The GIS – Centric Enterprise

Point of View by Jan Van de Steen

Contents

Glossary

CAD	Computer Aided Design
DMS/NMS	Distribution Management System / Network Management System
DSO	Distribution System Operator
EAM	Enterprise Asset Management
ERP	Enterprise Resource Planning
GIS	Geographic Information System
Network Operator	General term for a utility company managing a transport or distribution network: either a gas or electricity TSO or DSO or a water/wastewater distribution or transport company
SCADA	Supervisory Control And Data Acquisition
TSO	Transmission System Operator

Introduction

A Geographic Information System (GIS) has a central place in a utility company's application landscape, particularly for network operators including electricity and gas Transmission System Operators (TSOs) and Distribution System Operators (DSOs) together with water and waste water utilities.

A network operator without a GIS could be compared to a retail company with an incomplete customer database or inconsistent customer service information. That would be a serious issue because the customer is at the heart of the retail business, making customer data critical for the company. Similarly, network data is the most important master data for network operators who cannot afford incomplete, duplicate or inconsistent network records. They must be able to proactively manage performance and reliability, accurately bill and service customers, and respond promptly to network faults.

In today's unbundled utility sector, network operators have the exclusive responsibility for physically providing access to the networks for their customers and for managing these networks in a reliable and safe way.

TSOs and DSOs are refocusing on the networks after a decade during which unbundling itself was the main issue that took priority and resources. Their business profitability depends upon the performance of the networks, how this performance can be monitored and traced, and ultimately reported to regulatory bodies. A well-managed utility network is essential to meeting these challenges. More recently, water and waste water utilities are beginning to experience this same trend.

The understanding is growing that GIS is not just a technology to store and produce network maps. GIS technology has functional capabilities and offers advanced data structures that are a prerequisite for well-controlled asset information management.

The **GIS-centric enterprise** positions the GIS as the asset information master store at the heart of the utility's operations, with links to the majority of processes and applications across the business. It is the master system for the "normal state" as-built network.

Overcoming GIS implementation limitations

Many network operators nowadays encounter difficulties or limitations with their GIS implementations. The most common issues that are raised to management come from different parts of the company:

- Unavailability of one single accurate, actual and consistent net information source (graphic and non-graphic) throughout the company. Finding the right information to support decision making can be a real challenge as no single source of reliable and consistent information about the network is available.
- A variety of graphical and non-graphical applications describe parts of the network at different stages of its lifecycle. It is often a combination of (scanned) paper maps, technical databases or Enterprise Resource Planning (ERP)-centered equipment inventories, GIS and Computer Aided Design (CAD) applications combined with document management. In this legacy application landscape network documentation is either incomplete or inconsistent because the same network assets may be stored several times in different systems with a subset of their relevant attributes.
- Full lifecycle management of the network infrastructure tends to be impossible with this inconsistent set of applications. Engineering, planning, construction and operational management often rely on non-integrated solutions.
- Inappropriate GIS data models that were conceived for mapping, network operation or asset management but are not suitable for all of today's applications and processes.
- Missing end-to-end network connectivity model including client connections which is an enabler for the evolution towards smart grid and a necessity for regulatory reporting on customer service levels.
- Lack of awareness of a GIS' proximity analysis capability or the failure to utilize these capabilities effectively in risk management and other strategic decision making processes.
- Heavy paper-based update cycles of network information resulting in unacceptable backlogs between actual field situation and network documentation and, consequently, sharing of out-of-date information between different parts of the business.
- Inaccurate or poorly updated topographic base maps (including address positions). As a consequence, many utilities are facing a high percentage of wrongly positioned client requests and incidents resulting in weak customer service, lost time and unnecessary costs. Fluent exchange of network data with other

actors on the public domain tends to be impossible due to positional inaccuracy of the base maps.

- The need to make a technology transition from the first GIS systems that were implemented in the 1980s or 1990s. These legacy systems may no longer be supported by software vendors and may be difficult to integrate in a company's application landscape.

It is clear that the vast majority of these issues are not technology related. The growing interest in GIS is just another sign that businesses are becoming more data intensive.

This need will only increase with the other upcoming evolutions like distributed generation, smart metering and smart grid. Utilities that know how to connect the use of data to their strategic objectives are literally **"Thriving on Data"**.

Today's network operators do not merely have to face the challenge of operating their cable and mains networks safely without compromising performance. In the future they will have to guarantee still better performance via a well grounded investment policy.

Regulators want insight on the effectiveness of infrastructure companies. For their regulatory reporting they must rely on trustworthy information, centralized in the unique asset data repository. Asset quantities (including network lengths), performance, age profiles and investment status must be retrieved from one single reliable information source. The associated status and event data provide full insight into the behavior of the network.

This information, linked to the assets or sub-networks, is the justification for investment and maintenance programs as it provides insights on outages and intervention times.

Geo-processing power – embedded as a **service** in business applications – offers additional intelligence and insight into network information. Back-office information management tasks can be supported by intelligent rule bases (including topology) to guarantee the integrity of the network data.

And finally, the **graphical interface** of a GIS offers the ideal data quality enabler needed in improved asset information management processes: user-friendly point and click interfaces on mobile devices will make it possible to locate essential field information on the assets directly.

Recent history

GIS technology emerged in the 1970s and was first introduced in utility companies during the 1980s and 1990s. This introduction turned out to be a major challenge with many projects taking 5-10 years to complete, mainly because of the analog-digital map conversion that was involved. In these first GIS implementation waves the business focused on efficiency benefits in the map drafting and reproduction departments. The organizational impact seldom went beyond the traditional drawing offices that kept on delivering the same service to other processes in the utility: accurate and timely updated (graphical) network documentation.

The tangible benefits of these early investments were often disappointing. Instead of efficiency benefits, many utilities saw an increase in their mapping staff due to the huge data conversion projects that they had to go through. During the conversion project, parallel paper processes remained in place, while part of the permanent staff was occupied on the migration work together with external contractors.

Since the late 1990s GIS technologies have significantly matured. The tools evolved from proprietary packages to more open solutions that were developed on standard technologies. Open geo-application services defined by the Open Geospatial Consortium (OGC) created new opportunities for integrating mapping and geo-processing functionalities in other business systems.

Standard relational database providers like Oracle, SQL Server and PostgreSQL have extended their product capabilities to manage complex operations on spatial data. GIS vendors have integrated these capabilities into non-proprietary geospatial data storage solutions.

And finally the GIS vendor landscape itself matured around a limited number of solution providers that dominate the world market: ESRI, Intergraph and GE Energy, together with Autodesk and Bentley moving up from the CAD into the GIS area.

Network centric means GIS - centric

The position of GIS in a utility company's application and process landscape is often blurred by an unclear understanding of what GIS stands for.

When using the term GIS two distinct definitions can be understood:

- GIS can represent a bundle of geographic functionality (thematic mapping, spatial analysis, route or network tracing, geo-coding) commonly described as geo-application services.
- GIS offers models and structures to store and manage data, including, but not limited to, spatial data. This second understanding of GIS is essential for network operators, providing a way to establish a central asset repository holding infrastructure master data with all its complexity.

In its first definition, GIS technology shows an important functional overlap with CAD systems. Drawing automation and map production are just one of the functionalities of a GIS. Traditional CAD tools mostly perform better in this domain and provide very efficient drawing solutions. GIS packages carry more functional 'overhead' and are therefore usually less 'user friendly' in the pure drawing area. But for network-centric businesses, GIS is a key technology that is increasingly being adopted to complement CAD's drafting capabilities.

GIS offers important capabilities in three distinct functional areas that utilities need every day:

- **Mapping and visualization services:** The map is a natural entry point to geographical information, and through a geographical representation, it can provide insight into complex information. A clear visualization is essential for decision making in many of the utility's key processes. Now that public web mapping services are becoming a public good, pressure (from employees and customers) is rapidly increasing to enable intuitive access to localized information with a geographical user interface.
- **Connectivity analysis:** A network is an interconnected structure where network facilities, equipment and customers are connected through cables, pipes, and valves. Intelligent connectivity models support the management of network structures: switching options for operations; network analysis and simulations for investment decisions. Graphical tools as available in GIS support intelligent editing of the network model, ultimately serving other network applications like NMS/DMS[1], SCADA[2], Outage Management systems, and network calculation tools. To report on 'customer minutes lost', connectivity should enable tracing from the origin of the outage to the customer connection.
- **Proximity relationships:** Using geographical information, it is possible to relate and combine phenomena that have no specific relationship except that they are located close to one another. Spatial analysis and decision making based on 'proximity' is essential for utilities in critical processes like strategic planning or risk management. For example, 'gas burning distance' calculations are one of the key functionalities needed by gas transmission operators. Waste water companies need to estimate the area of land potentially flooded and the number of inhabitants affected by overloaded water drains during periods of heavy rainfall.

Business managers with a network focus almost naturally identify GIS as THE candidate technology for their central asset data repository, because graphic representation, geographic location, proximity, and network connectivity are essential features of the data.

When talking about GIS, today's network operators are no longer looking for an instrument to automate their mapping activity as they did in the 1980s and 1990s. They want to establish a central data repository as the unique information source for their network assets in support of all business processes.

1 Network Management System (NMS) / Distribution Management System (DMS)
2 Supervisory Control And Data Acquisition (SCADA)

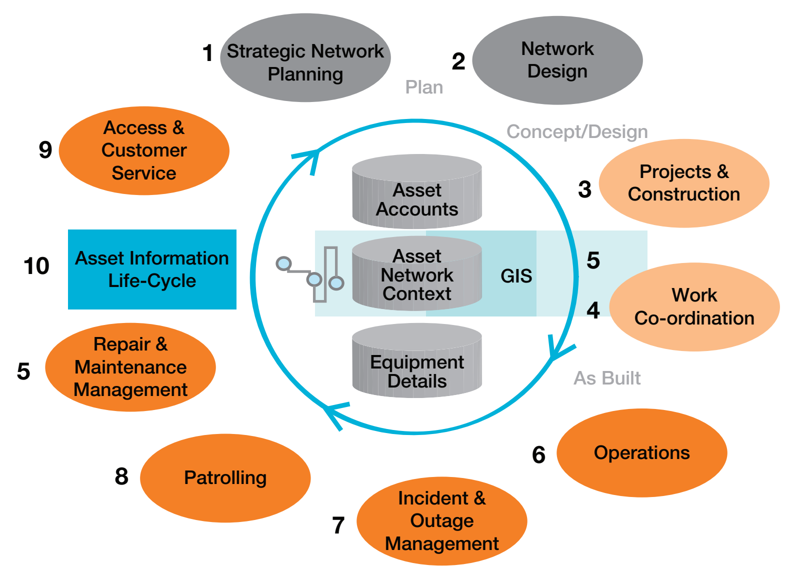
The (GIS based) central asset repository

Geographical information plays a central role in the day-to-day management of utility companies. Increasingly, this information is being integrated into both critical operational processes and into tactical and strategic decision making.

This is where the **GIS-centric enterprise** becomes a reality. Almost all processes require – to some extent – network information daily (see Figure 1):

1. Strategic network planning requires insight in actual and projected network performance (faults, incidents, repairs) in relation to (projected) capacity demand and the location on the network where it occurs.
2. Network design conceives network extensions and replacements based on well-documented as-built network data and internal or external constraints that are often geographically determined (rights of way, environmental and safety regulations, material choices).
3. Projects and Construction plan their work on detailed as-designed maps, enabling graphic designing and cost estimating and have to frequently exchange geographical information with external parties (engineering companies, civil contractors, government bodies).
4. Co-ordination of construction work (often imposed by government) includes the exchange of information (construction site location and timing of work) with other parties operating on the public domain. Further optimization is sought in shared trench work for multi-utility projects.
5. Construction, repair and maintenance work has to be documented to enable traceability (welding information on gas mains, equipment installed or replaced, initial pressure or voltage measurements) and linked to the right network element.
6. Network operations use an abstracted (schematic or geo-schematic) view of the same network to take operational decisions (switching, planned outages).
7. Outage and incident management processes need insight on network connectivity to identify the origin of a problem. The field workers receive detailed location information to perform an intervention in a timely and safe way.
8. Results of patrolling and surveying activities have to be reported back and associated to the network element they are related to.
9. Customer service agents evaluating the feasibility of an access demand look at network characteristics in the vicinity of the premises to be connected.
10. In addition to the network data, the asset information management processes themselves struggle with the integration of external data (topographic field survey, updates of public referential data (cadastral, street registers). True asset information management processes were seldom implemented in most utilities, resulting in an overall lack of data quality that compromised the effective use of information in the other processes.

Figure 1: Utilities processes requiring (daily) network information



Thriving on network data

As all these processes require accurate network data, together with associated status and performance information, a common geographic asset repository at the heart of the operation is essential. Legacy information models conceived with just one perspective (automate mapping, asset management or operations) are hindering the implementation of integrated asset information management, as required by today's processes and challenges. Network operators are replacing a 'stove-piped' organization and application landscape by an integrated operation based on a shared geographic asset data repository.

This common repository of network assets includes the geographic features, together with in-plant details (if relevant for the network connectivity) and technical and financial organizational groupings into sub-networks (see Figure 2).

The core GIS area is the 'asset network context', describing the topological organization of the network. In addition to common data structures, the GIS-based asset repository should provide support for complex network information models managing (see Figure 3):

- Multiple scales and representations (schematic, geo-schematic, geographic)
- Multiple connectivity models (for instance gas and cathodic protection)
- Multiple versions or lifecycle status (planned, projected, designed, as-built, out-of-service, retired).

Figure 2: Common repository of network assets - A combination of hierarchical and topological relationships

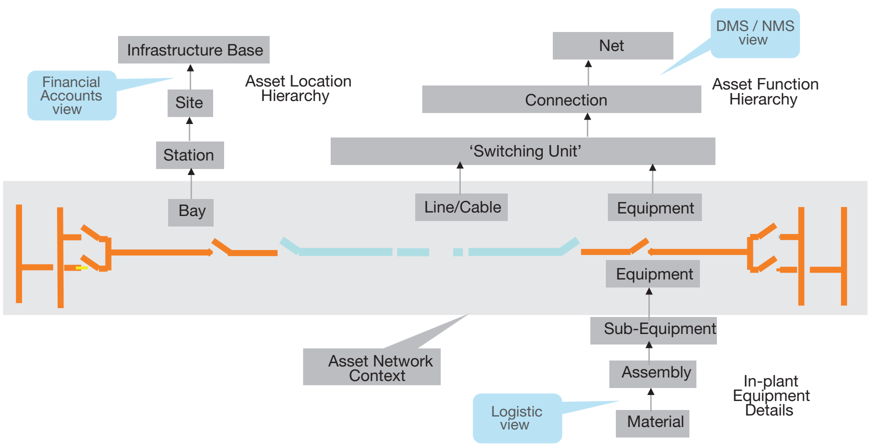
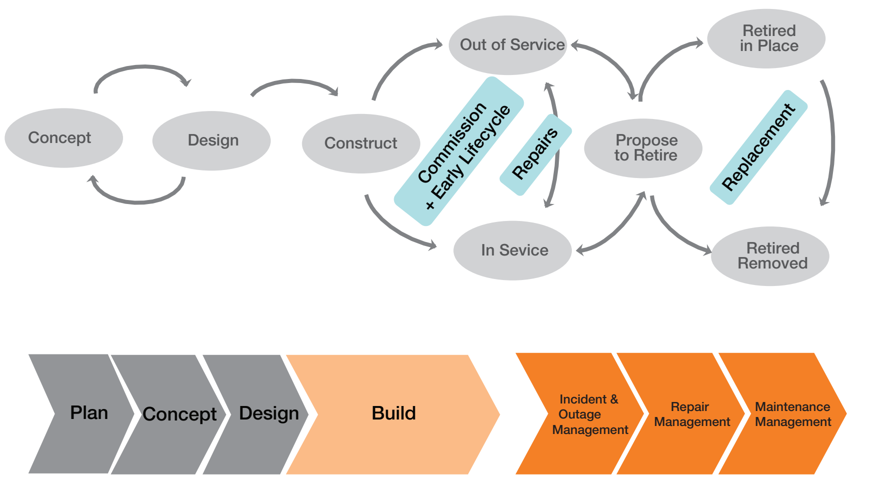


Figure 3: Lifecycle of Assets and Information Management



Utility GIS solutions are therefore more than a bundle of graphical functionality. They have advanced job and version management features, extensive rule bases governing data editing with respect for network integrity rules, industry-specific data models and templates, and capabilities for deploying web services.

They integrate with other key information systems in the utility's application landscape, such as:

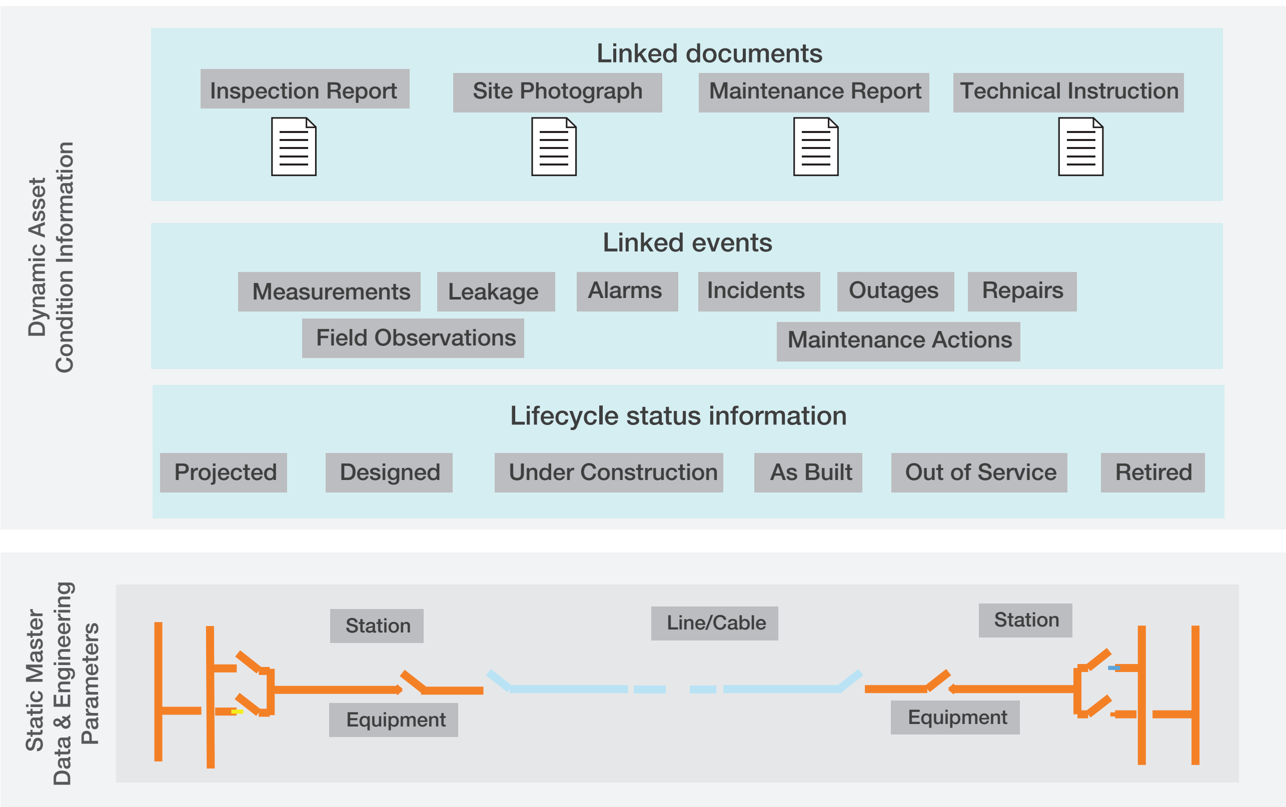
- Work and asset management / Enterprise Asset Management (EAM)
- Outage management
- Field force management
- Customer connection and access management
- SCADA / Telemetry and NMS/DMS.

To accommodate increased information needs, the GIS should allow capture, storage and retrieval of asset-related information. Related information consists of:

- Asset lifecycle status information
- Events reflecting asset condition and performance
- Linked technical and operational documents.

This information is often created in one of the other information systems, but should be linked as precisely as possible to the network assets it applies to, in order to build up the maintenance and the performance history of those assets. Without an intelligent geographical interface deployed to operators and field workers, it is impossible to capture this valuable information without massive quality losses. This is where the GIS meets field force automation, either directly or through other business applications.

Figure 4: The GIS should allow for dynamic asset condition information



Implementing the enterprise GIS

The central positioning of GIS and the information requirements from all asset-related processes and applications, make it easy to understand that "Enterprise GIS" implementations are generally characterized by their complexity. The scope can possibly cover the entire operation, including business change in process flows, master data management practices, roles and responsibilities, interaction with external parties, mobile operations and field data capture.

Some key business issues have to be addressed when **constructing the GIS-centric enterprise**. Strategic choices made in any of these areas will largely impact cost, feasibility and complexity of the implementation program. The following sections will highlight the most important ones.

Logistic asset management processes alongside asset information management

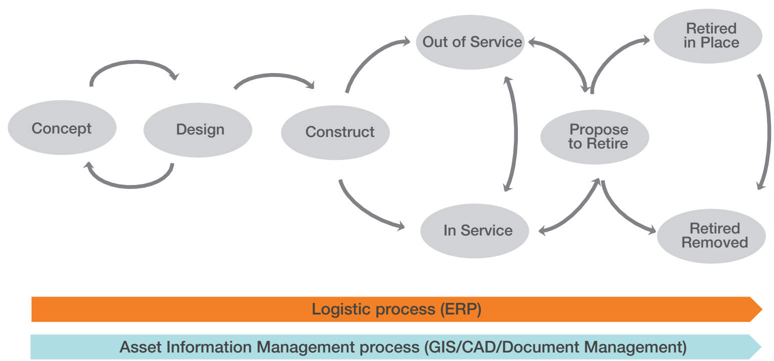
In most utilities, logistic processes (projects, work, materials, and procurement) have been structured and aligned with ERP or EAM-based processes.

The content part of this work is documented in several ways using GIS, CAD and document management tools, through a so-called "asset information management process".

Evolutions of the network configuration in the field have to find their way back to the back-office where they are documented. This process is usually less structured and not aligned with the logistic workflows. Actually, organizations support two processes that - from a business point of view - should ideally be ONE integrated process, serving both the 'content' and the logistic aspect of projects and work orders.

To optimize this situation, a fundamental review of business processes may be needed. With a GIS-centric perspective, advantage can be taken of today's maturing enterprise GIS solutions to deploy them into mobile applications and integrate them with ERP back-offices. The map is a natural entry point for anyone involved in the operation of a network.

Figure 5: Integrate parallel lifecycle processes



EAM/ERP and GIS integration

The GIS takes a position at the core of a utility's asset information management process. This can consist of graphical and non-graphical activities as long as they feed a unique registration of all assets in their network context.

EAM/ERP solutions have also implemented their view on the assets as a location reference for maintenance work. It is usually structured in a hierarchical way, and does not reflect any network concept.

In a streamlined organization, where asset information management is implicit in the logistic processes, the GIS should be integrated smoothly with the EAM/ERP solution to reflect the lifecycles of the equipment.

Typical ERP-GIS integration issues are:

- Who are the master / slave in the lifecycle of geographically located objects and how to translate this into integration cases between the ERP / EAM and the GIS?
- What is the level of equipment detail that is common in the interface between both worlds?

So far, there is no standard answer to these questions. The options vary between a highly ERP-centric enterprise and a GIS-centric enterprise, thereby largely impacting business workflows and information exchanges.

In projects and construction, for instance, GIS-centricity means that network extensions are first 'constructed' or 'designed' in the GIS. At a certain stage, the matured design automatically delivers work breakdowns, estimated bills of material, and initial assets that are created 'as designed' long before they will be constructed. The implementation of this workflow cannot be treated as a standalone case. It assumes a GIS-centric business philosophy. Therefore, interfacing GIS and EAM/ERP is not a technical issue. No standard (let alone single-vendor) solution integrating GIS and EAM/ERP has been found that can accommodate the number of possible business model variants.

CAD versus GIS

Asset information management in a utility is essentially a graphical activity. Two distinct but overlapping technology solutions have been competing over the last two decades to support this graphical editing activity: CAD and GIS. Still today, many organizations are struggling with the dilemma of which technology to privilege in their application landscape. As a matter of fact, many utilities have implemented very functional GIS applications with CAD tools while others have invested in powerful GIS packages without exploiting the full capabilities.

When evolving towards asset information management, there is a clear need for the full functionality of a utility GIS package. Version managed databases of the entire network, full topology support with utility-specific rule bases, multiple graphical representations (including in-plant schematics for example) and powerful geographic analysis functions are some of the key features of an enterprise GIS solution. Vendors like ESRI, Intergraph and GE Energy dominate the world market and offer predefined templates and data models for utilities.

The downside of these GIS solutions is that data integrity constraints, editing and validation rules, and the inevitable integration of additional – non graphical – features slow down the drawing and map production itself. In situations where flexibility and efficiency of drawing are essential, or where graphical information is exchanged frequently with external engineering and construction companies, CAD-based solutions are still leading the way. The leading CAD suppliers Autodesk (AutoCAD) and Bentley (Micro station) have continued their efforts to improve their products, specifically in the engineering and construction area where GIS solutions are not always the best alternative.

Today, emphasis is shifting towards improved data quality and integrity with more rigorous asset information management as a consequence. But the threshold when implementing the GIS-systems that support these processes for the graphical domain proves to be hard to take for many of the involved operational staff, which leads to considerable training and change management effort.

Is it worth the effort? Can we reorient drawing office functions that have been used to work with efficient CAD tools like Microstation or Autocad to become asset data managers? Are their alternatives?

It is true that the ideal situation would be to support the entire asset lifecycle with a single GIS-based repository (see Figure 6) where projected network extensions would be managed in a provisional state together with the as-built network. But the project lifecycle may require more flexibility to cope with various scenarios, specific layouts to comply with local construction and environmental regulations, integrate data from other networks and facilitate easy exchange of data with contractors who are working with Autocad or Microstation. In that case, a hybrid solution (see Figure 7) with CAD/workgroup/document management for projects and GIS for operations is a good option. Intelligent mechanisms are then needed to extract data from the operational asset repository into a project, and to re-insert the as-built situation once constructed, unless one decides to redraw the as-built from scratch.

Figure 6: Single GIS-based repository

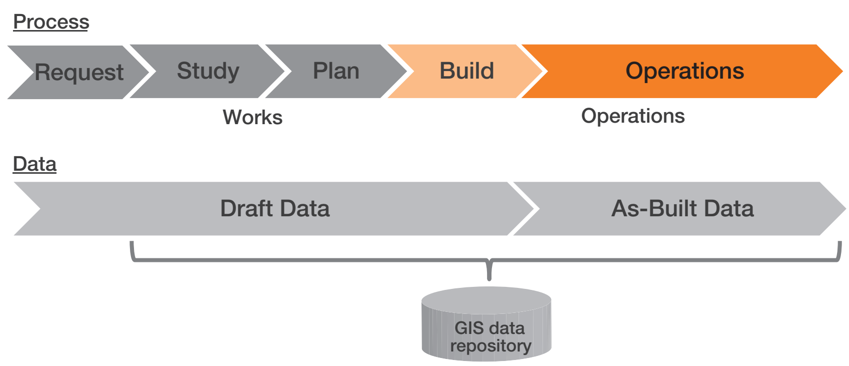
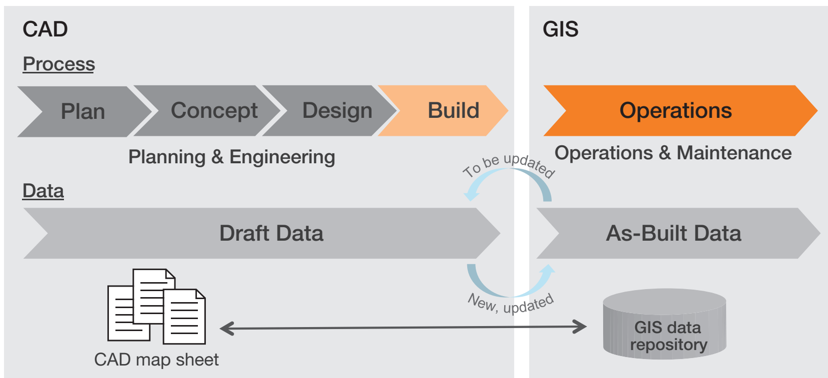


Figure 7: Hybrid solution with CAD and GIS



Conclusion

GIS is again perceived as an essential building block in the utility's application landscape. Drivers for the renewed interest in GIS are:

- Safety and compliance regulations
- Readiness for new network management practices (smart grid)
- Operational process improvements
- A general requirement for increased traceability of the network situation.

Many issues that were previously looked at from a different (departmental) perspective are now being placed in a broader enterprise context. The current GIS systems in many utilities are often inadequate for providing answers to these new enterprise requirements. Together with an inevitable technology transition for many older GIS implementations, this observation provides a clear case for action to engage in a GIS renewal project.

Utilities generally underestimate the effort associated with GIS implementations, which is why many past implementations were never fully completed and expected benefits were not realized.

The journey towards the **GIS-centric enterprise** requires some reflection and planning. In that process, some organizational and technological hurdles may need to be overcome.

A strong business case can be built only if the business adopts an enterprise vision for GIS and stakeholders from different departments become convinced how a GIS-centric enterprise will improve their daily operations and the business as a whole. The added value comes from applications such as Outage Management or Asset Management for which a central GIS service is a prerequisite.

Nevertheless, the establishment of a clear vision should not prevent organizations from moving forward step by step in a pragmatic way, with intermediate realizations that add value to the business.

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