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CS125433

Planning for Reality Capture

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Learning Objectives

- Learn how to create a Reality Capture Execution Plan
- Learn how to apply strategies for scheduling and planning scans
- Learn how to apply strategies for quick collection of data for deliverables
- Understand basic workflows for reality capture

Description

Laser scanning and flying drones can gather lots of data, but what can be done with it? Scanning for existing conditions is easy, but what about site monitoring, steel monitoring, concrete analysis, or installation comparison? Reality capture is often the fastest way to collect the information for these types of activities, but they have to be properly planned for, and strategies need to be in place so that time isn't wasted collecting data that won't be used. This session will focus on planning reality capture activities for success, and developing strategies for making sure the data can be turned into deliverables as quickly as possible.

Speaker

Nick Dyer received his Bachelor's Degree in Construction Management from Weber State University. He has been using Building Information Modeling (BIM) technology for the last 10 years and has been applying his knowledge in technology to both the design and construction sides of the industry. Currently, Nick works for Okland Construction as an Integrated Construction Manager working to expand and implement technology on the jobsite through the use of models and reality capture. He is also helping to support new talent in the industry as an adjunct professor at Weber State University and working with the local Revit Users Group. Pulling from experience on both sides of the industry, Nick is able to support the BIM process from design to project closeout.

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Introductions

I introduce myself and Okland Construction here so you may understand where I am coming from in this course. These are the tools and management practices we have developed over the last several years that have worked. There has been many lessons learned in developing these documents and they work for our market and project. You may need to modify parts and pieces of these documents in order to fit your own individual companies and markets.

The Speaker

Nick Dyer – I have been with Okland Construction for the past 6 years. I have been working on health care and higher education projects mostly, with some others sprinkled in-between. I have worked on projects in Utah, Arizona, Idaho, Colorado, and Hawaii.

Okland Construction

Okland Construction Company was founded in 1918 in Salt Lake city, Utah. We have offices in Salt Lake City, Utah, Tempe, AZ and Boise,ID and currently have active projects in 19 states. We are a general contractor and have built or are building just about anything you can think of.

The tool Bag

These are the tools we at Okland are using:

- Laser Scanners: FARO X330 Laser Scanner
- Drones: 3DR Solo and a Phatom 4 Pro
- Software: FARO Scene, Recap 360 Pro, 3DR Site Scan, Rhthm Builder App, Rhthm Inspector App, Struction Site

The purpose of a Reality Capture Execution Plan

The purpose of creating a Reality Capture Execution Plan is to communicate to the entire team when reality capture activities need to take place, what documents need to be in place, what deliverables are required, and what time frame this all takes place in. Even if a team still wants something last minute, having a template of a plan in place will be a useful tool in facilitating the needed communication for a project team who doesn't quite understand the workflows needed to perform what they are asking.

The Administrative stuff

There are a few things administratively that every plan needs, but in this case it's just the basics such as:

- Project name
- Owner
- Project Address
- Area of project to captured
- Airspace, if needed
- Others?

Depending on what is important to you and your company, what you want to include in this portion will vary.

What's on Menu?

Creating a "menu" with all of your available services is a great way to make teams aware of what you can do. There are a lot of misconceptions about what can be done and what can't be done, and what deliverables look like. The menu can be tailored to your company and even if you don't directly offer up something your project team may want to do, it facilitates a conversation. It's important to note all pertinent information alongside the service so that everything is known upfront. Here is an example of an item structure:

> **Laser Scanning an Existing Facility:**
>
> **Equipment Cost:** We charge an equipment cost in order to gain our return on investment for both our scanners and drones. We have half day, daily, and weekly rates. **Note:** all costs listed are fictional.
>
> **Labor Cost:** Depending on your company, this may be an hourly rate, daily, or weekly, but the point is to be as transparent as possible.
>
> **Time Estimating:** Sometimes this can be straight forward or it can start to be very complicated. Unless it is something really simple to estimate, you should note that consultation is required to get an accurate estimate.
>
> **Schedule:** If this is a reoccurring activity, then it needs to be part of the master schedule. If this is something you are doing only once, then maybe just the dates and times are all that is needed. In either case, it lets you know when it's needed and it's not a surprise.
>
> **Permits or Documents**: Sometimes these are required, a common one may be FAA authorizations or permits for drone flights.

Control: Reality Capture work flows almost always require survey control, it is important to note in the plan who is providing control and when they will be providing it. That said, because control points are easiest to use when they are targets, it is best practice to set permanent or semi-permanent targets and then use them for your control points.

Deliverable: Explain in text what the deliverable looks like, but then always provide examples. Pictures are good to have in your template, but when discussing this point with your team, plan to have an example to walk through so everyone has a clear image of what to expect. Otherwise, misconceptions will prevail.

Deliverable File types: Depending on what you use to process your data, and what your deliverable is, you can list the different file types you will be providing

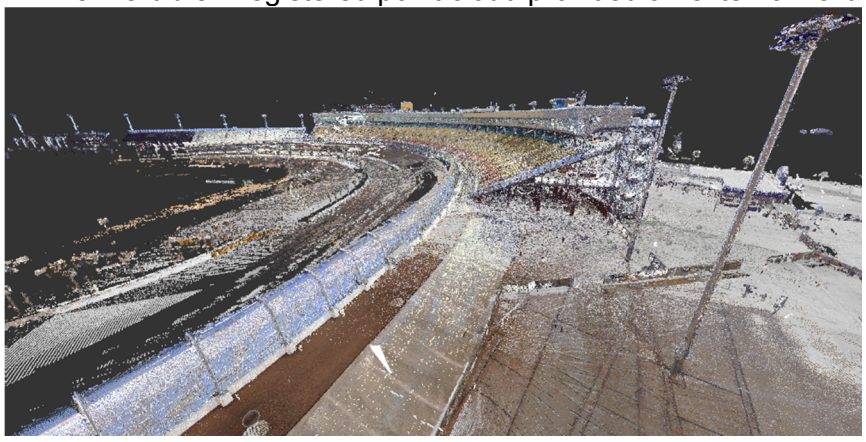
Required Software: Unless your deliverable is a PDF, it will probably requires some kind of special software or viewer to use the data.

Limitations: Each service always has 1 or 2 things that are common limitations that are also misconceptions; such as if you can't see something neither can the scanner. However, there are lots of people who do not understand the technology and think a laser scanner can see through walls. Those things need to be addressed up front to ensure team members know what to expect.

Here are examples of some more common services that can get you started on creating your own list of services.

Laser Scanning an Existing Facility

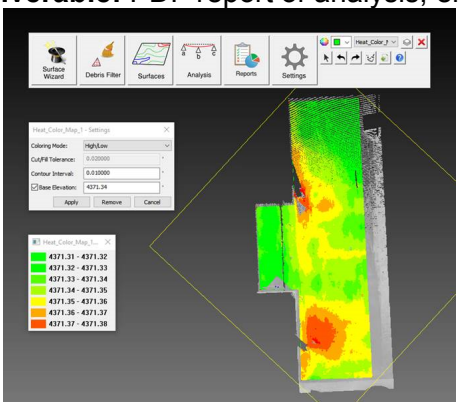
- **Equipment Cost:** $100/Half day, $200/Day, $600/Week
- **Labor Cost:** $95/Hour
- **Time Estimate:** Varies per building, consult ICT
- **Schedule:** Dates based on time needed for scanning and processing
- **Permits or Documents:** are any needed?
- **Control:** GC provided targets, data provided by?
- **Deliverable:** Registered point cloud provided an external hard drive

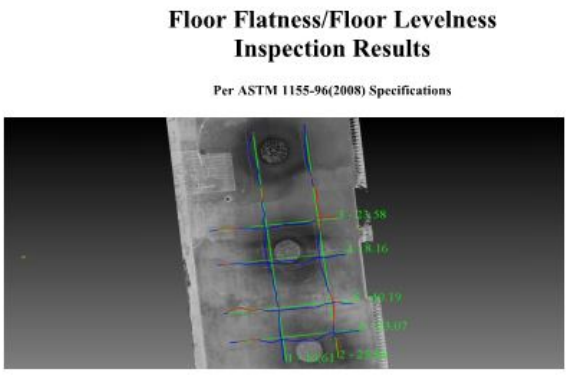


- **Deliverable File Types**: .fls, .pts, .rcs, .rcp,
- **Required Software:** Faro Scene LT, Recap 360, Navisworks, Revit, AutoCAD
- **Limitations:** If something is not exposed, it will not be scanned. File types can get very large.

Floor Flatness/Floor Levelness (FF/FL)

- **Equipment Cost:** $100/Analysis
- **Labor Cost:** $95/Hour
- **Time Estimate:** Plan for travel + 2 hours for each data collection +3 hours for each analysis
- **Schedule:** Needs to be scheduled for same day as each slab on deck pour
- **Permits or Documents**: are any needed?
- **Control:** GC provided targets, data provided by?
- **Deliverable:** PDF report of analysis, electronically delivered via e-mail or download link.

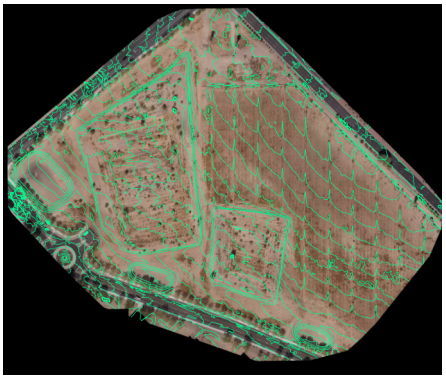


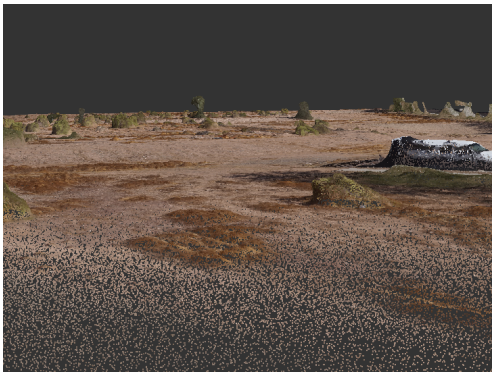


- **Deliverable File Types:** .pdf
- **Required Software:** Bluebeam or Adobe
- **Limitations:** In order for results to be accurate, the concrete must swept and free of obstacles.

Aerial Survey

- **Equipment Cost:** $100/Day
- **Labor Cost:** $95/Hour
- **Time Estimate:** Plan for equipment + Travel + data collection time + 3 hours for processing data + additional time based on desired deliverable file type.
- **Schedule:** recurring once/weekly/monthly?
- **Permits or Documents:** FAA documents? airspace?
- **Control:** GC provided targets, data provided by?
- **Deliverable:** Images, Image Map, Contour Lines, and/or Point Cloud, items can be sent via download links or on an external hard drive.



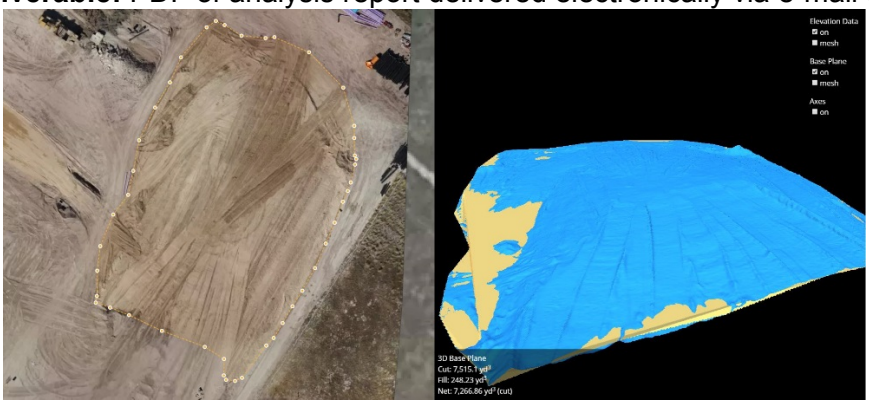


- **Deliverable File Types:** .Images – jpeg, Image Map – tiff, Contour Lines - .shx or .dxf, Point Cloud - .rcs, .rcp, .las, or .pts

- **Required Software:** Image Viewer, AutoCAD for Contour Lines, Recap 360, AutoCAD, Revit, or Navisworks for Point Cloud.
- **Limitations:** If something is not exposed, it will not be scanned. File types can get very large.

Soil Monitoring

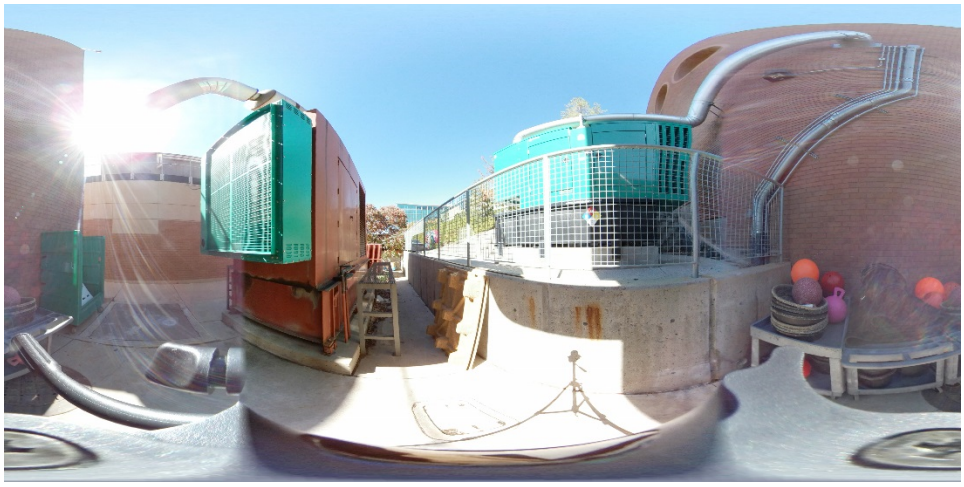
- **Equipment Cost:** $100/per day
- **Labor Cost:** $95/Per Hour
- **Time Estimate:** Travel + 3 hours data collection and processing data
- **Schedule:** recurring once/weekly/monthly?
- **Permits or Documents:** FAA documents? airspace?
- **Control:** Okland provided targets, data provided by?
- **Deliverable:** PDF of analysis report delivered electronically via e-mail or download link.



- **Deliverable File Types:** .pdf
- **Required Software:** Bluebeam or Adobe
- **Limitations:** Areas of interest need to be free of people and moving vehicles as much as possible. Too much noise will provide inaccurate results. If the soil is dark, direct sunlight is needed to provide accurate results.

360 Map: Measurable Photos

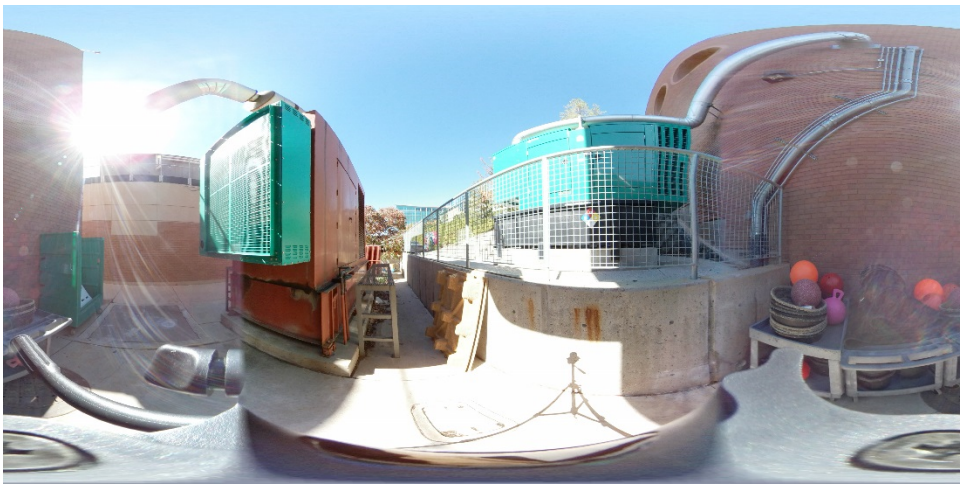
- **Equipment Cost:** $100/Half day, $200/Day, $600/Week
- **Labor Cost:** $95/Hour
- **Time Estimate:** Plan 15 images/half Day, 30 Images/day + Travel + 1 additional days' worth of labor per day of data collection.
- **Schedule:** recurring once/weekly/monthly?
- **Permits or Documents:** are any required?
- **Control:** Not Needed
- **Deliverable:** Recap file with linked 360 photographs delivered electronically via a download link if the file size is small enough. If the file size is too large it will be delivered on an external hard drive.



- **Deliverable File Types:** .rcp or .rcs
- **Required Software:** Recap 360
- **Limitations:** If something is not exposed, it will not be captured. Files size can get large and difficult to share.

360 Map: Photographs

- **Equipment Cost:** $10/day
- **Labor Cost:** $95/Hour
- **Time Estimate:** Plan 100 images per day + travel + 3 hours of processing time
- **Schedule:** recurring once/weekly/monthly?
- **Permits or Documents**: are any required?
- **Control:** Not Needed
- **Deliverable:** PDF with hyperlinked 360 images delivered electronically via e-mail or download link.



- **Deliverable File Types:** .pdf
- **Required Software:** Bluebeam or Adobe
- **Limitations:** If something is not exposed, it will not be captured. Must be connected to the internet in order to be usable.

Filling in the Gaps in the plan

Obviously there are some gaps in the menu items. This is partially to keep descriptions short. The other reasons are because if you are the one performing the work, you need to be the one to define it. The menu only describes those items that do not change or have very little variability. Defining the variability of every project for every service would be unreasonably time consuming. Since some items have lots of variability and others are very straight forward, we will look at a few examples.

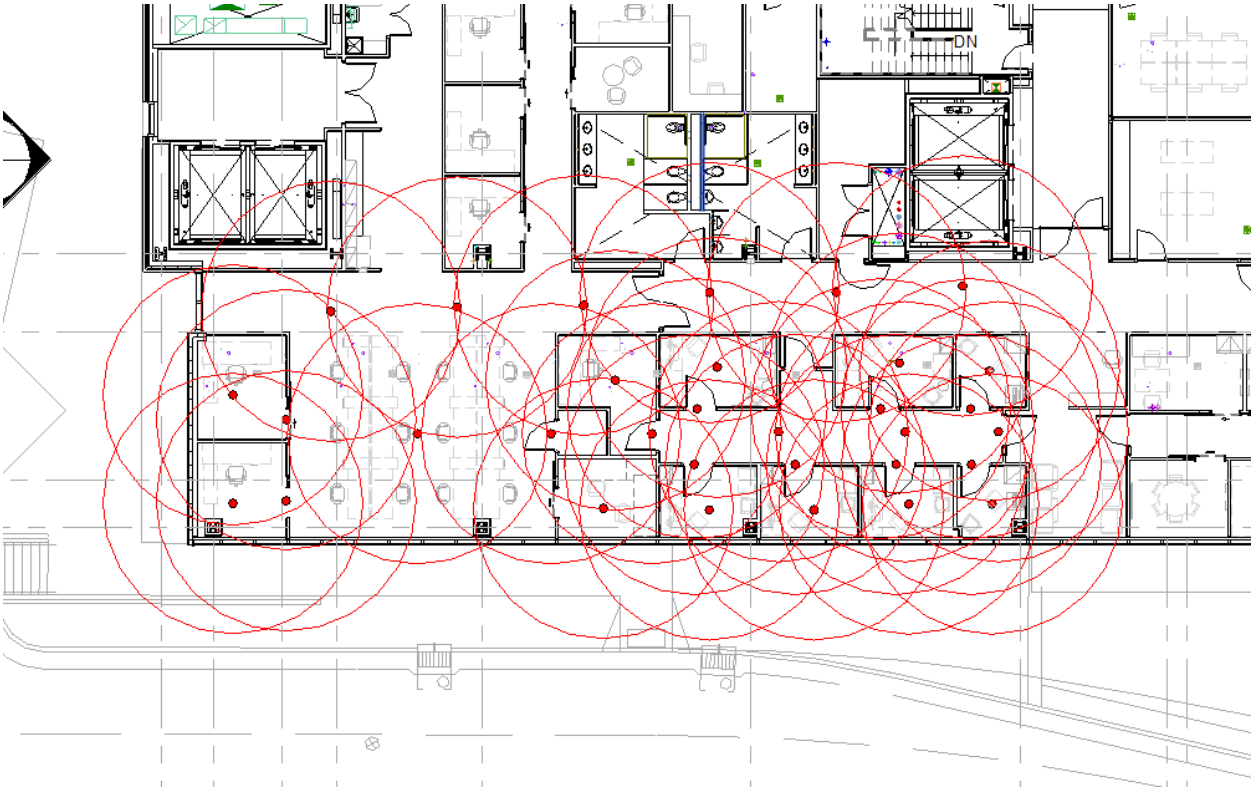
Laser Scanning Existing Facilities.

The Scenario

You need to scan an existing facility that is mostly doctors' offices and exam rooms and totals about 3,000 square feet.

The Estimate

This activity has the most variability, and time is your biggest enemy. Each scan takes a certain amount of time depending on scanner settings. The absolute best way to determine that amount of time a scan will take is to decide on what settings you will be using. Next, take a PDF of the floor plan and plan out where you need to place each scan station. I have created a Bluebeam stamps of scan stations showing a 30' radius for interior scans and a 60' radius for exterior scans. Obviously, there is some variability, but this will always be a conservative estimate. In the end you will have something like this to take with you to the jobsite.



Doing this will also provide you with a scan path to follow which will make your registration more efficient and you will know how many scan stations you will need, and thus how long it will take.

- 58 Scan Stations * (8 minutes per scan + 2 minutes setup between stations)
- 58 Scans * 10 Minutes Total = 580 minutes
- 580 Minutes/60 minutes per hour = 9.667 hours (Always Round Up) = 10 hours of scanning

Then there is always time to set up and clean up your jobsite. This is almost just as hard to calculate or plan for because the best practice is always to use both checker board targets and spheres. Targets take way more time than it feels like it should to set up, and spheres will be moving with you as you move through the space.

Planning for more time is always best, and I have found that 30 minutes is good for anything that is about 1,000 square feet or less. From there it depends on how many rooms you have to set up rather than a square footage, but it can also depend on the building type. For instance a manufacturing facility won't have very many rooms, but you will be setting up targets everywhere. You know your facilities better than I do, but as a general rule of thumb:

- Rooms: 3-5 minutes each
- Manufacturing space: 30 Minutes per 1,000 square feet
- Warehouse space: 1 hour per 10,000 square feet

In this example, we have a string of offices and total square footage of about 3,000 square feet.

- 20 rooms * 5 minutes each + 30 minutes for other misc. spaces = 130 minutes or 2 hours for setup and clean up.

Next, plan on the same amount of time to register scans as it does to take the scans, so an additional 10 hours of registration

Then, add the any additional time to create the final deliverable: getting the hard drive ready to be delivered. Plan an additional 2 hours, it'll cover just about anything unless you're trying to do something special.

Then we need to add any travel time that is billable and should be accounted for. For instance, let's say there is 1 hour per day of billable travel time.

- 10 hours scanning + 10 hours registration + 2 hours for setup and cleanup + 2 hours deliverable prep = 22 hours or 3 working days
- 3 days @ 1 hour per day of billable travel = 3 hours

Now adding costs

- Equipment: 1½ days @ $100/Half Day= $300
- Labor: 25 hours @ $95/hour = $2,375
- Total = $2,675

The next best way to deal with estimating this activity, if you don't have a drawing to estimate against, is to break different scenarios down by building types. These are some examples:

- Office Building: 1 scan per 350 Sq. Ft. + 1 scan per room
- Warehouse: 1 Scan per 700 Sq. Ft. + 1 Scan per room
- Manufacturing: 1 Scan per 350 Sq. Ft. + 1 scan per room
- Building Perimeter: 1 Scan per 60 linear Ft. + 1 Scan per building corner

Once you know how many scans you need, the formulas stay the same.

Workflow

For this example we will want to turn an .rcp over to the architect, which makes our decision easy. Since we can't get anything except a unified rcp from Scene, we will be using Recap 360 Pro for registration.

So the workflow works in this direction.

1. Estimating
2. Setup
3. Collection of the Data
4. Clean Up
5. Registration through Recap
6. Preparing hard drive for delivery

Finding the efficiencies

There are several ways we can find efficiencies in this workflow.

1. Estimating – in this example, we estimate things in a linear fashion and that is always the best practice. This is because we may not be able to count on some of the other efficiencies and thus we should not over promise our capabilities. However, in this example, the first efficiency we find is in the estimating phase. Since we had a floor plan we were able to plan our scan positions. Pre-planning our scan positions will always decrease the amount of scans taken in the field thus decreasing the amount of time spent collecting data.
2. Setup – You don't have to set everything up all at once. We have 8 minutes where the scanner is doing its thing, and we are doing nothing. This means we can walk away from the scanner and set up other areas while we wait. Some initial set up needs to take place, but if we assume that we take 30 minutes for some initial setup, and then start cleaning up areas as you move through the building we have gained 1½ hours off our initial amount of time allotted to collect the data.
3. Collection of Data – There really isn't any way around this amount of time. You will need a certain amount of scan stations, and each scan will take a certain amount of time.
4. Cleanup – Refer to the notes on setup. It seems like a small amount of time, but at the end of a long day of scanning you will be glad you did.
5. Registration – Recap and Scene both have the capability to start registering scans and add additional scans to the project over time. So starting the process as early as possible is the key. Having a laptop with the capability to register and process scans gives you the ability to have data drops throughout the scan process. This seems to work best in batches of 10 scans or less. All this means is collect about 10 scans, then take the SD card and transfer those scans to the laptop and get it started.
    a) In this example, you will be taking 58 scans over 10 hours, then another 10 hours for processing equaling 20 hours total. But doing most of the processing work as concurrently as possible, you are able to shave about 5 hours of processing time off your total.
6. Preparing hard drive for delivery – It probably won't take the full 2 hours to prepare this, but again, it's just planning that saves time here. Let's assume we don't need to make the errand to Best Buy to get the hard drive, so we save an hour.

Totaling everything up:

- 25 planned hours – 1.5 hours setup and cleanup – 5 hours registration – 1 hour for hard drive = 17.5 hours.

Now you're finishing in the morning of the third day rather than spending that day working on your registration and finishing in the evening.

Aerial Survey

The Scenario

You need to fly over a jobsite totaling 8 acres of land. You happen to be in class G airspace and there are no obstacles over 100 feet tall.

Estimating

Here the estimating is straight forward. However, there are some important variables to plan for. You will need to determine your time spent flying based on your drone's capabilities, but generally speaking, I have found that I can fly 16-20 acres in one flight from 150-200 feet above ground level in about 1 hour. No matter which drone, this seems to be highest efficiency of battery life to area covered ratio.

Since we have a site less than 16 acres and can flight at 150 feet AGL, we only need to plan 1 hour for data collection.

However, if the site were larger, we need to weigh the benefits of flying higher and burning through more batteries or make multiple flights to cover more area. If you choose to add additional flights, the flight time doesn't change, so plan on 1 hour per flight, but then you also need to account for batteries. Each flight will take about 3 batteries so unless you have a lot of batteries, most people only have about 6, you can only make 2 flights without being grounded 2½ to 3 hours to recharge your batteries. Because of this, you are only able to fly 4 flights in a given day.

Conversely, if you choose to fly higher, you burn up your batteries at an exponential rate. Flying at an elevation of just 225 feet AGL will gain you 10 acres in a single flight, but you will use 5 batteries. However, you will make that flight in about 1.5 hours rather than 2 flights at 1 hour each. In cases where these types of decisions need to be made, planning your flights before showing up on site is critical.

The rest is straight forward to let's just plug in some numbers for the example

- Travel time = 1 hour
- Data Collection = 1 Hour
- Processing Data = 3 Hours (This is your time you spend actually working with the data. Most flights are processed in cloud server and take anywhere from a couple hours to an entire day. I always tell people I will have next day results)
- Deliverable: The .las file created by the site scan software delivered as a web link to the civil engineer. This time can easily be absorbed in the processing data. However, if the deliverable is something like a grade comparison, you need to plan additional time for anything the software does not produce on its own.
- Equipment = $100
- Time = 5 hours @ $95 per hour = $475
- Total = $575

Work Flow

The basic workflow:

1. Estimating
2. Setup
3. Data Collection
4. Cleanup
5. Uploading the drone data to Site Scan
6. Processing the data in Site Scan
7. Creating the web link and sending it out.

Finding the efficiencies

There really isn't any efficiency to be found in this workflow as it's an all or nothing process. However, a drone is the more efficient choice in comparison to a laser scanner.

360 Photos

Technically this isn't a "reality capture" activity, and 360 cameras are now found on most jobsites. However, you may want or need the ability to share images that measureable, and this is where you will need to pull the laser scanner out. You can also combine 360 images from the laser scanner and a camera onto a single photo map. Estimating for either workflow is identical.

The Scenario

Need to take 40 images throughout a building all on a single floor.

Estimating

This is really straight forward, 40 images means you need to plan 1.5 days for equipment and data collection. Then an additional day and half of data processing and we will plan an hour for travel:

- Equipment = $300
- Time = 24 hours collection and processing + 1 hour travel = 25 hours = $2,375
- Total = $2,675

Workflows

First let's look at the workflow for measurable photos, and by measureable photo's we are really just meaning the 360 photos from Recap. The scans need to be close enough together to register, but you don't need to worry about the registration being tight because the pictures will be accurate unto themselves.

1. Data Collection
2. Registration and processing through Recap Pro
3. Creating the deliverable – You just need to make sure everybody has the free version of recap on their computers. They you can share it via A360 or place the files on a local network.

Finding the efficiencies

The efficiencies here are the same as laser scanning. Running registration concurrent with data collection and estimating scan stations so you aren't setting up more stations than you need.

Next, let's look at the workflow for combining the scan images with images from a 360 camera.

Workflow

1. Estimating
2. Data Collection
3. Import Scans into FARO Scene
4. Apply Pictures
5. Export Pictures to .jpeg
6. Upload a drawing to Structionsite.com to use as the background
7. Select locations of each scan on your background and upload the image to Struction site.

In this example we are using Struction site because you don't have to inject the images with metadata in order for them to be recognized as 360 images. There are lots of other good things about the way Struction site manages 360 images, but we can't cover them all here.

Monitoring Activities

Monitoring activities are simply just activities that take place more than once in order to monitor movement of a building. If you are using a drone, you would estimate the same as an aerial survey. If you're using a laser scanner, you estimate as if it's an existing facility, but most likely a much smaller area. Really, these only differ in workflow.

Floor Flatness/Floor Levelness using a Laser Scanner

1. Preparing the area to be scanned. The area should be clear of all obstacles and swept.
2. Data collection of the area of interest. This needs to be done immediately following the placement of the concrete
3. Import the scans in FARO Scene
4. Register the scans in FARO Scene
5. Using the Inspector Plug-in for FARO Scene, select the area to analyze.
6. Export the results of the test to PDF.
7. Repeat as is needed.

Soil Stock Pile Monitoring using a drone

1. Data Collection
2. Uploading the drone data to Site Scan
3. Processing the data in site scan
4. using the measure tools in site scan define the area of the soil stock pile
5. Create a PDF of the results
6. Repeat as needed.

Almost without exception, each analysis can be completed in less than 1 day. As a result, there are not a lot of efficiencies to be found. However, if you don't schedule your data collection dates and times correctly, it will slow you down. I have found that planning to collect data during lunch minimizes the amount of people on the jobsite, and subsequently allows me to work faster, as I don't have to work around anybody.

Getting on the schedule

As part of putting together any plan for reality capture, you need to have it incorporated in the master schedule for the project. Too often, a laser scanning activity will be scheduled few weeks in advance, and then because there are no reminders for yourself or for your project team they get forgotten or turned into emergencies.

Summary

Putting together an execution plan starts with creating a list of the basic services you can provide to your projects. Then, when services are selected, you can start to fill in the gaps in the plans with planning your laser scans by determining how many scans you need before you show up on the jobsite. Once you have decided when and how long it will take, you need to have the activities incorporated as part of the master schedule for the project. Then when it comes time to perform the activity, because you planned it out already, you have freed yourself up to be able to perform portions of your workflow concurrently.

Good Luck!