

Improving decision-making for major urban rail projects



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This paper considers how ‘metros’ – projects that carry a mass ridership rapidly should be developed to deliver predictable success. These projects are particularly important because large cities that are not poor often turn to metros as the centre-piece of their sustainable development and because of their high opportunity cost. Yet often they do not deliver success and then confidence is undermined. The author, having spent his career developing metro projects in Singapore, Bangkok, Manila, Kuala Lumpur, Jakarta, Bogotá, Lahore, Budapest, China, London and Nottingham, became convinced that this was a major problem. Research was undertaken to identify what could be done to improve things – not theoretically but practically. This paper summarises the findings of the author’s PhD thesis of the same title. The research was based on case studies of nine newly-opened metros in Asia and the UK. An understanding was developed that appeared to explain the causes of poor success. Practical approaches were developed and a change agenda formulated that could improve success. This agenda appears to provide a resource for effecting improvements that is richer and more comprehensive than previous approaches.

1. Metros and public policy

1.1 Metros

‘Metro’ is used as shorthand for any rail system that carries a mass ridership rapidly, including heavy rail, mainly segregated light rail and suburban rail systems. Metros achieve their strategic impacts through their operating speed and capacity, both of which have strategic impacts upon cities and their citizens. Typically fully segregated ‘metros’ achieve end-to-end operating speeds of 30–40 km/h, and have capacities of 35–60 000+ passengers per hour per direction (pphd); while partly segregated light rail transit (LRT) systems achieve speeds of about 20 km/h and capacities of about 10 000 pphd.

1.2 Public policy

Metros are at the heart of the public policy debate about sustainable cities. London, Paris, New York, Tokyo and more recently Hong Kong, Seoul and Singapore could not exist in their present form without their extensive metro systems and no city with a metro appears to regret having gone down this path. This leads some to argue that rail systems are essential for large cities. Certainly many city plans incorporate metros and often large metro networks, and most people seem to want metros. The recent trend towards private financing has reinforced such expectations.

Others argue that metros are usually unaffordable, ineffective in policy terms and unsuccessful in their own terms; and that they divert attention from the core transport agenda – of improving

buses and non-motorised transport, managing car use and using developmental roads to shape the future city. Recent advances in bus rapid transit systems they argue make metros in almost all circumstances an irrelevance.

Metro costs are central to this debate because they are so very large. Rule-of-thumb, all-in capital costs for a new-build 15 km line are: US\$0.2 to 0.5 billion when at-grade, US\$0.5 to 1.1 billion when elevated and US\$0.9 to 2.7 billion underground. Because revenues and operating costs are often similar this cost needs substantial funding by government, now or if financed by the private sector later. Metros thus have a high public sector opportunity cost and they face politicians with difficult decisions. Singapore’s government defined the opportunity cost of its US\$3 billion North-East Line as either the entire public budget for education and health for one year; or a new terminal at Changi Airport + two new hospitals + one new polytechnic + five people-mover systems + the interim upgrading of 10% of the housing stock. This project was implemented well, but others have faced daunting problems and cities have even been faced with bankruptcy as a result of ill-conceived projects committed on the basis of misleading forecasts.

1.3 Metro success

Metros are justified on the basis of their expected public policy outcomes, and their success is measured by the extent to which these are achieved. If rigorous before-and-after studies existed and we had the benefit of hindsight (many impacts take place over the long term) such an assessment would be feasible. But

in practice such studies rarely exist, reliable information is patchy and judgement is therefore needed.

Where information does exist it usually concerns financial out-turns that can be compared with expectations when projects were committed. Table 1 summarises this evidence. Until recently capital cost was typically 50–100% above expectations, implementation time 0–50% longer, operational costs 0–200% higher and ridership/revenues/benefits one-third to two-thirds below forecasts. Thus all out-turns were adverse and the viability estimates used to justify the metro were often completely misleading.

1.4 Explanations for lack of success

Several commentators have sought answers to why and how metros were developed despite this patchy record of success (Altshuler and Luberoff, 2003; Ardila, 2004; Feldman and Milch, 1982; Flyvbjerg, 1998; Flyvbjerg *et al.*, 2003; Hall, 1980; Kingdon, 1995). At root there is tension between the practice of rational planning and stakeholder behaviour in pursuit of power.

Flyvbjerg *et al.* (2003) provide a comprehensive analysis of why major projects fail based on the macro-analysis of 258 public sector transport megaprojects. They concluded that there are two principal causes – optimism bias, which is an ‘innocent’ psychological trait we all exhibit that presents the future in a favourable light, and strategic misrepresentation, in which sponsors understate costs and overstate benefits to gain strategic advantage (also termed ‘lying’).

Their solution is to require ‘optimism bias’ factors to be added to sponsor’s estimates based on evidence of out-turn costs of comparable projects, and structural change to the balance of power between the interested parties. This requires an increasingly

rational project development process and enforced accountability in the public and private sectors with greater openness and competition, outcome-defined performance specifications, a comprehensive regulatory regime, and a requirement for risk capital to force rigour on the critical commitment decision and ensure stronger monitoring of performance.

2. The research

2.1 Method

The research (Allport, 2008) recognised that the causes of poor success were, in all probability, complex and the project development process required understanding in the round if prescriptions were to be identified that carried conviction. The approach analysed the anatomy of project development by means of case studies of recently operational projects (whose early success was therefore known), applying a method that focused on interviewing the key decision-makers/stakeholders during the project’s development period to establish what ‘really’ happened and why.

A major effort was devoted to securing interviews with the key people. Eighty-nine interviews each lasting 1.5–4 h were conducted with project stakeholders (sponsor politicians and technocrats, private entrepreneur/developers, national economic/financial/transport civil servants, project planners/financiers/implementers and operators), and independent experts. The interviews followed a structured check-list of questions derived from literature search and experience, and provided the interviewee with the opportunity to expand on the subject matter.

2.2 Case study metros

The case studies were selected to encompass as wide a range of project environments, procurement forms and metro systems as possible. In practice this was constrained by the time required to

Year	Source	Location	Out-turn compared with forecast	
			Capital cost	Ridership
1973	Merewitz (1973)	Europe/North America	Average +54%	
1986	Wachs	USA	+132 to +221%	–47 to –68%
1990	Fouracre <i>et al.</i> (1990)	Developing cities	Half +50 to +500%	–50 to –90%
1990	Pickrell (1990)	USA	+17 to +156%	–28 to –85%
1998	Mackett and Edwards (1998)	UK, USA		2 out of 13 ‘successful’
2000	Babalik (2000)	North America, UK		–82 to +89% (eight selected systems)
2004	National Audit Office (NAO, 2004)	UK Light rail	Half as forecast, half above	–45 to +5%

Note: table shows how projects out-turns compare with forecasts at commitment.

Table 1. Record of new build metro project success

study each metro, the necessity to access the key stakeholders and the need to be opportunistic when opportunities arose. The result was nine very different case studies that were known to the author (Table 2). They varied in city size from 0.3 million to 10 million, in ‘developing’ and ‘developed’ societies, in project type from street-running trams to the world’s first fully automated metro, from public sector procurement to a range of private concessions, with initial cost between £0.15 billion and £2.15 billion, first year ridership between 10 000 and 170 000 passengers per day and financial performance (ratio of farebox revenues to direct operational costs) between 0.5 and 2.1.

2.3 Success updated

Three criteria were defined to assess success. As a minimum, projects should produce broadly the financial consequences forecast when they were committed; without this project development they would be seen to be out of control while with it the prospects for policy success should be good; in practice reliable facts about costs and revenues were, with perseverance accessible. Thereafter projects should achieve their promised policy impacts and be considered successful by their key stakeholders; here reliable facts were sparse and considerable judgement was required. The third criterion required the project impacts and development approach to be durable to ensure policy success over the long term; this was part a matter of fact and part judgement.

The case study assessments provided important new insights into success. Delivery performance to time and budget was

notably better than previous evidence showed – only one project delivered cost significantly above estimate and only one had a major time overrun. This appeared to be the result of good procurement/contracting and in particular concessioning (seven projects involved private finance). But operational performance remained poor: all but two projects attracted one-third to two-thirds of forecast ridership and operational costs were generally much higher too. This undermined the financial success in all but two projects and remains the central weakness of existing practice as operational impacts form the core purpose of metro investment.

Two-thirds of systems were considered to be a policy success on the basis of the early evidence. Stakeholder assessments varied widely: four sponsors were fully satisfied with their projects and another three broadly or mostly so. The travelling public were unambiguous winners with all popular systems having a high satisfaction rating. However, three civil engineering contractors took heavy losses and another had substantial losses, while one equipment supplier sustained a heavy loss. Of eight concessionaires three were satisfied but for five their projects were disasters and then the banks were usually hit too. In terms of overall value for money only one project could be judged unambiguously good on the basis of available evidence, but there was a strong probability that another three would be.

Success was more elusive in creating durable sponsor/operator institutions and replicable project development approaches

City	Project	Description	Procurement	Open
Manila	MRT3	17 km segregated tramway system down major corridor	BLT concession	2000
Manila	MRT2	14 km mainly elevated ‘first world’ metro above radial highway	Government ODA from Japan	2004
Bangkok	BTS (‘Skytrain’)	23 km three-leg network. Fully elevated first-world metro above radial highways	Full BOT concession	1999
Singapore	North-East Line (NEL)	20 km automated first-world metro under major highway	Government	2003
UK Birmingham	Midland Metro	20 km mostly segregated LRT along former rail route	DBOM concession	1999
UK London	Croydon Tramlink	28 km network. Street-running and segregated tramway	PFI concession	2000
UK Manchester	Metrolink Phase 1	31 km network. LRT mostly on former rail right-of-way	DBOM concession	1992
UK Manchester	Metrolink Phase 2	6 km spur line from Phase 1. Street + segregated LRT	DBOM concession	2000
UK Nottingham	Nottingham Express Transit (NET)	14 km street and segregated LRT	PFI concession	2004

BLT, build lease transfer; BOT, build operate transfer; DBOM, design build operate maintain; ODA, overseas development assistance; PFI, private finance initiative.

Table 2. Case study metros

with only two projects judged unambiguously durable. Most faced major uncertainty that could compromise their assessed policy success.

3. Research insights

3.1 Diagnosis

The research provided three central insights.

- (a) The management challenge: exogenous factors combine to create a formidable challenge for developers of metro projects. These are the hugely turbulent decision-making environment, the demanding characteristics of metro projects and the particular characteristics of their sponsors. These are facts whose consequences have to be 'built-in' to the approach to project development. Success needs to be defined in this new context. No longer (if at all) should project development be conceived as identifying an optimum project for a defined future; instead project developers need to identify a project that demonstrates robust viability for an uncertain future, that also has a strong support base. The project development process in most environments should not be conceived as following a predetermined programme; it will need to respond to setbacks and windows of opportunity and the project developed accordingly. Moreover, projects need to be planned to ride the turbulence that will impact them once operational, by forward planning to build in adaptability. So changed objectives, a responsive project development process and adaptable projects are the appropriate response to the defined management challenge.
- (b) It is necessary to stabilise this environment: many project environments are so turbulent, with uncertainty so large, that effective project management is impossible unless action is taken to stabilise the environment. Central government and sponsors can do much to create the conditions for effective project management even in very turbulent environments; the use of private sector resources can be a means to this end.
- (c) Changes to the practice of project management and planning are then necessary to develop major projects that are successful. The existing project management process is shown to be dysfunctional, and planning is shown to fail in many respects. Change here is necessary in order to take advantage of the stabilised project environment and deliver successful projects.

3.2 The change agenda

The change agenda (Figure 1) follows from this diagnosis, drawing on the case study and wider experience, including conclusions derived by Miller and Lessard (2000) that have many parallels with the case studies. When project participants take time to understand the turbulent nature of the project

environment and its implications, and central government/sponsors take action to stabilise it, and project managers/planners focus on managing the whole project with a focus on operational success then major projects should become much more successful.

3.3 The management challenge

3.3.1 A turbulent environment

There is growing recognition that environmental turbulence is large and increasing. For example, in 2000 climate change, terrorism security, energy security and the credit crunch were nowhere on the policy radar; yet 10 years later all are central urgent concerns. The sources of turbulence are many: macro-economic (the credit crunch), political (the political cycle and personalities), stakeholders and their agendas, policy [changing private sector participation (PSP) policy], natural disasters, financing availability, project development guidelines, technological opportunities, etc. Overall it is incontrovertible that uncertainty and risk are large and increasing.

3.3.2 Metro characteristics

Metros are not 'just another project' but instead hugely risky megaprojects (Table 3). This should determine how they are developed, but the research revealed that the reality of risk was often not appreciated, decisions were based on insecure foundations and projects were not managed effectively.

3.3.3 Sponsor characteristics

The sponsor is the driving force and 'guiding hand' necessary to champion the project and bring it to successful fruition; his effectiveness is of central importance. Metros were found to differ from many major projects because their large public funding and essential role in the functioning city lead to the need for public sector sponsorship. In fact most case study sponsors were local authorities who had little experience of developing major projects and sometimes a bureaucratic culture that proved ill-suited to the task.

3.4 Stabilising the project environment

The requirement that the major project participants – central government and sponsors – need to create some predictability in the project environment was identified repeatedly in interviews and project success was often directly linked to this being created.

3.4.1 Central government bureaucrats' role

Central government bureaucrats create the 'rules of the game' for major project development and often provide most of the funding. Metro sponsors desirably need powers over planning/land use and the management of the highway and public transport system. They need substantial revenue-raising powers if they are to carry large risk; and if they cannot carry

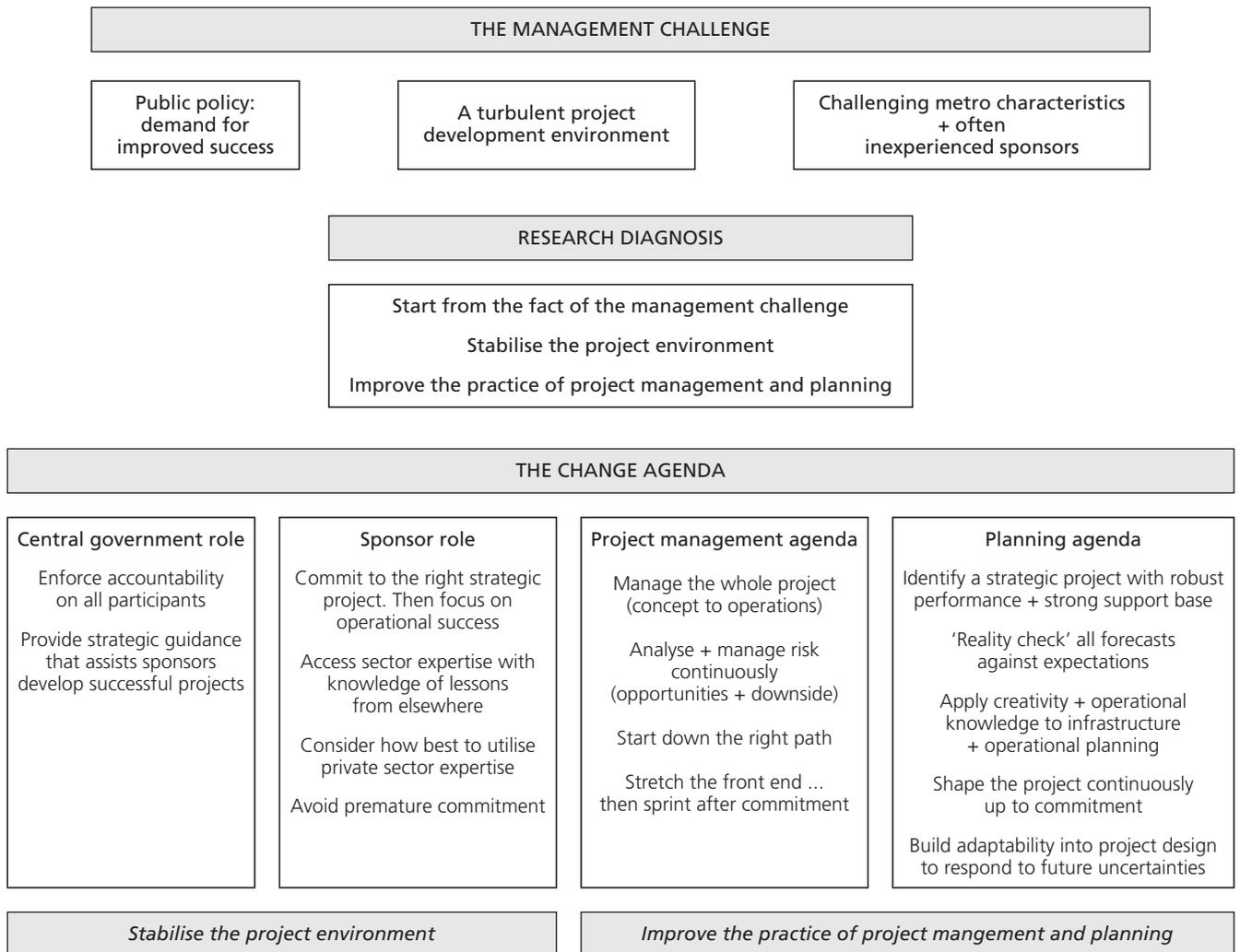


Figure 1. Development of the change agenda

risk it is difficult to hold them to account for spending large central funds. Central government has the responsibility for creating a process in which the key players are accountable for their actions.

Central government also has responsibility for balancing the legitimate interests of the different parties in major project development. While context dependent there is always tension between differing stakeholder interests and agendas. During project development, local people in a democracy should understand what is being done and why, and the project development and proposed delivery process require transparency. Without such legitimacy politicians may be unable to sustain the resources or the delivery mechanisms necessary to achieve desired strategic outcomes, and major projects may become the object of opposition that prevents implementation or damages their long-term success.

Clear rules that assist sponsors to develop good projects and provide funds for such projects provide considerable predictability for sponsors and project managers; whereas detailed changing rules with no promise of funding for projects that meet the requirements increase the sponsor's difficulties without necessarily producing good projects. The case study evidence is strong that strategic guidance together with the reasonable prospect of funding creates the basis for good project identification and effective project management.

But guidance does not always help sponsors develop good projects. In the UK this comprises a wide-ranging set of requirements necessary to secure project approvals and obtain implementation/operations powers (Table 4).

The case study interviews provided strong evidence that these complex, detailed and often changing requirements added to

Metros are megaprojects	Strategically important because of their potential to catalyse sustainable city development and their huge opportunity cost
Long-lived assets	Inherently inflexible in a fast changing world. Many assets have long economic lives of 10 to 30+ years
Each project unique	Often the only such project in a city. No template for successful project development
Challenging finances	Expected to be financially viable. Little understanding of challenging finances by major stakeholders
Inexperienced sponsor authorities	Often the first megaproject an authority has faced
Many stakeholders	A major management challenge. Danger of losing focus faced with competing agendas
Many key decisions	All need to be good – any one can fundamentally undermine success
Project development process	Major interactions between planning, implementation and operations. Challenge of managing the project as a whole
Procurement at a cross-roads	Private sector participation is evolving, creating opportunities and risks
Located in major city centres	Implementation disruptive, with potential for major adverse impacts
Technical complexity	Railways inherently complex systems, with many interfaces
Complexity increasing	Successful systems 20 years ago may not be successful today
No captive passengers	All passengers need to be attracted from existing modes or new trips generated
Little interest in operations	Operations are the purpose of metro development. But there is little interest in operations until there is a problem

Table 3. Metros as risky megaprojects

the turbulence sponsors faced, while not necessarily resulting in good projects (two projects were poor). The nature of the guidance creates inconsistencies and undermines sponsor ownership, which undermines accountability and contributes to strategic misrepresentation. The evidence is that sponsors

National/regional government policies for planning, transport and related areas

A statutory process for acquiring powers to implement and operate projects

A funding system that allocates responsibilities and risks to sponsors, and caps central government risk

Requirement and process for developing city/transport plans/strategies, that provide the context for project identification

A methodology/process for identifying projects; and a detailed appraisal methodology

Guidelines and procedures for securing funding for major projects

A procurement process that identifies the appropriate procurement method, specifically private sector options

Table 4. UK government guidance to sponsors

need space to strategise and build stakeholder support. Too often instead they were bent on following guidance that crowded out time and attention needed for more important activities. Metros require creativity and when this is smothered projects proved to be at high risk. The tension between highly prescriptive central guidance and responsive project development can perhaps be better met by strategic guidance and project monitoring that focuses on identifying potentially successful projects.

3.4.2 Sponsors' role

The evidence is that sponsors need to approach major projects with care and a strategic perspective. Their ambition needs to be tempered with considerable realism about the chosen project and its probable impacts. They need to apply due process and ensure project technical planning does not run ahead of financial planning. Desirably their city plans provide a firm foundation for project planning. They need to identify a good project, make the right procurement/financing decisions and strongly support implementation and early operations. When this is done the evidence is that success is much more likely than otherwise.

Ambition tempered with realism. Good projects are often ambitious projects. Good metros penetrate the heart of major

centres of activity that although difficult, disruptive and costly, can create great value. One sponsor's first ambitious project failed to get the go-ahead because of opposition and was followed by a project that although readily implemented was not so successful. Croydon Tramlink's route was determined in part by assessing and managing likely opposition, yet it retains its necessary success factors. Sponsors need to balance ambition with realism.

Long-term financial planning. Metros have threatened to bankrupt their cities so sponsors need to assess their financial 'bottom line' in outline well before important project development decisions are taken. This assessment depends partly on central government's guidance and the requirements for sponsors to provide matching funding. Often cities are constrained in the risk they can carry because they have limited revenue-raising powers and few realisable assets; and although innovative financing from beneficiaries (usually road-pricing and property development gain) sometimes appears to offer promise, too often this proves impractical and rarely does it provide large funding.

Effective plans. Singapore puts huge resource into developing effective plans that facilitate effective project planning. There is clarity about government policy and strategy and confidence in forecast disaggregate parameters that provide the context for project development. Of course this does not remove uncertainty but it hugely reduces it and allows projects that are more ambitious and successful to be developed than is the case in many cities. Plans that have faced up to difficult decisions and defined priorities for implementation create considerable stability for the project planner.

The procurement decision. The Philippines government procured a realistic concession from a very strong concessionaire which proved successful. It was criticised for not being more ambitious (the concession took no operational risk) but the project was risky and it was the Philippines first such concession. Some UK concessions have, by comparison, been ambitious but resulted in concession companies that proved dysfunctional, and 'walked away' when things went badly wrong. This was most unlikely in the Philippines because the concession company was backed by the Sumitomo parent company.

In Bangkok the sponsor arranged a forced marriage between the only contractor-supplier group who could probably have attracted the necessary financing; and the International Finance Corporation insisted upon conservative financing terms. These paid off when the Asian economic crisis hit Thailand and project implementation proceeded without delay. So realism about the concession form, selecting a strong concessionaire and the financing strategy provide great stability for project implementation and to some extent operations.

Support for implementation and operations. The case studies revealed examples of sponsors behaving as if their task was largely complete once a concession contract was signed. This may have been because of a reluctance to 'increase a private concessionaire's profits'. But the sponsor needs to do much throughout implementation and early operations to maximise the prospects of the project achieving its public purpose. Furthermore, by doing this he is stabilising the project environment. For example Nottingham's sponsor went to great lengths to liaise with frontagers as its tram system was implemented.

3.4.3 Private sector potential

PSP delivered far more than is widely recognised and often helped stabilise the project environment. There was often confusion about its financial role – that provides financing now in return for government payments from future taxes/borrowings (not free funding). Attitudes towards private concessionaires were often critical of their 'private profits for success' while being indifferent when faced with public failure. The rationale for PSP is usually argued on grounds of delivering services today more efficiently than the public sector and without increasing public sector debt (when financing does not appear on the government's balance sheet).

Private sector entrepreneurs demonstrated huge ability to strategise, mobilise finance and develop good projects, especially when the sponsor authority was inexperienced and the environment turbulent. They assisted public sponsors to develop successful projects in several ways. Independent experts participating in a small 'peer group' helped identify project concepts, ensuring major opportunities were not missed and provided a sounding-board for sponsors. Contractor/supplier/operator 'project development groups' validated the planned project's implementability, bankability and proposed concession structure; and subsequently bid, its costs being reimbursed if unsuccessful. Moreover, in one case the concessionaire was contracted to do everything from planning, financing and implementation to operations.

Taken together, much was achieved and almost £2 billion financing was raised, but problems remained. Concessionaires have not always been joint ventures with common interests/cultures and have proved dysfunctional when things went wrong. When the UK central government caps its risk and the city sponsor cannot carry large risk (because its revenue-raising powers are limited and local politics constrain what is acceptable) concessionaires then carry large risk. This led to some failed contracts when things went wrong and the concessionaire walked away, and to questionable value-for-money when large risk was priced into project costs. In addition, the objective of securing whole-life decision-making proved problematic in part because of the practice of rebidding the concession each time the operating system was extended.

3.5 Changing the practice of project management

Substantial change is apparently required to ensure the whole project is managed (not just its implementation) and it focuses on delivering operational success. Furthermore, major change is required to the planning task that needs to change from an often deterministic technocratic approach to engagement with the major stakeholders and developing a project suited to its uncertain environment.

3.5.1 Dysfunctional project management

The case studies took 9–18 years from concept to operations, and during this long period setbacks and opportunities were the norm, and many major decisions were required any of which could threaten success. In no case was a cradle-to-grave project development process defined and applied that was fully efficient; instead project development was usually closer to a hurdles race with an unknown number and spacing of hurdles. Usually commitment preceded the basis for an informed decision being available; and in most cases the process was focused on implementation of the physical project, not its operational success. Table 5 summarises this existing process.

Operational success requires decisions during the preceding planning and implementation stages to be informed; it is too late after operations start as by then most revenues, operational costs and broader impacts are substantially committed. It is therefore necessary that the project is managed as a whole and this needs some continuity in thinking, staffing, process and assumptions between the phases. This requires the project management skills that are well developed for implementation to extend upstream and to some extent downstream; and the consistent application of risk management processes. The UK Institution of Civil Engineers working with the UK Actuarial Profession provides relevant guidance on the management of project, strategic and operational risks (Allport and Ward, 2010; Institution of Civil Engineers and the Actuarial Profession, 2005, 2006). In many cases it is inconceivable that a good

project can first be identified and then implemented. The reality revealed by the case studies is that ‘show-stopper’ setbacks and windows-of-opportunity are common features of the project development process, and projects need to be shaped continuously by events and trade-offs made that permit implementation – up to the commitment decision. Those projects that adopted this approach (rather than having change imposed on them) – notably Bangkok BTS, Singapore NEL, Croydon Tramlink, Manchester Phase 1 and Croydon Tramlink – proved notably more successful than those that did not.

The front end is critical. This is when major project decisions are made and when major opportunities may be missed. The case study evidence is that it is essential to start down the right path by identifying and appraising all potentially viable project concepts (there is a reluctance to go back and open up the possibilities subsequently). This takes time and requires holistic pre-feasibility study by a small expert team.

3.5.2 Planning failure

The research revealed frequent profound planning failure. This was manifest in ineffective plans, an absence of front-end strategic study, infeasible projects that were changed after commitment, and incredible forecasts – most ridership and operational cost forecasts were in this category. Underlying these problems was the planners’ perception of his role – that was often technical/analytical, inward looking and uninvolved with stakeholders or with the needs of decision-makers. Sometimes also planners proved to be ‘hired hands’ who provided sponsors with the answers they required to help get the go ahead.

The planner’s necessary technical role is to develop projects with robust viability which are ready and adaptable to take advantage of windows of opportunity. This requires considerable creativity with the ability to conceive physical and operational forms that meet strategic needs and are *prima facie* feasible based on

	Planning	Implementation	Operations
Led by	Planners	Engineers	Operators
Role	Identify project and financing	Implement to time, cost and specification	Operate successfully
Approach	Starts without strategic study. Risk largely ignored	Strong risk focus – but on implementation only	Risk inherited from previous stages, found to be unexpectedly large
Effectiveness	Partial, rarely good	Implementation increasingly good (seven of nine privately financed). But no focus on operations	Often heavily compromised by past planning/implementation decisions

Table 5. A dysfunctional project development process

preliminary feasibility work. Such individuals have extensive practical experience of what others have done: in Bangkok there was an architect planner and for the UK street-running systems transport/operational planners with understanding of traffic management/engineering.

Their entrepreneurial role is to engage with stakeholders and seek a compromise between technical imperatives and stakeholder agendas such that strong support is developed for a project and sustained. A central problem was a failure to recognise and plan for the impact of uncertainty. This led to an approach akin to 'planning for certainty', a failure to build-in project adaptability or demonstrate robust project viability – and yet to claim misleading confidence for forecasts after trivial sensitivity testing. The result was then to undermine the weighty commitment decision.

Planners' forecasting performance varied. Overall, initial costs were estimated well – engineers were strongly motivated to deliver projects 'to time, cost and performance' and by and large did so for what were mainly private concessions. Operational forecasts (ridership/revenues and operational costs) were, however, often poor or very poor. To the outsider the failure was of common-sense, a failure to 'reality-check' forecasts against comparable cities/systems and existing demand levels to ensure they fitted with *a priori* expectations. The remedy is obvious and has been tested thoroughly – to compare analytical forecasts with such expectations and require them to agree.

4. Conclusion

The research has revealed a range of experience in widely differing environments, complex reasons for lack of success, and many opportunities for doing better. The case studies revealed much improved implementation delivery but critically continuing poor operational success that undermines the metros' core purpose. Metros are shown to be a particularly problematic type of major project, strategically important, inherently very risky and requiring effective management often by inexperienced sponsors.

The diagnosis is founded on analysing the anatomy of how projects are developed. An understanding of the project development process based on empirical fact and interview has been created, which to our knowledge did not exist. This provides a richer understanding of cause than formerly provided. Success is shown to be achievable even in environments where rational planning faces severe problems, and new insights are provided into factors that influence success.

The change agenda addresses the issues identified. Thereafter there is the need for enforced accountability on all participants. However, the causes of 'strategic misrepresentation' are found to be more subtle than implied by the term 'lying', although there were examples of this too. More usually participants

behaved rationally in response to a confusing and ambiguous situation that often resulted from central government guidance. There are also concerns about the efficacy of the proposed solution to optimism bias, that may be ineffective as a solution while itself undermining accountability.

The core challenge is to develop some predictability in the project environment amid great turbulence such that proactive management becomes feasible, and to provide space for the sponsor to develop a project strategically, recognising that this requires creativity, an entrepreneurial approach, operational knowledge and extensive sector experience. Then, the project development process should deliver projects that are 'ready and adaptable', with the pace and rhythm of project development depending on technical work, stakeholder management and outside events. This requires a proactive, entrepreneurial and incremental shaping process with measured decision-making – 'stretching' the front-end (sound planning takes time to achieve) and 'sprinting' after commitment.

Finally, metros in the right environment and developed wisely are demonstrably a major force for good in guiding the development of sustainable cities. The research has revealed much that is good and often huge achievement in daunting environments. Much remains to be done, however, such that it is possible to develop metros with predictable success. The change agenda comprises practical steps that key participants can implement alone or together. Most participants are aware that all is not well and want to do better – indeed many are champions for change. They provide considerable hope that, given understanding, improvements will indeed happen.

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