Asset Information Management Strategies for the Railways

K V Venter and M.R. West,

Quillion Ltd, UK and Shell Services International, UK

SYNOPSIS

The paper outlines the basic requirements of an asset information strategy that will be able to support effective and economic infrastructure management. It describes the methodology and technology required to underpin such a strategy and draws on the experience of the petrochemical process industries. A specific example is given of a major facilities development using the strategies described and points out the economic and other benefits flowing from the adoption of modern asset information management. Some current initiatives in the rail industry are mentioned.

1. INTRODUCTION

It is becoming increasingly important in the management of large infrastructure assets to increase the effectiveness of the maintenance and optimise the replacement/refurbishment decisions. This pressure arises from increased scrutiny by new owners and providers of capital (which includes government, where international markets and taxpayers are constraining inefficient spending). The rail industry is no exception.

The integrated nature of the assets gives the rail industry a unique sense of unity, across corporate and organisational boundaries, even if these boundaries still impede the efficient operation more than they should.

Technology and methodologies are now established which make infrastructure-wide full-lifecycle asset information management feasible and economic:- in fact make it essential for the achievement of performance levels being demanded of rail industry.

2. CHARACTERISTICS OF THE PROBLEM

Following the privatisation of British Rail, a significant part of the UK Rail Industry changed from being a single monolithic organisation, into a group of interacting companies, within a regulatory framework. This has produced companies that have a clearer business focus, but that also require collaboration between them to deliver a service to rail passengers.

The natural focus for these relationships is the infrastructure owner, in this case Railtrack. They are responsible for making the infrastructure available for trains to operate, and for directing trains over the rail network in a safe and timely manner. The infrastructure owner must interact with various parties over the life of the infrastructure. During the pre-design phase they must identify demand for a new line or upgrading of an existing line with train operators. They must deal with design and construction contractors and rolling stock and systems suppliers to meet the requirements. They must then make the rail system available for safe use by train operators, and maintain the infrastructure on a daily basis, through maintenance organisations.

Although there are many players, the infrastructure remains one, inter-connected whole. The safe and efficient operation of the network does not easily allow for fragmentation in any of signalling, planning, maintenance, renewal or safety.

However, the change in structure noted above acts to highlight the relationships that always exist between different parts of any rail service, whether run as a single entity, or as a set of interacting organisations.

3. CHARACTERISTICS OF THE SOLUTION

The essential characteristics of an effective asset information management strategy must recognise this dynamic and multi-layered structure of the industry. It has to ensure that the asset information captures the unity of the infrastructure: the information of the entire network and the whole life-cycle of all it parts, while allowing effective regulation and competition (where appropriate) and maintaining appropriate confidentiality and security.

3.1 Structuring of Asset Information

Figure 1 gives some visual representations of ways to structure information about assets, assemblies, systems and networks. The asset information strategy must reflect the multi-layered nature of the infrastructure. This extends from individual items (assets), through assemblies and systems, through to the entire infrastructure. These items, assemblies, systems and networks must operate safely and effectively together. This involves designers, manufacturers, contractors, operators and owners.

The segmented square in Figure 1 shows different break-downs or hierarchies flowing from a unified classification system. The break-downs typically comprise standard views:

- a systems view (types of thing or system) e.g. a transformer or signalling system
- a supplied system view (a unified suppliers' catalogue of equipment both current and past (and future) from which to pick at the design and purchase processes) e.g. a type ES/23 transformer rated at 10kVA, accepted for deployment, supplied by ElecCO
- a tagged location view (the association of a required function with a physical location), e.g. the points machine at location BAG1 10.1365
- an asset view (the actual physical thing installed or previously installed or to be installed at a tagged location) e.g. Minimel Automatic Track Safety Circuit serial number 12/435/98-1 active between 1/3/88 and 25/4/98 at a tagged location

The diagram nick-named "Canary Wharf" in Figure 1 visually shows how this classification system is used to find assets or information about assets. The grid is a representation of all tagged locations between the time boundaries under consideration. The cubes represent actual assets (no two can occupy a single location/time square simultaneously, but different assets can occupy a location at different times). One can locate an asset or information/documents about it stored in the engineering data store or document drawer by navigating down appropriate the break-down structures, and at any point in the hierarchy, all relevant information is indexed.

The network will generally be broken into geographic regions/zones, and specific projects will need to cross these boundaries.

The assets will naturally group into systems elements, such as power supply, civil works, communications, etc., which need to be managed in appropriate ways, sometimes crossing geographical or systems interfaces. These interfaces should not introduce unsafe or uneconomic barriers. Another way in which the assets will group is by "effective owner": i.e. the group or individual which is responsible for the actions that will change or examine the asset in the current time window.

All these hierarchies will change with time, and this essential element must be catered for in any asset information strategy.

3.2 Full Asset Lifecycle

It is important to capture the full lifecycle of the asset (Figure 2) in an information management strategy. This includes the assets, structures, systems and networks mentioned above. We need to do this so that we can make informed decisions about maintenance and replacement, and learn from experience in implementing systems, so that we can alter them and improve them at low risk.

3.3 Common Industry Business Model

An industry business model identifies the activities and information that are necessary to deliver services to the end customer (the fare paying passenger).

This is particularly important when the industry is divided into companies with discrete roles that need to work together effectively. However the industry is organised (either into companies or divisions) an industry model identifies the interfaces in both business and information terms.

3.4 Common Language

Each computer (and indeed human) system has its own data model and codes for the things it deals with. These represent the "language" of the system. Unfortunately it is unusual for any two systems to speak the same language, so when communication between them is required it is necessary to translate between them – you need interfaces. This is complicated when the interface crosses company boundaries.

There are two basic approaches to solving this problem: the United Nations solution, and the international business solution.

The United Nations solution means that each system outputs its information in its own language, and every other system that uses that information translates it into their own language. For n systems, the number of translators required is anything up to n x n.

The international business solution is that everyone translates into a common language even though it may not be the native language for any of them. The number of translators required here for n systems is n, a significant reduction, especially when one considers that n is typically in the 100's or 1000's.

So in order to communicate efficiently within and between different parts of the industry efficiently, it is necessary to have a common language for information, and particularly computer interpretable information (data). This needs to cover terms, and in particular, the codes used to indicate the types of things of interest in the industry. A common data model for exchanging data is also necessary, and provides the backbone to the language.

This does not mean that the applications that create or use the information must be standardised, but that there is confidence that the information they create or use is complete and accurate.

A key issue beyond the basic language, is the identification (names) of particular things, e.g.: a bridge, a set of points, a station; so that when information is brought together from different systems, or moved from one system to another, then it is clear what the information is about.

An efficient way to achieve this is to have an Asset Information System that manages the key asset data, and makes it available in a consistent way to all those systems and organisations that need it.

3.5 Multiple, Parallel Information Structures or Hierarchies

Whilst a common meaning for data is important, each application is designed to serve a particular purpose, and needs a particular view of the world to support that purpose. This means that a comprehensive asset information system must be able to cope with these different views of the same thing(s). This requires that the solution must be able to cope with multiple, parallel data structures or hierarchies. The system must also be able to cope with conflict and manage ambiguity between such models.

3.6 Dynamic Data Model

A data model represents some of our knowledge of the world. Usually it is a fixed part of any system, and is expensive to change. However, our knowledge of the world does change with time, so whilst the things in our world stay the same, what we know (or need to know) about them does not.

Thus an environment in which the data model (structure or hierarchies and relationships, etc.) is able to change dynamically is a distinct advantage. This advantage can be acquired using a range of technologies, but relational database solutions have typically proved complex and expensive means, but often perceived to be the only option.

3.7 Secure Access and Disaster Recovery

There is a requirement to know and manage the creators and users of information. This requires a very fine degree of access control, down to single attributes of each object.

The ability to follow a full audit trail, and to recover from disaster, such as hardware break-down or systems failure is a prime requirement of any solution.

3.8 Incremental Change

Any solution must be able to make differences in the short-term. This demands that the methodology and technology employed must allow implementation of very limited, partial solutions in local contexts, while supporting the overall objective in the long term. Legacy systems must be able to be retained until appropriate change is due, but integrated into the unified system easily.

4. METHODOLOGY AND TECHNOLOGY

The Process Industry has been engaged in a decade-long process to achieve control of asset information, and the lessons learned are most apt to the Railways. The paper will briefly outline this experience.

Recent advances in object theory and software put solutions with the above characteristics well within reach, and have been implemented in challenging circumstances.

A key initiative is that known as STEP: an ISO Standard for the Exchange of Product model data. The Process Industry has developed a small number of STEP-based standard data models which are now being deployed to considerable business benefit on large-scale projects and asset management problems.

4.1 Technology and Architecture

Figure 3 gives a potted history of the development of information systems as applied to asset information. Early computer systems integrated the data and the programs (e.g. BASIC program). The introduction of database technology allowed the progressive separation of the data and the programs. Current relational database technology allows several applications to address a single database (client-server technology), but still requires assumptions about the data structure and management to be hard-wired into the database and applications design.

Figure 4 shows the modern development which separates the data structure from the other components and allows true flexibility to be achieved at the data model layer. This architecture allows legacy systems to be interfaced to the data model and management layer, absorbing and delivering data to the underlying databases serving the user. This achieves the transition to complete data management, with each asset existing logically only once, with all its associated information, but as far as the user is concerned it exists as it always has done in his application.

4.2 Process Industry Experience

In the process industries, owner/operator companies are increasingly aware of the benefits of acquiring plant design information in electronic form as part of the project deliverables, in order to improve performance of the asset throughout its life. Contractors have been using CAD (Computer Aided Design) and related systems for a number of years, but have been used to support a paper based, rather than data based, delivery of information.

The requirement to deliver design information as data, so it can be used and maintained electronically during the operational part of the plant life-cycle, has placed a challenge on the design and construction contractors to deliver asset data in a consistent and integrated electronic form. This is leading contractors to develop engineering data warehouses able to support the integration and consolidation of data from a number of engineering systems as a mechanism to ensure consistency and appropriate quality of data prior to handover. Some are looking to gain benefits in the design and construction processes from having the integrated data available to support the engineering activities.

Similarly, owner operators are identifying benefits that access to design data in electronic form provides for decision-making during the life of a plant, and improvements that can be achieved in maintaining design data consistently to reflect plant changes. The results of this are in optimised maintenance management (such as predictive maintenance and effective scheduling), reduced unplanned downtime, and the increased plant availability and effectiveness that results from these. In addition, during major shutdowns, consistency of information reduces construction errors, and hence reduces total shutdown time.

Data warehousing of engineering data requires the use of data models that are able to support the data management requirements that bringing together data from different sources and integrating them demands.

4.3 The Shearwater Project

Shearwater is a £1.5b North Sea oil development project. The Shearwater Alliance is a consortium consisting of Shell Expro, AMEC Process and Energy, and Heerema. The project involves all aspects of the facility, incorporating design, fabrication, hook-up and on-shore commissioning, installation, offshore commissioning and operation.

The project sought to hand over the design information for the plant in electronic form, rather than paper, and in as intelligent a form as is practicable. This process started with the development of the Shearwater On-line Document System (SODS). However, significant amounts of the information is data rather than documents, and this lead to the requirement to develop an On-line Data Dictionary System (ODDS) to integrate data from a number of different design systems.

4.4 Pre-Existing Situation

The design systems used included major packages for CAD, intelligent Piping and Instrumentation Diagrams (P&IDs) and Electrical Diagrams, and a number (40+) smaller systems. These systems delivered design information on paper. Typically, the same information was to be found in a number of different systems simultaneously and at different stages of the design and construction process.

4.5 Project Objectives

Business. The main objectives of the On-line Data Dictionary System were:

- Integration of data from a range of design systems to support:

a) Improvement of design data quality, especially duplication and inconsistency of data, and

b) Delivery of consistent data to construction and commissioning systems,

- Delivery of design data to the operations and maintenance phase in a STEP-based (international STandard for the Exchange of Product data) form to meet <u>contractual</u> requirements.

Technical. The technical objectives of the project were:

1. Develop an Engineering Data Warehouse to provide an integrated and consistent source of data,

2. Acquire data from the source systems and integrate the data from different sources about the same things,

3. Prove the potential of an Engineering Data Warehouse to deliver benefits in the design and operations phases.

4.6 Approach

Quillion's PETS product was chosen as the basis for the development. To undertake the implementation Shell Services International was asked to provide technical direction for the project, and to provide a team to support the configuration of PETS and the implementation of the necessary interfaces.

A learning approach was deemed to be necessary. It was accepted that it would not be possible to predict what would happen, and mistakes were to be expected. It was important to be able easily to make a change of course to reflect learning.

A key part of a project of this nature is managing risk. If a project of this scale is undertaken on a "Big Bang" approach, there is significant risk of project failure. The approach taken was therefore to "Think Big, Act Small":- whilst the grand vision was kept firmly in mind, development was undertaken as a series of self-contained phases. Each phase was small enough to be manageable, yet significant enough to deliver benefits in its own right. Each phase contributed to the overall vision, and acted as a foundation for later phases. With this approach, the risk was limited to a single phase, which, since it was tightly focused, was easier to manage anyway.

4.7 Results and Experience

Figure 5 shows the implementation developed.

The essential elements of the On-line Data Dictionary System that were delivered from this project are:

- An Engineering Data Warehouse implementing a STEP-based data model, using Quillion's PETS data management product.
- A number of browsers to access the data in the data warehouse.
- A class library.
- Semi-automated interfaces from a number of source systems that map and integrate data from a number of source engineering systems into the data model and class library of the engineering data warehouse. The master data resides in the source systems.
- Data loaded from the source systems into the data warehouse.
- Links were provided from ODDS to SODS.
- An intelligent P&ID has been loaded and linked into the warehouse demonstrating the potential of integrated drawings and data.

The many source systems tend to hold their data in relatively simple databases. The striking thing that characterised all these systems was that they targeted delivery of design information on paper, to be read by an engineer. This should not be a surprise. The business requirement has historically been for delivery of design data on paper for handover to the user. However, it is an indication of how much there is to do to move from a paper based to a data based paradigm.

For example, a text field might be used to hold data like "109KW". This results in it being difficult or impossible to develop interfaces that support incremental updates, as there is no capability to deal with changes in design data, or to flag updates. These cases were dealt with through the data cleansing process into the warehouse, separating the data from units of measure, and clarifying the metric system and making explicit the design context of the data.

The original expectation was that permanent STEP-based interfaces would be developed between each of the source systems and the data warehouse. Building a permanent interface means that a thorough understanding is required of the:

- data model of the source system,
- the usage made of the data model by the application, and
- the usage of the application by users.

To gain this understanding, temporary interfaces were constructed to the source systems in order to examine both the data model and the data stored. This activity proved extremely valuable, and resulted both in a clear understanding of the source data, and in discovery of defects in the source data that could have been costly if they had not been detected.

In the light of the shortcomings of the source systems in a data-based rather than paper-based environment, and given the cost of permanently interfacing them to the warehouse, only temporary interfaces were developed. A programme was started of managed replacement of these individual systems with applications that address of the warehouse directly.

4.8 Conclusions from Shearwater

There are a number of conclusions that can be drawn from this project.

1. The development of the Shearwater On-line Data Dictionary System is one of the first projects in the process industries aimed at delivering benefit from the investment the industry has made in STEP (ISO 10303 Standard for the Exchange of Product model data).

2. The technology to support Engineering Data Warehouses based on EPISTLE (European Process Industries STEP Technical Liaison Executive) style models is available, and from evidence of other projects, from more than one source.

3. Many engineering systems today are designed to support the paper-based paradigm for managing information. From the experience of this project, it is clear that to move to a data-based paradigm will require the redevelopment of many of the existing engineering design systems.

4. STEP was vital to the success of this project. However, it was not used directly, but indirectly.

5. INITIATIVES IN THE RAIL INDUSTRY

The rail industry has been characterised by a rather adversarial approach to contracts, with the infrastructure owners dictating terms and procedures, while being jealous of sharing information with contractors conducting maintenance or construction work. The different perspectives on information required by the owners and the contractors has become more obvious, requiring that both co-operate to establish data-sharing to achieve greater infrastructure productivity and whole-life effectiveness.

There are early moves to achieve consensus in the rail industry on the above strategy, and, in particular, to create a neutral forum for the agreement of a common information language (data model). The commitment of all parties is necessary to ensure complete success, as the solution must eventually serve all parties' interests. The major infrastructure owners, Railtrack and London Underground will be required to take a constructive leadership role, both in supporting the forum's activities and in additional funding and initiatives focused on specific projects. This association of the forum with active major developments in the infrastructure will provide pay-back for incremental investment in the short-term, while contributing to the achievement of the long-term goals of appropriate standardisation across the industry. The potential benefits to the industry are incalculable, and their achievement is necessary to ensure its prosperous future in harmony with the regulator and the government.

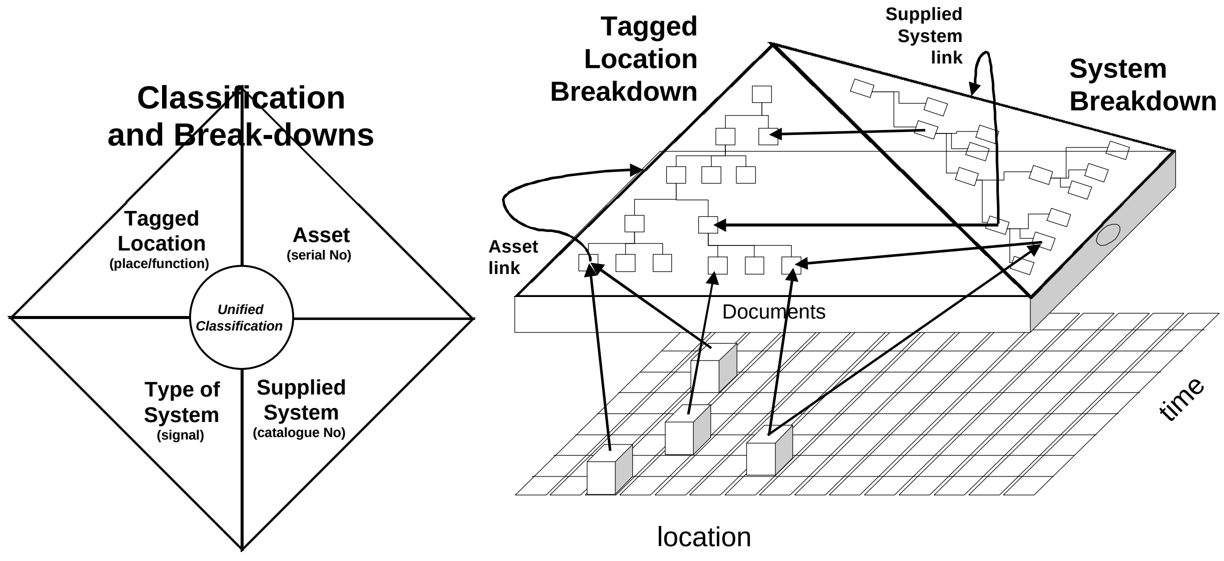

Figure 1: Asset Structures and Hierarchies

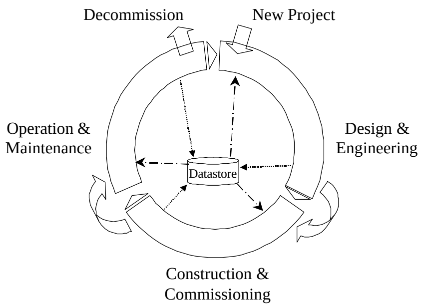

Figure 2: Asset Lifecycle and Information Store

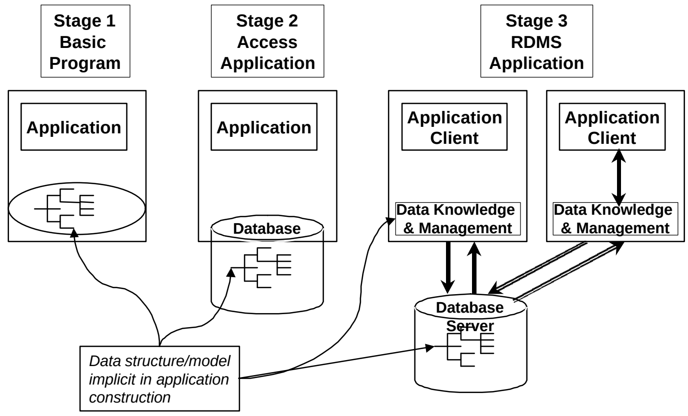

Figure 3: Application Architecture Evolution

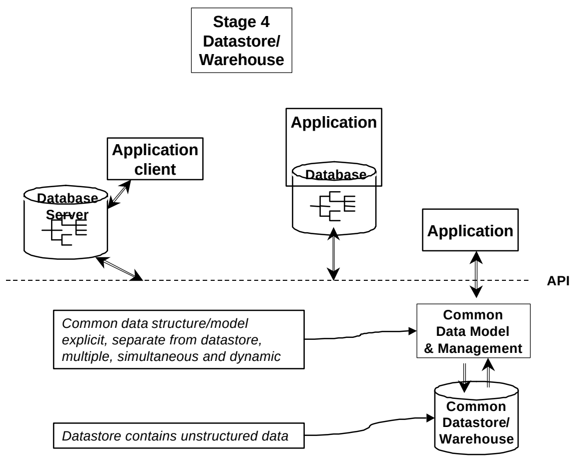

Figure 4: A Common Datastore Architecture

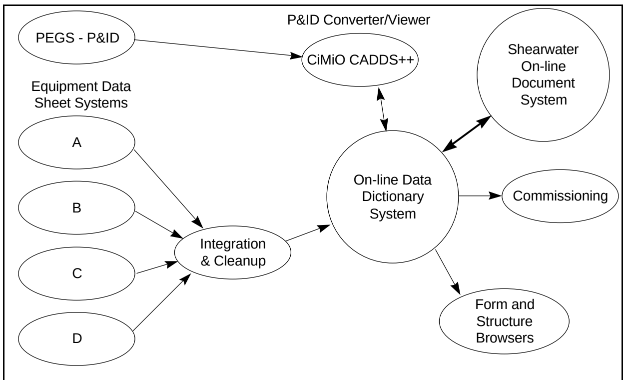

Figure 5: The Shearwater On-line Data Dictionary System.