Building a Data Warehouse at McMaster University

Authors: Anne McInnis, Eric Matthews, Debbie Weisensee

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About McMaster.

- Full service University located in Hamilton, ON
- 2004/05 enrollment is 19,984 full-time students, 3,622 part-time students and 4,705 summer school Students
- 1,189 academic staff, 2339 support staff
- Long-standing reputation as Canada’s “most innovative” university
- Committed to be Canada’s most student-centered research university
BACKGROUND

McMaster began investigating Business Intelligence in the spring of 2002

Driver – specific business need (Research and Financial Accounting) with defined requirements, a deadline - and funding opportunities
"Ten crates of data and one little envelope of information. Sign here."
Current Data Architecture

SOURCE DATA
- FAS
- HRIS/PAYROLL
- FRS
- STUDENT RECORDS
- UP
- RESEARCH
- ANCILLARY SYSTEMS
- GRADUATE STUDIES
- HEALTH SCIENCES
- EXCEL
- ACCESS
- FLAT FILES

DATA TOOLS
- SQL (QMF)
- SAS
- EASYTRIEVE
- EXCEL
- ACCESS
- PARADOX
- SPSS

DATA FORMATS/PLATFORMS
- DB2
- ORACLE
- IMS
- FLAT FILES
Non-integrated Systems Involve:

- Different tools for data extraction
- Reliance on specialized knowledge
- Time-intensive security efforts
- Re-keying, reconciling tasks
- Incompatible data elements
- Inconsistent definitions
Result of Disparate Systems:

- Excessive time defining, linking, assembling, verifying data
- Insufficient time devoted to planning, analysis, anticipating, innovation
- Duplication of effort
- Increased margin for error
- Decisions based on incomplete data
Business Intelligence Conceptual Architecture

**SOURCE DATA**
- FAS
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- HEALTH SCIENCES
- EXCEL
- ACCESS
- FLAT FILES

**END-USER TOOLS**
- Static/Live Reports
- Drill down (detail levels)
- Multi-dimensional analyses
- Graphics
- Budgeting/Forecasting
- Exceptions/Notifications
- Data Retrieval
- Process Input
- Balanced Scorecards
- Performance Indicators

**Extraction, transformation, loading**
Source data is transformed and consolidated into a relational databases

**Data Repository**
- RESEARCH
- FAS
- STUDENT RECORDS
- HR/PAYROLL

**Data structure Optimized to Produce Reports, Queries**
Recognizing the Need for BI – the opportunity

• Better correlation between financial and non-financial data
• Integration of data from disparate systems to provide all-inclusive, comprehensive reports
• Power and flexibility of software allows trends, anomaly, exception reports, and data modeling
• Supports university’s move towards standardization in creating single, authoritative source of data
Authoritative and Secure Environment

Provide an authoritative and secure environment for data management
Transformation of Data

Enhance business agility and ensure that data is timely and accessible and can be transformed into meaningful information to support effective decision-making.
Accessibility

• Information exchange and sharing of data – community access via email and web postings

Efficiencies

• Reduced duplication and re-keying
• Less resource-intensive reporting
Anticipated Changes

• Customization of reports according to business role (e.g., business managers, departmental coordinators, individual researchers, and faculty members)

• Increased sharing of information and accessibility due to scalable security

• Reduction of re-keying of data, creation and maintenance of shadow systems and reduced investment in additional *sil*o solutions
Anticipated Changes

• Reports will be “pushed” to users via email and web
• Research information will reflect “Awarded, Received, Spent” and will facilitate the reconciliation of reported data back to audited financial systems (not possible currently)
• Improved data quality (accuracy, consistency, etc.)
• Exception reports
• Standardization of data definitions and business processes
Increased Knowledge

- Actual data status (accuracy, consistency, definitions, etc.)
- Status of data environment (data sources, overlap, etc.)
- Data architecture (building data marts, data modeling, mapping, design, cleansing, performance structuring, etc.)
Iceberg Analogy

- 80% of Data Warehousing projects are unsuccessful because the up-front planning is not done
- 80% of the required work is in the detailed planning, requirements phase which is “under the surface”
- Final 20% of the effort is on the surface and what your stakeholders see as they expect the data quality, necessary infrastructure to be there
Key Success Factors to a successful data warehouse implementation:

- Executive sponsorship

- A well-defined plan that aligns with overall goals and strategic objectives of the University

- User participation, especially for defining needs and testing activities

- Small, well-defined scope (incremental within a larger plan)
Current McMaster “drill-down”
Detailed Requirements Analysis

- Interview key stakeholders across campus for information needs
- 71 common information needs were identified University-wide (e.g., support budget process)
- Identify underlying data sources required to support the information needs
- Evaluate status of the data sources
- Preliminary sizing for hardware requirements (volumetrics)
<table>
<thead>
<tr>
<th>Informational Need</th>
<th>Description</th>
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</table>
| **Informational Need** | - Data exists and can be used as is, or with minor transformations  
- Identified as a priority, and data is in scope  
- Applicable for Data Warehouse  
- All view of the data is possible |
| **Informational Need** | - Data exists but requires more involved transformation  
Some views related to data may not be possible due to integrity, consistency, data history problems or inaccuracy in the data  
- Identified as a priority  
- Applicable for Data Warehouse |
| **Informational Need** | - Data does not exist or cannot be used “as is”  
- Applicable for Data Warehouse  
- Some views related to data may not be possible due to integrity, consistency, data history problems or inaccuracy in the data |
| **Informational Need** | - Priority not applicable, out of scope |
Research

- # of Active GL Accounts
- Asset Management
- Expenditure Analysis
- Expenditure Tracking
- Funding Analysis
- Performance Reporting
- Revenue & Spending Trending
- Total Revenue
- Applied vs. Awarded Analysis
- Generated Research $ Tracking
- Overhead Reporting
- Research Grants & Contracts
- Faculty Research Tracking
- Intellectual Property Analysis
- Student Research Tracking
- Teaching Awards & Publications - Faculty
Characteristics of Quality Data

- Context in which to judge reasonableness
- Format that describes business
- Economic collection and reporting
- Accurate description of situation
- Timeliness of delivery
- Delivery to the right people

Source: Howard Rohm
Specific Data Quality Measures will be used to:

- Drive data collection process improvements and re-engineering opportunities
- Guide and support Financial/Research administrative management changes (including Business Rules) needed to support BI reporting deliverables
- Educate and inform data suppliers and information customers of documented best practices to ensure consistency and standardization of reporting interpretation
- Create teams to work on the above initiatives (e.g., Sub-Code Committee)
Subcode Standardization

- Definitions created for most commonly used subcodes
- Assigned all subcodes to major expense categories (approx. 20)

For example, salaries and wages, furniture and equipment
BI Reporting & Dimensional Modeling [Completed]

- Detailed Requirements Analysis (DRA)
- Information Needs Model + Team know-how & experience + Community know-how & experience

- Conceptual Data Model
  - Single/Integrated
  - 80% of time/effort
  - University-wide
  - Critical to success
  - Drives design of DW
  - Design for *information & reporting*

- Conceptual Report Validation
BI Reporting & Dimensional Modeling
[Completed & In Progress]

- Detailed Requirements Analysis (DRA)
  - Information Needs Model
  - Team know-how & experience
  - Community know-how & experience

- Conceptual Data Model
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- Logical Data Model
  - Conceptual Report Validation

- Physical Data Model
  - Develmt/Test/Prod’n

- Analytical Applications & Reports
  - Devil/Test/Prod’n

- Research
- Finance
- HR
- Student

Note: Modeling work to be validated internally & externally
Cycle

Corrections/Adjustments

Proof Of Concept → Pilot → Production Pilot

 Corrections/Adjustments

New Star Schema(s)
Logical Data Model:

- Logical data model is complete for Research Data Mart (September deliverable)
- Using the conceptual data model, 3 data bases and a number of key tables have been consolidated
- These consolidated tables and databases have proven to provide enough flexibility to generate the requested reports
Physical Data Mart:

Completed to Date:

- Using the ETL tool we have mapped the logical data model (LDM) into a research data mart.
- Physical data model has been validated against our conceptual data model (information hierarchies) and Decision Support Bus Matrix model (how end-users can see their information needs by, given the available data sources).
Physical Data Mart: …cont’d

Completed to Date:

- Dimension of “time” has been added by freezing the 2002/03 and 2003/04 data at a point in time.
- Data mart has been populated with at least 20 years of historical data. Monthly snapshots will be taken and kept for a period of 24 months allowing the comparison of any data element between two points in time.
Completed to Date:

- Business rules for the ETL process have been implemented and are working in a preventive manner.
- Rejected records are being directed to end-users for remedial action.
- Work has begun to create scheduled/automated tasks and documentation for implementation into a production environment.
Completed:

- Upgrade to SAS BI Server Bundle of Products v9.1.3. in progress
- Required database connectivity software (DB-2 connect) has been successfully tested.
Reporting/Presentation Standards

Completed:

- Establishing branding and communication protocol
- Researching best practices for presentation and delivery of financial information
This page is designed to provide background information on the Business Intelligence Project, as well as information on implementation. Please visit regularly for updates on the project implementation.

The University is currently refining its strategic long-term plan. Inherent in strengthening our position is the ability to perform long-term planning, to position ourselves strategically to take advantage of opportunities, to measure ourselves and have the ability to rationalize resources.

In addition to our own internal evaluation criteria and assessment, we have seen a significant increase in external demands for accountability as well as a growing emphasis on performance-based funding. With our non-integrated systems, our ability to respond is becoming even more difficult. While we have vast amounts of data we are unable to support the information needs required to meet institutional goals.

The investigation into a Business Intelligence solution for the university led to the conclusion that a simple report creation, report drill down, and a report delivery service will not meet the true requirements of those who will use the tools. What is required is efficient, effective and secure access to a clean and reliable source of raw corporate data upon which the Business Intelligence tools can operate.

The first deliverable of this project will be the creation of a data repository (data marts) which will comprise a single, authoritative source of data that is cleaned, transformed, consolidated, structured and modelled for high performance query and analysis. The initial focus will be on research (grants applied for and awarded) and financial data. The implementation of end-user query and reporting tools will enable fact-based decision-making.
Canned Reports

Completed to Date:

- Base SAS programs and Output Delivery System commands were used to generate the requested reports for Research.
- These programs will be reused as “Stored Processes” within the new BI reporting tools (Web Report Studio, Enterprise Guide).
- Reports using 2002/03 data have been validated through a parallel testing process.
In Process

Optimal Production Plan:

- Currently working with a SAS consultant to assess hardware requirements for production use
- Recommendations on acquisition and deployment of required third-party software for web information portal
- Installation of OLAP software for future ‘drill-down’ capability
- Project plan to be developed for implementation of a production environment
Security Roadmap

In Process

**Guiding Principles:**

- Alignment with IT Security Strategic Direction
- Common authentication (uses Mac ID which is stored along with password in Microsoft Active Directory)
- Authorization based on “role” not by individual
- Aggregate information should be open to all
- For information from the Research data mart, “funded information” should be open to all. “Applied for” information will have granular security
Guiding Principles: cont’d

- Currently working with a SAS consultant to create the roles and profiles (groups) required for our first group of “end-users”
- Researching security “best practices”
- Will initiate a meeting of the custodians of University data to review current Access to Information Policy in conjunction with provincial privacy legislation. Goal will be to migrate from the current “need to know” basis to a more “open access” environment (with appropriate checks and balances)
- Need to integrate the work of many people with different roles, different skills.
- SAS 9 provides several different application interfaces united by common metadata.
Metadata server defines:
- users
- data libraries
- datasets
- stored processes

Data libraries, data sets, or stored processes created by one Interface application are registered on metadata server and become available for other applications.
<table>
<thead>
<tr>
<th>Role</th>
<th>Tool(s)</th>
<th>Feature(s)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Systems Admin</td>
<td>SAS Management Console</td>
<td>Secure Metadata; Authorized Use and Apps Set Policies for Enterprise</td>
</tr>
<tr>
<td>IT</td>
<td>ETL Studio, OLAP Cube Studio</td>
<td>Technical Metadata; Embedded Data Quality; Data properly loaded/arranged for Analysis</td>
</tr>
<tr>
<td>SAS Analyst</td>
<td>Enterprise Guide, SAS Programs</td>
<td>Design flows; Embedded analytics; Stored Processes; strategic business rules</td>
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<tr>
<td>MS/ Office Users</td>
<td>MS Office Add-Ins</td>
<td>Consistent results; use Stored Processes; Access SAS Analytics</td>
</tr>
<tr>
<td>Business Analyst</td>
<td>Information Map Studio</td>
<td>Translate technical to business Embed rules in metadata</td>
</tr>
<tr>
<td>Mass Users/ Exec reports</td>
<td>Web Report Studio</td>
<td>Reports must all use business rules only – no code -</td>
</tr>
</tbody>
</table>
PROC SQL:

CREATE TABLE WORK.SALES_SUB AS

SELECT SUM(SALE).Quarter FORMAT=YYQ4,
    SUM(SUM.SALE.Oromott.Profit) FORMAT=DOLLAR13, as Oromott.Profit,
    SUM(SUM.SALE.Total_Retail_Price) FORMAT=DOLLAR13, as Total_Retail_Price
FROM OROMOTT.SALES AS SUM_SALE
GROUP BY SUM.SALE.Quarter;
QUIT;

%MACRO FORECAST(Out=SalesFor, Var=Total_Retail_Price, title=Sales, Forecast=4);
PROC SQL;
SAS® Programming interface

Turn SAS programs into stored processes for general availability and parameter input
Use metadata libname statement to access Metadata server libraries
The User of Information Map Studio can create views of the source data for others that can contain:

- joins of underlying data sources
- calculated columns
- limited rows or columns
- summarizations
- user friendly variable labels.

Advantages:

- limit access to information
- simplify access to information
- take advantage of metadata access to build each view once and share with all users.
SAS Web Report Studio lets you create, view, and save reports from your Web browser. Enter your user name and password to log on to SAS Web Report Studio.

User name: weisens
Password: ******

Log On
Please answer the prompts below and click the View Report button to continue.

1. For which Faculty?
   - Science

2. For which fiscal year?
   - 2003_2004
Each value of a group break will have its own table or graph.

Group breaks:
- None
- None
- None
### Web Report Studio

#### Select a table, graph, or both

- **Table**
  - Simple table
  - Crosstab

- **Graph**
  - Bar
  - Line
  - Pie

#### Title:

```
Title:

Show | Data Items
--- | ---
✔️  | Department Short Name
✔️  | Faculty Name
✔️  | FAS Account Number
✔️  | Sponsor Name
✔️  | Dollar Amount
```

```
Vertical axis:
Dollar Amount

Horizontal axis:
Department Short Name

Subdivide bars by:
None
```
Define the header and footer

Report header (appears on every page):
Banner: None
Text: 

Report footer (appears on every page):
Banner: None
Text: 
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Select an export option:

- Data with formats (Microsoft Excel file)
- Data only (tab-delimited text)

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**Faculty of Business - External Research Funding: 2002-2003**

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Reasoning From Outputs and Activities to Outcomes

1. Why? Draft a Rule
2. Why? Enact a Rule
3. Why? So Industry takes Action
4. Why? Reduce Oil Spills
5. Why? Improve Water Quality
6. Why? Reduce Disease in Fish & Humans

Source: Howard Rohm
Using Performance Information To Manage:

The *Data Definition* Table

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Source: Howard Rohm
Evaluate And Adjust Strategy

Strategic Direction

Balanced Scorecard

Perspective
Strategy | Objectives | Measures

Programs & Operations

Input → Process → Output

Budget Formulation & Costing

OUTCOMES

Source: Howard Rohm
Balanced Scorecard Development

**Phase I**
- Build the Scorecard
  - Strategic Foundations
  - Strategy
  - Strategy Map
  - Performance Measures
  - New Initiatives

**Phase II**
- Activity Gap Analysis
  - Performance Measures
  - Targets & Data Definitions
  - New Initiatives Underway
  - Expanded Buy-in & Communications
  - Performance Reporting & Decision-Making

**Phase III**
- Deploy the Balanced Scorecard
  - Activities Gap Analysis
  - Performance Measures
  - Strategy Map
  - Performance Measures
  - New Initiatives

**Phase IV**
- Cascade the System to Business and Support Units
  - Build Business and Support Unit Scorecards
  - Activities

- Cascade the System to Teams and Individuals
  - Build Team/Individual Scorecards
  - Incentive/Rewards

**INSTITUTIONALIZE** - Ownership & Accountability
- Success Celebration
- Incentives/Rewards
- Individual Development

**AUTOMATION** - IT Options, Reporting Requirements
- Software Selection, Implementation

**PERFORMANCE BUDGETING**
- 1) Performance Targets added to Budget
- 2) Strategy-based Budget
- 3) Outcome-based Budget

Source: Howard Rohm
Lessons Learned – Getting Started

• Combination of training and “mentoring” (knowledge transfer) helpful in quickly gaining familiarity with the new tools
• Commitment (time + resources) to complete the necessary planning, data quality initiatives prior to initiating first project
• Build in time for R&D and learning curve in your project plan
• Importance of having a cross-functional/organizational high performance project team
• Importance of “BI” branding
Contact us......

Debbie Weisensee
weisens@mcmaster.ca