

WIRELESS QUARTER

Issue 3, 2023

# Building the Clean Dream

The IoT is promising a smarter, greener way to manage urban waste and pollution

**A BRIGHTER TOMORROW:**  
PREPARING THE NEXT  
GENERATION OF  
DIGITAL INNOVATORS

**SAFETY FIRST:**  
WIRELESS TECH  
KEEPS US SAFE  
AT WORK AND PLAY

**YOU ARE HERE:**  
CELLULAR SERVICES AND  
Wi-Fi COMPLEMENT GNSS  
TO TRACK VALUABLE GOODS



INDUSTRY JOINS FORCES  
TO ACCELERATE RISC-V

MEET THE INTERNET OF  
MEDICAL THINGS

INSIDE THE nPM1300  
POWER MANAGEMENT IC







OCT 2023 - MAR 2024

We are hitting the road again, presenting our world-class low power solutions within cellular IoT, DECT NR+, Wi-Fi, Bluetooth LE, power management, Matter, LE Audio, and security!

OCT 17 Trondheim, Norway

OCT 18 Oslo, Norway

OCT 31 Utrecht, The Netherlands

NOV 7 Vilnius, Lithuania

NOV 8 Krakow, Poland

NOV 14 Zürich, Switzerland

NOV 15 London, United Kingdom

NOV 21 Paris, France

NOV 23 San Sebastian, Spain

NOV 28 Munich, Germany

DEC 12 Stockholm, Sweden

DEC 13 Helsinki, Finland

JAN\* Israel (location TBD)

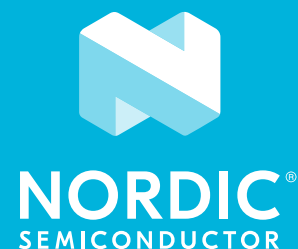
FEB/MAR\* Cape Town, South Africa

FEB/MAR\* Durban, South Africa

FEB/MAR\* Johannesburg, South Africa

SIGN UP

[nordicsemi.com/ntt-emea](https://nordicsemi.com/ntt-emea)



\* Dates to be confirmed

# Welcome

Svein-Egil Nielsen

CTO and EVP R&D



The IoT is already having a major impact on our lives. Sometimes its effect is obvious, for example when our fitness wearable tells us we've run faster than before. Personal safety is another example. The IoT helps prevent accidents, injuries and threats. (Find out more about how tech keeps us safe in this edition ([see pg20](#)).)

But it's the IoT's more subtle effects that are having the most dramatic impact. One example has a personal connection. My wife grew up in Seoul and whenever she was caught in the city's rain she took a shower to clean off any grime. This was not necessary when we were in the fresher air of Oslo. But now the South Korea capital is using the IoT to clean up its act. The city uses wireless sensors to check the level of particulate matter on the streets, and when it reaches a certain level, trucks are sent out to hose away the contaminants. This, and other measures such as limiting diesel vehicles, resulted in the skies over the city in 2022 being at their cleanest since 2008 (according to *The Korea Times*). See how the IoT is helping us clean up cities in an article in this edition ([pg14](#)).

Seoul's success is but one example of how the IoT is already impacting our lives. The long term promise is huge. At Nordic we see the IoT as enabling us to do ten times more with ten times less in every area it's applied. For example, the IoT could help reduce our energy consumption while still ensuring everyone on the planet has access to the electricity they need to lead happy and healthy lives.

It will still take some time before the IoT reaches its full potential in areas such as smart grids, industrial automation, healthcare and education. Our strategy at Nordic is to invest in the development and deployment of massive IoT technologies—such as [Bluetooth LE](#), [Wi-Fi](#), [DECT NR+](#) and [cellular IoT](#)—to bring that day much closer.



The long term promise of the IoT is huge. At Nordic we see the IoT as enabling us to do ten times more with ten times less in every area it's applied

Wireless Quarter is contract published on behalf of Nordic Semiconductor by Ecritech Media

#### Editor

Steven Keeping [sk@ecritech.media](mailto:sk@ecritech.media)

#### Assistant Editor

Chris Williams [cw@ecritech.media](mailto:cw@ecritech.media)

#### Contributing Editor

Kalon Huett [kalon@ecritech.media](mailto:kalon@ecritech.media)

#### Production Editor

Andrew Woolls-King [awk@ecritech.media](mailto:awk@ecritech.media)

#### Creative Director

Sam Grimmer [sam@ecritech.media](mailto:sam@ecritech.media)

#### Prepress

Nathan Sargent

#### Print & Distribution

Printech Europe



The Bluetooth® word mark and logos are registered trademarks owned by the Bluetooth SIG, Inc. and any use of such marks by Nordic Semiconductor is under license.

© Nordic Semiconductor 2023



To subscribe to WQ visit [www.nordicsemi.com/wqmag](https://www.nordicsemi.com/wqmag)

## Contents

News	4
News Extra	10
Nordic extends Wi-Fi product range with new companion IC	
Analysis	12
The Internet of Medical Things will transform healthcare	
Comment	13
The importance of massive IoT	
The Clean Dream	14
The IoT promises a smarter way to manage waste and pollution	
Safety First	20
Wireless tech is keeping us safe at home, work and play	
A Brighter Tomorrow	24
The BBC micro:bit is teaching the next digital innovators	
You are Here	28
Keeping track of valuable goods	
Nordic Inside	30
Lilbit pet tracker	
Case Study	32
Orthopedic sensor improves post-surgery patient outcomes	
Industry Viewpoint	33
Ken Everett, CEO, Digital Matter	
Tech Zone	34
Tech Briefing	36
Inside the nPM1300 Power Management IC	
Nordic Product Summary	38





## Corporate Partnership

### Leading industry players join forces to accelerate RISC-V

Semiconductor companies Robert Bosch, Infineon Technologies, [Nordic Semiconductor](#), NXP Semiconductors and Qualcomm Technologies have invested in a company to advance the adoption of open-source RISC-V architecture by promoting hardware development.

Formed in Germany, the company will accelerate the commercialization of future products based on RISC-V. The company will be a single source to enable compatible RISC-V based products, provide reference architectures and help establish solutions widely used in the industry. Initial application focus will be automotive but with an eventual expansion to include mobile and IoT.

At its core, RISC-V encourages innovation allowing any company to develop cutting edge, customized hardware based on an open-source instruction set. Further adoption of the RISC-V technology will promote more diversity in the electronics industry – reducing the barriers to entry for smaller and emergent companies and enabling increased scalability for established companies.

The company calls on industry associations, leaders and governments to join forces in support of this initiative which will help



increase the resilience of the broader semiconductor ecosystem. The company formation will be subject to regulatory approvals in various jurisdictions. "Nordic Semiconductor is a committed and enthusiastic supporter of the RISC-V initiative and stands ready to drive this important project forward," said Svein-Egil Nielsen, CTO/EVP R&D, Nordic Semiconductor, in a statement.

"Nordic's IoT solutions represent the leading edge of low power wireless technology and to retain that position it's critical we maintain continuous access to efficient and powerful embedded microprocessors. An open collaboration with like-minded companies to continually enhance innovative RISC-V microprocessor IP and ensure a robust and reliable supply of the technology is the ideal answer to this challenge."

## Sports & Fitness

### Casio watch offers 16 hour battery life with non-stop GPS

Multinational electronics giant Casio has launched a new addition to its sports inspired G-SQUAD line in the G-SHOCK family of shock resistant watches. The lightweight, water-resistant GBD-H2000 provides support for a range of different activities

including running, cycling and gym workouts. Equipped with Nordic's [nRF52833](#) SoC for wireless connectivity, the watch integrates GPS, a heart rate sensor, as well as magnetic, pressure, temperature, accelerometer and gyroscope sensors to record activity data. The [Bluetooth LE](#) connectivity not only allows the user to review their training and sleep analysis data via the Casio Watches iOS and Android app, but also enables various notification functions as well as phone finding and automatic time adjustment. In operation with continuous GPS and heart rate function,

the GBD-H2000 offers around 16 hours of battery life between recharge. "Casio is a pioneer in watch tech and the GBD-H2000 continues that tradition," says Bjørn 'Bob' Brandal, VP of Sales and Marketing, APAC with Nordic. "Today's consumers demand functionality from their watch, but they also want extended battery life. Alongside Casio's technology, Nordic's ultra low power wireless chips are uniquely able to meet this requirement."



## Connected Health

### Wearable provides walk cueing for people with Parkinson's disease

U.K. based gaitQ is launching a wearable device that provides walk cueing for people with Parkinson's disease. The gaitQ Tempo is made up of a handheld controller and two leg worn devices that use vibrational cues to help people with Parkinson's maintain a more fluid and stable gait.

"Parkinson's is the fastest growing progressive neurological disorder in the world," says Philippa Tsirgiotis, Product Engineer at gaitQ. "Loss of gait control is common, resulting in increased fall risk, loss of confidence and reduced activity. Additionally, early signs of Parkinson's are difficult to detect, as subtle gait abnormalities or changes in activity are often missed until the condition progresses."

The gaitQ Tempo employs Nordic Semiconductor's [nRF5340](#) SoC and uses its 2.4 GHz multiprotocol radio for wireless connectivity between the device's three parts for control and time synchronization.

Upcoming clinical trials will accelerate product development related to the analysis of gait data collected from the device's six-axis Inertial Measurement Units (IMUs). The data is



sent to the Cloud via a USB link allowing gait quality reports to be shared with healthcare providers. In future, the data could help monitor the progression of Parkinson's disease, and allow for later gaitQ products to provide more personalized service.

Using Li-Po batteries (with a 600 mAh battery in the leg worn devices and a 400 mAh battery in the controller), gaitQ Tempo can function for up to 36 hours between charges. "Thanks to past experience with Nordic solutions, we were confident that we could easily meet our [battery] lifetime requirements," says Tsirgiotis.

## Sustainability

### Smart buoy provides location updates for fishing equipment

Norwegian firm Innomar Ocean Technology has launched a smart buoy designed to help locate fishing traps, longlines and nets. The Sunfish Smart Buoy uses Nordic's [nRF9160](#) SiP cellular IoT solution to transmit its location to the Cloud. Users can then monitor the tracked device location from their smartphone.

"[The product] can reduce the time and cost spent looking for a catch and equipment, and therefore minimize the CO<sub>2</sub> emissions of each retrieval trip. This is responsible and profitable fishing," says Simen Dovland, CTO at Innomar.

The nRF9160 SiP combines GNSS with cellular network location data for precise position monitoring, which helps reduce the number of traps being lost in the ocean.

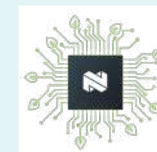


This also helps decrease instances of 'ghost' fishing, where lost traps continue to catch fish and other sea creatures, which is detrimental to conservation efforts and can result in the unnecessary deaths of marine life.

Using the DigiCatch app, users can see the location of all their devices, as well as view the distance to each buoy in meters. Users will also be alerted if a device moves outside of the set perimeter. When locating fishing gear, the app provides a direction arrow for easy navigation, and can show current direction in 'real-time'. The app can also be integrated with chart plotters, including Olex and BarentsWatch.

## In Brief

### NORDIC RECOGNIZED FOR CLIMATE LEADERSHIP



Nordic Semiconductor has been named one of [Europe's Climate Leaders 2023](#) by the *Financial Times* in partnership with Statista. Nordic ranked number 26 with a score of 75.1 points, making it the highest ranked Norwegian company on the prestigious list of 500 companies. The methodology for this third edition of Europe's Climate Leaders was tightened to reflect the increasing scrutiny from consumers and regulators of environmental performance. "I am honored [by] the recognition we've received for our dedication and initiatives toward promoting sustainable development," says Linda Pettersson, Chair of Nordic Semiconductor [ESG](#) Committee.

### WIRELESS SENSORS MONITOR WATER QUALITY



Supported by a three year seed grant from Fralin Life Sciences Institute, a research team from Virginia Tech is creating wireless sensor networks to survey microbial threats to water quality. The project, Technology-enabled Water Surveillance and Control, reflects the "one water" concept that views water quality as important to society and requires an integrated approach to policy planning and implementation. One recent example of successful water monitoring is wastewater-based surveillance, which has proven to be a useful tool to quantify the spread of viral pathogens such as the COVID-19 virus and antibiotic resistance within communities.

### HEADBAND DETECTS EARLY STAGES OF ALZHEIMER'S



A team of researchers from the University of Colorado and Washington University in St. Louis have identified ways a wireless electroencephalography (EEG) headband can be used as a "fitness tracker for brain health" that detects the early stages of Alzheimer's during sleep. The device uses EEG to detect brain wave patterns related to memory reactivation in sleep. Researchers analyzed data from 205 adults, identifying notable reactivation issues linked to protein levels such as amyloid and tau. Study results identify a relationship between EEG readings and molecular changes indicative of pre-symptomatic Alzheimer's disease.



## Sports &amp; Fitness

## Electric jetboard offers wireless remote control

Sweden based Radinn has developed a range of electric jetboards linked to a handheld remote controller used to adjust acceleration. Depending on the ride mode selected and weight of the rider, the Carve, X-Sport and Freeride jetboards can reach a top speed of 60 km/h, and have a battery life of up to 45 minutes. The jetboard and handheld remote controller integrate a u-blox BMD-340 module, powered by Nordic's [nRF52840](#) SoC, to provide Bluetooth LE wireless connectivity between the board and the handheld controller, as well as the user's smartphone.

"The electric jetboards embody the next generation of watersports," says Aleksandar Rodzevski, Head of Platforms at Radinn. "They let you soar across the water at incredible speeds with virtually no sound, using a handheld remote that provides effortless acceleration control."

The jetboards feature a modular design enabling the user to detach the battery pack and jetpack from one board and attach them to another providing the versatility



to use multiple boards for different surf conditions. All the user has to do is insert the fully charged battery into a board, set the performance level in the Radinn smartphone app and drop the board into the water.

As well as providing low latency wireless connectivity between the remote controller and the jetpack for responsive throttle control, the nRF52840 SoC provides Bluetooth LE connectivity between both the jetpack and battery and the smartphone app. From the app the user can configure devices

and view rider logs from completed rides.

In addition to the Nordic-powered module, the jetboards integrate a host of sensors and a GPS module, overseen by the nRF52840 SoC's Arm processor. Accelerometer and gyroscope sensors provide rider data on speed and performance, as well as crash/impact detection. The humidity and temperature sensors supervise jet pack and battery condition and maintenance. The GPS module provides positioning and speed parameter data via the Radinn app.

## Smart Health

## Wireless device offers catheter-free bladder pressure monitoring

A [wireless medical](#) device enables accurate, non-invasive monitoring of bladder pressure in patients with urinary problems, reports a pilot study in the American Urological Association's (AUA) *The Journal of Urology*.

Patients with incontinence and other urinary problems routinely undergo urodynamic testing to assess functioning of the lower urinary tract. However, these tests have important limitations – including the need for a catheter and instillation of fluid into the bladder, which can be uncomfortable for the patient and may not reflect normal daily functioning.

The UroMonitor was developed as a non-invasive approach for assessing function of the lower urinary tract, without the need for catheter placement. It is a small, flexible device—no more than five centimeters across—that is placed into the patient's bladder. Once in place, the device wirelessly transmits bladder pressure data to a small



radio receiver taped to the lower abdomen.

"The UroMonitor is the first device to enable catheter-free telemetric ambulatory bladder pressure monitoring in humans," says Senior Author, Margot S. Damaser, PhD, of Cleveland Clinic.

"With further evaluation, the solution may provide a safe

and reliable way to identify bladder events under more natural conditions, compared to standard testing in the urodynamic lab."

In a pilot study to evaluate clinical safety and accuracy, the device was tested in 11 women (median age 67 years) with symptoms of overactive bladder. After the patients underwent initial urodynamic testing, the device was inserted into the bladder via the urethra. Urodynamic testing was then repeated, with simultaneous transmission of bladder pressure data. Ninety-eight percent of bladder pressure events detected by urodynamic testing were accurately detected by the UroMonitor device.

## Logistics &amp; Transport

## Asset tracker solution provides heavy vehicle tracking

IoT technology company Jimi IoT has launched an asset location terminal designed for heavy vehicle, cargo and asset management. The LL701 long standby asset tracker is IP67-rated for operating in harsh environments and can help fleet managers effectively reduce fleet management costs by monitoring idle time, optimizing fleet use and eliminating unlawful vehicle usage. The device's light sensor also prevents tampering, as an alarm will activate if disassembly is attempted.

The LL701 includes three modes: 'standby' (which reduces power consumption by only reporting positioning information once every 24 hours), 'tracking' (which is used when an item needs to be located immediately, transmitting the location every 60 seconds), and 'recovery' (which can be activated

when the device is not in use). The tracking and transmission capability is enabled by Nordic Semiconductor's [nRF9160](#) low power SiP with integrated LTE-M/NB-IoT modem and GNSS. The nRF9160 SiP combines GNSS with cellular network location data for precise position monitoring.

"The cellular connectivity is key to this solution, as it provides a robust remote connection to the server," says Sam Huang, Product Manager at Jimi IoT.

"Once the positioning information from the LL701 has been transmitted, it can then be distributed to various management and business interfaces."



## Industrial Automation

## Monitoring devices detect equipment issues

Atomation has launched a series of remote equipment monitoring devices for use in manufacturing, mining, utility and agriculture sectors. The rugged Atoms include a variety of sensors, allowing users to monitor variables such as temperature, vibration, moisture, pressure, distance, tilt and impact. The Atoms reduce outages and downtime for most types of machinery and equipment. For example, they can detect whether a motor is vibrating more than previously.

The data is sent to a gateway via Bluetooth LE wireless connectivity, using Nordic Semiconductor's [nRF52840](#) SoC. The data is then transmitted to the Cloud from the gateway.



## Internet of Things

## Data logger supports sensor integrations for remote monitoring

An IoT data logger developed by Digital Matter enables IoT remote monitoring applications such as environmental monitoring, and resource and equipment management. The Hawk is a robust, modular, plug-and-play IoT data logging solution and sensor hub designed to support an extensive range of sensor integrations. It is available in several connectivity, power and housing variations.

The Hawk's architecture provides many options for interfacing to sensors that report data to be used for analysis or generating actions. The wide array of sensors currently integrated into the unit includes multiple temperature and humidity, tilt switches, pressure, thermal cameras, ultrasonic range and weather stations.

The device employs the computational

power of Nordic's [nRF9160](#) SiP's application processor to oversee the sensors and collate the relevant data. The SiP's multimode LTE-M/NB-IoT modem enables the data to be measured, logged and securely transmitted to any end platform via TCP Direct or HTTPS Webhook on a cellular IoT network. The SiP's integrated support for an external antenna can further increase range.

Powerful onboard task management functionality offers the ability to schedule tasks or run events based on sensor thresholds. For example, the Hawk can be configured to turn on a pump if the tank level gets too low, or to maximize battery life by setting it to regularly sample temperature but only upload to the Cloud if the temperature samples fall outside an allowable range.



## In Brief

### NORDIC EXPANDS GLOBAL PRESENCE IN ISRAEL



Nordic Semiconductor has expanded its presence in Israel following a new [distribution agreement](#) with major electronics distributor, Eastronics.

The agreement covers distribution, technical support and RF design services for Nordic's portfolio of wireless solutions in the country. In business for nearly 70 years, Eastronics says it is the leading independent high tech distribution company in Israel, servicing diverse end markets including IoT, industrial, security, automotive and retail. The company will supply Nordic's short range multiprotocol wireless and low power cellular IoT connectivity hardware, firmware, development tools and reference designs.

### BOOM TIME FOR THE SMART HOME MARKET



Fortune Business Insights reports the global [smart home market](#) size, which was valued at \$80.21 billion in 2022, is projected to grow from \$93.98

billion in 2023 to \$338.28 billion by 2030, exhibiting a CAGR of 20.1 percent during the forecast period. Based on device type, the market is classified into safety and security devices, energy and water control, climate control, lighting control and consumer electronics. The consumer electronics segment is projected to hold the largest market share due to increasing deployment of smart assistants and speakers. However, the energy and water control segment is expected to record the highest CAGR.

### NORDIC SUPPORTS NEW KNX IOT PROTOCOL



Nordic Semiconductor is supporting the [KNX IoT protocol](#) with membership of the [KNX Association](#). The support offers developers of

commercial building and smart home automation products a solution for evaluating KNX IoT technology and building prototypes. The Association comprises over 500 manufacturers and more than 100,000 system integrators, and is responsible for the promotion of the KNX standardized communication protocol for buildings and smart homes. It also provides an open source implementation of the KNX IoT Point API, which enables connectivity between KNX devices through IPv6 and [Thread](#).



## Connected Health

## Inflatable hip airbag reduces impact of falls

Dutch company Wolk is producing a smart wearable airbag designed for use by the elderly or those at risk of serious falls.

The Wolk can be worn discretely underneath the user's clothing, and is available in four sizes in both a belt and shorts version. If it detects that the wearer is about to fall, the device will activate to inflate the airbag within 75 milliseconds, lessening the impact of the fall on the hip and reducing the severity of hip injuries.

"The Wolk uses six motion sensors to register every movement up to 500 times per second," says Filippo van Hellenberg Hubar, CEO at Wolk. "The software then processes this data, and determines continuously whether the user might be falling. When the advanced algorithm recognizes a fall, the airbag will inflate and protect the hip against injury."

The proprietary algorithm is supervised using the computational power of Nordic's nRF9160 SiP's Arm Cortex-M33 processor.



Once the software has detected a fall and the airbag has inflated, an alarm is triggered, and a notification is sent to the Cloud using the nRF9160 SiP's LTE-M/NB-IoT connectivity. From there the notification is forwarded to a nominated family member or friend via the cellular network. From the Cloud based dashboard, users can view live data from the Wolk, as well as historical

information (such as previous fall alarms). The Wolk can achieve up to 20 hours of battery life between charges using a Li-Po battery, depending on the activity level of the wearer.

"Power consumption was key to this application, so the excellent power efficiency and power management of the Nordic SiP made it the obvious choice," says van Hellenberg Hubar.

## Smart Health

## Vocal activity monitor helps prevent voice fatigue

Researchers at Northwestern University in the U.S. have developed what they claim is the first smart wearable monitoring device of its kind to continuously track how much people use their voices – alerting them to overuse before vocal fatigue and potential injury set in. Vocal fatigue is a common condition that occurs when overused vocal folds swell, making the voice sound raspy and lose endurance.

Developed by an interdisciplinary team of materials scientists, biomedical engineers, opera singers and a speech-language pathologist, the battery powered wireless device sits on the upper chest to sense the subtle vibrations associated with talking



and singing. The captured data is streamed via Bluetooth LE to the user's smartphone or tablet, so they can monitor their vocal activities throughout the day and measure cumulative total vocal usage. Custom machine learning (ML) algorithms distinguish the difference between speaking and singing, independent of ambient sounds, enabling singers to separately track each activity.

With the associated app, users can set their personalized vocal thresholds. When they near that threshold, their smartphone or smartwatch provides an alert.

## Smart Agriculture

## Irrigation sensor enables water level notifications

A land irrigation monitoring solution launched by DitchFlow allows irrigators to reduce labor without sacrificing irrigation quality. The Nordic nRF9160 SiP-powered Land Irrigation Sensor is targeted at farmers that flood irrigate their fields within borders.

By placing the sensor in the irrigated land, users can remotely receive email/text notifications when the water reaches a specific point.

"Once the irrigator is notified, they can go to the ditch where the water is delivered and change the 'set' – taking away human error associated with not knowing when the water will reach that specific point," explains Ryan Mamer, Owner, DitchFlow.



## Semiconductor Industry

## U.K. scientists pledge to address electronics designer shortage

U.K. scientists are trying to take the lead in driving the future of semiconductors by joining with big tech businesses to train a new generation of skilled workers. Experts from the University of Southampton have joined the launch of the new Semiconductor Education Alliance which intends to address global shortages of electronic device designers and upskill the existing workforce.

"We have collaborated with individual partners over many years, but uniting as a global alliance gives a shared focus in addressing the design skill challenge," says Professor Geoff Merrett from the University of Southampton. "Southampton will lead on developing two important global communities of practise among the academic community. The first to improve delivery of skills in electronic design and the second in using state-of-art design to improve academia's ability to improve research outcomes."

"The alliance's goals of creating global communities of practice, promoting the sharing of knowledge and developing the skills we need to build a better, more sustainable, and inclusive world are goals we share in



common, and we look forward to addressing these shared challenges," adds Professor Mark Sparing, Vice-President Research and Enterprise at the University of Southampton.

Developing skills and talent is one of the three key initiatives identified by the U.K. government's new semiconductor strategy—alongside new research and better infrastructure—which it said the industry has recognised as barriers to progress. The alliance intends to address these challenges by bringing together industry and academic experts to upskill the industry by improving education, apprenticeships and industry-led learning. (See pg24.)

## Asset Tracking

## Asset tracker operates on harvested indoor light energy

A batteryless, indoor light-powered Bluetooth LE tag, developed by U.K. based Lightricity, provides a sustainable IoT asset tracking solution with a carbon footprint reduction of over 50 percent compared to battery-powered alternatives, says the company.

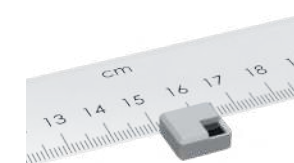
The plug-and-play 4EverTrack micro is compatible with a wide range of real time location systems (RTLS) including all Bluetooth LE based indoor navigation and wayfinding solutions used in, for example, hospitals, retail centers, airports, warehouses and exhibition venues. The tag also incorporates a temperature sensor for applications requiring environmental monitoring.

The integrated Nordic Semiconductor nRF52805 SoC's Arm Cortex-M4 processor provides the core processing capability for

the 4EverTrack micro to oversee the analysis of location and sensor data. The Nordic SoC-enabled Bluetooth LE wireless connectivity is used to relay this data to any Bluetooth gateway or a user's smartphone.

The 4EverTrack micro tracker comes in an ultra compact (10 by 10 by 2 mm) PCB form factor and is powered by photovoltaic (PV) energy harvesting through Lightricity's proprietary indoor PV cell (solar panel).

The tag is designed to operate from a light level as low as 50 lux to bright ambient light conditions of over 1000 lux. By integrating PV energy harvesting technology into their products and applications, solution providers and end users can eliminate the maintenance time and costs associated with battery recharge or replacement.



## By the Numbers

# \$14.26 billion

by 2028

The [cellular IoT](#) market size is expected to grow from \$5.0 billion in 2023 to \$14.3 billion by 2028 at a CAGR of 23 percent during the five-year forecast period, according to analyst Mordor Intelligence. Rapidly growing nations, rising adoption of advanced technologies and an increasing number of connected devices are some of the major factors expected to fuel this global growth, reports the firm, along with the rise in digitalization and automation.

# \$52.4 billion

growth over 5 years

The [wearable technology](#) market size will grow to \$52.4 billion from 2021 to 2026 and register a CAGR of 14 percent, according to a report by market research firm, Technavio. The analyst estimates North America will contribute 48 percent to the growth of the global market during the forecast period, with the popularity of wearable devices as a payment method set to facilitate market growth in the region. The presence of crowdfunding to help startups raise funds is also contributing to the growth.

# \$7.4 billion

by 2031

Transparency Market Research reports the global GPS tracking device market could reach a value of \$7.4 billion by 2031 – up from \$2.8 billion in 2022. According to the firm, this market growth will be driven by a combination of the increased adoption of fleet and asset tracking solutions for commercial and passenger vehicles, GPS tracking devices in security and resource management, and rescue operations.



## Wi-Fi

# Nordic extends Wi-Fi product range with companion IC for cost-optimized designs

The nRF7001 companion IC offers a low cost Wi-Fi 6 solution for low power Wi-Fi IoT products requiring 2.4 GHz connectivity only

Wi-Fi's widespread adoption has been driven by the technology's suitability for wirelessly connecting consumer PCs, mobile computers, smartphones and many other devices to the Internet. The Wi-Fi Alliance, an organization that promotes the technology, says Wi-Fi's economic value is set to reach a staggering \$5 trillion by 2025. More recently, the latest release of the IEEE 802.11ax standard, known as Wi-Fi 6, has added capabilities to the technology that make it more suitable for IoT applications and which will see its reach extend further. (See WQ [Issue 2, 2022 pg36](#).) Wi-Fi also forms a key part of the Matter smart home standard, a technology designed to bring interoperability to the connected home. (See WQ [Issue 1, 2022 pg14](#).)

Building on its low power heritage and the engineering expertise of the team the company gained as part of its acquisition of Imagination Technologies' Wi-Fi assets (see WQ [Issue 4, 2020 pg7](#)) Nordic has launched the [nRF70 Series](#) of Wi-Fi companion ICs. The first product in the series was the nRF7002, a 2.4 and 5 GHz dual band companion IC bringing low power and secure Wi-Fi to the IoT. Now the company has announced the nRF7001, a low cost Wi-Fi 6 solution for IoT products requiring 2.4 GHz single band connectivity only.

Like its sister product, the nRF7001 companion IC can be used together with Nordic's award-winning nRF52 and nRF53 Series SoCs and the nRF9160 cellular IoT SiP. It can also be used in conjunction with non-Nordic host devices. In addition to robust Wi-Fi connectivity, the nRF70 Series offers Wi-Fi assisted locationing based on Service Set Identifier (SSID) scanning. (See sidebar [Navigating urban canyons](#).)

## Lowering the BoM

"The nRF7001 is the perfect complement to the nRF7002 because it offers a drop-in, single band alternative to the dual band companion IC for products that only need to operate in the 2.4 GHz band," says Ioannis Glaropoulos, Technical Product Manager with Nordic Semiconductor.

The nRF7001 lowers the cost of the bill of materials (BoM) for designs requiring single band capability for smart home, smart city, industrial automation and other low power Wi-Fi IoT applications.

"The nRF7001 is designed to provide highly reliable 2.4 GHz connectivity and offers all the Wi-Fi functionality of the nRF7002—including compliance with the latest standard and power saving features—but at a lower cost. When matched with Nordic's [nRF52840 SoC](#) operating as a host processor, the nRF7001 offers a cost effective yet



“The nRF7001 lowers the cost of the BoM for designs requiring single band capability for smart home, smart city, industrial automation and other low power Wi-Fi IoT applications

high performance Wi-Fi solution,” explains Glaropoulos.

The nRF7001 companion IC supports Station (STA), software emulated Access Point (SoftAP) and Wi-Fi Direct operation, and is compatible with the IEEE 802.11b, g, n ('Wi-Fi 4') and ax ('Wi-Fi 6') standards. The product also offers ideal coexistence with Bluetooth LE, Thread and Zigbee. The nRF7001 supports Target Wake Time (TWT), a key Wi-Fi 6 power saving feature. Interfacing with the host processor is done via Serial Peripheral Interface (SPI) or Quad SPI (QSPI). The nRF7001 offers a single spatial stream, 20 MHz channel bandwidth, up to 64 QAM (MCS7), OFDMA, up to 86 Mbps PHY throughput and BSS coloring.

Developers can make a quick and easy start on nRF7001-based designs thanks to support for the IC in the [nRF Connect SDK](#), Nordic's scalable and unified software development kit. The nRF7002 Development Kit (DK) can be used to work with the nRF7001, as the nRF Connect SDK supports emulation of the IC on that DK. The nRF7001 companion IC, nRF7002 DK and the nRF Connect SDK make it simple for product designers to add 2.4 GHz Wi-Fi capabilities to their products, allowing them to easily connect to Nordic's nRF Cloud Services and communicate with other devices over a Wi-Fi network.

## Navigating urban canyons

Global Positioning System (GPS), the principal component of Global Navigation Satellite System (GNSS), is a technological marvel tracing its roots back to 1951. In that year, Raytheon scientist Dr. Ivan Getting designed a 3D position locating system based on the time difference in the arrival of radio signals from different transmitters. By 1983, the U.S. allowed its military GPS to be used for civilian purposes and in 2000, the precision of the civilian system was upgraded to match that of the military's own.

Today, billions of people benefit from GNSS, whether navigating at sea, surveying, mapping, farming, guiding heavy machinery or more. GNSS is also now providing a foundation for many IoT applications in the logistics and transportation sectors.

But GNSS is not foolproof. The system relies on 'line-of-sight' between satellites and receivers and there are many occasions when it can be obstructed. For example, 'urban canyons'—formed by rows of tall buildings on each side of a city street—can obstruct the signal. Moreover, there's little chance of GNSS signals penetrating buildings. But when GNSS is blocked, Wi-Fi can come to the rescue.

Wi-Fi devices connect to the Internet through access points (APs); the ubiquity of the technology means these APs are everywhere. APs are stationary and their location is generally known — that makes the units a [useful positional reference point](#) in the absence of GNSS.

Every Wi-Fi network is identified with a Service Set Identifier (SSID); the SSID can be cross referenced against one of several databases that will detail its location.

When used for Wi-Fi locationing, the [nRF70 Series](#) device interrogates nearby Wi-Fi APs for the SSID; a Nordic [nRF9160 cellular IoT SiP](#) then sends the SSID to a Cloud service such as nRF Cloud which checks one or more Wi-Fi SSID databases and returns the selected AP's location. Wi-Fi SSID locationing is not as precise as GNSS but offers accuracy down to a few meters in the city and consumes less power than the satellite system.



NORDICTECH  
WEBINARS

# Catch all the latest Nordic webinars on-demand

## HIGHLIGHTS

- Discover nPM1300 - The future of embedded power management
- Unleashing Wi-Fi Locationing: Nordic Chip-to-Cloud solution
- Accelerate cellular product development

WATCH NOW

[webinars.nordicsemi.com/videos](https://webinars.nordicsemi.com/videos)

NORDIC  
SEMICONDUCTOR



## Connected Health

# The Internet of Medical Things will transform healthcare

Connected medical devices and applications are changing the way care is administered for patients and providers alike

The burgeoning IoT will impact and shape different industries in different ways. One sector that's ripe for disruption by wireless connectivity is healthcare. That's because connected medical devices and systems are not only taking the pressure off stressed healthcare budgets and improving efficiencies in medical operations, they are also improving patient outcomes. During the height of the [COVID-19 pandemic](#), for example, remote healthcare came to the fore to limit the number of patients traveling to hospitals – alleviating the strain on overburdened facilities, while still allowing them to continue providing care to those in need.

The ecosystem of medical devices sensors, special infrastructure, data processing software applications, services and the networks that connect them to smart healthcare information systems, is collectively becoming known as the 'Internet of Medical Things' (IoMT), or 'healthcare IoT'. Medical devices and monitoring systems equipped with wireless connectivity such as [Bluetooth LE](#), [Wi-Fi](#) and [cellular IoT](#) enable the M2M foundation of IoMT. These devices link to Cloud platforms, where captured medical data or location/status information can be stored and analyzed to enhance decision-making.

The IoMT is built to improve patient care, but it also encompasses the optimization of clinical processes and the reining in of expenditure. Common examples of IoMT applications and use cases include keeping tabs on expensive medical equipment, tracking the location of patients admitted to hospitals, collecting data from patients' wearable health devices, connecting healthcare professionals to ambulances en route to medical facilities and remote patient monitoring (RPM) for people with chronic diseases and long-term conditions.

Forecasts suggest a bright future for IoMT. A recent study by Data Bridge Market Research predicts the IoMT market, valued at \$61.56 billion in 2022, will reach \$270.4 billion by 2030.

## The boom in virtual healthcare

RPM represents a major cost saving to healthcare authorities. In 2015, analysts at Goldman Sachs claimed U.S. healthcare organizations could save \$300 billion annually from RPM and other technology benefits. In 2019, a Spyglass Consulting Group study of U.S. healthcare providers determined 88 percent had invested in or were evaluating investments in RPM technologies for chronically ill patients.

RPM is a form of virtual healthcare that uses IoMT



### Tech Check

Finnish firm Movesense offers a lightweight wearable electrocardiogram (ECG) sensor for remote patient monitoring. In addition to ECG data, [Movesense](#) measures heart rate (HR), heart rate variability (HRV) and movement. Nordic's nRF52832 SoC looks after computation and transmits information wirelessly to the wearer's smartphone

devices such as smart glucose and ECG monitors, pulse oximeters and more to remotely monitor patients in their homes as opposed to a hospital or physician's office. This technology increases the amount, quality and accuracy of health data and insights available to clinicians and caregivers. It enables round-the-clock health monitoring of patients with chronic conditions, giving doctors better (and faster) access to critical information.

For example, an IoMT-enabled blood pressure monitor could provide several days of blood pressure and heart rate readings that yield a more accurate diagnosis than data from a single doctor's visit. The result is improved healthcare decisions for patients. Faster health data processing also saves time and money for providers, enabling those resources to be redirected to the areas most requiring attention.

Further, IoMT solutions can be used to track and monitor the location and health of expensive medical equipment—including ventilators or imaging systems such as MRI machines and PET scanners—and send alerts when machines go missing, or when maintenance issues arise.

According to one recent report by Mordor Intelligence, [Internet of Medical Things Market Size & Share Analysis – Growth Trends & Forecasts \(2023–2028\)](#), the advantages of IoT medical devices, including enhanced patient safety,



IoT medical devices have the potential to transform healthcare and improve patient outcomes while, at the same time, helping to reduce costs and make better-informed care decisions with more speed and ease

reduced medical errors and seamless transfer of electronic health records, "have the potential to transform healthcare and improve patient outcomes while, at the same time, helping to reduce costs and make better-informed care decisions with more speed and ease."

## Not so fast

While the IoMT offers much promise, there are challenges to overcome. Implementation of IoMT infrastructure can involve large upfront costs and difficulties ensuring devices are compliant with medical regulations. Exposure to security risks for protected health information and issues related to medical data ownership must also be countered.

Experts agree interoperability—when [standards-based communication protocols](#) work seamlessly together—holds the key to progress. To successfully integrate IoMT solutions into existing healthcare systems so data can be securely exchanged at scale, compatibility between devices and networks is vital.

If the forecasts prove accurate, the IoMT will be key in helping healthcare providers achieve better patient outcomes, lower healthcare costs and improved efficiency in healthcare facilities. For patients, the IoMT will simply bring a better quality of life.

Svein-Egil Nielsen  
CTO/EVP R&D,  
Nordic Semiconductor



## The importance of massive IoT can't be overstated

Massive IoT will enable us to do 10 times more with 10 times less by being 10 times smarter

[Massive IoT](#) is M2M communications on a scale of millions to billions of typically small, battery-powered, connected IoT sensors and 'things' packed into million device per square kilometer densities. Until now, the stumbling blocks were the wireless connectivity infrastructure required to connect so many things, and the ability for governments and businesses to rely on that infrastructure being around for decades to come.

From 4G, and now in 5G,

“Massive IoT hadn't truly arrived before now because it wasn't technologically or commercially viable

cellular IoT is the massive IoT-targeted version of cellular wireless technology that comes in LTE-M and NB-IoT versions and offers near blanket global geographical coverage. Cellular IoT offers the same legendary reliability and security benefits of cellular worldwide, with long range connectivity and power consumption that supports multi-year operation from small, lightweight batteries.

The downside of cellular IoT is that having access to a ubiquitous, secure, reliable, global network that already exists doesn't come for free. A big part of the security and reliability comes from devices being certified for operation on the network. And data is sent via a commercial carrier. All that

means cost and a certain degree of complexity. But the costs and complexity are falling all the time.

[DECT New Radio \(NR\)+](#) is the world's first non-cellular wireless technology to become a 5G standard. DECT NR+ fills the gap in the LPWAN market that proprietary alternatives previously addressed. If you don't require global operation and instead only need to operate within a geographically defined area, then enterprise IoT and public customers can now build their own private network that supports low-cost data transfer.

DECT NR+'s 1.9 GHz operating frequency is a global, license-free spectrum allocation (with the current exception of Japan, India, and China). It forms a single, secure and reliable radio standard that is future-proofed and scalable. Moreover, because it's license free, DECT NR+ incurs no data charges.

Massive IoT hadn't truly arrived before now because it wasn't technologically or commercially viable. But with cellular IoT and now DECT NR+ I believe that situation has permanently changed. And I predict that over the next decade hundred-million-unit-plus IoT deployments will become routine across the globe. And then we will be able to do 10 times more with 10 times less by being 10 times smarter.





# Building the Clean Dream

In the face of rapid urbanization, the IoT is promising cities a smarter way to manage the growing challenges of waste and pollution

In Short

Rapid urbanization is leading to mounting waste, escalating pollution and increased stress on transport and sewerage systems. Conventional methods of addressing these challenges are both inefficient and counter-productive, leading cities to adopt IoT solutions. Successful clean city IoT deployments could be the gateway to larger smart city deployments, by establishing credibility for IoT through addressing critical and universal needs of residents

During the lead-up to the 2017 New Delhi Marathon, a viral video showed a runner preparing for the big race by smoking cigarettes and inhaling exhaust fumes. The video was satirical, but struck on a poignant truth about the Indian capital. Breathing Delhi's air is equivalent to smoking 50 cigarettes in a day, according to doctors quoted at the time of the marathon. Many residents make plans for their day only after checking the city's air quality index. Delhi's environmental challenges are far from unique. Residents of other major cities contend with 'garbage towers', noise pollution and polluted waterways. Authorities have responded in various ways, including trying to purify air, closing schools to protect children and restricting cars to using roads on certain days. These examples come from the most polluted cities, but the challenge to clean things up would be familiar to many cities across the globe. With traditional measures to tackle waste and pollution falling short in the face of rapid urbanization, cities are turning to tech. Sensors and network connectivity combined with ML and AI promises authorities a smarter way to understand urban pollution and respond more precisely to the challenges it presents.

OUT WITH THE OLD

The world's cities have been getting bigger. According to the United Nations (UN), the share of the world's population living in urban areas is 57 percent today, but is set to increase to 7 out of 10 people by 2050. Urbanization has its benefits – greater job opportunities, centralized infrastructure and a wider range of services. But the scale of change has come at an environmental cost. This includes mounting waste, escalating pollution and increased stress on transport and sewerage systems. The amount of solid waste produced by cities is forecast to



Urbanization has its benefits – greater job opportunities, centralized infrastructure and a wider range of services. But the scale of change has come at an environmental cost

grow from 1.8 billion tonnes in 2016 to 3.1 billion tonnes in 2050. According to the World Health Organization (WHO), nine out of 10 people in urban areas breathe polluted air, while almost 40 percent lack access to safely managed sanitation services and adequate drinking water. The consequences are serious. Air pollution increases risk of lung cancer, stroke, heart disease and chronic bronchitis and is one of the world's leading fatal health risks, resulting in around 7 million deaths per year. Unclean cities are also unattractive to workers and tourists, resulting in adverse economic impacts. These are some of the reasons why those in charge of cities have long maintained efforts to keep the streets clean. Most city residents know all too well the sound of their local garbage collection service, typically heard in conjunction with birdsong in the dawn hours. Less apparent, but still there, is bulky equipment used to monitor air pollution and support interventions when pollution levels rise too high. But as city populations expand, measures like these are proving to be outdated, limited and in some cases even counter-productive to a cleaner city. Consider garbage collection, which usually involves municipal-funded garbage collectors travelling by truck to attend to every garbage bin in a given area of a city. This

turns out to be highly inefficient. A study of garbage bin collection practices in New Zealand by services company Ventia found that on most occasions, half the bins on a collection route are empty, while 10 percent of the bins—those in the most popular locations—fill up again in just three or four hours. As well as the glaring inefficiencies in use of labor and resources, the data illustrates the unnecessary distances covered by garbage collection trucks to attend to empty bins, which increases levels of exhaust emissions. When it comes to managing air quality, conventional approaches are slightly more scientific but still with drawbacks. Air quality monitoring is typically performed by large, expensive and permanently installed instruments. However, these tend to be placed at a "small number of fixed locations" and it takes time to aggregate and verify data extracted from them, according to a report by global mobile networks industry association GSMA. "London has around 100 monitoring stations ... [but it is] difficult for citizens to understand the levels of pollution they experience in their daily lives, as the monitoring data is not available in real time and is very sparse," the report said. The advent of IoT has opened the door to a radically new approach for maintaining clean cities, says Lorenzo

Amicucci, Business Development Manager at Nordic Semiconductor and who is leading the company's smart city initiatives. "The technology architecture is broadly similar for a range of applications for waste, air pollution and wastewater management," he says. "It generally involves deploying [low cost sensors](#) that can detect relevant conditions—like a full rubbish bin, changes in air quality, or deterioration of infrastructure—and then using network connectivity to convey that data to city administrators who, with help from AI and data analytics, can gain actionable insights to support proactive decisions that lead to clean outcomes for their cities."

EMPTYING THE TRASH

Barcelona in Spain, which was reportedly spending 1.5 billion euros over four years on waste and recycling, believed it could reduce this amount by limiting the number of times trash bins needed emptying. Now, connected sensors embedded in the bins communicate to city officials in real time when they are nearing capacity, limiting the number of collection trips. Other 'smart bin' solutions deployed around the world also use sensors to monitor gas and humidity levels in bins. Christian Wedekind, Senior

By the Numbers

90% of people in urban areas breathe polluted air

Source: WHO

\$2 billion

The size of the sensor market for water and wastewater treatment industries by 2030

Source: IDTechEx

156 hours

Number of hours during 2022 that each driver spent in London congestion (the worst in the world)

Source: INRIX

12.7 million tonnes

of trash are produced by New Yorkers every year

Source: nyc.gov



Product Manager at adhoc networks, a developer of a [smart waste solution](#) based on Nordic's [nRF9160 SiP](#) and cellular IoT connectivity, says solutions like these have reduced waste disposal emissions by 40 percent. Complementing the use of IoT technology to reduce trips, AI solutions are optimizing the routes garbage collectors take. According to NZ services company Ventia, use of these technologies reduced route time from seven-and-a-half hours to four, enabling the company to reduce its truck fleet by eight vehicles, lower its carbon footprint and minimize noise pollution in local communities.

A BREATH OF FRESH AIR

London has long battled air pollution, with a 2017 report revealing 95 percent of its population was exposed to air pollution levels exceeding WHO limits by more than 50 percent. The emergence of low cost sensor technology saw the city embark on an air quality proof-of-concept (PoC) in Greenwich in partnership with GSMA. Shifting from the old paradigm of small numbers of fixed monitoring stations, the IoT PoC saw low cost sensors deployed on everything from people to bikes, vehicles and buildings. "These portable IoT sensors can travel freely anywhere within Greenwich including across parks, along footpaths, pedestrian routes, major roads and side roads," says the GSMA's Aruna Srinivasan. "As they assess air quality in real time we expect they will provide much more granular data

“  
Connected sensors embedded in the bins communicate to city officials in real time when they are nearing capacity, limiting the number of collection trips



on the air quality in different locations throughout the day." Like London, Delhi too is turning to the IoT. In one particularly innovative pilot, air pollution sensing devices were attached to auto rickshaws, the popular taxi-like vehicles that zip across Indian cities. The devices sent air quality readings via cellular technology to a central platform every two minutes. While more dynamic tracking like this doesn't reduce air pollution itself, it arms authorities and policymakers with better data to understand root causes and introduce targeted measures to combat them. These include congestion pricing in areas of high traffic, restricting



or closing facilities that are heavy polluters, and even building support for longer-term initiatives such as new public transit systems. A study by McKinsey Global Institute found China's capital, Beijing, "reduced deadly airborne pollutants by 20 percent in less than a year by closely tracking the sources of pollution and regulating traffic and construction accordingly." Sharing real time air quality information with the public via smartphone apps also enabled individual residents to take steps to reduce negative health effects—such as prolonged journeys outside—by 15 percent.

SOMETHING IN THE WATER

Less visible than the air and solid waste around us in major cities are underground sewerage systems. While this keeps wastewater largely out of sight it can also be problematic, with issues going unnoticed until they, literally, bubble up to the surface. Many cities in Europe have combined sewerage systems, in which rainwater and wastewater flow in the same pipes. In times of heavy rainfall, systems often overflow, leading to flooding or the discharge of wastewater into rivers or canals. About 10 million cubic meters of wastewater enters Brussels' waterways through overflows every year, according to Belgian activist group Canal It Up, which runs a campaign humorously advising Brussels residents to "hold" their urge to use the toilet if it rains. IoT solutions are now helping cities gain visibility into sewerage issues and to manage them before they cause problems. One example is the ART Sewer wastewater and sewerage spill monitoring solution from remote monitoring solutions company Metasphere. The battery powered solution is about the size of a coffee cup and deployed below a manhole cover. Powered by Nordic's nRF9160 SiP, the device's sensors measure wastewater levels using radar every 15 minutes and send the data via NB-IoT or LTE-M cellular technologies to a data analytics platform.



Tech Check

[Metasphere's](#) battery-powered Contactless Sense Level IoT is positioned below manhole covers in a wastewater network. Each sensor takes a sample measurement of wastewater level using radar every 15 minutes and that information is sent to the Cloud, via Nordic's NB-IoT/LTE-M cellular IoT tech, to help manage water flow

"This enables wastewater utilities to prevent wastewater spills due to high level rain events, blockages or collapsed or leaking pipes, far more effectively," says Metasphere CEO Tim O'Brien. Among the blockages detected are so-called 'fatbergs', clumps of waste bound by fat and grease, which have increasingly been found clogging sewers around the world. A trial of IoT technologies in Australia resulted in 400 blockages being cleared at environmentally high-risk sites and produced savings of \$400,000 a month, according to managers on the project. [Predictive maintenance](#), where sensors combined with AI predict emerging maintenance needs, is another significant benefit from IoT for sewerage and drainage systems. The World Bank estimates utilities lose 25 to 35 percent of their water due to leaks and bursts. Another benefit, realized during the pandemic, was the use of IoT technology in city sewers to detect COVID-19 hotspots via traces in wastewater, rather than waiting for advanced symptoms to become apparent in residents.

CLEAN CITY OF THE FUTURE

According to the *Financial Times*, while sensors had become increasingly affordable, "the process of collecting and analyzing data continuously across a large area [required] a prohibitively high amount of Internet connectivity, computing power and energy." But development and [uptake of LPWAN technologies](#) has changed the game, says Nordic's Amicucci. "Cellular technologies not only have great coverage in cities, but they are ideal for IoT applications, both those needing low power and not," he says. "Among low power connectivity options, LTE-M supports use cases involving mobility such as monitoring the location of garbage trucks while NB-IoT suits stationary devices placed in areas with poor network coverage, such as sewer monitors." With technology trends aligning, the opportunities and

Gateways to a hidden world

In Japan, manhole covers have achieved the status of high art. The humble access covers to sewerage systems are adorned with colourful, intricate designs – featuring imagery like cherry blossoms, local fauna, famous landmarks and depictions of historic events. Such is their allure, Japan's 15 million covers have spawned an army of manhole enthusiasts, many of whom actively trade merchandise including manhole cards, keychains and coasters; they even attend manhole summits. The Japanese decision to start decorating manholes goes back 50 years to a campaign to improve awareness of the wonders of the sewerage system. The campaign was long overdue, given the role manhole covers and underground sewers have played for cities over the years. Among the first manholes were those in Roman times, with the Romans famously having developed

a system of aqueducts and underground sewage systems. Even the earliest sewers featured manholes for access, with covers made of stone. In medieval times, manholes might have conveyed a sense of intrigue and subterfuge, often used as they were by thieves and invaders to access underground sewers and tunnels as escape routes. By the industrial revolution, sewerage systems had become critical to urban life and the manhole had become a critical point of entry for workers needing to inspect and maintain sewers. Manhole covers would come to be made from iron and steel, for greater reliability and longevity. They also started to come in a variety of shapes and feature patterns and designs. For many cities, the manhole even offered a highly visible and novel branding opportunity. But through its evolution and many innovations, one fact has largely remained true about the



manhole cover – it has largely obscured and been unaware of what happens below it. The only real way to know the state of the sewers beneath was for someone to open the cover and lower themselves into the wastewater system. Now, manholes are being deployed with IoT technology, allowing them to convey data about how often they've been opened and the temperature and water levels below. They are becoming more than just a cover – but for some fans they always have been.





benefits from the IoT are coming into clearer view. Beyond city residents, who benefit from cleaner and healthier environments, device manufacturers and IoT solution developers also stand to gain. For instance, the sensor market for water and wastewater treatment industries alone is forecast to grow to \$2 billion by 2030.

Governments and regulators will also be winners, the former better able to promote their cities as attractive destinations, and the latter more able to govern and enforce regulations due to access to better data. IoT deployments for environmental and cleanliness use cases are already underway in many countries. Globally, initiatives like the UN's 'United 4 Smart Sustainable Cities' program are also supporting the use of technologies like IoT to help the transition to smart sustainable cities.

Amicucci says clean city IoT deployments are a gateway to larger smart city deployments, because they establish credibility for IoT through addressing critical and universal needs of residents – cleanliness and liveability. "Any good smart city strategy needs to put people at the core. By focusing on how people want to live and interact with the city, tech solutions are a great foundation for more adventurous use cases

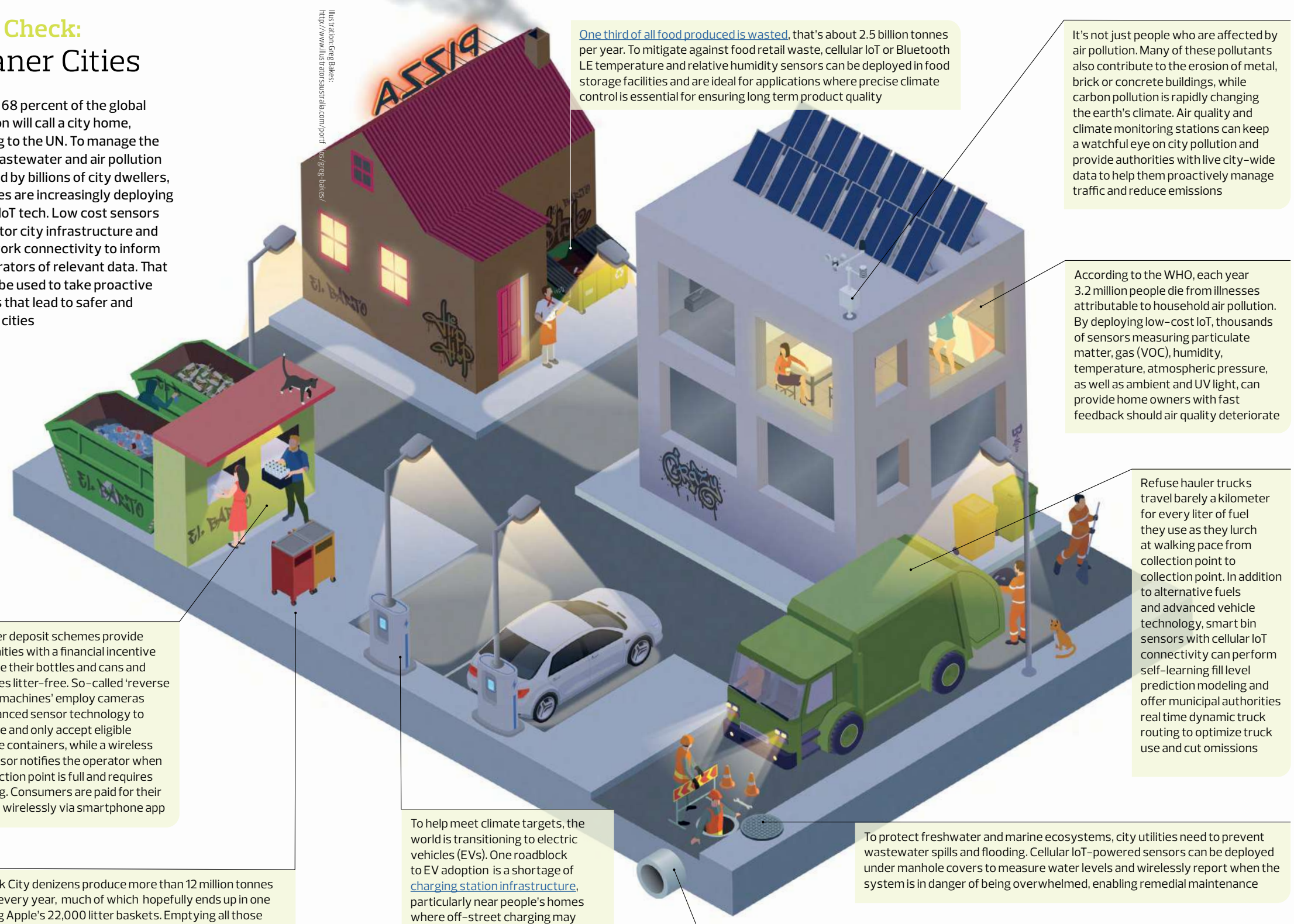
Any good smart city strategy needs to put people at the core. By focusing on how people want to live and interact with the city, tech solutions are a great foundation for more adventurous use cases

### Tech Check: Cleaner Cities

By 2050, 68 percent of the global population will call a city home, according to the UN. To manage the waste, wastewater and air pollution generated by billions of city dwellers, authorities are increasingly deploying wireless IoT tech. Low cost sensors can monitor city infrastructure and use network connectivity to inform administrators of relevant data. That data can be used to take proactive decisions that lead to safer and healthier cities

Container deposit schemes provide communities with a financial incentive to recycle their bottles and cans and keep cities litter-free. So-called 'reverse vending machines' employ cameras and advanced sensor technology to recognize and only accept eligible beverage containers, while a wireless level sensor notifies the operator when the collection point is full and requires emptying. Consumers are paid for their deposits wirelessly via smartphone app

New York City denizens produce more than 12 million tonnes of trash every year, much of which hopefully ends up in one of the Big Apple's 22,000 litter baskets. Emptying all those street bins is a major logistical challenge. Smarter cities like Oslo in Norway, are employing Nordic Semiconductor-powered cellular IoT devices equipped with optical sensors to determine which bins are full at any given time and which are not. This data is relayed to a web-based platform, enabling government bodies and private companies to better allocate rubbish collection resources and avoid overflow



One third of all food produced is wasted, that's about 2.5 billion tonnes per year. To mitigate against food retail waste, cellular IoT or Bluetooth LE temperature and relative humidity sensors can be deployed in food storage facilities and are ideal for applications where precise climate control is essential for ensuring long term product quality

It's not just people who are affected by air pollution. Many of these pollutants also contribute to the erosion of metal, brick or concrete buildings, while carbon pollution is rapidly changing the earth's climate. Air quality and climate monitoring stations can keep a watchful eye on city pollution and provide authorities with live city-wide data to help them proactively manage traffic and reduce emissions

According to the WHO, each year 3.2 million people die from illnesses attributable to household air pollution. By deploying low-cost IoT, thousands of sensors measuring particulate matter, gas (VOC), humidity, temperature, atmospheric pressure, as well as ambient and UV light, can provide home owners with fast feedback should air quality deteriorate

Refuse hauler trucks travel barely a kilometer for every liter of fuel they use as they lurch at walking pace from collection point to collection point. In addition to alternative fuels and advanced vehicle technology, smart bin sensors with cellular IoT connectivity can perform self-learning fill level prediction modeling and offer municipal authorities real time dynamic truck routing to optimize truck use and cut omissions

To help meet climate targets, the world is transitioning to electric vehicles (EVs). One roadblock to EV adoption is a shortage of charging station infrastructure, particularly near people's homes where off-street charging may not be available. To address this issue, smart cities are rolling out connected charging stations integrated into street lighting. This keeps sidewalks clear, provides a low cost near home charging option, and offers a built-in power source

To protect freshwater and marine ecosystems, city utilities need to prevent wastewater spills and flooding. Cellular IoT-powered sensors can be deployed under manhole covers to measure water levels and wirelessly report when the system is in danger of being overwhelmed, enabling remedial maintenance

In 2017, a 'fatberg' weighing 130 tonnes was discovered in a sewer in London. The 250 m long solid mass of wet wipes, nappies, fat and oil took a lot of elbow grease to budge. AI-powered sensors can detect partial blockages in sewers by monitoring water levels and notifying authorities using cellular IoT before the problem gets out of hand



# Safety First

The safety technology industry is in overdrive and wireless solutions are protecting us in our homes, at our places of work and while we play

In Short

At home, unifying connectivity standard Matter has addressed standardization and interoperability concerns and paved the way for further adoption of smart home security tech

At work, wireless tech can go where humans shouldn't, down unstable mine shafts, into farm storage silos and hazardous industrial environments to monitor and maintain equipment

At play, during sport and exercise, or a night out on the town, connected devices can keep a watchful eye on us, our loved ones and provide a lifeline in the event of an unexpected threat

From everything we see, read and hear in the news, you can be forgiven for thinking the world is a dangerous place. We might be living longer and healthier lives, but from economic uncertainty, political instability and the existential threat of climate change through to the fear of personal bodily harm, humans are a fearful species. We have to be because safety is a basic condition for our development. It's vital for our survival, but it's also vital to our ability to thrive.

For the last 10 years, Chapman University in California has conducted an annual survey of American fears. Most years, technology features prominently on the list, alongside human-made disasters and corrupt government officials. Unsurprising perhaps as a fear of technology is not a new phenomenon. For example, when the bicycle became popular in the late 1800s, people linked it with an increase in cases of insanity, especially in women. Today, doomsday preppers fret over AI, 5G and robots taking our jobs.

The irony is that without tech the world would be a far less safe place to be. It is keeping us safe at home, at work and at play, and we aren't just talking airbags and vaccines and CCTV on every street corner. As the 'Internet of Everything' delivers ubiquitous connectivity from personal wireless tech to smart city-wide infrastructure we have implemented a protective blanket of tech that looks after us as never before.

SAFE AT HOME

When we think of being safe in our home, security is often top of mind, in particular keeping out intruders. At one point in human history that was best achieved via moat and drawbridge, but such a solution is hardly practical in suburbia. The more prosaic solutions of recent decades include alarm systems that were hardwired and relied on physical phone lines and connections. This made the system difficult and expensive to install and upgrade and also meant it could easily be nobbled by a resourceful criminal.

Today, wireless technology has democratized the home security space, and behind personal assistance solutions—think Google Home and Amazon Echo—and entertainment

solutions such as smart TVs, home security is the leading driver of smart home technology according to analyst data. As such, the smart home device market has been flooded with simple, user friendly, easy-to-set-up wireless security systems, fully controlled and programmed via a smartphone app. For example, smart locks enable remote, wireless locking and unlocking, and the ability to issue temporary access to tradespeople or babysitters without handing over precious keys or lock combinations. An owner can also be notified if a lock is being tampered with, anywhere in the world.

Standardization and interoperability concerns have to some extent applied the handbrake to smart home tech adoption, but the advent of unifying connectivity standard Matter (see [WQ Issue 1 2022](#), pg14) has removed the obstruction. Matter will deliver consumers greater simplicity, ensuring, for example, any Amazon Echo device can control any third party smart security product, or any other Matter smart home device. This interoperability should act as a catalyst for connected security.

Smart security systems aren't the only wireless tech keeping us safe at home. When Hurricane Ida struck New York City (NYC) in 2021, it smashed the city's record for the greatest single-hour rainfall, causing widespread flooding and hundreds of millions of dollars of damage. Thirteen people lost their lives. In the wake of the disaster, NYC comptroller, Brad Lander, said the state needed to mandate and fund the installation of carbon monoxide detectors, smoke alarms and backflow preventers, as well as implement better data systems for early flood warning. In the two years since Ida, devices incorporating [cellular IoT connectivity](#) can now provide greater access to real time data to help improve situational awareness and mitigate the impact of such natural disasters.

SAFE AT WORK

In spite of the working from home movement inspired by the pandemic—and as safe and comfortable as even the smartest of smart homes may be—most of us still need to leave our house every day to go to work and earn our living. People working alone are at particular risk of workplace



accidents, where the ability to trigger warnings may not be available if someone becomes incapacitated. Wearable devices employing fall detection sensors and wireless connectivity can notify first responders and loved ones in such circumstances of the need to send help.

First responders themselves can also benefit from the technology. In 2018, Arizona-based DataSoft Corporation unveiled a Bluetooth LE connected wireless sensor integrated into 'man-down' vests for law enforcement and military applications. Described as the world's first wearable gunshot detection system, the sensor detects any piercing event to the wearer's body armor—front or back—such as the impact of a bullet, knife or shrapnel, and automatically sends an emergency alert to nominated agency backup units via SMS, or directly to an Internet location such as the dispatcher's console. Emergency notifications include the user's name and accurate personal medical information, the linked device's GPS location, and where on the vest the impact occurred, allowing medical responders to assess the urgency and seriousness of the potential injury.

[Bluetooth LE wireless connectivity](#) is also helping avert disaster in the air, with the recent launch of the [IQtag](#), a beacon tag that creates what is claimed to be the world's first self-loading digital manifest for remote operations across aviation, wildfire, mining and personnel transport applications. Once allocated and attached to work clothing or cargo, each tag can be quickly configured and programmed to broadcast the name and weight of respective crew, cargo and passengers to the onboard app using the Bluetooth LE connectivity provided by a

Nordic Semiconductor [nRF52832](#) SoC-based module. This provides 'real time' visibility of who and what is onboard the transport, taking the guesswork out of weight and balance calculations for pilots and dispatchers, while the automatically generated flight manifests are made visible to ground operations.

"The system provides a real time view of crew, cargo, passengers and total payload weight, which helps improve communications and decrease reliance on radio calls, at the same time eliminating the need for manual calculations and data entry," explains Vincent Hoog, CEO, IQonboard. An incorrect load manifest can have disastrous consequences. In 2015, a helicopter contracted by U.S. Department of the Interior and U.S. Department of Agriculture to support wildfire operations was destroyed while conducting external load operations. Fortunately, neither the pilot nor the firefighters who were in close proximity of the aircraft were injured. The cause of the accident was human error and an incorrect load manifest, resulting in a heavier load than what was recorded on the form, as well as what was communicated to the pilot over the radio.

Wireless tech can also go where it's better people don't — down unstable mines, into farm silos or cars about to be intentionally crashed (see sidebar *You're not as dumb as you look*). For example, using explosives in mining operations to break mineral-bearing rocks can result in toxic fumes lingering for hours. *In-situ* or wearable environmental sensors can ensure downtime is minimized and that workers don't re-enter the blast site until it is safe. Similarly, exhaust fumes from underground excavating equipment and drilling machines can be kept within limits



The IQonboard solution is designed to enhance aviation safety and reduce pilot workload for helicopter operators

Ultra miniaturized SoCs and SiPs enable designers to embed wireless connectivity in imaginative form factors such as bracelets or necklaces that double as panic buttons



by monitoring with gas detectors and particle sensors. "As cellular IoT network infrastructure matures worldwide, the technology is increasingly becoming available where [mining operations](#) are established," says Clay Hine, Business Development Manager – Tools & Machinery, Nordic Semiconductor. "The tech can either power a gateway to pass data from a group of Bluetooth LE devices to the Cloud or power sensors with end-to-end IP connectivity. Base stations can support tens of thousands of cellular IoT connections, [and] the communications are fully bidirectional, robust, reliable and secure.

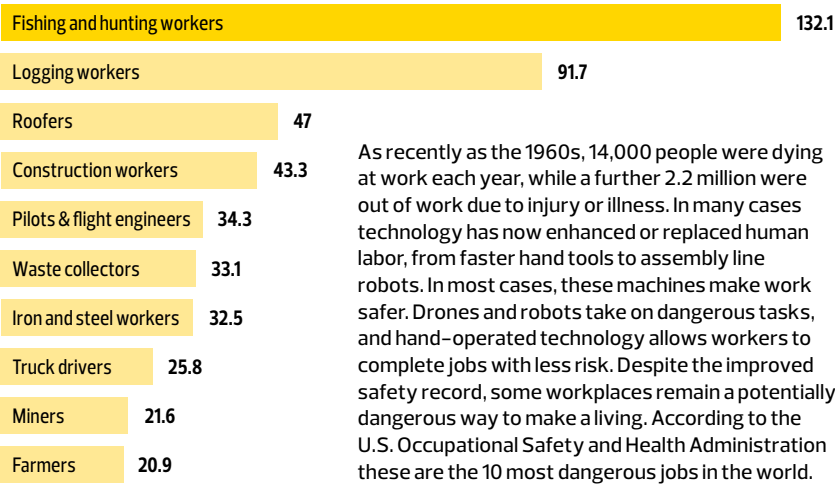
"Moreover, NB-IoT ... can penetrate further below ground than other wireless IoT technologies. Precisely how far depends on a host of factors, but certainly deep enough to support some fixed installations such as elevators or conveyor motor monitoring near the surface." On farms, checking there is enough grain to feed livestock is traditionally a manual exercise involving climbing to the top of a silo up to 90 meters in height to peer inside and gauge the grain level.

Aside from the risks of falling, inhaling dust emissions or the aspiration of silage gas can be extremely harmful, and like mines, explosion and fire are also real threats. Now, [LTE-M cellular connectivity allows tanks in remote agricultural locations to wirelessly report level sensor data](#) so the farmer can monitor feed, fuel, water or fertilizer levels through a Cloud platform, using their smartphone, tablet or computer. Not only is it safer, the tech also boosts productivity by saving hours of travel and its associated emissions.

State of Play

What are the risks?

Fatal injury rate per 100,000 workers (Source: U.S. Occupational Safety and Health Administration)



As recently as the 1960s, 14,000 people were dying at work each year, while a further 2.2 million were out of work due to injury or illness. In many cases technology has now enhanced or replaced human labor, from faster hand tools to assembly line robots. In most cases, these machines make work safer. Drones and robots take on dangerous tasks, and hand-operated technology allows workers to complete jobs with less risk. Despite the improved safety record, some workplaces remain a potentially dangerous way to make a living. According to the U.S. Occupational Safety and Health Administration these are the 10 most dangerous jobs in the world.



SAFE AT PLAY

Even for people with office jobs, wireless technology is on hand to ensure we are kept safe and comfortable in myriad ways – access control, environmental monitoring, HVAC and lighting, for example. Outside of our homes and our places of work, wireless technology in many guises is not only enabling us to enjoy a work/life balance, it is also ensuring we remain safe in the process. In the last five years wearable devices that double as safety devices have proliferated. Today's ultra miniaturized SoCs and SiPs enable designers to embed wireless connectivity in imaginative form factors such as bracelets or [necklaces that double as panic buttons](#). If the wearer feels threatened walking alone at night, a discrete press on the necklace's stone will trigger an alert on their smartphone that is sent to pre-selected safety contacts along with the wearer's location.

Similarly, U.S. based company [Littlebird](#) last year released a toddler-tracking device that can provide parents with peace-of-mind when they leave their young children with caregivers. The device integrates Nordic Semiconductor's [nRF52840](#) SoC to act as a wireless 'tether' between the child and the caregiver. In the event the child or caregiver moves out of Bluetooth LE range of one another and the connection is lost, the device automatically sends an alert to the parent and caregiver's smartphone using LTE-M wireless connectivity provided by a Nordic [nRF9160](#) SiP. The alert also includes the last known location of the child based on GNSS coordinates. The idea came about when Littlebird CEO and Founder, Monica Plath, was alerted by her smart security camera to her 'professional' babysitter leaving home without Plath's child. "It was a moment of panic that no parent should have to experience," says Plath. "I immediately went online to purchase something that could tell me what I needed to know—when is my toddler out of earshot and eyesight of his caregiver—but nothing existed." Plath set about developing the Littlebird CareTracker. While wireless wearables have long been synonymous



with keeping fit and urging us to increase our daily activity, they are now by design trying to keep us safe in the process. Sport can be dangerous, just ask a Tour de France cyclist hurtling down Col de Vars at 100 km/h. While the rest of us may have no intention of reaching such speeds, cycling is a hugely popular pastime with more than 51 million Americans riding a bike each year. In 2020, The Consumer Product Safety Commission reported nearly 426,000 emergency department-treated injuries associated with bicycles, while the number of preventable deaths from bicycle transportation has increased 44 percent in the last 10 years.

One company pioneering wireless bicycle safety technology is cycling equipment leader, Specialized, that launched a Bluetooth LE sensor-based device in 2019, designed to transform a cycling helmet into a live GPS tracker, crash detector and safety beacon. [ANGi \(Angular and G-Force indicator\)](#) is attached to a Specialized bicycle helmet, and once activated by the cyclist at the start of a ride, uses its built-in accelerometer and gyroscope to detect any potentially dangerous incident by the measurement of linear and rotational forces to the cyclist's head that typically occur during a bicycle crash. When ANGi detects the possibility of a serious accident during an activated ride, it launches a countdown alert on the partner smartphone app. If the rider is uninjured they can then manually cancel the countdown. However, if the rider is injured and unable to cancel the countdown, the app sends a text alert notifying the user's emergency contacts of a possible accident. In addition, the rider's location—established by the ANGi device's most recently uploaded GPS coordinates—is immediately sent to all contacts. It is one example among many of a traditional safety device made smart by wireless technology. And this connectivity has never been easier with today's SoCs and SiPs enabling connected devices with smaller form factors, that do even more using even less power. In a dangerous world, it's making everyday life simpler, safer and healthier for billions of us.



Tech Check

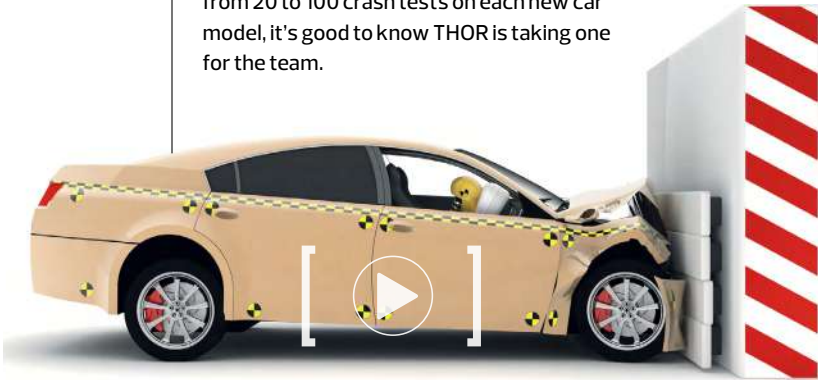
For personal safety device applications, Nordic's [nRF9160](#) low power SiP can provide cellular IoT wireless connectivity between the device and the Cloud, eliminating the need for a smartphone or gateway. The [nRF9160](#) SiP combines GNSS locationing with cellular network location data for precise position monitoring



You're not as dumb as you look

One of the most iconic safety inventions of the last 100 years are the unfortunate anthropomorphic devices otherwise known as crash test dummies, designed to simulate the dimensions, weight and articulation of the human body during collisions. The first crash test dummy was developed by Alderson Research Labs and Sierra Engineering back in 1949. Nicknamed Sierra Sam, it was used to test aircraft ejection seats, aviation helmets and pilot restraints, and was a welcome replacement for the ethically and morally dubious use of human cadavers, animals and live volunteers that had been previously employed in the role. U.S. Air Force Colonel John Paul Stapp was one of the first such volunteers when he was propelled to over 1,000 km/h on a rocket sled that was then stopped in 1.4 seconds. He described the experience in typically understated fashion as: "Somewhat like the extraction of a molar without anesthetic."

Sierra Sam was a limited success, but the automotive industry started taking a more serious interest in driver and passenger safety, requiring a more advanced crash test dummy. General Motors took the lead creating 'Hybrid 1', modeled on an average male in height and mass. 'Hybrid 2' followed but the design was still crude, before 'Hybrid 3'—introduced in the 1970s—upped the sophistication by including six high-strength steel ribs that simulated human chest deflection, and a lower torso with a rubber lumbar spine that curved just like ours when we sit. Fast forward to the current day, and the soon to be released 'THOR (Test device for Human Occupant Restraint) 5F ATD' is for now the final word in crash test dummies, although there is nothing dumb about THOR. According to the developers, THOR features 250 separate components and up to 160 measurement axes to enable the accurate assessment of loads that an occupant experiences in a frontal crash. An inertial measurement unit (IMU) is mounted in THOR's head, chest, pelvis and feet. Each of the IMUs can measure three acceleration and three rotation rates, while a Digital Transducer Interface recorder with 288 channels enables engineers to connect with the dummy's 160 measurement axes. By design, THOR is no better placed than you or I to walk away from a head-on collision, but with car manufacturers performing anywhere from 20 to 100 crash tests on each new car model, it's good to know THOR is taking one for the team.





# A Brighter Tomorrow

Now into its eighth year, the BBC micro:bit educational device is preparing the next generation of digital innovators to support the future workforce

In Short

As a global tech talent shortage threatens to stifle progress across sectors, industry leaders are trying to close the digital skills gap

The Micro:bit Educational Foundation is focused on creating the next generation of digital pioneers using the Nordic-powered BBC micro:bit programmable pocket computer

A new nationwide initiative will ready U.K. primary school children for the digital world, empowering them with the skills needed to shape the future

To advance society and tackle diverse global challenges, the world needs the coders, engineers, entrepreneurs and innovators of tomorrow to emerge from the classrooms – and soon. Because right now, a technology talent shortage threatens to stifle progress across all tech sectors. For example, in 2021 there were more than two million U.K. job vacancies in tech, more than any other labor area. Yet a large section of the British workforce is apparently nowhere near skilled enough to apply for many of these tech-based positions; according to FutureDotNow—a coalition of industry leaders focused on closing the digital skills gap for working age adults—some 11.8 million U.K. workers lack even basic digital skills.

In its 2022 Digital Strategy, the U.K. government asserted that while over 80 percent of all jobs advertised in the U.K. require some digital skills, employers say the lack of available talent is the single biggest factor holding back growth. Estimates suggest the digital skills gap costs the U.K. economy as much as £63 billion (\$79 billion) a year.

This gap not only plays an important role in the U.K.'s economic prospects, but also in an individual's life chances. A report by the Department for Digital, Culture, Media and Sport in 2019 found: "The move up the career ladder from low- to high-skill jobs comes with increased demand for specific digital skills. Acquiring specific digital skills makes career progression as well as a pay increase more likely." It

went on to state: "Overall, roles requiring digital skills pay 29 percent (£8,300 (\$10,418) per annum) over those roles that do not (£37,000 (\$46,440) p.a. vs £28,700 (\$36,022) p.a.). This difference is apparent at all skill levels, but the differential increases at higher levels."

CREATING DIGITAL PIONEERS

In March 2015, in response to the significant skills shortage across the U.K. at the time, the British Broadcasting Corporation (BBC) launched Make It Digital, a nationwide initiative focused on creating the next generation of digital pioneers. One year later, the project spawned the delivery of one million Nordic-powered BBC [micro:bits](#)—tiny yet powerful programmable pocket computers—to Year 7 school students throughout the country's schools. The micro:bit was designed to give children as young as seven years old the experience of building knowledge and gaining vital skills in computational and critical thinking. It was hoped the device could transform young people from passive consumers of technology into digital innovators via the power of 'coding'.

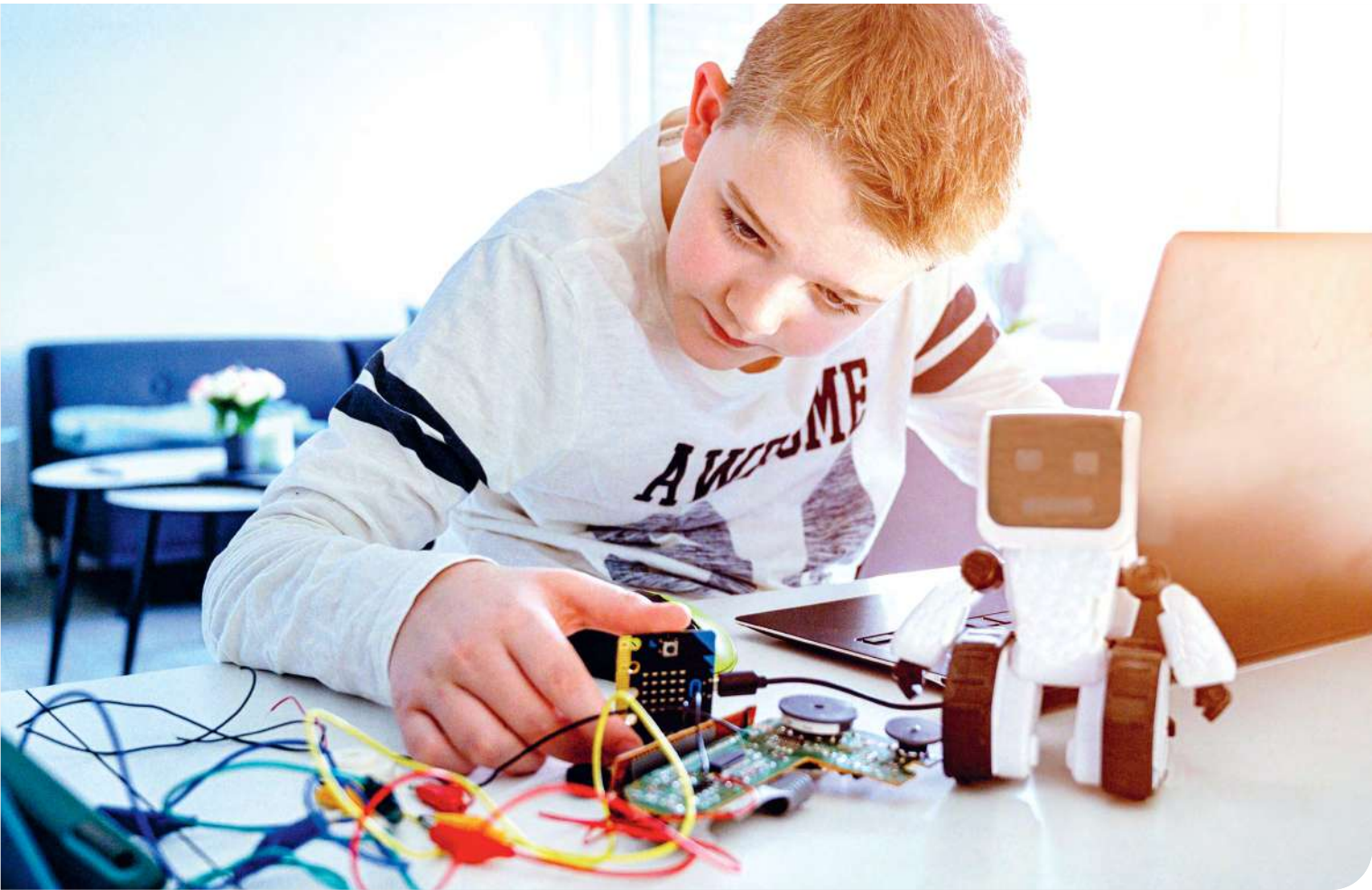
Within six months the not-for-profit [Micro:bit Educational Foundation](#) was established to promote the micro:bit project internationally. The foundation's vision was, and remains, to inspire every child to create their best digital future, with particular focus on girls and those from disadvantaged groups. To this day the foundation works in collaboration with educators to create curriculum materials, training and resources that empower a young person's creativity and boost their opportunities in an equal and purposeful way.

In turn, the materials and training support help teachers develop their own digital skills, establishing the micro:bit as one of the easiest and most effective active learning tools for digital skills.

"We believe that an ability to understand, participate and work in the digital world is vitally important to a young person's life chances," says Jonny Austin, CTO of the Micro:bit Educational Foundation. "Our ultimate impact is on the lives of young people – providing them with skills to succeed in an increasingly digital world. By learning



Students taking the micro:bit outside to log movement data, which can be transmitted by radio



digital skills with the micro:bit, they develop a better understanding of how the world around them works. This, in turn, gives them the ability to interact confidently with technology and apply their digital skills to all aspects of their professional and personal lives."

MINDING THE GAPS

The Foundation has good reason to focus its efforts on overcoming inequality in education. Research indicates factors such as socio-economic background can have a significant impact when it comes to children learning about coding. The gap between genders is also pronounced. Analysis of examination data from 2021 shows there are disproportionately few girls in computer science subjects, while the U.K. tech industry comprises only 26 percent women.

"The micro:bit is designed to excite and appeal to a broad range of young people including those who might have thought tech was not for them – this is particularly important for children from under-represented backgrounds, so the world benefits from more diverse perspectives influencing the creation of new tech," explains Austin.

"By inspiring more young people to learn digital skills, we aim to diversify the students who choose 'STEAM' [science, technology, engineering, the arts, and mathematics] subjects as they progress through school



Need to Know

The BBC micro:bit features an LED light display, buttons, sensors and many input/output features for programming and physical interaction. The latest micro:bit (V2) adds sound sensing and playback capabilities, and can even be used as a data logger. The board contains a microcontroller that can be programmed to perform specific tasks



and into their careers. This, in turn, grows a diverse pipeline of talent, boosting social equity and contributing to the creation of better technology."

GLOBAL IMPACT

Seven-and-a-half years on from the launch of the micro:bit, adoption is tracking impressively. Over 7 million micro:bit units have been sold worldwide. The device continues to be actively embedded in children's learning at schools and other education systems. Around 39 million young people in over 60 countries—including Denmark, Finland, Uruguay, Singapore, Canada and Bangladesh—have so far used the micro:bit to get hands-on with computer science and technology, learning important digital skills in the process.

Independent research has backed up the impact of this work and demonstrated high levels of engagement. Of the 11- and 12-year-olds who received micro:bits in the first year of the BBC project, 90 percent said it helped to show them anyone can code, and 88 percent said the micro:bit helped them to see that coding wasn't as difficult as they thought. Among teachers, 85 percent said the micro:bit had made Information & Communication Technology (ICT) and computer science more enjoyable for their students. Half of teachers who had used the micro:bit said they felt more confident teaching tech lessons.

Elsewhere, STEAM education programs are making a



““ We believe an ability to understand, participate and work in the digital world is vitally important to a young person's life chances

By the Numbers

Over 7 million micro:bit units have been sold so far

An estimated 39 million students have learnt with the micro:bit worldwide

86% of students say the micro:bit makes computer science more interesting

Source: Micro:bit Educational Foundation

meaningful difference. In Bangladesh, for example, where less than half of the country's 47 million children will attend school beyond the age of 15, the British Council has provided free workshops to increase public access to digital skills training and to teach children to create technology, not just consume it. In the first phase of the program, which reached 2,000 young people in 12 districts, participants were tasked with building a Kano computer (a simple-to-construct device) and then trying out apps that involved 'hacking' games or creating art. They were then introduced to the micro:bit and set a challenge designed to encourage their creativity through code.

Most participants (88 percent) were aged 12–16, with a fairly balanced gender split of 51.5 percent male and 48.5 percent female. The majority had never coded before, and 13 percent said the workshop was their first time using a computer. But 95 percent of participants said they would be interested in learning more coding in the future. And 70 percent more girls said they would choose computing as a subject at school after using the micro:bit.

Meanwhile, the “do your:bit” BBC micro:bit challenge brings together the micro:bit and the United Nations' (UN) 'Global Goals' for sustainable development. (See [WQ Issue 1, 2023 pg14](#).) The initiative provides inspiring activities for classrooms and clubs to run an exciting digital challenge that introduces young people to the global goals and asks them to think creatively about how technology can be used to solve global problems. By using a micro:bit as a catalyst for this learning, children and teens can research the problem, design a solution, make it and test their ideas.

From the Micro:bit Educational Foundation's perspective, the young organization is proud of the scale of impact it has been able to achieve internationally in such a short period of time. “We are very proud to work with expert partners around the world to make the micro:bit accessible to teachers and students of all backgrounds and it is exciting to see demand for micro:bit growing across so many countries,” says Austin.



A 'do your:bit' 2022 project by Mariem, Alaa and Mohamed, Tunisia – a sea turtle incubator that controls the temperature of the sand to help protect sea turtles and determine the gender of newborns



A 'do your:bit' 2022 project by Sara, Sebastian and Mariana, Colombia – a project that recycles used cooking oil into a renewable fuel

A VALUED PARTNERSHIP

Nordic Semiconductor has played a vital role from day one of the micro:bit journey. “Nordic has been incredibly supportive of the micro:bit since the inception of the project – for a start, the company donated the first one million nRF51822 chips to kickstart the device, and help move it from being more of a digital badge to being a real IoT device,” recalls Austin.

“The transition from the V1 device to the V2 device was really smooth – we replaced the core processor from the Nordic nRF51822 SoC to the Nordic nRF52833 SoC and managed to keep a very compatible experience for users across our editor and lots of the community editors. Nordic supported us brilliantly through this transition, helping us navigate the maze of software challenges we had in order to ensure great compatibility between V1 and V2.

“Finally, as the pandemic hit and supply became difficult, we actually doubled down on Nordic and added a second nRF SoC to the board – we now use [the company's] nRF52820 as the micro:bit's interface chip.”

In addition to processing capabilities, the micro:bit's Nordic-enabled wireless connectivity is used in two distinct ways. First, using the device firmware update (DFU) tools in the Nordic software development kit (SDK), the micro:bit has the capability to be updated from a phone or tablet over Bluetooth LE. This means schools or students without access to laptops can still easily use the micro:bit. And second, it provides a student-facing feature, which can be used with either a set of Bluetooth services or with the micro:bit radio feature.

“The wireless connectivity on the micro:bit is one of the features that really helps it stand out and engage kids,” says Austin. “When the micro:bit was launched, Lancaster University built a simple radio protocol on top of the Nordic radio interface that lets students easily send and receive messages.

“One of our most popular demos is called ‘the teleporting duck’, where students can teleport a duck from one micro:bit to another just by shaking the micro:bit (which triggers a radio message).”

Austin says Nordic has gone above and beyond its role



as a technology partner. “Nordic has also been very generous in its support of community-based micro:bit projects, which has enabled children from disadvantaged communities in Africa and Latin America to benefit from learning with the micro:bit,” he says. “Without Nordic's support, these projects would not have gone ahead.”

THE NEXT GEN

While the micro:bit has already influenced global digital education in myriad ways, its achievements to this point are just the beginning of its journey.

The Micro:bit Educational Foundation has now joined forces with BBC Education and Nominet (the U.K.'s official domain name registry) to launch 'BBC micro:bit – the next gen', a nationwide initiative designed to ready U.K. primary school children between the ages of 8 and 11 for the digital world that lies ahead, once again empowering them with the skills required to shape their future. The campaign will offer 30 micro:bit devices to every primary school in the U.K. – a giveaway of almost 700,000 micro:bits. Furthermore, teachers will be able to access training resources on how to use the micro:bit both online and in-person.

Whether programming it for useful functions such as a sunlight sensor or a step counter, or using it for an exciting treasure hunt challenge, the Nordic nRF52833 SoC-powered micro:bit will continue to teach practical computer knowledge in an accessible and authentic way.

“By engaging children in earlier, more formative years, the next gen project seeks to counter harmful stereotypes before they have time to bed in, and improve computing diversity in later studies and life,” says Austin.

“Coding and computing exists in an interconnected world, so we're continuing to look at ways to connect the micro:bit to other subjects and topics through our educational content,” he adds.

“We've got some major projects in the pipeline, including developing our content around machine learning. There's plenty more to come for the micro:bit – and it's all to inspire every child to create their best digital future.”



Tech Check

The Nordic Semiconductor nRF52833 integrated in the BBC micro:bit is a general-purpose multiprotocol SoC built around a 64 MHz Arm Cortex-M4 with FPU, and has 512 KB flash and 128 KB RAM memory available to support more complex applications



Constructionist theory: the art of learning

Renowned mathematician, learning theorist and educational-technology visionary, Seymour Papert (1928–2016)—one of the pioneers of artificial intelligence (AI)—proposed people build knowledge most effectively when the user or student is deeply engaged in the construction of something tangible and shareable with the world.

According to Papert's Constructionist theory of learning, education is improved by actively taking part in the process itself and having something to show for one's time and effort. Constructionism therefore values engaging students in creating their own products.

Papert recognized computers could be used not just to deliver information and instruction, but also to empower children to experiment, explore and express themselves.

His ideas and inventions transformed how millions of children around the world create and learn. In the 1960s, along with his team at Massachusetts Institute of Technology (MIT), Papert invented a computer programming language called 'Logo' to be used as an educational tool and aid in the research of problem solving. The designers of Logo attempted to capitalize on young children's natural interest in drawing and animation by offering them programming control over the 'turtle', an on-screen object that would move and draw according to instructions.

In his seminal book, *Mindstorms: Children, Computers and Powerful Ideas* (1980), Papert presented an alternative approach to “the computer being used to program the child”, whereby instead, “the child programs the computer and, in doing so, both acquires a sense of mastery over a piece of the most modern and powerful technology and establishes an intimate contact with some of the deepest ideas [from science and math].”

Papertian ideals apply in today's classrooms through the adoption of 'physical computing' – the use of tangible, embedded microcontroller-based interactive systems that can sense the world around them and/or control outputs such as lights, displays and motors.

Proponents of constructionist theory generally consider physical computing to be more positive than a traditional screen-based experience, as it more readily supports and stimulates open-ended creativity, which in turn produces a deeper engagement in computer science learning activities.



Seymour Papert with a turtle robot (Courtesy: Matematicamente.it)



By the Numbers

43 million containers used to move cargo around the world

Source: Budgetshipping containers.co.uk

2000 The year the precision of the civilian GPS system was upgraded to match that of the military

Source: gps.gov

-130 dBm Average GPS signal strength at Earth's surface

Source: gps-repeaters.com

52 million Number of Wi-Fi access points in the U.S.

Source: Cisco

# You Are Here

Cellular services and Wi-Fi can complement GNSS to keep track of valuable goods

Global Positioning System (GPS), the principal component of Global Navigation Satellite System (GNSS) which also includes Galileo, BeiDou and GLONASS among others, is a [technological marvel](#). The GPS constellation is made up of 24 satellites positioned around 20,000 kilometers above the Earth. The arrangement of the constellation ensures at least four satellites can be observed at any point on the planet. A GPS receiver picks up the signals from the satellites which provide their locations, status and the precise time from onboard atomic clocks. The receiver notes the arrival time of the signal and then determines the distance to each satellite from the difference in time between signal transmission and reception, and then multiplying by the speed of light. Information from four satellites fixes the receiver's position to a unique point. Billions of people rely on GNSS daily to help them determine where they are on the Earth's surface. GNSS is also now providing a foundation for many IoT applications in the logistics and transportation sectors helping keep track of valuable assets that might otherwise go missing. (See sidebar *Never to be seen again*.) This is why for asset tracking and other applications, Nordic's cellular IoT solution, the nRF9160 SiP, incorporates GNSS capability.

## SATELLITE SIGNAL LOST

Despite its impressive technical foundation, GNSS is not flawless. Some problems do occur with the satellites, such as inaccuracies with the onboard clocks resulting in timing errors. To mitigate such drift errors, GNSS systems compare multiple satellites and use algorithms to determine which clocks are in error and then reset them compared with an earthbound reference. Other problems occur because the relatively weak signal between satellites and earthbound receivers can easily be disrupted. For example, 'urban canyons'—formed by rows of tall buildings—can obstruct the signal. And there's little chance of GNSS signals penetrating buildings. But even if the signal does get through, so-called multipath errors can occur when it reflects off buildings before reaching the receiver. That can result in timing errors which in turn lead to incorrect positional information. Other errors can occur because of anomalies in the Earth's atmosphere, which can delay or distort the GNSS signal. Electromagnetic

interference (EMI) from other radio sources can also cause timing errors. To mitigate these problems, receivers use techniques such as filtering, correlation and signal power measurement, and for the atmospheric challenges, methods such as ionosphere and troposphere modeling are employed. Another challenge with a GNSS modem is that it can take several minutes to fix the location of a group of satellites from a cold start. That uses significant battery capacity. One solution, used by Nordic's [nRF9160](#) together with the company's [nRF Cloud Location Services](#), is Assisted- and Predicted- GPS (A-GPS and P-GPS). These methods use satellite assistance data stored in a database which is relayed to the nRF9160 via the LTE-M or NB-IoT network – saving significant power compared to an extended first fix. When required, the IoT device can then find the satellites in seconds, saving further energy. The P-GPS technique builds on A-GPS by providing over two weeks of assistance data to the IoT device resulting in even greater power savings. Even with power saving techniques, GNSS can still extract a heavy toll from batteries; that's an important consideration for things like wearables or asset trackers which are typically equipped with modest batteries yet are expected to deliver long battery life.

## COMPLEMENTING GNSS

If high accuracy is needed then the battery trade off of GNSS is worth it, but if less accurate locationing is acceptable there are ways to save power. One option to overcome the power consumption of GNSS—and which is also supported by the nRF9160 SiP and nRF Cloud Location Services—is to



use the known location of cellular base stations to narrow down the position of the receiver. The single-cell location method relies on identifying in which cell the tracked device is situated and then referencing the cell identification against a database of known base station locations. The technique offers accuracy down to kilometer level while only modestly impacting the receiver's battery life. Multi-cell location builds on the single-cell technique by referencing the position of several nearby base stations instead of just one, to offer accuracy down to a few hundred meters while keeping power consumption low. An interesting locationing technique which complements GNSS—and which can also be used to trade-off location precision against battery life—is Wi-Fi Service Set Identifier (SSID) scanning. Every Wi-Fi access point (AP) network is identified with a SSID – a technical reference for the AP's name. With knowledge of the network's SSID it's possible to cross reference against databases that will detail its location. SSID locationing is supported by Nordic's [nRF70 Series](#) of companion ICs. When used for Wi-Fi locationing, the nRF70 Series devices scan any nearby Wi-Fi AP for its SSID; a partner nRF9160 SiP then forwards the SSID (and other useful information) to nRF Cloud using cellular connectivity. nRF Cloud then checks one or more Wi-Fi SSID databases and returns the SSIDs location, plus a degree of uncertainty for that location, to the nRF9160, or elsewhere as directed. It's hard to beat the precision of GNSS. But when precision of tens of meters is acceptable and battery life is critical, or when the GNSS signal is interrupted, Wi-Fi SSID locationing is an excellent alternative as it consumes significantly less power than GNSS. If it's only necessary to determine the location of an asset to within a kilometer and battery life is critical, cell-based locationing is the answer. With Nordic's [nRF91](#), nRF70 Series, and nRF Cloud Location Services it's simple to switch seamlessly between all three methods to optimally trade-off location precision against battery life. With this locationing tech there is now no reason for valuable assets to ever be lost again.



## Need to Know

SSID information is found in the packet header of each communication transmitted over a Wi-Fi network and is distinct from the payload of the packet. The data is publicly broadcasted by every Wi-Fi enabled device and is accessible by any other Wi-Fi device within range, regardless of whether the Wi-Fi network uses encryption

## Never to be seen again

You might think that owners of valuable assets would make very sure they look after them. But no, just like your keys or pocketbook, items worth thousands or even millions of dollars have a habit of just disappearing. Some, like the 1,816 containers lost from the container ship ONE Apus, are down to pure bad luck. As reported in *Slash Gear*, the unfortunate vessel met with disaster due to extreme weather conditions in the Pacific Ocean, about 3,000 kilometers from Hawaii. \$90 million worth of goods sank into the abyss. Others, such as the lost Nazi train of Walbrzych, said to have been loaded with 270 tonnes of gold, weapons, jewels and art, and which allegedly disappeared late in WWII between Breslau and Walbrzych, might just be the stuff of myth. An extensive search for the train revealed naught, leading many to believe it never set off in the first place. If the carriages ever turn out to be real, the gold alone would be worth a cool \$19 billion at today's prices. But then there are the foolhardy. Reported in U.K. newspaper *Metro*, in 2009 IT worker James Howells got his hands on 7,500 Bitcoin which he stored on his PC's hard drive. When Howells ditched the computer, the hard drive went with it to landfill, only for him to later realise the Bitcoin therein were worth nearly \$5 million. Weeks of grubbing among the trash left him empty handed. And then there was British journalist Nigel Reynolds. He was one of the first journalists to interview author J.K. Rowling and received a first edition copy of *Harry Potter and the Philosopher's Stone* for his trouble. Reynolds assumed the book would fall flat and threw it in the bin – yet today, similar copies sell for over \$60,000. And finally, there's the downright incompetent. *Popular Mechanics* magazine [reports](#) over one million spare parts needed to keep F-35 fighter aircraft in the air have gone missing. The parts are believed to have a total value of at least \$85 million, but no one really knows because of some questionable book-keeping. One can only hope the government keeps the actual weaponry on a tighter leash.



Wearables

Lilbit

This smart [wearable](#) allows pet owners to constantly track the location and health metrics of their four-legged friend

Almost 10 million dogs and cats go missing in the U.S. every year, while animal shelters take in 7.6 million lost and abandoned pets during the same period. With the global pet care technology market forecast to reach \$61.20 billion by 2030 according to Verified Market Research, more animals could soon be reunited with their owners thanks to wireless wearable pet trackers

Some dogs have quite the resumé when it comes to remarkable achievements. Take for example [Swansea Jack](#) [ > ], a black retriever who came to notoriety in the 1930s in Wales when a 12-year-old boy accidentally fell off the local docks. Jack jumped in, grabbed the boy's shirt, and dragged him out of the water, saving the boy's life. Throughout his lifetime Jack repeated the heroics on numerous occasions, saving at least 27 people and one other dog, in the process receiving multiple bravery awards for his dogged service to the community

Everybody knows dogs have an incredible sense of smell—at least 10,000 times better than humans—but their sense of hearing is also remarkable. Dogs can hear sounds from about 65 to 45,000 Hz, compared to people hearing from 20 to 20,000 Hz. This means, for example, a dog can hear their owner's heartbeat from across the room. Dogs also have their own unique music preferences, with certain genres more likely to have a relaxing effect. According to one study, reggae music and soft rock genres result in more relaxed dogs

The [Lilbit pet tracker](#) is designed to attach to the collar of a pet, and once paired to a smartphone using Bluetooth LE connectivity provided by Nordic Semiconductor's nRF52811 SoC, ensures an easy way to monitor and record their location and movements. If the dog or cat moves beyond Bluetooth LE range, the device can detect and report the animal's position using LTE-M/NB-IoT cellular connectivity and GNSS locationing enabled by Nordic's nRF9160 SiP

Nobody really knows how long animals have been kept as pets, although according to the *Smithsonian Magazine*, we have likely kept baby animals for amusement as long as humans have lived. There is evidence that dogs were domesticated twice—once in Europe about 16,000 years ago and then again in Asia some 14,000 years ago—from two separate wolf lineages. Even further back, a 32,000-year-old canine-like skull found in a cave in Belgium also lays claim to possibly belonging to the first ever pet pooch



The Lilbit device's integrated inertial measurement unit—with accelerometer, magnetometer and gyroscope—records the animal's different movements and, with the support of proprietary machine learning, can associate these movements with particular behaviors and health issues. From the Lildog or Lilcat smartphone app, the owner can review the animal's activity data, current temperature, and potential health issues, as well as location



Tech Check

The combination of the [nRF9160](#)'s 64 MHz Arm Cortex-M33 application processor, and the [nRF52811](#) SoC's 64 MHz, 32-bit Arm Cortex M4 processor, provides Lilbit with the processing power to comfortably handle complex and processor-intensive computations. The nRF9160's Arm Cortex-M33 processor includes 1MB Flash and 256 KB RAM, a range of analog and digital peripherals, automated power and clock management



## Connected Health

# Orthopedic sensor improves post-surgery patient outcomes

The Digital Knee remote monitor from OPUM records key metrics to accelerate recovery from knee replacement surgery

Over 850,000 knee replacement surgeries are completed each year in the U.S. alone, according to non-profit medical center, the Cleveland Clinic. As recovery can take as long as six months—and more physically taxing tasks may be off-limits for up to a year, according to *Healthline*—encouraging effective rehabilitation and post-operation physiotherapy is critical.

Because of the extended timeline, consistently working with a clinician to monitor patient progress can be challenging. In these circumstances, remote monitoring can help improve outcomes, reduce healthcare costs and bring greater convenience.

"By providing real-time data on a patient's condition, technology solutions enable healthcare providers to monitor patients more closely," says Paul Mallinson, CTO at OPUM Technologies, a New Zealand-based orthopedic company, which has developed a solution capable of monitoring recovery from knee surgery or injury.

"Furthermore, remote monitoring solutions can reduce the burden on healthcare systems by limiting the need for in-person visits and enabling patients to receive care from the comfort of their own homes."



The OPUM Digital Knee is a remote monitoring product with a goniometer arm design and strategically placed sensors measuring the full range of motion of the patient's knee joint

## No calibration required

The [OPUM Digital Knee](#) is a remote monitoring product with a goniometer (a device for measuring angles) arm design and strategically placed sensors measuring the full range of motion of the patient's knee joint. Accurate to less than one degree, and requiring no calibration, the product is designed for pre-surgery monitoring and preparation and post-surgery recovery, as well as for those experiencing osteoarthritis of the knee. It is worn by clipping it on to a therapeutic brace.

Using the Bluetooth LE connectivity, patient data is transmitted to the 'my Digital Knee' smartphone app. The app creates a "digital twin" of the user's knee, helping to monitor their recovery journey. The app is also capable of receiving and tracking prescribed therapy plans.

From the user's smartphone, their data is uploaded to the Cloud. Clinicians can access this information using the web-based portal and identify if any of their patients require additional care and resources to help improve outcomes and reduce re-admission. Pre-surgery data can also be indicative of additional post-op risk factors, helping to provide early intervention after the surgery.

A 12-week trial completed in the Shirley Ryan Ability Lab in Chicago tested the Digital Knee in combination with a conventional knee brace and a self-guided physical

therapy program, in comparison with a control group using only the brace and program.

This study found that adding the Digital Knee increased patient retention by more than 20 percent. Additionally, the group that used the product experienced increased aerobic capacity, endurance, walking speed, strength and balance, as well as a reduced fall risk.

"The Digital Knee group saw clinically significant improvement in the KOOS [Knee Injury and Osteoarthritis Outcome Score] survey sub scores—pain, symptoms, activities of daily living, sports and quality of life—compared with only two for the control," says Mallinson.

The product has also been trialed for six weeks by a group of anterior cruciate ligament (ACL) patients, who experienced only a one-degree difference in knee bending when compared to an in-clinic goniometer.

OPUM is gathering a database of 10,000 digital twins (including control group measurements) to help clinicians provide more accurate analysis of the remotely gathered data, from initial assessment to identifying those in need of more intensive post-operative care.

The Digital Knee employs an integrated Nordic nRF52840 SoC-based Raytac MDT50Q-1MV2 module. The SoC's Arm Cortex-M4 processor provides the necessary processing power to oversee the sensor and



## Tech Check

The [nRF52840](#) is multiprotocol capable. It has protocol support for Bluetooth LE, Bluetooth mesh, Thread, Zigbee, 802.15.4, ANT and 2.4 GHz proprietary stacks. The nRF52840 is built around the 32-bit Arm Cortex-M4 processor with floating point unit running at 64 MHz



This study found that adding the Digital Knee increased patient retention by more than 20 percent



perform all data capture activities. The product's predictive models then work in combination with this sensor platform to understand how individual patients will recover. "The processing capability and memory capacity [of the SoC] enabled a design which did not require a [separate] dedicated application processor, which saves on cost, simplifies the design and reduces power," says Mallinson.

## Minimizing power consumption

By minimizing power consumption, the Digital Knee can achieve a battery life of several days of regular use between charges, thanks in part to the ultra low power operating characteristics of the nRF52840 SoC.

"The software architecture of the pre-certified module greatly reduced development time and allowed our team to focus on implementing core functionality rather than expending effort on connectivity," adds Mallinson.

"This meant that we could concentrate on the Digital Knee portal, and how we could make implementing remote patient monitoring effortless. Algorithms and notifications tell clinicians how their patients are progressing and help them perform assessments that can inform clinical decisions. All providers in the continuum of care are empowered to collaborate in supporting each patient."

## Industry Viewpoint

Ken Everett

Founder & CEO, Digital Matter



# Cellular asset tracking delivers efficiency gains

Wireless tech has transformed the global supply chain

Keeping tabs on products, components and valuable assets across vast distances, often with multiple couriers, is highly complex and resource-intensive. However, by employing [asset tracking](#) solutions, businesses can save both time and money.

And it's not just knowing where items currently are that can benefit companies – adding sensors can provide even

more insight into the supply chain, including things like high-G and tip events, among others. For example, food supply compliance laws have encouraged the combination of mobile asset tracking with temperature and humidity sensors to ensure the freshness of goods.

customers with large fleets, and has allowed for the creation of asset tracking [solutions](#) that are lower power, smaller size and lower cost.

The advantage of cellular IoT is that these networks are funded by telcos that have existing business built on cellular phones. For asset tracking in particular it is vital that the network coverage is excellent, and cellular infrastructure has been able to provide this.

Additionally, because cellular connectivity uses licenced spectrum it does not suffer the same downlink restrictions and

potential RF interference as ISM band technologies like Sigfox and LoRaWAN. This is an important point as it covers the basic requirement of getting an acknowledgement that data sent has been received.

In addition to this, the downlink capabilities of cellular allows for vital over-the-air updates. Any customer rolling out a large deployment needs to be across the importance of device management and that includes firmware, parameters, GNSS assistance data and other downlink messages.

The productivity gains have been massive, especially for customers with large fleets

When I started in this industry, our first product used a memory dongle to download the data from a vehicle – and this manual process had to be performed by the driver when they got back to the depot. This 'after the fact' approach obviously had some major limitations in terms of monitoring a fleet of assets.

When cellular modems were introduced, we were able to take a major step forward by seeing this data in 'real-time', and to automatically upload the information. The productivity gains have been massive, especially for

**Opportunities for expansion**  
I see major growth in the battery-powered asset tracking market segment as the technology matures and is adopted more broadly. The lower power of our new devices is enabling what we call 'deploy once' solutions where the major logistical challenges of changing batteries are removed.

I believe we will see continued rollout of cellular LPWAN across the globe, including regions where it is currently not offered yet. Cellular connectivity has allowed developers to continually push the envelope.



# [Tech Zone]

An in-depth look at Nordic's wireless solutions

## Power Management

## Nordic launches nPM1300 PMIC with unique system management features

Nordic Semiconductor has introduced its **nPM1300** Power Management IC (PMIC). With its two ultra efficient buck converters, two load switches/Low Drop Out voltage converters (LDOs) and integrated battery charging, the nPM1300 is ideal for battery-operated applications. It reduces an end product's Bill-of-Materials (BoM) by combining circuitry that typically requires five or more discrete components into a single chip.

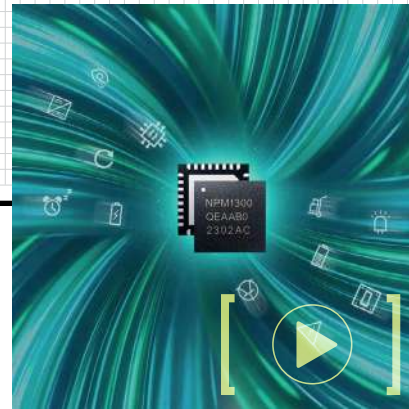
The launch is accompanied by the **nPM1300 Evaluation Kit** (EK) and the nPM PowerUP PC app. The EK and the app make it simple for developers to evaluate, configure and

implement the nPM1300 PMIC without having to write any code.

The PMIC also brings unique system management features and accurate fuel gauging for low power wireless applications. The unique algorithm-based fuel gauge functionality of the nPM1300 uses voltage, current and temperature monitoring for higher accuracy than voltage-based fuel gauges, while keeping the PMIC's own power consumption considerably lower than coulomb counter-type fuel gauges. Nordic is the first company to achieve this balance between high accuracy and low power consumption, and an equivalent can't be

found in any competitive PMIC product.

"We've launched the nPM1300 to make it easy for developers to add a compact, optimized power management solution to their low power products – eliminating the need to design-in system management functions from scratch," says Geir Kjosavik, Product Director – PMIC, with Nordic. "And we've similarly removed the complexity of PMIC evaluation and development with the associated EK. With the kit and the nPM PowerUP app, developers can quickly set things up to minimize the power consumption of their application without the need to write any software." (See pg36.)



## Internet of Things

## Sensor node Proof-of-Concept suits integration into existing products

U.K. based Crux Product Design has created an IoT sensor node Proof-of-Concept (PoC). The device can be seamlessly integrated into the existing form factor of various products to gather user data without influencing the product's function or user behavior. The Crux Modular Distributed Sensing Platform supports a range of applications across medical devices, fast moving consumer goods, user experience studies and general prototyping of future products.

Powered by the Wafer Level Chip Scale Package (WLCSPP) version of Nordic's **nRF52840** SoC, the fully customizable IoT sensor node device is intended to be an adaptable, future-proof platform. It is built around a modular concept where a main board contains the main technology and core

functionality, while simpler daughterboards extend the functionality to meet the needs of individual applications.

The PoC measures just 10 by 10 mm which was in part achieved due to the 3.5 by 3.6 mm dimensions of the Nordic WLCSPP. The PoC can even be reused in a second application, lowering cost, facilitating faster revisions and

keeping waste low in a sustainability-focused environment.

As an illustration, Crux Product Design embedded the node inside a needle safety device to evaluate the effects of modifying device ergonomics – specifically the plunger and the cap. The device wirelessly pairs with Crux proprietary software which gathers and displays device orientation and applied force data in real time.



## Smart Home

## Bluetooth LE and Wi-Fi power modules for Matter



U.S. company Fanstel has launched a series of combined **Bluetooth LE** and **Wi-Fi** modules for easing the development of Matter smart home product designs. The WT02E40E Series modules integrate both Nordic's **nRF5340** high-end multiprotocol SoC and **nRF7002** Wi-Fi 6 companion IC. **Matter** is the Connectivity Standards Alliance's unified application layer for smart home applications.

The Fanstel series of modules offer multiple antenna options. All other required hardware—including three crystals, inductors for DC-to-DC converters and a power switch—is embedded, delivering an easy-to-use, highly integrated and compact solution to the developer. Depending on the antenna configuration, the modules range in size from 16 by 28.2 mm to 16 by 35.5 mm.

## IoT Security

## nRF9160 and nRF5340 gain PSA Certified Level 2

Nordic Semiconductor has announced that its **nRF9160** low power SiP and **nRF5340** multiprotocol SoC have achieved **Platform Security Architecture (PSA) Certified Level 2**. The certification provides customers with an assurance that the nRF9160 and nRF5340 offer a secure platform upon which to build IoT products.

"While the cost of security doesn't come cheap, the cost of inaction is far greater and growing by the day. PSA Certified says that the average penalty of a successful IoT device attack is more than \$330,000," says Tiago Monte, Developer Marketing Manager with Nordic. "That's why we want to ensure our customers base their IoT end products on silicon and software that has been independently verified to ensure a robust level of protection. PSA Certified Level 2 for the nRF9160 and nRF5340 proves the SiP and SoC have passed that stringent security testing against malicious software attacks."



## Cellular IoT

## Collaboration brings software SIM to low power cellular IoT

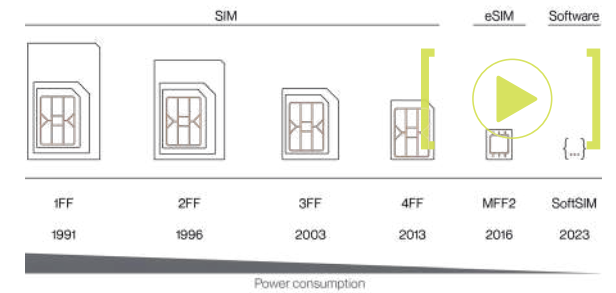
A collaboration between Onomondo and Nordic Semiconductor brings the former's SoftSIM to cellular IoT end-products based on Nordic's **nRF91 Series** SiPs. The collaboration makes it easy for cellular IoT device makers to add SoftSIM to their nRF91 Series-based designs, simplifying development and reducing costs.

Cellular IoT uses mature and widespread cellular infrastructure, so network access requires each end-device to carry a unique Subscriber Identification Module (SIM). Traditional SIMs are physical devices that need to be plugged-in to cellular products, and later developments such as non-physical eSIMs still demand additional supporting hardware. SoftSIM is a "world's first" 100 percent software IoT SIM alternative and is platform agnostic. The product is downloaded from the Cloud and then executed as

software by the nRF91 Series' embedded ARM Cortex-M33 application processor. The SoftSIM uses functionality implemented by the Arm TrustZone security environment.

By combining SoftSIM with Nordic's nRF91 Series SiPs, users have an 'out-of-the-box' connectivity solution that eliminates not only the need for the manufacture and shipping of SIM cards but also their associated overheads. In addition, SoftSIM eliminates the need for a physical SIM socket on the end-device design, reducing the bill-of-materials (BoM) and component costs, and decreasing product size.

Moreover, using SoftSIM enhances the nRF91 Series SiPs' already sector-leading low power consumption by eliminating idle mode power consumption almost completely because the SIM runs in software. Lower power consumption enables extended battery life or the use of smaller cells.



hackster.io  
AN AVRNET COMMUNITY

c5a  
connectivity  
standards  
alliance

# make it matter

## Smart Home Design Contest

Create an innovative, human-centered Matter-ready application with the **nRF7002 DK** and win great prizes.

**JOIN NOW**

[nordicsemi.com/makeitmatter](https://nordicsemi.com/makeitmatter)

**NORDIC**  
SEMICONDUCTOR



# Inside the nPM1300 Power Management IC

The latest addition to Nordic's PMIC range saves space and incorporates key system management features

Nordic Semiconductor's wireless technology, whether Bluetooth LE, Wi-Fi or cellular IoT, is built to support complex IoT applications while minimizing energy consumption and extending battery life. But there is more to [managing power](#) than efficient SoCs, companion ICs or SiPs. The supply voltage must be regulated and distributed over several power rails, and in the case of a rechargeable application, the battery will need to be charged from an external source.

No matter how efficient the processor and radio are, an inefficient power management system will compromise battery life. Moreover, conventional power management solutions typically comprise multiple chips—for example, voltage regulator, battery charger, fuel gauge, external watchdog and hard reset—which take up valuable real estate in space constrained designs.

Nordic has addressed both the efficiency and space challenges of power management for low power and space constrained IoT products with its nPM Family of power management ICs (PMICs). The family comprises the [nPM6001](#) (which features six independently controlled power rails), [nPM1100](#) (a dual-mode configurable buck regulator and integrated battery charger) and the [latest introduction](#), the [nPM1300](#).

The nPM1300 PMIC is optimized for maximum efficiency and compact size, and simplifies system design by integrating the essential functions required for Bluetooth LE operation into one small package.

## Intelligent power management

The nPM1300 is available in a 5 by 5 mm QFN32 and a 3.1 by 2.4 mm WLCSP. Within its compact form factor, the PMIC incorporates two buck converters, two load switches, a battery charger, USB-C compatible input, ship mode and fuel gauge. Such integration simplifies the power management circuit from as many as eight chips plus associated passives to one chip plus a handful of passives. And because the developer only has to work with just one device, it simplifies the interaction and configuration of the PMIC. To further simplify the process, the nPM1300 can be configured for the application using the nPM PowerUP PC-application, which produces the configuration code.

In addition to the high level of integration, the nPM1300 incorporates key system management features that typically must be individually added to conventional power management systems. These features make the product the most integrated PMIC on the market.

The first system management feature of the nPM1300 is failed boot recovery. If such an event occurs—with devices running through power cycling hanging before the watchdog is enabled—the PMIC waits until the host processor indicates that all is normal. If that message is



The nPM1300 incorporates key system management features; these make the product the most integrated PMIC on the market

not forthcoming, the PMIC will power cycle any connected devices to trigger another boot recovery attempt.

The nPM1300 also incorporates a hard reset. This allows the use of one or two buttons to power cycle a hung device. While there are peripheral chips that enable a hard reset, building the function directly into the PMIC saves space and is more convenient.

Next, the Nordic PMIC features a 'hibernate' mode. This is a power saving mode that powers just the essential parts of the PMIC. A timer runs (consuming just nanoamps of current) waking the PMIC after a predetermined period. The timer can be overridden by pressing a button.

In common with many PMICs, the nPM1300 incorporates a watchdog timer. This is an essential requirement so the watchdog can, for example, instruct the PMIC to stop battery charging if the software has crashed. The watchdog can also reset the host processor and, on timing out, power cycle the whole system.

The nPM1300's final system management feature is the power loss warning. This is for use when, for example, the

battery is about to be exhausted or has been removed, or mains power has been unplugged while a depleted battery is still charging. The power loss warning uses a dedicated line to the host processor to warn it when the power is about to fail. The warning informs the host that it is restricted to the reserve energy stored in a back-up capacitor.

There is also an evaluation kit (EK) for the PMIC, the [nPM1300 EK](#). The EK allows for simple evaluation and code-free configuration of the nPM1300. By connecting an associated app, the nPM PowerUP app (found in nRF Connect for Desktop), all settings of the nPM1300 can be easily configured through an intuitive user interface and exported as code to be implemented into the user application software. With the EK and app, the hardware engineer can configure the nPM1300 without needing to write code – and the software engineer does not need to read the datasheet.

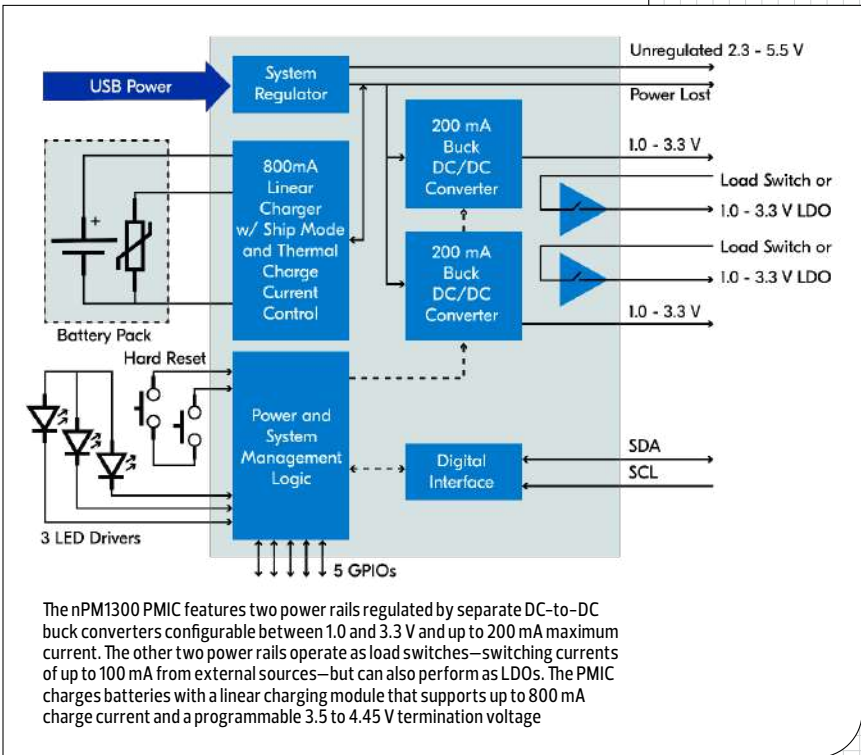
## Precise fuel gauging

Unlike many competitive solutions, the nPM1300 features a highly accurate fuel gauge which requires no external components. The device combines the precision of a coulomb counter—which continuously measures the current flowing into or out of a battery and integrates over time to determine the total cell charge—with the modest power consumption and simplicity of a battery voltage measurement.

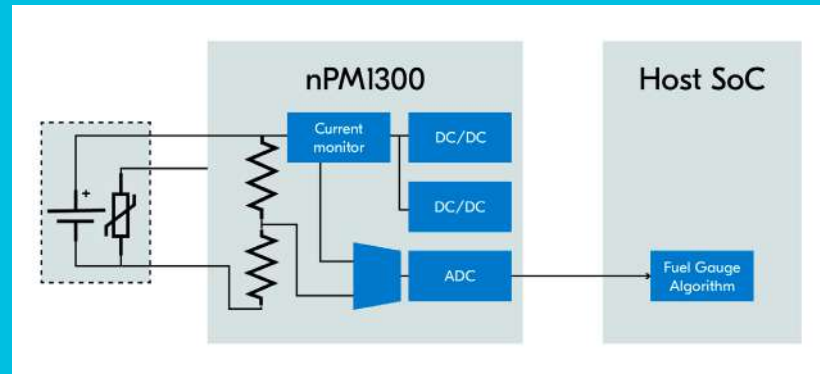
Because of its simplicity, battery voltage measurement is a popular fuel gauge technique. It works because the battery voltage declines as it discharges, so a voltage measured at a particular time is a good proxy for the cell's remaining energy reserves. But while the technique can give satisfactory results, major inaccuracies are common.

Nordic conducted some experiments that compared a coulomb counter with a battery voltage measurement and the nPM1300's fuel gauge. Compared to the coulomb counter, the battery voltage calculation showed nearly 20 percent error when fully charged reducing to 10 percent as the charge depleted. In comparison, the nPM1300's fuel gauge showed a maximum of two percent error at worst compared with the coulomb counter but was mostly within one percent as the battery depleted.

The inaccuracies of the common battery voltage measurement are made worse if the battery is subject to fluctuating temperatures. In an extreme test, with a battery temperature swing between -10 and +50°C over



## An accurate determination of battery charge



The key to the nPM1300 PMIC's accurate fuel gauge is the algorithm run on the host processor which is used to power the fuel gauge. An embedded processor such as the Arm Cortex-M33 used on Nordic's nRF5340 SoC has ample power to run the algorithm without any impact on the rest of the application code. The host processor uses information such as the current flowing into and out of the PMIC, the output from a voltage divider monitoring the battery terminal voltage and a thermistor providing information on battery temperature. With this current, voltage and temperature information, the host processor uses the Nordic-developed algorithm to accurately determine the battery's state of charge. Readings once every second are sufficient to obtain an accurate measurement and the memory requirement for the data is just a few kilobytes. Power consumption for a one-second measurement frequency adds about an extra four microamps to the typical host processor overhead. If the host processor is asleep, it won't make fuel gauge measurements, but as soon as it is woken up it will immediately make new measurements to determine the battery's current state of charge.

a 20-minute period, the voltage measurement technique exhibited up to 30 percent error while the nPM1300's fuel gauge exhibited a maximum error of just 4 percent, compared to the coulomb counter.

The key to the fuel gauge's accuracy over a wide temperature range is the software algorithm powered by the host processor. (See panel on page 36 *An accurate determination of battery charge*.) For the algorithm to produce accurate results it must first be 'taught' the battery characteristics – although this only has to happen once if the end product continues to then use the same type of battery. The teaching is done using the EK equipped with an nPM-FG (fuel gauge) board, to provide the right resistive load, and the nPM PowerUP App. The process is repeated three times at different temperatures to allow the app to build an accurate battery model – this is then exported, together with the rest of the configuration code, to the application software.

The nPM1300 is an efficient and compact PMIC that saves space by incorporating key system management features within the chip. It also incorporates a highly accurate fuel gauge. The PMIC will operate with Nordic's forthcoming nRF54H20, and with the nRF5340 and nRF52840 SoCs. It can also be used with other manufacturers' devices. The PMIC can also be used with the nRF9160 SiP to provide power to peripherals and for battery charging. The SiP takes an unregulated supply from the PMIC because it has its own integrated and high-efficiency power management circuit.

By using the nPM1300 with Nordic's SoCs and SiPs, a developer can optimize their wireless product's energy path, from battery to RF signals, to maximize battery life.

A Nordic webinar entitled *Discover nPM1300 – the future of embedded power management* is available from [tinyurl.com/m6zc7ekj](https://www.tinyurl.com/m6zc7ekj)



## Tech Check

The nPM1300 joins the nPM1100 and nPM6001 in Nordic's PMIC family. The PMIC is optimized for maximum efficiency and compact size and is configurable through an I2C-compatible Two Wire Interface (TWI). This interface enables easy access and configures a range of advanced system management functions







# Nordic Product Guide

This handy summary describes all of Nordic's IoT solutions




Full product details at: [www.nordicsemi.com/Products](http://www.nordicsemi.com/Products)

## RF SoCs and SiP

										
		nRF9160	nRF5340	nRF52840	nRF52833	nRF52832	nRF52820	nRF52811	nRF52810	nRF52805
WIRELESS PROTOCOL	LTE-M	●								
	NB-IoT	●								
	GNSS	●								
	BLUETOOTH LOW ENERGY		●	●	●	●	●	●	●	●
	BLUETOOTH 5.3		●	●	●	●	●	●	●	●
	LE AUDIO		●							
	DIRECTION FINDING		●		●		●	●		
	2 Mbps		●	●	●	●	●	●	●	●
	LONG RANGE		●	●	●		●	●		
	BLUETOOTH MESH		●	●	●	●	●	●		
	THREAD		●	●	●		●	●		
	MATTER		●	●						
	ZIGBEE		●	●	●		●			
	ANT		●	●	●	●		●		●
TYPE	2.4 GHz PROPRIETARY		●	●	●	●	●	●	●	●
	NFC		●	●	●	●				
CORE SYSTEM	SYSTEM-ON-CHIP (SoC)		●	●	●	●	●	●	●	●
	SYSTEM-IN-PACKAGE (SiP)	●								
CPU	CPU	64 MHz Arm Cortex-M33	128 MHz Arm Cortex-M33+64 MHz Arm Cortex-M33	64 MHz Arm Cortex-M4	64 MHz Arm Cortex-M4	64 MHz Arm Cortex-M4	64 MHz Arm Cortex-M4	64 MHz Arm Cortex-M4	64 MHz Arm Cortex-M4	64 MHz Arm Cortex-M4
	FPU	●	●	●	●	●				
	DSP INSTRUCTION SET	●	●	●	●	●	●	●	●	●
	CACHE	●	●	●	●	●				
	MEMORY	1MB Flash, 256 KB RAM	1MB Flash, 512KB RAM +256 KB Flash, 64 KB RAM	1MB Flash, 256 KB RAM	512KB Flash, 128 KB RAM	512 KB or 256 KB Flash, 64 KB or 32 KB RAM	256 KB Flash, 32 KB RAM	192 KB Flash, 24 KB RAM	192 KB Flash, 24 KB RAM	192 KB Flash, 24 KB RAM
	CLOCKS	64 MHz / 32 kHz	128 MHz / 64 MHz / 32 kHz	64 MHz / 32 kHz	64 MHz / 32 kHz	64 MHz / 32 kHz	64 MHz / 32 kHz	64 MHz / 32 kHz	64 MHz / 32 kHz	64 MHz / 32 kHz
SECURITY	ARM TRUSTZONE	●	●							
	ARM CRYPTOCELL	310	312	310						
	ROOT-OF-TRUST	●	●	●						
	SECURE KEY STORAGE	●	●							
	PSA CERTIFICATION	Level 2	Level 2	Level 1						
RADIO	LTE-M/NB-IoT/GPS MODEM	●								
	CERTIFIED LTE BANDS	1-5, 8, 12-14, 17-20, 25-26, 28, 66								
	FREQUENCY	700-2200 MHz	2.4 GHz	2.4 GHz	2.4 GHz	2.4 GHz	2.4 GHz	2.4 GHz	2.4 GHz	2.4 GHz
	MAXIMUM TX POWER	23 dBm	3 dBm	8 dBm	8 dBm	4 dBm	8 dBm	4 dBm	4 dBm	4 dBm
	RX SENSITIVITY	-108 dBm (LTE-M), -114 dBm (NB-IoT), -155 dBm (GPS)	-98 dBm (1Mbps)	-95 dBm (1Mbps)	-96 dBm (1Mbps)	-96 dBm (1Mbps)	-95 dBm (1Mbps)	-97 dBm (1Mbps)	-96 dBm (1Mbps)	-97 dBm (1Mbps)
PERIPHERALS	ANTENNA INTERFACE	50 Ω single-ended	Single-ended	Single-ended	Single-ended	Single-ended	Single-ended	Single-ended	Single-ended	Single-ended
	HIGH SPEED SPI		●	●	●					
	TWI, SPI, UART	4xTWI/SPI/UART	4xTWI/SPI/UART +TWI/SPI/UART	2xTWI/SPI, SPI, 2xUART	2xTWI/SPI, SPI, 2xUART	2xTWI/SPI, SPI, UART	2xTWI/SPI, UART	TWI/SPI, SPI, UART	TWI, SPI, UART	TWI, SPI, UART
	QSPI		●	●						
	USB		●	●			●			
	PWM	4	4	4	4	3		1	1	
	PDM	●	●	●	●	●		●	●	
	I2S	●	●	●	●	●				
	ADC, COMPARATOR	ADC	●	●	●	●	COMP	ADC, COMP	ADC, COMP	ADC
	TIMER, RTC	3, 2	3, 2 + 3, 2	5, 3	5, 3	5, 3	4, 2	3, 2	3, 2	3, 2
	TEMPERATURE SENSOR	●	●	●	●	●	●	●	●	●
	CERTIFICATIONS	<a href="http://nordicsemi.com/9160cert">nordicsemi.com/9160cert</a>	CE, FCC	CE, FCC	CE, FCC	CE, FCC	CE, FCC	CE, FCC	CE, FCC	CE, FCC
	OPERATING TEMPERATURE	-40 to 85°C	-40 to 105°C	-40 to 85°C	-40 to 105°C	-40 to 85°C	-40 to 105°C	-40 to 85°C	-40 to 85°C	-40 to 85°C
	SUPPLY VOLTAGE RANGE	3.0 to 5.5 V	1.7 to 5.5 V	1.7 to 5.5 V	1.7 to 5.5 V	1.7 to 3.6 V	1.7 to 5.5 V	1.7 to 3.6 V	1.7 to 3.6 V	1.7 to 3.6 V
	DEVELOPMENT KITS	nRF9160 DK, Nordic Thingy:91	nRF5340 DK, nRF5340 Audio DK, Nordic Thingy:53	nRF52840 DK, nRF52840 Dongle	nRF52833 DK	nRF52805 DK, Nordic Thingy:52	nRF52833 DK	nRF52840 DK	nRF52805 DK	nRF52805 DK
	PACKAGES	10x16x1.04 mm LGA	7x7 mm aQFN94 (48 GPIOs), 4.4x4.0 mm WLCSP95 (48 GPIOs)	7x7 mm aQFN73 (48 GPIOs), 6x6 mm QFN48 (30 GPIOs), 3.5x3.6 mm WLCSP94 (48 GPIOs)	7x7 mm aQFN73 (42 GPIOs), 5x5 mm QFN40 (18 GPIOs), 3.2x3.2 mm WLCSP (42 GPIOs)	6x6 mm QFN48 (32 GPIOs), 3.0x3.2 mm WLCSP50 (32 GPIOs)	5x5 mm QFN40 (18 GPIOs), 2.53x2.53 mm WLCSP44 (18 GPIOs)	6x6 mm QFN48 (32 GPIOs), 5x5 mm QFN32 (17 GPIOs), 2.48x2.46 mm WLCSP33 (15 GPIOs)	6x6 mm QFN48 (32 GPIOs), 5x5 mm QFN32 (17 GPIOs), 2.48x2.46 mm WLCSP33 (15 GPIOs)	2.48x2.46 mm WLCSP28 (10 GPIOs)

## Power Management ICs

				
		nPM1300	nPM1100	nPM6001
FEATURES	PMIC	●	●	●
	BUCK REGULATOR	2	1	4
	BATTERY CHARGER	●	●	
	LDO	2		2
CHARGER	LOAD SWITCH	2		
	TERMINATION VOLTAGE	3.5 to 4.45 V	4.1 to 4.2 V or 4.25 to 4.35 V	
	MAX CHARGING CURRENT	800 mA	400 mA	
	POWER PATH MANAGEMENT	●	●	
POWERRAILS	THERMAL PROTECTION	●	●	
	BATTERY COMPATIBILITY	LiFePO4, Li-Ion, LiPo	Li-Ion, LiPo	
	INPUT VOLTAGE	4 to 5.5 V	4.1 to 6.7 V	3 to 5.5 V
	USB COMPLIANCE	Type-C	●	
SYSTEM MANAGEMENT	REGULATED OUTPUT VOLTAGE	1 to 3.3 V	1.8 to 3 V	0.5 to 3.3 V
	MAX CURRENT PER BUCK	200 mA, 200 mA	150 mA	550 mA, 200 mA, 150 mA, 150 mA
	ADC	10-bit		
	FUEL GAUGE	●		
	HARD SYSTEM RESET	●		
	TIMED WAKE-UP	●		●
	WATCHDOG TIMER	●		●
	SHIP MODE / HIBERNATE	●	●	●
	BROWN-OUT DETECTOR	●	●	●
	LED DRIVERS, GPIOs	3, 5	2, 0	0, 3
	CONTROL INTERFACE	TWI	Pin-configurable	TWI
	REGULATORY COMPLIANCE	CE, JEITA, RoHS	CE, JEITA, RoHS	CE, RoHS
	OPERATING TEMPERATURE	-40 to 85°C	-40 to 85°C	-40 to 85°C
	EVALUATION KITS	nPM1300 EK	nPM1100 EK	nPM6001 EK
	PACKAGE OPTIONS	5x5 mm QFN32, 3.1x2.4 mm WLCSP	4x4 mm QFN24, 2.1x2.1 mm WLCSP	2.2x3.6 mm WLCSP

### Range Extender

## nRF21540

**Description:** The [nRF21540](#) is an RF front-end module (FEM) that improves range and connection robustness for Nordic nRF52 and nRF53 Series SoCs. The nRF21540 is a complementary device operating as a 'plug-and-play' range extender with the addition of just a few external components. The nRF21540's 13 dB RX gain and low noise figure of 2.7 dB, coupled with up to +21 dBm TX output power, ensure a superior link budget boosting the range of supported SoCs by between 6.3 and 10x. The RF FEM suits all applications that require increased range and/or robust coverage. In demanding RF environments, or where the application is operating close to the range limit, it can be more energy efficient to use the nRF21540 than continuously resend packets.

**Operation:** The nRF21540 supports Bluetooth LE, Bluetooth mesh, Matter, Thread, Zigbee and 2.4 GHz protocols. The RF FEM's TX output power is dynamically adjustable and can be set to comply across all geographical regions. The RF FEM can be used with Nordic's extended temperature-qualified nRF5340, nRF52833 and nRF52820 SoCs in industrial applications.



### Tech Spec

**Output power**  
Adjustable in small increments up to +21 dBm

**Receive gain and noise figure ratings**  
13 dB receive gain. 2.7 dB noise figure

**Input supply**  
1.7 to 3.6 V

**Package**  
4 by 4 mm QFN16

**Development bundle**  
nRF21540 DK and nRF21540 EK. The EK is a shield for use with nRF52 and nRF53 Series DKs

**Applications**  
Asset tracking, smart home, industrial, toys, audio

### Cloud Services

## nRF Cloud Services

**Description:** [nRF Cloud Services](#) are optimized for Nordic's low-power IoT Devices. nRF Cloud Services consists of nRF Cloud Location Services, and Device Management and Security Services will be available soon. Both Device-to-Cloud or Cloud-to-Cloud use cases are supported. CoAP and MQTT protocols are both supported.

**Services:** 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 the nRF7000 companion IC. Each location feature has accuracy and power efficiency advantages, so switching between different location services during operation can be useful. nRF Cloud also includes a Firmware-Over-The-Air update functionality, whereby the nRF91 Series' modem firmware, middleware and/or application firmware can be updated.



### Tech Spec

**Location services**  
Assisted GPS  
Predictive GPS  
Single-Cell  
Multi-Cell

**Additional features**  
Device-to-Cloud and Cloud-to-Cloud use cases  
CoAP, MQTT and REST API support

**Supported products**  
nRF9131 SiP, nRF9160 SiP, nRF9161 SiP, nRF9160 DK, Nordic Thingy:91, nRF7002 companion IC

**Applications**  
Industrial, smart appliances, asset tracking, RTLS

### Wi-Fi 6 companion ICs

## nRF70 Series

**Description:** The [nRF7001](#) companion IC is a low power Wi-Fi solution for end products requiring 2.4 GHz connectivity only. The [nRF7002](#) can be used in both the 2.4 and 5 GHz bands. The products offer good coexistence with Bluetooth LE devices and feature one Spatial Stream (SS), 20 MHz channel bandwidth, 64 QAM (MCS7), 86 Mbps PHY throughput and OFDMA (downlink and uplink).

**Operation:** The nRF70 Series companion ICs provide low power, secure Wi-Fi connectivity as well as Wi-Fi assisted locationing based on Service Set identifier (SSID) scanning. The ICs incorporate Wi-Fi 6's Target Wake Time (TWT), a power-saving feature allowing the ICs to negotiate a wake-up schedule with the access point (AP) to which it is connected. The nRF70 Series accompany Nordic's nRF52 and nRF53 Series Bluetooth LE SoCs, and the nRF91 Series cellular IoT SiPs. The nRF70 Series can also be used as companion ICs in applications hosted by non-Nordic products.



### Tech Spec

**Compliance**  
IEEE 802.11b (Wi-Fi 1)/a (Wi-Fi 2)/g (Wi-Fi 3)/n (Wi-Fi 4)/ac (Wi-Fi 5) (not the nRF7001)/ax (Wi-Fi 6)

**Package**  
6 by 6 mm QFN

**Features**  
Low power, good coexistence with Bluetooth LE, TWT

**Development tools**  
nRF7002 DK, nRF Connect SDK

**Applications**  
Asset tracking, smart home, industrial



nPM  
FAMILY

# The future of power management



## nPM1300 Power Management IC

*Stop using five or six separate chips in your power management design. Nordic's nPM1300 has everything you need in one PMIC, including some functions you didn't realize you needed. Until now.*

**START YOUR DEVELOPMENT TODAY**  
[nordicsemi.com/nPM1300](http://nordicsemi.com/nPM1300)



**NORDIC**  
SEMICONDUCTOR