THE APPLICATION OF A COMPUTERIZED FINANCIAL CONTROL SYSTEM FOR THE DECISION SUPPORT OF TARGET COST CONTRACTS

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SUMMARY: *This paper reports a study of the application of a computerized financial control system on a target cost contract for the development of a cable car construction project in Hong Kong. The author is one of the key system designers supplied by the consultancy services of the Hong Kong Polytechnic University. The system emphasizes the enhancement of the integrity and effectiveness of decision-support and the information flow among the various construction parties for construction target cost contracts aided by a computerized construction integrated management system, equipped with intelligent database and data mining technology. Complex and capital-intensive construction projects usually involve higher risks. A partnering approach can be applied to such projects as a basis to bring about better project results. Partly as a result of rational risk sharing, target cost contracting can also be effective, where a fixed target cost is set based on given parameters at the outset. If this fixed target is exceeded or undercut, the outcome is split between the contracting parties in a pain/gain sharing fashion. An advantage of this approach lies in the incentive to the contractor to be efficient and to achieve savings. Target cost contracting has been globally recommended as an appropriate means of realizing high-risk construction projects. So as to satisfy the high transparency requirement in financial controls and the information demand for forward financial planning, a computerized integrated management system, with data mining and neural capability, is recommended to support decision making in target cost contracting.*

KEYWORDS: *contract administration, cost controls, data mining, decision support systems, digital neural network, Hong Kong construction industry, target cost contracting.*

1. INTRODUCTION

Complex and capital-intensive construction projects are logically recognized as inevitably associated with higher risks, both technical and financial. If the procurement of such projects is through a conventional lump sum contract, the tenderers who have fully considered and allowed for the risks in their tender prices are likely to submit a higher tender offer than a tenderer who submits a lower price because of the overlooking of some of the risks. However, under the policy of safe guarding the public interest, the lower price tenderer will often get the contract particularly when procuring public projects. In this context, it seems that the rule of the game is to reward the parties who make mistakes in their bidding. The final outcome of a project using this kind of conventional lump sum contract procurement system may well include litigation, claims, bad quality and corruption problems, and ultimately the public at large will have suffered.

Target cost contracts have been used over a period of many years, and are viewed as particularly advantageous in certain complex construction projects (NEDO 1982). The Hong Kong Construction Industry Review Committee (CIRC) recommended the implementation of target cost contracting in its Report issued in January 2001 (CIRC, 2001). The ETWB (Environment, Transport and Works Bureau) of the Hong Kong Government currently plans to develop a policy on the use of target cost contracting for complex and high-risk construction projects. Under target cost contracting, a fixed target cost is set based on given parameters at the outset. If this fixed target is exceeded or undercut, the outcome is split between the contracting parties in a pain/gain sharing fashion calculated using a share ratio formula agreed at the start of the contract. The advantage of this approach lies in the incentives to the contractor to be efficient and to achieve savings. By providing a proper performance-based remuneration, the contractor's financial interests and those of the client become more closely aligned and it is in

the financial interests of both parties to co-operate. At the same time, the contractor is left with enough risk to motivate it to strive for better performance.

The CIRC Report also recommends the implementation of a target cost contracting approach through an open book accounting regime that adopts procedures to:

- monitor actual costs incurred against the target cost,
- substantiate claims for payment against milestones,
- agree to changes to the target cost to reflect additions to or deletions from the scope of the contract,
- assess the final costs and the final price payable and
- consider the impact of innovation proposals.

The use of open book accounting enables quantification of the costs of risks and prevents the project risks causing adverse effects on the contractor's cash flow.

2. TARGET COST CONTRACTS IN HONG KONG

The Mass Transit Railway Corporation Limited (MTRC), a stock listed public body about 76% held by the Hong Kong Government, was the first party in Hong Kong to adopt target cost contracting. This was used for the modification of the Tsim Sha Tsui MTR Station in April 2002 with an initial target cost of about HK$ 280 million and a contract period of 36 months. Under the target cost contracting arrangement, MTRC described the tender price quoted by the Contractor as the initial target cost. During the contract execution stage, the Contractor was paid the actual construction cost for the work done. If the final construction cost, termed the Final Total Cost, differed from the Initial Target Cost, the difference would be split between MTRC and the Contractor based on a pre-determined pain/gain share model set out in the contract.

MTRC planned to use the Tsim Sha Tsui MTR Station project procedures as the basis for future target cost construction projects. The second project by MTRC using target cost contracting was a world-class tourism facility project comprising a cable car system and a theme village at a target cost of around HK$ 500 million and a 36 months construction period. This Project was also the first target contract requiring the Contractor to provide a computerized financial control system to relate to the relevant contractual requirements including the monitoring of control points and the generation of required deliverables.

The description below by the author is based on his consultancy involvement in the MTRC Cable Car Project and his relevant report assessments on target cost contracting as a Committee Member of the Corruption Prevention Committee of the Independent Commission against Corruption in Hong Kong.

3. PRE-CONTRACT STAGE OF TARGET COST CONTRACTING

3.1 Tendering for Target Cost Contracts

The contractor selection process for target cost contracts involves the following three stages:

1. **Pre-qualification stage**: The client invites those contractors who have satisfactorily performed in previous construction projects to submit an expression of interest and a pre-qualification application for the target project.
2. **Stage one tender assessment**: The stage one assessment is used to eventually shortlist two contractors, using a two-envelope tender assessment method for the development of a detailed proposal used for assessment in stage two.
3. **Stage two tender assessment**: The two tenderers have three months to further develop their technical and financial proposals, which will be finally assessed by an assessment panel chaired by the client's senior management to finalize the contract award.

In the tender target cost summary for target cost contracts, the tenderers are required to list specific cost classifications including the base construction costs, preliminaries, head office overheads, profit, commercial risk to be borne by the contractor, technical risk to be borne by the contractor, shared commercial risk, shared technical risk, entrusted works and attendance on designated contracts.

3.2 Financial Formation of Target Cost

At the contract start, the financial formation of target cost contracts is based on an initial target cost, which is set as the estimated total project cost based on the given parameters in the format of bill of quantities. The initial target cost consists of two estimated cost elements: base cost and fixed cost. The base costs include all the costs directly related to the execution of the project work and the fixed costs are all the costs not directly related to the execution of the project work but necessary for ensuring that the work is properly executed such as construction management and contract supervision. The final target cost equals the initial target cost plus the target cost variations. The final total cost is defined as the expenditures on the project under certain pre-defined and permissible categories, actually incurred by the contractor. If the fixed target cost is exceeded or undercut, the outcome is split between the contracting parties in a pain/gain sharing fashion. The sharing of additional costs or savings is calculated from the share ratio formula agreed at the contract start. Fig. 1 shows a typical gain/pain share mechanism for target cost contracting:

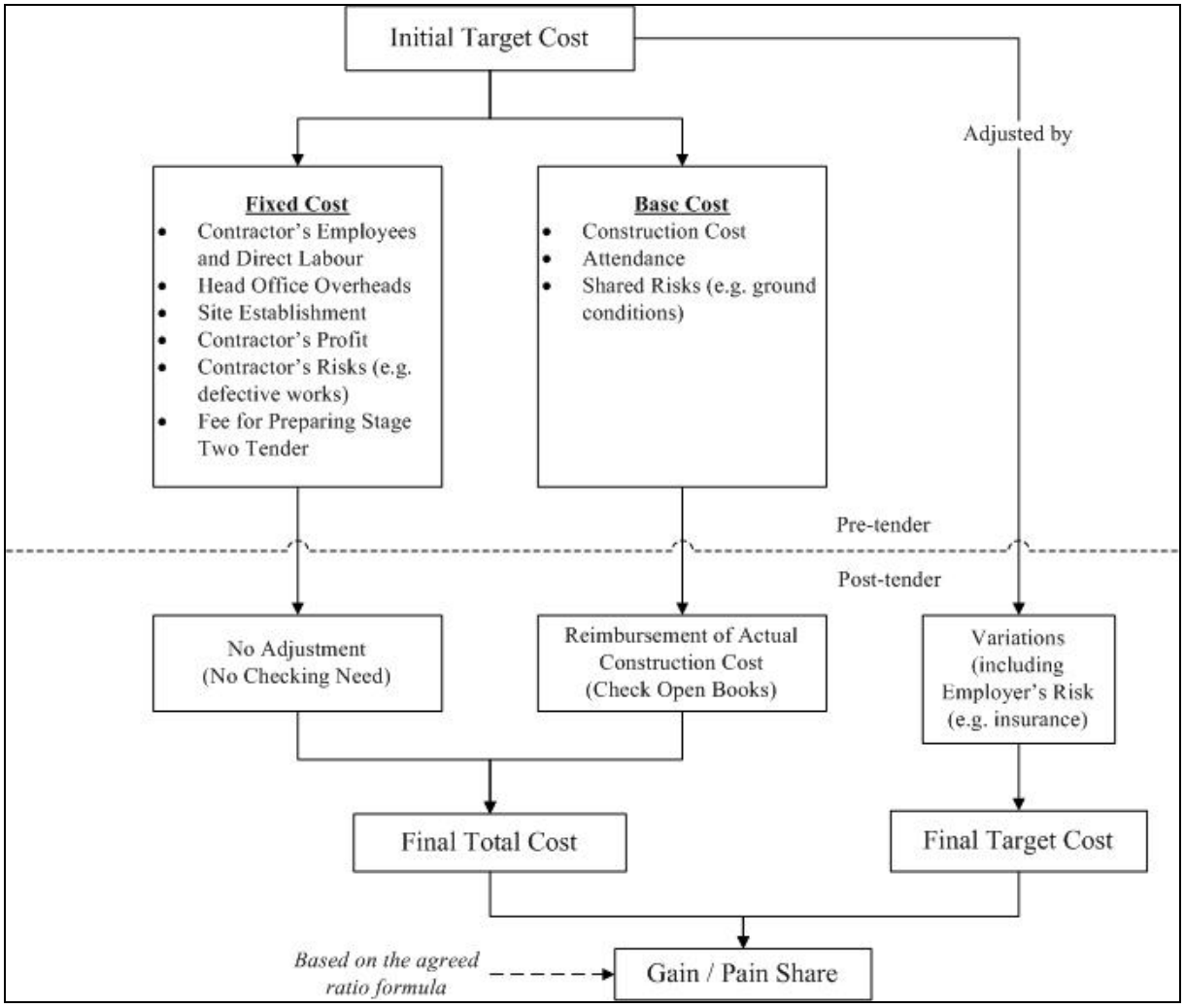

FIG. 1: Gain/Pain Share Mechanism under Target Cost Contracting Arrangement

4. POST CONTRACT STAGE OF TARGET COST CONTRACTING

4.1 Post-Contract Financial Control

During the post-contract stage, the contractor is required to keep accounts of the actual costs of the works executed. To achieve an optimum economic project with fair and reasonable financial return for the client and the contractor, both parties are required to operate in an open book environment, in which the contractor must establish a dedicated bank account in the contract name. All payments from the client under the project are made to this bank account, and all outgoing payments to subcontractors and suppliers by the contractor are also made from the account. The client verifies the contractor's expenditures regularly by checking the following transactions and records:

- payment receipts against the bank statements,
- the contractor's site diaries for labour only subcontracts,
- the site measurements for remeasurement subcontracts,
- the contractor's payment records for target cost subcontracts,
- the quantities of materials ordered and payment receipts for supply contracts and
- the payment receipts for sundry materials.

An audit team of two independent authorized representatives of the client will undertake audits as freely directed by the client. The contractor should be given 14 days notice for such an audit, and is required to be fully cooperative.

In target cost contracts, contract variations can be in the form of a value engineering proposal, which may be initiated by either the contractor or the client and is required to state the reasons for and the benefits of the proposal, the cost estimate and any programme benefits to the project. If a variation to the scope of work is required, the client has to issue an appropriate instruction in accordance with the Conditions of Contract clauses. Any revision to the initial target cost or the construction programme has to be agreed between the contractor and the client when the impacts and consequences of the instruction have been determined.

In determining the initial target cost adjustment value, the schedule of rates submitted by the contractor should be used; or the contractor is required to disclose the subcontractors rates if necessary. No adjustment is made to the target cost if the works vary only by minor substitutions of products, quality, workmanship, size and the like, from those shown in the drawings or described in the specification. The final target cost should not be adjusted to reflect initiatives, innovations, economies, procurement benefits and the like proposed by either the contractor or the client, and beneficial to the project as a whole. This approach is to enable the best reflection of cost savings at the final project outcome because the final target cost as the base line for the gain/pain share formula should not be adjusted so as to narrow down any saving to be shared by both parties.

The contractor is responsible for self-certification of his compliance with the contract requirements, and must identify and carry out any alterations, or remedial work necessitated by errors and omissions or by discrepancies identified during the self-certification of the works. The costs of such alterations and remedial work following self-certification by the contractor are charged as actual costs forming part of the final total cost.

If the client inspected the works following a self-certification by the contractor and identified additional items not already picked up by the contractor, then the contractor must also carry out such remedial rectification work. The cost of such alterations and remedial work are considered as disallowed costs, and would not form part of the total final cost. All costs in respect of contractor defective design and materials are also defined as disallowed costs. Disallowed costs are not to be included in the actual costs or fixed costs for the determination of the final total cost and are further defined as follows:

- Cost decided by the client as not justified, in the contractor's accounts and records.
- Cost which should not have been paid to a subcontractor under the terms of the subcontract.
- Cost for rectifying any part of the contract work that is not in accordance with the contract discovered after self-certification.
- The cost of redoing any aspect of the contract work that was not done in accordance with the contract discovered after self-certification.
- The cost of plant, goods and materials not used in the contract work after allowing for reasonable wastage and equipment downtime/idling time and inclement weather.

- The cost of resources not used in the execution of the works after allowance for reasonable breaks and standing time and inclement weather.

4.2 Contract Administration and Supervision

To implement proper contract administration and supervision for target cost contracting, the client also monitors the contractor's letting of subcontracts and supply contracts through the following policies:

- Approves the contractor's subcontract letting procedures, the terms of the subcontracts and the tender list for major subcontracts and supply contracts.
- Participates in the selection and consent to subcontracts and supply contracts of a value over 5 million Hong Kong dollars.
- Prohibits single subcontract tenders unless fully justified by the contractor, according to the criteria specified in the contract.

The supervision of works in progress by the client is important to any construction project. For target cost contracting, prior to the work commencement, the contractor is required to submit inspection and test plans for each part of the works, to identify holding points and witness points. A holding point is defined as a stage in the construction process where work cannot proceed further without a notification and successful inspection by the site supervisory staff. A witness point is defined as a stage in the construction process where the site supervisory staff must witness any physical tests and confirm that the results are correctly recorded.

The contractor may claim extension of time for completion or additional payment if there have been delays in progress or additional expenses incurred and not recoverable under the contract, but with justifiable reasons. Pre-determined liquidated damages stated in the contract are imposed on the contractor in the case of delays caused by the contractor and not justified. In addition, at six-month intervals, the client will assess the performance of the contractor and the associated subcontractors through the pre-determined criteria and marking scheme. The performance reports will be feedback to the parties concerned, and the assessment results should be taken into account in the pre-qualification of contractors for future projects. As a progress monitoring measure, the contractor is required to submit monthly reports to the client containing the following commercial and financial information:

- list of sub-contracts and supply agreements awarded up to the end of each reporting period,
- forecast of procurement activities for the next 3 months,
- summary of actual cost relating to the works completed,
- forecast of costs to complete the works including any revisions to the cash flow forecast,
- report on the status of items in the risk register which is a section of the progress report to reflect the effect of work progress to anticipated target cost,
- identify measures to be taken to mitigate risk on activities in next three reporting periods,
- report on the status of value engineering proposals and
- report on the status of claims, if any.

4.3 Financial Control Monitoring

- For financial control monitoring in target cost contracts, an earned value approach is used, where budget cost work scheduled (BCWS), actual cost work performed (ACWP) and budget cost work performed (BCWP) are plotted to identify the cost variance and time variance as in Fig. 2.

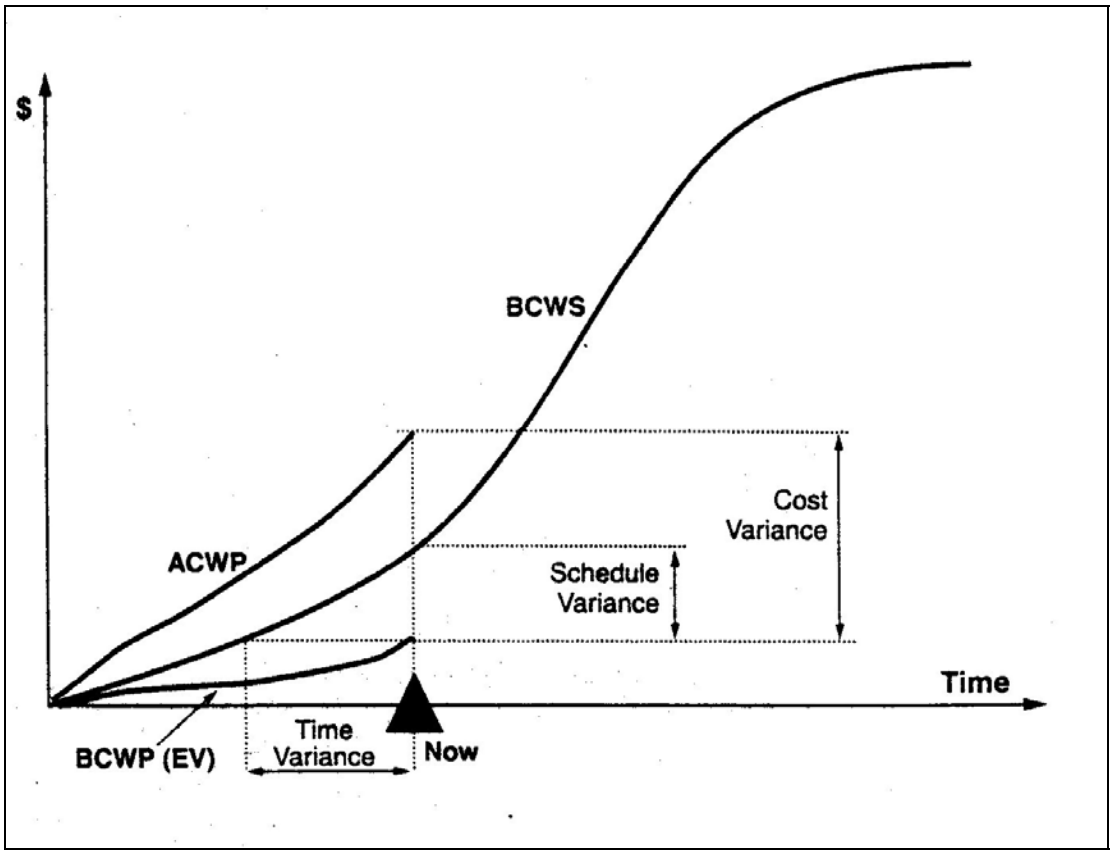

FIG. 2: Earned Value (EV) approach for financial cost monitoring

5. COMPUTERIZED FINANCIAL CONTROL SYSTEM

5.1 Main System Interface and Target Cost Model

Under the Cable Car contract, the Contractor is required to propose for MTRC's approval a single proprietary financial control programme to fully undertake the requirements of the financial control procedures including the monitoring of control points and the generation of deliverables. All data relevant to the project shall be stored on MTRC's server with equal rights of access by MTRC and the Contractor. Simultaneous access to the database and all programme functions shall be available to a minimum of six operators including two remote operators. The Contractor has to implement and maintain the financial software programme for the duration of the project and provide training for MTRC's related staff.

In this context, the Contractor selected the CIMS (construction integrated management system) that was developed by the author as part of his PhD research activity (Wong 2003a). Fig. 3 shows the main screen with the functions highlighted.

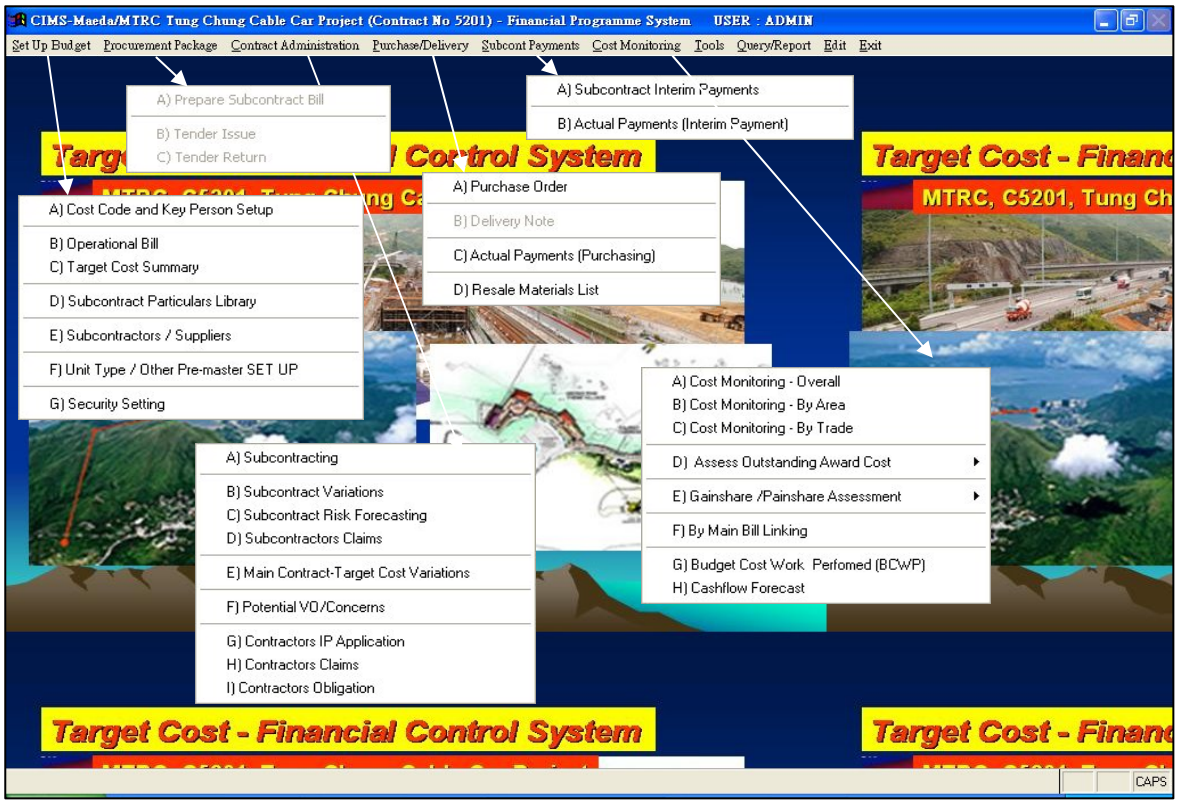

FIG. 3: CIMS-Target Costing main screen with the main functions highlighted.

The target cost model for supporting decision-making is shown in Fig. 4.

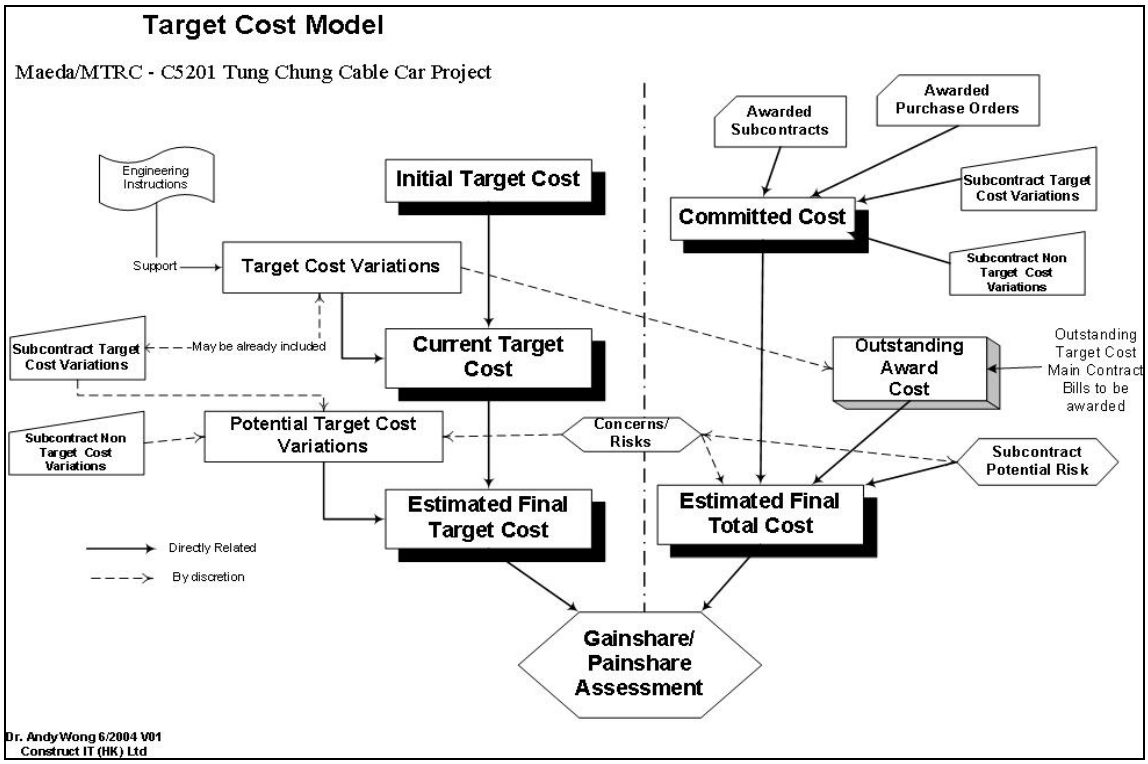

FIG. 4: The target cost model with the elements for the projection to forward looking for decision making during the construction stage.

5.2 Data Mining and Neural Network for Decision Supports

As the project progresses, CIMS deals with target cost variations with the support of engineering instructions to update the current target cost based on the initial target cost. The potential target cost variation section allows both parties to record engineering proposals which may induce further variations by taking into account the impacts of subcontract target cost variations and subcontract non-target cost variations. CIMS function “concerns and risks” is a mechanism for tackling any potential problem areas, which may affect the project final cost. This approach can be considered as a kind of dynamic budget monitoring.

For job cost monitoring, CIMS also records the factual cost data such as the subcontracts awarded, purchase orders awarded, subcontract target cost variations and subcontract non-target cost variations to form a category of committed cost, which is different from the total final total cost, in the sense that the actual payments may not yet be paid from the project dedicated account. The system also deals with the outstanding award costs in respect of each trade cost category. Together with the subcontract potential risk and the “concerns and risks” function mentioned above, CIMS can project the estimated final total cost. The purpose of dealing with these cost elements in such a manner is to generate the estimated final target cost and the estimated total cost from time to time for supporting decision-making.

In this target cost contracting project, CIMS is running in Microsoft SQL Server 2000, which provides Analysis Services architecture. A relational database algorithm in a client/server environment is applied for the projection of forward looking financial controls especially for the aspects of outstanding award costs, estimated final target cost and estimated final total cost. In the next stage of system development, data mining techniques will be used for the assessment of risks, potential variations and subcontractor performance. The Microsoft® clustering algorithm will be used as an expectation method using iterative refinement techniques to group records into neighborhoods as clusters that exhibit similar, predictable characteristics (Seidman 2001). In addition Digital dashboard (Microsoft® 2000) concept has been applied to support decision making through the interface as shown in Fig. 5.

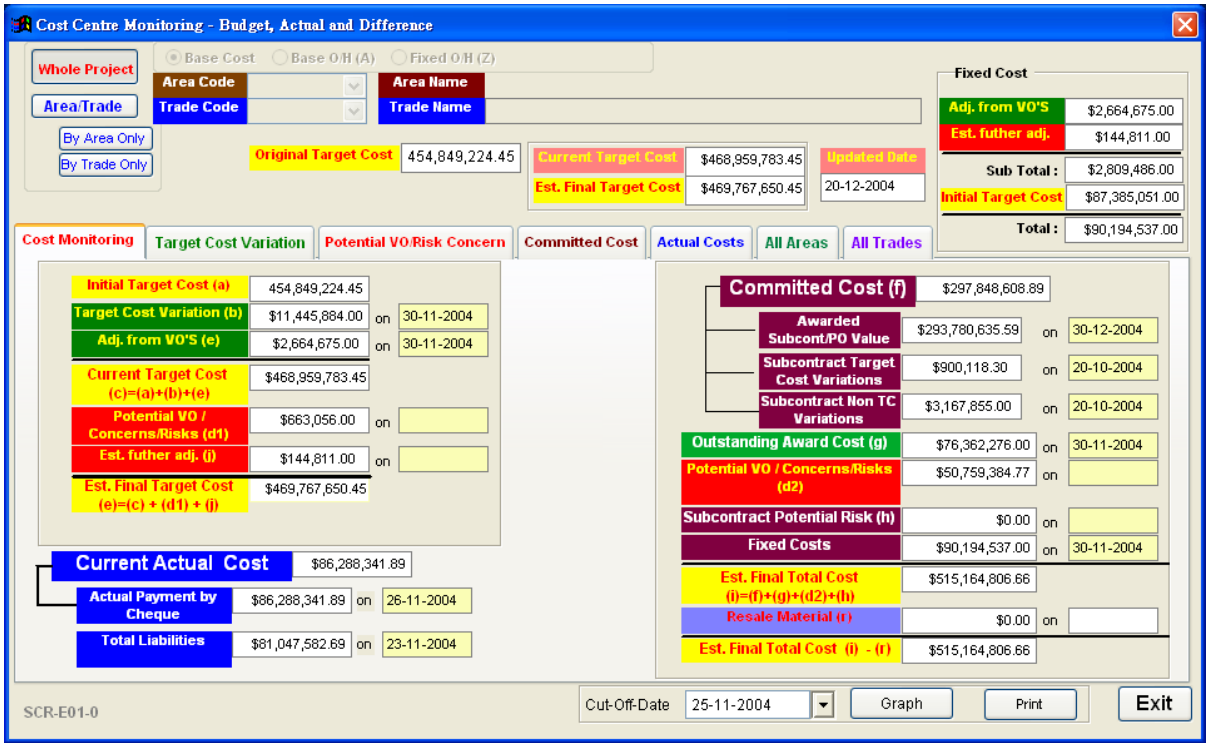

FIG. 5: A comprehensive system interface to show the cost elements with the corresponding updated dates.

To support decision making, various routine reports are provided to meet management needs as shown in Fig. 5 and Fig. 6 respectively.

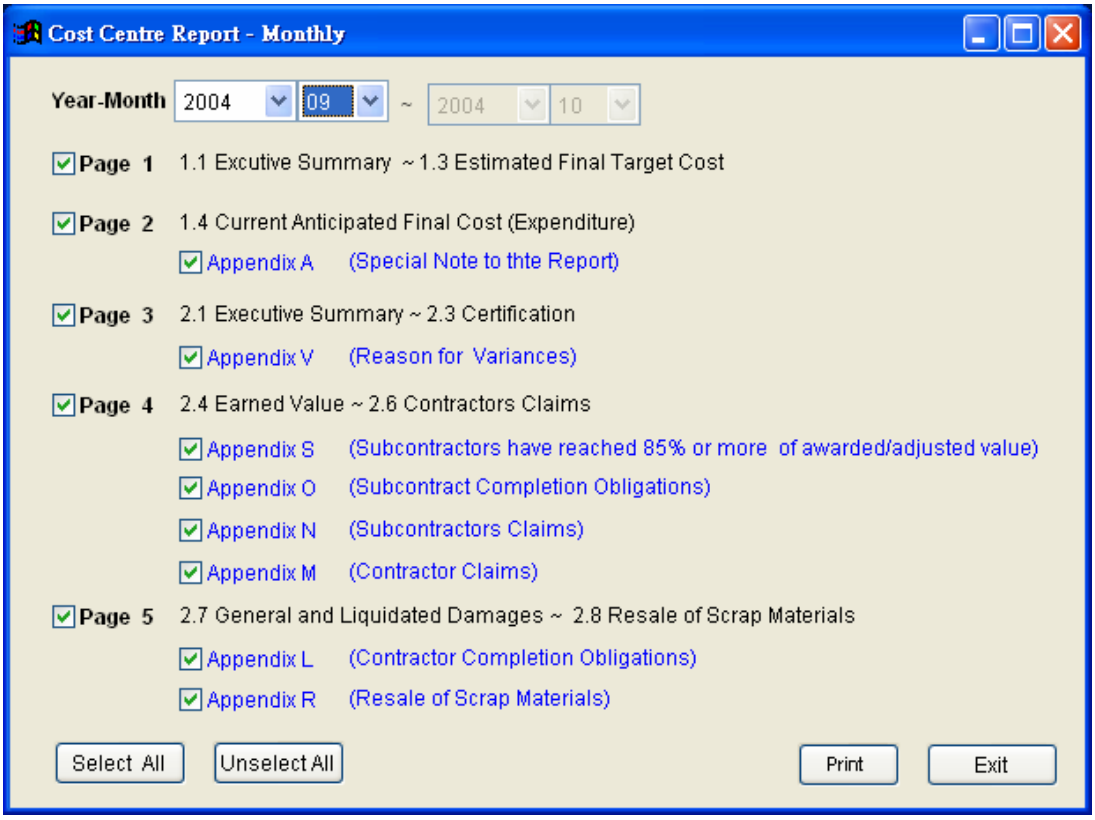

FIG. 6: Report generation interface for routine reports.

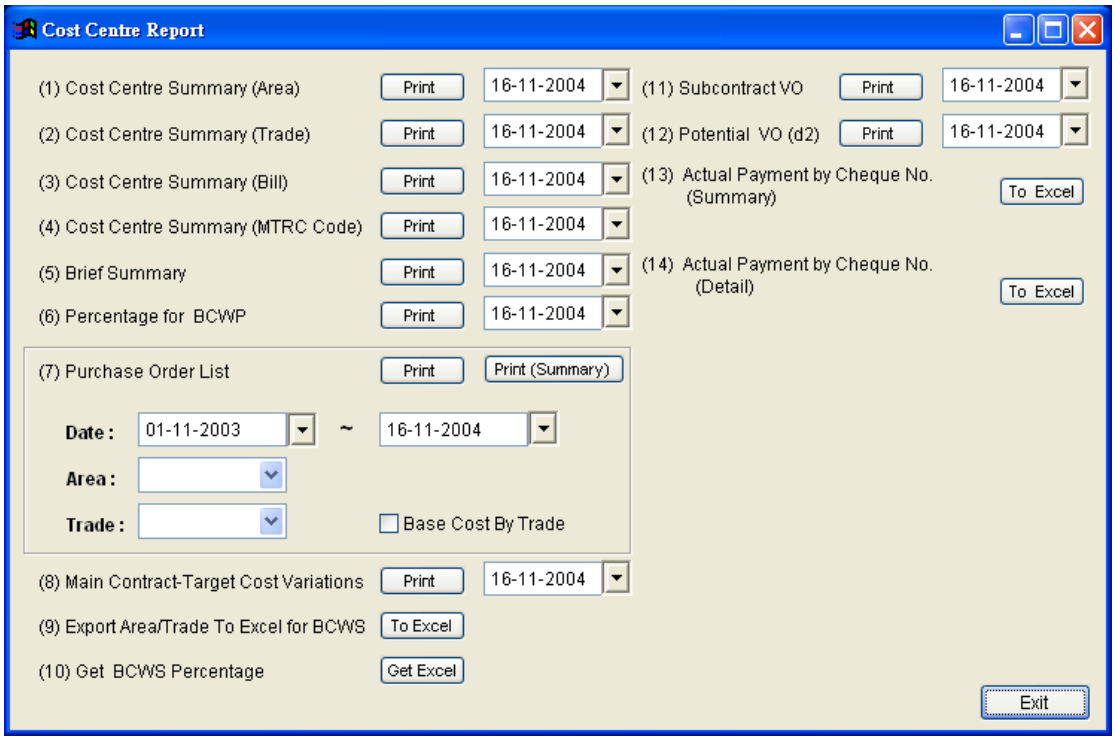

FIG. 7: Routine reports for cost centres and import and export to Excel.

Neural network in associate with data mining technology is a powerful tool to capture and represent complex data input/output relationships (Popovic 2004). Neural network technology stems from the desire of developing artificial systems to perform "intelligent" tasks similar to the function of the human brain (Gate 1999). This concept was applied by the author in his research for the development of a web-based construction project management system which can stimulate an early warning on project performance, through the live project data from the same project or different projects accumulating to the system (Wong 2004). A product called “NeuroSolutions” from NeuroDimension Corporation USA was used to test the model. The digital neural system for construction contractors acts as a computerized role in a construction company covering three main fields: business operation, E-commerce and knowledge management. In the field of business operation, the major goal is to do the daily process operation or the management activities more efficiently and more precisely by automatic and electronic means instead of by manual work. In E-commerce, it aims to make full use of the Internet to assist the commerce business upgrade of a construction company in order to meet lots of fast and direct requirements. The goal of knowledge management is to gather all the data flowing including project performance feedback in a construction company by converting it into usable information and company experience ready to share among the technical staff. A model of the web-based digital neural system for construction project mangement is Fig. 8.

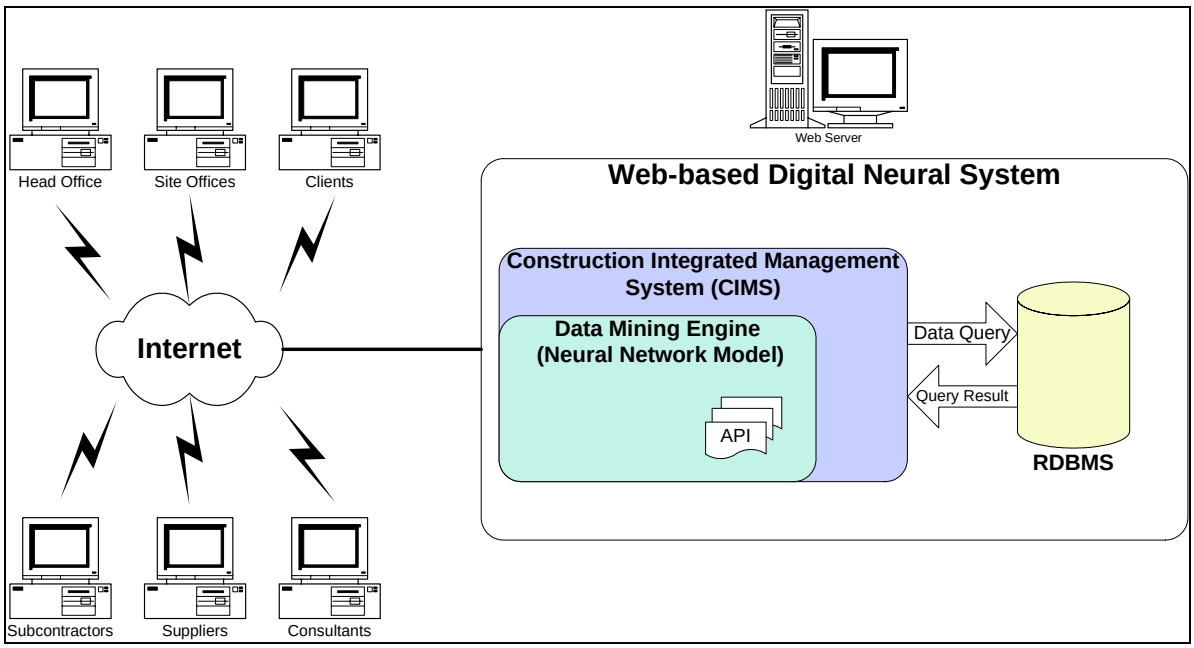

FIG. 8: A prototype of web-based digital neural system for construction project management.

The generic defintion of a decision support system is defined as a computer system under the control of one or more decision makers that assists in the activity of decision making by providing an organized set of tools intended to impart structure to portions of the decision-making situation and to improve the ultimate effectiveness of the decision outcome (Marakas 1999). In target cost contracting, with the need of higher transparency requirement in financial controls and the information demand for forward financial planning, it is suggested that a web-based neural network approach should be used in association with data mining techniques to cover more management aspects such as information controls, material controls, progress controls and quality controls for supporting decision making. In this context, the financial control sub-system should form the core of such a proposed decision support system.

6. CONCLUSION

Target cost contracts are used for complex and capital-intensive construction projects, which are recognized as inevitably associated with high technical and financial risks. In Hong Kong, the Construction Industry Review Committee (CIRC) stressed the significance of target cost contracting and the wider use of information technology in the construction industry in its Report issued in January 2001 (CIRC 2001). The advantage of target cost contracting lies in providing a framework for both the client and the contractor to progress as partner

towards the project aim. A crucial element of the framework is where a performance-based gain/pain share remuneration mechanism is set. Target cost contracting applies more vigorous controls in tendering, subcontract procurement, contract administration as well as higher transparency requirement in financial controls and higher quality of information demand for forward financial planning.

The Hong Kong Mass Transit Railway Corporation (MTRC) has applied target cost contracting to two projects. The latest is a world-class cable car development project where a dedicated computer system for financial control is used to support decision-making. The knowledge and experience acquired from the MTRC cable car project is of great significance to the application of target cost contracting in Hong Kong public infrastructure development projects.

The 2005 Hong Kong Government Policy Agenda published in January 2005 includes a section on effective governance (HKSAR 2005). Under the subsection for new initiatives, the Hong Kong Government explicitly states that it will develop a Works Project Information Standard to facilitate the electronic exchange of public works project data and the reliability of electronic communications among stakeholders (Wong 2003b). This is an essential step for the Government towards, the full implementation of web-based project management for public projects. In the near future for high-risk public infrastructure development project in Hong Kong, target cost contracting together with web-based project management will be the main practice. It is expected that the knowledge and experience described in this paper can form a significant benchmark reference in relation to the development of decision support systems for target cost contracting.

7. ACKNOWLEDGMENTS

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