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## Asset-management framework(s) for infrastructure facilities in adverse (post-conflict/disaster-zone/high-alert) conditions

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### Abstract

Public works departments have responsibility to manage and operate (transportation/water/power) infrastructure assets through careful planning and adoption of appropriate (facility) management techniques. Efficient asset-management becomes all the more important for countries subject to post-conflict/post-disaster adversity, not only to reactivate essential services, but also because programs that stimulate civil-engineering industry participation contribute much to recovery rates and can make-up 10% of a (recovering) nation's Gross Domestic Product. A good asset-management model needs to address key activities, communicate respective interconnectivities, and realize best practice. Limited study has been done into asset-management model frameworks that link directly with the change-management strategies required by recovering societies; this presents an obstacle to the prompt implementation of essential asset-management systems in sectors operating in adverse conditions. Asset-management techniques able to take account of the full range of factors in less stable environments require to link contributory variables including: dynamic user-needs analyses, life-cycle analysis, national design specifications, building codes, prefabrication opportunities, procurement routes, and project management tools towards re-build/retro-fitting. This early stage research project presents progress thus far in developing an integrative asset-management framework for infrastructure facilities in adverse/high-alert conditions using a multitude of North African case-study locations. Discussion centers upon developing framework(s) as a basis for workable procedures able to be amended with regard to (changing) design specifications/standards/legislation. Secondary research is presented that addresses the need to integrate economic whole-life evaluation techniques, asset-management tools and scopes in flux, and the extent to which such examination allows future development of flexible change-management for adverse situations towards incorporation into an integrative asset-management framework for infrastructure and civil engineering assets.

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## 1. Introduction

The construction industry contributes a significant percentage to the total Gross Domestic Product (GDP) of both developed and developing countries. In the United Kingdom, for example, the construction sector employs over one and half million people and accounts for 10% of GDP, making it a very important segment of the economy (Corporate Watch UK 2004). Other than established/developed nations, countries that are somewhat less stable or perhaps subject to post-conflict or post-disaster adversity, also require the construction industry to continue to contribute to their respective ongoing recovery; in Libya for example, the construction industry accounts for 6.3% of GDP and employs about 4% of the total workforce (Gherbal et al. 2012). Indeed the contribution of the construction industry to GDP in many countries ranges from 7% to 10% for developed countries and approximately 3% to 6% for developing countries (Lowe 2003). Thus, it can be argued that the state of building and heavy engineering affect measures of a nation's economy, notably GDP, the availability of capital, and the employment rate (Wibowo 2009).

The construction industry helps build and maintain necessary public infrastructure and (in some cases private) physical structures related to mechanical and electrical services, commerce, water and power (Wibowo 2009). Often, it is a nation's specific (public works) department of infrastructure that is directly charged to control and operate and maintain specific assets through careful planning and adoption of appropriate (facility) management techniques (Gherbal et al. 2012).

Infrastructure engineering is vital to the economic wellbeing of a nation, notably its hospitals, universities, public department buildings, roads, bridges, clean water systems, drainage/sewerage/sanitary systems, and metro-transit-facilities (Farran 2006). These infrastructure developments are subject to deterioration as a result of climatic effects, negligence, natural disaster and, not least, conflict, war and (resultant) (mis)management. Mistreatment and negligence of public infrastructure can occur due to insufficient funding or unsuitable support technologies (Vanier 2001) and can lead to costly repair or replacement as well as tragic technical/engineering failure (Wirahadikusumah 1999). In other words, infrastructure requires best practicable operational and maintenance control in order to retain respective safety standards in-use, as well extending usable life-cycles within budgetary constraints (Farran 2006).

The lack of available funds and a non-alignment of maintenance budgets for example, make future rehabilitation and necessary refurbishment difficult. The (creation and) maintenance of infrastructure faces many challenges such as elevated labor and material costs (due to the haphazard and somewhat ill-defined nature of the various tasks in retrospective refitting of facilities across life-cycles), as well as continually growing usage-networks, increased accountability aligned to public expectations and not least the need for repair outside periodic programs as a result of unexpected damage from conflict and disaster. Population growth (and refugee influx) is also a factor that can lead to accelerated deterioration of infrastructure and consequently increased concerns over safety, environment and congestion (Soti and Habing 2009). There is a clear need for an objective (both proactive and reactive) decision support system to optimize the usage of available funds through cost effective solutions (Farran 2006). This is true not only for stable environments but also national infrastructure in conditions of flux. It is argued that the construction industry plays a major role not only in shaping the environment but also in the development of society's quality of life. Therefore, providing a structured mechanism to best allocate (infrastructure) resources can make a major contribution to the stabilization and subsequent (re)development of society (Al-Sedairy 2001).

Beyond the need for best use of funds, newly developing nations and those emerging from conflict face many challenges including the need to reassess existing building-standards, poor quality-systems measurement, a lack of reliable data, relatively low productivity rates of construction workers in an uncertain environment, and resistance to change; Gherbal (2012) finds that most countries are likely to experience similar obstacles in their construction industry even though their economies are stable. Taking North Africa as a case in point, the construction industry has yet to achieve its full potential, and faces problems coping with the competitive challenges previously discussed within an ever changing market (Gherbal et al. 2012).

To cope with uncertainty and risk, there has been a world-wide trend by all industries (including the construction industry) towards a more structured (asset-management) approach to infrastructure monitoring. While this trend has

been demonstrated in most developed countries (notably the USA and the UK (Urquhart 2006)), there seems to be no or at least very limited evidence of this trend in (newly/) developing countries (Aabuzayan 2011).

The concept of asset-management has gained acceptance in (developed) countries such as Australia, USA, UK, and several newly stable environments such as Kuwait. Other countries are progressively adopting and implementing asset-management principles as their regions (re)develop (Kiwelu 2009). A successful implementation of asset-management requires that, in developing stable countries, the construction industry re-evaluate its methods of doing business; for example, the industry needs to focus on the life-cycle aspect of product/infrastructure rather than on the initial capital cost; this requires also a series of changes in specific management methods, organizational structure, and the overall approach to infrastructure decisions. Furthermore, growth requires not only a clear appreciation of all the activities related to the asset-management techniques, but also real commitment to change-management, investment in resource training and reward, consideration of life-cycle costing perspectives, enhancement of data collection and storage, as well as the adoption of *structured* approaches (Kiwelu 2009); *asset-management* provides a framework for handling both necessary short-&-long-range planning (FHWA 1999).

Given discussion above of asset-management opportunities, the following section clarifies the specific problem that *adverse environments* require a (more) structured approach to controlling facilities over their whole-life span.

## 2. Problem statement: change-management integration

Currently, several asset-management frameworks exist, but there are no reference-models documenting all key activities *and* change-management strategies, for the implementation of asset-management. This lack is an obstacle to the prompt implementation (needed in adverse conditions) of an asset-management system in a sector or an organization. A good reference model needs to explain all key activities, outline their flow, communicate and recommend the best practices during the entire implementation process (Kiwelu 2009); there are limited structured guidelines that show the key activities of successfully implementing/integrating all concept variables timeously.

Asset-management application and benefits have not yet been clearly documented to take account of the full range of factors in less stable environments. Thus, change-management, life-cycle costing approach, data quality, training (human resource perspectives) and standardization must play a major role (with a challenge to not only identify, but also factor-into implementation strategies of asset-management) (Kiwelu 2009). Also, due to the relatively long life-cycle of infrastructure assets, the whole/life-cycle approach is becoming increasingly important in related long-term investment decisions by society as it seeks best usage from its facilities. The life-cycle costs approach, according to the NSW Treasury (2004), is central to asset-management; conducting benefit cost analysis requires both the total capital cost and present net (future) worth, thus LCC as an integrated procedure, requires increasing recognition in asset-management tool(s).

Summerell (2005) claims that by applying asset-management procedures, both private and public sectors may go towards improvements in the efficiency and effectiveness of service delivery. Such improvement could be achieved by reducing operating and maintenance costs, improving delivery timescales and better managing value. In order to apply a successful asset-management framework to public sectors many challenges must be overcome. Being able to recognize those challenges will help to design value-adding strategies with the development of alternative solutions.

## 3. Secondary research: asset-management procedures and implementation

The secondary research discussion below reviews studies which have sought to examine asset-management procedures and implementation. Much literature has shown that there are major challenges to public sectors in adopting and implementing public asset-management. A study by Vanier (2001) examined the need for decision-support tools for municipal-type organizations, and determined the challenges for maintenance, repair, and renewal planning faced by asset owners and managers. He found that the needs were: unified data integration, improvement and standardization of currently obtainable tools, information exchange and technology transfer, and a need to address the lack of willingness to adopt asset-management principles by both the employees and senior-management. Also, this researcher discovered that the integration with newly computerized systems such as maintenance management, geographic information corporate legacy systems were perceived as the major challenge

for developing and using decision-support approaches in the area of asset-management. He recommended additional research in areas such as life-cycle analysis and service-life prediction.

A study was also undertaken by Hanis (2011) aimed at identifying the main challenges faced by a local government in a newly-developing region when adopting a public asset-management framework. The findings indicated there were significant challenges that the (Indonesian case-study) government had to manage when adopting a public asset-management framework: the absence of an institutional and legal framework to support the asset-management application; the non-profit principle of public assets; multiple jurisdictions involved in the public asset-management processes; the complexity of local government objectives; the non-availability of data for managing public property, and limited human resources. Hanis recommended that the (case-study) government address these challenges before accepting and applying a developed asset-management framework. The findings of this study are in line with another study undertaken by Hokoma (2010). Hokoma's study aimed to investigate the present status of the implementation levels of quality and manufacturing management techniques and philosophies within the Libyan iron and steel industry. The study revealed that the overall implementation status of total-quality-management TQM, just-in-time JIT and manufacturing-resource-planning MRPII (building upon materials-requirement-planning) was, at that time, at a most basic level of application even when it was indicated that these techniques and philosophies had been formally implemented. His study also showed that there was a lack of knowledge of key management techniques and their benefits across the surveyed industry. Of concern was the lack of senior management support indicated by *all* the respondents as an obstacle for non-implementation of the TQM practices. A recent study undertaken by GONDO (2012) reviewed the practices, challenges and policy options used in municipal-asset water and sanitation sector(s) in newly-developing countries. The results indicated that the water sector had gone through a number of reforms but had *not* resulted in any knock-on cascade into improved infrastructure asset-management. Lack of financial resources, human resource expertise and appropriate organizational strategy had constrained the adoption and application of systems-software for effective asset-management. The researcher recommended that, in order to improve asset-management in the water and sanitation sector (of this developing region), there is a need to address: the absence of an asset-management plan; the limited financial capability by the local authorities; the shortage of experienced personnel; the absence of a supportive organizational strategy; and, the lack of stakeholder commitment.

Asset-management systems then, require a full appreciation of the variables concerned and a commitment to implement the factors in a structured way and not least an appreciation of the challenges to be overcome. The range of variables to improve structured approaches is discussed in more detail below.

A study by Lemer (1992) identified the need for (new) national infrastructure policies requiring public infrastructure managers to acquire explicit *revenue* from public assets, thus moving from the old perception that public infrastructure are 'free goods'. That revenue, he reported, must be allocated to the department of infrastructure for future maintenance of public infrastructure assets. Such policies, he added, should address and seek to avoid being syphoned-off, as various levels of maintenance-management can result in (politicians) making decisions based on their own personal gains or political agenda. An example of this is (politicians) deferring necessary maintenance and using funds for a political agenda towards the creating 'jobs' or show-case projects towards placating the electorate. Lemer states a vital need for a non-aligned specialized expert groups (*such as the American Association of State Highway and Transportation Officials AASHTO*) to be responsible for technical leadership in the national development of infrastructure policies, publication of specifications and examination of protocols and guidelines, as well as to be a point of contact for any issues related to national or international infrastructure needs and impacts. Lemer concluded by emphasizing the need for public education as well as exploring partnership with private companies, to go towards better management of public assets in the long-run.

Another major challenge for public sector management of infrastructure assets is the availability of funds. Dornan's study (2010) aimed to develop a remedy for addressing the fiscal challenges facing highway infrastructure. This research explored asset-management in light of recent developments in the funding, conditions, documentation, and management of the USA's highway infrastructure. Dornan found that asset-management was an effective response to the fiscal challenges confronting the US highway infrastructure as it encouraged the public private partnership notion that would necessitate state and local transportation agencies to seek efficient ways in which the highway infrastructure is managed. He suggested a Governmental Accounting Standards Board (GASB-34) role for asset-management in order to increase accountability for public owned infrastructure and promote improved

management of long lasting capital assets as well as enabling public agencies to finance implementation of asset-management techniques and renewal of infrastructure assets through ‘covenants’ aligned with securitization or ‘shadow-tolling’. Shadow tolling, he stated, offers a helpful mechanism for generating a positive revenue stream to support securitized highway bonds. His study concluded that asset-management could be an effective process for helping the expansion, rebuilding or maintenance of any highway infrastructure.

Earlier research by Lemer and Wright (1997) demonstrated that improved infrastructure performance is achievable in spite of various obstacles (mentioned before) facing asset managers. The researchers undertook an integrated program, namely, the infrastructure innovation (I2) partnership, aimed at transferring research, education and technology to design, produce and publish new knowledge (knowledge management) that enables and encourages enhanced infrastructure performance, and a management and decision-support system. They found that a management system would provide responsible managers with significant information on the status and performance of their current infrastructure system and would provide a means for discovering how future demands and management policies may impact performance. Lemer and Wright argue improvement can be attained by: increasing the overall returns of the public assets and changing the old belief that the public assets are ‘free goods’ (albeit without suggesting how this might be done); improving the scope, efficiency and reliability of infrastructure technology; improving the effectiveness of human resource involved in the design, construction, operation, maintenance of an infrastructure; acquiring more knowledge of infrastructure behavior and then using that knowledge to improve design/ management; and, improving efficiency/reliability of infrastructure services delivery.

The researchers proposed an intelligent-infrastructure-management-system IIMS framework as a computer-based management tool that would apply advanced information collection and management technologies to provide more efficient, accurate, and effective bases for making decisions about infrastructure. The IIMS will combine a balance sheet (management report for accurate assessment of the value of infrastructure), an income statement, condition-assessment, predictive modelling such as LCC, scenario development, and user-friendly information-access capabilities. This suggested integrated procedure has yet to be put into any practical application.

Another study examining asset-management tools for municipal infrastructure planning in the construction industry was carried out by Vanier (2001). Based on a literature review, the study aimed to recognize the extent of the asset-management market in North America; the study found that there was a need for decision-support tools for municipal-type organizations, and identified the challenges for life-cycle (maintenance/repair/renewal) costs planning faced by asset owners and managers. His study categorized various stages for asset-management using the six ‘What’ questions: What do you own? What is it worth? What is its condition? What is the remaining service life? What is the deferred maintenance? The responses to these questions provided information on the currently available tools and techniques for asset-management. From this data, Vanier developed an asset-management framework with each ‘what’ establishing a growing framework for asset-management plan implementation. This study, however, did not discover any comprehensive solution that addresses the current and future needs for investment planning for municipal engineers and managers unlike the study by Lemer and Wright which was able to identify more criteria for an effective asset-management framework. However, Vanier considered integration with existing systems such as computerized maintenance management, geographic information, and corporate legacy systems to be the most significant challenge for developing and using decision-support tools in the area of asset-management.

A further study, which reviewed the goals of infrastructure asset-management, identified the core processes of infrastructure asset-management as well as developing an AM framework, was carried out by Too (2009). A multiple case design that allowed replication logic and interviews was used to gather data. His results showed that cost efficiency, capacity matching, meeting customer needs and market leadership were the main goals of AM. Two main barriers to the adoption of AM were observed: a ‘step-child’ status that is often bestowed upon asset-management groups within organizations; a lack of any strategic approach; and, contentious statements of what constitutes asset-management. Asset planning (capacity-management/options-evaluation), asset creation (procurement/delivery) and asset operation (maintenance management) were the core processes of Integrated AM. Too indicated information management as central to the effective performance of all the other processes. Somewhat excluded it is argued here, from Too’s illustration is an explicit inclusion of any Life-cycle costing analyses.

Too (2010) undertook another study in order to develop approaches that could be adopted in order to overcome challenges and improve the performance of the assets of Brisbane Airport (BAC). Through a Case study approach data were collected from various interviews with senior managers responsible for the management of infrastructure

assets as well as from a literature review. The challenges and approaches that were identified, were categorized as broad strategic core processes required to contribute to the achievement of asset-management goals. However, a need remains for future research to develop improved management processes to achieve optimal solutions. In order to develop a descriptive framework for strategic-infrastructure asset-management that can be applied to various types of infrastructure assets such as roads, rails, utilities, airports, seaports, a study was prepared by Too et al. (2006) through a review of the research on current asset-management practices in-use. The framework which he developed based on previous frameworks examined in his study, consists of three core components: strategic analysis, strategic choice and strategic implementation. Too et al. stated that an integrative strategic infrastructure asset-management framework is important as it is presented as a process model, is generic and can be applied to various types of infrastructure assets. His developed framework, presented as a process model, is generic seeks to be applicable to various types of infrastructure assets.

Other studies have examined asset-management methods. Brighu (2008), for example, investigated the viability of asset-management methods and their prospective contribution towards enhancing water service utility. A case study was chosen for this study, namely, a water utility serving Jaipur in India. A generic asset-management framework was developed and applied to this case study. The research indicated that it is possible to take a 'low-cost' first step towards asset-management, but it requires a change in the management approach. However, the study found that a lack of relevant data was a crucial factor influencing an effective and comprehensive application of a generic asset-management framework. Another study, carried out more recently, by Younis and Knight (2012) in Ontario Canada aimed at developing an integrated asset-management framework for wastewater collection systems. A case study based on real data presented the use of business intelligence tools to implement, monitor, and report various components of the developed framework. The researchers developed a new integrated asset-management framework for wastewater collection systems using a modified balanced scorecard model. The elements of the proposed management framework and modified balanced scorecard were developed based on multiple collaborative working sessions held in 2009 during the first Canadian National Asset-management Workshop (CNAM 2009). The framework took into account social/political, financial, operational/technical, and regulatory perspectives. This framework, the researchers stated, would only be suitable for waste water utilities and waste water collection. Some asset-management frameworks then, might be argued to be discipline specific; this presents a challenge for authorities seeking to adopt a generic system to manage facilities.

Another comprehensive building asset-management framework was developed by Elhakeem and Hegazy (2012). The proposed framework based on a two-phase optimization procedure was evaluated in a large school environment in the USA. The framework had a unique formulation in which all functions from inspection, to deterioration modelling, and life-cycle analysis, tracked the dynamics of building deficiencies, arguing that frameworks could assist, they stated, organizations with large building assets to enhance the overall condition of their inventory with the highest return on the limited repair budget. This framework developed and integrated versions of other frameworks mentioned earlier. It might be argued here that a Pareto's law (20:80 weighting) of input/output variables might enhance applications above for limited budgets to have most benefit, across a wide range.

As can be seen from this brief literature review, management of infrastructure changes as a result of difficulties triggered by many factors such as technical, economic, environmental (natural disasters providing an example), political (and not least the need to recognize explicitly, war and internal/cross-border conflict as big factors), human resources and social challenges. These factors have not yet been addressed in totality and this represents a gap in the current knowledge. In other words crises as a result of natural or man-made disaster have not been incorporated as criteria of concern in asset-management frameworks. Crises are inevitable challenges for projects (Mallak et al 1997). Traditional engineering management techniques for managing infrastructure require review, not only to meet the need of all key players when developing infrastructure management framework (namely regulators, policy makers, infrastructure managers, users and operational staff), but also, to address the vital need for an integrative approach that allows infrastructure decision-makers to deal with conditions in flux. Consequently, this study is being designed to develop an integrative asset-management framework for infrastructure facilities in adverse (post-conflict/disaster-zone/high-alert) conditions.

#### 4. Objectives, method and potential significance

The main aim of this on-going (early stage) project is to develop Integrative Asset-Management Framework(s) for Infrastructure Facilities in Adverse (post-conflict/ disaster-zone/ high-alert) Conditions, using Libya, Egypt, Tunisia and the surrounding region as a representative location; this framework will form the basis of workable and flexible sets of comprehensive procedures able to be amended with regard to specifications, design, standards, human resources and legislation (when appropriate) as well as accommodating the cost of whole-life values.

The Department of General Infrastructure for Libya sits nicely as a suitable location for case study (Five branches throughout Libya are available, namely Tripoli, Benghazi, Misurata, Sebha and Zawia) as well as the main infrastructure departments of border countries such as Tunisia and Egypt. Specifically, the objectives of the project are as follows: (i) with regards to *economic-evaluation-techniques*: to examine various economic evaluation techniques; to determine the current economic evaluation techniques utilized by nations in environments of flux, specifically; Libyan (five main cities), Egyptian and Tunisian main infrastructure departments; to determine the barriers, if any, preventing or slowing the adoption of the most efficient and effective techniques in these countries. (ii) with regards to *asset-management techniques*: to examine the major current asset-management frameworks utilized in developed and alternatively newly developing regions; to determine the current asset-management techniques utilized by the infrastructure departments in (high-alert) zones of interest such as Libya (five cities), Egypt and Tunisia; to identify factors, if any, preventing or slowing the adoption of AM techniques. (iii) With regards to *human resources*: to evaluate senior-management involvement in the adoption of asset-management techniques; to examine the relationship between managers and employees as well as between employees; to evaluate the managers and employees' willingness to adopt new asset-management techniques using new advanced technology. (iv) with regards to *change-management*: to examine the standards, specifications, design and regulations that have been set by the main infrastructure departments in the regions identified above addressing crisis management; and, identify how case-study departments of infrastructure deal (/dealt) with required change.

The above objectives, it is hoped, lend themselves to populate input for the development of a flexible change-management structure able to be amended with regard to design, standards and legislation in adverse situations and then to be incorporated into a proposed integrative asset-management framework.

This study utilizes a case study approach at the early stages. This case study incorporates literature reviews, individual interviews and document analyses. The early work of this project is being carried out in the following sequence: (A) Detailed analysis of the *literature review*: a suitable economic evaluation technique identified from the range of existing techniques in order to be then integrated into a proposed future development of a new asset-management framework; the current asset-management frameworks being analyzed to identify the gaps; and, review of current change-management strategies in the construction field. (B) *Qualitative data collection* through semi-structured interviews and questionnaire surveys with senior managers and civil engineers responsible for the management of infrastructure assets at the main department of infrastructure in the three regions (discussed above and including the five cities in Libya, as well as Egypt and Tunisia) to identify: current asset-management techniques, current economic evaluation techniques, factors, if any, affecting the adoption of the latter techniques; their familiarity of life-cycle costs perspective(s) and procedures of an infrastructure asset; the extent of the senior-managers' involvement in the adoption and support of asset-management techniques, as well as, relationships between managers and employees; and, current change-management strategies. (C) *Documents analysis* to examine: the infrastructure departments' policies and procedures; current design, specifications, standards and regulations utilized by the three infrastructure departments with relation to managing infrastructure assets; their respective change-management strategies, if any, regarding the management of adverse (post-conflict/disaster-zone/high-alert) conditions; opportunities to expand upon existing techniques towards the development of updated frameworks; and project outcome and significance clarifications of a deliverable integrated asset-management approach in adverse conditions.

Management of infrastructure is changing as a result of growing difficulties triggered by technical/software-input expectations, economic-imperatives, environmental stabilization after (natural) disaster, socio-political adversity and conflict, and resources challenges in conditions of skill shortage and enhanced asset/facility need. This study will go towards the development of an integrated infrastructure asset-management framework that includes: a flexible and amendable change-management structure that can be adapted by infrastructure departments (in North Africa) that

adapts to uncertain conditions. A deliverable is sought that structures procedure to help in amendment of specifications, standards, and design/legislation to suit a certain conditions, for conditions in flux. The ongoing results are addressing management processes: through life-cycle cost analysis of infrastructure assets; human capital strategies; information and technology resources; and, monitoring and feedback mechanisms. As stated above, a study addressing adverse conditions (post-conflict; disaster-zone; and high-alert locations) is somewhat absent from current academic review; this work strives to fill this present gap.

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