Volume 21 Number 10 2003

ISSN 0263-2772

Facilities

The official research publication of EuroFM

Applying and extending the global knowledge base. Nominated papers from the CIB W70 Global Symposium, Glasgow, 2002

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Contents

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Abstracts & keywords

A method for strategic client briefing

Jim Smith, Ray Wyatt and Norm Jackson

Keywords Stakeholders, Strategic management

Strategic client briefing is now recognised as an essential component of best practice in facilities management. A number of different briefing approaches have evolved, or are being developed, and this paper presents strategic needs analysis (SNA). It has been applied within six project-inception studies with real clients, for developing and choosing a strategic direction for the project being considered by all the stakeholders. Moreover, a survey of stakeholders was carried out after each study, in order to find out how well participants thought the workshop performed in terms of six key process characteristics. Such key characteristics were further divided into a total of 41 additionally assessed attributes considered as important within the client-briefing process. Analysis of such assessments revealed some interesting positive and negative features. Consequently, the SNA approach was refined. Presents the major findings of the work carried out along with some observations about overall processes, and suggestions for further improving strategic client briefing using SNA or similar approaches.

The impact of facilities on student choice of university

If Price, Fides Matzdorf, Louise Smith and Helen Agahi

Keywords Higher education, Students, Facilities, Assessment

Despite rhetoric of added value, facilities management suffers a dearth of objectively researched, publicly available information concerning the impact of facilities on businesses at the level of market sectors or individual organisations. This paper aims to correct that situation for UK higher education institutions. A survey of undergraduates starting university in 2001 has confirmed, to high levels of significance, earlier research with the 2000 intake. For many institutions, facilities factors, where provided to a high standard, are perceived as having an important influence on students' choice of institution. Year-on-year comparisons show strong agreement at the global level and, where data could be gathered, at the institutional level. Individual institutions show marked differences, significant at levels of confidence of over 95 per cent. A comparison of "reputational pull" and "facilities pull" is suggested as a means of differentiating the "brand" of different institutions.

Optimization of MVAC systems for energy management by evolutionary algorithm

K.F. Fong, V.I. Hanby and T.T. Chow

Keywords Air diffusion, Optimization techniques, Energy management, Hong Kong

Energy management in existing building services installations is an essential focus of contemporary facilities management. The subway company that is one of the major utilities services in Hong Kong Special Administrative Region has considered better energy management schemes in its subway stations to reduce the running cost. In the past few years some feasible measures in the mechanical ventilation and air conditioning (MVAC) systems were implemented, however the engineering decisions were supported by trial-and-error or imprecise estimation. Improvement to this process would be possible if numerical optimization methods were to be used. An evolutionary algorithm coupled with an external plant simulation programme was applied to determine the optimum conditions of the essential parameters of the MVAC systems. For the centralized MVAC systems under study, the developed optimization and simulation model was found useful in appraising the energy management opportunities for effective design and facilities management.

Decentralising asset management in a university environment using Web enabled technology

Gerard Cesar Gabriel

Keywords Decentralized control, Assets management, Information, Universities

With the advent of Web technology and the proliferation of Web enabled systems in the last few years, remote computer aided facilities management (CAFM) and computer integrated facilities management (CIFM) are starting to assume a more significant role. Computerised asset management (AM) has been widely discussed and various conceptual models, benchmarking and best

 · ISSN 0263-2772

Facilities
Volume 21 · Number 10 · 2003 · 199-200

practice principles have been proposed in the past. However, the vast majority of case studies involved private corporations as well as public sector institutions, with the majority using single-site studies, but very little dealt with the education sector spread on multi-sites. The effective management of assets forms an integral part of the management of the University of Sydney's (USYD) overall resources in order to achieve its goals towards excellence in teaching and research. Reviews the current, more or less, manual centralised AM system at USYD and proposes a framework for a more decentralised, Web-based AM system built on the existing CIFM system used by the Facilities Management Office. Further examines the strengths and weaknesses of the current and proposed systems and the possible application of the proposed system to a range of AM scenarios outside the context of the university environment.

Editorial

Following a successful run of symposia in Singapore (1998) and Brisbane (2000), the CIB Working Commission for Facilities Management and Asset Maintenance (CIB W070) held its 2002 symposium in Glasgow on 18-20 September 2002. The symposium's theme was "Exploring the global knowledge base on facilities management, workplaces, and asset maintenance management". The selected papers, most of which appear in this issue, represent the best of the excellent international commentary on the state of art and priority themes in these fields, and the breadth of perspectives that the symposium covered. All the papers in this issue were short-listed for the 2002 *Facilities* best paper award.

One of the key issues for the evolution of the FM profession is the development of its research base. And a pivotal issue for this is the requirement for robust evidence to support the case for the impact of FM on business. Price *et al.* present their findings from some research on the impact of facilities on student choice of university. Considering the critical impacts of facilities on the university, and discussing the relationship between aspects such as reputational pull and facilities pull, they note a range of facilities factors that affect the "pull" of universities for prospective students – for example (and as they note, rather unsurprisingly) accommodation, also learning and teaching facilities. They discuss a number of sub-factors and other differentiating issues that affect the impact of facilities in different university contexts.

Continuing with the issue of making an impact on the business, the topic of strategic client briefing is at the heart of the call for facilities managers to be involved in the whole life cycle of facilities. Smith *et al.* report on the development of a strategic needs analysis approach for use in the briefing phase of projects. The authors have developed workshop tools to allow high level strategic issues such as management commitment, stakeholder participation, and group dynamics. They conclude that such approaches are only tenable in an overall strategic culture and climate that reviews its score and related activities continually, thereby posing the challenge for continual involvement of FM in the core strategic process.

A second university-focused context appears in Gerard Cesar Gabriel's paper, where he considers the issue of decentralising asset management by using Web-enabled technology. Considering the scope of decentralised asset management as a means of empowering local ownership and accountability for built assets, he notes this enhances the scope to correlate asset management with the local context of the business aims of the organisation. However, as the author observes, such localisation serves to emphasise the criticality of data capture and management, and best practice management.

Staying with the context of focussing management on the business context, Paul Dettwiler and Jan Bröchner (whose chosen paper has already appeared in Vol. 21 No. 3/4 of *Facilities*) report on a study they have been undertaking on how growth companies actually manage their space needs – an area where the facilities dimensions have received little focus to date. Working from a study on six growth companies in western Sweden, they note that as growth companies expand from the entrepreneurial to managerial phase, usually involving relocation, the move tends to involve multi-site operations, and that there is a reluctance to deal with spatial needs through remote work – which they postulate may be driven by concerns over control and/or security.

Igal Shohet (whose chosen paper appeared previously in Vol. 21 No. 1/2 of *Facilities*) has

Facilities
Volume 21 · Number 10 · 2003 · pp. 201-202

Volume 21 · Number 10 · 2003 · 201-202

tackled the relatively complex issue of identifying key performance indicators for the maintenance of hospital buildings, and in his paper reports on research to quantify the effects of users, building characteristics and systems on the performance and maintenance of hospital buildings. The key factors that emerged are integrated in a model for the analysis of performance and maintenance state of hospital buildings. The author notes that it is important to now refine the modelling of the effect of occupancy rate on the rate of deterioration, and also of building surroundings on maintenance.

In their paper, Fong *et al.* look at the issue of energy management. They discuss the development of an evolutionary algorithm and its integration with a simulation programme to allow the energy aspects of mechanical ventilation and air conditioning to be optimised. This extends the use of simulation beyond its conventional application to design into the use phase, and offers scope for feedback analysis of data and optimisation philosophies for in-use versus the assumptions made at design stage. Clearly there is also scope for re-optimisation if needs profiles change.

The papers presented at the symposium represent a bubbling of increasingly integrative issues, and the convergence between asset maintenance management, workplace and facilities management themes. A suite of priority issues and hot topics for the future agenda for cooperative research within the CIB W070 membership emerged. Coming from the symposium as a whole was a clear call for cooperative research activity, to garner synergies from existing research and expertise, consolidate the knowledge base and coordinate the international research faculty. As a result special interest groups have been established for:

- building conservation (contact David Lawrence at: lawre122@msu.edu);
- health care facilities management (contact Igal Shohet at: ishohet@techunix.technion.ac.il);
- facilities/asset performance – measurements and management (contact John Hinks at: J.Hinks@caber.org.uk or Danny Then at: bessthen@polyu.edu.hk);
- asset management and maintenance systems (contact Danny Then at: bessthen@polyu.edu.hk or Keith Jones at: K.G.Jones@greenwich.ac.uk);
- building techniques in renewal and refurbishment (contact Russell Kenley at: rkenley@unitec.ac.nz or Elzbieta Trocka-Leszczynska at: etl@arch.wroc.pl);
- workplace design and implementation issues (contact Bob Grimshaw at: Robert.Grimshaw@uwe.ac.uk or Marie Cecile Puybaraud at: Marie.Puybaraud@uwe.ac.uk); and
- mapping knowledge about building defects and solutions (contact Kenji Motohashi at: ken-moto@kenken.go.jp or John Hinks at: J.Hinks@caber.org.uk)

Please contact us for complete sets of the proceedings for CIB W70 2002 or 2000. The next W070 symposium is due to take place 10-12 May 2004, in Michigan. For further details contact Dr David Lawrence on: lawre122@msu.edu

Danny Shiem-Shin Then and John Hinks
Joint Coordinators of CIB W70

A method for strategic client briefing

Jim Smith
Ray Wyatt and
Norm Jackson

The authors

Jim Smith is Senior Lecturer in the Faculty of Architecture, Building and Planning, The University of Melbourne, Parkville, Australia.
Ray Wyatt is Senior Lecturer at the School of Anthropology, Geography and Environmental Studies, The University of Melbourne, Parkville, Australia.
Norm Jackson is Lecturer in the Department of Building and Construction Economics, RMIT, Melbourne, Australia.

Keywords

Clients, Stakeholders, Strategic management

Abstract

Strategic client briefing is now recognised as an essential component of best practice in facilities management. A number of different briefing approaches have evolved, or are being developed, and this paper presents strategic needs analysis (SNA). It has been applied within six project-inception studies with real clients, for developing and choosing a strategic direction for the project being considered by all the stakeholders. Moreover, a survey of stakeholders was carried out after each study, in order to find out how well participants thought the workshop performed in terms of six key process characteristics. Such key characteristics were further divided into a total of 41 additionally assessed attributes considered as important within the client-briefing process. Analysis of such assessments revealed some interesting positive and negative features. Consequently, the SNA approach was refined. Presents the major findings of the work carried out along with some observations about overall processes, and suggestions for further improving strategic client briefing using SNA or similar approaches.

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Facilities
Volume 21 · Number 10 · 2003 · pp. 203-211

DOI 10.1108/02632770310493571

1 The process

A number of approaches towards the strategic client briefing process have been developed. We begin by briefly introducing what the literature and practitioners say such approaches should aspire to, before explaining how and why we developed our own approach.

1.1 Requirements

Many approaches, such as decision analysis (Coyle, 1972; Raiffa, 1968; Watson and Buede, 1988) aim to create and develop alternative strategies during strategic management activities. However, few of them appear to have been applied to the process that converts the strategy into property investment decisions or corporate real estate to support them. Indeed, Green (1992, 1996), Latham (1994), Egan (1998) and *Chartered Surveyor Monthly* (1998) have highlighted the need for skilled specialist practitioners to bridge the gap between corporate strategy and the development of building projects to realise such strategy.

Any process adopted should occur during the project inception stage. It should confirm and extend the decision to build (new-build, extend, renovate, upgrade, remodel) and it must reflect the environment of the organisation by being sensitive to the strategic direction identified within the strategic management process. The literature also states that any such process should capture the organisation's mission, vision and values that guide the process of considering alternatives that satisfy the strategic direction already determined. The process needs to be useful, flexible, well organised, sensitive to client and stakeholder needs and designed to provide more effective, efficient, innovative and better solutions (Gray *et al.*, 1994; Karma and Anumba, 2001).

Our own discussions of a proposed methodology with several client bodies, consultants, academics and colleagues pointed to a series of additional features that should be incorporated into any strategic client briefing process. However, the challenge was to have a minimum number of characteristics whilst still largely achieving the aim of each suggestion. Thus, in summary any methodology must ideally:

- satisfy the principles of problem solving;
- create a number of strategic options for the future direction of the organisation;
- actively involve a range of different types of stakeholder;
- adopt a rigorous means of decision making;
- allow each participant to contribute to the decision-making process irrespective of their position and role within the organisational hierarchy;
- involve external stakeholders who can contribute to development of a strategic direction;
- challenge organisational assumptions and prescriptive responses to service delivery;
- provide commitment to decisions in order to improve the chances of implementation;
- be supported by senior management through to final decision making; and
- complete the process in as short a time as possible – preferably in a maximum of two days.

In order to satisfy as many of these requirements as possible, we have developed our own approach – strategic needs analysis (SNA). It has been so named in order to capture its essence using a few words that identify its concentration on the strategic efforts of the client and stakeholder group. A feature of the approach is its use of the Strategizer (Wyatt, 1995a, b, 1999) software for decision making in SNA applications.

1.2 Our chosen approach – SNA

SNA was designed with the aim of making a positive contribution to the inception of a project. It also starts with the premise that the solution delivered will be the most appropriate to satisfy stakeholders' strategic needs and this is likely to be, but may not always be assumed to be, a construction project. SNA also reflects, and is sensitive to, the strategic direction identified within the strategic management process and so overlaps it. Indeed, strategic management (Viljoen, 1994; David, 1997; Thompson and Strickland, 1995) and problem-solving approaches (Ackoff, 1978; Popper, 1994) have much in common.

The process is based on the involvement of as many significant stakeholders as is practically possible. These are representatives, direct and indirect, who may have an interest in, and can make a contribution to, the proposed project. They include:

- the owner;
- managers, executives, facility managers, project manager(s);
- staff or employees;
- purchasers, sub-contractors, suppliers and other process or service providers;
- tenants, residents, community representatives, neighbours;
- visitors, customers, potential and future customers, users, partners or interest groups;
- design team members (if appropriate); and
- others, depending on the project and attitude of the organisation to participation, and involvement in the process.

This stakeholder group should ideally include members of the client group from the strategic to the operational levels of the organisation. Clearly, it should involve some participants who have an interest in the service, product or possible facility. An essential aim of the process is that stakeholders should broaden and re-orientate their frame of reference in defining projects from the prescriptive and standard response, to one where they have a strategic view of their own organisation's true goals, objectives, needs and requirements. Any identified options must be consistent with the strategic direction enunciated by the organization in its strategic management processes and statements.

In short, whatever the approach adopted during the project inception stage(s), we aim to implement a broad-based process that can deliver the following benefits:

- recognition of the opportunity created by the decision to build;
- client commitment to the project;
- greater client understanding of the brief and the problem(s) it is attempting to solve;
- clearer formulation of the service needs, functional requirements and objectives;
- improved versatility or flexibility of the selected project option because a more thorough evaluation of its purpose has been carried out;
- dissemination of client and user information to the design team; and

- broad discussion of the proposed activities within the new facility by all the participants.

Hence the objectives of SNA are to:
- develop a service vision for the organisation based on a clear understanding of the use and demand for such services;
- involve as many as possible of the existing and potential stakeholders in the definition of alternative strategies;
- identify many realistic alternative strategies for the achievement of the vision;
- analyse the alternative strategies with the stakeholders;
- decide on a preferred strategy; and
- assist in the preparation of the performance brief to guide the later, more prescriptive, design or project brief.

Finally, it recognises that in a strategic environment the options or choices facing the decision maker(s) may not, and often cannot, be fully described. It accepts that information at this stage is not exhaustive or perfect, but nonetheless a decision to set the course for the project has to be made. So SNA probably represents an effective decision gatekeeper for reflecting on the choices, possibly introducing a new one (or new ones) not previously considered and then confirming the agreed choice.

1.3 Mechanisms within SNA

The SNA process uses standard planning workshop, problem-solving techniques (Popper, 1994; Lichfield *et al.*, 1975; Rosenhead, 1989; Checkland and Scholes, 1990) and progresses through the following major activities:
(1) collect information to understand the nature of the problem;
(2) discuss and analyse the problem;
(3) develop options to solve the problem;
(4) decide on a preferred option or direction; and
(5) make a recommendation to implement the preferred option.

In practice, SNA is a three-stage process:
(1) information seminar (understand the problem);
(2) workshop one (develop appropriate options to solve the problem); and
(3) workshop two (decide and recommend).

The structure is shown diagrammatically in Figure 1.

SNA aims to not only achieve involvement of all the stakeholders, but also to ensure senior management is committed to the process and the outcome. It is a process designed to define clearly the problem that needs to be solved by the design team, and so provide a solid base for the project to succeed (Smith *et al.*, 1998). It should create a suitably defined project (for this early stage) that suits the stakeholders' needs whilst ensuring client and stakeholder satisfaction.

1.5 Outcomes of SNA

The product of any SNA workshop is an agreed strategy, which should satisfy the organisation's strategic requirements and should result in a decision to proceed with the project. This strategy in most cases is a built facility, in which case a performance brief will be prepared, by the stakeholders, in order to guide the design team. For an organisational arrangement strategy, a detailed statement of its requirements is developed that will consider the financial, human resources, social and other implications of its implementation.

Since a built facility is the most likely chosen strategy, a performance brief will document decisions in performance terms, stating the outcomes required, rather than a prescriptive way of how to do it. The designer will have to develop the project within the parameters defined in the brief, which will guide, but should not inhibit, the actual built solution.

2 Six applications of SNA

SNA was used on six studies during the project inception (pre-design) stage where guidance was needed to assist the client and stakeholders in defining the strategic direction for the organisation or in the providing of new facilities. The type of problem addressed in each study is shown in Table I. It can be seen that a broad range of perspectives was considered in each one. The types of study range from the truly strategic (college and yacht club) through the analysis of content within proposed facilities (youth training, faculty relocation and council) to an almost macro-strategic focus within an identified project (lighting lab).

Facilities
Volume 21 · Number 10 · 2003 · 203-211

Figure 1 The SNA process

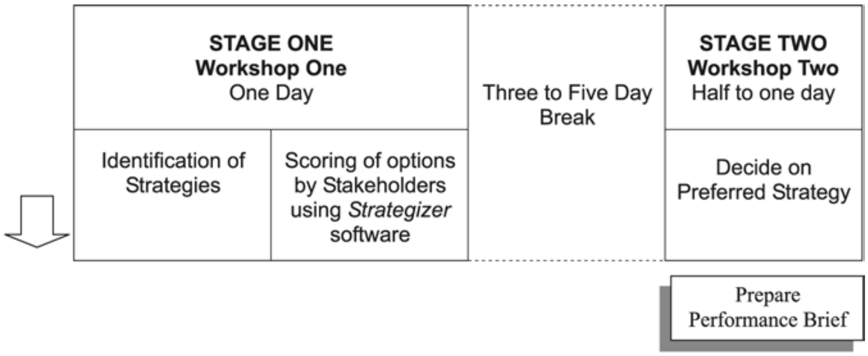


Table I Case studies

Case study	Problem	No. at workshop	Per cent return
1. Lighting lab	University property division and school making decisions on the type of teaching and research space to be planned and provided	15	73
2. College	Tertiary institution considering its strategic plan in relation to the type and need for educational facilities	42	86
3. Youth training	Government design group and juvenile justice department reviewing its master planning for a new facility within its present system	10	80
4. Faculty relocation	A university property division organising a faculty transferring to a new campus with a review of the type and form of facilities to be provided	11	45
5. Yacht club	Identification and selection of suitable options for the future development of the marina facilities in a sensitive area of city redevelopment	8	63
6. Council	Preparation of a performance brief for a new site for the redeveloped library facilities in a shopping precinct including identifying potential joint uses in the new facility	15	60
Totals		78	77

Nonetheless, in each of these studies, SNA, was able to inform, guide, define options and decide.

2.1 Criteria used in post-workshop surveys

For each of these studies a survey of stakeholders was carried out immediately following the final workshop and the numbers and response rate is also given in Table I. The survey collected participants' views and opinions about the effectiveness of the structure of the process, the software, workshop decisions and general comments.

A further survey some weeks after the completion of the study elicited participants' views on a number of key attributes forming the basis of this research:

(1) A. Management commitment (strategic);
(2) B. Stakeholder participation;
(3) C. Group dynamics;
(4) D. Workshop organisation;
(5) E. Tools; and
(6) F. Process (problem solving).

These six broad categories were further sub-divided into individual attributes under each category in order to carry out decision-making attributes assessment. The latter used a questionnaire survey in an attempt to integrate theoretical concepts with results from the practice of using SNA (Barrett and Stanley, 1999). In essence, these attributes provided the framework for assessment of this model of the project inception stage.

The final list of 41 attributes in all six categories is summarised in Table II.

2.2 Results of post-workshop surveys

All workshop participants were asked to score each of these 41 criteria in terms of how much they initially thought each one would be achieved at the workshop ("practice/ forecast"), how much it was actually achieved at the workshop ("practice") and how important it was in theory ("theory"). Rankings of respondents' scores are shown in Table III.

Facilities
Volume 21 · Number 10 · 2003 · 203-211

Table II Workshop-assessment criteria – decision-making attributes framework

A. Management commitment (strategic)	
A1.	Searching/aspiring to highest possible quality decision
A2.	Support for process by senior management
A3.	Ongoing commitment to workshop decisions
A4.	Support by capital works (assets) division
A5.	Involvement by senior management
B. Stakeholder participation	
B1.	Involvement by all potential internal representatives
B2.	Involvement by all potential external representatives
B3.	Stakeholder commitment to process
B4.	Significant contributions
C. Group dynamics	
C1.	Honesty (not role playing)
C2.	Suspension of political agendas
C3.	Shared vision
C4.	Levels of consensus
C5.	Success at generating ideas, new approaches
C6.	Working as a team
C7.	Extent of participation
D. Workshop organisation	
D1.	Aim adequately defined
D2.	Process defined followed
D3.	Participation encouraged
D4.	Level of manipulation
D5.	A learning experience
D6.	Challenge assumptions
D7.	Client/customer focused
D8.	Earnest organisation
D9.	Willingness to use all tools
D10.	Aim achieved
E. Tools	
E1.	Level of acceptance generally
E2.	Ease of understanding criteria
E3.	Ease of using software
E4.	Understanding output
E5.	Contribution to personal understanding
E6.	Contribution to decision
F. Process (problem solving)	
F1.	Quality of information provided
F2.	Awareness of participants of problem context
F3.	Problem defined
F4.	Problem discussed
F5.	Options generated
F6.	Clear decision made
F7.	Decision agreed
F8.	Decision supported
F9.	Decision implemented

Analysis of the Table III results was then carried out using the SPSS statistical software package. A number of significant correlations (five) were identified between different pairs of theory/practice scores, but no inferences could be clearly made from them. A larger number of significant correlations (16) were identified between theory/theory and practice/practice of attributes probably due to an overlap in the attribute(s). Also, a regression analysis that tried to predict theory scores on the basis of practice scores was made in order to test whether the workshop experience tended to alter respondents' attitudes about the theoretical importance levels of certain criteria. But results here were inconclusive.

The attributes were then ranked (one to 41), where attributes with the closest alignment between theory and practice scores (1.00 or lower) were ranked higher. The full list of rankings on this basis is given in Table III.

The ten most satisfied criteria (24 per cent of the total 41 criteria), placed in their categories, are shown in Table IV. The order of ranking on the theory/practice performance scale are shown in brackets in column two. The proportion of attributes in each category in this top ten listing are also shown in column three of the table. By classifying these attributes, a good impression is gained of the features of SNA that appear to be working effectively.

An interesting feature of this analysis is that none of the attributes in management commitment or group dynamics is included in these top-performing criteria.

In contrast, the eight most poorly performing attributes on the same theory/practice scale are shown in Table V. Similarly, their rank in the 41 attributes is shown in column two in brackets.

The major negative category in terms of better performance in SNA is concerned with "managerial commitment" (see Table IV). Whilst all the other categories have one attribute on the poorly performing list, the "managerial commitment" category fares the worst.

Accordingly, our conclusion is that there are some features of SNA that need reinforcing, or require more determined implementation, such as the "information seminar". The other feature that participants noted as making a positive contribution to "stakeholder participation" and "group dynamics" is the introduction of small group(s) options-development teams into workshop one and accepting that this change extends this workshop by an additional half or full day. The other feature that was

Facilities
Volume 21 · Number 10 · 2003 · 203-211

Table III Scores for workshop-assessment criteria

Attributes (1-41)	Practice/forecast Index	Practice/forecast Ranking	Practice ranking	Theory ranking
D2. The process defined must be followed	1.12	1	8	36
E6. Use of the tools must contribute to decision	1.13	2	32	40
F5. Options generated must be realistic	1.13	2	4	22
F4. Problem must be discussed adequately	1.14	4	16	7
F2. Participants must be aware of problem context	1.19	5	9	7
D5. It should be a positive learning experience	1.20	6	11	30
B2. Involvement by all external representatives	1.21	7	35	40
E5. Activities/process contribute to understanding	1.23	8	15	31
D8. Competent organisation of workshops essential	1.25	9	1	7
D3. Broad participation should be encouraged	1.26	10	5	19
D4. There must be low levels of manipulation	1.28	11	31	37
F3. Problem must be properly defined	1.28	11	7	1
D10. Basic aim must be achieved by process	1.30	13	13	26
F7. Important decision is agreed by participants	1.31	14	27	33
C3. Agreement on a shared vision is essential	1.33	15	31	36
E3. Tools (software) must be easy to use	1.34	16	15	12
C5. The group should generate new ideas	1.37	17	2	5
D9. Participants must be willing to use all tools	1.41	18	21	27
E4. Understanding of output is essential	1.41	18	10	16
F6. Clear decision on final direction must be made	1.41	18	27	28
E2. Easy understanding of criteria for assessment	1.43	21	19	25
C4. Reaching a high level of consensus important	1.46	22	27	28
D6. Participants must challenge some assumptions	1.49	23	13	14
C6. Participants should work effectively as a team	1.50	24	21	24
D7. There must be clear client/customer focus	1.51	25	21	19
A5. Involvement by senior management	1.52	26	21	19
C1. Honesty (not role playing) is important	1.53	26	38	32
C2. Participants should suspend political agendas	1.53	28	40	38
B1. Involvement by all internal representatives	1.56	29	12	9
A4 Support by capital works division	1.61	30	30	19
B4. The opportunity for significant contributions	1.61	30	15	9
F9. Decision must be implemented	1.63	32	41	38
F1. Information provided must be appropriate	1.65	33	3	5
D1. Aim should be clearly defined	1.70	34	5	3
F8. Decision must be supported by participants	1.75	35	33	17
B3. Stakeholder commitment to process	1.77	36	25	9
C7. Extent of participation should be broad	1.77	36	25	9
A3. Ongoing commitment to workshop decisions	2.02	38	39	17
A1. Searching for highest quality decision	2.03	39	20	1
A2. Support for the process by senior management	2.27	40	35	4
E1. High level of acceptance of tools in process	2.32	41	35	33

recognised particularly in the final case study (council) was the structuring of the options by the introduction of the purpose-designed software for situation structuring.

When these features are added to our basic model illustrated in Figure 1, the SNA process now takes on a structure represented in Figure 2. The formal addition of the "information seminar" is made to the structure; the small group options development is introduced into workshop one, as is the discretionary use of the situation structuring software (Dickey, 1995) to assist in the activity of options identification.

3. Implications for improved practice

One of the major lessons of this paper is that neither SNA nor any other approach can

Facilities
Volume 21 · Number 10 · 2003 · 203-211

Table IV The top ten practice/forecast criteria in categories

Category	Attribute	No. out of total in category
A. Managerial commitment	None	None of five (0 per cent)
B. Stakeholder participation	B2. Involvement by all external representatives (seven)	One of four (25 per cent)
C. Group dynamics	None	None of seven (0 per cent)
D. Workshop organisation	D2. The process defined must be followed (one) D5. It should be a positive learning experience (six) D8. Competent organization of workshops essential (nine) D3. Broad participation should be encouraged (ten)	Four of ten (40 per cent)
E. Tools	E6. Use of the tools must contribute to decision (two) E5. Activities/process contribute to understanding (eight)	Two of six (33 per cent)
F. Process	F5. Options generated must be realistic (three) F4. Problem must be discussed adequately (four) F2. Participants must be aware of problem context (five)	Three of nine (33 per cent)

Table V The bottom eight practice/forecast criteria in categories

Category	Attribute	No./total
A. Managerial commitment	A3. Ongoing commitment to workshop decisions (38) A1. Searching for highest quality decision (39) A2. Support for the process by senior management (40)	Three of five (60 per cent)
B. Stakeholder participation	B3. Stakeholder commitment to process (36)	One of four (25 per cent)
C. Group dynamics	C7. Extent of participation should be broad (37)	One of seven (14 per cent)
D. Workshop organisation	D1. Aim should be clearly defined (34)	One of ten (10 per cent)
E. Tools	E1. High level of acceptance of tools in process (41)	One of six (17 per cent)
F. Process	F8. Decision must be supported by participants (35)	One of nine (11 per cent)

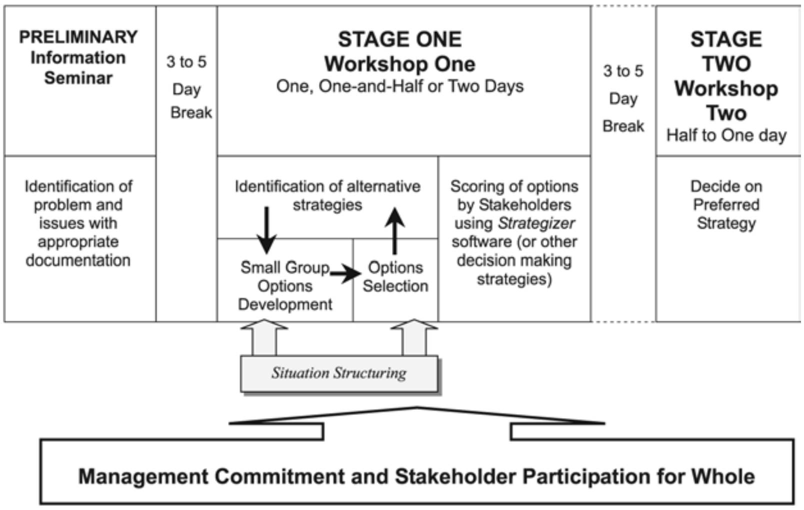
properly succeed unless it is sustained by a climate within the organisation that supports a strategic culture and environment that continually demand better ways of running its core business and related activities. If the organisation is not prepared to adopt a strategic management approach linked with corporate strategy where it aims to improve its performance continually, then this process is not likely to succeed.

A characteristic of the ideal situation is that the organisation creatively questions and justifies its own activities at the most fundamental level. The organisation must not complacently accept that the historical way of providing services should necessarily be projected indefinitely into the future. As a consequence, a problem-solving approach, combined with a demanding strategic management environment encompassing a greater number of stakeholders in the decision-making process, will generate the reward of alternative solutions and methods of problem solving that are more effective.

For over two decades clients and design teams have recognised that it is during the early stages in the life of a project where most of the critical decisions are made. However, progress towards greater involvement in this stage by the various built environment disciplines has been substantial. Lack of a client may be one of the major reasons why this has not occurred, but another reason may be the absence of suitable tools, techniques and approaches to assist the client team during these strategic stages of decision making.

This research proposed one methodology to enable clients, stakeholders and their design team advisers to work together. Clients need to be made aware of such approaches and it is only through use and practice that these approaches will become accepted as standard procedure. So, clients, project managers and design team members should work more closely to ensure that good advice is available at the project inception stages.

Figure 2 The restructured SNA process



In parallel to these client-based activities and awareness programmes, the professional bodies in the built environment (architects, engineers, project managers, urban planners, facilities managers and property advisers) should identify and target project inception, as well as the decision to build, for greater definition than they presently have in their standard "plans of work". That is, decision point(s) and time lines and the potential participants should be identified, together with a recommendation about possible techniques and approaches. An initial awareness program may bring this stage to the attention of clients and peak industry bodies (such as the Property Council of Australia and the British Property Federation). The latter should be encouraged to make their members aware of this stage and the assistance that can be enlisted from various sources.

However, as this research has shown, the commitment of the client group through its senior management is the crucial factor in achieving a successful outcome. None of the many techniques or initiatives being developed can succeed without honest client support, commitment and interest.

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Facilities
Volume 21 · Number 10 · 2003 · 203-211

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The impact of facilities on student choice of university

If Price
Fides Matzdorf
Louise Smith and
Helen Agahi

The authors

If Price is based at the Facilities Management Graduate Centre, Sheffield Hallam University, Sheffield, UK and holds an Adjunct Chair in Facility Management, University of Technology, Sydney, Australia.
Fides Matzdorf, **Louise Smith** and **Helen Agahi** are all based at the Facilities Management Graduate Centre, Sheffield Hallam University, Sheffield, UK.

Keywords

Higher education, Students, Facilities, Assessment

Abstract

Despite rhetoric of added value, facilities management suffers a dearth of objectively researched, publicly available information concerning the impact of facilities on businesses at the level of market sectors or individual organisations. This paper aims to correct that situation for UK higher education institutions. A survey of undergraduates starting university in 2001 has confirmed, to high levels of significance, earlier research with the 2000 intake. For many institutions, facilities factors, where provided to a high standard, are perceived as having an important influence on students' choice of institution. Year-on-year comparisons show strong agreement at the global level and, where data could be gathered, at the institutional level. Individual institutions show marked differences, significant at levels of confidence of over 95 per cent. A comparison of "reputational pull" and "facilities pull" is suggested as a means of differentiating the "brand" of different institutions.

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Facilities
Volume 21 · Number 10 · 2003 · pp. 212-222
© MCB UP Limited · ISSN 0263-2772
DOI 10.1108/02632770310493580

Introduction

The paradox of facilities management's (FMs) claims for strategic or value adding status on the one hand, and the subject's largely operational rhetoric on the other (Grimshaw, 1999), has become widely recognised in recent years. This has raised concern that the subject has failed to produce convincing evidence of its contribution to "businesses" (Duffy, 2000). An intensive literature review (Haynes *et al.*, 2000) seems to confirm the problem, and FM faces the challenge of either demonstrating its contribution or being limited to a relatively specialised future as the discipline of maintenance management (Price, 2002; Lord *et al.*, 2002): Nutt's and McLennan's (2000) operational trail. The nature of the "business critical" contribution of FM varies with sector (Price, 2002) and requires specifically tailored research evidence.

Various critical impacts of facilities on the "business" of a university might be considered, depending in part where a particular institution is positioned, or aspires to position itself, on the widening strategic space of research and teaching options (Matzdorf *et al.*, 1997; Price and Kennie, 1997). Facilities could for example be essential to attract key research personnel, or to provide environments for faster knowledge creation. Its impact on student perceptions of their pedagogic experience (Fleming and Storr, 1999) is not widely appreciated in the literature on lecture theatre design or pedagogy. Meanwhile, conventional government-funded and student-funded undergraduate teaching remains a significant, and for many institutions still a dominant, proportion of income. This study investigates the degree to which facilities and locational factors influence the decisions undergraduates make when choosing where to study: effectively the impact of the facility on a core group of customers.

The research was sponsored by members of the FMGC Higher Education Research and Application Forum, whose assistance and collaboration is gratefully acknowledged. The authors also thank HEFCE Estates for support for data processing. The conclusions are the authors' own.

Literature review

Investigations into the process through which potential students determine their choice of university have increased over the past decade, though the subject seems to have received more, and earlier, attention in the USA (Discenza *et al.*, 1985; Hossler and Gallagher, 1987; Hossler *et al.*, 1989; Heubner, 1989; Roberts and Higgins, 1992; Bredo *et al.*, 1993; Lauren, 1993; Galotti and Mark, 1994) where a marketing need came earlier than in the UK. In turn this means exploring the mechanisms through which decisions are made, the perceptions that potential students have of the university, and the contribution that these perceptions make to attracting or deterring application. In general the literature does not treat facilities as a potential differentiator or subject them to separarate research. Our understanding, based on conversations with estates directors or equivalent, and on more than five years of research in FM for HE, is that most university marketing surveys pay comparatively little weight to facilities-related factors, despite evidence of their impact on the student experience (Green *et al.*, 1994, cited in Yorke, 2000) and by reviews of literature on lecture theatre design and learning experience, which found a wide (and unbridged!) gulf between the architectural and pedagogical approaches (Fleming and Storr, 1999).

The term "student-institution fit" (Banning and McKinley, 1980; Banning and Banning, 1986, p. 1) has been suggested to examine:

> . . . the degree of congruency, or fit, between student characteristics and the ability of the institution to respond to those characteristics.

Characteristics of the student should fit with the ability of the institution to respond adequately to those characteristics, ultimately leading to increased student satisfaction, academic achievement and personal growth. Student enrolment and retention are determined in the theory by three sets of variables that comprise student-institution fit:

(1) Characteristics of the students such as their personal goals, abilities, needs, interests and values.
(2) Characteristics of the institutional environment, including the physical, academic, social and psychological variables, where facilities management has the most impact. Included in this variable is the physical design of the campus, such as its openness, privacy areas and wall decorations.
(3) The outcomes resulting from the interaction of the student with the environment. This will have an impact on the student's academic achievement, satisfaction and persistence within the institution.

Aspiring students today can apply for up to six places on many different degree courses offered by over 200 educational establishments. The vast range of degree courses and institutions available to them makes the decision-making process rather complex. As Tackey and Aston (1999, p. 2) argue:

> The feasible range of options are limited by a variety of factors but mainly educational qualifications, geographical mobility and financial considerations.

Marketing literature concentrates on the decision-making process which consumers go through before purchasing a product. Kotler and Armstrong (1994) describe the stages through which buyers supposedly pass to reach a buying decision. Need recognition is triggered when the buyer recognises a need or a problem. It is followed by information search, an evaluation of alternatives and a purchase decision. According to Kotler and Armstrong (1994), the purchase decision derives from the consumer ranking the alternatives to formulate a purchase intention. Two factors may however intervene. The first is the attitude of others, whose influence will depend upon both the strength of the other person's attitude towards the buying intention and the consumer's motivation to comply with that person's wishes. For the potential student this could include parental attitudes and opinions to their child's university and course choice. The second is unexpected situational factors. Such unexpected situational factors for the potential student could be:

- the failure to achieve the grades needed to warrant the course and university they had decided upon;
- achieving higher grades than expected, opening up opportunities for universities or courses not previously considered; or

- alternatively, being offered a good job subsequently leading to further alternatives.

The Institute of Employment Studies (Connor *et al.*, 1996; Tackey and Aston, 1999) surveyed over 20,000 students applying for entry to a full-time undergraduate course at a UK university or college in 1998. Questions were asked on who they regarded as being most influential on their choices, their perceptions of the costs of going to university, the likelihood that they would seek paid employment while studying, and views on their chosen university. For the information-gathering stage of the decision-making process, students consulted traditional sources such as UCAS handbooks and prospectuses, and made visits to the universities. More IT-based information, such as Web sites and CD-ROMs were least used overall. Cost was a significant factor in the choice process of the location of university. It encouraged students to consider choosing a university close to home. For the population included in this research, the most important factor when choosing a university was the course. Factors relating to the facilities management function of the university which were rated as being important were the "overall image of the university" and the "social life at university and social life nearby". Of lesser importance relating to FM were "accommodation for first years", "safety and security" and "sports facilities" (Tackey and Aston, 1999, p. 42).

Discenza *et al.* (1985) questioned US students about the importance they assigned to various considerations in selecting a university. Medium to least important FM-related variables were "location", "housing facilities", "social/cultural/ entertainment activities", "athletic facilities" and "dining facilities". Courses offered were once again the most important variable. Roberts and Higgins (1992) questioned students who had studied at the universities for a year and found the most criticised aspects of their university relating to FM were "poor facilities", "housing/accommodation", "buildings/site", "Students' Union", "overcrowding", "social/sports", "security and lighting", "canteen" and "split site". The best-rated FM-related aspects included "environment", "academic facilities", "sporting facilities" and "Students' Union". For first-year students the availability and quality of accommodation was found to be of high importance, and as such should be an important part of the marketing mix when recruiting students.

An ongoing UNITE/MORI study (MORI, 2001, 2002), sponsored by one of the main players in the field of private student accommodation, covers a range similar to that of Connor *et al.* (1996) and explores students' choice of university as one of the aspects of "student living". Their 2001 survey identifies "location" and "social facilities in town/city" as the second- and third-highest priority factors after "course", with "able to live at home", "close to my family", "able to travel home at weekends" and "social facilities at university" also among the top ten factors influencing students' choice. These ratings were generally confirmed in the 2002 follow-up survey (MORI, 2002, p. 13). However, the number of students for whom "social facilities" were important fell from 24 per cent to 20 per cent, whilst most other location-related factors showed either the same or an even higher level of importance in the second survey (MORI, 2002).

Overall, the results quoted above are somewhat patchy, and the research so far has made no attempts to draw institution-specific comparisons: a gap that this project was designed to fill.

Research methods

Access for the research was granted by institutions who participate in FMGC's Research and Application Forum Higher Education. Practical reasons of sample size dictated a questionnaire-based survey and, in consultation with forum members, a survey instrument was designed and piloted on the 1999 student intake. A total of 87 closed questions sought rankings of importance on a standard five-point Likert scale defined as "essential", "important", "neither important nor unimportant", "unimportant" and "not important at all". These categories were scored from 5 to 1 respectively. A total of 12 questioning modules were included, among them "type of university", "reputation of town/city", "accommodation", "learning facilities", "university security", "transport", "social facilities", "sporting facilities", "childcare facilities" and "university environment". Scores of 3.75 and above are classified as "important", 3.25 and lower as "unimportant". Ratings of 4 or above are considered as "highly important". Before the closed questions two open-ended questions asked students to list up to three reasons why they chose a particular university and three reasons why they did not choose an alternative institution.

The methods of distribution of questionnaires varied. Some facilities/estates departments were not able to secure the collaboration of the registry or marketing department at all. Some distributed the questionnaire in the offer package, others in freshers' week or with offers of accommodation. Where all first-year students were accommodated in halls of residence (under central administration), questionnaires were given out and collected there. Wherever we can identify potential bias, this is highlighted below. The problems do illustrate the generic issue of FM visibility. Across the majority of the universities, access to students was closely "guarded" by the university's Academic Registry. Often this part of the university was unaware of the Forum membership and details had to be provided before access to the students was even considered. In some institutions, access to students was entirely dependent on individual faculties'/schools' co-operation, whilst others organised distribution and collection centrally. From several participant institutions, we got the reply "Oh no, not another questionnaire!", as freshers were already "inundated" with information packs and survey questionnaires. This raises questions about the relationship between facilities providers and their customers – if one cannot reach the other, how can the providers be expected to deliver good value to their customers? Some institutions did not see the need for "another" survey, since they had already embarked on an in-house data-gathering exercise (e.g. student satisfaction surveys). These surveys would indeed complement our research, but would not provide data beyond the individual institution, and therefore not allow for comparison with other institutions and across the sector.

The pilot tests nonetheless proved robust and two surveys were conducted with samples from the 2000 and 2001 intake. Response rates are shown in Table I. In total the responses cover more or less the full spectrum of universities from Russell Group members to the "post-1992" sector; but the sample is limited to England and excludes the "research élite", the group of institutions in the top six places of various RAE league tables.

In terms of statistical validity, the total sample has Cronbach-Alpha values of 0.95 (year 1) and 0.96 (year 2), indicating a very high level of internal consistency – values of 0.7 and above are normally considered to be significant.

Overall findings

Closed questions

In both surveys a higher proportion (between 52 per cent and 70 per cent) of female students responded; in fact, the proportion (52 per cent) was unchanged in University A which returned significant numbers in both surveys. The two surveys did not show overall differences in age range of students, geographic origin, ethnic origin or course; however, significant differences were found between individual institutions (see below).

In the 2000 survey 12 factors had average importance scores of 4 or above. In 2001 this number fell to 11, though the differences are small (Table II). The top eight factors, on average, are identical. Of the top six, two might be considered entirely pedagogical: "course" and "teaching reputation". Four relate to impressions of the study facilities. Of the next six, in both surveys, four might be considered "pure" facilities factors, and two might be influenced by facilities. The evidence provided by the 2000 survey, namely of the importance of factors other than academic reputation in decision making, was confirmed in 2001.

For reasons of confidentiality individual institutional data cannot be published; however, it is important to note that for University A, the only participant to return a statistically significant sample in both years, the order of the highest items was unchanged and average scores varied by no more than a trivial ±0.02.

Table I Response rates for 2000 and 2001

University code	Year	Questionnaires out	Responses	Response rate (per cent)
A1	2000	2,600	1,245	47.9
A2	2001	2,000	1,228	61.4
B	2001	5,000	1,714	34.3
C	2000	3,000	438	14.6
D[a]	2000	7,000	1,106	15.8
E	2000	2,500	244	9.8
F	2000	2,700	353	13.1
G	2001	3,550	552	15.5
H	2001	1,200	358	29.8
I_1	2000	4,000	844	21.1
I_2[b]	2001	n/a	78	n/a
J	2000	7,000	412	5.9
L	2000	400	32	8.0
O	2000	500	138	27.6
Sub-total	2000	29,700	4,812	16.4
Sub-total	2001	11,750	3,930	35.3
Total		41,450	8,742	21.1

Notes: [a] Numbers of University D are estimates, since distribution was very decentralised and the exact number of questionnaires given out could not be established. A higher estimate obtained said: 11,000 questionnaires out ⇒ response rate 10 per cent, total 33,700, average 15.8 per cent; [b] University I could not put a large-scale distribution process in place before term, hence arranged for individuals to be surveyed by a postgraduate student. Strictly speaking, the 78 questionnaires make up a response rate of 100 per cent, but this would seriously skew the overall response figures

Table II Average ratings of 4 or higher in the two surveys

Item	2000 average	2000 ranking	2001 average	2001 ranking
Had the course you wanted	4.84	1	4.80	1
Availability of computers	4.48	2	4.41	2
Quality of library facilities (e.g. availability of books, journals, CD-ROM, IT)	4.47	3	4.41	3
University had a good teaching reputation	4.35	4	4.29	4
Availability of "quiet" areas (e.g. library, study rooms)	4.23	5	4.22	5
Availability of areas for self-study (e.g. group work areas)	4.16	6	4.21	6
Quality of public transport in the city/town	4.07	7	4.13	7
A friendly attitude towards students	4.05	8	4.04	8
Prices at the catering outlets	4.01	9	4.00	13
Cleanliness of the accommodation	4.00	10	3.92	15
Quality of the university grounds	4.00	11	3.94	18
Availability of university-owned accommodation	4.00	12	4.00	14
Quality of lecture theatre facilities	3.90	18	4.03	9
Quality of bars on campus	3.90	19	4.01	11
Union social facilities	3.92	17	4.01	12
Diversity/range of shops at the university (e.g. banks, bookshop, travel agents, food)	3.95	15	4.01	10

Open-ended questions

All responses were coded in 2000 and assigned to categories. In 2001 we found that no new categories emerged, hence the same categories were used. Since the number of reasons given varied between one and three per respondent, and, for reasons against other institutions, between none and three, the percentages given here are in relation to the total of reasons given, not respondents. In total, 22,627 "reasons for" and 16,855 "reasons against" were analysed. In general the average results from the two years are strikingly similar for items universally mentioned in 3 per cent or more of reasons given (Table III). In each case individual items at particular institutions also attracted a 3 per cent rating:

Table III Open-ended items cited by at least 3 per cent of respondents in each institution in each year

	2000 average (%)	2001 average (%)
Reasons for choosing a university		
Course/subject	22.2	20
Reputation of course/department/school/university/league tables	18.2	18
Convenient location/proximity to home	10.4	10.5
Location	6.7	7
Facilities resources	6	5
Reasons for deciding against alternative institutions		
Course not suitable (in some way or other)	20.5	13.5
Quality/standards/reputation/league tables	9	8
Did not get grades/no offers, etc.	5.5	6
Distance too far	10.5	12
Location	7.5	7.5
Did not like area/place/city unfriendly, etc.	5	5.5

Note: The average score is the average of mean results overall and mean results by institution

The one big change is in the frequency with which course was mentioned, especially as regards a reason for not choosing other institutions but also as a reason for choice. It appears that the availability of a particular course is becoming more of a "hygiene" factor; something which is essential but is not seen necessarily as differentiating one institution from another.

Inter-organisational differences

General observations

Both the above comparisons point to the survey instrument being reliable and capturing real preferences consistent from year to year. However, a look beyond the apparent homogeneity of the averages reveals major differences between institutions. In 2001 the number of factors rated "4+" (four or above) varies from a minimum of eight to a maximum of 32, with two distinct groups, one consistently with ten or fewer factors and the other with 23, 26, 31 and 32 factors respectively. The groups did not correlate with university type. Each included at least one "modern" university and at least one research-led institution. They did correlate with visual estimates of campus quality in that two of the "high scorers" are based on single, well maintained campuses, and the others are institutions that, although on multiple sites, are known to us for having made strategic investments in upgrading their estate (and reducing net costs in quality driven approaches to estates and facilities management). There was then evidence that where the estate has been treated as a strategic asset it figures more prominently in students' perceived reasons for choosing a particular institution. Not surprisingly, the four institutions with more factors in the 4+ rankings had higher overall scores for the importance of facilities-related factors in student choice. In 2002 the situation was more complicated. University A was confirmed in the "facilities-attractive" group with 26 4+ factors, and a further participant known to have invested in new campus facilities recorded 24 4+ scores. At the opposite end, a participating institution without campus investment joined the low-scoring group with eight high-importance factors. However an "intermediate" position was established by a university that registered 18 4+ ratings, whilst the institution which had scored most strongly in 2000 had only 15 factors rated as important in the second round, albeit from a much smaller sample, which was also taken fairly late (halfway through the first term). Furthermore, the same institution had, in 2000, distributed its questionnaires by sending them out with accommodation offers. Since the university could only offer approximately 70 per cent of freshers places in university-owned or -managed accommodation (80 per cent in 2002), this distribution method carried the risk of an accommodation bias in the 2000 sample. For both this reason and the low 2001 response numbers, the results for this institution had to be viewed with some caution. Clearly some bias can be expected, although the latter sample was too small to skew the overall results. Nevertheless, this prompted us to examine distribution methods in other high scorers, all of whom confirmed that efforts had been made to distribute to all students, not just those entering university-owned accommodation.

The availability of a desired course was universally rated as the most important factor in every institution, though even here the level of importance attached to this factor showed significant differences (at the 99 per cent level) between the three highest-scoring institutions and the lowest-scoring one. Notably the latter institution had higher ratings for a number of factors relating to the university environment and facilities. Where universities possess a particularly distinctive location and campus, the survey results clearly indicate that this is a marketing lever.

Apart from the number one item, "course", there is no consistent ranking throughout all institutions. The "availability of computers" is universally one of the top three items, sometimes relegated to third place by the "availability of library facilities" and in one instance by the university's teaching reputation. "Quality of library facilities" reaches the top three in all but two instances: one case is the institution where "teaching reputation" scored as particularly important, the other one where (by a statistically insignificant margin) the importance of library facilities was edged into fifth place by the "cleanliness of the accommodation"!

Academic factors

In a survey aimed at discriminating the relative importance of facilities factors only two strictly academic criteria were entered: the university's reputation for teaching and for research. The former is reported as much more important (in fourth place overall) than research reputation, which sits far down the list in fiftieth place. The overall correlation between the two is weak (0.46 in 2000).

Teaching reputation receives very high importance ratings in two institutions. One, an "élite" research-led institution, scores significantly higher (at the 99 per cent plus level) than all the others, except the second one, a modern university. That institution scores significantly (95-99 per cent) higher than four of the remaining six. At the opposite end of the ratings, one institution scores significantly less, at the 99 per cent level, than five others. We have not tested whether higher scores for importance reflect students' perceived judgement of the actual quality of any factors, though many individual differences (see below) suggest they do. To whatever extent the differences in perceived teaching quality reflect a reality, they are either disturbing or encouraging news for three institutions in particular.

To some extent the answers to the ratings for the importance of research reputation support the conclusion that judgements about actual quality are being made. One top-tier research-led institution scores significantly more highly (at the 99 per cent level) than all but two institutions, one a modern university and one not. A second institution in the same league, whilst clearly showing significantly higher scores than four others, scores significantly less than the first. The institutions for whom reputation for teaching is particularly positively or negatively relevant are not those for whom research reputation is markedly different.

Other non-FM factors

"Proximity to home" was significantly less important (at 99 per cent) for entrants to one of three "research led" institutions – lower than all but one other participant. It was also significantly less important for freshers at one new university than to the two others and another city centre institution.

"Opportunities for part-time employment" were significantly less important (95-99 per cent) in the institutions attached to smaller towns/cities.

"Graduate employment rate" showed few significant differences except between the highest and lowest rating institutions.

"Parents' opinion" tended to be of more importance in universities with campuses/colleges but only in a few cases the difference could be claimed as having high levels of significance. Interestingly, "parental opinion" was significantly more important in the choices made by students who had attended open days. The difference between the two groups is the largest for any factor. "Friends' opinion" shows no significant differences, while "cost of living" seems a significantly more important factor to students attending two metropolitan universities but not two others. The scores do not correlate with those for "proximity to home".

The location of the campus in a major city was significantly more important (at 99 per cent) for one institution that has made a considerable investment in such a campus and also significantly higher for another with some such investment. Not surprisingly, the factor was of lowest importance to those students who had chosen smaller towns/cities and for whom the location in a small city/town was significantly more relevant. No "out-of-town" campuses were represented in the group but, with that proviso expressed, importance closely follows the form of the campus or physical location. Overall, however, the type of campus comes way down on the importance list; and even if the strong differences expressed by those who had chosen particular types were factored out, "type of campus" would not reach the top 50 factors for the sample. "Collegiate structure" was only significantly different for the institution which operates a collegiate system, but even there it comes thrity-seventh in the order of priority.

"Crime rates" revealed few significant differences. One city university which had emphasised its low crime rate in its latest publicity materials scored a significantly (at 99 per cent) higher importance rating than others and scored more highly for having a "friendly attitude towards students" than others. It may be no coincidence that an institution which has invested more than many in the development of ancillary staff and has used them, deliberately, as "roving ambassadors" on open days, received strong ratings for that aspect and for its student-friendly attitude.

Facilities factors

Accommodation factors tend to follow provision. The importance of "availability of university-owned accommodation" was, hardly surprisingly, significantly lowest for three institutions where "proximity to home" was significantly more important. These institutions also had higher proportions of mature students. The "availability of self-catering accommodation" was rated significantly lowest in a collegiate institution (where basically all first-year students live in catered halls anyway), and high in three institutions that have gone to pains to arrange it (though not necessarily own it).

Catered halls were of significantly higher importance in the institutions which provide them. In two of the three, where *en-suite* facilities are provided, they were rated not only significantly more important but actually in the 4+ list; a stark contrast to most other accommodation ratings, which in general did not show this as an important factor. The message seems to be that where higher-quality arrangements are made, they are perceived as such and become differentiating factors. The same institutions receive significantly higher importance ratings for "IT in bedrooms", "telephones in the accommodation", "cleanliness" and "cost", factors where the population breaks down into two groups, one of which rates accommodation factors generally significantly higher than the other. The higher-scoring quartet are the same institutions that receive the higher number of 4+ scores overall. With various slight differences of emphasis, the same group generally receives higher ratings on other factors relating to accommodation.

Generally, all questions relating to learning and teaching facilities, especially library facilities and the availability of computers, receive high importance ratings throughout. Again two groups exist, showing to varying extents significant differences on most aspects except the "availability of quiet areas for study". Interestingly, the groups are not the same as those for accommodation. The institutions whose research reputation was most significantly rated as important tend to receive lower significance ratings for the importance of teaching accommodation and library facilities. In general, importance ratings seem to coincide with the researchers' impressions of aspects of physical quality gained during benchmarking visits, though it has to be emphasised that no rigorous verification has been attempted. In general, higher quality environments do seem to have an impact on choice; a conclusion that may also lead to problems of expectation, if impressions gained during recruitment are not matched by subsequent reality.

Discussion

With those caveats, the conclusions reached from the 2000 survey were confirmed

Facilities
Volume 21 · Number 10 · 2003 · 212-222

strongly in 2001. Groups of institutions with wider FM appeal do not correlate with university type. Each group includes at least one "modern" and one "research-led" university. They do correlate with visual estimates of campus quality. There is evidence that where the estate has been treated as a strategic asset it figures more highly in students' perceived reasons for choosing a particular location. This is not necessarily a description of an objective reality. Service quality literature is divided as to whether "importance" and "satisfaction" can be objectively separated (Robledo, 2001). It is quite plausible that respondents to the questionnaires attached greater notional importance to factors which they perceived as being better supplied: i.e. that they were more satisfied with. On the other hand, it can also be argued that dissatisfaction with a particular service or product might lead to greater attention to this factor and hence higher importance ratings. We have not been able to investigate this in depth, but a number of open-ended "reasons against" suggest the possibility.

That does not, however, detract from the potential of these factors to differentiate any particular institution. Models of customer service also tend to differentiate so-called "hygiene factors", without which a customer's basic expectations remain unfulfilled, and "differentiators", those aspects of a product or service which influence decisions on repeat business. Student choice does not, at least on the timescale of a few years, become repeat business[1], and it is perhaps hard to conceive of the top eight factors (Table I) as hygiene items. They are, however, what a university must have if it is to attract either particular students (the course) and students in general (learning facilities, good teaching, access and a student-friendly attitude). It is the other items, especially many facilities or estates factors, that can often differentiate a particular institution. In both years this point was confirmed by reference to specific examples.

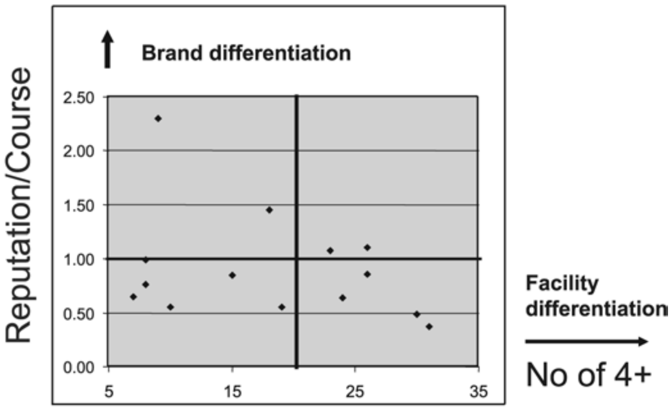
In the 2000 survey we identified one member of the low-scoring group as "facilities-independent"; that is, as having a perceived reputation that made it especially attractive to students. In the open-ended questions this was the only institution where comments relating to the university's overall reputation were much more frequent (by a ratio of over 2 : 1) than those related to having a particular course. One other institution had a ratio slightly above 1 : 1: i.e. reputation was mentioned more frequently than course although the ratio was lower: In 2001 a new (to the survey) participant had a ratio approaching 2 : 1 while University A, which had seen a rise in popularity, as recorded by UCAS statistics, between the two application years, saw the ratio change from slightly under to slightly over 1 : 1.

Taking these responses, and the overall number of factors scoring 4+, begins to identify a means of segmenting the undergraduate "market" (Figure 1), one which bears parallels with recently developed scenarios (Matzdorf and Price, 2001; Collis, 1999). One scenario, identified by Collis as the "liberal-arts college", has been dubbed in our work the "St Andrews Strategy"[2]; the appeal to the social as well as the intellectual role of a particular institution. It is of course a moot point how sustainable such a strategy is without some form of differential financing, but one can see the upper left-hand quadrant of Figure 1 as tending towards such a strategy. The lower right, on the other hand, is "facilities-differentiated" using provision of modern campuses as a factor in recruitment. Towards the upper right lies appeal on both reputational and facilities factors, though it remains to be tested whether the highest scorers in academic reputation terms, the "RAE élite", are differentiated from the "St Andrews strategists". Institutions in the lower left quadrant, meanwhile, struggle to differentiate themselves on either ground, a position which may only be sustainable with low costs and high volumes and which even then is vulnerable to better positioned competitors. We note that among the "new" universities in our survey some have developed "facilities-led" positions while one has achieved near parity of reputation and course.

Further statistical analysis of the data to refine a simpler component model of facilities impact on student choice is planned. Meanwhile, for a number of institutions that impact is clearly and unambiguously confirmed.

Facilities
Volume 21 · Number 10 · 2003 · 212-222

Figure 1 The position of individual institutions according to the number of 4+ factors recorded in the survey (*x*-axis) and the ratio of "reputation" to "course" in reasons given for choosing a particular institution (*y*-axis)



Note: Identities have been removed for reasons of confidentiality

Notes

1 The growing importance of alumni and life long learning is acknowledged.
2 Referred to as the "Wills effect", e.g. *THES* 29 March 2002.

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Optimization of MVAC systems for energy management by evolutionary algorithm

K.F. Fong
V.I. Hanby and
T.T. Chow

The authors

K.F. Fong is a Lecturer and **T.T. Chow** is Principal Lecturer, both at the Division of Building Science and Technology, City University of Hong Kong, Hong Kong SAR, China.
V.I. Hanby is Assistant Director at the Institute of Energy and Sustainable Development, De Montfort University, Leicester, UK.

Keywords

Air diffusion, Optimization techniques, Energy management, Hong Kong

Abstract

Energy management in existing building services installations is an essential focus of contemporary facilities management. The subway company that is one of the major utilities services in Hong Kong Special Administrative Region has considered better energy management schemes in its subway stations to reduce the running cost. In the past few years some feasible measures in the mechanical ventilation and air conditioning (MVAC) systems were implemented, however the engineering decisions were supported by trial-and-error or imprecise estimation. Improvement to this process would be possible if numerical optimization methods were to be used. An evolutionary algorithm coupled with an external plant simulation programme was applied to determine the optimum conditions of the essential parameters of the MVAC systems. For the centralized MVAC systems under study, the developed optimization and simulation model was found useful in appraising the energy management opportunities for effective design and facilities management.

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Facilities
Volume 21 · Number 10 · 2003 · pp. 223-232

DOI 10.1108/02632770310493599

1 Introduction

1.1 Promotion of energy management opportunities

Effective energy management in existing building services installations becomes a primary focus of facilities management, not just because of the environmental and sustainable concerns, but also due to the adverse impact of the global economic recession in recent years. In Hong Kong Special Administrative Region (HKSAR), such influence has not only been bound to the commercial and industrial sectors, but even to the utilities companies. The Electrical and Mechanical Services Department of HKSAR government has promoted a series of energy management schemes, one of them being to identify energy management opportunities (EMOs) through energy audits. There are three categories of EMOs:

(1) Category I requires no or insignificant capital investment to implement;
(2) Category II can be carried out at relatively low cost; and
(3) Category III needs significant capital investment but reasonable payback period.

Therefore there is a great priority and motivation to seek for the EMOs of Category I which may have insignificant investment implication but possible cost savings. In typical heating, ventilating and air conditioning (HVAC) systems, this category practically involves ideas such as:

- to readjust the operating conditions like space air temperature, supply air flow rate, chilled water supply temperature, etc. without sacrificing the built comfort requirements;
- to reset those operating conditions in the mid-seasons and during the non-peak periods;
- to reduce the operating time of the equipment not affecting the normal operation; or
- to minimize the night mode operation of the major equipment.

The choice of the EMOs of Category I depends on the system design, provisions and complexity. These EMOs can be implemented immediately, and their effects in energy saving can be evaluated quickly. However, in readjusting the operating conditions of the main equipment, it may

Facilities
Volume 21 · Number 10 · 2003 · 223-232

render the situation contradictory. For example, increase of supply air temperature due to raising chilled water supply temperature would save energy in chillers, but the supply air flow rate and hence energy consumption of air side equipment would be increased accordingly. This may counter-balance the advantage of the temperature adjustment in water side. So suitable optimization models are needed in order to consider the changes of different parameters in a holistic approach, and the objective of energy saving can be really achieved.

1.2 Usefulness of optimization and plant simulation models

The subway company that is one of the major utilities services in HKSAR has considered better energy management in its subway stations to reduce the running cost. In the past few years, in order to achieve energy saving, some feasible measures in the MVAC systems were implemented by the subway company, for instance to increase the space air temperatures of different function areas, and to readjust the time of start/stop of the MVAC systems. Although all those measures were adopted without sacrificing thermal comfort within the spaces, the engineering decisions were supported by the trial-and-error or imprecise estimation. And it depended on whether the operators could exercise the appropriate judgement in making the parametric changes and interpreting the results correctly. Therefore it would be better to use more robust tools to determine the satisfactory operating conditions and improvement schemes.

Nowadays, computer-based simulation is becoming increasingly popular and more designers and clients use this approach to evaluate the design alternatives (Kennett, 2001) and year-round energy consumption (Fong *et al.*, 2001). For design and operation optimization, a radical breakthrough would be possible if numerical optimization methods were used instead of operator judgement. Recent advancement in plant simulation model and development in optimization model would enable such problems to be tackled using appropriate optimum-seeking methods. Among different optimization methodologies, evolutionary algorithm (EA) has been found useful in a variety of problems (Michalewicz and Fogel, 2000), and they are able to handle common HVAC scenarios that often have discontinuous, non-linear and highly constrained characteristics in the search spaces.

The plant simulation package TRNSYS (see Solar Energy Laboratory, 2000) was used to model the whole MVAC system including the chiller plant, water side, heat rejection and air side systems. In addition, EA was applied to determine the optimum conditions of the essential parameters of the MVAC systems in order to provide a holistic energy management approach. The external plant simulation program TRNSYS was intentionally coupled with EA for evaluating the fitness of different parametric combinations. The results would suggest the solutions for the EMOs of these subway stations.

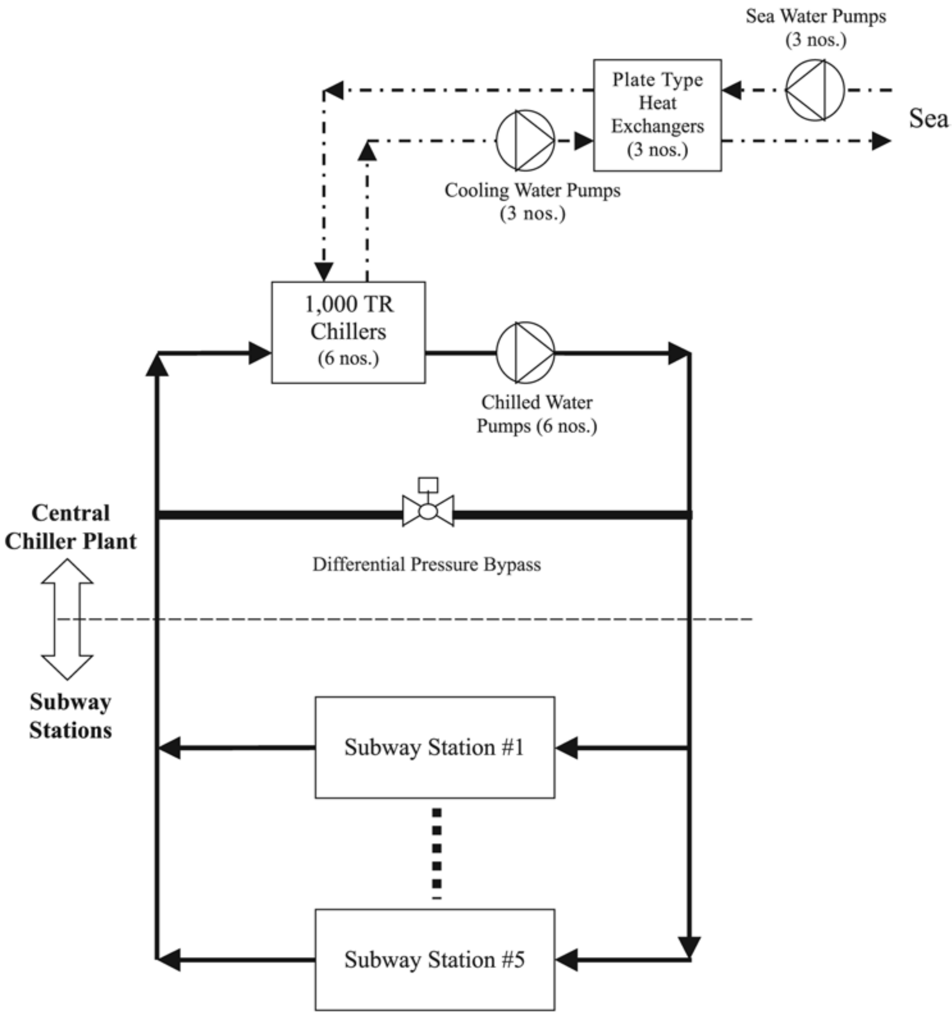
1.3 MVAC systems of subway stations

This study was focused on the MVAC systems including a 6,000 TR central chiller plant and the corresponding air side systems serving five subway stations in the urban line. The schematic diagrams of the central chiller plant and the air side system are shown in Figures 1 and 2 respectively, and the features are summarized as follows:

- The five subway stations were served by a central chiller plant which consisted of six numbers of 1,000 TR water-cooled chillers; each had an associated constant speed chilled water pump. Differential pressure bypass circuit was applied.
- For heat rejection, a cooling water pump was used to serve a group of two chillers, and carried heat to a plate heat exchanger, in which heat was removed by a sea water pump. Therefore there were altogether three sets of pumps and heat exchangers. Both the cooling water and sea water pumps had constant speed.
- For the air side system, the supply air was used to handle cooling loads from two major sources in sequence: the platform and the trains. First the platform cooling loads were tackled to maintain a platform space temperature T_s, which was checked against the pre-set platform design temperature T_p. On the other hand, return air grilles were intentionally installed under the platform and above the air-cooled condensers of the subway trains, so as to tackle the cooling loads from the trains, as shown in Figure 2.

Facilities
Volume 21 · Number 10 · 2003 · 223-232

Figure 1 Central chiller plant and chilled water distribution



2 Plant and energy simulation

With the simulation package TRNSYS, the plant and energy simulation model of the subway stations were developed according to the actual MVAC installations and operations, and the characteristics are summarized as follows:

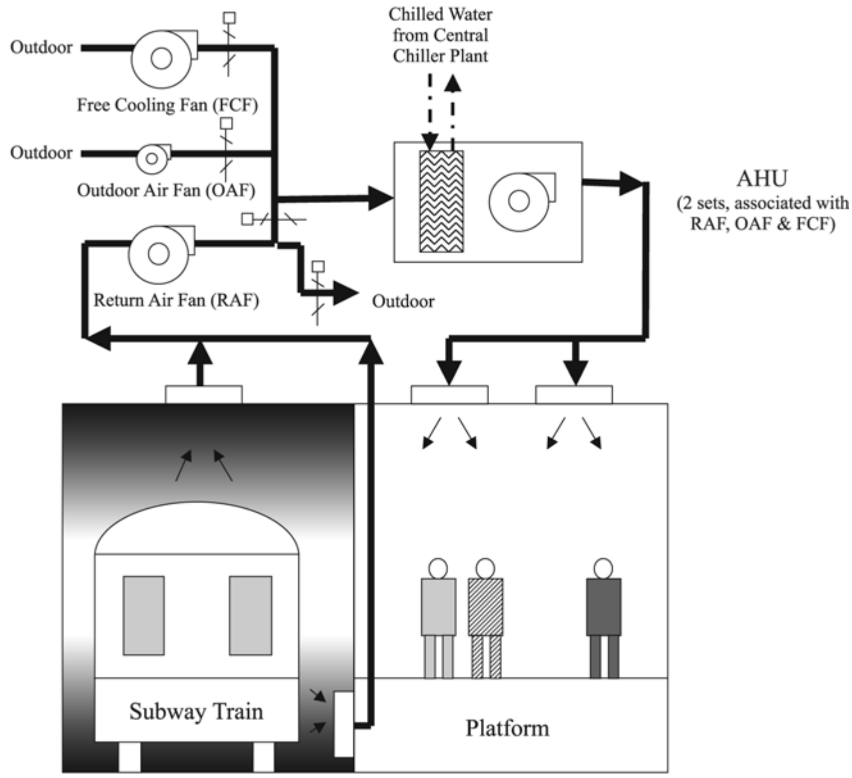
(1) Since it was not a dynamic simulation, all the operation conditions of different equipment were determined by the hourly cooling loads and outdoor air conditions, and the simulations were generated in steady state at the corresponding hours as illustrated in Figures 3 and 4. For each operating hour, total energy consumption was the sum of energy consumptions of all the major operating equipment, and the year-round energy consumption was the sum of all 8,760 hours.

(2) For part load control of the chillers and pumps, the control signals were determined by the amount of hourly cooling loads as shown in Figure 3.

(3) From full load to part load of the air side system, there were four strategies based on different loading situations:
- Full load cooling mode: AHU working in full speed.
- Part load cooling mode: AHU operating in half speed.
- Full load free cooling mode: free cooling with all fans in full speed.
- Part load free cooling mode: free cooling with all fans in half speed.

The change from full to half speed was determined by comparing T_s against T_p (with deadband 1°C). The change from normal to free cooling mode was based on the outdoor enthalpy ho lower than the actual platform space air enthalpy hs (with deadband 2kJ/kg). These full and part load control strategies are shown in Figure 4.

Figure 2 Air side system of a typical subway station



3 Evolutionary algorithm

3.1 Development of optimization techniques

The best optimization model should be both efficient and effective to determine the optimum conditions within the search space, approaching to the global optimum instead of the local ones. The optimization techniques have been developed for many years, from gradient-based methods, direct search methods (Hanby and Wright, 1989) to the recent random and evolutionary approaches (Wright, 1996). EA has become a popular stream of optimization techniques recently, and it includes the genetic algorithm, evolutionary programming and evolution strategy (Bäck *et al.*, 1997). Their differences depend on the emphasis and approach adopted for selection, recombination and mutation. Basically genetic algorithm and evolutionary programming are generally implemented with a probabilistic and stochastic approach, while evolution strategy is deterministic during the selection stage. Although it seems impossible to find a single method which can be applied in all problems (Bäck *et al.*, 2000), application of EA is effective in handling many HVAC problems with discrete, non-linear and highly constrained characteristics (Michalewicz and Fogel, 2000).

3.2 EA coupled with plant simulation model

The developed EA was real-coded, and handled floating point and integer variables by the use of variation operator. Modularity was the major characteristic, therefore the optimization model was developed by MATLAB which could effectively handle the parametric matrices across different generations. The plant simulation model was not integrated into the EA, but was coupled together and communication between these two modules was via an operating system call. There were four main constituents in this EA, they were initialisation, evaluation, selection and variation. The flow chart of the developed EA model is shown in Figure 5.

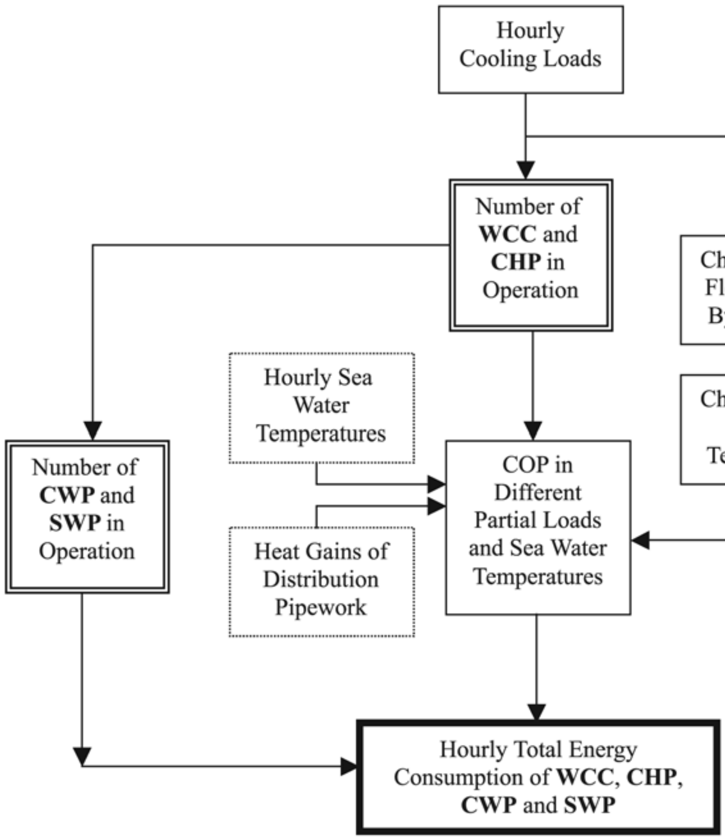
Initialization

Before starting the search for the optimum parameters, some basic information was decided:

- parameters to be optimized;
- lower and upper bounds of each parameter;
- population in each epoch; and
- maximum number of epoch to be investigated.

Facilities
Volume 21 · Number 10 · 2003 · 223-232

Figure 3 Determination of energy consumption in central chiller plant



In EA, each set of parameters to be optimized was treated as an individual, and the required number of individuals formed the population for each epoch of search. The stochastic nature of EA means that larger number of population would result in better choice of élites without trapping at local optimal. Similarly, larger numbers of epoch would guarantee the convergence of parameters contained in individuals. However the running time of optimization was compromised for this case, since the dominating processing time was not in EA itself, but in the plant simulation program already coupled with EA for evaluation purposes.

At the very beginning of the optimization, an initial population of individuals for investigation was produced. This initial group (first epoch) of individuals was generated randomly within the corresponding specified ranges of those parameters involved.

Evaluation

In general, an evaluation function should be developed and incorporated in this step in order to give the optimum and feasible solutions. In this study, the overall year-round energy consumption of the subway MVAC systems was the ultimate target, and optimization was simply to determine the minimum energy amount. Therefore each set of feasible parameters within the population should be input into the plant simulation program so that the evaluation solution could be determined and compared in the following stage.

The main feature of this evaluation process was being coupled with the external plant simulation program TRNSYS, so operating system call was involved between EA and the plant simulation program for each individual within the population in every epoch. This was the most time-consuming step for the complex simulation problems, for instance it took about 15 minutes to run a full set of 8,760-hour energy consumption for the entire MVAC systems of the subway stations for an individual being assessed. No matter how efficient was the programming of EA and how fast was the processing speed of the computer, the bottleneck was the number of hours involved in a year-round study, so the frequency of simulation could not be reduced and the running time of the entire optimization model could not be advanced significantly.

Facilities
Volume 21 · Number 10 · 2003 · 223-232

Figure 4 Determination of energy consumption in air side system

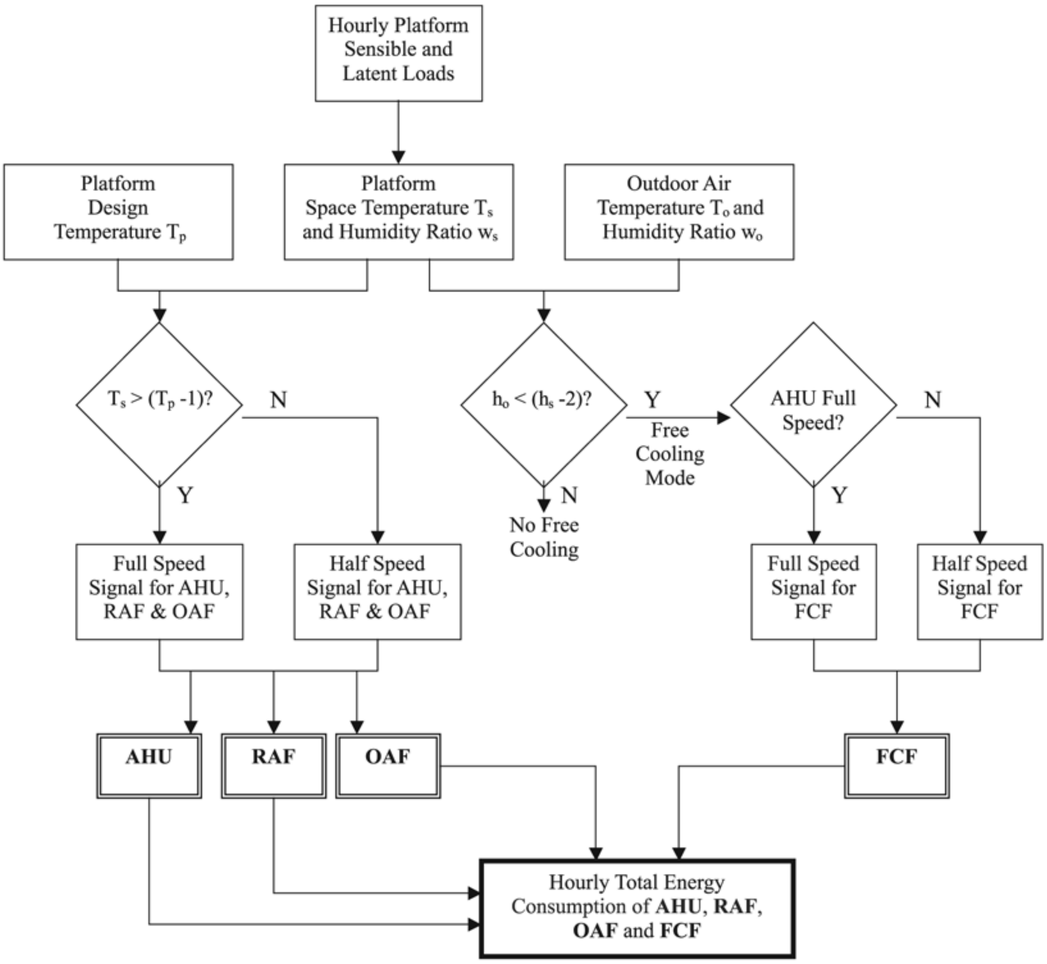
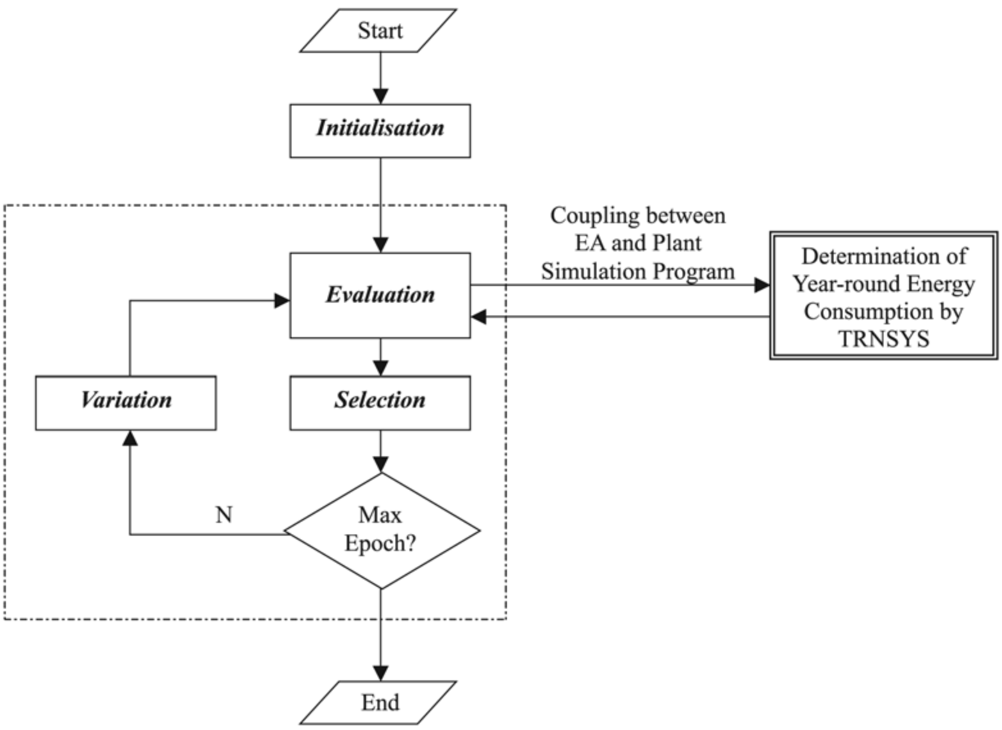


Figure 5 Flow chart of EA coupled with plant simulation model



Selection
After evaluation, selection of the individuals for variation should be carried out. Selection is a process to determine the next population based on current individuals' quality. It can be carried out in either stochastic or deterministic way. The stochastic approach would generate a probability function, e.g. by a roulette wheel, over the possible compositions for the next epoch; while the deterministic approach would develop the next generation according to the prescribed composition of parents and offspring.

As a preliminary study in this case, the selection process was carried out in the following ways:

- The philosophy of élitism was applied and the fittest individual was placed into the next epoch without any variation.
- The remaining individuals were all carried forward for variation.

Variation
In variation, a suitable variation operator should be selected for the problem, and it is crucial to generate a new population of individuals which would approach the true optimum but not be trapped by local ones. This step has the same purpose of crossover (mating) and mutation in genetic algorithm (Wright, 1996), for acquiring offspring with better fitness from parents in a probabilistic approach. In addition, after applying the variation operator, appropriate constraint handling technique is used in order to effectively highlight the feasible and fittest individuals, and repair the infeasible ones back to the search range.

In this study, Gaussian-distributed random number was applied as the variation operator since it was proven to be effective in perturbations and mutation (Michalewicz and Fogel, 2000). This number has a mean of zero and a dynamic standard deviation, and offspring were "born" by adding it to the parents. An initial range was set for the random variation of each parameter, and the standard deviation factor σ which decreased exponentially with each epoch was applied. This factor was determined as follows:

$$\sigma = e^{g-1/c}$$

where:

g = epoch;
c = constant.

On the other hand, constraint handling technique was applied for any infeasible parameter which was out of its specified range, and it was reset back to the respective lower or upper bound that was nearer to the mutated value. This generally occurred in the early stages of the search, before the standard deviation factor σ was reduced significantly.

4 Optimization for energy management

Based on the developed EA optimization and simulation model of the MVAC systems for the subway stations, optimization of different operating parameters could be carried out. The results were used to check against the existing operating conditions, and optimum settings could be suggested for the EMOs of Category I. After thorough appraisal of the currently installed equipment, operating speeds of the chilled water pumps, cooling water pumps and sea water pumps were all constant, so there was little chance to change the related parameters. For the major air side equipment, two-speed fans were used, and the algorithm of changing speed was already incorporated into the plant and energy simulation model, so there was also little opportunity to optimize their parameters. Finally, there were two essential parameters which could be investigated through optimization:

(1) the set point of chilled water supply temperature of chiller T_{cws}; and
(2) the platform design air temperature T_p.

For the existing plant operation of the subway stations, the set points of T_{cws} and T_p were 7.2°C and 27°C respectively. Although in the optimization model the number could be accurate up to many digits, it was meaningless to determine the optimum settings in such details. Since the resolution of the installed central control system of the subway stations was just up to the first decimal place in both T_{cws} and T_p, so the degree of convergence in optimization would be based on one-tenth of a degree C.

4.1 Input data

For the developed EA model, the following input data were used in optimization:

- lower bound of T_{cws}: 6°C;
- upper bound of T_{cws}: 8°C;
- lower bound of T_p: 25°C;

Facilities
Volume 21 · Number 10 · 2003 · 223-232

- upper bound of T_p: 27°C;
- population: ten; and
- maximum epoch: 20.

For T_{cws}, the range of 6-8°C was used since it was common in practice to balance the required dehumidification effect in air side and good efficiency of chillers. For T_p, since the maximum platform design temperature should not be higher than 27°C, so it was set as the upper bound. The lower bound was preliminarily set according to the temperature difference of 2°C as that of T_{cws}. Since the optimization running time was mainly the plant simulation time, the numbers of population and epoch were determined by compromising the stochastic selection and variation, and the efficient convergence of T_{cws} and T_p.

4.2 Optimization results

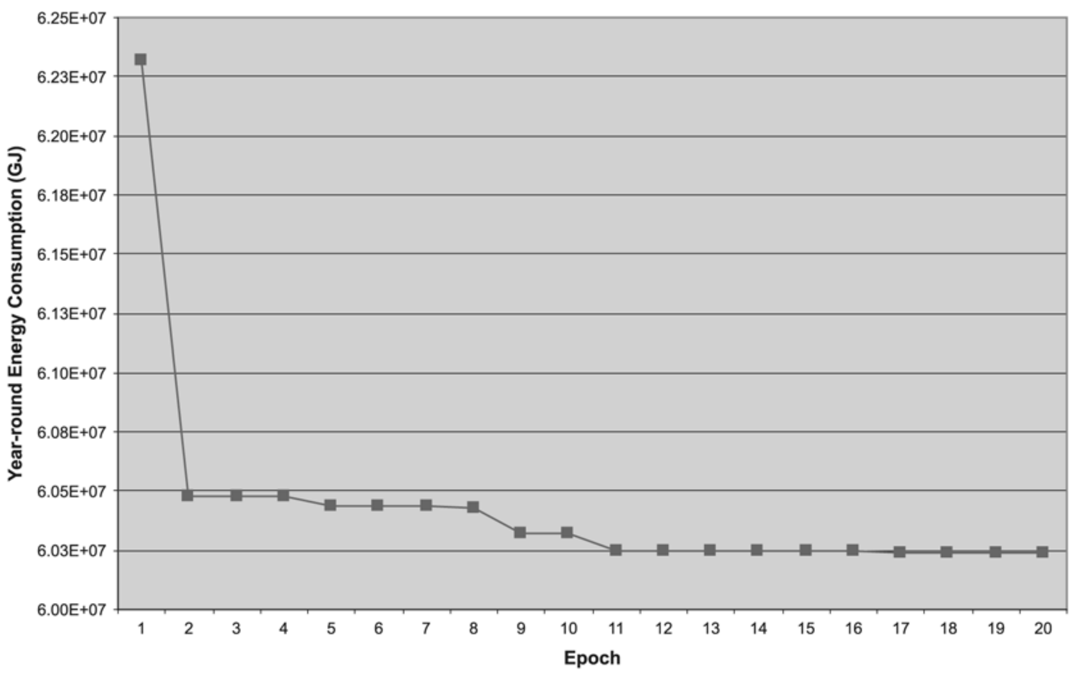
Based on the developed EA optimization and simulation model, the optimization results of the MVAC systems of the subway stations were determined, and those of year-round energy consumption, T_{cws} and T_p are presented in Figures 6-8 respectively.

From Figure 6, the minimum year-round energy consumption was found from epoch 11 and there was no significant change thereafter. From this evaluation result, the optimum conditions of T_{cws} and T_p were 7.0°C and 27.0°C respectively. As compared to the existing conditions 7.2°C and 27°C, the set point of T_{cws} could be further decreased by 0.2°C and no change was required for T_p. Although the optimization results were close to the existing ones, it indicated that lower T_{cws} could be achieved since the effect of less operation of air side equipment could outweigh the reduced efficiency of chillers during part load situations. In reality, if the optimum conditions were determined by the judgement of the plant operators, there would be a tendency to increase T_{cws} for chillers for saving energy, but ignore the effect from the air side and part load operations. Therefore the EA model provided an effective and numerical means to determine the optimum conditions, instead of trial-and-error experience and insight.

4.3 Further applications

The studies were mainly focused on the EMOs of Category I, which was the starting point of energy saving based on the installed equipment and systems. In fact the developed EA optimization and simulation model can also be used to investigate the energy saving potential for different EMOs of Categories II and III, i.e. involving investment and saving return. For example, the existing installations consist of constant speed pumps, saving potential can be determined by changing them to variable speed type. Another idea would be to study the replacement of the

Figure 6 Optimum year-round energy consumption in each epoch



Facilities
Volume 21 · Number 10 · 2003 · 223-232

Figure 7 Optimum chilled water supply temperature in each epoch

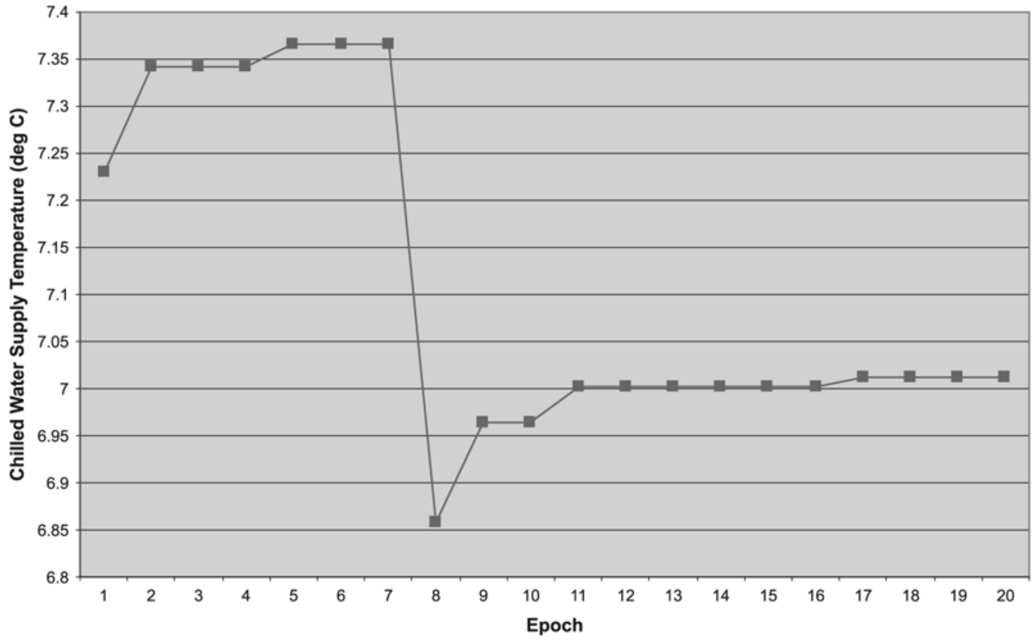
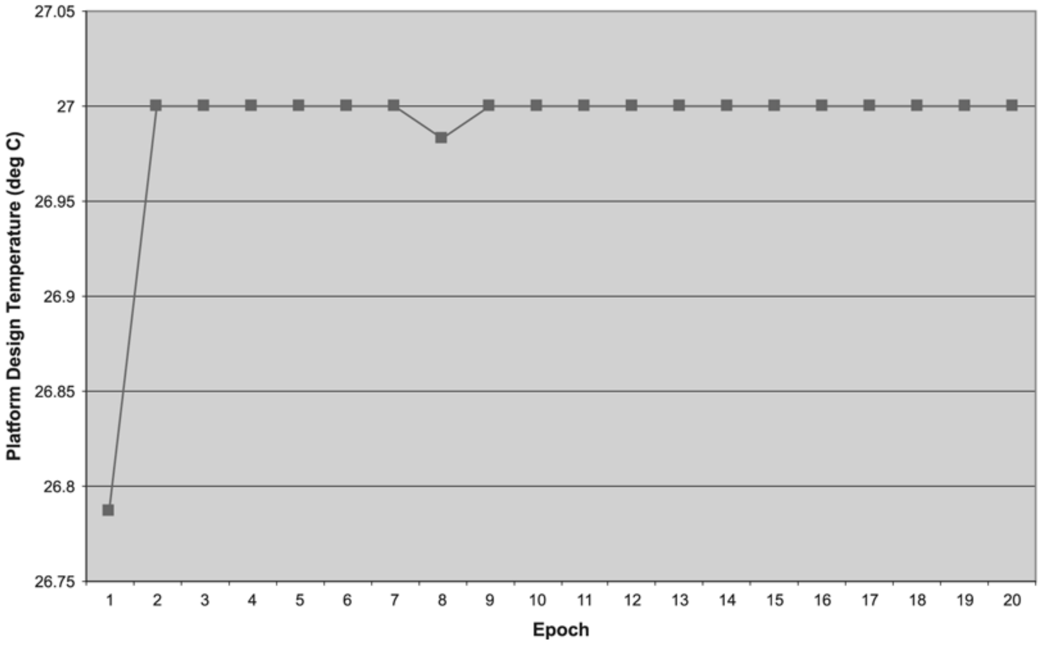


Figure 8 Optimum platform design temperature in each epoch



two-speed fans of major air side equipment by variable speed fans. Therefore the current EA optimization and simulation model can be used in handling a variety of different scenarios in performance-based approach for the subway stations.

5 Conclusion

Although it was common to use simulation in design, it could also be effectively adopted in facilities management, especially to consider different EMOs and to review the current settings of system operation. In this study, plant simulation package was adopted to develop the model of the MVAC systems of subway stations in a holistic approach, with full considerations of their part load operations, in order to determine the year-round energy consumption. Regarding the EA model, it was developed for searching the optimum for different design and operating parameters. Through the coupled

EA and simulation model, the optimum chilled water supply temperature and the platform design air temperature were determined. EA was demonstrated to be useful, and it could replace the traditional parametric studies for the HVAC optimization problems.

On the other hand, further development would be focused on a more robust optimization and simulation model, which would be useful for both design and facilities management of the HVAC systems. Especially in the processes of variation and selection, more choice of operators and approaches should be allowed, so that different HVAC problems can be optimized in an efficient way. For constraint handling technique, constraints can be introduced by incorporating penalty function, so the fittest individuals can be sought out more easily, and convergence of evaluation can be achieved more quickly. Since plant simulation process is lengthy, more effective variation and selection would reduce the number of running plant simulation, hence the optimization and simulation package can be more useful in different applications.

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Decentralising asset management in a university environment using Web enabled technology

Gerard Cesar Gabriel

The author

Gerard Cesar Gabriel is Facilities Information Manager at the Facilities Management Office, University of Sydney, Brighton-le-Sands, Australia.

Keywords

Decentralised control, Assets management, Information, Universities

Abstract

With the advent of Web technology and the proliferation of Web enabled systems in the last few years, remote computer aided facilities management (CAFM) and computer integrated facilities management (CIFM) are starting to assume a more significant role. Computerised asset management (AM) has been widely discussed and various conceptual models, benchmarking and best practice principles have been proposed in the past. However, the vast majority of case studies involved private corporations as well as public sector institutions, with the majority using single-site studies, but very little dealt with the education sector spread on multi-sites. The effective management of assets forms an integral part of the management of the University of Sydney's (USYD) overall resources in order to achieve its goals towards excellence in teaching and research. Reviews the current, more or less, manual centralised AM system at USYD and proposes a framework for a more decentralised, Web-based AM system built on the existing CIFM system used by the Facilities Management Office. Further examines the strengths and weaknesses of the current and proposed systems and the possible application of the proposed system to a range of AM scenarios outside the context of the university environment.

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Facilities
Volume 21 · Number 10 · 2003 · pp. 233-243
© MCB UP Limited · ISSN 0263-2772
DOI 10.1108/02632770310493607

Challenges for the new millennium

The 1990s heralded a brave new world, one of instant global communication, collaborative environments and information dissemination through the Internet and the World Wide Web. The Internet paradigm is so powerful that it affected in some way almost all existing business technologies and solutions, and perhaps is at last realizing the potential of the technological revolution evident over the past 50 years (Varcoe, 2000, p. 13; Cox, 2001, p. 26.8). The technology is relatively easy and cost effective to implement for the benefits it delivers, while assuming widely distributed but centrally managed information. According to Teicholz (2001, p. 25.17), the benefits of the internet (and its associated manifestations in Intranets and extranets) are clearly discernible and have been well defined and understood. Today, many current applications rely on a free browser to access centrally managed information by distributed users. Given that information is an important element of business, the idea here is to involve more users with business information, in order to help improve workflow and business processes as well as the elimination of redundant data.

In addition to the Internet revolution, the last decade witnessed rapid developments in computer hardware. This in turn paved the way for more sophisticated software applications, in the field of facilities management (FM), in terms of computer aided drafting (CAD), CAFM and CIFM systems.

First- and second-generation Web browsers were mostly used by universities worldwide, since they were amongst the first institutions to adopt Internet strategies early on, primarily for education and research. However, it was only a matter of time before a growing number of businesses saw the benefits of the Web in terms of global reach and started developing technologies, which would render it more usable and accessible to a wider audience. By the time third-generation Web browsers came into use in the late 1990s, the

Reference to asset management in this paper is considered in terms of furniture and equipment, which are managed by individual departments in conjunction with the Financial Services Division of the University of Sydney.

Internet took on a more dynamic role whereby, for example, interaction with and manipulation of relational databases in real time became a reality (for static vs dynamic information models see Finch and Davies, 2000, p. 96). This in turn meant that remote access to CAFM and CIFM systems started assuming a more significant role, one of helping decentralise and disseminate information management on single or multi-site environments.

With the continuous drop in federal funding in the last decade, facilities departments within Australian universities experienced a period fraught with significant changes in their business practices and restructuring to meet tighter budgets. As a result it became a matter of urgency for the FMO to look at consolidating its practices. Part of this was to bring in new methodologies and technologies in order to maintain the university's facilities in good condition, thus allowing the academic divisions to be in a better position in order to deliver first-class teaching and research programs. This in turn meant reliance on the strategic management and effective use of the university's assets, in terms of property, infrastructure as well as plant and F&E.

Facilities management at USYD

Established in 1850, USYD is Australia's oldest university, with approximately 40,000 students and 5,500 staff spread over 600 buildings (equivalent to a large country town with associated services and infrastructure), which in turn are distributed over 15 campuses (see Figure 1). The remote nature of some of those campuses, combined with the vastness of the Australian landscape, render the idea of delivering reliable centralised facilities and AM services a challenge to modernday facilities managers and users alike. According to Davies (2002):

> The University's investment in it's assets is significant, with property valued at approximately $1.9 billion of which $263 million is related to infrastructure, plant and equipment as well as computer equipment.

The FMO is responsible for planning, development, maintenance and operations of the university's facilities. FMO carries out this responsibility through its four operational groups:

(1) facilities strategic planning;
(2) project services;
(3) facilities services; and
(4) environment and heritage.

The following is an extract of the FM information scope at USYD:

- 629 buildings owned by the university of which 470 buildings are maintained by the FMO;
- 19,000+ rooms on 1,074 floors maintained by the FMO (to date, data of five campuses only entered into the system);
- 550,000+ m^2 (5.4Msqf) of floor space maintained by the FMO;
- 22,000+ items of plant (mechanical, electrical and fire, etc.) and around 37,000 preventive maintenance schedules and increasing (to date, data of three campuses only entered into the system); and
- 16,000 average of work requests (WR) p.a. and increasing (current WR from three campuses only).

Strategic nature of a CIFM system at USYD

In the past two decades, databases proliferated around the university environment from central systems (like finance, student and HR systems) in their various reincarnations, to the "feral", more localised financial and specialised systems. The lack of integration between those disparate systems often resulted in the duplication of efforts, in terms of collecting and managing data and thereby increasing data redundancy. This unworkable situation prompted two major reviews in the past few years. The first reviewed the existing FM systems within FMO, and the second was a more general, university wide investigation. However, both reviews identified the importance, where possible, of a more integrated approach between the plethora of existing systems university wide, thus making the university's "corporate knowledge" more accessible, and in the process reducing the data redundancy factor to a minimum.

FMO initiated its internal FM system "integration process" in 1999, thereby reducing the number of FM systems used and

Facilities
Volume 21 · Number 10 · 2003 · 233-243

Figure 1 Remote campus locations of USYD

consolidating them into a single, multi modular[1] CIFM system, Archibus^{TM}[2], and as a first step, porting some of its functions onto the Web. This gave faculty and department managers, for the first time ever, access to graphically report, in real time, on the spatial areas they occupy. In the near future those same users would be able to report on the location of their assets by faculty, department, employee or by room, thus further empowering and assisting them when making strategic decisions. This in turn makes the CIFM system more strategic in nature, thereby increasing the significance the FMO has in the role of managing spatial and work-related information (Gabriel *et al.*, 2001, pp. 157-79).

Computer integrated facilities management at USYD

In 1995, the FMO put in place a five-year program in order to implement a CAFM system, since a more integrated approach was required following the FM systems review. A multi-modular CIFM system was seen as an important tool in order to allow the FMO to implement its mission statement while operating within restricted budgets.

Phase one of this project (1995-1999) saw the CAD Group[3] physically survey a total of seven campuses with approximately 425 buildings, totaling around 475,000m^2 and subsequently producing CAD drawings of architectural floor plans of the surveyed buildings using AutoCAD^{TM}. Phase two started in 1997 once part of the CAD data became available. The CAD Group then proceeded to perform "space audits" along space standards on buildings in terms of usage and type (hierarchy and function). In turn, the audited data were entered into ArchibusFM^{TM} and linked to the existing CAD drawings, thus producing a space inventory. Space, by definition, incorporates the concept of location and, when documented graphically, provides a context for graphically locating all other physical assets, e.g. equipment, furnishings, people, etc. (Tracy, 2001, p. 21.1). Following is a list of Archibus/FM^{TM} modules in use at the FMO as well as modules to be implemented, all of which rely in more than one way on the accuracy of the CAD and space databases:

- *Space module.* (A standard Archibus/FM^{TM} module, implemented with minor modifications.) The first module implemented by FMO in 1997. This module is at the core of the USYD CIFM system, since it links all information and properties related to the smallest space cell in the spatial hierarchy, the room, to the entity defining that same space in the CAD drawing. This then allows for the effective and intelligent management as well as reporting on any space and its set of attributes in the database. Therefore the room plays an important role since its hierarchical and spatial attributes make it unique out of 19,000+ current rooms in the database. For example, a room, of a particular type and function[4] with a defined room number, belongs to a particular department, is situated on a floor of a building, which in turn belongs to a campus, has a defined area in m^2 (calculated from the CAD drawing), has a particular floor finish and has one or more employees who use it. This room could also have data, voice, mechanical, electrical and fire services, F&E and possibly items on the risk management (RM) list, like dangerous goods, as well as art objects, and could have some heritage significance, etc. (see Figure 2). Therefore all other modules in the USYD CIFM system rely on the accuracy of the CAD and space database in order to function properly as illustrated in the USYD CIFM model (see Figure 3).

- *Service desk module.* (Customised by FMO, based on building and operations module.) Implemented in early 1999 in order to track and manage corrective WR lodged by USYD staff through the Service Desk. In an effort to improve this service the FMO launched the e-Service Desk during December 2001. This facility gives UYSD staff access via the Web to lodge WR, receive e-mail updates concerning the status of WR and review the status of their WR directly from their workstations. All WR use the space data for problem location.
- *Building operations.* (Standard Archibus/FM module, Bldg & Opps with extensive modifications.) Implemented in early 2000, a maintenance module which helps in managing building operation issues by providing tools for monitoring maintenance and repair jobs, scheduling employees and outside contractors to perform preventive and corrective maintenance jobs, budgeting costs, and analysing all aspects of the building operations process. All plant items use the space data for location and service.
- *Cleaning module.* (Developed by FMO.) Implemented early 2000, this module allows facilities services managers to prepare accurate reports for cleaning contract tenders as well as track existing cleaning contract and reports on building areas by floor finish in sqm meters. The space data are used to capture floor finish by room.
- *Venue management.* (Developed by FMO.) Integrates with the room booking/time tabling system and the student system. Some of its main functions are managing internal and external venues that include lawns, etc. and their "fitness" for purpose, as well as reporting on analysis and utilisation of venues and efficiency of bookings by venues/campus location/number of hours booked. Therefore full integration with the space and Bldgs Opps modules allows for coordination between various users of the system in order to schedule preventive maintenance on mechanical/electrical equipment in venues with minimal disturbance to venue users.

Figure 2 Space hierarchy model, with extract of attributes and objects attached to room level, in the CIFM system used by the FMO at USYD

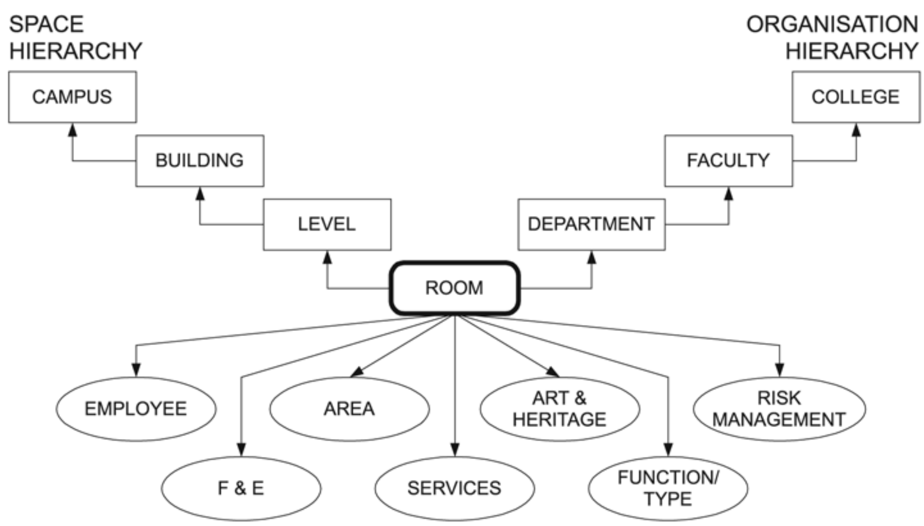
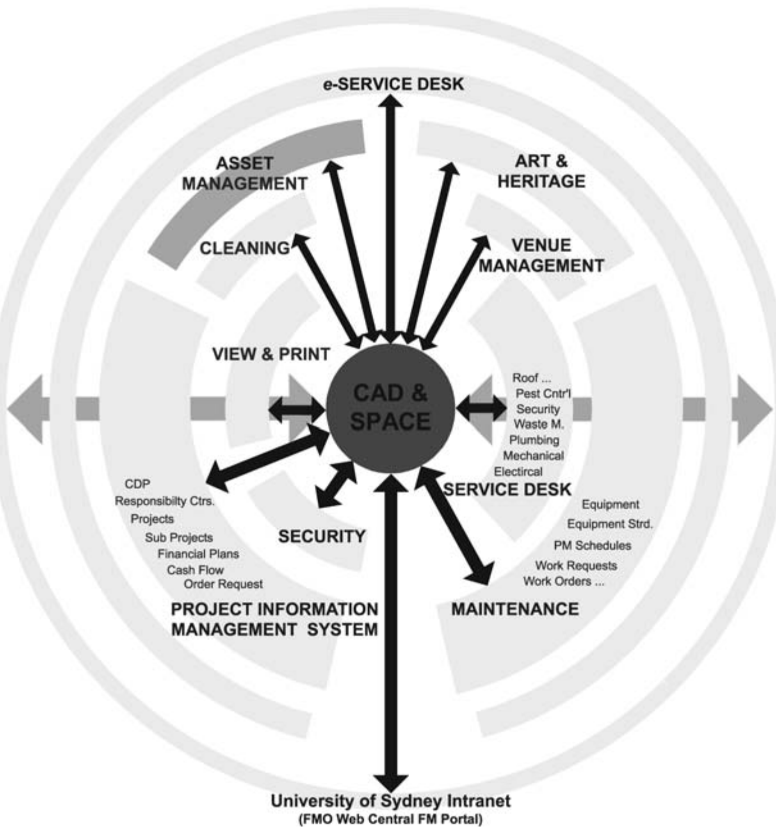


Figure 3 University of Sydney CIFM model



- *Access module.* (Developed by FMO.) This is a module that catalogues and reports on disability access issues relying on the space data for location.
- *Art module.* (Developed by FMO.) The real benefit of a specialised art database, as a module in Archibus/FM^{TM}, is the integration of the management of space and buildings, maintenance and services with curatorial functions and AM of the art collection. This is essential for the security of the art collection and encourages people to work together across departmental boundaries.
- *Heritage module.* (Developed by FMO.) captures the university's natural and built heritage assets by recording their significance and condition. It is also used to prioritise and record essential works that have been carried out and develop and implement responsible heritage management practices.
- *PIMS module.* (Developed by FMO.) A project management information system, which integrates with the university's financial system, PeopleSoft^{TM} also running on a Sybase^{TM} SQL platform. PIMS allows project managers (PM) to manage projects and project funding details over nine years (past three, current + five future years). It also allows PM to manage sub projects within a project and their financial plans, cash flows and order details. It also integrates with Microsoft Project^{TM} in order to manage phases and milestones. PIMS is another critical module, since it plays a major role in the "notification system" of the CIFM system (discussed later in the paper).
- *Furniture and equipment module.* (Standard Archibus/FM – to be implemented.) As a prospective AM tool, the F&E module within Archibus/FM^{TM} would provide USYD an integrated approach to facilities and AM, through integration with CAD drawings and the space module. F&E would provide an electronic inventory, as a sub-ledger to the general ledger of PeopleSoft^{TM} financial module, for the management of assets throughout the life cycle.
- *Risk management.* (To be developed by FMO.) This would benefit both RM and end users, since the proposed module takes into consideration operational

Facilities
Volume 21 · Number 10 · 2003 · 233-243

health and safety issues, allows for the location of dangerous goods stores, gene technology laboratories, etc.

- *Telecommunication.* (Standard Archibus/FM^{TM} – to be implemented.) This would for example allow the information technology services (ITS) to locate the servers, cabling routes, down to the face plate location. ITS can benefit from overseeing physical location of all networked servers and networked computers, in turn maintained as assets by the department asset managers (DAM) within USYD, locate them graphically and accurately for maintenance and trouble shooting, etc.

Centralised asset management at USYD

According to Tan (2000, p. 17, citing DPWH, 1996):

> Assets exist primarily to support delivery of services. A comprehensive understanding of assets and their life cycle can allow asset owners and users to influence directly the quality of service delivery, and to optimise the value (use) and returns (benefits) from the assets under their control.

Therefore in order to ensure cost-effective, reliable delivery of services in the university environment, the adoption of best practice AM is very important. This would cover the asset's whole life cycle including, but not limited to, planning, acquisition, operation, maintenance, RM and disposal (Coonan, 2000, p. 41; Davies, 2002).

The financial accounting unit of the financial services division (FSD) at USYD is responsible for the co-ordination of the annual financial accounts as well as AM amongst other things. The process of capturing and managing assets' details is at the moment carried out in conjunction with individual DAM. While the purchasing policy of the university is fairly decentralised, with departments acquiring assets directly, the management of those assets in terms of warranty, condition, registered location, current user, and monetary value is centralised through the PeopleSoft^{TM} AM module, currently accessible only by the FSD.

At best, the current manual process of creating and managing assets can be described as laborious and time consuming. It is laborious because DAMs have to maintain their own records of the department's assets locally, using at times satellite financial systems or simple spreadsheets and:

> . . . completing numerous paper forms to advise of relocations and disposal to the Financial Accounting Unit (Davies, 2002).

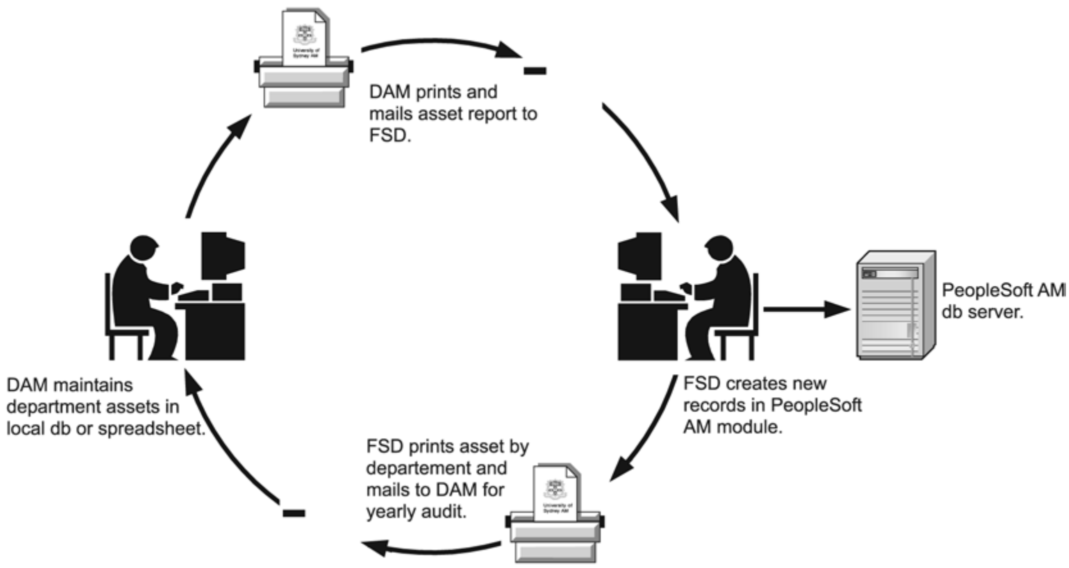
It is time consuming since it is not done in real time, with assets entered twice and managed at two levels, the departmental and FSD levels.

Figure 4 shows the current AM model used at USYD, whereby the FSD distributes on an annual basis, by internal mail, printed reports to the various DAM detailing the assets in their possession. It is then the DAM responsibility to go through those reports and check whether anything has changed since the last audit and update them where necessary. The report is fairly limited in the information it conveys, in terms of asset description, location, monetary value and current registered users (which are often outdated). The reports are returned to the FSD, by internal mail, where they are used to update the central AM database.

Since its deployment, this model has been unsuccessful and did not live up to expectations in terms of AM, with the high level reporting well below satisfactory levels. The following is a summary of problematic points in the current AM model:

- Duplication of data capture by DAM and FSD creates situations of potential user error and data redundancy.
- Reports sent to DAM for checking often have redundant information, which the DAM had requested the FSD to remove after the previous audit.
- Inefficient management of asset auditing, which in turn translates into lengthy cycle time for stock takes and reconciliation of general ledger in PeopleSoft^{TM}.
- The current system does not have the capabilities to capture historical details on assets, e.g. current registered user/location/move history and maintenance history.
- The current system does not provide adequate tools in order to allow DAM to monitor appreciation or depreciation of their assets.
- The current system does not have the capabilities of graphically reporting on location of assets.

Figure 4 Current centralised AM model at USYD



- The current version of PeopleSoft™ AM module used by the FSD does not support bar coding of assets.
- The current version of PeopleSoft™ AM module used by the FSD does not support Web integration and runs on USYD network through Citrix™ Nfuse.
- The current version of PeopleSoft™ AM module used by the FSD is not fully integrated with the PeopleSoft™ financial module and data are exchanged through a manual interface.
- In the absence of direct access to information stored on the PeopleSoft™ AM module, numerous satellite financial systems were created by departments in order to monitor and track their assets.

Decentralising asset management at USYD

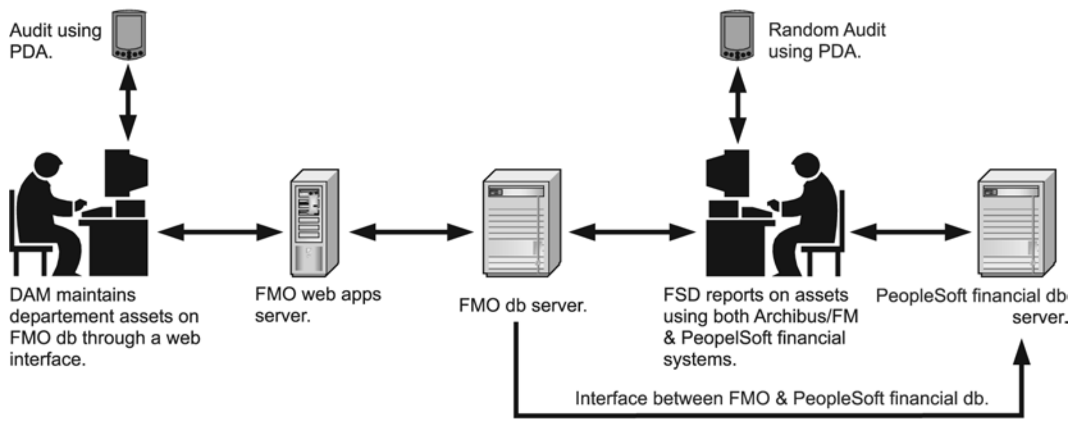
In order to overcome the majority of issues highlighted previously, the logical and strategic solution would be to opt for a university wide decentralised AM model. The proposed model would be achieved by interfacing the existing PeopleSoft™ financial module with the FMO's CIFM system. The DAM will then be able to remotely manage assets, on the centralised FMO database, in real time through Web asset management (WAM) pages via the FMO Web applications server (see Figure 5). On the other hand, the FSD will then be able to remotely access the FMO database through the Archibus/FM™ thin-client/server[5] setup in order to access more sophisticated, high level reporting tools.

Asset management at departmental level

At the departmental level, DAM will then take ownership of their data and therefore, through WAM, be able to edit assets' details in real time as well as use a variety of search forms to report on assets by standard, by value, by employee, by location, by maintenance history, etc. DAM will be able to better manage asset details like date of purchase, make/model, price, current location by room and move/location history (through move orders), serial number, condition, maintenance history, current registered user(s), monetary value (appreciation, depreciation, cost of replacement, etc.). Another important tool, accessible through WAM, is the proposed graphical reports to locate each individual asset, using floor plans with asset symbols and asset photographs. This attribute of graphic location is often missing from other AM systems (Tracy, 2001, p. 21.2).

For auditing purposes, DAM will then utilise a personal digital assistant (PDA)[6] equipped with a bar code scanner to carry out detailed audits on an as need basis. The PDA in turn interfaces with the FMO database to upload/download asset details.

Figure 5 Proposed decentralised AM model at USYD



Asset management at FSD level

The FSD will be able to access executive, high level reporting on university assets through the FMO database using the Archibus/FM™ thin-client. They will be able to report on assets by standard, by value, by department, by room, by building, by campus, by risk factor, or a combination, e.g. by building/department/asset/value. They would also have the ability to access assets graphically through Archibus/FM™ and WAM. However, WAM will allow them to graphically drill down through the drawings from campus, to building, to level, to room and asset. This kind of reporting becomes very important since it can be used by a multitude of administrative areas across USYD, e.g. RM could report graphically by campus, on buildings with high-risk equipment, etc. Also available to FSD is the ability to use PDA for carrying out random spot check audits throughout USYD.

Benefits of integrated decentralised asset management at USYD

An important aspect of a CIFM system is that it provides a set of interactive tools whereby groups of users, from diverse sections of an organisation, can benefit from data maintained by other groups and vice versa. An example here would see the DAM benefiting from up-to-date space data (maintained by FMO) to locate accurately their assets, and RM would benefit from the accurate location of those assets in order to report on the location of high-risk equipment. Similarly, the FMO Trades Services Group (TSG) could use the asset location/standard to schedule tests on "portable electronic appliances" according to Australian Standards.

Having said that, such a large CIFM system will require constant, ongoing maintenance, by the stakeholders, in terms of keeping the database up-to-date. Falling behind on such an important task could spell disaster. Therefore a crucial part of developing the AM system at USYD would be to perform thorough process modeling, given that it helps clarify the existing problem, which the proposed system is attempting to solve, and the way it goes about solving that problem (for process modeling see Alter (1999, p. 75)).

Needless to say that the immense gains from using a decentralised AM system far outweigh any fears of possible bureaucratic data management. The proposed decentralised AM system will address the problematic points of the exiting centralised system, identified previously, in the following way:

- Data ownership makes DAM accountable and will eliminate redundant data capture.
- Better asset auditing as well as significant reduction in time and effort of cycle time for stock takes and reconciliation of general ledger, because of DAM auditing and updating asset details directly. In all likelihood, the FSD and perhaps the CAD group using PDA, will perform random spot check audits as well. This way the FSD can concentrate more on verifying the data flowing in from the FMO database into PeopleSoft™ financial to reconcile the general ledger

Facilities
Volume 21 · Number 10 · 2003 · 233-243

and satisfy the university auditors, as per Figure 5.

- Better control of move management of assets through "move order process" and therefore capturing historical information on asset movement as well as current user/custodian. This in time will help in the analysis of the asset's maintenance history, since this is captured through the corrective WR of the Service Desk/e-Service Desk.
- The proposed system will provide DAM the capability to monitor asset's value in terms of appreciation and depreciation.
- The proposed system will allow DAM to locate assets graphically through the WAM. The system will populate the designated room with the appropriate asset symbol in real time. Furthermore updated CAD files, by the CAD group, are published automatically into vector-based Web format files on a daily basis, and this ensures that DAM are always using up-to-date floor plans.
- Archibus/FM™ supports bar coding of assets and that will be carried out by the DAM whenever they generate a new record for an asset. They will also have the capability to print bar code labels locally.
- The proposed system supports Web integration through WAM and the FMO has already ported some space reports onto the Web. Deploying FM functions and reports through WAM is cost effective and simple to use because of interface familiarity and any training will then stress more on the business processes rather than the GUI.
- The proposed system using WAM will then standardise AM across all departments and campuses of USYD and therefore dramatically reduce the need for alternative financial satellite systems.

The following are some of the functionalities that will also be available through the proposed decentralised AM system:

- *Improve employee exit processes*, i.e. asset recovery when an employee leaves the organisation or simply transfers from one department to another.
- *Disposing of assets.* Asset life cycle management and recycling/disposal is carried out according to the university's environmental management program. Assets reaching retirement stage will be flagged and disposed off either through special recycling programs or will be automatically listed on a dedicated USYD Web site for online or physical auctions, at regular intervals during the year.
- *Service Desk/e-Service Desk.* Break down or power failure that affects particular rooms, where critical assets are involved, would then alert TSG through the WR system, since assets are flagged by degree of importance.
- *The ability to drill graphically down through vector-based Web formatted drawings from campus, to building, floor, room, and to asset details.*
- *Notification procedures.* This central function is probably one of the most important features of FMO's CIFM system. PM at FMO use the PIMS module for all capital and refurbishment work. At the onset of any project, the PM will set out the boundary of the space to be refurbished on the appropriate CAD drawing(s) using a special layer, which is then picked up by PIMS, through the space module. This process will then flag any assets, plant items, artwork, etc. that fall within that particular area of the building and automatically notify the PM and the appropriate end users of the ensuing situation. For example, the CIFM system will automatically notify DAM by listing assets located in the area earmarked for refurbishment, thus giving them enough time to get in touch with the PM for more details on the proposed work to see if there is the need to protect assets or even consider temporary relocation. Similar notifications will be sent to other users of the FMO system, like for example the art curator if any artwork will be affected by the proposed work. On the other hand, if DAM try to use the WAM to locate assets in an area already earmarked for refurbishment by a PM, the system will notify them of any impending refurbishment projects with dates and PM contact details.

Summary

DAM at USYD are responsible for managing a substantial resource that encompasses a broad range of assets. They are also responsible for managing substantial expenditure on maintenance, repair and asset renewal. As a result it is their responsibility to optimise their expenditure and to maximise the value of the asset over its life cycle. This, however, cannot be achieved using the existing centralised AM system because of the limitations discussed in this paper. Therefore the proposed decentralised model is a radical advance away from the centralised model currently in place, since it empowers DAM to take ownership and accountability of their own assets. Having said that, the benefits of implementing such a model are not only limited to education institutions but can just as well be adapted to a range of scenarios and situations, from large global institutions to local area governments.

In the current climate of reduced government funding, it is critical that all departments manage their assets in a proactive and cost effective manner. This is achieved by integrating accurate asset performance information as well as corporate and strategic asset planning with the needs of the university community in the delivery of the teaching and research programs. Consequently all investment decisions for new assets need to be matched against the business aims of the organisation.

A decentralised AM model as part of a CIFM system will increase the importance of proper data capture and management in terms of best practice, which in turn lead to superior performance as well as overall productivity. Nevertheless, productivity does not improve because information is captured, it improves because it is properly managed in order to make timely, better-informed decisions.

Notes

1 By multi-modular system we mean an open system that is flexible enough, in terms of customisation and integration, to cater for most of the facilities and AM divisions instead of being a "specialist" system tailored for one or two divisions, e.g. space and building management.

2 Archibus/FM™ is a CAFM program, which is a fusion of a relational database, CAD, graphics and spreadsheet application features. A number of application modules run on top of this unique computer application, which allows users to follow the facilities management methods from start to finish within one environment – an example of a multi-modular CAFM system.

3 "CAD Group" in this paper refers to the group of FMO employees (four full time as well as up to 15 casuals) who have worked on this project since 1995. They included half a dozen postgraduate students in Architecture and Engineering, as well as architects, system engineers, CAD and space officers. The physical survey was carried out room-by-room using laser-measuring devices with an overall building tolerance of ±50mm.

4 Standardised room attributes, for example a room could be of a laboratory type with a function of wet or dry laboratory, etc.

5 The FMO and FSD are located on the same campus and the thin-client architecture will run on a gigabyte optic fibre backbone. Speed is not an issue here, but access to the FMO database via a thin-client will give the FSD access to more sophisticated *ad hoc* as well as customised high level reporting tools. However, if the FSD choose to, they can always use WAM to access the database from anywhere on campus.

6 In this case the PDA is a Symbol SPT1800™ converted Palm Pilot™, equipped with a bar code scanner, which interfaces with Archibus/FM™.

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