

TECHNICAL NOTE

Overcoming key challenges in HK Electric's GIS transformation journey

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ABSTRACT

The Hongkong Electric Co. Ltd. (HK Electric) has a long history of integrating Geographic Information System (GIS) technology into its operations, starting with its first computer mapping system in the 1980s. Over the years, HK Electric has transitioned from a Computer-Aided Design and Drafting (CADD)-based system to an Automated Mapping and Facilities Management (AM/FM) system. In 2019, HK Electric initiated a significant transformation of its GIS platform to create robust and future-proof infrastructure. The implementation began in February 2021 and was completed by February 2024, following data verification and user acceptance tests. Key challenges included transitioning to a standardised commercial off-the-shelf (COTS) product, managing a lengthy migration process, ensuring data accuracy, and addressing performance issues. Solutions involved emphasising the importance of data models, automating data transformation, and leveraging the intrinsic design and data structure of the product. The project also focused on streamlining business processes and managing changes effectively. This paper shares the project team's experiences and solutions to benefit other companies embarking on similar journeys.

KEYWORDS Geographic Information System; GIS; Automated Mapping and Facilities Management; transformation; data migration

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1. Project background

The Hongkong Electric Co. Ltd. (HK Electric), esteemed as one of the longest standing power companies globally, integrated Geographic Information System (GIS) technology into its operations with the launch of its inaugural computer mapping system in the 1980s. The company has consistently invested in enhancing its mapping capabilities and network functionalities, transitioning from a Computer-Aided Design and Drafting (CADD)-based system to an Automated Mapping and Facilities Management (AM/FM) system, enriched with bespoke features to support its highly efficient operations. Nevertheless, this has also led to increasing maintenance challenges.

In a strategic move in 2019, HK Electric initiated a significant overhaul of its GIS platform and technology. The goal was to create robust and future-proof GIS infrastructure that aligns with both the immediate and future business needs of HK Electric. This initiative also included the formation of a dedicated team of GIS experts from within the company's user and IT divisions. These specialists are equipped with the necessary skills and knowledge to effectively manage, support, maintain, and advance the GIS solution in a cost-effective manner. The transformation began with product research, the development of a proof-of-concept system, and the drafting of a business process blueprint.

2. Project timeline

The implementation project commenced in February 2021, and by August 2023, the principal development phase was completed. This was followed by a meticulous process of data verification and user acceptance tests, culminating in the system's successful deployment in February 2024.

3. Key challenges

The initiative to rejuvenate the GIS platform, which underpins the daily operations of one of the world's most densely interconnected power networks while sustaining world-class availability and stability, is inherently complex. It presents a multifaceted challenge, with the primary hurdles outlined below:

- Transitioning from a highly customised application to a standardised commercial off-the-shelf (COTS) product and its data model, while preserving essential functionalities to maintain a competitive edge.
- A lengthy migration process that spans many weeks with the standard migration tools provided by the new GIS product.
- An extensive data verification process to guarantee data precision following significant changes to the data model, amidst a large volume of data.

- Change management concerning alterations in business processes and the performance variances arising from rule-based connectivity as opposed to graphical interpretation.
- discuss the merits and limitations of three individual glazing materials (VO₂, hydrogel, and perovskite-based TSWs from the literature with a Tc of about 30°C), and
- investigate if a particular TSW is better suited to a humid subtropical climate.

4. Respective solutions to key challenges and experience sharing

4.1. Transition to a COTS product

Based on our experience with this project, the success factors for transitioning from a highly custom-built application to a standard product involve the following key elements:

- Emphasising the importance of the data model and strictly following a “model first” implementation strategy.
- Remodelling of non-standard data to comply with the model design and automating this transformation process.
- Leveraging third-party products to complement the GIS platform for specific processes.

4.1.1. Data model as a strong foundation

One of the key tasks in this project is data modelling. The new GIS system closely mirrors the physical asset model, with rules defined for every connectivity and association type to prevent data entry errors in future operations. Every network modification is validated by the new GIS engines, making it crucial to prioritise model design.

HK Electric's design is based on Esri's best practices, specifically the Utility Network Foundation.

The Utility Network Foundation (UNF) evolved from its predecessor, the Utility Network Community (UNC) model. The UNC was developed and promoted by a group of Esri's European users with the goal of establishing a consistent grid model across all Esri Utility Network implementations, optimised for three-phase operation. Over time, Esri formally adopted this community-driven standard and refined it into the Utility Network Foundation.

By leveraging this standardised approach, HK Electric has been able to implement industry best practices while extending and customising the model to meet specific customer and market requirements—both now and in the future.

For more details on the Utility Network Foundation, please refer to Esri's official website:

- Esri (2025). Electric Utility Network Foundation. [online]. Esri. Available at: < <https://shorturl.at/HwXrD> > [Accessed on 24 April 2025]



It is important to note that the data model encompasses more than just network spatial data. It should also consider relationships (containment and association), attribute design, attribute rules, layer grouping, annotation, labels, and more. The data model should be finalised, and preferably “signed-off” before fully automating the migration process, although some trial migrations are necessary to help users understand the model design. Our experience shows that late-stage changes to the model design had significantly increased effort due to ripple effects on functionality, configuration, and system integration.

4.1.2. Transformation to model compliance (Preprocessing)

Once the model is defined, an automatic transformation logic, known as “pre-processing”. will be developed. The main objective of the pre-processing program is to manipulate the existing geometric data so that it can be automatically fitted into the new data model to form a subnetwork.

Over 100 pre-processing programs were carefully discussed, designed, and tested during the project implementation. The more topology rules added, the better the validation and data integrity. However, this significantly increases the effort required for data cleansing. Defining topology rules is a balancing act. This is why we have over 100 pre-processing programs to cleanse the data; otherwise, a valid network cannot be formed. Companies should adjust the number of rules based on their data quality.

Table 1. Pre-processing examples.

Pre-processing	Visual examples	Description
Add termination junctions to HVCABLE ends		<ul style="list-style-type: none"> • Create a new cable termination junction for each record in HVCABLE_TERMINATION
Snap cable ends within the buffer of [0.001m ; 0.1m]		<ul style="list-style-type: none"> • Cable end to schematic point feature (HVBUSBAR, HVCABLE, HVSWITCHGEAR_CONNECTOR to HVSWITCHGEAR)

In Table 1 below are some simple examples that demonstrate the more stringent requirements of the new system. For instance, additional nodes or fine-tuning the original geometric positions of equipment are necessary data-cleansing steps to comply with topology requirements.

4.1.3. *Third-party products' support*

A unique competitive edge of HK Electric's GIS practice is its stringent and well-controlled planning process, which proactively simulates the "future state" of the supply network for evaluation to ensure supply reliability.

One major challenge in migrating to a standard platform is supporting the current planning process. The legacy GIS system supports advanced planning by visualising the "future state" of the network and seamlessly integrating with the load flow analysis engine for evaluation. In practical scenarios in Hong Kong, due to excavation coordination, development projects usually have different construction stages and take years to complete, with numerous other projects occurring in between. Therefore, it is necessary to support scenarios such as "plans on planned versions".

Although the new GIS platform offers comprehensive branch versioning, it currently does not support "plans on planned versions". To address this, a workaround configuration was implemented while preserving the platform's standards.

The solution has two key elements:

1. Transitioning to a modern GIS and best practice data model, including advanced data transformation as part of the migration from the legacy Intergraph system.
2. Implementing a creative configuration to support planning in GIS and software integration based on international standards.

The project team has developed a solution that allows HK Electric to ask, "How will the grid look on a given day in the future?" This solution creates a non-postable branch version representing all designs for the desired project type, planned for execution before that date. Project designs are initially drawn schematically at 1000 metres above sea level. After validation, the contractor's proprietary Common Information Model (CIM) adaptor software exports the data as CIM files to the load flow analysis engine.

After commissioning, the z-coordinates are adjusted, final modifications are made to reflect the as-built state, and a geographic representation is created.

4.2. *Lengthy migration process and risk mitigation*

This data conversion preparation is an iterative exercise. There is no one-size-fits-all solution, because:

- Users need visualisation and interaction with the function to understand how the model actually behaves, necessitating fine-tuning.
- Pre-processing programs may not handle all cases present in the geometric network.
- The original source data may contain inaccuracies that cause additional complications during transformation. Users must decide whether data cleansing should be performed during migration, through the source data, or corrected in the target system.

4.2.1. *Migration accuracy—"Effortless is a myth"*

To quote our tennis star Roger Federer, there is no easy way to success. Migrating to the new system involves transitioning from an unstructured or semi-structured design to a highly structured and stringent modelling technology that mimics physical behaviour and constraints.

Typically, GIS contains a massive amount of spatial and non-spatial data, especially in a dense city environment like Hong Kong. The considerations are not just topology accuracy but also geometric concerns with precise requirements for asset and text location. Unfortunately, with such an immense amount of data, there are always errors and exceptions in the original system.

Automatic migration is a repetitive discovery process, ensuring that the migration script covers all scenarios, identifies dirty data, and fixes it (or parks it for post-processing in rare cases). The only feasible way to achieve accurate results is by repeating the "migration and check" cycle.

In the HK Electric project, seven migration iterations were performed until the algorithms finally produced an acceptable result.

4.2.2. *Full migration cycle—streamlining opportunity*

After multiple attempts, a comprehensive and consistent migration procedure was established, including all auto-conversion programs, migration mapping tasks, and pre-processing logic. A chronological event list was created to ensure that these tasks could be executed consistently during rehearsals and the actual cutover.

Migration runs are an intensive process in a new GIS migration project. Beyond hard work, it is crucial to execute the migration run intelligently. As the project progresses, the migration cycle tends to lengthen due to the temptation to execute the full cycle that mimics the actual cutover. In the HK Electric project, each full migration run took approximately six weeks, roughly divided into the following steps as shown in Table 2.

Table 2. Task breakdown of the full migration run.

	Task	Duration (including a quality check in every step to ensure that there are no mistakes. The actual execution time is shorter.)
1	Preparation of the source database. Migration to the new GIS platform.	5 calendar days
2	Apply pre-processing.	2 calendar days
3	Apply mapping and the actual migration run.	2 calendar days
4	Apply configurations, update attribute rules, and post-processing.	17 calendar days
5	Publish the GIS network and Subnetwork formation.	2 calendar days
6	Simulate the night batch report and program update for specific attributes.	14 calendar days

The complete full migration takes about five weeks when everything runs smoothly. However, during the project phase, unexpected situations often arise, such as:

- Ongoing changes to the source code and configuration, leading to new problems.
- Undiscovered software defects in the new GIS system.
- New data or scenarios introduced to the database, requiring changes to the migration packages.

In reality, full migration often takes longer than five weeks, so it must be approached with care. Based on our experience, it makes sense to perform a full migration during rehearsals or when implementation is nearly complete. However, comprehensive migration in the early phase of the project is not recommended.

To streamline and tailor the migration run for efficiency during the project period, consider the following questions:

1. What do we want to verify or achieve with this migration run?
2. Can we migrate partial networks or feature classes instead of the entire dataset?
3. Applying symbology, executing attribute rules, and completing batches are all expensive and time-consuming processes. Can we skip some of

the data but still achieve the project’s purpose? Can some verification tasks be performed in parallel without waiting for the full completion of the migration?

4.3. Validation and performance challenges

Once the model has been transformed, it is essential to validate the final deliverable to ensure no data loss and that accuracy has not been compromised. Unlike typical database migration projects, GIS involves a massive amount of data, including geometric and display concerns, making data validation a lengthy and complex process. Balancing cost and risk is crucial to avoid an endless validation loop.

4.3.1. Validate the result but balance the effort

The new GIS system represents a significant change in data representation. Throughout the process, various data transformations are necessary, either for model enhancement or to clean up inaccurate legacy data. A consistent methodology should be developed to ensure migration accuracy. However, given the volume of data, validation must be prioritised, as it often involves more than simple comparisons.

For example, introducing extra nodes and connectivity logic into the system requires additional reverse logic to validate whether the trace paths are equivalent to the source system before a sensible comparison can be made.

During the project, the team created over 1,000 reports to aid in data verification. However, achieving 100% automation in checking is unattainable, and some degree of compromise with sample checks is inevitable. The key strategy is to prioritise—allocating more resources to automate the checking of data critical to the organisation, while data of lesser importance may be subjected to semi-automated or manual checks to optimise cost efficiency.

4.3.2. Be aware of performance impact

Unlike geometric GIS, the system is a fully rule-based technology where even minor network changes can trigger numerous validation checks on the server. This can lead to performance degradation during the editing process. Therefore, a comprehensive change management program should accompany the technology change to ensure that end users are aware of the potential impacts and benefits of the new platform.

Streamlining business processes and data structures is essential in this transformation. In the HK Electric project, the team worked extensively with business users and the IT team to reduce the number of layers, symbology, and colour configurations. In our situation, we have reduced the number of layers from over 2,000 to just over 200, enhancing performance by carefully examining the

relationships between objects and their visual representation in real business scenarios. By grouping related layers, we boosted performance while maintaining visualisation flexibility for normal operations. This re-engineering exercise ensures that HK Electric will have a sustainable system with a more structured approach to managing dense displays in the future.

Beyond the default database indexing of the GIS product, implementing custom indexes is crucial. By strategically indexing key columns involved in frequently executed operations and resource-intensive queries, query efficiency and overall system performance can be significantly enhanced.

Another effective method to increase performance is setting scale ranges for layers. This ensures that layers are only displayed at certain map scales where they are most relevant. For instance, a layer can be configured to display detailed information only when zoomed in closely and to display less detailed information or generalised features when zoomed out. Additionally, users can identify and set as 'on' the layers that are critical for initial map display or analysis, such as base maps and key operational layers. Furthermore, organising layers into groups based on functional relationships helps manage visibility settings more efficiently, allowing users to toggle entire groups of layers on or off as needed.

4.4. Business process impact and change management

Migrating from a legacy platform to a new one often involves changes to business processes. These processes may evolve over time or be further optimised with new functionalities. During the project, the team organised weekly meetings with business users, as much as possible, to discuss potential changes to the business processes. They sought feedback on and endorsement of these changes to achieve a win-win outcome and ensure the project's success. Additionally, full-time Subject Matter Experts (SMEs) were appointed from the business units to ensure quick decision making, facilitating the smooth operation of the project. These SMEs are a critical success factor for the project.

5. Conclusion

This paper aims to share our project implementation team's experience to benefit other companies embarking on a similar journey in the future. We have outlined four key challenges encountered, along with our respective solutions to address these challenges, mitigate risks, and ensure the project's successful completion.

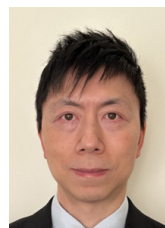
The new GIS product is still a relatively new technology. Based on our experience and other implementations worldwide, the system still has quite a bit of room for improvement in terms of stability (bugs) and

performance optimisation. For those planning to implement the new GIS system in the near future, it is advisable to make provisions in the timeline to avoid being overly optimistic.

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