outsight

WHITEPAPER

Motional Digital Twins

Unlocking Operational Excellence through **Motion-Based Spatial Intelligence**

outsight.ai

About Us

Outsight's Spatial Intelligence solutions leverage Spatial AI and 3D native sensors such as LiDAR to empower infrastructure operators by continuously monitoring the movement of people and vehicles in real time—enhancing efficiency, improving customer experiences, and strengthening security. This Spatial Intelligence is made accessible through Motional Digital Twins.

As the most experienced team in the industry, we lead the deployment of Spatial Intelligence solutions worldwide, operating from our offices in San Francisco, Paris, and Hong Kong.

Additional details about our company can be found in Annex A of this whitepaper.

Abstract

This whitepaper describes Motional Digital Twins—**real-time digital replicas that continuously track and analyze how people and vehicles move through physical spaces**.

Unlike traditional digital twins that monitor static assets, **Motional Digital Twins capture the dynamic reality of physical flows** with centimeter-level precision while preserving privacy, through anonymous tracking.

Currently deployed at scale across five continents in **airports, tourism venues, hospitals, factories, and stadiums**, this technology delivers unprecedented operational intelligence.

Spatial AI transforms raw data from 3D native sensors such as LiDAR into actionable insights, by processing movement patterns as structured, spatially-defined events for each individual—*creating the rich, contextualized insights and datasets that both operators and Agentic AI systems require.*

As organizations face mounting pressure to maximize existing infrastructure capacity amid growing complexity, **Motional Digital Twins provide the Spatial Intelligence foundation** essential for achieving breakthrough improvements in operational excellence, customer experience, and safety.

Table of Contents

Introduction: **The natural evolution** of Digital Twins 5

Capabilities and **Must-Have Features** 14

Reference System Overview 31

Agentic AI for Motional Digital Twins 34

Market Applications and **Use Cases** 36

Key **Takeaways** 46

ANNEX A: Learning more about **Outsight** 50

ANNEX B: Understanding **LiDAR Technology**, the enabling technology of MDT 56

The natural evolution of Digital Twins

Digitizing Individual Movement

What's a Motional Digital Twin?

This technology extends traditional Digital Twins beyond static buildings and assets by adding the critical dimension of movement digitisation, revealing unique insights about real-world interactions.

A Motional Digital Twin (MDT) is a real-time digital replica of a real-world space that delivers **Spatial Intelligence** by continuously tracking how every person and object moves and interacts within that environment.

It collects and processes real-time data from native 3D sensors, such as LiDAR, combined with supplementary sources from external sensors and systems*.

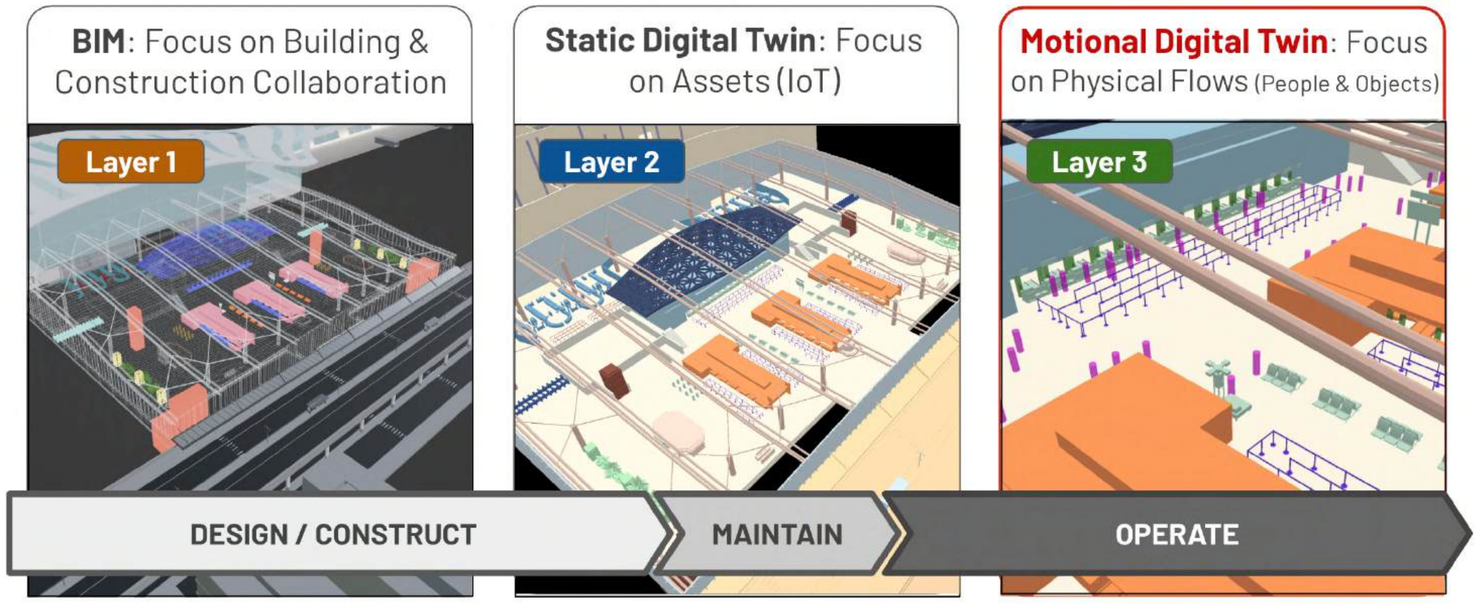
** e.g. point of sale information in retail, flight information in airports, license plates information in parkings, and camera classification data in many contexts.*

A natural evolution

The next frontier of Digital Twins

Digital Twin Consortium defines the general term of "Digital Twin" as an integrated data-driven **virtual representation of real-world entities and processes**, with synchronised interaction at a specified frequency and fidelity.

This definition encompasses the evolution of Digital Twin technology through three distinct generations, each representing successive layers of capabilities: from **Building Information Modelling** (BIM) to static **Real-Time Digital Twins**, and now to the emerging third generation of **Motional Digital Twins**.



Traditionally, BIM and traditional Digital Twins have been focused on delivering value during the **Design & Construction** phases, with the latter providing increasing benefits for **Predictive Maintenance** through real-time IoT data.

By capturing movement and spatial interactions in real-time, Motional Digital Twins deliver benefits that directly impact the **day-to-day Operations** of any Smart Place.

Real-time & Dynamic

Now and Here

Given its core principle of capturing individual movement, Motional Digital Twins inherently require real-time awareness, unlike previous generations of Digital Twins that rely on static data or operate without real-time requirements.

	Static	Moving
Real-Time	Real-Time Digital Twins	**Motional Digital Twins**
Record-Based	BIM	

Only recently have the essential technology, hardware, and software components become available to support this emerging generation of Digital Twins.

Learn more in the section "Why Now?"

Processing Requirements vs. User Consumption Patterns

It's important to distinguish that "real-time" applies to data acquisition and processing, which must match object maximum velocities in the physical environment, whereas insights delivery—*including position updates and related KPIs*—can operate at lower frequencies optimized for end-user applications.

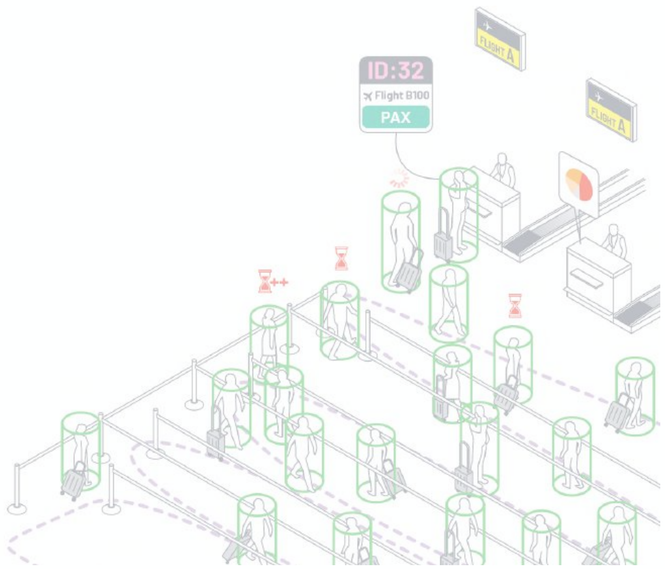
For example, an emblematic tourism site in Paris leverages Outsight's MDT across multiple timeframes:

- Immediate text message alerts for sudden incidents,
- Dashboards updated every minute for queue management,
- And monthly snapshots of historical KPI data to understand long-term operational trends.

Some definitions

Core principles

The transformative impact of MDT is built upon a foundation of unique characteristics.



The following foundational concepts are critical to understanding what constitutes a Motional Digital Twin (MDT):

Movement-driven: Examines reality from the perspective of motion and behavioral data, rather than static structural information or simple sensor readings.

Real-world: Focuses on physical reality and tangible environments, not merely virtual representations or simulated scenarios.

Individual data: The capability to attach information and insights to each individual moving entity, rather than relying solely on aggregated or statistical data such as general flow dynamics.

Continuous Tracking: The capability to track the position of each individual object or person through space and time, maintaining a consistent unique identifier throughout their complete presence within the MDT.

Spatial Interactions: Capturing not only positions, but also how individuals behave and interact in real-world environments—with each other, available assets, and their surroundings.

High Frequency: Data capture rates must be consistent with individual movement dynamics specific to the context *(e.g., capturing a person's running speed in indoor environments or maximum driving speeds in roadway infrastructure).*

Precision: Spatial accuracy must be consistent with the behaviors and interactions that must be captured *(e.g., sub-20cm precision for person-to-person interactions in crowded environments, or sub-1-meter accuracy in parking monitoring applications).*

Why a Motional Digital Twin?

Shedding light on Physical Flows Obscurity

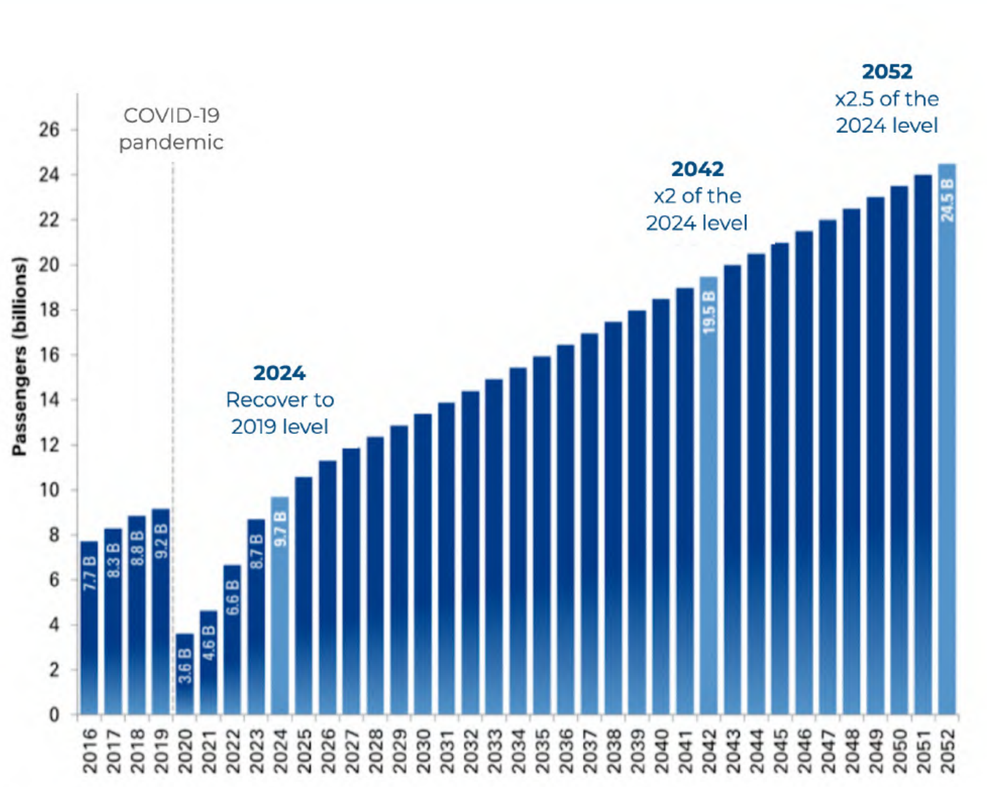
Infrastructure Operators lack visibility into physical flows, preventing them from **identifying and resolving inefficiencies**, **addressing customer dissatisfaction**, and **mitigating safety risks** in their operations.

This blind spot represents both their most powerful lever for improvement and their most significant data gap.

Across sectors, Operators face similar pressures: expansion, capacity management, increasing security threats, revenue growth, and environmental sustainability.

Airports exemplify this challenge: with passenger volumes projected to reach 19.5 billion by 2042, most facilities are already nearing full capacity.

Since new infrastructure is unlikely to be built in time to match this growth, operators must optimize operations and improve passenger flow within existing terminals through precise monitoring and actionable insights.



Long-term global passenger traffic forecast (2016-2052) - Source: Airports Council International

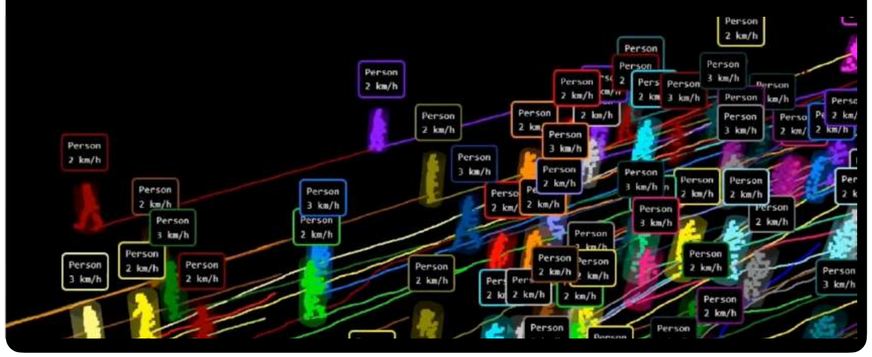
Generating value across the board

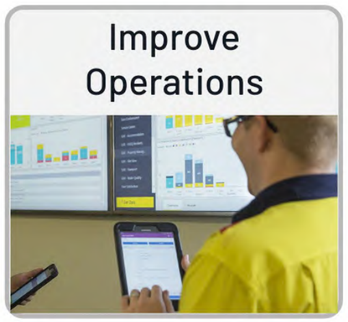
Unique Benefits

Transforming invisible movement patterns into actionable insights represents one of the greatest opportunities for value creation in most infrastructures.

Rather than serving a single purpose, the MDT platform-based approach enables different stakeholders to extract value tailored to their specific needs.

See Annex A for more details on how Outsight, as a market pioneer and leader, is helping major operators worldwide achieve these outcomes.

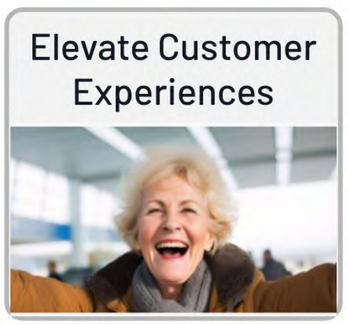




Improve Operations

Operational Excellence

- Identify and prioritize bottlenecks
- Align workforce with demand
- Optimize service providers' operations
- Understand resource usage
- Plan premises modifications
- Manage risks and compliance



Elevate Customer Experiences

Brilliant experiences

- Reduce wait times
- Enables seamless circulation
- Provide reliable journey times
- Improve staff-customer interactions
- Personalize service based on needs
- Provide a safe environment

Ensure Security & Safety

Increased Security & Safety

- Improve regulatory compliance
- Prevent & Respond quickly to emergencies
- Detect unauthorized access
- Create safer environments
- Ensure operational continuity
- Protect brand reputation

Optimize Retail Activities

Retail Revenue Optimization

- Profile potential customers
- Detect missed conversion opportunities
- Optimize & Objectivize digital advertising
- Improve layouts & displays
- Enhance shopper-associate engagement
- Make informed rental adjustments

Six main drivers have converged

Why now?

The need to precisely monitor and manage the physical flow of people, vehicles and objects as they move is not new.

However, the comprehensive capabilities of a Motional Digital Twin cannot be realized using legacy technologies.

Today, a combination of technological advancements, market dynamics, and evolving societal expectations have converged to reshape what is possible, with two main pillars forming the foundation.

Native 3D Sensors

LiDAR sensors—the only technology capable of accurately perceiving in 3D over long distances—are now both mature and affordable.

Spatial AI

Comprehensive Spatial Intelligence software platforms, leveraging 3D AI, such as Outsight's, are ready and proven at scale.

Additional drivers:

Edge Computing

Processing massive 3D data in real time is now possible with next-generation edge hardware combined with cloud computing.

Web-based 3D

A 3D-native interface that perfectly complements Spatial insights can currently run seamlessly in web applications with a simple browser.

Privacy Concerns

Rising privacy concerns are fueling public resistance to image-based and wireless surveillance, requiring respectful alternatives.

Global adoption

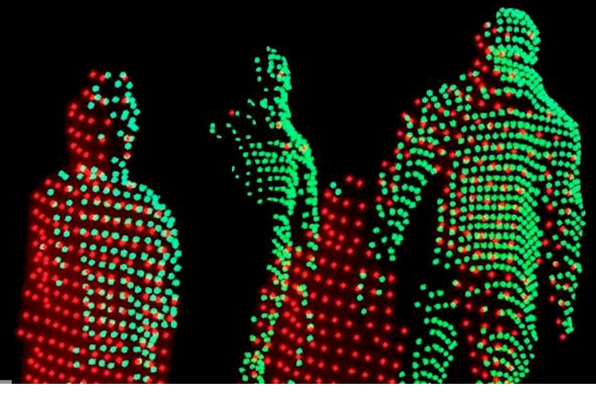
Leading operators across the USA, Europe, the Middle East, and Asia are deploying MDT solutions at scale, with many more exploring adoption.

Revealing Real-World Insights

Spatial AI: the Technological Foundation

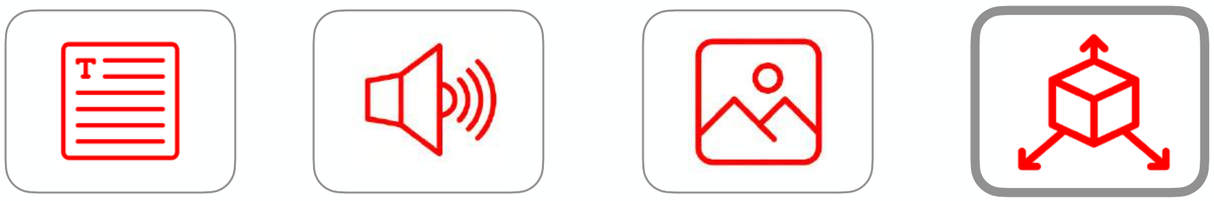
The emergence of Motional Digital Twins has been made possible by the convergence of two critical technologies: Spatial AI and 3D native sensors.

See Annex B for more details on how 3D LiDAR technology is redefining what's possible from the hardware perspective.



Spatial AI is a set of artificial intelligence techniques designed to understand and analyze movement and behavior in three-dimensional space. It processes 3D sensor data to track individual objects, recognize patterns, and generate insights about how people and assets interact within physical environments.

What makes this possible is that Spatial AI handles the fourth major data modality in artificial intelligence:



Spatial Intelligence represents the actionable insights generated by **Spatial AI** as it processes data from **3D native sensors** and other external sources within a consistent 3D reference system.

3D Sensing + Other data + Spatial AI = Spatial Intelligence

A **Motional Digital Twin** is the concrete medium for users to leverage the value of Spatial Intelligence.

Capabilities

Unlocking Premises-wide Physical Flows Insights

End-to-End Journey Understanding

A Motional Digital Twin continuously delivers insights on each individual's Profile (**who**[1]), Position (**where**[2]), Behavior and Interactions (**what**[3])—instantly, historically (**when**[4]), and predictively (**what if**[5]).

[1] *Each individual is represented by a unique anonymous ID, enabling every action and event to be accurately tracked and associated.*

[2] *Positions are monitored with high precision and updated continuously to digitize events and movements with the level of detail required for each specific application.*

[3] *Insights extend beyond customers to include how they interact with the infrastructure assets, driving actions based on unique behavioral patterns.*

[4] *Every data point is precisely time-stamped, enabling integration with external data sources and the generation of actionable historical analyses.*

[5] *This rich dataset supports both immediate alerts triggered by predefined thresholds and predictive insights to guide future actions.*

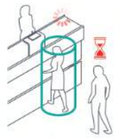
A comprehensive understanding of the Customer's Journey provide insights on **four key aspects**:

Individual Position & Movement

Current location, historical trajectory, dwell times & queuing...

Profiling & Attributes

Staff vs. Visitor, Adult/Child, Wheelchair, Car/Bus, External information and other attributes linked to each person (e.g. POS data)



Events (Time & Location)

Interactions with physical resources, zones of interest and touchpoints (arrival/leaving time, joining a queue, made purchase...)

Business assets utilization & Analytics

Equipment use, Seats, Boarding gates, check-in counters, Sanitaries, Immigration desks... and any other asset.

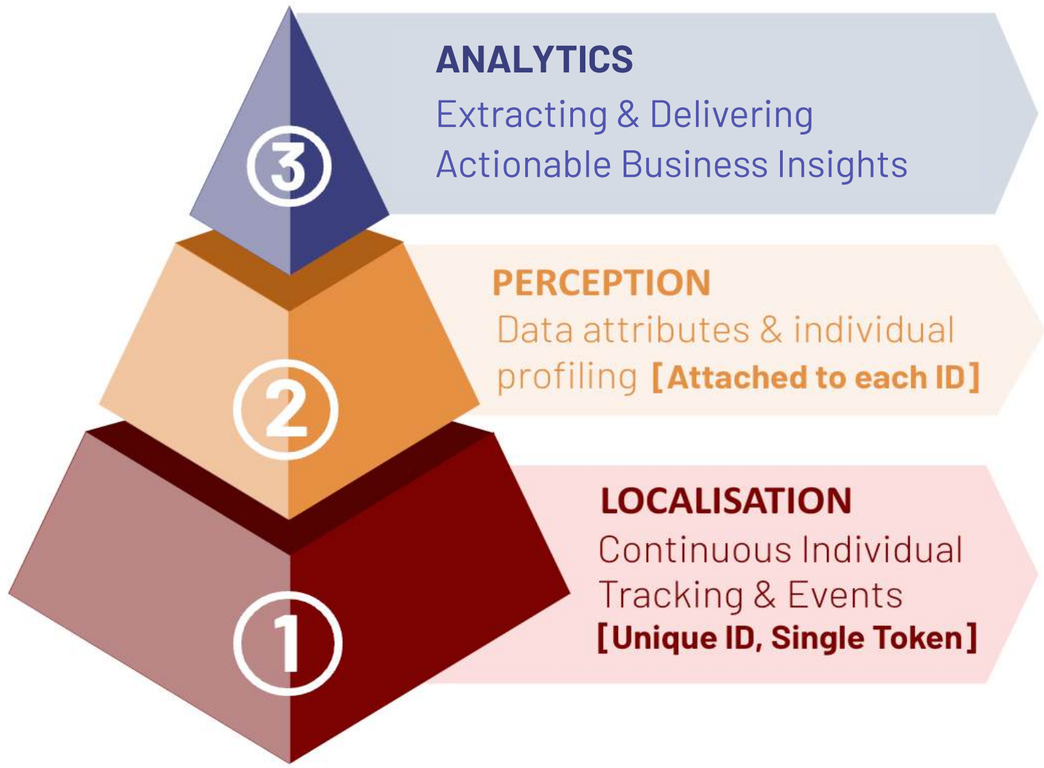
As described in greater detail in the next section, the Spatial AI technology powering a MDT must seamlessly perform three key processes:

- **Localization** -*determining where objects are in the real world,*
- **Perception** -*identifying who they are and what they are doing,*
- **Analytics** - *extracting and delivering actionable insights.*

The essential building blocks

Critical Processing capabilities

Three processes enable the functionality of a Motional Digital Twin, with each building upon the other.



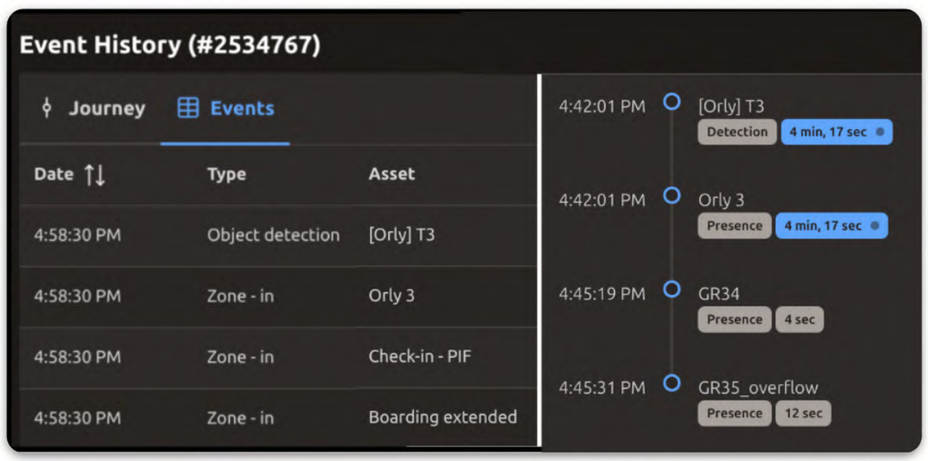
1. **[LOCALISATION] Continuous Individual Tracking**: Precisely positioning each individual person or object, without interruption, across large distances, while assigning a unique anonymous ID to every object.
2. **[PERCEPTION] Situational Awareness**: Perceiving the environment to understand behaviour and associating external data and attributes with each ID.
3. **[ANALYTICS] Actionable Insights**: Converting raw tracking and perception data into business intelligence, performance metrics, and predictive insights that inform strategic and operational decisions.

See Annex B for more details on why legacy sensing technology cannot deliver these capabilities.

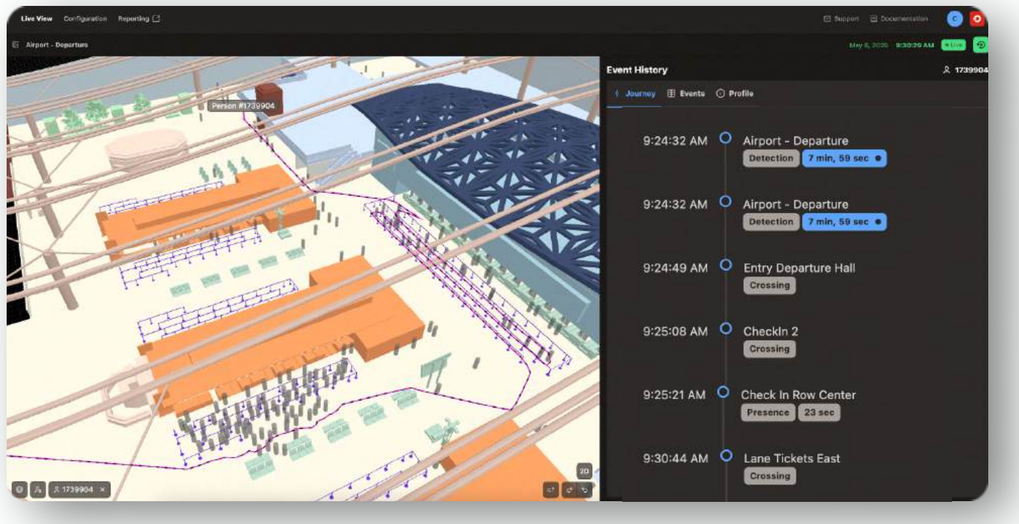
The cornerstone of Spatial Intelligence

1 Continuous Individual Tracking

The first and most critical function, on which all others depend, is the ability to continuously track the position of each person or object [Localisation] across the entire premises and trigger relevant business events based on their behavior.



LiDAR technology's ability to natively and accurately perceive in 3D, combined with advanced Spatial AI software stacks like Outsight's, enables **Continuous Individual Tracking**—the foundation for monitoring movements and interactions in real time.



By assigning a unique, consistent ID to each object, it enables the integration of external data sources, such as attributes, and establishes a stable reference frame for advanced capabilities like Situation Awareness.

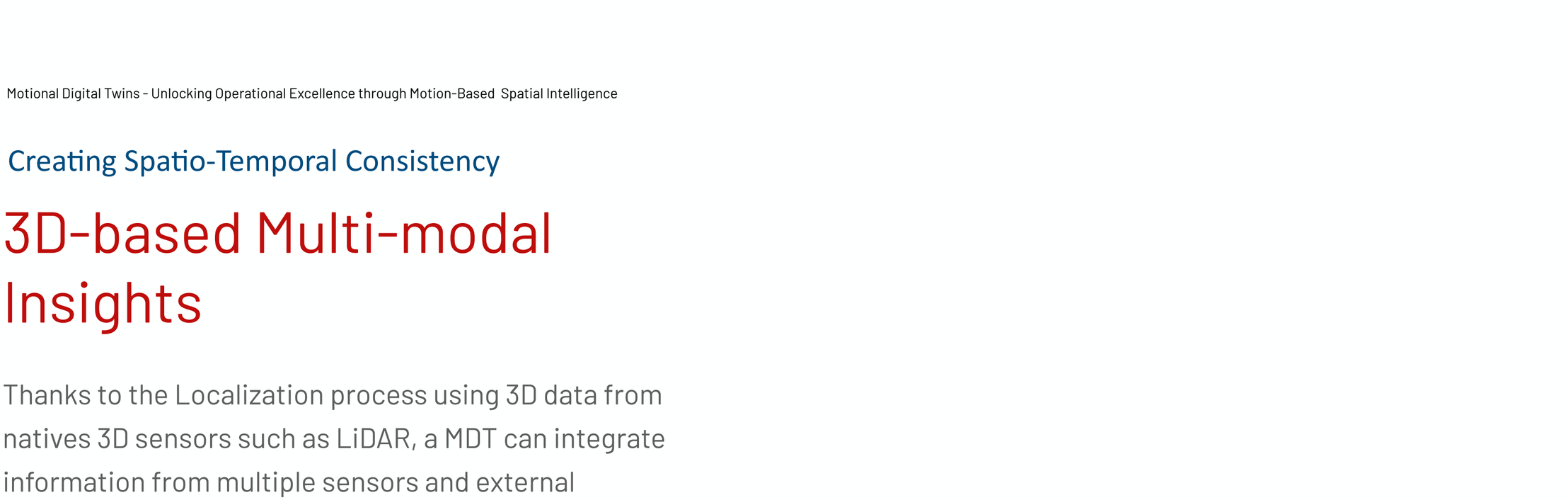
Delivering precise, granular data across large areas, an MDT captures events within a unified spatial and temporal context, transforming them into a comprehensive and actionable understanding of the entire customer* journey.

** this being a customer, shopper, tourist, vulnerable road user, patient, intruder, robot, or worker—depending on the use case and the infrastructure's purpose. See Section "Use Cases" for examples.*

Creating Spatio-Temporal Consistency

3D-based Multi-modal Insights

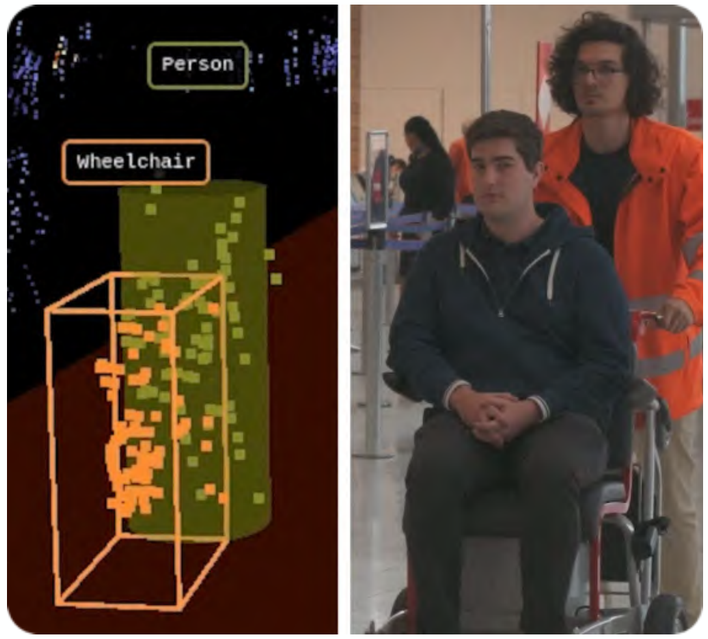
Thanks to the Localization process using 3D data from natives 3D sensors such as LiDAR, a MDT can integrate information from multiple sensors and external sources into a consistent, unified spatial reference.



Perceiving Reality

2 Situational Awareness

Perceiving the physical world is essential to understanding the complex reality of the situation, assigning attributes to each individual, and defining their profile.



Perception capabilities enable Situational Awareness also by scene understanding and object classification.

When combined with ❶ **Continuous Tracking**, the personal attributes can be associated with its unique ID (Single-token).

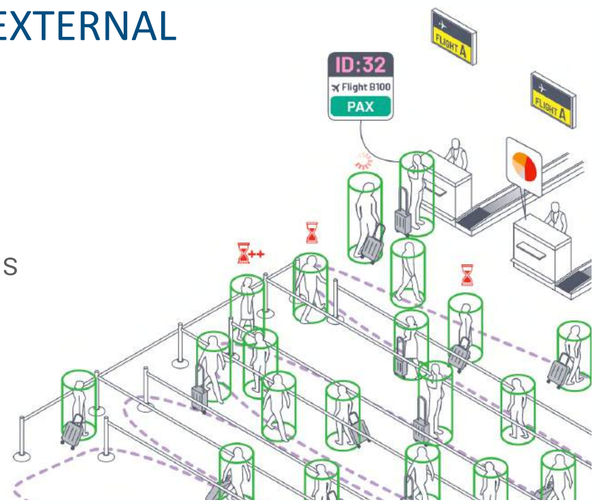
Examples of outcomes enabled by Situational Awareness capabilities:

AUTOMATIC STAFF DETECTION

Detecting employees enhances the accuracy of KPIs *(e.g., excluding them from wait time calculations)* while also enabling new actionable insights, such as workforce optimization.

ATTRIBUTES BASED ON EXTERNAL DATA SOURCES

Each person's ID can be linked to external data sources, such as flight information in Airports or POS data in Retail, enabling a new level of business intelligence to support better decision-making.



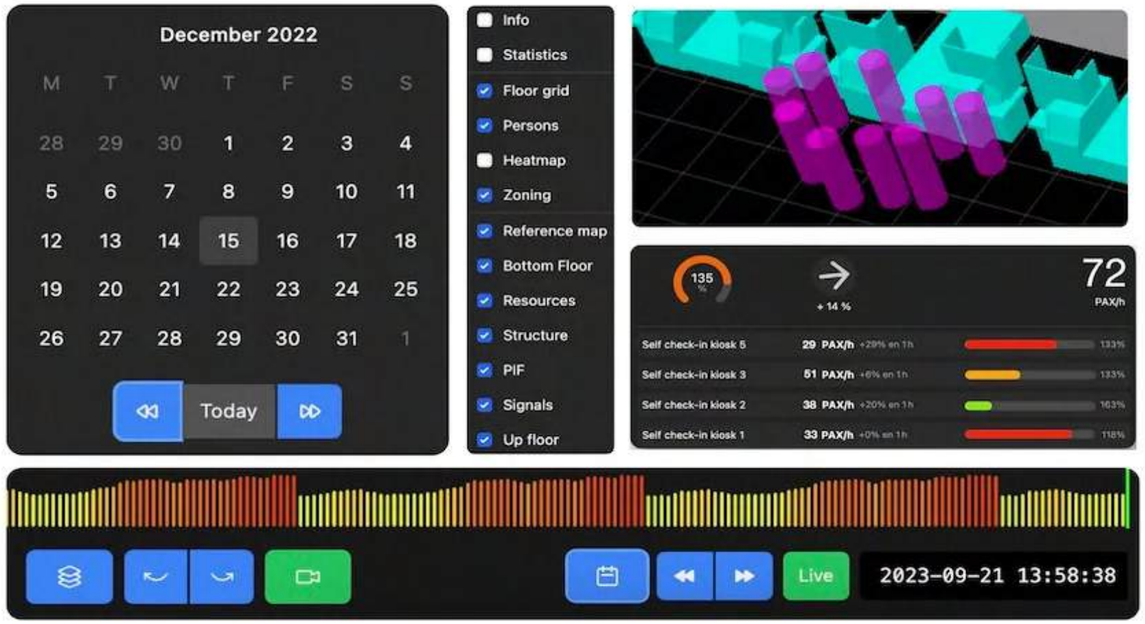
Understanding the real world

3 Analytics

This process transforms raw tracking and perception data into meaningful business intelligence, delivering performance metrics and predictive insights that guide both strategic planning and day-to-day operations.

A MDT must deliver insights across multiple time frames, tailored to the type of information the user needs

Present	Live 3D Map Current KPIs in Dashboard Immediate alerts through SMS/Alerting System ...
Past	Full Customer Journey and Mine History data Navigate to live view at any moment of the past Re-compute current KPIs with past data ...
Future	Anticipate KPIs Predicted Journey per individual profile Event occurence prediction ...

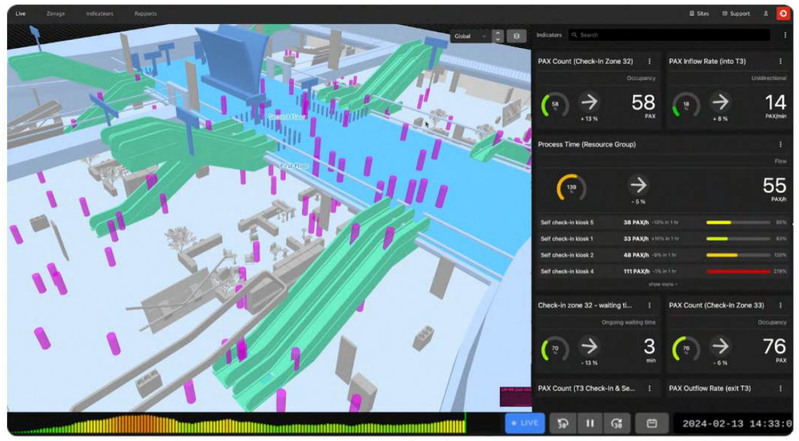


Displaying Reality

Live 3D Map

A 3D replica of the physical world provides a shared spatial reference for all gathered or computed information, enabling users to seamlessly understand the context.

Massive amounts of 3D data can now be streamed live through a simple web browser, with no need for local software installation.



Because the real world is three-dimensional, a Motional Digital Twin must be able to effectively represents scenarios involving multi-level settings.

HETEROGENEOUS DATA DISPLAY

Data from different sources and visible in 3D across the whole premises.

SYNTHESIZED VISUALISATION

A unified, multi-level view of all zones, presenting real-time data in an user-friendly format.

NATIVE PRIVACY PRESERVATION

No images are captured or displayed; each person and asset is represented by a symbol.

INTUITIVE CONFIGURATION

Defining zones of interest and linking assets to their exact locations is as simple as drawing them.

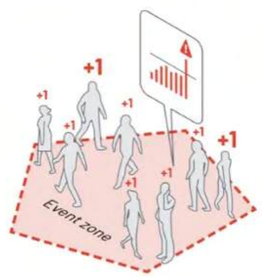
Must-have Features

Key Features (i)

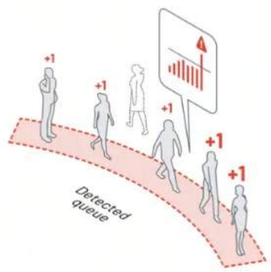
Actionable KPIs

The Analytics' capabilities of a Motional Digital Twin must allow users to seamlessly generate dozens of distinct KPIs through individual person tracking, leveraging a combination of some essential building blocks:

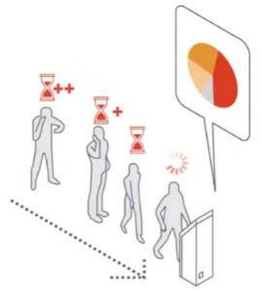
ZONE-BASED KPIS Custom Zones of Interest	Measure occupancy, dwelling time, Count of people In & Out ...
QUEUES KPIS Everything related to queuing	Occupancy in the queue, Actual & Predicted Waiting time & queue length...
LINE CROSSINGS Understanding the Flow	Number of people crossing virtual lines in both directions, Measure and prediction of In&Outflow ...
USAGE OF RESOURCES Interactions with physical assets	Utilization status of each resource, Usage rate, Usage time per person, Staff occupancy ...



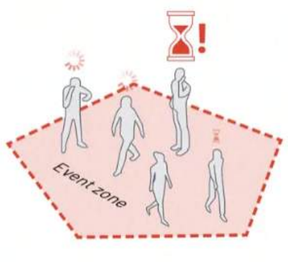
People occupancy in a Zone



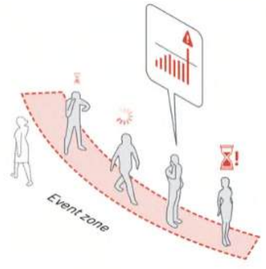
People occupancy in a Queue



Usage of Resources



Waiting time in a Zone

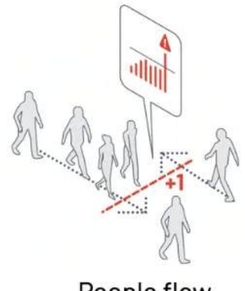


Waiting time in a Queue

Safe distance detection

Premises-wide 3D Heatmap per KPI

Cluster of people detection



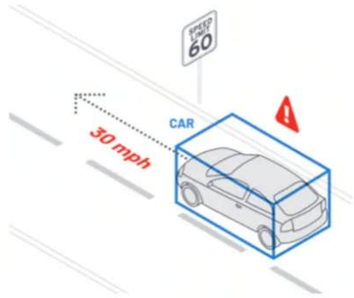
People flow across a line

Key Features (ii)

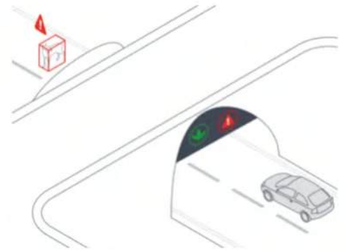
Actionable KPIs

The Analytics' capabilities of a Motional Digital Twin must allow users to seamlessly generate dozens of distinct KPIs by tracking not only individual people but also vehicles and their complex interactions, including pedestrian-vehicle encounters and Vulnerable Road User (VRU) behaviors.

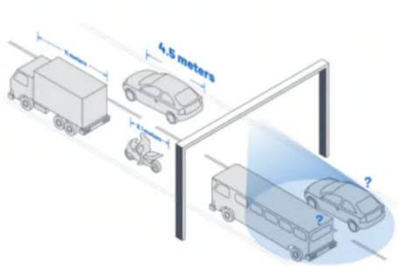
Pedestrian & VRU Safety



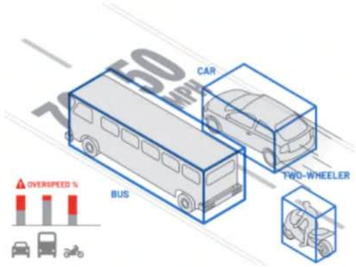
Speed Measurement



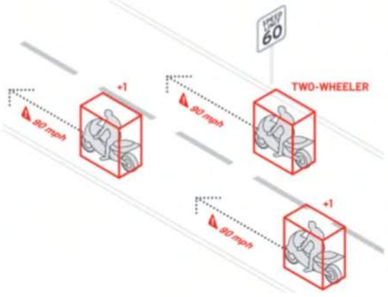
AID & Tunnels



Advanced Tolling



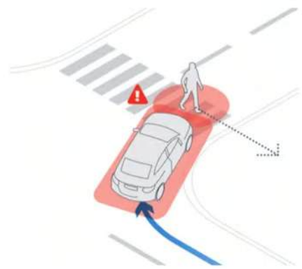
Free-flow & Classification



Multi-lane awareness

Waiting time & Yellow zone

Illegal turns



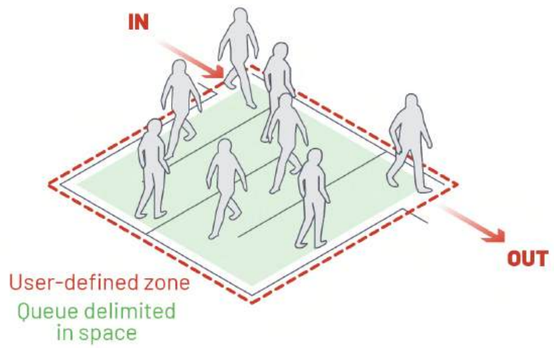
Near-misses

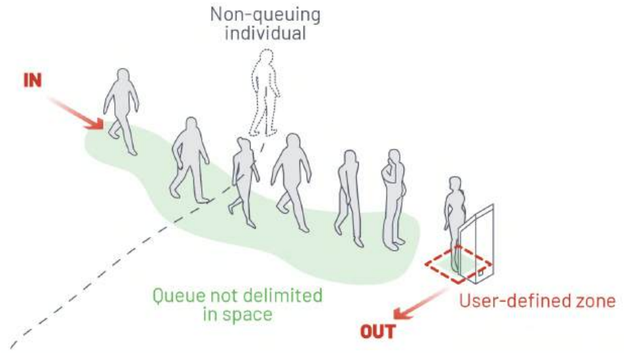
Key Features (iii)

Support for various types of Queues

An efficient MDT manages both structured and unstructured queues, enabling the application of advanced features such as Overflow Detection and Waiting Time analysis in dynamic queues.

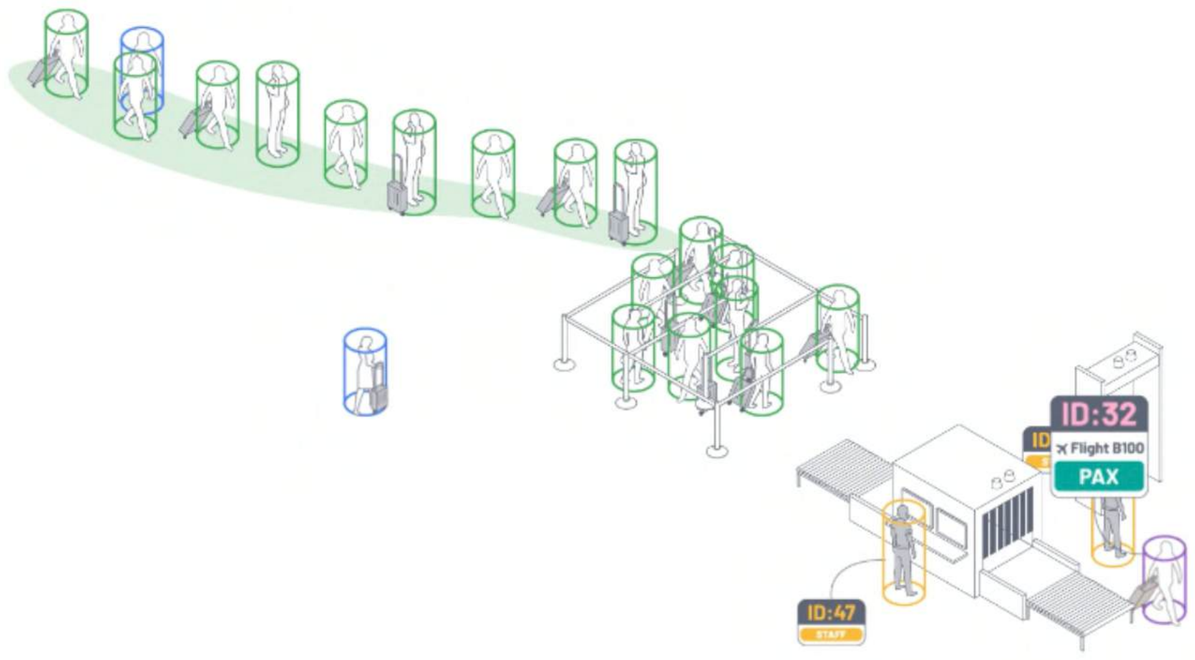
These capabilities support real-time adjustments and optimize staffing efficiency.





Precise individual tracking, staff detection, and external data attributes and resource utilisation KPIs can be integrated to provide robust, **real-time actual and predicted wait times**—dynamically excluding non-queuing individuals.

The Digital Twin view adds also a live visualisation and related KPIs of the current and past situation on any waiting zone.



Key Features (iv)

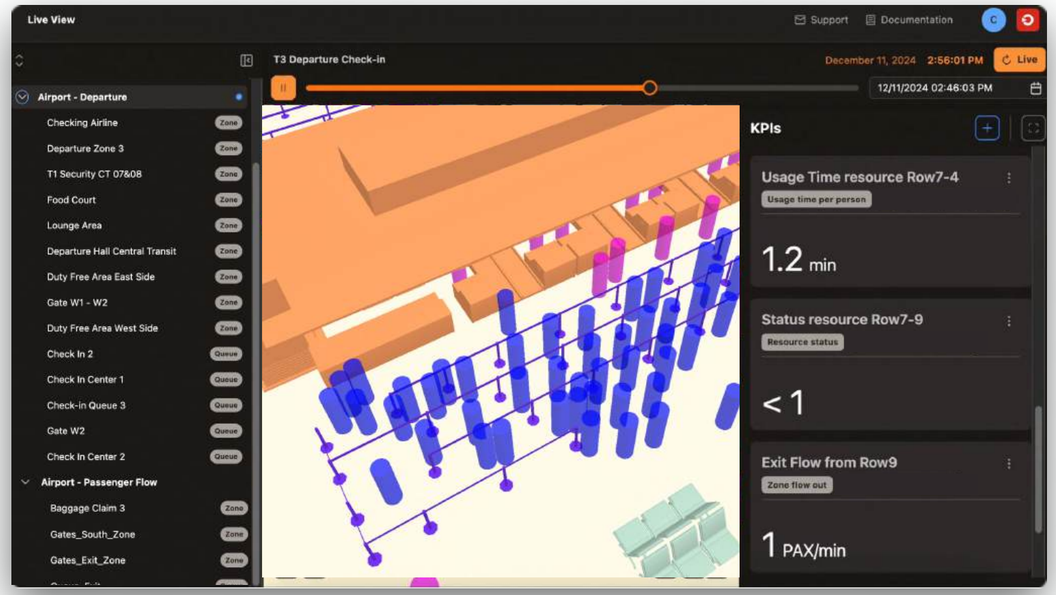
Business Assets Utilization

An comprehensive MDT must provide detailed insights into the utilization patterns and operational status of critical assets, enabling precise monitoring and data-driven decision-making.

These capabilities enhance resource allocation, improve efficiency, and support predictive maintenance strategies to minimize downtime and maximize performance.

A Business Asset, in this context, is a broad, abstract term used to define any physical location or equipment that a person can interact with, represented on the live 3D map as a Zone of Interest.

Examples include diverse elements such as check-in counters, passport control counters, retail displays, or waiting seats.



The Motional Digital Twin representation provides a seamless interface for creating and configuring these assets across the entire terminal or airport.

KPI data generated from asset utilization—including resource status, usage rates, usage time per person, and staff occupancy—must be accessible in real time through live views and alerts based on custom thresholds. A State-of-the-Art MDF platform must also provide the ability to analyze historical trends through a dedicated Timeline feature.

Key Features (v)

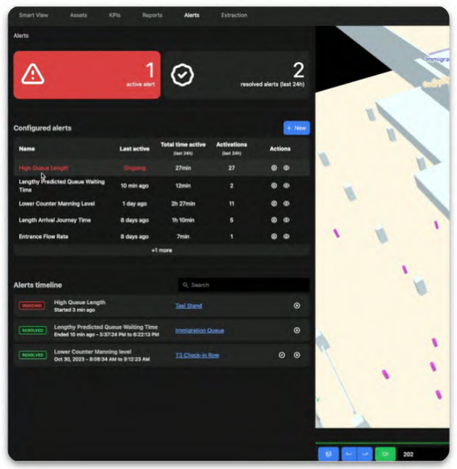
Alerting module

Any authorized user must be able to conduct centralized monitoring, perform real-time data analysis, and manage optimized operations across interconnected locations, ensuring efficiency and scalability.

In addition to the 3D immersive view and KPI widgets, the platform must be able to deliver alerts directly within the dashboard or trigger them via text message or email.

Outsight Solution at Charles-de-Gaulle Airport: The live view must be accessible through any standard web browser.

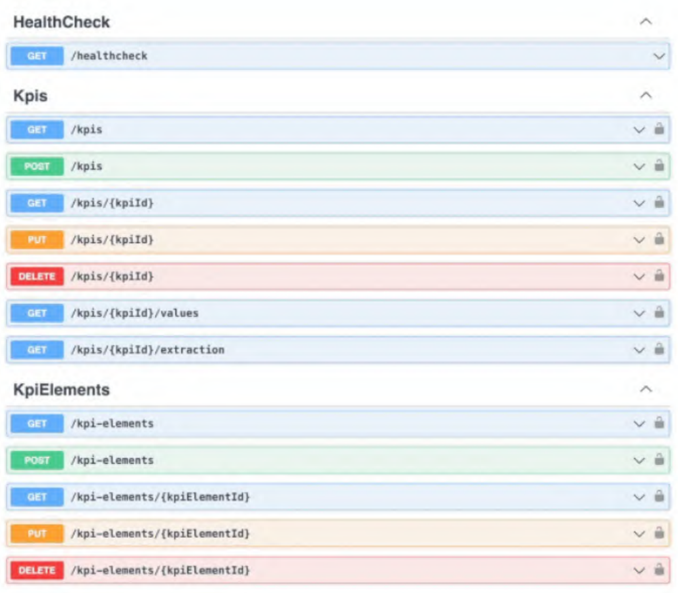
Authorized end-users must be able to configure their own alert thresholds and event's types:



Key Features (vi)

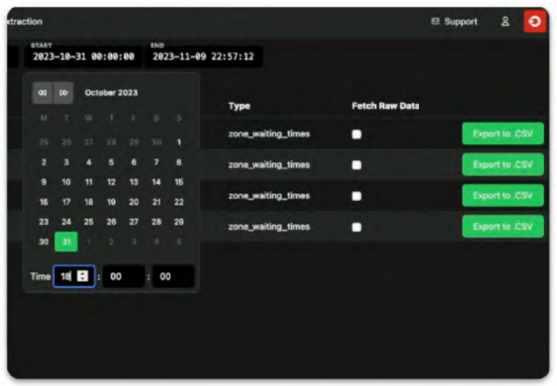
Timely and Relevant Data Delivery

The MDT caters to the diverse needs of infrastructure stakeholders by providing flexible access to business insights through multiple formats.

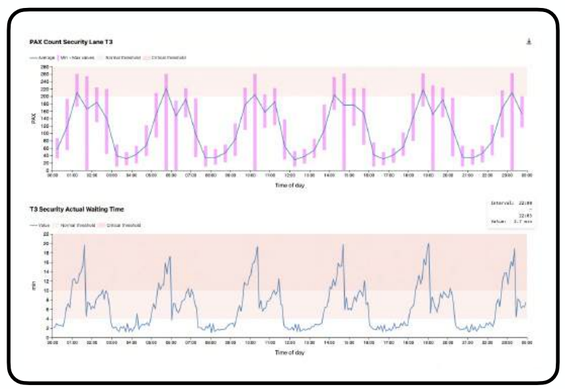


The API must provide an additional way to integrate a MDT with other systems

Whether requiring **immediate action** via alerts, **live monitoring** through an immersive 3D view, **in-depth analysis** with regular PDF reports, or **data mining** through exportable datasets, each user must be able to access information in the most suitable and effective way.



CSV Data Export



PDF Reports

A Timeline feature must allow users to replay the "Live" view from any point in the past while also displaying all events of the passenger journey within the 3D map.

As a result, the data can be accessed across various time frames—past events, the current situation, and predicted future— and in multiple formats.

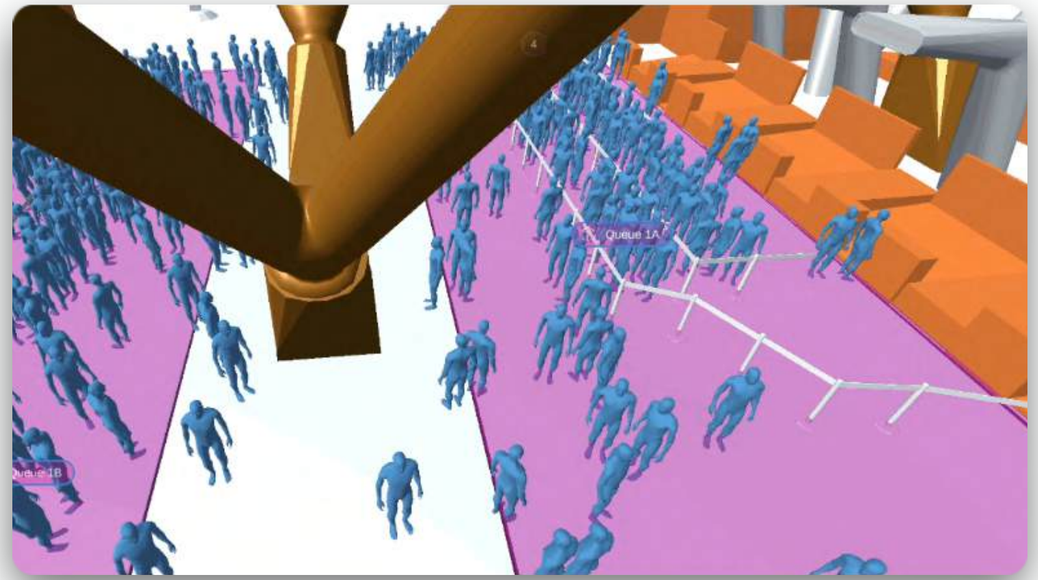
Multi-Vendor Simulation capabilities

Cost-Effective Hardware Planning and Positioning

Selecting the right sensors during the Design phase of a Motional Digital Twin can be challenging, as multiple manufacturers offer models that differ significantly in features, performance, and price.

Ranging from affordable options to premium high-end sensors costing two to three times more, a Multi-Vendor 3D Simulator is an essential capability of any MDT state-of-the-art platform, enabling users to evaluate trade-offs, optimize configurations, and ensure seamless integration—delivering the best performance at the lowest cost.

A Multi-Vendor 3D Simulator must allow users to plan deployments, optimize configurations, and simulate performance across multiple hardware vendors. It ensures the ideal selection and positioning of sensor models at the lowest cost, identifies strategic installation locations, and supports seamless integration.



Monitoring Module

Scalable Sensor Telemetry and Management

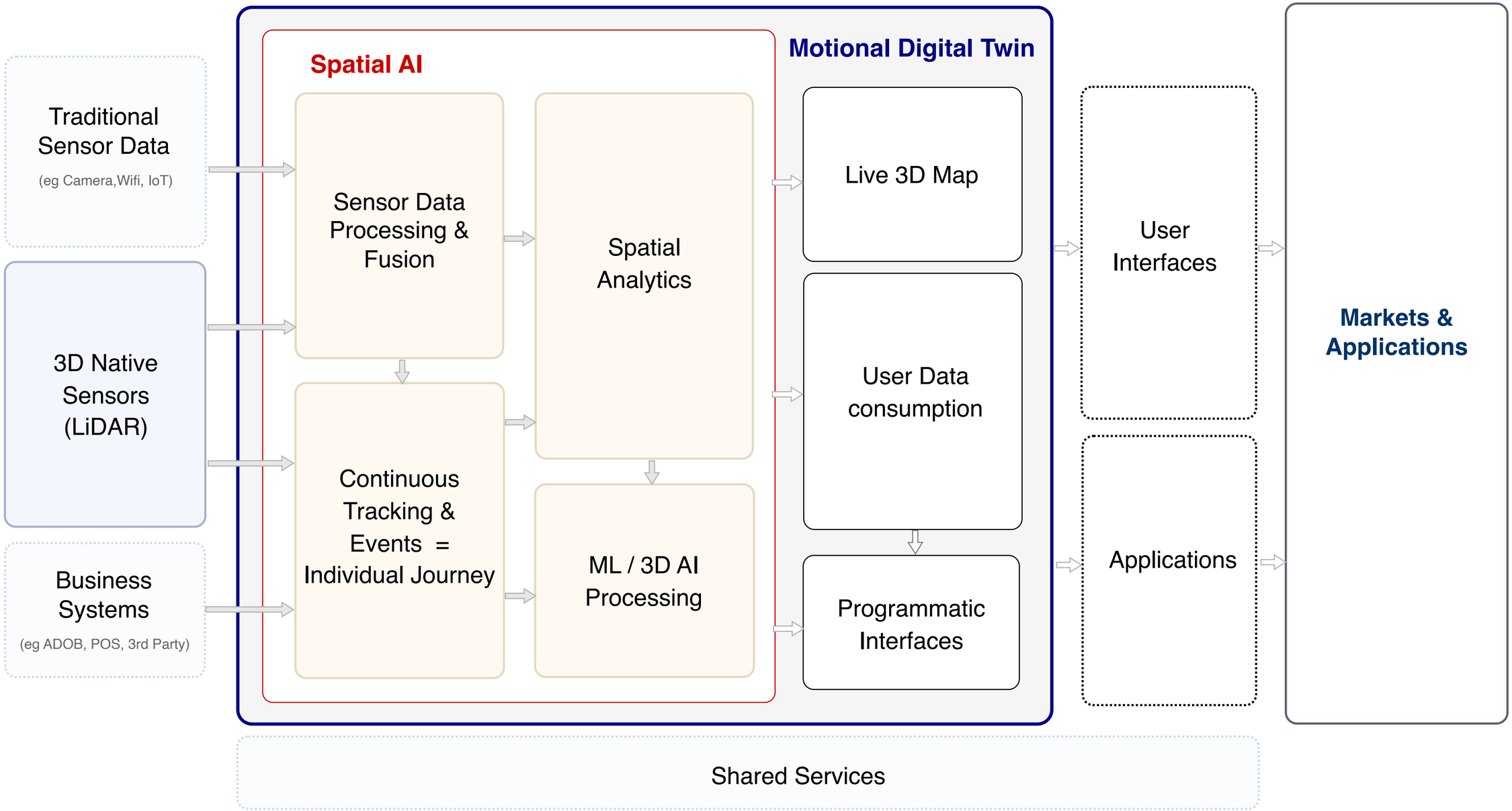
A robust MDT platform must include a monitoring module capable of supporting the deployment and operation of a large fleet of 3D native sensors and external data sources across expansive areas, such as airport terminals, smart cities and large venues.

An effective monitoring module should enable seamless deployment, real-time monitoring, and ongoing maintenance of thousands of devices, ensuring reliability, scalability, and optimal performance.

Reference System Overview

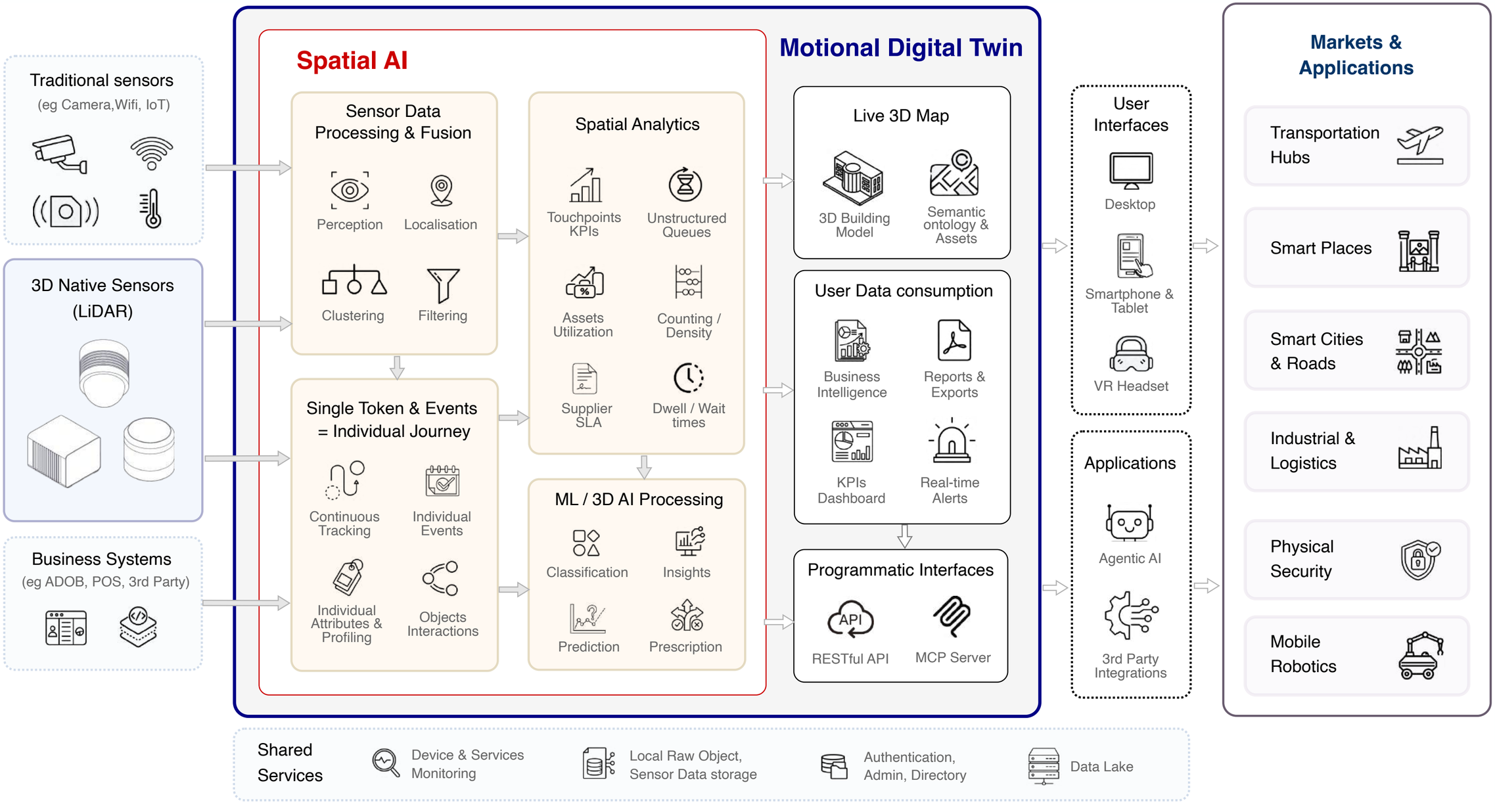
Functional Architecture

Simplified view of the main components.



Functional Architecture

Detailed view based on Outsight's SHIFT Platform



Agentic AI for Motional Digital Twins

Leveraging Spatial Intelligence with genAI

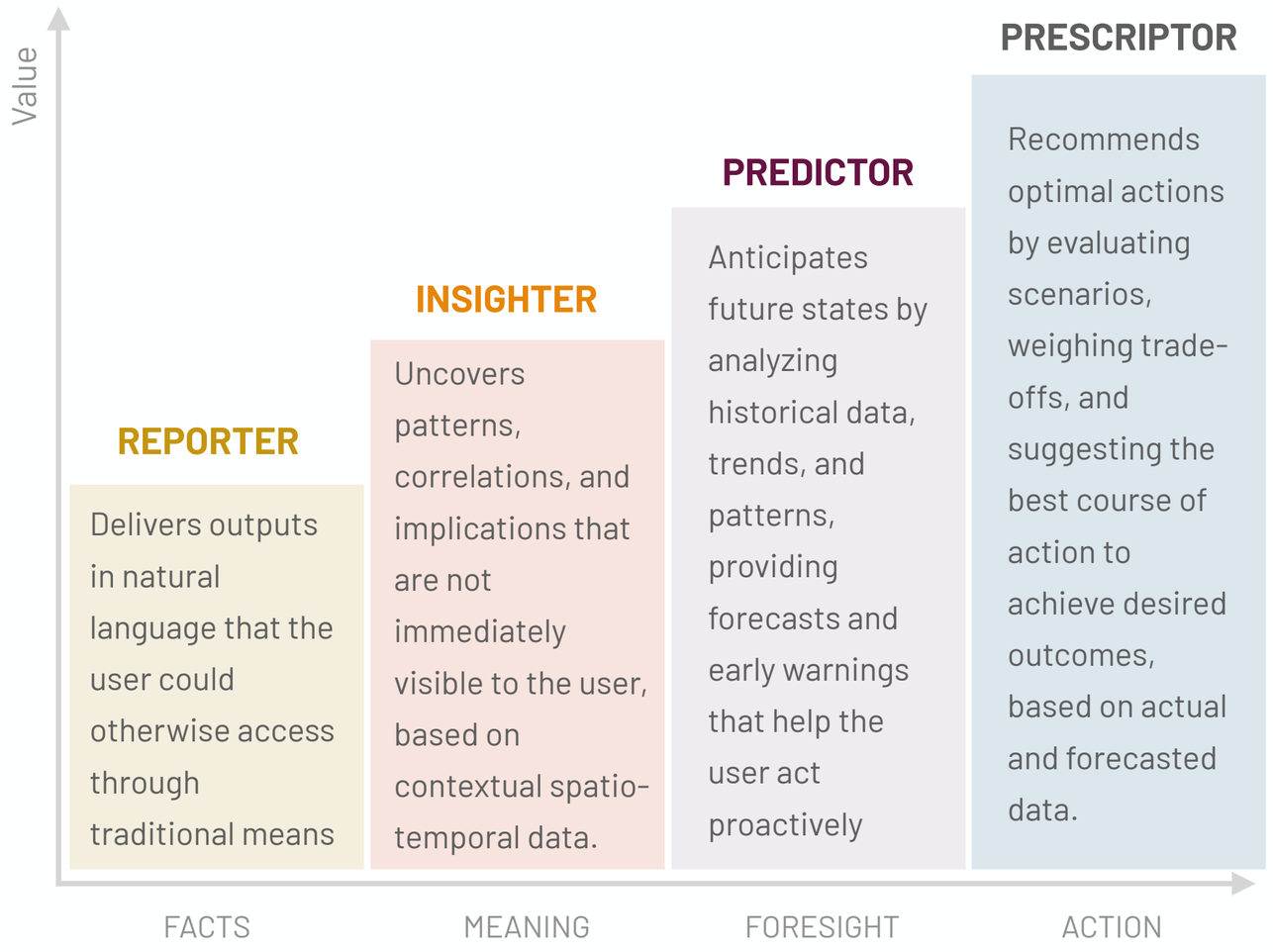
AI Agents in the Motional Digital Twin era

Motional Digital Twins generate unprecedented volumes of structured data, capturing both granular individual-level insights—including complete person journeys and detailed profiling—and comprehensive aggregated KPIs.

This data uniquely stems from a real-world reference system where every behavior is captured through time-stamped, spatially-defined events for each individual, establishing unique relationships to external data sources.

This rich, contextualized dataset creates an ideal environment for AI Agents to thrive and evolve through four distinct maturity levels.

Type of Agents by maturity level, leveraging Motional Digital Twins insights:



What is the current waiting time at the United Airlines check-in counters?	FACTS
Show me the anomalies detected in Terminals 1 and 2 last week, by airline.	MEANING
What is the expected Duty Free revenue from First Class passengers next week?	FORESIGHT
Build the workforce schedule for passport control tomorrow to keep waits under 3 min.	ACTION

Market Applications and Use Cases

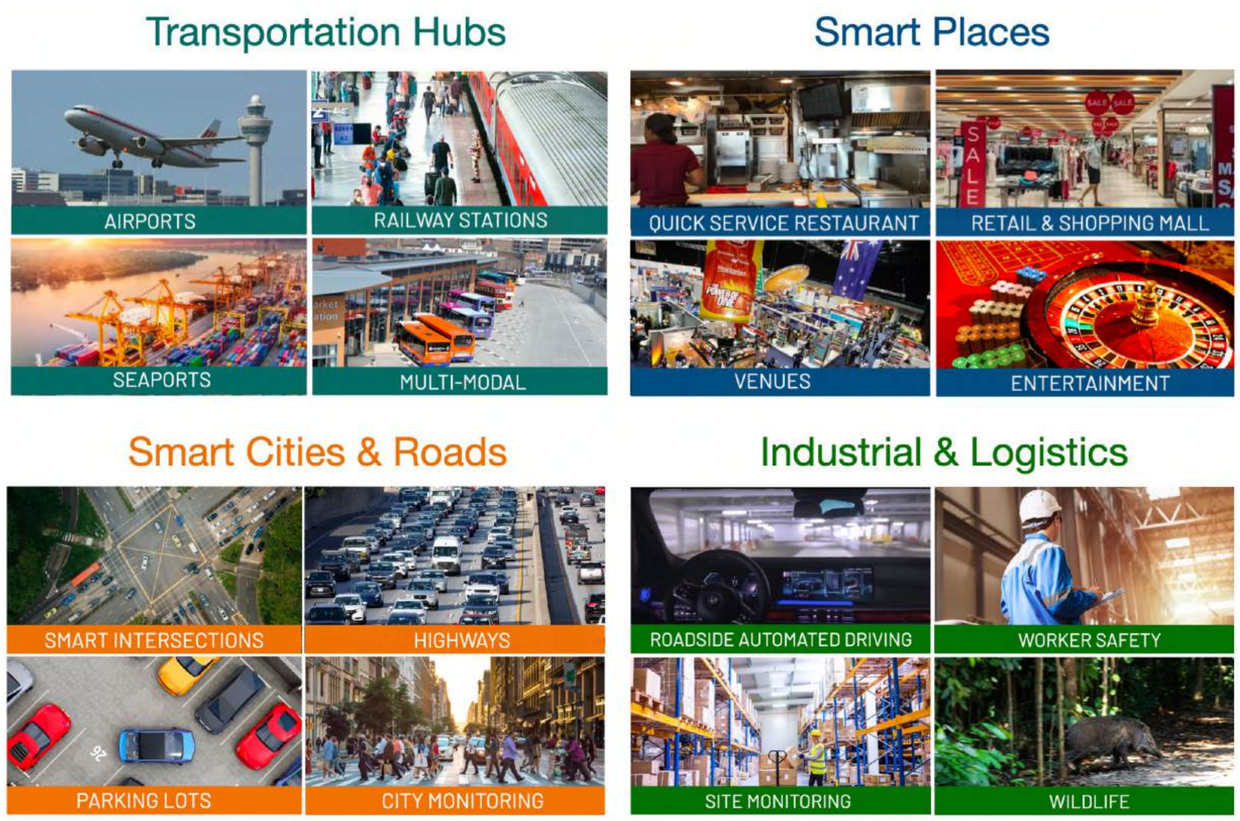
A horizontal solution

One platform, many markets

Users of Motional Digital Twins are operators managing complex infrastructures with intense human and vehicle activity, across all vertical markets.

Looking for a detailed description of these use cases? Request access to our Applications Overview document.

Motional Digital Twins are no longer an innovation—they are a proven solution, deployed at scale by market leaders like Outsight across diverse contexts and geographies.



In the following pages, we highlight some real-world examples that show how this transformative solution is being applied across diverse use cases and markets.

Transportation Hubs

Adoption Drivers

- Increasing traffic requires **improving operations** within current facilities.
- Provide brilliant **Passenger Experiences** while ensuring privacy.
- **Enhance Security & Safety** (outdoor & indoor)
- **Optimize Revenue** from Retail, Parking & other ancillary activities.

International Airports all over the world are deploying Motional Digital Twins at scale.

NEWS

Aeroporti Di Roma selects Outsight's LiDAR Solution

NEWS

The Paris Airport Group (ADP) chooses Outsight's solution

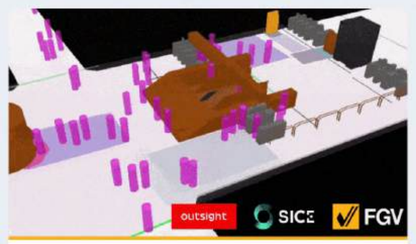
NEWS

A Major US Airport Selects Outsight for the World's Largest 3D LiDAR Deployment

While airports are leading the way, the adoption of Motional Digital Twin platforms is rapidly expanding across train stations, port terminals, and beginning to take hold in public transport hubs, including multi-modal platforms.

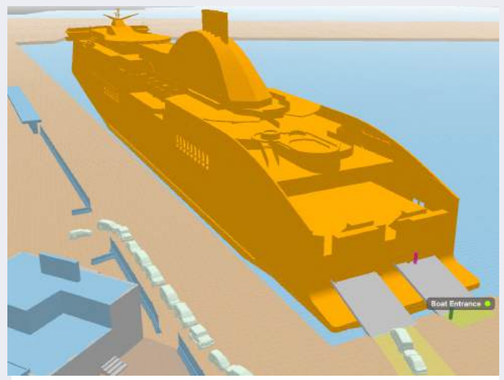
APPLICATIONS

Enhancing Passenger Flow at train stations: SNCF Gares & Connexions Partners with Outsight



NEWS

Outsight, Sice and FGV partner to use 3D Spatial Intelligence for Train Stations in Spain



Motional Digital Twin of Port of Valencia - Ferry Terminal

More Than Indoor Applications

Use Cases Spotlight

Beyond managing passenger flows inside terminals, transportation hubs present a wide array of additional applications for Motional Digital Twins, with several standout use cases worth highlighting.

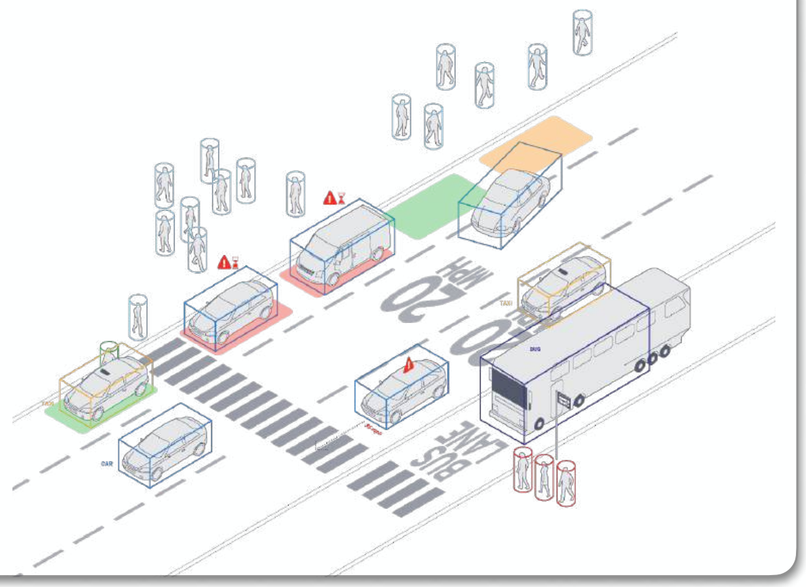
APPLICATIONS

LiDAR monitoring for Safer and Smarter Parking Lots

Another common use case in Transportation Hubs is to efficiently manage parking lots.

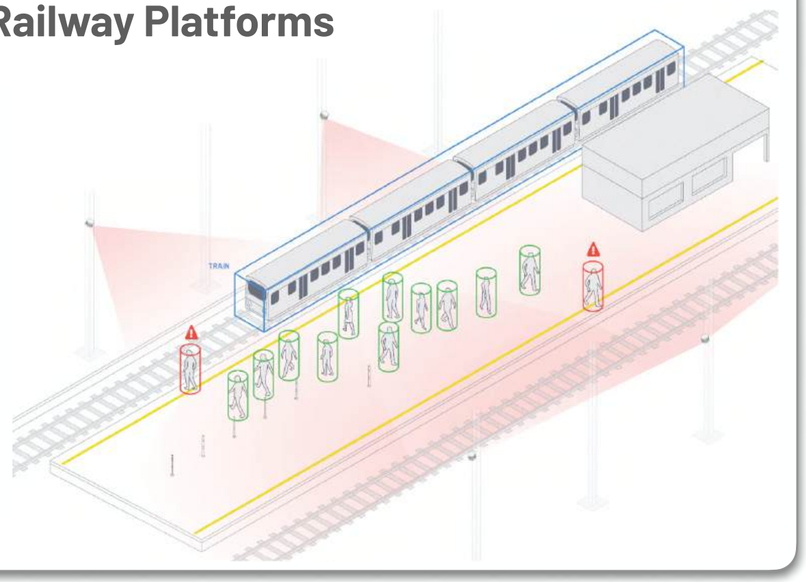
Curbside Monitoring

Accurately count people and vehicles, measure dwell times, monitor queues, and receive real-time alerts on overstays, vehicle spacing, and speed—all enhancing efficiency and safety.



Passenger Safety in Railway Platforms

Continuously monitor passenger trajectories to anticipate risky behaviors in crowded situations, ensuring safety on railway platforms through real-time alerts and proactive incident prevention.

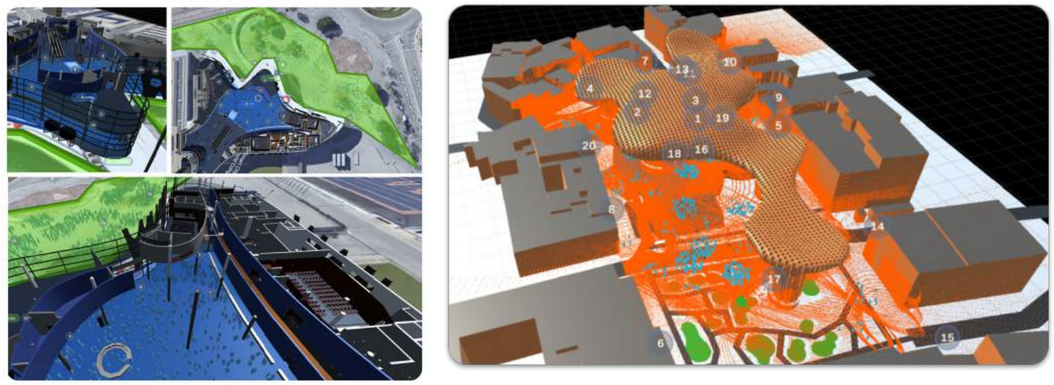


Smart Places

Adoption Drivers

- **Improve Visitor's experience** and eliminate line abandonment by reducing waiting times and bottlenecks.
- **Optimise Sales** by Full Shopper Journey and conversion patterns understanding.
- Increase Security & Safety in crowded spaces.
- Find solutions to **growing Privacy concerns**.
- **Adapt the Workforce to actual demand** thanks to accurate predictions and precise KPIs.

Beyond transportation, Motional Digital Twin technology is transforming a wide range of sites—from world-renowned tourism landmarks and museums to retail malls, stores, casinos and sports venues—each becoming smarter through the unique actionable insights unlocked by digitizing the physical flow of people and vehicles.



It is not only about people—many environments involve a constant interplay with vehicles. Quick Service Restaurants are a prime example, where Motional Digital Twins create value by unifying outdoor vehicle monitoring with indoor customer behavior analysis, delivering seamless insights within a single frame of reference.

Indoor

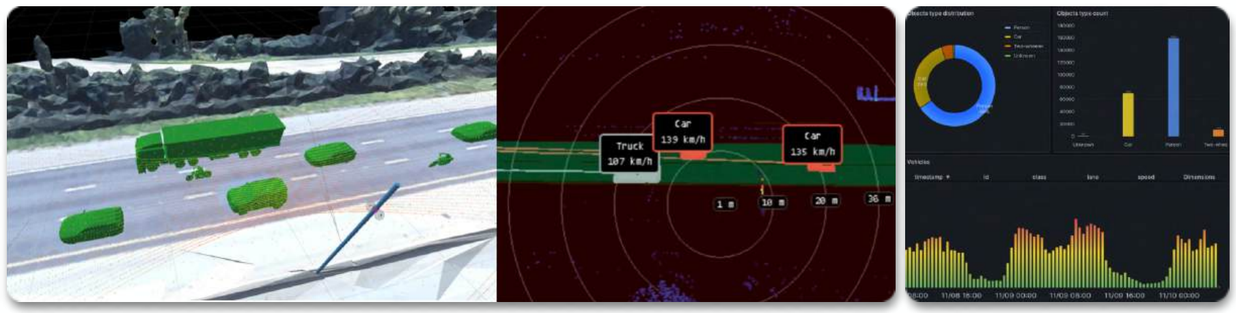
Drive-through

Smart Cities & Roads

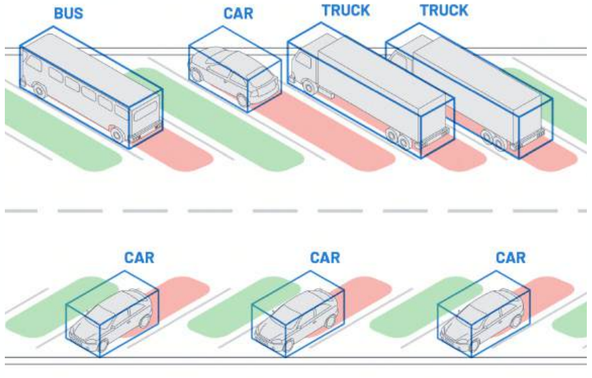
Adoption Drivers

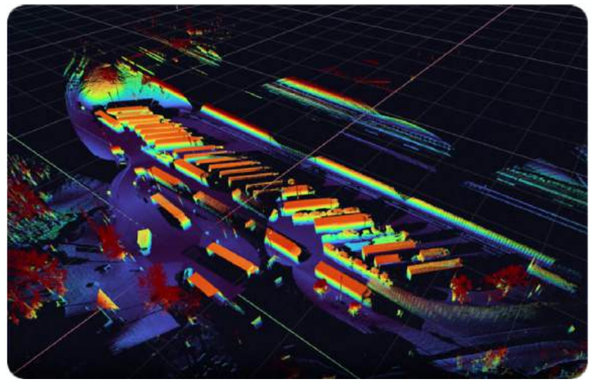
- **Accident Reduction** ie. Vision Zero, with increased mixed traffic (ie. Vulnerable Road Users)
- Managing and **Optimising traffic flow (**ie. Tolling), requiring accurate Perception in all lighting and weather conditions
- **Sustainability requires increased Awareness** (ie. Parking & Lighting optimization, City access)
- **Replacement of older ITS solutions** (ie. 2D LiDAR, Low-Res Radar)

In the context of Smart Cities and Intelligent Transportation Systems, the applications of Motional Digital Twins are virtually endless—from highway monitoring and safer, smarter intersections to optimized parking efficiency—unlocking new levels of urban mobility and resilience.



As the market leader, Outsight has deployed Motional Digital Twin solutions across most ITS contexts and is the only company worldwide to obtain BASt certification from the German Federal Highway and Transport Research Institute for highway truck parking monitoring with native 3D sensors.





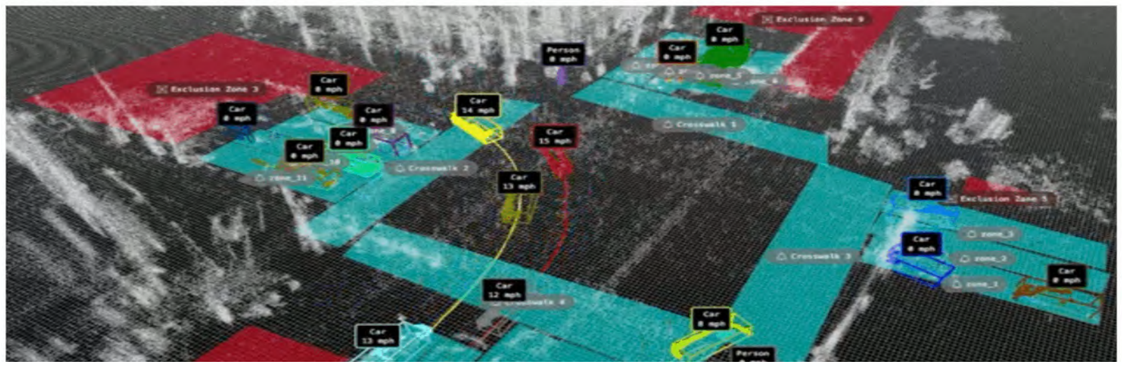
Use Case Spotlight

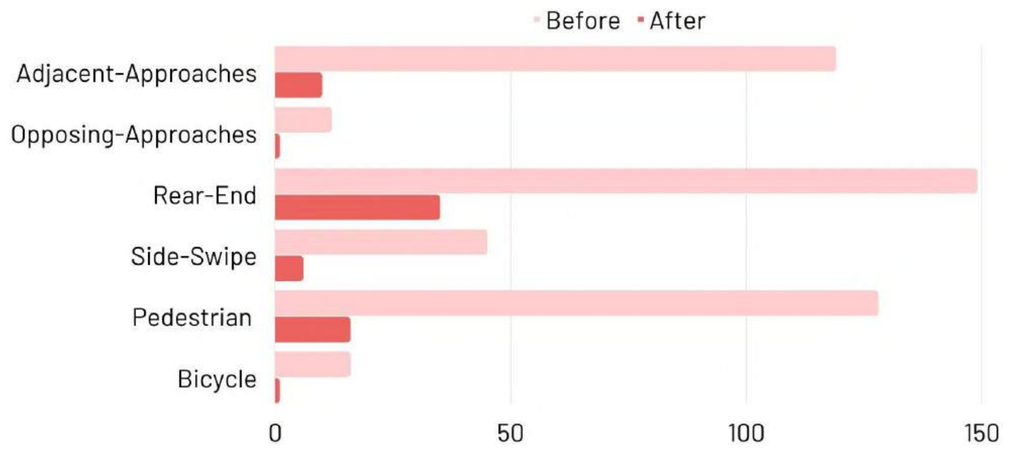
Safer & Smarter Intersections

Traffic safety data reveals a critical disparity in crash outcomes for vulnerable road users, as people walking and bicycling represent just 5% of all crashes but account for a disproportionate 55% of all fatal and serious crashes, with 41% of all pedestrian fatalities and serious injuries being attributable to failure to yield.

Recognizing the urgent need to address this safety gap, the City of Bellevue, Washington, deployed Motional's Digital Twin solution from Outsight specifically focused on improving Vulnerable Road Users (VRU) safety, achieving significant improvements across all key performance indicators

	Before	After	Difference
Adjacent-Approaches	119	10	-91.60%
Opposing-Approaches	12	1	-91.67%
Rear-End	149	35	-76.51%
Side-Swipe	45	6	-86.67%
Pedestrian	128	16	-87.5%
Bicycle	16	0	-100%





Making City of Bellevue's Roads Safer: How Outsight's Software Changed the Game

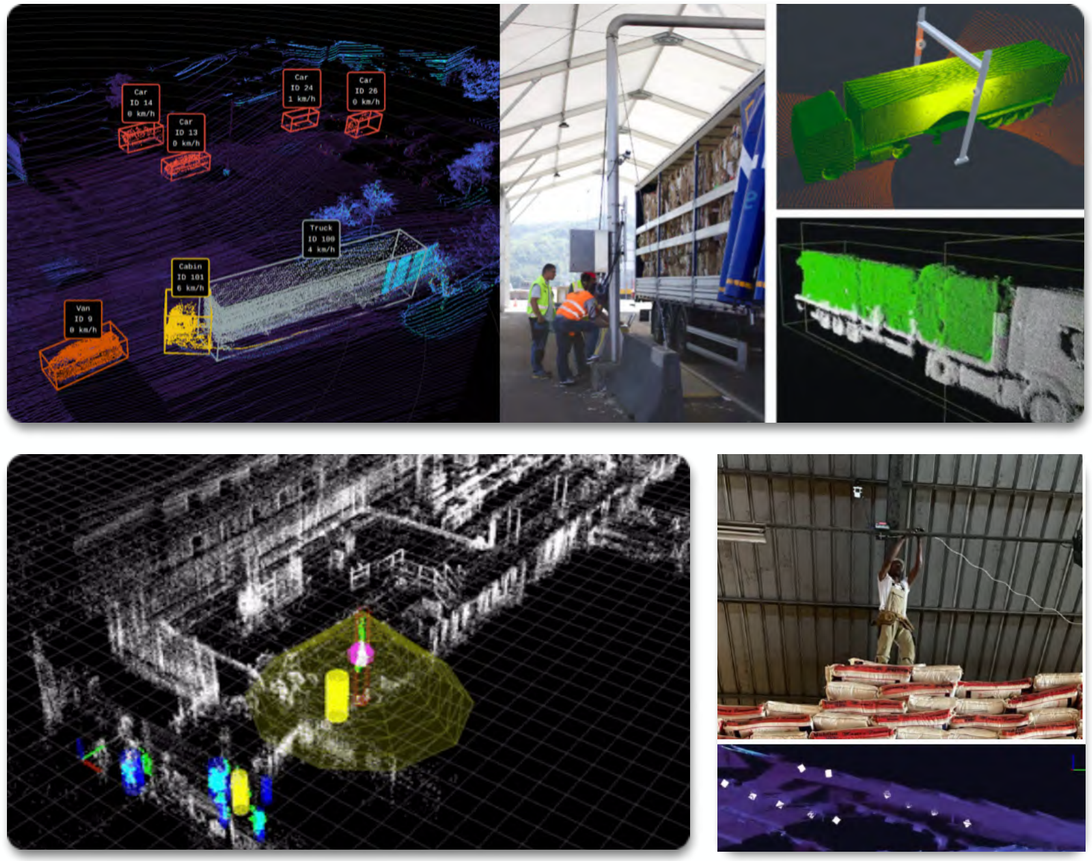
Learn more about this customer testimonial at insights.outsight.ai

Industrial & Logistics

Adoption Drivers

- **Process Automation** requiring precise 3D data.
- Increasing needs to **Improve Operations** through accurate Perception
- **Replacing 2D LiDAR Sensors** by 3D Perception (fewer sensors, cheaper and easier installation)
- **Increasing Worker Safety** with fewer false positives while keeping full Privacy
- **Sustainability** requiring increased Physical Flow Awareness

In industrial and logistics environments, typical use cases of Motional Digital Twins include the precise and anonymous monitoring of workers to enhance safety, along with comprehensive situational awareness of industrial vehicles and equipment across the site.



On the left, a Volumetric Crane Safety use case; on the right, Outsight's MDT solution deployed in a rice warehouse in Cameroon.

Mobile Robotics

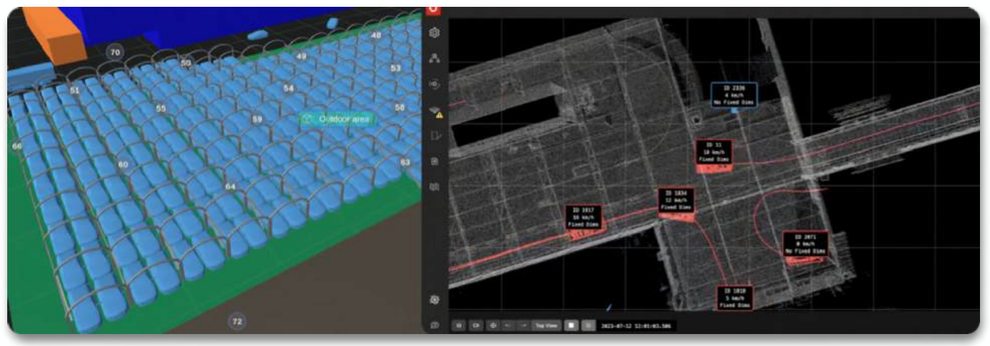
Adoption Drivers

- **Beyond Line of Sight** – Needed for full awareness and obstacle detection.
- **Autonomous Navigation** – Requires 3D mapping and localization.
- Fleet Coordination – Needs **shared spatial intelligence** for safe sharing and cost reduction.
- Enhanced Safety – **Accurate detection with privacy preserved.**

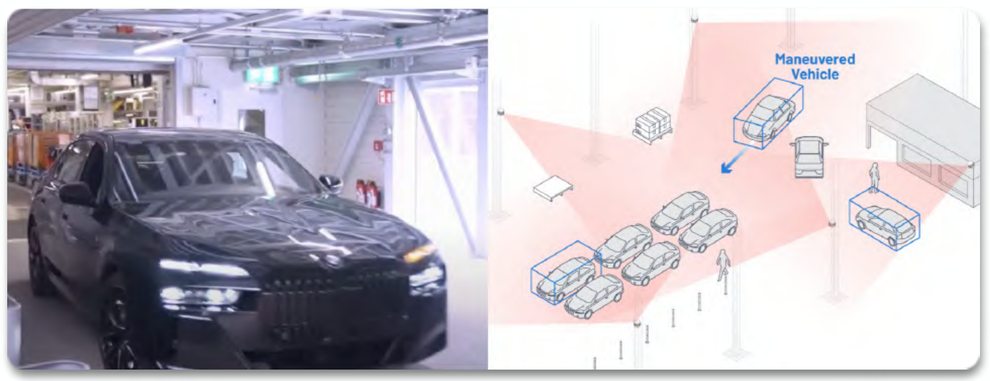
Outsight's solutions deployed for mobile robotics in Oil & Gas contexts (credit Cybernetix)

A mobile robotics solution deployed at scale at BMW factories

Outsight's MDT is deployed in factories and warehouses for mobile robotics, guiding vehicles from production lines to parking lots or across yards while ensuring pedestrian safety.



Outsight's Spatial AI enables ultra-low latency 3D perception for autonomous vehicle guidance and fleet awareness, beyond the line of sight of each robot, with over 280,000 moves completed and thousands added daily.



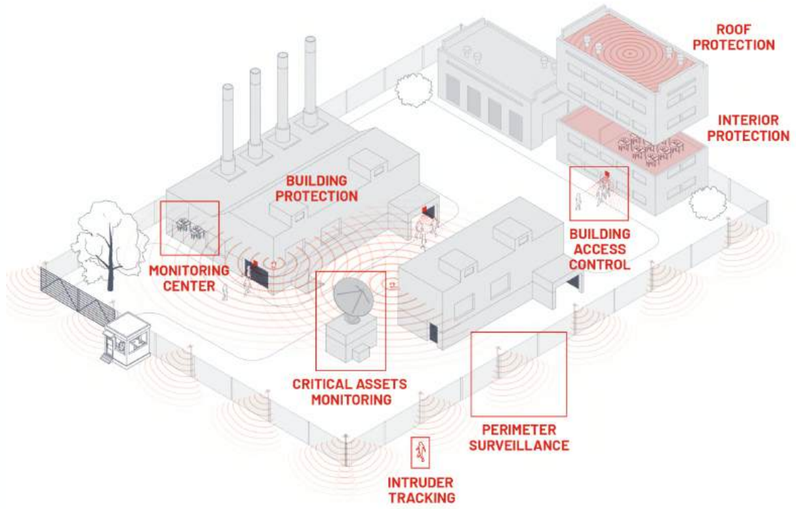
Providing full situational awareness from the infrastructure applies not only to cars and trucks in factories but to any mobile robot use case.

Physical Security

Adoption Drivers

- **Rising Threats:** Demand for smarter, more precise security solutions.
- **Beyond Perimeters:** Protection must cover pre-intrusion and on-site behavior.
- **Critical Assets Monitoring**:Requires 3D perception beyond legacy sensors.
- **Fewer False Positives:** Reliable detection in all weather and lighting.

In security applications, a Motional Digital Twin goes beyond providing comprehensive 3D perception, by creating a seamless reference frame for integrating other valuable data sources.

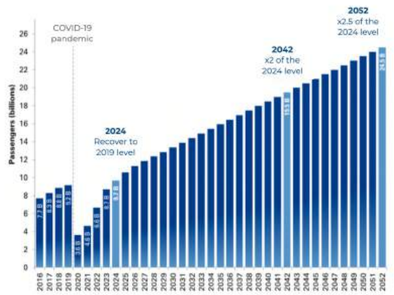


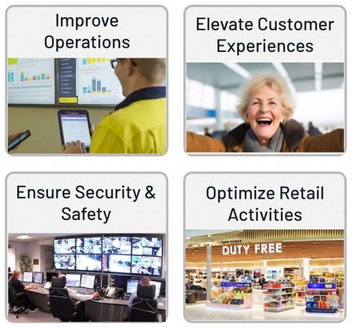
Third-party systems such as VMS can both consume MDT insights—like KPIs from smart cameras—and act upon them, for example by automatically directing a PTZ camera toward a specific event detected by the platform.

Key Takeaways

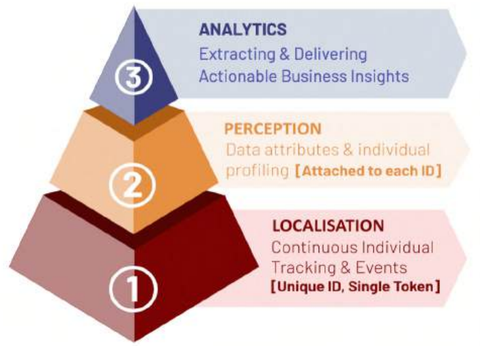
Key Takeaways

In a context of growing challenges to operate their infrastructures, operators must **optimize existing facilities through precise monitoring** to enhance efficiency, safety, and customer experience.

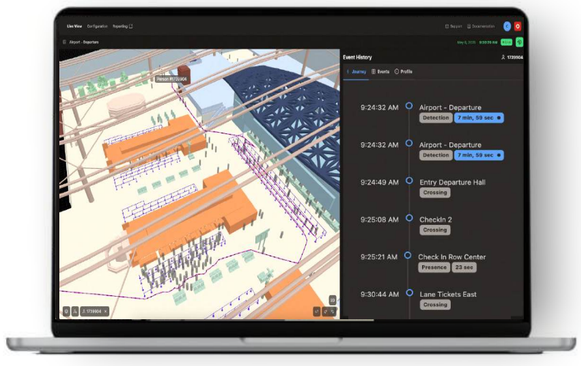


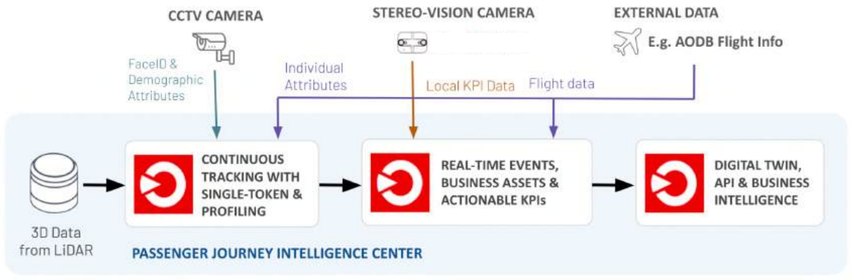


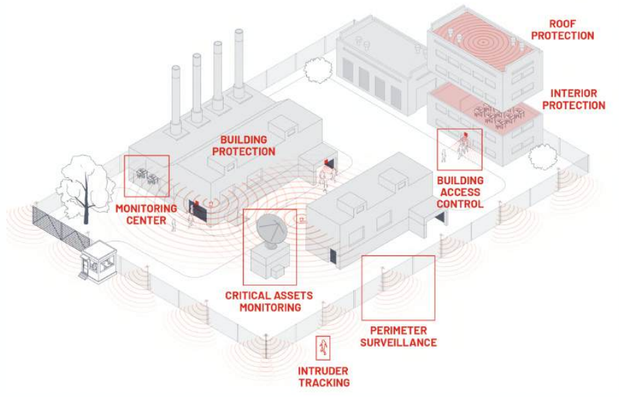
This requires solutions to **digitize each customer's full journey in real-time**, going beyond the capabilities of legacy technologies, in an integrated platform that replicates reality.



A **Motional Digital Twin (MDT)** is an advanced Digital Twin platform that enables infrastructure operators to monitor and optimize people and vehicle flows. It combines 3D sensing hardware, additional external data sources, and Spatial AI to generate Spatial Intelligence—actionable insights delivered within a consistent 3D reference system. By providing a live replica of reality, a MDT unlocks capabilities far beyond traditional static Digital Twins, serving as the concrete medium through which both operators and AI Agents can fully leverage the value of Spatial Intelligence.







Other resources

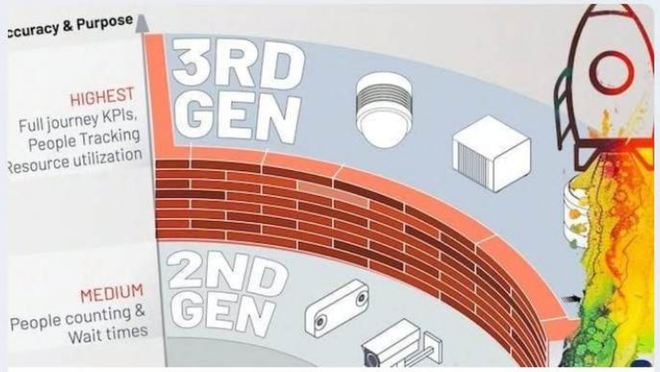
Find all our Insight Articles here: www.outsight.ai/insights

TECHNOLOGY

What Happens in Airports… Happens Everywhere

Airports combine all the complexities of modern infrastructure, making them the ideal launchpad for solutions that will soon scale to cities, industries, and beyond.

Aug 11, 2025
Anne-Sophie Dubois



TECHNOLOGY

Meet the 3rd Generation of People Counting Technology

Mirroring the technological evolution seen across various industries, People Tracking and Counting Technologies have already entered their third generation.

May 7, 2024
Charlotte Simon

APPLICATIONS

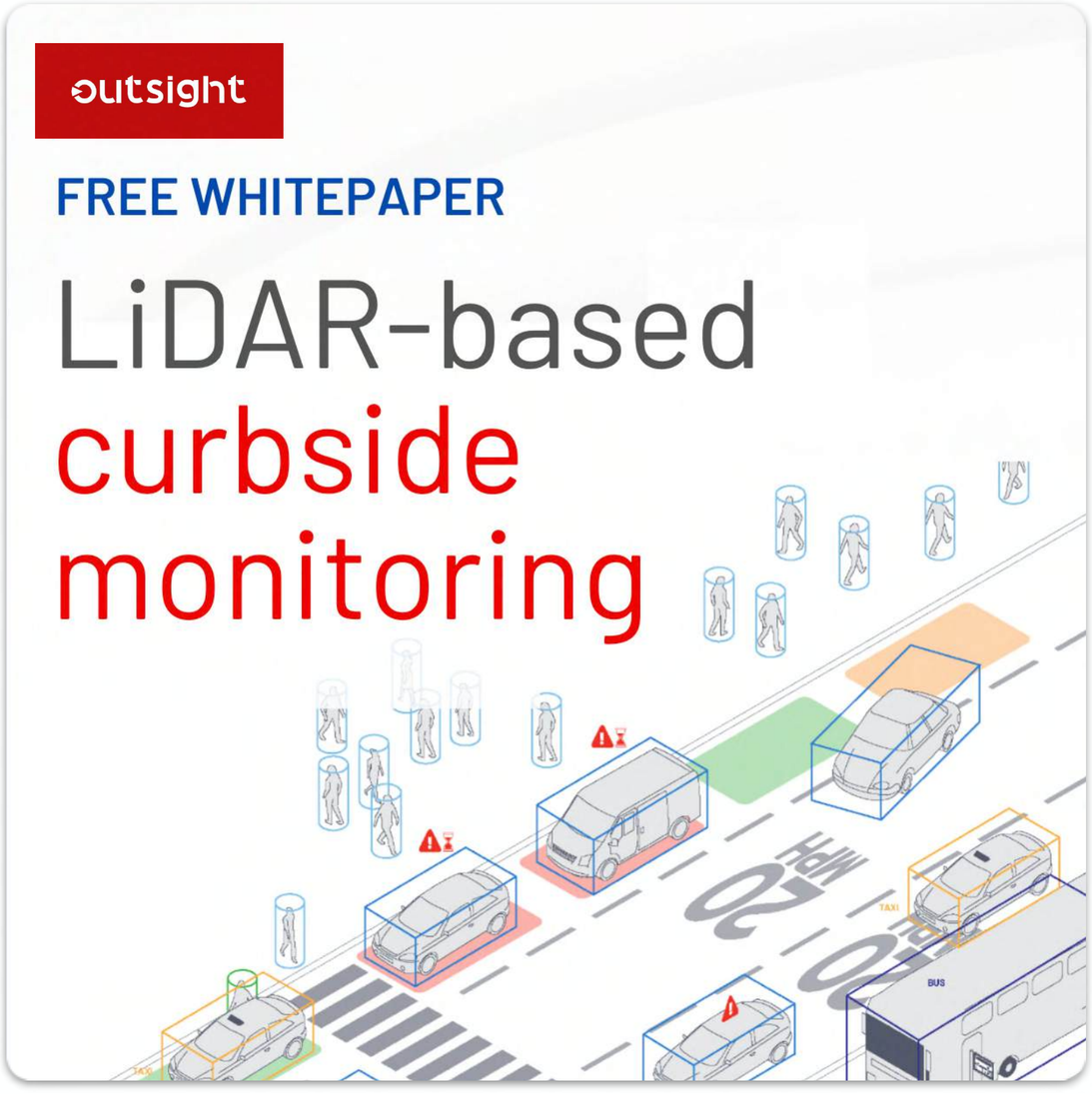
LiDAR Software Helps Airports to Manage Increased Traffic

See how and why Airports are increasingly using LiDAR-based software solutions to tackle their biggest challenges, leveraging the unique value of Spatial Intelligence.

Nov 22, 2023
Anne-Sophie Dubois

Other resources

Download our latest whitepapers here: www.outsight.ai/resources/whitepapers



Annex A

Outsight's Spatial Intelligence solutions leverage Spatial AI and 3D native sensors such as LiDAR to empower infrastructure operators by continuously monitoring the movement of people and vehicles in real time—enhancing efficiency, improving customer experiences, and strengthening security.

This Spatial Intelligence is made accessible to both Operators and AI Agents through Motional Digital Twins.

As the most experienced and awarded team in the industry, we lead the deployment of Spatial Intelligence solutions worldwide, operating from our offices in San Francisco, Paris, and Hong Kong.

outsight

WHY OUTSIGHT

Pioneers and Leaders of 3D software solutions

The most experienced team in the industry by far.

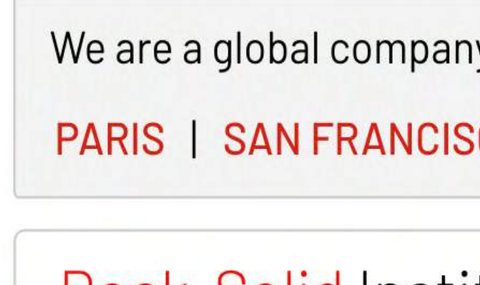
We are a global company:

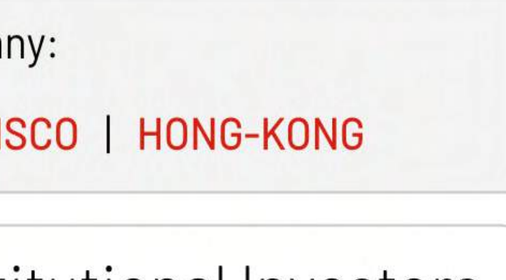
PARIS | SAN FRANCISCO | HONG-KONG

Rock-Solid Institutional Investors

Energy Innovation Capital · bpifrance · BNP PARIBAS · SPDG Ventures · DEMETER PARTNERS · GROUPE ADP · SAFRAN · FORVIA

Recognized 7 times by Gartner as Category-Defining Emerging Leader:





37 Patents, +100 FTE Expert team, +5 years development

OUR SOLUTION

We deliver **Spatial Intelligence**

Our Spatial AI Software Platform converts raw 3D LiDAR data into actionable insights **by continuously tracking every individual across the entire premises.**

We're compatible with all relevant LiDAR hardware models and manufacturers and can get input from other sensors like Cameras

SHIFT
SPATIAL AI PLATFORM

Our Software runs in real-time and delivers unique Spatial Insights (KPIs), for Past, Present and Future events

API

The output is delivered as a user-friendly Digital Twin and Dashboard or an API

SPATIAL INTELLIGENCE CREATES UNIQUE VALUE

Transformative benefits

Elevate Visitors Experience

Reduce bottlenecks, waiting times and create a seamless journey for your shoppers, visitors or passengers.

Improve your Operations

Streamline your processes and optimise Workforce efficiency based on accurate spatial insights.

Increase Security & Safety

Accurately manage risks ranging from unauthorized access to overcrowding, both indoors and outdoors.

Grow Revenue

Improve throughput in queueing and check-in so visitors spend more time in retail and concession areas.

Accurate Infrastructure Planning

Trend analysis and simulation with historical data that leads to better data-driven investment decisions.

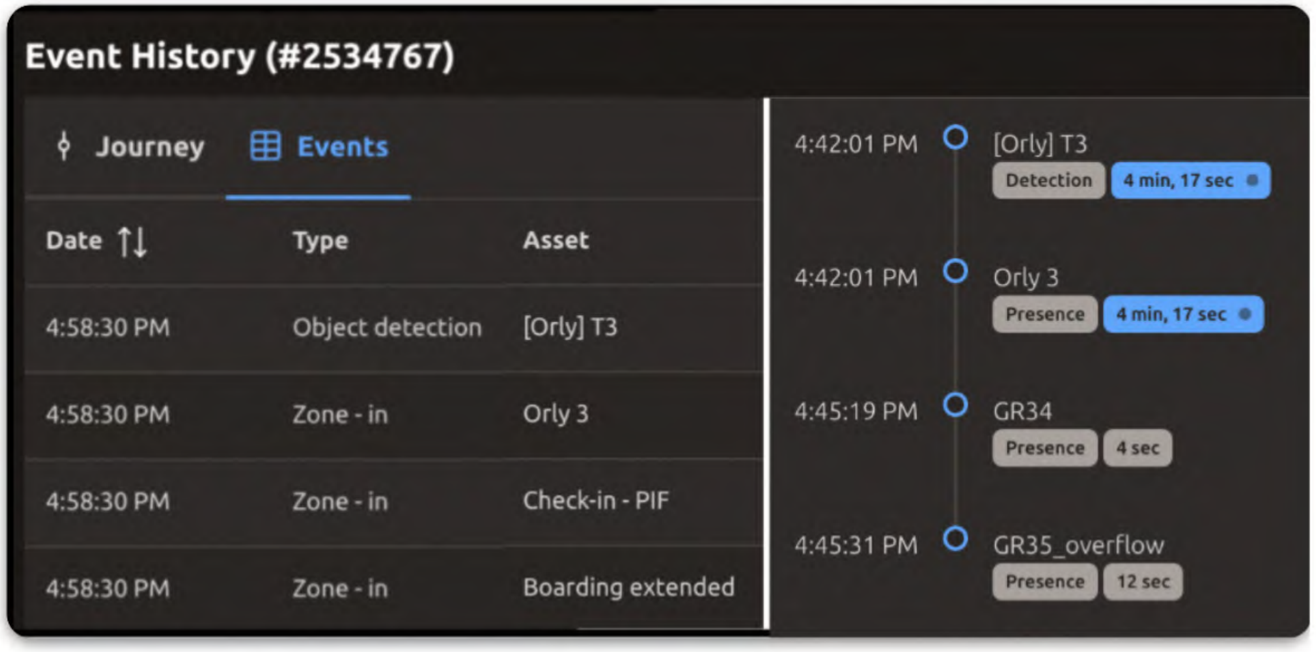
Enjoy Privacy by Definition

Experience the simplicity of GDPR compliance: LiDAR sensors never capture personal identification data.

UNIQUE CAPABILITIES

Premises-wide **Continuous Tracking**

We provide **the most advanced solution able to continuously track the complete customer/passenger journey at scale**, generating unparalleled insights about the behaviour, interactions (events) and resource utilization across the entire premises.



WHY OUTSIGHT ?

Partner with the best

Our team, with over two decades of expertise, is by far the most experienced in the business of LiDAR real-time processing.

Fast & Easy deployment

Working in hours, not weeks. **Deployment made simple** with auto calibration & synchronisation.

Use the right LiDAR sensor

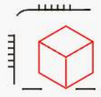
With our software and tools you can use the best combination of sensors and manufacturers for your needs.

Achieve world-class performance

Independent third-party audits have verified an impressive accuracy rate of up to 99% in critical metrics

Optimise cost & energy

Our Edge & Cloud architectures minimise processing, network and setup costs while ensuring scalability.



Leverage the most advanced tools

We've built the most advanced set of tools, including **the first Multi-Vendor 3D LiDAR Simulator**.

Future proof

Our solution grows with you, with OTA updates and ensuring hardware availability over time.

Annex B

Light Detection and Ranging, also known as LiDAR, is a technology for remote sensing that is used to measure distances in an environment. Unlike legacy 2D-based perception technologies such as cameras, the 3D data from LiDAR produces highly detailed, accurate spatial measurements and works in various environments, contexts and changing lighting conditions.

These unique characteristics unlock new possibilities, enabling seamless tracking, enhanced safety, and precise monitoring of movements in complex environments, offering capabilities that were previously unattainable with traditional technologies.

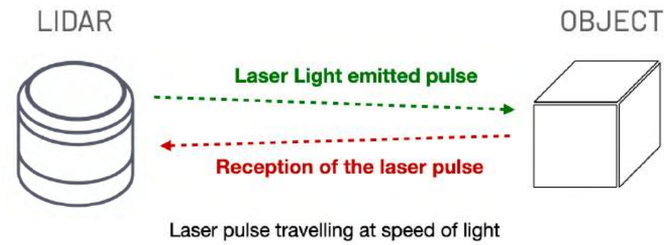
What is LiDAR?

NASA initially developed LiDAR in the 1970s for use in space. It uses laser beams to create 3D vision for a computer to perceive its surroundings.

When deployed at scale, LiDAR offers an important nontechnical advantage: no personally identifiable information is ever captured.

Light Detection and Ranging, also known as LiDAR, is a technology for remote sensing that is used to measure distances in an environment.

This is accomplished by illuminating the environment in question with light that is invisible to the human eye and timing how long it takes for the light to reflect back.



Repeating this process millions of times per second gives computers an accurate portrayal of the environment that is being scanned, allowing them to "see" the world in three dimensions.

Unlike existing 2D-based perception technologies such as cameras, the 3D data from LiDAR produces highly detailed, accurate spatial measurements and works in a range of environments and contexts, such as during the night and under direct sunlight.

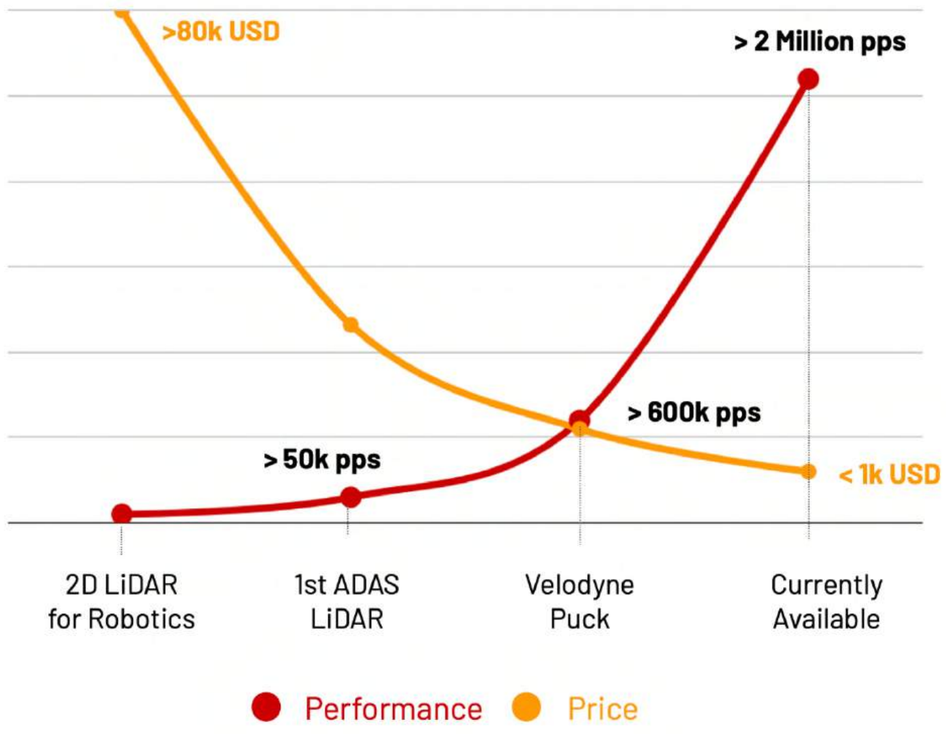
Thanks to multi-Billion Dollar investments in the context of Self-Driving Cars, customers in all other industries now have the choice of many different LiDAR manufacturers, all of them with specific strengths and weaknesses.

> Only in the US, more than five LiDAR Companies are public. The other continents have also several key players each, with some seven key players in Europe and a dozen more in Asia.

Price and performance are no longer barriers to widespread adoption

LiDAR Hardware is maturing and becoming more affordable.

There are many sensor models on the market right now with the right price-performance ratio, because, unlike automotive, prices in the tens of dollars are not an absolute requirement for deployment in most applications.

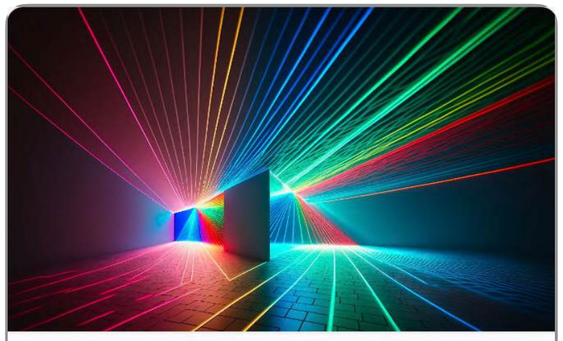


Similarly, performance is rapidly improving, with millions of points per second* becoming the norm rather than the exception.

This allows for use cases that were previously impossible with low-resolution models.

* In general, the higher the device's laser hits per second, the better its performance. Note that this is only a partial performance estimate; many other KPIs strongly influence which LiDAR to use.

Learn more in this article



TECHNOLOGY

Understanding the Basics of 3D LiDAR Technology

Learn about the underlying technology enabling a whole new level of 3D Perception and Situation Awareness.

Read the article

Anne-Sophie Dubois

Why LiDAR is a key enabling technology

Compared to legacy technologies like Camera-based perception, 3D LiDAR brings unique value.

Uninterrupted Tracking*

Thanks to continuous tracking across the entire facility, you can view end-to-end traffic flow throughout the airport or detailed individual level data in any location.

It provides Spatial Insight

With the help of 3D native data, it is possible to gather important information like distance, size, volume, and speed, improving performance and providing new insights.

Centimetre-level Accuracy

Thanks to the use of Laser light, the high precision is constant regardless of the distance, which is crucial for tracking in wide areas.

You can cover large areas

Thanks to detection ranges of up to 300 meters, large areas like terminals can be covered by a few units, which translates into lower hardware & setup costs.

Privacy by design

It is not possible to identify specific people using LiDAR data. Therefore, tracking is completely anonymous; no need to record facial information.

It emits its own light

It can function in complete darkness and is unaffected by changing lighting conditions because it is an active sensor (as opposed to a passive one like cameras).

Multi-Purpose

It's not only about tracking passengers: the same LiDAR infrastructure can be used for a variety of purposes, from managing parking lots to streamlining tarmac operations.

** Requires a processing Software Solution*

Meet the 3rd Generation of People & Vehicles Counting Technologies

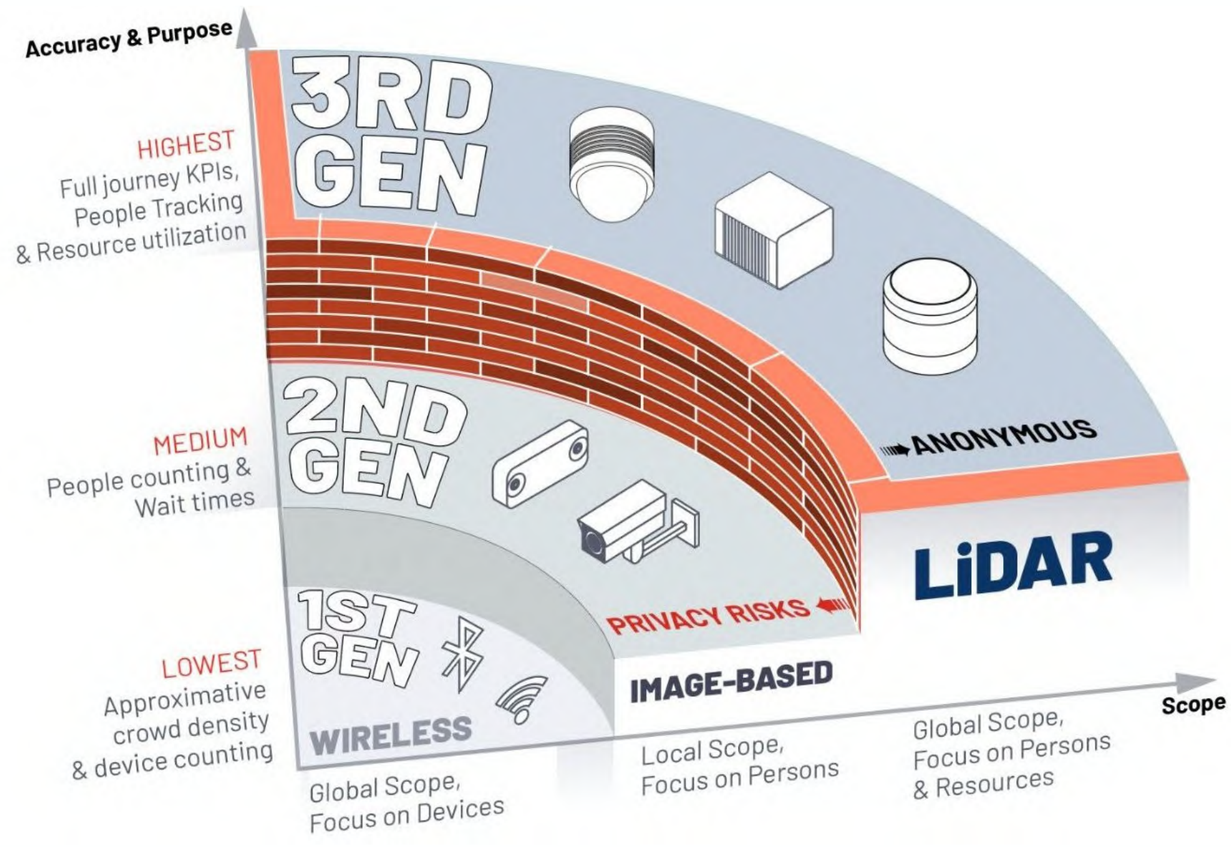
From rudimentary People Counting to encompassing Spatial Intelligence, two evolutionary leaps have been made.

Technological evolution is not a linear or uniform process. Significant improvements in performance and capabilities, which open up previously impossible possibilities, typically follow quantum leaps or technology generations.

The transition from approximate People Counting solutions to comprehensive Spatial Intelligence, based on continuous People Tracking, involves not just one, but two generational steps.

This evolution simultaneously also spans two axes, Performance and Scope, as summarized in the figure below and explained in more detail in this article.

LiDAR Technology is the key enabler of the 3rd technology Generation.



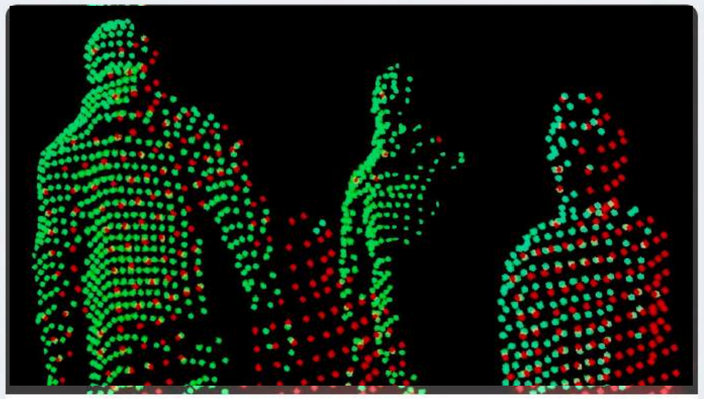
People counting technologies

Comparative Table

	Light-emitting	Image-based		Radio signals	
	Lidar	CCTV	Stereovision	Wifi/Bluetooth	Radar
Position Detection Rates	Very high	Moderate	High	Low	Moderate
Unique ID Tracking	Premises-wide	Low	Locally	Low	Low
cm-level Precision	Yes	No	No	No	No
Choice of HW manufacturer	High[1]	Very high	Low	Very high	Moderate
Flexible mounting	Yes	Moderate	No	No hardware	Moderate
Real-Time Views	Yes	Yes	Yes	No	No
Cost of Processing	Low (CPU[2])	High (GPU)	Moderate	Low	Moderate
Lightning interference	None	Yes	Yes	None	None
Reliability	Very high	Moderate	High	Low	Moderate
Devices per sqm	Few	Many	Many	No hardware	Several
Installation & Maint. Cost	Low	Low	High	No hardware	Low
Sensor Cost	Moderate	Low	Moderate	No hardware	Moderate
Privacy risks	None	Significant	Significant	Significant	None

Other resources

Find all our Insight Articles here: www.outsight.ai/insights

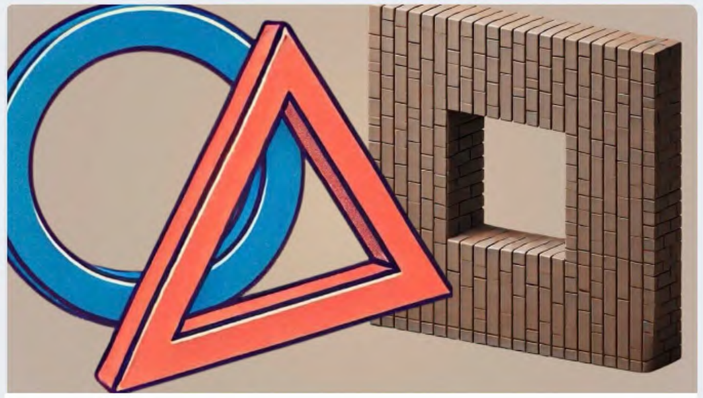


TECHNOLOGY

Understanding Shadowless 3D Perception

Unlike cameras, which perceive reality from a single point of view, 3D native data from LiDAR opens up new possibilities.

Jun 17, 2024
Charlotte Simon

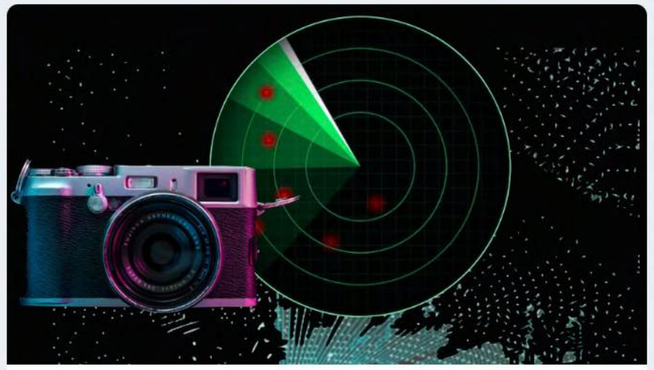


TECHNOLOGY

Why All LiDAR Sensors Aren't Created Equal

This article explores LiDAR differences and why customers use multiple vendors to meet their needs.

Jun 14, 2024
Anne-Sophie Dubois



TECHNOLOGY

An in-depth comparison of LiDAR, Cameras, and Radars' technology

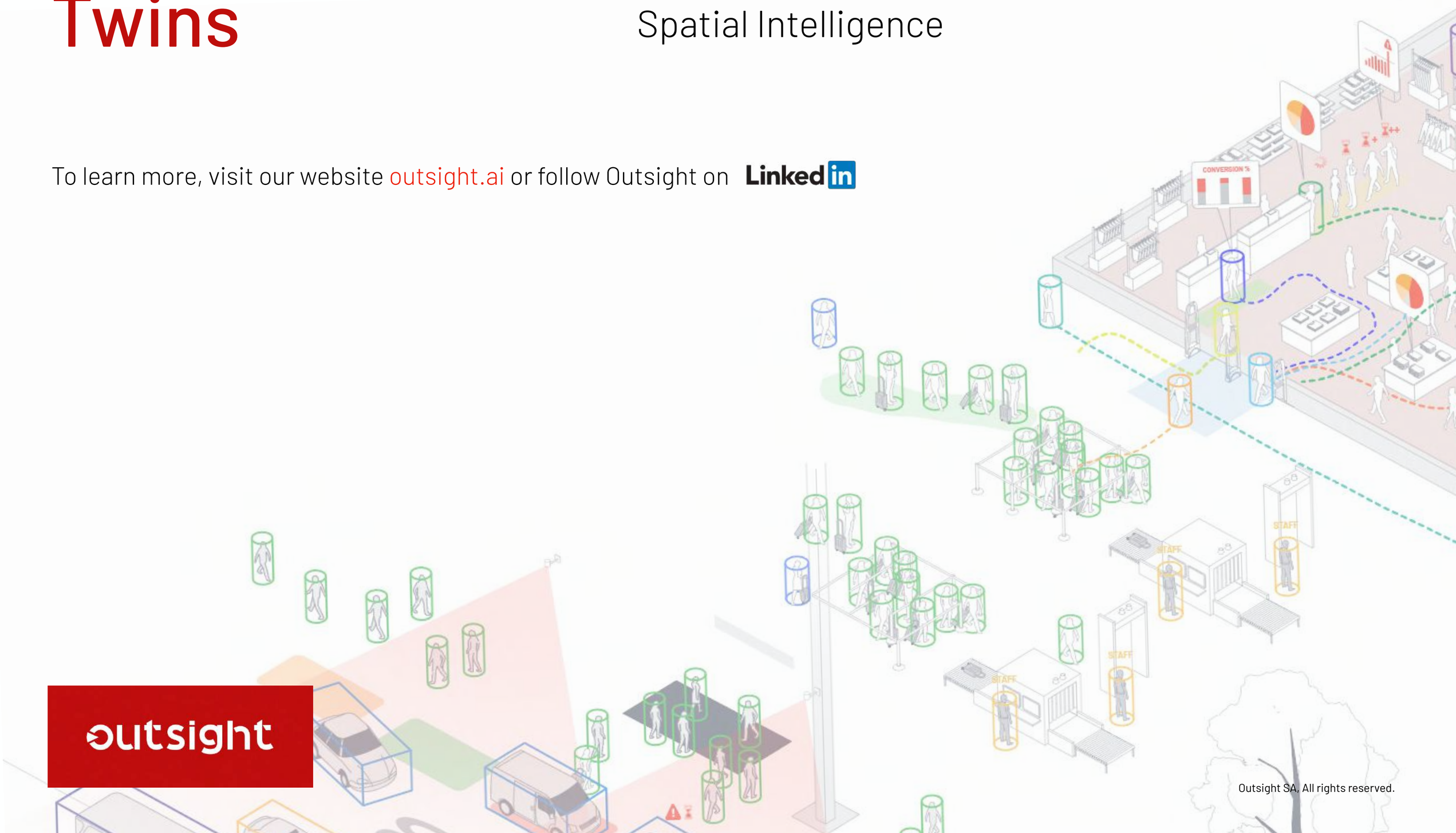
This article explores the capabilities and limitations of each type of sensor, to provide a clear understanding of why LiDAR has emerged as a strong contender in computer vision tech race.

Jul 31, 2023
Anne-Sophie Dubois

Motional Digital Twins

Unlocking Operational Excellence through Motion-Based Spatial Intelligence

To learn more, visit our website outsight.ai or follow Outsight on LinkedIn



outsight