



The Power Advantage

Achieving Terrestrial-Class Low Power
in Non-Terrestrial Networks (NTN)
with Skylo and Nordic nRF9151



EXECUTIVE SUMMARY

IoT deployments increasingly depend on reliable connectivity in remote and infrastructure-poor environments, yet traditional satellite solutions have long been associated with high power consumption, proprietary hardware, and limited scalability. This white paper presents new measurements using the low power nRF9151 module from Nordic Semiconductor operating over Skylo's 3GPP-standardized NTN service, demonstrating that for the most common IoT reporting patterns—small, intermittent data transmissions of 20–200 bytes—the total energy consumed over NTN is highly comparable to a device operating in poor terrestrial coverage conditions.

This finding represents a significant shift for large-scale IoT design. By combining standardized NTN connectivity with Nordic's low-power, dual-mode nRF9151, device makers can achieve multi-year battery life, global coverage, and simplified hardware architectures, all without incurring the power or cost penalties historically associated with satellite networks. These results validate NTN as a practical, scalable, and power-efficient extension of terrestrial NB-IoT and LTE-M, enabling reliable IoT operation anywhere on Earth with a single, universally certified and deployable module.

INTRODUCTION

The rapid expansion of the Internet of Things (IoT) has driven the need for reliable connectivity far beyond the reach of terrestrial cellular networks. Large portions of the world—across rural, maritime, agricultural, industrial, and environmental settings—remain underserved or entirely unserved by terrestrial infrastructure. These are precisely the environments where IoT devices deliver the greatest value and where uninterrupted connectivity becomes essential for safety, efficiency, and real-time visibility.

At the same time, massive IoT deployments must adhere to strict power, hardware, and cost constraints. Devices are expected to operate for years on small batteries or minimal solar input, maintain compact form factors, and connect reliably without access to continuous reliable power source. These realities make power consumption a defining requirement for IoT design and a critical benchmark for evaluating any alternative connectivity method.

As IoT solutions scale across increasingly remote environments, meeting these power and cost requirements—while expanding coverage beyond terrestrial limits—has become central to enabling the next wave of global IoT innovation.

Methodology

To evaluate the impact of non-terrestrial network (NTN) connectivity on device power consumption, we conducted a series of controlled measurements comparing Skylo NB-NTN performance with terrestrial NB-IoT operation under equivalent “edge-of-coverage” conditions.

Test Equipment and Setup

- **Device Under Test:** Nordic Semiconductor nRF9151-SMA-DK (Development Kit)
- **Measurement Tool:** Nordic Power Profiler Kit II (PPK2)
- **Hardware Configuration:** nRF9151 SMA DK development kit; tests can also be replicated using customer prototypes as long as the exact same antenna is used.
- **Networks Evaluated:**
 - **Skylo NB-NTN** (live NTN network) in Finland (outdoor with view of the southern sky)
 - **Terrestrial NB-IoT network** configured to emulate NTN-like weak-signal conditions by putting an attenuator between the nRF9151 and the antenna such as the signal level where as described below (“edge of coverage”)

Network Conditions

Measurements were taken in live commercial networks. As a result, individual results may vary depending on operator configuration, location, and SIM. The key radio parameters for each environment during testing were:

Parameter	Skylo NTN	Terrestrial NB-IoT
Band	B256	B20
RSRP	-124 dBm	-128 dBm
SNR	>0 dBm	~1dB
CE Level	2	2

Testing Approach

1. Live Network Measurements:

All current-consumption profiles were captured from live NTN and terrestrial NB-IoT networks rather than lab simulations to reflect real-world performance.

2. Attach and Data Transfer Procedures:

For both NTN and terrestrial scenarios, we captured:

- Attach procedure behavior
- Uplink data transmission
- Downlink reception
- Idle-mode intervals

3. Edge-of-Coverage Comparison:

To ensure a meaningful comparison, the terrestrial network test conditions were intentionally selected to reflect the degraded coverage scenarios in which NTN would realistically be used—i.e., when terrestrial connectivity is lost or unstable.

4. Power Profiling:

- Current traces were recorded for each major network event.
- Between events, the nRF9151 transitioned to **RRC Idle**, which appears as periodic current spikes corresponding to DRX cycles.
- Deeper sleep behavior (e.g., **PSM**) was not the focus of this measurement set but is available for applications requiring further power optimization.

Reproducibility

All tests can be reproduced using:

- A PPK2,
- An nRF9151 DK or customer hardware (with exact same antenna shipped with the the DK)
- A live NTN subscription (e.g., Skylo) and a terrestrial NB-IoT SIM.
- Testing location: for NTN from the northern hemisphere (open sky facing south). For NTN from the southern hemisphere (open sky facing north). For terrestrial - need to be at the edge of the network or for example use an attenuator to control signal strength as described earlier in this white paper.

While results may vary across networks and geographies, the methodology provides a consistent and repeatable framework for evaluating NTN vs. TN power consumption.



The Need for NTN and the Paramount Importance of Power

The Connectivity Gap

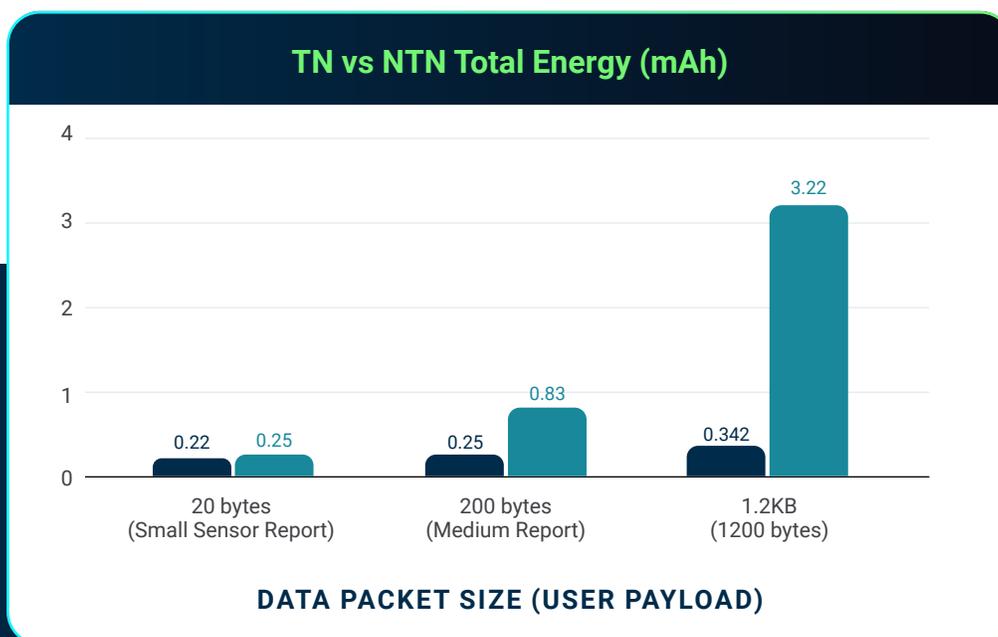
While mobile network coverage is continually evolving, significant portions of the globe remain unconnected, especially in rural, maritime, and isolated areas. NTN, by leveraging satellite communications, seamlessly extends existing cellular communications to these unserved regions. This is where assets—like remote pipelines and grids, agricultural and environmental sensors, livestock tracking, and fleet vehicles—operate, and they require a connection not just as a fallback, but as the primary means of communication from the same device that supports terrestrial today.

Why Every Milliwatt Counts for IoT

For Massive Machine-Type Communications (mMTC) and remote IoT devices, **low power consumption is paramount**. These devices are often battery-powered for years, or rely on small solar panels, necessitating extreme power efficiency.

- **Remote Deployment:** Devices are deployed in distant, hard-to-reach locations beyond terrestrial coverage like deserts, offshore rigs, energy infrastructure or rural farms, making frequent battery changes prohibitively expensive and logistically complex.
- **Longevity:** Battery life is a core competitive feature. An extra year of operation can drastically lower the Total Cost of Ownership (TCO) for solution providers.
- **SWaP-C Constraints:** Hardware must adhere to strict Size, Weight, Power, and Cost (SWaP-C) limits for integration into compact designs (e.g., livestock trackers, wearables, or small condition monitors).

The active time the radio is on to transmit or receive data directly impact battery life. Every increase in current draw or connection duration can shorten a device's functional lifespan by months or even years.



Legacy Satellite's Limitations: Proprietary and Power-Hungry

Historically, connecting to satellite networks (such as Iridium or Orbcomm) required **proprietary, non-standards-based hardware**.

- **Increased Complexity and Cost:** These legacy solutions necessitate a specialized satellite terminal or module, adding complexity and significant cost to the device Bill of Materials (BOM), in addition, training, sparring and other increases in Total Cost of Ownership (TCO).
- **Vendor Lock-in:** The integration of proprietary hardware often locks the solution provider into a single service, limiting choice, increasing service costs, and hindering the ability to scale globally across different networks
- **Power Consumption Challenge:** Legacy satellite modems present a considerable power challenge. Studies show that energy consumption, especially with higher message rates, significantly impacts battery life, often yielding device lifetimes of less than a year for typical IoT reporting profiles.

This presents a clear pivot point: there must be a better, standards-based, and more power-efficient way to provide ubiquitous connectivity.

The 3GPP Standards Advantage: Skylo and Nordic

The new era of NTN, driven by 3GPP standardization (starting with Release 17), overcomes the proprietary limitations of the past.

Skylo: Standards-Based NTN Service

Skylo delivers a 3GPP standards-based NTN service, meaning devices communicate using the same NB-IoT protocol as a terrestrial network. This allows for seamless, non-proprietary Location integration. Skylo provides global coverage, with service already rolled out across parts of North America, South America, Europe, and Australia/New Zealand (ANZ), with plans for a fifth continent soon.

Nordic nRF9151: Single Module, Dual Network

Nordic Semiconductor addresses the low power and hardware challenge with the fully integrated **nRF9151** module for cellular IoT, NTN, and DECT NR+. This single, compact, and low-cost module is globally certified and connects dynamically to both **NTN and TN networks** where available. Critically, it also includes an integrated **open MCU (Microcontroller Unit)**, enabling simple, compact, and low-cost final device design by allowing the nRF9151 to also host the device application firmware.

¹ <https://www.jec.senate.gov/public/index.cfm/democrats/2023/10/climate-exacerbated-wildfires-cost-the-u-s-between-394-to-893-billion-each-year-in-economic-costs-and-damages#:~:text=The%20JEC%20Democratic%20Majority's%20analysis,%2D4%25%20of%20U.S.%20GDP.>

Comparative Low-Power Performance: NTN vs. Poor TN

The core finding is that for the most common IoT data transfers, the nRF9151 operating on Skylo NTN is **highly comparable** in power consumption to the same device operating on a terrestrial NB-IoT network under “edge of coverage” or poor signal conditions—the real-world scenario where NTN provides value.

Typical IoT Use Case: Small Data Packets (20–200 Bytes)

The vast majority of IoT applications—such as tracking a single location point, a sensor reading, or a simple status update—use very small data packets, typically between 20 and 200 bytes of user data.

Use Case	Data Sent (User Payload)	TN Total Energy (mAh)	NTN Total Energy (mAh)	TN:NTN Ratio
Small Sensor Report	20 bytes	0.22mAh	0.25mAh	1:1
Medium Report	200 bytes	0.25mAh	0.83mAh	1:3

1. 20-Byte Packet (e.g., GPS location, single sensor reading):

- **NTN vs. TN:** The energy consumption is nearly 1:1, with NTN requiring 0.25mAh and the poor TN network requiring 0.22 mAh.
- **Energy per Bit:** The difference is minimal: 0.0125 mAh/bit for NTN versus 0.0111 mAh/bit for TN.

2. 200-Byte Packet (e.g., Multiple sensor readings, detailed status):

- The difference remains manageable. While the NTN connection event duration is longer due to the higher latency of the Geostationary (GEO) satellite link, the energy consumption for the full event is 0.833mAh for NTN compared to 0.25 mAh for TN.
- **Energy per Bit:** NTN is 0.00417mAh/bit compared to 0.001/bit for TN.

¹ <https://www.jec.senate.gov/public/index.cfm/democrats/2023/10/climate-exacerbated-wildfires-cost-the-u-s-between-394-to-893-billion-each-year-in-economic-costs-and-damages#:~:text=The%20JEC%20Democratic%20Majority's%20analysis,%2D4%25%20of%20U.S.%20GDP.>

Small Packet Use Cases

This minimal power difference for small data is a critical enabler for various industries:

- **Agriculture (Livestock Tracking):** Sending a 20-byte GPS coordinate and a battery level update.
- **Fleet/Asset Management (Construction/Mining):** Transmitting a 50-byte hourly asset status (location, idle time, fuel level).
- **Oil & Gas/Condition Monitoring:** Sending a 20-byte alert for a pressure or temperature threshold violation on a remote pipeline.

Case Study: n5Sensors

SOLAR POWERED, SOLUTION FOR MONITORING WILDFIRES POWERED BY NORDIC NRF9151 ON SKYLO NETWORK

Wildfires have become an ever-more pressing threat in the United States — in 2024 alone, The National Interagency Fire Center reported nearly 65,000 wildfires scorched approximately 8.9 million acres of land, surpassing the ten-year national average by more than a quarter. Suppression efforts alone have imposed a heavy financial burden — in recent years wildfire-fighting and containment have cost the federal government around \$3.0 billion per year on average. Meanwhile the broader economic toll — factoring in damage to property, infrastructure, ecosystems, air quality, health, and lost productivity — has been estimated in to reach as much as \$394 to \$893 billion annually, accordingw to US Joint Economic Committee, equivalent to 2-4% of GDP.

The rising human, environmental, and economic cost of these events has underscored the urgent need for more effective early-warning and detection systems — a challenge that N5's wildfire detection sensors are specifically designed to address. Unchecked fire ignitions in high-risk areas can escalate with astonishing speed, turning a small spark into a catastrophic wildfire within minutes under dry, windy, or fuel-rich conditions. Once an ignition grows beyond the earliest stages, suppression becomes dramatically more difficult— flame fronts intensify, spotting pushes embers

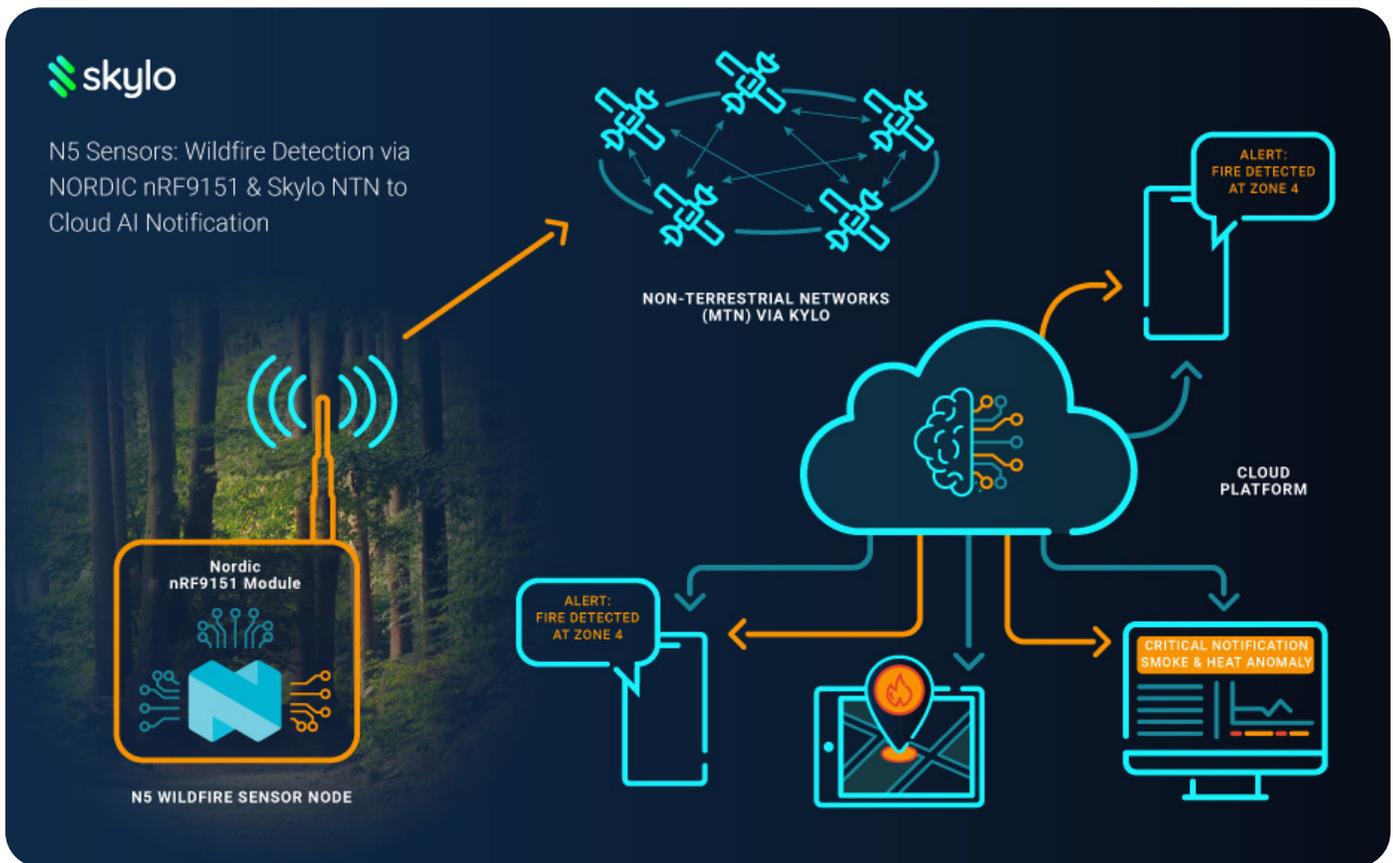


miles ahead, and response agencies lose the critical window in which a fire can still be contained. These runaway fires threaten lives, destroy infrastructure, disrupt energy operations, and impose enormous environmental and economic costs. This is why immediate detection is so essential: recognizing an ignition at its inception is the single most effective way to prevent escalation.

N5SHIELD® and its distributed network of sensors offered by N5 Sensors play a critical role in areas of extreme fire danger by providing immediate detection of early-stage wildfire ignitions—Their ability to detect and identify fire from smoke at ground level gives firefighters precious minutes to mobilize suppression efforts and prevent catastrophic spread.

However, the environments where sensor based wildfire detection is most needed also present significant deployment challenges: The wildfire-prone regions where these ground based sensors are most valuable are typically remote, and lacking reliable power and communication infrastructure. N5SHIELD's sensors must therefore operate on long-life batteries powered by only by Solar in order to maintain continuous cloud connectivity, mandating the need to have very power efficient

hardware that can connect via NTN. This is where N5's partnership with Skylo and Nordic enables an exciting enhancement in hardware innovation. The wildfire detection application requires sending small packets of data with high frequency without compromising the ability of the device to operate on rechargeable batteries. The NTN connectivity offered by the nRF9151 module enables always-on, satellite-backed communication with extremely low energy demand, ensuring that N5's sensors can remain connected even in remote, infrastructure-poor regions where wildfires often ignite. This kind of ultra-reliable, low-power satellite link will extend battery life, improve alert delivery, and ensure that early-stage ignition signals reach responders instantly—further reducing the risk of small fires growing into catastrophic events.



Latency Impact on Large Packets

As data size increases, the difference in latency between NTN and TN becomes more pronounced. For a 1200-byte packet, the NTN connection event stretches to 1 minute and 18 seconds, with an energy consumption of 3.22mAh, leading to a ratio of 10:1 compared to the TN's 0.342 mAh. The takeaway is clear: while NTN is not optimized for high-throughput, latency-sensitive applications, it excels in the very typical the low-power, intermittent data transmission of massive IoT. However, we note that for these types of applications, latency is typically not a requirement, but having access to that information is.

Conclusion

The adoption of 3GPP-standardized NTN services like Skylo, coupled with highly efficient modules like the Nordic Semiconductor nRF9151, fundamentally changes the economics and power-budget reality for global IoT deployment.

For the most common IoT data transfers—the 20 to 200-byte packets that power critical remote monitoring applications—the total energy consumed on the Skylo NTN network is **highly comparable** to what a device experiences when struggling for connection on a poor terrestrial network. This means that deploying devices with ubiquitous NTN coverage no longer necessitates a compromise on long-term battery life.

The nRF9151 module delivers the promise of global, standards-based, and **low-power consumption** connectivity, ensuring that the next generation of IoT devices can operate reliably for years, regardless of where they are in the world.

