CS323944

Construction Technology Showdown – Does one Reality Capture solution rule them all?

Shane Saltzgiver & Leo Castillo
VEC – Virtual Engineering & Construction

Learning Objectives

- Is there really one Reality Capture solution that rules them all?
- Identify which Reality Capture solution is best for each project type.
- Turn reality capture and point clouds into ACTUAL value that project teams will utilize now and going forward.
- Understand the reliability of data from each solution.

Description
At AU 2018 we unveiled our innovative approach to deploying High-Definition 3D Laser Scanning on cast-in-place concrete projects in San Francisco the day prior to concrete placement, analyzing the 3D point cloud against the BIM, and delivering a highly detailed report of deviations the following morning that the construction team can use to rectify any out of tolerance elements prior to concrete placement. The result... highest quality ever achieved on CIP projects.

The logical next step was to look inward at our process, software, and hardware for efficiency and quality gains, then look outward for other solutions. We deployed, tested, and analyzed the data from the following Reality Capture solutions in our quest to see if there truly is one tool that rules them all. We will compare the results from each unit and suggest the appropriate application for each.

Speaker(s)

Shane Saltzgiver
Mr. Saltzgiver has over 15 years of experience in the construction and technology industries managing large-scale aviation infrastructure, public-private-partnerships (P3s), and numerous vertical construction projects ranging from high-rises in San Francisco to high-end tech projects in Silicon Valley for clients such as Google, Facebook, and Adobe. He has extensive experience in BIM/VDC applications and has particular expertise in solving complex engineering and construction challenges through the use of innovative technologies. Mr. Saltzgiver also has a passion for sustainable building design and construction and is a LEED Accredited Professional.

Leo Castillo
Throughout his 18-year career, Mr. Castillo has been at the forefront of developing 3D design, survey, and construction workflows to benefit project coordination, risk management, and cost control. His diverse project experience includes large-scale transportation and master planning efforts, as well as local community improvement projects. He has extensive experience in 3D including building information modeling (BIM), high-definition 3D laser scanning (HDS), GIS, and unmanned aerial vehicle (UAV) mapping and surveying. He is a member of both the U.S. Institute of Building Documentation (USIBD) and the Project Management Institute (PMI).

1. Is There Really One Reality Capture Solution

The common thinking and knowledge is that there is an all-in-one solution, the reality is there is not. Most if not all reality capture hardware has advantages in one application and overlapping benefits in others. Our goal with this case study was to provide some direct industry experience and recommendations to help our colleagues in the industry make sense of the marketing and make informed decisions.

2. Why Did We Want to Do This?

As a company who works from the inside out, we at VEC are never content with just provided a service. We always ask ourselves why we want to pursue something before we advance. This case study was no different. Our Mission Statement is to Make Construction Easy and to accomplish this mission we realized long ago that we had to establish a constant upgrade cycle; not so much for fear of missing out (FOMO) on the next best thing, but we are not immune to the barrage of marketing pressures of new technology in the construction industry.

Constant Upgrade Cycle

So, we embraced the challenge of remaining aware of the latest technology trends, evaluating the technology subjectively to our needs, and then analyzing the suitability and reliability of the technology to separate the marketing from the actual value and effectiveness the technology could provide us. We have done this before with other technologies such as Augmented Reality, Virtual Reality, Facility Management, BIM, VDC and Cloud technologies and it has proven very effective to drive us to always deliver the maximum value for our customers. Our process has also allowed us to become trusted advisors to our customers to help them filter their same experience in trying to make sense of what they should invest in to accomplish their business goals as well. So, this gave us the opportunity to share a small glimpse into our evaluation method with our AU colleagues, customers and friends and become Tech Reviewers if only for a moment.

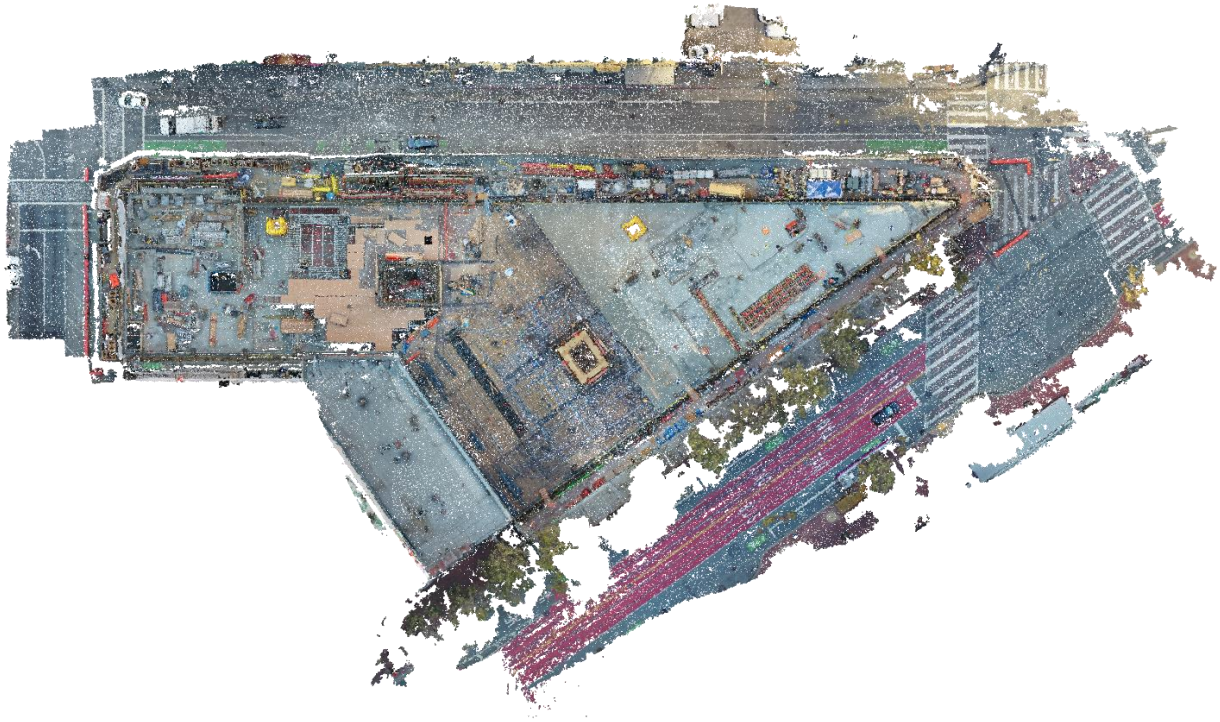
VEC Tech Magazine…coming to a news stand near you!

3. Reality Capture Solutions Evaluated

We operate or rent quite a few reality capture technologies for our projects and this is one of the areas we see the most innovation happening in the construction space. So we selected what we believe to be the widest segment of the reality capture technologies available and that are most talked about by our colleagues and customers. These generally fall into 3 categories:

Unmanned Aerial Vehicles or Small Unmanned Aerial Systems

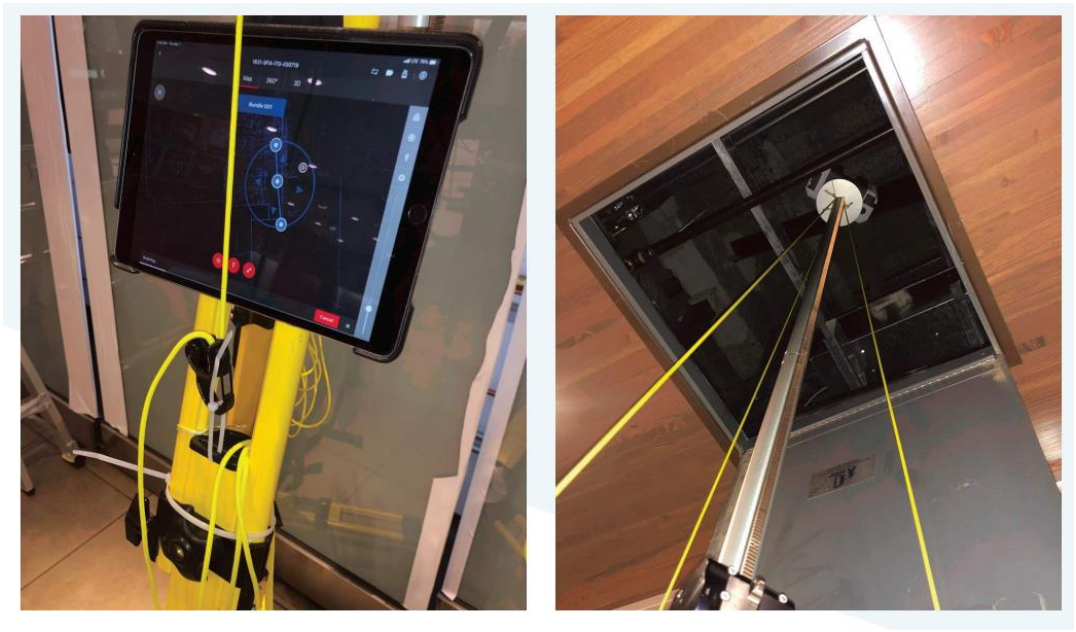
If you want to get the most “bang for your buck” UAV’s, UAS, sUAS’s…whatever you want to call them, drones provide you with the largest capture area as compared to the other Reality Capture technologies. Because of the altitudes they can reach and combined with a very you are capturing what is on the ground in the form of pixels.



UAV Area Captured in 20-minute Flight

Static or Tripod Mounted Reality Capture

Static LiDAR scanning has been around since the 1970’s but only within the last 10-years has mobile battery technology really allowed static scanning technology to become smaller, lighter and mobile to the point where it has broader applications for Design & Construction. With aging facilities and the cost of real estate increasing dramatically in urban markets along with construction labor and materials, the justification for reuse and renovation has never been greater. Any technology that accurately and precisely captures the true conditions of an existing facility puts the best information at the hands of owners, designers and builders.



Static Scanner and Tablet used in overhead interstitial ceiling space at Airport

Handheld 360-degree Camera Reality Capture

They are small, cheap, light and with cloud services like Matterport, StructionSite, Cupix3D and others creating point clouds from photos it's a no-brainer to have one of these in your pocket no matter what your line of business is. Putting aside the question that is always asked of "Where is something at?" and answered to a high-degree of accuracy by static scanners, a 360-degree camera can answer the most basic question of "Is something there?" in the first place. This technology presents possibly the greatest potential impact in the construction industry due to the long-tail effect of providing a simple tool that does one thing well for the largest audience possible.

Matterport blurs the lines between 360-degree camera and static scanners

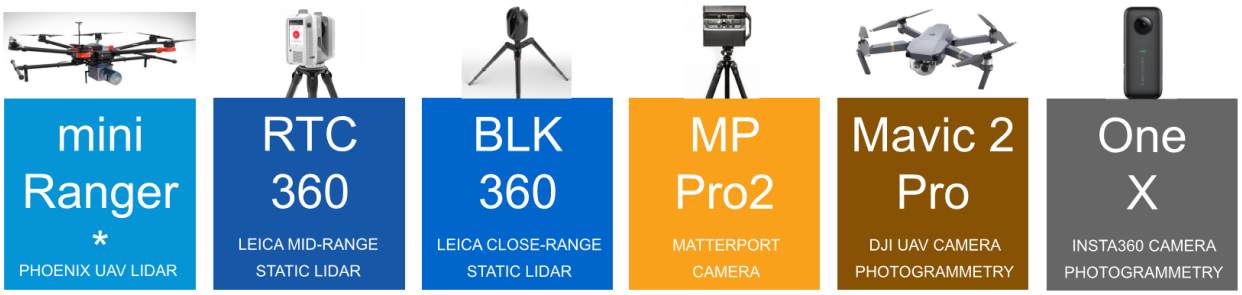
4. How Did We Evaluate The Reality Capture Solutions?

Never content with just giving results of our work, we decided to present the results of our reality capture evaluation through the lens of one of our active construction technology projects for Pankow Builders in the heart of San Francisco, California. Meet 950 Market Street where VEC is contracted to provide pre-concrete and post-pour concrete scanning, inspection of embedded structural metals and MEP embeds and report errors back to the contractor within 24-hours in order to resolve issues prior to concrete pour. We took the following reality capture hardware devices and their associate processing/registration software to the test and measured their effectiveness in getting the job done.

Reality Capture Equipment

A) MiniRanger Reigl MiniVUX UAV LiDAR System
B) Leica RTC360 static lidar & Cyclone Register360 processing system
C) Leica BLK360 static lidar & Recap Pro Mobile/Register360 processing system
D) Matterport Pro2 structured Light (Infrared) scanner/camera/cloud processing service
E) DJI Mavic 2 Pro UAV Camera & Pix4D Mapper photogrammetry system
F) Insta360 One X camera and Matterport cloud processing service

Players on the Field



* Based on sample data provided

Suitability and Reliability Evaluation Criteria

Never content with just giving results of our work, we decided to present the results of our reality capture evaluation through the lens of one of our active construction technology projects for Pankow Builders in the heart of San Francisco, California. Meet 950 Market Street where VEC is contracted to provide pre-concrete and post-pour concrete scanning, inspection of embedded

Portability

How effortless is this technology to deploy and implement considering power requirements, safety considerations, regulatory considerations and personnel carrying convenience?

Accessibility
How easy is this technology to rent/purchase in the open market? How quickly can it be deployed to the project site.

Cost
How expensive/inexpensive is this technology including the minimum hardware/software to rent/purchase in the open market?

Resolution/Accuracy/Precision
What repeatable resolution & accuracy can be achieved with this technology with minimum training (2 weeks) and a minimal impact to construction schedule/operations?

Capture Speed
What is the length of time it takes to setup onsite, deploy and capture the area of interest?

5. The Results of Our Suitability and Reliability Study?

Which Reality Capture Solution Is Best for Different Project Types
When deciding to evaluate the various reality capture technologies, we categorized them into the six (6) primary types of construction we frequently provide Reality Capture and BIM/VDC services for and identified the primary value of reality capture technology for each application.

Exterior Structural Core/Shell
Core and shell construction consist of the main structural elements of a building, including walls and windows, foundation and structural skeleton, building envelope, stairwells and vertical circulation, subbasement structures, etc. Given that this construction occurs at the start of the project and includes installation of structural embeds that will connect to building exterior cladding systems at a much later date in the project, reality capture technology is highly valuable for identify errors or out-of-tolerance installation so they can be corrected well before the impacts compound in the form of change orders, schedules delays, and cost overruns.

Exterior MEP Core/Shell
MEP core and shell construction consists of the main mechanical, electrical, plumbing, fire detection, and security systems elements of a building including central energy or utility plants, equipment, and all MEP elements that must be embedded within concrete decking for distribution of energy throughout the building. Reality capture is highly valuable for this application as building systems embedded within core and shell construction are often obscured from view for the lifespan of the building. Therefore when embedded core and shell MEP elements or documents and located, this information can be invaluable during post-pour correction work, or future renovation work that building go through in their decades of life-cycle.

Exterior Finishes
Exterior Finishes are the outside covering or cladding that protects the structure of a building against the outside weather elements. When a building is undergoing an exterior renovation and finishes will be removed and replaced reality capture is often used to accurately locate existing joints, seams, and paneling. Also, in the case of

historic preservation reality capture can document the existing conditions of an existing historic building façade.

Interior Structural Fit-Out

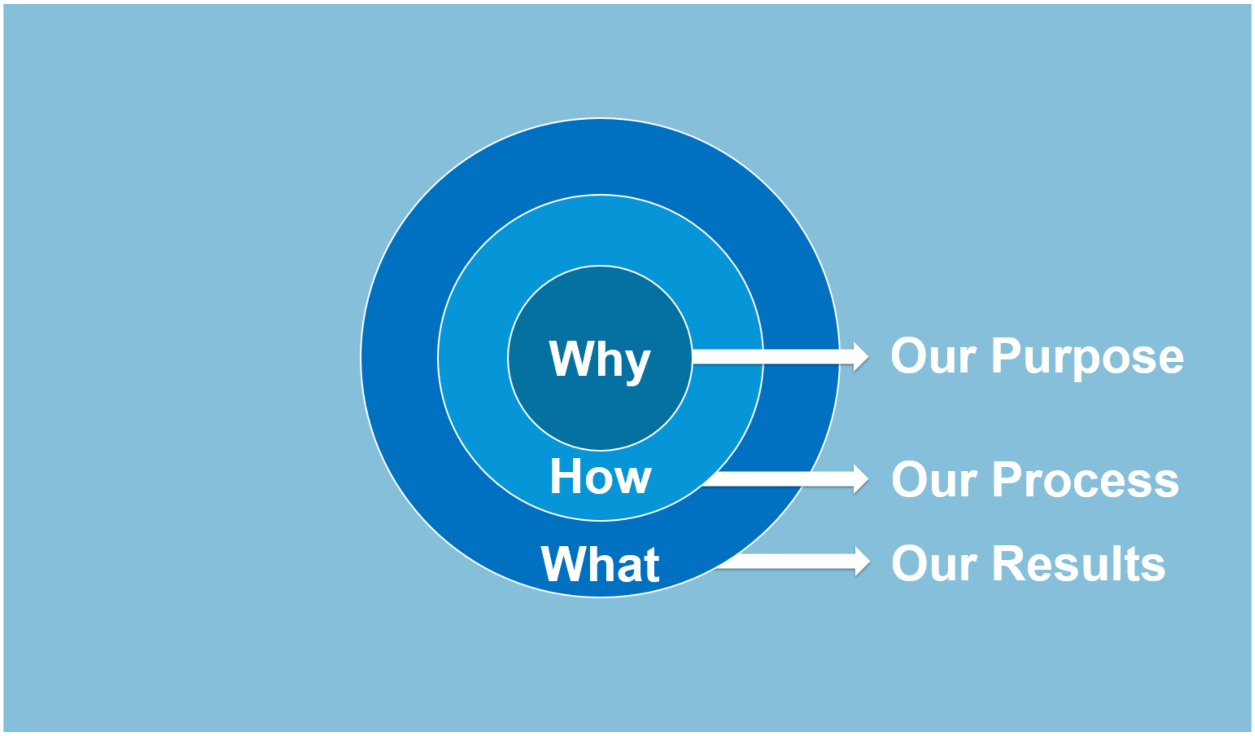
Construction of interior framing, walls, doors, ceiling framing, metal columns and posts, coring and penetrations, and other structural supporting metal installation benefits from reality capture by locating non-load bearing walls and structural framing for future tenant operating equipment such as medical devices, lifts, manufacturing equipment, etc.

Interior MEP Fit-Out

Interior mechanical, wet and dry piping systems, HVAC, equipment and electrical/telcom distribution system installation benefit from reality capture given the fact that these systems will frequently undergo renovation, upgrade, maintenance, and value-engineering throughout the life cycle of a building renovation. As new tenants move in and out of a building, interior MEP systems must be redesigned or reused to suit the new occupant of the building or space which could be drastically different. Having an accurate as-built document or point cloud of these systems can prove invaluable to this design and construction effort.

Interior Finishes

Interior decorative elements and finish material work on walls and wall treatments, furniture, ceilings and treatments, floors and flooring, space division systems, posts and columns can benefit from reality capture by documenting the conditions of the space at turnover and commissioning of the building. Reality capture imagery can be utilized for O&M purposes and innovation in the Facility Management (FM) space can utility reality capture heavily as a backdrop to serve up data to FM staff or owners and tenants.



Our Track Record

0	0	0	0	0
MISSED EMBEDS	MISPLACED EMBEDS	SLAB EDGE ERRORS	BLOCKOUT ERRORS	TIMES THIS HAPPENED IN WEBCOR HISTORY

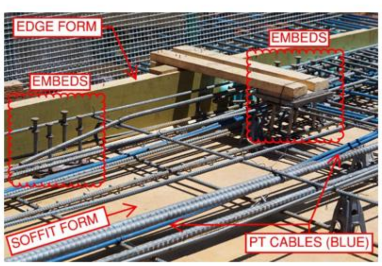

AUTODESK UNIVERSITY

3D Laser Scanning – Pioneering a New Approach to Maximize Contractor & Project Value

Learning Objectives

Description

Page 1



VEC Tech Magazine Construction Technology Reviewers

To live up to our Vision to “Make Construction Easy” we are constantly testing new Construction Technology hardware, software and workflows. We decided to share our research with our colleagues, customers and enthusiasts for the next reason…

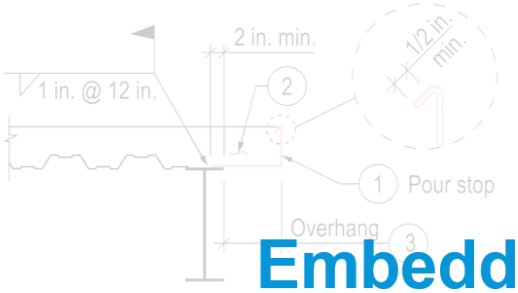
Drink From the Firehose

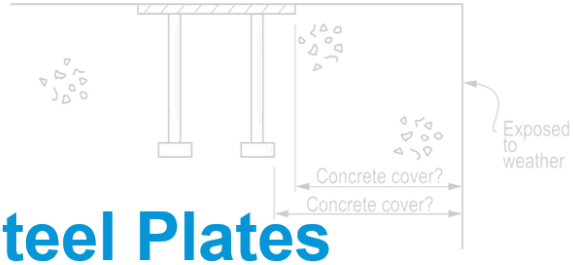
Construction industry is bombarded with $$$ in advertising for new technology, services, products and workflows. Chasing the next new trend that comes along could cost significantly without any guarantee that it will provide ROI. The most expensive part of anything new is going to be in training your personnel. We decided to help you drink from the Fire Hose.

950 Market Street

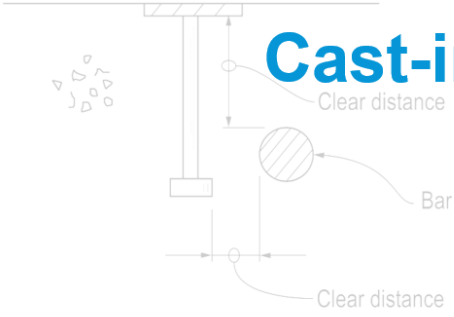
The project will enliven the neighborhood by providing room for a wide range of activities, including a dedicated non-profit space for Magic Theatre at the corner of Turk and Taylor, a community open space on Turk Street, outdoor food and beverage garden, event space, a selection of retailers, and a landscaped rooftop as well as hospitality, housing, and retail space.

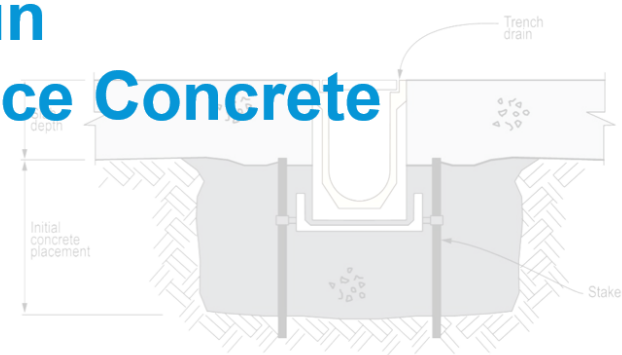
Group 1 | Handle Architects | Lendlease | Pankow





Embedded Steel Plates in Cast-in-Place Concrete





Embedded Steel, MEP & Void Features

BLUE BANGER

PULL BOX

MEP SLEEVE

PANEL RISERS

HANGER EMBED

CONDUIT ELBOWS
(PER SYSTEM)

Embedded Steel, MEP & Void Features

FORMS

EDGE FORM

PT CABLES

BLOCKOUT

SLEEVE

SLEEVE

Embedded Steel, MEP & Void Features

DRUM

SHEAR WALL

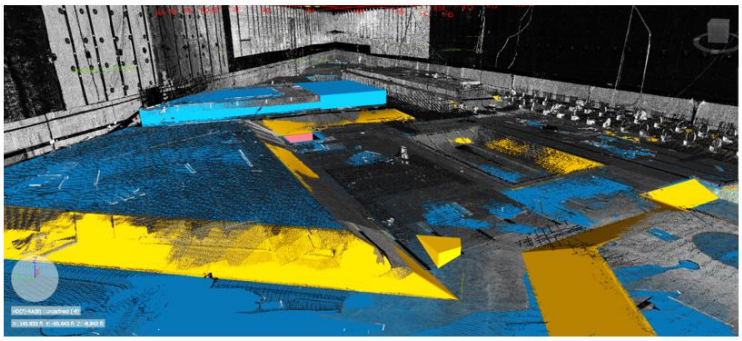
STAIR EMBED

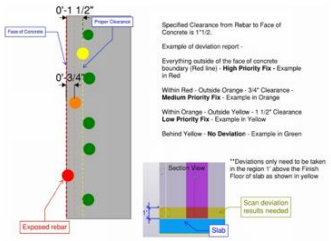
CONSTRUCTION DRAWINGS

SLEEVE

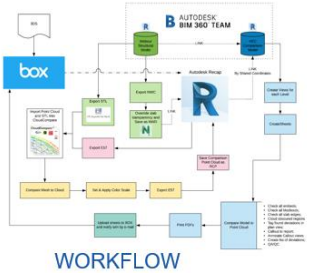
STUD RAILS

PreciseConstruction QA/QC & Deviation Method





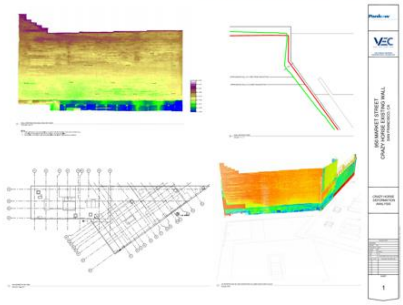
SPECIFICATIONS

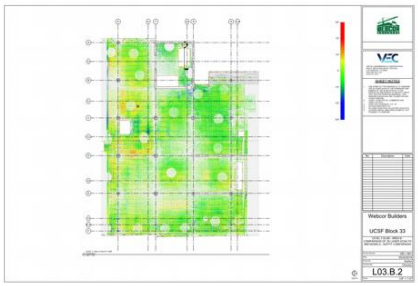


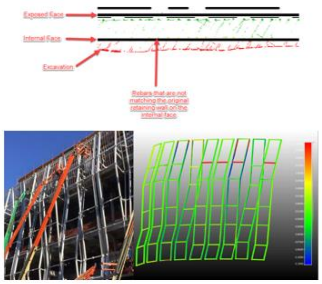
WORKFLOW

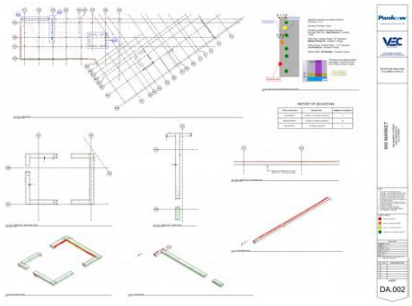
DETAILED MODEL
+
CLIENT SPECS
+
REALITY CAPTURE

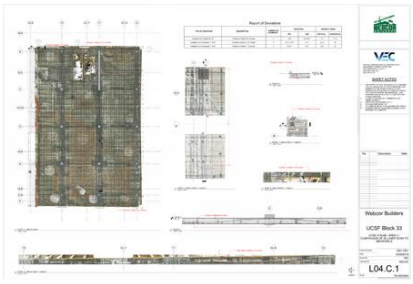
QA/QC Reporting Results & Deliverable



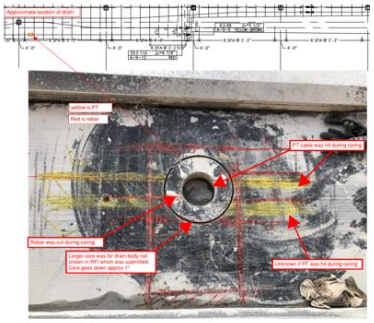


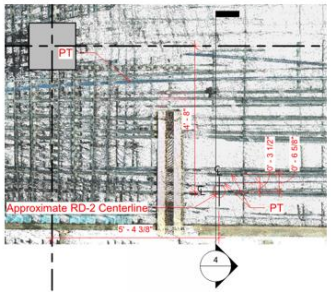




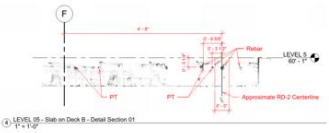


Additional Benefits of Reality Capture Technology





"I need a better understanding of where some PT cables are located on level 5. We hit a PT cable while coring for the roof drain noted below and may have to do some chipping in this area in order to repair this cable. Based on the PT shop drawings there may be two PT cables directly adjacent or they may be sweeping back together from the construction joint however scanning the concrete does not tell us this level of detail. I am hoping to get a bit more info about exactly where the PT cables are in order to help us fix the broken cable or cables."



"Just as before with the details of the slab, can you guys shoot me over some detailed pictures of the in slab items of the marked area (red) of the PDF attached? The team is looking to do some drilling in this area and would like to know where Rebar/PT is in the slab. Dimensions would also be appreciated."

Players on the Field

mini Ranger *
PHOENIX UAV LIDAR

40 Lbs
1/3 Hour Battery
42 MP Camera
0.1 Pts/Sq In
~$165,000

* Based on sample data provided

RTC 360
LEICA MID-RANGE STATIC LIDAR

11 Lbs
4 Hours Battery
432 MegaPixel
500 Pts/Sq In
~$100,000

BLK 360
LEICA CLOSE-RANGE STATIC LIDAR

2.2 Lbs
2 Hours Battery
15.1 MegaPixel
35 Pts/Sq In
~$25,000

MP Pro2
MATTERPORT CAMERA

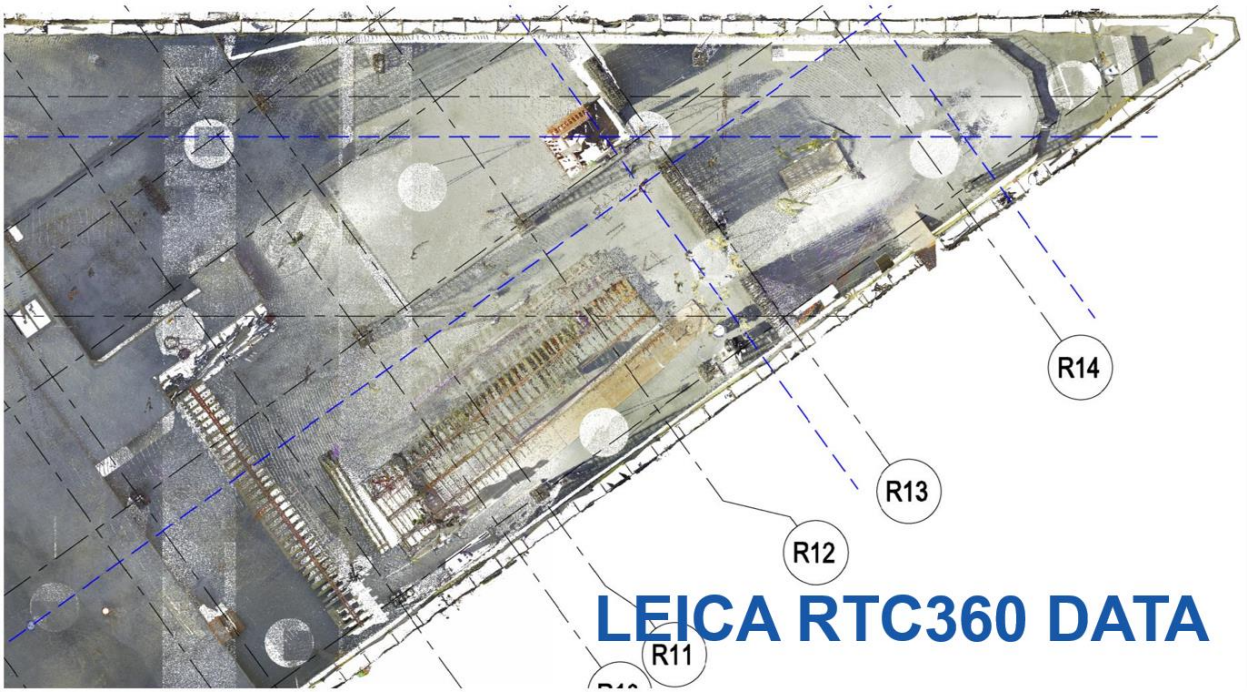
8 Lbs
8 Hours Battery
8 MegaPixel
15 Pts/Sq In
~$10,000

Mavic 2 Pro
DJI UAV CAMERA PHOTOGRAMMETRY

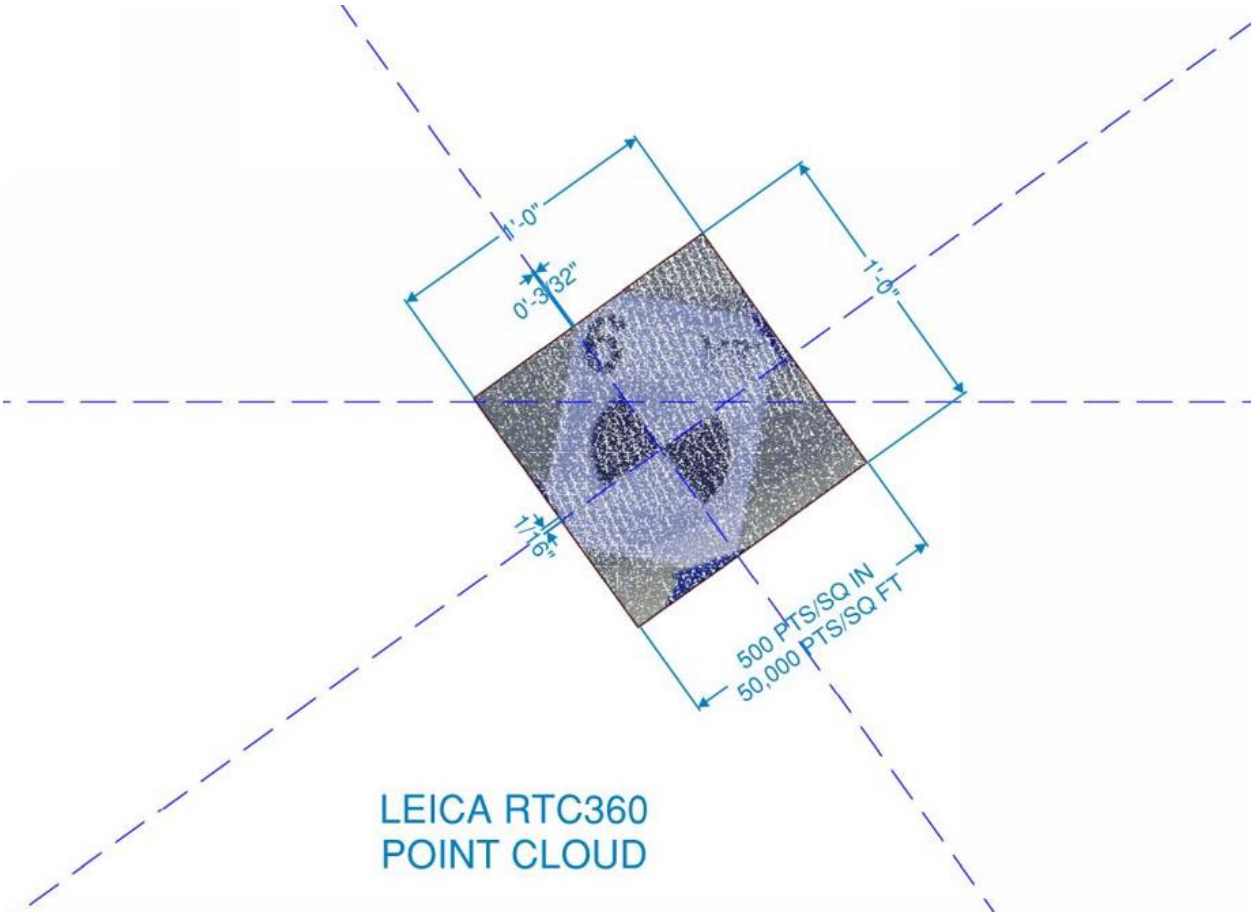
2 Lbs
½ Hour Battery
13 MegaPixel
7 Pts/Sq In
~$3,500

One X
INSTA360 CAMERA PHOTOGRAMMETRY

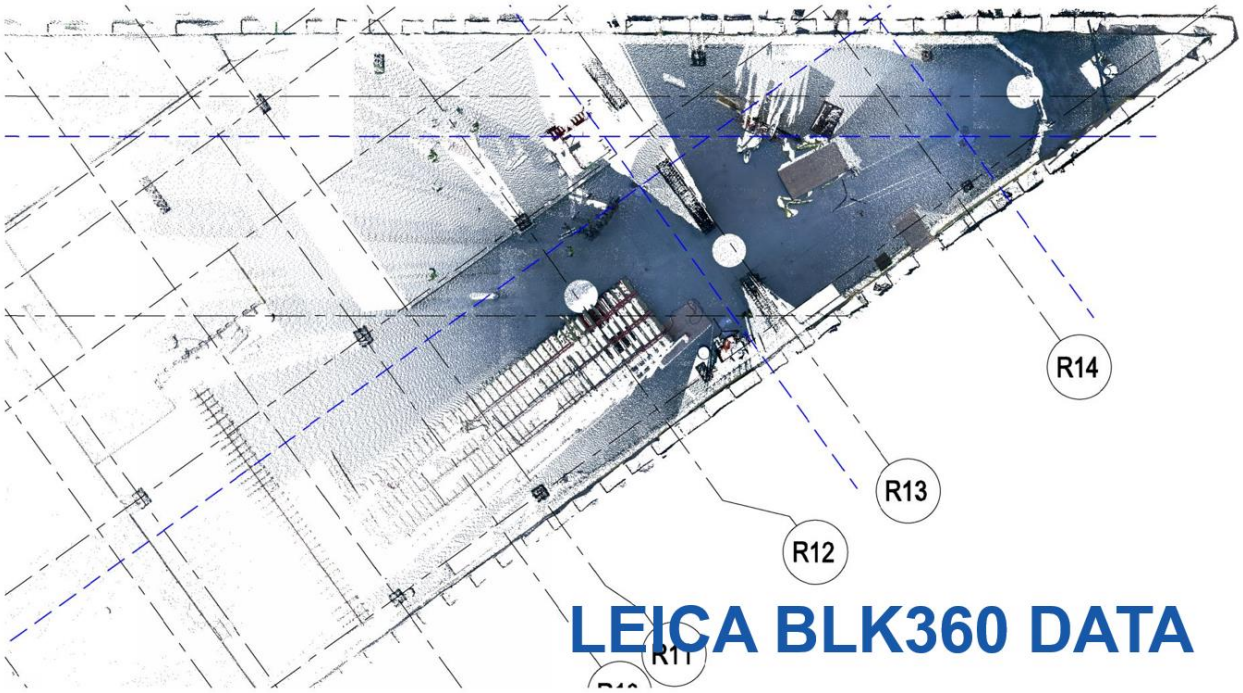
0.2 Lbs
1.5 Hour Battery
24 MegaPixel
X Pts/Sq In
~$1,500



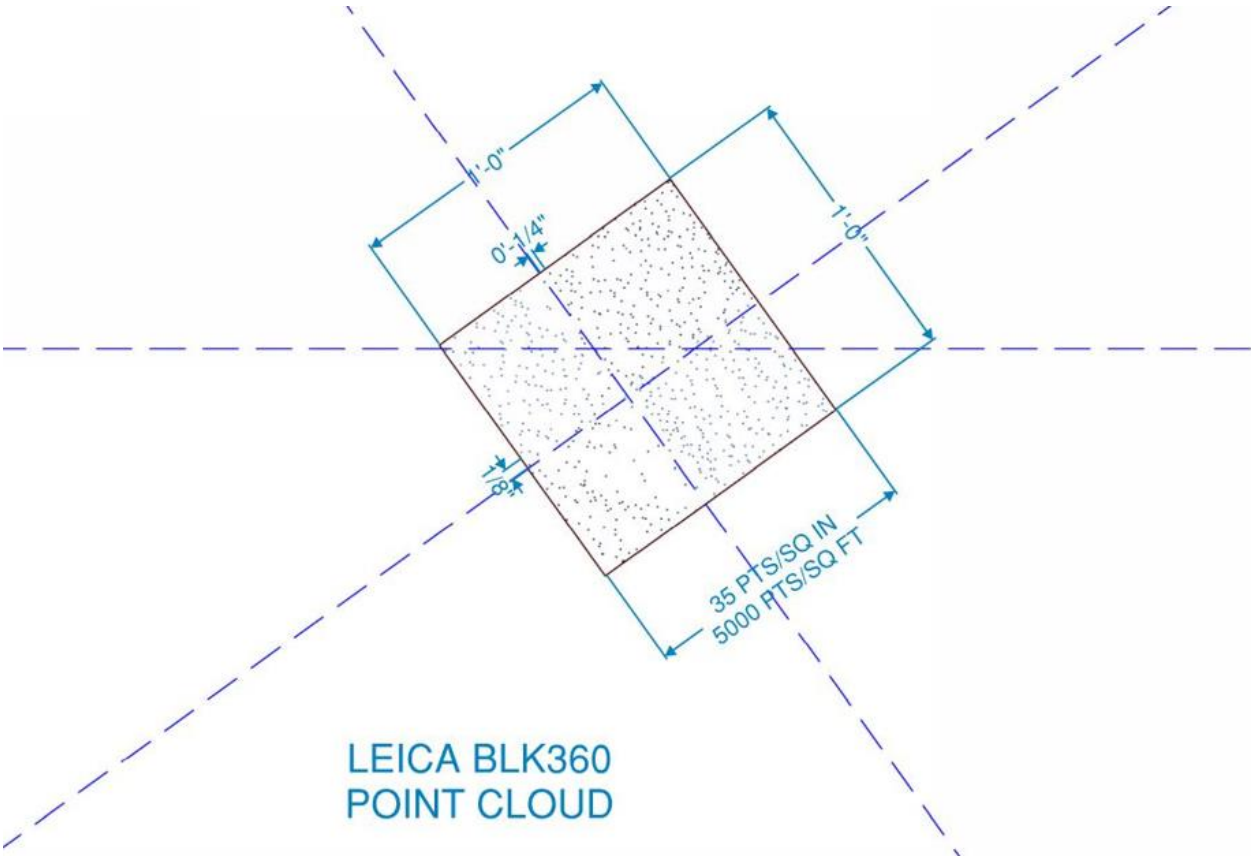
LEICA RTC360 DATA



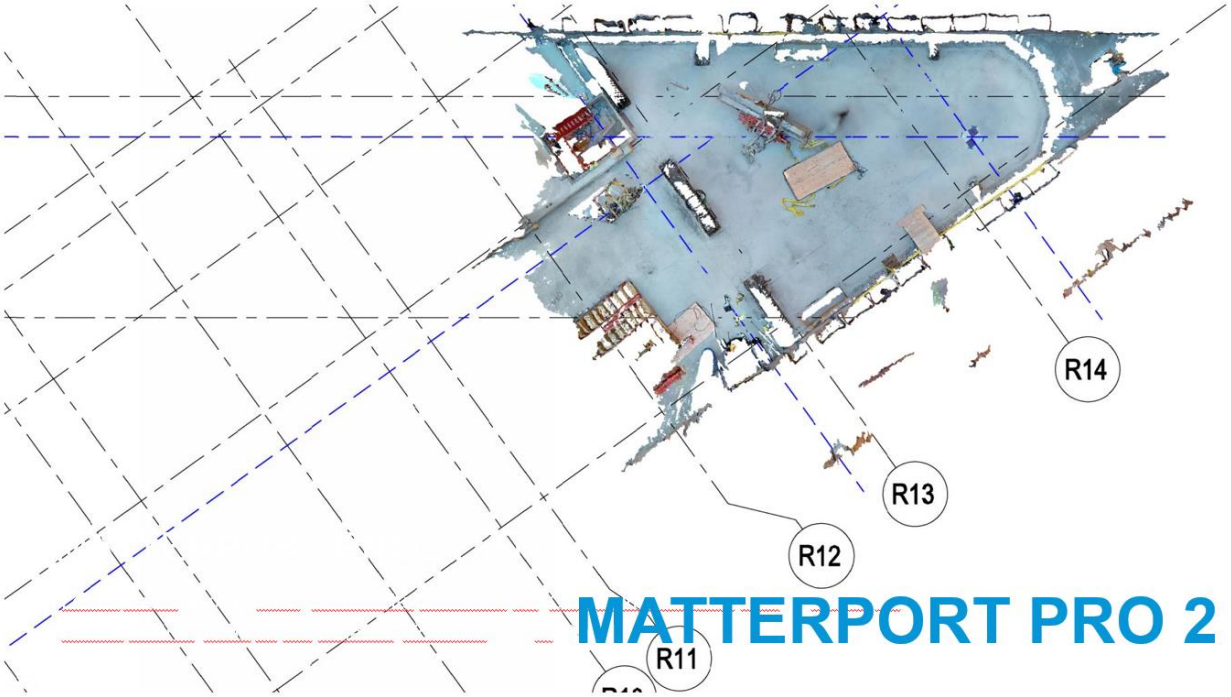
LEICA RTC360
POINT CLOUD



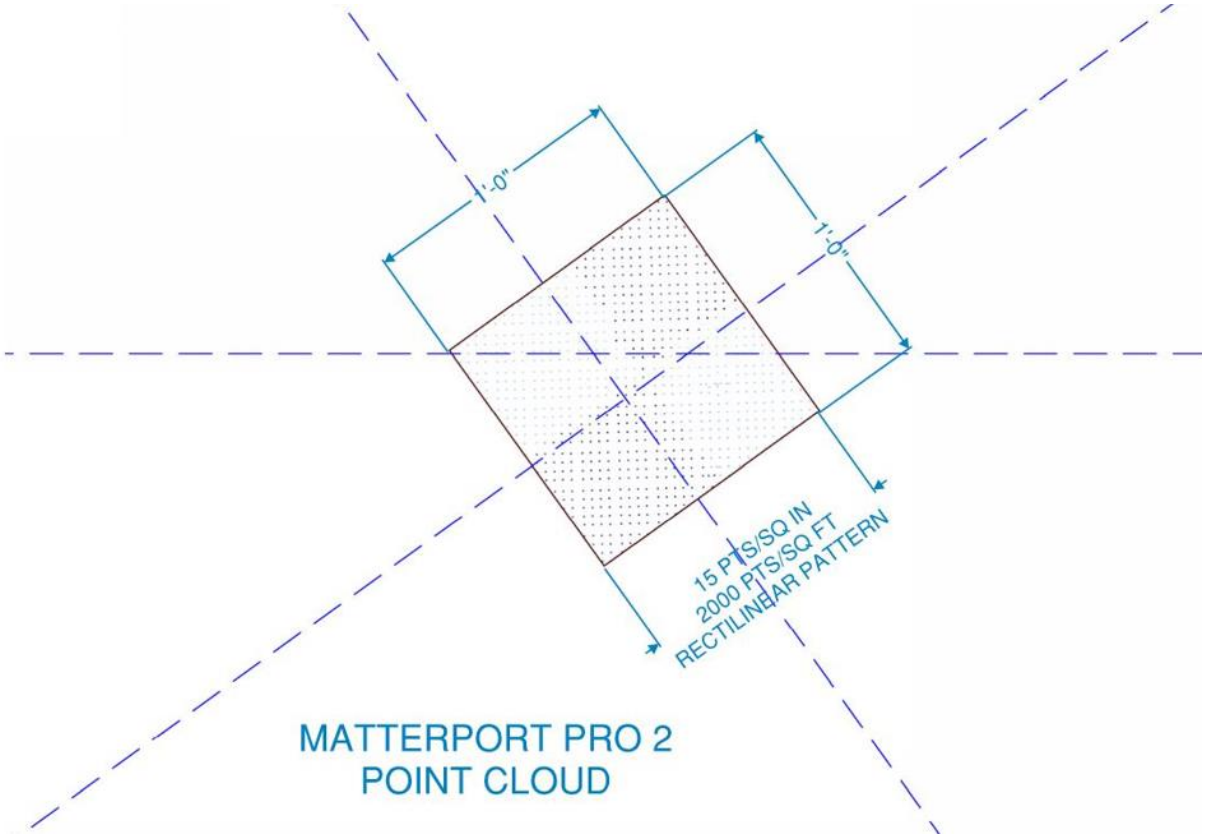
LEICA BLK360 DATA



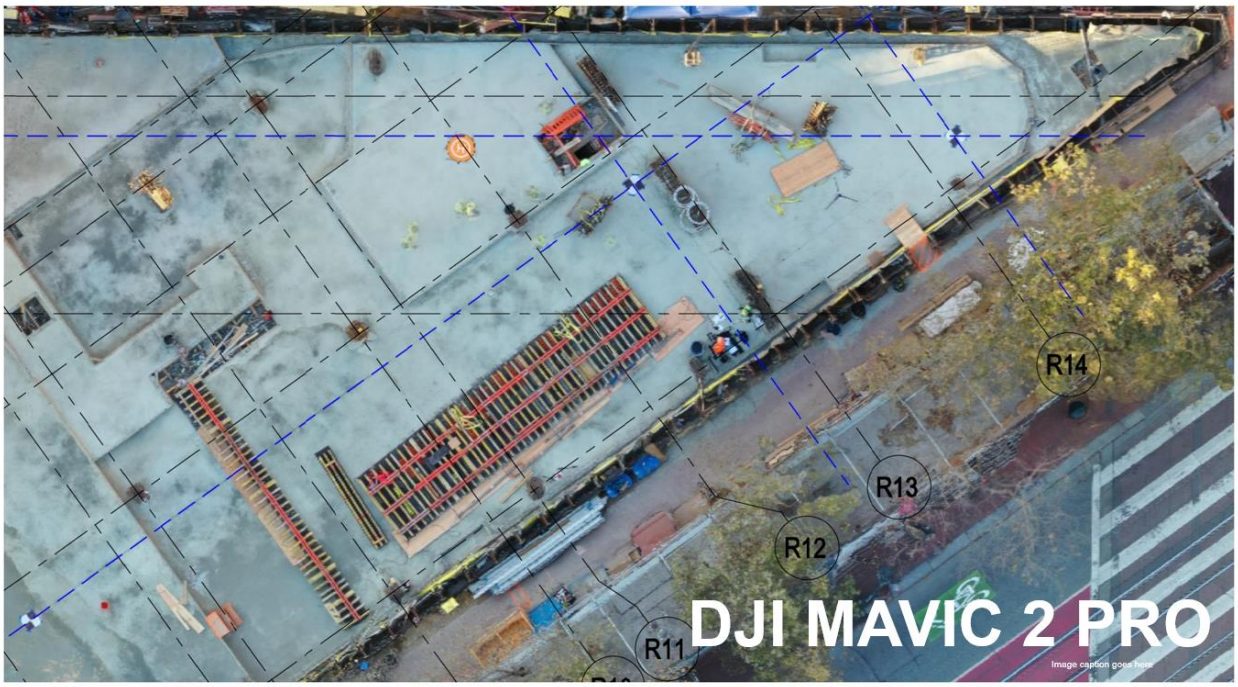
LEICA BLK360
POINT CLOUD

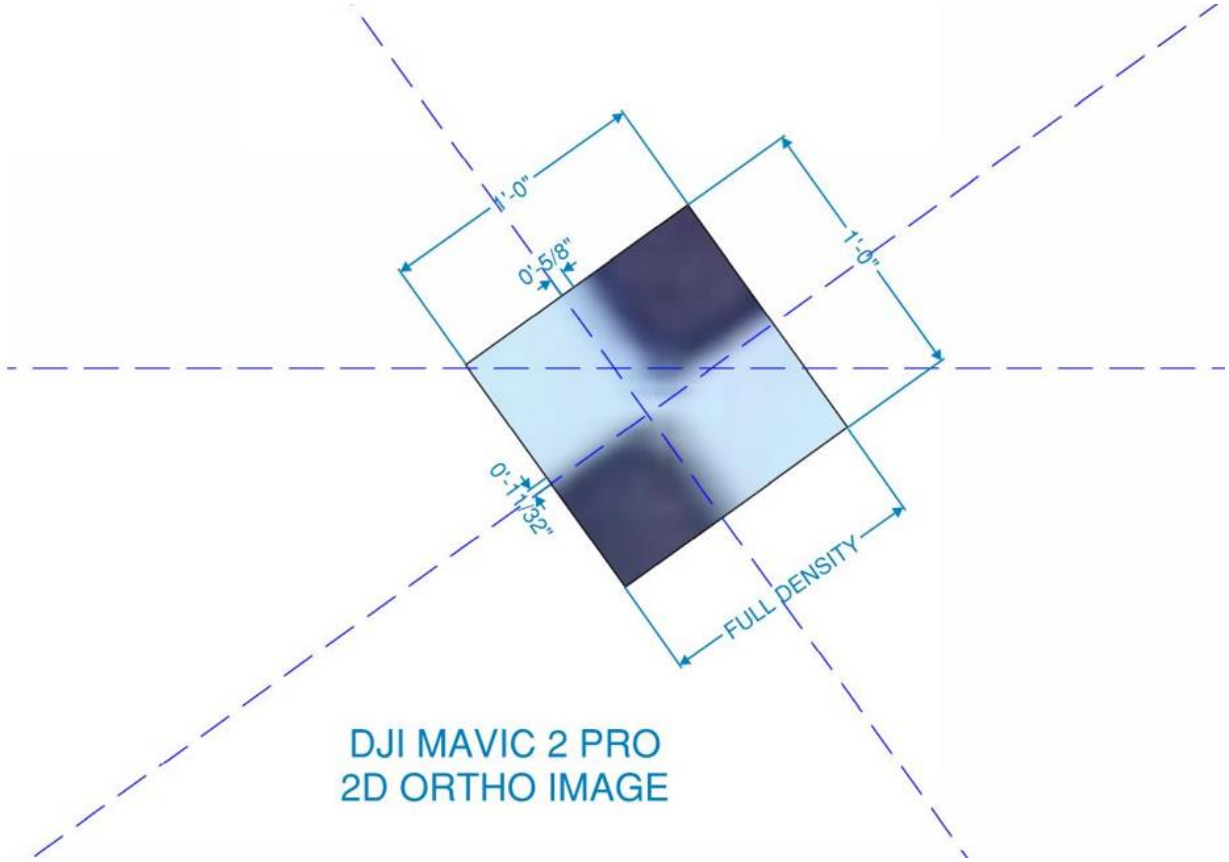


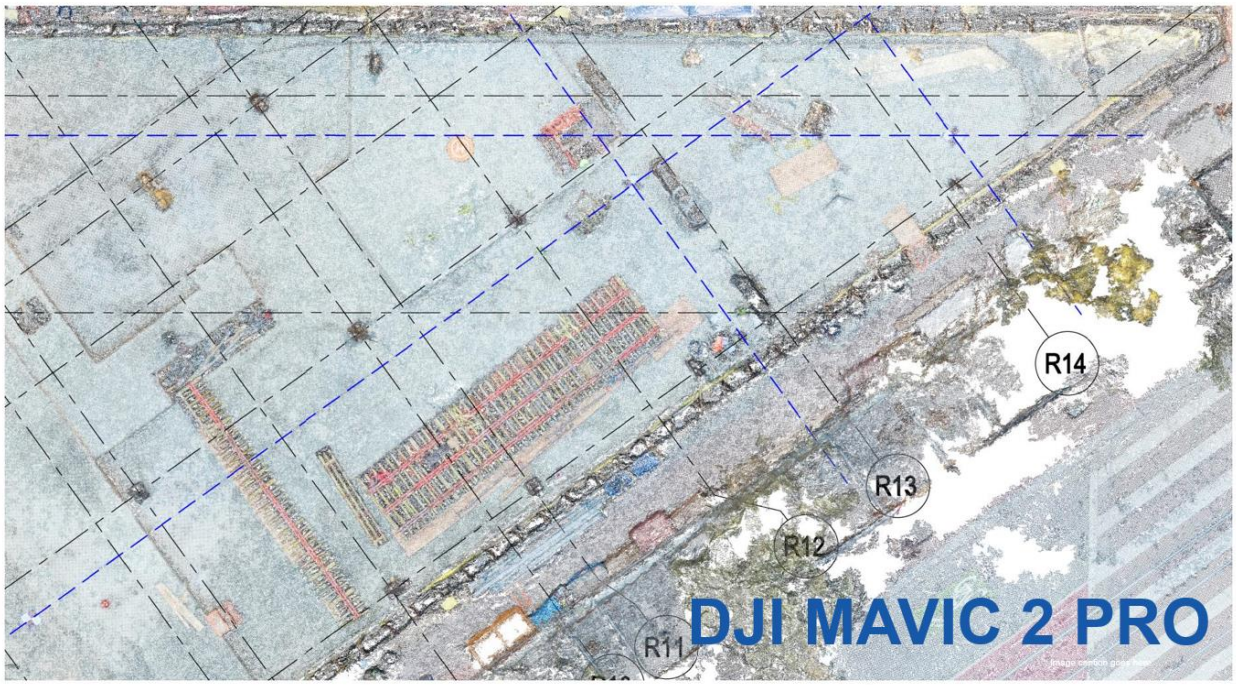
MATTERPORT PRO 2

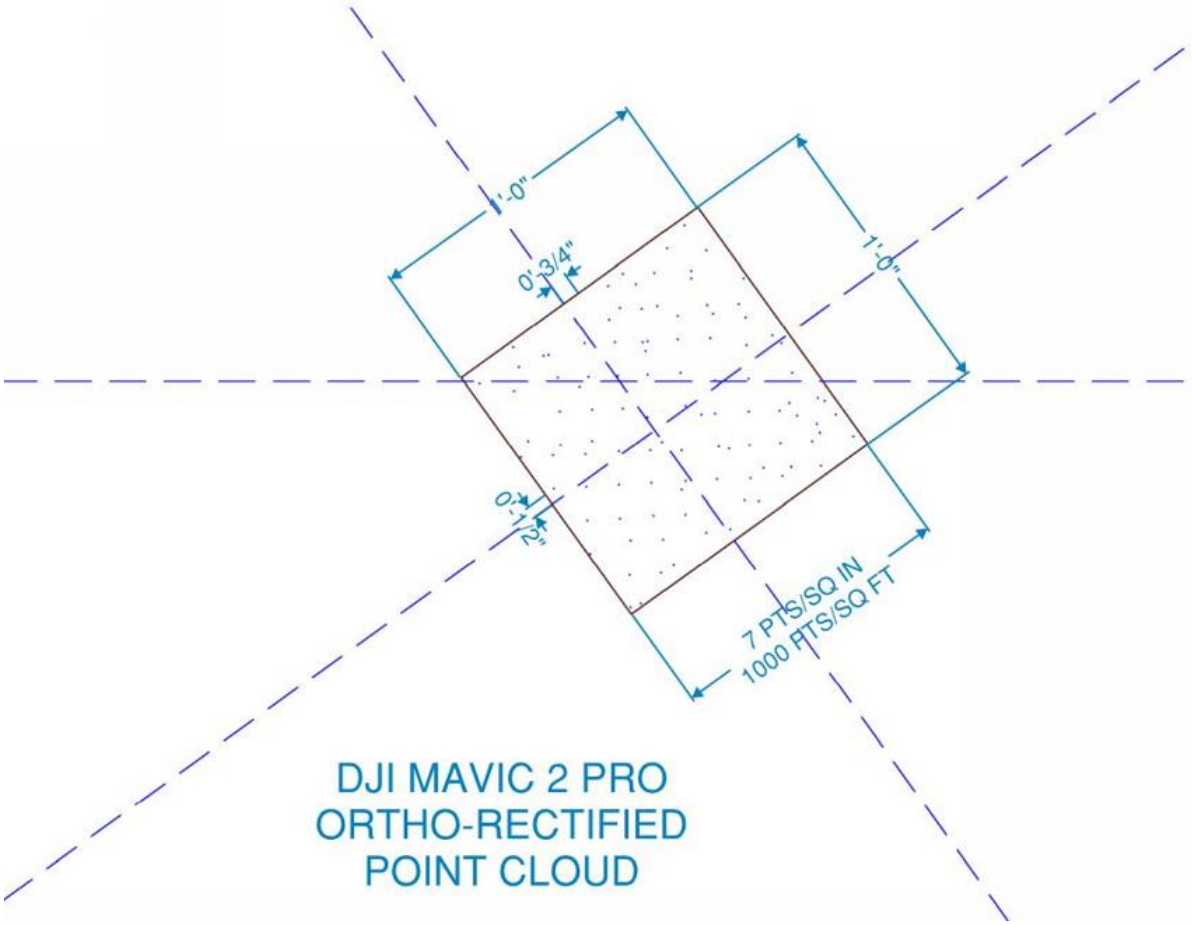


MATTERPORT PRO 2
POINT CLOUD

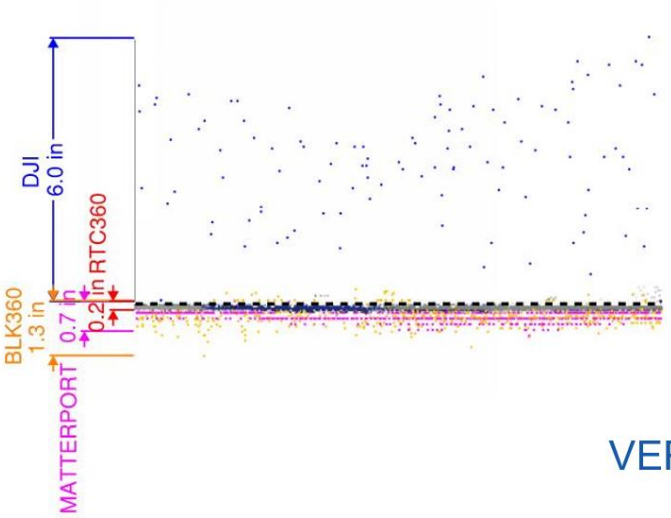

R14
R13
R12
R11
DJI MAVIC 2 PRO
Image caption goes here


1'-0"
0'-5/8"
1'-0"
0'-1 1/32"
FULL DENSITY
DJI MAVIC 2 PRO
2D ORTHO IMAGE

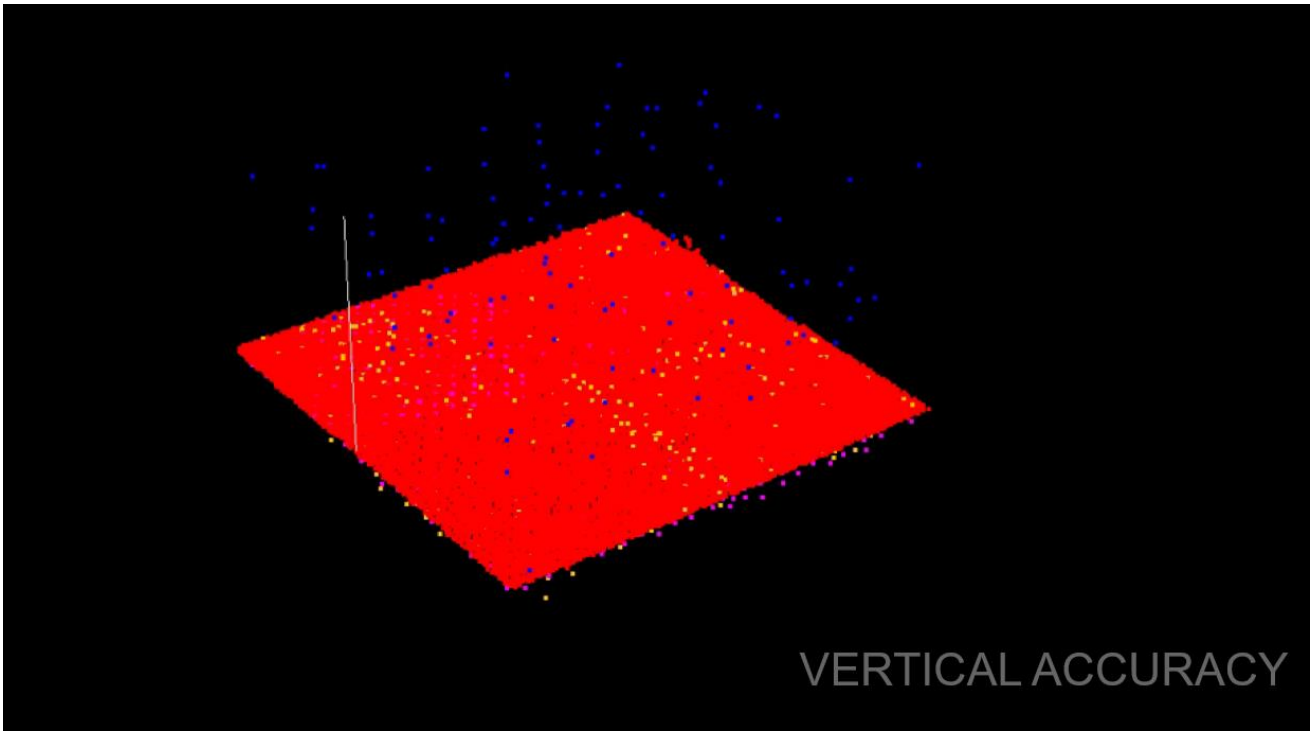

R14
R13
R12
R11
DJI MAVIC 2 PRO

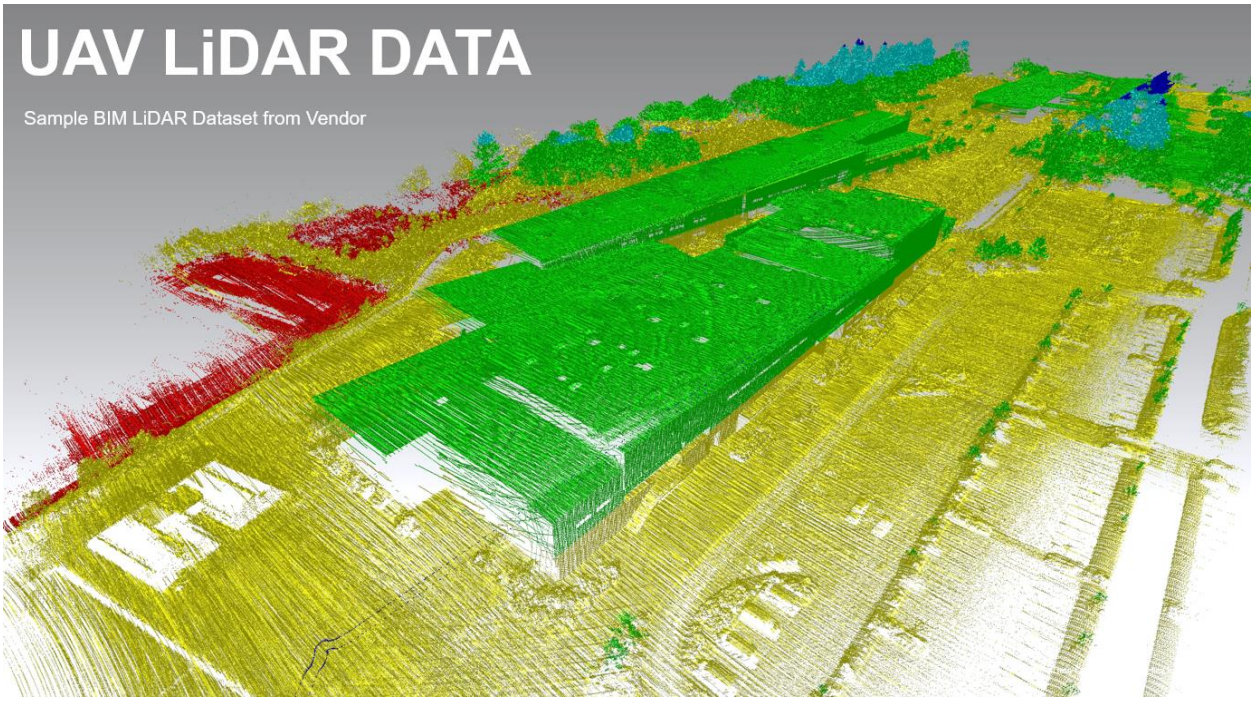

1'-0"
0'-3/4"
1'-0"
0'-1/2"
7 PTS/SQ IN
1000 PTS/SQ FT
DJI MAVIC 2 PRO
ORTHO-RECTIFIED
POINT CLOUD

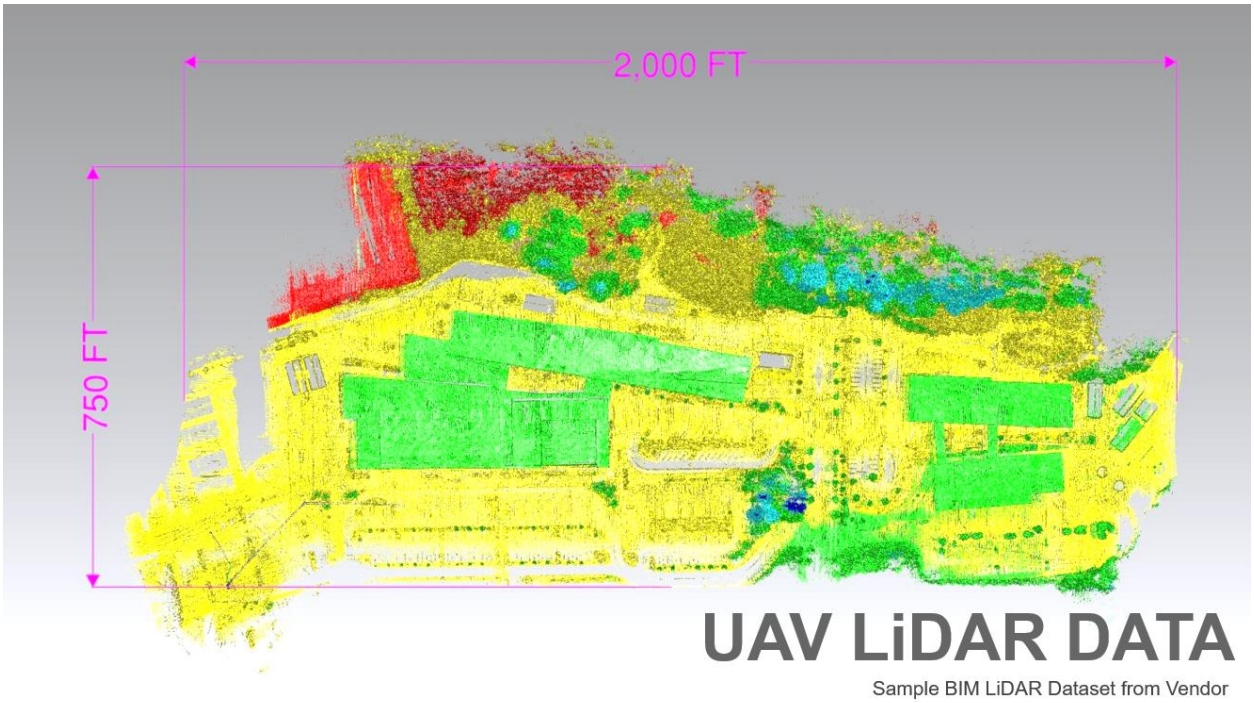
RTC360 V ERROR	BLK360 V ERROR	MATTERPORT PRO2	DJI MAVIC 2 PRO	INSTA360
3/32”	5/8”	3/8”	3”	0/0”
0.1”	0.6”	0.35”	0.25-ft	0.0”
0.008-ft	0.05-ft	0.03-ft		0.00-ft



VERTICAL ACCURACY




UAV LiDAR DATA
Sample BIM LiDAR Dataset from Vendor


2,000 FT
750 FT
UAV LiDAR DATA
Sample BIM LiDAR Dataset from Vendor

■ MINIRANGER H ERROR

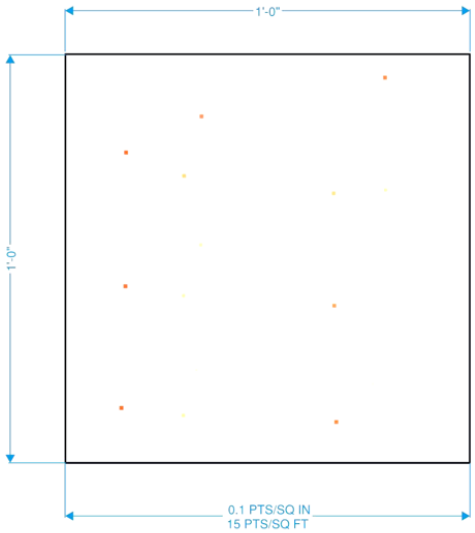
Not Analyzed by VEC

2” Provided by Vendor

MINIRANGER ACHEIVABLE H ERROR FROM VENDOR

3/4”

0.06-ft



UAV LIDAR HORIZONTAL ACCURACY

■ MINIRANGER V ERROR

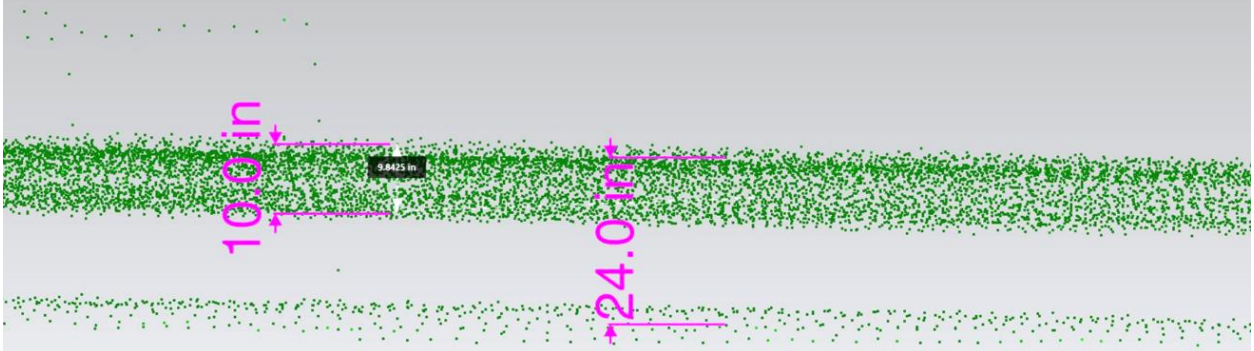
5”

0.4-ft

MINIRANGER ACHEIVABLE V ERROR FROM VENDOR

2”

0.17-ft



UAV LIDAR VERTICAL ACCURACY

Qualifications & What We Did Not Include

mini Ranger
PHOENIX UAV LIDAR

RTC 360
LEICA MID-RANGE STATIC LIDAR

BLK 360
LEICA CLOSE-RANGE STATIC LIDAR

MP Pro2
MATTERPORT CAMERA

Mavic 2 Pro
DJI UAV CAMERA PHOTOGRAMMETRY

One X
INSTA360 CAMERA PHOTOGRAMMETRY

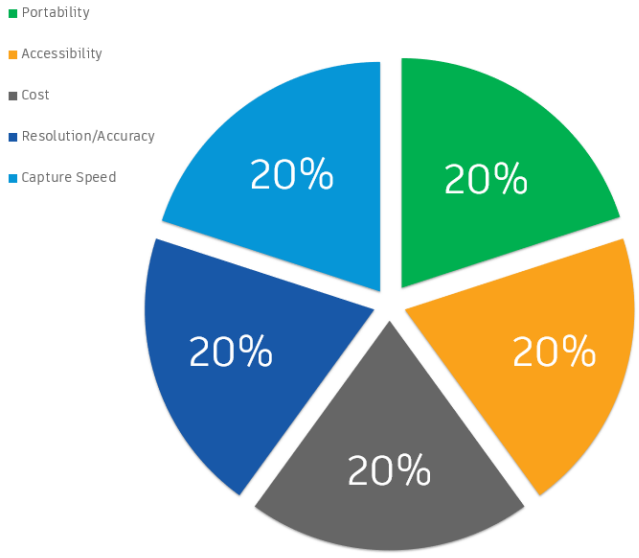
Included in our Capability & Suitability Review:

1. The Reality Capture hardware
2. Reality Capture Processing/Registration Software
3. Averaged ~2-weeks of training time to use the software
4. 2-person team to operate scanners & UAV systems

Not Factored in to our Capability & Suitability Review

1. Post-Registration Modeling Software
2. Software add-ons for deliverable production
3. Training time/cost over 2-weeks for expert-level use
4. Recap Point Cloud Decimation

Evaluation & Rating Weighting Criteria



PORTABILITY

How effortless is this technology to deploy and implement considering power requirements, safety considerations, regulatory considerations and personnel carrying convenience

ACCESSIBILITY

How easy is this technology to rent/purchase in the open market? How quickly could it be deployed to the project site?

COST

How expensive/inexpensive is this technology including the minimum hardware/software to rent/purchase in the open market?

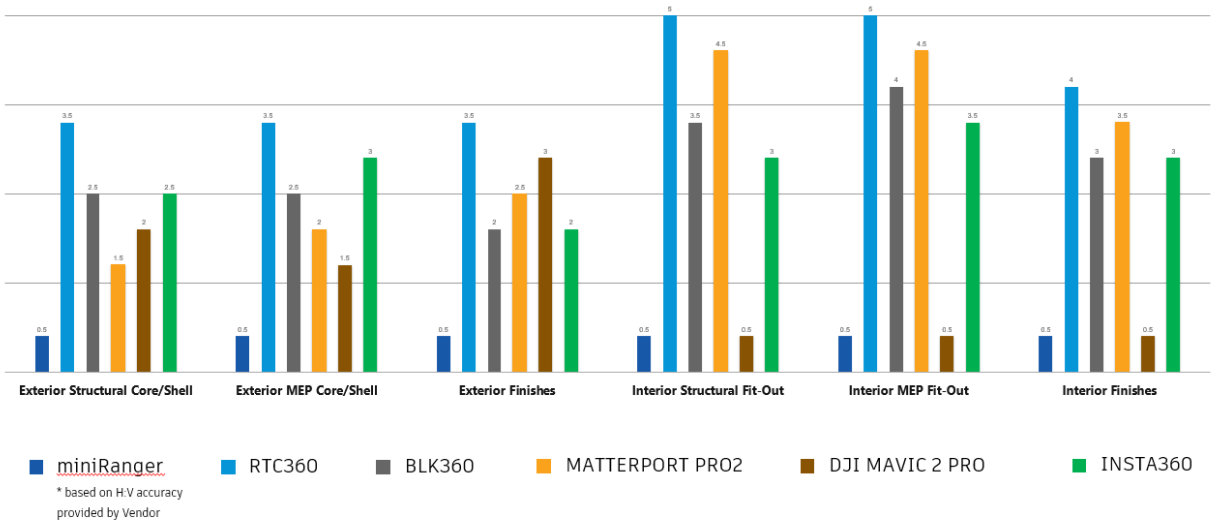
RESOLUTION/ACCURACY/PRECISION

What repeatable resolution & accuracy can be achieved with this technology with minimum training (2 weeks) and a minimal impact to construction schedule/operations

CAPTURE SPEED

What is the length of time it takes to setup onsite, deploy and capture the area of interest

VEC Suitability & Reliability Rating



* based on H:V accuracy provided by Vendor

We Make Construction Easy