THE PROBE OCCUPANT SURVEYS AND THEIR IMPLICATIONS

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The Probe occupant survey utilises techniques first introduced by Building Use Studies in their groundbreaking Office Environment Survey in the 1980s. The questionnaire is a stripped-down version of the earlier survey, much shorter than the original, but compatible for benchmarking purposes. The update presented here incorporates further findings from the Probe 2 series of post-occupancy studies (for further information see [Reference 1] and the original articles in Building Services Journal). Better design and management in these newer buildings appears to have reduced occupants' perceptions of building-related ill-health, but thermal problems persist and noise nuisance is increasing. The results confirm the importance of combining design and management strategies to avoid vicious circles. It discusses how recognition of users' satisficing behaviour can lead to simpler and more effective solutions.

INTRODUCTION

This is a companion paper to [Reference 2]. It gives brief details of the background to the Probe (Post-Occupancy Review of Buildings and their Engineering) project as well as technical lessons from the Probe 2 phase. Probe is written up in the original articles in Building Services Journal [Reference 3], and in over 20 other publications. An up-to-date list of references, and details on where to get them, is available on the Probe website. The buildings studied are in Table 1.

Occupant surveys are an integral part of the Probe methodology. This paper gives an outline of the method and discusses some of the implications of the findings, especially for the type of strategic thinking that should underpin the briefing process. We are particularly keen to promote managed feedback from buildings in use so that design and management inputs are improved. One of the most important findings from Probe is already known as a basic maxim of quality control - as feedback improves, better buildings result.

THE SURVEYS UNDERTAKEN

Probe[1] collects information from occupants[2] for 49 variables, which fall into twelve groups:

- background (age, sex etc);
- the building overall (its design and how well it meets perceived needs);
- personal control (over heating, cooling, lighting etc and speed of response in meeting needs);
- speed and effectiveness of response after complaints have been made to the management;
- temperature;
- air movement;
- air quality (in both summer and winter for the last three);
- lighting;
- noise;
- overall comfort;
- health;
- productivity at work.

A standard two-page, tick-box questionnaire[3] is used. This has evolved from a twelve-page version first piloted by Building Use Studies (BUS) in 1985. It now includes what experience has shown to be the most significant questions, with most of the more detailed questions, such as those on health, removed. For a few buildings, extra questions were added on special topics of interest to the study team (e.g. perceptions of floor supply ventilation at TAN) or to the managers of the visited building (e.g. journey to work data at C&G). Sometimes a shorter secondary questionnaire was also given to specialist user groups (e.g. school pupils at CAB, students at APU and magistrates at RMC). When opportunities arose, meetings with management were also held, and occasionally staff focus groups.

DATA MANAGEMENT AND BENCHMARKING

Probe uses a relatively small core set of key performance indicators (KPIs), which remain essentially the same across all building types studied. Many surveys end up with too much data and not enough time to consolidate and analyse the results. A smaller core data set avoids this "data bloat" problem, and also releases

1 This paper covers occupant survey findings from the Probe 1 and Probe 2 series of studies.

2 Normally, questionnaires are issued to a sample of 125 permanent staff per building - or of all staff if the building is smaller than this. With the BUS technique used, response rates are typically 90% or more.

3 Licensed from Building Use Studies (BUS). http://www.usablebuildings.co.uk/BUS

time for managing the wider data set. This makes benchmarking achievable, using average scores from the last fifty buildings surveyed by BUS. To maintain these benchmarks, questions are changed as little as possible; and then by omitting those found to convey little information and adding ones on issues found to be important or interesting. For example:

- About two years before Probe started, questions had been added on system and management response, as a study on controls had found that these were important to user satisfaction.
- Questions on spring & autumn comfort were omitted, being less reliable than summer/winter.
- Late in Probe 1, questions on satisfaction with the design of the building and the degree to which the facilities met occupant needs were trialled. These were included in Probe 2

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As more buildings are added to the dataset, the burden of data management and quality control increases. However, the larger knowledge base makes the information gained more valuable, and the early trade-offs between "must have" and "nice to know" questions particularly important. An important aspect of Probe, especially in benchmarking all-round performance, was its early decision to use tried-and-tested methods to collect both energy and occupant data, and to alter these techniques only incrementally.

DATA PRESENTATION

In spite of frugal data gathering, there is still a prodigious amount of potential information[4]. To provide overall statistical snapshots of occupant responses, Probe uses two summary indexes:

- One based on comfort, see Figure 1, based on scores for summer and winter temperature and air quality, lighting noise and overall comfort.
- One on satisfaction, Figure 2, based on scores for design, needs, productivity and health.

These indexes are usually the first step in presenting results on a particular building. For example, buildings may score highly for satisfaction but less well for comfort (e.g. MBO); or well on both (e.g. permanent staff at FRY).

Percentile presentation. Figure 1 shows how the comfort indexes for all the Probe buildings (shaded data points)) relate both to each other and to the other (anonymous) buildings which make up the benchmark data set of 50 buildings altogether[5]. Occupants' rating scores on the 7-point questionnaire scales (1=Uncomfortable; 7=Comfortable)[6] are averaged for each building, and the values plotted at their positions on the vertical overall comfort scale. On the horizontal scale, buildings are in their rank order with the first-ranked (i.e. the best) placed at the 99th percentile, and the lowest-ranked at the 1st percentile. Using the percentile scale, it is then possible to say where the index for a building lies with respect to whole the dataset (e.g. is it in the top 20 per cent or the bottom 25 per cent?). This type of diagram thus combines absolute (i.e. real) scores on the vertical scale and relative (i.e. derived) scores on the horizontal scale. Figure 2 does the same thing for the satisfaction index.

Presentation of study scores with statistics. Scores based on the averages of occupant responses to a particular question in each building can also be presented in rank order on graphs, together with their benchmarks. These graphs can also include confidence intervals[7], to emphasise that they are based on sample statistics, and so subject to variations owing to sample size, variability of responses and random fluctuations. This permits rapid visual checks to see whether buildings differ significantly (in a statistical sense) from the benchmark, the scale midpoint or another building. For example, Figure 3 shows ratings for glare from sun and sky for each of the Probe buildings, together with the benchmarks from the BUS dataset:

- If the range shown for a particular building is intersected by the line for the benchmark mean, then that building is not significantly different from the benchmark (e.g. #10 POR).
- If the scale midpoint intersects the range, then the building is not significantly different from the scale midpoint (e.g. #8 RMC). This is of particular interest in scales which run from "too little" at one end to "too much" at the other, making 4 the point of balance.
- If a mean for a particular building intersects the range for another, then the buildings are not significantly different from each other (e.g. #4 (HFS) and #7 (FRY)).

In these comparisons, we are usually interested in the buildings significantly above benchmark (e.g. with too much glare from sun and sky, here APU, C&W, CAB, CAF and MBO); and those significantly below (here CRS, ALD, HFS and TAN); and to consider the reasons why. In this instance, all the low-glare buildings

4 Forty-nine (now 55 in Probe 3) variables are included in a typical survey. There are 15 Probe buildings nested with 35 others in the benchmark dataset; and typically 100 completed questionnaires per building. To be credible, the results must demonstrate that they have statistical validity and are reasonably comprehensive, so you need large samples and plenty of data. Given this, however, most people only are interested in a few things (e.g. how do the best buildings compare with the worst; is noise a serious problem?) so one must be concise and not overwhelm with statistics. To help overcome this, Building Use Studies has developed a statistical graphic on the internet which enables users to browse through the buildings and extract the data that interests them. This may be found via the home page of www.usablebuildings.co.uk.

5 For some variables, there are fewer than 50 data points, because the question concerned may have been omitted from some of the benchmark surveys for some reason, for example for confidentiality, in a short survey, or if newly-introduced.

6 Most of the scales used in the BUS questionnaires are 7-point tick-boxes.

7 Confidence intervals are ranges which give the chances of whether or not a measured score is significantly different from the benchmark dataset. Normally a measured score that falls within the range of the confidence interval has 19 chances out of 20 that it is the same as (ie not significantly different from) the benchmark dataset.

were AC ones with tinted glass, good provision of blinds, and limited use of daylight. The high-glare ones were shallower-planned and had all attempted to make good use of daylight; and the survey shows that this was not entirely successful for the occupants.

Scores for an individual building. For a single building, scores (along with the details for statistical tests) can be shown alongside the benchmark.

INTERPRETING THE RESULTS

Probe buildings are not a random statistical sample. Nor is the BUS sample, which is based on buildings in which post-occupancy evaluations have been commissioned. All will be self-selecting to some extent: managers who are prepared to commit resources to post-occupancy evaluations will also be interested in improvement, so they are already likely to have better buildings. The purpose is not a statistical study of a representative sample, but a wider understanding of the main risk factors which affect occupants in different circumstances, and helpful advice for designers and managers for improvement.

In buildings, obtaining statistically structured samples with requisite "random" elements of choice is almost impossible, owing to the difficulty of defining the sampling frame. Physical design and human and management issues are also inextricably linked. The questionnaire seeks responses on building-related issues, but a complete separation of influencing factors is not possible. For example, if occupants are not happy with their work, managers and colleagues, they may project their dissatisfaction onto the environment and facilities[8]. People can also use their physical environment as a risk-free way of protesting about poor management.

Interpretation also requires readers to consider particular contextual factors. High levels of occupant satisfaction are easier to achieve when the following features are present:

- shallower plan forms and depths of space (workstations typically 6m or less from a window);
- cellularisation;
- thermal mass (provided the acoustics are satisfactory);
- stable and comfortable thermal conditions;
- freedom from distracting noise;
- air infiltration under control;
- openable windows close to the users;
- views out;
- effective controls with clear, usable interfaces;
- a non-sedentary workforce (including relatively low VDU usage);
- predictable occupancy patterns;
- well-informed, responsive and diligent management;
- places to go at break times inside or away from the building.

All these features tend to give individual occupants some autonomy, and to reduce their reliance upon management. For example, occupants of FRY like many aspects of the building very much. However, this building has features that most occupants like anyway, which adds leverage to the scores: stable, comfortable conditions winter and summer; individual offices with openable windows for most staff; reasonably effective acoustic separation; and excellent controllability over ventilation, noise, and to some extent lighting. FRY also has work-related features which are associated with higher scores, in particular:

- nearly half of the staff use the building fewer than five days a week;
- when there, they also move around more, e.g. teaching and doing surveys; and so
- they spend less time at their desks and VDUs.

Features which make occupant satisfaction harder to achieve include:

- deeper plan forms with fewer window seats and views out;
- unpredictable thermal and acoustic conditions, often moving outside comfort thresholds and with low levels of user control;
- open work areas, with
- larger workgroups, sometimes split between different locations;
- greater mixes of activities with greater potential for conflict between them;
- higher densities, perhaps driven by space-planning criteria rather than operational needs;
- longer working hours, but with main support services active only during core time;
- presence of complex technology, particularly if unfamiliar.

These tend to make individual occupants more dependent on the systems and management in the building. If management is inadequate or unresponsive (or bossy, dismissive or intrusive), or finds it difficult coping with the building and the technology, occupants will be dissatisfied and vicious circles of decline can easily develop. On the other hand (but on fairly rare occasions) excellent management can look after complex buildings, satisfy staff, and engage in virtuous circles of continuous improvement. For example, the deep-

8 Even the best buildings (e.g. TAN) still have 65 per cent of their staff pointing out that something is not right!

plan AC TAN has many of the physical (e.g. very deep plan) and usage (e.g. predominantly clerical staff) factors which are often associated with poor occupant satisfaction. The fact that TAN's occupant scores are good is a great credit to the designers and the management - not only of the building, its furnishings and equipment, but also of its briefing and procurement.

COMFORT IN GENERAL

Occupants tend to rate buildings as most comfortable when:

- conditions are stable (and reasonably predictable from day to day so that people know what to wear); and fall for most of the time within acceptable (not necessarily ideal) comfort thresholds; but
- if necessary, conditions can be quickly altered in response to perceived fluctuations (like the weather) or unpredictable events (like glare, draughts, or noises outside); and
- if conflicts or unsatisfactory conditions occur, occupants can decide for themselves how to resolve them, by over-riding default settings rather than having conditions chosen for them.

For a control action to be perceived as effective, occupants must experience a rapid improvement. Conditions must no longer be beyond their threshold of discomfort, but do not have to be ideal.

The best buildings for comfort often also have:

- ratings for summer which are better than or equal to winter, as at FRY and RMC (in NV buildings, summer ratings are nearly always worse than winter - a problem unless a MM emergency cooling approach can be adopted);
- a perception of slight coolness, as at FRY; cooler buildings often also have higher health ratings (FRY is rated as healthiest), while many buildings are now perceived as too hot;
- lower variances, so that there is either less disagreement about the conditions; and people are more readily able to resolve any differences that do exist; and
- high levels of perceived control, especially over heating, cooling and ventilation. Control over noise is also becoming more important with trends to more open buildings, and sometimes also with exposed surfaces to increase their thermal inertia.

COMFORT, PRODUCTIVITY AND RESPONSIVENESS

Occupants who perceive that they are comfortable also tend to say that they are healthy and productive at work, so responses to health, comfort and productivity questions can often be surrogates for each other. As an illustration of this, we split respondents' scores in each building into those who are uncomfortable (i.e. they rate the overall comfort variable as 1, 2 or 3 on the scale) and neutral or comfortable (4, 5, 6 or 7). In the Probe buildings, uncomfortable staff overall report productivity losses of minus 8.8% and comfortable staff productivity gains of plus 4.0%, a difference of 12.8 percentage points.

The implication of the above is that there is more is to be gained not by aiming for better and better levels of comfort (as defined perhaps by engineering design criteria), but by strategies which seek to understand and eradicate factors that lead to perceived discomfort, ill health and low productivity. Productivity ratings for the Probe buildings are shown in Figure 4.

Probe has confirmed that respondents' perceptions of performance are linked to how rapidly they think the buildings' systems respond to their needs. The faster the better. The implication for design is that greater usability at interfaces perceived as critical by occupants (e.g. controls for heating, cooling, ventilation and glare) pay dividends, and that better management and manageability also helps to improve the overall responsiveness of the system.

PERCEIVED CONTROL

Building designers are now well aware of the importance of control to building occupants. However, the move towards open planning, linked furniture, and more automated control is causing occupants' ratings of perceived control to decline! In the BUS dataset the average control rating[9] for all buildings is 2.69, split by AC 2.13, ANV 2.90, NV 2.92 and MM 3.10. The Probe buildings with highest control ratings are WMC 4.4, RMC 3.9 and POR 3.4 (see Figure 5). Unusually low perceived control scores were found at HFS (1.3) and ALD (1.6).

High perceived control is frequently associated with better comfort, health and productivity, but not invariably so. Low perceived control may not matter much if conditions are good, management is good, and problems seldom occur, as at TAN. Control is particularly valued when it provides practical and effective means of mitigating discomfort without adversely affecting others and where it does not need to be exercised too frequently.

LIGHTING

One emerging finding from Probe (yet to be tested more fully) is that lighting tends to influence overall ratings of comfort only when it is either very good or very poor. Overall ratings of lighting in Probe are in Figure 6. Interestingly, the two buildings judged best for both had indirect systems (cornice lighting at FRY and metal halide uplighting at TAN). FRY's top score is probably related to the simple usability and

9 On a 7-point scale from 1=no control to 7=full control.

responsiveness of an individual room with a light switch. In some buildings, problems with controls had forced the score down, most notably at MBO, where occupants were disproportionately affected by an unfriendly automatic control system and some difficulties with the window blinds.

Occupants are asked to rate whether they have too much (=1 on the scale) or too little (=7) natural and artificial light. Occupants often say that they have too little natural and too much artificial. If the scores are subtracted (i.e. natural minus artificial) the Probe buildings come out with AC showing the highest differences, partly owing to their deep plan forms (see Figure 7). However TAN, the deepest in plan form, shows the least difference amongst the AC buildings, illustrating how thoughtful design can compensate to some extent even in the most challenging circumstances.

NOISE

Next to thermal comfort and personal control, occupants usually complain most about noise and its consequences, especially random disturbances which affect concentration. Noise is particularly difficult to deal with because relevant noise (e.g. workgroup colleagues' conversations) is acceptable to many, while irrelevant but intrusive noise (e.g. conversations of others) is not. Not surprisingly, buildings with the greatest degree of cellularisation (WMC and FRY) score best on noise ratings (see Figure 8).

Figure 9 gives percentages of staff who say they were dissatisfied or satisfied/neutral with noise. For the Probe buildings overall, 42 per cent of staff are dissatisfied. Dissatisfaction was lowest in HFS (high absorption, low density, some cellular) and WMC (cellular), highest in DMQ (dense, reverberant, open plan offices for some staff). In their written comments, occupants also draw attention to particular areas of dissatisfaction with noise. These include:

- the normal factors of open plan offices and insufficient acoustic treatment;
- layout, in particular poorly integrated workgroups, circulation routes cutting through clusters of workstations, adjacent kitchens, meeting areas and vending points, and banging doors;
- external noise including loading bays and car parks;
- noisy colleagues, particularly if not in the same workgroup;
- telephone ringers and computer feedback noises.

Figure 10 also shows differences in perceived productivity between staff who are dissatisfied with noise and those who are satisfied or neutral. Productivity differences of 15 percentage points are reported at POR, C&W and ALD. At POR, satisfied/neutral staff make the most difference - reporting high productivity gains; at C&W and ALD, the dissatisfied staff make the difference, reporting losses. Only two buildings, HFS and APU have negligible differences in productivity: HFS is lightly-occupied and quiet, but at APU, although occupancy levels were also low, noise was more of a reported problem. The differences at the well-managed TAN are also small; but here the large open-plan spaces are very uniform in character, and the ceilings unusually high.

IMPROVING CONDITIONS FOR OCCUPANTS

Concern about occupant satisfaction came to the fore in the 1980s with the discovery that chronic ill-health was often building-related (that is, reported symptoms like lethargy, headaches, dry eyes and dry throat appeared during the day and went away again after people left in the evening). These clusters of symptoms tended to be most common in deep-plan, air-conditioned offices, so it was naturally, but rather prematurely, concluded that AC was the cause.

Things are no longer so cut-and-dried, partly owing to developing survey techniques and partly to improvements in the design, maintenance and management of AC buildings; and more complication in NV ones. For instance, TAN has many of the risk factors associated with chronic ill-health (very deep plan form, AC, open office layout) but staff perceive it as comfortable, healthy, and improving their productivity at work. FRY also scores very well on occupant comfort, but has many physical and work-related characteristics which one would expect to create good scores.

It is tempting to focus on design and technical features to explain good occupant satisfaction, but the real reasons may be more to do with how design and management come together to create a total system. Buildings which the occupants perceive as best tend to have good ratings for perceived quickness of response (Figure 11); which is itself associated with comfort and productivity. Responsiveness is related to:

- usable controls which are easy for occupants to understand, deliver acceptable performance and can be seen to be obviously working;
- comfortable conditions for the majority of the year, with the ability for occupants to trim and fine tune if things alter for the worse;
- a space plan which accommodates workgroups properly to maximise within-group requirements and minimise between-group conflicts (for example, people within a group can decide for themselves how the window blinds can be set, without affecting the preferences of the adjacent group);
- a diligent facilities management team backed up by a proactive help desk which deals with complaints sensitively and rapidly;
- a management culture which takes staff needs seriously and strives to achieve them, even if everything is not always working in their favour.

The last point may be the most important. Amongst the Probe buildings it is well illustrated by MBO, which scores reasonably on the comfort index (fifth in Figure 1), but comes first (just) in the summary index of satisfaction (Figure 2)[10]. MBO is instructive not just for its design philosophy and its pioneer window system but because all levels of staff were involved at most phases in the design, development and handover processes, albeit at modest level. For example, when MBO was being fitted out prior to occupancy, the architect and senior management hosted staff meetings in the new building to explain what things were for and how they worked. The occupier's senior management were also committed to the Investors in People programme, and proud of their achievements in it. The developer, Lansdown Estates Group (now Milton Park Ltd), encouraged independent post-occupancy feedback on its buildings, and has striven to ensure that its clients obtained value in the buildings it supplied.

MBO itself had flaws and disappointments - particularly lighting control, together with glare and air leakage, but the total package as a working building pleased both management and staff. Its energy performance is also reasonable, with prospects of further improvement. While FRY was best on most performance indicators and has received most of the plaudits, MBO is an instructive all-round example of how developer, client, architect, management and staff - working within modest budgets and the added constraints of large warehousing requirements alongside - create value and performance in a building which has exceeded most expectations.

CONCLUSIONS

Many things occupants want in buildings are clear: comfort, health and safety are prominent at the strategic level; and functionality, airtightness and usability at the technical. Most clients will not even think of asking for these in a project brief, because they will assume that they come as part of the service. However, while the good buildings are getting better, Probe and other studies indicate that chronic problems are still rife, and affect occupants' perceptions and performance. Many of these never come high enough on anyone's priority list to receive the attention they require, so slamming doors, glare, overheating, unresponsive or intrusive control systems and random disturbances are widespread. Even the best-laid plans can be undermined by a leaky fabric (as at HFS and CAF); a rogue lighting system (MBO); too much noise (POR or APU); or too few usable controls (ALD).

In the buildings occupants like most (FRY, MBO, RMC, TAN, C&G, WMC and to some extent CAB, POR and CRS), what are the factors for success? Best results tend to occur when:

- Features like shallow plan depths, openable windows, comfortable thermal conditions (especially in hot and humid summer periods), acoustic separation and good views out are all present. Ideally, as at FRY and WMC, there should also be no need for high management intervention to achieve an acceptable working environment.
- If some or all of these features are absent for any reason (e.g. if the building is large, complex and deep-plan), they are compensated for by all-round excellence in facilities services such as cleaning and a responsive help desk (e.g. TAN, C&G, and to some extent CRS).
- These need to be additionally underpinned by a stream of managed feedback about performance, not just relating to occupants' main preoccupations like comfort, but also data on areas such as cost-in-use, space utilisation, energy, cleaning and maintenance outcomes.
- This managed feedback stream creates the self-fulfilling loops so necessary for quality control (e.g. at TAN). Outcomes should be constantly re-assessed against benchmarks and/or in-house targets (e.g. FRY which was monitored by a research team) and remedial action taken where necessary).

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10 The "design" and "needs" components of this index were introduced halfway through Probe, so the earlier buildings are not included.

However, contexts and circumstances change from case to case, making buildings different from consumer products like cars. Success often emerges from a combination of clear-minded foresight and a happenchance of factors, many of which will not be repeatable on the next job[11]. At each stage of the design, and during the early stages of occupancy, basic issues of risk and relevance need to be set against perceived occupant benefits (for example, the open-plan layout at DMQ was not suited to staff needs). This why the last of the points above is the most critical: monitoring gives advance warning of unusual contextual factors which may threaten or undermine performance, and highlight areas of risk more successfully.

Improving conditions for occupants requires not only:

- better tactics which take account of risk factors in design (e.g. deep plan, lack of control etc.);
- more enlightened design (e.g. more humane workgroup layouts or space plans); and
- better environmental performance (because the associated design and monitoring activities have carry-over effects on occupants' comfort, health and productivity).

It also needs to embed design issues in a much broader picture of technological and management consequences, with:

- strategic foresight in perceiving the right links between ends (such as business goals, staff satisfaction and energy efficiency) with the available means to meet those ends (e.g budget, cost, quality, and perceived constraints); and
- putting emphasis in the right places (on both ends and means, rather than just means as is often the case, or confusing the two by treating means as ends).

Because of volatility and the difficulty of predicting outcomes, strategic thinking in the early stages is particularly important, and especially

- a targeted strategy, preferably expressed in a well-structured, jargon-free brief; together with
- constant evaluation and re-evaluation of performance outcomes against objectives during design, handover and occupation; and, most vital of all
- a programme of reality checks throughout the design process protects the occupants' interests, by keeping ends in view.

If buildings put means (e.g. higher space densities; natural ventilation; or open planning) before broader ends and performance criteria (e.g, customer service, productivity; energy efficiency, adaptive comfort, or a more open culture); there can be revengeful problems later on. Difficulties often arise not so much from the eventual space layout or appearance of the building, but with less visible interactions between performance, operation of technical systems and their manageability in use.

Noise is an important illustration of this in action. Only in Probe's cellular buildings (FRY and WMC) was it under good control from the occupants' point of view. Cellularisation delivers privacy and freedom from distraction, but cuts people off from each other. Increasingly, clients and designers perceive that the benefits of greater communication (and associated higher occupant densities) can be traded off against lack of privacy. In some cases the risk is low - as at MBO and HFS; in others very much higher - as at DMQ, where academic staff were moved from cellular offices into crowded, insecure and poorly-furnished open areas. Although outcomes are mostly predictable, lack of foresight at the briefing stage, and poor evaluation procedures, mean that solutions are seldom checked against likely outcomes.

Designers and clients also tend to assume that technology will take care of the basics, whilst imposing little or no burden on facilities management. Our experience is the opposite: added technology requires increased management vigilance; and if not properly managed can reduce a building's overall effectiveness. Probe's findings suggest that thoughtful simplification could make many buildings more appropriate for a wide range of uses; and deliver all-round benefits in occupant satisfaction, environmental efficiency, productivity and cost-effectiveness. On the other hand, complex, but very well managed buildings will be the appropriate solution for other needs: in practice, however, we have found that only a small proportion of occupiers find themselves able to afford and to justify the levels of management that such buildings demand.

References

1 Leaman A, Bordass W, Cohen R and Standeven M, **The Probe Occupant Surveys,** Buildings in Use 1997, CIBSE (February 1997).

2 Bordass W, Bunn R., Cohen R. and Leaman A., **The Probe Project: Technical Lessons from Probe 2,** CIBSE National Conference, (October 1999), paper no 103.

3 Building Services September 1995 - January 1999. See also Table 1 of the present paper.

11 As the architects and engineers of FRY reported at a Probe seminar in 1998.

Table 1: Probe buildings investigated

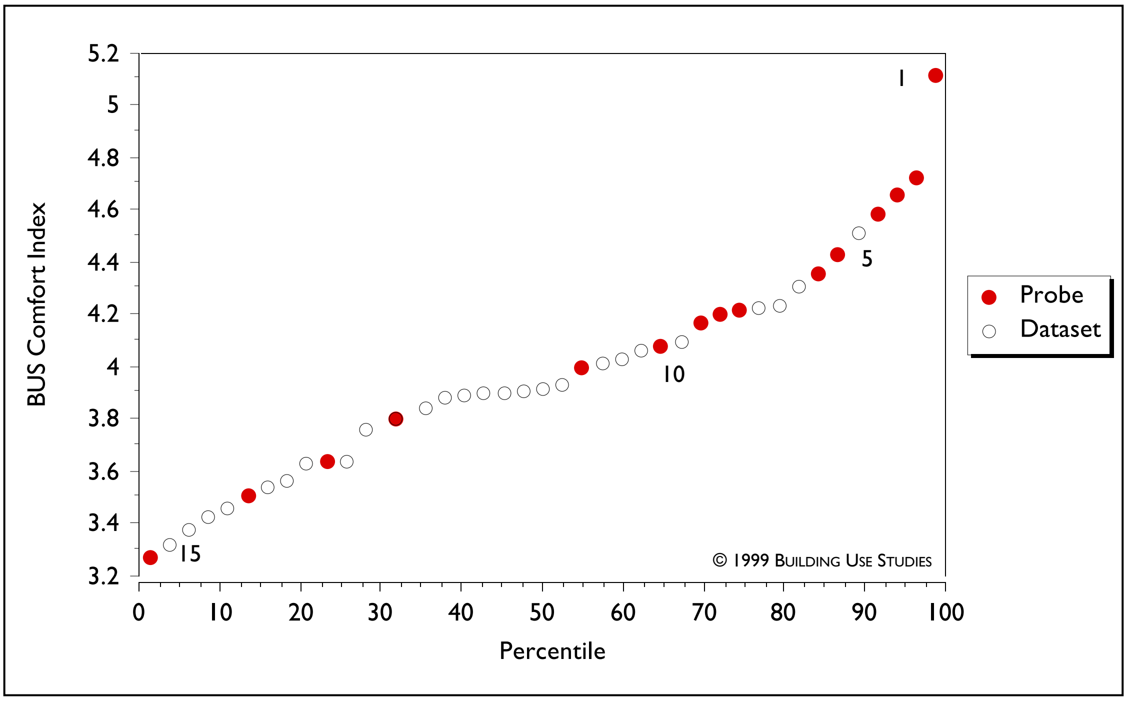
Probe 1

Sequ #	Full name	Location	Site	Short name	3-letter	Type	Gp	HVAC	Article	#
1	Tanfield House	Edinburgh	IC	Tanfield	TAN	Large administrative centre	O	AC/(MM)	Sep-95	1
2	1 Aldermanbury Square	London	CC	Aldermanbury	ALD	UK Head office (speculative)	O	AC	Dec-95	2
3	Cheltenham & Gloucester	Gloucester	BP	C&G	C&G	Large head office	O	AC	Feb-96	3
4	de Montfort Queens Building	Leicester	IC	de Montfort	DMQ	University teaching	E	ANV	Apr-96	4
5	Cable & Wireless	Coventry	BP	C&W	C&W	Company training college	M	ANV/NV	Jun-96	5
6	Woodhouse Medical Centre	Sheffield	IC	Woodhouse	WMC	Medical surgeries	M	NV/(MM)	Aug-96	6
7	HFS Gardner House	Harrogate	BP	HFS	HFS	Principal office	O	AC	Oct-96	7
8	APU Queens Building	Chelmsford	IC	APU	APU	Learning Resources Centre	E	ANV	Dec-96	8
Probe 2										
9	John Cabot CTC	Bristol	IC	Cabot	CAB	Secondary education	E	NV/ANV	Oct-97	11
10	Rotherham Magistrates Courts	Rotherham	IC	RMC	RMC	Courtrooms and offices	M	MM	Dec-97	12
11	Charities Aid Foundation	West Malling Kent	BP	CAF	CAF	Principal office (per-let)	O	MM	Feb-98	13
12	Elizabeth Fry Building	Norwich	UC	Elizabeth Fry	FRY	University teaching	E	MM	Apr-98	14
13	Marston Books Office	Abingdon	BP	MB Office	MBO	Principal office (per-let)	O	NV/(ANV)	Aug-98	16
14	Marston Books Warehouse	Abingdon	BP	MB Warehouse	MBW	Warehouse (pre-let)	M	NV	Aug-98	16
15	Co-operative Retail Services	Rochdale	BP	CRS	CRS	Large head office	O	AC/(MM)	Oct-98	17
16	The Portland Building	Portsmouth	IC	Portland	POR	University teaching	E	ANV/MM	Jan-99	18

Site: BP=Business Park or similar; CC=City Centre; IC=Inner City; UC=University campus
Group: E=Educational; M=Miscellaneous; O=Office

HVAC: AC=Air Conditioned; NV=Naturally Ventilated; ANV= Advanced NV; MM=Mixed Mode (Bracketed if minor influence)

Figure 1 Comfort index showing Probe buildings and BUS dataset

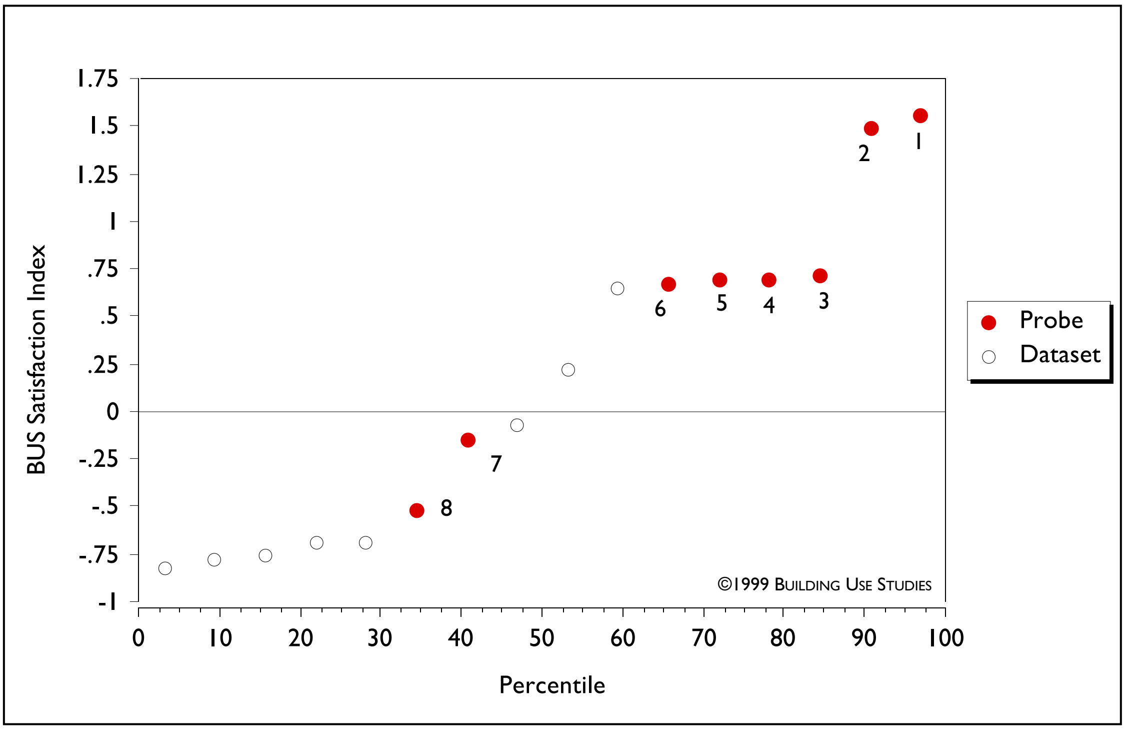


Comfort index score

1	FRY	5.12
2	TAN	4.73
3	C&G	4.66
4	RMC	4.59
5	MBO	4.44
6	WMC	4.36
7	HFS	4.22
8	CAB	4.20
9	POR	4.17
10	CRS	4.08
11	ALD	4.00
12	Benchmark	3.96
13	DMQ	3.81
14	CAF	3.64
15	APU	3.51
16	C&W	3.27

The BUS comfort index is an average of seven comfort variables with the scale 1=Uncomfortable; 7=Comfortable.

Figure 2 Satisfaction index showing Probe buildings and BUS dataset

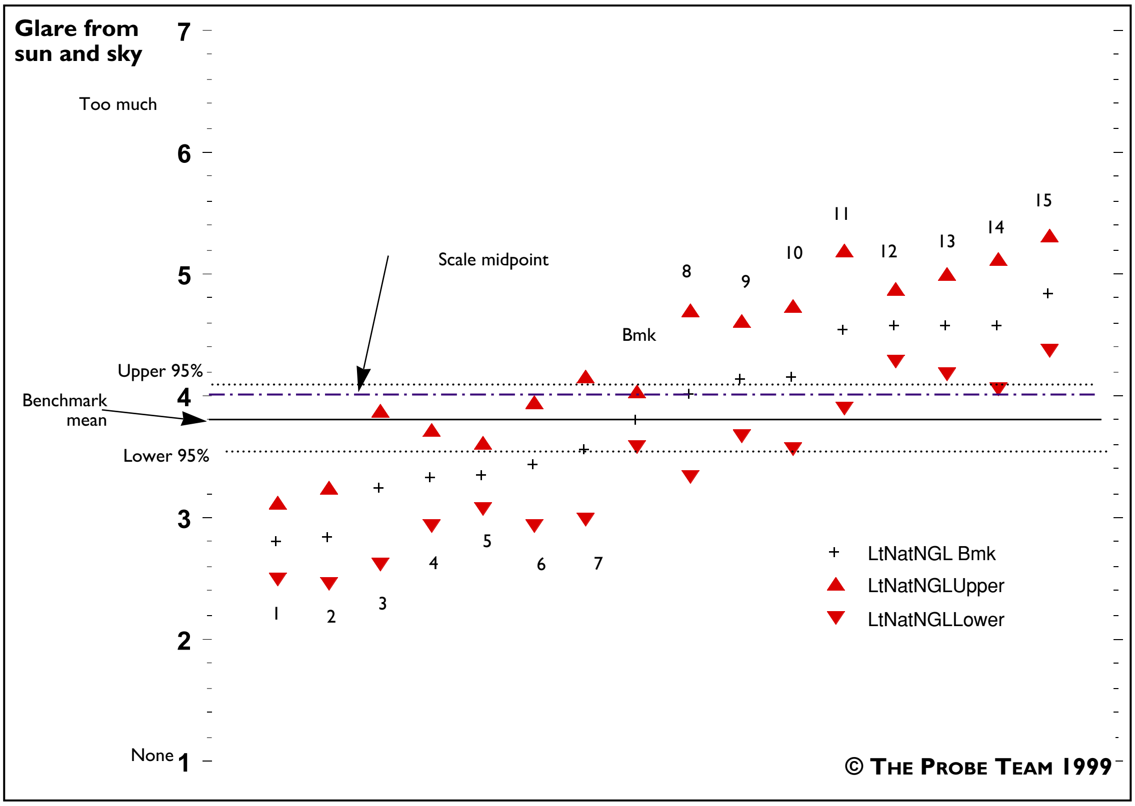


Satisfaction index score

1	MBO	1.56
2	FRY	1.49
3	RMC	0.72
4	CAB	0.70
5	CRS	0.69
6	POR	0.68
7	CAF	-0.15
8	APU	-0.52

The BUS satisfaction index uses the average of standard z-scores for four variables - Design, Needs, Health and Productivity.

Figure 3 Benchmark example for glare from sun and sky



Key to buildings

1.	CRS	6.	C&G	11.	MBO
2.	ALD	7.	FRY	12	CAF
3.	WMC		Benchmark	13.	CAB
4.	HFS	8.	RMC	14.	C&W
5.	TAN	9.	DMQ	15.	APU
		10.	POR		

Notes

Upper and lower ninety-five per cent confidence intervals are shown for 1) individual building means; 2) Building Use Studies dataset benchmark for 50 buildings.

A building mean is significantly different from the benchmark mean if the mean value falls outside the interval range for the benchmark mean. A building mean is significantly different from another building if its mean value falls outside the interval range for that building.

Figure 4 Perceived productivity ratings: Probe buildings

	Productivity ratings
WMC	10.9
TAN	8.0
MBO	7.1
CAB	6.3
FRY	6.2
POR	4.8
HFS	2.1
RMC	1.8
CRS	1.1
Scale midpoint	0.0
Benchmark	
CAF	-3.5
ALD	-4.2
APU	-5.6
C&W	-8.1
DMQ	-10.0
C&G	No data
	Plus or minus %

Figure 5 Perceived control ratings: Probe buildings

	Control ratings
WMC	4.4
Scale mid point	4.0
RMC	3.9
FRY	3.4
POR	3.4
CAB	3.2
C&W	3.0
DMQ	2.9
CAF	2.9
MBO	2.7
Benchmark	
APU	2.3
CRS	1.7
TAN	1.7
ALD	1.6
HFS	1.3
	Average based on 5 rating scores: Scale 1=No control; 7=Full control

Figure 6 Perceived lighting ratings: Probe buildings

	Lighting ratings
FRY	5.26
TAN	5.01
CAB	4.68
RMC	4.52
HFS	4.20
POR	4.12
WMC	4.07
Benchmark	
DMQ	4.01
Scale midpoint	4.00
CRS	3.99
ALD	3.98
MBO	3.94
C&G	3.88
CAF	3.67
C&W	3.64
APU	3.36
	1=Unsatisfactory; 7=Satisfactory

Figure 7 Differences in ratings of natural and artificial light: Probe buildings

Original scale: 1=Too much 7=Too little	Differences in ratings of natural and artificial light (natural mean scores minus artificial)
C&W	-0.21
CAB	0.21
POR	0.84
APU	0.86
DMQ	0.86
WMC	0.97
RMC	1.00
FRY	1.18
MBO	1.21
TAN	1.34
CAF	1.54
CRS	1.60
ALD	2.13
HFS	2.32
C&G	2.66

Figure 8 Perceived noise ratings: Probe buildings

	Noise ratings
WMC	5.07
FRY	5.05
HFS	4.73
CAB	4.72
C&G	4.40
MBO	4.35
TAN	4.33
Scale midpoint	4.00
CRS	4.00
Benchmark	
RMC	3.86
ALD	3.55
APU	3.54
CAF	3.36
POR	3.29
C&W	2.96
DMQ	2.74

1=Unsatisfactory; 7=Satisfactory

Figure 9 Staff satisfaction and noise: Probe buildings

	% staff	
	Dissatisfied with Noise	Neutral / Satisfied
HFS	18.6	81.4
WMC	20.0	80.0
FRY	22.5	77.5
CAB	25.5	74.5
MBO	31.5	68.5
C&G	31.9	68.1
TAN	33.9	66.1
CRS	42.5	57.5
RMC	42.9	57.1
ALD	45.5	54.6
APU	52.6	47.4
CAF	55.4	44.6
POR	60.0	40.0
C&W	63.6	36.4
DMQ	72.9	27.1
Total	42.4	57.6

Figure 10 Noise and perceived productivity: Probe buildings

	% Productivity		
	Dissatisfied with noise	Neutral / satisfied with noise	Difference
POR	-3.0	12.8	15.8
MBO	4.3	8.2	4.0
TAN	7.7	8.1	0.4
CAB	2.0	7.5	5.5
FRY	1.3	7.0	5.8
WMC	1.7	4.4	2.8
RMC	0.8	3.3	2.5
C&G	-3.0	3.1	6.2
CRS	-2.6	2.4	5.0
HFS	2.7	1.9	-0.8
C&W	-14.0	1.3	15.3
DMQ	-14.2	0.6	14.8
ALD	-9.2	0.4	9.6
CAF	-4.1	-2.6	1.5
APU	-6.0	-5.3	0.7

Note : Buildings are ranked by reported productivity of staff satisfied/neutral with noise.

Figure 11 Perceived quickness of response: Probe buildings

	Average quickness
RMC	4.8
WMC	4.5
FRY	4.2
Scale midpoint	4.0
POR	4.0
CAB	3.9
CAF	3.8
TAN	3.6
MBO	3.5
Benchmark	
C&W	3.4
DMQ	3.3
APU	3.2
ALD	3.1
CRS	3.0
HFS	2.4
C&G	No data

Average based on 5 rating scores: Scale 1=No response 7=Very quick response