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Using 3D scanning to drive supply chain innovation

A series exploring Industry 4.0 technologies and their potential impact for enabling digital supply networks in manufacturing

Contents

Do you need 3D scanning in your supply chain? 3D scanning can be used to improve the speed and accuracy of routine operations; fosters faster delivery or product movement rates; reduces human error and improves productivity; and improves access to sites and locations that are difficult for humans to access.

Of interest because: As the cost of underlying technology decreases, the computing power of the image processing system increases and the accuracy of sensors increases; and 3D scanning systems are being adopted across a wide array of fields such as life sciences, consumer products, media and entertainment, construction, logistics, and manufacturing.

Could improve your supply chain by: Enhancing productivity via digitization of product design data and customization of that data for unique needs; lowering operational cost by preventing downtime by analyzing potential failure; reducing error rates by reducing human effort in redundant and time-consuming tasks; optimizing picking, sorting, and storing times; and increasing access to difficult locations.

Why not? 3D scanning requires an up-front capital investment, which may not justify the potential benefit; could require a significant effort to train employees to adopt the system; poses a challenge to integrate with other technology/management systems in the organization; and requires a careful assessment of copyright laws, which are still evolving as it pertains to 3D scanning.

What is 3D scanning?

Overview

3D scanning is revolutionizing the way we design, model, and visualize real-world environments and objects. By absorbing an environment or an object into a virtual space, a deeper and more thorough understanding can be achieved.[1] Models can be developed with higher precision, design processes can become more efficient, and difficult-to-access areas can be easily viewed. 3D scanning enables the ability to determine the shape of a surface or volume in 3D space.[2] The scanning device analyzes a real-world environment and object to collect 3D data on its shape and appearance.[3] 3D scanning technology collects large sums of geometric data points to create a high-resolution, accurate digital model of a real-world object.[4]

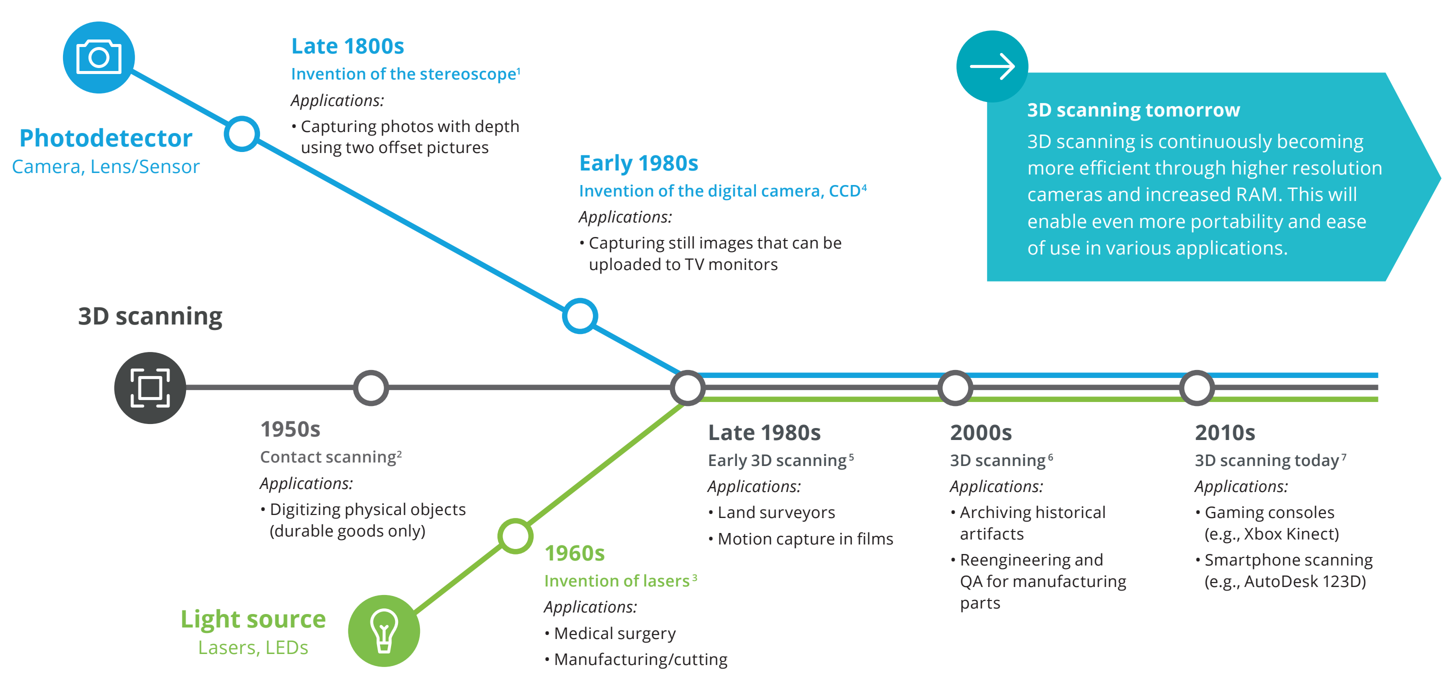
Major components of a 3D scanning device could include photodetectors (e.g., camera, lens/sensor), light source (e.g., lasers, LEDs), and associated computing systems inclusive of hardware and software components (e.g., augmented/virtual reality, 3D printers).[5]

Evolution of 3D scanning

3D scanning has evolved greatly over the last few decades (see figure 1). All three components of the scanner—light source, photodetector/sensor, and computing system—are becoming more and more technologically advanced and producing more accurate scans. As the technology is popularized, it is becoming more cost-efficient to manufacture and distribute as well. Recent developments in handheld 3D digitizers and robust 3D printers have created an evolutionary boom within the 3D scanning marketplace.

Overview	
Value drivers	• Enhances accuracy of data captured • Enables rapid design and prototyping • Improves workforce productivity • Increases collaboration amongst workforce • Provides the ability to obtain data in environments inaccessible to humans
Scope	• Enhanced productivity across all segments of the supply chain
Technology substitutes	• 2D scanner • Manual measurement techniques: molds/casts, measurement devices

Figure 1. Evolution and applications of 3D scanning



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Components of a 3D scanning system

Light source

3D scanners utilize a light source for triangulation in one of two ways. For objects that are close to the scanner (less than one-meter focal distance), the angled reflection of the light source off the object is measured by the photodetector or sensor.[6] For objects that are further from the scanner (greater than one-meter focal distance), the time taken for the light source to reflect off the object from the source and back to a photodetector or sensor is measured.[7] There are two different light sources that can be used to measure object distances. The type of light source used will depend on the scan requirements and the object being scanned.

Lasers are a more recent invention and are a vital part of 3D scanning.[8] Lasers were invented in the 1960s and primarily were used for research purposes.[9] Lasers use electrical discharges to excite atoms and release them, which in turn emits energy in the form of photons (i.e., light energy) that are reflected off a mirror and propagated. The uses of lasers expanded into the medical and manufacturing industries shortly after.[10] The advantages of using lasers in 3D scanners are that they can gather data more quickly and in areas with less lighting, and they can cover a larger area (e.g., outdoor environments).

3D scanners can also use white light or LEDs instead of lasers to illuminate and collect data on the object being scanned. This technique requires repeatedly projecting a "fringe" pattern on the object being scanned to estimate the shape of the object. The repetition required in this method allows for an accurate image, even if the object moves slightly (e.g., in face and body scanning). In addition, white light scanning does not have the same level of eye safety concerns as laser scanning.

Photodetector/Sensor

Photodetectors first implemented the "3D" concept in the mid-1800s with the invention of the stereoscope,[11] which used two offset images to create the illusion of a "foreground" and "background." However, it was not until the late-1900s that photodetectors became advanced enough to support the concept of 3D scanning. It was at this time that sensors in digital cameras were popularized and information they captured could be sent to a computer for further analysis.[12] 3D scanners use this information to calculate geometric points and distances between the photodetector and the object.[13]

There are two main sensors that are generally used within a digital camera. They both collect imaging information by converting light into electrons within the photovoltaic cells of the sensor, but they differ in how they "read" the information:

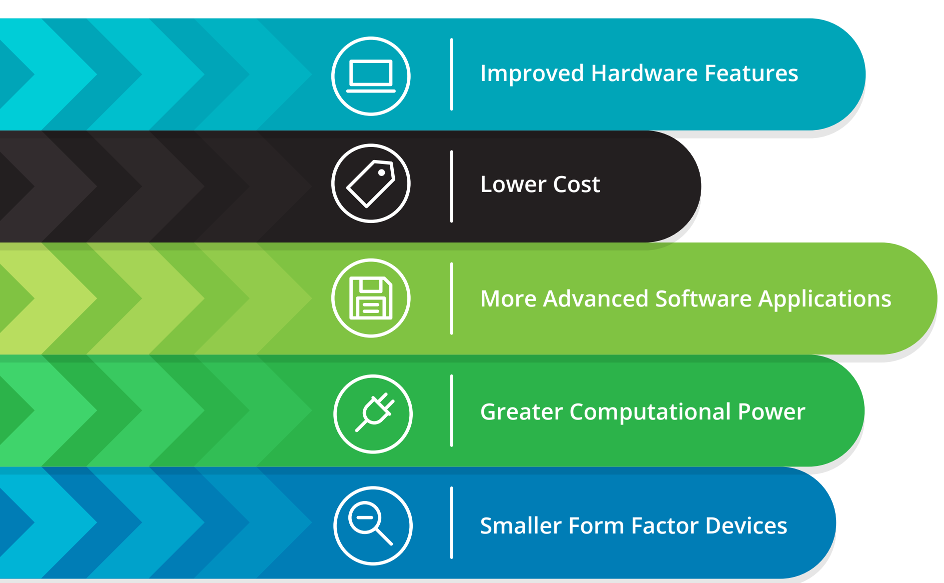
- A charge-coupled device (CCD) image sensor is a component of a digital camera that takes a charge (from a light source) and transports it across the chip to an analog-to-digital converter where it is read and digitized. It is the more expensive option and consumes more power, but it is the most mature technology today. A CCD produces higher-quality images because of its special manufacturing process that allows the charge to move through it without distortion.[14]
- A complementary metal-oxide-semiconductor (CMOS) image sensor is a more flexible and cheaper option that uses transistors and wires to amplify and move the charge. CMOS image sensors use traditional manufacturing processes to build. They require less power but have lower light sensitivity and higher image noise.[15]

Computing system

As the cost of computers and graphic processors decreases and availability of 3D applications increases, computing systems for 3D virtualization are becoming more widespread.[16] Both software and hardware are integral to a computing system utilized in 3D scanning. Mainstream components such as the CPU, GPU, and RAM are instrumental to providing computational power while advance software applications provide the processing capabilities and visualization means.

To capture dimensions of a real-world object in 3D space, 3D scanning utilizes a triangulation methodology. An array of captured values is converted to 3D points within the scanning coordinate system via software.[17] The hardware governs the speed of converting and summing values to produce each data point.[18] The subsequent conversion and summation of collected coordinates is processed by the overall computational system to develop a 3D visualization in which the real-world object is digitized.[19] The exponential improvement in computing power and processing capabilities over the years has played a pivotal role in expansion of 3D scanning technology commercially. As computing technology improves, more data points can be processed quickly in an effort to produce a more granular and rich 3D visualization.

Figure 2. Key developments in 3D scanning technology



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Benefits of 3D scanning in the supply chain

3D scanning across industries

The 3D scanning industry is experiencing high growth with the emergence of low-cost systems, improved scanning capabilities, and increased availability of data storage and data processing capabilities. As a result, a number of industries are benefiting from greater accessibility and capabilities of 3D scanners. Examples are illustrated below.

Life Sciences

3D scanners can readily scan and image a human body, enabling more accurate and cost-effective customization in a number of use cases where products must be individualized. One such use is in prostheses. Using 3D scanning, SHC Design has developed a prosthetic leg that can quickly be designed and built by scanning the patient's leg and his or her desired footwear. While prosthetics of this kind are typically handmade and cost on average $4,200, SHC's product is rapidly made and costs only $100.[20]

Consumer Products

3D scanning is making modeling and design capabilities available to the masses. With new technology, smartphone owners are now able to take accurate scans of objects using just their mobile devices. On a larger scale, new apps with attachments for tablet devices are giving homeowners the ability to 3D scan their homes for DIY projects.[21]

Construction

High-end scanners enable rapid surveying, site modeling, and layout design. With accurate and quickly produced scans, structural designing can be completed much more quickly. In addition to user-operated devices, 3D scanning technology has the potential to be a key component in service robotics. In one case study, a rotary laser scanner was used to function as an "eye" for an autonomous robot to navigate sewer pipes.[22]

Media and Entertainment

In the entertainment industry, 3D scanners are used to create digital models for a variety of purposes such as video games and virtual cinematography. 3D models are quickly and accurately created by scanning real-world objects, including actors, instead of creating the models from scratch. CAD software coupled with portable 3D scanners allow entertainment design companies to make sets, costumes, and props in a matter of hours as opposed to weeks.[23]

Overall, 3D scanning technology offers a versatile array of tools that can benefit a number of industries. Organizations may leverage 3D scanning in order to remain flexible and adapt to continually changing demands.

Case study: 3D scanning in Construction industry[24]

3D scanning offers construction companies the ability to perform scans that facilitate more accurate and rapid planning.

Providence, Rhode Island–based construction company Gilbane has used a 3D laser scanner in a number of projects to drastically improve efficiency and enable savings.

On one project, the company's 3D scanner greatly facilitated up-front preparation and planning for a renovation project. Kreger Hall at Miami University was an 85-year-old building that is now home to Miami's Physics department. When renovations were being discussed, Gilbane only had the original, hand-drawn plans of the building to start with. Using their 3D scanner, Gilbane was able to scan 50,000 square feet of the facility in a single day and get accurate measurements for prefabrication, scheduling, and sequencing of what would be a $12 million upgrade.

On another project, performing a 30-minute scan, upload, and conversion to a digital design file, 3D scanning saved Gilbane $30,000. Cost savings such as this help to justify the up-front cost of a 3D scanner, which can be a huge barrier of entry to smaller companies. Gilbane uses a FARO Focus 3D laser scanner, which costs approximately $60,000 after software and operations training.

For more information on the role that scanning plays in the digital thread, see 3D opportunity and the digital thread and 3D opportunity for scan, design, and analyze.

Primary potential benefits

- Product design
- Product customization
- Quality enhancement
- Logistics optimization
- After-market sales and services

3D scanning for flexible, more effective supply chains

3D scanning can provide tangible cost benefits across the supply chain and greatly enhance the overall design and production process.

Product design

As scanning and sensor technology become more accurate and cost-efficient, 3D scanning can enable rapid product assessment and design. By creating 3D models of desired devices, companies can generate custom product designs with minimal input from design professionals. This eventually enables automated design approaches and fundamentally changes the design process.[25] The digital image of the product design can be shared with teams across the world for further analyses and review, significantly cutting down costs and fostering collaboration.[26]

Product customization

As product designs become more and more digitized, 3D scanning is creating additional opportunities for customization. In industries such as medical devices and prostheses, 3D scanning can facilitate easier, more accurate customization in the design phase and allow prostheses to be automatically designed for rapid production. 3D scanning can also drive more flexible customization at point of use. By scanning a component on the spot, such as military equipment damaged in the field, 3D scanning enables rapid, customized parts replacement. Within a week in Afghanistan, the US military was able to reproduce a modified version of an m249 (a light machine gun) bipod attachment, which was restricting horizontal motion of the gun. An actual customized replacement would have taken many months.[27] In retail, 3D scanning can quickly capture body measurements to help suggest in-stock apparel for customers, or to use in creating custom or tailored apparel.[28]

Quality enhancement

Today's scanning technologies are fast and accurate and capture a good level of detail (high-end scanners above $20,000—speed: 500K–2M points per second (pps); accuracy: 0.001 mm; resolution: 0.05 mm; average scanners around $1,000—speed: 50K–500K pps; accuracy: 0.1 mm; resolution: 0.5 mm).[29] Rapid, accurate scanning can be utilized to improve product and quality control. 3D scanners quickly take precise measurements to determine if products are made within specification thresholds. Today, manufacturing companies are able to utilize plug-and-play solutions produced by a variety of companies to automate quality control directly on the production line.[30]

Startup Spotlight: ShapeScale[31]

The ShapeScale is a revolutionary weight scale that uses 3D scanning to show users exactly how their body changes over time. Using 3D scanning capabilities that not only measure the shape of the body but also use heat emanated through infrared sensors, the ShapeScale can offer localized body composition measurements that far exceed the accuracy of the electrical impedance scales that are standard today.

In addition to offering precise and accurate body composition measurements, the ShapeScale integrates augmented reality technology in order to create an image of the user at each weigh-in and visually track progress toward fitness goals.

Logistics optimization

Another use of 3D scanning is in augmented reality (AR), in which computer simulation models are layered over the physical layout of current surroundings. Already, AR is driving increased productivity and performance in logistics. DHL has recently piloted AR in their warehouses in order to help pickers locate, scan, and deliver the correct product to the loading dock before identifying the fastest route to the next product.[32] Field tests of these systems have improved productivity of warehouse operations—constant picking validation reduces errors by as much as 40 percent.[33]

After-market sales and services

3D scanning technology also facilitates a number of after-market sales and services opportunities including predictive and preventative maintenance. Predictive maintenance technologies rely on advanced 3D scanning sensors to identify potential areas of concern before they become failures. For instance, ultrasonic scanning can detect leaks that are not audible to the human ear and provide early detection of deterioration. Infrared scans can highlight hot areas on the component that may indicate an imbalance or wear problem. Payback from such systems varies widely based on the size and type of facility and the cost of the sensor. On average, a production facility can expect payback in fewer than 12 months.[34]

In addition to maintenance, 3D scanning can help to lower the cost of replacement parts by identifying production components that are candidates for MRO commercially available parts. 3D scanners take accurate images of the original part in order to facilitate product redesigns, thus improving lead times and reducing inventory.[35] In some cases, 3D scanning can also be used to create custom replacement parts, when either the replacement parts are unavailable or the long lead time is not acceptable. In the US Navy, 3D scanning and printing has brought down the time to mend broken components of aircrafts from two to three weeks to a mere couple of days.[36]

Summary

Overall, recent advances in 3D scanning technology have the potential to yield benefits in a number of industries and drive cost savings across the supply chain.

The primary benefits of 3D scanning are improved scanning accuracy, product customization (by modifying the digital representation of the original), and scanning speed. The increased speed of design, maintenance, and repair afforded by 3D scanning technology will enable additional opportunities for innovation in the supply chain.

As 3D scanning technologies continue to advance, companies should explore and experiment with ways to utilize this technology to deliver unique capabilities and benefits for their business.

Startup Spotlight: Stefanka[37]

Stefanka is a technology partner for retailers and uses 3D scanning to offer customers personalized clothing recommendations. Using software that analyzes volumetric measurements, customers can find clothes to match their body type through an interactive fitting room, which has been shown to improve customer satisfaction and increase sales. The company also aggregates data and offers analytics and insights back to its retail partners.

Stefanka's technology reduces online buyers' uncertainty and also helps online retailers decrease the volume of items returned due to sizing and fit issues. While the company is currently focused on lingerie and swimwear markets, it looks forward to expanding its services to the entire clothing industry.

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Criteria for evaluation and adoption

Operational considerations

To begin or expand the use of 3D scanning technologies across supply chains, start by developing a product's operations, logistics, and services strategy based on the company's profile and specific needs. The following five attributes can help shape your decisions and determine the potential overall return on your company's investments in 3D scanning solutions.

Company and facility profile

3D scanning solution procurement options and constraints vary according to company size and facility profile. Key questions include:

- What are the key operational functions (product design, manufacturing, logistics, and services) along the supply chain?
- What types of facilities (design center, manufacturing or testing facility, distribution center, office, retail store) do you operate?
- As of today, what are the biggest inefficiencies throughout the end-to-end supply chain?
- What is your asset management strategy (i.e., maintenance, servicing, and disposition) in your facilities, and do you have the processes, training, and tools to appropriately manage additional capital equipment (i.e., 3D scanners, associated computer systems, AR/VR headsets)?

Choice of 3D scanning solution and employee expertise

Various types of 3D scanning systems exist. The choice of the sensor, analysis software, and visualization medium are dependent on the particular issue that needs to be alleviated and your organization's ability to accept the change. Operational areas that require a high level of manual effort may be indicators of the potential bottlenecks within your supply chain. Automating mundane tasks and reducing time-critical efforts can improve time to market, reduce supply chain bottlenecks, and improve overall business strategy.

- How much precision is required by the task that could benefit from 3D scanning (helps determine the sophistication and extent of the 3D scanning solution)?
- How will the 3D data model be stored, transmitted, archived, and secured?
- Does the task that will be augmented by 3D scanning have any timing constraints?
- Is there physical space to add the 3D scanning system to the existing infrastructure or equipment?
- Which tasks do your employees find to be the most repetitive, redundant, or time intensive?
- What training is available to enable employees and partners to adopt the new technology and associated processes?
- Is there a large enough available talent pool in the region to operate the 3D scanning system?

Business value

Investing in 3D scanning solutions should be analyzed via a critical cost–benefit analysis across the supply chain. Key questions include:

- What is the business value of the investment?
- What is the cost of capital?
- Should the solution be adopted as a service or should it be purchased outright?
- What are the projected interest rates and labor rates in the foreseeable future?
- How long will the 3D scanning solution be utilized (expected life, potential obsolescence)?
- How will the depreciation, disposition, and replacement of the system be handled?
- What is the annual recurring cost to maintain the 3D scanning solution?
- What additional infrastructure (if any) will need to be set up to have a seamless implementation?

Operating environments and perception

Employers will need to mitigate negative perceptions of safety or labor outsourcing among individuals who interact with 3D scanning solutions. It will take time to train employees, and training must be updated with each improvement in technology.

- How will you address any health concerns workers might have about working with 3D scanners?
- How do you expect the current workforce to respond to adopting 3D scanning?
- Will you need to create a communication strategy with labor unions or current employees?

Regulations

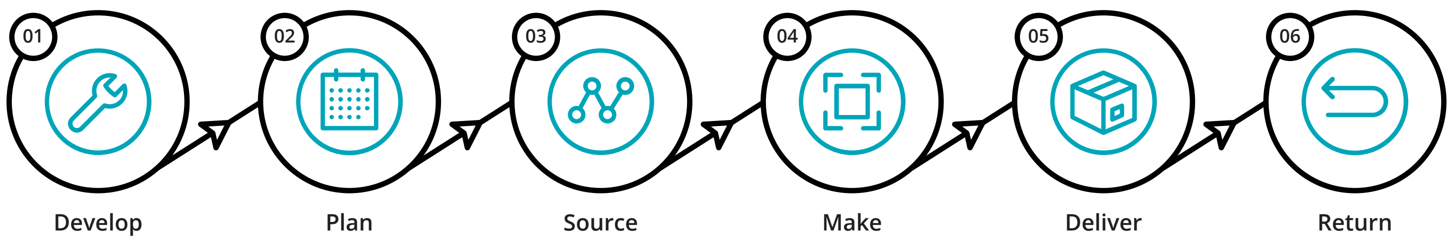
Scanning any object that doesn't belong to a company is fraught with the risk of infringing on copyrights, patents, and trademarks held by third parties. Furthermore, the validity and interpretation of the copyrights, patents, and trademarks differ from country to country. These issues get complicated when an image is scanned in a country but is electronically transferred to a different location for visualization and reproduction.

- Do you have permission to scan the object of interest?
- How will regulations in each location impact your use of 3D scanning technology?
- Will the scanned image be transferred across geographic boundaries?
- Will the scanned image be stored? If so what medium will be used, and is your company compliant with the data residency requirements?

Key levers for 3D scanning in your supply chain

Supply chain applications

Significant 3D scanning opportunities exist at each stage of the supply chain.



Examples

1. Develop: Utilize 3D scanning to capture design of existing products. These scanned designs can be leveraged by virtual design simulation tools to enable collaboration between production teams around the world. Teams can independently upload designs and test design feasibility by leveraging input and feedback from designers in various facilities.
2. Plan: Use 3D scanning methods to manage inventory needs and asset utilization in real time (e.g., "smart" shelves to dynamically price inventory).
3. Source: Utilize 3D scanning and printing to transform your business model by enabling mass customization, manufacturing at the point of use, and supply chain disintermediation.
4. Make: 3D scanning is utilized in AR-enabled wearables to support worker operations and to enable remote communication (e.g., remote specialists can guide colleagues through complicated maintenance procedures). 3D scanning is also utilized to monitor wear and tear of assets to predict future issues or failures and automatically schedule maintenance windows that minimize disruption to production schedules.
5. Deliver: 3D scanning-enabled AR wearables support logistics operations and enable remote communication (e.g., remote specialists can guide colleagues through complicated logistics procedures—delivery, installation, maintenance). 3D scanning is employed in driverless trucks and cars for autonomous transportation operations.
6. Return and Service: 3D scanning and printing on-site at remote locations in order to simplify and accelerate the development, manufacturing, and delivery of spare parts and tools (e.g., "pop-up factories")

These examples are just a few of the many opportunities to advance supply chain with 3D scanning. Opportunities exist in the end-to-end supply chain for cost reduction and value creation.

Motivation for action

The time for companies to assess their supply chains for 3D scanning is now.

Recent developments in the field: Improvement in computational power (faster hardware and software algorithms), reduction in scanning technology cost, and decrease in size of the scanner and reproduction end-to-end systems have made 3D scanners and the associated technologies more affordable and accessible to the wider market. Depending on the needs and existing capabilities within the supply chain, implementing 3D scanning—from virtual designing to 3D scanning and printing of spares, can provide significant improvements in productivity and efficiency, while reducing labor costs and significantly improving customer satisfaction.

3D scanning enables more efficient supply chains from end-to-end by:

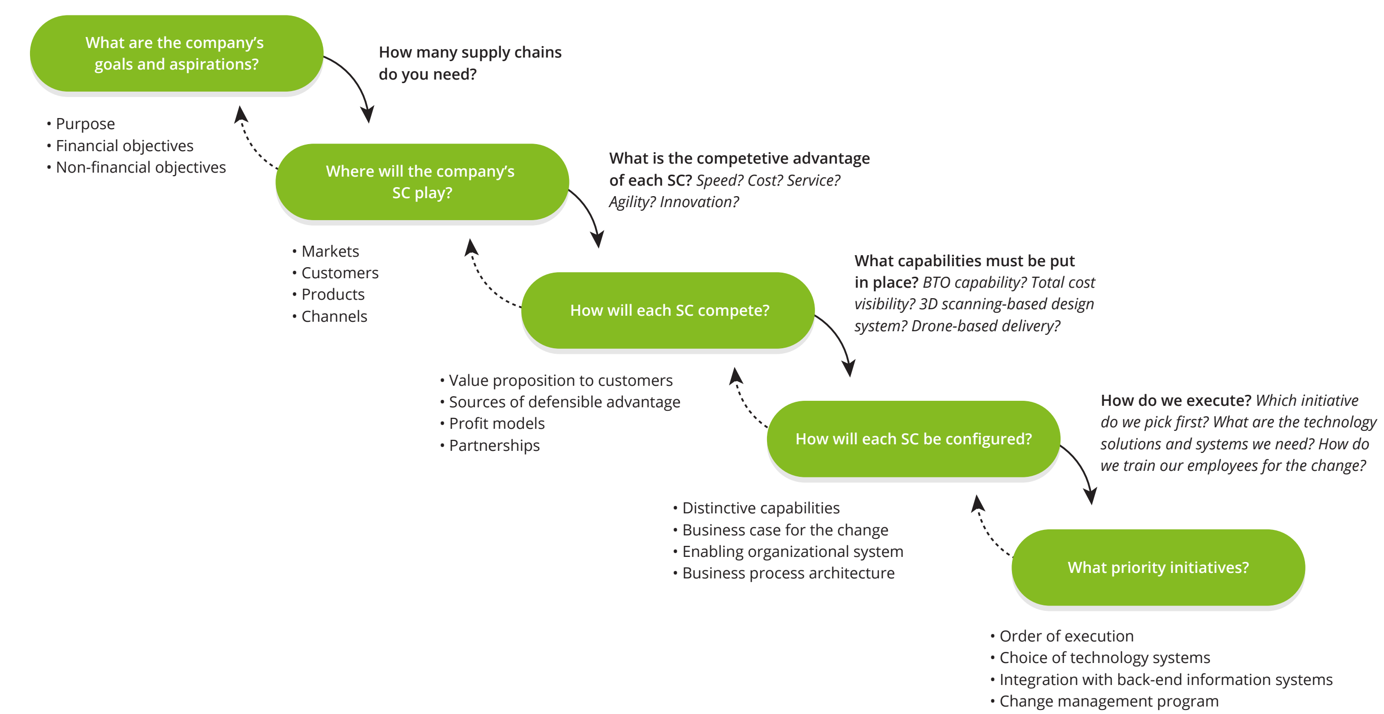
- Increasing efficiency
- Reducing error and return rates
- Improving safety in high-risk environments
- Collaborating with humans
- Faster delivery or product movement rates

Framework for decision making

The choice cascade

Successful adoption of 3D scanning technology is demonstrated by the impact it makes on the overall supply chain. For maximum impact, it is imperative that the adoption of 3D scanning aligns with the imminent technology needs of the supply chain. The technology needs of the supply chain are articulated in the supply chain strategy, which should be in lockstep with the overall corporate or business unit strategy. The choice of 3D scanning solution will depend on the bottleneck that is being addressed and will then necessitate a change to the associated processes, workforce, and technology systems.

Figure 3. The choice cascade



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Endnotes

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