

White paper

Smart Labels

An opportunity and a call for
standardisation.

Content

Executive Summary

**The current state of affairs:
patchy information**

The technology has caught up

**The development journey:
theory into practice**

Pilot study shipments

A whole new level of visibility

Executive Summary

New low-cost technology provides the opportunity for real-time supply chain insights and hence optimisation like never before. But it will only be successful if standards are agreed and adopted by all stakeholders across the industry. The time to strike is now.

Kuehne+Nagel has developed a low-cost, scalable smart label that has the potential to revolutionise the industry by providing real-time, affordable, piece-level visibility. The true benefits, however, will only be realised if common standards are adopted by all players.

The technology is a combination of a robust, Bluetooth Low Energy (BLE) device embedded within a label that is printed by a smart printer that captures and uploads the sensor ID at the moment of labelling. Signals are captured by smart phones with installed apps for tracking shipments during road transport in combination with a limited network of BLE readers in specific locations such as warehouses.

The use cases and potential benefits to the entire transportation sector for real-time, piece-level visibility are enormous, not least in the quest for ever improving sustainability and lowering CO2 emissions, so Kuehne+Nagel are inviting anyone who sees an opportunity for improving visibility and efficiency to their operation from using this technology to get in touch.

The current state of affairs: patchy information

Knowing where your shipments are at any given point in time has long been the holy grail of anyone working in transportation and logistics. Shippers require accurate information to ensure expectations are met and that planning is enabled for all subsequent supply chain steps. Forwarders need to understand if shipments are moving as expected or if actions need to be taken to correct deviations that could impact transportation processes and, ultimately, delivery date and time. Air carriers and ground handling agents need to understand which shipment pieces are inbound to their warehouse to facilitate planning of shipment build up and loading of aircraft or road feeder service.

The current situation is best reflected by stating that we have indications of where shipments are based on various sources of information that vary in their degree of accuracy.

Understanding inefficiencies, issues and delays needs to be done at the lowest level of transportation: the shipment piece. Shipments arriving incomplete, misrouted or even stolen affect downstream processes

that can lead to complete shipments being held for longer or even destroyed.

This granular level of detail has theoretically been available to us using expensive tracking devices that transmit on a real time basis. However, from a technical and financial point of view it cannot be deployed for all shipments without creating additional and costly processes to enable visibility at piece level.

The technology has caught up

As we now have arrived at the dawn of Industry 4.0 and the digitalisation of transportation we can see the potential of Internet-of-Things (IoT) smart devices that tell you their status of operation, or, in the case of transportation and logistics: where something is and how it's doing. Low-cost technology is a game changer and opens up a suite of potential opportunities we have never had before.

Where in the past RFID met some of the required parameters, there was still the challenge of obtaining data without building expensive physical infrastructure that impacts processes and logistics flows. At Kuehne+Nagel we decided to develop a solution that met the following parameters:



- Fitted in to the existing process
- Low cost to enable widespread adoption
- Data transmission over substantial distances
- Data collection without physical infrastructure
- Automatic linking of physical shipment pieces to data sources

In theory, the current state of technology allows for data capture without building expensive infrastructure and is flexible in its deployment.

We can now therefore fully address piece level visibility thanks to the key component: IoT smart labels based on Bluetooth Low Energy (BLE) technology that can communicate over longer distances and do not have the need for large infrastructure investments.

The label periodically communicates the unique label identifier so that it can be captured by a multitude of devices that accept the Bluetooth Low Energy signature.

However, several hurdles needed to be overcome in order to turn theory into practice.

The development journey: theory into practice

Before any pilot shipments could be envisaged, we needed to ensure that our vision of creating a smart label as a replacement for the standard House Air Way Bill (HAWB) label would actually work. We basically wanted to replace the HAWB label without



having to alter any handling and operational processes because that would destroy any value created by adding activities and therefore adding cost. So what were the hurdles to be addressed?

- No Lithium batteries to power the smart label
- Auto-association of smart label to shipment file
- Only activated at point of labeling to save battery power
- No import or export challenges additional to the shipment itself
- Limited to no infrastructure needed
- 1-way use
- Shock proof to resist handling activities
- Spray (rain) watertight
- Low cost

Over a period of 8 months, and in partnership with our suppliers Tag N Trac, and Zebra Technologies we dealt with all of the above requirements in order to create a 1-to-1 replacement of the label. We were able to print a label and simultaneously link each label to a specific shipment piece whilst receiving data from each label individually as a data set consisting of:

- Serial Shipping Container Code (SSCC)
- Label ID QR code
- Geo location of the reading devices

Interview with Torsten Steinke

The Printer

The label printer is a crucial part of the process and combined technological solution. We talked to Torsten Steinke, Director Sales Engineering, DACH at Zebra Technologies, our partner in the solution along with Tag-N-Trac.



Hi Torsten. The Kuehne +Nagel smart label project was not something you'd done before right? It wasn't an off-the-shelf solution.

Correct. It's what we would call a Customer Product Request – we get them quite frequently and are happy to work with our customers to develop something new and exciting.

So, at the beginning of last year, Kuehne+Nagel reached out to us with an idea about a smart label. Normally with smart labels you would do something using RFID technology in order to wirelessly capture the data you need. However, Kuehne+Nagel label supplier – Tag-N-Trac – were using Bluetooth Low Energy (BLE) technology in their labels. The advantage this has is that pretty much every modern mobile phone can communicate using Bluetooth so there was no need for the extra infrastructure that RFID would require. After an initial call with Kuehne+Nagel and Tag-N-Trac, we received the labels from Tag-N-Trac. This first iteration was essentially a solid piece of plastic with all the technology inside it and a surface on which to print. It was pretty thick.

Most labels come on either rolls or folded, this was neither. The solution we came up with was to use one of our top of the range printers – the super robust ZT411 – fitted with a print-on-metal head. The results of our initial testing were somewhat disappointing unfortunately, but we worked really well and closely with Tag-N-Trac to improve both the thickness, flexibility and printability of the labels, so that they met the specifications required. We also improved the design of the label to avoid damaging the print head, and came up with a solution to better let the printer work out where a label started and ended.

→

Interview with Torsten Steinke





So now you had the label print process working, how was that then connected to the airway bill?

Well, this was the next challenge, because as the label wasn't active, the printer couldn't do what it normally does and read the label ID and print accordingly. So the alternative would have been to do it manually and apply the label on the good to ship and then activate it by peeling or bending. But that process wasn't scalable for global implementation and efficient use. So, between us, we came up with the idea of printing a QR code that identified the sensor ID already known by Tag-N-Trac onto the label in order to associate it with the airway bill by scanning it at the point of printing.

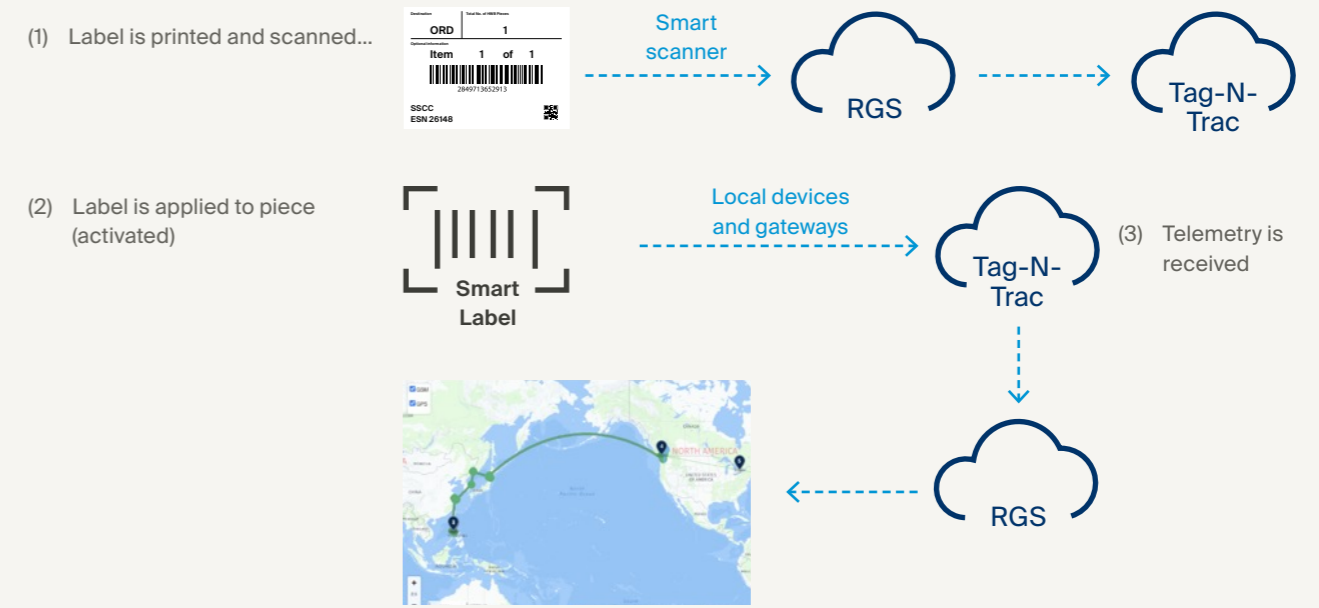
Pairing of Piece and Smart Label

- Labels come with their own QR code
- Scanner associates label code to piece SSCC
- Pair is sent to Cloud for registration

Destination	Total No. of HWB Pieces
ORD	1
Optional information	
Item 1 of 1	
	
2849713652913	
SSCC ESN 26148	

↑
Label is printed with piece information

↑
QR code identifying smart label (pre-existing)



The solution was a specially developed mount for the printer and a Zebra fixed scanner. The mount is designed to be adjustable and allows the scanner to be positioned in front of the printer in any way to ensure the best possible performance. During the printing process, the shipping ID of the printed barcode and the smart label ID on a second 2D barcode are captured, merged and transmitted to the ERP system via MQTT protocol. The printer and scanner communicate with each other via Ethernet to ensure the best possible timing for capturing the required information.

That's great. So, what is your take on the future of smart labels within transport and logistics?

Well first off, I'd just like to say that when you work with partners who are all experts in their particular fields, and there is real knowledge transfer like on the label development between ourselves and Tag-N-Trac, then that's where you move the needle and advance the technology.

As for the future, I think we have proven the concept, and the possibilities are huge. But this only works if it is done to scale, right through the industry and across all stakeholders. And that requires standardisation, to achieve interoperability and economies of scale.



A short testing period in Switzerland with the Kuehne+Nagel Zurich Air Logistics organization was meant to verify if theoretic modelling and assumptions were accurate enough to deploy the actual smart label pilot. We tested facility BLE readers, smart phones, Android based scan guns and the visibility platform to check that during trucking from Zurich Airport to the Kuehne+Nagel Frankfurt Gateway we would have the necessary visibility to fulfill a successful pilot study.

Facilities in Zurich and Frankfurt were outfitted with BLE readers that would capture smart label signals and in combination with geo-fences and logic would create an automatic CargoIQ status update. All Kuehne+Nagel air freight shipments have a built-in Cargo iQ Route Map, an end-to-end transportation plan, which enables the visualisation and proactive monitoring of every shipment along its journey. Working under such Cargo iQ framework, together with

other key industry partners, ensures reliable shipment planning and pro-active monitoring along the customers' door-to-door transportation supply chain. The outcome was that although everything worked as planned, it was best to have BLE readers integrated with wifi systems versus using BLE readers based on 4G technology. Doing so would create a more robust BLE reader solution and have the ability to scale when moving towards further functionality such as zoning of facilities and tracking shipment pieces whilst inside facilities.

Furthermore we tested if Android scan guns could be used for crowd sourcing of signals whilst being used for other tasks. Everything worked as hoped for and we are able to make scan guns a part of the overall BLE smart label solution if and when required.

Various smart phones were tested during the truck movement from Zurich to Frankfurt and it became clear that different types of smart phones acted slightly different when capturing signals. Newer and higher specification smart phones had more sensitive BLE reading hardware than older or simpler phones. As an Operating System (OS) Android proved to be the best solution as it can be configured more easily than other smart phone OSs and would allow the Tag-N-Trac application to work fully in the background without creating challenges with other applications. The last test was

to verify if different cell network providers would have differences in delivering data to the visibility platform. There were some small differences in performance but negligible for the outcome of the pilots.

The main lesson learned was to keep things as simple as possible.

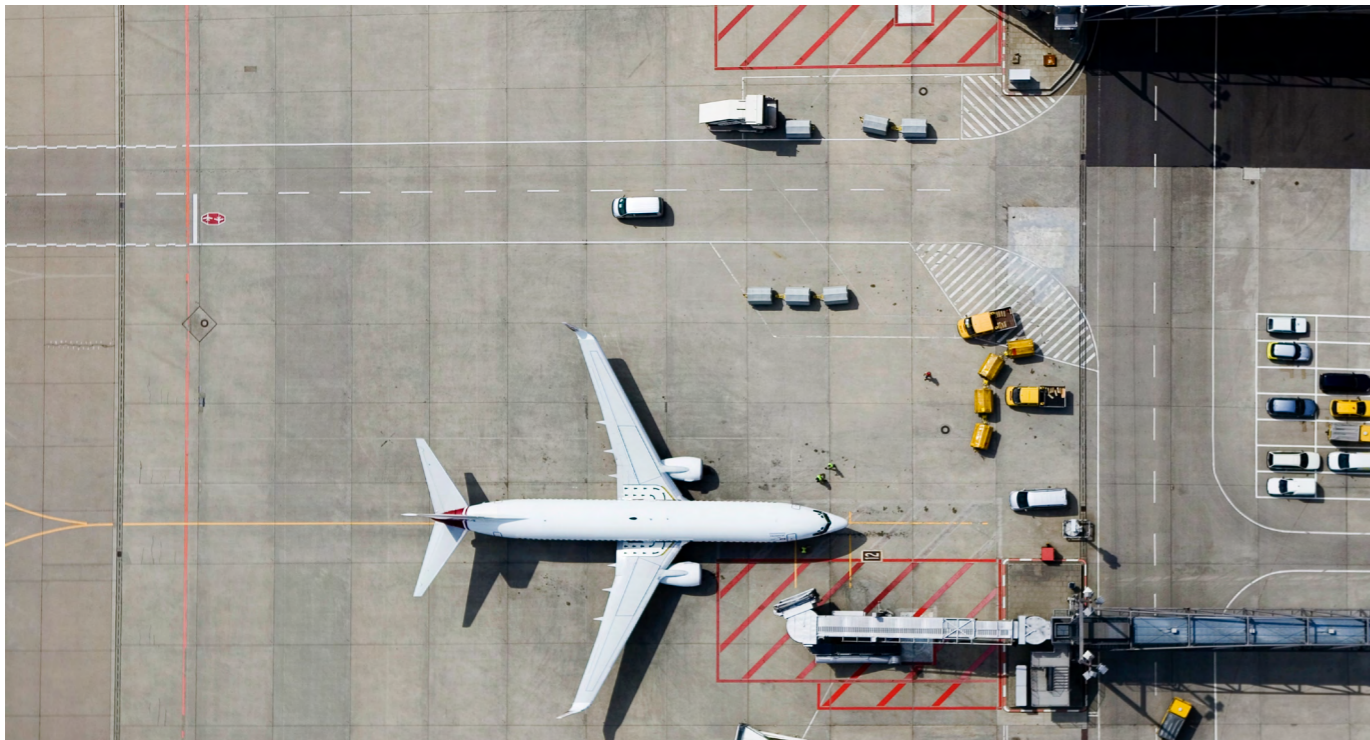
This required an explanation of why we were doing what we were doing and what that would mean from a visibility point of view. The pilots were designed to answer how this could be done.

Once this initial phase was complete we moved testing to Kuehne+Nagel in Milan. This was done due to a greater variance in customers as well higher shipment volumes on the gateway to gateway route from Milan via Munich and Frankfurt to Atlanta. Although in lab conditions the smart printer worked as planned, it was time to test it in real life circumstances with greater smart label volumes and fully deploy the solution. This resulted in a challenge with the printers stopping mid label as well as having sub optimum quality. By taking a deep dive into printer software and label detection by internal devices we found that electronics inside the label could on occasion stop the

printer feeding. Following numerous tests we decided that to each label separation we would add a notch or gap to distinguish where the labels started and ended. Together with applying a different print overlay the matter was resolved and print quality was where it needed to be and we could print smart labels in any volume required with no print stoppage.

Our final challenge was how to receive BLE signals when transporting from Airport to Airport with no smart phones or standard BLE readers available?

The solution was found by re-configuring carrier approved Roambee 'BeeSense' devices to become mobile BLE hotspots during the Airport to Airport move. It is unlikely that this device will be deployed in great numbers because of the associated reverse logistics and other matters that make it too cumbersome for piece level tracking. We rather foresee that fully functional labels are deployed that can act as BLE hotspot and have the benefit of being able to measure more shipment parameters such as light, temperature, relative humidity etc.



Interview with Venu Gutlapalli

The Label



Hi Venu. Tell us about how you came to be involved in the project.

So we first spoke to Kuehne+Nagel in late 2020, after having been put in contact through a supply chain conference. We were eventually introduced to Reinier who had written the concept paper for the smart labels five years previously, but had been unable to find anyone to develop the required tech. When we pitched our technology to him he basically said – “that’s what I wrote 5 years ago!”.

So the technology had finally caught up with his vision?

Right, so he gave us his requirements and along with the printer supplier Zebra we took around eight months to develop a viable label that did what was needed within the specifications.

When you think that a typical package goes through an average of 17 manual scans from start to end destination, the smart label solution avoids a huge amount of manual effort along with any potential errors, as the package is constantly “chirping” its location which is being fed to the cloud through ubiquitous blue tooth readers in drivers’ phones.

Previously, if the data was unavailable for some reason, or a scan was performed incorrectly, the entire shipment could be held up until the data could be obtained. The downstream consequences and inefficiencies due to this could be substantial.

This was why Reinier expressed the importance of the solution being error-free!



Interview with Venu Gutlapalli



What would you say the key benefits of the smart label solution are over the current situation?

I would say there are two main areas – the first, as I just mentioned, is efficiency, and the second visibility.

Let's take the first – when you're dealing with the kind of volumes that K+N are, anything that avoids manual intervention and increases automation is going to have a big impact. Not only is it much quicker, but it is also error-free, meaning the efficiency of your operation goes up substantially.

Second, the real-time visibility that the smart labels provide means you can plan ahead so much better. Think about spoke and hub operations for example where ULDs are consolidated before being shipped out. If you know that different parts of the shipment are all arriving at the hub within, say 30 minutes of each other, you can book the flight out with much more accuracy, and ensure maximum load.

What kind of future do you see for this technology?

The technology is what we would term vertically agnostic. Today we're working with logistics, tomorrow it could be pharmaceuticals, food and beverage or asset tracking of high value goods. Any field where there needs to be condition monitoring and active visibility. Temperature, humidity, shock levels, tampering all these things can be monitored, it's just a question of adding another sensor to the smart label. The number of potential use cases is huge. But of course, their true potential will only be fulfilled if common standards are adopted by all stakeholders.

Pilot study shipments

Now that everything was checked and working the pilots could officially start. The Kuehne+Nagel stations involved were notified to expect smart label shipment to come through their facilities. In the locations where cargo was handed over to the air carrier the Roabee unit needed to be added to the shipment so close coordination was needed to make things work as designed.

The visibility results were very encouraging and we had a good basis to truly assess if smart label technology could provide the functionality needed. By shipping multiple shipments with multiple pieces we were able to verify:

- Signal completeness throughout shipments
- Signal coverage at facilities
- Data set (Barcode + QR code) consolidation
- Cloud communication functionality
- Ingestion of API feeds into real-time geo systems
- Visibility availability of entire shipment

Because cell network coverage is less than optimum in certain locations we needed to apply logic to cover for any missing signals during the instances when a cell network was unavailable. But all in all the data sets generated were communicated and received as expected.

The greatest challenge we faced was the dependency on individual drivers and their varying types of smart phones loaded with the tracing app.

The pilots demonstrated that if the entire industry were to make use of this type of technology we would avoid having to ask drivers to switch on phones and run the Tag-N-Trac application in the background. We could then instead focus on data sharing with other parties in the supply chain, optimize visibility platforms and most importantly: industrialize visibility without having the need for manual shipment tracking activities.

Pilots will continue as we move on to special commodities and specialised networks. We will be able to control all steps of the shipment and truly uncover the value of shipment piece visibility.



Interview with Reinier Danckaarts

The initiator

We spoke with Reinier Danckaarts, Vice President, Head Product Development Air Logistics at Kuehne+Nagel about the importance of standardization and how that might be achieved.



Hi Reinier, could you explain why you believe standardization is key to the success of this technology?

Well, we could implement this technology just within Kuehne+Nagel, and it would certainly be of some benefit. It would change our processes and lead to improved efficiency. But the impact would be limited compared to if the entire industry adopted the same technology with the same standards. Because we operate as part of an ecosystem. It's called a supply chain because we're all dependent on each other.

If all the players in the movement of goods, from the shipper, to the ground handling agent, the trucking company, to the airport and airline and so on were equipped with the same technology, and feeding the cloud with real-time information, it would bring the entire industry enormous benefits. As an industry we still operate with decades old technology and processes, and of course there is a reluctance to share data. But with minimal investment, because BLE readers are cheap compared to RFID technology for example, we could uplift the entire sector and simultaneously bring benefits such as lower cost and increased sustainability. Better load consolidation and a decrease in lost shipments means less emissions due to fewer trips by ships, trucks and airplanes.



Interview with Reinier Danckaarts



And how do you envisage the industry-wide adoption of these standards will come about?

I'm under no illusion that this will be a smooth and rapid process. Change is always difficult. I think the most likely outcome will be a snowball effect if say the top five industry players got together, as part of an industry organisation for example. In fact this might even be driven by the technology itself, as the most efficient way of collecting the data emitted by the sensors would be through middleware, which would require a neutral independent organisation to collect the data and then send it out to the various parties involved.

The important thing right now is to effectively communicate the potential benefits this technology could bring, which is partly what this white paper is intended to achieve. Although we developed this technology, we absolutely want to share it with others. So, I'm putting the message out: if you think this technology could benefit your operation, whichever part of the supply chain you're involved in, call us, ask us questions, give us your views. We look forward to talking with you.

A whole new level of visibility

Our efforts have shown that low-cost, scalable, real-time piece level visibility is a reality. The implications this has for our industry are profound, from automated milestones to being able to accurately and quickly locate individual pieces throughout the shipment life cycle.

As the technology matures the use cases will multiply and the data will become ever more granular and allow for predictive visibility. Imagine adding further data sources such as carrier status updates, live weather forecasts en-route, news events and geo-fences around infrastructures such as facilities and airports. Then think what the application of machine learning and AI on all this data could deliver.

However, it will only become truly scalable if all stakeholders across our industry, globally agree on standards. Interoperability and economies of scale are vital if we are to fully reap the rewards of this new era.

It's time that accurate logistics data handling standardisation takes place across freight forwarders and other supply chain stakeholders to avoid fragmented solutions.

This is why we are proposing to share the full results and technical details of our pilot studies via an open consortium or industry body in order that common and agreed standards are developed for the benefit of all of us.

If you would like to be part of defining the next era for our industry, then let's talk:

→ reinier.danckaarts@kuehne-nagel.com

About us

Kuehne+Nagel is one of the world's leading logistics providers. We support our customers in sea, air, road, and contract logistics with a clear focus on integrated and industry-specific solutions.

We continuously work to offer relevant and innovative supply chain solutions to the aerospace community. Our network of global and local specialists ensures compliance with all regulations and industry requirements.

Learn more about our services

[→ kuehne-nagel.com](https://www.kuehne-nagel.com)

Inspire. Empower. Deliver.

