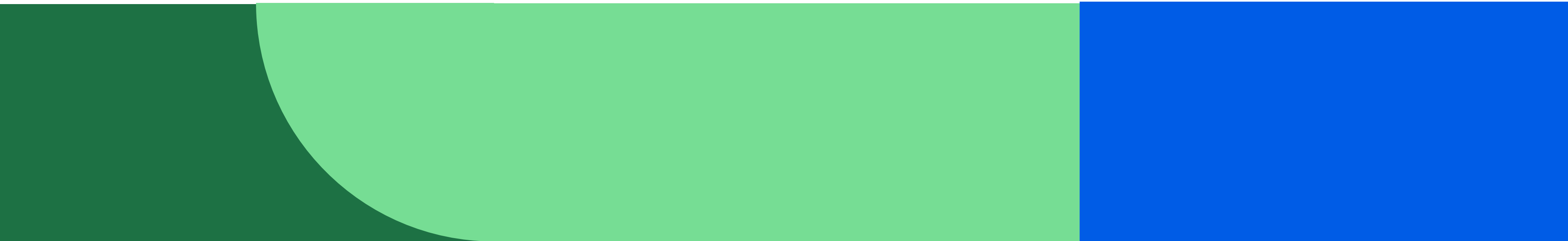


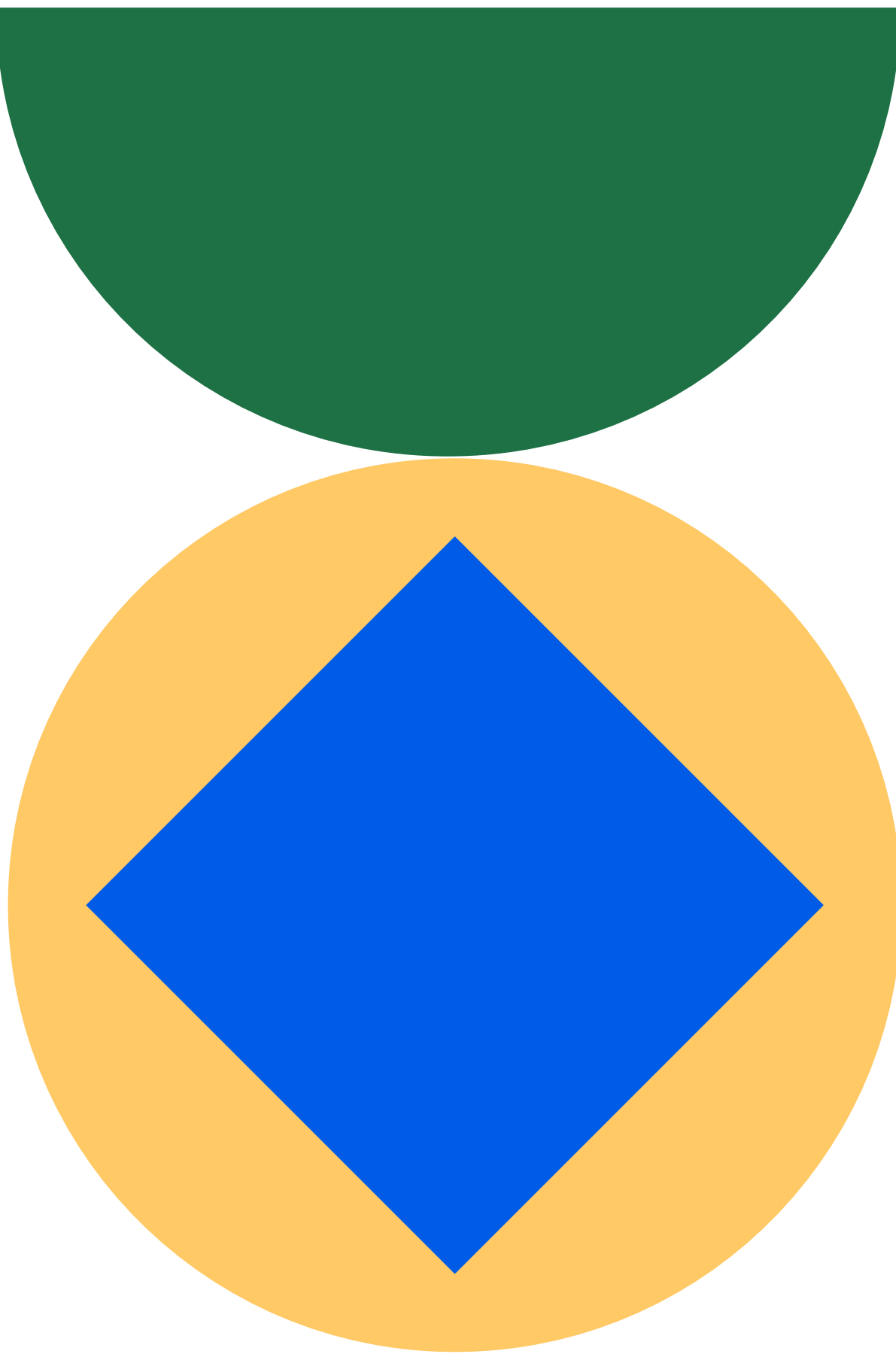
AI- DRIVEN NETWORK ORCHESTRATION UNDER PARTIAL SOVEREIGNTY: ARCHITECTURAL CHALLENGES AND OPERATIONAL IMPLICATIONS IN CRITICAL NETWORKS

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Sara Çela
String Consulting



Motivation and Research Problem

Critical infrastructures increasingly depend on:

- Federated and hybrid architectures
- AI-enabled orchestration systems
- External models and cloud environments
- Cross-domain data pipelines

Operators increasingly rely on AI systems they do not fully control.

RESEARCH OBJECTIVES

This research examines how delegated AI decision - making under conditions of partial sovereignty within critical infrastructure networks influences operational control through:

- Response latency
- Accountability structures
- Error propagation.

RESEARCH QUESTIONS

- Q1: How does partial sovereignty reshape AI - driven orchestration?
- Q2: How does delegated AI decision making affect response latency?
- Q3: How is accountability distributed across layers?
- Q4: How do errors propagate across interconnected infrastructures?

Architectural Evolution

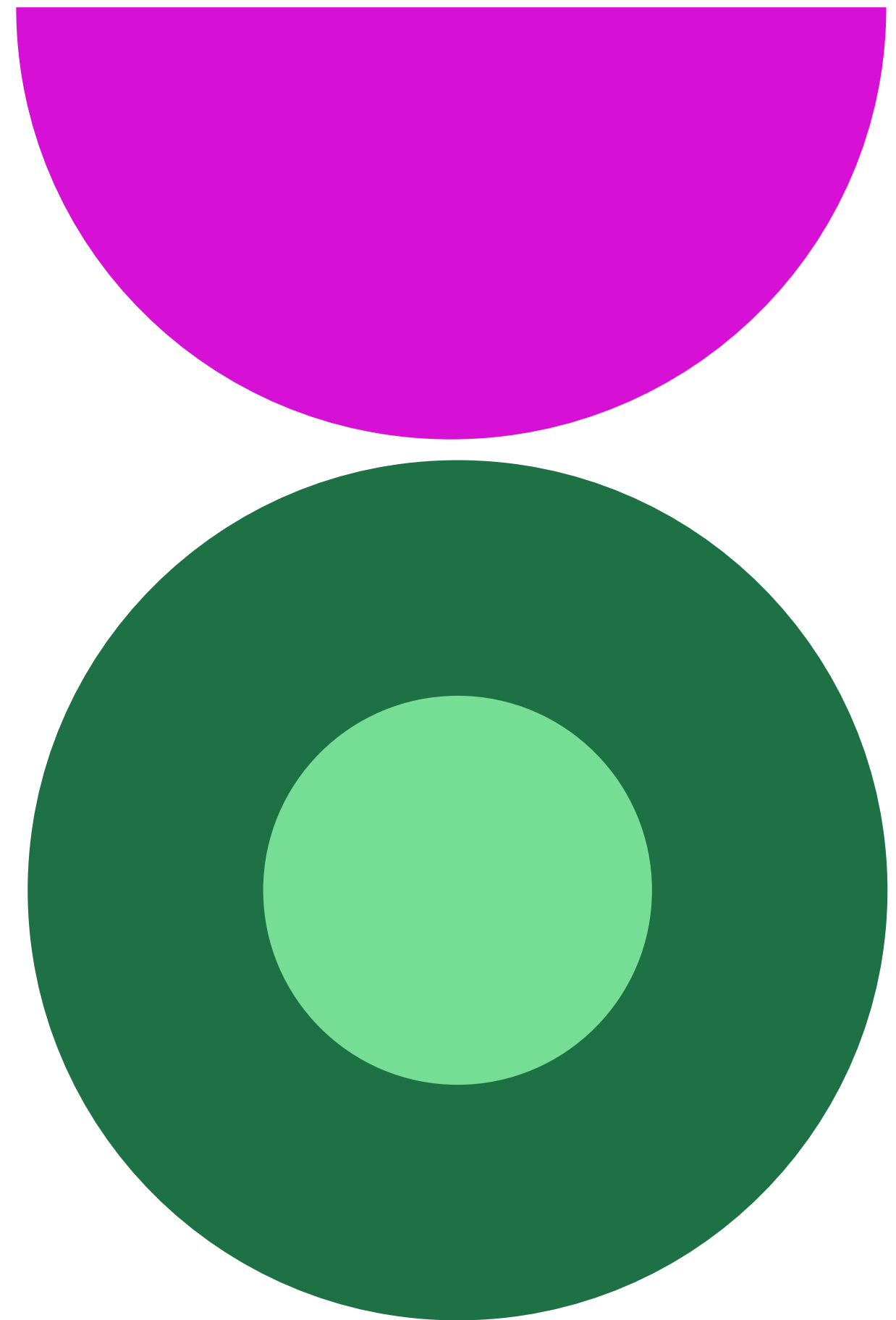
From Coordination Mechanisms

- Resource management
- Workflow coordination

To Decision - Making Substrates

- Prediction
- Prioritization
- Automated Response

AI- driven orchestration increasingly functions as an embedded decision layer.



Q1 How Does Partial Sovereignty Reshape Orchestration?

In federated and hybrid environments:

- AI models may be externally developed
- Data pipelines may cross jurisdictions
- Deployment environments may be vendor-managed

Control becomes fragmented across layers. Partial sovereignty transforms orchestration from a coordination function into a delegated decision layer.



Model Layer

- Prediction and optimization

Data Pipeline Layer

- Monitoring and updates

Orchestration Logic Layer

- Decision rules and priorities

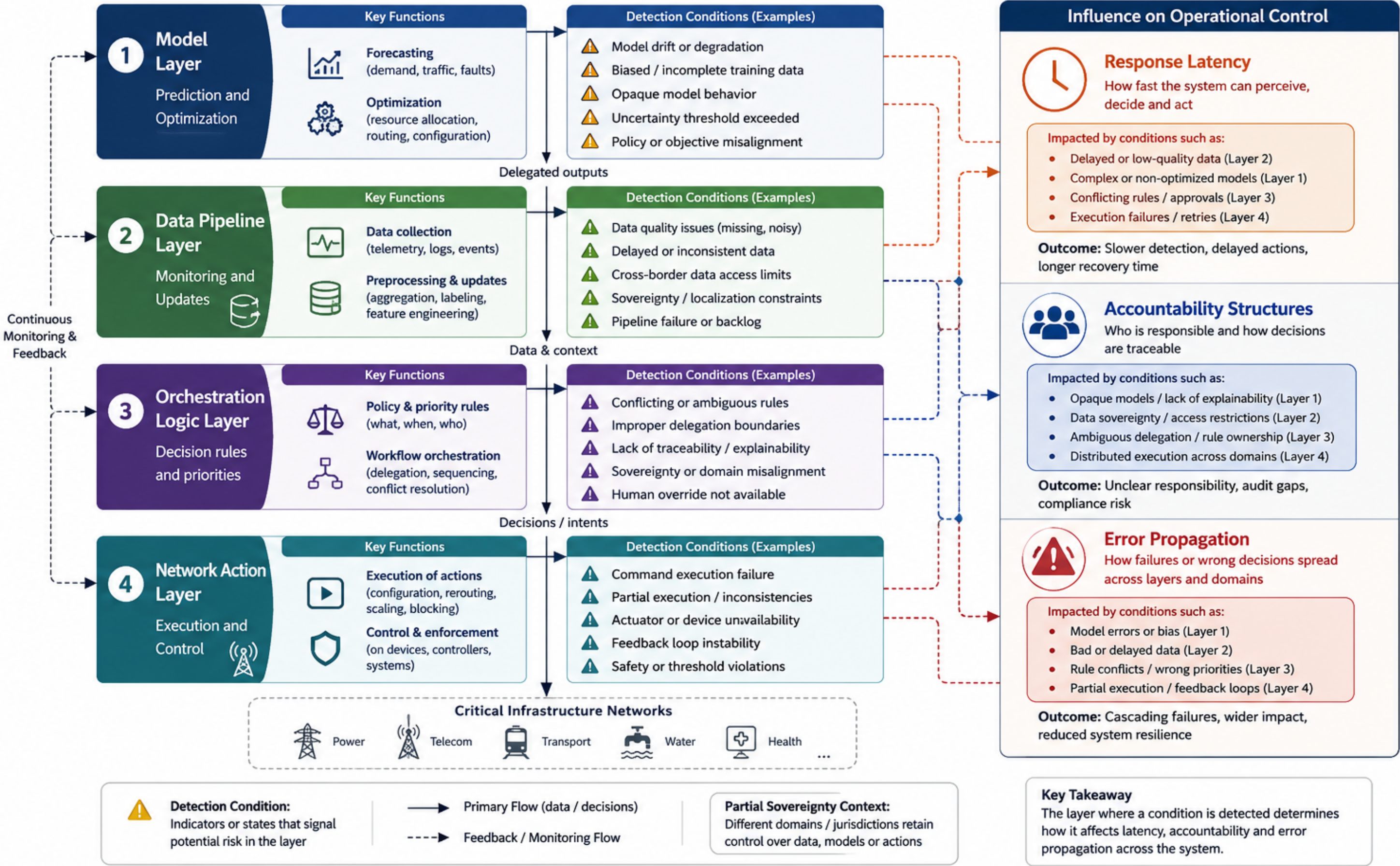
Network Action Layer

- Execution and control

Four-Layer View of Delegated AI Decision - Making

Delegated AI Decision-Making Under Partial Sovereignty

Influence on Operational Control in Critical Infrastructure Networks



Q2 How Does Delegated AI Affect Response Latency?

Latency depends not only on computational efficiency but also on:

- External inference services
- Synchronization delays
- Connectivity degradation
- Cross - domain communications

Response latency becomes an emergent property of architectural dependencies.

Example: Energy distribution networks.



Q3 How Is Accountability Redistributed?



Decision generation may involve:

- Model developers
- Data providers
- Integrators
- Platform operators
- Infrastructure managers



Operational consequences occur locally, while decision logic is distributed.



Accountability becomes fragmented across AI enabled public - space monitoring systems technical and operational layers.

Q4 What Error - Propagation Patterns Emerge?

Limited observability may delay :

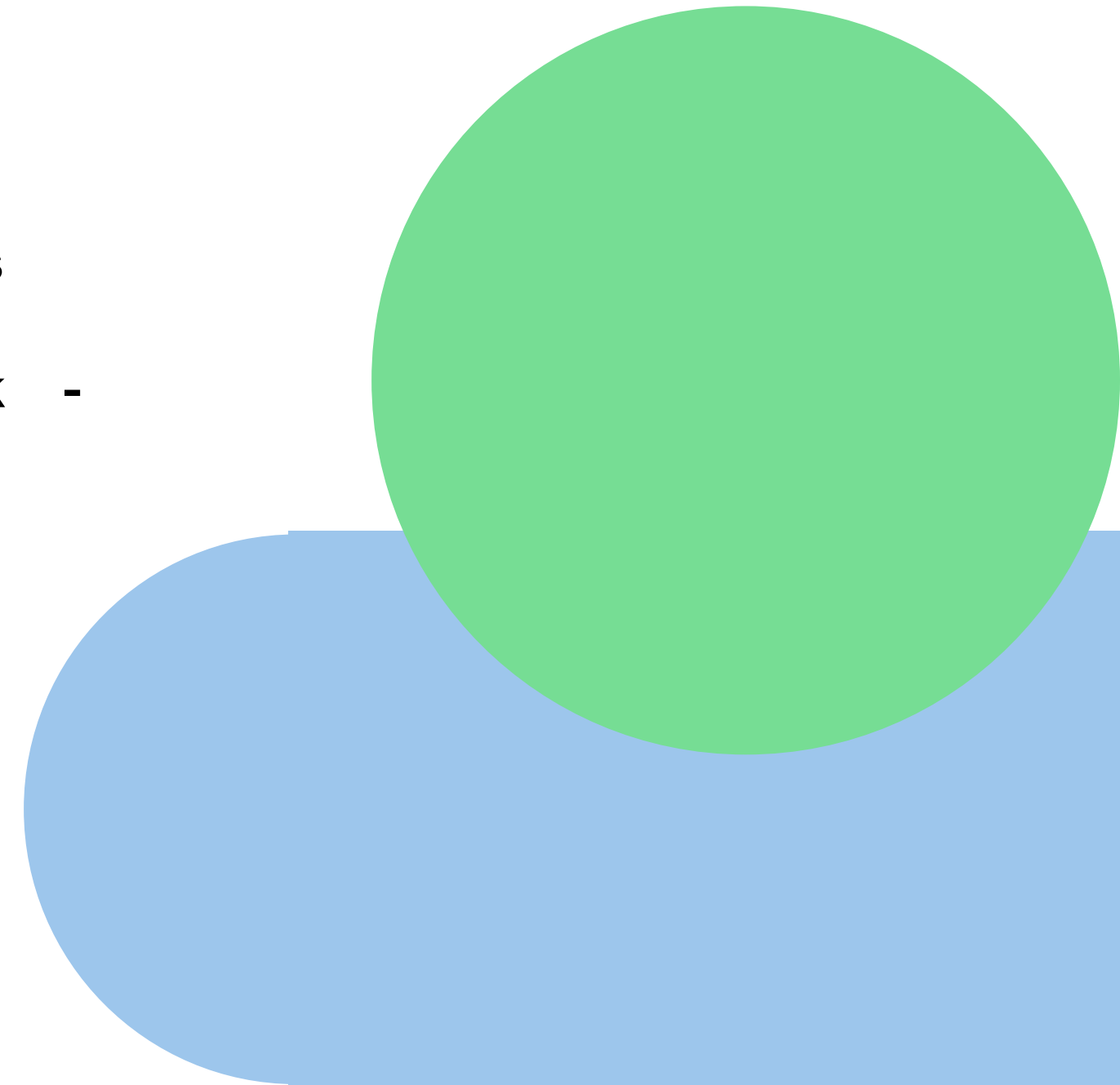
- Error detection
- Containment
- Recovery

Small deviations can cascade across interconnected systems

Model Layer ; Orchestration Layer ; Network Actions ; Network - wide effects

Errors become architectural phenomena rather than isolated failures.

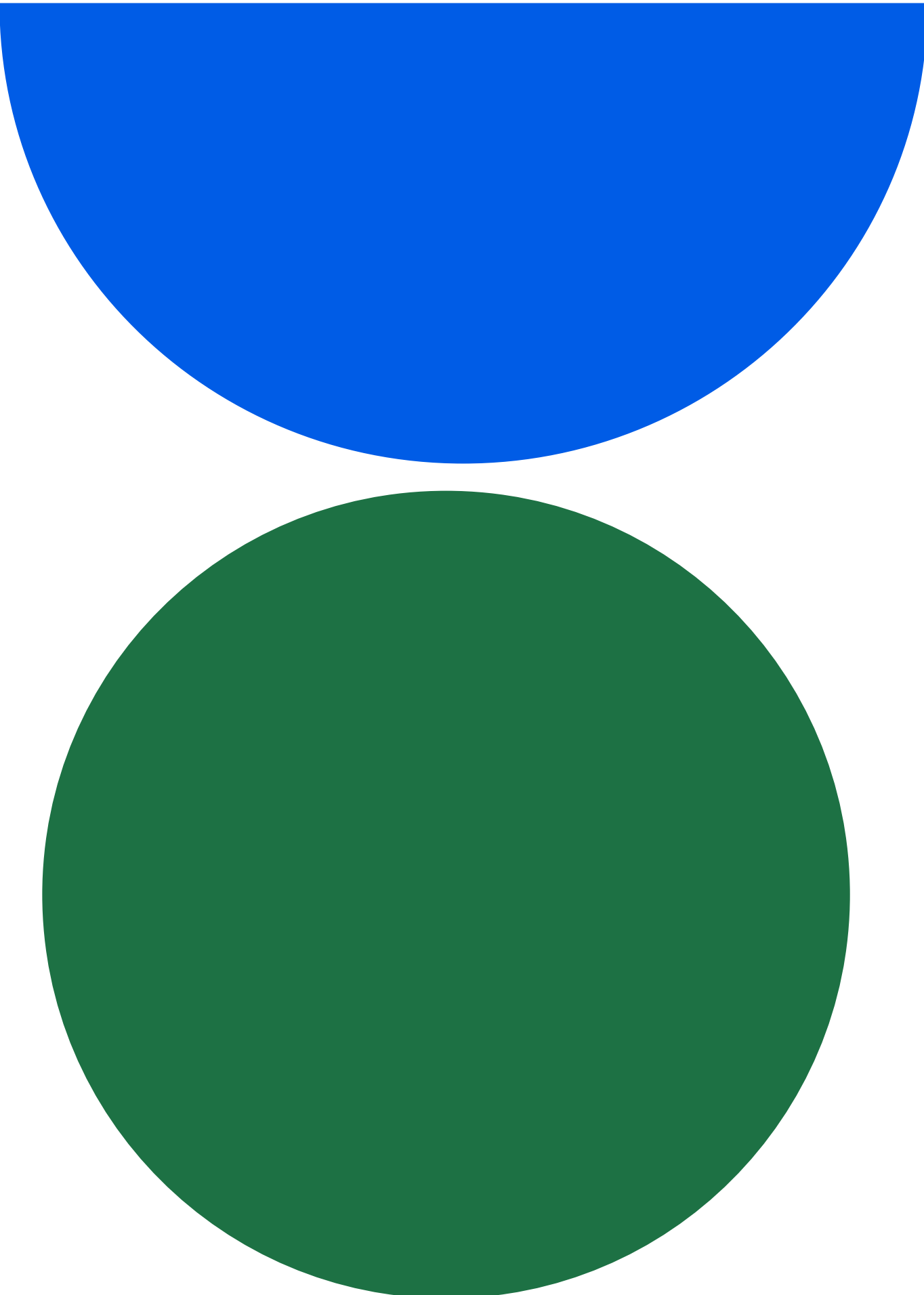
Example : Telecommunications backbone networks.



Main Findings

Response latency,
accountability distribution,
and cascading failures
do not emerge from isolated technical
components.

They are consequences of
Architectural Dependency Structures
under conditions of
Partial Sovereignty



Architectural Design Implications

Future AI - enabled infrastructures should incorporate:

Observability : Visibility into orchestration behavior

Traceability : Reconstruction of decisions

Layer Separation : Recommendation VS Execution

Bounded Autonomy : Constraining cascading failures

These become architectural requirements rather than optional features.

Implications for Standards

Future autonomous network architectures should support:

- Orchestration-layer observability
- Decision traceability
- Bounded autonomy
- Controllability

Relevant ecosystems:

- ITU-T
- ETSI
- ISO/IEC 42001
- NIST AI RMF
- GAIA-X
- EuroHPC



Conclusion

CLOSING STATEMENT

AI-driven orchestration increasingly acts as
Delegated Decision - Making Infrastructure
rather than merely a coordination function.

Future critical infrastructures should be designed
for partial sovereignty,
not despite it.

