



WIRELESS QUARTER

What a Wearable World

Go anywhere wireless connectivity, advanced sensors, and Edge AI are a new dawn for wearable tech



THE REAL DEAL:
EXTENDED REALITY
ENTERS THE MAINSTREAM

FIELDS OF DATA:
SMART AGRICULTURE TECH
TRANSFORMS FARMING



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Welcome

Oyvind Strom
EVP Short-Range BU



The year Nordic reinvents the standard for Edge AI

The future of AI isn't in the cloud—it's on device. And with our new nRF54L Series SoCs and [Neutron Edge AI](#) models, Nordic is now delivering the world's most energy efficient platform for ultra-low power Edge AI.

The recent launch of the [nRF54LM20A](#) and [nRF54LV10A](#) (See news, page 4), and announcement of the nRF54LM20B, offers developers more resources and flexibility to build advanced connected products across a wider range of markets. These SoCs are at the absolute cutting edge of ultra-low power wireless technology, and are central to Nordic's key commitment to innovation that has helped us stay ahead of the competition and maintain our leadership position.

The Nordic-unique Neutron models are another first, providing embedded developers access to ultra-low power Edge AI. When combined with Nordic's ultra-low power architecture, the Neutron AI models can solve a range of Edge AI challenges on resource-constrained devices, for example anomaly detection, biometric monitoring, and activity and gesture recognition.

This Edge AI capability is built on two unique and complementary ultra-low power technologies. The Neutron models optimized for resource-constrained products, and an Axon Neural Processing Unit, an AI hardware accelerator that is integrated in the nRF54LM20B SoC. These dual technologies give developers unmatched flexibility to push the limits of what's possible with Edge AI, without compromising on power or performance.

With these launches, Nordic is offering developers more choice than ever before, staying true to the developer-first design philosophy that has always been central to Nordic's DNA.



Nordic is now delivering the world's most energy efficient platform for ultra-low power Edge AI

Contents

News	4
News Extra	8
Memfault acquisition delivers complete chip-to-cloud platform	
Analysis	10
The rise of indoor location services	
Comment	11
Zephyr RTOS powers innovative IoT development	
What a Wearable World	12
Sophisticated wireless tech drives wearables innovation	
The Real Deal	16
Extended Reality is evolving from a niche to the mainstream	
Fields of Data	20
Smart agriculture technologies are transforming farming operations	
Nordic Inside	24
Puttshack Trackaball	
Case Study	26
NR+ mesh energy monitoring in Africa supports grid stability	
Industry Viewpoint	27
Valery Chekalkin, CEO, Jetbeep	
Tech Zone News	28
Product Focus	30
nRF54L15 SoC	
Tech Briefing	32
Getting started on advanced cellular IoT projects	
Nordic Product Summary	34



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New Products

Nordic expands the nRF54L Series with nRF54LM20A and nRF54LV10A

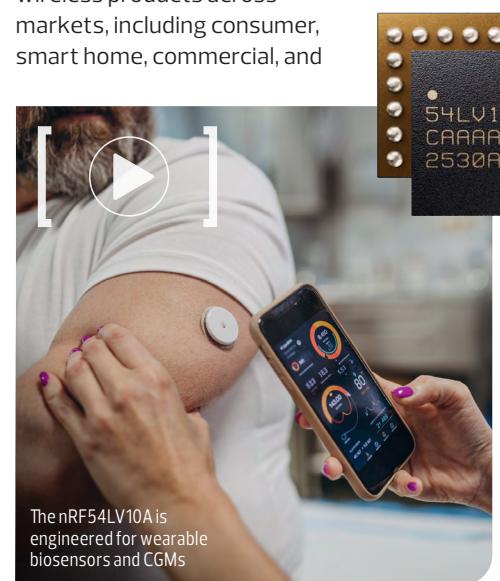
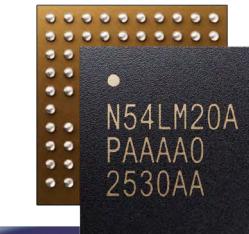
Nordic Semiconductor's highly successful, next-generation nRF54L Series of ultra-low power wireless SoCs continues to grow with the addition of the [nRF54LM20A](#) and [nRF54LV10A](#), offering developers more resources and flexibility to build advanced connected products across consumer, industrial, and healthcare markets. Built on Nordic's innovative 22nm technology platform, the nRF54L Series simplifies design challenges while enabling reliable communication, extended battery life, and compact product designs.

The nRF54LM20A expands the nRF54L Series with a high-memory option, featuring 2 MB non-volatile memory (NVM) and 512 KB RAM, while maintaining the same MCU functionality with a 128 MHz Arm Cortex-M33 processor, RISC-V coprocessor, and enhancing the comprehensive peripheral set with high-speed USB and up to 66 GPIOs. It also integrates Nordic's fourth-generation ultra-low-power 2.4 GHz radio, supporting [Bluetooth LE](#), [Channel Sounding](#), Matter over Thread, and more.

The nRF54LM20A is designed for advanced wireless products across markets, including consumer, smart home, commercial, and



The nRF54LM20A is designed for connected products demanding low latency



The nRF54LV10A is engineered for wearable biosensors and CGMs

industrial. It is particularly well-suited for [Human Interface Devices](#) (HID), including gaming peripherals that require low-latency wireless connectivity and high-speed USB. With 2 MB of NVM and 512 KB of RAM, it's ideal for smart home devices—such as a Matter implementation—offering ample overhead for the application without requiring external memory.

"The nRF54LM20A opens up more opportunities for developers to build innovative connected products demanding more memory, interfaces, and performance," says Oyvind Strom, EVP Short-Range at Nordic Semiconductor. "This product launch signifies the next step in delivering a comprehensive nRF54L Series portfolio to cover a broad range of applications – marking the nRF54L Series as the front-runner in the industry."

Nordic has also announced the launch of the nRF54LV10A. Engineered specifically for space-constrained, low-voltage applications, the nRF54LV10A can be powered directly by a single silver oxide coin cell, making it ideal for wearable biosensors, continuous

glucose monitors (CGMs), and other healthcare applications. Consumer demand for connected healthcare wearables has never been greater, due to a major increase in remote patient monitoring and home healthcare.

"The new nRF54LV10A reflects a clear trend in the healthcare segment, engineered to solve some of the key design challenges for next-generation medical devices," continues Strom. "Better power efficiency and smaller size are becoming key requirements for CGMs and wearable biosensors. The nRF54LV10 SoC delivers both – setting a new high standard for integration, optimized performance, and extended battery life in the smallest medical devices."

The nRF54LV10A introduces a new dimension to the nRF54L Series by providing a fit-for-purpose feature set for applications demanding ultra-low power consumption and reliable connectivity in the most compact form factor possible.

Uniquely, the nRF54LV10A is also the world's first Bluetooth LE SoC to combine low voltage with Bluetooth Channel Sounding support.

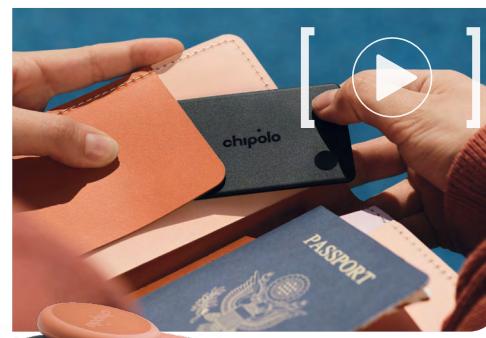
Asset Tracking

nRF54L Series powers new line up of Chipolo tracking solutions

Renowned tracking device company, Chipolo, has introduced a suite of new premium tracking solutions powered by Nordic Semiconductor's next generation ultra-low power nRF54L Series SoCs.

The Chipolo POP and Chipolo LOOP trackers are lightweight and compact devices designed for tracking valuables or locating missing items such as keys, bags and luggage. The Chipolo CARD meanwhile comes in a credit card-sized form factor designed to be easily stored in a wallet or passport pouch, for example.

Nordic's nRF54L15 SoC provides robust Bluetooth LE wireless connectivity over longer ranges between the trackers and the user's smartphone. The Chipolo LOOP also integrates Nordic's ultra-small form factor nPM100 power management IC (PMIC) to supervise battery charging over USB-C and to improve the battery life in ship mode. Once a tracker is connected to a smartphone, users can find missing or misplaced valuables through the Apple Find My or Find Hub app, and the private and secure networks of hundreds of millions of



Apple or Android devices around the world.

"When we were selecting an SoC for our Chipolo POP, LOOP and CARD trackers, the most important thing was its ability to implement simultaneous support of Apple Find My, Find Hub, and Chipolo functionality on one device," says Jure Zdovc, VP of Hardware Engineering, Chipolo.

"Nordic's nRF54L15 SoC's 1.5 MB non-volatile memory (NVM) and 256 KB RAM provided the large memory capacity we required, while still keeping our product pricing in the range of our previous devices."

Cellular IoT

nuSIM solution for nRF91 Series simplifies cellular IoT connectivity

Nordic Semiconductor has announced the availability of nuSIM for its [nRF91 Series of cellular IoT modules](#). This innovative, software SIM solution eliminates the need for a physical SIM card and socket, allowing product developers to reduce device size, simplify manufacturing, and enhance the robustness of their cellular IoT designs.

[nuSIM](#) is an open standard approach to integrated SIM (iSIM) where SIM credentials are encrypted and managed within a secure, protected area of the device. By operating as a dedicated software component inside the secure Arm TrustZone of the nRF91 Series' application processor, nuSIM removes all external SIM hardware, directly reducing

the BOM and saving valuable board space. This is ideal for devices deployed in harsh environments as removing the SIM socket eliminates a common point of mechanical failure and protects against corrosion and vibration. The fully digital provisioning process streamlines the supply chain, allowing SIM profiles to be securely delivered to devices during manufacturing, simplifying logistics and reducing costs.

"By integrating the nuSIM standard into our [nRF9151](#) and [nRF9160](#) modules, we are removing the physical barrier to creating compact, robust, and cost-effective cellular IoT products," says Oyvind Birkenes, EVP Long-Range at Nordic Semiconductor.



In Brief

NORDIC WINS CLOUD COMPUTING INNOVATION AWARD



Nordic Semiconductor's [nRF Cloud](#) powered by [Memfault](#) platform has been awarded 'Cloud Computing Innovation of the Year' in the [2025 Mobile Breakthrough Awards](#).

[nRF Cloud](#) powered by [Memfault](#) brings [Memfault](#)'s proven observability and over-the-air (OTA) infrastructure directly into [nRF Cloud](#), Nordic's established cloud services platform. The annual [Mobile Breakthrough Awards](#) recognize the most innovative products, companies and individuals in the global mobile, wireless and telecommunications technology industries, and are organized by leading global market intelligence firm, [Tech Breakthrough](#).

WIRELESS SENSOR MONITORS ANEURYSM PATIENTS



Hanyang University researchers have developed a sensor for continuous monitoring of endoleaks – a complication of endovascular aneurysm. The wireless and implantable sensor can be inserted endovascularly with a stent to detect Type-I endoleaks with the maximum rupture risk. This transforms a passive implant into an active, smart monitoring device, enabling proactive detection of the silent but potentially fatal risk of endoleaks for aneurysm patients. The longer-term vision is for these smart implants to be connected to telemedicine platforms enabling continuous remote monitoring.

MICRO-LOCATION TECHNOLOGY MARKET ON THE MOVE



Grand View Research projects the global micro-location market size will reach \$134 billion by 2033, growing at a CAGR of 17.1 percent from 2025 to 2033. The key trend driving this growth is the shift toward cloud-native, AI-driven micro-location platforms that analyze spatial data for decision automation and workflow optimization. By technology, the Bluetooth LE segment held the largest revenue share in 2024, due to its unique blend of affordability, energy efficiency, and seamless integration with existing consumer and enterprise ecosystems. By application, the asset tracking and management segment accounted for the largest revenue share.

Smart Home

Smart thermostat employs machine learning for intelligent home automation

eCozy has released a machine learning (ML)-powered smart thermostat solution for water heating radiators in the smart home automation market. eCozy 2.0 is designed to provide intelligent heating control and enable remote energy consumption monitoring, helping users save up to 30 percent on annual heating costs, according to the company.

The eCozy 2.0 platform comprises a smart thermostat device powered by the Nordic Semiconductor [nRF5340](#) SoC, alongside a central unit (connected to the home's Internet router via Wi-Fi) that performs as a wireless gateway to the cloud and can be used as a [Matter](#) controller, and an associated app for remote system management.

The smart thermostat physically replaces the existing thermostatic head on a water



heating radiator and contains a stepper motor with plunger to open and close the radiator valve. The device features two integrated high-precision temperature sensors, optional external temperature sensor (via Matter over Thread), high-precision humidity sensor, and high-level accuracy microphone.

eCozy 2.0 employs the nRF5340 SoC's advanced multiprotocol radio for wireless communication via Matter over Thread and [Bluetooth LE](#). The hardware has also

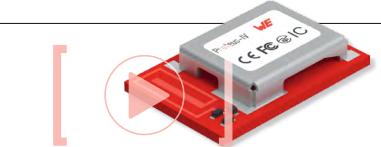
been architected to support [Zigbee](#) in future firmware releases, ensuring future-proof interoperability. This multiprotocol connectivity enables the smart thermostat to connect to the gateway (eCozy Central Unit and other gateways based on Matter over Thread) in the smart home, which in turn securely relays the sensor data to eCozy's Cloud servers, and to the user's smartphone from where the eCozy app can be used to view the information and control the device.

Modules

Wireless modules offer high performance and development flexibility

Würth Elektronik, will launch high-performance RF modules based on Nordic Semiconductor's next generation of wireless SoCs, the nRF54L Series. The Ophelia-IV and Proteus-IV radio modules are designed, manufactured, and tested in Germany, and can be used globally for all types of wireless IoT applications.

The two modules are built on the same hardware platform in a compact 8 by 12 by 2.3 mm form factor featuring the CSP version of Nordic's next generation nRF54L15 SoC. The [nRF54L15](#) integrates a 128 MHz Arm Cortex-M33 processor, a RISC-V co-processor, and an ultra-low power multiprotocol 2.4 GHz radio providing multiprotocol connectivity including [Bluetooth LE](#), [Thread](#), [Zigbee](#), Matter, and



By the Numbers

\$179 million in revenue

Nordic Semiconductor [has reported](#) Q3 2025 revenue of \$179 million, an increase of 13 percent (from \$158.8 million) in Q3 2024 and 9 percent from Q2 2025 respectively. Short-range revenue amounted to \$166.7 million in Q3 2025, an increase of 7 percent year-on-year and up 8 percent from the previous quarter. Long-range revenue amounted to \$9.8 million in Q3 2025, representing almost a fourfold increase in revenue compared to Q3 2024, and up 30 percent over Q2.

Automotive

Nordic nRF54L10 SoC powers TomTom road alert assistant

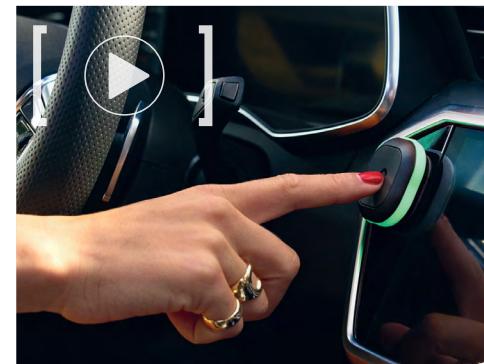
TomTom, the location technology specialist, has launched a wireless dashboard solution providing road alert assistance for regular drivers in various countries across Europe – including Germany, U.K., France and Italy.

Tom by TomTom is powered by Nordic's ultra-low power [nRF54L10](#) SoC. The device features an accelerometer for movement detection and provides clear visual (via an LED indicator) and audible alerts whenever a driver is approaching a fixed or mobile speed camera (considering specific legislation per country), obstacle, or traffic congestion.

Using the Bluetooth LE wireless connectivity provided by the nRF54L10 SoC, the Tom device receives all up-to-date traffic control data from the user's Android/iOS smartphone via the associated TomTom app. Tom then only informs the driver of road-relevant situations.

The nRF54L10 SoC features a 128 MHz Arm Cortex-M33 processor, 1MB NVM and 192 KB RAM, providing ample processing power to supervise the built-in sensors and run the complex algorithms for the Tom device to provide consistently accurate information.

If a user also requires navigation, the



subscription-free, Apple CarPlay- and Android Auto-compatible app offers a seamless driving experience supported by a global network of 600 million connected devices. This makes TomTom's traffic data—including traffic jams, obstacles, speed cameras, and speed limits—extremely accurate, not only in the user's home country, but also abroad.

"Unlike a smartphone which can be a huge distraction ... Tom provides only road-relevant alerts and is designed to increase the driver's focus and confidence on the road," says Pim Spaanderman, MD for Consumer at TomTom.

In Brief

LOBARO OBTAINS SISVEL CELLULAR IoT PATENT LICENSE



Nordic has announced that its customer Lobaro has obtained a license to the Sisvel Cellular IoT patent pool via Nordic's sub-licensing agreement.

The license provides Lobaro—a developer of smart metering and industrial sensor technology for the IoT—access to more than 35 separate LTE-M and NB-IoT standard essential patent (SEP) portfolios on terms negotiated by Nordic with pool administrator Sisvel, and made available to all Nordic customers. Nordic and Sisvel's innovative licensing framework brings greater predictability around SEP royalties while offering an efficient way for device makers to obtain end-product licenses through Nordic.

PROTOTYPE USES 6G NETWORK TO SENSE OBJECTS



At the ARENA2036 research institute in Germany, engineers are finessing the prototype for a wireless cellular system that can sense its surroundings, [MIT Technology Review](#) reports. By gauging the reflective strength of signals as they bounce off of objects, people and machinery, the 6G communications and sensing system can detect their distance, direction and speed to construct a dynamic digital twin of its physical environment in as little as 20 milliseconds. It is hoped that this technology could, for example, improve worker safety on factory floors by pausing machinery as it approaches employees.

NORDIC CLIMBS TIME MAGAZINE SUSTAINABILITY RANKINGS



Nordic Semiconductor has been honored again by TIME magazine as one of the top 500 of the "World's Most Sustainable Companies". Building on its achievements and ranking in 2024, Nordic's increased commitment to sustainability efforts has resulted in the company rising more than 200 places in the 2025 rankings. Nordic has long championed aggressive greenhouse gas (GHG) reduction; focused on making new component reels from recycled plastics; and dedicated itself to self-imposed companywide sustainability principles. The top 500 World's Most Sustainable Companies list is based on an assessment of factors such as total revenue and public prominence.

Auracast broadcast audio solution powers assistive listening in public spaces

Ampetronic and Listen Technologies have introduced what is claimed to be the first Auracast broadcast audio-based solution for assistive listening. Powered by Nordic Semiconductors' dual-core [nRF5340](#) multiprotocol SoC, Auri is a complete solution to allow venues and end users to adopt [Auracast](#) broadcast audio tech for assistive listening in public spaces.

The solution is comprised of the Auri TX2N Transmitter, the Auri RX1 Receiver, Auri D4 and Auri D16 docking stations, as well as Auri Manager software. The TX2N Transmitter is a professional-grade broadcaster that accepts a variety of audio inputs to



suit different venues and applications. Audio inputs can be assigned in mono or stereo to one or two channels; and venues can add more channels by connecting additional transmitters. Each nRF5340 SoC-powered transmitter broadcasts over a wide area, but the system can be expanded by adding additional transmitters in repeater mode.

The Auri RX1 Receiver also integrates Nordic's nRF5340 SoC, and allows end users to choose how they receive a broadcast. They can use their own Auracast-compatible device or an Auri receiver to scan for available broadcasts. Auri receivers can be programmed to support both open and encrypted broadcasts.

Nordic's Memfault acquisition delivers complete chip-to-cloud platform

Nordic combines market-leading hardware and software with a best-in-class cloud platform, transforming how connected products are built, deployed and maintained

According to IoT Analytics' State of IoT Summer 2024 report there were 16.6 billion connected devices at the end of 2023, expected to grow by around 15 percent a year until the end of the decade.

These IoT devices must be managed across their entire lifecycle—from deployment to decommissioning—to ensure secure, scalable provisioning and onboarding, enable remote over-the-air (OTA) updates and feature enhancements, safeguard device identity and trust, meet regulatory requirements, and maximize operational efficiency and cost savings. Early investment in the lifecycle support of IoT devices can not only lower the total cost of deployment, but also prevent underestimating the real lifecycle cost.

Comprehensive chip-to-cloud solution

In June, [Nordic Semiconductor announced its acquisition of Memfault Inc.](#), the market-leading cloud platform provider for large-scale deployments of connected products. The acquisition signaled Nordic's evolution from a best-in-class wireless hardware and software developer to a comprehensive chip-to-cloud solution partner. The announcement was followed in September by the launch of '[nRF Cloud powered by Memfault](#)', a full device observability, device management and location services platform enabling developers to monitor, manage, and update their devices with unprecedented ease and efficiency.

"This is a game-changer for developers building on Nordic's world-leading product portfolio," says François Baldassari, VP of Software Services at Nordic Semiconductor and Founder of Memfault. "With observability, device management, and location services pre-integrated, developers get instant chip-to-cloud visibility and control – without wasting time and resources building custom cloud infrastructure."

Proven observability and OTA infrastructure

Memfault brings proven observability and OTA infrastructure directly into nRF Cloud, Nordic's established cloud services platform. This gives Nordic customers out-of-the-box access to remote diagnostics, fleet health monitoring, and secure updates across not only its [nRF91 Series of cellular IoT modules](#), but also the [nRF54, nRF53 and nRF52 Series of multiprotocol wireless SoCs](#). With simple integration, users can get started at no cost and scale efficiently.

The new nRF Cloud powered by Memfault enables development teams to monitor real-world device



Developers get instant chip-to-cloud visibility and control – without wasting time and resources building custom cloud infrastructure



behavior, prioritize fixes based on data insights, and deploy updates reliably—even on low-power, intermittently connected devices. This enhanced visibility and control shortens debug cycles, improves production quality, and strengthens security throughout the product lifecycle. For example, nRF Cloud powered by Memfault automatically collects core dumps, logs, and metrics from devices and makes them available for analysis without the end user, or the engineer having to take any manual action. Using this data helps teams accelerate field testing and improve product quality pre-launch by eliminating elusive bugs. Once in production, teams can resolve issues before they cause widespread problems and without organizing expensive returns or site visits. As the fleet grows, prioritizing issues against innovations will be easier, shipping updates to production can happen faster, and customer support can be proactive instead of reactive.

"Our customers increasingly need to rely on cloud infrastructure to monitor and manage their devices in the field, and we want to help them with thoughtful turnkey solutions," says Oyvind Birkenes, EVP Long-Range at Nordic Semiconductor. "The acquisition of Memfault significantly expands the features offered in our cloud services, providing nRF Cloud with a combination of device management, embedded observability and location services, while expanding our offering to all our wireless connectivity technologies."

Simplify your development



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Location Finding

New technologies take indoor location services to next level

Indoor positioning and navigation systems powered by advanced wireless networks are making asset tracking and wayfinding easier, even in complex environments

While cellular IoT platforms and non-terrestrial networks (NTNs) are enabling ever-more efficient tracking of goods across the globe (See [WQ Issue 2, 2025 pg12](#)), once those goods move indoors the picture changes. As goods or assets pass from the outside environment governed by GNSS/NTN into the complex world of shelves, aisles and racks, operational visibility drops drastically as GNSS signals are unavailable or greatly attenuated.

As such, forecasts suggest indoor asset tracking technologies are on the rise. A Mordor Intelligence report predicts the indoor location services market will grow from \$14.88 billion in 2025 to \$43.32 billion by 2030. Another recent study by Growth Market Reports projects the indoor positioning and navigation market—valued at \$13.5 billion in 2024—will climb to \$86.1 billion by 2033. According to the analyst: "This substantial growth is attributed to the rapid adoption of smart technologies across industries and the increasing need for seamless indoor navigation in complex environments."

The case for indoor positioning

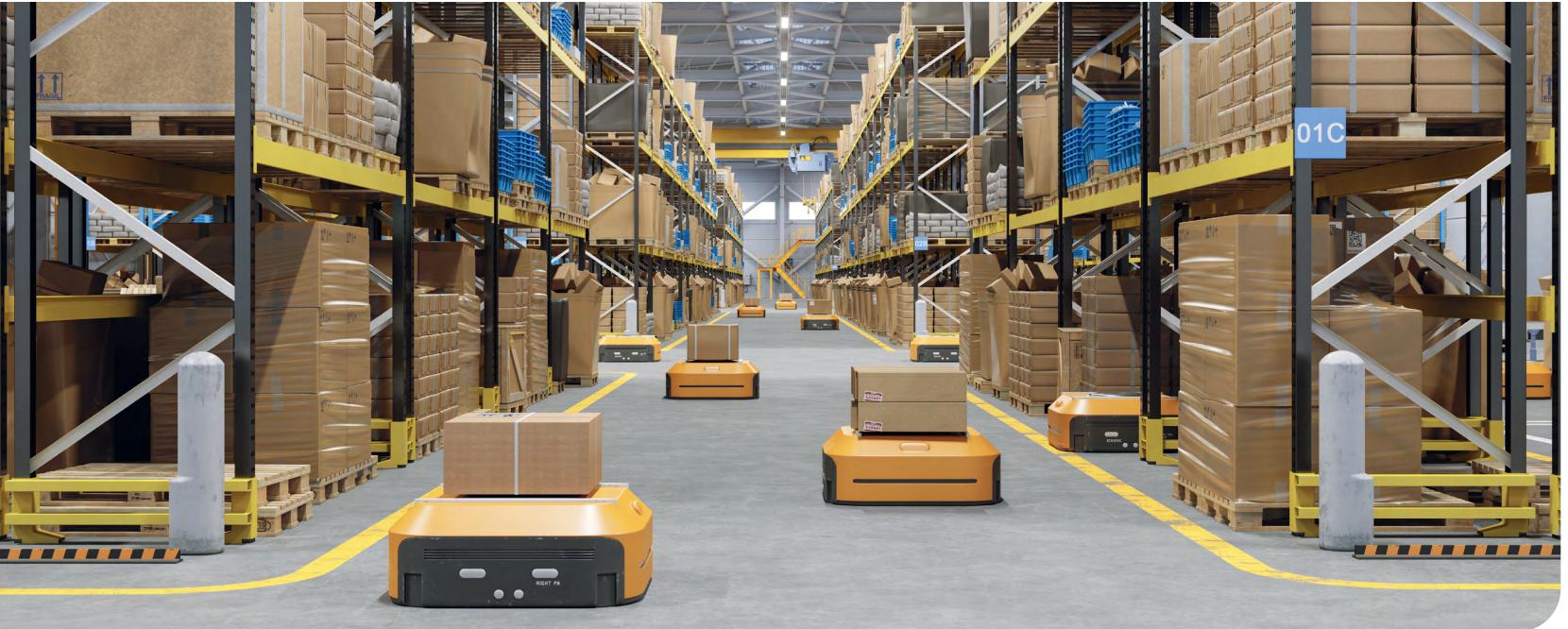
More specifically, the anticipated surge for indoor positioning technologies is driven by the simple fact losses, inefficiencies and downtime inside facilities cost money—and location data is foundational to digital twin architectures, workflow optimization, labor reduction and asset-utilization improvement.

In the warehouse context, for instance, the shift to online shopping and high velocity fulfilment means the time spent locating an item, waiting for a forklift or manually verifying inventory becomes a competitive disadvantage.

From an ROI standpoint, when companies deploy indoor asset tracking or positioning systems, they often reduce labor effort, reduce lost-asset risk and shrink idle time of tools, pallets or trolleys. A robust growth outlook, spanning hardware, software and services in indoor location systems, indicates organizations recognize the business value.

Locationing technologies converge

In the domain of indoor asset tracking and position finding—such as in warehouses, fulfilment centers, factories or large retail operations—a number of technologies are converging to make this practical and cost effective. Locating goods in increasingly



large warehouses presents a growing challenge. By attaching connected sensors to assets, workers can quickly pinpoint product locations and retrieve them more efficiently. Facility-wide sensors can also enable digital twin applications, guiding staff to key areas and streamlining operations.

Of the multiple IoT technologies that support indoor positioning, Wi-Fi-based locationing offers strong signal propagation and the advantage of leveraging existing warehouse infrastructure. With solutions such as Nordic Semiconductor's nRF70 Series Wi-Fi Companion ICs built into trackers, devices can use the known positions of access points (APs) to accurately determine asset location.

In a large warehouse with a widespread Wi-Fi network, the [nRF7002](#), for example, could be used with Nordic nRF Cloud location services to reveal the position of stored items relative to the warehouse APs. The [nRF7000](#) Wi-Fi Companion IC, meanwhile, supports scanning of Service Set Identifiers (SSIDs)—every Wi-Fi AP broadcasts a SSID (a technical reference for the AP's name) which can be looked up in a database via nRF Cloud location services to yield an approximate location of the tag/device when GNSS is unavailable.

Another key enabling technology is [Bluetooth LE](#), which



Tech Check

Developed by MOKO SMART, the Nordic [nRF54L15](#) SoC-powered [L03 Bluetooth 6.0 beacon](#) enables room-level positioning applications in large venues. The nRF54L15 provides the low power Bluetooth LE wireless connectivity enabling highly reliable positioning across wide indoor (and outdoor) areas. The L03 beacon is also hardware-compatible with Bluetooth Channel Sounding to increase the accuracy and reliability of distance measurements.

In indoor positioning systems are emerging as a critical layer of the IoT stack



In indoor positioning systems are emerging as a critical layer of the IoT stack

has long been a favorite for indoor locationing due to its low-power tag/beacon ecosystem, widespread availability in smartphones and straightforward deployment in RTLS (real-time location systems). [Bluetooth LE beacons](#) and Ultra Wideband (UWB) systems can support sub-meter accuracy for picking and asset location.

Newer capabilities such as [Bluetooth Channel Sounding](#)—supported on all Nordic nRF54L Series SoCs—enables accurate and secure distance measuring with built-in security and seamless interoperability. Bluetooth Channel Sounding enables indoor ranging by using Phase-Based Ranging (PBR) and Round-Trip Timing (RTT) to determine the distance between two Bluetooth devices. These methods bring accuracy, reliability, security, and convenience without adding complexity to hardware design or notably increasing cost.

Moreover, indoor navigation systems benefit from ultra-efficient and easy-to-use ML on the edge. Edge AI/ML software solutions enable on-device sensor fusion (for example, combining inertial measurement unit data with Bluetooth LE signals for more accurate tracking), local anomaly detection such as identifying unexpected movement or behavior, and efficient handling of complex navigation algorithms directly on the chip. This reduces dependence on external processors and minimizes latency.

Comment

Oyvind Strom

EVP BU Short-Range, Nordic Semiconductor



Zephyr RTOS powers innovative IoT development

Nordic made a commitment to back Zephyr 10 years ago, today that means developers can get to market faster

included' solution, because Zephyr is much more than just an RTOS. It is a powerful ecosystem and a full software suite for embedded products used in lots of different applications.

We knew it was important to give Zephyr Nordic's full support to ensure it was a success. We participate extensively in both technical and marketing committees, and have devoted thousands of hours of engineering resources to upstream contributions. Of all the contributions made to the Zephyr Project down the years, Nordic is responsible for roughly a quarter.

We have collaborated with partners, customers and even competitors to strengthen the ecosystem, and invested heavily in educating the people who were going to use it. This hard work has resulted in the [nRF Connect SDK](#) that is available to customers today.

The nRF Connect SDK uses Zephyr as its foundation, on top of which it also includes some Nordic proprietary features and technology. This powerful and comprehensive blend provides developers with a breadth and depth of functionality available out of the box.

This ensures they can focus their time and energy where it matters most, in adding value and differentiation to their application.



As importantly it was a 'batteries

What a Wearable World

Increasingly sophisticated wireless technology is driving innovation for the wearable devices of today and tomorrow

In Short

Wearables today operate at the intersection of advanced sensor technology, Edge AI, and ultra-efficient wireless connectivity

While Bluetooth LE remains the cornerstone for most wearables, cellular IoT is unlocking new use cases that demand wide-area coverage and autonomous connectivity

Nordic Semiconductor's class-leading portfolio of wireless solutions represents a technological foundation upon which the next generation of wearables is being built

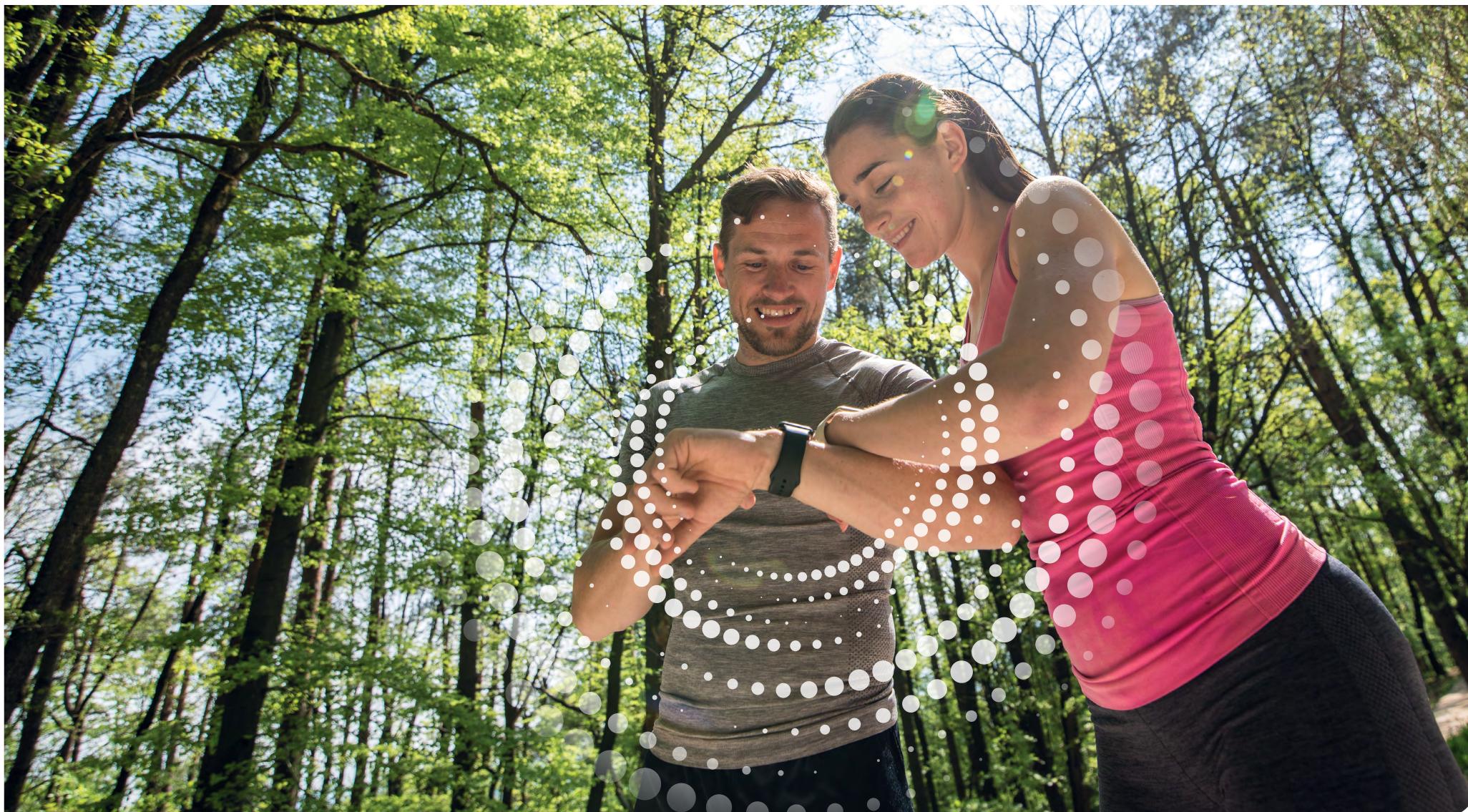
As popular as they have been since the early-to-mid 2010s, when smart wristbands and fitness trackers began to gain mainstream adoption, wearables were still seen as novelty gadgets or lifestyle accessories. Their appeal was the ability to count steps or calories, and perhaps as a fashion statement.

The modern wearable, on the other hand, operates at the intersection of advanced sensor technology, Edge AI, and ultra-efficient wireless connectivity. And their capabilities appear almost limitless.

In just one example of wearable tech's remarkable effectiveness, arguably the world's best-known smartwatch was credited with helping guide rescuers to the precise location of injured backcountry skiers near Steven's Pass in Washington State in January 2025. When one of the skiers' Apple Watch—which includes a sensor-based crash and fall detection feature—sent an SOS alert, the Chelan County Sheriff's Office was promptly notified, enabling a swift and successful response from the King County Sheriff's Office Air Support Unit.

Beyond emergency response situations, the era of advanced wearables is redefining what's possible in sectors like healthcare and sports tracking, among others. Think early signs of infection or illness being transmitted directly to caregivers, who can use the information and tailored insights to support their patients remotely, or unique biometric data analytics helping to prevent injury and enhance performance for athletes at any level.

Behind these compact yet capable devices are equally sophisticated electronic architectures, led by a new generation of wireless solutions. With escalating demands for both power efficiency and computational performance, the latest SoCs and SiPs are revolutionizing the wearable domain—enabling longer battery life, more accurate sensing, seamless connectivity, and even AI-at-the-edge.



Whether it's a Bluetooth LE sports data tracker, a cellular-connected healthcare device, or a multifunctional smart ring, the wearable landscape is evolving at unprecedented speed. At the heart of this evolution are advanced low power wireless technologies and power management solutions—designed to give developers the freedom to innovate without compromise.

SMALLER YET SMARTER

Wearable technology has evolved from single-purpose devices into multi-sensor ecosystems. Today's solutions can incorporate an impressive array of sensors for motion, temperature, heart rate, blood oxygen and more, all working in real time to provide actionable insights. As devices shrink, the technology enabling them must evolve.

Cutting-edge chips like Nordic's nRF54L15 SoC, part of the nRF54L Series—designed for highly integrated, ultra-low-power operation that makes next-generation wearable designs both practical and powerful—exemplify this evolution. The nRF54L15 brings unprecedented efficiency and compute capability to compact, battery-powered devices. It delivers significantly higher processing

power, enables AI at the edge, and affords significantly greater energy efficiency.

The nRF54L15 SoC features a powerful Arm Cortex-M33 processor with advanced security, a large memory footprint, and a highly flexible multiprotocol radio that supports Bluetooth 5.4 and beyond. This combination allows wearable developers to integrate complex algorithms directly on the device—reducing latency, improving privacy by processing sensitive data locally, and minimizing the need for constant cloud connectivity. For end users, it translates to faster responses, smarter data interpretation, and extended battery performance.

Wearables like smart rings are a prime example of how miniaturized chip power is enabling new form factors. In this space, Bravechip, a developer of chiplet chip-level solutions for the IoT (Artificial Internet of Things), has launched a suite of modules based on Nordic's nRF54L15 SoC. The modules are designed to help developers of smart rings bring new products to market faster, while providing a compact yet powerful solution with extended battery life.

The BCL603S2H smart ring chiplet uses the nRF54L15 SoC to supervise a host of sensors while maintaining seamless wireless connectivity.

"Thanks to Nordic's nRF54L15 SoC there is no limit to the functionality smart ring developers can provide to the end user," says Jin Zongming, CEO, Bravechip. "In addition to medical-grade health monitoring, it supports gesture control of smart glasses, smartphones, and smart home devices, as well as touch control of a smartphone camera or music. In-built NFC powers payment functionality, the microphone supports voice recording, while the haptic sensor enables message reminders. From a single smart ring anything is possible."

Elsewhere, smart wearables company, IDO, has launched its first ever smart ring, redefining what is possible from health and fitness tracking wearables. The IDR01 is based on Nordic's nRF54L15 SoC, enabling the smart ring to combine a host of powerful sensors to deliver precise health insights, early warnings and personalized guidance. The device integrates three built-in sensors—a PPG sensor, an accelerometer, and a skin temperature sensor—each designed to monitor and track health in a unique way.

"Thanks to the nRF54L15 SoC's multi-core architecture, IDR01 can support real-time tracking of 18 different sports and monitors your performance during every workout, making it the most comprehensive sports

By the Numbers

\$186.14 billion

Estimated global market size for wearable technology by 2030

Source: Grand View Research

13.8%

Projected CAGR of wearable technology market between 2025–2034

Source: Zion Market Research

49%

Market share in 2024 for Bluetooth wearable segment based on technology

Source: Global Market Insights

Feature: Wearables

smart ring available," says YanXiong Zhu, CEO, Shenzhen DO Intelligent Technology Co., Ltd. "It calculates energy reserves using heart rate variability, blood oxygen, breathing rate, and your daily routine – helping you train smarter and avoid overexertion. Beyond fitness, IDR01 tracks health metrics like sleep quality, blood oxygen saturation (SpO_2), stress levels, and skin temperature."

If smart rings offer a glimpse into a future that's already begun to arrive, smartwatches are the flagship of the wearable category. A standout example is Withings' [ScanWatch Nova](#), which employs Nordic's [nRF52840](#) SoC to run sensor algorithms and wirelessly relay data to smartphones. The ScanWatch Nova uses the Nordic SoC's ample processing capability and [Bluetooth LE](#) support to handle real-time data from its health sensors—including ECG, SpO_2 , and heart rate—while maintaining exceptional battery life. This combination of computational strength and power efficiency enables continuous monitoring and analysis without compromising comfort or endurance.

EXPANDING REACH

While Bluetooth LE remains the cornerstone for most personal wearables, [cellular IoT technology](#) is increasingly unlocking new use cases that demand wide-area coverage and autonomous connectivity. Devices no longer need to rely solely on proximity to smartphones or Wi-Fi networks – they can now communicate directly with cloud servers and emergency services via local cellular towers.

This transformation is being accelerated by energy-efficient solutions such as Nordic's [nRF9151](#) SiP, a compact and highly integrated LTE-M/NB-IoT and GNSS module optimized for wearables and other small devices. The

State of Play

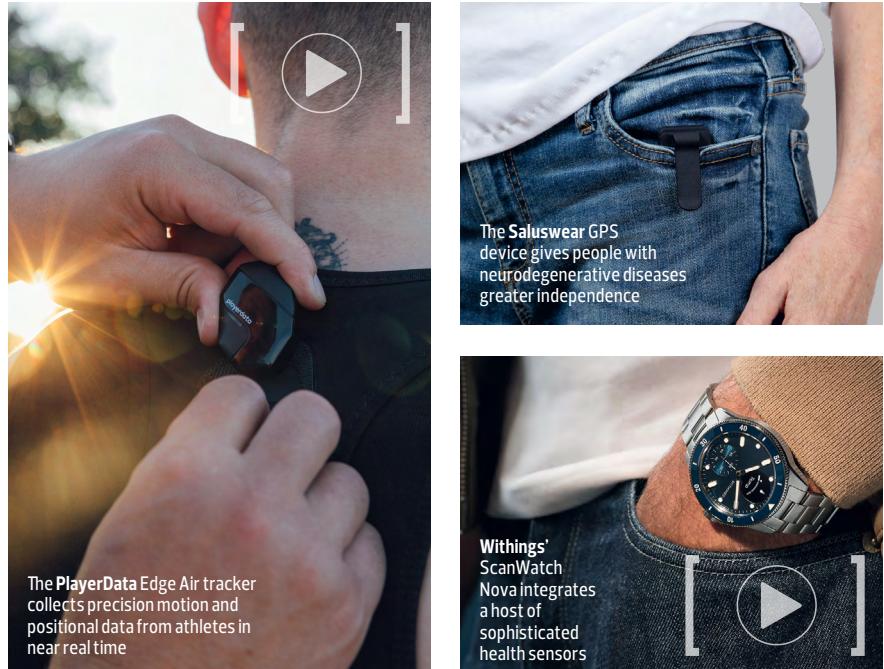
The next wave of the wearable revolution

The global wearables market reached 534.6 million units in 2024, marking year-on-year growth of 5.4 percent, according to the latest data from the International Data Corporation's (IDC) *Worldwide Quarterly Wearable Device Tracker*. Hearables remained the largest category within the wearables market and grew by 8.9 percent in 2024. This growth is set to continue in the coming years, driven by emerging markets and regular refresh cycles. Overall, the wearables market is evolving, with new form factors and innovative products at the heart of its progress. As consumer preferences shift, vendors will need to adapt their strategies to stay competitive in this dynamic landscape.

Worldwide wearables forecast by product

Year	Earwear	Smartwatch	Wrist Band	Glasses	Rings	Clothing	Other
2025	355,795,354	155,307,657	37,132,470	5,473,412	2,331,774	332,164	252,355
2029	401,877,880	165,585,295	34,316,621	12,442,818	3,464,284	368,686	269,345

Source: International Data Corporation (IDC)



The rise of Edge AI has become a pivotal factor in the evolution of advanced wearables

nRF9151 combines low power consumption with robust cellular connectivity, offering battery lifetimes once considered achievable only in Bluetooth LE applications.

A prime example of cellular technology in action is the Saluswear GPS device, a wearable designed to give people with neurodegenerative diseases a greater degree of independence and security. The solution integrates Nordic's [nRF9160 SiP](#), [nPM1300 Power Management IC](#) (PMIC), and [nRF Cloud Services](#) to deliver continuous, low power location and fall tracking for elderly care and vulnerable individuals. It ensures caregivers receive immediate, reliable updates on wearer location and condition even in outdoor environments, while still maintaining battery longevity.

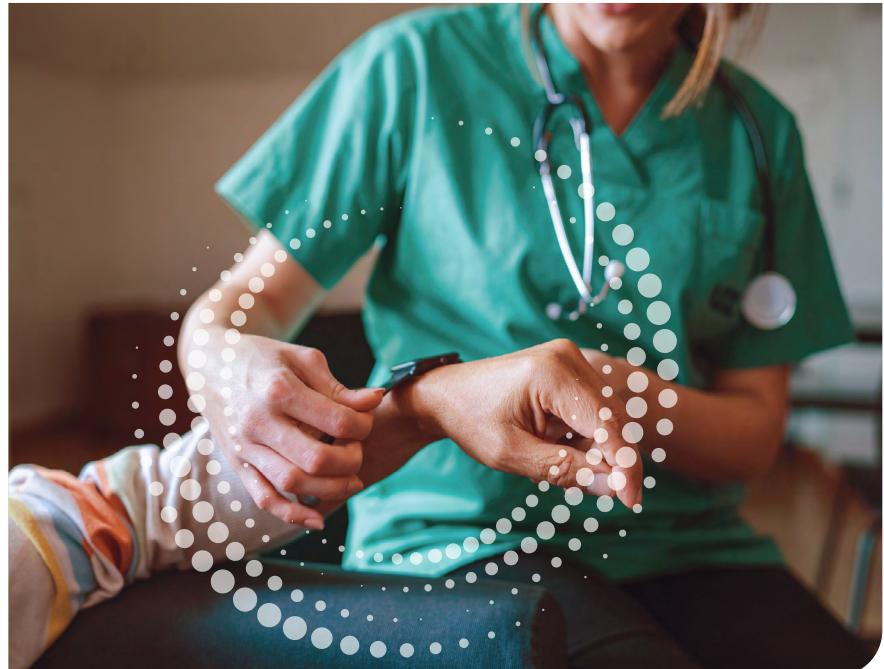
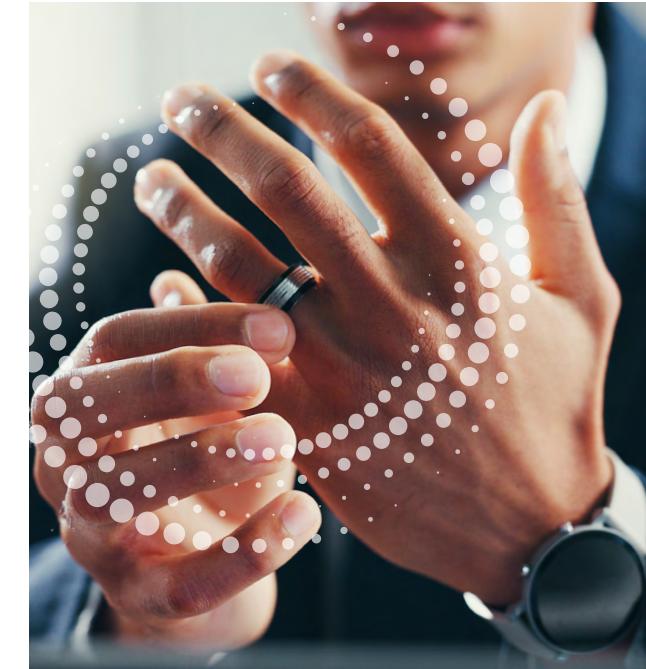
The inclusion of Nordic's nPM1300 PMIC is central to this balance. The PMIC provides efficient power management and battery charging, enabling designers to minimize size while maximizing runtime. Its compatibility with both Bluetooth LE and cellular-based devices makes it ideal for modern wearables requiring dynamic power distribution across multiple functions.

With such advancements, the once-significant power gap between cellular and short-range wireless technologies has narrowed dramatically. Developers can now combine both in one device without sacrificing energy efficiency.

THE EDGE AI DIFFERENCE

The rise of [Edge AI](#) has become a pivotal factor in the evolution of advanced wearables. Processing data locally on-device rather than in the cloud reduces latency, enhances security and enables immediate decision-making – all while conserving bandwidth. This is vital for fitness and sports wearables, where millisecond-level insights can make a significant performance difference.

The Nordic-powered [PlayerData Edge Air](#) indoor and outdoor sports data tracker exemplifies the convergence of low power connectivity, processing, and intelligent



analytics in wearable technology. Designed for professional and amateur athletes alike, the device uses Nordic's [nRF52840](#) SoC for core processing and Bluetooth LE connectivity, supported by the nPM1300 PMIC to achieve up to 12 hours of continuous operation. Once attached to the individual athlete's custom sports vest, the Edge Air tracker collects precise motion and positional data, transmitting it in real time to a companion app where metrics like speed, workload and movement patterns are visualized and analyzed.

By combining efficient wireless communication with onboard computation, the device delivers insights without compromising responsiveness or endurance. This empowers over 50,000 athletes and 1,500 teams, including English Premier League football club, Crystal Palace, to make tactical and health decisions backed by live data.

"Power management is the first step towards having a good product, and by incorporating the highly configurable nPM1300 in our solution, we have addressed this key element of any sports data tracker," says Roy Hotrabhanon, CEO of PlayerData.

With powerful yet energy-efficient wireless tech at their disposal, developers can deploy neural networks directly on the device, detecting patterns, anomalies and trends locally. The result is a new breed of wearables that are not only connected but truly intelligent and capable of adapting dynamically to the user's environment and physiology.

MORE THAN A TREND

As wearable technology continues to advance, it is rapidly becoming an indispensable part of daily life. The convergence of ultra-efficient SoCs, SiPs, power management, and Edge AI capabilities is enabling this new era, where even the smallest devices deliver profound impact. The rise of advanced wearables is more than a trend – it is a transformation driven by the relentless pursuit of better, safer, and more connected living.

Nordic Inside:



Tech Check

Nordic's [nRF9151](#) SiP module comprises an Arm Cortex M33 programmable application processor combined with 1MB Flash and 256KB RAM dedicated to the user's application, a multimode LTE-M/NB-IoT modem with DECT NR+ support and GNSS, power management, RF Front End, passives and crystals



Last year [Joint Chinese Ltd](#) launched a turnkey smart ring design, the [J-Style JCRing](#), in a miniaturized 8 mm wide and 2.9 mm thick form factor, and in a range of U.S. standard ring sizes. The out-of-the-box solution comes with a breadth of monitoring options, including VO2 max, blood oxygen saturation (SpO_2), blood glucose estimation, temperature, heart rate, and heart rate variability (HRV), as well as sleep and activity data. Nordic's [nRF52840](#) Bluetooth LE SoC provides the wireless connectivity and supervises the health and wellness sensor algorithms.

[Embr Labs](#) has released a wearable solution designed to provide relief from temperature-related discomfort, such as the hot flashes often experienced by women during menopause and people undergoing breast and prostate cancer treatments. The wrist-worn [Embr Wave 2](#) device works by delivering controlled thermal sensations in wave patterns on the sensitive area of the inner wrist. The Nordic [nRF52832](#) SoC's powerful 64 MHz, Arm Cortex M4 processor with FPU supervises the multiple high-resolution temperature sensors integrated in the wearable, ensuring safe and reliable performance across a range of environments.

Swiss sensor technology company, [greenteg AG](#), has launched what it says is the world's first non-invasive, wearable core body temperature sensor. The [CORE 2 sensor](#) clips to a heart rate monitor strap and is placed on the skin, from where it uses a proprietary heat flux sensor to measure thermal energy transfer from the body to the environment. The device is powered by Nordic's [nRF52840](#) SoC, and is designed to be used by athletes of all levels to improve performance.

The Real Deal

Powered by advanced wireless and Edge AI technologies, extended reality is evolving from a niche to mainstream platform that will change the nature of education, healthcare and industry

In Short

Extended reality technologies are being rapidly adopted in various domains, thanks to their ability to improve spatial understanding, engagement and real-time collaboration

The promise of XR and the metaverse is enormous, but its success depends on the quality of the wireless experience

As the boundaries between the physical and digital continue to blur, XR will redefine how people learn, collaborate, and experience the world



Reality has always been too small for the human imagination." When Brenda Laurel, a pioneering writer, researcher, designer and entrepreneur in the fields of human-computer interaction, spoke these words in 1993, the world looked rather different to today. Back then, VR arcade games were still a novel idea, and the dot-com bubble was seven years from bursting.

Fast-forward to May 2025, a team of surgeons in a brightly lit operating theater in Spain successfully performed a complex spinal procedure using a wireless headset that overlaid 3D anatomical data directly onto the patient's body. Thousands of kilometers away, a group of trainees in Australia observed the same procedure in real time through immersive mixed reality glasses, guided step-by-step as if they were physically in the room.

Meanwhile, in classrooms across Europe, students are learning history by walking through ancient civilizations in fully interactive virtual environments. And in bustling manufacturing facilities, engineers are training on digital twins of complex machines before touching the real thing.

Welcome to the world of extended reality (XR) and the 'metaverse' – a 3D-enabled digital space where a network of interconnected XR environments create lifelike personal and professional experiences. This immersive and interactive world is powered by the invisible engine of wireless technology. The rapid convergence of XR

DIFFERENT REALITIES

In addition to [VR](#), [XR includes augmented reality \(AR\)](#) and [mixed reality \(MR\)](#). VR immerses users entirely in computer-generated environments, typically experienced through headsets that block out the physical world. AR overlays digital content onto real-world settings, often viewed through smartphones, smart glasses, or lightweight head-mounted displays. MR blends both, allowing digital and physical objects to interact in real time.

These technologies are converging into increasingly seamless experiences. For example, a field technician might use AR to receive step-by-step repair instructions overlaid on machinery, while remote experts join via MR to guide the process interactively.

Market projections paint a vivid picture of what's ahead in the XR space. According to International Data Corporation (IDC), worldwide spending on AR and VR solutions is expected to reach \$50.9 billion by 2027, growing at a compound annual growth rate of more than 30 percent. Analysts note the next leap forward in XR won't just come from more advanced headsets, but from the wireless infrastructure and silicon innovations that make these experiences seamless, untethered and intelligent.

BEYOND GAMING

Early XR innovation was heavily driven by the gaming and entertainment industry. Headset sales rocketed as consumer demand grew for immersive environments. But over the past five years, XR has been migrating from living rooms into classrooms, hospitals, construction sites and factory floors.

One of the most impactful use cases is in education and training. Immersive simulations offer learners the ability to interact with complex subjects in intuitive, spatially aware



ways. Medical students can practise surgical procedures in VR before entering an operating room. Engineering apprentices can disassemble and reassemble digital twins of expensive equipment without the risk of damaging physical components. These applications are not only more engaging but can significantly reduce training costs and increase knowledge retention.

The healthcare sector is also embracing XR at a remarkable pace. Surgeons are using AR to overlay patient imaging data during procedures, allowing for more precise incisions and reduced operation times. Therapists are integrating VR into rehabilitation programs, giving patients controlled and engaging environments for physical or cognitive recovery.

Industry is another frontier. Manufacturing plants are deploying XR for remote collaboration and maintenance. When combined with IoT sensor data, AR headsets can show engineers live diagnostics and instructions overlaid directly onto machinery. This not only speeds up repairs but also reduces downtime and improves safety.

For example, a VR headset using [Nordic 2.4 GHz proprietary wireless connectivity](#) to communicate with controllers and audio systems can deliver input and feedback in real time, with imperceptible lag. Low latency ensures hand movements translate instantly into virtual space, while stable throughput supports the crisp spatial audio that is key for immersion. This kind of wireless performance allows developers to offload compute tasks, enabling sleeker, lighter headsets with longer battery life.

XR is often a multi-device ecosystem, with headsets, controllers, gloves, audio peripherals, and sometimes



XR devices can run continuously for extended periods without frequent recharging, making them practical for professional environments like healthcare where reliability is paramount

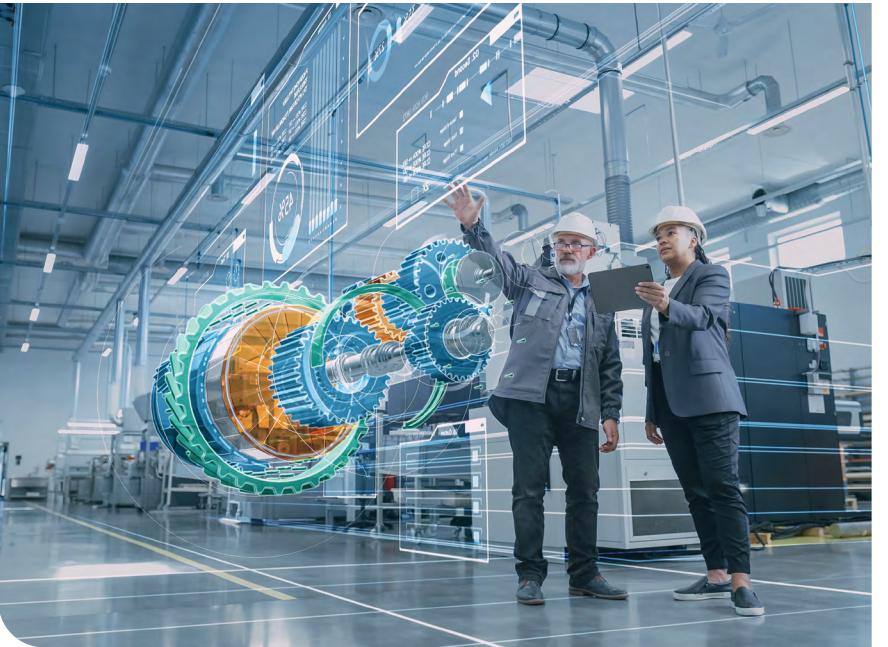
(left) Hisense's XR-V3 Bluetooth LE connected VR headset and handheld controllers offer low latency gaming, entertainment, and virtual training

Feature: Extended Reality

edge compute nodes all communicating simultaneously. Advanced multiprotocol SoCs enable seamless device orchestration in these dynamic environments, where reliable connectivity is absolutely essential.

[Hisense's XR-V3 solution](#), for example, includes a VR headset and two handheld controllers that transmit their position and orientation using the [Bluetooth LE](#) connectivity of Nordic's [nRF52832](#) SoC. Designed for use in gaming, entertainment, education, training and simulation applications, XR-V3 also integrates image and motion sensors to obtain head and body position, rotation and acceleration to establish the user's attitude positioning.

In 2025, a leading technical college in Germany rolled out an ambitious training program using AR headsets connected via Bluetooth LE and Wi-Fi 6E to simulate complex industrial processes. Students learned to operate CNC machinery, hydraulics and electrical systems in a mixed reality environment before touching real equipment. The result was faster certification times, reduced accidents, and lower equipment maintenance costs. Similarly, a major hospital network in Singapore has been equipping its surgical teams with MR headsets to assist in neurosurgical procedures. The headsets receive high-fidelity imaging data over a low-latency wireless network and project it onto the surgeon's field of view. With this setup, the surgical team can visualize 3D brain structures



in real time, collaborate with remote specialists, and adjust their strategy mid-procedure without ever looking away from the patient.

These scenarios are only possible with powerful SoCs and robust wireless connections. Advanced chips offer enough compute performance to run complex sensor fusion and AI/ML algorithms directly on the device, without constant reliance on cloud connectivity. This not only improves responsiveness but also enhances privacy and reduces bandwidth costs.

In the workplace, XR is reshaping everything from onboarding to productivity. New employees can receive interactive orientation in immersive 3D. Remote teams can collaborate on product designs in real time, manipulating 3D objects as if they were in the same room. Maintenance workers can view AR overlays on malfunctioning equipment, accessing live data and remote support.

LEADING EDGE

These applications are particularly compelling when paired with Edge AI, which brings intelligence closer to the user. Controllers powered by Nordic's nRF54 Series, for example, can process sensor data on the fly, providing insights that make XR interactions more natural and intuitive.

Edge AI is one of the most significant enablers of the next generation of XR both for content generation and for enhanced user interface. For example, in a workplace training scenario, Edge AI could recognize when a user is struggling with a particular task, adjusting the complexity of the simulation or providing contextual guidance through AR overlays. In a healthcare context, a headset could track a surgeon's hand movements and anticipate required tools or display critical information at the right moment.

For enhancing the user interface, [Edge AI](#) also needs to be supported on the controllers or human interface devices (HIDs). To this end, [Nordic-patented Neutron technology](#) allows developers to build small, fast and efficient AI models running directly on resource-constrained devices,

such as a controller or [HID](#), without sending the full data to the headset.

For embedded developers, Nordic-unique Neutron models enable Edge AI on CPUs for time-series sensor data like from accelerometers, IMUs (inertial measurement units), and PPG (photoplethysmography) sensors in ultra-low-power wireless applications. The Neutron Edge AI models are typically under 5 KB in size and, up to 10x smaller, faster, and more efficient than other CPU-run models based on TensorFlow Lite, PyTorch, or Keras. The technology is suitable for solving Edge AI challenges such as real-time gesture recognition, reducing the amount of data transmitted over the wireless links, and further reducing system latency.

This AI-at-the-edge approach is particularly powerful when combined with Nordic's ultra-low-power architecture. XR devices can run continuously for extended periods without frequent recharging, making them practical for professional environments like education and healthcare where reliability is paramount. For developers, this new XR landscape presents both exciting opportunities and technical challenges. XR applications require careful balancing of processing power, wireless bandwidth, battery life and thermal constraints. High-fidelity sensor data must be delivered in real time without compromising user comfort or safety. Nordic's nRF54 Series SoCs provide developers with the tools to meet these demands. Their powerful processing capabilities, support for multiple wireless protocols, and AI integration give developers a flexible foundation to build applications that are both immersive and scalable. In practical terms, developers can design XR headsets that rival the performance of wired systems, with wireless multi-controller input systems with near-zero lag – all while running ML models locally to adapt to user behavior.

LIMITLESS POTENTIAL

Looking ahead, XR will become more pervasive in everyday life. Headsets will continue to shrink in size, making them as comfortable and unintrusive as a pair of sunglasses. Low-latency wireless networks will enable people to participate in the same shared virtual environment from anywhere on the planet. AI at the edge will make these experiences intelligent, context-aware and seamlessly adaptive.

Extended reality is evolving from a niche technology into a mainstream platform that touches multiple sectors. The shift from tethered, high-power systems to lightweight, wireless and intelligent XR devices is accelerating this transition. As the boundaries between the physical and digital continue to blur, XR will redefine how people learn, collaborate, and experience the world. With wireless tech and Edge AI working hand-in-hand, we might be closer to this vision than many had ever imagined.

Extended reality is evolving from a niche technology into a mainstream platform that touches multiple sectors

What is the metaverse – and what does it mean for the future?

The 'metaverse' is more than a tech buzzword – it's a rapidly evolving vision of the next era of the Internet. At its core, the metaverse is a persistent, shared digital space where physical and virtual worlds merge through immersive technologies like augmented, virtual, and mixed reality. Unlike today's web, which is largely two-dimensional, the metaverse is designed to be spatial, social and interactive, creating a sense of presence rather than just connection.

Importantly, it's not about abandoning the real world. "The metaverse isn't about escaping reality," said futurist Cathy Hackl. "It's about embracing and augmenting it with virtual content and experiences that can make things more fulfilling and make us feel more connected to our loved ones, more productive at work, and happier."

Far from being a single platform, the metaverse will be a vast network of interoperable environments. People will work, play, shop, learn and collaborate inside these spaces – whether through a VR headset, AR glasses, or mobile device. Wireless connectivity is its lifeblood, enabling real-time interaction, ultra-low latency, and seamless blending between physical and digital.

Industries are already laying the groundwork: brands are launching virtual storefronts, sports teams are hosting immersive live events, and manufacturers are building digital twins of their operations. McKinsey research shows the metaverse has the potential to generate up to \$5 trillion in value by 2030 across consumer and enterprise use cases.

In the future, the metaverse could reshape how we communicate and create value – transforming the Internet from something we look at into a space we live in.

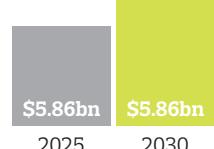
State of Play

AR headsets lead innovation despite VR dominance

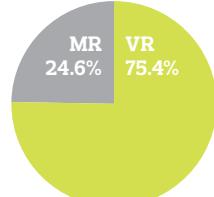
The AR and VR headsets market reached \$5.86 billion in 2025 and is on course to climb to \$9.04 billion by 2030, translating into a 9.06 percent CAGR. Steady enterprise roll-outs, breakthroughs in optics that shrink bill-of-materials cost, and national industrial policies that diversify the supply base are the main levers widening addressable demand. Virtual reality headset models accounted for 75.4 percent of 2024 shipments by device type – sustained by entrenched game libraries and simulation-training bundles that keep refresh cycles steady. Augmented-reality devices, although a minority today, are forecast to grow at a 12.7 percent CAGR to 2030 as enterprise field service, logistics picking, and on-site engineering adopt see-through displays. By application, while gaming and entertainment commanded 60.5 percent revenue share in 2024, healthcare and medical training will progress at an 11.3 percent CAGR through 2030 – making it the fastest-growing vertical. By end user, consumer usage still drives 67.4 percent of headline revenue, yet enterprise spend is growing faster at 9.4 percent CAGR as CFOs green-light productivity-linked hardware outlays.

Source: Mordor Intelligence

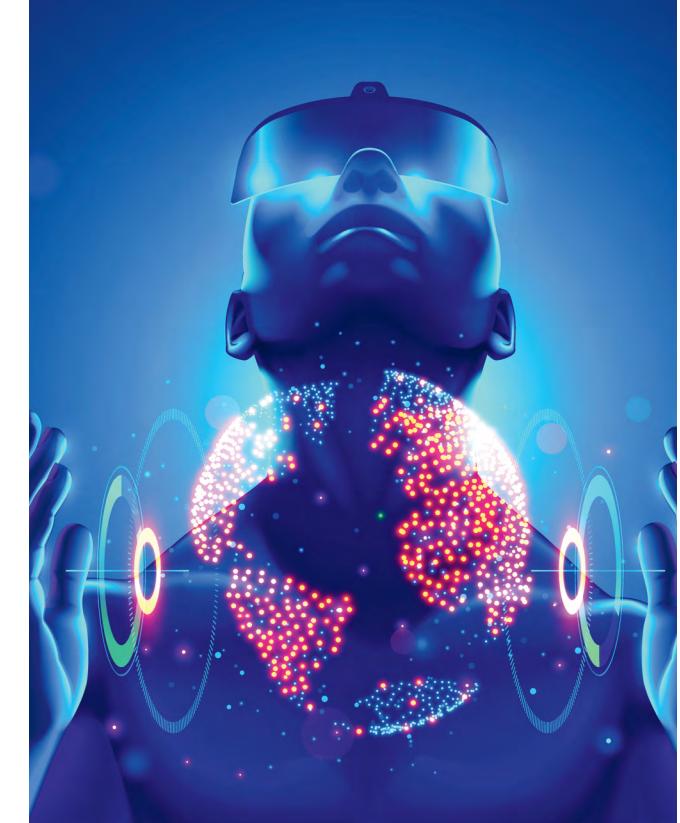
AR and VR Headsets Market Size CAGR 9.06%



AR and VR Headsets Market Share by Device Type, 2024



75.4% Virtual-reality (semi-immersive, fully immersive)
24.6% Combined share of mixed-reality (pass-through) segment



Fields of Data

Smart agriculture technologies, wireless connectivity, AI and non-terrestrial networks are transforming farming operations, increasing yields, productivity and sustainability

In Short

Feeding a growing global population while tackling formidable environmental challenges has thrown the need for smart agriculture technology into the spotlight

Nordic's cellular IoT technology enables devices to communicate efficiently on a very tight energy budget, vital for farming applications where replacing or recharging batteries is both difficult and costly

NTNs leveraging satellites, in combination with terrestrial-based cellular infrastructure, is extending coverage to rural and remote areas where cell tower coverage may be patchy or non-existent

For many thousands of years, agriculture has played a fundamental role in human civilization. From rudimentary sickles that enabled nomadic tribes to settle on and cultivate land, to modern tractors and harvesters powering commercial farms feeding entire societies, farming has been a shaping force. Now, this foundational part of the human story is itself being radically transformed by the IoT. Apart from the introduction of mechanization more than 100 years ago, the pace of technological change is faster today than at any point in the history of agriculture.

Through its history, agriculture's core mission hasn't changed: harnessing land to feed large numbers of people. But the industry today faces the formidable challenge of feeding a rapidly growing global population, just as severe environmental changes make farming ever more difficult. The UN says while more than 670 million people are already going hungry today, food production will need to further increase by sixty percent if we are to feed the world's population as it nears 10 billion in 2050. The conditions are ripe for radical change.

THE CONNECTIVITY REVOLUTION

That change is coming – via a revolution in farming methods driven by advances in connectivity. Smart agriculture has emerged as the answer to a question that's



troubled farmers: "how do we produce more with less?".

[Smart agriculture](#) involves the use of connected devices, combined with technologies like AI, to optimize farming operations and increase productivity and sustainability. By attaching sensors to various aspects of their operations – to farm machinery, crops, in the soil and even on livestock – farm operators gain a level of visibility and control they could once but dream of.

This means farmers can make smarter decisions, resulting in a more precise and impactful form of farming, says Clay Hine, Business Development Manager at Nordic Semiconductor. "Smart agriculture ensures crops and livestock get what they need, when they need it, giving them the best chance to flourish," says Hine. "As a result, smart farms tend to have higher yields and use less resources. Smart farming also gives farm operators rich data and insights into their operations, which helps them anticipate and stay ahead of emerging challenges."

While short range connectivity technologies also have their place in farming operations, the backbone of smart agriculture is [cellular IoT](#), often because of the sprawling nature of modern farms that can range over thousands of square kilometers.

Nordic has been deploying its cellular IoT technologies into a range of smart farming use cases for several years now, including its next generation [nRF9151](#) SiP module. The nRF9151 enables devices to communicate efficiently on a very tight energy budget, which is critically important for farming applications where regularly replacing or recharging batteries is difficult and costly.

Examples of Nordic cellular IoT devices in agriculture include the placement of moisture or humidity sensors in soil and among crops which can trigger irrigation systems to deliver water when plants need it, and the deployment of [sensors to track sprinkler carts](#) and detect when they have sprung leaks or overturned. In the area of livestock, [a collar developed for cattle using Nordic's cellular IoT technology](#) is enabling farmers to monitor the location and wellbeing of cattle in real time (see *Nordic Inside* p.22).

These advances in precision farming are already delivering tangible improvements in efficiency, crop output and quality for farms across the globe. A collection of farms



in China reported a 200 percent increase in strawberry production after the introduction of smart agriculture, in a trial that was supported by the UN. A study of over 5000 smallholder farmers in India found a 40 percent reduction in water use after the adoption of IoT-based soil sensors and smart irrigation systems. With suppliers, regulators and the broader public increasingly expecting farms to demonstrate sustainable practices, positive environmental impacts such as these are even more significant.

The same cellular IoT technologies are also optimizing the use and maintenance of critical farm machinery. Using connected sensors that monitor levels of vibration, water pressure or temperature, farm operators can proactively track the health of equipment like pumps, tanks and gates and perform predictive maintenance to prevent unexpected downtime.

NTNs EXTEND TECH'S REACH

Farmers are also using connected sensors to find ways to produce yields from compact spaces, rather than relying solely on massive tracts of land. Vertical farming is one example, and involves plants being stacked on shelves in controlled environments under LED lights, eliminating the need for pesticides. These installations use connected sensors to monitor and adjust levels of humidity,

fertilization, temperature and lighting for optimal growth. While vertical farming is helping farmers go up, other advances in connectivity are pushing smart farming further outward. Not all farms are within reach of the cellular coverage that enables most smart agriculture solutions. But now, [non-terrestrial networks](#) (NTNs) can help farm operators reach the once unreachable. NTNs leverage satellites, in combination with terrestrial-based cellular infrastructure, to extend network coverage to these rural and remote areas where cell tower coverage may be patchy or non-existent.

"NTNs could help us extend the many benefits of smart farming applications to farms in remote and mountainous regions, or even to more developing countries where cellular infrastructure is sparse," says Hine.

Nordic's [nRF9151](#) cellular IoT SiP module supports both terrestrial and non-terrestrial connectivity, including NB-IoT, LTE-M, [DECT NR+](#), and NTNs. At the same time the company has also been [actively partnering with multiple NTN providers](#) including Iridium Communications, Skylo, Myriota, Omnispace, Sateliot and Gatehouse Satcom to offer its customers commercial options for their NTN deployments based on the [nRF9151](#) SiP module.

"NTNs provide redundancy and resilience, by working together with cellular IoT," continues Hine. "Many farms operate in areas that are prone to natural disasters or



Tech Check

In the [nRF9151](#) SiP module Nordic has developed a low power, integrated solution that will support both terrestrial and non-terrestrial connectivity. The nRF9151 supports NB-IoT, LTE-M, DECT NR+, and NTN.

extreme weather events that can damage terrestrial cellular infrastructure. In these situations, NTNs can help ensure critical farming operations continue uninterrupted."

While improved farming yields tend to grab the headlines, the promise of greater resilience could be the biggest upside from this wave of smarter, data-driven farming. With climate change continuing to intensify, farming conditions are becoming both more severe and more unpredictable. Anything that helps farm operators get better at anticipating and responding to changing circumstances, is a win.

Not surprisingly, the AI boom currently re-shaping entire economies is playing a key role. Solutions like Nordic's nRF9151 SiP module that draw on sensor data about soil and crops can also send it to cloud-based AI platforms for analysis. This delivers farmers with powerful insights into soil health, weather patterns, yield predictions and disease prevalence – enabling them to foresee and navigate potentially turbulent times ahead. AI can also support interventions to improve and refine farm operations, for instance by recommending optimized irrigation or fertilization schedules.

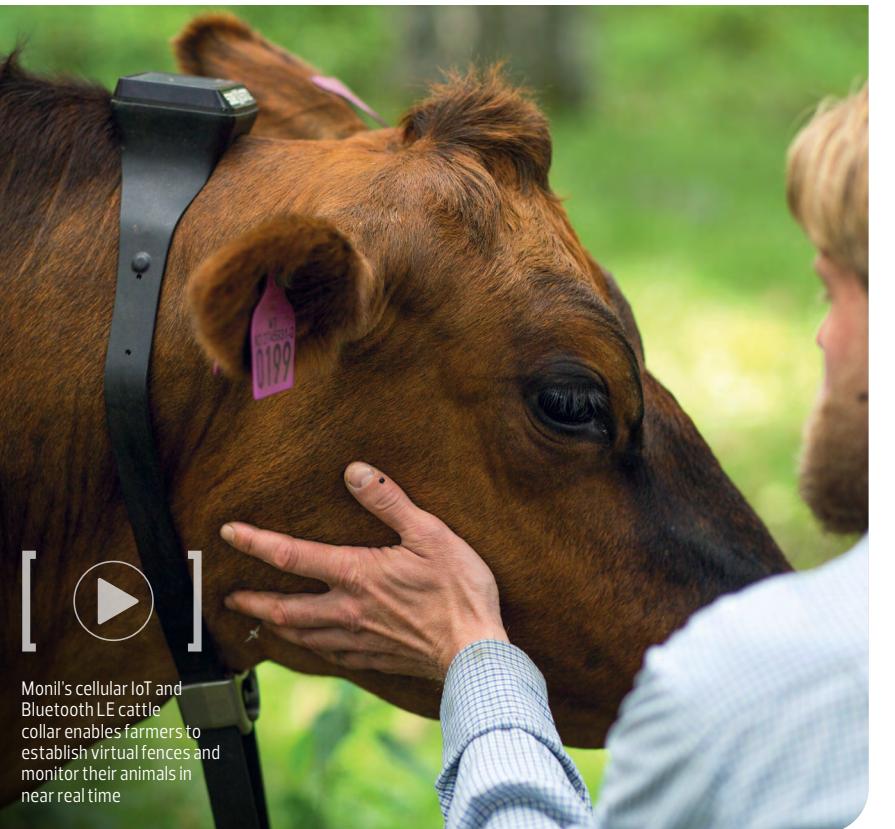
SUSTAINABILITY FIRST

By 2030, advanced connectivity infrastructure is expected to cover 80 percent of the world's rural areas, according to McKinsey. There is also increasing global institutional support and momentum behind promoting smart agriculture. The benefits speak for themselves, but there's also a moral imperative to help farmers overcome the challenges of climate change. Initiatives like the World Bank's Climate-Smart Agriculture Investment Plans are helping countries like Bangladesh, Ghana, and Zimbabwe adopt smart agriculture technologies.

Private sector companies like Nordic Semiconductor are also finding ways to support the spread of smart agriculture that go beyond product development. Nordic is a public supporter of the [UN's Sustainable Development Goals](#), which includes goals around sustainable agriculture, hunger and food security.

The company is also a member of [IoT4Ag](#), a National Science Foundation Engineering Research Center. "IoT4Ag has been very effective at supporting the increased implementation of smart agriculture solutions," says Hine. "By involving a wide range of experts and industry partners, IoT4g takes precision farming ideas beyond concepts and develops them into practical solutions."

The transformation of farming from a grueling and labor-intensive pursuit to a technologically oriented and data-centric profession is well under way. It will hopefully lure an entirely new generation of young workers into a sector that has a brighter and more sustainable future. If it does that's a win for all of us.



Smart agriculture ensures crops and livestock get what they need, when they need it, giving them the best chance to flourish

Nordic Inside: Virtual wireless cattle fence delivers sustainable solution

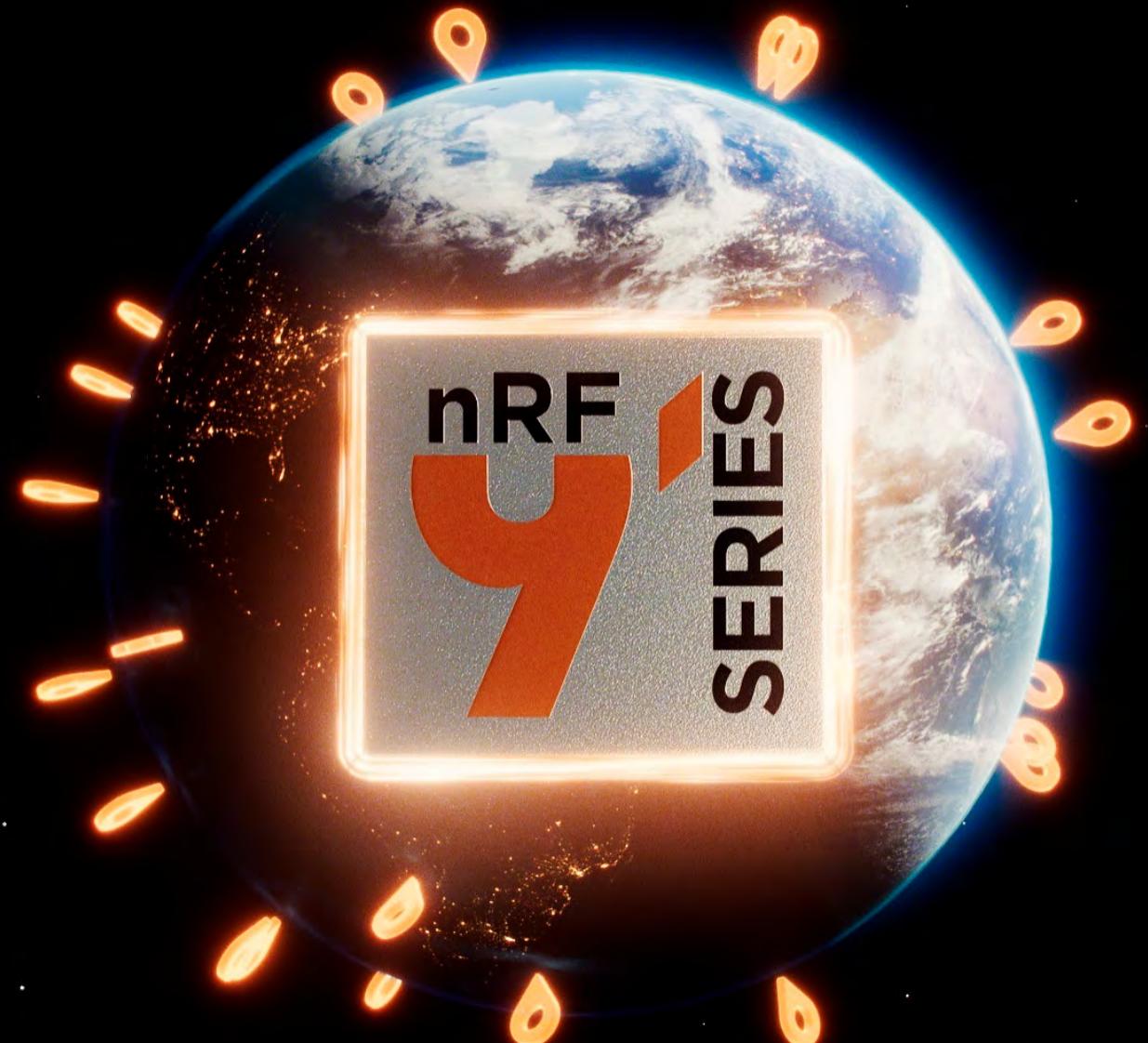
Norwegian technology company, Monil, has developed a [cellular IoT and Bluetooth LE-powered cattle collar](#) that eliminates the need for traditional farm fencing while simultaneously monitoring the well-being of grazing animals. The Monil Collar can be comfortably fitted to the neck of grazing cattle and employs Nordic Semiconductor's [nRF9160 SiP module](#) and [nRF52833 SoC](#) to provide cellular IoT and Bluetooth LE connectivity. This wireless connectivity enables farmers to establish virtual fences and then monitor cattle in near real time to ensure they stay within set boundaries. Integrated sensors also allow farmers to remotely review data that could indicate concerns for livestock wellbeing.

Once fitted to the neck of the animal, farmers can use the Monil smartphone app to define the grazing area. When a cow approaches the virtual boundary, the collar emits a sound. If the cow ignores the sound, a gentle electrical pulse is applied. After three rounds of sounds and electrical pulses, the system stops and the farmer gets an immediate notification that the cow has escaped. A training period of up to 10 days enables cows to understand the signals and thereafter graze within the planned and unfenced areas.

In addition to providing animal location data, the device integrates a range of sensors to provide device diagnostics as well as animal well-being information. For example, the integrated inertial measurement unit can confirm if an animal is stationary for an extended period which might indicate injury. Powered by a Li-poly battery, the device can be recharged using harvested solar energy alone.

nRF9151 cellular IoT module

Delivers seamless global connectivity supporting terrestrial and non-terrestrial networks



Designed for smart agriculture, smart metering, asset tracking, and more

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Entertainment

Puttshack Trackaball

This Nordic-powered smart golf ball tracking technology brings mini golf into the 21st century, enhancing gameplay by tracking ball metrics and automatically keeping score

The use of [Bluetooth LE](#) in entertainment venues is on the rise to improve operational efficiency and the guest experience. [Beacons](#) are being deployed to provide location-based notifications, guide players through mini golf courses, as well as manage waitlists. IoT sensors meanwhile can monitor the health of lane machinery at a bowling alley, for example, enabling operators to quickly respond to maintenance issues

The [nRF54L15](#) SoC's 128 MHz Arm Cortex-M33 processor and RISC-V coprocessor supervise Trackaball's integrated movement and acceleration sensors, enabling the specific game status and scoring data from each ball to be collected and processed during live play. In addition, Trackaball employs the nRF54L15 SoC's ultra-low power multiprotocol 2.4 GHz radio to provide the Bluetooth LE wireless connectivity for automatically transmitting the data from the ball to the digital scoreboard



If you hope to make it into the Guinness World Records for mini golf, the bar is a high one. In 2022, American Alex Russell took the record for most holes played in an hour, completing 231, or one every 18 seconds or so. Not to be outdone, three months later Mick Cullen completed 4,951 holes in a 24 hour period. Peter Edenborough meanwhile holds the world record for the most number of holes-in-one on a single day, draining 934 of them at a charity event in Australia

[Puttshack's Trackaball](#) solution works by monitoring and understanding the state of each golf ball from hole to hole – for example, when the ball is moving, picked up, downhill, slowing down, stationary, or in a 'feature' such as a hole or gate. Each ball is linked to a player's personalized game profile and can be used to keep track of every stroke, hazard, and point scored throughout the game

Walt Disney was a huge fan of mini golf. He was fascinated by scaled-down play environments and taking 'big' adult pastimes and reimagining them for family fun. It was this mindset that directly influenced his approach to Disneyland, designing attractions with miniature wonder in mind and featuring whimsical obstacles common on mini golf courses in the 1920s and 1930s. To this day Disney designers still borrow heavily from mini golf design language, using exaggerated props, interactive elements and kinetic obstacles

Mini golf, also known as putt-putt or crazy golf depending on where in the world you live, originated in Scotland in 1867 with The Ladies' Putting Club of St. Andrews, a course made from pipes and tires designed to allow women to participate in golf without the 'unladylike' act of swinging full-sized clubs. Fast forward to the modern day and the game has become so competitive there is now a World Mini-Golf Sport Federation. It also has its own dedicated holiday, Worldwide Miniature Golf Day, celebrated on September 21



Trackaball integrates Nordic's [nRF54L15](#) SoC that features a world-class multiprotocol radio providing up to +8 dBm TX power (with 1 dB increments) with -98 dBm RX sensitivity for 1Mbps Bluetooth LE. The radio power consumption significantly improves in TX and RX compared with the nRF52 Series. Compared with the nRF52840 SoC, the radio RX current is halved (running from a 1.8 V DC supply), allowing for more compact batteries or extended battery life



Tech Check

Trackaball also employs the Nordic [nPM2100](#) Power Management IC (PMIC). The [nPM2100 PMIC](#) features an ultra-efficient 150 nA IQ internal boost regulator, a 35 nA sleep mode to prevent battery drain during shipping, and a hibernate mode including timed wakeups for applications that spend most of their time in deep sleep. The hibernate mode lowers sleep current to 175 nA, and enables Trackaball's CE2447 coin cell to achieve an estimated battery life of over 7.5 years

Smart metering

Energy monitoring solution uses NR+ mesh technology to provide reliable usage data

GridsMesh's Pawane Energy App for Africa empowers users to manage their electricity consumption and support improved grid stability

Smart metering does more than just ensure accurate billing – it empowers consumers to better understand their energy use patterns and make informed decisions. By encouraging households to shift usage to off-peak periods, smart meters can help lower electricity costs and ease pressure on the grid.

This is particularly valuable in regions with less consistent grid stability, impacting reliable access to electricity. For example, South Africa has been experiencing repeated periods of 'load shedding' – scheduled power outages implemented to reduce strain on the grid – since 2007.

"Utility providers across Africa are gradually moving towards the implementation of [smart metering](#) solutions," explains Joseph Wamicha, CEO of GridsMesh – a South African design and manufacturing company that has developed its own smart metering solution. "Currently, most utilities are using cellular connectivity as a means of transmitting the recorded data, while others are opting for Power Line Communication [PLC G3]."

However, while cellular-based meters can provide long-range transmission, this method relies on SIM cards, which can be difficult to manage at scale and are vulnerable to the widespread connectivity blackspots across Africa. Similarly, PLC G3 also offers a number of drawbacks in the form of poor signal quality and interference from ageing infrastructure.

"The foundation of smart metering is built upon dependable communication," says Wamicha. "The broad range of wireless technologies available today – including LTE, NB-IoT, PLC G3, PLC+RF and Wi-SUN – provides utilities with many options. However, we have found none of these are currently able to deliver the level of reliability required for effective smart metering across Africa."

Mesh networking for reliable transmission

To help address these challenges, GridsMesh has launched its '[Pawane Energy App for Africa](#)' smart metering solution. Based on [DECT NR+](#) (NR+) – a non-cellular radio standard that employs a self-healing mesh network – the system eliminates single points of failure to provide more robust performance, maintaining connectivity even if individual nodes go offline.

"Many areas in Africa suffer from poor cellular network coverage," says Wamicha. "With NR+, smart meters extend and strengthen wireless network coverage. In urban environments each smart meter can connect with over 50 neighboring meters, and a singular cellular



Image courtesy of Sunshine Seeds

subscription can be shared across 1,000 smart meters."

This communication is enabled by Nordic's [nRF9151](#) low-power SiP module, which has been purpose-built for DECT NR+ and cellular IoT applications. The module delivers powerful transmission, supporting Power Class 3 up to 23 dBm output power and Power Class 5 up to 20 dBm output power. It also offers excellent receiver sensitivity, allowing the device to detect weak signals from distant network nodes.

Powerful connectivity

The use of NR+ technology has a number of other benefits. Unlike most iterations of cellular connectivity, it doesn't require SIM cards or external telecom networks. This allows utilities to establish and manage their own independently-operated private 5G network.

"Traditional cellular smart meters typically send data overnight, or a few times per day, because of the cost of data," continues Wamicha. "This lacks 'real time' visibility. With NR+, data can be transmitted every minute without a significant increase in cellular subscription fees."

The collected information is then made accessible via the corresponding mobile app, allowing end users to view detailed energy consumption data including daily and

Need to Know

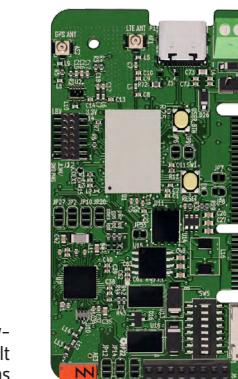
Energy regulators across Africa face significant challenges related to maintaining a reliable grid supply. Today, according to the World Bank Group, one in three people across the continent do not have access to electricity at all, while many others face ongoing grid reliability issues



With NR+, smart meters extend and strengthen wireless network coverage



The Pawane Energy App for Africa empowers consumers to better understand their energy use patterns and make informed decisions



Connectivity is enabled by Nordic's nRF9151 low-power SiP module, which has been purpose-built for DECT NR+ and cellular IoT applications

monthly usage tracking, cost monitoring and the ability to purchase additional prepaid energy tokens.

Unlike traditional prepaid systems that require consumers to enter STS (Standard Transfer Specification) tokens, NR+ enables cloud-based prepaid electricity management, removing the need for direct meter interaction. Supported by the reliable communication capabilities of the nRF9151, the prepayment feature can be integrated and managed through a centralized platform.

"In simple terms, this allows the prepayment functionality to operate at the system level rather than being confined to individual devices," explains Wamicha.

Transforming energy in Africa

"Our solution was developed with the key stakeholders in Africa's energy transformation in mind, including electricity distribution utility companies ... along with smart city projects, off-grid solution providers, and meter manufacturers across Africa."

By addressing Africa's connectivity challenges, this solution delivers clear insights that enable both users and utility companies to manage electricity more effectively – reducing household costs for consumers while increasing grid stability for providers.

Industry Viewpoint

Valery Chekalkin

Co-Founder and CEO, Jetbeep



Smart lockers provide effective last-mile delivery solution

Autonomous wireless lockers avoid electricity grid restraints, enabling improved last mile logistics

Consumer demand for more convenient last-mile delivery solutions continues to grow. However, dependence on the electrical grid has made traditional smart lockers a logistical challenge. Many operators are continuing to focus on large, grid-connected units, which limits deployment flexibility and slows expansion.

Integrating wireless connectivity into autonomous lockers provides a practical and cost-effective alternative. They can provide the same reliability and functionality without the need for grid power. This makes installation cheaper, deployment faster, and networks easier to expand.

Due to lower cost per location, the 'traffic threshold' is decreased, meaning carriers can build locker networks with higher granularity, or in other words, closer to customers.

By placing smaller, autonomous lockers closer to customers, carriers can achieve a much higher first-time delivery rate and fewer missed



Wireless technology ... has the potential to fundamentally change last-mile delivery

parcels. Smaller, distributed units can serve neighborhoods efficiently, cutting the average distance a courier has to drive and reducing unnecessary repeat trips. Autonomous lockers also enable

more flexible delivery schedules, including night-time deliveries. This reduces daytime traffic congestion and helps lower CO₂ emissions from vehicles stuck in traffic. In the end, companies save money, and consumers save time.

Cost-effective expansion

Shifting towards smaller, autonomous lockers closer to customers does take time, but the way to overcome this is through proven technology. Real world cases show wireless autonomous lockers can deliver the same reliability and functionality, but at much lower cost.

Because autonomous lockers are easier to roll out in both urban and suburban areas, expansion is more flexible and cost-efficient. They can also operate on open, carrier-agnostic networks, hosting parcels from multiple providers and enabling last-mile consolidation. Operators can also remotely monitor performance, update software and gain full control of their networks.

For us at Jetbeep, the turning point came in 2021, when a partner asked us to design a battery-powered device capable of unlocking a parcel locker without grid connection. We built a prototype, and the response from the market was incredible.

Looking ahead, our main focus is on launching our own open network of carrier-agnostic smart lockers across the EU, where clients can rent compartments and integrate their services through our technology.

Ultimately, wireless technology turns lockers into smart, scalable infrastructure, and that has the potential to fundamentally change last-mile delivery.

Tech Zone

An in-depth look at Nordic's wireless solutions

Power Management

Nordic's launches nPM1304 Power Management IC

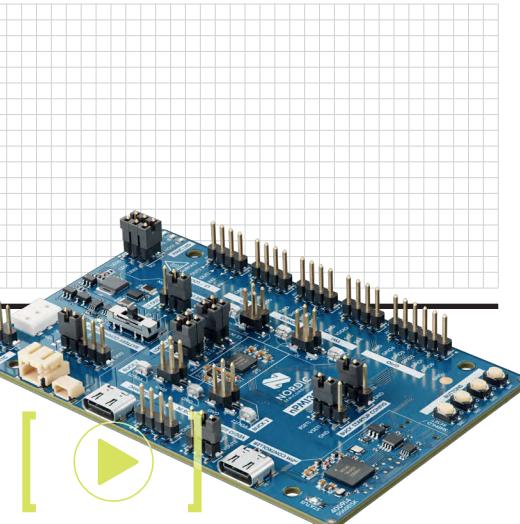
Nordic Semiconductor has announced the availability of the [nPM1304](#) Power Management IC (PMIC) for development and ordering. The nPM1304 PMIC complements Nordic's award-winning [nPM1300](#) PMIC with a highly integrated, ultra-low power solution and precision fuel gauging. Its support for charging currents down to 4 mA make it ideal for small-sized battery applications, such as smart rings.

All developers can now leverage the nPM1304 PMIC's capabilities to optimize application integration and system performance.

The nPM1304 PMIC offers unique system

management features and delivers the industry's first ultra-low power precision fuel gauging for small battery products. Nordic's advanced algorithm-based fuel gauge method combines voltage, current, and temperature monitoring with a mathematical battery model to accurately estimate the battery's state of charge, using minimal power consumption.

Key features of the nPM1304 PMIC include up to four regulated power rails, ultra-low power precision fuel gauge, 370nA sleep mode, and external watchdog. In addition to its core power management features, the nPM1304 includes advanced system



management features—hard reset function, failed boot recovery, and power failure warning—to enable developers to design more reliable products with enhanced end-user experience. With these features and functions packed into a compact 3.1 by 2.4 mm CSP package, the nPM1304 delivers an unmatched power management solution.

The nPM1304 is suitable for all end products with small rechargeable batteries, including smart rings, stylus pens, and sports performance trackers. It manages the power supply for Nordic's ultra-low power wireless SoCs and other MCUs, optimizing for maximum efficiency and compact size.

Asset Tracking

Samsung SmartThings Find enables device tracking across Nordic wireless SoCs

Nordic Semiconductor now offers support for Samsung's SmartThings Find SDK across its next-gen [nRF54L15](#) and [nRF54L10](#) wireless SoCs, as well as its [nRF52840](#), and [nRF52833](#) SoCs. This software-level integration enables developers to build advanced location tracking solutions, using Nordic's ultra-low power wireless tech and Samsung's global SmartThings ecosystem.

Samsung SmartThings Find SDK is a development toolkit designed to enable device manufacturers and developers to integrate location-tracking capabilities into their devices, without building everything from scratch. The SDK works across various device types, reducing development complexity, while providing comprehensive documentation and robust

technical support. For end users, SmartThings Find provides peace of mind and convenience by ensuring they can locate lost or misplaced devices using the SmartThings ecosystem. For Nordic devices, the SmartThings Find SDK is delivered as an add-on to the [nRF Connect SDK](#). "SmartThings Find SDK support on Nordic's market-leading wireless SoCs marks a major step forward in simplifying and scaling location tracking solutions," says Oyvind Strom, EVP Short-Range, Nordic Semiconductor.

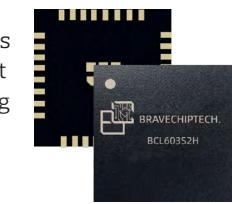
"We're giving developers a powerful combination: Nordic's proven ultra-low power wireless performance and seamless access to Samsung's global IoT ecosystem. This unlocks new possibilities for innovation in tracking devices."



Modules

Smart ring modules integrate nRF54L15 SoC

Bravechip has launched a suite of modules based on Nordic's [nRF54L15](#) ultra-low power wireless SoC. The modules are designed to help developers of smart rings bring new products to market faster, while providing a compact yet powerful solution with extended battery life. The 5 by 5 mm BCL603S2H smart ring chiplet integrates the nRF54L15 SoC to provide Bluetooth LE connectivity between a smart ring and a smartphone. In addition, the SoC's Arm Cortex-M33 processor is clocked at 128 MHz, and a RISC-V coprocessor runs software-defined peripherals while handling time-critical tasks. Together with 1.5 MB NVM and 256 KB RAM, this ensures the Bravechip chiplet has ample processing power for running a suite of smart ring sensors.



Modules

Fully-featured cellular IoT module unveiled

Sercomm Corporation has launched a high-performance, multi-band, dual mode LTE-M/NB-IoT module based on Nordic Semiconductor's [nRF9151](#) reference design with Nordic's nRF9120 SoC and related power management and RF front-end components.

The TPM530M cellular IoT module delivers a fully featured solution in a compact 14.55 by 14.51 by 1.85 mm package size. The pre-certified Sercomm module is designed for a wide range of space-constrained cellular IoT applications including smart metering, bike sharing, wearables, smart city, security, asset tracking and environmental monitoring.

"Nordic has a proven track record in ultra-low power consumption solutions, and access to Nordic's nRF9120 SoC with power management and RF front-end components, provides the best performance and cost solution for Sercomm in a very compact size."



Bluetooth LE Development

Nordic launches nRF Connect SDK Bare Metal option for nRF54L Series

Nordic Semiconductor has launched the [nRF Connect SDK Bare Metal](#) option, a software solution for the next-generation nRF54L Series ultra-low power wireless SoCs. The Zephyr RTOS-independent option enables development of simple Bluetooth LE products, making it ideal for designs that do not benefit from an RTOS or advanced features.

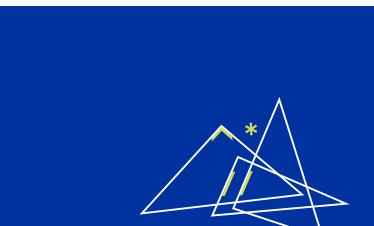
Built around Nordic's widely adopted SoftDevice, the Bare Metal option introduces architecture and API similarities to the nRF5 SDK, simplifying migration for developers moving from the nRF52 Series and nRF5 SDK, to the next-generation nRF54L Series. It also supports a streamlined upgrade path to [Zephyr RTOS-based development](#) within the same SDK and development environment, allowing developers to scale their applications when needed.

"With the Bare Metal option, we are lowering the entry barrier for developing simple



Bluetooth applications, while also offering a clear upgrade path to Zephyr RTOS and the full capabilities of the [nRF Connect SDK](#) for new and existing customers," said Oyvind Strom, EVP of Short-Range Business Unit at Nordic Semiconductor. "This software option is a meaningful addition that reflects our goal to support a broad range of developers and applications. Nordic's commitment to the world-class nRF Connect SDK and the Zephyr community remains strong, and this strategy continues to shape our long-term direction."

The launch reinforces Nordic Semiconductor's commitment to offering flexible development paths tailored to the needs of embedded developers, whether optimizing for simplified application use cases or building advanced multiprotocol systems.



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HIGHLIGHTS

- Introducing nRF Cloud powered by Memfault - Debug, monitor and update deployed devices
- Bluetooth® Channel Sounding: From theory to practice on the nRF54L Series and Android
- Custom Neutron Edge AI Models: From overview to nRF Connect SDK Integration
- Tackling RF Loss, Band Coverage, and Multi-Radio Challenges in the Thingy:91 X

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Product Focus

nRF54L15 SoC

Nordic's [nRF54L15](#) is a next-generation wireless SoC delivering ultra-low power and superior performance, making it ideal for smarter, longer-lasting connected devices

With extended range, robust security, and multiprotocol support, the nRF54L15 SoC gives engineers and developers a strong foundation for tackling complex IoT designs. It streamlines development while enabling new classes of smarter, longer-lasting devices across consumer, industrial, and [medical](#) applications

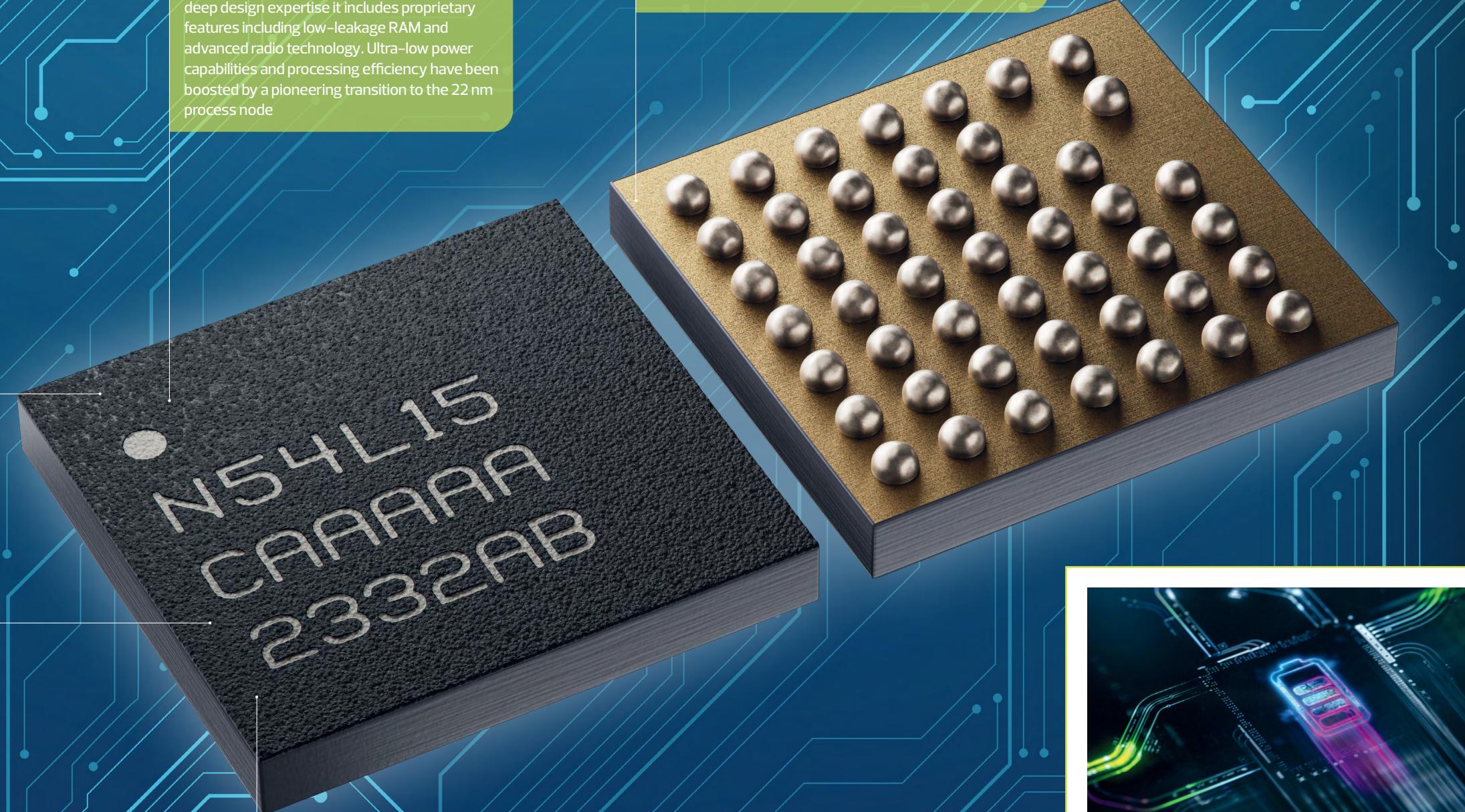
The nRF54L15 features an Arm Cortex-M33 processor clocked at 128 MHz and an ultra-low-power 2.4 GHz radio. It is designed to support advanced application software and wireless protocol stacks on a single chip, reducing the need for external MCUs or additional memory. The nRF54L15 offers 1.5 MB non-volatile memory and 256 KB RAM, ideal for demanding applications

The nRF54L Series 2.4GHz radio, combined with an efficient MCU, enables significantly lower power consumption for typical Bluetooth LE use cases, both when advertising and in connections. These power consumption improvements are enabled along with up to 8 dBm TX power and -96 dBm RX sensitivity

The [nRF54L15 DK](#) makes all the features of the wireless SoC available to the developer. The nRF54L15 DK is supported by a comprehensive set of nRF Connect tools and has support in the nRF Connect SDK. Developers can explore the full potential of the nRF54L15 using the extensive range of software samples, modules, and libraries available within the nRF Connect SDK

The nRF54L15 offers lower power consumption, double the processing power, and triple the processing efficiency of the previously market-leading nRF52 Series SoCs. Built on Nordic's deep design expertise it includes proprietary features including low-leakage RAM and advanced radio technology. Ultra-low power capabilities and processing efficiency have been boosted by a pioneering transition to the 22 nm process node

The nRF54L15 is suitable for products using Bluetooth LE, Bluetooth Mesh, Zigbee, Thread, Matter, Amazon Sidewalk, and proprietary 2.4 GHz protocols. In addition, it can run a Wi-Fi stack for the nRF70 Series companion ICs



Seamless PMIC integration

For developers with demanding wireless designs that require maximum energy efficiency and extended battery life, Nordic's family of Power Management ICs (PMICs) is designed to work seamlessly with nRF54L Series SoCs, including the nRF54L15



Nordic's PMICs are highly integrated solutions that reduce system complexity, bill-of-materials (BOM), and board space. The PMICs integrate essential power management features like highly efficient power regulation, battery charging and fuel gauge, load switches, GPIOs and LED drivers, with advanced system management features like hard reset, system level watchdog, power loss warning and recovery from failed boot. By integrating a PMIC into their design, developers can optimize battery performance and system efficiency from the battery to the antenna. The PMICs are designed to complement all Nordic's market-leading nRF54, nRF53 and nRF52 Series SoCs, including the nRF54L15, ensuring highly efficient power management for wearables, smart home devices, industrial sensors, and other primary battery-powered IoT applications.



Tech Spec

Processing
128 MHz Arm Cortex-M33 processor, 128 MHz RISC-V Coprocessor

Memory
1.5 MB NVM and 256 KB RAM

Supported protocols
Bluetooth LE, Bluetooth Mesh, Bluetooth Channel Sounding, Matter, Thread, Zigbee, Amazon Sidewalk, 2.4 GHz proprietary

Development tools
nRF54L15 DK

Digital interfaces
High-speed SPI/UART, 4x SPI/UART/TWI, PDM, I2S, PWM, QDEC

Tech Briefing

Getting started on advanced cellular IoT projects with nRF9151 SiP module

The nRF9151 SiP module provides a highly integrated, low power and secure solution that is simplifying the development and deployment of scalable products across massive IoT markets

Before Nordic unveiled its first LTE-M/NB-IoT SiP module back in late 2018, most cellular IoT modules were relatively bulky, power hungry, and not particularly developer-friendly. Nordic's [nRF9160](#) changed that by being highly integrated, lower power, more secure, and easier to design-in than any other cellular IoT module available at the time.

Last year the company announced its successor, the [nRF9151 SiP module](#), setting a new standard for a highly integrated and compact SiP for [cellular IoT](#), [Non-Terrestrial Networks](#) (NTN) and [DECT NR+](#) (NR+) applications.

Previously, cellular IoT design has often involved sourcing components from various suppliers. The cellular module, host MCU, RF front-end, GNSS module, secure element and Power Management IC (PMIC) could all be supplied by different vendors. From a system perspective this requires a lot of interfacing between all these elements, leading to challenges in cost, performance, and power efficiency, and increasing the possibility of running into problems.

With the [nRF9151](#) SiP module, Nordic has integrated everything into a single 12 by 11 mm device—all fully designed by Nordic—streamlining the development process, and reducing both the power consumption and footprint of cellular IoT and NR+ solutions.

Reduced power by design

While a high level of integration not only reduces the footprint of the nRF9151 SiP module and the end design, it also lowers system complexity and power consumption. Designs where the modem and cellular module are external to the MCU, inevitably lead to a lot more power being consumed, because an integrated SiP can eliminate the overhead of external high-speed interfaces, reduce duplicated resources, and enable coordinated low-power management between the MCU and modem.

The nRF9151 adds support for Class 5 20 dBm output power, complementing the Class 3 23dBm output power of the existing nRF91 Series SiP modules. This enhancement allows developers to reduce peak currents in their designs by around 40 percent. This is important because when developers are deciding what battery to use in their cellular IoT design, they need to take into consideration that an aging battery won't be able to service the required peak current in the same way as a new battery. However, if you can reduce peak current by 40 percent, then the developer can choose from a wider selection of batteries providing design flexibility.



With the nRF9151 SiP module, Nordic has integrated everything into a single 12 by 11 mm device—all fully designed by Nordic

The nRF9151 also supports eDRX (Extended Discontinuous Reception) to extend battery life by allowing the modem to enter a longer, low-power sleep mode between network interactions. This feature allows the device to remain registered with the network in between listening for any incoming messages, reducing power consumption significantly. Using eDRX, with just under 82 seconds of interval between network interactions, the average power consumption on the nRF9151 is 18 μ A. When you are not using the radio but still attached to the network, the PSM (Power Saving Mode) floor current is 2.7 μ A, not just for the modem but for the whole SiP.

The nRF9151's new firmware stack (v2.0.x) is compliant with the LTE-M/NB-IoT specifications for 3GPP release 14, and also introduces some new power-saving features, including PSM for roaming devices. For roaming devices

using a Mobile Virtual Network Operator (MVNO), a request for a PSM may not be granted if the right agreements are not in place. To get around this Nordic has developed its own emulated PSM, that will act as if you have been granted PSM while keeping the device connected. If the device moves to a location where the PSM is granted because the agreements are in place, it will automatically change to the regular PSM.

Another supported power-saving feature is Release Assistance Indication (RAI). Most cellular IoT devices send small, infrequent messages such as sensor readings, meter reports or location updates. After transmission the device stays connected until the network's inactivity timer expires. During this time (5–10 seconds, sometimes longer), the modem remains powered, drawing tens of mA continuously. RAI allows you to skip the paging period after you send data if you know there is no more data to be sent. This can save about 60 percent of the power consumption over not having the RAI feature.

Integrated SIM support

The nRF9151 SiP also includes integrated SIM support, enabling a purely software-based SIM implementation. Eliminating a SIM card holder not only delivers cost savings, it delivers a more reliable end product as SIM sockets are prone to erosion in harsh conditions encountered in certain applications. It also enables a PCB size reduction because of the absence of a physical slot for the SIM. On top of which it is also a power-saving tool for the developer because you don't have the physical SIM that can drain energy during cellular communication.

Finally, from a power-saving functionality perspective, the nRF9151 provides pre-evaluation of a connection. This feature allows you to ask the modem, before you even send data, what the quality or status of the connection is. If the evaluation is that the connection is poor, instead of sending data you can instead trigger a timer, to say wait 10 minutes, and try again. Similarly if you want to do a firmware-over-the-air (FOTA) update. This connection pre-evaluation enables you to build a more energy conscious application, and avoid spending energy to get data across a link that is poor.

All of these features are making power consumption for cellular IoT much lower than it has ever been before, but it is important developers remember to evaluate modules in real world environments, not from a datasheet or specific data points. If you see numbers on a datasheet that seem too good to be true, they probably are. For example, 'system off' power consumption figures and/or without RAM or GPIO retention might look impressive, but that means the module must renegotiate with the network every time it wakes up, which can lead to 5 or even 10 times higher power consumption overall.

Over the horizon

For developers of IoT tracking solutions that want to provide their customers with uninterrupted global coverage no matter where on the planet the device may



be, the nRF9151 SiP module also supports 3GPP NTN technology in a future firmware release. NTNs support NB-IoT via satellites rather than relying on terrestrial cellular infrastructure. The technology is serviced by a satellite constellation, complemented by cellular IoT infrastructure where it is available. The result is access to global cellular networks that are accessed in a similar way to terrestrial LTE-M/NB-IoT networks. The core cellular network allows NTN and terrestrial networks to seamlessly interact, enabling mobile IoT devices such as asset trackers to roam from a ground network to NTN, in the same way roaming occurs on today's terrestrial networks.

Getting started with the nRF9151

Getting started with the nRF9151 couldn't be easier. Available with SIM Cards from Onomondo and Wireless Logic preloaded with free data, the nRF9151 Development Kit (DK) is the ideal starting point for cellular IoT application development. The DK is supplied pre-flashed with Nordic's Serial LTE Modem application for interfacing through AT Commands. This also enables the nRF9151 to be used as a stand-alone cellular modem, simplifying its integration into existing customer solutions. Developers can get started with other firmware samples from the Quick Start tool, found in nRF Connect for Desktop, Nordic's cross-platform development software.

With a streamlined development process, end-to-end support, and by reducing both the power consumption and footprint of end product designs, the nRF9151 provides cellular IoT, NR+ and NTN solution developers everything they need to get started, all they need to bring is the idea.

A Nordic webinar entitled [Meet the nRF9151 SiP for cellular IoT](#) is available from: <https://tinyurl.com/nznb658>



Tech Check

The nRF9151 comprises an Arm Cortex-M33 programmable application processor combined with 1MB Flash and 256 KB RAM, a multimode LTE-M/NB-IoT modem with NR+ support and GNSS, power management, RF Front End, passives and crystals. The SiP module supports 3GPP release 14 LTE-M/NB-IoT and the integrated modem ensures global connectivity without regional limitations.

Nordic Product Guide

This handy summary describes all of Nordic's IoT solutions



Full product details at: www.nordicsemi.com/Products

RF SoCs and SiPs

	nRF91 SERIES	nRF70 SERIES	nRF54 SERIES	nRF54 SERIES	nRF SERIES	nRF52 SERIES
IC TYPE	Wireless SiP	Wi-Fi Companion IC	Wireless SoC	Wireless SoC	Wireless SoC	Wireless SoC
ICs	nRF9160, nRF9151	nRF7002, nRF7001, nRF7000	nRF54H20	nRF54LM20B, nRF54LM20A, nRF54L15, nRF54L10, nRF54L05, nRF54LV10A	nRF5340	nRF52840, nRF52833, nRF52832, nRF52820, nRF52811, nRF52810, nRF52805
WIRELESS	LTE-M, NB-IoT, GNSS	Yes				
	NON-TERRESTRIAL NETWORKS (NTN), DECT NR+	Yes (nRF9151 only)				
	DUAL-BAND Wi-Fi 6		Yes (with host)	Yes (with nRF70 Series)	Yes (with nRF70 Series)	Yes (with nRF70 Series)
	WI-FI LOCATIONING	Yes (with nRF70 Series)	Yes (with host)	Yes (with nRF70 Series)	Yes (with nRF70 Series)	Yes (with nRF70 Series)
	BLUETOOTH LE			Yes	Yes	Yes
	BLUETOOTH CHANNEL SOUNDING			Yes	Yes	
	BLUETOOTH LE AUDIO			Yes		Yes
	BLUETOOTH MESH, ZIGBEE, THREAD, MATTER, AMAZON SIDEWALK, NFC			Yes	Yes	Yes
	ESB AND 2.4 GHz PROPRIETARY PROTOCOLS			Yes up to 4 Mbps	Yes up to 4 Mbps	Yes up to 2 Mbps
MCU FUNCTIONALITY	PROCESSOR	64 MHz Arm Cortex-M33		2x Arm Cortex-M33, up to 320 MHz	128 MHz Arm Cortex-M33	2x Arm Cortex-M33, up to 128 MHz
	AI ACCELERATOR				128 MHz NPU	
	COPROCESSOR			2x RISC-V, 320 MHz and 16 MHz	RISC-V, 128 MHz	
	NVM	1MB		2 MB	Up to 2 MB	1MB + 256 KB
	RAM	256 KB		1MB	Up to 512 KB	512 KB + 64 KB
	STANDARD PERIPHERALS AND INTERFACES	Yes	High-speed SPI/QSPI	Yes	Yes	Yes
	HIGHLIGHTED DIGITAL INTERFACES			High-speed USB, CAN-FD	High-speed USB	Full-speed USB
SECURITY	ISOLATION	TrustZone		Secure Domain and TrustZone	TrustZone	TrustZone
	CRYPTOGRAPHIC ACCELERATOR	Yes		Yes with side-channel leakage protection	Yes with side-channel leakage protection	Yes
	TAMPER DETECTORS			Yes	Yes	
	GPIOs	32		64	Up to 66	48
	PACKAGE TYPES	LGA	QFN, CSP	CSP	QFN, CSP	aQFN, QFN, CSP
	MINIMUM PACKAGE SIZE	12x11x1 mm	3.8x3.4 mm	4.7x4.3 mm	1.9x2.3 mm	3.5x3.6 mm
	Neuron EDGE AI MODELS	Yes	Yes	Yes	Yes	Yes
	COMPATIBLE PMICs	nPM1300, nPM6001	nPM6001	nPM1300, nPM1100, nPM6001	nPM1300, nPM1100, nPM6001	nPM1300, nPM1100, nPM6001
	nRF Cloud SERVICES	Yes	Yes	Yes	Yes	Yes

PMICs		nPM FAMILY				
TYPE	PMIC	nPM6001	nPM2100	nPM1304	nPM1300	nPM1100
BUCK REGULATOR	4	●	●	●	●	●
BOOST REGULATOR			1			
BATTERY CHARGER				●	●	●
LDO			1	2	2	2
LOAD SWITCH			1	2	2	2
TERMINATION VOLTAGE				3.5 to 4.65 V	3.5 to 4.45 V	4.1 to 4.2 V or 4.25 to 4.35 V
MAX CHARGING CURRENT				100 mA	800 mA	400 mA
POWER PATH MANAGEMENT						●
THERMAL PROTECTION						●
BATTERY COMPATIBILITY				LiMnO ₂ , AA/AAA1S or 2S, Silver Oxide	LiFePO ₄ , Li-ion, LiPo	LiFePO ₄ , Li-ion, LiPo
INPUT VOLTAGE	3 to 5.5 V		0.7 to 3.4 V	4 to 5.5 V	4 to 5.5 V	4.1 to 6.7 V
USB COMPLIANCE				Type-C	Type-C	
REGULATED OUTPUT VOLTAGE	0.5 to 3.3 V		1.8 to 3.3 V	1 to 3.3 V	1 to 3.3 V	1.8 to 3 V
MAX CURRENT PER DC/DC	550 mA, 200 mA, 150 mA		150 mA	200 mA, 200 mA	200 mA, 200 mA	150 mA
SYSTEM MONITORING				Battery-voltage and -temp (derived from die temp)	System-, input bus- and battery-voltage; battery-current and -temp; die temp	System-, input bus- and battery-voltage; battery-current and -temp; die temp
FUEL GAUGE				●	●	●
HARD SYSTEM RESET				●	●	●
TIMED WAKE-UP (HIBERNATE)				●	●	●
WATCHDOG TIMER	●		●	●	●	●
SHIP MODE	●		●	●	●	●
BROWN-OUT DETECTOR	●		●	●	●	●
LED DRIVERS, GPIOs	0,3		0,2	3,5	3,5	2,0
CONTROL INTERFACE	TWI		TWI	TWI	TWI	Pin-configurable
REGULATORY COMPLIANCE	CE, RoHS		CE, RoHS	CE, JEITA, RoHS	CE, JEITA, RoHS	CE, JEITA, RoHS
OPERATING TEMPERATURE	-40 to 85°C		-40 to 85°C	-40 to 85°C	-40 to 85°C	-40 to 85°C
EVALUATION KITS	nPM6001EK		nPM2100EK	nPM1304EK	nPM1300EK	nPM1100EK
PACKAGE OPTIONS	2.2x3.6 mm CSP		4x4 mm QFN16, 1.9x1.9 mm CSP	5.5 mm QFN32, 3.1x2.4 mm CSP	5x5 mm QFN32, 3.1x2.4 mm CSP	4x4 mm QFN24, 2.1x2.1 mm CSP

Cloud lifecycle services

nRF Cloud powered by Memfault



Description:

Following Nordic's acquisition of Memfault, [nRF Cloud](#) now provides device management, embedded observability and location services, optimized for all Nordic's low power IoT devices. Both device-to-cloud and cloud-to-cloud implementations are supported as are CoAP and MQTT protocols.

Services:

nRF Cloud provides critical cloud operational infrastructure and modern embedded development tools pre-integrated and power-optimized for Nordic devices. With nRF Cloud teams can accelerate development, launch with more confidence and operate in production more efficiently.

nRF Cloud device management includes general fleet management services, message routing and storage, and a firmware-over-the-air (FOTA) update function, whereby modem and/or application firmware can be updated automatically and remotely. Device management simplifies management of IoT fleets in the field and ensures they remain secure and reliable across their lifecycle.

nRF Cloud embedded observability automates the collection of core dumps, crash logs, and performance metrics from devices in the field and makes it available for analysis and investigation. With observability, engineering teams can identify and resolve faults in the field much faster, monitor performance easily, and identify improvements based on real world data. This helps teams accelerate field testing, improve reliability in production, and ship software updates with more confidence.

nRF Cloud location services include Assisted GPS, Predictive GPS, Wi-Fi, single-cell and multi-cell, and supply accurate and power-efficient location data for IoT devices employing nRF91 Series products. The Wi-Fi feature requires a Wi-Fi scanning IC, such as one of the nRF70 Series Companion ICs. Each location feature has accuracy and power efficiency benefits, so switching between different location services during operation can be useful.

All nRF Cloud services are available to try for free for Nordic customers on up to 10 non-production devices, can be integrated in minutes, and scale at very low cost.

Tech Spec

Supported products

All wireless products

Location services

A-GPS, P-GPS, Wi-Fi, Single-Cell, Multi-Cell

Additional features

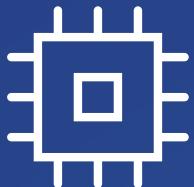
Device-to-cloud and cloud-to-cloud use cases. CoAP, MQTT and REST API support

Applications

Consumer electronics, Industrial, smart appliances, access control, asset tracking, RTLS

Your complete wireless solution partner

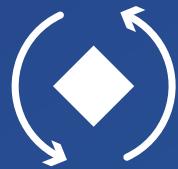
Market leadership across three fundamental pillars



Next-generation
hardware



Embedded
software



Cloud lifecycle
services

Transforming how connected products
are built, deployed, and maintained

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