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# Effective, ethical and rapid distribution of urgent medical goods



# Abstract



The Covid-19 vaccine production and distribution will be the most significant industrial challenge tackled by governments since the end of the Second World War. At the same time, this challenge presents ethical dilemmas for global fair play. Governments need to maximize the effect of an initially limited supply of vaccines to safeguard human lives, prevent long-term health conditions and ensure a quick return to a fully prosperous economy.

Ensuring real-time visibility, predictive supply chain planning, and the immediate ability to address exemptions has become paramount to meet this challenge. Understanding the world around R&D, manufacturing and factories, customers and the movement of goods provides the necessary context to reduce risk and streamline production to distribution.



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# Introduction

As part of our commitment to move the world forward, we want to ensure that our technology can be used to reduce the immense human suffering caused by SARS-CoV2.

Over the next 18 months, more than 2 billion doses of vaccines will be manufactured – a significant achievement of human ingenuity. This means that an entire economy covering the production of the vaccines - from raw material to a local doctor's office or pharmacy - needs to be created, validated and monitored.

However, there are several significant issues around this distribution:

- Physical traceability of the vaccine during transport
- Visibility of transport, estimated time of arrival
- Security, immediate information around physical security issues
- State management of the shipment: temperature, shock and various other sessions
- Global fair play and distribution of the vaccine

## Why is this a location problem?

Let's break the issues at hand into two main categories: the supply-chain challenge and the socio-economic challenge. Firstly, the effective transport of goods from complex location matrices has the potential to become one of the most complex location problems ever solved. Secondly, the understanding of demographics and location itself will be key to ensuring the fair rollout of vaccines and protecting the most vulnerable populations. Thanks to the power of location, we can gain access to important information, such as population density, age demographics and physical location. And that, in turn, will encourage data-driven decision-making.

## Why HERE?

Over the last few years, HERE has been studying the challenges around the effective distribution of high-value medical goods. During this time, we've learned how to combine location technology, location context and real-time tracking technology to reduce risks and improve distribution.

HERE Technologies has made significant investments into positioning IP, both outdoors and indoors. That is how we could create HERE's shipment visibility solutions for the optimization and time-sensitive distribution of high-value, fragile goods. Since then we've gained the trust of the world's leading logistics providers and enterprise resource planning software vendors.





# Problem / opportunity

## Optimizing the initial rollout of the vaccine

### Identification of vulnerable populations

Using location data to identify which groups are more prone to be affected by SARS-CoV2 (Center for Disease Control and Prevention, 2020) can optimize the benefits of the initial vaccine rollout. The demographic information can help to identify negative outcomes of the infection. But when trying to stop the virus's rapid transmission, there are also other factors to be considered. One

example is monitoring the effectiveness of social distancing by accessing datasets that include population density or historical and live traffic patterns. Using various historical and real-time data sources can help us predict the effectiveness of new regulations or the spread, and even likelihood, of new infections. When vaccine availability is limited, such data can maximize the effectiveness of the initial rollout.





## Efficient distribution planning

Efficient distribution planning should be an inside-out and an outside-in approach, working backwards from the core distribution targets (centers of the population) to the manufacturing capacity. Following this concept, we could approach the site selection by finding the right warehouse and a controlled storage facility or identify a new location.



These locations can be vital in determining the distribution range and the effectiveness of the distribution network; particularly in cold-chain scenarios that are likely when it comes to SARS-CoV2 vaccines. Even the less temperature-sensitive vaccines will require general refrigeration (Kaiser, 2020), leading us to believe that all distribution will happen in a controlled, cold-chain scenario. Minimizing the transport routes could remove some of the limited risks from cold-chain shipments. Additionally, most modern refrigeration units include temperature reporting allowing the shipment owner to receive an after-action temperature report. However, the data quality provided by the refrigeration units is only as good as their most recent calibration.





Optimizing the route length should be part of every workflow. Not only does it reduce the CO2 footprint but also the risk exposure by minimizing the time shipments spend outside of controlled environments, like temperature- and access-controlled warehouses. Matrix routers have been employed to optimize these routes for years now, particularly for shipments with multiple destinations. This solution to the proverbial traveling salesperson challenge has also tremendously improved in efficiency over the years. Companies that depended on large-scale matrix routing in the past would be smart to reexamine their choices today; calculations that took hours in the past can now often be completed in minutes or even seconds.

This matrix planning can also be a vital tool when it comes to the selection of new distribution sites. Calculations that compare fuel costs, CO2 emissions and the time drivers spend on the roads could help justify the choice of a particular building site over others. Other variables, such as the proximity of healthcare facilities or large demographic pools of vulnerable populations, could also be included.



### Effective distribution execution

Another cold-chain logistics challenge is understanding the integrity of the cold chain in real time and taking immediate action when temperatures are trending off. To this day, most freight movements have scheduled slot times and are observed by following a stage/gate system. Such practice is mostly a reminder of past technological limitations that can now be replaced with real-time data streams.



## Challenges of the stage/gate approach

The stage/gate system limits transport visibility as it only tracks the start and the end of a stage, called event-based data. Delays aren't logged unless the estimated time of arrival (ETA) has passed or a delay has been manually logged in as an event.

Such practices can lead to significant issues, especially in multimodal supply chains where the transport may already be booked for the next leg of the journey and expected to depart within a specific time slot. An inaccurate ETA is a especially problematic when the goal is to minimize the time in transit for high-value, temperature-sensitive goods.

What is more, in countries with challenging physical security environments, the stage/gate approach can also lead to additional risk exposures, where sudden stops and freight delays aren't captured immediately.



## Real-time shipment monitoring

To address the stage/gate issues, modern fleet management systems (FMS) can produce real-time data. Intelligent backends can then translate it into event-based data that enterprise resource planning (ERP) systems can work with. However, due to data silos, many shippers don't get direct access to the fleet data and can't use the FMS data.

This inability to collect data is one of the many reasons that the monitoring of individual shipments continues to increase in popularity. It gives excellent granularity of the shipment, doesn't rely on knowing exactly which truck a shipment was placed in, and can be used to understand mispicks and failed deliveries. It also captures information such as the shipped object's temperature, shock from drops, improper handling and even tampering.

When a shipment's integrity is paramount, it's crucial to monitor the individual objects in real time. We address some of the best practices around this process in the Hardware flexibility section below.





# HERE capabilities to aid in vaccine distribution

## Location enrichment

### Predictive ETA via Traffic

Predictive and accurate ETA has always been hard to achieve but it remains a constant goal for supply chain visibility, nonetheless. Today we have several solutions that can predict ETA based on factors, such as historical performance, traffic patterns and routes. Their usage in the real world, however, is still somewhat limited. Pinpointing shipments' real-time location and receiving a system update live, with ETA based on actual performance versus plan, isn't also widely used.



HERE location enablers provide the components to create a predictive ETA system with live updates that interfaces directly into an ERP system or another planning system of record. This allows customers to have an accurate view of when their orders arrive and transportation companies to understand their logistics systems.

Location technology can also indicate road roughness and allow for route planning that helps fleets stay away from roads that could damage their shipment.

Additionally, location technology can also enhance the visibility into unbroken custody chains when unexplained stops along the route indicate a physical security issue. Such events trigger automatic security protocols to flag shipments for additional verification at their point of arrival.



## Basic solution

### A platform

The HERE Tracking platform is available as a platform-as-a-service (PaaS) solution. The platform enables real-time tracking solutions and can be natively integrated with other HERE services.

Let's take this case study as an example:

Predicting ETA using HERE location components like traffic and truck-enabled routing. Thanks to the indoor tracking visualized on a HERE Indoor Map, the movement pattern of the shipment can already be detected from the inside of a factory or a warehouse.



### Applications

- To enable shippers/carriers seamlessly onboard the HERE Tracking into their IT infrastructures, HERE provides a suite of web and mobile applications that deliver instant value without the need for expensive and time-consuming integration and customization. The suite includes a quick-to-deploy web application, mobile trackers and much more.
- Combining data from the internet of things (IoT) sensors and HERE's world-leading location platform (Zoller, Eden; Palfrey, Charlotte, 2020), the HERE Tracking platform can give detailed analytics around deviation of conditional parameters like temperature, humidity and pressure. This way shippers know exactly what went wrong within their supply chain and can maintain an unbroken chain of custody.
- Furthermore, data coming from the movement of shipments provides insights around other inefficiencies in the supply chain, like excess dwelling, loss of shipments or ETA bottlenecks. These data insights will be essential in distributing the vaccines with the least amount of wastage and inefficiencies.





## Form factor of trackability

Tracking is most commonly conducted either at a shipment or a fleet level. This means that a fleet asset (a truck, a ship or a plane) is tracked as a representative of the entire freight. This low-cost form of tracking can be accurate provided that the checkpoints, scans and the rigor of the system design are of good quality. Such level of visibility, however, may not track or represent the actual status of the shipped goods.

Shipment visibility, i.e., tracking at the unit level, has been considered a more costly approach in the past but when it comes to vital goods, its benefits outweigh the costs by far. The accuracy of temperature readings, precise tracking of shocks and the certainty that a shipment has made it onto a ship, plane or truck provide additional peace of mind. Something that the traditional visibility solutions with their scans and Radio Frequency Identification (RFID) simply can't give.



## Better planning with data

ETA is one of the most important variables in shipments. It indicates whether the existing schedule will continue to hold or if it requires modifications. Having access to accurate ETA in real-time helps optimize slot management, reschedule shipments or pinpoint chokepoints over time. It also brings better visibility to the driver efficiency.

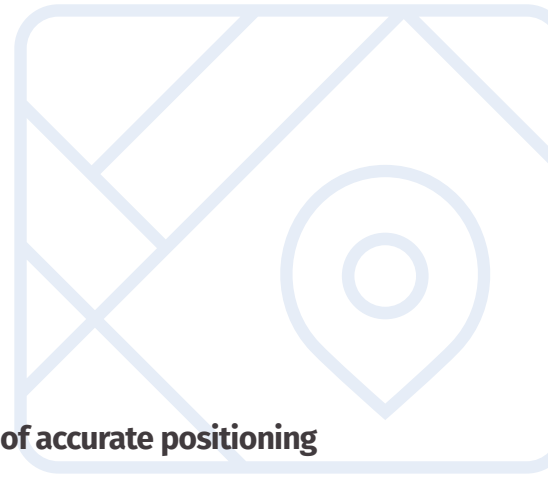
The team that distributes or dispenses of the vaccinations can use the accurate ETA of the next shipment to optimize the entire process by making the right staffing decisions, last-mile shipment planning and appointment setting.



## Underlying technology utilized

When IoT tracking first entered the market some years ago, the adoption of the new technology has taken longer than one would've expected. The main concerns around the shipment tracking included the cost of the tracking device, its capabilities, battery life and return logistics.

Maximizing the tracking device's battery life can significantly reduce the materials cost of the hardware. With its extensive geo-positioning portfolio and other location-related technology, HERE can optimize tracking accuracy and reduce battery consumption. And adding HERE's partner network for IoT hardware to the equation, gives an apt form factor for every shipment type.



## The importance of accurate positioning

For us at HERE, only highly accurate and authoritative location data is satisfactory for most use cases we work on. We would never risk the security of a shipment by relying only on GPS signals, as these are often inaccurate. In the last couple of years devices that can spoof or jam GPS signals became available on the grey and black market websites, significantly lowering the barrier of entry. This development has brought new threat vectors, especially when it comes to valuable freight, such as medical equipment or vaccinations. Defeating spoofed location and jamming is key to ensuring safety in global transit for this type of freight.

Jamming and spoofing work in similar ways. Jamming floods the GPS receiver with countless inconsistent GPS readings, preventing the device from accurately determining its location. Spoofing overpowers the real signal with a stronger facsimile with modified data that convinces a standard GPS device of an incorrect location. These types of attacks can be used to redirect shipments, cover theft and even hijackings.

The HERE Positioning suite of products can defeat both types of attacks as it ensures that freights provide or log their accurate positions. It can also collect and trend data over time

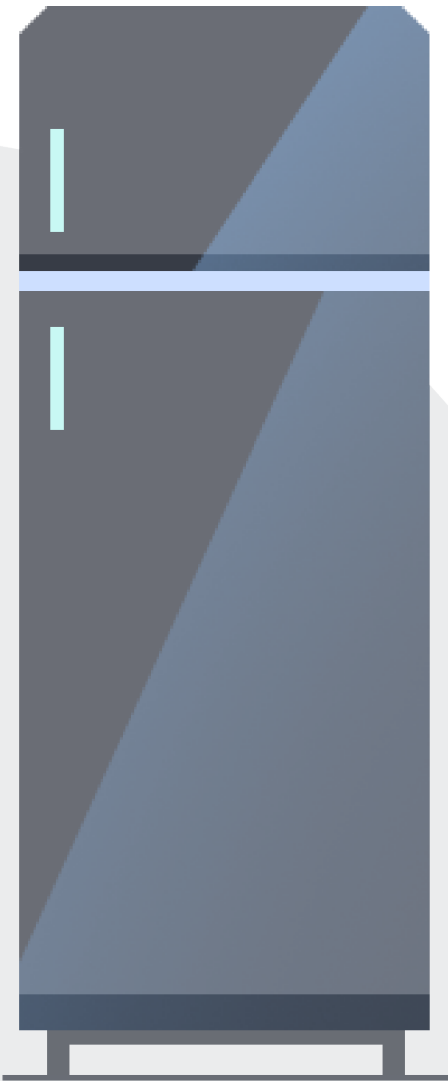
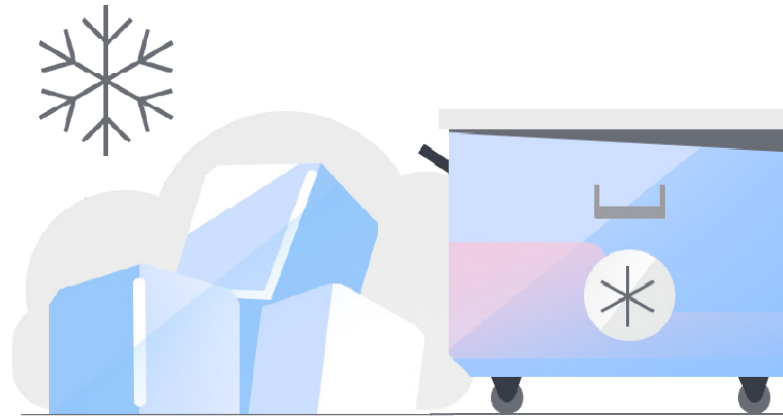
providing another valuable piece of the end-to-end visibility puzzle for critical goods.





## Enhanced environmental sensing

Environmental recording and sensing verify your shipments' integrity and allow the pinpointing of issues along the supply chain. These issues include malfunctioning equipment or a human error that could affect the integrity of the shipment. Understanding when and where fluctuations occur helps prevent future problems, pinpoint inadequate staff training and make preventative maintenance before any inventory losses occur.



### Temperature and humidity

Accurate temperature recording is paramount to ensuring the integrity of a vaccine and other critical shipments. As previously argued, many 'reefer' containers and trucks have a recording of temperatures and reporting built into the cooling units' intelligence.

However, the accuracy of these readings can only be as good as their last calibration. Many shipment owners prefer an approach of 'trust but verify' and capture accurate temperature readings during the loading and unloading scenarios.

Data logged and collected by a temperature-sensor-equipped GPS tracker can serve as verification. It provides accurate temperature readings tied to time and location stamps that help pinpoint temperature fluctuations during handover. Those temperature readings can also identify points prone to disruption within the supply chain.



## Shock and vibrations

Adding shock sensors to shipments enables the verification of the shipment mishandling. It identifies where supply-chain shipments may not have been handled with the diligence they require. When dealing with thousands of shipments, accurate trends can help the supply chain owners and their vendors to identify areas for procedure improvements and re-training and upskilling requirements of their workforce.

Shock-tracking is also a valuable set of data for insurance purposes as it gives information about the custodian of the shipment at the time of the incident.

## Tampering

Tampering with medical goods is greatly concerning, even if it's an edge case in the vast majority of shipments. As is the outright theft of high-value shipments or theft with replacing the goods with forgeries. When packages or containers have been opened or disturbed, receiving immediate reports about the intrusion and shipment's current location can help react to such a scenario.





## Online and offline logging

HERE Technologies provides a scalable location and data platform. This platform can collect various information in diverse formats, normalizing it into a common data set necessary for more in-depth analysis.

Data collection can be done in various ways, including real-time or batch transmissions that maximize the devices' battery life in the field. The best practice is to use case-dependent and largely variable collection method based on how much time in the field your shipment will spend.

### Hardware flexibility

Use cases that drive hardware requirements are numerous, however many traditional tracking solution vendors have standardized their hardware offerings to drive scale and reduce individual unit cost.

We recommend a platform-centric tracking approach that is mostly hardware agnostic. This independence from a set hardware solution gives room to customize any given use case and enables long-term cost optimization.



### Connectivity flexibility

A key consideration for the choice of hardware is connectivity. The predominant solutions for freight tracking used today work on gateway technology. The devices are often based on BLE or RFID technology due to their lower power requirements. However, both technologies carry significant downsides as they limit real-time insights and connectivity. They will also only transmit signals along a defined path of gates. This means that in case of deviations, the location of the shipment may remain unknown.

Still, some technologies provide real-time connectivity while not being cost-prohibitive. The most established of these are older, patent-unencumbered versions of GSM such as 2G. While 2G would traditionally not be considered an energy-efficient transfer method, using it in conjunction with HERE's technology, that allows transmission batching, can lead to longer battery life and a low CapEx on the trackers' acquisition.

Newer technologies such as LoraWAN and Sigfox can also provide real-time connectivity and at a very low cost. Yet, the single, most significant limitation of these technology choices is network coverage outside the major freight corridors and cities. Ignoring the network coverage, these technologies quickly provide the most competitive real-time tracking connectivity solutions.



# Technological deep dive

## HERE HD GNSS Positioning

Some of the most accurate location technologies are the well-known Global Navigation Satellite System (GNSS) and the US-based Global Positioning System (GPS). GPS leverages the location of 32 satellites in orbit to provide a meter accurate position on earth.

The challenges of a GPS positioning include its comparatively high power consumption when getting a location. This devices must first find the satellite signals and that can take more than one minute of radio time without assistance data. Modern assistance data can take this time down to well below 20 seconds, with HERE's assistance data implementation continuously performing around the 5-second mark.

Tests run by HERE and its customers have shown that the inclusion of assistance data alone can lead to as high as a twelve-fold power usage reduction. This fact significantly reduces the need for battery capacity and drives a notable reduction in the total cost of the solution ownership without sacrificing performance.



## HERE Network Positioning – cellular

GSM-based trackers can virtually use power-neutral positioning by applying a radio signature of the surrounding cell towers. This way devices that make use of the natural overhead from the GSM modem can be placed with an accuracy of 30 to 100m, which is considered adequate during transit.

Depending on rules in the tracking device's logic or remotely triggered events, the device can use its more accurate technologies to provide a highly accurate position when required. Such events can be automatically triggered when the shipment approaches its final destination, leading to smart battery savings during the entire transit part without sacrificing usability.





## HERE Network Positioning – Wi-Fi

A more accurate positioning methodology that is still highly power-efficient is Wi-Fi positioning. A technology that leverages a database of over 3.6 billion Wi-Fi hotspots worldwide to provide an accurate position to approximately 3 to 15m indoors and outdoors as well as, potentially, floor level detection. This feature provides complete end-to-end visibility also inside of facilities.

Using Wi-Fi positioning instead of GPS provides significant battery savings in the scenarios where medium accuracy location is sufficient or within indoor environments. HERE Wi-Fi Positioning can also serve as a sanity check to GPS signals. It cancels reflection in urban canyons and other environments that may significantly reduce GPS accuracy.



## HERE Tracking - message batching

Enhanced onboard logic allows HERE to connect compatible trackers to batch messages, sensor readings and related locations in situations where connectivity is nonexistent or for additional power savings. This is possible because the device tracker can use ultra-low energy technology, such as HERE Network Positioning, to monitor sensor readings along the way. The tracker continues to do so until it enters/exits a specific geofence, the sensor reading exceeds a specified threshold or until it is triggered by other business logic. At that point the tracker switches to active mode, gets a more accurate position, using GPS or a high-power technology, and uploads all location readings collected on the road. This methodology provides the most proactive and long-lasting tracking experience. It allows a traditional tracker designed for several-week duty cycles to last up to a year.







The endeavor to create herd immunity through a thorough and speedy vaccination movement across the globe stands unique amongst the challenges we have encountered and solved before. Every day we discover **new challenges** concerning the production, raw material sourcing, distribution and the final delivery and dispensing of the vaccine.

**HERE is ready** to help our partners, governments and NGOs to continue this herculean effort. Our mission is to continue to **use our fullest capability to help solve location and visibility challenges** around the shipment of critical goods.





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Need more details? Talk to us about how location can help distribute urgent medical goods.

Contact us

### About HERE Technologies

HERE, a location data and technology platform, moves people, businesses and cities forward by harnessing the power of location. By leveraging our open platform, we empower our customers to achieve better outcomes – from helping a city manage its infrastructure or a business optimize its assets to guiding drivers to their destination safely. To learn more about HERE, including our new generation of cloud-based location platform services, visit **360.here.com** and **www.here.com**.