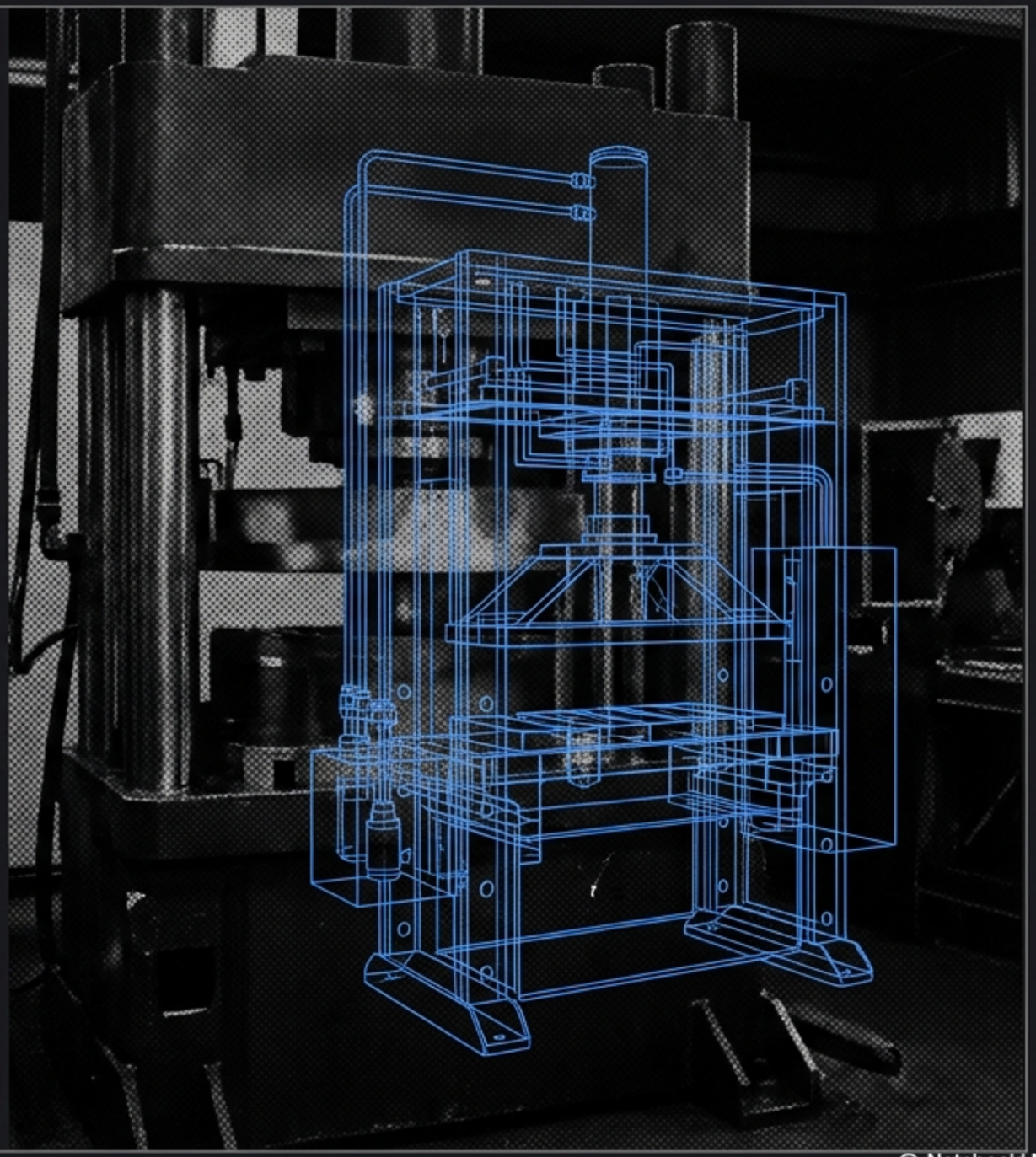
GHOST IN THE MACHINE

From Reactive Failure to AI-Driven Predictive Maintenance.

FDP WORKSHOP :: STRATEGIC FORENSIC OVERVIEW :: SESSION 1



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CASE FILE: INCIDENT AT MACHINE 07

PERSONNEL FILE

NAME: Neelakantha (Neel)

ROLE: Operator, Shift B

MACHINE: HYD_PRESS_07 (8 Years Service)

STATUS: Injured / Medical Leave (6 Months)

IMPACT: Sole provider for family of four.

SYSTEM EVENT LOG

- **DAY 0:** Normal Operation. Baseline established.
- **DAY 3:** +0.5% Harmonic Frequency Drift. (IGNORED)
- **DAY 10:** Motor Current +3%. (IGNORED)
- **DAY 14:** Temperature +2°C. (IGNORED)
- **DAY 21:** CATASTROPHIC BEARING FAILURE.

"The machine was screaming for help for 21 days. No one heard it."

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THE PROBLEM: DROWNING IN DATA

500+
Active Sensors

JetBrains Mono Warm Grey

2,000+
Daily Alarms

JetBrains Mono Warm Grey

3
Human Operators

JetBrains Mono Warm Grey

The Visibility Gap: Alarm Fatigue. When the dashboard flashes red 2,000 times a day for minor issues, critical warnings become invisible. Manual monitoring at this scale is not difficult—it is mathematically impossible.

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TELEMETRY FUNDAMENTALS

Listening to the Machine

TEMPERATURE
68°C
Range: 45-75°C (Normal)

VIBRATION
0.8 mm/s
Range: 0.1-2.0 mm/s (Normal)

MOTOR CURRENT
125 A
Warning: Gradual Increase (+3%)

HARMONICS
0.18
Status: DRIFT DETECTED

SENSOR NODE → PROTOCOL (MQTT/OPC-UA) → COLLECTION GATEWAY → STORAGE (Time-Series)

Telemetry: The automated collection, transmission, and analysis of data from remote sources.

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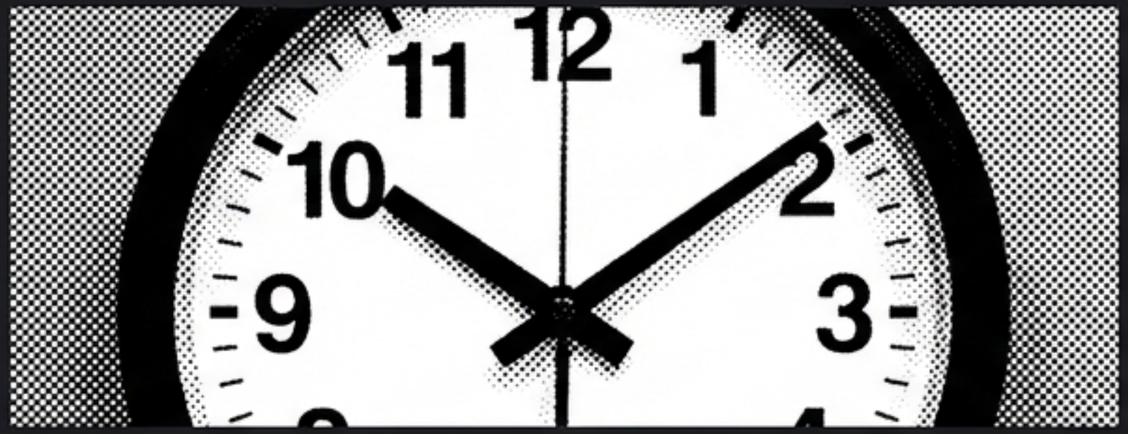
WHY SQL CAN'T HANDLE THE PULSE

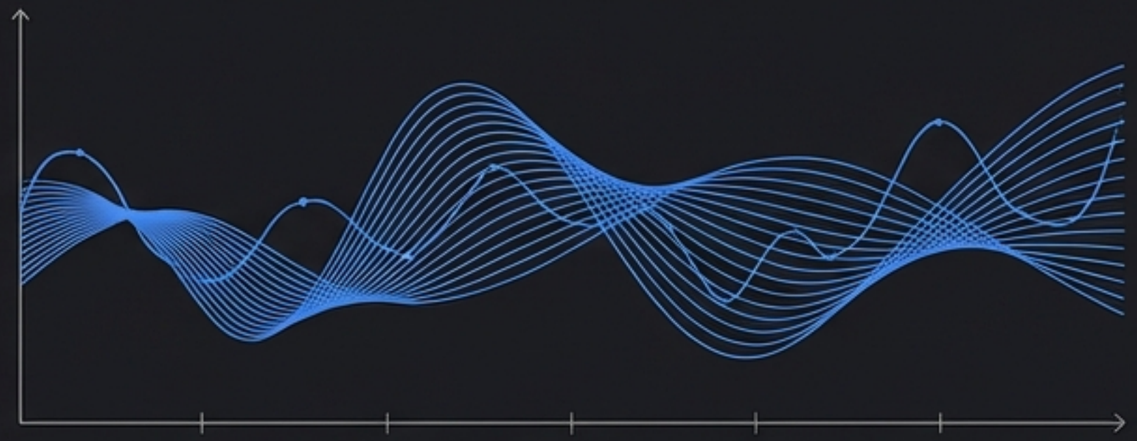
RELATIONAL DB (SQL)



Designed for **Current State.**

```
Query: "What is the temperature right now?"
Result: Single Value.
```

TIME-SERIES DB (InfluxDB)



Designed for **Trends & History.**

```
Query: "How has temperature changed over the last 300 hours?"
Result: Contextual Trend.
```

DATA STRUCTURE BREAKDOWN

```
MEASUREMENT: temperature
TAG: machine_id=hyd_press_7
FIELD: value=72.5
TIMESTAMP: 2024-01-15T10:30:00Z
```

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OPENTELEMETRY: A UNIVERSAL LANGUAGE

The Three Pillars of Observability

METRICS

The Heartbeat

Numeric measurements over time. (e.g., Temperature Gauge, Request Counter).

LOGS

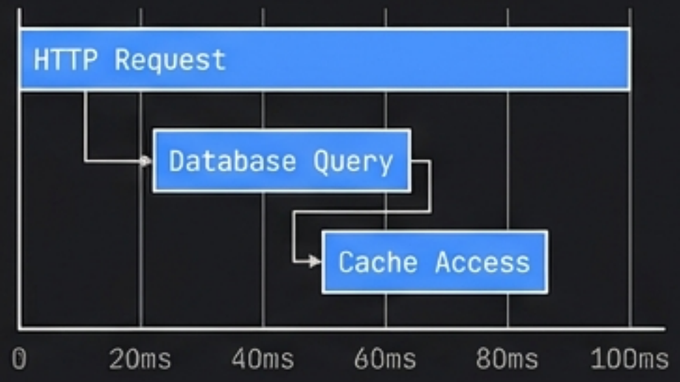
The Diary

```
[2024-05-15T10:30:00Z]
INFO: Cycle started.
[2024-05-15T10:30:00Z]
WARN: Pressure drop.
[2024-05-15T10:30:00Z]
ERROR: Valve failure.
[2024-05-15T10:30:00Z]
DEBUG: Data synched.
```

Structured text records of events. (e.g., INFO: Cycle started. WARN: Pressure drop.)

TRACES

The Nervous System



The flow of requests through the system. Tracking operations and relationships.

OpenTelemetry (OTEL) standardizes data flow so any tool can understand the machine's pain.

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SEEING IS NOT BELIEVING

The Limit of Visualization: Dashboards show us *what* happened. They don't tell us *why* or *what's next*. *what's next*. To a busy human, the big spike demands attention, masking the real threat.

RED HERRING.
Looks critical, but is harmless. Distracts the operator.

THE KILLER.
0.5% Drift. Subtle, quiet, and catastrophic.

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ENTER THE AI AGENTS

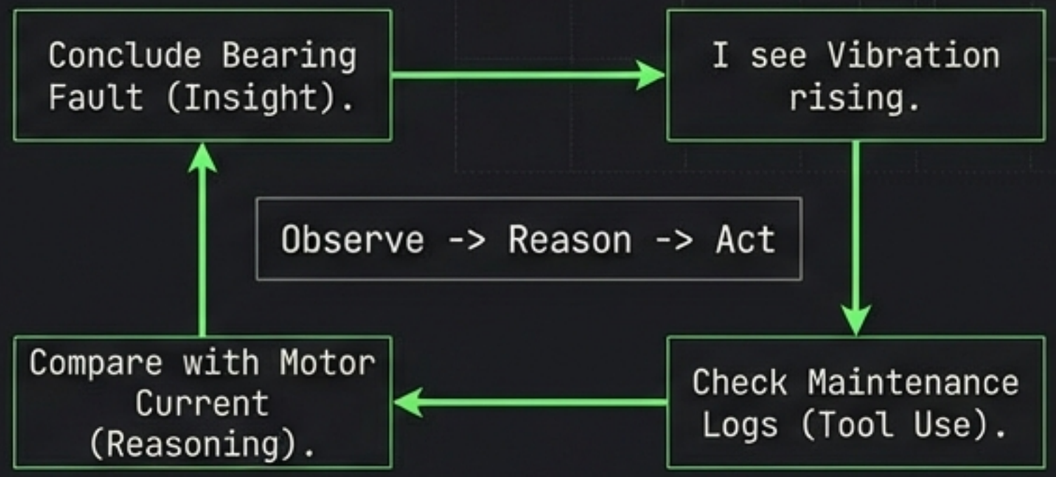
Beyond Automation: Agency

TRADITIONAL SCRIPT

```
IF Vibration > 2.0 THEN Alert.
```

Rigid. Reactive. Prone to false positives.

AI AGENT



Reasoning. Tool Use. Memory. Context-aware.

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GIVING THE AI HANDS

The Model Context Protocol (MCP)

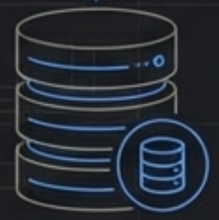
THE BRAIN (LLM)

MCP CLIENT & HOST

THE HANDS (MCP TOOLS)

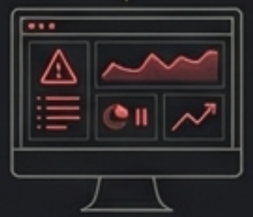
TOOL 1	TOOL 2	TOOL 3
`query_influxdb(range: -30d)`	`read_maintenance_logs(id: 'press_7')`	`send_alert(priority: 'high')`

THE FACTORY



DATABASE

FILE SERVER



SUPERVISOR'S DASHBOARD

The Agent uses MCP to execute code against factory infrastructure, bridging the gap between chat and action.

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MEET THE DIGITAL SWARM

Specialized Agents. One Mission.

DRISHTI
The Monitor _

Watches raw telemetry 24/7. Never blinks.

JIBREEL
The Detective _

Detects anomalies. Asks: "Is this pattern weird?"

ATHENA
The Doctor _

Root Cause Analysis. Diagnoses the specific failure.

VIDHAATA
The Scheduler _

Checks inventory and plans maintenance windows.

HERMES
The Messenger _

Delivers the right alert to the right human.

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REWRITING HISTORY: THE SIMULATION

How the Swarm Would Have Saved Neel

DAY 3

DRISHTI spots 0.5% harmonics drift. Flags for review.

DAY 3.5

JIBREEL correlates drift with rising Motor Current. Rules out sensor error.

DAY 4

ATHENA matches pattern to 'Bearing Failure Signature'. Predicts failure in 17 days.

DAY 4 (14:00)

HERMES alerts Supervisor. Maintenance booked.

DAY 3 → DAY 3.5 → DAY 4 → DAY 4 (14:00)

BEARING REPLACED DAY 5. NO INJURY.

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THE INTERVENTION

Co-Pilot, Not Autopilot

URGENT: PREDICTIVE MAINT REQ - MACHINE 07

Agent Hermes via Monitoring Swarm

ISSUE: Inboard Bearing Degradation Detected.	CONFIDENCE SCORE: 87% (High)

EVIDENCE: Harmonics drift (0.5%) + Current Rise.

RECOMMENDATION: Replace bearing during next shift change (Tuesday 08:00).

INVENTORY STATUS: Part #B-772 in stock (Aisle 4, Bin C).

[APPROVE ACTION] [REJECT / FLAG FOR REVIEW]

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THE NEW STANDARD FOR SAFETY

Summary & Key Takeaways

1. TELEMETRY IS TRUTH

Without granular, high-frequency data (OTEL), we are blind to the machine's reality.

2. CONTEXT IS KING

Time-series databases (InfluxDB) turn isolated data points into actionable history and trends.

3. AGENTS PROVIDE VIGILANCE

AI Swarms (via MCP) solve the human bandwidth problem, turning noise into insight.

We don’t lack data. We lack insight. And insight saves lives.

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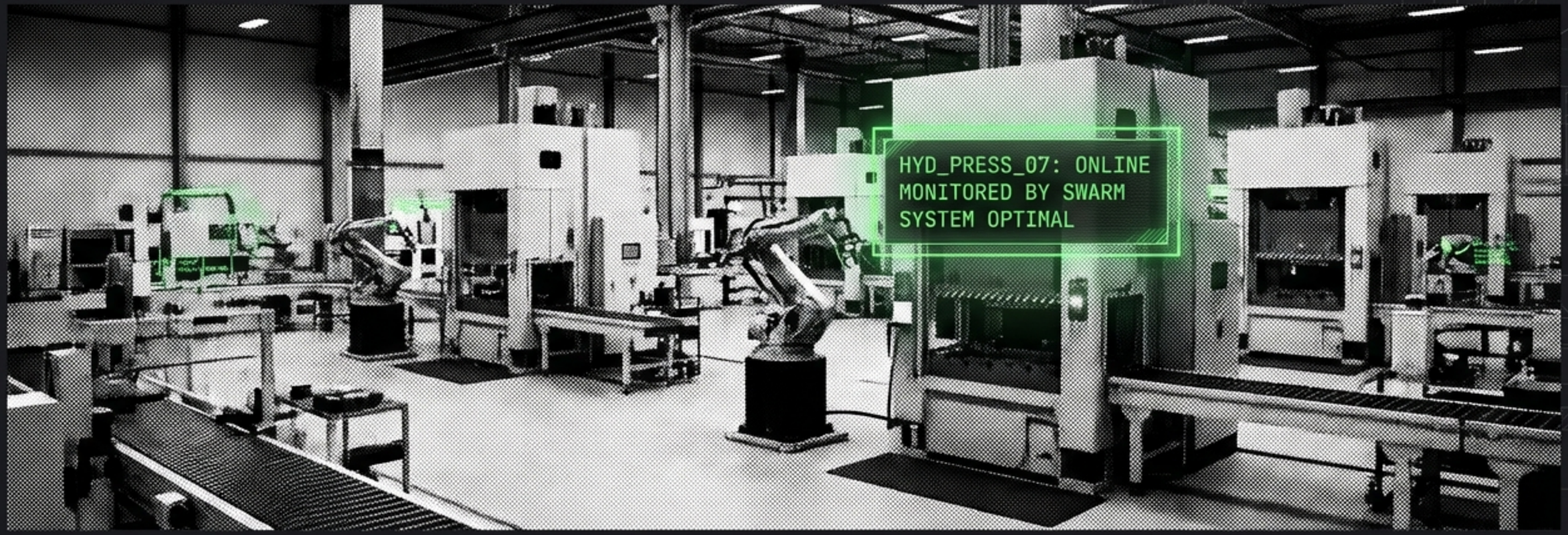
BUILD THE GHOST

The technology exists. The protocols are open.
The agents are waiting to be built. Let’s begin.



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