Case study: Statistics Canada

Statistics Canada is undergoing an agency-wide modernization initiative to promote organizational efficiency, increase robustness of systems and processes and shorten implementation time for new projects. One of the key principles guiding this review is: Create metadata at the beginning of every process and use them throughout the project life cycle. A working group with members representing all phases of the statistical business process has been developing a strategy for statistical metadata management and an action plan to support these principles. The goals being considered for the strategy relate to four themes: drive, make available, structure and manage. Actions required to implement the strategy are expected to cover:

- Establishing governance;
- Creating centres of expertise;
- Adopting standard structure and content specifications (including GSIM);
- Developing a metadata portal to identify authoritative sources of metadata and make them available to users, and;
- Identifying metadata gaps required to enable metadata-driven processes.

Current situation
The strategy for statistical metadata management and high-level actions are being reviewed by senior management. Implementation of activities identified in the action plan is expected to begin in spring 2013. This includes the adoption of GSIM as a recommended reference model for the Agency. Some of the anticipated challenges to implementing the strategy and GSIM include limited resources, on-going work, transitioning to a SOA and Government of Canada initiatives (i.e., Open Data project). Establishing governance, assigning a project manager to lead implementation and validating GSIM through a pilot project are key steps to realize a metadata-driven environment.

Metadata Classification
GSIM is being adopted to specify, design, and implement components that will easily integrate into “plug’n’play” solution architectures and seamlessly link to standard exchange formats (e.g. DDI, SDMX). It is important to note that GSIM does not make assumptions about the standards or technologies used to implement the model, which leaves the Agency room to determine its own implementation strategy.

Statistics Canada is beginning to use GSIM’s Concepts and Structures Groups as the main classifiers of metadata. These groups contain the conceptual and structural metadata objects, respectively, that are used as inputs and outputs in a statistical business process. The Structures group defines the terms used in relation to data and their structure. The Concepts group defines the meaning of data, providing an understanding of what the data are measuring.

Work focuses on aligning the new GSIM-based classification with other internal metadata classification models currently in use. For instance, IBSP identifies the following types of metadata:

- Reference metadata: Describes statistical datasets and processes.
- Definitional metadata: Description of statistical data (with meaning to business user community) E.g., concepts, definitions, variables, classifications, value meanings and domains.
- Quality metadata: Quality evaluation of a dataset or individual records; helps users assess the fitness of associated data for their specific purposes. E.g., CV, rolling estimates, analysts comments about the quality of a set of records.
- Operational metadata: links between the concepts and the physical data.
- **Processing specifications**: Capture, edit and output specifications and processing flags.
- **Processing results**: Content, outcomes, outputs of processing.
- **Paradata**: Data from the collection operation or statistical analysis used to support decision making in the survey process or statistical analysis. These include system logs, history files and comments.\[1\]

- **Systems metadata**: Low-level information about files, servers and infrastructure that allows the physical IT environment to be updated without re-specification by the end user.

\[1\] For example: analyst comments about their analysis, output of statistical processes; respondent comments, interviewer comments or additional information about the respondent obtained during collection.

## Metadata system(s)

### (a) Integrated Metadata Base (IMDB)

The IMDB is based on the ISO/IEC 11179 Metadata Registries and the Corporate Metadata Repository model (CMR). The metadata layer extends across all phases of the statistical business process and can support disseminated data, analysis, archived data files, and the planning and design of surveys. Metadata in the IMDB is beginning to be linked to some data warehouses, which hold both micro- and aggregate data; and can be potentially used for data analysis including data benchmarking and data confrontation.

### (b) Integrated Business Surveys Project (IBSP)

The business statistics program includes approximately 250 surveys and administrative-based programs. The IBSP was initiated in April 2010 to make use of shared and generic corporate services and systems for collecting, processing, disseminating and storing statistical information. Content for business surveys is to be harmonized wherever possible\[1\] and the approach to data analysis streamlined across programs.

### (c) The Common Tools Project

The goal of the Common Tools Project is to implement a harmonized set of processes and tools to support social surveys. The project is divided into two primary environments, the Social Survey Metadata Environment (SSME) and the Social Survey Processing Environment (SSPE). SSME uses four tools to feed information to and from a metadata repository. This allows metadata to be documented once and reused throughout the process to improve quality and generate efficiencies.

## Costs and Benefits

Detailed costs associated with implementing these projects are not yet available. Benefits from establishing the IMDB include more rigorous information and metadata management, harmonization and standardization of concepts, knowledge sharing and reuse of information assets.

The IBSP has incorporated good metadata management and is starting to integrate systems that are metadata-driven and that optimize the use of corporate services such as collection and methodology. Reuse of content modules, increased use of administrative data and the adoption of electronic questionnaires are expected to reduce micro-editing, standardize methods and processes and lead to operational efficiencies.

Creating a metadata environment (SSME) within the Common Tools project has facilitated the transfer of information between business processes through a suite of tools for survey documentation.

Overall, these projects are reducing system maintenance, development and training costs while improving sharing of standards and best practices.

## Implementation strategy

### (a) Integrated Metadata Base (IMDB)

The IMDB has been implemented using a "step-wise" approach with three development phases and future opportunities to re-use metadata and expand the IMDB metadata model to link to other information systems in the Agency.

Phase 1 produced a set of static web pages displaying data sources and methods for each statistical program and survey. These were accessible to external users through hyperlinks from data tables and publications on the Statistics Canada website. Internal users could browse the full inventory through the Agency's Intranet site.

In 2000, Phase 2 began collecting reference metadata including survey methodology and data accuracy. Information was formatted and validated by subject matter areas before being loaded into the IMDB. Like the initial phase, Phase 2 information is available to external users through hyperlinks on the website and an internal version on the Intranet site. Updates are triggered by new data releases so that metadata accompanies every release.

The past 10 years have seen improved quality of Phase 2 content and a push to include more information in the IMDB. Phase 3 has been initiated to add definitions of concepts, variables and classifications for all subject matter areas. This work is expected to be completed by spring 2015.

### (b) Integrated Business Surveys Project (IBSP)

The IBSP has produced a semantic model with a proposed IBSP metadata classification, along with an agreed-upon vocabulary of terms and definitions. Details of metadata by system components are being identified. Current plans are to develop one single portal to make accessible overarching metadata, the data it describes and the processes it controls. This tool will enhance reporting capabilities and built-in quality assurance.

### (c) The Common Tools Project

Systems have been developed using the Rational Unified Process (RUP), an iterative approach. Using this method, several tools are in development concurrently. The priority is to deliver basic functionality as quickly as possible and to combine all tools into an integrated processing and metadata management environment. The initial phase of the project created a processing environment and associated standards including naming conventions and directory structures. Subsequent phases cover individual processing steps.
IT Architecture

Statistics Canada is moving towards a SOA. A key enabler of SOA is the Enterprise Application Integration Platform (EAIP) that allows the delivery of solutions based on meta-data driven, reusable software components and standards. Most business segments will benefit from the common core business services, standard integration platform, workflow and process orchestration enabled by the EAIP. The platform also simplifies international sharing and co-development of applications and components.

Web services currently in use and under development by EAS are associated to information objects representing core business entities (e.g., questionnaires, classifications, tax data, business registry) that are classified into GSIM’s Concepts and Structures groups. This fits nicely with GSBPM as well: services provide the inputs and outputs to GSBPM statistical processes. They satisfy a basic set of SOA principles, i.e., they are loosely coupled (consumer and service are insulated from each other), interoperable (consumers and services function across Java, .NET and SAS), and reusable (they are used in multiple higher-level orchestrations and compositions). Work continues to establish a complete framework, including discoverability (via a service registry and inventory) and governance.

At this point, Statistics Canada has a combination of services and silo-based/point-to-point integration that can be described as a combination of maturity levels 3 and 4 in terms of the Open Group Service Integration Maturity Model (OSIMM) maturity matrix (see Figure 1). During the transition years to a corporate-wide SOA, incremental changes are being made by applying SOA adoption and governance by segment in which cross-silo services and consumers coexist with point-to-point integration of systems and data. Early adopters of SOA services include IBSF, SSPE and SNA.

Developing Data Service Centres (DSC) is a key initiative that fits into Statistics Canada’s emerging SOA. The objective of the DSC is to manage statistical information as an asset – to maximize its value by improving accessibility, utility, accuracy, security and transparency through the use of a centralized inventory of statistical data holdings, associated metadata and documentation. Key statistical files and associated standard metadata (i.e., file name, type, description, creators, owners, etc) will be registered and integrated into statistical processes via SOA. This integration will rely on a data access layer with common interfaces to access statistical files without the user needing to know their location, format and/or technology.

Metadata Management Tools

IMDB metadata discovery is performed via a Wiki-based solution and MetaWeb. Each Wiki page provides the context of the information and all available links. These pages are programmatically generated based on templates developed for the IMDB. MetaWeb is a JSP and Servlets-based application. Data are collected and populated into the IMDB via a Microsoft Excel IMDB Extraction/Loader, an Oracle PL/SQL IMDB Loader and MetaWeb.

The starting point for the Common Tools project (See Section VII - Figure 2) is the Questionnaire Development Tool (QDT) used to enter specifications for social survey data collection instruments. All question metadata is entered in the QDT, including questions and answer category text, interviewer instructions and conditions controlling flows. The Processing and Specifications Tool (PST) then loads variable metadata such as variable name, length and type. These are linked to question metadata already entered via QDT so no re-entering of question or answer category text is required. Finally, the Social Survey Processing Environment (SSPE) utilities use collection layouts or schema to generate variable metadata to be loaded to the metadata repository. Two projected tools will complete the picture: the Data Dictionary Tool (DDT), which will provide an interface to the metadata repository for updating descriptive variable metadata, and the Derived Variable Tool (DVT), which will allow entry of specifications for derived variables and will be used to produce detailed documentation for data users. Within Statistics Canada’s SOA, the SSPE metadata repository will export metadata in a canonical model to IMDB via an EAIP service under development.[1]

Solutions and tools are needed to support other types of metadata, specifically in the GSIM Structures and Production groups.

[1] See Section IV-F for more information on SOA.

Standards and formats

The following is a list of standards and formats and where they are being used:

- BPMN – EAIP orchestrations;
- ISO/IEC 11179 Metadata registries – IMDB;
- CMR – IMDB;
- DDI 2.1 – DL and Research Data Centres;
- DDI 3.0 – IMDB tool (automate metadata “wrap” for microdata files/PUMFs) and web services (extract metadata from IMDB for DLI and Research Data Centres). See Section IV-E for more details on this project;
- ISO/TS 17369 SDMX ML – Formatted data from dissemination;
- Neuchatel Terminology Model Part 1;
- Classification database object types V2.1 – Standards Division;
- ISO 19115 Geographic Information – Geography Division;

Version control and revisions

For web services that expose information assets, not only the underlying data evolve (both in content and structure) but also the services that expose it. As a result, (potentially) different versions of the same data will be published and exchanged by (potentially) different versions of the same service. No centralized versioning framework for data exists and many areas have customized versioning schemes.

For example, the IMDB allows time travel by version and effective period. A new version of a metadata item is created by copying an existing item, making necessary changes and assigning the version number to the immediate next version. Each version has an interval of validity (or effective period) associated to it. In other words, the lifespan of each version of a metadata item can be determined; conversely, the version of an item in effect at a specific point in time can also be determined.[1]
Service versions are identified using a three-digit versioning scheme: major.minor.patch. An increment in the major version requires some of its consumers to change their code. This happens because of a major change in the service contract, e.g., at least one operation has been removed or an operation signature has changed in a way not foreseen by the extension points defined in the Web Service Description Language (WSDL) file.[2] An increment in the minor version does not require changes on the consumer applications. These are implementation changes and/or backwards compatible changes to the interface, e.g., additions of operations or extensions to data types in the WSDL file. An increment in the patch version is only used for bug fixes.

Service versions are designed with the goal of making them as forw and backward compatible as possible. By making the interface extensible, forw and compatibility makes room for future, uncertain functional requirements. This approach is guided by knowledge and best practices in SOA interface design, XML schema design and type theory (since forward compatibility of service interfaces is essentially a special case of subtyping). Backward compatibility is achieved in the usual way: by ensuring that consumer applications developed for older versions of the service can continue to work with the new version.

[1] Not every change to a metadata item generates a new version: versioning of different entity types (surveys, classifications, questionnaires, etc) are handled by a different set of business rules.

[2] Interface specification that describes the functionality and data types of a web service.

**Outsourcing versus in-house development**

External consultants were contracted for building DDI services and tools, specifically to develop in-house DDI expertise and a set of core SOA web services around the IMDB. These services expose IMDB content in a standard format compliant with the DDI XML specification to support applications that focus on different types of metadata (e.g., surveys, variables, classifications, concepts, etc.). Rather than integrating with the IMDB on a case-by-case basis (point-to-point integration), the web services enable applications to gain access to its content in a standard based format. This initial effort defined and implemented a core metadata service that delivers IMDB content encoded in DDI XML. A testing tool was also developed based on a set of common use cases (see Figure 3) to validate the effectiveness of the approach. The service is used to support the Data Liberation Initiative (DLI) and the Canadian Research Data Centre Network (CRDCN) Metadata projects comprising 25 Research Data Centres (RDCs) from universities across the country. The services were developed with a Java technology stack, including some JPA components for database access that were reused in other in-house services.

See diagram for the overall architecture of the IMDB DDI services.

In addition, EAS developed a proof-of-concept client based on JSPs, Servlets and XSLTs to transform and render the DDI XML content returned by the data service into human-readable HTML and other propriety formats for interoperability with internal applications (e.g., SQL Server, SAS).

**Sharing software components of tools**

Statistics Canada’s emerging SOA is providing the next generation of software components to be shared across the Agency. Services are reusable: they are designed to be combined with other services to create more complex solutions. In addition, generalized systems are being wrapped with a service interface to increase interoperability by shielding users from older technologies and multiple platforms.

One of the main challenges of this approach is that the same abstract information object (e.g., questionnaire, classification, T1 tax data) can be physically implemented by different data producers (and even by different data consumers) in different ways. This “impedance mismatch” has historically been addressed by point-to-point data integration, i.e., either the producer or the consumer has to conform to the other’s data model. With SOA, canonical information models are created to which both producers’ and consumers’ models will map (SOA data integration). Canonical information models are enterprise-wide, common representations of information objects – a sort of “lingua franca” for data exchange. These models enable the organization to share and exchange enterprise information that is consistent, accurate and accessible. A mapping is a specification that describes how concepts from two different models relate to each other. At the physical level, it actually specifies how data are translated between two models. Canonical models are not intended to replace the disparate set of heterogeneous physical models in use across the organization. Prescribing a single model would be impractical and counterproductive. Instead, both data consumers and producers can continue to use their own models (relational database schemas, SAS files, etc.) within their own environments and just map to the canonical only when data need to be exchanged.

Within the SOA framework, canonical models are implemented as object models that are serialized into XML Schema Definition (XSD) types. Data producer and consumer schemas are mapped to the canonical object models used by services via schema mappings – object-relational (ORMs) or object-XML (OXMs). An inventory of canonical XSD types is currently being created; it can be referenced and reused by multiple service contracts (WSDL) in the EAIP schema registry. These XSD types will be maintained by the service developers within the governance framework set up by the EAIP.

When exchanging data from a source database to a consumer application, there are a number of mappings involved along the way. First, data need to be extracted from a relational or multidimensional database into the canonical object model. This could be done automatically by object-relational mapping (ORM) tools, when the source schema is close in structure to the canonical, or it may require customized SQL/MDX extraction queries. At the other end of the process, the canonical object model is serialized into XML/JSON to be shipped to the client application via a web service interface. This mapping is done automatically by the EAIP tools. Finally, the client application needs to map the XML/JSON produced by the service into its own object model via an automatic de-serialization process. This process may include some XSLT transformation when the canonical model is very different from the consumer model and requires restructuring.[1]

(a) Example: Classification service

Classifications were one of the first core business entities to use an EAIP service. The Classification canonical model is based on GSIM and Neuchätel. The first version contains the basic classes needed to support a classification structure, namely Scheme, Levels and Items. Each Scheme consists of one or more Levels (i.e., classes), each of which consists of one or more Items (i.e., members). This model will be extended to include Versions and Variants as necessary.
Section VII - Figure 5 depicts the entire process of exchanging data from a source database to a consumer application. Lessons learned can be leveraged to support this stage of development.

A major challenge has been integrating international work with Statistic Canada's internal projects. In particular, (1) the GSIM development with IBSP and ICOS Questionnaire/Survey Instrument (described in Section III-B), and (2) the GSIM implementation task team (Production group) with current work on IBSP. The IBSP project is beginning to look at Production metadata and it is hoped that involvement in the GSIM Implementation task team can be leveraged to support this stage of development.

Overview of roles and responsibilities

Each change activity identified in the proposed Strategy for Statistical Metadata Management action plan will be assigned a lead division or area to take responsibility for the business plan, resources and reporting regularly on progress.

Centres of expertise or responsibility for each statistical domain in the Agency will also be formally recognized. These centres would provide a stewardship function for statistical metadata within their domain including providing advice related to design and standards development and ensuring that the authoritative source is comprehensive, up-to-date and accessible to the users (people and systems) who need it.

Roles and responsibilities for all areas of metadata management will become clearer as the key activities in the action plan are implemented.

Metadata management team

A steering committee is expected to oversee implementation of the operational phase of the proposed Strategy for Statistical Metadata Management action plan. This committee would be comprised of senior managers from key stakeholder areas and would focus on the activities necessary to build capacity. A project lead will be assigned to monitor implementation projects and lead the communication and learning initiatives.

Once the first phase of implementation is complete, a permanent governance structure will be established to ensure the use of standard metadata structures, content and exchange protocols; to provide guidance on creation of metadata at the appropriate stage of the statistical business process and to identify opportunities to align the Agency's on-going work with the adopted enterprise architecture.

Training and knowledge management

Communication and learning initiatives are essential to realize statistical metadata management across the Agency. Building capacity among staff about the scope of statistical metadata, its role in the statistical business process and use of reference models like the GSIM and the GSBPM are key priorities. Roles and responsibilities and best practices for the planning, design, creation, use and management of statistical metadata will also be communicated across the Agency.

Partnerships and cooperation

Statistics Canada continues to support and participate in international initiatives such as the GSIM and the GSBPM. The Agency was involved in the original GSIM sprints and is currently participating in the Plug & Play sprint and three separate task teams: GSIM-DDI mapping, GSIM-SDMX mapping, and GSIM implementation – all initiatives have senior management commitment.


Evaluating DDI and the role of other international format standards in the statistical business process has been flagged for further discussions.

Other issues

A major challenge has been integrating international work with Statistic Canada's internal projects. In particular, (1) the GSIM development with IBSP and ICOS Questionnaire/Survey Instrument (described in Section III-B), and (2) the GSIM implementation task team (Production group) with current work on IBSP. The IBSP project is beginning to look at Production metadata and it is hoped that involvement in the GSIM Implementation task team can be leveraged to support this stage of development.

Lessons learned

Links:

Attachments