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Using the right digital technologies for supply chain visibility

An array of data-gathering options can trace, track and optimize operations

By Stephan M. Wagner and Christian Postel

Firms may claim that they aim for, possess or already benefit from full supply chain visibility (SCV) in their inbound, internal and outbound supply chains. In our experience, this seems an idealized world. Firms may at best have partial visibility, and have realized some of the potential that visibility offers. Numerous software companies and IT service providers offer solutions to increase SCV in various niches of the supply chain.

However, before firms adopt technology, they should understand what they want to achieve, which technology is most appropriate and weight the costs for technology adoption and use against the benefits it offers.

What is supply chain visibility?

Several years ago, Mark Barratt and Adegoke Oke ("Antecedents Of Supply Chain Visibility in Retail Supply Chains," Journal of Operations Management, 2007) defined SCV as "the extent to which actors within a supply chain have access to or share information which they consider as key or useful to their operations and which they consider will be of mutual benefit." Let's discuss two fundamental components of this definition.

First, SCV should encompass information that is key or useful to the firm. What firms strive for is to increase the robustness and reliability of their supply chains and to avoid supply chain disturbances or even disruptions. This might involve various types of data and information, such as the status of an expected delivery from a supplier, the temperature of a shipment throughout the transport or the vibrations it experienced, the level of inventory in a warehouse or the geolocation of supply chain assets, such as loading, transport or handling devices (see Figure 1).

Next to higher sustainability standards, information about status and locations of products, loading devices and other supply chain assets will improve customer service and lower costs.

Another priority is sustainability of the supply chain. Here, SCV can help to increase fill rates of loading devices – from boxes or roller cages to containers or bulk tanks. SCV can also cultivate reverse supply chains. Only if the geolocation of products or loading devices is known can they be returned for reuse or recycling. All this reduces resource consumption and carbon footprint. Next to higher sustainability standards, information about status and locations of products, loading

FIGURE 1

Data to enhance supply chain visibility

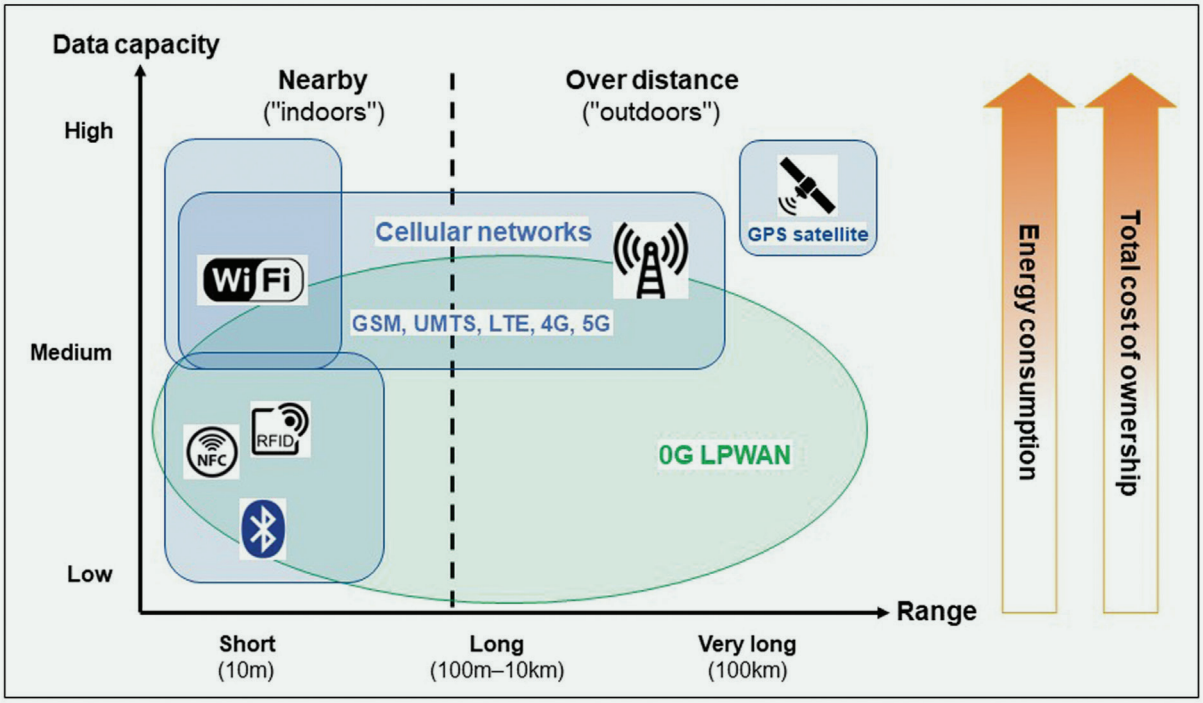
With technology, firms can collect, capture, transfer and analyze various types of information that are critical for the responsiveness, efficiency and sustainability of supply chains. Here are examples.

- Geolocation
- Temperature
- Humidity
- Product conditions
- Bumps or shocks
- Acceleration
- Wear and tear of products, loading devices and other supply chain assets.

FIGURE 2

Tech options

The key technologies supporting supply chain visibility.



devices and other supply chain assets will improve customer service and lower costs.

Second, the access and sharing of information for SCV requires technology for data capture on the one hand, and data sharing, tracking, tracing and monitoring on the other. This is where the digital technologies come into play. Digital technologies have advanced and offer new opportunities. Sensors, 5G, Internet of Things (IoT) networks, radio frequency identification (RFID), near-field communication (NFC), data loggers, control towers and blockchain all are technologies that should help increase SCV.

It begins with bridging the physical and the digital world through some form of automated information capturing via contact and noncontact devices, or various types of sensors. While still prone to corruption or fraud for high value items in supply chains (e.g., luxury goods), the data capture is reliable for regular logistics and supply chain operation.

Once the needed supply chain-related data has been collected and captured, it needs to be transferred to and shared with the relevant stakeholders. For example, once the geolocation of a shipment or loading device is identified, this information needs to be transmitted to a system for further processing.

Applicability and trade-offs of technologies

Technologies to enhance SCV can be classified based on, 1. the field of use which determines the needed data capacity, and 2. whether the goal is to enhance SCV in nearby ("indoors") or over distance ("outdoors") which determines the range of data capture and transmission.

Figure 2 maps the major technologies along these two dimensions. In addition to the range of data capture and the data capacity they can transmit, these technologies vary with respect to their energy consumption and costs. Higher data capacity normally is associated with larger energy needs and higher total costs.

Collecting and transmitting data indoors. For larger organizations, it might be necessary to track the flow of products or loading devices within a factory or a warehouse, within a larger property or free storage areas, in a logistics operation (such as a terminal area) and certainly for inbound or outbound transfers. At least when the ownership of products is transferred to another party, it is necessary to know if, when and how the transfer occurred. SCV has to ensure that goods receipt or dispatch information is meaningful and correct. Tracking and tracing systems of logistics service providers use technology to capture the information for unit-level product traceability. Data concerning the shipment is captured indoors at the factory door of the shipper and the depots or sorting centers of the logistics service provider. Such indoor digitization is quite mature.

Capturing the geolocation or other information noted in Figure 1 is done through barcode scanning or sensors in combination with technologies such as NFC, Bluetooth, RFID, low-power wide-area network (LPWAN) or Wi-Fi. While

all are primarily used for indoor applications, they still vary in terms of range and data capacity. Passive NFC, Bluetooth low energy (BLE) and RFID transponders can be integrated into loading devices, such as boxes or pallets, and allow to monitor their flow. Wi-Fi taps into wireless local area networks (WLANs); that is, networks of devices that connect to a 2.4 GHz or 5.0 GHz radio frequency. The Wi-Fi device transfers signals for a range of up to 100 meters (328 feet), which means Wi-Fi can cover larger premises.

LPWAN systems extend from the indoors to the outdoors with low latency and low device cost coverage of large numbers of connected devices. The need for low power consumption solutions is reflected in the BLE low-power personal area network that operates on 2.4 GHz.

Collecting and transmitting data outdoors. Longer data capture and transmission ranges are required in supply chain and logistics networks. Once shipments leave the factory, warehouse, depots or sorting centers, they are exposed to a more uncertain environment. They are handed over to various carriers, often intermodal, and might be exposed to rough handling, cross-country borders or the ocean on long-haul transportation.

Once shipments leave the factory, warehouse, depots or sorting centers, they are exposed to a more uncertain environment. They are handed over to various carriers, often intermodal, and might be exposed to rough handling, or cross-country borders or the ocean on long-haul transportation.

Tracking of cargo is rarely done in real time. Rather, checkpoints are the dispatch at one node of the supply chain and the arrival at another node of the supply chain. Cellular network technologies, such as global message services (GSM), universal mobile telecommunications service (UMTS), long-term evolution (LTE), 4G or 5G, however, would allow a real-time tracking of the geolocations and also other critical information.

GPS satellite technology is highly performant and provides geolocation and time information to a GPS receiver with an accuracy of up to 10 meters. While offering high data capacity, all have high demands in terms of power consumption and are rather costly.

Supply chains in the spotlight

Recent articles, podcasts and webinars have highlighted the supply chain challenges of the last year in the wake of the COVID-19 pandemic. ISE magazine articles include:

- "Labor pains reveal a 'systems change' for workforce" (*link.iise.org/isejuly22_sclabor*)
- "Not all disruptions are the same" (*link.iise.org/isejuly22_tompkins*)
- "Supply chain myths – and why Lean was not the culprit" (*link.iise.org/isemay22_thakurweigold*)

Also, several Performance Excellence webinars address recent supply chain challenges; access them at *link.iise.org/pe_webinars*.

And a 2021 episode of *Problem Solved: The IISE Podcast* focused on "The Global Pandemic: Supply Chain's Finest Hour" at *link.iise.org/podcast_s3e5*.

Generation 'zero' – energy conscious and efficient for many use cases

The technologies discussed above have both advantages and drawbacks. Some are either limited to indoors while others offer very high performance, which comes along with high energy needs and high costs of operation. Hence, low-power wide-area network (LPWAN or 0G IoT network) technology, which has been around for more than 10 years using an open standard in the sub-GHz frequency, might offer a worthwhile alternative to consider. LPWAN networks revolutionized the IoT market as they open up the opportunity to combine transmitting data indoors and outdoors with one single device. The ecosystem of available sensors is huge. The users appreciate the robustness, low power consumption, low maintenance, user friendliness and zero touch.

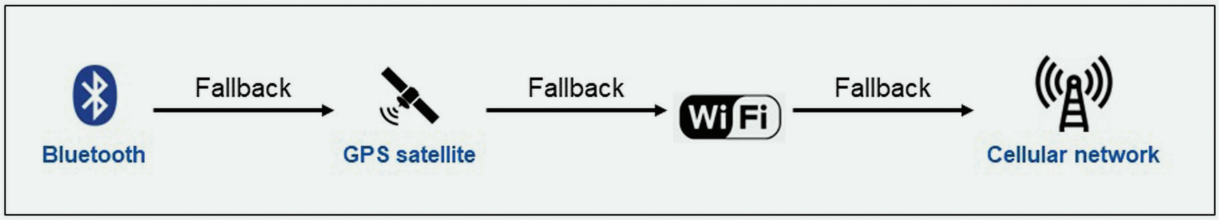
Larger logistics-intensive companies were first to implement this technology. One has equipped almost 1 million roller cages with trackers to enhance SCV in a LPWAN network. Another, an international brewery and keg provider, is challenged by an estimated 12% of the world's beer kegs that go missing each year. While some kegs might end up at a warehouse or in the wrong brewery, others are stolen and sold for scrap. Constantly losing kegs or other valuable assets reduce profitability. This is an especially serious problem for what the industry considers returnable or reusable supply chain assets (RSAs).

Beyond SCV, trackers and LPWAN technology can also offer solutions for fleet optimization. In every supply chain there are congestion points where assets stay longer than they

FIGURE 3

Honing in

The dynamic capturing of geolocation data by tracking devices using different technologies.



should. Rotation cycles can be improved, and the size of the fleet and the loss of assets can be reduced. Generally, depending on the value of the assets, the fleet size and the loss rates (frequently anywhere between 10% and 40%), digital technologies and trackers can easily recover the assets.

Recommendations for the choice and use of technologies

Enhancing SCV with the right digital technologies is not an easy task. Firms should have a clear strategy concerning the information that is most urgently needed and that will help to achieve the desired outcome (e.g., increasing reliability of the supply chain, lowering cost or enhancing sustainability). Only if the purpose is clear should a technology be chosen and applied. Managers should keep the following points in mind when they consider enhancing SCV in their supply chains.

Combining technologies. Each technology has its strengths and weaknesses. The real strength lies in knowing how and when to use which technology to ensure it supports the necessary data capacity and accuracy at minimal energy consumption and costs, and with maximum data accuracy. Modern trackers can combine technologies in one device. Capturing the geolocation of products, loading devices or supply chain assets should be dynamic, allowing to use the optimal technology at each location and fallback to another technology if needed.

A tracking device might first try BLE localization. When this fails, it falls back on GPS; if that also fails, there is still the option for a Wi-Fi or even network location. Regardless of the physical location, outdoors or indoors, the tracking device will always find a technology to localize itself with the necessary precision (see Figure 3).

Purposeful use. The type and density of data needed for SCV depends on the use case. The choice of the digital technology can vary per location. In a factory, 10 meters of accuracy might be required, while at a supplier, such a precision is not necessary. The ability to add additional infrastructure only where more precision is needed adds flexibility. In some locations, factories, depots, etc., investment in additional infrastructure is worth the extra costs; in others it would not add value and therefore should be abandoned.

Purposefulness also encompasses smart energy use. For example, certain sensors (e.g., gyroscope sensors) can help reduce battery consumption. They can be used to capture GPS data only when assets are moving with a certain speed. During idleness or nonmovement, geolocation is captured only once a day, which saves battery life. To differentiate between moving assets which are actually in use and assets waiting in a distribution center can open up new business models or "pay-as-you-use" models for both vendors of load carriers and poolers or logistics companies.

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Combining different types of data. Another dimension of innovation and intelligence can also boost the value of the data if geolocation is enriched by additional information. In mission critical incidents – for example, a broken cold chain, broken seals, damaged packaging or intrusion – this can provide valuable information additionally to the geolocation. A confirmation goods having been delivered at final destination, or "package opened," could trigger usage commencement dates, including guarantee regulations. Withdrawal of goods out of stock can easily be monitored to offer competitive payment options for the clients.

Making use of condition monitoring. A major problem often is the lack of transparency along the supply chain. Goods spoil because the cold chain is interrupted or their

condition is not known during transport. Smart pallets and transport containers, for example, with sensitive food or pharmaceuticals should be equipped with IoT sensors. The sensors, which are networked with the cloud, monitor temperature, humidity, vibration or acceleration and immediately report deviations from the target via an alarm. The ones responsible can directly initiate countermeasures. Condition monitoring results in fewer rejects, and hence, replacements and unnecessary transportation are reduced.

To mitigate climate change, transportation and logistics, service firms must optimize and decarbonize their processes.

Considering the back end. Technology for capturing data via sensors or trackers is only one but insufficient component of the entire system. Equally important is the back end, which we refer to as the intelligence on the platform to analyze the data and link it to the operational systems. It plays an integral role in combining all information and incidents in the supply chain. For example, there are tools for predictive analytics that estimate an expected arrival time of a shipment based on its current location, and algorithms that calculate optimal reorder times and quantities for material based on the warehouse inventory data.

Similarly, if the front end brings the visibility where transport boxes of logistics service providers are in a logistics network, it is possible to predict whether and when they will return in the system to be reused, or if new boxes have to be organized.

Benefits of the technology and an example

Capturing, sharing and analyzing data for supply chain visibility with IoT results in tangible benefits. It reduces the size of supply chain assets, such as the fleet, without compromising availability or service levels. Turnaround times can be decreased by up to 20%, and tied-up capital by 15%.

What becomes even more important to firms is the positive impact on the sustainability of the supply chain. The use of energy and CO_2 emissions play a critical role in logistical decision-making processes. To mitigate climate change, transportation and logistics, service firms must optimize and decarbonize their processes.

Digital technologies, especially the IoT and smart sensors, can make a valuable contribution. IoT paves the way to green transport logistics. For example, with its GoGreen sustainability initiative, Deutsche Post DHL Group, which delivers around 5 million parcels nationwide every day, has worked for years to reduce its emissions with the goal to be CO_2 neutral by 2050. One contributor to reaching this goal is the intelligent tracking of the logistics roll containers in the parcel division. It used to be challenging to manually locate the roll containers used as loading devices for carrying parcels between the 35 DHL parcel centers and distribution centers of major customers. Often new containers had to be added to meet the demand. To enhance SCV, DHL decided in 2019 to equip all roll containers with intelligent trackers that provide precise information about the location and detect movements. This not only automates roll container management but also helps avoid many empty runs and saves unnecessary resources. A positive impact on cost and sustainability were achieved.

Using digital technologies for supply chain visibility is on its way. With stricter demands for better utilizing supply chain assets, reducing costs, improving customer service and enhancing sustainability of supply chains, more companies will consider this a necessary project to consider. ❖

Note: For a full list of references for this article and additional readings, see the *ISE* reference page, *iise.org/isemagazine/references.*

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Glossary of technological terms

Here are some of the common technologies used for supply chain visibility and common abbreviations used to identify them:

- Bluetooth Low Energy: BLE
- Global Message Services: GSM
- Global Positioning System: GPS
- Internet of Things: IoT
- Long-Term Evolution: LTE
- Low-Power Wide-Area Network: LPWAN
- Near-Field Communication: NFC
- Radio Frequency Identification: RFID
- Universal Mobile Telecommunications Service: UMTS
- Wireless Fidelity: Wi-Fi
- Wireless Local Area Network: WLAN
- Zero-Generation Technology Standard: 0G
- Fourth-Generation Technology Standard: 4G
- Fifth-Generation Technology Standard: 5G