Successful System Deployment through Operational Readiness

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“Where then does wisdom come from? Where does understanding dwell? ... But it is the Spirit in a man, the breath of the Almighty, that gives him understanding.”
– Job 28:20 and 32:8
About this book

Operational Readiness (OR) falls within the ambit of SE Transition Process and it seeks to assure successful System Deployment of newly-built systems. However, even at this juncture, at the dawn of the ‘Fourth Industrial Revolution’, OR remains one of the least developed practices of both Project Management (PM) and Systems Engineering (SE).

As a result, satisfactorily completed ‘systems’ (e.g., satellites, aircrafts, mine shafts, power plants, road and rail networks, hospitals, and schools completed on time, on budget, and to specifications) are often failing to add value by providing improvements in their intended operational environment. In numerous cases, System Deployment is also accompanied by adverse and detrimental effects on the business and operational environments, and at times on the broader environment (e.g., persistent pollutions, negative economic externalities, exacerbation of social ills like deprivation and crime).

Completing any ‘system’ on-time, on-budget, and to specifications, real-life experience and recent studies suggest, is but a “basis” for improving operations. Notwithstanding the need for any ‘system’ that is being developed to eventually attain maturity (i.e. fully implemented product) and readiness (i.e. fitness for intended purpose), the imperative of securing a sustainable ‘Capability Readiness’ is rather achieved by way of eliciting operational requirements from both ‘system’ owners and users at the project outset and, subsequently, by validating that such have been satisfied before start of operations.

Systems would fail when operations are not ‘made ready’ to safely receive and, thus, efficiently and effectively utilise them. This difficulty largely arises from two situations, (1) the misplaced focus of many lifecycle methodologies on constructability rather than on operability, leading project managers into thinking that their onus ends at Close-Out, and (2) the absence of a holistic framework for Operational Readiness (OR). This book seeks to address the latter; hence, it discusses the processes and challenges of deploying the Solution-System (product) into its intended operational environment.

In its format and content, this material is devised to meet the needs of various readers; (i) Project professionals (to provide them with both knowledge and tools about OR). (ii) Company executives (to increase awareness of the necessity and benefits of OR). (iii) Academia (to kindle the desire to undertake further research on the topic of OR).

It is therefore hoped that the above entities will work together to further establish OR.
Dedicatees

To my God-given wife and children,

To the project management fraternity across the African continent,

I humbly dedicate this work.
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Acronyms

BIM  Building Information Modelling
EPC/M  Engineering Procurement and Construction/Management
ERP  Enterprise Resources Planning
ISO  International Organization for Standardization
NASA  National Aeronautics and Space Administration (USA)
NETLIPSE  Network for the dissemination of knowledge on the management and organisation of Large Infrastructure Projects in Europe
NPV  Net Present Value
PMIS  Project Management Information System
ROCE  Return on Capital Employed
ROI  Return on Investment
Foreword

For decades, the ‘triple constraints’ principle (i.e. completing projects on time, on budget and within specification) has been the bedrock for defining project success. Even though the principle is well known, it is however clear that many projects do not deliver value after they have been completed. As the author has pointed out on numerous occasions within this book, the ‘missing link’ at times is the lack of understanding with regards to Operational Readiness: Making the organisation ready to safely receive and effectively utilise the ‘products of projects’ (which are systems).

During project execution, project practitioners can be so caught up in the delivery of tasks as per the schedule, but often fail to ask themselves critical questions on Operational Readiness. Hence, the project at times becomes a ‘white elephant’. Moreover, some practitioners may even overlook the implications of Human Capital Readiness as it relates to the project. That is why so many products and services end up not being accepted (by stakeholders) or supported after handover.

It is common knowledge that without people, organisations cannot build successful projects or systems. Human Capital Readiness, as pointed out by the author, should become a necessity to the sustainability of the organisation. Having said that, dealing with the ‘behavioural’ component of Operational Readiness is more of an art than science. This might prove a challenge for those practitioners who tend to have a steadfast approach on the ‘science of projects’; this book will actually assist them as it creates a balance between these rather complementary perspectives.

As the author asserts, Operational Readiness is not an aspect to be considered just before handover, but it shall be built-in within the project, right through the end, and verified at Post-Implementation Reviews (PIRs). Like any other profession, project management is constantly evolving and practitioners such as the author are bringing forth the knowledge that is so critical to the effective and efficient running of projects. It is therefore crucial that project practitioners take note and apply the principles articulated in this book – I see its application stretching beyond project management!

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Chapter 01. Introduction

The effective execution of organisational strategies carries the business from a current ‘alpha’ status to a more desirable, more competitive ‘beta’ status. Thus, it brings to organisations the challenges of translating such strategies into project-like initiatives and of relying on proper and effective project management to successfully deliver such projects – and poor implementation has been the nemesis of many brilliant strategies.

A global mining company operating in South Africa noted in their 2013 Annual Report, “The Company captures value across the value chain through its commercial and logistics strategies and by executing its growth projects efficiently, while continuing to deliver on its organisational responsibilities, capabilities and societal obligations”. Companies must be aware that until their ‘growth projects’ are satisfactorily delivered both operations and value creation (i.e. their long-term viability) will be compromised.

At governmental level, it is estimated that the world will need more infrastructure than any nation can deliver. Long-term projections call for an estimated US$ 57 trillion globally to build new and refurbish existing infrastructure between 2013 and 2030\(^{[57]}\). It is hoped that such infrastructure investments will create jobs and, when completed, those projects will help a society increase its wealth and its citizens’ standard of living.

Unfortunately, chronic project failures will affect companies and governments in terms of both strategy realisation and financial performance (e.g., adverse impacts on their Income Statement and Balance Sheet), as well as the ‘overall competitiveness’ of either entities – Poor project performance erodes long-term sustainability. The Independent Project Analysts (IPA) gives a stern warning to companies delivering Large Infrastructure Projects (LIPs), “As we look back over the past 23 years at IPA customers that have disappeared, all but one of them grossly overspent for their capital assets (i.e. LIPs)”\(^{[41]}\). It is therefore crucial that projects, large ones in particular, are reasonably completed.

Completing any system on time, on budget, and to specifications is necessary, but not sufficient to assure sustained improvements in the intended operational environment. A successfully completed system that fails to add value to its operational environment is basically a ‘white elephant’, only good for the beholding – it is a ‘successful failure’, with operational expectations not met, and business promises not being delivered\(^{[08]}\).

Newly developed systems should not be deemed successful unless and until they are successfully deployed in their intended operational environment (having transitioned
from the project realm to operations – where acquired ‘capabilities’ are exploited) to
derive the benefits for the owner-organisation. This looks farther than commissioning.

Therefore, “The successful transition of systems to operations and support, which
includes maintenance and improvements, depends on clear transition criteria that the
stakeholders agreed on”, according to the NASA Handbook of Systems Engineering
(2007)\textsuperscript{[52]}. Moreover, “The purpose of the Transition Process is to establish a capability
to provide services specified by stakeholder requirements in the operational
environment. This process installs {or else deploys} a verified system, together with
relevant enabling systems, e.g., operating system, support system, operator training
system, user training system, as defined in agreements”\textsuperscript{[26]}. This applies to all projects,
be they power plants, mines, road or railway networks, hospitals, factories or aircrafts.

The transition from the project environment (i.e. where the system is delivered) to the
operational environment (i.e. where its capabilities are exploited through ongoing
processes focused on sustaining the organization\textsuperscript{[27]}) generally brings the challenges
of ‘readiness’ of the operational functions. Such functions include to manage, operate,
maintain, support, and dispose of the deployed system; indeed, “Organizational units
cooperate to ... deploy, operate, maintain and dispose of the system-of-interest”\textsuperscript{[23]}.

Readiness as a concept originated from the military; it is defined as: “The capability of
a unit or formation, ship, weapon system, or equipment to perform the missions or
functions for which it is organized or designed”\textsuperscript{[13]} – It shall apply to all ‘systems’\textsuperscript{[23]}\textsuperscript{[51]}. The term readiness is used in a general sense or to express a level or degree of
readiness to transition to operations; hence, its recent application in capital projects
– Operational Readiness (OR) as a project management tool is used to prepare the
‘operational environment’ of the owner-organisation to effectively accommodate the
product or solution, and accept changes resulting from a particular (set of) project(s).
This OR could prove a decisive factor for project success because, as Al-Ahmad argues,
“Few organizations are armed with the necessary infrastructure, education, training,
or management discipline to bring project initiatives to successful completion”\textsuperscript{[02]}.
(Chapter 09 refers to such organisational aspects as part of ‘organisational energy’\textsuperscript{[06]}.)

The Large Infrastructure Projects (LIPs) industry is strewn with ‘corpses’ of projects
that failed due to an inadequate or lack of Operational Readiness. For example, the
colossal 2,350-store New South China Mall (Dongguan) was ‘abandoned’ soon after its
2005 grand opening ... because the remote, inaccessible mall was only 20% occupied. At that point, having successfully completed a facility ‘ahead of schedule’ proves vain.

Particularly when it comes to large infrastructure, it might not make much difference whether the ‘system’ is failing to reach its design capacity or that it has delivered capacity or capabilities in excess of what is required at a certain point in time – either scenarios will still negatively impact on both operations and financial viability. Indeed, the installed capabilities (whether they be in surplus or in deficit, it might not matter) will not be fully exploited through steady operations to generate sufficient returns to recoup the initial investments (capital outlay) and ensuing maintenance expenditures.

When a certain municipality elected to “build that damn thing once and for all”, they ended up delivering a 40 giga-litres water treatment plant, despite indications that the demand will probably remain at around 8.5 giga-litres for the next seven years or so. They deliberately discarded the initial (phased approach) option of installing the plant in four incremental modules of 10 giga-litres to align production throughput to actual demand. But soon after a grand launch, they turned and accused ‘technical consultants’ of misleading the municipality into building the massively oversized facilities; it is now proving costly to operate and maintain “all four 10 giga-litres units”, while a single unit would have sufficed given the current demand – a failed ‘customer-demand’ readiness.

On the other extreme, the City of Port Elizabeth (South Africa) approved a Bus Rapid Transit (BRT) project in response to increasing pressure on public transport. The BRT was devised to offer a more efficient means of moving passengers and reduce travel time, delay time, and number of stops; it was adopted as an improvement on regular bus services through the combination of features like infrastructure changes in order to provide better operation speeds and reliability. However, the City Press newspaper reported on the 26th April 2015 that, six years on, the 60 buses acquired by the Nelson Mandela Bay Metropolitan Municipality in 2009 for R100 million (to kick-start the BRT system) as part of its “integrated public transport system” were still gathering dust outside a fresh produce market. The same newspaper also wrote that the BRT project, although piloted in 2010, has been plagued by problems and allegations of corruption.

Besides its poor intermodal coordination/network, the BRT system is making use of a median lane configuration (i.e. BRT lane located in the middle of the roadway in a two-way direction, although a mixed flow traffic lane is very problematic). There is no proper shelter for commuters and some pedestrian crossways are not controlled by traffic light.
All these problems have led to the demise of the BRT; “Now this project will never take off and the buses and infrastructure will continue to deteriorate”, a local politician said. Even so, later attempts succeeded in reviving “Libhongolethu” (our pride) BRT system and got it to operate along seven routes despite technical challenges and taxi opposition – Still, not only ‘benefits’ were delayed for years, but they also proved quite inadequate.

The Information and Communications Technology (ICT) as a sector is equally guilty of littering dis-benefits to the business community by failing to meet operational targets; “More often, IT projects fail to achieve most of their intended purpose of increasing productivity, lowering operating costs, improving the quality of work product, and shrinking the time to market ... Billions of dollars have been wasted on failed projects {rather than in reducing carbon-footprint A}, and many highly expensive projects had to be shelved after a short time due to massive resistance from end-users” [02] – Again, the blame for such failures could be placed on a failed or lack of Operational Readiness.

Al-Ahmad proposes a definition of project failure that aligns to Operational Readiness; “Project failure is defined as any project that is set to support the operations of an organization by exploiting the resources ... {but} fails to deliver the intended output ... as well as the project comfortably satisfying the stakeholders and being accepted {as non-detrimental to society} and largely used by the end users after deployment” [02]. This stems from the community of end users not being made ready to efficiently operate a ‘system’ or the latter not being safely accommodated in the intended environment.

Operational Readiness is about accommodating both the system and its impacts on the environment; “Capabilities are exploited in order to achieve outcomes ... {one has} to make some changes in ‘business as usual’ in order to enable outcomes ... outcomes and benefits are what enable you to achieve transformational corporate objectives ... but {one has to} also recognise that they may lead to dis-benefits {in the operational environment}” [18]. In fact, “Business increasingly is seen as a major cause of social, environmental, and economic problems” [47], either by commission or omission; thus, both business and public sector ought to welcome and promote Operational Readiness.

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A The world is preparing to spend $ trillions on infrastructure over the next 20 years; but not everyone realises that failure to integrate climate change into the planning of this infrastructure could lead to major adverse and negative development impacts, e.g., crop losses, traffic disruption, reduced power production and higher energy costs.
Chapter 02. Systems, Systems Engineering and Systems Thinking

Readers who do not need a ‘refresher’ on Systems Engineering may skip this section.

When Louis Armstrong sang, “I see trees of green, red roses too. I see them bloom for me and you ...”, perhaps only those who cherish romance could know what the man was really talking about – a fonder heart might not bring about wonders to every soul! For sure, when he got to the stanza that says, “I hear babies crying, I watch them grow. They'll learn much more than I'll never know. And I think to myself what a wonderful world ... Yes, I think to myself what a wonderful world”, then somebody realised that what one has been taught so far is not all there is to know, nor all there is to be known.

It is amazing what happens to project managers and sponsors when they venture into the world of Systems Thinking and Systems Engineering – What a wonderful world! There is more to be known (beyond what engineering and project management have taught us) about how things should work, how to create a world ‘as it should be’ that is as wonderful as “The colors of the rainbow so pretty in the sky”, as Armstrong put it. But unlike babies project managers wouldn’t cry, though they crave to learn and grow.

If anything, just as ancient navigators used to rely on True-North when embarking on a long journey, project managers should perhaps heed the words of Maya Angelou, “Do the best you can until you know better. Then when you know better, do better”. Infrastructure and ICT projects are becoming larger and more complex by the day, and project management is expected to constantly evolve to remain effective and relevant – academia and practitioners alike are opening a vein of thinking and new approaches.

To return to the so-called ‘practical’ world of large-scale projects, Bar-Yam argues that, “A fundamental reason for the difficulties with modern large engineering projects is their inherent complexity. Complexity is generally a characteristic of large engineering projects today” [05]. He further remarks that, “Complexity implies that different parts of the system are interdependent so that changes in one part may have effects on other parts of the systems. Complexity may cause unanticipated effects that lead to failures of the system, and in terms of emergent collective behaviours of the system as a whole. Such behaviors are generally difficult to anticipate and understand” [05].

A system is defined as, “A construct or collection of different elements that together produce results not obtainable by the elements alone. The elements, or parts, can
include people, hardware, software, facilities, policies, and documents; that is, all things required to produce system-level results” [52]. Haskins and Forsberg put it in simple English as follows, “A combination of interacting elements organized to achieve one or more stated purposes”. The key words here are ‘interacting elements’, without which this ‘combination’ is reduced to a mere ‘grouping of things’ and, therefore, will not necessarily contribute to achieving a common purpose or a set of objectives [23]—From that perspective, both satellites and shopping malls are construed as ‘systems’.

Kossiakoff [32] supports the foregoing definition, as well as its practical implications; “It was noted previously that the term ‘system’ as commonly used does not correspond to a specific level of aggregation or complexity, it being understood that systems may serve as parts of more complex aggregates or super-systems, and sub-systems may themselves be thought of as systems. For the purpose of the ensuing discussion, this ambiguity will be avoided by limiting the use of the term ‘system’ to those entities that (1) possess the properties of an engineered system, and (2) perform a significant useful service with only the aid of human operators and standard infrastructures (e.g., power grid, highways, fueling stations, and communication lines)”. Hence, he further submits, “A passenger aircraft would fit the definition of a system, as would a personal computer with its normal peripherals of input and output keyboard, display, and so on” [32].

Furthermore, “The complexity of a systems is usually determined by the number of parts or activities, the degree of differentiation between the parts, and the structure of their connections ... Complex systems have multiple interacting components whose collective behaviour cannot be simply inferred from the behaviour of the individual components” [21]. Maqsood suggests similarly, “Construction (and ICT) projects are faced with a challenge that must not be underestimated. These projects are increasingly becoming highly competitive, more complex, and difficult to manage. They become problems that are difficult to solve using traditional approaches” [35].

It is common cause that modern ‘man-made’ systems (e.g., missiles, housing estates, bridges) and systems of systems (i.e. independently useful systems incorporated into a larger system that delivers ‘unique’ capabilities) continually increase in complexity. These systems are being increasingly developed by partnerships involving multiple suppliers and developers and often geographically dispersed project teams, involving several key stakeholders with conflicting concerns and requirements.
INCOSE has acknowledged the complex nature of Large Infrastructure Projects (LIPs); “In LIPs there are many complexities. There may be a number of outcomes required by a variety of stakeholders, some seemingly contrary to each other, and many alternative ways to satisfy the requirements all competing for priority and for the same resources and finances”[25] – New and systematic project management approaches are needed.

So in a paper discussing the application of Systems Engineering (SE) to building design, Yahiaoui wrote, “A more focused use of applying Systems Engineering approach to the building design support is presented in response to the ever-increasing complexity of buildings. In particular, this paper addresses all issues of interrelated dynamic optimisation, as local optimisations do not give a global optimisation. The paradigm used here is to extend and particularly to adapt the {SE} work carried out in military and space systems to modern building services by taking into account the semantics of buildings in terms of different engineering fields and architecture issues”[58].

SE is therefore “An interdisciplinary approach and means to enable the realisation of successful systems. It focuses on defining customer needs and required functionality early in the development cycle, documenting requirements, and then proceeding with design synthesis and system validation while considering the complete problem: operations, {phasing and} schedule and cost, performance, training and support, test, manufacturing, and disposal”[23] – ‘Operations’ feature prominently in this definition.

NASA also offers a definition of Systems Engineering that reflects operational needs; “A disciplined approach for the definition, implementation, integration and operation of a system (product or service) with the emphasis on the satisfaction of stakeholders functional, physical and operational performance requirements in the intended use environment over its planned life cycle within cost and schedule constraints”[52].

The International Council on Systems Engineering (INCOSE) has published a Guide for the Application of Systems Engineering in Large Infrastructure Projects. It seeks to reposition the traditional Systems Engineering practices that have been successfully developed and applied on complex projects in the military, aerospace, manufacturing and telecommunications industries, into the context of the construction industry and thereby provide professionals engaged on large infrastructure projects a convenient and comprehensive access to the relevant parts of the system engineer’s toolkit.” [25]
INCOSE further maintains that, “The motivation for introducing SE processes on LIPs is a desire to better manage the risks associated with the likely significant degree of change in the environment and associated scope of the project over the extended timescales. Also, the construction process on LIPs can be complex and therefore would benefit from being carefully planned and controlled through implementation using a structured, systematic approach”[25]. This book shares this perspective regarding LIPs.

Moreover, Systems Engineering processes have been retrospectively identified in the construction of ancient mega-projects. Kasser notes, “Depending on their perspective, authors have written that the activities performed in producing the ancient pyramids, the canals and railways of the 19th century and other systems of the past are those embodied in systems engineering”[30].

The emphasis, however, ought not to have been placed on using Systems Engineering “… to better perform the construction stage of a project. The focus is on the realisation of the designed (or engineered) solution during construction and the transition into service of the resulting built product, and as a consequence, the application of SE practices is concentrated more on the construction process than on the design of the product or on the continuing operation and maintenance stage {i.e. operability}”[25].

One important implication of applying Systems Engineering concepts and principles to enhance project lifecycle methodologies entails a lifecycle that reflects an Operational Environment – with the understanding that projects are primarily about improving the particular environment, which extends the responsibility of project teams (thus linking project success) to improvements (or lack thereof) that occur during operations. The whole idea is about starting the project with the end (i.e. improvements in operations) in the mind of the project team – which is a Systems Engineering principle[49][33].

![Figure 01 – Project Lifecycle in accordance with ISO 15288, by the author][33]
The above SE principle raises the matter of Operational Readiness into prominence, understanding that, in the first place, projects are initiated for the sake of operations. Hence, another major implication of applying SE concepts to project delivery involves the notion of Verification and Validation (V&V)\footnote{\[33\]}, which INCOSE defines as follows:

(i) Verification Process is, “To confirm that all requirements are fulfilled by the system elements and eventual system-of-interest, i.e. that the system has been built right.”

(ii) Validation Process is, “To confirm that the realised system complies with the needs and required functionality of stakeholders, i.e. that the right system has been built.”

Verification and Validation of requirements should indeed take central stage in project delivery because Systems Engineering focuses on managing requirements throughout the project lifecycle\footnote{\[33\]} – This focus (i.e., “It focuses on defining customer needs and required functionality early in the development cycle, documenting requirements”) is key to project delivery as “project management is the application of knowledge, skills, tools, and techniques to project activities in order to meet project requirements”\footnote{\[48\]}. For instance, it was said that the requirements for the ill-fated space shuttle Challenger seemed to be acceptable. But the design, manufacturing, testing, and operation were faulty. Thus, verification was poor – and validation was questionable, because putting schoolteachers and Indian art objects in space does not profit the American taxpayer.

On the other hand, Systems Engineering itself, as a perspective, is based on Systems Thinking, which occurs through discovery, learning, diagnosis, and dialog that lead to sensing, modeling, and talking about the real-world to better understand, define, and work with systems. Further, INCOSE states, “Systems Thinking is a unique perspective on reality – a perspective that sharpens our awareness of wholes and how the parts within those wholes interrelate. A systems thinker knows how systems fit into the larger context of day-to-day life, how they behave, and how to manage them”\footnote{\[23\]}.

Many authors would agree with this statement; “There seems to be a consensus in the literature that you need to apply Systems Thinking to develop solutions to complex problems irrespective of whether you are facing the problems professionally as a trouble-shooter, a systems engineer, a project manager and a diagnostician or if you are facing problems in your personal life, hobby as well as in any other situation.”\footnote{\[30\]}

Still, some authors even offer a mode beyond Systems Thinking; “While it can help you to understand relationships in situations and think systemically and systematically,
Systems Thinking alone cannot help you provide innovative solutions to complex problems … understanding situations is only the first step on the journey that provides those innovative solutions”[30] – Hence, the new approach could be Holistic Thinking!

Holistic Thinking is the combination of analysis, systems thinking and critical thinking. Indeed, building on the work of Richmond (Richmond, 1993), Kasser[30] has introduced Holistic Thinking as a set of ‘viewpoints’ on the perspective perimeter called the Holistic Thinking Perspectives. This approach can be used to provide a standard set of anchor points for thinking and communicating in a systemic and systematic manner; “Holistic thinking goes beyond systems thinking by not only thinking about a system as a whole but also by doing the thinking in a systemic and systematic manner …”[30].

These viewpoints go beyond combining analysis (i.e. internal views) and systems thinking (i.e. external views) by adding quantitative and progressive (i.e. temporal, generic and continuum) viewpoints. In essence, the Holistic Thinking as an approach seeks, (1) to separates facts from opinion, and (2) to provides a standard format or template for storing information about situations that facilitates storage and retrieval of information about situations such as those documented in case studies.[30]

Kasser therefore advocates that ‘Holistic Thinking’ would equip project managers with the requisite skills for creating innovative solutions to nowadays complex problems; “The needed skill for providing acceptable solutions is the ability to think differently to that of your contemporaries. You need to go beyond systems thinking and apply holistic thinking to the matter at hand … {to devise or deploy successful systems}”[30].

Many project practitioners probably started off by studying engineering; they then had to ascend to Systems Thinking, to Systems Engineering, and of late to Holistic Thinking. As complexity increases in Large Infrastructure Projects, so will the need to update our thinking regarding project delivery – for “Problems that were created by our current level of thinking cannot be solved by the same level of thinking”, noted Albert Einstein.

Whether this journey will ever end should thus be left for Tantalus (i.e. Greek legend) to tell; nevertheless, as for those readers who have already taken baby-steps towards Systems Thinking and Systems Engineering, and might be crying for more ‘learning’, they should consider consulting INCOSE, the NETLIPSE and the Dutch Ministry of Public Works and Water Management for additional information and resources.
This free online version does not include Chapter 03 to Chapter 10; please contact E 6 Project Consulting to order a complete copy of this book.

Our email address is: consult@e6pc.com
Our website address is: www.e6pc.com
Chapter 11. Conclusion

Projects that deliver or upgrade systems should be completed on time, within budget, and to specifications. This is the ‘triple-constraint’ principle (a.k.a. iron-triangle) of project management. However, many organisations have lost billions on projects that were satisfactorily delivered (i.e. passed commissioning with flying colours), but failed ‘to deliver value’ in, or to their operations. Of the many examples included in this book, the Heathrow Airport Terminal 5 and the New South China Mall are quite remarkable.

While both projects were satisfactorily completed and hailed as a feat of engineering and project management, Terminal 5 failed to operate effectively after inauguration due to shortcomings in the ‘system’ itself (i.e. Transition Requirements not met). The colossal New South China Mall failed and was ‘abandoned’ after opening due to the ‘environment’ not being ready (or willing) to utilise it. Systems were satisfactorily completed, but benefits were jeopardised (Terminal 5), not realised (New China Mall).

Many other organisations involved in capital projects at some point wonder why they could not seem to get any real “bang” for all the “bucks” invested thus far for ... well, something was not “ready” in their operations. Project management should seek to go beyond the delivery of the physical infrastructure to pursuing the deployment (after such delivery) of a working ‘system’ that provides improvements to the intended environment.

Unsurprisingly, a notable NETLIPSE finding was that Large Infrastructure Projects (LIPs) “... must be conceived, managed and operated as an integrated whole, focussing not only on the completion of a physical project as an end in itself, but also on stakeholders involved ... LIPs are an important link for European transport {and for Africa} and on a higher level contribute to economic and social sustainable growth of our society” [44].

According to ISO/DIS 21500 – Guidance on project management, it is made plain that, “A project usually exists within a larger organization encompassing other endeavours. In such cases there are relationships between the project and its {broader} environment, business planning and operations. Pre- and post-project activities may include activities such as preparing the business case, conducting feasibility studies and transition to operations. Projects may be organised within other related structures such as programmes and project portfolios” [27].
Most statistics on project failure (e.g., Chaos Report, Prosperus Report) suggest that a mere 32% of projects are ‘completed on time, on budget and with required features functions’; 44% are challenged (e.g., late, over-budget, and with less required features and/or functions) and, sadly, as many as 25% are generally deemed outright failures. It would therefore be sad, again, that a substantial portion of those 75% reasonably completed projects will subsequently fail to provide the expected benefits owing to a poor/lack of Operational Readiness. But the reality of LIPs industry is not far from that!

According to GP Strategies (a global company based in USA) 64% of capital projects exceed their original budget; as much as 30% of the original expected value can be lost due to ineffective transition to operationalization; 73% of capital projects are delayed beyond their original scheduled launch – and the Construction Industry Institute (CII) found that only 5.4% of 975 industrial projects met ‘best in class’ predictability in terms of cost and schedule. Definitely, such predicamental tendencies ought to be reverse.

Project Management pursues a satisfactory completion of projects (i.e. iron-triangle); Operational Readiness (OR) supports project delivery by ensuring that systems (i.e. products of projects) are “safely received and effectively utilised” in their intended environment. In turn the operational environment shall not impair the system, either. Operational Readiness plays a crucial role in delivering project benefits. Ideally, Operational Readiness should be implemented to ensure a Vertical Ramp-Up, with near 90% of Design or Nameplate Capacity being attained at Start-Up.

The extent Operational Readiness is applied correlates with project delivery maturity. The Portfolio, Programme and Project Management Maturity Model (P3M3®) [46] aptly reflects Operational Readiness as a key aspect of project delivery maturity as follows:

(i) Project management at Maturity Level 2: OR is reflected as a Management Control; “... concepts of project management will have been grasped by the organization, and there may be local experts, such as experienced project managers, working on key projects ... There will be active consideration of transition management {i.e. OR} to ensure that project deliverables are capable of being exploited by the user” – Operational Readiness is expected as early as when reaching Level 2 ‘Maturity’;
(ii) Programme management at Maturity Level 2: OR is to enhance Risk Management; “Risk will be viewed in terms of aggregation and operational transition ... Risk management is recognized and used on programmes, but there are inconsistent
approaches which result in different levels of commitment and effectiveness ... Some programmes recognize different categories of risk (e.g. by distinguishing between project and transition/operational risks); and,

(iii) Portfolio management at Maturity Level 3: OR is to support Benefits Management; “Business and service areas actively engaged in defining and realizing benefits ... Benefits realization objectives linked to operational business plans”.

The foregoing insights make it clear that Operational Readiness significantly enhances the chances for the project success by preparing the end-user environment, not as an afterthought, but as an integral part of project delivery. In fact, the concept of readiness embraces five of the ten PMBoK Guide Knowledge Areas, i.e., Scope, Time, Cost, Quality, and Risk – having a ‘system’ more ready than its environment may prove fatal.

A recent Deloitte & Touche publication\textsuperscript{[12]} boldly put forward that, “It is increasingly recognised that a \{deliberate\} focus on operational readiness is a key differentiator in a programme’s ability to deliver against the commitments in its business case. Programmes that embed operational readiness from the outset typically identify risks earlier, mitigate design issues when they are less costly to resolve and build highly capable teams ... Evidence suggests ... ongoing operations and maintenance costs over an asset’s lifecycle are typically 1-2\% higher, year-on-year and for the entire life of the asset, where operational readiness was not sufficiently achieved at the outset.” \textsuperscript{[12]}

Four organisational domains that must be addressed through OR are: (1) Legal and Statutory, (2) Human Resources, (3) Processes, and (4) Utilities and Infrastructure. Commercial considerations such as the ‘readiness of customers’ to procure and/or utilise the deployed system cannot be ignored. An inquiry on the Terminal 5 debacle pointed to items (2) and (3), whereas commercial issues (i.e. lack of customers) and difficult access, which falls under item (4), probably caused the New South China Mall to fail (due to poor or low occupancy). It is a costly mistake not to consider operability.

Decisive OR requirements will derive largely from two sources, namely: (1) Operative requirements that drive changes to current or planned operations, and (2) Transition requirements that support System Deployment during Transition, bridging into sustained Operations. Both requirements must consider and address long-term sustainability of the system and, more importantly, that of the broader environment.
Common wisdom even reminds us that “Neither do people pour new wine into old wineskins. If they do, the skins will burst; the wine will run out and the wineskins will be ruined. No, they pour new wine into new wineskins, and both are preserved.” [Matthew 9:17] – putting new wine (i.e. newly created system) into an old wineskin (i.e. any unprepared operational environment) would only be asking for it to “burst”.

Human Capital Readiness, in particular, will entail adjustments and improvements to a number of organisational aspects within the environment of the owner (or even the delivery agent, in rare cases) to accommodate the deployment (or even realisation) of the new Systems (e.g., product/output of projects). Not surprisingly, Human Capital Readiness is the most complex and onerous of OR parameters due to the dynamic nature of human elements. People react to, and affect changes! OR changes shall, however, apply to all relevant organisational aspects of the operational environment. Thus, the accelerated change capital projects entail calls for a ‘process reengineering’.

OR Planning and Implementation ought to evolve over the project lifecycle and include a Continuity of Operations Plan (COOP) that takes care of emergencies. The OR Plan, including Post-Implementation Reviews (PIRs) and Disposal, should be executed by a suitable OR or Change Manager. This will ensure that activities (and impacts) flowing from the OR Scope are treated with same diligence as other ‘core’ project activities. No ‘system’ is deemed successful until it is successfully deployed in its operational environment. Successful commissioning and inauguration are only steps towards such.

While Heathrow Terminal 2 successfully transitioned into operations from day-one, it must be noted that if the appointed Operational Readiness consultant had been involved from the project outset, the same (if not better) levels of readiness would have been achieved (on the opening day), but using far less organisational resources.

Recent studies have indicated that, (1) retrofitting Operational Readiness (or applying it ‘at the tail end’ of projects) may cost an additional 25% of Estimated Total Costs, and (2) Failure or lack of Operational Readiness may cause 30% loss of returns due to ailing or delayed Ramp-Up. This has the potential to defeat the viability of the business case, considering a cost overrun of 25% is sufficient to cause a project to fail altogether[^41]. Operational Readiness, thus, requires adequate planning and robust implementation – Many LIP-delivery entities have ignored Operational Readiness at their own peril.
Readers who do not wish to ‘practice’ Operational Readiness may skip this section.

PMBOK 5th Edition states, “Project Management is the application of knowledge, skills, tools, and techniques to project activities in order to meet project requirements”. Project management is a practical discipline, whereby knowledge and skills, tools and techniques are applied in the pursuit of project success.

This book features four concise case studies that afford the reader an opportunity to begin putting into practice the concepts, principles, and practices discussed herein, even before challenges in their own project would require them to do so.

In addition to case studies, a recent article by the author and a paper by Moriarty and Honnery[42] discuss issues of operations and sustainability, reflecting that projects are primarily about improving (or establishing) the operational environment. Projects should therefore be initiated with the goal of making improvements to operations in mind. This is a fundamental Systems Engineering (SE) principle[50].

It is hoped that through these practical examples, the reader may indeed grasp the intricacies of OR, upon which successful System Deployment depends. It is also hoped that, through the insights provided, the reader will be capacitated and equipped to make the connection between project and operational requirements.

There is no such a thing as ‘partially attained’ Operational Readiness. One ‘missing’ readiness-item could cause the operability of the whole ‘system’ to collapse. Many developing countries are indeed finding themselves with largely ‘inoperable’ military hardware (e.g., fighter-jets, submarines, tanks) soon after their purchase, due to poor maintenance, lack of spare-parts, or operators (e.g., pilots) having lost combat-fitness.

In another example, the introduction of electric locomotives was hailed as a ‘green’ achievement by reducing diesel consumption. However, an upsurge in the mining and transportation of coal (which is ‘dirtier’ than diesel) resulted to supply power-plants that needed to generate more electricity. The ‘burden’ of carbon-footprint was not reduced, but shifted to another sector[38] in the same economy. Operational Readiness is never about the proverbial “robbing Peter to bless Paul”, but rather about finding ways and means of blessing them both, as it were. This is no easy task, one will argue.

The journey to OR mastery might be long and taxing – yet practice shall make perfect!
12.1. Large Infrastructure Projects — Putting Empathy in Operations [by the author]

How shall project teams apply their ’hearts and minds’ throughout the project lifecycle to ensure successful delivery?

We are still coming out of an era where the project manager’s job revolved around either spending the budget or building the *damn thing*, namely completion of the physical deliverable(s) at any costs. Very few project practitioners appreciate that projects are primarily about improving (or establishing) the workings of the operational environment. It is our contention that no project should see the light of day unless it will add value to operations!

It is said, “Charity begins at home”. Good projects begin with a deep appreciation of the operational needs. A good marriage does not start at the wedding but prior to it, from a shared perception of the kind of family the husband and wife intend raising. *Only upon such shall thy wed be locked*, or else divorce will soon loom (i.e. project failure).

Project teams often wallow through the mud of scope creep, cost and schedule overruns, and organisational politics with the hope that in the end “something new and great” will be standing where there was none before. Any concerns as to whether *that something* will add value by improving the operational environment (e.g., increased production, lower operating costs, improved quality of services, enhanced welfare) seem relegated to a bottom drawer – the one some reviewers might look into long after the project team has moved on to the next job.

When it comes to project delivery, and indeed in anything else in life, our charity should start at (the project’s) home, at the operational environment where the delivered solution (e.g., new infrastructure, facility, and equipment) will be deployed.

Before a new project is launched, some stage of empathy is required. This should take place in the operational environment to gain a deep appreciation of ills, issues, challenges, and needs begging to be addressed in a technically and socio-economically viable manner. Only thereafter shall a project team revert to the conceptual phase and kick-start the project.

To return to our earlier analogy, locking the project’s wed (i.e. launching the project) upon a lack of common understanding of project objectives, an evasive sense of agreement as to its worth, and a poor commitment to make it work is the harbinger of divorce or, in the project context, of project failure.

The question is: How will this ‘empathy’ practically apply to your project? We maintain that a good project should start with an appreciation of operational matters (i.e. with the team planting their hearts in operations’ concerns) and only then revert to the onset of the lifecycle or FEL-1 (i.e. whence the project team will apply their minds in planning and executing infrastructural elements that are lacking in that particular operational environment). The whole idea is to start with the end (e.g., improved operations) in mind, which is a Systems Engineering principle.
During this ‘empathy’ phase, the project team should attain: (1) a shared perception about the project objectives, (2) a broad sense of agreement that the project is worth doing, and (3) an expressed commitment to make it happen – and (4) elucidate items reflecting the operational environment from the sponsor and operational staff, including:

(i) Competing systems – facilities, equipment, and processes vying for resources with the system once deployed;
(ii) Collaborative systems – facilities, equipment, and processes that will collaborate with the deployed system;
(iii) Sustaining systems – facilities, equipment, and processes to support the operations of the deployed system.

Failing to secure the above ingredients, the project team would face the predicament of “building a puzzle over an ever-changing canvas”. Despite all their efforts and creativity, only one thing is guaranteed: even when the pieces fit together, they will still fail to match the canvas. In our context this is deliverables that fail to add value to operations.

If the project team does everything else right (which many project professionals are capable of achieving) they might still disappoint the client (i.e. owner, sponsor) by delivering assets, facilities, and systems that turn into white-elephants. Such ‘investments’ will drain resources (e.g., capital outlay, operating and maintenance budgets) ad infinitum without adding value by improving the operational environment.

GreenPoint stadium (Cape Town, South Africa) was completed on-time and on-budget for the 2010 Soccer World Cup. Nevertheless, it is common knowledge that the charming Xhosa Lady (i.e. referring to its outline) is not adding much value to the City – it is forever gulping resources just to keep standing pretty, with hardly any hope of a steady income. (Are you surprised? Well, not too far from there, no big airplane might land at the R4.5 bln Saint Helena Island airport due to windshear.) A mere trip in thought to its operational environment might have led to a ‘concept’ that connects the stadium to the City’s touristic sites (thus, making it a tourist attraction as well) and even secured revenues from rugby, cycling, etc. – for instance, albeit incidentally, Moses Mabhida stadium (Durban) connects to beaches and thus attracts tourists. As it is, the City might join the public chorus baying for flattening of GreenPoint to make way for a low-cost housing.

Worse still, the Spanish-built AFRO 4000 locomotives that PRASA procured in 2012 sparked a vivid controversy when it turned out that their height was out of clearance specifications (i.e. too tall for South African railways) and, thus, were failing to operate in many sections of the Transnet-owned network – billions of Rands got thrown off the rails. Then as in a twist of irony, the infamous locomotives were finally dumped under the Nelson Mandela Bridge in Braamfontein.

What more shall be said? Infrastructure delivery will prove vain unless acquired capabilities are effectively exploited in improved operations to derive the benefits and add value to the business – He who has ears to hear, let him hear!
12.2. Sustainability Article [Excerpt only]

Energy policy and economics under climate change

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Abstract: Most anthropogenic greenhouse gas emissions are the result of the combustion of fossil fuels. Proposals for mitigating climate change thus include various carbon dioxide removal technologies, replacement of fossil fuels by non-carbon alternatives (renewable and nuclear energy), and reduction in energy use overall by improving energy efficiency. We argue here that deep controversy surrounds the efficacy and likely costs of all these technical fix proposals. Optimistic conclusions are often drawn for these technical solutions partly because many of the analyses do not follow an Earth Systems Science approach. Instead, we argue that in future solutions based on nontechnical solutions will need to be a key approach for mitigating climate change in the short time frame we have left.

Keywords: carbon dioxide removal; climate mitigation; fossil fuels; energy costs; energy policy; energy return; Earth System Science; nuclear energy; precautionary principle; renewable energy; uncertainty

1. Introduction

The December 2015 Paris agreement committed the world’s nations to limiting global temperature increases above the pre-industrial value to well below 2.0 °C, with an aspirational target of 1.5 °C increase. However, based on research reported in New Scientist [1], the world could breach the 1.5 °C limit as early as 2026. Anderson [2] has similarly argued that even 2 °C will be very difficult to achieve. But according to an analysis by climate scientists Xu and Ramanathan [3], any rise above 1.5 °C should be classed as “dangerous”—and increases above 3 °C as “catastrophic”. A 2017 report [4] discussed the likely adverse consequences: for every 1.0 °C global temperature rise, wheat and rice yields are expected to decline by 6% and 10% respectively, and by 2050, a billion people, additional to the 125 million in 2016, will be exposed to deadly heat waves. Recent findings do not suggest that governments are taking climate change seriously, despite the rhetoric: according to Peters and his colleagues [5], annual carbon dioxide (CO$_2$) emissions from energy sources will rise by a projected 2% in 2017 to 37 gigatonnes (Gt), after no net growth from 2014 to 2016. Total CO$_2$ emissions, including net deforestation, are likely to be 41 Gt. The IEA, in their latest World Energy Outlook [6] have projected that global fossil fuel consumption will continue to grow until 2040, fuelled by population and economic growth.

Very clearly, we are entering uncharted and dangerous climate territory, and deep reductions in anthropogenic greenhouse gases (GHGs) are urgently needed. Since most of these emissions are related to fossil fuel energy production and combustion, the obvious question is: “What is the best way to greatly reduce energy GHGs, especially the dominant and long-lived one, CO$_2$?”

A key problem for energy policy is that the field of energy research relevant to climate change mitigation is beset by pervasive uncertainty. There are profound disagreements among reputable researchers on almost all topics of importance for making energy policy decisions. This disagreement is in marked contrast to the question of the reality of anthropogenic climate change itself, about which there is an overwhelming consensus among climate scientists [7]. An incomplete list of energy—related controversies would include the items presented in Table 1.

<table>
<thead>
<tr>
<th>Energy controversy</th>
<th>Higher values</th>
<th>Lower values</th>
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<tbody>
<tr>
<td>Recoverable reserves for fossil fuels, especially oil</td>
<td>[8]</td>
<td>[9,10]</td>
</tr>
<tr>
<td>The technical potential for the various renewable energy (RE) sources</td>
<td>[8,11–14]</td>
<td>[15–24]</td>
</tr>
<tr>
<td>The Energy Return on Energy Invested (EROEI) and relative climate change benefits for the various RE sources</td>
<td>[25]</td>
<td>[26–30]</td>
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<tr>
<td>The time frames needed for these alternative fuels to replace fossil fuels</td>
<td>[31–35]</td>
<td>[36]</td>
</tr>
<tr>
<td>The likely monetary costs of these alternative fuels, compared with fossil fuels</td>
<td>[19,37]</td>
<td>[11,14]</td>
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<tr>
<td>Estimates of the social cost of carbon (SCC)</td>
<td>[38,39]</td>
<td>[40]</td>
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<tr>
<td>The technical potential for both biological CO$_2$ reductions and for various carbon capture and mechanical sequestration (CCS) methods, including from bioenergy (BECCS)</td>
<td>[41,42]</td>
<td>[43–46]</td>
</tr>
<tr>
<td>Costs for both biological CO$_2$ reductions and for various CCS methods, including BECCS</td>
<td>[47,48]</td>
<td>[41,42]</td>
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One way that can at least partly help resolve many of these controversies is to use an Earth System Science (ESS) approach [49]. In the context of climate change, this approach attempts to understand how all elements of the Earth system—atmosphere, biosphere, cryosphere, hydrosphere, biosphere, geosphere—interact to produce climate changes in the short- and long-term. More ambitiously, it also attempts to include human actions and responses into ESS modelling. In energy research and analysis, a parallel, if more restricted, approach is Life Cycle Analysis (LCA), which tries to document, for example, all the environmental and resource consequences of introducing a new energy technology compared with existing ones. Accordingly, this review mainly discusses papers with a global rather than a national or regional focus. Climate change is a global problem, and too often what looks like a solution at a national level merely displaces the problem elsewhere. As an example, the reduced energy-related CO₂ emissions in some OECD countries are largely the result of energy-intensive industry being shifted to Asia, particularly China.

This review is necessarily selective: entering in just the phrase “energy policy” into Google Scholar turned up nearly 800,000 hits. We thus focus on recent papers, since these in general will be based on the most up-to-date cost estimates, policy decisions (such as US withdrawal from the Paris climate agreement), and energy technology advances.

The rest of this review examines in turn the future prospects for each of the three competing energy sources: Fossil fuels, nuclear energy, and RE in its various forms. Each section examines the controversies given in Table 1, and attempts to reduce the areas of uncertainty. In the final, Discussion section, the implications of the preceding analysis are drawn out for energy policy, teasing out definite policy conclusions for global energy in a climate-constrained—and more generally, environment- and resource-constrained—world. Given that few of the controversies can be resolved with certainty, we urge an approach that is best able to deal with these. Accordingly, we advocate policies which rely less on technical fixes such as alternative fuels replacing fossil fuels and more on non-technical approaches based on re-examining the question of whether OECD countries in particular need to use so much energy at all.

2. Energy future: Fossil fuels

In attempting to forecast future energy, we need to look at present global energy production, given the decades it takes to change the energy production and distribution system [32]. Globally, fossil fuels still dominate primary energy, as they have for over a century. Although their share of electricity production is somewhat less, fossil fuels still generate nearly two-thirds of global electricity output (Table 2) (Electricity rather than primary energy data is presented here because of uncertainties regarding global bioenergy use, and conflicting methods for accounting for direct electricity production from, for example, hydro or wind [50]).

The table shows that despite rising concern about climate change, fossil fuels’ share of electricity production actually increased slightly over the period 1985–2016. Both hydro and nuclear power lost share over the period, with non-hydro RE, especially wind and solar, gaining share. However, the global figures conceal vast differences between various countries. Some countries still generate all electricity from fossil fuels (e.g. Saudi Arabia and other Gulf states); some are already close to 100% from renewable energy (Iceland, Norway); in a few others nuclear power presently dominates electricity production (Belgium, France) [51].
12.3. Practical Exercise No 1

The text provided below is sourced from the literature and refers to a real OR case.\[^{41}\]

“The actual production of the projects that failed in this dimension averaged a miserable 41 percent of the plan in the second six months after startup. Even worse, however, when a project suffers significant production shortfalls, a great deal of money is spent trying to rectify the problems. Although we lack the systematic data we would like, my guesstimate based on a limited data is that 25 to 50 percent added cost over the initial capital is common. Most of this is not actually capitalized, and in many cases, there are no reliable records of the amount spent at all – because nobody actually wants to know …

The effects of production problems can be debilitating for a business. One global chemical company client had a $9 billion per year business earning 22 percent return on capital employed (ROCE) – a very nice commodity business. A single megaproject that failed to produce as planned reduced the ROCE from 22 to 16 percent for the five years after the project was supposed to have started. They ended up divesting the business. Another example is a metals project that was to debottleneck and expand a major processing complex by 90 percent. After a 39 percent overrun (76 percent nominal) and an 85 percent schedule slip, the complex actually produces 10 percent less than before the project. This project managed to achieve the unachievable: negative production!

When megaprojects fail, the results are rarely publicized unless the failure is spectacular. When the failures do make the press, they are damaging to a company’s reputation. Large overruns and delays in cash flow due to schedule slippage or production shortfalls jeopardize the sponsor’s ability to fund other projects in its portfolio. Megaprojects are by nature lumpy investments. Only a handful of companies in the world are large enough to be able to support a genuine portfolio of these projects to spread the risk internally, which is why most industrial megaprojects are joint ventures.”

- From a project delivery perspective, discuss the main business and/or operational challenges that transpire here; how will such challenges affect business viability?
- What recommendations will you make to the heads of Planning and Operations?
Discuss how such challenges might manifest (have been manifesting) themselves in the context of your organisation or in any particular project and/or programme;

Discuss what should be done in your organisation and/or project to prevent such challenges from arising. Would you support the adoption of an OR Framework?

At what stage of the project lifecycle (and through what specific deliverables) would you recommend that “operational requirements” be gathered from key stakeholders? At what stage of the lifecycle and through what process should be followed in confirming that such requirements have been satisfactorily attained?

“Wouldn’t you also revert to prayer every time operability failure strikes? – If not, then you should fix your Operational Readiness (OR) processes ...”
12.4. Practical Exercise No 2

This case is based on a real ‘operability failure’ situation as discussed by Kossiakoff[32].

**Facilities and Personnel Limitations**

Neither the facilities nor the personnel assigned to the task of system installation and test are normally equipped to deal with significant difficulties. Funds are inevitably budgeted on the assumption of success. And, while the installation staff may be experienced with the installation and test of similar equipment, they are seldom knowledgeable about the particular system being installed until they have gained experience during the installation of several production units. Moreover, the development contractor staff consists of field test engineers, while systems engineers are seldom assigned until trouble is encountered, and when it is, the time required to select and assign this additional support can be costly. The lesson to be learned is that the installation and test part of the life cycle should be given adequate priority to avoid major program impact. This means that particular attention to systems engineering leadership in the planning and execution of this process is a necessity. This should include the preparation and review of technical manuals describing procedures to be followed during installation and operation.

**Early System Operational Difficulties**

Like many newly developed pieces of equipment, new systems are composed of a combination of new and modified components and are therefore subject to an excessive rate of component failure or other operational problems during the initial period of operation, a problem that is sometimes referred to as “infant mortality.”

This is simply the result of the difficulty of finding all system faults prior to total system operation. Problems of this type are especially common at external system interfaces and in operator control functions that can be fully tested only when the system is completely assembled in an operational setting. During this system shakedown period, it is highly desirable that a special team, led by the user and supported by developer engineers, be assigned to rapidly identify and resolve problems as soon as they appear. Systems engineering leadership is necessary to expedite such efforts, as well as to decide what fixes should be incorporated into the system design and production, when this can best be done, and what to do about
other units that may have been already shipped or installed. The need for rapid problem resolution is essential in order to effect necessary changes in time to resolve uncertainties regarding the integrity of the production design. Continuing unresolved problems can lead to stoppages in production and installation, resulting in costly and destructive impact on the program.

15.3 **IN - SERVICE SUPPORT**

**Operational Readiness Testing**

Systems that do not operate continuously but that must be ready at all times to perform when called upon are usually subjected to periodic checks during their standby periods to ensure that they will operate at their full capability when required. An aircraft that has been idle for days or weeks is put through a series of test procedures before being released to fly. Most complex systems are subjected to such periodic readiness tests to ensure their availability. Usually, readiness tests are designed to exercise but not to fully stress all functions that are vital to the basic operation of the system or to operational safety.

- On the above insert, underline and discuss any sections that could pertain to one of your projects. What recommendations could have been made to ‘Operations’?
- Discuss whether the true story below relates to Operational Readiness or rather to Operational Excellence – or perhaps to both;

> “When John Egan joined Jaguar in April 1980 as chairman and chief executive losses had been running at about $ 3 million a month. The situation was grave. His brief from the British Leyland parent board was blunt – either stop the losses and get on a profit course or close the business. Under Egan’s direction Jaguar set about developing a quality control programme intended to turn the business around. Now nearly four years later, the dramatic effect of that programme can be seen in Jaguar sales, the raising of morale, and the boost of wages.” [37]
12.5. Practical Exercise No 3

This case study involves ‘teaching and learning’ operations at a fictitious high-school;

ZuQS Platinum, a global mining company operating in Southern Africa, had decided to establish the Thuto Pele Education Trust (T-PET) which will serve as a conduit to promote free high-quality education in the region. Their first initiative included a ‘boy-only’ boarding school, the Ditaung High-School, situated at some 27 km North of Mahikeng (North-West Province, South Africa). The school consisted of five 20-learner classes, libraries & laboratories, an assembly-dining hall, as well as a dormitorium (Thabo’s Home) to accommodate learners from South Africa, Namibia, Botswana, Zimbabwe, and other Southern African Development Community (SADC) countries.

After two years of smooth operations, following a steady lobbying by gender-equality groups, the Trust decided to add 10 more classes, upgrade Thabo’s Home from a 100 to a 150-bed capacity, and construct a brand-new 150-bed dormitorium (Winnie’s Home) for girls who will henceforth attend the school. Furthermore, the school has expanded its assembly-dining hall (The Lekgotla Hall) to accommodate 400+ people; the catering job (400 meals, 3 times/day) is outsourced to Moji-le-Dijong, who are also supplying catering to the majority of ZuQS Platinum mines in the surrounding areas.

The next phase of this expansion, which is already under construction, will consist of upgrading and expanding the libraries & laboratories, the sport field, the gymnasium – to be completed by October this year.

Question No 3.1

From an Operational Readiness perspective, assuming the said physical infrastructure is all suitably designed and constructed, what organisational adjustments should have been considered?

- Discuss the school as a ‘system’ (i.e. interacting elements that serve a common purpose) and answer the above question based on Beer’s Viable System Model;
- Answer the same question based on Porter’s Value-Chain Model provided below;
- Discuss which of these models is more suitable and provides the best outcome.
Question No 3.2

Assuming the SA Department of Basic Education (DBE) insists that *Ditaung High-School* would not be issued a ‘Licence to Operate’ under the new operational setup (i.e. 300+ boys and girls) unless and until a satisfactory submission is made to DBE (including Emergency Plans) that complies with the Crisis, Disaster & Emergency Act of 2017.

The Act stipulates that any new facility where more than 120 people assemble which is located more than 20 km of the nearest municipal police or fire station, shall provide its own fire and/or emergency processes and facilities. How will your team advise the school about compliance?

- Should you have known about such a requirement before the school elected to expand its operations and include a girl-section, what would you have advised the school board as a possible way forward?

- Discuss, from an Operational Readiness point of view, any reasons why the school could/should disagree with the Department of Basic Education;

- Draft an elementary Emergency Plan for the facility, discussing its key elements and implications thereof to the normal functioning of the school routines (e.g., teaching and learning)?
12.6. Practical Application No 4

This case study reflects Operational Readiness issues in a hospital expansion project.

Philafuthi Hospital is operating at full capacity in the remote Eastern Cape, 240 km from East London; the 70-bed medical facility has served the local communities for years providing free and specialised pediatric care. The provincial government of the Eastern Cape has now allocated some R 1.7 billion for the urgent rehabilitation and expansion of the hospital – which should become self-funded within a 7-year period. The approved plan consists of (1) upgrading and expanding the existing pediatric hall from the current derelict 70-bed to a fully-equipped 200-bed facility, (2) building a modern 40-bed maternity ward, and (3) building an “out-patient” facility specialising in communicable diseases such as Tuberculosis and HIV/AIDS.

At this stage, it is assumed that Philafuthi Hospital will reach full capacity within six months, reaching its self-funded target way before the required 7-year period. These projections are based on the current “turn-away rate” (i.e. number of patients sent back home and/or referred elsewhere due to a lack of capacity) and the increasing incidence of communicable diseases in the region, especially among the youth.

However, the proposed funding is largely based on some cursory ‘feasibility study’ conducted by hospital administration itself and the allocated budget will only cover the infrastructure part of the project, which is scheduled to take 28 months (including feasibility study, design, construction, and closeout).

Question No 4.1

Considering the Operational Readiness (OR) Requirements as summarised in the table overleaf, answer the following questions:

- Does Philafuthi Hospital stand a chance of turning “self-funded” within the said 7-year period? Given the above Introduction, what infrastructure-related items seem to have been ignored/left out? What will be the impacts of such oversight?
- What considerations shall have changed, had this facility been located close to another (currently running) general hospital? Or rather close to a shopping mall?
- Would you have the same discussions with the hospital management team, whether the project be at FEL-1 (Conceptual Phase) or FEL-3 (Feasibility Phase)?
# Question No 4.2

In order to approach the Department of Environmental Affairs for Waste Disposal permits, please use the template provided below to summarise the Waste Disposal Strategy/Plan for PhilaFuthi Hospital.

<table>
<thead>
<tr>
<th>Primary OR Domain</th>
<th>OR Domain’s Aspects</th>
<th>OR Domain Considerations, as per Operating Model</th>
</tr>
</thead>
<tbody>
<tr>
<td>Human Resources</td>
<td>Training &amp; Skills Transfer</td>
<td>New skills required? For whom? Skill Provision Scheme?</td>
</tr>
<tr>
<td></td>
<td>Human Resources Capacity</td>
<td>New recruits required? By when?</td>
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<tr>
<td></td>
<td>Organisational Change Management</td>
<td>Any changes to Structure (and office space) or Culture?</td>
</tr>
<tr>
<td>Operational Support</td>
<td>Bulk Supply/Services &amp; Utilities</td>
<td>New, extra Water/Electricity Supply, Sewerage needed?</td>
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<tr>
<td></td>
<td>Supply Chain Management</td>
<td>Wherewithal to procure/dispatch goods, services needed?</td>
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<tr>
<td></td>
<td>Customer/Commercial agreements</td>
<td>Are off-take contracts in place for end-products/services?</td>
</tr>
<tr>
<td></td>
<td>Financials (A Working Capital, Budget)</td>
<td>Additional funds needed to support “added” operations?</td>
</tr>
<tr>
<td></td>
<td>Configuration Management</td>
<td>How to maintain current &amp; accurate versions of data?</td>
</tr>
<tr>
<td></td>
<td>Technology Integration</td>
<td>How to migrate existing systems to new technology?</td>
</tr>
<tr>
<td>System Utilisation</td>
<td>Operational Health &amp; Safety &amp; Security</td>
<td>What HSS regimen required for safe utilisation?</td>
</tr>
<tr>
<td></td>
<td>Operational Licencing &amp; Permitting</td>
<td>Any Operating Licence, Waste Disposal Permit needed?</td>
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<tr>
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<td>SOMAR – flies</td>
<td>Any set-up to allow system operate in its environment?</td>
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<tr>
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<td>Product Testing</td>
<td>What testing process, equipment and spares needed?</td>
</tr>
<tr>
<td>Facilities &amp; Tools</td>
<td>Operations Facilities</td>
<td>Any facilities, equipment, tie-ins required for operations?</td>
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<td></td>
<td>Spare Parts and/or Components</td>
<td>Any spares, feedstock needed for testing, for operations?</td>
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<tr>
<td></td>
<td>Maintenance Facilities and Equipment</td>
<td>Any facilities, equipment needed for maintenance?</td>
</tr>
<tr>
<td>Processes &amp; Procedures</td>
<td>Maintenance Regime &amp; Plans</td>
<td>What types, scope, budget and timing of maintenance?</td>
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<tr>
<td></td>
<td>Operational Risk Management</td>
<td>What operational risks to mitigate? Manuals needed?</td>
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<tr>
<td></td>
<td>Warranties Management</td>
<td>What types, scope &amp; processes, whose responsibility?</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>No</th>
<th>Waste Item</th>
<th>Hazardous/Polluting Effects</th>
<th>Disposal Frequency</th>
<th>Disposal Method</th>
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</thead>
<tbody>
<tr>
<td>01</td>
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<td>02</td>
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</table>

- What adverse consequences would you anticipate should the hospital proceed with the planned expansion without attempting to reduce its “Waste Footprint”? Which stakeholders are likely to benefit/suffer the most in that woeful scenario?

- What practical measures (e.g., policy, infrastructure, processes, personnel) should be taken by the hospital in a bid to reduce the “Waste Footprint” of this facility?
**Question No 4.3**

PhilaFuthi currently recycles 8 m$^3$ of solid waste per day using their own R 17.4 m (12 m$^3$/day capacity) Waste Treatment Plant (WTP); the planned expansion might generate some additional 5 m$^3$ of solid waste per day. Considering WTPs come in ‘standard’ 12 m$^3$/day capacity modules, complete the table below and discuss the effectiveness of investing in additional WTPs – and smarter investment(s) options.

<table>
<thead>
<tr>
<th>Status</th>
<th>Volume</th>
<th>Plant Capacity</th>
<th>Cost Factor</th>
<th>Plant Utilisation</th>
<th>Cost Effectiveness</th>
<th>Comments</th>
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</thead>
<tbody>
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<td>Before</td>
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</table>

**Question No 4.4**

Given the planned architecture and operations of PhilaFuthi, use the provided template to work out an “Annual” Maintenance Plan, reflecting both routine and capital maintenance regimes applicable to hospital operations and the environment.

<table>
<thead>
<tr>
<th>No</th>
<th>Facility/Equipment Item</th>
<th>Rationale/Purpose</th>
<th>Maintenance Scope</th>
<th>Frequency</th>
<th>Budget</th>
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<tbody>
<tr>
<td>01</td>
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<td>Routine Maintenance Costs [A]</td>
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<td>Capital Maintenance Costs [B]</td>
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</table>

**Total “Annual” Maintenance Costs [C=A+B]**

- How would you compare the costs of routine against capital maintenance, and “annual” maintenance against total capital outlay? What would you recommend?
- Can a lack of routine maintenance render void capital maintenance, or vice-versa?
Personal Reflections
References


Additional Readings


Pascal Bohulu Mabelo has earned more than twenty years of professional experience and possesses a wide range of technical and managerial skills pertaining to projects – he has previously served as the national chairman of Project Management South Africa (PMSA). He has also had the opportunity to work in large-scale projects, with people from various backgrounds and across Southern Africa.

Pascal has written Project Management articles that promote the application of Systems Engineering and Thinking concepts to unravel complexity in Large Infrastructure Projects, in order to address their persistent risks of failure – and massive cost and schedule overruns.

Systems fail when operations are not “made ready” to safely receive and effectively utilise them. This difficulty largely arises from two situations, (1) the misplaced focus of lifecycle methodologies on constructability rather than on operability, leading project managers into thinking that their onus ends at Close-Out, and (2) the absence of a holistic framework for Operational Readiness. This book seeks to address the latter; it discusses the processes and challenges of deploying the Solution-System into its intended operational environment.

“This book will help many people and organizations ... in a simple way, it makes the reader understand the risks of bad project management decisions and gives a complete ... understanding of the strengths, weaknesses, opportunities, and threats in projects.”

Sergio P. Capitine (Mechanical Engineer) — Project Manager at BP Mozambique

"The concept of operational readiness lies at the heart of systems development. Awareness of it should be maintained throughout the SDLC ... A book that is easy to read and a ‘must-have’ for system developers from all walks of life."

Tapiwa Bande (M.Eng) — Managing Director of African Hard Systems (Pty) Ltd

“A comprehensive treatise on Operational Readiness ... OR and PIR Planning are indeed business activities ... operability failure may lead to business failure.”

Saseka Vara (Chartered Accountant) — Senior Manager at Transnet SOC