oneNav

# The Next Generation of Mobile GNSS

# 下一代移动GNSS

## Introducing the oneNav Pure L5 Mobile GNSS Receiver

## oneNav 纯L5 移动GNSS 接收器


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## Introduction to the 5th generation of Mobile GNSS: oneNav Pure L5 GNSS

## 第五代移动 GNSS 简介: oneNav 纯L5 GNSS

GNSS receivers first reached the commercial domain in the early 1980s. They were bigger than your average carry-on suitcase, weighed more, and consumed so much power that they needed to be plugged into an outlet. But technology advanced quickly and by the mid-1980s commercial GNSS receivers were appearing in survey and marine markets.

GNSS 接收器于1980 年代初首次进入商业领域。它们比普通随身行李箱大、也更重，且十分耗电，因此需要插入电源插座。随着技术飞速发展，到1980 年代中期，商用GNSS 接收器已经在测量和航海市场中应用。

Gen 1: The first generation of truly mobile receivers were L1 C/A code only, usually with very narrow front-end bandwidths of 2-5MHz and were typically found in ruggedized handhelds used by outdoor enthusiasts for hiking and sailing. These first-generation architectures began appearing in mobile phones in the late 1990s, and were the key technology in enabling E911.

**第 1 代：**移动接收器第一代实际上仅仅是 L1 C/A 码，通常具有非常窄的 2-5MHz 前端带宽，通常用于户外爱好者远足和航行时使用的坚固耐用的手持设备。这些第一代架构于1990 年代后期开始出现在手机中，并且是使 E911 得以启用的关键技术。

Gen 2: The second generation of mobile receivers added GLONASS satellites beginning in approximately 2010 when the GLONASS system became modernized and reliable. These receivers had to have wider bandwidths on the order of 20-30MHz in order to support the GLONASS FDMA signals at a slightly offset frequency from GPS L1. However, both the GPS and GLONASS signals were utilized in a narrow band signal processing methodology.

**第2 代：**第二代移动接收器于2010 年左右开始使用GLONASS 卫星，当时GLONASS 系统完成了现代化且更可靠。这些接收器需要20-30MHz 量级的较宽带宽，才能以略微偏离GPS L1 的频率支持GLONASS FDMA 信号。不过，GPS 和GLONASS 信号都用于窄带信号处理方法中。

Gen 3: The third generation of receivers added support for the Galileo system launched by the European Union and started appearing in mainstream cellphones in the 2014 timeframe. These phones still retained a single frequency front end in the L1 band but had separate digital processing chains for all 3 satellite systems.

**第3 代：**第三代接收器增加了对欧盟伽利略系统的支持，并于2014 年开始出现在主流手 机中。此类电话仍在L1 频段中保留一个频率前端，但对所有3 个卫星系统都有单独的数 字处理链。

Gen 4: The evolution to the 4th generation took some time as it added 2 new capabilities: 1) the ability to process the Beidou signals and 2) support for a single sideband L5 receiver where Beidou, Galileo and GPS all have modernized signals. Throughout this paper, we will refer to all signals from all constellations (L5, E5 and B2) in the 50MHz band centered at 1192MHz as

**第4 代：**一段时间后，第4 代升级完成。它增加了2 种新功能：1）处理北斗信号的能力2）支持单边带L5 接收器，北斗、伽利略和GPS 都具有现代化信号。在本文中，为简便起见，我们将以1192MHz 为中心的50MHz 频段中所有星座（L5，E5 和B2）的所有信号称为“L5”。

“L5” for simplicity’s sake. Despite having been available in other markets earlier, these receivers only first appeared in phones in 2019 because of the added size, power, and complexity of supporting a dual band receiver in a mobile phone. Many expected that this would be the final generation of GNSS for cell phones as it seemed to have covered all the bases.

尽管这些接收器较早已在其他市场销售，但由于在移动电话中支持双频接 收器的尺寸、功率和复杂性的增加，它们直到2019 年才首次在手机中应用。由于它似乎已经面面俱到，许多人预期这将是用于手机的最后一代GNSS。

However, at oneNav we recognized several problems with these 4th generation receivers:

1. A dual frequency front end was a huge burden on many phone models, especially with the rise of 5G.
2. The L1 band still had reliability issues with jamming and interference but was needed to aid the acquisition of the L5 signals.
3. The receivers only supported a single sideband at L5 and were not utilizing the full capability of the L5 band to further enhance sensitivity, improve accuracy, and mitigate the impact of multipath.

然而，在oneNav，我们发现了第四代接收器存在的几个问题：

1. 双频前端成为许多手机型号的沉重负担，尤其是在5G 兴起的今天。

2. L1 频段仍然存在卡顿和干扰等可靠性问题，但还需要使用L1 频段帮助获取L5 信号。

3. 接收器仅支持L5 频段一半的带宽，却没有利用L5 频段的全部 功能来进一步增强灵敏度，提高准确性并减轻多径的影响。

As a result, oneNav set out to build a fifth generation of GNSS receivers for mobile consumer products that had the following key characteristics:

1. A single frequency design that only uses the modernized, wideband signals at L5.
2. An acquisition engine sophisticated enough to acquire L5 signals directly.
3. A navigation engine that utilizes Artificial Intelligence/Machine Learning (AI/ML) techniques to fully exploit all the signals in 50MHz wide band at L5, in order to increase accuracy by greatly reducing multipath errors.

因此，oneNav 着手为具有以下关键特性移动消费产品构建第五代 GNSS 接收器：

1.单频设计，仅使用 L5 频段的现代化宽带信号。

2.足够复杂精密的采集引擎，可直接采集L5 信号。

3. 利用人工智能/机器学习（AI / ML）技术来充分利用 L5 频段 50MHz 宽带上所 有信号的导航引擎，以便通过大大减少多径误差来提高准确性。

## Why L5 is so important for consumer devices

Every GNSS user in every segment benefits from using the new, modernized signals in the L5 band. L5 signals are more accurate, more reliable, and are currently available in sufficient numbers to support all user segments. A quick overview of the major advantages of L5 over L1 is presented below.

### 1. Signal structure (narrow correlation peak) accuracy

The GPS L1 has a chipping rate of 1.023 MHz, while the modernized signals in the L5 band have a ten times higher chipping rate of 10.23 MHz. This means that the correlations peak of L1 covers 293m, while an L5 peak covers only 29.3m. This yields inherently more precise measurements as well as effectively eliminating multipath distortions from any reflection that exceeds 29m.

### 2. Wide bandwidth (multipath mitigation) accuracy

Multipath mitigation ability is directly proportional to bandwidth. By having a larger bandwidth, signal observables contain additional information that can be used to determine reflections that are present in the combined received signal. By identifying these reflections, they can be corrected, and the signals can be used in the solution rather than eliminated due to measurement uncertainty. In addition, because our wide bandwidth captures both the A and B channels, we increase our resistance to multipath fading since the signals have different fading patterns.

### 3. Pilot codes (longer coherent integration increasing SNR)

The original GPS L1 CA code has a single component with a data bit every 20 milliseconds, while the modernized signals in the L5 band have two quadrature components: a data channel with the data symbols and a pilot channel without data symbols. The European Galileo and the

## L5对消费类设备为何如此重要

各细分市场中的所有GNSS 用户都将从L5 频段的新型现代化信号中受益。L5 信号更准 确、更可靠，且目前已有足够数量的信号来支持所有用户群。下文将简要介绍L5 优于L1 的主要优点。

### 1. 信号结构（窄相关峰）精度

GPS L1 的码片速率为1.023 MHz，而L5 频段中现代化信号的码片速率为10.23 MHz，高出十倍。这意味着L1 的相关峰覆盖293m，而L5 的相关峰覆盖仅29.3m。这将自然生成更精确的测量结果，并有效消除任何29m 以上反射引起的多径失真。

### 2. 宽带宽（多径缓解）精度

多径缓解能力与带宽成正比。具有较大的带宽，可观察到的信号包含可用于确定组合接收信号反射的附加信息。通过识别这些反射，可以对其进行校正，并且可以在解决方案 中使用信号，而非由于测量不确定性而消除信号。此外，由于较宽的带宽同时捕获A 和 B 信道，而信号具有不同的衰落模式，我们因此强化了对多径衰落的抵抗力。

### 3. 导频码（更长的相干积分可提高SNR）

原始的GPS L1 CA 代码只有一个分量，每20 毫秒有一个数据位，而L5 频段中的现代化信号有两个正交分量：一个带有数据符号的数据信道和一个不带数据符号的导频信道。欧洲伽利略版本和

Chinese BDS versions have a 2nd sideband with two more quadrature components enabling a second data and pilot channel. Since these pilot channels have no data bits, they enable longer coherent integration which greatly enhances the sensitivity of the receiver. Combining these multiple components also provides additional sensitivity in acquisition mode.

中国北斗BDS 版本具有第二个边带，并具有另外两个正交分量，从而支持第二个数据和导频信道。由于这些导频信道没有数据位，因此可以实现更长的相干积分，从而大大提高接收器灵敏度。组合这些要素还可以在采集模式下提供更高的灵敏度。

## 4. Multiple constellations and signals with common signal structure

The signals in the L1 band were mostly designed in the 1970s and each system uses its own modulation scheme. When the L5 signals were being defined by different countries across the globe, the UN OOSA (Office of Outer Space Affairs) set up the ICG (International Committee on GNSS) that allowed the countries to discuss designs that would facilitate interoperability through conferences and working groups. This led to a relatively common baseline across all systems that eliminates the HW and SW complexity in L1 receivers as each system required its own digital processing core.

## 4. 具共同信号结构的多个星座和信号

L1 频段的信号大多数是在1970 年代设计的，每个系统都使用自己的调制方案。当全球不同国家定义L5 信号时，联合国外空事务办公室（外层空间事务办公室）成立了ICG（国际GNSS 委员会），使这些国家可以通过会议和工作组讨论有助于互操作性的设计，因此 形成了所有系统之间相对通用的基准，消除了L1 接收器中的硬件和软件复杂性——因为每个系统都需要各自的数字处理核心。

## 5. Stronger signal transmission

The satellites now in space that transmit L5 signals are significantly evolved from the original satellites built in the 1970s. In particular, they are far more power efficient due to better solar arrays, larger batteries and significantly improved transmitter efficiency. The result is that power can be used to transmit additional signals and at higher power while still conforming to international coexistence requirements. Each component of the modernized signal can be at least 0.5dB stronger than L1 CA, and the combination of all four components can be 6 dB stronger. This results in faster acquisition times and better coverage in dense urban environments.

## 5. 信号传输得以加强

目前在太空中传输L5 信号的卫星是从1970 年代建造的原始卫星演进而来的。尤其是，由于采用了更优质的太阳能电池板、更大的电池以及发射器效率显着提高，它们具有更高的功率效率。结果是，更高的功率可以传输更多信号，同时仍然符合国际共存要求。现代化信号的每个分量可以比L1 CA 至少强0.5dB，且所有四个分量的组合可以强6dB，因而可以缩短采集时间，并在密集的城市环境中提供更好的覆盖范围。

## 6. Lower BER and cross correlation

The original L1 C/A code used a simple parity bit scheme for error detection only. The modernized signals switched to a much more robust system of convolutional encoding that adds more robustness to error detection and also adds the ability for error correction. In addition, modernized signals added a secondary code that is used to ensure that the correct satellite is being detected and not cross correlated with another satellite with a much stronger signal. The combination of a longer primary code and secondary coding leads to a reduction in cross correlation by more than 13dB. Cross correlation in L1 receivers can inhibit detection of weaker signals by 10% when a strong satellite is present: (jamming 100Hz out of each 1kHz of BW). These techniques enhance the reliability of the L5 measurements which prevent position errors which occur with L1 measurements.

## 6. BER 和互相关更低

原始的L1 C / A 代码仅使用简单的奇偶校验位方案进行错误检测。现代化的信号切换到更 鲁棒的卷积编码系统，强化了鲁棒性和纠错能力。此外，现代化的信号还添加了辅助代 码，用于确保检测到正确的卫星，且不会与信号更强的另一颗卫星互相关。较长的主代 码和辅助代码的组合使交叉相关性降低了超过13 分贝。如果存在一颗强大的卫星，L1 接 收器中的互相关会抑制对较弱信号检测能力的10%：（每1kHz 带宽干扰100Hz）。这些新技术增强了L5 测量的可靠性，可防止L1 测量产生的位置误差。

## 7. Cleaner band with less interference

The L5 band is centered 400MHz lower in frequency than L1 in the heart of the ANRS (Aeronautical Navigation Radio Services) band which is protected worldwide for navigation purposes. This means no communication bands which can cause interference are present, nor can they ever be added. Furthermore, the L1 band is situated in frequency band that has significant harmonic interference from certain cellular bands, which causes major issues for handset developers. As a result, the L5 band has much less RF interference and much far fewer jamming issues.

## 7. 频段更干净，干扰更少

L5 频段的中心频率比ANRS（航空导航无线电服务）频段中心的L1 频率低400MHz，在全 球范围内受导航保护。这意味着目前不存在会引起干扰的通信频段，也永远不会添加此类干扰。此外，L1 频段位于某些蜂窝频段具有明显谐波干扰的频段中，对手持设备开发 人员造成了重大问题。结论是，L5 频段的无线射频干扰少得多，而干扰问题也少得多。

## 8. Signal availability

The GNSS systems in the L5 band have seen significant build out in the last few years to where there are now 66 satellites transmitting operational signals in the L5 band. As a rule of thumb, individual systems declare full operational capability (FOC) at 24 satellites. Both Galileo and Beidou are complete which accounts for 48 signals, plus 12 GPS Block IIF, plus 3 GPS Block III, and 3 QZSS to get to the total of 66 signals. Also, for most

## 8. 信号可用性

在过去几年中，L5 频段的GNSS 系统得到了巨大发展，迄今已有66 颗卫星在L5 频段传输操作信号。根据经验，单个系统会占据24 颗卫星的完全操作能力（FOC）。伽利略和北斗都完成了，共为48 个信号，加上12 个GPS 块IIF，3 个GPS 块III 和3 个QZSS，总 共为66 个信号。而且，对于大多数

commercial operations, using more than 12 satellites in the solution provides very little benefit in terms of accuracy and robustness. There are more than enough L5 satellites today and more GPS III satellites are being launched regularly.

商业运营而言，在解决方案中使用12 颗以上的卫星在准确性和鲁棒性方面收效甚微。如今，L5 卫星数量已足够多，且会定期发射更多GPS III 卫星。

## Why not just use a current L1/L5 solution?

## 为何不直接采用当前的L1/L5 解决方案？

The benefits of L5 are clear. That's why many GNSS suppliers have started building L1/L5 solutions, and they are starting to appear in smartphones. It seems to be quite a natural progression to add an L5 receiver chain on top of an existing L1 solution and be able to reap the benefits. But there are a number of reasons why bringing along the legacy L1 solution could actually be having a negative impact on the overall solution.

L5 的优越性显而易见，这就是许多GNSS 供应商开始构建L1 / L5 解决方案，并开始用于智能手机中的原因。在现有的L1 解决方案之上添加L5 接收器链似乎很自然，且会有所斩获。然而，出于多种原因，采用传统的L1 解决方案实际上可能会对整个解决方案产生负面影响。

### 1. Extra receive chain

### 1. 额外的接收链

Using a dual band solution requires having a second, separate RF receive chain for each band. That means 2 antennas as well as an extra set of amplifiers and filters. These take up space, consume power and cost money at the handset level. Since the L5 measurements are more accurate, many receivers turn off L1 to save power in tracking mode. Why incur the size, cost and power of L1 just for acquisition? These can be at a premium in 5G handsets and wearables, and eliminating them provides more flexibility without giving up any performance when using the oneNav solution.

使用双频段解决方案需要为每个频段配备第二条单独的RF 接收链。这意味着两根天线以及一组额外的放大器和滤波器，会导致占用空间，消耗功率并使手持设备花费昂贵。由于L5 的测量更加准确，因此，许多接收器会关闭L1 以节省跟踪模式下的电能。既然如此，为何要仅为采集而背负L1 的大小、成本和功率？有它们在5G 手机和可穿戴设备中可能导致价格昂贵，而消除它们，在使用oneNav 解决方案时则实现了更大的灵活性并保持性能。

### 2. Interference and Jamming

### 2. 干扰和卡顿

The L1 band has significantly more issues with interference and jamming than L5. This is because several cellular bands are at nearly exactly ½ of the L1 frequency and therefore the transmitters are actually putting out signal harmonics that can jam the L1 receiver. Furthermore, there are more 2nd and 3rd harmonic combinations that can also impair the L1 reception and they are closer to the L1 signal than the comparable ones at L5.

与L5 频段相比，L1 频段的干扰和卡顿问题明显更多。这是因为数个蜂窝频段几乎恰好是 L1 频率的1/2，因此发射机实际上发出了可能干扰L1 接收器的信号谐波。此外，还有更 多的二次谐波和三次谐波组合也可能有损L1 接收，而且与L5 处的可比谐波组合相比， 它们更接近L1 信号。

Finally, the L5 band is a protected band worldwide for navigation and there are no nearby interferers unlike Ligado Networks (former Lightsquared) in the L1 band. This problem is especially concerning since if the L1 signal cannot be acquired, then the receiver cannot use that information to acquire the L5 signals. Having a clean L5 band that can't be acquired because L1 is jammed is a major reliability problem.

最后，L5 频段是全球范围内受导航保护的频段，与L1 频段的 Ligado Networks（先前的 Lightsquared）不同，L5 频段附近无干扰源。尤其令人关注的问 题是，由于如果无法获取L1 信号，接收器无法使用该信息来获取 L5 信号。因L1 受到干 扰而无法获得干净的 L5 频段是可靠性方面的重大问题。

## 3. No benefit to navigation accuracy

Because the L5 signals are stronger and more accurate, once they are acquired, there is no need to use the L1 signals in the navigation solution. They have more noise and more multipath and therefore DEGRADE the solution, so most suppliers ignore L1 measurements once L5 has been acquired. Some receivers use the L1/L5 combination to reduce ionospheric errors, but these can easily be corrected in connected devices using readily available global data services that provide the same level of accuracy for reference networks.

## 3. 无助于导航精确性

由于L5 信号更强，更精确，因此一旦获得L5 信号，就无需在导航解决方案中使用L1 信号——它们有更多的噪音和多径，导致解决方案降级。因此，一旦获得L5，大多数供应 商便会忽略L1 测量数据。某些接收器使用L1 / L5 组合来减少电离层误差，但这些误差可以通过随时可用的全局数据服务在连接的设备中轻松纠正，这些数据服务可以为参考网络提供相同级别的精确度。

## Introducing the oneNav Pure L5 wideband receiver

Based on the above, it would seem clear that the ideal solution would be a pure L5 solution that provides all of the benefits of L5 without the downsides of L1. In this case, LESS IS MORE. Unfortunately, no one is offering such a solution in the marketplace today and that is what motivated us to develop the oneNav Pure L5 receiver. Leaving L1 behind and focusing solely on building an L5 receiver from scratch that can acquire L5 directly and resolve multipath to the 1-2 meter level is a highly challenging task. Here are several of the key innovations that have allowed oneNav to build such a unique product.

## oneNav 纯 L5 宽带接收器

基于以上所述，显然，理想的解决方案是纯 L5 解决方案，它具备L5 的所有优点却没有 L1 的缺陷。在这种情况下，**少即是多**。遗憾的是，目前市场上没有这样的解决方案，这正是促使我们开发oneNav 纯L5 接收器的动因。将L1 抛在身后，专注于从头开始构建L5 接收器，它可以直接获取L5 并将多径解析为 1-2 米，这是一项极富挑战性的任务。以下介绍令oneNav 构建出如此独特产品的几项关键创新。

## Optimized L5 acquisition engine 优化的 L5 采集引擎

Building an acquisition engine for the L5 signal is a huge mathematical task. Since the codes are 10X longer and have a 10X faster chipping rate, it's a 100X more difficult search problem. oneNav has created an engine that is optimized for that problem without using 100X more silicon or 100X more power by developing a customized array processor that tackles the L5 acquisition problem using a more GPU like approach. In this way, we are able to maintain TTFF without an oversized engine and without any assistance from L1.

为L5 信号构建采集引擎是一项艰巨的数学任务。由于代码的长度增加 了10 倍，并使码片速度提高了10 倍，因此，搜索难度增加了100 倍。oneNav 打造出针对该问题的优化引擎，通过开发定制的阵列处理 器来解决L5 采集问题，该处理器采用的是类似于GPU 的方法，而无 需耗用100 倍的硅或100 倍的功率。由此，我们得以在没有超大引擎和L1 的任何帮助的情况下保持首次定位 TTFF。

## Single frequency simplified architecture 单频简化架构

As noted previously, the pure L5 architecture completely eliminates the need for a second RF chain. Furthermore, since all the L5 signals were designed to be interoperable as a result of international cooperation, the DSP architecture can be harmonized. Rather than having independent correlation engines, the oneNav L5 engine uses common hardware (the customized array processor) for signals from all GNSS systems. This greatly reduced hardware and software complexity and provides flexibility in implementation.

如前所述，纯 L5 架构完全消除了对第二条 RF 链的需求。此外，由于国际合作的结果，所有L5 信号均设计为可互操作，因此DSP 体系结构 得以协调统一。oneNav L5 引擎没有独立的相关引擎，而是采用通用硬件（定制阵列处理器）处理来自所有GNSS 系统的信号。这大大降低了硬件和软件的复杂性，并提供了实施的灵活性。

## Increased sensitivity for acquisition and tracking 获取和跟踪灵敏度得到提高

The L5 signal has a modernized signal structure that allows for increased sensitivity for both acquisition and tracking. In acquisition, combining multiple components from both sidebands increases total signal energy resulting in improved sensitivity. In tracking, the pilot channel allows for longer coherent integration to maintain signal lock in difficult environments including enhanced resilience from fading. Since the oneNav architecture is wideband, all parts of the L5

L5 信号具有现代化的信号结构，可以提高采集和跟踪的灵敏度。在采集时，将来自两个边带的多个分量组合在一起会增加总信号能量，从 而提高灵敏度。在跟踪时，导频信道允许更长的相干积分，在困难环 境中保持信号锁定，强化抗衰减能力。由于oneNav 体系是宽带结构，因此可合并L5 signal can be combined for maximum performance. In this way, there is significantly more signal strength coming off the satellite in L5 vs L1. That means in the same environment, the L5 signals appear stronger.

信号的所有部分实来现最佳性能。采用这种方法， 与L1 相比，L5 从卫星传出的信号强度明显更高。这意味着在相同环境下，L5 信号更强。

## Improved time to an L5 based fix

## 缩短了基于 L5 的定位时间

Current dual band receivers first get a fix on L1 and then begin the acquisition process on L5. By doing the L5 acquisition directly, we skip the entire process of acquiring and navigating using L1, which saves time. The L5 measurements are more accurate and therefore the time to an L5 based fix is critical.

当前的双频接收器首先在 L1 上进行定位，然后在 L5 上开始采集。通过直接进行L5 采集，我们跳过使用 L1 进行采集和导航的整个过 程，从而节省了时间。L5 的测量更加准确，因此，基于L5 进行定位的时间至关重要。

## Increased acquisition reliability

## 提高采集可靠性

The L1 signal structures are outdated. They do not have the longer primary codes and the secondary codes like modernized signals on L5 that mitigate many of the reliability problems associated with cross correlation, jamming and spoofing. In difficult conditions, using these unreliable signals can even cause the L1 acquisition to take longer and produce incorrect results.

L1 信号结构已过时。它们没有较长的主代码和辅助代码，无法像L5 的现代化信号那样，可以减轻与互相关、干扰和幌骗相关的许多可靠性问题。在困难条件下，使用这些不可靠的信号甚至可能导致L1 采集花费更长时间并产生错误结果。

## Improved tracking and measurement

## 跟踪和测量得到改进

a. The L5 signals are inherently more accurate as discussed previously but they also hold more information in the full bandwidth. The Galileo and BDS signals have both an A and B channel which when used together produce significant improvement in tracking sensitivity as well as improved measurement accuracy.

a. 如前所述，L5 信号本质上更精确，但它们在全带宽中还容纳更多信息。伽利略和北斗 BDS 信号同时具有A 和B 信道，当一起使用时，可显著提高跟踪灵敏度并提高测量精度。

b. Using the full bandwidth allows a more sophisticated channel estimation than a

b. 与其他接收器中常见的简单伪距测量相比，使用全带宽可以进行更复杂的信道估计。

simple pseudo range measurement that is common in other receivers. The oneNav receiver determines a representation of the full channel impulse response (CIR) using unique signal processing of the satellite signal, which allows better multipath correction by the navigation engine.

oneNav 接收器采用卫星信号的独特信号处理方式来 确定全信道冲激响应（CIR）的表示形式，从而使导航引擎能够更好地 进行多径校正。

c. Since there are multiple signals contained within the L5 wideband signal, we gain advantages from channel diversity as well. These signals are separated by about 30 MHz which provides further resilience against multipath, especially at low speeds common for pedestrians.

c. 由于L5 宽带信号中包含多个信号，因此，我们也将从信道分集中获得裨益。这些信号相隔约30 MHz，提供了更高的抗多径能力，尤其在常见的行人低速时。

## AI/ML enhanced navigation engine

## 导航引擎经人工智能/ 机器学习强化

a. The oneNav enhanced measurements are processed by a cloud connected Navigation Engine that uses advanced AI/ML techniques to further improve navigation accuracy. The inference engine and navigation algorithms that produce the final navigation output run on the mobile device, while the learning engine resides in the cloud. This allows the mobile device to operate even when temporarily disconnected from the cloud.

a. 强化的测量能力由云连接的导航引擎处理，该引擎使用先进AI / ML 技术进一步提高导航精度。生成最终导航输出的推理引擎和导航算法在移动设备上运行，而学习引擎位于云中。这使移动设备即使暂时与 云断开连接也能保持运行。

b. The Navigation Engine uses sophisticated ML techniques to 1) predict if the received signal is Line of Sight (LOS), and 2) predict the measurement error caused by multipath. These techniques require the extra information contained in the CIR and the correlation function from the oneNav measurement engine. Combined with data from building models, the propagation model of the urban canyon can be learned and used to resolve multipath and improve positioning accuracy. The oneNav Cloud service uses this model to allow reflected signals to be used correctly in the navigation solution rather than being excluded due to their multipath content.

b. 导航引擎使用复杂的ML 技术实现以下功能：1)预测接收到的信号是否为视线（LOS），以及，2) 预测由多径引起的测量误差。这些技术需要信道冲激响应（CIR）中包含的额外信息以及oneNav 测量引擎的相关函数。结合建筑模型中的数据，可以学习都市峡谷的传播模型， 并将其用于解决多径问题并提高定位精度。oneNav 云服务使用此模型可使反射信号在导航解决方案中正确使用，而不是由于其多路径内容而被排除。

c. The Navigation Engine uses a sophisticated pattern matching-based positioning algorithm that combines the pseudorange measurements and the environment's 3-D building map model to enhance the positioning accuracy in deep urban canyons.

c. 导航引擎使用了基于模式匹配的精密定位算法，该算法结合伪距测量值和环境的3-D建筑地图模型，从而提高了都市深处峡谷的定位精度。

## Integrating the oneNav receiver into your product

## 将 oneNav 接收器集成到您的产品

The oneNav receiver was designed from the beginning as a licensable IP core rather than a discrete silicon solution. oneNav provides a complete solution, including all the firmware and an RF front end reference design from antenna all the way to A/D converter. This allows customers to determine how to best bring the oneNav advantages to their products. The IP core can be integrated into a larger ASIC such as a modem or an SOC. It could also be implemented as a discrete silicon solution if desired. The RF could be combined into any of these solutions or implemented with other RF components in the system. The measurement and position engine firmware can be run on a dedicated CPU or shared in either the same or different CPUs. This methodology allows the customer to decouple the GNSS capability from other functionality and implement in whatever silicon process or partitioning that is most effective for the application and do the system integration that is optimal for that application.

从一开始，oneNav 接收器就设计为可授权的 IP 核，而非离散的硅解决方案。oneNav 提供完整的解决方案，包括所有固件以及从天线到A / D 转换器的无线射频前端参考设计。这使客户可以确定如何最好地将 oneNav 优势带入其产品。IP 内核可以集成到更大的 ASIC 中，例如调制解调器或系统级芯片SOC。如果需要，它也可以实现为分立的硅解决方案。可将无线射频组合到任何这些解决方案中，或与系统中的其他视频组件一起实施。测量和位置引擎固件可以在专用 CPU 上运行，也可以在相同或不同的CPU 中共享。这种方法使客户可以将 GNSS 功能与其他功能脱离，并在对应用程序最有效的任何硅工艺或分区中实施，并进行最适合该应用程序的系统集成。

The IP core is implemented to be both process independent and scalable. With oneNav support, the core can be customized to provide an optimal balance of size, power and GNSS performance that is specific to the application. The core has build time scalability to support different memory sizes and clock speeds to support different performance requirements. For example, trading off search size and speed with silicon area may be different for different applications. The measurement engine supports run time scalability that allows optimization of power and performance

IP 内核的实施方式既独立于流程又可扩展。借助 oneNav 支持，内核可自定义，以提供特 定于应用程序的大小、功率和 GNSS 性能的最佳平衡。该内核具有构建时间延展性，以支持不同的内存大小和时钟速度，以及不同的性能要求。例如，对于不同的应用，在搜索 大小和速度与硅面积之间的权衡可能会有所不同。测量引擎支持运行时间延展性，从而可根据主要信号条件以及主机应用程序要求优化功率和性能。

depending on prevailing signal conditions as well as host application requirements. Furthermore, an integrated GNSS core means that GNSS performance can be maintained across multiple platforms and silicon generations providing consistency of measurement and positioning performance needed to maintain system reliability and fusion.

此外，集成的 GNSS 内核意味着可以在多个平台和不同代的硅上维护 GNSS 性能，从而提供保持系统可靠性以及融合所需的测量和定位性能的一致性。

In summary, the oneNav Pure L5 Wideband Receiver is the next generation, the 5th generation, of GNSS for mobile consumer products. This high-performance receiver based on a modern design and modern signals provides a best in class receiver that will set the standard for GNSS products in cellular, wearable and IOT products.

总之，oneNav 纯 L5 宽带接收器是用于移动消费产品的下一代——即第五代GNSS。这种基于现代设计和现代信号的高性能接收器提供了一流的接收器，将为蜂窝、可穿戴和物联网产品中的GNSS 产品树立新标准。