The Revolution Of Advanced Technologies As a Platform For Mapping, GIS And Autonomous Vehicles

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SUMMARY

Kav Medida is a land survey firm, ISO 9001 certified, and a national service provider of superb mapping products in the fields of land survey, geodesy, photogrammetry, indoor mapping, mobile mapping, construction layouts, topographical boundaries, subdivision design, geodetic control surveys, BIM modeling, GIS, laser scanning and computer vision 3D reconstruction. We are registered and authorized vendors of the above-mentioned services to all major construction and infrastructure institutions in Israel.
Kav Medida's expertise is providing mapping solutions for massive scale complex infrastructure projects such as Tel Aviv's Metro, Jerusalem's Old City cable railway, 4,000 kilometers of traffic indication mapping for Netivei Israel – Israel's major national transport infrastructure company.
In Israel, Kav Medida is known as a hub of knowledge in the geodesy field. Each year, dozens of Technion interns compete for internship spots with us.
Kav Medida is constantly researching and adapting new technologies tailored to our clients' needs, which substantially increase efficiency of labor-intensive projects. Our proven success contributes to Kav Medida's continued growth.

Being fast, accurate and reliable – in the world of "everybody needs it for yesterday" - efficiency and flexibility are crucial. Moreover, the challenges of COVID led to the need for accelerated and immediate remote survey solutions – both remote sensing and remote office work, globally.

In this article we will share some of our major innovative solutions, increasing productivity immensely while keeping operational costs to a minimum.

1. Advanced Mobile Technology Utilization Complex High Output Scenarios

1.1 Road Indication Mapping – GIS Road Mapping

Israel is constantly developing its transportation infrastructure. 90% of the roads in Israel are planned, built and maintained by Netivei Israel – Israel's major national transport infrastructure company.

In the past year, Netivei Israel came out with a tender for a massive project: to map all of their roads using advanced GIS methodology. This methodology was chosen in order to interface with an existing GIS system and is a game changer for the way roads are being maintained and monitored vis-a-vis infrastructure.

1.1.1 Project's Scope –

Delivering batches of 200km of mapped roads per month under strict automatic quality assurance supervision.
The required deliverables for each batch –

1. A 37-layer geographic database (ESRI GDB).
   Examples of such layers: guard railing, bus stops, paint stripes etc.
2. A set of PDF maps divided into numerous indexes according to a pre-defined cartographic logic, with and without an orthophoto background.
3. 3 levels of accuracy scales, depending on the section being mapped – intersection (1:250), interchange (1:500), and a freeway (1:1250).
4. 360 degree panoramic images to be delivered as a link to a web application.

1.1.2 The challenge

For us, land surveyors, there are many challenges in this project –
Working in GIS (not in the familiar DWG/DGN CAD environment), high production output, dealing with mapping in blind spots, and working in GPS-denied areas while keeping accuracy within the project demands.

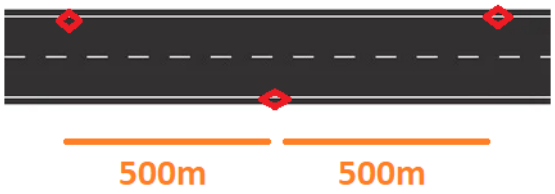
1.1.3 Our methodology

Our unique methodology was developed in order to yield long term and reliable consistent results. It consists of 3 parts: **Data collection**, **digitization & classification** and **data distribution**.

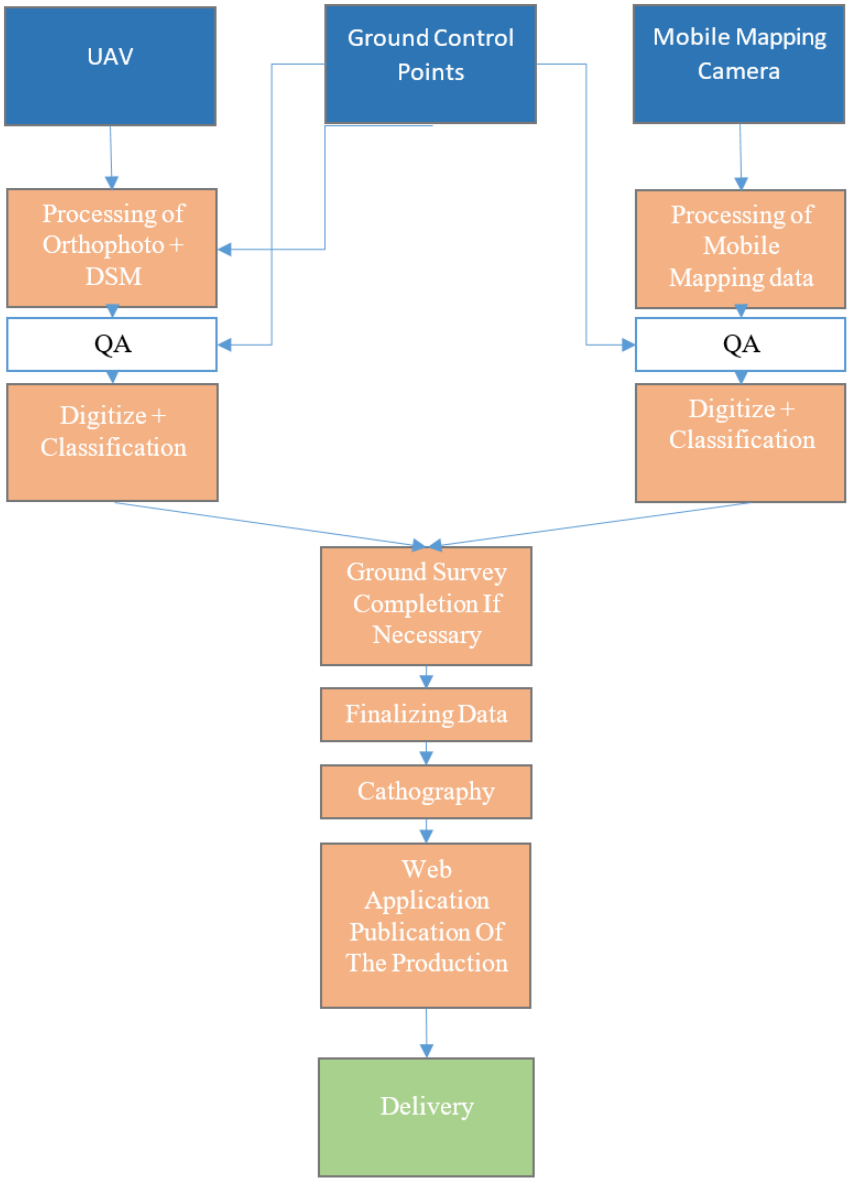
1.1.3.1 Data collection

The data collection phase uses 2 main mapping devices – UAV (drones) and Mobile Mapping 360 photogrammetric camera. The two devices share 80% overlapping area which ensure redundancy.
By using these two devices simultaneously, we can ensure 95% of items to be mapped can be done without field work.

Achieving consistent geographic positioning from both devices is done by using the same GCPs for geo-referencing and benchmarks – 1 GCP every 500m.



The following diagram describes our main workflow:



As this project is extremely large, we needed to use equipment which would minimize our post-production labor. Thus, we decided to use the reliable DJI Phantom 4 RTK, for a more comfortable photogrammetric process.

UAV flight routes are planned as NADIR (vertical) layout, with a front and side overlap of 80% between photos.
Israel's entire SRTM topographic elevation database was uploaded into the UAV's controller. The UAV's flight paths are configured to follow terrain, ensuring overlap and resolution remain within the nominal range.

UAV data processing consists of aero-triangulation of the image block, then creating true orthophoto in a resolution of 1.5cm/pixel. The decision to create true and not standard orthophoto was taken due to digitization requirements – tall objects like bus stations and walls can then be digitized with absolute 2D accuracy ensured.

Generating 200km of true orthophoto per month is very PC-hardware intensive and therefore needed a solution. For that, a network cluster array of high-end PCs was established and has been working 24/7 ever since the project started. The processing is mostly automated using Python scripts for all phases of orthomosiac and product exportation.
Additional sub-products are DSM, and a variety of external orientation files that can later be used for stereo mapping systems for additional detail extraction and 3D mesh productions.

The Mobile Mapping data processing is mainly a PPK solution and is paired with the Applanix IMU device which is integrated into the Trimble MX7 system we use.
The Mobile Mapping processing is automatic until accuracy issues are encountered. When this happens, we then use the Orbit Content Manager for a proper trajectory adjustment based on the GCPs on the road.

Solving the accuracy issues in mountainous areas with extreme elevation differences was a project of its own. Although we planned and used meticulous GPS redundancy array (1 RTK UAV, 1 RTK GPS measuring device, and 1 PPK mobile mapping camera), the true challenge was to have the mobile mapping camera trajectory re-align in full coordination with the UAV's data. GPS logging errors and jamming is a common issue, but when you have 3 GPS fixes off of 3 different devices (and 2 separate NTRIP networks) – the data can be cross-referenced and verified. In order to do so, we used Content Manager combined with Agisoft Metashape and developed a workflow to master virtual GCP generation and support the two systems in their weak areas.

1.1.3.2 Digitization & Classification

After all batch data is acquired and processed, the office mapping part begins. 9 GIS operators then start splitting the data into chunks while the GIS manager prioritizes assignments for the team. Each operator has a field of expertise – data arranging, digitization, classification, QA and so on. Although the whole project is thoroughly managed, there is a technology limitation which needs to be addressed – Parallel GDB work. GIS mapping has different software with limited functionality when it comes to multiple-user mapping. We found a solution by using QGIS and building a server environment to control all the work being done by the operators.

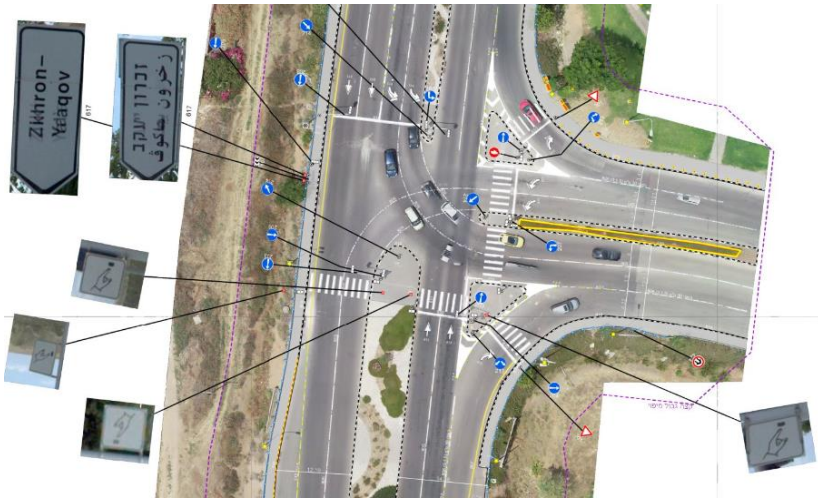
The solution consists of a server that can monitor and build the GDB on the fly, while producing many more insights automatically – e.g. which layer was mapped by each operator, what the weak link is in the QA process, which layer consumes more time per operator, GDB list errors and more. Moreover, using QGIS is more cost effective due to the fact there are no license fees and there is no limit for the project's team size. In fact, this unique server method enabled us to work from home more effectively during COVID-19 lockdowns, and even to hire specialized staff from overseas. On top of that, Orbit built a QGIS plugin so all the mobile mapping imagery is then streamed online onto the working environment.

Digitizing using mobile mapping camera combined with a high resolution orthophoto:

1.1.3.3 Data distribution

After all the work is done, the data is delivered to the client and to the external QA team. The data includes tens of terabytes of raw data from both UAV and Mobile Mapping camera, GIS database, orthophoto + DSM files and ground control points.
We set up a 180 Terabytes in-house server, upgraded our internet to high volume fiber optics and added a firewall to shield the project from cyber-attacks.
By using our published Mobile Mapping interface, all users can access any part of any road, from both mobile and aerial angle of view. Moreover, users can use the built-in photogrammetric tools to measure, test and check all the files via their internet browser.

Finally, creating the cartographic PDF maps is done 60% automatically by using ESRI ArcGIS Pro. Below is a sample of a PDF map generated on a 1:250 scale:



1.1.4 Caution - Autonomous Vehicle Ahead!

Following by this massive project, many autonomous vehicle software companies approached us in order to create fruitful commercial cooperation. Their purpose was to integrate our data on-the-fly into their autonomous car's geo-database using online push updates. "The data we tested is outstanding," said one of the company's executives. "A 2-3 cm accuracy database in the most demanding places in the country is like gold to us, autonomous vehicle developers. The information will assist us to expedite the development of our sensors and maneuvering algorithms, and ultimately will help to alert the vehicle when something is wrong," he added. Kav Medida's vision is clear – to cooperate with an AI computer-vision company in order to develop an automatic road mapping device with a 1:250 scale survey grade accuracy which could then be used for highly detailed urban planning.

2. Project Monitoring – a new role for the land surveyor in the digital era

As service providers, we are committed to the clients' complete satisfaction and are also responsible for all measureable outputs at the highest level.

When we are involved in live projects, our role is to have all the data required for mapping as promptly as possible due to the projects' rapid progress and development.
Nowadays, project management and construction supervision companies rely on people in the field and ad-hoc mapping to create reports such as earthwork volume delta, as-made vs as-built and so on. The problem is that this method is too slow. Contractors' bills need to be checked within a 3 day time frame. Using the old methods described above – by the time reports are generated, a new month starts with new billable work to check once again, which is extremely inefficient. Also, lots of area isn't covered and there is no way of monitoring large sites efficiently enough. Moreover, there is a need to provide the project's team an added value of accurate representation of the project on different dates, updating every month. That's why we established a project monitoring service which includes RTK UAV photogrammetric scanning combined with a state-of-the-art online 3D GIS based solution, enabling quick collaboration, data access, high-end visualization and advanced analysis tools. In our case, Skyline's TerraExplorer is used. TerraExplorer is a flexible CAD, GIS and BIM hybrid software, which has a built-in ability to access information both online and offline (for remote sites which most of the time have poor cellular internet connectivity).

When project monitoring starts, we establish a **strong control network** as a foundation for UAV flights to be executed as the project progresses. By using the same control points in the photogrammetric process, we can make sure our surface and volume comparisons are reliable over time.

Jacob, one of our senior project monitoring clients, describes the use of our system as "futuristic and necessary" and added, "I don't know how we could have managed without it, the amount of time and money saved is incredible."

Jacob is a project supervisor in Ashdod, Israel. The project he is in charge of is an 11,000 housing unit neighborhood which should be ready by 2025. Last month, Jacob received an invoice from an earthwork contractor which seemed odd. The first thing he did was calculate the earthwork quantities for that month's bill using TerraExplorer, immediately pressed the "publish" button to update the system with the new report layer, making the report transparent to be examined by the supervision team.

Screenshot taken from TerraExplorer Earthwork Comparison

Sitting in his office, without even stepping out to the field, within 5 minutes Jacob had insights regarding the elevation difference and the net volume of earthwork extraction. The difference between the contractor's bill compared to the automated report was more than 50%.

After a short argument with the contractor, the report was presented and the outcome was conclusive; all thanks to the fact the project is being monitored month-by-month, consistently using our system. Eventually, the contractor sent a corrected bill for the exact amount which the automated report presented.

Jacob's scenario is one of many similar scenarios. Kav Medida's UAV teams are spread country-wide in over 50 different construction sites, monitoring each site one to three times per month. Each construction site has its own unique setup tailored in our TerraExplorer Skyline Globe Server – different CAD layers, various infrastructure layouts, underground monitoring, laser point cloud integration, road planning geometry, subdivision layouts and much more. Every day we produce automated reports which then become a survey map signed off by one of our licensed land surveyors.

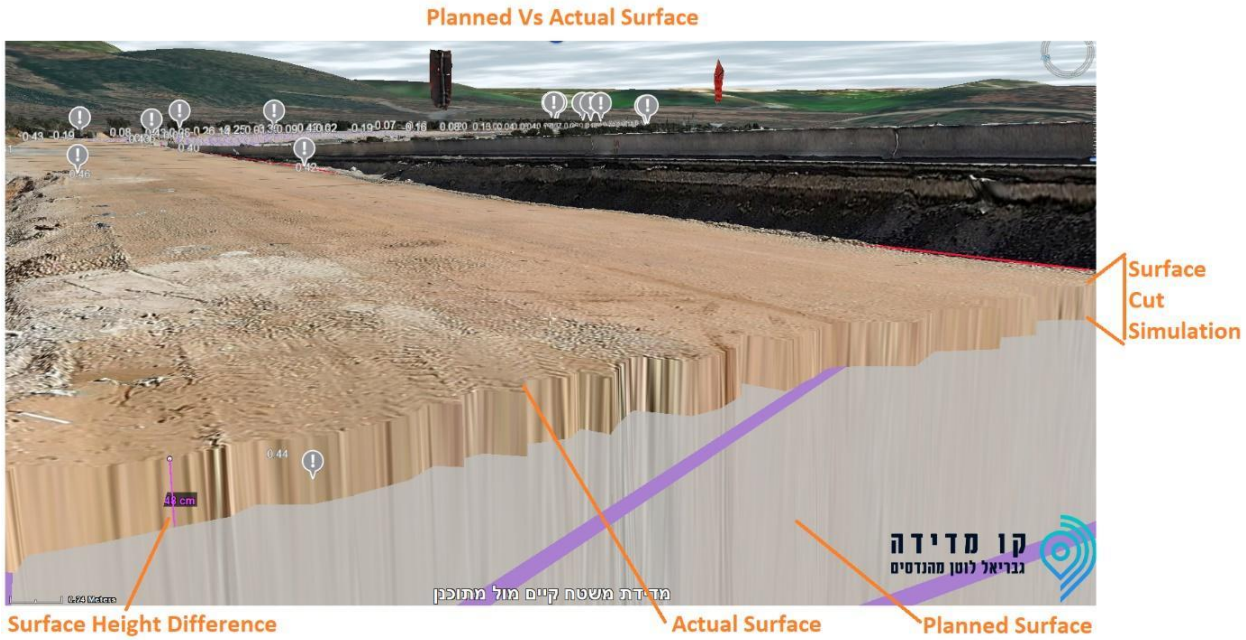
Project	Issue	Test Parameter	Using Kav Medida's Project Monitoring Method	Using standard methods
Ashkelon 2234	Earthwork quantity	Time spent creating the repot (days)	3	10
		Total budget saved in project using supervision reports (NIS)	32,500	20,000
Ashdod 3944	Sewage pipeline as-built vs as-made	Time spent creating the repot (days)	2	4
		Total budget saved in project using supervision reports (NIS)	41,000	35,000
Yehud 10398	Total gardening area quality	Time spent creating the repot (days)	5	8
		Total budget saved in project using supervision reports (NIS)	46,200	32,500
Yavne 38276	Earthwork quantity	Time spent creating the repot (days)	4	12
		Total budget saved in project using supervision reports (NIS)	155,000	90,500
Rosh Ha'ayin 39247	Asphalt markings and sidewalk paint	Time spent creating the repot (days)	2	5
		Total budget saved in project using supervision reports (NIS)	33,250	26,000
			SUMMARY	
		Total Days Spent Creating Reports	16	39
		Total Budget Saved	307,950	204,000

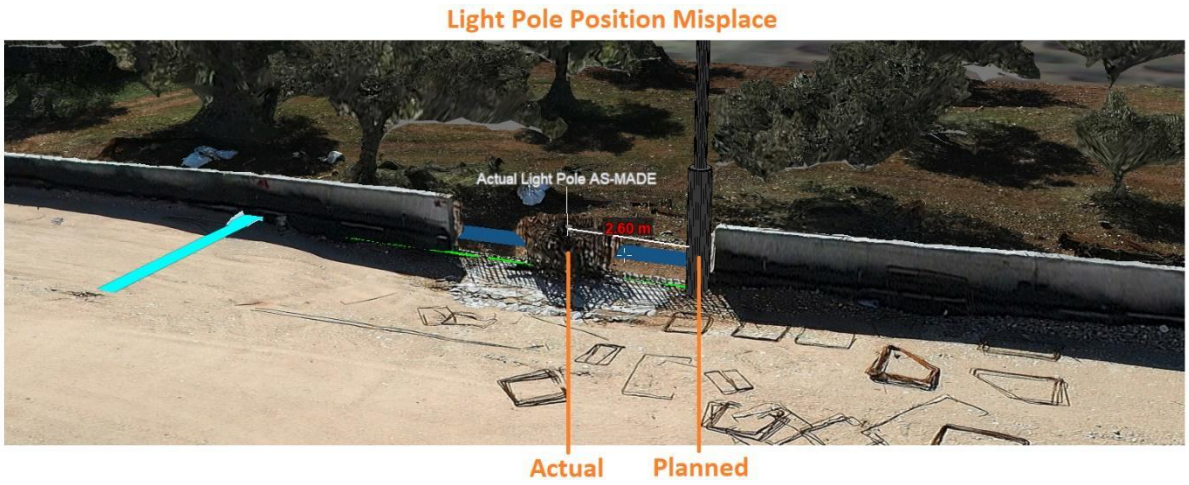
The table depicted above represents some of our projects where our system monitors on a monthly basis. For each project we took one issue which we had addressed both using standard methods (ground survey using total station/RTK GPS) and our project monitoring system (UAV scans on top of TerraExplorer).
The conclusion is clear: by using Kav Medida's high-end project monitoring methods which yield **2.5 times faster results**, and **save 33% more out of the budget**, the benefit to our clients is immense. In addition, when 3D mesh models and orthophotos are a by-product of every map created, the decision to order our system for the project is an obvious one.

2.1 The 48-hour infrastructure survey report challenge

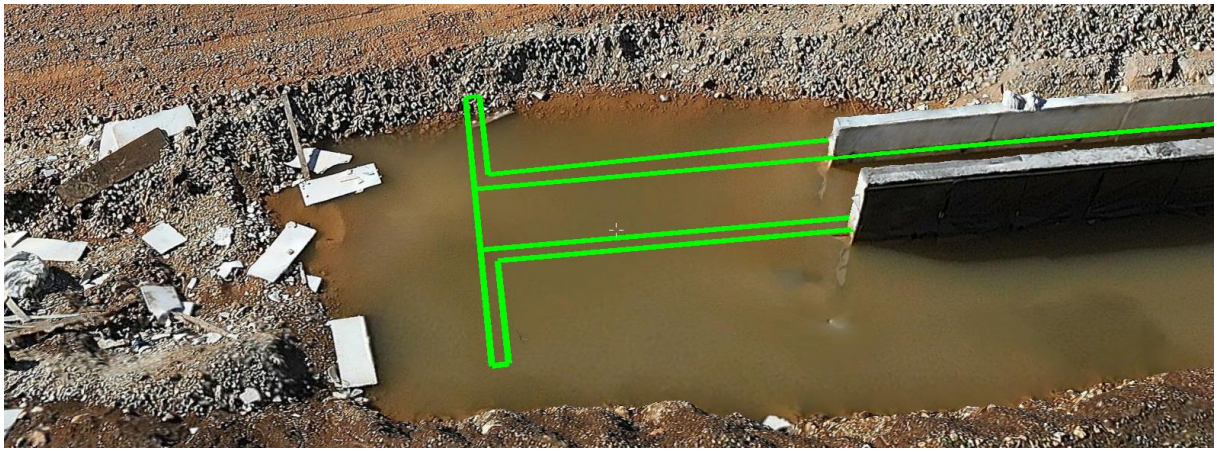
"Road 85" project is a Gantt vs As-built project. In this unique project we were asked to generate a progress report of the project Gantt vs actual construction, in a challenging time frame of **48 hours**. The report consists of all discrepancies that can be monitored - volume differences, incomplete/missing Gantt items, safety hazards, potential flood areas and construction accuracy errors.
The deliverables we decided to provide were a topographic map in DWG on a 1:250 scale, a progress report in PDF, online 3D GIS system and a mobile mapping interface for extra visual angles.

Screenshots taken from “Road 85” progress monitoring project:
This is not a photo – It’s a 1cm per pixel 3D Mesh reconstruction – “Digital Twin”





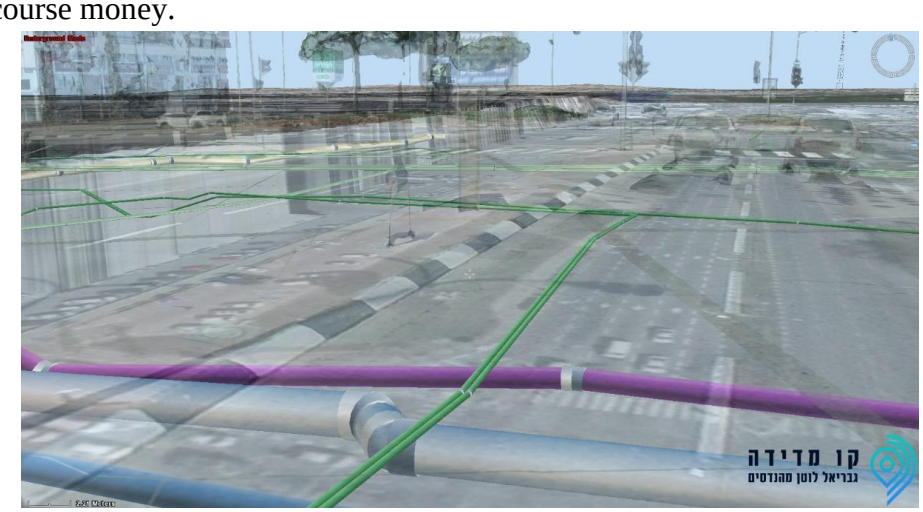
A 3D Revit light pole model represents the position of the planned light pole. The actual concrete base was misplaced by 2.6m.



Incomplete supporting walls extensions. However, wall's absolute location is satisfactory.

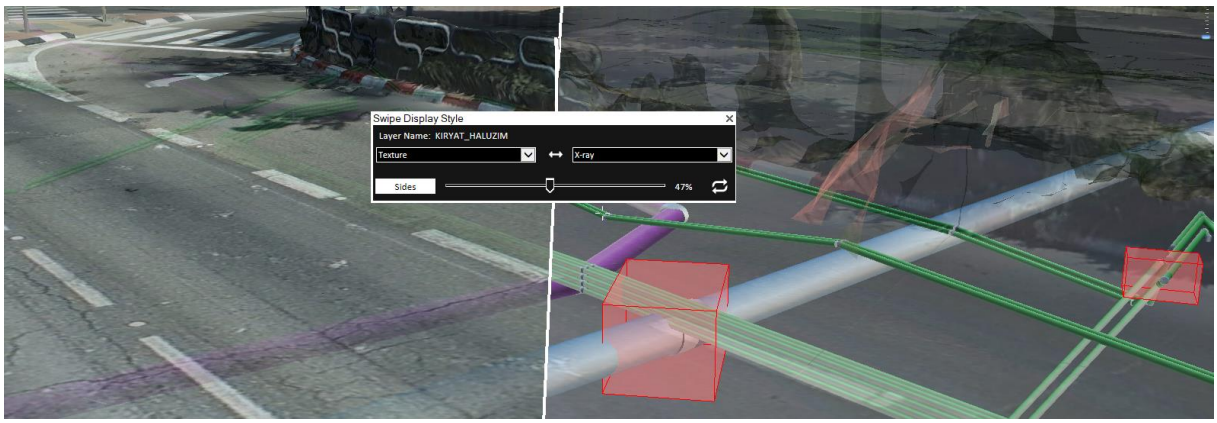
The final results were more than sufficient, and the products were delivered 4 hours prior to the dead-line.

Not only can the system be used for project progress and quality monitoring, it is also a great tool for planning purposes. Let's take this opportunity to reflect on the practical digital twin-related benefits in the infrastructure domain. When a project is in its preliminary stage, many of the project's planning team members can benefit from using TerraExplorer and the 3D Mesh digital twin. Having an accurate digital twin can help create a 1:1 simulation environment for almost every planned subject.
For example, if we take an underground infrastructure coordination case – it's a highly efficient simulation tool, enabling clash detection and manual digitizing on-platform to save time and of course money.



TerraExplorer's underground mode – enabling 3D model transparency while underground infrastructure can be inspected.

There were many disastrous situations where heavy drilling machinery started earthwork although pipes had been deployed incorrectly. The consequences of such cases are catastrophic, not only for the paying customer, but also to the environmental devastation and unnecessary traffic interference.



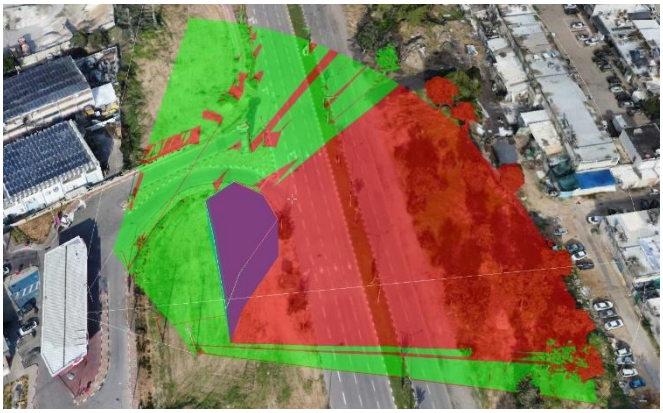
Clash detected between communication lines and sewage pipe - represented by red cubes

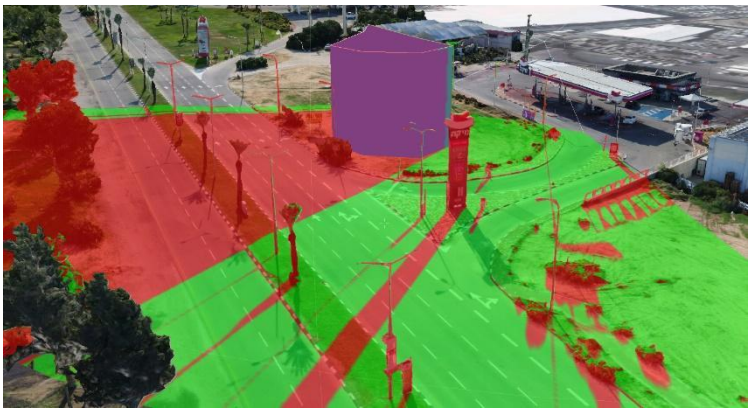
2.2 Adding Value in The Early and Advanced Stages of Planning:

After delivering the final map of the AOI, data can then be uploaded onto the system to create various simulations and raw conceptual planning. Having photo-realistic accurate data on top of a software which can manipulate the surface and add value, can create a major impact on the project's design decision making. For instance, placing a Revit IFC model, straight out of the planning environment, directly onto the photo-realistic field as depicted below, allows for a clear visual picture of how things will look, which will lead to better and quicker decisions to be made.

Also, the reverse can be done – using the 3D mesh model in TerraExplorer to extract geometry and build an accurate LOD250 BIM model. The system is flexible, versatile and user-friendly.
BIM model extraction out of 3D mesh in the photo below:

Architects can use this environment to test and share their abstract models and simulate viewshed:





Road planners can test their planned road geometry:

The expedited advancement of survey equipment and software is the key to the evolution of the surveyor's role in the market. That being said, it is incumbent on all professionals in the field to acquire and research these new technologies. Today, the surveyor has greater influence on projects he's involved in than ever before, and this is only the beginning.

BIOGRAPHICAL NOTES

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