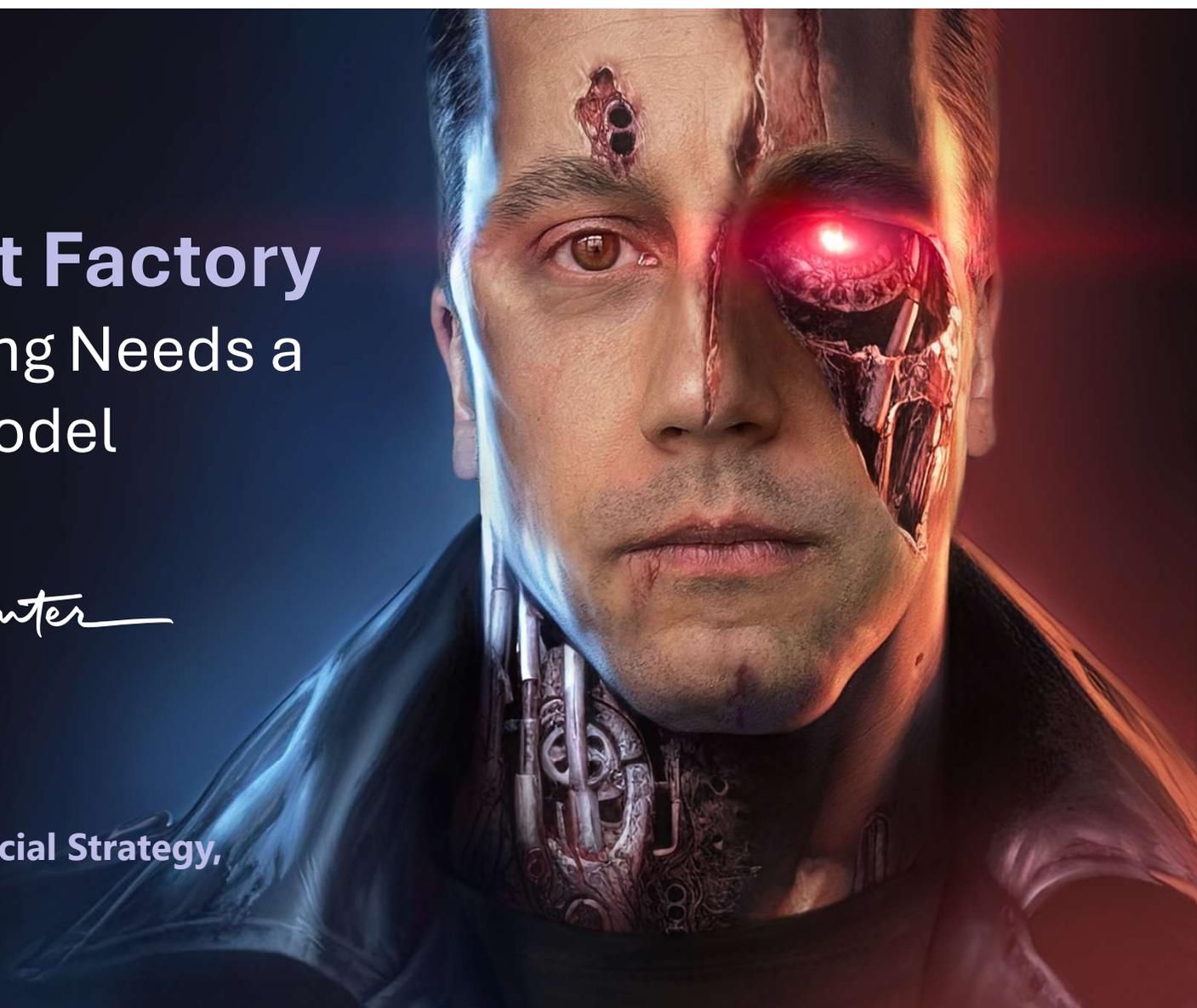


# The Intelligent Factory

## Why Manufacturing Needs a New Operating Model

*Jeff Winter*

**Vice President – Commercial Strategy,**  
Belden





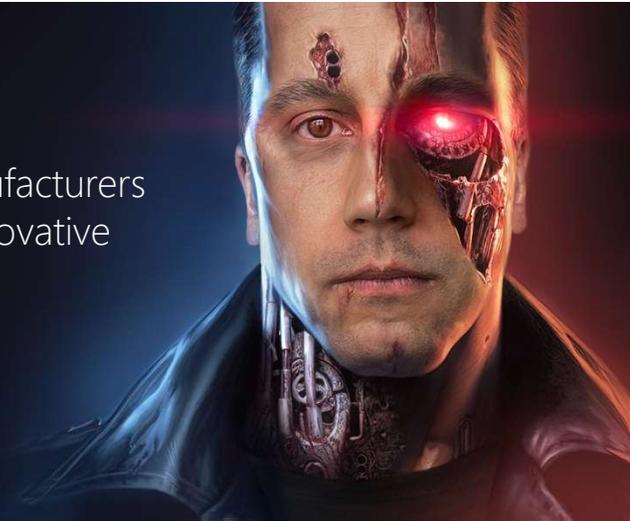
Linked in  Top Voice

169,904 followers

90+ million views of content

11.5% of viewers are manufacturing executives

My passion is helping manufacturers **digitally transform** in innovative ways utilizing **Industry 4.0 technologies**



### CURRENT INDUSTRY INVOLVEMENT:

- Board of Directors of ISA (International Society of Automation)
- Board of Directors of MESA (Manufacturing Enterprise Solutions Association)
- Board of Advisors for Purdue University's Smart Manufacturing Innovation Center
- Board of Advisors to IoT Analytics
- Board of Advisors to IIoT-World
- Board of Advisors to INCIT (International Center for Industrial Transformation)
- U.S. Registered Expert for IEC TC 65 for JWG21 on Smart Manufacturing
- Global AI Ambassador for SwissCognitive (only one representing Manufacturing)
- Smart Manufacturing Advisor of CESMII (U.S. Government Agency dedicated to Manufacturing)

*Jeff Winter*



Jeff Winter



### Production Schedule

Item	QTY	DATE	TIME	STATUS
...	...	...	...	...



### Daily Targets

Monday Targets - 110  
Tuesday Targets - 110  
Wed Targets - 50  
Friday Targets - 30

...	...	...	...	...	...
...	...	...	...	...	...

Jeff Winter

**LINE STOPPED**



*Jeff Winter*

Number of  
**Connected IoT Devices**

00.0

**BILLION**

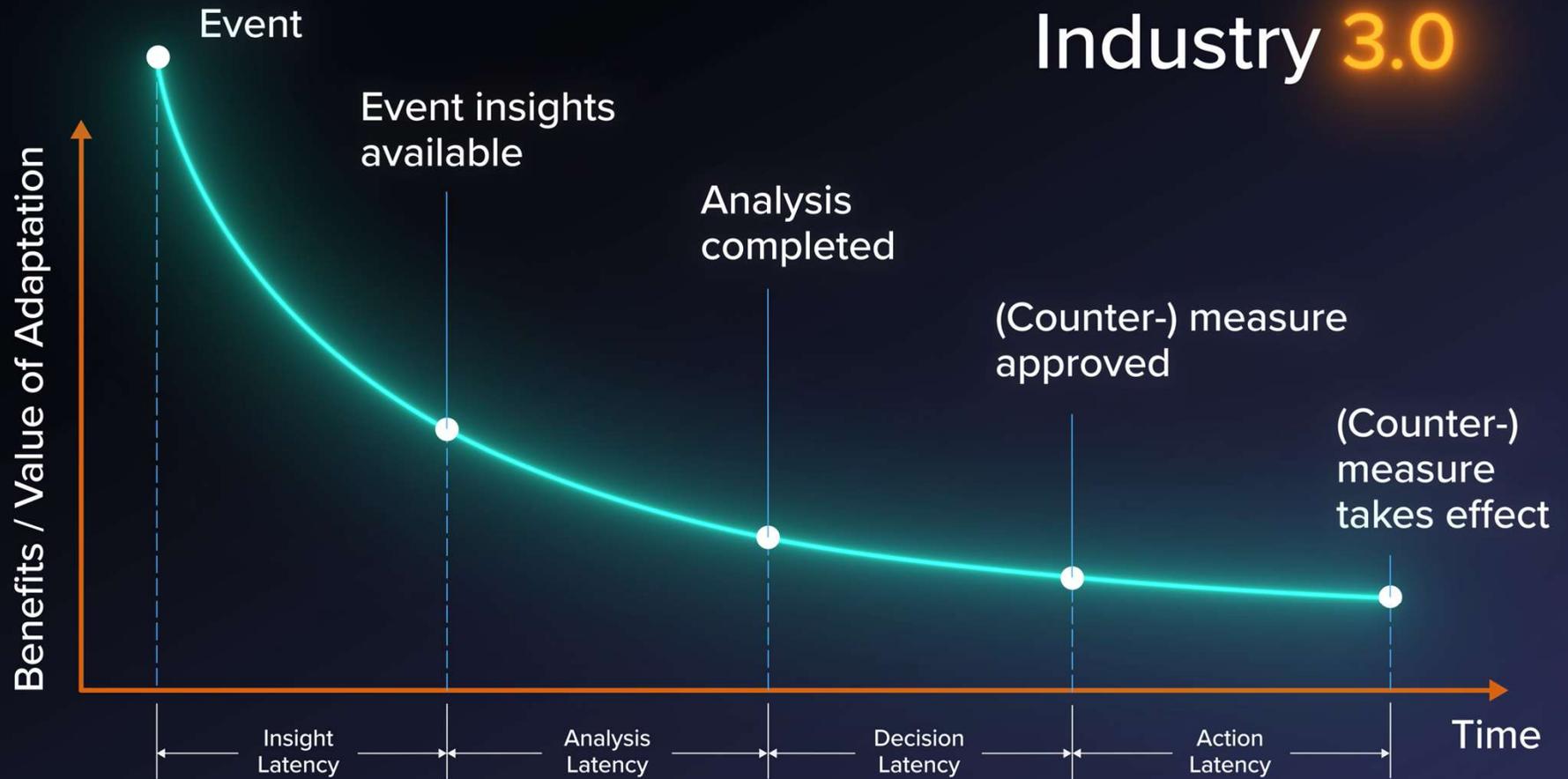


# 1 Terabyte

*Jeff Winter*

# Decision Latency

# Industry 3.0



Source: Acatech's Industrie 4.0 Maturity Index

*Jeff Winter*

# John McCarthy

The Father of Artificial Intelligence

Artificial intelligence is the science of making machines do things that would require **intelligence** if done by humans

*John McCarthy*

# Why Artificial Intelligence is Hard to Define

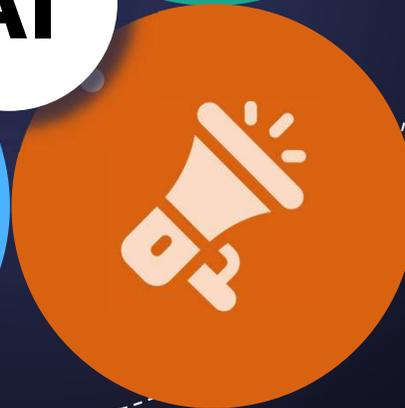
**Technology**  
What systems do and how they act



**Philosophy**  
What intelligence really means

**AI**

**Law and Policy**  
What regulators need to enforce

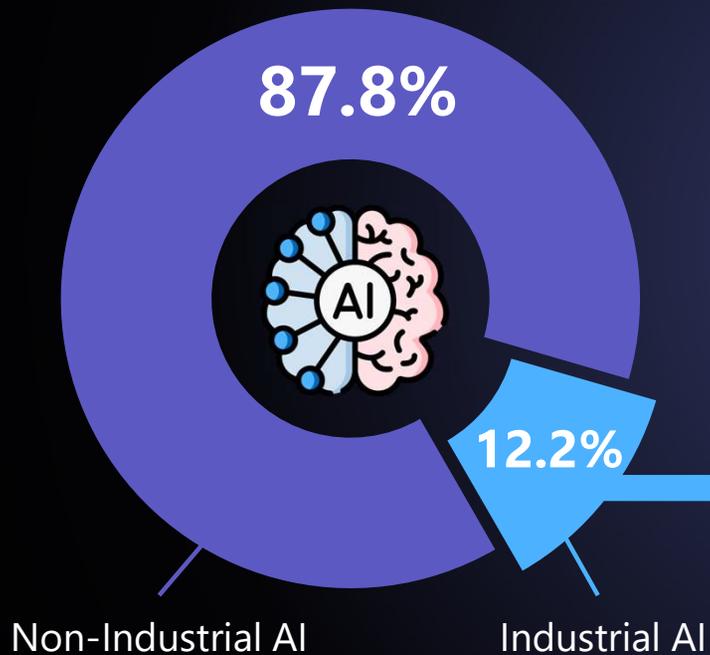


**Marketing**  
What companies want to claim

*Jeff Winter*

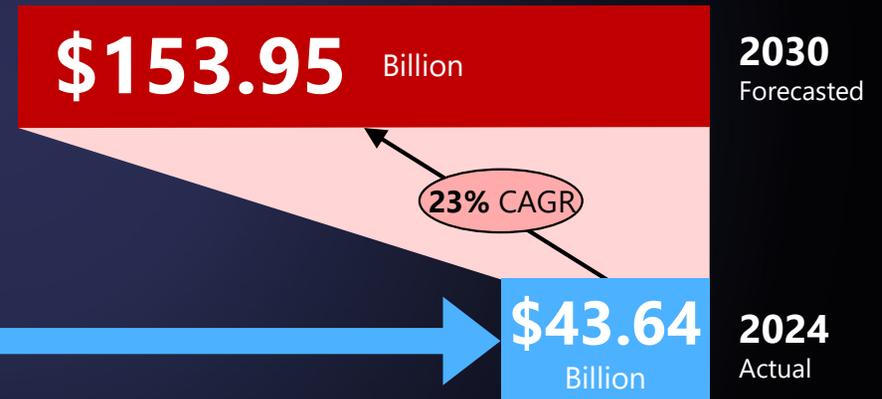
# Artificial Intelligence Global Enterprise Market Size

**\$358.16 Billion**



## What is Industrial AI?

Industrial AI is the application of artificial intelligence to operational and engineering data generated by industrial systems, equipment, and processes.

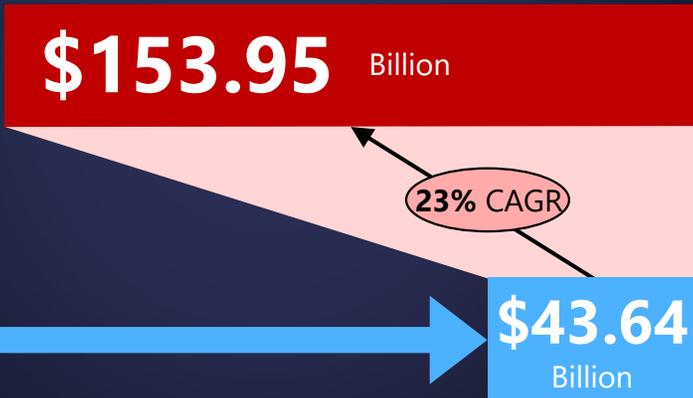
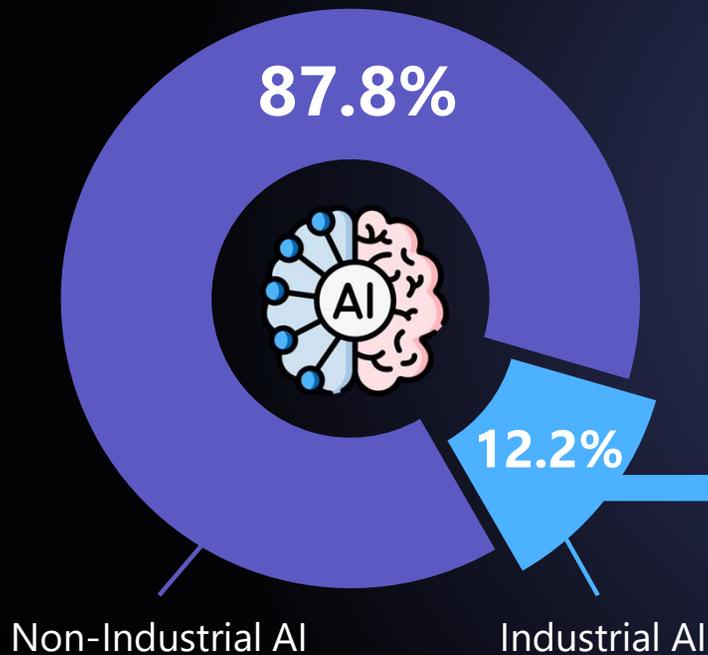


# Artificial Intelligence Global Enterprise Market Size

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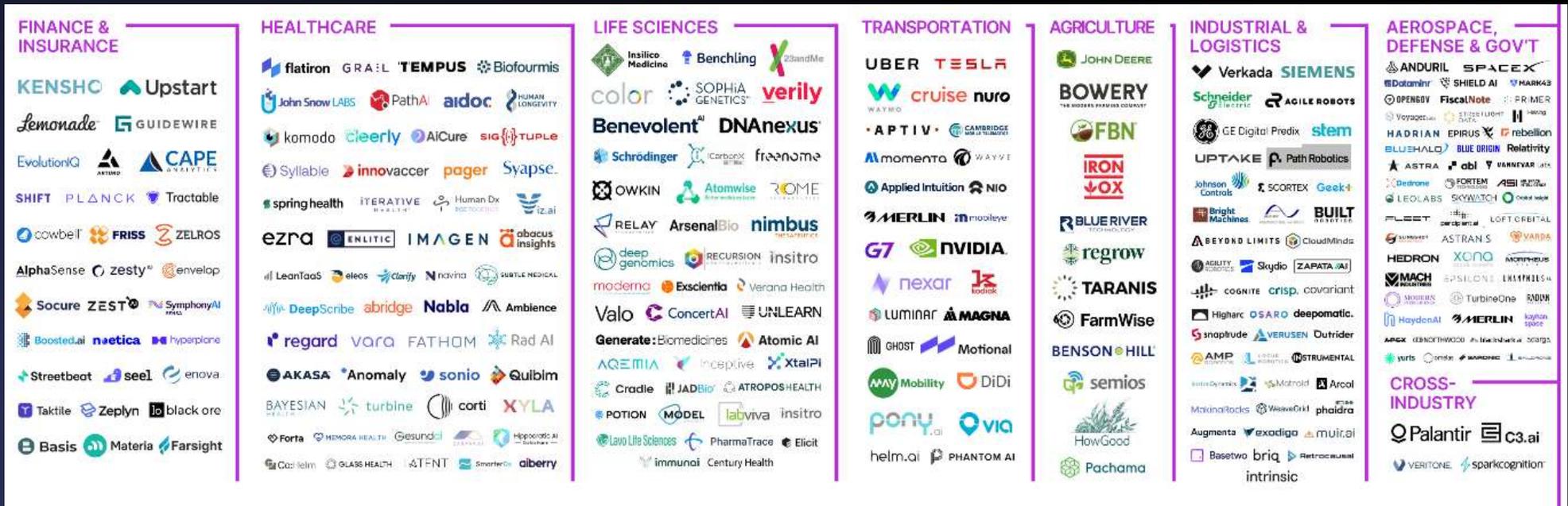
Industrial AI is the application of artificial intelligence to operational and engineering data generated by industrial systems, equipment, and processes.



Source: IoT Analytics Industrial AI Market Report 2025-2030

*Jeff Winter*

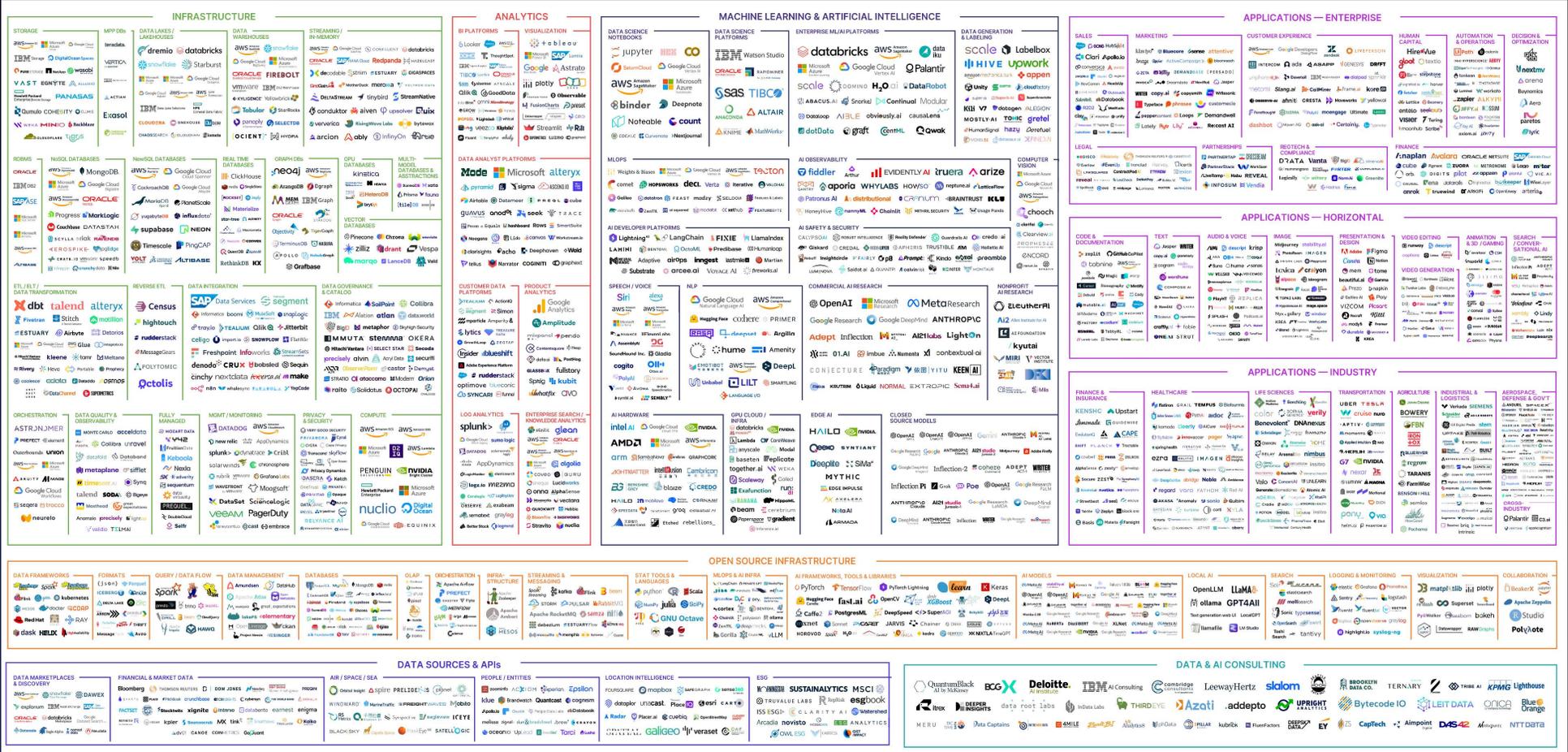
# Artificial Intelligence Global Enterprise Market Size



Jeff Winter

Source: Matt Turk

# Artificial Intelligence Global Enterprise Market Size



Jeff Winter

Source: Matt Turk

# Primary Ways AI is Being Used

83%



## Analyze

Processing and interpreting vast data sets to derive meaningful insights

### Example Use Cases:

- Plant floor IoT analysis
- Sentiment analysis
- Image analysis
- Pattern analysis

48%



## Generate

Creating content, designs, code, or concepts from scratch

### Example Use Cases:

- Content generation
- Report generation
- Code generation
- Synthetic data generation

42%



## Predict

Anticipating future outcomes based on existing data patterns

### Example Use Cases:

- Predictive maintenance
- Demand forecasting
- Sales forecasting

40%



## Detect

Recognizing specific features or characteristics within data inputs to classify or categorize information

### Example Use Cases:

- Anomaly detection
- Fault detection
- Fraud detection
- Instruction detection

36%



## Control

Dynamically managing or optimizing systems and workflows

### Example Use Cases:

- Process control
- Energy management
- Autonomous vehicles
- Drone navigation

32%



## Connect

Acting as an interface for engagement between people and systems

### Example Use Cases:

- Customer facing chatbots
- Personalized marketing campaigns

# Global Lighthouse Network



**>48%**

Reduction in lead times



**>50%**

Reduction in new product introductions



**>40%**

Increase in labor productivity



**>30%**

Reduction in material waste



**>30-50%**

Scope 1 & Scope 2 emissions reduction



**>25%**

Reduction in energy and water consumption



**Anthony Loy**  
Vice President,  
Industrial Digital  
Transformation Consulting



**Zongchang Liu**  
Rotating CEO at Foxconn



**Biswaranjan Sen**  
Global Chief Product  
Supply Chain Officer



**Bart Talloen**  
Executive Fellow,  
World Economic Forum,  
Former J&J Executive



**Jackie Jung**  
Vice President,  
Global Operations Strategy



*Jeff Winter*

# Jensen Huang

Founder & CEO, Nvidia

“ In the future, every industrial company will operate two factories: one physical factory for manufacturing actual products and a second, digital "AI factory" to create the artificial intelligence that powers them. ”

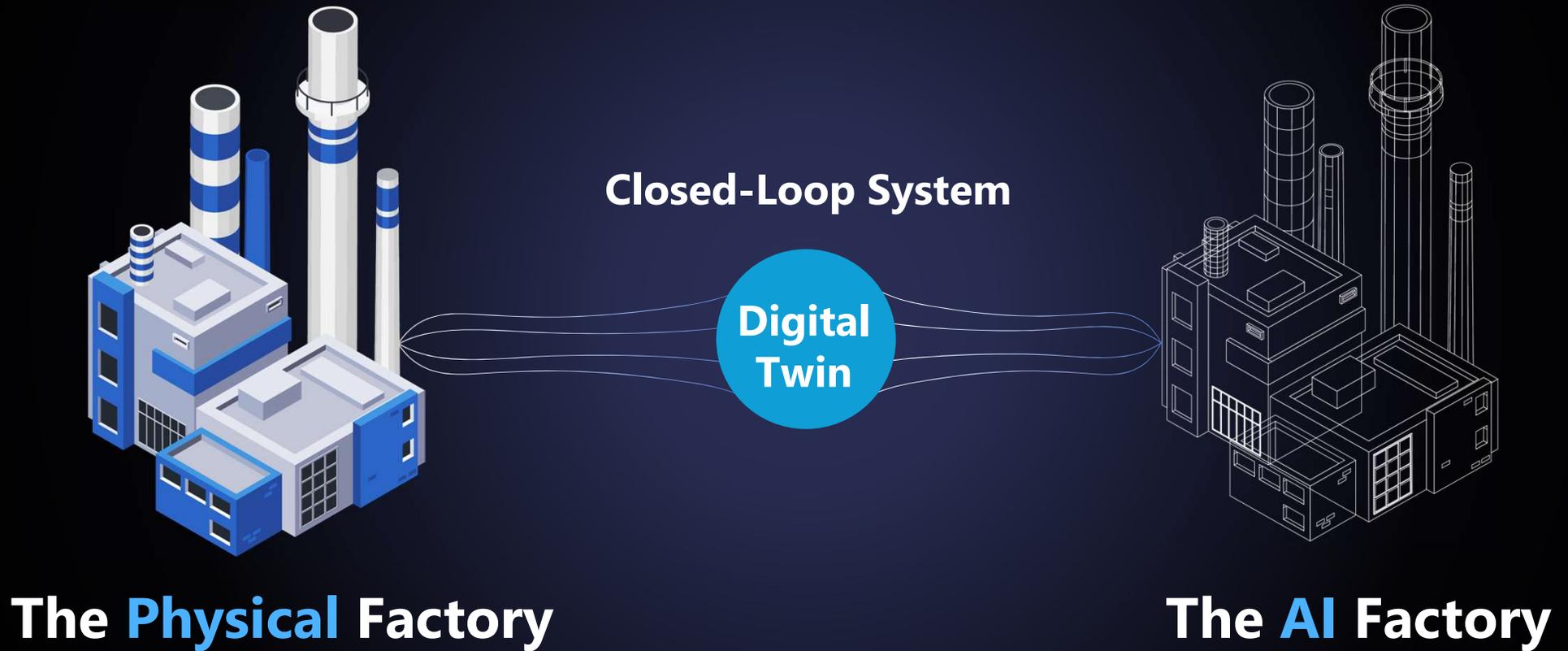


# The 'Two Factories' Every Manufacturer Needs



*Jeff Winter*

# The 'Two Factories' Every Manufacturer Needs



*Jeff Winter*

# Three Waves of Artificial Intelligence

~2012



FIRST WAVE  
**Classical Machine Learning**

---

Supervised learning, Unsupervised learning,  
Reinforcement learning, Deep learning

Helps reduce Insight & analysis latency

~2020



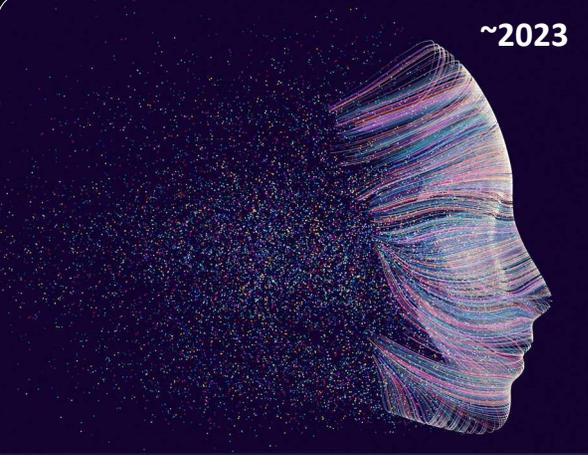
SECOND WAVE  
**Large Language Models**

---

Foundation models, RAG models,  
Multimodal models

Helps reduce analysis & decision latency

~2023



THIRD WAVE  
**AI Agents**

---

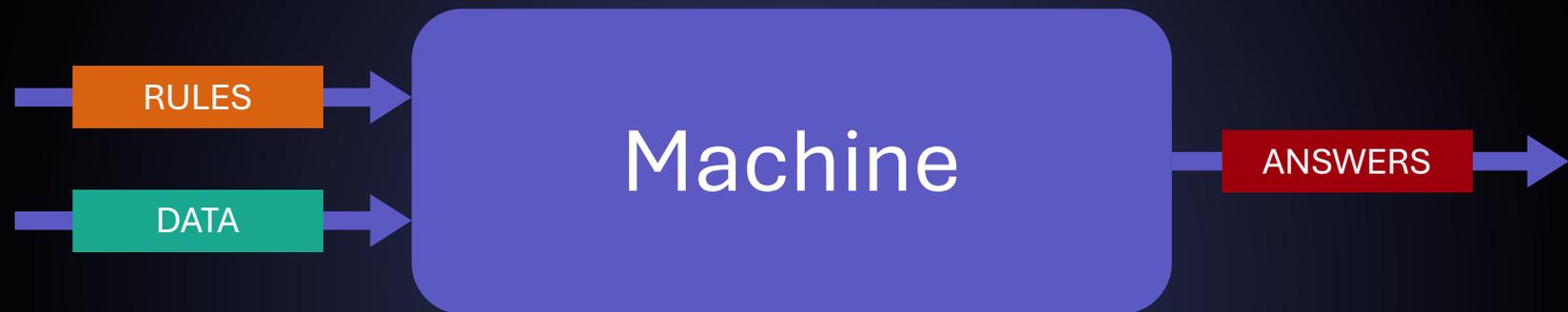
Reactive agents, Goal-oriented agents,  
planning agents, multi-agent systems

Helps reduce decision & action latency

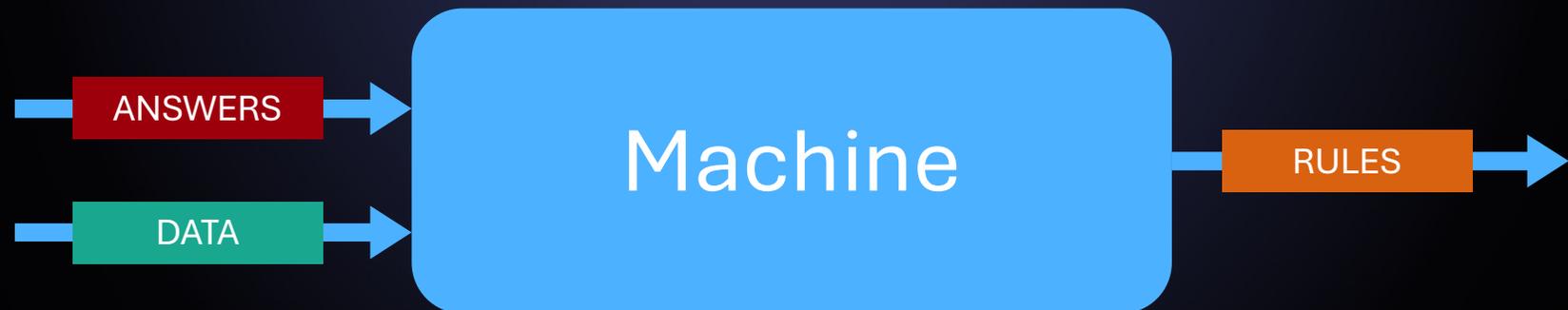
*Jeff Winter*

# What is Machine Learning?

## Traditional Programming



## Machine Learning



*Jeff Winter*

# What are **Large Language Models (LLMs)**?

**Large** →

Refers to the extensive training data and model size

**Language** →

Refers to its focus on natural language processing

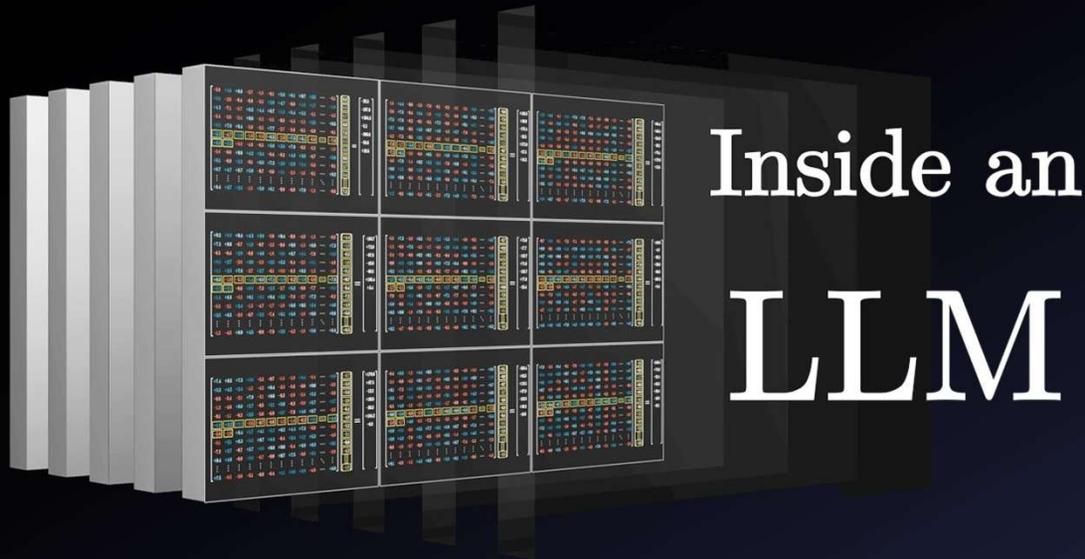
**Models** →

Refers to it making predictions or responses based on learned data patterns

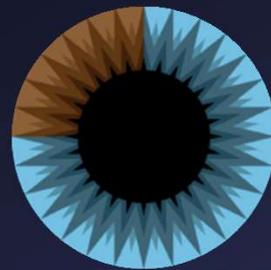


*Jeff Winter*

# How Large Language Models Work



**Grant Sanderson**



3Blue1Brown



*Jeff Winter*

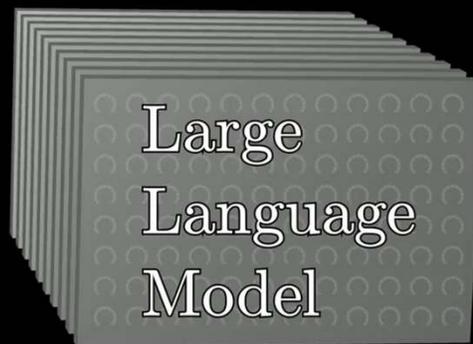
# How Large Language Models Work

The mitochondria is the powerhouse of the cell.

Julius Caesar was assassinated on the Ides of March in 44 BC.

My neighbor's kid asked me what I wanted to be when I grew up. I'm 35. I told him I'd let him know when I figure it out.

Call me Ishmael.



I spent three hours customizing my character in a video game, only to immediately put on a helmet that covers their entire face. Peak gaming experience right there.

I have this thing where I get older but just never wiser

The Great Wall of China is a series of fortifications built along the northern borders of China.

The halflife of Carbon-14 is approximately 5,730 years.

The human genome contains approximately 3 billion base pairs.

Who controls the past controls the future. Who controls the present controls the past.

# How Large Language Models Work

It was the best of times it was the worst of times



What is an **AI Agent**?



*Jeff Winter*

## What is an **AI Agent**?



Goal-Directed Behavior



Powered by LLMs



Context Aware



Decision-Making & Planning



Ability to Act

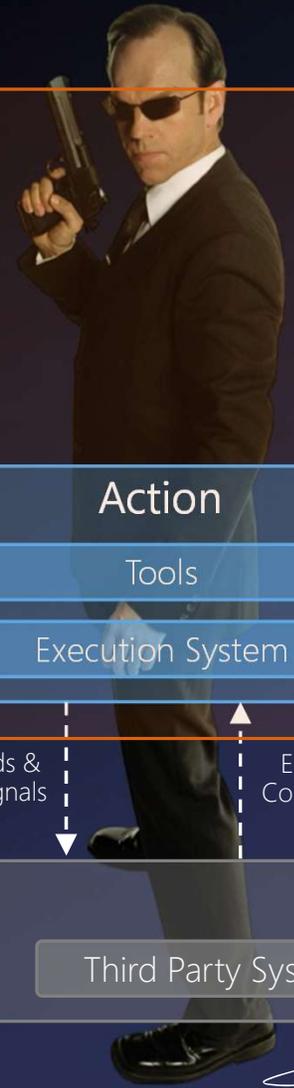
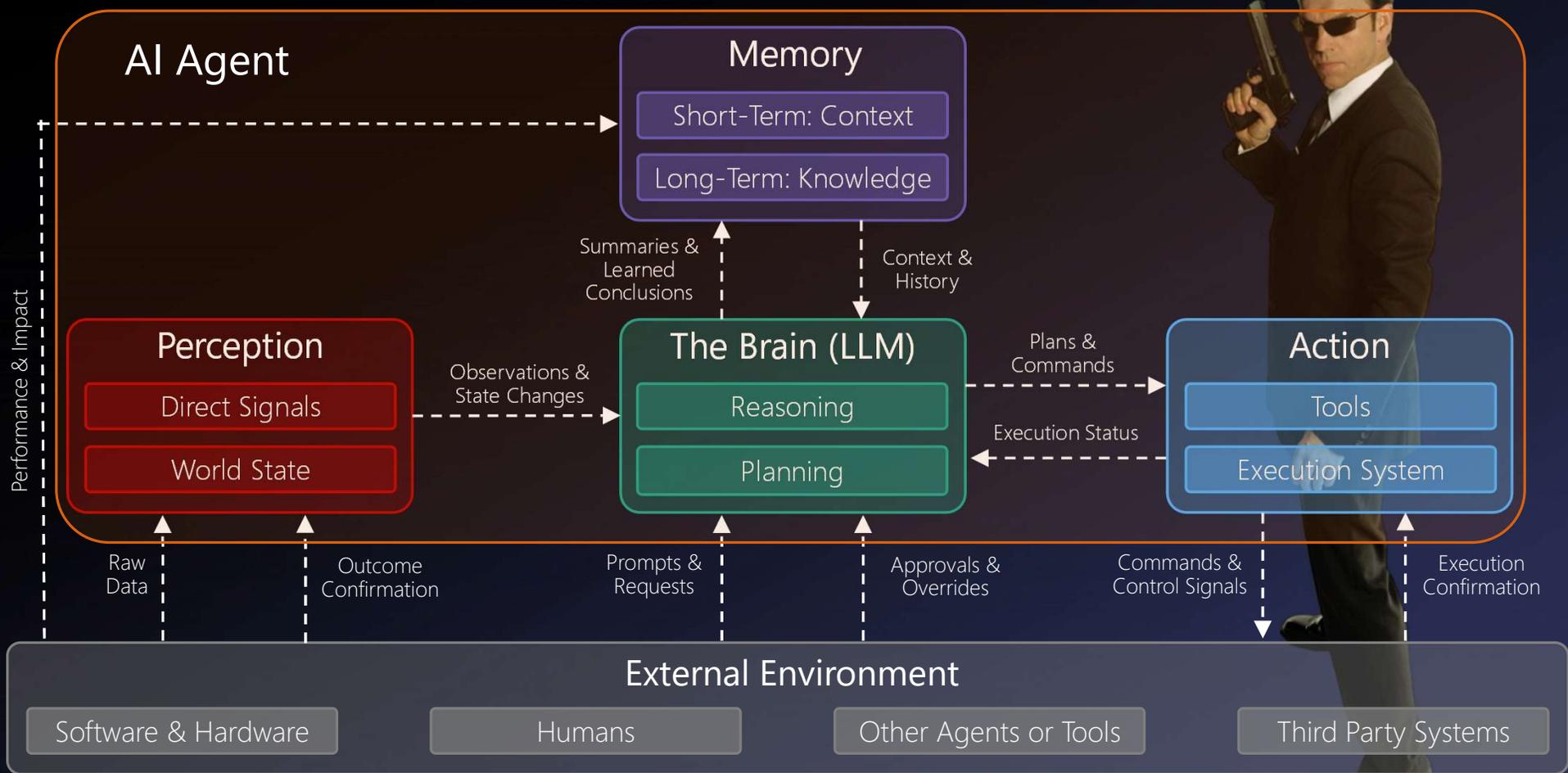


Self-Correcting



*Jeff Winter*

# Composition of an AI Agent



Jeff Winter

# Levels of Intelligence (Machine Understanding)

		What it understands	Example technologies
<b>Level 5</b> System Intelligence		Interactions and impact across the entire system	<ul style="list-style-type: none"><li>• Digital twins</li><li>• Graph neural networks</li><li>• Physics models</li></ul>
<b>Level 4</b> Reasoning Intelligence		Causality, tradeoffs, and implications	<ul style="list-style-type: none"><li>• Large reasoning models (LRMs)</li><li>• Chain-of-thought</li><li>• Causal inference models</li></ul>
<b>Level 3</b> Semantic Intelligence		Meaning, language, and domain concepts	<ul style="list-style-type: none"><li>• LLMs</li><li>• Ontologies</li><li>• Knowledge graphs</li><li>• Vector databases</li></ul>
<b>Level 2</b> Contextual Intelligence		Situations, conditions, and when patterns matter	<ul style="list-style-type: none"><li>• Feature engineering</li><li>• Bayesian models</li><li>• Conditional and contextual models</li></ul>
<b>Level 1</b> Perceptual Intelligence		Signals, patterns, anomalies, and statistical relationships	<ul style="list-style-type: none"><li>• Classical machine learning</li><li>• Deep learning</li><li>• Computer vision</li></ul>

*Jeff Winter*

# Levels of AI Agency

Human role	What the AI does	
Human-out-of-the-loop for execution; in-the-loop for governance	Systems self-direct, learn, and act without human intervention	<b>Level 5</b> Fully Autonomous Agentic Systems
Human-in-the-loop for intent, not steps	Agents operate independently within constrained conditions	<b>Level 4</b> Semi-Autonomous Agentic Systems
Human-on-the-loop (supervisor)	Agents plan, reason, and act within defined domains	<b>Level 3</b> Agentic Workflows
Human-in-the-loop (decision maker)	Uses AI models to enhance automation and decision-making	<b>Level 2</b> Intelligent Automation
Human-in-the-loop (always)	Executes predefined rules with no learning or autonomy	<b>Level 1</b> Rule-Based Automation

# Three Critical Considerations for Making AI Operational



## Anchor it

Ground intelligence in a trusted, real-time operational foundation



## Authorize it

Deliberately define your ownership and agency boundaries



## Adapt it

Build an operating model built for learning, not stability

*Jeff Winter*

# Anchor It: Operational Data as the Foundation of Intelligence



Semantic stability

+

Structural integrity

ERP



MES



PLM



SCM



**APM**

Asset  
Performance  
Management

**QMS**

Quality  
Management  
System

**CMMS**

Computerized  
Maintenance  
Management  
System

**WMS**

Warehouse  
Management  
System

**APS**

Advanced  
Planning &  
Scheduling

**EHS**

Environmental  
Health &  
Safety

**CWP**

Connected  
Worker  
Platform

**LMS**

Learning  
Management  
System

**CAD**

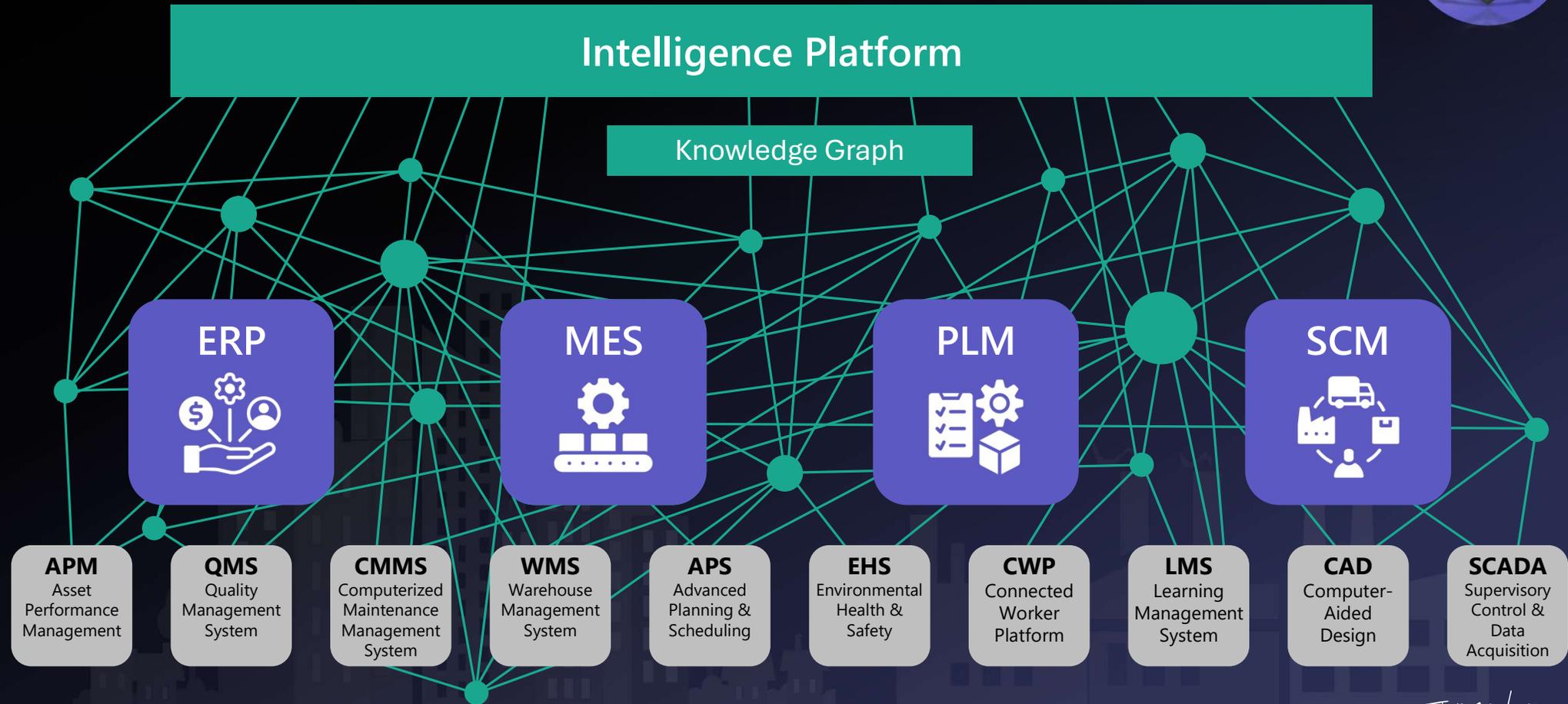
Computer-  
Aided  
Design

**SCADA**

Supervisory  
Control &  
Data  
Acquisition

*Jeff Winter*

# Anchor It: Operational Data as the Foundation of Intelligence



*Jeff Winter*

# Authorize It: Define Ownership & Decision Boundaries



## The Hand-Off Line

Which decisions are we explicitly authorizing the system to make without human approval, and under what conditions?



## The Adult in the Room

Who is accountable for the outcomes of system-made decisions, and how is that accountability enforced?



## The Guardrails

What non-negotiable boundaries define the limits of autonomous decision-making?

*Jeff Winter*

Adapt It: **Build a New Operating Model**



# Frederick Winslow Taylor

The Hero of Scientific Management

If work can be fully analyzed, standardized, and controlled, then performance can be maximized by removing variability and decision-making from execution.

*Jeff Winter*

## Adapt It: **Build a New Operating Model**



### **Role Evolution**

You must decide how human roles change as intelligence and agency increases



### **Performance Definition**

You must decide what 'good' looks like when learning is involved



### **Behavioral Ownership Over Time**

You must decide who owns how intelligent systems behave after deployment



### **Trust & Escalation Rules**

You must decide when humans are expected to trust the system, challenge it, or override it

*Jeff Winter*



Jeff Winter

Running



*Jeff Winter*

The **Intelligent  
Factory** is not a  
system upgrade.

It is a structural  
redesign.



Jeff Winter



**Thank You.**

*Jeff Winter*