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BAHCESEHIR UNIVERSITY

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COMPUTER ENGINEERING HEAD OF THE DEPARTMENT

VGIS DIGITAL TWIN PLATFORM FOR DISASTER MANAGEMENT AND ENVIRONMENT PROTECTION USING OILFIELD DATASET

MASTER'S THESIS

AWAB ALABBASI

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I hereby declare that all information in this document has been obtained and presented in accordance with academic rules and ethical conduct. I also declare that, as required by these rules and conduct, I have fully cited and referenced all material and results that are not original to this work.

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ABSTRACT

VGIS DIGITAL TWIN PLATFORM FOR DISASTER MANAGEMENT AND ENVIRONMENT PROTECTION USING OILFIELD DATASET

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VGIS (Virtual Geographic Information System) Platform is a unified oilfield operations management platform based on MaaS (Management as a Service) that integrates advanced technologies such as AIoT (Artificial Intelligence & Internet of Things), GIS (Geographic Information System), Digital Twin, and AR (Augmented Reality)/ VR (Virtual Reality). The VGIS platform connects, collects, integrates, analyses, and acts on disparate data sources to provide the oilfield with a centralized view to help make informed decisions fast, bring operational visibility across all assets to improve safety and operational efficiency, reduce costs and improve margins, provide comprehensive analytics and decision support, increase business agility, and reduce management complexity. This is a case study of the application of the VGIS platform of oilfield. VGIS digital transformation, production process, and KPIs (Key performance indicators) are highly managed taking oilfield management to a higher level globally.

Key Words: VGIS Platform; MaaS; Augmented Reality; Virtual Reality; Artificial Intelligence; Internet of Things; Digital Twin.

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VGIS DIGITAL TWIN PLATFORM FOR DISASTER MANAGEMENT AND ENVIRONMENT PROTECTION USING OILFIELD DATASET

I wish to express my deepest gratitude to my supervisor Prof. Dr. Pınar Sarısaray Bölük and Asst. Prof. Dr. Maalim A. Aljabery for their guidance, advices, criticisms, encouragements, and insights throughout the research.

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LIST OF ABBREVIATIONS

VGIS	Virtual Geographic Information System
BOPD	Barrels of Oil Per Day
IOF	Intelligent Oil Field
VR	Virtual Reality
SLAM	Simultaneous Localization and Mapping
BP	British Petroleum Company
BI	Business Intelligence
HSE	Health, Safety, And Environment
UAV	Unmanned Aerial Vehicle
GIS	Geographic Information Systems
FSA	Field Situational Awareness
HSSE	Health, Safety, Security & Environment
SAP	System Applications and Products in Data Processing
OA	Office Automation
PI	Process & Instrumentation
DCS	Distributed Controlling System
CCTV	Closed-Circuit Television
EAM	Enterprise asset management
EDW	Engineering Data warehouse
SCADA	Supervisory Control and Data Acquisition
AR	Augmented Reality
GeoJSON	A file format for representing map data
SHP	Shapefile is a vector graphics format
ANSI	American National Standards Institute
UTF-8	8-bit Unicode Transformation Format
ETL	Extract, Transfer and Loading
GBK	Chinese Internal Code Extension Specification

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Chapter 1

Introduction

Data on the Earth is gathered from several sources, including remote sensing data, GPS data, photogrammetric or surveying measures, drones, and historical drawings. This enables the potential for 3D presentations. Maps are often utilised as a primary means of conveying information. In the present era, numerous companies are engaged in the production of three-dimensional (3D) representations of both urban and rural settings.

These 3D representations facilitate comprehension and acquisition of knowledge about the physical world, which may be effectively conveyed to users. The enhanced level of photo-realism exhibited by these models, as depicted in *Figure 1*, renders them suitable for a diverse range of users, spanning from young students to highly proficient experts across several scientific and practical domains (M. H. Al-Jaberi et. al.). This case study elucidates the utilisation of the VGIS platform for the Majnoon oil field situated in Iraq, renowned as one of the most abundant oil reserves globally, believed to contain over 38 billion barrels of oil (Remondino et. al.).

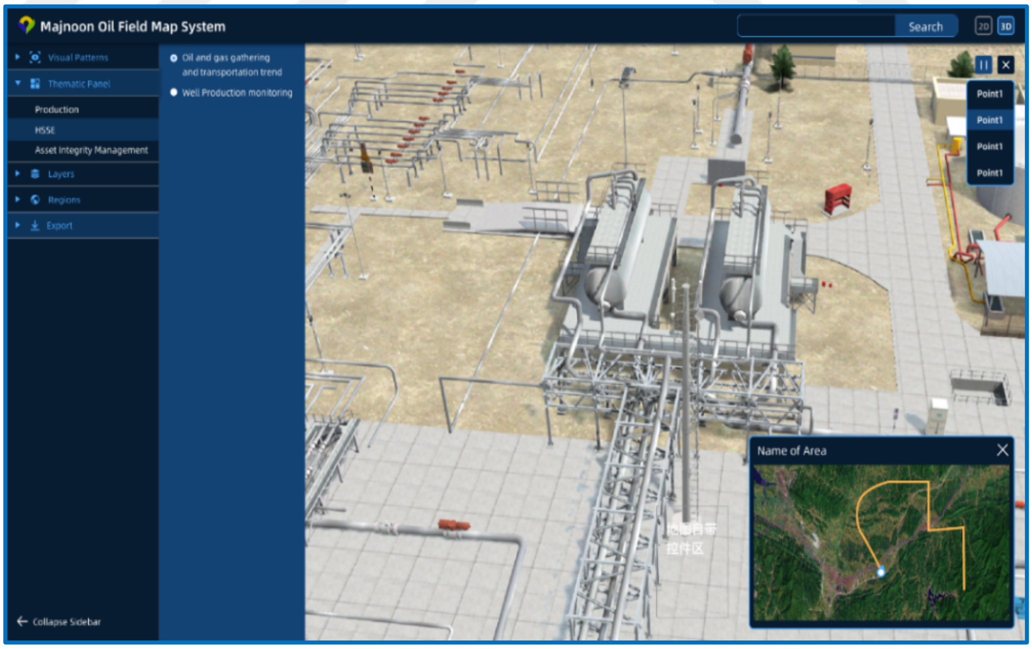


Figure 1. VGIS 3D Digital Map System

1.1. Statement of the Problem

The Oilfield's expanding exploration and production endeavours present a significant obstacle to improving efficiency and reducing risk, given the constantly shifting dynamics. Routine operations and management necessitate extensive technical data for analysis, which is distributed across various departments and hampers operational and managerial efficiency. The Field Y2021-2025 (Field Development Plan) prioritises the implementation of production enhancement measures in the intelligent oil field (IOF).

1.2. Purpose of the Study

The deployment of VGIS (Virtualized Geographic Information System) commenced as the fundamental framework of Intelligent Oilfield (IOF) to address the encountered difficulties. The IOF's application centre is a comprehensive and integrated VGIS platform that facilitates cooperation and enables intelligent decision-making. The VGIS platform will generate a virtual reality representation of the oilfield and assist operators in developing and optimising production plans, processes, workflows, and monitoring operational performance. The objective of the VGIS platform is to enhance efficiency, safety, and productivity while reducing risks and costs in the oilfield.

1.3. Research Questions

Creating 3D models for a complex corridor of pipes, including oil, gas and water pipes, as well as various components such as valves, transmitters, instruments, pumps, vessels, coolers and heaters, is a significant challenge. The goal is not only to accurately represent the physical layout in the digital world but also to capture all the intricate details. Furthermore, there is a significant amount of work required to break down this large number of assets into distinct components, as well as extensive usage of GPU rendering and RAM space to ensure that all assets are functioning properly within the engine. The next point is that the modelling of materials or things in the 3D world occurs automatically based on the data provided by apps. The efficiency of integration and the accuracy of live data are crucial variables in ensuring that the digital world keeps pace with real production processes. The final application is a GIS map loading and tools application. GIS, which stands for geomatics database, contains a vast array of information in various formats. It is utilised across multiple disciplines and facilitates collaboration among nearly all departments in the oilfield. This application greatly enhances the efficiency of GIS service performance, resulting in cost savings in terms of economic proficiency and communication for the company.

1.4. Significance of the Study

Virtual Reality (VR), a technology that has been lately embraced by numerous multinational oil companies, is increasingly being embraced in the oil and gas sectors. Virtual reality (VR) generates a replica of actual oilfields by constructing a holographic reproduction of genuine settings. This is a cutting-edge visualisation platform designed for geographical data. It serves as a platform for gathering, managing, and interpreting oilfield production and operational data. BP (British Petroleum Company) and Chevron, among other major international oil firms, have implemented Generation VR technology to automate their oilfields and effectively decrease expenses related to suppliers and equipment. The core principles of VGIS involve the development of a three-dimensional digital representation of a specific area, the incorporation of both static and real-time data, the provision of GIS services, the integration of all relevant business data through data governance, and the implementation of intelligent decision-making processes using BI (Business Intelligence) tools. VGIS will offer a user-friendly interface that displays locations, statistical data, reports, and charts. This interface will facilitate collaboration and decision-making, and serve as a strong basis for future applications like omnipresent security, remote inspection, and online training. The VGIS Project has created a Digital Twin of the field by use drones to generate a 3D model of the assets in the real environment. This involves connecting various data sources and systems, and combining them into a Geographic Information System (GIS). VGIS provides operators with comprehensive situational awareness and business process visibility to effectively monitor field assets and operations. Additionally, VGIS allows for reduced expenditures on operations, maintenance, training, and travel. Operators, contractors, and international specialists can remotely perform site inspections and monitor the current operating state of the field using VGIS. Furthermore, VGIS has the capability to accelerate the process of transferring information and localising the workforce by decreasing speeds.

1.5. Limitations

This study aims to present a technique for transforming a real image from a two-dimensional (2D) format to a three-dimensional (3D) format, also known as 2D-to-3D conversion. Additionally, it will explore how this method enhances the versatility of Virtual Geographic Information Systems (VGIS). 2D-to-3D depth generation methods often encounter two primary obstacles. One factor to consider is the consistency of depth inside a single object. Another problem pertains to obtaining a suitable depth relationship among all items. The task of creating a depth map from individual 2D photos is a challenge that lacks a unique solution. Not all depth cues can be extracted from an image.

Chapter 2

Literature Review

2.1. Related Works

A summary of previous studies to VGIS (Virtual Geographic Information System) platform are listed below, it summarized within *Table 1*, which includes the source number, year, and topic technique in earlier research that was compiled in this study:

(Fabio Remondino and Sabry El-Hakim) 2006, the results discussed and cover various aspects of 3D modelling from terrestrial images.

(Paul A. Longley et. al.) 2015, highlight the comprehensive approach taken in this research to address various aspects of spatial data representation, visualization and analysis, which are fundamental to effective image-based 3D modelling.

(James B. Campbell and Randolph H. Wynne) 2013, the results regarding image-based 3D modelling techniques, these results highlight the importance of accurate spatial representation, data quality and advanced analysis techniques in the development and use of image-based 3D modelling in GIS.

(Robert W. Christopherson) 2015, gives detailed explanations and reviews of various aspects of image-based 3D modelling techniques, which highlight the versatility and potential of image-based 3D modelling techniques across various domains, while pointing out areas that require further research and development.

(Albert K. Yeung) 2011, explain and review the various aspects of image-based 3D modelling techniques, and highlight the versatility and potential of image-based 3D modelling techniques across various domains, while pointing out areas that require further research and development.

(Alan M. MacEachren) 1995, covers various aspects of map representation and design including how maps are perceived, understood, and used, this research highlights the theoretical foundations and practical considerations involved in the design and use of image-based 3D modelling techniques, focusing on visual cognition, symbolization, semiotics, and geographic visualization.

(Michael F. Goodchild and Donald G. Janelle) 2004, provide a comprehensive review of the results of image-based 3D modelling techniques, focusing on the applications, methods, and advancements with highlight the versatility and potential of image-based 3D modelling techniques across various domains, while pointing out areas that require further research and development.

(Michael J. de Smith) 1989, illustrates the results of image-based 3D modelling techniques as explored in the provided document, this research highlights several key areas of advancement and application as well as underscore the growing importance and utility of 3D modelling techniques in geospatial analysis, driven by advancements in software tools, data processing capabilities, and practical applications in various fields.

(Olivier Dubois) 2010, mentions to image-based 3D modelling techniques from the documents provided indicate a variety of applications and methods, the image-based 3D modelling techniques have advanced significantly by providing robust tools for visualizing and analyzing spatial data across various applications as well as the choice of technique and tool often depends on the specific requirements of the project such as the need for high accuracy, speed, or the ability to handle complex patterns and large datasets.

(Michael F. Goodchild) 1997, gives the results of image-based 3D modelling techniques, these techniques and tools represent the ongoing advancements in 3D modelling and visualization, facilitating more effective spatial analysis, and decision-making.

(Timothy W. Foresman) 1998, provides detailed insights into the results of image-based 3D modelling techniques, findings highlight the versatility and potential of image-based 3D modelling techniques in various domains, emphasizing the importance of accurate spatial representation, data quality, and advanced analysis techniques.

(Chrisman and Nicholas R) 1997, used the image-based 3D modelling techniques as extracted from the provided document: findings demonstrate the versatility and potential of image-based 3D modelling techniques across various domains, highlighting their importance in spatial analysis, urban planning, environmental monitoring, and other fields.

(Michael Grieves and John Vickers) 2017, their results indicate several key findings regarding the impact and utility of image-based 3D modelling techniques in various fields and findings demonstrate versatility and potential of image-based 3D modelling techniques with enhancing spatial analysis, urban planning, environmental monitoring, and other applications as well as emphasis on tools, algorithms, and practical uses underscores the importance of accurate spatial representation, data quality, and advanced analysis techniques in various domains.

(Yunqiang Chen) 2019, provides an overview of augmented reality (AR) technology and its applications, provide a comprehensive understanding of the current state and future direction of augmented reality technology, and highlighting its potential to transform various industries and everyday experiences.

(Ashish Ghosh) 2018, illustrates the image-based 3D modelling techniques which detailed in various documents provided and highlight the progress and practical applications of 3D modelling techniques, demonstrating their importance in various geospatial, and AR contexts.

Table 1
Summary of the studies mentioned above.

SN	Year	Author	Title
1	2006	Fabio Remondino	Image-based 3d modelling: a review (Remondino et. al.)
2	2015	Paul A. Longley	Geographic Information System (Paul A. Longley et. al.)
3	2013	James B. Campbell and Randolph H. Wynne	Introduction to Remote Sensing. Fifth Edition (James B. et. al.)
4	2015	Robert W. Christopherson	Elemental Geosystems (Robert W. at. al.)
5	2011	Albert K. Yeung	GIS Research Methods: Incorporating Spatial Perspectives (Albert K. Yeung)
6	1995	Alan M. MacEachren	How Maps Work: Representation, Visualization, and Design (Alan M. MacEachren)
7	2004	Michael F. Goodchild and Donald G. Janelle	Spatially Integrated Social Science (Michael F. et. al.)
8	1989	Michael J. de	Geospatial Analysis: A Comprehensive Guide (Michael J. et. al.)
9	2010	Olivier Dubois	Applied Geostatistics with SGeMS: A User's Guide (Olivier Dubois)
10	1997	Michael F. Goodchild	Geographical Information Systems: Principles and Applications (Michael F.)
11	1998	Timothy W. Foresman	The History of Geographic Information Systems: Perspectives from the Pioneers (Timothy W.)
12	1997	Chrisman, Nicholas R.	Exploring Geographic Information Systems (Chrisman et. al.)
13	2017	Michael Grieves and John Vickers	Digital Twin: Mitigating Unpredictable, Undesirable Emergent Behaviour in Complex Systems (Michael Grieves et. al.)
14	2019	Yunqiang Chen	An overview of augmented reality technology (Yunqiang Chen et. al.)
15	2018	Ashish Ghosh, Debasrita Chakraborty	Anwesha Law. Artificial Intelligence in Internet of Things (Ashish et. al.)

2.2. Background

The VGIS platform aims to established a practical information platform, to effectively improve management.

2.3. What is GIS:

Geographic information systems, are computer-based tools used to store, visualize, analyse, and interpret geographic data. Geographic data (also called spatial, or geospatial data) identifies the geographic location of features.

Components of GIS:

A GIS system in working order integrates the following five key components:

- Data
- Hardware
- Software
- Users/People
- Methods

-Data is a set of values of subjects with respect to qualitative or quantitative variables. Data and information or knowledge are often used interchangeably. The data can be defined as a collection of facts, such as numbers, words, measurements, observations or even just descriptions of things, and it may be classified as:

i) qualitative and ii) quantitative. Qualitative data is descriptive information whereas Quantitative data is numerical information. For example, slope of the hill is very steep, that is a qualitative information whereas slope of the hill is in between the slope range of 30 - 40%, so that is a quantitative information. Geographic data refers to information about the earth's surface and the objects found on it. This information comes in three basic forms: spatial data, tabular data, and image data. Spatial data contains the locations and shapes of map features. Tabular data is collected and compiled for specific areas and the descriptive data that GIS links to map features. Image data includes such diverse elements as satellite images, aerial photographs, and scanned data-data that's been converted from printed to digital format. Data can be created or bought. For example, a GPS receiver can be used to identify sites in an agricultural field where weed data is collected. A table can be created in the GIS showing location as well as species and number of weeds present in the measured area.

Alternatively, data can be purchased. In most cases, images are bought from satellite or aircraft companies that used cameras to collect images of the Earth’s surface.

-Map Data is an essential tool for execution of various kinds of activities. Maps or GPS based ground coordinates act as input coordinate system in GIS spatial data domain. Geo-referenced remote sensing data is also equally helpful in creating spatial information. It becomes more realistic approach when take the help of all three data types to prepare the spatial database. Map data provides information about location. *Figure 2* represents the latitude and longitude points (graticules) on the polygon graphics formed by digitizing the feature from map.

-*Attribute Data* provides the information about what can be found at a particular location. The attributes of a river, for example, might include its name, length, average depth, rate of flow, water quality, how many dams are on it, and how many bridges cross it. *Table 2* shows the GPS Coordinates VS. VGIS Coordinates:

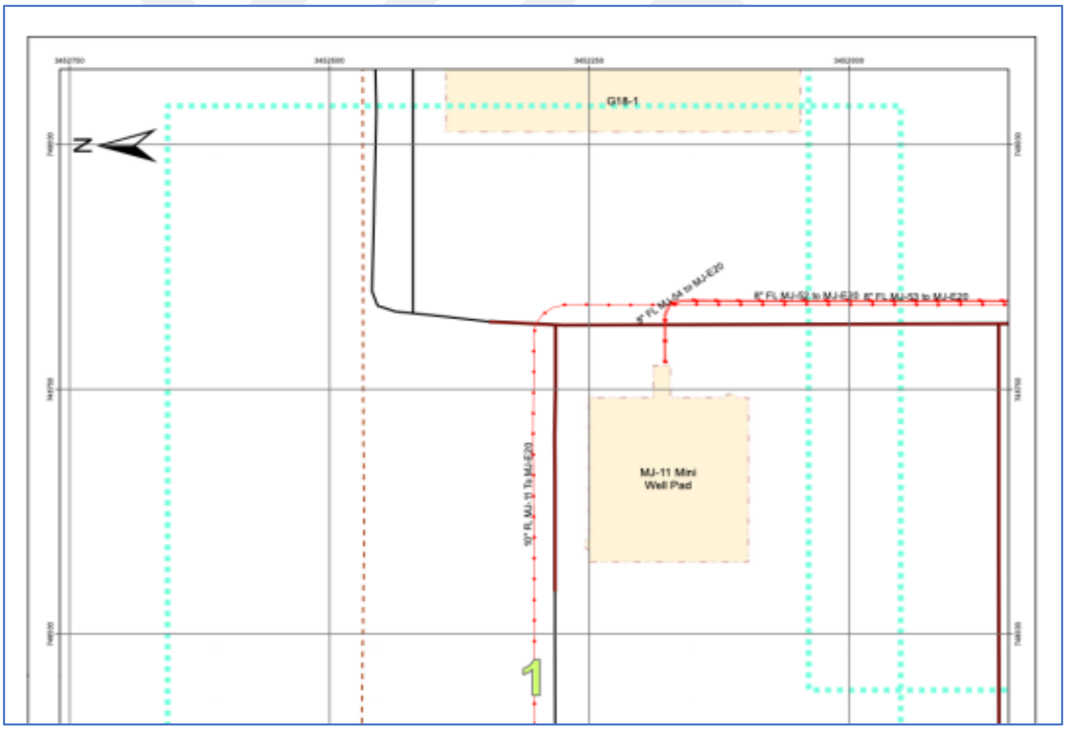
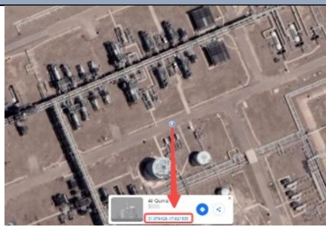
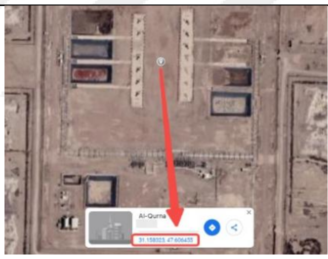
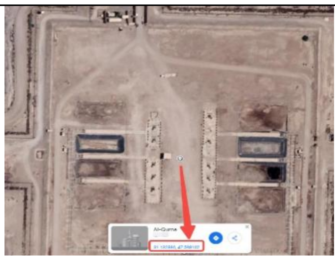
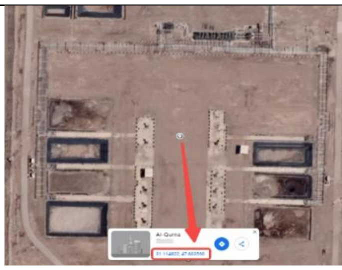


Figure 2. Map data of GIS

Table 2

GPS Coordinates VS. VGIS Coordinates

Facility	GIS	VGIS
CPF1 31.07942 9, 47.621535		
DS1 30.89475 5, 47.540285		
DS2 31.06445 4, 47.620544		
MJE20 31.15832 3, 47.606455		
MJE22 31.13288 6, 47.598102		
MJE24 31.11482 2, 47.603560		

-Hardware *i*s a computer on which GIS software runs. There are different range of computers like Desktop or server based. Arc GIS, Arc Info and Arc view GIS software servers are server-based computers where GIS software runs on network computer. The good computer hardware components must have high capacity. Examples of hardware components are: server, digitizer, PC, Printer, plotter, Hard driver, processor, graphics card, etc. All these components are work together to run GIS software smoothly, as *Figure* 3 shows.

-Software is a GIS component, a technology for storing and analysing location and attributes data. GIS Software is designed to store, retrieve, manage, display, and analyse all types of geographic and spatial data. *Figure* 4 represent the spatial and attribute data within the computer software. Examples of GIS software are Arc GIS and Arc View for desktop, Web GIS, Arc Info as server GIS etc.

-GIS User/People/Personnel*,* GIS technology may have many limitations without the involvement of people who manage the system and develop plans for applying it to real world problems. GIS users range from technical specialists who design and maintain the system to those who use it to help them perform their everyday work. GIS user/people/personnel specifically include the following categories of working environment:

- Project coordinators
- Data analysts
- Programmers
- Data and knowledge managers
- Librarians Types of GIS

Map data of GIS showing the Graticules after digitization of a particular feature from hard copy of a map:

Figure 3. GIS Hardware consists of CPU, Monitor, Plotters, and Printers

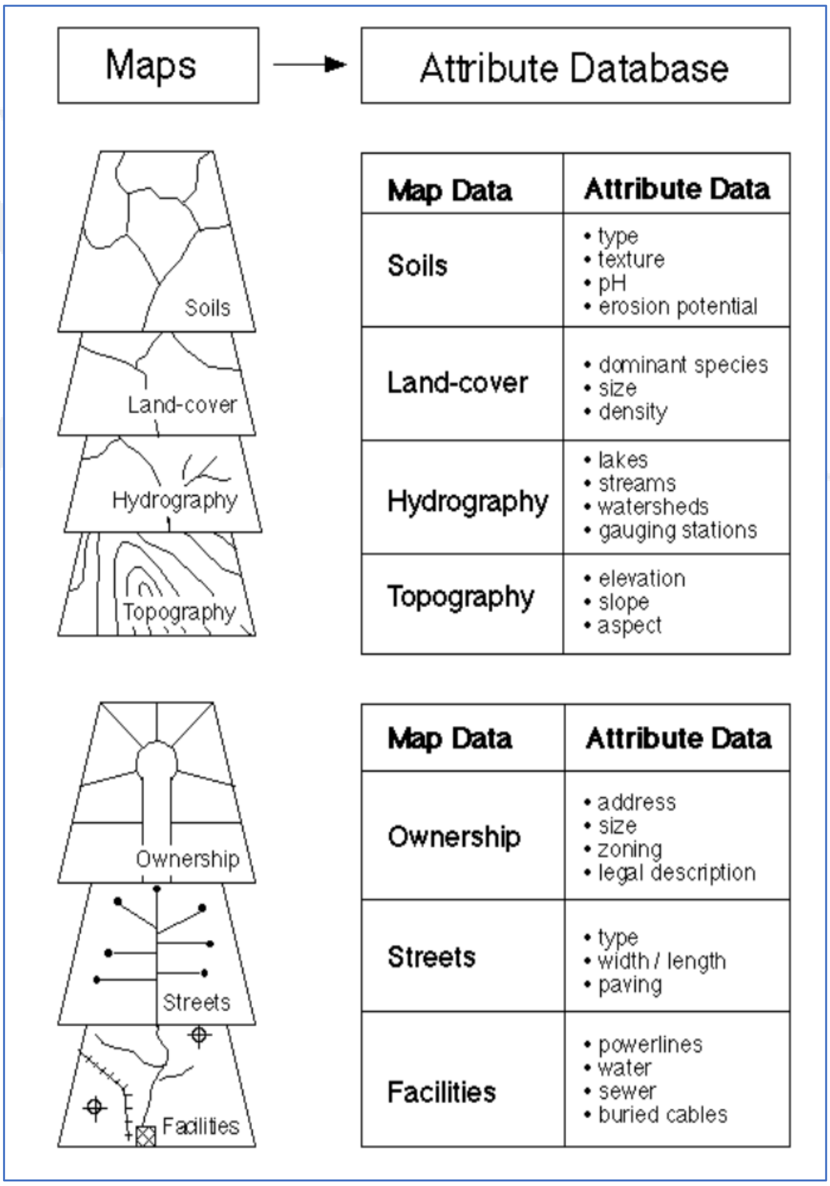


Figure 4. GIS Map Showing Map and Attribute Data

-SuperMap iDesktopX is a cross-platform GIS application. It can run not only on Windows OS but also on Linux OS. It has the ability to data production, data processing, analyses, mapping, and 3D data processing. Besides, it can manage spatial data, provides Geospatial Processing Automation, and supports Python and extension development. To meet different kinds of requirements from users, SuperMap provides four versions of SuperMap iDesktopX including Basic, Standard, Professional, and Advanced. Software interface is shown in *Figure* 5.

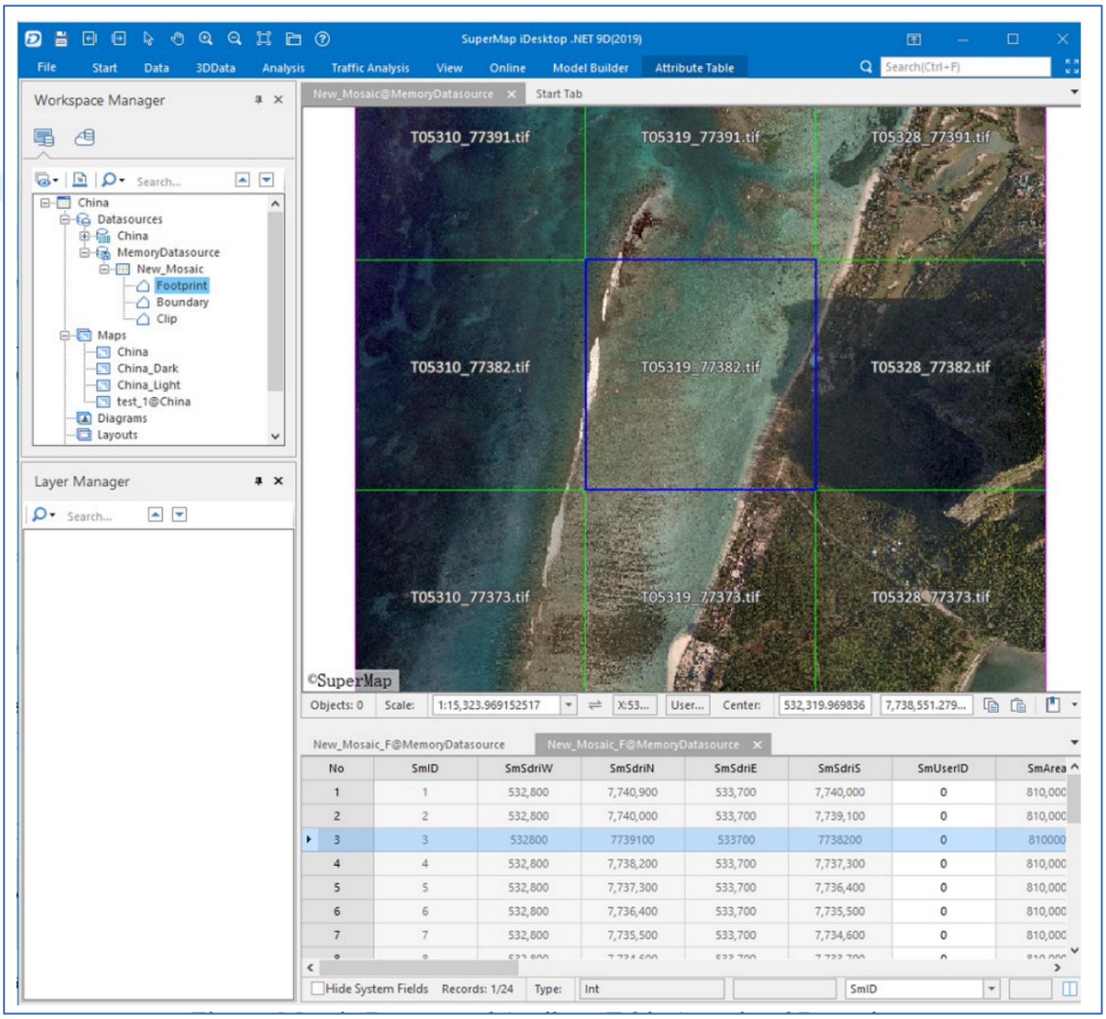


Figure 5. GIS Software on the computer monitor

-Methods*:* The successful GIS operates according to well-designed plan and business rules, which are the models and operating practices unique to each organization, as shown in *Figure* 6.

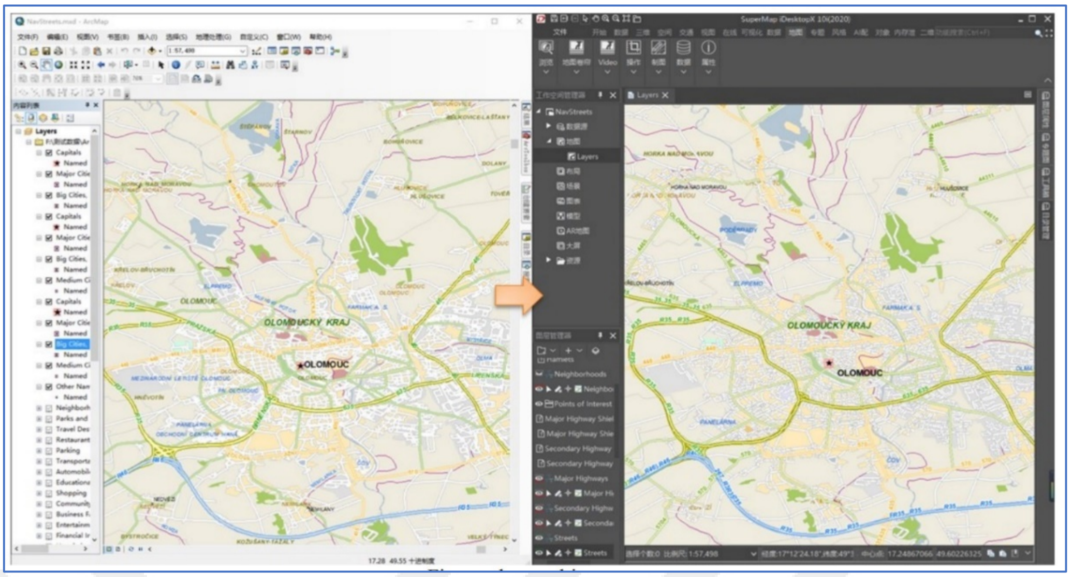


Figure 6. Sample Map of ARCMAP application

GIS Map – Super Map

The Main steps of creating a map in SuperMap are:

- Creating a map.
- Setting the layer style of the map.
- Labelling the map.
- Saving the map

-Create a Map*:* Open Data source and do the following steps:

1. Start the SuperMap iDesktopX application.
2. Open majnoon.smwu workspace from the Majnoon folder.
3. The unnamed workspace in the workspace manager will be changed to Majnoon.
4. One or more nodes will be added in the data sources node, as shown in *Figure* 7.

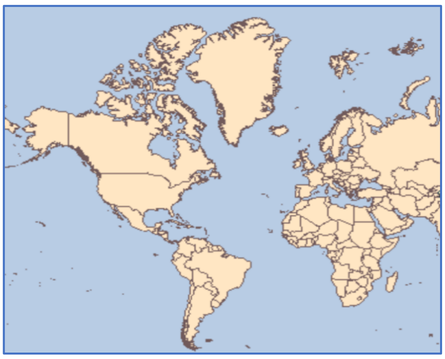


Figure 7. Sample of the nodes which adding to the Map

-Set a Layer Style*:* The display mode of the new map is the default style of each layer. The user can modify the layer style according to users' requirements.

-Setting Province_R Region Layer*:* Style the Province_R layer represents the provinces of Iraq and serves as the base map in this course. The color of this region can change through the following steps:

1- Select the "Province_R@Iraq" layer in the Layer Manager. This will cause the Styles panel to appear on the right side of the map window, as depicted in *Figure 8*.

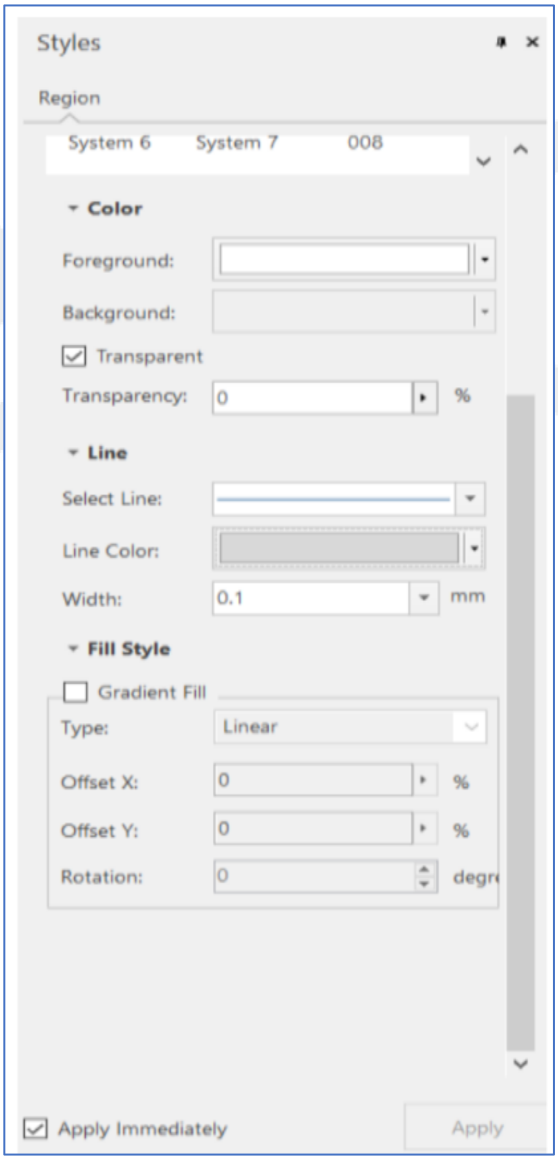


Figure 8. Styles panel

2- Within the styles window, adjust the foreground colour to white using the Foreground button in the Colour panel, and set the line colour to Grey using the Line Colour button in the Line panel.

3- Use the identical approach to assign a light grey foreground colour to the "Country_R" layer and a blue foreground colour to the "WorldsElements_R" layer. As seen in *Figure 9*.

Figure 9. Basic coloring of Maps

-Set a StateRoad_L Line Layer Style***:*** The StateRoad_L layer represents national highways (including expressways) as:

1- In Layer Manager, use the "StateRoad_L@Iraq" layer, the "Styles" panel will pop up on the right side of the map window.

2- In Styles window, type road in the search bar and choose Search button. The relevant symbols of the roads will be displayed like National Road, Provincial Road, Township Road and so on. Usually, higher-level road uses broader lines with more dense colors than the lower-level roads. Road symbols can be selected from "Resources/line symbols library" or can be made by oneself.

3- In the styles window, set the line color to orange by the Line Color button from the Line panel.

-Label a Layer***:*** Map annotation makes it easier to identify the important elements on the map.

1- In Layer Manager, choose the "ProvinceCapital_P@Iraq" layer and select "Create Thematic Map...”. The "Create Thematic Map" dialog box will pop up.

2- In Create Thematic Map dialog box, Select Label Map from the left side of the dialog box and Select Uniform in the corresponding list on the right side of the dialog box. Thematic Map manager dialog box will dock on the right side of the application interface.

3- The Thematic Map dialog box has Properties, Styles and Advanced panels, as shown in *Figure* 10.

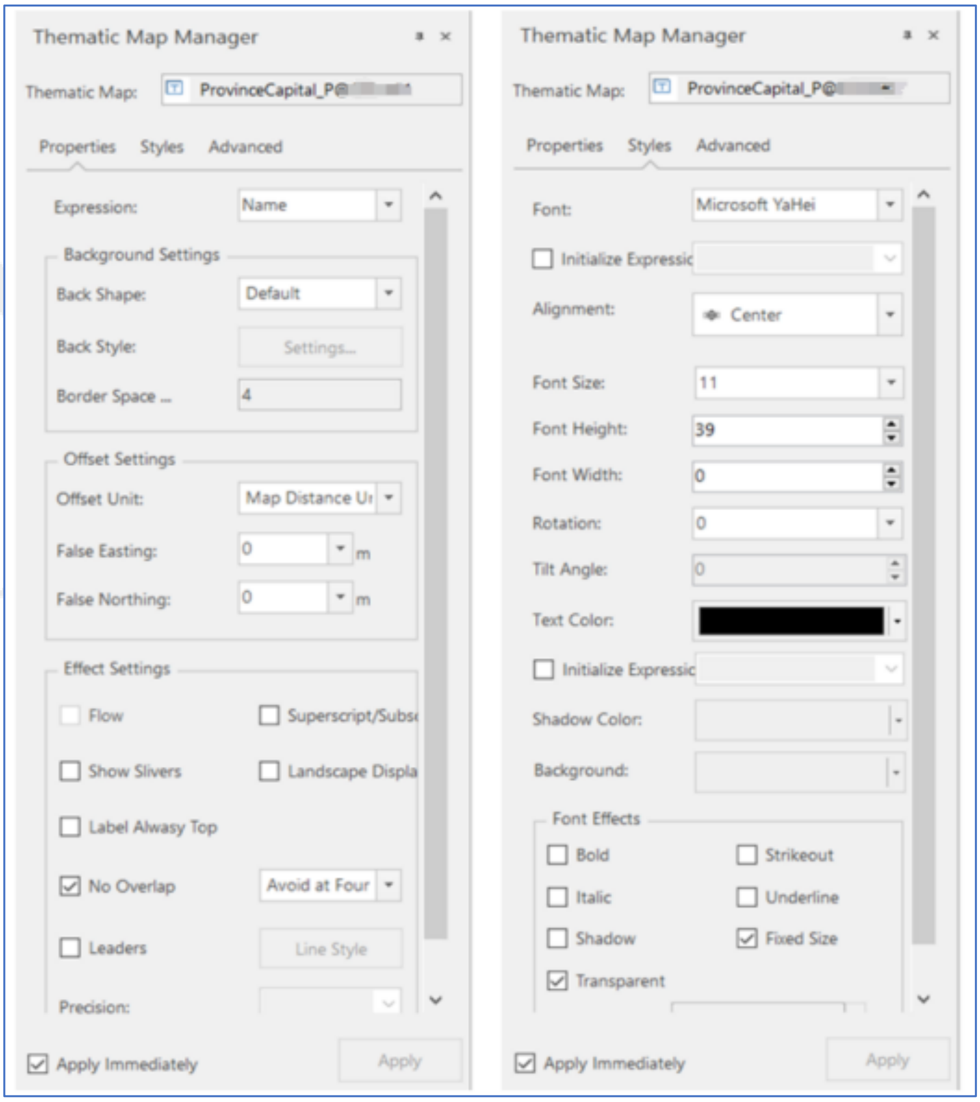


Figure 10. Layers Label

-Save Maps**:** The results of operations in a workspace can be saved only when they are stored in a map or scene. The saved workspace can be opened again at any time to get the last working environment and operation results, the following steps illustrates the saving maps:

1- Select the Start tab. In the Workspace group and Save button. The save dialog box will pop up.
2- In the Save dialog box, Select the checkboxes from the list of maps or scenes of the current workspace which the user wants to save.
3- In the Save dialog box, select map or scene, and select the Rename button to change the name of the map or scene.
4- In the Save dialog box, select the Save button to save maps or scenes in the workspace.

2.4. Quick 3D Scene Start Tutorial

The 3D quick start tutorial introduces the knowledge of 3D scene operations in SuperMap iDesktop through some examples. Scenes in SuperMap iDesktopX are divided into two view modes: *spherical scene* and *plane scene*. The spherical scene simulates the globe in three-dimensional space, while the plane scene simulates the globe in an expanded plane. The plane scene is applicable to scenarios of small scenes, such as communities, residential building representation, etc.

The following steps illustrate the 3D Scene creation:

1. **Create a New 3D Scene:** as *Figure* 11 shows:

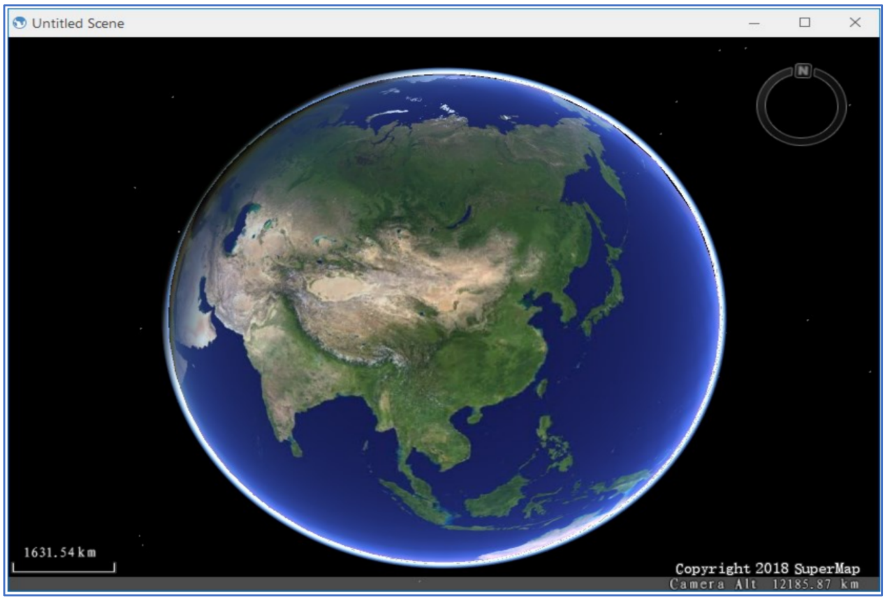


Figure 11. New Scene

2. ***Load a 3D Model*****:** 3D model cannot be loaded to a 3D scene directly, so a KML layer should add or create first, as the following listed steps:

- Create a KML layer.
- The new created layer and select Model.

To open the Open 3D Model File dialog box, select the 3D model and click Open. Note that can add several models have supportive model formats like *.3ds, *.mesh, *.obj, *.x, *.dae, *.osg, and *.osgb.

- Modify Model Position: When the model is added to the list, the default file name is *.x, and default latitude and longitude values are latitude and longitude coordinates of the current scene centre point. If the location of the currently added model is known, then can move the mouse to the longitude, latitude column, make it editable to change the latitude and longitude. If the location information is unknown, it is recommended that prepare a map of the area where the model is located, superimposed on the model layer, the model is loaded into the scene, the image as a reference, set the KML layer can edit, select, and move the model to the exact location. Taking *Figure* 12 as an example.

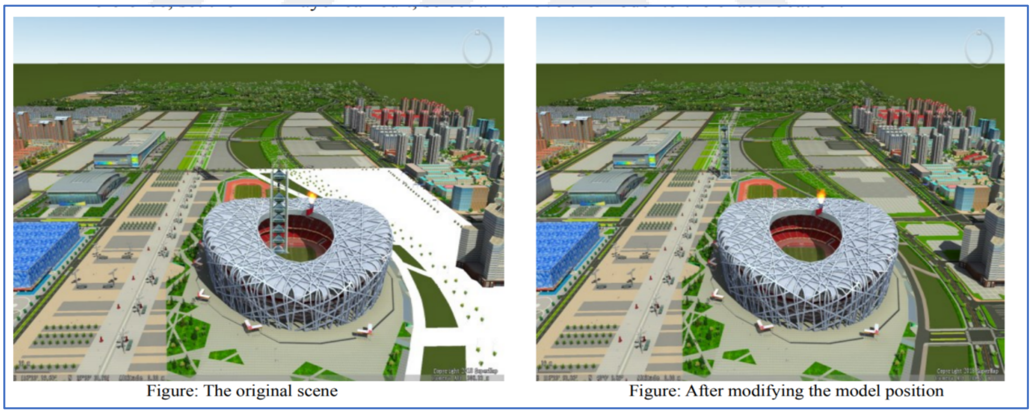


Figure 12. Modify Model Position

3. ***Load Data***: The following listed steps illustrate the load of data to the model:

- The Scenes node in the workspace and select New Spherical Scene.
- For loading a global framework data, select Auto load framework data when creating new scenes. SuperMap iDesktopX will load the frame data included in the package. Therefore, after create a new scene, there will be some data for the globe.

4. ***Add terrain cache data:*** The following steps illustrate how terrain cache data added:

- Select the node Terrain Layers in the Layer Manager and select Add Terrain Cache Layer.
- Find the terrain cache data (*.sct) that want to load. In this sample, choose JingjinTerrain.sct which is generated from JingjinTerrain data, and click Open in the dialog box.
- After the terrain caches are added, there is a sub-node appears under the node Terrain Layers. This sub-node is the created terrain cache data created. The effect of adding the terrain caches to the scene is shown in *Figure* 13.

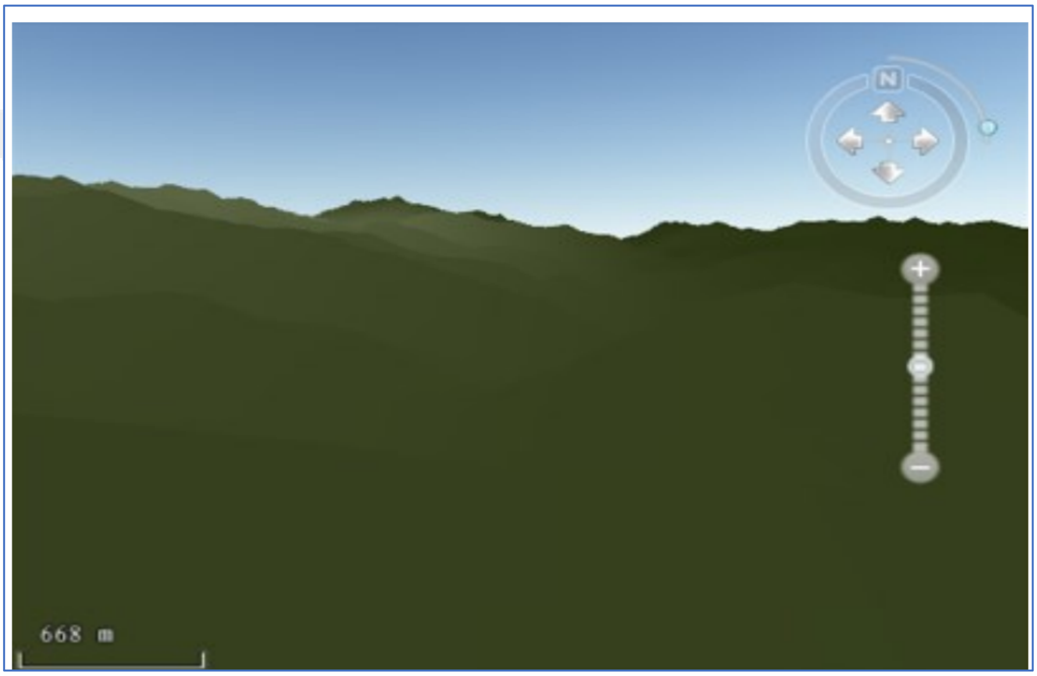


Figure 13. Add Terrain Caches to Scene

Add Image Cache Data:

The following steps illustrate how image cache data added:

- Select the node General Layers in the Layer Manager and select Add Image Cache Layer.
- Find the image data which want to load, choose this file, and open in the dialog box. SuperMap supports the following types of image cache: *.sci, *.sci3d, *.sit, and *.tiff. In this sample, use the data DEM and add *.sit cache file.
- After the image caches are added, there is a sub-node appears under the node General Layers. This sub-node is the created image cache data.

Add CAD Model Dataset:

The following steps illustrate how CAD Model Dataset added:

- Select the Sample Data to City Model.
- Add all datasets in the CBD data source to the spherical scene. The result of scene is shown in *Figure* 14.

Figure 14. The result of scene

Save 3D Scene:

There are two methods to save the scene:

Method 1: Save a scene to the workspace

Select Save Scene in the scene window. If it is the first time to save scene, it will pop up a dialog, input the scene name and click OK. The scene will be saved in the workspace. After the workspace is saved, the scene will be saved in the existing workspace.

Method 2: Save a scene as:

- Select the scene node in workspace manager, select Save Scene as...
- Input the name of the new scene, click OK.
- Then a new scene node will be added to the workspace manager.
- Notice that the workspace must be saved.

2.5. Aims of the VGIS Project Application

The primary objectives of the VGIS platform are to establish a comprehensive geographic information system for oilfields, develop a standardised system, and employ advanced information technologies like Data Lake, cloud computing, and microservices to deliver a reliable, efficient, and precise mapping service. Additionally, the platform aims to integrate all map data and services from the Department, eliminate information barriers, and achieve seamless connectivity and sharing of map data. This project combines advanced GIS technology and information technology with oilfield business to enhance the construction and integration of oilfield management capabilities. These capabilities include rapid mapping of thematic oilfield data, data aggregation, data sharing, business collaboration, and the improved application of geographic information visualisation and perception capabilities to effectively enhance oilfield management. Sharing and effectively utilising all business data in an oilfield prevents the unnecessary creation of duplicate data, enhances the organisation and scientific nature of management decision-making processes, and offers robust and substantial support for the generation of oilfield information.

2.6. Overview

The VGIS system consolidates preexisting systems inside the oilfield and gathers location-specific data to offer novel business insights that enhance analysis and decision-making. The input data for the VGIS system consists of various types of data, including exploration data, production data, storage data, HSE (health, safety, and environment) data, Internet of Things (IoT) data, etc. These data types encompass vector data, image data, and VR modelling data, all related to different topics such as exploration, drilling, production, storage, construction, operation, and HSE.

2.7. VGIS Data Provider – Data Lake

Majnoon Data Lake platform consists of Five Computing nodes for data analytics, Two AI nodes for video stream live analytics and alarming, two BI nodes for business data analytics and reporting, 10Gbps fiber channel connection for data exchange, as shown in *Figure* 15.

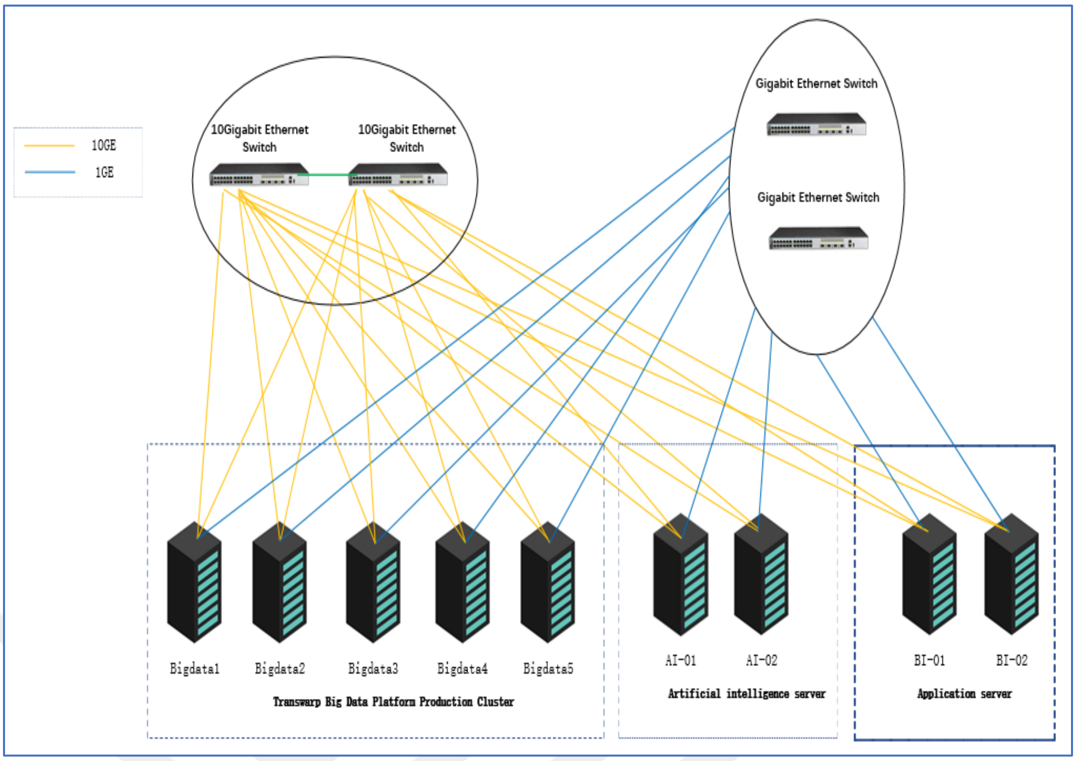


Figure 15. Data Lake Hardware Architecture

Data Lake workflow, as shown in *Figure* 16, it integrated with as much as business systems, offline semi-structured and unstructured data etc. as the data source, extract the data by ETL method, build several data layer after cleansing and governance for multiple purpose, prepare the data for further big data analytics and feed the data to such as vGIS system, it supports batch and stream data processing both.

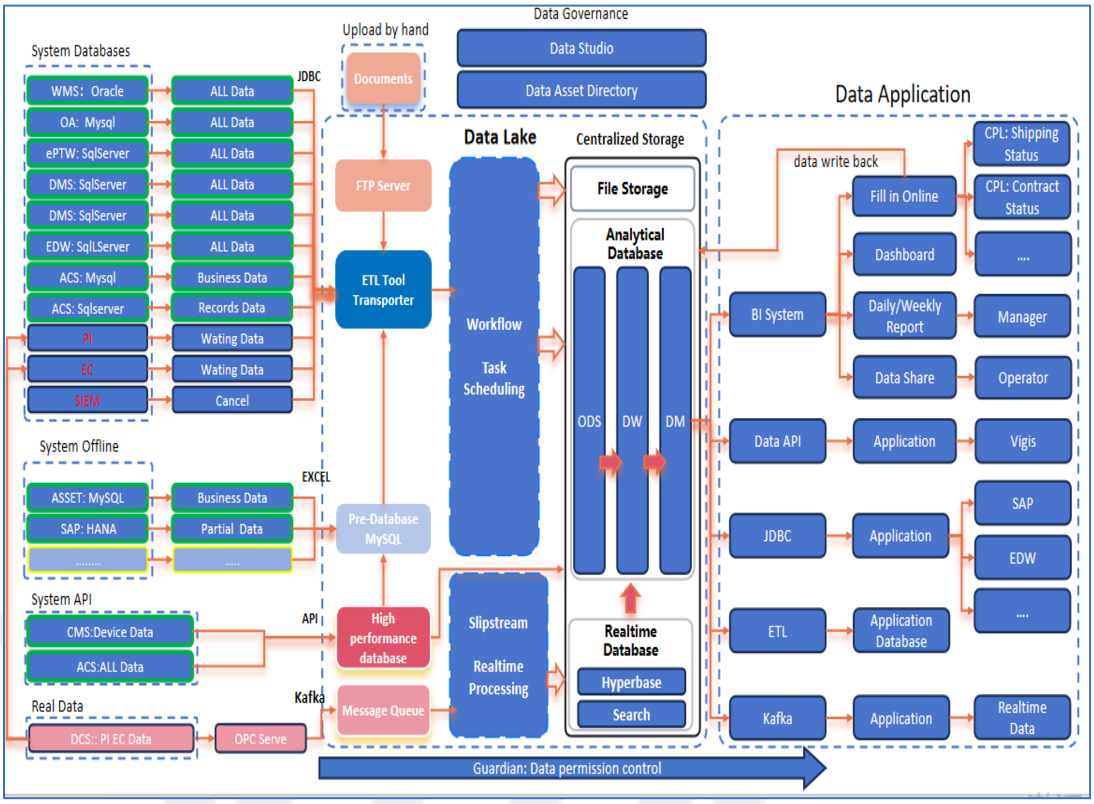


Figure 16. Data Lake Architecture Workflow

The overall Data Lake architecture provided include the following functionalities and achievements:

- Integrate with online system extract the data with the way of real-time or periodically scheduling.
- Transforming and loading offline data, develop online unified manual filling tool to realize data importing to Data Lake instead of traditional paper file records or personal saved electronic documents.
- Customized dedicated data governance standard and rules for the Majnoon Oilfield, the process of data governance must ensure that the incoming data meets the data standards and quality requirements by general Oil & Gas industry standards and current Majnoon Oilfield's rules. The scope of governance includes metadata management, data standards construction, data quality construction, and master data management.
- Build the unfiled and trusted data resource channel, ability to provide validated data to other business system and applications in Majnoon Oilfield with the format of data assets or data sets.

- Provide standardized and open interface to support interacting with other business system and applications in Majnoon Oilfield for all the governed data assets in the data lake.
- Build the unified data hub platform, realize the cross-departmental and cross-regional data sharing and collaboration in internal of organization, meanwhile support data sharing beyond the organization under strict data security protection mechanism.
- The overall architecture includes flexible but extremely strong data security management and authorized mechanism that meets big data industry security standards and data security policies from Majnoon Oilfield.

2.8. Overview of the vGIS platform

The VGIS platform is a GIS-based management platform that integrates data from many sources and enables data administration and display for various business departments. This is illustrated in *Figure 17*.

The vGIS platform functions as a higher-level application on the Data Lake. It receives data from the Data Lake and presents it visually on the vGIS application. Additionally, it overlays GIS map layers, GPS, terrain, attribute data, and other relevant information. This platform offers a uniform virtual GIS platform and service to all users in Majnoon.

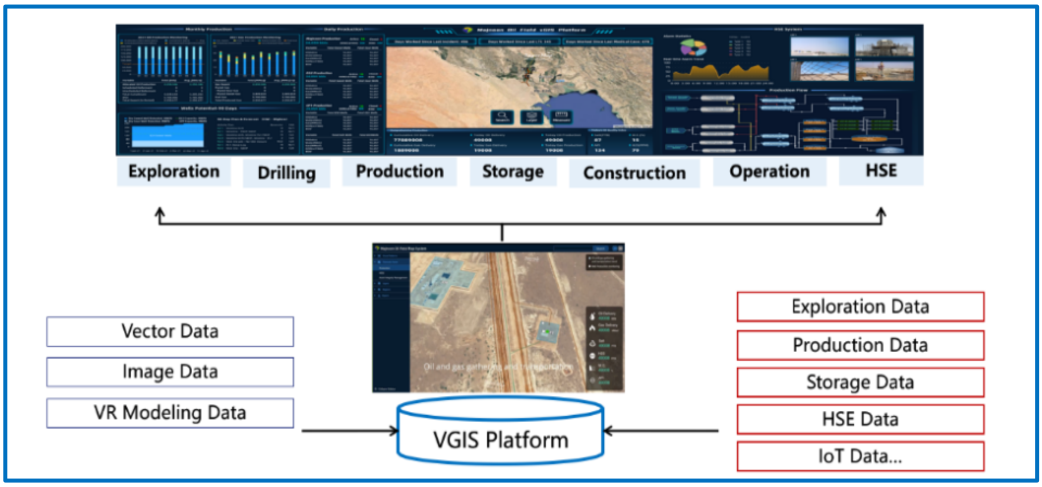


Figure 17. VGIS Platform Data Structure

The VGIS project utilises a data lake as its backend to offer APIs, while employing the Space Engine as the frontend rendering engine to handle the large-scale oil field model and execute many functionalities. The front-end deployment is processed on the GPU workstation and subsequently transmitted to the client web page as a video push stream. This enables users to access extensive 3D resources on regular PCs and execute intricate 3D programmes.

Figure 18 displays the structure of 3D rendering and Web application in vGIS, serving as a reference. Additionally, *Table 3* provides the VGIS GPU Server Specification.

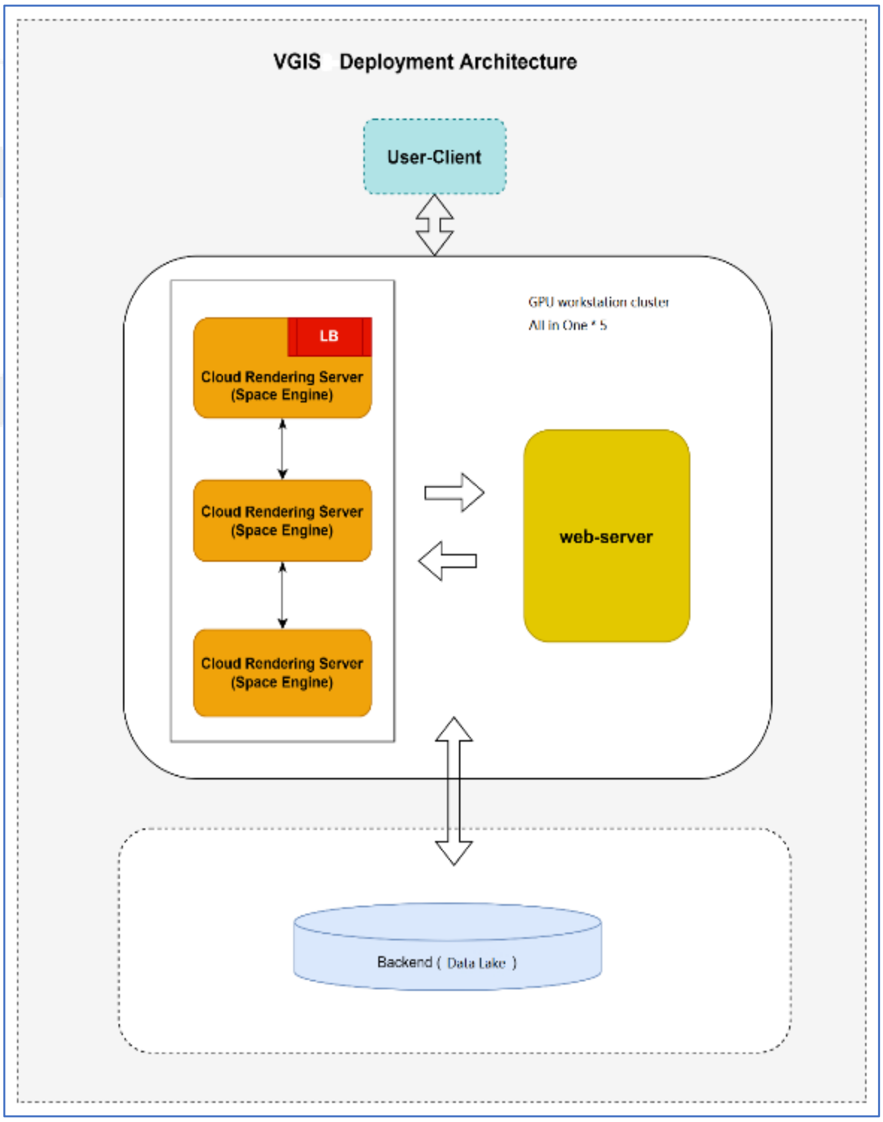


Figure 18. VGIS Hardware Architecture

Table 3

VGIS GPU Server Specification

No.	Description	Manufacturer	Unit of Measure	Qty.
1	MSI MB Z690 TORPEDO	MSI	Pcs	1
2	MSI VGA RTX 4080 GAMING X TRIO 16GB	MSI	Pcs	1
3	CPU 19 12900K	Intel	Pcs	1
4	A-DATA RAM DDR5 16GB 4800MHZ	A-DATA	Pcs	4
5	MSI SSD 500GB NVME G4 M450 HS	MSI	Pcs	1
6	SEAGATE HD 1TB SATA BARRACUDA 3.5"	SEAGATE	Pcs	1
7	MSI CORELIQUID 360R V2	MSI	Pcs	1
8	THERMALTAKE POWER SUPPLY 1200W PLATINUM	Thermaltake	Pcs	1
9	MSI CASE VELOX 100R BLACK	MSI	Pcs	1

3D Rendering Engine DIGITWIN. Based on double-precision coordinates, it is possible to create highly detailed unrestricted virtual worlds that support the expansion of 3D scenes

- Data fusion of more than 30 file formats
- Algorithms based on the underlying platform and front-end loading and rendering technology to support dynamic model updates
- Close to the real weather particle system, to provide customers with a nearly real scene
- Reading of PB/TB level models (100,000 camera data, etc.)
- Hardware devices use only 1/4 of the power of the game engine, support cloud rendering

The Portal VGIS Platform shown in *Figure 19,* provides an overview of the oil field. It supports the tracking and visualization of critical business metrics for each oilfield management department, allowing managers to keep a close eye on-field operation. Production, safety, process operations, and other aspects of the business are covered.

Figure 19. VGIS Platform Portal

Procedures: The following construction procedures are used in the implementation of the VGIS system.

2.9. Survey

A laser scanner primarily consists of a laser range finder, which use a reflective prism to guide the laser beam in scanning the object's surface at a consistent velocity. The scanner also receives signals reflected from the object's surface to determine the distance, and utilises an algorithm to compute the depth data.

Prior to laser scanning, it is typically imperative to affix a marker onto the object, which reflects the emitted light from the instrument, and the device subsequently receives the reflected signal for further data processing.

Using high-speed laser scanning, precise three-dimensional coordinate data of the object's surface may be rapidly obtained with a wide coverage and high level of detail. The acquisition method is straightforward, with a high level of data accuracy, but it requires a significant amount of time. The depicted scenario is illustrated in *Figure 20*.

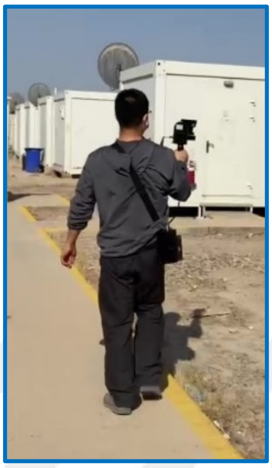


Figure 20. Laser Survey

2.10. Modelling from Laser scanning

The scanned point cloud data needs to be initially processed. Because in the process of laser scanning, the acquisition of data is often affected by factors such as object occlusion and uneven illumination, resulting in the scanning of blind spots in the region of complex-shaped objects and the formation of holes. Therefore, it is necessary to pre-process the 3D point cloud data by removing noise, simplifying, aligning, and patching the holes.

vGIS project used ContextCapture Editor to proceed the data from Laser scanning, ContextCapture Editor is a 3D CAD based on PowerDraft that allows to leverage reality meshes, terrain models, and point clouds made of billions of points and triangles for use in information modelling workflows. The user interface is shown in *Figure* 21.

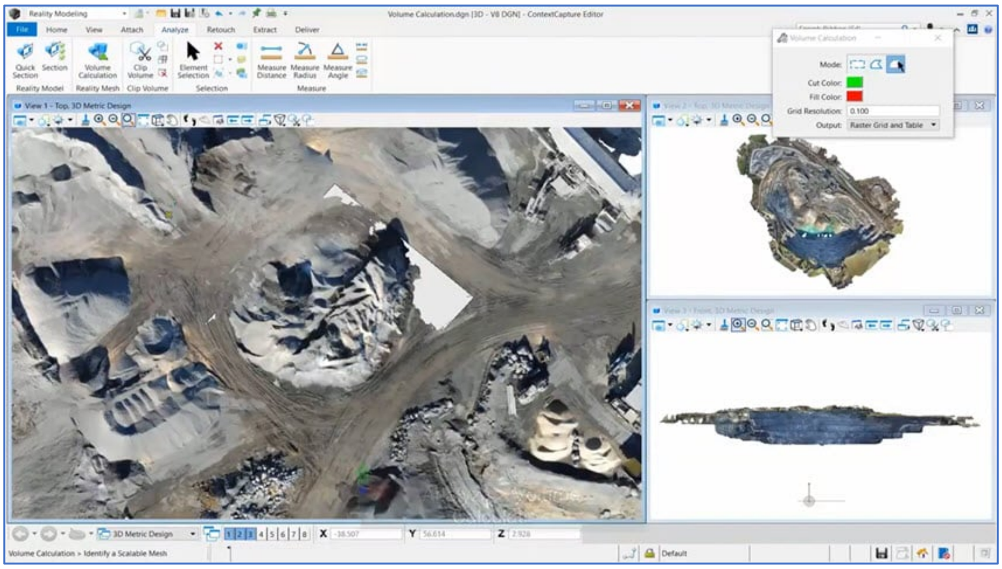


Figure 21. ContextCapture Editor

UAV (*unmanned aerial vehicle*) Photography shows in *Figure* 22.

Figure 22. UAV Photography Controller

Photos taken by UAV:

- *vGIS project used DJI Mavic two Pro.*
- *As Figure 23 shows, to collect the image data from top and multiple angles for the facilities, surface and pipes etc.*

Figure 23. DJI Mavic 2 Pro

==

The image sample shows in *Figure* 24.

Figure 24. Photos Taken by DJI

- *Photos taken by HD camera.*

The image sample shows in *Figure* 25.

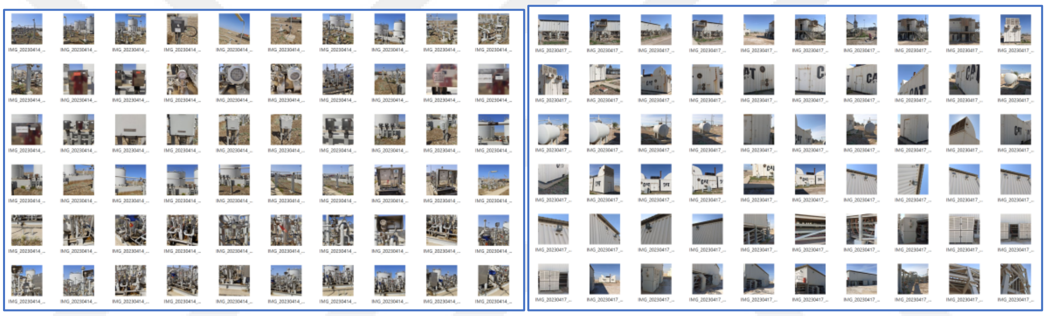


Figure 25. Photos taken by HD camera

- *3D Modelling*

vGIS project used cinema 4d and 3ds max to do the modelling during the project's 3D modelling implementation.

Cinema 4D is a professional 3D modelling, animation, simulation and rendering software solution. Its fast, powerful, flexible and stable toolset make 3D workflows more accessible and efficient for design, motion graphics, VFX, AR/MR/VR, game development and all types of visualization professionals.

User design interface of 3ds max shown in *Figure* 26.

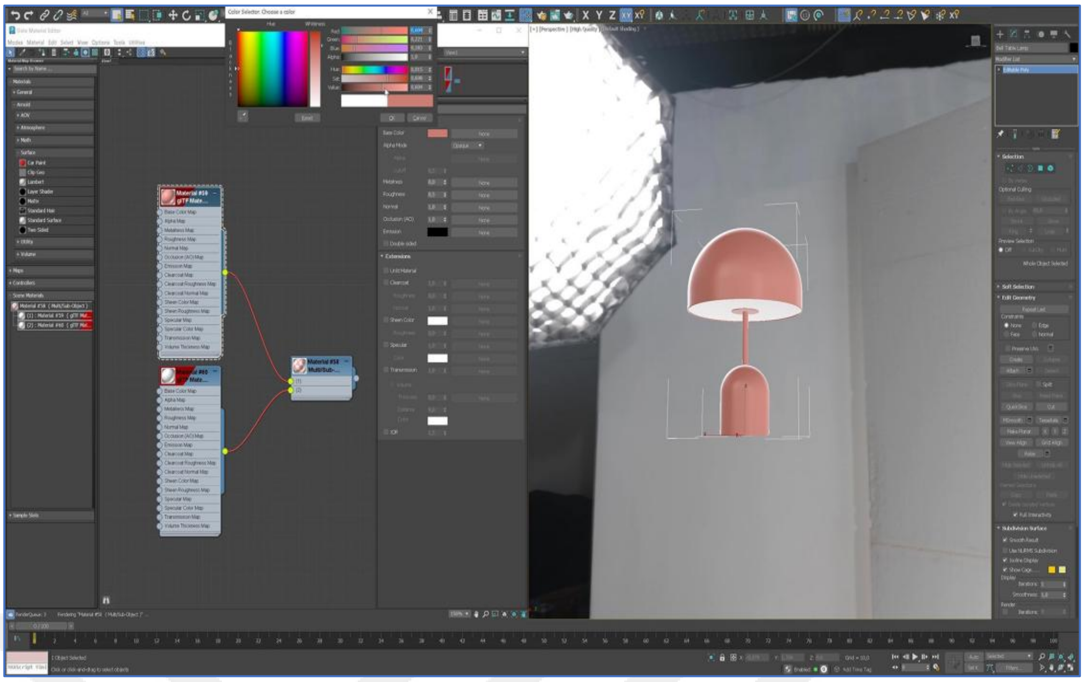


Figure 26. 3D modelling - cinema 4d

Autodesk 3ds Max® professional 3D modelling, rendering, and animation software enables to create expansive worlds and premium designs.

- Breathe life into environments and landscapes with robust modelling tools.
- Create finely detailed designs and props with intuitive texturing and shading tools.
- Iterate and produce professional-grade renders with full artistic control.

User design interface of 3ds max shown in *Figure* 27.

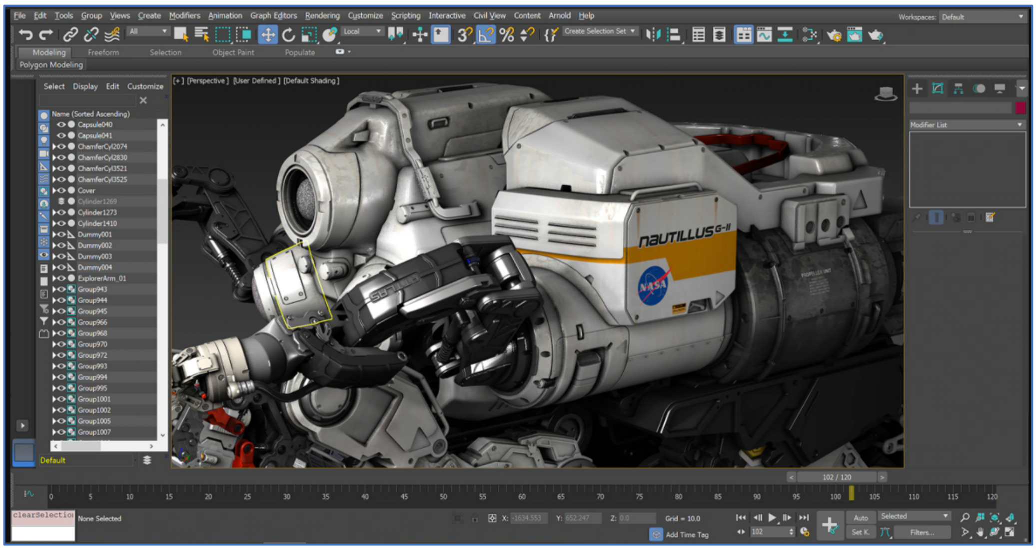


Figure 27. 3D Modelling - 3ds max

- *Model Visualization: As shown in Figure 28.*

Figure 28. 3D Model of the Oilfield

- *Go Live System: As shown in Figure 29.*

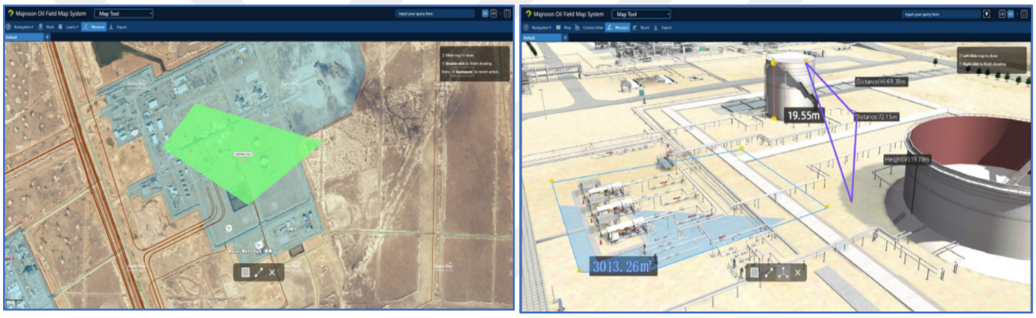


Figure 29. VGIS 3D Digital Map System

2.11. Supporting Methods

The VGIS platform has strong technique support, including convert 2D to 3D and 3Ds Max modelling graphic, which can help graphic the pictures.

Convert a Real Picture to 3D: Convert a 2D image into 3D can generate the representation of the scene.

1- Introduction:

The process of transforming a two-dimensional image into a three-dimensional representation is an intricate undertaking that usually entails generating a depth map or height map based on the original image.

Subsequently, the obtained depth map can be utilised to create a three-dimensional depiction of the scene. Although this process is not simple and may necessitate the use of sophisticated computer vision algorithms.

This method offers a simple illustration of how to generate a fundamental depth map from a 2D image using MATLAB. It is important to understand that this approach will not yield a 3D representation that is highly detailed or lifelike. It can provide a fundamental understanding of how to initiate the process. Accurate 3D reconstruction is often achieved using more sophisticated methods, such as photogrammetry or depth sensing.

2D-to-3D depth generation methods typically encounter two obstacles. One factor to consider is the consistency of depth within the same object. Another problem pertains to obtaining a suitable depth relationship among all items. The task of creating a depth map from individual 2D photos is a challenge that lacks a unique solution. Not all depth cues can be extracted from an image.

2- *Designation:*

For addressing these two obstacles, this study introduces an innovative technique that utilises a hazy veil to produce a simulated depth map instead of simply extracting the depth value from the depth cue. Initially, the system generates a generated haze image to depict the segmentation of prominent regions. Subsequently, the pseudo depth map is automatically created within a single view image by utilising the transmission information. The experimental findings suggest that the suggested algorithm has the potential to produce favourable stereoscopic outcomes with minimal adverse impacts (Remondino et. al.).

Here are the basic steps to create a depth map from a 2D image in MATLAB:

- Load the 2D image into MATLAB.

[MATLAB Code]

" image = imread('your_image.jpg'); % Load your image "

- Convert the image to grayscale if it's not already in grayscale. Grayscale images are easier to work with for depth map creation.

[MATLAB Code]

" gray_image = rgb2gray(image); % Convert to grayscale "

- Apply edge detection to highlight object boundaries in the image. The Canny edge detector is a common choice.

[MATLAB Code]

```
edges = edge(gray_image, 'canny');
```

- Convert the edge map into a binary image, where the edges are set to 1 and the background is set to 0.

[MATLAB Code]

```
binary_edges = double(edges);
```

- Create a depth map using the binary edge image. can use various techniques, such as the distance transform, to assign depth values based on the distance from edges.

[MATLAB Code]

```
depth_map = bwdist(binary_edges); % Distance transform
```

- Normalize the depth map to the desired range of depth values.

[MATLAB Code]

```
min_depth = min(depth_map(:));
max_depth = max(depth_map(:));
normalized_depth_map = (depth_map - min_depth) / (max_depth - min_depth);
```

[MATLAB Code]

```
imshow(normalized_depth_map(:));
```

- Visualize the depth map. Can use MATLAB's `imshow` function to display the depth map.

3-* Limitations of this method*:

Keep in mind that this simplified approach will not create a highly accurate 3D representation and may not work well for all types of images. For more advanced 3D reconstruction, may need to explore techniques like stereo vision, structured light, or depth-sensing cameras. Additionally, rendering a 3D scene from a depth map is a complex task that goes beyond the scope of this basic example (M. H. Al-Jaberi et. al.).

***4-* The Technique of converting 2D-to-3D:**

The technique described in the previous response is a basic approach to creating a depth map from a 2D image using edge detection and distance transform. This technique is primarily based on computer vision and image processing methods.

The following steps listed the breakdown of the techniques used:

- ***Edge Detection***. Edge detection is the process of identifying sharp changes in intensity or color in an image. The Canny edge detector is used in this example to highlight object boundaries.
- ***Binary Edge Image.*** The resulting edge map is converted into a binary image, where edges are represented as 1 and the background as 0. This binary image helps identify where objects or boundaries exist in the scene.
- ***Distance Transform.*** The binary edge image is processed using the distance transform (in this case, MATLAB's `bwdist` function) to calculate the distance of each pixel to the nearest edge. This step effectively assigns depth information to each pixel based on its proximity to an edge.
- ***Normalization.*** The depth values obtained from the distance transform are then normalized to a desired range. This step ensures that the depth values are within a specific scale for visualization or further processing.
- ***Visualization.*** Finally, the normalized depth map is visualized using MATLAB's `imshow` function, allowing to see the depth information represented as grayscale values.

2.12. Discussion and Benefit

1. ***Discussion.*** It is crucial to acknowledge that this technique offers a rudimentary method of estimating depth and is not appropriate for generating extremely precise 3D models. This example is designed to be easily understood for teaching purposes and does not consider important elements such as occlusions, texture information, or fluctuations in illumination, which are necessary for achieving precise 3D reconstruction.

For achieving more advanced 3D reconstruction, particularly for practical applications in the real world, it is customary to utilise more complex methods such as stereo vision, structured light, depth-sensing cameras, or photogrammetry. These methods utilise several perspectives of a scene or supplementary sensor data to create precise 3D representations, as depicted in *Figure 30*.

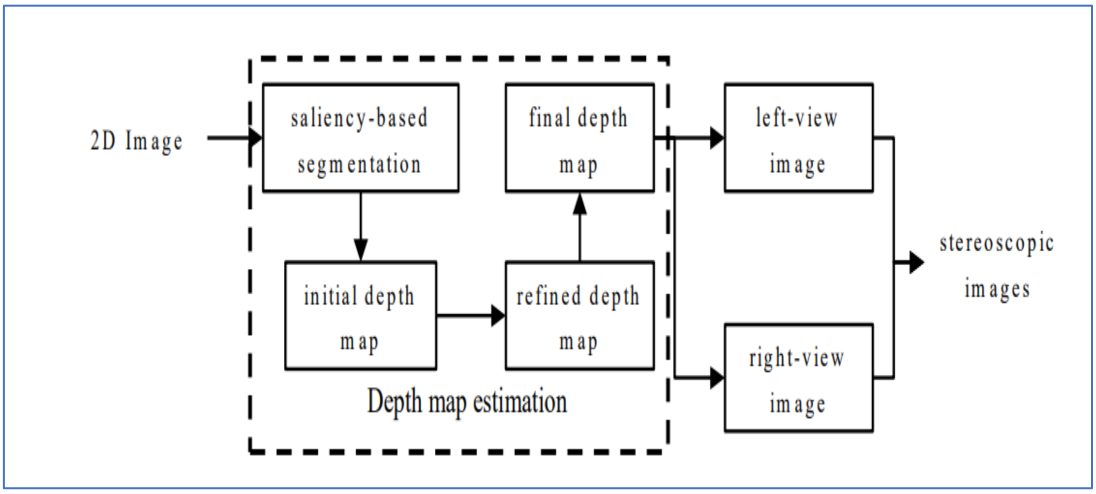


Figure 30. Depth Map Estimation

2. ***The Benefit.*** Converting 2D images into 3D representations can offer several benefits and applications, depending on the context and the quality of the 3D conversion. Here are some potential benefits of converting images from 2D to 3D:

- Enhanced Visualization. 3D images can provide a more immersive and realistic viewing experience compared to 2D images. This can be especially valuable in fields like entertainment, virtual reality, and gaming.

- Depth Perception. 3D images can help convey depth information, which is crucial for tasks like medical imaging, where understanding the spatial relationships between different structures in the body is essential.

- Simulation and Training. 3D representations are often used for training simulations in fields such as aviation, medicine, and military training. These simulations can help individuals practice complex tasks in a controlled and safe environment.

- Architectural Visualization. Converting architectural floor plans or 2D drawings into 3D models can aid in architectural visualization, allowing architects and clients to better understand the design and spatial relationships within a building.

- Product Design and Prototyping. 3D models of products can be generated from 2D images or sketches, allowing designers to visualize and iterate on their designs more effectively before manufacturing.

• Augmented Reality. 3D models can be overlaid onto the real world in augmented reality (AR) applications, enhancing the user's interaction with the environment. This is commonly used in mobile apps and wearable devices.

• 3D Printing. Converting 2D images into 3D models is useful for creating 3D printable objects. Artists and designers can use this technique to transform 2D artwork into 3D sculptures or figurines.

• Medical Imaging. In medical imaging, converting 2D medical scans (such as CT or MRI scans) into 3D representations can aid in diagnosis, surgical planning, and treatment visualization.

• Art and Entertainment. Artists and animators may use 3D conversions to add depth and realism to their artwork or animations.

• Geospatial Analysis. In GIS (Geographic Information Systems) applications, converting 2D maps into 3D representations can provide a more accurate and comprehensive view of geographic data (Y. J. Jung et. al.).

It's important to note that the quality and accuracy of the 3D conversion process can vary significantly based on the techniques and tools used. High-quality 3D reconstructions often require specialized equipment and software, such as 3D scanners, photogrammetry software, or depth-sensing cameras. In contrast, simple 2D-to-3D conversions, as discussed in the previous responses, are basic and may not provide the level of detail required for many professional applications. The choice of technique should be based on the specific needs of the project or application (Neittaanmäki et. al.), as *Figure* 31 shows.

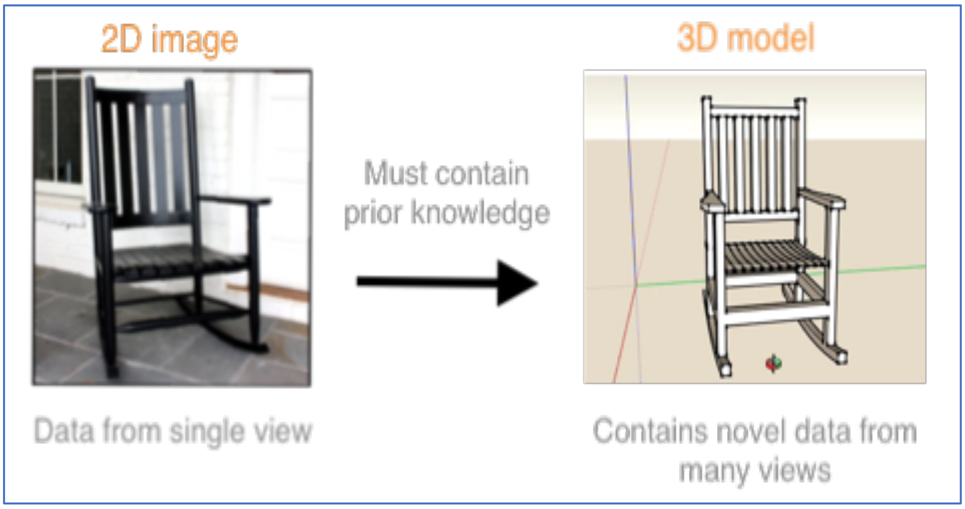


Figure 31. Data from Single View of Real 2d Image to 3d Mod

2.13. 3Ds Max modelling graphic tutorial

Reference modelling from the perspective matching of images. It's important to keep perspective in mind when creating architectural models; by knowing simple dimensions like the height of a door or the average height of a human, can often pick out visual clues that can then be used to reconstruct the model as accurately as possible. One of the biggest challenges in architectural modelling is trying to maintain "realistic" proportions in our 3D applications, as *Figure* 32 shown.

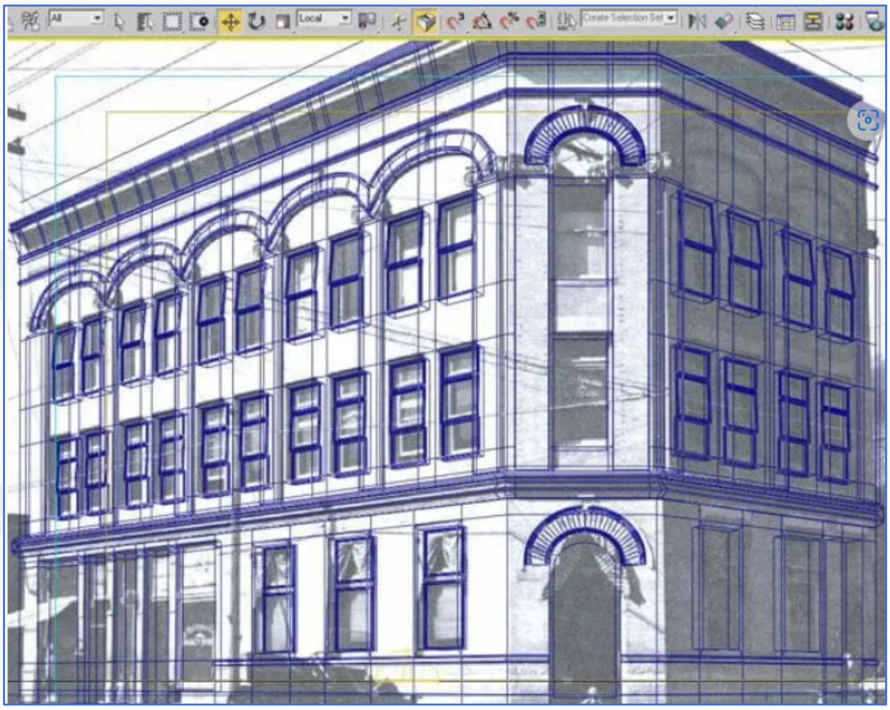


Figure 32. 3Ds Max modelling graphic tutorial

A reference image (whether a drawing or a photograph) can be characterized by one of three different perspective types. The main difference between these three types is the number of "vanishing points" - actual points or points in the scene where all lines converge.

The following steps illustrate each type in turn:

1- One-point perspective.

An image with "one point" perspective will only contain one of these "vanishing points", so there are only 3 ways to show the lines in the scene: 1) running vertically, 2) running horizontally, or 3) at an angle to the " Vanishing Point" convergence.

The following example image illustrates that the camera has been positioned so that it looks directly towards the street. The facade of the building is exactly perpendicular to this direction, thus giving us only vertical or horizontal lines. However, the top and bottom of the building (and other lines in between) are angled. If take a pencil and ruler and extend these lines into the scene that they all come together and intersect at a point, which is our vanishing point, as *Figure* 33 shown.

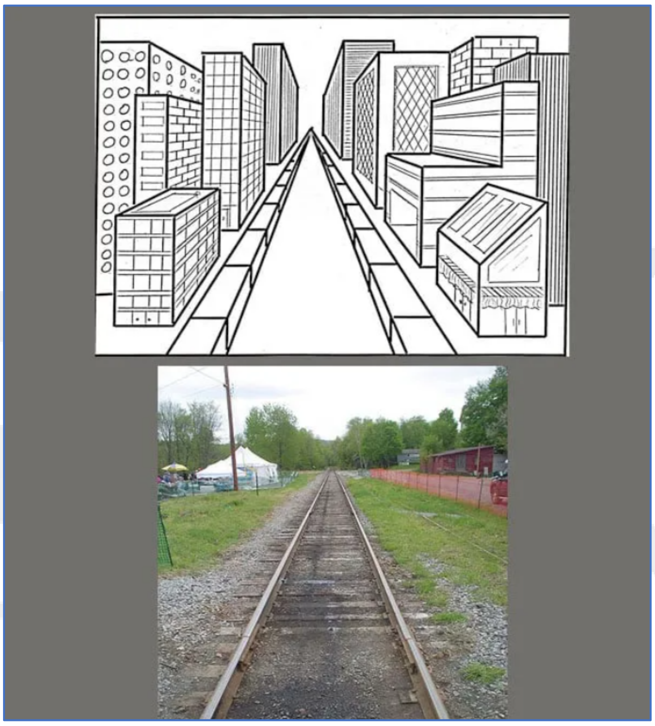


Figure 33. One Point Perspective

2- *Two-point perspective.* As the name suggests, two-point perspective involves the use of two vanishing points. Examining the given example, the camera is no longer oriented in a way that it directly faces a particular vanishing point. As a result, the horizontal line from the previous perspective runs at an angle, which introduces a second vanishing point. When the slanted lines are expanded as previously mentioned, it can be observed that they converge either on the left or right side of the image. Nevertheless, the vertical lines remain perpendicular to the horizontal axis. Another factor to consider is the "horizon" line, which is an imaginary line that is parallel to and at the same level as the camera. A rapid method for doing this involves connecting two vanishing points with a straight line, which may then be utilised to approximate the camera's height. The provided image exemplifies a common occurrence of two-point perspective, specifically depicting the intersection of a building as illustrated in *Figure 34*.

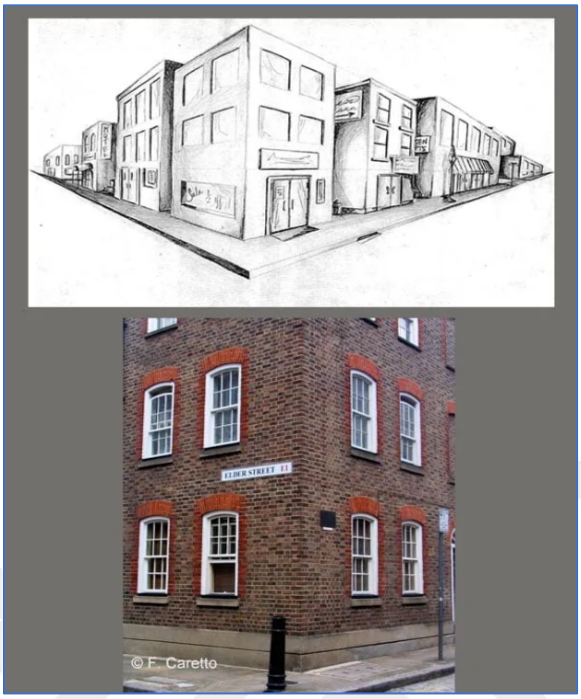


Figure 34. Two Point Perspective

This type of perspective brings things to their natural conclusion. Our camera has been rotated, giving us two vanishing points, but also tilted to look up or down at the scene. This tilt angles our previous vertical lines, introducing a third vanishing point either above or far below the scene. The following examples show this three-point perspective, and can see how this makes the image feel more dramatic, as *Figure* 35 shows.

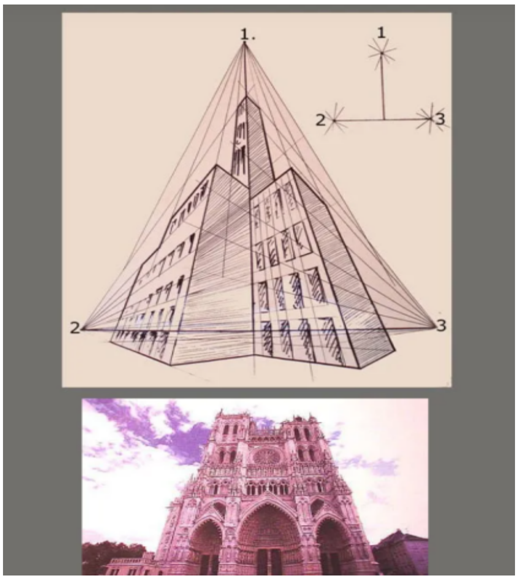


Figure 35. Three Point Perspective

3- ***The advantage can take.*** Will continue using what learned above to generate a 3D model of the oil field. It will be separated into 11 steps like *Figure* 36 shows.

Figure 36. Majnoon Equipment

Step 1. Need to import the image into 3Ds Max. To do this will first create a free camera in the front view, located directly at 0,0,0 on the grid. Since don't have any lens information for the camera used, will choose 35mm for the camera (a good "default" value). However, if using a more modern reference, the camera information can usually be found in the properties of the image itself, like *Figure* 37 and *Figure* 38:

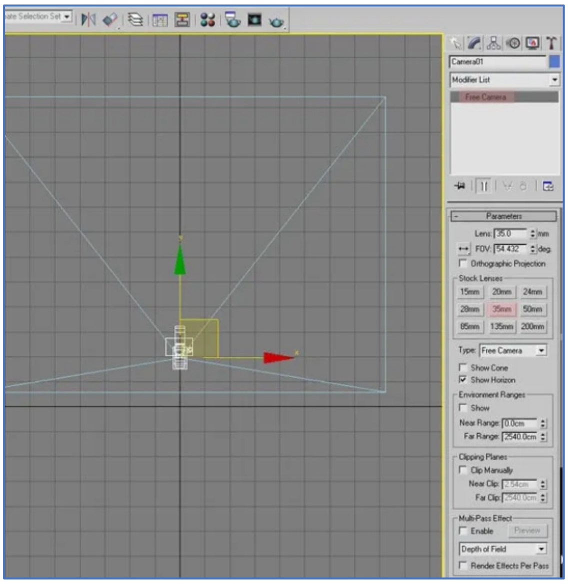


Figure 37. Step1

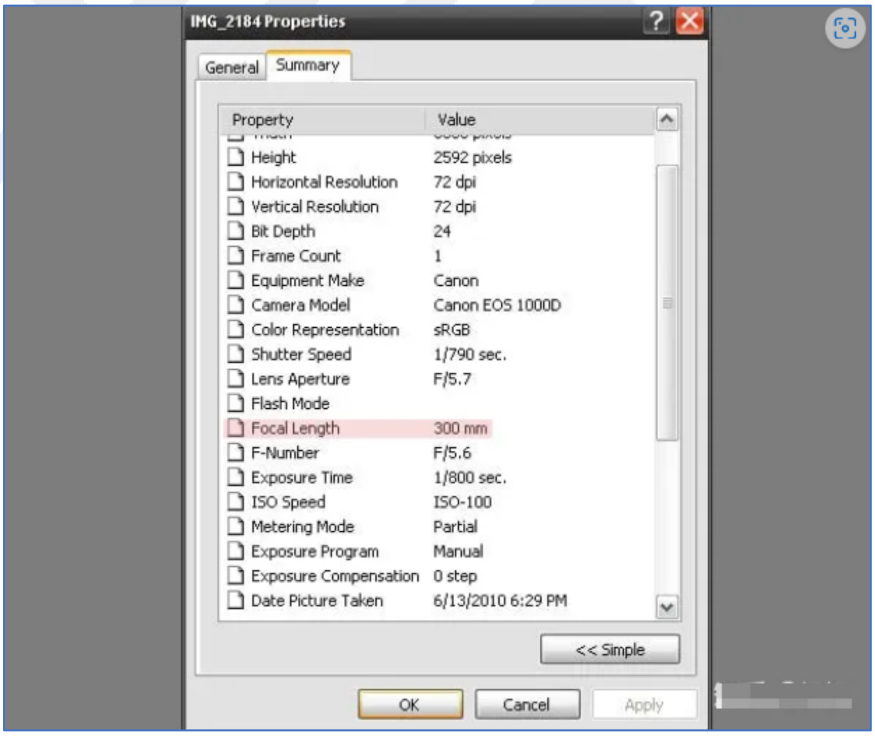


Figure 38. Step1-2

Step 2. Add the Camera Correction modifier to our camera. This is used to minimize perspective distortion. Once added, click Guess to let 3DsMax calculate some appropriate initial values, as *Figure* 39 shows.

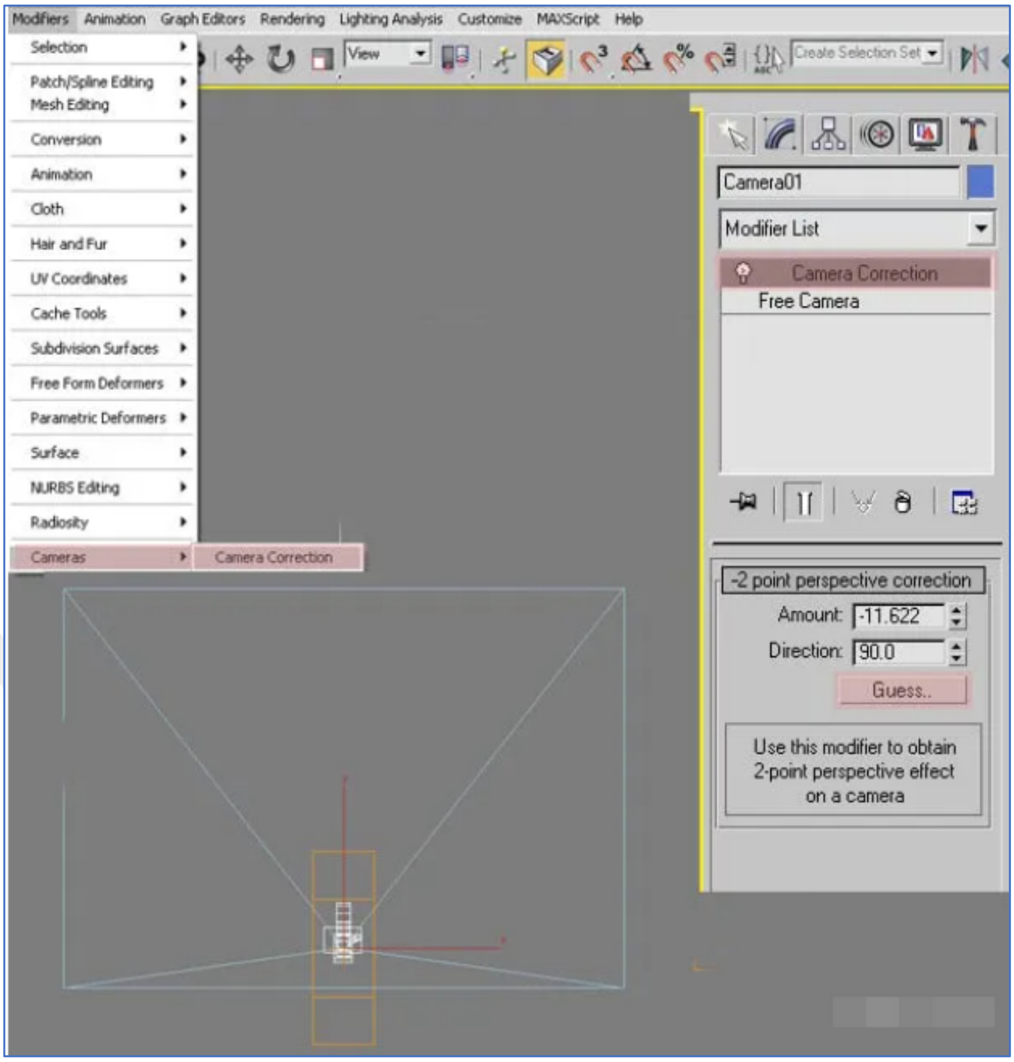


Figure 39. Step2

Step 3. Select the camera view and press Alt+B to bring up the viewport background settings. Browse to reference image and in the settings make sure Match Render Output, Show Background and Lock Zoom Pan are ticked before pressing OK.

Step 4. Open the render settings, set the output size to match the size of the reference image, and lock it, as shown in *Figure* 40.

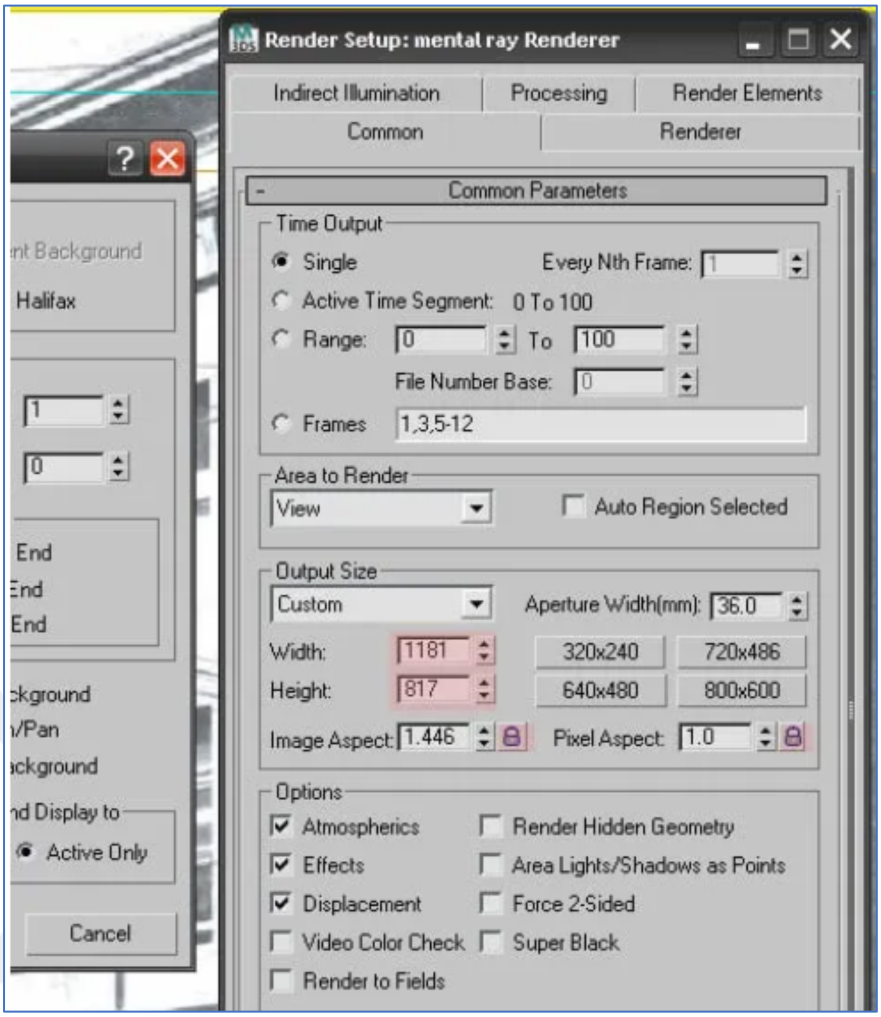


Figure 40. Step 3, 4

Step 5. In the camera settings, turn on Show Horizon. Comes the tricky part! First, need to estimate the rough height of the camera in the scene using the horizon line, and move the camera to that height. and create a box to represent the very front of the building and position it so that it roughdly matches the reference image. What happens here the camera is rotated only on the X axis so that the boxes match as closely as possible. If after some experimenting things don't line up as closely as like, try changing the focal length of camera, as *Figure* 41 shows.

It's not an easy process and does require some trial and error, but once go through it a few times, it gets easier and easier!

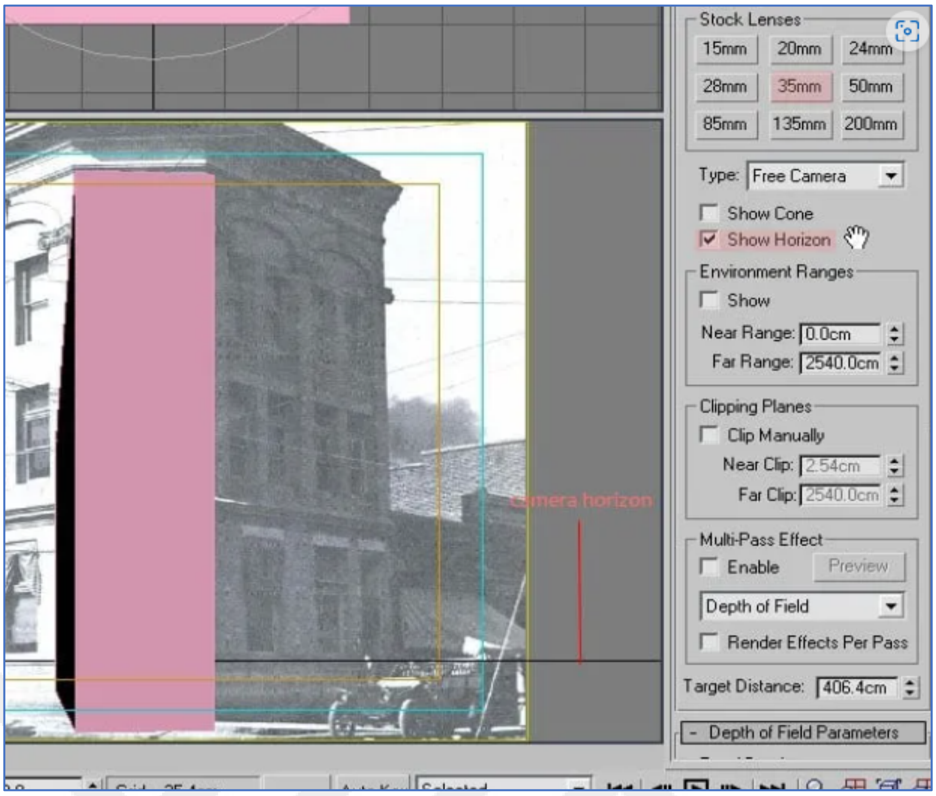


Figure 41. Step 5

Step 6. Once camera set up and in place, remember to freeze it so don't accidentally move it, as *Figure* 42 shows.

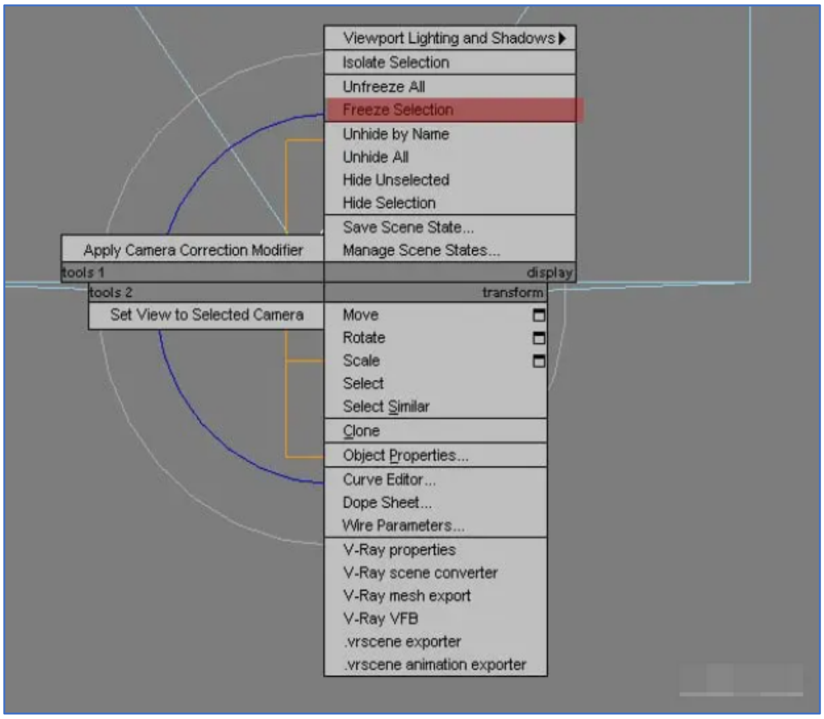


Figure 42. Step 6

Step 7. Create a plane in the front view and extrude its left and right edges to match the main sides of the building. Remember, don't want to move these new edges in Y at all - they would be straight in real life! If squeeze out and things don't line up, I'm afraid it's time to go back and adjust the cam rotation again, as *Figure* 43 and *Figure* 44 show.

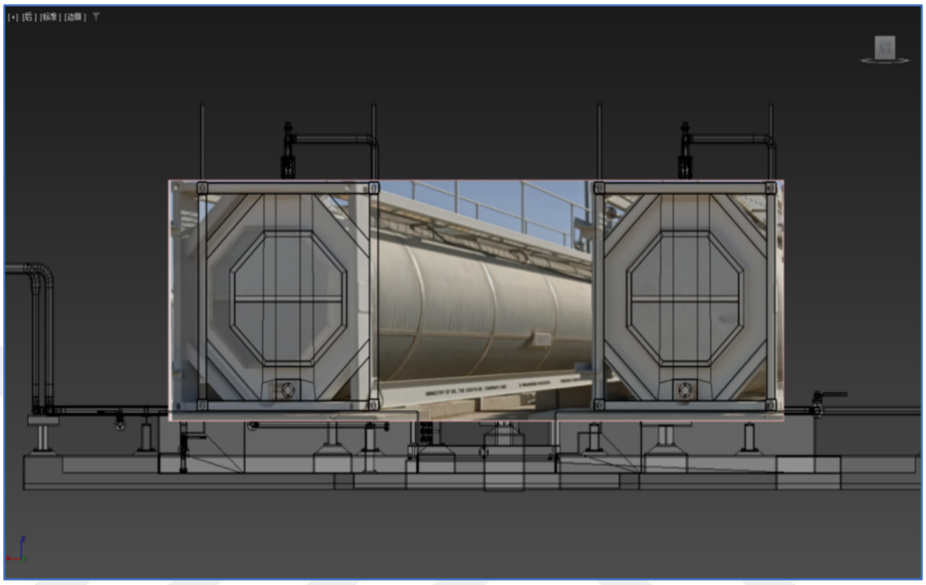


Figure 43. Step 7-1

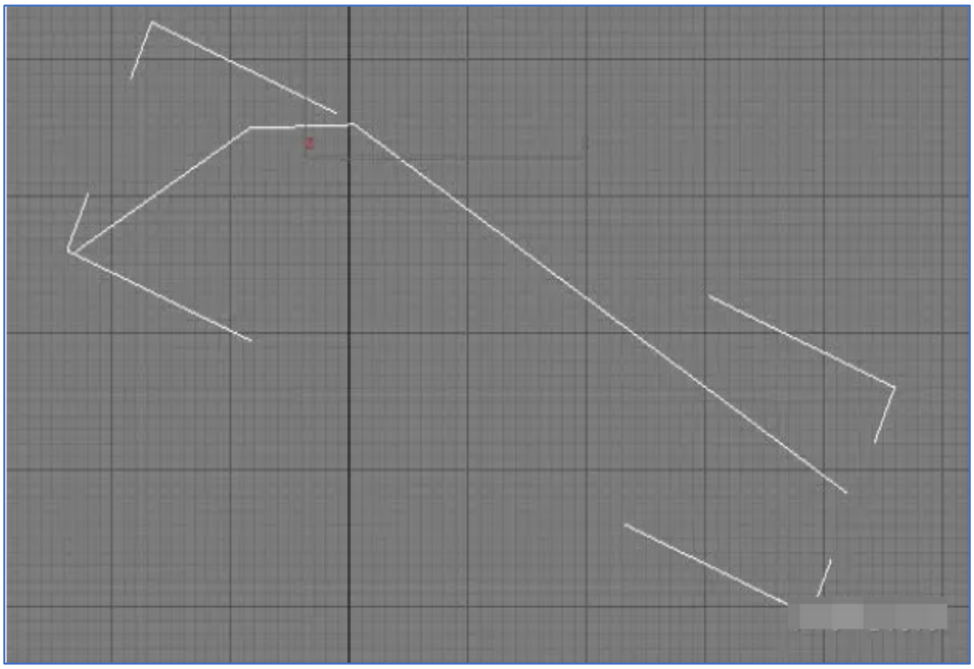


Figure 44. Step 7-2

Step 8. Select three edges and connect them with 4 partitions. Adjust these splits to match the building's features, as shown in *Figure* 45.

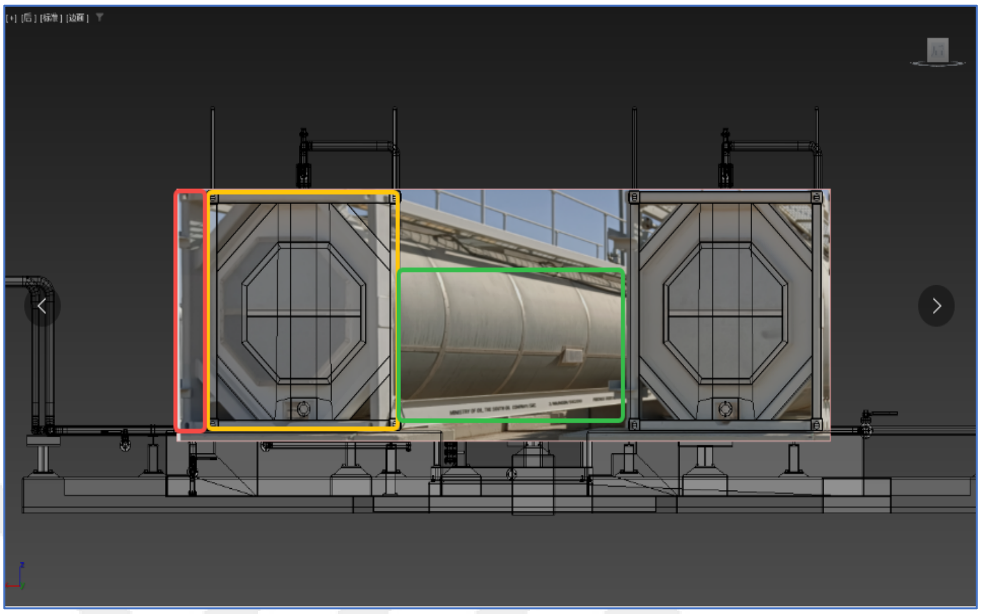


Figure 45. Step 8

Step 9. It's time to start modelling the details, as shown in *Figure* 46.

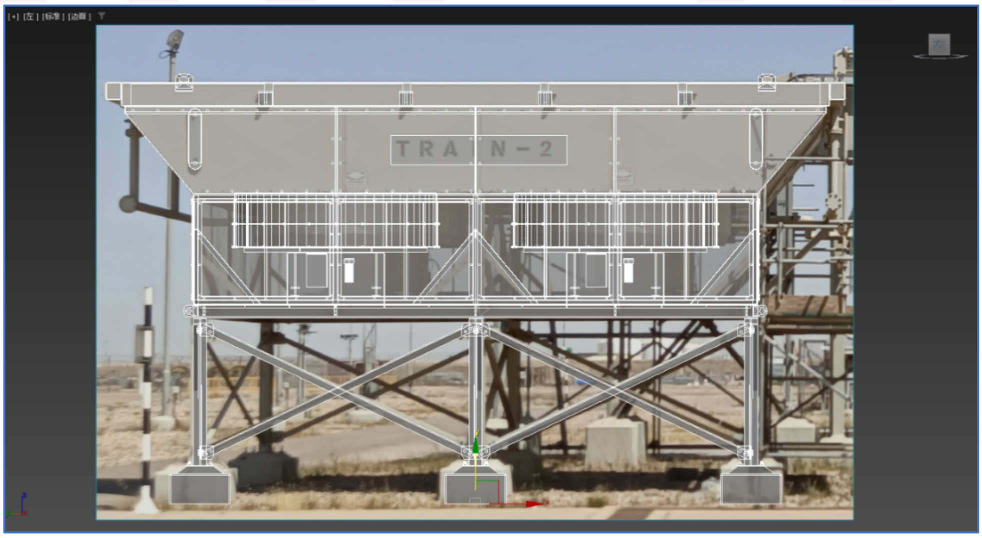


Figure 46. Step 9

Step 10. It really depends on how far take this transformation. can leave it here, or move on to the finer details, as shown in *Figure* 47.

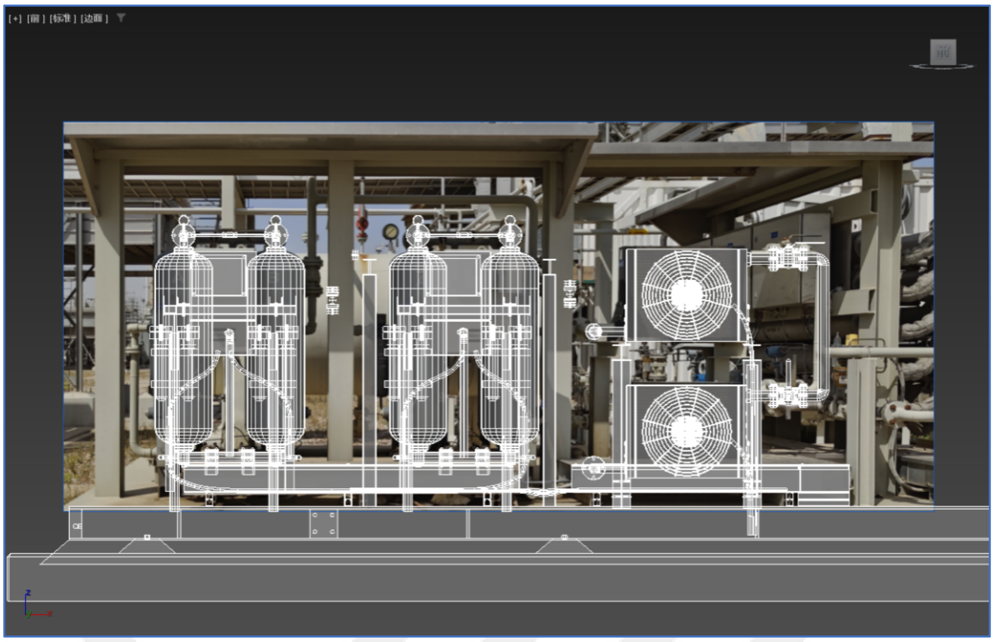


Figure 47. Step *10*

Step 11. Happy with this model, can proceed with lighting and rendering as usual, and should end up with something very similar to the original reference image, as shown in *Figure* 48.

Figure 48. Step 11

2.14. Photos compared to the finished model

As the method mentioned in the above chapter, 3D modelling of key equipment in the process area is carried out in the form of monomer through modelling technology to meet the needs of function development and asset management. The completed 3D model is imported based on GIS information about the location of its physical center point. Space Engine. Thousands of these monomer models make up a complete oil field digital twin scenario.

As *Figure* 49 shows how to change pictures for equipment in process area from 2D real picture to 3D model, after that, integrate with vGIS system.

Name	Picture	3D Model
400 VOLTS		
Atlas Copco		
Tank		
TRAIN-2		
TRAIN-1		

Figure 49. Compared-1 of 2D real picture to 3D model

As *Figure* 50 shows, took real pictures from Drones to facilities, Then the comparison is made by the countless monomer models mentioned above and the 3D digital twin scenes composed of terrain, film and other materials.

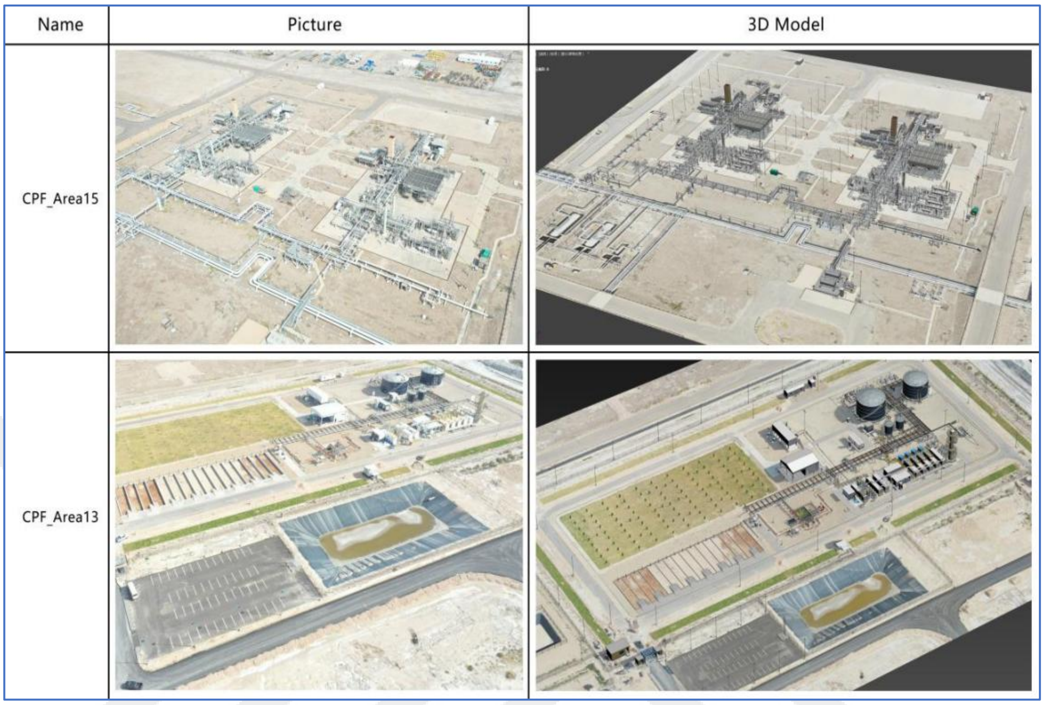


Figure 50. Compared-2 of 2D real picture to 3D model

2.15. Converting 2D pipeline vector data into 3D models

Using customized conversion tools of a 3D GIS engine to transform 2D vector data exported from ArcGIS into three-dimensional model formats usable in the project and displaying them in a 3D scene, including various types of underground pipelines, fibre optics, wellheads, underground spaces, underground oil reservoirs, etc.

Introduction. The original survey data are all provided in the format of mdb database, and ArcGIS cannot directly open the vector of pipelines inside. The data only contains information tables for pipeline points and lines, without vector data. However, services like map services require SHP files, so it is necessary to use three-dimensional tools to convert the data into models.

Approach. First, examine the data attribute structure inside the data - points information can be directly converted into XY display points using ArcGIS - for pipelines, a program needs to be written to match the coordinates of the pipeline endpoints and form a GeoJSON file, then convert the GeoJSON to SHP - and it's done.

Specific Operation, as listed in the following steps:

Step 1. Viewing MDB, Excel import and open.

As shown in *Figures* 51 and 52, Microsoft Access Database tool supports the uploading of batch data files with multiple data tables per file, and flexible view switch between tables does better job for 3D model attributes data reading and data analytics.

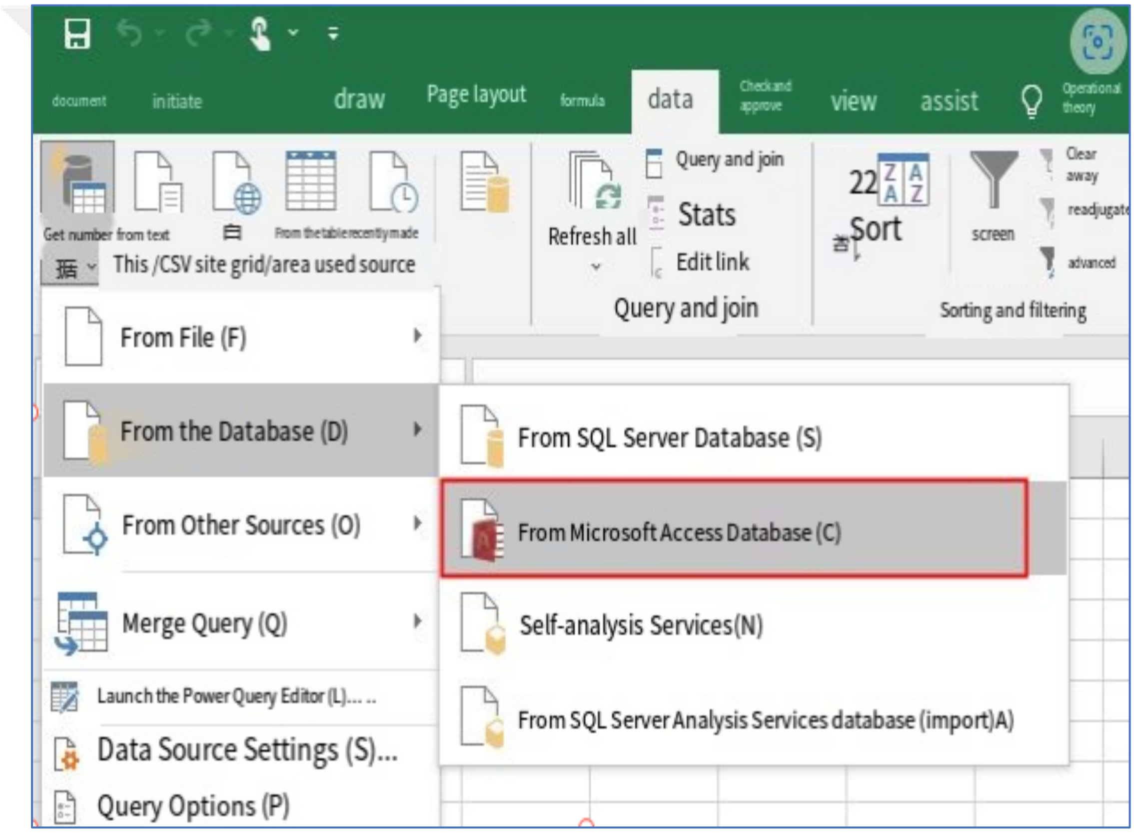


Figure 51. Excel Operation-1

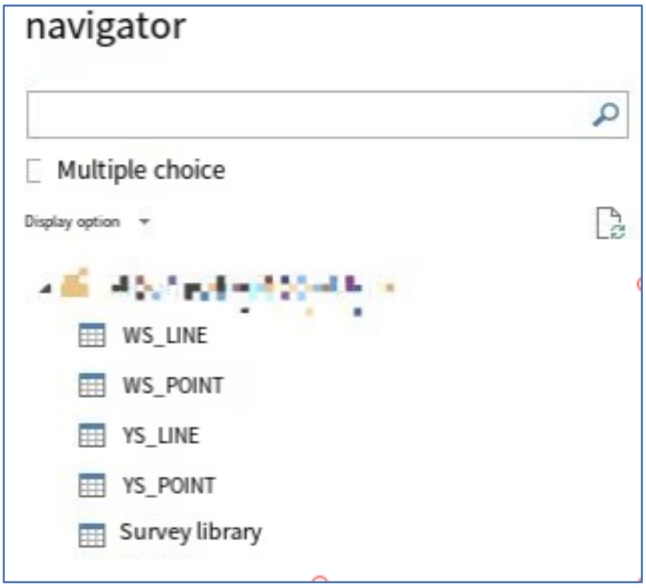


Figure 52. Excel Operation-2

Step 2. Open in ArcGIS, select the corresponding table and drag it in, vGIS project mainly used 2 GIS map software during the implementation, SuperMap which's been introduced in above section, ArcGIS is introduced for next sections, the user design interface is shown in *Figure 53*.

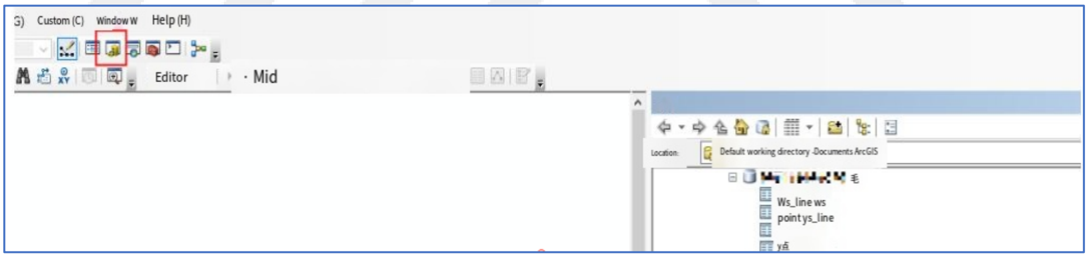


Figure 53. Open in ArcGIS-a

Step 3. Displaying point information of pipelines. Set the appropriate coordinate system, using the (X, Y) coordinate fields, then export the SHP file, as *Figure* 54 shows.

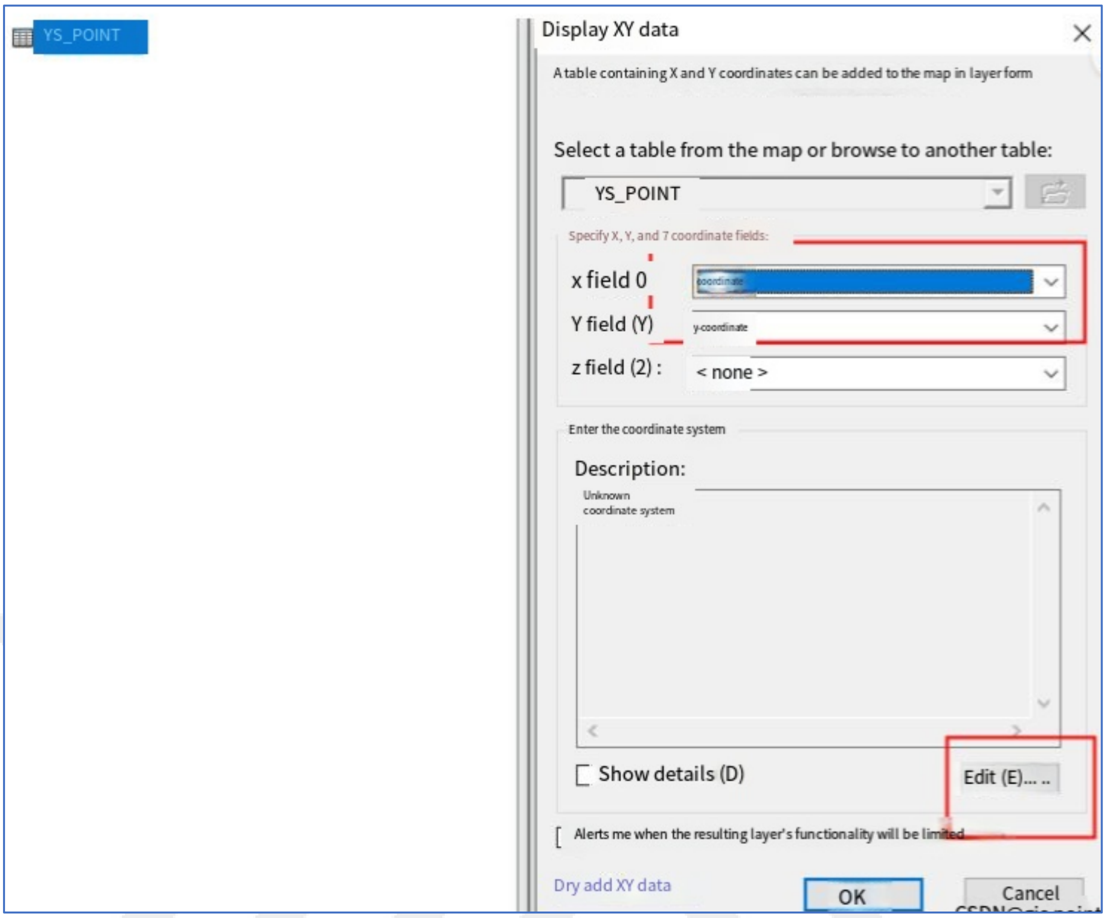


Figure 54. Open in ArcGIS-b

Step 4. For pipelines, programming is needed for matching.

For programming, can choose to enter the database or directly read the MDB file. Here, will only discuss the approach using a sewage representation example in *Figures* 55 and 56.

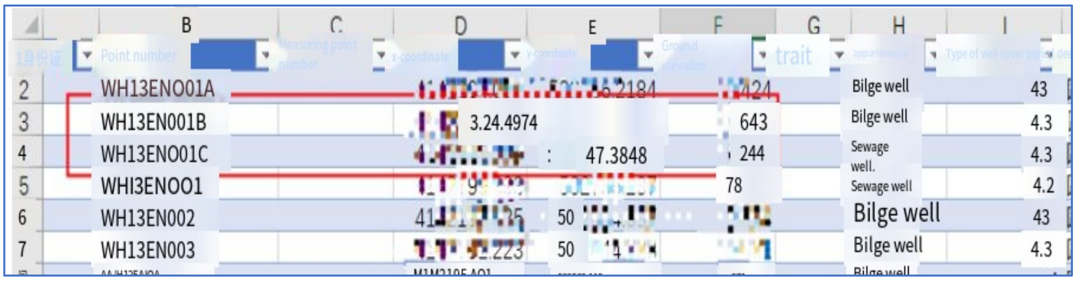


Figure 55. Pipeline Points

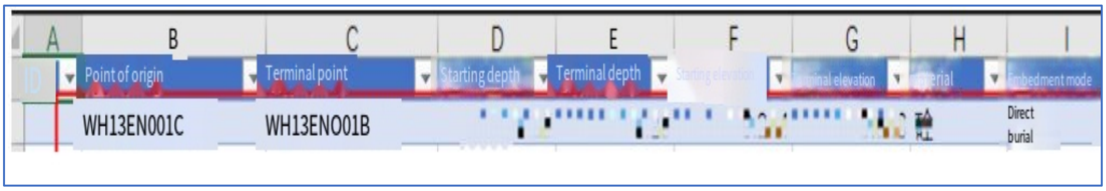


Figure 56. Pipelines

Finally, output in GeoJSON data format, as *Figure* 57 illustrates an example of the exported GeoJSON data, including the names of the start and end points and the latitude and longitude coordinates of a pipeline.

```
{
    "type": "FeatureCollection",
    "features": [
    {
      "type": "Feature",
            "geometry": {
                "type": "LineString",
                "coordinates": [
                    [502847.384761, 4142225.568719]
    [502834.497419,4142213.881936]
                ]
            },
            "properties": {

                "startPointNum":"WH13EN001C",
                "endPointNum":"WH13EN001B",
```

Figure 57. Data Format

Note that during the conversion process, pipelines may not be able to match related points. Please pay attention to troubleshooting.

Step 5. Convert the GeoJSON to SHP using https://mapshaper.org/. To prevent Chinese characters from becoming garbled in attribute values, can use Notepad++ to set the GeoJSON to ANSI or UTF-8 format, then when exporting, set the encoding to GBK.

Step 6. Completed as *Figure* 58 shows.

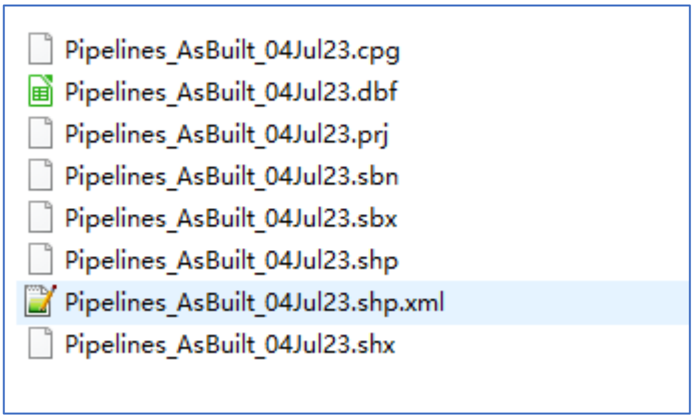


Figure 58. Completed-1

Figure 59 is a sample preview of SHP vector data's 2D pipeline and points.

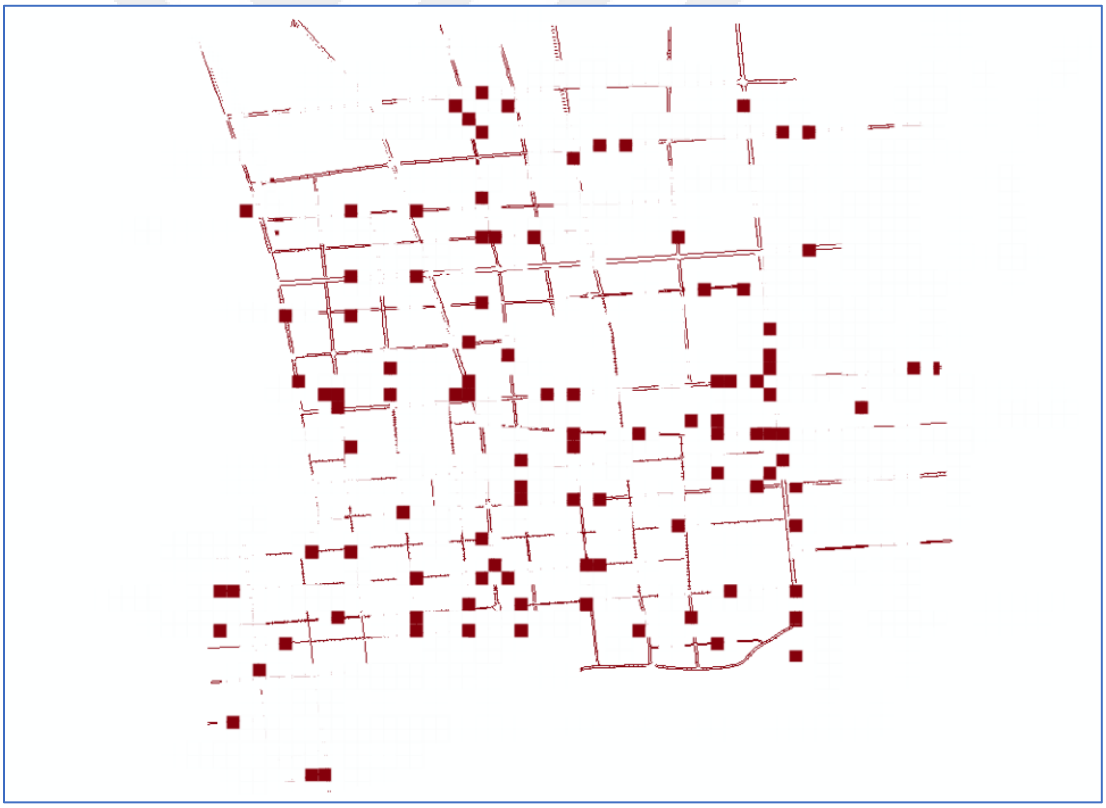


Figure 59. Completed-2

Step 7. Load the exported SHP files into the 3D GIS engine. The 3D model conversion tool will read the latitude and longitude of the starting point, length, diameter, material, burial depth, and other information of each segment of the pipeline from the SHP file to automatically generate 3D pipeline models, as *Figure* 60 shows.

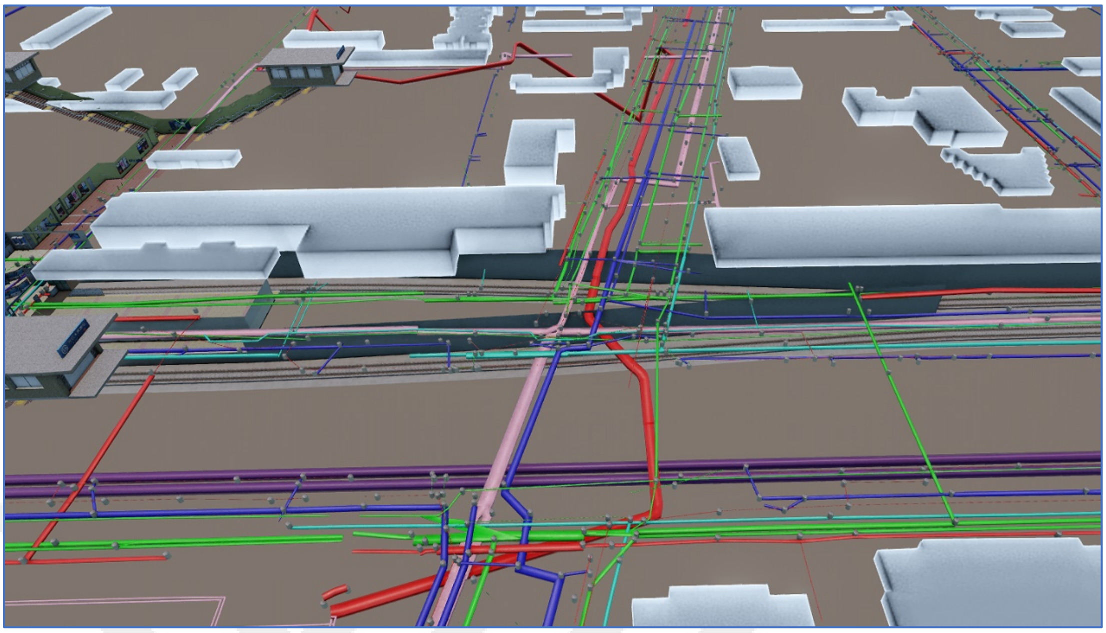


Figure 60. 3D GIS Engine

2.16. Literature Review

The incorporation of cutting-edge technologies such as Artificial Intelligence (AI), Internet of Things (IoT), Geographic Information Systems (GIS), and Digital Twins into the domains of disaster management and environmental protection is a swiftly progressing area, besides, the VGIS (Virtual Geographic Information System) Digital Twin Platform demonstrates the integration of many components to improve operational efficiency, safety, and decision-making in oilfield management (M. H. Al-Jaberi et. al.).

This literature review examines the present status of research and practical implementations of these technologies, with a specific emphasis on their involvement in disaster management and environmental preservation. GIS is a crucial technology for analysing and managing geographic data.

(Longley et al.) (2015), state that GIS combines hardware, software, and data to capture, manage, analyse, and display many types of spatially related information, since GIS consists of essential elements such as data, hardware, software, personnel, and methodologies, these systems are widely employed in many industries, including as environmental monitoring, urban planning, and natural resource management, because of their capacity to efficiently visualise and analyse spatial data, Digital Twin technology encompasses the creation of a virtual duplicate of a tangible object, enabling instantaneous monitoring, simulation, and analysis.

According to (Grieves and Vickers) (2017), Digital Twin is composed of three primary elements: the real object, virtual representation, and data that connects with others, so, within the realm of oilfields, Digital Twins facilitate the visualisation of infrastructure, the monitoring of activities in real-time, and the ability to predict and schedule maintenance tasks, this technology is essential for improving the efficiency and safety of oilfield operations by offering a complete understanding of the situation and assisting in making informed decisions.

(Ashish Ghosh.) October 2018, Emphasised the amalgamation of AI and IoT technologies with GIS and Digital Twins constitutes the fundamental framework of intelligent systems designed for disaster management and environmental preservation, AI algorithms have the capability to analyse large volumes of data produced by IoT sensors, thus, this analysis allows for the extraction of valuable insights and the generation of predictive analytics, which can be used to make proactive decisions, while IoT equipment, such as sensors and drones, gather up-to-the-minute information on environmental conditions, structural soundness, and operational efficiency, hence the data is crucial for generating precise and dynamic Digital Twins.

(Yunqiang Chen) June 2019, Stated an augmented reality (AR) and virtual reality (VR) technologies improve the way of interact with digital twins AR superimposes digital information over the real world, whereas VR completely immerses users in a virtual environment, these technologies are especially beneficial in the areas of training, remote monitoring, and operational planning, for example, VR can replicate emergency situations to train individuals, whereas AR can offer live data overlays for technicians working in the field.

VGIS and Digital Twin platforms are utilised in disaster management to prioritise real-time monitoring, predictive analytics, and response coordination, during a natural disaster, IoT sensors have the capability to identify alterations in environmental circumstances, such as escalating water levels or seismic activity, by subjecting this data to AI algorithms, it is possible to forecast future consequences and activate early warning systems, thus, GIS and Digital Twins offer a graphical depiction of the impacted region, facilitating effective distribution of resources, and planning for emergency response (James B. et. al.).

These technologies aid in the surveillance and administration of natural resources, pollution mitigation, and conservation endeavours in the field of environmental protection, Digital Twins have the capability to replicate natural situations and enabling the evaluation of the influence of different elements on ecosystems, IoT sensors are used to monitor various metrics, including air and water quality, then AI employed to analyse patterns and detect any deviations from the norm, while GIS offers the spatial framework essential for comprehending the arrangement and progression of environmental events (Michael F.).

The practical advantages of integrating these technologies are demonstrated by the implementation of the VGIS platform in the Majnoon oilfield in Iraq. The platform integrates data from diverse sources, such as exploration, production, and environmental monitoring, into a centralised system. It allows for immediate understanding of the current status, proactive maintenance, and efficient production planning. The utilisation of unmanned aerial vehicles for gathering data and augmented reality for providing on-site support showcases the sophisticated functionalities of the VGIS platform in overseeing intricate oilfield activities.

Chapter 3

Methodology

3.1. VGIS Platform Main Functions

Field Situational Awareness

As *Figure 61* shows, the Field Situational Awareness (FSA) is the function that integrates individual systems across Value Chain, divided into several systems like production, Health, Safety, Security & Environment (HSSE), Process Flow, and Asset Integrity Monitoring systems, integrating the data from SAP (System Applications and Products in Data Processing)/OA (Office Automation)/PI (Process & Instrumentation)/DCS (Distributed Controlling System)/CCTV (closed-circuit television)/EAM (Enterprise asset management)/EDW (engineering data warehouse) and so on to help make the critical data that may be used in the daily management vitalized on one single screen.

Figure 61. VGIS Platform Field Situational Awareness

3.2. Overall Oil & Gas Process Flow Monitoring

As shown in *Figure 62,* through integration with the production control system such as SCADA (Supervisory Control and Data Acquisition) system, instrument parameters, environmental information, and personnel dynamic information can be displayed in real time in a digital environment, which can be used for operation, maintenance, control guidance, risk assessment, emergency plan formulation, in comparison with traditional method, on-site operators cannot grasp the status information of the whole process, and remote collaborators have no resources for on-site status, environment, and personnel location. The collaboration working environment built through the VGIS platform can improve the efficiency of the remote operation, improve operation safety, and eliminate incidents and minimize risks.

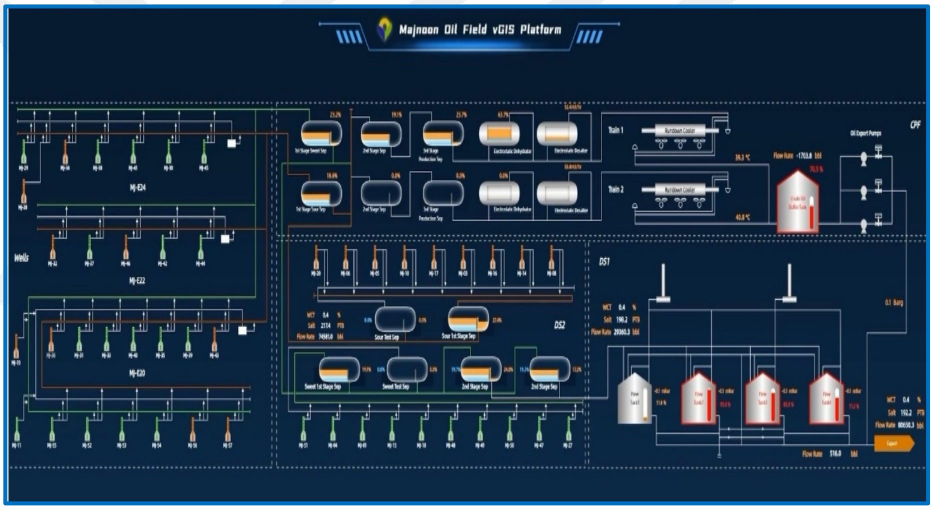


Figure 62. Process Flow Monitoring and Management

3.3. Situational Awareness in Production

The process of oilfield exploitation, from reservoir management to development planning and production, is intricate and poses significant challenges to scientific management in the oilfield industry. An important obstacle is the lack of precise real-time data sharing among different departments. The VGIS platform enables integrated development planning and provides real-time monitoring of various production aspects such as process status, output report, energy consumption analysis, and equipment maintenance progress. Through business intelligence analysis, it can accurately present the plan completion rate, identify factors that hinder progress, conduct correction analysis, identify bottlenecks that restrict production, optimise production processes, improve maintenance plans, enhance energy efficiency management, and ultimately improve the plan completion rate.

Figure 63 illustrates how VGIS enables production engineers to generate reports that display production volumes, injection rates, and production efficiency. These reports use different colours (red, orange, and green) to indicate whether production meets the expected or target levels (K. A. Abdalla et. al.).

Figure 63. Production Monitoring and Management

3.4. Asset Integrity Management

As shown in *Figure 64,* using Asset Integrity Monitoring and Management, the VGIS platform integrates decision planning, minimizes conflicts in field layout planning, supports the development of a centralized database, enables design review using 3D simulations, promotes training, enables review of solutions before order placement, improves understanding between operation owners and EPC contractors, enable life cycle management of key equipment.

Figure 64. Asset Integrity Monitoring and Management

3.5. Health, Safety, Security & Environment (HSSE) Situational Awareness

HSSE management which shown in *Figure 65,* is an integral part of petroleum operations throughout the oilfield lifecycle. By connecting with the local meteorological, firefighting, and public safety information systems, the weather information can be updated and presented in real time, and the information can be pushed to on-site operators for on-site work guidance. By integrating the location information of on-site operators, vehicle information, docking public information resources can formulate a complete emergency response plan to deal with emergencies and ensure safe production.

Figure 65. HSSE Monitoring and Management

3.6. Digital Twin for Oilfields

The digital twin of the oilfield is the core function of VGIS. Based on the 2D/3D map and 3D models of facilities/wells combined with the images and models produced by drones, a full image of the oilfield is created. As the core of the digital twin, the functions of the VGIS map system are developed including the overview of the production facilities and pipelines, combined with the monitoring of the overall production situation in real-time and the monitoring of the production situation of the wells. In addition, the system can visualize the path of wells, which greatly facilitates oilfield exploration and development.

Furthermore, the system provides a 3D view of facilities and supports 3D roaming of production facilities, living camps, and real-time equipment monitoring to take oilfield management to a new level.

Figure 66 shows the VGIS platform enables the overview and visualization of underground pipelines. The pipeline overview function collects the inventory data of the underground pipeline and ground facilities and creates a special layer on the map system to highlight them. The course of media flow in the complicated pipeline system can be visualized on the map so that the total flow can be easily seen and the connection between stations can be easily found.

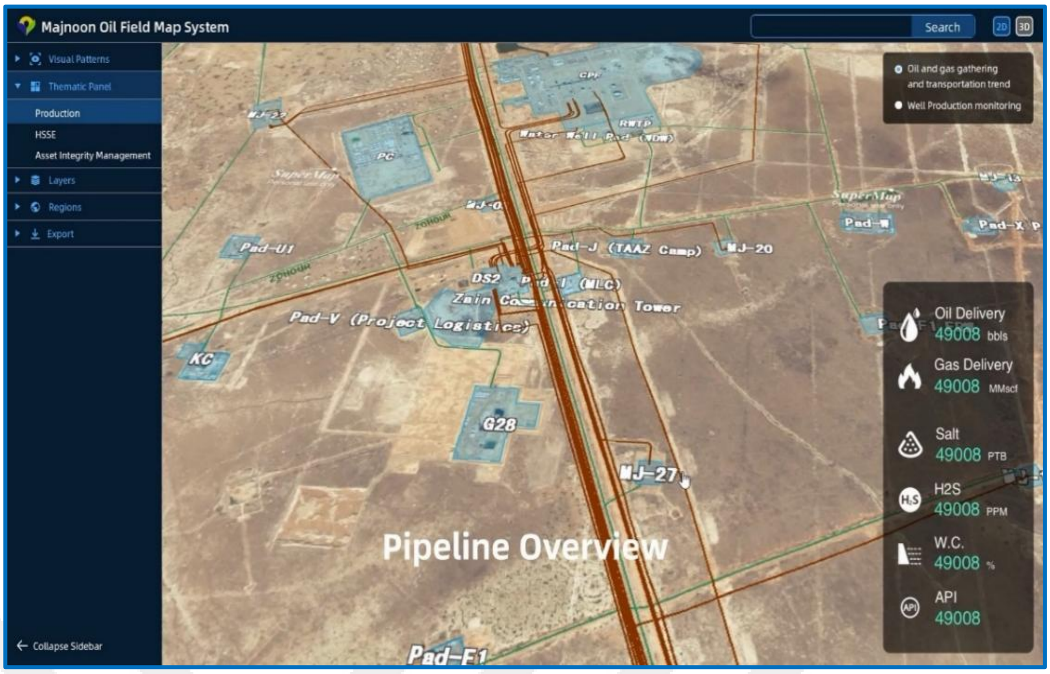


Figure 66. Oilfield Pipeline and Facilities Overview

The VGIS platform allows monitoring of oil production through wells on the 3D map are shown in *Figure 67.* This function provides the link between the oil production situation and the 3D map to make the management of production simple and clear.

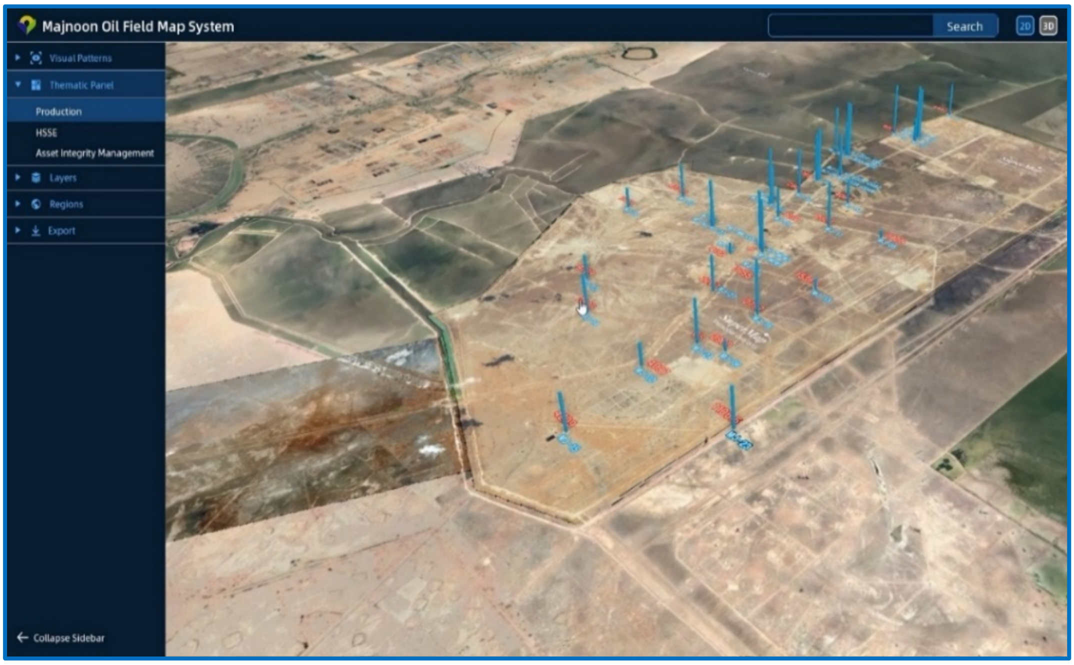


Figure 67. Oil Production Monitoring by Wells

3.7. Intelligent VGIS system

With the VGIS platform and the functions of BI, the overall view of the oil field is created. To make better use of the functions of BI, the functions of VR/AR are developed in the VGIS system. As *Figure* 68 shows, the VR system can realize real-time monitoring and remote training remotely.

Figure 68. VR Function of VGIS Platform

The AR system as shown in *Figure* 69, can realize real-time monitoring, inspection, and professional suggestions for operation remotely. The AR system is also combined with drones flying in real-time and transmitting the videos into the AR system, as shown in *Figure* 70, so that anyone using the equipment from AR can get an overview.

Figure 69. AR Function of VGIS Platform

Figure 70. UAV Photography and Inspection Function

Even without safety training, can quickly navigate the entire oil field through VR and enter dangerous areas. Through VR, can view the basic information of each area and real-time production data, quickly introduce new personnel to the oil field, and help managers of production management or other business departments to achieve remote management and monitoring, as shown *in Figure*s 71,72,73 and 74.

Figure 71. Intelligent Applications with VR/AR-1

Figure 72. Intelligent Applications with VR/AR-2

Figure 73. Intelligent Applications with VR/AR-3

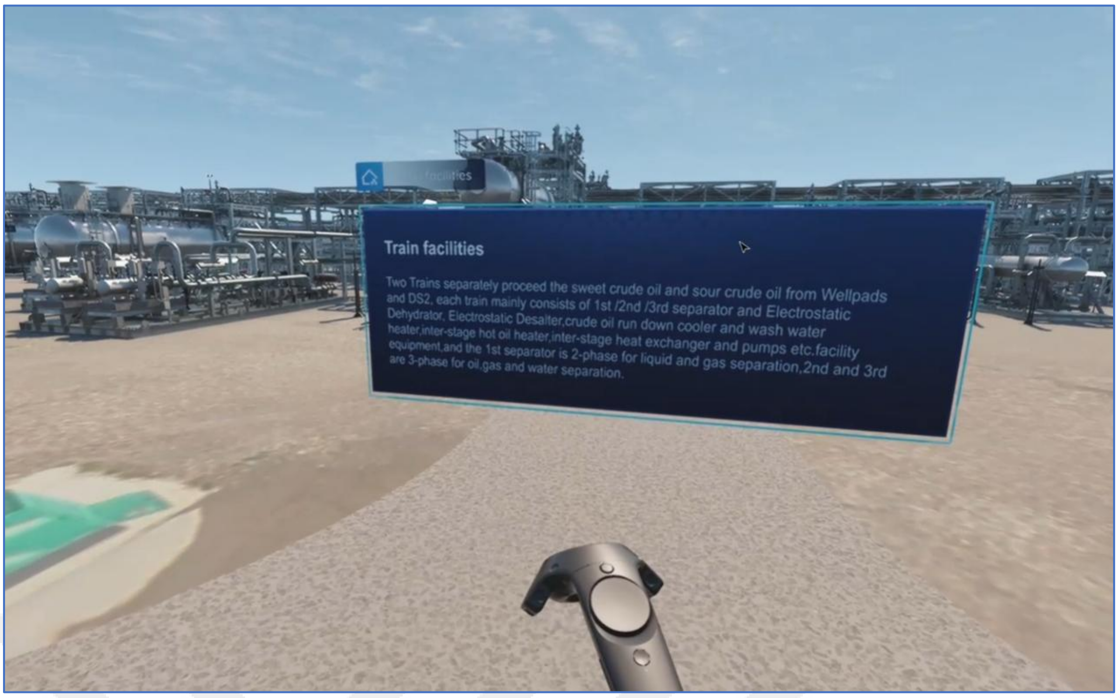


Figure 74. Intelligent Applications with VR/AR-4

VR can also be used for equipment maintenance training, in a low-risk and low-cost way to achieve the training of new and old employees, and even assessment.

The training scene in VR brings a near real training environment for the operation of the equipment by highlighting or other prompts, take the power generation room as an example, then follow the steps to turn on the lights and blinds, after that connect the wires to turn on the air switch, as *Figure*s 75 and 76.

Figure 75. Intelligent Applications with VR/AR-5

Figure 76. Intelligent Applications with VR/AR-6

3.8. Methods and Results:

The digital twin of the oilfield serves as the central feature of the VGIS (Virtual Geographic Information System). By leveraging 2D/3D maps and models of facilities and wells, along with images and models captured by drones, a comprehensive representation of the oilfield is generated. At the core of the digital twin, the VGIS map system is developed, offering various functionalities such as an overview of production facilities and pipelines, real-time monitoring of overall production, and well-specific production monitoring. Moreover, the system provides visualizations of well paths, greatly aiding oilfield exploration and development efforts, as shown in *Figures 77* and *78.*

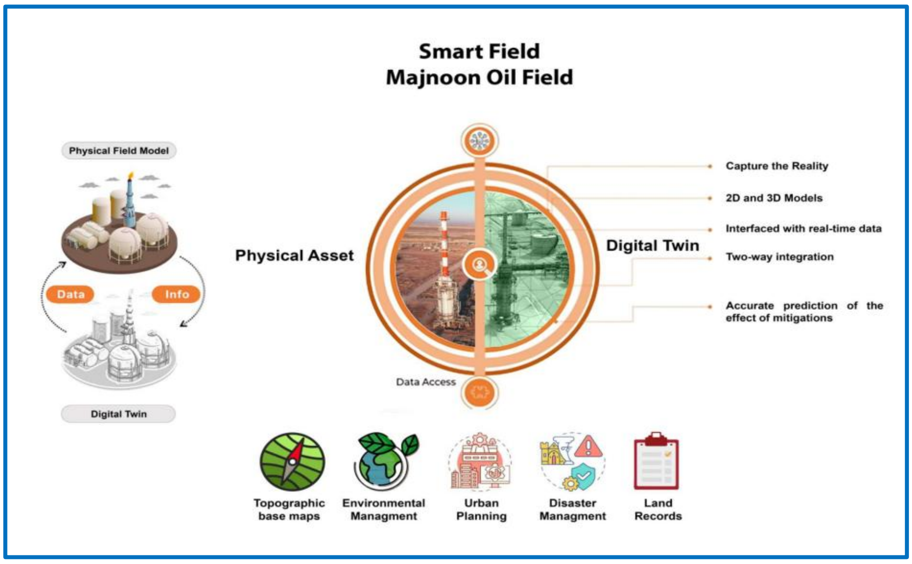


Figure 77. Smart Field of Oil Field-a

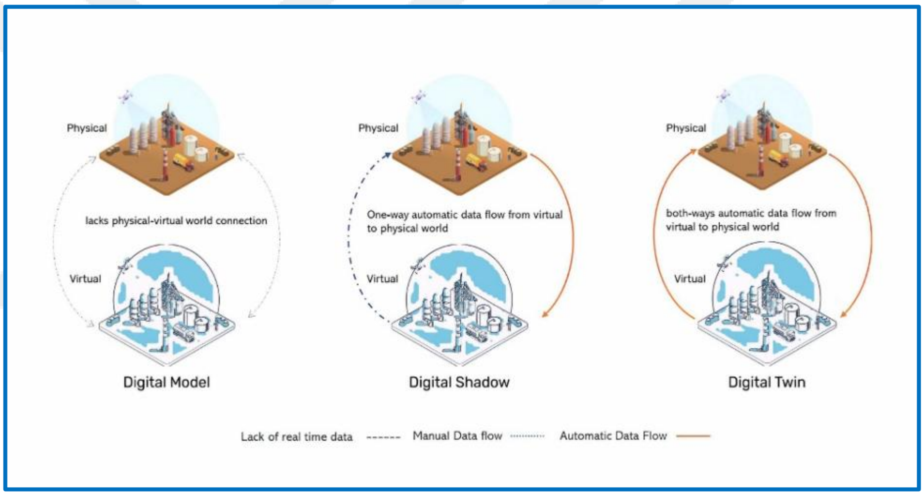


Figure 78. Smart Field of Oil Field-b

The VGIS platform takes oilfield management to new heights by offering a 3D view of facilities and supporting immersive 3D exploration of production facilities and

living camps. Real-time equipment monitoring further enhances operational control. *Figure 79* shows the cases of VGIS platform's capability to provide an overview and visualization of underground pipelines. The pipeline overview function aggregates inventory data from underground pipelines and ground facilities, creating a specialized layer on the map system to highlight them. This visualization enables easy comprehension of media flow throughout the intricate pipeline network, facilitating identification of total flow and connections between stations.

Figure 79. Oilfield Pipeline and Facilities Overview

The VGIS platform also enables monitoring of oil production through wells, as shown in *Figure 80.* This functionality establishes a connection between oil production data and the 3D map, simplifying production management and providing clear insights.

Figure 80. Oil Production Monitoring by Wells

3.9. Intelligent Applications with VR/AR

By leveraging the VGIS platform and its business intelligence (BI) capabilities, a comprehensive view of the oilfield is attained. To maximize the potential of BI, the VGIS system incorporates virtual reality (VR) and augmented reality (AR) functionalities. *Figure 66* illustrates the VR system, which facilitates real-time monitoring and remote training.

The AR system which depicted in *Figure 67,* enables real-time monitoring, inspection, and professional suggestions for remote operations. This AR system is complemented by drones capturing live videos, which are transmitted into the AR system, as shown a cased in *Figure 81.* Users equipped with AR devices can gain an overview of the oilfield through these real-time feeds.

Figure 81. UAV Photography and Inspection Function

Chapter 4

Findings

4.1. Overview

VGIS is a Real-time 3D Digital Twin platform which re-constructs 3D models of the oilfield, connects disparate systems & data into one system; it enables different function roles to manage the daily operation more efficiently, as *Figure* 82 shows.

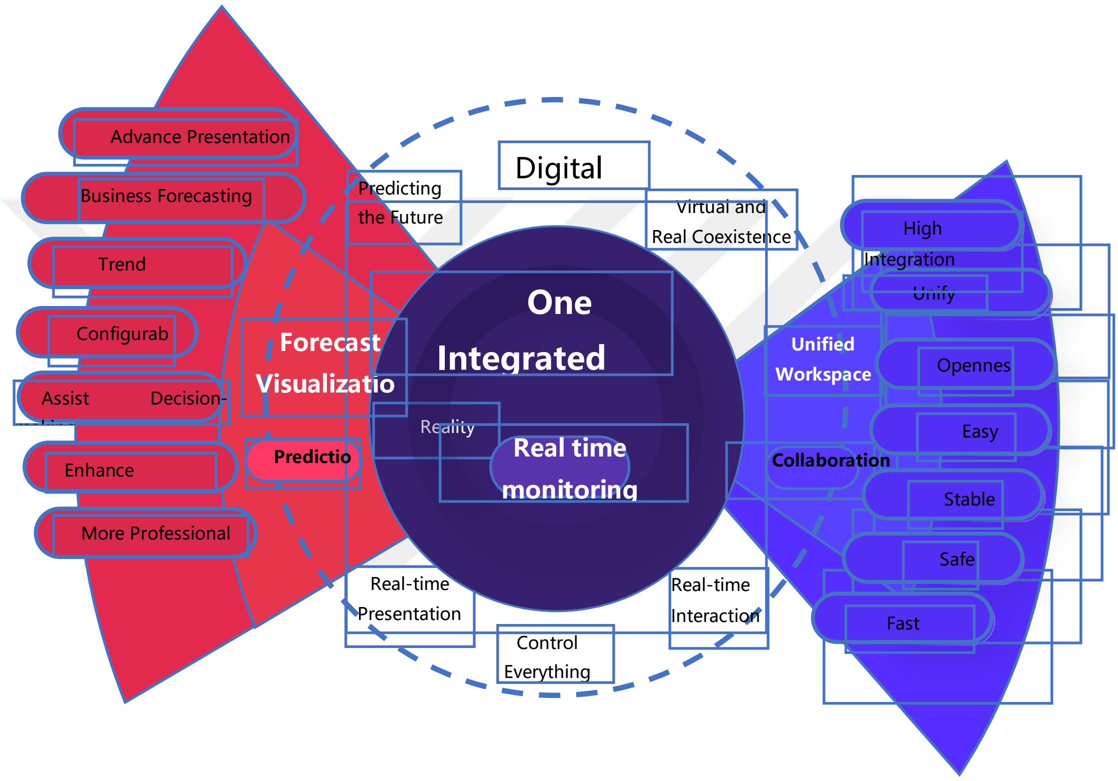


Figure 82. One Integrated 3D System

VIGIS was started in 2020 as part of key initiatives to build a Smart Digitalized oilfield to improve management efficiency, and it is in 2nd Phase of construction after its initial success in 2021. As the production increased, the ever-changing dynamics imposes great challenges for efficiency increasing and risk mitigation, as the daily operation and management require vast amounts of technical data to analyse, which is subdivided into different departments and limits the work efficiency.

Building a Smart Oilfield through Digitalization, Emphasis on Data Lakes, Big Date, Various Smart Applications, and Establishing a Digital Twin Platform.

4.2. VGIS Project implementation

VGIS Project

The project has constructed the Digital Twin, by producing a real-scene 3D model of assets with drones, connecting disparate data sources/systems, and integrating them into a GIS system.

VGIS empowers operators

VGIS empowers operators with overall situational awareness, and business process visibility to monitor field assets and operations.

VGIS helps field to decrease the cost

VGIS enables field to spend less cost on operations, maintenance, training, and traveling. Operators, contractors, and international experts can remotely conduct site visits and monitor real-time field operational status with VGIS.

VGIS offers more benefits

VGIS can reduce speeds up knowledge transfer & workforce localization.

4.3. Project Execution Steps

Challenges steps:

Step 1: 3D Modelling/Design Data. 3D Modelling is totally relying on reconstruction due to missing design Data or clarity (e.g., production equipment grouping). Some additional information from other partners is hard to get (e.g., KBR GIS data)

Step 2: System & Data Integration Data Readiness & Quality is Late & Poor. Lack of connection API or right authority to connect.

Step 3: Business Process Integration Difficult to engage different department people to understand their business process to design a better user story.

4.4. VGIS Code

4.5.

```
// Initialize the measurement area and the UI Settings of the area measurement function. The idea is the same as above
this.measurements.area = new Cesium.MeasureHandler(viewer, Cesium.MeasureMode.Area, 0);
this.measurements.area.capturePointSize = 1
this.measurements.area.capturePointColor = new Cesium.Color.fromCssColorString("#4FACFF")
this.measurements.area.fillColor = new Cesium.Color(79 / 255, 172 / 255, 1, 0.4)
this.measurements.area.lineWidth = 0.5
this.measurements.area.lineColor = new Cesium.Color.fromCssColorString("#4FACFF")
this.measurements.area.measureEvt.addEventListener(function (result) {
  let mj = Number(result.area);
  that.measurements.area.areaLabel.text = mj > 1000000 ? `${parseFloat((mj / 1000000).toFixed(2))}km²` : `${parseFloat(mj.toFixed(2))}m²`;
});
this.measurements.area.activeEvt.addEventListener(function (isActive) {
  if (isActive) {
    viewer.enableCursorStyle = false;
    viewer._element.style.cursor = '';
    $('body').removeClass('measureCur').addClass('measureCur');
    // viewer.scene.pickPointEnabled = pickPointEnabled;
  } else {
    viewer.enableCursorStyle = true;
    $('body').removeClass('measureCur');
    viewer.scene.pickPointEnabled = false;
  }
});
```

This code is a JavaScript function that initializes a map measurement feature, including measuring distance, area, and height. The following steps listed an explanation of the functionality:

- Creates a Cesium.MeasureHandler instance to handle area measurement, with parameters including viewer and Cesium.MeasureMode.Area.
- Sets properties such as measurement points, fill color, and line attributes.

Adds an event listener to listen for area measurement events. When a measurement is completed, it updates the display with the measured area.

4.6. Corrosion Monitoring Upgrade

The current situation in the filed were total 70 corrosion monitoring points, 64 of them were corrosion coupons, and 6 of them were corrosion probes which were only data, as *Figure* 83 shows.

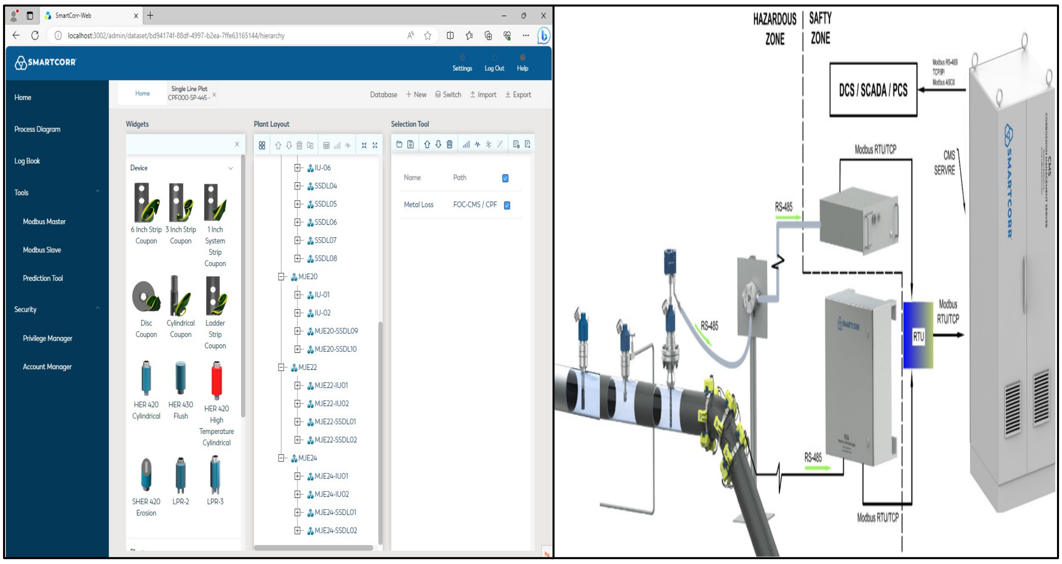


Figure 83. Corrosion Probes

logging type but not on-line type, so we couldn't measure real time corrosion situation. There were no other corrosion monitoring measures in the field, such as On-line Pipeline Wall Thickness Monitoring and other monitoring techniques.

The advantage of combination technique corrosion monitoring:

Combination of corrosion monitoring techniques (known as multi-technique corrosion monitoring), it using to provide more accurate and comprehensive data about corrosion processes. The following steps listed some of the reasons that why they are necessary:

- **Overcoming Limitations:** Individual corrosion monitoring technique may only provide an indication of one type of corrosion and may not show another form even if it exists. Multi-technique approach combines various complimentary technologies to provide maximum coverage.

- **Increase in temperature contributes:** Increase the number of active centers of corrosion on the metal surface and accelerates the development of corrosion processes.

- **Differentiating Corrosion Types:** Some of these additional techniques allow the systems to differentiate between general and localized corrosion processes.

- **Reliable Data:** The data from such a combined system is more reliable in identifying a suitable inhibitor for the localized corrosion, thus helps in managing corrosion and providing economic benefits to businesses and the users.

- **Continuous Monitoring:** The monitoring enables the detection of changes in the rate of corrosion as well as the variations in corrosion behaviour. The system allows customer to obtain real time data.

*Figure*s 84 and 85 show the describe whole structure of the new corrosion monitoring system.

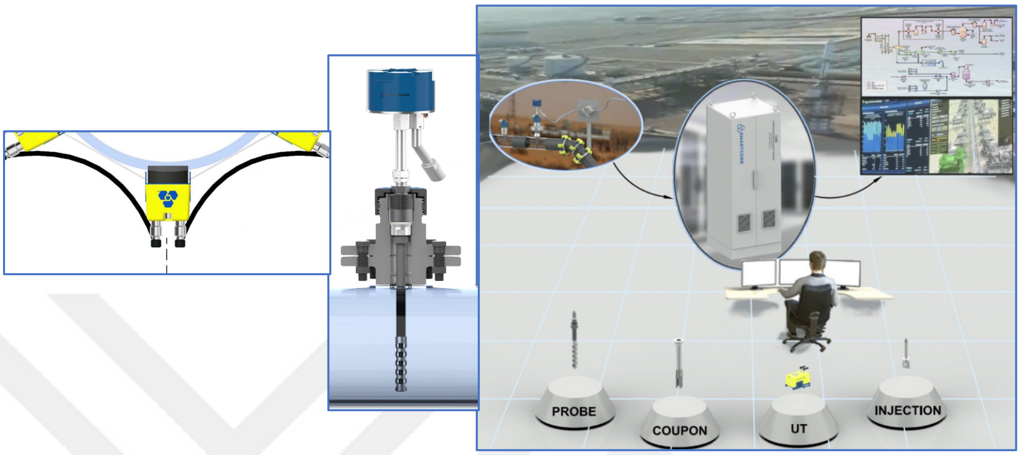


Figure 84. The structure of the new corrosion monitoring system

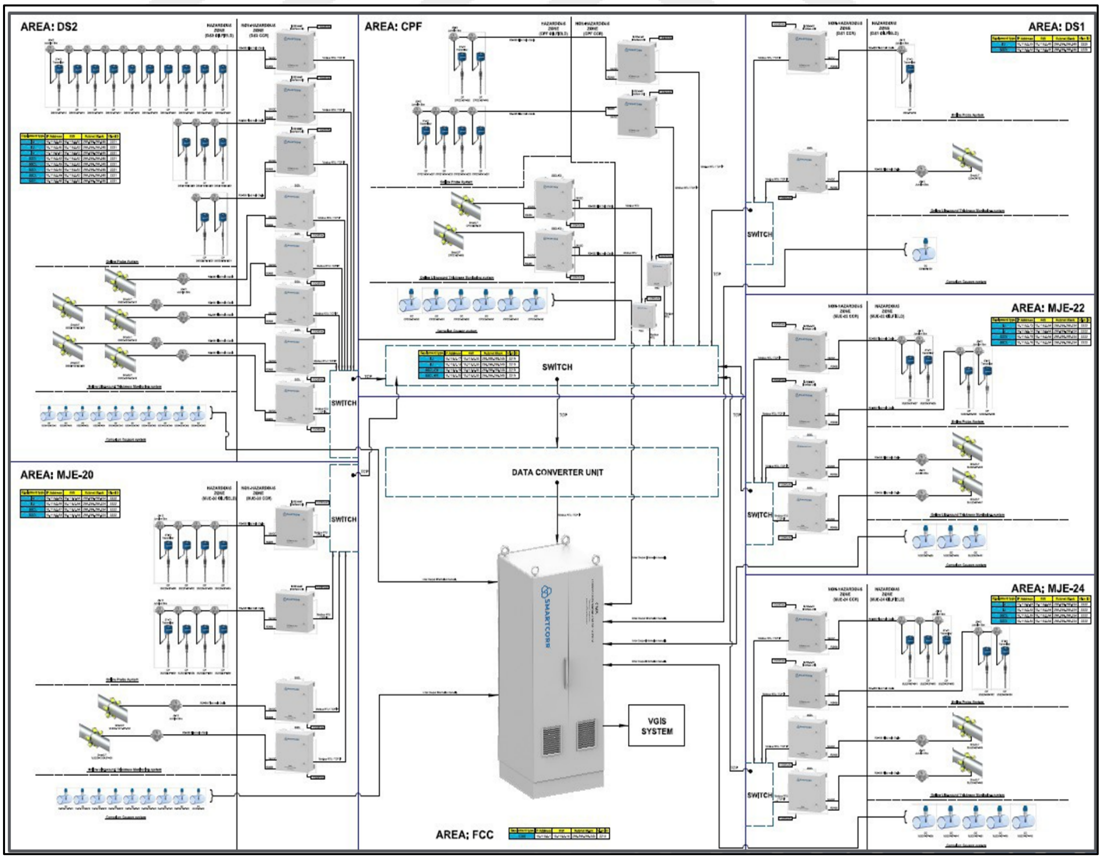


Figure 85. The structure of the new corrosion monitoring system

- **Corrosion method:**

The provided equation is related to the calculation of the corrosion rate using a slope calculation method. Here is an explanation of the components and the interpretation of the equation:

Slope (Corrosion Rate) = $\frac{\sum_{1}^{m} y_i(x_i-\mu)}{\sum_{1}^{m}(x_i-\mu)^2}$ $\mu = \frac{\sum_{1}^{m} x_i}{m}$

Where:

- *yi* is the metal loss at the i-th measurement.
- *xi* is the time of the i-th measurement.
- μ is the mean of the xi values.
- *m* is the number of measurements.

- **Interpretation:**

1. Corrosion Rate Calculation:
- The corrosion rate is calculated as the slope of the line that best fits the data points (xi,yi) where xi is the time and yi is the corresponding metal loss.
- This method is used to determine how fast the metal is corroding over time by finding the linear trend in the data.

2. Numerator:
- The numerator represents the covariance between the metal loss and time. It measures how much the metal loss varies with time from their respective means.

3. Denominator:
- The denominator represents the variance of the time measurements. It measures how spread out the time values are around their mean.

- **Practical Application:**

- Corrosion Monitoring: This calculation is typically used in corrosion monitoring systems to provide a quantitative measure of the corrosion rate. By analysing the rate of metal loss over time, we can predict the remaining life of metal structures and schedule maintenance or replacements accordingly.

- Data Analysis: The method is a form of linear regression analysis where the corrosion rate is derived from the slope of the best-fit line through the metal loss data points.

This approach allows for the systematic and accurate estimation of the corrosion rate, aiding in the proactive management of corrosion in various industrial applications.

Examples of HER data:

Timestamp and number of corroded units

3711408155, + 178134

3711408755, + 178146

3711409355, + 178152

Meaning of metal loss:

Probe Life Unit (PLU), each probe 262144 units in total.

Probe T20's thickness is 20 mil, measurement range 10mil, 10/262144 = x/y, x is corroded thickness, y is number of corroded units, as the HER data example, y = 178134, then calculate x = (10/262144) * 178134 = 6.8mil

Unit conversion:

1mil=0.001inch=0.0254mm

So, x=0.17272mm

Data curve fitting algorithm:

Slope = Corrosion Rate = $\frac{\sum_1^m y_i(x_i-\mu)}{\sum_1^m (x_i-\mu)^2}$ $\mu = \frac{\sum_1^m x_i}{m}$

Slope is corrosion rate, y_i is metal loss, x_i is fitting period, μ is average of x_i , m is sum of corrosion sample data.

According to the value of x and y, corrosion rate needs to be converted to mil per year(mpy), millimetre per year(mmpy)

m=4,

x_i *is 0, 5, 10, 15* y_i is $0.1, 0.2, 0.3, 0.4$

$\mu = \frac{0+5+10+15}{4} = 7.5$

Numerator of Slope = (0.1) (0-7.5) + (0.2) (5-7.5) + (0.3) (10-7.5) + (0.4) (15-7.5) = 2.5

Denominator of Slope = (0-7.5)2 + (5-7.5)2 + (10-7.5)2 + (15-7.5)2 = 125

Slope = 2.5/125= 0.02 mil/hour = 175.2 mil/year(mpy) = 4.45 mm/year(mmpy).

Chart 1 illustrates the explains of the results for metal loss with time.

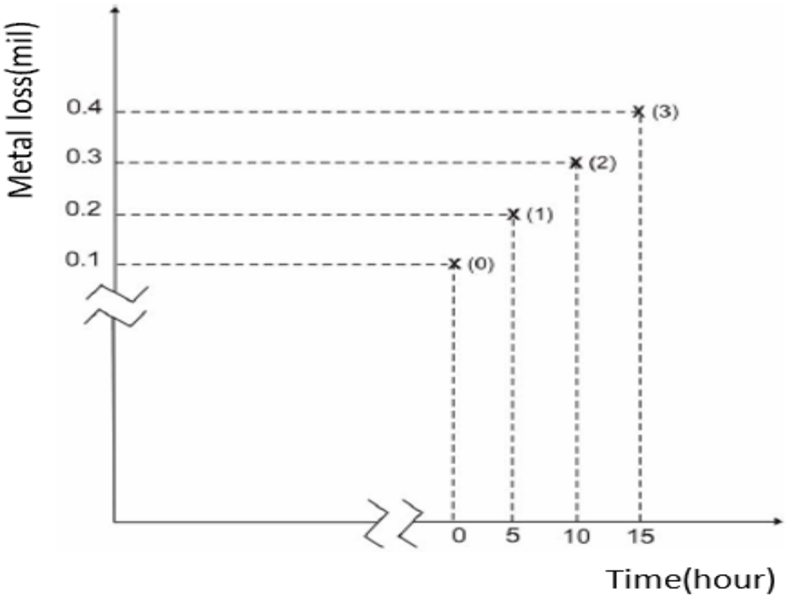


Chart 1. Metal loss

Chapter 5

Prospect

5.1. VGIS Future

In Dec 2021, the Minister of Oil of Iraq inaugurated Field Control Center and set a high value on the new technologies utilized by VGIS.

5.1.1. Introduction of background for future

To further improve the operational efficiency and reduce cost, the implementation of VGIS Phase 2 is to expand and upgrade the platform to cover more key business areas of field management. Visualized Reservoir Management System, 3D Warehouse management, and Visualized Project Management System will be the major Scope of Work. After the project is completed, it can better support the full field development, commissioning of the new warehouse, and more upcoming construction activities.

Project Objectives

Oil Field plans to implement the VGIS Phase 2 to expand and upgrade the platform, to make another new step into the digital Oilfield. The main purpose of the VGIS Phase 2 project is to build three new systems based on the current VGIS Platform, covering the requirement of visualized management in the reservoir, warehouse, and projects areas, respectively.

1- Visualized Subsurface Asset Management System:

Oilfield Reservoir Engineering Introduction: The Oil Field in Iraq. The 50 km long and 15 km wide field was discovered in 1976. The field comprises a banana-shaped, sinuous crested anticline with an overall N-S elongation.

The field consists of 5 major and 8 minor stacked reservoirs of Lower Cretaceous to Palaeocene age that span a vertical interval of ~3000 m. About 80% of field's hydrocarbon accumulation occurs in five major reservoirs (in depth order): Hartha, Mishrif-Ahmadi, Nahr-Umr, Zubair and deepest discovered high-pressure carbonate Yamama formation. The Lower Fars, Ghar, Shiranish, Sa'di, Tanuma, Khasib A and Shu'aiba are referred to as minor reservoirs in field.

Visualized Reservoir Management is to construct the virtual model of field subsurface asset, realizing reservoir and wellbore visualization and surveillance on the VGIS Platform. This system is to support integrated production system management and optimization, field development plan design, and local workforce training for PE, as *Figure* 86 shows.

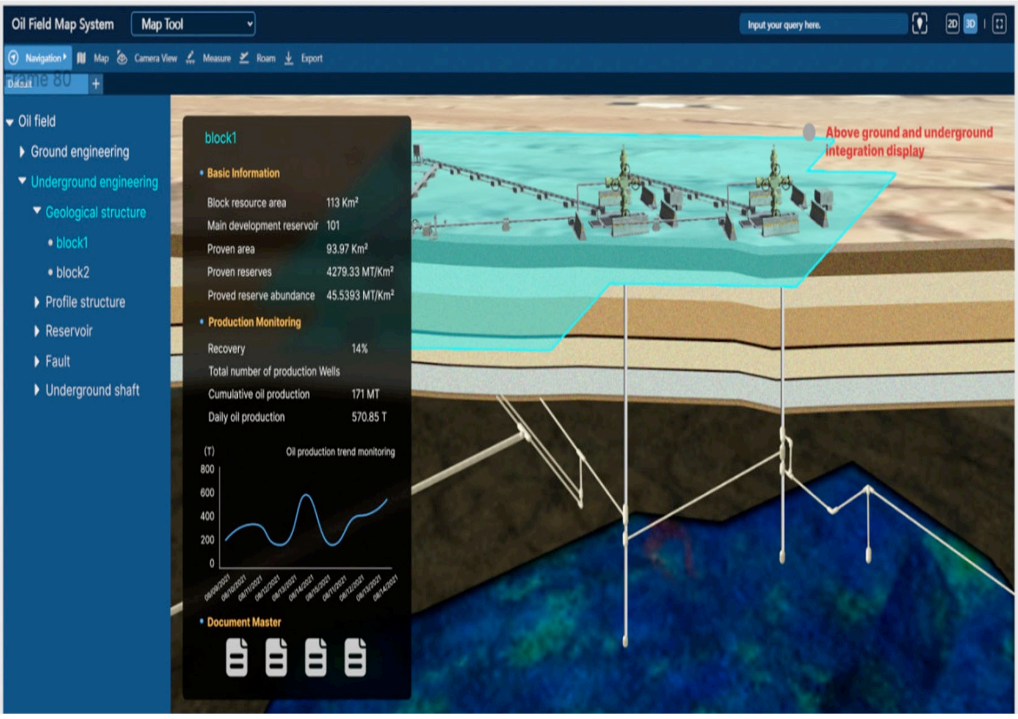


Figure 86. Integrated Above and Below Ground Property Display

The KPI dashboard is crucial for Majnoon, as *Figure* 87 shows, couple of charts indicates the most important production and operation performance, such as oil production rate and gas production rate in reservoir basis and yearly statistics, daily production monitoring on oil, gas, oil saturation, porosity, permeability. Overview is a top view of Majnoon key elements after an intelligent filtering.

Figure 87. KPI Reservoir Monitoring Dashboard

2- 3D Warehouse Management System:

Is to construct the digital twin of the new warehouse, realizing centralized warehouse data management and real-time condition monitoring of key warehouse elements to improve warehouse operations efficiency and support strategy optimization of material management. The system is to support centralized warehouse data management with VGIS by the integration with key IT systems in the new warehouse, including WMS, CCTV, Access Control, Fire Alarm System, etc., and to realize3D browsing of the new warehouse, and real-time condition monitoring of stocks, equipment, workflow status, and security situation with 3D Model, achieving different management levels as per warehouse, storage rack, goods slot, and inventory. As *Figure* 88 shows.

Figure 88. KPI Warehouse Management Dashboard

Free roaming tourist mode is to help people who are not familiar with the warehouse quickly understand the layout of the warehouse and the function and basic information of each warehouse. Provides oilfield fundamentals to help new employees and partners get started faster, as *Figure* 89 shows.

Figure 89. Free Roaming Tourist Mode

Working Mode provides comprehensive and real-time storage data display to improve work efficiency and accuracy. Provide key metrics and reports to help management evaluate and optimize performance, as *Figure* 90 shows.

Figure 90. Working Mode

According to the material inventory data in the WMS system, restore the goods placement in the warehouse in the digital twin scenario, and help the management personnel realize the inventory and spatial positioning of the goods remotely, as *Figure 91* shows.

Figure 91. Implementation in Inventory-a

Through docking and integrating data lake, the warehouse can query all kinds of data and display reports, equipment alarm, CCTV viewing, etc., as *Figure* 92 shows.

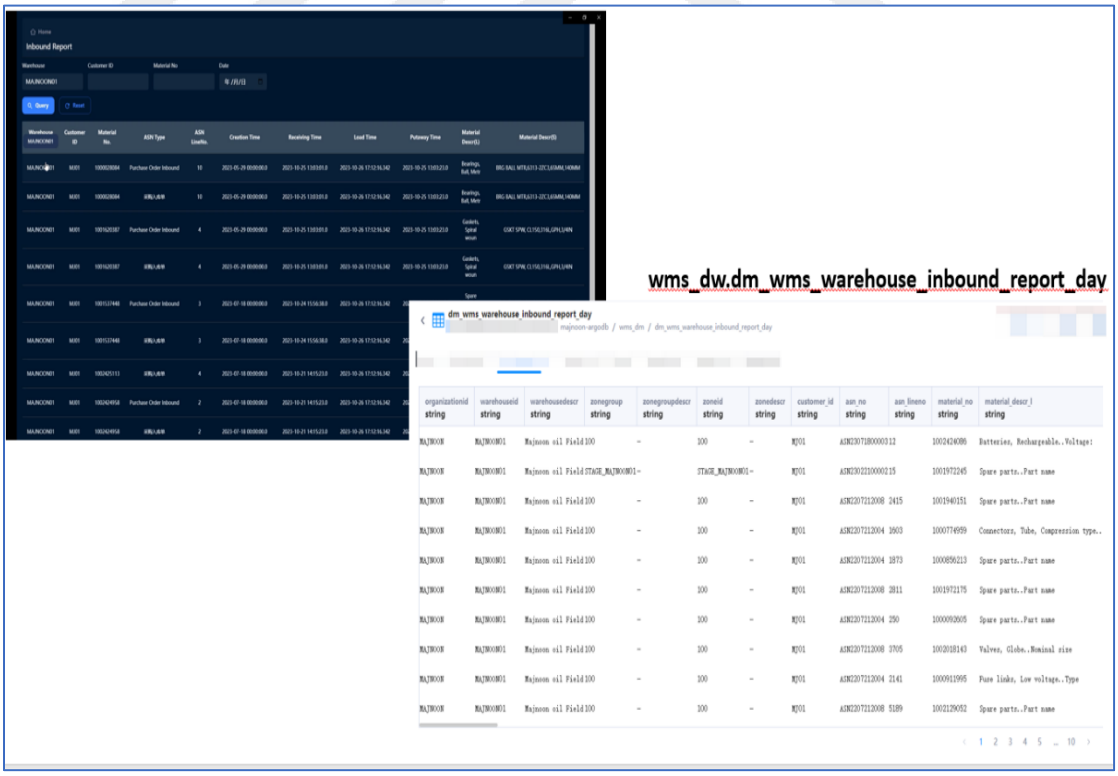


Figure 92. Implementation in Inventory-b

3- Visualized Project Management System:

Visualized Project Management System. Based on project data and project 3D Model, the system is to support project status monitoring, and project management activities from the owner's side with VGIS, covering the scope of progress, engineering, procurement, construction and QHSE management.

This system is to support EPC projects management based on Building Information Modelling (BIM) technology, including BIM based project status monitoring, to implement project construction progress simulation to demonstrate the planned and actual project progress on the project BIM model, together with their difference and identified risk of project delay, to enhance project management efficiency and better control project progress, as *Figure* 93 shows.

Figure 93. KPI Project Management Dashboard

4- Creating a Geo-Referenced Terrain:

Traditionally, the process of creating such environments is time consuming and costly. This process normally consists of gathering the source data, pre-processing these data, setting up the terrain generator, and then the terrain build itself. There are additional steps such as testing and rebuilding, if necessary, as *Figure* 94 shows.

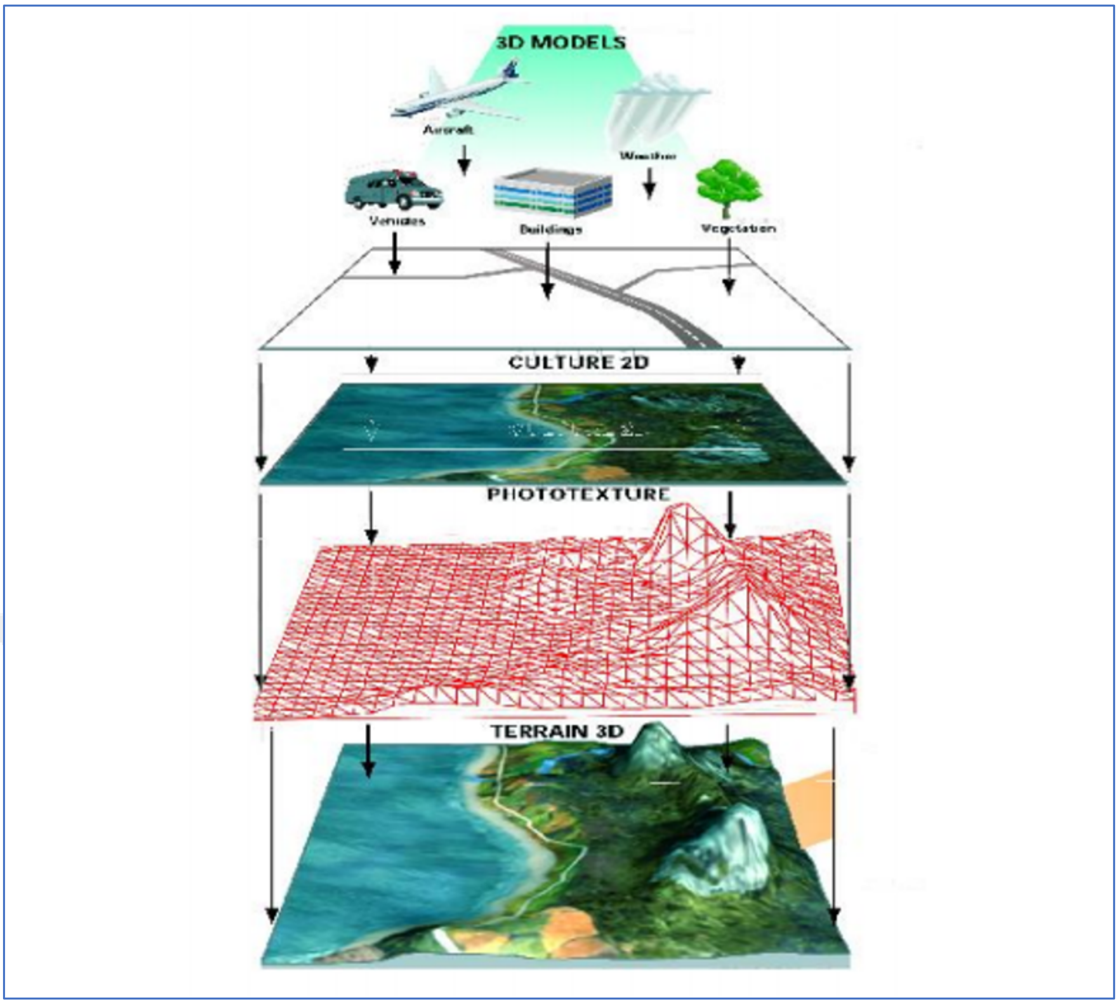


Figure 94. Typical data used for creating a terrain in 3D

Gathering source data involves mainly imagery data, elevation data, and vector data. While there are numerous image and elevation data vendors, vector data is often harder to find. At present, vector data providers often rely on manual work to generate and curate the data from imagery data. Often, such vector data relies on crowd source (OpenStreetMap) for more up-to-date data. When new imagery data are acquired, such vector data will have to be updated as well to have good correlation.

Pre-processing of data, setting up the terrain generator and building the terrain are often the job of the terrain engineer. Due to the flexibility of source data formats, terrain engineers must grapple with missing attribution, conversion of formats, correlating, data fusion, etc. All these will have to be done within the requirements of the terrain generation software. This forms a bulk of the manpower in any terrain project.

A sample flow could be shown in *Figure* 95**.**

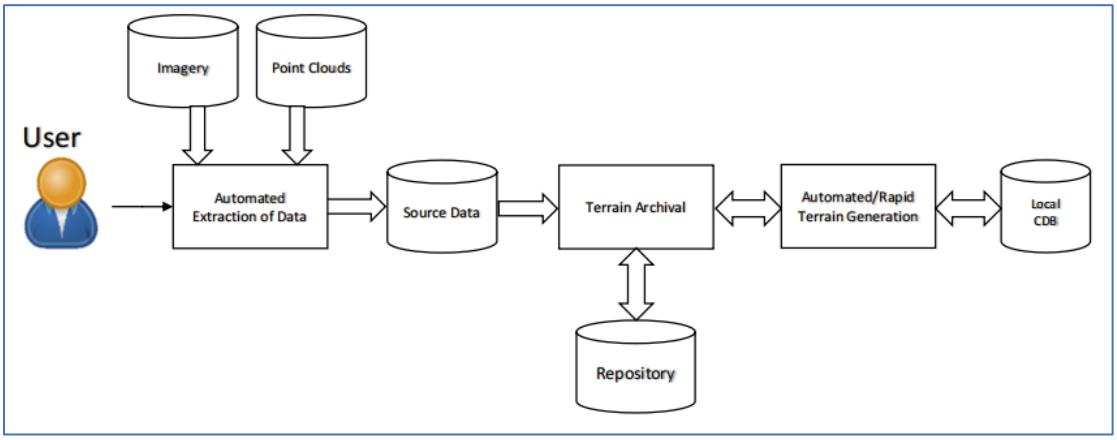


Figure 95. Sample Flow

5- *Specifying Data Sources:*

The data sources should be specified before proceeding. All geo-referenced data sources are divided into five types (layers):

Height (Elevation) (optional) - this type of data is used to generate terrain geometry.

Albedo (Imagery) - this type of data is used to generate textures for the terrain surface.

Masks (Landcover) (optional) - this type of data is used to generate natural features of the landscape (details, grass, trees, etc.).

Vector (optional) - this type of data is used to generate roads, communications, buildings, landmarks, etc.

Procedural (optional) - this type of data is used for procedural refinement.

To add a new source, click the **Add Source** button.

In the SpaceEngine editor, the Landscape tool can import a variety of different data, such as models with latitude and longitude, elevation data, satellite images, vegetation, two-dimensional data, and so on. Through these data, the three-dimensional terrain of geographic information can be formed, as *Figure* 96 shows.

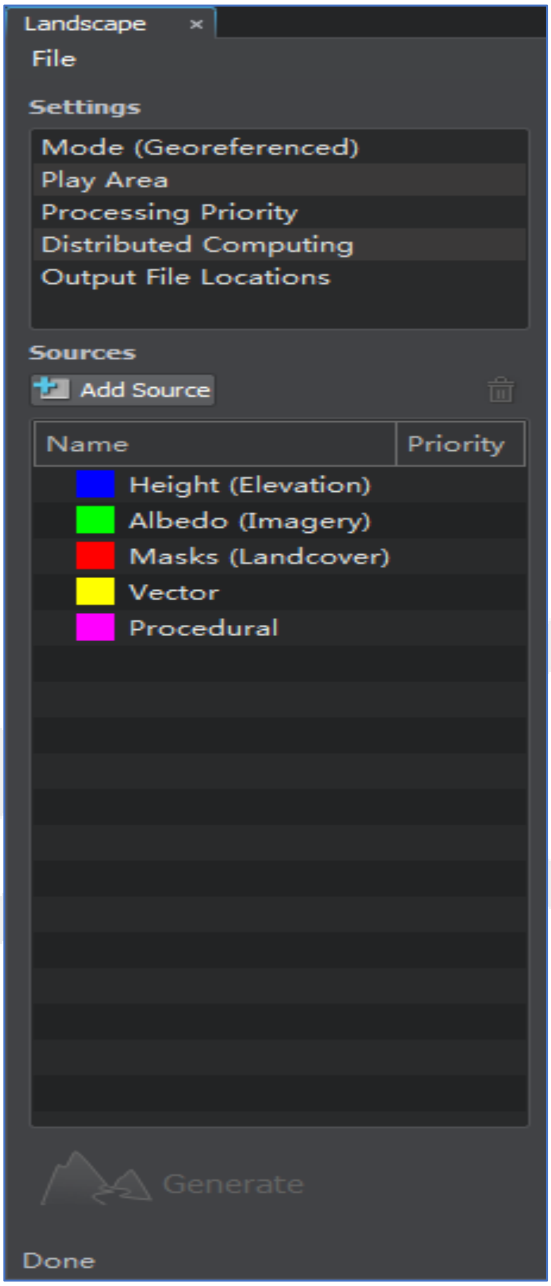


Figure 96. Add a New Source

In the opened window, specify the following fields:

Layer The imagery, elevation, landcover, vector or procedural layer of the data source.

Name The name of the layer that will be displayed in the Sources panel.

Path The path to the data source file or folder. For geo-referenced terrain generation, the sources with no geodata can be used along with the geo-referenced ones. So, there are the following options:

-To specify the geodata source, choose the geo-referenced type in the drop-down list and specify the path.

-To specify the ordinary image(s) with no geodata, choose the source tile set type and specify the path.

When add the imagery, elevation, landcover, vector or procedural data sources to the Landscape tool, their areas will be highlighted on the *Preview* panel with corresponding colors: blue for elevation, green for imagery, red for landcover, yellow for vector and magenta for procedural. Area size of procedural sources is adjustable.

To delete the selected data source, as *Figure* 97 shows.

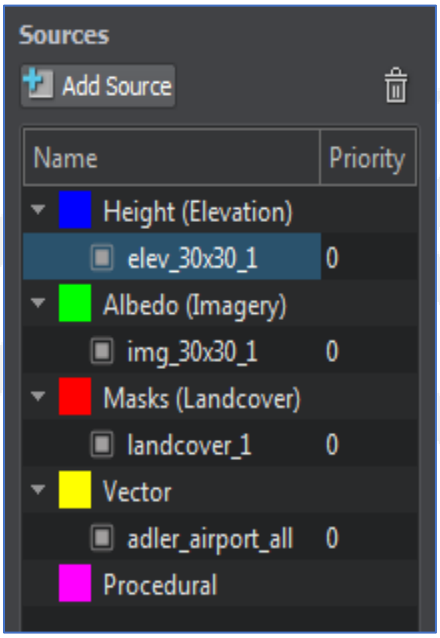


Figure 97. Delete the Selected Data Source

6- Specifying Data Source Parameters:

When select a data source, can see its parameters in the *Parameters* panel. Depending on the type of the data source, the contents of this panel differs, as *Figure 98* shows.

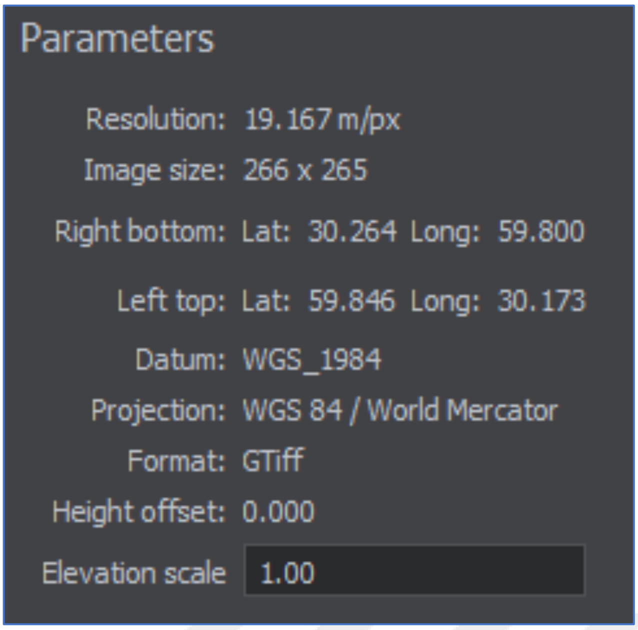


Figure 98. Elevation Parameters

For the geo-referenced data source, can specify the following parameter:

Elevation scale:

The scale factor used for elevation data.

Imagery Parameters:

As *Figure* 99 shown, for the geo-referenced data source, can specify the following parameter:

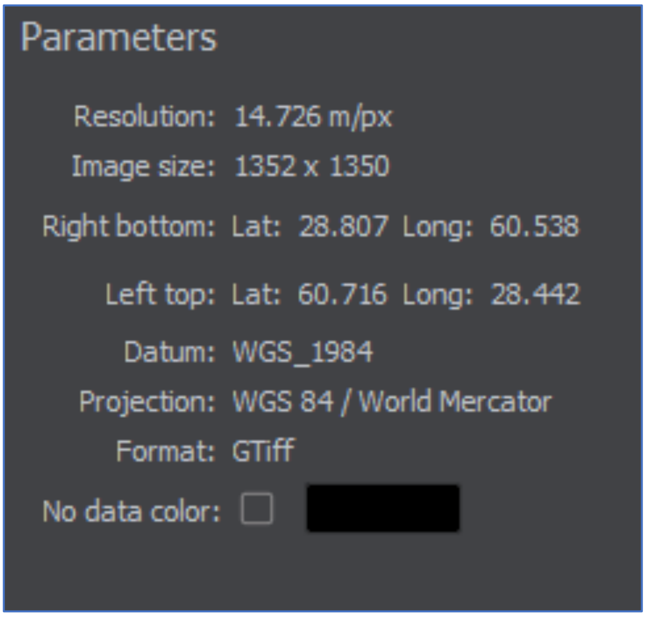


Figure 99. Imagery Parameters

No data color: the color to be used for areas with no data available.

Landcover Parameters:

This type of data source is optional and should be added when generation of terrain details or vegetation is needed. It allows specifying both the geo-referenced and non-georeferenced sources.

Vector Parameters:

This type of data source is optional and should be added when generation of roads, communications, buildings, landmarks, etc. is needed. It allows specifying only the geo-referenced sources.

Chapter 6

Discussion and Conclusion

6.1. Contributions

This research explores the extensive range of studies that can be encompassed by advanced technology, such as GIS, AR, DCS, and CCTV, wherein finding similar projects has proven challenging due to the novelty of this technology, despite extensive online searches and consultation of journals, no identical technology has been found. However, there are some partial similarities, such as the use of drones and sensors for data collection in the monitoring of Shanghai port but this project does not incorporate 3D maps and rely solely on GPS. In this study, the objective is to address and resolve the issue of high costs associated with using cloud services by utilising a local Data Center (a large group of networked computer servers typically used by organizations for the remote storage, processing, or distribution of large amounts of data). This approach involves directly uploading 3D maps to ensure faster service on the intranet, eliminating the need to pay for cloud services.

As depicted in the *Figures 7, 12, 31, 33 and 35*, both GIS and 3D, as well as DCS, offer similar solutions. However, there is currently no platform that effectively integrates these technologies. vGIS aims to bridge this gap by providing a platform for researching and implementing monitoring and controlling processes in a more convenient and remote manner.

The vGIS platform has emerged as a crucial instrument in the realm of disaster response and crisis management. This technology enables responders to rapidly evaluate, analyse, and respond to crucial information in real-time. This research examined the application of vGIS technology in disaster response and analyse the potential advantages and obstacles associated with its utilisation.

6.2. Disaster Management and Environment Protection

The fundamental component of vGIS is a platform that acquires, retains, verifies, and exhibits data pertaining to geographical coordinates on the Earth's surface. Within the framework of disaster response, this information encompasses the tangible characteristics of the impacted region, whereabouts of susceptible populations, and magnitude of the event's repercussions. This data is vital for decision-makers who want efficient resource allocation and strategic decision-making in times of crisis.

This study focuses on conducting inspections of the process area and facilities within an oilfield in order to detect potential alarms before a disaster occurs and prevent environmental damage caused by Gases.

By addressing these issues proactively, the study aims to mitigate potential problems.

6.3. Conclusion

The implementation of the VGIS platform in the oilfield offers numerous advantages, including enhanced profitability, improved operational efficiency, optimised equipment performance, increased personnel productivity, and enhanced collaboration and capacity. The VGIS system, which serves as the central component of the Oilfield Digital Transforming project, addresses the issue of data fragmentation and incompatible systems. This allows the efficient aggregation and use of large amount of Big Data generated throughout the operation and production process. In addition, digital transformation enables the efficient administration of the production process and Key Performance Indicators (KPI), thereby elevating oilfield management to a global scale.

Presenting the existing and planned infrastructure as three-dimensional entities in Accurate Augmented Reality (AR) enhances comprehension of the environment, boosts efficiency, minimises mistakes, ensures a safer work setting, and improves overall understanding of the surroundings.

vGIS seamlessly connects with Geographic Information Systems (GIS), Distributed Control Systems (DCS), and Closed-Circuit Television (CCTV) systems, allowing for efficient data exchange and collaboration. In order to generate AR representations of the surrounding infrastructure, this technology collects and combines geospatial data from many sources and process minimises or eliminates the need for manual labour in preparing the digital-twin data. vGIS has the capability to perform this task automatically.

Upon reviewing all previous research, no similar design was founded. However, various studies have focused on specific aspects such as GIS, 3D modelling, DCS, and CCTV. In contrast, the vGIS integrates all these platforms using advanced technology.

This study considers the project presented as the first of its kind globally, making it challenging to find a comparable solution. Although a project in China's Shanghai port utilises similar technology, it does not encompass all the technologies examined in this thesis. Furthermore, the vGIS technology offers high maintenance, monitoring capabilities, and reduces both time and errors, leading to potential future advancements. Consequently, this study represents the most comprehensive and pioneering research on vGIS technology.

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APPENDICES