Surveying with SmartStation
An introduction to RTK

- when it has to be **right**

Leica Geosystems

Contents

1. Why SmartStation?

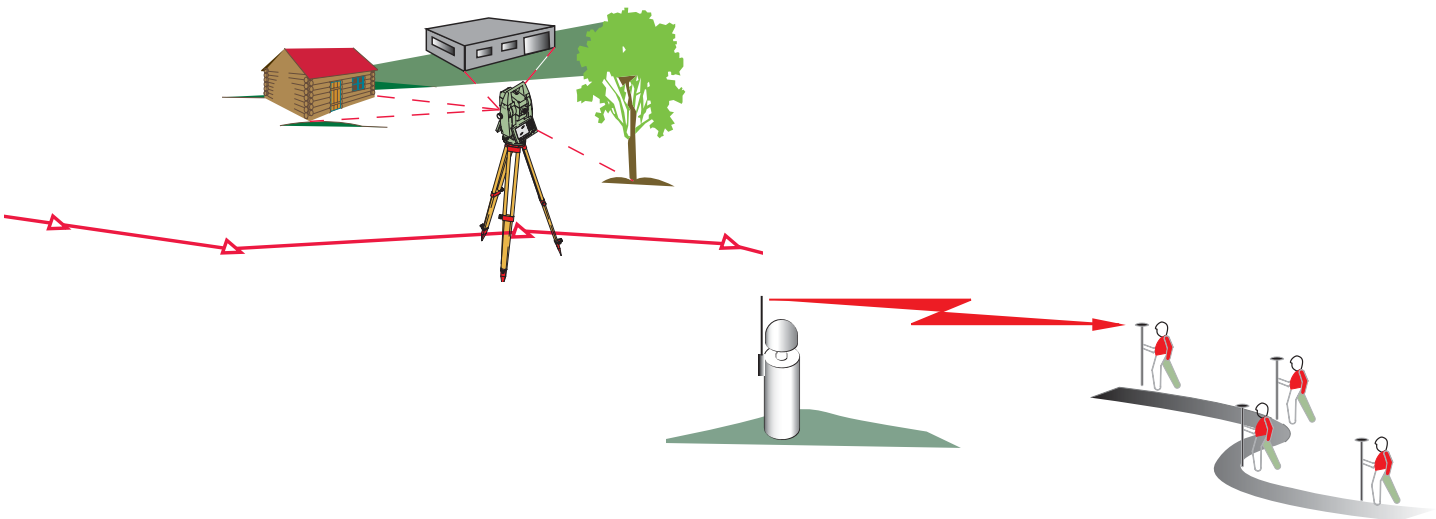
Total stations need local control points over which they can be set up, from which they can traverse, and to which they can measure to resect their positions.

On the other hand, GPS RTK receivers can determine their positions within a few seconds to centimeter-level accuracy using data from GPS reference stations that may be 50km or more away.

GPS RTK rover receivers are fast and efficient to use but need an open view of the sky in order that they can receive the satellite signals. They are at their most advantageous in wide, open areas.

By contrast, total stations can measure and stakeout where RTK cannot be used: to building corners, to points under trees and bushes, in city canyons, on construction sites where there are large obstructions.

Total stations and GPS RTK equipment each have their advantages. SmartStation combines the best of both.



2. SmartStation: TPS and GPS perfectly integrated

SmartStation comprises a TPS1200 total station with an ATX1230 SmartAntenna. The SmartAntenna is a 12L1 + 12L2 dual frequency GPS RTK receiver that fits on and communicates with the total station. All commands, displays, functions, operations and computations relating to GPS reside in the total station. TPS and GPS are perfectly integrated.

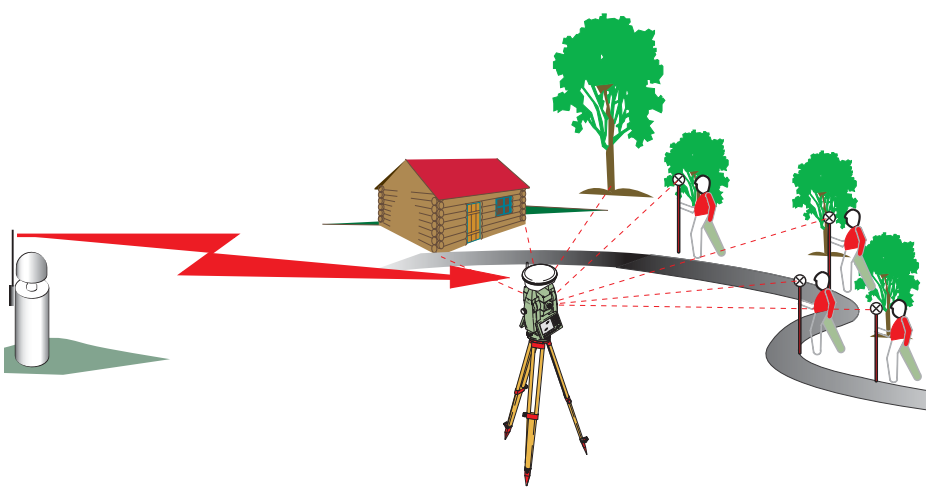
With SmartStation there is no need to search for and set up over control points, to run long traverses, or to resect the position.

With SmartStation you simply:
- Set up wherever it is convenient.
- Determine the position coordinates in a few seconds to centimeter accuracy with RTK.
- And then survey and stake out with the total station.

And with SmartStation:
- You can measure to points and objects that can never be occupied with an RTK receiver.

As a result of RTK position fixing, SmartStation is much more flexible than a standard total station.

SmartStation can save an enormous amount of time, speed up work, reduce costs and increase your profits.



3. This book

This book:

- Describes how to carry out SmartStation surveys utilizing the full freedom of RTK position fixing.
- Points out the differences between surveying with SmartStation and surveying with a standard total station.
- Explains RTK in a simple way that will be understood by surveyors and total station operators that have never used GPS before.

This book is not an instruction manual and does not deal with individual commands, keystrokes, operations, menus, functions, on-board programs etc. For these details, please refer to the TPS1200 manuals.

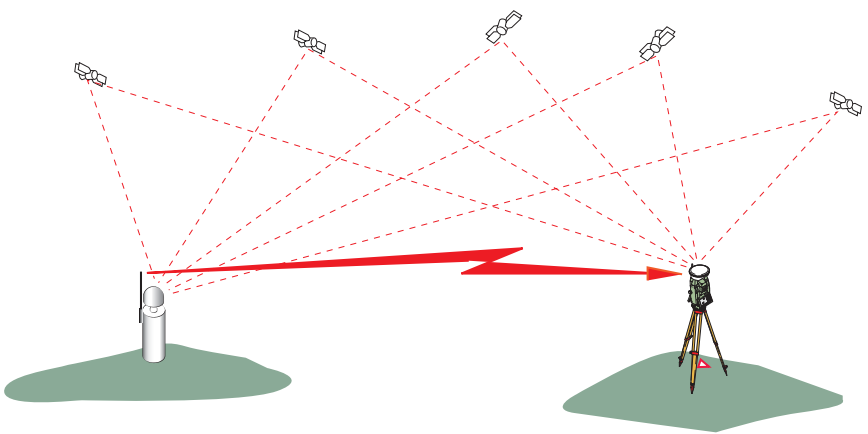
4. A short note on RTK

In order to be able to determine its position using RTK, SmartStation has to collect data from satellites and has also to receive the satellite data taken by a reference receiver that is set up on a known point.

The data are transmitted from the reference to SmartStation by radio, phone or the Internet. The reference will often be a public GPS reference station that transmits data for use by all GPS rover units in the surrounding area. However, it could also be a private reference receiver that is set up on a known point specifically to support SmartStation.

RTK stands for Real Time Kinematic and is extremely reliable. Using RTK, SmartStation will usually determine its position within a few seconds to centimeter-level accuracy at 50km or more from a reference station.

For details on the use of RTK with SmartStation see 7, 8, 9 and 10.



5. Examples of the use of SmartStation

The following examples illustrate how SmartStation is used and the advantages that it has over a standard total station and a standard RTK rover.

5.1 Topographic survey in a remote area

The task
A topographic survey has to be carried out in a remote area. Due to trees, vegetation and the nature of the work, a total station is more suitable than an RTK rover for surveying the detail. Unfortunately, there are no control points in the area on which a total station survey can be based. However, there is a reference station about 40km away that transmits data for use by RTK rovers.

The conventional way
Fix a series of control points throughout the area using standard GPS equipment. Transfer the coordinates into the total station. Occupy the control points with the total station, orient to other control points, and survey the detail.

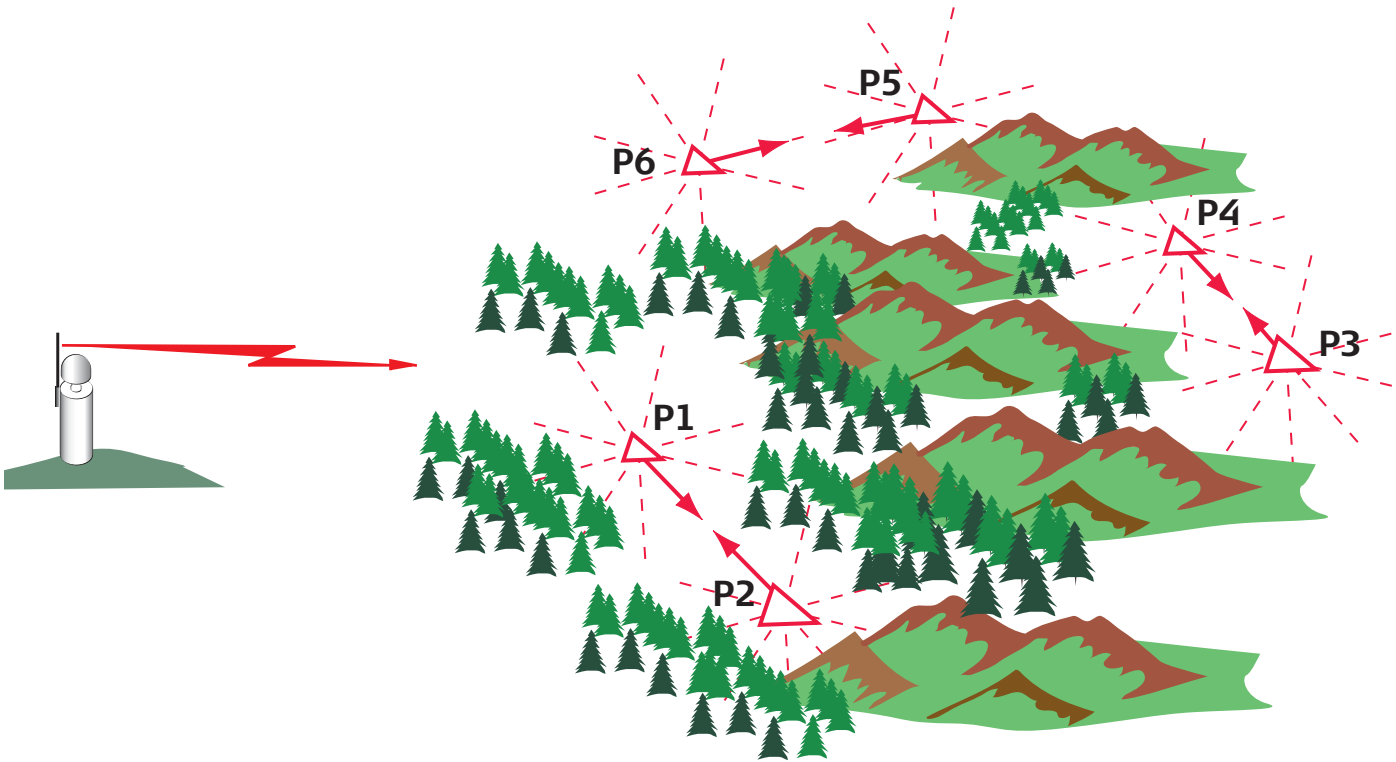
Points have to be occupied twice, once with GPS and once with the total station. Two sets of equipment are needed. Two crews may be needed.

The SmartStation way
Set up SmartStation wherever it is convenient and where there is a reasonably open view of the sky. At the first point P1, determine the position with RTK. Orient to a second point P2 that will be used but is not yet fixed. Survey the detail from P1.

Set up at P2 and determine the position with RTK. As the bearing P1-P2 is now known, SmartStation will automatically transform the coordinates of all of the detail points surveyed from P1. Orient to P1 and survey the detail from P2.

Continue in this way.

The advantages
- Control points established where required by RTK.
- Points occupied only once.
- Only SmartStation is needed.
- Only one crew is needed.
- Transformations made automatically in SmartStation.
- The survey takes less time.


P5
P6
P4
P3
P1
P2

5.2 Property surveys in a rural locality

The task
Property boundaries have to be surveyed in a rural locality. As there are trees and hedges along many of the boundary lines, it is much easier to measure to the property markers with a total station than to attempt to survey them with an RTK rover. The nearest control points that can be used by a total station are 5km away, but data for RTK can be received from a distant GPS reference station.

Using a total station
Bring in control by measuring a long traverse from the control points. Traverse close to the boundary lines and coordinate the property markers from the traverse stations. An open traverse is liable to error and is usually not acceptable for property surveys. A closed traverse will be twice as long. Even with careful planning, long traverses are difficult and time consuming. At least three people are needed.

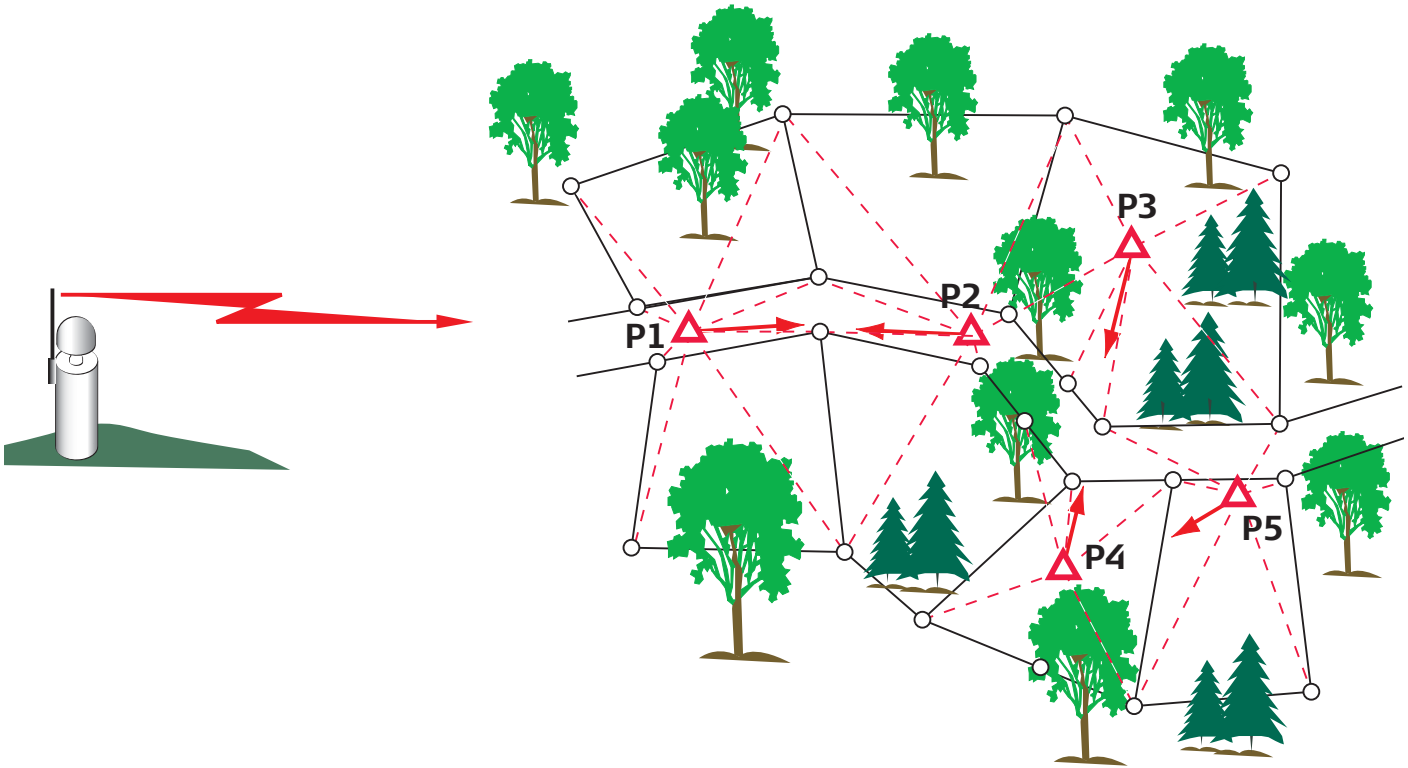
Using an RTK rover
An RTK rover could be used to fix points from which the property markers can be seen. But then either a total station or some cumbersome hidden-point method has to be used to measure to the markers.

Using SmartStation
Set up SmartStation at a first point P1 from where one or more markers can be seen and fix the position with RTK. Orient to a second point P2 that will be used but is not yet fixed. Measure angles and distances to the markers.

Set up at P2 and determine the position with RTK. All measurements made at P1 are transformed automatically in SmartStation. Orient to P1 and measure to the property markers from P2.

Survey the boundaries in this way using pairs or clusters of SmartStation points. Note that it is not necessary to connect the pairs or clusters of SmartStation points.

The advantages
- No long traverses needed.
- Less set ups needed.
- Two people are sufficient.
- Takes less time.
- Uniform, higher accuracy.


P1
P2
P3
P4
P5

5.3 Stakeout on a large construction site

Stakeout job
A large number of markers have to be placed and many components positioned. Control points exist but often get damaged or are covered by equipment, material, vehicles etc.

There is a GPS reference station transmitting data to RTK rovers but, due to obstructions and the type of construction, most points cannot be set out with RTK.

Conventional stakeout
Stakeout with a total station is possible but difficult and time consuming. Traversing is needed to get around obstructions. Temporary points, which can be used for stake-out, have to be established. The work plan has to be revised constantly. Equipment and material have to be moved, which slows both the survey and construction work.

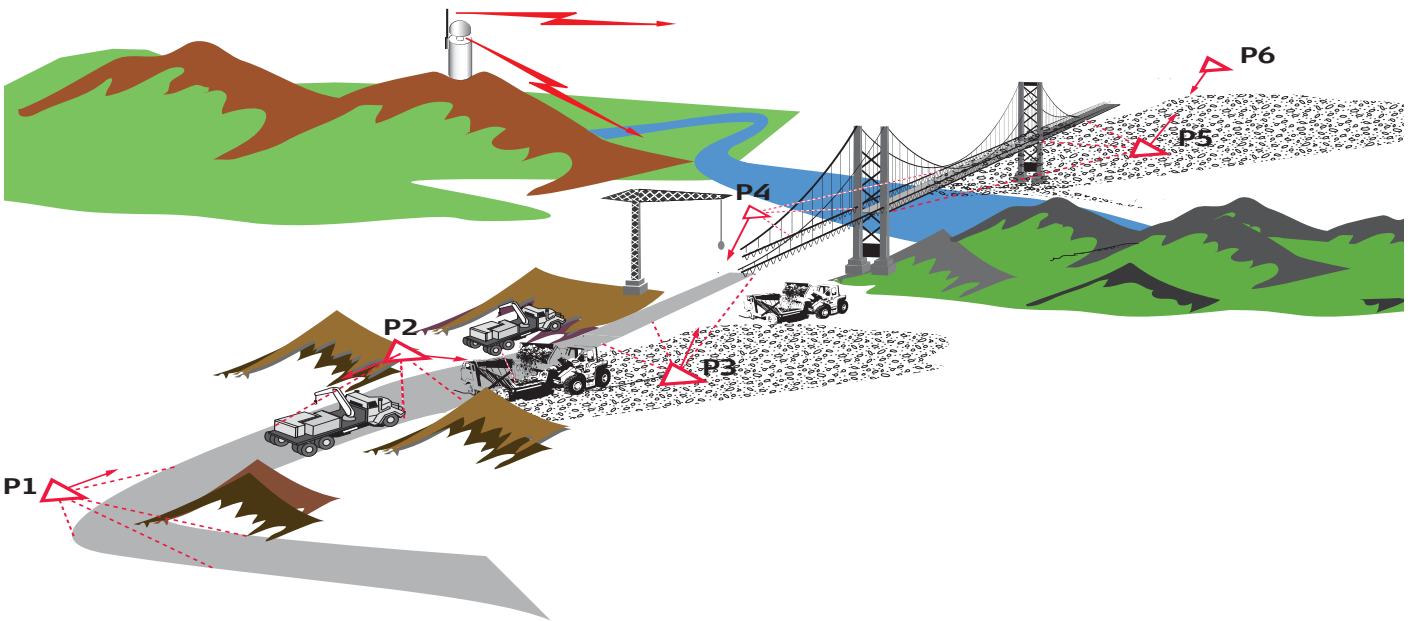
SmartStation stakeout
Control points are not required. Simply set up SmartStation wherever it's convenient and let RTK determine the position.

Set up at P1 and fix the position with RTK. Set up at P2, fix the position with RTK and orient to P1. Now stakeout from P2.

Move to P1 and set up SmartStation. Orient to P2. Now stakeout from P1.

Work in this way establishing pairs or groups of points from which to stake out. As the positions are determined by RTK, the pairs or groups do not have to be connected by total station measurements.

The advantages
- Set up where it's convenient.
- No traversing needed.
- Fewer obstructions.
- Faster stakeout.
- Faster construction.


P1
P2
P3
P4
P5
P6

5.4 Surveying utilities in an urban environment

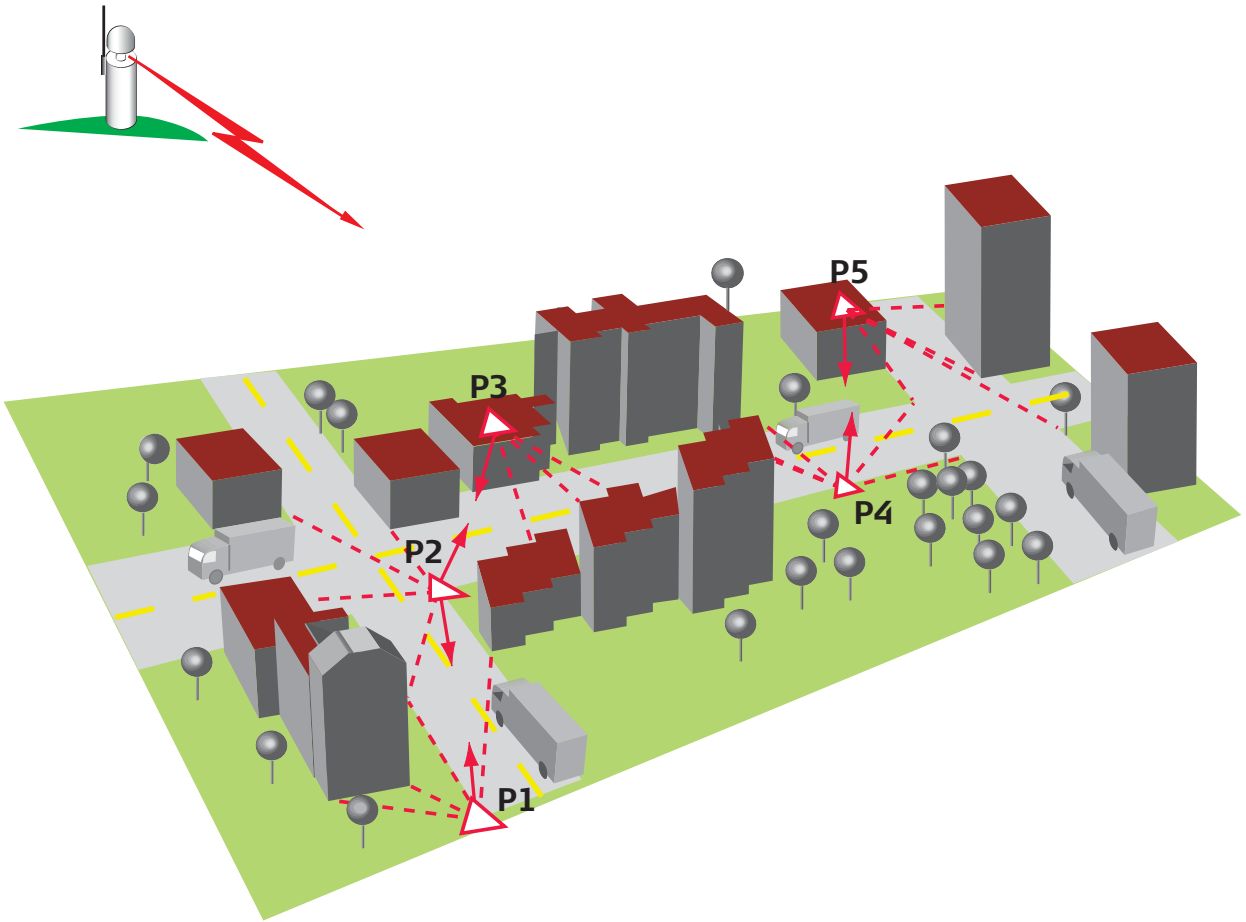
Mapping public utilities
The positions of all manholes, covers, hydrants, distribution boxes etc. for water, gas and electricity have to be determined. High buildings and trees along the roads make it difficult to use RTK rovers. As many objects are close to buildings or under trees, they can be measured to with total stations but cannot be occupied by GPS rovers. The city operates GPS reference stations.

Using a total station
Control points exist but traffic, parked vehicles and other obstructions make it difficult to set up over them and to orient between them. If a standard total station is used, a lot of traversing in a very difficult environment is necessary. Both careful planning and improvisation are needed. The work is awkward and slow.

Using SmartStation
Set up SmartStation where RTK fixes are possible, such as at road intersections, open spaces and even on the tops of buildings. Use pairs or groups of SmartStation setups as explained in the previous examples.

Measure angles and distances to the objects that have to be surveyed. If the correct circle orientation is only available after the measurements have been taken, SmartStation will transform all the coordinates correctly and automatically.

The advantages
- Control points not needed.
- No awkward traversing.
- Positions determined by RTK.
- Consistent high accuracy.
- Fast, flexible, convenient.
- Much easier, saves time.


P5
P3
P4
P2
P1

6. Setting the horizontal circle, three methods of orientation

RTK determines the coordinates and height of the point over which SmartStation is set up.

The horizontal circle has to be set by orienting to another point (or points). The point (or points) used should be sufficiently far away to provide a good orientation.

There are three ways in which the orientation can be carried out:

- Orienting to a known point (Known BS Point)
- Orienting to a point the coordinates of which are not yet known (Set Azimuth)
- Orienting to one or more known points and transferring the height from one or more of these points (Ori & Ht Transfr)

6.1 Orienting to a known point (Known BS Point)

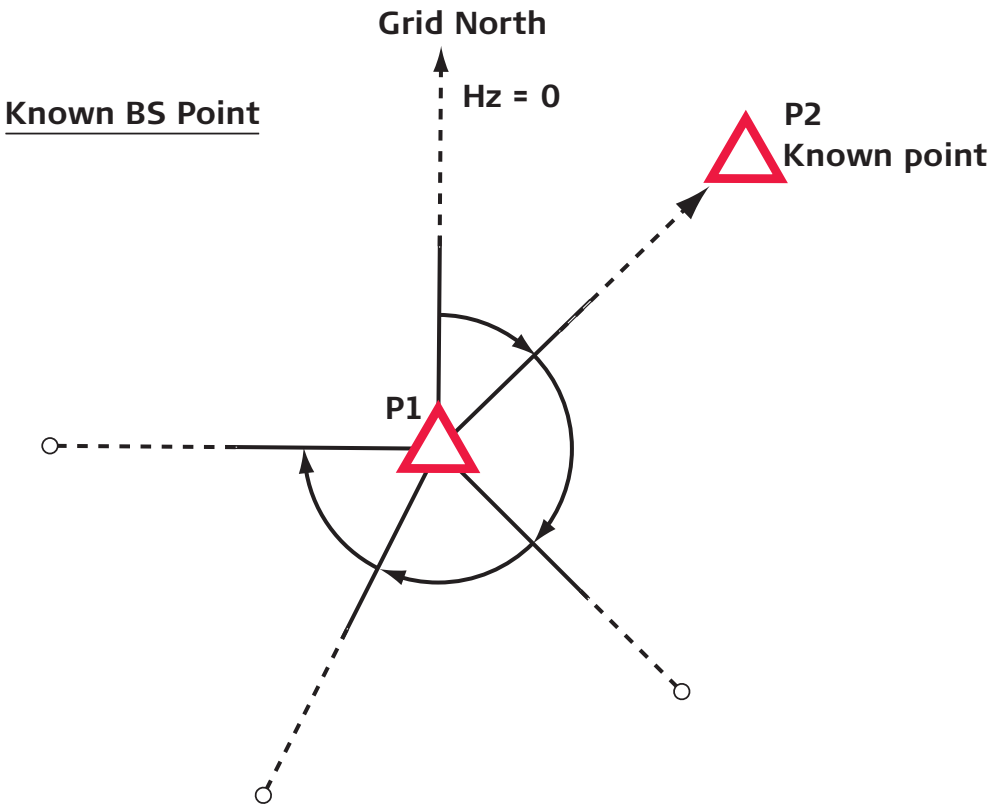
Set up SmartStation at a point P1. Determine the position of P1 with RTK. Point accurately to a second point P2, the coordinates of which are known and are stored in SmartStation.

SmartStation computes the bearing P1 › P2 and sets the horizontal circle reading correctly. You can now measure angles and distances, survey and stakeout, with SmartStation.

P2 can be a standard control point, the coordinates of which have been stored in a job in SmartStation.

P2 can also be a point that has been occupied by SmartStation and the coordinates of which have been determined by RTK.

When using this method, the position coordinates (E, N) and the height (H) are determined by RTK.


Grid North
Hz = 0
Known BS Point
P2
Known point
P1

6.2 Orienting to a point the coordinates of which are not yet known (Set Azimuth)

In this method, the orientation is to a point whose coordinates will be determined later.

Set up SmartStation at a point P1 and determine the position with RTK. Point accurately to a second point P2, the coordinates of which have not yet been determined.

You can now measure angles and distances and survey from P1. Note, however, that as the bearing P1 ›P2 is not yet known, the horizontal circle readings (bearings) and, therefore, the coordinates of the surveyed points will not be the final ones.

After all the points and detail have been surveyed from P1, move to P2.

Set up SmartStation at P2 and determine the coordinates with RTK. SmartStation does the following fully automatically:

- Computes the bearings P1 ›P2 and P2 ›P1.
- Applies the correct bearing P1 ›P2 to all of the measurements taken at P1 and re-computes the coordinates correctly.

Orient to P1. SmartStation sets the horizontal circle reading correctly. You can now measure angles and distances and survey from P2.

Note that P2 does not have to be occupied and determined immediately after P1. The coordinates of P2 can be determined (or input) at any time, whenever convenient. As soon as the coordinates of P2 are determined (or input), SmartStation will transform the coordinates of all points surveyed from P1.

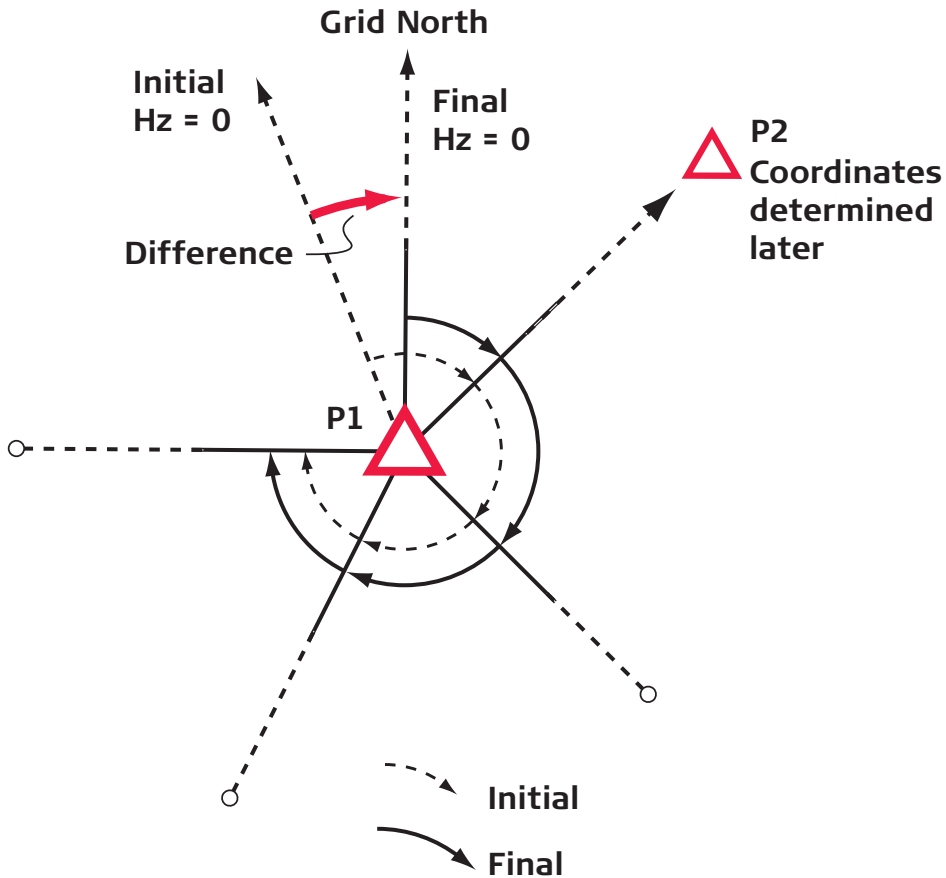
The advantage of the method is that there is no need to determine control points before starting surveying.

Simply go to the site, setup SmartStation wherever it's convenient and start work. Determine the control points where you can see the detail to be surveyed as you go along.

When using this method, the position coordinates (E, N) and the height (H) are determined by RTK.

Note that this method cannot be used for stakeout. For stakeout, either of the other two methods (6.1 or 6.3) has to be used. For stakeout you must orient to a known point (or points).

Set Azimuth


Grid North
Initial
Hz = 0
Final
Hz = 0
P2
Coordinates
determined
later
Difference
P1
Initial
Final

6.3 Orienting to one or more known points and transferring the height from one or more of these points (Ori & Ht Transfr)

This method is similar to 6.1, except that it provides the following options:
- The orientation can be made to one or more points (maximum 10 points).
- The height can be derived from one or more of the control points (height transfer from control points).
- Or the height that is determined by RTK can be accepted.

Set up SmartStation at P1 and determine the position with RTK.

You can now point to one or more (up to 10) control points. The control points can have:
- Position coordinates (E, N) and height (H).
- Position coordinates (E, N) only.
- Height (H) only.

If a control point has only a height (e.g. a benchmark), the distance has to be measured.

After pressing the CALC (calculation) key, SmartStation does the following:
- Sets the horizontal circle based on the orientation to all of the points
- Computes the height of P1 from the height of the control points.

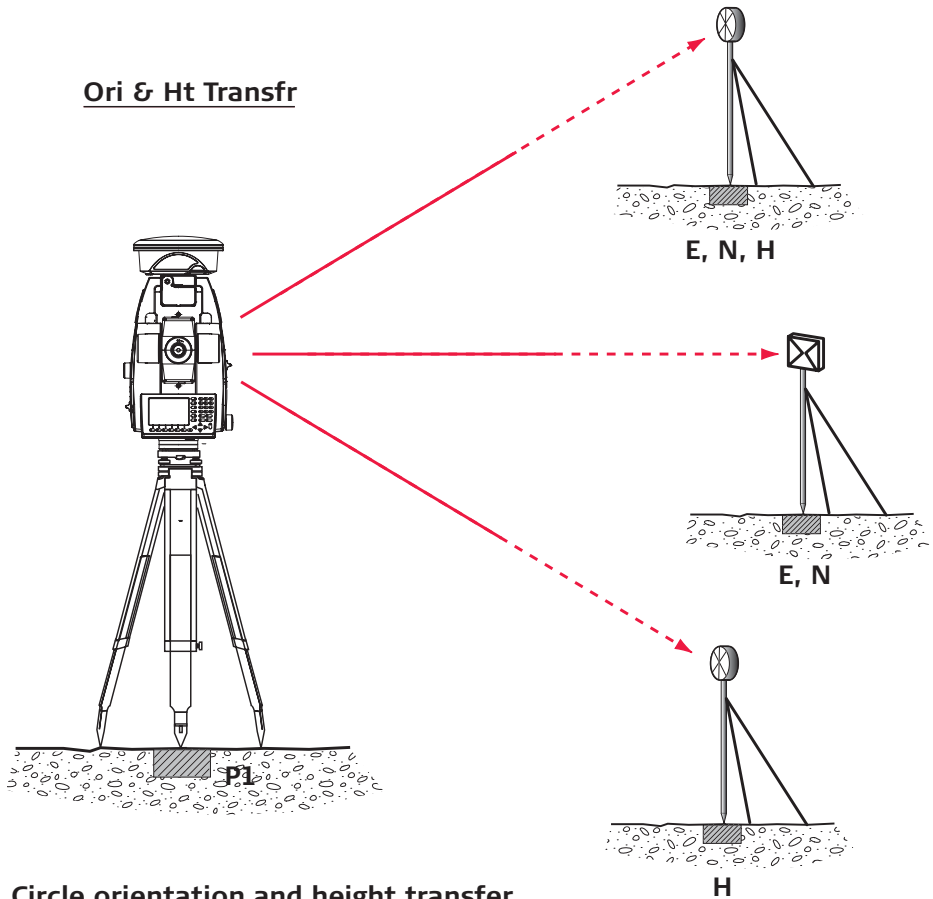
With this method, the position coordinates (E, N) are determined by RTK.

You can accept the height (H) computed from the control points or the height (H) determined by RTK.

This method of orientation has many options and provides total flexibility.

You can now measure angles and distances, survey and stakeout, with SmartStation.

When heights have to be based on a particular height datum for the area, e.g. for irrigation, drainage, water, construction and engineering surveys, it can be advantageous to accept the height computed from the control points.

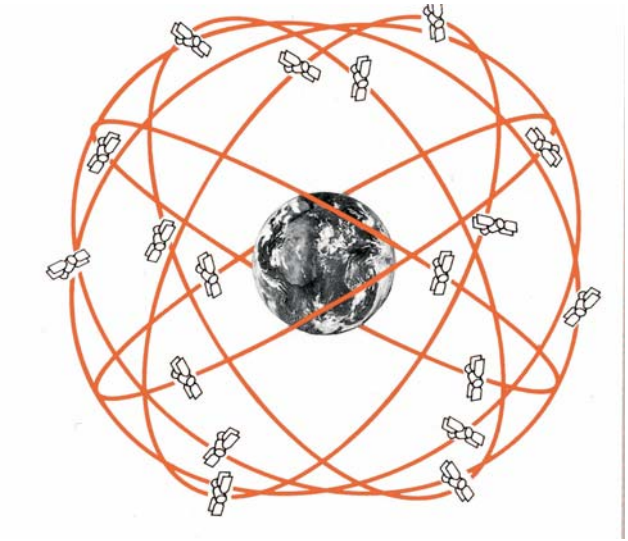


Circle orientation and height transfer

7. A short introduction to GPS positioning methods

At the time of writing there are 30 GPS satellites in orbit. Each satellite transmits on two frequencies, L1 and L2. The signals are carrier (sine) waves on which codes are modulated.

The operator of SmartStation does not need a detailed knowledge of GPS. However, the operator should understand that, when using SmartStation, or any other GPS RTK receiver, there can be three levels of GPS positioning depending on how the signals are received and used. The operator should understand the basic differences between them.

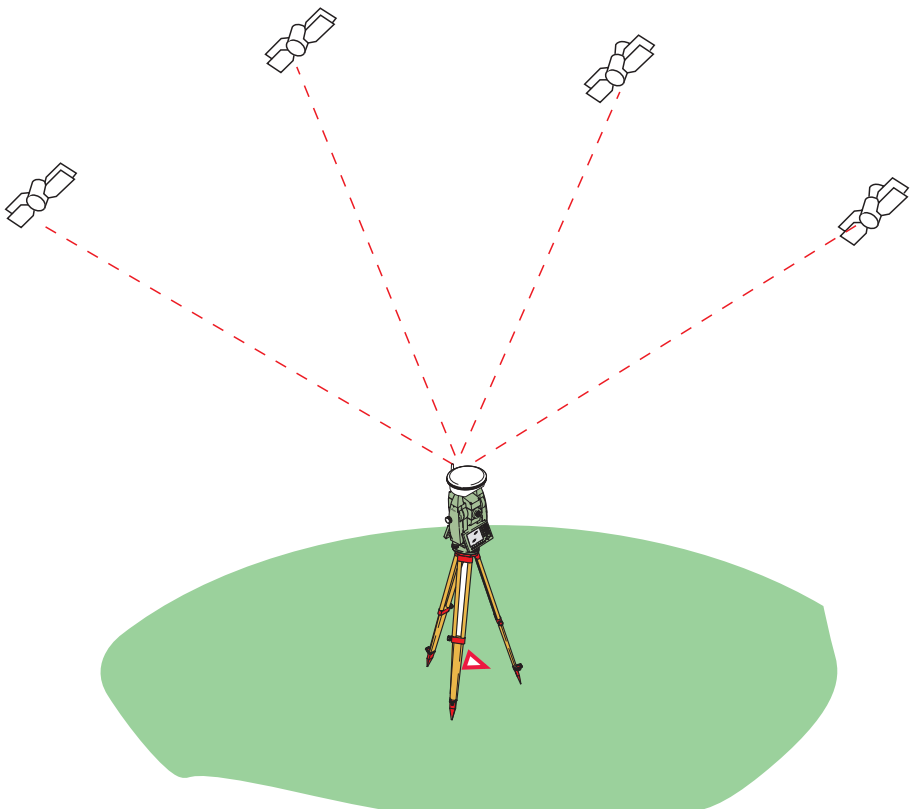


L1 1575.42 Mhz	**C/A Code 1.023 Mhz**	**P-Code 10.23 Mhz**
L2 1227.60 Mhz		**P-Code 10.23 Mhz**

7.1 Navigation position

When a GPS receiver of any type receives signals from 4 or more satellites, it will calculate and display its position. This is known as the navigation position.

Uncertainties in the satellite orbits, disturbances to the signals as they pass through the ionosphere and troposphere, and other errors limit the accuracy of the navigation position to about 5m.



7.2 Differential GPS

The errors mentioned above can be reduced and the position accuracy improved if measurements on the satellite signals are taken simultaneously at two stations and differenced (subtracted from each other). This is termed differential GPS.

One of the receivers is set up at a known point and is termed the reference; the other receiver is set up at an unknown point and is termed the rover.

The position of the rover is obtained **relative** to the position of the reference.

All high accuracy techniques are based on differential GPS.

7.2.1 DGPS, differential code

The reference receiver transmits its code measurements to the rover. The rover uses the code measurements from the reference together with its own code measurements and computes its position **relative** to the position of the reference receiver.

Code measurements from at least 4 satellites are needed.

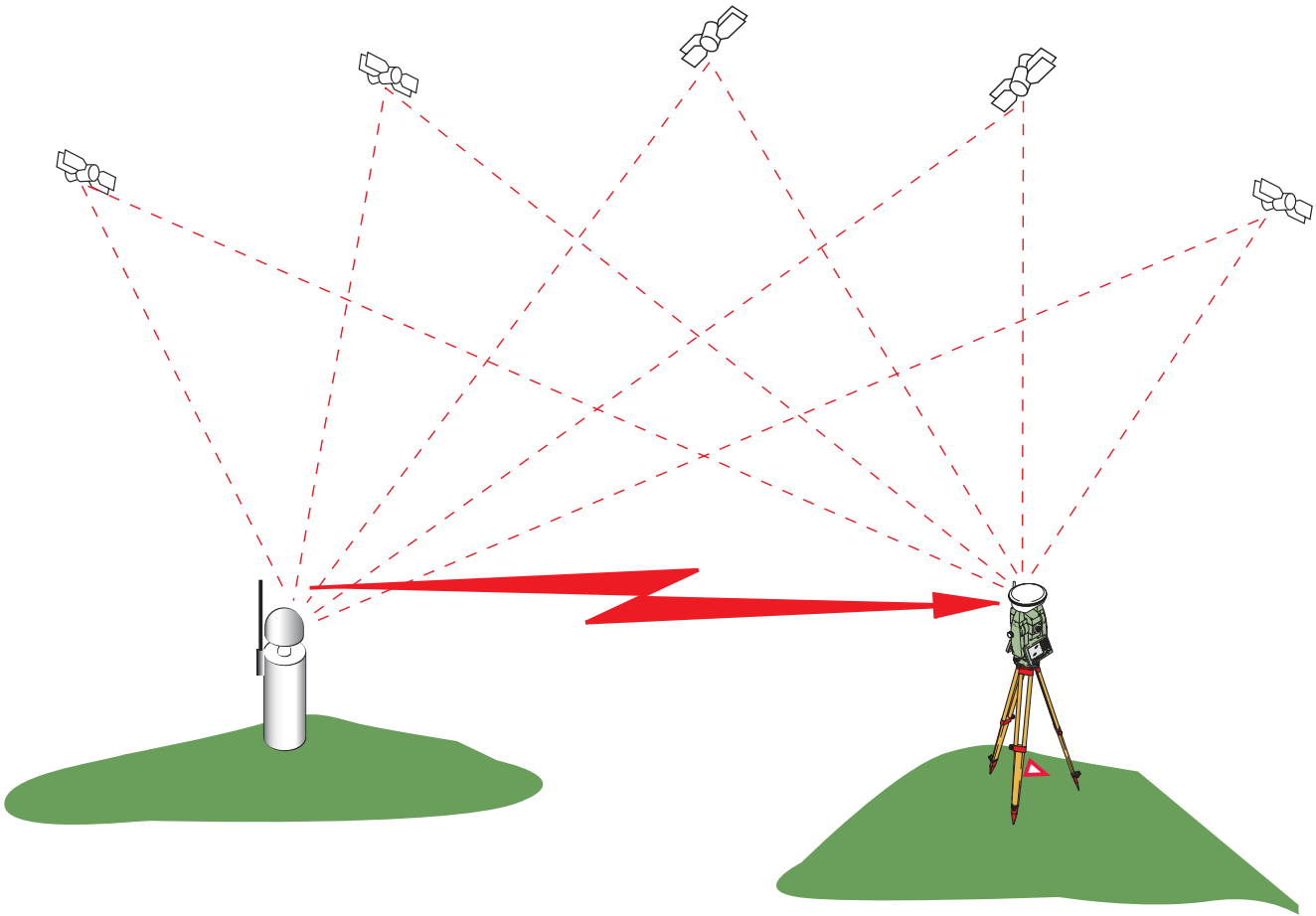
With good quality receivers, DGPS (differential code) position accuracy will usually be about 30cm to 1m.

7.2.2 RTK, differential phase

Dual frequency receivers designed for surveying take phase measurements on the L1 and L2 carrier waves (frequencies) as well as code measurements. As the phase measurements are made to a fraction of a millimeter, very high accuracy can be achieved.

The reference receiver transmits its phase and code measurements to the rover. The rover uses the phase and code measurements from the reference together with its own phase and code measurements and computes its position **relative** to the position of the reference receiver.

With L1 and L2 phase and code measurements from at least 5 satellites, an RTK rover will compute its RTK (differential phase) position to an accuracy of about 1cm to 5cm.



7.2.3 The range of differential GPS

The range at which differential GPS is possible depends upon:

- The communication link between the reference and rover.
- Whether the rover can compute its position.

With a reliable, long-range communication link (mobile phone or very powerful radio), a GPS receiver can usually compute a DGPS (differential code) position at distances of several hundred kilometers from the reference receiver. DGPS is used for GIS, ship navigation, positioning to meter-level accuracy, etc.

The computation of an RTK (differential phase) position is much more difficult than the computation of a DGPS (differential code) position.

Error influences, particularly those related to the ionosphere, troposphere and satellite orbits, limit the range at which an RTK rover can calculate centimeter-level accuracy positions.

Depending on the prevailing atmospheric conditions, the range limit for RTK can vary from about 30km to 60km. RTK is used for surveying, engineering, construction, stakeout etc.

RTK is extremely reliable and, used correctly, is unlikely to fail. In spite of this, the user should be aware that:

- If obstructions block some of the satellite signals, or if the distance to the reference is too great for the prevailing conditions, it can happen that an RTK rover may only be able to compute a DGPS position and not an RTK position.

- If the reference receiver stops working, or if the communication link between the reference and the rover fails, the rover will not receive data from the reference and will only compute a navigation position.

The above applies to all RTK rover receivers as well as to SmartStation.

When using SmartStation, accuracy status icons and the coordinate quality indicator always show the type of position and the accuracy achieved.

8. SmartCheck for total RTK reliability

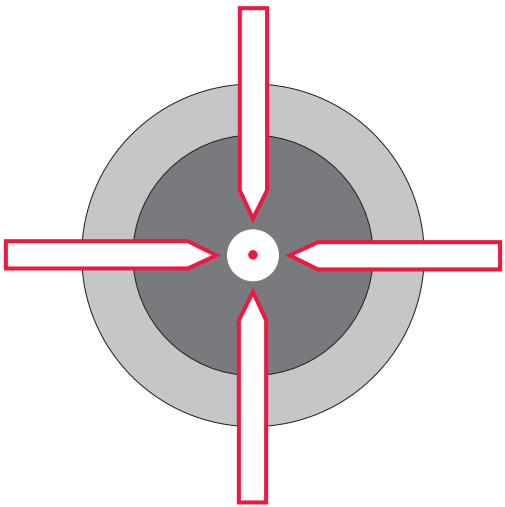
SmartStation uses SmartCheck, Leica Geosystems RTK technique, to determine the position coordinates.

SmartCheck computes at least two independent RTK fixes before the position coordinates are first displayed. The coordinates are then updated continuously as long as SmartStation continues to receive the required L1 and L2 phase and code data from the SmartAntenna and the reference.

SmartCheck uses the incoming data and continuously computes fully independent position fixes in order to ensure that the displayed values are correct. This continuous computation and checking process ensures the highest possible RTK reliability, 99.99% for SmartStation RTK fixes at up to 50km from a reference station.

SmartStation needs only a few seconds to compute its position with RTK.

The horizontal accuracy is 10mm+ 1ppm. The vertical accuracy is 20mm + 1ppm.



SmartCheck

Reliability 99.99%

Accuracy 10mm + 1ppm

Range about 50km

9. Before using SmartStation and RTK for the first time

SmartStation will probably have been configured for you so that you can start using RTK immediately. This may have been done by your Leica representative or by the technical support personnel in your own organization.

If SmartStation has not been configured for RTK, the following have to be considered:

- Reference stations
- Communication link
- Coordinate system
- Configuration set

9.1 Reference stations

Reference stations can transmit data in various ways and in various formats (Leica, CMR/CMR+, RTCM V2/V3).

SmartStation has to be configured to receive the data in the transmitted format.

Depending on how the data are transmitted, it may or may not be necessary to enter the following into SmartStation:

- Identification number of reference station,
- Type of receiver at reference station,
- Type of antenna at reference station.

9.2 Communication link

Data can be transmitted from the reference to SmartStation by radio, phone or Internet.

SmartStation has to be equipped with the appropriate communication device and configured for it. Various parameters have to be set.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9.3 Coordinate system

GPS coordinates are always in the WGS84 coordinate system. This is a three dimensional Cartesian coordinate system with the origin at the center of the earth. WGS84 coordinates are given as X, Y, Z Cartesian coordinates, or latitude, longitude and height (above the WGS84 ellipsoid).

A total station always works in grid coordinates. The coordinates are Eastings, Northings and Height (above a datum).

SmartStation determines its position to centimeter accuracy using RTK. In order to be able to use this position as the starting point for total station measurements, the RTK WGS84 coordinates have to be converted to the required grid coordinates - Easting, Northing and Height.

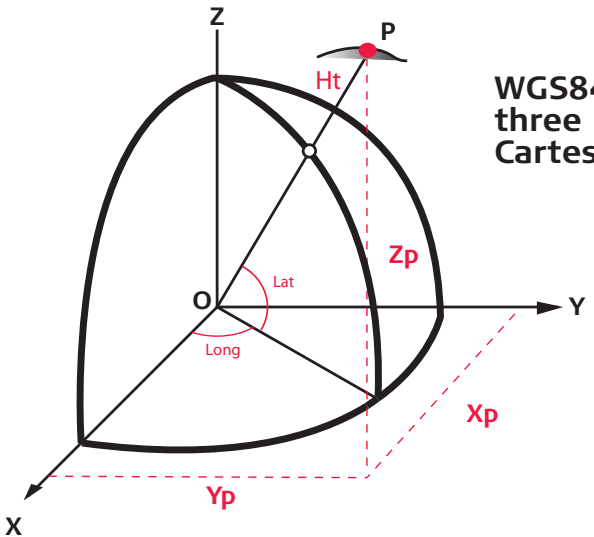
In most cases your technical support personnel, or possibly even your Leica representative, will have entered a so-called coordinate system into SmartStation for the area, region or even country in which you are working.

SmartStation uses the coordinate system and transforms the RTK WGS84 coordinates instantly into the required N, E, H grid coordinates. You can survey and stake out immediately with the total station.

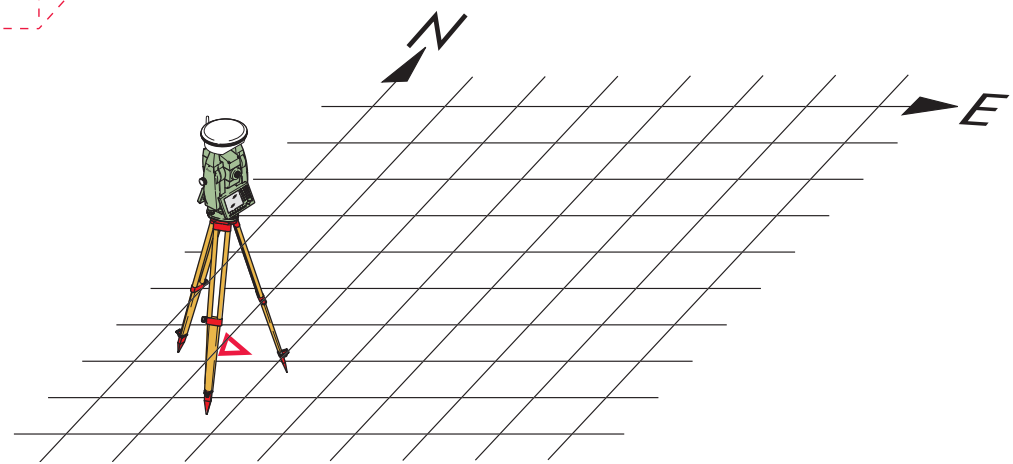
If the required coordinate system has not been entered, you will have to determine and enter it.

If you move to a completely new area or region that has a different system of local grid coordinates, you will have to determine and enter a new coordinate system for that area.

For details on determining coordinate systems, please refer to the TPS1200 Technical Reference Manual.



WGS84
three dimensional
Cartesian coordinates



Grid coordinates

9.4 Configuration set

SmartStation is a TPS1200-type total station with full RTK rover capability.

SmartStation is designed for use all over the world, by many different types of people, in many different ways, and for many different applications.

In order to fulfill all of the different requirements, SmartStation has many functions, options, routines and programs.

As different users will use SmartStation in different ways, SmartStation can be set to work in exactly the way that the individual user wants it to work.

Your technical support personnel, or even your Leica representative, will normally have defined a so-called configuration set that includes the correct settings for the reference stations (9.1) and the communication link (9.2) that you will use and that will make SmartStation work and display in exactly the way that you want it to do for the jobs that you have to carry out.

If your needs change, or if you have to undertake completely new applications, or if you move to a new area with different reference stations, you may have to modify the configuration set or define a new configuration set for the new way in which you have to work.

For details on defining configuration sets, please refer to the TPS1200 Technical Reference Manual.

10. What the SmartStation operator needs to know about RTK

Due to its ease-of-use, versatility, cm-level accuracy and high reliability, RTK has become a standard survey tool with tens of thousands of RTK rovers almost certainly in daily use all over the world.

Provided that you set up SmartStation where there is a reasonably clear view of the sky and reliable communication with the reference station, determining the station coordinates with RTK will usually be a simple matter of a few seconds only.

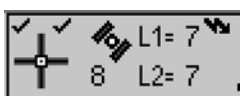
Although RTK position fixing is an easy, routine procedure, the SmartStation operator (as any other RTK rover operator) should possess a certain amount of background knowledge about the technique.

10.1 Number of satellites

In order for SmartStation to compute its position using RTK:

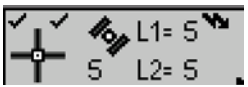
- SmartStation has to track at least 5 satellites.
- The reference has to track at least the same 5 satellites
- The reference has to transmit the data to SmartStation.

The status icons in the display show the number of satellites above the cut-off angle and the number of satellites being tracked. The cut-off angle is usually set to 10° in the configuration set.



Position fixed with RTK.
8 satellites above 10° above the horizon (10° cut off angle).
L1 data from 7 satellites used by SmartStation.
L2 data from 7 satellites used by SmartStation.

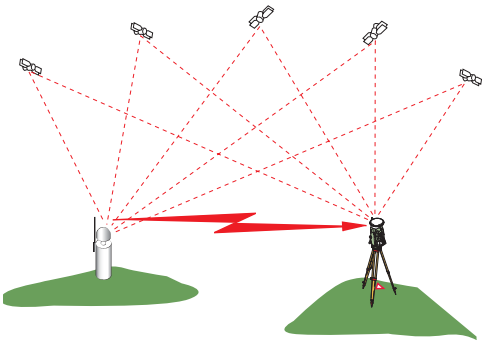
A minimum of 5 satellites is needed for an RTK position fix:

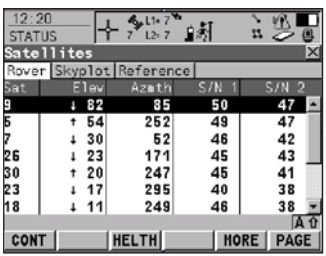


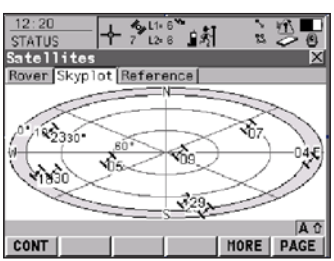
Position fixed with RTK.
5 satellites above 10° above the horizon (10° cut off angle).
L1 data from 5 satellites used by SmartStation.
L2 data from 5 satellites used by SmartStation.

With the present constellation of 30 satellites, there will almost always be at least 5 satellites available provided that you set up SmartStation where there is a reasonably clear view of the sky. In most cases there will be more than 5 satellites.

Touch the satellite icon for more information on the satellites being tracked.





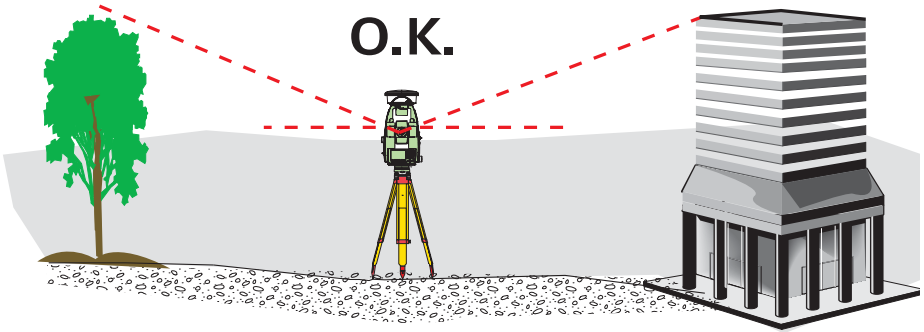


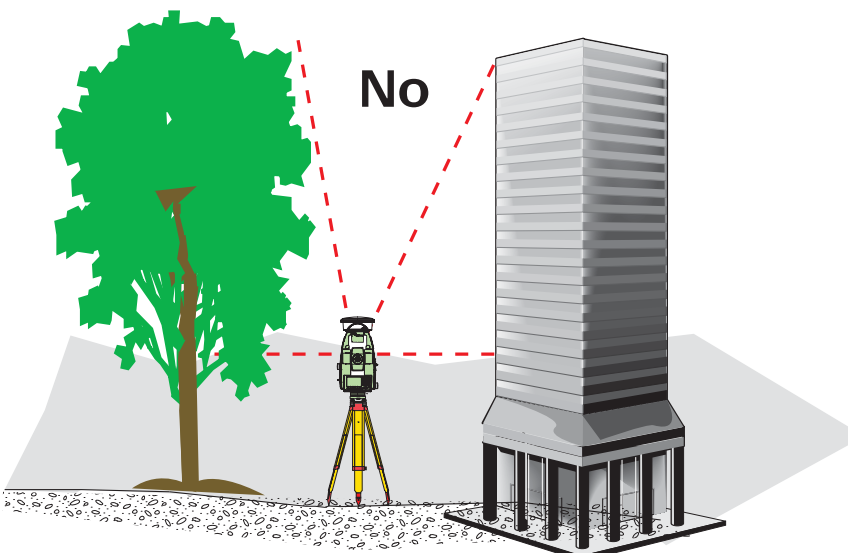
10.2 Obstructions

Buildings, large trees with heavy foliage and other obstructions can block the signals from one or more satellites. Although the signals can pass through trees with light foliage, the strength of the signals will be reduced.

Whenever possible, set up SmartStation in clear areas or where there are few obstructions. When surveying in or around wooded or developed areas, it is usually impossible to avoid obstructions completely.

With experience you will soon be able to judge where you can set up SmartStation and acquire sufficient satellites.



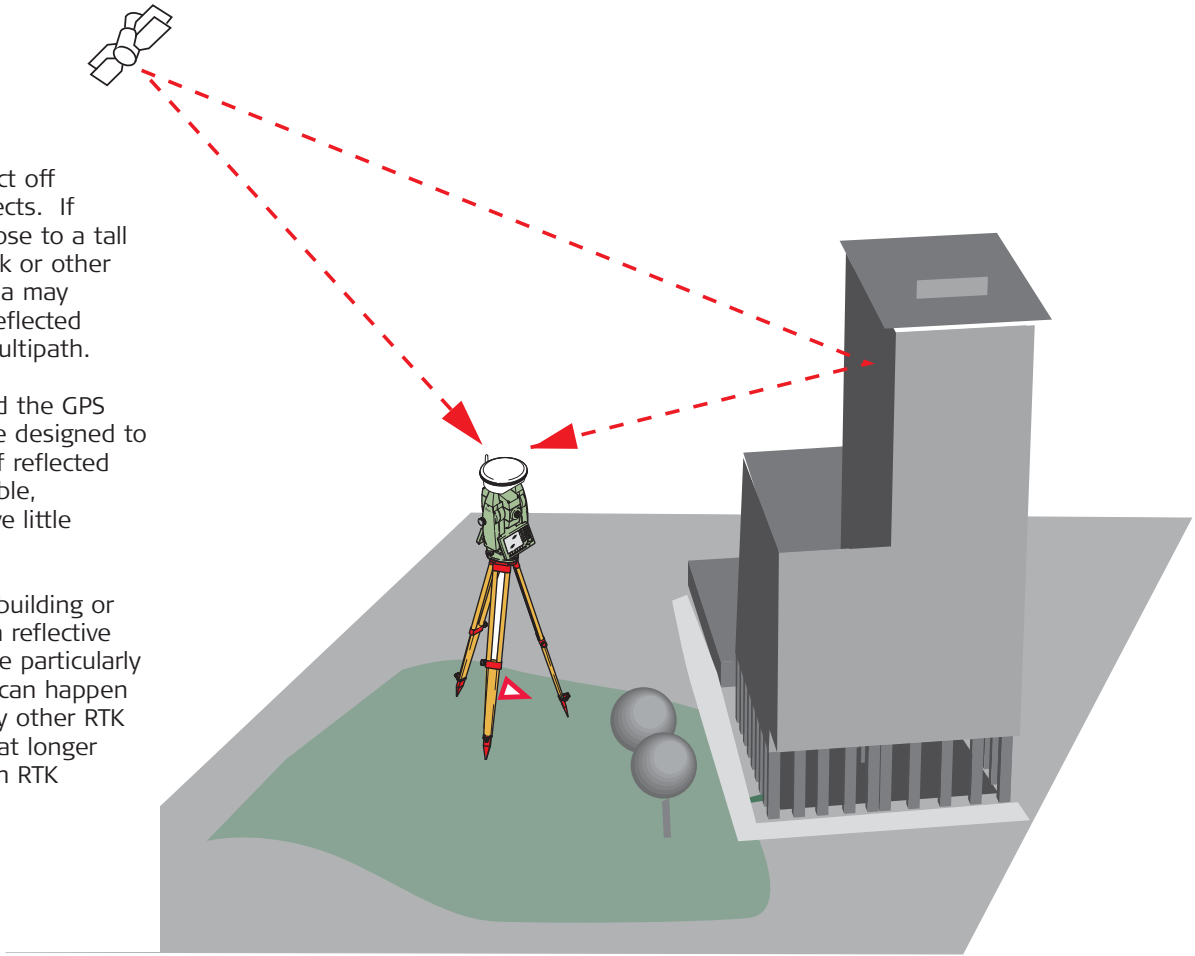


10.3 Multipath

The satellite signals reflect off buildings and similar objects. If SmartStation is set up close to a tall building or next to a truck or other vehicle, the SmartAntenna may receive both direct and reflected signals. This is termed multipath.

As the SmartAntenna and the GPS processing algorithms are designed to suppress the influence of reflected signals as much as possible, multipath will usually have little influence.

Note, however, that if a building or object has a very smooth reflective surface, multipath may be particularly severe. In such a case it can happen that SmartStation (as any other RTK rover) may take somewhat longer than usual to compute an RTK position fix.



10.4 Range and accuracy of RTK

Various error influences, particularly those relating to ionospheric delays, tropospheric delays and satellite orbits, affect the satellite signals and the data received. If the rover is close to the reference, the errors will be similar at both the rover and reference and will be largely eliminated by the differential RTK technique. The greater the distance between rover and reference, the more the errors will differ and the more difficult it becomes to eliminate them. It follows that, as the distance increases, a range will be reached at which RTK can no longer determine the position to centimeter-level accuracy.

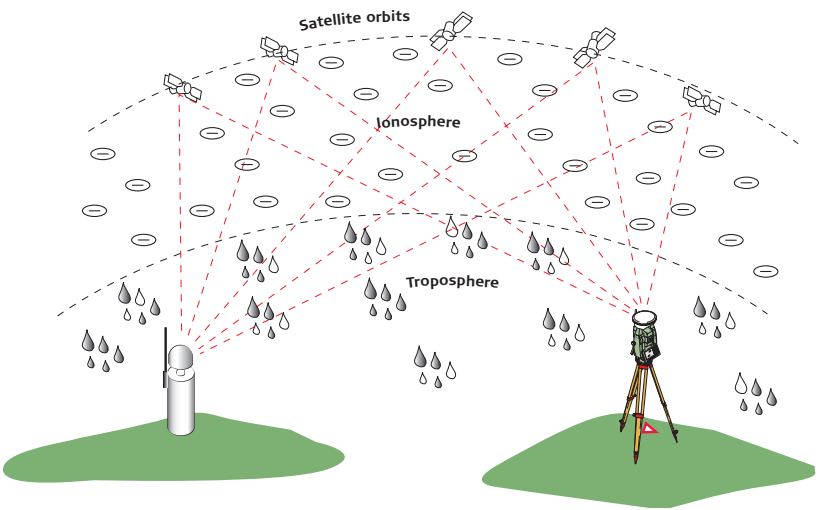
As the troposphere and ionosphere vary considerably from place to place, with the time of day, time of year, and from year to year, it is impossible to specify an exact maximum range. RTK range will often be somewhat longer during the cool of the night than during the heat of the day. RTK range also tends to be longer in mid latitudes than at low and high latitudes.

The RTK range for a moving RTK rover is usually quoted as about 30km in mid latitudes in favorable conditions. The RTK accuracy is usually given as 10mm + 1ppm.

As SmartStation is static (on a tripod), movements do not affect the data.

SmartStation's RTK algorithms are optimized for static mode and will compute position fixes at about 50km from a reference station in mid latitudes in favorable conditions.

The RTK accuracy of 10mm + 1ppm is maintained, even at maximum range.



10.5 Standard reference stations and networks of reference stations

10.5.1 Standard reference stations

A standard GPS reference station transmits data directly to SmartStation and other GPS rovers. The range and accuracy for SmartStation RTK, quoted in 8 and 10.4, are for standard reference stations. A standard reference station is not part of a network of reference stations.

10.5.2 Networks of reference stations

If RTK measurements could be carried out in a perfect environment, there would be no ppm accuracy component and no restriction to range. Unfortunately, however, the environment is never perfect and it also changes continuously. Various influences, particularly those relating to ionospheric delays, tropospheric delays and satellite orbits, lead to distance-dependent errors and restrict the range at which a rover can compute an RTK position fix.

By connecting reference stations to a central processing computer, combining them into a network, and continuously analyzing the data, it is possible to model the distance-dependent errors and compute network correction parameters to compensate for them.

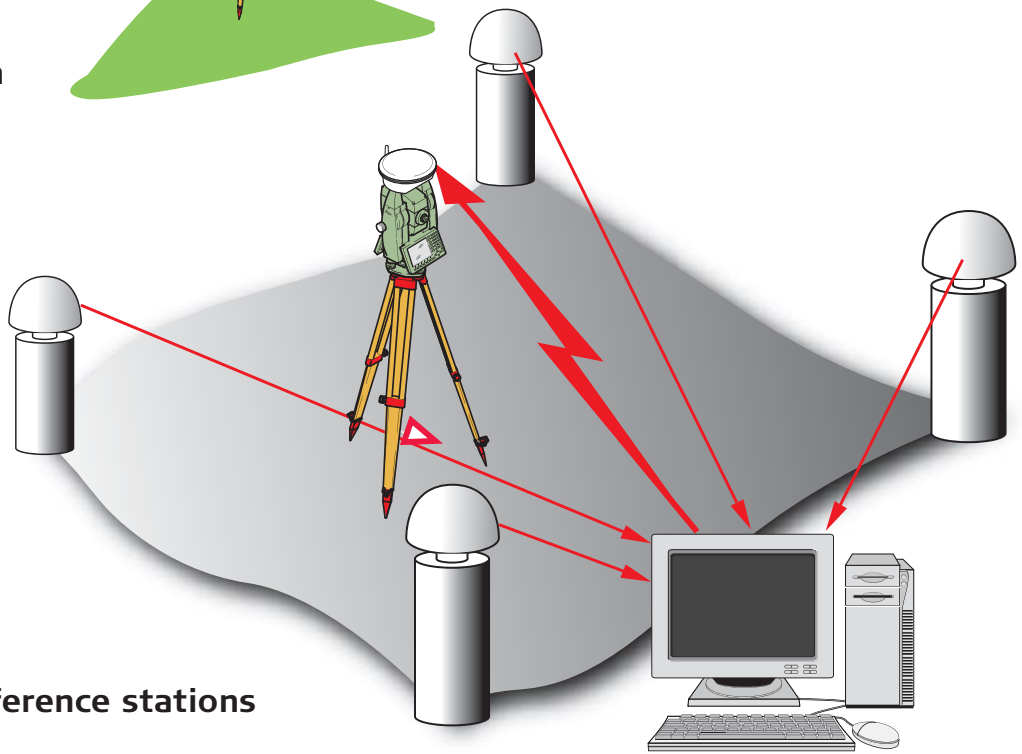
Reference station measurement data and correction parameters, or corrected reference station measurement data, can be transmitted to the rovers. The rovers can then compute RTK position fixes at longer ranges and with higher accuracy.

10.5.3 SmartStation accepts data from standard stations and networks

SmartStation will accept data from standard reference stations and from networks of reference stations. Settings have to be made in the configuration set according to the format of the data and how the data are transmitted.

Your technical support personnel, or possibly your Leica representative, will usually have defined the configuration set for the reference stations or networks that you will use. If not, you may have to modify the configuration set or define a new configuration set.

Standard reference station



Network of reference stations

10.6 Communication between the reference and SmartStation

Reference stations, or control centers in case of networks, transmit the measurement data to RTK rovers. Radios, phones or the Internet can be used to transmit the data.

In order to receive the data, SmartStation has to be equipped with the appropriate communication device. Various settings have to be made in the configuration set depending on the device that is used.

Your technical support personnel, or possibly your Leica representative, will usually have defined the configuration set for the reference stations or networks and for the communication device that you will use. If not, you may have to modify the configuration set or define a new configuration set.

10.6.1 Radio modems

The advantages:
- No running costs (charges).
- Any number of RTK rovers can obtain the data.

The disadvantages:
- The range at which a rover, i.e. SmartStation, can operate is usually less than if phones are used.
- Obstructions, particularly at longer ranges, can cause loss of reception.
- Interference on adjacent frequencies may also lead to poor reception.

10.6.2 Phone modems

The advantages:
- Reliable connection.
- No interference.
- Little loss of reception due to obstructions.
- Few restrictions to the range at which reliable communication is possible.

The disadvantages:
- Rovers, i.e. SmartStation, incur call charges.

10.6.3 The Internet

The Internet is still not widely used for transmitting measurement data from reference stations, or from network control centers, to RTK rover receivers. However, it will certainly be used much more in future.

The advantages:
- Charges should be less than with mobile phones.
- Few restrictions to range at which communication is possible.

The disadvantages:
- The reliability of connections may not always be as high as with phones.

10.7 Type of position and coordinate quality indicator

RTK is extremely reliable. Provided that SmartStation is configured correctly, is receiving data from the reference, and is set up in a reasonably open area, RTK is unlikely to fail. Position icons and the coordinate quality indicator in the display show the type of position.

If there is no communication between the reference and SmartStation, the communication arrow in the display will not move/blink. As SmartStation receives no data from the reference it can only compute a navigation position.

Navigation position
CQ quality indicator - about 3m to 20m

If only 4 satellites are used, or if the distance to the reference is too great for the prevailing ionospheric conditions, SmartStation will compute a differential code position.

DGPS Differential Code Position
CQ quality indicator - about 0.3m to 2m

If 5 or more satellites are used, and if the distance to the reference is not too great for the prevailing ionospheric conditions, SmartStation will compute an RTK position. **This will be the usual case.**

RTK position
CQ quality indicator - about 0.01 to 0.05m

The two ticks indicate that SmartCheck is computing independent position fixes to ensure that the RTK position is correct (see 8).

A maximum value for the CQ quality control can be specified in the configuration set. If the value is exceeded, a warning appears when you try to STORE the computed coordinates.

If you set a maximum value of 0.05m for CQ, you can be sure that only centimeter level RTK position fixes will be accepted and stored.

For additional information on the position and quality, touch the position icon .

The Position screen appears.

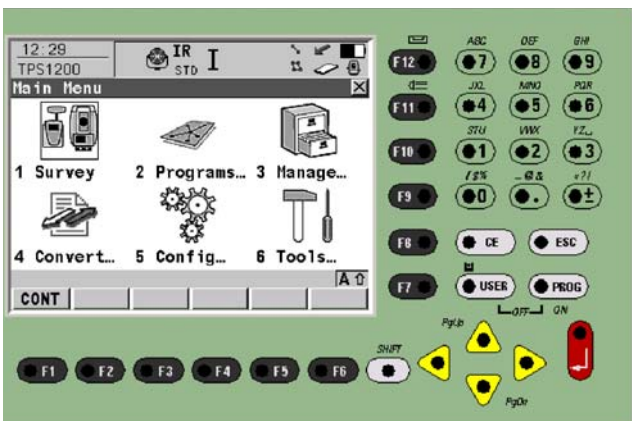
10.8 Coordinate system

As explained in 9.3, a coordinate system is needed in order that SmartStation can determine its position in grid coordinates.

Your technical support personnel, or possibly your Leica representative, will usually have defined the coordinate system for the area in which you work. If not, you will have to determine the required coordinate system.

11. A quick tour of SmartStation

Switch ON.



1 Survey

Program for angle and distance measurements, i.e. for using SmartStation as a total station. The program is not used when determining the position of SmartStation with RTK.

2 Programs...

```
01 Survey
02 Setup
03 Alignment Tool Kit
04 COGO
05 Determine Coordinate System
06 RoadRunner
07 GPS Survey
08 Hidden Point
09 Reference Line
10 Reference Plane
11 Sets of Angles
12 Stakeout
13 Traverse
```

Select Programs to view SmartStation's on-board programs. The only programs applicable to RTK are:
02 Setup
05 Determine Coordinate System
07 GPS Survey

Setup
Setup is the program you use when setting up SmartStation, determining the coordinates with RTK, and orienting the horizontal circle.

After completing Setup, select one of the other programs and use SmartStation for angle and distance measurements, for surveying and stakeout.

Determine Coordinate System
As explained in 9.3, SmartStation needs a coordinate system for the area or region in which you work. SmartStation uses the coordinate system to transform the RTK WGS84 coordinates instantly into the required N, E, H grid coordinates.

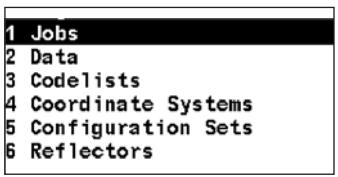
If the required coordinate system has not been defined, use the program Determine Coordinate System.

GPS Survey
You only need GPS Survey if you have to determine a coordinate system.

Use GPS Survey to determine the WGS84 coordinates of control points that have E, N, H grid coordinates. Afterwards, determine the coordinate system.

All the other programs are for total station measurements and total station applications. They are not dealt with in this book.

3 Manage...



This is the data management and data library component.

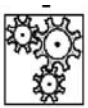
The following have to be considered when determining the position of SmartStation with RTK:

1 Jobs
2 Data
4 Coordinate Systems
5 Configuration Sets

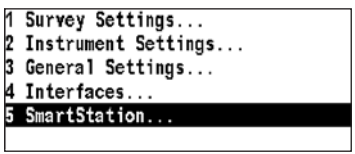
As explained above:

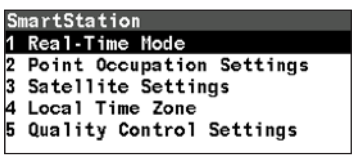
- An appropriate configuration set has to be defined before SmartStation can be used.
- An appropriate coordinate system has to be defined before RTK can be used.

Your technical support personnel, or your Leica representative, will normally have defined the required configuration set and coordinate system.



5 Config...





SmartStation needs a configuration set. If an appropriate configuration set has been defined, which will usually be the case, you should not have to use Config, at least not initially.

After using SmartStation for some time, you may find that your needs change. You may have to carry out different types of jobs, move to new areas with different reference stations, or use different types of communication links. In this case, you can change or modify the configuration set easily by using Config.

The settings that you may have to change or modify for RTK can be accessed via **Config › SmartStation**.

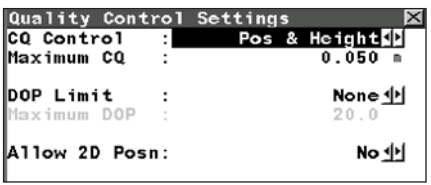
Real-Time Mode: Provides access to settings for rover mode, type of data, port, communication device, reference receiver, reference antenna etc. These settings are **important;** RTK will only function if they are correct.

Point Occupation Settings: Provides various options for occupying a point. Not important for determining the position of SmartStation with RTK.

Satellite Settings: To set cut off angle. Usually 10°.

Local Time Zone: To set time zone.

Quality Control Settings: To set limits for a position fix. The following settings are usually suitable. They will ensure that only RTK position fixes are accepted and stored.



12. An exercise to set up SmartStation, determine the coordinates with RTK, and set the circle by orienting to a known point.

The easiest way to learn how to start using SmartStation and to determine the position with RTK is to carry out the following exercise.

A coordinate system (9.3), a configuration set (9.4) and a job should have been defined. The coordinate system should be for the area in which you are working. The configuration set should include the correct settings for the reference stations (9.1) and communication link (9.2) that you will use.

In the following example:

- The coordinate system is called MY COORD SYSTEM.
- The configuration set is called MY CONFIG SET.
- The job is called MY JOB.

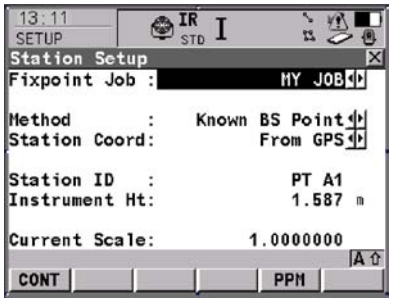
The exercise
Set up SmartStation in an open area with a clear view of the sky and from where you can see at least one point, the coordinates of which you know. The point will be used for orientation.

Select your coordinate system
Manage > Coordinate systems > CONT > Select your coordinate system > CONT.
This will now be the active coordinate system.

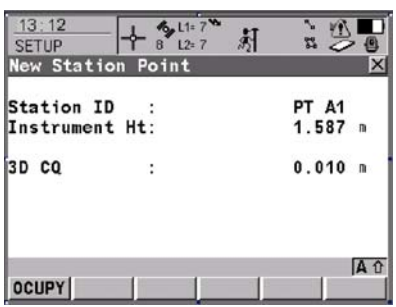
Data
Enter the Point id., Easting, Northing, Height, for the point that you will use for orientation, into the job that you created.
Manage > Data > List of points > NEW > Input Point Id, E/ing, N/ing, Ht > STORE

Complete SmartStation setup and determine the coordinates with RTK
Select *Programs* and then *Setup*.
The screen *Station Setup Begin* appears.

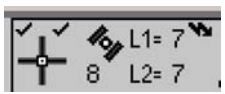
Select your job: MY JOB
Your coordinate system is shown:
MY COORD SYSTEM
Codelist: ignore = none
Select your Config Set: MY CONFIG SET
Reflector: Leica Circ Prism
Add Constant 0.0mm
Press *CONT*.
The screen *Station Setup* appears.



Select fixpoint Job: MY JOB
Select method: Known BS Point
Select Station Coord: From GPS
Input station Id: e.g. PT A1
Input instrument Ht: e.g. 1.587m
Current scale: accept, 1.000000
Press *CONT*.
The screen *New Station Point* appears.



Note that:
- The SmartAntenna will have switched on automatically.
- If a radio modem is used, it will have switched on automatically.
- If a phone is used, you have to dial the reference station.
- Icons appear at the top of the display.

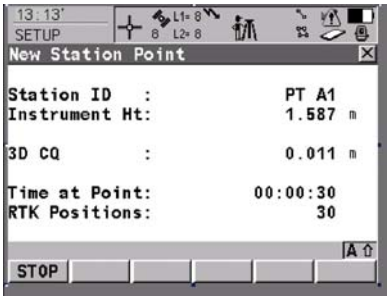


The icons show:
- The type of position
- The number of "visible"satellites
- The number of satellites used by SmartStation.
- The communication link, radio or phone. The arrow blinks/moves as data is received from the reference.

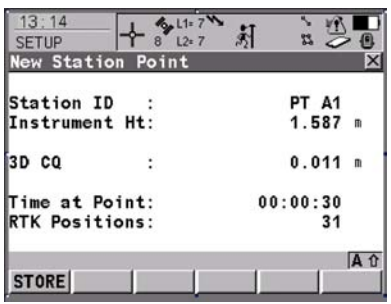
Wait until the position icon shows

This tells you that SmartStation has computed an RTK position.
The quality indicator 3D CQ should now be in the centimeter range. e.g 0.01 to 0.05m.

Press *OCCUPY*.



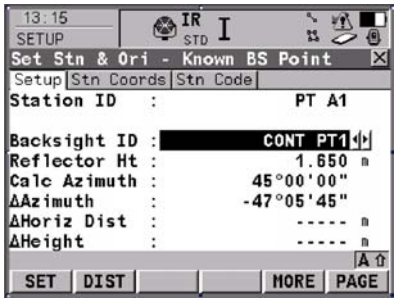
Wait for a few seconds until a few RTK positions have been calculated.
Then press *STOP*.



And afterwards press *STORE*.

The coordinates of the point PT A1 over which SmartStation is set up are stored in MY JOB.

The screen
Set Stn & Ori - Known BS Point
appears.
You now have to orient the total station.



You entered the Point id., Easting, Northing, Height for the point that you will use for orientation.

Open the box Backsight ID and select the point. In the screen example it is called CONT PT1.

If a reflector is set up at the orientation point, input the reflector height. If there is no reflector at the orientation point, for instance if it is a target or flag, input 0.00.

Point accurately with the total station and then press *SET*.

The horizontal circle is now correctly oriented

A message appears stating that the station (coordinates) and orientation have been set.

Press *OK*.

After pressing OK the Main Menu appears.

You can now use SmartStation as a standard TPS1200 total station.

Select *Programs* and then select the program you want to use, e.g. *Survey, Stakeout* etc.

13. SmartStation - a new way to survey

SmartStation is a new, revolutionary surveying system that combines a high-performance TPS1200 total station with a powerful GPS RTK receiver.

With SmartStation there's no need to worry about control points, traverses and resections. Just set up wherever it's convenient and let the SmartAntenna do the rest.

RTK determines the position to centimeter accuracy within a few seconds at ranges up to 50km or more from a reference station. The on-board coordinate system transforms the WGS84 GPS coordinates instantly into the required local grid coordinates.

With SmartStation you're ready to go in the shortest possible time. Simply fix the position with RTK, orient to a suitable point, and then survey and stakeout with the total station.

SmartStation is incredibly versatile and can do almost any type of job. Surveying is easier and quicker, and fewer set ups are needed. SmartStation saves you time and money, and increases your productivity and profits.

All TPS1200 total stations can be upgraded to SmartStation.

With SmartStation's modular design, you can use the equipment in any way you like, in the most efficient and productive manner for the work you have to do.

Use SmartStation with TPS and GPS together when there are no control points available.

Once SmartStation is accurately positioned, take off the SmartAntenna, put it on a pole, and use it with the RX1210 controller and GTX1230 sensor as a fully-fledged RTK rover. And use the TPS1200 by itself for all total station work.

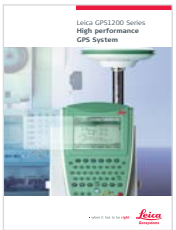
With SmartStation you're completely flexible.

Notes

Notes

Leica SmartStation
Product brochure

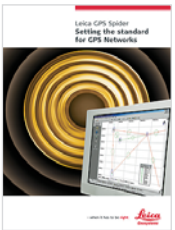
Leica TPS1200
Product brochure



Leica GPS1200
Product brochure

Leica System1200 Software
Product brochure

Leica GRX1200
Product brochure



Leica GPS Spider
Product brochure

Leica Geosystems AG
Switzerland

www.leica-geosystems.com

- when it has to be **right**

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