Validaide

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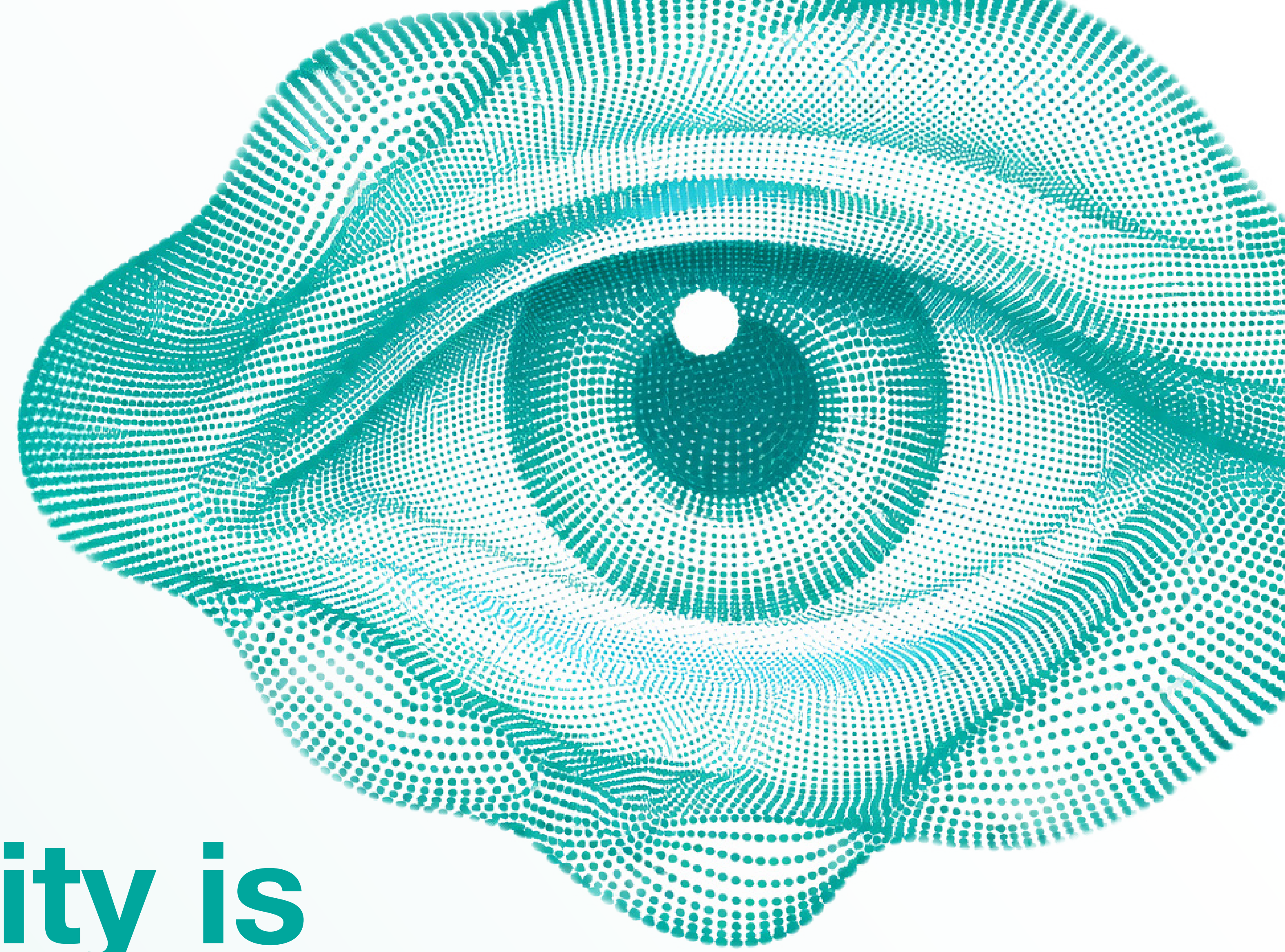
Visibility is not enough

Exploring the levels of intervention
capabilities in pharma logistics



Executive summary

Pharmaceutical supply chains have made significant progress in monitoring shipments. Real-time telemetry, connected devices, and centralized dashboards now provide continuous visibility across global networks. Teams can track location, temperature, and environmental conditions in real time. And yet, excursions, delays, and product losses remain persistent. **In many cases, issues are identified earlier, but they are not prevented.**

Visibility has improved. Outcomes have not. The limiting factor in pharma logistics is no longer knowing what is happening, but acting on it in time.

Most systems in use today are designed to detect and report conditions. Fewer are designed to anticipate risks or support timely intervention. This creates a gap between awareness and outcome. In practice, this means many excursions are not surprises. They are visible risks that were not acted on early enough.

To address this, this paper introduces levels of intervention capability. These levels describe how effectively a logistics system can detect, predict, and resolve shipment risks.

Across the industry, most organizations operate at Levels 2 and 3. They have access to real-time data and automated alerts, but interventions remain reactive and dependent on human decision-making. Advancing beyond this requires more than additional data. **It requires systems that can interpret context, anticipate risk, and support or execute intervention as part of operations.**

The gap between visibility and intervention

The reality of modern pharma logistics

Pharmaceutical supply chains are operating under increasing pressure.

Product sensitivity has risen with the growth of biologics and advanced therapies. Distribution networks are more global, more fragmented, and less predictable. At the same time, expectations around quality, compliance, and delivery performance continue to increase.

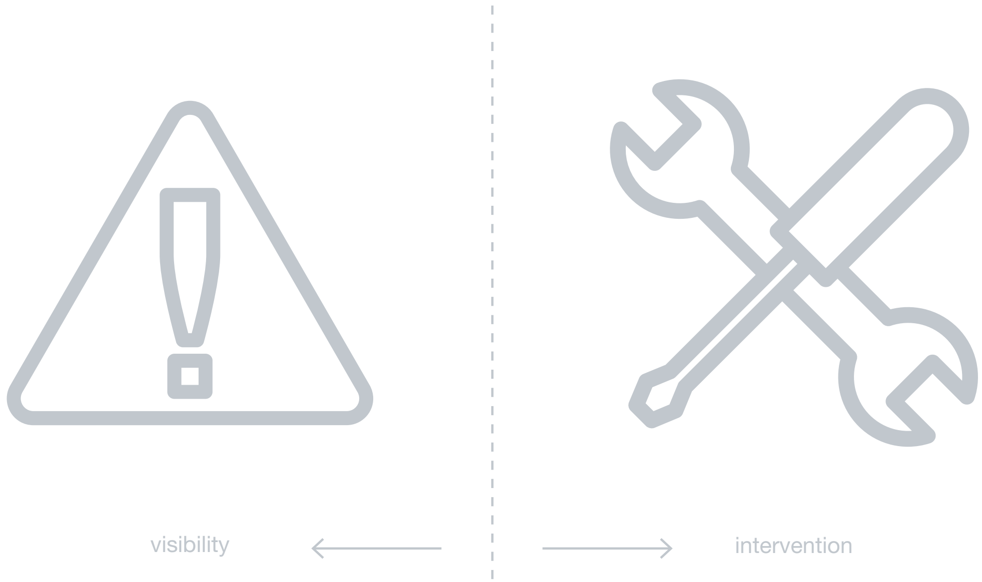
To manage this complexity, most organizations have invested in visibility. Real-time telemetry provides continuous insight into shipment conditions. Alerts notify teams when predefined thresholds are exceeded. Dashboards consolidate data across partners.

These capabilities improve awareness, but they do not change how intervention happens. In most cases, the response still depends on manual action. Teams review alerts, interpret data, and coordinate next steps across multiple stakeholders. This introduces delay and inconsistency, especially in time-critical situations. In many cases, multiple stakeholders see the same data, but no system is responsible for driving a coordinated response.

Current systems are also constrained by how they operate:

- **Event-driven logic:** Alerts are triggered after a condition has been exceeded
- **Limited context:** Data is available, but not always interpreted within the full shipment or lane
- **Fragmented execution:** Acting on a risk requires coordination across systems and partners

As a result, many supply chains remain reactive.



A shipment can be fully visible and still at risk. Data can show a deviation in real time. Alerts can flag a delay immediately. But neither ensures that the right action is taken, or that it is taken in time.

The constraint is not visibility. It is the ability to intervene effectively. Detection without action simply compresses the time available to react. In high-risk shipments, this often means reacting too late.

92%

of pharmaceutical supply chain leaders say product loss, theft, and temperature excursions have increased, despite ongoing investments in monitoring and visibility.[1]

[1] "Rethinking Network Design in Pharmaceutical Supply Chains: A new framework for resilience, cost and network control" LogiPharma Report 2026

Introducing intervention capability levels

To understand how effectively a logistics system can protect a shipment, it is useful to look beyond visibility and focus on intervention.

Intervention capability describes how well a system can detect, anticipate, and respond to risks as they occur. This ranges from basic monitoring to fully autonomous resolution.

Each level does not just represent a technical capability, but a different level of control over shipment outcomes. The five levels of intervention capability provide a structured way to assess this progression.

1. **Milestone-based monitoring**
   Event-driven tracking based on transport updates

2. **Real-time telemetry visibility**
   Continuous monitoring through sensor data

3. **Rule-based exception monitoring**
   Automated alerts triggered after thresholds are exceeded

4. **Predictive lane--based monitoring**
   Early risk detection based on context and historical patterns

5. **Autonomous intervention**
   Systems that detect, decide, and resolve risks automatically

Levels of intervention capability

This framework provides a common language to compare approaches and understand what is required to move from reactive monitoring toward proactive and autonomous intervention.

Milestone-Based Monitoring

What it looks like

Shipment monitoring is based on logistics events. Monitoring is **periodic rather than continuous.**

Visibility is tied to predefined milestones such as departure, arrival, or handover, typically provided through transport management systems, carrier updates, or manual inputs. Monitoring is periodic rather than continuous, with little or no insight between events.

As a result, response times are often delayed, and intervention options may already be limited by the time an issue becomes visible.

Where it falls short

and how to move to the next level

This level provides limited visibility into what is happening during transit.

There is no real-time insight into location or environmental conditions, and no ability to detect deviations as they occur. Issue identification depends on delays or exceptions becoming visible through milestones.

Progressing beyond Level 1 requires continuous visibility. This shift enables continuous monitoring and earlier detection of deviations.

Real-time telemetry

Access to live data on location and conditions during transit

Sensor deployment

Devices capable of capturing and transmitting shipment data

Data accessibility

Ability to monitor and interpret incoming signals in real time

Real-time telemetry visibility

What it looks like

At Level 2, shipment monitoring is based on **real-time telemetry**.

IoT sensors and tracking devices provide continuous data on location, temperature, and environmental conditions throughout the journey, typically visualized through monitoring dashboards.

Visibility becomes continuous rather than milestone-based. Teams can observe shipment conditions as they evolve and detect deviations such as temperature excursions or delays earlier, often while they are still developing.

This reduces blind spots during transit and enables closer monitoring of critical shipments.

Where it falls short

and how to move to the next level

While data is available in real time, interpretation and action remain manual.

Teams must continuously monitor dashboards, identify potential issues, and decide whether intervention is required. This creates operational overhead and increases reliance on individual attention and experience. Without structured logic, there is also a risk of inconsistent decision-making across shipments and teams.

Progressing beyond Level 2 requires structured detection of risk. This enables a shift from passive monitoring to active identification of exceptions.

Defined thresholds and rules

Clear criteria for identifying when conditions require attention

Automated alerting

Systems that notify teams when predefined conditions are exceeded

Standardized monitoring practices

Reducing reliance on continuous manual observation

Rule-based exception monitoring

What it looks like

Many organizations today are at Level 3, where real-time telemetry is **combined with automated alerting**.

Systems monitor incoming data against predefined rules and trigger alerts when conditions are exceeded (such as temperature threshold breaches, unexpected delays, or deviations from planned routes).

Monitoring becomes event-driven, with attention focused on exceptions rather than continuous observation. The need for constant monitoring is reduced. Teams are notified when a shipment requires attention, allowing them to focus on managing exceptions rather than tracking every movement.

Where it falls short

and how to move to the next level

At this level, detection remains reactive.

Alerts are triggered after a condition has already been exceeded. By the time a notification is received, the issue is already in progress, and the available intervention options may be limited. At this level, systems are optimized for notification, not prevention. Operations still rely on teams to interpret alerts, assess severity, and coordinate a response, which introduces delays and variability.

Moving beyond Level 3 requires shifting from event-based detection to forward-looking assessment. This shift enables earlier and more targeted intervention, before deviations escalate into excursions.

Contextual understanding of shipments

Interpreting data within the context of the full route and expected conditions

Use of historical patterns

Identifying how similar shipments have behaved under comparable circumstances

Predictive assessment of risk

Detecting potential issues before thresholds are exceeded

Predictive lane-based monitoring

What it looks like

At Level 4, monitoring moves beyond reacting to events and begins to anticipate them.

Systems combine real-time telemetry with historical shipment data and validated transport lanes. Instead of only tracking current conditions, they assess how a shipment is expected to behave across the route.

This level typically requires combining three elements: validated lane intelligence, real-time telemetry, and a behavior-based digital twin of the packaging. Predictive capability emerges from the combination of packaging behavior (digital twin) and transport reality (lane intelligence). Neither alone is sufficient to reliably predict shipment outcomes.

This allows risks such as delays or temperature excursions to be identified before they occur, often at specific points in the journey.

The key shift is not only earlier detection, but actionable foresight: knowing where and when a shipment is likely to fail. The timing of intervention changes.

Instead of responding once a threshold is exceeded, teams are able to act earlier, when more options are still available. This can include adjusting handling, rerouting, or coordinating with partners before conditions deteriorate.

Interventions become more targeted and more effective. Fewer issues escalate into excursions, and operational effort shifts from constant monitoring to focused decision-making.

Where it falls short

and how to move to the next level

At this level, prediction improves visibility into future risk, but action still depends on people. Teams must interpret predictions, decide on the appropriate response, and coordinate execution across stakeholders. This introduces variability and can limit consistency, particularly at scale.

Moving beyond Level 4 requires extending prediction into execution. This shift transforms predictive insight into consistent, system-driven intervention.

Decision logic

The ability to translate predicted risk into a defined course of action

Automated triggering of interventions

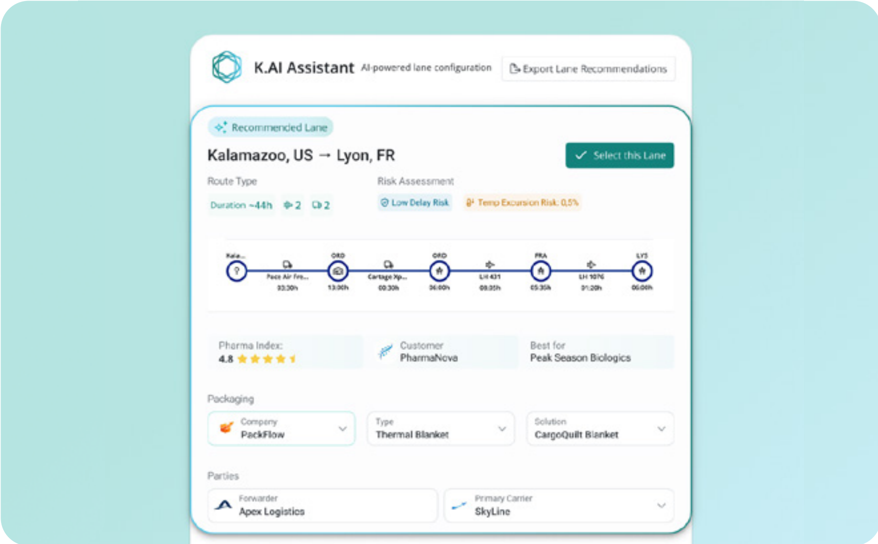
Initiating actions without relying on manual coordination

Integration into operational workflows

Connecting insights directly to the systems and partners responsible for execution

Closed-loop confirmation

Verifying that the intervention has been carried out and the issue resolved

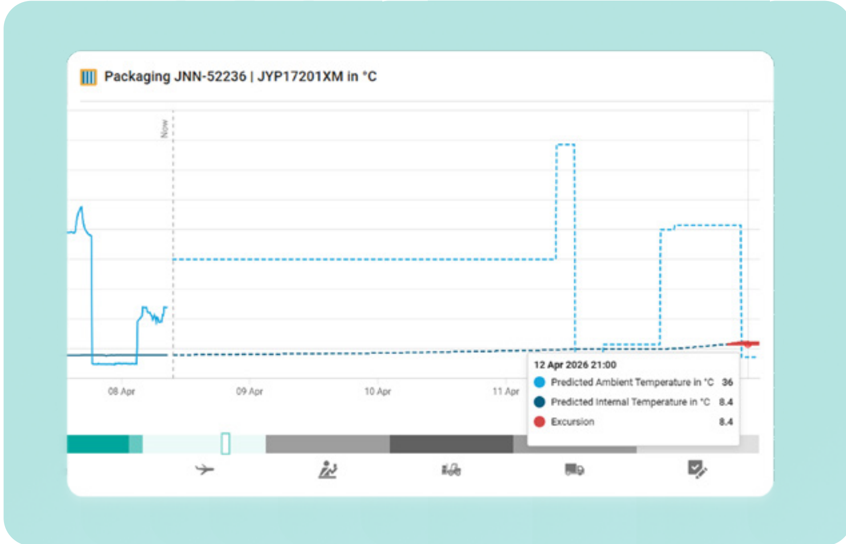


Lane Intelligence

Predictive monitoring relies not only on packaging behavior, but also on understanding how transport lanes perform in reality. **Lane intelligence refers to the structured understanding of how shipments behave across a specific route**, including:

- Typical transit times and variability
- Dwell times at key nodes (e.g. airports, hubs)
- Exposure patterns (e.g. tarmac, seasonal conditions)
- Reliability of partners and handovers

This goes beyond planned routes or static lane definitions. It reflects how a lane actually performs in practice. Lane intelligence is not a static route definition, a planned itinerary, or a theoretical transport scenario. It is derived from observed shipment behavior and continuously refined with real operational data.



Understanding Digital Twin Approaches in Thermal Logistics

Not all digital twins are the same. In thermal logistics, three primary approaches are used to model packaging performance:

- Physics-based digital twins model performance based on material properties, packaging construction, and heat transfer equations. They are primarily used in packaging design and engineering.
- Behavior-based digital twins model performance based on observed data, using measured external conditions and internal temperature response. They reflect how packaging behaves in real-world logistics conditions.
- Hybrid approaches combine physics-based models with calibration data, but often require high effort and do not scale easily across packaging types.

For operational risk prediction, behavior-based models provide the most reliable representation of how packaging performs under real-world conditions.

Autonomous intervention

What it looks like

At Level 5, intervention is executed as part of the system.

Building on predictive capabilities, the system does not only identify risk, it determines the appropriate response and initiates action. This can include instructing logistics partners, triggering predefined workflows, or adjusting handling conditions based on the situation. It also confirms that the intervention has taken place, with a full audit trail.

Autonomy in this context does not mean removing control. It means standardizing and executing predefined, validated decisions consistently and without delay.

The role of the operations team changes. Instead of continuously monitoring and responding to alerts, teams oversee performance and manage exceptions. Interventions are executed consistently and without delay, reducing reliance on individual decision-making. Response times improve, variability decreases, and the system is able to scale across larger and more complex networks without a proportional increase in operational effort.

Building trust in autonomous intervention

Autonomous systems must be transparent, predictable, and controlled, especially in pharma logistics. Autonomy is not introduced all at once. It is applied progressively, starting with well-defined use cases and expanding as confidence in the system increases. In practice, trust can be established through a combination of:

Defined intervention logic

Clear rules that determine when and how actions are triggered

Validation and testing

Ensuring decisions are based on reliable data and proven models

Human oversight by design

Introducing autonomy in controlled scenarios, with the ability to review and intervene

Traceability of actions

Full visibility into what actions were taken, when, and why

The five levels of intervention at a glance

Level	Monitoring Approach	Detection Timing	Data & Context	Decision Model	Execution	Operational Outcome
1	Milestone-based tracking	After event (delayed)	Limited to transport updates	Manual	Manual	Delayed visibility, limited ability to respond
2	Real-time telemetry	As event occurs	Live sensor data (location, temperature)	Manual	Manual	Continuous visibility, high monitoring effort
3	Rule-based alerts	After threshold is exceeded	Real-time data with predefined rules	Human decisions based on alerts	Manual	Faster awareness, but reactive intervention
4	Predictive monitoring	Before event occurs	Real-time + historical data + lane context	Human decisions supported by prediction	Manual	Earlier intervention, reduced risk of escalation
5	Autonomous intervention	Before and during event	Integrated, contextualized data across systems	System-driven decisions	Automated	Consistent, timely intervention at scale

Looking forward: predictive and autonomous intervention

From insight to execution

As intervention capability advances, the focus shifts from identifying risk to resolving it.

Predictive systems improve the timing of intervention by identifying potential issues before they occur. This allows teams to act earlier, when more options are available, and the likelihood of preventing escalation is higher.

However, prediction alone does not ensure outcome as iintervention is not a single step. It consists of two distinct capabilities:

- **Decision:** identifying the right action
- **Execution:** ensuring that action is carried out

Most systems today support detection. Fewer support decision. Almost none ensure execution.

The next step is connecting insight directly to execution. Autonomous intervention extends predictive capability by embedding decision-making and action into the system itself.

Detect → Predict → Act → Confirm

This transforms monitoring from a passive function into an active control system. Intervention becomes part of how the shipment is managed in real time, rather than a separate, manual process.

What this enables in practice

- **Earlier and more consistent intervention**
  Actions are taken at the right moment, without delay from manual coordination
- **Reduced dependency**
  Less reliance on continuous monitoring and individual decision-making
- **Scalability across complex networks**
  Interventions can be executed consistently across shipments and regions
- **Improved control over outcomes**
  Risks are actively managed, not just observed

Closing perspective

Over the past years, we've seen a clear shift in how pharmaceutical supply chains operate.

Visibility has improved significantly. Most organizations today have access to real-time data and a much clearer view of what is happening across their networks. That progress has been important, but in many cases, it hasn't changed how interventions actually happen.

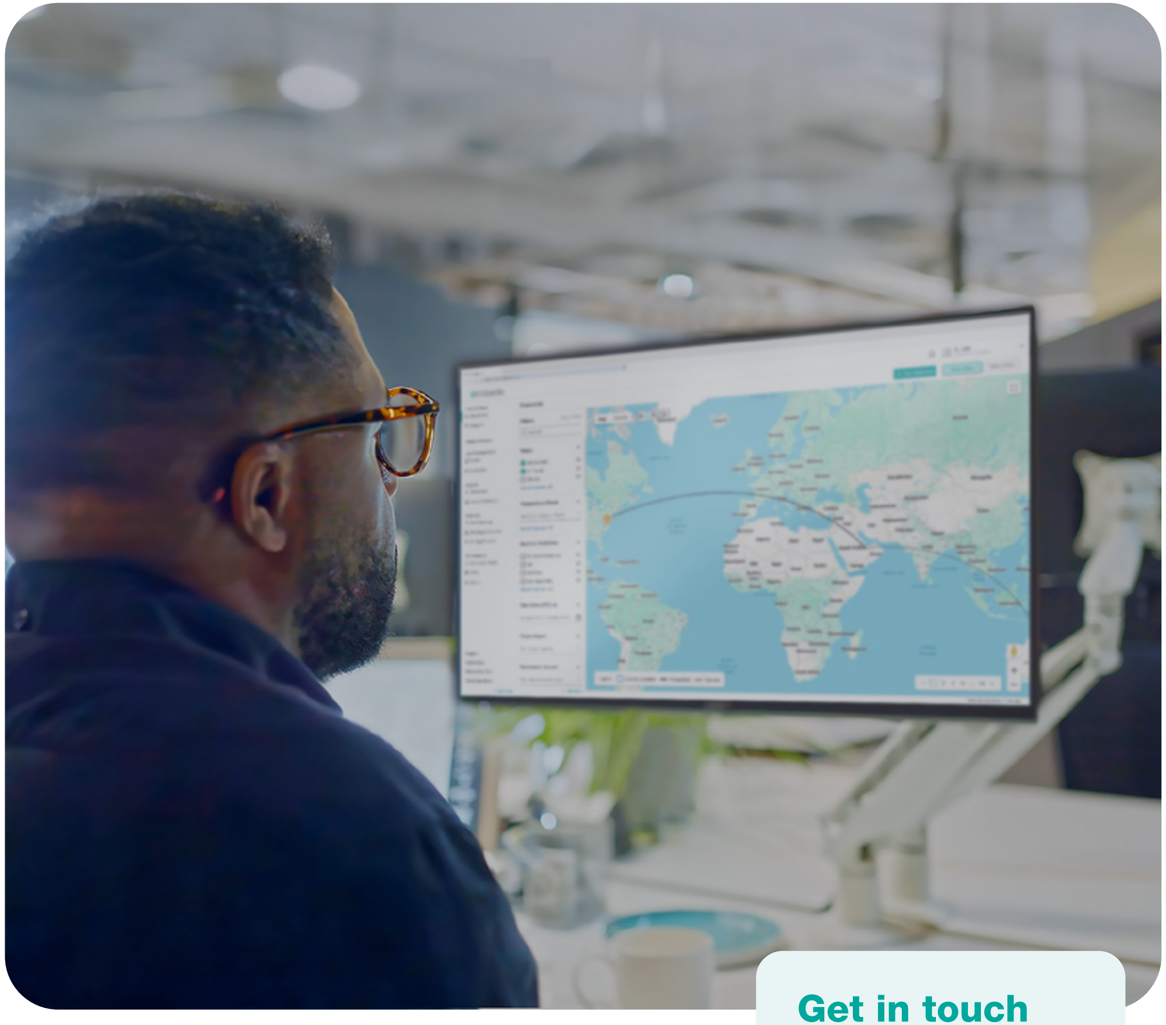
Teams are still working under pressure to interpret signals, assess risk, and coordinate responses manually. The tools have evolved, but the operating model often hasn't.

From our experience, organizations do not reduce excursions by adding more data. They reduce them by changing how and when they intervene.

Validaide and SkyCell provide the foundation to operationalize this shift, combining lane intelligence, real-time monitoring, and behavior-based digital twins into a single intervention-driven system.

In some cases, this is already extending into autonomous workflows, where interventions are initiated and managed within clearly defined parameters. The impact is tangible. Decisions are made earlier. Interventions are more consistent. Fewer issues escalate into excursions. There is less firefighting and more control.

If you're interested in taking the next step, we'd love to hear from you.



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