

TOP-DOWN AND BOTTOM-UP CONSTRUCTION INDUSTRY DEVELOPMENT

M.M. KUMARASWAMY*, S.T. NG, E. PALANEESWARAN, M.M. RAHMAN, O.O.UGWU and E.K.K. SZE
Centre for Infrastructure & Construction Industry Development, The University of Hong Kong, Pokfulam, Hong Kong; email address of corresponding author*: mohan@hku.hk

ABSTRACT

An overview of two R&D projects provides summarised case studies of the ongoing development of two distinct performance improvement systems that can help empower different segments of the industry. The first project focuses on a Management Support System (MSS) for large clients (LCs); while the second aims at Information and Knowledge Management Systems (IKMSs) for Small & Medium Contractors (SMCs). Finally, the paper points to the potential for an integrated system that can provide useful linkages across these extremities of the construction supply chain by proposing a LC based Project Information & Knowledge Management Platform (PIKMAP). The latter could serve specific projects by providing useful seamless interfaces with all stakeholders, including the LC, its consultants, contractors and suppliers, as well as SMCs involved. Certain issues will of course need to be carefully addressed e.g. in terms of confidentiality, security levels and legal liabilities in respect of each stakeholder.

Keywords: *Construction Industry Development, Information & Knowledge Management, Management Support System, Small & Medium Contractors*

INTRODUCTION

This paper commences with a ‘tale of two projects’ that summarises the main thrusts and status of two ongoing R&D projects. Each project aims at enhancing opposite corners of the construction industry supply chain, namely Large Clients (LCs) and Small & Medium Contractors (SMCs). However, they both focus on supporting management through better information & knowledge management and decision support systems. The paper concludes with a basic conceptual proposal for an integrated Project Information & Knowledge Management Platform (PIKMAP) that should accelerate the exchange of information, the development of broader knowledge bases, and thereby empower better decisions in the construction industry.

The first R&D project aims to develop an integrated framework and sample working modules of a knowledge-based MSS that will empower the formulation of more effective and efficient construction project procurement and delivery systems – for innovative and improved ‘total’ management of construction projects – from a large client’s viewpoint. The objectives include developing: (A) rich knowledge-bases for selecting and optimising construction procurement and operational/ delivery sub-systems, in the context of both client priorities and project contextual conditions; and (B) prototype modules – to

demonstrate management support possibilities, including decision aids in specific sample areas: such as in incorporating ‘relational contracting’ principles and best practices in more sustainable partnering and alliancing arrangements in an area that is attracting increasing attention [Walker and Hampson, (2003)].

The second project is entitled SMILE-SMC. It aims at empowering continuous improvement of Small and Medium Contractors (SMCs) by providing a SMC-friendly framework and innovative tools for boosting productivity, quality and image, through strategic information and knowledge management. Project deliverables include SMC-friendly platforms, incorporating web-based and mobile communication linked systems and tools - for boosting business and operational processes of construction contractors in general, and SMCs in particular - to be developed and disseminated through the proposed SMILE web-site, newsletters, industry seminars, training workshops and self-learning packages. Work is proceeding on (a) formulating a basic SMILE framework and (b) on a wider questionnaire survey and workflow analyses to prioritise SMC needs, following the completion of a preliminary ‘needs analysis’ survey.

Both projects are based in Hong Kong, and include inputs from overseas bodies and experts, as well as strong participation from local organisations, including clients, contractors, government-sponsored bodies and trade associations. The projects were conceived, proposed and funded separately, with the first started about a year before the second. However, it is not surprising that the possibilities of an eventually seamless solution are now being envisioned. Such an over-arching initiative could integrate improved ‘decision support’ and ‘information and knowledge management’ across complex construction supply chains. This would in turn help to accelerate technology diffusion and construction industry development.

MSS (MANAGEMENT SUPPORT SYSTEM) FOR LARGE CLIENTS

Project formulation and main thrusts

This project aims for ‘top-down’ improvements by developing an integrated framework and sample prototype modules of a knowledge-based Management Support System (MSS). This will empower the formulation of more effective and efficient construction project procurement and operational/ delivery systems, from a large client’s viewpoint, for innovative and improved ‘total’ management of construction projects.

This project is funded by a grant from the Research Grants Council of Hong Kong. It was launched in September 2002 and planned for a three year duration. The proposal was strongly endorsed by two large construction clients (one being a private developer and the other a railway corporation). It also involved two overseas co-investigators, one based in the UK, and the other originally in Singapore.

The objectives are to develop: (1) rich knowledge-bases of sound principles, best practices and innovations, in optimising selected construction procurement and operational/ delivery sub-systems, in the context of both client priorities and project contextual conditions; (2) an MSS framework and (3) prototype working modules – to provide management support, including decision aids in the following sample areas: (a) in incorporating ‘relational contracting’ principles in more sustainable partnering and alliancing arrangements in construction projects e.g. by adapting proven ‘joint risk

management' protocols; (b) public-private partnered procurement; (c) contractor selection; and (d) 'extension of time' evaluations.

Present status

The framework and two of the sample modules are presently being developed. A wide literature review, interviews, two questionnaire surveys and two project case studies have been completed. A third questionnaire survey and three more project case studies are now underway. The first two questionnaires focused on: (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; and (2) 'barriers to, and prospects for mutual technology transfers' and 'relational integration in Joint Venture teams' – surveyed in Hong Kong only, this being an additional survey, also linked to another research exercise.

The two completed case studies were on: (1) 'partnering' in a housing estate construction project of the Hong Kong Housing Society; and (2) 'extended partnering' in a building refurbishment project of the Hong Kong Housing Authority. The three other case studies that have commenced are on: (3) relational contracting and joint risk management approaches on a MTRC (Mass Transit Railway Corporation) station extension project; (4) 'partnering' on a foundations project of the Housing Authority; and (5) a recently commenced public-private partnership type project of the MTRC.

These questionnaire surveys and case studies are yielding interesting outcomes, for example on a proposed structure and sample contents of a 'partnering knowledge-base' that would form part of the 'relational contracting' module (Kumaraswamy et al., 2003), weak links in the partnering supply chain [Sze et al., (2003)] and on potential for relational approaches and technology exchange in joint ventures [Kumaraswamy et al., (2004a)] while analysis is in progress on other material. The framework and related principles for structuring the findings of the case-studies, are being drawn from both the case interviews and literature on previous research and theories e.g. [Cheng and Li, (2001); Chan et al., (2002); Luu et al., (2003); ESCAP, (1994); Carrillo, (1995)]. These are being consolidated and framed in the context of improving procurement and delivery sub-systems.

The third questionnaire survey is on the potential for developing a relational contracting culture. It was launched in five countries. 86 responses have been received from Hong Kong and another 96 from Singapore. A smaller cluster of high quality responses has been received from the Netherlands. Surveys using the same questionnaire in UK and Australia have not yielded many responses to date, apparently the victims of a questionnaire-weary industry. Analysis has commenced on the Singapore and Hong Kong samples and the eventual cross-country comparison is expected to yield interesting outcomes.

A prototype web-based Decision Support System for assisting in the evaluation of 'Extension of Time' entitlements has been formulated (Palaneeswaran et al., under review), demonstrated to a small group of industry experts and positive feedback received. The frameworks for 'contractor selection', for 'relational contracting' and 'joint risk management' are being developed further. A rationalised re-classification/ re-

definition of procurement & delivery systems terminology has commenced, along with the formulation of a basic decision support tool for procurement system selection.

Basic conceptualisations

Clearer conceptualisation and differentiation has been proposed between project 'procurement' and 'delivery' systems, although North American terminology indicates an overlap e.g. in terms of 'Project Delivery and Contract Strategy' (Anderson and Oyetunji, 2003). These are differentiated herein by distinguishing the initial overall 'procurement' system decisions e.g. on project packaging, contractual, organisational and team selection strategies; and the downstream project management (more 'operational') decisions that are taken during project 'delivery'. While this differentiation has been described in detail by [Kumaraswamy et al. (2004b)], Figure 1 serves to summarise the various interactive components of the envisaged Integrated Procurement System (IPS) and Collaborative Delivery System (CDS). These will be at the core of the proposed MSS framework. Decision support protocols will be developed to assist in selecting and assembling appropriate sub-systems in order to formulate the most suitable procurement and delivery systems for a given project of a large client, depending on specific project priorities and contextual conditions. The initial concepts are described in more detail by Kumaraswamy et al. (2004c), while [Ugwu et al. (2003)] expand on the ICT conceptualisations.

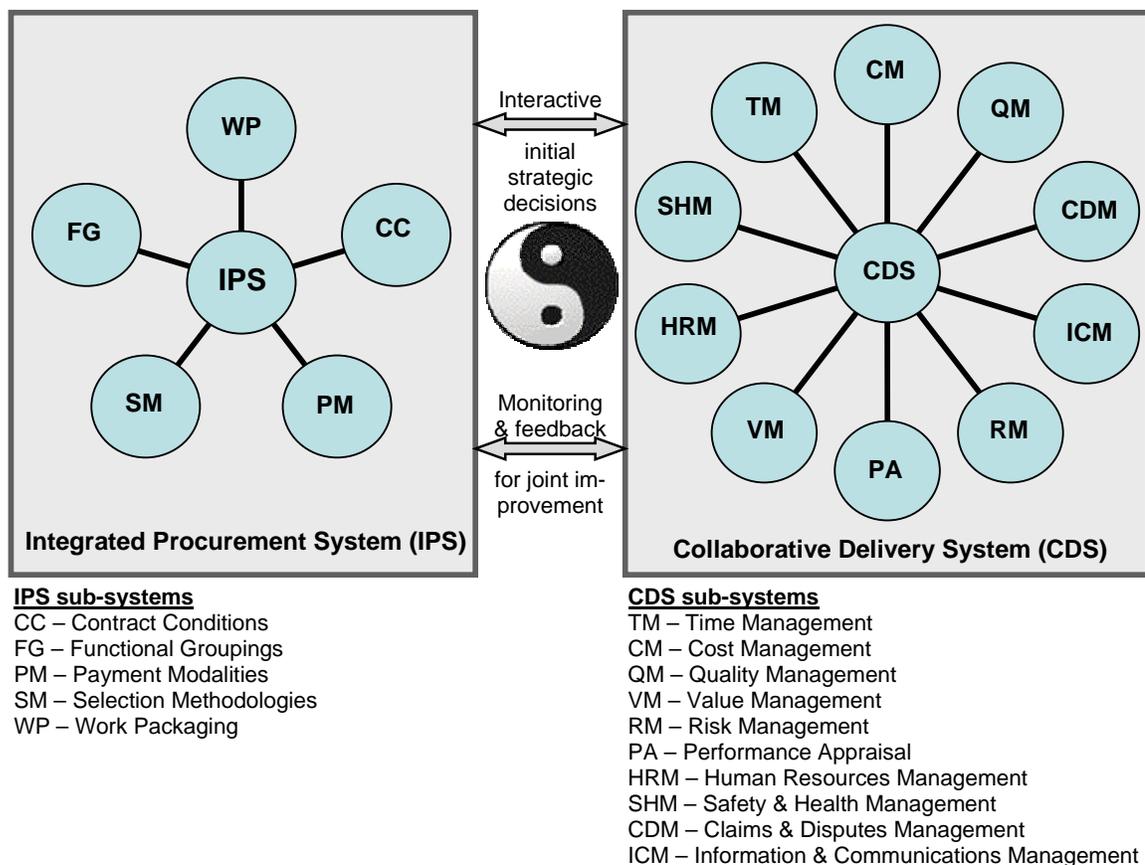


Figure 1 Collaborative Procurement and Delivery Systems in proposed MSS

**SMILE-SMC (STRATEGIC MANAGEMENT WITH INFORMATION
 LEVERAGED EXCELLENCE FOR SMALL AND MEDIUM CONTRACTORS)**

Project formulation and main thrusts

This second R&D project aims for 'bottom-up' improvements through the development of Small and Medium Contractors (SMCs), by providing a SMC-friendly framework and innovative tools for boosting productivity, quality and image, through strategic information and knowledge management. For example, savings are envisaged through more efficient and timely information flows, enhanced 'business knowledge', reduced wastage (of resources) and less rework (in rectifying substandard or defective works). Quality and image improvements will be derived from guidelines based on good/ best practice examples. These will be made available/ accessible through various modules of the proposed SMILE system.

The SMILE-SMC project is funded by a grant from the Small and Medium Enterprises Fund of the Hong Kong SAR Trade and Industry Department, with support funding from the Faculties of Engineering and Architecture of The University of Hong Kong. The proposal for this project, which commenced in November 2003, was strongly endorsed by the Provisional Construction Industry Co-ordination Board of the Hong Kong SAR, as well as the Hong Kong Federation of Electrical and Mechanical Contractors; and supported from the outset by both the Hong Kong Construction Association (HKCA) and the Construction Industry Training Authority (CITA), as collaborating organizations; five 'partner contractors' (PCs) in Hong Kong; and five overseas Universities/ R&D Centres from the UK (two), Australia (two) and Singapore (one) as collaborators/ advisors. The interest and momentum generated have led to 9 more SMCs joining as PCs on this project; and strong support has been enlisted from two other contractor associations: the Hong Kong General Building Contractors Association (HKGBCA) and the Hong Kong Construction Sub-contractors Association (HKCSA), both of which represent many SMCs. Representatives of these associations and our PCs share their views and experiences and provide feedback for improving system development at Team Meetings and follow-up opportunities.

This project focuses on developing a suite of ICT-aided tools for up-grading Small and Medium Contractors (SMCs) who form the 'back-bone' of the construction industry in most countries. The benefits expected from the project outcomes will be particularly valuable to Hong Kong, where extensive multi-layered sub-contracting perpetuates a large number of SMCs. There is a special emphasis on dissemination, to penetrate further - to the many who can benefit. The planned project deliverables include: (a) a web-based information library; (b) a collaborative information and knowledge management framework; (c) a 'strategic information and knowledge manager'; (d) templates and initial issues of periodical (e.g. quarterly) newsletters/ e-bulletins; (e) a basic training workshop package and a self-learning package.

Status summary and initial conceptualisations

The initial exercises aimed at the 'R' part of this 'R&D' project. Firstly structured interviews were held with senior staff of the 14 PCs. These were supplemented with general information and knowledge derived from monthly 'full' team meetings that included the PCs and representatives of the local collaborating organisations. These interviews, joint meetings and follow-up have helped to identify a preliminary profile of

the information ‘needs’ of SMCs and to formulate the presently proposed framework for the web-based information and knowledge management systems which comprise:

1. ‘Wanted Zone’ (for ‘Services Wanted’)
2. SMILE Members Register (‘Available Zone’ to convey ‘Services Available’)
3. Discussion Forum (to exchange information on useful topics)
4. Information and Knowledge Management Modules (includes web-based zones and tools/ formats for enhanced communications within **and** between organisations e.g. site office & head office; and sub-contractor & contractor, or contractor & consultant)
5. Performance Improvement Module (to help improve productivity, quality, etc.)
6. Benchmarking Club (to share and compare performance indicators, where so desired).

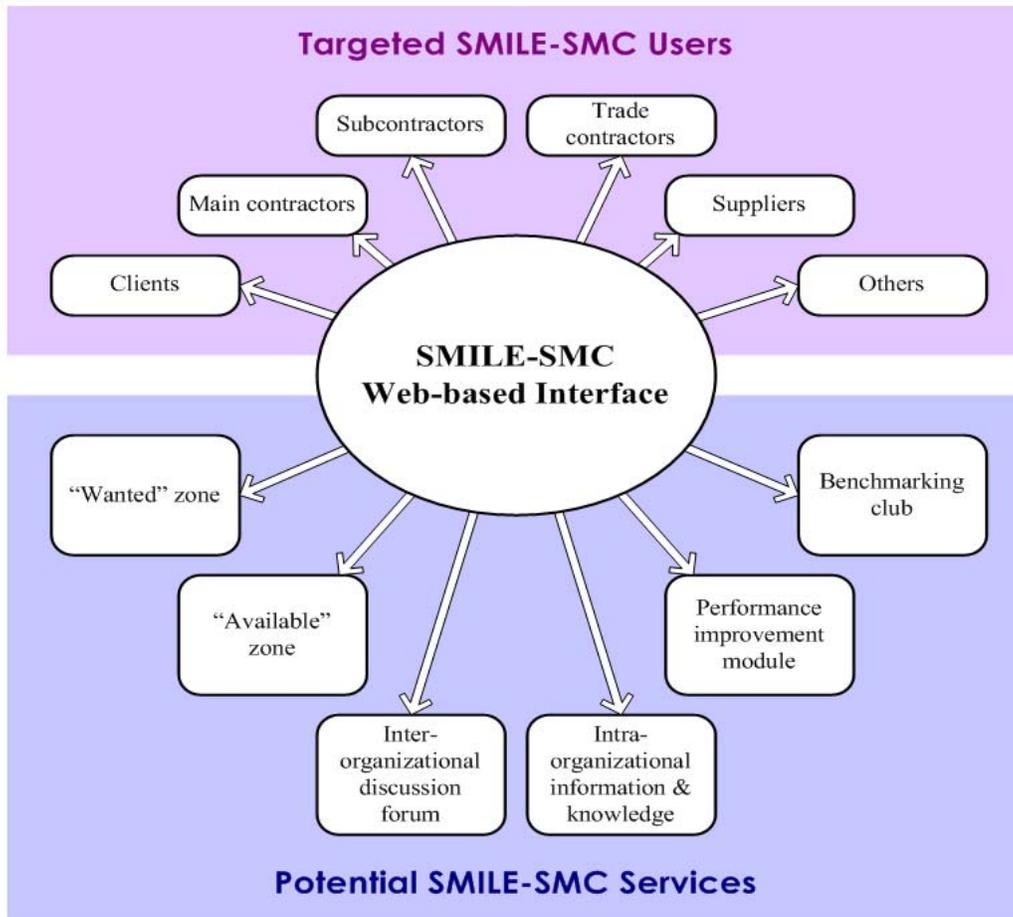


Figure 2 Potential Uses and Users of the SMILE-SMC System

Figure 2 indicates potential SMILE services and the envisaged broad range of potential users, given the information and knowledge that may be derived from the web-site. A temporary SMILE website has been set up to provide a pilot platform for testing such systems.

In order to capture wider collective industry perceptions, and to validate and prioritise identified ‘user needs’, a questionnaire was developed on the basis of initial findings. This questionnaire was issued to a wide range of contractors, 100 responses have been received up to now, and analysis has commenced.

A 'workflow analysis' exercise is also in progress to capture some of the critical SMC business processes through interviewing the site staff and senior management of PCs. Typical workflow and information transmission patterns are being analysed. Outcomes are expected to provide pointers to better ways of structuring some common and/or critical processes and information flows e.g. even in the transmission cycle of 'requests for information' (RFIs). 'Use cases' are being modelled using UML (unified modelling language) in order to visualise and streamline the present flow patterns.

After analysing and consolidating the incoming data, it is expected to propose better ways to help streamline / improve some prioritised (more important/ common) business processes by making use of increasingly available, but under-utilised information and communication technology (ICT) tools (including basic web-based systems and mobile communication technology). Lack of time and resources presently restrict SMCs from developing and using such ICT tools, whether in Hong Kong or elsewhere [Rahman et al., (2004); Caillaud and Passemad, (2001); Keeble and Wilkinson, (1999)]. It is hoped that SMILE-SMC will help these SMCs to make a good start in this direction towards continuous improvement.

A SMILE-SMC Development Workshop held in June 2004 helped to take stock, prioritise user needs and identify better directions for the future development. The Workshop aimed to (1) discuss, consolidate and prioritise present findings (on SMC needs) and initial developments (of the SMILE system) and (2) generate ideas and suggestions on: (a) the relative usefulness of different modules within the proposed framework, and (b) how best to develop the more useful modules within the limited time frame.

Plans for maintaining and up-dating the SMILE-SMC system beyond the two year development period presently rely on collecting minimal/ nominal post-development subscriptions from users to sustain a research/ project assistant for basic tasks. However, if interest is demonstrated and users seek up-grading and/or extra services, it is possible to raise the system operation & maintenance levels and even hand it over to an interested independent body, such as a government or professional organisation.

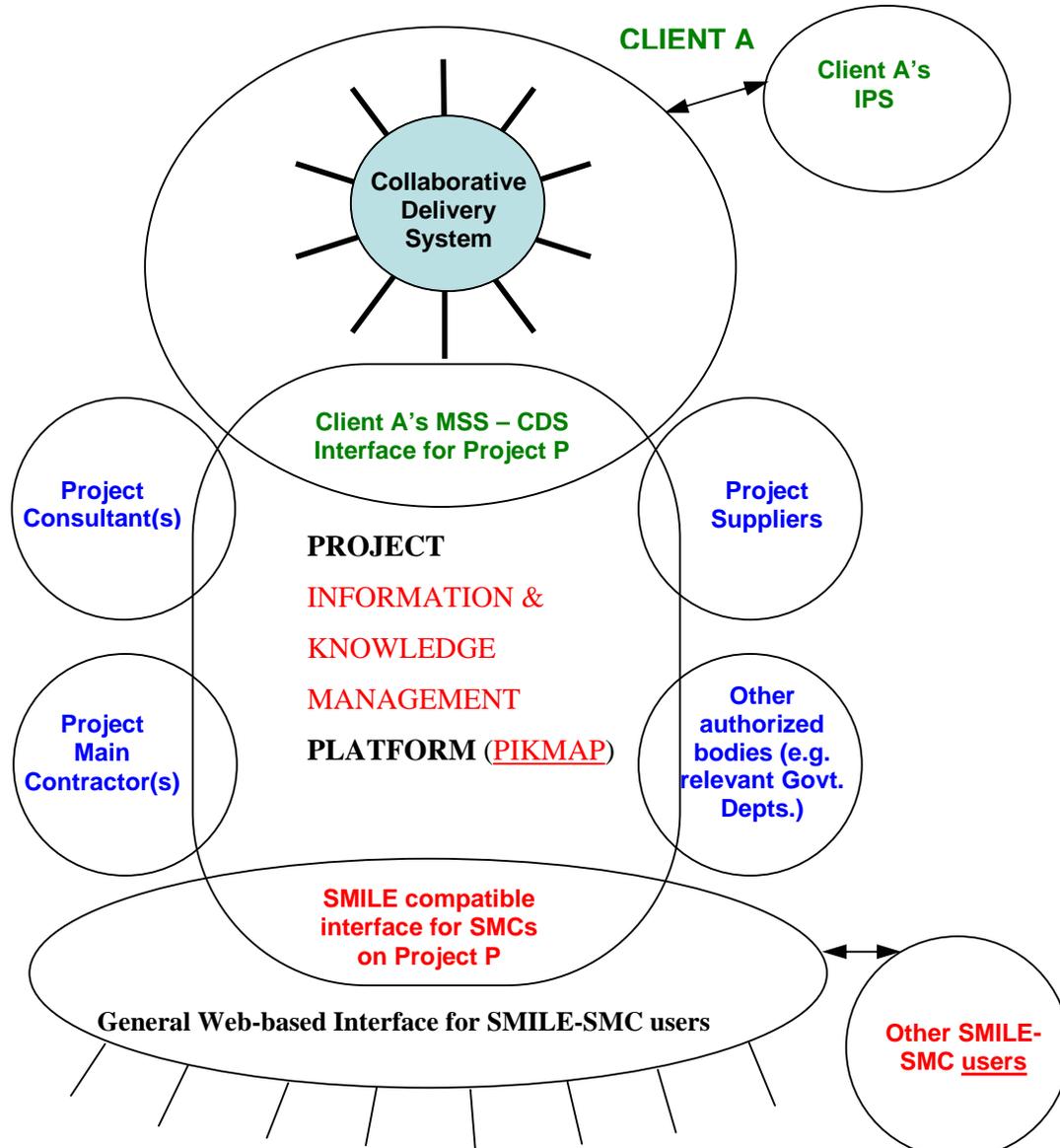
POTENTIAL FOR AN INTER-PARTICIPANT INTEGRATED PROJECT MANAGEMENT PLATFORM

There have been many previous exercises to develop integrated project management systems. However, most have not been truly integrated. For example, (a) some large clients like the Hong Kong Works Bureau (now the Environment, Transport and Work Bureau) developed a Project Information Management System for tracking costs and progress of their extensive portfolio of projects across many Works Departments; while (b) some large contractors have tried out commercially available or specially developed 'project management systems'. However, interviews in Hong Kong have indicated that some of the latter have been found to be glorified 'document management systems'.

What is targeted in the two reported R&D exercises delves deeper and spans wider: (1) into knowledge-based decision support for critical project procurement and delivery choices of large clients (LCs) in the top-down exercise; and (2) for more efficient and

effective information & knowledge flows that will lubricate and accelerate the development of SMCs in the bottom-up exercise.

Figure 3 conceptualises an over-arching Project Information & Knowledge Management Platform (PIKMAP) that can effectively link the above two systems. PIKMAP will be applied on a specific project and designed to selectively mobilize identified (project-critical) groups across that project supply chain in respect of different types of information flows and knowledge sharing. For example, the information systems of the consultants and main contractors (and if needed suppliers), can be linked to those of sub-contractors, so that any design changes can be rapidly transmitted on a selected 'need to know' basis.



General SMILE-SMC uses e.g. in (a) sourcing 'available' services & 'information',
 (b) posting 'wanted' notices, and (c) improving 'performance'

Figure 3 Proposed PIKMAP (Project Information & Knowledge Management Platform)

IPS – Integrated Procurement System; **MSS** – Management Support System;
SMCs – Small & Medium Contractors – could be on small direct contracts or subcontracts
SMILE – Strategic Management with Information Leveraged Excellence

Bottom-up information flows e.g. due to non-availability of a critical building material can also alert consultants faster. All these would facilitate faster and better decisions. The ICT issues of inter-operability, common standards, formats and protocols need to be addressed, but these may be easier to tackle if the next phase of MSS and SMILE-SMC project developments take into account this longer-term goal.

CONCLUDING OBSERVATIONS

The collaborative information, knowledge-sharing and decision support systems that are being developed in the two reported R&D projects target different ends of the construction supply chain. Appropriate links and protocols are seen to be useful in generating valuable synergies and wider coverage across the entire supply chain. The planned top-down and bottom-up industry development can be both extended and effectively ‘connected’ – by a project-specific Project Information & Knowledge Management Platform (PIKMAP) that provides appropriate interfaces and mutual benefits to all project participants.

Specific groups of participants will receive information on a ‘need to know/ share’ basis, guided by a principle of getting the right amounts of the right information to the right people at the right time. Different security level settings will enable control, while each information ‘originator’ may also screen out potential recipients who would have no particular interest in that piece of information. This will minimise the ‘information overload’ that can easily arise from each participant sending every bit of information generated to all other authorized participants. Security and legal liability issues will need addressing if sub-contractors and suppliers are to access consultants’ design changes directly, rather than through their ‘parent’ contractors. While this saves time, it does not mean a supplier can act on the changes without authorisation from its ‘contracting party’.

On the other hand, the collaborative working arrangements envisaged in ‘partnering’ and ‘alliancing’ projects would benefit from such an inter-participant PIKMAP. Second and third generation partnering and alliancing arrangements increasingly advocate such collaborative interactions and information sharing but lack the mechanisms to enable them. Most existing project/ document management systems are geared towards facilitating the traditionally restricted/ guarded communications in ‘adversarial’ scenarios. PIKMAP could address this shortfall e.g. in facilitating group inputs where needed, better informed decisions and faster dissemination. Given the choices to be made and the issues to be addressed it is envisaged that each PIKMAP will be client-driven, i.e. the information flow, specific interfaces and access protocols will be designed into the ‘collaborative delivery system’ set up by the client and his principal adviser/ consultant.

ACKNOWLEDGEMENTS

Grant HKU/7011/02E from the Hong Kong Research Grants Council and D02 002 074 from the Hong Kong Trade & Industry Department are gratefully acknowledged, for enabling R&D work on the MSS and SMILE-SMC projects respectively.

REFERENCES

- Anderson, S. and Oyetunji, A. (2003) Selection Procedure for Project Delivery and Contract Strategy, *Proceedings of the 2003 ASCE Construction Research Congress*, Hawaii, USA, CD Rom, 9 pages.
- Caillaud, E. and Passemad, C. (2001) CIM and virtual enterprise: a case study in a SME. *International J. Computer Integrated Manufacturing*, Vol. 14, No. 2, pp. 168-174.
- Carrillo, P. (1995) "Technology Transfer on International Joint Venture Projects", *First International Conference on Construction Project Management*, Nan yang Technological University, Singapore, Jan. 1995, pp 327 - 334.
- Chan A.P.C., Chan D.W.M. and Ho K.S.K. (2002) *An analysis of project partnering in Hong Kong*, Department of Building and Real Estate, The Hong Kong Polytechnic University, Hong Kong.
- Cheng E.W.L. and Li H. (2001) Development of a conceptual model of construction partnering *Engineering, Construction and Architectural Management*, Volume 8, 292-303.
- ESCAP (1994) *Application and Extension of the Technology Atlas*, United Nations, New York, USA, 145 pp.
- Keeble, D. and Wilkinson, F. (1999). Collective learning and knowledge development in the evolution of regional clusters of high technology SMEs in Europe. *Regional Studies*, Vol. 33, No. 4, pp. 295-303.
- Kumaraswamy, M.M., Yeung, N., Sze, E., Law, S. and Rahman, M. (2003) Knowledge-Building for successful Partnering, *Joint International Symposium of CIB Working Commissions*, 22-24, Oct. 2003, Singapore, Vol. 1, pp. 468- 480.
- Kumaraswamy, M.M., van Egmond, E.L.C., Rahman, M.M. and Ugwu, J. (2004a) Technology Exchange through Relationally Integrated Joint Venture Teams, *CIB W92 International Symposium on Procurement Systems "Project Procurement for Infrastructure Construction"*, 7-10 January, 2004, Chennai, India, pp. 326-334.
- Kumaraswamy, M.M., Ng, S.T., Luu, D.C., Anumba, C. and Palaneeswaran, E. (2004b) 'Proactive Procurement and Improved Project Delivery', *CIB W92 International Symposium on Procurement Systems "Project Procurement for Infrastructure Construction"*, 7-10 January, 2004, Chennai, India, pp. 179-187.
- Kumaraswamy, M.M., Ng, S.T., Ugwu O.O., Palaneeswaran, E and Rahman, M.M. (2004c) Empowering Collaborative Decisions in complex project scenarios, *Engineering, Construction & Architectural Management*, Vol. 11, 2, pp. 133-142.
- Luu, D.T., Ng, S.T. and Chen, S.E. (2003). "A Case-based Procurement Advisory System for Construction." *Advances in Engineering Software*, 34, 429-438.
- Palaneeswaran, E., Nadarajah, R and Kumaraswamy, M.M. (under review) 'EOTDSS - A Web-based Decision Support System for Assessing Time Extension. *International Journal of Project Management*.
- Rahman, M.M., Kumaraswamy, M.M., Ng, S.T., Lam, E., Ho, E. & Lee, S. (2004) Needs of SMCs in Hong Kong: Information Management and IT, *Proceedings, CIB W102 Information and Knowledge Management*, April 29-30, Ryerson University, Toronto, Canada, (eds. C.J. Katsanis, B. Dimitrijevic & C. Davidson), pp. 59-66.
- Sze, E., Kumaraswamy, M.M., Wong, T., Yeung, N. and Rahman, M. (2003) Weak Links in Partnering Supply Chains? - Consultants' and Subcontractors' Views on Project Partnering', *2nd Intl. Conference on Construction in the 21st Century*, Hong Kong, Dec. 2003, pp. 108-113.

- Ugwu O.O., Kumaraswamy, M.M., Rahman, M.M. and Ng, S.T., (2003) IT tools for collaborative working in Relationally Integrated Supply Chains, *2nd Intl. Structural Engineering and Construction Conference*, Rome, Sept. 2003, editor: F. Bontempi, A.A. Balkema, Netherlands, ISBN 90 5809 599 1, Vol. 1, pp. 217-222.
- Walker, D and Hampson, K. (2003) *Procurement Strategies – A Relationship-based Approach*, Blackwell Science, UK.

