system. For that reason, we need to consider how to integrate data and data structure of different types of transportation system. In this section, we analyze the existing different types of transport system and implementation approach for the Integration of different types of transportation system.

Generally, transportation systems are classified into four types: road, rail, water and air transport. Moreover, different types of transport system can be classified into other ways, such as public and private transport, passenger and cargo transport. In fact, among the above general classification, there are many specific types of transport system such as, helicopter, taxi, bus, ship, airplane, private automobile, passenger train.

Beside, it is evident that geographic information system (GIS), nowadays, is very useful in society. GIS is not only used in the management of transportation systems but also used in military operations, disaster mitigation, etc., however, our focus is transportation systems management and therefore, we will analyze the requirements of GIS for transportation systems. Giving the necessary geographic information to transport related persons can improve the safety and efficiency of the system. Requirements of geographic information are not only for the routes and the stop points but also for the transport related information such as fire stations, hospitals, etc. Moreover, climatic information of specific location is also very important to improve the safety and efficiency of transportation systems.

3.1. Sharing resources of organizations

In accordance with the existence of various types of transportation systems, there were many ways to share resources between organizations. One approach is linking databases of each system for sharing data. In this approach, all transport organizations must have their own database and software programs to manipulate the information. That unify database should be managed by each organization. Figure 2 shows one example to share original data inside one organization. Data can be updated by one transaction program (3) or shared by many transaction programs (1, 2).
Concerning with sharing data between organizations (figure 3), for example, a road that be used by map management system as well as train control system. However, information of that road must record separately in bus transport database, taxi transport database, private vehicle database, etc. Furthermore, some of the functions of different types of transport system are similar. Therefore, data structures for those functions can also be shared among different types of transport organization (figure 4).

Beside, the data can also be integrated from different types of organizations. Figure 5 is an example of accident data which can be reported from traffic management center or rail operations center to police.

Along with the different ways to share the data or data structure above, the data and data structure can be shared by online access. Figure 6a and 6b is two examples about data access service and data service.
In 6a case, the weather data is managed by the GIS, the Bus control system accesses the necessary of weather information to modify its bus schedule. In 6b case, the data of road or hospital is provided by the Bus control system as package to modify the bus stop information; thus the bus stop base table can use same data structure of hospital or packing base table. Thus, the usage of some types of resource is distributed among the different types of transport systems. Therefore, the integrated transportation data structure is necessary to design for collecting common data of different types of transportation system.

3.2. Layer Approach for Integration of Different Types of Transportation

In order to facilitate the reduction of data redundancies, data structure redundancies and operational redundancies, we propose a layer structure to the design of the transportation system data structure. Currently, we have defined some of this structure using existing technologies, such as object-oriented design, telecommunication and web-design; however, the significance of a layered structure in this research is to classify the common information and specific information for the integration of specific transportation modes and different types of transport modes.

4. FOUR-LAYER DATABASE MODEL

4.1 Architecture Design

ITS data structure is proposed by a four-layer database model shown in figure 7. The lowest layer manages specific transportation mode data and structured in order to record detailed mode performance information.

The primary middle layer is separated into two data structures namely a ‘Schedule Based Transportation System Database’ (SBTD) and a ‘Non-Schedule Based Transportation System Database’ (NSBTD). The SBTD data structure is for the transportation mode in which vehicle operations are running based on the fixed schedule and NSBTD data structure is for the transportation system in which vehicle operations are running independently.
The secondary middle layer is named the ‘General Transportation System Database’ (GTD) and manages common information of any kind of transportation mode/entity. Some entities might have vertical relationship with the entities of general map database because they are associated with each other such entity.

The top layer is used to manage geographic and climatic information relating to the transportation environment. This layer’s name is the ‘General Map Database’ (GMD) because the data structure is designed based on the properties of a map.

4.2. Physical Design of the Four-Layer Database Model

Figure 8 shows the physical structure of the four-layer database for transportation system. Some common tables are represented for all layers and the level of detailed can be classified by assigning the specific attributes. Geographic and climatic information are assigned in the top layer and therefore, some tables might not be related with transportation data structure.
With relation to specific modes, the common tables are located in GTD layer to support general information for any kind of transport mode. The classification of SBTD and NSBTD is expressed by the secondary middle layer and some tables are used to collect the data related with schedule based system and some are used for non schedule based transport system. The bottom layer expresses the existence of unique group data for each specific transport mode and they do not have any relation with other layers.

4.3. Data Structure of Four-Layer Database Model
To design the data structure of the four-layer database model, we use the entity-relationship diagram. In conceptual modeling for the four-layer database model, there are four different entity relationships diagram for the lower three layers. The bottom layer is for the specific transportation system database and therefore, it might be many different ER model. Therefore, in this paper, we will present ER model of the GMD, GTD, SBTD and NSBTD. The sample specific transport mode is railway transport and we will show how to implement the railway data structure based on the higher layer of four-layer database model in the remainder of this paper.

Figure 9 mentions object ER diagram of the four layer database. Figure 10 is a design of railway transportation database. We present the description of the entities and how to assign the entities of specific transport layer with the sample entity relationship diagram of rail transport in below.

**Area** – An area is a generic term referring to a large area on the map. Examples area entity records includes: ‘administrative region’, ‘sea’, ‘mountain’, and ‘city’. One area might be composed of many areas (e.g., city is composed of townships) and therefore, an area might be a part of another area. **Calendar** – Simply a ‘calendar’ of days. **Spot** – A spot is a generic term referring to any kind of place which can be used to assist transport related activities, stop or start vehicles for the purposes of safety or change of course, allow the passengers to board or alight or load/unload cargo on freight vehicles and keep the vehicles for the purposes of maintenance, parking, etc. Some examples to be record in this table are hospital, road intersection, rail point, railway station, vehicle workshop, etc. **Route Block** – A route block stands for any kind of transport route that is used by transportation vehicles. This entity is intended to record the road, rail track, sea lane, airplane runway, etc. There are three recursive relationships and a ‘part of’ represents the inherit route, ‘neighbor’ represents the adjoining route and ‘connect’ represents the front of back route that are connected with a particular route. **Location** – This entity generalizes the data of ‘spot’ and ‘route block’ in order to simplify the existence of transport places and route in the big area. **Climate** – A ‘climate’ is a many-to-many relationship between ‘area’ and ‘calendar’ entities in order to record the weather or climatic information of wide area for calendar days. **Include** – An association between ‘area’ and ‘location’ entities is ‘include’ because small locations are included in big area. This relationship table is intended to record the associated information of big area and small location. **Connected** – In order to record the information of connection between place and route block (e.g., intersection and road), there is a ‘connected’ relationship between ‘spot’ and ‘route block’.
Figure 9 Object diagram of Four-Layered Data structure
**Vehicle** – A vehicle is a generic term referring to any kind of vehicle which can be used to transport people or freight. Examples include: automobile, airplane, locomotive, passenger coach, ship. This entity exists in the upper three layers of the data structure because both schedule and non schedule based transport modes (thus, any kind of transportation mode) must use a vehicle. Considering the rail transport data structure as an example of specific transport layer, railways use locomotives, passenger coaches, freight wagons, etc and therefore, we can assign the entity as ‘rail car’.

**Vehicle Type** – In order to avoid repeated information in vehicle entity table, a vehicle type entity is assigned because there are many similar types of vehicles in the different transportation modes and although each vehicles has unique information (e.g., registration number, colour), there exists basic information which are common across vehicle instances (e.g., size, manufacturer). A vehicle type is a term for type of vehicle which can be classified by the brand and model of vehicle.

**Logical Vehicle** – A logical vehicle is a general term for the logical existence of trips for vehicles for any kinds of transportation mode. Examples are taxi, train, road train.

**Operation** - There are various types of vehicle operation such as bus operation, train operation, airplane operation, etc., in transportation network. The term ‘operation’ represents the moving vehicle which is running from one place to another. This entity is intended to record the real time information of vehicle operation.

**Person** – A person is a term for human being who is related with any transportation mode. This entity must group the data of human information. Concerning with SBTD layer, the entity name becomes staff because the functions of schedule based transport system are performed by the person who are related with relevant organizations.

**Department** – A term department represents any kind of organization, bureau, office, company, etc., that are related with the transportation system.

**License Type** – A license type is a term referring to any kind of authorization which are used to allow ‘driver/operators’ to operate a specific type of vehicle in the context of the transport mode for which the licence has been issued. Examples include: private vehicle license, rapid train driver license, and employee identification card.

**Facility** – Any types of transportation system use the devices or materials for the purposes of safety, efficiency, reliability, etc.

**Facility Type** – The information of same type of facility must be collected in this entity.

**Place** – A place is a generic term referring to any kind of places which can be used to assist transport related activities, stop or start vehicles for the purposes of safety or change the course, allow the passengers and freight to board or leave the vehicles and keep the vehicles for the purposes of maintenance, parking, etc. This entity is intended to record the place data which are related with transportation system and general map layer collects the geographic and climatic information.

**Route Block** – The study of being or existence in transportation system clearly shows that any types of transportation system are relying on the route for their operations. Road vehicles use the street, highway, etc., railway use the rail track, ship use the sea lane, etc. Therefore the route block entity exists in GTD layer and, in fact, it is originated from GMD layer. The hierarchical decomposition can support to record the detailed information of transport routes and therefore, a ‘part of’ unary relationship is assigned in this entity. Moreover, most of the routes are connected with other routes and this existence is expressed by the ‘connect’ unary relationship.

**Location** - A location is a term for referring any kinds of locality which are related to a transportation mode. In fact, this entity generalizes the ‘place’ and ‘route block’ entities in order to simplify the relationship among other entities and ‘is a’ relationships represents the generalization. This entity exists in all layers of the four layer database model because the location data is related with any types of transportation system.

**Incident** – An incident is a general term for the unexpected events which might have occurred in transportation system. Examples include: natural disasters, accidents, etc.

**Time Schedule** – This specifically relates to schedule based transportation modes in the previous sections. It applies to any mode which uses a fixed ‘schedule’ of arrival/departure from fixed (and generally linearly related) geographical
locations forming a ‘route’. A ‘time schedule’ is a term referring to any kind of transportation timetable which are officially issued by the relevant transport authorities. This entity originates in the SBTD layer of the four-layer database model because GTD layer is unable to support information relating to non-schedule based transportation modes. **Running Time** – In order to support the driving time or running time of the specific route for non-schedule based transportation system, the ‘running time’ entity is assigned in NSBTD layer. This entity is unnecessary in SBTD data structure because time schedule entity has support this information of schedule based trips. **Route Schedule** – A route schedule is a term referring to the possibility of route settings for the schedule based transport operations. This entity is originated from SBTD data structure. The detailed information can be recorded by the hierarchical structure and a ‘part of’ unary relationship represents for this requirement. **Navigate Route** – This entity is originated from the secondary middle layer of NSBTD data structure because transport control center can only recommend the suitable route for non-schedule based operations and they could not be able to assign the fixed route and therefore, this entity also expresses the difference between schedule and non-schedule based transport system. Examples to be entry are shortest distance route, shortest time route, etc. **Ticket Type** - Schedule base transportation system is a kind of public and cargo transportation system and in order to manage the financial resources, the revenue information is very important and those kinds of information is related with passenger or cargo ticket. A ticket type is a term for any kinds of ticket which are available in schedule based transport system and therefore, the derivation of this entity is started from the secondary middle layer of SBTD data structure.

![Figure 10 Entity Relationship Diagram of Railway Transportation System Database](image)

**Belong To** – stores employment information relating to staff in relevant organizations. This is a relationship table between the ‘department’ and ‘person/staff’ entities in the data structure of four-layer database model. **Have** - All transport related person must have license to identify their occupation and therefore, an association ‘have’ is existed between ‘person/staff’ and
‘license type’ entities. The information relating to licenses which is associated with individual persons must be recorded in this table. **Work** – In transportation management, the information relating to a person who operates a vehicle plays an important role for safety, efficiency, etc. A ‘work’ relationship which exists between the ‘person/staff’ and ‘operation’ entities expresses to record the information of automobile driver, train drivers, train conductors, pilot, etc who are working on particular vehicle operation. **Maintain** – This relationship exists among the ‘person’, ‘department’ and ‘vehicle’ entities in GTD data structure because the maintenance of particular vehicle might be performed by individual person or organization in different types of transportation system. **Live** - In order to record the residence information of transport related person, this relationship is assigned between ‘person/staff’ and ‘department’ entities. **Used** – An association between ‘vehicle’ and ‘logical vehicle’ entities is a ‘used’ table because transport vehicles are used for transport trips (e.g., rail cars are used for train). **Pass** – A ‘pass’ relationship exists between the ‘operation’ and ‘location’ table because vehicle operation might pass through transport locations. **Park** – If the transport vehicle is out of service for any reasons, it must be parked at some location. Therefore, a relationship ‘park’ is assigned between ‘vehicle’ and ‘location’ entities. **Manage** - A ‘manage’ relationship is assigned between the ‘facility’ and ‘department’ entities because the responsibility of management of facility is related with transport organization. Maintenance information of individual facility which will perform or which was done by department is recorded in this table. **Located** – In order to record the location of individual facility, a ‘located’ relationship is assigned between the ‘facility’ and ‘location’ entities. **Sustain** – This relationship is assigned between the ‘department’ and ‘location’ entities. Transport organizations need to sustain or maintain the transport places and routes in order to achieve the highest potential of efficiency and effectiveness and location entity is the generalize entity of ‘place’ and ‘route block. **Administer** – The administration on the specific location is done by the relevant organization or bureau. According to the above reason, there is a relationship between ‘administer’ and ‘department’ and ‘location’ entities. **Occur** – This relationship is assigned among ‘operation’, ‘location’ and ‘incident’ to record the information of unexpected events which impact to location and vehicle operation. **Recover** – To recover from unexpected events the relevant department needs to be informed in order to get the location back to its normal condition. Therefore, this association is assigned between ‘department’ and ‘incident’ entities and this table is able to support historical and current information and future responsibility of recovering incident by relevant department. **Provide** – A ‘provide’ relationship is the association between ‘logical vehicle’ and ‘ticket type’ table in SBTD data structure. The target goal of this table is to record the number of tickets which are available in a particular schedule based trip because any types of transport service have limited number of seats or space for passenger, commuter and freight and this information is very important for customer services. **Freight** – In order to record the associated information between the ‘ticket type’ and ‘department’ entities, a ‘freight’ relationship is assigned in SBTD data structure. Relevant department must sell the freight ticket for customers and this table is used to record the future plan, current condition and history of sold tickets based on the season. **Passenger** – The same concept with the ‘freight’ relationship, a ‘passenger’ relationship is assigned between the ‘department’ and ‘logical vehicle’ entities in order to record the future plan, current condition and history of sold tickets based on the season. **Comprise** – This relationship exists between the ‘route schedule’ and ‘location’ entities. One assigned route schedule might comprise many locations and one location might be comprised for many route schedules. **Connected** – Transport places, such as intersection, bus stop, are connected with route. This relationship exists between the ‘place’ and ‘route block’ entities. **Apply** – A ‘apply’ relationship is assigned between the ‘logical vehicle’ and ‘navigate route’ entities of NSBTD data structure. The non-schedule bases trips might apply or follow the navigate route that recommended
from the relevant transport control and therefore, this relationship is occurred. The data in this table can be analyzed for some activities, such as driver behavior, performance of control, etc. **Impact** – An association between ‘incident’, ‘operation’, ‘location’ and ‘facility’ is an ‘impact’. This relationship table is intended to record damages of transport physical resources by incidents.

### 4.4. Benefits of Layer Database Model

The four-layer database model is able to reduce data redundancy because the common information for different types of transportation modes is collected in the lower layer and it ensures that there is a ‘one-to-one’ relationship between objects and the data collected for it (that is, more than one distinct record for each object is not recorded). For instance, roads are used by taxis, buses, private vehicles, motorcycles, etc and road data can be organized in a table and the detailed information for specific organization can be classified by the attributes in each layer.

In this paper, we will propose the data structure for the lower three-layers and we will use the railway transport data structure as an example of a specific transport mode data structure. In reality, there are various types of transport modes in our society and developers can develop for other specific transportation modes the necessary data structures based on the four-layer database model. Therefore, layer structure is able to extend for specific transport system and it can facilitate the development of transportation data management system.

In addition, the layer structure can assist to reduce the program redundancy by sharing the same or similar programs and software components. For example, although data itself might be different, there are similar functions with relation to time scheduling for different types of schedule based transportation modes and they can be developed as general components and the special features for specific schedule based transport modes can be developed as program. Therefore, the general component for scheduling can be used for any kinds of schedule based transport mode.

Moreover, the layer database approach can reduce operations (e.g., developing programs, updating database).

The most important contribution from the four-layer database model is that it can support the reorganization of disparate transport organizations and, therefore, this is the goal of future integrated transportation system.

### 5. CONCLUSION AND DISCUSSION

This paper focused on the implementation of a database structure of ITS. We proposed an architectural design and physical design of the four-layer database model for integration of different types of transportation system. The four-layer database model consists of a general map database in the bottom layer, a general transportation system database in the primary middle layer, a schedule and a non-schedule based transportation system database in the secondary middle layer and a specific transportation system database layer in the top layer. A data structure of general map, general transportation system, schedule based transportation system and non-schedule based transportation system is shown in the ER model. Furthermore, ER model of rail transport system is described as an example of the specific transportation system. The application profile of the four-layer database model is also presented.
The advantages of a layer model include the reduction of data redundancies, program redundancies and operation redundancies. In addition, the four-layer database model is able to reorganize the transport related organizations for the future integrated transportation system. This factor is very useful to increase the collaboration among different types of organization for improving safety, efficiency, effectiveness and reliability of transportation systems.

We leave, however, the implementation of transaction programs by using the four-layer database model for the future forum.

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