SCIRT Rebuilding Infrastructure

LEARNING LEGACY

Lessons learned from one of New Zealand's most challenging civil engineering projects: rebuilding the earthquake damaged pipes, roads, bridges and retaining walls in the city of Christchurch 2011 - 2016.

2016 New Zealand Spatial Excellence Awards: Category: Award for Technical Excellence - Award Application

Story: Data Governance – Standardise, Process and Deliver

Theme: Finance and Business Systems

An award submission nominating SCIRT for the 2016 New Zealand Spatial Excellence Awards: Category: Award for Technical Excellence.

This document has been provided as an example of a tool that might be useful for other organisations undertaking complex disaster recovery or infrastructure rebuild programmes.

For more information about this document, visit www.scirtlearninglegacy.org.nz

Programme funded by
Christchurch City Council
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A Dynamic Process Governance Model for Quality Assurance and Delivery of Infrastructure Survey Data

The Technical Excellence Award recognises products or projects that implemented spatial solutions to an exceptionally high technical standard, overcoming significant technical challenges, and delivering outstanding results for the client. In contrast with the Innovation Award, this category focuses on excellence in applying existing technology and methodologies.

Executive Summary or Statement of Excellence (600 words)

Following the Canterbury earthquakes of 2010-2011, the Stronger Christchurch Infrastructure Rebuild Team (SCIRT) was created to repair the damaged horizontal infrastructure of Christchurch including roads, bridges, retaining walls and the '3 waters' networks of water supply, wastewater and stormwater. SCIRT is an alliance, joining three clients as funders with five construction companies ('delivery teams') and various consultancies to complete the rebuild programme. The programme, totalling 741 projects over 5 years and costing over $2bn, is scheduled to finish construction in December 2016 (figs. 1 & 2) with project handover concluding 3 months later. To achieve this, SCIRT must complete projects and hand over all records within time and budget, achieving high quality and providing value for the city.

In addition to physical works, SCIRT's deliverables include a complete spatial dataset of all newly-installed 3 waters network assets plus an update of the existing spatial network with decommissioned assets. The data are required by the network asset owner as one of SCIRT's clients. This information is supplied by the delivery teams after construction works are completed for each project, and subsequently processed and delivered by the SCIRT GIS team to the asset owner.

In addressing the requirement for 3 waters network data, a major challenge arose primarily associated with non-standardised, incomplete and ambiguous data incoming from multiple sources. The initial data management process (fig. 3) was uncoordinated, time-consuming and error-prone, providing expensive and poor quality results. Client standards were poorly applied, and processing was both manual and cumbersome. Since GIS data is linked to many key processes at SCIRT (fig. 4) including asset assessment, traffic management, design, cost allocation, reporting and project handover, poor quality data derived from a highly inefficient process threatened to hinder the wider programme.

To overcome this challenge, the GIS team developed a comprehensive process governance model to provide standardised, high quality data to the client within the expected timeframes. The model allies to a survey guidance document and standardised data supply template developed by SCIRT GIS, plus mobile device apps used to facilitate data supply. The model is based upon the concept of a centralised governance database named the 'G-File' acting as a single 'source of truth', holding all data schema information used by SCIRT GIS for 3 waters network data, details for mapping data to the asset owner's schema and all required information for automated data quality assurance (Fig.5). The G-File is structured using database tables that can be manually amended, while all changes are monitored through an automated quality assurance process to ensure the consistency and correctness of the core information. This represents an efficient one-stop maintenance approach to manage a complex GIS system.

The model incorporates a range of automated processes (fig. 6) for facilitating spatial data collection, data updates and conversion, quality assurance, publishing and handover to the asset owner, using the G-File database to obtain all schema information. Automated processes were created using Safe Software's Feature Manipulation Engine (FME) software, ESRI ArcGIS toolboxes and Python scripting with some manual support. Processes using the G-File database are designed to avoid hardcoding of attributes or parameters with these only editable via the database itself. The result of this is a dynamic, highly flexible, centralised and controlled model that is suitable for standardised delivery of high quality, high volume data and the seamless introduction of new asset types and requirements.

Acknowledging the benefits of utilising a single governance database as the core of their geospatial data infrastructure, the asset owner has adopted the SCIRT GIS model, and is involved in its use to establish new national standards for horizontal infrastructure data in New Zealand.

Short Project Summary (200 words)

The SCIRT GIS team faced a significant challenge to collect, process and deliver a large volume of high quality '3 waters' network survey data for wastewater, stormwater and water supply as part of the multi-billion dollar horizontal infrastructure rebuild of Christchurch following the 2010-11 Canterbury earthquakes.

Improvements from the pre-existing data management process were required regarding standardisation and quality. For this purpose the GIS team developed and applied a dynamic process governance model, built around a database named the 'G-File'.

The G-File database is a single 'source of truth', holding all data schema information used by SCIRT for the 3 waters networks, and enabling and controlling automated processes developed to facilitate spatial data collection and supply, updates and conversion, quality assurance, publishing and handover to the network asset owner. Any changes to schema information are made only to the single database and flow through all processes dynamically. The outcome is an efficient one-stop maintenance model, capable of providing a high quality and quantity of survey data and managing a complex GIS system to successfully support the SCIRT programme.

The asset owner has adopted this model, and it is also being used in the definition of new national infrastructure data standards.

Degree of technical methodology to overcome the challenge in delivering the solution (500 words)

The G-File is first defined in a spreadsheet acting as a single interface for editing by the SCIRT GIS team, holding all SCIRT and asset owner schema details including feature datasets, feature classes, fields and domains required for data processing. This spreadsheet is used to create and update the core G-File database as an ESRI file geodatabase, from which all processing of 3 waters asset data is governed (fig. 6). Processing involves 38 automated extract-transform-load processes created in FME that read the database, plus ESRI ArcGIS toolboxes and Python scripting. Processes are designed to read the governing database dynamically, meaning that any new feature datasets, feature classes, fields or values are added only to the single database and flow seamlessly through all processes, avoiding hardcoding and complex, time-consuming and error-prone editing of multiple processes.

In order to ensure the integrity of the database, an FME process reads the spreadsheet and passes its data through 17 categories of validation, each with many individual tests on fields, domains, values and other schema information, providing strong automated control of schema and preventing fundamental data omission and errors.

Once the database is defined, it is then used via FME to define entirely and create the template through which all survey data is supplied to consistent standards by the 5 delivery teams, plus guidance tables used to convey mandatory survey requirements and other optional data. The database facilitates delivery team data flow and provision by supplying geometries for datalogger outputs, the data supply template and mapping any data provided to the SCIRT schema through intelligent, logical automated analysis in FME.

Further to this, the GIS team has introduced the use among delivery teams of the Zerion iForm Builder and ESRI Collector apps to create, edit and provide data. The G-File database defines the iForm structure entirely (fig. 6) in supplying all features and fields, schema, domains and mapping for form creation via an FME process. Similarly for Collector, the database is used to create supporting geodatabases and domains, determines all fields used by surveyors, maps all data to SCIRT schema and creates automated tracking of data completeness with processing involving FME, ArcGIS Online and Python. Supplied data are subject to extensive fully-automated quality assurance via self-service FME processes operated using the FME Server web interface, with in-depth logical tests against schema, geometry, domains and requirements based upon the G-File database.

Following data delivery to the GIS team, the G-File database supports its integration with existing asset owner networks by holding all SCIRT and asset owner schema information and managing the mapping of field names and values between the different schemas (figs. 5 & 6). Validation of fields and values used in iForm, FME, ESRI and Python processes is enabled using this schema information. Final quality assurance processes are then run on the data, again based upon the database and using automated logical testing in ArcMap and FME, with additional outputs using the database including survey data to drafting, CCTV checking and data for financial reporting.

Potential as a new spatial sciences benchmark (250 words)

The G-File model developed by SCIRT GIS acts to facilitate and govern 3 waters network asset data collection and processing in a standardised, dynamic, controlled and centralised fashion not previously implemented. Similar to the function of metadata in providing information regarding spatial data, the G-File governance database contains the necessary metadata for spatial data collection and supply, updates and conversion, quality assurance, publishing and handover to the network asset owner. Due to the G-File's operation as a single source of truth, its dynamic structure and its extension or alteration without disrupting subsequent processing, the model provides a very effective, consistent and centralised approach to managing survey data input and supply from any number of sources. Previous data management was disparate, non-standardised and potentially producing inaccurate data.

The application of this model at SCIRT has significantly improved the quantity (fig. 7) and quality of survey data delivered to the asset owner, promoting the centralisation and standardisation of data specifications. It has enabled delivery of spatial network data for a major rebuild programme. The potential for this model to become a benchmark is reflected in the asset owner's initiative to adopt the G-File model and use it, together with survey guidelines and a template defined by SCIRT, to establish a system to create and manage the new national spatial data standards for horizontal infrastructure in New Zealand. The potential for the G-File model as a benchmark is thus to be realised in the near future both at a local and national level.

Peer review and/or client satisfaction (500 words)

The G-File model has been highly praised by SCIRT's client as the 3 waters network asset owner in Christchurch. The asset owner is using the model both for asset management and also with other organisations as the foundation to drive a new set of national data standards for New Zealand and potentially also Australia. They regard the current model as the cornerstone for managing data standards in their organisation, with a view to developing the model further. Using the model, they are able to transfer survey data deliverables from the multi-billion dollar SCIRT programme into their organisation in alignment with their standards and with 100% compliance.

The asset owner has received the structure and content of the model, leading to its active adoption as their core method for maintaining metadata standards, underpinning infrastructure design standards and related construction specifications. To the asset owner the G-File represents a construction industry mindset change for all capital delivery organisations in the Christchurch rebuild and in other areas, highlighting the importance of geospatial data related to the asset life cycle.

It is understood that a new asset management unit has been created by the asset owner to oversee the 3-waters and also roading, with a key strategy to plan an end-to-end life cycle for an asset throughout a project. This will involve the creation of a full digital design network in 12d software, based upon the G-File model and edited dynamically during construction before being finalised as working. The unit aims to see the G-File model and related standards being used in new subdivisions and all capital works projects, improving quality control and efficiency of the data supply process and demonstrating the value of spatial information about constructed assets to the wider industry.

National infrastructure design standards for New Zealand are being developed, also based upon the core principles behind the SCIRT G-File model and related survey guidance. Organisations involved in developing the standards are reviewing a draft set based upon the asset owner's advice. It is also understood that a national data standards management database, being developed in conjunction with the asset owner, will be version-controlled and dynamic in that rules can be amended by participant organisations subject to central governance based upon the SCIRT G-File model. This allows retrospective views of standards applied to past projects. A specific G-File model will be exported from the central database for each specific project type.

The G-File governance model organised and improved upon standards previously developed by the asset owner but situated in disparate file locations and with little compliance, and they recognise that SCIRT has implemented this successfully. Locally in Christchurch, the asset owner has also expanded the G-File model to include green space assets and it is understood that they also intend to do this for transport infrastructure, superseding methods such as road centreline offsets in favour of accurate survey and representation of features as GIS points, lines and polygons. These are positive and significant steps for spatial data standards in New Zealand.

Level of complexity of the challenge (250 words)

The scale of SCIRT's construction programme and limited timeframe requires a large volume of 3 waters network survey data from numerous sources to be collected, processed and delivered. These data were previously disorganised, ambiguous and lacking in quality. Data were to be supplied by 5 separate delivery teams, standardised and quality-assured, meeting requirements to define a high-quality spatial dataset. Subsequent processing was previously very manual, error-prone and time-consuming (fig. 3).

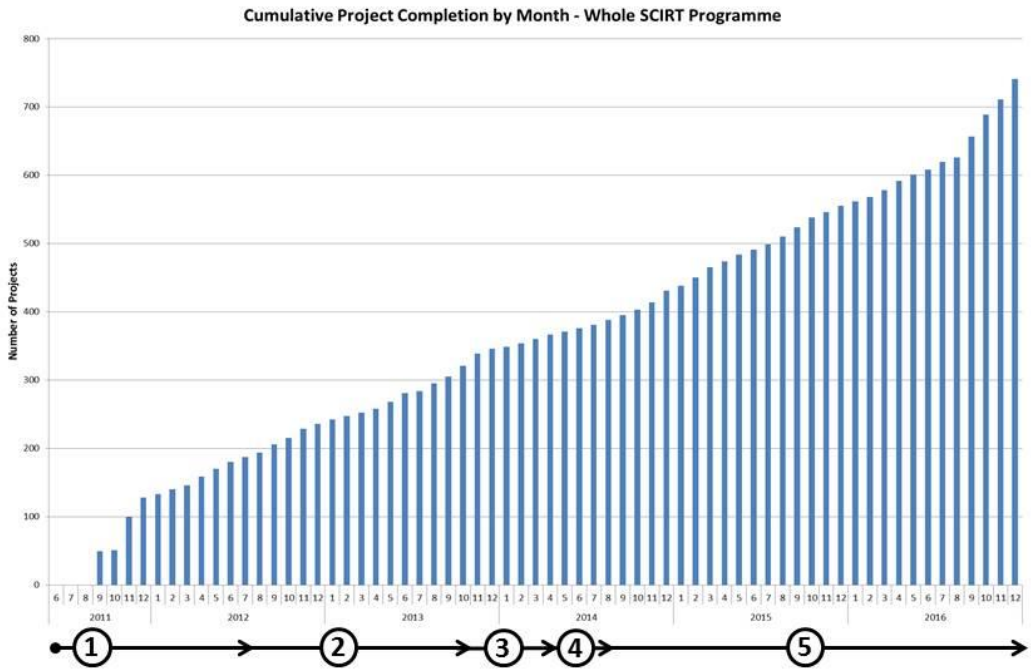
A complete system redesign by the GIS team was necessary in order to standardise data collection, ensure quality, allow integration with existing network data and support delivery to the asset owner across hundreds of projects. Existing standards were disparate, requiring retrieval, reformatting and organisation into guidance for survey collection before data supply and processing occurred. Additionally, training was required to enable data suppliers to provide an increased quantity and improved quality of data compared to the existing process.

Technically, this model development involved the creation and testing of the G-File database and automated workflows incorporating 38 FME processes, ESRI ArcGIS, Python scripting and mobile device apps. All have been successfully united by the G-File model (fig. 6).

Developing and centralising this system into a single, dynamic process governance model required time, support and teamwork involving all of SCIRT's participants including clients, delivery teams and consultants together with the GIS team. Thus the challenge was not only complex technically, but also in managing diverse interpersonal relationships and expectations. Its successful accomplishment and legacy is a credit to all involved.

Figures

Fig. 1



1 – Start up & orientation; 2 – Manual data processing; 3 – System development; 4 – System implementation & training; 5 – Operation phase of Dynamic Process Governance Model

Fig. 2

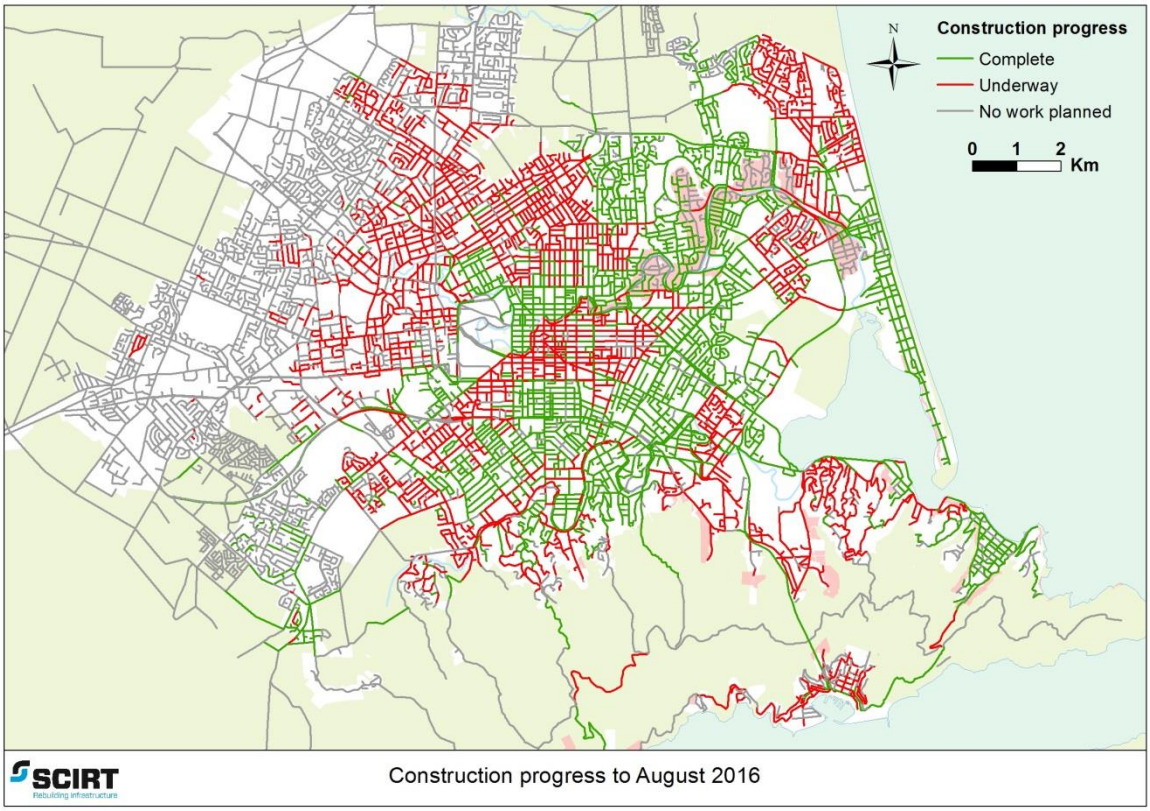

N
Construction progress
Complete
Underway
No work planned
0 1 2
Km
SCIRT
Rebuilding infrastructure
Construction progress to August 2016

Fig. 3

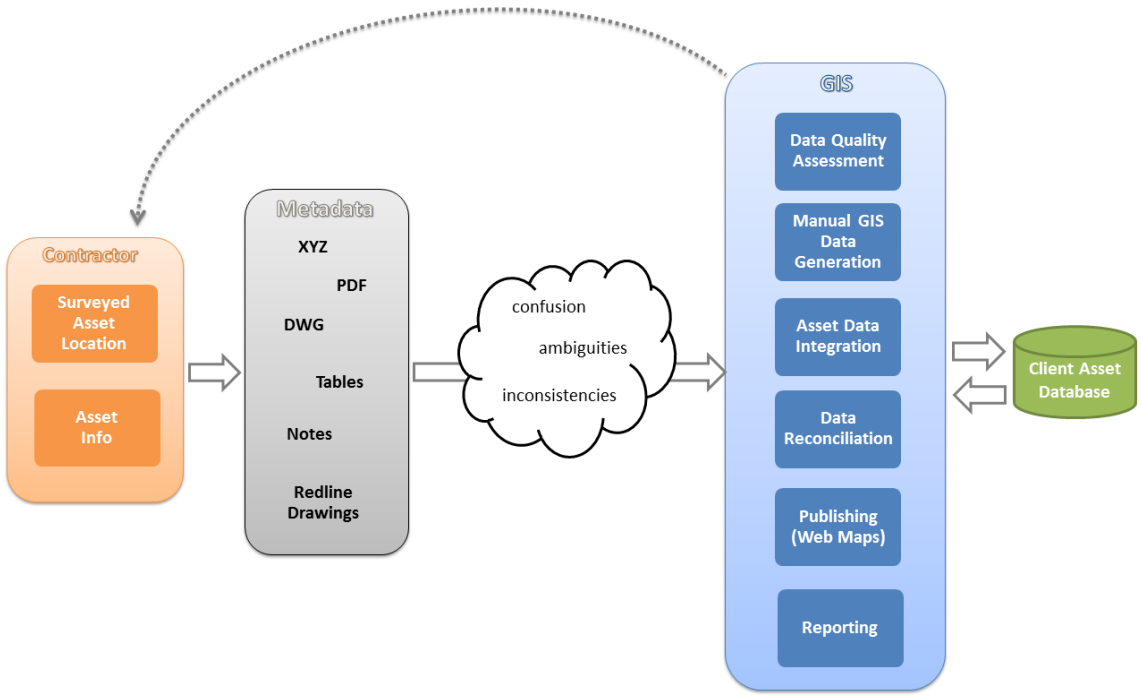

Contractor
Surveyed Asset Location
Asset Info
Metadata
XYZ
PDF
DWG
Tables
Notes
Redline Drawings
confusion
ambiguities
inconsistencies
GIS
Data Quality Assessment
Manual GIS Data Generation
Asset Data Integration
Data Reconciliation
Publishing (Web Maps)
Reporting
Client Asset Database

Fig. 4

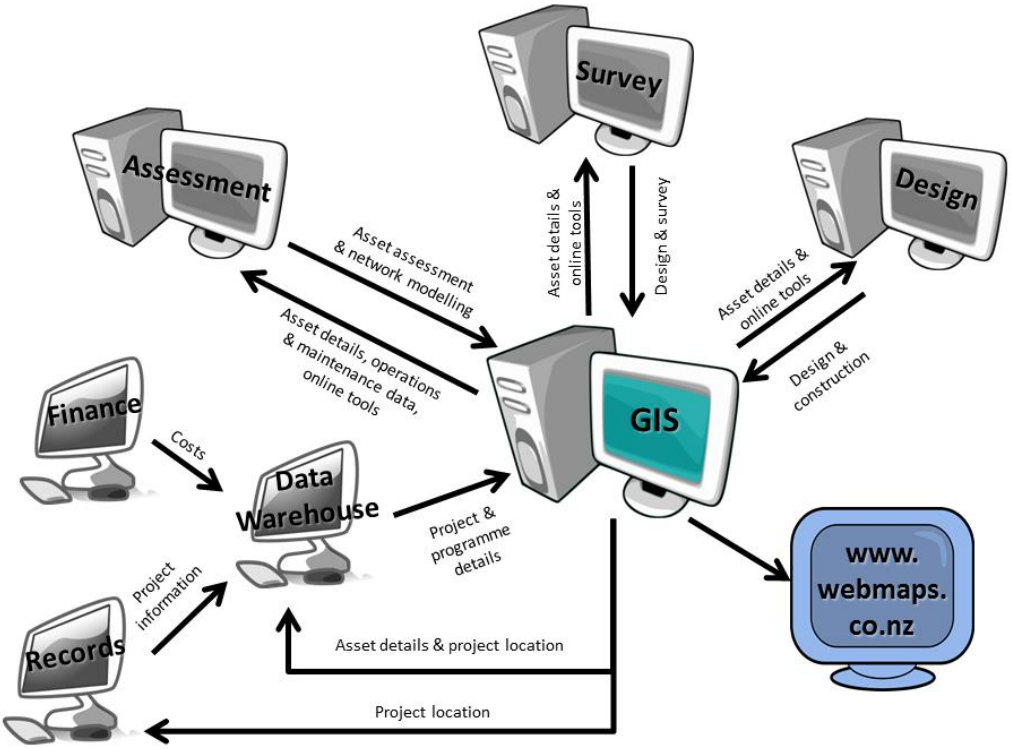

Survey
Assessment
Design
Asset assessment & network modelling
Asset details & online tools
Design & survey
Asset details & online tools
Asset details, operations & maintenance data, online tools
Design & construction
Finance
GIS
Costs
Data Warehouse
Project & programme details
www. webmaps. co.nz
Project information
Records
Asset details & project location
Project location

Fig. 5

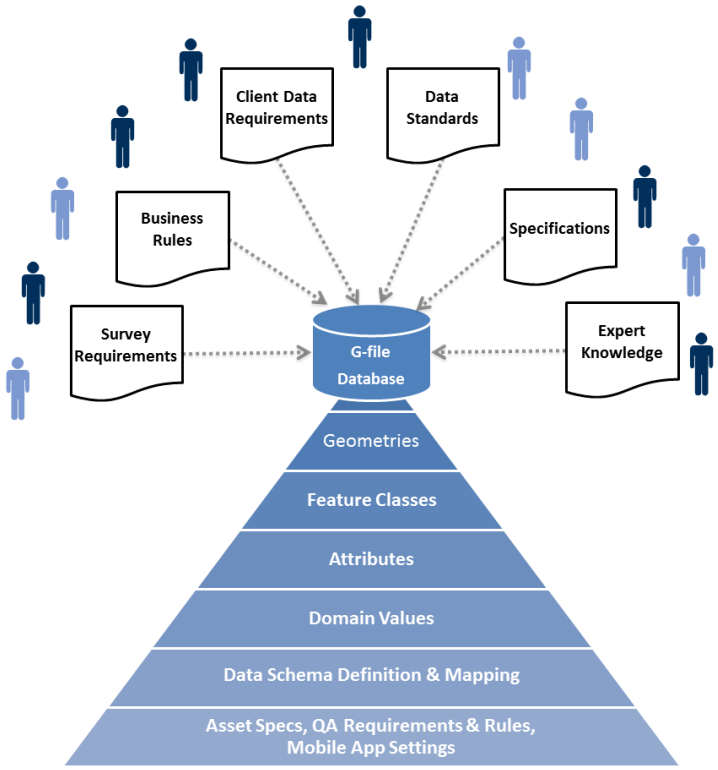
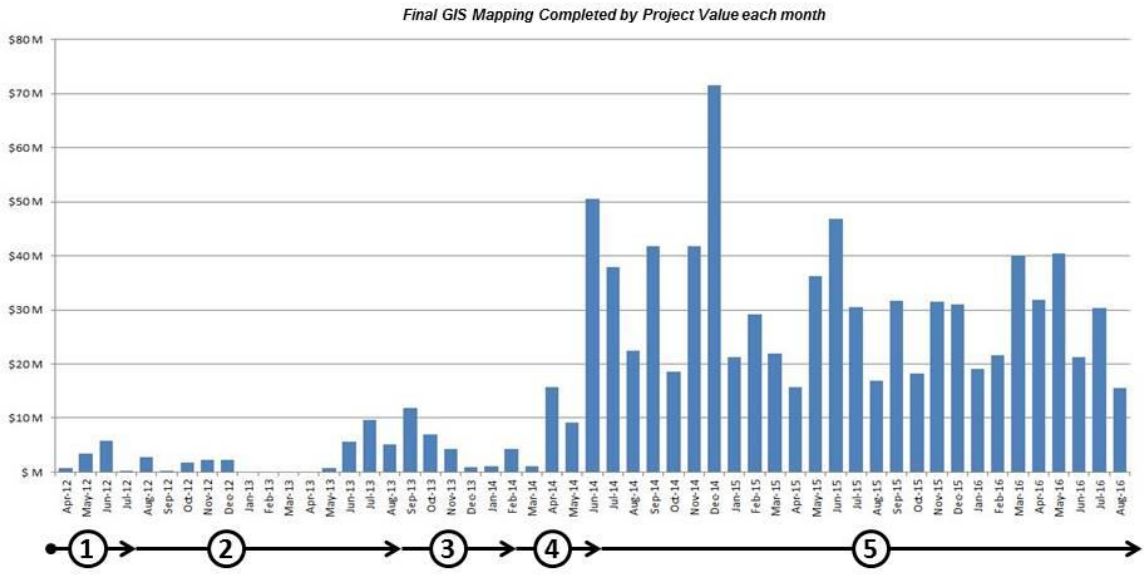

Client Data Requirements
Data Standards
Business Rules
Specifications
Survey Requirements
G-file Database
Expert Knowledge
Geometries
Feature Classes
Attributes
Domain Values
Data Schema Definition & Mapping
Asset Specs, QA Requirements & Rules, Mobile App Settings

Fig. 6

Fig. 7



1 – Start up & orientation; 2 – Manual data processing; 3 – System development; 4 – System implementation & training; 5 – Operation phase of Dynamic Process Governance Model