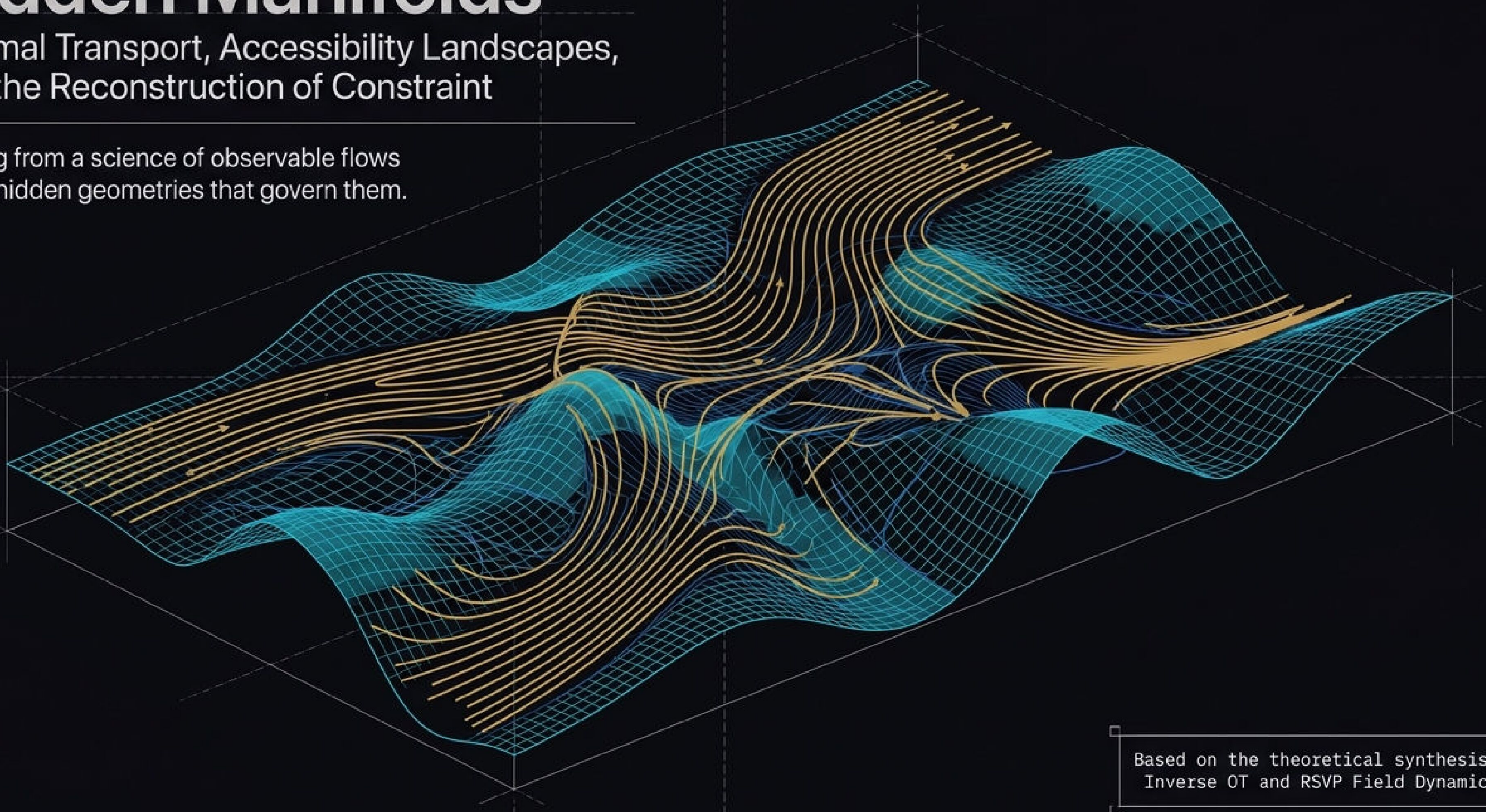


# Hidden Manifolds

Optimal Transport, Accessibility Landscapes,  
and the Reconstruction of Constraint

Moving from a science of observable flows  
to the hidden geometries that govern them.



Based on the theoretical synthesis of  
Inverse OT and RSVP Field Dynamics.

# Trajectories Are Not Fundamental

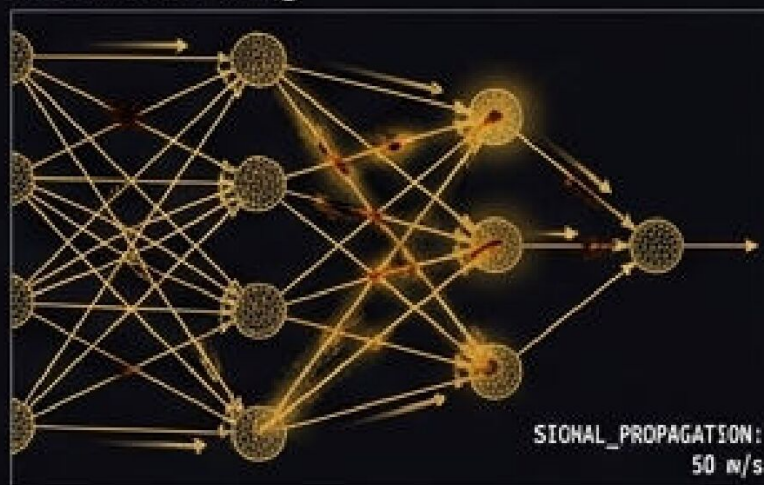
## The Visible

Trade Volumes

FL0a\_Ba1E:  
1.2e9 RT/YR



Neural Firing

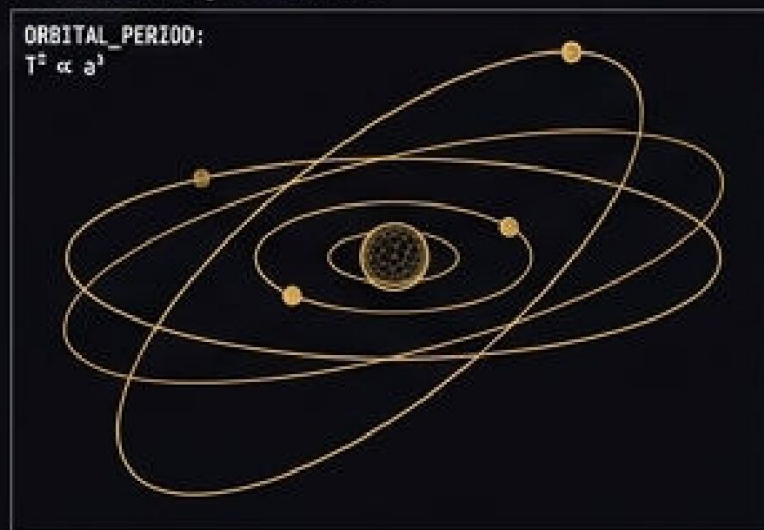


Migration

DISPLACEMENT\_VECTOR:  
[As, Ay] > THRESHOLD

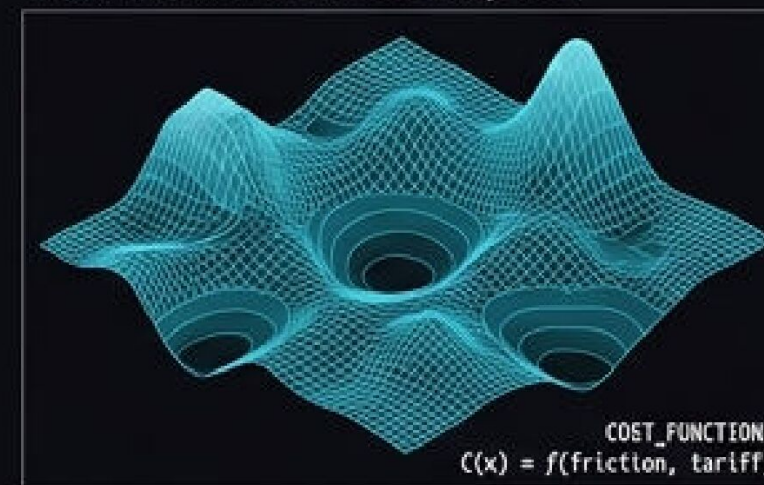


Planetary Orbits

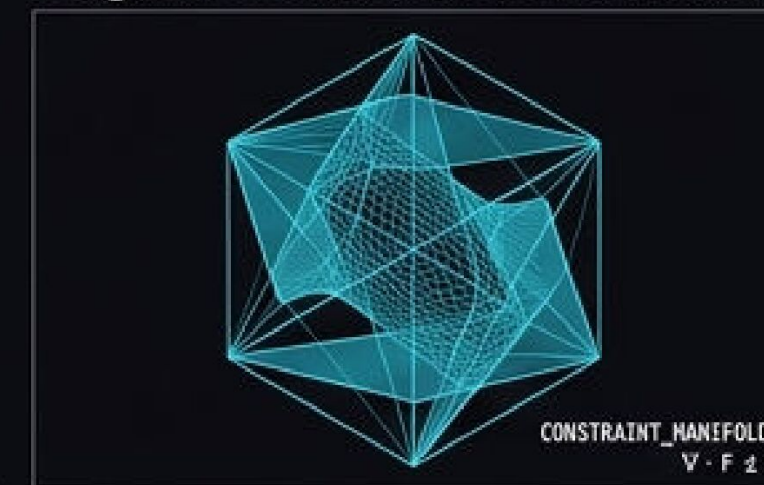


## The Hidden

Trade Cost Landscapes



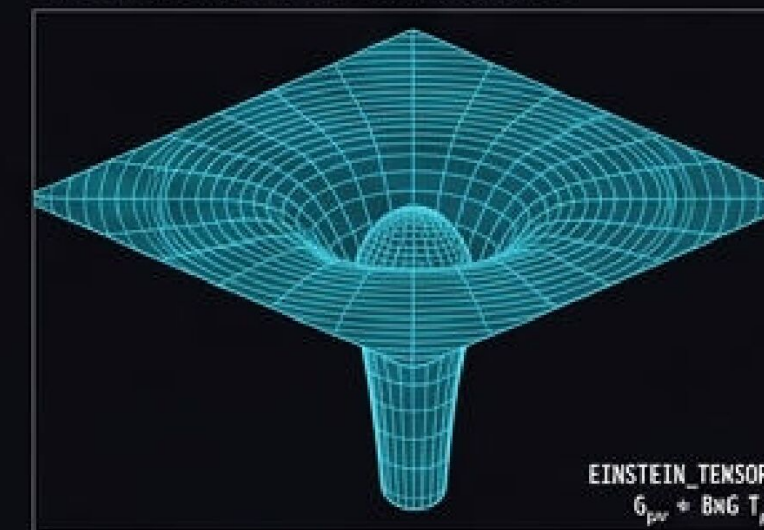
Cognitive Constraint Geometries



Border Friction Fields



Gravitational Curvature



The observable trajectory is merely data. The hidden field is the explanation. The goal of modern inference is inversion: reconstructing the hidden manifold directly from the motion it produces.

# The Flaw of the Grammar Approach

The Grammar Approach  
(Gravity Models)

## Assumed Costs:

Gravity models guess trade costs by parameterizing observable proxies (covariates).



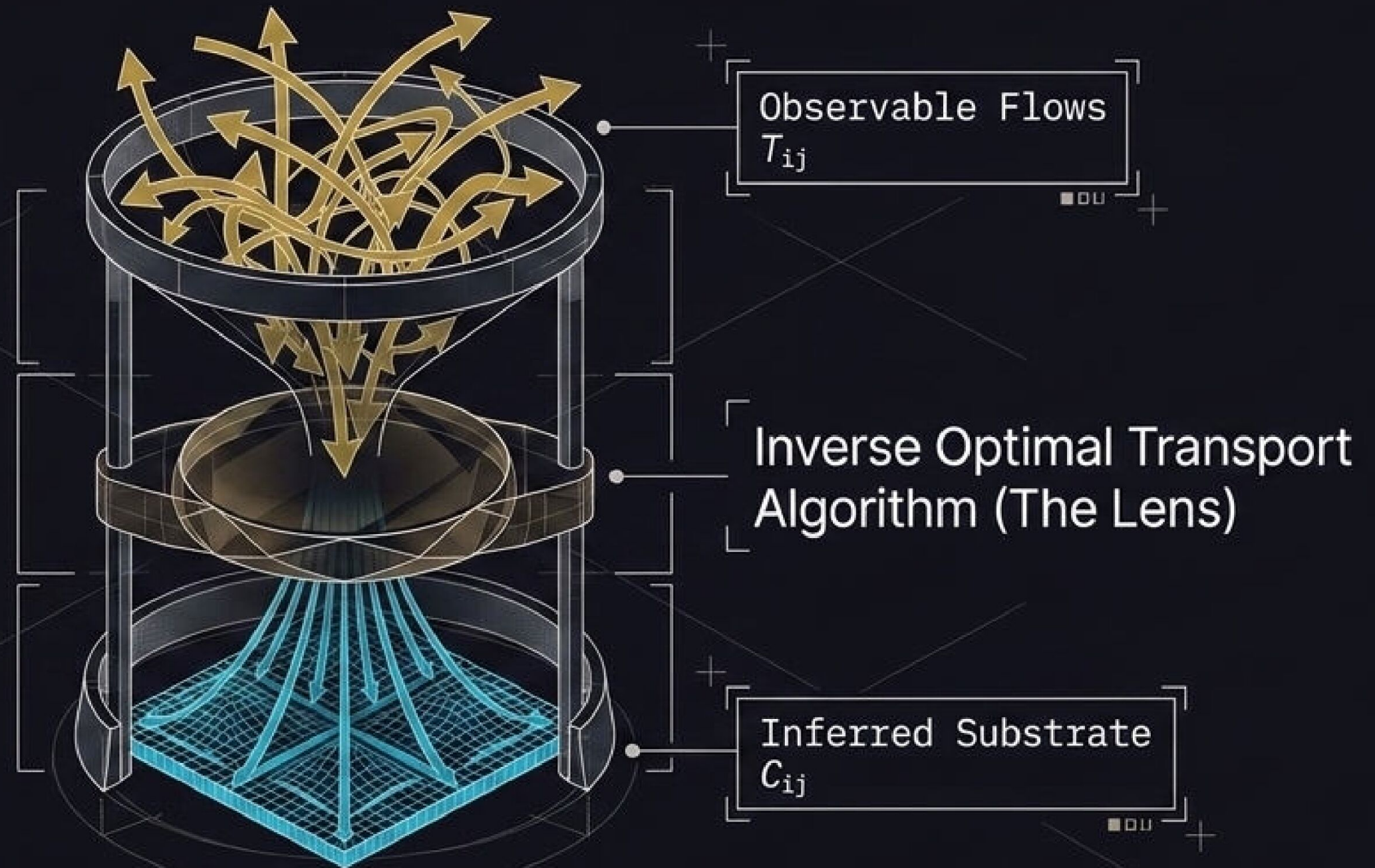
$$T_{ij}(t) \approx \frac{O_i(t)E_j(t)}{C_{ij}(t)}$$

## The Error Term:

When unmeasurable realities shift—geopolitics, institutional trust—the map fails, dumping reality into a statistical error term.

Unobservables  
(War, Boycotts, Trust)

# The Substrate Solution: Inverse Optimal Transport



IOT reconstructs the cost directly from the flows. It finds the exact hidden accessibility landscape that makes the observed trajectories mathematically optimal. It lets the **territory speak for itself.**

# Two Modern State-of-the-Art Inversions

## Stuart-Wolfram (2019)

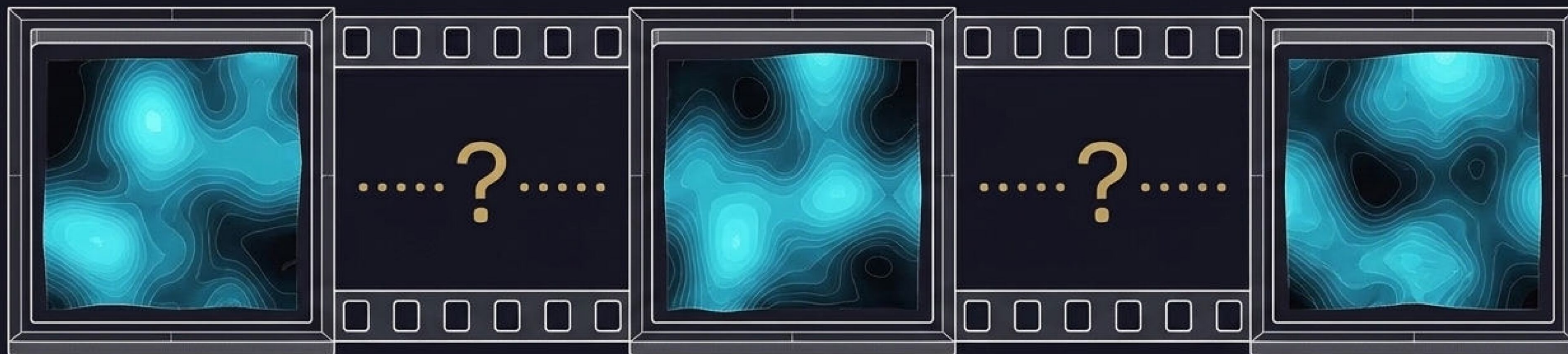
<b>Method:</b>	Bayesian Inverse OT
<b>Domain:</b>	European Migration Flows
<b>Mechanism:</b>	Learns cost from graph-based edges, recovering the true cost of crossing borders while generating full uncertainty quantification.

## Gaskin et al. (2026)

<b>Method:</b>	Neural Inverse OT
<b>Domain:</b>	Global Agricultural Trade
<b>Mechanism:</b>	Minimizes loss against Sinkhorn projections to uncover massive geopolitical cost asymmetries from FAO data.

**Synthesis:** Both methodologies prove that treating cost as an inferred structure outperforms covariate-based gravity models by an order of magnitude.

# The Missing Link: The Problem of Static Substrates



Current Inverse OT recovers the exact cost matrix  $C_{ij}(t)$  at a single given moment.

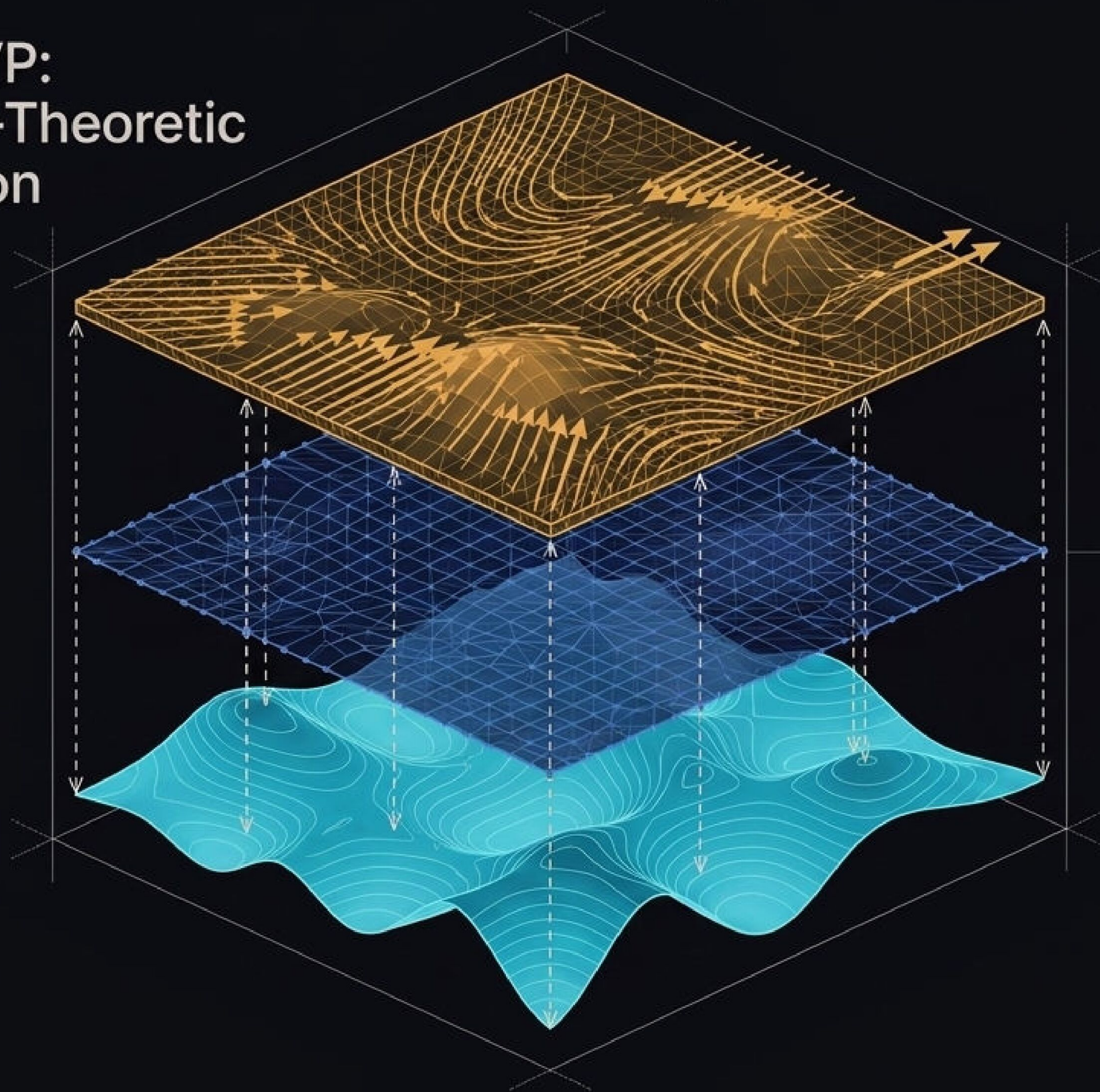
## No Spatial Continuity

Matrices treat countries as disconnected nodes rather than spatial coordinates on a continuous manifold.

## No Temporal Arrow

There are no equations governing how or why the topography deforms from time  $t$  to time  $t+1$ .

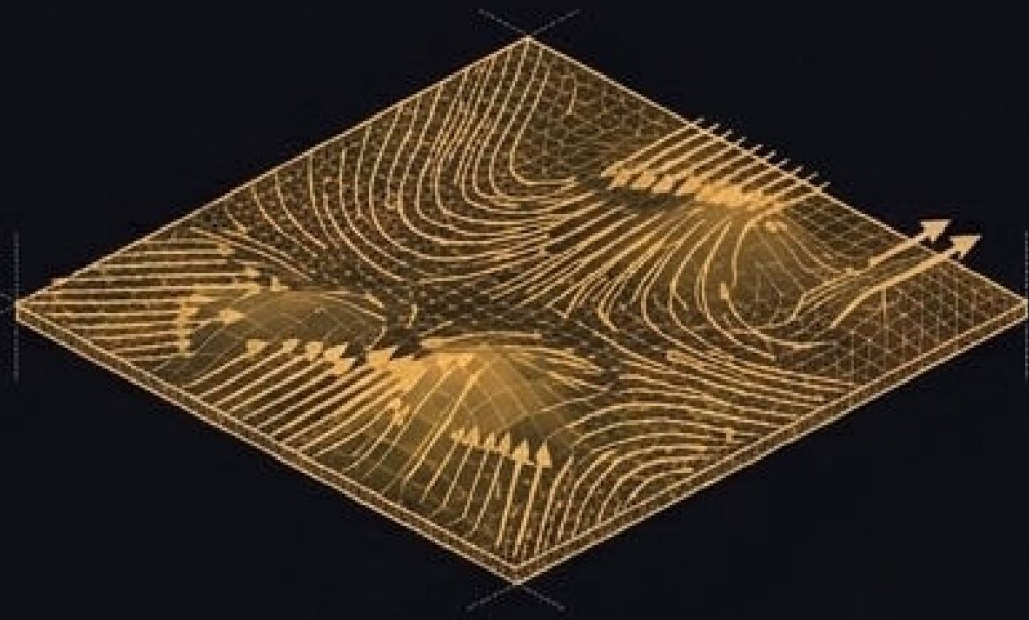
# Enter RSVP: The Field-Theoretic Completion



## The Relativistic Scalar-Vector Plenum (RSVP)

RSVP provides the dynamic engine missing from Optimal Transport. It treats entities not as discrete nodes, but as coordinates in a continuous manifold governed by non-linear partial differential equations.

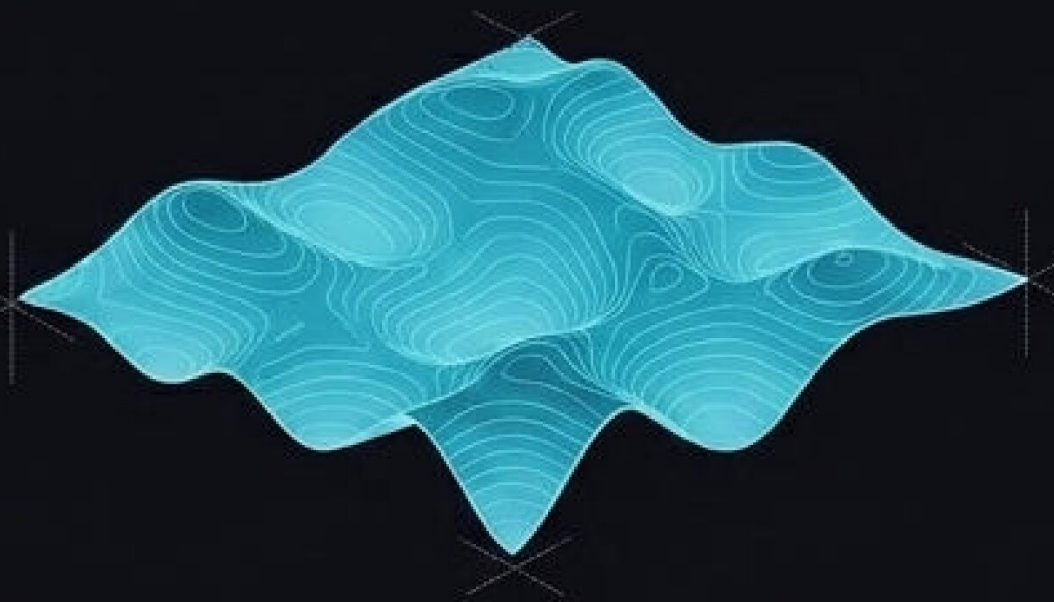
# Anatomy of the RSVP Field Triple



**The Vector Flow Field ( $v$ )**

The visible trajectories.

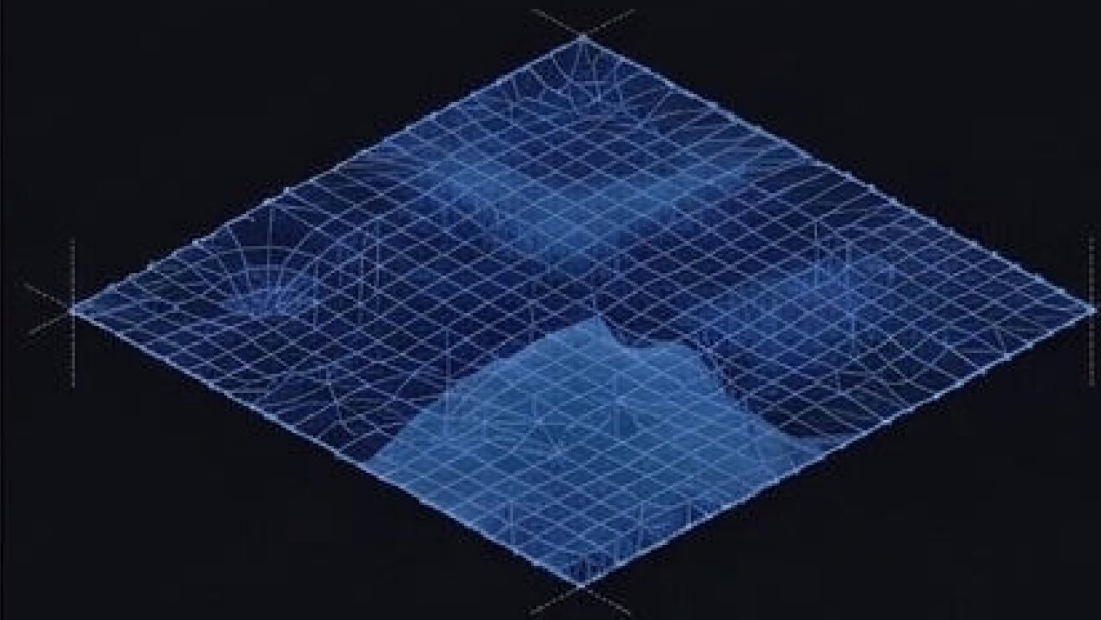
Replaces the static  
Transport Plan  $T_{ij}$ .



**The Scalar Cost Field ( $\Phi$ )**

The underlying friction  
potential.

Replaces the static  
Cost Matrix  $C_{ij}$ .



**The Accessibility Field ( $S$ )**

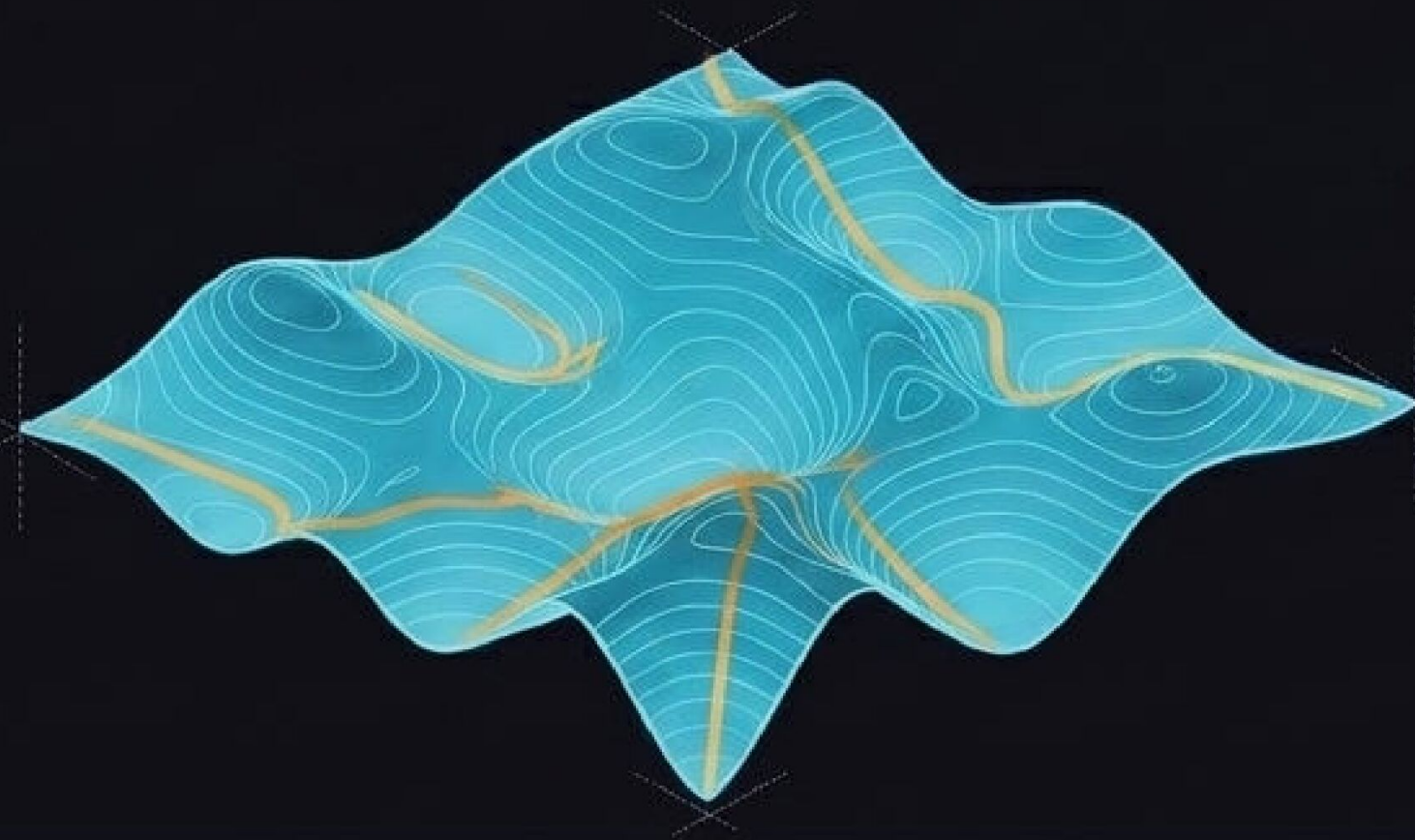
The thermodynamic work  
and route resilience.

Replaces the static  
Entropy Regularization  
constant  $\epsilon$ .

# Rethinking Entropy: The Accessibility Field

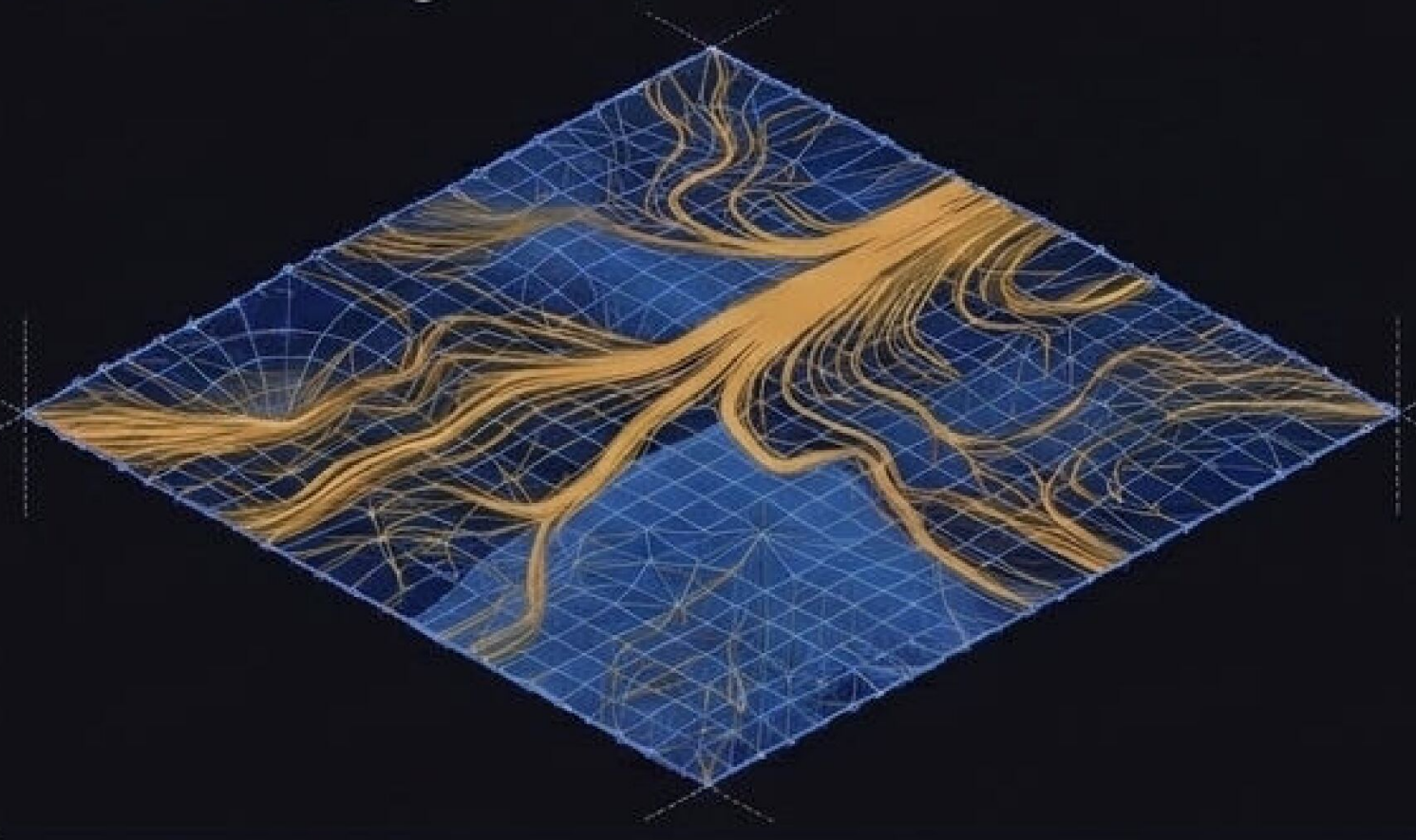
Entropy ( $\epsilon$ ) is not a computational trick to make algorithms run faster; it is a physical temperature field.

Network A (Low  $S / \epsilon$ )



Constrained: Highly optimized, rigid flows easily broken by friction.

Network B (High  $S / \epsilon$ )

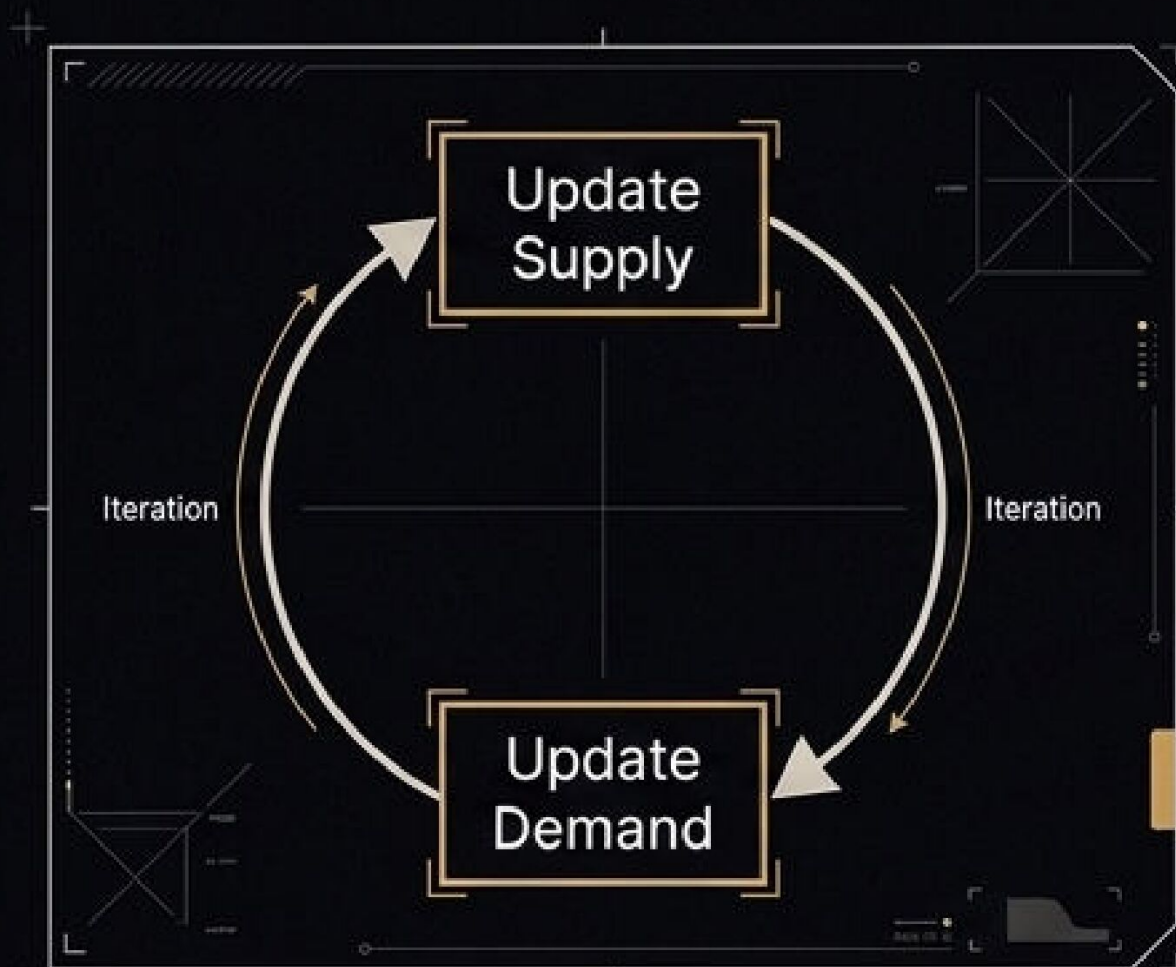


Accessible: Diffuse routes, political stability, high trust, resilience to geopolitical shocks.

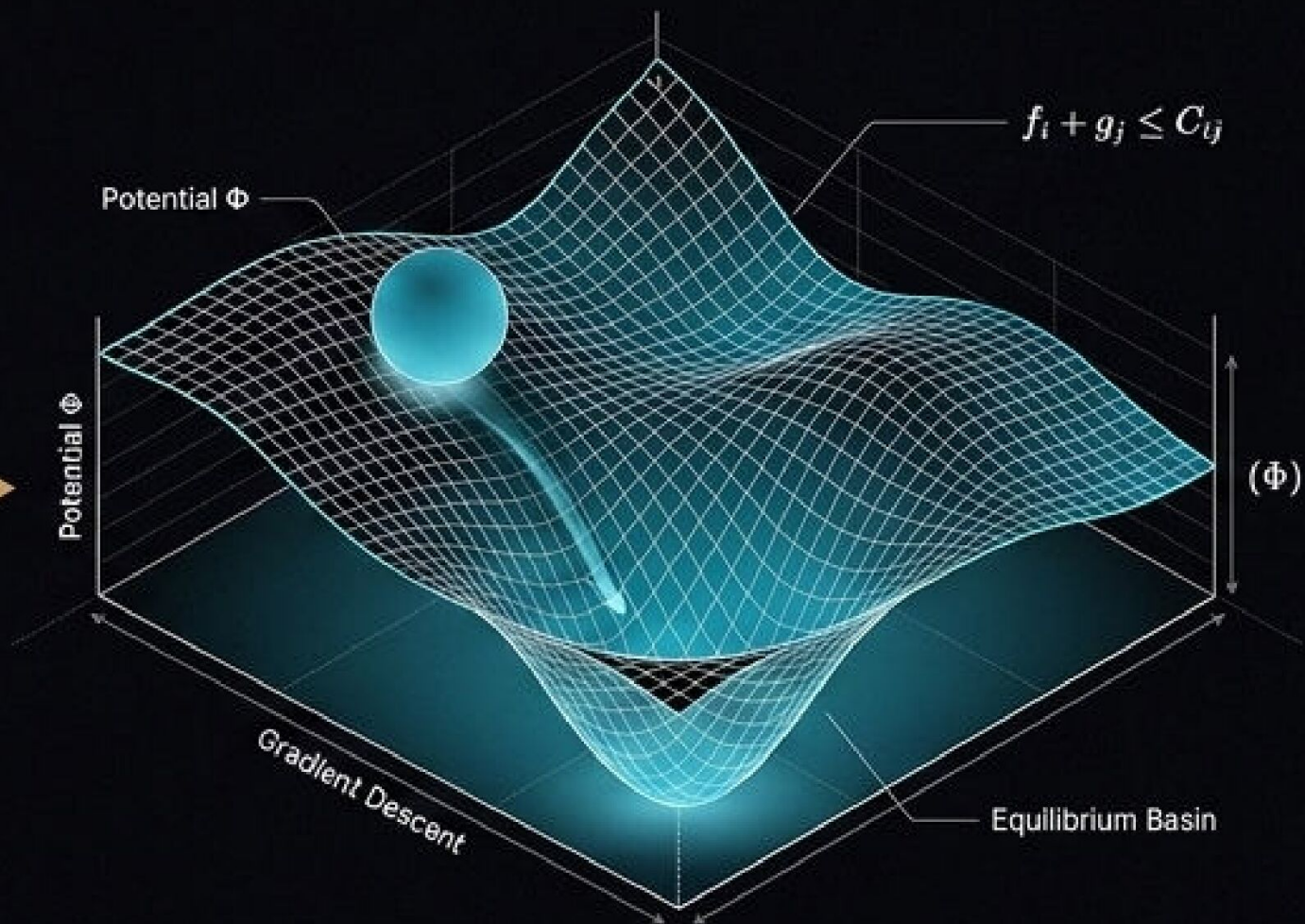
# Sinkhorn as Physics (RSVP Gradient Flow)

Sinkhorn Algorithm

Thermodynamic Relaxation



Translation



## 1. The Algorithm

The Sinkhorn algorithm iteratively adjusts matrices to meet node constraints.

## 2. Physical Translation

This is the physical system relaxing into equilibrium. The cost field ( $\Phi$ ) adjusts to flow divergence ( $\mathbf{v}$ ), back and forth.

## 3. Admissibility

$f_i + g_j \leq C_{ij}$  translates mathematically to the RSVP entropy production inequality  $\sigma_{\text{prod}} \geq 0$ . The system halts when it reaches thermodynamic balance.

# Real-World Dynamics: The Ukraine Wheat Shock

Cost Field  
Deformation ( $\phi$ )

**AFRICA (e.g. Zambia)**  
Volume Drop: 97%  
Cost Spike: +0.48 units  
Low baseline Accessibility (S) forced catastrophic cost absorption.

**EUROPE**  
Volume Drop: High  
Cost Spike: 0 units  
High baseline Accessibility (S) to alternative routes allowed flow redirection without thermodynamic penalty.

**Takeaway: RSVP explains why cost and volume decoupled—a reality Gravity models entirely miss.**

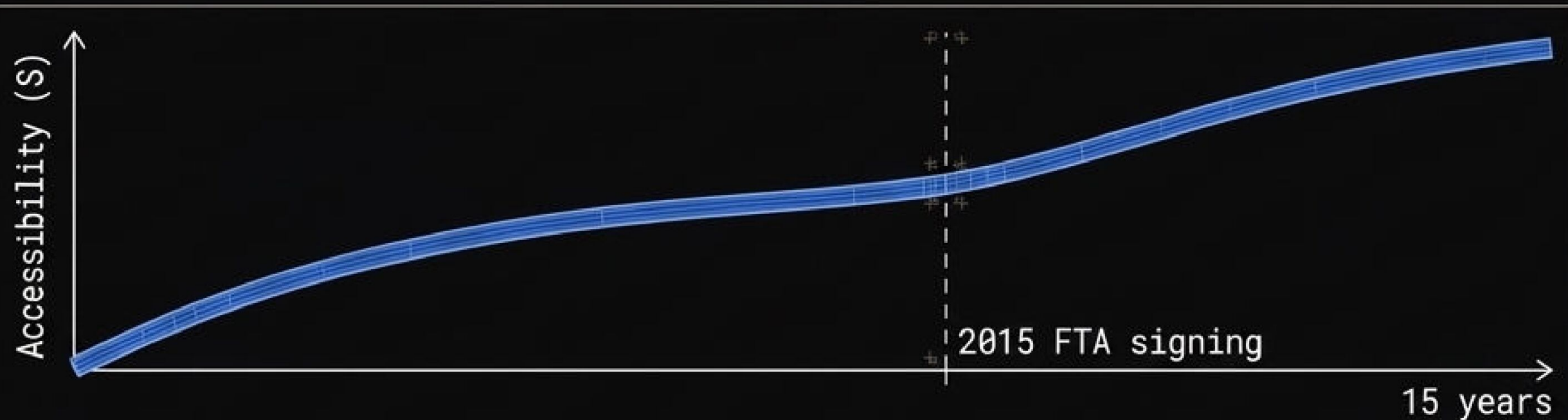
# Field Deformations vs. Field Manipulation

## Brexit (Persistent Deformation)



Introducing non-tariff barriers created a permanent asymmetry in the cost field. UK costs rose; Ireland's did not. Flows sought lower  $\Phi$ .

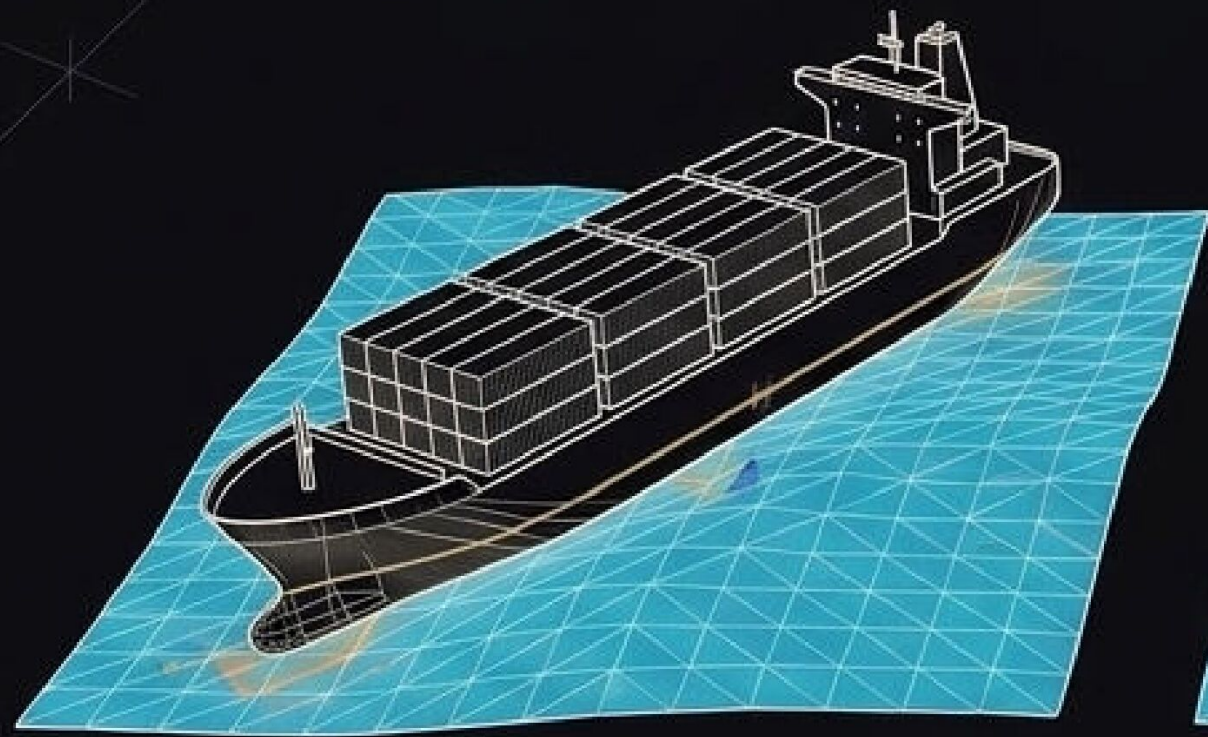
## ChAFTA (Accessibility Ratification)



Free Trade Agreements rarely drop costs instantly; they formally ratify accessibility that has organically grown over decades.

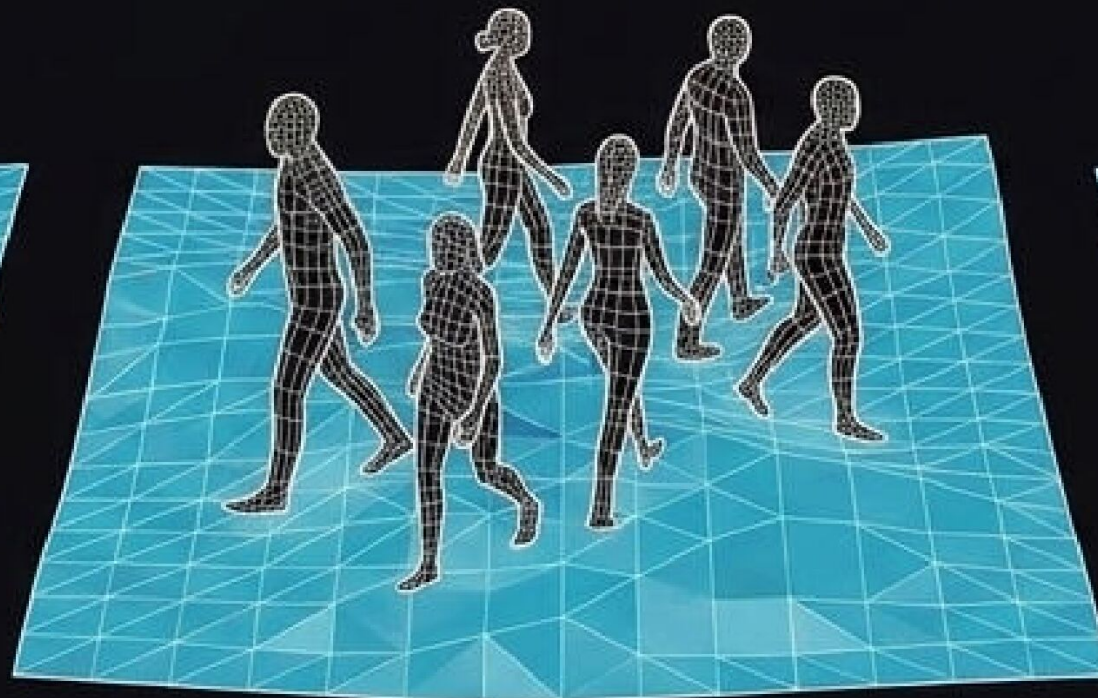
# Universal Substrates: Migration, Trade, and Cognition

The mathematics does not care what is flowing. The unifying objective remains identical: infer the hidden constraint geometry from the visible behavior.



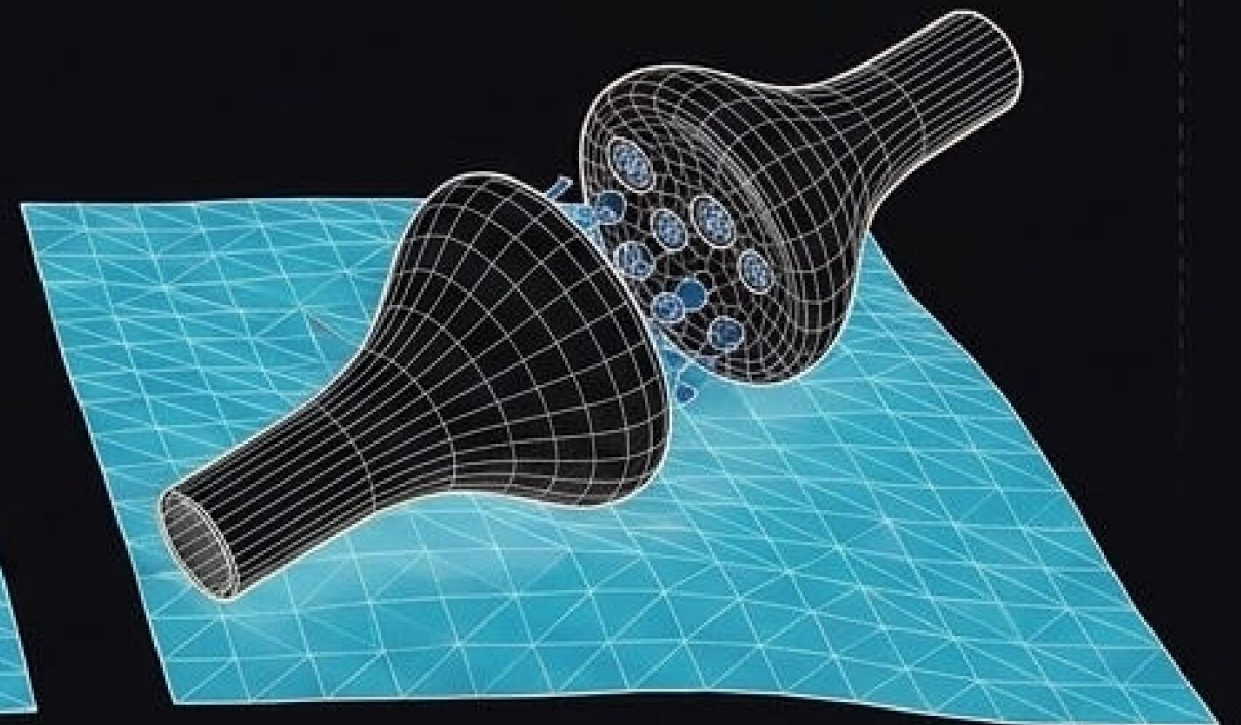
Trade

Tariffs and logistics form the friction manifold.



Migration

Visas, language, and borders form the friction manifold.



Cognition

Thoughts are trajectories on a constraint manifold of attention and memory.

# The Evolution of Scientific Inference

	Gravity Models	Inverse OT	RSVP Framework
Paradigm	Grammar	Static Substrate	Dynamic Substrate
Prior Structure	Assumed Functional Form	OT Optimization	Field Equations (PDEs)
Cost State	Parameterized Covariates	Inferred Isolated Matrices	Continuous Evolving Field
Treatment of Unobservables	Dumped into Error Term	Captured in Matrix State	Mapped as Topographic Deformation



## Constraint Before Content

The ultimate epistemic shift. What we observe is merely a sample from what is permitted by the hidden manifold. We must move from an ontology of distinct objects—countries, brains, planets—to an ontology of continuous fields and constraints. The admissibility structure is primary.