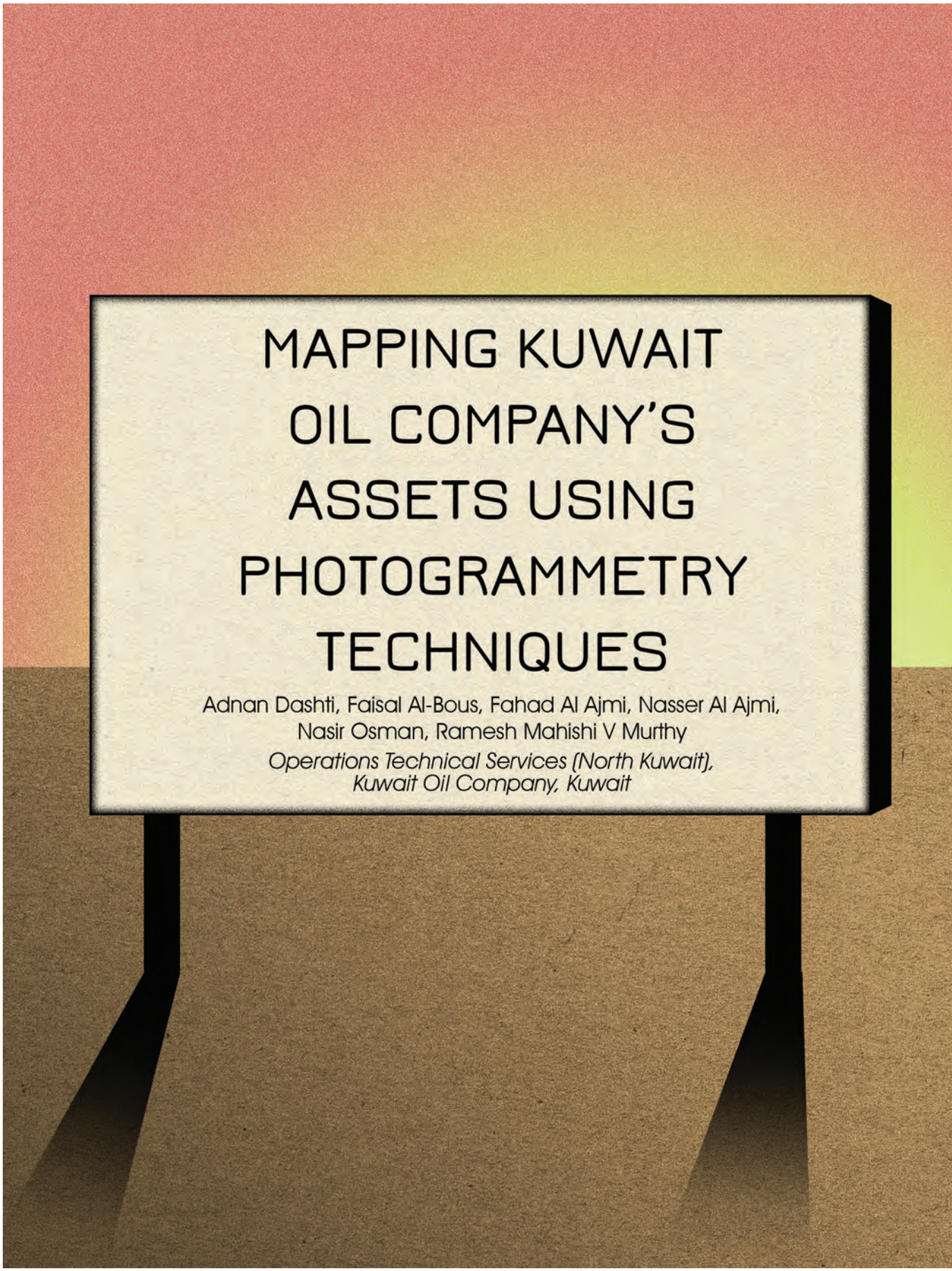

MAPPING KUWAIT OIL COMPANY'S ASSETS USING PHOTOGRAMMETRY TECHNIQUES

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Introduction

The Infrastructure Master Plan (IMP) of the Operations Support Group, Kuwait Oil Company (KOC) is responsible for developing a Master Plan to manage the oil field's surface footprint. IMP produces and maintains the data used for planning, operations and Health, Safety & Environment (HSE) activities. IMP primarily uses the data from land survey to create a basemap. However, areas that are hazardous and inaccessible to surveyors create data voids. IMP supplements the missing details with data compiled using photogrammetry techniques. IMP utilizes DATEM Summit Evolution with ArcGIS and ArcGIS Pro for stereo visualization and photogrammetry data compilation.

Mapping Approach

Aerial data acquisition for photogrammetry data compilation was performed using Leica RCD 30 Digital Imagery Sensor mounted on a Rockwell International 690A aircraft. The details of Aerial acquisition of the project were published in Photogrammetric Engineering & Remote Sensing, Vol. 87, No. 5, May 2021, pp. 313-317, DOI: 10.14358/PERS.87.5.313.

Mapping KOC assets involves coincident activities such as land survey and photogrammetry data compilation which were carefully planned so there were not duplication of effort or areas creating data voids. KOC fully understands that the utilities within inaccessible areas cannot be mapped by land surveyors. For instance, the extents of oil lakes which were created due to oil spills from the invasion of Iraq, the vital KOC assets within oil lake boundaries, etc., the access to which could pose life threatening risks to land surveyors.

Challenges during Photogrammetry Data Compilation

The industry experts would agree that photogrammetry data compilation, though sounds easy, is quite a tedious task influenced by various external factors. The experience of IMP was no exception. Some of the challenges faced during the project life cycle and mitigation steps were:

1. Manpower mobilization- Kuwait has a small Photogrammetry industry in comparison to other third-world countries where there are many more photogrammetry production suppliers. Identifying experienced photogrammetry data compilers within the State of Kuwait posed to be a major challenge. The project could not be outsourced due to data sensitivity. In order to complete the task, manpower with experience in similar projects from the Middle East region were selected. With the onset of the COVID 19 pandemic, the selected manpower could not be mobilized on time due to the closure of international borders. In order to mitigate the risk of delay, locally available manpower was trained and used for data compilation. When International borders were open for foreigners to enter Kuwait, specialized manpower was mobilized
2. Changing the order of Survey- The project was conceptualized with photogrammetry data compilation as the first step, followed by land survey to update the attribute information. Since the photogrammetry data compilation schedule was pushed ahead, due to non-availability of manpower and other resources, the priority of areas of land survey had to be changed.
3. Updating Attribute information- Photogrammetrically compiled data does not have all the attribute information which are otherwise collected by field surveyors. Updating missing and/or incorrect attribute information to the compiled data was a challenge as some of the infrastructure had changed or were removed over time.
4. Connecting Above ground and Underground features- KOC's infrastructure such as pipelines, instrumentation cables, electric lines, etc., are both above and underground. Data compilation is possible for features visible and identifiable on stereo aerial images. However, underground assets can only be collected by field survey techniques. Working with data continuity from two sources is often a challenge. In order to overcome this, surveyors are provided with maps of areas where photogrammetry data compilation was completed. Changes to the above ground assets and connectivity of underground assets were updated.
5. Data currency- Aerial Images used for data compilation dates back to 2019, meaning the changes to the infrastructure post aerial acquisition date are not reflected in the images, making it difficult for surveyors to use the data in all areas. In order to overcome this, priority was given to areas within close vicinity of facilities such as Gathering Centers (GC) and Booster Stations (BS) where there would be little change to the infrastructure. Additionally, since the general topography within the oil fields have not changed much over the past three-years,

Photogrammetric Engineering & Remote Sensing
Vol. 89, No. 4, April 2023, pp. 197–201.
0099-1112/21/197–201

doi: 10.14358/PERS.89.4.197

the data was also used to generate a Digital Terrain Model (DTM).

Software

The selection of Software was another important step in the project's life cycle. KOC uses ESRI ArcGIS to create, edit, and store data. The ease of data integration within the enterprise GIS system could not be overlooked. Therefore, DATEM for ArcGIS and ArcGIS Pro software were selected for 3D visualization and data compilation. The selected software allows the user to edit, add, delete, and modify the features in the database concurrently. In addition, the data from feature compilation could be directly integrated to the enterprise GIS system.

Photogrammetry Data Compilation

The primary goal of the project was to update the digital database that users' access to manage the assets, analysis for modeling purposes, as well as produce hard-copy maps. In addition to KOC assets, to depict the terrain as per the required accuracy standards, breaklines are also being captured. Breaklines are compiled to support 1-meter contour interval. The data compilation is being carried out using digital photogrammetric vector data acquisition methods, skilled photogrammetry compilers, following strict quality control (QC) procedures. Data processing techniques, the algorithms used in the topographical structuring of the data, the processing sequence and the procedures employed in the production of the final dataset are in strict accordance with KOC specification.

The process involved in data compilation is shown in Figure 2:

- Input data consists of aerial images, exterior orientation (EO) parameters, camera details, etc. The number of images are checked against the corresponding EO file to ensure completeness.
- Project setup is completed in DATEM Summit Evolution and in ArcGIS Pro. The project setup in DATEM Summit Evolution is carried out by creating the camera file referring to ADS 30. A control file is created by importing the EO parameters obtained after the completion of the aerial triangulation process. The project is set to UTM Zone 38 N projection of WGS 84. In ArcGIS Pro, a new geodatabase is created followed by a mosaic dataset. Camera details are entered and the EO parameters from summit evolution are imported. Stereo models are built for data compilation.
- QC of the project setup involves verifying that the correct camera file is being used, checking if all the images are imported to the project, checking the stereo model footprint, checking the project parameters, etc.
- Data compilation is carried out adhering to KOC's specification and using the Enterprise Geodatabase. Tools within DATEM Summit Evolution such as contour generation and seamless update during data compilation come in handy during the production of the DTM. Only supplementary breaklines to support contours of 1-meter interval were compiled..

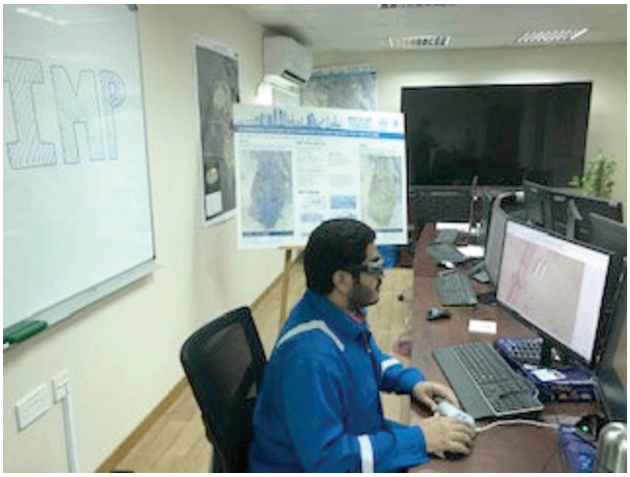


Figure 1. Photogrammetry Data Compilation.

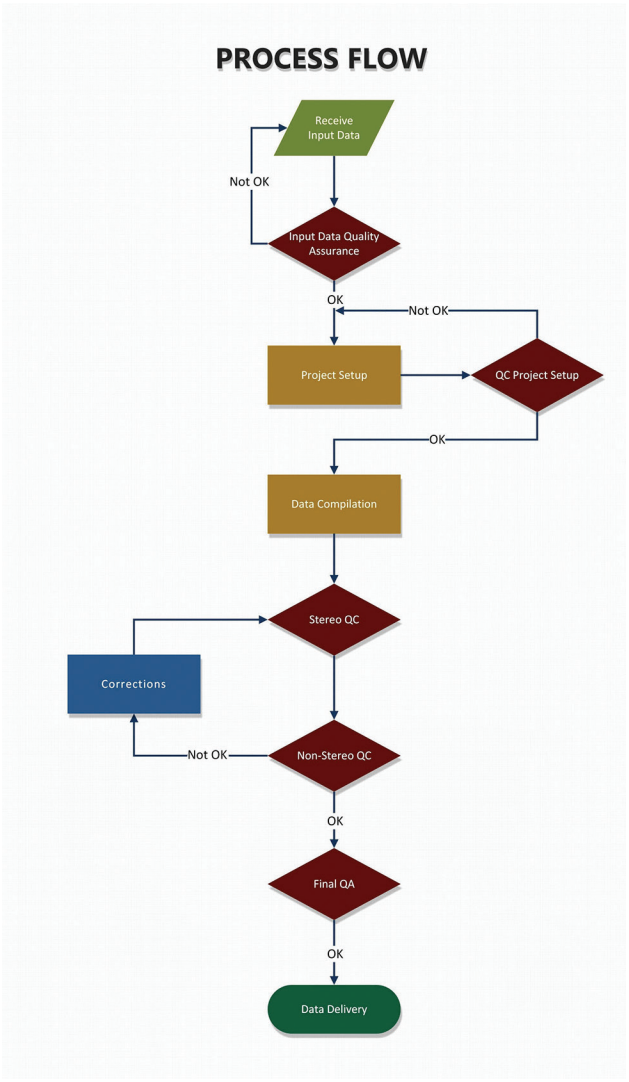


Figure 2. Process flow.

Stereo QC

- Stereo QC is performed on all compiled models for interpretation, omissions, and any other compilation errors.
- Checking the compiled data for positional and elevation accuracies.
- Checking the data for the correct usage of data structure/feature classes.
- Checking the edge match of the compiled model with adjacent models.
- Generating contours at 1-meter interval and checking for DTM quality.

Non-Stereo QC

- Verify model limits, buffer limits, and area limits to check completeness.
- Check for data connectivity and continuity between adjacent stereo models.
- Perform automated topological checks for overlaps, gaps, duplicates, etc., and perform corrections where required.
- Ensure uniform height in closed water polygons.

Metadata Creation

The Federal Geographic Data Committee's (FGDC) Content Standard for Digital Spatial Metadata (CSDGM) is a well-known metadata standard that is being used around the world. With ArcGIS 10, the metadata editor is capable of creating and publishing FGDC CSDGM metadata. Information such as Data Quality Information, Spatial Reference Information, Entity and Attribute Information, Distribution Information, Time Period Information, Contact Information, etc., are embedded into the metadata file.

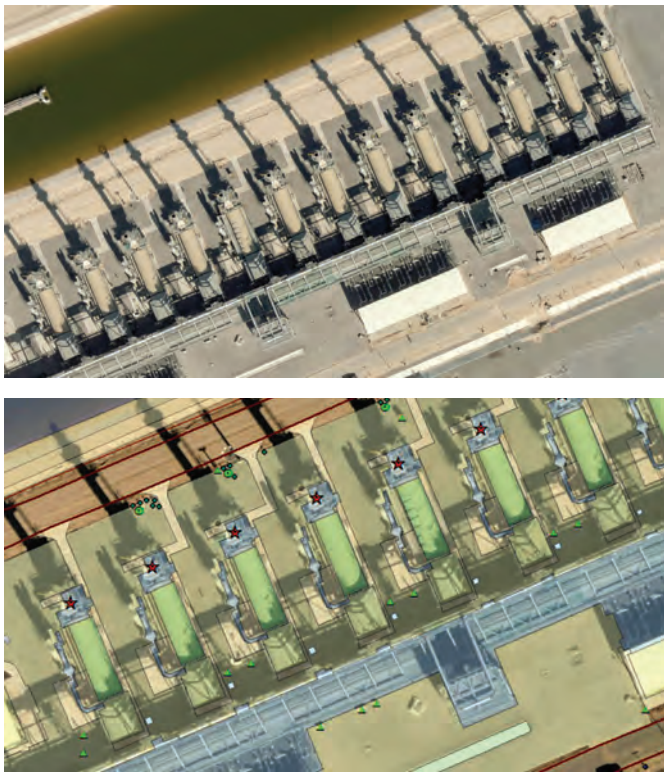


Figure 3. Hazardous area.

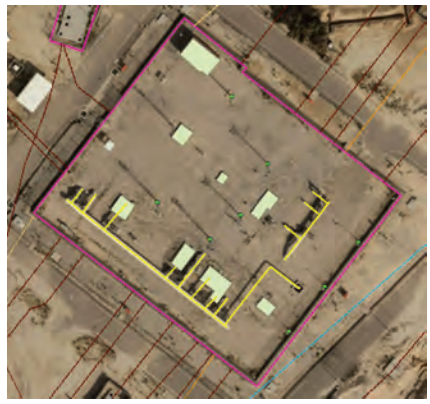
Advantages of Photogrammetric Data Compilation Over Land Survey

1. Data compilation in hazardous areas- The upstream process of oil and gas production in KOC involves several steps starting from exploration, extraction to production of crude oil and natural gas. One of the activities during production of crude oil is to burn gases that usually accompany oil. This process is called flaring. The area around smokestacks or flares have high level of toxic gases making it hazardous for the surveyors to be exposed to. However, this vital infrastructure must be mapped and the information included in the database. Mapping data through photogrammetry techniques allows this in a safer and faster way without having to physically visit areas with high levels of toxins. An illustration of one such area is shown in Figure 3.
2. Data compilation within inaccessible areas- The vital installations of KOC are often secured by a fence and require special permission for access. Also, these areas are not always accessible due to security reasons. Mapping assets within such installations through land survey techniques poses a challenge. In order to obtain information in these areas, photogrammetry techniques are used (See Figure 4).
3. Data collection in a faster way- Features such as pipelines over large areas would require surveyors to spend more time in the field collecting the data. Whereas, the same data, when collected photogrammetrically, saves a significant amount of time. To quantify the efforts, photogrammetry compilation takes about 30% of the time in comparison to field survey. The surveyors could use the vector data and update the attribute information thus saving several man-hours.
4. Creation of DTM- Compiling data photogrammetrically enhanced the creation of an accurate digital terrain model by delineating hard and soft breaklines; such as ridge lines, hilly areas, wadis, drains, hydrographic features, etc. The DTM thus created, is used to create contours on the fly and terrain information is updated in areas where the DTM does not accurately represent the ground.

Conclusion

Photogrammetry data compilation has helped KOC in optimizing their use of human resources to a great extent. In addition to mapping the KOC field assets faster, it also helps in keeping the working environment safe for the surveyors. This is done by mapping KOC assets photogrammetrically in hazardous and inaccessible areas, which would otherwise be not possible for the surveyors. It can be argued that the data compiled photogrammetrically would be less accurate in comparison with the field survey data. However, the purpose of this exercise was to fill in the missing information within hazardous and inaccessible areas which would be adequate for infrastructure planning purposes. The collected data was updated in the central enterprise geodatabase.

Data collected by field survey



Additional data collected photogrammetrically

Dry Oil Lake

Figure 4. Inaccessible areas.

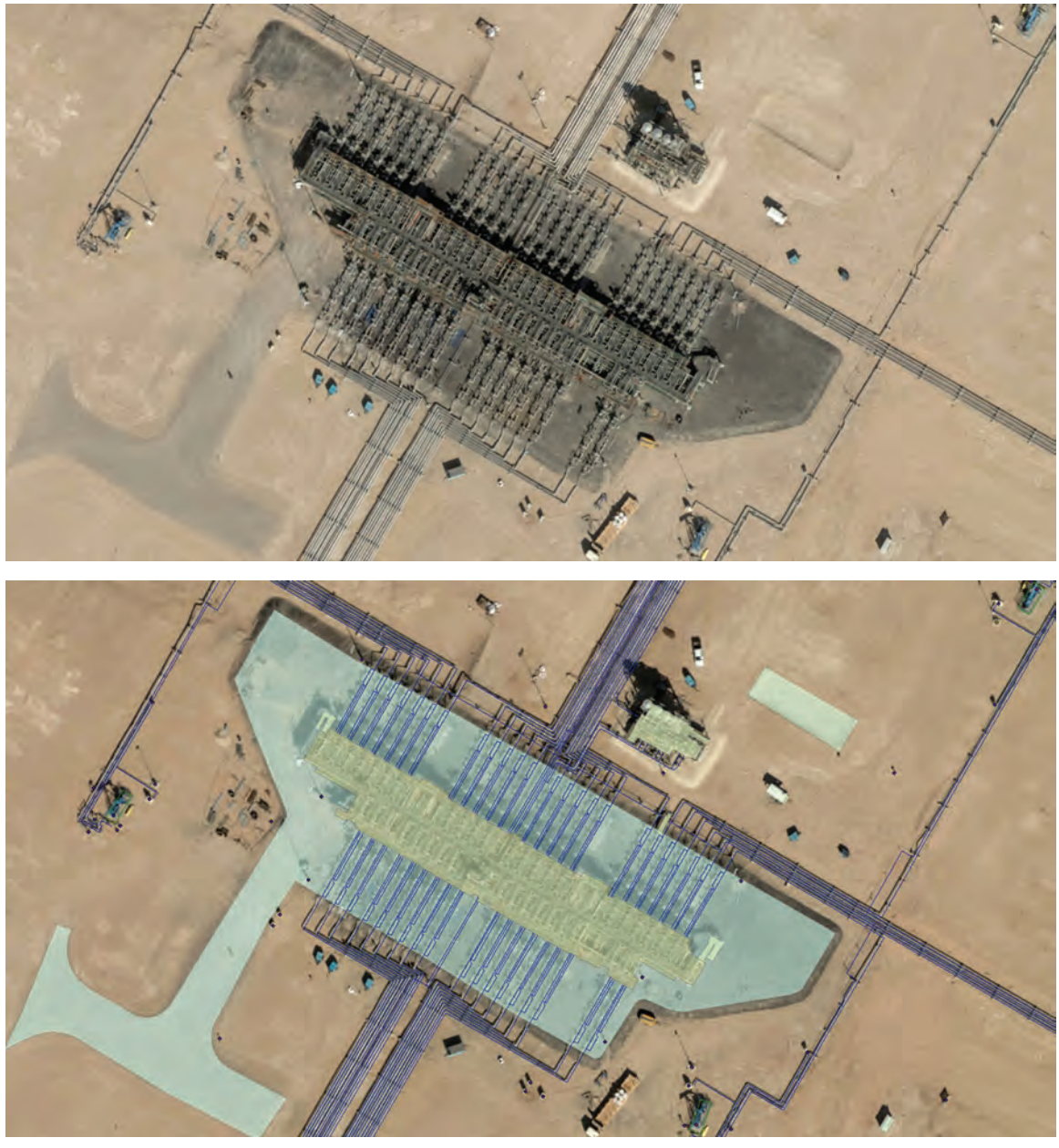


Figure 5. An example of pipelines over large areas.