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An Investigation of the Feasibility of Using Group Decision Support Systems to Improve Value Management Studies

by

Chung Kin Hung, Jacky

A thesis

submitted in fulfillment

of the requirements for the degree of

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The Hong Kong Polytechnic University

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ABSTRACT

Abstract of thesis entitled 'An Investigation of the Feasibility of Using Group Decision Support Systems to Improve Value Management Studies' submitted by Mr. Chung Kin Hung, Jacky for the degree of Master of Philosophy at the Hong Kong Polytechnic University in January 2002.

There has been a surge of interest in Value Management (VM) applications in Hong Kong's construction industry since the Asian financial crisis in 1997. However, it is observed that the implementation of VM studies is subject to a number of difficulties and therefore, the benefits of VM are not fully achieved. For these reasons, Group Decision Support Systems (GDSS), which is a branch of information technology (IT), has been introduced to improve VM studies in this research. The research aims (i) to investigate the difficulties in implementing VM studies, (ii) to explore what and how GDSS functions can be applied to improve VM studies, and (iii) to examine their usefulness in the construction industry. Following a comprehensive literature review, a survey has been conducted to investigate the difficulties in implementing VM studies at the first stage of the research. The survey findings report that (i) lack of information, (ii) lack of participation, and (iii) difficulty in conducting the analysis are the most frequently encountered difficulties in VM studies in the construction industry.

At the second stage of the research, a framework of three-dimensional GDSS support has been proposed to illustrate how GDSS technologies can be integrated with VM methodology. The framework suggests that GDSS technologies can provide (i) information support, (ii) communication support, and (iii) analysis support for VM

studies. These supports are further elaborated and developed into a set of GDSS functions in the research.

In addition, a GDSS prototype system called the Interactive Value Management System (IVMS) has been developed based on the proposed framework. The IVMS is comprised of four toolboxes, which are designed to (i) improve collaboration between members, (ii) facilitate information management, (iii) promote exchange of ideas, opinions, and preferences, and (iv) improve the productivity and accuracy of data analysis in VM studies. The IVMS has illustrated how the three-dimensional GDSS support can be integrated and applied to improve VM studies as a computer system.

At the third stage of the research, a validation has been conducted and a group of VM practitioners including (i) VM facilitator, (ii) client, (iii) architect, (iv) project manager, (v) quantity surveyor, (vi) engineer, and (vii) contractor, is invited to evaluate the usefulness of the GDSS functions. The validation results suggest that the three-dimensional GDSS support, in particular the information support and the communication support (technological efficiencies), are highly supportive and they can contribute to (i) improve the effectiveness of presentation, (ii) avoid the conformance pressure in evaluation, and (iii) improve availability of information and enhancing communication in VM studies.

To sum up, the research has successfully applied GDSS to improve VM studies in the construction industry. It explores a new direction of IT application in VM and increases the efficiency and effectiveness of implementing VM studies while maintaining the traditional roles and functions of VM team members.

ACKNOWLEDGEMENTS

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I would like to express my special appreciation to Ms. Virginia Lo, Mr. Boris Yuen and Ms. Y.M. Tsang, for their continual encouragement and endurance in the study. Finally, I would like to express my deepest gratitude to my parents, who give their sincere love and support during my entire life.

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1 INTRODUCTION

Value Management (VM) is a structured and analytical process which seeks to achieve value for money by providing all the necessary functions at the lowest costs consistent with required levels of quality and performance (AS/NZS 4183: 1994). Unnecessary costs are bound to exist in construction projects and they are mainly caused by factors such as lack of information, communication and coordination (Norton and McElligott, 1995). VM suggests that these costs contribute to poor value and, therefore, value for money is greater if they can be identified and removed. VM was developed at the General Electric Company in the USA in 1947 and first introduced to Hong Kong in the late 1980s. There has been a surge of interest in VM applications and it is becoming more popular and more important in the construction industry since the Asian financial crisis in 1997. Many government departments, public corporations, and private enterprises have applied VM in preliminary project feasibility studies in order to improve project performance (Grosvenor, 1997; Wilson, 1998; and Fong et al., 1998). However, it is observed that the implementation of VM studies is constrained and some users encounter difficulties while conducting VM studies. As a result, the performance of VM studies has been affected and there is a strong demand for improvements to the practice, so as to maximise the benefits gained

The continuing improvement in performance/price ratio of personal computing facilities has made information technology (IT) an effective tool for solving some of the efficiency-related difficulties (Shen, 1996). IT can be a very useful tool in VM specialists' toolbox and a number of successful applications in VM studies are reported (Murray, 1988; Paulson et al, 1989; Shen and Brandon, 1992; Shen, 1993; Shen, 1996; and Otero, 1997).

Group Decision Support Systems (GDSS) is a branch of IT designed to improve the group decision-making processes. Substantial amounts of research activities (Gallupe, 1986; Gallupe et al., 1988; Nunamaker et al., 1987) have demonstrated that GDSS improves the efficiency, reliability, and quality of the group decision-making process in face-to-face meetings (Thierauf, 1989) and, therefore, it has great potential to be introduced to improve VM studies. For the above reasons, this research has been conducted to investigate the feasibility of using GDSS to improve VM studies in the construction industry.

1.1 Research Methodology

1.1.1 Research Objectives

This research aims to investigate the feasibility and benefits of using GDSS to improve VM studies and its scope is limited to focus on the construction industry in Hong Kong. The research objectives are as follows:

1. To investigate the difficulties in implementing VM studies.
2. To explore what and how GDSS functions can be applied to improve VM studies.
3. To examine the usefulness of the suggested GDSS functions.

1.1.2 Research Methods

VM is still at an embryonic stage in Hong Kong's construction industry and, therefore, the number of VM users in Hong Kong is limited. There were 70-80 members in the Hong Kong Institute of Value Management (HKIVM) in 2000. Due to this small population, a combined approach of using both quantitative analysis method and qualitative analysis method has been applied in the research. This approach aims to enhance the objectivity of research findings through reaping the advantages and overcoming the deficiencies involved in using a single

analysis method. Consequently, the research will produce a more comprehensive analysis. The data collection methods are given below:

Questionnaire Surveys

Two structured questionnaire surveys, which aim to investigate the most frequently encountered difficulties and to evaluate the usefulness of GDSS functions, have been conducted to collect quantitative data in this research. A "quota sampling" method has been applied in the survey because of the small population of VM users and the details will be given in the next section. The design of questionnaires mainly contains a set of "tick-the-box" format questions and "open-ended" questions so as to allow quick and easy responses for both standard and non-standard answers. The details of questionnaire survey will be illustrated in section 4.1 and 7.1.

Focus Group Meetings and Interviews

Three focus group meetings and a series of interviews have been conducted to collect qualitative data in order to supplement the quantitative data in the research. VM users and practitioners are invited to join the discussion and their comments and suggestions are recorded in the focus group meetings. Besides, a series of follow-up interviews are also conducted to have an in-depth discussion regarding some specific topics raised in the focus group meetings.

1.1.3 GDSS Research Advisory Group

The "quota sampling" method has been applied in the questionnaire surveys. A group of VM practitioners has been select to invite to the GDSS Research Advisory Group (GDRAG) in

accordance with their professional and working experience in VM. The backgrounds of the GDRAG members are presented in the following table.

Table 1.1: Background of the GDRAG Members

Name	Position	Organisation
Mr. Anthony R. Wilson	Chief Architect	Architectural Services Department
Mr. Conrad T.C. Wong	Vice Chairman	Yau Lee Holdings Ltd.
Mr. Yau Kai Cheung, David	Assistant General Manager	Henderson Land Development Co. Ltd.
Mr. Kenneth P.K. Wong	Senior Assistant Director	Estates Office, the University of Hong Kong
Ms. Lindsay Pickles	Director	Pontex Ltd.
Mr. Evenlyn K. S. Kwok	Associate Director	Northcroft Hong Kong Ltd.
Mr. Li Ho Kin	Senior Architect	Architecture Services Department
Mr. Ho Ping Hing, Herbert	Commercial Manager	Paul Y. ITC Construction Ltd.
Lau Kwong Hon, Kenneth	Senior Structure Engineer	Architectural Services Department
Law Chun Cheong, John	Senior Planner	Leighton Contractors (Asia) Ltd.

The GDRAG members are well-experienced VM practitioners in the construction industry and they mainly come from the Hong Kong Institute of Value Management (HKIVM). Table 1.1 shows that most of them are senior managerial staff members in local construction organisations and government departments, and their professionals include: (i) VM facilitator, (ii) client, architect, (iii) project manager, (iv) quantity surveyor, (v) engineer and (vi) contractor. These diverse backgrounds contribute a very good representation of local VM users in the research. In addition, the GDRAG is contributed to establish a link between research team and industry participants and therefore, to enhance the reliability and practicability of research findings.

1.1.4 Research Significances

The research aims to investigate the feasibility and benefits of applying GDSS to improve VM studies in Hong Kong's construction industry. There has been a surge of interest in VM applications and it has become more popular and more important in the construction industry. However, it is observed that the implementation of VM studies is subject to certain constraints and unfortunately, little work has been undertaken to address this problem. The research investigates these constraints in sufficient depth. The research findings are very useful for users to understand the constraints and therefore, to improve their practice.

The research will develop a GDSS framework in order to illustrate how GDSS can contribute to VM and what the benefits are. The research findings are contributed to integrate VM methodology with GDSS technologies and to explore a new direction of using IT to improve VM studies. As a result, the efficiency and effectiveness of conducting VM studies will be enhanced while maintaining the traditional roles and functions of VM team members.

1.2 Organisation of the Thesis

The thesis is comprised of three major parts and a brief introduction to the thesis organisation will be given below.

Part one aims to introduce the research and gives the literature on VM and GDSS. Chapter one provides an overview of the research, which covers the background, objectives, research methodology and significance of the research. Chapter two provides an introduction to VM. It describes the definitions, principle, and reviews the application of VM in Hong Kong's construction industry. Chapter three provides an introduction to GDSS. It describes the

emergence of GDSS and discusses how GDSS can be used to improve the group decision-making process.

Part two aims to illustrate how GDSS can be applied to VM studies and what the benefits are. Chapter four introduces a survey on the difficulties of conducting VM and discusses what are the most frequently encountered difficulties in VM studies. Chapter five discusses the potential of applying GDSS to improve VM studies. A framework of three-dimensional GDSS support is introduced in order to illustrate what and how GDSS functions can be used applied to VM studies. Chapter six provides an introduction to the Interactive Value Management System (IVMS). It provides an overview of the system structure and demonstrates how the GDSS functions can be integrated a whole system and implemented in a VM study.

Part three aims to discuss the feasibility of applying GDSS to improve VM studies. A validation has been conducted to examine the usefulness of the GDSS functions in the research and the validation results are summarised in chapter seven. Chapter eight, which is the final chapter, summarises and concludes the research findings some recommendations are suggested for further research.

2 VALUE MANAGEMENT IN HONG KONG'S CONSTRUCTION INDUSTRY

2.1 Introduction to VM

Value Management (VM) was developed at the General Electric Company in the USA in 1947. Owing to the shortages of materials, Mr. Lawrence Miles first developed a system of techniques, called value analysis (the origin of VM), to achieve substantial cost reduction by using various substitutes in the production process. This successful story enabled VM to further evolve and spread widely into the engineering and manufacturing sectors in North America. Over the past decades, VM has spread throughout the world and is now well received by the European countries, Japan, Australia, Korea, India, Saudi Arabia and China.

VM was first introduced into the construction industry by Mr. Dell'Isola in 1963. A VM incentive clause was added into contracts, which aimed to encourage contractors to suggest alternatives to improve the design in order to sharing the savings. Recently, the outstanding track records of VM have been recognised by government departments and VM is mandatory to apply to all mega size public projects in United States and Korea.

2.1.1 Definitions of VM

VM is a creative, organised approach whose objective is to optimise cost and/or performance of a facility or system. Through a system of investigation, the unnecessary costs are identified and eliminated while assuring that all critical factors, such as quality, reliability and performance, meet the clients' expectations (Dell'Isola, 1997). Today, the terms of Value Management (VM), Value Engineering (VE), and Value Analysis (VA) are used synonymously and a number of well-known definitions are as follows:

1. VM is a structured and analytical process, which seeks to achieve value for money by providing all the necessary functions at the lowest costs consistent with required levels of quality and performance (AS/NZS 4183: 1994).

2. VM is a service, which maximises the functional value of a project by managing its development from concept to completion and commissioning through the audit (examination) of all decisions against a value system determined by the client (Kelly and Male, 1993).

3. VM is a systematic, multi-disciplinary effort directed toward analyzing the functions of projects for the purpose of achieving the best value at the lowest overall life cycle project cost (Norton and McElligott, 1995).

Kelly and Male (1993) suggest that a set of characteristics to distinguish VM from other cost reduction exercises and they are presented as below.

1. A positive and pro-active approach through the use of a multi-disciplinary team-oriented creative process to generate alternatives to the existing solution;

2. The use of a structured systems method;

3. The relationship of function with value.

2.1.2 Principle of VM

Norton and McElligott (1995) suggest that unnecessary costs, which have contributed to poor value, are bound to exist in construction projects and they are mainly caused by the following factors.

Table 2.1: Factors Contributed to Poor Value in Construction Project (Norton and McElligott, 1995)

- Changes in owner requirements
- Habits and attitudes
- Honest wrong beliefs
- Lack of communication and coordination
- Lack of ideas
- Lack of information
- Outdated standard and specifications
- Temporary circumstances

In Table 2.1, each factor shows an opportunity for improving the value in management and hence, the project performance improves if unnecessary costs are identified and removed. To achieve this exercise more efficiently and effectively, a methodology called the "VM Job Plan" has been developed to standardise the process and it will be illustrated in the next section.

2.2 VM Job Plan

The VM job plan is a sequential approach to implementing the core elements of a value management study. It outlines specific steps to effectively analyse a product or services, and develops the maximum number of alternatives to achieve the product's or service's required functions (SAVE, 1998). Dell'Isola (1997) suggested that the job plan is an organised problem-solving approach, which distinguishes VM from other cost-cutting exercises. There is a variety of VM job plans, such as Charette, SAVE 40-hour Plan, VM Audit, Contractor's Change Proposal, Truncated Workshop, and Concurrent Study. In this thesis, discussion is mainly focused on the SAVE 40-hour Plan that is the most popular approach in the construction industry.

According to the Value Methodology Standard (SAVE, 1998), the SAVE 40-hour Plan is comprised of three major phases including: (i) pre-study phase, (ii) value study phase, and (iii) post-study phase and they are illustrated in the following figure.

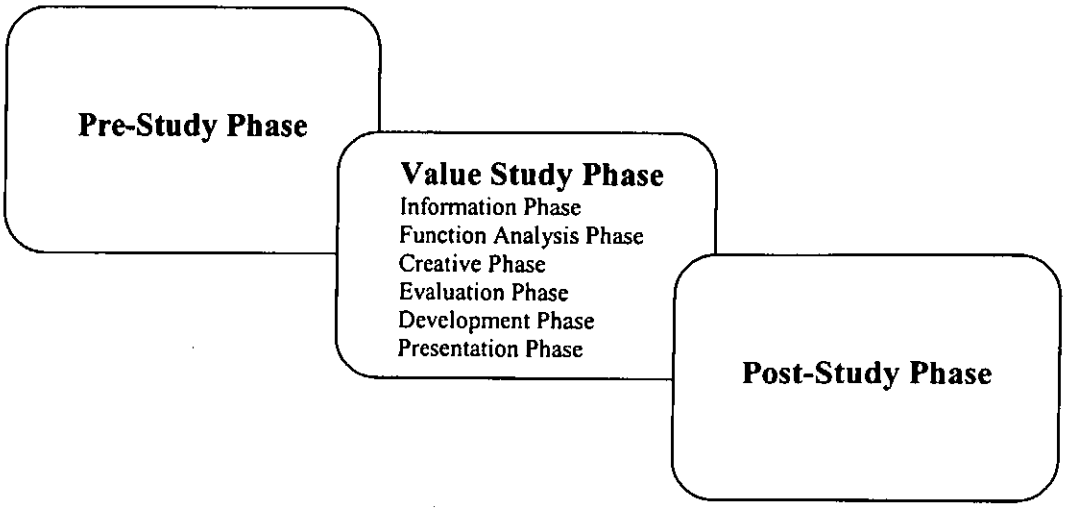

Figure 2.1: SAVE 40-hour Job Plan (SAVE, 1998)

2.2.1 Pre-study Phase

The pre-study phase aims to provide an opportunity for all parties to understand project issues and constraints, therefore, to give and receive information before VM workshops. The preparation tasks involve six areas including: (i) collecting user/customer attitudes, (ii) completing the data file, (iii) determining evaluation factors, (iv) defining the scope of the study, (v) building data models and (vi) determining team composition.

2.2.2 Value Study Phase

The value study is the core element of the job plan and it consists of the following six phases:

Information Phase

The objective of the information phase is to complete the value study data package in order to produce an information base in VM studies. It also confirms the objectives, clarifies the assumptions and reviews the scope of the studies.

Function Analysis Phase

The function analysis phase is the heart of VM methodology. It aims to determine the areas that have the greatest potential for savings or need improvement. The exercises of function definition and function analysis are usually achieved through the following tasks:

1. Identify functions using verbs and measurable nouns
2. Classify functions as basic functions or secondary functions
3. Develop function models by the use of Function Analysis System Technique (FAST)
4. Establish function worth cost functions
5. Establish value indexes
6. Select functions for further analysis

Creative Phase

The objective of the creative phase is to develop a large quantity of ideas for performing the functions defined in the analysis phase. It is because the number of good suggestions remains fairly constant as a proportion of wild - the more suggestions, the more good suggestions (Kelly and Male, 1993). To achieve this, various creative techniques, such as brainstorming, Delphi technique and lateral thinking, have been applied in order to motivate members to generate and produce as many ideas as possible. Moreover, creativity is a mental process and no judgment or criticism is allowed in order to maintain the free flow of ideas and thoughts in the creative phase.

Evaluation Phase

The objective of the evaluation phase is to explore ideas and concepts generated in the creativity phase, and to select those feasible ideas for development into specific value improvement. The collected ideas are examined according to both economic and non-economic factors, which are defined during the pre-study or evaluation phases, in order to highlight the best ideas for further studies (Norton and McElligott, 1995).

Development Phase

The objective of the development phase is to select and prepare the "best" alternative(s) for improving value. It investigates the selected ideas in sufficient depth and develops them into written recommendations for implementation. A technical data package for each proposed idea and a detailed improvement proposal would be completed at the end of this phase.

Presentation Phase

The objective of the presentation phase is to obtain concurrence and a commitment from designers, project sponsors, and related stakeholders in order to proceed with implementation of the recommendations. The recommendations are summarised in a final proposal and presented to all decision-making bodies and related interested parties for approval.

2.2.3 Post-study Phase

The objective of the post-study phase is to assure the proper implementation of the approved value study change recommendations. Assignments are carried out to track the progress and collect feedback on the proposal.

2.3 Benefits of VM

The primary objective of VM is to allocate and to formally schedule the application of an organised effort to gain facilities of better value. The benefits of VM suggested by Dell'Isola (1982) are illustrated in the following:

Time

The application of VM at an early stage is successful in clarifying scope and reducing false starts, which helps to save deign time and to prevent budget overruns and redesign.

Standardisation and Simplification

The application of VM ensures that simplification and standardisation alternatives are considered to reduce cost through analysis of redundant and unnecessary functions.

Isolating Design Deficiencies

The application of VM enables the project team to uncover the potential design deficiencies that may have occurred in the design process.

Help in Solving Problems

VM is one of the best methods for solving the problems of performance, reliability, unforeseen conditions etc.

Conducting Special Studies and Programs

VM provides an optimised solution through combining the comprehensive inputs from different techniques, such as cost control, life cycle costing, energy conservation, and risk studies.

Besides the stated benefits, Norton and Elligott (1995) suggested that the team approach of VM also improves the decision-making process. It is because decisions made by individuals could be costly, inefficient, and incomplete and therefore, the results might be less optimal. VM provides a forum to allow all involved parties working together to seek the best value solution for a particular situation and thus, the quality of recommendations is improved.

2.4 VM in Hong Kong's Construction Industry

VM was first introduced to Hong Kong in the late 1980s but the development of VM was very slow before the Asia financial crisis in 1997. Only a few property developers applied VM to the construction industry (Shen, 1997a and Fong et al, 1998). Findings of a survey (Fong et al., 1998) revealed that only 18 out of 90 respondents were experienced with VM studies in 1998 and the major reasons for not using VM at work are summarised in Table 2.2.

Table 2.2: Reasons for Not Using VM at Work (Fong et al., 1998)

Reasons	Percentage
Lack of knowledge to implement this new approach at work	24.4%
Lack of time to implement this new approach at work	21.1%
The client and/or other team members are reluctant to change	16.7%
Traditional cost saving methods are considered more adequate or better	7.8%
No confidence to introduce to clients	7.8%

In recent years, the benefits of VM is gaining acceptance in Hong Kong. There has been a surge of interest in VM applications and it has become more popular and more important in the construction. Many government departments, public corporations, and private enterprises have applied VM in preliminary project feasibility studies in order to enhance project performance. In addition, the success of VM has been recognised by the Hong Kong SAR Government in 1998 and a number of government departments including: Architectural Services Department, Civil Engineering Department, and Water Supplies Department, are encouraged to selectively apply VM in order to achieve the following objectives in public works contracts (Planning, Environment & Land Bureau Technical Circular No. 9/98, 2001).

1. Clarifying objectives
2. Updating criteria
3. Solving problems
4. Breaking a dead-lock situation
5. Optimising resources
6. Surfacing erroneous assumptions, and
7. Enhancing communication/team support

Besides the government departments, many quasi-government organisations, including Hospital Authority, Mass Transport Railway Corporation, and Kowloon-Canton Railway Corporation (KCRC), also apply VM to enhance the project performance of construction projects. For example, the KCRC saved HK$2 billion in West Rail Project through VM studies (Thoms & Lyall, 2000).

In Hong Kong, it is observed that the VM practice is different from the two main VM practices in the USA and Australia/ UK. A mixed VM, which is similar to that used in Australia and the UK model, is widely used in the construction industry and a comparison of VM practice in Hong Kong, Australia/UK, and USA is given in the following table.

Table 2.3: Comparison of VM Practice in Hong Kong, Australia/ UK, and USA

	Hong Kong	Australia/ UK	USA
Stage of Application	Feasibility or concept design	Feasibility or concept design	Sketch or detail design stage
Duration of Study	4-16 hours	8-24 hours	40 hours
Study team	Original project team + Other Stakeholders	Original project team + Other Stakeholders	Independent team
Number of Participants	20-70	15-30	5-8
Job Plan	Information Analysis Creativity Evaluation Development Presentation	Information Analysis Creativity Evaluation Development Presentation	Information Creativity Evaluation Development Presentation
Function Analysis	Not Essential	Not Essential	Essential
Facilitation	Essential	Essential	Not essential
Use FAST	No	No	Yes
Use Function Cost Analysis	Rarely	Rarely	Yes
Target Cost	Rarely	Rarely	Yes

Comparing with the VM practices in Hong Kong and Australia, the duration of studies has been shortened from 8-24 hours to 4-16 hours and thus, one–day workshop (8 hours) seems to be most popular in Hong Kong. It is because many clients are trying to shorten the duration of studies in order to save time and reduce consultancy fees in construction projects. Moreover, the size of study teams is larger in Hong Kong. Besides the members from original project teams, many stakeholders are usually invited from various departments or organisations in order to wider the expertise gained in studies. These stakeholders usually contribute a significant portion in study teams and their number may be up to 70 in a single project (Pickles, 2000). To sum up the discussion, the success of VM in improving the procurement systems has gained acceptance and the application of VM is becoming more important and more popular in Hong Kong's construction industry.

2.5 Information Technology Applications in VM

The continuing improvement in performance/price ratio of personal computing facilities has made information technology (IT) an effective tool for solving some of the efficiency-related difficulties (Shen, 1996). The continuing improvement in performance/price ratio of personal computing facilities has made information technology an effective tool for solving some of the efficiency-related difficulties (Shen, 1996). IT can be a very useful tool in VM specialists' toolbox and a number of successful applications are reported (Murray, 1988; Paulson et al, 1989; Shen and Brandon, 1992; Shen, 1993; Shen, 1996; Otero, 1997). Some examples of IT applications in VM studies are given below.

The United Technologies Corporation in the US has developed a software package called the Value Management Software Tools Set. The package can integrate data throughout VM studies and improve the productivity through standardising the methodology, computerising the recurring tasks, and eliminating human errors in VM studies (Otero, 1997). In France, a specialised software package called the Functional Performance Specification has been applied in VM studies (AFAV, 2000). In United Kingdom, a Knowledge-Based System has been applied to support the decision-making process in VM studies (Shen, 1993). These packages, however, are specifically designed for particular organisations and they are limited for internal use only.

In Hong Kong, it is observed that IT is under-utilised in VM and none of the specialised software package or advanced computer tools is being applied in practice. For the above reasons there is a strong demand for addressing the needs of local VM users and more resources should be put in exploring the application of IT in VM studies.

3 USING GROUP DECISION SUPPORT SYSTEMS TO IMPROVE THE GROUP DECISION-MAKING PROCESS

Group Decision Support Systems (GDSS) is a branch of Information Technology (IT), which combines communication, computer, and decision technologies to support problem formulation and solution in meetings. Research findings suggest that GDSS is a powerful tool in improving the group decision-making process. This chapter aims to introduce the GDSS and discuss how it can be used to improve the group decision-making process.

3.1 Introduction to GDSS

GDSS, which is also known as Group Support Systems (GSS), Computer Supported Collaborative Work (CSCW) and Electronic Meeting System (EMS), is a computer system designed to improve the group decision-making process in meetings. In the late 1980s, the focus of Decision Support Systems (DSS) shifted from supporting the problem-finding and problem-solving processes for individuals to the consensus building process of a group of people. As a result, GDSS emerged and it is a derivative of the DSS. This section introduces GDSS, which includes the definitions, characteristics, components, classifications and configurations of GDSS.

3.1.1 Definitions of GDSS

Research findings show that there is lack of consensus about the true definition of GDSS and a number of well-known definitions are as follows:

1. Huber (1984) defined GDSS as a set of software, hardware, language, components, and procedures that support a group of people in a decision related meeting.

2. Aiken et al. (1995) defined GDSS as a computer-based system, which supports groups of people engaged in a common question and provides an interface to a shared environment. It enhances the group productivity by supporting the exchange of ideas, opinions, and preferences within the group.

In this thesis, a well-received definition of GDSS given by DeSanctis and Gallupe (1987) has been adopted and it is illustrated in the following figure.

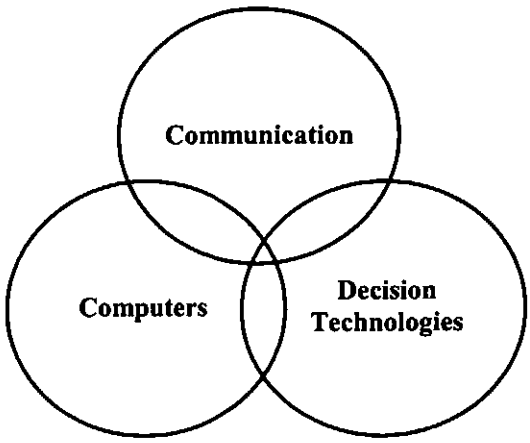

Figure 3.1: Definition of GDSS (DeSanctis and Gallupe, 1987)

GDSS is defined as an interactive computer-based system, which combines (i) communication, (ii) computers, and (iii) decision technologies to support problem formulation and solution in group meetings. It aims to improve the group decision-making process by removing common communication barriers, providing techniques for structuring decision analysis and systematically directing the pattern, timing, or content of discussion (DeSanctis and Gallupe, 1987).

3.1.2 Characteristics of GDSS

Besides the definition, DeSanctis and Gallupe (1987) also suggested five characteristics of GDSS, which are listed as below:

1. GDSS should be a specially designed system, not merely a configuration of already-existing system components.
2. GDSS should be designed with the goal of supporting groups of decision-makers in their work. As such, GDSS should improve the decision-making process and/or decision outcomes of groups over that which would occur if the GDSS were not present.
3. GDSS should be easy to learn and easy to use. It accommodates users with varying levels of knowledge regarding computing and decision support.
4. GDSS may be specifically designed for one type, or class, of problems or generally designed for a variety of group-level organisation decisions.
5. GDSS should contain built-in mechanisms, which discourage the development of negative group behaviors (such as destructive conflict, miscommunication, or group thinking) in the group decision-making process.

Finlay (1989) further elaborated the definition and suggested that GDSS should facilitate communication between participants and permit voting and ranking for developing consensus. The decision aids should be transparent in operation, and participants should understand and be comfortable with the results.

3.1.3 Components of GDSS

In reference to a generalised GDSS model proposed by DeSanctis and Gallupe (1985), a GDSS should have at least one computer processor, one input/output device, and one viewing screen. A facilitator is responsible to coordinate the group's use of the technology, and there is a flexible, friendly user-interface language available for use by the facilitator of each group.

There are four basic components of a GDSS and they include (i) hardware, (ii) software, (iii) people, and (iv) procedures, which are illustrated in Figure 3.2.

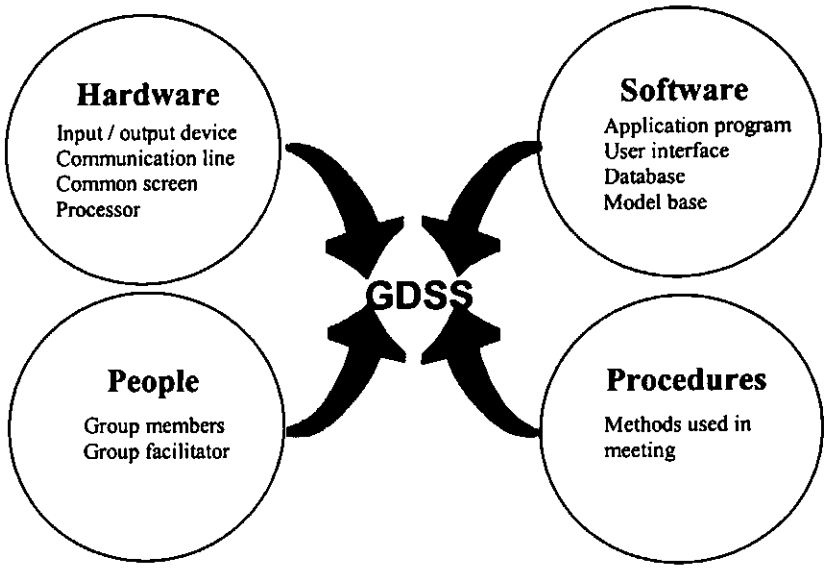

Figure 3.2: Components of GDSS (DeSanctis and Gallupe 1985)

Hardware

The hardware components of GDSS include: an input/output (I/O) device, a processor, a communication line between the I/O device and the processor, and either a common viewing screen or individual monitors for use in displaying information to the group. The design of the hardware should allow each participant to work independently and enable them to demonstrate the personal work done in meetings.

Software

The software components of GDSS include a database, a model base, and specialised application program(s) to be used by the group, and an easy-to-use, flexible user's interface. Gray (1987) pointed out that the software packages should provide support both to the individual and the group. Regarding the individual, the features of text editing and formatting, data file creation, modification, and storage for group members should be

provided at individual workstations in order to allow for private work. Regarding the group, the features of information retrieval and display should be provided in order to summarise and present the group members' ideas and votes. Text and data transmission among the group members, and between the group members and the facilitator should be allowed in order to share and distribute the information in meetings.

People

The people components of GDSS include group members and a facilitator. The facilitator is responsible to maintain the smooth operation of GDSS technology when it is in use in meeting. He may provide training to group members or act as a "chauffer" to assist in operating the system.

Procedures

The final component of GDSS consists of "procedures" which enable the ease of operation and effective use of GDSS technology by group members in meetings. These procedures may only apply to the operation of the hardware and software, or they may extend to include rules regarding the verbal discussion among members or the flow of events during a group meeting.

3.1.4 Classifications of GDSS

In order to describe how GDSS technologies can be applied to the decision-making process, DeSanctis and Gallupe (1987) classified the application of GDSS into three levels and their details are summarised in Table 3.1.

Table 3.1: Three-level GDSS Application

Level	GDSS Function	Feature Provided
1	**Computer-supported conference** To facilitate the information exchange among members	• Electronic messaging and broadcasting exchange between members • Instantaneous display of public information such as generated ideas or other information on a large screen • Anonymous input of ideas and voting • Voting solicitation
2	**Provision of decision modeling and group decision techniques** To apply systematic techniques in the decision-making process	• Automatic planning tools • Modeling tools to support analysis such as risk analysis • Automating the Delphi method and the Nominal Group technique
3	**Machine-induced group communication** To reduce uncertainty and "noise" that occur in the group's decision process To provide the highly structured communication	• Automatic planning tools • Modeling tools to support analysis such as risk analysis • Automating the Delphi method and the Nominal Group technique

Level 1 GDSS provides technical features aimed at removing common communication barriers by facilitating information exchange among participants. For example, large screens are used to display, analysis results, voting results, anonymous input ideas, and preferences in meetings.

Level 2 GDSS evolves beyond the functions provided at level 1. Besides the communication support, it also applies decision modeling and group decision techniques in order to reduce uncertainty and "noise" during the group decision-making process. For example, automatic

planning tools and multi-criteria decision models, which are commonly found in the DSS, are used to facilitate the data analysis and decision analysis processes respectively.

Level 3 GDSS is the most sophisticated GDSS system and "machine-induced, group communication" has been introduced to structuralise the group decision-making process. For example, a level 3 GDSS system determines who speaks first and when, in what order, to whom, and for how long etc. However, it imposes a significant intervention into the group's natural decision process and only a small number of researchers have completed studying this level.

3.1.5 Configurations of GDSS

GDSS can be applied to a meeting with a few participants sitting in a conference room or to a hundred people dispersed geographically and hence, a variety of GDSS settings is found. DeSanctis and Gallupe (1987) proposed a framework, which emphasises the factors of (i) group size and (ii) proximity of members during meetings, to determine the configurations of GDSS and four types of GDSS settings are presented in Figure 3.3.

		Group Size	
		Smaller	**Larger**
Member Proximity	**Face–to Face**	Decision Room	Legislative Session
	Dispersed	Local Area Decision Network	Computer-mediated Conference

Figure 3.3: Four Types of GDSS Settings (DeSanctis and Gallupe, 1987)

Decision Room

Decision room is designed to support a small group of participants (less than 24) who are staying in a single physical location. It is a typical conference room equipped with electronic facilities. As shown in Figure 3.4, participants are arranged to sit at a U-shaped table and a public screen is placed at the front of the room. Besides, workstations are provided so that communication can be transmitted both verbally and via computer messaging in meetings. The decision room is the most typical and the most popular GDSS system, and examples of institutions that using decision rooms include: the London School of Economics, University of Arizona, University of Minnesota, and IBM.

Figure 3.4: Decision Room (University of Arizona)

Legislative Session

Legislative session is designed to support a large group of participants (50-100), who are staying in a single physical location. In this circumstance, verbal communication is removed and participants are mainly relied on electronic communication via workstations. Moreover, a hierarchy of member-to-member communication is established. Members are limited to send messages to fellow party members and only facilitators or chairpersons are allowed to

send information to the public screen. This approach is ideal for participants who engage in day-to-day meetings working in same office.

Figure 3.5: Legislative Seminar Room (University of Arizona)

Local Area Decision Network

Local area decision network is designed to support small groups who are dispersed geographically. A computer network, including local area communication network and long distance communication network, can be used to electronically connect participants who are at oversea offices, homes or remote locations in meetings. Participants can meet synchronously or asynchronously by using a teleconference or a computerised bulletin board respectively.

Computer-mediated Conference

Computer-mediated conference is designed to support large groups who are dispersed geographically. It combines the long distance communication networks and group support software to create a "virtual meeting". In this scenario, there is no need to schedule meetings in advance. Participants can join the virtual meetings through sending their inputs such as ideas, comments, or preferences, to a central database and eventually, decisions are made by

consensus. The rapid growth of the Internet and the development of support software, such as Microsoft Internet Explorer and Net Meeting, are likely to accelerate the trend of people working in dispersed groups (Lai and Turban, 1998). Consequently, the application of computer-mediated conference is expected to becoming more in the near future.

Besides the framework described in Figure 3.3, Gray (1987) suggested that GDSS can be further classified by the delivery mode, which includes (i) permanent installations at the user's site; (ii) portable installations brought to the user's site; and (iii) permanent installation at the vendor's site.

3.2 Previous Research in GDSS

There is great worldwide interest in GDSS research and a substantial amount of studies has been conduced in various institutions including University of Arizona, University of Georgia, University of Minnesota, and the Indiana University in the past two decades (Pervan, 1998). The first GDSS paper was published in 1984 and the earlier studies including Huber (1984), DeSanctis and Gallupe (1985), Gary (1987), and DeSanctis and Gallupe (1987) were mainly concentrated on the theory development and system design, and these studies had contributed to establish a foundation of GDSS research. For examples, the papers of "Group decision support systems: A new frontier" (DeSanctis and Gallupe, 1985) and "A foundation for the study of group decision support systems" (DeSanctis and Gallupe, 1987), which first introduced the classifications and configurations of GDSS, were used in the GDSS research commonly even though they were old. (e.g.: Maryam, 1991; Tyran et al., 1992; Poole and Holmes, 1993; Aiken et al. 1995; Jackson, 1995; Poole, 1995; Lam, 1997; Dennis et al., 1997; and Borges et al., 1999)

In the 1980s, GDSS technologies were becoming more mature and the research focus shifted towards experimentation. Many researchers attempted to investigate the effectiveness of GDSS by studying the differences between GDSS-supported groups (with GDSS), and traditional groups (without GDSS support). Some of their research findings are demonstrated in Table 3.2.

Table 3.2: Summary of GDSS Experimental Studies (Dennis et al., 1988)

Variables/ Studies	Decision Quality	Time to Decision	Participation	Satisfaction w/ Process	Satisfaction w/ Outcome
Steeb and Johnston, 1981	GDSS better	GDSS takes longer	No report	Increased w/GDSS	Increased w/GDSS
Lewis, 1982	GDSS better		GDSS reduces individual dominance	No effect	
Ruble, 1984	No effect				
Gallupe et al., 1988	GDSS better	GDSS takes longer	No effect	Reduced by GDSS	Reduced by GDSS
Beauclair, 1987	No effect	No effect	No effect		No effect
Watson et al., 1988	GDSS worse than manual; better than nothing			Reduced by GDSS	
Zigurs, 1987	GDSS better		More even distribution of influence		
A. Easton, 1988	No effect	No effect	No effect	No effect	GDSS more satisfied

The above table illustrates the three most investigated dependent variables (quality of decision, level of participation, and satisfaction with the group process) in these ten studies. The results revealed that quality of decision was generally rated better in GDSS groups than in non-GDSS groups. The GDSS groups had no effect on the level of participation of group members and they were no more and no less satisfied with the process than non-GDSS groups. In addition, the GDSS groups required more time or no effect in decision time, so there was no benefit from GDSS application in terms of the decision time saved (Dennis et al.,

1988). However, it is interesting to note that, unlike the experimental studies, the findings from all field studies (Table 3.3) consistently showed positive results.

Table 3.3: Summary of GDSS Field Studies (Dennis et al., 1988)

Observations / Studies	Satisfaction	Effectiveness
Adelman, 1984	final design well supported by all participants	action taken within a week after GDSS exercise
Nunamaker et al., 1987	participants reported high levels of satisfaction	more equal participation
Vogel & Nunamaker, 1988	participants reported high levels of satisfaction	participants said they did as much in one morning as would have normally taken two days
Dennis et al., 1988	participants reported high levels of satisfaction	meetings rated extremely effective by management and participants
Nunamaker et al., 1989	participants reported high levels of satisfaction	found man-hour savings of 61% from GDSS use, compared to unsupported sessions

Table 3.3 has summarised five studies that utilised the case and field study methodologies. The above results show both enhanced decision quality and shortened meeting time with the use of a GDSS compared to a similar conventional meeting (Chun and Park, 1998). In addition, "real world" users were reported to be extremely satisfied with GDSS applications. This finding was in contradiction with the inconsistent laboratory results. Dennis et al. (1988) explained that real users (industry participants) in field studies were working on their own problems instead of the experimental tasks assigned to students in laboratory studies. Moreover, real tasks were more complicated and, therefore, more illustrative in demonstrating the benefits of using GDSS in practice. These findings provide evidence that the application of GDSS is successful in improving the decision quality and reducing the decision time required. It is particularly suitable for the larger groups and the more complex tasks because of a high fixed overhead cost (Dennis et al., 1988; Chun and Park, 1998).

GDSS research progressed through theory building, theory testing and theory extension since 1984. The research could be grouped into four stages: 1984-1987, 1985-1990, 1991-1993, 1994-1996 and a review of GDSS research is given below:

Table 3:4: A Review of GDSS Research in Major Journals (Pervan, 1998)

	1984-1987	1985-1990	1991-1993	1994-1996	Total
No. of GDSS Research	15	36	88	95	234

Table 3.4 shows that the overall growth of GDSS research was significant in the 1980s and however, the rate was slowed down since 1994. One possible reason was the inconsistent findings among field studies and experimental studies described in Table 3.2. Another reason was that GDSS research over the past years was mainly focused on decision rooms and it was dominated by a small number of institutions, in particular University of Arizona and Minnesota (Pervan, 1998, Chun and Park, 1998).

In a modern organisation, people frequently work and make decision in groups and they are much more interested in working together though electronic communication. Recently, there is an increasing amount of research in the area of distributed GDSS and some examples are Tung and Turban (1998), Borges et al. (1999), Glezer and Yadav (1999). The distributed GDSS is also known as Distributed Group Support System and it aims to combine face-to-face communication with videoconferencing and electronic communication in order to overcome the difficulties associated with being in different places and sometimes in different time zones. However, the distrusted environments provides several challenges for participants, facilitators, and technology developers and a number of studies are still going on to explore them into details (Adkin, 2000).

3.3 Advantages of Applying GDSS to the Group Decision-making Process

Nunamaker et al. (1996) suggested that many things might go wrong with teamwork. As a result, the group decision-making process can be very difficult and unproductive, and some of the difficulties are listed below.

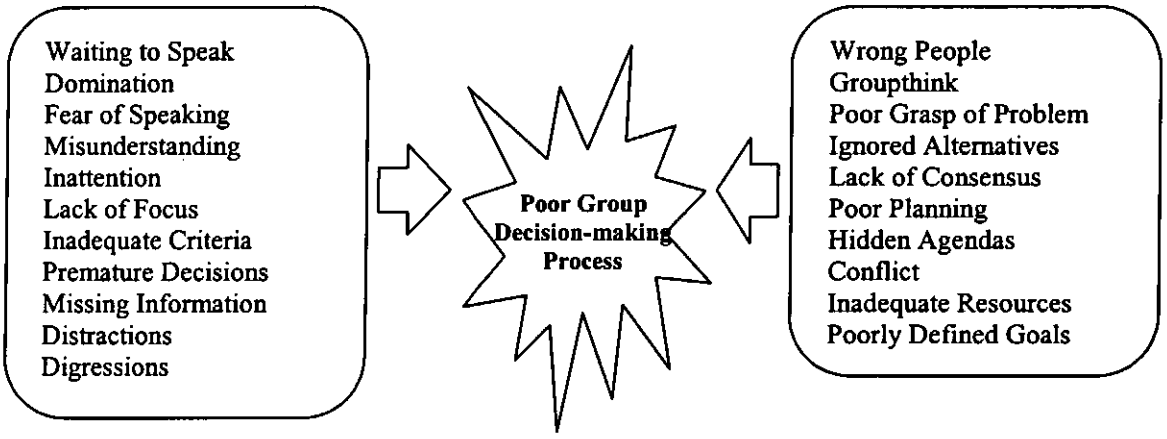

Figure 3.6: Problems of the Group Decision-making Process (Nunamaker et al., 1996)

The primary objective of GDSS is to improve the group decision-making process, which in turn results in a more effective decision. As suggested by Jessup and Kukalis (1990), the benefits of GDSS are mainly divided in two categories: "technological efficiencies" and "interaction advantages". A summary of GDSS advantages is demonstrated in Figure 3.7.

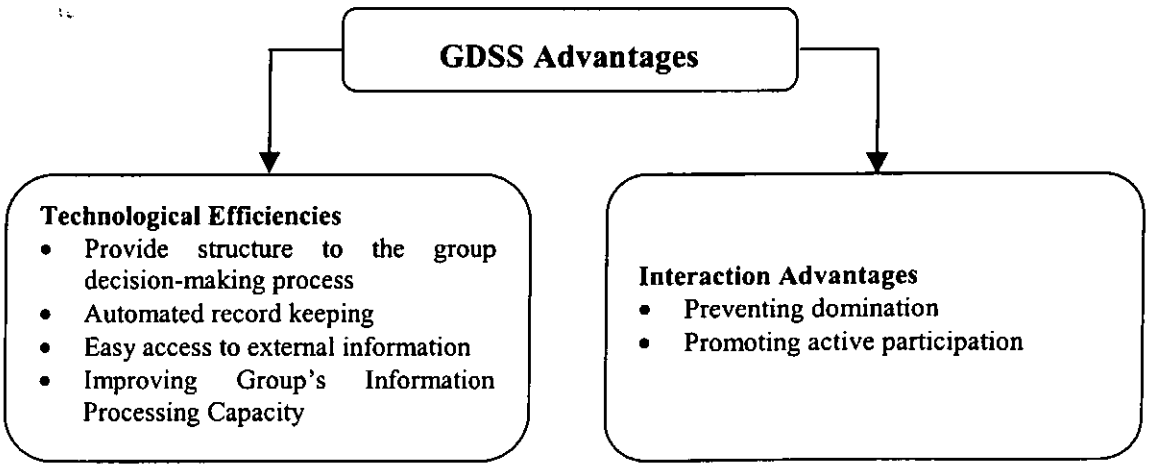

Figure 3.7: Summary of GDSS Advantages

3.3.1 Technological Efficiencies

The technological efficiencies of GDSS aim to improve the efficiencies of decision making related tasks, such as information processing, retrieval and storage, and some advantages are stated below.

Providing Structure to the Group Decision-making Process

GDSS can structuralise the group decision-making process and, therefore, to avoid costly diversion and distraction in meetings (Aiken, 1995; DeSanctis and Gallupe, 1987). For example, electronic agenda of the level 3 GDSS provides a set of pre-defined procedures to assist those participants who have no prior experience of working together. It also keeps the group on track and prevents over-concentration on one or two narrow-minded issues during discussion.

Automated Record Keeping

GDSS can keep a track record of meetings and, therefore, allow participants to concentrate on thinking during discussion. It is because participants must listen to speakers cannot pause to think in traditional meetings. Otherwise, they may forget what is heard earlier. GDSS can automatically record all comments, votes, and preferences produced in meetings. The track record of meetings enables participants to spend more time in thinking rather than note taking (Aiken, 1995 DeSanctis and Gallupe, 1987). In addition, the records also assist to develop an "organisation memory", which is useful in providing information to support similar meetings in the future.

Easy Access to External Information

Information is essential in evaluating the alternatives and it is very important to decision-makers. GDSS can improve the availability of information through accessing external information in meetings. It provides valuable and timely information for decision-makers in order to response to the changing conditions quickly. Moreover, GDSS also enlarges the base of information in meetings by integrating the internal and external information sources. For example, participants can retrieve the organisation data such as annual reports, previous meeting minutes or financial information from the central database. In addition, they can access the external information through the Internet.

Improving the Group's Information Processing Capacity

GDSS can enhance the group's ability to process more information more rapidly. In general, the group information processing capability is limited. The use of GDSS tools, such as spreadsheets, and statistical analysis software, can simplify the information analysis process and participants can process a large amount of complicated and repeated data quickly in meetings (Thierauf, 1989). It can shorter information processing time and avoids the annoyance of interrupted concentration while waiting for the results. Moreover, it speeds up turnaround in evaluation and hence, participants can generate and consider more alternatives in meetings. In addition, GDSS can assist participants in data presentation, concept briefing and idea illustration in meetings. The diagrammatic reasoning and multi-media presentation features of GDSS improves the effectiveness of presentation and this improves the members' understanding of information given in meetings (Watson, 1987).

3.3.2 Interaction Advantages

The interaction advantages aim to modify the communication pattern among participants so as to control those inhibiting factors in the group decision-making process (Watson, 1987). They are the key benefits of GDSS and some advantages are stated below.

Preventing Domination

The parallel communication feature of GDSS contributes to increasing interaction and reducing domination. In oral meetings, only one participant is allowed to speak out and GDSS can improve this by electronic communication. GDSS tools, such as chat rooms and instant messaging, allow participants to communicate simultaneously through computer networks. Participants can interact with others' ideas immediately; hence, the interaction is enhanced (Jackson et al., 1995). The problem of domination is common in oral meeting and a few participants may monopolise the speaking time because of strong personality or personal interests. The parallel communication provides an equal opportunity in speaking for everyone; hence, the chance of domination can be minmised in meetings.

Promoting Active Participation

Anonymity is one of the key features of GDSS and it reduces the social context in the group decision-making process. It aims to create a democratic atmosphere to promote active participation and interaction. The electronic communication tools of GDSS enable participants to communicate without showing their identities. Participants can contribute ideas by typing on screen and then enter into the electronic discussion. Research findings have found that participants become more active and critical in discussion. They are free to exchange, synthesise, and display ideas because they no longer fear ridicule due to "foolish" ideas or comments (Jackson et al., 1995). In addition, anonymity also enables discussion to

become more issue-oriented and avoids the conformance pressure and the pitfalls of groupthink in discussion. Participants can judge the merit of people's ideas solely based on the merits of the ideas. This approach maximises the synergy gained from group discussion and, therefore, the decision quality is improved (Aiken, 1995; Thierauf, 1989; DeSanctis and Gallupe, 1987; and Jackson et al., 1995).

3.3.3 Limitations of GDSS

There are many advantages in using GDSS to improve the group decision-making process; however, some constraints are reported in implementation. GDSS causes intervention to the group's nature. The more sophisticated GDSS technology would result in more dramatic intervention. Any misuse of the technology may be harmful to the groups (DeSanctis and Gallupe, 1987). Aiken (1995) also identified a number of limitations of GDSS and they are listed in the following.

1. The impersonal nature of the GDSS environment lacks the richness of body language and facial expression, and participants may feel uncomfortable.
2. Anonymous electronic communication may result in loss of key participants (leaders) and an increase in conflict. It may also slow down the speed of communication because typing is slower than speaking.
3. Computers may intimidate people, especially high-level executives. Any bias against using information technology may result in resistance to GDSS implementation.
4. GDSS facilities (hardware and software) can be relatively expensive and additional resources are required to provide training and setting up the facilities.

3.4 GDSS Applications in Industries

The success of GDSS is gaining acceptance and it has been widely used, particularly in strategic management and planning, in many academic institutions, government departments and business organisations worldwide including University of Arizona, University of Minnesota, IBM, Motorola, Xerox, 3M, US Navy, and NASA (Tyran et al, 1992 and Dennis et al., 1997). A short list of various GDSS systems that have been developed is shown in Table 3.4.

Table 3.4: Various GDSS Systems

GDSS Systems	Users
GroupSystems (Formerly known as Plexsys system)	University of Arizona
SAMM (Software Aided Meeting Management)	University of Minnesota
Claremont System	Claremont Graduate School
Team Focus	IBM
Colab System	Xerox

4 DIFFICULTIES OF IMPLEMENTING VM STUDIES IN HONG KONG'S CONSTRUCTION INDUSTRY

VM is still at an embryonic stage in Hong Kong, and there is lack of information regarding its application in the local construction industry. In order to understand the current practice of VM, a survey had been conducted to investigate the most frequently encountered difficulties in VM studies between December 1999 and January 2000. The survey results are contributed to consolidate the foundation of the research, and to facilitate the development of the GDSS framework at the next stage. This chapter introduces the survey methodology and discusses the most frequently encountered difficulties in VM studies.

4.1 Survey Methodology

In Hong Kong, VM is still at an embryonic stage and there were 70-80 members in the Hong Kong Institute of Value Management in 2000. As a result, the number of VM users is limited, and quantitative method alone might be inappropriate due to a small population. For this reason, a combined approach using both quantitative and qualitative methods is adopted in this survey in order to achieve a more comprehensive analysis. This approach is expected to enhance the objectivity of findings through reaping the advantages and overcoming the deficiencies involved in using a single method. The quantitative and qualitative data are collected through a structured questionnaire survey and a set of focus group meetings respectively.

Questionnaire Survey

A structured questionnaire has been prepared to collect the quantitative data regarding (i) the satisfaction with the practice of VM studies, and (ii) the difficulties encountered in VM studies. The questionnaire comprises a set of "tick-the-box" format questions and "open-ended" questions, which allow quick and easy responses for both standard and non-standard answers. There are 15 possible difficulties listed in the questionnaire, and respondents are asked to rate their frequency on the scale of "always", "frequently", "sometimes", "seldom", and "never". Besides, the option of "other" is also available in each category, which enables respondents to introduce any new difficulties if necessary. In order to facilitate data analysis, a five-grade scoring system is introduced and these five options are represented by the scores of 5, 4, 3, 2, and 1 respectively. The total scores of each difficulty are consolidated to produce an average score, where a higher score means a higher frequency of occurrence.

Focus Group Meetings

The qualitative data is mainly collected through a set of focus group meetings. The quantitative data from questionnaires are useful in providing a framework for conducting discussion in the focus group meetings.

4.1.1 Sources of Research Data

In Hong Kong, awareness of VM is relatively high among construction professionals but only a small group of them are experienced in VM studies. To accommodate this particular situation, the views from both experienced and less experienced VM users have been considered in the survey. This aims to produce a collective view to reflect Hong Kong's situation rather than making any comparisons between the experienced and less experienced users. Below are the groups of industry participants who are invited to participate in the survey.

Group 1 - Experienced VM Users

Group 1 consists of eight VM practitioners, who are the most active and experienced VM users in the construction industry. They mainly come from the GDRAG that is introduced in section 1.3 and their professional backgrounds include: (i) VM facilitator, (ii) client, (iii) architect, (iv) project manager, (v) quantity surveyor, (vi) engineer and (vii) contractor. The backgrounds of the Group 1 members are summarised in the following table.

Table 4.1: Backgrounds of Group 1 Members

	Name	Position	Organisation
1	Mr. Anthony R. Wilson	Chief Architect	Architectural Services Department
2	Mr. Conrad T.C. Wong	Vice Chairman	Yau Lee Holdings Ltd.
3	Mr. Kenneth P.K. Wong	Senior Assistant Director	Estates Office, the University of Hong Kong
4	Ms. Lindsay Pickles	Director	Pontex Ltd.
5	Mr. Evelyn K. S. Kwok	Associate Director	Northcroft Hong Kong Ltd.
6	Mr. Ho Ping Hing, Herbert	Commercial Manager	Paul Y. ITC Construction Ltd.
7	Lau Kwong Hon, Kenneth	Senior Structure Engineer	Architectural Services Department
8	Law Chun Cheong, John	Senior Planner	Leighton Contractors (Asia) Ltd.

As shown in Table 4.1, most of the members are senior managerial staff in local construction organisations and government departments. Hence, their diverse backgrounds and excellent reputations ensure that they are a very good representation of experienced VM users in the construction industry.

Group 2 - Less Experienced VM Users

Group 2 consists of nineteen professionals from the construction industry, and their professional backgrounds include: (i) architect, (ii) client, (iii) project manager, (iii) quantity surveyor, (iv) engineer and (v) site agent. These members come from a postgraduate training module entitled "Value Management in construction and real estate" at the Hong Kong Polytechnic University. This is one of the major VM training programme in Hong Kong and it produces 20 students per module, which contributes a significantly portion of VM users in comparison with eighty members of the HKIVM. The training (a module worth 140 hours of student effort) not only provides students with theoretical knowledge of VM but also practical knowledge as well through a simulated VM workshop. All of them have a good understanding of VM methodology, but less practical experience. Hence, these students have been adopted as a sample of representing less experienced VM users in Hong Kong. The use of student group would wider the scope of study and thus, to produce a comprehensive result in the survey. Nevertheless, the problem of small sample size is considered as the key limitation and therefore, a mixed approach of using both quantitative analysis method and qualitative analysis method has been applied in the survey.

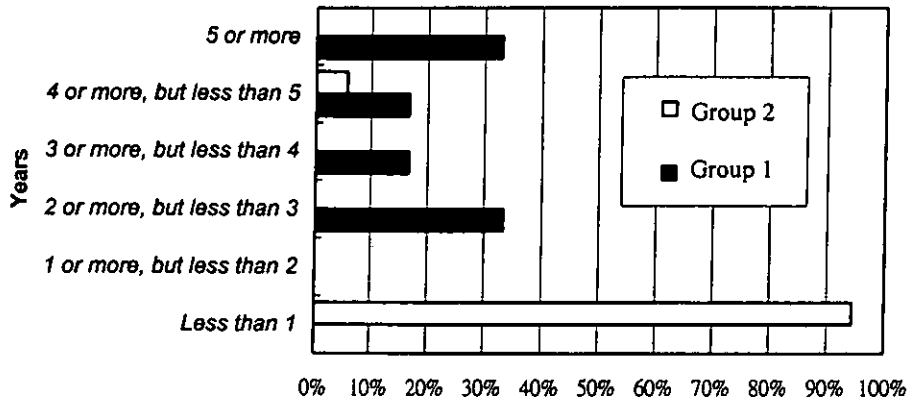

Figure 4.1: Years of Experience in VM Studies

The years of VM experience of Groups 1 and 2 are summarised in the Figure 4.1. It shows that the members in Group 1 have 2-5 years' experience of practicing VM in the construction industry, whereas nearly all the members in Group 2 have less than one year of experience only. It may be suggested that the experience of the members in Group 1 is relatively short compared with overseas VM practitioners; this is because VM development is still in an embryonic stage in Hong Kong's construction industry. Considering this factor, there could be no doubt that taking a local sample would be the most representative method in the survey.

4.1.2 Respondents' Profile

The questionnaires are distributed to the members of Groups 1 and 2, from which a total of 6 and 18 completed questionnaires are returned respectively. The distribution of returned questionnaires is summarised in the following table.

Table 4.2: Distribution of Collected Questionnaires

Data Sources	No. of Questionnaires Collected	Response Rate
Group 1	6 out of 8	75%
Group 2	18 out of 19	95%

4.2 Survey Results

The survey aims to identify the difficulties encountered most frequently while implementing VM studies. Survey results are mainly divided into two parts including (i) satisfaction with VM studies implementation, and (ii) frequency of difficulties encountered in VM studies, and they are presented in the following paragraphs.

4.2.1 Satisfaction With VM Studies Implementation

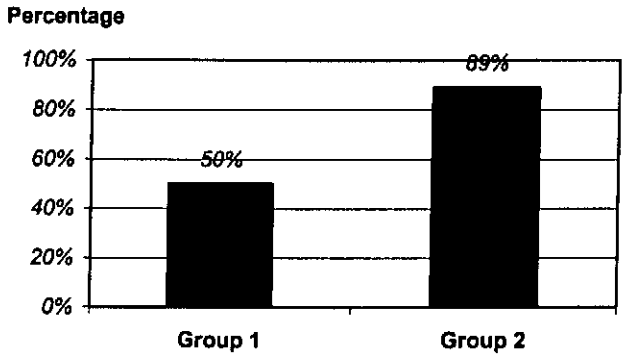

Figure 4.2: Satisfaction With VM Studies Implementation

Figure 4.2 shows that only 50% of members in Group 1 are fully satisfied VM studies implementation. It is inconsistent with the findings of Group 2, in which over 80% of members are fully satisfied. This discrepancy may be caused by the limited experience of members in Group 2, who have only completed one satisfactory VM workshop in training. It is concluded that the implementation of VM studies is only fairly satisfactory in Hong Kong's construction industry.

4.2.2 Frequency of Difficulties Encountered in VM Studies

The second part of the questionnaire is designed to investigate the frequency of difficulties encountered in VM studies. A total of 15 possible difficulties, covering the phases of

information, analysis, creativity, evaluation, and development, are suggested in the questionnaire, and a summary of the difficulties is given below:

Table 4.3: Suggested Difficulties in VM Studies

Phase	Difficulties
Information Phase	1. Difficult to collect instant internal or external data
	2. Difficult to share or disseminate information in briefings
Analysis Phase	3. Not all group members actively participate in the discussion and some may be reluctant to speak out
	4. Lack of interaction in group discussion
Creative Phase	5. Lack of ideas or alternatives
	6. Difficult to illustrate an new idea or concept
	7. A few members may dominate the discussion
	8. Conflicts raised in discussion due to personal issues
Evaluation Phase	9. Difficult to conduct analysis on suggestions from members
	10. Difficult to proceed with the evaluation process
	11. Difficult to proceed with the voting process
	12. Difficult to present the results of evaluation
Development Phase	13. Difficult to record the minutes of meetings
Overall	14. Failure to stick with the meeting plan or agenda
	15. Failure in time management

In reference to the scoring system described in section 4.1, the options of "always", "frequently", "sometimes", "seldom", and "never" are represented by the scores of 5, 4, 3, 2, and 1 respectively. The total scores of each difficulty are consolidated to produce an average score, where a higher score means a higher frequency of occurrence. The scores of the 15 possible difficulties given by the members of Groups 1 and 2 are listed in the following table.

Table 4.4: The Frequency of Difficulties Encountered in VM Studies

		Group 1	Group 2	Average
1	Difficult to collect instant internal or external data	4.20	4.07	4.14
2	Difficult to share or disseminate information in briefings	3.40	3.82	3.61
3	Not all group members actively participate in the discussion and some may be reluctant to speak out	3.60	3.69	3.65
4	Lack of interaction in group discussion	3.20	3.13	3.17
5	Lack of ideas or alternatives	3.00	3.25	3.13
6	Difficult to illustrate a new idea or concept	2.60	3.50	3.05
7	A few members may dominate the discussion	3.40	3.75	3.58
8	Conflicts raised in discussion due to personal issues	3.40	3.19	3.30
9	Difficult to conduct analysis on suggestions from members	4.20	3.88	4.04
10	Difficult to proceed with the evaluation process	3.80	3.75	3.78
11	Difficult to proceed with the voting process	3.40	3.00	3.20
12	Difficult to present the results of evaluation	3.40	3.19	3.30
13	Difficult to record the minutes of meetings	3.00	3.13	3.07
14	Failure to stick with the meeting plan or agenda	2.80	3.63	3.22
15	Failure in time management	3.20	3.94	3.57

5: always; 4: frequently; 3: sometimes; 2: seldom; 1: never

As shown in Table 4.4, the average scores are ranged from 4.14 (frequently) to 3.05 (sometimes), which reveal that the frequency of difficulties encountered in VM studies is relatively high in Hong Kong's construction industry. Based on the findings from section 4.2.1 and 4.2.2, it is concluded that the implementation of VM studies has not been optimised and there is a strong demand for improvements to the practice, so as to maximise the benefits gained.

4.2.3 The Top Five Difficulties

In order to identify the most frequently encountered difficulties in VM studies, the difficulties in Table 4.4 are ranked in descending order according to their scores. The top five difficulties are demonstrated in the following table, where "1" means the most frequently encountered.

Table 4.5: The Top Five Frequently Encountered Difficulties in VM Studies

	Ranking		
	Group 1	**Group 2**	**Overall**
Difficult to collect instant internal or external data	1	1	1
Difficult to conduct analysis on suggestions from members	1	3	2
Difficult to proceed with the evaluation process	3	5	3
Not all group members actively participate in the discussion and some may be reluctant to speak out	4		4
Difficult to share or disseminate information in briefings	5	4	5
Failure in time management		2	6

Table 4.5 shows that the top five difficulties reported by the Groups 1 and 2 are quite similar that four out five are in common. This result shows that both experienced and less experienced users have encountered similar difficulties and therefore, the experience with VM would not be considered as a major reason for these difficulties. In order to investigate them in details, a series of focus group meetings and follow-up interviews have been conducted and the findings will be presented in the next section.

4.3 The Most Frequently Encountered Difficulties in VM Studies

The top five most frequently encountered difficulties in VM studies have been summarised into three major areas, which include (i) lack of information, (ii) lack of participation and interaction, and (iii) difficulty in conducting evaluation and analysis. These are presented in the Table 4.6, and a detailed discussion is given below.

Table 4.6: Summary of Difficulties Encountered in VM Studies

Problem	Reason	Impact
1. Lack of information	Project information is poorly coordinated in the pre-study phase The difficulty of retrieving project information in VM workshops	Increases the "uncertainty" in evaluation
2. Lack of participation and interaction	Shy of public speaking Domination Poor team spirit Conformance pressure	Members' contributions of are reduced
3. Difficulty in conducting evaluation and analysis	Insufficient time to complete analysis Insufficient information to support analysis	Members are unable to response the type of "what if" question

4.3.1 Lack of Information

Research findings show that lack of information is ranked as the most frequently encountered difficulty in VM studies. It in line with the work conducted by Park (1993), who suggested that insufficient information is a key problem in VM studies. Some reasons are suggested below.

Project Information is Poorly Coordinated in the Pre-study Phase

Respondents suggested that all project information should be gathered to produce a completed data file in the pre-study phase but this process is not well coordinated in the

construction industry. As described in Table 2.3, the duration of studies has been shortened from 8-24 hours to 4-16 hours in Hong Kong. They suggested that it is costly to arrange for 20-30 stakeholders to work together in meetings. Many clients are trying to shorten the duration of VM studies and thus, one–day workshop (8 hours) seems to be most popular in the construction industry. As a result, facilitators have difficulty in arranging any pre-meeting workshops to coordinate the information exchange and gathering and therefore, project information is reported to be poor distributed and circulated in VM studies. In a worst case scenario, participants can only receive the project information paper, which is a set of documents describing the study, one day before the workshop. In addition, stakeholders from various departments or organisations are invited to join the study teams and they must learn project information prior to the studies. Consequently, they do not have sufficient time to study the paper and prepare the relevant materials and hence, function analysis could not be started quickly at the beginning of workshops.

The Difficulty of Retrieving Project Information in VM Workshops

Respondents also reported that the direction of creative thinking is unpredictable, and therefore, it is difficult for them to ensure that all relevant project information is ready in workshops. Moreover, conference room is a semi-closed environment and the physical boundary has prohibited them to retrieve any new information during workshops.

As a result, respondents are lack of project information in VM studies. They often make assumptions and put "unanswerable questions" into an action plan. This will delay subsequent tasks and increase "uncertainty" in the evaluation phase.

4.3.2 Lack of Participation and Interaction

The VM process is centred upon a participatory workshop involving a multi-disciplinary, representative group of people working together to seek the best value solution for a particular situation and thus, the contributions and involvement of stakeholders are important to the success of VM studies (AS/ NZS 4183: 1994 and Reichling, 1995). However, lack of participation and interaction were ranked as one of the most frequently encountered difficulties in the survey. Respondents suggested that the problem is very common in VM studies, and some reasons are given below:

Shy of Public Speaking

Due to their personality, some members are shy of public speaking, and are therefore reluctant to speak out in VM workshops.

Domination

The duration of the VM workshop is very short, so any domination of the discussion would result in an uneven chance for each member to participate. Respondents pointed out that the problem of domination is commonly found in VM studies because of the conflicting objectives or interests of the participants. A few active members may tend to dominate the discussion and prevent others from participating in the process. As a result, this lowers the participation and interaction of members in VM studies.

Poor Team Spirit

The VM team is a temporary formal group. Members come from different disciplines and organisations and hence, they need extra time to develop trust and good relationships so as to integrate in VM studies as a team. However, the short duration of VM studies imposes

difficulty in team building, and some of them may therefore lack a sense of belonging and not fully contribute to the studies. As a result, "free-riding" may occur in VM workshops.

Conformance Pressure

Conformance pressure from senior members may prohibit the interaction and participation of junior members in VM studies. The members of the VM team come from different levels, including senior executives, middle managers, and workers. Hence, there is a possibility that senior members may exert pressure on junior members intentionally or unintentionally in VM studies. For example, junior members may be afraid to criticise bad ideas from senior members because of the traditional culture and social status. As a result, some junior members become inactive and remain silent in VM workshops.

Regarding this problem, facilitators apply various techniques to promote active participation in VM workshops. For example, they make use of "role-playing" to motivate the junior members in VM workshops. However, the factors described above are believed to prohibit members' participation and interaction to a large extent in VM studies.

4.3.3 Difficulty in Conducting Evaluation and Analysis

The difficulty in conducting data analysis is also ranked as one of the most frequently encountered difficulties in VM studies. The reasons are listed below:

Insufficient Time to Complete Analysis

Respondents suggested that the ideas produced in the creative phase require extensive consultation and in-depth investigation to analyse their feasibility and potential benefits, but that they have insufficient time to complete the analysis in VM workshops. Norton and

McElligott (1995) suggest that the analysis activities, such as backup calculation and cost analysis, are time-consuming and might take over half of the time of a VM workshop. In addition, the problem of time constraints is believed to be more serious in Hong Kong than in America and Australia. Shen (1997b) suggests that the duration of VM workshops is very short and some sessions are used to educate participants who are unfamiliar with VM processes. As a result, it is difficult to complete all the necessary analysis within VM workshops in Hong Kong's construction industry.

Insufficient Information to Support Analysis

Besides the problem of insufficient time, respondents also suggested that they had insufficient information to support the analysis in VM studies, which has been discussed in previous section.

For these reasons, members cannot conduct the evaluation and analysis processes efficiently in VM workshops, and sometimes they are unable to respond to the "what if" type of question very quickly. This may delay the progress of the evaluation and development phases in VM studies.

4.4 Summary and Conclusion

In this chapter, the difficulties of implementing VM studies in Hong Kong's construction industry are investigated and a shortlist of the most frequently encountered difficulties in VM studies has been identified. The research findings suggest that 50% of VM users are not quite satisfied with the practice of VM studies in the construction industry. The difficulties of (i) lack of information, (ii) lack of participation, and (iii) difficulty in conducting the analysis are reported to be the major factors, which lowers the efficiency and effectiveness of VM studies in the research. As a result, it is strongly believed that the performance of VM studies improves if these difficulties can be identified and removed.

5 POTENTIAL OF APPLYING GDSS TO IMPROVE VM STUDIES

In Chapter 4, an investigation of the difficulties of implementing VM studies in the construction industry is described. The research findings show that lack of information, lack of participation and interaction, and difficulty in conducting evaluation and analysis are the most frequently encountered difficulties in VM studies. This chapter aims to investigate the potential for applying GDSS to improve VM studies and it is divided into two main sections: (i) to explore how GDSS can contribute to improve VM studies; and (ii) to study how it can implemented in practice. A framework of three-dimensional GDSS support for VM studies is suggested in order to illustrate how GDSS functions can be used to improve VM studies and what are their benefits.

5.1 How GDSS Can Contribute to VM Studies?

GDSS consists of three technologies including (i) communication technologies, (ii) computing technologies and (iii) decision technologies, which have been described in section 3.1.1. This section briefly introduces how these technologies can contribute to VM studies respectively. A framework of GDSS contributions to VM studies is suggested in the following figure and their details will be discussed more fully in the next section.

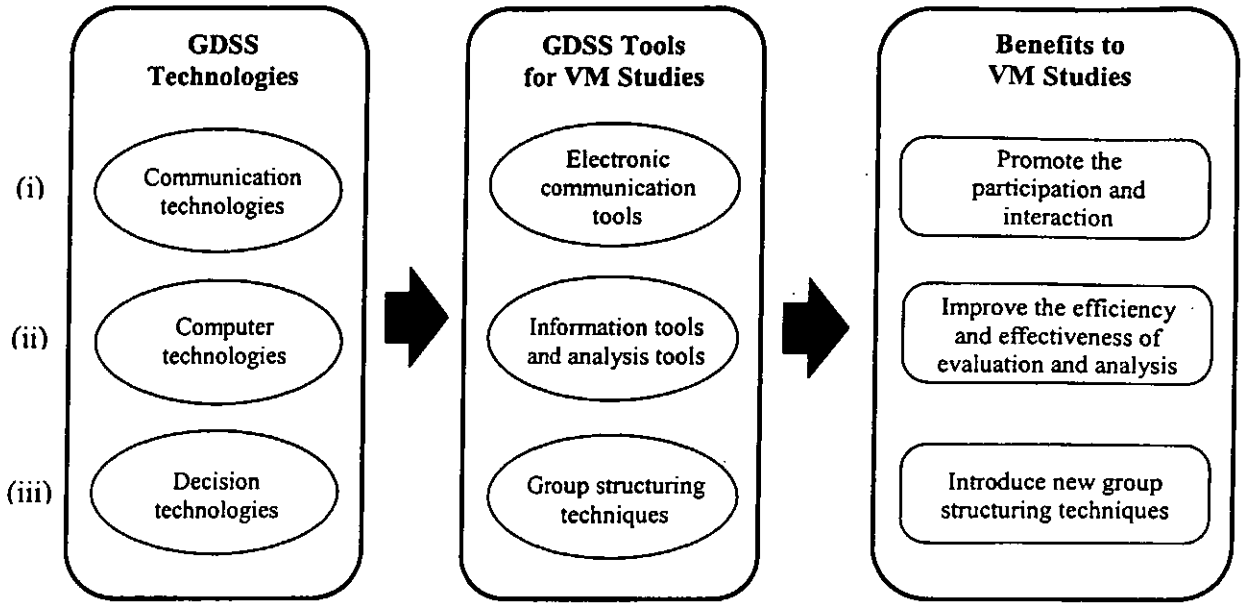

Figure 5.1: GDSS Contributions to VM Studies

5.1.1 Communication Technologies

Communication technologies aim to promote human dynamics through controlling prohibitive factors in face-to-face meetings. As described in section 4.3.2, the obstacles including shy of public speaking, domination, and conformance pressure have inhibited the participation and interaction of members, which results in "lack of participation" and interaction in workshops. In order to avoid these, electronic communication tools can be applied to create a pressure-free environment and thus, to promote the participation and interaction in VM studies

5.1.2 Computer Technologies

Computer technologies include data exchange, storage, management, and analysis facilities. Information tools can be applied to facilitate the processes of information retrieval and storage in VM studies and thus, to overcome the problem of "lack of information" described in section 4.3.1. Moreover, analysis tools can also be applied to resolve the problem of "difficulty in conducting the evaluation and analysis" described in section 4.3.3. The analysis

tools standardise and computerise the evaluation and analysis processes so as to improve their accuracy and productivity in VM studies.

5.1.3 Decision Technologies

Decision Technologies include (i) decision-modeling methods (such as decision trees and risk analysis), (ii) structured group methods (such as the Nominal Group and Delphi techniques), and (iii) rules for directing group discussion. With the creative use of communication and computer technologies, these technologies enable facilitators to introduce those group structuring techniques, which are difficult to be implemented in ordinary VM studies.

5.2 How GDSS Technologies Can Be Used to Improve VM Studies?

The communication technologies, computer technologies, and decision technologies of GDSS will be further elaborated and developed into a set of GDSS functions in this section. It is suggested that these technologies can be integrated and applied to VM studies in different areas and a framework of three-dimensional GDSS support for VM studies is suggested as follows.

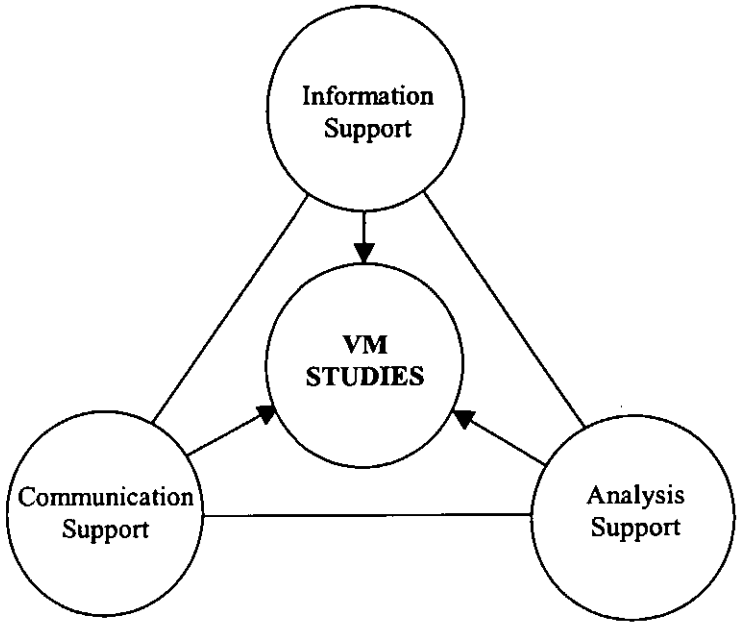

Figure 5.2: Three-dimensional GDSS Support for VM Studies

Fig. 5.2 shows that GDSS can contribute to providing (i) information support, (ii) communication support, and (iii) analysis support for improving VM studies. These types of support can either work alone to improve a particular task, or closely together to improve a particular process (a group of tasks) in VM studies. DeSanctis and Galluple (1987) suggested that there are four GDSS environments but the following discussion is mainly focusing on the decision room, which is designed to support a small group of participants who are staying in a single physical location.

5.2.1 Information Support

The information support of GDSS mainly applies electronic information tools to facilitate information management in VM studies and provides the following functions for VM studies.

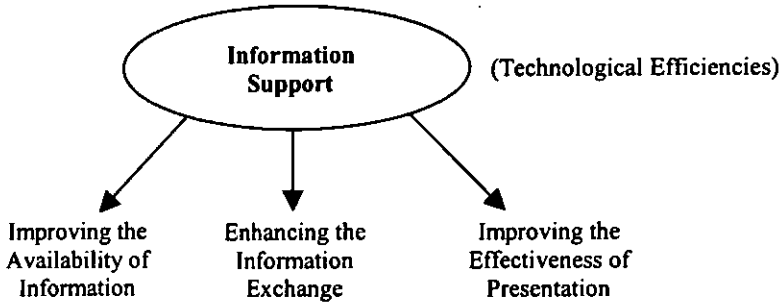

Figure 5.3: Information Support for VM Studies

GDSS Improves the Availability of Information

The information retrieval tools of GDSS can be applied to improve the availability of information and resolve the difficulty of retrieving project information described in section 4.3.1. The computer network of GDSS breaks the physical boundaries of conference rooms and allows members to access external information during workshops. This enables members to collect public information such as government news and official indexes easily through the Internet. Moreover, they can remote access corporate information such as annual reports and project drawings, through an Intranet. In advance, they can also remote access the private information stored in their desktop computers at their offices through a telnet or dial-up connection. The application of GDSS has improved the availability of information and provided additional information sources to enhance the information support for VM studies.

GDSS Enhances the Information Exchange

The data exchange and storage tools of GDSS can be applied to enhance the information exchange process and overcome the problem of poorly coordinated project information described in section 4.3.1. These tools can be used to develop an electronic project information center so as to computerise the processes of information gathering, distribution, and circulation in VM studies. The information center acts as an "electronic messenger", which delivers the project information to VM team members in the pre-study phase through the Internet. It is suggested that the information center should start working two weeks before the workshops. An operation schedule is presented as follows.

Table 5.1: Two-week Schedule for the Electronic Project Information Center

Stage		Time	Person	Activity
1	Information Collection	Day 1	Technician	Set up the server
		Day 2	Facilitator	Design the structure of filing system
		Day 3-4	Members	Upload project information to the server
2	Information Review	Day 5	Facilitator	Review the draft of information package
		Day 6	Members	Upload additional information upon request
		Day 7	Facilitator	Finalise the information package
3	Information Distribution	Day 8	Members	Download project information from the server
		Day 8-14	Facilitator	Revise the information throughout the study

At the information collection stage, a technician assists the facilitator to set up an FTP server at the client's office. The facilitator designs the structure of the filing system, which aims to provide guidelines for members to upload the project information to the server systematically. For example, geotechnical reports should be put into the site investigation folder. At the information review stage, the draft of information package is completed. The facilitator reviews the package and invites members to upload additional information if necessary. At the information distribution stage, the information package is completed and members can download the project information from the server through the Internet. This schedule is only

an example, which illustrates how the electronic project information center can be implemented in a VM study. It should be subject to modification in order to accommodate different VM studies.

The electronic project information center simplifies the information exchange process through computerisation. It allows the method of "point-to-group" communication and therefore, members can simply upload project information to the server. The information will be distributed automatically to all members through the Internet. Moreover, the information center also shortens the time of information distribution. The use of electronic communication enables the real-time transfer of project information and therefore, members can always receive the most up-to-date project information in the pre-study phase. It also enhances the information circulation process by sharing project information on the Internet.

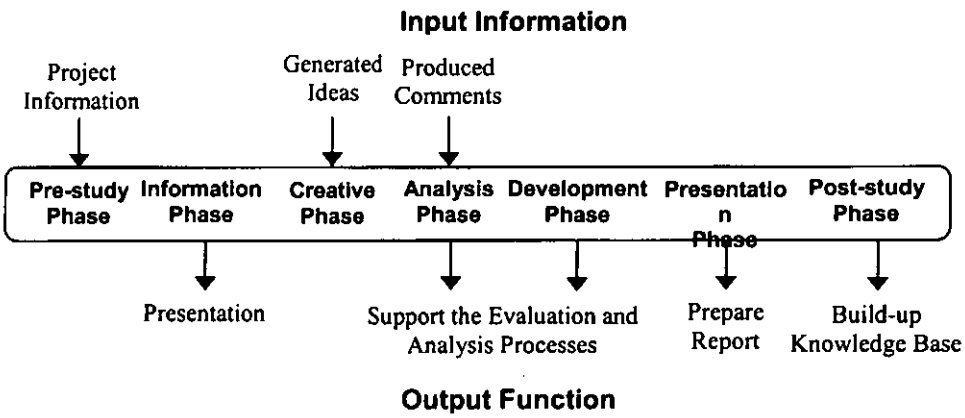

Figure 5.4: Information Flow in the Electronic Project Information Center

The information center stores all information in a physical location and improves the consistency of information in VM studies. Figure 5.4 shows that the information center acts as a project hosting system to keep track of all information in VM studies. Besides the information uploaded during the pre-study phase, it also records the data produced in

meetings including generated ideas and comments, and voting results. The information center aims to store all information in a physical location in order to facilitate information management. It improves the consistency of information and promotes a standard understanding in VM studies. In addition, the information center also facilitates knowledge acquisition and provides a full record to support VM studies.

GDSS Improves the Effectiveness of Presentation

The electronic project information center supports the use of multi-media applications and enables facilitators to apply multi-media presentations in VM studies. For example, an MPEG movie can be used to present the site location and environment, which are difficult to be described by text. The application of GDSS enriches the media richness and enhances the effectiveness of presentation in the information phase.

To sum up, GDSS can be applied to resolve the problem of lack of information in VM studies and the advantages of information support are summarised in the following table.

Table 5.2: Summary of Information Support

	Addressed Difficulty	GDSS Function	Description
1	The project information is poorly coordinated in the pre-study phase	Improving the availability of information	Connection to the Internet can improve the availability of information in workshops
2	The difficulty of retrieving information in workshops	Enhancing the information exchange	Electronic file transfer can simplify the information exchange process and shorten the time required in the pre-study phase Sharing the information on the Internet can enhance the information circulation The centralised information storage can improve the consistency of information
3	-	Improving the effectiveness of presentation	The use of graphics, photos, and video can increase the media richness of presentation

5.2.2 Communication Support

The communication support applies electronic communication tools to improve the effectiveness of discussion in workshops and enhances the communication between members in the pre-study and post-study phases. The functions of communication support are divided into types of interaction advantages and technological efficiencies and they are summarised in the following figure.

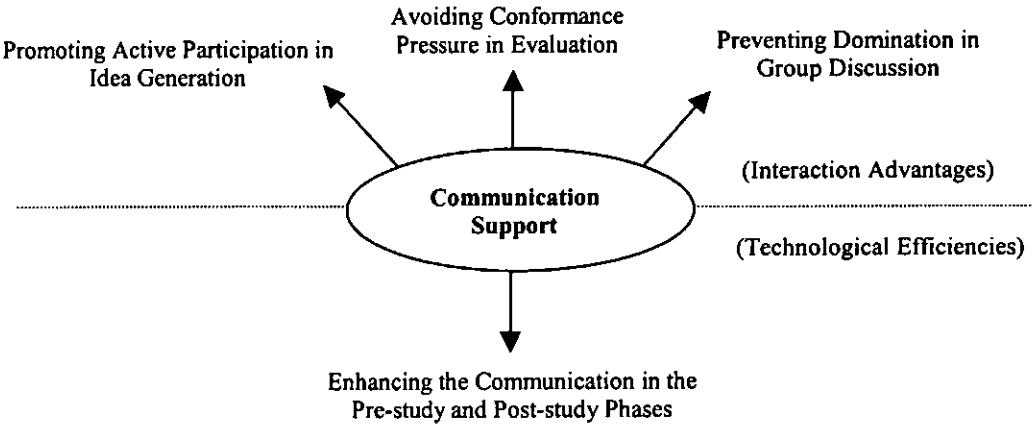

Figure 5.5: Communication Support for VM Studies

GDSS Promotes Active Participation in Idea Generation

Anonymous communication is one of the key features of GDSS. It can be applied to promote active participation and overcome the problem of shy of public speaking described in section 4.3.2. Some members are reluctant to speak out because they are shy of speaking in public or afraid of sounding stupid in the idea generation process. In order to encourage them, anonymous communication can be applied to improve the idea generation process. A "two-stage brainstorming technique" is suggested as follows:

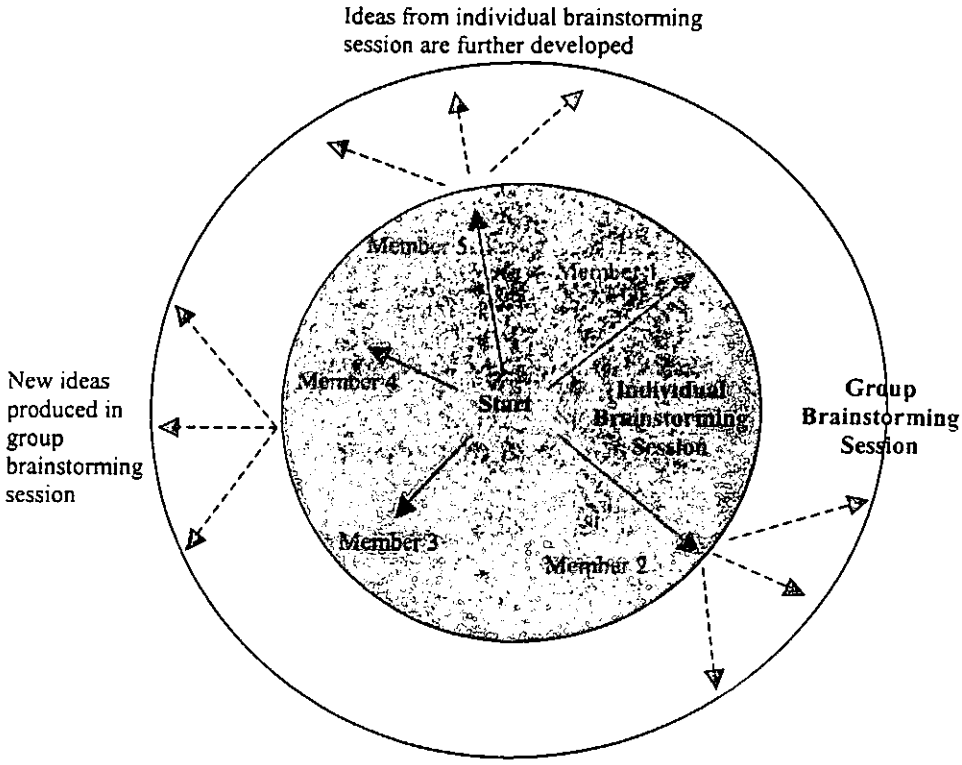

Figure 5.6: Two-stage Brainstorming Technique

The two-stage brainstorming technique divides the idea generation process into two sessions including (i) an individual brainstorming session (inner circle) and (ii) a group brainstorming session (outer circle). Anonymous discussion creates a pressure-free environment to promote active participation in the individual brainstorming session. The electronic brainstorming tools of GDSS allow members to key in ideas through workstations and the ideas would appear on a public screen simultaneously. GDSS enables all members to remain anonymous and it encourages members who are afraid of public speaking to speak out in the idea generation process. It would also promote independent brainstorming to diversify the directions of thinking at the beginning of idea generation. Facilitators would present the ideas from the individual brainstorming session and invite additional ideas in the group brainstorming session.

Face-to-face communication, which is essential in human interaction, is important in VM studies. However, there are many problems including domination and conformance pressure reported in this communication. The two-stage electronic brainstorming method aims to apply electronic communication to overcome the limitations of face-to-face communication in the idea generation process. It integrates the face-to-face communication with the electronic communication and, provides a balanced solution to grip their benefits. In short, GDSS would apply electronic to supplement face-to-face communication in VM studies and thus, human interaction is promoted. This method can effectively promote active participation without losing human interaction. In addition, the electronic brainstorming tools also streamline the idea generation process and enable members, who are located in remote locations, to participate in the process electronically. This would bring in more expertise into idea generation and thus, the application of GDSS would result in producing more feasible ideas in the idea generation process.

GDSS Avoids Conformance Pressure in Evaluation

Anonymous communication can be applied to promote interaction and overcome the problem of conformance pressure described in section 4.3.2. The survey findings suggested that the members from senior levels might intentionally or unintentionally exert conformance pressure on junior members in VM studies. The pressure would prohibit the interaction of junior members and result in groupthink in discussion. The electronic communication tools of GDSS create an impersonal environment in order to avoid the conformance pressure in discussion. It is suggested that the evaluation process be divided into two sessions, which are similar to the two-stage brainstorming technique. The first session is designed to collect comments from individual members anonymously through electronic communication tools. Facilitators would present the collected comments and invite additional comments in the

second session. Anonymous discussion encourages members to judge the ideas solely based on the merits of ideas rather than considering any social factors. As a result, members would not fear criticising the ideas of powerful players and therefore, discussion would become more vigorous and more issue-oriented in VM studies.

GDSS Prevents Domination in Discussion

The parallel communication of GDSS can be applied to promote the chance to participate and resolve the problem of domination described in section 4.3.2. Due to conflicting objectives, a few active members may dominate the discussion and prevent the opportunities for other members to express their comments in traditional meetings. For example, Figure 5.7 shows that member 1 has occupied a large portion of airtime in a meeting.

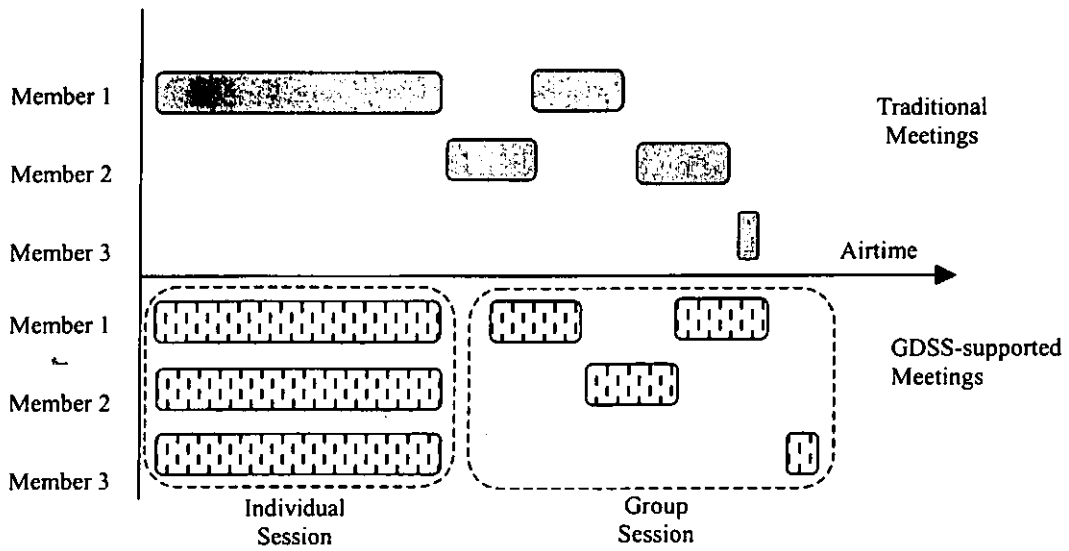

Figure 5.7: Parallel Communication in the Evaluation

As shown in Figure 5.7, the electronic communication tools of GDSS including chat room or electronic forum allow a group of people to communicate simultaneously. Some of the participants may have better keyboard skills and they would produce more ideas and comments in the discussion. However, this would not result in domination because they do

not have power over other users or prohibit others to participate the discussion under the electronic communication. As a result, all members can freely contribute their ideas or comments and an equal opportunity of participation is maintained in the individual session. Moreover, the parallel communication also increases the total available airtime in discussion and hence, more ideas and comments can be produced in VM studies.

GDSS Enhances Communication in the Pre-study and Post-study Phases

The VM team is a temporary working group. Members come from different disciplines and organisations and hence, they need extra time to develop trust and good relationships so as to integrate in VM studies as a team. In order to enhance the communication and collaboration between members, the information and communication tools of GDSS can be used to develop a "virtual pre-workshop" in VM studies. The workshop is an Internet website, which provides the tools of electronic bulletin board and forum to improve the communication between facilitators and members. It enables members to work as a team and to develop a closed relationship before workshops. They are able to work easily together at any time and any place through the Internet before workshops. Moreover, the workshop also provides an online presentation to provide briefing in the pre-study phase. It can improve members' understanding about the study before attending workshops and shorten the information phase.

To sum up, GDSS can be applied to resolve the problem of lack of participation and interaction in VM studies. The advantages of communication support are summarised in the following table.

Table 5.3: Summary of Communication Support

	Addressed Difficulty	GDSS Function	Description
1	Shy of Public Speaking	Promote active participation in idea generation	Anonymous communication can create a pressure-free environment to promote active participation The use of electronic brainstorming would result in producing more ideas
2	Conformance Pressure	Avoid conformance pressure in evaluation	Anonymous discussion can avoid the conformance pressure from senior members in producing comments
3	Domination	Prevent domination in discussion	Parallel communication can promote the equity of chance to participate The use of electronic communication would result in producing more comments
4	Poor Team Spirit	Enhance communication in the pre-study and post-study phases	Electronic bulletin board can improve the communication between facilitators and members Electronic forum can improve the communication between members Online presentation can improve members' understanding about the study before attending workshops Online presentation can shorten the information phase

5.2.3 Analysis Support

The analysis support of GDSS applies electronic analysis tools to improve the efficiency and effectiveness of evaluation and analysis in VM studies. It provides the following functions to improve VM studies:

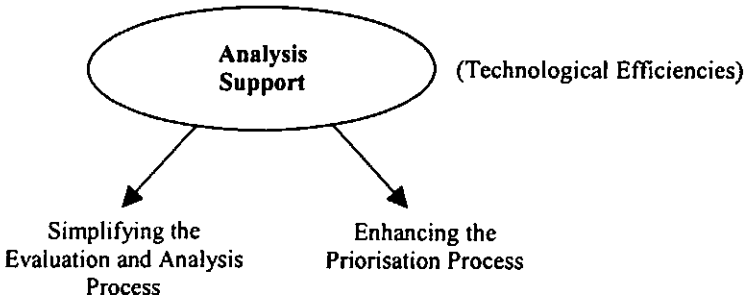

Figure 5.8: Analysis Support for VM Studies

GDSS Simplifies the Evaluation and Analysis Processes

The electronic analysis tools of GDSS can be applied to simplify the evaluation and analysis process and resolve the problems of insufficient time to complete analysis described in section 4.3.3. The modeling tools of GDSS, such as the life cycle cost model and the multi-criteria evaluation model, provide analysis frameworks to standardise the evaluation and analysis processes. Members can simply input data into the models and results would be generated automatically. Besides, some commonly used software, such as Microsoft Excel and Access, can also be used as analysis tools in VM studies. This software enables members to modify the data in prepared tables so as to anticipate the results of different scenarios in workshops. Members can vary the input data and the general pattern or the impact of different solutions can be produced quickly. These analysis tools improve the productivity of evaluation and data analysis processes, and facilitate members to respond easily to the type of "what if" questions in workshops

GDSS Enhances the Prioritisation Process

The Prioritisation tools of GDSS can be applied to enhance the efficiency and effectiveness of voting in VM studies. The rating tools, such as the voting tool, idea categorisation tool, and weighting evaluation tool, simplify and shorten the required time for voting. Moreover, anonymous voting avoids the conformance pressure in voting and therefore, the quality of voting is improved.

To sum up, GDSS can be applied to resolve the difficulty in conducting evaluation and analysis in VM studies. The advantages of analysis support are summarised in the following table.

Table 5.4: Summary of Analysis Support

	Addressed Difficulty	GDSS Function	Description
1	Insufficient time to complete analysis	Simplify the evaluation and analysis processes	The provision of commonly used software can simplify the analysis process and assist members to address the type of "what if" questions easily in workshops
		Enhance the priorisation process	Electronic voting can simplify and shorten the required time required for voting
			Anonymous voting can avoid the conformance pressure in voting

5.3 Summary and Conclusion

This chapter introduces how GDSS technologies can be integrated with VM methodology and a framework of three-dimensional GDSS support is developed. The framework suggests that GDSS is contributed to provide (i) information support, (ii) communication support, and (iii) analysis support for VM studies and achieves the following functions.

- Improve the availability of information
- Enhance the information exchange process
- Improve the effectiveness of presentation
- Promote active participation in idea generation
- Avoid conformance pressure in evaluation
- Prevent domination in discussion
- Enhance communication in the pre-study and post-study phases
- Simplify the evaluation and analysis processes
- Enhance the prioritisation process

6 DESIGN OF THE INTERACTIVE VALUE MANAGEMENT SYSTEM

A GDSS prototype system, called the Interactive Value Management System (IVMS), has been developed to assist the validation of the GDSS functions and the details of validation will be described in the next chapter. It is a demonstration system, which illustrates how the GDSS functions suggested in chapter five can be implemented in a VM study. This chapter introduces the IVMS and demonstrates how it can be used to improve the implementation of VM studies.

6.1 Introduction to the IVMS

The IVMS is a specific GDSS system designed to improve VM studies, particularly in Hong Kong's construction industry, and it aims to achieve the following objectives:

- Improve collaboration between members
- Facilitate information management
- Promote exchange of ideas, opinions and preferences
- Improve the productivity and accuracy of data analysis

6.1.1 System Characteristics

The GDSS characteristics suggested by DeSanctis and Gallupe (1987) have been implemented in the IVMS. In addition, a series of interviews with VM practitioners had been conducted to improve the system specification and the following system characteristics have been built into the system.

Multi-platforms Design

The IVMS is an Internet-based application, which software is essentially installed and operated on a server. The use of HTML and JAVA languages enable the IVMS to run on multi-platforms including Windows 95 and 98, Windows 2000, and Mac OS. This design enables users to access the IVMS at any machine, anytime, and anywhere throughout studies.

Portable Design

The IVMS is essentially operated in a server and thus, no installation is required in workstations. Members can bring along their laptop computers and use them as workstation in workshops. This portable design not only reduces the installation cost of workstations, but also enhances the system mobility in order to accommodate the ordinary design of conference rooms in the construction industry.

User-friendly Design

The web interface of the IVMS is simple, consistent, and easy to use. This user-friendly design facilitates the users with varying levels of computer knowledge in using it. In addition, technical assistance will be given all users. What they have to do is to key in their preferences and ideas, and then technicians could complete the remaining part for them in workshops. And therefore, the IVMS still could be applied to VM studies even through some users are not very familiar with computers.

Toolbox Design

The IVMS is designed as a set of toolboxes in order to accommodate the unique requirements of different VM studies. The toolbox design allows facilitators to choose what GDSS

functions, when and how to be used in VM studies and, therefore, to enhance the system flexibility.

Hybrid Communication Design

The IVMS is designed to incorporate both verbal and electronic communication in VM studies. For example, it divides the idea generation process into two sessions including (i) an individual brainstorming session (face-to-face communication) and (ii) a group brainstorming session (electronic communication). This aims to balance the strength and weakness of each communication and, therefore, to maximise the synergy gained in the process.

6.1.2 System Architecture

The design of the IVMS is based on the GDSS model proposed by DeSanctis and Galluple (1987). It is composite of (i) users (members and facilitators), (ii) user interface (web browser), (iii) software (IVMS), and (iv) hardware (input and output devices, databases, servers). A pictorial representative of the system architecture and a summary of the system components are demonstrated in Figure 6.1 and Table 6.1 respectively.

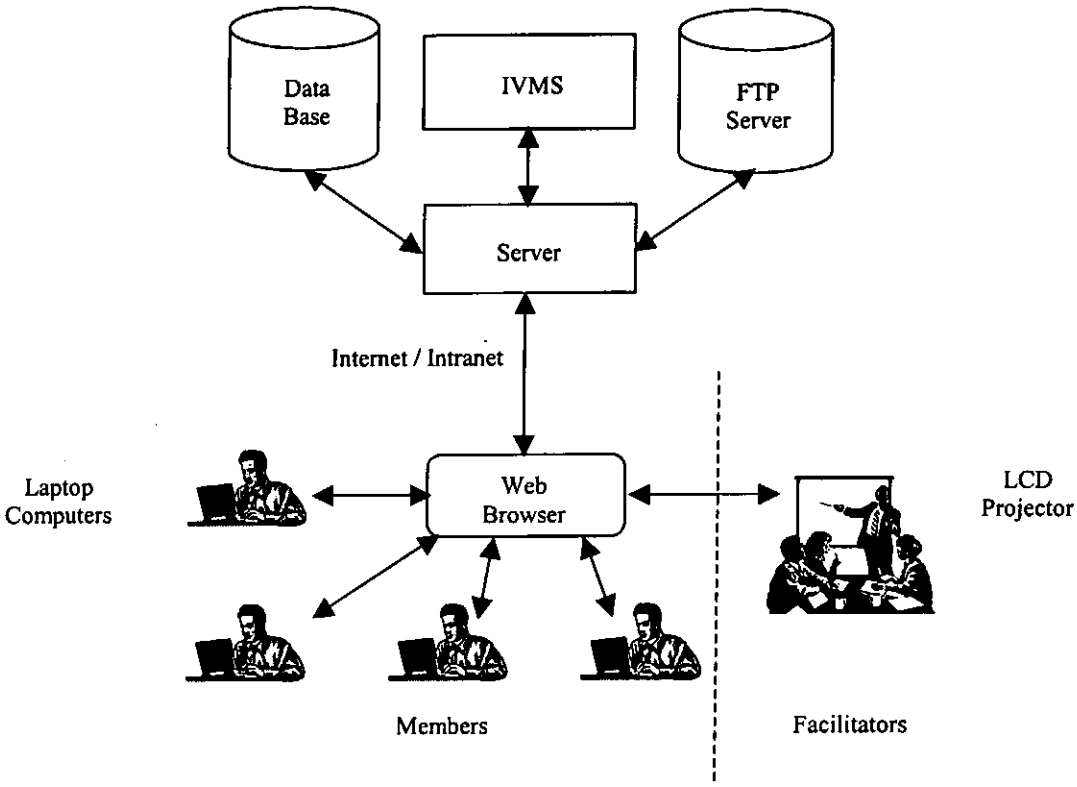

Figure 6.1: System Architecture of the IVMS

Table 6.1: Components of the IVMS

Components	Description
Members and facilitators	Users
Laptop computer	An input and output devices for users
Internet/Intranet	A connection link for laptop computers and the server
Web browser	An interface for users to operate the system
IVMS Software	A set of GDSS tools
LCD projector	A public screen for information display
Server	A processor for data calculation and coordination
FTP server	A storage device for project information uploaded in the pre-study and post-study phases
Database	A storage device for data produced in meetings

The IVMS is designed to improve VM studies and its users include both members and facilitators of VM study teams. In a GDSS-supported VM study, facilitator is responsible for the smooth operation of IVMS and he/ she has to decide what GDSS functions to be used, and when and how to use them in accordance with VM job plans. In order to share additional workload, an assistant helps him/her to operate the system by starting and stopping the software, and provides technical support to members.

Figure 6.1 shows that members and facilitator are provided with laptop computers, which are using as input and output devices in workshops. The computers are connected to a server through the Internet or Intranet, and they allow members to operate the IVMS or carry out private work, such as text editing, formatting, data file creation and modification. In addition, a LCD projector is provided so that facilitators and members can present the results of idea generation, voting, analysis, and private work on a public screen. Besides, a server, a database, and an FTP server are also included in the IVMS. The server is a computer processor and it is linked up the workstations to the database and the FTP server. These storage devices are designed to manage all project information uploaded in the pre-study phase, and record the generated ideas, collected comments, and voting results in meetings. Due to the security reason, the databases and severs can be placed in either the office of client or service provider, and maintained by assistants.

6.1.3 System Structure

The IVMS is designed as a set of toolboxes and it is comprised of four boxes including (i) a pre-workshop unit, (ii) an information unit, (iii) a communication unit, and (iv) an analysis unit. A detailed discussion of these toolboxes is given below.

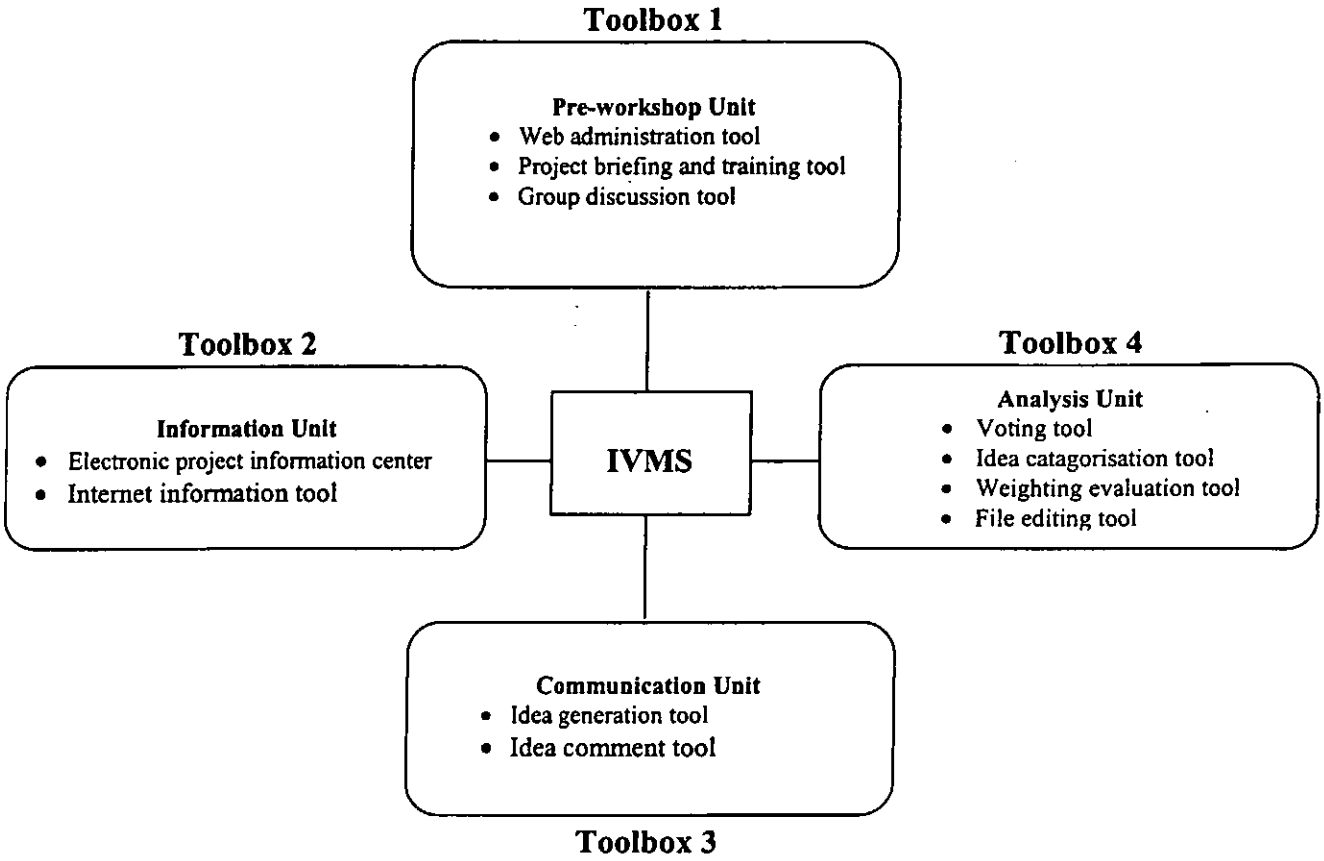

Figure 6.2: System Structure of the IVMS

The toolboxes are designed to support a group of specific tasks and, therefore, different toolboxes would be applied to different phases of VM studies. Some examples are presented as below.

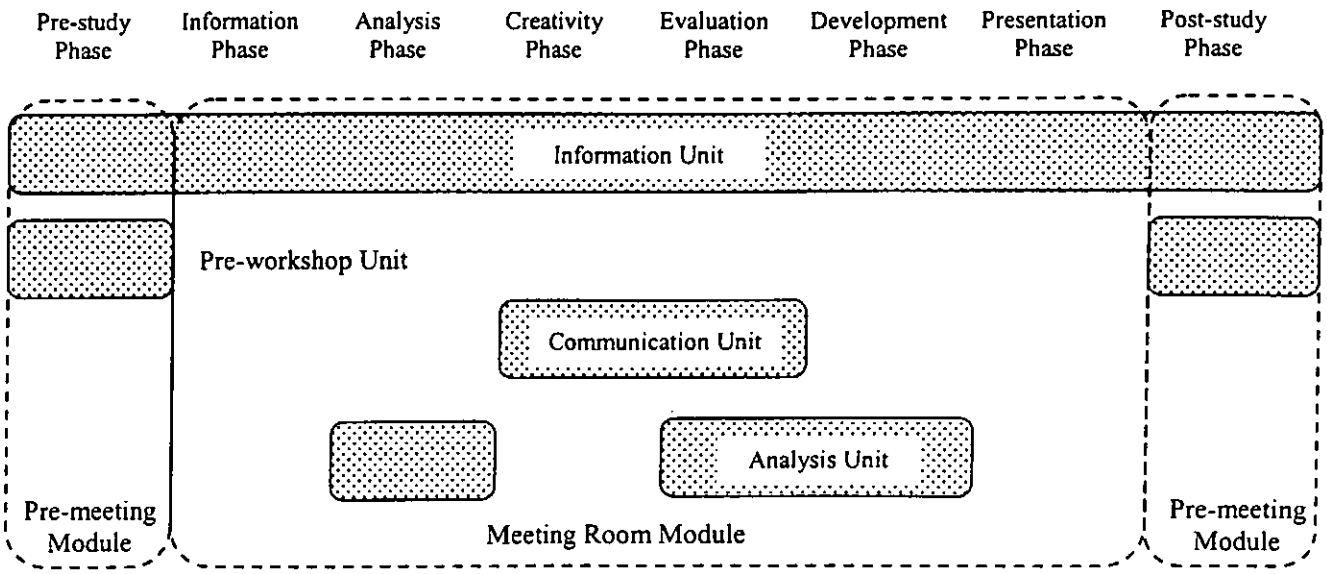

Figure 6.3: Toolboxes of the IVMS

As shown in Figure 6.3, Toolbox 1 (Pre-workshop unit) aims to improve the collaboration between team members and it mainly applied to pre-study and post-study phases. Toolbox 2 (Information unit) aims to facilitate information management throughout the studies. Toolbox 3 (Communication unit) aims to promote the exchange of ideas, opinions and preferences within groups and it is mainly applied to the creativity and evaluation phases. Toolbox 4 (Analysis unit) aims to improve the productivity and accuracy of data analysis and it is mainly applied to the analysis, evaluation and development phases.

In addition, these toolboxes are integrated into two modules including: (i) the Pre-meeting Module and (ii) the Meeting Room Module in accordance with the SAVE 40-hour job plan. The following sections provide an introduction to these modules and illustrate how they can be applied to improve VM studies.

6.2 Pre-meeting Module of the IVMS

6.2.1 Toolbox 1 (Pre-workshop Unit)

Figure 6.4: Front Page of the Pre-meeting Module

The pre-workshop unit aims to improve the collaboration between team members in the pre- and post-study phases. It enables members to work together as a team at anytime and anyplace through the Internet and, thus, better coordination and preparation work can be achieved. It comprises three tools, including (i) a web administration tool, (ii) a group discussion tool, and (iii) a project briefing and training tool.

Wed Administration Tool

The web administration tool is designed to assist facilitators in organising VM studies and they include an electronic bulletin board and an electronic calendar. Facilitators can simply post a message on the bulletin board and it will be distribute to all members though email automatically.

Figure 6.5: Electronic Bulletin Board of the Wed Administration Tool

Facilitators can also post a meeting schedule on the electronic calendar in order to ensure that all members are kept informed about the progress.

Figure 6.6: Electronic Calendar of the Wed Administration Tool

Project Briefing and Training Tool

The project briefing and training tool is designed to assist facilitators in providing online presentation in the pre-study phase. Besides the PowerPoint presentation, it also supports the use of photos and video (short MPEG movie). The tool enables facilitators to provide some pre-workshop briefing and training and, therefore, members would have a better understanding about the study before attending workshops. For example, a virtual site visit is demonstrated in Figure 6.8.

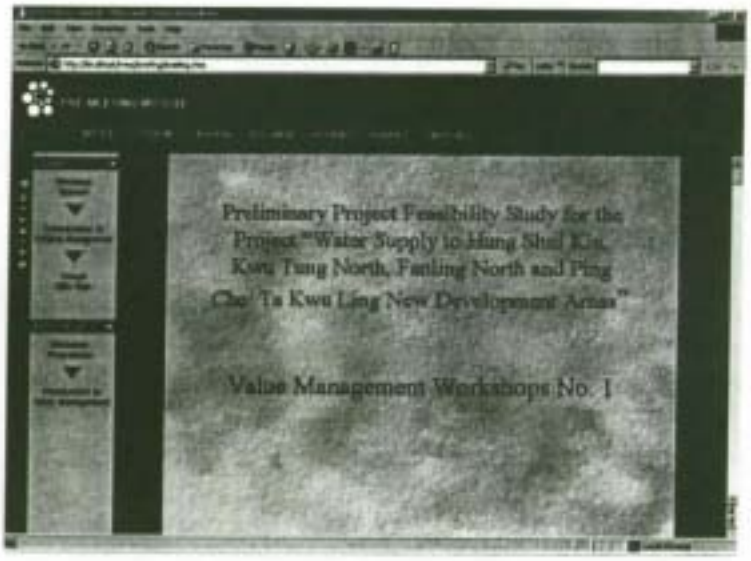

Figure 6.7: Online Presentation of the Project Briefing and Training Tool

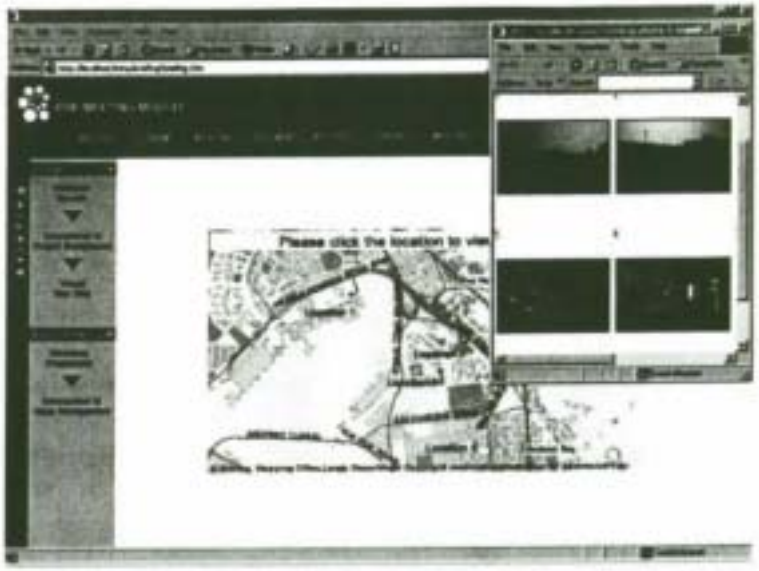

Figure 6.8: A Virtual Site Visit of the Project Briefing and Training Tool

Group Discussion Tool

Group discussion tool, which is an electronic forum, is designed to improve group communication in the pre-study phase. It facilitates members to work as a team through electronic communication. Members can raise new topics or comment on people's topics by posting messages on the forum, and the messages will also be sent to all members simultaneously.

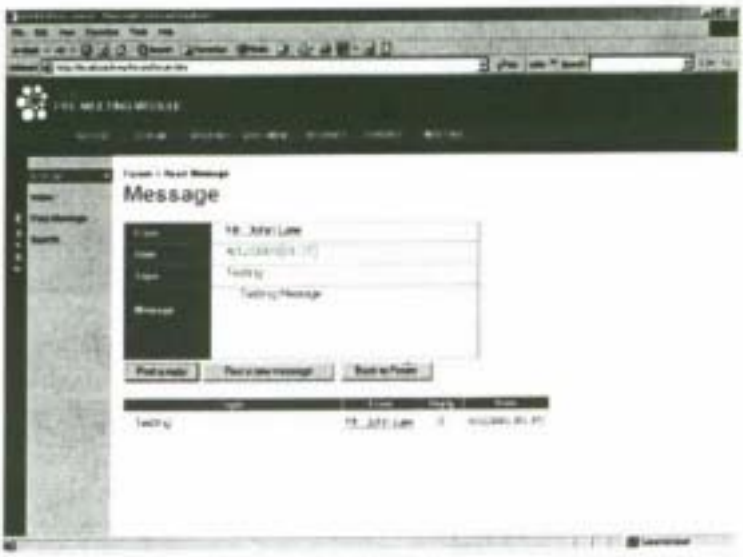

Figure 6.9: Electronic Forum of the Group Discussion Tool

6.2.2 Toolbox 2 (Information Unit)

The information unit aims to facilitate information management and improve the availability of information in VM studies. It includes an electronic project information center and a set of Internet information tools. A detailed description of these tools is given as below.

The electronic project information center is an FTP server, which allows members to store and share project information on the Internet. To achieve this, members are provided with individual folders in the server and they can simply use Internet browsers to upload project information including correspondences, reports, and drawings, to the folder. If there is any new information in the server, a notice will be automatically email to all members and so that they can log into the system to download it. Moreover, the information center keeps a full record of project information so as to facilitate knowledge acquisition in VM studies.

Figure 6.10: Electronic Project Information Center of the Information Unit

Internet Information Tool

The Internet information tool is designed to facilitate information searching on the Internet and a number of hyperlinks to search engines (HK SAR Government Information Center, Yahoo, Google), government departments (Architectural Services Department, Civil Engineering Department), and construction information providers (CIOB, HKIS) are provided. The tool allows members to access outside information in meeting and therefore, to improve the availability of information in VM studies.

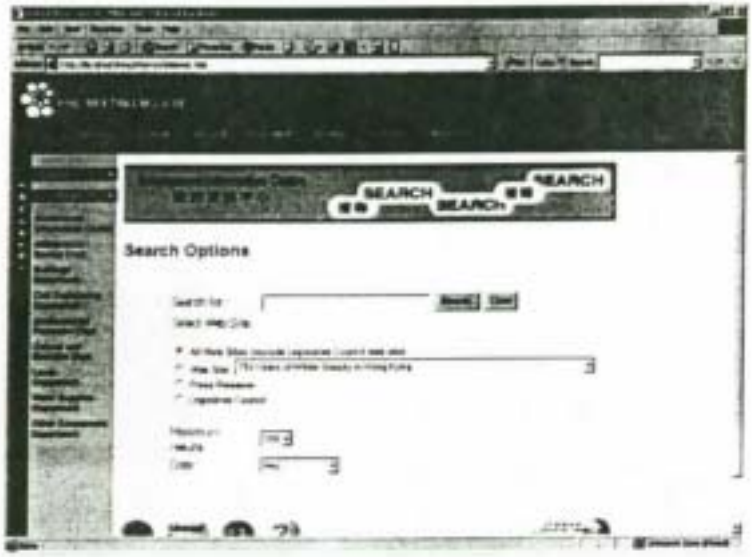

Figure 6.11: Government Information Center of the Internet Information Tool

Referring to the suggestions described in section 5.2.2, the pre-workshop unit and information unit can be integrated to form a "virtual pre-workshop". The workshop is a virtual meeting place, which enables members working together at any time and any place through electronic communication and information management tools.

6.3 Meeting Room Module of the IVMS

6.3.1 Toolbox 3 (Communication Unit)

The communication unit aims to promote the exchange of ideas, opinions and preferences within groups. Research findings show that people become freer to exchange ideas, comments and preferences in an anonymous environment. The communication unit makes use of this technique to promote participation and encourage interaction in VM studies and it is comprised of an idea generation tool and an idea comment tool, which are shown in Figure 6.12 and 6.13.

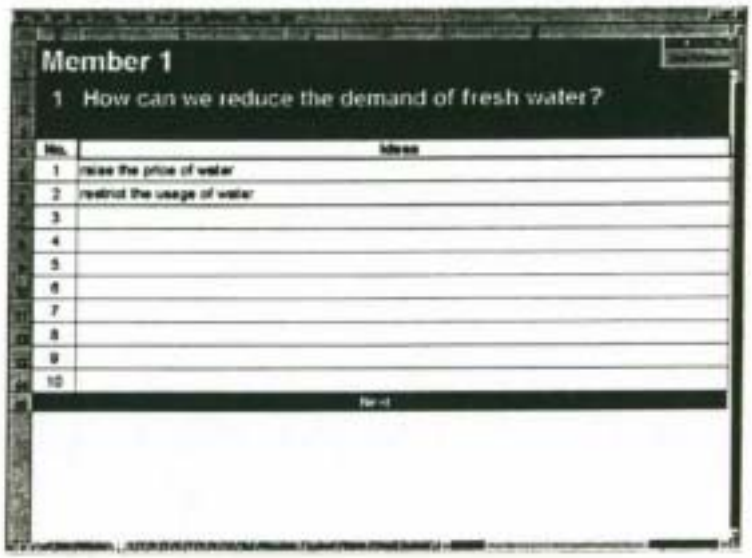

Figure 6.12: Idea Generation Tool of the Communication Unit

The idea generation tool is designed to create a pressure-free environment in the creative phase. In reference to the two-stage brainstorming method described in Figure 5.6, the idea generation tool breaks the idea generation process into two sessions: individual brainstorming session and group brainstorming session. In the first session, members are encouraged to key in ideas through workstations in accordance with a set of questions (stimulators) prepared by facilitators. The tool enables all members to remain anonymous and the ideas would display

on a public screen simultaneously. In the second session, facilitators present the collected ideas to members and invite additional ideas in meetings.

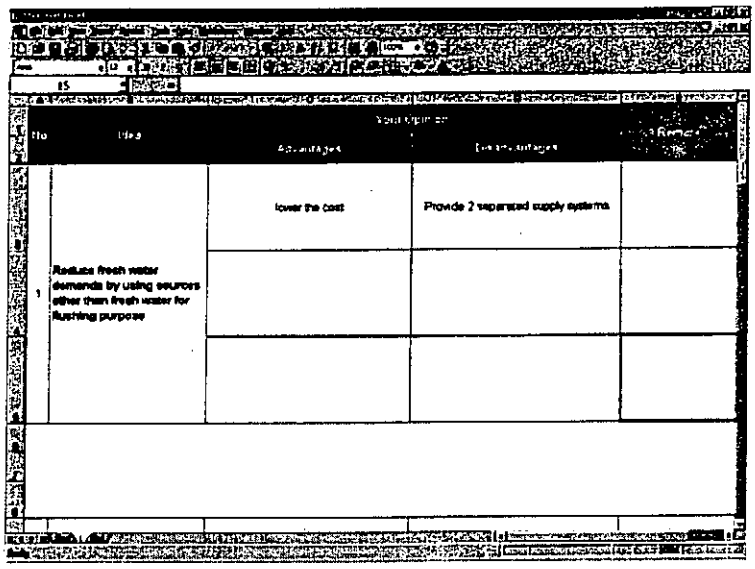

Figure 6.13: Idea Comment Tool of the Communication Unit

The idea comment tool is similar to the idea generation tool and it also breaks the discussion into two sessions. This two-stage approach has empowered the idea generation and group discussion processes by balancing the strength and weakness of face-to-face communication and anonymous communication.

6.3.2 Toolbox 4 (Analysis Unit)

The analysis unit is designed to improve the productivity and accuracy of data analysis in the analysis and evaluation phases. It is comprised of a set of analysis tools including an electronic FAST diagram, a voting tool, an idea categorisation tool, and an electronic weighting evaluation tool, which are illustrated in the following figures.

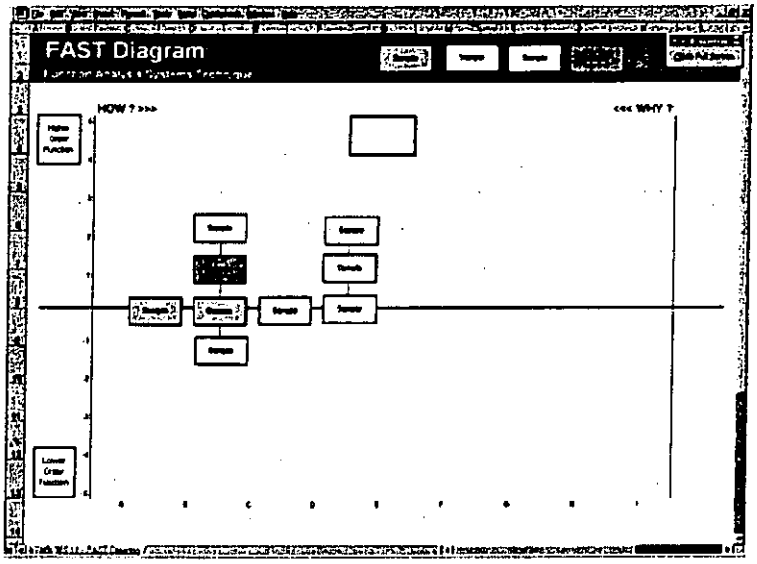

Figure 6.14: Electronic FAST of the Analysis Unit

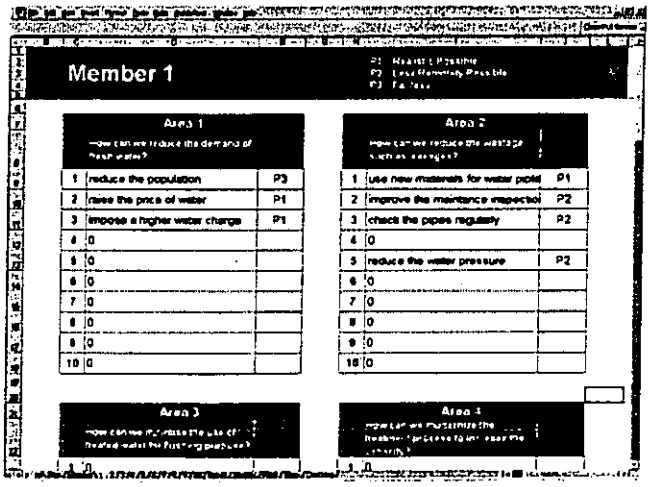

Figure 6.15: Idea Catagorisation Tool of the Analysis Unit

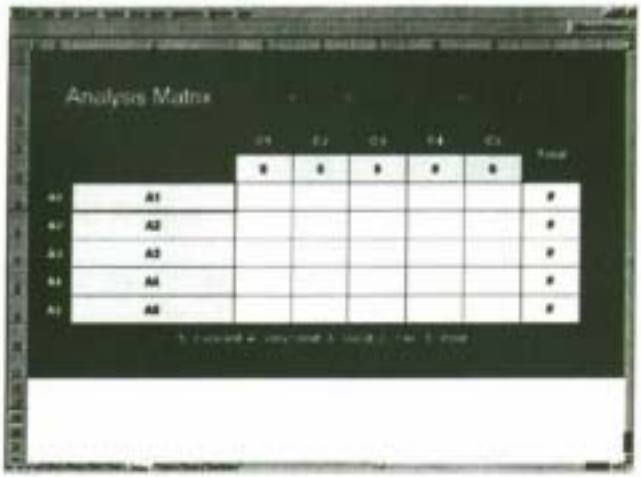

Figure 6.16: Weighting Evaluation Tool of the Analysis Unit

These analysis tools provide a set of analysis frameworks to standardise the analysis process. Members can simply input data into the tools, and results are generated automatically. In addition, some commonly used software, such as the Microsoft Excel and Access, can also be used as analysis tools in VM studies. This software enables members to modify the data in prepared tables so as to anticipate the results of different scenarios in VM workshops. As a result, these analysis tools eliminate human error and shorten the data processing time in workshops assist members to respond to the type of "what if"-type questions in workshops.

6.4 How does the IVMS Operate in VM Studies

Facilitation is one of the critical successful factors in VM and the appropriately equipped facilitators should possess all tools and techniques to manage teams and team dynamics in VM studies (Male and Kelly, 1998). Hence, the role of GDSS is to help facilitators perform these techniques in a more efficient and effective way instead of replacing their roles in the studies. Let takes the two-stage brainstorming technique as an example, this technique can be applied to enhance the team performance by using pen and paper (without GDSS) as well. The information and computer technologies of GDSS assist facilitators to streamline and shorten the time required of this process and therefore, to maximise the benefits gained in VM studies.

Regarding the IVMS, it is designed as a toolbox, which allows facilitators to decide what tools and when to apply them in accordance with their leadership style and the project characteristics. Facilitators can apply the pre-meeting unit to enhance the team building process and the communication unit to promote team dynamics in the studies. As a result, the success of IVMS application is largely depending on the skills of facilitators and it is suggested that the IVMS could be used to enhance good facilitation but not to compensate for poor facilitation. In addition, a job plan should be prepared in order to ensure a smooth operation in practice. For example, the idea generation tool breaks the idea generation process into individual brainstorming session and group brainstorming session and both face-to-face communication and electronic communication would be applied in workshops. Facilitators should provide clear instructions to illustrate what communication and when to be applied in the creative phase.

6.5 Summary and Conclusion

A GDSS prototype system called the IVMS has been developed to facilitate the validation of GDSS functions in the research. This chapter provides an introduction to the system and describes how it can be used to improve VM studies. The IVMS is a specific GDSS designed to improve VM studies, particularly in Hong Kong's construction industry. It is comprised of four toolboxes including (i) a pre-workshop unit, (ii) an information unit, (iii) a communication unit, and (iv) an analysis unit. These toolboxes aims to improve collaboration between members, facilitate information management, promote exchange of ideas, opinions, and preferences, and improve the productivity and accuracy of data analysis in VM studies respectively. This chapter has illustrated how the three-dimensional GDSS support can be integrated and applied to VM studies as a computer system.

7 FEASIBILITY OF APPLYING GDSS TO IMPROVE VM STUDIES

The application of GDSS in VM studies has been discussed and a set of GDSS functions is illustrated in chapter five. In order to investigate the feasibility of applying GDSS to improve VM studies, a validation has been conducted to evaluate the usefulness of the GDSS functions. This chapter introduces the methodology and results of the validation, and then discusses the feasibility of applying GDSS to improve VM studies in the construction industry.

7.1 Methodology of Validation

A validation, which aims to evaluate the usefulness of the GDSS functions in improving VM studies, was conducted at the Department of Building and Real Estate of the Hong Kong Polytechnic University in April 2001. To achieve this, a GDSS conference room is established temporarily to simulate the environment of a GDSS-supported VM study. The IVMS, which is a GDSS prototype system, is used to introduce and demonstrate how the GDSS functions can be implemented in VM studies. Moreover, a group of well-experienced VM practitioners, mainly the GDRAG members, are invited to test the GDSS functions and evaluate their usefulness through professional judgment.

In order to produce a more comprehensive analysis, both quantitative and qualitative data are adopted in the validation. They are mainly collected from questionnaires and focus group meeting respectively. A structured questionnaire (shown in Appendix IV) is prepared to collect quantitative data regarding the subjects of (i) the respondents' attitude toward the application of GDSS in VM studies, and (ii) the usefulness of GDSS functions. The questionnaires were distributed to 11 respondents and 9 completed questionnaires were collected successfully. The response rate is 82% and it is illustrated in the Table 7.1.

Table 7.2: The Number of Returned Questionnaires

Sources	No. of Returned Questionnaires	Response Rate
GDRAG Members	9 out of 11	82%

Regarding the questionnaire, its design is similar to the questionnaire described in section 4.1.1 that comprises a set of "tick-the-box" and "open-ended" questions. 17 statements, which describe the benefits of the GDSS functions, are stated in the questionnaire and respondents are asked to validate these statements on the scale of "strongly agree", "agree", "neutral", "disagree", or "strongly disagree". In addition, a focus group meeting was conducted to collect qualitative data though in-depth discussion in the validation.

7.1.1 GDSS Conference Room

A GDSS conference room is established to simulate the environment of a GDSS-supported VM study in the validation. It is designed to support a VM study team, which maximum has 30 members. The conference room is an ordinary teaching room equipped with computer and network facilities and its layout is illustrated in the following figure.

Figure 7.1: A GDSS Conference Room at the Hong Kong Polytechnic University

As shown in Figure 7.1, respondents are provided with laptop computers and arranged to sit at a U-shaped table facing a public screen. Laptop computers are used as workstations and they enable respondents to prepare individual work and communicate electronically with other members in meetings. A public screen is placed at the front of the conference room so that the public information such as personal work, generated ideas, voting results, and analysis of results could be presented to all members easily in meetings. The design of the conference room enables communication can be transmitted verbally or via computer messaging in meetings and therefore, facilitators are allowed to apply the appropriate communication methods to different tasks in VM studies. Moreover, the use of laptop computers in the conference room allows members to bring along their notebooks and, therefore, to reduce the installation cost of workstations. The portable design of laptop computers also enhances the mobility of the conference room settings so as to accommodate the design of ordinary conference rooms in the construction industry. Due to temporary nature, most of the computer facilities of the GDSS conference room are mainly come from various sources in the university and they are summarised in the following table.

Table 7.2: Computer Facilities at the GDSS Conference Room

	Workstation	Server
No. of Units	14	1
CPU	PIII Class	Dual PIII 500
Memory	128 Mb	1G
Operating System	Windows 98	Windows 2000
Connection to Internet	Yes	Yes
Internet Brower	Internet Explorer 5.5	Internet Explorer 5.5

Besides the workstations, audiovisual equipment including a LCD projector, an overhead projector, a printable whiteboard, a laser printer, and an audio device are also available in the conference room.

7.2 Results of Validation

The main objective of the validation is to evaluate the usefulness of the GDSS functions in VM and, therefore, to investigate the feasibility of applying GDSS to improve VM studies. The validation results are mainly divided into four parts including: (i) the respondents' attitude toward the application of GDSS in VM studies, (ii) the usefulness of information support, (iii) the usefulness of communication support, and (iv) the usefulness of analysis support.

7.2.1 Respondents' Attitude Toward the Application of GDSS in VM Studies

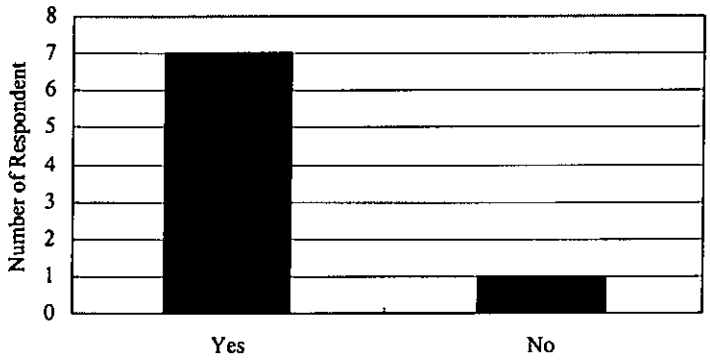

Figure 7.2: Interest in Applying GDSS to VM Studies in the Future

As shown in Figure 7.2, the application of GDSS in VM studies is highly supportive and most of the respondents (7 out of 8) are interested to implement the GDSS functions to VM studies in the future. Nevertheless, a respondent disagrees with this. It is because many users are unfamiliar with VM and the application of GDSS may induce additional difficulties in implementing VM studies. This is considered as a limitation of GDSS but it would be definitely offset by the improvement in VM studies in long run.

7.2.2 Information Support

The information support of GDSS aims to apply electronic information management tools in order to facilitate the processes of information retrieval and storage in VM studies. Table 7.3 illustrates the validation results of information support and the overall results show that GDSS was useful in improving the information retrieval, exchange, and presentation processes. These findings are in line with our suggestions made in chapter five and a detailed discussion about them is given below.

Table 7.3: Validation Results of Information Support

	GDSS Function	IVMS Tool	Description	SD	D	N	A	SA
1	Improve the availability of information	Internet gateways, Internet search engines	Connection to the Internet can improve the availability of information in workshops	0	11%	11%	45%	33%
2	Enhance the information exchange process	Electronic project information center	Electronic file transfer can simplify the information exchange process and shorten the time required in the pre-study phase	0	0	0	89%	11%
			Sharing the information on the Internet can enhance the information circulation process	0	0	22%	56%	22%
			Centralised information storage can improve the consistency of information	0	0	44%	44%	12%
3	Improve the effectiveness of presentation	Multi-media presentation tools	The use of graphic, photo, and video can increase the media richness of presentation	0	0	0	33%	67%

SD: Strong Disagree, D: Disagree, N: Neutral, A: Agree, SA: Strongly Agree

GDSS Improves the Availability of Information

Table 7.2 reveals that the information retrieval tools of GDSS are very useful in improving availability of information in VM studies. Nearly 80% of the respondents agree that the use of Internet gateways and Internet search engines enable members to access external information and significantly improve the sources of information in workshops. Respondents suggested

that these information tools might not be used frequently, but they do assist members to retrieve new information if necessary. It is noted that there is a lot of unstructured information on the Internet. Some specific Internet tools for construction, such as the CEM Gateway (http://www.cem.ac.uk/campus/gateway/building.htm) and the Construction Information Gateway (http://cig.bre.co.uk), could be used to facilitate information searching and avoid information flooding in VM studies. Moreover, the application of the Internet is growing rapidly in the construction industry and more construction related information searching tools would be available in the near future.

GDSS Enhances the Information Exchange Process

Table 7.3 shows that GDSS is extremely useful in enhancing the information exchange process in VM studies and the electronic project information can achieve the following advantages:

All respondents (100%) agree that the electronic file transfer function of GDSS can simplify the information exchange process in the pre-study phase of VM studies. The "point to group communication" feature of GDSS facilitates members to distribute information - members simply upload information to the information center and it will be sent to all members automatically. Moreover, the electronic data transmission feature of GDSS enables real-time information transfer and this dramatically shortens the time of information exchange process in the pre-study and post-study phases.

The information center is a web-based project hosting system, which shares all project information on the Internet. Most of the respondents (78%) agree that the center can improve the information circulation process in VM studies. The individual folders of the information center allows members to circulate project information through the Internet and thus, to overcome the problem of information dissemination described in section 4.3.1.

The information center can also improve the consistency of information in VM studies. Half of the respondents (56%) agree that storing all project information in a physical location facilitates the development of an information platform and this ensures a common understanding about the study. They further suggest that the information center also facilitates the accumulation of project information and the development of a knowledge base in VM studies. In a long term, the knowledge base would be a useful information source to support similar studies and it is extremely useful for those clients who conduct VM studies frequently.

GDSS Improves the Effectiveness of Presentation

The information center supports multi-media presentation, and all respondents (100%) agree that it can improve the effectiveness of presentation in VM studies. It is observed that many limitations are found in traditional approach of presentation. For example, drawing is ineffective in describing site condition and thus, imagination sometimes is required. Respondents agree that the multi-media function of GDSS enables the use of graphic, photo, and video, which enhances the media richness and effectiveness of presentation in VM studies. As a result, the presentations would become more lively and interesting and this enables members to have a better understanding about the project background, objectives, and limitations in VM studies.

7.2.3 Communication Support

The communication support aims to apply electronic communication tools in order to improve the effectiveness and efficiency of communication in VM studies. Table 7.4 illustrates the validation results of communication support and the overall results show that GDSS is useful in supporting the communication process. It can be applied to promote active participation, avoid conformance pressure, prevent domination, and enhance communication, and a detailed discussion is given as below.

Table 7.4: Validation Results of Communication Support

	GDSS Function	IVMS Tool	Description	SD	D	N	A	SA
1	Promote active participation in idea generation	Idea generation tool	Anonymity can create a pressure-free environment to promote active participation	0	11%	22%	45%	22%
			Electronic brainstorming can result in an increase in the number of ideas	11%	22%	34%	22%	11%
2	Avoid conformance pressure in evaluation	Idea comment tool	Anonymous input can avoid the conformance pressure from senior members in producing comments	0	11%	0	67%	22%
3	Prevent domination in discussion	Idea comment tool	Parallel communication can promote the equity of chance in participation	0	0	22%	78%	0
			The application would result in producing more comments	0	22%	11%	56%	11%
4	Enhance communication in the pre-study and post-study phases	Web administration tool	Electronic bulletin board can improve the communication between facilitators and members	0	0	11%	67%	22%
		Group discussion tool	Electronic forum can improve the communication between members	0	0	22%	67%	11%
		Project briefing and training tool	Online presentation can improve members' understanding about the study before attending workshops	0	0	22%	56%	22%
			Online presentation can shorten the time of the information phase	0	0	22%	56%	22%

SD: Strong Disagree, D: Disagree, N: Neutral, A: Agree, SA: Strongly Agree

GDSS Promotes Active Participation in Idea Generation

Anonymous communication of GDSS can create a pressure-free environment in meetings, and most of the respondents (67%) agree that it can promote active participation in the creative phases. It is in line with the finding of GDSS research that anonymity promotes active participation in meetings (Aiken et al., 1995). They suggested that the idea generation tool of GDSS allows members to communicate without showing identities and therefore, it should be very useful in overcoming the problem of shy of public speaking described in section 4.3.2.

However, some of them are not confident about the anonymous communication because it might be difficult to control the discussion flow in such an environment.

As shown in the table, there is lack of consensus about using electronic brainstorming to increase the number of ideas in the creative phase. Thirty-three percent of respondents agree that the idea generation tool of GDSS promotes active participation and, therefore, more ideas would be obtained. However, twenty-two percent of them disagree this because many factors, such as professional knowledge and personality, would also affect the number of ideas. The overall results suggest that GDSS is useful in promoting active participation in idea generation but this might not directly result in increasing the number of ideas.

GDSS Avoids Conformance Pressure in Evaluation

Conformance pressure is reported to be one of the most frequently encountered difficulties in VM studies in chapter four. It prohibits the interaction and participation of members and consequently, junior members may be afraid to criticise the bad ideas from senior members in VM studies. The validation results shows that the anonymous input function of GDSS can avoid conformance pressure in producing comments. Respondents suggest that anonymous communication of GDSS develops an impersonal environment by breaking the link between names and people. This opens up opportunities for members to judge ideas solely based on their merits. As a result, discussion would become more vigorous and diversified in VM studies. Moreover, respondents also support that the two-stage evaluation, which integrates face-to-face communication with anonymous communication, is useful in avoiding conformance pressure while retaining human interaction in VM studies. It is concluded that the anonymous input function of GDSS is useful in improving the quality of discussion, in particular of sensitive issues, in VM studies. It is noted that facilitators should provide proper guidelines and supervision to members in order to ensure the operation smoothly.

GDSS Prevents Domination in Discussion

The problem of domination lowers the participation and interaction of members in VM studies. As described in section 4.3.2, a few active members may dominate and prevent the opportunities for other members to express their comments in discussion. The results from Table 7.4 reveal that of GDSS can be applied to prevent domination in discussion. Most of the respondents (78%) agree that the parallel communication of GDSS is useful in promoting the equity of chance to participate. They agree that a number of high-status or more experienced members may occupy a large portion of airtime in discussion and some good comments or suggestions would be lost. As a result, the discussion is unbalanced and it might tend to endorse those suggestions coming from the dominant people. Respondents believe that the parallel communication of GDSS allows all members to discuss simultaneously and, consequently, ensures an equal chance in discussion. It is one of the best solutions to avoid domination and reduce the danger of groupthink in VM studies. This is consistent with the findings that GDSS reduces individual dominance and more equal participation is achieved (Lewis, 1982 and Easton, 1988). Moreover, most of them (67%) also support that the parallel communication can overcome the problem of domination and prolong the total available airtime in discussion. It would promote active participation and result in producing more comments in VM studies.

GDSS Enhances Communication in the Pre-Study and Post-Study Phases

VM study team is a temporary working group and its members come from different disciplines and organisations. The validation results demonstrate that the virtual pre-workshop of GDSS, which includes an electronic bulletin board, an electronic forum, and an online presentation, is highly useful in enhancing the communication between members in the pre-study and post-study phases.

Nearly all respondents (89%) agree that the electronic bulletin board can improve the communication between facilitators and members. It is not only to simplify the information distribution process, but also to reduce the workload of facilitators. With the help of GDSS, facilitators can simply post a message on the bulletin board, and it will be sent to all members automatically. The improved communication ensures that all members are kept informed and they would not miss any important information in the pre-study and post-study phases.

It is observed that information is usually distributed from facilitator to members and, therefore, the communication is very weak between members. Most of the respondents (78%) also agree that the electronic forums of GDSS can improve the lateral communication between members and enabled them to work together as a team in the pre-study and post study phases. The forum allows members to discuss the preparation work. It also enables them to work as a team and develop a close relationship during the pre-study phases.

Most members (78%) support that the online presentation function of GDSS can improve members' understanding about the study before attending the workshops, and shorten the time of the information phase. It is very useful for assisting facilitators to provide some pre-workshop briefing and training prior to the workshops. This function ensures all members to have a better understanding about the study and, therefore, saves time in the information phase.

7.2.4 Analysis Support

The analysis support of GDSS aims to improve the efficiency and effectiveness of evaluation and analysis in VM studies. Table 7.5 illustrates the validation results of analysis support and the overall results show that GDSS is the analysis support is useful to simplify the analysis and enhance the priorisation process in VM studies and a detailed discussion about them is given below.

Table 7.5: Validation Results of Analysis Support

	GDSS Function	IVMS Tool	Description	SD	D	N	A	SA
1	Simplify the evaluation and analysis processes	File-editing tools	The provision of commonly used software can simplify the analysis process and assist members to address the type of "what if" questions easily in workshops	0	0	25%	62%	13%
2	Enhance the prioritisation process	Voting tool / Idea categorisation tool / Weighting evaluation tool	Electronic voting can simplify and shorten the required time required in voting	0	0	33%	56%	11%
			Anonymous voting can avoid the conformance pressure in voting	0	12%	33%	22%	33%

SD: Strong Disagree, D: Disagree, N: Neutral, A: Agree, SA: Strongly Agree

GDSS Simplifies the Evaluation and Analysis Processes

Most of the respondents (75%) agree that the provision of commonly used software allows them to work on existing materials in meetings. This enables them to anticipate the general pattern or the impact of different solutions by simply varying input data. It simplifies the analysis process and assists members to address the type of "what if" questions easily in meetings. This is further supported by the discussion with Dr. Steven Male at the SAVE 2001 Annual Conference. Dr. Male also agreed that the electronic analysis tools facilitated the calculation of repeated data and he had already applied Excel software to VM studies. The result was extremely satisfactory and it significantly improved the productivity and accuracy of data analysis.

GDSS Enhances the Prioritisation Processes

The voting tools of GDSS including a voting tool, an idea categorisation tool and a weighting evaluation tool are introduced in order to enhance the productivity and effectiveness of the prioritisation process in VM studies. Over half of the respondents (67%) agree that these tools are useful in collecting and presenting of voting data in meetings. They are contributed to

computerise and streamline various analysis techniques, and hence to improve the productivity of prioritisation process in VM studies.

Moreover, nearly half of the respondents (55%) support that anonymous voting can avoid conformance pressure in voting and, therefore, the effectiveness of prioritisation would be enhanced. However, a respondent pointed out that it might not be able to avoid the conformance pressure in voting. It is because a full record of voting process is stored and, therefore, facilitators are strongly advised to keep all records in confidential so as to maintain a pressure free environment in VM studies.

The validation results of information support, communication support, and analysis support have been reviewed in the above sections and an analysis of these validation results is given in the next section.

7.2.5 Analysis of Validation Results

A five-grade scoring system has been introduced to facilitate data analysis, and the options of "strongly agree", "agree", "neutral", "disagree", and "strongly disagree" are represented by a score of 5, 4, 3, 2, and 1 respectively in the following analysis. The scores of each GDSS function are added up to produce an average score, where a higher score means a higher level of consensus. A summary of the analysis results is presented in the following table.

Table 7.6: Summary of the Validation Results

Type of Support	GDSS Function	Score (Function)	Score (Support)
Information support	1. Improving availability of information	4.00	4.20
	2. Enhancing the information exchange process	3.93	
	3. Improving the effectiveness of presentation	4.67	
Communication support (Interaction advantages)	4. Promoting active participation in idea generation (technological efficiencies)	3.39	3.69
	5. Avoiding conformance pressure in evaluation	4.11	
	6. Preventing domination in discussion	3.67	
Communication support (Technological efficiencies)	7. Enhancing communication in the pre-study and post-study phases	4.00	4.00
Analysis support	8. Simplifying the evaluation and analysis processes	3.78	3.83
	9. Enhancing the prioritisation processes	3.88	
5: Strongly Agree, 4: Agree, 3: Neutral, 2: Disagree, 1: Strongly Disagree			

Table 7.6 shows that the information support (4.20) is the most useful GDSS support in VM studies and the rankings of GDSS supports in descending order are (i) information support; (ii) communication support (technological efficiencies); (iii) analysis support; and (iii) communication support (interaction advantages). Among these supports, respondents seem to support those functions that can directly improve the productivity of VM studies and some reasons are suggested below:

- The improvements in productivity are tangible and easily to identify.
- The improvements in productivity may directly reduce the cost of VM studies.
- Respondents may lack experience in using electronic communication tools and, therefore, the benefits of interaction advantages are not fully explored.

In addition, the table also suggests that most of the GDSS functions are useful in improving VM studies and their scores are ranged from 4.67 (strongly agree) to 3.67 (agree). The above findings are in line with the result of section 7.2.1 that most of the respondents are supportive to

the application of GDSS in VM studies. In order to identify the top five GDSS functions, the functions are ranked in descending order, where "1" is the most useful and the results are presented in the following table.

Table 7.7: The Top Five GDSS Functions in VM Studies

Rank	GDSS Function
1	Improving the effectiveness of presentation
2	Avoiding the conformance pressure in evaluation
3	Improving availability of information Enhancing communication in the pre-study and post-study phases
4	Enhancing the information exchange process
5	Enhancing the prioritisation processes

Improving the effectiveness of presentation is ranked as the most useful GDSS function in VM studies. As shown in Table 7.3, all respondents (100%) strongly agree or agree that the multi-media presentation function of GDSS can improve the effectiveness of presentation in VM studies. However, the difficulty of illustrating a new idea or concept has not been reported as a key problem in chapter four. This result concludes that the traditional approach of presentation is functional in VM studies but the multi-media presentation tools of GDSS can further improve it. Besides, avoiding the conformance pressure in evaluation, improving availability of information and enhancing communication in the pre-study and post-study phases are also reported to be the second and third most useful GDSS functions. They are in line with the top three frequently encountered difficutlies reported in Table 4.5. This finding provides a strong argument to support the GDSS functions suggested in chapter five, and the feasibility of using GDSS to improve VM studies in the construction industry.

7.3 Summary and Conclusion

A validation, which aims to investigate the usefulness of GDSS functions, has been described in this chapter. The validation results show that all interviewed VM practitioners are highly supportive of using GDSS to improve the GDSS functions of information support and communication support (technological efficiencies), which are particularly useful in enhancing the information exchange and communication processes in VM studies. Moreover, the information support, communication support, and analysis support can be integrated to provide three levels of GDSS applications in VM studies and they aim to (i) improve the communication and information exchange processes in the pre-study phase, (ii) improve the efficiency and effectiveness of the evaluation and analysis processes in workshops, and (iii) promote human dynamic in workshops.

8 CONCLUSIONS

The research aims to (i) to investigate the difficulties in implementing VM studies, (ii) to explore what and how GDSS functions can be applied to improve VM studies, and (iii) examine their usefulness in the construction industry. It has successfully achieved these objectives and the research findings have been presented in previous chapters. This final chapter concludes the research by summarising the research findings, discussing the research significances and the directions for further study.

8.1 Conclusions of the Research Findings

The research findings can be concluded by the following statements.

1. ***The implementation of VM studies is subject to a number of difficulties in Hong Kong's construction industry and it is, therefore, strongly believed that the performance of VM studies improves if these difficulties have been identified and removed.***

A survey has been conducted to investigate the difficulties of implementing VM studies in the research. The research findings suggest that 50% of VM users are not quite satisfied with the practice of VM studies in the construction industry. The difficulties of (i) lack of information, (ii) lack of participation, and (iii) difficulty in conducting the analysis are reported to be the major factors, which lowers the efficiency and effectiveness of VM studies. As a result, it is strongly believed that the performance of VM studies improves if these difficulties can be identified and removed.

2. ***GDSS technologies can be integrated with VM methodology to provide three-dimensional support for VM studies. In addition, a GDSS prototype system has been developed and demonstrated how GDSS functions can be integrated as a system and implemented in a VM study***

Substantial amounts of research activities support that GDSS can improve the quality, efficiency, and reliability of the group decision-making process. This research has introduced how GDSS technologies can be integrated with VM methodology and a framework of three-dimensional GDSS support is developed. This framework suggests that GDSS is contributed to provide (i) information support, (ii) communication support, and (iii) analysis support for VM studies. These supports can either work alone to improve a particular task, or closely together to improve a particular process (a group of tasks) in VM studies. In addition, a GDSS prototype system called the IVMS has been developed to illustrate how the three-dimensional GDSS support can be integrated and implemented as a computer system in VM studies. The IVMS is comprised of four toolboxes, which are designed to (i) improve collaboration between members, (ii) facilitate information management, (iii) promote exchange of ideas, opinions, and preferences, and (iv) improve the productivity and accuracy of data analysis in VM studies.

3. ***The interviewed VM practitioners are highly supportive for applying GDSS to improve VM studies, in particular using GDSS to enhance the efficiencies of information exchange and communication process.***

A validation has been conducted to examine the usefulness of GDSS functions in the research. The validation results demonstrate that respondents are highly supportive for applying GDSS to improve VM studies. The information support and the communication support (technological efficiencies) are particularly useful in enhancing the information exchange and

communication process in VM studies, and the top three useful GDSS functions are as follows:

- The multi-media presentation tools can improve the effectiveness of presentation.
- The web administration tool can enhance the commutation between facilitators and members in the pre-study phase.
- The electronic project information center can simplify the information exchange process and shorten the time required in the pre-study phase of VM studies.

In reference to the GDSS framework described in section 5.2, it is concluded that the information support, communication support, and analysis support of GDSS can work closely together to improve a particular process (a group of tasks) in VM studies and a taxonomy of three-level GDSS application is suggested below.

Table 8.1: Three-level GDSS Application in VM Studies

	Information Support	Communication Support		Analysis Support	Achieved Function
		Technological Efficiencies	Interaction Advantages		
Level I	√	√			• Enhancing the information exchange process • Enhancing communication in the pre-study and post-study phases
Level II	√			√	• Improving availability of information • Improving the effectiveness of presentation • Simplifying the evaluation and analysis processes • Enhancing the prioritisation processes
Level III			√		• Promoting active participation in idea generation • Avoiding conformance pressure in evaluation • Preventing domination in discussion

Level I GDSS aims to apply information support and communication support (technological efficiencies) in order to improve the information exchange process and enhancing communication in the pre-study and post-study phases. A virtual conference room (VCM) is introduced to improve the collaboration between members. The VCM is similar to the pre-workshop unit described in section 6.2.1 and it comprises (i) a project briefing tools, (ii) an electronic notice board, (iii) an electronic forum, (iv) construction library and (v) project information center. A detailed description of the VCM is given below.

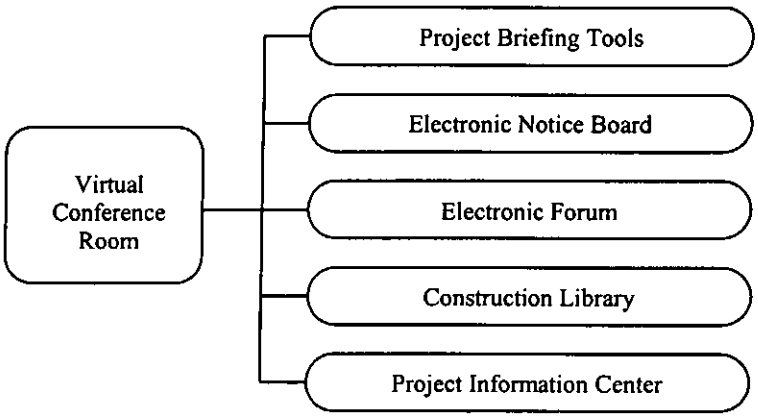

Figure 8.1: A Virtual Conference Room for VM Studies

The project briefing tools assist clients and facilitators to provide an introduction to workshops in the pre-meeting phase. Other than the online PowerPoint presentation, it also applies photos and short MPEG movie to create a virtual site visit so that members can have a better understanding about the project. The electronic notice board allows members to disseminate information by posting messages on a bulletin board. The messages not only display on web, they will also email to the whole team automatically so that all members are notified. The electronic forum allows members to enjoy the group discussion in the pre-meeting phase. They can raise new topic or comment on people's topics by posting messages on a newsgroup. Similar to the notice board, the messages will also email to the team members. The construction library aims to provide a set of search engines and construction

information gateways in order to facilitate members in searching information on Internet. The project information center is a FTP server, which allows members to store and share project information on Internet. Members are provided with web folders and they can simply use Internet browsers to upload or download the files including correspondence, cost data and drawing, in particularly the pre-meeting phase. If there is new information, notification will be automatically sent to the whole team through email and they can login the system to download

Level II GDSS aims to improve the efficiency and effectiveness of analysis through improving availability of information, improving the effectiveness of presentation; simplifying the evaluation and analysis processes, and enhancing the prioritisation processes in workshops. A GDSS conference room has set up in order to introduce the information support and analysis support to workshops.

Level III aims to apply communication support (interaction advantages) to provide a modified environment so as to enhance the quality of discussion in workshops. The GDSS features of anonymous communication and parallel communication would be applied to promote active participation, avoid conference pressure, and prevent domination in workshops.

In addition, the application of GDSS can be applied to achieve three different purposes in VM studies and a taxonomy of three-approach GDSS application is suggested below:

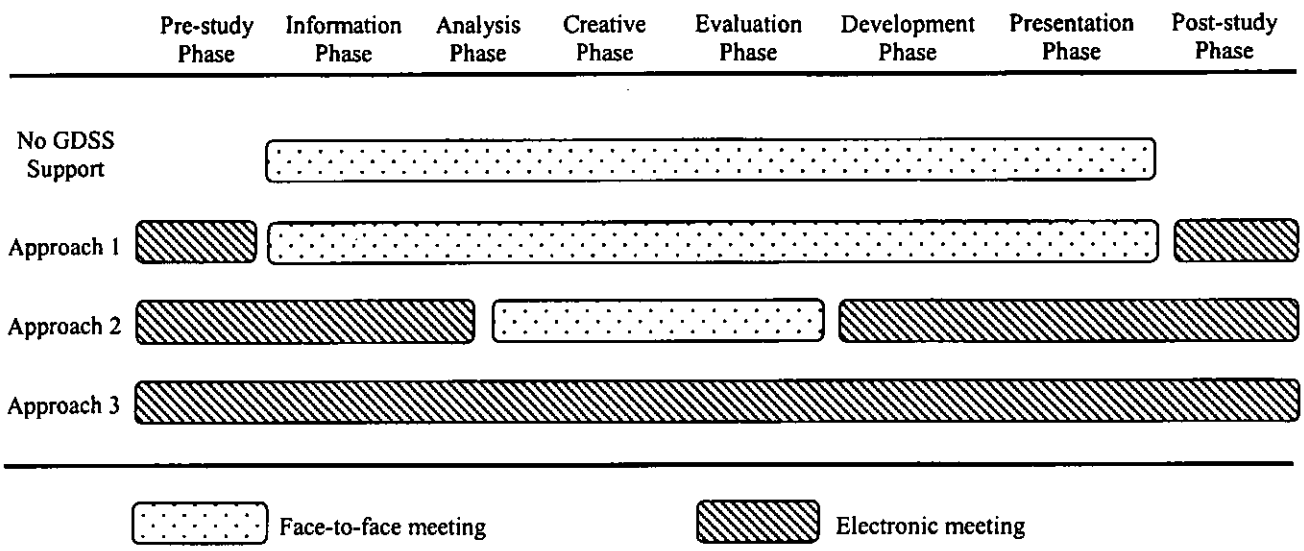

Figure 8.2: Three-approach of GDSS Application in VM Studies

Approach 1 applies level I GDSS to improve the collaboration between members in the pre-study and post-study phases only. The duration of workshops remains the same.

Approach 2 further develops the VCM of level I GDSS in order to replace the information, development, and presentation phase and part of the analysis phase in workshops. All members can finish part of the function analysis through the Internet before attending the workshop ~~so~~ to reduce the meeting time. The running cost of VM studies is very expensive and, therefore, it is mainly applied to the preliminary stage of the project cycle. This modified VM study would reduce the human interaction in VM studies and, thus, the synergy of human dynamics might be lower in comparison with traditional VM studies. However, it would definitely reduce the resources input to VM studies and provide an alternative approach to conducting VM studies. In considering the balance between input and output resources, it is ideal for VM users who want to enjoy the benefits of VM without paying too much. For example, contractors could implement this modified VM study through the project circle.

Approach 3 is the most sophisticated GDSS application, which aims to virtualise VM studies. In this approach, VM studies can be done electronically and members can participate in workshops through chat room or videoconference. It allows all members to participate in the workshop without traveling and reduces the running cost of VM studies.

8.2 Significances of the Research Findings

The significances of the research findings are illustrated as follows:

1. ***The research has successfully identified the difficulties in implementing VM studies in Hong Kong's construction industry.***

There has been a surge of interest in VM applications in Hong Kong's construction industry since the Asian financial crisis in 1997. However, it is observed that the implementation of VM studies is subject to a number of difficulties and therefore, the benefits of VM are not fully achieved. Unfortunately, little work has been undertaken to address this in sufficient depth. The research has successfully identified the difficulties in implementing VM studies and these findings can be used as guidelines for practitioners to improve their practice.

2. ***The research has successfully integrated VM methodology with GDSS technologies and applies GDSS to improve VM studies.***

The research is the first study to explore the potential of applying GDSS to VM studies. It has successfully integrated VM methodology with GDSS technologies and this links up the knowledge between the domains of VM and GDSS. Moreover, the framework of three-dimensional GDSS support is developed. It clearly illustrates how GDSS technologies can be applied to VM studies and what the advantages are.

3. ***The research has successfully explored a new direction of using IT to improve VM studies.***

IT has been applied to improve the technological efficiency of manual processes in VM studies. GDSS evolves beyond this technical support and it improves the effectiveness of communication in VM studies. The research has explored a new direction of using IT to improve the efficiency and effectiveness of VM studies. The research findings contribute to increasing the efficiency and effectiveness of conducting VM studies while maintaining the traditional roles and functions of VM team members.

8.3 Limitations of the Research Findings

The limitations of research findings are listed as follows:

Source of Research Data

VM is still at an embryonic stage in Hong Kong's construction industry. The population of VM users is too small for quantitative analysis alone and therefore, a mixed approach of using both quantitative analysis method and qualitative analysis method has been applied in the research.

Method of the Validation

In order to complete the study within the normal period of two years, a group of well-experienced VM practitioners are invited to validate the GDSS functions through professional judgment instead of using laboratory studies or field studies in the research. This is one of the shortcomings of the research and it could be improved if a control group is introduced in the described experiment. The control group would be useful in comparing the performance between GDSS supported VM teams and non-GDSS supported VM teams and

therefore, explores to "what extent" GDSS can improve VM studies that has not been studied into details in the research.

Scope of Study

The research is limited to investigate whether and how GDSS can be applied to improve VM and it has not cover the following issues:

- The cost implication of the GDSS applications
- The users' satisfaction with the GDSS functions
- The impacts of the GDSS applications

The research findings have consolidated a very good foundation regarding the application of GDSS to VM. A framework of three-dimensional GDSS support has been introduced in the research and this framework can be further developed to formulate hypotheses in further study. Some research areas of the application of GDSS in VM are suggested below:

- What are the impacts of applying GDSS to VM studies?
- To what extent can we reduce the running cost of VM studies by using GDSS?
- To what extent can we shorten the duration of VM studies by using GDSS?

LIST OF RESEARCH PUBLICATIONS

1. Shen, Q.P. and Chung, K.H. (2000) Overcome difficulties in VM studies: The use of information technology. IN: Proceedings of the 4th HKIVM Int'l Value Management Conference, pp. 28-36, 22-23rd November, Hong Kong: HKIVM.

2. Shen, Q.P. and Chung, K.H. (2001) Using information technology to overcome difficulties in value management studies – Hong Kong's experience, Journal of Construction Research, Vol. 2, pp. 147-156.

3. Chung, K.H. and Shen, Q.P. (2001) Computerised group decision support systems assist VM studies, Value World, Volume 24, No. 2, pp. 7-10.

4. Chung, K.H. and Shen, Q.P. (2001) Improving the implementation of VM studies in Hong Kong's construction industry – A GDSS Approach, IN: SAVE Int'l Proceeding 2001 Annual Conference, Vol. XXXVI, pp. 83-94, 6-9th May, Fauderdale, NorthBrook: SAVE International.

5. Chung, K.H. and Shen, Q.P. (2001) A conceptual framework of using group decision support systems to improve VM studies in the construction industry, IN: Fourth European Project Management Conference, 6-7th June, Café Royal London, London: PMI Europe.

6. Shen, Q.P., and Chung, K.H. (2002) A group decision support system for value management studies in the construction industry, International Journal of Project Management, Vol. 20, pp. 247-252.

7. Chung, K.H. and Shen, Q.P. (2002) Applying the Interactive Value Management System to support VM studies in the construction industry, IN: Proceedings of the 5th HKIVM Int'l Value Management Conference, in print.

8. Chung, K.H. and Shen, Q.P. (2002) An exploration of using Group Decision Support System to improve VM studies in Hong Kong's construction industry, IN: Proceedings of the International Postgraduate Conference.

9. Chung, K.H. and Shen, Q.P. (2002) IVMS – An Interactive System for improving value management studies in construction IN: Proceedings of the ABT 2002, in print.

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9 December, 1999

Dear Sir ,

Invitation for joining the GDSS Research Advisory Group

I am a MPhil Research Student of the Hong Kong Polytechnic University. I am writing to invite you as a member of the ***Advisory Group*** for the research project entitled "***Development of a Diagram-orientated Group Decision Support Systems for Value Management Applications in the Construction Project Scope Management***".

Group Decision Support System (GDSS) is a relatively new technology, which combines the information technology of computers, data communications, and decision methods to support the group decision making process. The substantial evidence of positive research results and field studies have already confirmed its success in improving the quality of decision making and reducing the decision time required.

The project is a pilot study to bring the benefits of Value Management and GDSS into Construction Project Scope Management: a prototype of a web based diagrammatic orientated GDSS would be produced to investigate how the GDSS assists the Value Management implementation in the project scope management. The findings of this research may lead to a computerized project scope management that could enhance both the productivity and competitiveness of the local construction industry.

The formation of the GDSS Research Advisory Group aims to establish a linkage between the research team and the construction industry. The shared comments and experience from group members would enlarge the knowledge base of GDSS research in the construction industry and this could enable the proposed GDSS to be more practical and applicable for the Hong Kong construction industry.

Your participation is very important. It is not only essential for the project success, it is also critical for the IT development in construction industry as well. You would be entitled to enjoy benefits and rewards as described in the enclosed proposal for research advisory group.

Please contact us to confirm your participation. For any further information or enquiry, please contact Jacky Chung at 9779 or jackychung@

Thank you very much for your kind attention.

Sent by:

Endorsed by:

Mr. Jacky K. H. Chung
MPhil. Research Student
The Hong Kong Polytechnic University

Dr. Geoffery Q. P. Shen
Associate Professor
The Hong Kong Polytechnic University

Encl.

Survey on the Most Frequently Encountered Difficulties in VM Studies

Name of company : _____

Name of respondent : _____

Position : _____ **Contact Phone No. :** _____

Instructions:

There are two ways of attempting the questions in this questionnaire

a) Put a ✓ in ❑ for your selected answer (some questions may have more than one ✓)

b) Answer short questions

Background of Interviewee

1. **What is the nature of the company you are working for? (could have more than one ✓)**

❑ Architectural
❑ Project Management
❑ Cost Consultation
❑ Value Management Facilitation
❑ Land Development
❑ Site Construction
❑ Other (Please specify) _____

2. **How many year(s) have you been exposed to Value Management?**

❑ Less than 1 year
❑ 1 year or more, but less than 2 years
❑ 2 years or more, but less than 3 years
❑ 3 years or more, but less than 4 years
❑ 4 years or more, but less than 5 years
❑ 5 years or more, please specify _____

3. **How many Value Management Workshops have you attended?**

❑ None ⇨ **Please go to the question no. 8**
❑ 1 – 2 workshops
❑ 3 – 4 workshops
❑ 5 – 6 workshops
❑ 7 – 8 workshops
❑ More than 8 workshops, please specify _____

Practice of Value Management Workshops

4. **Are you satisfied with current practice of Value Management Workshops?**

❑	❑	❑	❑	❑
Extremely satisfied	Satisfied	Neutral	Dissatisfied	Extremely dissatisfied
⇨ **Please go to the question no. 6**		⇨ **Please go to the question no. 5**		

5. **Have you experienced the following difficulty / difficulties in Value Management Workshops?**

	Always	Frequently	Sometimes	Seldom	Never
a. Information Phase					
1. Difficult to collect instant internal or external data	❑	❑	❑	❑	❑
2. Difficult to share or disseminate information in briefings	❑	❑	❑	❑	❑
3. Other, please specify _____	❑	❑	❑	❑	❑
b. Analysis Phase					
4. Not all group members actively participate in the discussion and some may be reluctant to speak out	❑	❑	❑	❑	❑
5. Lacks of interaction in group discussion	❑	❑	❑	❑	❑
6. Other, please specify _____	❑	❑	❑	❑	❑
c. Creativity Phase					
7. Lack of ideas or alternatives	❑	❑	❑	❑	❑
8. Difficult to illustrate an new idea or concept	❑	❑	❑	❑	❑
9. A few members may dominate the discussion	❑	❑	❑	❑	❑
10. Conflicts raised in discussion due to personal issue	❑	❑	❑	❑	❑
11. Other, please specify _____	❑	❑	❑	❑	❑
d. Evaluation Phase					
12. Difficult to conduct analysis on suggestions from members	❑	❑	❑	❑	❑
13. Difficult to proceed with the evaluation process	❑	❑	❑	❑	❑
14. Difficult to proceed with the voting process	❑	❑	❑	❑	❑
15. Difficult to present the results of evaluation	❑	❑	❑	❑	❑
16. Other, please specify _____	❑	❑	❑	❑	❑
e. Development Phase					
17. Difficult to record the minutes of meetings	❑	❑	❑	❑	❑
18. Other, please specify _____	❑	❑	❑	❑	❑
f. For the whole workshop					
19. Failure to stick with the meeting plan or agenda	❑	❑	❑	❑	❑
20. Failure in time management	❑	❑	❑	❑	❑
21. Other, please specify _____	❑	❑	❑	❑	❑

6. **Have you experienced any computing or information technology application in Value Management Workshops?** (could have more than one ✓)

❑ Yes

a. Decision-making
- ❑ Group decision support system or Decision support system
- ❑ Decision tree
- ❑ Expert System

b. Data analysis
- ❑ Planning tools (i.e. MS Project)
- ❑ Statistical analysis tools

c. Network
- ❑ LAN (Local Area Network)
- ❑ Internet / Intranet

d. Other
- ❑ (Please specify) _____

❑ No

7. **Please briefly comment on the above system(s) in terms of advantages or disadvantages.**

_____

_____

_____

_____

This is the END and thank you for your cooperation!

Survey on the Usefulness of Using GDSS to Improve VM Studies

Name of respondent : _____

Instruction **Please circle the number for your selected answer**

1. **By referring to the features demonstrated by the IVMS, to what extent do you agree that the following statements?**

Toolbox 1 – Pre-workshop Unit	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
a. **Web administration tool** can improve the communication between facilitators and members	1	2	3	4	5
b. **Group discussion tool** can improve the communication between members	1	2	3	4	5
c. **Project briefing and training tool** can improve members' understanding about the study before attending workshops	1	2	3	4	5
d. **Project briefing and training tool** can shorten the time of the information phase	1	2	3	4	5

Toolbox 2 – Information Unit	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
e. **Connection to Internet** can improve the availability of information in workshops	1	2	3	4	5
f. **Electronic project information center** can simplify the information exchange process and shorten the time required in the pre-study phase	1	2	3	4	5
g. **Electronic project information center** can enhance the information circulation process by sharing it on the Internet	1	2	3	4	5
h. **Electronic project information center** can centralise information storage and improve the consistency of information	1	2	3	4	5
i. **Multi-media presentation tools** can increase the media richness of presentation	1	2	3	4	5

Toolbox 3 – Communication Unit	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
j. **Idea generation tool** can create a pressure-free environment to promote active participation	1	2	3	4	5
k. The **use of idea generation tool** can result in an increase in the number of ideas	1	2	3	4	5
l. **Idea comment tool** (anonymous input) can avoid the conformance pressure from senior members in producing comments	1	2	3	4	5

m. **Idea comment tool** (parallel communication) can promote the equity of chance in participation	1	2	3	4	5
n. The **use of idea comment tool** would result in producing more comments	1	2	3	4	5

Toolbox 4 - Analysis Unit	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
o. **File-editing tools** can simplify the analysis process and assist members to address the type of "what if" questions easily in VM workshops	1	2	3	4	5
p. **Electronic voting tools** can simplify and shorten the required time required in voting	1	2	3	4	5
q. **Electronic voting tools** (anonymous input) can avoid the conformance pressure in voting	1	2	3	4	5

2. Are you satisfied with the performance of the IVMS?

1	2	3	4	5
Extremely dissatisfied	Dissatisfied	Neutral	Satisfied	Extremely Satisfied

Please briefly state the reason(s)

_____

_____

_____

3. Would you be interested to try implementing GDSS in VM studies in the future?

1 Yes
2 No

Please briefly state the reason(s)

_____

_____

_____

This is the END and
thank you very much for completing this questionnaire

RESULTS OF THE VALIDATION

1 Information Support

Function	Feature	SD	D	N	A	SA	Score (Feature)	Score (Function)	Overall Score
Improving Availability of Information	The connection to the Internet can improve the availability of information in VM workshops	0	1	1	4	3	4	4.00	4.20
Enhancing the Information Exchange Process	Electronic file transfer can simplify the information exchange process and shorten the time required in the pre-study phase	0	0	0	8	1	4.11	3.93	
	The centralised information storage can improve the consistency of information	0	0	4	4	1	3.67		
	Sharing the information on the Internet can enhance the information circulation process	0	0	2	5	2	4		
Improving the Effectiveness of Presentation	The use of graphic, photo, and video can increase the media richness of presentation	0	0	0	3	6	4.67	4.67	

2 Communication Support

Function	Feature	SD	D	N	A	SA	Score (Feature)	Score (Function)	Overall Score
Promoting Active Participation in Idea Generation	Anonymity can create a pressure-free environment to promote active participation	0	1	2	4	2	3.78	3.39	3.77
	Electronic brainstorming can result in an increase in the number of ideas	1	2	3	2	1	3		
Avoiding Conformance Pressure in Evaluation	Anonymous input can avoid the conformance pressure from senior members in producing comments	0	0	0	8	1	4	4	
Preventing Domination in Discussion	Parallel communication can promote the equity of chance in participation	0	0	2	7	0	3.78	3.67	
	The application would result in producing more comments	0	2	1	5	1	3.56		

Enhancing Communication in the Pre-Study and Post-Study Phases	Electronic bulletin board can improve the communication between facilitators and members	0	0	1	6	2	4.11	4.00	
	Electronic forum can improve the communication between members	0	0	2	6	1	3.89		
	Online presentation can improve members' understanding about the study before attending workshops	0	0	2	5	2	4		
	Online presentation can shorten the time of the information phase	0	0	2	5	2	4		

3 Analysis Support

Function	Feature	SD	D	N	A	SA	Score (Feature)	Score (Function)	Overall Score
Simplifying the Evaluation and Analysis Processes	The provision of commonly used software can simplify the analysis process and assist members to address the type of "what if" questions easily in VM workshops	0	1	3	2	3	3.78	3.78	3.83
Enhancing the Prioritisation Processes	Electronic voting can simplify and shorten the required time required in voting	0	0	3	5	1	3.78		
	Anonymous voting can avoid the conformance pressure in voting	0	0	2	5	1	3.88	3.88	

REFERENCES

Adkins, M. (2000) http://www.cmi.arizona.edu/research/dist_collab/dynamics.htm, view at 3/7/2000.

AFAV (2000) http://www.afav.asso.fr/index.html, view at 1/05/2000.

Aiken, M.; Vanjani, M.; and Krosp, J. (1995) Group decision support systems, Review of Business, Vol. 16, No. 3, pp. 38-42.

Borges, R.S.; Pino, A.; Fuller, A.; and Salgado, C. (1999) Key issues in the design of an asynchronous system to support meeting preparation, Decision Support Systems, Vol. 27, pp. 269-287.

Chung, K.J. and Park, H.K. (1998) Examining the conflicting results of GDSS research, Information & Management, Vol. 33, pp. 313-325.

De Sanctis, G. and Galluple, R. B. (1987) A foundation for the Study of group decision support systems, Management Science, Vol. 33, May, pp. 598-600.

Dell'Isola, A.J. (1982) Value Engineering in the Construction Industry, Third Edition, New York: Van Nostrand Reinhold Co.

Dell'Isola, A.J. (1997) Value Engineering: Practical Applications, Kingston: R.S. Means Company Inc.

Dennis A.R.; George, J.F.; Jessup, L.M.; Nunamaker, J.F.; and Vogel, D.R. (1988) Information technology to support electronic meetings, MIS Quarterly, December, pp. 591-624.

Dennis, A.R.; Tyran, C.K.; Vogel, D.R.; and Nunamker, J.F. (1997) Group support systems for strategic planning, Journal of Management Information Systems, Vol. 14, No. 1, pp. 155-184.

DeSanctis G. and Gallupe R.B. (1985) Group decision support systems: A new frontier, Data Base, Winter, pp. 3-11.

DeSanctis G. and Gallupe R.B. (1987) A foundation for the study of group decision support systems, Management Science, Vol. 33, No. 5, pp. 589-609.

Easton, G.K. (1988) Group Decision Support Systems vs. Face-to-Face Communication for Collaborative Group Work: An experimental investigation, Doctoral dissertation, University of Arizona, Tucson.

Finlay, P.N. (1989) Introducing Decision Support Systems, Oxford: NCC Blackwell.

Fong, S.W.; Shen, Q.P.; Chiu, W.I.; and Ho, M.F. (1998) Applications of Value Management in the Construction Industry in Hong Kong, Hong Kong: The Hong Kong Polytechnic University.

Gallupe, R.; DeSanctis, G.; and Dickson, G. (1988) Computer-based support for group problem finding: An experimental Investigation, MIS Quarterly, June, pp. 277-296.

Gallupe, R.B. (1986) Experimental research into group decision support systems: Practical issues and problems. IN: Proceedings of the Nineteenth Annual HICSS, pp. 515-523.

Glezer, C. and Yadav, S.B. (1999) A conceptual model of an intelligent meeting-scheduler, Journal of Organisational Computing and Electronic Commerce, Vol. 9, No. 4, pp. 233-251.

Gray, P. (1987) Group decision support systems, Decision Support Systems, Sep., Vol. 3 No. 3, pp. 233-242.

Grosvenor, R. (1997) Introduction to VM, The Value Manager, Vol. 3, No. 1, Hong Kong: The Hong Kong Institute of Value Management, pp. 3-5

Huber, G.P. (1984) Issues in the design of group decision support systems, MS Quarterly, Vol. 8, pp. 195-204.

Jackson, N.F.; Aiken, M.W.; Vanjani, M.B.; and Hasan, B.S. (1995) Support group decision via computer systems, Quality Progress, Vol. 28, No. 5, pp. 75-78.

Jessup, L.M. and Kukalis, S. (1990) Better planning using group support systems, Long Range Planning, Vol. 23, No. 3, pp. 100-105.

Kelly, J. and Male, S. (1993) Value Management in Design and Construction, Norwick: E & FN Spon.

Lam, S.K. (1997) The effects of group decision support systems and task structures on group communication and decision quality, Journal of Management Information Systems, Vol. 13, No. 4, pp. 193-215.

Lewis, F.L. (1982) Facilitator: A Micro Computer Decision Support Systems for Small Groups, Doctoral dissertation, University of Louisville: Louisville.

Male. S and Kelly, J. (1998) Value management: the value management benchmark, London: Thomas Telford.

Maryam, A. (1991) Group decision support systems. Information Systems Management, Vol. 8, No. 3, pp. 36-41.

Murray, L.C. (1988) The computer and the value engineer. IN: Proceedings of the 23rd SAVE International Annual Conference, pp. 216-226.

Norton, B.R. and McElligott, C.W. (1995) Value Management in Construction: A Practical Guide, London: Macmillan Press Ltd.

Nunamaker, J.; Applegate, L.; and Konsynski, B. (1987) Facilitating group creativity: Experience with a group decision system. IN: Proceedings of the 12th Annual HICSS, pp. 422-429.

Otero, F. (1997) Real time integrated computer tools for value engineering events. IN: Proceedings of the 32nd SAVE International Annual Conference, pp. 221-227.

Park, P.E. (1993) Creativity and value engineering teams. IN: Proceedings of the 28th SAVE International Annual Conference.

Paulson, L.W. and Simpson, J.J. (1989) VE-PRO, software for value engineering program management. IN: Proceedings of the 24th SAVE International Annual Conference, pp. 197-201.

Pervan, F.P. (1998) A review of research in group support systems: leaders, approaches and directions, Decision Support Systems, Vole 23, pp. 149-159.

Pickles, L. (2000) Save Tai O, IN: Proceedings of the 4th HKIVM International Conference, pp. 37-41, November, Hong Kong, China.

Planning, Environment & Land Bureau Technical Circular No. 9/98, Works Bureau Technical Circular No. 16/98: Implementation of Value Management, http://www.wb.gov.hk/circular/index.htm.

Pools, M.S. and Holmes, M. (1993) Group decision support systems and group communication, Communication Research, Vol. 10, No. 2, pp. 176-214.

Reichling, L. (1995) What makes a successful team? IN: Proceedings of the 35th SAVE International Annual Conference, pp. 99-102.

SAVE (1998) Value Methodology Standard, 2nd Revised, Northbrook: SAVE International.

Shen Q.P. (1993) A Knowledge-Based Structure for Implementing Value Management in the Design of Office Buildings, A thesis submitted to the University of Salford for the degree of doctor of philosophy, Published by the British Library, UK, Feb., 342 pages.

Shen Q.P. (1996) Enhancing VM studies through information technology. IN: Proceedings of the CIB international conference "Construction Modernization and Education", pp. 21-24 October, Beijing, China.

Shen, Q.P. and Brandon, P.S. (1992) Can Expert Systems Improve VM Implementation? Value World – The Journal of Value Technology for the Society of American Value Engineers, Vol. 15, No. 1, pp. 18-24.

Shen, Q.P. (1997a) Value Management in Hong Kong's construction industry: Lessons learned. IN: Proceedings of the 32nd SAVE International Annual Conference, pp. 260-265.

Shen Q.P. (1997b) A Critical Review of VM Applications in the Construction Industry in Hong Kong. IN: Proceeding of the 30th Annual Conference of the Society of Japanese Value Engineering, 17-19 November, Arcadia Ichigaya, Tokyo, Japan, pp. 221-226.

Standards Australia (1994) Australian/New Zealand Standard: Value Management (AS/NZS 4183: 1994) Homebush: Standards Australia.

Thierauf, R.J. (1989) Group Decision Systems for Effective Decision Making, Westport: Greenwood Press, Inc.

Thoms M. & Lyall T.W. (2000) Value Management on the West Rail Project. IN: Proceedings of the 4th HKIVM International Conference, pp. 7-11, November, Hong Kong, China.

Tung, L.L. and Turban, E. (1998) A proposed research framework for distributed group support systems, Decision Support Systems, Vol. 23, pp. 175-188.

Tyran, C.K.; Dennis, A.R.; Vogel, D.R.; and Nunamker, J.F. (1992) The application of electronic meeting technology to support strategic management, MIS Quarterly, pp. 313-334.

Watson, R.R. (1989) A Study of Group Decision Support System Use in Three and Four-person Groups for a Preference Allocation Decision, Michigan: UMI.

Wilson, A.R. (1998) The development of value management in Architectural Service Department, The Value Manager, Vol. 4, No. 2, pp. 3-5.