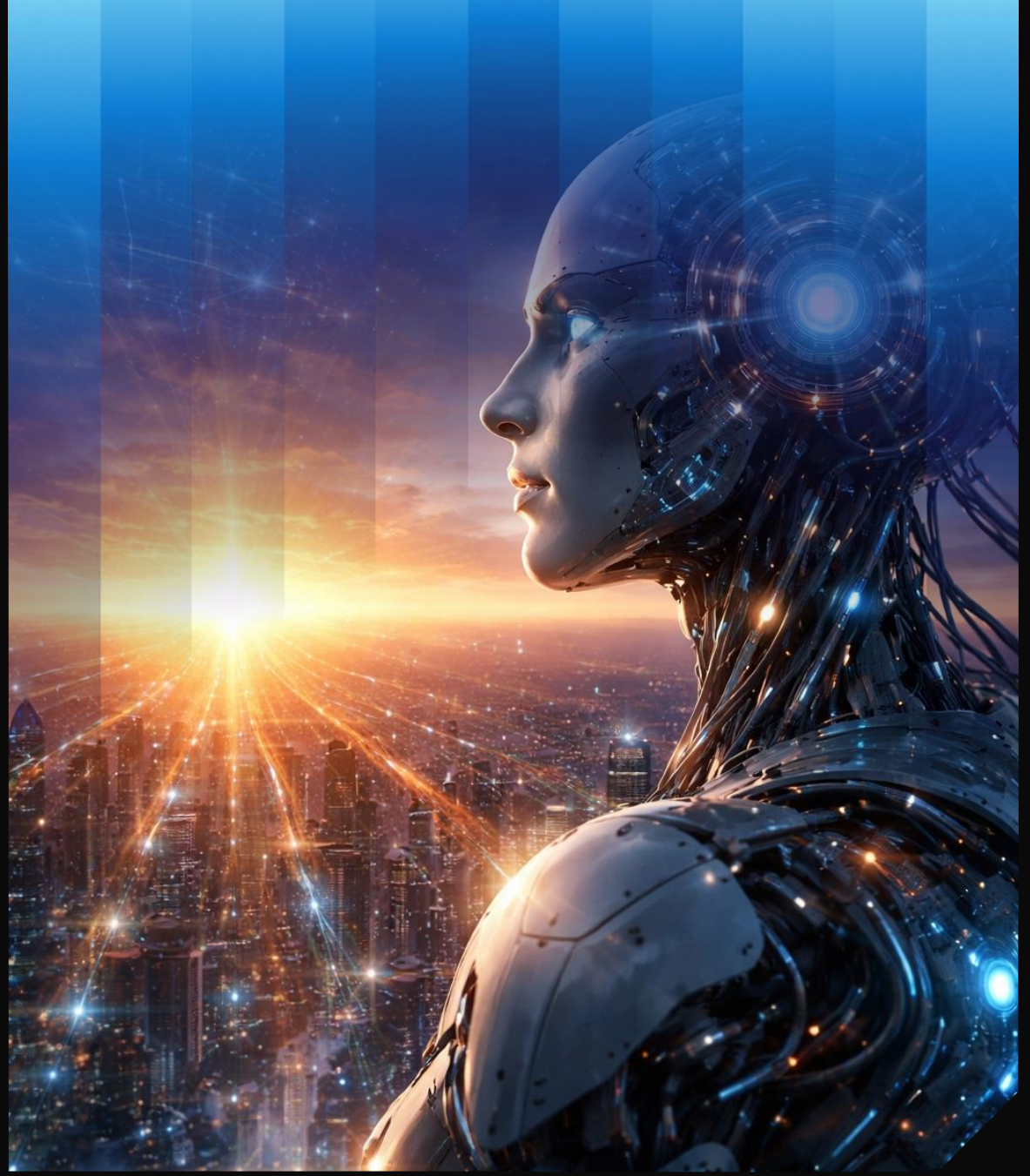
Gurobi in the AI Space

Past, Present, Future

Kostja Siefen
Senior Director Technical Account Management



Agenda

01 Company Introduction

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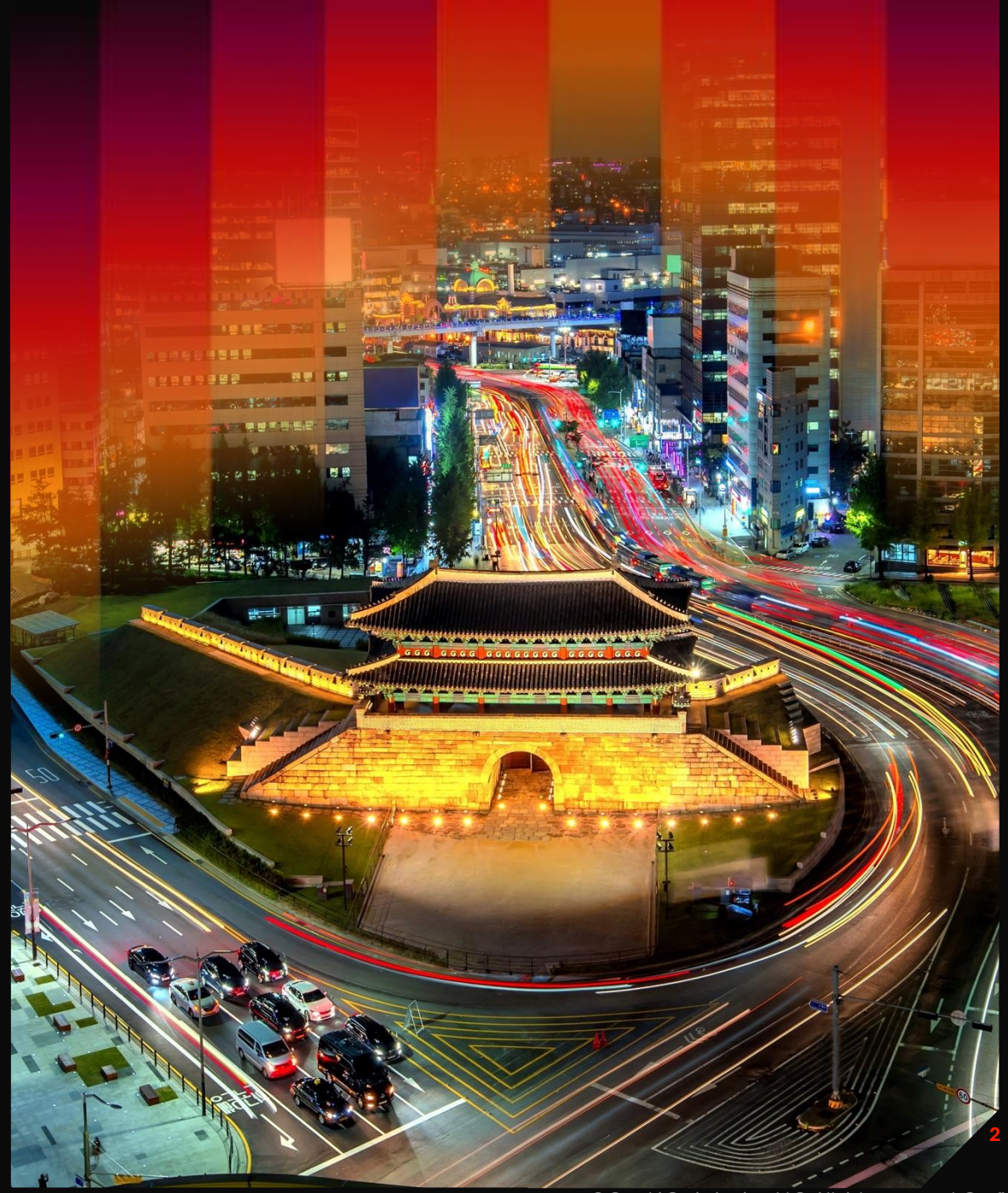
04 Our History & The Road Ahead



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Our People

UNTIL NOW. Gurobi is the most powerful - fastest, versatile, and reliable - mathematical optimization solver which enables confident decision-making at scale.

LOOKING FORWARD. Gurobi powers high-impact decisions with trusted AI. It sets the standard in decision intelligence technology through unmatched performance, developer productivity, and deployment capabilities to enable continuously improving outcomes.

Gurobi in the AI Space

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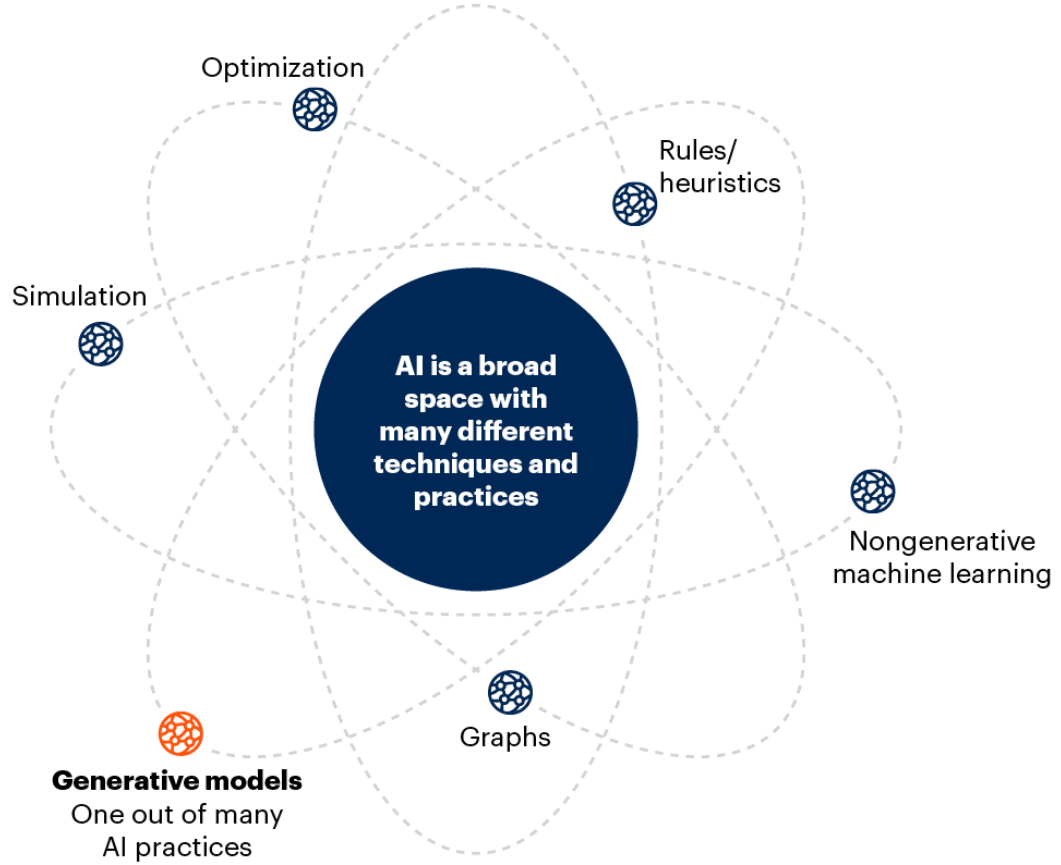
Defining AI

Per **Gartner**…

"Artificial intelligence (AI) applies advanced analysis and logic-based techniques to interpret events, and support and automate decisions and take actions."

Gartner IT Glossary, Artificial Intelligence (AI), 16 October, 2024, https://www.gartner.com/en/information-technology/glossary/artificial-intelligence

AI Does Not Revolve Around GenAI



Source: Gartner
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Gartner

„Intelligence“

Human Intelligence

Learning **Logic**

Problem-Solving

Creativity **Deciding**

Artificial Intelligence

Artificial Intelligence is the capacity of computer systems to exhibit or simulate intelligent behaviour by processing data and performing tasks typically associated with human intelligence.

AI for Decision Intelligence

Decision Intelligence is the tailored combination of the right data, the right AI disciplines and the right human influence in a business decision-making process.

- **Learning** using **Machine Learning**
  Generation of insights from business data
- **Logic** using **Algorithmic Reasoning**
  Generation of conclusions (logical inference) through algorithms
- **Creativity** using **Generative AI**
  Generation of new content from a natural language prompt based on learned structure
- **Problem-Solving** using **Forecasting and Simulation**
  Generation of predictions and scenarios
- **Deciding** using **Mathematical Optimization**
  Generation of optimal planning outcomes

Optimization as Trusted AI

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Why Can You Trust Optimization?

Optimization		ML / Gen AI
Mathematically **correct** and **provably** optimal	✓	✗ Outputs are **plausible**, not provably correct
Deterministic and **reproducible**	✓	✗ Sensitive to training data **drift** or prompt **phrasing** (LLMs)
Constraints are **explicit** and **inviolable**, states when no feasible solution exist	✓	✗ Constraints are learned/inferred, can be ignored and violated, or **hallucinate** compliance
Quantifies **trade-off** and allows **sensitivity** analysis	✓	✗ **Confidence ≠ Correctness**

Optimization is AI that…

Is built for decision making

The building blocks and structure of optimization are the same as many decisions

Compliments machine learning and generative models

Not all problems are a nail, so you need more than a hammer

Provides explainability, trust and value

The declarative and deterministic nature of optimization allows for justifiable and auditable outputs

Is a key component of Decision Intelligence

Rigorous mathematical framework that gives confidence to business decisions

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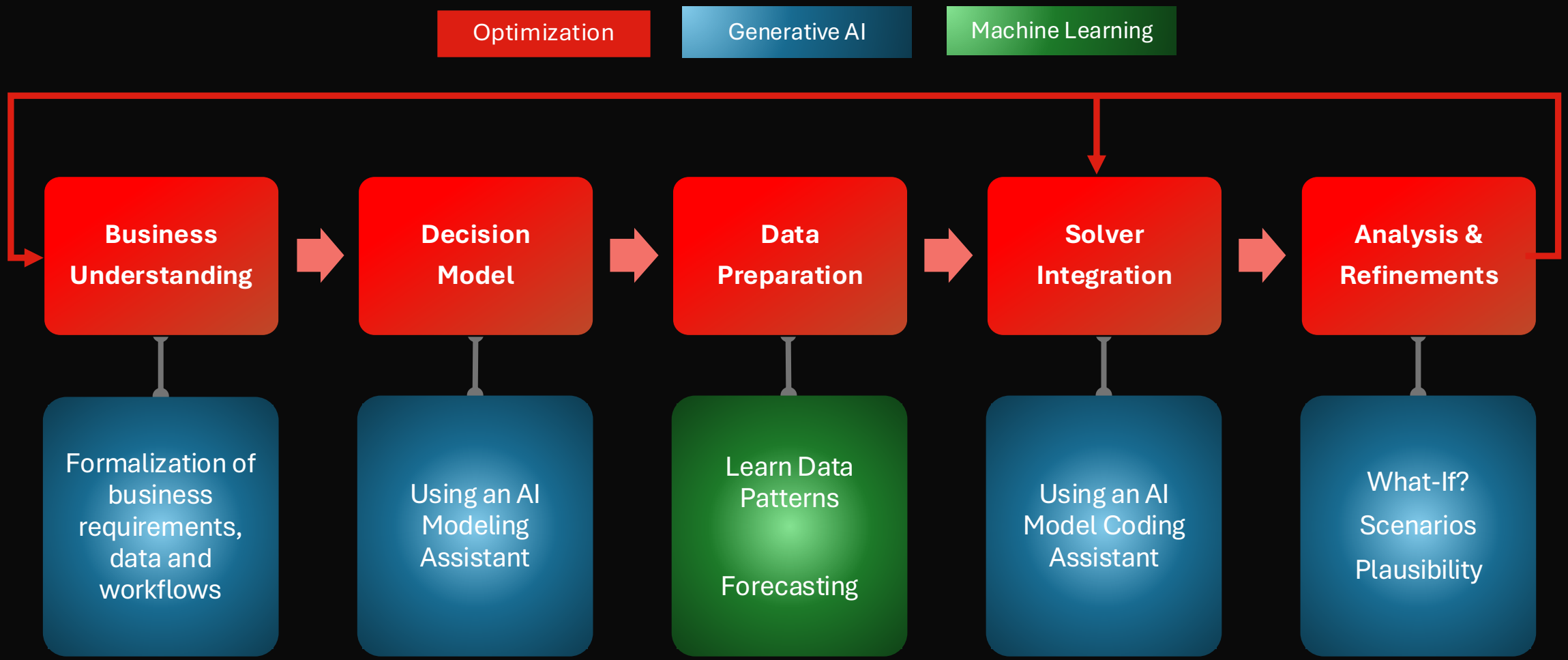
Elements of Optimization Solutions



Trusted Functionality

Your Expertise

Your Users. Their feedback, questions, and viewpoint show where trust or clarity is missing.

Domain knowledge. You know the key variables, intuition, interaction, and constraints.

Real-World Context. Show what the model did and didn't include—like recent changes.

Familiar Benchmarks. Compare results to rules of thumb and past decisions.

Alternative Metrics (KPIs). Show results using the metrics your users care about.

Gurobi Tools

+ Speed

Solution Pool. See multiple near-optimal solutions, not just one.

Multiple Objectives. Define a hierarchy of multiple optimization objectives.

Multi-Scenario Analysis. Solve the same model under different assumptions.

Shadow Prices & Dual Values. Show how much constraints impact the objective.

Infeasibility Analysis (IIS & FeasRelax). Why no solution exists—and what can be relaxed.

Trusted Impact

A universal framework for measurable business goals

Business Value Drivers				
Costs	**Quality**	**Time**	**Complexity**	**Explainability**
Desired Outcomes				
Increase profit, reduce cost or loss	Exceed requirements, Performance & Sustainability	Effective use of available time	Master Complexity & Achieve Competitive Advantage	Manage Risks, Ensure Fairness, Regulatory Compliance
Example KPIs				
Cost per unit, per cycle, per hour, resource utilization, setup costs	Reliability/Durability, Experience Score, Satisfaction, Compliance, Maintainability, Waste Reduction	Time-To-X, Lead Time, Cycle Time, Handle-Time, On-Time Rate, Throughput, Idle/Waiting Time	Optimality, Adaptability, Scalability, Robustness, Degree of Automation	Interpretability, Fairness, Trust Score, Compliance, Consistency

Trusted Patterns

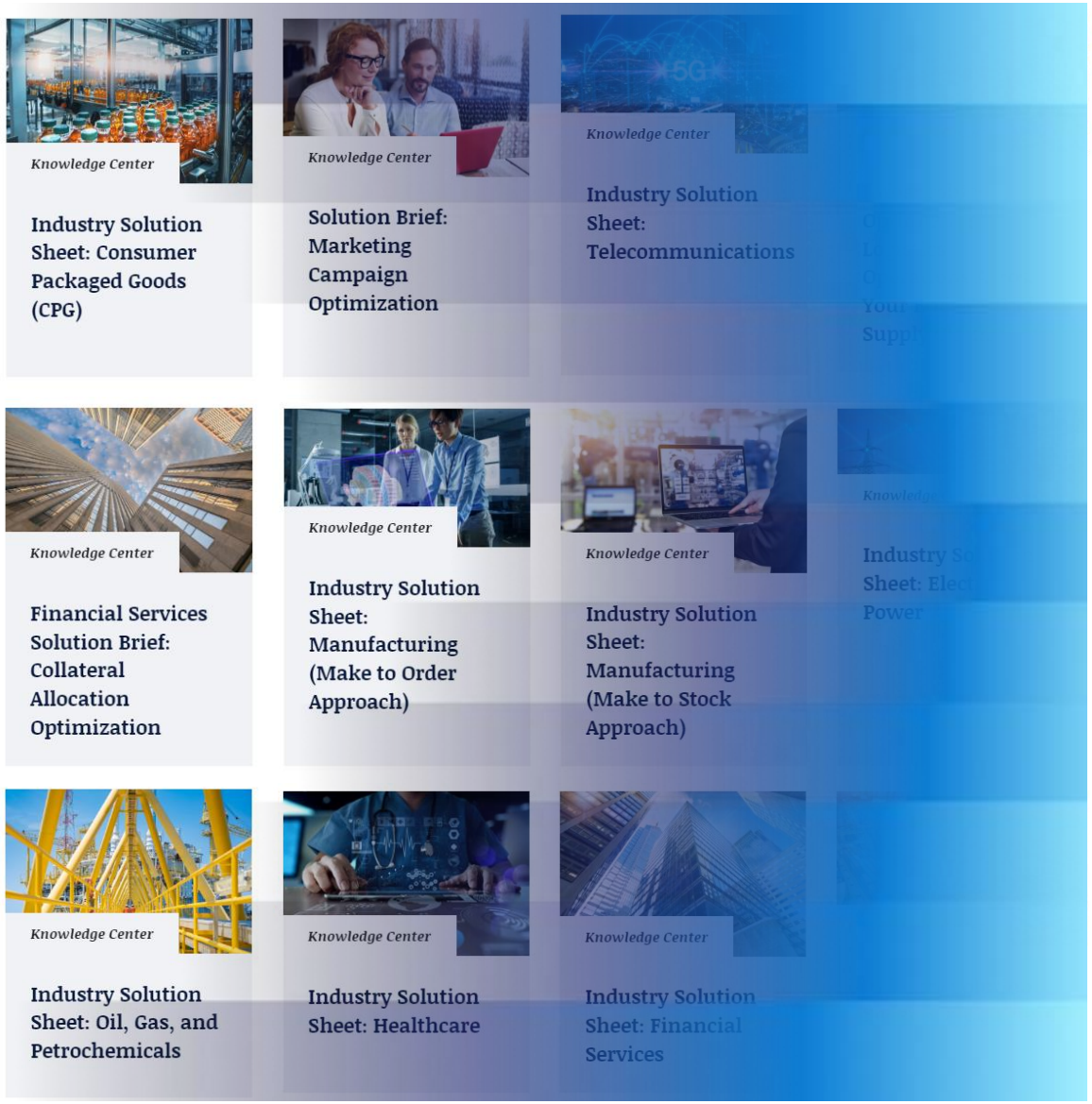
Anatomy of impactful Gurobi Use Cases

1. Business challenges that involve large-scale, **complex**, interconnected decision situations.

2. Decision-making processes with **quantifiable** outcomes and clear KPIs

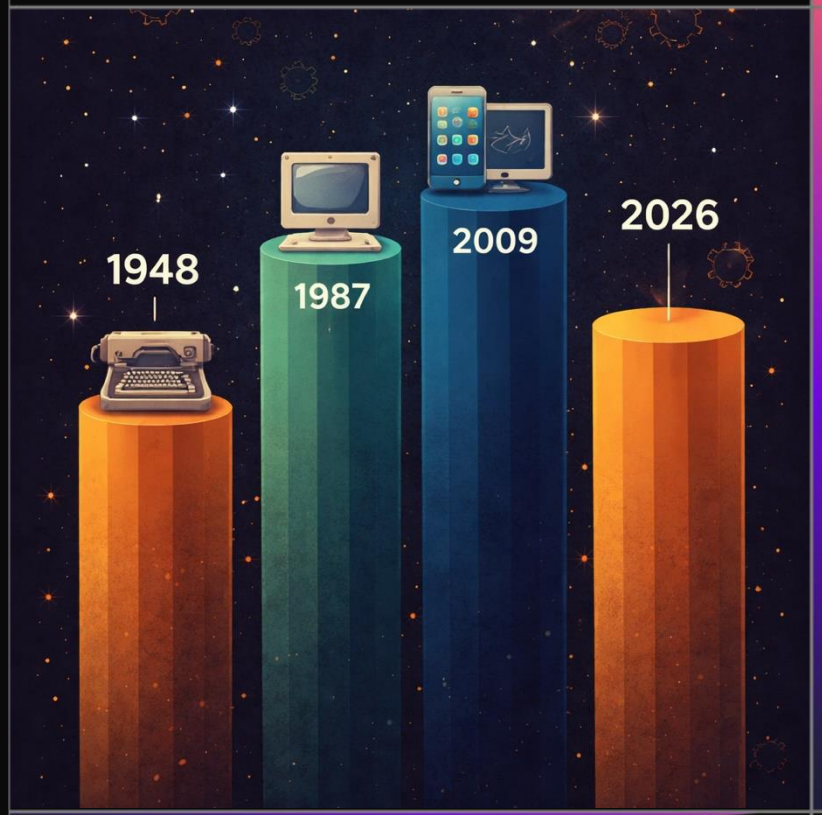
3. A strong economic impact through better **allocation planning** of limited resources.

4. Time-sensitive decision-making with constantly **changing** business requirements.



Trusted Research & Development

Our History



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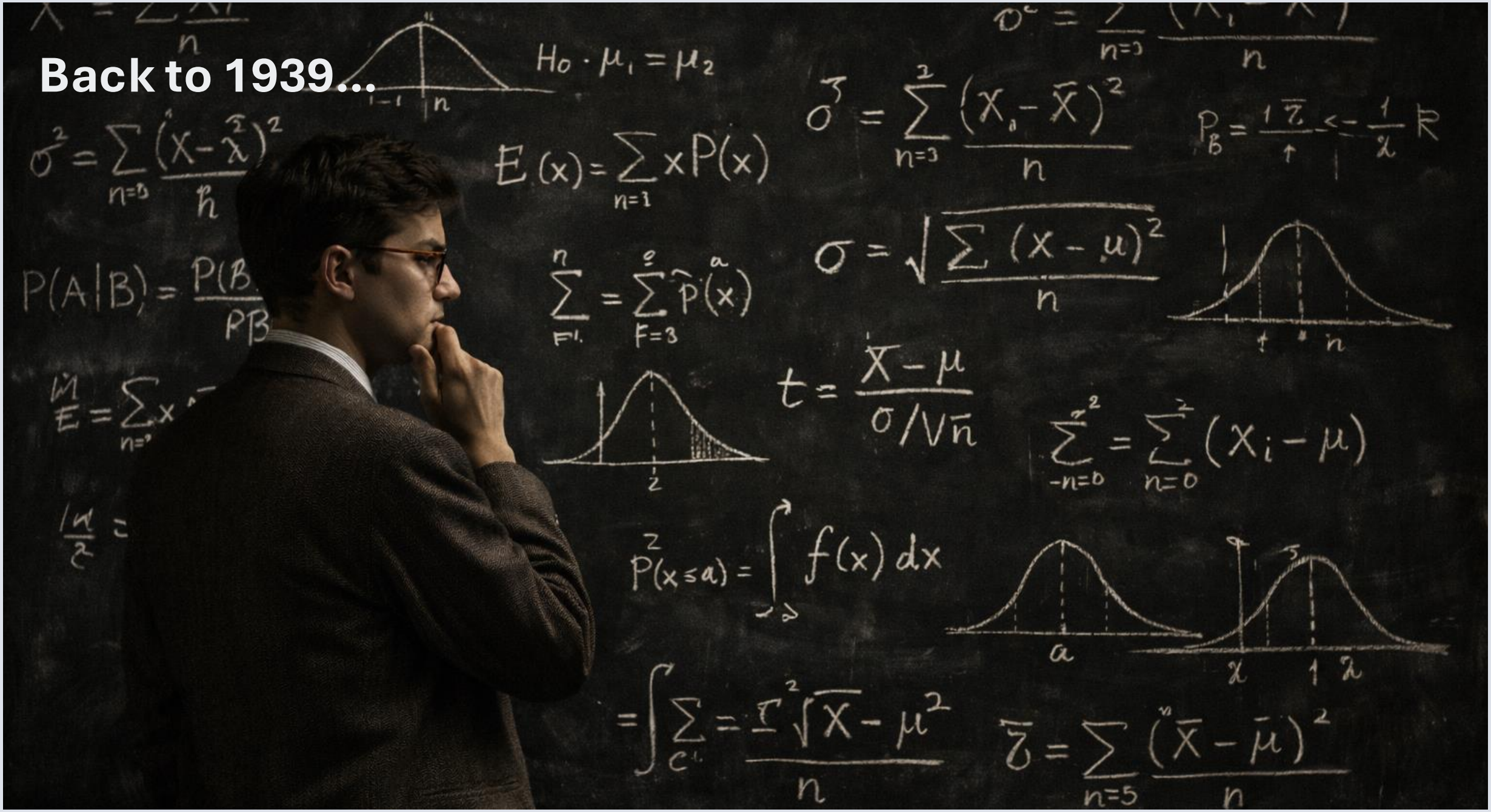
Back to 1939...
$H_0 \cdot \mu_1 = \mu_2$
$E(x) = \sum x P(x)$
$\sigma = \sqrt{\frac{\sum (x-\mu)^2}{n}}$
$t = \frac{\bar{X} - \mu}{\sigma/\sqrt{n}}$
$P(x \le a) = \int f(x)\,dx$
$\sum_{n=0} = \sum_{n=0} (X_i - \mu)$

1939

George Dantzig solved two problems he thought were homework, only to discover they were long-unsolved statistical challenges.

His story shows that what we believe is possible can shape what we achieve.

1948

> “A certain wide class of practical problems appears to be just **beyond the range of modern computing machinery**. […] Typically, these problems involve a complex of different activities in which one wishes to know which activities to emphasize in order to carry out desired objectives under known limitations.”

“Programming in a linear structure,”
George B. Dantzig, published August 1948 by U.S. Air Force Comptroller

1948 - 1988 – 4 decades of R&D

1952-54 LP code on “Card Programmable Calculator”

1971 Supersparsity, P4, Pre-assigned pivot factorization

1979 Khachian’s paper on the “ellipsoid method”

1984 Karmarkar’s paper on interior-point methods

1972-1985: Very theoretical research in OR by Bixby et al (“matroid theory”)

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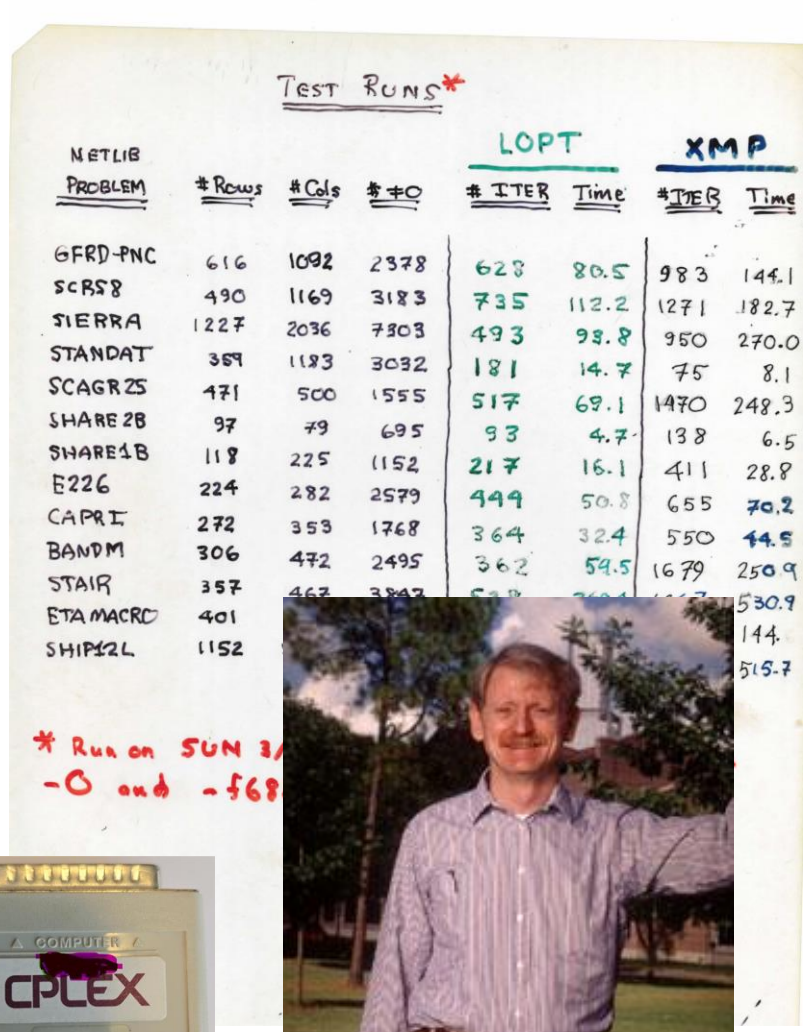
The 90‘s

1988 - Robert E. Bixby founded CPLEX Optimization

A lot of development in the 1990s

- LP performance took off (Primal-dual log-barrier algorithms completely reset the bar)
- Data became plentiful and accessible
- ERP systems became commonplace
- Popular new applications begin to show that integer programming could work on difficult, real-world problems (airlines, supply chain, etc)



Progress in LP (1988-2004)

Operations Research, Jan 2002, pp. 3—15, updated in 2004

Algorithms (machine independent): 3,300x

Primal versus best of Primal/Dual/Barrier

Machines (workstations → PCs): 1,600x

NET: Algorithm × Machine 5,300,000x

(2 months/5300000 ~= 1 second)

2009 - Public Gurobi Launch at INFORMS

Gurobi Optimization

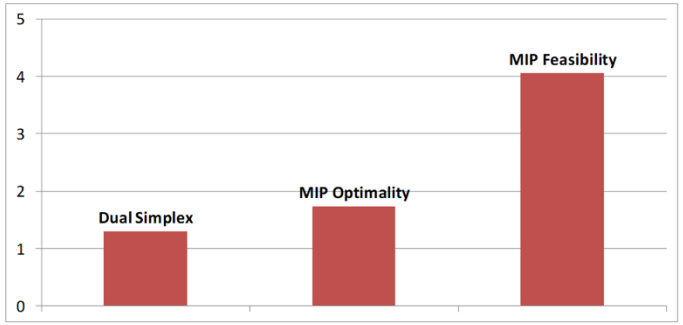
- Gurobi Optimization, Inc. founded July, 2008
- Building a suite of products:
  - LP (simplex) and MILP in version 1.0
  - Barrier, QP, QCP, MIQP, and MIQCP later
- Gurobi available through partners January
- Gurobi standalone available 6 May 2009

Gurobi Optimization

Building From the Ground Up

- Start from a clean slate
  - With the benefit of 20+ years of experience
- Things have changed:
  - Two examples:
    - "Sub-MIP" as a pervasive approach
    - Ubiquitous parallel processing

Performance Summary – Gurobi 2.0 vs CPLEX 12.1



Gurobi Optimization

Missing on the pictures: Sonja Mars

10 Years Ago (2016) - Our Team

The Hardware & Software Performance Race

- **Single threaded CPU performance**

  1991-2022: ≈ 1,542x speed-up

- **MIP Algorithm/Software performance**

  1991-2022: ≈ 2,035,000x speed-up

- **Performance gain CPU & MIP Optimization**

  1991-2022: ≈ 3,138,000,000x (3.14bn) speed-up

Mathematical illustration: An Optimization business problem which would have taken **100 years in 1991** to solve would do so **today in 1s**.

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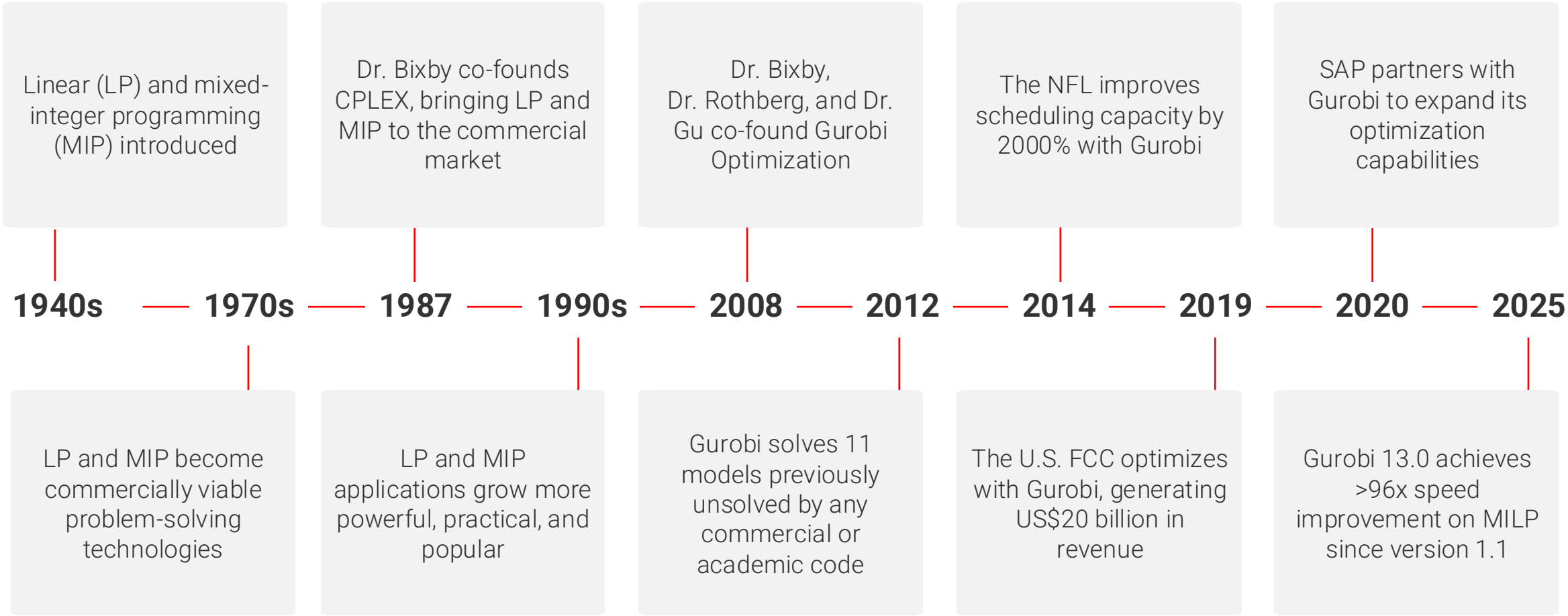
70+ years of problem-solving innovation

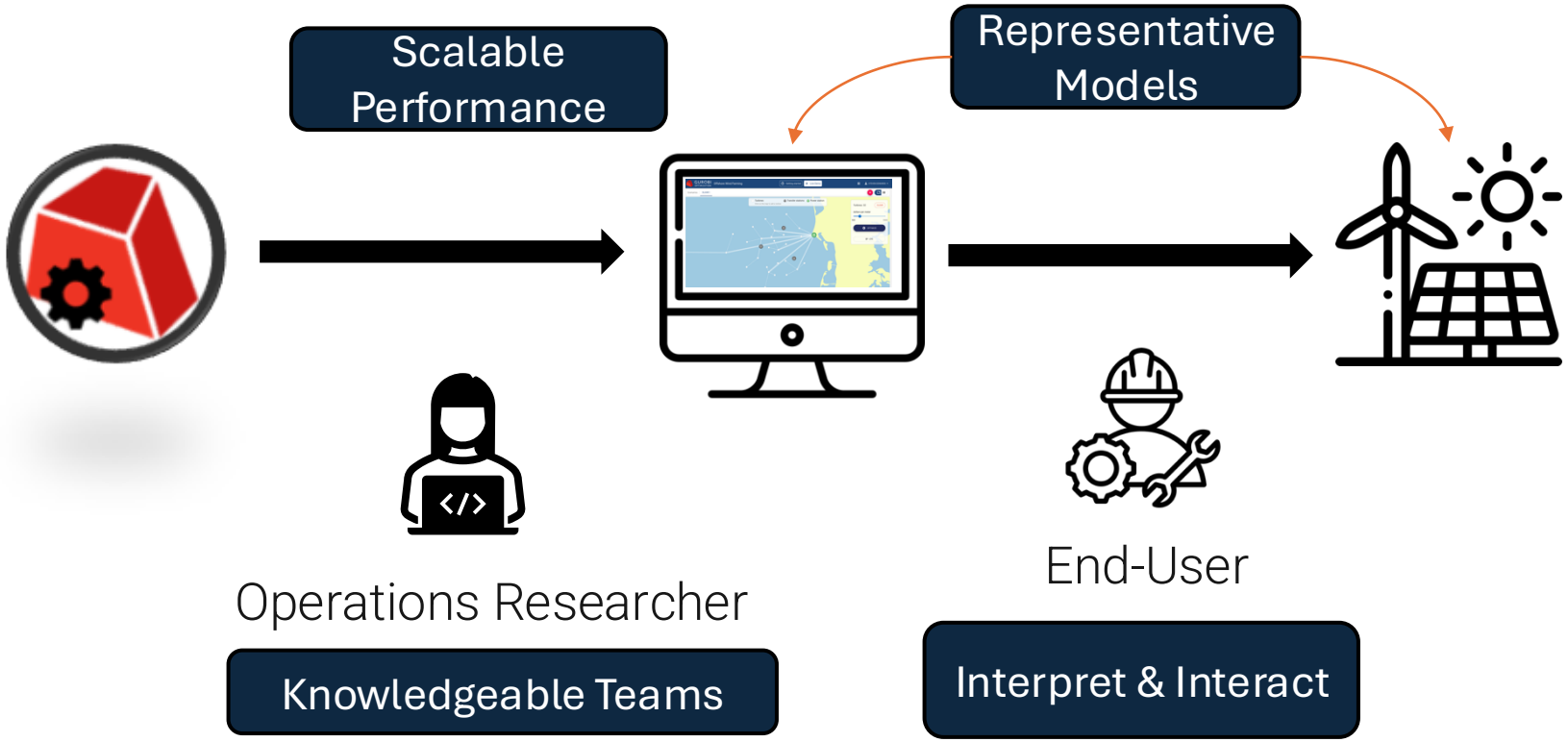


The Road Ahead

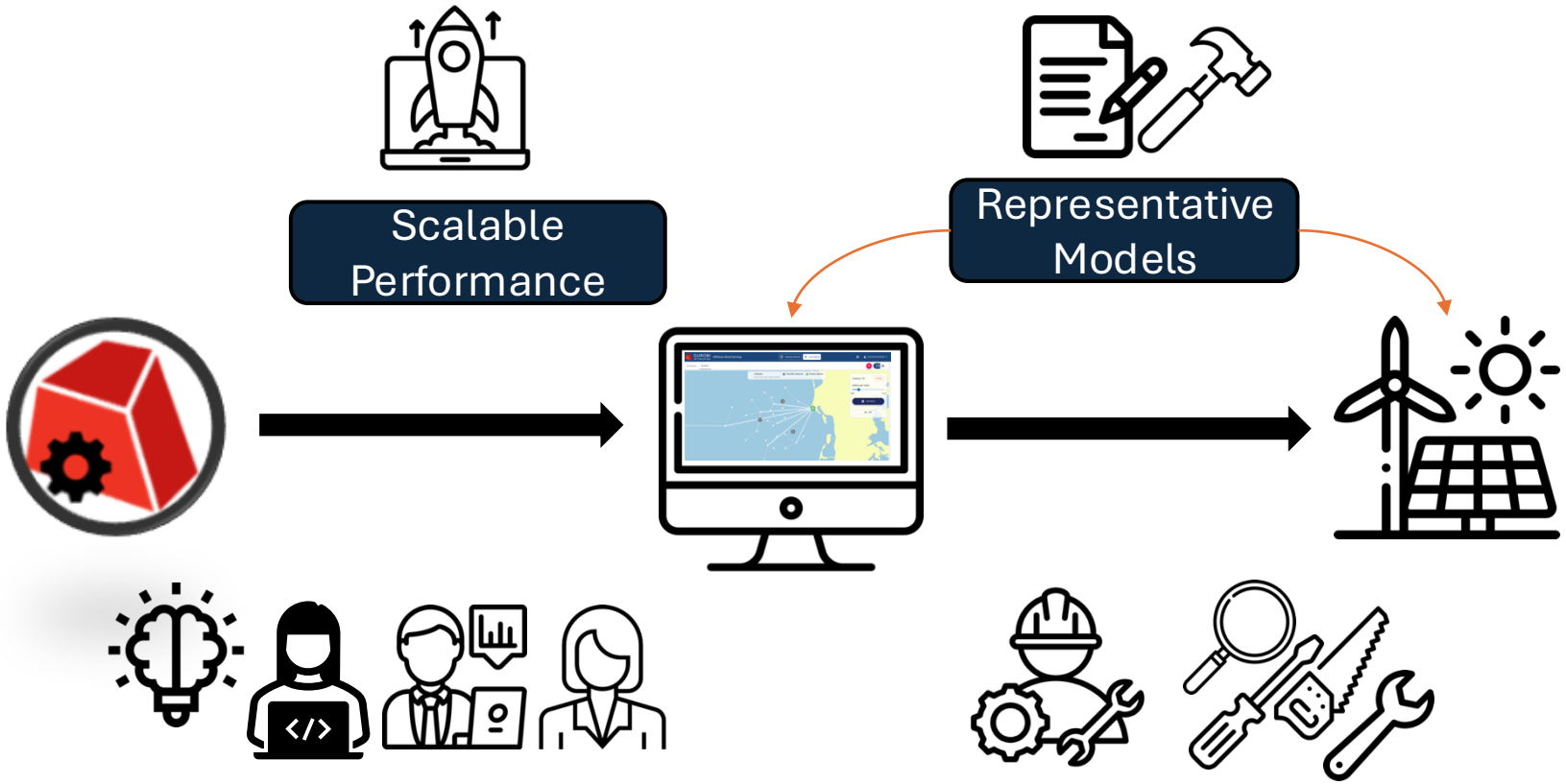
Our Intelligence Vision

Generative AI – Use Cases?

What makes customer projects succesful?

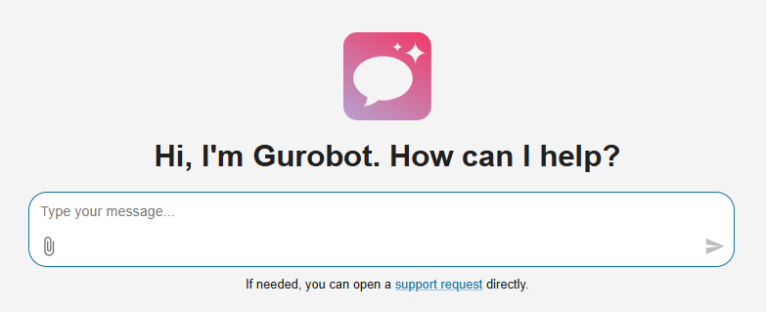


GenAI will make Optimization more accessible



Gurobot – Your Always-On Gurobi Expert Agent

Gurobot is our support powerhouse designed to streamline your experience and put expert guidance right at your fingertips, with:



- **Instant Answers and Assistance:** Real-time help with troubleshooting, licensing, and more.
- **Smart Resource Links**: Gurobot connects you to the most relevant documentation
- **Built-in Best Practices**: Responses are backed by Gurobi's knowledge base
- **Code Snippets on Demand**: Tailored, ready-to-run gurobipy snippets
- **Enterprise-Grade Security**: Powered by Anthropic's Claude Foundation LLM and securely hosted on AWS, Gurobot is designed to safeguard your data.

Agentic AI – Our Focus - Explainability

Support decision intelligence with **explainability agents** that enable *interactive* analysis of phenomenons through intuitive, trustworthy insights.

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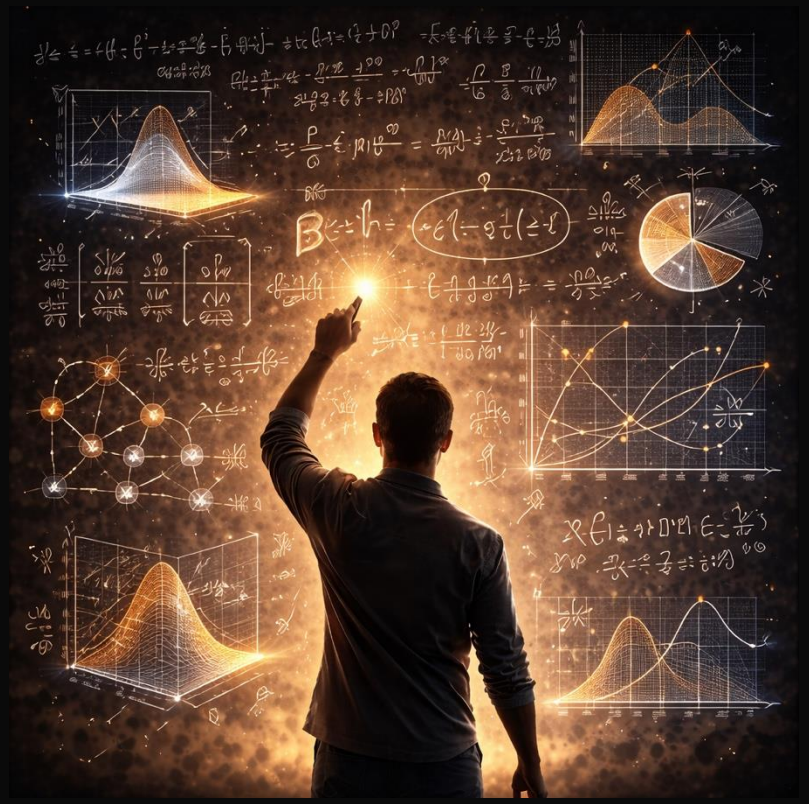
Agentic AI – Our Focus - Modeling



Empower users to build, test, refine, and deploy decision models with ease through **modeling agents** that connect requirements with robust optimization formulations and integrate seamlessly across the Gurobi ecosystem.

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Agentic AI – Our Focus - Performance

Build intelligent **performance agents** that unlock a new generation of hybrid AI optimization solutions by seamlessly combining the proven strength of the Gurobi engine with both generative and classical AI technologies.

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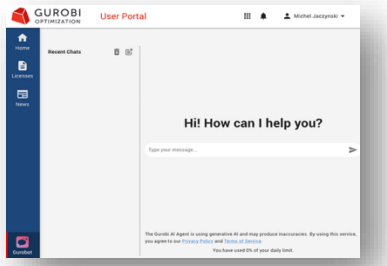
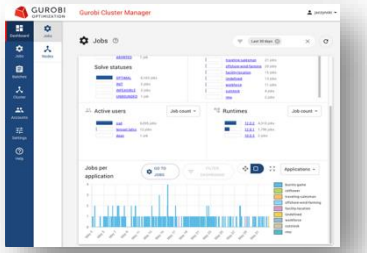
Gurobi's Intelligence Vision

Interfaces and Integration



Chatbot

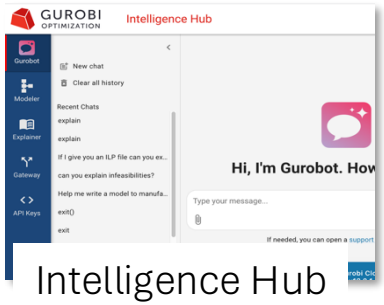
Coding Agents / IDEs



Assistants in context:
Cluster Manager, CLI

Interoperability:
MCP, A2A

Orchestration and APIs



Intelligence Hub

Agents for Gurobi related tasks:
Support, Tuning, Insight, Modeling, Solving…

Components

Knowledge Base to capture
Gurobi best practices

Gurobi Tools:
Optimizer, Tuner, Explainer
Instant Cloud, Compute Server

LLMs:
Claude, Cohere…

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Thank You

For more information, visit gurobi.com