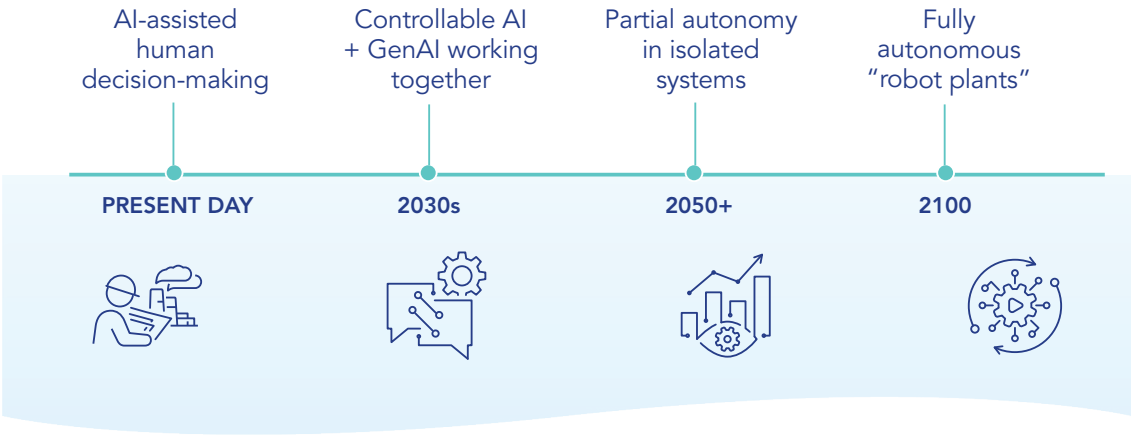
The Next Decade of Industrial Process Modeling

By Gil Cohen, CEO, Imubit

Large Language Models (LLMs) and Generative AI are becoming increasingly strategic for enterprises across all industries. Imubit CEO, Gil Cohen, predicts certain impacts of this revolution on the modeling frameworks of industrial companies in the next decade.

Will AI Ever Run the Plant Autonomously?

Let's start with the ultimate question. When will AI be able to take over and run the plant autonomously? Looking far into the future, we can imagine AI constructing a plant and operating it autonomously without human intervention. This concept of a robot plant will likely happen 100 years from now. Could it be 50, or even 30 years from now? It's hard to predict.



We can, however, grasp where technology might take us over the next decade. We predict that plant decision-making and modeling will be based on "Controllable AI models", Large Language Models (LLMs), and notably, human domain experts who continue to make critical decisions.

Traditional Plant Modeling Framework

A complex manufacturing plant includes 5-7 major technical decision-making domains, each built on technical expertise acquired over a long career. Major examples include Process Engineering, Maintenance, Advanced Process Control, Control Systems, Process Safety, Control Room Operations, and Planning & Economics.

In each domain, information is received from the plant and processed by a carefully engineered scheme of tailored models and human expert reasoning, to generate decisions, fed into other decision-making domains or the plant processing equipment itself. Each decision-making domain uses a different modeling technique to describe overlapping plant areas, representing different "versions of the truth". The reason for these different, often conflicting, versions of the truth has long been the computational limitations of modeling technology — most process manufacturing plants operated for decades before personal computers were introduced.

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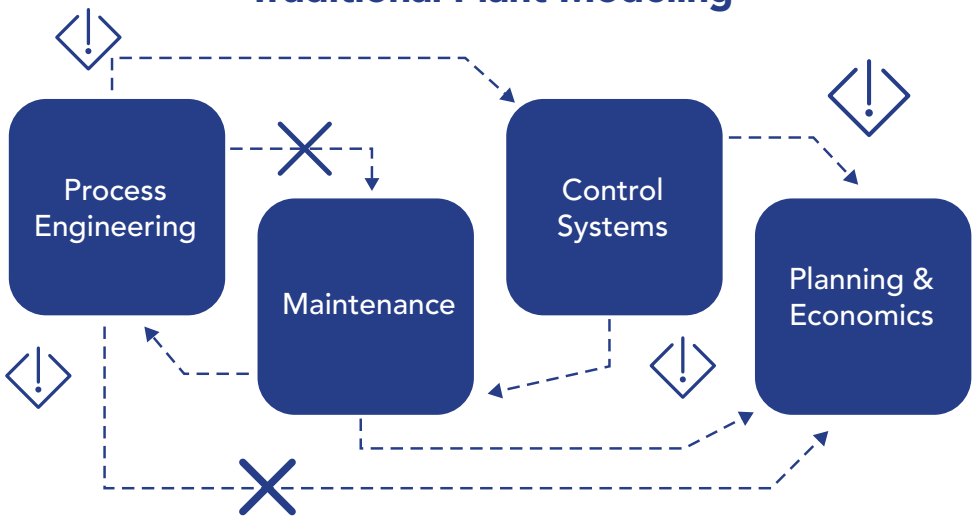
Traditional Plant Modeling



Developed in a compute-limited and data-limited era, each model was tailored to solve a specific problem within a decision-making domain. Each domain developed its own set of first principles and mathematical assumptions in order to build parametric models that support their automated and manual decisions. For example, Planning and Economics teams use a linear programming (LP) model to optimize complex, nonlinear plants. Applying linear solutions to nonlinear problems involves a delicate system of assumptions and procedures that have been honed over decades to approximate, validate, maintain, and adapt these models.

Over decades, the user community of plant technical staff from each domain built their careers around the modeling technologies that served them, honing their skills and developing methodologies around their modeling technology. Modeling technology providers delivered solutions tailored to their specific domain users. The effect of these supplier and consumer behaviors on today's technology landscape is a series of domain-specific toolsets that are difficult to interconnect and do not automatically communicate. All communication between the decision-making domains is done manually by the plant's technical staff.

Generative AI is Encumbered by the Traditional Modeling Framework

Modern Generative AI is based on Large Language Models (LLMs) that are trained on large portions of human-generated data and increasingly used throughout enterprises as co-pilots for human decision support. To get ahead of the curve, most companies are pushing their own limits of autonomous decision-making, exploring how their future operations will look with AI-assisted workers, and further down the road, even AI agents that work alongside human workers.

LLMs ar showing promising human-like autonomous capabilities, as they are able to acquire human collective knowledge and interact with the world in a way that mimics human interaction. However, LLMs are fundamentally flawed in terms of reliability, safety, stability, and explainability. Significant research is being applied to solve these LLM flaws, and until these issues are fundamentally solved, we do not expect that plant operating companies will allow LLMs to make autonomous decisions in such mission-critical environments.

The probability of an industrial plant allowing AI to make all the decisions made by human technical experts is extremely unlikely in the next 1-2 decades. Before enabling AI automation, any AI decision must be transparent, explainable, and verifiable by a human expert. Thus, AI operating on top of traditional, siloed decision-making domains will need to respect the established habits and methodologies, mimicking human analysis and decision-making. AI on top of traditional modeling will provide value to each decision-making domain by capturing knowledge, organizing human decisions and discussions, and formalizing communication between teams. However, applying AI within the confines of the traditional plant modeling framework will fail to unlock the power and value that modern AI can provide in pushing a manufacturing plant to its true global optimum with respect to its business goals and constraints. This approach will burden AI with the same assumptions, biases, and limitations that plague traditional approaches. A truly optimized plant means that every action taken will best probabilistically serve the plant's business goals within its constraints, given all the available raw plant data at the time of the action. That will require a holistically different plant modeling framework.

Next Generation of Plant Modeling via Controllable AI

Increasing computing capacity and market needs have given rise to a new type of AI, which we'll refer to as 'Controllable AI' for the remainder of this piece. Controllable AI models are not Generative AI or Large Language Models, nor are they hybrid models—traditional approaches with AI bolted on. The goal of Controllable AI models is to empower domain experts to operate the plant at a higher state of optimization with respect to the plant's business goals, within its constraints, and while providing domain experts with a high degree of observability and controllability into the AI models.

— Controllable AI models possess the following qualities —

1. **They're constructed through an architecture that is known to the user, and trained only on datasets known to the user.** The user has full decision-power over the precise dataset used for model training, including each and all data sources, and the data points within each data source.

2. **Once trained, Controllable AI models are well-defined deterministic mathematical functions or algorithms.** Key properties of the model are mathematically or statistically observable in a way that is easily understood by the user.

3. **They include certain engineering selections that allow the user to steer the model training,** to express, for example, a set of desired relationships between variables.

These traits of Controllable AI give engineers high degrees of controllability and observability, which meet the harsh requirements of a safety-critical environment like an industrial process plant.

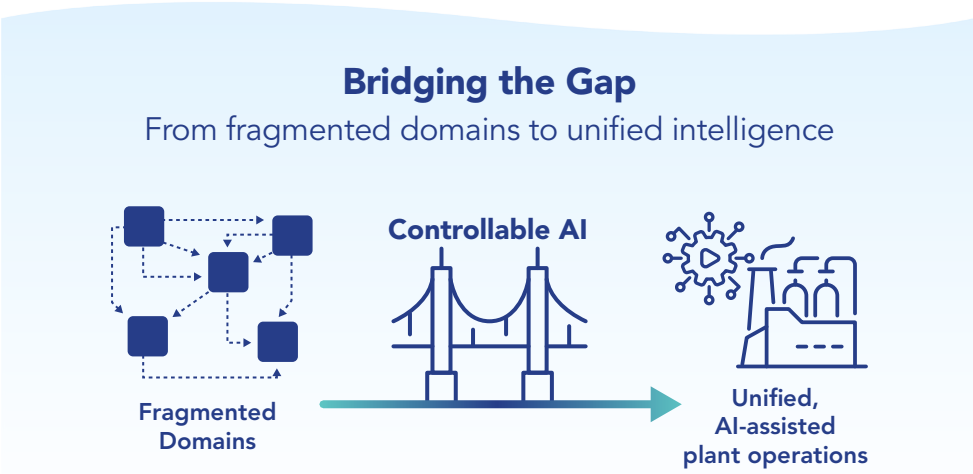
The 2035 Equation:

Human Domain Experts + **Controllable AI** + **Generative AI** = **Improved Plant Performance**

For Generative AI to unlock its exponentially increasing strengths and opportunities, it must be unburdened by the siloed human assumptions and biases developed over the past decades by the experts of each domain. Generative AI must be able to generate decisions that are as close to the optimum as possible with respect to current plant data, based on a single, shared, and verifiable version of the truth.

In the next decade, this effective and safe use of Generative AI will be accomplished through the integration of Generative AI with Controllable AI. Through Controllable AI, Generative AI serving all domains will develop the same understanding of the plant through the shared Controllable AI models. This understanding of the plant will be validated, verified and approved by various domain experts through Controllable AI. Generative AI will explain its decisions and recommendations using a sequence of reasoning, also known as a "chain of thought," based on Controllable AI models, that are shared and understood by all decision-making domains.

To come back to our originally posed questions—No, we do not expect any decision-making domain to vanish in favor of Generative AI, at least not in the next decade. Each domain will employ GenerativeAI that boosts the productivity of its human experts, and generates high-frequency automated decisions and recommendations for manual decisions made between domains. Controllable AI will serve as a bridge, protocol, or platform between the decision-making domains where the shared model presents a single lens of reality.



This integration between Controllable AI and Generative AI will not only empower the entire plant workforce and enable high-performing collaborative teams, but it will unlock the true power of modern AI within process plants.

Unlock the power of modern AI in process plants and see how it can transform your operations.

To learn more about AI in industrial processing, visit **Imubit.com** today.