WHITE PAPER

Selecting the right hardware architecture for IoT tracking solutions

u-blox combo modules address many of the limitations of cellular-GNSS SoCs currently on the market.

Abstract
No single hardware architecture addresses the diverse IoT tracking market's full spectrum of needs. This white paper offers guidance to select the technology solution that best meets your use case's requirements.

White paper: Selecting the right hardware architecture for IoT tracking solutions

Author: Samuele Falcomer, Oreste Concepito, u-blox AG

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1 Wireless tracking solutions: addressing what, when, where in the IoT

Cloud-connected tracking solutions are among the most prevalent IoT endpoints. They single-handedly address the “where,” the “what,” and the “when” questions that define common IoT use cases, e.g. “Where is my shipment of fresh strawberries being held up?” Additional sensors offer further insights, both real-time and historical: “Are they exposed to sunlight? Has the temperature been properly maintained? Were the crates handled harshly during transit?”

In the past, IoT tracking solutions have typically been composed of fully independent modules: (a) a GNSS receiver with its own RF front-end and antenna, mounted alongside (b) a cellular modem, it too connected to its own RF front-end and antenna. Seeking to reduce the size and bill of materials (BOM) of their solutions, hardware vendors scaled them down by shedding some components and fitting all the elements onto a single piece of silicon in a system-on-chip (SoC) design.

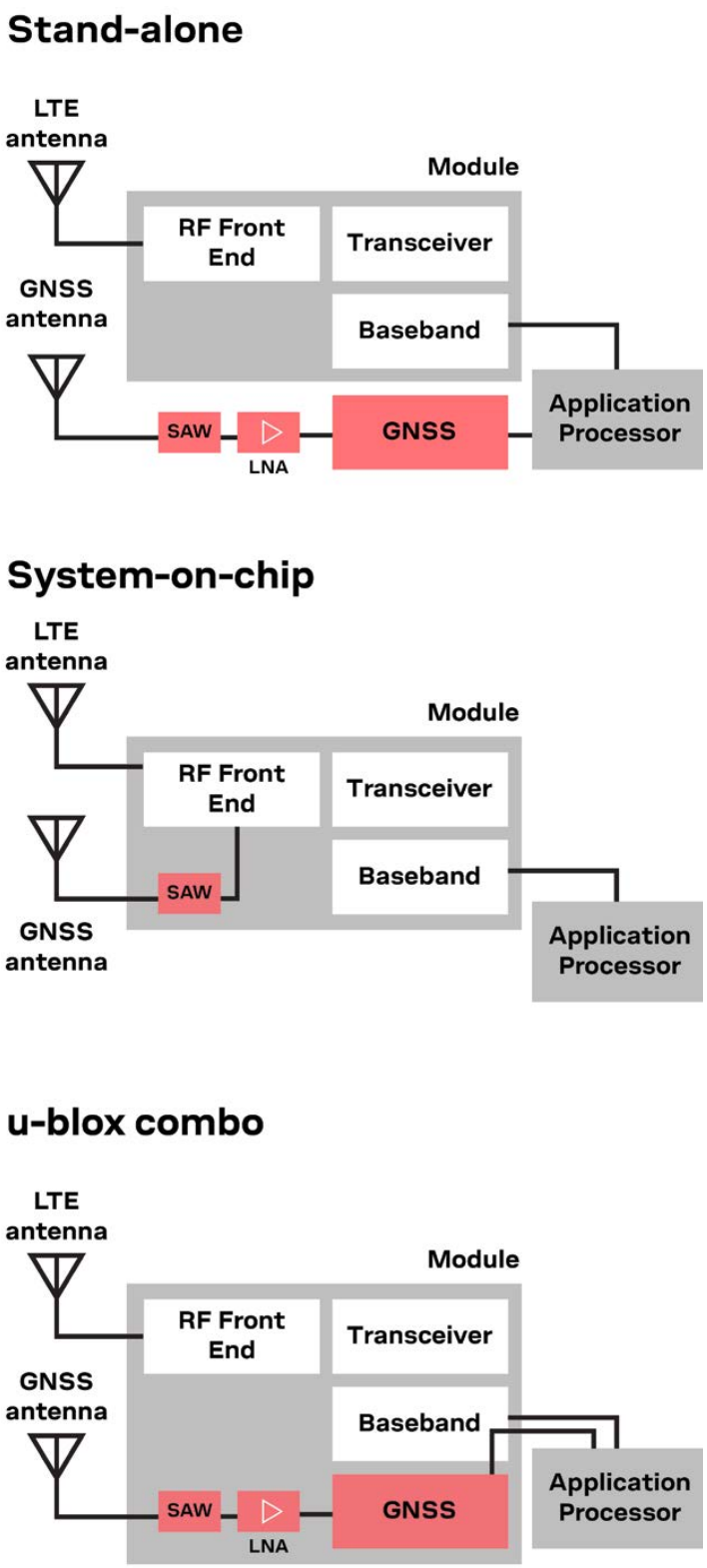
This, however, has come at a cost, both in terms of the performance of the GNSS positioning receiver and the cellular modem. In most solutions, the GNSS receiver and the cellular modem share a common RF front-end, rendering concurrent GNSS signal reception and cellular signaling impossible. Others have shaved 3dB off of the maximum transmit power of their cellular modems to reduce their bill of materials, but resulting in retransmissions, higher latencies, higher power consumption, and reduced coverage in challenging environments, such as indoors and at cell edges.[1]

Recognizing the value of small and cost-effective products for the IoT tracking market, yet unwilling to accept the compromises associated with the

[1]) https://www.u-blox.com/en/blogs/insights/now-no-time-whisper-why-industrial-iot-needs-23-dbm-transmission-power

system-on-chip (SoC) architecture, we at u-blox have pursued an alternative approach, which we refer to as a combo solution. Our combo solutions are the first tracking offering on the market to be based on a complete chip-down design, offering fully integrated GNSS positioning and cellular communication functionality in a single module without compromising performance.

The IoT tracking market covers a wide range of highly diverse use cases. While combo solutions cover the needs of several of them, they cannot replace stand-alone solutions, which will continue to be the hardware architecture of choice for applications requiring a great degree of design flexibility or exceptional performance. With no one-size-fits-all solution at hand, choosing the most appropriate hardware architecture for your specific application requires weighing the pros and cons of available solutions. This white paper offers guidance to select the technological solution that best meets your use case's requirements.



Architectural differences between stand-alone, system-on-chip, and combo IoT tracking solutions.

2 The diverse tracking market needs diverse solutions

Over the past years, expectations on the performance of tracking and telematics solutions have been rapidly rising. While accuracy, size, and price have long dominated sales pitches, factors such as coverage, availability, security, power consumption, and full life-time support have been gaining in importance. This trend has been paralleled by rapid market growth, with ever more varied tracking and telematics use cases relying on satellite-based positioning and cellular communication technology.

Common tracking use cases can be grouped into four broad categories.

Fleet management

- Trucks
- Commercial car fleets (rental, business)
- Taxis
- Ride-hailing
- Micromobility
- Emergency vehicles

Automotive services

- Stolen vehicle recovery
- Pay-as-you-go road tolling
- Usage-based insurance

Asset tracking

- Container tracking
- Pallet tracking
- Expensive equipment tracking

People and animal tracking

- Child tracking
- Lone worker tracking
- Offender tracking
- Pet tracking
- Wild animal tracking

3 Balancing competing requirements

Finding the optimal balance between **functionality, performance, power consumption, size, and cost** can be challenging. If you are a device developer sourcing satellite-based positioning and wireless communication solutions, you will likely have to weigh some of the factors below to find the hardware solution that best fits your needs:

GNSS performance/accuracy: Over the past years, GNSS performance has advanced considerably, with solutions available today that meet even the most challenging needs. The latest generation of GNSS receivers leverage satellite signals in multiple frequency bands from multiple satellite constellations concurrently to achieve single-meter-level accuracies in most common environments. With GNSS correction services, some of which now target mass-market applications, accuracies can be increased further still, down to just a few centimeters.

GNSS availability: GNSS receivers require good sky visibility for optimal performance. Tunnels, parking garages, and even dense forests or deep urban canyons can cause receivers to lose their position reading. Hybrid (cellular network-based) positioning solutions and inertial measurements can extend service coverage and improve performance in hard-to-reach environments.

Cellular availability: The trend for real-time tracking services has stepped up demands on cellular network coverage. Fleet managers, for instance, increasingly expect to be able to locate and interact with their vehicles at a moment's notice, regardless of where they are. For one, this requires that cellular modules be compatible with and certified for available technologies in all territories they may find themselves in. They should also have maximum service availability across those territories, for example at cell edges, underground, or in other hard-to-reach locations. This can be achieved using 5G-ready low power wide area (LPWA) cellular technologies (LTE-M, NB-IoT) or by offering fallback options to legacy technologies, such as 2G networks which remain common across Europe, Latin America, and elsewhere.

Concurrent operation: Size-constrained, cost-effective telematics devices may require integrated LTE and GNSS solutions. How, precisely, they are integrated can determine whether positioning and cellular communication can operate concurrently. Most integrated products on the market are SoCs. These share the same RF front-end to receive satellite signals and transmit cellular data. This has some major drawbacks as data transfers can interrupt GNSS positioning, or, vice versa, GNSS positioning can interrupt or delay LTE signaling. This can result in an inability to get a GNSS position fix when needed and can introduce latencies and waste power due to repeated cellular reconnections with the base station.

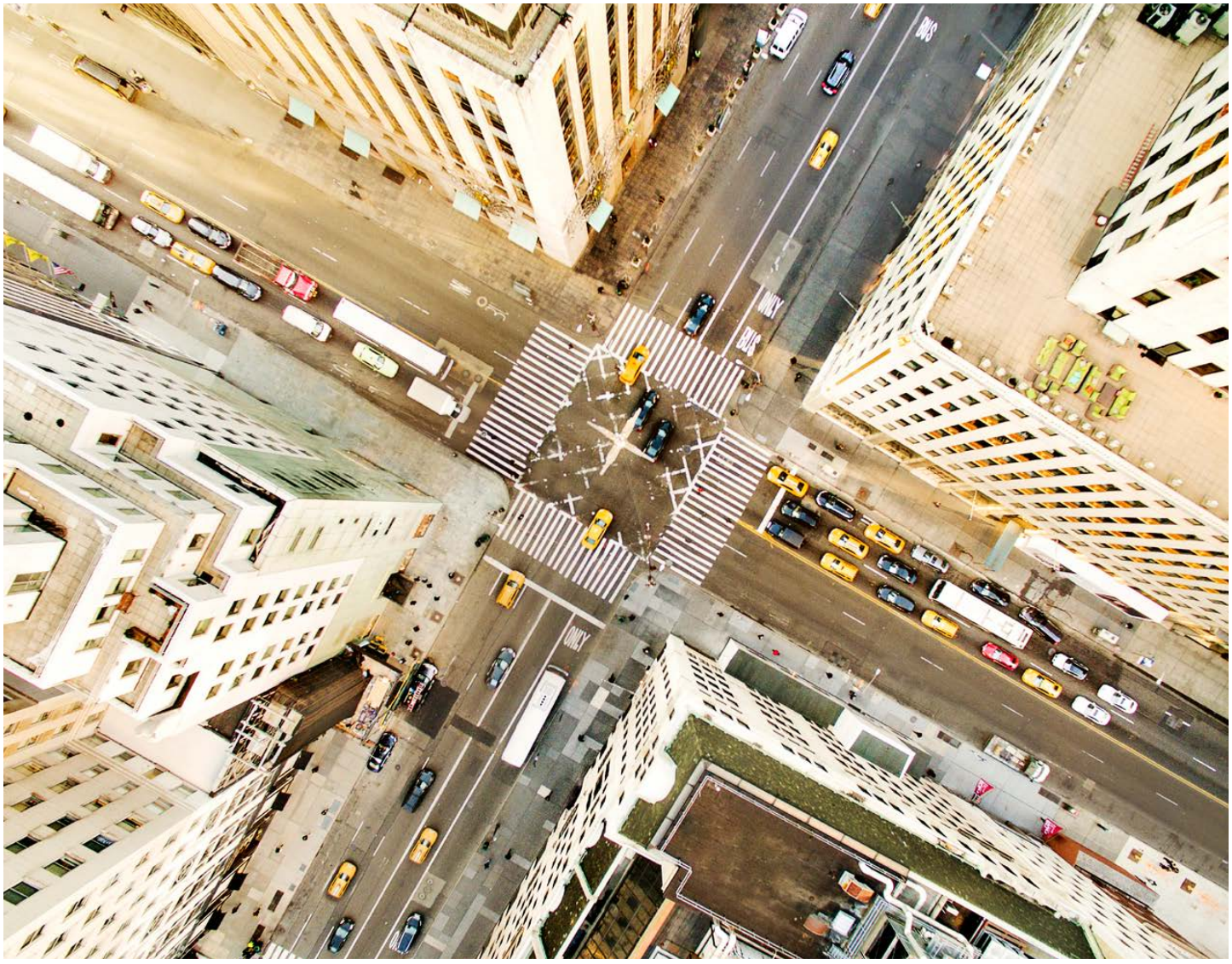
Security: GNSS security is playing a growing role in use cases in which satellite signals are known to be spoofed to evade commercial or legal restrictions. Examples include hiding private deliveries made using commercial vehicles; avoiding payments in pay-as-you-go road tolling schemes; driving shared vehicles outside their geofenced area of operation; jumping the queue in popular locations such as airports; and making tracked assets or people "disappear."

Security is also critical when sensitive business information or confidential personal data are transmitted over cellular data networks, especially for solutions used to track valuables and business-sensitive assets. In these cases, resilient end-to-end security, from the GNSS receiver all the way up to the cloud application can become a non-negotiable feature.

Power consumption: In particular for battery-powered tracking devices, low power consumption can be vital for many use cases. Because GNSS position acquisition (leading up to a position fix) and cellular data transfer are the main sources of power consumption, ensuring that GNSS position fixes are not lost and data transfer is carried out only as often as necessary are surefire ways to extend the battery life of battery-powered tracking devices.

Size: The size of tracking hardware depends on the size of all the integrated components. Compared to stand-alone solutions, combo modules share components that are needed by both cellular and GNSS functionality to shrink down the size of the final product and shorten the bill of materials.

Cost: In the same way that combo solutions reduce the size of tracking hardware by sharing components that are needed by both cellular and GNSS functionality, the abridged bill of materials also lowers the final cost of the tracking solution.



4 u-blox combo modules: chip-down design with no compromises

Driven by market demand for ever smaller and more affordable tracking solutions, we have, for the first time, introduced a series of LTE and GNSS combo products into our portfolio. Our combo solutions target the size, price, and performance constraints of IoT applications, leveraging LPWA technologies that have recently been included in the 5G spec: LTE-M and NB-IoT.

Size reduction: Integrated chip-down design combining cellular and GNSS solutions reduces the size by 14% compared to an equivalent stand-alone solution made up of u-blox components.

Cost reduction: By saving costs on integrated components and leveraging economies of scale, the overall cost of the integrated solution is reduced compared to the stand-alone solution.

Zero compromise LTE: Featuring a dedicated LTE RF front-end, u-blox combo modules pack the full punch of the LTE chipsets they comprise, including unbridled 23 dBm transmission power, unlike the standard SoC solutions that are currently on the market.

Zero compromise GNSS: u-blox combo modules use a full chip-down design of the GNSS receiver, including all the components required to optimize performance (antenna interface, LNA, SAW filter, passive filters). This allows them to deliver the full promise of the GNSS chips they integrate in terms of sensitivity, accuracy, time to first fix, etc.

Full concurrent LTE and GNSS operation: With two separate dedicated RF front-ends for GNSS and LTE, u-blox combo modules allow for full concurrent operation of their GNSS and LTE subcomponents, unlike the standard SoC solutions that are currently on the market.

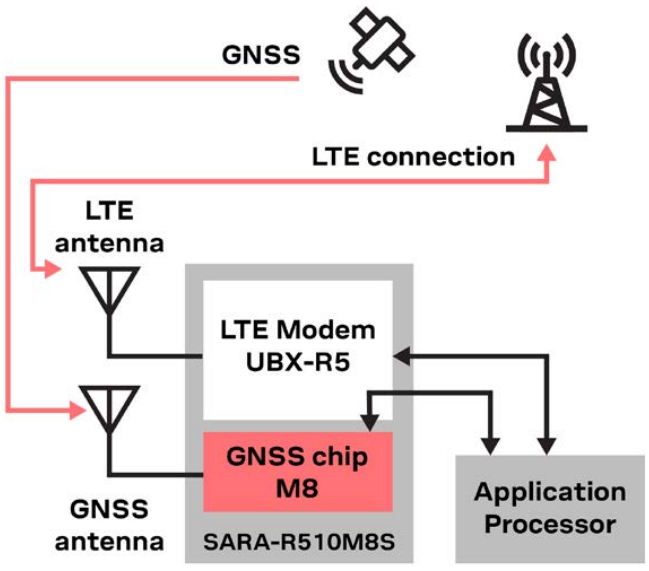
Constant access to the GNSS receiver, even when the LTE modem is in power save mode or switched off in airplane mode, gives users maximum reliability and flexibility, while continuous availability of the LTE modem ensures that no paging events are lost.

Careful design eliminates signal interference between the two RF components.

Security and communication services: u-blox combo modules feature Secure Cloud functionality based on a root of trust that enables u-blox IoT Security-as-a-Service for full end-to-end security with unlimited encryption, key rotation, and zero-touch provisioning to cloud platforms in a lightweight, low-power implementation that is ideal for IoT applications.

All standard u-blox bells and whistles: u-blox combo modules benefit from assisted positioning using AssistNow (online, offline, autonomous) to more quickly access the ephemerides of the GNSS satellites, and CellLocate ® for coarse cellular network-based positioning when GNSS satellites are unavailable.

And, it goes without saying that they are designed, manufactured, validated, and tested according to u-blox's strict processes and protocols.



Hardware architecture used in the u-blox SARA-R510M8S combo module.

5 Comparison of competing GNSS solutions

In addition to the performance highlights listed above, u-blox combo modules are the only modules on the market today that deliver the full benefits of concurrent LTE and GNSS.

- **No time-sharing between GNSS and LTE means that both functionalities can be accessed at all times, increasing the reliability and flexibility of the solution.**
- **The time it takes to achieve a first position fix is minimized by preventing interruptions caused by LTE communications, saving both time and power.**
- **Shutting down the LTE RF front-end does not impact GNSS performance, which means that the GNSS receiver can operate when the LTE modem is in power save mode or airplane mode.**

	Concurrent LTE & GNSS	Sensitivity	Accuracy	TTFF Cold	Supported GNSS	Number of concurrent GNSS systems	GNSS aidings	CellLocate® equivalent
SARA-R510M8S* SARA-R422M8S*	**Yes**	**-167 dBm**	**2.5 m**	**26 s**	GPS, Galileo GLONASS, BeiDou	**3**	**AssitNow online, offline, auto-nomous**	**Yes**
Company A	No	-157 dBm	3 m	n/a	GPS, Galileo, GLONASS, BeiDou	2	offline	No
Company B	No	-151 dBm	3 m	36 s	GPS	1	No	No
Company C	No	-161 dBm	2.5 m	35 s	GPS GLONASS	2	offline	No

* u-blox combo modules outperform competing GNSS solutions on multiple metrics.

6 Stand-alone solutions meet the needs of demanding applications

u-blox combo modules are tailored to the needs of most common IoT applications that require robust GNSS and LTE technology with no compromises on a small footprint and at a low cost point. There are, however, several common use cases that would benefit from lower power consumption, superior performance, enhanced design flexibility, or increased independence between the technologies. In these scenarios, stand-alone solutions comprising a GNSS module and a separate LTE module may be the best fit. Stand-alone solutions can meet requirements that are beyond the reach of combo modules:

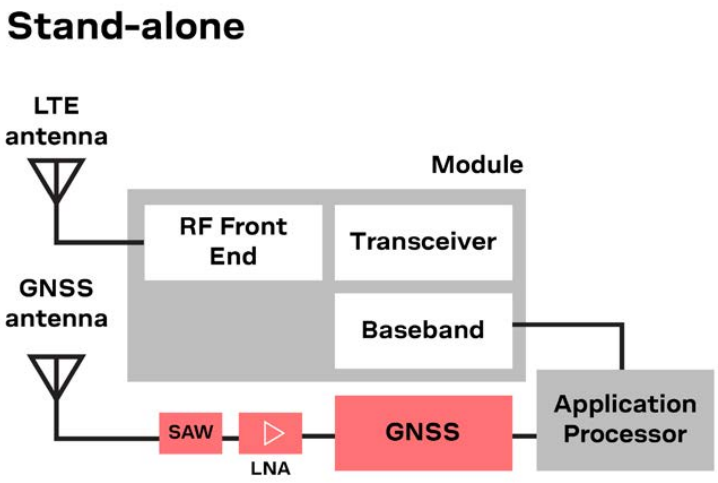
- Ultra-low power consumption using a power-optimized GNSS receiver
- Positioning without sky view or in poor signal conditions such as urban canyons using dead reckoning modules
- Sub-meter accuracy using multi-band and high precision solutions
- Ease of upgrading the GNSS module for state-of-the-art devices

For particularly demanding applications that require bespoke combinations of GNSS and LTE technologies, u-blox offers a wide range of positioning solutions that can be used in combination with SARA-R4 and SARA-R5 modules, as well as with 2G/3G or LTE Cat 1 and higher.

These GNSS solutions are available as chips and as modules:

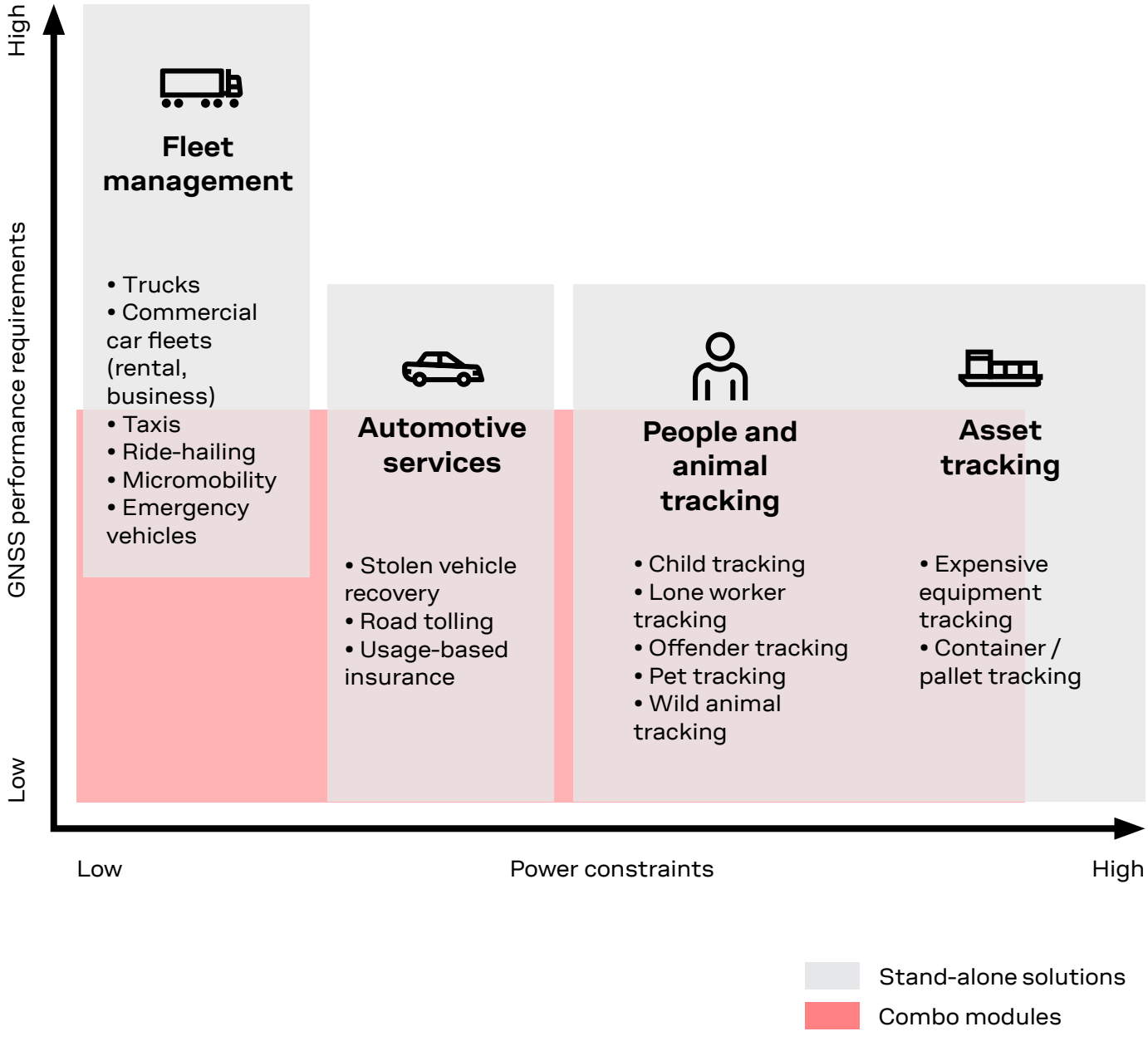
- Single-band and dual-band GNSS receivers
- Standard precision and high precision GNSS receivers, including GNSS correction data receivers.
- Ultra-low-power receivers
- Dead reckoning solutions

All u-blox tracking solutions are designed to eliminate interference between the GNSS and LTE components.



7 A guided product selector

No single hardware architecture addresses the full spectrum of needs of the diverse IoT tracking market. The chart below offers guidance to select the technology solution that best meets the requirements of common use cases.



8 Conclusions

With the introduction of combo modules for IoT tracking into the u-blox portfolio, we have focused on delivering solutions that optimize cost and size, while making no compromises in terms of GNSS and LTE performance.

Competing solutions have cut cost and size by shedding components that can be shared by GNSS and LTE, sacrificing the performance of both technologies. By opting for a full chip-down design with independent RF front-ends, u-blox combo modules such as the SARA-R422M8S and the SARA-R510M8S deliver the full performance of their constituent components with concurrent operation of both cellular and positioning technologies, and no interference.

By delivering the full functionality of our u-blox M8 multi-constellation GNSS receiver and our UBX-R5 cellular low power wide area (LPWA) modem, our IoT tracking combo modules strike an optimal balance for small, cost-effective, high-volume tracking solutions.

The u-blox SARA-R510M8S and SARA-R422M8S combo solutions feature full chip-down integration of the u-blox UBX-M8 GNSS chip, including LNA, SAW filters, TCXO, and the other necessary matching components. The result is an up to 14% overall board size reduction compared to a traditional stand-alone solution combining two separate LTE and GNSS products.

But the tracking and telematics market is diverse, and the requirements on the performance vary strongly from one use case to another. IoT tracking use cases with heightened demands in terms of power consumption, coverage of positioning, or design flexibility might benefit from stand-alone solutions, in which two separate LTE and GNSS components work side by side.

To find out which hardware architecture is best suited for your design, please contact your nearest u-blox sales representative or fill out a project information form.

About the authors

Samuele Falcomer, Senior product manager for product center cellular, u-blox.

Samuele has been working at u-blox since 2013 and joined the product strategy team in 2017.

He is responsible for the definition of the product specifications and the go-to-market strategies of the NB-IoT product lines as well as LPWA IoT products based on u-blox LTE chipsets.

He holds a M.Sc. in Telecommunication Engineering from the University of Trieste (Italy) and a Master in Business and Administration from MIB Trieste School of Management.

Samuele has a strong technical background, having worked as an RF and antenna engineer in companies including Calearo Group and Adant before joining u-blox.

Oreste Concepito, Product line manager for standard precision GNSS, product center positioning, u-blox.

Oreste Concepito is product line manager for Standard Precision GNSS products in the Product Center Positioning of u-blox.

At u-blox he focuses on low power consumption solutions, with special focus on wearables and asset tracking applications.

Prior to joining u-blox, Oreste occupied several roles as technical leader in large semiconductor companies like STMicroelectronics and Philips Semiconductors.

He dedicated several years of his working career to the development of a start-up company in the IoT

About u-blox

u-blox (SIX:UBXN) is a global provider of leading positioning and wireless communication technologies for the automotive, industrial, and consumer markets. Its solutions let people, vehicles, and machines determine their precise position and communicate wirelessly over cellular and short-range networks.

With a broad portfolio of chips and modules, and a growing ecosystem of product supporting data services, u-blox is uniquely positioned to empower its customers to develop innovative solutions for the Internet of Things, quickly and cost-effectively.

With headquarters in Thalwil, Switzerland, the company is globally present with offices in Europe, Asia, and the USA.

u-blox AG
Zuercherstrasse 68
8800 Thalwil
Switzerland

www.u-blox.com