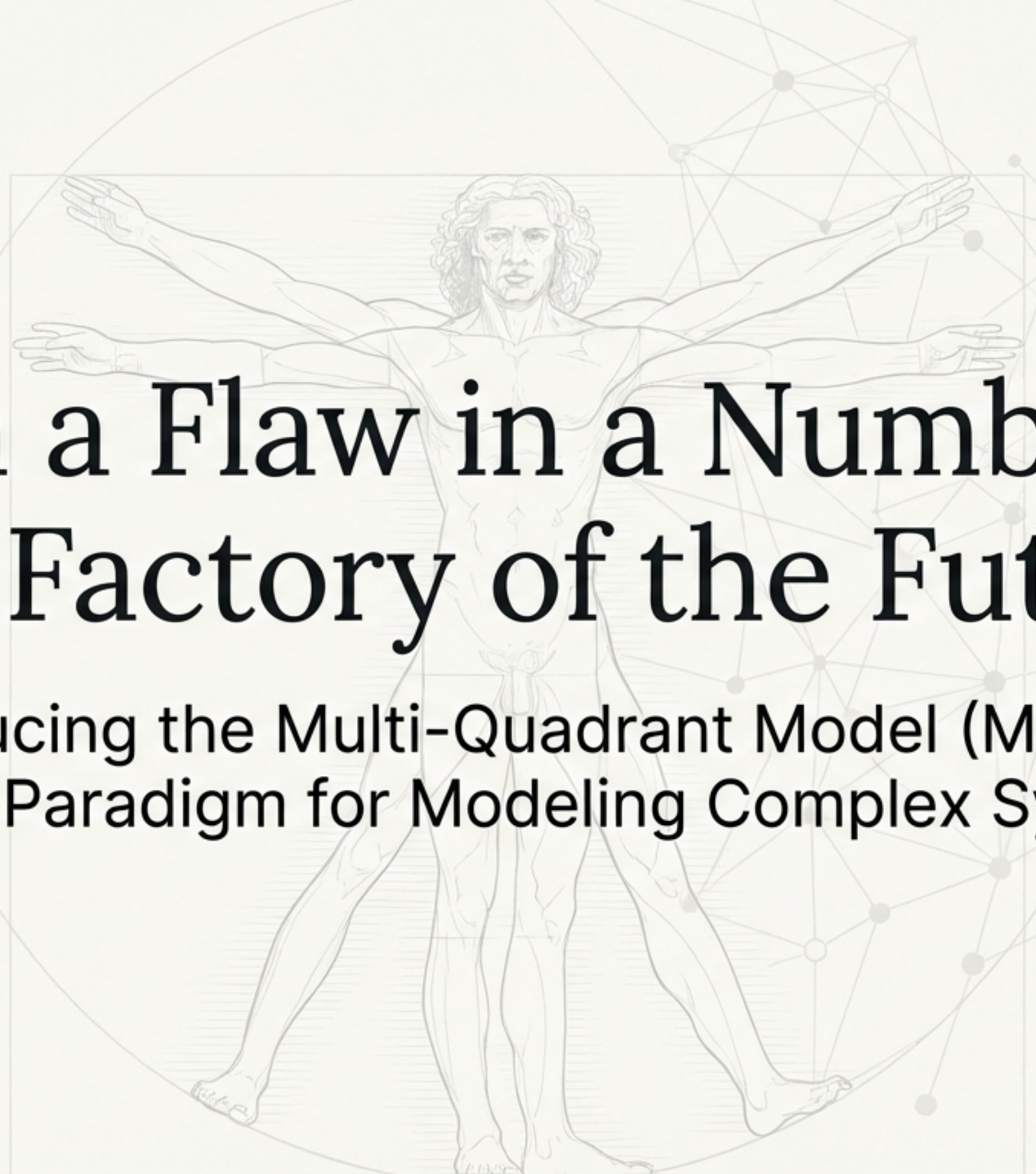


From a Flaw in a Number to the Factory of the Future

Introducing the Multi-Quadrant Model (M-Q-M): A New Paradigm for Modeling Complex Systems

Singularities

Black Holes

The Big Bang

Our Most Profound Theories Are Built on a Mathematical Paradox

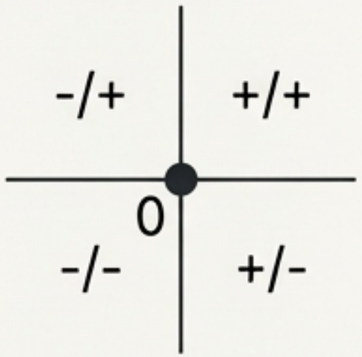
Modern physics relies on a mathematics where division by zero is forbidden, yet its most profound theories are born from singularities—mathematical consequences of approaching zero.

The Big Bang, black holes, the infinite energy of the vacuum—these "riddles of nature" are artifacts of a number, the 'Zero', that breaks the logic of our arithmetic.

This fundamental 'crack' in our analytical foundation leads to paradoxes and prevents the unification of relativity and quantum mechanics.

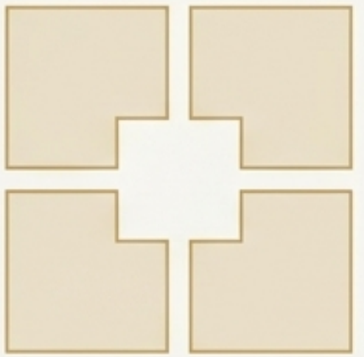
We Must Shift Our Perspective from a World of ‘Zero’ to a World of ‘One’

The World of Zero (The Cartesian View)



- **Represents:** Nichts (Nothingness), static points, elements in a void.
- **Leads to:** A coordinate system with a central origin, positive/negative values, and the problem of infinity at the edges and paradox at the center.
- **Limitation:** Models things and spaces, but struggles to natively represent movement, relationships, and dynamic systems.

The World of One (The M-Q-M View)



- **Represents:** Equilibrium, flow, balance, constant movement.
- **Leads to:** A system of four interconnected, exclusively positive quadrants without a central zero.
- **Principle:** ‘Everything is Movement.’ Systems are not static objects but bundles of activity and energy flows.

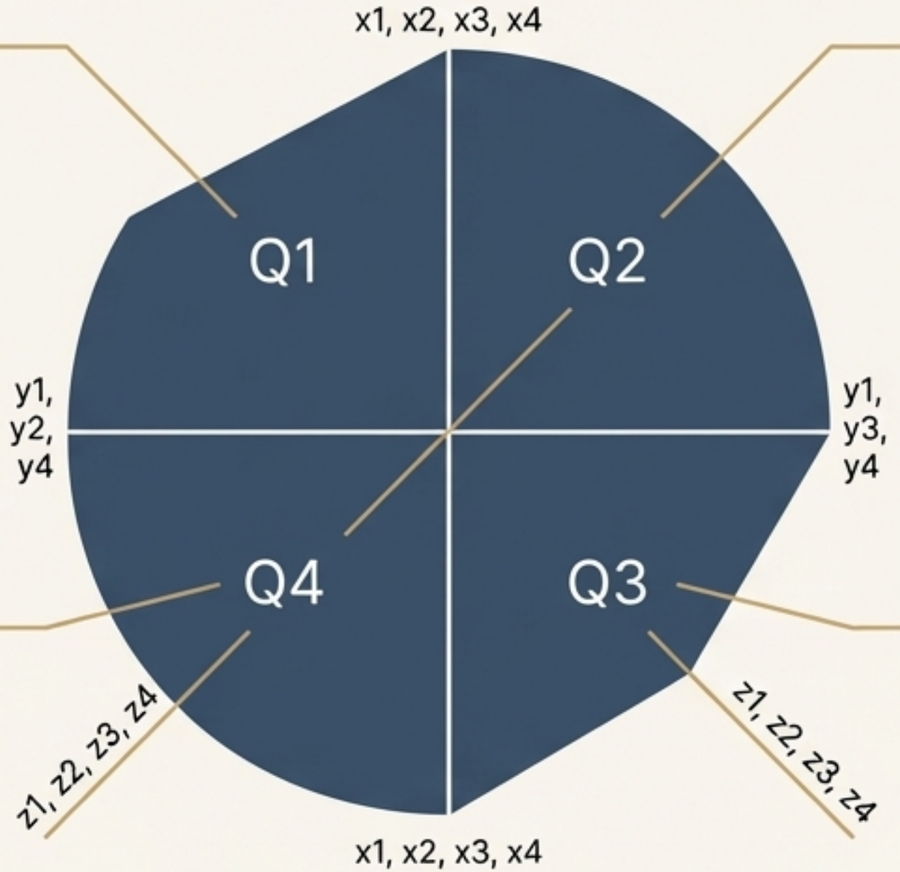
The Multi-Quadrant Model: A Universal Grammar for Systems

Q1: Transformation / Rules

The logic, the process, the "how." Describes the rules that convert inputs to outputs. (Corresponds to `PutPut`)

Q2: Flow / Input

The continuous consumption of resources, the kinetic energy. (Corresponds to `Input`)



Q4: Outcome / Potential

The discrete result, the stored energy, the potential for future action. (Corresponds to `Outcome/Output`)

Q3: Plan / Identity

The total system, the idea, the absolute state, the "why." (Corresponds to the system itself, e.g., "Huhn")

This structure provides a consistent, holistic way to describe any system—from a photon to a person to a production line—based on its essential facets of activity.

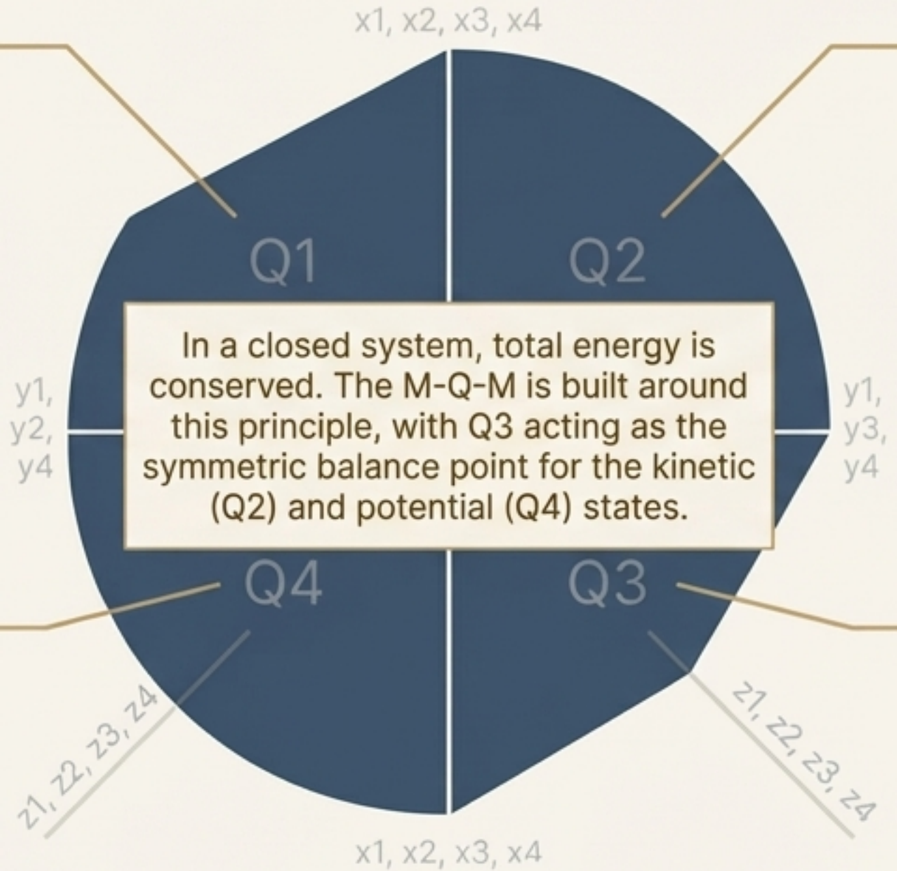
Translating the Universal Grammar into the Language of Energy

Q1: Transformationsenergie

The energy of conversion, including losses like heat or waste.

Q2: Kinetische Energie

The energy of motion, of consumption and flow.
`$E_{kinetisch}$ = ½ m * v^2`



Q4: Potentielle Energie

The stored energy, the output, the result.

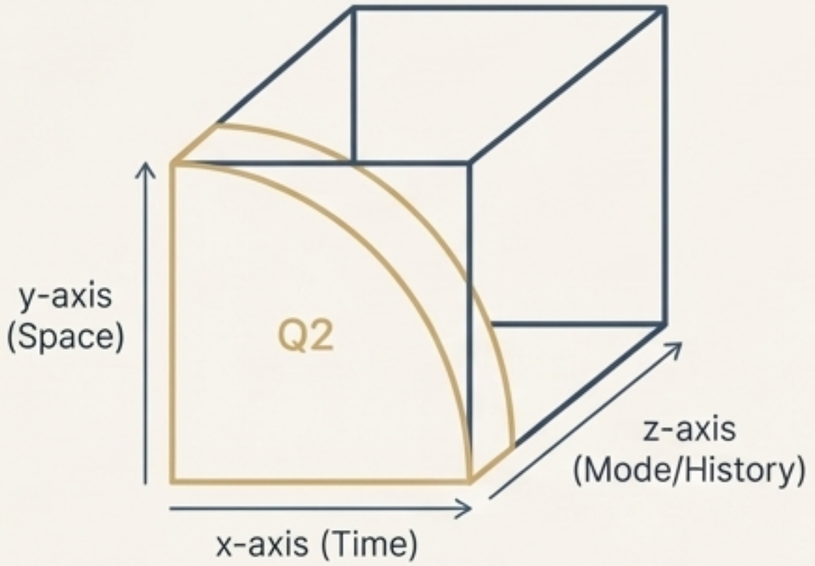
Q3: Gesamtenergie

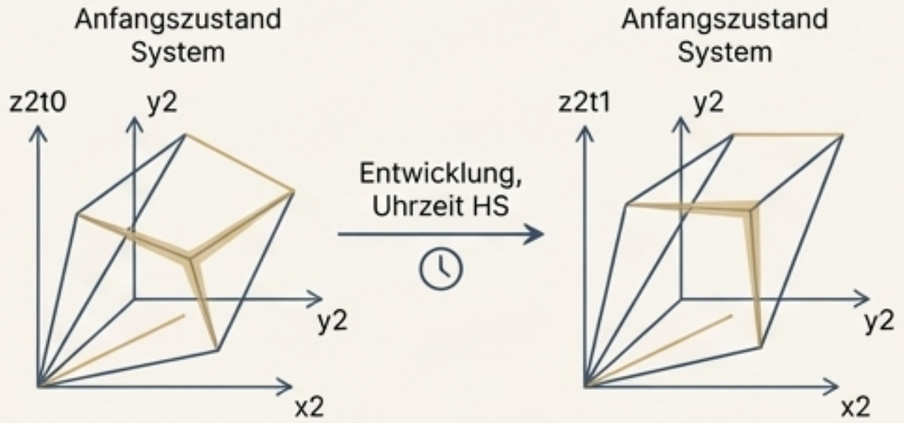
The total energy of the system, its identity and plan. The energetic mirror axis.
`Q3 = Q2 + Q4`

A Third Dimension for Time, History, and Emergence

Traditional models treat time as a single, linear dimension. The M-Q-M introduces a multi-faceted view of time and existence through its axes:

- **x-axis (Time):** Differentiates between **Absolute Duration** (Chronos, the total lifecycle) and **Relative Period** (*Kairos*, the opportune moment, the cycle time).
- **y-axis (Space)**: Differentiates between **Absolute Expanse** (total scope or variance) and **Relative Difference** (the potential that drives flow).
- **z-axis (Mode/History)**: The crucial third dimension. It tracks the system's evolution, its emergence from a parent system, different states of being (modi), and its historical development over time (`HS`). This allows for **modeling not just** *what* a system does, but *what it becomes*.





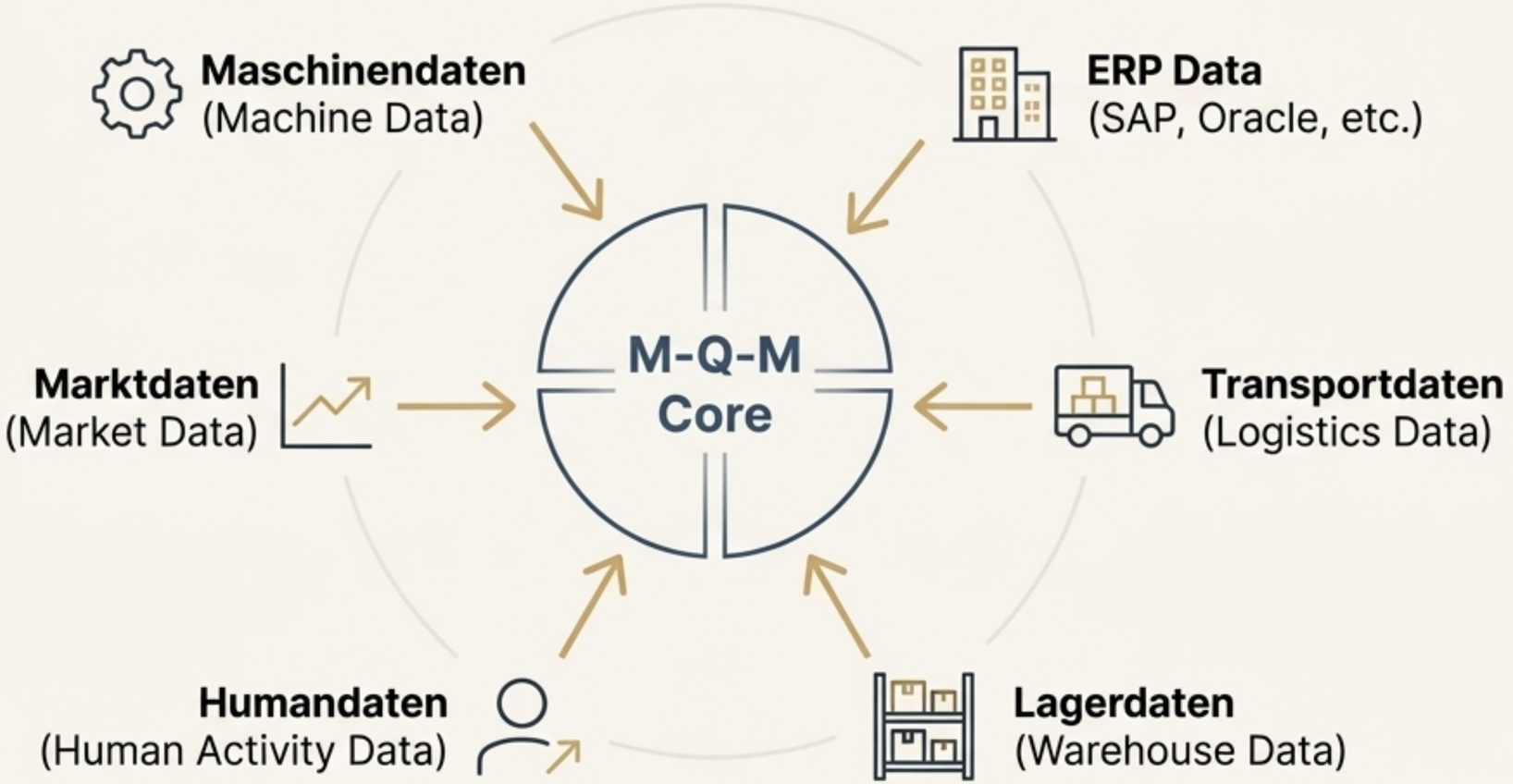
The M-Q-M in Action: A BMBF-Funded R&D Project Dynamic Control of Highly Complex Systems

The modern industrial landscape demands agile, temporary collaborations between specialized companies—the **'Green Virtual Factory.'**

How do you plan, operate, and optimize a factory that doesn't physically exist as a single entity? How do you overcome the 'tangle of different interfaces and data models' (`wirrwarr unterschiedlicher Schnittstellen`)?

Our Solution: The Green Digital Energy Twin (gDEZ)

The gDEZ is a dynamic, multi-dimensional model of the entire virtual value chain, built on the M-Q-M framework. It acts as the central “operating system.”

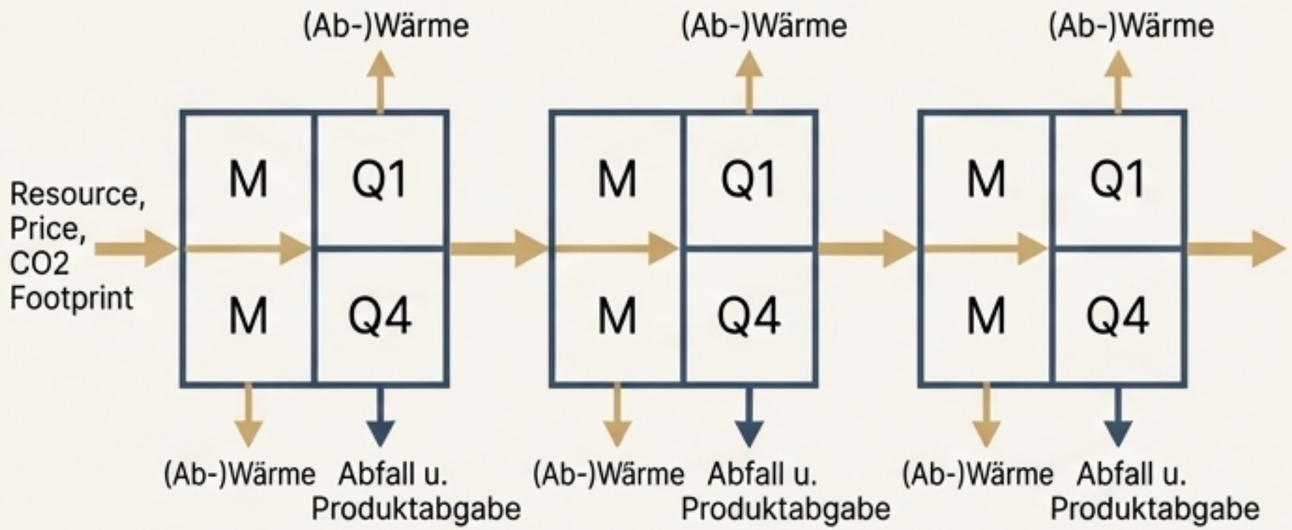


A Unified Metric: Modeling the Entire Value Chain in the Language of Energy

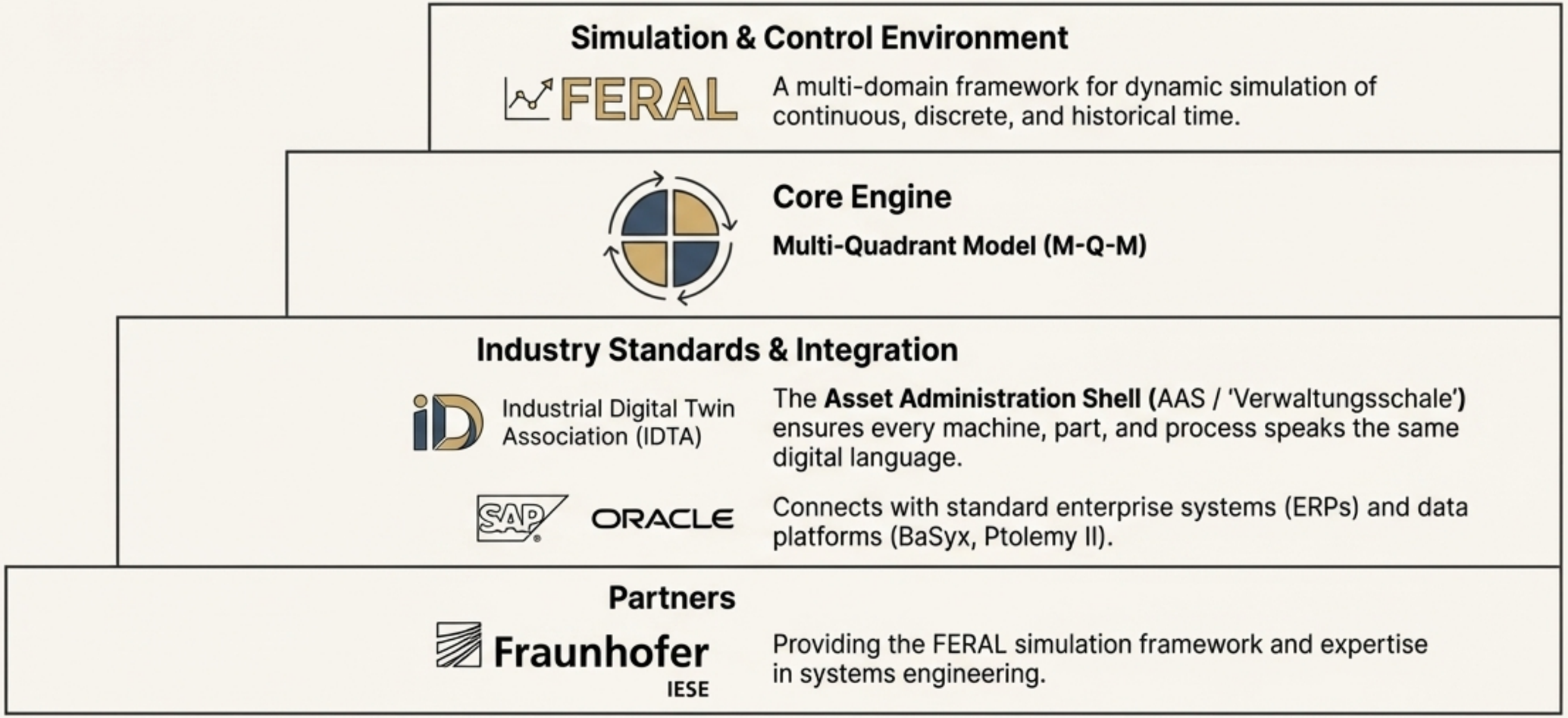
The M-Q-M allows every aspect of the virtual factory to be modeled and optimized within a single, consistent, energy-based framework.

- A machine's power consumption (kWh)
- The CO_2 footprint of a transport leg (kg CO_2e)
- The wear and tear on a tool (dissipated energy)
- The market price of a resource (€/kWh equivalent)
- The information flow in a planning process

We can now perform true holistic optimization. For the first time, we can ask questions like: "What is the total energy and CO_2 cost of this specific customer order across all partners, and how can we minimize it in real-time?"



Built on a Foundation of Advanced Technology and Expert Partnership



The Mathematical Foundation of a Closed System in M-Q-M

Core Algebraic Structure

Quadrant Functions:
$Q_i = f_i(\text{inputs})$

System Block Form:

$$Q \begin{bmatrix} Q1 & Q2 \\ Q3 & Q4 \end{bmatrix}$$

Geometric Coupling Conditions

$y_1 = y_2$
$y_3 = y_4$
$x_2 = x_3$
$x_1 = x_4$

Historical Evolution (z-axis)

$z_n(t) = z_{n-1} + \Delta z$

where n represents a discrete historical step or mode change.

Core Energy Balance

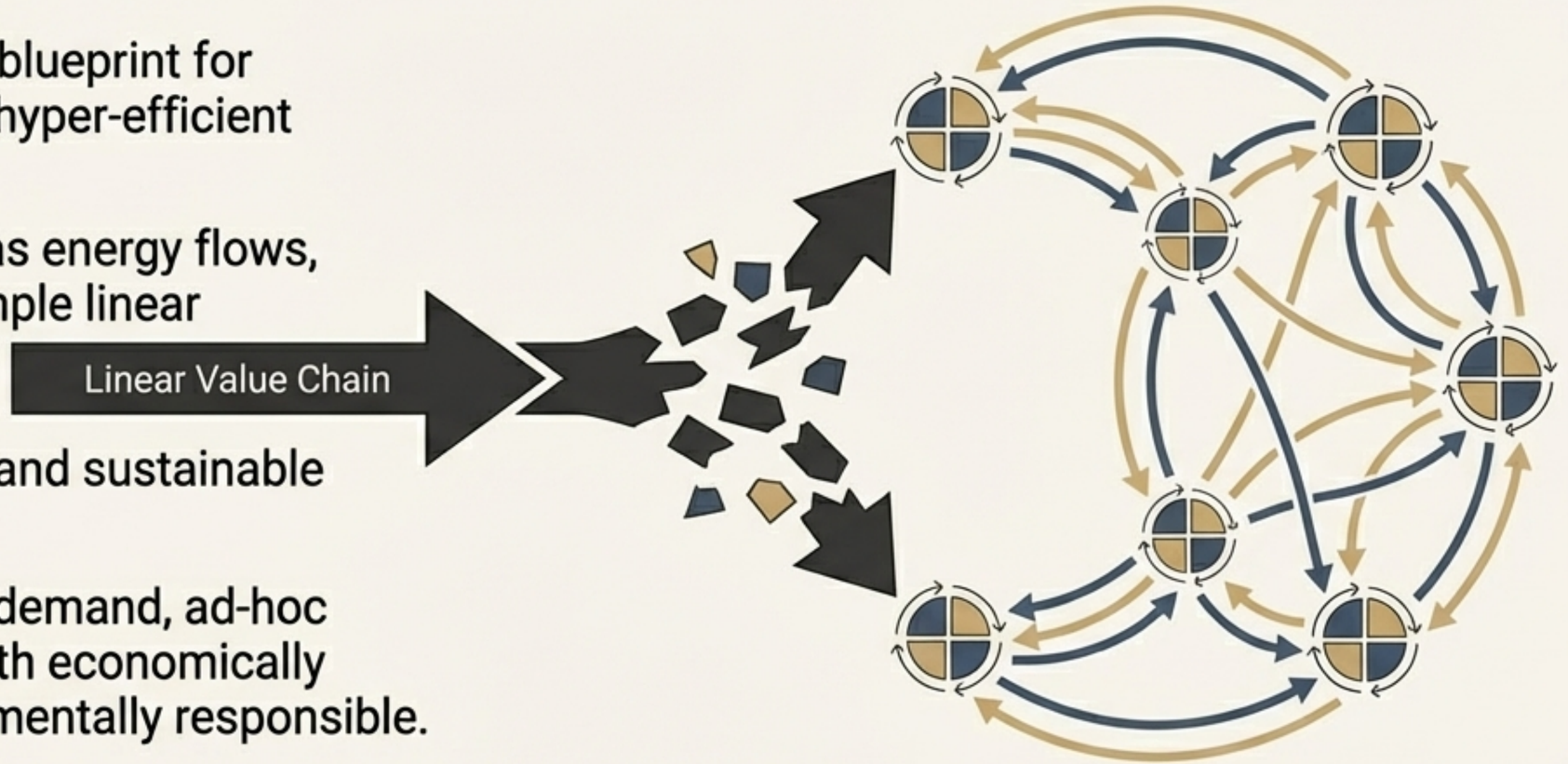
$Q_3 = Q_2 + Q_4$
(Total Energy = Kinetic + Potential)

$Q_1 + Q_3 = \text{const}$
(Transformation/Losses are balanced with Total Energy)

The M-Q-M is not just a conceptual diagram; it is a formalydefined mathematical structure that enables consistent and verifiable simulation of system dynamics.

From Linear Chains to Circular Economies: A New Operating System for Industry 4.0

- The M-Q-M provides the blueprint for scalable, replicable, and hyper-efficient value networks.
- By modeling everything as energy flows, we can move beyond simple linear production ("take, make, waste") and sevtant towards a truly dynamic and sustainable circular economy.
- It enables a future of on-demand, ad-hoc manufacturing that is both economically competitive and environmentally responsible.



By fixing a flaw in how we count, we have created a new way to build.