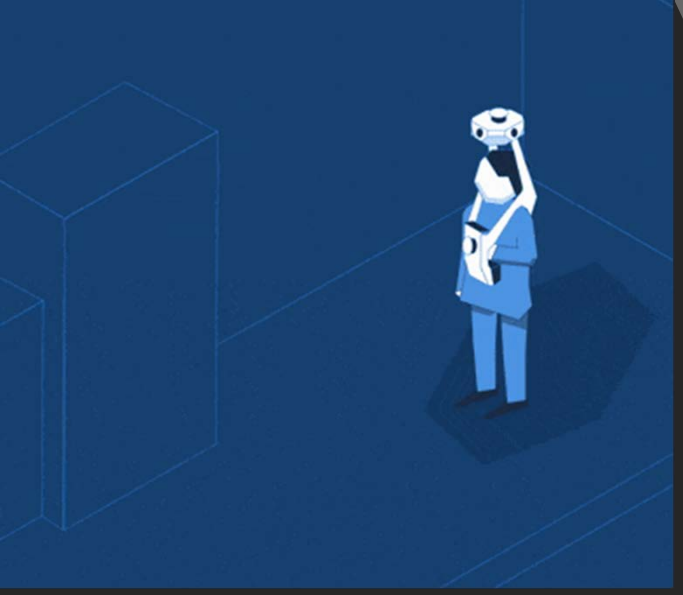

Reality Capture and Digital Twin Creation

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SURVTECH SOLUTIONS
Surveying Today with Tomorrow's Technology

Reality Capture and Digital Twin Creation

Authors of Today's Presentation:

- Presenter - David O'Brien, PSM
- 3D Scanning – Fabiano Santos
- UAVs – Mark Bickel, Part 107 Pilot
- Terrestrial LiDAR Processing- Andy Goss
- Aerial LiDAR Processing- Chase Comeaux, CLT
- Multi Beam Sonar – Henry Simpkins, PSM, and Jason Ellard

Reality Capture and Digital Twin Creation

Presenter's Background

- President and Founder of SurvTech Solutions, Inc. (2004)
- Surveyor and Mapper Licensed in 11 States
  - FL, AR, SC, NC, GA, KY, TN, AL, LA, MS, & TX
- Certified Federal Surveyor (CFedS)
- Certified Floodplain Surveyor (CFS)
- Bachelor of Science – Surveying Engineering
  - University of Maine, 1993
- Owner/Operator of a Surveying Business for 29+ years.

Reality Capture and Digital Twin Creation

Definitions:

- Terrestrial LiDAR and/or 3D Scanning – Stationary LiDAR from a tripod.
- SLAM – Simultaneous Localization and Mapping (Mobile LiDAR without GPS)
- UAV – Unmanned Aerial Vehicles (Just the drone)
- UAS – Unmanned Aerial System (UAV with sensor)
- UASs – Unmanned Aerial Systems or Unmanned Aerial Systems (Small)
- USV – Unmanned Survey Vessel
- IMU – Inertial Measurement Unit
- GPS – Global Positioning System
- GNSS – Global Navigation Satellite System (GPS, Glonass, Civil, Galileo, Bei Dou, & QZSS – USA, Russia, Europe, China, & Japan)
- PPK – Post Processed Kinematic (GPS)
- RTK – Real Time Kinematic (GPS)

Reality Capture and Digital Twin Creation

What is “Reality Capture” per Google?

“Reality capture is a process that uses technology to record and document the physical world as digital data. This data can include images, videos, 360-degree panoramas, and scans. The data is then converted into digital models or representations, such as 3D models, point clouds, or meshes”.

Reality Capture and Digital Twin Creation

What is “Reality Capture” per Chat GPT?

Reality capture is the process of using various technologies to digitally record the physical world. This involves creating accurate and detailed representations of objects, environments, and structures. The captured data can be used in various applications, such as architecture, construction, engineering, gaming, and virtual reality. Here are some key components and technologies involved in reality capture:

- Photogrammetry
- Laser Scanning (LiDAR)
- 3D Scanning
- Drones and UAVs equipped with cameras and sensors
- Mobile Mapping
- Ground Penetrating Radar
- Augmented and Virtual Reality (VR)

Reality capture is essential in various industries for tasks such as site analysis, construction monitoring, heritage preservation, and virtual simulations. The technology continues to evolve, becoming more accurate, efficient, and accessible.

Reality Capture and Digital Twin Creation

What is a “Digital Twin” per Google?

A digital twin is a virtual representation of a physical object, process, or person that can be used to understand and test the physical counterpart. Digital twins are linked to real data sources and can update in real-time to reflect changes in the physical world. They can be used to simulate, predict, and optimize the physical product or process before investing in physical prototypes.

Reality Capture and Digital Twin Creation

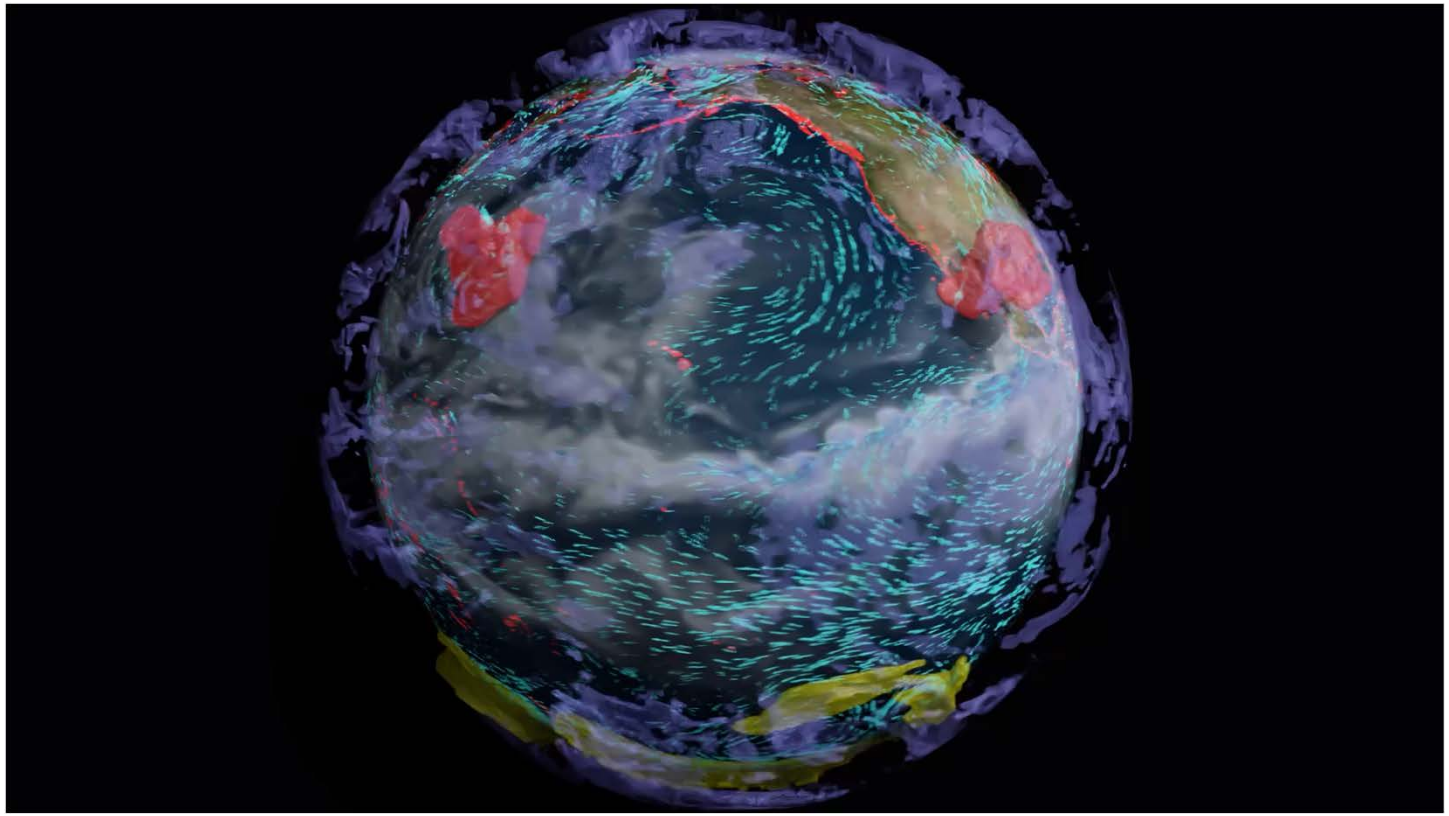
What is “Digital Twin” per Chat GPT?

A digital twin is a digital replica of a physical object, system, or process. It serves as a bridge between the physical and digital worlds, enabling real-time monitoring, analysis, and optimization. Digital twins are used across various industries, including manufacturing, construction, healthcare, and urban planning, to improve efficiency, reduce costs, and enhance decision-making. Here are the key aspects of digital twins:

- Real-Time Data Integration
- Simulation and Modeling
- Predictive Analytics
- Visualization
- Control and Automation

Overall, digital twins represent a transformative approach to managing and optimizing physical assets and processes by leveraging the power of digital technology.

Reality Capture and Digital Twin Creation

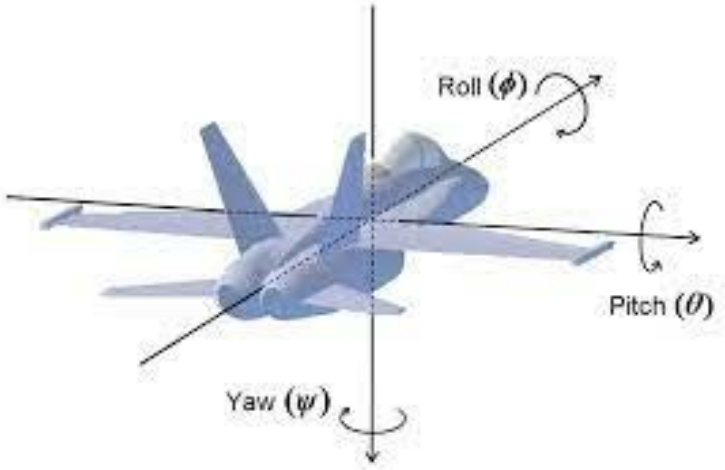


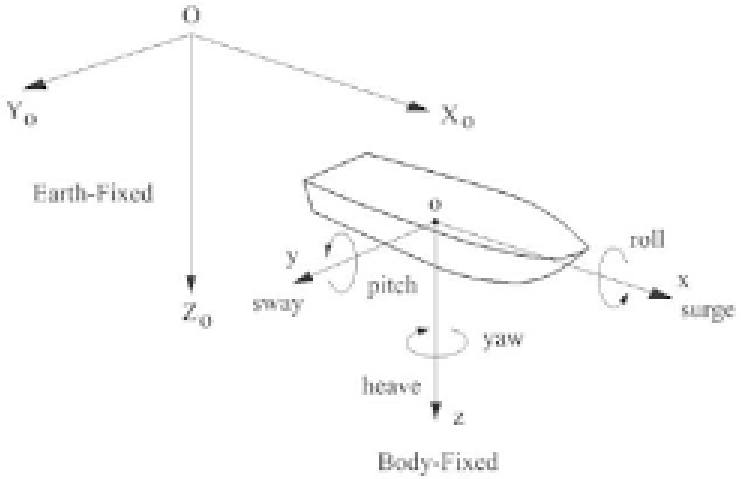
NVIDIA to Build Earth-2 Supercomputer to See our Future (Digital Twin of Earth)

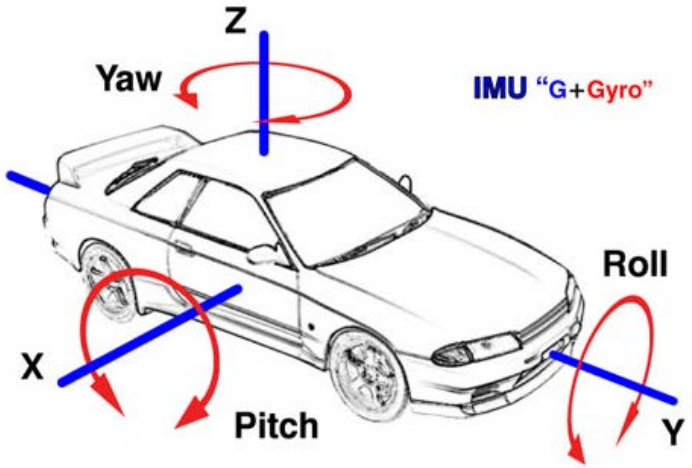
Reality Capture Platforms

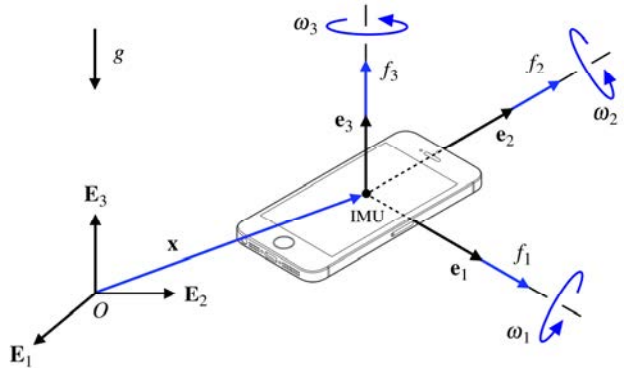
IMU – Inertial Measurement Unit for Kinematic (Moving Acquisition)

- IMU corrects for motion
  - Heave
  - Pitch
  - Roll
  - Yaw
- IMU overall position drifts over time – corrected by GPS
- Backward corrections in post-processing between GPS signal loss.
- IMUs are used in all mobile mapping systems
  - Aerial (Planes, UAVs, and helicopters)
  - Boats
  - Automobiles
  - Backpack and handheld









Aerial Mapping

Airborne LiDAR Fixed Wing Aircraft

- Teledyne/Optech Galaxy T2000 LiDAR System
- PhaseOne RGB medium format camera
- Designed for high density topographic data
- Ultra wide area high altitude mapping
- Corridor Mapping
- Complexed Urban Environments
- City Modeling
- Agriculture and forestry

Aerial Mapping

Helicopter

- Jet Ranger / Long Ranger
- Concurrent LiDAR and Imagery
- Oblique Imagery
- Riegl VPX-1 aerial pod VUX-160
- Corridor Mapping
- Power Line, Railway Track, and Pipeline inspection, Transportation

UAVs

- LiDAR
- Orthometric Photos
- 3D Point Cloud Models
- Volumetric Calculations
- DEM/DTM Generation
- Contour Maps
- HD Photo/Video
- Asset Inspection
- Forward Looking IR (FLIR)
- Thermal
- Multispectral
- Identify encroachments (transmission corridors)

Hydrographic Surveying Vessels

- LARGE SURVEY VESSELS
- ONE-MAN SURVEY VESSELS
- USVS (UNMANNED SURVEY VESSELS)
- SINGLE-BEAM, MULTI-BEAM, SIDE SCAN, MAGNETOMETER, SEISMIC, SUB-BOTTOM PROFILING
- MOBILE LIDAR

MANNED & UNMANNED VESSELS

- 6-FOOT USV
- BREAKS IN HALF
- STAINLESS STEEL PROPELLER
- CEE SYSTEMS SINGLE BEAM SONAR
- FORWARD-LOOKING CAMERA WITH REAL-TIME VIEWING.
- RTK AND PPK GPS

Terrestrial, Mobile and SLAM LiDAR

Outdoor Mobile

Terrestrial Scanning

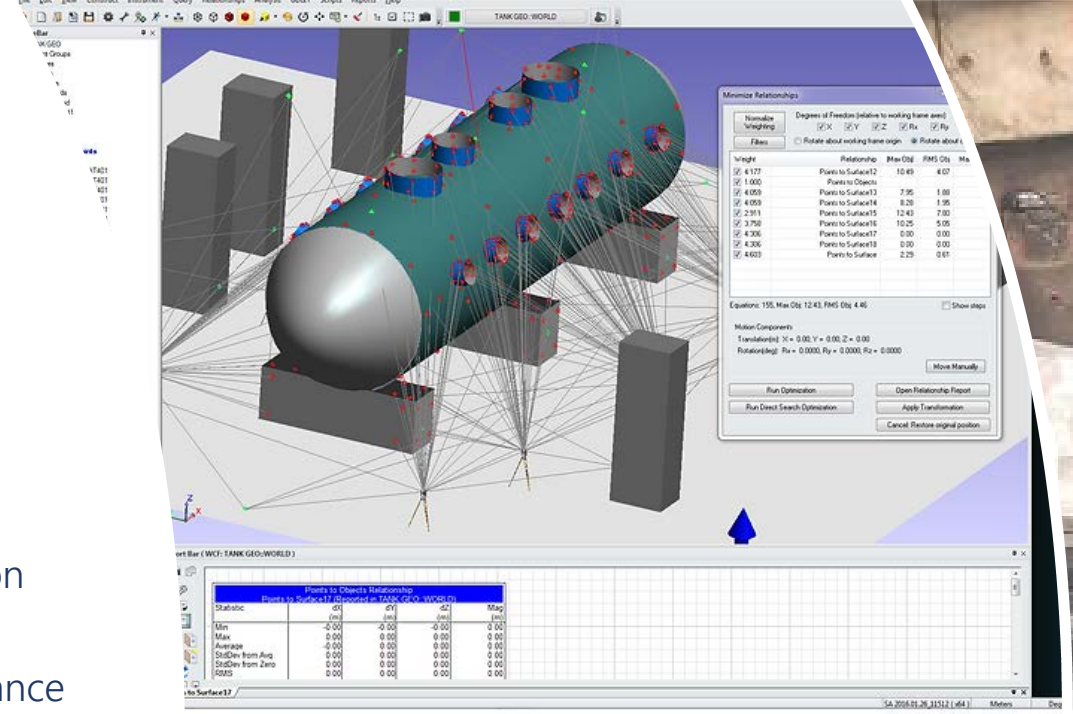
Indoor Mobile Cart

Indoor Mobile (Backpack)

- SurvTech Personnel have been working with LiDAR data since the late 90's.
- Terrestrial LiDAR (3D Scanning on a Tripod)
- Vehicle-Mounted LiDAR and 360° Imagery (Lady Bug 5.0) Units (Boats and Trucks)
- Other Means – NavVis Mobile LiDAR using SLAM (Simultaneous Localization and Mapping)

Metrology

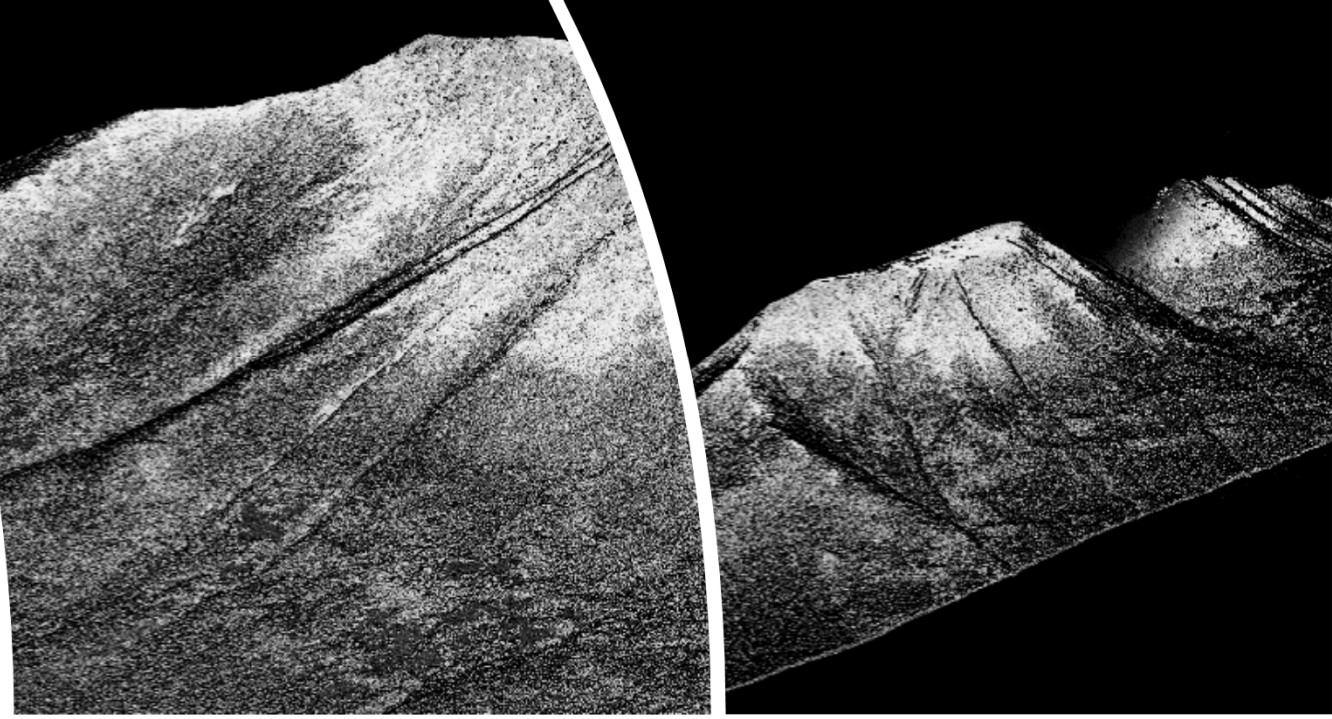
- Key Feature Alignment
- Part and Assembly Inspection
- Virtual Component Feature Alignment and Clash Avoidance
- Onsite Machining Alignment
- Machine Tool Calibration
- Robot Alignment and Calibration
- Real-time Build and Monitor
- Metrology Engineering, scripting and process improvements
- Heavy Equipment and Monument Tooling Installation



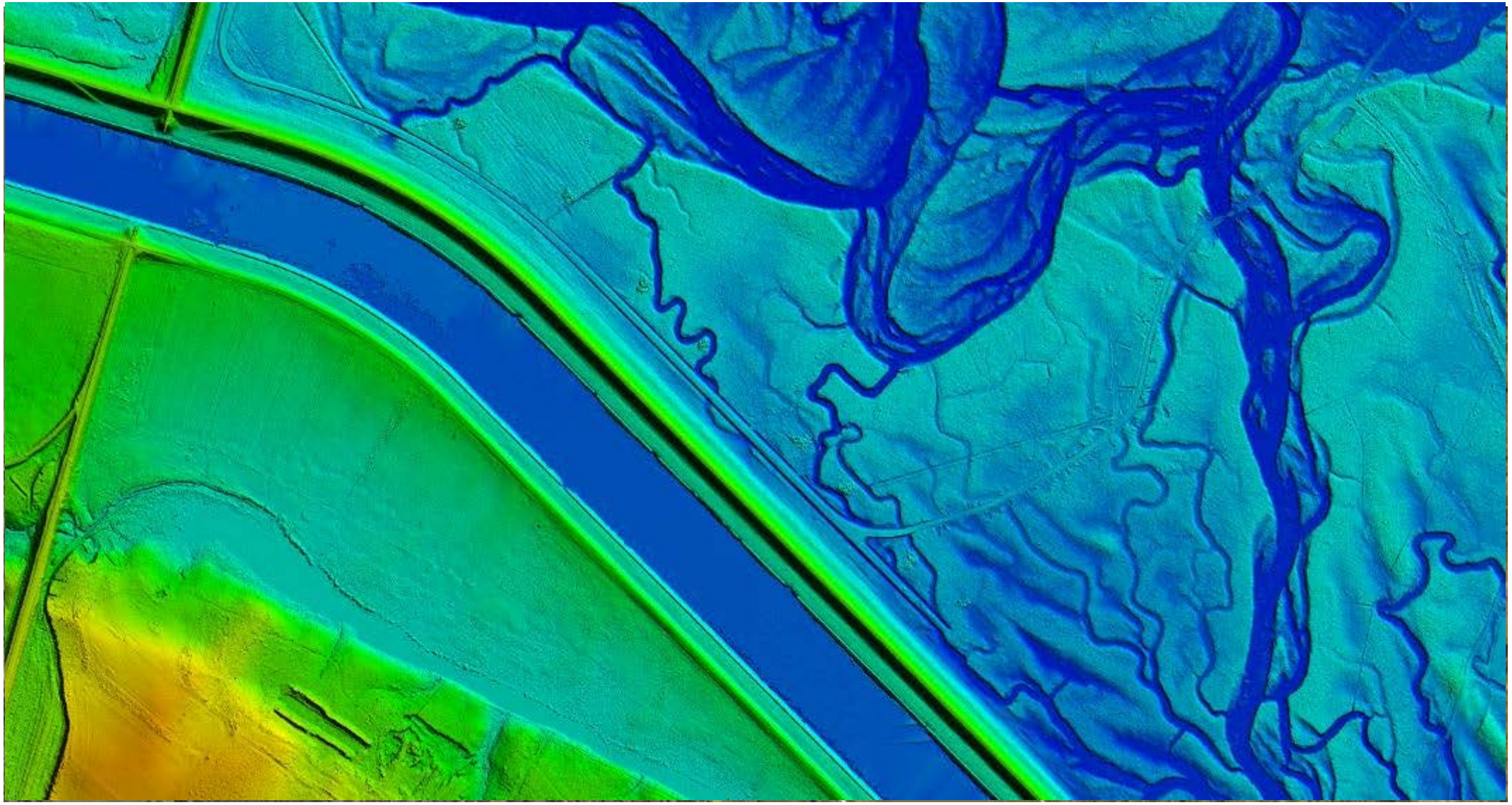
Aerial Mapping

Fixed Wing Aircraft

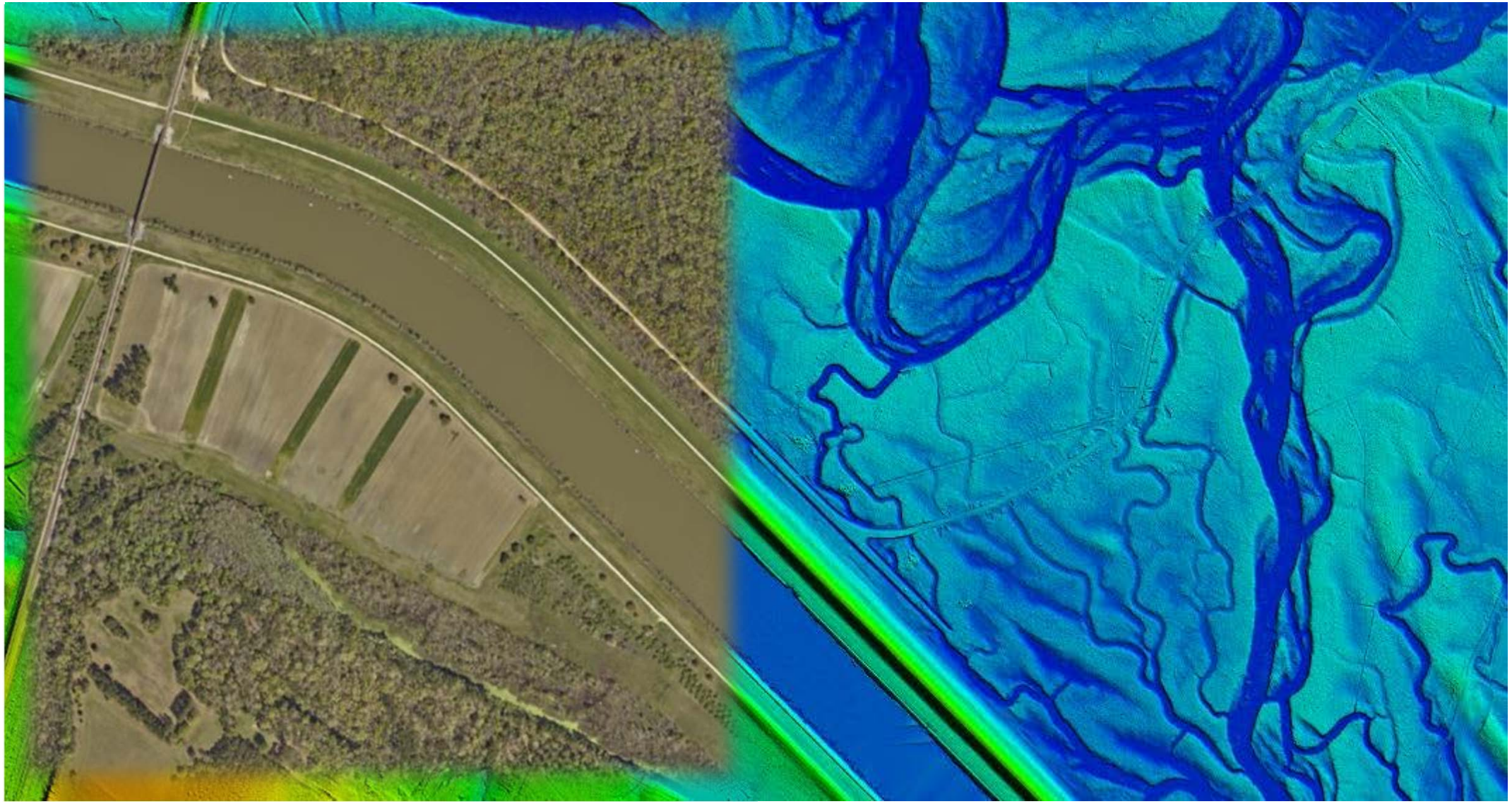
- Teledyne/Optech T2000 LiDAR Sensor (Latest Model)
- PhaseOne Medium Format RGB Camera
- Concurrent Imagery and LiDAR Collection
- Long Corridors
- Wide Area Mapping – 1000's of Square Miles
- CONUS (Maine to California)



Concurrent Airborne LiDAR and Imagery

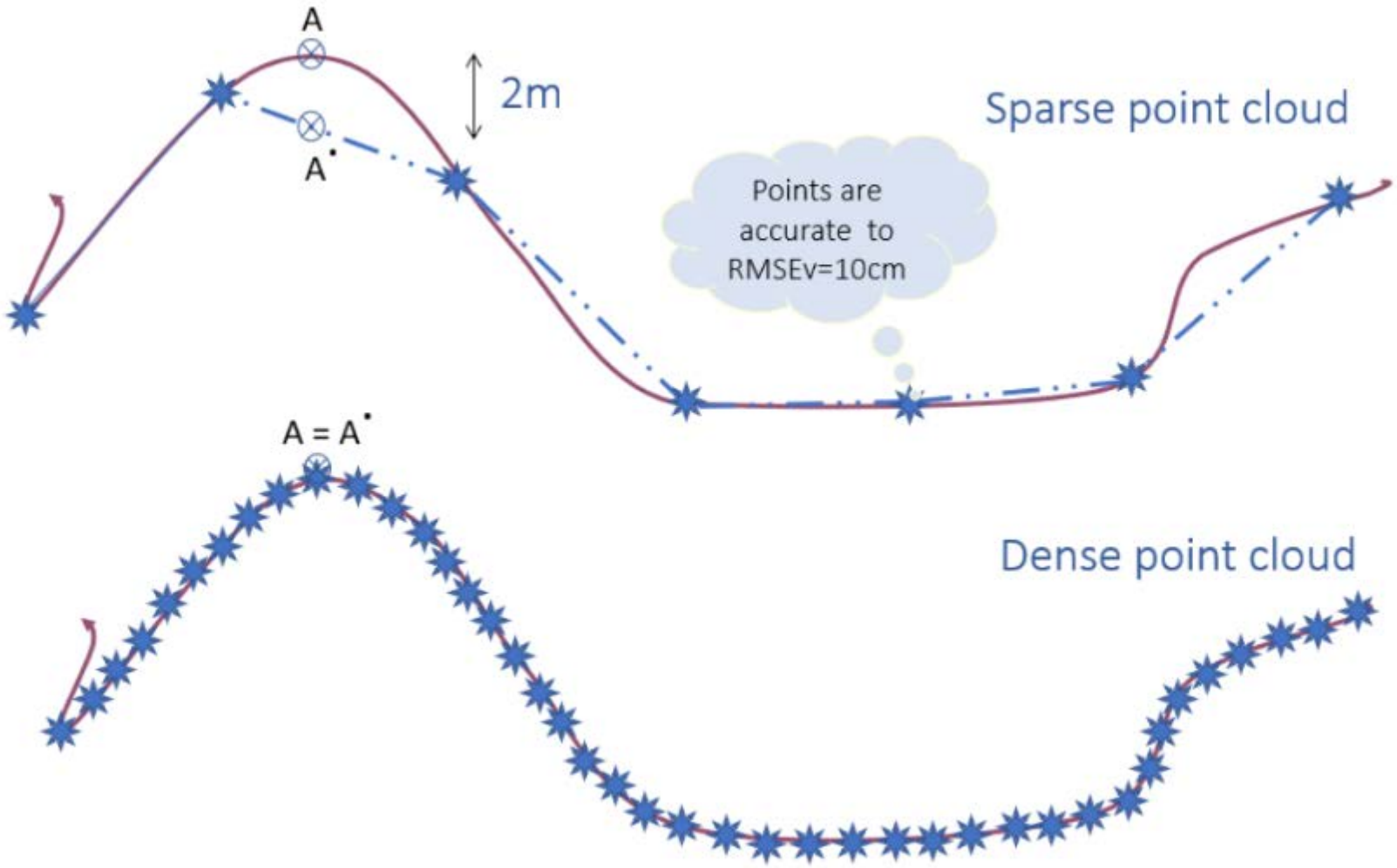


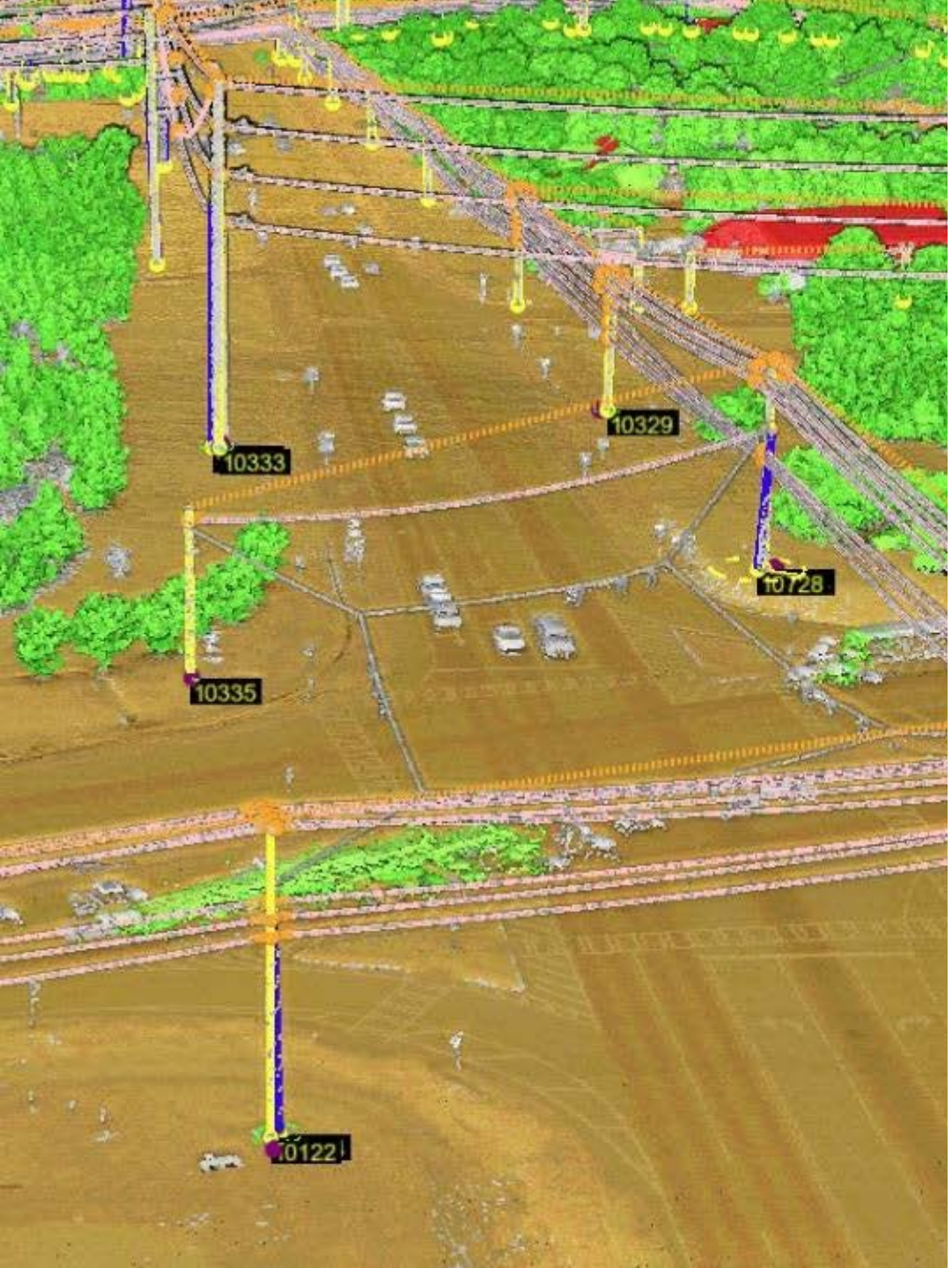
Concurrent Airborne LiDAR and Imagery



How Accurate and Detailed is your Digital Twin?

Quality as a Function of Point Density and Vertical Accuracy (Terrain Model Example)



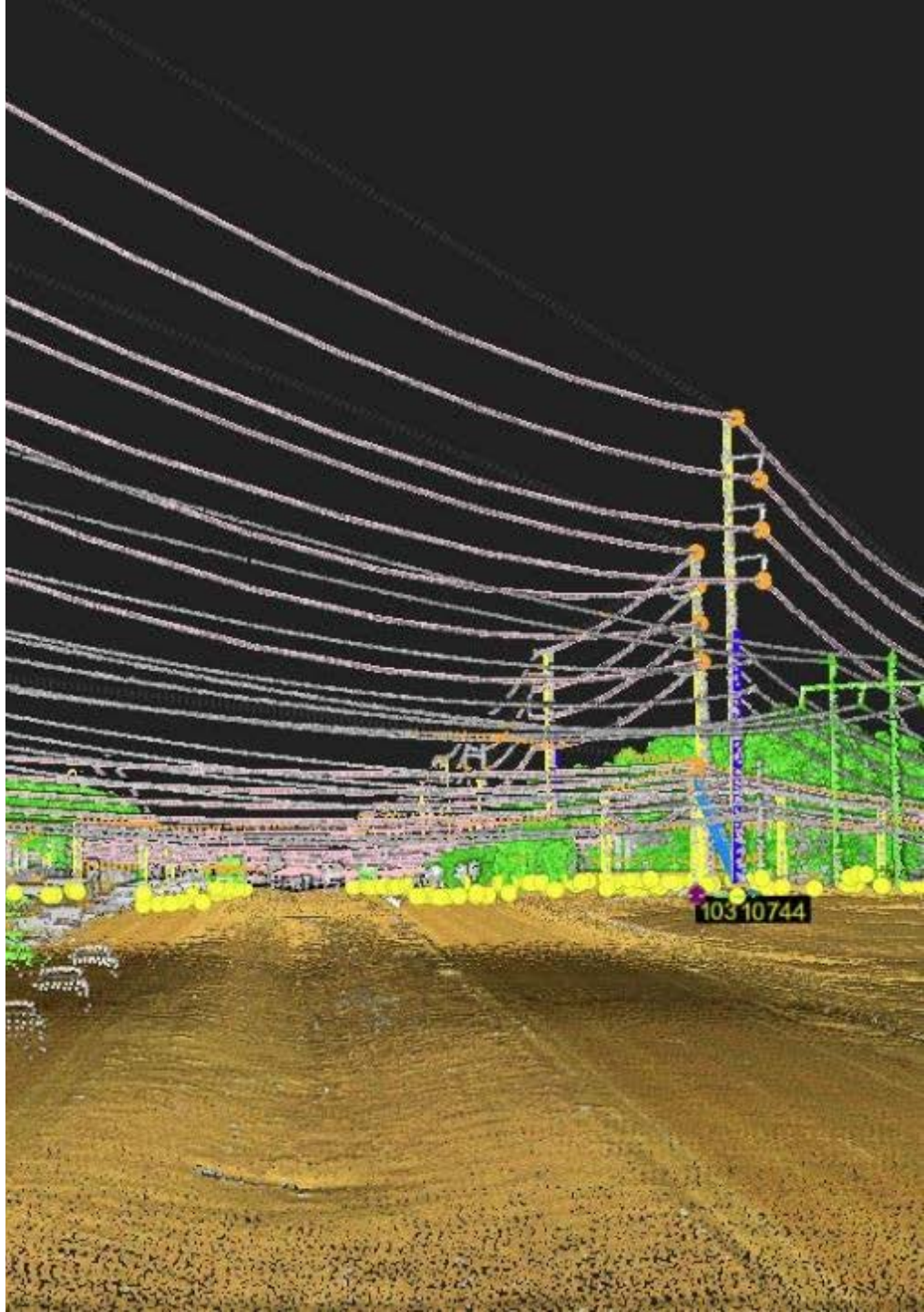


Digital Twin Collection of Power Grid from Helicopter

- Jet Ranger / Long Ranger
- Concurrent LiDAR and Imagery
- Oblique Imagery
- Riegl VPX-1 aerial pod VUX-160
- Corridor Mapping
- Power Line, Railway Track, and Pipeline inspection, Transportation

Digital Twin Collection of Power Grid

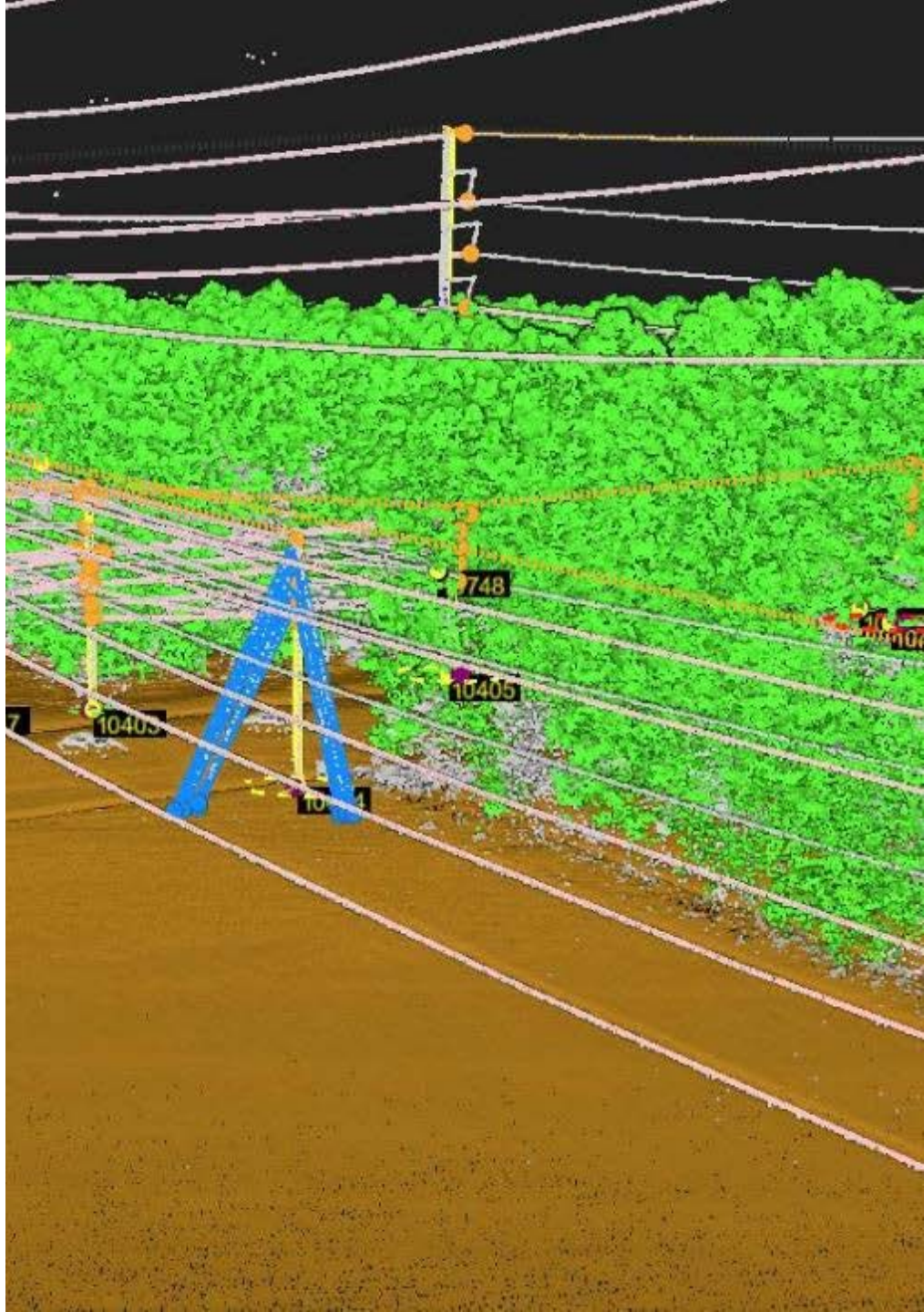
- Simultaneous LiDAR & Imagery Collection
- LiDAR
- Downward RGB Imagery
- Oblique (forward and aft) RGB Imagery



Digital Twin Creation of Power Grid

Benefits of Airborne LiDAR/ Image Data

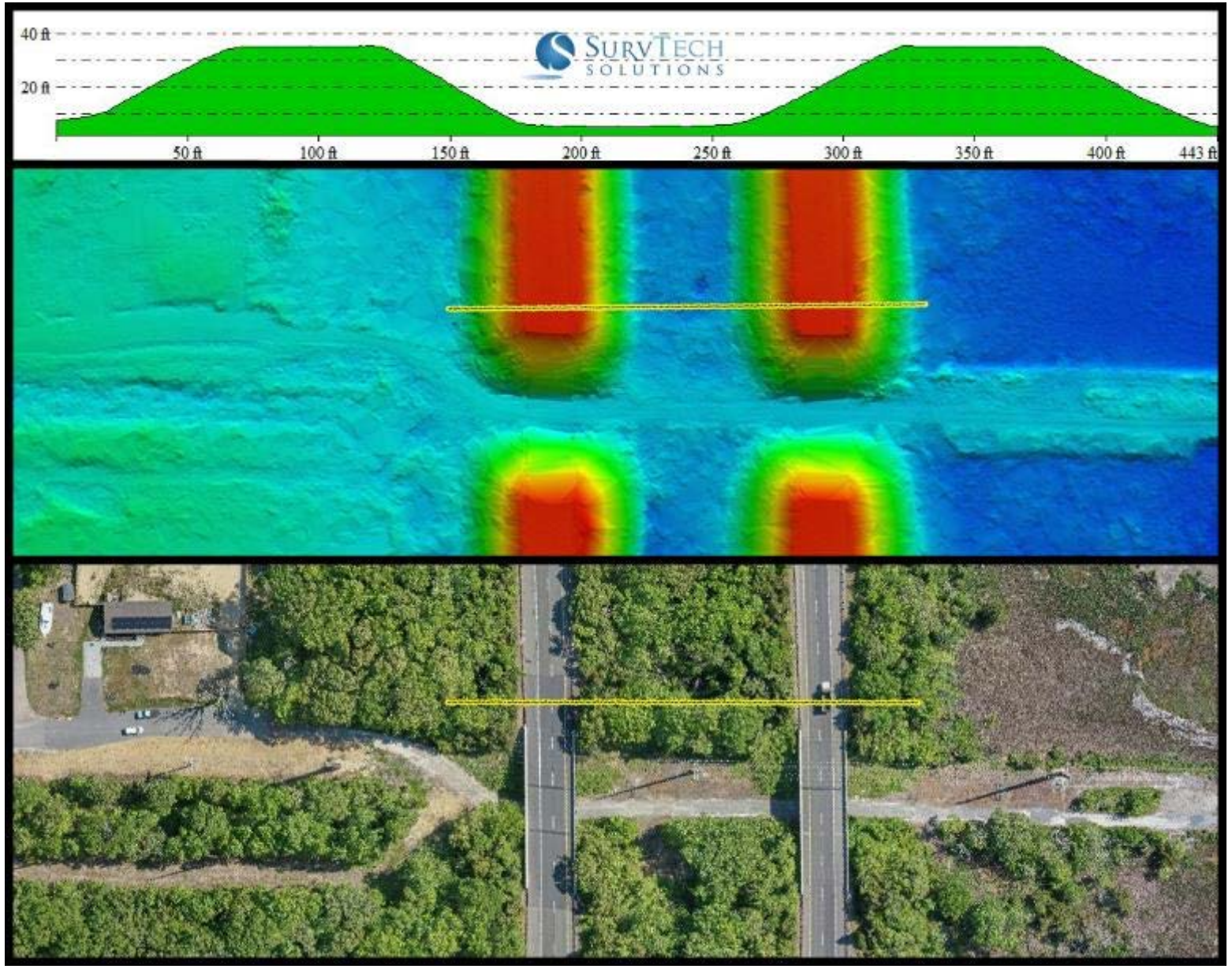
- Asset Health Management
- Custom Reports
- Power Grid Inventory
- Vegetation Management
- High Accuracy Models
- Better Faster Decisions
- Risk Management
- Digital Terrain Model (DTM) – Topography
- Tree Canopy Encroachment into Right-of-way



UAVs

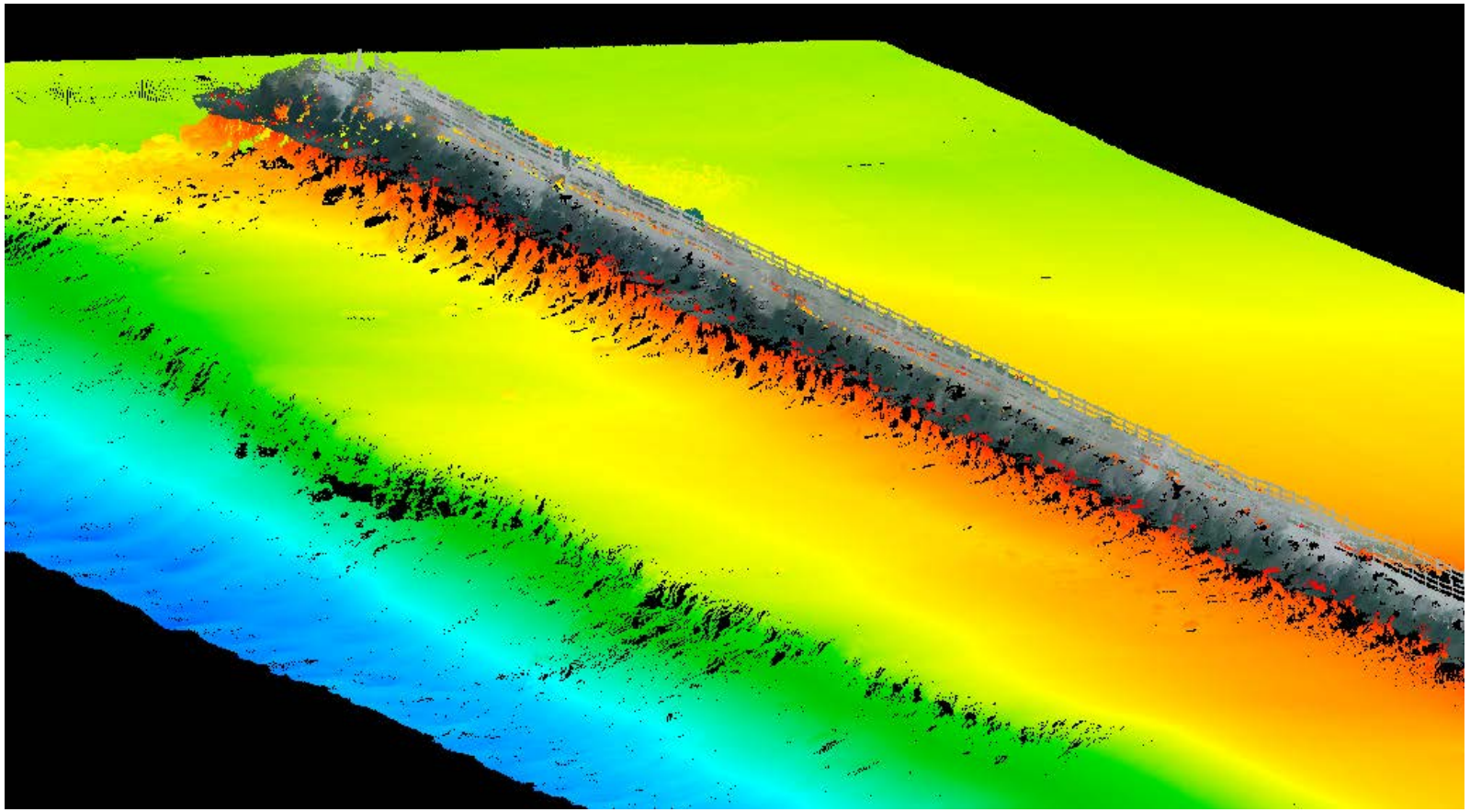
LiDAR and Imagery

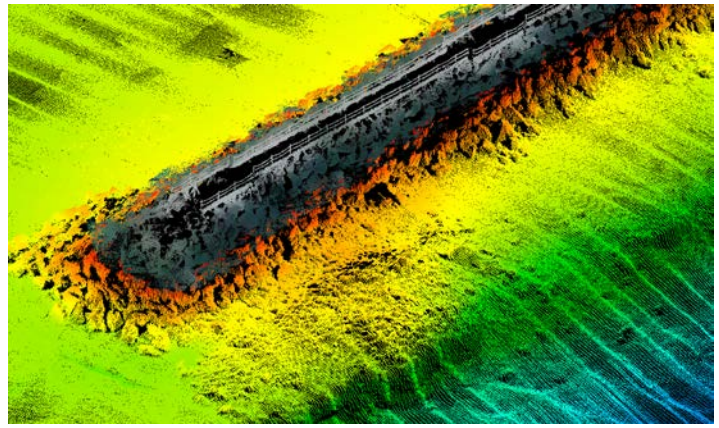
- LiDAR Calibration
- LiDAR Classification
- Colorized Point Cloud
- Bare Earth DEM

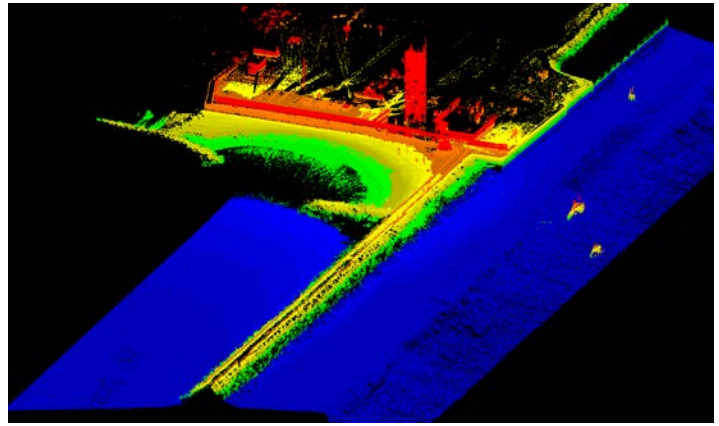


Upland & Subaqueous Digital Twin

(UAV LiDAR and Multi-Beam Sonar)

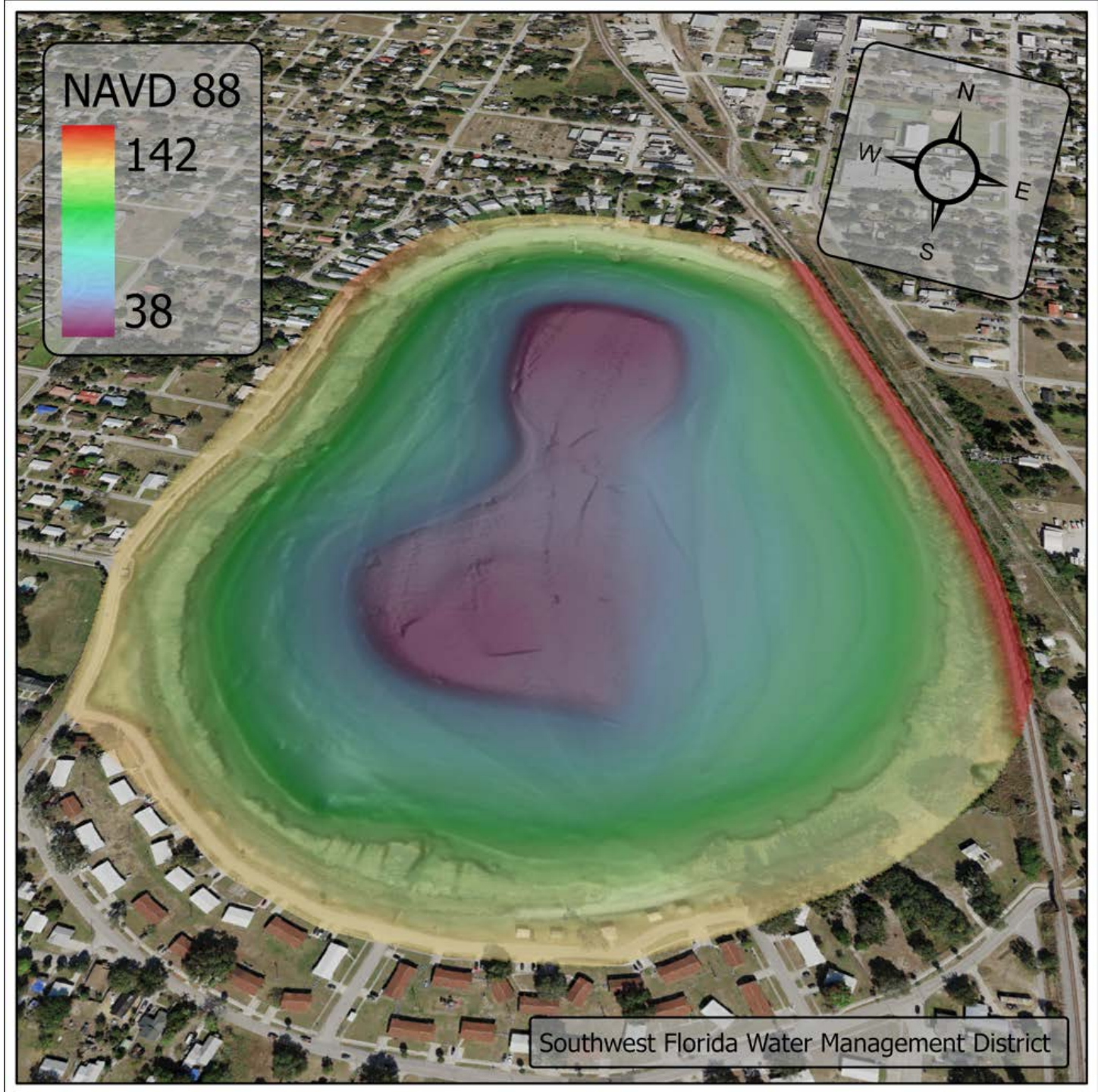






Upland & Subaqueous Digital Twin Digital Twin Digital Twin

Multi-Beam Sonar from Survey Vessel
UAV LiDAR
RTK GPS



Digital Twin – Upland, Underground, & Underwater

Water Crossing Reporting and Analysis

- The data to the right depict a comparison between the same river crossing measured at different times. Data depicted in red was measured in 2016 and data depicted in blue was measured in 2021.
- The bathometric shape generally stayed the same however the cover reported in 2021 was slightly less than measured in 2016

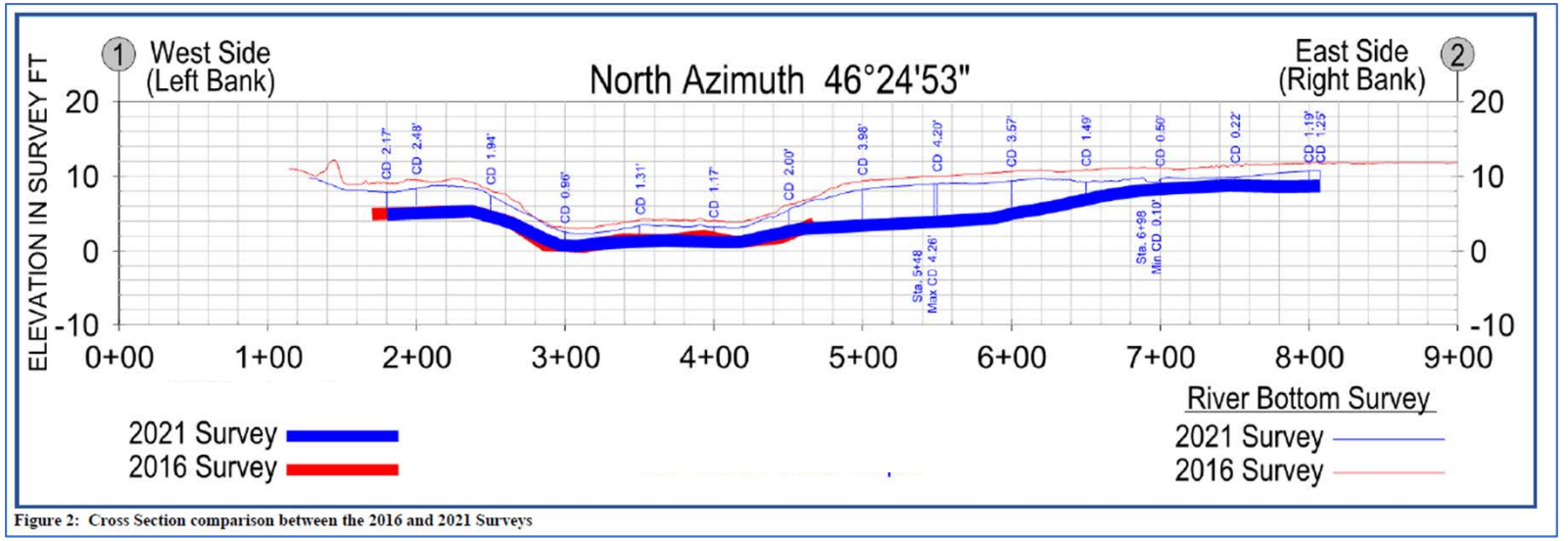


Figure 2: Cross Section comparison between the 2016 and 2021 Surveys

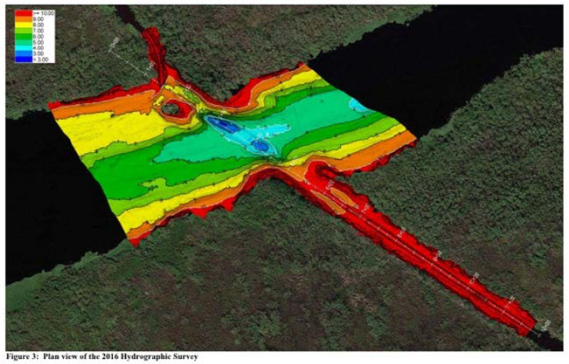


Figure 3: Plan view of the 2016 Hydrographic Survey

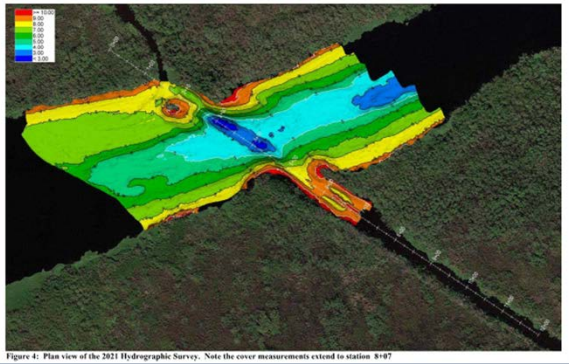


Figure 4: Plan view of the 2021 Hydrographic Survey. Note the cover measurements extend to station 8+07

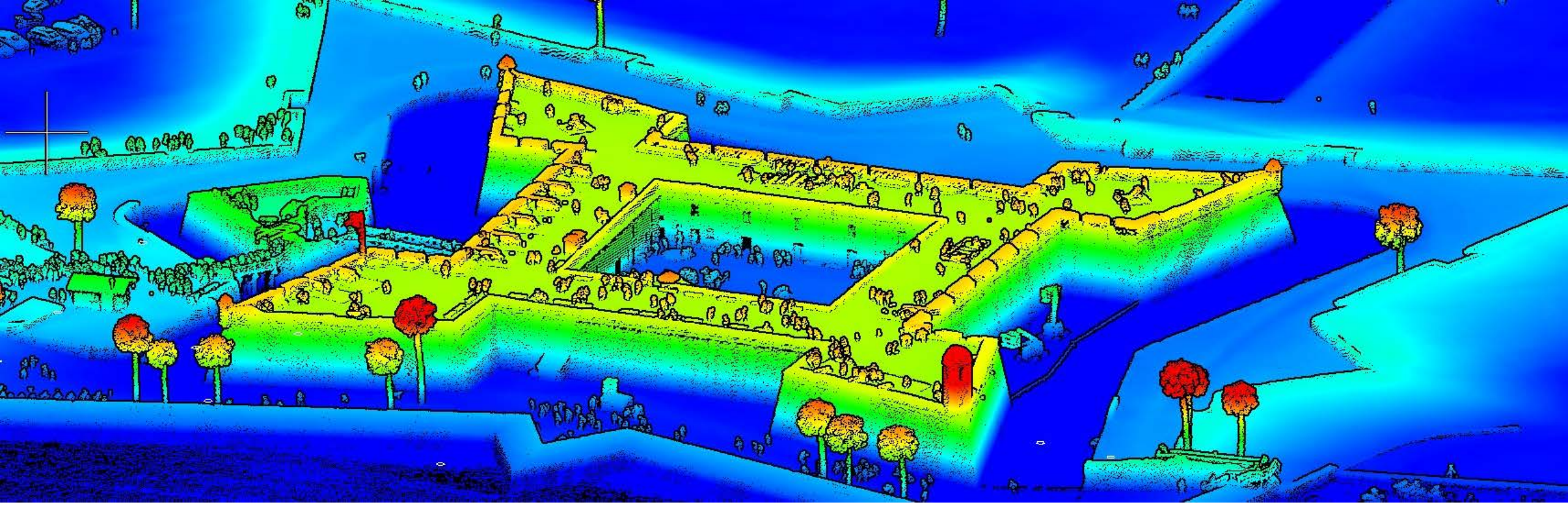
Station	2016 Survey				2021 Survey				2021 vs 2016 Survey
	2016 Water Depth	River Bottom Elev	Top Pipe Elev	Cover Depth (ft)	2021 Water Depth	River Bottom Elev	Top Pipe Elev	Cover Depth (ft)	Cover Depth (ft) Change
1+81	6.7	9.1	5.8	3.3	5.9	7.9	5.7	2.2	-1.1
2+00	6.3	9.5	5.9	3.5	5.5	8.3	5.9	2.5	-1.1
2+50	7.7	8.1	5.5	2.6	6.4	7.4	5.5	1.9	-0.6
3+00	12.7	3.1	1.5	1.6	11.3	2.5	1.6	1.0	-0.6
3+50	11.7	4.1	2.3	1.8	10.4	3.4	2.1	1.3	-0.5
4+00	11.7	4.1	2.6	1.5	10.6	3.2	2.0	1.2	-0.3
4+50	9.6	6.2	3.1	3.1	8.3	5.5	3.5	2.0	-1.1
5+00	-	-	-	-	5.6	8.2	4.2	4.0	-
5+48	-	-	-	-	5.1	8.7	4.5	4.3	-
5+50	-	-	-	-	4.8	9.0	4.8	4.2	-
6+00	-	-	-	-	4.4	9.4	5.8	3.6	-
6+50	-	-	-	-	4.6	9.2	7.7	1.5	-
6+98	-	-	-	-	4.6	9.2	9.1	0.1	-
7+00	-	-	-	-	4.2	9.6	9.1	0.5	-
7+50	-	-	-	-	4.0	9.8	9.6	0.2	-
8+00	-	-	-	-	3.1	10.7	9.5	1.2	-
8+07	-	-	-	-	3.0	10.8	9.5	1.3	-
Minimum	6.3	3.1	1.5	1.5	3.0	2.5	1.6	0.1	-1.4
Maximum	12.7	9.5	5.9	3.5	11.3	10.8	9.6	4.3	0.7
Average	9.5	6.3	3.8	2.5	6.0	7.8	5.9	1.9	-0.5

Table 1:

- " – " indicates a value not measured or calculated
- 2016 Water Surface Elevation: 15.80', 2021 Water Surface Elevation: 13.79'
- The table above is a tabulation and compairison between the 2016 and 2021 bathymetric data sets. Table doesnot include overbank data

Upland & Subaqueous Digital Twin

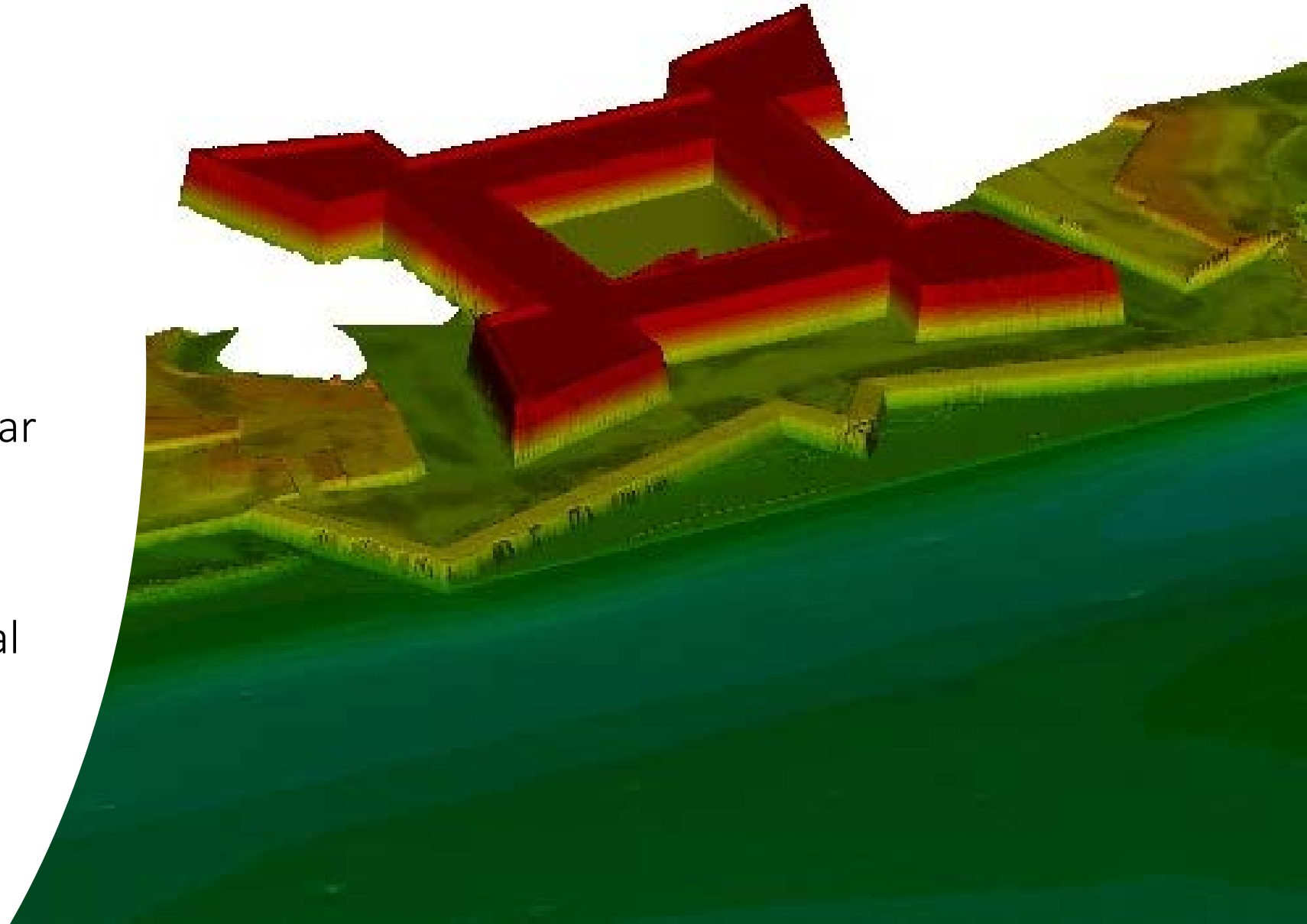
Multi-Beam & Single Beam Sonar from Survey Vessel
UAV LiDAR
RTK GPS
Land Surveying (RTK GPS & Total Station)
Subsurface Utility Engineering (SUE)



UAV LiDAR Before Cleanup

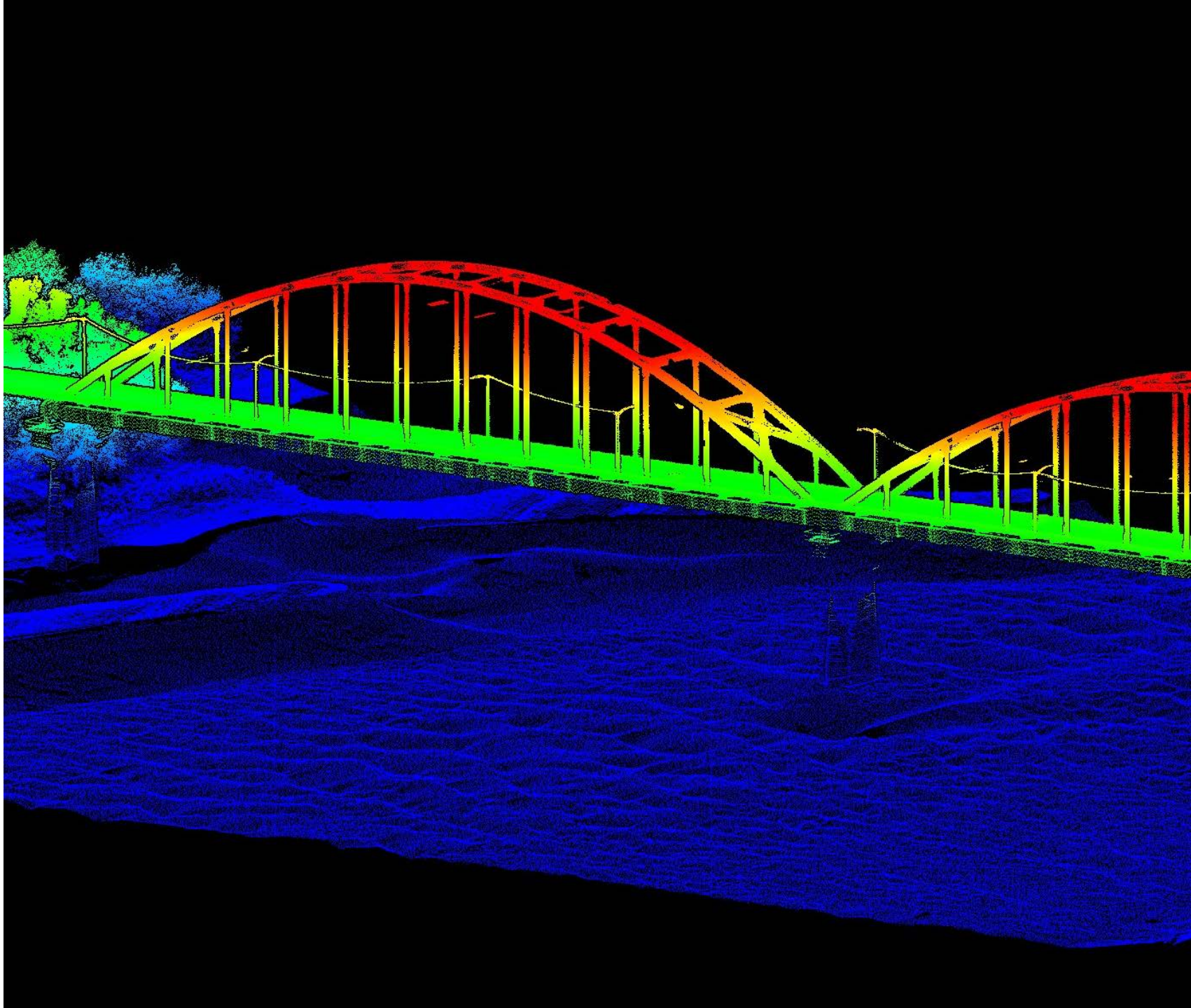
Upland & Subaqueous Digital Twin

Multi-Beam & Single Beam Sonar from Survey Vessel
UAV LiDAR
RTK GPS
Land Surveying (RTK GPS & Total Station)
Subsurface Utility Engineering (SUE)



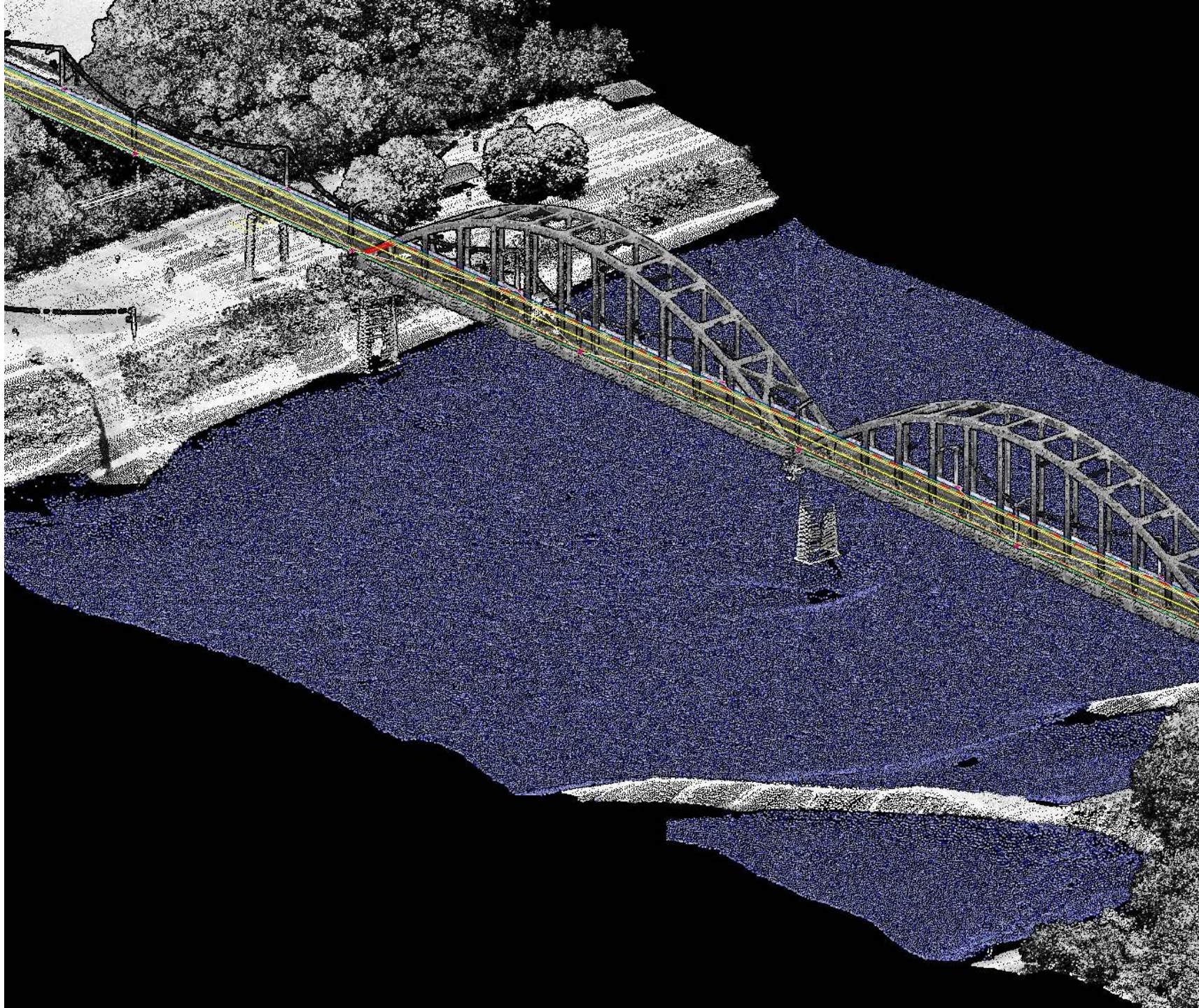
Missouri Bridge Digital Twin

Multi-Beam Sonar
UAV LiDAR
UAV Downward RGB Imagery
Mobile LiDAR – Truck
Mobile 360° Imagery



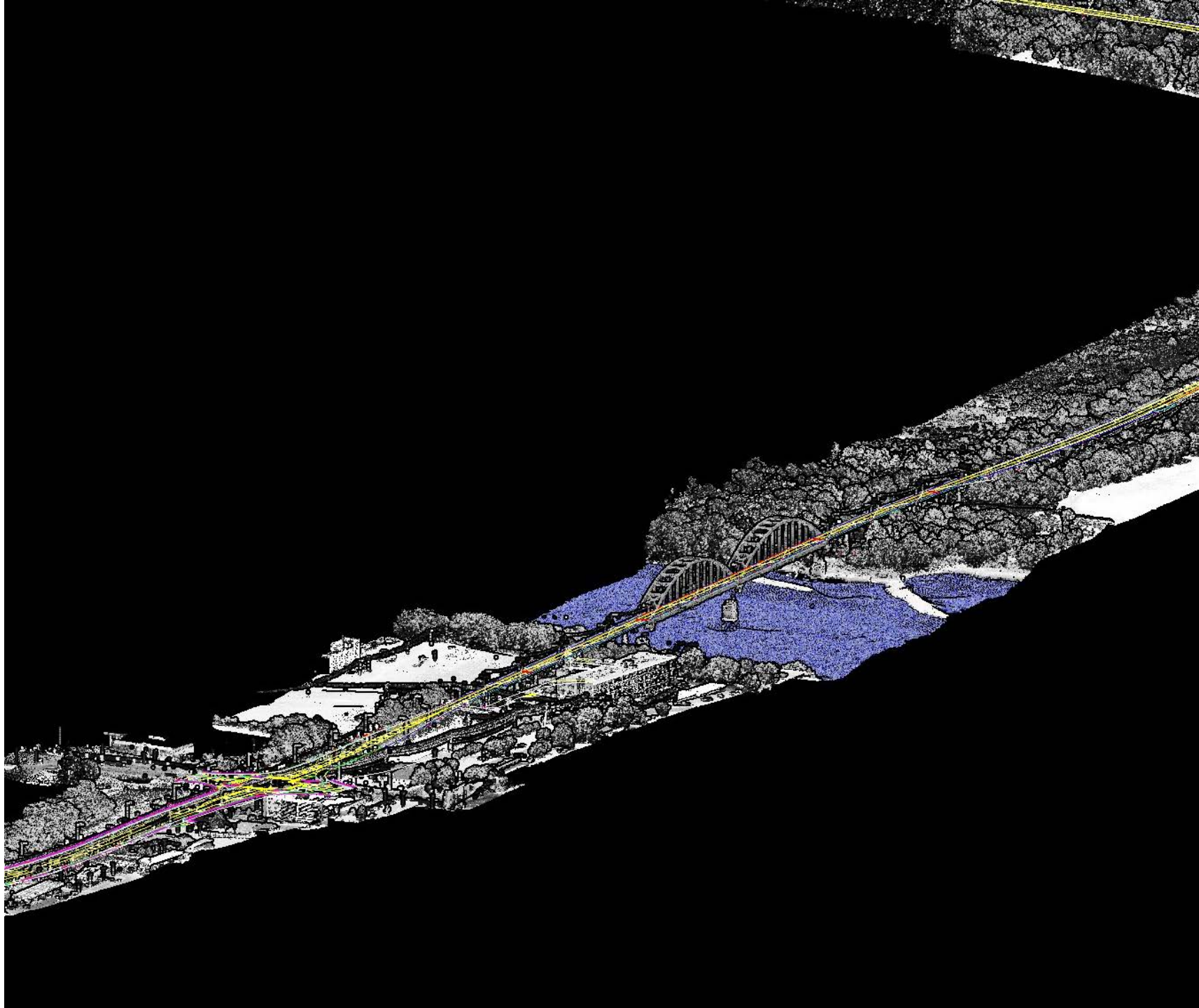
Missouri Bridge

Multi-Beam Sonar
UAV LiDAR
UAV Downward RGB Imagery
Mobile LiDAR – Truck
Mobile 360° Imagery



Missouri Bridge

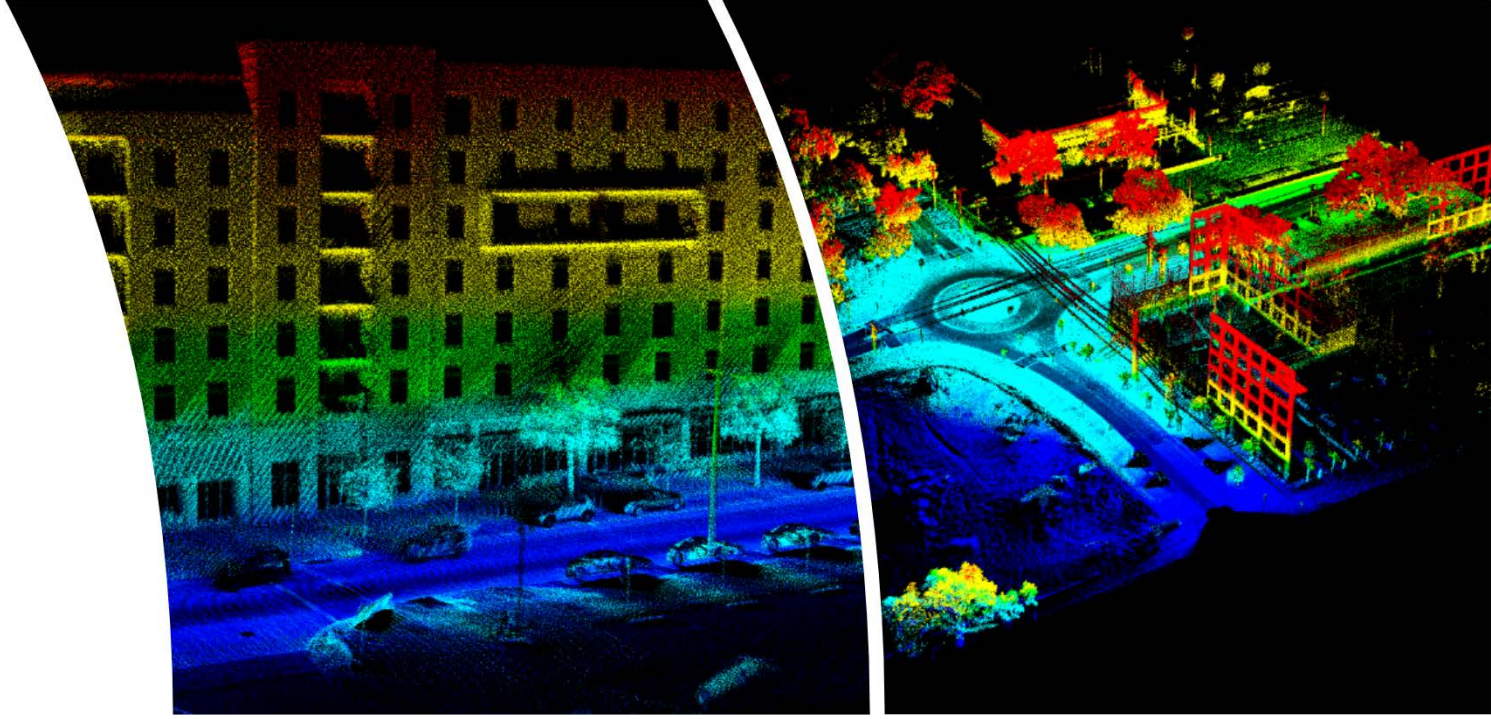
Multi-Beam Sonar
UAV LiDAR
UAV Downward RGB Imagery
Mobile LiDAR – Truck
Mobile 360° Imagery

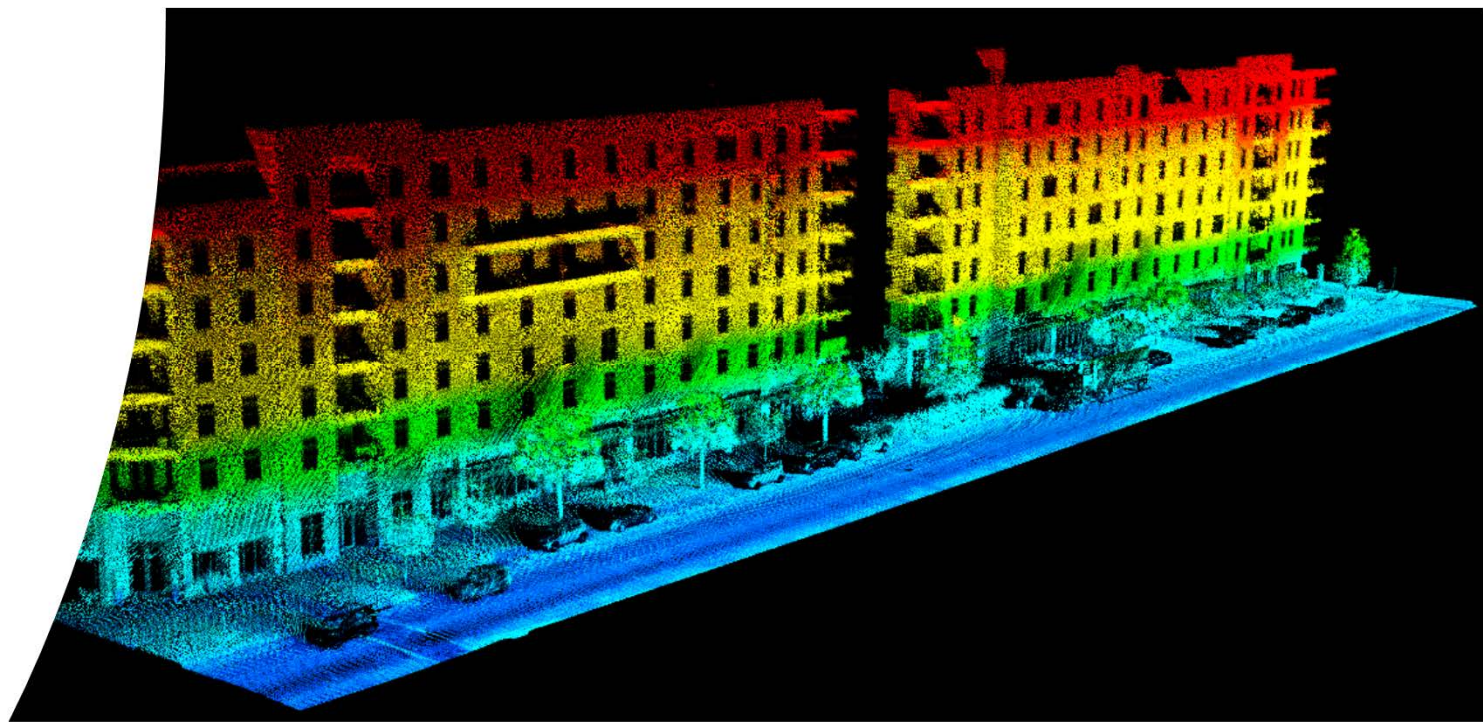


Reality Capture

Mobile LiDAR from Vehicles (Trucks, Boats, and ATVs)

- LiDAR Point Cloud of Tampa Streets
- Collected with LiDAR USA Snoopy System (HDL 32 with Novatel GPS and IMU)
- Navigation (IMU and GPS) data post processed in Inertial Explorer.
- LiDAR calibration, filtering, and noise reduction performed in TerraSolid.
- Building faces, overhead utilities, and tree drip lines.



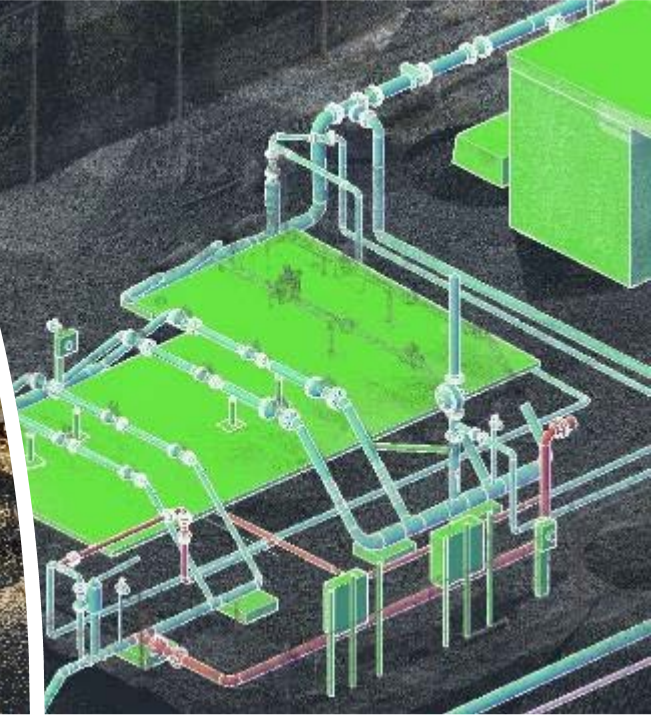


Mobile LiDAR Sebring Raceway

- LiDAR Point Cloud of Raceway for Video Game Creation.
- Imagery and Video Capture Along Route.
- Digital Twin Creation – Colorized point Cloud
- Virtual Reality

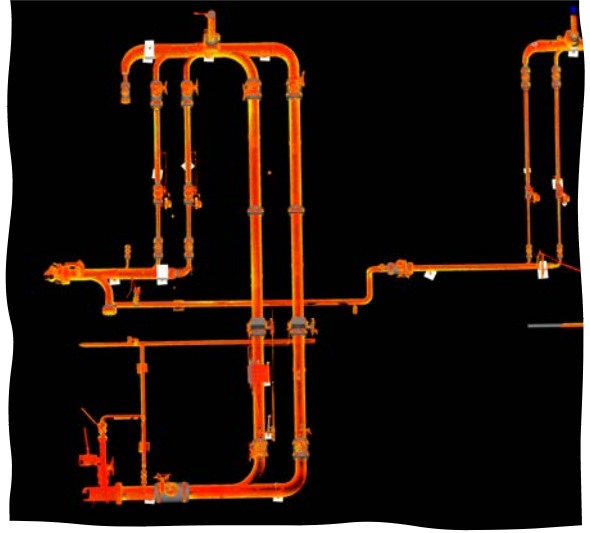
Digital Twin of Gas Transmission Gate Station

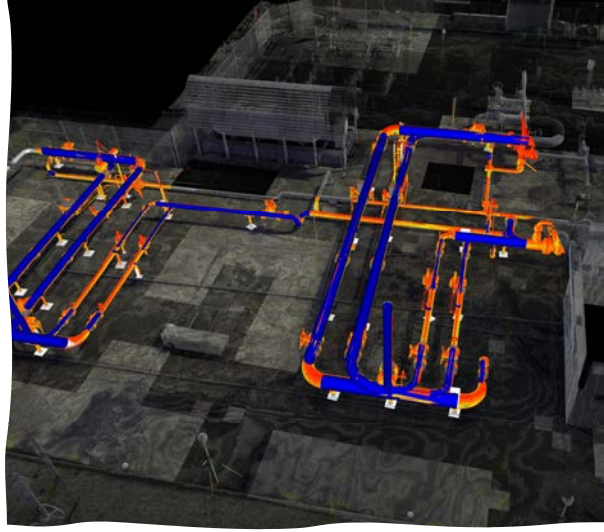
- Terrestrial LiDAR point cloud
- Subsurface Utilities
- 3D CAD Modeling
- Topographic Survey

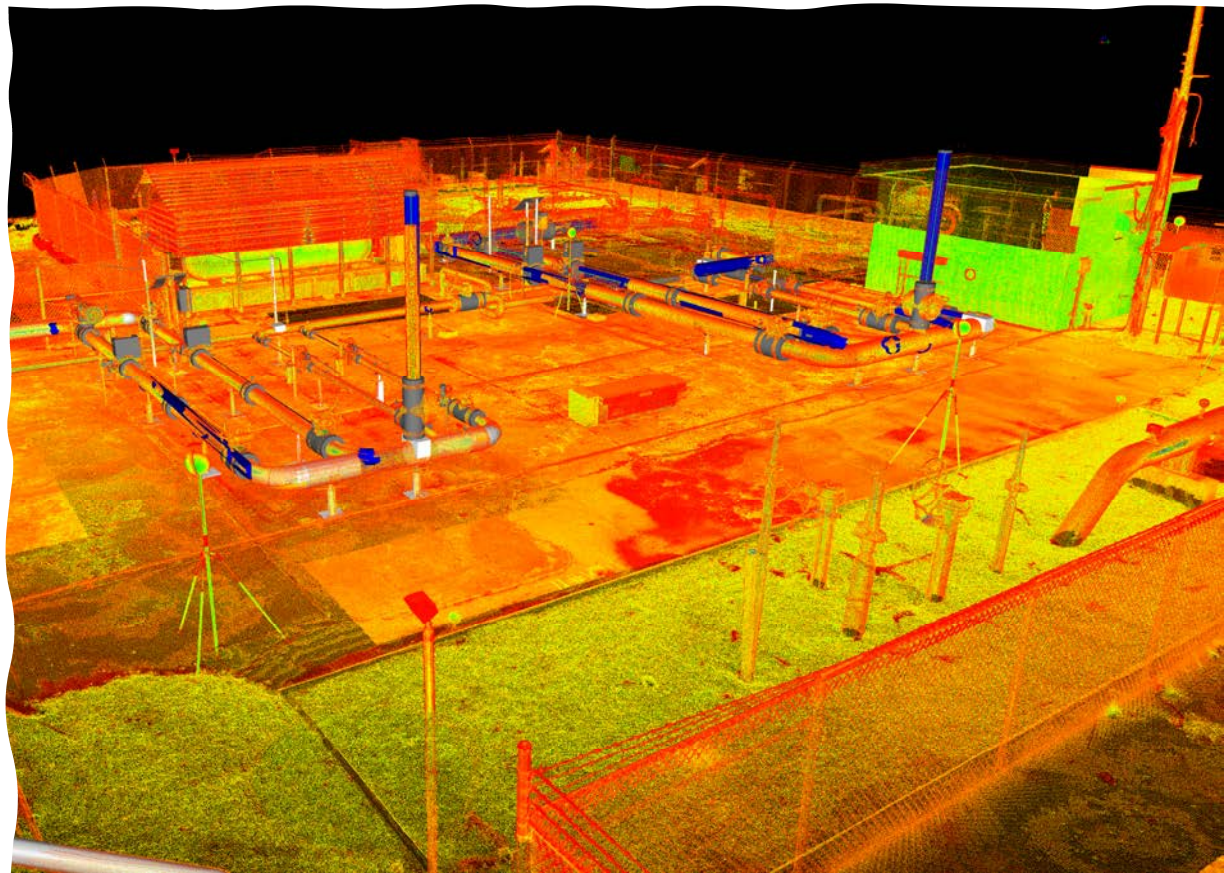


Digital Twin of Gas Transmission Gate Station

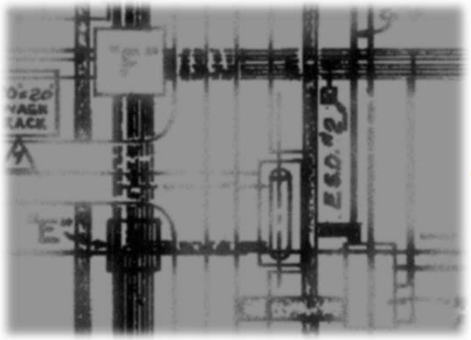
- Terrestrial LiDAR point cloud
- Subsurface Utilities
- 3D CAD Modeling
- Topographic Survey
- Point cloud
- AutoCAD 3D piping.



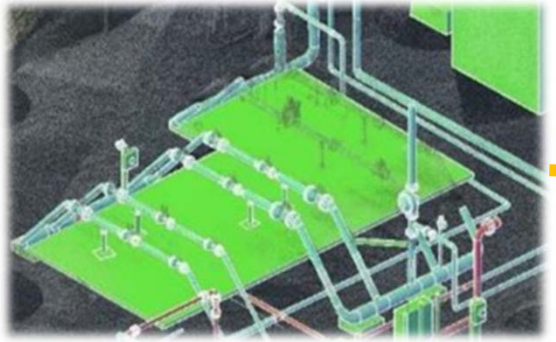




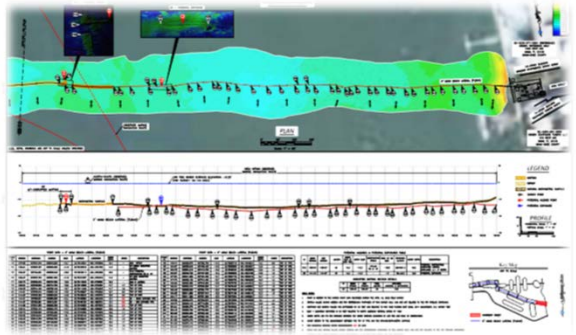
Example of a workflow: Records to BIM



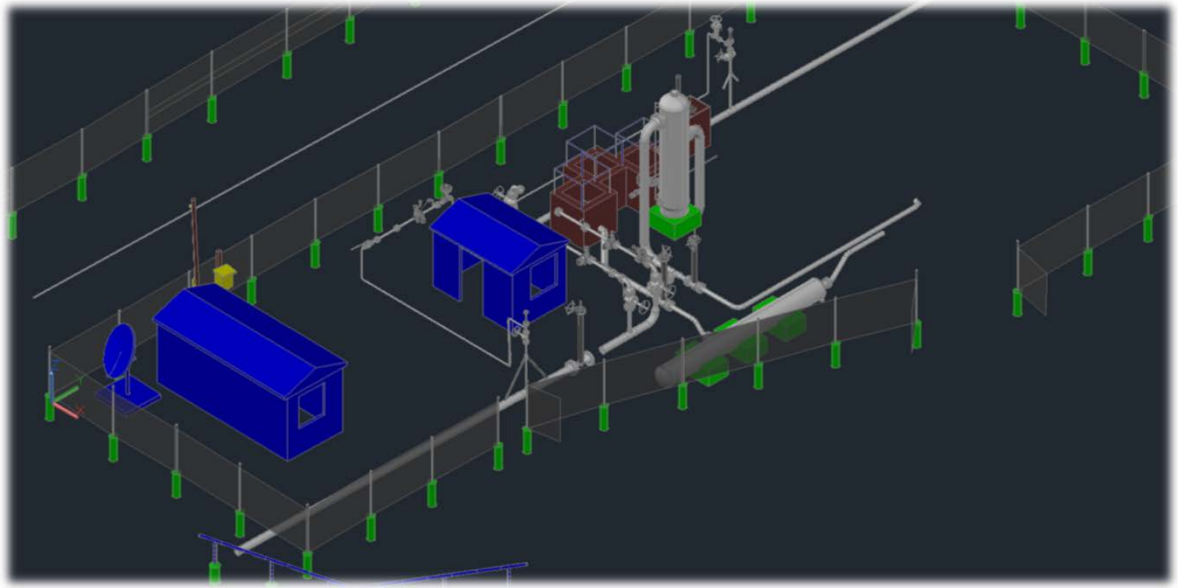
1. Review existing records



2. Data Acquisition: SUE, GPS, Terrestrial & UAV



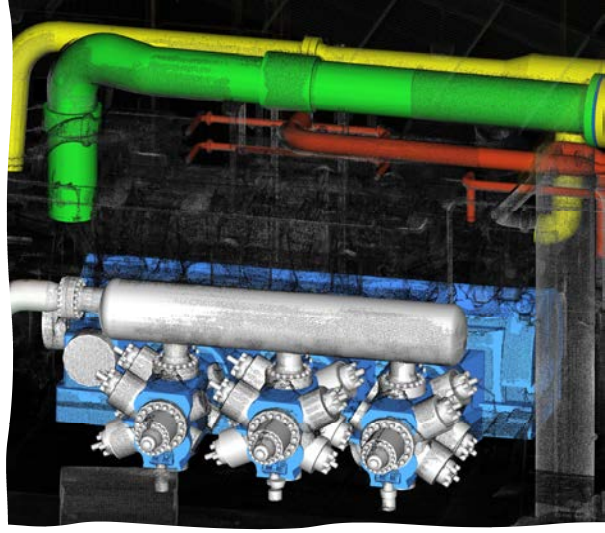
3. Land survey and SUE to verify records & fill in the gaps



4. Design-Ready BIM Model

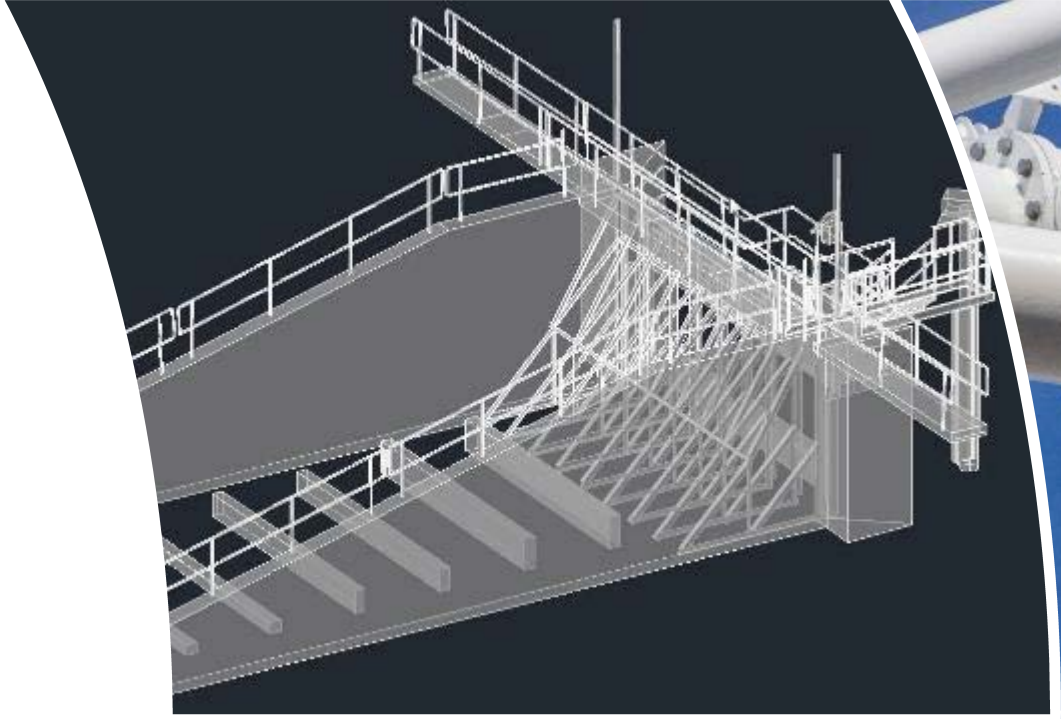
Digital Twin of Compressor Station

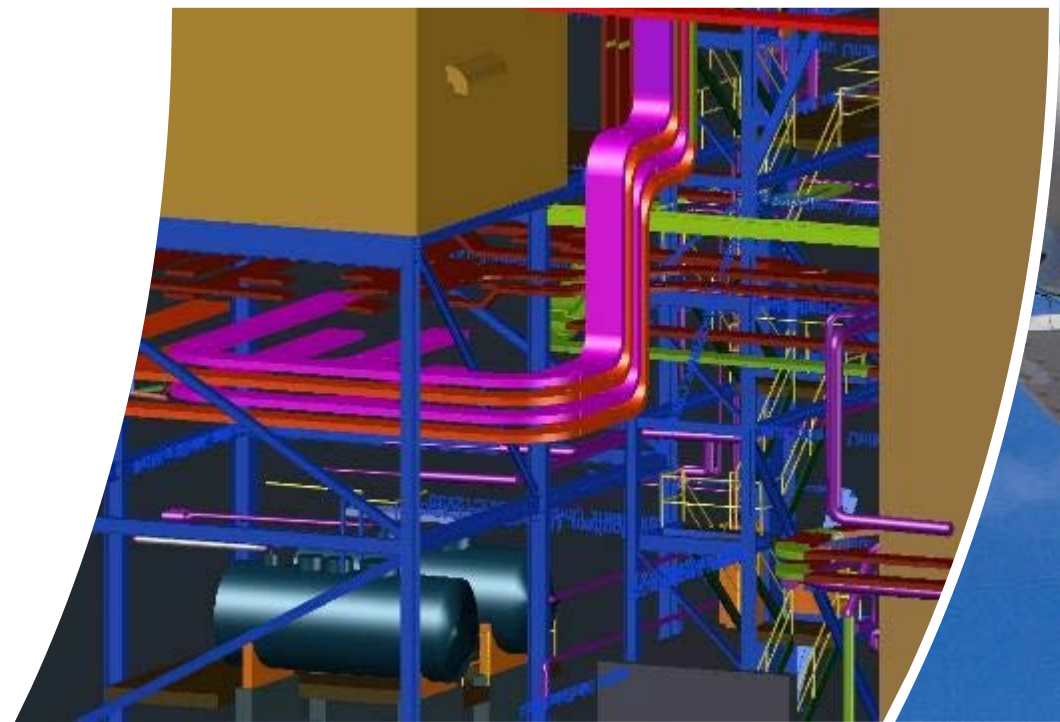
- Terrestrial LiDAR point cloud
- Subsurface Utilities
- 3D CAD Modeling
- Topographic Survey
- Point cloud
- AutoCAD 3D piping.



Digital Twin - Structures

- Terrestrial LiDAR
- Land Surveying
- Metrology

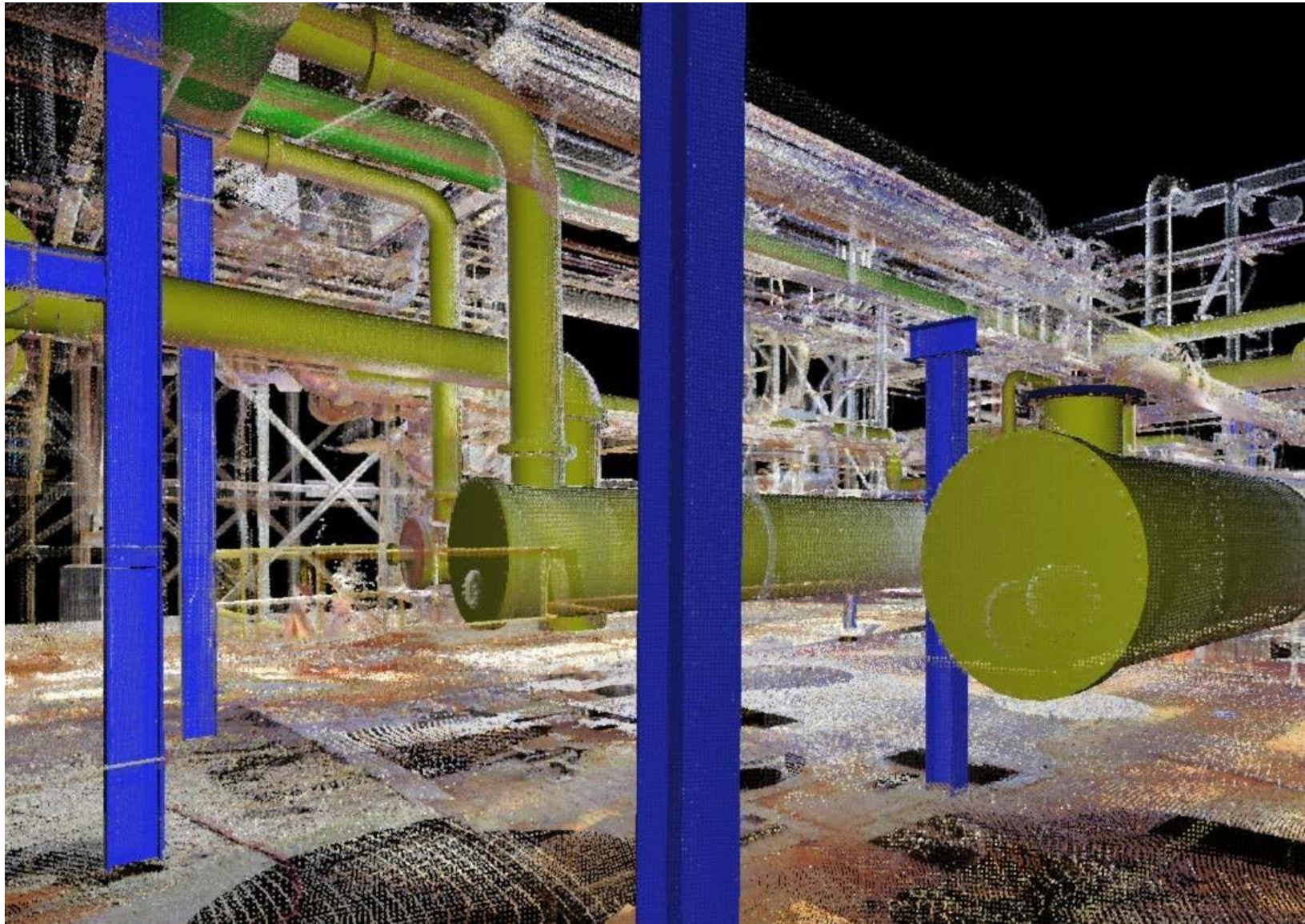




Terrestrial, Mobile and SLAM LiDAR

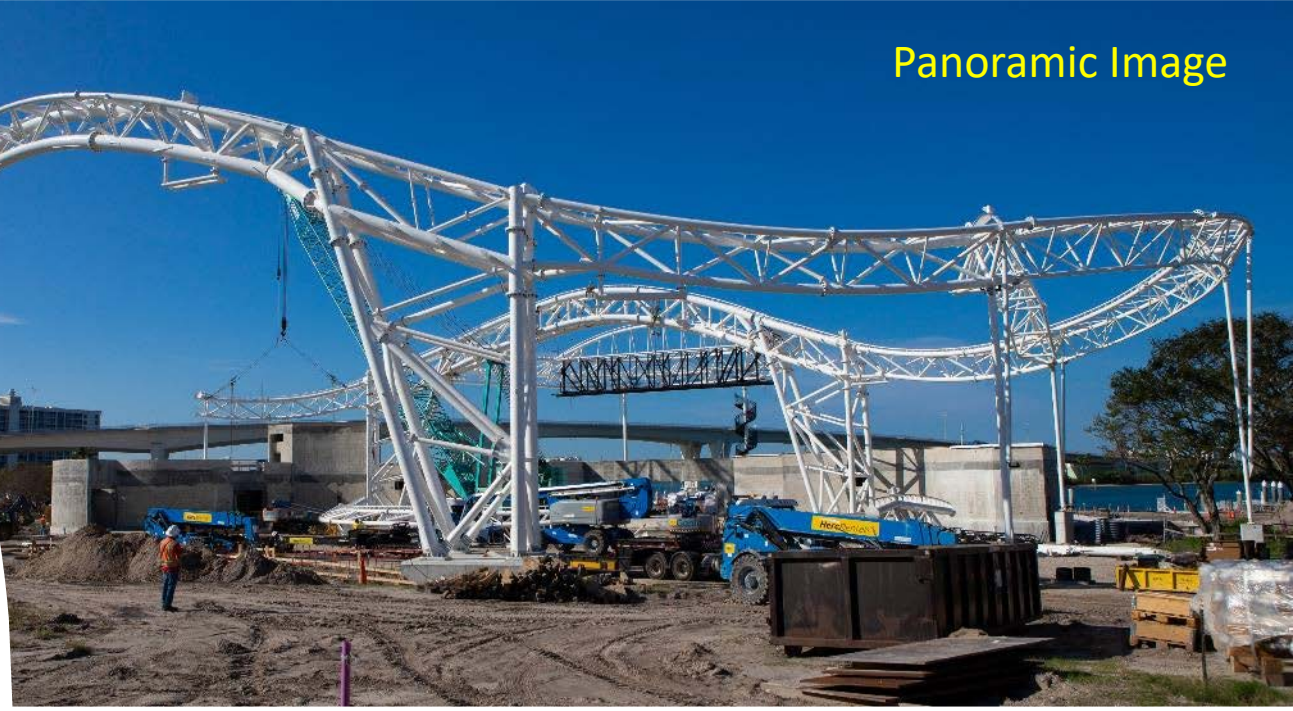
3D Scanning

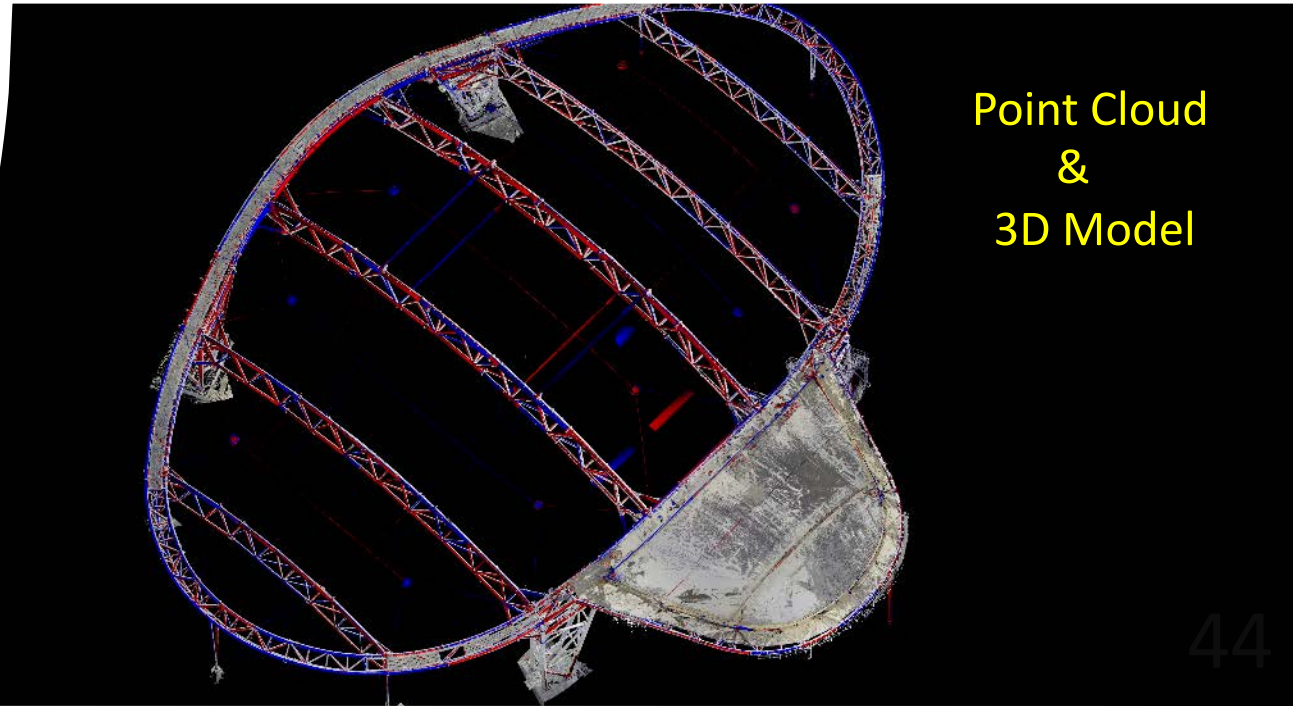
- Leica Cyclone
- TopoDOT
- AutoCAD
- MicroStation
- LFM
- Bricscad
- Revit



Reality Capture

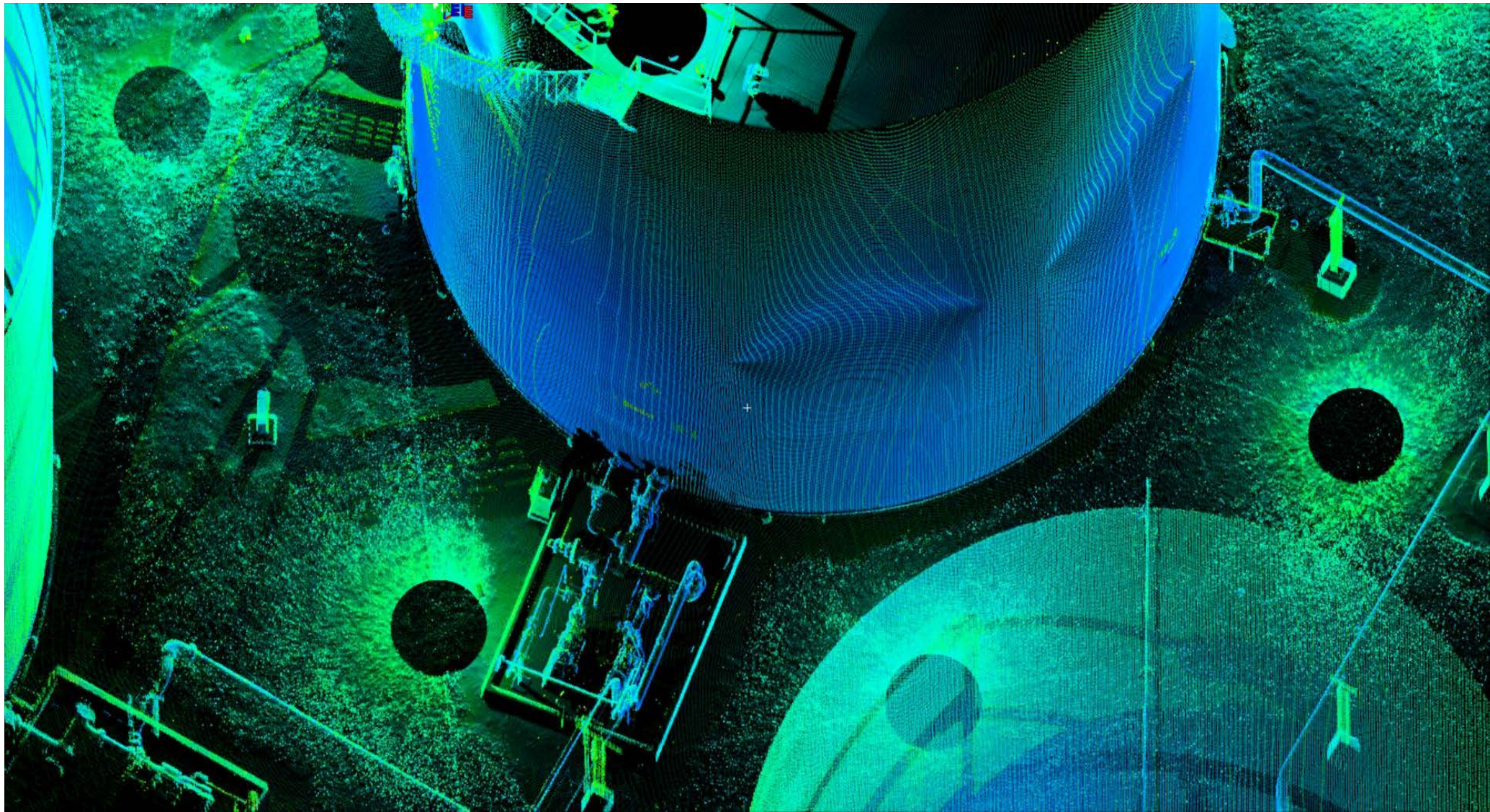
- Land Surveying – Hundredths of a Foot Accuracy; Density – feet.
- Terrestrial Scanning – Millimeter Accuracy; Density - Millimeters
- SLAM Scanning – Centimeter Accuracy; Density - Millimeters
- Metrology – Ten-Thousandths of an Inch Accuracy; Density – Feet or Millimeters depending on equipment.





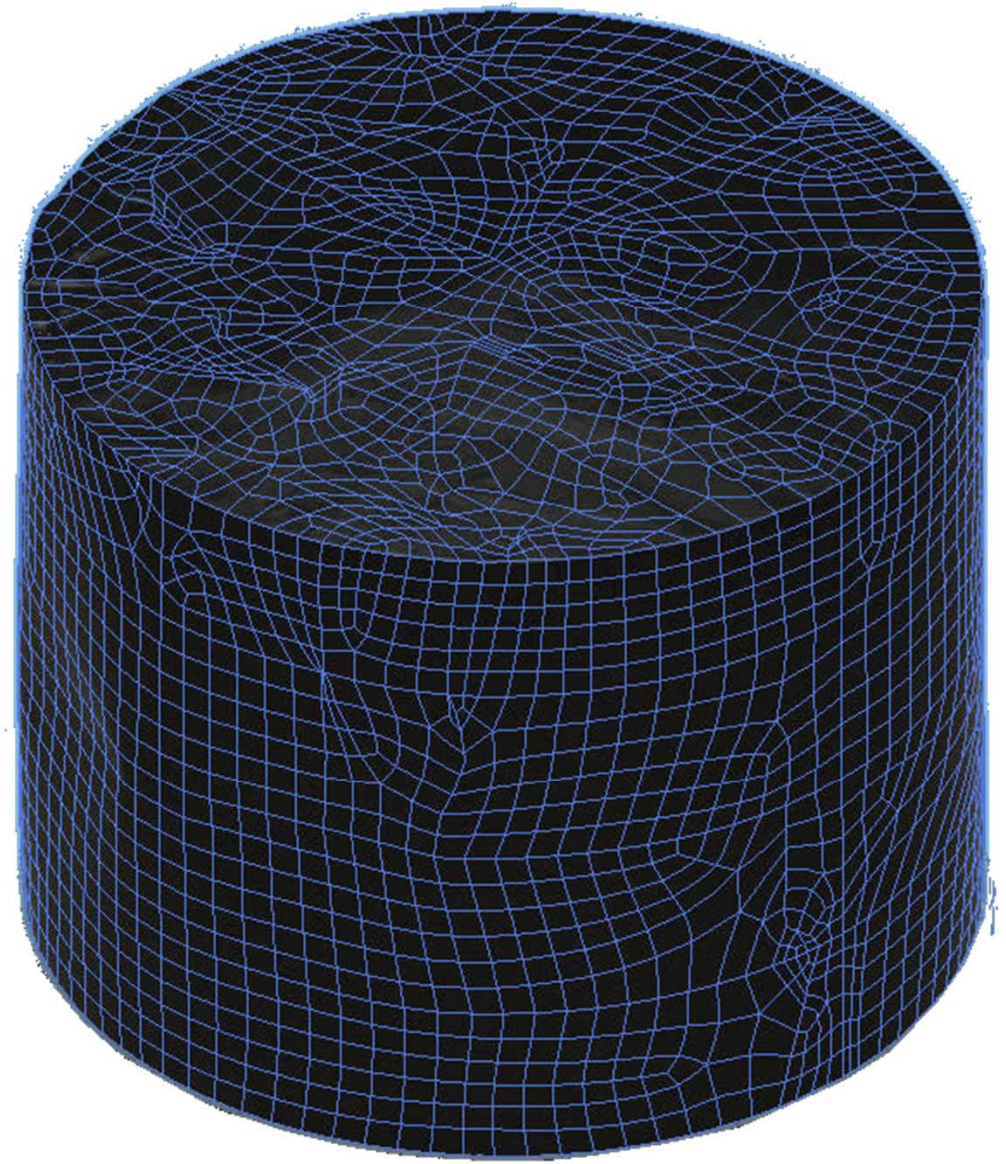
Reality Capture

- Storage Tanks



Reality Capture

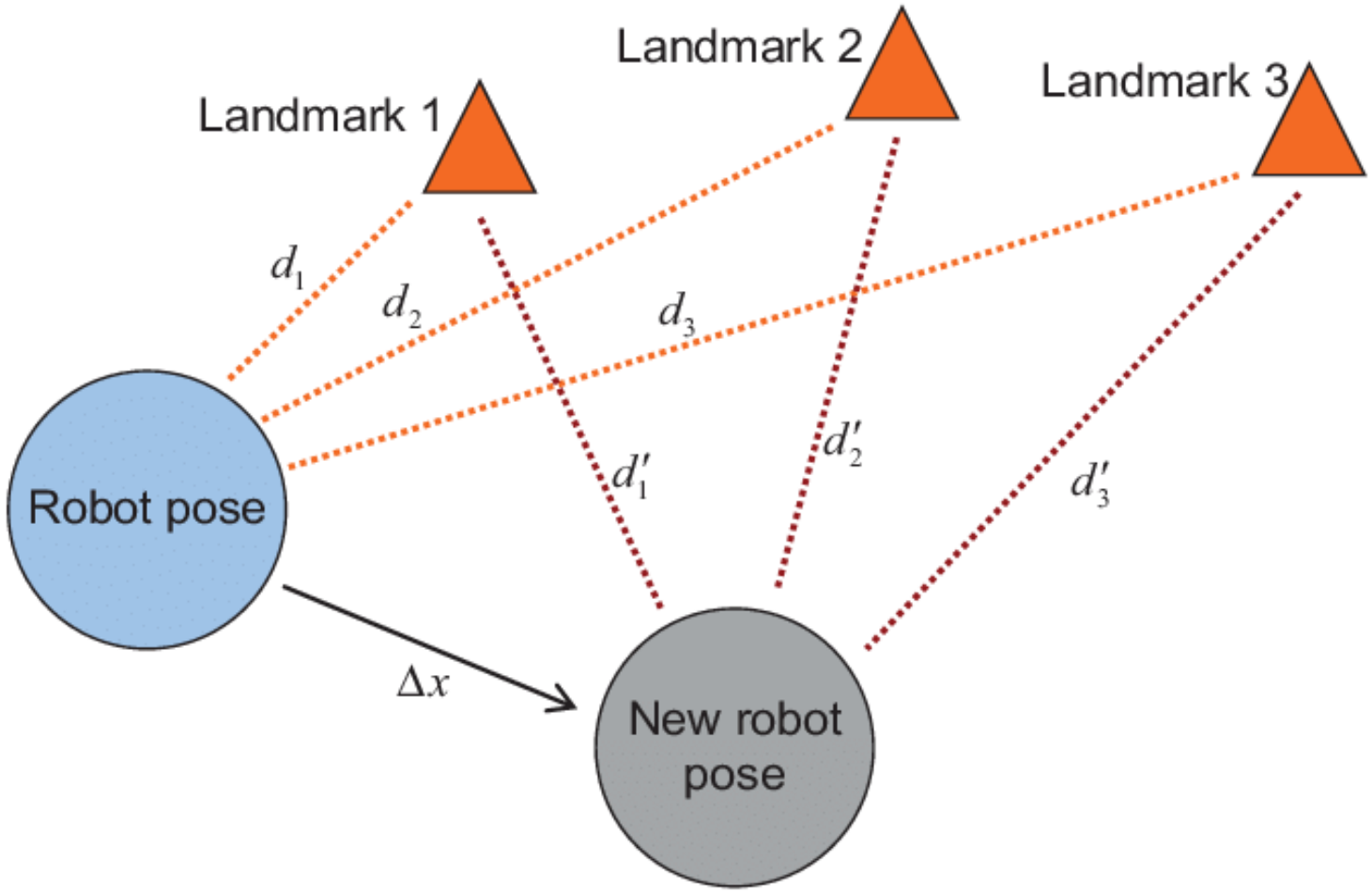
- Storage Tanks
- T-Mesh for Finite Analysis of the Tank
- Will it fail when refilled?



Reality Capture – SLAM LiDAR

INDOOR MOBILE LIDAR MAPPING WITH SLAM ALGORITHM

- HOW DOES IT WORK?
- LOOKS FORWARD AND BACK.
- DETERMINES LANDMARKS IT'S ALREADY SCANNED.
- REFERENCE THE SCAN BASED UPON THE POSITION OF THE LANDMARK FROM THE PREVIOUS SCAN.
- POST PROCESSING IS 12:1 (12 HOURS OF PROCESSING FOR 1 HOUR OF COLLECTION)
- SLAM ANCHORS – HORIZONTAL AND VERTICAL CONTROL POINTS THAT TIGHTEN UP ACCURACY.



Reality Capture – SLAM LiDAR

- BMW Auto Manufacturing Facility
  - 12 Million Square Foot of Buildings
  - Some buildings had as high as five stories.
  - Coordinate Structure (Plant & State Plane)
  - Terrestrial LiDAR (3D Scanning) with 360° Imagery
  - SLAM LiDAR with 360° Imagery
  - 3D Point Cloud
  - Digital Twin hosted on IVION Cloud
  - Facial Blurring and Removal of Proprietary Information
  - Up to 200,000 square feet of collection per day.

360° IMAGERY

SLAM DERIVED LIDAR POINT CLOUD

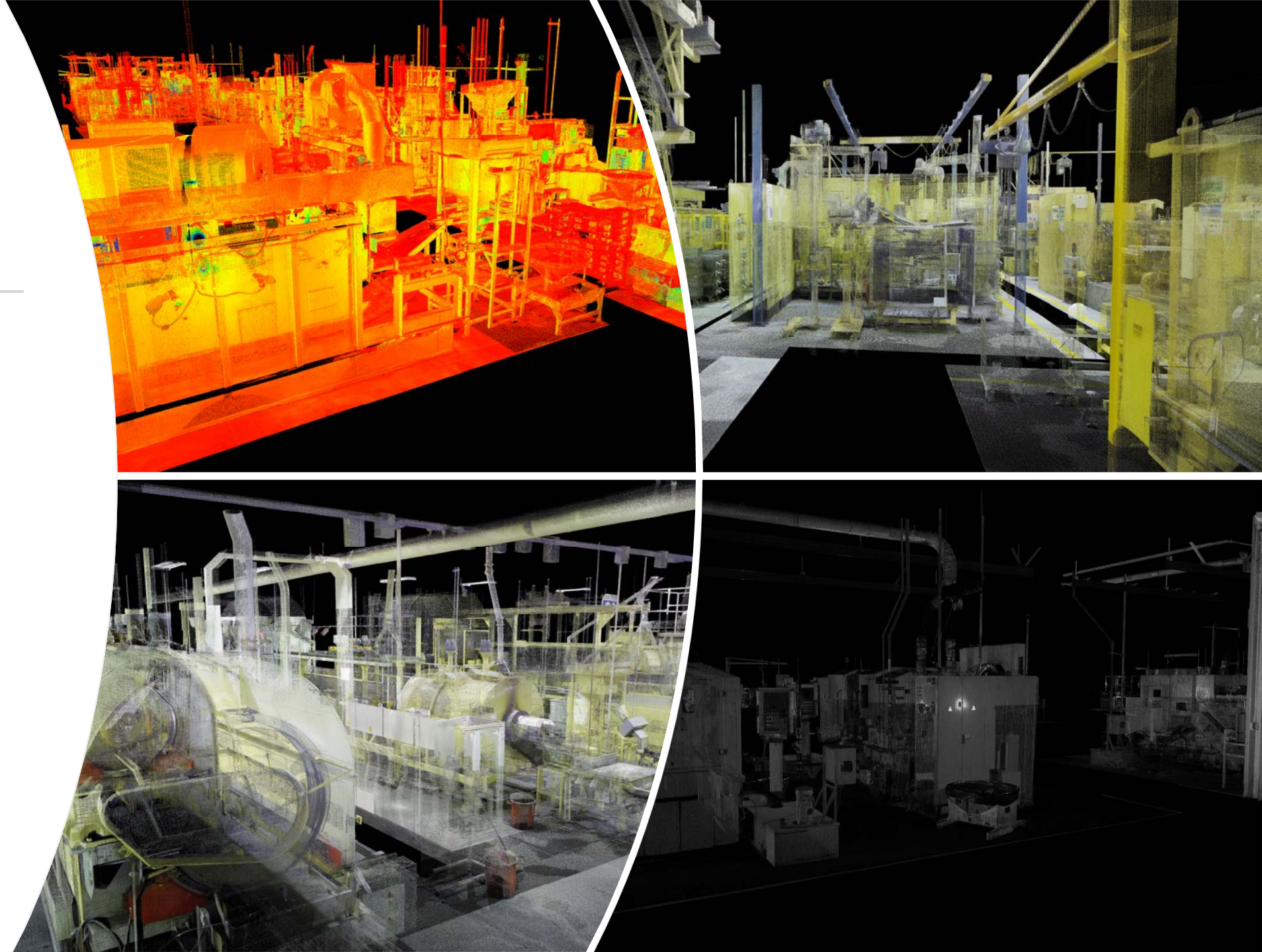
TRANSITION FROM LIDAR TO IMAGERY

Digital Twin - Power Transmission Sub Station

- SLAM LiDAR with NavVis VLX
- Colorized Point cloud

Digital Twin-Manufacturing Facility

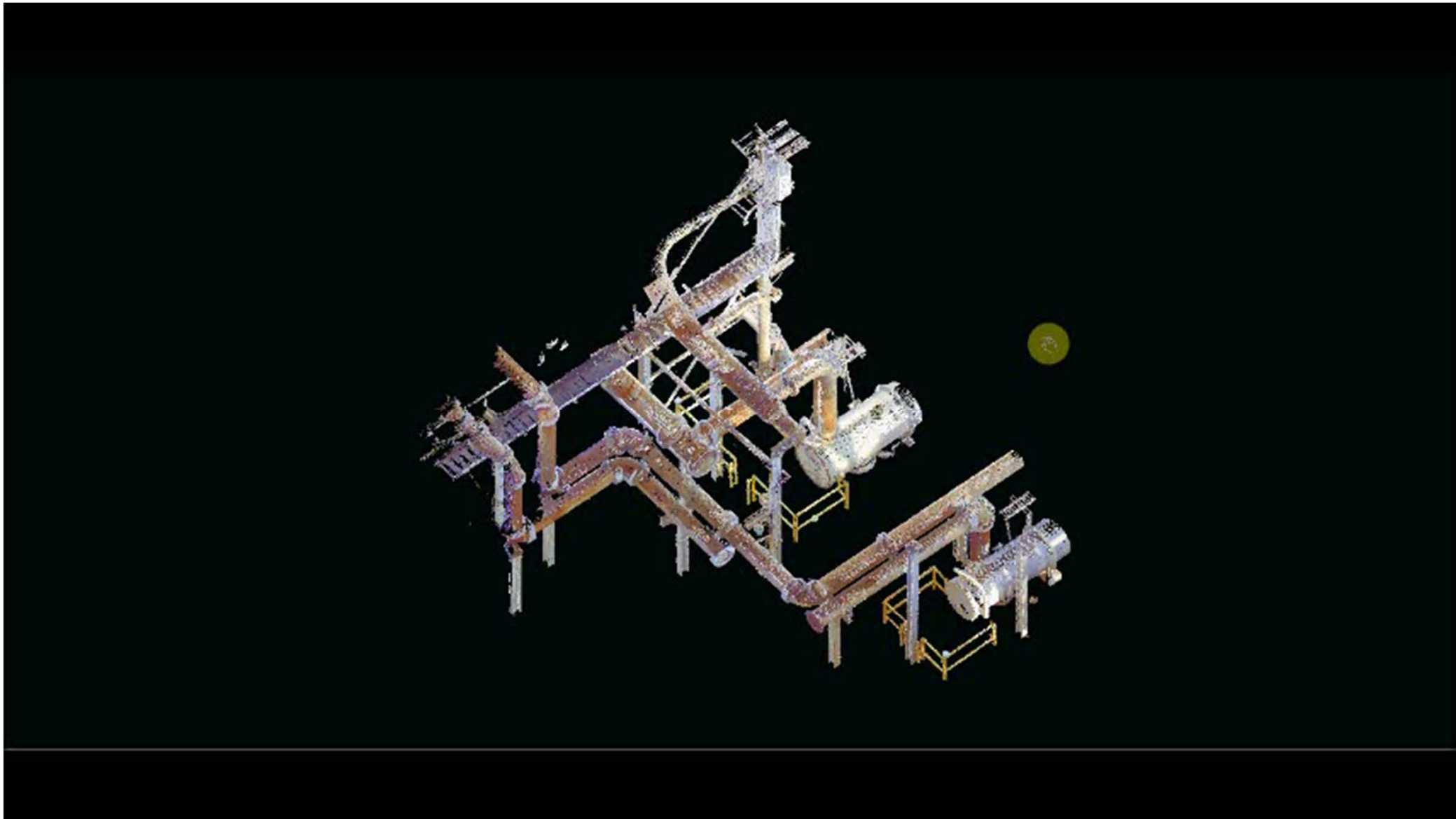
- SLAM LiDAR with NavVis VLX
- Colorized Point cloud



Digital Twin- Industrial Plant

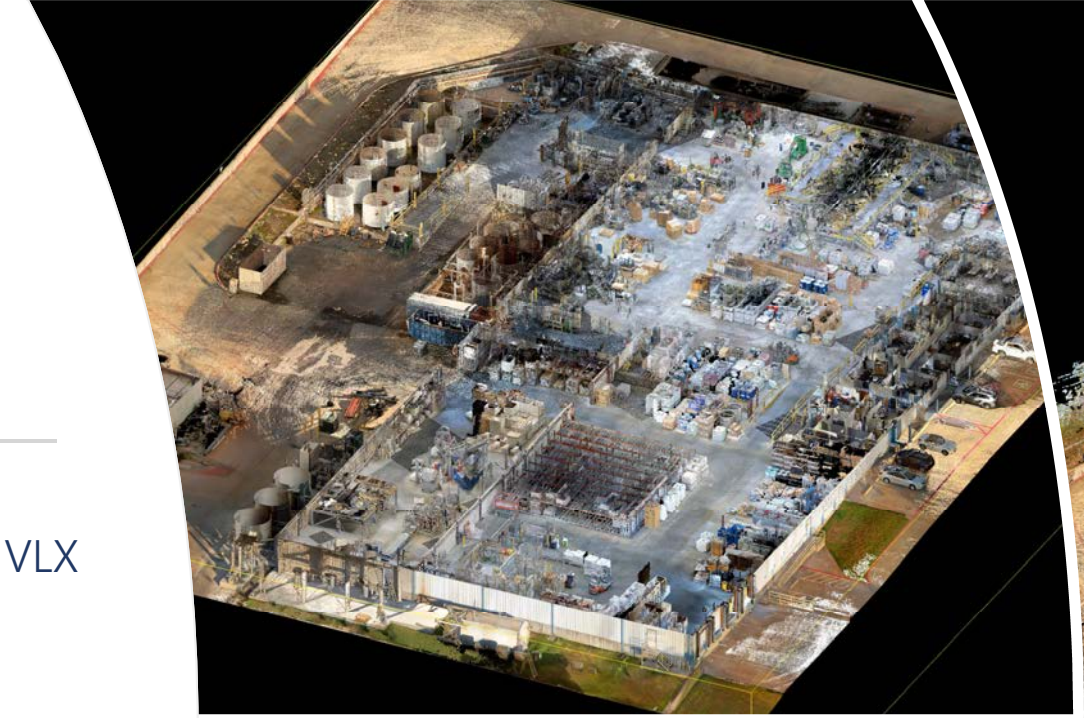
- Terrestrial LiDAR
- SLAM LiDAR with NavVis VLX
- Land Surveying
- Colorized Point cloud
- Level of Detail

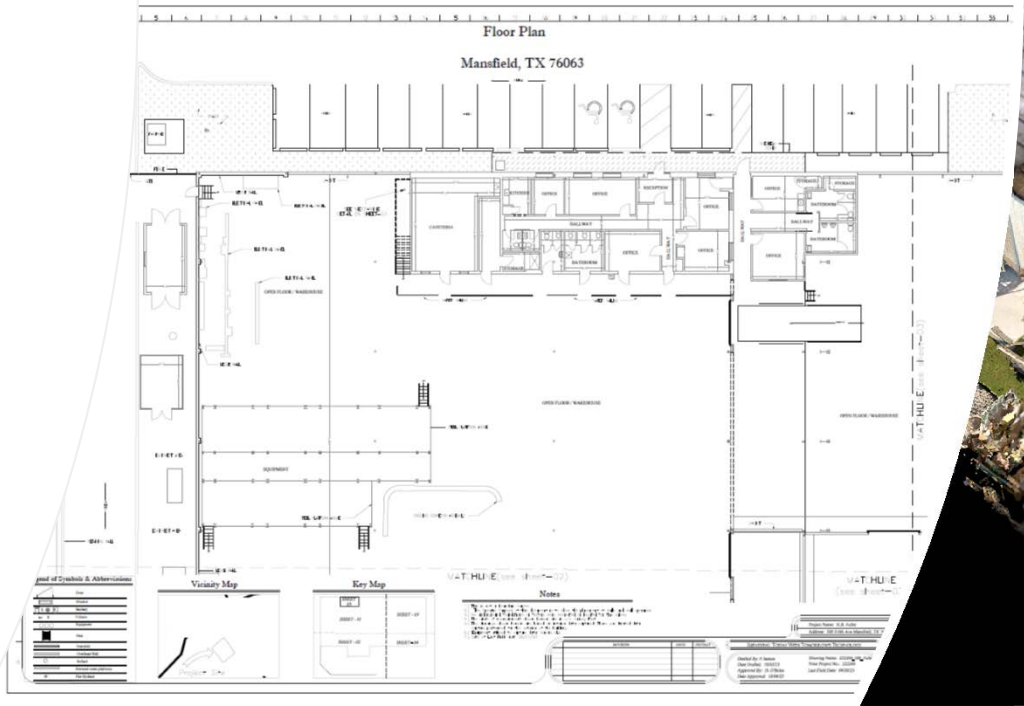
Digital Twin Creation – 3D Modeling

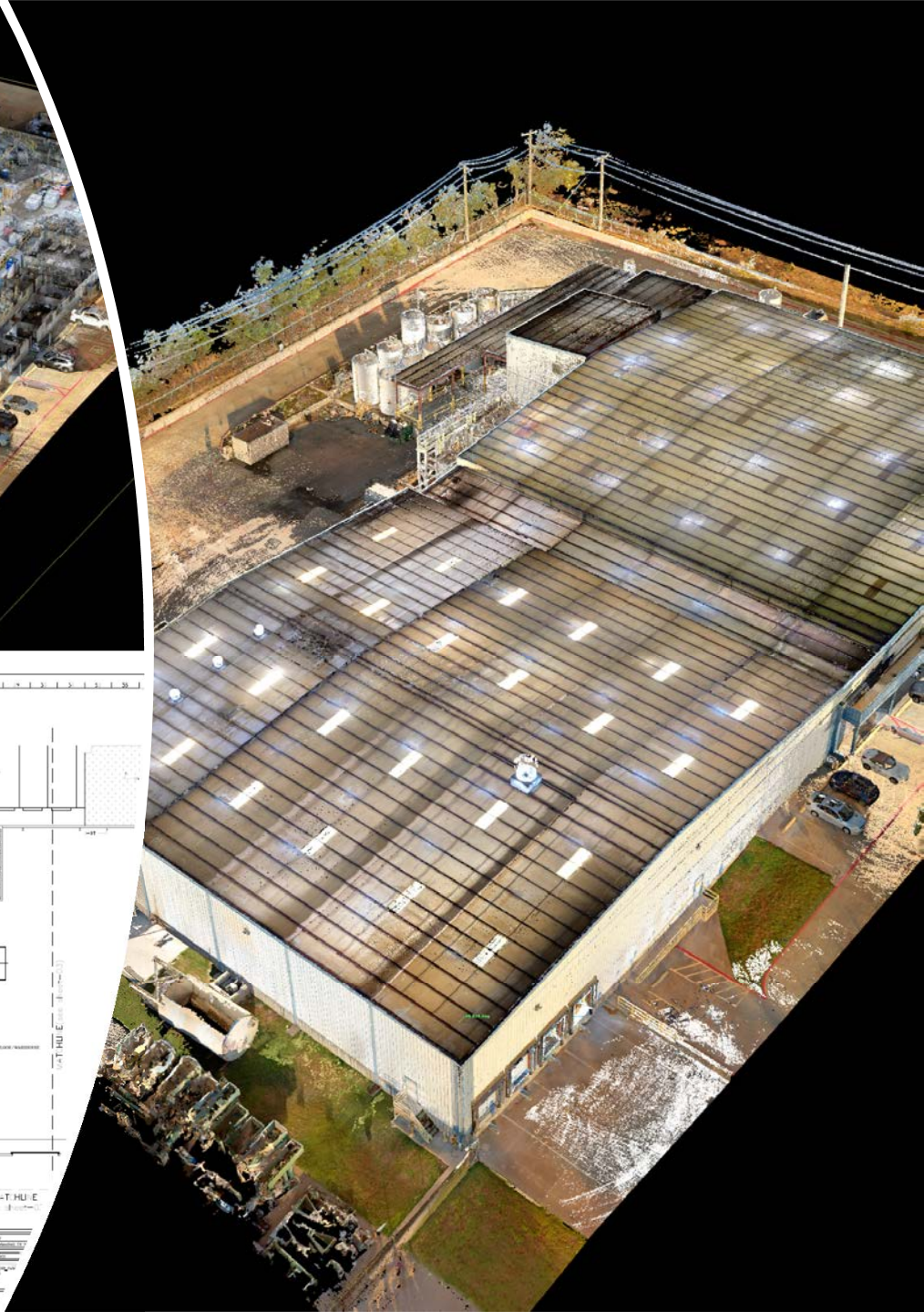


Digital Twin- Industrial Plant

- Terrestrial LiDAR
- SLAM LiDAR with NavVis VLX
- Land Surveying
- Colorized Point cloud
- Level of Detail
- 2D Floor Plan

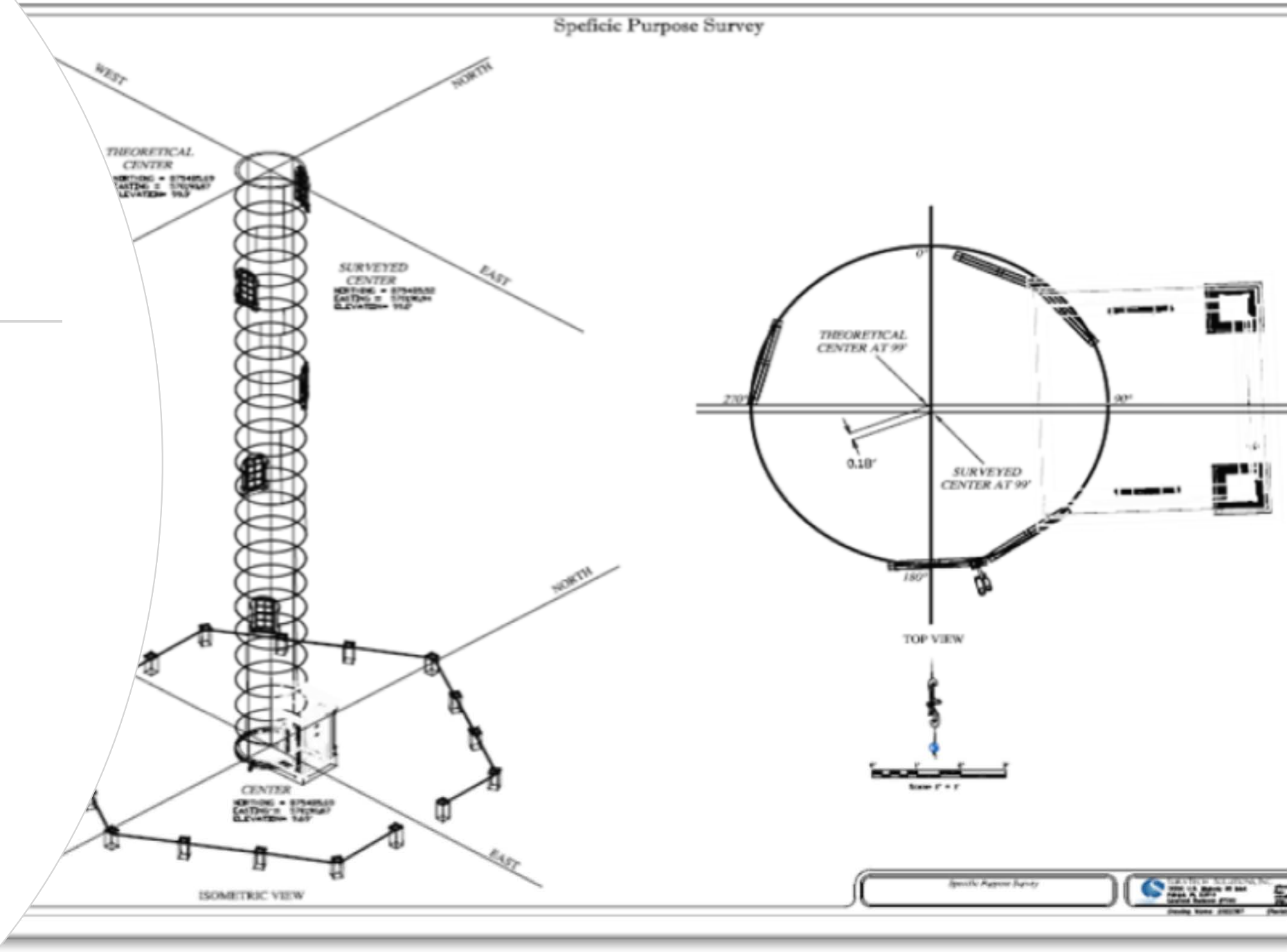






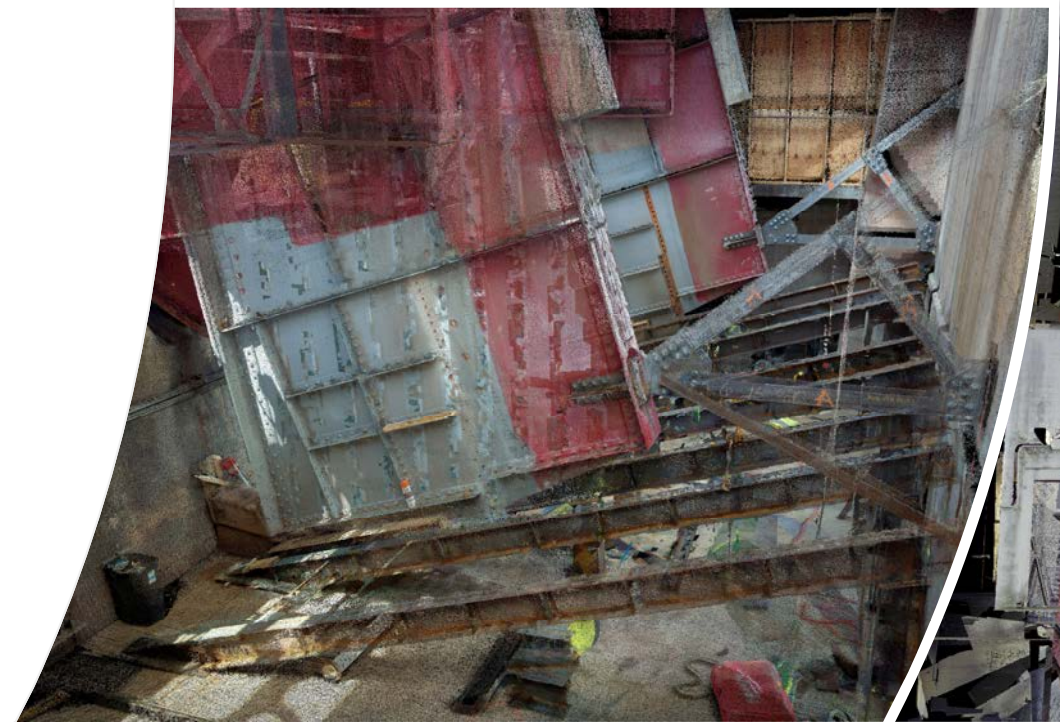
Digital Twin- Light House

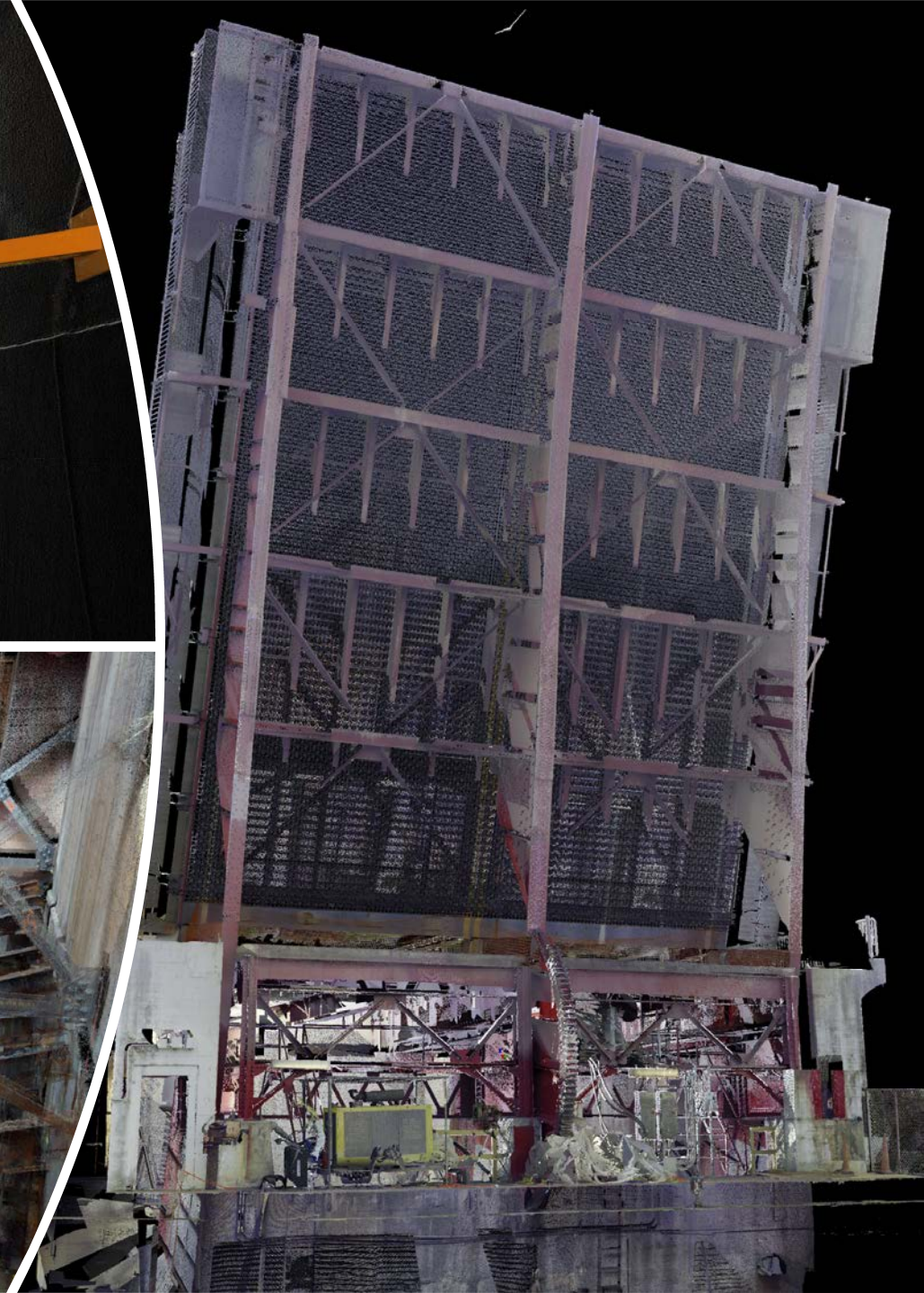
- Verticality
- Deformation



Digital Twin - Drawbridge

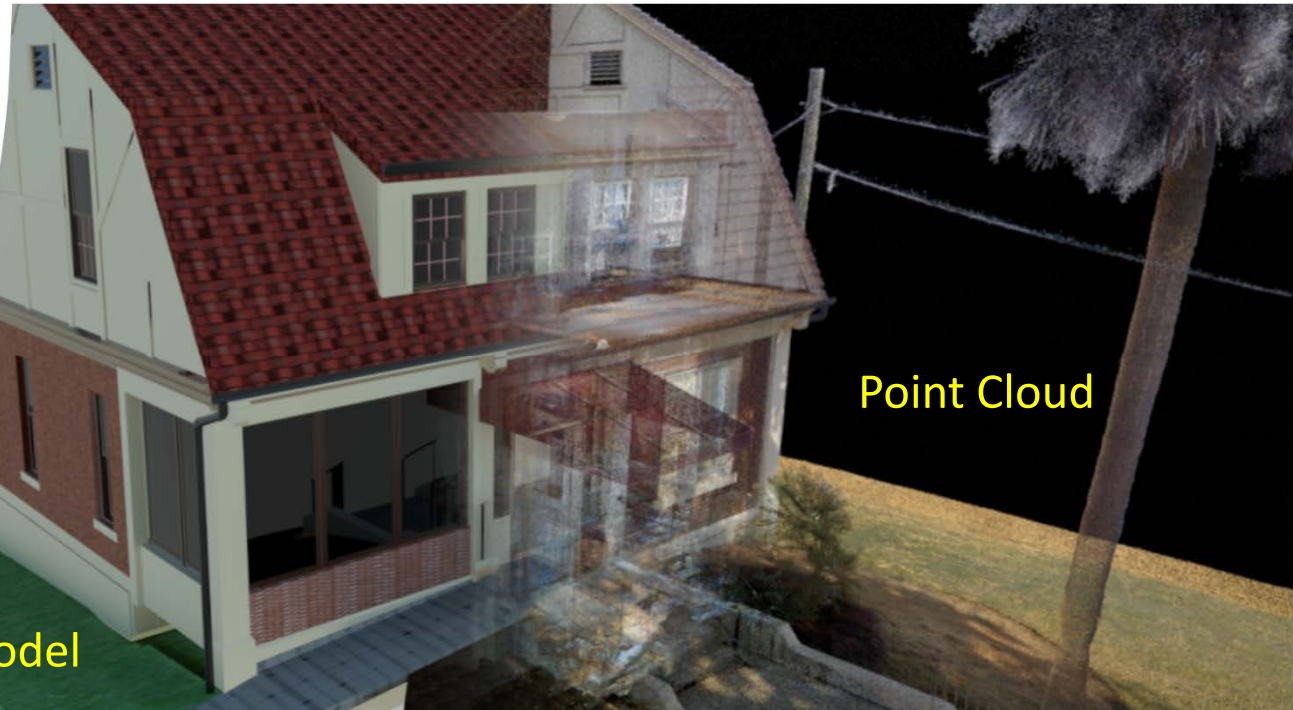
- Terrestrial LiDAR
- SLAM LiDAR with NavVis VLX
- Land Surveying
- Metrology
- Colorized Point cloud
- Level of Detail
- 3D AutoCAD deliverable.
- Bridge alignment





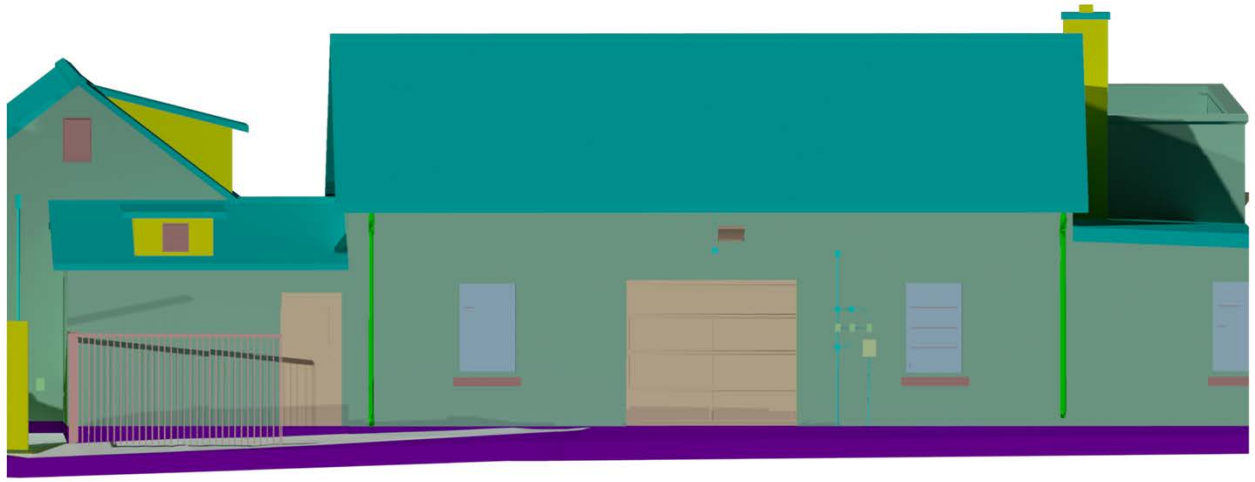
Digital Twin Data Fusion
Scan to BIM (REVIT)

- Terrestrial LiDAR
- SLAM LiDAR (Mobile Shoulder Mount)
- Land Surveying – 3D Control
- Bottom photo – 3D Model from Point Cloud / Point cloud transition.
- Data can be viewed like a 360° image.
- Model accurately created from Point Cloud
- Accurate measurement data can be obtained.
- Notes and data can be added.
- Asset Management.
- Augmented Reality compatibility.
- BIM (Building Information Model) - REVIT

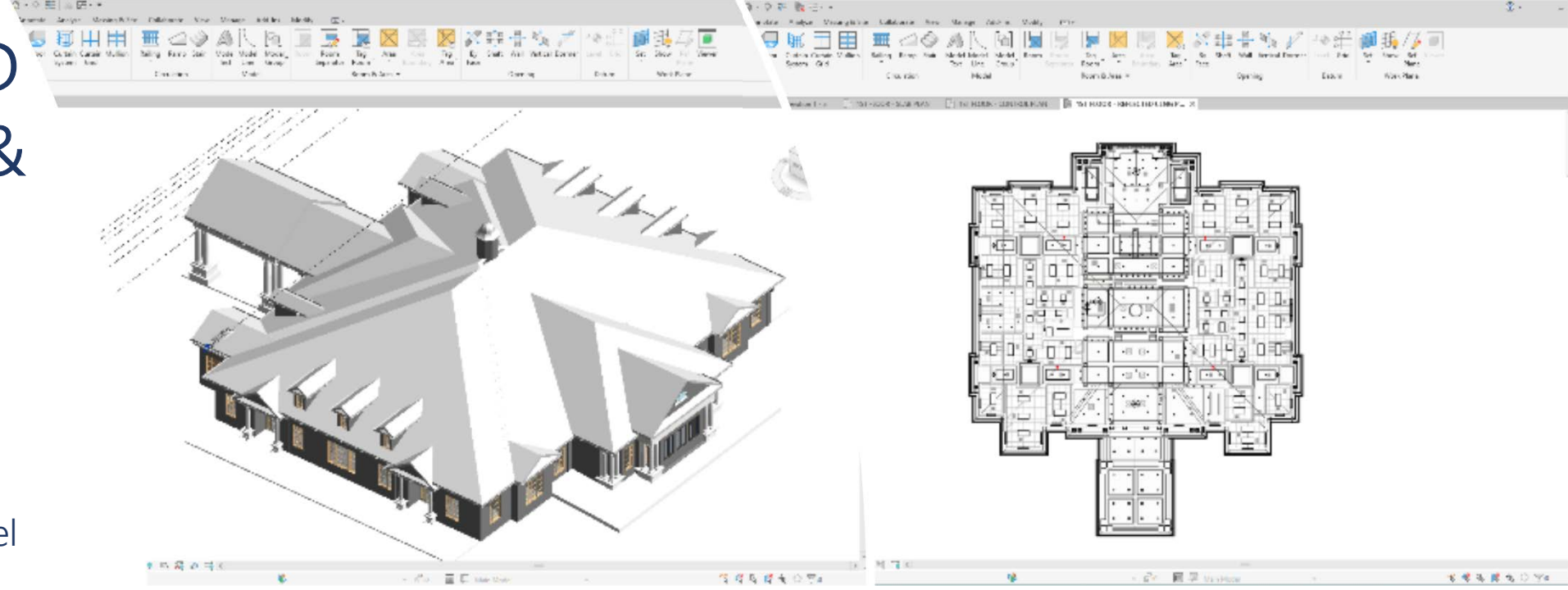


Digital Twin Data Fusion

Scan to BIM (REVIT)



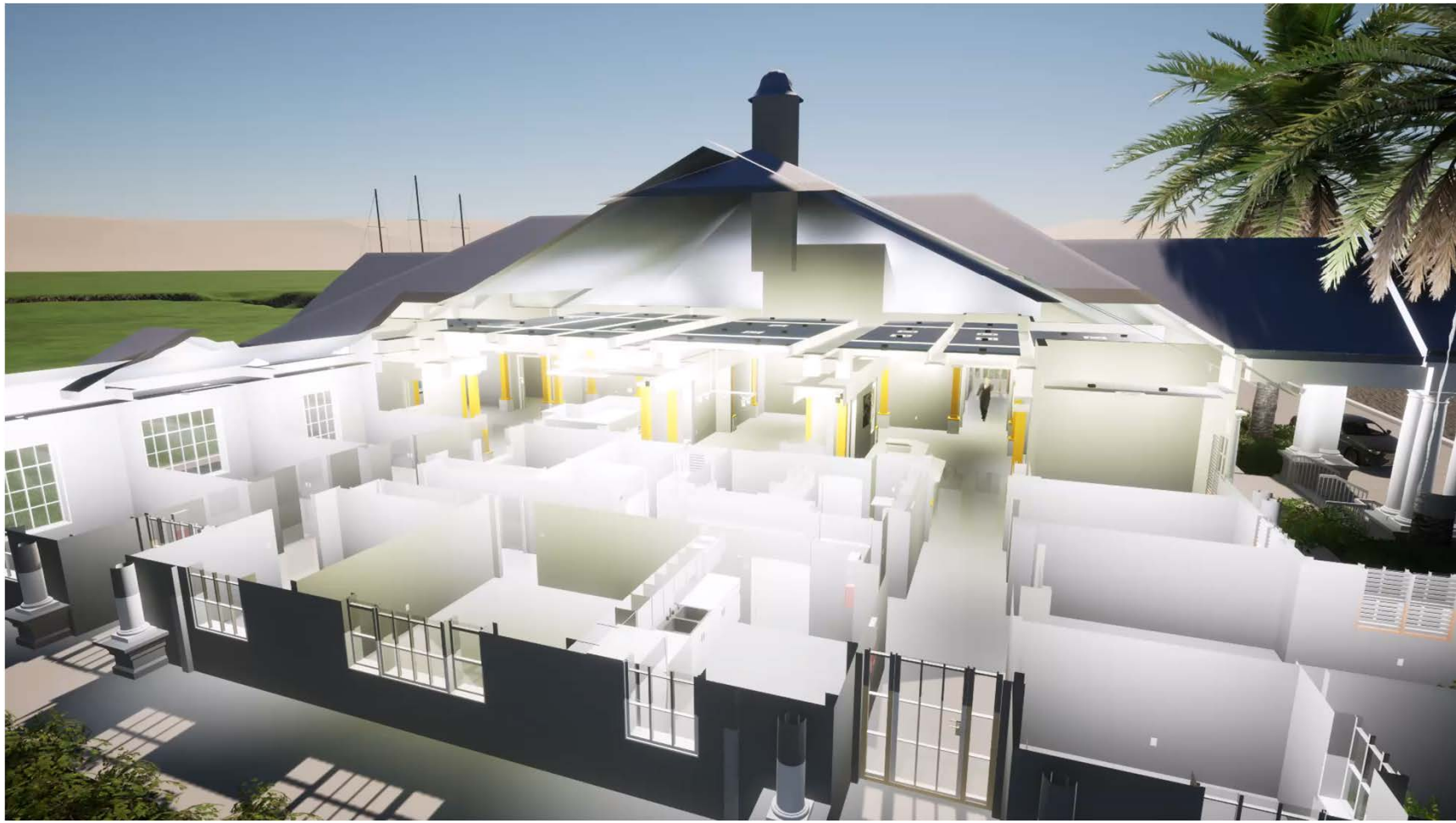
Digital Twin – 3D Modeling (BIM & CAD)



- Colorized Point Cloud
- Survey, Cloud, and 3D Model Combined
- Full Digital Twin Creation
- Scan to BIM (REVIT)
- Virtual Reality
- Emergency responders will be able to view government buildings through immersive technology.
- Floor plans
- Planning, maintenance, and emergency response tools.

Digital Twin – Virtual 3D Walkthrough

- Virtual walkthrough showing a cut out of the walls, presenting the floor layout.

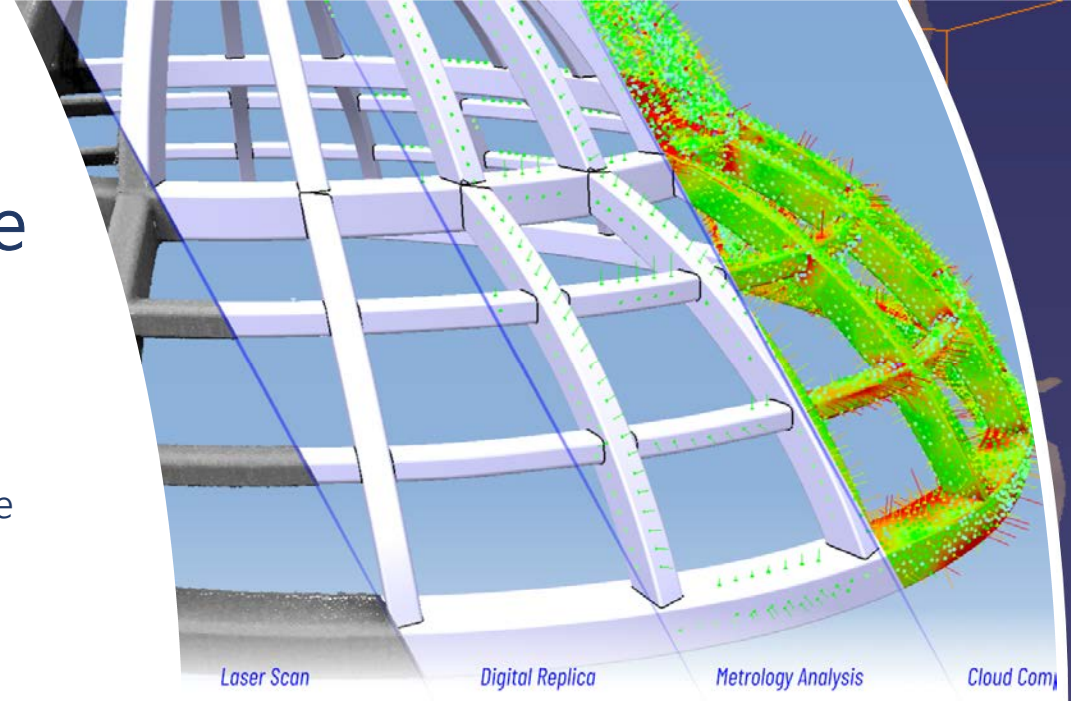


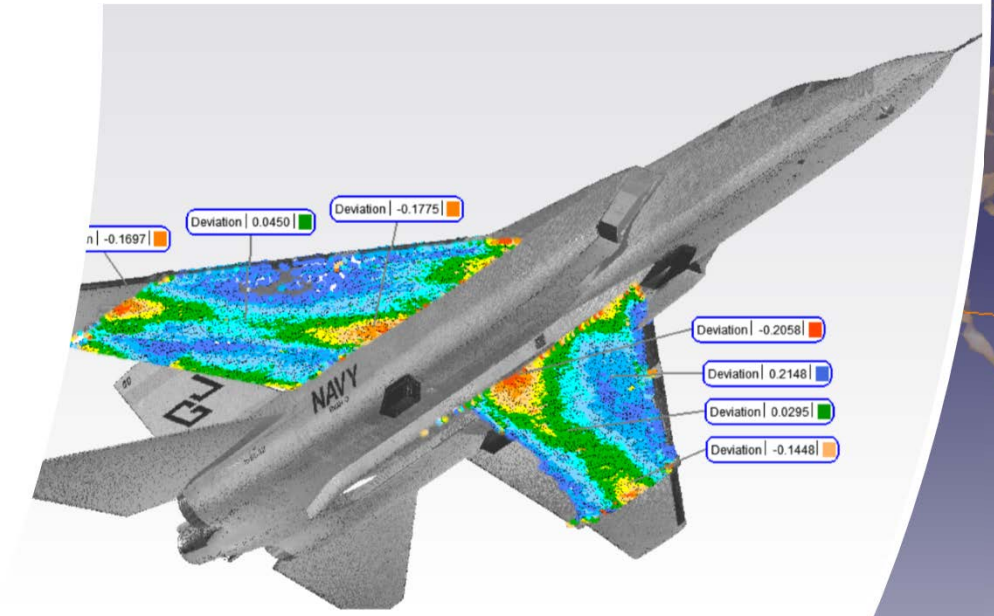
Digital Twin – Virtual 3D Walkthrough

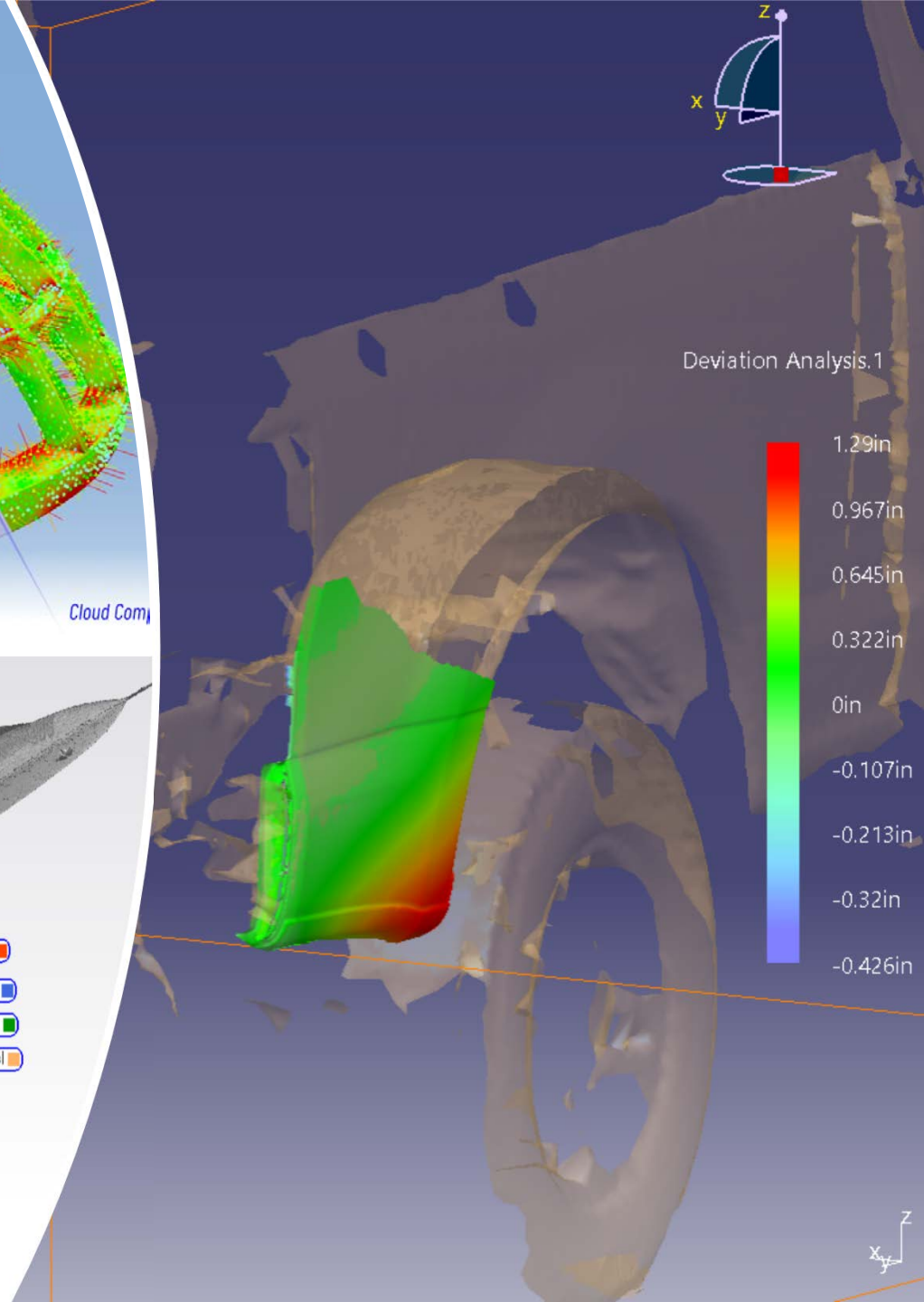
- Virtual walkthrough showing asset perspective

Digital Twin Reverse Engineering

- Utilizing advanced aerospace software saves time while enhancing accuracy.
- Hi Resolution meshes and surfaces
- Able to drive robotic manufacturing such as Additive, CNC or NDI programming.
- Backfeed engineering inputs such as FEA and CFD.

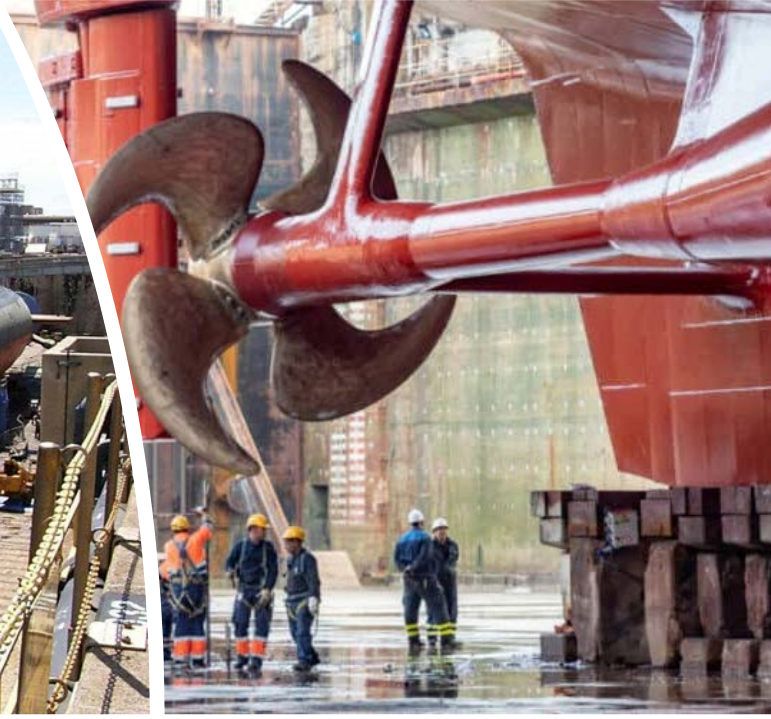


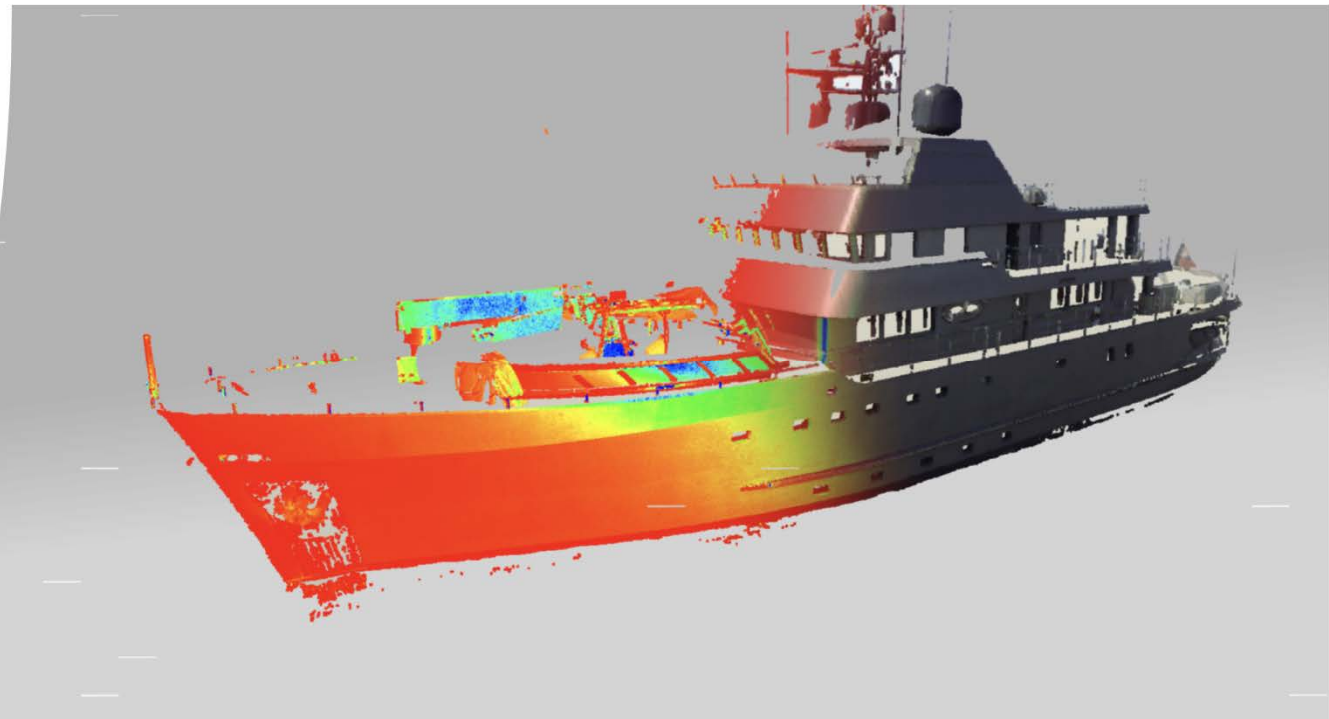




Digital Twin Shipbuilding

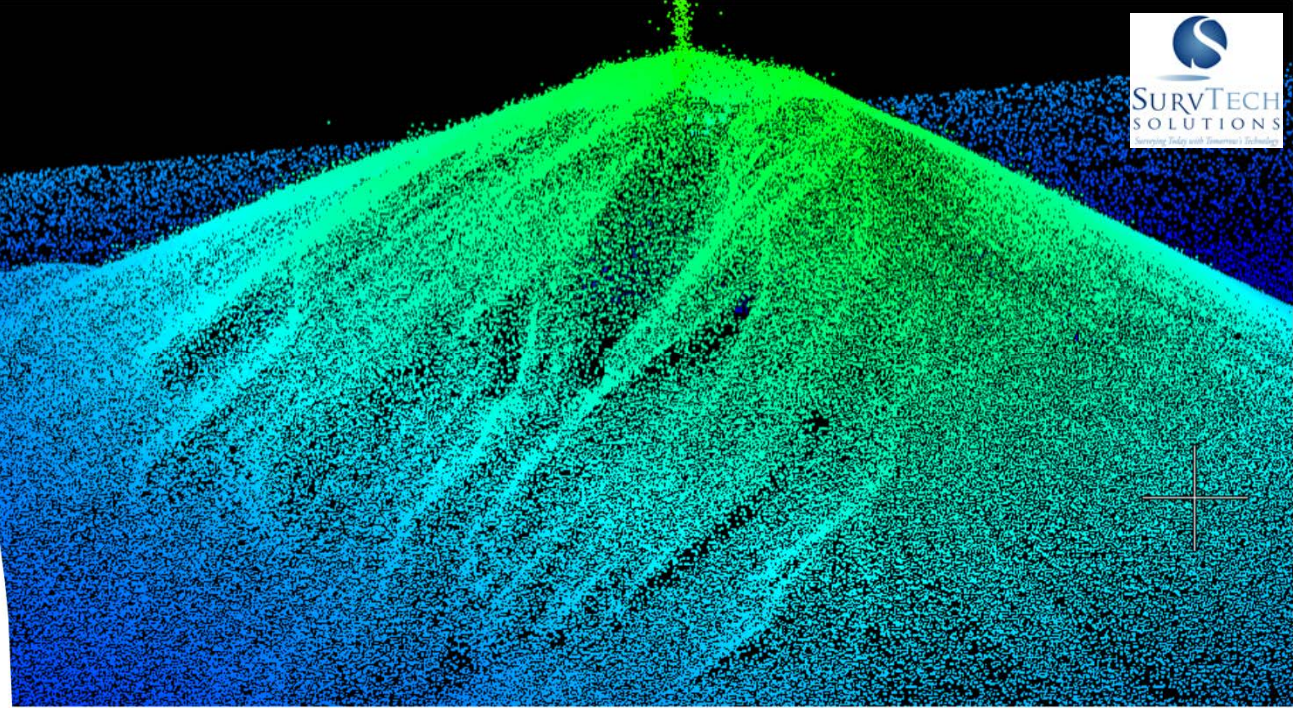
- Inspect complex geometry features and surfaces.
- Casting patterns
- Model propellers and analyze cavitation/damage
- Propeller hub bores and propeller shaftings
- Thruster and major component alignment
- Module alignment and weld monitor
- New build, Refurbish and Maintenance
- Custom installation 3D digitization and virtual fit check.

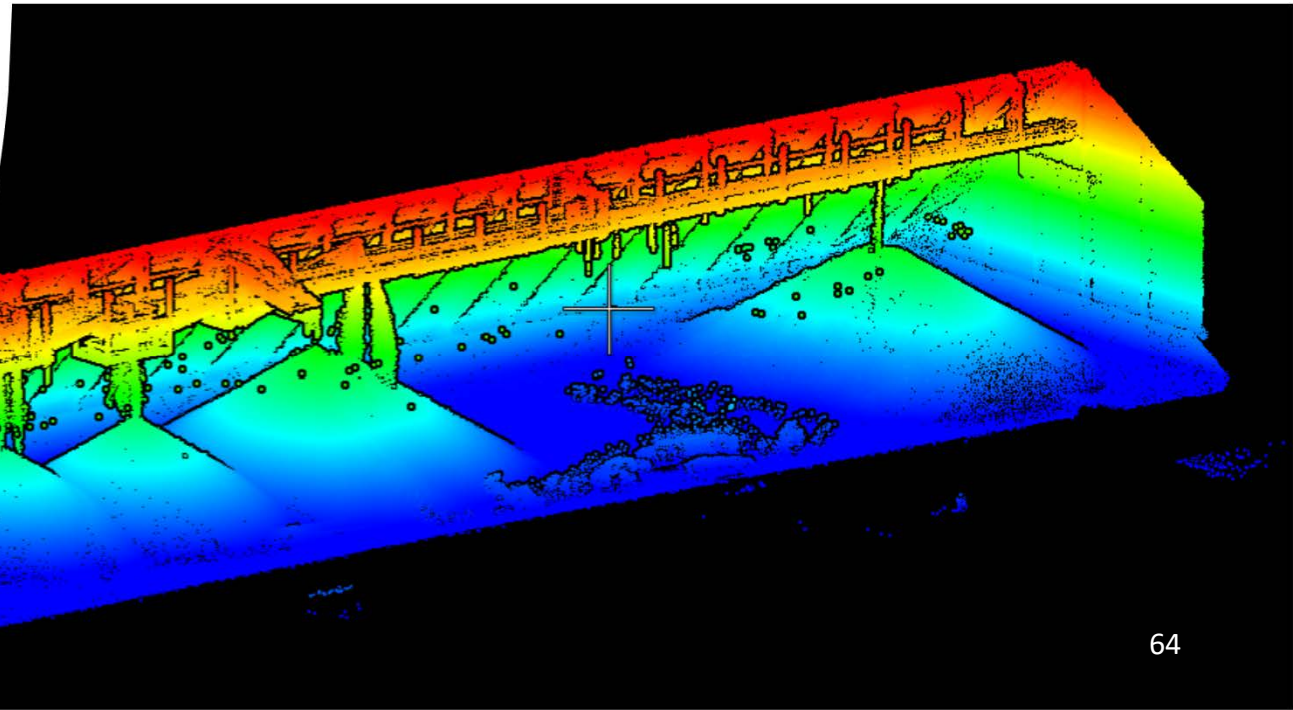




SLAM Mapping on UASs as Predicted by Sci Fi Movie in 2012 Digital Twin of Cave System on Alien Planet

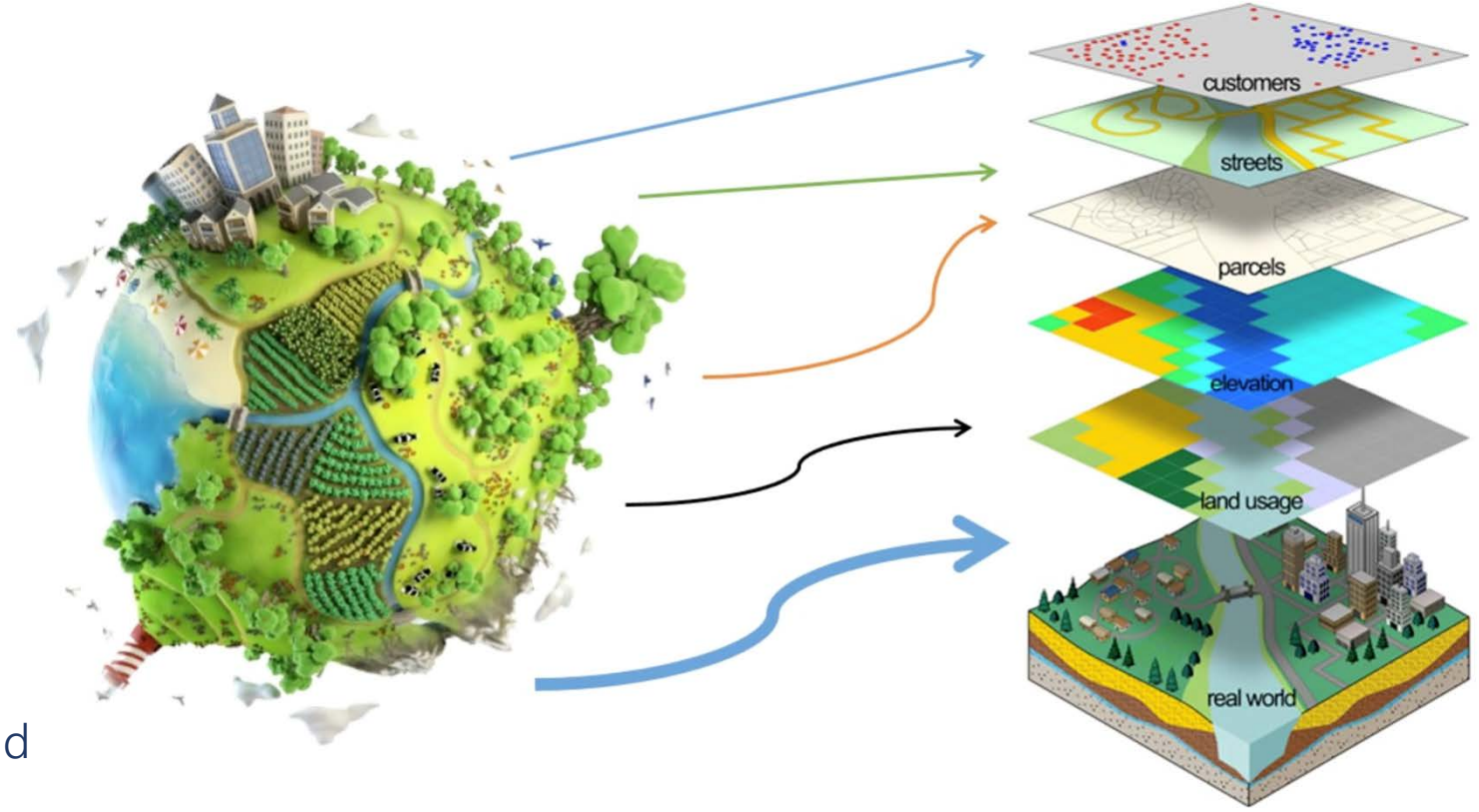
UAV SLAM LiDAR NO GPS (Inside Warehouse)





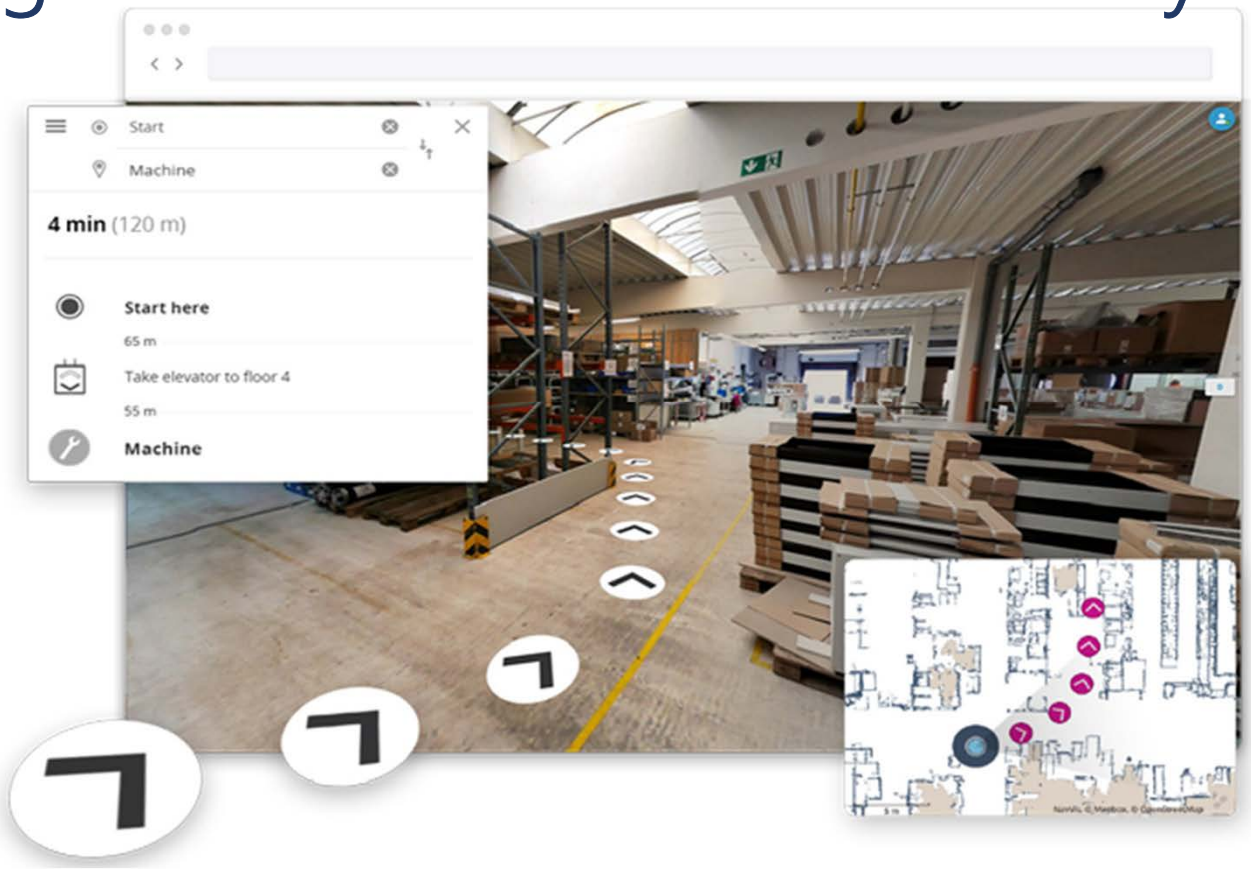
GIS - Geographic Information Systems

- Data Schema Development
- GIS Data Generation
- ArcGIS Analyses
- Geodatabase Development
- GPS – Survey Grade GPS
- Web Development & Deployment: GIS Server
- Customized Tools, Applications, and GUI Front-ends
- Aerial Photography and Photogrammetry
- On-site Support & Training



Facility Models – BIM and Digital Twin Viewers

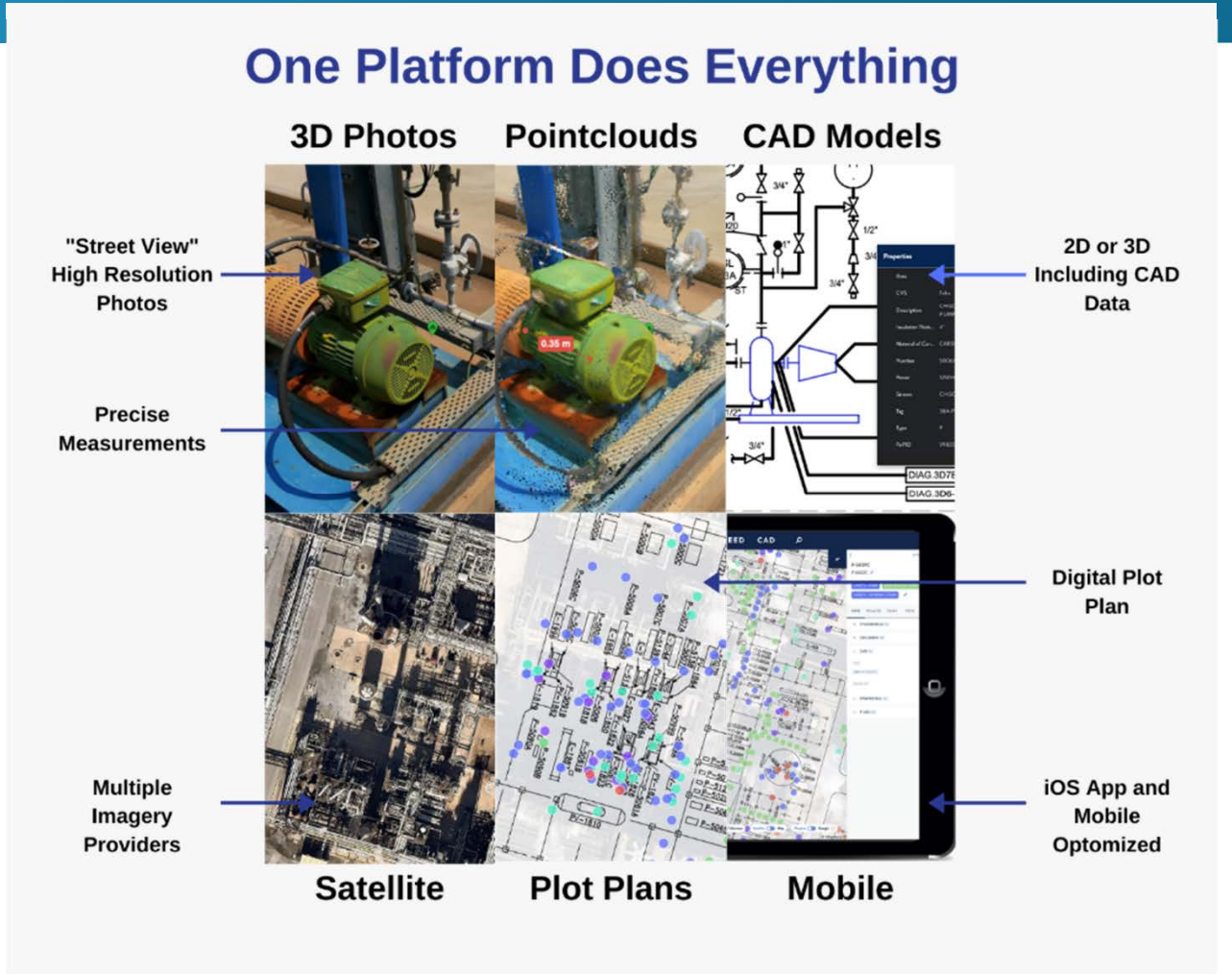
Navigation / Virtual Walkdowns – Digital Twin Planning and Measurements from Anywhere



Digital Twins with Intelligence

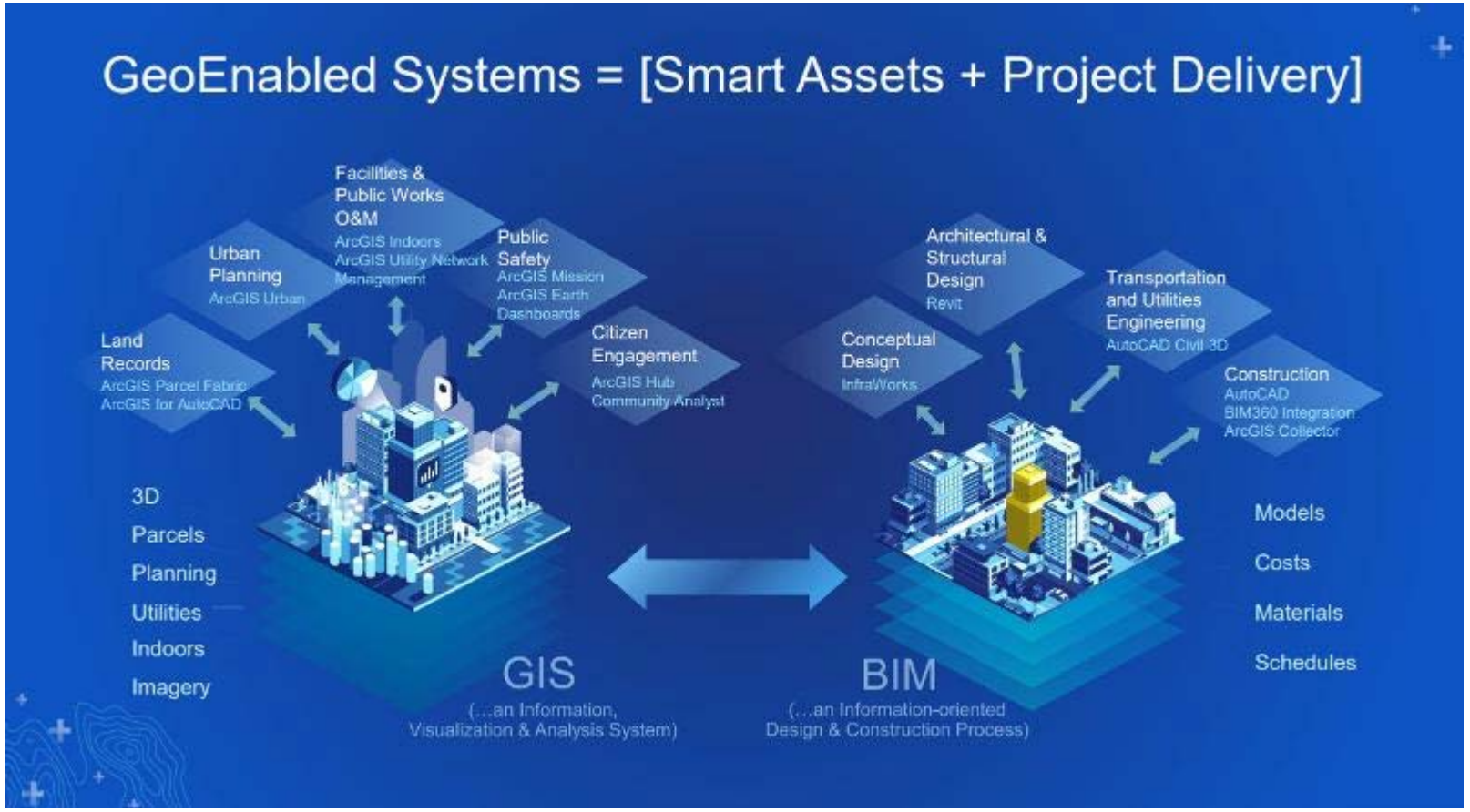
'Google Maps' for Your Facilities

- No software to install
- End user works in internet browser.
- As easy to use as Google Maps, but powerful enough to integrate with existing systems, drawings, and workflows
- Desktop and mobile-based
- Add intelligence and processes to your digital twin.

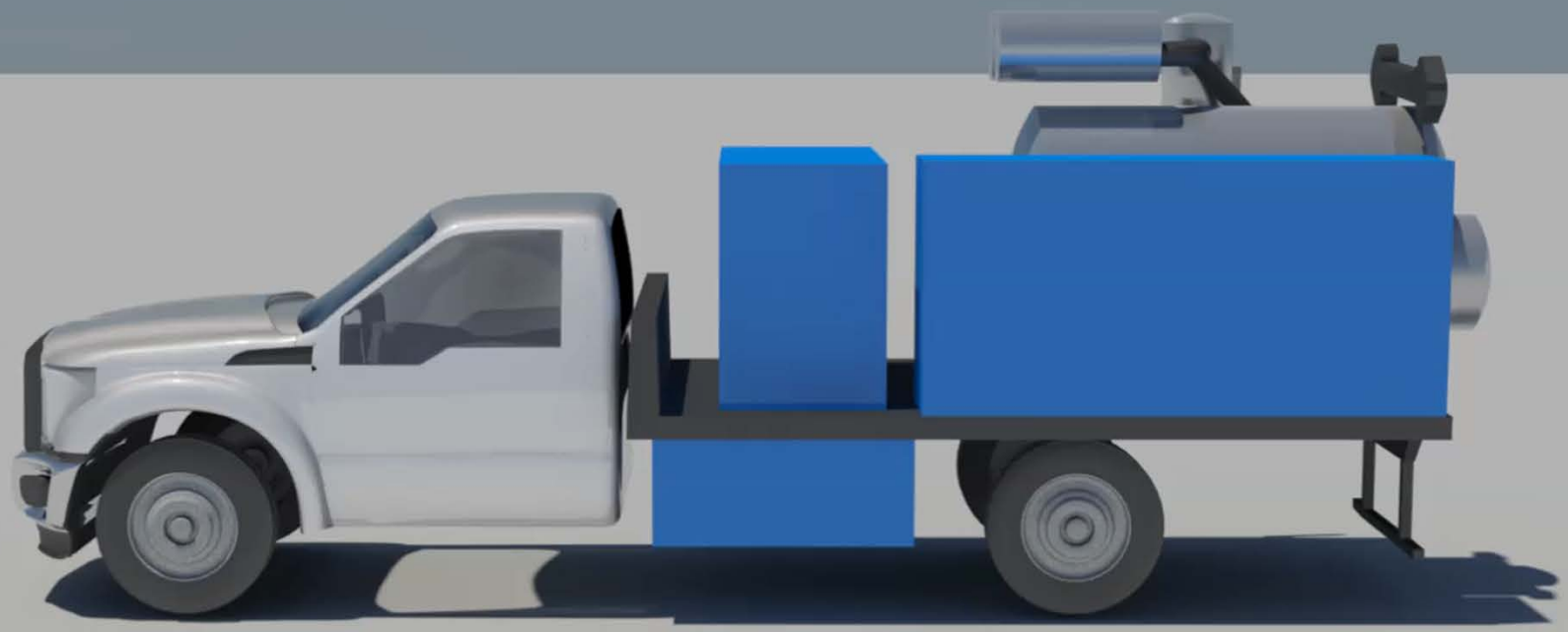


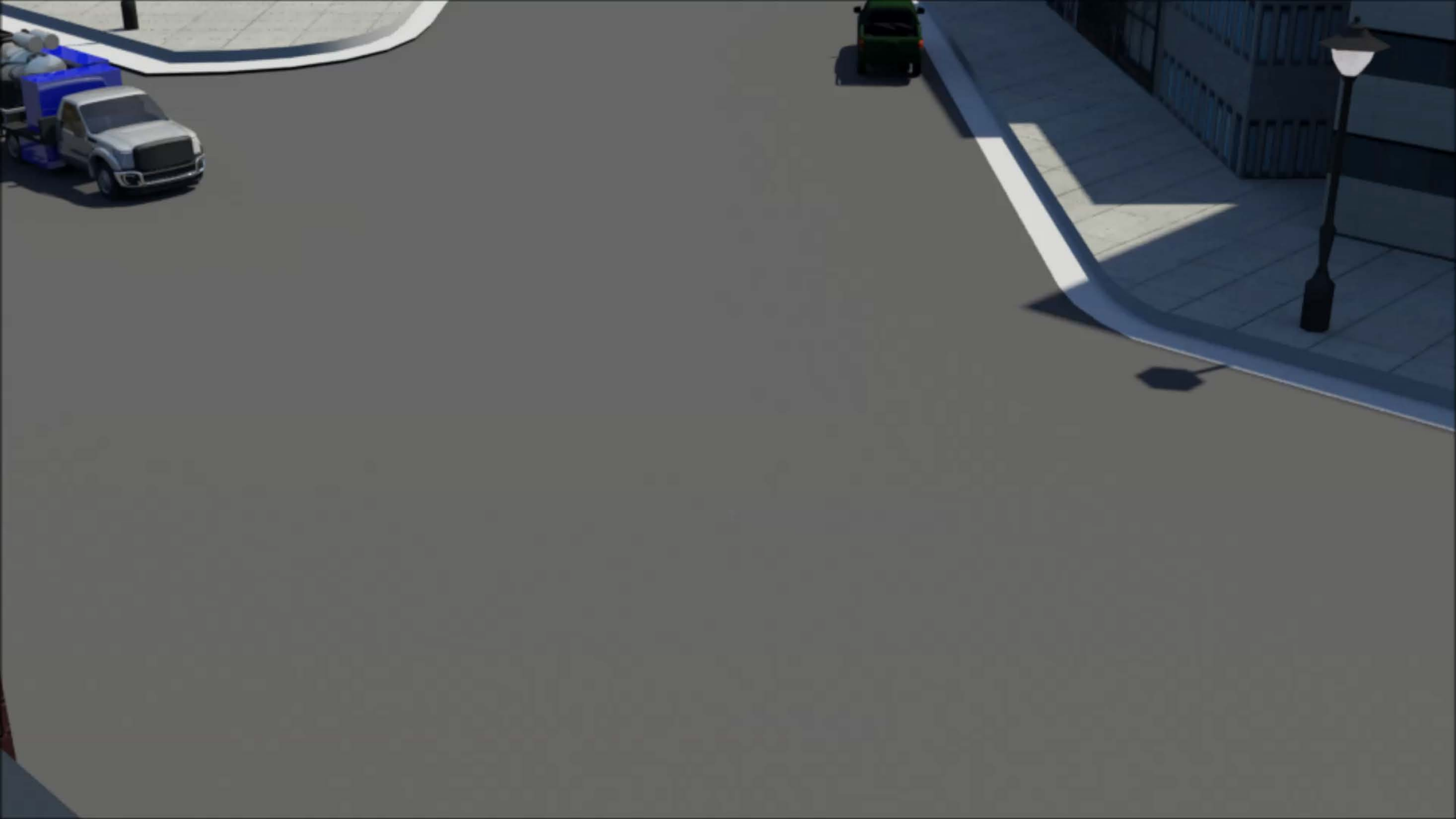
GIS - Geographic Information Systems and BIM

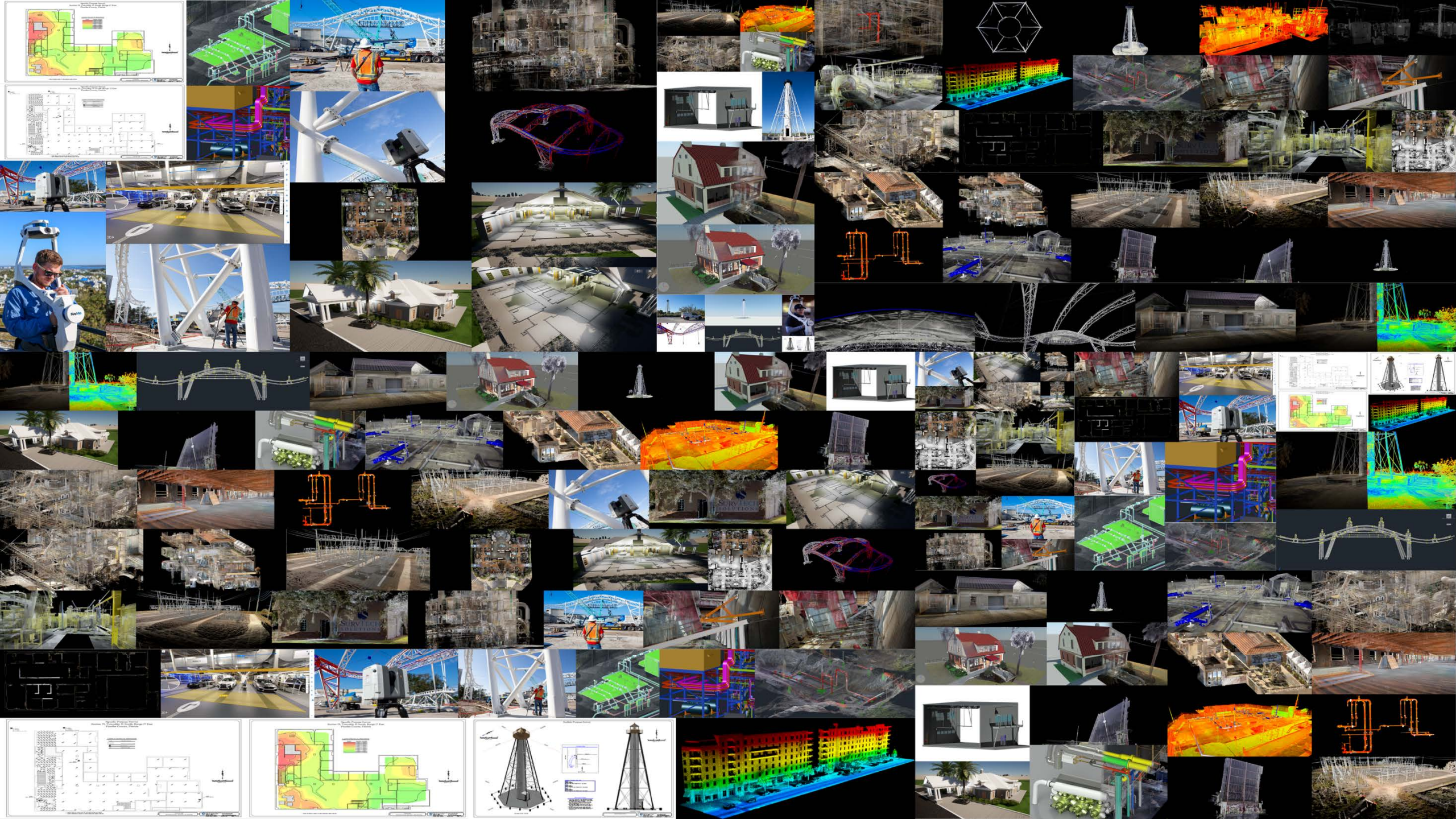
- A True Digital Twin of the Earth would include what?
  - Inside Buildings and other Man-Made Structures.
  - Facilities, Utilities, and geology underground.
  - Facilities and utilities underwater.
  - Facilities and utilities underground beneath a waterway.



Digital Twins
Animation & Forensics







QUESTIONS?

SURVTECH SOLUTIONS

Surveying Today with Tomorrow's Technology