DATA MANAGEMENT for ROAD ADMINISTRATIONS

A Best Practice Guide

WERD
Western European Road Directors

DREO
Directeurs des routes d'Europe de l'Ouest

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FOREWORD

Data are amongst the most important, if not the most important, assets that an organisation holds. These assets must be managed to gain best value from them. This *Data Management for Road Administrations – a Best Practice Guide* has been written to provide guidance and support on this matter.

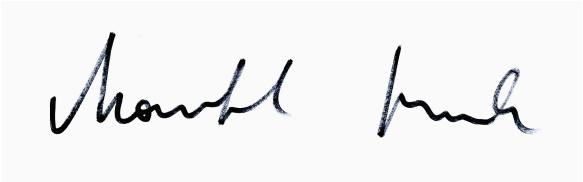
The Western European Road Directors (WERD) have been promoting collaboration and exchange of information and expertise amongst their members since 1988. In particular, they aim to:

- Provide support to the activities of the Road Directors and their administrations
- Promote a high level of common information
- Give assistance to the European Commission in the preparation of reports concerning the development of the Trans European Road Network

The success of the objectives is largely dependent upon the availability of consistent, high-quality information and data from within European Road Administrations. WERD aims to promote the availability of a high standard of common information by harnessing the collective expertise available in member organisations.

Data Management for Road Administrations – a Best Practice Guide has been produced by Sub-Group Road Data on behalf of WERD. The guide promotes good practice and provides practical guidance, in order that Road Administrations can reap the benefits of good Data Management and so that the WERD can be more effective in reporting on the European road network to the European Commission.

This Best Practice Guide is commended to all organisations, particularly local and national Road Administrations that want to maximise benefit from their data.



Manfred HESSLE
WERD Moderator

EXECUTIVE SUMMARY

This *Best Practice Guide* is intended as an introduction to Data Management for senior managers and data specialists in Road Administrations with an interest in getting the best value from data within their organisation. It has been written by practitioners, for practitioners, with the aim of sharing good practice in all aspects of data and information management in the context of a Road Administration, of whatever size or jurisdiction. Organisations that have introduced Data Management have achieved benefit in a number of areas:

- By improved decision support (for example, management reporting, Performance Indicators etc.)
- By reducing risks (for example, accident claims reduction)
- By improved efficiency (in both organisational and financial terms)

Road Administrations will be familiar with the concept that they are responsible for *Assets* in which they must invest, and for which Design, Construction, Maintenance and Operational work must take place if they are to provide an acceptable level of performance, and return on investment. What they may not have considered is that as well as roads, bridges, tunnels and other physical Assets; the *data* that they hold are also numbered amongst their most important Assets. Just as Asset Management seeks to achieve maximum value from physical Assets at minimum life cycle costs, Road Administrations should be aiming to achieve maximum value and performance from their data resources and Assets at minimum life cycle cost. The application of Data Management, effectively *Asset Management of the data Asset*, seeks to achieve this.

Aside from the value of a Road Administration's data resource itself - the result of considerable historic investment - the fact that accurate data are critical to so many of the decisions made and services provided by a Road Administration, means that a Road Administration cannot afford to ignore Data Management.

It is surprising how much data accumulate in an organisation; much of the data are of little value, with no one taking responsibility for their upkeep. The first step in good Data Management is to identify the business needs of the organisation and then to determine what data are required to support those business needs. Once this has been done, you should determine what data you have; how they are created; who owns and looks after them; what they mean, in terms understandable by non-specialists, and to what extent those data are important to the organisation. Data become *information* only when they are put to constructive use and are able to assist decision-making, and to add value to a Road Administration and to the users of its services. All the subsequent steps in establishing Data Management policy and setting up an effective Data Management Regime can be said to flow from this starting point.

What is Data Management?

Data Management is the set of processes and procedures that an organisation puts in place to ensure that its data are contributing positively to the organisation's aims. Good Data Management at its simplest level is purely *good housekeeping* - ensuring the data you want are accessible when you want them, and provided at a cost and quality that meets your needs.

Effective Data Management allows an organisation to make decisions based on information about the cost, quality and the benefits of data. Most

importantly, Data Management is about *understanding* data – turning *data* into useful *information*.

Why should I be concerned about Data Management?

For many years, ad-hoc arrangements for the management of data have appeared sufficient for most purposes, despite inefficiencies and Data Duplication leading to costs being higher and benefits lower than might be desired. However, data volumes are increasing exponentially with growing Information Systems' capacity and usage. Critical decisions depend more heavily upon the information contained in these systems. Moreover, legal responsibility, particularly for issues of Public Safety, places heavier burdens on those keeping records and defining policies and decision-making processes. Nowhere is this trend more apparent than in Public organisations, and Road Administrations are no exception.

In addition, the trend towards the introduction of Performance Indicators, for use both within and between organisations, requires that common data definitions are agreed and that the quality of data is maintained.

Finally, recent technological developments in the provision of near real-time information to road users are increasing the demand for up-to-date, high-quality, data.

The implementation of effective Data Management will help you to satisfy these increasing demands.

What are the benefits of good Data Management?

Effective Data Management will result in the availability of a stable, high-quality information resource across the whole organisation, and in more reliable, better-understood data. This, in turn, will provide *hard* financial benefits and quantifiable improvements in service delivery, as well as *soft* benefits, which although less easy to quantify and to cost, are an important part of the value of Data Management.

Public organisations are accountable for their decisions, and good Data Management provides the necessary audit path to demonstrate the basis for decision-making. Data that are *meaningful* and relevant can form the basis of sound decision making. This can lead to cost savings.

Good Data Management reduces Data Duplication and Data Redundancy, which again saves money. Well-managed data may also have commercial value - something that many Road Administrations have yet to fully appreciate and capitalise on.

How can I sell it to my organisation?

In order to persuade your organisation that Data Management will be worthwhile, you must first convince senior management and politicians of the value of data as a *resource* and not as an overhead. Data Management *will* bring about benefits, both in cost terms, that can be quantified, and other softer benefits, that cannot, but which still form part of the Business Case for Data Management. It must be acknowledged that Data Management is a long-term commitment, and that the costs must be considered as a long-term investment that will result in both cost savings, and in the organisation providing better, services that are more responsive.

How much will it cost?

There is no single answer to the question of what a Data Management Regime will cost. Successful Data Management Procedures, while clearly taking time and resources to establish initially, will pay for themselves in efficiency savings over time. The ongoing cost, and loss in benefits, in not applying Data Management needs to be recognised.

How can I assess the effectiveness of my organisation's Data Management?

You may already have a very clear understanding of how data are managed in your organisation. However, if you are not sure, or if you feel out of touch with what may be seen as a largely technical subject, this Guide can help you gain an understanding of how Data Management can influence your organisation's efficiency and effectiveness.

The principles described in this Guide will help you to locate data, identify Data Duplication and Data Redundancy, discover the true *meaning* of data and challenge whether there is a real *need* for each item of data held. Data Management will help identify the true costs of collecting and *maintaining* data. Simple techniques can be used initially; for example, the Guide includes a Data Management Health Check to enable you to make initial assessment of your Data Management needs.

An easy way round this Guide

The Guide includes a simple approach that can be applied by any Road Administration's, which is described as 'The 7 Steps to Successful Data Management'. This approach recognises that each organisation will be starting from a different position; some are already addressing some of the steps, others have yet to start, and yet others may be using some of the Data Management principles but see a need to review and improve their practice. Throughout the Guide, Key Points, Recommendations, Benefits, Quotes and Examples, as well as Lessons Learned are highlighted using easily identified icons.

The Guide concludes with nine Case Studies, drawing upon the experiences of Road Administrations around Europe including pre-accession countries. Importantly, these share openly the challenges as well as the opportunities of introducing key aspects of Data Management.

Do I need to read the whole Guide?

Senior Managers who are not data or IT specialists who wish to gain an appreciation of the importance of Data Management should read this Executive Summary and the subsequent section on data and Data Management. Those Managers with additional responsibility for sponsoring Data Management within a Road Administration will find the whole document of interest, but should particularly focus upon the seven steps and some of the Case Studies in Appendix 2. They will also find the Data Management Health Check in Appendix 1 of particular interest. Data and IT/IS specialists responsible for Data Management implementation should read the whole Guide.

INTRODUCTION

Aim of Document and Target Audience

The aim of this Guide is to demonstrate the benefits of good Data Management and to provide guidelines for those seeking to ensure effective Data Management in Road Administrations of all sizes and jurisdictions. The target audience is expected to be primarily senior managers and information managers, but may also include those responsible for implementing Information Systems.

The combined experience of many European Road Administrations has shown that inefficient use is made of data and that data exchange is difficult because of the lack of good Data Management techniques and practices.

This Guide is based on an honest appraisal of the strengths and weaknesses of current Data Management Regimes in 'typical' Road Administrations represented in Sub-Group Road Data.

Coverage and Scope

The scope of the Guide includes Western European countries and pre-accession (TINA) countries. It is aimed at both national and local Road Administrations and to private and publicly funded organisations.

Application

The Guide is applicable to the planning of Information Systems and data collection projects and their implementation as well as the development of Corporate Data Management strategies. Organisational and technical aspects of Data Management are also addressed.

The following countries have contributed to the production of this Guide:

	Organisation	Country
Full Members	Road Directorate Informatics Unit	Denmark
	SETRA	France
	Bundesministerium für Verkehr, Bau- und Wohnungswesen	Germany
	Highways Agency	UK
Corresponding Members	Bundesministerium für Wirtschaftliche Angelegenheiten	Austria
	Ministère Wallon de l'Equipement et des Transports	Belgium
	Directorate of Roads & Motorways	Czech Republic
	Finnish Road Administration	Finland
	Ministry of Environment, Physical Planning & Public Works	Greece
	ANAS - Ente Nazionale per le Strade	Italy
	Direction de l'Administration des Ponts et Chaussées	Luxembourg
	Rijkswaterstaat	Netherlands
	Norwegian Public Roads Administration	Norway
	IEP	Portugal
	Slovak Road Administration	Slovakia
	Swedish National Road Administration	Sweden
	Bundesamt für Strassen	Switzerland

DATA AND DATA MANAGEMENT

Context

This chapter describes the concepts of data and Data Management and provides an overview of the main Data Management processes. These processes can be applied to all types of data and to any.

Data and Road Data

What are Data?

Data are defined as:

> *"Facts (quantities, values, names, etc) from which other information may be inferred" (Chambers, 1998)*

It is only by deriving meaning from data, and by managing data to ensure that they are of sufficient quality and accuracy, that they become valuable. Data Management is the key to adding value to data - **data are of no value without Data Management.**

Data as Resources

Any organisation wishing to make most efficient use of its data should recognise that data are some of its most important resources. Data are rarely perceived in the same way as the money, people and materials that comprise the other major resources, since they are less easy to value in financial terms but they are just as, if not more, valuable as the organisation cannot operate without them. Data are not usually shown on the accounts of an organisation. However, it is important for an organisation to understand that the financial value of its data comprises not just the cost of collection, but also the inherent value of any derived information to the organisation. Data may also have commercial value.

> *"For an organisation to be effective and efficient, data should be regarded as a commodity that requires management in the same way as materials, money or people" (CCTA, 1995)*

Why have Data?

It is safe to say that no organisation has the option not to hold data; indeed, as one of its most valuable resources, an organisation that does not have a clear understanding of the data that it holds will not be operating effectively. Data are collected and maintained by Road Administrations for a number of reasons:

- Because they are legally required to do so. For example, there may be statutory requirement for a Road Administration to collect accident statistics
- Because the situation on a road network is dynamic and therefore needs to be monitored
- To support decisions. For example, data relating to pavement condition may support decisions about the timing and design of treatments
- For research purposes. For example, data on the performance of pavement materials may be collected with aim of developing improved materials and techniques
- As an incidental consequence of an organisation's activities. For example, if a road authority is collecting tolls from vehicle users on a part of its network, a large amount of incidental data may be generated on the numbers and types of vehicles using that part of the network, which may be of value for other purposes
- As a result of a decision to collect data with commercial value
- To improve the quality of service provided to users of the road network; indeed, in some cases, the provision of the data may form part of that

service. The collection and dissemination of real time information to road users is an example of this
- To promote the activities of the organisation to users and potential users of the road network

Road Data Groups and Coverage

The road Data Types held by both national and local Road Administrations typically include Data Groups (or 'domains') identified in the Table below[1]. These have been drawn from the European Road Data Dictionary which illustrates how co-operative, international Data Management can facilitate the exchange of data between Road Administrations which can add value to that data. One example of this is the ability to provide information on the performance of the Trans-European Road Network (TERN) network to the European Commission. Case Study 4 in Appendix 2 describes the process by which the European Road Data Dictionary was defined.

Data Group (or 'Domain')	Example Data Items	
Road Network	National Road number Road Section type	Road Section reference Node references
Restriction	Restriction type	Restriction direction
Traffic	Traffic Flow Vehicle Type	Traffic Flow type
Structure	Structure Structure Function	Structure Type Structure Location
Equipment	Equipment detail Equipment location	Equipment item Equipment type
Accident	Accident Type Weather conditions Vehicle Type	Person in accident Vehicle in Accident
Condition	Road Condition	Road Condition type
Road Geometry	Grid Point Arc Point	Grid Type Arc Position Type
Route	Country National Route Definition National Route Type	European Route Definition European Route Type

Table 1 - Road Data Types

Data Management

What is Data Management?

Data Management is a set of processes and procedures that allows an organisation to realise value from the data that it holds. Data Management promotes understanding of the data held. The essence of Data Management is for an organisation to be able to answer the following questions of the data held:

- What data are held?
- Who is responsible for collecting and for making those data available to others?
- To what level of quality should they be collected and maintained?
- How up to date should they be?
- How much does it cost to collect and to maintain that data?
- How much is the data worth?

[1] *Of course, a Road Administration will hold a wide range of data other than that directly related to the roads for which it is responsible, such as financial and administrative data, all of which could benefit from Data Management.*

- How critical are they to the core activities of our organisation?
- What decisions and Business Processes do they support?
- Do we *need* them?
- What do the data *mean*, in terms that are understandable to the non-specialists that make use of the data?

The Benefits of Data Management

Effective Data Management, results in a well structured, stable, integrated data resource that is available across the whole organisation and that can be easily and quickly adapted. This in turn will result in:

- Better data quality
- Improved service quality
- Greater responsiveness to change
- Cost savings
- Improvements in co-operative working
- Co-ordinated service provision across organisations
- Employees better equipped to take decisions
- Faster and more cost effective system development

Informal vs. Formal Data Management

It is important to recognise that, just as all organisations collect and hold data; all organisations will have, at some level, Data Management Procedures. It is likely that a large part of this Data Management will operate in an informal, ad-hoc way. In some instances, where data are simple, have clear meaning, and where there is little need to exchange and disseminate data, informal Data Management may be sufficient. It is likely, however, that by taking a more formal, structured approach to Data Management, an organisation will identify instances where the cost of collecting and maintaining data can be reduced and where greater value and benefit can be obtained from that data.

The Elements of Data Management

Data Management is involved at every stage in the life of data from its collection or creation, to its storage and use, through to its archive or deletion.

Identification of Data Needs

Effective, benefits-focussed Data Management requires that the organisation's data needs be clearly related to the business needs and priorities of the organisation. This exercise will inform both the application of Data Management to existing data and the identification of additional data requirements.

Data Analysis and Modelling

Data Analysis identifies and defines the data requirements of a system and determines how those data are acquired and used. The analysis normally results in the production of a Data Model and a Data Dictionary, which provide definitions of the individual Data Items and show how they relate to each other. It may also address the Relationship between Data Items and the business needs of the organisation.

The main aim of Data Analysis and modelling is to identify any additional data requirements and to clarify the meaning of data already held. This in turn will enable an organisation to make more efficient use of its data through data sharing, reducing Data Duplication and removing Data Redundancy. Data Analysis and modelling is discussed in more detail in Step 3.

Allocation of Data Management Roles and Responsibilities

One of the most important features of effective Data Management is the allocation of responsibilities for the ownership of each data set. Key amongst the roles allocated as part of Data Management is the Data Owner, who is

ultimately responsible for ensuring that the data meet the needs of the organisation and must therefore be an individual or group in a position to confirm whether or not the data are correct. Data Owners may delegate some of their responsibilities for the day-to-day control of the data to Data Custodians. Step 4 discusses Data Management roles in more detail.

Data Creation and Collection

Data are acquired by an organisation as a result either of its normal business activities or by explicit data collection exercises. The nature and frequency of data collection, as well as any quality standards to be applied, depends on the types of data, systems and the business requirements that they support.

Data Storage and Retrieval

As with their collection, the processes for the storage and retrieval of data should be defined according to the types of data and the business needs that they support. This definition should include roles and responsibilities as well as the processes required to support the life cycle of the data from their creation or collection to storage and use through to their archive or deletion.

Data Sharing and Exchange

Where data are being shared by different systems or parts of an organisation or exchanged between different organisations, there is a risk of inconsistencies or misinterpretations arising from the lack of a common understanding of what data means. This must be corrected before there can be successful integration.

Change Control

Effective Data Management requires the adoption of an appropriate Change Control procedure, particularly where data are being shared by different systems. This in general involves the appointment of a Change Control authority to manage changes to data definitions and to make sure that the impact of any change has been fully assessed and that different users of the data have had a chance to review and comment on the proposed changes.

Data Archiving and Deletion

An important and often neglected aspect of Data Management is the identification of data that are not providing, or are not capable of providing, value to the organisation, and to delete, decommission or archive those data in such a way as to minimise cost and impact upon the organisation.

Key Points

- Data Management helps an organisation gain value from its data
- Data Management is involved at every stage in the life cycle of data
- The procedures to be defined for data collection, integration, storage, retrieval, archive and deletion will depend on the types of data and the business requirements that they support
- Where data are being shared and exchanged, there is a risk of inconsistencies or misinterpretations arising from the lack of a common understanding of what the data mean. This must be rectified by Data Management so that there can be successful integration between both different systems and different users
- One of the most important features of effective Data Management is the allocation of ownership for each data set
- Data Analysis and modelling helps to identify any additional data requirements and enables more efficient use of the data already held by encouraging sharing of data, reducing duplication and removing redundancy

- The adoption of an appropriate Change Control procedure is an important feature of effective Data Management, particularly where data are being shared by different systems

THE 7 STEPS TO SUCCESSFUL DATA MANAGEMENT

The following sections describe the '7 Steps' that need to be taken to successfully introduce Data Management. From the initial review of current practices through to the ongoing operation of the Data Management Regime, key concepts are introduced as appropriate, and examples drawn from the experiences of European Road Administrations are given. Figure 1 illustrates the '7 Steps' approach.

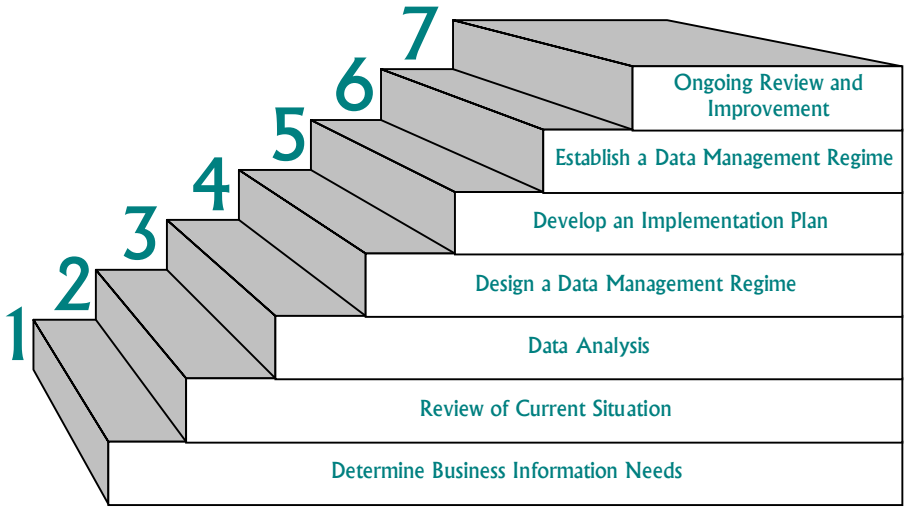


Figure 1 - The 7 Steps to Successful Data Management

STEP 1 – DETERMINE BUSINESS INFORMATION NEEDS

Context

In this chapter, the term 'business' is used in the widest sense, to mean all of the activities carried out by a Road Administration in support of its role as provider of roads and related services.

Step 1 consists of two parts, providing guidance on the analysis of the business and the organisational background, and then looking at Data Management solutions that support and promote the business of the Road Administration. The aim of this step is to determine what data are needed to support the business needs of the organisation.

Analysis of Business and Organisational Background

Introduction

The aim of Data Management is to enable an organisation to make more efficient use of its data. Determining the intended benefits (which may be financial or less tangible in nature) depends upon there being a clear understanding of the business, and of the data and data flows that support the operation of the business. For a Road Administration, this analysis must account for both statutory requirements, and the requirements of the customers or road users, as well as safety and environmental considerations.

In order for Data Management to be successful, it is important that it receives the support of the whole organisation. This support will be dependent upon the benefits being expressed in terms that are relevant to the aims of the organisation, and on the data that are subject to management being identified in clear, business-relevant terms. Data Management can easily be perceived by an organisation that is subject to pressures for cost savings and more accountable spending, as an unnecessary expense. By identifying the long-term value and attendant business-benefits of managed data, and by incorporating mechanisms to ensure sustained benefit from data, a sound case can be made for Data Management.

Analysing the Key Business Information Flows

Departmental or functional boundaries, and responsibilities for data in an organisation, change over time. The fundamental Business Processes and associated information flows do not generally change (unless there is a fundamental change in the role of that organisation). Therefore, when applying Data Management, it is important to be able to take this Corporate, or organisation-wide perspective, independently of Functional or system boundaries. However, when analysing the key information flows, it is important to identify the end users of data, as this is where the information flows ultimately lead.

For example, Figures 2a and 2b describe the Corporate application of Data Management, independently of Functional boundaries, to a particular Road Administration Business Process - the identification of road maintenance schemes. In Figure 2a, before Data Management is applied, there is considerable overlap between the various teams and Functions involved in the process, and consequent Data Duplication resulting in inconsistencies and inefficiencies and additional costs in generating and managing data.

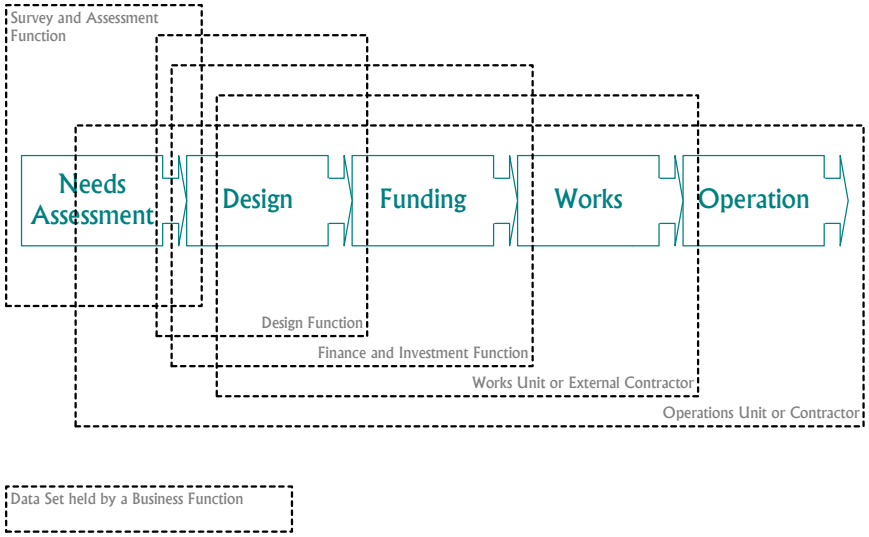


Figure 2a - The Planned Road Maintenance Process (before Data Management)

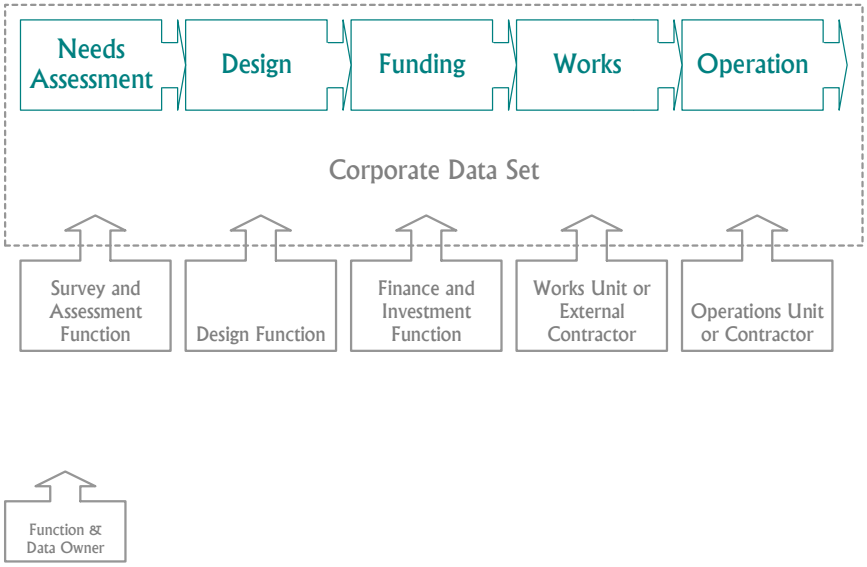


Figure 2b - The Planned Road Maintenance Process (after Data Management)

Following the application of Data Management (Figure 2b) shared data are seen as supporting the whole of the process, and consistent data are accessible by all those involved in the process, with a legitimate interest in that data. Although there will be responsibilities and ownership for data allocated to the various Functions involved in the process, access to those data is not restricted to the Function with responsibility for a particular set of data. Importantly, in the latter post-Data Management scenario, changes to the structure of the organisation can be implemented much more easily, without affecting the Business Process, and upon the supporting data.

Data exist independently of the organisational Functions, and of individual systems. **Data exist as resources that should be maintained independently of such divisions, over time.**

Data Management promotes independence of data and information from the organisation's structure, and separates Data Ownership from data utilisation. For example, the traffic department may *own* the traffic data in the

organisation, but there is considerable potential for use, and therefore for value and benefit, more widely within and without the Road Administration.

Data Management can also be applied across organisations to assist data exchange and sharing; **an example of this is the European Road Data Dictionary**, as described in Case Study 4.

In practice, of course, the relationship between data and the Business Processes that they support is likely to be considerably more complex than described here. Using the example of road maintenance, there are likely to be situations where different organisations are involved in the maintenance process (e.g. contractors and other third party organisations) that will raise issues about how far the Data Management Functions can be de-centralised, as Data Management will need to exist in each of the organisations.

Traditionally, in many organisations, there has been no co-ordination in the acquisition and provision of data and information. Data have been collected by those with a direct interest in those data, very often to meet the requirements of a specific application. This can result in a number of problems:

- Data Duplication, inefficiency, and Data Redundancy
- A need to re-collect data as and when applications are replaced
- Data only being available to those with direct responsibility for those data thus reducing the opportunities for data exchange and sharing, and the attendant benefits. This may be made worse by different conventions for referencing data in the organisation[2]
- Inconsistency of decision making, based upon different information, and interpretations of information being used in different parts of the organisation
- Over-dependency upon applications and specific application providers

Identifying Opportunities for Delivering Benefits

"data must be managed to maximize the benefit it can bring to the organisation through whatever means are appropriate to meet the organisation's goals and objectives" (CCTA, 1995)

"The biggest cost savings [of Data Management] consist of money that is not wasted when data are properly managed" (CCTA, 1995)

One of the main purposes of Data Management is to engender a culture of giving access to information to all those who could derive benefit from it. Benefit in this context is related to the business aims and values of the organisation.

The table below identifies the range of benefits that may be brought about by the application of Data Management. It distinguishes between:

1. *Hard* benefits, where direct, quantifiable benefits can be attributed to the application of Data Management.
2. *Soft* benefits, where Data Management results in less tangible benefits to the organisation which, whilst making a positive contribution to the aims and values of the organisation, are difficult to quantify and cost.

[2] *For example, those in the Traffic department of the Road Administration, as opposed to that used in the Maintenance department may use a different road network referencing convention.*

Benefit	Hard	Soft	Example
Costs savings resulting from reduction in Data Duplication.	✓		If a single road-referencing model is adopted for the whole Road Administration, where multiple networks were maintained previously, there is likely to be a reduction in total resource requirements.
Better quality decision-making, based upon more reliable, accurate and current data.		✓	If Data Management is applied to the collection of pavement condition data, improved decisions on the location, timing and specification of maintenance schemes can be taken.
Costs savings resulting from not collecting or maintaining redundant data.	✓		Visual condition data may be collected and maintained for reasons of historic precedence whereas the introduction of newer, machine-based techniques may mean that equivalent data are available from other sources, so that the visual condition data are not longer required.
Cost savings resulting from a better understanding of data requirements.	✓		A Road Administration may be expending excessive resources in maintaining Asset inventory up to date, whereas Data Management may reveal that a lesser level of currency would be appropriate to the use to which those data are put.
Commercial exploitation of data.	✓		Traffic count data may be of value to other organisations.
High quality data may help to present an image of the organisation as professional and concerned with the provision of a high-quality service.		✓	If the data presented to road users in real-time driver Information Systems are shown, over time, to be reliable, then this will have a positive impact upon those Road Users' perception of the Road Administration that is responsible for those data.
Users spend less time locating and collating data	✓	✓	If users of traffic count data can easily locate the data that they require, there will be clear efficiencies.
Support for research and development based upon an historic base of information.	✓	✓	If a reliable base of historic data about pavement condition exists, opportunities may arise for the development of new materials and maintenance techniques in the light of the performance of existing ones.
Improved, faster, more effective system development.	✓	✓	If a well-defined Corporate Data Model is available, new systems will be able to make use of that Data Model, instead of having to define data definitions from scratch.
Reduced risk of inaccurate or incomplete data when the organisation is subject to audit.		✓	An organisation may have a statutory duty to store records of accidents
New opportunities for data exploitation		✓	Use of road surface texture data to identify areas with potentially excessive tyre noise levels
Organisational flexibility and responsiveness to change.		✓	Data Management will make it easier for the organisation to change systems, or to make changes to its Business Processes
Ability to combine and summarise data from different parts of the organisation.	✓	✓	Combining a range of data including construction, road condition and financial to estimate the value of the road asset managed by the organisation.
Improvements in staff performance		✓	Allocation of Data Ownership will result in individuals and teams taking pride in that quality of that data.
Opportunities for the provision of new, data-based services.	✓	✓	The availability of real-time road utilisation data will present opportunities for new services which present information to drivers.
Improvements in Co-operative working		✓	Different organisations will be able to share and exchange data more effectively.

Table 2 - Typical Data Management Benefits

"Where business requirements cross Functional boundaries there is a greater return on investment in Data Management because it is there that there will be the potential for conflict and mismatch" (CCTA, 1995)

Additionally, some data held by an organisation may be of commercial value to other organisations and Data Users, and a charge could be levied to gain access to those data. Within a Road Administration, an example of this might be traffic count data that could be of value to providers of in-car driver information services.

Organisations are recommended to establish an Information Trading Policy, related from their business aims and strategy that addresses the following:

- The cost of collecting that information
- The Asset value of information
- Identifies data from which the organisation is seeking to profit
- Identifies data for which the organisation is seeking to recover or offset the cost of collection of data or maintenance

Relating Solutions to the Business and Organisational Background

Determining the Data Types and Requirements of the Organisation

As described earlier, the key consideration for any organisation developing a Data Management Regime is to understand the business context in which the data are required. Once this business context is understood, a Data Management Regime can be developed which is appropriate to the particular needs of the organisation.

An important benefit of this process is that it enables the different levels in an organisation, responsible for supporting the business objectives, from Senior Management down, to recognise the value of the data to the organisation and to support the requirements of the Data Management Regime.

Mission Statement

In order to understand its business objectives, an organisation must first understand what its core Business Function is. This can generally be encapsulated in a single 'Mission Statement'. The Mission Statement is "*a recognition of the fundamental purposes for which the road organisation has been set up and the responsibilities with which it has been charged*" (Robinson et al, 1998).

Business Objectives

Whereas the Mission Statement will be broad, the objectives of the organisation should be more specific and should set targets and define actions required to put the policy of the organisation in place. In order to be effective, each objective should be specific, measurable, achievable, relevant, and traceable (sometimes abbreviated in the UK to SMART). Examples of objectives might include 'to maintain the surface condition of the road network to a defined standard' or 'to carry out maintenance works in such a way as to minimise the disruption to road users'.

Business Processes

The processes that are carried out by the organisation to support the business objectives may include:

- Provision of the Asset in support of the key values of the organisation — E.g. Meeting the need of users, minimising the impact on the environment, etc.

▪ Operation of the Asset in support of the core values of the organisation	E.g. Carrying out maintenance to minimise whole life costs, etc.
▪ Maintenance of the Asset to a specified standard	E.g. Ensuring the quality of the road surface meets specified standards, etc.
▪ Operation of the Asset to meet specified service requirements	E.g. Minimising user delays, providing traffic information to users, etc.

Information Needs

An important prerequisite for the allocation of priorities to data subject to Data Management is the identification of the information needed to inform the decisions the organisation must make when carrying out the business activities identified above.

For example, when carrying out the Business Process 'maintenance of the Asset to a specified standard', the organisation must make decisions about:

- When and where maintenance is needed
- The type and cost of maintenance required
- Any required changes or amendments to specified standards

Data Needed to Inform Decisions

The World Bank (Paterson and Scullion, 1990) defines the following criteria that should be considered when selecting Data Items required by an organisation:

- Relevance (every Data Item must support a clearly defined decision need)
- Appropriateness (the volume of data and frequency of update must be appropriate to the current needs and resources of the organisation)
- Reliability (in terms of accuracy, spatial coverage, completeness and currency)
- Affordability (in terms of financial and staff resources)

These questions will also enable an identification of any additional data that needs to be collected as well as any data that are collected unnecessarily. **This may provide benefits to the organisation by reducing the cost of data collection and making the overall process more efficient.**

It should be noted that, in practice, a particular Data Type may be used by one or more systems to support a number of different activities and Business Processes and the relationships between them may be complex.

Figure 3 illustrated the relationship between data and the needs of the business.

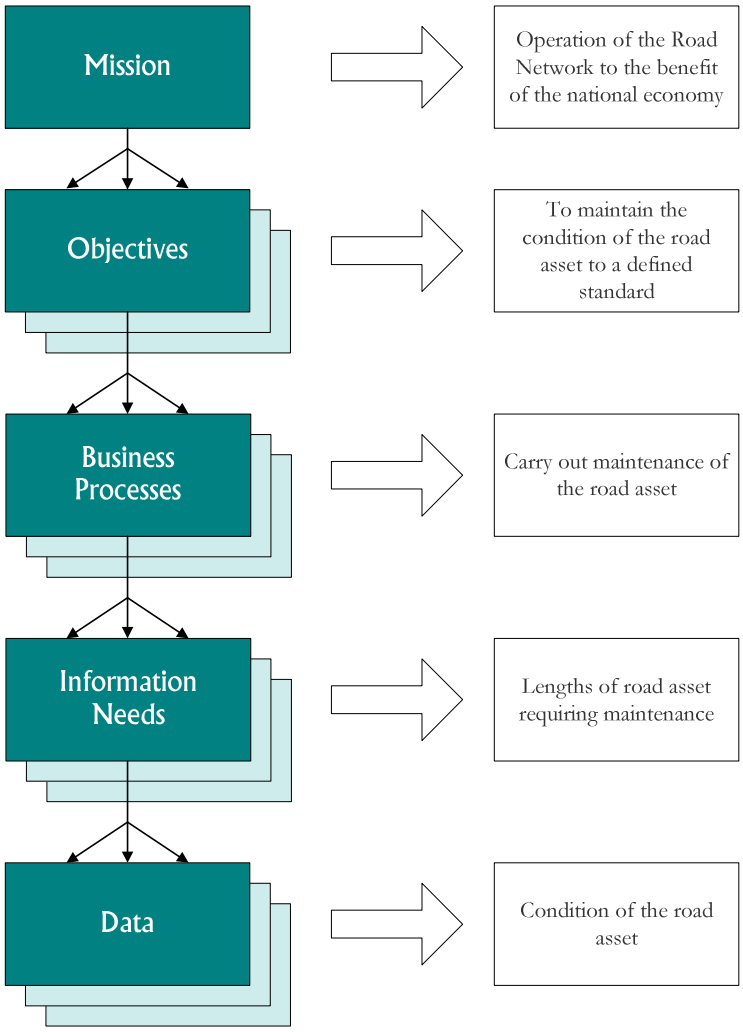


Figure 3 - Relating Business Requirements to Data

Key Points

- Data exist as resources that should be maintained independently of business functions and computer applications, over time
- The return on investment in data can be maximised by the application of Data Management
- The strategic level Corporate Data Model should incorporate a clear statement of what each Data Item means, and how they relate, in business terms
- Organisations are recommended to establish an Information Trading Policy
- All data collected and stored by an organisation should be relevant, appropriate, reliable and affordable

- It should be noted that a particular Data Type may be used by one or more systems to support a number of different activities and Business Processes and the relationships between them may be complex

STEP 2 – REVIEW CURRENT SITUATION

Context

Before an organisation embarks on designing and implementing a Data Management Regime, it needs to assess and understand the current situation and determine how effective any current Data Management Procedures are.

Current Data Management Procedures

Any organisation that holds or makes use of data will have some sort of Data Management Procedures. These procedures may range from a formally defined regime to an ad-hoc approach with controls that have evolved over time to meet the changing requirements of the local users of the data. In general, most organisations will have a mixture.

As it is likely that there will be a range of different Data Management Procedures in use within an organisation, it is important to invest sufficient time and care in understanding them. Identifying, at a relatively high-level, those data the organisation holds and those parts of the organisation or Business Functions that make use of them may help this process. The following example shows a number of different Business Functions that might exist in a Road Administration and the different Data Domains that they might use. In the example, it can be seen that location-referencing data is used by all the Business Functions whereas traffic data is used by strategic planning and traffic management but not routine maintenance. In practice, the situation is likely to be considerably more complex with many Data Domains likely to be shared by different users and different Business Functions, although they may use different aggregations or levels of detail.

Data Domains	Example Business Functions		
	Strategic Planning	Routine Maintenance	Traffic Management
Location Referencing	✓	✓	✓
Construction data	✓	✓	✖
Condition data	✓	✓	✖
Traffic data	✓	✖	✓

Table 3 - Example of the use of different Data Domains by different Business Functions

It is particularly important to identify areas of overlap and Data Duplication, since these will give immediate scope for benefit through the application of Data Management.

Effectiveness of Current Procedures

Once the various different procedures have been identified, their effectiveness can be assessed. The fundamental question to ask when assessing the effectiveness of any current procedures is 'Do the current procedures meet the needs of my organisation?'.

A Data Management Health Check is included in Appendix 1 and this can be used to carry out an initial assessment of the effectiveness of the current procedures as well as to identify any areas of particular concern.

Redundant Data

If any data are of no value to the organisation and can therefore be decommissioned, it may be possible to exclude them from further analysis.

Legacy Systems and Data

As well as identifying the current Data Management practices in an organisation, it is also important to identify any existing systems or data that must be included in any new Data Management Regime. These inherited

systems and data are known as Legacy Systems and may require particular consideration so that their value to the organisation can be maintained.

Key Points

- All organisations that hold or make use of data will have some sort of Data Management Procedures
- Current Data Management Procedures may be formal or informal and may vary between different parts of an organisation
- Understanding the current procedures is important before embarking on the development of a new Data Management Regime and sufficient time and resources should be available
- Understanding those data the organisation holds and who makes use of them can help understand the current procedures
- The Data Management Health Check in Appendix 1 can help understand and evaluate the current procedures
- Redundant systems and data that are no longer required should be excluded from further analysis
- Legacy systems and data might require particular consideration

STEP 3 – DATA ANALYSIS

Context

All organisations hold large amounts of data and in many cases the acquisition of data has evolved in an uncoordinated way to meet the requirements of individual parts of the business. The function of Data Analysis is to understand the Data Items, and the relationships between them, and the Business Processes that they support.

Having carried out a successful analysis of the data, the organisation will be in a position to change any inefficient processes, identify additional data requirements or remove redundant data, based upon an accurate understanding of the current situation.

Data Analysis

Data Analysis identifies and defines the data required by an organisation and determines how they are acquired and used. As the following diagram illustrates, an organisation should have a single set of data that supports all its information needs but the data will generally be used at different levels of detail or aggregation by different levels of the business.

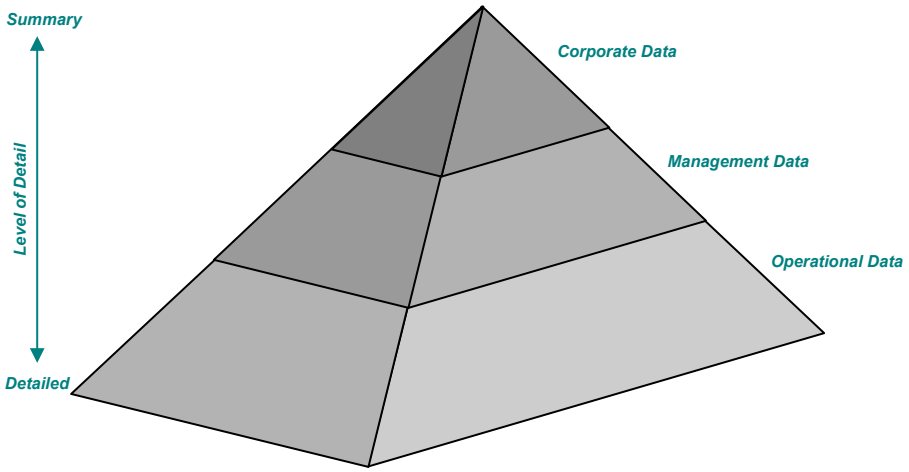


Figure 4 - The Data Pyramid

The analysis should also provide a definition of the Data Access and security requirements of the business.

There are a number of formal techniques available for the analysis of the data requirements of business systems or Business Processes and these techniques are often used in the early stages of the design of new Information Systems. The use of these techniques does not need to be confined to a single system or process and can, and indeed should, be applied to all the processes undertaken by an organisation or even between organisations.

Data Types

A detailed Data Analysis should include all types of data required by an organisation including standing and meta-data as well as static and dynamic data. The following table shows the different Data Types that an organisation will generally require:

	Data Category	Description	Examples	Audit Requirements
Rate of Change of Data Values: HIGH → LOW	Operational Data: Dynamic Data	Data continuously subject to update, either being operational records or periodically monitored performance records	Near-real time traffic data. Road surface ice and temperature sensors. Roadside pollutions measurements	Frequent calibration of equipment
	Operational Data: Periodic Data[3]	Data requiring regular collection and updating	Routine inspections, correspondence and call logging, pavement condition surveys, traffic counts	On-site validation (e.g. using data Capture Devices and other data collection systems), load validation to include referencing to location on the road network, codes, value ranges and other checks
	Operational Data: Static Data	Data requiring one-off capture and validation, and infrequent update (as need dictates)	Road Network Asset Inventory, Construction records	Initial load validation against 'real world', procedures in place to capture changes as they occur (e.g. when new construction takes place)
	Supporting Data: Standing Data	Data such as constants, rules parameters and the like are essential to the operation of a system, but which are not, in general, the day-to-day concern of users. Changes occur relatively infrequently over time	Look-up tables for all coded database fields, standards, valid data ranges	Confirm consistency with national or Road Administration standards
	Supporting Data: Meta Data	Data that describes data	Data Dictionary	

Table 4 - Data Types

Data Ownership

Once the data sets required by the organisation have been identified, individuals or groups can be given responsibility for Data Ownership and Data Custodianship. As described earlier, the concept of Data Ownership is one of the most important aspects of an effective Data Management Regime as it is the Data Owner who is ultimately responsible for ensuring that the data satisfies the business requirements of the organisation.

Data Modelling

The result of an analysis of the data will generally be documented in a Data Model, which provides definitions of the various Data Items and shows the relationships between them. It may also include an assessment of appropriate

[3] *In practice, the Periodic Data Type covers the range of collection and updating frequencies, with Static and Dynamic data being the upper and lower extremes.*

quality levels for Data Items. The definitions of the various Data Items are often documented in a Data Dictionary.

Where Data Analysis and modelling extends beyond one system to include a number of systems, or indeed a whole organisation, then a Corporate Data Model can be developed.

The main function of a Corporate Data Model is to harmonise the definitions of data that are shared between different systems and different parts of an organisation.

In Data Analysis and modelling, information is collected about the various Data Items held by an organisation. There are a number of different Data Analysis and modelling techniques. Each of these different techniques aim basically to create a model of a limited set of Data Types, defining in a formalised way what these Data Types mean, values that data can hold, the typing of data (integer, real, string etc.) and how data interrelates.

In one technique, this information is represented in terms of Entities, Attributes and Relationships. An Entity is a representation of something real that an organisation wishes to record information about. These data are held as a set of Data Items that form the Entity's Attributes. Each Entity must also have a unique identifier, which may itself be an Attribute or combination of Attributes. For example, a Road Administration might be interested in considering a section of road as an Entity which might have a number of Attributes including the road the section is on, length of the section, number of lanes, construction, traffic flow, etc.

	Attributes			
	Sections	Length (m)	Lanes	Construction
Entities	A76_001	500	3	Bituminous
	A76_002	350	3	Bituminous
	A76_003	1200	2	Concrete

Table 5 - An example of Entities and Attributes relating to Road Data

In addition to collecting information about the Entities themselves, the Data Analysis must identify and describe how the Entities relate to each other. Again, many techniques exist but all will seek to model the interrelations of data and limitations that one Data Type may place upon another. For example, some data may only be permitted if other data are also present.

As an example, one technique will make use of an Entity-Relationship Diagram, which is a pictorial representation of the data a business needs or uses to carry out its activities. It should be noted that, in itself, an Entity-Relationship Diagram can only provide a limited understanding of the data and will have to be supported by detailed definitions of the Entities, Attributes and Relationships.

There are many Data Modelling approaches available, with techniques such as Universal Modelling Language (UML) and other Object Oriented approaches being the latest developments.

Key Points

- Data Analysis and modelling techniques provide an organisation with a clear picture of the data it needs to carry out its business
- Data Models enable an organisation to make more efficient use of its data by maximising the sharing of data by different systems and by reducing Data Redundancy and Data Duplication
- Corporate Data Models harmonise the definitions of data shared by different parts of an organisation

STEP 4 – DESIGN A DATA MANAGEMENT REGIME

Context

By this stage of the '7 Step' approach, the Business Processes should be fully understood and the associated data and information needs identified. Having carried out an analysis of the data and constructed, where appropriate, a Data Model, it will be possible to critically look at the data that are currently collected and maintained, and those required in the future, and to be able to answer the following questions, for each type of data:

- What does it mean in business terms?
- What decisions and Business Processes does it support?
- What are the quality requirements?
- How are we going to collect it?
- What are the costs of collecting it?
- What value or benefit does it have?
- How often should it be collected?
- How complete does it need to be?
- How accurately does it need to be collected?
- Is the data currently collected?
- Can we do without it whilst the Data Management Regime is implemented?
- Is there any historical continuity?
- Is the data of local or Corporate relevance, or both?

Designing a Data Management Regime

The design of the Data Management Regime should take account of these questions, and in particular, must ensure that they can be answered and periodically re-answered in future.

Designing the Data Management Regime will involve at least the following activities:

- Determine the scope of the Data Management Regime, and relate this to the organisation's 'Information Environment' (see Figure 5)
- Determine implementation priorities for each Data Type
- Identify any Legacy Systems for which ongoing support and data must be provided while Data Management is being implemented to determine when those Legacy Systems may be decommissioned
- Identify risks and actions to manage those risks, according the importance of the associated data to the activities of the organisation
- Produce an implementation programme for Data Management that is explicitly related to the programme for the development, implementation and decommissioning of systems and applications within the organisation
- Explicitly identify benefits associated with the application of Data Management to data and to their associated systems and applications, and ensure that a mechanism is in place to ensure the ongoing delivery of those benefits
- Establish a programme for data Decommissioning, and for changes to data collection arrangements
- Identify costs of implementing and operating Data Management for each Data Type
- Determine what changes are required to systems, architecture and physical infrastructure as well to the organisational structure and to human resources
- Appoint a project team, and identify a Data Management Sponsor with responsibility for bringing about a recognition of the importance of data and information as a valuable resource within the organisation

- Determine a minimum level of access and service for data and applications that must be maintained during the implementation of Data Management, and identify any transitional arrangements to ensure that this level of service is maintained, particularly for critical business and operational systems

Scope of Data Management

For Road Administrations – indeed for any organisation – the scope of the 'Information Environment'[4] is wider than both the organisation itself, and than those data for which direct Data Management is possible or desirable. There will be information or data, such as paper records or unstructured records, that cannot be managed or for which management would be too costly, or would not be beneficial. For example, the review of data and of data requirements may have revealed that data are of purely local relevance, and there is no value in managing those data and of sharing and disseminating those data more widely. In such instances, it may be appropriate to hold these data in a stand-alone system, and manage them informally at the local level[5].

Moreover, some data in which the organisation has an interest will be held by other organisations, and must be managed co-operatively, or at the interface between the organisations. Figure 5, below, illustrates this point.

The organisation's Information Environment, that is the data in which they have an interest as a provider or user, is wider than just the data held within the organisation. The *Managed* data environment and therefore Data Management encompasses both all the data held by the Road Administration together with the data interface to other organisations.

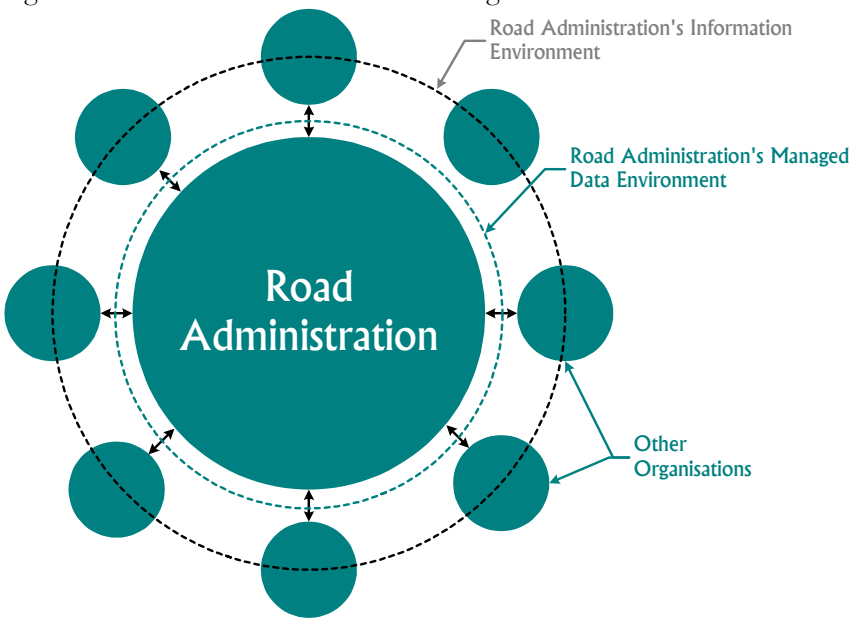


Figure 5 - Managed Data Environment

"Widespread sharing of information from a variety of sources requires considerable integration, based upon a representative high-level global model. All users can then look at the same or consistently related models, the same meanings and definitions and therefore the same or copied occurrences of information". (Ward & Griffiths, 1997).

[4] *Information Environment - all the data and associated information in which an organisation has an interest*
[5] *Experience has shown that this situation is the exception rather than the norm and that the application of Data Management may reveal opportunities for benefit that were not previously identified. It is more likely the case that cost will be prohibiting factor*

"promoting the management of information as a Corporate resource does not imply building an all-embracing Corporate database....but does support information independence" (Ward & Griffiths, 1997).

Although, in principle, sharing of information implies that each item is held only once, this is difficult to achieve in practice. Even under Data Management, there may be separate databases containing the same information, but every attempt should be made to retain consistency of definitions across all databases, and to eliminate Data Duplication.

Components of the Data Management Regime

The Data Management Regime comprises the following components:

- Assigning ownership of data and other Data Management roles
- Mechanisms for data creation, collection, updating and deletion /decommissioning
- Mechanisms for data storage and retrieval, and for ensuring consistency of data
- Mechanisms for sharing and exchange of data on a consistent basis
- Mechanisms for defining and promoting the business-relevant meaning of data

Assigning Data Management Roles

Figure 6 shows the various roles that should be identified and assigned by an organisation seeking to establish Data Management. A key role is that of Data Owner, who has responsibility for the definition of a Data Item. This is important since a premise of Data Management is that each definition exists only once, and is used consistently throughout the organisation. Only if that definition is correct and understandable, will the data to which it relates be used effectively, to bring value to the organisation. Of course, the actual values of the data may be modified and updated by any number of individuals and processes within the organisation. The Data Owner is assigned the following formal responsibilities:

- Agreeing the business description and function of the Data Group or Data Item
- Defining who can create, access, modify and delete the data
- Assign Data Custodians, who are in day-to-day control of the data
- Define a structure, valid ranges and logical definitions for the data
- Eliminate Data Duplication
- Co-ordinate dissemination of the data
- Promote the use of those data to bring value to the organisation
- Identify the benefits and value of the data
- Identify and meet any legal requirements for the data
- Ensure data are maintained to any agreed quality standards

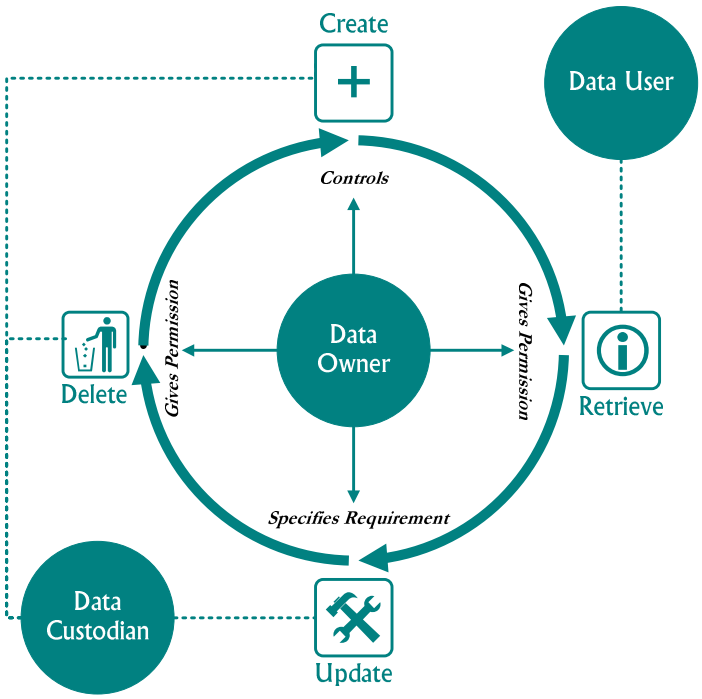


Figure 6 - Data Management Roles

It is likely that ownership will rest with the area of the organisation with the prime business interest in the data. For example, if there is a Traffic division in the organisation, it is likely that ownership of traffic data will rest there. In such an instance, however, the success of Data Management will be dependent upon that owner being able and prepared to apply a Corporate perspective to Traffic data, and to disseminate and promote the value of Traffic data to the Road Administration as a whole. Experience has shown that over-protectiveness of specialist data sets by Data Owners has limited the scope for benefit to organisations. It should be noted that such protectiveness might well result from a desire to ensure the quality and integrity of data. If this is the case, then the relevant Data Owners must be reassured that appropriate processes will be introduced to ensure that the quality and security of data are maintained when those data are opened up to use by to the organisation as a whole.

Data Collection and Maintenance

Having analysed the data and the business definitions of that data, the Organisation is in a position to determine the most effective means of collecting that data. Data Management addresses the following when determining mechanisms for data collection:

- Specification of data
- Frequency of collection
- Accuracy and quality
- Completeness and currency

Whereas previously there may have been Data Duplication, with the same or similar data collected in different parts of the organisation, leading to Data Duplication and inefficiencies or even conflicts, under Data Management data should be collected only once. The Data Management process will also give the organisation the opportunity to review whether it is necessary to collect particular Data Groups altogether.

Particularly where data are of Corporate, rather than local relevance, the organisation will also wish to consider whether data are best collected centrally, locally, or by engaging external data providers.

In determining the frequency of collection, the Road Administration will need to consider the rate of change of values of particular Data Types, from near real-time data that requires continual collection and updating through to physical data such as road geometry where collection can be considered as essentially fixed, unless updating is triggered by changes to the road network.

The accuracy, quality and currency of the data should be determined with reference to the cost of collecting those data and the value and benefit of that data. Unless fulfilling a specific legal requirement to collect near-100% accurate data, which must be collected whatever the cost, Organisations should be realistic in specifying levels of accuracy. It is often contended that 20% of the cost of data collection accrues 80% of the value and vice versa. The costs of achieving 100% accuracy or completeness - if indeed it can be achieved - is far greater than 20% of the cost of achieving 80% accuracy.

As a general principle, data should only be collected if the benefits that they provide outweigh the cost of their collection and maintenance.

Data Storage and Retrieval

As has been said previously, a Corporate Data Model is unlikely to imply that all data held by an organisation are stored in a single database, to be used by all users and applications. The Corporate Data Model must be kept up to date in response to changes in the organisation as this model is used by all databases and applications in the organisation.

The determination of an appropriate physical architecture for the storage and retrieval of data is outside the scope of this document; suffice to say that, within the context of Data Management, the organisation will wish to consider the following:

- The most effective distribution of data and information. For example, should it be held centrally or split and distributed separately or should multiple, controlled copies be distributed?
- The method to be used to maintain the data, particularly where multiple copies exist
- The type and mix of database technologies (e.g. hierarchical, network, relational and object-based)

In practice, of course, these factors will change over time as old systems become redundant and the organisation embraces Data Management and possibly migrates to new systems.

Data Promotion and Value Realisation

It is vital to the success of Data Management that its benefits, and the value of managed data, are promoted (and delivered) to the organisation as a whole, in particular to users and potential users of data. The success of this is dependent upon senior management's commitment and upon well thought-out and implemented policies

It will also be necessary to:

- Identify opportunities to realise value to the business from data through promotion of awareness of data's existence and of their meaning

- Identify opportunities to add value to those data by combining with other Data Groups
- Identify commercial opportunities for data utilisation
- Establish mechanisms to allow feedback on the usefulness of data, and to identify possible future items for collection

Data Sharing and Exchange

The success of Data Management may be directly related to the success with which data can be shared in the organisation. There are a number of ways that information can be shared effectively in the organisation. Given that the holding of a single copy of each Data Item that can be accessed by all users is unlikely to be achieved, solutions must be found that enable sharing of managed data. The technical issued involved are complex, and well outside the scope of this document; possible solutions that could be considered include:

- Purchase of databases and associated applications from a single supplier. In practice, it is highly unlikely that a single supplier will be able to meet all the requirements of an organisation, although adoption of standard technologies and one, or a limited number of suppliers, for the organisation may well have a positive impact
- Point to point integration between applications. Given the number of disparate applications and requirements for a 'typical' Road Administration, such an approach is unlikely to be achievable, except for a limited number of application interfaces.
- Data Access. The provision of direct access to data using desktop tools. A data warehouse would be an example of this.
- Use of client server 'middleware' that enables applications to talk to each other

In practice, organisations are likely to rely on a combination of solutions to meet their requirements.

In considering the mechanisms by which data sharing is to be achieved, the organisation should also consider how to overcome barriers created by different management styles and cultures within the organisation, and to resolving issues of rivalry between departments, divisions, or different offices within the organisation.

Key Points

- The scope of Data Management is likely to be wider than the organisation's own data
- data should only be collected if the benefits that they provide outweigh the cost of their collection and maintenance
- Data Management roles should be allocated
- A Corporate perspective should be taken

STEP 5 – DEVELOP AN IMPLEMENTATION PLAN

Context

Once a Data Management Regime has been designed, the next step is to plan its implementation. This plan will cover the transition from the current situation as identified in Step 1 to the full Data Management Regime designed in Step 4.

Selling Data Management to the Business

Before an implementation plan can be developed, it is vital that the organisation accepts the need for change. The key to this acceptance will be to appoint a Data Management Sponsor who will promote the benefits of the new Data Management Regime to the business. The Sponsor should be someone with sufficient authority to:

- Encourage the support of the various parts of the organisation with Data Management responsibilities
- Make decisions about changes to Business Processes and working practices
- Ensure that sufficient resources are available to carry out the implementation plan

Identify the Required Changes

The first exercise in developing the implementation plan is to consider the changes needed to move from the current situation to the new Data Management Regime. These generally include:

- Changes to existing processes and working practices
- Removal of redundant processes and systems
- Introduction of new processes
- Defining roles and responsibilities
- Migration path planning and processes

For example, an organisation may:

- Decide not to collect data that are currently collected
- Decide to collect data that are not currently collected
- Decide to allocate, or reallocate ownership of data
- Change mechanisms for data collection
- Change the frequency of data collection
- Transfer responsibility for the collection and/or maintenance of Data Items outside of the organisation (or vice versa)
- Make changes to the required level of quality, accuracy or currency for particular Data Items
- Make changes in priorities for the collection of data and for the development and implementation of associated systems

Ultimately, the introduction of Data Management is likely to result in a change in the way the organisation handles data and information, leading to its recognition as a significant resource. In the longer term, this will reduce or eliminate Data Duplication and will increase sharing of data, and will result in the realisation of greater value from the data resource, for less cost.

Other Factors to Consider

In addition to the changes in Data Management processes, it is essential to have a clear understanding of any other factors likely to influence the implementation of the new Data Management Regime. These may include:

- Organisational and business changes

- The current and likely future Information Systems strategy of the organisation
- The planned introduction of any new systems or applications
- Planned upgrades to existing systems and applications

Prioritise Changes

Once these activities have been completed, the various changes must be prioritised. The key consideration here is that during the implementation the organisation must continue to carry out its business with the minimum of disruption. This means that the criticality of each process to organisation's business should be considered and it may be necessary to introduce interim or parallel processes during the implementation depending on the criticality of the process and the nature of the changes. For example, if an organisation relies on real-time data to manage traffic flows on the network, then it might be necessary to operate a parallel system to ensure that the data are available while changes to the normal process are introduced. Conversely, it might not be necessary to introduce an interim process whilst changes to annual data collection processes are made.

Determining Implementation Priorities

In designing the Data Management Regime, one should recognise from the start that it will not be possible to introduce Data Management at a single point in time.

> *"The provision of critical business information with the necessary quality Attributes in an appropriate set of databases should be the migration target...this is likely to be a long, multi-step progression towards an elusive goal". (Ward & Griffiths, 1997)*

It will therefore be necessary to determine priorities for the rollout of Data Management to particular Data Groups and applications. In doing so, it is recommended that a balance is struck between short-term Quick Wins that will help to bring credibility and organisation support to the Data Management process, and more extensive, problematic initiatives with potential for sustained long-tem benefit. Moreover, it will be necessary to continually review and update those priorities as Data Management progresses, in response to changes in the business objectives and processes of the organisation.

Developing the Implementation Plan

Finally the implementation plan can be developed. The plan should define all the activities required to implement the new Data Management Regime and should identify the timescales and resource requirements. As well as the factors discussed above, the following activities should be considered during the development of the implementation plan[6]:

- Definition of roles and responsibilities (including Data Ownership)
- Introduction of interim processes or systems if appropriate
- Data Migration from existing to new systems
- Data Cleaning to ensure the quality of data are appropriate
- Testing of any new processes or systems
- Change control procedures
- User training and documentation
- Archiving and back-up of existing data and systems
- Availability of key resources

[6] *These activities equally apply to any temporary or interim processes that are introduced*

There are many techniques available to assist in the development of an Implementation Plan. For example, the PRINCE2 Project Management methodology (OGC, 2001) introduces the technique of Product Based Planning, which can be applied to any project to give a logical sequence to the project's work.

The Danish Road Laboratory provides the following advice for systems implementation:

- *"Believe that it is worth doing*
- *Only start if resources will be allocated*
- *Get acceptance within the organisation*
- *Give prestige to those participating*
- *Make reasonable, but indispensable demands*
- *Develop step by step*
- *Implementation must be staged*
- *Each stage should improve current management*
- *Make investments in education and training*
- *Invest in data-updating starting yesterday" (Schacke and Ertman-Larsen, 1990)*

Key Points

- Appoint a Data Management Sponsor to promote the benefits of the new Data Management Regime to the business
- Consider other factors that may influence the implementation
- Prioritise the changes after consideration of the criticality of the processes and data that supports them
- During the implementation the organisation must continue to carry out its business with the minimum of disruption
- Ensure sufficient resources are available

STEP 6 – ESTABLISH A DATA MANAGEMENT REGIME

Context

The next step is to put the Implementation Plan into action and establish the Data Management Regime

Managing the Implementation as a Project

The implementation of the new Data Management Regime should be managed as a project in its own right. The PRINCE2 Project Management Methodology describes a project as "*a management environment that is created for the purpose of delivering one or more business products according to a specified Business Case*". (OGC, 2001).

Unfortunately, project failures are all too common and the reasons for failure are many and varied. Some common causes of failure are:

- Lack of co-ordination of resources and activities
- Lack of communication with interested parties resulting in the delivery of products that do not meet the business requirements
- Poor estimation of duration and costs leading to projects taking more time and costing more money than expected
- Insufficient measurables resulting in a lack of control
- Inadequate planning of resources, activities and scheduling
- Lack of control over progress so that the exact status is not revealed until too late
- Lack of quality control resulting in the delivery of products that are unacceptable or unusable

The effective use of a formal project management methodology will help to reduce the risk that these mistakes will be made. There are a number of different project management methodologies, and indeed some organisations may have their own prescribed systems for managing projects. The key is to be flexible and to tailor the project management methodology to meet the particular needs of the implementation. The key factors for managing a successful project are often defined as:

- Controlled and organised start, middle and end
- Regular reviews of progress against the plan and Business Case
- Flexible decision points
- Management control of any deviations from the plan
- Involvement of management and Stakeholders at the right time and place during the project
- Good communication channels between the project, project management and the rest of the organisation

Other important aspects of project management that will play a part in the implementation of an effective Data Management Regime (e.g. people management techniques, risk management, Quality Management generic planning techniques etc.) are beyond the scope of this Guide.

The project planning should include ongoing provisions for the operation of Data Management once the implementation project is complete.

Roles and Responsibilities

The size and structure of the project depends, of course, on the extent of the changes necessary to move from the current situation to the new Data Management Regime. However, it may be useful to consider the following roles, or their equivalents, when setting up the project team:

Role	Responsibilities
Project Director	Likely to be the Data Management Sponsor identified in Step 5. Has ultimate responsibility for the success of the implementation
Project Board	Appointed by the Project Director. Provides overall direction and management of the implementation
Project Manager	Manages the project on a day-to-day basis on behalf of the Project Board. Ensures that the project produces the required result, to the required standard of quality and within the specified constraints of time and cost. Manages the Project Team
Project Assurance	Provides an independent monitoring of all aspects of the project's performance and products. May be a role of the Project Board
Project Support	May be required depending on the size of the project. May include administrative support or specialist advice
Project Team	The team appointed to carry out the work associated with the implementation

Table 6 – Typical Roles during Implementation

Quality Management

One of the most important aspects of successful project management is Quality Management. ISO 8402 defines quality as "*the totality of characteristics of an entity which bear on its ability to satisfy stated and implied need*". Quality Management is the process of ensuring that the quality expected by the organisation is achieved. **It is of vital importance that due consideration is given to Quality Management when implementing a new Data Management Regime.**

Key Points

- The implementation of the new Data Management Regime should be managed as a project
- The size and structure of the implementation project will depend on the nature of the Implementation Plan and the required changes to move from the current situation to the new regime
- The use of a formal project management methodology that encompasses Quality Management will reduce the risk that the implementation will fail
- When planning the project, provision should be included for the operation of the Data Management Regime once the implementation is complete.
- Due consideration must be given to Quality Management.

STEP 7 – ONGOING REVIEW AND IMPROVEMENT

Context

Data Management is not a one-off exercise; it is an ongoing activity. Not only should the Data Management Regime be stable and integrated, it should also be flexible and responsive to change in the requirements of the Organisation. The Corporate Data Model and associated definitions, together with the allocation of ownership for data should be periodically reviewed and updated.

Data Management Audit

The Data Management Health Check questionnaire, described in Appendix 1, should be periodically reapplied to the Organisation to determine progress and effectiveness of Data Management. In doing so, areas of weakness where attention is required can be determined.

Change Control

Change Control is considerably more important under Data Management using a Corporate Data Model than in the scenario where local models are maintained. Changes in one application or area of the business, that impact upon the Corporate Data Model, will have implications for all users of the affected data throughout the organisation. An effective Change Control procedure that takes account of the requirements of all Data Users is required.

It is common for requests for changes to be made through a Change Control Authority, who will be in a position to canvass all users of data affected by a change before authorising a change. Figure 7 shows the steps that the Change Control procedure may typically comprise.

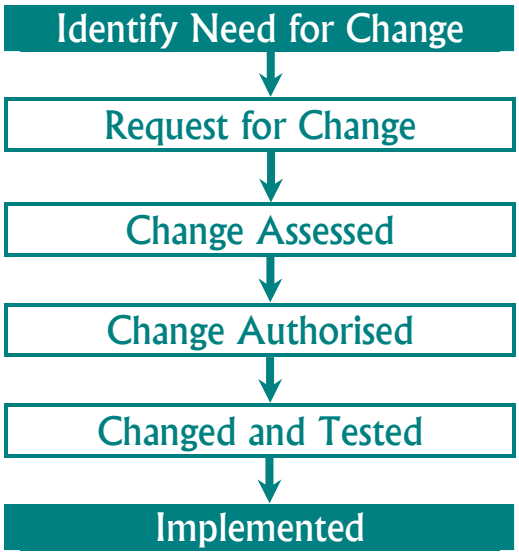


Figure 7 - Steps in a Typical Change Control Procedure

A key part of the Change Control procedure is that the implementation of agreed changes must be synchronised so that all users start using the new or revised data definitions at the same time. Failure to do so can result in serious problems and errors.

Benefits Review, Realisation and Management

It is a common failure in the implementation and operation of Information Systems that there is little or no effort put into ensuring the realisation of the benefits that were the basis of the case for investment in the first place.

In order to ensure sustained value and benefit, it is recommended that the Data Management Regime include steps for the measurement of identified

benefits, together with mechanisms for management of benefits realisation. Such an approach, termed 'Benefits Management' when applied to investments in data and in Data Management comprises the following:

- The identification of expected benefits, and the contributions to business objectives and Stakeholders
- An assessment of assess value and organisational impact, dependencies and risks
- The identification of interrelationships between benefits
- The establishment of accountability for benefit realisation
- A means of tracking benefit realisation
- The identification of remedial actions where such tracking determines that intended benefits are not being fully realised

Training

The success of the implementation of Data Management will depend upon Data Management Sponsors, Owners, Custodians and Users being equipped with the necessary skills to enable them to effectively fulfil their roles within the Data Management Regime. The design of the Data Management Regime should have included an assessment of training needs, and ongoing Data Management should provide for periodic re-training. Overseas Road Note 15 *(TRL, 1998)* provides guidelines on training requirements for the implementation of road management systems within Road Administrations; they apply equally to the implementation of Data Management within such organisations.

Data Updating and Re-Collection

Having determined Data Currency and quality standards for each Data Item or group as part of the Data Analysis described in 'Step 3', an organisation will be able to make provision for ongoing recollection and/or updating of data. The most appropriate means by which such updating is achieved will be influenced by both the importance and the propensity to change of a particular item, and would typically include:

- Periodic recollection of the whole of the data set
- Recollection of a proportion of the data set each year
- The establishment of procedures and/or automatic systems to ensure that required changes to data are identified and effected on a continual basis

Ongoing Review and Improvement

The 'Seven Steps' approach to planning for an implementation of Data Management is, necessarily, a simplification. To ensure ongoing success of and benefit from Data Management, an organisation should be continually reviewing and updating its Data Management Regime to ensure that changes in the organisation; its business objectives and priorities, and availability of resources are reflected.

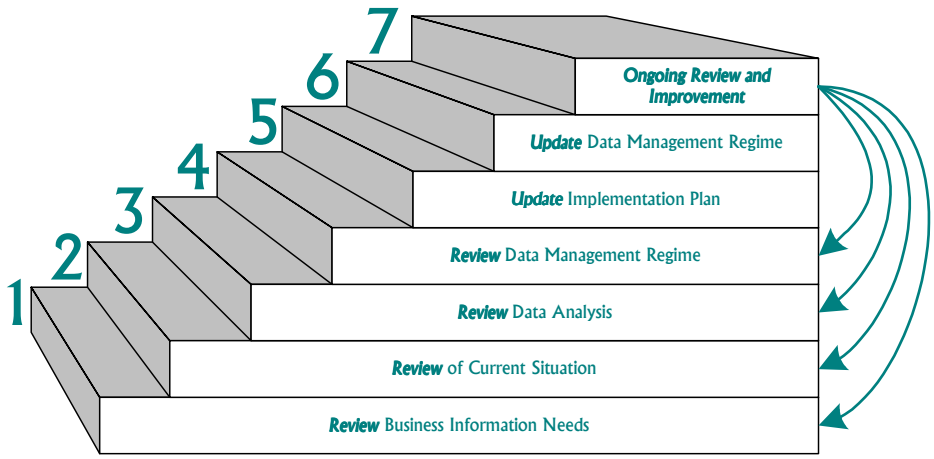


Figure 8 - Ongoing Review and Improvement

Key Points

- Data Management should include effective Change Control procedures
- Benefits Management procedures should be instituted in conjunction with the introduction of Data Management to ensure that investments in data and Data Management deliver benefit
- Effective Data Management requires that associated training needs are identified and delivered on an ongoing basis
- The ongoing success of Data Management requires that data analyses and Data Management Regime are continually reviewed to ensure that they continue to reflect the organisation's business objectives and priorities

SUMMARY

It is hoped that this Best Practice Guide has provided Senior Managers and data specialists within Road Administrations with a useful introduction to Data Management, both highlighting the importance of Data Management and introducing its key concepts.

It should be recognised that this Guide is only a starting point and that, by following the practical information contained in the 'Seven Steps' approach to Data Management, it is hoped that Road Administrations will be able to understand the current level of Data Management within their organisation and identify the areas in need of improvement.

If further information or advice is needed about the implementation of Data Management within a Road Administration, the contact details of the Drafting Group are included in Appendix 4.

KEY TO HIGHLIGHT ICONS


Key Point


Question


Recommendation


Quote


Benefit


Example of Good Practice


Warning


Further Reading


Lessons Learned

GLOSSARY AND ABBREVIATIONS

Asset	Anything that has value e.g. plant, machinery, shares, invoices, data, etc.
Asset Management	Optimising the utilisation of Assets in terms of service benefits and financial return.
Attributes	A software engineering term concerning data that are explicitly linked to other data i.e. cannot exist in isolation; for example, "vehicle length value" is an attribute of "vehicle".
Benefits Management	The identification of potential benefits, their planning and tracking, the assignment of responsibilities and authorities and their actual realisation as a result of investment in change.
Business Case	Costed justification for expenditure on a project or investment, encompassing costs, benefits and risks.
Business Function	What a business does or needs to do, irrespective of how it does it.
Business Process	Process undertaken by a business to achieve its Business Functions.
Change Control	A formal process of managing and controlling change within an organisation, software system, specification, standard etc.
Change Control Authority	Person or group of persons with formal responsibility, within the data Change Control procedure for the approval of changes to the Corporate Data Model
Corporate	Referring to the whole of the organisation, for example, the whole Road Administration.
Data Access	The process or procedures needed the make data accessible to users.
Data Analysis	A formal process to identify and define the data requirements of a system and determine how those data are acquired and used.
Data Cleaning	Process(es) undertaken to validate unprocessed 'raw' data to remove erroneous data.
Data Currency	The elapsed time between the time/date at which data are created or modified and the reference time.
Data Custodian	Person, body or organisation with day-to-day responsibility for a Data Item, delegated by the Data Owner.
Data Decommissioning	The process of taking data out of service that are no longer required in a structured way, in order to minimise negative impact upon the organisation.
Data Dictionary	An organised collection of the descriptions of the data Objects or Items for the benefit of programmers and others who need to refer to them.
Data Domains	Broad groupings of data that share a common functional purpose or classification.
Data Duplication	Data, held for an identical purpose, which occur more than once.
Data Group	Groups of data are either related or considered together in the way they are used within an organisation.
Data Items	Individual items of data, such as an attribute.
Data Management	A set of processes that an organisation puts in place to ensure that its data are contributing positively to the organisations aims.

Data Management Regime	An overall framework – including the rules, responsibilities and processes, for the management of data.
Data Management Sponsor	Individual having responsibility for the success of Data Management and for supporting and promoting Data Management at a strategic and Corporate level. This person should have sufficient authority to be able to effect change and to allocate resources across the organisation.
Data Migration	Movement of data from one system or data store to another.
Data Model	A representation of a set of data that defines the various Data Items and the relationships between them. The Data Model could be defined for the whole of an organisation, in the case of a Corporate Data Model, or for individual systems, Data Groups or organisational divisions.
Data Owner	Person, body or organisation with responsibility for the definition and for ensuring that it meets the needs of the organisation.
Data Redundancy	Data that are held but no longer needed by an organisation to support its business needs.
Data Types	Specific groups of data that share strong commonality.
Data Users	Person or group of persons who utilise data.
Entity	A software engineering term for a discrete, self-contained set of related data.
Entity–Relationship Diagram	A formalised graphical representation of the Relationship between Entities.
European Road Data Dictionary	Formerly known as the RADEF Data Dictionary and originally developed as part of RADEF, this Data Dictionary defines common data definitions that could be adopted by all European Road Administrations, or to which local definitions could be defined.
Function	A sub-division within the Organisation providing a defined service or range of services.
GIS	Geographic Information System
GDF	Geographic data Files
Information Environment	All data that are used by an organisation, including information held in a structured manner, its unstructured data and data held by other organisations.
Information Management Policy	An organisation's statement and procedures for the management of information and data inside the organisation and potentially across the interfaces with other organisations.
Information Systems	Computer based software systems that provide access to and functionality related to the provision of data to support the Business Functions.
Information Trading Policy	An organisation's statement and procedures for making information available to other organisations. This may include issues such as charging for access or usage, data usage, ownership, service levels, liability, access rights, etc.
Legacy data	Data associated with or collected by Legacy Systems.
Legacy Systems	Systems that remain in use after new systems are installed.
PRA	Public Road Administration

Performance Indicator	A statistically derived measure of the performance of an organisation.
Quality Management / Assurance	Formal processes used by an organisation to ensure consistency and quality of processes undertaken or outputs produced.
Quick Wins	System or other initiative, usually temporary in nature and limited in scope, intended to deliver short-term benefit and to satisfy an immediate business need. Often used to demonstrate the longer-term value of a more extensive, more costly, permanent version.
RADEF	RADEF (Road Administration data Exchange Format) was a project to enable the exchange of highways related data between European Road Administrations and other third party organisations.
Road Data Bank	A system (typically a computer database) for the storage of road-related data.
Road Data Bank Unit	A unit within a Road Administration with responsibility for providing road-related data to other Data Users within a Road Administration. The Road Data Bank Unit may or may-not have a computerised Road Data Bank.
Relationship	A software engineering term defining how two or more sets of data or processes interrelate.
Road Administration	Public or privately owned organisation with responsibility for the provision of a local, national and/or international road infrastructure, and for the provision of related services and information.
Service Level Agreement	Agreement between a service provider and the organisation procuring a service, detailing the quality, scope, cost and quantity of that service. When applied to an information system, for example, the agreement might include response times to faults, system availability etc.
Stakeholder	Individuals or groups of individuals with an interest in a system or organisation. In the case of Road Administrations in general, this may include system users, employees, road users, members of the public, central Government etc.
Transport Infrastructure Needs Assessment (TINA)	The Transport Infrastructure Needs Assessment (TINA) process is designated to initiate the development of a multi-modal transport network within the territory of the candidate countries for accession: Estonia, Latvia, Lithuania, Czech Republic, Slovakia, Hungary, Poland, Slovenia, Romania, Bulgaria and Cyprus.
Trans-European Road Network (TERN)	The European Community-wide network of roads was created to promote the carriage of goods and passengers by improving the major highway infrastructures needed by the internal market and the area without frontiers. The TERN has the following characteristics: ▪ It comprises motorways and high-quality roads and will be supplemented by new or adapted links ▪ It comprises infrastructure for traffic management and user information, based on active cooperation between traffic management systems at European, national and regional levels ▪ It guarantees users a high, uniform and continuous level of services, comfort and safety
UML	Universal Modelling Language. See www.w3c.org.
XML	Extensible Mark-up Language. See www.w3c.org.

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APPENDIX 1 - DATA MANAGEMENT HEALTH CHECK

Introduction

The Data Management Health Check is intended to start you thinking about Data Management within your organisation. There are no 'correct' answers to the questions, but by considering these questions, areas of weakness that require further investigation can be identified. If responses are predominantly on the left hand side then Data Management within your organisation is likely to be in a relatively healthy state, whereas more responses on the right indicate areas where further investigation is required. This approach can also be applied to the separate sections of the questionnaire in order to identify particular areas of Data Management success or concern. The questions in Part 1 are intended to elicit background information, and there is no 'good' or 'bad' response.

The Health Check could be completed by a number of individuals with different levels of interest within your organisation, in order to provide a more comprehensive view. You may also find it useful for someone external your organisation to use the questionnaire as the basis of an independent Data Management audit.

Additional notes on interpreting the responses to the Health Check are given after each question.

Part 1: Background

1. Does your organisation exchange data with other organisations?	Frequently	Occasionally	Never
The greater the levels of data exchange with other organisations, the greater the need for Data Management, and for common data definitions, particularly at the interface with those organisations.			
2. Does your organisation have Data Management Procedures?	Formal for all data	Both informal and formal	Informal only
The existence of formal Data Management Procedures is likely to indicate a higher level of commitment to Data Management within your organisation.			

Part 2: The Need for Data Management

	☺	😐	☹
1. Does Data Analysis for new systems take a long time?	Never	Sometimes	Always
The need for extended Data Analysis each time that a new system is implemented indicates a need for Data Management, and in particular, for a Corporate Data Model, that exists independently of systems and applications.			
2. Do new systems require additional data translation and interchange routines to integrate them with existing systems?	Never	Sometimes	Always
Successful Data Management should minimise the need to carry out ad-doc data conversion and translation associated with new systems.			
3. Do information users generally understand where to find the data that they require?	Yes	Sometimes	No
Successful Data Management should incorporate mechanisms to ensure that users are able to realise benefit for the organisation through utilisation of data, and are made aware of the existence and location of data within the organisation. This is particularly the case within organisations where Data Ownership does not correspond with data utilisation.			
4. What is the level of Data Duplication within your organisation?	Low	Medium	High
One of the principal objectives of Data Management is to minimise Data Duplication within the organisation; higher levels of Data Duplication indicate that there is a need for Data Management or that existing Data Management is not operating successfully.			
5. To what extent is the physical location of Data Groups coincident with functional groups within the organisation	Not at all	Partially	Completely
Coincidence of functional divisions within the organisation and groups of data may be indicative of poor Data Management and of an organisation where data sharing cannot easily take place. Such coincidence may of course be justified in circumstances where there is minimal overlap in areas of data interest, but in such circumstances, organisations should guard against the existence of barriers to data sharing and utilisation.			
6. To what extent is the decision to collect data within your organisation associated with decisions on development or procurement of new systems/applications?	Never	Partly	Always
Data Management promotes independence of the data held by the organisation from the systems and applications that make use of those data. If data specification and procurement is generally associated with the introduction of new systems, this may be indicative of poor Data Management, and may result in Data Duplication and Data Redundancy.			

Part 3: Awareness of Data Management with the Organisation

	☺	😐	☹
1. To what extent are data recognised as a Corporate Asset by senior management?	Most	Some	None
Senior management commitment to Data Management is one of the most important factors in determining whether Data Management is successful. Without senior management commitment to Data Management, and a recognition of data as an Asset, it is unlikely that Data Management will be invested with sufficient credibility			
2. Is your organisation aware of the need for Data Management?	Very	Slightly	Not at All
Awareness of the need for - and benefits of - Data Management is clearly an essential prerequisite to the introduction of Data Management.			
3. Has your organisation formally adopted Data Management?	Fully	Partially	Not at All
Although informal Data Management can be successful in delivering limited benefits, only by the application of rigorous Data Management Procedures can the full potential be realised.			
4. Does your organisation ensure that the existence of data is communicated to potential users within the organisation?	Always	Sometimes	Never
If the existence of data is communicated to potential users, together with definitions of those data, in terms meaningful to non-specialists, then the value of those data can be best realised. Successful Data Management is dependent upon this effective communication to potential users.			
5. Does your organisation ensure that the existence of data is communicated to potential users outside of the organisation?	Always	Sometimes	Never
Similarly, if data sharing with external organisations is to be effective, there must be complementary communications of the existence, meaning and value of data.			

Part 4: Corporate Data Model

	☺	😐	☹
1. Does your organisation have a Corporate Data Model?	Yes - Single	Yes - Multiple	No
A key component of a Data Management Regime is the Corporate Data Model. Although not in itself a guarantee of effective Data Management, the existence of a Corporate Data Model demonstrates Corporate commitment to Data Management. If multiple Corporate or sub-Corporate Data Models exist within your organisation, then this is likely to be indicative of data inefficiencies and a need to rationalise, or for Data Management to be instituted to ensure that shared definitions exist where there is overlap between Data Models.			
2. How much of the data held by your organisation have been subject to Data Analysis?	All	Most	Some	None
The response to this question indicates the progress that has been made in the establishment of Data Management.				
3. Are entries in the Data Model ever reviewed and updated?	All	Some	None	
The value of the Data Model can only be realised if the definitions within the Data Model are maintained and updated. A Data Model containing redundant and inaccurate data definitions is of very limited value, and indeed will make it difficult for Data Management within the organisation to be perceived as both credible and of value.				
4. Does each data item have a definition that is understandable to non-specialists?	All	Some	None	
If business-relevant definitions that enable non-specialists to understand what data are held, and derive information from that data, then there is potential for Data Users within the organisation to derive benefit. If they are not available, or if potential users are unable to access or understand those definitions, then it is likely that the benefits and returns on the investment in those data will be severely constrained.				

Part 5: Data Management Practice

	☺	😐	☹
1. Does your organisation know what data it holds?	All	Some	None
It may seem self-evident, but if an organisation does not know, on a Corporate-wide basis, what data are held, then there will almost certainly be Data Duplication and constraints upon the sharing of data. By building an inventory of data held within the organisation, in the early stages of Data Management, such Data Duplication and data inefficiency can be identified and addressed. Indeed, such an exercise is likely to assist in making a case for the introduction of Data Management, since it will highlight specific instances where benefit can be realised by the application of Data Management.			
2. Does your organisation know how much it costs to collect and to maintain its data?	All	Some	None
Part of the changes an organisation will need to make when introducing Data Management, is to change the way data are perceived within the organisation; specifically, data must be regarded as a resource and an Asset, the result of considerable investment. In order to make cost-benefit justification for the collection and ongoing maintenance of data, then the costs of those data must be assessed.			
3. Have data quality standards been determined for each item of data?	All	Some	None
Different types of data held within your organisation will justify the application of different quality standards, depending upon the frequency with which they change and the use that is made of them. Quality in this context will cover accuracy, tolerance and currency of data. data upon which business-critical decisions are based will clearly be subject higher quality standards than those that are of lesser value.			
4. Does your organisation have a formal Data Management Change Control procedure?	Yes	No	
The definitions held about data as part of Data Management practice will need to be updated in response to changes in the uses that are made of data and in response to requests made by users and owners of those data.			
5. Are Data Groups routinely assessed to determine whether they should be decommissioned?	Always	Sometimes	Never
There is a danger of data and Data Groups being recollected as a matter of routine despite the fact that the need for those data no longer exists, or is not of sufficiently valuable to justify the expense of data collection. Good Data Management will incorporate procedures to ensure that only data that continues to deliver appropriate value to the organisation is collected.			

Part 6: Data Benefits and Benefits Management

	☺	😐	☹
1. Do data investment decisions have to be supported by a cost-benefit case?	Always	Sometimes	Never
Investments in data should be treated no differently than investments in any other Asset owned by an organisation, and should be justified with an appropriate Business Case.			
2. Are the benefits of collecting a Data Item determined in advance?	Always	Sometimes	Never
Good Data Management should incorporate an identification of intended benefits in advance, integral with data specification and design. Indeed, it is not possible to make an accurate cost-benefit case for data investment if this does not take place.			
3. Is the achievement of benefit monitored following collection of a Data Item?	Always	Sometimes	Never
By monitoring the realisation of intended benefits, following data collection and utilisation, success can be measured and corrective action can be taken if necessary.			
4. Does your organisation have an Information Trading Policy?	Yes	No	
If your organisation holds data that are of potential value to other organisations, then good practice dictates that a policy on commercial exploitation of those data be established. This is particularly the case within governmental organisations, where there may be political barriers to commercial exploitation of publicly owned data.			

Part 7: Data Management Roles

	☺	😐	☹
1. Does your organisation have someone at senior level who promotes and sponsors Data Management?	Yes		No
Support and sponsorship at a senior level within the organisation, including the investment of appropriate authority and resources, are essential to the successful implementation of Data Management.			
2. Does your organisation know who the users are for each item/group of data?	All	Some	None
Determination of current users of data will assist in identifying additional users that could beneficially access data, and will also held in determining appropriate Data Owners.			
3. Have Data Owners been formally identified for each Data Group?	All	Some	None
Clear allocation of responsibilities for data, and of Data Ownership, is fundamental to successful Data Management.			
4. Do Data Owners fully understand their roles?	Always	Sometimes	Never
Data Owners must fully understand their roles and responsibilities within the Data Management Regime.			
5. Do Data Users know who the Data Owners are?	Always	Sometimes	Never
The relationship between Data Owners and Data Users must be clearly understood for Data Management to be successful.			

APPENDIX 2 - CASE STUDIES

Introduction

This Appendix contains Case Studies that raise some of the practical issues associated with Data Management in six national Road Administrations. In addition, two Case Studies are included that provide an international perspective. Some of the Case Studies address technical issues related to road data while others focus more on organisational issues.

Title	Author	Description
1. Implementing Data Management in Danish Road Administrations	Denmark	Describes the implementation of a Data Management Regime, associated with the Danish Road Data Bank (VIS), on Danish National and Local public Road Administrations. It focuses upon the lessons learned, including successes and failures.
2. Exchange format for Road Location Referencing	France	Describes the use of an exchange format for road location referencing information that has helped to reduce Data Duplication and Data Redundancy and has enabled different parts of the organisation to use a common definition of the road network.
3. Highways Agency Operational data Strategy Scoping Study.	UK	A review of the operational data needed to meet changing business requirements was undertaken. The review identified the business context and requirements for operational data; the current position and changes needed for future needs and the actions required to ensure the business requirements for operational data could be met.
4. The European Road Data Dictionary	International	Discusses the co-operative European Data Management exercise that led to the development of the European Road Data Dictionary, which through international consensus provides a common terminology for the description of road-related data.
5. Standardising Graphic/Geometric data in the Area of Highways and Traffic Engineering	Germany	Describes the development of a catalogue of road Data Items and demonstrates the benefits and problems of the Data Analysis and modelling procedures needed to develop a Corporate Data Model to harmonise the definitions of data that are shared between different application systems.
6. Road Data Bank Unit Ostrava	Czech Republic	The Road Data Bank Unit ensures working of its Information system that includes data processing, regular data updating, output data processing, data supplying to users, exchange, ending and selling data, system development and innovation.
7. Development of Road Data Bank and Data Management in Slovakia	Slovak Republic	Describes the process of the application of computer art in the administration of national road network technical data in Slovakia and the usage of information systems in daily practice.
8. The Management and Exchange of Traffic Information in France	France	Describes the development of a system for the management and exchange of traffic information in France and identifies the issues associated with the exchange of traffic information between a wide range of organisations.
9. Performance Indicators	International	Provides an overview of the concept of Performance Indicators, including their benefit and usefulness and the connection to the location referencing, system. Examples are described, including definitions and data requirements.

It is hoped that, by sharing the experiences described in these Case Studies, other Road Administrations will recognise the benefits of effective Data

Management, and will be able to capitalise on the successes and avoid the failures made.

Case Study 1 Implementing Data Management in Danish Road Administrations

Description

This case study describes the implementation of a Data Management regime, associated with the Danish Road Data Bank (VIS), for Danish National and Local public Road Administrations. It focuses on the lessons learned, including successes and failures.

Author

Danish Road Directorate

Country

Denmark

Background and Business Issues

In the 1970's the road authorities within the Danish state and the 14 local counties recognised a lack of a common, objective mechanism for evaluating investments in the construction and maintenance of the main road network and for determining future funding requirements. It was discovered that each Road Administration used its own set of data definitions and this made cross comparisons on the road network impossible. A particular area of concern was the nation-wide accident statistics and analysis, which suffered from the different data definitions. Consequently, a Data Management exercise involving both National and Local Road Administrations was instituted, which led to the implementation of the first version of a Danish Road Data Bank. The Road Administrations defined a common database with an associated shared Data Model, with common data definitions as the basis for the evaluation of traffic, safety, pavement management and other projects. There is general agreement amongst the participants that the Data Management Regime and associated Road Data Bank, delivers significant benefit, by ensuring best value for investment on their road network.

The Data Management Regime was then developed and improved in subsequent years. This process is described below.

Although the Road Data Bank was successful in that it provided for nationwide analysis and reporting, it was user-unfriendly, and few individuals at the counties were able to use the Road Data Bank without support. The focus on developing a comprehensive Road Data Bank had resulted in a complex system, which was difficult for non-specialists to use, and the vision of the Road Data Bank being 'every-man's' tool was not achieved. This made the Road Data Bank 'invisible' and, in many cases, users were not aware of the existence of the Road Data Bank. This lead to the development of small independent subsystems, containing a redundant subset of data similar to the definitions in the Road Data Bank, and used for a narrow specific purpose. This highlighted a failure in the Data Management Regime - if users are to make full use of a system, such as the Road Data Bank they must have a clear understanding of the data definitions. The lack of such clear, non-specialist definitions is a barrier to data and system utilisation.

From late 1980s to 1995, the Road Data Bank was migrated from a mainframe platform to client/server architecture with local area networks at the counties, which are linked to a central server containing all data for the entire network. The aim of this project was to provide the data directly on the user's desktop PC in order to make the Road Data Bank more accessible and to provide better support for daily working. Data Management enabled this downsizing of the Road Data Bank, without losing the concept of common data definitions and the existence of a single national road dataset. An important objective was to provide a much more user-friendly interface including a GIS-

interface because it was widely held that the broader use of the existing Road Data Bank was almost impossible due to a complex interface.

The following paragraphs deal with the outcome of the migration project how it was managed and how the Data Management was carried out.

Data Analysis and Modelling

First phase of the migration project included the review and updating of the existing common Data Model, through Data Analysis and modelling. Techniques used included Entity-Relationship Diagrams, data Flow and CRUD schemas. Models and dataflow were documented in CASE-tools.

An important part of this review and analysis was to identify the data that should be retained, which new data were required and which redundant data should be decommissioned.

The data review and analysis exercise was time-consuming and, at times, it proved difficult to sell the benefits to users and sponsors of the system. The result however was a very good and flexible Data Model that can easily adapt to new ways of looking at the road network. The disadvantage is that it requires specialist skills and takes time to understand the model and this can make it difficult to recruit suitable new staff.

Benefits Justification

An attempt was made during the process of determining which data should be included within the Data Model, to do so on the basis of the costs and benefits of collecting and maintaining those data. This proved problematic - it was difficult to express benefits, particularly 'softer' benefits, associated with particular Data Items in financial terms. Ultimately, it was decided to use both a 'common sense' qualitative approach in selecting certain Data Types and full, financially based cost/benefit analysis for others. In Denmark, this approach to data needs is still taken when the VIS is enhanced.

Design and Implement of the Data Management Regime

During the last year the design and development of the Data Management Regime, required to operate the new Road Data Bank, took place. A number of alternative approaches were discussed between representatives from the 15 involved Road Administrations.

Project Management

Experiences from the first implementation had shown that emphasis on the project organisation is very important. A project involving 15 independent road authorities requires a robust, well-organised project organisation. The project was organised with a steering committee, a daily coordination group and a project secretariat, which acted as project manager without having the power to actually control the project. Project work was carried out in several project teams with its own budget and project leader. First year experience showed delay in the activities and that the project organisation needed to be changed and it was recommended to assign a project manager with the power to actually follow up on the project itself and the project teams and not only do coordination work. The impact was that the project teams came back on schedule. Direct command lines and clear responsibilities showed again that they could not be omitted if a project is going to meet targets.

In Danish terms, the project was huge and involved many users at different levels. The high degree of user involvement caused resulted in a greater overhead on the budget than that needed to develop the system, but at the end of the day there is no doubt that the resources were well invested because the users adopted the new concept very quickly. Budgets were limited and only given for one year at a time. To secure that cost were within the budget one-

year contracts with the project teams were made. Total project duration was 5-6 years and each year the steering committee assessed the obtained results before the budget of the next year was released. During a project year, the project manager defined a number of milestones for the project teams in order to reach the targets of the year and to get the approval of the steering committee to continue the project. The advantage of this approach was that in the end the total project reached its goals very close to the original budget and almost on time. The focus on the budget limits had one disadvantage: parts of the deployed system were unstable and needed further development before the users were satisfied with the performance.

The steering committee emphasised that the good experiences with high user involvement during the development phase should be reflected in daily operation after implementation, and that this should inform the developed Data Management Regime. It was also decided that all 15 administrations should share both responsibility for and financing of coming activities associated with the new Data Management Regime.

Data Management Organisation

It was decided to establish a formal Data Management organisation and a secretariat. The formal organisation consisted of three levels:

Steering Committee: Responsible for determining the scope, direction and resourcing of Corporate Data Management and of Road Data Bank-related activities. The six members are representative decision makers from the road authorities with delegated financial authority. This committee acts as the Change Control authority within the Data Management Regime.

User Representatives Committee: Serving as the link between the steering committee, Data Owners and the general users of the Road Data Bank, the User Representative Committee is responsible for co-ordinating user experiences and change requests into specific proposals for future changes, actions for consideration by the steering committee. The eight members represent all 15 road authorities.

User committee: a forum where 2 or 3 experienced users from each of the 15 road authorities meet twice a year with the secretariat in order to share experiences, to learn and to discuss new activities etc.

The secretariat is established as a permanent organisation within the Danish Road Directorate funded by both the state and the 14 counties. The secretariat is responsible for the daily operation and support of the Road Data Bank and responsible for the implementation of development plans and other actions decided by the steering committee and the User Representatives Committee. In practice, it was a continuation of the secretariat from the first version but adapted to the new situation with respect to both the new principles of workflow and financing.

Lessons Learned about the Organisation

The organisation described above, incorporating a high level of user involvement, requires an overhead that might be avoided with a more 'slim' organisation. Nevertheless, as the steering committee is charged with determining budget charges and the link to the end users is assured, this overhead is justified because practice has shown that decisions are made at the correct level with minimal delay.

The Data Management organisation described above has been in operation for six years and in general, the formal part works very well. On all levels, the system is well accepted and the scope of the Data Management Regime has

been extended on a systematic basis. The common view of all 15 Road Administrations is that the system is a good investment and, at the management level, the system has full support.

Change Control

The secretariat is organised in a way that enables it to systematically collect errors and new requirements for the Corporate database. These are analysed, and if the resources required are minor the changes are prioritised and carried out as soon as is possible, funded from a maintenance account, which is part of the annual budget. Major changes are transferred to and handled through the formal organisation resulting in either rejection or inclusion in the work programme for the next year.

This approach has both advantages and disadvantages. Although some changes are implemented very quickly, new and innovative ideas, which require significant resources to implement, can be delayed for years due to budget constrains or lack of agreement within the formal organisation. This is a common feature of enterprise-wide systems.

Many benefits are achieved with the new system but not all of the expected goals have been. All major technical management systems base their calculations on the data in the VIS by having a direct link to the database. The system is developed as a client/server system with a user interface based upon Windows. It was expected that this would allow the non-specialist user to directly retrieve and analyse information from the Road Data Bank, leading to an increased data utilisation. This goal has not been realised. The system is mainly used by trained, specialist users who have a good understanding of the data and the Data Model. These users find the new system much easier to use than the former system, but they are also of the general opinion that the current concept will not lead to increased system and data utilisation because it requires a high level of proficiency and familiarity with the system tools. Consequently occasional, non-specialist users tend to get specialist 'super users' to access data on their behalf. It is believed that the fundamental reason is not the software tools but that the occasional users do not understand the data definitions in the relationships between data; this knowledge is a prerequisite in order to be able to use a Road Data Bank efficiently. One possible solution is for the user interface to be provided with an explanation advising users of the excepted results of retrievals, so that the context in which the retrieval can be used is clear.

The most onerous activity associated with ongoing Data Management is the maintenance of accurate, current data. Although top management has approved procedures and regulations addressing the location and timing of data collection and updating, all too often these procedures are not reflected in operational practice. The reasons for this are many: not enough resources, no awareness of the existence of a specific Data Group, low priority to data activities and the feeling in many technical sections that: 'we can do this better and cheaper'.

Experience shows that Data Management, whilst having a beneficial impact, does not in itself solve these problems, and that other cultural and organisational factors must be addressed for Data Management to realise its full potential in the coming years.

Lessons Learned

- If users are to make full use of a system, such as the Road Data Bank they must have a clear understanding of the data definitions. The lack of such clear, non-specialist definition is a barrier to data and system utilisation.

- Data Management and the existence of single Data Model and national data set enables the development of new systems, such as the new Road Data Bank, without a costly exercise to remodel and recollect data.
- It can be difficult to convince the organisation that the costs and effort required to create a high-quality, flexible Corporate Data Model are justified.
- An organisation embarking upon Data Management should not underestimate the skills and time required on the part of existing and new staff tasked with supporting the Corporate Data Model.
- The lesson learned was that a combination of quantitative cost/benefit analysis and common sense is the best way to determine the data content for a Road Administration's Corporate database and Corporate Data Model.
- Organisations should not underestimate the resource requirements required to implement a Data Management organisation that provides for a high level of user involvement, but there is the potential for considerable benefit arising from of such user involvement. Such benefits include improved responsiveness to change, improved user awareness of existence, meaning and potential for utilisation of data, and improved user support for Data Management.
- A flexible, responsive Change Control mechanism is required if innovation is to be encouraged, and good new ideas adopted.
- Occasional users must be provided with appropriate support, help, and in particular easy to understand data definitions, in order to make best use of, and access to data.
- Projects involving the development of Corporate databases require the assignment of a project manager with the power and authority to assign resources and to make Corporate decisions, rather than merely liaising between the various parts of the organisation.

Case Study 2 Exchange format for Road Location Referencing

Description

This Case Study describes the use of an exchange format for road location referencing system information that has helped to reduce Data Duplication and Data Redundancy and has enabled different parts of the organisation to use a common definition of the road network.

Author

SETRA

Country

France

Interurban Location Referencing

The Interurban Location Referencing System is a system that provides different users with a common model of the road network. It enables them to examine the road network and allows road data to be located accurately.

It is formed of:

- A system of road identification (nomenclature)
- A system of locating the road data (i.e. a method of reference points)
- A map representation of the road network
- A representation of the topology of the ground

The Interurban Location Referencing supports the following Functions:

- Location of point, line or area data
- Linear calculations
- Area calculations
- Cross referencing of data (e.g. traffic compared with accidents)
- Representation of the data against a map background

Management of the Location Referencing System is the responsibility of the Road Network Administrator, who then makes it available for use by his different clients or users.

Context

In the recent past, the development of systems to support the management of road data was structured according to the different business areas of the organisation (traffic, maintenance, security, etc.). This approach presented the following disadvantages:

- Different definitions of the road network existed and changes were not synchronised
- The definition of the road features (roads, slip roads, etc.) differed between systems
- The different data definitions and formats made it difficult to update and exchange road data between systems
- There was considerable redundancy and duplication in both data and systems

In order to compensate for these difficulties, SETRA has defined a new development policy for its systems, based on a common definition of location referencing common to all, or at least most, of the systems developed by all parts of the organisation.

A New Approach

This new approach relies on the following principles:

- In the development and use of these systems, the location referencing management role is separated from the development and use role
- The location referencing is independent of the organisational structure and from the business areas that use it
- Mapping information is provided by a commercial map database. This provides a coherent, national coverage of the territory and allows access to other information including administrative boundaries, rail networks, electrical power lines, etc.

An exchange format called MERIU (Modele d'echange de referentiel routier interurbain) has been defined. The main entities managed by the exchange format are:

- The roads (connecting lanes)
- The distance marker reference points
- The inter reference points (section of roads between two kilometre marker reference points, or between one kilometre marker reference point and the end of the road)
- Junctions and slip roads
- Administrative boundaries
- Road sections (mapping representation of the road)
- The link between the reference point system and the IGN (Institut Geographique National Francais) map

Ongoing Development

The implementation of the MERIU data exchange format has reduced Data Duplication and Data Redundancy and has enabled data to be exchanged between different systems used by different parts of the organisation. The use of a common location referencing system has produced greater consistency in the use of data and has reduced the amount of time spent in the identification and resolution of data errors and inconsistencies.

Successful though the introduction of MERIU has been, there are still a number of difficulties that need to be resolved to further enhance the exchange of data:

- The quality of the data entry for the production of the location referencing needs to improve
- The precision of the location of the kilometre marker reference points is insufficient to map junctions accurately
- The definition of the map cannot be precise enough for certain applications, specially for slip roads and interchanges;
- The delay in updating the map means that it can be out of step with changes to the road network (at the moment, the map is updated once a year by the IGN);
- The are some layout anomalies in the map compared with reality
- There is a large amount of work generated by the supply of referencing information to different users

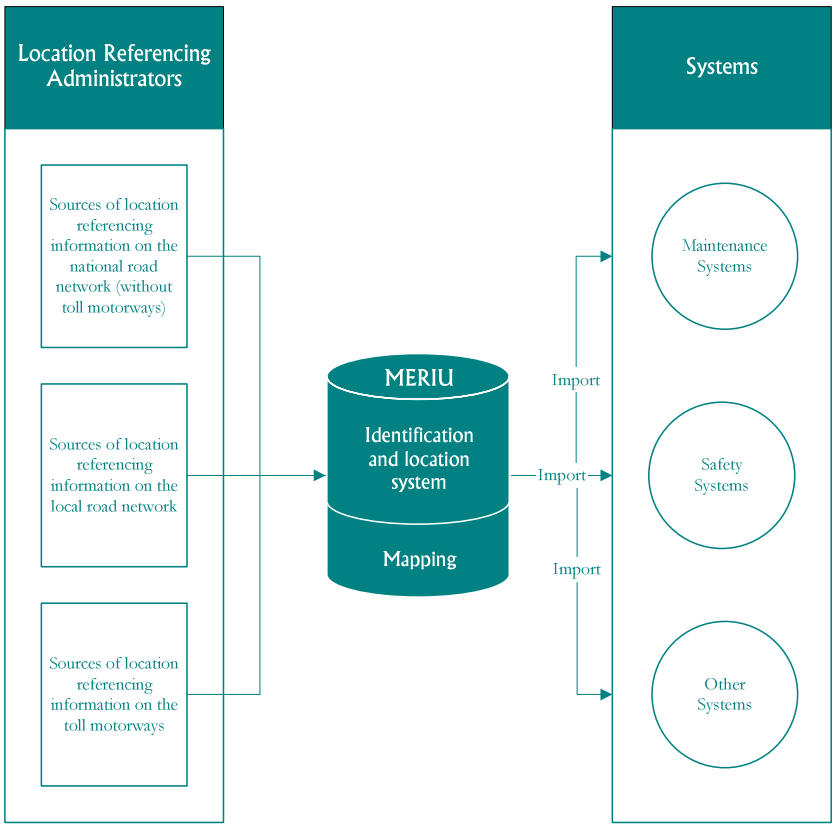

Figure 9 - Exchange format for Road Location Referencing

Lessons Learned

- By adopting a common exchange format for road Data Items, with clear ownership of the different Data Items, Data Duplication and Data Redundancy have been reduced.
- Despite the success of the implementation of the common exchange format, there are still practical difficulties concerning the quality of location referencing information that need to be resolved before the benefits can be fully realised.

References

Meriu V1.1b: the exchange model of the interurban location referencing.
Bdcacrto: User structure METL v98.

Case Study 3 Highways Agency Operational Data Strategy Scoping Study

Description

The Highways Agency undertook a wide-ranging and high-level review of the operational data needed to meet its changing business requirements. The review identified the business context and requirements for operational data; the current position and changes needed for future needs and the actions required to ensure the business requirements for operational data (including Data Management issues) could be fully met. This Case Study broadly coincides with Step Two 'Review of Current Situation' identified in this Guide.

Author

Highways Agency (HA)

Country

UK (Highways Agency has responsibility for the Motorway and All Purpose Trunk Road network in England only)

Background

Since 1997, the role of the Highways Agency has evolved from that of a network provider and maintainer to that of a Network Operator. This change had far-reaching implications in terms of the aims and objectives of the HA and new strategies had been developed to monitor the performance of the HA in its new role.

These strategies in turn required changes to the operational data requirements of the HA and in December 1998 a Scoping Study undertook a constructive, high-level analysis of the measures, enhancements and improvements required to operational data capture and deployment including:

- data needs both now and in the future
- data needs in the future but not currently available
- data collected / available now but likely to be or become redundant

The Scoping Study set out to define a clear Strategic Framework for undertaking the work required to meet the HA's future operational data needs, in particular:

- The business needs and priorities for operational data
- The operational data required and their required characteristics
- Gaps and shortfalls in current provision
- Ownership, management and organisation (roles and responsibilities) of operational data and information

Business Context

The changing role of the HA at the time of the Scoping Study meant that the traditional approach to the specification, management and deployment of data and information, including the specification and development of supporting Information Systems, needed to change.

In order to support this changing role, the HA's vision for operational data was defined as:

- A common map of the road network which would provide the foundation for consistent access and retrieval of operational data
- The integration of the four core Asset Data Groups (Asset, condition, traffic and operations)

The Study identified the following priorities:

- There was a need for greater business assurance regarding the management of data as a vital resource
- Data needs to keep in step with business and operational needs
- Ownership of and responsibility for data and information needs to be made more explicit with clearly defined roles, responsibility and accountability that are understood at all levels throughout the organisation
- Commitment to the development and utilisation of the data and information resources and the creation of knowledge and data partnerships between all parties is a prerequisite for successful information and Data Management
- Value for money must be assured and all investment in information and data resources – whether sponsored internally or via third parties – must demonstrate a suitable return on investment
- The more effective and strategic co-ordination of all IS/IT development within an over-arching business framework will considerably enhance the potential for project and data integration at the earliest stages of an IS/IT project's life-cycle
- As a vital resource, all specified data and information must be subject to appropriate procedures, measures and controls, designed to protect it for future use
- Adoption of common data and data referencing standards throughout the HA and by its service providers and business partners will provide the level of consistency and re-usability of data and information that are now demanded
- Shared knowledge and visibility of the data and information resources will considerably enhance the ability of the HA, its service providers and business partners to exploit and deploy data more efficiently and to more readily identify gaps, Data Duplication and Data Redundancy

Identified Problems

The Scoping Study identified the following problems with the management of operational data within the HA:

- The use of existing systems was found to be extremely variable with different solutions being developed to meet similar or shared requirements
- The accuracy, quality and completeness of most existing operational data was highly variable and frequently deficient
- 'Core' data holdings were widely dispersed and inaccessible
- Data specification and management was compartmentalised by Function with opportunities for rationalisation or integration being overlooked or not exploited
- Contractual obligations for data and records management were unclear and frequently overlooked by all parties
- An increasing dependence on local knowledge was largely as a consequence of poor retention of data and information in a reliable and consistent format, whereby its future access and use could be assured
- Data integration and re-use prevented or was made unnecessarily difficult by the absence of common (Corporate) agreed data standards and format
- Information Systems development and approval processes lacked strategic focus and co-ordination

Recommendations and Anticipated Benefits

The two key elements identified to support the HA's Strategic Framework for the management of operational data were:

- Information Management Policy and Standards to set out the Corporate standards, policies and criteria for developing and managing the HA's information and system requirements and for meeting the Corporate management information needs
- Operational Data Strategy[7] to set out the requirements for developing integrated operational systems to address the specific needs identified by the strategic business plans and those that were emerging from operational and technical management of the road network

The Study made the following specific recommendations concerning Data Management and identified the associated benefits:

Recommendation	Anticipated Benefit
Appoint a Corporate Information Manager and a Highways Agency Information Management Unit	This would provide a focal point for co-ordinating data and information issues and requirements – providing the HA Management Board with assurance on data and information integrity, quality and integration
Define information and Data Management roles and responsibilities	In assigning specific responsibilities for meeting and delivering the operational data requirements, the HA is able to communicate and manage operational data more effectively, reducing wasted effort, Data Duplication and Data Redundancy
Research, define and implement a Corporate network/spatial referencing standard, applicable to all operational data and management systems	Common standards, definitions and referencing will result in consistency and reusability of all data.
Research, define and implement a common set of data definitions, terms, formats and data quality standards	
Develop detailed business requirements and specification for a Corporate inventory of data and information held by the HA, business partners and data/information providers	Visibility of the information and data resource will enable better management and control of the resource, eliminating Data Duplication and Data Redundancy of data and enabling gaps and shortfalls to be more readily exposed and addressed.
Research, target and initiate contact/discussions with current and potential external data/information providers	Identification and exploitation of external data sources will enable the HA to reduce its direct data costs in favour of procuring a range of 'added value' and information services.
Investigate the feasibility, scope, potential costs and benefits of further outsourcing of some or all operational data collection and management services	

Ongoing Situation

The recommendations were submitted in a paper to a Main Board committee looking after the operational aspects of the network. Despite acceptance of the findings of the report, no definitive action was taken on any of the recommendations, no plan approved, no resources allocated and, more importantly, no 'Champion' appointed.

Lessons Learned

- It should be recognised that it will not be easy to persuade Senior Managers and Decision Makers, whose support is vital for its success, to

[7] *The Operational Data Strategy effectively described how operational data should be managed in order to satisfy the information needs described in the Information Management Policy.*

give Data Management the priority it deserves throughout the implementation of a new Data Management Regime.

- The adoption of consistent Data Management practice across the whole organisation (for example by the development of a Corporate Data Model or by using common location referencing etc.) can often seen as a first step towards the adoption of a fully integrated approach to Asset Management.
- Although maximum benefits will only be realised by the adoption of good Data Management practices across the whole organisation, some benefits can still be realised by adopting good Data Management practices in individual business areas. It should be remembered however that the more localised the implementation of Data Management is, the lesser the benefits that will be realised.

Case Study 4 The European Road Data Dictionary

Description This case study discusses the co-operative European Data Management exercise that led to the development of the European Road Data Dictionary which through international consensus provides a common terminology for the description of road-related data.

Author Sub-Group Road Data

Country International

Background Comparable information on national, regional and international transport infrastructure is essential for informed public planning decisions. However, because highway data are held in different formats and databases across Europe, conversion and analysis for the sharing of valuable information and for reporting upon the performance of European road networks becomes a time-consuming and costly task.

RADEF (Road Administration data Exchange Format) was originally a two-year project on behalf of the Western European Road Directors and their Public Road Administrations and funded by the Road Administrations with support from the European Union. RADEF has its roots in early European Union research activity. The current members of RADEF are the Road Administrations of Belgium, Denmark, Finland, France, Germany, Italy, Luxembourg, The Netherlands, Sweden, Switzerland and the UK.

The RADEF project has been working to facilitate the exchange of highway information among both transport authorities and commercial organisations involved in mapping, construction and transport investment by developing common standards and tools and promoting their use.

A key part of the development was the creation of a common Data Dictionary, providing agreed terms, definitions, categorisations and relationships for highway data, such as traffic, accident, and road network and condition statistics. Additionally, computer tools were developed, to support the maintenance of the Data Dictionary, and the extraction and summarisation of highway data from participating databases according to the standards set out in the Data Dictionary.

The RADEF Solution The RADEF solution developed has two main components:

- The European Road Data Dictionary provides agreed terms, definitions, categorisations, and relationships for various types of highway data, such as traffic, accident, road geometry and road condition statistics. Common location referencing is a particularly important component. The Data Dictionary is the result of extensive co-operative research by the Road Administrations.
- With the Data Dictionary in place, the RADEF tool can be used to 'mine' the data in participating databases to extract the particular information needed. This powerful software tool uses an application to provide a common front-end to the various Road Administration databases and a standard format for the data retrieved.

Data Dictionary Development

The European Road Data Dictionary has been developed to identify and record the requirements of the Road Administrations in a logical Data Model of nine Data Domains:

- Road Network
- Restriction
- Traffic
- Structure
- Equipment
- Accident
- Condition
- Road Geometry
- Route

An extensive programme of workshops was held in order to agree the requirements and the content of the Road Data Domains. The scope of each domain workshop was agreed in advance. The workshops were well attended by Road Administrations representatives, who were able to bring their specialist and national knowledge to the development of the requirements. The work took place in a positive environment, and the workshops were able to make significant progress on common meanings and classifications of entities, Attributes, and coded values.

The European Road Data Dictionary has been fully defined as a series of entities, Attributes and coded values, with associated business-meaningful definitions. This work has also been incorporated into the RADEF Tool. The RADEF Tool allows for the preparation and storage of the national version of the Data Dictionary, with all the elements originally defined in the English language being translated into all the languages of the Road Administration representatives. The RADEF Tool also allows for the specification of parameters that convert national measures or codes into the standard measures or codes described in the Data Dictionary.

RADEF Technical Issues

Because highway data are held in different formats and databases across Europe, conversion and analysis of comparable data are currently a time-consuming, costly and difficult task. This situation inhibits the sharing of valuable information, which may be needed because:

- Particular environmental factors and characteristics occur across borders, calling for a common approach
- Accurate national, regional and international infrastructure data are not easy to obtain, yet are vital to informed public planning decisions
- Highway infrastructure information is fundamental to the development of operational Intelligent Transport Systems (ITS), in both the private and public sectors.

The challenge for RADEF has been to provide a technical solution to facilitate the exchange of highway data among the Data Owners (the Road Administrations), and between these and other interested Data Users. In addition, commercial organisations involved in mapping, construction, service and product development and investment for the international transport sector also need access to such information.

Location Referencing

A major issue for all highway network referenced data is the location referencing system to be used. As part of the series of Road Administration workshops, an agreement was reached on a standard method to be used for

referencing data. This method identifies objects by their linear distance along a road section from a reference point. This method has applicability for all Road Administrations, both those whose networks are represented as a directed graph of arcs and nodes, but also those whose networks are represented as a set of long sections not connected topologically.

All Road Administrations involved in RADEF, because of their organisational and business needs, have independently adopted this common approach to referencing. Work has taken place during the project to establish if and how the RADEF approach supported by the Road Administrations can be integrated with the GDF standards work undertaken primarily by the in-car navigation system industry. This work has taken place under the aegis of the European Technical Committee on Road Transport and Traffic Telematics (CEN TC278) Working Group on digital map databases.

RADEF Deployment

Although the European Road Data Dictionary and the supporting tool have been successfully trialled, it's deployment and operation, and the attendant benefits resulting from improved data sharing has been limited to date. The major success of the RADEF initiative has been the development of the European Road Data Dictionary, which has potential to be the basis of future co-operative Data Management and data sharing.

Next Steps

Following the successful completion of the RADEF project, the Road Administrations involved decided to extend the deployment, to review and update the European Road Data Dictionary, and to undertake some technical enhancements to the Tool. Further work has also taken place in developing RADEF for reporting on the Trans-European Road Network, (TERN), and in encouraging the use of RADEF by all 15 members of the EU for TERN data supply.

Further developments of the RADEF Tool have been undertaken to allow access via the Internet, using a map-based interface in addition to the existing text-based interface. However, this development may be superseded by the advent of next standardised exchange formats such as eXtensible Markup Language (XML).

However, future and further developments require a clear definition of the data exchange requirements, which in turn are defined by the business requirements, as defined by user organisations such as the European Commission.

Moreover, if the European Road Data Dictionary is to continue to be a valuable shared resource, then ongoing Data Management must take place to keep it up to date, and to ensure that it reflects current requirements.

Lessons Learned

A number of lessons have been gained from the experience of the RADEF project and the subsequent deployment of the European Road Data Dictionary and supporting Tool. These include:

- A well structured and managed Data Management exercise incorporating definitions of user requirements, with well-defined objectives, led within the RADEF project to the successful development of the European Road Data Dictionary.
- The Data Dictionary that underpins a Data Management exercise must be continually reviewed and updated if it is to deliver ongoing benefit.

- Trials undertaken in the RADEF project have proved that the approach and technology are appropriate for the proposed task, yet deployment has been limited due to the limited definition of business needs within the operational environment. This subsequent Business Case definition may necessitate further development and adaptation of the existing solution.

Case Study 5 Standardising Graphic/Geometric data in the Area of Highways and Traffic Engineering

Description

This Case Study describes the development of a catalogue of road Data Items (OKSTRA – Objektkatalog Strasse), which was started in 1995 and is still ongoing. The objective of the OKSTRA project was to ensure the ability to represent road Data Items in a uniform manner and to facilitate the exchange of graphic/geometric data in the area of highways and traffic engineering. The Case Study demonstrates the benefits and problems of the Data Analysis and modelling procedures needed to develop a Corporate Data Model to harmonise the definitions of data that are shared between different application systems of the Road Administrations in Germany. It therefore broadly coincides with Step Three 'Data Analysis' identified in this Guide.

Author

Federal Ministry of Transport, Building and Housing

Country

Germany

Background and Business Issues

From the mid 1970s to the late 1980s, the Federal Ministry of Transport and the 16 Federal Laender [8] of Germany identified two key problems with the information available about Federal Highways and Trunk Roads Network:

- Shared information was often missing
- The lack of a common road database resulted in technical and administrative problems with controlling the complex traffic and transportation systems

Not all efforts in establishing common road databases on compatible IT systems succeeded due to organisational differences and financial problems.

At the same time, it was recognised that, despite a federal directive implementing common standards for the development of road databases, in some areas different data definitions and rules for data collection and implementation had been set up which made the common use of data difficult or even impossible.

Due to this lack of it was decided in the early 1990s that the first step towards a common road database would be to establish OKSTRA, a common procedure for data exchange between the different databases of all Road Administrations in Germany.

Another reason for this approach was the development of new methods and tools for graphical data processing in highways and traffic engineering. It was soon obvious that there was a growing need to share and exchange data between the different applications used by the different parts of the organisation responsible for design, construction, maintenance, operation, traffic management etc. to ensure that the whole process of highway management was highly efficient and provided best value for the money invested. See Figure 10.

The benefits of the standardisation of data exchange were especially seen in linking the existing databases among one another, between federal and

[8] *Under German Law, the 16 Federal Laender build and manage the Motorways and Federal Trunk Roads on behalf of the Federal Government. The Federal Ministry of Transport has the right of legal, budget and technical supervision.*

Laender offices, surveying and mapping agencies, European commission and third parties.

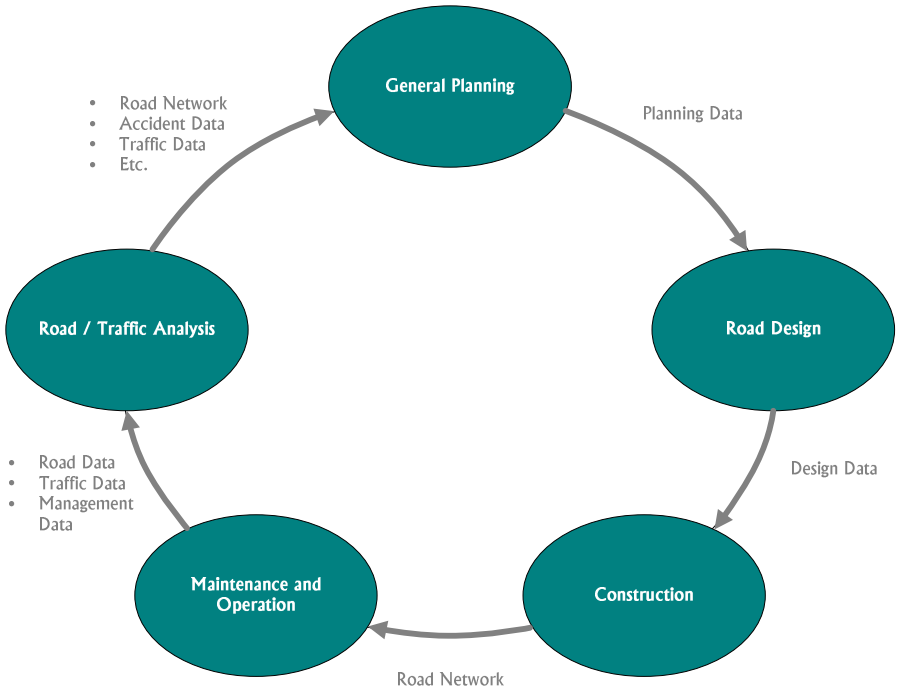

Figure 10 - Dataflow Cycle in Highways and Traffic Engineering

Data Analysis and Modelling

To ensure the long-term validity of OKSTRA it was clear from the beginning that the data exchange standard should be able to take into account other existing standards in the business areas of highways management and data exchange, including the European Road Data Dictionary, as well as other Data Types used in highway design.

In preparation for the development of OKSTRA, the following steps were taken:

- Defining the requirements of the existing software and determination of all relevant standards, regulations and systems
- Developing an overall OKSTRA Data Model compatible with the other relevant existing standards
- Designing data schema for the most important Data Groups
- Investigating existing interfaces and designing processes for the exchange of OKSTRA data
- Planning the various activities required to implement OKSTRA

The investigations showed the following results:

- The data flow has not been properly defined and is interrupted at several points during the cycle. There exists a large number of different standards, regulations, catalogues etc. which need to be supported
- The overall OKSTRA Data Model lays down the entities and relations between them, which will not change over time. For this reason the OKSTRA Data Model has been kept very general

- The OKSTRA data schemas are designed to be flexible in order to permit extensions in the future. OKSTRA should be conceived as an open standard
- The investigation of existing data exchange and Data Access procedures resulted in the proposal that an existing standard should be used. The advantages of this approach are obvious: It makes no sense to reinvent the wheel when existing standards fulfil the requirements and have already been proved to be successful

Successes and Failures, Ongoing Situation

The biggest success of the OKSTRA project has been the willingness of all parties to strive towards the objective of a common Data Model for all road data. This has been done by involving all Data Owners in the discussions to confirm the business requirements and by reinforcing the message that the adoption of more effective Data Management practices will enable all organisations to make more efficient use of their data by maximising the sharing or exchange of data between different systems and by reducing Data Redundancy and Data Duplication.

So far, more than 2000 Data Items in the area of Highway and Traffic Engineering have been defined and modelled, each represented in terms of entities, Attributes and relationships. The next stage will be the modelling of Data Items used by other areas of the Road Administration including environmental protection, landscape and nature, air and noise, water and soil or in the field of pavement, structures and road drainage.

It has taken a great effort to reach the current situation, and particular problems have been found in finding enough people with the right expertise to contribute to discussions and to comment on the drafted Data Models. On the other hand, including the large number of people who identified themselves as Data Owners in the discussions meant that the project took more time than expected and is still ongoing.

Lessons Learned

- For sound, practical reasons the implementation of an effective Data Management Regime will often consist of a gradual process but benefits can often be derived from many of the intermediate steps
- It is important not to underestimate the preparatory work required before starting a project such as OKSTRA, especially the required training of staff to understand Data Analysis and modelling techniques
- By involving members of the organisation at an early stage, it may be easier to gain their support for the proposed Data Management Regime and this is likely to make it easier to introduce any required changes to businesses processes and procedures at a later stage

References

Further information is available from Roman Limbach or is provided on the Internet at www.okstra.de.

Case Study 6 Czech Road Data Bank Unit

Description

In the Czech Republic national Road Administration, Road and Motorway network data is managed in the Road Data Bank Unit, a unit of the Technical Division of Road and Motorway Directorate of the Czech Republic, based in Ostrava. The Road Data Bank Unit manages an Information System that includes data processing, regular data updating, output data processing, data supplying to users, exchange, and selling data, system development and innovation, for the whole national network.

Author

Czech National Road Administration

Country

The Czech Republic

History

In 1977, a special Road Data Bank Unit was established in Czechoslovakia and in 1995, it became part of the Road Directorate of the Czech Republic. In 1997, the Road Directorate of the Czech Republic joined with the Motorway Directorate of the Czech Republic and Road Data Bank Unit became part of the technical division of Road and Motorway Directorate, a contribution-raising organisation under the Ministry of Transport and Communication.

The Road Data Bank Unit has developed its own Information System, the original establishment of which was not easy. Data processing was achieved via punch cards on mainframe EC 1030/1045. Data were saved on magnetic tapes or discs and output information for customers was distributes in form of output reports. Recent developments in computer systems have opened up new possibilities of collaboration with users and customers, and new possibilities of using collected information.

Activity of Road Data Bank Unit

The activity of the Road Data Bank Unit is divided into three sections:

a) Data collection
b) Data base administration, and
c) Programming and user output.

The Road Data Bank Unit administers data about road network that include motorways, the first class, second-class and third class roads.

Road Type		Length (km)
Motorways:		501.538
Roads:	1st class	6,030.552
	2nd class	14,694.682
	3rd class	34,166.812
TOTAL		55,393.584

Road Data Design

The Road Data Bank Unit manages a range of road-related data including:

1. Network Referencing data
   - Nodal points
   - Road sections
   - Connectivity of traffic directions in complicated junctions,
   - Description

Coordinates of nodal points and elevation (X, Y, Z) on the motorways, the 1st and 2nd class roads are collected under contract, using GPS technology.

2. Inventory data
3. Pavement parameters
   - Bearing capacity
   - Skid resistance
   - Profile and surface evenness

Pavement parameters, characterising the condition of the pavement, are collected by diagnostic vehicles

4. Records of construction activity:
   - New Construction
   - Maintenance works

5. Traffic data
   - Traffic census,
   - Traffic capacity.

Data Processing, Presentation and Distribution

The Road Data Bank Unit makes extensive use of GIS, since 1995. New data are loaded, updated, selected, sorted, checked, summarised and printed, twice a year.

The other way of data processing and displaying is by using software called the Road Property Administrators Data Bank (RPADB). It is intended for Road and Motorway Directorate offices and for Road Administration and Maintenance District Divisions and it contains all necessary data. RPADB is created with the help of GIS tools - MapObjects program environment. The program provides functions of scanning, selection, summarizing and printing. Furthermore, digital map is equipped with standard functions as zoom, pan, query builder (data searching and data graphics displaying), documents accessing, photos displaying, drawings, designing, implementing personal raster and vector user map levels, cadastral map etc.

Data Sharing

The Road Data Bank Unit has recognised that the key to realising value and benefit from their data, is the wide availability, sharing and utilisation of that data. The Ministry of Transport and Communication of the Czech Republic is currently the main user of the road and motorway Information System. data are also shared with data are delivered to the army, county offices, municipalities, police, other state administration offices, schools, engineering firms and cartographic firms. The data are offered free of charge to the state sector but the Road Data Bank Unit are keen to realise the commercial value of data, and sell data to the private sector. Road Data Bank Unit data are distributed to customers in map form or in digital form (i.e. on discs).

Future

The Road Data Bank Unit is keen to continue to promote and make reliable data available widely both within it's own organisation and by other users. They have already made significant developments in making data available – internally and externally – through the used of Web and internet-based solutions that allow more effective Data Management, maintenance and transfer. The target is consequently to establish central data warehouse for many users that will have possibility to use permanent or temporary Data Access from any place. Some users will have possibility to update and edit data. This comprehensive and flexible system for various types of users is based on client/server principles, using relational databases and the system will access all the data in the Road Data Bank Unit.

Lessons Learned

- The key to realising value and benefit from their data is the wide availability, sharing and utilisation of that data.
- Exchange within the public sector.
- Lack of common GIS standards for public sector data can limit opportunities for data sharing

Further Reading

Road Data Bank Unit data can be downloaded from www.rsd.cz.

Case Study 7 Development of Road Data Bank Unit and Data Management in Slovakia

Description This study describes the process of application of a central computerised administration of national road network technical data in Slovakia. Progress in Data Management (benefits, successes and failures), and problems concerning organisational issues, Data Ownership and usage are described.

Author Slovak Republic Road Data Bank Unit

Country Slovak Republic

Background The development of a Road Data Bank in Slovakia goes back to the time of the former Czechoslovakia, during the 1980s. A central Road Data Bank Unit in Ostrava (nowadays in the Czech Republic) was established, while the Institute of Road Management (UCHD) in Bratislava performed some activities such as data collection, and processing for Slovakia. The intention was to replace the old manual system of road records ('register') by a more sophisticated method of automated computer data processing. However, the expectations were not fully met, due to the slowness of this system on mainframe, as well as problems with data gathering.

The ambition to improve knowledge about the condition of the road network in Slovakia resulted in a state research project in 1990. The UCHD Bratislava in co-operation with the Research Institute of Transport, universities and other co-operators implemented this state research project titled 'Increase of performance and transport quality on the road network in Slovakia'. The main tasks were to define the Road Data Bank system to be used in Slovakia and to identify implementation requirements.

After the split of Czechoslovakia in 1993, Slovakia was no longer connected to the Road Data Bank Unit in Ostrava and established the Department of Road Management Informatics at the UCHD Bratislava. A Road Data Bank Unit responsible for data collection, verification, processing, software development, personnel training, testing of system, etc. was started in 1994 and became part of a newly established Slovak Road Administration (SRA) in 1995. In 1997, it was decided that the Register would also be covered by this new system. It practically meant that all the outputs and statistics concerning the performance of the national road network for the year 1997 and onwards have been produced and presented using the new system.

Business Context The development of the Road Data Bank started in 1994, with the main emphasis put on the development of a high quality reference system for the localisation of data. Inventory data on the entire network was collected, forming the basis for statistical reviews and technical condition reports on the network, for the Ministry of Transport, and other Stakeholders. This information has been mainly used to support decision-making processes in the fields of transport planning and road infrastructure management.

The Road Data Bank Unit's activities were widened following the establishment of the SRA in 1995. There was an urgency to introduce Pavement Management and Bridge Management Systems, and the Road Data Bank Unit focused on providing adequate inputs for the operation of these expert systems. This also resulted in a purchase of high-quality pavement diagnostics equipment, used for subsequent data collection and loading into

the Road Data Bank. These expert systems provided by Road Data Bank Unit served as a basis for dividing the budget among the individual regional Maintenance and Operation Depots.

Identified Problems

Despite meeting many of its original objectives, central support for the Road Data Bank Unit is weaker than it used to be. In general, the Road Data Bank Unit is considered to be of high quality, operated with simple software tools but still to have a low usability, and this view was confirmed by foreign consultants. Regional take-up has been below expectations. Awareness of the importance of data and Information Systems is still insufficient, and it has not been possible to quantify financial benefits of having good-quality data available at all times. The majority of managers view the existing level of information sufficient for supporting the present SRA business. They are reluctant to consider the development and introduction of new sophisticated Information Systems given the large financial and time resources needed without quickly noticeable benefits. The technical terms and interpretations, etc are not well understood; there is a reluctance to share data and unclear rules for data quality.

Future Developments

In the context of Slovakia, and the Road Data Bank Unit, supporting legislation is regarded as being very important. The Road Act does not deal with the topic of the Road Technical Register sufficiently, and operational regulations are missing.

- Review Road Data Bank Unit and Data Management in relation to Business Plan of the SRA
- Implementation of Information Management Policy and standards,
- Systematic project management for the development of unified Information System within the SRA covering all business activities, and further development of the Road Data Bank Unit as an Information Centre
- Development of GIS system, as a tool for effective data handling and its geographical interpretation,
- Increase in data quality, quality of localisation, data transmission and expansion of database in order to support the SRA Business Plan.
- Consider procurement of some activities via contractors in co-operation with external specialised companies

Lessons Learned

Based on experience and knowledge from the development of the Road Data Bank Unit in Slovakia we have found that it is necessary to:

- Prepare legislation, technical standards and regulations in advance
- Consider starting with most important data throughout the whole road network, which can be quickly put to use in practice
- Clearly define users, particularly their demands and needs, and prioritise data to be collected accordingly
- Be prepared for the inevitable changes in the ways of thinking and working, which are not always welcome and popular.
- Create a steering committee, consisting of Road Data Bank Unit representatives, as well as users,
- Define competencies and responsibilities within the Road Data Bank Unit,
- Position the Road Data Bank Unit's operation within the framework of overall road management,
- Define options, processes and conditions for gathering necessary data,
- Provide accuracy of data localisation as well as proper data quality,
- Supply effective software tools for data administration,

- Improve usability in presentation of data and outputs,
- Define clear rules for providing data, and its necessary level of quality.

Case Study 8 The Management and Exchange of Traffic Information in France

Description

This Case Study describes the development of a system for the management and exchange of traffic information in France. The Case Study identifies the issues associated with the exchange of traffic information between a wide range of organisations.

Author

SETRA

Country

France

Background and Business Issues

Since the beginning of the 1990s, the different Traffic Information Centres (TICs) in France have used different dedicated software applications for different tasks without having any true exchange capabilities. There was indeed no true global Information System.

There are seven regional TICs; each covering an area of 7 to 20 départements, forming an overall network steered by the national TIC. The TICs have existed for more than 30 years.

Two particular features of the TICs are:

- They are managed by three different ministries involved in road traffic and safety
- They have two main functions:
  - Provision of traffic information to end-users and authorities
  - Traffic coordination in case of incidents

The key objectives of the project were:

- The data collection had to be cost efficient and had to improve data quality and coverage
- The system had to help authorities make decisions more quickly and safely
- Even if the expression was not used at the time, the system should tend to become 'real time'. However, it was decided that traffic data collection should be excluded from this project as it was covered by a parallel project launched at the same time.

Data Analysis and Modelling

As the software had to integrate with all the activities and needs of each TIC, one of the first tasks was to define a global Data Dictionary, (each existing software application possessed its own data definitions). This involved firstly defining a geographical reference, and secondly developing an event-oriented Data Model, which defined the Attributes for each entity and the relationships between them. As this Data Model had to be shared by both national and regional TICs, its development required a consensus to be reached between all users.

The road network covered by the system also had to be defined (around 60,000 km roads including all the national road network and the most important local roads) along with the roles attributed to police services (accidents, traffic jams) and to local units of the ministry of Transport (road-works). One of the issues was to partly automate the input of data coming from external systems (for example, those used by the Gendarmerie Nationale).

Design and Implementation

The design approach was to base the system around a common shared GIS and data. This approach would support the requirement of the organisation to allow rapid conversion between any existing referencing systems. As the Ministry was not able to create and maintain a proprietary solution and, at the time, the national geographic institute (IGN) was not able to provide a suitable data source, a market-based geographical data source was chosen: the Michelin map database. This data source was immediately available and provided regular, efficient updates and improved data quality. The scale range allowed by this map is around 1:250,000.

There were a number of design issues:

- As most of the information collected by a TIC arrived by phone or by fax, there was a need for manual input by an operator. To help the operators, a rich interface was designed to help minimise gaps and inconsistencies.
- The system also had to accept messages produced by Gendarmerie with the minimum of translation. This organisation had its own system with a specific referencing method, ('axe-commune' i.e. road and community) less precise than other modes like markers.
- Another key issue was to ensure that both national and regional TICs shared the same data. A database synchronisation mechanism was implemented As the synchronisation rate was low, the transmitted messages had to be compact, which implied the use of very compact location referencing and abbreviated attribute names. The implementation of such a system would encourage precision and concision.

There were a number of implementation issues:

- This project was very ambitious and thus required a long time to implement. In fact, the objectives of the different participants were different and inconsistent. Thus, it was sometimes difficult to reach a real consensus or an agreement on the design choices. This resulted in very (and perhaps too) complex software with a lot of rarely used functionality and significant variation in the level of utilisation.
- These differences also led to inconsistencies in the Data Model itself. For example, the referencing method for a lane closure for cars (which uses two points) is different from that used for lorries (one point and an application length).
- To achieve the very ambitious objectives, the decision was made to use what were, at the time, very innovative technical solutions: relational databases, GIS with real time performance and object-oriented design. On the other hand, this approach meant that market availability of suitable software solutions was quite poor. This explains why some now obsolete software solutions were adopted.
- Another drawback has been discovered concerning the development of the Data Model itself. As the model was developed during different design stages, inconsistencies were introduced in the model.

The system has now been operational for more than seven years. Some new features, not foreseen at he beginning, have since been afterwards which have been appreciated by users.

Ongoing Development

Since the software development, the technical and operational environment has changed. New requirements have been identified, leading in the same direction: integration, data sharing, and real time Information Systems. A very

strong impact has been given by the DATEX exchange format and the European Commission is strongly encouraging the setting up of a TIC network over the whole of Europe. Such a network requires common concepts and especially a common Data Model and Data Dictionary. As a first step, a gateway was developed for translation between data Dictionaries. Thus, the French TICs are able to exchange with others in Spain or Luxemburg for example. Nevertheless, the situation is not ideal because, after translation, some data are missing or misrepresented and the communication architecture becomes very complex and even unstable.

Amongst all these difficulties, a specific item has to be highlighted: location referencing. To locate an event is a basic task for any road data system. Each country has one, or maybe several, defined referencing systems, the concepts of which are more or less compatible. Therefore, a common system has been adopted: Alert-C locations. The system should be able to translate local referencing systems into Alert-C points and vice versa. As there are also other proprietary systems in existence, the translation need becomes greater and greater. Such a system has been designed, using very comprehensive conversion tables. An alternative solution could be to use a GIS but, in this case, the system would need to know XY co-ordinates for each referencing system and the conversion may be more complex. Finally, yet importantly, the road network often changes and all these systems must be kept update.

Following all the consideration, the Directorate for safety and road traffic decided to build a new coherency framework for traffic information called SDIR (Schéma Directeur pour l'Information Routière). This framework is currently been drawn up based on services offered to motorists, and other users, and in partnership with the different members of the supply chain. A very strong choice has been made to abide by standards where they exist. The prominent role of DATEX (dictionary and specifications) has been pointed out. However, it is not sufficient to be confident that all the people involved in traffic information can understand one another. As well as a Data Dictionary, there should exist a guide explaining, for example, what is actually meant by a road closure and how to encode a roadwork in a common and consistent way.

Another principle is to be pragmatic. It is unrealistic to try to provide true real-time information everywhere and about all types of event. Hence, it may be more realistic to provide real-time information for a subset of events (the most relevant ones, defined with some mandatory Attributes) coming from a restrictive road network (more or less TERN plus some stretches of road along motorways and some very important routes). Moreover, the deployment of such a system is likely to take 10 years.

The consequences of these developments on the current Information System are very heavy and it may need to be completely redesigned. Currently, an architectural study is in progress and should be finished by this year. This study should clarify the required Data Model, the data exchanged by the different partners and the location referencing methods. The first pieces of software should be available within three years.

Lessons Learned

- The use of a global Data Dictionary and Data Model enables data to be exchanged between different systems and different parts of an organisation but problems can arise when trying to account for the views of all parties.

- The adoption of innovative technical solutions can mean the use of untested or soon-to-be obsoletes software.
- To avoid falling into disuse, the system needs to be kept up-to-date and in step with the needs of users. It is likely to be more efficient if this is done in an ongoing way rather than waiting until significant changes are needed.
- Location referencing is the single most important issue to be resolved if data exchange is to be effective.

References

More information about DATEX and Alert C is available on the DATEX website http://www.datex.org/.

Case Study 9 Performance Indicators

Description

This case study describes the framework for the development of Performance Indicators (PIs). The benefits as well as the usefulness of PIs are described and discussed. The connection to the location referencing system of the road network is also described. Examples of PIs and their definition, as well as their data requirements are also described. This case study provides only a brief overview of the concept of PIs because their development is ongoing both in a number of individual countries and in the European Union itself.

Author

Sub-Group TERN

Country

International

Background

In most European countries, the task of developing a set of Performance Indicators for the road network is taking place. These PIs are, of course, of National and regional level interest within each country. Several developments highlighted the need for the Western European Road Directors (WERD) to develop a coherent set of Performance Indicators describing the performance of the Trans-European Road Network (TERN). One of the objectives is to facilitate a transparent evaluation of proposed projects to improve the TERN (e.g. for the evaluation of financial contributions from the European Commission).

In WERD Subgroup TERN (SG-TERN), a comprehensive project within all contributing countries is in progress to define and describe a set of Performance Indicators appropriate for use at a European level. Co-operation between the two WERD Subgroups responsible for TERN and Road data will make it possible to combine the data collection and the use of PIs.

Implementation

To enable high Quality Management of the PIs at a European level, it is important that the respective National Road Administrations fully accept the Data Management routines and collect the necessary data as well as analysing and presenting the PIs.

Another important factor is the definition and implementation of a robust and consistent referencing system for the road network. The development of and appropriate network topology is essential for the use of PIs. This item is discussed in more detail in Appendix 3.

Also important is the tool for presenting the PIs. Today, one the most preferable tools is a GIS. On the market there are several suitable GIS including ArcView, MapInfo, etc. Of course, some of the PIs will be presented in the form of spreadsheets and other documents.

The Benefits of Performance Indicators

PIs can be very useful within the planning process for the development of a road network. By the use of PIs, the National Road Administration can easily describe the condition of the road network in terms of a various parameters such as speed, accidents, accessibility, etc. This analysis is also relevant on the TERN.

On a European level, every two years an Implementation Report is produced that describes the implementation of decisions about the TERN. A Revision Report is produced every 5 years that reports whether the Guidelines should require revision. In the both cases, the need for robust and reliable PIs is

essential. At the strategic level of long term planning it is important to define a set of goals and policies for the further development of the road network, both on a National level as well as on the European level e.g. TERN. For these purposes, some of the PIs can be used to measure the impact of actions taken on the road network e.g. the value of the PI from year to year.

The selection of projects on the road network needs a transparent method of evaluation. PIs are one of several tools that are used to describe the impact and benefits of one selected road project compared with another.

Examples of Performance Indicators

In order to develop a method to develop these PIs in a structured way, a framework needs to be developed, which enables PIs to be derived from policy objectives, as described in policy documents such as the Guidelines and the White Paper. Concepts from different policy frameworks can be used. E.g. concepts from the perspective of the different partners involved such as EU-policy, national policies, users of the road networks and road administrators. In addition, concepts from the field of policy analysis are used such as policy objectives, policy instruments and external influencing factors. Furthermore, many concepts from the field of transport are used. The development of a method to create an appropriate framework for selecting PIs is being undertaken by the WERD SG-TERN.

Many PIs can also be useful at a national level. The table below represents a selection of a long list of PIs, considered useful at a national level. An estimated relevance at a European level is also indicated. The list is not complete and is only used as an example.

Descriptor	Description	Indicator	Level
Travel time	Travel time from origin to destination	Mean speed	EU
Traffic Safety	Traffic safety on TERN	Accident rate	EU
Congestion	Congestion on the TERN	Hours of congestion	EU
Reliable journeys	To avoid congestion, varying journey time etc.	Variation in speed	EU
Comfort	Level of service e.g. petrol station, parking lot with toilet, restaurant etc.	Number of services per km road	EU
Environment	▪ Reduction of emissions ▪ Reduction of noise ▪ Secure water supply	Emissions Noise level Distance to the road	EU
Accessibility	Travel time to important centre e.g. hospital, airport, railway station, commercial centre etc.	Mean travel time.	Nat.
Road capacity	The capacity of the road	Number of km where the traffic volume is more than 75% of the capacity.	Nat.
Road Information	Road users access to relevant information and experience of the road by using road user survey.	Number of satisfied road users.	Nat.
Quality of transportation from road user point of view.	Road users expectation and experience of road maintenance.	Number of satisfied road users.	Nat.
Quality of transportation from the road system point of view.	The quality of the surface to the road	Number of km with IRI > 4 compared to total road length.	Nat.
Economic	Cost for new constructions, maintenance etc.	Cost in Euro per km road length.	EU

Required Data

In order to satisfy these descriptors and PIs, it is necessary to have good quality data related to the road, including the area surrounding the road. The following table describes the data needed for some of the descriptors. Some will be more difficult to define than others. The table represents a selection of some of the Data Items that must be determined and defined and is intended to serve as an example. From a Data Management point of view, it is clearly important that all Data Items are clearly described and that these descriptions, and the data availability, have been agreed by all national Road Administrations.

Descriptor	Data Item
Travel time	▪ Road type ▪ Road length ▪ Travel volume ▪ Measured speed
Traffic safety	▪ Road length ▪ Traffic volume ▪ Number of fatalities
Congestion	▪ Measured speed at free flow ▪ Measured speed at congestion ▪ Number of congestion hour
Comfort	▪ Road type ▪ Link length ▪ Proximity of the rest area to the link in the road network. Distance from a node or the x y-coordinates.
Environment	▪ Traffic volume ▪ Measured speed ▪ Emissions and noise calculated by mathematic model from value and composition of vehicles and the speed.

Future Developments

The future development of PIs must be focused on the following steps: ·

- Close examination and understanding of the goals and policies concerning the transportation fields, both on a European as well as on a National level.
- Understand the demands of road users that could have some significance to the PIs.
- Identify and clearly define the descriptors and PIs that are derived from the goals and policies
- Carry out a 'benchmarking' exercise in order to assess the PIs within the planning process and to determine their usefulness. Remove a PI if not useful
- Examine and define the required Data Items for each PI ensuring agreement from all parties on data definitions and data availability. If necessary, go back one step and redefine the descriptor and its associated PI.
- Define the rules and processes (including quality and currency requirements) for the measurement and collection of the Data Items
- Define and determine the tools for storage of data, analysis and presentation of data

- Define and determine how to use each PI, especially how to present in an understandable way. Any limitations or qualifications should also be clearly understood. This will be important to the upcoming Implementation and Revision Reports of the TERN

Some of these points have already been discussed earlier in this document, as they are part of the development of a Data Management Regime.

Lessons Learned

Many lessons can be learned throughout the activities concerning the development of Performance Indicators: -

- Do not underestimate the time needed to examine and understand the goals and policies of an organisation. It requires a lot of time, especially the time needed for dialogue with policymakers
- Try to keep the number of PIs as low as possible. Too many will require a lot of effort for data collection, storing and presentation of the data
- Make the PIs as simple as possible. They must be understandable enough to be used within the everyday activities of the Road Administration
- Comprehensive dialogues and co-operation between the PI development team and those responsible for data collection. Otherwise some of the suggested PIs could be difficult to realise if the data is unavailable
- From the beginning, have a clear picture of how the PIs are going to be used and what the limitations of the PIs are. This will avoid inappropriate definitions and unnecessary data collection

References

- Working documents from the 'Performance Indicators' study performed by WERD SG - TERN, 2000 - 2002. Mainly document 02-005 dated 20 February 2002.
- Working documents from the Swedish National Road Administration's activities for the development of Performance Indicators.

APPENDIX 3 - SPECIFIC ISSUES RELATED TO ROAD DATA

Context

Much of the principles and good practice of Data Management could apply equally to any organisation. This chapter seeks to address Data Management issues that are peculiar to road-related data, and to consider how good Data Management can be applied to Road data, focusing in particular upon Road Network Referencing, Geographic Information Systems and map-based interfaces and upon so-called 'Real-Time' or highly time sensitive data.

Road Data Groups and Coverage

The road Data Types held by both national and local Road Administrations typically include Data Groups (or 'domains') identified in the Table below[9]. These have been drawn from the European Road Data Dictionary which was produced to support the exchange of Road-related data between western European national Road Administrations by defining and agreeing common data definitions that could be adopted by all participants, or to which local definitions could be defined using the RADEF tool. The Case Study in Appendix 2 describes the process by which the European Road Data Dictionary was defined. For the purposes of this document, the European Road Data Dictionary is significant because it illustrates how co-operative, international Data Management can facilitate the exchange of data between Road Administrations. This adds value to nationally held data, through summarisation and international reporting, for example, to provide summary statistics on the TERN network to the EU.

Data Group (or 'Domain')	Example Data Items	
Road Network	National Road number Road Section type	Road Section reference Node references
Restriction	Restriction type	Restriction direction
Traffic	Traffic Flow Vehicle Type	Traffic Flow type
Structure	Structure Structure Function	Structure Type Structure Location
Equipment	Equipment detail Equipment location	Equipment item Equipment type
Accident	Accident Type Weather conditions Vehicle Type	Person in accident Vehicle in Accident
Condition	Road Condition	Road Condition type
Road Geometry	Grid Point Arc Point	Grid Type Arc Position Type
Route	Country National Route Definition National Route Type	European Route Definition European Route Type

Table 7 - Road Data Types

[9] *Of course, a Road Administration will hold a wide range of data other than that directly related to the roads for which it is responsible, such as financial, salaries and administrative data, all of which could benefit from Data Management.*

Road Network and Locational Referencing

A Road database or Management System of any kind must relate its information to the physical network on the ground. This is a very practical principle and ensures that cross-referencing of different Data Types, the spatial location of road-related information, and analysis over time, as well as space, can be achieved. This subject covers two *key principles*:

- The conventions used for network labelling and description; and
- The locational/spatial model used for uniquely placing and identifying data to its position on the network

Although not every type of data owned and managed by a Road Administration will need to be location-referenced to the network, the majority *will*. It is not an over-statement to say that a good network and location-referencing model will form the successful basis of every subsequent data set and application introduced by the Road Administration. It is very important therefore, to establish the right principles for setting up a network referencing model.

The principles of establishing a robust network and locational referencing model are to:

- Establish rules for referencing at the outset that are rigorously applied even when the network changes
- Adopt a locational referencing model that suits the type of network under consideration
- Ensure that the owners of different data sets all subscribe to the common network model, if sharing of data is a requirement
- Establish clear ownership of the network-updating task, and ensure that this is regularly enforced

Organising Spatial Data

Roads, like other natural features and manufactured Assets in the environment, are located in geographical terms by systems of co-ordinates. In this way, they may be portrayed graphically (as a map), or analysed geo-spatially (for example counting the number, length or areas of a feature). The organisation of road-related data in this way has proved very powerful for technical experts, political representatives and the public alike. With the development of specific computer software to deal with data that possess these spatial qualities (called *Geographic Information Systems* or GIS), it has become even easier to organise road data in this way.

Network Topology

Topology is the study of geometrical properties and spatial relationships, and as such is relevant to the spatial description of a road network.

In general, road network topology is *two-dimensional.* In some instances, a *three-dimensional* model (that is, including height above a datum such as sea level) can be justified, but the complexities that this adds to data handling and integrity usually rules it out in practice.

Network Topology involves the study of:

- Point features (such as junctions, bridges, etc.)
- Linear features (such as the roads themselves, which are usually represented by a single string of points, forming a centreline or edge line)

- Area features (such as areas of grass verge, or the area within the legal highway boundary)

Road network topology may stand alone, containing all the information likely to be needed when representing the road-related information. However, with the advent of GIS, it is now much more common for road topology to co-related to other topological features such as rivers, coastlines, railways, and buildings. Virtually all road network models are now based on a variant of the basic link-and-node concept (line and point topology). Issues can arise when roads are modelled differently (across boundaries, for instance), and when connectivity is not made explicit between different parts of the network (between motorways and local roads, for example).

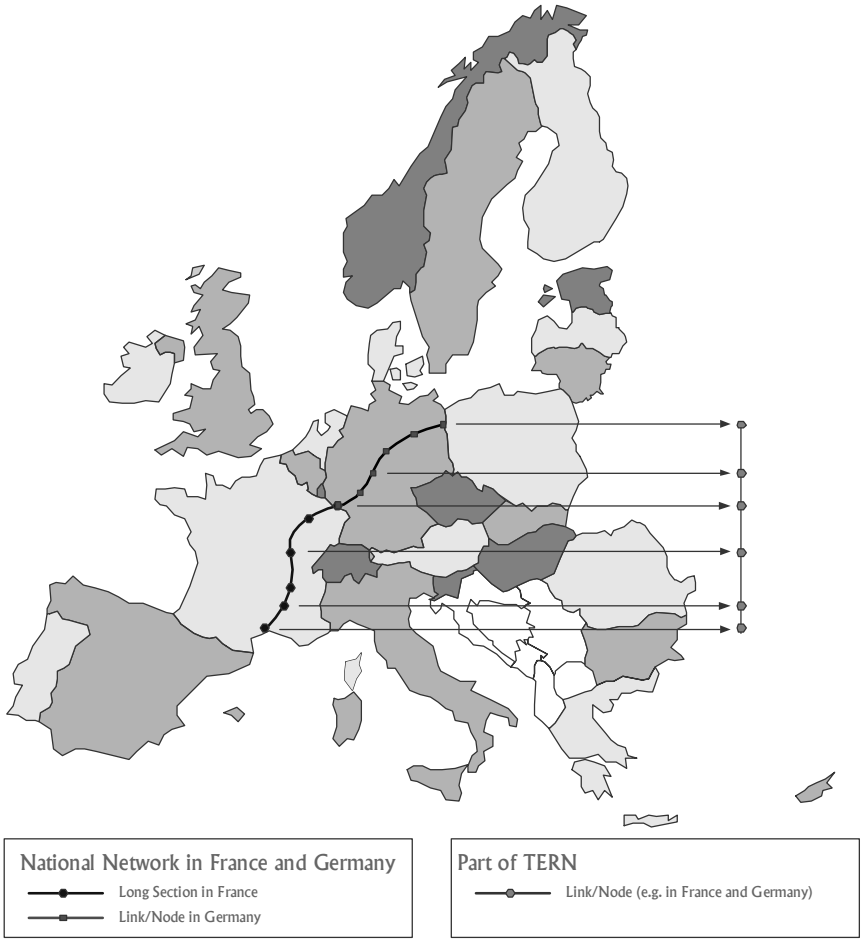

Figure 11 - Some Networks can cross boundaries (E.g. TERN Link crossing a national boundary)

Building a Conceptual Model of the Road Network

Development of a road network model is an important and integral part of building the Corporate Data Model (see Step 3). This covers not only data definitions and formats related to the network entities, but also the important relationships (including topological concepts) linking the elements of the network.

The development of both a Spatial Data Model and conceptual referencing model for the road network are essential pre-requisites for the effective management of all road-related data sets.

Defining the boundary of this model is important, as this will be unique to each Road Administration, given its jurisdiction and responsibilities on the road network as well as its geographic location.

Updating the Network Model

Never are the issues of Data Currency and integrity more prominent than in the context of the road network data itself. It is therefore crucially important that **a Road Administration intending to implement an integrated management system should place a high importance on the maintenance of its underlying network Data Model.**

Resolution and Accuracy

When considering data related to spatial location, there are many issues of *locational accuracy* to be considered. This is often confused with '*resolution*' – the smallest measurement capable of being recognised by the system. In Data Management terms, it is important to decide at an early stage what level of resolution spatial data will be captured at, and this is usually governed by the scale at which output has to be reproduced and the availability of suitable survey equipment and methods. Accuracy, on the other hand is more about 'correctness' and should ensure, or example, that roads join other roads at the correct point in space.

Network History

It is fundamental to achieving a system with a high level of integrity, that the model must be capable of embracing the natural course of change in the built environment over time. This is actually not as easy to achieve in practice as it initially sounds. It requires skilful Data Modelling in the first instance, and then rigorous application of the updating regime for the network, co-ordinated with the updating of associated data sets. History addresses the important issue of Data Currency – without which a system is likely to lose its entire credibility.

Special Considerations for Geographic Data and Digital Mapping

Geographic Information Systems

For Road Administrations, Geographic Information Systems (GIS) have the potential to serve case handling and decision-making in a way that is not possible when using traditional databases. Seen from the user's perspective GIS is simply using a map as a means of easily accessing information in the database and from this to make decisions. Road technicians and road users have always used paper maps and will continue to use maps for road-related tasks - the habit is so ingrained that they are not always aware of this fact. As Information Technology develops it is natural that use of maps will increase in the digital world too.

Benefits of using GIS in a Road Administration

Except from the fact that use of maps are unavoidable in many occasions what then are the main reasons to use GIS within a Road Administration?

At least four can be highlighted:

1. Easy interpretable presentations of information from Road Information and Management Systems

A road is characterised by being a very long but narrow element where the details in geometry, pavements, surroundings and other information vary all the time. Retrieval in table format is usually difficult to interpret when requiring an overview of a given situation, e.g. pavement condition of the road network in a given region.

However, if the information is presented on a map in a simple way the case handler only needs a moment to get an impression of where condition is good and where it is not good.

2. Easy access to information by using geographic location methods.

Experiences show that traditional road databases require superior user skills when retrievals are done from the system. Other users who do not use the system every day have difficulties in setting up queries using specialist query languages to select the roads and associated information.

A GIS provides tools which makes its easier to select the roads; for example, the user may click on a road or draw a rectangle around the road and road segments which are to be included in an analysis.

3. Potential for combining road information with other geo-referenced data

GIS provides the possibility to combine road information with information from other areas such as land use, environmental and demographic issues, area development plans etc. This can be more or less sophisticated depending on the level of data integration, where the simplest way is to overlay one theme on another.

4. Introduction of new methods of analysing road information

A characteristic of GIS is its ability to do analyses that are not possible in a traditional road database. Examples include overlay analysis and buffer-zone analysis, which can answer questions such as 'How many people are affected by traffic noise within a distance of 200 meters from the road?'

A specific kind of analysis is the *dynamic segmentation*, which is an important feature for systems doing analysis on line-orientated objects like roads, railways and the like.

In a GIS, geographic objects carry information in a way that descriptive information are stored in database tables and the objects in the geographic part of the system. Often the commercial GIS-systems link occurrences in the database directly to geographic objects. This way of linking eases the geographic analysis.

In the case of roads, it would require that a road is divided into segments of finite length and then each segment is linked to occurrences in the database. This approach does not hold in practice because the descriptive information along the road are so detailed and vary so often that the necessary number of segments to be created are infinite and this is not manageable for any system.

Instead, the segmentation of the road is done on the fly based on the exact content of the query in question. If as an example a traffic GIS-analysis is required, the road is segmented according to the actual values of traffic data in the database and then transferred to the GIS-part of the analysis. Here the segments are provided with spatial coordinates, linked to traffic numbers, and, depending on user-defined intervals of traffic numbers, colours to the segments are selected and the analysis is then presented on a map.

Definition of GIS

There are many definitions of GIS. One is that GIS are computer-based systems that are used to store and manipulate geographic information where location is given directly or indirectly by spatial coordinates.

A road data bank is a database, which contains information that have a well-defined location in the form of road number, link number and chainage. The distinction between a GIS and a road data bank is narrow. If the road databank is provided with spatial data in a way that all data can be geo-referenced, the road database has developed to be a GIS according to the definition.

Data Management issues relating to GIS

GIS contains enterprise-wide information and consequently the principles for Data Management described in other chapters are valid for GIS. In practice the management of the digital maps, and the combination of a spatial reference system and a road reference system, adds further dimensions to Data Management of GIS-based road databases.

A Road Administration does not usually deal with mapping activities except from the specific detailed mapping of a corridor around existing roads and new roads in the design phase.

When a Road Administration embarks upon the implementation of GIS, the normal procedure is to buy a background map and to establish or to improve the geographic representation of the roads in the database. The latter is done by defining a centreline representing the road and assign spatial coordinates to fix points (markers) and to intermediary points between the markers. A variant is the case where the Road Administration also purchase the road centreline from a map provider typically from a company or an agency, which has surveyed the road network for other applications (routing and the like).

Because the map and the road database often have different accuracies and often use different road models, problems might arise due to the following situations when purchasing a digital map:

1. The background map does not include a road layer.

If the background map and the centreline in the database are not calibrated, it is very often the case that the resulting GIS-presentation shows roads running through buildings and though other objects located near the road. The problem is cosmetic but for non-technicians this causes confusion and affects the decision making process. One way to avoid the problem is to go through a cartographic editing of either the background map or the road centreline or both. Another possibly more expensive way is to purchase a map based on the same spatial reference system and with the same accuracy as the centreline in the road database.

2. The background map includes a road layer but not a road model.

A common used way of purchasing background maps is from mapping agencies, which are able to provide all kind of traditional maps digitally. Such maps very often contain a road layer including a representation of the network of the given Road Administration.

This situation might cause similar problems as mentioned in the previous example supplemented by the problem that the GIS-presentation will have two 'pictures' of the same road network which do not coincide but cross each other randomly.

3. The background map includes a model of the road network.

This is often the case when the map is purchased from a mapping vendor that also provides data for navigation and route guidance purposes. If the model is close to the model for the centreline in the Road Administration database, the actual implementation of the map will be easy and beneficial. However, if not it must be foreseen that a major task in combining the two models to a mutual data structure has to be carried out. The reasons for that vary from case to case but one of the most common problems is that nodes are defined and placed differently in the two models. Junctions and intersections might only be represented by one node in the Road Administration database but in the map, several nodes are used to describe the very same junction. Another example is that the map might contain two centrelines - one for each carriageway - where the carriageways are physically divided by a barrier/rail whereas the Road Administration database represents the road by one centreline. In these situations, the necessary work to combine the road models might be very time consuming.

4. Data exchange

Map data are often delivered in accordance with a formal or an informal standard. However, some standards accept different interpretations and in these cases, problems arise when the exact format of a dataset is not defined explicitly before the delivery process starts.

Not having prepared concrete specifications will lead to costly data maintenance activities following implementation of the map.

Anchoring the reference system (centreline) from the PRA-database in the digital map

A well performing GIS on road data requires a good connection between the road model in the database and the spatial description in the map. The task is to combine a line-orientated road reference system with a linear object described by spatial coordinates in a map. This requires that fixed points in the road reference system are identified in the map and then a set of spatial coordinates are assigned to the fix point (known marker, node or alike).

Experience shows that this process cannot be made fully automatic but decisions from an operator are needed through the whole process. The process also must include algorithms (or decisions) which deal with the often seen occurrence that the distance along the centreline between two fixed points in the database are different from the geometric distance which can be calculated in the map. In hilly or mountainous terrain, the dynamic segmentation analysis also needs to consider this fact. It is difficult to establish a GIS where the actual and mapped distances are exactly the same and in practice, it is impossible to maintain this state.

Future trends concerning GIS

The commercial GIS-tools that are in operation today are to a certain degree proprietary systems, which store the geographic information and the links to the descriptive information in their own standards. This has several reasons. One is that until now the available technology has forced the vendors to develop their own standard in order to deliver products with an acceptable performance.

From the users point of view this situation is not beneficial because it reduces the possibility of being somehow independent of a specific GIS-tool. It also forces the Road Administration to acquire the data in a way that is not efficient from a general viewpoint. On the other hand, on-going standardisation in the GIS area, and development in database techniques, have come so far that the current situation will change in the future. The first version of a so-called 'Open-GIS' standard is defined and some of the leading market vendors have released the first version of relational geo-databases, which can be accessed - in principle - by any GIS-tool.

Real-time Data

All data has a currency and validity. Most data held by Road Administrations will be gathered, processed, analysed and stored over a considerable period, and small delays in this handling will not affect the validity or usefulness of these data. This is not true of near real-time or real-time systems. Examples of such systems are traffic monitoring and control systems, incident detection and response systems and driver Information Systems.

There is no clear distinction between systems at either end of the spectrum of real-time systems to those that process information infrequently, say even, annually. However, the demands and criticality of real-time and near-real time systems require careful consideration. Close examination is required of the currency of data and how ageing data affects the reliability of the system. This enables system parameters to be determined that illustrate when a system's results cannot be considered reliable or valid. These boundaries are often set within the scope of a Service Level Agreement that details what the expected normal and minimum performance levels of a system or process are. Service Level Agreements often have multiple service levels that define what is expected under different levels of system degradation or during different processes.

In addition to the currency of data, operational and real-time systems have special consideration concerning error checking and the handling of erroneous data. Error checking must be performed in real-time (or rather close to real-time) such that the degradation of the system or some of its input data are handled in a correct and sensible manner in the real-time context. Error-checking itself adds additional processes into the normal cycle of operations performed by real-time systems; these make the overall process larger and more complex and therefore careful consideration is needed about how much error-checking should be undertaken, what data it requires, and how that affects the overall performance of the system.

For example, with real-time dynamic speed limit control (which links monitored vehicle speed, to variable message signs to enforcement systems, such as is found on the M25 to the west of London), how should the malfunction of a vehicle speed monitoring station be detected, and then what happens to manage a graceful degradation of the system? Does the loss of data or erroneous data from one monitoring station cause the system to fail or be globally inaccurate? This degradation process requires planning during the design and testing of the system.

APPENDIX 4 MEMBERS OF DRAFTING GROUP

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