SOFTEQ

51 Use Cases of Digital Transformation with IoT

E-book

Introduction

For your convenience, we've compiled 51 use cases of digital transformation with IoT in different industries. Each use case comes with a real-life example of how businesses put digital transformation into practice and the benefits they got.

If you're an operating company, you might find inside ideas on how to improve operations. If you're a startup looking for a new niche, you can get some inspiring insights for your future solution.

So, let's go!

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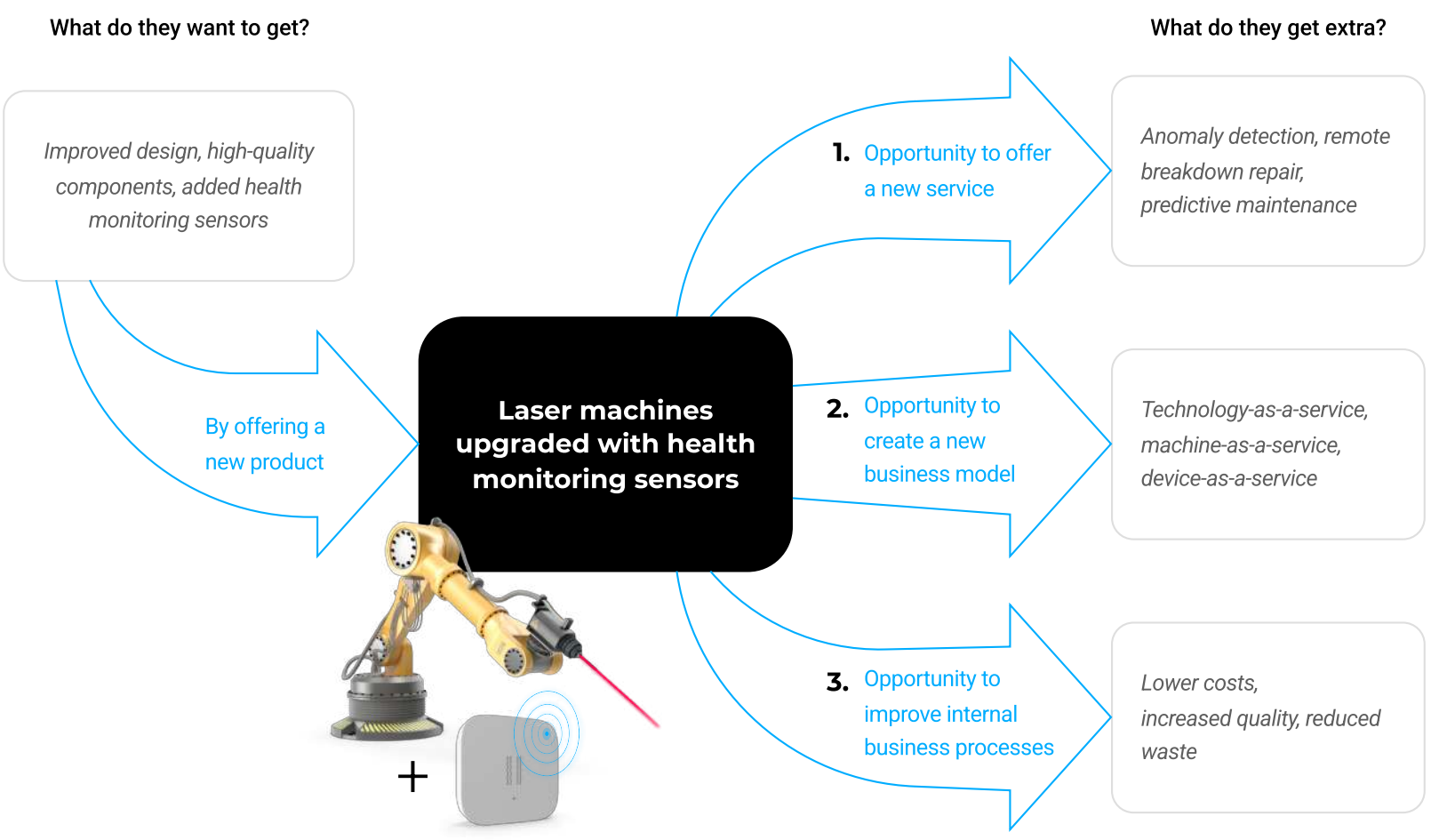
Businesses Can Make the Most of Digital Transformation in Several Ways

A machine manufacturer decided to upgrade their sensor-based laser machines. They improved design, replaced the components with high-quality ones, and added health-monitoring sensors. But, by entering digital transformation through a new product, the company got other opportunities. See the example below.

Digital transformation through just one area gives you additional opportunities

For example, a manufacturer decided to upgrade their sensor-based laser machines.

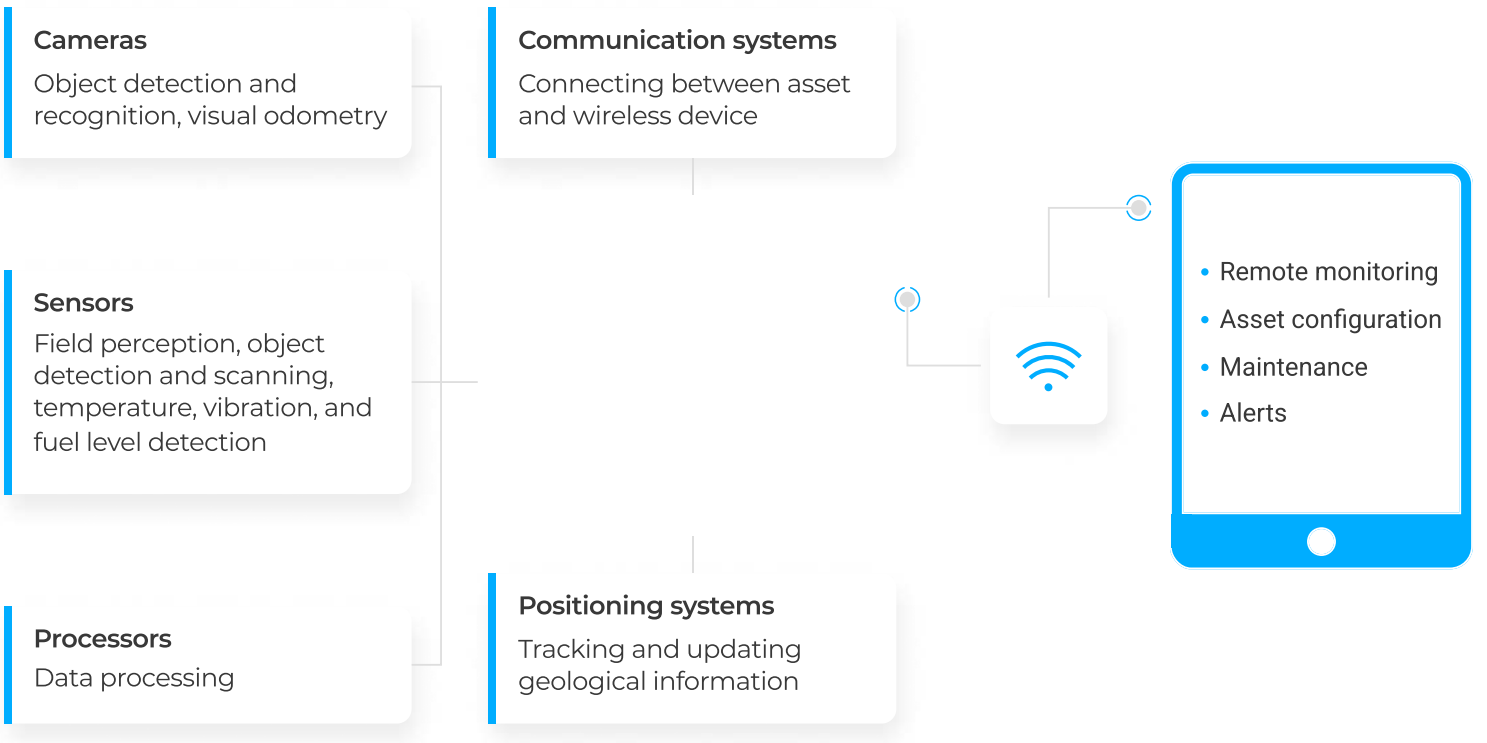


Digital Transformation in Different Industries

Construction

IoT and AI are game-changers for construction; they not only cure its most common pain points but also disrupt the industry. The technologies can enhance on-site safety, increase staff productivity, reduce delays, and even support environmental sustainability. Take a look at the most promising areas for deployment.

Today, a smart heavy machine may look like this:



Use Case 1: Asset Tracking

This allows construction companies to control their fleet of heavy machines at multiple sites. With IoT, you connect thousands of equipment pieces.

And thanks to GPS technology, your on-site and remote workers can track the location and performance of each asset in real time. Geofencing can show how often and for how long workers use machines. It's convenient to analyze wear and tear and plan repairs or calculate the rental cost. Additionally, a virtual map can present a vivid view of all construction assets. Planning reallocation of heavy equipment has never been so easy!

Protecting costly machines is another convincing reason to deploy IoT in the construction industry. Loaders, backhoes, tractors, bulldozers, and forklifts are the most appealing construction equipment for thieves in the US because of their high resale value. With IoT on board, it's possible to track the location of assets, get instant alerts if any are taken off-site, and even automatically shut down costly trucks when they leave the designated area.

> According to the National Insurance Crime Bureau (NICB), the annual cost of equipment theft ranges from $300 million to $1 billion.

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Real-Life Example: Monitoring Equipment in Real Time

Bouygues Construction Matériel implemented an IoT platform to monitor

heir equipment on more than a thousand sites. On a virtual map, their fleet managers view the location and tracking sheet of each piece of equipment in real time. The solution can also calculate performance indicators, equipment turnover, utilization rates, inventory by technical base and worksite, and the number of billable days.

Now, the company can identify unused equipment on worksites and mobilize it to avoid external rentals. The company also expects direct annual savings of 5% to 10% in maintenance and fleet management, as well as ROI within three years.

Main Benefits

- Ensuring more efficient and cost-saving use of assets with real-time data and the possibility of controlling utilization and profit
- Reducing man hours by automating the process of machine tracking
- Keeping equipment highly functional and safe
- Shortening construction time

Use Case 2: Safety Management

Hard hats, steel-toed boots, and safety glasses protected workers for decades. Today, IoT wearables are taking protection to the next level. Now,

you can have smart caps, smart vests, and smart eyewear. It's possible to go even further with on-site security and connect workers' wearables to construction equipment. Sensors ensure heavy trucks detect nearby users, while workers get instant alerts on approaching machines.

Real-Time Example: Restricting Access to Hazardous Areas

Plinx created a system that prevents workers from entering hazardous areas. It detects a worker's location via a helmet-mounted device. The system notifies the wearer when they are approaching the danger zone. Managers can also use the solution to set up a hazard zone around machinery. When someone enters it, the system alerts both the machine operator and pedestrian. In this way, companies can keep their workers safe and avoid insurance payments.

Main Benefits

- Keeping employees safe by reducing the number of accidents and hazards on site
- Preventing project delays
- Saving budget for insurance payments
- Avoiding reputational damage

Use Case 3: Predictive Maintenance

Deploying IoT for costly heavy trucks will let you see abnormalities before they cause failures. Sensors attached to heavy equipment can collect data about various parameters, like temperature, humidity, and vibrations. Dedicated applications can alert you to possible problems. When data from smart trucks is within reach, it also helps technicians control machinery wear and tear.

> Having enough time to carry out repairs and having some fixes on hand is more convenient.

Real-Life Example: Providing Predictive Maintenance for Heavy Machinery

Caterpillar is a well-known manufacturer of construction and mining equipment. They provide their clients with a solution that monitors machine health. It tracks machine parameters, sends real-time alerts, and predicts failures. When a suspicious trend shows up, Caterpillar sends technicians to the site. Now, Caterpillar’s clients can avoid costly shutdowns and extend the life of their machines.

Main Benefits

- Making more accurate predictions about the assets that are needed/available for upcoming projects
- Reducing operational costs associated with equipment that needs repairs
- Identifying performance issues before they cause downtime
- Enhancing risk management and preventing missed deadlines

Use Case 4: Survey Work

Survey work is an important part of almost any construction project. It enables companies to determine the project's feasibility, provide the basis for an accurate design, and locate project features.

Construction teams traditionally take the measurements manually, then they create an aerial view or 3D model of a worksite based on the collected data. This approach means construction teams often have to travel and take detours of huge distances. Depending on the site size, data collection can take days.

Drones do an excellent job at handling this task. They take hundreds of pictures as they fly over an area of land.

> What humans do in hours, drones do in minutes.

Real-Life Example: Accelerating Survey Work

Bogh Engineering is a family-owned construction and engineering firm from California. Their core capability is pouring concrete. They carry out site surveying before and after every major step.

They only have one survey engineer in their team. Using traditional topographic methods, the survey engineer had to spend two days on a construction site (per survey). Then it took another day to process data and perform a cut-and-fill analysis.

To speed up the work, the company started using a drone-based solution. The drone is able to survey a site in 30 minutes. Together with data processing and analysis, the whole job now takes just half a day at each site.

Main Benefits

- Fast measurement collection (4x faster at Bogh)
- Fast preparation of terrain analysis (3x faster at Bogh)

Use Case 5: Project Management

The site constantly changes as a construction project progresses. Keeping track of these changes with traditional methods is time-consuming. By the time the data is collected, it's already outdated. This makes project planning possible only by rough estimation.

That's why subcontractors tend to over or underestimate the amount of time they need, often resulting in missed deadlines or inefficient resource usage. Drones provide real-time information about every step of the construction project.

> Based on data, companies can optimize work plans to meet deadlines and avoid team and equipment downtime.

Real-Life Example: Avoiding Scheduling Inefficiencies

Grade Tech Services is a family-owned excavating and grading company. They have a small team and need to carefully plan where to send their people and equipment.

The company previously used ground-level progress photos and manual calculations for planning, meaning they often underestimated the amount of time needed to finish the work. At the same time, most superintendents wanted subcontractors to arrive earlier than required. This meant Grade Tech

had to send their crew and equipment to the site earlier than necessary, causing downtime that cost the company about $3.5k per day.

Now, Grade Tech uses a drone to capture the condition of the site. As a result, they only send their team down when they're sure the project is ready for them. They also use drones to measure stockpiles and cut and fill with greater accuracy than ever before. This helps them avoid exporting material off-site, which results in $10-20k savings from just one calculation.

Main Benefits

- Avoided downtime ($3.5k savings each day at Grade Tech)
- Precise calculation of cut and fill ($10-20k savings from one calculation at Grade Tech)

Energy

Energy management using IoT can empower plant growth and rooftop solar power plants. Smart systems reveal usage trends, prevent downtimes and interrupted supply, and help optimize pricing. They bring a number of benefits for companies in the energy sector—both for grid operators and asset owners. Find proven application areas of energy management using IoT below.

Use Case 1: Smart Metering

During the last 30 years, the average electricity bill has nearly doubled. Decreasing energy consumption can reduce spend, and IoT is here to help make energy management more effective.

Consider smart meters that replace analog solutions for tracking electricity. These consumer-facing devices track energy consumption and send this data to utility companies. It's also possible to connect individual smart meters to a network—a smart energy grid.

Real-Life Example: Tracking Electricity Usage

Sense, a smart home energy monitor, is an example of a device tracking household electricity usage in real time. It can tell how much energy each in-home device uses—from bathroom lights to the water heater and garage door—and identifies spenders. What's more, the device can send alerts if an iron is left on or a refrigerator is off.

Main Benefits

- Revealing usage trends and peak times
- Forecasting demand for electricity
- Optimizing distribution and pricing

Use Case 2: Smart HVAC Control

Heating, ventilation, and air-conditioning (HVAC) use an enormous amount of energy in residential and commercial buildings. They're responsible for up to 60% of the total power consumption. With IoT on board, it's easy to regulate the level of energy consumption in real time.

> A smart energy system allows you to watch and manage temperature, lighting, and humidity.

You can build a multi-zone variable air volume (VAV) system to track each air-conditioning area separately. IoT-powered HVAC systems also make it possible to detect issues and find their root causes.

Real-Life Example: Managing Tenant Complaints

California's county San Bernardino covers more than 20,000 square miles. For the county's facilities management staff, this used to mean a lot of work. They had to spend hours daily managing tenant complaints. And just to diagnose the issue, they needed to drive about an hour and a half in one direction.

The county decided to make a technological upgrade. They replaced outdated controllers in the building units. Then, they combined HVAC, safety, lighting, water, and power systems from different manufacturers into a

single system with web access. Now, facility managers can identify problems remotely. They receive email alerts 24/7 and adjust the system over the network instead of on-site.

In the first two years alone, the county has managed to save $222,120 and has improved customer service.

Main Benefits

- Cutting electricity bills for residents and companies
- Distributing areas of energy consumption and monitoring them separately
- Providing better conditions for residents
- Keeping equipment highly functional
- Addressing performance issues and preventing equipment downtime
- Helping governments reduce carbon emissions

Use Case 3: Energy System Monitoring and Maintenance

It’s cheaper to predict problems with energy systems than deal with the consequences. Moreover, it may be quite hazardous to go in person to detect issues across energy equipment. Opt for IoT development and you’ll

be able to check many system metrics remotely in real time. These include performance, operating efficiency, and the wear and tear of equipment. The monitoring of energy systems simplifies maintenance and increases the productivity of energy flow. AI in the pipeline helps predict possible failures.

> Energy companies can use sensor data to schedule and optimize maintenance services and thereby reduce the risk of downtime.

An example is a tandem with digital twin technology that helps reduce high repair costs. Sensors attached to physical units can feed performance data to virtual replicas of equipment units—digital twins. Thus, the technology enables remote support and virtual bug fixing.

Real-Life Example: Detecting Anomalies

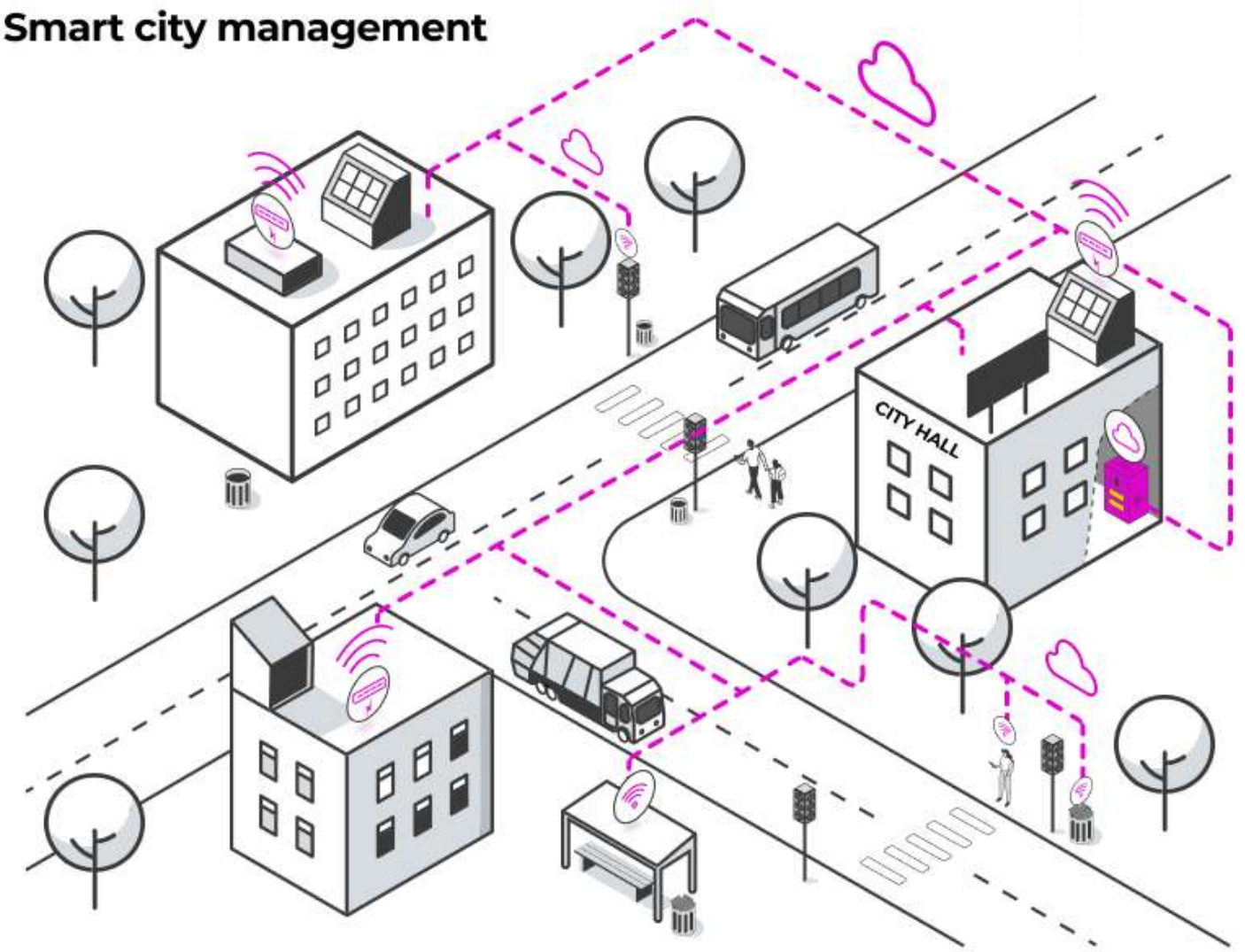
Heimdall Power offers sensor-based devices that are installed directly on the live wire. The sensors collect data on power flow, line inclination, vibration, wire temperature, and snow load. Then, this data is analyzed in the cloud with AI algorithms to provide insights to the engineers. As a result, utilities can reallocate broken lines and increase grid capacity by 25%.

Main Benefits

- Watching crucial metrics like performance and wear and tear remotely in real time
- Cutting costs for maintenance and repairs
- Avoiding supply chain interruptions
- Detecting supply issues and responding to them immediately

Smart City

IoT and AI solutions help city managers control various city functions. These include energy distribution, water management, air quality, security, and mobility. Such solutions can function separately or connect with each other, creating complex ecosystems. Through this, municipal authorities can arrange and manage assets and services more efficiently. Let’s look at how this can be applied in the real world.



Municipal governments manage and analyze city traffic, energy distribution, and waste collection

Use Case 1: Smart Transportation

With smart city technology, transport companies can provide convenient and fast public transportation. IoT systems help analyze fill rates, optimize routes, and ensure immediate reactions to incidents. Even a slight change in schedules can improve traffic rates and reduce CO2 emissions. There are many solutions to improve city travel:

- Smart traffic signal control systems
- Speed cameras

- Intelligent public transport systems
- Smart payment systems
- Electric carsharing
- Smart parking solutions

All these help local authorities manage city resources both smartly and wisely.

Real-Life Example: Managing Transportation

Big cities around the globe lead the deployment of smart transportation systems. New York installs cameras and sensors at city intersections. Berlin integrates e-carsharing and builds new charging stations. Seoul adds sensors around the city to reduce traffic, invests in connected vehicles, and builds 5G infrastructure.

Main Benefits

- Reducing accidents
- Eliminating traffic jams
- Cleaner air in the city
- Reducing energy consumption

Use Case 2: Smart Waste Management

Technologies can boost the operational efficiency of city managers. Sensors on containers can watch trash levels and detect overflows, fires, and illegal interference. ML algorithms can help make predictions on waste pick-ups, waste collector workload, and the spread of bins across the city.

> Energy companies can use sensor data to schedule and optimize maintenance services and thereby reduce the risk of downtime.

Real-Life Example: Smarter Recycling

Most American cities collect waste the same way they did 50 years ago. But San Francisco, the American king of recycling, proves cities can do better. The city saw a profit when technology was added to its recycling and composting programs. Smart container-line robots clean up and recover plastic after optical sorters. Optical sorters can't differentiate between thermoform and bottle PET, but robots can, which increases recycling rates as a result.

Main Benefits

- Decreasing the frequency of trash collection

- Cutting costs on ineffective waste management
- Reducing CO2 emissions and traffic congestion

Use Case 3: Smart Water Management

City administrators need to keep a close eye on water supply, consumption, and equipment. With IoT, the whole water supply chain can become more transparent and easier to control.

With the help of sensors, a smart city water management system can enable you to collect real-time data—information that helps you visualize water distribution across the network.

> Residents with smart meters can make more informed decisions as a result, leading to a more sustainable city overall.

Water waste and disrupted water supply chains are a drain on the city's budget. IoT can help you watch the health of water equipment and detect problems like leaks in pipes. This allows operators to receive alerts and start fixing issues immediately. In the meantime, AI predictions allow you to nip problems in the bud by preventing failures before they cause severe incidents. With AI, city administrators can also watch the watershed and predict which areas are likely to flood, information that will help local

authorities warn residents, manage traffic, and keep the city on its feet.

Real-World Example: Irrigating City Parks In A Smart Way

Cartagena, a city in Columbia, has smart irrigation in its municipal parks and gardens. The solution calculates the amount of water each area needs depending on the state of the soil, weather forecast, and irrigation calendar. If something goes wrong, such as a leak, the authorities are alerted right away and they're even shown the location.

Main Benefits

- Enabling better transparency in water management
- Minimizing incidents
- Enhancing control over the water supply
- Saving city budget
- Making the city more sustainable

Use Case 4: Water Quality

Watching the quality of water that comes into our houses is crucial. Rivers, lakes, and reservoirs may contain contaminants that are dangerous to us, and the increasing world population combined with urbanization has also

worsened water quality. In our changing world, IoT can help monitor and analyze distributed water and ensure it complies with regulatory standards.

> A water quality management system using IoT can deal with quality issues effectively.

You only need to consider a simple comparison to appreciate the difference: Without IoT, water samples need to be collected and analyzed manually. This process is costly and time-consuming because it requires large equipment and an expensive workforce. In contrast, IoT sensors can measure a variety of parameters like temperature and turbidity. Operators receive regular data from multiple samples, enabling them to remotely perform quality control on water reserves.

Real-Life Example: Watching the Quality of River Water

A solution from Ericsson and AT&T monitors water quality in the city of Atlanta, Georgia, where four million citizens get drinking water from the Chattahoochee River. IoT helps authorities check the quality of water, while sensors measure its conductivity, turbidity, temperature, and thermometry.

Main Benefits

- Increasing water quality
- Saving budget on the manual analysis of water samples
- Reducing the workforce required
- Enabling remote quality control
- Complying with regulatory requirements

Use Case 5: Dam Management

Dams bring water to livestock and irrigation and supply many industries. They also play a pivotal role in flood control and can assist river navigation, so it’s crucial that dams and reservoirs function properly and their water levels are safe. The trouble is that traditional monitoring methods are time-consuming and complex.

> A water quality management system using IoT can deal with quality issues effectively.

With pressure sensors, in particular, you can detect leaks in pipes and receive instant alerts. Predictive technologies ensure dam operators get

early warnings and are able to keep watch over water availability in each reservoir. This may be particularly helpful for irrigation.

Real-Life Example: Monitoring Dams

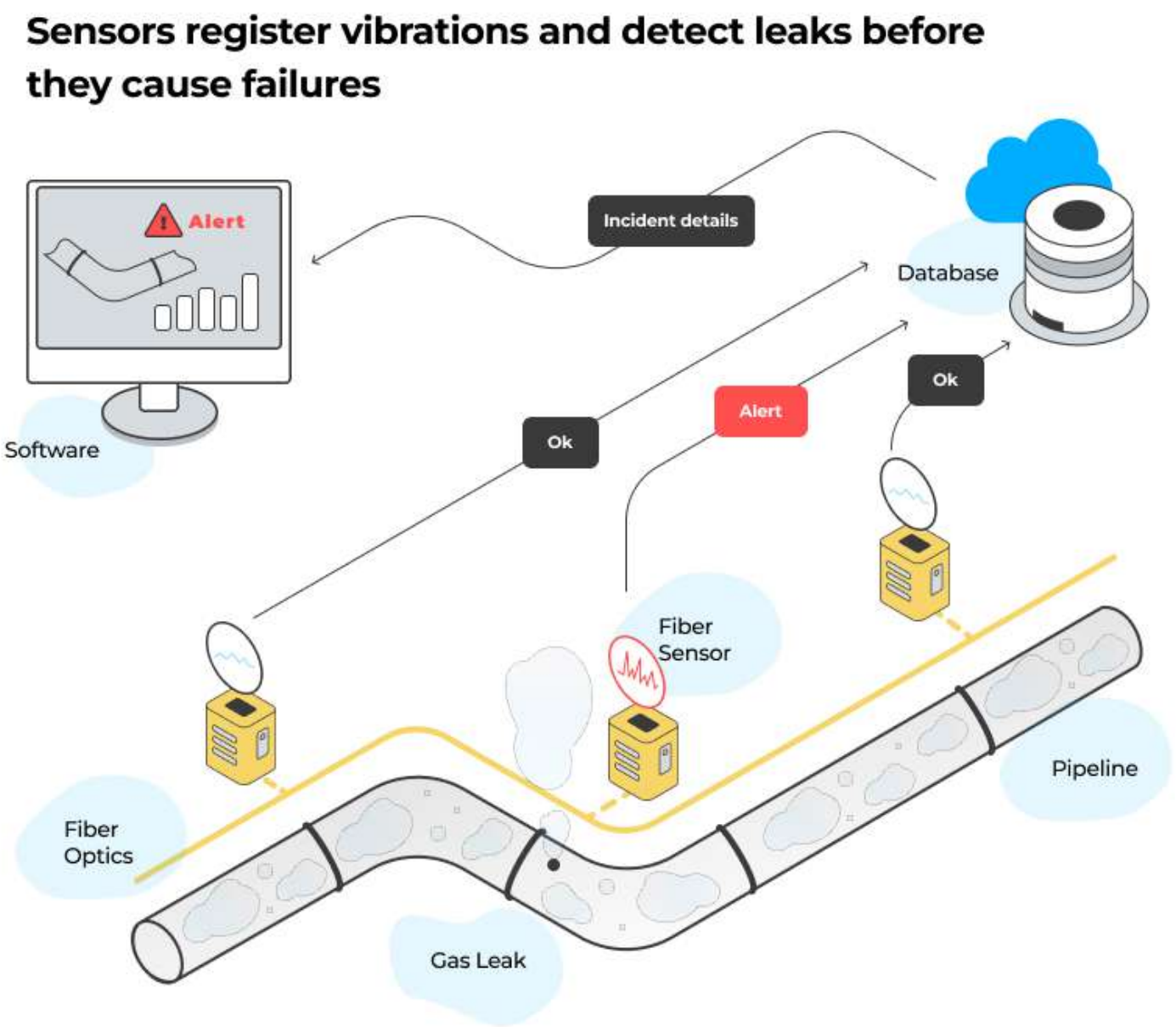
A ThingsLog level monitoring solution helps dam owners in Bulgaria to manage more than 100 dams in the region. IoT sensors remotely watch water levels at each dam site. The system sends instant alerts if flooding is possible. With smart capabilities, there's no need to send staff to measure water levels on site. The system even has pre-programmed formulas that replace manual calculations.

Main Benefits

- Improving dam functionality
- Enhancing dam reliability
- Enabling faster decision-making
- Saving time and resources
- Enabling remote control with no human involvement

Oil and Gas

IoT technology is a business change accelerator for oil and gas companies. They can benefit from an IoT solution, whether they're upstream, midstream, or downstream. There are many areas to watch, like containers, drilling equipment, pipelines, trucks, and tanks. And there are lots of things to predict, like failures, downtimes, and market demand. Let's take a look at promising IoT applications in the oil and gas industry.



Use Case 1: Enhanced Performance

With IoT in oil and gas, it’s possible to collect sensor data from containers, drilling equipment, pipelines, and trucks. This can be the product level in tanks, equipment health, or historical data about time spent on transfer to the refinery.

> Smart predictions in the pipeline give you hints about how to increase efficiency, meaning you can maximize earnings.

Real-Time Example: Restricting Access to Hazardous Areas

Siemens Energy and Bentley Systems created a joint solution for oil and gas. It uses predictive analytics to track assets and improve maintenance schedules in compressor stations and gas processing plants. The tool runs powerful tests and risk scenarios to enhance plant uptime.

Main Benefits

- Getting accurate and real-time information on product levels in containers and tanks so companies can plan refills or the replacement of parts
- Producing oil and gas materials more effectively

- Getting accurate and real-time information on product levels in containers and tanks so companies can plan refills or the replacement of parts
- Producing oil and gas materials more effectively
- Watching equipment components and keeping them highly functional

Use Case 2: Remote Monitoring

IoT systems can replace human workers where remote monitoring is possible, enabling you to watch pipelines, oil wells, or production in refineries remotely. At a basic level, sensors collect data, algorithms analyze it, and systems notify you of what's happening. Now, there are even more sophisticated alternatives available.

> Consider monitoring with digital twins—virtual replicas of equipment units.

It's possible to attach sensors to physical objects in the field and send performance data to virtual copies. Upstream companies can drill down virtually and keep track of project updates. A 3D look-around shows bottlenecks and issues. You can also compare real-time outputs with

historical data to see how grid upgrades have affected performance. The digital twin technology can even enable virtual bug fixing.

Where sensors can't help, drones come in handy. They can check equipment conditions by capturing photos and videos. Software with ML capabilities processes the collected visuals to detect abnormal behavior. Such monitoring helps smart oil and gas companies reduce operational costs. There's also no need to send employees to hazardous areas.

Real-Life Example: Inspecting Oil Rigs with Drones

A solution from Sky-Futures helps oil and gas companies inspect oil rigs with drones. Dedicated software uses smart algorithms to process visual data. ML capabilities, in turn, identify equipment faults in 2D images.

Main Benefits

- Increasing the speed and quality of oil and gas production
- Watching processes in real time
- Improving maintenance services through optimized parameters and forecasted issues

Use Case 3: Predictive Maintenance

Deploying IoT for costly equipment will let you see abnormalities before they cause failures in vacuum pumps or shaft bearings. IoT enables you to attach sensors to rigs, tanks, and pipelines and collect data on their parameters. If a problem occurs, a dedicated app will send an alert. Technicians can also control the wear and tear of each piece of equipment. This makes it easier to provide timely repairs and avoid catastrophes.

> In terms of sustainability, alerts will prevent hazardous waste from leaking.

Real-Life Example: Using Machine Learning for Predictions

Uptake created an ML-assisted application to predict what will happen in the field. The solution collects and analyzes the health status of each asset and detects signatures that communicate potential issues.

Main Benefits

- Keeping equipment highly functional to maximize uptime
- Predicting rig failures or downtimes to avoid shortages and costly repairs

- Deploying automatic shutdowns to prevent more serious issues
- Boosting production

Use Case 4: Safety Management

IoT solutions for the oil and gas industry help create a healthier working environment. To comply with industry safety regulations, you may need to:

- Watch working conditions
- Track emission levels at production sites
- Check offshore rigs for anomalies

There are plenty of working solutions here. Consider GPS systems, hazard-reporting apps, and even drone inspections. Some companies are also advancing protection with wearables, including smart wristbands, smart vests, helmets, or AR glasses. These wearables keep workers safe while monitoring conditions and the surrounding environment, warning of emergencies. Sensors can also notify a manager that a worker is showing signs of distress or fatigue.

Real-Life Example: Enablement with Wearables

Blackline protects staff with wearables. An individual device equipped with

two-way communication tracks the location of each worker, watches for possible gas exposure, and shows hazardous areas. Team members can receive notifications and send voice messages.

Main Benefits

- Keeping employees safe and reducing the number of accidents and hazards in the field
- Avoiding project delays
- Saving budget for insurance payments
- Preventing reputational damage

Mining

Improving operational safety is the primary aim for the mining sector. And digital technologies have proved viable here. Discover use cases of how mining companies can transform their operations and make them safer with AI and IoT.

Use Case 1: Protecting Worker and Equipment Health

Coal dust inhalation is one of the most common concerns for miners. The ongoing inhalation of coal dust can cause “miner’s black lung”. Its

symptoms include shortness of breath and scarring of lung tissue. Dust is also harmful to the gears of machines.

To protect workers and mining machinery from dust pollution, companies can implement IoT dust control systems. They consist of real-time monitoring sensors, data APIs, and analytics platforms. Data on the generated dust is monitored and analyzed in real time. Then, the analytical engine provides service engineers with unique insights into the dust level in the selected areas.

> This helps engineers make informed decisions on how to reduce the dust level to make mining operations safer.

Workers also face the risk of methane and carbon monoxide poisoning. To prevent this, technology providers have introduced gas detection, airflow, and ventilation monitoring sensors. These sensors monitor the levels of toxic and flammable gas in an environment. If a gas leak or explosion occurs, alerts are sent to workers. Sensors also ensure that airflow and ventilation are kept to optimal levels.

Real-Life Example: Controlling Coal Mine Dust Levels

Dust Master System (DMS)—the solution from the Canadian company ABCDust—watches and suppresses dust levels during the mining process.

This IoT system is a set of suppressive additives, vehicles, and sensors. A special vehicle diffuses these additives in the mines. Sensors monitor and control the whole process in real time. The system also includes an integrated management solution that is used for the continuous tracking and optimization of dust suppression.

Main Benefits

- Up to 99% dust suppression
- Enabling water savings of 90%
- Reducing CO2 emissions
- Enabling safety at mining sites
- Preventing health hazards to personnel
- Cleaner operations

Use Case 2: Accident Management

From mine cave-ins to gas explosions and extreme temperatures, mining accidents are extremely dangerous. However, they are manageable. Here is where AI and IoT for worker safety come to the rescue.

> Companies may leverage AI algorithms and IoT-based suites consisting of sensors, alarms, and mobile and web applications.

Sensors monitor and detect any hazardous issue, and alarms immediately warn about casualties. Data is analyzed in real-time and translated into easy navigation recommendations. All this is displayed in an application in the form of guidance.

Using real-time data and analytics, AI in the mining industry can predict process failures. With AI, mining companies know where to deploy autonomous machines instead of staff. It’s all thanks to the technology’s data-driven decision-making capabilities.

Real-Life Example: Replacing Humans in Risky Places

To enhance mine safety by optimizing supervisory efficiency, Huawei designed the AI-powered Mine Brain solution. The system’s main purpose is to replace humans where there are dangerous conditions.

Thanks to the trained AI algorithms, Mine Brain detects any potential danger. Computer vision identifies unsafe scenarios and sends them to the central system. Then, the system generates safety recommendations for where humans should be replaced. One Mongolian coal mine already uses Huawei’s solution. They apply it to reduce the number of people needed in the shafts and maintain safety records.

Main Benefits

- Enhancing the safety of its workers by replacing them with equipment
- Halving the number of injuries
- Drawing up safety programs and safety assessment plans

Use Case 3: Monitoring Staff Wellbeing

IoT and AI in mining have also brought positive change to personal health management. Miners are at constant risk of drowsiness and fatigue-related injuries, heat and humidity stress, and other health dangers.

To monitor workers underground, vendors offer various smart devices, like watches, helmets, vests, and caps. These devices provide real-time information about major biometrics and notify of any deviation.

> This may help save lives and considerably reduce work-related injuries and costs.

Real-life Example: Tackling Driver Drowsiness

An Australian-British mining company, BHP, has recently implemented AI-

powered smart caps in their copper mines in Chile. Fatigue and drowsiness have been leading causes of accidents there, so BHP decided to eliminate the issue.

The caps measure driver fatigue by analyzing brain waves. Inside the cap, there is a sensor strip that measures brain waves and detects patterns that show signs of fatigue. The sensor talks to a unit in the truck's cabin. If it detects fatigue, it notifies drivers and safety supervisors.

Main Benefits

- Reducing the number of costly and dangerous accidents by 70%
- Achieving better safety, health, and productivity outcomes at the mine
- Providing workers with specialized treatment for associated sleep disorders

Use Case 4: Compliance With Safety Rules

Unfortunately, miners often fail to follow basic safety rules. This may involve a lack of awareness or even deliberate violations. Unsafe actions may cost lives, but smart technologies step in to prevent this.

> For example, the use of IoT and AI platforms helps detect whether workers are wearing their personal protective equipment (PPE).

AI-enabled cameras monitor miners working at height. They must wear safety wires and harnesses. Not only do the sensors detect if the workers are wearing their PPE, but they can also establish whether the PPE is fixed and tethered.

Real-Life Example: Tracking Miners for Wearing PPE

A US company, Guardhat, uses IoT-powered helmets to collect data on worker activity. The helmets also track location, pulse, body temperature, and work environment. Each hard cap sends data to a safety control center for monitoring, analysis, and quick response.

The helmets combine cameras, sensors, and microphones used for data collection. Sensors monitor workers and detect how and where they operate. They also determine whether miners are safe to do work there. For example, they detect whether or not a worker is wearing appropriate safety kits for work off the ground. If they are unequipped, the system stops the worker from doing their job. In the event of a fall, exposure to toxic gasses, or proximity to moving equipment, the system alerts safety supervisors.

Main Benefits

- Improving safety management
- Reducing workplace injuries by 20%
- Gaining a deeper understanding of the workplace situation

Industrial Waste Management

The global industrial sector produces 7.6 billion tons of waste annually. The task of disposing of such volumes is often expensive, unsafe, and difficult. Annually, it costs about $9 trillion to recycle industrial waste. But failing to manage it effectively may result in environmental damage, fines, and financial losses.

IoT solutions make waste collection and recycling much more efficient. They can optimize and automate the waste management process. For businesses, this means less trash produced and less money spent. Let’s consider how smart waste management works in different sectors.

Use Case 1: Smart Waste Management in Transportation

Waste in the transport industry is generated by freight fleets and their maintenance. Much of this waste is toxic. Handling this waste in compliance with environmental regulations is a must, but it’s better to avoid it in the first

place to cut expensive disposal costs. Warehousing activities also generate paper, pallets, and packaging materials which are much easier to reuse or recycle. But many companies still don’t.

> Those who fail to manage their waste face legal liability and financial and reputational losses.

To reduce the amount of packaging waste they create, companies can install connected IP video cameras on waste dump sites. These cameras can watch waste inflow and inform staff for proactive decision-making. Businesses can also deploy sensors to check the state of waste management equipment. Based on the information, they can predict and schedule equipment maintenance.

Real-Life Example: Scheduling Equipment Maintenance

Waste Management, Inc. is a Texas-based waste management company. They create novel environmental solutions. The company not only helps businesses manage their waste, but it also makes it less harmful to the environment. For instance, one of their customers from Arizona deployed smart sensors across its fleet. The sensors transmit maintenance and operating data to a central software platform. Using the platform, managers schedule maintenance activities. This results in reduced amounts of waste and costly downtime for the company.

Main Benefits

- Reducing risk in the workplace
- Minimizing carbon footprint
- Cutting storage and disposal costs

Use Case 2: Smart Waste Management in the Food Industry

Around 1.3 billion tons of food is wasted each year during food production and sales. This amounts to one-third of all food produced for consumption. When poorly handled, food waste finds its way into local landfills with costly pick-up routes.

> For businesses, this means inefficient use of budget, landfill taxes, and fees.

To avoid these issues, companies can utilize IoT suites combining smart sensors, apps, GPS systems, and user portals. This helps streamline waste storage and collection processes. Sensors notify the management system when the container reaches a predetermined capacity, so organizations can schedule their pick-ups more efficiently and optimize routes.

Composting can also reduce waste service bills and methane emissions. As

most food waste can be composted, companies may track the level of decay in their organic waste dumpsters using pH sensors.

Real-Life Example: Tracking Recycling Activities

Enevo created an IoT suite to measure, analyze, and manage waste. Their sensor technology for containers works with analytics software. It manages containers and fleets and it also plans collection routes. By using this solution, food companies across the US and Europe admit they have managed to reduce their waste-related operational costs and increase sustainability.

> For example, in 2018, the company helped McDonald's decrease their costs by 12% and track a 50% increase in recycling diversion.

Enevo installed sensors in the restaurant's bins at all seven locations across Nottingham in the UK to track recycling diversion and reduce waste inefficiencies. Now, McDonald's is able to track their recycling rates and better understand what happens to waste when it leaves their restaurants.

Main Benefits

- Optimizing truck journeys

- Lowering carbon emissions
- Saving money
- Improving public image

Use Case 3: Smart Waste Management in Agriculture

About 998 million tons of agricultural waste is produced yearly. That's because almost all agricultural activities, from planting to bagging, generate byproducts. Agro-waste consists of animal waste, food waste, crop waste, and hazardous agricultural waste. The biggest concern with agricultural waste is the pollution of groundwaters with pesticides. Waste produced by transporters, millers, and baggers contributes to the problem.

IoT plays a crucial role in addressing these issues. The technology helps reduce waste generation and promote proper waste disposal on farms. Additionally, by leveraging drones, companies can check soil nutrient levels and find out how much or how little fertilizer is needed to support plant growth. IoT also helps track all stages of the growing cycle to apply the right amount of fertilizer at the right stage. This results in less run-off.

Farming bins, equipped with sensors and actuators, automate human-led processes. The technology measures the fill levels in bins and containers several times a day. The data is then processed in the cloud, and farmers get data on the bins' fill states. With this information in mind, they can then

decide whether to empty the bins. This helps them optimize waste collection routes, vehicle loads, and bin distribution.

> The result is at least a 30% reduction in waste collection costs and up to a 60% reduction in carbon emissions.

Real-Life Example: Planning Routes in a Smart Way

A US-based farming company, Northerly Farms, uses smart technology to grow grains. To support their sustainability mission, Northerly utilizes tech for recycling and combating waste. Above all, the company focuses on managing fertilizer byproducts, pesticides, and herbicides. Drones monitor pesticides accumulated in the soil. They also help check the soil's nutrient levels. With that data, Northerly always knows exactly how to enrich the soil. The company managed to reduce waste, maximize field productivity and resource utilization, and make a profit with IoT.

Main Benefits

- Becoming more efficient
- Becoming greener and more sustainable
- Cutting costs

- Refining recycling

Use Case 4: Smart Waste Management in the Energy Industry

Energy businesses are leveraging IoT to minimize their impact on the environment and reduce operational costs. As the sector shifts from fossil-based energy production to renewable sources, its waste changes too. Waste from the use of renewable sources includes steel, paper, copper, glass, and others.

> Many of these materials can be recycled and reused, and IoT is a great helper here.

Ultrasonic sensors installed on sorting lines help distinguish between recyclable and non-recyclable materials. This helps engineers reintroduce some materials into the production cycle.

Real-Life Example: Automating Sorting

A Greek energy company, Protergia, utilizes sensor-based recycling solutions to sort their waste. The company separates valuable resources from waste streams. Sensors recognize the target material through typical material characteristics. This allows Protergia to combat the worsening resource

crisis by sorting their run-offs. The company reports it optimized resource recovery, minimized waste, and saved costs.

Main Benefits

- Managing waste sorting
- Decreasing carbon footprint
- Creating a cleaner and safer working environment
- Sorting waste with 99% accuracy
- Optimizing waste collection and management processes
- Reducing collection cost

Retail

IoT in retail and e-commerce is becoming mainstream due to the endless improvements it offers the industry. The technology helps investigate customer behavior, create new business models, and optimize productivity. Here are some of the most promising examples of how IoT is being used in the industry.

Use Case 1: Predictive Equipment Maintenance

Predictive maintenance allows for managing energy, predicting equipment failure, and detecting other issues. For example, think of a grocery store tooled up with complex equipment and data-generating sensors. With this data, store engineers can predict maintenance issues that affect power consumption. They can also monitor temperature fluctuations to ensure food safety.

Real-Life Example: Maintaining Refrigeration Systems

The Danfoss Group is a manufacturer of refrigeration systems. The group developed a solution that helps their food retail customers reduce their maintenance efforts. The system uses AI to identify issues like compressor failure or coil icing, and provides technicians with guidance to fix them. Using the software, food retailers can reduce their energy bills and prevent unplanned refrigerator downtime.

Main Benefits

- Ensuring appropriate storage
- Avoiding costly repairs down the line
- Eliminating downtime

Use Case 2: Smart Transportation and Vehicles

Retail companies can equip their freight vehicles with IoT-connected sensors, GPS trackers, or radio frequency identification (RFID) tags. IoT helps track an item's location and monitor its state and environmental conditions. With IoT, managers can understand how close a pallet of merchandise is to a given store.

> This means that goods on their way from suppliers to warehouses or from warehouses to end-users become visible in real time.

Retailers can also turn to smart routing solutions to reduce costs and fuel consumption. They use AI algorithms to analyze data, like local traffic, weather, and gate codes. These solutions then propose a route with minimal mileage and time spent on the road.

Real-Life Example: Optimizing Routes

The farm-to-table supplier of chicken products, George's, serves 250 fast-food restaurants. On one delivery day, each truck makes about 35 stops. Planning these routes manually was a mind-blowing task for George's employees, so the company decided to use AI. As a result, they managed to reduce their fleet size by 10% and save $31k per year in fuel costs. This became especially important in the context of rising diesel prices.

Main Benefits

- Managing logistics effectively
- Keeping supply chain management seamless
- Eliminating issues with missing shipments while optimizing vehicle routes
- Making self-driving delivery vehicles a reality

Use Case 3: Optimized Inventory

Retailers always run the risk of being out of stock on popular items and overstocked on the products that sell less. In this case, a retailer will constantly lose out on sales of a popular item, tying up revenue in unsold inventory. Today's risks make it even more difficult to choose whether to save money on expensive storage or purchase and store more stock.

> Operational tasks like these take up to 80% of retailers' time.

They have to track inventory, calculate ideal stock levels, and replenish inventory in advance. They also need to consider external risks, which have become more frequent over the past few years. This may be a daunting task for humans, but smart supply chain solutions with AI are perfectly capable.

Real-Life Example: Finding the Perfect Replenishing Strategy

The US startup, Flieber, developed a platform for e-commerce retailers. It uses advanced data analytics and machine learning to predict sales and determine an ideal inventory level. The system also tells retailers when to replenish so that new inventory arrives before they become out of stock.

For example, the system determines how certain items are sold. Then, it alerts the retailer, telling them to place an order for new inventory by a certain date so that they can sell it several months from that date. If a retailer launches a new product, the system can predict how well it will sell.

As a result, companies can reduce excess inventory (which hurts sales) and stock enough strategic products on time.

Main Benefits

- Optimized replenishment
- More time for retailers to focus on core tasks instead of operational tasks

Use Case 4: Smart Shelves

Smart shelf systems are equipped with RFID tags, readers, and antennas. As a consumer walks around the shop with a digital shopping list, their

smartphone will vibrate if a product they need is on the smart shelf nearby. Additionally, when a smart shelf starts running low, it can light up to attract the attention of merchandisers—humans or robots. Smart shelves also share real-time customer-related insights with a store manager.

Real-Life Example: Monitoring Customer Behavior

Adastra developed an IoT-based device to monitor the product load on each shelf. The shelf knows when a buyer picks up a product, and displays this information on a dashboard. The solution provides retailers with insights into customer behavior. It also notifies retailers about stock replenishment and merchandising.

Main Benefits

- Streamlining inventory management and eliminating manual errors
- Preventing overstocking and shortages
- Ensuring orders and proper placement of each item
- Detecting potential theft

Use Case 5: Smart Stores

Equipped with sensors, video, and Wi-Fi points, smart stores help determine

the best physical store layout. They also analyze store traffic, understand if goods meet customer needs, and automate checkouts.

Real-Life Example: Shopping Checkout-Free

Camden Food Express, a store at John F. Kennedy International Airport, uses checkout-free technology. It combines inputs from overhead cameras with product tracking. When shoppers pass through the turnstile, they tap their credit card to the terminal, and the solution keeps track of their selected items. When they leave, their credit card will be charged for the chosen products. In this way, the shop eliminated queues and improved customer experience.

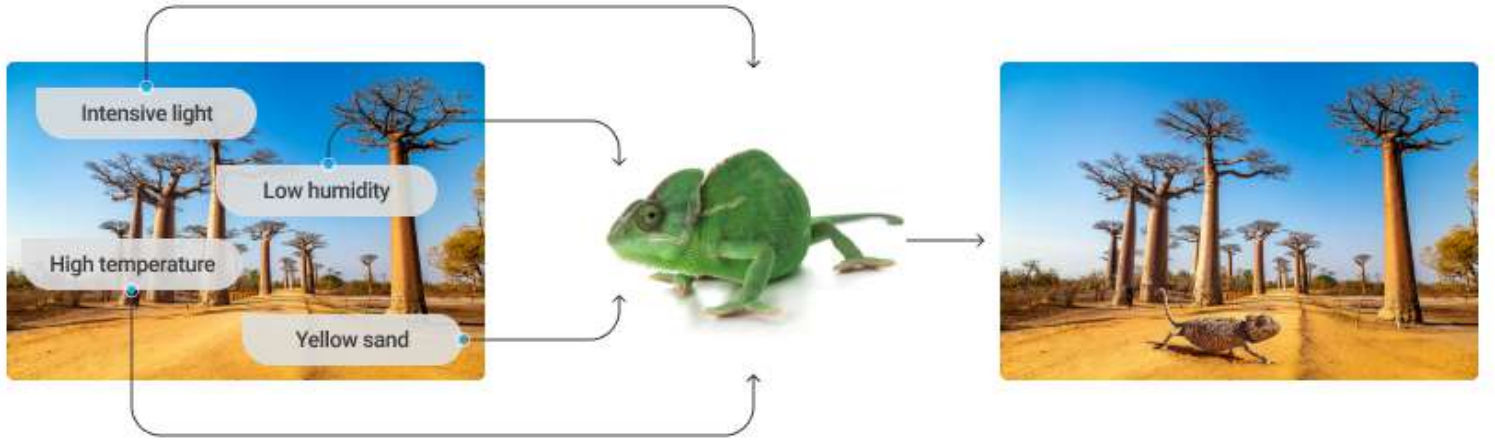
Main Benefits

- Understanding customer behavior to create efficient merchandising strategies
- Offering unique selling propositions that differentiate them in the eyes of their customers
- Establishing a long-term relationship with the customer and developing loyalty

HVAC (Heating, Ventilation, and Air Conditioning)

Smart HVAC is among the key components of a building automation system (BAS) as it makes an interior space comfortable. Such systems can adapt themselves to changing conditions. When any parameter changes, like weather, occupancy, or energy consumption, the HVAC control regulates itself right away. Here's how IoT and AI can improve efficiency in commercial buildings.

A BAS is like a chameleon's skin cells: it makes a building efficient and comfortable based on the environmental conditions



Use Case 1: Automated HVAC System Management

A smart HVAC system is able to adapt itself to changing circumstances. An AI-based solution processes real-time data from IoT sensors and adjusts the system automatically, not manually.

Here is a brief recap of how such a system learns to adapt itself:

- The system analyzes occupant behavior and comes up with more accurate demand predictions.
- Distributed AI in the end-control devices generates optimal setpoints. Hardware parts stick to these setpoints. This ensures a more dynamic reaction to indoor and outdoor changes.
- The system uses non-linear HVAC control techniques instead of a rule-based approach. Non-linear control allows HVAC systems to process complex data from various sensors, mirroring human management.

Real-Life Example: Reducing the Amount of HVAC Equipment Needed

SHARP Development is a real estate company from California. They transformed a 1970s class C building in Silicon Valley into a net-zero energy class A office.

They wanted to reduce the amount of HVAC equipment needed. To achieve this, the company insulated the building well and installed operable windows and skylights, which are controlled by the building automation system. At night, when the temperature has dropped, the BAS tells the windows and skylights to open in order to cool the building down and exchange the air.

> Now, the building has 20% of the HVAC equipment that a normal building has, and it’s almost never switched on.

Originally, the company expected to lease the building in 18 months. But instead, they found tenants in three months and earned an extra $2.40 per square foot per year above the market rent.

Main Benefits

- Enabling quick responses when occupants’ requirements change
- Reducing bills by eliminating excessive heating and cooling
- Ensuring compliance with federal and state requirements

Use Case 2: Flexible Adjustments

Traditional ready-to-use HVAC systems work with a preset number of parameters. If you have a standard commercial building, you would go for a more basic control. Should you decide to integrate HVAC into a healthcare institution, you would use a more advanced solution.

Problems occur when a traditional HVAC system used in a commercial building needs a serious upgrade. Should your occupants’ criteria change or

a new law be adopted, you may have to replace the current solution with a new one that is more configurable. This would definitely result in high upfront investments and additional discomfort.

The power of smart HVAC solutions lies in their ability to learn depending on the data sets presented. Once you have an additional factor to control, HVAC system software developers add a number of new data sets. For example, imagine a new legal order now compels you to measure and control indoor pollution levels. AI enables you to set and adjust new parameters in a more sophisticated way.

> You can upgrade the system's logic while keeping its hardware in place without significant changes and extra costs.

Real-Life Example: Safely Reopening a Building During the Pandemic

1111 Broadway is a class A commercial building in California. It uses AI to dynamically control AHU fan speed, temperature, and humidity in the building. The system makes decisions based on data from temperature and humidity sensors. Based on this data, the AI algorithm determines heating and cooling requirements and sends setpoints to the HVAC system. Insights from AI also help engineers identify malfunctioning equipment.

In the summer of 2020, in the midst of the COVID-19 pandemic in California, it was the smart BAS that allowed the owners to safely reopen the building.

They could easily adapt ventilation, filtration, humidity, and temperature settings in accordance with recommendations by the American Society of Heating, Refrigerating, and Air-Conditioning Engineers (ASHRAE) to suppress virus transmission.

When someone had a positive COVID test result, the building ran decontamination mode. Once the last person had left the building in the evening, it was heated up for approximately nine hours. Then, the BAS used the outside air to cool the building back down. By 6 am the next day, the building had returned to normal temperature and humidity settings.

Main Benefits

- Quickly reprogramming an HVAC system
- Enabling the system to be upgraded without changing the existing hardware or software parts for new ones

Use Case 3: Predictive Maintenance

A traditional HVAC system responds to system outages after a failure occurs. It uses ready-to-use protocols and reactive maintenance strategies. Smart HVAC solutions help take immediate control of an HVAC system the moment something goes wrong. Now they can:

- Perform proper HVAC equipment performance analyses

- Detect problems early on before they turn into significant issues
- Plan further steps

> For example, such a platform can generate reports based on data machine analysis and propose recommended actions to take.

Real-Life Example: Detecting and Predicting Breakdowns in HVAC Systems

Santagostino is a network of 35 medical centers in Italy. Occasional HVAC system breakdowns were a problem for their staff and patients. After a breakdown was noticed, it might have taken days or even weeks for a technician to find and fix the problem. This meant that whole departments weren’t able to operate until the repairs had taken place.

To solve this problem, they decided to apply IoT. The solution monitors their HVAC equipment in real time to immediately find unwanted stoppages. The system also uses AI to identify and predict excessive stress on the machines and provide timely maintenance measures. Now, the clinics are able to prevent delays, save energy, and extend the equipment’s life cycle.

Main Benefits

- Enhancing the operations and maintenance (O&M) of commercial buildings
- Quickly detecting anomalies
- Creating recommendations to plan further actions and system optimization

Healthcare

Disruptive innovations in healthcare help businesses improve patient care and cut costs. For instance, IoT can lower the costs of operational and clinical inefficiencies by $100 billion per year. IoT also provides patients with high-quality, accessible care, which means more satisfied customers and growing revenue. Let’s take a closer look at the key use cases of IoT in healthcare.

Use Case 1: Artificial Intelligence to Analyze Big Datasets

AI applications may end up saving $150 billion for the industry by 2026. The technology supports healthcare professionals in terms of accurate diagnosis, treatment, and disease prevention.

Some areas of AI usage include:

- Clinical workflow management
- Chatbots
- Patient check-in management
- Medical image reading
- Advanced surgery aid

AI is driving digital transformation in the industry, and is capable of solving some critical challenges. For example, data storage, analysis, and management issues. In healthcare, the amount of medical data increases each year. This data includes medical health records, prescriptions, clinical research data, and more. The industry is failing to cope with such high volumes. Backed by big data storage capacities, AI algorithms can extract, segment, and arrange the data. Then, when needed, algorithms analyze the data and share insights into respective processes.

> This way, healthcare providers can make informed decisions about diseases and treatment, and in general, drive better patient care.

Another challenge is disease detection. AI technology measures and tracks symptoms faster and more accurately than humans, while AI-powered tools have the ability to find a disease even when a patient is asymptomatic.

AI also contributes to early disease treatment. This helps achieve a higher

survival rate, even for the most challenging diseases. AI models analyze real-time data, assess the disease type, characterize it, and suggest necessary treatments.

Real-Life Example: Treating Cancer

Some years ago, a Swiss company, Novartis, collaborated with an artificial intelligence solutions provider, IBM Watson Health. Their common goal was to advance breast cancer treatment. The duo created a cognitive technique that uses advanced analytics for real-world data. This technique provides better insights into the expected outcomes of treatment. It can also simulate the intake of complex drug combinations. Using this data, physicians can choose the right therapy for cancer treatment.

The collaboration was mutually beneficial. Doctors were introduced to new treatment techniques, and both companies developed new revenue streams. They were also able to expand their client base. For example, IBM persuaded Pfizer and Teva to use its software for drug research.

Main Benefits

- Increasing productivity and efficiency of care delivery
- Structuring and categorizing data
- Simplifying the lives of the sector’s key players

- Improving healthcare accessibility

Use Case 2: Telemedicine and mHealth to Treat Patients More Effectively

You know what telemedicine is if you have ever used video calls for medical care. But telemedicine is not just about treating people remotely. It is used for follow-up visits, preventative care support, and medication management.

Telemedicine addresses some of the hottest healthcare problems, including rising costs, access to high-quality services, and the shortage of personnel. For example, remote monitoring can improve follow-up care and save money by reducing readmissions.

> Just imagine, hospitals spend over $41 billion to treat patients readmitted within 30 days of discharge—$15,200 per patient on average.

Implementing and using remote monitoring costs much less than this, making telemedicine a key part of hospital programs for combatting high readmission rates.

MHealth, a subset of telemedicine, is medical service delivery via mobile

technologies. It makes healthcare services accessible anywhere, anytime, and at an affordable price. What's more, smartphone use is improving patient engagement.

During the pandemic, mobile apps played a critical role in controlling the spread of COVID-19. For example, some apps can locate people who may have come into contact with the virus. Apps also help capture data and track the movement of people, speeding up and improving the process of finding COVID-19 contacts. People could identify those who may have been exposed to the virus, so they knew to isolate and watch for symptoms.

Common use cases of mHealth and telemedicine in general include:

- Appointment scheduling
- Care initiation
- E-prescriptions and consultations
- Medication management
- Medical imaging

Real-Life Example: Reducing Readmission Rates

Ohio Living Home Health and Hospice successfully reduced hospital readmissions. They employed a remote monitoring system by issuing patients with tablets equipped with healthcare software and wearables to track their vitals. The program sends alerts to doctors' dashboards and

enables communication via audio, video, and messages. This way, patients receive further care, even after discharge from the hospital. This resulted in a twice lower readmission rate and total cost savings of more than $10 million.

Main Benefits

- Reducing office space and saving budget
- Improving patient satisfaction
- Increasing patient engagement

Use Case 3: Reducing Operational Costs

According to McKinsey, the healthcare industry spent $335 billion on healthcare IoT in 2021. By 2025, this is estimated to reach $1 trillion—a growth of 300%. This will set the stage for personalized and accessible medical care for everyone.

There are endless use cases for IoT in healthcare:

- Remote patient monitoring (RMP) and virtual visits
- Tracking staff and patients
- Facilitating the care of chronic disease
- Automated patient care workflow

- Diagnosis and preventive medicine
- Robotic surgery

With their ability to solve some hot issues in healthcare, IoT devices have proved crucial for the industry. One of the hottest is failing to comply with industry regulations. Organization-wide compliance ensures that every stakeholder follows proper procedure, with the goal of providing safe, high-quality patient care. IoT can provide automatic screenings to help providers comply with regulations.

> Dealing with a high volume of medical errors is another area where IoT can win the race. In fact, medical errors are responsible for 251,000 deaths annually and are the third-leading cause of death in the US.

Providers can automate various processes so that the chance of human error is negligible. IoT can also help reduce the number of mistakes by providing real-time patient monitoring and obtaining real-time data.

The industry also seeks to decrease operational costs. Healthcare expenses in the US have been rising for decades, and there are no signs of them slowing down. Automated real-time monitoring of hospital devices and assets is one method for doing so. Using IoT sensors, healthcare providers can get usage reports of their medical equipment. This helps maintain

optimum operational efficiency and leads to reduced costs for healthcare facilities.

Real-Life Example: Providing Predictive Maintenance

Philips' e-Alert is a good example of how IoT can reduce inspection and maintenance costs. The system is a smart hardware and software-based tool that keeps a close eye on magnetic resonance imaging (MRI) system performance. Using sensors, it continuously monitors key system parameters: magnetic field, helium level, temperature, and humidity. If any of these parameters fail, technicians get notified automatically and can respond quickly.

It also predicts and prevents any possible issues. If maintenance is required, service engineers receive alerts. One of Philips' customers confirmed that using e-Alert helped them grow their revenue. They also managed to improve operational efficiency, reduce costly downtime, and scan more patients.

Main Benefits

- Reducing costs
- Increasing productivity of healthcare providers
- Minimizing errors

Trendy Technologies to Keep an Eye On

If you plan to transform your business, it's also worth keeping an eye on other trendy technologies. We believe digital twins, edge computing, AR (especially for the automotive industry), and smart charging have great potential. As IoT and AI improve, so too are these technologies, and they are becoming more accessible even to small businesses. Here's how they can come in handy.

Digital Twins

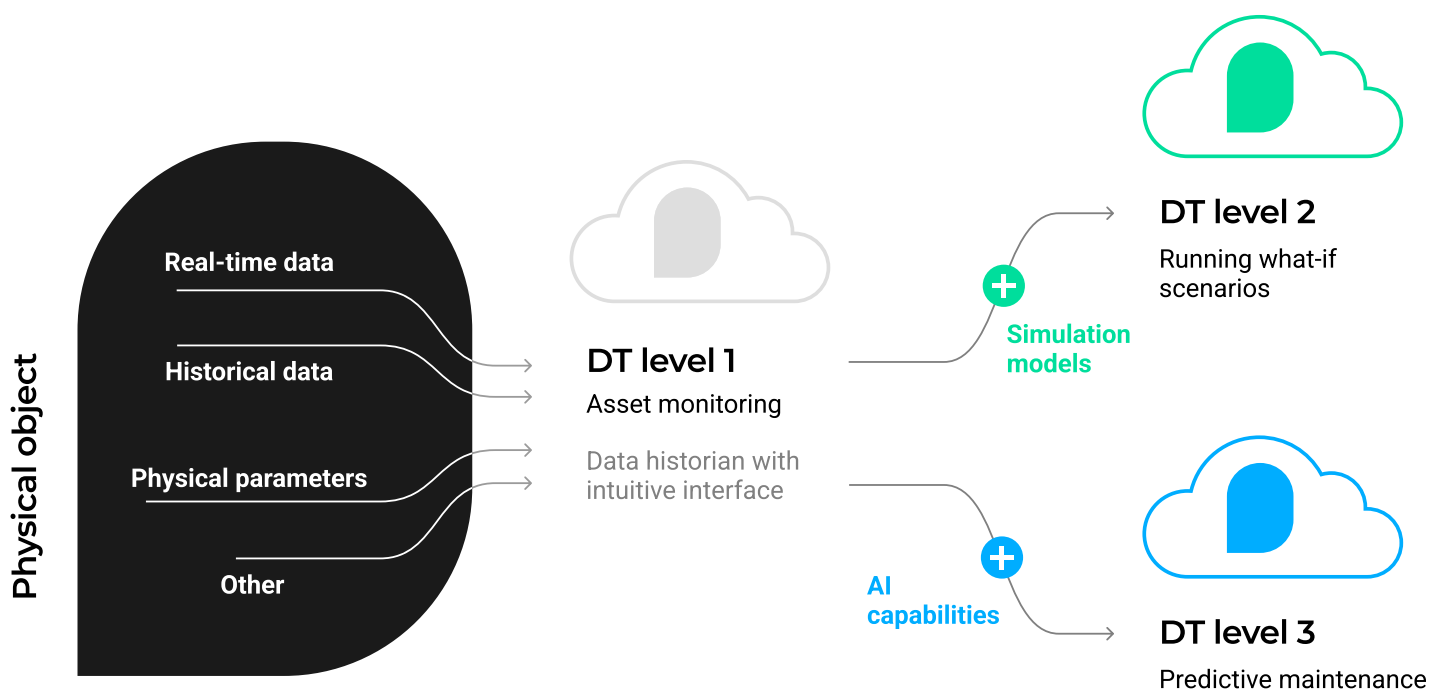
Digital Twins are digital duplicates of physical objects. Using this technology, businesses can gain better insights into product performance, enhance product quality, improve customer service, reduce operational costs, and more.

Depending on the business goal, there can be three scenarios of digital twin use with different complexity levels:

- **Basic level: asset monitoring.** This allows for monitoring physical assets and collecting data on them for future use. On this level, DTs are no more than data historians with intuitive interfaces, both in terms of functionality and costs.
- **Middle level: what-if simulations.** This enables companies to experiment with operational settings of assets or processes to find the optimal operational configuration.

- **Advanced level: AI-enabled systems.** Such systems can quickly detect abnormal behavior and suggest or initiate corrective action.

Digital twin models can monitor physical objects, optimize their operations, and fully control their behavior



Let’s take a closer look at digital twin uses and their benefits.

Use Case 1: Digital Twins in Retail

In the retail industry, digital twins may come in handy both in the supply chain and in store. To create supply chain simulations, retailers use real-time sensor and equipment data, as well as ERP and other business system data. The models give an overview of a supply chain’s performance, including assets, warehouses, material flows, inventory positions, and people. To create in-store digital replicas, retailers use data captured by RFID readers,

motion sensors, and smart shelves. These models allow them to analyze customer movement and purchase behavior, as well as test the optimal placement of products.

Real-Life Example: French Supermarket

French supermarket chain Intermarché created a digital twin of a brick-and-mortar store based on data from IoT-enabled shelves and sales systems. Now, store managers can easily manage inventory and test the effectiveness of different store layouts.

Main Benefits

- Effectively managing product supplies
- Avoiding supply chain disruptions
- Optimizing logistics costs

Use Case 2: Digital Twins in Water Utilities

Water utility organizations use digital twins to ensure an uninterrupted water supply and be better prepared for emergency situations. With digital replicas, they can get an accurate assessment of how the current water system behaves, identify failures before they happen, and simulate what-if scenarios.

> Water utilities create virtual representations of water systems based on sensors and actuators capturing data on the physical system's performance.

Additionally, they use data from information systems in the water industry, such as CMMS (computer maintenance management systems), GIS (geographic information systems), and SCADA (supervisory control and data acquisition).

Real-Life Example: Water Supply in the City

Aguas do Porto (AdP), a Portuguese utility organization, is responsible for the water supply in the city of Porto. AdP uses digital twins to forecast flooding and water quality issues, improve city services and responsiveness, and ensure resilience of water infrastructure.

The solution creates virtual models based on sensor and telemetry data together with information from 20 other sources: customer service management, billing, maintenance, asset accounting, etc. Digital twins enable AdP to monitor the water supply systems in real time. They are also used to create forecasts on water consumption and simulate burst pipe scenarios along with valve and pump shutdowns.

Main Benefits

- Quickly locating potential leaks to reduce water loss
- Improving emergency response
- Increasing water supply reliability
- Saving energy

Use Case 3: Digital Twins in Manufacturing

In industrial manufacturing, digital twins are used to simulate the production process. Based on data from sensors connected to machines, manufacturing tools, and other devices, manufacturers can create virtual representations of a real-world product, equipment elements, production process, or whole system. Thus, for production purposes, such simulations help track machine operation and adjust it in real time.

> Augmented with machine learning algorithms, digital twins help manufacturing companies identify problems before they occur and predict future outcomes.

For maintenance purposes, digital twins allow for monitoring equipment health and recognizing potential anomalies in a timely way. They capture

real-time data on equipment operations and augment it with historical data on failures along with contextual maintenance data. With the help of machine learning and artificial intelligence, the solution predicts when maintenance work will be necessary. Based on this data, companies can take proactive measures to prevent production stoppages.

Real-Life Example: Consumer Goods Manufacturing

Unilever PLC is using digital twins to make the production process more efficient and flexible. The company has created virtual models of its factories. At each location, the IoT sensors feed real-time performance data such as temperature and motor speed into the enterprise cloud.

Using advanced analytics and machine learning algorithms, an IoT digital twin simulates complex what-if scenarios to identify the best operational conditions. This helps manufacturers use materials more precisely and limit waste from products that don’t meet quality standards. Right now, Unilever is operating eight digital twins across North America, South America, Europe, and Asia.

Main Benefits

- Enhancing product quality
- Increasing production efficiency

- Improving profitability

Use Case 4: Digital Twins in Healthcare

In healthcare, digital twins can be used for designing medical devices—vena cava filters in particular. They require two virtual replicas: the patient's digital twin, with specific anatomical and physiological characteristics, and the medical device's digital twin, with device parameters.

> By correlating both models, healthcare researchers can see what happens when a particular device is installed into a patient's body.

Digital twins also help optimize the device's performance by running hundreds of simulations with different conditions and different patients.

Real-Life Example: Human Heart Models for Device Design

The Living Heart Project is an international research collaboration dedicated to developing and validating highly accurate personalized digital human heart models based on MRI images and ECG data. The project involves the FDA, leading cardiovascular researchers, educators, medical device developers, and practicing cardiologists. They leverage the digital twin heart to simulate in-vivo (in a living organism) conditions, visualize anatomy that

cannot be seen, and refine the designs of cardiological devices faster. The team hopes this experiment will serve as a playbook for future in-silico (performed via computer simulation) trials.

Main Benefits

- Customizing complex medical devices for individual patients
- Accelerating the product design
- Reducing costs by lowering the need for surgery and clinical trials
- Minimizing animal testing
- Reducing side effects

AR for the Automotive Sector

AR has the ability to add robust capabilities to solutions across multiple modalities—visual, auditory, haptic, somatosensory, and olfactory. In the automotive sector, visual forms of augmented reality—via screens or glasses—prevail. For example, AR in the automotive industry contributes to creating various types of head-up displays (HUDs) for applications.

So what does AR bring to the table and why do so many carmakers invest their funds and efforts into this technology? Unlike expensive virtual reality,

which has to generate the entire environment, augmented reality only enhances the physical world with virtual elements, so it is much more affordable. AR places 3D models into real situations and adds context to a display.

From a tech side, the AR automotive market can be segmented by technologies, functions, and the level of autonomous driving.

By sensor technology:

- LiDar
- Radar
- Sensor fusion
- CCD/CMOS image sensor

By function:

- Standard AR HUD
- AR HUD-based navigation
- AR HUD-based adaptive cruise control
- AR HUD-based lane departure warning
- Advanced AR HUD

By display technology:

- TFT-LCD
- OLED, AMOLED, and other advanced technologies

By level of autonomous driving:

- Conventional
- Semi-autonomous

Take a look at the benefits automotive AR brings to OEMs, suppliers, software development companies, startups, and drivers.

Use Case 1: Enhanced Driver Experience

New safety standards, as well as an ever-increasing demand for comfort and luxury, propel the automotive market. Industry 4.0 also calls for sustainability and consideration of future impact. So it’s no surprise that vehicles are becoming more complex and sophisticated year after year.

> Imagine a modern car. It incorporates multiple cameras, dozens of sensors, microprocessors, and about 100 million lines of code. Infotainment systems connected to the cloud make the vehicles of today technological marvels on wheels.

Augmented reality, in turn, is here to improve navigation and infotainment systems and enhance vehicle safety. For instance, it can augment navigation, adaptive cruise control, and lane departure warning. Other examples include AR-assisted dashboards, real-time street signs and accident warning, and AR entertainment systems. As a result, drivers get instant information on the surrounding environment and road conditions.

Real-Life Example: 3D-powered Augmented Reality Interface

The invisible-to-visible technology (I2V) from Nissan introduces a 3D space around a vehicle. It enables an AR-assisted interface that was first presented at CES 2019. The idea is to provide drivers with real-time road data and

make manual navigation assistance smarter and safer. Data from the vehicles shows hidden hazards or unforeseen traffic situations.

Main Benefits

- Improving product quality
- Increasing sales
- Providing top-notch functionality in line with the latest tech trends
- Getting a leg up on the competition

Use Case 2: Presentation Guides and Car Manuals

Augmented reality applications used in showrooms help salespeople show car functionality with the help of a headset or smartphone camera. The technology allows for a visualization of lots of overlapping information, such as interior and exterior parts, performance, weight, and financing. It’s possible to present this data in an interactive way and keep it up to date on the go.

> AR-powered guides and instructions easily replace long and complex manuals. Manual applications provide car owners with access to vehicle features, maintenance, and information for repairs via smartphone or tablet.

Real-Life Example: Genesis Virtual Guide

The AR-powered virtual guide app from Hyundai is a vivid example. At first, the application appeared to recognize about 50 vehicle features of the 2015 and 2016 Sonata. Today, it supports Genesis luxury sedans that use augmented reality. With this guide, consumers get how-to information for repairs, maintenance, and vehicle exterior and engine parts. 2D and 3D tracking technologies allow the delivery of in-depth information related to specific parts.

Main Benefits

- Enabling more efficient and cost-saving demonstrations in showrooms and sales
- Increasing brand awareness by making car demos eye-catching
- Driving sales by offering useful, easy-to-use applications instead of complex, old-school manuals

- Serving customers better with interactive manuals that can prevent them from visiting a service center or car mechanic, ensuring a more efficient diagnosis and repair process

Use Case 3: Product Development and Maintenance

Augmented reality improves manufacturing and inspection operations on the factory floor. Spatial AR applications assist designers in matching various design options to physical vehicle models. Technicians can receive documentation and instructions in their AR glasses without being distracted. AR-guided part location helps warehouse employees become faster and more efficient.

AR is also helpful for vehicle maintenance. Instead of a monotonous manual search, technical workers can use AR devices to identify machines and equipment that need servicing simply by checking their data and history.

Training factory workers with AR is another powerful perk. Augmented reality coupled with digital twin technology can introduce virtual clones of physical assets, which help automate the training process in manufacturing. These digital models facilitate the training process—employees can see internal components to learn how to repair and service vehicles.

> An example of this is an iPad training app created by Jaguar Land Rover in tandem with Bosch.

Real-Life Example: AR Manufacturing Environment

BMW is among the early adopters of AR on the factory floor. The company uses augmented reality to inspect delivered tools at its toolmaking and plant engineering units in Munich, Germany. The AR-assisted app helps technicians get related data about each tool—its drill holes and clear surface features—before using it. Algorithms overlay each image taken with around 50 criteria. If a tool doesn't meet the specifications, there is a chance to rework it before sending it to the assembly area.

Main Benefits

- Optimizing the assembly process with AR images of vehicle parts or technical information on AR glasses
- Saving operational costs by reducing the price of design and prototyping
- Boosting the productivity and efficiency of product development with automated processes for storing parts and equipment, like AR-guided warehouse location

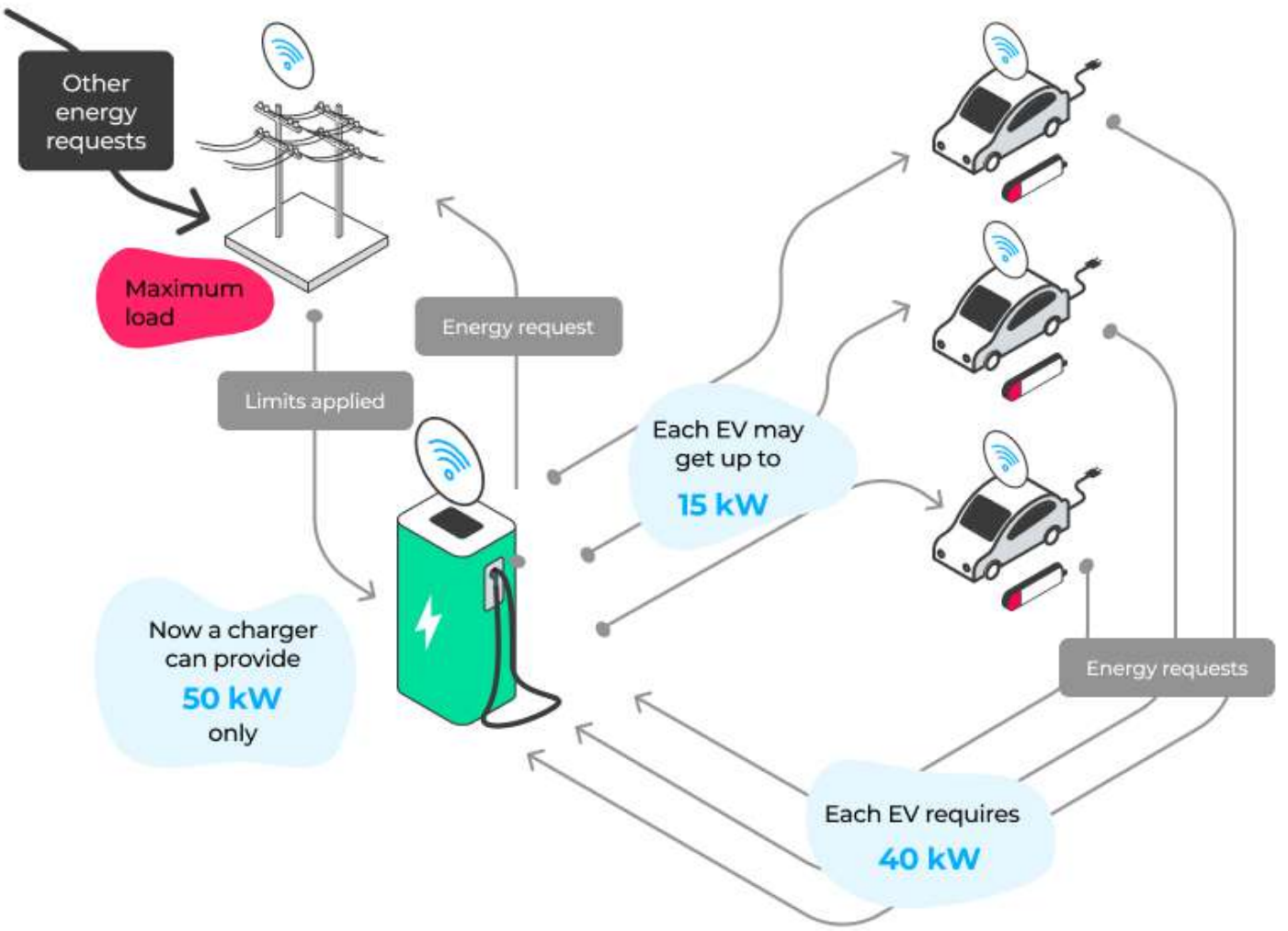
- Automating the worker training process, allowing them to repair a vehicle without removing parts
- Shortening production time by using AR to automate routines on the factory floor

Smart Charging

Smart charging is a technology that stabilizes an imbalance between produced and consumed power. The technology comes to the rescue where traditional EV charging points can’t handle the growing number of EVs, which overloads a power grid.

Smart charging creates a single ecosystem where EVs, chargers, and local energy grids communicate and exchange data. This allows systems to:

- Share their real-time data: how many EVs are waiting to be charged, what will be the stress on the power grid, and so on
- Automatically specify how much energy to give a plugged-in EV



As a result, they make optimal use available in a certain time period. No more hassle with an unprotected grid during peak loads or exceeding energy capacity. Here are three scenarios of how smart charging replaced traditional EV charging.

Use Case 1: Fleet EV Charging

More and more businesses and public services are turning to EVs in their fleets. Delivery services and public buses are two examples. All these companies have to think about charging their fleets. Problems usually include insufficient energy availability, the low capacity of a local grid, and

increased electricity bills.

> Grid operations can upgrade charges into more powerful models.

Smart charging can run on the existing solution and get the most out of it. The technology relies on data exchange and management systems—not on expensive equipment. The data about energy consumption helps predict peak demand. And the built-in dynamic load management functionality allows the company to balance the load.

Real-Life Example: Charge Upgrade

Here's how Enexis, a Dutch grid operator, found a budget-friendly smart charging solution. They had trouble with high energy consumption during peak hours and a lack of control over their charging stations. So the company decided to upgrade charges into more powerful models. Upgrade, not replace. This allowed them to avoid making $300k of additional payments.

Main Benefits

- Predicting peak energy demand
- Enabling reliable electricity delivery

- No need to rebuild the whole infrastructure

Use Case 2: Smart Charging of Electric Vehicles at Home

Families and individuals often buy EVs and equip their own parking with chargers. Along with other household devices, this increases the load on the grid and sometimes leads to blackouts.

> Routine EV users want a solution that will charge their vehicles when the demand for energy is low (as well as its costs). That would also reduce the burden on the grid.

OEMs don’t usually manufacture chargers themselves, though Tesla makes an exception. Car manufacturers partner with hardware providers to supply homes with rapid and affordable charging points. Once access to home charging increases, the faster EV ownership will rise.

Real-Life Example: Smart Charging for Homes

The market is full of EV smart charging solutions for home use. Wi-Fi-enabled units, for example, can synchronize optimal vehicle charging times with peak renewable energy generation periods. An EV is charged during an off-peak period, and its owner gets lower electricity bills and less load on the

distribution system. Some other solutions guarantee 10 times faster charging compared to a standard socket. Others offer additional built-in security features to protect an EV and a house against power fluctuations.

Main Benefits

- Reducing load on the grids and blackouts as a result
- Ensuring faster EV charging
- Reducing electricity bills
- Protecting EVs against power fluctuations

Use Case 2: Smart Charging of Electric Vehicles at Home

Users want more predictability in en-route EV charging at public places. This means real-life data about the closest available charging points and charging costs.

> A mobile app that provides this information would be the most obvious solution. What's more, users also want simple charging session authentication and automatic payments.

A mobile app such as this can be an additional sales driver for electric car

manufacturers. It can be user-friendly, feature an integrated payment solution, and an intuitive interface. One step forward for OEMs is integrating charge points into the app's navigation system and offering additional bonuses to app users. For example, bonuses could be premium access to a station or lower charging costs.

Real-Life Example: Smart Charging Stations

While most public EV charging networks run basic en-route charging stations, the industry leaders are turning to smart solutions. For example, the FLO EV charging solutions manufacturer and the Los Angeles Bureau of Street Lighting released an urban EV smart charging project.

They deployed 75 SmartTWO charging stations that covered 89% of the city—quite a number, which reduces range anxiety. The devices are placed at service stations, in public parking spaces, at retailers' parking lots, and other locations. They are accessible via a mobile app or through an RFID card.

Main Benefits

- Helping EV drivers find the closest available charging station
- Creating an additional sales driver for electric car manufacturers

Edge Computing

Edge computing is a technology that processes data right where it's created—at the edge. So, we have extra-fast response time and immediate reaction to events. That's why edge computing is getting acclaim in the most risk-prone industries, like mining and healthcare. Let's consider how different industries can benefit from this technology.

Use Case 1: Mining

Mining remains one of the most dangerous jobs in the world. Lack of control may lead to serious incidents. But setting up Wi-Fi in shafts and stops underground is difficult and expensive. This means cloud solutions are not the best option. However, safe work conditions remain a top priority in the industry, and this won't work without process automation.

> Automation means that devices collect and process data at the edge. Such devices can be controlled and adjusted remotely.

Real-Life Example: Process Automation Underground

Bolodine is one of the largest mining companies in the world. It recently partnered with the telecom giant Ericsson for digitalizing Aitik, an underground mine in Sweden. Bolodine wanted to automate the most

dangerous processes, like drilling blast holes. This would improve safety significantly.

Bolodine equipped drill rigs with sensors and cameras for remote control. Edge applications ensure their repetitive work continues autonomously, such as:

- Drilling a hole into the surface of the mine
- Packing it with explosive material
- Detonating

If an operator needs to modify a process, they can do so from a safe and remote location. Edge computing allows the mining company to remove human workers from the blasting process and avoid risking their lives.

Main Benefits

- Ensuring miners’ safety
- Saving 1% of Bolodine’s total annual budget
- Using small solutions instead of buying new multi-million-dollar drill rigs

Use Case 2: Construction

Construction companies buy functional equipment for millions of dollars. Unfortunately, its high price doesn't guarantee 100% smooth work. Imagine that one day something fails. Management panics, downtime extends, and the company's expenses increase.

That's why businesses deploy predictive maintenance solutions. Edge computing is an essential part of this.

> The technology detects signs of unexpected equipment failure and sends an alert right away. This helps the company extend asset life and save a fortune on repairs.

Real-Life Example: Production Issue Monitoring in the Energy Sector

General Electric is a US company in the energy production industry. Among other things, it manufactures gas and steam turbines, engines, generators, and high-voltage equipment. One of the major problems in the production cycle is related to equipment health. Due to lack of control, the company couldn't detect issues on time. As a result, manufacturing yields were reduced and the company incurred multi-million-dollar scrap costs.

Everything changed when they empowered their winding machines with edge computing technologies. Now, the equipment processes raw sensor

data and quickly identifies failing machinery. This saves the entire manufacturing floor from disruptions and production delays.

Main Benefits

- ncreasing yields by 8%
- Providing timely failure alerts

Use Case 3: Manufacturing

A modern industrial site is equipped with thousands of devices. They track temperature, humidity, start of operation, end of operation—everything. But using cloud solutions to process such an avalanche of data can cost you a fortune.

Edge technology offers an affordable alternative. Such solutions can process data right on the device. This allows workers on the factory floor and managers to quickly react to accidents and manufacturing defects.

Real-Life Example: Zero Defect Culture in Steel Manufacturing

Harrison Steel Castings Company in Indiana produces carbon and steel castings for agriculture, energy, and oil and gas industries. The company has deployed a virtualization platform on site for faster operations and reduced risks and defects.

The solution relies on edge computing and a distributed architecture. Among other benefits, it helps identify defective parts produced in steel manufacturing. Harrison Steel Castings Company saves millions of dollars by tackling defects as early as possible.

Main Benefits

- Automating quality control and diagnosis of steel defects
- Increasing production efficiency
- Guaranteeing product quality

Use Case 4: Healthcare

In 2021, the American Hospital Association calculated nearly 14 million bedside devices. To collect medical data from all of them is a big challenge. To make use of it is another.

Edge computing is a perfect fit for real-time analysis of big files. Plus, it’s a go-to solution for virtual visits and consumer wearables which are booming in the post-COVID world.

> The technology allows clinicians to get alerts beyond hospital walls and physician exam rooms.

Real-Life Example: Data Exchange Between Ambulances and the Hospital

We have seen many edge computing examples in remote patient monitoring and hospitals. So why not equip ambulances with edge technology too?

Here's a use case with connected ambulances in Barcelona, Spain. Onboard medical devices collect and analyze the patient's biometric data and compare it with their EHRs. That's how paramedics know what treatment to give en route without a lot of consideration. And emergency room personnel receive alerts on how best to prepare the room for the patient's specific care needs.

Main Benefits

- Quickly evaluating a patient's state in an extreme situation
- Accelerating the registration process in hospitals

Use Case 5: Retail

Brick-and-mortar retailers use edge computing to stay relevant and compete with online stores. The technology helps improve customer experience in real time. It doesn't mean that a retailer should buy dozens of devices and place them inside a store instead of stocking display.

> Space is money in the physical retail world. That's why modern solutions combine multiple functions in a single device.

Real-Life Example: Automated Checkout with a Single Device

Cohesity is a California-based IT company. It builds data management solutions for global clients, including retailers. Its devices replace several hardware pieces and let a retailer save space to store and display products.

The device runs on a PoS machine and doesn't require large amounts of computing power. It combines data from scanners and weighing equipment with video footage in the checkout area.

Main Benefits

- Minimizing accidental or fraudulent behavior at self-checkout
- Reducing the necessary hardware

Digital Transformation Is Taking Root in Every Major Industry

Digital transformation is changing all industries and business areas. With IoT and AI, companies can increase their efficiency, reduce costs, keep their employees healthy, and even get closer to a green economy. We hope you found some inspiring ideas in this e-book to help you win in your target market.

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