AN INFORMATION SYSTEM PROMOTING THE DEVELOPMENT OF THE MANAGEMENT STRATEGY OF ROAD ASSETS

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ABSTRACT

Responding to the needs of users while ensuring the preservation of its assets within the framework of a restricted budget : this is the aim set by the road network managers. To successfully fulfil this objective, they need efficient and evolutive tools and methods to assist in management, evaluation and maintenance.

Mandated by the SETRA (Service d'Etudes Techniques des Routes et Autoroutes – Technical Research Service of Roads and Highways) and the DGR (Direction Générale des Routes – Road Transport General Management office) to design a new computer system to manage France's national road network, the CETE Méditerranée has conducted a series of studies on a functional, organisational and technical level so that managers can have software tools equipped with all the necessary requirements at their disposal.

This report addresses the solutions chosen to give this system the necessary capabilities and flexibility required :

- *A digital representation of the network* in which the components of the assets can be geographically or linearly positioned
- *An asset data base* which offers the manager an objective, global and updated view of his network
- *The integration (in the information system) of software* using tested management techniques
- *A data history management device* which ensures that the successive states of the components of the assets will be preserved over time, and which allows the manager to study their evolution

1. MANAGEMENT OF THE FRENCH ROAD NETWORK

1.1. The composition of the national road network

Management of French roads is carried out by the State (le ministère de l'Equipement – Ministry of Public Works) for the national roads and by the regional authorities for local roads. The decentralisation law of 13 August 2004 has modified the current repartition by attributing the management of a portion of the national roads to the regional authorities. This led the State to reorganise the way the national network is managed. Eleven Interdepartmental Road Management Offices (Directions Interdépartementales des Routes, DIR) have been created and these share the management of 11,800 km of roads and highways which from now on make up the national non-conceded road network. The national plan was run by the Road Transport General Management office (DGR, Direction

Générale des Routes). Moreover, the management of 8,000 km of highway belonging to the national network remains the responsibility of highway concession companies.

To illustrate this, the map below shows the network of 1550 km managed by the DIR West.

Figure 1 – The DIR West road network

1.2. Management needs in terms of the information system

Management of a DIR network must do its best to meet the needs of road users, while at the same time overseeing the improvement and preservation of its assets, within the framework of a restricted budget.

The needs of a road user can be described in different ways : pleasant driving conditions, maximum safety, relevant and updated information about traffic conditions… In order to meet these needs [1], the manager must know his network well. He must also have access to efficient tools to evaluate and maintain the different components of his network. The following information specifies what a DIR network manager expects from the information system.

1.2.1 Knowledge of the network and road assets

This consists of building a data base in which components of the assets are identified and described. It is the manager's responsibility to define what these components are and the level of precision that the corresponding data should be collected and stored.

This need of knowledge can vary over time ; therefore the data base structure needs to be evolutive. It should be possible to add new types of components to the data base and to complete the description of the existing types of components, depending on the new needs of the manager.

1.2.2 Assistance to evaluate the state of the network and to define the maintenance programmes

Beyond a simple description of the components of the assets, it is equally necessary that the manager is given the capability to save in the asset data base the management

operations concerning these components, such as inspections, diagnoses, proposals for future works, completed works…

The following figure [2] illustrates the cycle of actions in the management of one asset component.

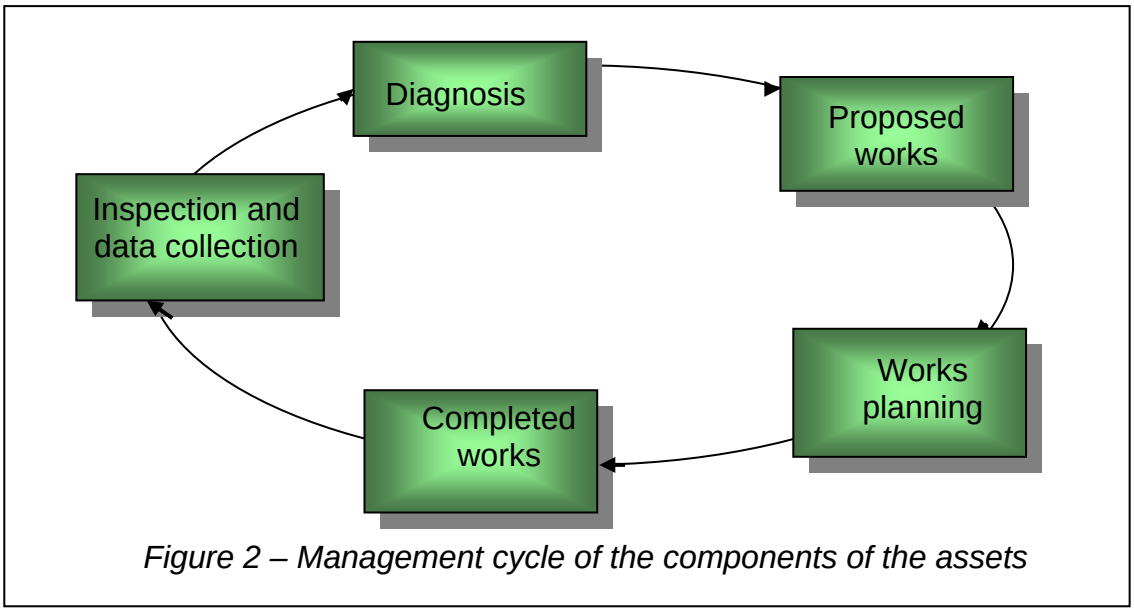

Figure 2 – Management cycle of the components of the assets

Techniques and maintenance methods can evolve over time ; hence the data necessary for their automatisation can be made to evolve. The information system should therefore be designed so that it can always be updated regularly with these evolutions.

1.2.3 Assistance of the multi-year evaluation of the maintenance policies

The effectiveness of maintenance policies is judged in the long term, typically over several years. It is therefore essential for a manager to be able to compare the states of the assets with specific dates.

For example, the IQRN operation (Image Quality of the National Network - Image Qualité du Réseau National) periodically evaluates the state of the national network's pavements (one third of the network each year), and gives a grade to the sections of the pavement. The comparison of these grades over several periods (every three years, the entire network is auscultated and evaluated) enables an assessment of the policies implemented to maintain the pavements.

Likewise, the IQOA operation enables the evolution of the assets of the bridges to be monitored over time. The same IQDE operation is envisaged for the monitoring process of its ancillaries.

In order to carry out these evaluations, the managers of the national road network must therefore organise the preservation of the data concerned (grades given to the sections of the pavement for IQRN) and to have access to stable and reliable methods of comparison. Depending on the results observed for the different components of the road assets, the managers can develop their maintenance policies or balance their budgets assigned to the different sectors (pavements, bridges, equipment, ancillaries…).

It is therefore important to consider that the maintenance and management policies of different components of the assets are liable to vary over time, depending on what is at

stake and the objectives. For example, in recent years, the importance given to the respect of the environment or to safety has grown, which results in growing demands for the level of service in these sectors.

The new computer system for the management of the national road assets was designed to cover several decades, which should make it sufficiently flexible to handle these developments and to adapt to new choices made by managers.

1.2.4 Exchange and circulation of information

Within the same area, several managers (regional and national) share the road management. Each manager must know the main characteristics of the neighbouring networks, notably to take mutually agreed operating measures in case of disruption to traffic (creation of a detour due to road work or an accident…).

Similarly, numerous activities (road transport, for example) need exact information on the characteristics of roads and their operations. Moreover, French authorities are strongly encouraged to circulate information to the public as widely as possible.

Consequently, the structuring of these exchanges and the circulation of road information is becoming essential and this must be applied to all aspects of the new information system.

1.3. The existing information system

The device consists of a set of software developed in the 1990s and 2000, adapted to the previous organisation of the national road network management based on the sharing of 30,000 km of roads between one hundred Departmental Public Works Management offices (Directions Départementales de l'Equipement). It consists of software known as « generic » that could handle all types of road data, and « speciality » software designed to handle specific tasks relating to certain components of the road assets.

The generic software enables the collection of road data, the analysis of current data or the mapping of the data. This software today depends on outdated computer technology and therefore does not benefit from the evolution and the maturing of geographic information systems, satellite positioning, hand-held computers and Internet.

Concerning the specific software, the developed evaluation and maintenance methods concerning the most technical aspects (pavements, bridges, accidents…) have been updated, automated and stabilised. This is the case, for example, of the GIRR software that is specialised in calculating the pavement maintenance programmes. On the other hand, the other components of the assets (equipment, ancillaries…) do not currently benefit from the formalised methods instrumented by the software.

This computer device has numerous limitations, whether it is on a functional, organisational or technological level. In particular, these include:

- The possibility of insufficient assistance on a daily management level
- The absence of data historisation
- Major constraints for the implementation in a divided organisation
- A weak adaptation to new computer technology

2. DIRECTIONS FOR THE NEW INFORMATION SYSTEM

For several years now, various general or specific studies [3] concerning an aspect of road management have been conducted to determine which directions to favour in order to improve the coherence and efficiency of the information systems used to manage the national road network. These reports have converged on a certain number of points, enabling the direction of the SIGR to be determined (name given to the new Information System for the Management of the National Road Network - Système d'Information pour la Gestion du Réseau routier national).

2.1. The SIGR: an information system on two levels

The operations management of the national road network is therefore ensured by eleven DIR under the control of the DGR. The SIGR [4] has been designed to supply to each level (local or national) the services that it rightly expects. Each player (the DIR and the DGR) views the SIGR from the perspective of its own needs.

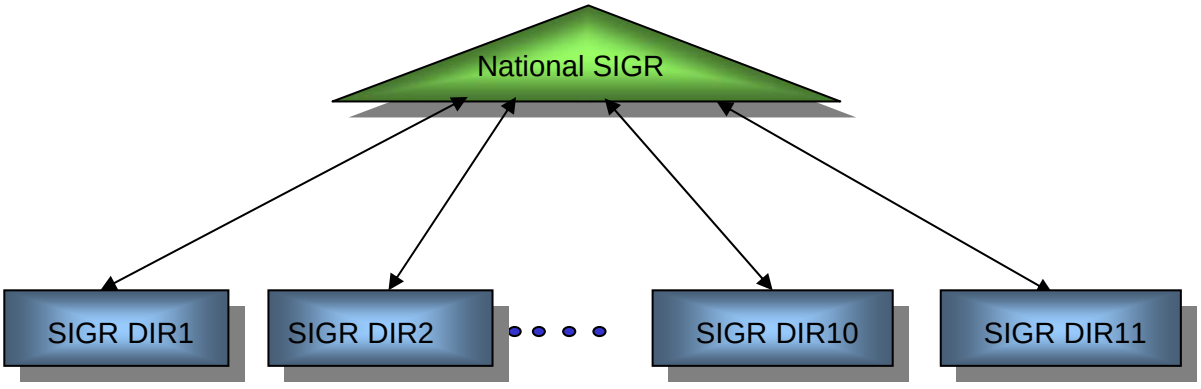

Figure3 – An information system on two levels

2.1.1 At a DIR level

For a DIR, the SIGR should be able to supply all assistance necessary to the management activities and operation of the road, benefiting as much as possible from the latest information technologies and in particular from geomatics, the Internet and hand-held computers.

On the whole, the needs of the DIR are the same, which means that shared solutions are possible. However, disparities exist, whether it concerns the organisation of the DIR itself (division of activities in the different units) or at a data management level (different geographical or economic conditions). The SIGR should therefore be capable of adapting to each DIR to a certain extent.

2.1.2 At the national level

Relations between the DIR and the DGR rest on the structured exchanges of information. The national data base, which consists of the aggregation of the local DIR data bases, needs to be designed in a way that enables the DGR, and equally other road transport parties of the Publics Works Ministry, to have access to the knowledge necessary (of the road assets) to carry out their tasks. Consultation services, presentation and analysis (statistics, spatial and temporal) of this data base must be possible to facilitate access to the information.

2.2. Business sub-systems share a common foundation

For a DIR, the different business needs are similar, but they are also quite different:

- Similar, because they encounter identical problems of positioning, of cartographic representation and analysis
- Different, because the structure of the manipulated data can be of varying complexity, differing collection methods, (manual or on the contrary, automatic) and the management techniques more or less complex or specific.

This means it is necessary to seek the right balance between the respect of the specificity of each business and the advantages of mutual co-operation. It is also necessary to note that the systems management operations undertaken by the different businesses are long-term projects (from 5 to 10 years) and that calling into question this approach will have major repercussions.

The decision to build business sub-systems sharing a common foundation has therefore been confirmed for the new system.

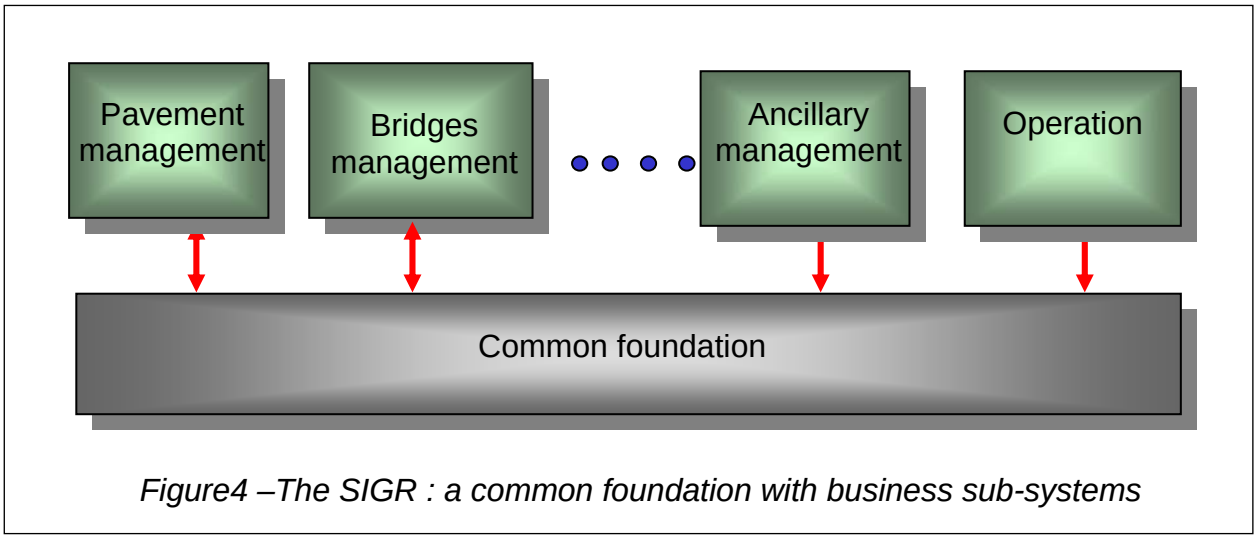

Figure4 –The SIGR : a common foundation with business sub-systems

2.2.1 The common foundation

It includes tools that can be mutually used between the business sub-systems, and in particular :

- *A linear and geographic referencing system* [5] as well as software necessary for its management and use. This system relies on a digital representation of the network and makes it possible to position the different objects of the assets either in a geographic mode (in a system of given coordinates) or in a linear mode from different points (boundaries, notable landmarks…),

- *Management software for the asset data base* that makes it possible to describe the different components of the assets as well as the management operations concerning these components, equally ensuring the storing of this data over several decades. The FEOR [7] model designed for the SIGR proposes different types of road objects to represent the most common components and the associated management operations.

- *Generic visualisation, analysis or representation software* of road objects and the visualisation of sequences of images taken along the road.

2.2.2 The business sub-systems

The SIGR's objective is to host all the business sub-systems which manage the components (located with the assistance of the location referencing system) of the assets or which need access to information available in the asset data base.

Some business sub-systems are perfectly identified and today benefit from specific software used in the DIR. Others are likely to be defined in the future, in response to the DIR's current or future priorities.

In the first place, the sub-systems dedicated to the management of objects or events relative to the assets are concerned, such as:

- management of pavements
- management of bridges
- management of ancillaries
- road traffic counters
- operation of the network
- safety

Equally concerned by the SIGR are the business sub-systems which manage the data which is related to the asset data, such as:

- management of traffic decrees
- monitoring of the maintenance teams' activities
- financial monitoring of maintenance programmes

These business sub-systems should respect a certain number of rules in order to benefit from the services offered by the common foundation.

2.3. Conservation and distribution of data

The road data itself is considered as an asset, so its conservation over time needs to be ensured, as well its distribution to various interested parties, whether they are internal in the DIR or external.

2.3.1 Data conservation

An administrative device concerning road data and successive versions of the location referencing system is to be implemented at a national level. As well as its role of conserving data over time, this device also needs to be seen as a major node for the exchange of road data, whether this is between the components of the SIGR, with other information systems of the State or with external partners. These exchanges will use the exchange formats that will be standardised as far as possible, as recommended by the guide for the exchange of road data. [8].

It will also be necessary to enhance this device with analytical tools using the data history in a way that enables the evaluation over time of the maintenance or development policies, as well as the comparison of situations.

2.3.2 Road data distribution

Beyond the exchange of data between the road professionals, the DIR will be required to communicate the state and the functioning of their network. In particular, the communication with the general public should come from the asset data base. Publication on the Internet in the form of maps (traffic, road works…) is to be favoured, taking into account the cost/benefit ratio which is particularly advantageous.

2.4. The geographic dimension of the data base

Introducing the concept of location referencing has enabled the road information system to open up to geographic information systems, without however, benefiting from all the advantages currently offered by geomatics. The SIGR needs to favour the access of the business sub-systems [9] to geomatic technology. Numerous advantages are expected:

- Organisation [10] of the sharing of geographic referencing system between different road transport parties: managers, operators, private operators, suppliers…
- Development of GPS use : constitution and updating of the location refererencing systems, improvement of the automatic data collection process, help with object location
- Crossing of road information with all types of data concerning an area
- Stability of the geographic location, very useful for storing data over time and with a view to studying its evolution

3. FUNCTIONS ENSURED BY THE SIGR FOUNDATION

As has been previously discussed, the SIGR consists of a foundation and business sub-systems. The following describes the functions of the main components of the foundation.

3.1. Asset data base management (GPR)

The GPR is generic software which manages a road data base. It offers all the necessary functions to feed and operate the data base :

- The definition of types of objects managed in the GPR data base and the modification of existing ones
- The administration of user rights describing the operations authorised for the different types of objects for a given geographical area
- The interactive data entry of road objects with graphic assistance (cartographic or schematic) and the geographic and linear location modes
- The import of data collected by software other than the GPR : business system, data entry on a hand-held computer, collection with automatic measuring devices
- The export of data towards other SIGR software or to other partners
- The aggregation of data at a national level
- Consulting and analysis of the data base via different forms (documents, maps, synoptic, images)
- Preparing data for long-term conservation

The GPR offers to all the employees of the DIR and the DGR a global, synthetic and updated view of road assets. It makes available all the functions of the shared management of the road objects, by a large number of users. Its implementation in a DIR can be customised depending on the organisation chosen by the DIR.

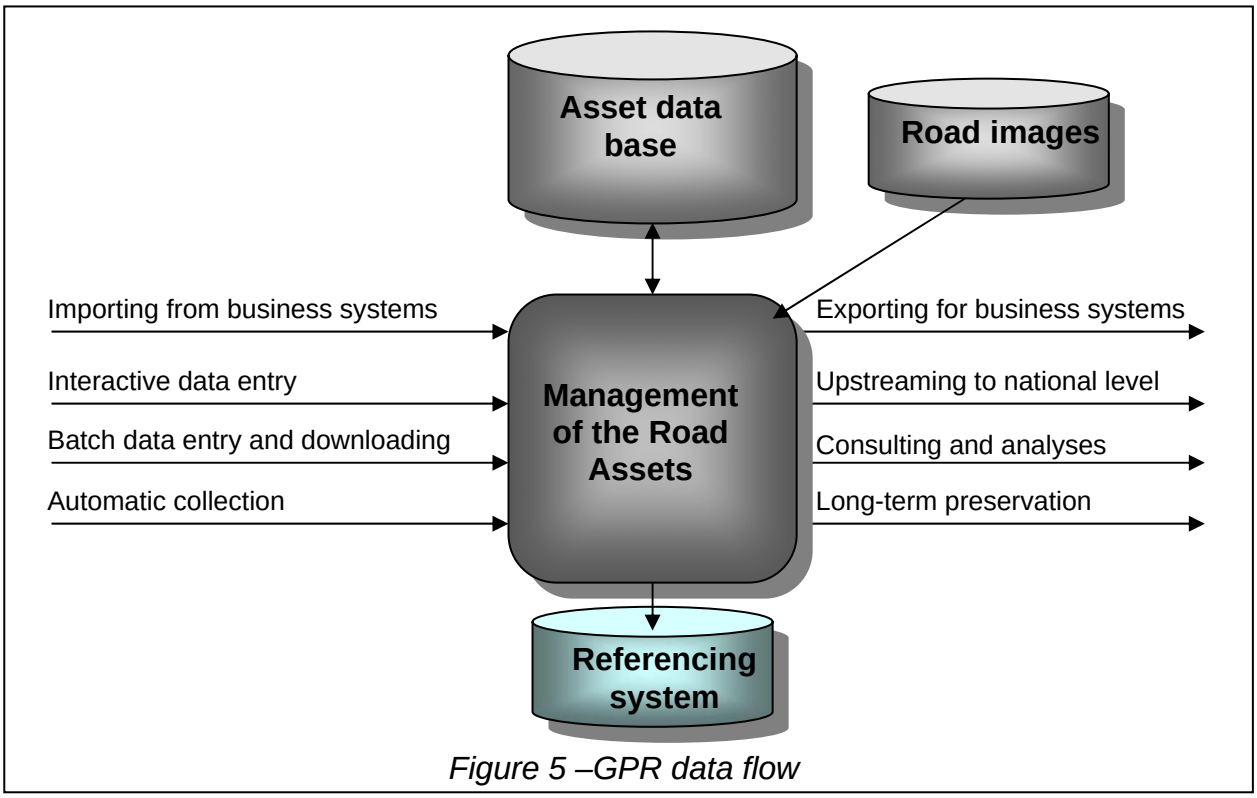

Figure 5 –GPR data flow

To enable managers to develop their maintenance methods, it is possible at any time to enrich the data base with new types of objects, to modify or delete all types of obsolete objects.

3.2. Production of the location referencing system

Location referencing model [11] is a digital representation of the road network in which all the objects managed in the asset data base can be located. Location referencing consists of one (or several) geographic representations (the layout of roads and intersections) coupled with one (or several) linear systems of location [12].

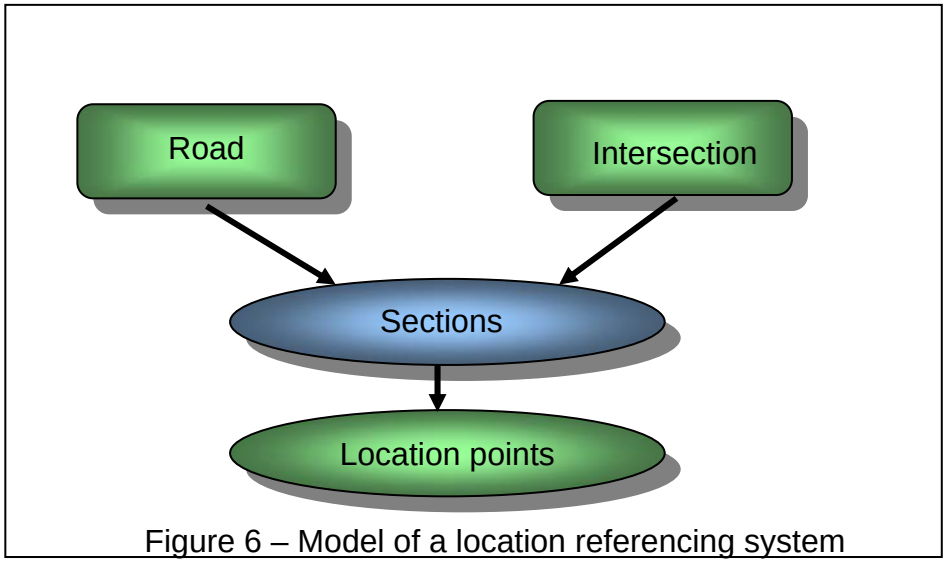

Figure 6 – Model of a location referencing system

The model used for the linear location system makes it possible, as shown in the simplified diagram in figure6, to describe roads and intersections (grade-separated interchanges, roundabouts, simple intersections…) in the same way.

Therefore, a road or an intersection is made up of sections. For a road, the division into sections generally corresponds to a change in the road's characteristics (discontinuity, passage from one to two separate carriageways or the inverse …). For an intersection, one section generally corresponds to a highway ramp, to an acceleration lane, deceleration lane or a roundabout ring.

Each section (of the road or intersection) possesses location points (the PLO) on which the linear location system depends. The components of the assets will be located relative to the PLO.

3.3. The preservation and use of « old » data

The asset data base managed by the GPR aims to give an updated view of the road network at any moment, a view necessary for the day-to-day management. It therefore evolves in a continuous manner, from the different modes of data collection : patrols, inspections, automatic collection… New objects therefore, will be added into the base and existing objects will be modified or deleted.

In order to preserve the old data necessary to multi-year evaluations, a conservation device (of the infocentre type) for « old » data has been installed for the SIGR. This function enables the hosting and storage in a data warehouse of the batches of data to be conserved (for example : the state of the pavements on December 31 of the current year) and for this information to be distributed to managers at a local and national level. The re-use of this old data is thus made considerably easier.

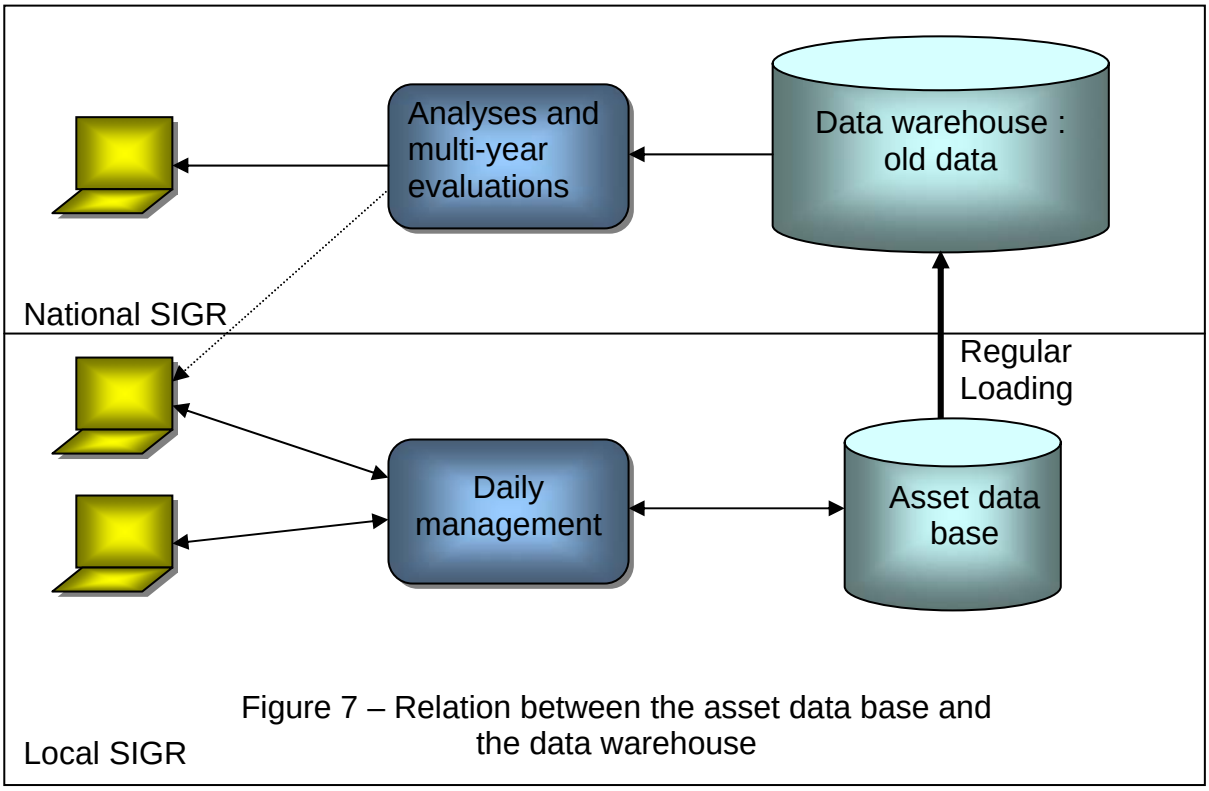

Figure 7 – Relation between the asset data base and the data warehouse

Basic services to process old data have been designed to facilitate evaluations which run over several years. It is therefore possible to determine changes that appear on a certain part of the network between two dates.

The comparison of data of the same nature on two different dates is also facilitated. Figure 7 explains the way the national data warehouse is loaded by the asset data base managed communally by the eleven DIR's.

4. THE POSITIONING OF THE BUSINESS SUB-SYSTEMS

4.1. The types of business sub-systems

A business sub-system concerns a family of components of the assets. Some of these sub-systems are satisfied (totally or partially) with the features offered by the SIGR foundation, which enables the minimisation of software development specific to the management of the corresponding components (business objects).

Other sub-systems (management of bridges, for example) require more advanced features than those supplied by the foundation. In this case, specific software has been developed for the corresponding business objects.

Depending on the usage of the foundation tools, three types of business sub-systems can be identified :

4.1 1 Type 1 – The sub-system relies on the GPR

In this case, the GPR ensures the management and treatment of the objects of the business sub-system.

4.1.2 Type 2 – The business sub-system feeds the asset data base

In this case, the business sub-system has access to specific software which takes total charge of the management and operation of the business objects.

This software feeds the asset data base managed by the GPR.

4.1.3 Type 3 – The business sub-system consults the asset data base without feeding it

The business sub-system has access to specific software which takes total charge of the management and the operation of the business objects.

The business sub-system retrieves certain objects from the asset data base but does not feed it.

4.2. The inventory of the business sub-systems

Table 1 identifies the main business sub-systems which the SIGR is currently composed of, and proposes a type for each of these sub-systems.

Business sub-system	Type proposed	Characteristics
Pavement management	Type 2	Large volume of data
Bridges management	Type 2	Complex data structure Specific management rules
Accidentology	Type 2	Complex data structure Advanced treatment
Traffic observation	Type 2	Large volume of data Real time collection
Real time operation	Type 2	Specific acquisition modes Short-lived data
Ancillary management	Type 1	Simple data structure Simple management rules
Equipment management	Type 1	Simple data structure Simple management rules
Horizontal road-marking management	Type 1	Simple data structure Simple management rules
Works authorisation	Type 3	Specific treatments
Monitoring human activity	Type 3	Non-asset data management

Table 1 – Typology of the business sub-systems

4.3. Integration rules of the business sub-systems in the SIGR

These rules only concern the business sub-systems (of type 2 and 3) that do not use the GPR; the sub-systems of type 1 being integrated into the SIGR by design.

4.3.1 Rules concerning the location referencing system (business sub-system of type 2)

The business sub-system should have the components necessary to locate the business objects on the location referencing system, to be capable of replacing one version of the system by another more recent one, and to carry out, if necessary, a location synchronisation of the business objects of which the location could have been modified.

4.3.2 Rule concerning the exchange formats (business sub-systems of type 2 and 3)

In order to exchange their data with the common foundation tools, software of the business sub-systems should be capable of exporting (and importing if necessary) data conforming to the formats chosen for the SIGR.

4.4. SIGR architecture

It has been designed to be as flexible and evolutive as possible:

- Flexible, to allow the integration of the existing sub-systems with a minimum of constraints

- Evolutive to accept the changes susceptible to arise during the SIGR's existence. In this way, a type 1 business sub-system could, if necessary, evolve towards the type 2, and the inverse.

Figure 8 shows a concentric vision of the SIGR architecture, emphasising the central role of the common foundation and the « distancing » to a greater or lesser degree (vis-à-vis the common foundation) of the business sub-systems according to their type. A business sub-system of type 3 is further from the common foundation than a business sub-system of type 1, which results in greater independence concerning technical choices for the type 3.

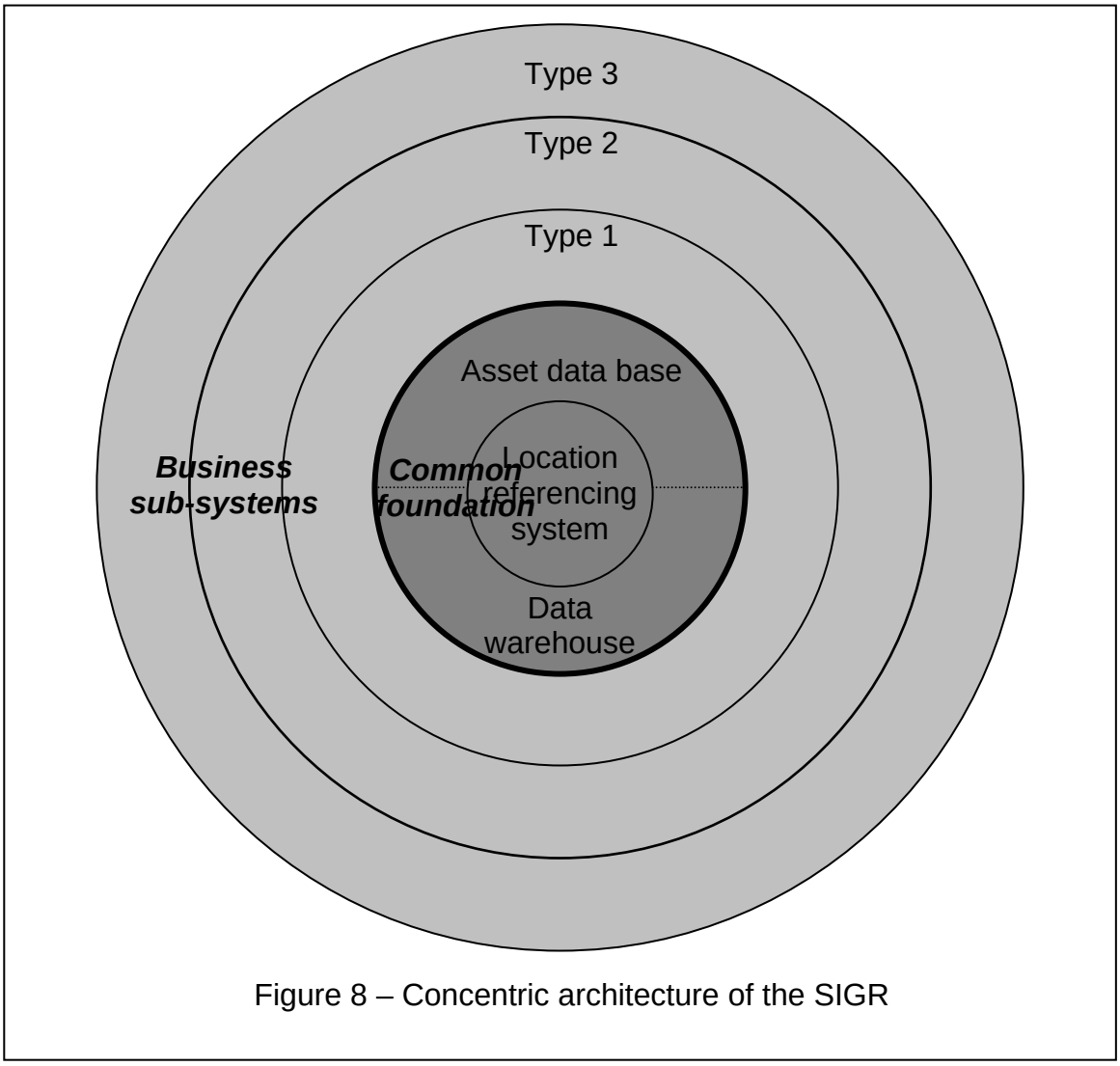

Figure 8 – Concentric architecture of the SIGR

5. CONCLUSION

Because of the speed of the reorganisation of the management of the French national road network, it was necessary to reform the existing information system. If the experience of the Ministry in charge of road management is of course taken into account, the effects of the reorganisation will only be fully grasped in a few years. It was therefore fundamental to design a new information system that could on one hand be operational in a short time, and on the other hand be refined and enriched over the years.

The implementation of new technologies (Internet access, cartography, positioning by satellite, ”on-the-road” collection, spatial analysis…) offers extremely favourable perspectives for all the parties involved in the field of management and operations of the road network.

The consideration of all the problems linked to the historisation of data and its reuse will allow the efficiency of the maintenance policies implemented to be objectively evaluated, and improvements made when necessary.

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