LoRaWAN and Cold Supply Chain

An Introduction to LoRaWAN IoT for Cold Supply Chain and Other Temperature-Sensitive Use Cases

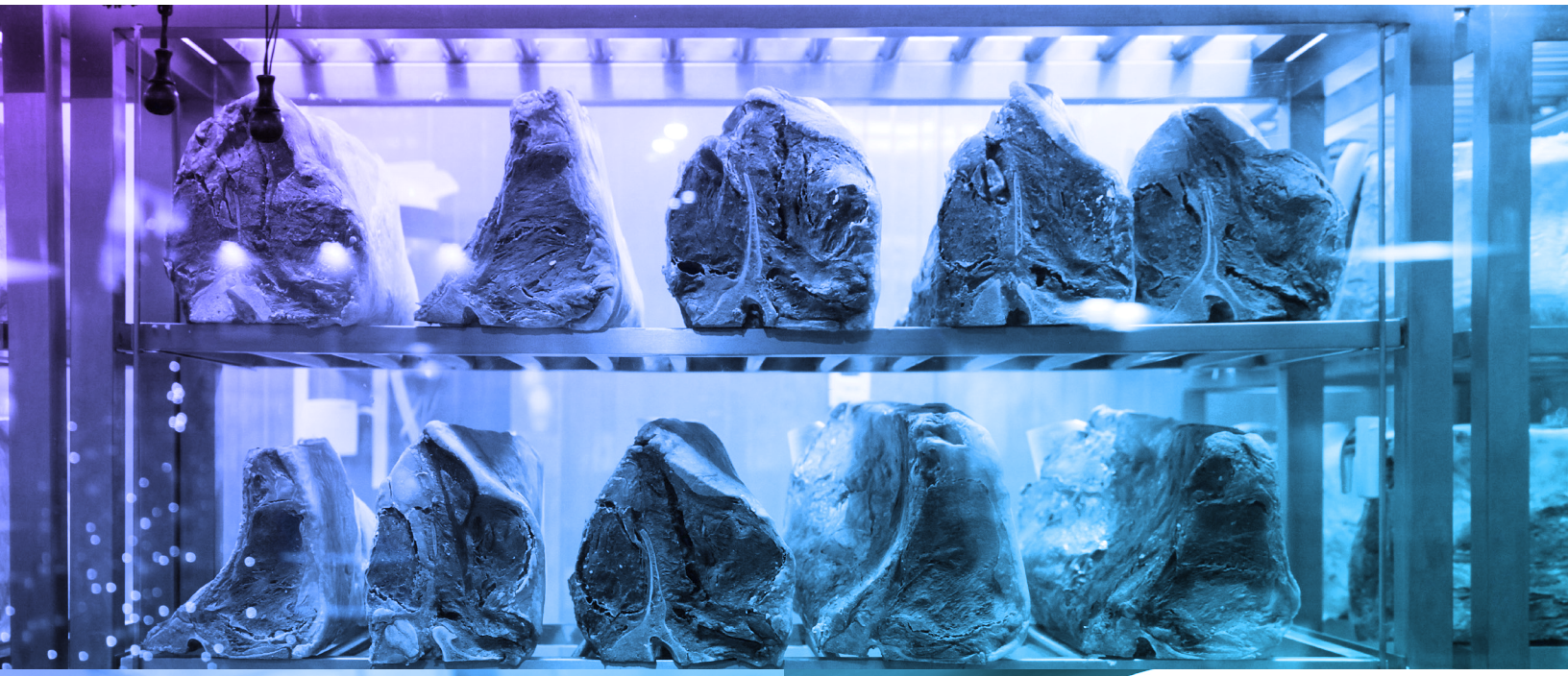
Laird™ CONNECTIVITY

Chris Boorman, Senior Product Manager, IoT Platforms at Laird Connectivity

In ordinary times, cold supply chain wouldn't be a dinner table conversation. That's even true in my house, despite it being a focus of my job for the past few years. Cold storage monitoring just isn't the kind of topic that fits neatly in between asking someone how their day was and offering to pass the mashed potatoes.

But that was then. Now is a very different story. Today, cold supply chain is a household topic in a way that no one would have predicted a year ago. Seemingly everyone has an awareness of the critical role that temperature-controlled storage and distribution is playing in the rollout of the Moderna and Pfizer-BioNTech vaccines. It will continue to be a household topic because cold supply chain will also be important for distribution of other COVID-19 vaccines that are in the development and approvals process – all of which must all be kept within precise temperature ranges. This cold supply chain infrastructure will also continue to be important for delivering booster shots to maintain the levels of antibodies in vaccinated people. Specialized refrigerated containers, refrigerated vehicles, and ultra-cold storage warehouses are the foundation for the last-mile delivery channels that enable shots to be administered in clinics, doctor's offices, pharmacies, and other locations for as long as the virus remains a threat.

Cold supply chain deserves all the attention not just because of its critical role in distributing vaccines, but because modern life wouldn't be possible without it. So many of the foods we eat and products we use must be distributed in temperature-controlled environments that ensure their safety and quality. As an example, salads would only be seasonal if not for the sophisticated cold supply chain that delivers those vegetables year-round. Many kids would be perfectly happy if salads were only seasonal, but they are stuck with vegetables being available 365 days a year. Then again, chicken nuggets wouldn't be a thing without cold supply chain either, so thank goodness for those refrigerated warehouses and trucks.



A Wireless Revolution in Cold Supply Chain

Cold supply chain technology has been around for decades, but it has largely been a manual process prone to human error and gaps in visibility throughout a product's journey. In the past, employees would take manual temperature readings at certain points in the distribution process and jot those notes onto paper reports – a process that has always been time consuming and notoriously error prone. That process also only took snapshots of temperatures at certain moments in time, meaning that there were major gaps in data about whether products were staying in the required temperature ranges.

Today, cold supply chain practices are being transformed by the use of wireless sensors that solve these challenges by allowing continuous temperature and humidity monitoring that is far more accurate, efficient, and effective than the previous intermittent, manual processes. However, some common wireless technologies that provide the connectivity for these wireless sensors struggle to perform in harsh cold supply chain environments, where insulated metal walls and other factors can negatively impact technologies like Bluetooth and Wi-Fi. Because of this, LoRaWAN technology has emerged as a key wireless technology for these cold supply chain applications because of its ability to perform even in those challenging environments.

LoRaWAN Performance in Harsh Environments

For those of you unfamiliar with the LoRaWAN specification, it provides secure, bi-directional data transfer and communications with IoT networks. It is often thought of for long-range applications because of its range of 10 miles or more on a single hop. This can be valuable for some aspects of cold supply chain, particularly when other wireless infrastructures are less reliable or available.

But the biggest reason why LoRaWAN is becoming a preferred technology for cold supply chain is its ability to maintain connectivity in the kinds of facilities, vehicles, and equipment that presents so many challenges to other wireless protocols. The LoRa physical layer translates data into RF signals that can be sent and received over the air using chirp spread spectrum communications which are robust in harsh RF environments and very resistant to interference. The result is excellent radio propagation, penetration, and resilience against interference in environments where other technologies struggle.

But the biggest reason why LoRaWAN is becoming a preferred technology... is its ability to maintain connectivity in the kinds of facilities, vehicles, and equipment that presents so many challenges to other wireless protocols.

As an example, this allows companies to install the LoRaWAN sensors inside their thick insulated fridges, the signal gets out and through to the gateways for backhauling for delivery to the cloud. It has similar performance advantages over other wireless technologies when deployed in refrigerated warehouses and vehicles, both of which also have notoriously difficult RF environments that LoRaWAN excels in.

LoRaWAN has a number of other advantages for cold supply chain. Its extraordinary energy efficiency gives devices years of battery life in the field. It's also highly scalable, highly interoperable, and compatible with both public and private networks for the data backhaul and bi-directional communications. Despite the fact that data throughput is a primary limitation with LoRaWAN IoT applications, it works extremely well for sensor networks that generate small packets of periodic or event-driven data that are sent by the network back to a central location. This is exactly the type of data transfer that is involved with cold chain supply distribution – so limited data throughput is not an issue for this use case.

I should note that this is not merely at the concept stage. LoRaWAN-enabled cold supply chain monitoring is a reality today, proven in large-scale implementations that demonstrate its value for more effective monitoring of temperature-controlled goods. All of the elements for global use in vaccine distribution and food distribution are available today. For example, LoRaWAN-enabled sensors like Laird Connectivity's Sentrius RS1xx series and the full range of external RTD (Resistance Temperature Detector) temperature probes – which can monitor temperatures ranging from -100°C up to +450°C – are the building blocks for these implementations.

LoRaWAN also has a robust ecosystem of companies that are able to support rapid, large-scale IoT deployments. There is an abundance of LoRaWAN network ecosystem partners and LoRaWAN Network Server (LNS) providers (e.g., ChirpStack, Senet, The Things Network) and application servers to support and accelerate implementations. In recent months LoRaWAN has also been embraced by Amazon Web Services (AWS) through their new AWS IoT Core for LoRaWAN platform, another fully managed service, which enables users to connect their LoRaWAN networks directly into AWS IoT Core via AWS qualified LoRaWAN gateways, such as the Sentrius RG1xx.

Best Practices for Selecting Temperature Sensors

For companies that decide to work with LoRaWAN for cold supply chain use cases, below are some important best practices and design considerations to help your team be successful:

- RTDs are more precise than other types of sensors – There are generally three types of temperature sensors that organizations need to select from for their cold supply chain projects: thermocouples, thermistors, and RTDs. RTDs are more precise and have other advantages that make them ideal for cold supply chain use cases. Thermocouple-based sensors are more common because of advantages such as cost, self-powered operation, and fast measurement speed. But they lack the precision that is needed for many cold supply chain needs. Their

performance can also suffer when longer control cables are involved. Thermistor-based sensors have more precision than thermocouples and have some other advantages, but their temperature range is far too narrow for many cold supply chain uses. Laird Connectivity's RTD temperature probes are designed with extreme heat and cold in mind, allowing them to be used for use cases ranging from ultra-cold storage in warehouses to ensuring that hot food is held at hot enough temperatures in restaurant kitchens. RTD's precision and wide temperature range are possible because of its measurement mechanism which is based on the minute changes in electromagnetic resistance when metals in the sensor change temperature. That relationship between temperature and resistance is very precisely measurable and very repeatable. This means that a sensor can be very accurate over time and with many heating/cooling cycles. In applications where accuracy is critical and temperatures are at the extremes, RTD sensors deliver precision and reliability that other technologies cannot. For this reason, it is important for engineering teams working on cold supply chain projects to evaluate RTD sensors alongside those alternatives to ensure they achieve the desired performance.

- Remember that hot is just as important as cold – Despite the name "cold supply chain", the teams working on these IoT projects often need to put as much focus on precise high-temperature management in addition to keeping things frozen. The restaurant example in the bullet above is a perfect example of that. The same sensor systems that are designed to ensure that cold and frozen food stays in the correct temperature ranges often need to be flexible enough to also measure hot foods to ensure they do not dip below the allowable temperatures to ensure food safety. The same is true in industrial settings where sensors must measure the temperatures of super-cooled gases and liquids as well as the operating temperatures of machines that operate at very high temperatures. For this reason, it is important for engineering teams to define the temperature ranges that these sensors operate in throughout the organization's operations to ensure that the selected sensors have a wide enough temperature range to be versatile.

- Decide early if smartphone/tablet controls are important – Too often, discussions about the user interface happen late in an IoT planning process after key decisions are made about the kinds of technologies that will be deployed. This can add complexity and delays to the rollout as the engineering team must build cloud connectivity as well as smartphone/tablet interfaces into the project plan – both of which can be arduous, slow, and costly. For this reason, selecting sensors that operate on a platform that has cloud connectivity and configurability baked into its DNA prevents a lot of headaches on the back end. Laird Connectivity's RTD temperature sensors are based on the Sentrius platform, which simplifies and accelerates the process of connecting sensors to the cloud and allowing employees to access that data on their mobile devices.

- Sensors must be durable in a number of ways – For cold supply chain use cases, durable means a number of things. The outer casing must be tough because the chances of impact are extremely high in environments such as warehouses, crowded restaurant kitchens, delivery trucks, etc. The sensors also need to live without missing a beat inside some extreme environments, such as cold storage and freezer units. They also need to withstand constant cleaning, which is a must in food-related environments where a device may get sprayed and wiped down repeatedly. Laird Connectivity's temperature sensors are IP-65 rated and are designed to perform in these environments that put sensors through a gauntlet of challenges.

About Laird Connectivity's LoRaWAN Solutions

Laird Connectivity offers a wide range of external RTD temperature sensors for use in cold supply chain use cases.

At their core, the RS1xx external RTD temperature sensor utilizes Laird Connectivity's field proven and reliable RS1xx Series hardware, providing LoRaWAN options in 868, 915, and 923 MHz frequencies. The RS1xx works with Laird Connectivity's Sentrius RG1xx Gateway for simple out-of-the-box integration and is compatible with third-party Cloud and LoRa network ecosystem partners.

The sensors are configurable for data transfer schedules that allow the device to remain in the field for years on the same set of two replaceable AA batteries. These LoRaWAN sensors enable organizations to easily create a sensor network that provides miles of coverage and that can be managed and configured using a smartphone or tablet. Connect to any existing LoRaWAN network server or gateway or combine with our RG1xx Gateway to build your own end-to-end sensor network.

For more information about Laird Connectivity's LoRaWAN solutions, visit: https://www.lairdconnect.com/wireless-modules/lorawan-solutions.

Wide Range of External Temperature Monitoring Options

The RS1xx external RTD temperature probes serve specialized temperature ranges for accurate temperature reading in extreme environments.

NOTE: The RTD external temperature probe cable assembly is not included with the Sentrius sensor enclosure, or vice versa, each part must be ordered individually. It's a 1:1 ratio of region-specific sensor enclosure to sensor cable assembly. For the full list of RTD supporting sensor enclosure part numbers, please refer to the product briefs (linked below) or the Part Number table below.

Low Temp
(-100°C to +100°C)
455-00124(B)

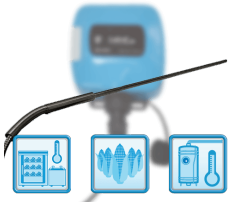
Low temperature RTD sensor probe suited for cold-chain applications such as food safety, vaccine storage, industrial cooling, and more

LEARN MORE

Mid Temp
(-40°C to +180°C)
455-00112(B)

Mid temperature RTD sensor probe suited for applications such as industrial cookers and smokers, food safety, HVAC, and more.

LEARN MORE



High Temp
(-50°C to +450°C)
455-00123(B)

High temperature RTD sensor probe suited for applications such as extreme industrial applications, fryers, pizza ovens, and more.

LEARN MORE

About the Author:

Chris Boorman is Senior Product Manager at Laird Connectivity, which provides a full range of wireless modules, antennas, and sensors that simplify the process of using wireless technology. In his role at Laird Connectivity, Boorman oversees engineering and innovation for the company's IoT platforms, including those that utilize LoRa technology. Boorman has more than 20 years of engineering experience in the telecom and IoT field. Prior to joining Laird Connectivity, he held senior engineering positions at Fujitsu Services, Toshiba Business, and UL Global Services. He is based in the U.K.

About Laird Connectivity:

Laird Connectivity simplifies the enablement of wireless technologies with market-leading wireless modules and antennas, integrated sensor and gateway platforms, and customer-specific wireless solutions. Our best-in-class support and comprehensive engineering services help reduce risk and improve time-to-market. When you need unmatched wireless performance to connect electronics with security and confidence, Laird Connectivity delivers — no matter what.

Learn more at www.lairdconnect.com.

For the latest news or more information, visit:

Lairdconnect.com

twitter.com/lairdconnect

facebook.com/lairdconnectivity

linkedin.com/company/lairdconnectivity

Laird™ CONNECTIVITY