TOWARDS AN INTEGRATED MANAGEMENT SUPPORT SYSTEM FOR LARGE CLIENTS

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SUMMARY: *Infrastructure mega projects involve several complex clusters of interacting activities. Establishing suitably integrated management support systems for construction clients should be useful in targeting best value with reduced rework and wastages. This paper presents highlights from a co-ordinated cluster of ongoing Hong Kong based research initiatives that aims to develop an integrated Management Support System (MSS) framework for large clients in the construction industry. Also, an overview of the MSS framework and brief descriptions of some sample subsystems and prototype modules are included in this paper. The envisaged MSS is planned to enhance the infrastructure project procurement and operational/ delivery mechanisms.*

KEYWORDS*: construction clients, management support system, procurement, project delivery.*

1. INTRODUCTION

Large infrastructure construction projects involve several inter-related activities. The management of large projects is usually quite complicated and therefore challenging for many construction clients. The necessity for information and communication technologies (ICT) enabled management support systems is increasingly evident (Love et al. 2000; McCaffer and Hassan, 2002). However, general observations of several existing decision-support aids and management support systems in various client organizations indicated that many of those systems targeted only narrowly focused independent sets of objectives (Kumaraswamy et al. 2004a). They are therefore mostly discrete or non-connected. An ongoing Hong Kong based research initiative aims to develop a more holistic framework and sample working modules of a knowledge-based and integrated Management Support System (MSS) that will empower the formulation of more effective and efficient infrastructure project procurement and operational/ delivery systems.

The main objectives of this MSS research are (i) to build rich knowledge-bases of best practices, founded on sound principles, in optimizing selected infrastructure procurement and operational/ delivery sub-systems, in the context of both client priorities and project contextual conditions; (ii) to develop these knowledge-bases further, e.g. by incorporating and extrapolating both paradigmatic/ theoretical frameworks, as well as recent and potential innovations in particular scenarios; and (iii) to design an MSS framework and develop prototype working modules of this MSS that would draw on these knowledge-bases in providing appropriate advice on the selection, development and integration of procurement and operational sub-systems for a particular infrastructure construction project. The proposed MSS framework primarily targets the improvement and integration of important procurement and operational/ delivery decisions in client organizations, e.g. relating to issues of contractor selection, productivity, quality, safety, and dispute containment. Thus, this MSS project envisages a suite of ICT based management support solutions which would be ultimately integrated in a web-based interface.

2. SUMMARY OF RESEARCH METHODOLOGY AND SYSTEM DEVELOPMENT

2.1 Research strategies, approaches and methods

A multi-pronged research methodology was developed to address the above objectives. A wide literature review was followed by interviews of industry experts on innovations in construction procurement and operational/ delivery systems; and an initial questionnaire survey on such innovative approaches. Subsequent questionnaires and case studies were developed to extract, codify and consolidate rich knowledge bases of good/ best practices. For this purpose, the emphasis has now shifted to intensive case studies, which include interviews and in some cases smaller questionnaire surveys of participants.

Up to now, three independent questionnaire surveys (unrelated to the case studies) have been completed, while seven project case studies have been launched (of which four are complete and another is almost complete).

The questionnaires surveyed:

1. 'Innovations and their implementation, including barriers, and lessons learned' - surveyed in both Hong Kong and Singapore, using the same questionnaire, to enable comparisons within the same region and a somewhat similar setting. Analysis of the responses provides interesting insights (Sze et al. 2005) and pointers to potential strategies for improving the initiation and implementation of useful innovations in project procurement and delivery.
2. 'Barriers to, and prospects for mutual technology transfers' and 'relational integration in Joint Venture teams' – surveyed in Hong Kong. Analysis of 150 responses from Hong Kong professionals with an average experience of 11.9 years has led to useful conclusions and model developments (Kumaraswamy et al. 2004b).
3. The potential for developing (a) a Relational Contracting Culture and (b) Integrated Teams – surveyed in five countries using the same questionnaire - Hong Kong, Singapore, Australia, UK and the Netherlands. 86 responses were received from Hong Kong and another 96 from Singapore. Three smaller sets of high quality responses (from very experienced industry personnel) were received from the Netherlands (13 no.), the UK (9 no.) and Australia (23 no.). Analyses and cross-country comparison are yielding interesting outcomes, which are being published (Kumaraswamy et al. in press; Rahman et al. 2005).

The seven case studies were on:

1. 'partnering' in a housing estate construction project of the Hong Kong Housing Society,
2. 'extended partnering' in a building refurbishment project of the Hong Kong Housing Authority (HKHA),
3. relational contracting and joint risk management approaches on a Mass Transit Railway Corp. (MTRC) station extension project – almost complete,
4. 'partnering' on a foundations project of the HKHA,
5. a public-private partnership (PPP) type cable-car project of the MTRC – ongoing,
6. a private sector commercial building project – ongoing and
7. a road maintenance project of the Highways Dept. (of the Hong Kong SAR) awarded on a part PPP basis.

The case studies are designed to capture knowledge for incorporation in the planned knowledge bases of best practices. They have yielded and are continuing to yield interesting outcomes, some of which have been published, with good feedback, while investigations and analysis are in progress on others.

For example: (A) different aspects of the development of the 'partnering knowledge-base' have been presented by Kumaraswamy et al. (2003) and Sze et al. (2003, 2004); and (B) useful findings from case-study (7) on the part-PPP road maintenance project were summarised in a Report to the Highways Department. Review of the vast body of emerging literature on the PPPs, together with the experiences gained on this case-study led to the formulation of a framework for injecting 'relational' and 'sustainability' elements into PPP systems of the future, and this was presented at a conference (Kumaraswamy et al. 2005).

The related principles for structuring the findings of the case-studies are being drawn from the case interviews and the latest literature etc., and are being framed in the context of improving procurement and operational/ delivery sub-systems.

The development of basic/ conceptual frameworks is continuing on the following:

- MSS (Management Support System) for 'Integrated Procurement and Delivery/ Operations' (that is planned to provide decision support for selecting and integrating a cluster of critical sub-systems, such as for contractor selection, joint risk management etc.),
- 'Partnering Knowledge Base' (that is planned to include critical success factors, lessons learned, etc.),
- 'Relationally Integrated Project Teams' with a value focus,
- 'Relationally Integrated Joint Ventures' with a Technology Transfer focus,
- Contractor Selection system and
- Claims and Disputes Management.

For example, a prototype web-based Decision Support System for assisting in the evaluation of Extensions of Time' was developed and demonstrated to a small group of industry practitioners. Having received very positive feedback, one published and another submitted journal paper are expected to elicit further feedback prior to the next stage development.

The frameworks for 'contractor selection', for 'relational contracting' and 'joint risk management' are being developed further – moving into the 'team selection' and 'implementation' phases. In terms of the proposed PPP module, the framework presented at a recent conference (Kumaraswamy et al. 2005) has been developed further and submitted for feedback expected from a small group of experts from academia and industry.

Furthermore, an attempt was made to reconcile conflicting terminology in construction project 'procurement' and 'delivery'/ operational/ project management systems and sub-systems and presented at the Jan. 2004 CIB W92 Conference in Chennai, India (Kumaraswamy et al. 2004c). This team was then invited by CIB W92 (Working Group on Procurement Systems) to initiate a rationalization/ re-classification (including re-definitions) of procurement & delivery systems terminology. As invited, a working paper was developed, presented and well received at the Feb. 2005 CIB W92 Conference in the USA (Palaneeswaran et al. 2005). Further development is planned at the next stage, involving a small group of academics based in different countries who are interested in joining this initiative.

2.2 System development strategies and framework

The various approaches chosen for developing the pilot modules of the MSS include: (i) Delphic strategies for mapping and prioritizing client-specific requirements and project-based needs; (ii) bespoke decision-making constructs and group decision arrangements; (iii) hybrid decision logic strategies of both data driven forward chaining and goal driven backward chaining; and (iv) reusable system modelling and integrated system designing with object oriented programming concepts. Some of these approaches have been used already, while others are being used or will be applied in due course on relevant modules.

The envisaged MSS is structured under the following four broad clusters: (i) integrated procurement system, (ii) collaborative delivery system, (iii) inter-organizational learning system, and (iv) synergistic technological system. The present initiative focuses on the development of procurement related subsystems and operational/ project delivery related subsystems; i.e., on the first two broad clusters; while the third and fourth are expected to be dealt with later.

The procurement subsystems include work packaging, payment modalities, contract conditions and selection methodologies. The operational/ delivery subsystems include time management, cost management, quality management, performance appraisal, safety management, risk management, value management, claims and dispute management, human resources management, and information and communications management.

Fig. 1 portrays a broad outline of the conceptualized MSS 'development' and 'usage'.

At the basic profiling level, structured constructs for capturing client preferences (e.g. time, cost, and quality) and project parameters (e.g. complexity, risk level) in suitable database formats are considered. The set of sample 'solutions' that would be suggested following the basic profiling would include suggestions on the choice of appropriate procurement route, functional groupings and payment modalities.

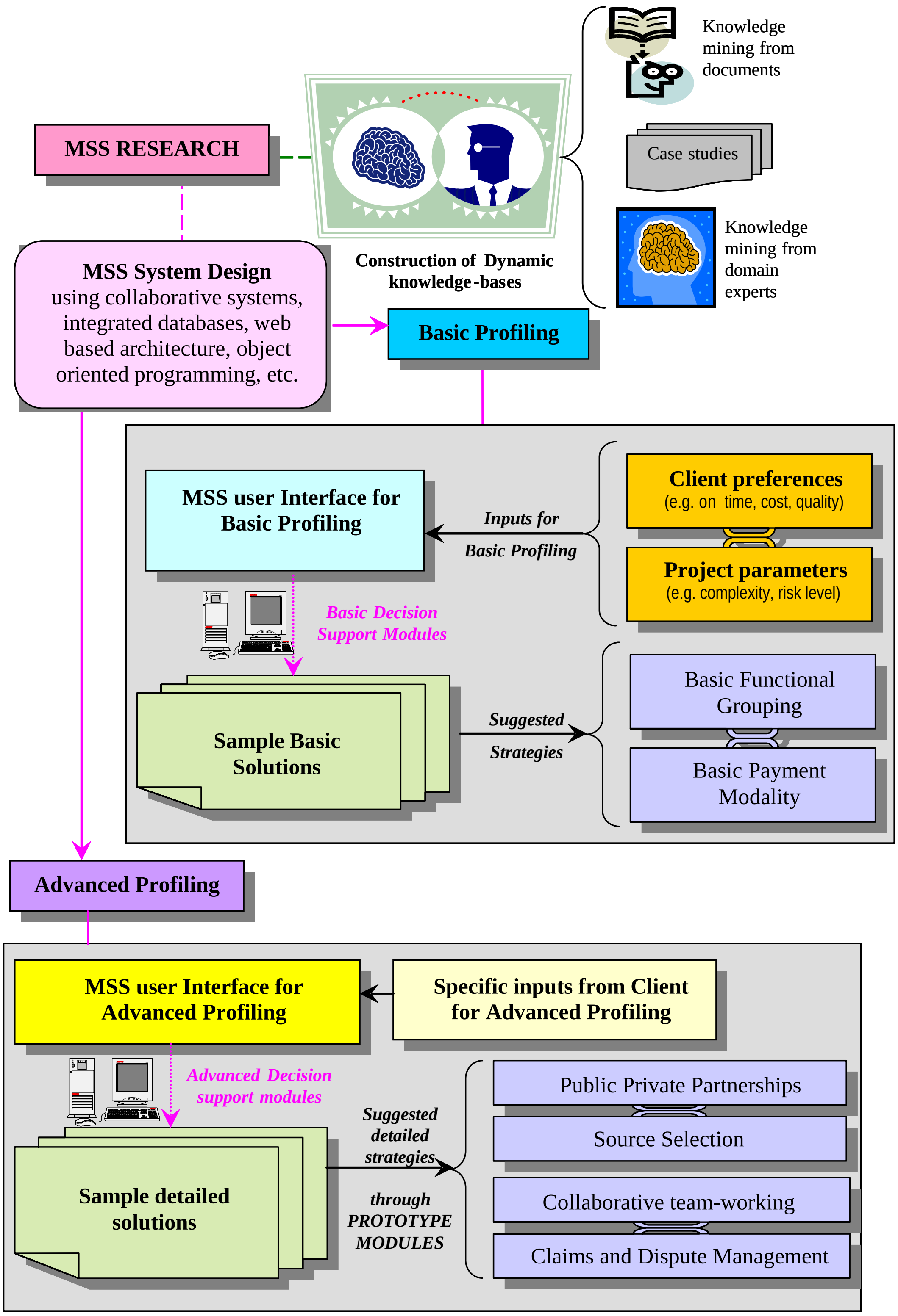


FIG. 1: MSS 'development' and 'usage'.

The advanced profiling include structured constructs for capturing specific inputs (e.g. from relevant stakeholders) required for individual subsystems. The suggested set of MSS 'solutions' of detailed strategies yielded by the advanced profiling would include construction of various subsystems in both procurement (such as proposed contractor selection subsystem) as well as operational/ delivery stages (e.g. performance appraisal subsystem, claims and disputes management subsystem).

A set of structured database architectures, client-server platforms and web-based interface arrangements are planned for the construction of prototype modules of the envisaged MSS. Such modules include for example, a centralized contractor registration framework (Ng et al, 2003), a dynamic e-reporting model for assessing and reporting on contractor performance (Ng et al. 2002), a prototype system for web-based design-builder prequalification (Palaneeswaran and Kumaraswamy, 2005), a prototype decision support system for dealing with time extension claims (Palaneeswaran et al, 2001; Kumaraswamy et al, 2001).

The 'mining' of appropriate knowledge from various related research initiatives such as on applications of relevant artificial intelligence techniques and decision-making strategies are also explored in this research. Some such initiatives include (i) rule-based expert systems (e.g. Palaneeswaran and Kumaraswamy, 1999; Ng and Skitmore, 2000); (ii) case-based reasoning (e.g. Ng et al. 1998), (iii) multi-agent systems (e.g. Ugwu et al. 2003), (iv) artificial neural networks (Lam et al. 2000), (iv) knowledge-based decision support system formulations (e.g. Kumaraswamy and Dissanayaka, 2001), and (v) fuzzy logics based management applications (e.g. Cheung et al. 2001; Ng et al. 2002).

3. OVERVIEW OF MSS FRAMEWORK ONTOLOGY

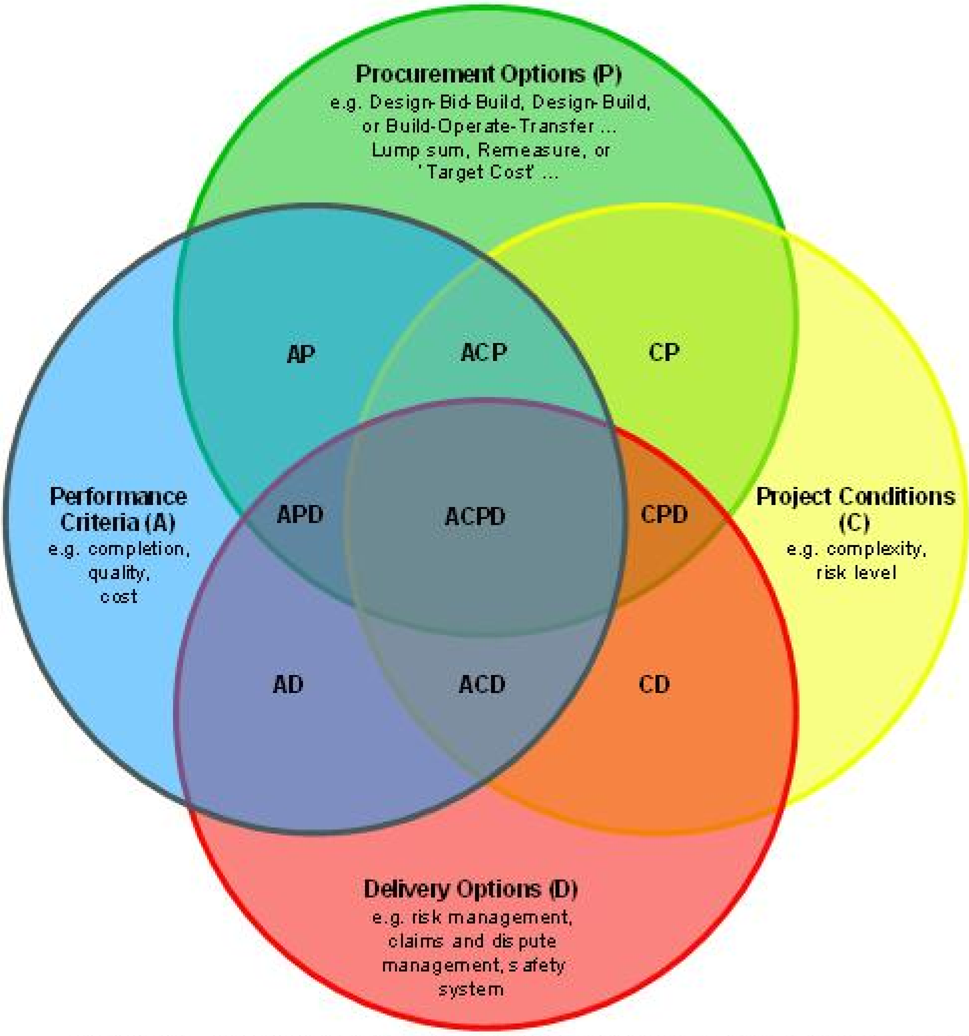
It is increasingly difficult to choose well from the rapidly proliferating procurement and delivery options, given the complex multi-criteria decisions needed in 'poly-variable' scenarios. Fig. 2 below illustrates the databases and knowledge-bases that are needed to model the relationships between the many variables. For example, in choosing from many possible 'Procurement options' (P), one would need to be better informed about typical impacts (based on previous experiences in similar cases) on desired 'performance criteria (A) e.g. lower 'whole life cost' or prestige quality; as well as how well they would match (or be incompatible) with project Conditions (C) such as the various client characteristics and project complexity level e.g. in terms of procurement options, the AP, CP and next the ACP relationships need to be modelled, with the crucial ACPD relationships in Fig. 2 being the most critical in predicting potential performance against specific criteria under particular conditions on a given project. Similar approaches are thus needed for choosing synergistic 'Delivery options' (D), with cross-checks against Procurement options too.

4. EXAMPLES OF SOME PROTOTYPE CONSTRUCTS FROM MSS

The sample subsystem prototype modules of the MSS were originally planned to provide guidance to management on: (a) incorporating 'joint risk management' and 'relational contracting' principles in more sustainable partnering and alliancing arrangements in the construction supply chains; (b) public-private partnership subsystems; (c) contractor selection strategies; and (d) evaluation of 'extension of time' entitlements. This section provides sample snapshots of some such subsystem constructs, also incorporating some further developments that were found to be useful as the research and development (R & D) exercises proceeded in each of the above modules.

4.1 Collaborative team-working subsystem

Effective risk management requires that (1) all foreseeable risks are clearly and equitably allocated to the appropriate party and/ or shared between the contracting parties, and (2) an appropriate contractual flexibility is maintained to address unforeseen risks, as and when they occur, using the best available options at the time of their occurrences and, from among many others, under a Joint Risk Management (JRM) strategy. This calls for a clear 'meeting of minds' of the contracting parties, which can be streamlined through improved relationships and cooperative teamwork, where the motivation and attitudes of the project participants are critical (Rahman and Kumaraswamy, 2002a; 2002b; 2004b). Relational Contracting (RC) principles are found to provide such 'soft' qualities: in mobilizing (1) rationalized evaluation criteria for selecting the potential team members, and (2) useful strategies for improving relationships and building a coalesced project team for JRM – so that all stakeholders work closely together with common objectives for a successful project delivery (Rahman and Kumaraswamy, 2004a; 2004b).



Note: C, P, D, A represent data-bases, while AP, AD, ACPD etc. represent the knowledge-bases that are needed to capture the relationships and interactions at these interfaces

FIG. 2: Schematic representation of interacting sets of Variables, and of the Knowledge-bases needed – for guiding the selection of appropriate Procurement and Delivery Systems.

For an appropriate functional arrangement, the above delineates that owners maintain a periodically updated databank (named by these researchers as a Relationally Integrated Supply Chain – RISC) of performance records of other contracting parties (i.e. contractors, consultants subcontractors and suppliers), against both 'hard' (e.g. time, cost, quality) and 'soft' (e.g. attitude to joint decision making/ problem solving) factors. This will help owners to assess "competency" (relating to hard factors – to carry out a specific project) and "compatibility" (relating to soft factors - to work harmoniously with other team members) of the potential team members, to form the 'optimal'/ 'best' possible team for a specific project, based on previous performances and working relationships, and with an estimation of potential compatibilities and synergies in the new project scenario (Rahman and Kumaraswamy, 2005). After modelling the project requirements (i.e. project priorities and owner's preferences/ constraints as in Stage 1 of Fig. 3), when the outline of the procurement arrangements is firmed up, a few from each category of the potential team members are brought into the project scenario (Stage 2 of Fig. 3). This enables the various potential team members to interact with each other, providing the opportunity to appreciate their mutual strengths and weaknesses – under the teambuilding protocols like the 'partnering workshop'. Following the various stages of the framework shown in Fig. 3, it may be that only one from each contracting party category will be finally selected for the Relationally Integrated Project Team (RIPT). Still, the longer-term interactions and RC-based teambuilding protocols in the RISC will help build trust among them, even before finally entering into RIPT.

Irrespective of the procurement system chosen, the RIPT will proactively address and jointly decide on all uncertainties and any changes during project progress (i.e. using JRM), choosing the best available options in the pursuit of project objectives. Unresolved issues or disagreements may also be referred to this RIPT for firm, if not binding decisions. Benefits or losses sustained in addressing unforeseen events will be apportioned among different parties according to their resource deployment, or on the basis of previously agreed formulae (e.g. pain/ gain share). If only one party is assigned to address any such unforeseen event, the party should be properly compensated. The degree of integration of an RIPT may vary from post-contract partnering type arrangements to alliancing, through to vertical integration – as if all the project team members belong to a single organization (Rahman and Kumaraswamy, 2005).

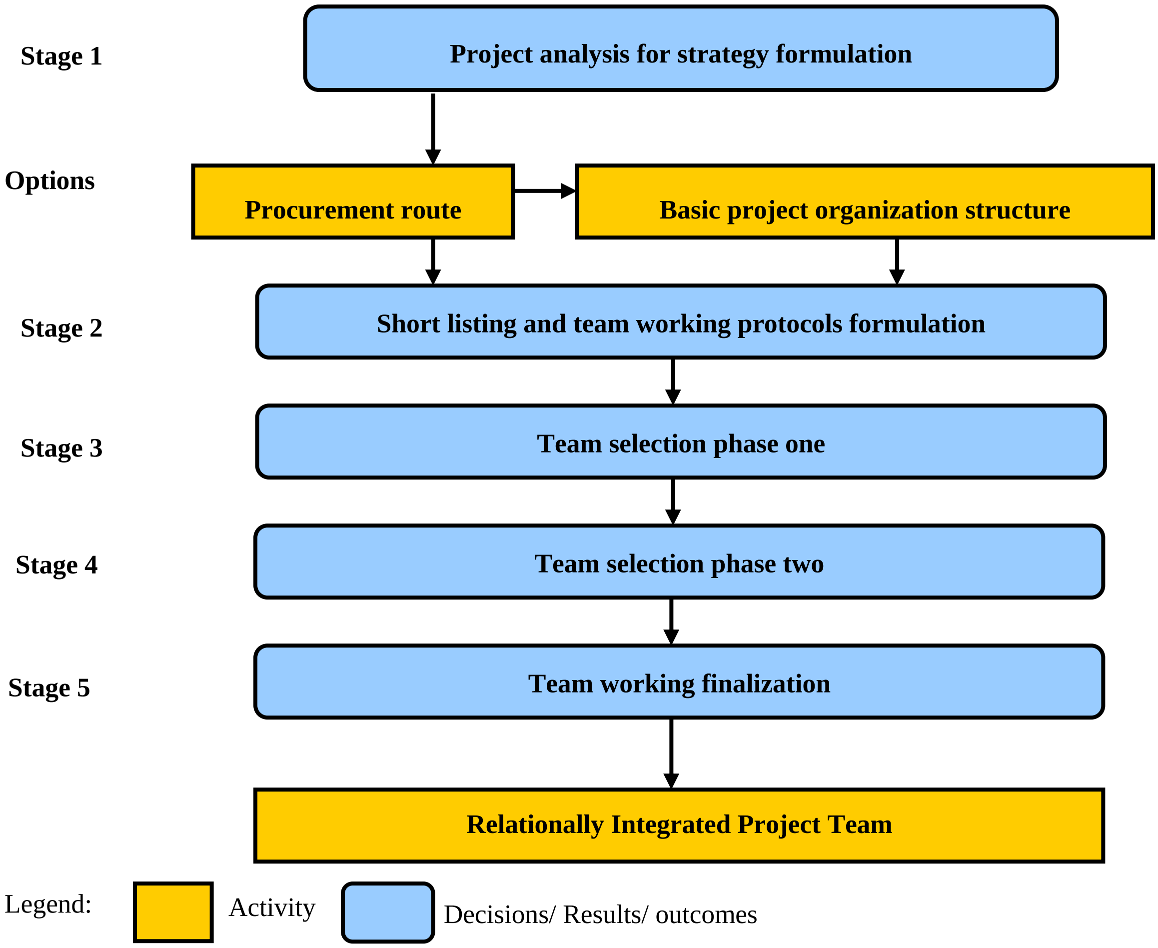
The above collaborative team-working decision-support subsystem is being developed as the first of the above four prototype modules of the envisaged MSS. It includes (1) a joint-risk assessment mechanism and (2) a relationally integrated team selection framework both of which will assist in the initial/ upstream 'Procurement' Phase – specially in cases where it has been decided to incorporate such 'relational' approaches in the project (as is increasingly common); and (3) joint-risk management, through for example an appropriate incentive-disincentive procedure integrated with performance appraisal and best value realization – which will feed into the downstream 'delivery/ operational phase' of the project. Currently, construction of a comprehensive knowledgebase is underway, based on which this web-based decision-support subsystem will be developed.

4.2 Source selection and performance management subsystems

Selection of suitable contractors, consultants and subcontractors is important for overall success in construction projects. Several clients have recently focused on deriving 'optimum' or best value from such 'source' selection exercises rather than merely relying on apparent cost-saving economies from purely price-based selections (Palaneeswaran et al. 2003 and 2004; Lighthouse Club, 2005). Thus, previously proposed multi-criteria based selection strategies and assessments with multi-disciplinary inputs are being revisited (e.g. Russell, 1992; Hatush and Skitmore, 1998; Holt, 1998). A set of structured selection frameworks for specific selection scenarios have been developed e.g. for design-builder selection model (Palaneeswaran and Kumaraswamy, 2000) and concessionaire selection in build-operate-transfer (BOT) type PPP projects (Zhang et al, 2003).

Due to various inherent complexities and multi-disciplinary expertise requirements of such source selection exercises in large client organizations, structured knowledge-bases, archived datasets (e.g. past performance records) and decision support mechanisms are generally considered to be necessary. Appreciating the significance of source selection, several decision aids have been proposed by various researchers, such as computer software for contractor selection (e.g. Russell and Skibniewski 1990), case-based expert system for contractor prequalification (e.g. Ng et al. 1998), source selection related decision-support models (e.g. Hanna et al. 1997; Taha et al. 1998; and Lam et al. 2000). Similarly, from a set of local research initiatives a dynamic e-reporting system for contractors' performance appraisal (Ng et al. 2002) has been modelled, which could be seamlessly integrated with the proposed web-based centralized contractor registration system framework (Ng et al. 2003). Furthermore, for specific selection scenarios a network of relevant systems suitably integrated such as through web-based platforms have been considered, e.g. a sample prototype web-based design-builder selection system module has been constructed and validated with relevant domain experts (Palaneeswaran and Kumaraswamy, 2005). The design-builder selection system includes a set of structured frameworks such as selection criteria knowledgebase, 'clustered' criteria evaluation architecture, and lexicographic tie-breaking arrangements for two-stage design-builder selection, i.e. (a) design-builder prequalification and (b) design-build proposal evaluation.

A sample framework of an integrated system for subcontractor selection and performance assessment is presented in this section. A collaborative subcontractor registration (CSR) framework as in Fig. 4 outlines a possible strategy for scrutinizing the information collected from the subcontractors. As shown in the figure, there are four essential steps involved, including the formulation of subcontractor assessment criteria, screening, assessment and feedback.



Notes: Options - Traditional, D&B, BOT, Management Contracting, etc.

Stage 1 begins after feasibility study

Examples of activities:

Stage 2 - Invite and shortlist different parties from RISC, workshop, outline of RIPT, outline contractual adjustment protocols, outline win/ lose agreement, outline partnering/ alliancing arrangement, etc.

Stage 3 - Assemble consultants and/ or management team, prepare specifications, and/ or preliminary/ detail design, and/ or project requirements, etc.

Stage 4 - Tender assessment, negotiation, selection, contract award, etc.

Stage 5 - Workshop, detailing of RIPT, finalisation win/ lose arrangement, contract adjustment protocols, 'issue' resolution mechanisms, partnering/ alliancing arrangements, etc.

FIG. 3: Flow chart for assembling a 'Relationally Integrated Project Team'.

Criteria formulation leads to a list of subcontractor assessment criteria to suit a particular category and size of subcontractors and works, which will form a basis for the rest of the assessment. Companies seeking registration, or those that wish to be considered for renewal and/or upgrading their registration status, will be prompted to submit relevant data.

Screening aims to eliminate any inherently unsuitable or incapable subcontractors. To remain in business, many subcontractors including the very small and incapable ones would apply for registration. Decision rules may be established for rejecting inherently unsuitable subcontractors, such as those which do not have a business registration in the relevant trade.

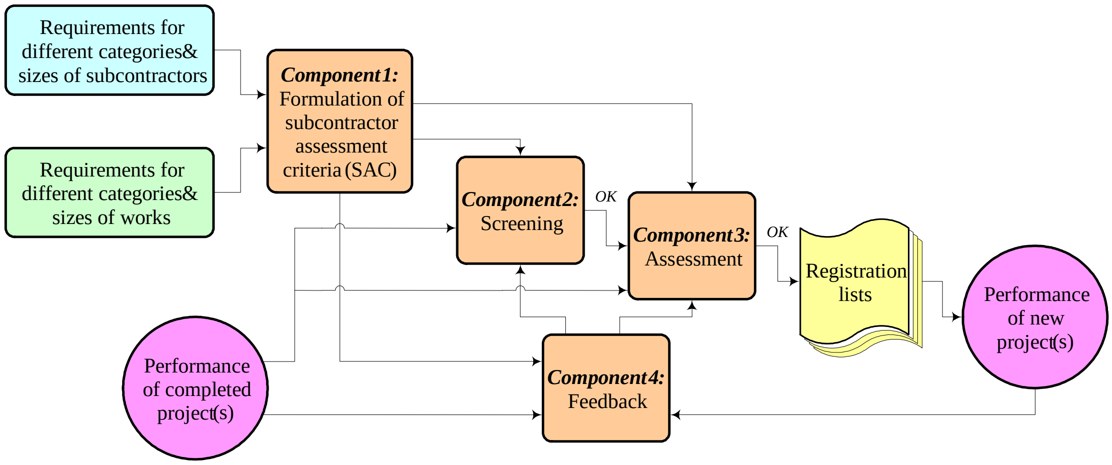


FIG. 4: Conceptual framework for CSR decision-making.

Assessment evaluates subcontractor's organizational and performance data, e.g. financial, technical and managerial abilities. Here, a uniform system of rating subcontractors should be devised to determine the size of subcontract upon which each registered firm shall be deemed qualified to bid.

A feedback loop should exist to act as a monitoring mechanism for any subcontractor registration scheme. Significant non-conformance should necessitate adequate regulatory measures such as warning letters, while a pattern of continuous non-conformance should attract disciplinary measures such as penalties, relegation of registration status, temporary suspension or removal from the registered lists.

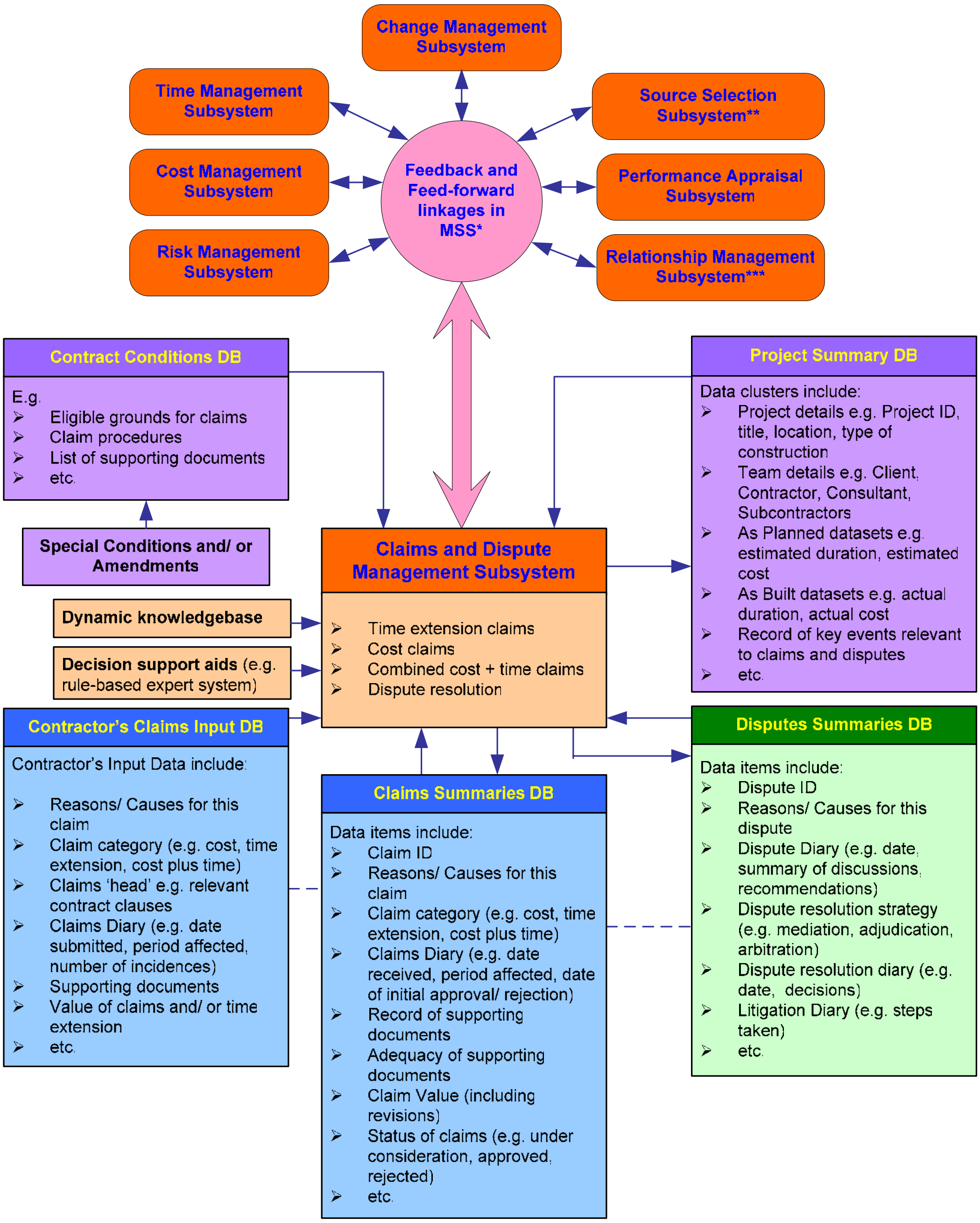
4.3 Claims and dispute management subsystem

Claims and disputes are common in construction projects (AbouRizk and Dozzi, 1993; Yogeswaran et al. 1998). Dealing with claims and disputes is arduous for several clients and decision support aids will be beneficial reducing such difficulties (Alkass et al. 1995; Ren et al. 2001). Furthermore, structured archiving and tracking mechanisms will be beneficial for further analysis and effecting better management strategies. In differentiating between 'claims' and 'disputes', Kumaraswamy (1997) drew on dictionary and construction industry definitions and descriptions as follows: (1) a 'claim' is an assertion of the right to money, remedy, relief or property and noted that construction claims themselves usually arise as assertions for extra money or time. Claims on construction projects can be based on the contract itself, a breach of contract, a breach of some other common law duty, a quasi-contractual assertion for reasonable (*quantum* merit) compensation or an *ex-gratia* settlement request. So some disputes are needed to accommodate damages in project conditions or clients' needs. If not settled reasonably, some these claims can lead to disputes. (2) Disputes have been said to arise 'when a claim or assertion made by one party is rejected by the other party and that rejection is not accepted' (Eggleston 1993).

Fig. 5 portrays the framework of the proposed claims and dispute management subsystem of the MSS. The envisaged claims and dispute management subsystem module will be mainly having the following features:

- a suite of interlinked databases, e.g. project summary, contract conditions, claims summaries, disputes summaries,
- a dynamic knowledge-base of best practice procedures and protocols for dealing with claims and disputes,
- a versatile decision support mechanism, e.g. an inference engine with appropriate rules and guidance derived from relevant sources such as contract conditions,
- suitable mechanisms for data/ information exchange with relevant stakeholders, e.g. feedback from contractors and
- feedback and feed-forward linkages with other subsystems of the MSS, e.g. (i) procurement subsystems such as contractor selection and (ii) operational/ delivery subsystems such as time

management, cost management, risk management, change management and relationship management.



* Only those 'Feedback/ Feed-forward' linkages relevant to the Claims and Dispute Management Subsystem are portrayed here and other similar linkages (i.e. for other Subsystems) in the MSS are not shown in this Figure

**This Source Selection Subsystem is part of the 'Procurement System' and includes modules for contractor and sub-contractor selection as discussed in Section 4.2

*** This 'Relationship Management Subsystem' while under 'Delivery System' is linked to the selection of 'Relationally Integrated Supply Chains' (as in Section 4.1), and itself within the more 'relational route' under the Procurement System's Source Selection Subsystem.

FIG. 5: Framework of the Claims and Disputes Management Subsystem.

A web-based prototype decision support system for dealing with time extension claims in particular (named EOTDSS by the researchers) has been developed and demonstrated to a group of industry experts and positive feedback obtained. Furthermore, constructive feedback from conference audiences (Palaneeswaran et al. 2001 and Kumaraswamy et al. 2002) have also been included in further fine-tuning of the system. The main modules of the EOTDSS are: (i) a Time Extension Eligibility Checking System (TEECS); (ii) an Extension of Time Quantification Method Selector (EOTQMS); (iii) a module for Quantification of Time Extension Claims (QUANTECS). By means of some interactive querying sessions in the TEECS module, the eligibility for time extension from a particular occurrence of delay event could be checked. The EOTQMS provides some basic guidance for choosing a particular quantification method (e.g. "Windows Analysis") for calculating the EOT. The QUANTECS module is a basic advisory system (e.g. with several formulae and example calculations) for determining the eligible period of EOT using a particular quantification method.

A couple of sample screenshots from the web-based EOTDSS prototype subsystem module are presented in Fig. 6. Descriptions of the EOTDSS are provided by Kumaraswamy et al. (2004a); while further developments will be presented by Palaneeswaran et al. (under review). This EOTDSS will be an important part of the 'Claims and Dispute Management' subsystem, given the large proportions of time-based claims and their common contributions to cost claims in many construction claims scenarios.

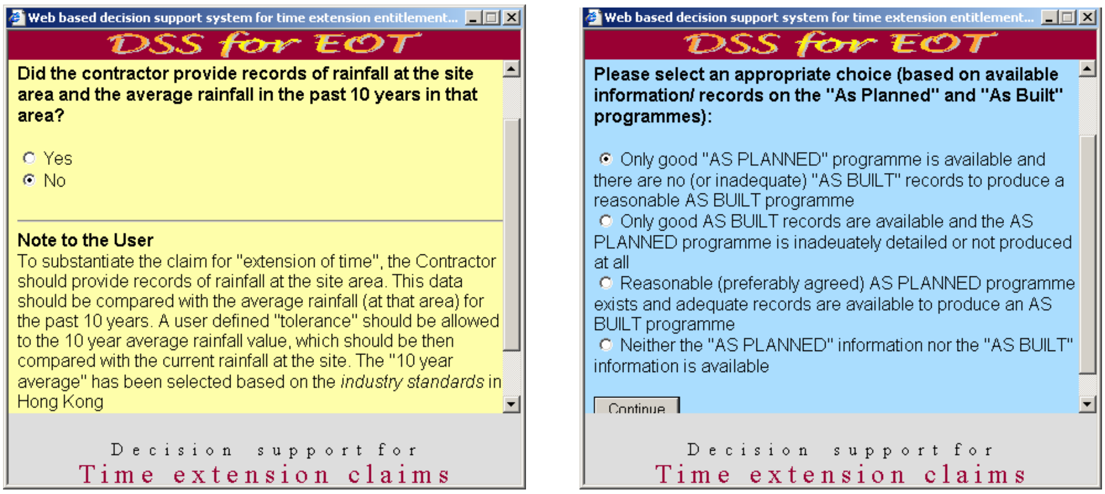


FIG. 6: Sample screenshots from EOTDSS prototype subsystem module.

5. CONCLUSIONS

Managing mega infrastructure projects involves several complex tasks that are quite challenging for many clients. Establishing suitably integrated management support ontology and taxonomy constructs covering the commonly encountered important transaction segments of construction client operations should be useful in targeting 'best value', lowering transaction costs and reducing rework and wastages. Such structured constructs will be useful for developing the searching (e.g. advanced search engines) and mining (e.g. from data mining) facilities that are essential for project-based synergistic knowledge management transactions such as knowledge discovery from lessons learned. The envisaged management support system framework has been synergistically formulated, and is being developed from various related research initiatives. The planned suite of seamlessly knitted subsystems of the conceptualized MSS mainly should assist in the continuing pursuit of best value, sustainability and harmonious team-working arrangements amongst the construction industry stakeholders through stronger client-led supply chain linkages and better informed decisions.

6. ACKNOWLEDGEMENTS

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7. LIST OF ABBREVIATIONS

BOT	-	Build-Operate-Transfer
CIB	-	International Council for Research and Innovation in Building and Construction
CSR	-	Collaborative Subcontractor Registration
D & B	-	Design-Build
EOT	-	Extension of Time
EOTDSS	-	Decision Support System for Extension of Time
EOTQMS	-	Extension of Time Quantification Method Selector
HKHA	-	Hong Kong Housing Authority
ICT	-	Information and Communication Technologies
JRM	-	Joint Risk Management
MSS	-	Management Support System
MTRC	-	Mass Transit Railway Corporation
PPP	-	Public Private Partnership
QUANTECS	-	Quantification of Time Extension Claims
RC	-	Relational Contracting
RIPT	-	Relationally Integrated Project Team
RISC	-	Relationally Integrated Supply Chain
SAR	-	Special Administrative Region
TEECS	-	Time Extension Eligibility Checking System

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