Study of Methods of Sharing Information Handled at the Maintenance and Management Phase

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ABSTRACT: As a result of the rapid advance of information technology (IT) and development of CALS/EC in recent years, the MLIT (Ministry of Land, Infrastructure and Transport) and other organizations that order public works projects now deliver the results of survey and design work and completed work drawings as electronic data and can now directly handle information related to construction projects as electronic data. Of these, work at the maintenance stage is expected to benefit the most from the use of electronic information because it permits the collection of preliminary study, surveying, design, and execution information. And although GIS and other data bases are being constructed, data bases that have been construction and operated up till now have been constructed as separate systems that cannot share and link their information. Linking data bases is counted on to permit integrated handling of their information and linked searching and bloc updating of the data bases to increase their effectiveness among the project groups that have systems.

This report describes rules applied to share and link information in different databases so that their users can exchange their data and thereby synergistically receive the benefits of the electronic handling of information. It also discusses the effects of linking information by comparing present and future conditions based on a work process analysis.

KEYWORDS: CALS/EC, Maintenance and Management, Sharing Information, Electronic Delivery.

1. INTRODUCTION

In Japan, through efforts to introduce CALS (Continuous Acquisition and Life-cycle Support) /EC (Electronic Commerce), the MLIT has, since April 2001, approved and introduced the submission of the results of design work and completed drawings of work in a form prepared by recording CAD, application files, PDF or other electronic files on electronic media (electronic delivery) instead of on printed documents that include conventional drawings and written reports. This is counted on to permit project participants to easily use electronic data that has been delivered and to encourage the creation of data bases and data handling systems.

The purpose of the rules for data exchange proposed by this paper is to permit linking and sharing of data by carrying out the minimum level of improvement instead of reconstructing data bases when progress in data base development requires that information be linked and shared between a variety of data bases.

2. UTILIZATION OF INFORMATION AT THE MAINTENANCE STAGE: REQUIREMENTS AND CHALLENGES.

The maintenance of public works structures after the completion of public works projects is neither as automated nor as mechanized as work performed at the construction stage, with human labor accounting for most of this work. For this reason, inspection and repair plans, maintenance related plans, instructions, and records of work results are retained on paper (print-outs, etc.). As these stored records are prepared daily and their volume grows steadily, searching for and referencing past records in order to utilize them becomes an extremely laborious task. Therefore, we hope that recording these types of information in electronic form and incorporating them in data bases and data systems will increase the efficiency of searching, referencing, and other data processing.

Normally, converting paper records to electronic form is a laborious and costly process. The introduction of electronic delivery of completed drawings of work will permit electronically delivered data representing completed work and quality and construction

management that are work records to be registered in a data base to be used for maintenance without modification. Because this will simplify the task of converting the information used to electronic form, it is counted on to encourage the development of new data bases.

But because data bases and data processing systems are developed and introduced for the convenience of system owners and users, their development ranges and introduction periods vary. This results in the provision of a variety of finely demarcated data bases instead of the construction of single data base that can be applied to all work. Because these groups of data bases are developed by different developers, they are constructed as independent systems. When data bases are developed this way, the only restrictive conditions are the specifications demanded by the user, mainly regarding the screen configuration and functions, while the data base configuration and the data specifications are determined to suit the vendors. The key problem in developing a data base, particularly one used at the maintenance stage, is to find a way to simplify the preparation of print-outs. It essential that drawings and text prepared by a data base user during work conform with the print-outs and that they are processed efficiently until they are printed, but because data base users lack the specialized knowledge needed to know what form of data to use in order to realize this function, specific functions are not presented.

A characteristic of electronic data is that, unlike text information recorded on paper, it can be reused; not used only one time. For example, one data base can be accessed from another data base to search for and refer to needed information (electronic data) that can be combined, then displayed or output (Figure 1). Data in data bases must be shared and linked to realize this function.

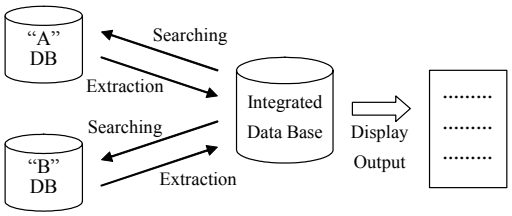


Figure 1. Linked and Shared Use of Different Data Bases.

But because the configurations and data specifications of different data bases differ as explained above, it is difficult to link and share data between data bases, so that electronic data cannot be used and the essential benefits of using it are not obtained.

3. DATA EXCHANGE RULES

To share and link electronic data in different systems and data bases, it is important to establish rules governing data exchange in a case where data is transferred between two data bases without prioritizing the structure of each data base or the methods each uses to process its data. This means that it is possible to develop a new data base that can easily share and link data by prioritizing its structure, but when dealing with an existing data base, it is necessary to carry out extensive modification to prioritize its structure and this is very costly. So when sending data to a data base whose data is to be linked and shared, if the data is exchanged after conversion to data that can be easily comprehended by the other data base, the data can be shared and linked with only slight modification of the data base and at low cost.

Specifically, the conversion function that operates when data is exchanged sets the rules for data conversion, and it is not necessary to develop an omnipotent conversion system.

Although an omnipotent conversion system can exchange data between data bases whose data are shared and linked at the time the systems were developed, a new conversion system (for example, version up) must be installed to exchange data with data bases developed at a later date, incurring new development costs every time data is shared and linked with a more recently developed data base. If data exchange rules have been established in advance, the data base is equipped with a conversion system that conforms with the exchange rules during development. And because the exchange rules also apply to a data base that is developed later, data can be exchanged without upgrading the conversion system, so development costs need not be incurred to exchange new data.

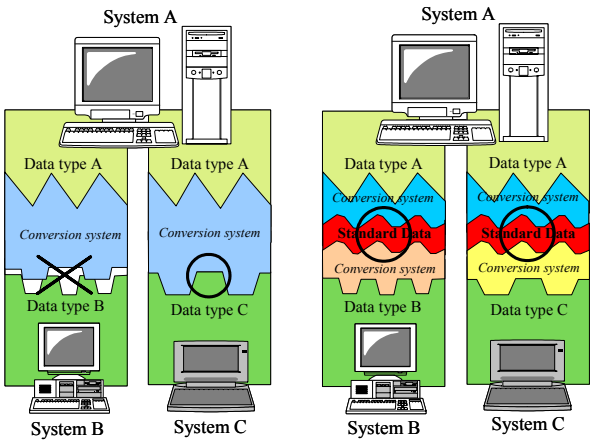


Figure 2. Image of Data Exchange between Data Bases.

Then what are the basic technologies necessary for comprehensible data exchange with other data bases? If the configuration and structure of the data that is exchanged and if the definitions and formats of the data elements are decided, data can be recognized even when it is exchanged. So as a way to visualize the configuration and structure of data and relationships between data, the application schema is assumed to be uniformly confirming the definition and format of data elements in element units and a data dictionary is prepared and stipulated, permitting data exchange necessary to share and link the data.

And if data exchange rules are standardized, it is possible for all kinds of data bases and systems to share and link data. The targets of the standardization are a conceptual data model that organizes all information used at the management stage and data exchange rules (application schema, data dictionary) prepared with reference to this model.

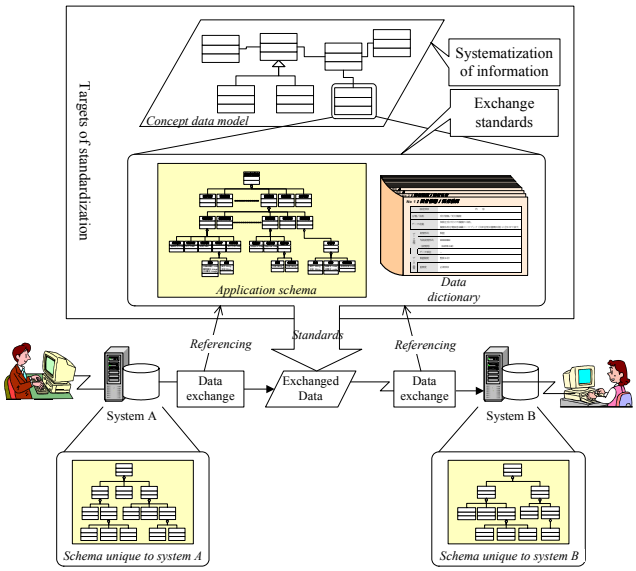


Figure 3. Positioning of Data Exchange Standards.

3.1 Application Schema

The application schema classifies the electronic data handled by the data bases and systems by category to present the stratified structure (hierarchical relationship) of the relationships and links between data. Because it can be used to visualize the form of data that could not be presented by the program language during data base development, it can contribute to mutual understanding between data base users (owners) and developers. Therefore, because the data configuration can be developed without dependency on the development (creation of a black box), data bases can be expanded to operate more efficiently even by other developers. Here the application schema is presented on a UML (Unified Modeling Language) class diagram.

And the application schema is discussed by the ISO/TC211 that handles GIS (geographic information systems). [1)]

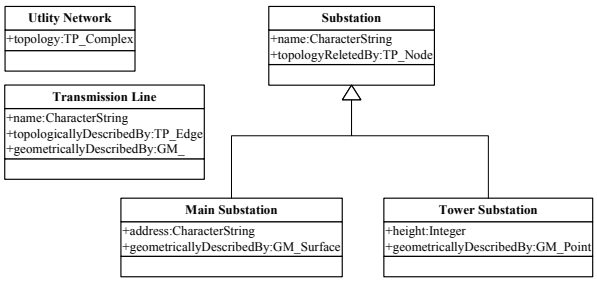


Figure 4. Example of an Application Schema (GIS)

3.2 Data dictionary

The data dictionary is, if we liken the data to a language, used as a translation function that allows data bases that exchange data to understand the meaning of each other's data. The contents of the data dictionary are data element names, definitions, formats, units, qualities, and relationships with the application schema.

And the data dictionary is discussed by the ISO/TC204 that handles ITS (Intelligent Transport Systems). [2)]

Meta Attribute	***Instance***
Data Concept Type	Value Domain
Descriptive Name	multiplicity
Descriptive Name Context	ITS/TICS
ASN.1 Name	Multiplicity
Definition	A representation of a range of integral values. The representation is intended be used with the Multiplicity property. Two special values exist for this usage, composite and transient-composite.
Source	UML
Keyword	
Remarks	Examples: composite transient-composite 0..5 5..10 3..* 0..* 1 5
Data Type	IA5String
Valid Value Rule	The value shall be a string of characters per one of the following four formats: "composite"- shall indicate that there is exactly one Data Concept instance of the subject element for a given paired element. In addition, the subject element is defined to be the owner of the paired element and is responsible for creation and deletion of that element. "transient-composite"- shall indicate that there is either zero or one instance of the subject element for a given paired element and when the state is one, the subject element is responsible for the delection and/or reassignment of the paired element. M..N - where M is an unsigned integer, .. is a string literal, and N is either an unsigned integer or an asterisk *, representing an unbound number. m - where m is an unsigned integer.
Format	
Unit	N/A
Standard	ISO 14817

Figure 5. Example of a Data Dictionary (ITS)

3.3 Conceptual data model

Almost all types of information handled at the maintenance stage in Japan are information items

and contents on print-outs. The print-outs are prepared for each necessary work unit (date, period, range, work type, personnel, etc.) based on a maintenance task and work categorization system. Because the contents of each type of task and work can be understand by referring to a print-out, there are many similar or related tasks and work that are similar to items on the print-outs. This means that although work has been systematically organized, information items are not systematically organized. Information must be systematically organized in order to standardize the data exchange rules.

The conceptual data model is a reference model that clarifies the scope of the standardization (range, purpose, effects, etc. of the standardization) of the types of information used at the maintenance stage. This means that the conceptual data model plays a role as an overall map (bird's eye view) to study the standardization range or to remove overlapping work when performing detailed standardization (preparation of the application schema).

It is prepared by systematically categorizing data on print-outs used for maintenance work considering the quality of the data, the work, person preparing the data, timing of the preparation etc.

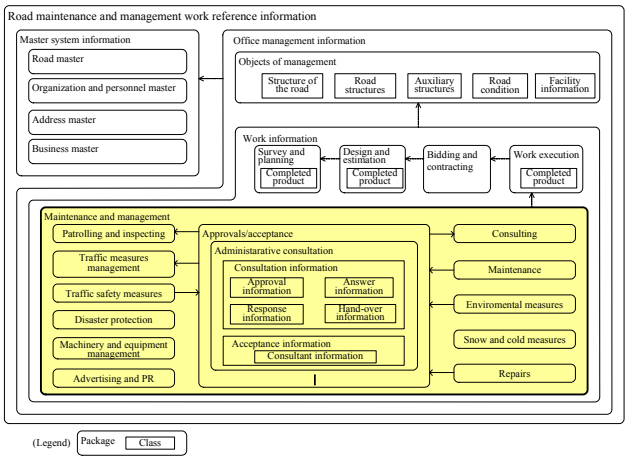


Figure 6. Conceptual Data Model (Birds-eye View)

4. CASE STUDY

Here, maintenance work using the data exchange standards is verified taking consultation with local residents, responding to and processing their complaints, and providing them with information concerning roads as a sample of processing work.

4.1 Services verified

Daily inspections of roads by road managers in Japan are performed about once a day. These inspections are generally done by inspectors visually examining the road from a patrol car, because of restrictions on the time the work can be done. It is, therefore, difficult to carry out detailed inspections. As a result, road managers are forced to receive, respond to, and process almost daily complaints about the roads from local residents and those who live beside the roads.

However, through hearing residents' complaints, consulting with them, and providing information, road managers are often able to obtain useful inspection information.

For example:

- Roads signs are hard to see because they are covered by roadside trees.
- Water is overflowing a roadside ditch.
- Cars crossing a joint on the bridge make a loud noise.

These and other complaints support tree trimming, roadside ditch cleaning, and other maintenance, and also support the planning of bridge joint replacement work.

Till now, the tasks involved in consultations with residents have included recording and storing the results on print-outs, but because it is troublesome and time-consuming to search and refer to the necessary records (information), it has made a very small contribution to planning maintenance. So various offices are now taking steps to convert records of the handling of consultations with residents to electronic data to construct data bases and systems. Where the goal is to reduce the quantity of print-outs stored (paperless office), the data base is constructed using a general purpose spread sheet application. And at work places where the goal is speeding up processing residents' consultations by searching for and referring to records of past consultations, the data base is constructed using a separately developed system suited to the flow of the work.

Because the number of consultations or complaints and the method of responding to them differ at each work place even though the types of information entered—requests for consultations and complaints from residents—are identical, the required specifications, development scope, functions, and configuration of each data base or system differ, and mutual links between data bases are not considered.

Using data exchange standards to link and share data between these data bases and systems would obtain the following benefits.

- If an upper level body with jurisdiction over many work places can transmit and receive electronic data to and from data bases at other work places, it can combine and refer to data, permitting statistical handling such as the categorization of resident's consultations, clarifying the state of their projects and supporting project planning.
- Work place A can, by exchanging electronic data with data bases at work place B, process its work more efficiently by searching for and referring to similar information.
- If the process of responding to a resident's complaint originally received by work place A has a ripple effect on work place B (example: construction noise), information can be shared during the process, so that work place B does not have to prepare initial data and data is not recorded more than once.
- It is possible to exchange data about residents' consultations and complaints in data bases with other maintenance work support data bases (example, patrol support data base) mutually improving the efficiency of work.

This service is shown in Figure 7.

4.2 Application schema, data dictionary

The data exchange standards that have been prepared by abstracting the data handled by this service based on a conceptual data model and by considering the process of responding to residents requests for consultations and their complaints and the way the data will be used are shown on the figures and tables described below.

The structure of the application schema was established by categorizing classes according to the situation that created the information (reception, approval, response, answer, hand-over) to simplify referencing from other services. Linkages between classes were constructed accounting for frequency and timing of data creation and for expandability to other services.

In the data dictionary, priority in naming the data elements was placed on names used generally nationwide as opposed to names used only in specified regions, and the attributes of the data elements were prepared with reference to road communication standards studied in the ITS field.

5. CONCLUSIONS

The data exchange standards proposed by this report will soon be applied to actual data bases in order to verify their usefulness and effectiveness. If the anticipated results are obtained, expanding them to other services in the future will be considered.

In Japan, social capital that are civil engineering structures (infrastructure) are generally provided and in the future, their maintenance and asset management will be the core issues. We hope that the data exchange standards will be indices used to create electronic information concerning maintenance in order to absolutely minimize the cost of this future maintenance work.

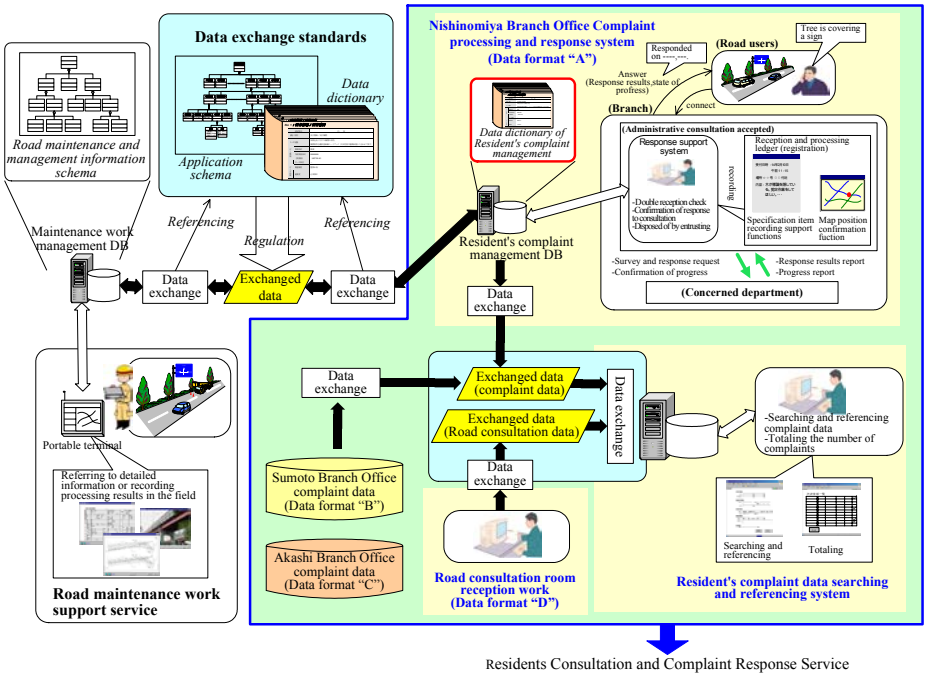
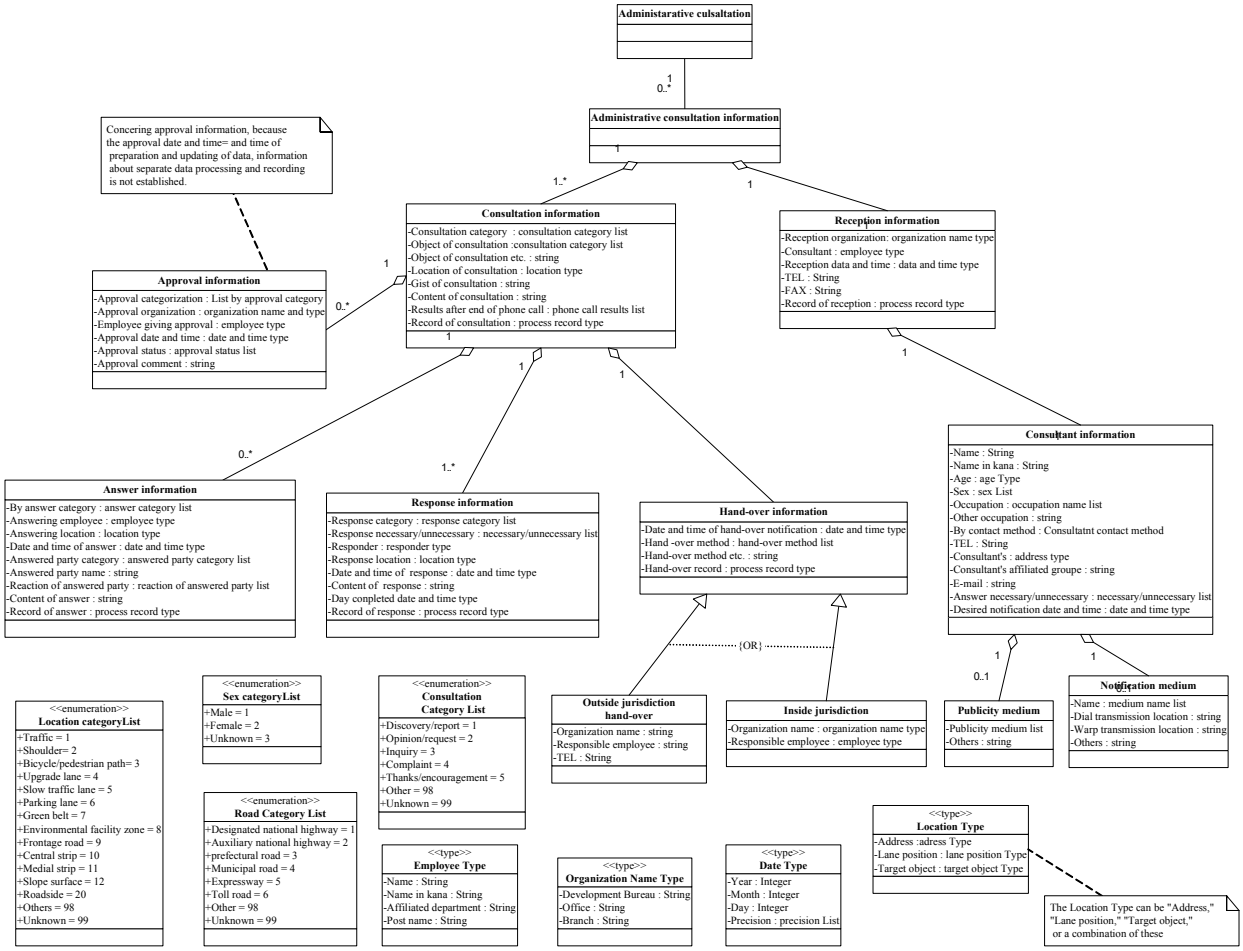


Figure 7. Image of Residents Consultation and Complaint Response Service Using Data Exchange Standards.

6. REFERENCES

1)ISO/DIS 19109, Geographic information – Rules for application schema. ISO/TC211

2)ISO 14817:2002, Transport information and control systems – Requirements for an ITS/TICS central Data Registry and ITS/TICS Data Dictionaries.



No	Class	Data item	Data definition	Data representation				Data quality	
				Data type	Internal representation type	Representation example	Data unit	Numerical precision	Importance
1	Consultatin information	Consultation category	Category of consultation content The category of consultation content is represented,matched to the following codes. 1)Discovery/notification 2)Opinion/request 3)Inquiry 4)Complaint 5)Gratitude/encouragement 98)Others 99)Unclear	Numerical	99	4	-	Two-delight integer	
2		Object of consultation	Location or item that is the object of the consultation represented, matched to the following codes. 1)Traffic lane or road surfeace 2)Accessory structure 3)Accessory facility 4)Sidewalk 5)Pedestrian bridge 6)Lighting 7)Sign 8)Guard fence 9)Roadside tree 10)Other structure .... 98)Others	Cleaning	99	2	-	Grass cutting	
3		Consultation location	Location where the consultation provided consultation(road lane, address, target object, etc.)	Refer to "Location type"	-	-	-	-	
4		Gist of consultation	Gist of the consultation received	Text	-	-	-	-	
5		Contents of consultation	Overall contents of the consultation received	Text	-	-	-	-	
6		Record of consultation	Date and time the consultation information was processed (recording and updating) and employee responsible for the processing	Refer to "process record type"	-	-	-	-	

Figure 8. Data Exchange Standards Suited to a Residents' Consultation and Complaint Response Service (Summary).