

## Evaluating Success levels of mega-projects

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### SYNOPSIS

Today's mega-projects transcend the traditional trajectories traced within national and technological limitations. Powers unleashed by internationalization of initiatives, in for example space exploration and environmental protection, are arguably only temporarily suppressed by narrower national, economic and professional disagreements as to how best they should be harnessed.

While the world gets its act together there is time to develop the technologies of such supra-mega-project management that will synergise truly diverse resources and smoothly mesh their interfaces. Such mega-projects and their management need to be realistically evaluated, when implementing such improvements.

This paper examines current approaches to evaluating mega-projects and questions the validity of extrapolations to the supra-mega-projects of the future. Alternatives to improve such evaluations are proposed and described.

### 1. MEGAPROJECTS OF TODAY..... AND TOMORROW

#### 1.1 From projects to mega-projects

First focusing on projects, most simplified definitions portray a project as an amalgamation of inter-related non-routine non-recurrent activities aimed at specific objective(s) and with definite start and finish points in time. Distinctions between project and general management stress the limitation of resources, specificity of goal(s) and the short sharp imperatives facing temporary project teams as against the longer term almost self-perpetuating and relatively routine roles of general managers maintaining streamlined operations in steady state scenarios.

To distinguish mega-projects from projects is less simple; and admittedly a matter of choice: whether to use criteria based on money value/ cost; or on impact to the community and/or environment; or on the number of people deployed; or key parameters involved such as hectares of land, cubic meters of earth or concrete, kilometers of road or tunnel; or a combination of the foregoing.

#### 1.2 Examples of mega-projects

Traces of past megaprojects continue to fascinate us as for

example in the great pyramids of Egypt, the Great Wall of China, mega-irrigation works and other edifices of ancient civilisations.

Voyages of discovery were megaprojects whether across the uncharted seas, into unexplored forests of yore, into the depths of the Ocean or into Space. What springs to mind today may be the mega-undertakings such as the Space Station, Moon Base or Mission to Mars. It is useful to consider these in the context of some contemporary or imminent examples on Earth itself; each of which had/ has/ will have a mega-impact on its people and environment:

(a) the proposed Three Gorges Project is on the 6300 km. long Yangtze river which has a drainage area of 1.3 million sq. km and a 'mean annual runoff of 1 trillion cu m<sup>1</sup>. The proposed concrete gravity dam requiring 15.27 million cu m. of concrete will be 2546 m long and 175 m high at the crest. The reservoir capacity will be 39.3 billion cu m. and the two hydropower plants will have a total installed capacity of 17,680 MW.

On the other hand 23,793 hectares of farmland, 13 towns, 140 townships and 1500 villages will be affected by the reservoir and the population to be moved may well be over 1.1 million.

The cost was estimated at 57 billion yuan (about US\$ 10 billion) based on 1990 prices, the net economic benefit at 13.2 billion yuan, the Economic Rate of return at 14.5%, the Financial Rate of Return at 11%; and the Payback Period at 20.6 years which is about 2 1/2 years after estimated total completion.

(b) The Channel Tunnel will soon change the character of earth-bound traffic between the UK and the rest of Europe. However the approximately US\$ 13 Billion project is already 60% over budget and over one year behind schedule.

Furthermore the US\$ 1.8 billion claim by the consortium of contractors recently resulted in a deadlock in Paris<sup>2</sup> which perhaps exemplifies that the problems of megaprojects are not very different from smaller ones except that the repercussions can be that much greater. The potential for problems is perhaps heightened by the interactions between the many powerful personalities of the multi-project participants; but then the opportunities for bigger and better solutions is also hopefully heightened on synergistic grounds.

(c) The proposed new airport in Hong Kong vividly illustrates the problems of multi-stake-holder interests in mega-projects. The program estimated at approximately US\$20 Billion, has been split into 10 'Core' projects. Some of these are underway; while others may be modified in order to meet the self-imposed deadline of 1997; and also as a compromise in the on-going prestige battle between Britain and China on broader issues.

This megaproject includes transportation links to the airport that is being built mostly on land reclaimed from the sea. The 'Core' projects include long span bridges and road and rail

links and interchanges which are 'big' projects in themselves.

(d) It is worth comparing the foregoing with the \$ 2.7 billion new Denver International Airport megaproject in USA. At its ultimate capacity it will exceed the combined capacities of the worlds two largest airports at present<sup>3</sup>.

(e) The Mahaweli irrigation and hydropower program in Sri Lanka launched in the late 1970's sought to compress into the life span of one parliament, a previously phased out program that would have spanned 30 years and cost over US \$ 1 billion. Foreign funds from many countries were injected to fuel this acceleration. It was not difficult to achieve (on paper) the required rates of return, by for example changing some designated crop areas from paddy to higher return yielding cash crops. The relative merits of the nature and magnitude of the foreign inputs are still being questioned by those who point out to the stifling of the domestic construction industry, for example.

Even the foregoing small sample of contemporary mega-projects indicates the nature of the emerging agendas to be addressed; for example of the increasing size, scope and linkages of mega-projects; and of the delicate interface management needed between the many powerful and sometimes culturally and technologically diverse project participants. Issues to be resolved sometimes include those arising from divergent value systems and from real or imagined impacts on the environment.

### 1.3 The need for evaluation

The foregoing random scan of a few mega-projects, illustrates the need for evaluating every project against relevant criteria. The stakes are so high and the variables so many that ground-rules need to be established, targets set and evaluated against from the outset for many reasons; including the efficient allocation of scarce resources, for example.

President Clinton recently directed NASA to redesign Space Station 'Freedom' to make it more efficient and effective and capable of producing greater returns on investment. No doubt NASA has translated these into a set of detailed 'evaluatable' targets. The imperatives for proper evaluation are just that much more compelling on mega-projects which can have mega-impact on so many living things; and even those who are still unborn.

## 2. EVALUATION

### 2.1 What is evaluation?

Unfortunately the word evaluation has been used in various contexts and with different connotations. It can for example mean different things to economists, engineers or human resource managers. This paper which espouses a multi-disciplinary approach to evaluation, takes evaluation to cover both ongoing and completed project reviews. It excludes pre-project appraisals of

feasibility but must necessarily relate to the setting and validation of objectives at that stage.

In comparison, Imboden defined<sup>4</sup> evaluation as the 'ex-post analysis of an executed project' and project appraisal as the 'ex-ante analysis of a proposed project'. The Overseas Development Administration of UK defines it similarly<sup>5</sup>; while using 'monitoring' for reviews of ongoing projects. Here mid-project evaluation is taken to include a more detailed performance analysis against targets, than may be implied by monitoring. On the other hand Corrie extends the scope of evaluation to include planning and feasibility studies<sup>6</sup>.

This paper also distinguishes evaluations from audits which may merely test compliance with management controls and regulations. Evaluation implies testing performance against pre-determined targets; that may or may not be adjusted for changed circumstances. More fundamentally, evaluation refers to the process of determining the merits, worth or value of things; or to the result of that process<sup>7</sup>. It is implied that the reference is to the net value; so that both value and cost aspects are assessed.

## 2.2 Why evaluate?

Briefly, project evaluators may seek (a) to assess performance on on-going or completed projects; in order to reward or reprimand participants; (b) to improve future performance (by lessons learnt from failures); (c) to improve future target setting (eg: incorporating weightings for project circumstances so as to yield more realistic targets).

Top management, shareholders, governments or the community itself (in the case of mega-projects) would also want to know what went wrong and why, how bad it really was and how things could be improved. For example they may want to know the exact impact on project success of for instance the mirror defect in the Hubble Space Telescope or the jammed high gain antenna in the Galileo mission.

While there are already many stakeholders in a smaller project, those with interests in a mega-project multiply tremendously. eg: those affected by the environmental impact or whose tax payments may have contributed to the funding.

## 2.3 How to evaluate?

Will a systematised approach to evaluation of mega-projects provide the necessary answers? What of the grey areas that may need qualitative judgements? How does one evaluate the ability of the project team to hit the 'moving targets' that often result from changing project priorities and circumstances eg: sudden price restrictions; mid-stream scope expansions; or intermediate time targets, for sectional completion or meeting other milestones.

Except in major disasters like the 'Challenger' or a breached dam, it is usually the time and cost targets that are over-run, as in the case of the Sydney Opera House; since the performance specifications can often be met by incurring more time and money. It is difficult to be excellent, fast and economical all at once, but that is the essence of a good project and of its management.

#### 2.4 Differentiating project success from that of its management

Drastic changes in conditions affecting a project can result in project failure; and successful management can sometimes only mitigate the effects of such failures. At the other extreme unrealistically 'easy' targets and very favourable conditions can precipitate project success in spite of management mishaps.

The evaluator(s) should therefore be clear what/ who is being evaluated; whether it is the project, its management or both. Effectiveness (in achieving results) must be distinguished from efficiency (in optimising resource usage in achieving such results).

The consequent distinction between 'impact' or 'outcome' evaluation (of results) and 'implementation' evaluation of process (and management) is self-explanatory.

The formulation of suitable targets against which to measure success must therefore take account of such distinctions.

### 3. CRITERIA AND INDICATORS OF SUCCESS

#### 3.1 Establishing criteria of success

Since every project is unique and the major stakeholders may have special priorities, it is essential to jointly establish the criteria by which success will ultimately be judged. Securing the agreement of multiple stakeholders of a mega-project may well prove a formidable project by itself. Incorporating such agreed criteria in the project brief is therefore a primary management task.

Criteria of project success which were traditionally based on the cost-time-quality tripod, have grown in both number and sophistication. Health, safety and environmental criteria, as well as stakeholder satisfaction criteria are also often (consciously or otherwise) considered when evaluating the success level of a project or its management. For example Ashley et al listed in 1987 six criteria most frequently used to measure construction project success as: budget performance; schedule performance; functionality; client satisfaction; contractor satisfaction and project manager/ team satisfaction<sup>8</sup>.

As for increased sophistication; the cost criterion for instance may not be confined to initial capital cost; but may well

include life-cycle cost; elemental (sectional) costs; cash flow profile factors etc for management or implementation evaluation and economic rates of return incorporating social benefits as well, for impact or outcome evaluation. Thus life-cycle cost, elemental costs etc. may be sub-criteria within the overall cost criterion. Return on capital is an example of a criterion relating to the overall project success itself.

The relative significance of each criterion (and sub-criterion) would necessarily vary with the project priorities on different projects. Cost may be paramount in some, while timing or prestige / performance levels may be of the essence on others.

The multiple criteria against which projects are to be evaluated often result in varying degrees of success/ failure against each criterion and sub-criterion. Figure 1 illustrates a model proposed by the author to illustrate a profile of performance against each such criterion (a,b, c....) and sub-criterion (a1, a2, ...b1, b2, ... etc)<sup>9</sup>.

Appropriate measures to be used for each such criterion and sub-criterion need to be defined and suitable scales established for such measurement. Measurement can be by suitable 'indicators'<sup>9</sup>

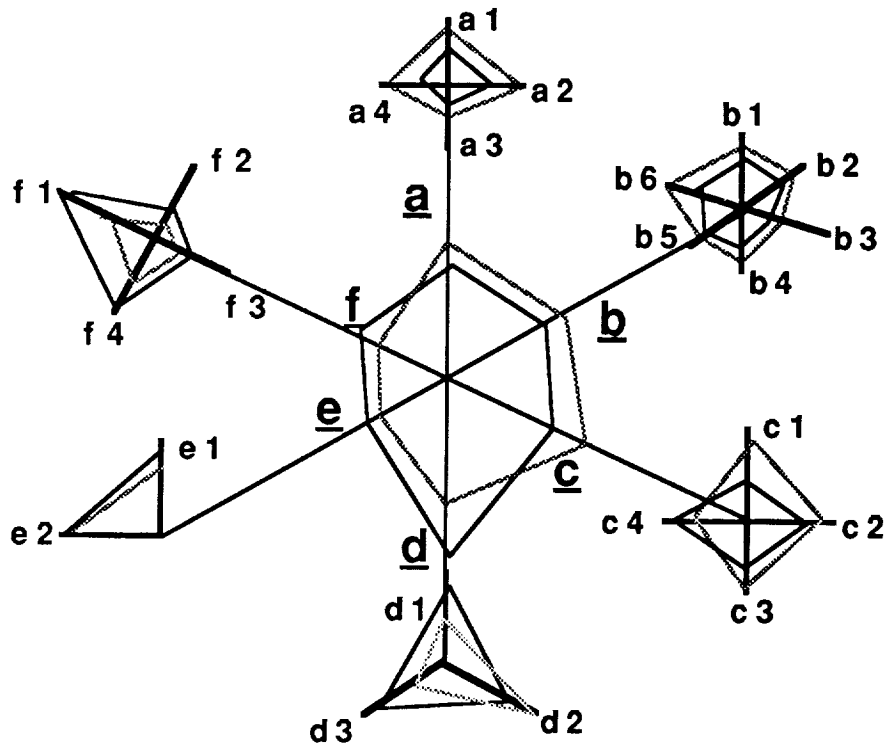
### 3.2 Formulating indicators of success

Indicators are needed here: (a) as proxies for measurement where direct measurement is difficult; (b) as short-hand symbols to measure vast quantities of data; (c) as short-cuts to a quick first approximation of the status of a project or its management; (d) to present such status through measurements against relevant criteria for example on the above-mentioned project performance profiles.

Examples of such basic primary indicators can be cost/kg of payload launched or cost/ m<sup>3</sup> of usable space, in a Space mission; or cost/m<sup>2</sup> of building, cost/ m<sup>3</sup> of water stored or cost/MW of power generated etc. A combination of primary indicators may be designed to represent one criterion if necessary ie if one indicator is deemed inadequate by itself. Each primary indicator in turn can be analysed into secondary (and tertiary) indicators related to relevant criteria, for example in elemental cost break-downs.

### 3.3 Using indicators in evaluation

'Norm' values of such indicators as derived from a databank could convey the industry standard under average circumstances. These can be weighted by factors (based on 'weighting indicators') to adjust for special project conditions and client priorities. Evaluators would then compare actual performance against such weighted 'norms'.



**KEY**

Targetted Profile      
 Achieved Profile    

**NOTE**

The further a point is from the origin along any criterion (or sub-criterion) axis: the better is the performance against that criterion (or sub-criterion).

**EXAMPLE OF A PROJECT PERFORMANCE PROFILE**

FIGURE 1

Figure 2 illustrates how deviations from the norms, say in certain primary indicators, would alert the evaluator to investigate relevant areas further; by checking out the secondary (and tertiary) indicators therein. Thus the evaluator is directed through a structured search for the root causes of under-performance<sup>9</sup>.

However two caveats are noted. Firstly apparently 'normal' primary indicators may mask a 'delinquent' secondary indicator which is over-compensated by over-performance against a parallel secondary indicator. Secondly parallel qualitative assessments are essential to place apparent 'good' or 'bad' variances in context.

### 3.4 Examples from international mega-project evaluation

International funding agencies such as USAID, the overseas Development Administration (ODA) and other bilateral aid agencies have used indicators - based evaluation systems to measure the success levels of their programs in other countries. Figures 3 and 4 illustrate the evaluation frameworks used for such systems. Different cultures, diverse value systems, divergent views and conflicting claims would have proved the worth of such a systematized approach to evaluation in such situations. Similar scenarios would arise in the multinational mega- projects of the present and future.

## 4. PROBLEMS AND PROSPECTS OF MEGA-PROJECT EVALUATION

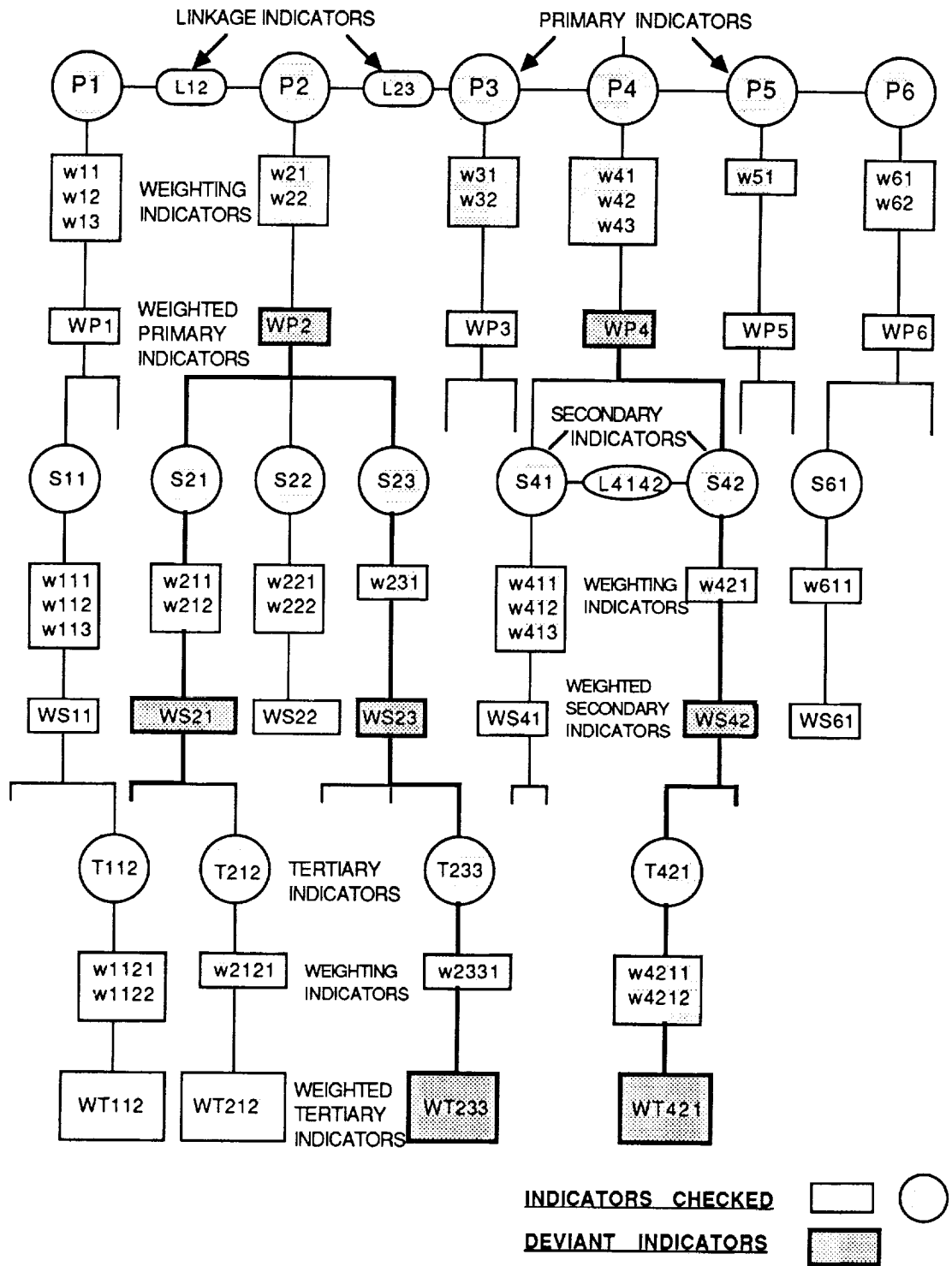
### 4.1 The changing nature of mega-projects

While projects were always about change, the mega- projects of today reflect the ultra high rates of change that technology has facilitated. The multiplicity of participants and the effects of the project increasingly transcend national boundaries; as in joint venture in space exploration and environmental control. Technology advances much faster than the frameworks needed to manage it, generating human and environmental stresses and strains.

Since mega-projects may take longer than the average projects, the success criteria are more susceptible to revision eg. with the change of governments or other project stake-holders. Multi-attribute evaluation becomes more complex with such shifting goal-posts. Even on a macro scale Purchasing Power Parity and various forms of Quality of Life indices are supplanting GNP. Environmental impact indicators are another growth industry. A mega-project evaluator needs to quantify social costs and benefits as well.

The author found specialist software designed for integrating a series of pairwise comparisons to be useful in reducing the residual subjectivity of some such basically qualitative assessments<sup>9</sup>. It is also useful to make allowances for possible distortions by effects such as the 'Halo' effect, the 'Hawthorne' effect, the 'Placebo' effect or the 'Harvard fallacy'





**SELECTING FROM A TYPICAL FAMILY OF INDICATORS**

**FIGURE 2**

<b>Narrative Summary</b>	<b>Objectively verifiable indicators</b>	<b>Targets</b>	<b>Means of verification</b>	<b>Major assumptions</b>
<b>Goal</b>				
<b>Objective</b>				
<b>Target</b>				
<b>Output</b>				
<b>Input</b>				

**LOGICAL FRAMEWORK MATRIX USED BY USAID<sup>10</sup>**

**FIGURE 3**

<b>Project structure</b>	<b>Indicators of Achievement</b>	<b>How indicators can be quantified or assessed</b>	<b>Important Assumptions</b>
<b>Wider (ie sector or national) objectives</b>			
<b>Immediate objectives</b>			
<b>Outputs</b>			
<b>Inputs</b>			

**PROJECT FRAMEWORK USED BY THE ODA  
(OVERSEAS DEVELOPMENT ADMINISTRATION OF UK)<sup>11</sup>**

**FIGURE 4**

C-2

The matrix or hybrid project matrix structures typical of projects may be inadequate to convey the mechanisms of mega-project operations. Additional dimensions are introduced by the multiple stake-holders.

For example the consortium of contractors on the Channel tunnel is composed of 5 major British and 5 major French contractors. The Eurotunnel client is similarly diverse. Joint ventures in Aerospace have exposed project participants to even wider ranges of diversity. Build, Operate and Transfer (BOT) type contracts (and their variations) for major infrastructure projects bring together an array of stake-holders with an apparent multiplicity of objectives, from various countries and cultures.

Thus a third dimension (at the very least) is needed in the organisational picture to accommodate the multiple organisations, each of which have their own functional hierarchies; from each of which in turn, project participants will be drawn. The participants therefore have linkages (however weak) to their parent organisations as well as to their functional disciplines. The nature of each industry (and specific factors such as mobility therein) would determine the relative strengths of such linkages. Evaluators of mega-projects need to make allowances for such linkages and loyalties; and to be aware of the particular management structures, styles and operative information flow mechanisms.

#### 4.2 Integrating evaluation mechanisms into management systems

Another characteristic of most mega-projects is that the special priorities and conditions governing them are that much more different from the average. While every project is unique, and therefore diverges from each other in most respects, such divergences are magnified many fold in mega-projects. However the assimilation and analysis of databanks of relevant information from 'similar' projects is an important step in placing the project in context.

Project planning is another critical function in such mega-projects. The multi-attribute success criteria of multiple stake-holders is hopefully translated into meaningful management targets.

It is an obvious advantage to build in monitoring, evaluation and control (remedial) systems to integrate with the management systems. For instance the management information system disseminating information required to run the job can be designed to retrieve reports for review. The Quality Assurance or Safety systems could have similar built in evaluation mechanisms.

'Bechtel' which manages many mega-projects has installed systems where the 'Controls' function incorporating progress and cost control personnel, is separated from the 'Management' function; perhaps so that an independent assessment is facilitated. However the actual information gathering could be integrated to prevent duplication; apart from specific

investigations from time to time which are necessary to vary the procedures so as to minimise cheating; to cater to specific situations and to evaluate from fresh angles.

#### 4.3 Integrating progress, cost and quality management systems

Progress and cost control systems have been advantageously integrated under 'earned value' analysis where cost and schedule variances are generated. The U.S. Departments of Defence and Energy for example have used 'cost/schedule control system criteria' (C/SCSC) to interrelate work scope definition, schedule, estimate/budget, physical performance and actual expenditure<sup>12</sup>.

'Cost trending' is a similar procedure used for example, in the Airport Core Programme in Hong Kong where project cost, scope and programming are continuously monitored and hopefully controlled.

Recent international emphasis on quality, 'galvanised' contractors, consultants and even large client organisations to seek accreditation under ISO 9000 or the relevant local standards such as BS5750. Quality now has to be 'designed, in' 'built in' and 'assured' rather than checked or inspected for after the event. One of the key advantages of installing internal systems geared to such accreditation is the opportunity to incorporate recording and reporting sub-systems that can also service the monitoring and evaluation functions. The discipline instilled in maintaining these provisions, helps overcome previous resistance to such procedures.

Another relatively recent concept is that of using 'feedforward' mechanisms that alert management to deviations in inputs; rather than relying only on feedback from output variances.

#### 4.4 Trends in mega-projects; and related criteria and indicators of evaluation

Jargon such as 'out-sourcing' 'down-loading' and 'down-sizing' operations, convey the moves towards sub-contracting out specific activities to specialists while whittling down one's own operations to core activities and interface management. 'Joint-venturing' and 'partnering' are other manifestations of similar trends. Claims of interface interference by the many interacting parties can thus prove crucial.

This leads to criteria and indicators such as numbers and values of claims, related to numbers of such interfaces and values of such work packages.

Some clients and consultants even use (official or unofficial) indicators of the 'claims - consciousness' of contractors, in order to weight tenders accordingly. Of course such indicators should themselves be weighted by the circumstances (of justification or otherwise) of the original claims. Diverse

sources of information contribute to construct such indicators. eg: the number of referrals to arbitration; the number of rejections therefrom; comparisons with other contractors.

Disputes themselves are not settled only by litigation or arbitration but by mediation, conciliation etc. Alternative dispute Resolution (ADR) underlines the philosophy of such new approaches; just as alternative procurement systems are spawning many variations of contracting for design, supply and construction services. For instance alternative contracting is now challenging the traditional lowest - bid system even in public-sector construction in USA<sup>13</sup>. Even payments are linked to the statistical quality of work, for example on some New Jersey DOT sponsored highway construction projects. Statistical indicators of concrete or asphalt strength, thickness, smoothness and riding quality can enhance contractors payments up to 103% of contract value. The trade-off is in less maintenance and future repairs.

Impact evaluation would continue to rely heavily on variance indicators to assess deviations from set targets, while implementation evaluation also uses indicators of resource utilisation or resource idling rates. The evaluation of social and environmental costs and benefits in computing Economic Rates of Return for example, are areas where evaluation expertise needs refinement.

The effectiveness of technology transfer is a sensitive area in mega-projects that straddle national boundaries. The evaluation of cross-benefits that accrue to, and costs incurred by joint-venture partners is another crucial area where criteria and indicators used are often inadequate to track the longer term impacts and trace the wider repercussions of participation in such mega-projects. The Asia & Pacific Centre for Transfer of Technology (of ESCAP) formulated a system of evaluating technology content using sets of indicators related to 4 different aspects of technology<sup>14</sup>.

Trends appear to favour the increasing 'size' of mega-projects; as the benefits of comparative advantages (for instance of different operations in different nations) and of synergistic linkages gradually overcome traditional apprehensions. 'Drivers' are also derived from providing opportunities to regions in temporary recession or decline for example; while resistance arises for instance from heightened environmental apprehensions aroused by mega-impact projects.

However the need to tackle environmental, Space exploration and even ocean exploitation endeavours on a broader basis, justify the overall push towards globalisation. This will perhaps herald the supra-mega-projects of the future.

Such trends highlight the needs not only to develop technologies of supra-mega -project management, but also for their realistic evaluation, so as to continue improving that management.

#### 4.5 Concluding observations

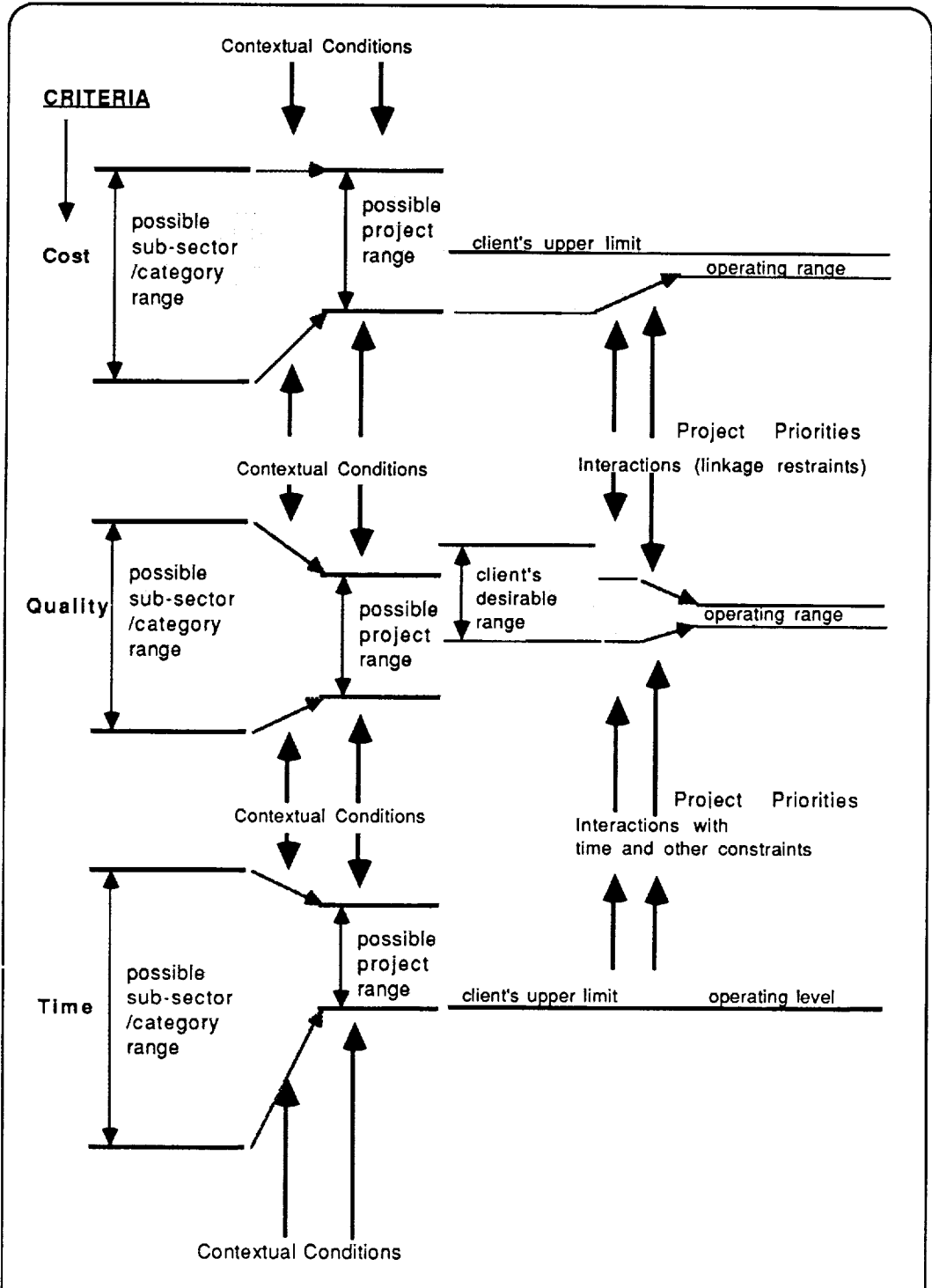
'Trade-offs' are often warranted where for example high performance against one criterion is sacrificed to enable exceptional performance against others which are of higher priority, as for example illustrated in Figure 5. While such 'trade-offs' are easier appreciated and accommodated on small projects with less stake-holders, they become the source of conflict in multi-participant mega-projects. Even if agreed, unless it is explicitly so, these could lead to conflicts and unfair future evaluations. The moral is the enhanced importance of a detailed project brief in mega-projects; and also the criticality of the conceptualisation phase where such trade-offs are best incorporated; rather than making adjustments mid-stream in the project when the costs of disruption can be tremendous.

The multi-dimensional character of mega-projects arise from the usually multi-disciplinary, multi-cultural multiple stake-holders and warrant multi-attribute evaluations which can become somewhat complex, and more so in view of the foregoing trade-offs, that may continue in the dynamic project environment.

The purpose of this paper is to focus on the evaluation of mega-projects and to highlight the need for a systematisation of approaches based on multi-dimensional criteria (and sub-criteria) and appropriate indicators for measuring against such criteria and sub-criteria. Data banks of previous project parameters are useful to assess and weight 'norm values' of such indicators so as to facilitate more realistic expectations. Their usefulness presupposes classification according to appropriate categories and sub-categories. The multiplicity of such variables (criteria, indicators and weighting factors) and the ranges of possible values led the author to propose (a) a modular structure and (b) a knowledge-based front-end to facilitate the efficient use of such a system. It's viability<sup>9</sup> was demonstrated in a pilot construction project evaluation system<sup>9</sup>.

The evaluation system should not grow so complex as to 'hide the wood for the trees'. Furthermore the rewards from evaluation as in improved performance on on-going and future projects should exceed the costs of the evaluation itself. Such objectives are easier to ensure through the foregoing systematisation of broad approaches to evaluation. A given broad core approach can be selected to suit a particular category of projects; and then modified according to particular project priorities and contextual conditions<sup>9</sup>.

The integration of evaluation mechanisms into the planning, operational and information sub-systems further facilitates efficient evaluations. The next question that surfaces relates to the effectiveness and efficiency of the evaluation itself; possibly leading on to the evaluation of the evaluations and evaluators themselves.



**EXAMPLE OF THE NARROWING RANGES OF PERFORMANCE CRITERIA DUE TO CONTEXTUAL CONSTRAINTS AND PRIORITY INTERACTIONS**

**FIGURE 5**

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