Bridging the Gap from Development to Implementation of Tools for the South African Transport Department

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ABSTRACT

The South African government has invested significantly in developing digital decision-support systems to improve road infrastructure planning and maintenance. Despite their technical robustness, the impact of these tools, such as the Abnormal Loads System, Road Asset Management Systems (RAMS), the PotholeFixGP application, and the STRUMAN Bridge Management System, has been limited by institutional, governance, and funding challenges. This study examines whether these systems are being used as intended, and identifies the barriers between development, implementation, and sustained network-level use. Drawing on interviews with system developers and implementation stakeholders, the paper presents four case studies highlighting common implementation bottlenecks. Findings show that while technical design was sound across all systems, uptake was constrained by weak institutional ownership, inconsistent operational funding, and misalignment with budgeting and decision-making processes. The study concludes with recommendations for strengthening the long-term integration of digital tools into infrastructure governance frameworks.

Key words: Decision support tools, transport, infrastructure, heavy vehicles, potholes, bridge management systems, road asset management systems

1. Introduction

Over the past four decades, the Council for Scientific and Industrial Research (CSIR) has developed numerous decision-support systems for South Africa's transport sector. These systems were designed to assist government in making informed, evidence-based decisions regarding road infrastructure planning, maintenance, and investment, with the ultimate aim of improving the condition and performance of the national transport network. Despite the technical sophistication of many of these tools, their impact on infrastructure outcomes has remained limited. While several systems generate clear recommendations on maintenance needs, prioritisation, and asset condition, challenges persist in translating these outputs into consistent implementation at both network and project levels. As a result, the potential benefits of these tools are often not fully realised in practice.

This paper examines this gap between system development and real-world application. It seeks to answer a central question: have the systems developed to support the state been implemented, and if so, are they being used as intended? More specifically, are the recommendations produced by these systems being applied in practical decision-making and project execution?

By addressing these questions, the paper aims to identify the institutional, organisational, and procedural factors that influence the effective use of decision-support tools in the transport sector. Based on these findings, the paper proposes recommendations to improve the uptake, integration, and sustained use of such systems, with the objective of strengthening infrastructure planning and improving the condition and performance of South Africa's road network.

1.1. Background

South Africa has one of the largest road networks in the world, with an estimated total length of approximately 750 000 km, of which the majority consists of provincial, district, and municipal roads (SANRAL, 2023; DBSA, 2022). While the national road network performs relatively well in terms of connectivity and strategic mobility, a substantial proportion of the secondary and tertiary network has deteriorated significantly over time. According to the Development Bank of Southern Africa (DBSA, 2022), less than a quarter of rural roads in South Africa qualify as all-weather roads, and a large share of unpaved and low-order paved roads are currently classified as being in fair to poor condition.

The progressive deterioration of the road network has direct safety, operational, and economic consequences. South Africa continues to record a high number of road crashes and fatalities annually, with infrastructure condition identified as a contributing factor alongside human behaviour and vehicle condition (Road Traffic Management Corporation, 2023). Poor surface condition, potholes, inadequate drainage, and structural distress increase accident risk, raise vehicle operating costs, and contribute to frequent road closures and load restrictions that disrupt freight and passenger mobility (Paterson, 1987; World Bank, 1995).

Several national reviews have linked these outcomes to persistent weaknesses in infrastructure asset management and institutional capacity. Maintenance backlogs, constrained budgets, fragmented governance between national, provincial and municipal authorities, and shortages of skilled technical personnel have been identified as key drivers of declining pavement and bridge condition (DBSA, 2022; South African Human Rights Commission, 2021). Even where condition data and technical assessment tools exist, their influence on budgeting, prioritisation, and project implementation remains inconsistent.

Empirical studies confirm a long-term downward trend in pavement condition across much of the non-national network. Performance analyses based on pavement condition indices and ride quality measures show steady depreciation driven by traffic loading, climate effects, ageing materials, delayed maintenance, and overloading (Blaauw, 2022).

Figure 1 illustrates a typical pavement deterioration trajectory expressed in terms of International Roughness Index (IRI) under different climatic conditions and maintenance strategies. In the absence of timely heavy maintenance interventions, pavement roughness increases steadily over time, with deterioration occurring most rapidly in humid climatic regions. In contrast, regular maintenance interventions maintain IRI values within acceptable limits throughout the analysis period, demonstrating the critical role of asset management and preventive maintenance in sustaining pavement performance (Blaaw, 2022).

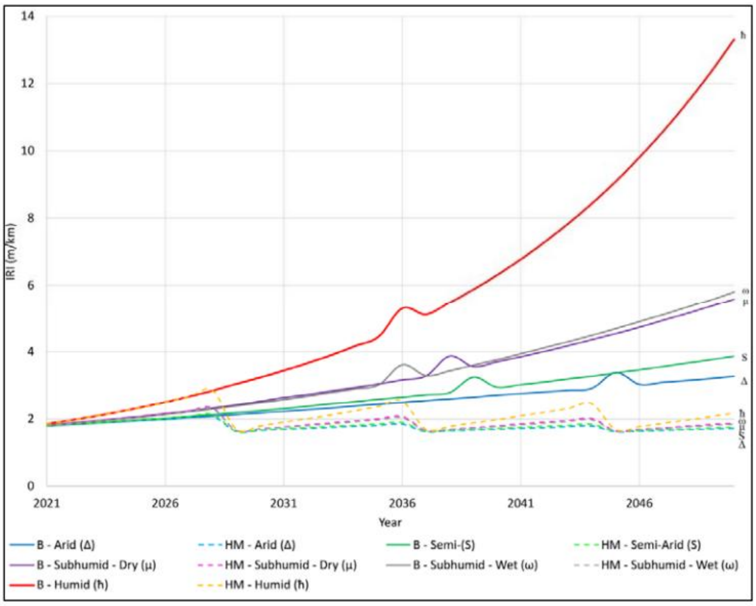

Figure 1: Pavement roughness (IRI) deterioration over time under different climatic conditions with and without heavy maintenance (adapted from Blaauw, 2022, Figure 5)

In response to these challenges, South Africa's transport infrastructure is undergoing a digital transformation to improve resilience, extend asset life, and enable evidence-based planning. This shift is being led by national and provincial agencies, often in partnership with the Council for Scientific and Industrial Research (CSIR), to develop integrated systems that respond to maintenance backlogs and systemic inefficiencies. This section focuses on four key systems, each designed to address a specific failure mode in the road and bridge network: the Abnormal Loads System, Road Asset Management Systems (RAMS), the PotholeFixGP mobile application, and the STRUMAN Bridge Management System.

1.1.1. Abnormal Loads System

Oversized or heavy vehicles, commonly referred to as abnormal loads, pose significant risks to public infrastructure, particularly bridges and pavement layers. In response, the Abnormal Vehicle Registration (AVR) system was developed with support from the CSIR to streamline and regulate the movement of these loads. The system captures vehicle and payload data, calculates permit fees, recommends escort or speed restrictions, and automates the issuance of digital permits (CSIR, 2025a). This process strengthens compliance with overload regulations and ensures that only authorised vehicles access the network, reducing the likelihood of accelerated road deterioration. A similar approach has been adopted regionally; for example, Namibia's Roads Authority upgraded its permit software to align with Southern African Development Community (SADC) standards, with technical input from CSIR consultants (Roads Authority of Namibia, 2015). Figure 2 shows an abnormal load vehicle under inspection and Figure 3 shows an abnormal vehicle carrying an abnormal load.

Figure 2: Abnormal loads system (CSIR, 2025b)

Figure 3: Abnormal Loads Vehicle (PVK, 2026)

1.1.2. Road asset management systems

Road Asset Management Systems (RAMS) provide an integrated platform for recording, monitoring, and planning interventions across road networks. These systems combine various modules, such as Geographic information systems (GIS)-based registries, Pavement Management Systems (PMS), Unpaved Road Management Systems (URMS), Bridge Management Systems (BMS), and roadside and traffic inventory databases, into a single decision-making tool (Tamrint, 2018; CSIR, 2025b). South African frameworks such as Technical Methods for Highways (TMH)-22 formalise RAMS architecture, outlining that an effective system should integrate asset inventories with traffic and condition data to support lifecycle planning (SALGA, 2021). With CSIR's technical support, RAMS have been implemented across provincial and municipal levels, enabling more effective prioritisation of maintenance and more transparent allocation of resources see Figure 4 (CSIR, 2025b).

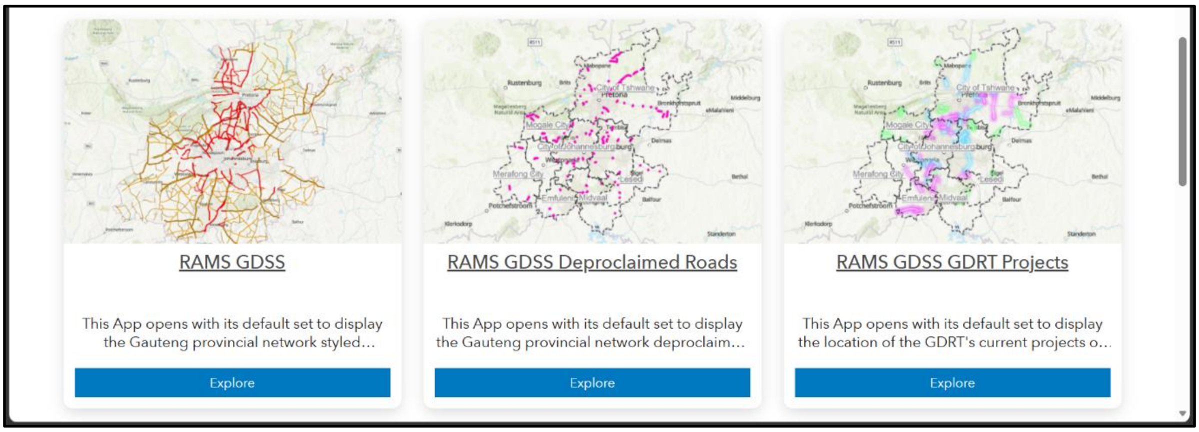

Figure 4: Various RAMS applications (also referred to as "Viewers")

1.1.3 PotholeFixGP Mobile Application

In response to widespread road surface damage, the Gauteng Department of Roads and Transport (GDRT), in partnership with the CSIR, launched the PotholeFixGP mobile app in 2023. The app allows users to report potholes using GPS-tagged images and descriptive inputs submitted via mobile devices (CSIR, 2025a). Each report is logged with a unique case number and tracked through a public dashboard, from initial assignment to closure. This system improves transparency and maintenance responsiveness (Figure 5). By crowdsourcing defect data, the app enhances early detection and complements scheduled inspections. Early adoption figures indicate high public engagement and demonstrate the value of digital tools in participatory infrastructure governance.

Figure 5: Layout of PotholeFixGP Reporting Page

1.1.4 STRUMAN Bridge Management System

The STRUMAN Bridge Management System (BMS) is a structured platform developed by the CSIR for prioritising and planning bridge maintenance (Figure 6). Since its adoption in the late 1990s by agencies including SANRAL and the Western Cape Department of Transport, STRUMAN has provided a modular framework comprising Inventory, Inspection, Condition, and Budget modules (Nell et al., 2000). Structural data such as geometry, materials, and hydraulics are recorded in the inventory module, while inspections focus on 21 structural elements using a visual assessment scale. Severity and relevancy ratings are applied to each defect to calculate Condition and Priority Indices, which in turn inform budget planning (Kruger, 2003). This system enables authorities to move from reactive interventions to planned, lifecycle-based bridge asset management, Figure 7 shows a deteriorating bridge undergoing rehabilitation.

Figure 6: Struman BMS login interface

Figure 7: A deteriorating bridge under rehabilitation (Van, 2010)

Collectively, these four systems reflect a growing shift toward data-informed, technology-enabled infrastructure governance in South Africa. Grounded in local institutional experience and supported by applied research, they offer a replicable model for sustainable asset stewardship.

2. Methodology

This study adopts a qualitative research approach based on semi-structured interviews with key stakeholders involved in the development and use of transport decision-support systems. The objective of the methodology is to understand how these systems were conceived, developed, implemented, and utilised in practice, and to identify institutional and organisational factors that influence their effectiveness.

Data were collected primarily through semi-structured interviews with system developers, project leaders, and technical specialists who were directly involved in the design and implementation of the selected systems. This approach aligns with established qualitative research methods that seek to capture expert perspectives in complex, context-dependent environments (John W. Creswell, 2014). Interview responses were analysed using a thematic approach to identify recurring patterns and insights (Virginia Braun and Victoria Clarke, 2006), and subsequently synthesised into system-specific case studies. The use of case study analysis is consistent with exploratory research strategies for examining contemporary phenomena within real-world contexts (Robert K. Yin, 2018). Lessons emerging from these case studies were then integrated to inform the discussion, conclusions, and recommendations.

The methodological process consisted of four main stages: system identification, system selection, stakeholder interviews, and data synthesis.

2.1. System identification

An initial survey was distributed to current and former employees of the CSIR transport research unit to compile an inventory of decision-support systems developed for the South African transport sector over time. The survey collected basic descriptive information, including system name, development period, intended purpose, and the infrastructure management problem addressed. This process produced a long list of candidate systems from which a smaller subset was selected for detailed investigation.

2.2. System selection

From the identified systems, a subset of tools with high relevance to the current state of South Africa's transport infrastructure was selected for detailed analysis. Selection was guided by the following criteria:

- relevance of the system to contemporary infrastructure management challenges in South Africa;
- evidence that the system had been implemented, piloted, or deployed within industry or government;
- availability and accessibility of developers or team members involved in the system's development for interview participation; and
- potential for the system, if implemented effectively at network level, to contribute meaningfully to the restructuring and improvement of transport infrastructure management practices.

Based on these criteria, four systems were selected for inclusion in the study.

2.3. Stakeholder interviews

Key stakeholders associated with each selected system were identified through purposive sampling and invited to participate in semi-structured interviews. Participants were selected based on their direct involvement in the design, development, implementation, or ongoing management of the systems, ensuring that responses were grounded in technical and operational expertise (John W. Creswell, 2014).

A total of six (n = 6) participants were interviewed across the four systems. For the Abnormal Loads System, three participants were interviewed, including individuals involved in system development and ongoing implementation. For the Road Asset Management Systems, including the PotholeFixGP application and STRUMAN Bridge Management System, three participants were interviewed, both of whom are actively involved in system coding, management, and maintenance.

Although the sample size is limited, participants were selected for their specialised knowledge and direct responsibility within each system. This aligns with qualitative research approaches that prioritise depth of insight and information-rich cases over large sample sizes (Guest et al., 2006). These systems are highly specialised, with a limited pool of individuals directly involved in their development and operation, making expert-based sampling both appropriate and necessary.

The interviews were designed to explore seven thematic areas:

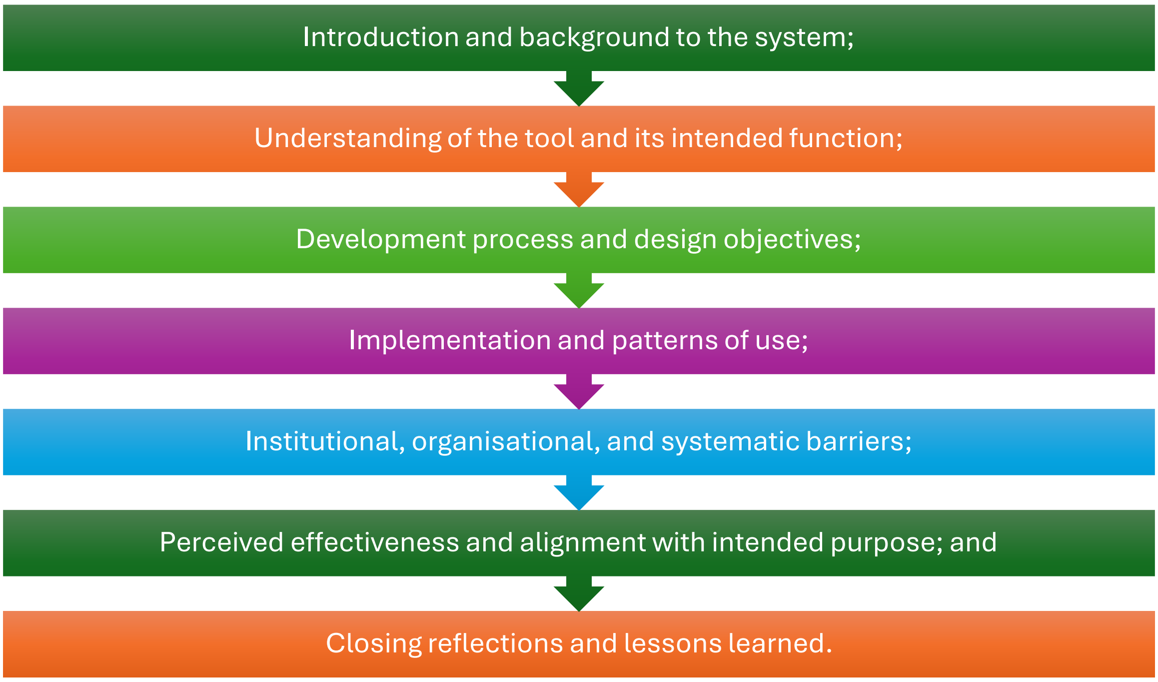

Figure 8: Interview thematic areas

All participants provided informed consent prior to participation. To protect confidentiality, participant names and institutional affiliations are not disclosed in this paper.

2.4. Data analysis and synthesis

Interview data were analysed thematically using a structured coding approach informed by the predefined interview protocol. The protocol was organised around key thematic areas, including system design, development processes, implementation, governance, and institutional capacity, which provided an initial analytical framework for coding.

Interview recordings were transcribed, and responses were systematically reviewed and coded according to these thematic categories. Additional sub-themes were identified inductively where new patterns emerged from participant responses, allowing for both structured and exploratory analysis. Coding and data organisation were conducted manually using tabular methods in Microsoft Excel to group responses, compare perspectives, and identify recurring patterns across participants.

For each system, findings were synthesised into an individual case study presented in the results section. Cross-cutting themes were subsequently identified across the case studies to support comparative analysis, with particular emphasis on recurring barriers, implementation gaps, and institutional factors influencing system uptake.

These insights informed the discussion, conclusions, and recommendations presented in the final sections of the paper.

3. Case studies: Are the Systems Achieving Their Intended Use? Examining the Gap Between Development, Implementation, and Network-Level Uptake

This section assesses the performance of four infrastructure management systems, Abnormal Loads System, Road Asset Management Systems (RAMS), the PotholeFixGP application, and the STRUMAN Bridge Management System, against their intended purposes. Drawing from interviews with developers and implementation stakeholders, the analysis considers how far each system has progressed from conceptualisation to meaningful use, particularly at the network level.

3.1. System Implementation, Intended Use, and Operational Challenges

3.1.1. Abnormal Loads System

The Abnormal Loads System was created to support permitting decisions for oversized and heavy vehicles by assessing proposed loads against the structural capacity of road and bridge assets. It was intended to be a routine decision-support tool for infrastructure protection, flagging unacceptable loads or routes, automating permit fee calculations, and recommending route-specific conditions such as escort vehicles or reduced speeds.

In practice, implementation has not achieved the intended network-wide uptake. While the system has been embedded in certain provincial departments and used effectively to regulate abnormal transport operations, this use has been partial and largely dependent on the initiative and capacity of local institutions. Interview data revealed that the system's core technical capabilities are sound and well-validated, but its application has often been project-based or limited to pockets of activity rather than mainstreamed as part of standard operations.

Interviewees described challenges including inconsistent budgeting, weak institutional ownership, and limited formal integration into regulatory processes. In some departments, there was no designated entity mandated to maintain or update the system, resulting in operational neglect. While it has successfully supported infrastructure-aware permitting in select regions, its broader impact has been constrained by fragmented adoption and the absence of enforceable regulatory embedding.

3.1.2. Road Asset Management Systems, PotholeFixGP, and STRUMAN Bridge Management System

Road Asset Management Systems (RAMS) were envisioned as comprehensive tools for strategic infrastructure oversight. They aggregate condition assessments, inventory data, and traffic information to enable lifecycle-based planning and prioritisation. According to interview accounts, RAMS are deployed in various provincial and municipal departments, often with CSIR's support. However, system usage tends to be disconnected from annual budget cycles or departmental decision-making frameworks, limiting its ability to guide funding allocation or maintenance schedules at a network level.

Key barriers cited include fragmented data availability, misalignment with procurement and reporting timelines, and a lack of high-level policy directives enforcing RAMS integration. Some departments still rely on ad hoc inspections or reactive maintenance models, undermining the system's potential to shift practice toward predictive, condition-based strategies.

The PotholeFixGP application represents a different approach: using public participation to identify surface defects in real time. Launched as a collaborative initiative to crowdsource data from motorists, it achieved initial success in public adoption and generated significant volumes of pothole reports. Interviewees noted that it created a clearer picture of urban road degradation and helped elevate the political visibility of maintenance backlogs.

Despite its value in data collection and civic engagement, the app's overall impact was limited by implementation gaps on the backend. In many cases, the authorities responsible for responding to reported issues lacked the staffing or procedural alignment to close the feedback loop. Without active follow-through, the risk emerged of the system becoming a reporting tool without corresponding repair capacity, raising citizen expectations while failing to improve infrastructure outcomes.

The STRUMAN Bridge Management System was designed to provide structured, prioritised assessments of bridge assets. It integrates inspection-based ratings with budgeting modules to inform targeted maintenance planning. The system has been adopted by several departments, and in some cases, it remains in routine use. However, interviews revealed that adoption is highly dependent on dedicated personnel. Once key staff leave or shift roles, institutional knowledge is often lost and system use declines.

As with the other systems, STRUMAN's success was tied more to continuity in funding, staffing, and policy support than to its underlying technical quality. Departments with high turnover, lack of maintenance budgets, or weak asset management mandates tended to underutilise or abandon the system, even where initial uptake had been strong.

The implementation trajectories of the four systems are summarised in Table 1, which highlights the extent of progress across three key stages: initial development, operational implementation, and eventual uptake at network level. This synthesis draws directly from interview responses and offers a comparative lens through which systemic bottlenecks can be identified and addressed.

Table 1: Comparative Progress of Infrastructure Management Systems Across Key Implementation Stages

System	From Idea to Development	From Development to Implementation	From Implementation to Network-Level Uptake
Abnormal Loads System	Successfully developed to assess infrastructure capacity for abnormal vehicle permitting.	Partially implemented in select provinces; strong technical base but uneven institutional integration and	Network-wide integration lacking; limited by inconsistent funding, low prioritization from authorities, and absence of formal

		reliance on project-level champions for uptake.	mandates. Risk of infrastructure damage if underutilized.
Road Asset Management System (RAMS)	Designed as a strategic tool to support lifecycle-based planning, with GIS, PMS, URMS, and BMS modules. Concept fully developed	Implementation varies across provinces; where used, it aids planning, but data availability and institutional buy-in remain uneven.	Integration into budgeting and planning cycles is limited; often sidelined by reactive maintenance cultures and short-term political priorities.
PotholeFixGP App	Successfully launched to improve reporting of road defects; developed collaboratively between GDRT and CSIR.	High public uptake and media visibility; effective in crowdsourcing defect data.	Backend responsiveness from authorities inconsistent; without follow-through, risks being a data sink rather than a tool for actual repair prioritization.
STRUMAN Bridge Management System	Developed for structured bridge inventory, condition assessment, and budget prioritization.	Adopted in several agencies; system functionality proven, but longevity tied to staff retention and institutional ownership.	Inconsistent use over time; when key personnel leave, knowledge and usage often fade. Lack of mandate and sustained funding weakens long-term effectiveness.

Across all four systems, the common thread emerging from interviews is not technical failure, but implementation inertia. Each tool was designed to strengthen evidence-based planning, improve transparency, and prolong infrastructure lifespan. However, their long-term use has been hindered by structural misalignments, such as non-mandatory adoption, lack of governance ownership, inadequate funding for updates or training, and limited integration into broader policy instruments.

While there are pockets of successful application, none of the systems has yet achieved sustained, full-network institutionalisation. This suggests a significant gap remains between development and consistent, long-term implementation. Future uptake may require regulatory reform, embedded mandates, and formal alignment with budgeting and reporting frameworks to close this gap and realise the systems' intended impact.

4. Key Lessons and Recommendations from the Case Studies

The four case studies underscore critical insights into the lifecycle of digital infrastructure systems, from their design to real-world application. While each system targeted a specific gap in transport infrastructure management, their trajectories reveal shared systemic challenges. The findings point to the conclusion that the value of a tool lies not only in its technical sophistication but also in the institutional environment into which it is introduced.

4.1. Key Lessons

- Technical merit is necessary but not sufficient

All the systems examined, whether focused on permitting, asset management, public reporting, or structural prioritisation, were built on solid analytical and engineering principles. However, strong design alone did not guarantee meaningful uptake. In every case, the degree of implementation success correlated less with the system's technical performance and more with factors like institutional ownership, leadership support, and the presence of formal integration mechanisms.

- Operational continuity depends on secure, long-term funding.

Most systems benefited from early-stage investment during development and pilot phases. However, this support often did not extend into operational phases. Interview insights highlighted a recurring pattern: systems that lacked dedicated, sustained funding streams for software updates, training, and institutional integration were prone to stagnation or abandonment, regardless of their proven utility.

- Institutional capacity and skills determine depth of use.

The effectiveness of each system hinged on the availability of internal capacity, both human and organisational. Where teams had technical training, data management systems, and decision-making frameworks aligned with the system, the tools were used as intended. Where capacity was thin or organisational workflows resisted change, system use became tokenistic or dropped altogether.

- Accountability must follow visibility.

In tools designed to promote transparency, such as the PotholeFixGP app, visibility of infrastructure faults did increase. However, this visibility alone did not ensure remediation. The absence of reliable downstream processes, repair crews, budgeted maintenance plans, or performance tracking, meant that citizen engagement data often went unacted upon. Transparency tools without response capacity risk eroding public trust rather than improving service delivery.

5. Conclusions

This paper set out to assess the extent to which digital infrastructure systems developed by the CSIR and partner institutions have achieved their intended use. The findings reveal a consistent pattern: technical quality is not the primary limiting factor, systemic, institutional, and organisational barriers are. All four case studies demonstrate that even well-designed tools can fail to achieve network-level impact when support systems, such as secure funding, skilled personnel, and aligned decision-making structures, are weak or absent. To close the gap between development and meaningful use, infrastructure systems must be supported by regulatory mandates, sustainable resourcing, and institutional structures capable of turning insights into action. Without these, digital tools risk becoming isolated successes in design rather than drivers of long-term infrastructure transformation.

References

Blaauw, J. (2022) *Flexible pavement performance and life-cycle modelling under South African climatic and traffic conditions*. PhD thesis, University of Pretoria, Pretoria.

Braun, V. and Clarke, V. (2006) 'Using thematic analysis in psychology', *Qualitative Research in Psychology*, 3(2), pp. 77-101.

Council for Scientific and Industrial Research (CSIR) (2025a) *Asset management*. Mobility and Logistics page. Available at: https://www.csir.co.za/what-we-do/mobility-and-logistics/asset-management (Accessed: October 2025).

Creswell, J.W. (2014) *Research design: Qualitative, quantitative, and mixed methods approaches*. 4th edn. Thousand Oaks: Sage.

Council for Scientific and Industrial Research (CSIR) (2025b) *GDRT in collaboration with CSIR launch the PotholeFixGP app for Gauteng motorists*. CSIR Media Room. Available at: https://www.csir.co.za/gdrt-collaboration-csir-launch-potholefixgp-app-gauteng-motorists (Accessed: October 2025).

Development Bank of Southern Africa (DBSA) (2022) *Beyond the Gap: Transport Sector Report*. Midrand: DBSA.

Guest, G., Bunce, A. and Johnson, L. (2006) 'How many interviews are enough?', *Field Methods*, 18(1), pp. 59-82.

Kruger, E.J. (2003) 'A South African perspective on bridge management and some unique problems encountered', *Proceedings of the PIARC International Seminar on Managing Road Infrastructure*, Durban.

Nell, A.J., Nordengen, P.A. and Newmark, A. (2000) *A bridge management system for the South African Western Cape*. Pretoria: CSIR Built Environment Research Report.

Paterson, W.D.O. (1987) *Road deterioration and maintenance effects: Models for planning and management*. Washington, DC: World Bank.

PVK (2026) 'Gallery | Pretoria Vervoerkonsultante | Client images', *Pretoria Vervoerkonsultante*. Available at: https://pretoriavervoerkonsultante.co.za/about-us-37-years-experience/gallery-client-images/ (Accessed: 10 April 2026).

Road Traffic Management Corporation (RTMC) (2023) *State of Road Safety Report 2022/2023*. Pretoria: RTMC.

Roads Authority of Namibia (2015) *Annual Report 2014/2015*. Windhoek: Roads Authority.

SALGA (2021) *Model for municipal road asset management system: Background and recommendations*. Pretoria: South African Local Government Association.

South African Human Rights Commission (SAHRC) (2021) *Inquiry into the state of road infrastructure in the Eastern Cape*. Johannesburg: SAHRC.

South African National Roads Agency SOC Limited (SANRAL) (2023) *Integrated Annual Report 2022/2023*. Pretoria: SANRAL.

Tamrint, R. (2018) ‘Road Asset Management Systems’, *Journal of Infrastructure Engineering*, 5(4), pp. 123-134.

Van, R.H. (2010) ‘CSIR system contributes to well-maintained bridges : transport logistics’, *CSIR Science Scope*, 5(1), pp. 20–21. Available at: https://doi.org/10.10520/EJC29713.

World Bank (1995) *Highway development and management tools (HDM)*. Washington, DC: World Bank.

Yin, R.K. (2018) *Case study research and applications: Design and methods*. 6th edn. Thousand Oaks: Sage