

# Persistent Infrastructure Identity (PIID)

## Establishing the Identity Layer for the Built World

A Framework for Persistent Infrastructure Identity and Lifecycle Continuity in Physical Infrastructure Systems

Introducing the Persistent Identity Layer for Physical Infrastructure Assets

### Framework Introduction

This paper introduces the Persistent Infrastructure Identity (PIID) framework, establishing a persistent digital identity layer for physical infrastructure assets across their lifecycle.

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Infrastructure Framework White Paper

# Visual Summary Page

## Persistent Infrastructure Identity (PIID) The Identity Layer for the Built World

### The Infrastructure Identity Gap

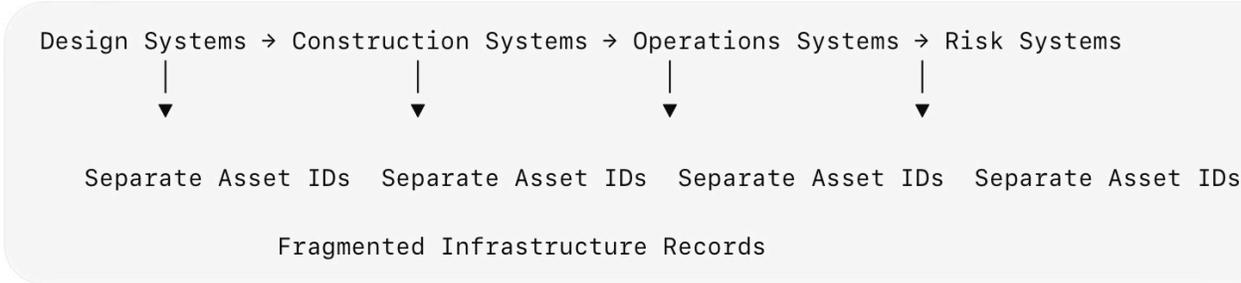
Infrastructure assets move through many systems across decades, yet the asset itself has no persistent digital identity.

### Section 1 — The Problem

Title:

The Infrastructure Identity Gap

Diagram:



**Persistent Infrastructure Identity (PIID)**

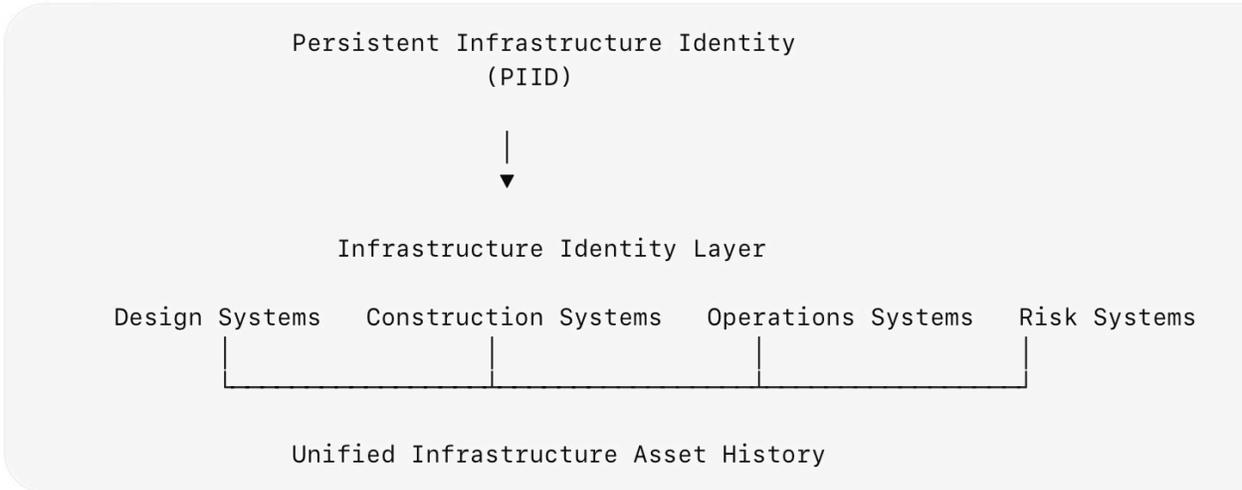
PIID assigns a globally unique persistent identifier to infrastructure assets, linking lifecycle data across systems.

**Section 2 — The Solution**

Title:

**Persistent Infrastructure Identity (PIID)**

Diagram:



## The Infrastructure Identity Stack

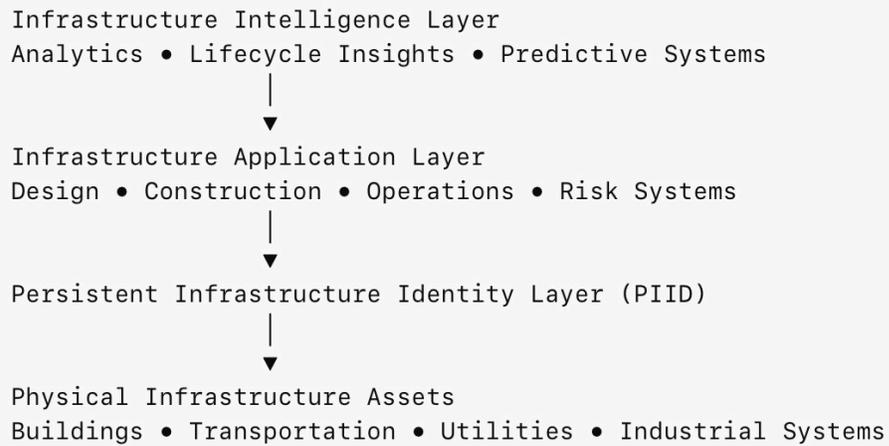
A globally unique, persistent digital identifier assigned to a physical infrastructure asset that enables lifecycle continuity across systems, ownership transitions, and operational history.

## Section 3 – The Outcome

Title:

The Infrastructure Identity Stack

Diagram:



## **PIID Framework Summary**

### **Persistent Infrastructure Identity (PIID)**

#### **The Identity Layer for the Built World**

Persistent Infrastructure Identity (PIID) introduces a foundational framework for assigning a globally unique and persistent digital identifier to physical infrastructure assets.

Infrastructure assets such as buildings, transportation systems, utilities, and industrial facilities operate for decades and generate information across numerous digital systems throughout their lifecycle. Design systems, construction management platforms, operational systems, and risk analysis environments all maintain records related to these assets. However, the assets themselves typically lack a persistent identity capable of linking information across these systems.

As a result, infrastructure records frequently become fragmented across lifecycle phases and organizational boundaries. Data is recreated, historical information becomes difficult to trace, and institutional knowledge may be lost over time.

Persistent Infrastructure Identity addresses this structural limitation by introducing a persistent identity layer for infrastructure assets. A PIID is assigned to an asset once and remains associated with that asset throughout its lifecycle, enabling lifecycle continuity across systems, ownership transitions, and operational history.

By providing a stable identity framework for infrastructure assets, PIID enables infrastructure data generated across independent systems to remain connected to the same physical asset. This persistent identity layer establishes the foundation for improved lifecycle transparency, infrastructure intelligence, and long-term stewardship of the built environment.

Persistent Infrastructure Identity represents a foundational step toward establishing a continuous digital record for infrastructure assets across their full lifecycle.

#### **Core Principles of the PIID Framework**

##### **Persistent Identity**

Each infrastructure asset receives a globally unique identifier that remains associated with the asset throughout its lifecycle.

##### **Lifecycle Continuity**

Infrastructure records remain linked across design, construction, operations, and ownership transitions.

### **System Interoperability**

Independent infrastructure systems can reference a common identity layer without requiring direct integration.

### **Historical Traceability**

Lifecycle events and infrastructure records remain connected to the same asset across decades of operation.

### **Definition**

#### **Persistent Infrastructure Identity (PIID)**

A globally unique, persistent digital identifier assigned to a physical infrastructure asset that enables lifecycle continuity across systems, ownership transitions, and operational history.

### **Framework Introduced**

This summary accompanies the **Persistent Infrastructure Identity White Paper**, which presents the architectural framework, lifecycle model, and governance considerations required to implement persistent infrastructure identity across the built environment.

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## Abstract

Modern infrastructure systems are increasingly digital. Design, construction, operations, insurance, and asset management processes now rely on complex software ecosystems to plan, build, and maintain physical infrastructure assets.

Despite these advancements, a fundamental structural limitation persists across the built environment: physical infrastructure assets themselves lack a persistent digital identity capable of surviving across systems, organizations, and decades of operational life.

Infrastructure assets frequently operate for fifty to one hundred years or longer. Over this time span, assets transition through numerous systems, owners, regulatory environments, and technology platforms. During these transitions, digital records are repeatedly fragmented, recreated, or lost due to the absence of a consistent identity framework linking infrastructure data across the lifecycle of the asset.

This paper introduces the concept of **Persistent Infrastructure Identity (PIID)**—a globally unique, persistent identifier assigned to physical infrastructure assets that enables lifecycle continuity across systems, ownership transitions, and operational history.

Persistent Infrastructure Identity establishes a foundational identity layer for the built environment. By enabling infrastructure assets to maintain continuous digital records across decades of development and operation, the PIID framework provides the structural basis for improved infrastructure transparency, lifecycle intelligence, and long-term asset stewardship.

## 1. Introduction

Infrastructure is among the most complex and long-lived asset classes in the global economy. Buildings, transportation systems, utilities, industrial facilities, and other physical infrastructure assets support the daily functioning of societies and economies worldwide.

The lifecycle of infrastructure typically spans multiple decades and involves a diverse set of stakeholders including planners, engineers, contractors, operators, insurers, investors, regulators, and public agencies. Each participant interacts with infrastructure assets through specialized digital systems designed to support particular lifecycle phases.

Design systems manage engineering models and specifications.

Construction management systems coordinate project execution.

Operational systems monitor facility performance and maintenance activities.

Risk management and insurance systems evaluate exposure and historical performance.

Asset management systems track ownership and financial reporting.

While these systems generate valuable data throughout the lifecycle of infrastructure assets, they operate largely as independent environments with their own internal identification structures. As infrastructure assets move through lifecycle phases, new identifiers are frequently created by each system or organization interacting with the asset.

The result is a fragmented digital record in which the physical asset itself lacks a stable, persistent identity capable of linking information across systems and over time.

This absence of persistent identity introduces structural limitations for infrastructure lifecycle management. Historical records may become disconnected during ownership transitions, operational data may not be traceable to original design conditions, and institutional knowledge is often lost as projects evolve across decades.

Despite significant progress in digital engineering and smart infrastructure technologies, the foundational issue of persistent infrastructure identity remains unresolved.

This paper introduces the concept of Persistent Infrastructure Identity (PIID) as a foundational identity framework for physical infrastructure assets, establishing a persistent digital identity layer capable of maintaining lifecycle continuity across systems, organizations, and decades of infrastructure operation.

## 2. The Infrastructure Identity Gap

Infrastructure systems have undergone rapid digitization over the past two decades. Advances in digital design tools, project management platforms, sensor networks, and operational analytics have dramatically increased the volume of information available about infrastructure assets.

However, these digital systems are typically designed to support specific lifecycle phases rather than the full lifespan of the infrastructure asset.

As a result, infrastructure data is frequently fragmented across multiple software environments and organizational boundaries.

During the lifecycle of a typical infrastructure asset:

- Design teams generate digital models and specifications.
- Construction teams manage schedules, documentation, and project records.
- Operations teams track maintenance activities and performance data.
- Insurers and risk analysts evaluate asset exposure and incident history.
- Asset owners and investors maintain financial and regulatory records.

Each of these environments creates identifiers that reference the asset within the context of the particular system in which it operates.

Yet these identifiers rarely persist beyond the boundaries of that system.

When infrastructure assets transition between lifecycle phases or ownership structures, identifiers are often replaced or abandoned. Documentation becomes distributed across disconnected systems, and the continuity of the asset's digital history is weakened or lost.

This structural condition can be described as **the Infrastructure Identity Gap**.

The Infrastructure Identity Gap refers to the absence of a persistent digital identity layer capable of linking infrastructure data across the full lifecycle of physical assets.

The consequences of this gap include:

- fragmented lifecycle records
- repeated recreation of infrastructure data
- reduced traceability of operational history
- increased uncertainty in infrastructure risk evaluation
- diminished visibility into long-term asset performance

Given the scale and longevity of global infrastructure systems, the absence of a persistent identity framework represents a foundational limitation within the digital infrastructure ecosystem.

### **3. Identity Systems in Complex Industries**

Several industries have addressed similar challenges through the development of standardized identity frameworks designed to maintain continuity across complex systems and long operational lifecycles.

Persistent identity systems provide a stable reference point that allows data generated across multiple environments to remain linked to the same underlying asset or entity.

Examples of such identity frameworks exist across numerous sectors of the global economy. Persistent identifiers are commonly used to track financial instruments across capital markets, physical goods across manufacturing and logistics networks, and digital resources across global information systems.

These frameworks function as foundational infrastructure layers within their respective domains. By assigning globally unique identifiers that remain stable over time, identity systems allow information generated across different systems to remain connected to the same underlying entity.

The presence of such identity layers has enabled significant advances in interoperability, lifecycle traceability, and data integrity across complex systems.

Despite the widespread adoption of identity frameworks in many industries, no comparable system has yet been established for physical infrastructure assets themselves.

Infrastructure assets remain among the few large-scale economic systems without a persistent identity layer capable of preserving continuity across decades of operation and numerous system transitions.

Persistent Infrastructure Identity is proposed as a framework designed to address this structural absence.

#### **4. Persistent Infrastructure Identity (PIID)**

Persistent Infrastructure Identity (PIID) is defined as:

**A globally unique, persistent identifier assigned to a physical infrastructure asset that enables lifecycle continuity across systems, ownership transitions, and operational history.**

A PIID is assigned once to an infrastructure asset and remains associated with that asset for the duration of its lifecycle.

The identifier functions independently of any specific software platform, organization, or stakeholder group. This independence ensures that the identity of the asset remains stable even as technologies, ownership structures, and operational systems evolve.

By providing a stable reference point for infrastructure assets, PIID enables data generated across multiple systems to remain linked to the same physical asset throughout its lifecycle.

This identity layer allows infrastructure information to be preserved and connected across decades of development, operation, renovation, and ownership transfer.

Persistent Infrastructure Identity therefore establishes the structural foundation necessary to support long-term digital continuity within the built environment.

## **5. Infrastructure Identity Architecture**

The implementation of Persistent Infrastructure Identity requires a supporting architecture capable of issuing identifiers, maintaining lifecycle continuity, and enabling interoperability across infrastructure systems.

The PIID architecture is designed to function as a foundational identity layer for physical infrastructure assets. Rather than replacing existing software environments, the architecture establishes a stable identity reference capable of linking data across systems and lifecycle stages.

At a structural level, the architecture includes three core components:

- **Identity Issuance**
- **Lifecycle State Management**
- **Historical Record Continuity**

Together, these components form a persistent identity infrastructure capable of supporting long-term digital continuity for infrastructure assets.

### **Identity Issuance**

Persistent Infrastructure Identities are issued through an identity registry responsible for generating globally unique identifiers for physical infrastructure assets.

The issuance process ensures that each identifier is associated with a single infrastructure asset and remains unique across the global infrastructure ecosystem.

The issuance of a PIID typically occurs during early lifecycle stages such as planning, permitting, or initial project registration. However, existing infrastructure assets may also be assigned identifiers through retrospective indexing processes.

Once issued, the identifier remains permanently associated with the asset throughout its lifecycle.

### **Lifecycle State Management**

Infrastructure assets transition through multiple operational states across their lifespan. These states may include phases such as design, construction, commissioning, operation, renovation, ownership transfer, and eventual decommissioning.

The PIID framework incorporates lifecycle state management to record these transitions as part of the asset's digital history.

Lifecycle state management enables infrastructure assets to maintain a structured historical record describing how the asset has evolved over time.

By linking lifecycle state transitions to a persistent identity, infrastructure history becomes traceable and auditable across decades of operation.

## **Historical Record Continuity**

Infrastructure assets generate large volumes of information throughout their lifecycle. Maintaining the continuity of this information is essential for effective asset management, risk evaluation, and long-term operational planning.

The PIID framework supports historical record continuity through an append-only model in which lifecycle events and associated data references are recorded sequentially over time.

This model preserves historical records while allowing new lifecycle information to be appended as the asset evolves.

By maintaining historical continuity, the identity layer enables infrastructure systems to retain institutional knowledge across ownership transitions and technology changes.

## **6. Infrastructure Identity Registry**

At the center of the PIID architecture is the Infrastructure Identity Registry.

The registry functions as the authoritative system responsible for issuing and maintaining Persistent Infrastructure Identities.

The registry performs several essential functions:

- generation and assignment of globally unique infrastructure identifiers
- validation of identity integrity
- maintenance of lifecycle state records
- coordination of identity references across infrastructure systems

The registry does not replace existing operational systems used to manage infrastructure assets. Instead, it provides a neutral identity layer that allows those systems to reference a common infrastructure identifier.

By maintaining this identity layer, the registry enables infrastructure information generated across multiple environments to remain connected to the same underlying physical asset.

Over time, the registry may support additional functions related to infrastructure lifecycle governance, regulatory coordination, and cross-system interoperability.

## **7. System Interoperability**

Infrastructure systems are typically deployed to address specific lifecycle functions such as design coordination, construction management, facility operations, and risk analysis.

These systems are often developed independently and operate using proprietary data structures and identification schemes.

The PIID framework does not require these systems to change their internal architectures.

Instead, interoperability is achieved by enabling systems to reference the same persistent infrastructure identifier.

When multiple systems reference a common identity layer, information generated in one environment can be linked to data generated in another environment without requiring direct integration between the systems themselves.

This identity-based interoperability allows infrastructure information to remain connected across systems while preserving the independence of each software environment.

Over time, the presence of a shared identity layer may facilitate the development of new interoperability standards across infrastructure technologies.

## **8. Economic Implications**

Infrastructure represents one of the largest and most capital-intensive sectors of the global economy.

Infrastructure assets operate across extended time horizons and generate large volumes of operational, financial, and regulatory data throughout their lifecycle.

However, the absence of persistent identity frameworks limits the ability of organizations to maintain complete lifecycle records for infrastructure assets.

Fragmented identity structures lead to repeated recreation of infrastructure data, incomplete historical records, and inefficiencies in risk assessment and asset management.

Persistent Infrastructure Identity introduces the possibility of a continuous infrastructure data framework in which asset history remains connected across decades of operation.

The availability of persistent identity infrastructure may enable improvements in several areas:

- lifecycle asset transparency
- infrastructure risk modeling
- operational performance analytics
- infrastructure investment evaluation
- long-term infrastructure stewardship

By enabling continuous asset histories, identity frameworks may also support the development of new infrastructure intelligence systems capable of analyzing performance patterns across large infrastructure networks.

## **9. Adoption Pathways**

The introduction of persistent identity systems for infrastructure assets may occur through incremental adoption across multiple segments of the infrastructure ecosystem.

Initial adoption may occur in new infrastructure projects where identifiers can be assigned during early lifecycle stages such as planning or permitting.

Over time, existing infrastructure assets may be incorporated into the identity framework through retrospective indexing and registry integration.

As persistent identifiers become more widely referenced across infrastructure systems, organizations may begin to adopt identity frameworks as a standard method for maintaining asset continuity.

Long-term adoption may include integration with regulatory reporting systems, infrastructure financing frameworks, and operational monitoring platforms.

The gradual expansion of identity frameworks across infrastructure systems may ultimately establish persistent identity as a foundational component of the digital infrastructure ecosystem.

## **10. Governance and Standards**

The development of infrastructure identity frameworks raises important questions related to governance, standardization, and interoperability.

Identity systems that support large-scale infrastructure networks require consistent implementation across multiple jurisdictions, organizations, and technology environments.

In many industries, identity systems are supported by governance structures that define standards for identifier issuance, data integrity, and lifecycle management.

Similar governance models may emerge for persistent infrastructure identity as adoption expands.

Standardization bodies, industry organizations, and public institutions may play a role in establishing guidelines that ensure consistent implementation across infrastructure ecosystems.

Establishing governance frameworks may also help ensure that infrastructure identity systems remain neutral, interoperable, and resilient across evolving technology landscapes.

## **11. The Future of Infrastructure Identity**

Infrastructure systems are expected to become increasingly digital over the coming decades. Advances in sensor networks, operational analytics, and digital infrastructure modeling will continue to expand the availability of infrastructure data.

The long-term value of these technologies depends on the ability to maintain continuous records linking infrastructure information to the physical assets that generate it.

Persistent identity frameworks provide the structural basis necessary to support this continuity.

By assigning infrastructure assets a stable digital identity, PIID enables infrastructure information to remain connected across decades of development, operation, and ownership transition.

This identity layer may ultimately support new forms of infrastructure intelligence, enabling organizations to analyze asset performance across entire infrastructure networks and across long time horizons.

Persistent Infrastructure Identity therefore represents a foundational step toward establishing a long-term digital memory for the built environment.

## **12. Conclusion**

Infrastructure assets form the physical foundation of modern societies. Despite the increasing digitization of infrastructure systems, physical assets themselves remain largely disconnected from persistent digital identity frameworks.

The absence of a stable identity layer contributes to fragmented records, reduced lifecycle visibility, and inefficiencies in infrastructure management.

Persistent Infrastructure Identity introduces a framework designed to address this structural limitation.

By establishing a globally unique and persistent identifier for physical infrastructure assets, the PIID framework enables infrastructure data to remain connected across systems, ownership structures, and decades of operation.

The establishment of persistent infrastructure identity represents a foundational step toward improving transparency, continuity, and long-term intelligence within the built environment.

### **13. Origin of the Persistent Infrastructure Identity Framework**

The Persistent Infrastructure Identity (PIID) framework was developed to address the structural absence of a persistent identity system for physical infrastructure assets.

While digital systems used throughout the infrastructure lifecycle have advanced significantly over the past several decades, the infrastructure assets themselves have historically lacked a stable digital identity capable of maintaining continuity across systems, organizations, and extended operational timelines.

The PIID framework introduces the concept of assigning a globally unique, persistent identifier to physical infrastructure assets. This identifier functions as a foundational reference point capable of linking lifecycle information generated across design, construction, operational, and risk management environments.

The framework presented in this document establishes the architectural principles necessary to support persistent identity for infrastructure assets, including identity issuance, lifecycle state continuity, and registry-based identity management.

By introducing a persistent identity layer for infrastructure assets, the PIID framework provides a structural foundation for maintaining long-term digital continuity across the built environment.

## 14. The Infrastructure Identity Stack

Infrastructure systems operate across multiple layers of physical assets, digital platforms, and analytical technologies.

The Infrastructure Identity Stack provides a conceptual model describing how persistent identity functions as a foundational layer within the infrastructure technology ecosystem.

At the base of the stack are physical infrastructure assets such as buildings, transportation systems, utilities, industrial facilities, and other constructed assets. These assets form the physical foundation of the built environment.

Above the physical layer resides the **identity layer**, represented by Persistent Infrastructure Identity. This layer assigns each infrastructure asset a globally unique identifier that remains associated with the asset across its entire lifecycle.

Above the identity layer operate the various digital systems used to design, construct, operate, and analyze infrastructure assets. These systems generate large volumes of information but typically operate using independent internal identifiers.

By referencing a common persistent identity layer, these systems can maintain continuity of infrastructure records without requiring direct integration with one another.

At the top of the stack are analytical and intelligence systems that derive insights from infrastructure data. These may include operational analytics, predictive maintenance systems, risk modeling tools, and lifecycle performance analysis platforms.

Within this layered structure, Persistent Infrastructure Identity functions as the foundational reference layer that enables infrastructure information to remain connected across systems and across time.

## 15. Definition of Persistent Infrastructure Identity (PIID)

Persistent Infrastructure Identity (PIID) is defined as:

**A globally unique, persistent digital identifier assigned to a physical infrastructure asset that enables lifecycle continuity across systems, ownership transitions, and operational history.**

A PIID is assigned to an infrastructure asset once and remains associated with that asset throughout its lifecycle.

The identifier functions independently of specific software platforms or organizational systems, allowing infrastructure data generated across different environments to remain connected to the same physical asset.

By establishing a persistent identity layer for infrastructure assets, PIID enables the preservation of infrastructure history across decades of development, operation, renovation, and ownership transfer.

Persistent Infrastructure Identity therefore provides the structural foundation necessary to support long-term digital continuity within the built environment.

## **16. Figure Index**

The following figures illustrate the conceptual and architectural components of the Persistent Infrastructure Identity (PIID) framework presented in this document.

### **Figure 1 - The Infrastructure Identity Gap**

Illustrates the fragmentation of infrastructure asset identifiers across lifecycle phases including design, construction, operations, and ownership transfer. The figure demonstrates how the absence of a persistent identity layer results in disconnected infrastructure records across systems.

### **Figure 2 - Persistent Infrastructure Identity Layer**

Depicts the PIID identity layer as a shared reference framework linking multiple infrastructure systems. The figure illustrates how independent lifecycle systems can maintain continuity by referencing a common persistent infrastructure identifier.

### **Figure 3 - Infrastructure Lifecycle State Model**

Illustrates the lifecycle state transitions of infrastructure assets including design, construction, commissioning, operational phases, renovation, ownership transfer, and decommissioning. The figure demonstrates how lifecycle events can be recorded sequentially through persistent identity.

### **Figure 4 - Infrastructure Identity Registry Architecture**

Presents the architectural structure of the Infrastructure Identity Registry responsible for issuing persistent identifiers, validating identity records, and maintaining lifecycle history associated with infrastructure assets.

### **Figure 5 - Global Infrastructure Identity Network**

Illustrates the potential global scope of persistent infrastructure identity across multiple infrastructure asset classes including buildings, transportation systems, utilities, and industrial facilities. The figure depicts a shared identity layer connecting infrastructure assets to a common registry.

### **Figure 6 - Economic Impact of the Infrastructure Identity Gap**

Demonstrates how fragmented identity structures across infrastructure lifecycle systems contribute to inefficiencies in data continuity, operational visibility, and risk assessment across the infrastructure ecosystem.

### **Figure 7 - The Infrastructure Identity Stack**

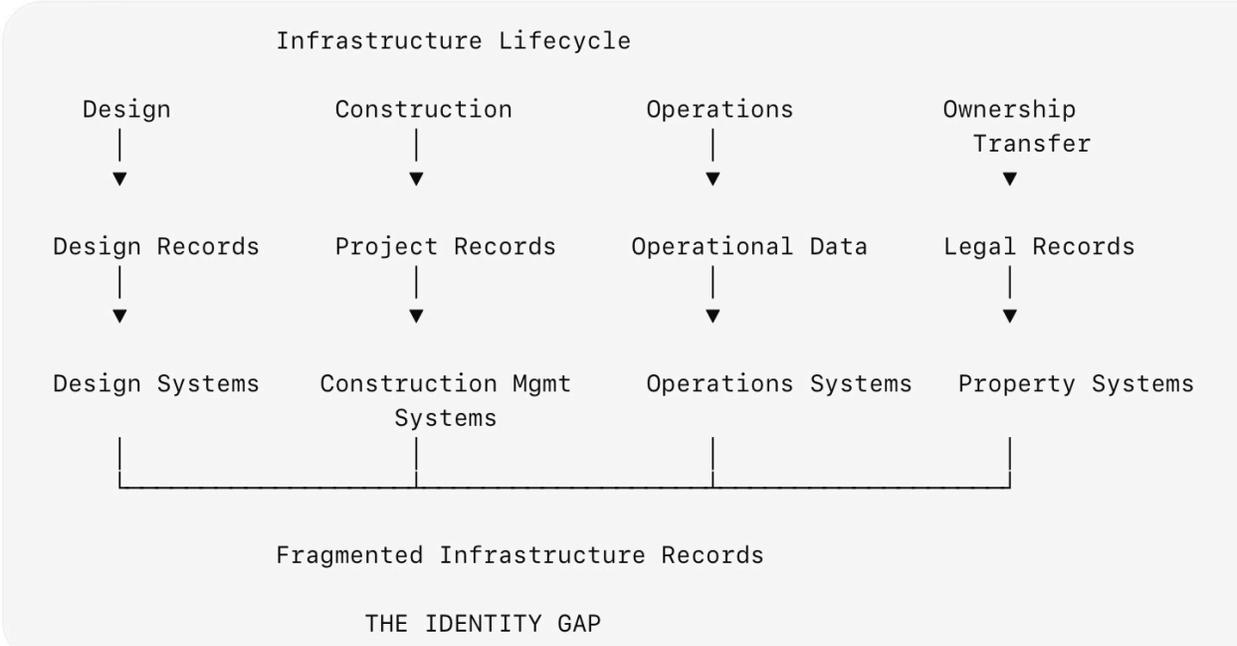
Illustrates the layered architecture of the infrastructure technology ecosystem. The diagram shows how Persistent Infrastructure Identity functions as a foundational identity layer connecting physical infrastructure assets to application systems and infrastructure intelligence platforms.

**The Infrastructure Identity Gap**

Infrastructure assets generate information across multiple lifecycle systems. Each system maintains its own internal identifiers, resulting in fragmented records and limited lifecycle continuity for the physical asset.

**FIGURE 1**  
**The Infrastructure Identity Gap**

**Diagram Structure**

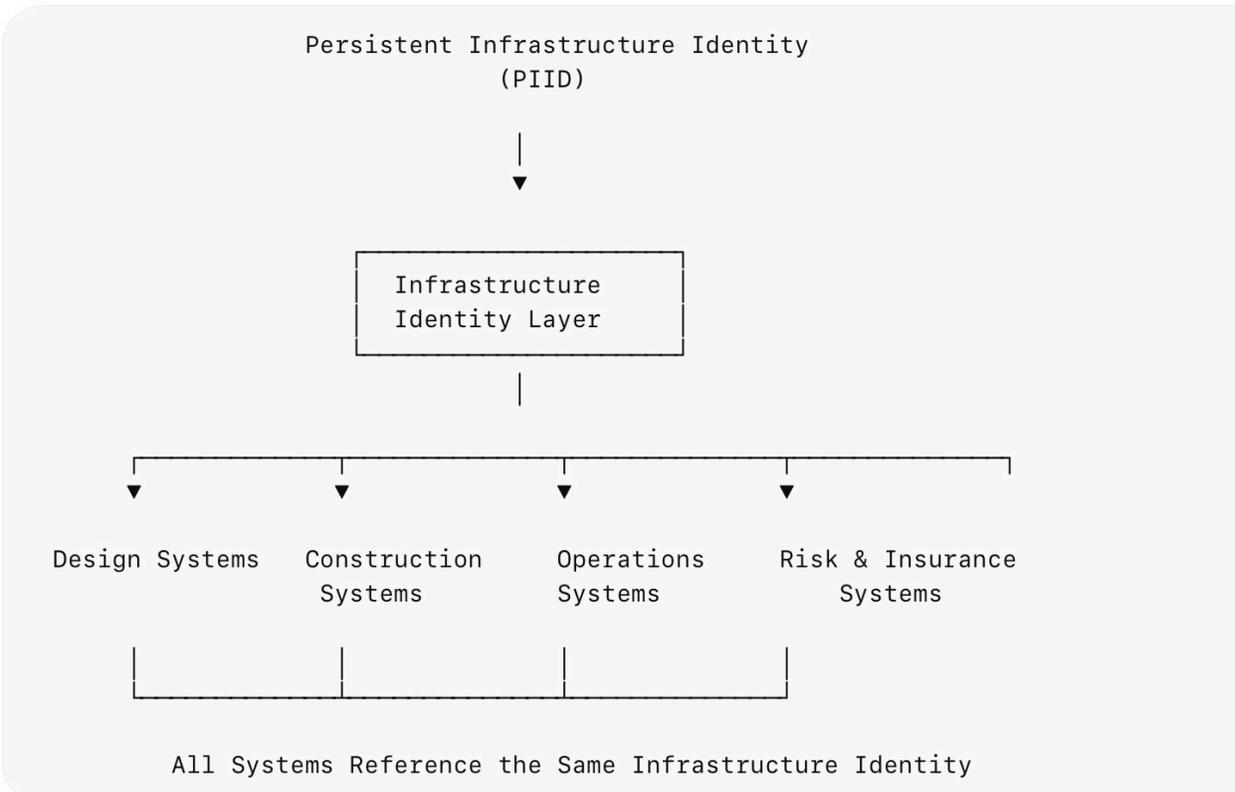


**Persistent Infrastructure Identity Layer**

Persistent Infrastructure Identity establishes a shared identity layer linking infrastructure data across design, construction, operational, and risk management systems.

**FIGURE 2**  
**Persistent Infrastructure Identity Layer**

**Diagram Structure**



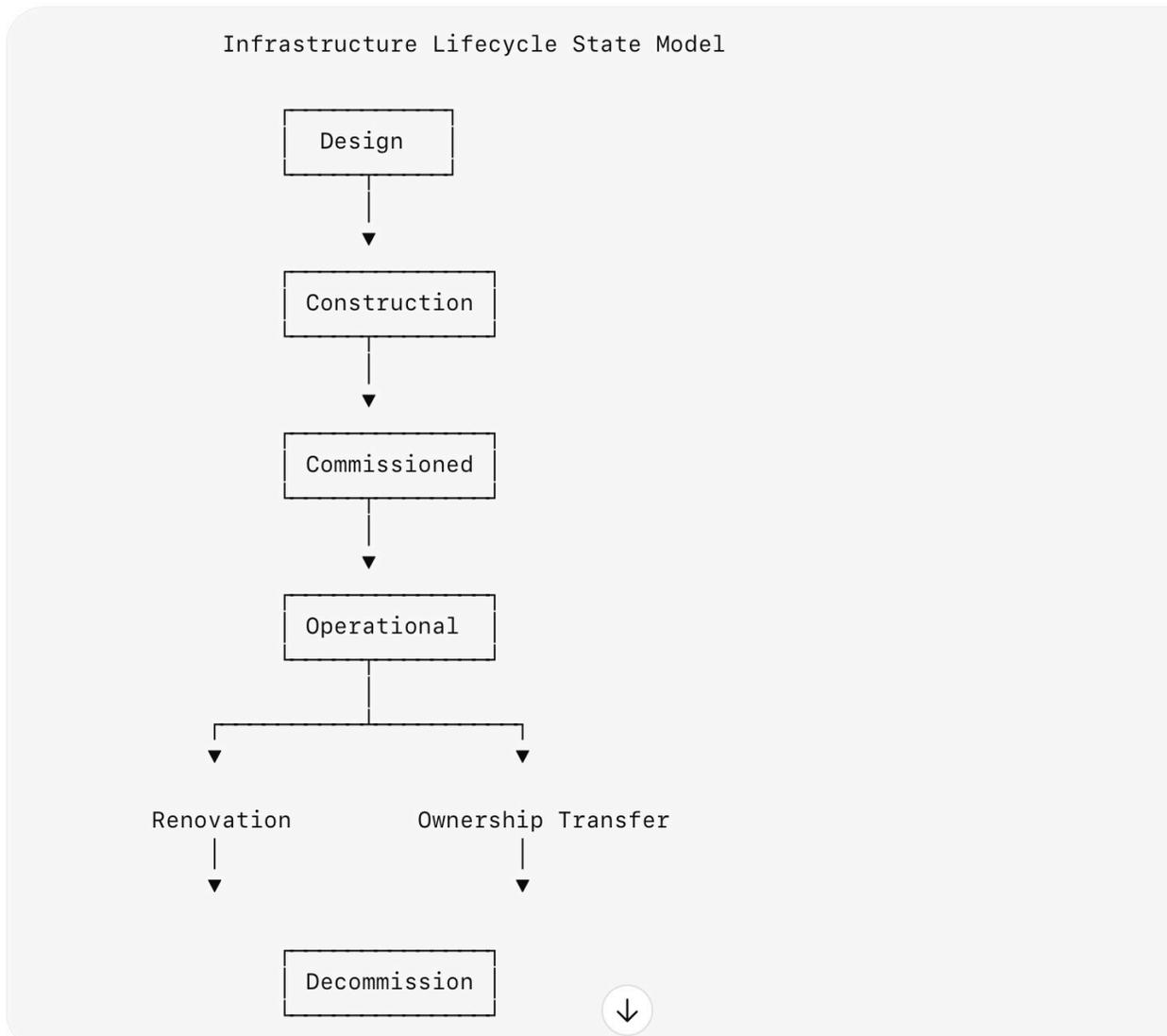
### **Infrastructure Lifecycle State Model**

Infrastructure assets transition through multiple lifecycle states over their operational lifespan. Persistent identity allows lifecycle events to remain linked to the same asset over time.

## FIGURE 3

### Infrastructure Lifecycle State Model

#### Diagram Structure



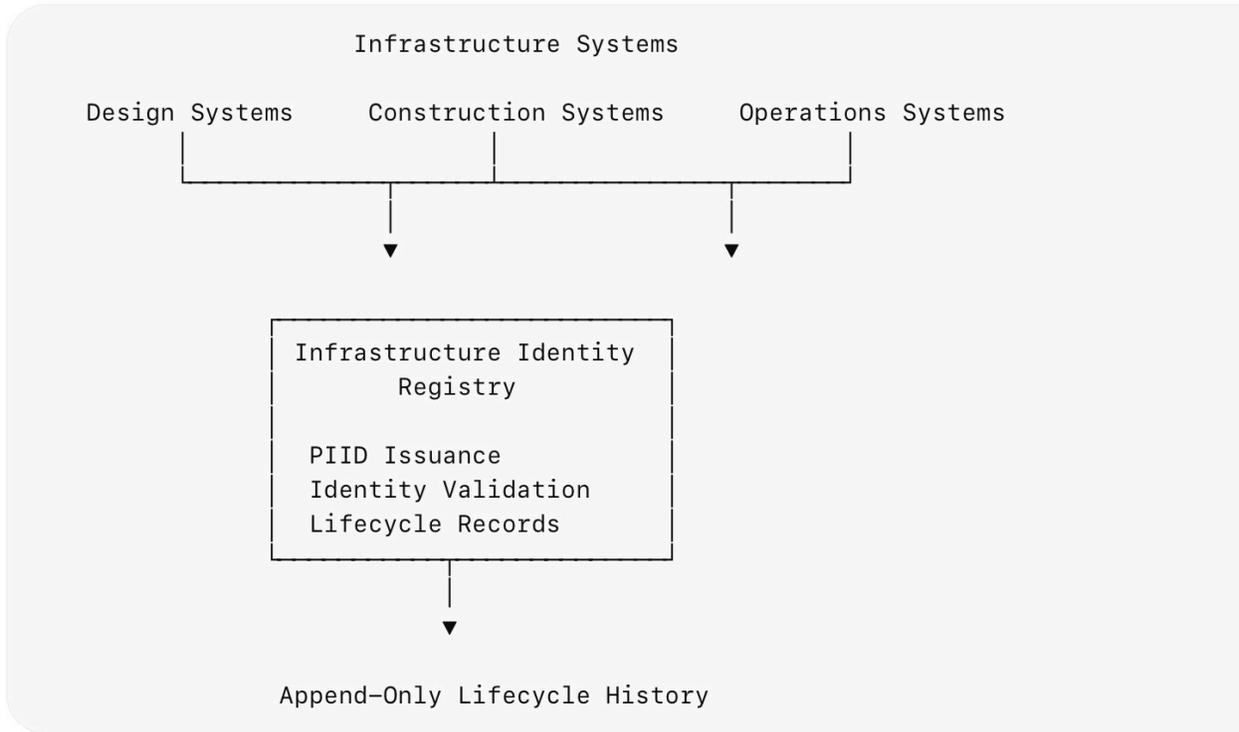
#### Infrastructure Identity Registry Architecture

The Infrastructure Identity Registry issues and maintains persistent infrastructure identifiers and records lifecycle state transitions associated with physical infrastructure assets.

# FIGURE 4

## Infrastructure Identity Registry Architecture

### Diagram Structure

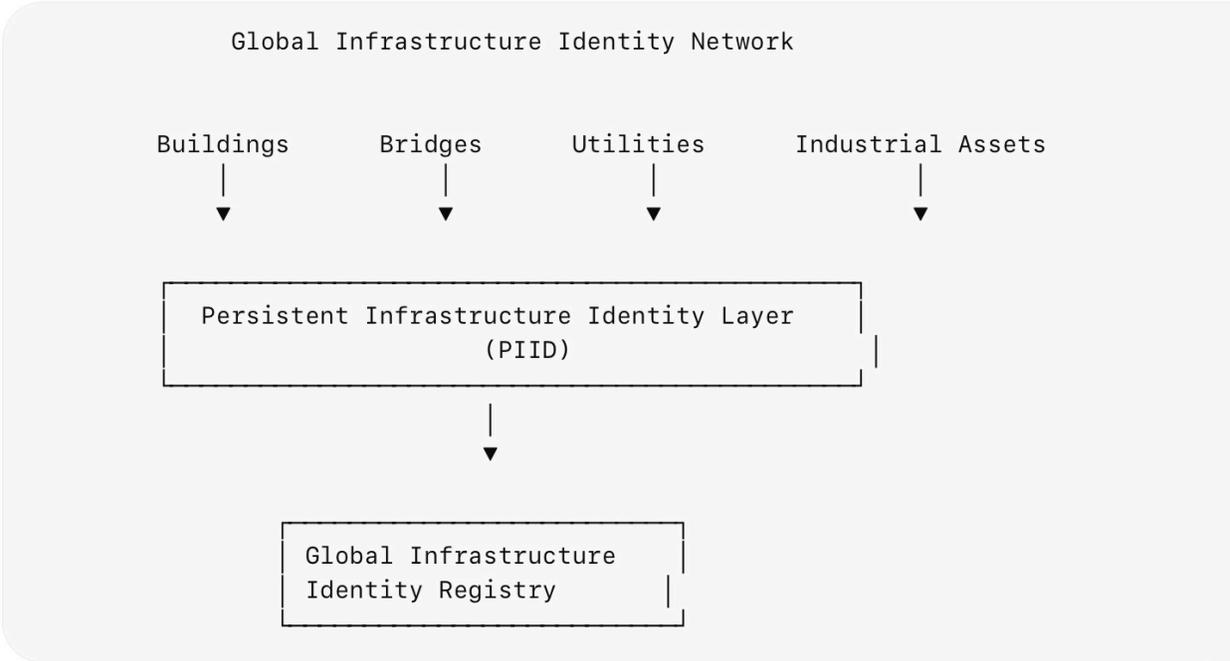


**Global Infrastructure Identity Network**

Persistent infrastructure identity enables a global identity framework capable of linking multiple classes of infrastructure assets through a shared registry.

**FIGURE 5**  
**Global Infrastructure Identity Network**

**Diagram Structure**

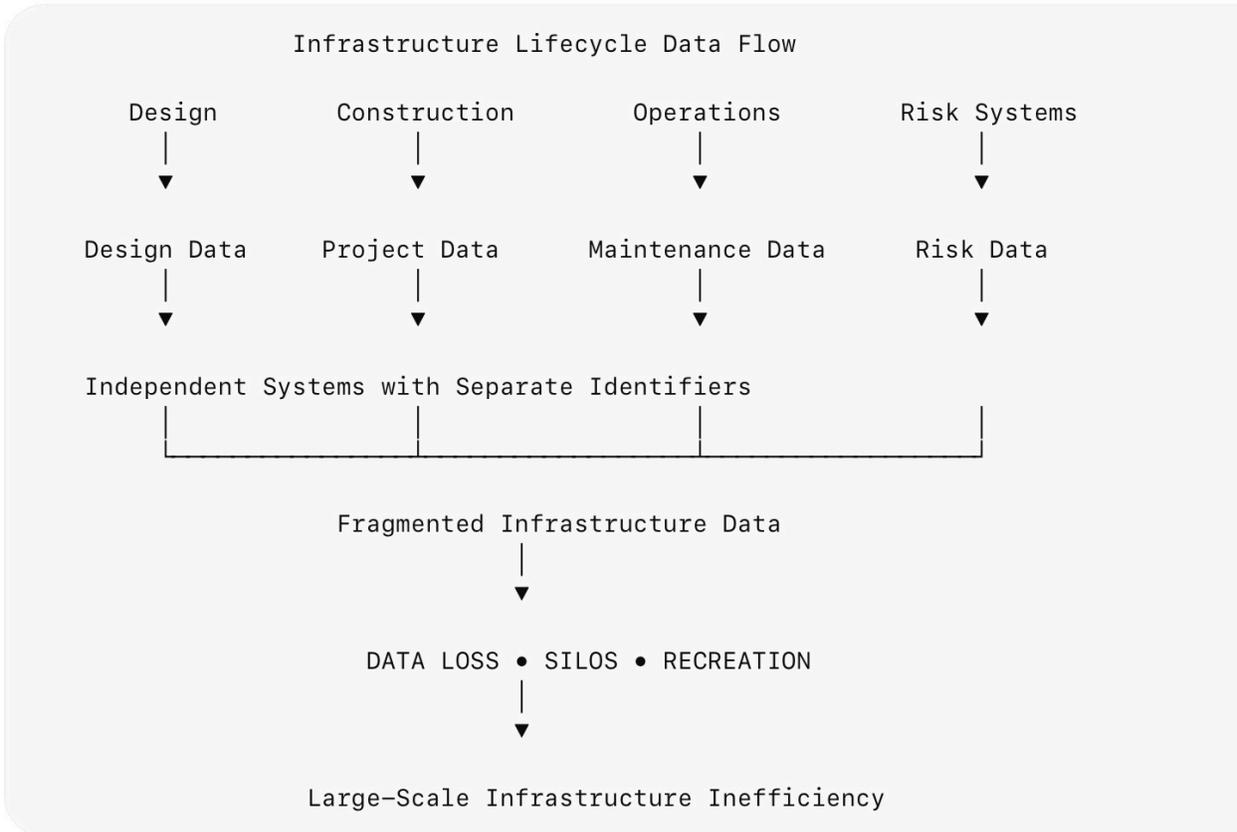


**Economic Impact of the Infrastructure Identity Gap**

Fragmented identifiers across infrastructure lifecycle systems reduce continuity of infrastructure records and contribute to inefficiencies in lifecycle management and risk assessment.

**FIGURE 6**  
**The Infrastructure Identity Gap — Economic Impact**

**Diagram Structure**

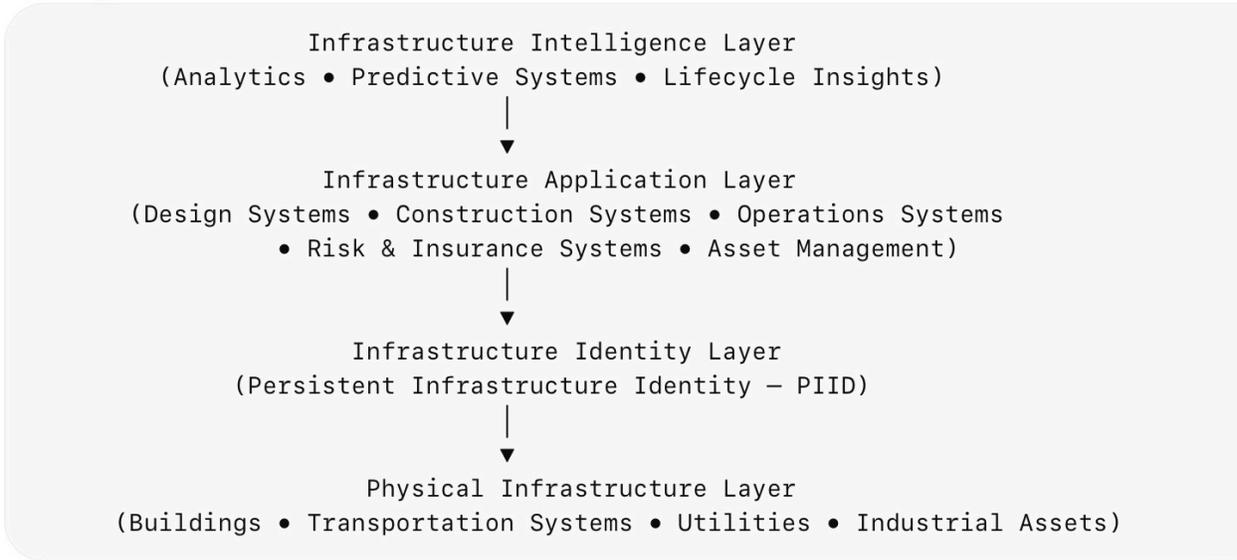


### The Infrastructure Identity Stack

The Infrastructure Identity Stack illustrates how Persistent Infrastructure Identity functions as a foundational layer within the infrastructure technology ecosystem. Physical infrastructure assets form the base layer of the built environment. Above this layer, PIID establishes a persistent identity system capable of linking infrastructure records across systems and over time. Application systems operating above the identity layer generate operational and lifecycle data, while analytical systems derive insights from aggregated infrastructure information.

## FIGURE 7 The Infrastructure Identity Stack

### Diagram Structure



## 17. Glossary of Key Terms

The following glossary provides definitions for key concepts used throughout the Persistent Infrastructure Identity (PIID) framework.

### **Infrastructure Asset**

A physical constructed asset forming part of the built environment, including buildings, transportation systems, utilities, industrial facilities, and other long-lived constructed infrastructure.

### **Persistent Infrastructure Identity (PIID)**

A globally unique, persistent digital identifier assigned to a physical infrastructure asset that enables lifecycle continuity across systems, ownership transitions, and operational history.

### **Infrastructure Identity Layer**

The architectural layer that assigns and maintains persistent identifiers for infrastructure assets, enabling interoperability between systems that generate and manage infrastructure data.

### **Infrastructure Identity Registry**

The system responsible for issuing, validating, and maintaining Persistent Infrastructure Identities and associated lifecycle records.

### **Lifecycle Continuity**

The ability to maintain consistent historical records for an infrastructure asset across design, construction, operations, ownership transitions, and long-term asset management.

### **Lifecycle State Model**

A structured representation of the operational stages an infrastructure asset progresses through during its lifespan, including design, construction, commissioning, operation, renovation, and decommissioning.

### **Infrastructure Data Interoperability**

The ability of independent infrastructure systems to exchange or reference information about infrastructure assets through a shared identity framework.

### **Identity Issuance**

The process by which a globally unique persistent identifier is assigned to a physical infrastructure asset.

### **Append-Only Lifecycle Record**

A record structure in which lifecycle events are added sequentially over time, preserving historical information without modification of prior records.

### **Infrastructure Intelligence Systems**

Analytical systems that derive insights from infrastructure data, including predictive maintenance models, lifecycle performance analytics, and risk analysis platforms.

## 18. References and Conceptual Foundations

The Persistent Infrastructure Identity framework draws upon principles widely used in identity systems, infrastructure lifecycle management, and distributed information architecture.

Persistent identity frameworks have historically served as foundational infrastructure layers across multiple industries, enabling continuity of records and interoperability between systems.

Examples of identity frameworks that have played similar roles in other domains include:

- standardized identification systems used to track manufactured goods and physical assets across supply chains
- persistent identifiers used in financial markets to track securities across trading and regulatory systems
- network identity systems used to uniquely identify devices and resources across digital communication networks

These frameworks demonstrate how persistent identifiers can provide a stable reference point linking information generated across multiple independent systems.

The PIID framework applies these principles to the domain of physical infrastructure assets, introducing a persistent identity layer designed to maintain continuity of infrastructure information across decades of asset operation.

As infrastructure systems continue to evolve toward increasingly digital and data-driven environments, persistent identity frameworks may become an essential component of long-term infrastructure information architecture.

The Persistent Infrastructure Identity (PIID) framework was introduced by Trevor Vick to address the absence of persistent digital identity systems for physical infrastructure assets.

