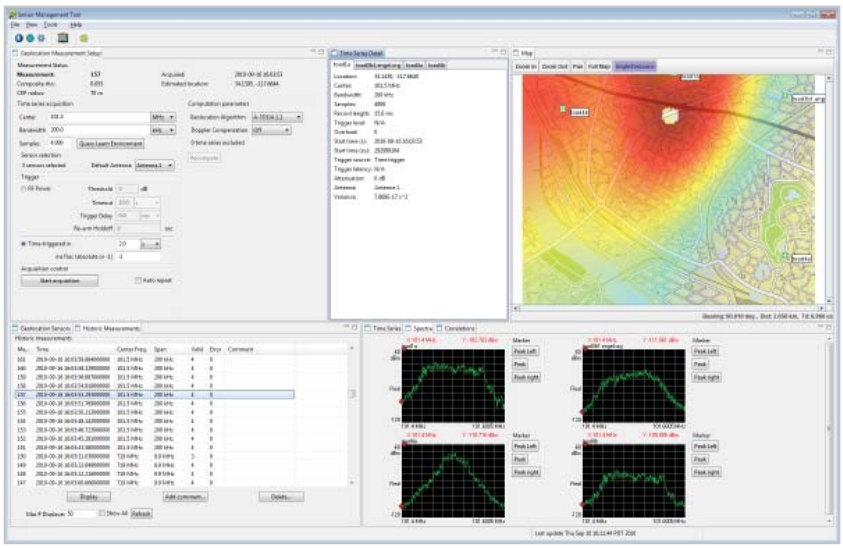
Agilent N6854A
RF Geolocation Server Software

Technical Overview

The Agilent N6854A geolocation server software extends the capabilities of a wide area network of N6841A RF sensors with integrated real-time RF emitter geolocation and mapping. This software computes the estimated position (EP) of emitters based on several unique geolocation methods. It usually operates in conjunction with a signal search system that provides signal detection and characterization and initiates geolocation measurements once a signal of interest is detected. Results are logged to the database and may also be displayed real-time in the user interface.



- Geolocation computation for RF emitters from 20 to 6000 MHz
- Locate CW, narrow or wide band-width signals including signals below the noise floor
- Supports deployments in indoor, rural, suburban or dense urban monitoring environments from 10 meters to 10's of kilometers
- Use with fixed site or a land mobile network of Agilent N6841A RF Sensors
- Software tasks 3 or more sensors to geolocate signals of interest using the following user-defined techniques:
  - Time-Difference-of-Arrival (TDOA)
  - Relative Signal Strength (RSS) Amplitude Ratio
  - Adaptive hybrid technique combining both TDOA and RSS
- EP results include accuracy and confidence indicators
- Measurement triggering based on RF power level or time-of-day
- Intuitive visual displays of estimated position, signal correlation and propagation characteristics
- Import underlay raster maps in most standard image formats
- Export geolocation results in KML format to Geographical Information Systems such as Google Earth®
- Operates in conjunction with Agilent's E3238S/N6820E/N7100A surveillance/monitoring systems
- API C library for external application interface

Agilent Technologies

Improve Detection and Geolocation of Modern Signals

New methods for quickly detecting and locating modern wireless transmitters are now available with the N6854A geolocation server and multiple N6841A RF sensors. Modern signals can be intermittent, short-duration, low power, at higher frequencies, with wider signal bandwidths and more complex modulation – making them especially challenging to detect and locate. Either deploying a large quantity of traditional signal monitoring systems, or using systems with increased performance, higher gain antennas, at higher elevations can be cost prohibitive.

Many signal monitoring organizations have a staff of trained people operating portable receivers with access to transportation and internal communications. Not only are these operational costs expensive, they are also potentially unreliable. Using permanent or semi-permanent low-cost, networked sensors in close proximity to the target emitters can be the best alternative for detecting and locating modern signals.

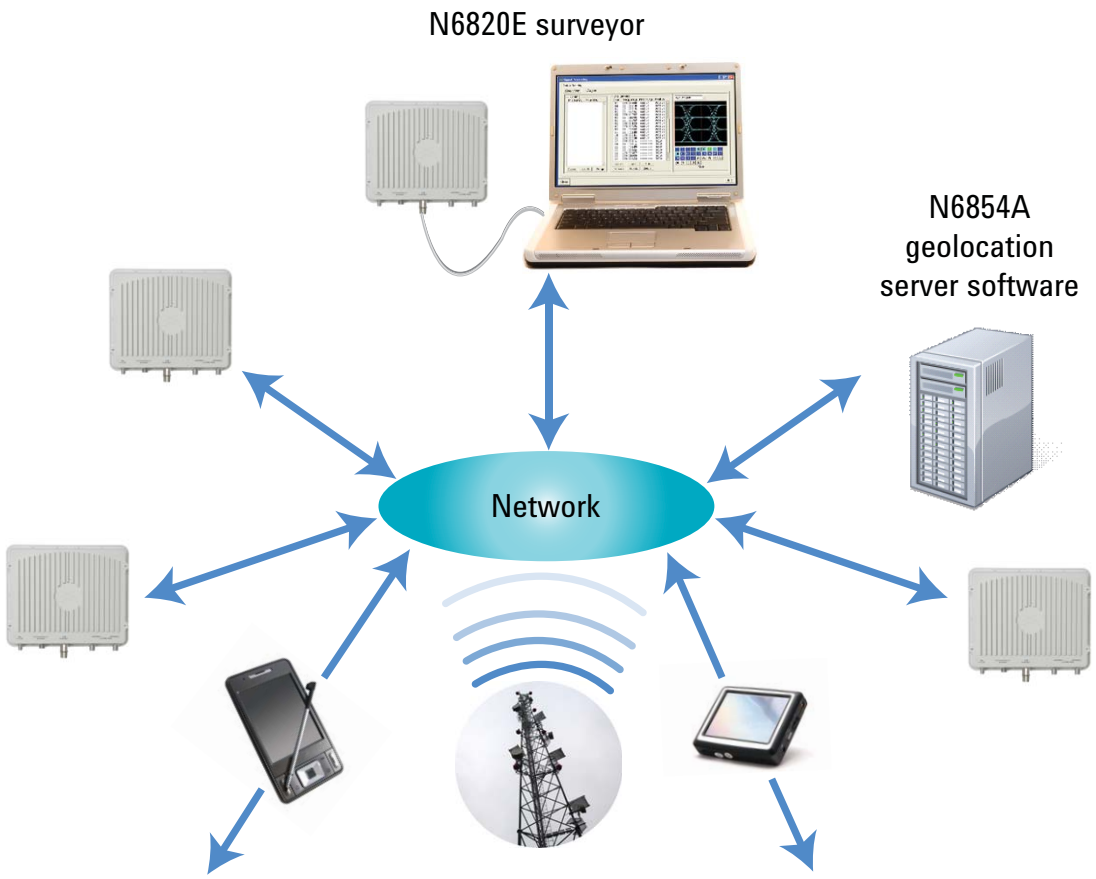


Figure 1. An RF search system, a network of RF sensors combined with the geolocation server software estimates the position of numerous modern signals.

Geolocation Methods

Unlike traditional direction-finding (DF) systems which determine the signal's angle of arrival (and thus a line of bearing), the N6854A geolocation server uses a network of RF sensors to locate emitters using several different techniques.

1. Time Difference of Arrival

The TDOA technique is based on the concept that an RF signal of unknown location and time of emission can be located if the precise time of arrival of the signal can be determined at three or more receivers of known location. By precisely time-stamping the signal arrival, the measured time difference of arrival between any pair of sensors form a hyperbolic relationship. Where multiple hyperbolic lines of position intersect is the reulting EP. For emitters outside of the region covered by sensors, only the TDOA method provides a hyperbola of bearing (HOB). The Agilent A-TDOA approach works well when used outdoors over longer distances (typically > 1 km) and for wider bandwidth signals (> 200 kHz). Signals of interest must be modulated.

2. Received Signal Strength Amplitude Ratio

The RSS amplitude ratio technique is based on the concept that signal power decreases in a predictable manner as the signal propagates away from the emitter. In free space, the power drops off with the square of the distance ($1/r^2$). For actual indoor environments, this has been measured to actually be between ($1/r^3$) and ($1/r^4$). It can be shown that independent of the exponent, the ratio of signal power measured at two different receivers leads to a circle of position. Circles of position from multiple pairs of receivers will (under ideal circumstances) intersect at a single point – the EP.
The Agilent A-RSS technique is well suited for indoor (high multipath) and close proximity deployments. It may also be used for un-modulated CW signals which overcomes a key deficiency of TDOA.

3. Hybrid TDOA and RSS

The Agilent A-HYBRID algorithm is an adaptive technique that uses both TDOA and RSS information in an optimal approach. When time-of-arrival data is suspect, it relies more heavily on signal power to determine the EP - and vice versa. The A-HYBRID method is optimal for outdoor, dense urban environments and for narrow bandwidth signals.

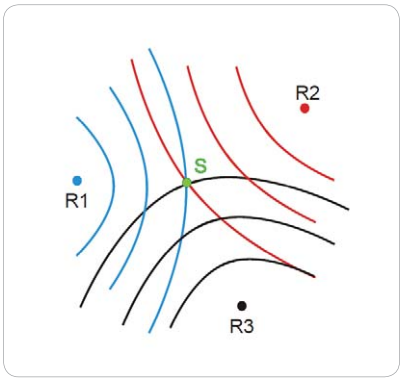


Figure 2. With TDOA method, hyperbolic lines of position intersect at the estimated position of the emitter

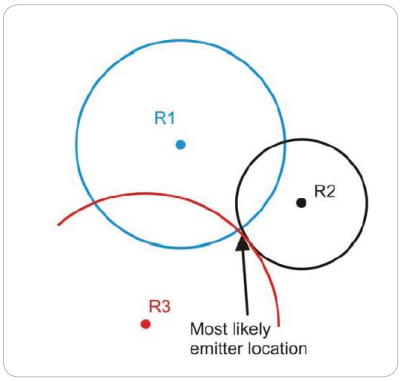


Figure 3. RSS techniques show circular lines of position intersecting at the estimated position of the emitter

Flexible Sensor Network Operation

Operating the sensor network can be either manual, i.e. directly controlled by the user, or automated in a tipped hand-off scheme with a signal search system such as the Agilent E3238S family. The raw measurement data and measurement parameters for each synchronized sensor are logged to the system database and available for later analysis and post-processing.

Measurements are executed in a number of different ways. A time-of-day measurement is ideal for most conventional long-duration signals. For short duration and transient signals, once RF energy is above the noise floor of the receiver's IF section, a measurement can be triggered. A peer-triggered measurement is effective when all sensors cannot receive the signal above the noise floor, such as in dense urban or rugged terrain environments. In this case, one sensor will initiate a measurement with several other adjacent sensors. Lastly, there is a free-run mode where the system will make rapid continuous measurements at a specific frequency range.

Locate Signals Below the Noise Floor

Agilent's TDOA solution in the N6854A software uses a proprietary coherent detection technique for estimating the position of RF emitters. Non-coherent detection schemes require transmitter signal power that is greater than the noise when comparing measurement results from multiple receivers. When the signal-to-noise ratio (SNR) is not positive, the noise obscures low-level signals and the receivers cannot detect differences in power. Agilent's coherent detection uses a cross-correlation algorithm between sensor measurements for detecting and locating signals that are not visible in the spectrum data of each individual sensor.

In traditional monitoring stations with non-coherent detection, performance of the system is limited to the performance of the receivers. With Agilent's coherent detection of synchronized receivers, the system performance far exceeds each receiver's performance.

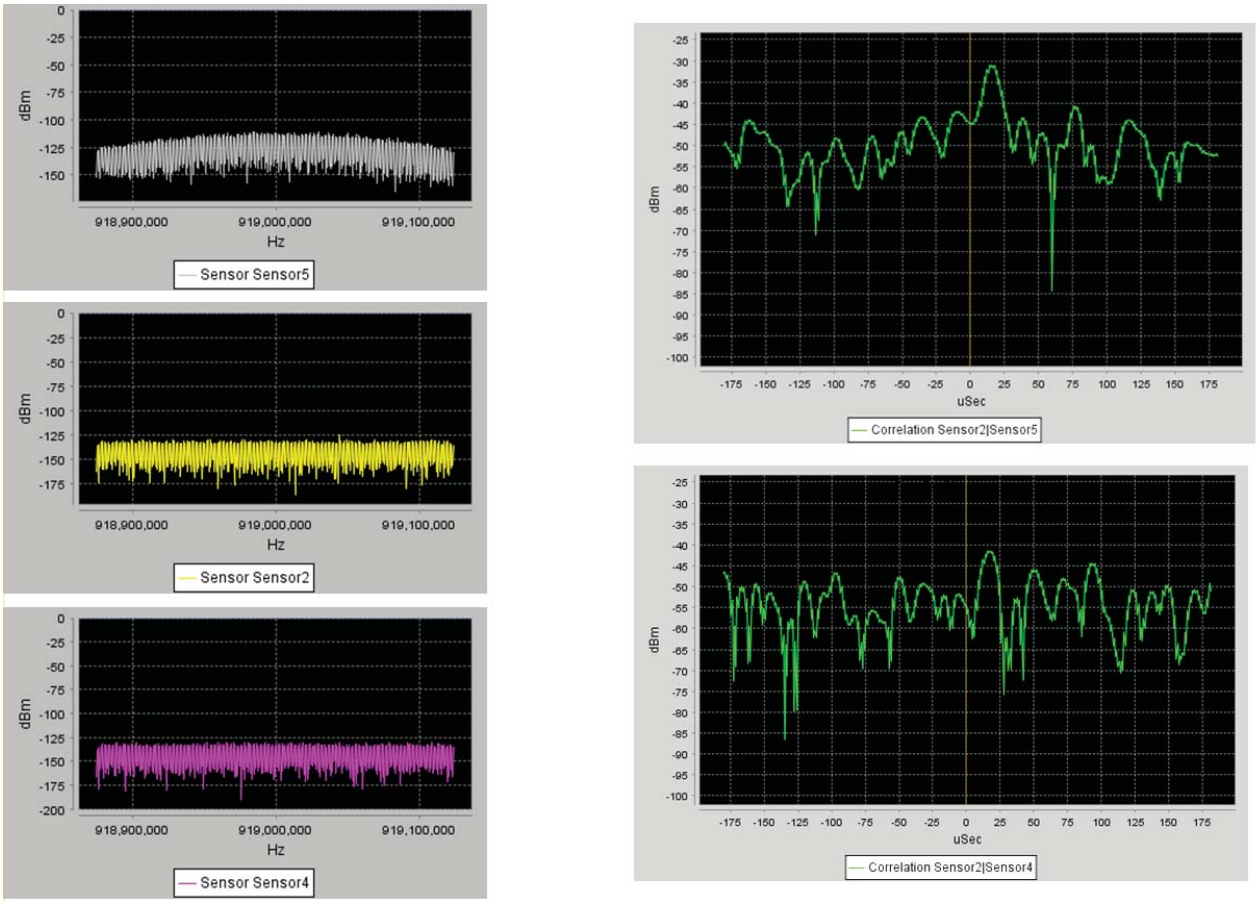


Figure 4. Non-coherent detection would conclude the signal is closest to sensor 5 (spectrum data on the upper left). However, coherent detection and sensor cross-correlations (shown on the right) provides the signal geolocation.

Intuitive Geolocation Analysis

The N6854A user interface is implemented as a plug-in application for the N6841A RF sensor management tool and displays data from the system server. This interface integrates all measurement data – raw time-series I/Q data, computed spectrums and sensor cross correlations – into one convenient portal.

N6854A geolocation software displays include recorded spectrums, signal cross-correlations and sensor location map with the tentagram overlay. An important new tool developed by Agilent is the tentagram display which provides valuable insight into the signal environment. When a geolocation measurement is initiated to determine EP, an optional computation of the spatial degree of signal correlation between sensors is also made. This provides additional qualitative information about the measurement itself and can highlight such effects as multipath and multiple emitters on a frequency.

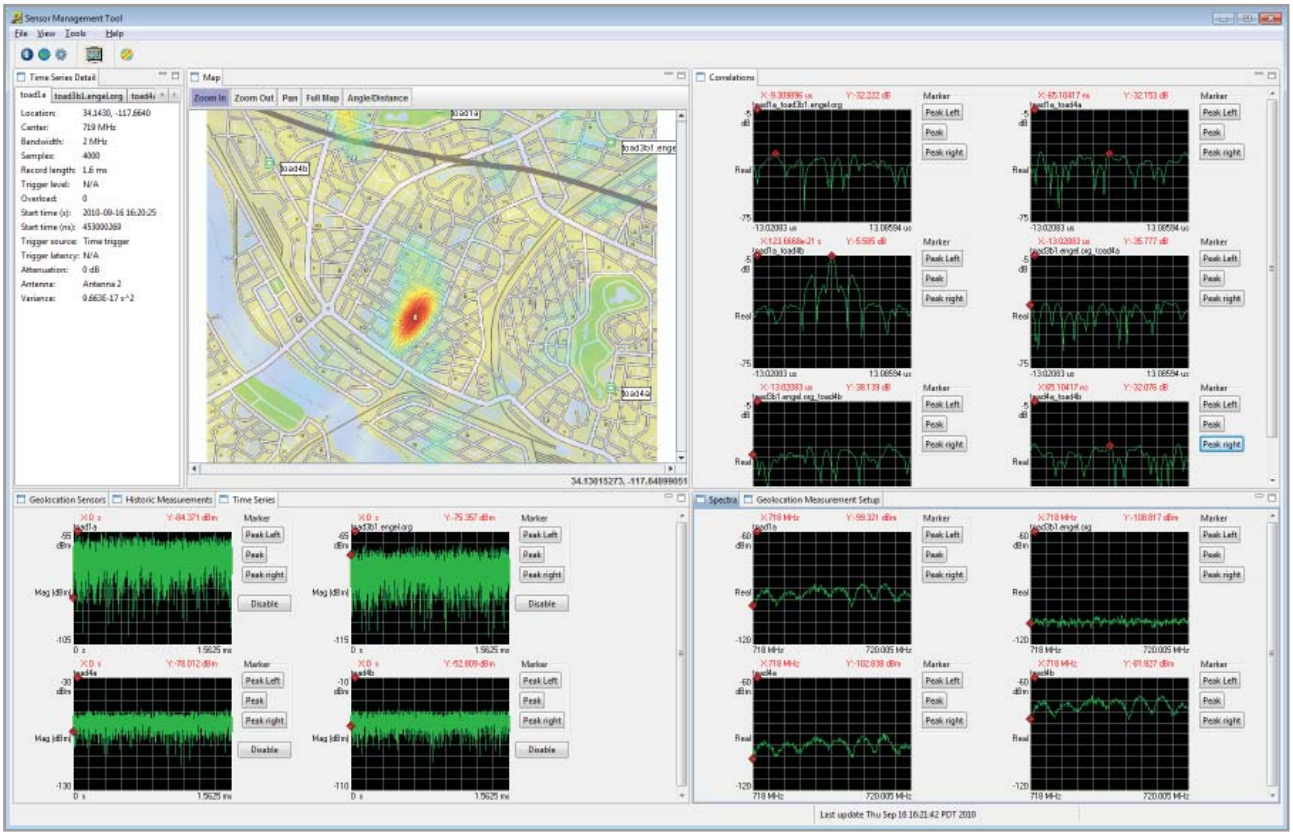


Figure 5. Agilent's tentagram display provides valuable insight into signal propagation characteristics and measurement quality.

Optimize Estimated Position

The accuracy of an estimated position (EP) calculation depends on a number of factors including the relative location of the sensors, the number of sensors used in the measurement, the effects of multipath and the signal bandwidth. The wider the signal bandwidth, the more accurate the EP since it provides a sharper cross-correlation peak.

Multiple RF sensors deployed spatially in an area can be configured to monitor the spectrum coherently and sweep the spectrum synchronously. In such configurations, higher system processing gain is realized derived from measurement redundancy. High precision clock synchronization is enabled by support for Precision Time Protocol (based on the the IEEE1588-2008 standard) or by using GPS - which also provides sensor location for mobile deployments.

Circular Error Probable (CEP) is a common accuracy metric used in geolocation systems. The N6854A software returns a CEP value expressed as distance from the EP based on a 50% probability estimate.

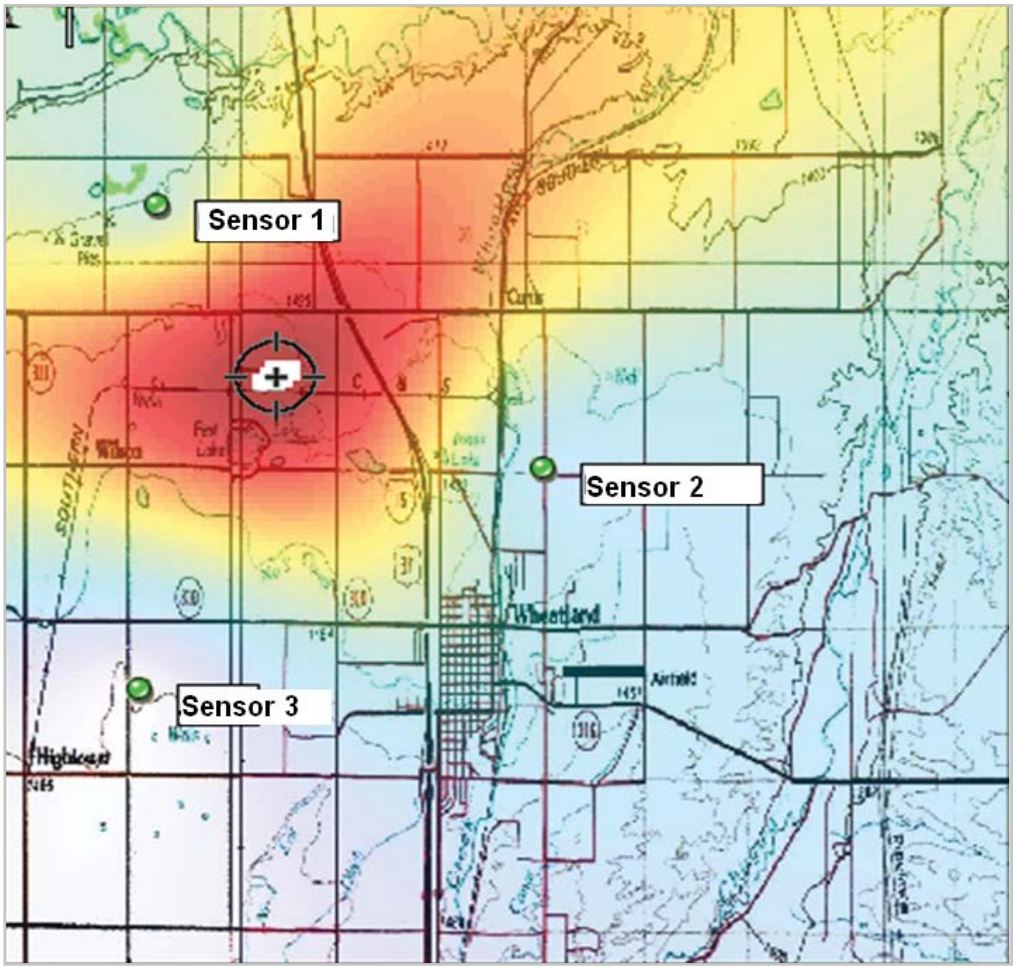


Figure 6. The cross-correlations of signals received by each sensor provide the basis for the time-difference-of-arrival determination. Estimated position is shown in colors with the highest probability location in dark red.

Consulting and Assistance for Successful Deployments

Agilent wants all of your sensor network deployments to be successful. Your first few deployments will need our consulting expertise because of new measurement technology in the N6854A software. Our experts are available and ready to engage with customers for design and recommendations, including:

- Sensor placement geometry for maximum resolution and sensitivity
- Network infrastructure requirements
- Signal measurement optimization
- Integration assistance with search systems

Our startup assistance is tailored to suit the specific deployment and application requirements.

System Characteristics

Description	Specification
Frequency coverage	20 to 6000 MHz
Measurement bandwidth	Up to 10 MHz[1]
Measurement modes	Manual or remote application control Single or Auto-repeat measurements
Measurement methods	Time-Difference-of-Arrival Relative Signal Strength Amplitude Ratio Adaptive Hybrid (TDOA + RSS)
Measurement trigger modes	RF power in Sensor IF Time-of-Day
Signal data capture	1k to 32k samples of I/Q data (user definable)
Doppler Compensation for moving targets and/or sensors	User enabled up to 100 km/hr [2]
Sensor configurations	Minimum of 3 / sensors for a geolocation computation
Measurement history database	User Defined size limit
Programmatic interface	C development library for remote application control

1. *The signal of interest may be wider than the measurement BW and still result in an accurate EP.*
2. *Timing accuracy is degraded when sensors are moving.*

Minimum PC requirements for server

- 3 GHz Pentium duo-core or equivalent
- 2 GB memory
- 50 GB available hard disk space
- Windows XP Pro SP3, Win7 (32/64 bit) or Vista (32/64 bit)

Minimum networking requirements

- TCP network with UDP
- Bandwidth: DSL 128 kb/s minimum
- 100 MB/s LAN or better strongly recommended
- VPN operation recommended

Note: System is suitable for operation wireless backhaul (e.g. WiFi, 3G cellular) but a wired connection is recommended. If using a wireless network, the optional GPS must be used for time synchronization.

Ordering and configuration

N6854A	Geolocation server software
N6854A-103	Core software, includes server and client display software plug-in; TDOA Geolocation method only
N6854A-AG1	Add advanced Geolocation methods (RSS, Hybrid)
N6854A-0B1	DVD media for Microsoft ® Windows ® XP, Vista®, 7
N6854A-LK2	Node locked license to use
N6841A	RF sensor
N6841A-GPS	Add GPS, cable and antenna
N6841A-PS1	Add AC power adapter 24V
N6841A-0B1	DVD media for Windows® XP, Vista®, 7
N6820E	Signal survey software
N6820E-114	Core software for N6841A RF sensor only

Consulting and assistance is required for initial deployments. Scope and duration is application dependent.

R2004A-001	Specialist assistance (division/factory application engineers)
PS-S20-100	Startup assistance (field application engineers)

For convenience of ordering, Agilent offers a quick-start solution package.

N6860A — RF Geolocation server bundle, including:

- One N6854A geolocation server software
- One N6820E signal survey software
- Five each N6841A RF sensors with GPS, PS1

A minimum of 5 days of R2004A-001 or PS-S10 specialist technical startup assistance is recommended. Additional startup assistance may be required depending on application.

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