Built Is Not Complete – Governing Public Projects for Operational Value:

A multiple case analysis of systems engineering, project governance, and benefits realisation [1]

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Editorial Preface

This manuscript is prepared as a research-supported working paper for substantive review. Artificial intelligence tools assisted with synthesis and readability; authorship, factual verification, and professional judgment remain entirely with the named author. Evidence is triangulated from documentary records, Auditor General reports, parliamentary oversight, credible media, and anonymised professional reflections.

Abstract

Purpose This study advances the systems claim that *"built is not complete"* until infrastructure projects are validated through operational readiness, stakeholder legitimacy, and systemic value. It investigates recurring governance failures across eight South African infrastructure case studies, reframing completion as systemic validation rather than milestone delivery.

Methodology A multiple case study design was employed, drawing on Yin's analytic generalisation, Stake's interpretive lens, Winegardner's emphasis on transparent evidence chains, and Warfield's systems design logic. Cases were selected across energy, transport, defence, housing, and public works to ensure sectoral diversity. Each case was analysed for governance failures, distilled into propositions, and consolidated into a systemic framework.

Findings Eight propositions were identified, revealing systemic failures in accountability, sequencing, capture, usability, sustainability, and adaptive capacity. These were interpreted as governance implications (Chapter 6), consolidated into a systemic framework (Chapter 7), and translated into actionable reforms (Chapter 8). Key recommendations include independent integration audits, governance exit gates, demand validation for innovation, rigorous front-end definition, insulated procurement oversight, sustainability validation, usability audits, and adaptive reuse accountability.

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Contributions Methodologically, the study demonstrates the value of a hybrid approach that integrates rigorous case study design, interpretive depth, disciplined sequencing, and systemic design logic. Substantively, it provides a governance framework that embeds systemic validation into institutional practice, ensuring that infrastructure projects deliver usable, legitimate, and sustainable outcomes.

Policy and Practice Relevance The recommendations are directly transferable to ongoing infrastructure programmes, offering policymakers and practitioners concrete mechanisms to embed resilience, transparency, and legitimacy into governance practice.

Keywords Public infrastructure governance; Project management reform; Case study methodology; Operational readiness; Section 11D (Income Tax Act 58 of 1962, R&D Tax Incentive); Systemic sequencing discipline; Stakeholder legitimacy and usability validation

Practitioner Takeaway

Public infrastructure projects often declare "completion" at physical delivery, yet fail to validate usability, sustainability, and stakeholder legitimacy. The eight cases analysed here show recurring governance gaps — optimism bias, weak sequencing, procurement without clearance, and neglect of operational readiness. By applying the evidentiary framework of the Research and Development (R&D) Tax Incentive under section 11D of the Income Tax Act 58 of 1962, the study demonstrates that prior art, technological uncertainty, and systematic experimentation were consistently absent. The lesson for practitioners is clear: governance must embed validated readiness and demand anchors as conditions of completion, ensuring that infrastructure is not only delivered but truly usable, sustainable, and legitimate.

Executive Summary

This study advances the systems claim that *"built is not complete"* until infrastructure projects are validated through operational readiness, stakeholder legitimacy, and systemic value. Drawing on eight case studies across energy, transport, defence, housing, and public works, the research demonstrates that governance failures are systemic rather than incidental, recurring across diverse sectors and contexts.

Evidence and Propositions: The case studies revealed recurring governance failures — optimism bias, weak sequencing, capture, neglect of usability, and institutional dysfunction. From these, eight propositions were distilled, each validated by case evidence and reinforced by methodological anchors (Yin's analytic generalisation, Stake's interpretive lens, Winegardner's rigor, Warfield's systems design). Together, the propositions establish systemic validation as the cornerstone of infrastructure governance.

Governance Implications: Chapter 6 interpreted the propositions as governance implications: accountability must extend beyond compliance, oversight must mature, procurement must be insulated from capture, usability and sustainability must be embedded, and adaptive governance

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must be institutionalized. These implications reframed completion as validated readiness rather than milestone delivery.

Systemic Framework: Chapter 7 consolidated the propositions into a systemic framework, showing that governance resilience requires a hybrid methodological approach — rigorous, interpretive, disciplined, and systemic. This hybrid lens explains failures more comprehensively than single-lens methodologies and positions systemic validation as the foundation of reform.

Recommendations: Chapter 8 translated the framework into actionable reforms:

- Independent integration audits (Majuba)
- Exit gates to counter escalation (Lilian Ngoyi)
- Demand validation for innovation (PBMR)
- Rigorous front-end definition (Hoefyster)
- Insulated procurement oversight (Afro4000)
- Sustainability validation (Ikhwezi)
- Usability audits (Wilge)
- Adaptive reuse accountability (Telkom Towers)

These reforms embed resilience, transparency, and legitimacy into governance practice.

Contributions: Methodologically, the study demonstrates the value of hybrid case study design, integrating analytic generalisation (Yin), interpretive depth (Stake), disciplined sequencing (Winegardner), and systemic design logic (Warfield). Substantively, it provides a governance framework that is both analytically robust and practically relevant.

Policy Relevance: The recommendations are directly transferable to ongoing infrastructure programmes, offering policymakers and practitioners concrete mechanisms to ensure that public investments deliver usable, legitimate, and sustainable outcomes.

Future Research: Comparative studies across national contexts and sectors, deeper inquiry into adaptive governance, and methodological innovation in systems engineering and institutional design will further refine the propositions and strengthen their applicability.

1. Introduction

Infrastructure governance in South Africa has repeatedly equated "completion" with physical delivery, while neglecting operational readiness, systemic usability, and stakeholder legitimacy. This paper reframes completion as *validated usability*, situating the analysis within governance and systems engineering debates. Drawing on eight emblematic case studies, it demonstrates how governance failures manifest across defence, energy, transport, housing, public works, and urban infrastructure, and develops propositions for resilient governance in complex, high-risk projects.

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1.1 Background

Globally and in South Africa, public infrastructure projects often fail to translate physical completion into service readiness. Billions are invested, yet assets remain idle or underutilised. Examples include locomotives delivered but unusable, housing units abandoned, and defence vehicles never produced despite massive expenditure. These failures highlight a governance gap between delivery and usability. Addressing this gap requires situating infrastructure governance within systems engineering logic and case study methodology, ensuring that completion is defined by validated throughput and systemic integration rather than construction milestones.

1.2 Research Problem

Governance frameworks continue to emphasise milestones, compliance, and financial closure rather than validated throughput, adaptive oversight, and sustainability. This leads to systemic failures in readiness, resilience, and legitimacy. The eight case studies illustrate how optimism bias, weak sequencing, capture, and neglect of usability repeatedly undermine infrastructure value.

1.3 Research Aim

The study aims to develop propositions that explain governance resilience in complex, high-risk infrastructure projects. Using a hybrid case study methodology anchored in systems engineering, it seeks to demonstrate how validated usability can be embedded as a condition of completion.

1.4 Methodological Approach

The research integrates six methodological anchors, combining case study rigor with systems engineering discipline:

- **Yin (1994):** Rigour and analytic generalisation, operationalised through dated source anchors in Appendix A.
- **Stake (1995):** Interpretive depth, ensuring experiential insights are systematically validated.
- **Winegardner (1998):** Process discipline, reinforcing transparent evidence chains.
- **Warfield (1994):** Systems design principles, embedding validated interfaces as essential for managing complexity.
- **Kossiakoff (2011):** Systems engineering lifecycle discipline, emphasising that completion must extend beyond construction to validated operations, sustainability, and adaptive reuse. His framework highlights integration points, trade-off analysis, and holistic responsibility for usability.
- **U.S. Department of Defense (2001):** Systems Engineering Fundamentals, providing a structured process model — requirements analysis, functional allocation, design synthesis, verification, and validation. This anchor reinforces governance sequencing, risk management, and the principle that completion must be validated against operational needs, not just contractual milestones.

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Together, these anchors provide a dual methodological scaffold: case study methodology ensures empirical grounding and analytic generalisation, while systems engineering logic embeds lifecycle discipline, validated interfaces, and systemic integration. This hybrid approach ensures that propositions are both evidence-based and operationally robust, reframing completion as validated usability within complex, high-risk infrastructure projects.

1.5 Structure of the Paper

- **Section 2 (Literature Review):** Situates infrastructure governance within systems engineering and governance debates.
- **Section 3 (Methods):** Justifies the hybrid case study design and evidentiary strategy.
- **Section 4 (Conceptual Framework):** Anchors governance in systems engineering logic.
- **Section 5 (Case Evidence):** Presents eight case studies, each validating a distinct proposition.
- **Section 6 (Cross-Case Findings):** Synthesises recurring governance patterns across cases.
- **Section 7 (Discussion):** Interprets findings against literature and methodological anchors.
- **Section 8 (Implications):** Draws policy, institutional, methodological, and practice implications.
- **Section 9 (Conclusion):** Weaves all anchors into a unified methodological synthesis.

1.6 Contribution

The study contributes to infrastructure governance literature by demonstrating that methodological integration is both possible and necessary. By combining rigour, interpretation, discipline, and systems design, it advances a unified governance model capable of managing complexity in high-risk projects. The explicit use of dated source anchors in Appendix A ensures methodological transparency, while reframing completion as validated usability strengthens the systems claim that governance must embed operational readiness and systemic integration as conditions of completion.

2. Concepts and Literature

This section outlines the methodological foundation, drawing on Yin's case study approach to ensure depth, replicability, and analytic generalisation, and systems engineering logic to embed lifecycle discipline and validated usability. It explains how propositions are tested across multiple cases.

2.1 Completion as a Systems Claim

Systems engineering frames a system of interest as the engineered product together with its operators, interfaces, enabling services, operating environment, and life-cycle support. International standards such as **ISO/IEC/IEEE 15288:2023**, the **INCOSE Systems Engineering Handbook**, and the **NASA Systems Engineering Handbook** distinguish between **verification**

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(requirements met) and **validation** (stakeholder needs satisfied in context). A civil structure may therefore pass inspection (verification) while failing validation because it does not deliver usable outcomes.

Recent scholarship reinforces this distinction. **Whyte et al. (2020)** argue that infrastructure delivery must be understood as a socio-technical system, where failures stem from poor systemic integration. **Große (2023)** highlights that critical infrastructure is inherently a "system of systems," requiring governance that anticipates adaptation and emergence. **Boden (2026)** and **Joseph (2026)** confirm that breakdowns typically occur at boundaries and interfaces.

These findings align with the South African context, where decisive boundaries lie between constructed assets and enabling environments—for example, rail and loading facilities, building and user occupation, or reconstructed streets and traffic access.

Proposition: South African public infrastructure projects underperform not because construction packages fail verification, but because systemic interface boundaries are poorly managed, leading to failures in validation against stakeholder needs.

Governance Synergy: The **Support Programme for Industrial Innovation (SPII)** requires structured stage-gates, usability outcomes, and claw-backs for non-delivery. This mirrors the verification–validation distinction and highlights the importance of managing interfaces. Comparable frameworks such as the UK Government's **Teal Book (2026)** codify the same principle.

Systems Engineering Anchors: Kossiakoff (2011) emphasises lifecycle discipline and integration points, while the **USDOD Systems Engineering Fundamentals (2001)** defines a structured process of requirements analysis, functional allocation, design synthesis, verification, and validation. These anchors reinforce the claim that completion must be validated against operational needs, not just contractual milestones.

Supporting Literature:

Author / Framework	Contribution	Application in This Paper	Source Anchor
Yin (1994, 2003)	Analytic generalisation; replication logic	Structures propositions and ensures cross-case comparability	*Case Study Research*
Stake (1995)	Interpretive depth; context and meaning	Narrative construction of case histories	*The Art of Case Study Research*
Warfield (1994)	Systems design framing; complexity management	Embeds systemic governance logic	*Science of Generic Design*

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Author / Framework	Contribution	Application in This Paper	Source Anchor
Winegardner (1998)	Evidence chain discipline; transparency	Supports appendix evidence boxes	*Case Study as a Research Strategy*
Flyvbjerg (2001)	Power and rationality in case study research	Frames governance failures	*Making Social Science Matter*
George & Bennett (2005)	Structured, focused comparison	Guides proposition-driven synthesis	*Case Studies and Theory Development*

2.2 Project Success Is Not Merely the Iron Triangle

ISO 21502:2020 separates delivery efficiency from strategic value. Benefits realisation practice requires ownership, measures, baselines, and post-handover reviews (PMI, 2019; UK Government, 2025). **ISO 55001:2024** extends this logic to asset management. **Whyte et al. (2020)** and **Große (2023)** reinforce that infrastructure must be treated as a socio-technical system, judged by systemic value creation rather than the Iron Triangle.

Proposition: South African infrastructure projects fail to deliver long-term value because benefits realisation is not institutionalised, leaving outcomes unmeasured after handover.

Synergy with SPII/dtic: SPII requires proof of usability and commercial viability beyond technical completion, mirroring benefits realisation practice.

2.3 Front-End Definition, Optimism and Escalation

Front-end decisions disproportionately influence outcomes. **Samset & Volden (2016)** identify paradoxes in front-end definition. **Flyvbjerg (2014, 2021)** shows large projects are structurally exposed to optimism bias and escalation of commitment. **Boden (2026)** and **Joseph (2026)** confirm that crises often emerge at organisational interfaces.

Proposition: Weak front-end definition and optimism bias in South African infrastructure projects lead to escalation of commitment, sustaining flawed projects despite evidence favouring redesign or exit.

Synergy with SPII/dtic: SPII's structured stage-gates force early clarity on problem definition and feasibility before large commitments, reducing optimism bias and escalation.

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2.4 South Africa's FIDPM as a Governance Backbone

South Africa's **Framework for Infrastructure Delivery and Procurement Management (FIDPM)**, complemented by the **CIDB Infrastructure Delivery Management System**, provides staged control for planning, procurement, and delivery. The challenge lies in incomplete application and weak evidence at decision gates. International practice, such as the UK Government's **Teal Book (2026)**, reinforces the verification–validation distinction.

Proposition: South Africa's governance challenge lies not in the absence of frameworks like FIDPM, but in incomplete application and weak evidence at decision gates.

Synergy with SPII/dtic: SPII enforces gate evidence and accountability. If FIDPM adopted SPII-style enforcement—requiring usable evidence at each gate and linking funding to milestone validation—it could strengthen accountability and reduce fragmented oversight.

3. Methods

The systems claim is formally articulated: infrastructure governance must validate completion through operational readiness and stakeholder usability, not construction milestones. Propositions are introduced as analytic anchors.

3.1 Research Design

The study adopts a **hybrid case study methodology**. Yin (1994) provides analytic generalisation, Stake (1995) interpretive depth, Winegardner (1998) process discipline, and Warfield (1994) systemic design logic. Together, these anchors ensure rigor, transparency, and contextual richness.

3.2 Systems Engineering Integration

To complement case study rigor, the research integrates systems engineering logic from **Kossiakoff (2011)** and the **USDOD (2001)**. These anchors embed lifecycle discipline, validated interfaces, and verification processes into the analysis. Failures are traced to neglected integration points, reinforcing the claim that "built is not complete."

3.3 Case Selection

Eight cases were purposively selected to represent diverse sectors and governance challenges: Majuba Railway, Lilian Ngoyi Street, PBMR, Project Hoefyster, Afro4000 Locomotives, Project Ikhwezi, Wilge Residential Project, and Telkom Towers.

3.4 Data Collection and Evidence Chains

Evidence was triangulated from Auditor General reports, parliamentary oversight records, institutional documentation, credible media investigations, and anonymised professional

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reflections. Yin stresses converging lines of evidence, Stake validates experiential insights, and Winegardner reinforces transparency in evidence chains.

3.5 Analytic Strategy

Propositions guided pattern matching across cases. Yin ensured analytic generalisation, Stake provided contextual meaning, Winegardner reinforced transparency, and Warfield situated governance analysis within systemic design logic.

3.6 Limitations

Access to interview data was constrained by institutional sensitivities. To mitigate this, triangulation across multiple sources was adopted. While interviews could have added richness, the hybrid methodology provides sufficient transparency and validity for analytic generalisation.

4. Conceptual Framework

4.1 Systems Engineering Foundation

Warfield's *Science of Generic Design* (1994) anchors the systems design foundation, emphasising throughput, sequencing, and integration. **Kossiakoff (2011)** reinforces lifecycle discipline and holistic responsibility, while the **USDOD (2001)** provides a structured process model of requirements analysis, design synthesis, verification, and validation.

4.2 Governance Logic

Public infrastructure governance is conceptualised as a systemic process where value is realised not at physical completion but at validated service readiness. This aligns with systems engineering's emphasis on interfaces, sequencing, and integration, and with governance literature highlighting oversight maturity and benefits realisation.

4.3 Methodological Anchors

The conceptual framework anticipates the hybrid case study methodology:

- Yin (1994) → analytic generalisation
- Stake (1995) → interpretive richness
- Winegardner (1998) → process discipline
- Warfield (1994), Kossiakoff (2011), USDOD (2001) → systems engineering logic

Together, these anchors ensure that the framework is both systemic and methodologically robust.

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4.4 Link to Propositions

The conceptual framework sets up the logic for the propositions in Section 5: validated throughput, sequencing discipline, oversight maturity, methodological alignment, and adaptive governance. Literature confirms that governance failures are systemic and recurring, preparing the ground for empirical case evidence

5. Case Evidence

Section 5 presents eight case studies that collectively illustrate systemic governance failures across South Africa's public infrastructure programmes. Spanning energy (Majuba, PBMR, Ikhwezi), transport (Lilian Ngoyi Street, Afro4000), defence (Hoefyster), housing (Wilge), and public works (Telkom Towers), these cases demonstrate how completion is often declared at the point of physical delivery, while systemic validation of usability, sustainability, and stakeholder legitimacy remains absent. Each case validates a distinct proposition, reinforcing the systems claim that governance must embed operational readiness and systemic integration as conditions of completion.

Evidence Integration Note: The propositions advanced in this study are explicitly grounded in verified case evidence. Each proposition is supported by documentary records, Auditor General findings, parliamentary oversight reports, and credible media sources, triangulated with my professional reflections. This explicit mapping ensures analytic generalisation (Yin, 1994), interpretive richness (Stake, 1995), process discipline (Winegardner, 1998), and systemic grounding (Warfield, 1994). By infusing systems engineering anchors (Kossiakoff, 2011; USDOD, 2001), the analysis also demonstrates lifecycle discipline and validated interfaces as conditions of completion.

5.1 Majuba Railway – Completion Without Full Throughput

Proposition: Infrastructure value lies not in physical completion but in validated throughput across interfaces. **SPII Synergy:** Usability trials and anchor customer evidence before commercialization.

Personal Insights: In my professional practice, I have repeatedly observed how projects were declared "complete" once physical assets were delivered, even when systemic throughput remained untested. While conducting SPII due diligence and milestone audits, compliance reporting emphasised delivery milestones, while usability and customer readiness were deferred. In my venture capital portfolio monitoring at IDC, early-stage firms often celebrated prototype delivery before validated service integration, echoing Majuba's premature declaration of completion.

Earlier in my career at Accenture, I worked on proposal development and requirements definition for large transport and telecommunications projects. Although I was not directly involved in implementation, this exposure highlighted how governance frameworks often emphasised

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contractual milestones and vendor selection, while systemic readiness and integration were treated as secondary.

My SARS section 11D adjudication work sharpened this perspective further. Every application had to demonstrate prior art, technological uncertainty, and systematic experimentation. In Majuba, none of these anchors were visible — throughput validation was absent, and completion was declared prematurely.

From a systems engineering lens, Kossiakoff's lifecycle discipline stresses end-to-end integration, while the USDOD process model requires verification and validation across interfaces. Majuba failed precisely at this boundary. Yin, Stake, Winegardner, and Warfield all converge on the same point: validated interfaces and evidence chains must define completion, not construction milestones.

5.2 Lilian Ngoyi Street – Sequencing Without Usability

Proposition: Governance resilience requires sequencing discipline and usability validation. **SPII Synergy:** Sequencing construction, clearance, and usability validation before declaring completion.

Personal Insights: In my professional practice, I have often encountered situations where sequencing discipline was weak: projects reported "completion" of phases, yet systemic readiness was absent. SPII audits revealed cost saving opportunities only after milestones were declared, showing how sequencing gaps obscured delivery reality.

My section 11D experience reinforced this: every application had to demonstrate prior art, uncertainty, and systematic experimentation. In Lilian Ngoyi Street, none of these evidentiary anchors were visible — sequencing discipline was absent, uncertainty was not defined, and usability validation was deferred.

Systems engineering anchors confirm this failure: USDOD's process model emphasises sequencing requirements analysis → design synthesis → validation, while Kossiakoff highlights validated interfaces as essential for managing complexity. Yin, Stake, Winegardner, and Warfield reinforce the same lesson: sequencing without usability validation erodes legitimacy.

5.3 Hoefyster Defence Project – Optimism Bias Without Delivery

Proposition: Optimism bias at initiation undermines governance resilience. **SPII Synergy:** Anchor customer evidence and milestone audits before commercialization.

Personal Insights: In my professional practice, I have seen how optimism bias drives projects forward without validated readiness. SPII due diligence reviews revealed proposals ambitious in scope but lacking anchor customers or usability validation. This mirrors Hoefyster, where optimism bias led to premature declarations of success.

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My section 11D adjudication work sharpened the lesson: uncertainty must be defined, experimentation documented, and prior art demonstrated. In Hoefyster, none of these anchors were visible — optimism substituted for validated readiness.

Systems engineering anchors reinforce this: Kossiakoff stresses trade-off analysis and uncertainty definition, while USDOD requires systematic experimentation before validation. Yin, Stake, Winegardner, and Warfield confirm that optimism bias must be countered with validated readiness.

5.4 Afro4000 Locomotives – Procurement Without Usability

Proposition: Procurement must embed usability validation. **SPII Synergy:** Clearance validation and operational readiness before delivery.

Personal Insights: In my professional practice, I have seen prototypes delivered without integration, echoing Afro4000's idle locomotives. Procurement frameworks emphasised delivery milestones while systemic readiness was deferred.

My section 11D experience confirmed the gap: Afro4000 emphasised contractual delivery, but uncertainty was not defined and usability validation was absent.

Systems engineering anchors highlight the failure: USDOD requires verification and validation against operational needs, while Kossiakoff stresses lifecycle responsibility. Yin, Stake, Winegardner, and Warfield reinforce the same lesson: procurement without usability validation constitutes governance failure.

5.5 Ikhwezi Gas Turbine – Sequencing Without Integration

Proposition: Sequencing discipline is essential for governance resilience. **SPII Synergy:** Sequencing technical packages with systemic integration before declaring completion.

Personal Insights: In my professional practice, I saw how sequencing discipline was critical: projects that aligned technical milestones with usability validation achieved higher success rates. Conversely, projects that delivered technical packages without integration struggled to sustain outcomes.

My section 11D adjudication work reinforced this: Ikhwezi lacked defined uncertainty and systematic experimentation. Sequencing was fragmented rather than systemic.

Systems engineering anchors confirm the lesson: Kossiakoff emphasises validated interfaces, while USDOD stresses integration reviews. Yin, Stake, Winegardner, and Warfield reinforce that sequencing discipline must be embedded in governance frameworks.

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5.6 Pebble Bed Modular Reactor (PBMR) – Innovation Without Anchor Customers

Proposition: Innovation projects must secure anchor customers and validated demand. **SPII Synergy:** Anchor customer evidence before commercialization.

Personal Insights: In my professional practice, I managed early stage technology firms that delivered prototypes but struggled without anchor customers. This resonates with PBMR, where innovation advanced technically but lacked systemic legitimacy.

My section 11D experience sharpened the perspective: demand validation was absent, uncertainty was not defined in terms of usability, and systematic experimentation was insufficient to prove scalability.

Systems engineering anchors reinforce this: Kossiakoff highlights holistic responsibility for usability, while USDOD stresses validation against stakeholder needs. Yin, Stake, Winegardner, and Warfield confirm that innovation governance must embed validated demand and anchor customers.

5.7 Wilge Flats Housing – Delivery Without Occupancy

Proposition: Completion must be defined by validated usability and sustainability. **SPII Synergy:** Occupancy plans and stakeholder legitimacy before declaring completion.

Personal Insights: In my professional practice, I observed projects delivering physical structures but failing to secure long-term usability. Empowerment initiatives often achieved technical delivery but faltered when demand analysis and stakeholder legitimacy were neglected.

My section 11D adjudication work confirmed the absence of evidentiary anchors: demand analysis was missing, uncertainty about occupancy was undefined, and systematic experimentation to validate usability was not undertaken.

Systems engineering anchors reinforce this: USDOD requires validation against operational needs, while Kossiakoff emphasises lifecycle responsibility. Yin, Stake, Winegardner, and Warfield confirm that sustainability and usability must be embedded as conditions of completion.

5.8 Telkom Towers – Assets Without Stakeholder Legitimacy

Proposition: Completion must embed stakeholder legitimacy. **SPII Synergy:** Usability trials and stakeholder validation before commercialization.

Personal Insights: In my professional practice, I saw projects deliver physical assets but falter when stakeholder legitimacy was absent. Empowerment initiatives collapsed when legitimacy with customers and partners was neglected, echoing Telkom Towers.

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My section 11D experience sharpened the lesson: prior art on occupancy readiness was ignored, uncertainty about systemic usability was not defined, and no systematic experimentation was undertaken to validate stakeholder legitimacy.

Systems engineering anchors reinforce this: Kossiakoff stresses validated interfaces between assets and stakeholders, while USDOD requires stakeholder validation as a condition of completion. Yin, Stake, Winegardner, and Warfield confirm that legitimacy must be embedded in governance frameworks.

5.9 Comparative Synthesis

The eight case narratives presented in Sections 5.1–5.8 demonstrate recurring governance failures across diverse sectors. Despite sectoral differences, the cases converge on systemic patterns that reveal how completion is repeatedly declared at the point of physical delivery, while systemic validation of usability, sustainability, and stakeholder legitimacy remains absent.

- **Optimism bias** (Hoefyster, PBMR) sustained flawed projects long after evidence of failure emerged.
- **Weak sequencing discipline** (Majuba, Lilian Ngoyi, Ikhwezi) led to premature declarations of completion without systemic readiness.
- **Procurement gaps** (Afro4000) delivered technically complete assets that remained unusable.
- **Neglect of usability and sustainability** (Wilge, Telkom Towers) produced idle or deteriorating assets, undermining legitimacy and value.

Personal Insights: In my professional practice, I have seen these patterns recur across different contexts. At Accenture, proposal development and requirements definition often emphasised contractual milestones and vendor selection, while systemic readiness was treated as secondary. In IDC venture capital portfolio monitoring, firms celebrated prototype delivery before validated integration, echoing the premature declarations seen in Majuba and Afro4000. At Nampak Mono Containers, industrial projects delivered technical packages without validated integration, mirroring Ikhwezi's sequencing failures. Through SPII programme management, I observed milestone audits that emphasised compliance but deferred usability validation, paralleling Lilian Ngoyi Street. And in SARS section 11D adjudication, I saw how evidentiary anchors — prior art, technological uncertainty, and systematic experimentation — were required for innovation funding, yet consistently absent in public infrastructure governance.

Systems Engineering Anchors: Kossiakoff's lifecycle discipline and USDOD's structured process model reinforce the same lesson: completion must be validated against operational needs, not declared at delivery milestones. The absence of validated interfaces, integration reviews, and stakeholder legitimacy across these cases confirms that governance frameworks failed to embed systems engineering logic.

Comparative Table: To sharpen this synthesis, Table 5.1 provides a comparative snapshot of planned versus actual outcomes, cost escalation, governance failures, current status, and — newly

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added — the presence or absence of section 11D evidentiary anchors. This sixth column highlights whether each case demonstrated the three spines required under section 11D: prior art, technological uncertainty, and systematic experimentation.

Compressed Comparative Table (All 8 Cases)

Case Study	Planned Outcome	Actual Outcome	Cost Escalation	Governance Failure	Current Status	Section 11D Evidentiary Anchors
Majuba Railway	Rail line for coal transport	Delivered, throughput constrained	R1.5bn → R8bn	Declared completion without validated throughput	Operational but limited	**Absent** — no prior art, uncertainty, or experimentation applied
Lilian Ngoyi Street	Urban street reconstruction	Declared complete, remained closed	Escalated	Sequencing failure, usability absent	Closed	**Absent** — completion declared without usability validation
Hoefyster Defence Project	Infantry combat vehicle	Never delivered	Escalated	Optimism bias, weak oversight	Cancelled	**Absent** — optimism substituted for uncertainty definition
Afro4000 Locomotives	Passenger locomotives	Delivered, unusable	Escalated	Procurement without clearance validation	Idle	**Absent** — delivery milestones without systematic experimentation
Ikhwezi Gas Turbine	Energy project	Technical packages delivered	Escalated	Sequencing without integration	Incomplete	**Fragmented** — experimentation attempted but not systemic
PBMR	Nuclear innovation	Prototype advanced, no demand	Escalated	Innovation without anchor customers	Terminated	**Absent** — scaling risks ignored, demand validation missing
Wilge Flats Housing	Housing units	Delivered, unoccupied	Escalated	Delivery without occupancy	Idle/deteriorating	**Absent** — occupancy validation missing

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Case Study	Planned Outcome	Actual Outcome	Cost Escalation	Governance Failure	Current Status	Section 11D Evidentiary Anchors
Telkom Towers	Public works asset	Delivered, idle	Escalated	Stakeholder legitimacy absent	Vacant	**Absent** — no experimentation to validate stakeholder le

Interpretive Synthesis: Across all eight cases, the absence of section 11D evidentiary anchors and systems engineering discipline converges on the same systemic failure: governance frameworks reward milestone declarations and physical delivery, while neglecting validated usability, sustainability, and legitimacy. Yin's analytic generalisation confirms that these failures are not isolated but recurring; Stake's interpretive lens validates the experiential conviction that usability defines completion; Winegardner's process discipline underscores the need for transparent evidence chains; and Warfield's systemic design principles highlight validated interfaces as essential for managing complexity.

Lesson: The comparative synthesis confirms the systems claim advanced in Section 2: governance must embed operational readiness, validated interfaces, and stakeholder legitimacy as conditions of completion. Without these anchors, infrastructure projects risk becoming idle assets, eroded by optimism bias, weak sequencing, procurement gaps, and neglected sustainability.

Chapter 6 – Governance Implications

This chapter interprets the case evidence in terms of governance accountability, institutional reform, and systemic validation. Across the eight case studies, recurring governance failures emerge — optimism bias, weak sequencing, capture, neglect of usability, and institutional dysfunction — all of which undermine infrastructure readiness. The eight propositions distilled in Chapter 5 are now mapped into five broader governance implications. This mapping demonstrates how case-specific lessons translate into systemic governance patterns, preparing the ground for the integrative framework in Chapter 7.

6.1 Accountability Beyond Compliance

The cases show that compliance checklists and milestone reporting are insufficient. Governance must shift toward accountability for validated outcomes.

- **Linked Propositions:**
  - *Proposition 1*: Completion must be validated through operational readiness.
  - *Proposition 2*: Optimism bias distorts readiness claims.

Together, these propositions reveal that accountability cannot rest on physical delivery alone. Milestone compliance obscures whether infrastructure is usable, sustainable, and legitimate in practice.

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- **Implication:** Accountability frameworks should measure usability, sustainability, and stakeholder legitimacy, not merely physical delivery.
- **Anchor:** Ostrom (1990) highlights institutional resilience through adaptive accountability rules, while Yin (1994) reminds us that analytic generalisation requires accountability frameworks to extend beyond compliance checklists toward validated outcomes.

6.2 Institutional Reform and Oversight Maturity

Weak sequencing and immature oversight bodies undermined readiness across multiple cases.

- **Linked Propositions:**
  - *Proposition 3*: Weak sequencing undermines systemic integration.
  - *Proposition 4*: Immature oversight bodies fail to enforce stage-gate discipline.

These failures demonstrate that institutional reform is required to embed sequencing discipline and oversight maturity.

- **Implication:** Institutions must strengthen oversight capacity, embedding stage-gate discipline and systemic integration checks.
- **Anchor:** Blanchard & Fabrycky (2011) emphasize disciplined sequencing as essential for complex projects, while Kossiakoff et al. (2011) extend this by showing that lifecycle validation and systemic integration are critical to readiness.

6.3 Insulating Governance from Capture

Procurement irregularities (Afro4000) and strategic overreach (PBMR) highlight how governance capture distorts accountability.

- **Linked Propositions:**
  - *Proposition 5*: Procurement irregularities distort accountability.
  - *Proposition 6*: Strategic overreach compromises governance independence.

These cases illustrate how capture undermines institutional legitimacy and distorts reform trajectories.

- **Implication:** Independent validation mechanisms insulated from political interference are essential.
- **Anchor:** Winegardner (1998) underscores transparent evidence chains as a safeguard against capture, reinforcing the need for independent oversight.

6.4 Embedding Usability and Sustainability

Cases such as Wilge and Ikhwezi reveal that usability and sustainability are often neglected.

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- **Linked Proposition:**
  - *Proposition 7*: Neglect of usability undermines completion.

This proposition demonstrates that infrastructure declared "complete" may fail in practice if usability and sustainability are not embedded.

- **Implication:** Governance must embed usability audits and sustainability validation before declaring completion.
- **Anchor:** Checkland (1999) emphasizes alignment between systemic design and institutional practice, while Stake (1995) highlights that usability and sustainability are not technical add-ons but embedded in institutional meaning systems.

6.5 Adaptive Governance Capacity

Adaptive governance emerged as a critical requirement in contexts of uncertainty and complexity.

- **Linked Proposition:**
  - *Proposition 8*: Adaptive oversight is required under uncertainty and complexity.

This proposition underscores the need for governance systems that evolve with dynamic environments.

- **Implication:** Institutions must adopt iterative oversight and adaptive rules to respond to uncertainty and complexity.
- **Anchor:** Warfield (1994) situates adaptive oversight as a systemic response to complexity, reinforcing the need for governance capacity that evolves with uncertainty.

By explicitly mapping the eight propositions into five governance implications, Chapter 6 demonstrates how case-specific lessons translate into systemic governance patterns. This mapping ensures continuity: methodological anchors (Yin, Stake, Winegardner, Warfield) and systems engineering anchors (Blanchard & Fabrycky, Kossiakoff, Checkland) are strategically integrated. The chapter thus bridges empirical evidence (Chapter 5) and systemic consolidation (Chapter 7), preparing the ground for reform recommendations in Chapter 8.

Chapter 7 – Discussion

Building on the governance implications identified in Chapter 6, this chapter consolidates the eight propositions into a systemic framework. The case evidence demonstrated recurring failures in accountability, sequencing, capture, usability, sustainability, and adaptive capacity. Chapter 6 interpreted these as governance implications, showing that accountability must extend beyond compliance, oversight must mature, procurement must be insulated from capture, usability and sustainability must be embedded, and adaptive governance must be institutionalized. Chapter 7 now advances the discussion by crystallizing these lessons into eight propositions, each validated by a case study and reinforced by methodological anchors (Yin, Stake, Winegardner, Warfield) and systems engineering anchors (Blanchard & Fabrycky, Kossiakoff, Checkland, Ostrom).

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Together, they provide a coherent framework for understanding systemic governance failures and charting pathways for reform.

7.1 Framing the Findings

The findings across eight propositions reveal systemic governance challenges in public infrastructure projects. These challenges include failures of throughput validation, weak sequencing, immature oversight, misaligned frameworks, and inadequate adaptive capacity. Yin's emphasis on analytic generalisation validates these as recurring governance mechanisms, while Stake situates them within the lived complexity of institutional practice. Winegardner reinforces the methodological rigor of the evidence chains, and Warfield provides the systems design foundation for managing complexity.

- **Proposition 1 (Majuba Railway):** Completion must be validated at the system level, not by isolated technical packages.
- **Proposition 2 (Lilian Ngoyi Street):** Governance must counter optimism bias and sunk-cost escalation by enforcing exit or redesign when viability collapses.

7.2 Governance Throughput and Readiness

The Wilge flats and Telkom Towers cases illustrate that physical completion does not equate to service readiness. This resonates with Flyvbjerg's (2001) critique of megaprojects, where delivery milestones obscure usability outcomes. Yin's framework supports generalisation of this failure, Stake validates its experiential resonance, Winegardner stresses transparent readiness criteria, and Warfield situates readiness within systemic design logic.

- **Proposition 7 (Wilge):** Governance must validate stakeholder usability and institutional legitimacy as conditions of completion.
- **Proposition 8 (Telkom Towers):** Governance must ensure institutional accountability and adaptive reuse of public assets.

7.3 Sequencing and Oversight

Weak governance sequencing undermined operational readiness across cases. This aligns with Blanchard & Fabrycky's systems engineering principles, which emphasise disciplined sequencing for complex projects. Kossiakoff et al. extend this by stressing lifecycle validation and systemic integration. Winegardner underscores sequencing as a methodological necessity, while Warfield situates it as a systemic tool for managing institutional complexity. Oversight bodies relying on compliance checklists struggled to achieve maturity, echoing Ostrom's (1990) insight that institutional resilience requires adaptive rules rather than rigid compliance.

- **Proposition 4 (Hoefyster):** Governance must ensure front-end definition and capability alignment before committing resources.

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7.4 Sustainability and Alignment

Sustainability was contingent on methodological alignment between due diligence frameworks and governance mechanisms. Yin frames these synergies as transferable lessons, Stake highlights their contextual meaning, Winegardner reinforces transparency, and Warfield situates sustainability within complexity management. This finding resonates with Checkland's *Soft Systems Methodology* (1999), which emphasises alignment between systemic design and institutional practice.

- **Proposition 3 (PBMR):** Technical innovation must be aligned with validated demand and stakeholder usability.
- **Proposition 6 (Ikhwezi):** Governance must validate sustainability and operational readiness before scaling resource commitments.

7.5 Adaptive Governance

Adaptive governance emerged where oversight was iterative and responsive to uncertainty. This reflects broader governance literature on resilience, where institutions must adapt to dynamic environments. Yin validates this as an analytic pattern, Stake situates it within experiential practice, Winegardner underscores replicability, and Warfield highlights adaptive oversight as a systemic response to complexity.

- **Proposition 5 (Afro4000):** Governance must embed independent validation mechanisms insulated from capture and irregular procurement.

7.6 Synthesis (Closing)

Together, the eight propositions demonstrate that governance resilience requires a hybrid methodological approach: rigorous (Yin), interpretive (Stake), disciplined (Winegardner), and systemic (Warfield). Systems engineering anchors (Blanchard & Fabrycky, Kossiakoff, Checkland) and institutional anchors (Ostrom) reinforce this hybrid lens, explaining governance failures more comprehensively than single-lens methodologies. The synthesis positions systemic validation as the cornerstone of infrastructure governance.

Having consolidated the propositions into a systemic framework, the next step is to translate them into actionable reforms. Chapter 8 advances this task by mapping each proposition to a concrete governance recommendation, ensuring that the analytic insights of Chapter 7 are operationalized into institutional practice. In this way, the manuscript moves from evidence and synthesis toward reform pathways, bridging scholarship and policy relevance.

Chapter 8 – Recommendations

This chapter translates the eight propositions into actionable governance reforms. Each recommendation addresses a systemic failure identified in the case studies, ensuring that infrastructure governance embeds systemic validation, stakeholder legitimacy, and operational

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readiness as conditions of completion. In doing so, the chapter operationalises the analytic insights of Chapter 7 into institutional practice, bridging scholarship and reform.

8.1 System-Level Validation (Majuba Railway)

Recommendation: Establish independent system-integration audits before declaring project completion. These audits should validate operational readiness across subsystems, ensuring that assets function as a coherent whole.

- **Linked Proposition 1:** Completion must be validated at the system level, not by isolated technical packages.
- **Anchor:** Blanchard & Fabrycky's systems engineering principles reinforce the necessity of integration audits.

8.2 Countering Escalation of Commitment (Lilian Ngoyi Street)

Recommendation: Introduce governance "exit gates" at key project milestones, where independent panels assess viability and authorize continuation, redesign, or termination. This prevents optimism bias and sunk-cost escalation.

- **Linked Proposition 2:** Governance must counter optimism bias and sunk-cost escalation.
- **Anchor:** Ostrom's adaptive accountability rules support iterative exit mechanisms.

8.3 Aligning Innovation with Demand (PBMR)

Recommendation: Require demand validation studies and stakeholder usability assessments before committing to large-scale innovation projects. Strategic ambition must be matched with proven systemic value.

- **Linked Proposition 3:** Technical innovation must be aligned with validated demand and stakeholder usability.
- **Anchor:** Checkland's Soft Systems Methodology emphasises alignment between systemic design and institutional practice.

8.4 Strengthening Front-End Definition (Hoefyster)

Recommendation: Mandate rigorous front-end definition processes, including capability alignment and clear specifications, before procurement contracts are signed. This ensures disciplined sequencing and oversight.

- **Linked Proposition 4:** Governance must ensure front-end definition and capability alignment before committing resources.
- **Anchor:** Kossiakoff et al. highlight lifecycle discipline as essential for readiness.

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8.5 Insulating Governance from Capture (Afro4000)

Recommendation: Create independent procurement validation bodies with statutory authority to review acquisitions. These bodies must be insulated from political interference and empowered to enforce accountability.

- **Linked Proposition 5:** Governance must embed independent validation mechanisms insulated from capture and irregular procurement.
- **Anchor:** Winegardner underscores transparent evidence chains as safeguards against capture.

8.6 Validating Sustainability and Readiness (Ikhwezi)

Recommendation: Require sustainability assessments and readiness validation before scaling resource commitments. Governance must ensure that technical feasibility aligns with long-term operational oversight.

- **Linked Proposition 6:** Governance must validate sustainability and operational readiness before scaling resource commitments.
- **Anchor:** Warfield situates sustainability within systemic design logic for managing complexity.

8.7 Embedding Usability and Legitimacy (Wilge Residential Project)

Recommendation: Institute stakeholder usability audits for housing and social infrastructure projects. Completion should only be declared when assets are habitable, accessible, and institutionally legitimate.

- **Linked Proposition 7:** Governance must validate stakeholder usability and institutional legitimacy as conditions of completion.
- **Anchor:** Stake highlights usability as embedded in institutional meaning systems.

8.8 Ensuring Adaptive Reuse and Accountability (Telkom Towers)

Recommendation: Establish governance mechanisms for adaptive reuse of public assets. Idle or misallocated assets must be repurposed or divested under transparent accountability frameworks.

- **Linked Proposition 8:** Governance must ensure institutional accountability and adaptive reuse of public assets.
- **Anchor:** Yin validates this as an analytic pattern generalisable across infrastructure governance.

Together, these recommendations embed systemic validation into governance practice. They translate case-based propositions into actionable reforms, ensuring that infrastructure completion is judged by operational readiness, stakeholder legitimacy, and long-term systemic value.

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Chapter 8 thus prepares the ground for Chapter 9, where the cumulative argument is consolidated into the manuscript's conclusion, closing the loop between evidence, synthesis, and reform.

Chapter 9 – Conclusion

The conclusion consolidates the insights from the entire study, reaffirming the systems claim that infrastructure governance must be judged not by construction milestones but by validated operational readiness and stakeholder usability. It reflects on the methodological rigor, the case evidence, and the propositions, showing how they converge into a coherent framework for reform.

9.1 Consolidating the Systems Claim

The eight case studies demonstrate that governance failures are systemic, recurring across energy, transport, defence, housing, and public works. Each case validated a proposition, confirming that completion must be reframed as systemic validation rather than physical delivery. The methodological anchors — Yin's analytic generalisation, Stake's interpretive lens, Winegardner's rigor, and Warfield's systems design — ensured that these findings are both analytically robust and practically relevant. Together, they establish systemic validation as the cornerstone of infrastructure governance.

9.2 From Evidence to Reform

The propositions distilled in Chapter 7 and the recommendations advanced in Chapter 8 translate empirical lessons into actionable governance reforms. They show that systemic validation requires:

- Independent integration audits (Majuba)
- Exit gates to counter escalation (Lilian Ngoyi)
- Demand validation for innovation (PBMR)
- Rigorous front-end definition (Hoefyster)
- Insulated procurement oversight (Afro4000)
- Sustainability validation (Ikhwezi)
- Usability audits (Wilge)
- Adaptive reuse accountability (Telkom Towers)

Together, these reforms embed resilience, transparency, and legitimacy into governance practice, ensuring that infrastructure projects deliver systemic value rather than symbolic milestones.

9.3 Implications for Infrastructure Governance

The study demonstrates that governance resilience requires a hybrid methodological approach: rigorous, interpretive, disciplined, and systemic. This hybrid lens explains failures more comprehensively than single-lens methodologies and positions systemic validation as the foundation of infrastructure governance. By reframing completion as validated readiness, the study advances both scholarly understanding and practical reform.

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9.4 Methodological Contributions

This research demonstrates the value of a hybrid methodological approach: rigorous case study design (Yin), interpretive depth (Stake), disciplined sequencing (Winegardner), and systemic design logic (Warfield). By combining these lenses, the study advances methodological practice in infrastructure governance, showing how analytic generalisation and experiential resonance can be integrated to explain complex institutional failures. The methodological contribution lies in demonstrating that governance analysis benefits from methodological hybridity rather than reliance on a single paradigm.

9.5 Policy and Practice Relevance

The propositions and recommendations provide actionable guidance for policymakers, regulators, and practitioners. They highlight the need for independent validation mechanisms, stakeholder usability audits, and adaptive governance frameworks. These reforms are not abstract but directly transferable to ongoing infrastructure programmes, ensuring that public investments deliver usable, legitimate, and sustainable outcomes. In this way, the study bridges scholarship and practice, offering a roadmap for institutional reform.

9.6 Future Research Directions

While the study consolidates systemic lessons from eight case studies, future research should expand comparative analysis across different national contexts, sectors, and governance models. Further inquiry into adaptive governance, stakeholder legitimacy, and systemic validation can refine the propositions and strengthen their applicability. Methodological innovation — particularly in systems engineering and institutional design — will be critical for advancing infrastructure governance scholarship and ensuring that reforms remain responsive to evolving complexity.

By looping back to the systems claim, Chapter 9 consolidates the manuscript as a coherent, cumulative argument: infrastructure governance must be judged by validated operational readiness, stakeholder legitimacy, and systemic value. The conclusion not only synthesises the evidence and propositions but also charts pathways for reform, methodological advancement, and future research. In doing so, it ensures that future infrastructure projects deliver outcomes that are usable, sustainable, and legitimate — fulfilling the promise that "built is not complete" until validated in practice.

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Disclaimer / Disclosure Notes

This manuscript is prepared for academic and policy review purposes. All case evidence is drawn from publicly available documentary records, Auditor General reports, parliamentary oversight proceedings, credible media sources, and anonymised professional reflections. Financial figures, timelines, and governance assessments are based on verified sources, with dated anchors provided in Appendix A to ensure transparency and traceability.

The author declares no conflicts of interest in relation to the projects analysed. No external funding was received for this study. All professional insights included are anonymised to protect institutional confidentiality and comply with ethical research standards.

The interpretations and propositions advanced are those of the author and do not represent the official position of any government department, public entity, or professional body. Responsibility for errors or omissions remains with the author.

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Appendix A Case Evidence Sources (APA Style)

Case Evidence Box 1: Project Hoefyster

- Daily Investor. (2026, September 9). Eskom's Majuba railway under utilisation. *Daily Investor.*
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Case Evidence Box 2: Afro4000 Locomotives

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Case Evidence Box 3: Ikhwezi Turbine Project

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Case Evidence Box 4: PBMR Nuclear Initiative

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Case Evidence Box 5: Majuba Railway Project

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Case Evidence Box 6: Lilian Ngoyi Street

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Case Evidence Box 7: Wilge Flats Housing Project

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