

Functional Intelligence and a Foundation for Generative AI in Ironmaking

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The Complexity Challenge of Raw Data

The Scale of Data

MILLIONS

of data points generated daily

THOUSANDS

of industrial sensors continuously streaming

From Iron and Steelmaking Processes

The Cognitive Bottleneck

Workload and Ergonomy

People/tech to identify the right actions from data by keeping an eye on everything that matters

Subtle Behaviors

Correlations and trends across the ironmaking process are hard even for experts to track and translate to priorities.



Alert Fatigue And Data Waste Are Correlated

The Reality

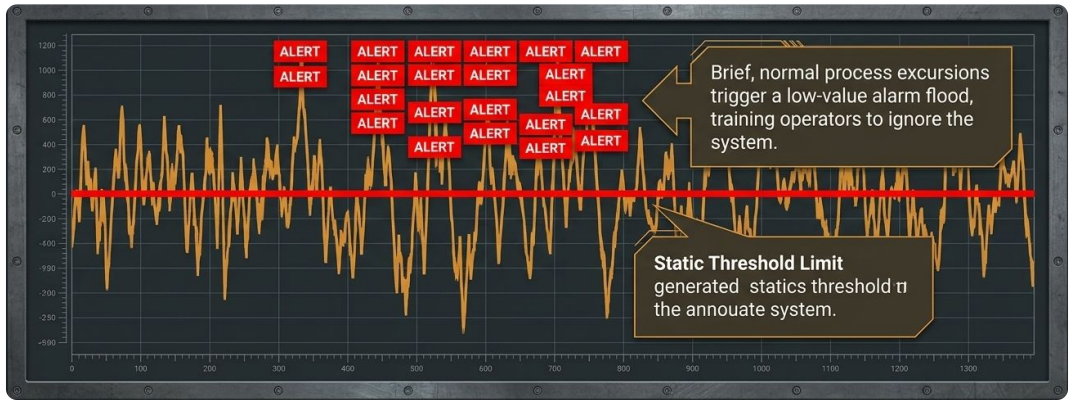
100s alarms / hour

Exceeds 150 alerts per day ANSI/ISA 18.2 recommendation.

Data is heavily underutilized

Only a handful of parameters are monitored in the pulpit or by monitoring tools

Alarm Flood Resulting From Limits



Automated Monitoring That Lowers Cognitive Load

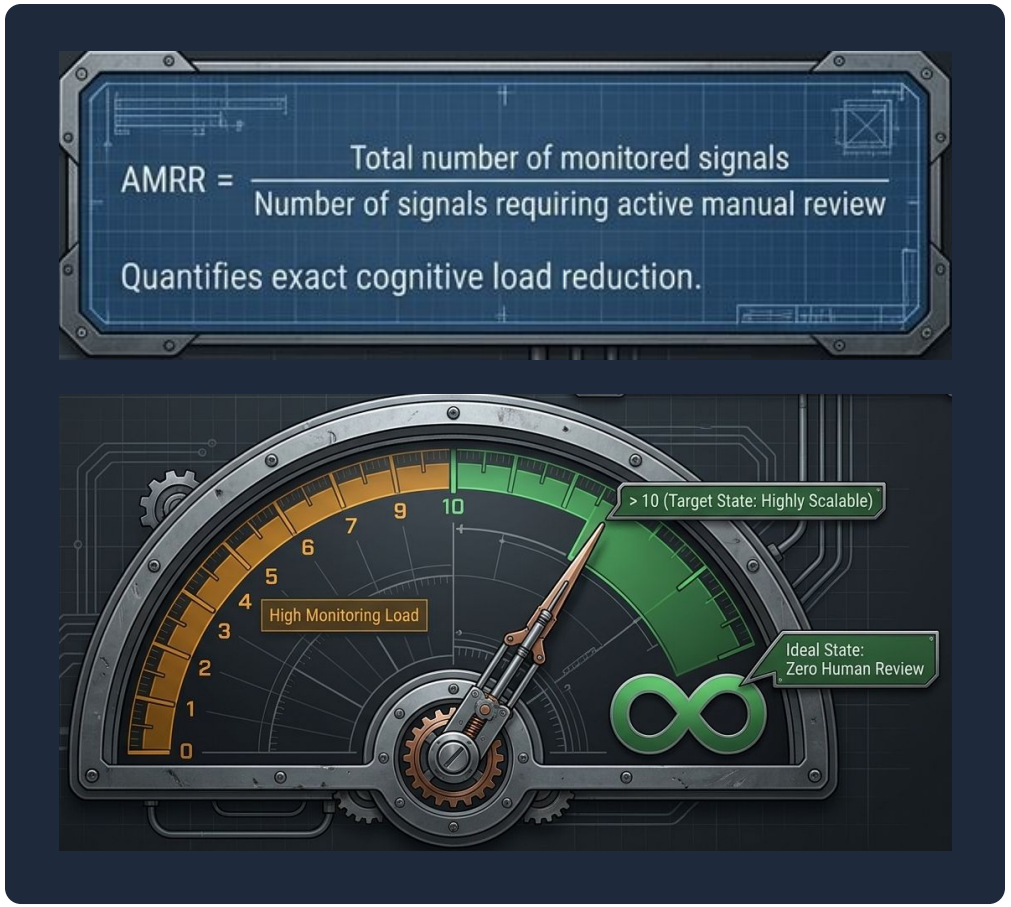
Results That People Adopt

Different monitoring technologies at work
Intelligently combine events to reduce cognitive demand

Organize results for situational awareness
Create operational view to focus attention

Targeted attention
Prioritize based on asset criticality and incident severity

Simple Metric for progress tracking
Use Average Monitoring Reduction Ratio to see how well automated monitoring is functioning



Time Series AI-based Automated Monitoring Studies with Observed AMRR

STELCO

45.4

Only 5 signals out of 227 need manual review

Blast Furnace

AISTech 26

AM/NS CALVERT

∞

0 signals out of 34 need manual review

Tandem Cold Mill

AIST DX Forum 24

European Steelmaker

67

Only 5 signals out of 335 need manual review

Reheat Furnace

AISTech 26



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Improving The Cognition Equation

Limit-Based Alarms

Static, One Dimensional Limits

Fires on every simple breach

Blind to Operating State

Does not adapt to current industrial phases

No Correlation

Cannot see the forest for the trees across asset tags

Unified Incidents

Dynamic Envelopes

Adapt to baseline-learned operational envelopes and critical limits

Context-Aware

Suppress non-operational issues, e.g., shutdown periods

Data-Driven Recommendations

Match pieces of evidence into a coherent recommendation based on expert knowledge along with plausible root cause analysis



The Path To Autonomy Is Paved With AI

Level 2, iba Data Foundation → **Contextualized Signals** → **Find and Report Incidents** (Time Series AI) → **Recommend and Root Cause Analysis** (Gen AI)



The Structure of An Incident

Events Related by Asset Grouping and Time

Contributing Signals

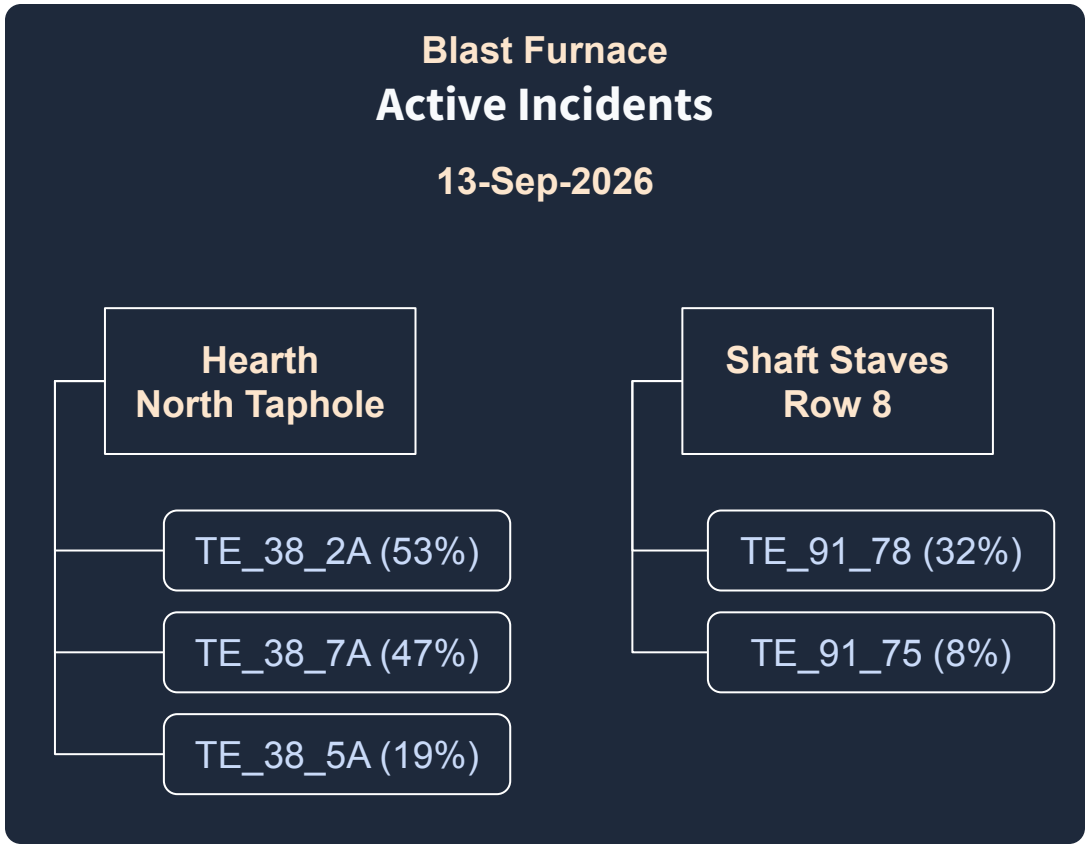
Signal durations when trends, patterns or limit crossings occur in an asset

Sequence of Events

Explain how an incident breaks out and spreads through the asset

Similarity to Past Incidents

Previous incident traces identified through structural similarity of events



Recommended Action for Incidents

Use Verified Domain Expertise

Map to known incident structure

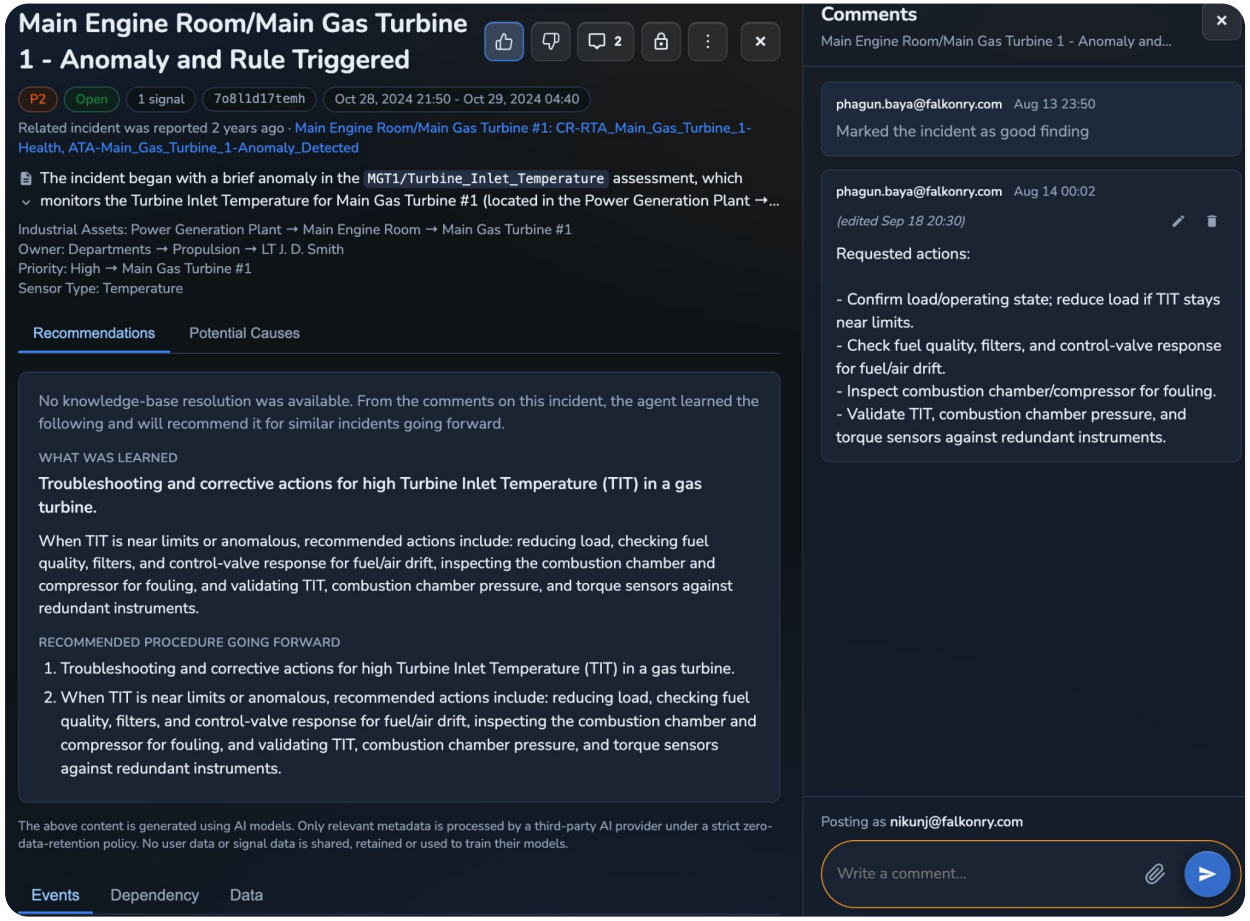
Match incident structure to locate diagnostic steps and corrective actions drawn directly from the knowledge base

Unrecognized sequence of events

Flag the gap in knowledge to avoid producing a low confidence recommendation, likely to be incorrect

Capture expert knowledge

Expert's incident resolution becomes a permanent, attributable recommendation for future incidents



Visualizing Underlying Behavior In An Incident

Trust Built Through Real Data

Display underlying process parameters

Plot contributing signals for the relevant period of time

Display domain criteria for reporting incidents

Incorporates rules and limits

Highlight anomalies before alarm level

Create confidence in AI that provides timely warning



Conversing using Incidents

LLMs struggle with complex questions on process data

Incidents organize process data

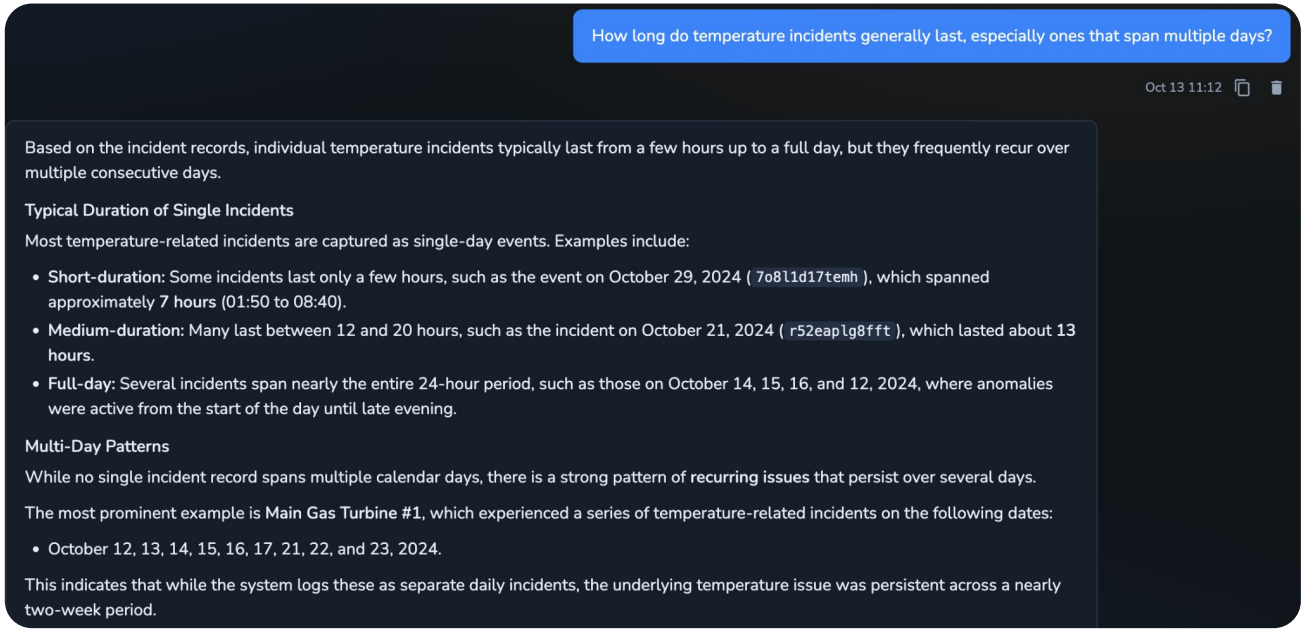
Only data during incidents really matters

Reduce token usage/response time

Mathematics and correlations are already handled

No hallucination allowed

LLMs are focused on translation and not allowed to do primary processing



Interrogating Temporal Structure of Incidents

How long do temperature incidents generally last, especially ones that span multiple days?

Oct 13 11:12

Based on the incident records, individual temperature incidents typically last from a few hours up to a full day, but they frequently recur over multiple consecutive days.

Typical Duration of Single Incidents

Most temperature-related incidents are captured as single-day events. Examples include:

- **Short-duration:** Some incidents last only a few hours, such as the event on October 29, 2024 (`7o8l1d17temh`), which spanned approximately **7 hours** (01:50 to 08:40).
- **Medium-duration:** Many last between 12 and 20 hours, such as the incident on October 21, 2024 (`r52eaplg8fft`), which lasted about **13 hours**.
- **Full-day:** Several incidents span nearly the entire 24-hour period, such as those on October 14, 15, 16, and 12, 2024, where anomalies were active from the start of the day until late evening.

Multi-Day Patterns

While no single incident record spans multiple calendar days, there is a strong pattern of **recurring issues** that persist over several days.

The most prominent example is **Main Gas Turbine #1**, which experienced a series of temperature-related incidents on the following dates:

- October 12, 13, 14, 15, 16, 17, 21, 22, and 23, 2024.

This indicates that while the system logs these as separate daily incidents, the underlying temperature issue was persistent across a nearly two-week period.

Enabling Root Causes Analysis of Incidents

Generally which issue occurs first temperature or pressure at the inlet?

Oct 13 11:10

Based on the analysis of several incidents involving **Main Gas Turbine #1**, temperature anomalies at the inlet generally occur before pressure anomalies in the combustion chamber.

Examples of this pattern include:

- **October 23, 2024**: The turbine inlet temperature anomaly began at midnight, while the combustion chamber pressure anomaly did not appear until approximately 5:50 AM.
- **October 21, 2024**: High turbine inlet temperature rules triggered starting at 10:32 AM, followed by combustion chamber pressure anomalies starting at 12:00 PM.
- **October 17, 2024**: Temperature rules were active through most of the morning, whereas the combustion chamber pressure high rule first triggered later at 2:58 AM.

There are exceptions; for instance, on **October 22, 2024**, the combustion pressure anomaly was active from the start of the day, preceding the turbine inlet temperature anomalies that appeared later in the morning.

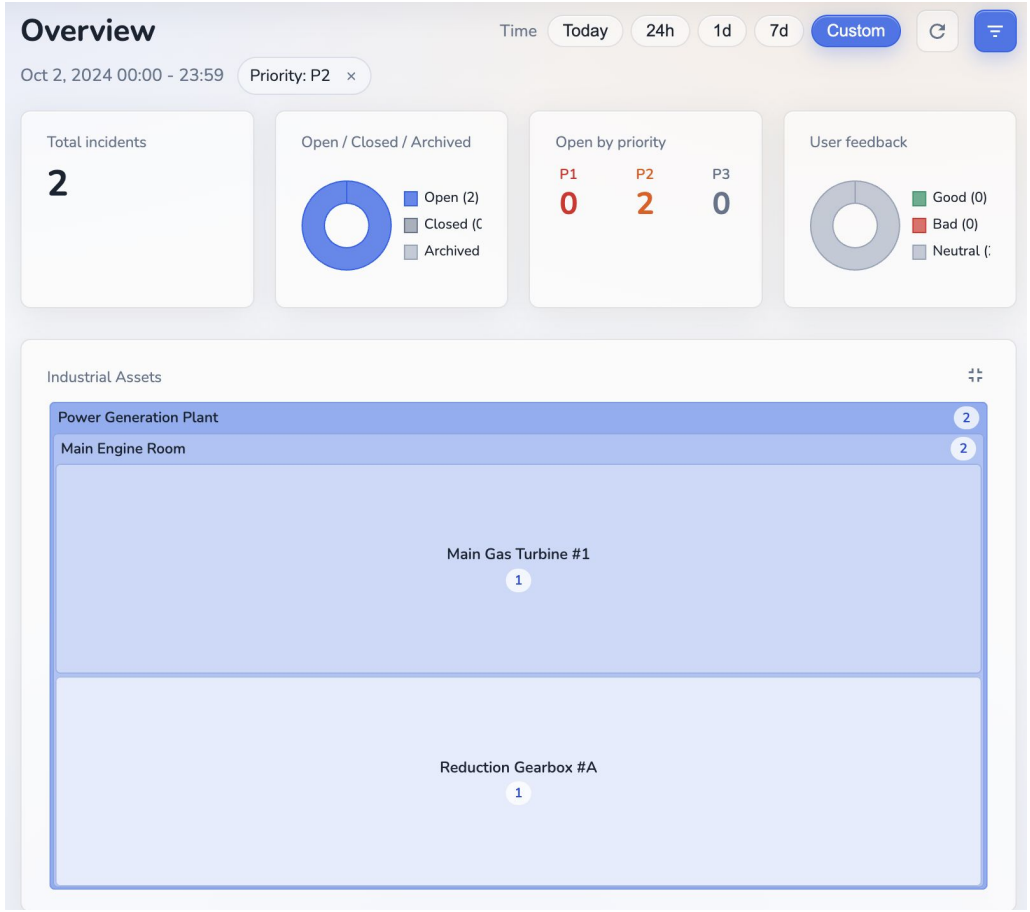


Operational Dashboard for Daily Work

Distribution
Daily distribution by assets

Attention
Direct attention in a priority-driven manner

Noise Control
Incidents consolidate events

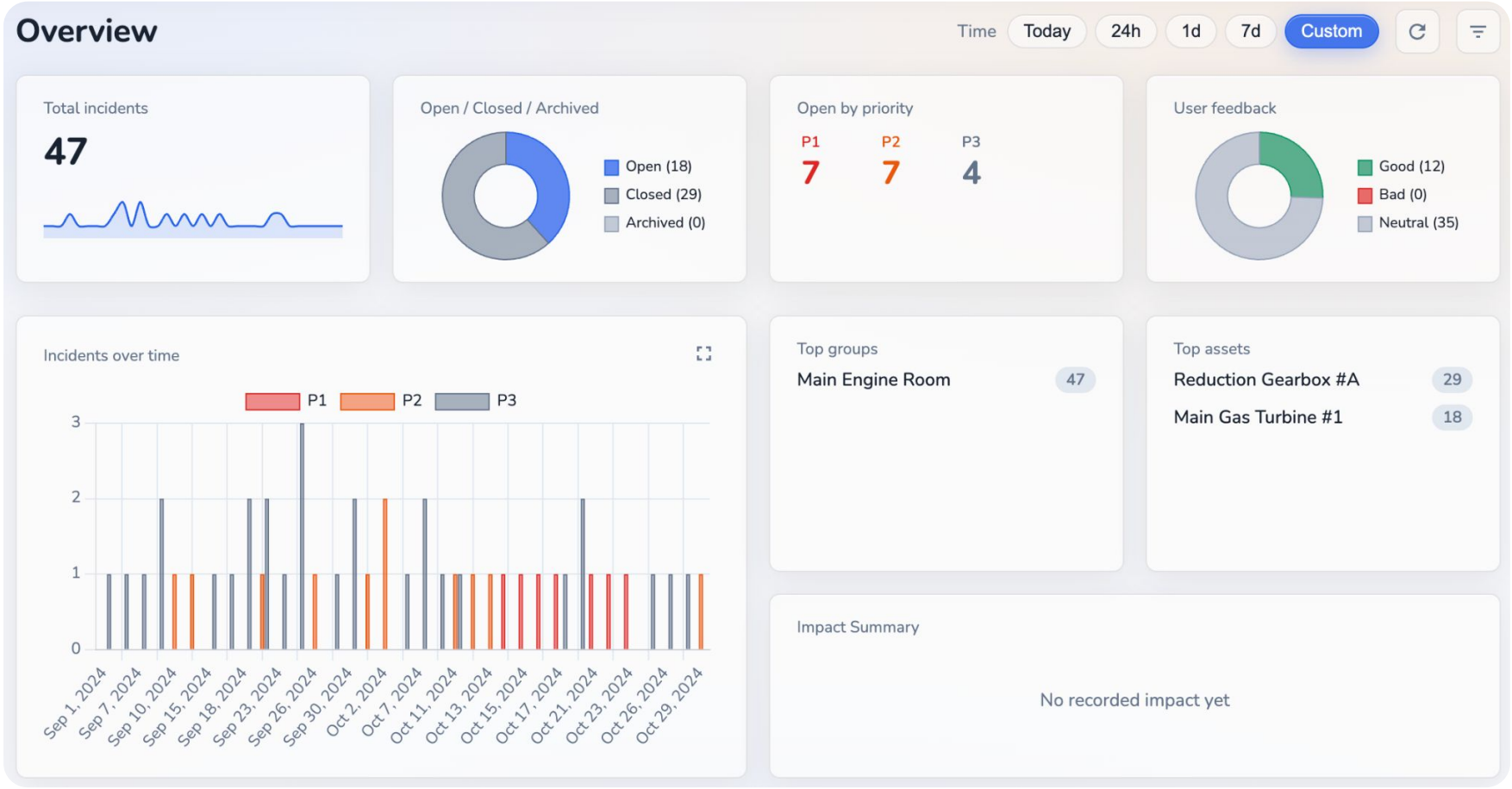


Executive Incident Dashboard

Track Metrics
Weekly and monthly incident & KPI trends

Assess AI Value
Use feedback to judge team & plant benefit

Knowledge Base
Capture resolutions and prepare for future



Automated Monitoring Made Better with GenAI

Empowering plant operations with an automated, secure, and trustworthy solution

Recommendations

Accelerate recovery and reduce diagnostics with RAG powered by signal contributions and incident history.

- **Signal Contributions:** Identify sensors that are prevalent during the anomaly.
- **Recommendation Matching:** From similar past incidents, and identify expert guidance.

Secure & Grounded

Ensure maximum operational safety with zero hallucinations and complete localized context security.

- **Zero Data Retention:** Deterministic outcomes with secure SLM deployment.
- **SME Grounding:** Verify outcomes inside certified physical documentation.

Closed-Loop Action

Drive downstream value directly from incidents into maintenance execution systems.

- **CMMS Integration:** Trigger work orders from incidents.
- **Round-Trip Validation:** Automatically validate completed work and recommended actions for future incidents.

