VERTICAL LOCATION SERVICE

WI-FI 6E/7

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TABLE OF CONTENTS

INTRODUCTION

Since the late nineties we have come to rely on Wi-Fi to wirelessly connect devices in the home, office and countless other locations using the unlicensed 2.4GHz or 5GHz spectrums. As devices with Wi-Fi capabilities continue to proliferate, the need for better connectivity and improved speeds grows. Meeting this need requires additional bandwidth.

Wi-Fi 6E/7 has been introduced by many countries to help meet the increased demand for reduced congestion, improved bandwidth and faster speeds. Wi-Fi 6E/7 expands the capabilities of Wi-Fi 6, enabling devices to operate in the unlicensed 6GHz spectrum where it makes use of super-wide channels that support greater capacity, lower latency, and increased throughput.

With an increased number of access points and devices operating across the 2.4GHz, 5GHz and 6GHz spectrums, interoperability and interference are two important factors that need to be addressed by device manufacturers and providers/operators of Wi-Fi access point networks. In addition to 6GHz Wi-Fi technologies, interference is a factor with other systems that rely heavily on the 6GHz, for example Point-to-point microwave and earth-to-satellite communications.

Managing the interference between Wi-Fi access points (APs) and other systems operating in the same 6GHz spectrum requires precise location data. This not only means knowing the AP position on the 'horizontal' X and Y axes but also understanding the vertical location of the AP. This is because Standard Power (SP) access points installed for either fixed indoor or outdoor operations are controlled by Automatic Frequency Coordinators (AFCs). To mitigate interference issues the frequencies and the point angle of the antenna systems are recorded and managed by the AFCs. Wi-Fi-6E/7 providers are required by FCC regulation FCC-20-51 to report the height above ground of Wi-Fi APs operating at the higher SP power level and in the 6GHz spectrum to the AFCs.

For access point installers and system operators, a solution that provides an automated method for recording the vertical location of the access points becomes critical to meeting the FCC requirement in a cost-effective manner.

THE CHALLENGE

The challenge facing installers and system operators is that they are mandated to add a complete and accurate geolocation solution to each Wi-Fi AP to meet the FCC requirement but they must do this in a simple and cost-effective manner to deliver commercially viable systems that unlock the full potential of the 6GHz market.

The question, therefore, is - how to meet the FCC requirement for accurate height positioning for each AP in a network and maximize the AP power of operation with a cost-effective solution that does not involve manual surveys and truck rolls?

To achieve a complete and accurate solution for recording the vertical location of the AP, system operators need to meet a number of key requirements:

- Provide an altitude measurement that is consistent with FCC requirements for the measurement format. Most devices provide a height above the earth's ellipsoid (HAE) and therefore, altitude measurements from a device are not sufficient, especially in hilly areas. The FCC measurement format in determining the altitude measurements is height above ground, also known as height above terrain (HAT).
- Provide the vertical location within an accuracy confidence level of 95%.
- Provide an accurate altitude in a variety of deployment configurations, which may include indoor or outdoor APs.
- Allow for multiple deployment models (e.g. consumer, enterprise, managed services) as AP operators serve multiple markets with varying use cases.
- Enable automatic reporting of height above ground of each Wi-Fi AP to the AFC, reducing the time, effort, and cost of manual surveying.
- Allow for on-demand, real-time height data generation of each Wi-Fi AP to detect post-installation movement and validate other deployment errors.

HAT & HAE

Height Above Terrain (HAT)

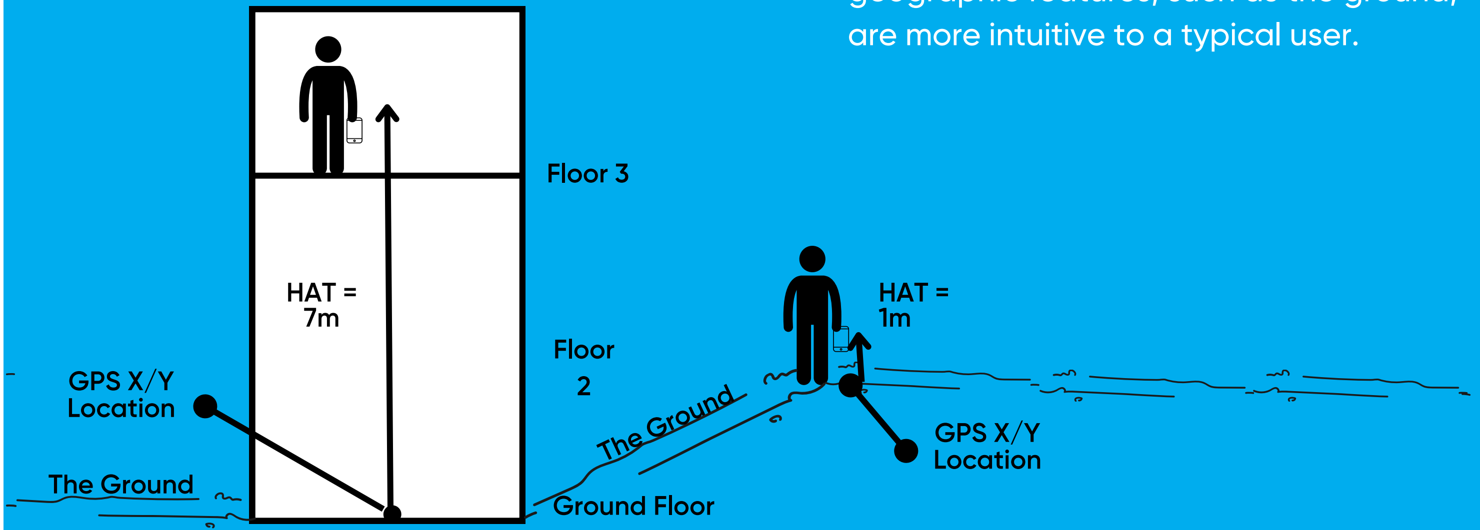
Measurement of height relative to your surrounding context (GPS x/y)

- HAT compares an absolute altitude such as an HAE to publicly available terrain data where the user is located
- A person's location is significant for HAT measurements: The horizontal (x/y) location delivered by GPS

Height Above Ellipsoid (HAE)

Measurement that tells you how high up you are relative to a theoretical model of the earth's surface

- The "ellipsoid" part of HAE refers to a mathematical model of the earth. The earth is not a sphere - it actually bulges at the equator, hence "ellipsoid"
- The ellipsoids used by GPS devices vary - most currently use a model called the WGS84 ellipsoid
- Absolute altitude isn't entirely useful for finding out how high you are in buildings or other structures. Altitude relative to geographic features, such as the ground, are more intuitive to a typical user.



For more info visit: nextnav.com/hat & nextnav.com/hae

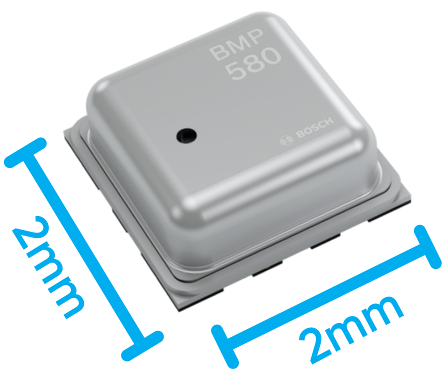
THE SOLUTION

One way of addressing the challenge is to deploy a barometric pressure-based solution capable of providing the accurate height above ground value for each Wi-Fi AP. The key elements of such a solution will involve:

- Adding a barometric pressure sensor to each AP. Choice of sensor is particularly critical as many are susceptible to "drift" away from accurate measurement over time. Drift is a natural phenomenon and it's contributing factors include pressure changes, frequency and amplitude changes, temperature and humidity extremes, material responses and environmental changes. Because drift prevents the barometric pressure sensor from accurately reporting pressure data from the device over a long period it is important to choose a low-drift sensor that can consistently report the observed pressure at the AP within +/-10-15Pa of reality - ideally for the life of the device.
- Converting the pressure reading from the barometric pressure sensor in the AP into an accurate height above ground vertical location value with a 95% confidence – even in severe weather conditions. This requires use of real-time, accurate reference pressure data that factors in environmental conditions such as weather changes during the day as well as air pressure variances measured within a localized area. Achieving this is possible with cloud-based services that support device data, surveyed localized weather station measurements and suitable software algorithms.
- Reporting the height value to the AFC based on the chosen architecture of each AP. Architectures for reporting can be as simple as the AP directly reporting to the AFC or, in the case of multiple, APs, an enterprise service manager or proxy server.

CHOOSING & SETTING UP A SUITABLE PRESSURE SENSOR

Bosch Sensortec's BMP580 and BMP581 provide a good example of a sensor technology that can meet the criteria outlined above and is, therefore, well-suited to generating pressure-based altitude data in Wi-Fi AP deployments. This industry-leading platform is based on the very latest capacitive sensing principles and has best-in-class power consumption, noise reduction, and accuracy over the required full temperature and pressure range.



Bosch Sensortec BMP580 and BMP581 are the ideal candidates to use in Wi-Fi AP for the purposes of generating pressure-based altitude data.

Key specifications of BMP580 and BMP581 sensors include:

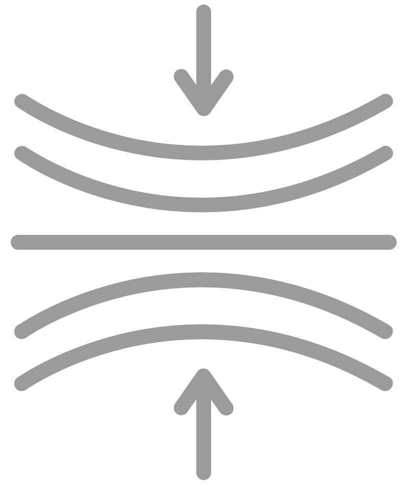
- Low annual drift - typically less than +/- 10Pa, or approximately 0.8m vertical.
- Maximum absolute pressure variability of less than +/-50Pa - though with proper factory calibration after soldering this can be greatly reduced as explained below.
- Relative accuracy over temperature is typically within +/- 0.5 Pa/K (5 - 65°C).
- Relative accuracy over pressure is typically within +/- 6Pa (700hPa - 1100hPa, 100hPa steps).

END-OF-LINE CALIBRATION

While BMP580 and BMP581 devices are delivered in a completely calibrated form, the soldering process can generate additional offsets. Typically, soldering induces a change in pressure output of +/- 30Pa (typical 1 sigma limit). However, absolute accuracy may be improved by adding an additional offset compensation step after the soldering process. While ensuring the accuracy and reliability of the end-of-line calibration is the task of the user, the steps below outline the best practices for performing offset calibration. However, it is highly recommended to consult with a local Bosch Sensortec representative for review before implementation.

1. CALIBRATION SET-UP

- The reference sensor should have an absolute precision of below +/- 10Pa in order to get a noticeable accuracy gain. The reference sensor must be positioned at the same height as the sensors which are recalibrated.
- The environment needs to be free of pressure peaks and offsets. These can be caused by wind gusts, steady winds, closing doors or windows and other events.
- Pressure during calibration can be ambient pressure, but the temperature should be as close as possible to the temperature at which the sensor is intended to be used.



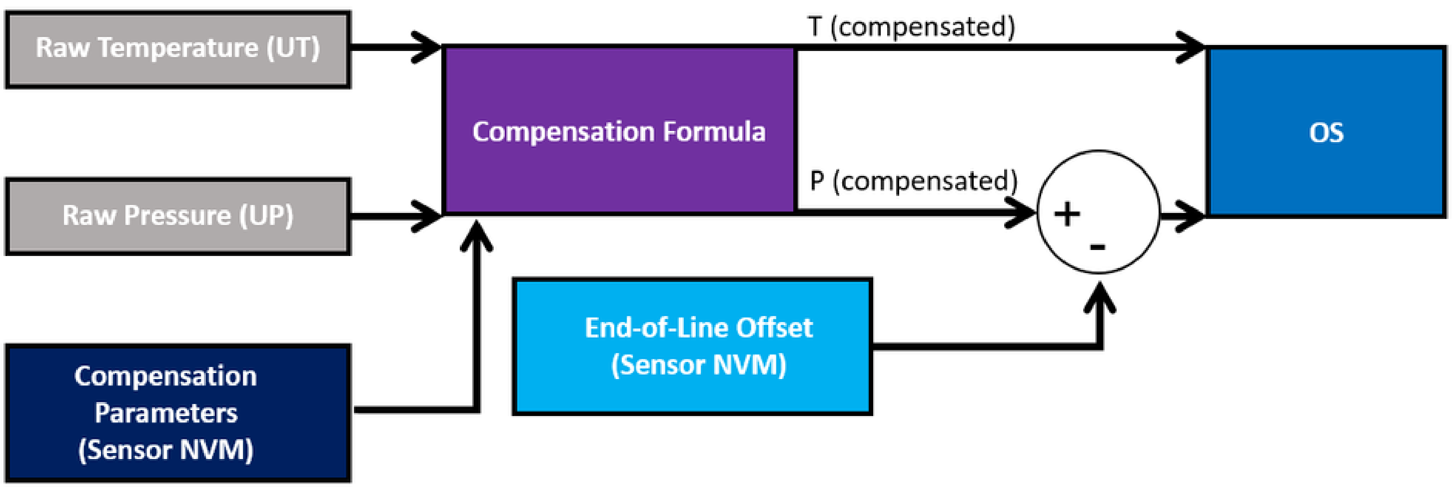
- Wait at least 24 hours after soldering before applying the end-of-line calibration. This is to minimize additional solder drift.

2. IMPLEMENTATION

- The sensor should be operated in ultra-high-resolution mode and it is recommended to take several measurements (16 is a good number) and use the average result so as to compensate for a potentially noisy environment.
- The reference measurement and the sensor measurement should be done at the same time and have about the same duration. This is to make sure that any disturbance effects are reflected in both measurements. If the offset is continuously higher than the maximum datasheet values, please consider replacing the barometric pressure sensor.

2. IMPLEMENTATION CONTD.

- Recommendations for the soldering process are available in our HSMI (handling soldering and mounting instruction) or via a Bosch Sensortec representative.
- The offset can be calculated as offset = mean (sensor measurement) - mean (reference measurement). If the offset is larger than the data sheet maximum deviation, the measurement should be repeated to make sure that it was not an error due to a disturbance.
- The correction of offset should be applied before using the data provided by the sensor. The offset correction needs to be implemented in software. Although the BMP580 and BMP581 pressure sensors have a memory area (NVM) in which the coefficient can be stored, the correction itself is not implemented in the sensor. The recommended method of compensation is depicted in the figure below:



NEXTNAV PINNACLE SERVICE

The final part of the solution is to take the pressure data from the calibrated sensor hardware and turn it into a meaningful and accurate calculation of vertical position. This can be done using a cloud-based service that is able to compare device data to local conditions and subtract the weather and other factors to provide a precise altitude measurement.

A good example here is the NextNav Pinnacle vertical location service, which is the industry-leading solution for providing accurate pressure-based height information for a variety of geolocation applications. A proven and reliable cloud-based solution, this service has been used since 2020 by FirstNET for location of first responders and has been deployed by telecom operators to meet FCC 911 vertical location regulations applicable to locating individuals who dial 911.

SERVICE COVERAGE
More than 4,400 cities, covering 90% of buildings greater than 3 stories

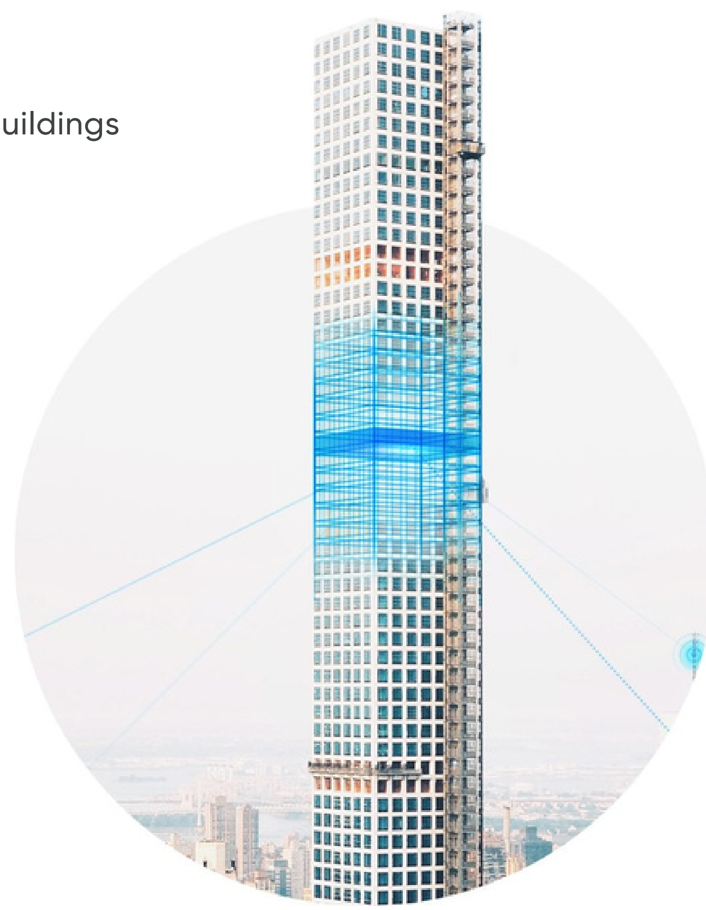
FUNCTIONAL ELEMENTS
Passive Sensors

NETWORK DESIGN DRIVERS
Atmospheric Conditions

SITE LOCATIONS
Almost anywhere outdoors with power

INSTALLATION SURVEY ACCURACY
10cm or better

LOCATION ACCURACY
94% accuracy +/- 3m (CTIA Report)



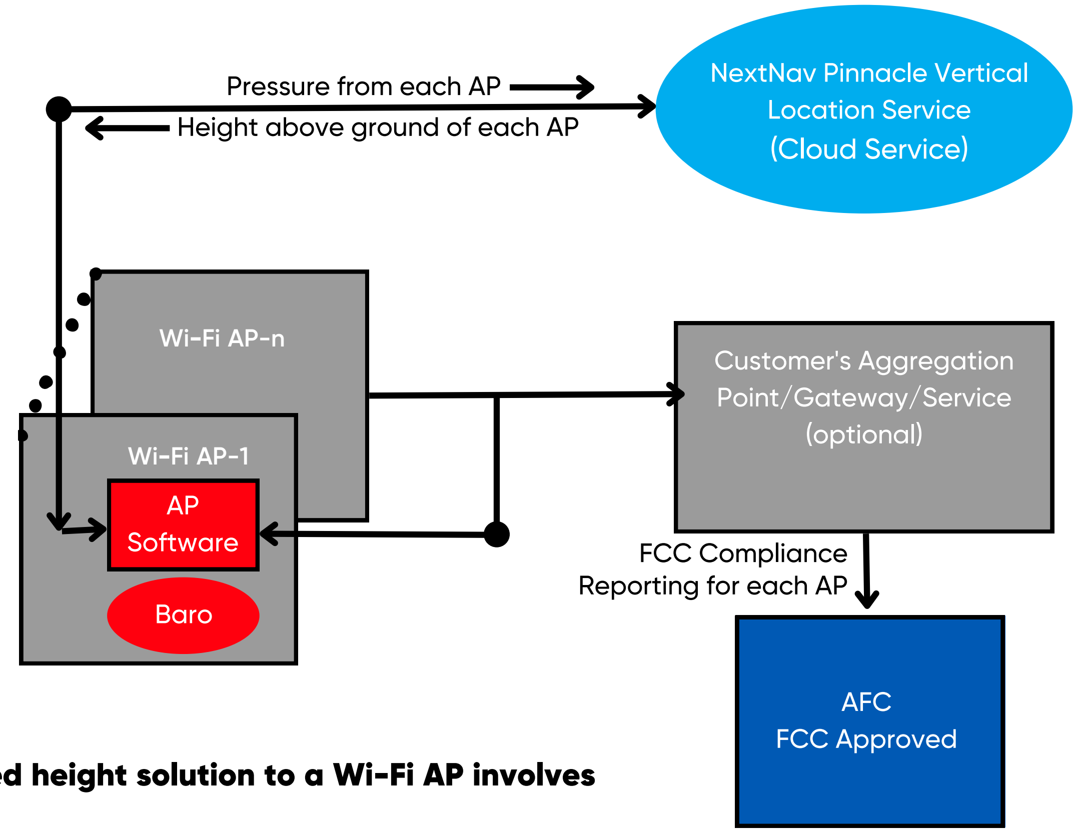
THE NEXTNAV PINNACLE SERVICE PROVIDES HIGHLY ACCURATE ALTITUDE MEASUREMENT

The NextNav Pinnacle service gives access point installers and system operators on-demand height generation using real-time pressure data from barometric pressure sensors and the simple-to-integrate Pinnacle-API. This API can provide height in the “height above ground” format that the FCC regulations demand, while vertical location accuracy has been proven in independent FCC/CTIA testing to meet +/- 3m accuracy over a substantial range of weather conditions (for more details on this testing download the report here).

Among the advantages that AP installers and operators gain from using the NextNav Pinnacle service are:

- Automation of “height above ground” reporting of APs to AFCs using the Pinnacle-API.
- Out-of-the-box height above ground information at 95% confidence per FCC regulation – ready to report as-is to AFCs.
- Real-time height generation - enables flexible deployments by reducing installation complexity.
- Elimination of the need to manually and/or statically survey the height of AP installs – reducing error and cost.
- Support for detection of AP movement after installation – reducing regulatory risk.
- Peace of mind that the NextNav Pinnacle service has been independently tested by the CTIA to exceed the FCC requirements for vertical location accuracy.
- Ability to estimate the ongoing drift of the barometric pressure sensor in each AP by periodically querying the Pinnacle-API.

THE COMPLETE SOLUTION



Adding a Pinnacle-based height solution to a Wi-Fi AP involves the following steps:

1. Integrating the BMP580 or BMP581 barometric pressure sensor from Bosch Sensortec into the Wi-Fi AP per Bosch Sensortec instructions.
2. Performing factory end-of-manufacturing-line barometric pressure sensor calibration per Bosch Sensortec instructions.
   a. In order to get an accurate height at the time of the AP installation, ensure that the factory calibration is maintained for the planned initial out-of-box deployments.
   b. Alternatively use the Pinnacle-SDK at the time of install in the installation app to calibrate the barometric pressure sensor in the AP.
3. Implementing software on the AP that integrates the Pinnacle-API and that will be triggered by appropriate events to obtain vertical location data for reporting to the AFC.
   a. The software must read pressure data from the barometric pressure sensor and post it to the Pinnacle-API to receive the height-above-ground value at the 95% confidence level.
   b. Each time the AP's height above ground is needed, the AP software must read the pressure data from the barometric pressure sensor and post it to the Pinnacle-API to return the vertical-location information.
   c. The AP software may optionally query the Pinnacle-API periodically to also estimate the drift of the barometric pressure sensor on the device.
4. Height-above-ground information can then be sent to the appropriate AFC to meet the FCC compliance requirements.
5. Providers may also optionally implement an aggregator that collects each AP's information and posts it in bulk to the AFC. Other configurations are also possible.

HOW TO GET STARTED

Contact your Bosch Sensortec & NextNav rep

Visit nextnav.com/developers/
to access details of the Pinnacle-API

bosch-sensortec.com/products/
environmental-sensors/pressure-sensors/
for details on the barometric pressure sensors