Optimal Standards for Effective Infrastructure Delivery

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***Abstract*— Optimal standards for road infrastructure may have different meanings to different road authorities, but to most, an optimal standard means the most appropriate standard under the circumstances, taking account of a combination of factors such as road safety, cost benefit ratios and affordability as well as other external factors. The standards adopted by a road authority for the construction and maintenance of infrastructure are a combination of its own development, and the standards researched and developed by renowned institutions and research boards around the world. The optimization of standards and processes is not an attempt to challenge or ignore best practice, but rather to adapt these standards to the context and challenges that are faced.**

A common challenge is the decline in funding levels for road infrastructure, affordability and the growing backlog in road maintenance - not only in Africa but worldwide. In solving this problem countries have found relief in increasing their funding through State tolls and PPPs. Others use their best endeavors to optimize the use of available funding, Countries like South Africa have had the benefit of both.

The focus of this paper is to demonstrate how, in the South African context, SANRAL has optimized its processes and standards in the delivery of road infrastructure since its inception in 1998. Key areas discussed in this paper are the development of an effective asset management system as well as the implementation of toll, long term performance contracts, and concession projects. This electronic document is a "live" template and already defines the components of your paper [title, text, heads, etc.] in its style sheet.

Keywords—optimal standards; infrastructure delivery; SANRAL; Public-Private - Partnerships;

I. INTRODUCTION

A common challenge for road authorities is the decline in funding levels for road infrastructure, affordability and the growing backlog in road maintenance - not only in Africa but worldwide. In solving this problem countries have found relief in increasing their funding through State tolls and Public-Private -Partnerships (PPPs). Others use their best endeavors to optimize the use of available funding, Countries like South Africa have had the benefit of both.

The South African National Road Agency (SOC) Limited (SANRAL) is a corporate entity operating at arm's length from Government and was created out of the need by Government to separate the roles of policy maker and operator in the infrastructure delivery of National departments in order to remove conflict of interests and improve effectiveness.

SANRAL was established in April 1998 by an act of Parliament and is mandated to, inter alia, develop and maintain the National road network, both toll and non-toll. SANRAL finances its operations from various sources, including annual grants from National Treasury, loan financing from primarily the domestic market, income from State tolls, and off-government balance sheet financing in the form of PPPs. The National Road network has grown from a mere 6900 km at inception to 22214 km in 2018.

The focus of this paper is to demonstrate how, in the South African context, SANRAL has optimized its processes and standards for effective delivery of infrastructure since its inception in 1998, and mainly in the following areas:

- Optimize the use of available funding from the fiscus and additional financing from State tolls through the asset management and the supply chain systems for effective infrastructure delivery.
- To extend SANRAL's funding capability through optimized and performance driven PPPs.

II. ASSET MANAGEMENT SYSTEM (AMS)

Asset management in SANRAL has over the years developed into a state-of-the-art system for the execution of the asset management activities. This is performed in a methodical and coordinated manner with the objective of determining the optimum strategies in the development and maintenance of the national road network at an adequate level of service for the available funding. To do this, extensive knowledge of the condition of the road network is obtained through regular surveys over the entire network. An important objective of these surveys is to capture the information as timely as possible to avoid any adverse environmental and traffic loading influences. This necessitates the development and acquiring of automated data acquisition systems, including some manual methods. A significant amount of effort is placed on data collection as this data forms the basis of the decision-making process.

The most important optimization in the delivery cycle is the interaction between available budget, the selection of the optimal asset preservation strategies and implementation. Optimisation selects one strategy for each uniform network sections so that the established network objectives are met while not exceeding the budget. If zero budget is available, the AMS selects the do-nothing strategy for each uniform pavement section. If an infinite budget is available, the AMS selects the best strategy for each uniform pavement section. Between these two extremes optimization takes place by using the incremental benefit cost technique to find the most economic strategy for each uniform section without exceeding the budget. The investigative optimization happens after the AMS calculates the incremental benefit cost for all strategies on all the uniform sections.

South African roads are built with thin surfacing's when compared with typical pavements of America and Europe. This has the advantage of savings in construction cost, in the order of 60 % without sacrificing design life. However, the thin surfacing's, be they asphalt or chip seals, do require regular maintenance in order for the pavement to reach its full design life. Implementing an effective routine road maintenance program has been a key factor in SANRAL achieving effective assent preservation of its road infrastructure. In the AMS work programming procedure, there is no true do-nothing option, the minimum strategy for each network section is a routine road maintenance program.

Figure 1 illustrates the asset management cycle with all the elements and activities in the optimization process.

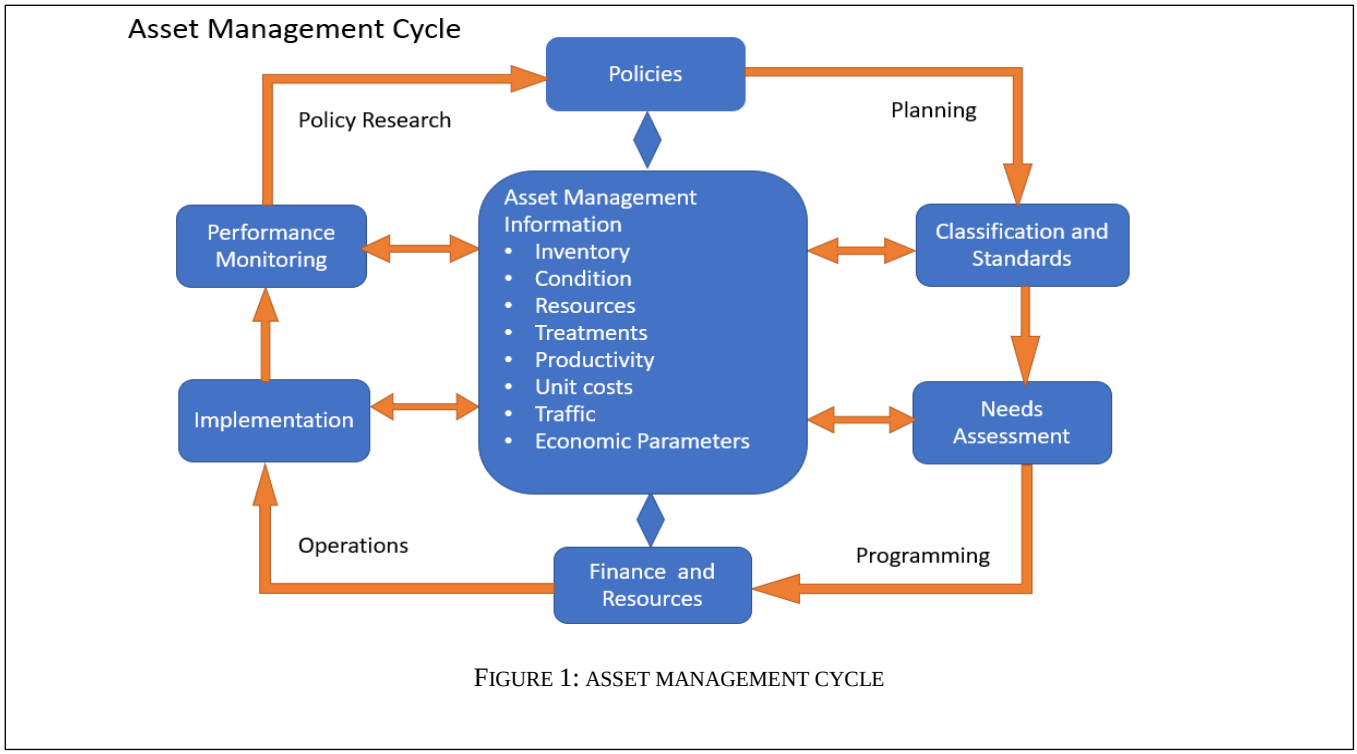

FIGURE 1: ASSET MANAGEMENT CYCLE

Asset management brings a perspective to the way SANRAL takes a long-term view of optimization and performance in infrastructure delivery. It is driven by policy goals, processes and standards, needs, finance and resources, rate of return, implementation and performance monitoring. Most of the optimization goals takes place and impacts on almost all aspects of SANRAL's business.

The other part of the optimization in effective delivery of infrastructure and services takes place in the supply chain through fit for purpose contract arrangements, processes and standards. As reflected in the recent Standard for Infrastructure Procurement and Delivery System (SIPDM), infrastructure delivery is the combination of all planning, technical, administrative and managerial actions with the supply, refurbishment, construction, rehabilitation, maintenance and operations of infrastructure.

The South African Government's Infrastructure Delivery Management System (IDMS) comprises three core systems, namely, a planning and budgeting, a supply chain management and an asset management system, all of which have forward and backward linkages. These core systems are located within portfolio, program and project management, and operation and maintenance systems. Collectively these processes and systems, together with a performance management system (comprising various standards), establish the institutional system for infrastructure delivery as indicated in Figure 2

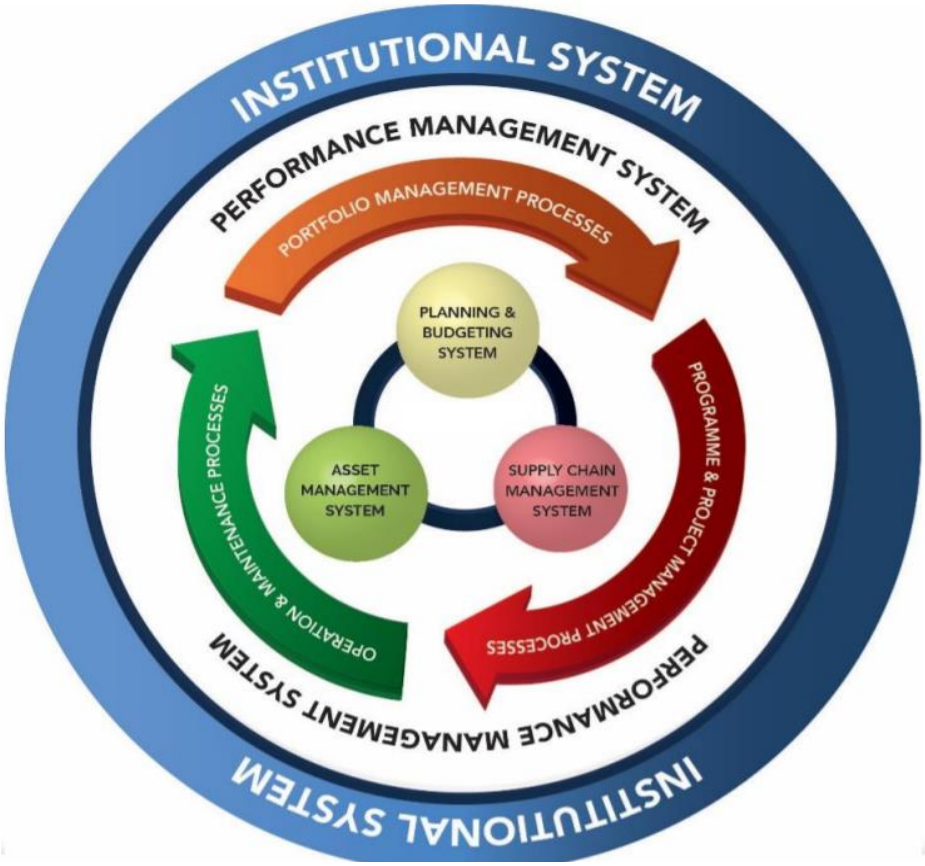

FIGURE 2: INFRASTRUCTURE DELIVERY MANAGEMENT SYSTEM

Underlying this standard is the notion that the effective and efficient functioning of the supply delivery chain management system for the procurement and delivery of infrastructure will realize value for money through the optimization of processes and standards, i.e. a good quality service delivery. Value for money may be regarded as the optimal use of resources to achieve the intended outcomes. Underlying value for money is an explicit commitment to ensure that the best results possible are obtained from the money spent, or maximum benefit is derived from the resources available. It is about striking a balance between economy, efficiency and effectiveness.

A practical way to explain SANRAL's optimization efforts in effective infrastructure and services delivery, is to describe the optimisation in the type of contracts, processes and standards applied since its inception.

III. Consulting Engineering Agreements

Prior to the inception of SANRAL in 1998, agreements with consulting Engineers were awarded on a roster system. After 1998, SANRAL embarked on a competitive tendering system where the adjudication points for eligible tenderers were weighted between functionality and price where functionality reflected competence and experience. After the enactment of Preferential Procurement Act in 2002 tenders were made more accessible for previously disadvantaged and emerging consultants. Adjudication criteria were then changed to functionality, price and preference, where preference was weighted between 10 to 20% of price. In 2011 National Treasury decided to take functionality out of the point system and use it as an eligibility criterium (or gateway) before the price (90%) and preference (10%) are calculated in the points system.

The procurement of experienced consulting engineers is a crucial aspect in the optimization of processes and standards for infrastructure delivery. In the traditional Employer-Consulting Engineer-Contractor relationship, quality of the design, tender documentation and contract supervision are key to optimization and value for money. However, whether competition for professional services extracts the best value for money is an issue that requires further investigation There is some evidence to suggest that competitive bidding for consulting engineering services has led to much greater overall project delivery cost. It has also lead to lower standard of services provided by consulting engineers. Despite many efforts to close the loopholes and ensure properly priced tenders, undercutting of prices resulted in non-optimal designs in many instances and sub-standard documentation. This increases the costs of construction of projects far greater than the cost saved by competitive bidding. A further disadvantage is that this doesn't allow for proper development of design options and training of young engineers. The increased demands of procurement procedures means that SANRAL project managers spend more time dealing with procurement processes and subsequently have less time to focus on providing a technically optimized engineering solutions.

IV. Construction contracts

Despite the occasional deviation with good merits, the mainstream construction contract for non-toll and State toll projects is based on the FIDIC Conditions of Contract for Works of Civil Engineering Construction. Optimization of this procurement is driven by:

- Compliance and consistency in the applicable procurement and Treasury rules – selecting the best value for money.

- Quality documentation, open tender and award processes in line with prescribed procurement standards
- Fit for purpose design standards as informed by available funding through asset management system- not less than minimum requirement standards and no compromise on road safety.
- Acceptance of value engineering proposal from contractors that may include modification and alterations to standards, subject to contract conditions.
- Considering where feasible and allowable in terms of the tender rules, alternative tenders providing better value for money which, inter alia, may include suggested changes to standard specifications and contract provisions.
- Proactive and experienced Engineer's supervision.
- Seeking solutions to current disruptions in the industry and normalise community participation in all infrastructure development processes to optimize production and growth.

V. MAINTENANCE CONTRACTS

Historically routine road maintenance of national roads was carried out by the relevant (jurisdictional) provincial road authorities on a force account basis. Between 1985 and the early 90's the routine road maintenance function was reincorporated in the then Chief Directorate Roads of the Department of Transport and carried out on a competitive tender basis. After the inception of the South African National Road Agency Limited in 1998 the routine road maintenance model (Schedule of Quantities Contract) was further developed to become a hybrid between an end product-, a method- and a performance specification. So, in stark contrast to the previous uneconomic and inefficient force account method of procurement, all new routine road maintenance was procured on a competitive basis. Established small and medium size contractors dominated this market and to maximize their success in the open tender competition, they first opted to rather labour enhance their construction team in the maintenance contract as appose to the development of SMMEs in a substructure under the main contract. This was then changed to a management model that compelled tenderers to create a sub level where SMME's could tender for the different activities. Optimization in routine road maintenance comprise, inter alia, the following;

- Introduction of performance specifications where it suits the situation to transfer performance risk to contractor and to save on administration and supervision costs.
- Selection of optimized road lengths per project in the maintenance portfolio.
- Use of latest technologies on site - certificates generated on the SANRAL's central database system.

- Latest technology is using dash cam cameras with GPS for daily route patrols which give an immediate view of defects on the road, these footages are also stored on hard drive for claims verification.
- The implementation of route patrols makes reporting of defects and fixing thereof faster.
- Site personnel using smart phones to issue job instructions, requests and inspections of work.
- Using WhatsApp as communications platform to expedite communication on site and for record purposes.
- Capturing workers and service providers' details and expenditure on the central database/ computer system to monitor trends and simplify reporting etc also captures all the subcontractors used on site and their expenditure. This simplifies reporting to other authorities like the Department of Labour.

VI. Construction Contract for State Toll roads

All procurement of infrastructure and services for State toll roads are procured by SANRAL and is similar to the procurement for non-toll roads. The only differences are that State toll roads are financed from private sector loans and all income and expenditure are accounted for separately in accordance with the South African National Road Agency Limited Act.

VII. Operations Contract for State Toll roads

The most important contract relevant to State toll roads is the operations contract. At inception of SANRAL the operations contract for State toll roads was structured in a very fragmented way in that the operator had to enter into various selected subcontracts with amongst others a Toll Equipment Integrator, a mechanical contractor, a Plaza Maintenance Contractor, a Equipment Maintenance Contractor etc. where SANRAL was partly responsible for performance and associated risks under these nominated contracts. To establish a single line responsibility between employer and operator and transfer the full operations risk to the operator, SANRAL embarked on a *Contract for Toll Operations and Maintenance and Routine Road Maintenance Contract* (CTROM) with a duration of 5 or 8 years. Routine Road Maintenance which was historically a separate contract, could be included under plaza and route operations to eliminate duplication and to increase the economy of scale. The aim with this was to increase the plaza operations and maintenance capacity in the country and ultimately the competition. However, this only worked marginally during the first tranche tenders, where after only the contractors who traditional tendered for the work participated and subcontracted the routine road maintenance work to contractors operating in that space.

Optimization in operations revolves mainly around the:

- Competitive contract structure with fixed and variable quantities where tender amounts are quite often varying by less than 3% on a tender amount around R 600 million.
- A single line responsibility with operator carrying full operations risk. As the Operator is in the best position to manage the subcontracts, the low premium for taking this risk and the downscaling of consulting supervision turned out to be more cost effective.
- Introduction of electronic toll collection as opposed to very costly plaza expansions.

VIII. DESIGN, BUILD AND OPERATE (DBO) CONTRACT MODEL FOR TOLL AND ITS CONTRACTS

The implementation of a toll system for the Gauteng Freeway Improvement Project (GFIP) required SANRAL to consider an appropriate contract model for the implementation of a very sophisticated toll system. The GFIP was implemented as a state implemented toll project and as a result SANRAL (not a concessionaire) was responsible for the implementation and operation of a toll collection system. An open road toll system was required to manage the estimated 2,5 million daily transactions. The procurement model had to optimize the following:

- Implementation cost
- Operational cost
- Risk transfer
- Single point of responsibility
- Customer services

To achieve the above, a Design, Build and Operate (DBO) contract model was adopted. SANRAL developed the scope of project deliverables and the user requirement specifications. Tenderers were required to provide a tender price based on the above stated requirements in terms of a detailed schedule of rates.

The model addressed the above optimization requirements as follows:

A. *Implementation & Operational Cost:*

A competitive tender environment is the primary way in which to ensure optimized tender pricing. However, there are two distinct phases in the project namely the system delivery and toll operations. Since the contractor will operate the system designed and build by himself, an inferior toll system at potentially lower cost will result in higher operational cost to the contractor, since the contractor had to optimize the costs associated with the future 8 years of toll operations. In order to provide the contractor with an opportunity during the tender process to demonstrate value for money to SANRAL, a compliance matrix had to be completed as part of the tender submission. The compliance matrix showed the contractor's current toll system capability, and the potential cost savings to SANRAL if certain user requirements don't need to be implemented. Although these savings were not

considered during the tender evaluation phase (did not change the tender price), the contract allowed for a project optimization phase after the tender award where SANRAL together with the contractor could agree to changed user requirements with an associated adjustment to the contract price.

B. *Risk transfer, Single Point of Responsibility & Customer Services*

Similar to the objective of the CTROM model, it is important that the risk for the toll system development, toll system operation and toll system maintenance is transferred to the contractor. The contractor in terms of the DBO contract model has a single responsibility for all of the above. The contractors' performance is managed in terms of a Key Performance Indicators (KPI's) regime. The contract also makes the contractor responsible for all revenue losses in the event that the said revenue is not collected as a result of the contractor's non –performance. The contractual KPI performance regime includes thresholds at which the contractor receives an incentive payment or is penalized in accordance to different performance bands.

The KPI regime also monitors the contractor's performance with respect to customer services. The KPI regime provides a balance between protecting SANRAL's exposure to revenue loss and incentivizing the contractor to perform in terms of the contract, thereby promoting optimum revenue collection under the contract as well as the provision of customer services and compliance with audit and financial reporting requirements.

IX. PUBLIC-PRIVATE-PARTNERSHIPS – N1 NORTH

Public-Private-Partnerships were introduced in South Africa at a time when constraint spending by Government on large infrastructure and services was recognized as a major stumbling block for continued growth and development. While the expansion of State toll roads appeared to be an obvious route to close the growing funding gap, National Treasury decided to cap the State guaranteed loan funding to a limit of 6 billion Rand which would severely restrict the development of State toll roads.

In response to this, the then Department of Transport, Chief Directorate Roads attempted to finance the proposed N1 North between Bela-Bela and Polokwane (300 km) on a limited recourse financing deal. However, due to delays in the passing of enabling legislation and uncertainties in the financial markets at the time because of the change in Government, the deal was structured as long-term State-guaranteed Performance contract, better known as a Design-Built-Maintain.

The contractor was required to procure the funding (State guaranteed), design, construction and maintenance over a 23-year period in exchange for a State guaranteed revenue stream that was to be derived from actual tolls to be collected on the route by the SANRAL. Even though this project

could not be financed as an off-Government balance project, the following optimizations made it worth a while.

- Good documentation and clear tender instructions gave rise to responsive and innovative bids.
- The contractor carried the risk of interest rate fluctuations, the nature and mix of the loan funding, the adequacy of the cost estimates on which the funding amount was based and exchange rate fluctuations. Project finance was structured to mitigate the financial risk, i.e. inflation linked bonds.
- Contractor carried full design and construction risk e.g. to date this is the only project where a G1 crushed stone base was built at a thickness 125 mm (optimum thickness for minimum stresses under loading) as appose to the traditional 150mm (for constructability reasons). This gave rise to a massive saving in G1 material in exchange of taking more construction and pavement performance risk.
- The contractor carries the pavement performance risk for the entire 23-year project period. The road pavement performance is monitored on performance-based criteria/specifications including, inter alia, road roughness, surface friction, rut depth, deflections, faulting and macro texturing.
- The contractor needs to hand the pavement back at specified residual life conditions, which ensure that SANRAL will have adequate time to plan, design and construct follow up pavement and capacity upgrades.

X. PUBLIC-PRIVATE -PARTNERSHIPS – CONCESSION CONTRACTS

Following from lessons learned of the N1 North regarding the enabling environment requirements for limited recourse private sector financing, the South African National Road Agency – still part of the Department of Transport prior to inception in 1998 – spearheaded this process and commenced in 1995 with the conceptualization and development of three major projects – the N4 Maputo Development Corridor, the N3 Toll Highway and the N4 Platinum Toll highway.

General optimization areas for the concession projects include inter alia the following:

- Off government balance sheet financing release funds from fiscus for utilization on other non-toll projects.
- Concessionaires carry the full finance, toll collection, construction, operation and maintenance risk.

- As the full function above is delegated/concessioned it requires less resources from SANRAL.
- Concessionaire must hand the road back after concession period at specific hand back conditions/residual life.
- The Concessionaire must within reason conform to improved standards over time, e.g. when traffic volumes necessitates the change from manual to electronic tolling.
- The concessionaire fulfills an employer's role and carries out its own quality assurance, which leaves the freedom of innovative pavement strategies/designs.

XI. CONCLUSION

While the lack of funding and scarce resources are the main drivers behind optimization in the asset management and supply chain systems, road safety plays an intricate role in both optimizations. On the asset management side, data is required in order to correctly prioritize maintenance interventions. The optimization needs to ensure that funds are allocated to the selected strategies to ensure the best asset preservation for the available budget. On the supply chain side, the optimization of processes and standards may require less or more funds from the budget than what was allocated. The cross links or methodology through which the budget, asset management and supply chain systems informs each other to find the optimal solutions in effective delivery, are entrenched in policies and supply chain framework of controls.

Although SANRAL had limited application and success on the so-called Product Performance Guarantee System through the normal run of the mill construction contracts – mainly because of the higher risk exposure for contractors on small performance-based contracts – The PPP projects that was undertaken since the inception of SANRAL proved that large and long term (20 to 30 years) performance contracts are better manageable from a risk point of view. Not only because of the spreading of risk over many uniform sections, but due to the opportunity to stretch the limits of affordability within a ring-fenced environment with limited funds and minimum requirements. This, more than often, leads to innovative phasing of capacity and pavement enhancements over time.

As historic funding levels from the fiscus have always indicated the need for supplementary funding, SANRAL should further pursue different user pays funding models through PPPs.

Those setting the procurement rules should consider a more optimized model for the procurement of consulting engineers for quality design, documentation and supervision. More weighting should be put on quality and less on price. If a tender price comes in below the optimum point of value for

money, quality starts declining. It is better to spend more to maintain a high standard of design, documentation and supervision, than to pay a high premium during construction.