RedLore

# SUPPLY CHAIN MONITORING & TRACKING

## 7 AMAZING SUPPLY CHAIN MONITORING PREDICTIONS

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# INTRODUCTION

In the last few years supply chain monitoring and tracking has become a top priority in many industries, ranging across pharma, automotive, defense, food and others. Today's COVID times have increased our reliance on ecommerce, food delivery services, home-based working and effective vaccine delivery, putting even more weight on the importance of reliable supply chain monitoring and tracking.

In this paper we will discuss the current situation, shed a light on what technology is promising vs what is real today, and share our view on how technology will support an increasing number of use cases in the next few years. We will also present the long-term vision, with some very promising emerging technologies that will make our lives healthier and more comfortable. Finally, we will provide a recipe for fast tracking your own adoption of supply chain monitoring and tracking.

# USE CASE: TRACK & TRACE


Track & Trace in its purest implementation allows you to track the location of an asset over time, such as the location of a truck during transport. Track & Trace usually provides real-time updates at regular time intervals, such as hourly or every 15 minutes. Track& Trace has been adopted widely by the ground transportation companies, locating their fleet in real-time, and help predict ETAs and manage route changes.

The asset that is being tracked can potentially be anything, from the truck that transports the goods down to the tiny screw being transported. This distinction is important. If the truck is being tracked, then one can never be sure where the screw really is: the trailer could have been separated from the truck tractor, the pallet that holds the screw may have been dropped off or the box with the screw may have been separated from the pallet, etc. This is the problem of tracking granularity.

Most today's Track & Trace implementations work at the level of the truck of trailer. Unfortunately, the lack of granularity accounts for a lot of the losses in supply chains. Until a few years ago truck-level tracking represented the best trade-off between benefits and cost. Luckily, better solutions are available today.

# USE CASE: COLD CHAIN MONITORING

Cold Chain Monitoring tracks the temperature of perishable goods such as pharmaceuticals and food through the supply chain and raises a flag when the temperature at any point went outside of the acceptable range, such as 2°C to 8°C (36°F to 46°F). Ideally one wishes to track the temperature from the origin to the final destination, across multiple modes of transport and when the goods are held in temporary storage.

The most widely used device for cold chain monitoring solution is the temperature logger. It logs the temperature in local memory as the goods travel through the supply chain. After arrival, the temperature logger is connected to a computer, typically through USB, and the log is uploaded to a program for analysis.

The downside of the temperature logger is the reliance on skilled human interaction. More sophisticated solutions are available today, which do away with the human interaction altogether.

# THE LONG-TERM VIEW

Before delving into what is today the most technically and economically viable solution for supply chain monitoring and tracking, let us look at the long-term and define what the ultimate supply chain monitoring & tracking solution should be, unencumbered by today's technological limitations:

| | |
|---|---|
| **Item-Level Granularity** | Each item it tracked individually. Item-level tracking automatically provides serialization. |
| **Real-Time** | Items are monitored in real-time, sending alerts as soon as a potentially harmful condition occurs. |
| **Ubiquitous Connectivity** | The item can communicate its status wherever it is in the world, when in transit in a trailer, on ship or in an airplane, and in storage. |
| **Predictive and Prescriptive** | Harmful events, such as temperature excursions, are not just detected, but also predicted. In addition, the solution prescribes which actions need to be taken to prevent damage from occurring. |

## End-to-End

The item can be tracked from the moment it is created by the manufacturer to the moment it is consumed by the end-user.

## Extremely Low-Cost

The cost of the solution per item being tracked cannot be more than a fraction, e.g. 1%, of the replacement cost of the tracked item itself. As some goods, such as food, are inexpensive to begin with, the cost of the solution must be extremely low, sometimes in the order of a few cents per item tracked.

## Small and Flexible

The goods being tracked range from a large machine (e.g. a PET-scanner) down to a small glass vial. For the solution to be practical the physical tracker must be easy to fix to the item. For small goods, it follows that the tracker too must be very small and mechanically flexible, not unlike an RFID tag today (see Figure 2).

# SERIALIZATION

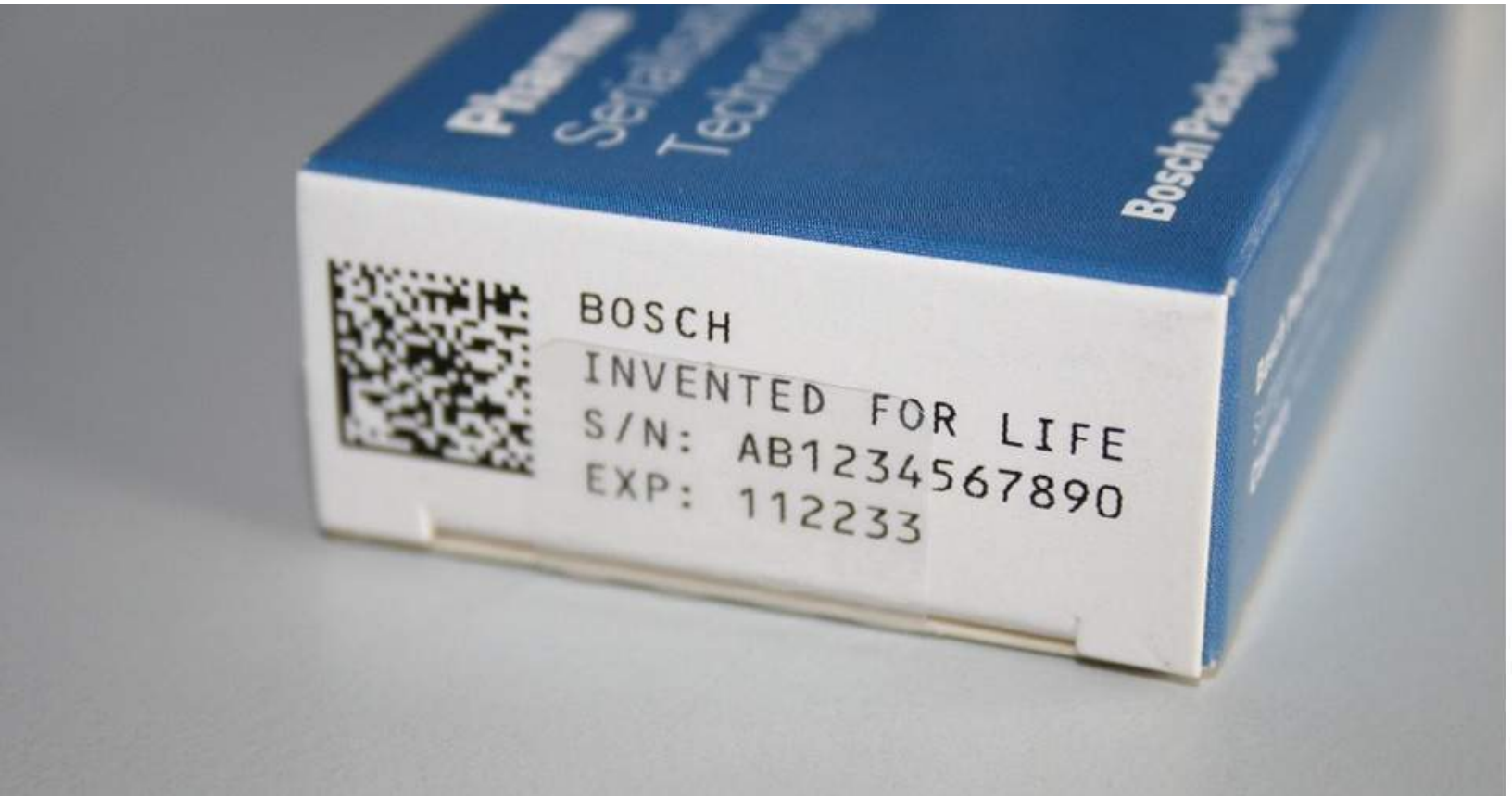


Figure 1: Serialized drug carton. The Serial Number is available both as a printed number (AB123...) and as a datamatrix (on the left) for easy machine reading.

Serialization gives a unique code to each individual unit of sale, the Serial Number or S/N. Serialization is very different from SKU (Stock Keeping Unit) level identification, where each product type rather than each individual product receives a unique number. For example, if a drug manufacturer of the product pictured above produces 10,000 of these boxes daily, they will each have the same SKU number (they are interchangeable). With serialization each box will in addition contain a worldwide unique serial number.

Some industries, driven by tightening legislation, are already implementing serialization. In the pharma industry serialization allows users to track the product from the pharmacy shelf back to the source, and is put in place for reasons such as a counterfeiting deterrent.

Item-level tracking automatically supports serialization by linking the item-level tracker to the item's unique serial number. Increased serialization will drive the adoption of item-level tracking.

Legislation across the world is increasingly demanding that manufacturers serialize their products, especially for health-related and dangerous goods, such as drugs and toxic chemicals.

Serialization today is typically implemented using 2-dimensional barcodes, such as a QR code or a data matrix, and RFID.

An RFID tag performs the same function as a barcode: it encodes a number or a short string of text. Most people are familiar with RFID tags from the tags sewn into clothing.


Figure 2: An RFID tag (metal traces on the right) is embedded in the product label.

Instead of using a barcode scanner to scan it, and RFID tag requires an RFID reader to scan it. The advantage is than and RFID reader can read over distances of meters whereas a barcode scanner scans over a range of roughly 1m.

Both 2D barcodes and RFID allow for item-level tracking granularity but they do not offer tracking by themselves. To use barcodes and RFID for tracking, a scanner and reader infrastructure needs to be installed. Hence barcodes and RFID are ill-fitted solutions for real-time and end-to-end tracking with ubiquitous connectivity. A technology upgrade is called for.

In short, the ideal supply chain monitoring & tracking solution offers item-level granularity, real-time and ubiquitous connectivity, can track end-to-end, predicts harmful events, prescribes the actions to avoid losses, and is extremely low-cost while being small and flexible enough to affix to any product.

The ideal embodiment of such a solution is a tag no bigger than an RFID tag yet has all the powerful features developed above.

# INNOVATIONS IN SUPPLY CHAIN MONITORING

**Ubiquitous, Real-Time and End-to-End:** In most inhabited parts of the world ground transport can rely on a dense network of terrestrial cellular towers to wirelessly transmit data, the same that service the data to our phones. Novel cellular communication standards such as NBIoT and LTE-M offer a low-power communication solution using the cellular networks.

Airline operators are still very limitative when it comes to in-air wireless communication. The regulations, however, do allow for tracking devices to fly along with the goods, but do not yet offer an always-present transmission link to the ground. We expect that within 5 to 10 years this limitation will be lifted.

Communication from a ship is achieved through satellite communication. Today satellite communication is very expensive, but prices are bound to come down in the next 5 years, e.g., with the advent of new satellite networks such as SpaceX's Starlink.

**Predictive and Prescriptive:** Novel AI algorithms, such as those developed by RedLore, are becoming very effective in loss prediction. The pattern matching AI analyses a large set of historic data and learns from the data when and where losses occur. Once the AI algorithm is trained, it is very effective at recognizing a pattern in the sensor data that will result in a loss. Subsequently the algorithm can suggest a remedy to avert the loss. E.g., when the temperature in a trailer starts to rise, the AI can predict when the temperature limit will be breached.

**Item-level Granularity:** The communication mechanisms described above can, in theory, be provided at the item-level. For terrestrial connectivity, an increasing number of vendors are offering low-power chipsets following open standards such as NBIoT, LTE-M and LoRaWAN.

**Extremely Low-Cost, Small and Flexible:** The total material cost for a sensor tracker with NBIoT/LTE-M connectivity in 2021 is around $10 - $20, depending on the capabilities. Price-erosion will most likely drive down this this price to $5 to $10 within 5 years and to the $2 to $5 range in 10 years.

The size will drop accordingly from a matchbox to the size of an RFID tag.

# OVERCOMING TODAY'S LIMITATIONS

Even if the tracker that combines all the qualities above cannot yet be built today, we can build a solution that comes very close and is more than adequate for many applications.

The ideal solution uses a tracker that provides item-level granularity, just like a serializing barcode or RFID tag does. For high-value goods such as capital equipment (e.g. a PET-scanner) this ideal solution is feasible today. However, for lower-value goods, the omnipotent tracker may not be possible because of communication, cost and size limitations. For these applications the solution lies in using a 2-tier architecture.

In a 2-tier architecture, each item still receives its own tag, which we define as a level-2 tag. The level-2 tag uniquely identifies the item and has all the sensors on board that are required at the item-level, such as a temperature and a vibration sensor. The tag, however, is not capable of cellular connectivity. It relies on a more powerful level-1 tracker to provide the communication function. The level-2 tag communications wirelessly to the level-1 tracker using a dedicated sensor protocol such as Wirepas Mesh™, which is a technology somewhat similar to Bluetooth but developed for industrial applications, which require a higher level of security and robustness. The level-1 tracker provides additional functions which are not required at the item level, such as for example location and humidity.

One example of a 2-tier architecture uses just one level-1 tracker for the entire shipment and hundreds or thousands of level-2 tag, each attached to an individual item. The higher cost of the level-1 tracker can thus be distributed over the large number of items, solving the cost challenge. The level-2 tag can be made small enough to affix to even small items, and the cost in 2021 is in the range of a few dollars.

# 5 STEPS TO FAST TRACK YOUR IMPLEMENTATION OF SUPPLY CHAIN MONITORING & TRACKING

There is no need to wait 10 years for the ideal solution. The 2-tier solution provides an economically and technically feasible solution today.

The following 5-step recipe allows you to understand if and how it can solve your use case:

1. **Inventorize:** Make an itemized list of all the ways you are losing money in your supply chain, directly and indirectly. It can be from damaged goods, logistics-related insurance premiums, late arrival of goods which impact your own operations.

2. **Quantify:** Estimate the value of each loss on your itemized list. In addition, estimate how much of each loss you expect to recover by implementing a Supply Chain Monitoring & Tracking solution. Order the list from high to low and you have your shortlist of items you wish to focus on at the top of your list. These numbers will also support your ROI calculation.

3. **Scope:** Define what and where you need to track to address the target losses. Is it temperature? Shock? Do you need to track the supply chain end-to-end? Do you also wish to track items in storage?

4. **Expected ROI:** It is obvious that you are seeking a healthy *Return-on-Investment* (ROI). But how much is healthy? The ROI is very situation dependent, but expectations range from 200% to 500%. This means that for every $1 invested in the solution you wish to get back between $2 and $5. This presents a huge span and depending on where you position yourself will automatically include or reject certain solutions.

   Companies with a high confidence that the losses can be mitigated and in addition have a high confidence in the capabilities of the solution, typically expect an ROI around 200%. Companies with a low confidence of mitigating their losses or in the capabilities of the solution will lean towards a 500% ROI expectation.

   A too high ROI expectation will often prohibit finding a viable solution and risk extending the losses long-term. The trick is to reduce the risk by engage in a limited-scope pilot, to validate both ROI-defining factors.

5. **Involve your solution provider in finding the right solution:** It is tempting to define what your ideal solution looks like all by yourself and searching for the products that will get you there. Solution providers, even if they all want to sell their own products first, will be able to explain the capabilities and limitations of various solution architectures and help you define what you need. Allow them to educate you, their time is usually free. The final decision will be yours after all.