

Emerging Technologies in Ready-Meal Production

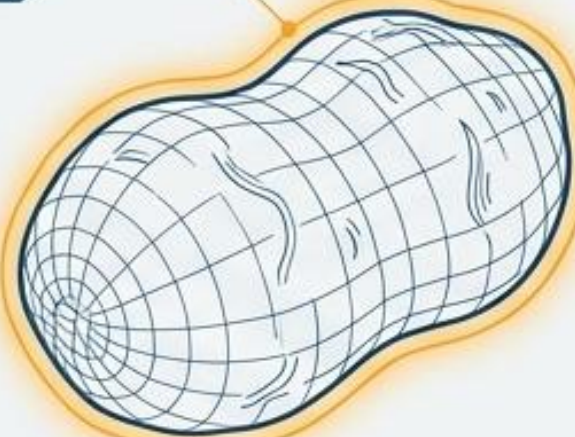
By
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Food manufacturing presents unique environmental constraints

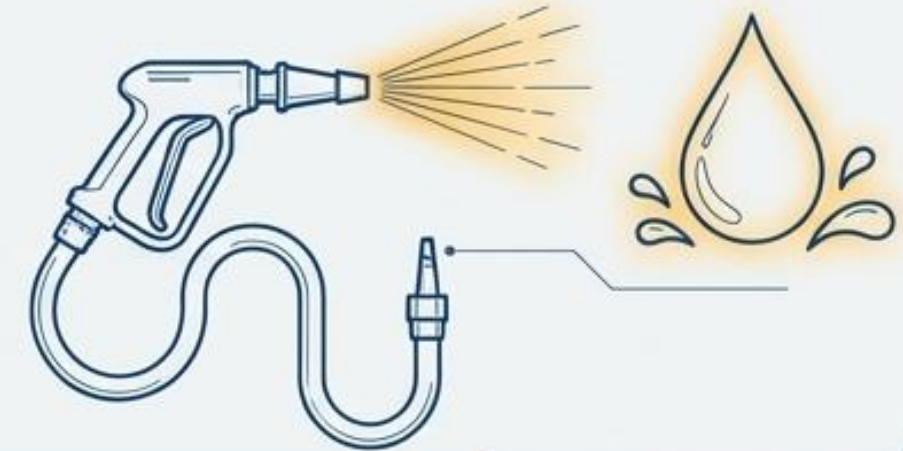
Food Variability

- Organic ingredients feature highly variable shapes and textures.
- Significantly harder to handle than rigid, uniform manufactured objects.



Hygiene Requirements

- Strict compliance with food safety standards.
- Demands HACCP compatibility and frequent chemical washdowns.



Temperature Constraints

- Machinery must perform flawlessly in highly regulated chilled and frozen environments.



High SKU Variety

- Requires extreme agility for frequent changeovers between different ready-meal product lines.





Cost Margin:
High operational costs.



Labor Gap:
Severe labor shortages and turnover.



Quality Constraints: Shelf-life limits and stringent food safety standards.



Visibility: Lack of end-to-end traceability.



Market Shift: Rapidly changing consumer behaviors and intense competition.

Are you still using Excel to plan your factory's future?



Industry 2.0:
Mechanized machines.



Automation Era:
Inflexible, rigid programming.



Industry 4.0: Connected but siloed systems.



Industry 5.0: Intelligent, Human-Centric, Sustainable, Resilient.

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Industry 4.0



Smart Machines



Rigid Automation



IoT Connectivity



Big Data (Volume)

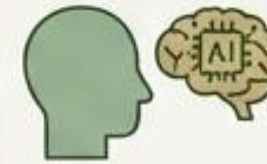


Efficiency First



Mass Production Focus

Industry 5.0



Human + AI Collaboration



Sustainability Integration



Systemic Resilience



Purpose-Driven Outcomes



Mass Personalization

Industry 5.0 leverages technology for People, Sustainability, and Systemic Resilience

Emerging Technologies Architecture (Sense, Think, Act)

A clean software stack view of the next-generation manufacturing ecosystem.

Sense (Data Capture)



IoT & Sensors

Real-time environment and machine state capture.



Computer Vision:

Automated visual inspection and quality control.

Think (Processing & Logic)



AI / Machine Learning: Pattern recognition and optimization.



Digital Twin: Virtual replication for scenario testing.



Cloud / Edge Computing: Rapid data processing (Edge for speed, Cloud for scale).



Gen AI / LLM: Natural language operator assistance.



Blockchain: Immutable trust and traceability.

Act (Physical Output)



AGV / AMR: Autonomous material transport.



Cobots:

Collaborative robotics augmenting human labor.

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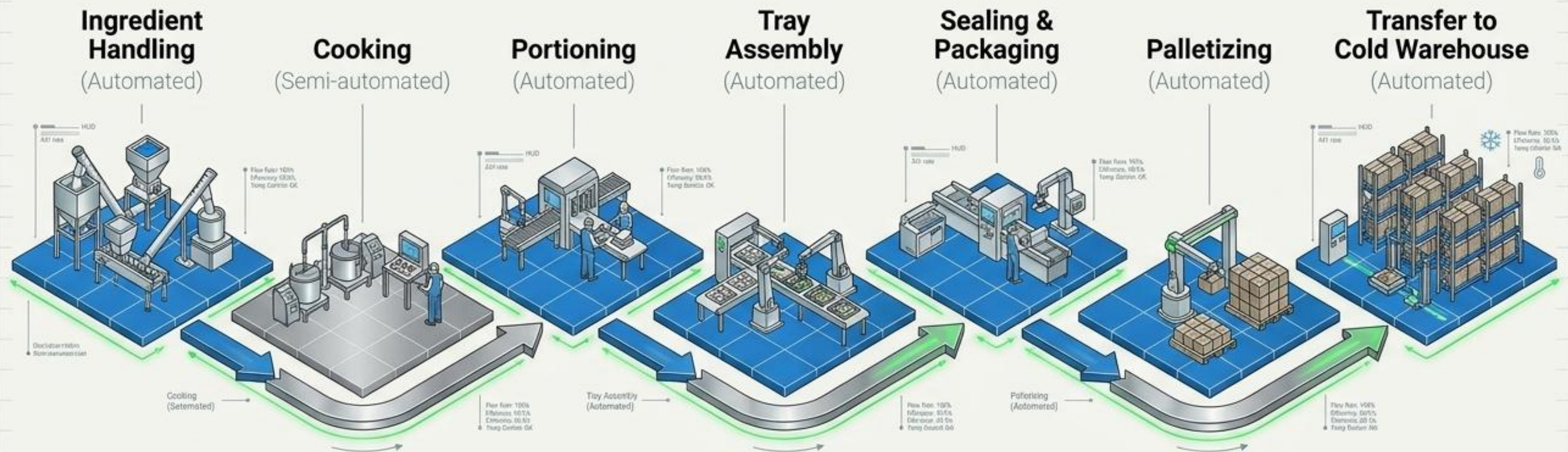
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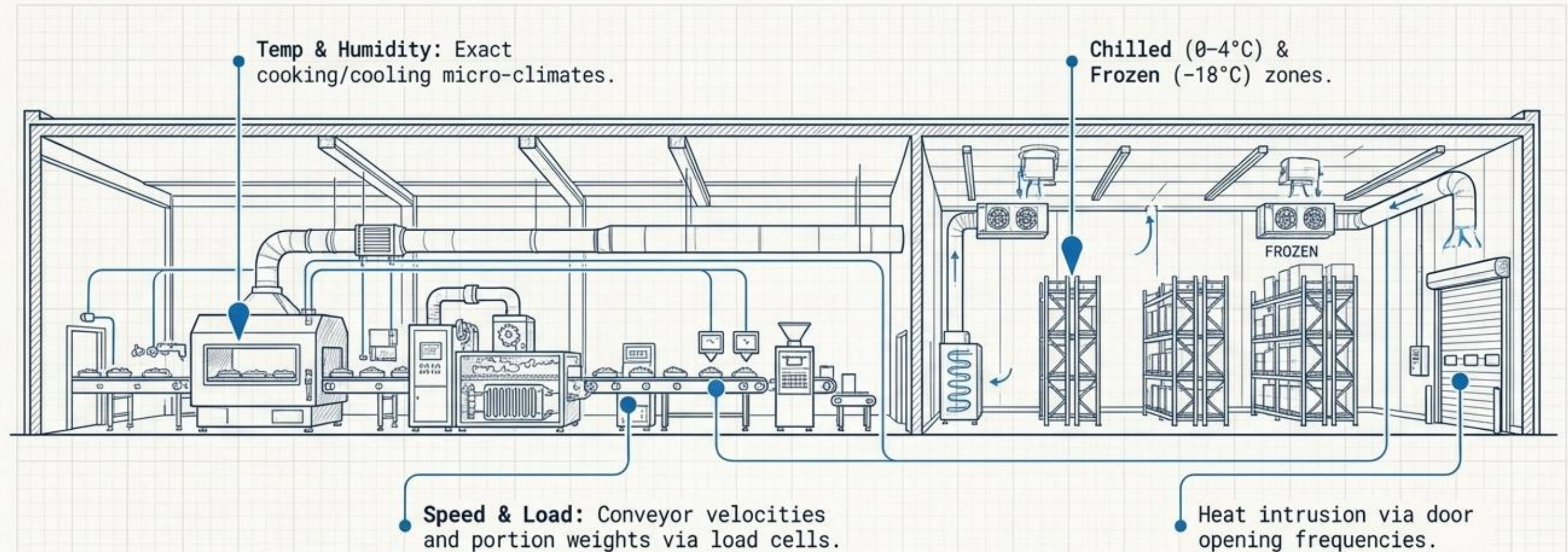
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Mapping the end-to-end automated production pipeline



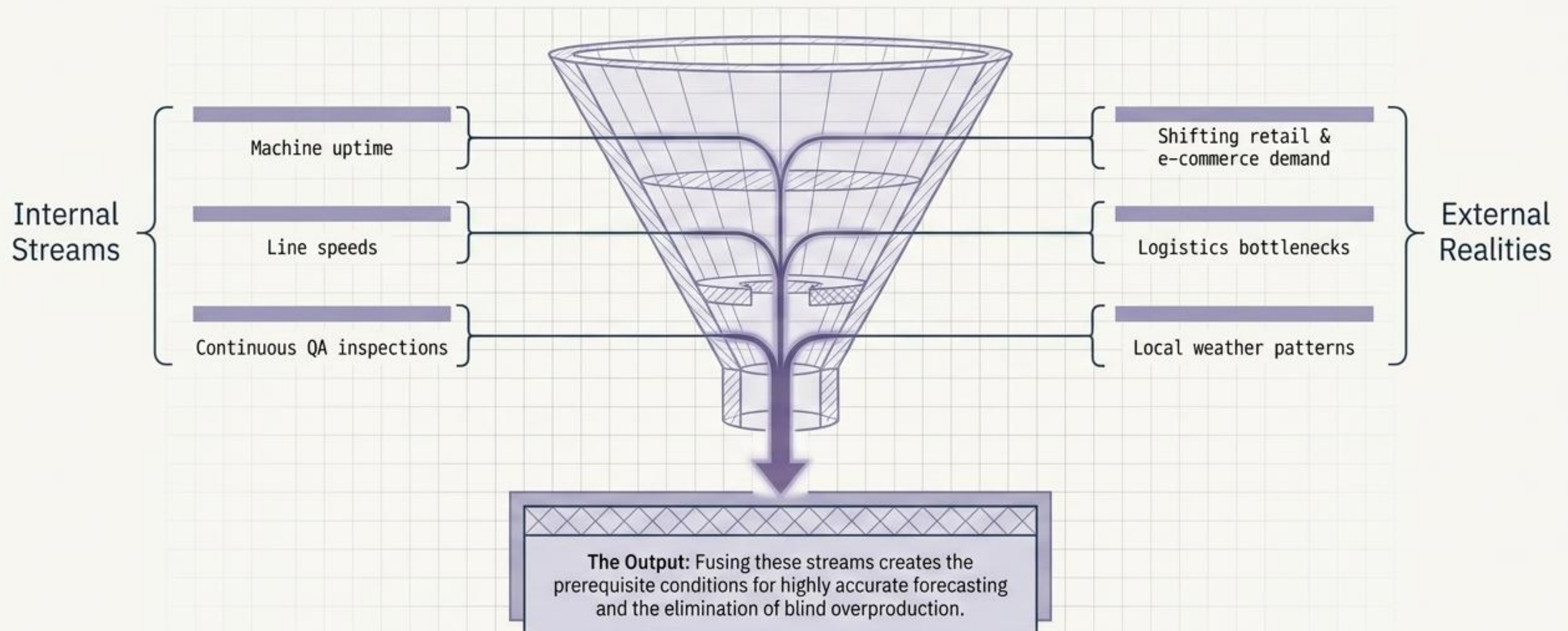
Layer 1: The Sensory Foundation of the Factory Floor



Real-World Proof: Tyson Foods utilizes these exact networks to monitor core temperatures and cooling rates every few seconds, dramatically improving food safety compliance and reducing spoilage.

Layer 2: Structuring the Data Infrastructure

In food production, 'Big' data means High Velocity, High Variety, and High Importance.



Layer 3: The Autonomous Decision Engine

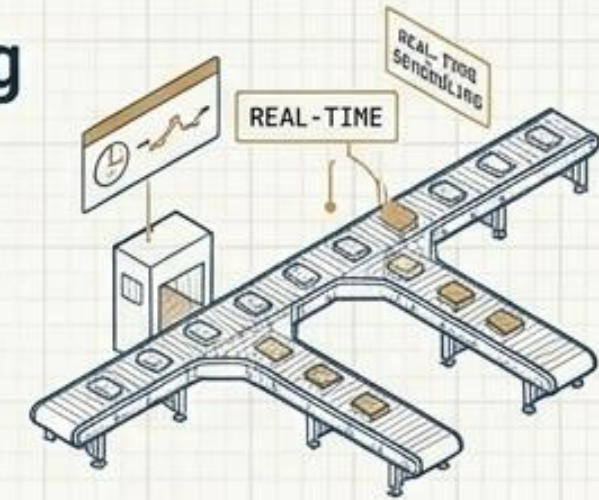
Demand Forecasting

Machine learning models absorbing seasonality, promotions, and sales history to predict exact order volumes.



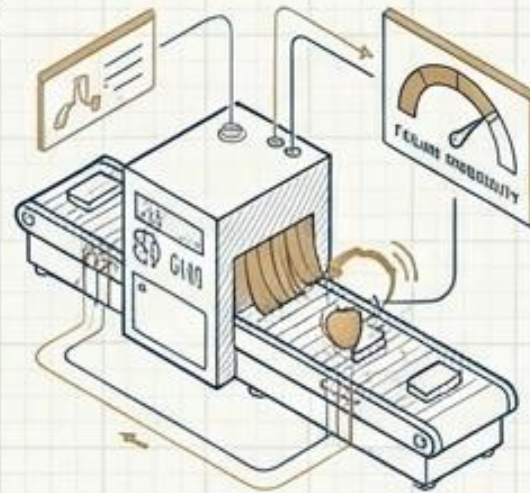
Production Scheduling

Dynamic algorithms adjusting real-time runs across multiple SKUs to maximize capacity and minimize changeover losses.



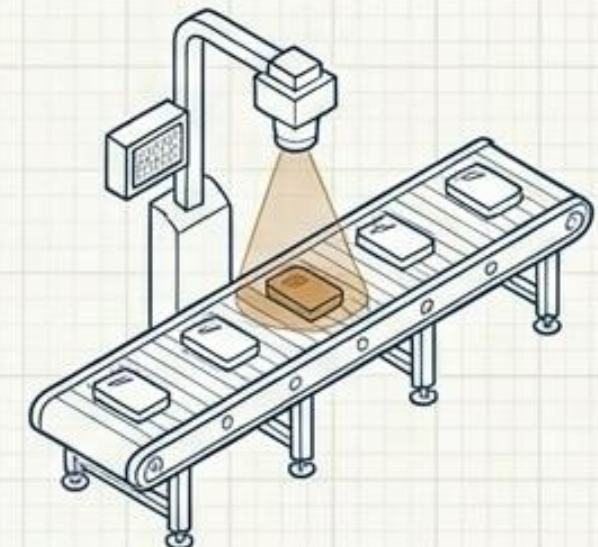
Predictive Maintenance

Analyzing historical failure data alongside live vibration and temperature feeds to prevent cold-chain-breaking equipment failures.



Quality Control

Computer vision networks instantly detecting contamination, color degradation, or portion errors on high-speed lines.



The Four Pillars of the Industry 5.0 Paradigm.

The core of 5.0 relies on the intersection of four critical capabilities:

Human-Centric Operations

Technology built to augment and assist operators, not just replace them.



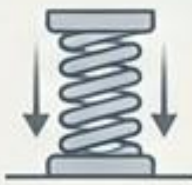
Intelligent Automation

Machines that learn, adapt, and self-correct using continuous data streams.



Resilient Systems

Operations capable of absorbing supply chain shocks and pivoting instantly.



Sustainable Supply Chains

Minimizing waste through exact production matching and total traceability.



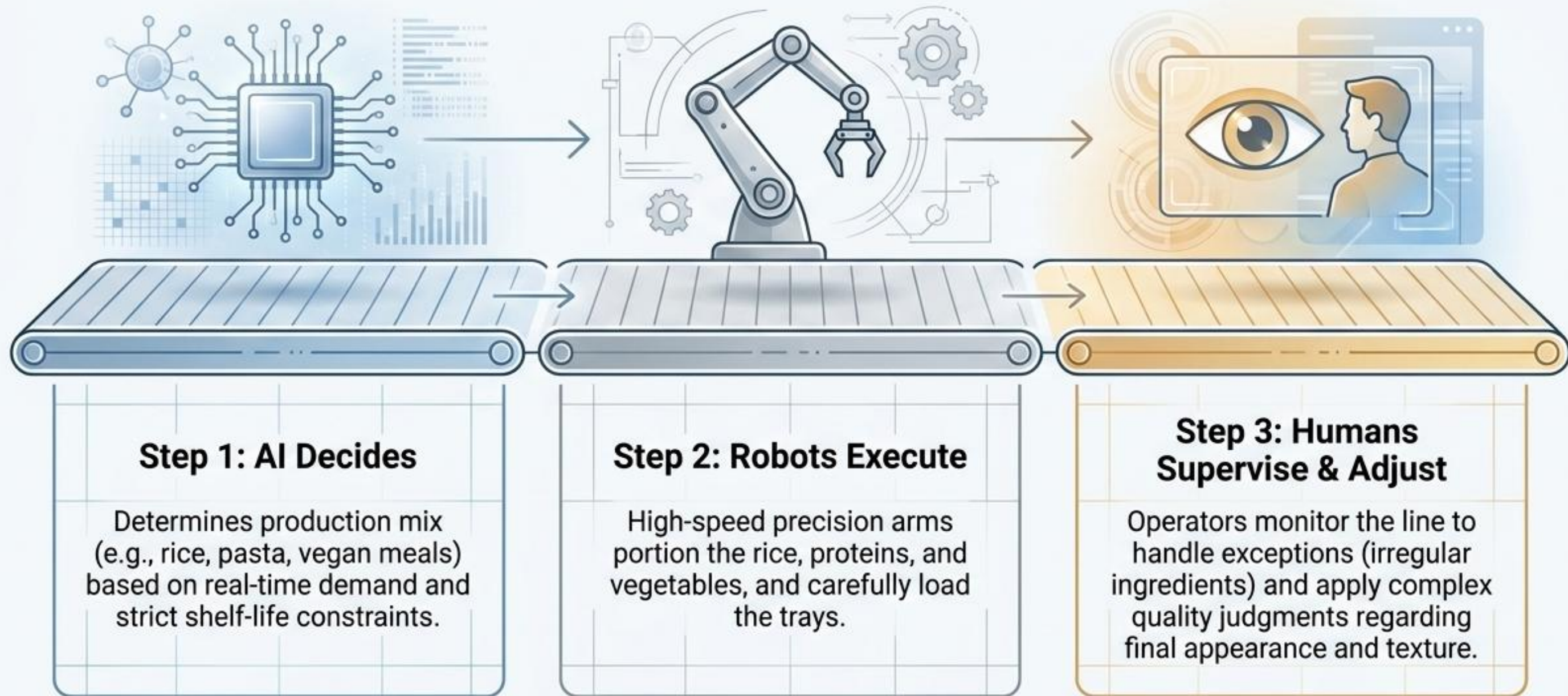
Human-in-the-Loop Decision Making

AI is augmenting human intelligence, not replacing it.

Task	AI	Human
Demand Forecasting	✓	—
Production Optimization	✓	—
Quality Judgment (taste, appearance)	—	✓
Exception Handling	—	✓

The Rule of Allocation: Humans handle complex, sensory tasks while machines handle repetitive, precise tasks.

Orchestrating the Smart Assembly Line



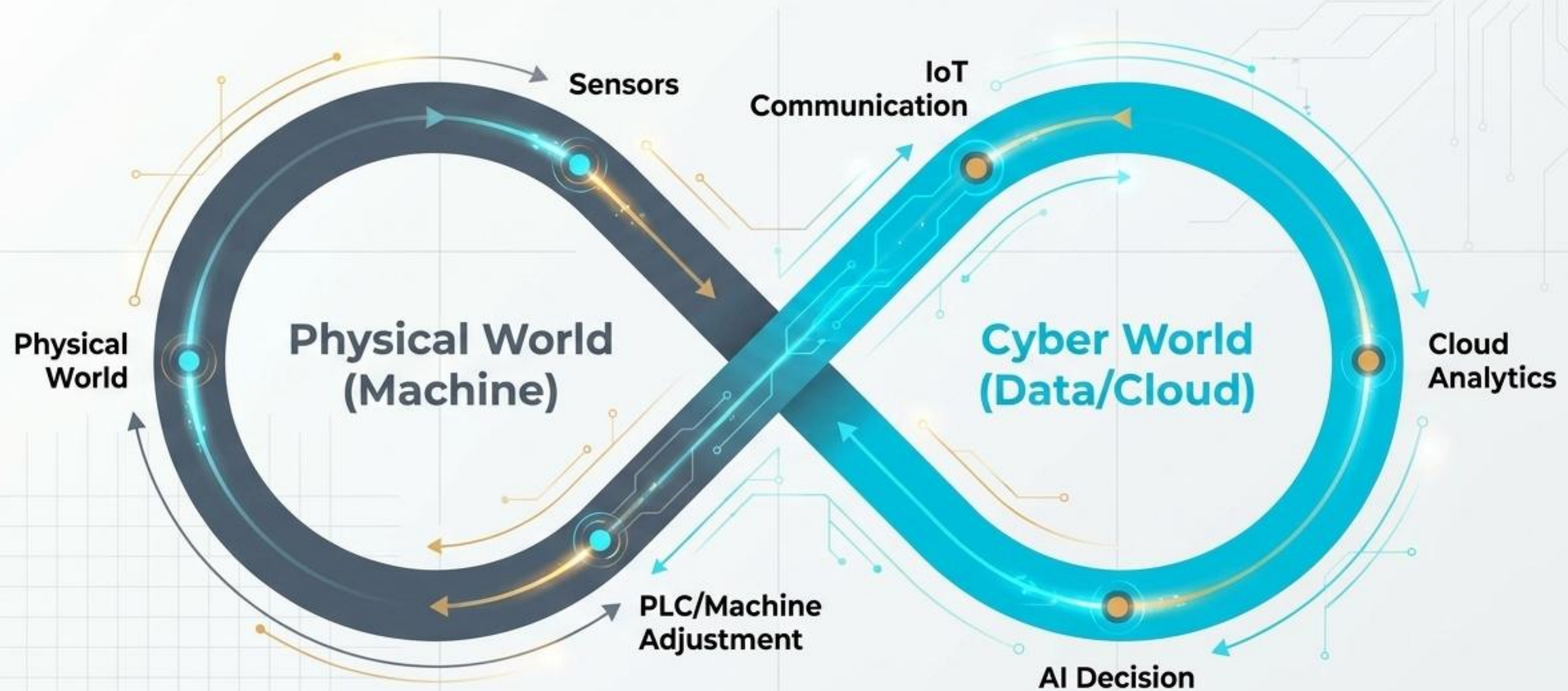


Augmentation, not replacement. The Human-Centric Promise.

Industry 5.0 is not about robots replacing humans. It is about Cobots doing the heavy lifting, AI supporting complex decisions, and Large Language Models empowering operators with instant knowledge bases. The technology does the math; the human remains the ultimate decision-maker.

Cyber-Physical Systems (CPS) are the heartbeat of 5.0.

Moving beyond basic IoT. CPS is the continuous, automated loop where data controls the physical world.



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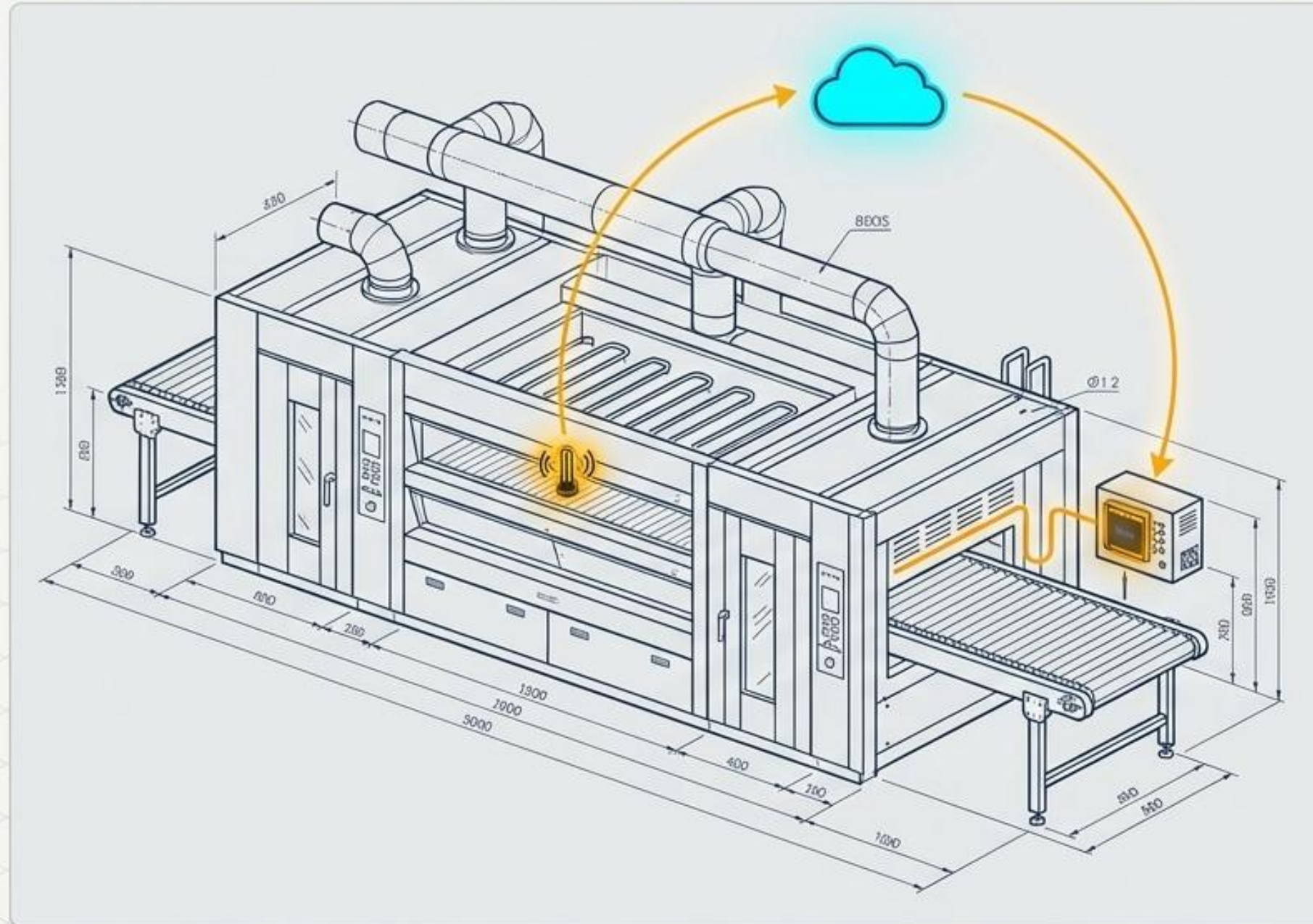


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The Micro-Second Decision: CPS in Action

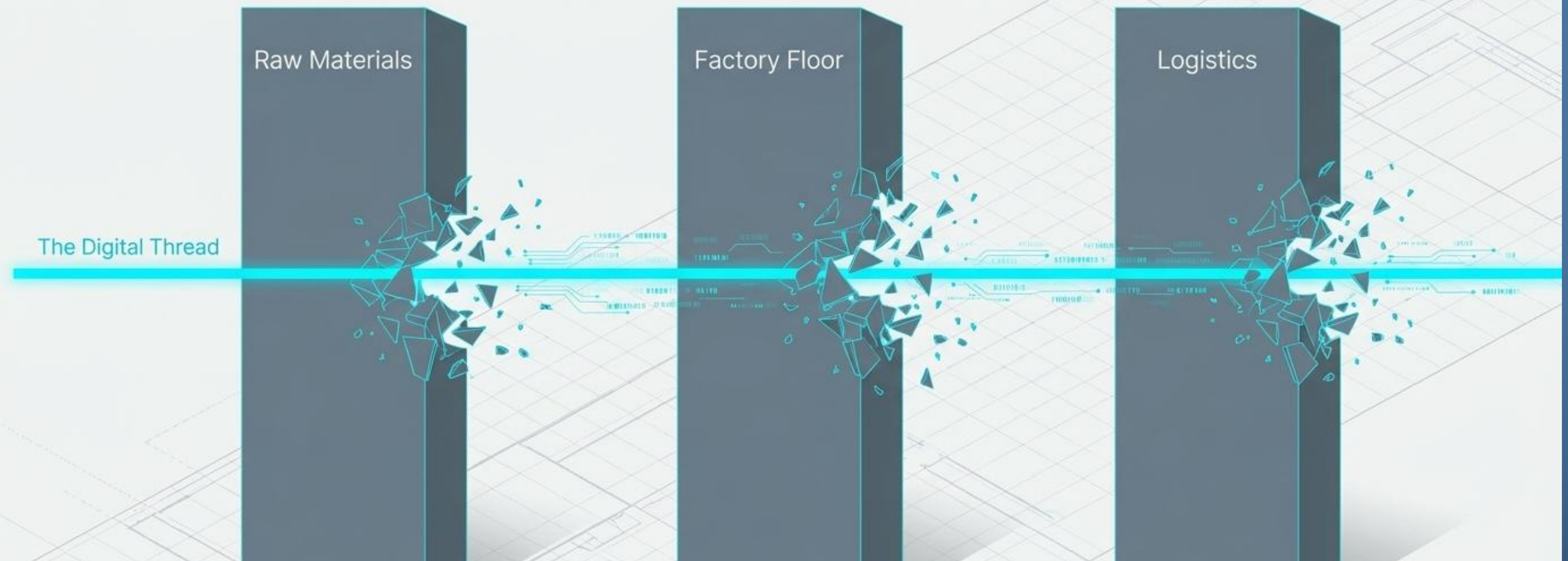
Real-Time Closed Loop Control (Total time elapsed: < 3 seconds):



1. Oven temperature drops slightly below the critical threshold.
2. Internal sensors capture the thermal data instantly.
3. Edge AI analyzes the data and detects a quality-threatening anomaly.
4. The system sends a direct command to the PLC to auto-adjust the heat.
5. The human operator's dashboard is updated with the correction log.

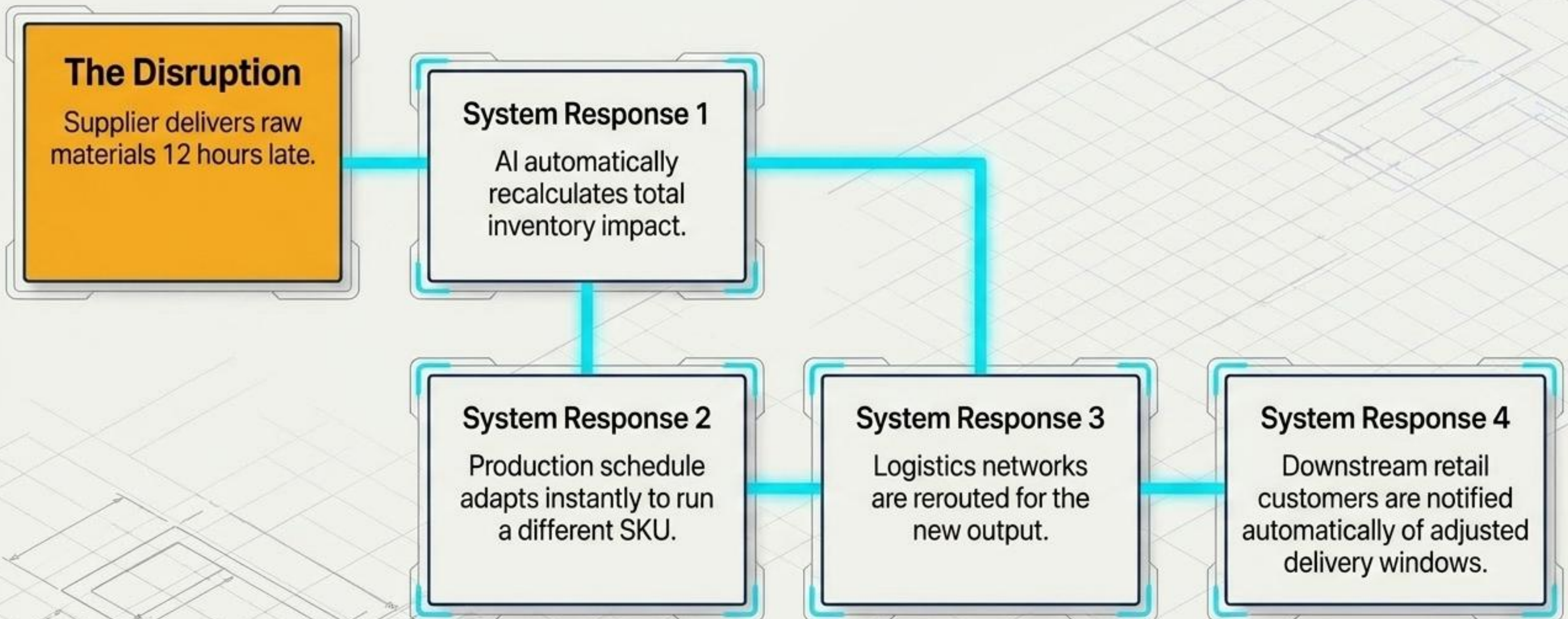
The Digital Thread eradicates operational silos.

Data must flow as seamlessly as the physical product. The Digital Thread is the unbroken stream of information traveling from the raw material supplier directly to the end consumer without interruption. It guarantees total visibility and predictability.



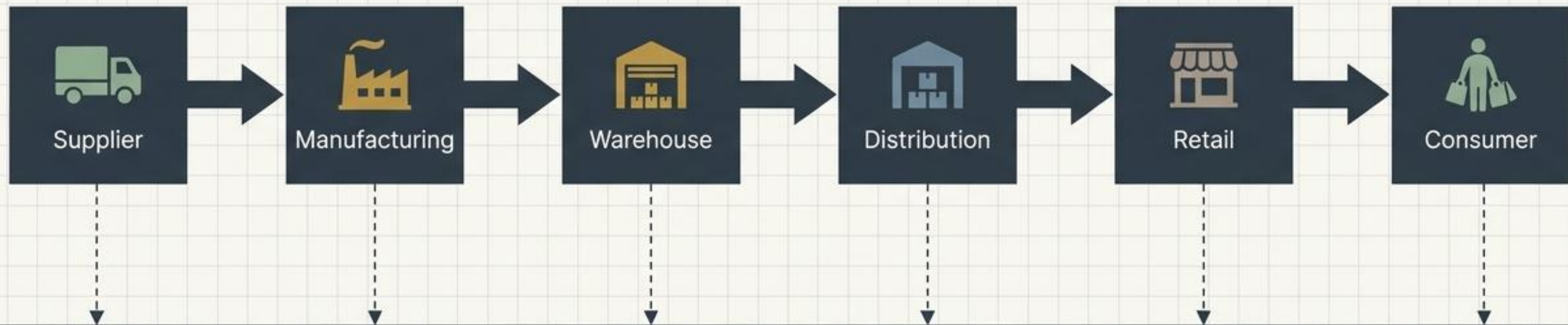
The Agility Reflex in Action.

How a Smart Food Ecosystem absorbs a shock organically:



X-Ray Supply Chain: Revealing the Digital Pillars

The Physical Pipeline



The Digital Pillars - The "X-Ray"

					
Visibility: Unobstructed view of every node in real-time	Transparency: Traceable data logs from farm to fork	Traceability: Immediate upstream/downstream tracking for safety	Predictability: Forecasting bottlenecks before they occur	Resilience: Adapting instantly to sudden shocks or shortages	Agility: Rapidly pivoting schedules based on new variables

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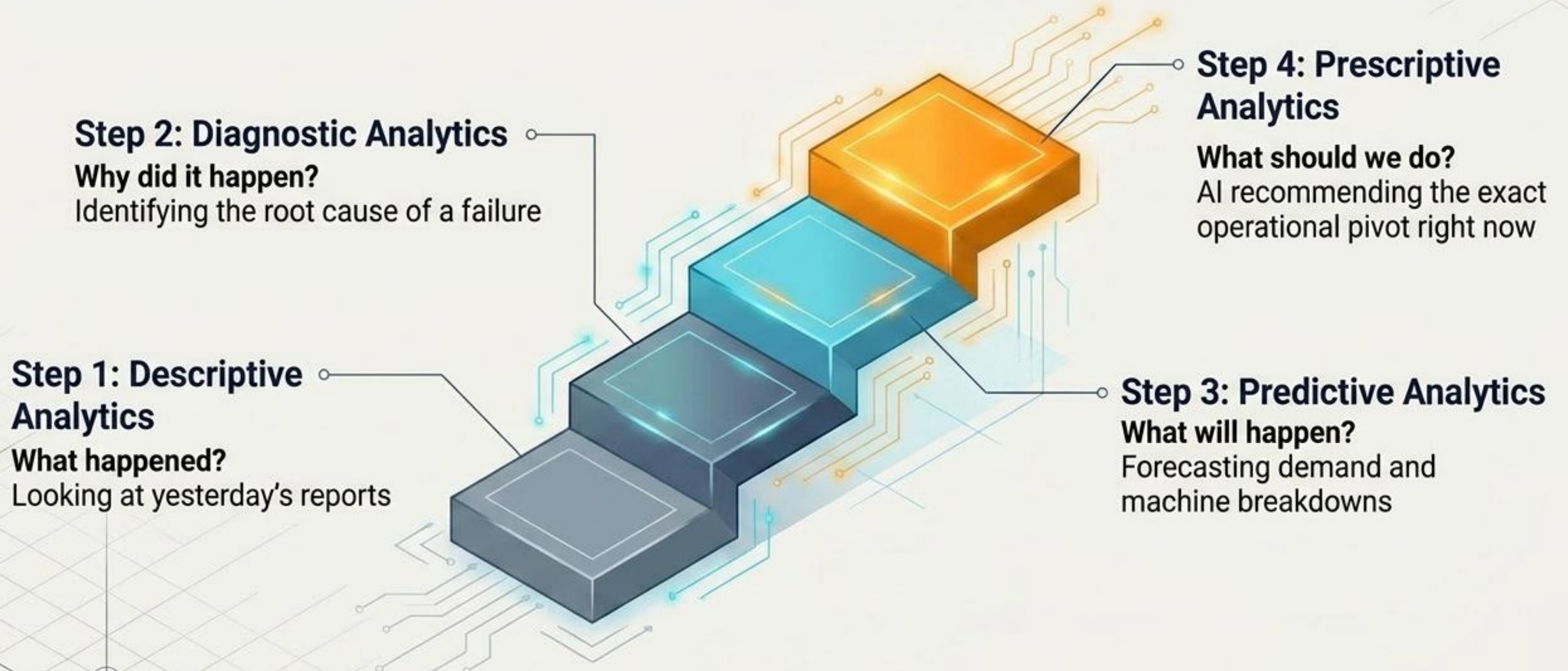


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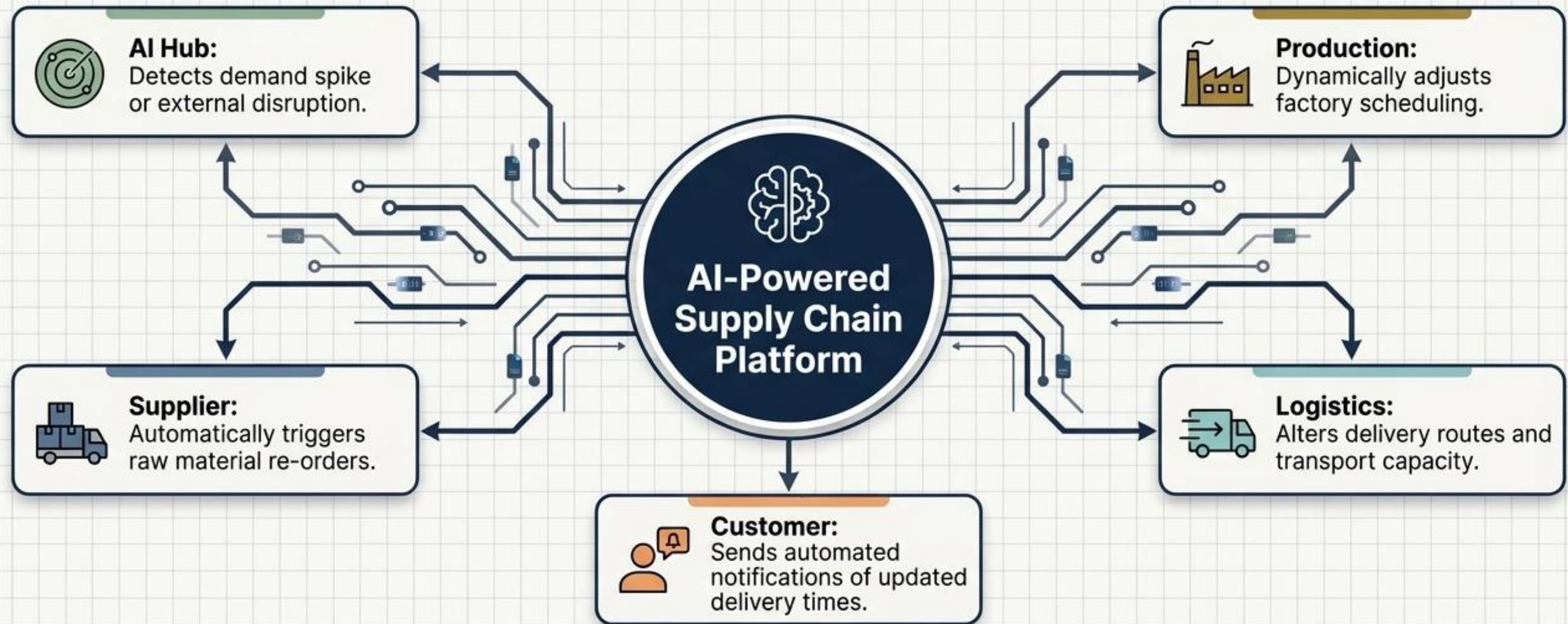
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Data is the new raw material of food manufacturing.

A food factory does not just produce food; it produces data. The value of this data scales with analytical maturity:



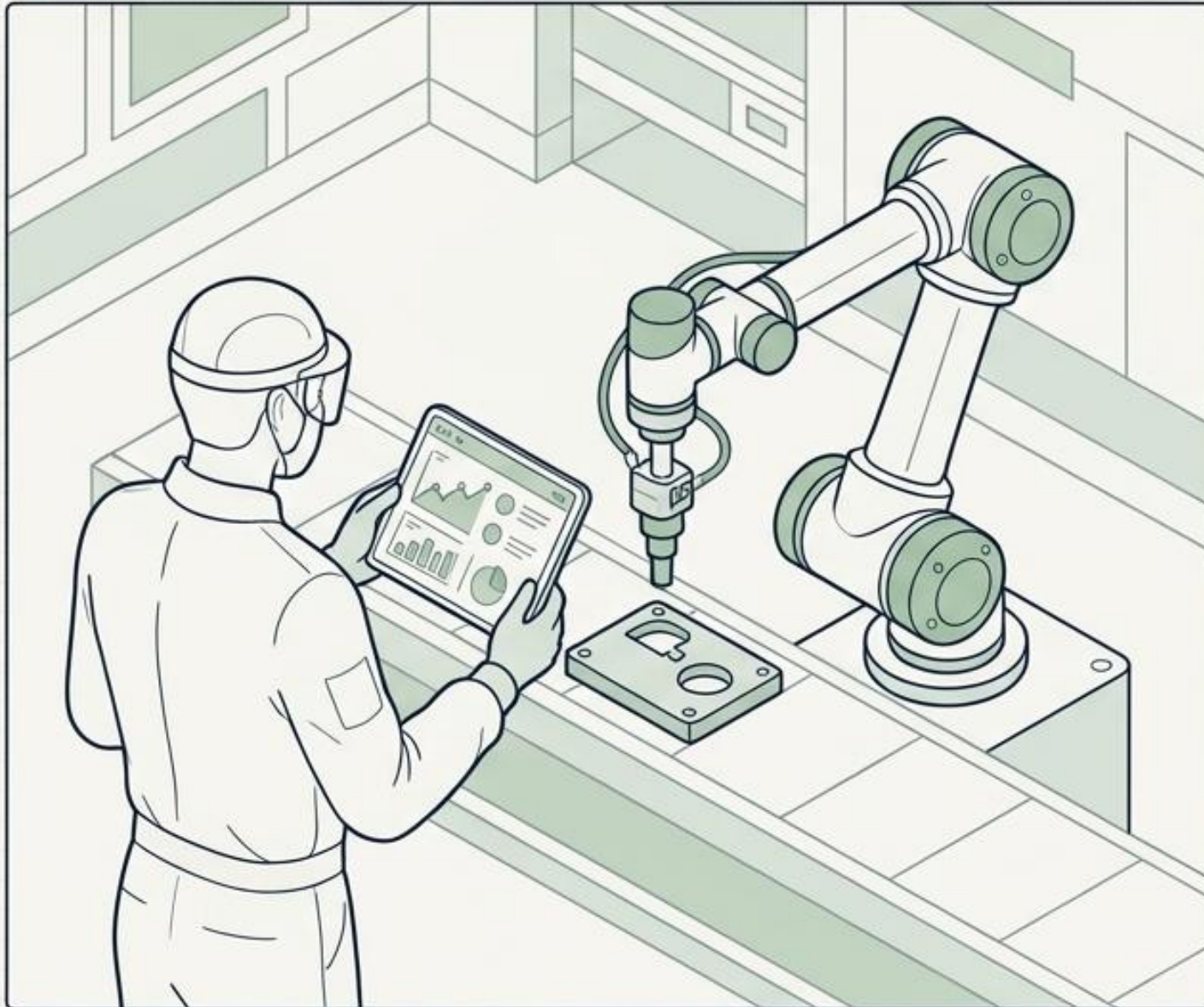
Smart Supply Chain Platform: Automated & Adaptive Flow



Real-time data  Automated Decisions  Guaranteed On-time delivery

Human-Centric Factory: Harmonious Collaboration for a Better Future

Editorial Blueprint & Executive Dashboard



AI as Co-Pilot:

Assisting humans to reduce cognitive fatigue and manual analysis.

Cobots for Safety:

Handling dangerous, repetitive physical tasks so humans don't have to.

Augmented Decision-Making:

Systems provide the data; humans provide the nuanced judgment.

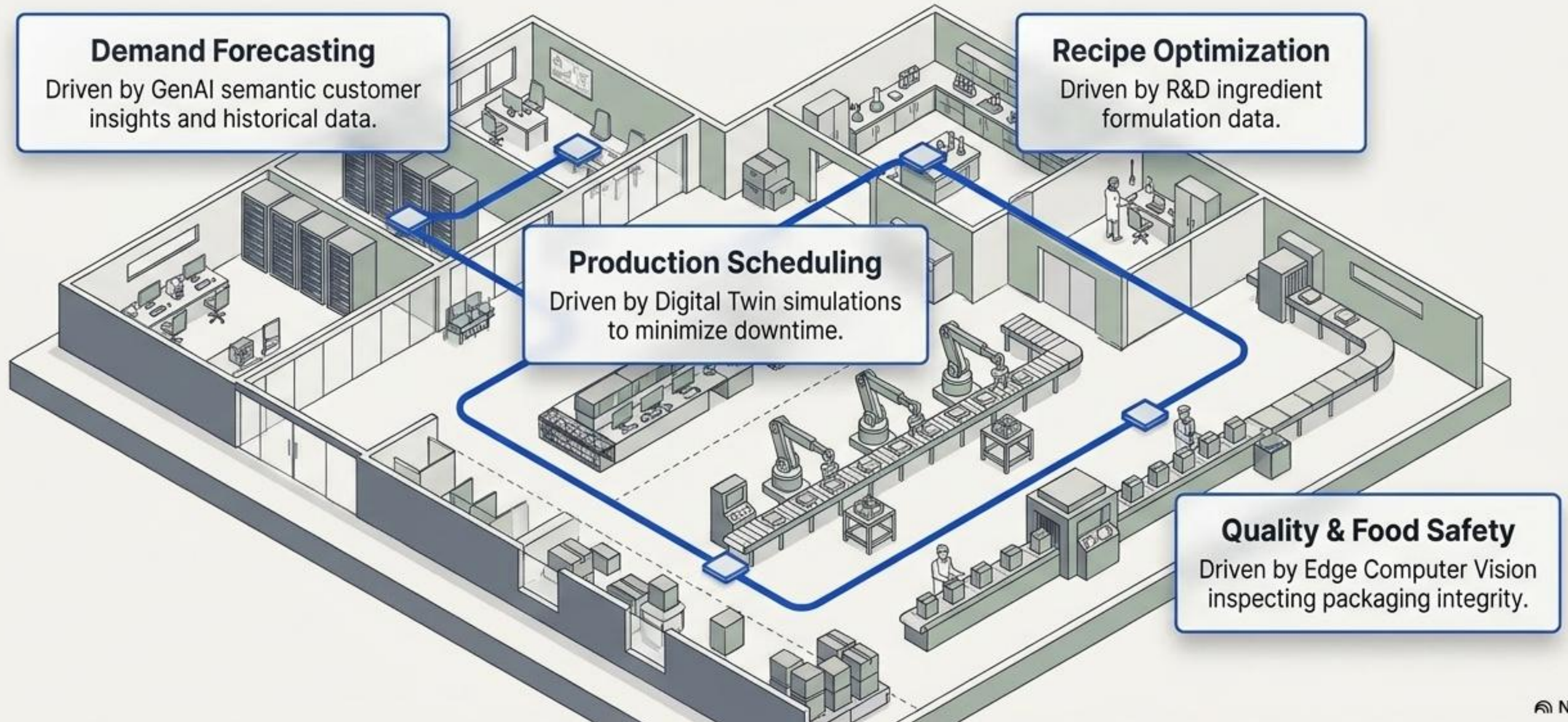
Strategic Upskilling:

Shifting floor workers from manual operators to system supervisors.

Technology works with humans to build a better, more sustainable operational reality.

Blueprint for Food Factory 5.0

Applying the enterprise AI model to Ready-to-Eat (RTE) manufacturing.



The Connected Value Chain: Executive Summary

1

Virtualize for Scale

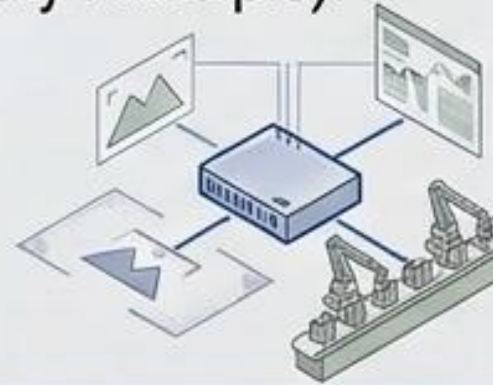
Create one accurate digital representation of assets or systems to unlock exponential reuse (The Nestlé Principle).



2

Close the Operational Loop

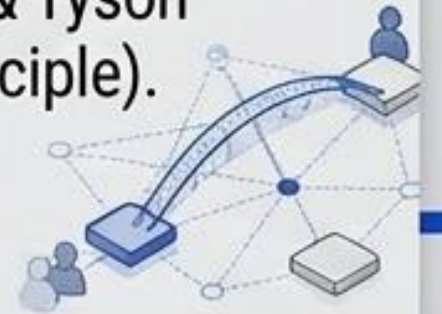
Transform physical data into real-time operational decisions using Edge AI and Computer Vision (The Tyson Factory Principle).



3

Bridge the Edges

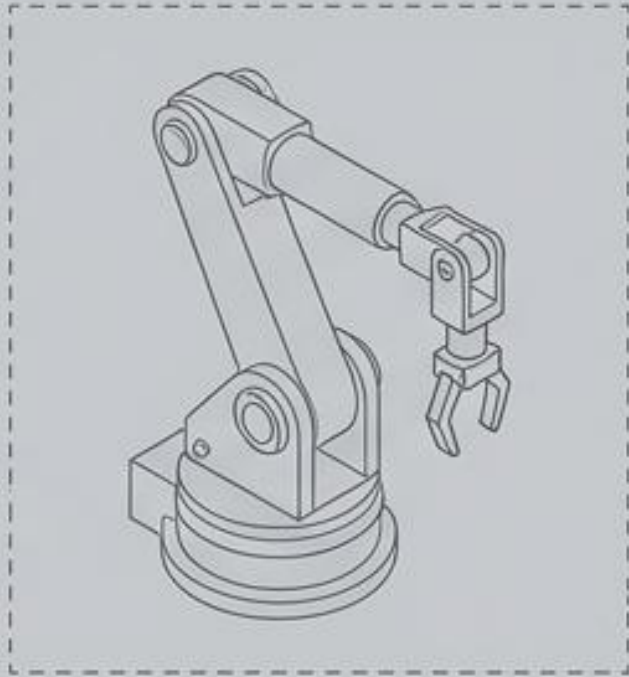
Connect unstructured customer insights directly to supply chain forecasting, making AI an enterprise-wide nervous system (The Unilever & Tyson Customer Principle).



MOVING BEYOND THE FACTORY FLOOR

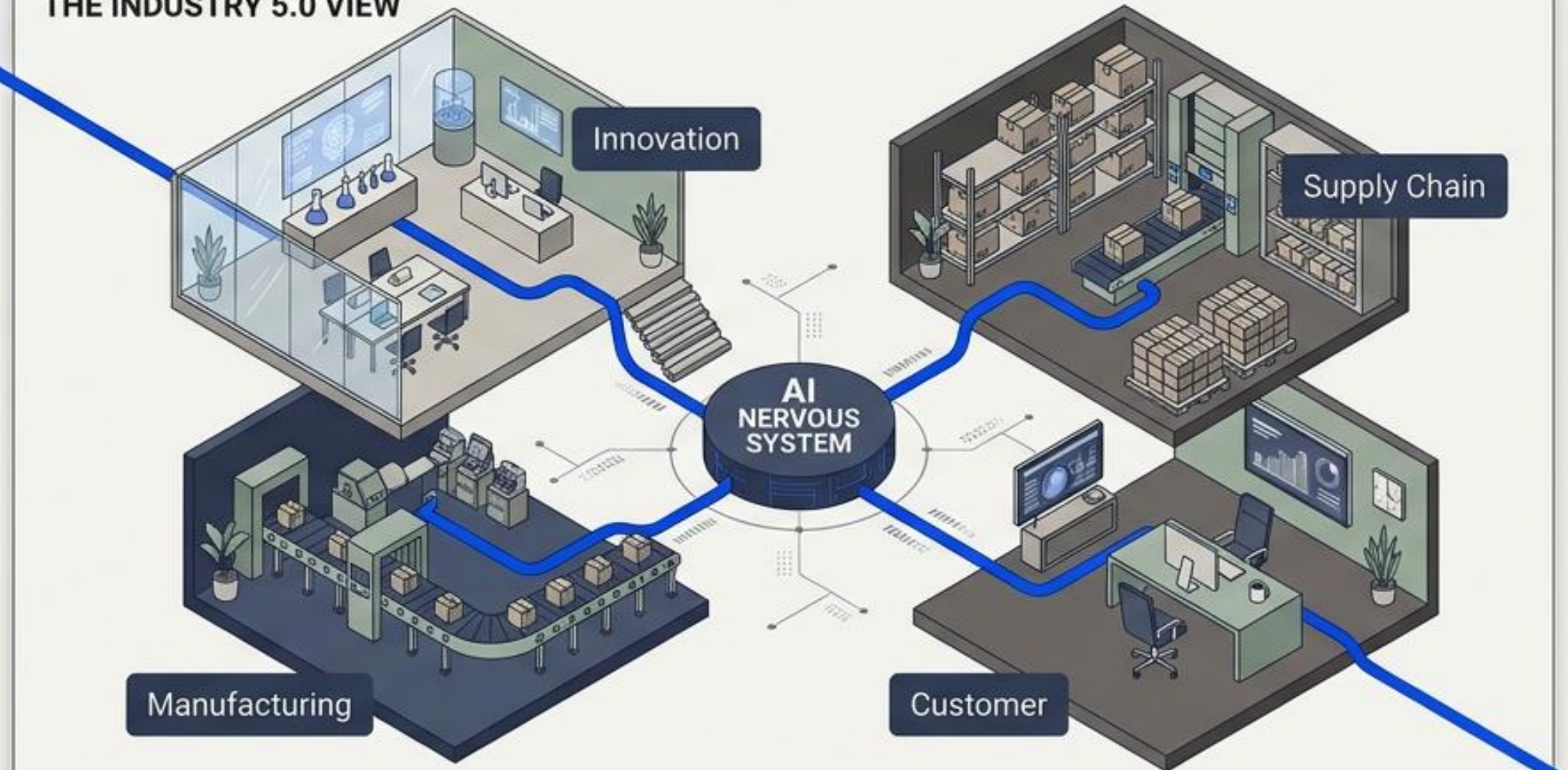
AI is no longer a standalone technology—it is an enterprise capability connecting Consumer, Innovation, Manufacturing, Supply Chain, and Customer.

THE OLD VIEW



Standalone Automation

THE INDUSTRY 5.0 VIEW



The End-to-End AI Framework



1. Consumer Insight

Analyzing millions of reviews to detect emerging trends early.



2. R&D & Innovation

Accelerating formulation development and ingredient selection.



3. Manufacturing

AI-assisted production planning and smarter operations.



4. Supply Chain

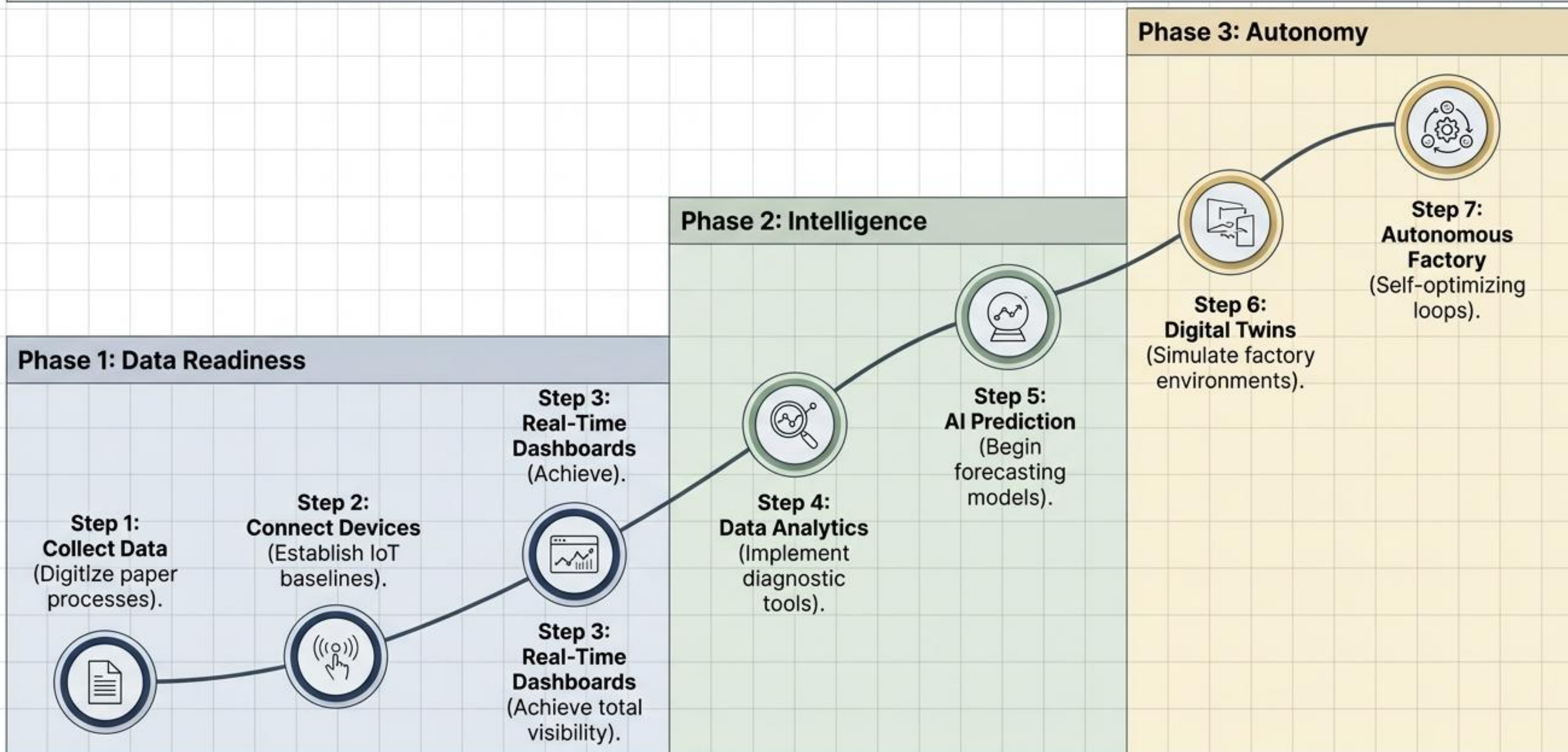
Inventory optimization and better demand forecasting.



5. Marketing & Sales

Personalized campaigns and AI-generated content.

Start small, expand gradually, deliver tangible results.





1. Data is the New Raw Material: It flows through the factory just like physical ingredients.



2. Real-Time Decisions: Moving from reactive reports to instant automated actions.



3. Connected Ecosystems: True value lies in integrating the entire supply chain.



4. Human-Centric: Technology designed to elevate human potential and sustainability.

“

Factory 5.0 is not defined by the sheer number of machines, but by the agility to transform data into rapid, accurate decisions across a fully connected supply chain.

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