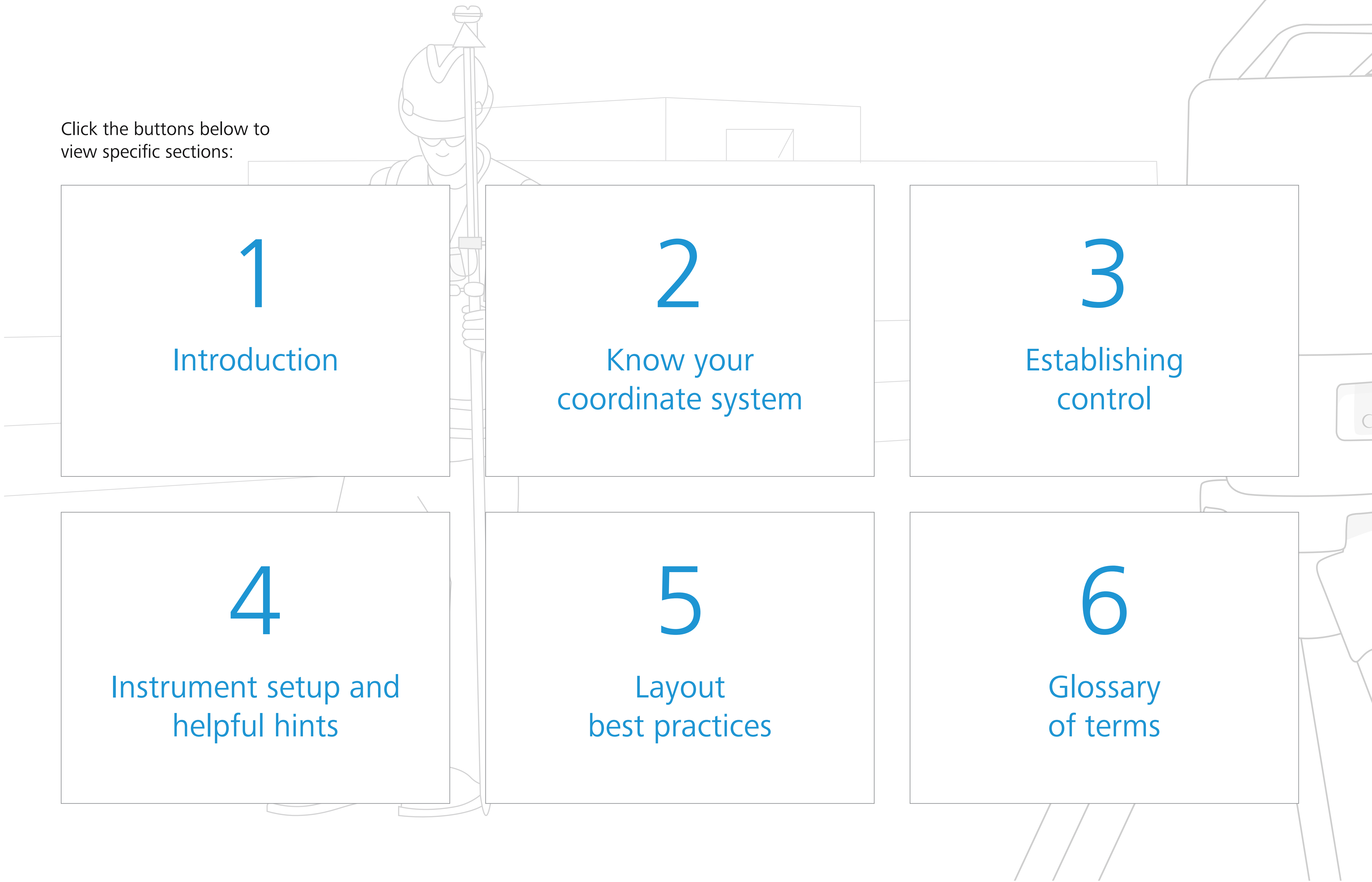

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Autodesk Field Layout Guide

Introduction

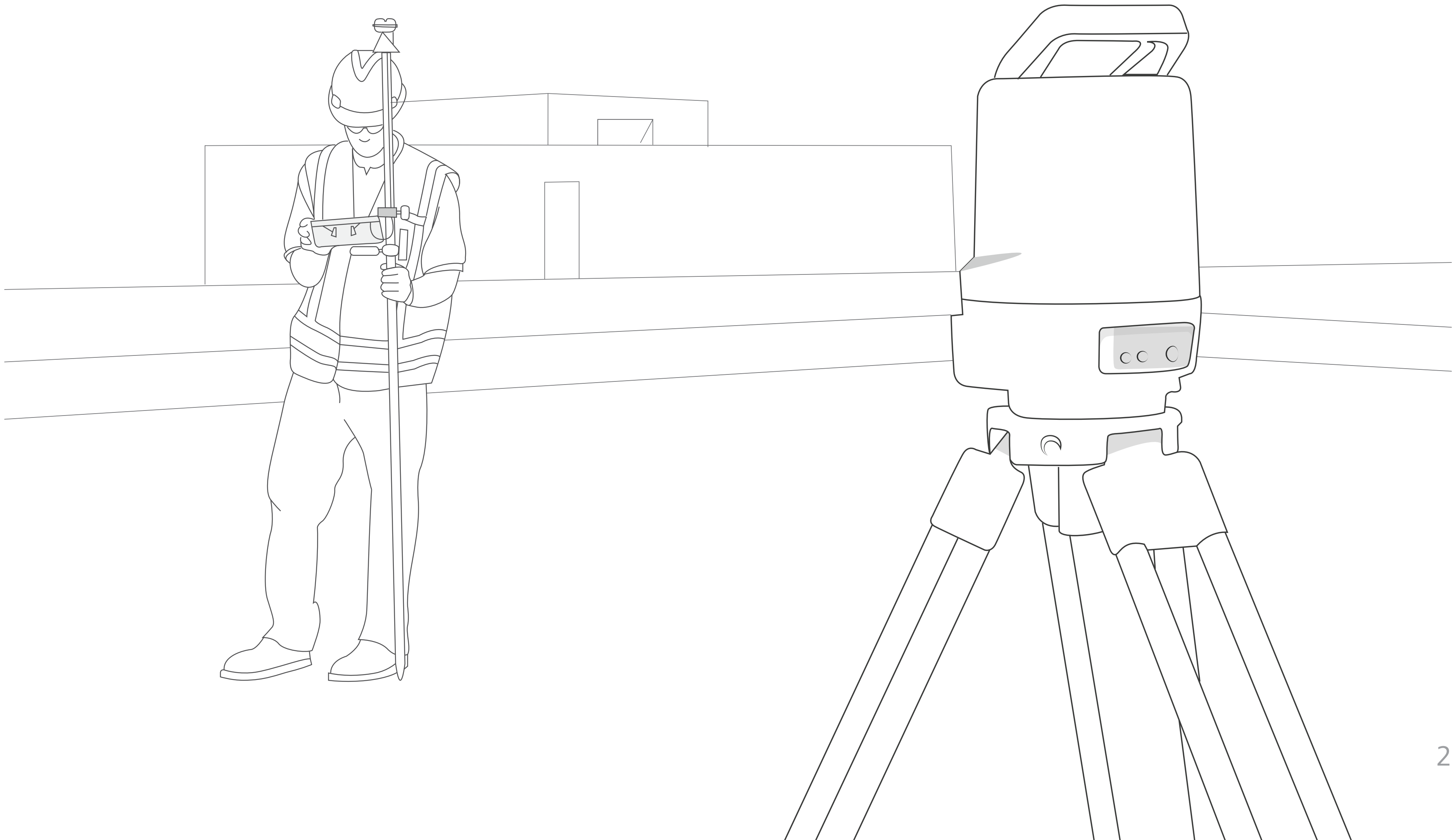
The *Autodesk Field Layout Guide* is a reference manual for contractors and non-surveying professionals working in vertical construction applications. It is meant to be a general guideline to common construction layout practices that use today's robotic total stations.

Helpful links for understanding Coordinate Systems

http://www.ngs.noaa.gov/PUBS_LIB/UnderstandingSPC.pdf

http://en.wikipedia.org/wiki/State_Plane_Coordinate_System

http://www.ngs.noaa.gov/TOOLS/spc.shtml

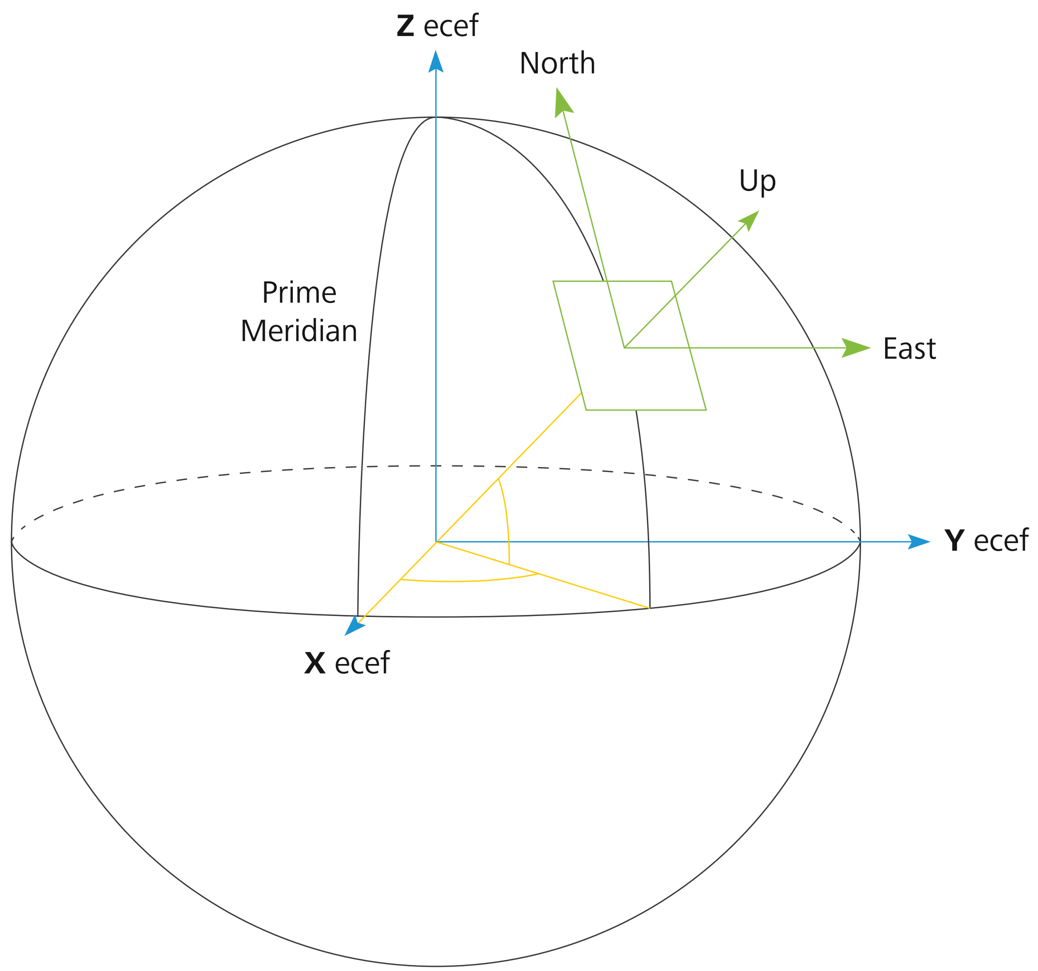


Know your coordinate system

What is the State Plane Coordinate System?
A coordinate system based on geographic zones in the United States, the State Plane Coordinate System was developed to make it easier to compute grids while maintaining geodetic and grid distances of one part in 10,000 or better.

Coordinates can be communicated in:
1. Latitude, longitude, and elevation
2. Northing (Y), Easting (X), and elevation (Z)
3. Easting (X), Northing (Y), and elevation (Z)

Surveyors typically rely on the State Plane Coordinate System, but some also use the Universal Transverse Mercator (UTM) coordinate system or Northing 5,000 feet/ Easting 5,000 feet.



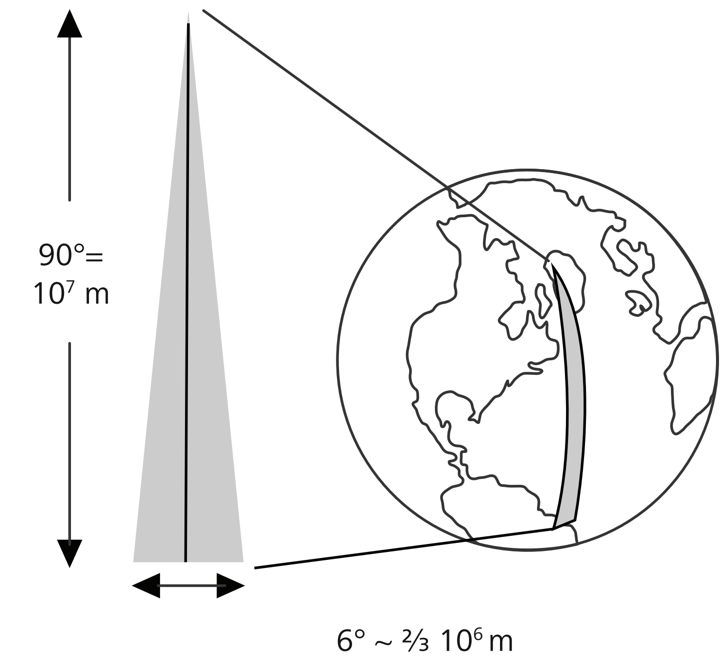
Know your coordinate system

Surveyors communicate in real coordinate systems, such as:
1. State Plane or World
2. Northing (Y) and Easting (X)
3. True North

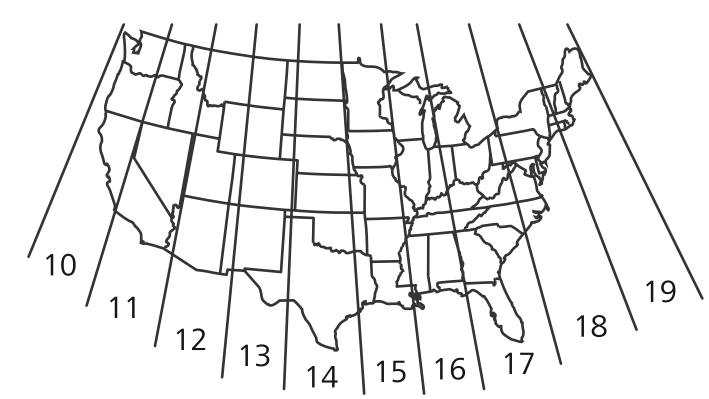
CAD software communicates in:
X, Y, Z where Easting (X), Northing (Y), and elevation (Z)

Always confirm that the import settings format in your data collector software matches the file format of the Building Information Modeling (BIM)/CAD software.

If you import points into a total station data collector in an X, Y, Z format, and the data collector format is to be Northing, Easting, and elevation, the points will be rotated 90 degrees and mirrored from how those points appeared in the CAD file. While the distances between the control points stay the same, the coordinates will no longer match.



UTM divides the earth into 60 zones.
The continental United States occupies 10 of them.



Establishing control

Control can be established many different ways, but the goal is always the same: **accuracy**. Accurate control ensures creation of an efficient multi-trade, model-based layout.

What is “control”? At its most basic, the definition of control is the matching of points in the model to those in the field. Sounds simple, right? But before you set off to measure points, remember that there are different types of survey and building controls available in the industry. In most cases, the initial data will be from a surveyor or an offset from a building grid.

Here are three points to keep in mind as you prepare to match control in your model to control in the field:

1

The general contractor may provide surveyor control points or offsets from the grid through a list of coordinates in a PDF, CAD, or .CSV/.TXT file. Most often, these points are provided in some sort of offset from the structure or the survey monument locations for the site.

2

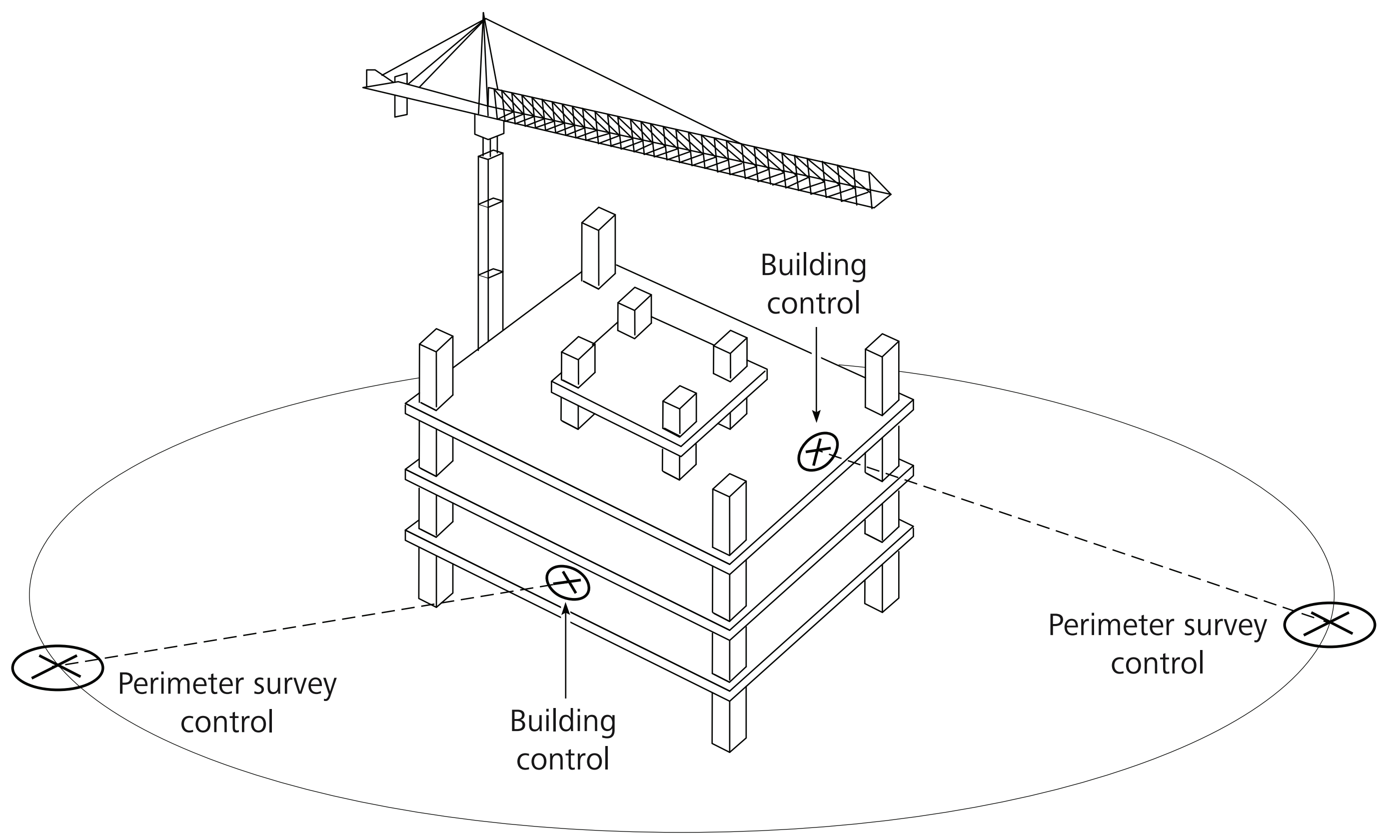
If the site has no control, you can make your own by laying out offset points from the structure and matching them to the BIM/CAD model. For example, a 4 x 4-foot offset from Column A1, H1, A10, and H10 can be laid out in the field using string and tape. Use the same offsets in the CAD model.

3

Verify BIM/CAD points with field reality. If your CAD model says the control point at A1 is 200 feet from control point H10, check that measurement in the field for deviations. If the CAD file says that between control points A1, A10, and H1 is a 90-degree angle, make sure that is the case in the field. Angles are more critical to accurate layout than the distance measurement alone.

Control begins with matching at least two points in your BIM/CAD model to physical locations in the field. It is better to use three or more points because it allows you to check angles and distances.

Establishing control



Checking control

Establishing control on a job site is the act of physically checking all the control points necessary to continue your work. Never trust that control points are accurate unless you have checked them yourself.

When checking control, verify deviation or error from the CAD file and the total station measurement. A deviation of zero is optimal but normal real-world conditions leave us with about a 0.1875-inch deviation. Deviations of 0.25 inches or more need to be verified and noted. Check the distance between two points as well as the angular accuracy of a third point.

Instrument setup and helpful hints

Total station setup

1. Set the total station on a tripod and secure with the mounting screw.
2. Use Optical or Laser Plummet to align the total station with the control point.
3. Level the total station with the digital level and the tribrach leveling screws. Or, if equipped, allow your instrument to self-level.
4. Check the Plummet for alignment with the control point and use the mounting screw to adjust if necessary.
5. Re-level with the digital level and check the Plummet again.

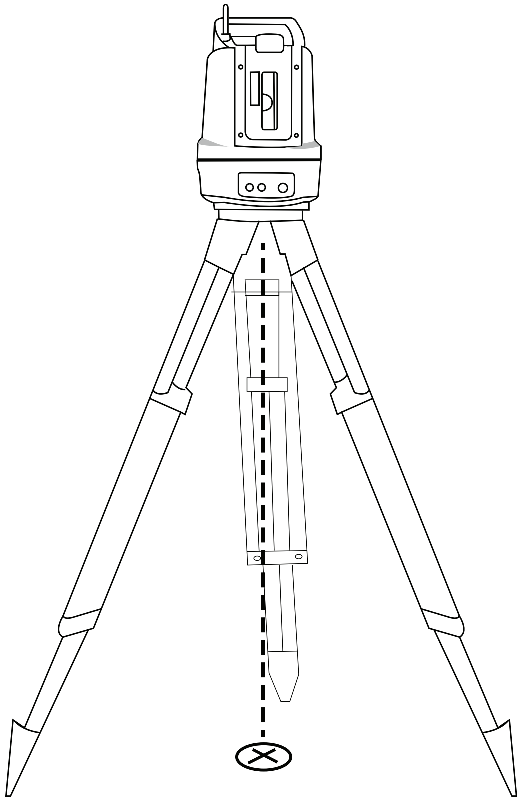
Setup routines

Before you can use a total station on a job site, you need to complete a setup routine.

A setup routine completes the orientation of the total station equipment with the BIM information and the job site. Without a completed setup routine, the total station has no idea where it is in the world.

The standard setup routine includes:

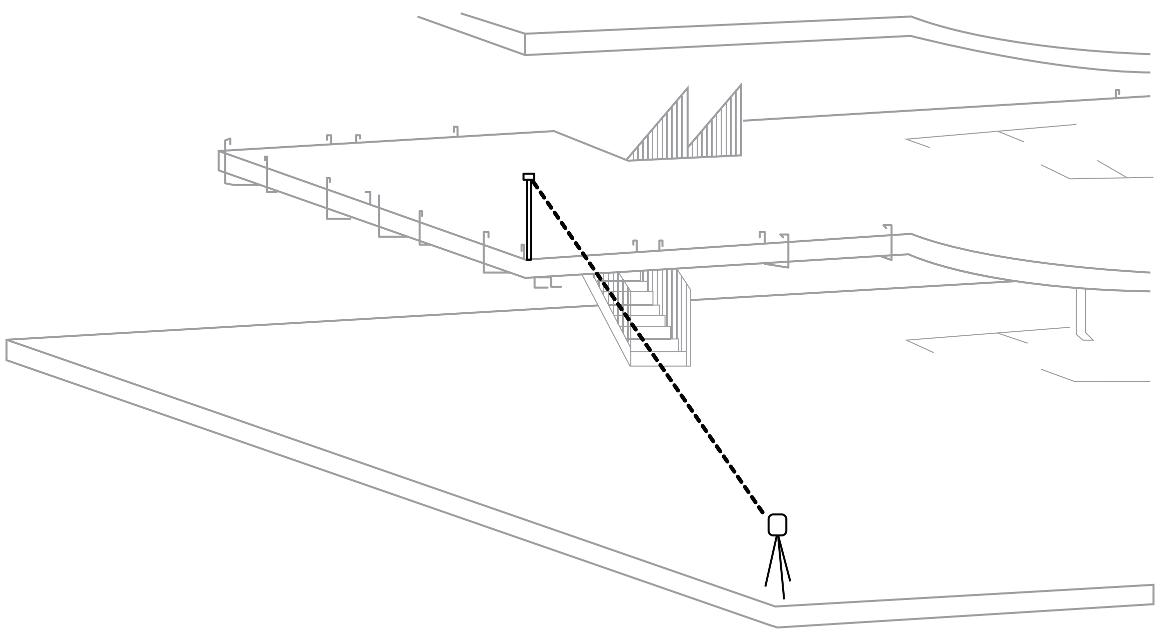
1. **Occupy Point:** This routine is used to check control points and set up your total station. Occupy a known control point with the total station and backsight to another known control point.
2. **Control Distances:** Be careful not to lay out positions past your control distance. If two points are 100 feet apart, you should not stake out points past a 100-foot radius from the total station. The farther your control shot, the more accurate your layout.
3. **Reference Point:** With this routine, you can set your total station in a random location and reference two to five known control points to triangulate the total station's current position. Reference a minimum of two control points; three is better. The more angles and the more distance, the more accurate the triangulation. A rule of thumb is to try to reference at least 90 to 120 degrees of the angle.



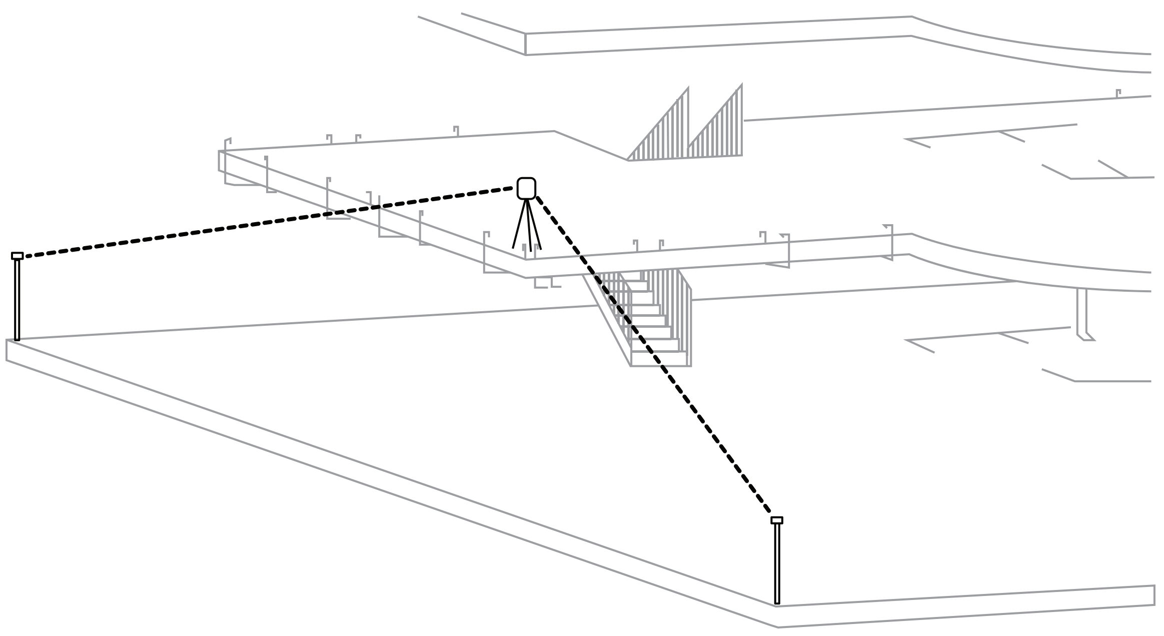
Known point

Instrument setup and helpful hints

Occupy Point setup routine vs. Reference Point setup routine



Occupy Point setup routine
The instrument is placed over a known control point to orientate the instrument with the physical world and the CAD/BIM file coordinates.



Reference Point setup routine
The instrument is set up by referencing two to five known control points to triangulate the instrument's current position, orientating it with the physical world and the CAD/BIM file.

When using the Reference Point setup routine, try to use at least three points and 90 to 120 degrees of the angle.

Layout best practices

Instrument checks

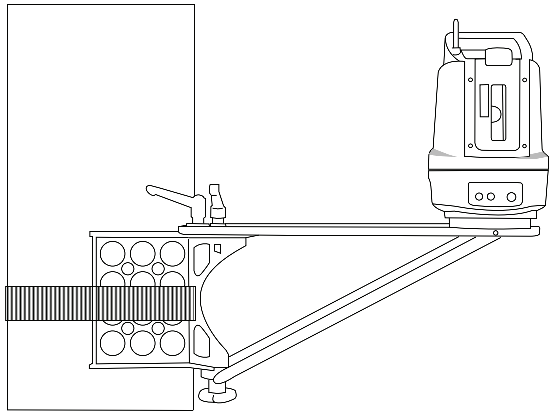
1. Calibrate your total station according to the manufacturer's recommendations to avoid instrument error.

2. Calibrate the level bubble on your survey poles to avoid error.

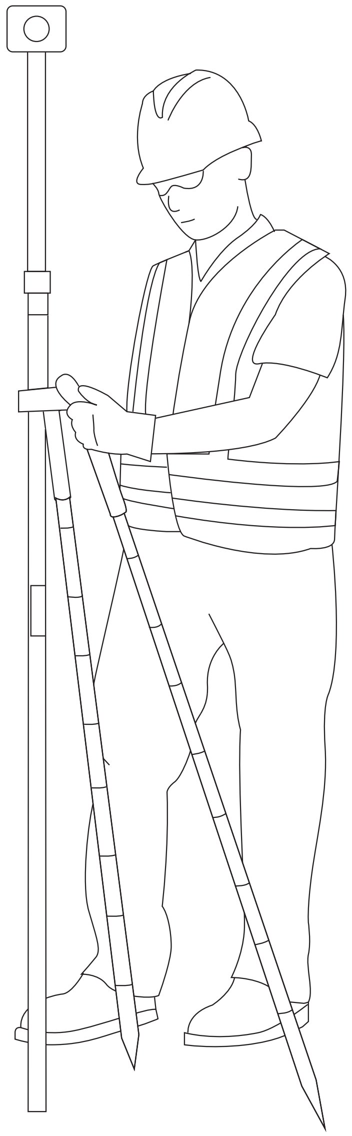
3. Check the Optical Plummet on the total station and calibrate, if necessary.

Layout setup

1. If possible, set up your total station on solid ground, such as concrete or a column clamp (see below). Dirt or pavement expands and contracts depending on the surrounding environmental conditions, which will move your total station out of level throughout the day.



2. Use a tripod stabilizer and weigh down your tripod. It takes a lot less wind than you might think to blow over a total station.



After setting up your total station, verify your setup is correct by measuring at least one other known point.

Layout best practices

During production

1. Check your setup and the level of your total station every 40 shots or so.

2. Try to use the same control points each day; this will help to minimize the propagation of errors.

Shoot long on control and work close to your total station. If you have the choice to use two control points that are 50 feet apart or two control points that are 200 feet apart, use the longer set.

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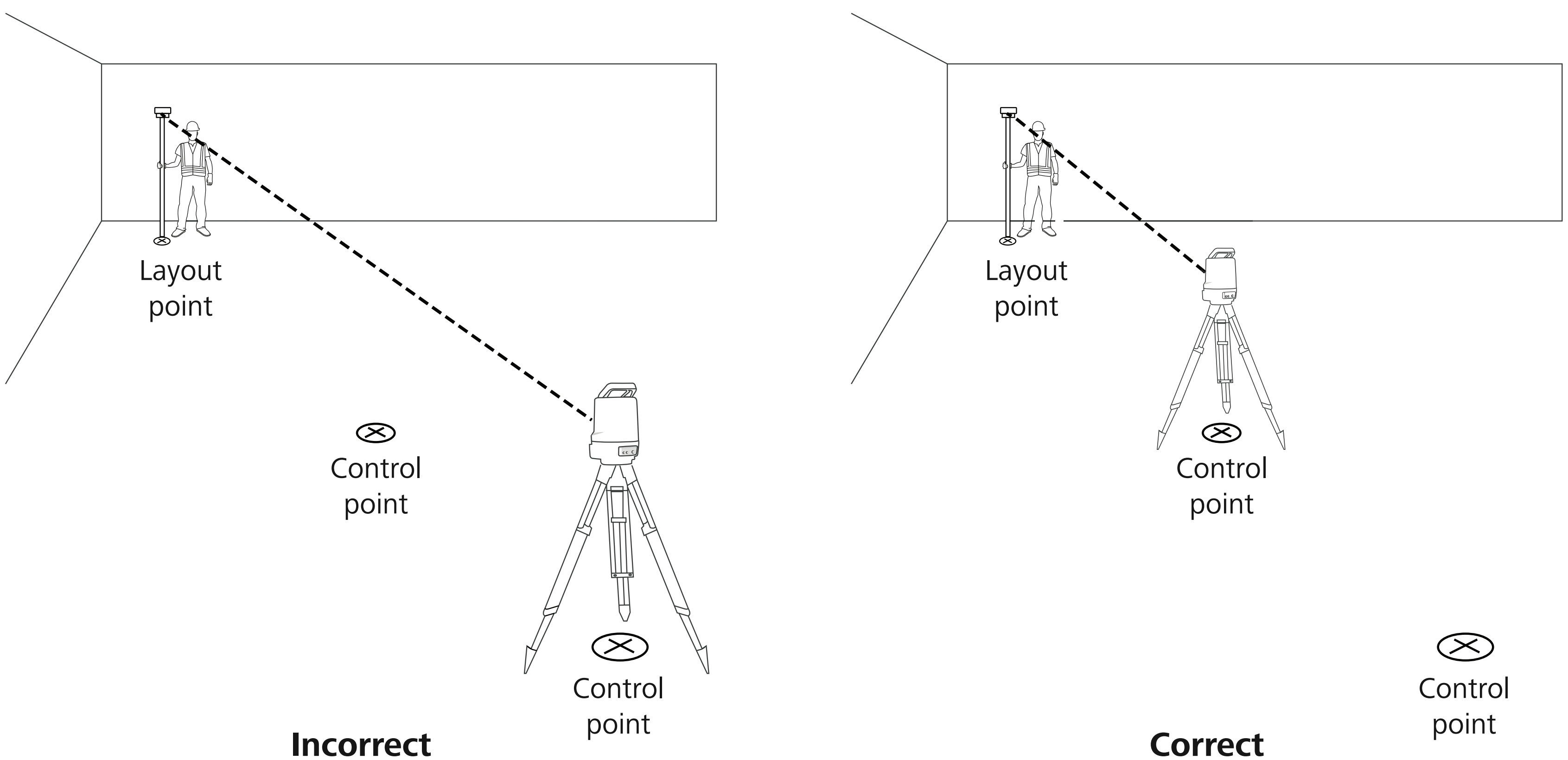
3. Do not shoot past your control setup. If the control points used are only 200 feet apart, you should not lay out or store points past 200 feet from the total station.



Glossary of terms

Backsight
A setup over a control point that is used as a reference to establish orientation with the total station.

Bipod
A two-legged support used to hold and assist with leveling a prism pole.

Control point
A point used for a datum derived from the original surveyors or the general contractor. This is an extremely accurate point used to set up the total station or a backsight. It is used to establish orientation on the job site and relate to the CAD file.

Data collector
A handheld device used to transfer data to and from the total station. This unit runs on the Windows® mobile platform or Windows® operating system, or on an Apple® iPad®.

Foresight
Any prism and pole setup used to store or lay out a point.

Point
A coordinate located with the total station that represents a hanger, sleeve, wall, housekeeping pad, or equipment.

Prism
A transparent optical element with flat, polished surfaces that refract light.

Prism 360°
A prism that can be viewed from 360 degrees and has a -7 mm offset.

Prism -30/0
A larger-diameter directional prism that can be set at a -30 mm or 0 mm offset.

Prism peanut -30/0
A small-diameter directional prism that can be set at a -30 mm or 0 mm offset.

Prism pole
An adjustable pole that holds the prism and remote unit.

State Plane Coordinate System
A coordinate system based on geographic zones in the United States that was developed to make it easier to compute grids while maintaining geodetic and grid distances of one part in 10,000 or better.

Total station
The total station is an electronic theodolite (transit) integrated with an electronic distance meter (EDM) to read distances from the instrument to a particular point. Distance, horizontal angle, and vertical angle information is received from and stored to an external data collector.

Tripod
A three-legged support used for the total station instrument or a backsight setup.