# GNI Digital Twin Report

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Digital Twin

# 1 Document Control

## 1.1 Confidentiality Statement and Non-disclosure



## 1.2 Document History

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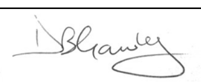
| David Gawley |  | BIM Consultancy Director | 12th May 2023 | Final |

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## Document Content

# 2 Executive Summary

## 2.1 Introduction

GNI commissioned Pentagon Solutions to compile a study reporting on digital twins. The commission was split into two phases to (i) research and report on digital twins by reviewing the current industry state (ii) and the feasibility of adopting a digital twin approach based on a maturity assessment. The second phase depended on the recommendations and findings from phase one. If the report identified benefits and maturity capability to develop a digital twin, a business case is justified for a prototype to test and assess measured benefits.

## 2.1 What is a digital twin?

Digital twins are not a new concept, albeit with different terms previously used (Hetherington and West, 2020). They are prevalent in healthcare, manufacturing, automotive, and now a recent shift focusing on building and infrastructure industries. For project clarity, a baseline level definition was vital. The research revealed various meanings and terminologies with examples of reviewed descriptions as collated in Table 1.

*Table 1: Digital twin terminologies uncovered during the state of industry research.*

| |
|---|
| "A digital twin is a virtual representation of real-world entities and processes synchronized at a specified frequency and fidelity." (Digital Twin Consortium, 2020). |
| "A realistic digital representation of assets, processes or systems in the built or natural environment." (Bolton *et al.,* 2018, p.10). |
| "A Digital Twin is a digital duplicate of the physical environment, states, and processes. Construction IT Alliance" Construction IT Alliance (CiTA, 2019, p.1). |
| "Digital asset on which services can be performed that provide value to an organization." International Organization for Standardization (ISO, 2019). |

The Centre for Digital Built Britain (CDBB) has executed a significant amount of work and provided a collaborative network via the National Digital Twin Hub. The CDBB, through the publication of the Gemini principles, offers specific examples of digital twins and a definition of "A model representing a digital representation of an asset that is physical and planned to move towards a dynamic data connection between the physical twin and digital twin". (Bolton *et al.,* 2018, p.10). The CDBB toolkit provided additional descriptions from models of constructed assets and assets to be built (CDBB, 2021). However, GNI has already embarked on a journey of modelling physical and planned assets as part of its BIM strategy, engaging in several pilots, studies, and projects. Therefore, for clarity, the terms of reference for digital twin for GNI is defined as:

> "Virtual representation of the physical asset, enriched with real-time data that is updating the operator on the status and condition of the asset to inform decision making."

The language used in this context refers solely to GNIs assets as governed by the company taxonomy. The report findings determined that this term needed to be less restrictive based on GNI's systems required to integrate with a digital twin, as discussed in Section 2.3.

## 2.2 Research Methodology

The study firstly reviewed the status of digital twins externally to GNI, reviewing professional bodies, white papers, and case studies. The review offered insight into how applicable sectors align with adopting digital twins, i.e. the 'current state'. Internally to GNI, a brief circulated survey (Appendix A) provided knowledge and feedback on how digital twins could drive benefits. In addition, Pentagon facilitated a series of workshops in parallel with the survey for identified stakeholders to provide valuable input on current digital workflows. Appendix B details the list of participants and workshops.

Developing a benchmarking process to review specific tasks from the workshops facilitated a mechanism to assess proposed ideas by the stakeholders. The sessions started by identifying the participant's role and understanding their digital processes. Classification of the challenges helped discover opportunities for a digital twin use case. For due diligence, for proposed use cases, a question had to be asked, "what could we do if a digital twin was not applied?" Finally, statements are reviewed with the Gemini principles and benefits realization. Figure 1 illustrates the workflow for the digital twin statements and the emergence points.

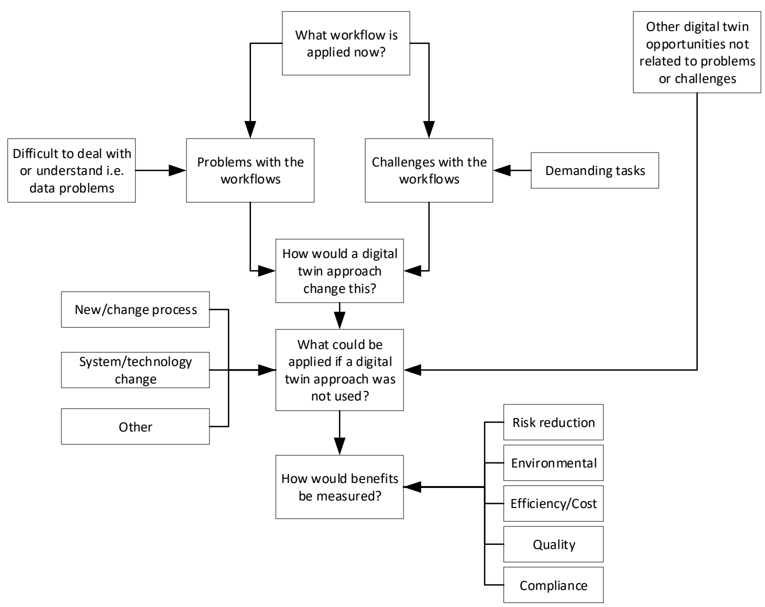



*Figure 1: Workshop workflow for identifying a digital twin.*

## 2.3 Findings and recommendations

The stakeholder engagement through 18 participants raised five detailed statements. First, all of the ideas had countermeasures, as illustrated in Appendix C. The statements are broadly related to accessing data and information quickly in a digital modelled environment on the asset, avoiding complex searches or lookups. As identified in the current state review, digital twins are relatively new to the engineering industry. The workshops found that 42% of stakeholders did not understand the concept before the meeting, with 42% just being aware. Therefore is essential that any pilot project approach is scalable to adopt and accommodate future needs, which may not be evident to GNI at this juncture.

The workshops unveiled interesting discussions on digital twins. However, some of the suggestions for the pilot whilst exceptional scenarios are aspirational. First, the digital twin must be considered within the current capability and reasonable limits of GNI. The organization are involved in a line of sight, asset improvement schemes, departmental restructures and implementing new systems and technology. Furthermore, considering the complexity of data, the abundance of systems, and departments, a simplistic approach for the pilot digital twin needs to be considered. Despite the challenge points, there is a general lack of maturity within the industry (The Digital Twin Hub and Mott MacDonald Digital Ventures, 2020; Broo and Schooling, 2021) with standards that must be aligned or created (Rossiter, 2021). The investigation of 44 cases illustrated these points as digital twin understanding varied with different approaches and frameworks.

Moreover, when compiling the report, there is a focus on climate change, with COP26 concluding. Reflecting on the urgent need to strive for sustainable energy solutions and the rising prevalence of digital twins, particularly in the energy sector, we propose that the business case is viable for a pilot project with specific caveats. The digital twin should be an exemplary model of how systems should work and represent the base template for the future. Considering the current level of maturity in industry and the complexity of GNI's technology systems, the report's recommendation is to:

- Use an existing audited and verified installation
- Develop the digital twin based on a simple, achievable example
- Build the digital twin based on a 'green' solution, Compressed Natural Gas (CNG) station
- Adjust and relax the language on the digital twin definition to exclude 'live.'
- Develop the digital twin schema as part of the project
- Feedback lessons to Building Information Modelling (BIM) projects and the modelling standard
- Develop a multi-purpose concept digital twin based on:
    - Health and Safety/Risk
    - Training
    - VR – Safety and risk aligned based on BIM frameworks
    - Telemetry feedback (proof of concept)
    - Maintenance and connected asset and documentation alignment (proof of concept)
    - Asset information rollback – what has changed (proof of concept)
    - Data specific to the asset operator interrogating, i.e. adaptive to a work order
- Position future objectives for the digital twin on:
    - Energy
    - Costs
    - Design
    - Modelling and analysis

The justification supports the need for the digital twin to use standardized and quality-assured data. Developing a CNG drives the innovation requirement for GNI to expand into a more 'green' market. The scalability of the process is essential to create models of new renewable gas solutions incorporated into GNI's network in the future. In addition, GNI is developing a new off-network facility to test renewable deployments. By ensuring a digital twin framework is in place, the solution is scalable.

The research and workshops helped identify a series of functional areas (Figure 2) that the pilot project can focus on aligned with the stakeholder cases. The workshops' aspirational suggestions fall under future scope when GNI's integrated systems and the relevant industry frameworks help expand the digital twin functionality.

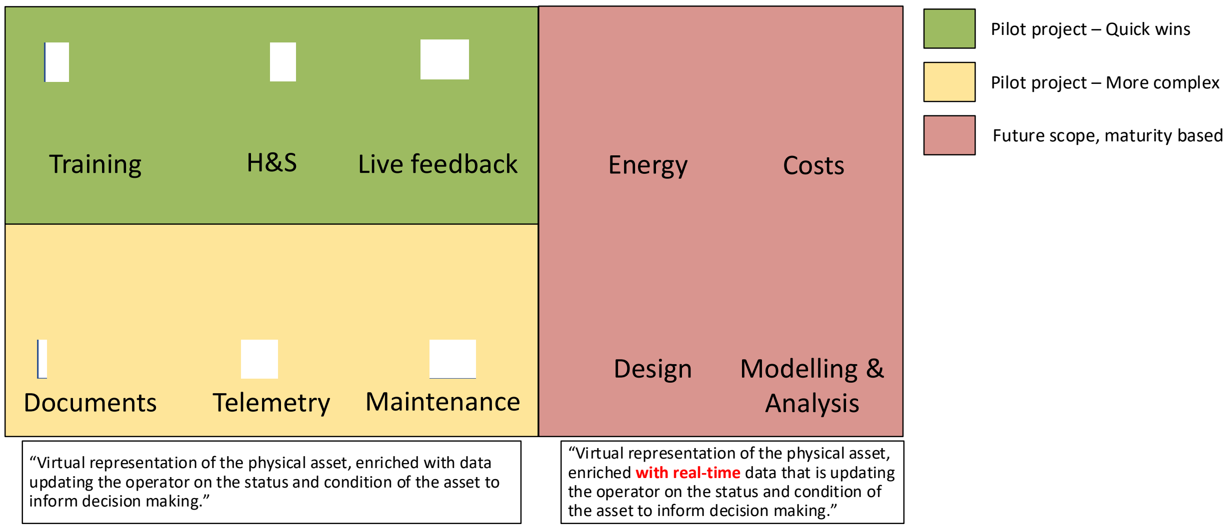



*Figure 2: Proposed digital twin development functions*

# 3 Industry review

National Grid (2021) Deeside Innovation Centre have adopted a digital twin approach using VR applied to energy projects where operatives can review PPE, schematics, and access to equipment. Moreover, the virtual environment helps review emergency processes, asset tasks and identify site risks. National Grid Gas Transmission (NGGT) and National Grid Electricity Transmission (NGET), as part of their digitalization strategy, highlight the use of digital twins facilitating feedback for fluctuations in network capacity (National Grid, 2020). National Grid (2020, p27) "Maintains a pipeline risk model that considers where pipelines are relative to things like housing, rail and motorways and uses this to inform what level of safety mitigation is required in the network (e.g., the thickness of pipes)". However, the models do not have a 'live' connection from the physical to the digital. Live links fall under the future strategy plans concerning predicting when assets fail for gas compressors. Northern Gas Networks (2020), an industry early adopter of cloud-hosted technology, including SCADA in 2021, embarked on implementing a new GIS system with plans for a digital twin implementation from Q4 2021 to the end of Q1 2023. The planned concept model will first address high-rise buildings and then expand to other business functions.

In Ireland, the Energy Supply Board (ESB, 2020) applied a digital twin solution to a 292MW pumped hydro station at Turlough Hill initially constructed in the 70s. The station operation exceeded its original design parameters. The twin assessed the longevity of the asset by modelling a replica of the site factoring the previous operational history. ESB assessed the hydro station for optimization and health monitoring by modelling stress analysis and fatigue. Future predictive Downtime savings of approximately €100K were identified, along with multiple other benefits on extending gaps between downtime, safety, extended asset life, risk reduction, and short analysis calculations. Dublin City University (DCU, 2021) announced they are creating a digital campus using IoT devices to evaluate pedestrian campus flows and infrastructure data, including energy consumption. The project collaboration involves the Science Foundation Ireland (SFI), Research Centre for Data Analytics and Bentley Systems, a technology provider.

A critical evaluation of ESBI and NGGT indicates these are not 'real-time' feedback systems from the field physical asset to digital asset corresponding to the terminology adopted for the project. Moreover, recent research into leading UK infrastructure organizations, including natural gas, has indicated that the application of digital twins is at the early development stages with no actual practical implementations. The research also highlighted different views on digital twin definitions; however, opinions on the barriers and potential gains are shared (Broo and Schooling, 2021).

From a standards perspective, the Internal Electrotechnical Commission (IEC) has a working committee (ISO/IEC JTC 1/SC 41) for the IoT and digital twins (IEC, 2021), with standards already developed for the manufacturing industry (British Standards Institution, 2021). However, digital twin standards for infrastructure are not in place but referenced in other standards, and in the UK, the GEMINI principles are the recommended framework. GNI operational standards such as IS328:2021 is specific on data and records but does not refer to digital twins or even Building Information Modelling (BIM). However, as standards require development, this essentially illustrates the challenge in infrastructure projects for aligning processes and frameworks.

Many software vendors are developing solutions for digital twins for building and infrastructure projects. For example, Autodesk is developing a cloud-based solution project Tandem, whereas Bentley is developing an open-source approach through iTwin.

A recent Climate Resilience Demonstrator (CReDo, 2021) involving a series of industry, academic and technology providers presented a digital twin at COP26. The demonstration illustrated the potential for digital twins concerning flooding and emergency response through an integrated dashboard geospatial model for utility data. The project is available to review online, providing options to solve the emulated flood model, albeit for a fictional data set.

A series of case studies were reviewed from the Digital Twin Hub (2021) and the previously mentioned projects related to building and infrastructure. The project information varied in structure and was assembled at a high level with common factors for review. The case date range varies; therefore, a higher level of maturity may be in place today than the original published content documented.

Figure 3 illustrates the breakdown of digital twin projects reviewed per industry sector and region. Energy projects represent the highest number overall for the study, with most projects reviewed within the UK.

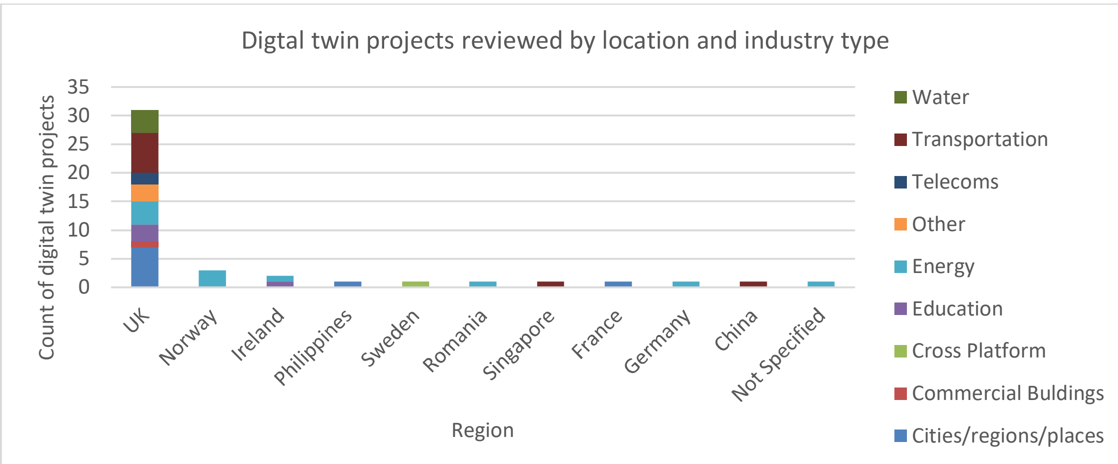



*Figure 3: Digital twin projects reviewed by region and industry type.*

Isolating the industry by specifying the subcategory of the sector provides a more detailed overview, i.e. Energy included wind, gas, electricity, district heating, nuclear and off-shore oil & gas (Figure 4).

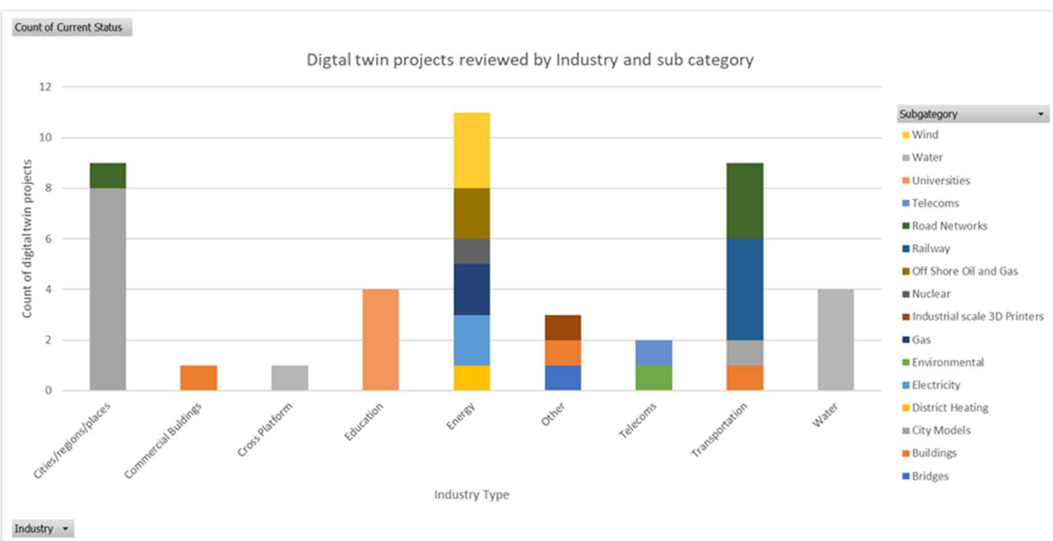



*Figure 4: Subcategory of the industry type.*

The solution applied to a digital twin pilot is critical as GNI has specific systems and infrastructure. The case studies indicate that most solutions are developed or proprietary and operational (Figure 5). However, the definition of the digital twin was not known for each case study as each output varied in technology and processes. For example, a digital twin could be a laser scan of building or infrastructure assets in some situations.

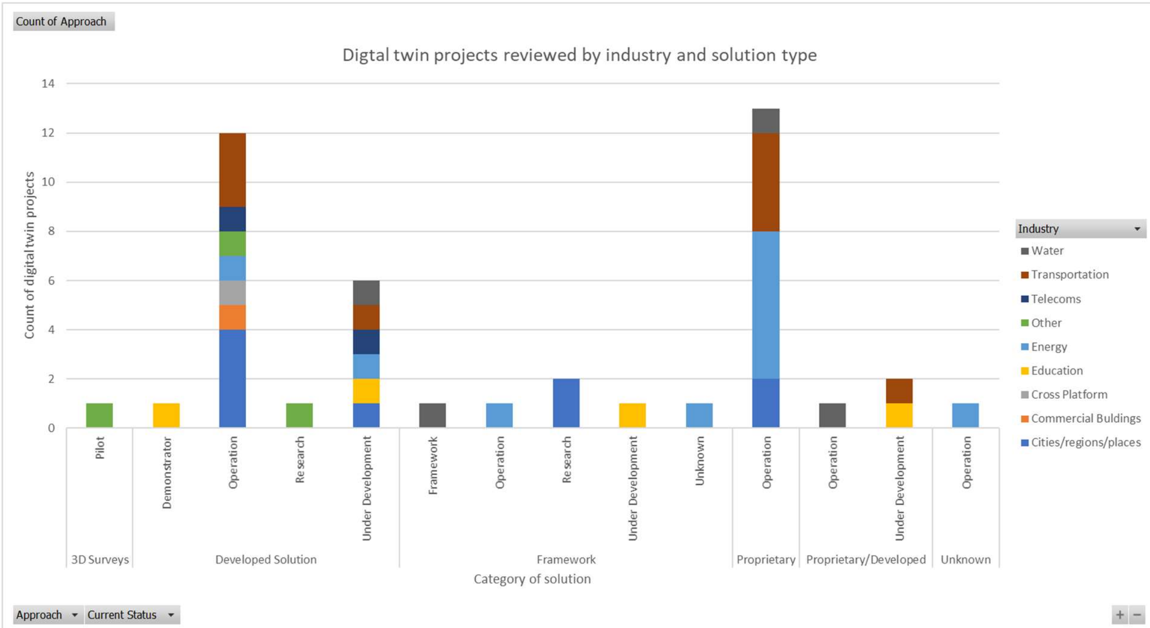



*Figure 5: Digital twin case studies per industry and solution type*

Reviewing the cases illustrated that less than 10% of the digital twins listed had quantifiable benefits, with some reporting the gains against the capital costs of the development in the first instance (Figure 6). However, nearly all the cases reported qualitative benefits. If projects are in their infancy, measurable benefits are complex; however, this is speculative for these cases, and more data would be required.

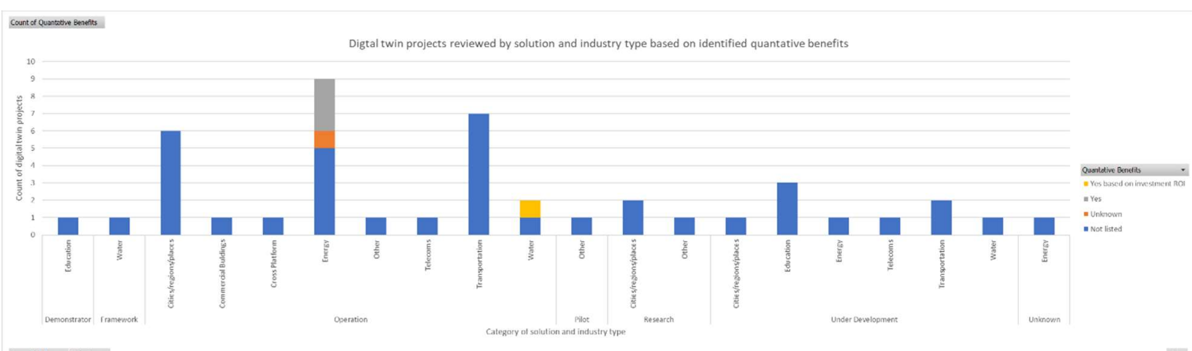



*Figure 6: Quantitative benefits per project sector and type of solution.*

Common to all projects is no single technology solution applied in isolation. Even the proprietary solutions need engagement with other technologies. A significant number of studies relied on geospatial processes, indicating the need for GIS or modelling mapping solutions. From a framework perspective, Anglian Water presented a straightforward and logical approach aligned with BIM principles for BS EN ISO19650, considering the organizational and asset requirements supported with the digital business needs. The engineering blocks of the organization are split out and consider how the processes drive the asset information models. In addition, there is a commonality to how the water industry structures its assets similar to GNI's Asset Data Hierarchy (ADH).

Discussions around digital twins are prevalent with multiple definitions, technology solutions and methodologies. Many of the cases reviewed were innovative, but there is scope for greater maturity, particularly for the proprietary software approach. Projects suffer from a different concept of a digital twin, which is why appropriate governance and clarity are vital. In summary, the main observations from the industry review are:

- There is a diverse understanding of:
    - What a digital twin is
    - Applying a digital twin to a project
    - Separating technology from a digital twin
    - What it means to the organization
- The energy sector has already engaged in digital twin projects with some in operation and measured benefits captured.
- Based on the knowledge of GNI's infrastructure and systems, a developed solution is the most fitting
- Off the shelf proprietary solutions are improbable in isolation
- Qualitative benefits are prevalent in digital twin projects, whilst measured benefits are sparse
- Standards and governance need further maturity

# 4 Workshop insights

The workshops covered a broad spectrum of representatives within GNI. Before the meeting, a presentation and video set expectations and explained digital twins. It was essential to uncover if the individual understood the principle after viewing the digital twin PowerPoint and explaining the concepts. The users' knowledge would support the discussions helping deduce how a digital twin approach can solve current challenges and generate opportunities within GNI. In addition, a series of questions were applied to the participants to identify if perceived benefits could be determined and developed into cases. The analysis indicates that the majority of stakeholders were not aware of digital twins before the workshop (Figure 7), with 42% identifying a benefit to their department (Figure 8) and 74% to GNI as an organization (Figure 9).

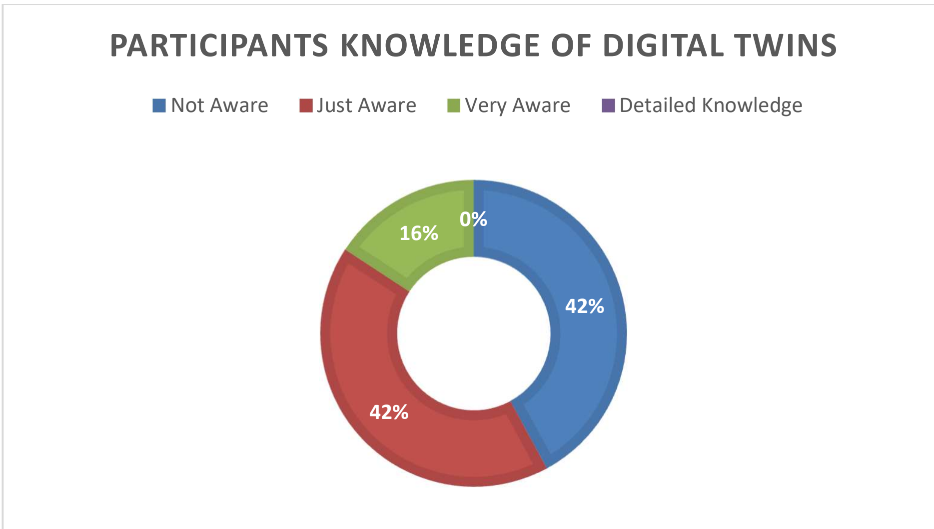



*Figure 7: Participants knowledge of digital twins prior to the workshop engagement.*

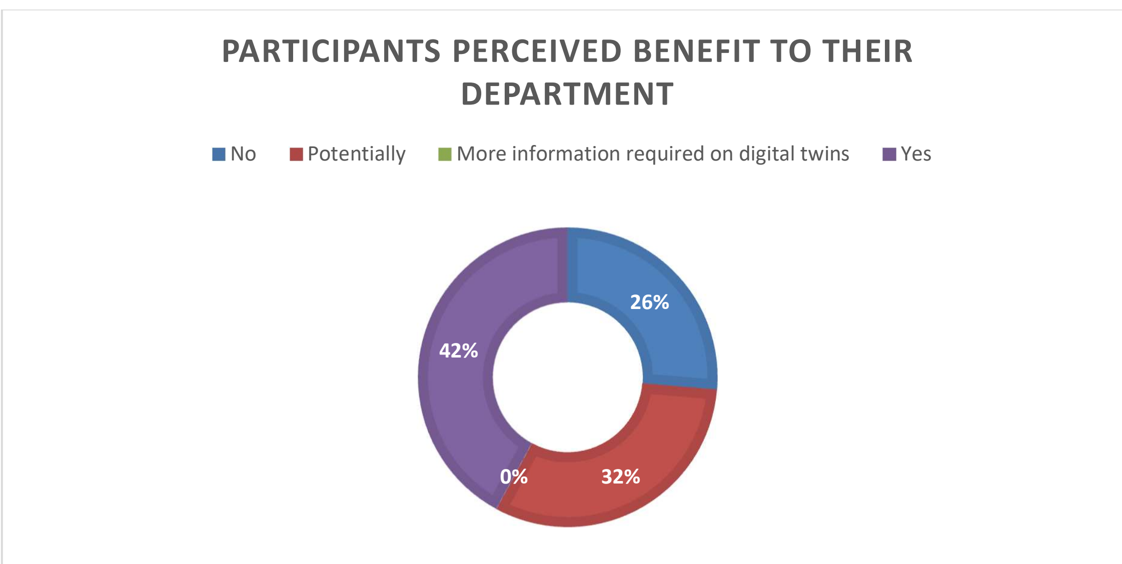



*Figure 8: Participants perceived benefits of using digital twins within their department or business unit.*

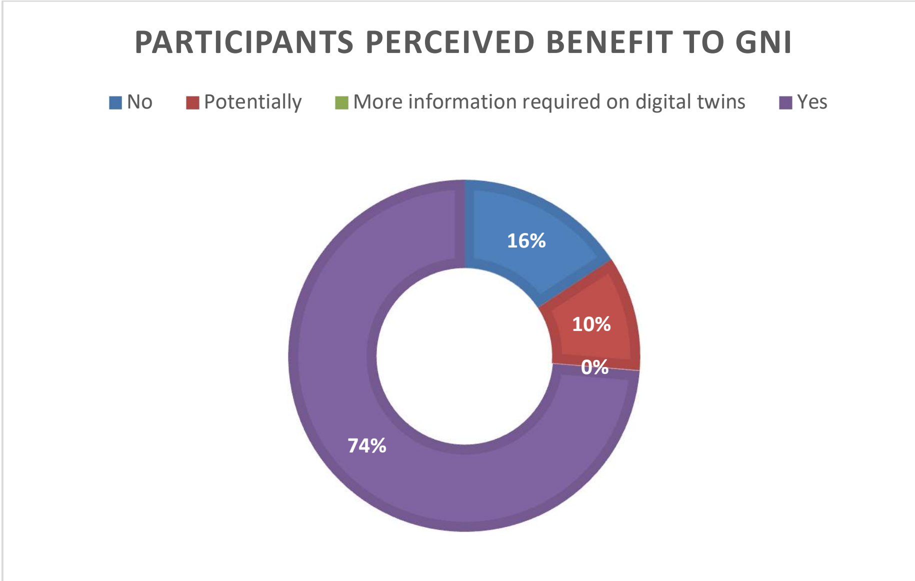



*Figure 9: Participants perceived benefits of using digital twins to GNI as an organization.*

The workshops raised a series of high-level opportunities, concerns and observations. Many of the apprehensions were related to data, systems and accessing or searching for information, as listed:

- Introducing new systems could add to the complexity of the existing systems internally with the business
- Implementing a digital twin could add to existing workloads or complicate current procedures
- Data outputs, particularly for assets, are not fully aligned
- There are mixed opinions for the participants' departmental digital twin benefits
- Security levels are critical to GNI for cyber and national data threats
- Records on-site can prove challenging which involves hand copies or searching for information

Participants felt they needed to know what they were looking for in systems such as Maximo to follow a chain of cascading events. For example, information retained in SharePoint related to asset record information (O&M) is stored by the last project number. Record information exists over several systems depending on what is required. Data integration between systems is challenging, not to mention the future security requirements. A common discussion point on the benefits was accessing information by linking asset data or records in the model. Accessing readily available data and records was raised on a few occasions. However, this does not fulfil the initial digital twin statement but certainly drives obvious business benefits. Opportunities discussed but not explicitly made into a proposed case due to a lack of specific detail or data maturity as listed:

- Applying a digital twin for gas regulation as a 'single source of truth.'
- Data 'mashups' could be applied to help with future predictive maintenance and integrate systems
- Potential for digital twins to help with investment decisions
- Potential for review of digital twins with smart metering projects
- Digital twins could help with distribution leak challenges.
- Pipe support analysis, can a digital twin reduce the time is taken (6-8 weeks)

- Digital twins for gas transmission vibrations at certain flow levels
- Ability to model what-if scenarios on whole networks
- Use digital twins for more complex training functions
- Potential to take leverage from scans or surveys

Figures 10 and 11 illustrate paraphrased comments on high-level digital twin applications and concerns raised during the discussions.

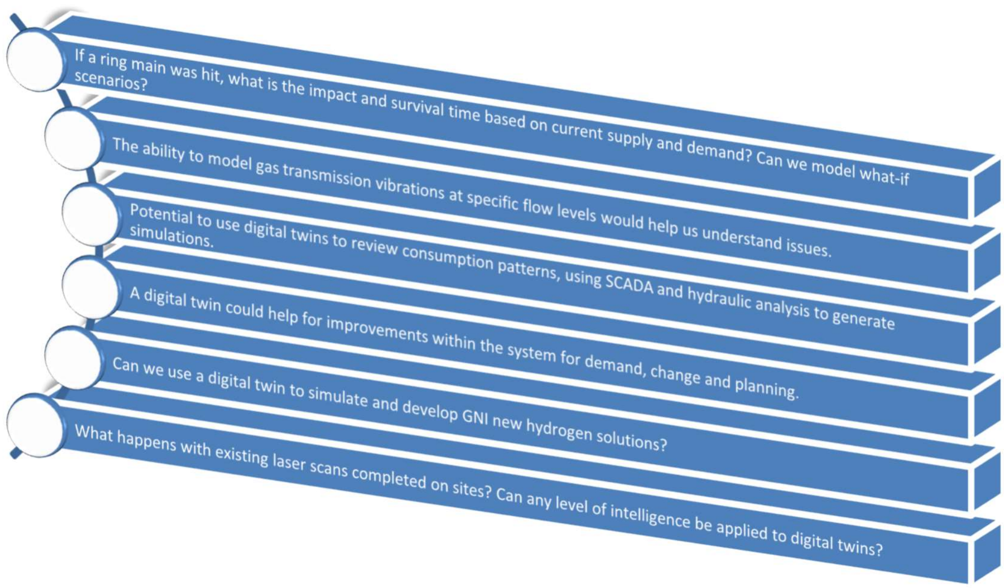



*Figure 10: Commentary on high-level discussion points*

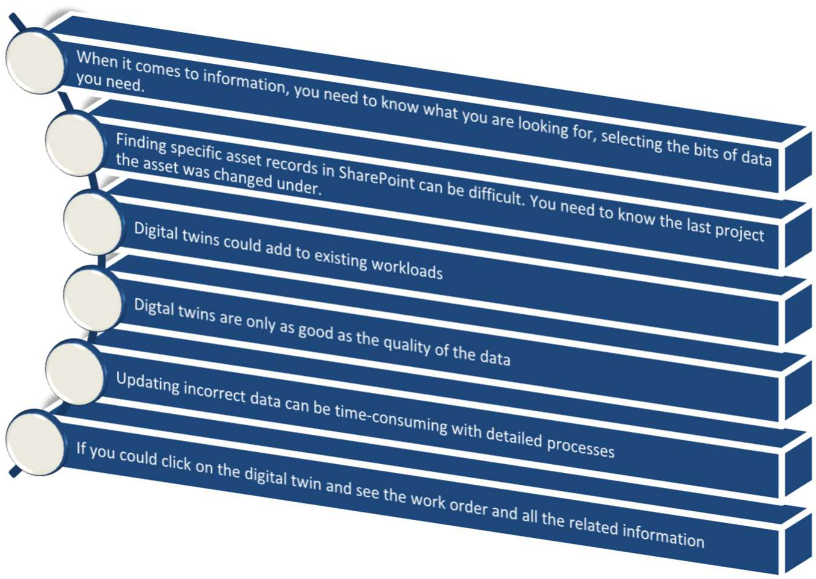



*Figure 11: Commentary on challenge points*

Reviewing the feedback and discussion points unlocked a series of interviewer observations providing insight throughout the business functions:

- The stakeholders were generally unaware of digital twins before the project discussions (Survey)
- Numerous software/technology systems are in place, some of which operate in a silo
- Potential existing technology is planned within the organization for dashboard functions (SAP)
- Current systems are under strategic alignment (Line of sight)
- There appear to be a series of projects in the early stages of development or being proposed that would influence the digital twin pilot
- There is a level of fragmentation between departments
- Individuals' roles have changed, or departmental restructuring is taking place
- Live feedback systems already exist for transmission and distribution
- Users need a 'departmental system-level skill set' to find information. Many of the interviewed groups had detailed experience and knowledge of the systems

## 4.1 Internal GNI Projects

GNI undertakes numerous improvement schemes; an example is project Horizon, which spans the organization and addresses many data silos as an overarching approach. The workshops reviewed the Asset Information Improvement Strategy (AIIS), which involves auditing and updating 197 site records, with 42 completed to date and the remainder due by 2026. AIIS involves inspecting assets on-site and updating the mechanical and electrical records, including SCADA, Maximo, Meridian and the Operational Field Drawings (OFD). As structured and quality data is vital to implementing a digital twin, only a new project or one already audited should be deemed appropriate within the scope of the pilot.

During the discovery stage in the workshops, other potential projects came to light, some of which are at the early proposal stages. In addition, there is an opportunity for digital twin development to intersect/integrate Project Horizon and strategically align with proposed schemes primarily related to asset data.

## 4.2 GNI early data review from SCADA

GNI has a Supervisory Control and Data Acquisition (SCADA) system that integrates on-site telemetry feeding back to Honeywell PKS via dashboards and graphical representations. Live data from multiple sites sent through sensors have a communication redundancy that allows Grid Control to make informed decisions on gas demand and faults. The data is sensitive and governed by security policies for cyber threats. Under the discovery workshops, Operational Technology (OT) provided 12 months of data at two-second intervals for a valve in Glenn Mooar, Isle of Man, detailing differential pressure and saturation level. Simulating the data in a SQL database for the delayed response was integrated into the model to prove the concept of connecting models with databases. The output was recorded via a video and presented in the remaining workshops (Figure 12).


*Figure 12: Integration of simulated pressure readings connected to the model.*

Accessing SCADA data is challenging as IEC 62443 series compliance is required for Industrial Automation and Control Systems (IACS), and GNI is striving for Level 3 maturity. A vital role of OT is to safeguard data through cyber security, thus reducing the risk of an impact from national threats. The workshops uncovered that a project is in the early scoping stages of making the SCADA data available through a database for GNI internal consumers. However, this currently is in the conceptual stages with no funding allocated. Moreover, feedback from the participants on linking assets in a model to updated ‘live’ databases did not receive positive feedback for benefits. The common question was, why does having live asset information in the model help drive benefits if this is already available on a dashboard? Finally, the industry research uncovered at least four projects that integrated SCADA data to the digital twin approach.

## 4.3 Virtual Reality (VR) and assets

National Grid’s success in adopting a digital twin using VR provided insight into an example in the gas supply industry. VR and digital twins for safety received positive feedback during the workshops as users could relate to the benefits. Moreover, it was a relatively easy concept to discuss with stakeholders. GNI take pride in their safety record, and in April 2021, GNI achieved one million hours accident-free (GNI, 2021).

Using a digital twin for H&S represents a low overhead, as a standard is in place for BIM via PAS1192-6:2018. However, it is undergoing ISO 19650 alignment. As new ‘green’ technology is being tested and developed, it is important to understand risks and how assets are operated and maintained. Hydrogen solutions are currently under review, with plans to test solutions at a new off-network facility. Developing green solutions are vital for Ireland to meet net-zero energy systems by 2050 (Government of Ireland, 2021) as 62% of Ireland’s Green Houses Gases (GHG) are due to energy production emission (MaREI and Wind Energy Ireland, 2021). Building physical replications of new technology solutions are costly and time-consuming. The ability to model and introduce a digital twin delivered through a VR environment could help understand the transition to new, greener solutions.

Considering the opportunity in VR, a demonstrator of Glenn Mooar Isle of Man (Figure 13) and a Compressed Natural Gas (CNG) station was created through the Oculus Quest 2. The modelled datasets already existed, and asset information was interrogated through the VR controls. As a result, any changes in property values from a database are updated live in the VR, desktop and mobile environment. The value proposition means that users see live feedback data regardless of their location.

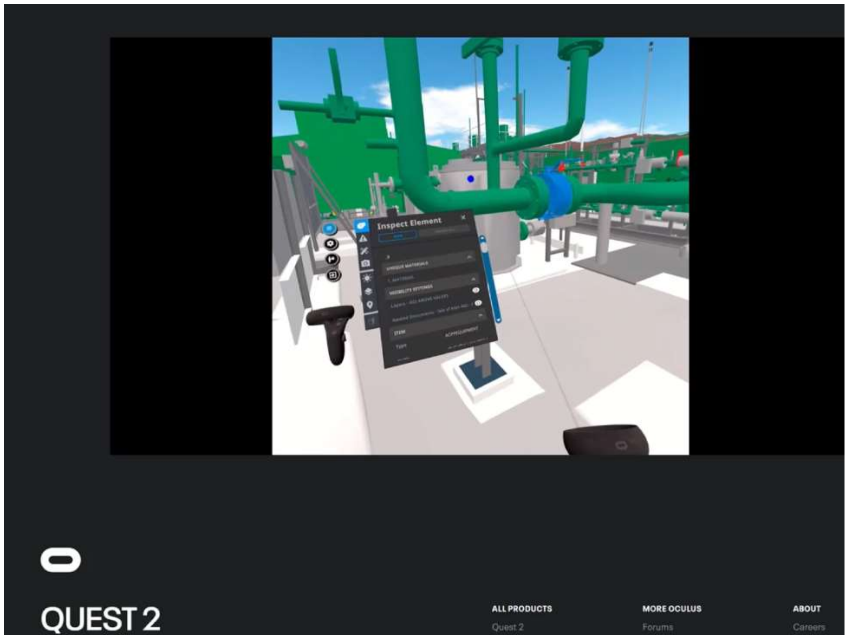



*Figure 13: Glen Mooar Isle of Man Oculus Quest2 and asset data.*

## 4.4 Challenges in digital twin selection and terminology

There is a joint alignment between Building Information Modelling (BIM) projects and digital twins. GNI has already embarked on BIM centric projects and the development of processes and technology approaches. Some participants related the digital twin to the previous BIM initiatives.

The workshops have indicated that alignment with GNI's systems and data is complex and unlikely. In effect, this illustrates one of the anticipated project risks with and proposed mitigations and countermeasures to utilize 'harvested' data and build a 'mocked' system. Considering this, the digital twin definition for GNI remains the same as this is the level of maturity required within the organization, albeit not achievable at this point.

Data standards represent another layer and this risk of avoiding duplication or restructuring existing data records. The challenges are mainly:

- Security
- Common language and ontology – how does this tie in with GNIs
- Interoperability

The report's recommendation is to relax the terminology by removing the live data as follows:

| |
|---|
| "Virtual representation of the physical asset, enriched with data updating the operator on the status and condition of the asset to inform decision making." |

# 5 Recommendations

Arguably and in the context of the case studies reviewed, GNI already operates a digital twin through SCADA and Honeywell interfaces, as this presents live data from multiple '*physical'* assets connecting to a '*digital'* output facilitating operational decisions. However, there is a much broader prospect to integrate with various data sources and between departments removing silos.

There are two challenges that GNI will have when it comes to digital twins, firstly there is a lack of knowledge within the organization, and secondary data integration is complex between systems. The first issue should not be portrayed negatively, as the industry review indicates this state is mirrored with digital twins having several connotations and an alignment required on terminology and standardization. However, the energy sector of the reviewed cases is an area of digital twin growth with measured benefits in some cases. There is an opportunity to learn lessons from the 44 projects and lead locally within Ireland in the energy sector. The argument with most prevailing shifts in technology and processes is that there is an onboarding point at some stage, and an entry point is inevitable. As the project reviewed some of GNI's rich asset models, including geospatial and data outputs, it is clear that there is a level of digital model maturity and capability with internal and external stakeholders. Regarding the second concern on data and system integration, relaxing GNI's terminology on digital twins (Section 4.4) overcomes these issues, including the security of systems such as SCADA. In effect, this allows a scaled approach to digital twins as data workflows become more aligned.

The workshops produced a series of cases (Appendix C) primarily interlinked and driven by accessing the correct information at the right time. All outputs could have a non-digital twin approach to resolve or improve the potential challenges. However, given the pace of internal projects, an alignment for a non-digital twin approach could be problematic with elevated efforts and costs.

The report justifies delivering a pilot on a digital twin based on:

1. Five cases are available with potential benefits
2. Initial investigation into the technology workflows indicates potential benefits
3. There is a mixed maturity and understanding in the industry, meaning that GNI are at a similar level and not lagging
4. GNI already have a maturity in integrating live asset data and digital outputs through SCADA
5. Despite having siloed assets and documents, several projects are rectifying these issues, which will help the digital twin pilot
6. GNI and project stakeholders have a strong knowledge of BIM, a practice closely linked to digital twins in the building and infrastructure sectors
7. Based on the model and data assessments, a simple GNI digital twin maturity progression is identified for:
    a. Pilot functions
    b. Scalable future functions
    c. Terminology maturity, i.e., moving to 'real-time data

## 5.1 GNI Pilot Project selection

Considering the potential innovation project pipeline factored with GNI's line of sight, the digital twin mustn't add a layer of complexity or new data. It is worth noting that a hydrogen ready project would have been ideal for a digital twin, but the asset data and physical network is not in place. In effect, this does not exclude the creation of hydrogen ready digital twins later as one of the key functional areas is training, where models simulate the proposed environment and conditions. When compiling the seminars and report, COP26 was underway, influencing media coverage. Therefore, as hydrogen ready projects have limited data, a CNG refueling station has been selected as the digital twin pilot. Several factors influenced this decision, mainly:

- The models have been reviewed and tested as part of the research for:
    - Integration with VR
    - Integration with databases
- The models are well developed and manageable for a pilot project
- CNG is a new clean technology solution for refueling HGVs with future stations planned
- There are around 50 assets that need to be maintained
- CNGs are within the asset alignment project

## 5.2 Digital Twin Approach

The data integration and security challenges previously mentioned generates a major constraint. The discovery sessions discussed over 16 different systems, with 39 known technologies/solutions used at GNI. As a direct connection to Maximo, Syclo, SCADA, or other systems are improbable *at this stage,* an emulated database and records system will be made available. Essentially, the asset data records, telemetry, manuals are captured in an 'ideal' environment leading to the single source of truth to the CNG station for a '*point in time*. Some data records may be available through a direct connection, such as Meridian or SharePoint, which is reviewed in the pilot. Figure 14 details the process for the data acquisition.

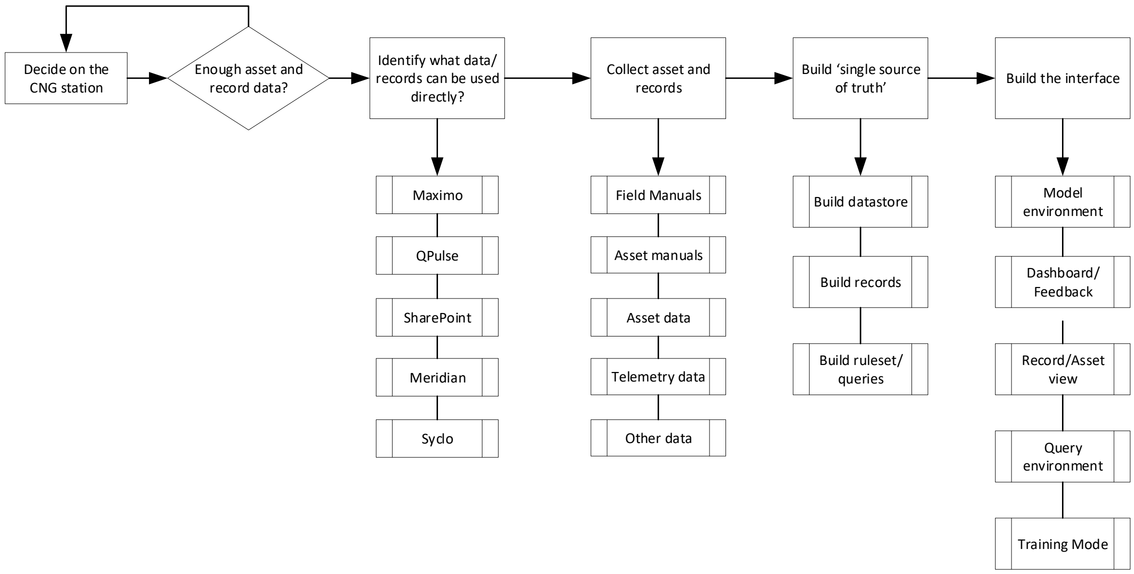



*Figure 14: Process for building the CNG digital twin environment*

## 5.1 What will the pilot digital twin look like?

The digital twin will be a modelled CNG station with available asset data and appropriate records. In addition, there are 'functional areas' that the pilot digital twin will cover and future scope areas when a greater level of maturity has been reached within GNI, as illustrated in Figure 15.

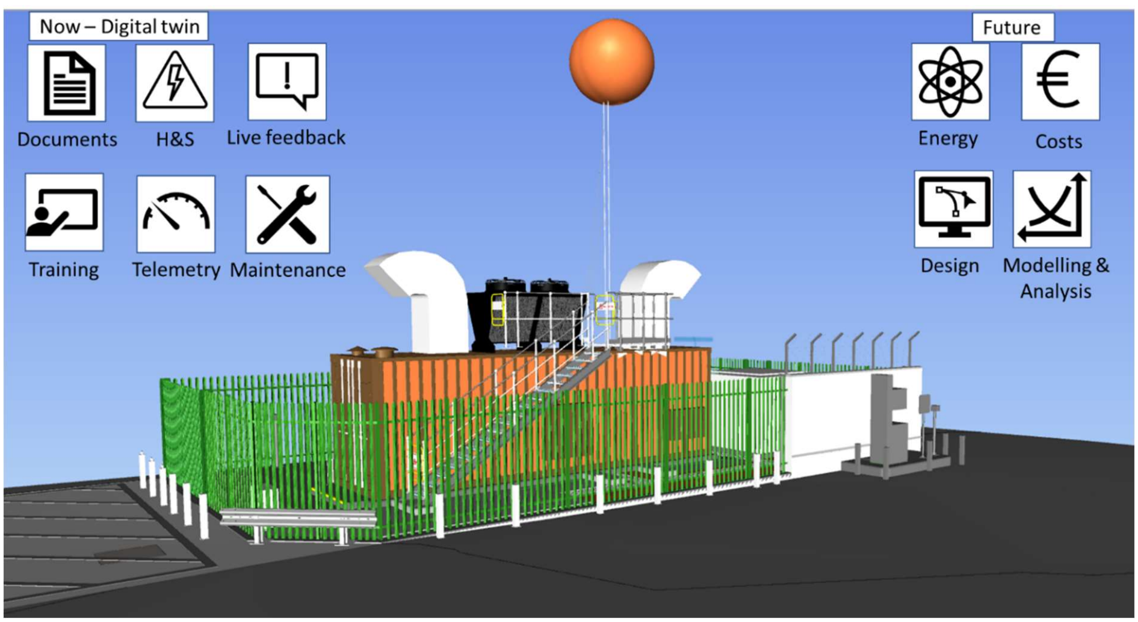



*Figure 15: CNG digital twin pilot and future functional areas.*

Expected user interaction will be through a model environment where the asset can be interrogated and visible with information, data and records. Users will roll back readings, see recent changes and variations, and then access manual and maintenance data. Example scenarios are listed in Table 2.

*Table 2: Example table of features in the digital twin and functional areas*

| | |
|---|---|
| An operative can digitally view the asset before going to a site, checking the current readings and available records of information. | Documents, Telemetry, Maintenance |
| Proposed new CNG stations could be modelled and used in a VR environment for asset training and reviewing risks for new operatives. | H&S, Training |
| An operative would navigate to a site model on a device and select the asset they need to perform the work order on. The asset will contain 'live' data regarding readings and specific documentation and records accessible specifically through the model. | Documents, Telemetry, Maintenance |
| Feedback on changes could be communicated in the digital twin, avoiding prolonged updates. For example, marking a variation or note on the digital twin would make other operatives aware of pending MER changes that must be incorporated into the system. | Live feedback, Documents, Telemetry, Maintenance |
| Perform rollbacks on the digital twin for recent changes or readings for the asset. In effect, this would allow the asset member to view the changes and problem solve. | Telemetry, Maintenance |

## 5.1 Benchmarking

Throughout the pilot project benchmarking applies to reviewing the cases for the approach from the digital twin and the current process. In addition, the workflow considers any additional risks and opportunities, as highlighted in Figure 16.

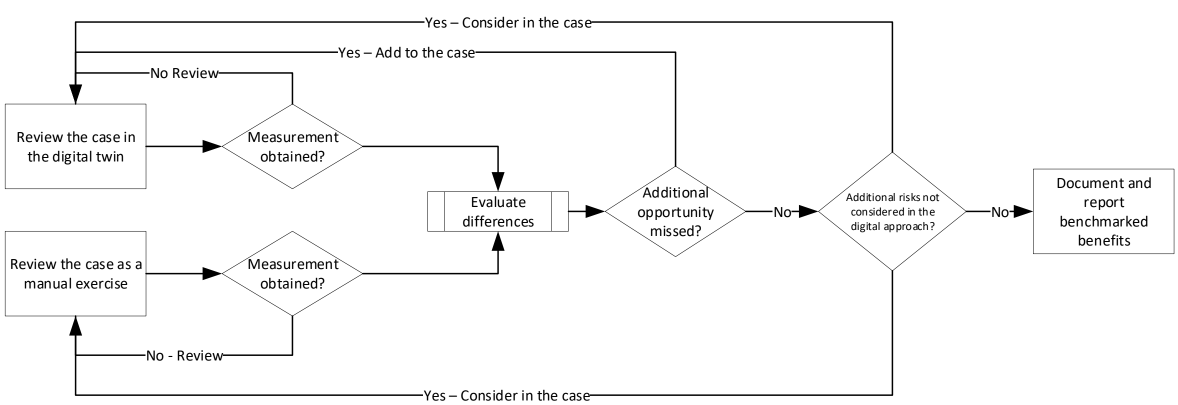



*Figure 16: Benchmarking process for comparing the cases and capturing additional benefits and risks.*

## 5.2 What does the future digital twin do?

The pilot will be constrained to a point in time dataset for a CNG. However, as open standards, interoperability and a streamlined approach are key, it is vital that the following are aligned to develop the twin for 'live asset feedback':

- Monitor changes in standards and frameworks and alignment with GNI taxonomy

- Intercept future line of sight projects
- Move GNI to a 'true' open single source of truth that can connect with the digital twin

It was observed that simulated live feedback from SCADA generated little interest to participants. However, the ability to interrogate why a change had occurred by rollbacking recent adjustments would be of significant interest. The future digital twin could address the aspirational issues reported in Section 4 for transmission and distribution. A more mature model approach will facilitate better design, modelling, energy prediction and cost certainty, provided the systems are integrated, connected and represent a 'single source of truth'.

## 5.3 GEMINI Principles

The CDBB has established the GEMINI principles (Figure 16), the foundational beliefs that digital twins have a defined 'purpose', are 'trustworthy' and 'function' successfully. Ultimately digital twins can be aggregated to a National Digital Twin (NDT), which integrates multiple twins through sectors by 'federations' (Bolton *et al.,* 2018). Moreover, the Information Management Framework (IMF) outlines the "landscape and data environment which will adequately define parties, processes, information, technology to support the National Digital Twin." (CDBB, 2020).


*Figure 17: The GEMINI Principles (Bolton, Enzer, Schooling et al., 2018, p.6.).*

There is also a Digital Twin Hub, an environment for sharing case studies, ideas and collaboration on digital twins. Many of the case studies reviewed created after 2018 align with the GEMINI principles, but the research has identified no similar framework or scheme within Ireland. Therefore the ideology has been adopted for the project providing guidance and leadership with an initial narrative established in Table 3.

*Table 3: GNI concept narrative for the GEMINI principles.*

| | | | |
|---|---|---|---|
| **Purpose – Must have a clear purpose** | Public Good: GNI's digital twin approach helps to improve maintenance reducing time spent on assets, delivering a better service to customers. | Value Creation: The benefits of a digital twin for reducing unnecessary time wasted maintaining assets. | Insight: The digital twin has been developed based on 'Functional Areas' for GNI, which are scalable as the twin evolves. |
| **Trust – Must be trustworthy** | Security: As GNI is concerned about security, the digital twin is proposed at two stages, (i) offline, point in time data connections, then (ii) considering live systems and a security approach. | Openness: GNI taxonomy needs to be maintained, open standards will be reviewed as part of the delivery process. | Quality: The quality of the data, models and records are already governed by GNI's standards and procedures. |
| **Function – Must function effectively** | Federation: GNI shares data, models and documents with project teams. The pilot will develop the digital twin in an environment that is scalable and transferable as GNI maturity develops. | Curation: Ownership of all data, models and outputs remain with GNI. | Evolution: The solution is planned to be scalable by first establishing a framework for GNI to align assets, documents and future scope. |

## 5.4 Project Delivery

The proposal is to build an exemplary or validate an existing CNG station with asset records and an 'offline' database and associated documentation. Accessing GNI staff is required as one of the early project dependencies for:

- Asset and document records
- Specific maintenance tasks and processes
- General checkpoints and feedback on the digital twin
- Development and assessing benchmarking in:
  - The digital twin
  - The current process

# 6 Appendix A - Survey

Gas Networks Ireland

## Digital Twin

**GNI Digital Twin Survey.**

GNI is conducting a digital twin feasibility project. This survey will help provide insight into GNI's understanding of a digital twin and potential applications.

* Required

1. What is your department/team? *

Select your answer

2. What is your role? *

Enter your answer

3. Are you aware of Building Information Modelling (BIM)? *

- ○ Not aware
- ○ Just aware
- ○ Aware
- ○ Detailed knowledge

4. How would you describe BIM? *

Enter your answer

5. Are you aware of what a Digital Twin is? *

- ( ) Not aware
- (•) Just aware
- ( ) Aware
- ( ) Detailed knowledge

6. Considering the term Digital Twin do you think it is? *

Tick as many that apply

- [ ] A computer model as a digital representation of a physical asset (e.g., a 3D model of an AGI);
- [ ] A digital asset where the physical twin may exist or may not yet exist (e.g., a model of an unbuilt asset)
- [ ] A dynamic data connection between the physical twin and the digital twin.
- [ ] Something else not listed

7. How would you describe a digital twin? *

Enter your answer

8. Where do you think Digital Twins are in industry from a maturity perspective? *

- ◯ Not started yet
- ◯ At the early stages of adoption
- ◯ Commonly adopted
- ◯ Very mature and well adopted
- ◯ Don't know

9. Considering Digital Twins, how could these benefit GNI? (Tick all that apply) *

If selecting don't know, do not select the other boxes.

- ☐ Improved efficiency and costs
- ☐ Improved safety and reduced risk
- ☐ Improved quality
- ☐ Improved regulatory compliance
- ☐ Improving sustainability and environmental factors
- ☐ Don't know

10. Considering the previous question, please provide some comments on your selection with examples if possible. *

| |
|---|
| Enter your answer |

# 7 Appendix B - List of workshops

List of workshops attendees as per Table 2.

*Table 4: List of workshop participants*

| Workshop Date | Participant | Department |
|---|---|---|
| 11th October 2021 | Declan Burke | Design Services |
| 13th October 2021 | Kevin Murphy | Asset Management |
| 14th October 2021 | Kevin Quaid | Operational Technology |
| 20th October 2021 | Eddie Collins | Design |
| 20th October 2021 | Danny Hourigan | Design |
| 20th October 2021 | Pat O’Connell | Asset Management |
| 21st October 2021 | Sean D O’Connor | Asset Improvement |
| 22nd October 2021 | Aidan Bugler | Grid Control |
| 27th October 2021 | Lisa Walsh | Grid Control |
| 27th October 2021 | Brid Sheehan | Grid Control |
| 4th November 2021 | Simon Mullen | GIS |
| 4th November 2021 | Danny McDade | GIS |
| 9th November 2021 | Ita Ryan | Dispatch |
| 11th November 2021 | Derek Forde | Design Services |
| 11th November 2021 | Pat Daly | SCADA |
| 11th November 2021 | Sean O’Riogain | Consultant |
| 19th November 2021 | Donal O'Caoimh | Engineer |
| 19th November 2021 | David O'Farrell | Field Operative |
| 29th November 2021 | Saran Jackson | C&I Asset Stewart |

# 8 Appendix C - Use cases

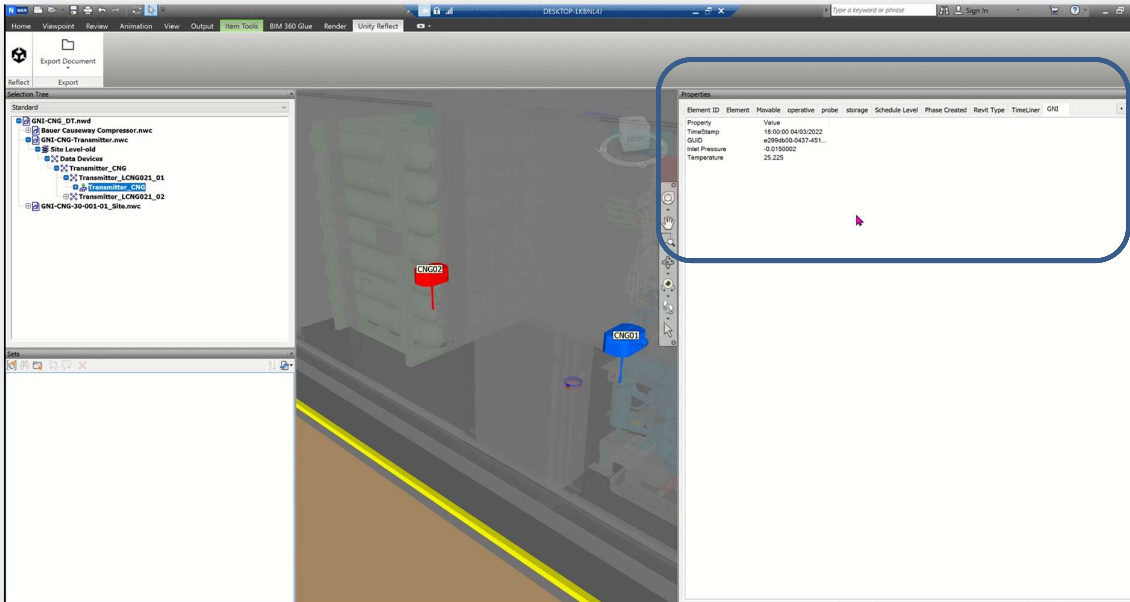
*Table 5: Digital twin use cases identified during the workshops.*

| Session - Assets | | | Problem, challenge or opportunity identification | | | | | | | NON DT Approach | | | | | DT Approach | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Task | Statement and description | Related | Frequency | Benefit - Classification | Task - Classification | Logic for DT consideration | What could be done in a DT? | What is done now? | Measurement | Could the process be improved without using a DT? | Logic | Non DT Effort | Effort Non DT | Costs Non DT | Data | Model | Model Approach | Visualisation |
| 1 | *It is hard to find information regarding specific assets as you need to drill down at a project level in SharePoint, then filter to the AGI and through the project work. The user needs an awareness of the system.* | 4 | Daily | Efficiency/Cost | Challenge | *If information was available related to the asset at hand rather than searching through previous projects.* | *The model could hold links via the asset to the current documentation in SharePoint.* | *The user manually searches through the projects until they find the last change related to the asset in question.* | Time | *By restructuring SharePoint or searching for tags related to the asset.* | Change process and change technology | *Identify from a SharePoint power user or administrator.* | Medium | Medium | SharePoint | *Federated Model in Meridian or stored with a change control process* | Direct Connection | Model |
| 2 | *Visiting sites has several risks for associated from COVID to hazards. A interactive model could help reduce risks by reviewing safety factors such as confinement and ATEX.* | | Daily | H&S | Challenge | *GNI have an exceptional record in respect to accident free periods. The introduction of new 'green' technology and systems will mean understanding updated configurations. Using a digital twin to model such environments capturing ATEX and other safety aspects will help in driving awareness for PPE, risk and emergency response.* | *The digital twin could hold all information related to safety. Not just visually, but associated documentation or interactive query points and risks. A VR level model could be applied similar to National Gas considering PPE, risk and tasks* | *ATEX and H&S data is maintained in records corresponding to the site. The operative manually checks this information.* | Risk reduction | *Yes, a more integrated approach with links in the drawings or published assets could help alleviate time taken to search for asset information.* | Change process and change technology | *Make connections between the records, update and circulate.* | Medium | Medium | SharePoint | *Federated model* | Direct Connection | Model |
| 3 | *It is challenging to find asset data changes as there is information related to the note (what is filled in when completed) and the log (history of values) via SYCLO.* | | Daily | Efficiency/Cost | Problem | *Access live and historical 'roll back' data in a model environment would facilitate better problem solving.* | *Use the model to drill down to the asset and link into the previous notes and logs to see what was changed.* | *The last note and log is only visible.* | Time | *Yes, needs integration with Maximo. However, the digital twin solution will need integration with Maximo.* | Change process and change technology | Integration between the rugged devices and Maximo and existing records | High | High | Maximo/Syclo | Integrated asset and model data | Direct Connection | Model/database |
| 4 | *When performing asset tasks on site the record could be wrong. For example a Mains Exception Report (MER) needs to be completed to adjust the position of an asset. This could take a few weeks to update.* | 1 | Daily | Efficiency/Cost | Challenge | *Want to have access to the latest drawings and most recent version of the information.* | *Feedback from operators on site could be held directly in the model environment tracking comments until the MER is updated.* | *MER is completed and records updates could take a few weeks to be completed.* | Time | *Yes, shorten the cycle or let the operative redline the record and have this recorded 'live' until the information is officially updated.* | Change process and change technology | Introduce a mechanism for redlines and sharing the information globally. | Medium | Medium | GIS and SharePoint | Model with redlining process | Direct Connection | Model |
| 5 | *Accessing all the appropriate information for C&I work orders is challenging as there are several sources, depending on the requirements of the task. Users need to search several system or have data copied from SharePoint to Sharefile.* | 1&4 | Daily | Efficiency/Cost | Challenge | *A connection to the single source of truth for assets, documents and historic data.* | *The operative on site could navigate to the model an access the information they require.* | *Users need to search for information and Engineers will share records for on-site operatives.* | Time | *Yes, better restructuring of asset and record data.* | Change process and change technology | Improve data connections and direct access | High | High | SharePoint and Maximo | Integrated asset and model data | Direct Connection | Model/database |

# 9 Appendix D – DT POC Deliverables

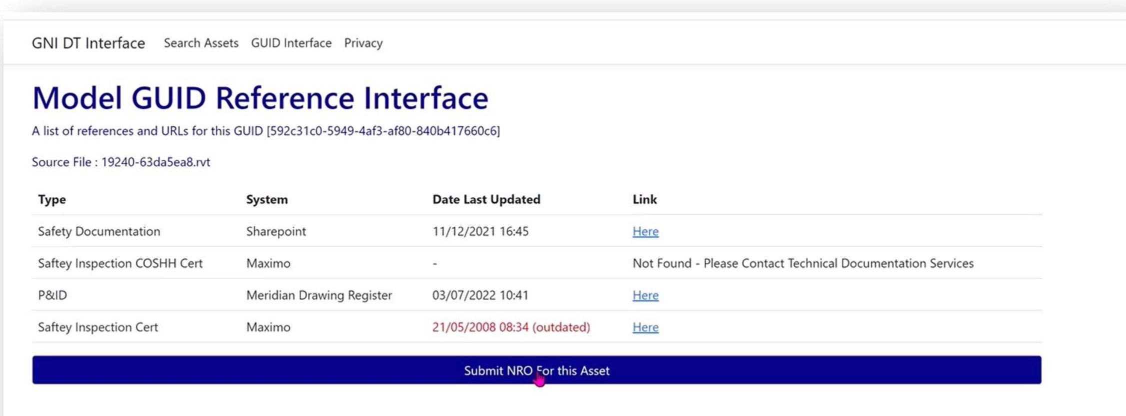
### 1. Navisworks 3D model

- Assets selected in the model will show live information that comes through database connected with SCADA.

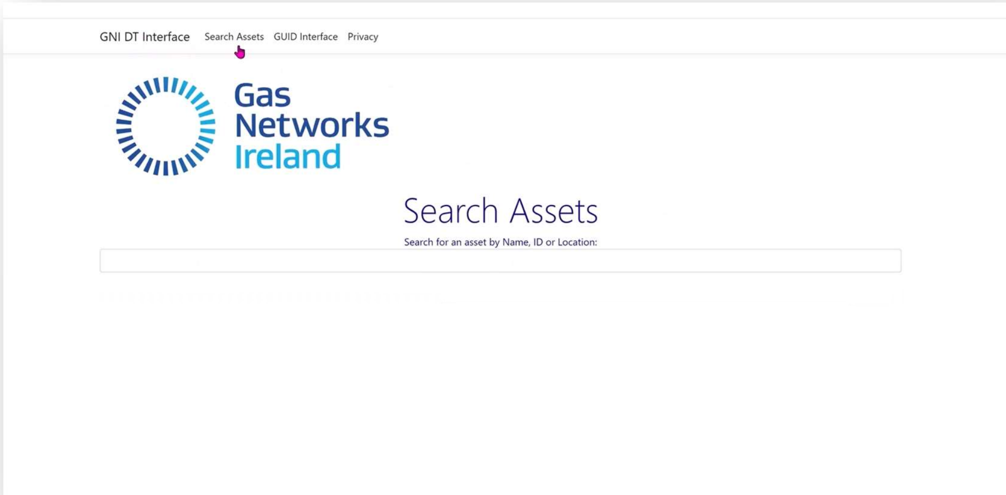



### 2. Digital Twin Management System.

- DT Management system tailored to fit specific GNI project needs. Link for each asset is embedded into the 3D model. Any Common Data Environment (CDE) used on project/company level linked to the portal – BIM360, Maximo, SharePoint etc. Documents from different sources available for each asset.:



- Searching Assets by Name, ID, GTIN (GS1) or GUID :

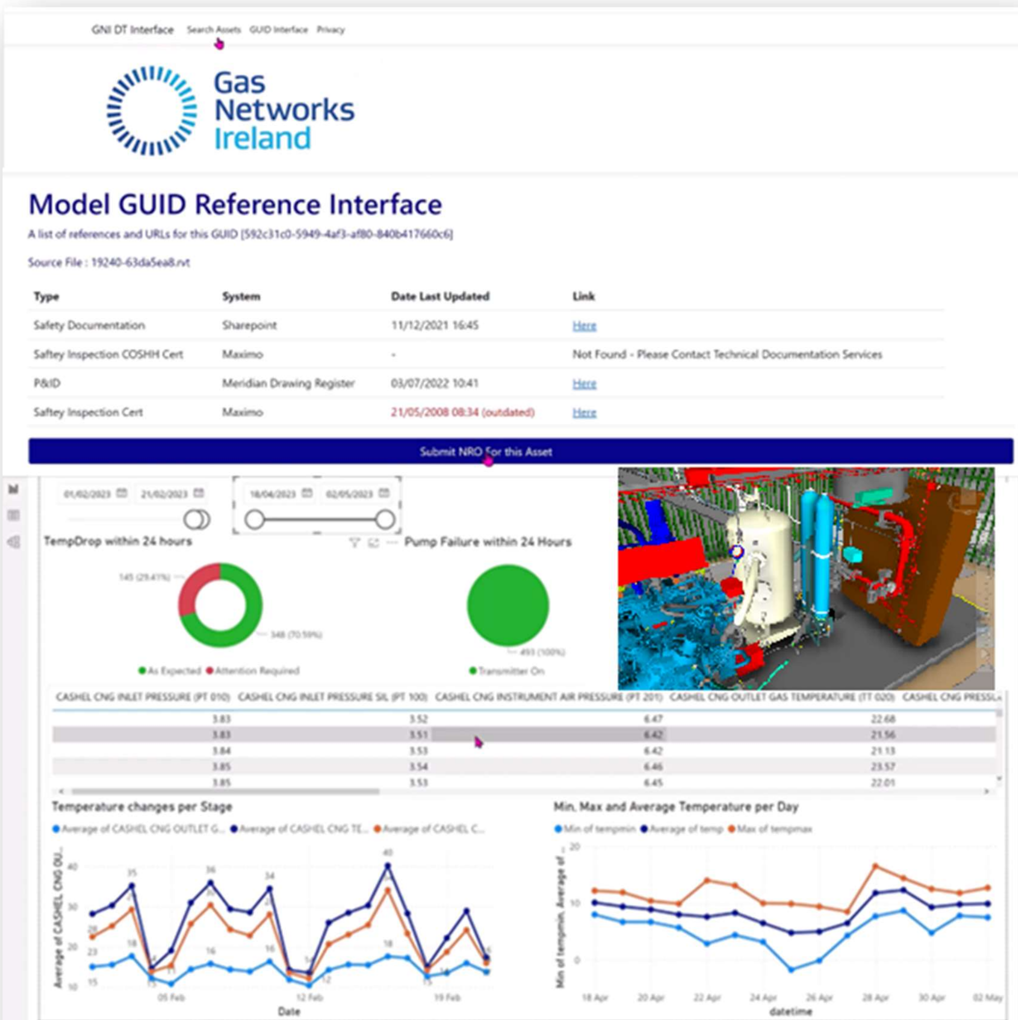



### 3. Data Visualisation Interface

- Visualise through PowerBi, connected to the GNI database. Showing pressure & temperature changes per stage for each of the assets. You can review live information or go back and check the performance at any particular point in time . This is highly customizable setup and can visualise different aspects of the assets based on information available in the GNI database.

## 4. Future functionality

- Embedded data visualisation into the GNI DT portal with open source BIM model viewer. User can highlight/isolate objects in the viewer per their status based on real-time data from sensors.
- Access to real-time asset data information, 3D model and documentation in one centralise place.
- Submit changes, track status of any ongoing maintenance task in the platform.
- GTIN/GUID asset integration, tracking the product lifecycle in the Digital twin platform.



# 10 Appendix E - Recommendation for future DT Projects

To achieve a real Digital Twin, Gas Networks Ireland would need to integrate all the different systems involved in the project, including the BIM software, data collection devices, SCADA system, and other systems. This would involve ensuring that all systems can communicate with each other in real-time. To achieve system integration, Gas Networks Ireland would need to:

- Develop an integration plan that outlines the requirements for system integration, including the types of systems that need to be integrated and the data exchange protocols.
- Ensure that all systems are using the same data exchange protocols.
- Test the integration of all systems to ensure that they are communicating effectively.
- Early engagement of all the stakeholders (for example developing 3D BIM models)
- Avoid access/ integration limitations between different software platforms due to IP policy – plan to implement authentication and authorization

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