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ABSTRACT

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To C6 Technical Committee on Road Management
Session; Management and Administration of the Road System

Getting what you expect from Road Management Systems – putting Data Management on the map

The authors describe in this paper the development of the *Best Practice Guide on Data Management for Road Administrations*[1] which they have been involved in on behalf of the Deputy European Road Directors (DERDS) Group. The paper highlights the benefits which the adoption of the Guide can offer a Road Administration, from whichever continent or country, or at whatever stage of data and systems development.

Even in well-developed countries and road administrations, there is a growing recognition that the full benefits of management systems are only realised when the data underpinning them is relevant, complete, up-to-date and without major errors. While improvements in the quality of data collection have multiplied in recent years, there is a more fundamental issue which is more often overlooked – the act of data management itself. There can hardly be a Road Administration in the world which can say that its data is managed in an ideal way. As a result, the authors argue that users are often not getting what they expect from their management systems.

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[1] 'Data Management for Road Administrations – A Best Practice Guide', published by WERDS/DERDS 2002

When the Road Data Sub-Group of DERDS reviewed available published material on data management, they found it seriously lacking, and in particular found nothing of direct relevance to the roads industry. The Best Practice Guide which has subsequently been produced draws on a wide range of experiences from a number of countries, and the knowledge and experience of several experts, to arrive at a practical set of procedures and practices that, if implemented should realise many benefits for a road administration. A summary of these is given in this paper.

The paper starts with a definition of Data Management and describes why it is such an important discipline in ensuring that data are contributing positively to the organisation's aims.

The paper goes on to deal with Data itself – how it supports all business aspects including the technico-economic aspects of a public administration.

Different Data Types are described, how they align with the organisation's business and how a logical approach to Data Modelling can assist in maximising the use made of data.

The Best Practice Guide describes '7 Steps to Good Data Management', and these will be covered in a very practical way in the paper. Examples will be given from several countries and types of Administration.

To conclude, the paper will suggest the steps towards implementing a Data Management Regime in a Road Authority and how to focus on delivering the benefits – in other words, getting what you expected from your management systems through better organisation and management of the data underpinning it.

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Introduction

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 paper is based upon the work carried out to prepare the publication *Data Management for Road Administrations – a Best Practice Guide*[2] recently carried out on behalf of the Western European Road Directors (WERD) organisation. The paper covers the definition and relevance of data management in the business context of road management. It highlights the benefits which the adoption of these best practice principles can offer a Road Administration, from whichever continent or country, or at whatever stage of data and systems development.

There can hardly be a Road Administration in the world which can say that its data is managed in an ideal way. This means that, following the frequently-quoted maxim, 'Garbage In – Garbage Out', users are often not getting what they expect from their management systems.

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[2] 'Data Management for Road Administrations – A Best Practice Guide', published by WERDS/DERDS, Sub-Group Road Data 2003

Several practical issues, highlighted by experience from a range of European countries, are addressed in the paper, with the aim of preventing repetition of the problems found in implementing management information systems in the roads context.

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 – and turning *data* into useful *information*.

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 the data?

How much is the data worth?

How critical are they to the core activities of our organisation?

What decisions and Business Processes do they support?

Do we *need* to hold all these items of data?

What do the data *mean*, in terms that are understandable to the non-specialists that make use of the data?

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

It is important to recognise that, just as all organisations collect and hold data; all organisations should have Data Management Procedures and Standards, albeit developed to a greater or lesser extent. It is likely that much 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 basic 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. Data Management is therefore about the life cycle of every item of data, and also the roles that people take at different stages in the process, This is illustrated in Figure 1. It is perhaps surprising that in many Road Administrations, these basic roles are never clearly defined or allocated.
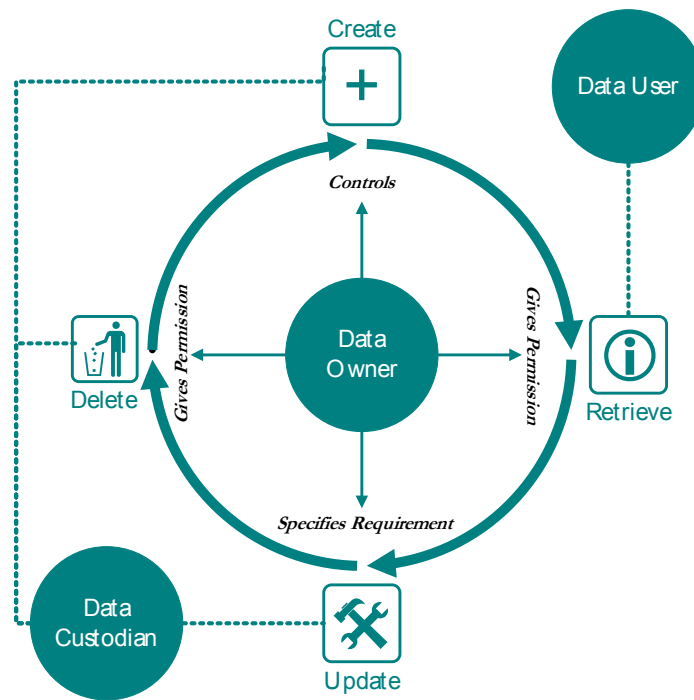
Figure 1; Data Life Cycle and Management Roles

What is often better appreciated within an organisation is that data are often out of date, of poor quality, duplicated or redundant. It is also often the case that old or superseded data are simply never deleted or archived – highlighting another of the basic reasons why good data management needs to be put in place.

Data and its relevance to Road Administrations

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 in its data is not just the cost of collection, but also the inherent value of any derived information to the organisation. Data may also have commercial value, and some Road Administrations are already exploring ways in which their knowledge of, for example, road traffic conditions might be exploited.

It is not realistic to say that an organisation can choose *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
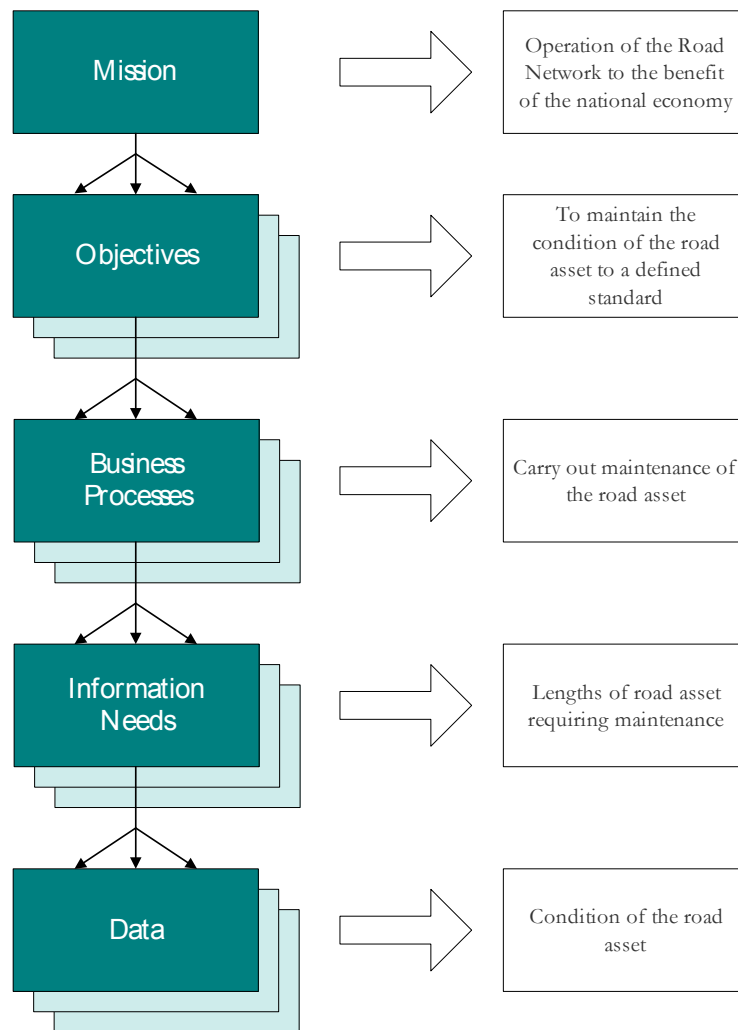
Figure 2; Relating Business Requirements to Data

To gain an understanding of the data owned or managed by a road administration, it is necessary to carry out an analysis of the data types and items within each type. As an example, generic data types (or 'domains') identified in the European (RADEF) Road Data Dictionary were;

Road Network, Restrictions, Traffic, Structure, Equipment,
Accidents, Asset Condition, Road Geometry, Routes

More detailed examples of data items within these domains are given in the Best Practice Guide, and the data analysis process is further described in the 'Seven Steps' below. The process by which the lowest-level data items become transformed into *information* which in turn supports *processes* and these, at the highest level support the overall objectives or mission of the organisation, is illustrated in Figure 2, with examples at each level shown in the boxes on the right.

The Best Practice 'Seven Steps'

When producing the Best Practice Guide, the authors felt that it would be important to provide practitioners with an easy-to-implement set of steps to assist them in improving their Data Management. This took the form of a 'Seven Steps' approach, illustrated in Figure 3. These steps are founded on good business practice, where 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. A summary of each step is given below, while a fuller description may be found in the Guide itself.
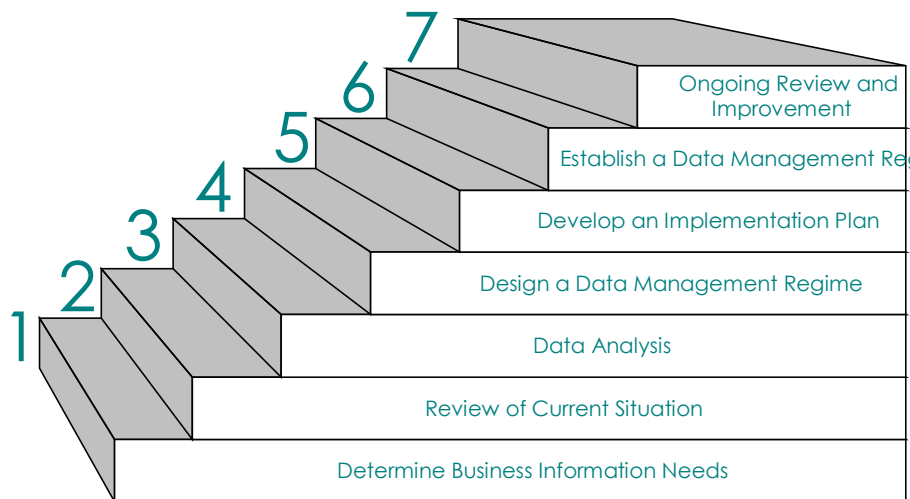
Figure 3 - The 7 Steps to Successful Data Management

Step 1 – Determine Business Information Needs

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 legal 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 business aims of the organisation. The 'Step 1' analysis of the business and organisational background will identify;

- Organisational, functional and system boundaries

- Flows of information, and broadly, the data needed to support decision making

- End users of data

- Overlapping and redundant processes

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Step 2 – Review Current Situation

In Step 2, the organisation assesses and understands the current situation in respect to its data and determines how effective any current Data Management Procedures are. In the Best Practice Guide, a comprehensive 'Data Management Health Check' is provided, which may act as a basis for this exercise. In addition, as a means by which the high-level data may be related to business functions, it is suggested that a table is drawn up identifying which general 'data domains' are used by the different business functions (similar to that shown below). This exercise will also help to identify areas of overlap, data duplication or redundancy, and any systems that are essential to be retained after any review (often referred to as 'legacy systems').

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

Table 1 - Example of the use of different Data Domains by different Business Functions

Step 3 – Data Analysis

The function of Data Analysis is to understand the Data Items, and the relationships between them, as well as more detailed understanding of the processes that they support. It is a specialist technical task and many Road Administrations may decide to employ an analyst to carry out this step for them.

The analysis should be comprehensive, including all data types held. These will generally fall into one of the categories shown in table 2 below.

During Data Analysis, data items ('entities'), attributes, types (text, numeric etc.) and valid ranges, will be identified and a Data Model documented, using a standard technical notation, to describe the relationships between items. In addition, data ownership and custodianship should be defined. It is assumed for the purposes of an Engineer or Road Manager, they will not require detailed knowledge of these methodologies, and so this paper will not describe them in any further detail.

The comprehensive Data Model for the organisation is known as the Corporate Data Model, and is a key document in determining the next step towards good Data Management.

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 Category	Description	Examples	Audit Requirements
Operational Data (Rate of Change of Data Values: HIGH)	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
	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
	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 (Rate of Change of Data Values: LOW)	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
	Meta Data	Data that describes data	Data Dictionary	

Rate of Change of Data Values (vertical axis: HIGH at top, LOW at bottom)

Table 2 - Data Types

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[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.

Step 4 – Design a Data Management Regime

In Step 4, a specific Data Management Regime for the organisation will be written, and this will involve at least the following activities:

- Determine the scope of the Data Management Regime, and relate this to the organisation's 'Information Environment'

- Determine implementation priorities for each Data Type

- Identify Legacy Systems

- Identify risks and actions to manage those risks

- Produce an implementation programme for Data Management

- Identify costs and benefits associated with the application of Data Management to each data type and to their associated systems and applications,

- Establish a programme for data Decommissioning, and for changes to data collection arrangements

- 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'

- Determine a minimum level of quality, access and service for data and applications

In the Data Management Regime, the following will be described;

- Roles assigned to individual people in respect of each Data Type; Owner, Custodian, User (as illustrated in Figure 1)

- Mechanisms for data creation, collection, updating and deletion /decommissioning

- Mechanisms for data storage and retrieval, and for ensuring consistency of data

- Mechanisms and standards for sharing and exchange of data on a consistent basis

- Mechanisms for defining and promoting the business-relevant meaning of data

When considering the Data Management Regime, it is worth bearing in mind that the scope of data covered may be wider than that owned within the Road Administration itself. This may mean that the Regime has to make reference to interfaces with external systems and data.

Step 5 – Develop an Implementation Plan

Once a Data Management Regime has been designed, the next step is to plan its implementation. The organisation must accept the need for change, and the appointment of a Data Management Sponsor who will promote the benefits of the new Data Management Regime to the business is key to this.

The implementation plan will identify;

- 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 some data that are currently collected

- Decide to collect some data that are not currently collected

- Decide to allocate, or reallocate ownership of data

- Change the way that data collection is procured, outsourcing where necessary, and improving the quality specifications written into contracts

- 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

Step 6 – Establish a Data Management Regime

In this step, the Implementation Plan developed under Step 5 will be put into practice, and this should be actively managed as a project answerable to the Sponsor. If required, a formal project management methodology may be adopted, including Quality Management aspects as necessary.

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Step 7 – Ongoing Review and Improvement

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.

The Data Management Health Check questionnaire, described in the Guide, 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.

Implementation in Practice – Some Examples

The Best Practice Guide contains nine case studies of data management in European Road Administrations, including two collaborative European projects. These are briefly listed in Table 3 below, and for more detail readers should refer to the Guide. It is interesting to note that, even in advanced and forward-thinking organisations, lessons are constantly being learned of how to improve data management, resulting in better data quality, more reliable systems and ultimately, better decision making.

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.

Table 3; A summary of European Case Studies in the Best Practice Guide

Conclusions

The Best Practice Guide produced by the Road Data Sub-Group of DERDS draws on a wide range of experiences from a number of countries, and the knowledge and experience of several experts, to arrive at a practical set of data management procedures and practices. 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.

In this paper the authors have described the practical steps towards implementing a Data Management Regime in a Road Authority and steps to be taken to realise the benefits – in other words, getting what you expected from your management systems through better organisation and management of the data underpinning it.

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