An Open Value-Based Perspective to Healthcare Building

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ABSTRACT

Aim: This paper aims to build a conceptual relationship between value and open building and scenario planning to aid the assesment of healthcare infrastructures over the short, medium and long term and against dynamically changing contexts.

Background: Faced with the current financial climate, organisations often find themselves debating the impact of short-term economic pressures, at the expense of planning the strategic long-term sustainability and value of their physical assets. Existing decision making and stakeholder consultation approaches are inadequate and as such an open and dynamic value-based approach to scenario planning is required that will capitalise on the benefits of standardisation, customisation and learning.

Methodology: This paper is supported by a critical and comparative review of health infrastructure, value management and open building literature to understand similarities and differences. It also reports on a workshop with academics and industry professionals and coins “open value” as a new direction for research.

Findings: This paper advances the emergent understanding of open building and planning by classifying workshop data into value and evidence based dimensions that can be used to assess value at two levels - open planning and open building.

Implications: Value is an important concept in open scenario planning and building. Furthermore, a new method of categorising open value as benefits, sacrifices and resources is trialed.

KEYWORDS:
Open, Planning, Building, Scenario, Value

BACKGROUND CONTEXT

In the present climate there is a propensity to focus on static short-term demands, rather than more dynamic long-term organisational value. This tendency is driven by uncertainty and is exacerbated in an industry such as healthcare, which is characterised by perpetual, and complex building types, many spatial configurations, continuous innovation and competing evidence on what delivers value. One consequence is that the effective life span of healthcare buildings are shortening and contributing to growing numbers of buildings being renovated or abandoned because of technical, social or economic obsolescence. Open building offers levels of malleability to accommodate inevitable changes at various building and site scales however, on some occasions these buildings and sites themselves can become victim to broader structural changes and developments to the landscapes around them that can result in building redundancy. These high investment and long lasting asset-based decisions should ultimately be made to optimise value (if indeed this is ever fully possible).

According to Engel and Browning (2006) systems provide value against stakeholder needs and expectations that emerge over time, degrade and change. The implication is that value-related decisions must be made about which assets to invest in and which to disinvest in. The healthcare infrastructure system is like a kaleidoscope and certainly complex (Mills et al., 2010b). It raises then the question how can adaptability be designed into the system so that it can provide maximum whole life value. What is certain is that a system’s value is likely to diminish and depreciate over time as stakeholders’ value judgements emerge (and their expectations and experience rise), technology changes, system’s maintenance costs increase and components become obsolete. Upgrades come at a substantial cost and disruption, and are often critical since the cost of complete replacement is prohibitive.

Open value is proposed as a useful research direction to bring planners, designers and wider stakeholders together to agree a common reconciling infrastructure solution that goes beyond the functional and so can accord with the underlying values of the NHS. However, functional “ware hanger” and “shed” like construction is today seen, as the best most efficient and adaptable building solution. Rogers (2011) for example, cites comments made by todays UK ministers on the importance of building economic hospital “sheds around people and equipment”.

THE CONCEPT OF VALUE

Value is according to Mills (2010) inherently complex with various people, product and process perspectives overlapping, interlocking and at odds. This makes adaptable and open buildings more challenging. There is a need for a new broader interpretation of value that includes an emergent and iterative process of stakeholder engagement and sensemaking, which goes beyond standard approaches and integrates unique stakeholder views into the asset planning and design process. Since its conception in 1945 (Miles, 1972), value managements application has often centred on understanding static, functional and cost effective product alternatives at a single point of time and within a single coherent stakeholder group. Open building, in contrast, looks for the dependency and interdependency between products and systems seperation between expert decision makers and in integrated teams. As larger and more complex products and systems were analysed, the emphasis in value management shifted to more strategic, whole system and upstream decisions, "Function Analysis System Technique" (FAST) evolved to accommodate this change (Bytheway, 1965), however time and undertainty were not centrally incorporated as core principles. Whole life value however, evolved to emphasis the importance of the time and cost uncertainty dimensions in evaluating long lasting built assets. Ellingham and Fawcett (2006) within the field of whole life costing presents a “fan of uncertainty” and “binominal tree” as a means of quantifying future favourable or unfavourable outcomes against numerous diverging events and options on a timeline, which is a useful principle in value-based decision making for open scenario planning and building. Other techniques such as lean have looked to re-engineer activities to maximise value using relatively quantitative measures to minimise waste, while useful these are by-and-large applied at a micro level (Mills et al., 2010a, Mills et al., 2011).

The overarching definition of value used in this paper follows research carried out by Thomson et al. (2003) and Mills et al. (2006), which follows an economic output input model however, is more socially determined by stakeholder trade-off, rather than objective mechanisms of transformation. Fundamentally it comes down to: “what you get” (outcomes in terms of Benefits and Sacrifices) for “what you give” (inputs in terms of resources). As such, this equation is used to characterise the nature of a stakeholders’ definition and evaluation of a proposition over time and between alternatives. The pseudo equation presented in Figure 1 provides a common unified definition and consensus view of the literature, where stakeholder perspectives (Sn) are sumed and aggregated to form a project view of value. However, it should be noted that it is not presented as the only one way of universally representing value, for example against a healthcare context we may talk of “health” and “harm” as top line outcomes, and “investments”, “disinvestments” and “risk contingency” as inputs.

$$\text{Value} = \sum\left(\frac{\text{Benefits (B) - Sacrifices (S)}}{\text{Resources (R)}}\right) + \left(\frac{\text{B-S}}{\text{R}}\right)^{\text{Sn}}$$

Figure 6. Value Equation Mills (2006) and Thomson (2006)

The engagement of wider stakeholders in the decision making process is gaining much greater importance to ensure that wider feelings of involvement, however open building has not been extended to incorporate a broader stakeholder viewpoint beyond the system seperation of teams. Within value management authors on the subject have described it as a multi-stakeholder approach, however in practice the breadth of those stakeholders consulted have often been only those stakeholders in support of the project; this is further described elsewhere (Mills et al., 2009). Today there is a clear recognition that there needs to be broader stakeholder consultation, however that this consultation also needs to be controlled to deliver value (to ensure that it does not lead to considerable design change and escalations in scope, specification and cost). There is a clear need for a hierarchy of project roles that range from those who are informed of the project outcomes, those who are consulted on design alternatives (scenarios and options) and asked to make compromises and trade-offs and those who decide and approve schemes based on stakeholder participation roles, structure and levels (Arnstein, 1969).

OPEN BUILDING INFRASTRUCTURE PLANNING

State-of-the-art debates in the field of open and adaptable building are focused on strategies for adapting to changing task, space, performance, function, size and location (Schmidt et al., 2009). Other definitions primarily centre around Brand (1995) and the exploration of physical and spatial building scales, rather than looking at the wider systems of business operations and a wider definition of what makes up value over a buildings whole life. Kendall (2002) was perhaps the first to relate broader performance (and its various measures and economic, technical and social purposes) to open building. However, he also limited value, using spatial constraints in open building levels (against a view of “territorial control” and “time”) as the rational spatial bounds of value. Kendall (2002, 2007) did however define the importance of a three tier design team system separation. This same principle applies to wider project stakeholders, however this has significant implications on project management control.

Brand (1995) describes a building adaptability model, where buildings are stratified into layers that function in a totality, but are most adjustable and adaptable to specific uses and technical changes when different layers can be changed independently or with few consequences for the other layers. For Brand (1995) the totality and interdependence between the systems and layers are critical to decision making to create a clear purpose in use. Kendall (2002) defines a level as “...a configuration of spaces and physical elements under the control of a party”. Kendall (2002) states that there are a number of situations that contribute to a buildings complexity, these include for example multi-tenant, design process responsibility change, operating and tenant change, real estate sale, differing fit-out performance expectations. While for Ellingham and Fawcett (2006) complexity is increase by whole life development, expansion, switch of use, reconfiguration, refurbishment and new technology options. All of which are critical in the definition and realisation of value. Kendall (2002) uses a hospital example to describe the importance of thinking about organisations and systems of buildings over time. Using the Inselspital Hospital, Bern, Switzerland Kendall (2002) noticed that the principle of optimising the constructed whole, at once as a "large lumpy and static object", and from the beginning around dependencies, lists of technical parts and performance was unachievable, generalising that the "whole" of such complex hospital buildings is organised and comes into existence over time and that artefacts are organised according to the "...distribution of control". Facing this "evolving rather than static" (p. 5) paradigm, the hospitals administration at Bern changed its strategy to "open" building, with specific and detailed "accommodation capacity" for a range of "programmatic scenarios" to "balance stability and change" and to organise on three primary system (100 year), secondary layout (20 year) and tertiary levels (changeable over 5-10 years) (p. 5). Such timescales and scenarios should be the basis of value based decision making. Kendall (2002) concludes that "it may be possible to account for performance in terms of whole buildings, [but] it may be more meaningful to attribute performance to distinct levels of control, of interest to distinct parties, whose performance expectations nevertheless are not in conflict" (p. 8). Jensø (2007) provides a study of Rikshospitalet and St. Olavs Hospital to show that hospital projects often change drastically, particularly as a result of decisions on investment, concept, size and shape of the building site. However, this work is still ongoing. The importance of these finding for this paper is that value is nested and emergent at various levels and that it can be organised and equated. That value at a wider site or system level, could be the sum of value from the lower dominated levels. However, this requires further definition as the social complexity of building may be more chaotic, dynamic and dependent on subjective judgments and relative stakeholder powers.

Outside of open building, perhaps one of the most applicable and advanced property and real estate approaches to layering hospital developments was published by the Netherlands Board for Healthcare Institutions (2007). This approach sees "acuity" being the most central value concept in organising assets. Where different building types are measured by their specificity, cost, flexibility and marketabiliy. Acuity, a measure of the level of health or possible harm, defines the severity of the condition and prioritises the patients' treatment (what team, what space and what urgency). As such, it is a critical overarching organising principle. Acuity has no bounds, it is organised around patients wherever they are. This layered approach divides the hospital into four buildings, referred to as the layers. These layers are the:

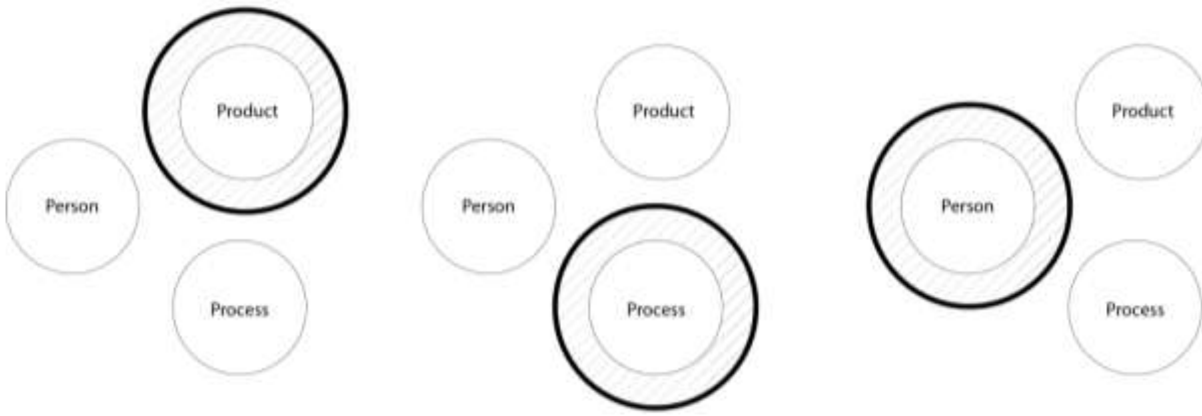
- Hot floor, the high-tech, complex capital intensive specialist functions.
- Hotel, all accommodation and inpatient functions.
- Office, these are the administration, management and simple diagnostics, examination and treatment functions.
- Industry accommodates all medical supporting and facilitating functions.

If acuity can be modelled and understood against open value levels, changes in patient acuity must determine spatial adjacency, flow and movement through the system. Technologies are the means of managing acuity, and for every change in technology modality value and disruption must be understood. Whether blood clotting drugs that stop stroke, organisation around helicopter access, ambulance based diagnostic technologies or remote tele-care systems; open planning and building must accommodate these changes if it is to deliver value. With organising around the concept of "acuity" and "changes in acuity", infrastructures will be more open and adaptable to change/refurbishment and so will deliver higher long term value.

DEVELOPMENT OF A NEW VALUE-BASED OPEN APPROACH

Value, at its most fundamental, can be understood in terms of the interaction of people over time in the creation of service and built products. What is needed therefore, is an open framework of levels that supports an understanding of this interaction, so that uncontrolled and closed views of value interactions can be limited (Figure 2)

A concentration on the routine engineered product (whether it be the built product or service), rather than its interaction with people (and their values and behaviours) can predictably result in overly mechanistic, systematised and hard outcomes (Figure 2a). The creation of an overly controlled process using structured tools, which do not acknowledge stakeholder differences and product variations can lead to lost opportunity for learning and inflexibility (Figure 2b). While overly people driven "designing by committee" processes (centred around changing baseline expectations and experiences) and missing competencies within integrated teams can limit the experience and expectations encapsulated in the product (Figure 2c), a topic of discussion in Mills et al. (2009). Open building may enable interactions between stakeholders and the emergent product solution however, various levels of control must be put in place to facilitate value dialogues and clear interacting lines of decision making. What is necessary is an open interaction between stakeholders during the process of design that is managed according to open planning and building levels and robust people and process controls. This interaction of learning, customisation and standardisation is a process that asks people to be adaptors (to be involved in the processes of trading-off adaptable building qualities and coming to compromise). This interaction is defined in Figure 2d. Standardisation and design re-use in open building can have many benefits; however without project customisation and the maintenance of standards and standardisation systems, these can become quickly outdated and obsolete against changing environments and customer needs and expectations. What is needed therefore is an evaluation and learning system that provides some flexibility and openness during design delivery rather than prescriptive and standardised re-use alone. Designers must develop approaches that provide a rich and diverse multi-stakeholder and multi-criteria understanding that can be reconciled into a more creative "satisficing" as in Simon (1969) and open solution. It is clearly important to understand and learn to decrease customer sacrifice to lessen the gap between what each customer expects and what they judge they get. If organisations can find ways to reduce sacrifices, they will be able to create significant value for each customer. The introduction of value in planning and design will also stimulate value based learning, sacrifice reduction and sustained competitive advantage.



a) Closed product value b) Closed process value c) Closed person value

d) Open value

Figure 7. Open Interaction of Person, Process and Product

METHOD

This section describes the application of the Value Equation (Figure 1) in a workshop with 32 participants (14 practitioners and 18 academics). The participants were grouped into two sub-work-groups according to their expertise. The aim was to consider the dynamic nature of value (against the proposed benefit, sacrifice and resource definition) for open planning (defined as lean assets, lean logistics and lean access) and open building levels (described as lean space, lean flow and productive departments). To understand the trade-off between value criteria, and the similarities and differences between open planning value and open design value. These two sub-work-groups answered the following to investigate whether value can be universally measured using a common structuring equation: 1) benefits; 2) resources; and 3) sacrifices.

DATA AND FINDINGS

The columns in Table 1 and 2 contain a summary of the value-related issues expressed in the workshop. Open value in planning, in Table 1, was considered from a commissioner perspective.

Table 1: Open Planning (defined as lean assets, lean logistics and lean access)

Benefits	Sacrifices	Resources
Whole-system organisation	Opportunity cost (time, money, hassle)	Built Estate assets
Social enterprise and cooperation	Hospitals going bust and closing / Risk of market failure - Barriers to market entry and exit	Informal carers and family members
Patient access and time	Workforce issues (skills lost due to localisation) / Re-skilling and redundancy of particular clinical specialists / staff access	Cost of preventative mechanisms
Acceptability to the public	Loss of local service / fear of distance from protected services / rural in-access	Staff / Skills
Improved thru-put	Lost whole-system organisation power	IT / Data Information / Knowledge / Access to Evidence
Health outcomes (mortality)	Market power of GPs / Loss of control for GPs in consortia	Available Capital / Options
Convenience	Social care cuts	Space
Patient satisfaction through care closer to home	Carbon footprint and whole system organisation / sustainability	Equipment
Carbon footprint	Wasted opportunities for innovation and diffusion	Branded and Clearly Understood Service Models / User and Patient Knowledge
Self-management / personalised resources	Political leverage (Kidderminster)	Wellbeing and Social Cohesion / Team Stability / Culture / Creativity, Invention and Ideas
GP equity stake / shareholding in a consultant led service / commissioner control		Forecast-ability / dynamics and understanding of resource scenario
Equitable access and distribution		Self management / personalised resources
		Competitive market and choice "Any willing provider"

Open value in building design. Table 2 was considered from a user perspective.

Table 2: Open value in Building (described as lean space, lean flow and productive departments)

Benefits	Sacrifices	Resources
Single rooms	Floor space utilisation	Energy
Quality contact time	Flexibility	Time planning
Infection control	Aesthetics	Investment in cultural / behavioural change
Privacy and dignity	Too generic standardisation	Plan – Do – Check – Act
Flexible use of rooms – e.g. gender separation	Patient experience	Management and sustainability
Better sleep	Longer distance for staff	Budget
Reduced length of stay / Quicker recovery / Speedy treatment and response times	More land	Land
Space for family	Patient isolation	Stress and pain
Standardisation	Direct observation and communication	Visitors
Safety	Storage	Drugs
Lack of waiting between departments – user flow		Flows – Information, Waste, Food and water / goods / movement
Good communication / information		
Healing by natural daylight		

This activity showed that very few of the open planning value interactions were spatially constrained; rather, they were driven by market organisation, economics (scale and scope), investments, assets and real estate or location. Therefore, to understand the dynamic interaction of these value criteria, there is a need for a broader and open scenario planning approach. Very few of the criteria identified could be attributed to open building as it is presently defined. However, at an open spatial scale there were a number of interacting value criteria that related to open building and adaptability. These included: flexibility of rooms, standardisation, and gender separation. One concept, "flow" however was identified by both groups and as such may be an integrating concept. For open buidling, this is the movement between departments and spaces and the flow of resources (good, waste, food, etc) and the elimination of wasteful flows. For open planning, flow is more associated with access, transport and the distribution of clinical skills. Social capital, cultural change and human values were expressed at a building scale, while an understanding of clinical service, access and branding was identified at a planning level.

FUTURE RESEARCH – OPEN VALUE LEVELS

Value assessments should be made within the context of a process of decision making that responds to the underlying baseline case for change (standards, evidence and models) and potentiality of scenarios (uncertainties, horizons, opportunities). Value should be assessed at various levels of infrastructure scale, against the baseline case for change and possible open scenarios (Figure 3).

Value is nested, in that equating value at a higher systems level requires the summation of value from lower "dominated" levels. Figure 4 shows this. However, it is important to consider the limitations of this mechanistic argument, to recognise both ordered nested hierarchies and complex networks. Which have different types and uses such as: inclusion, control, level, tangled, sandwiched emergence and triadic (Anderson, 1972, Holland, 1998, Lane, 2006, Simon, 1962), and that not all of these are spatially constrained as in open building. Figure 4 shows the multi-disciplinary evidence and multi-level interaction at open building levels (were open planning may require input from all such disciplines to deal with future-orientated uncertainties). Researchers must come together from across disciplines: economics, health planning, architectural design, transport planning, public health, engineering, technology development, ICT, innovators and inventors, ergonomics, micro-biologists, nano technologists, clinicians and nurses, to develop new integrated approaches that can support healthcare infrastructure planning and design decision making and value delivery.

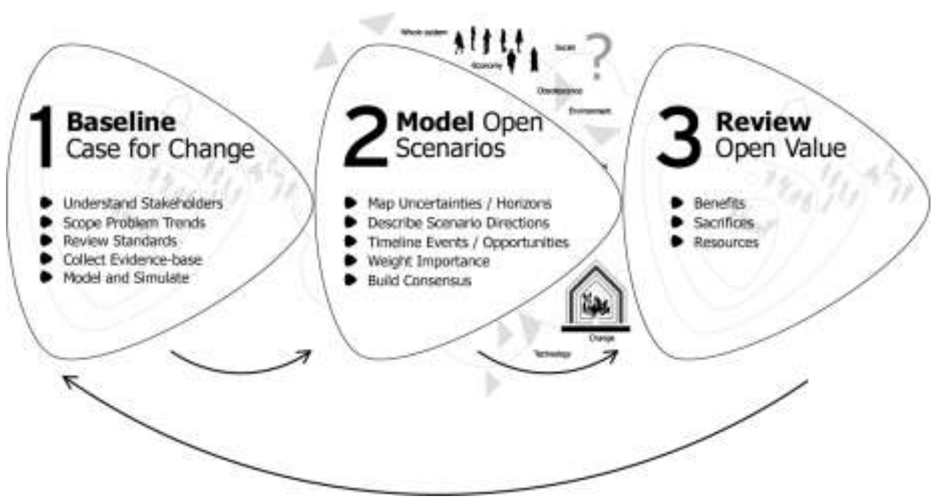


Figure 8. Open Value-based Scenario Planning Process

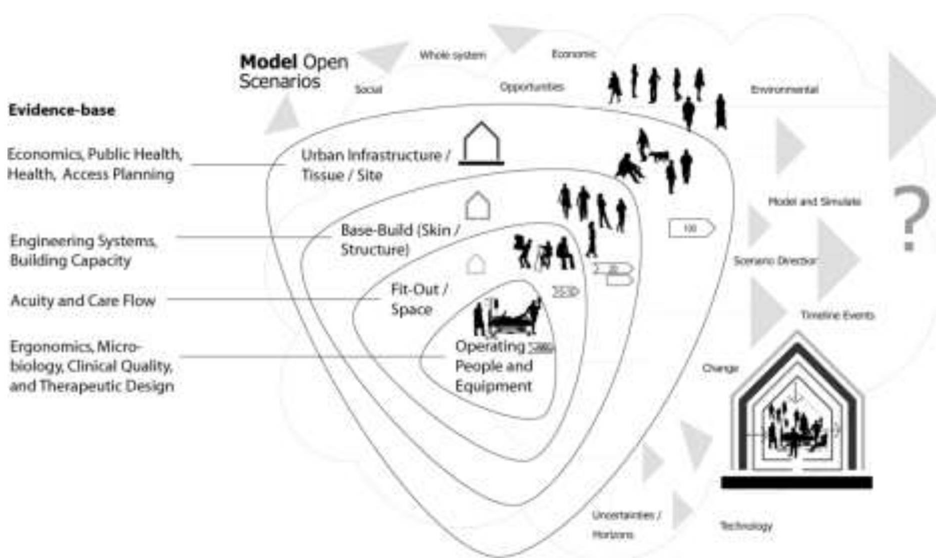


Figure 9. Open Value Interaction at Open Planning and Building Levels

$$\text{Infrastructure Open Value} = \sum \left(\frac{B-S}{R}\right)^{\text{Scenario Value}} + \left(\frac{B-S}{R}\right)^{\text{Base-Build Value}} + \left(\frac{B-S}{R}\right)^{\text{Fit-Out Value}} + \left(\frac{B-S}{R}\right)^{\text{Operating Value}}$$

Figure 10. Infrastructure Open Value Equation

What is needed is a more dynamic approach that recognises open levels. While crude, the equation in Figure 5 shows that value must be understood and calculated at each level of open scenario planning and building, and that tools must be developed to facilitate this nested assessment.

Value at open planning and building scales must also be understood over time against a baseline (existing project, experience or expectation) as shown in Figure 6, where benefits and sacrifices must be understood against various alternative scenarios and building level options (e.g. base-build, fit-out and operation).

However, value assessment (over time and against various scenario and option alternatives) cannot be categorised and constrained to levels alone. For example the influencial technical systems, which are organised at a basebuild level (like power cables) will interface with the infill level and must be organised according to the positioning of furniture, equipment, bodies and utensils. The most flexible and high value spaces are those that allow the greatest number of changes and flexibility, while also delivering everyday benefits and minimising sacrifices and resource use.

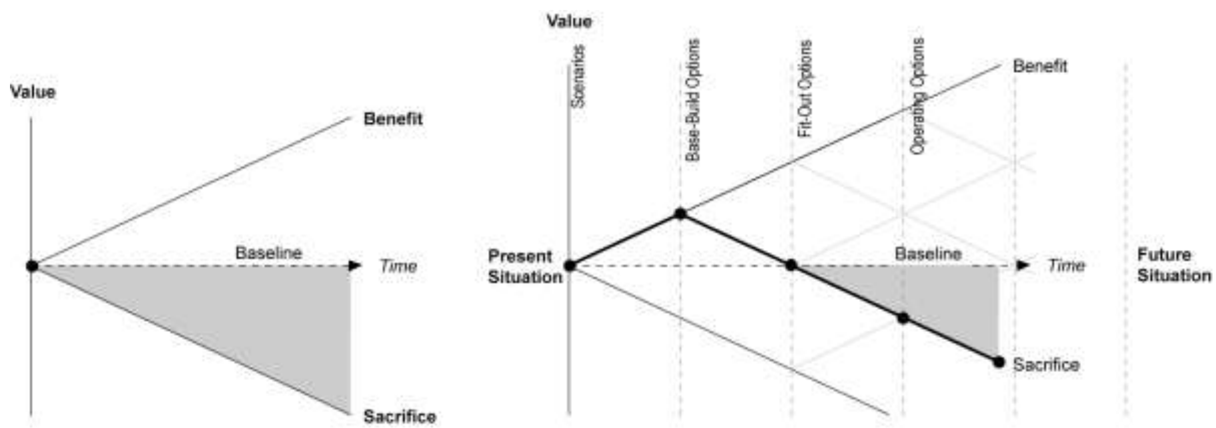


Figure 11. Fan of Uncertainty and Binominal Tree, adapted from Ellingham and Fawcett 2006

CONCLUSION

This paper has discussed the multi-organisational, multi-stakeholder and multi-disciplinary delivery of value in open healthcare construction. A clear definition is emerging that can be used to inform standardised (structured, evidence based, standards, guidance and tools) and customised (dynamic, stakeholder unique) views of value-based decision making and learning.

Workshop findings show that there are many different perspectives and categories of value that will sit across open levels. Some of these may include for example:

– Market Value (e.g. demand and choice)
– Economic Value (e.g. scale, scope and volume)
– Asset Value (e.g. real estate, equity, liability)
– Location Value (e.g. distribution, logistics, amenity and access)
– Flow Value (e.g. clinical process, acuity and capacity)
– Built Environment Value (e.g. evidence-based design)
– Open Building Value (e.g. adaptability and flexibility)
– Intangiable Value (e.g. wellbeing, social capital, sustainability, culture, brand)

This paper extend the need defined by Mills et al. (2010b) to evaluate emergent scenarios against value and the complexity of achieving whole system, scalable and dynamic buildings that can handle growing or shrinking capacity, increasing or decreasing demand, the adding or removing of resources without impacting the performance or value of that system (Mills et al., 2010b). As long as mechanisms can remain functionally equivalent then the whole system can be scalable and performance and value can be maintained and changed. However, hierarchies must forever adapt and change according to emergence, learning and innovation (Anderson, 1972, Holland, 1998, Lane, 2006, Simon, 1962).

UK healthcare infrastructure planners and designers must develop tools and systems that are among the most advanced in the world, as existing tools and approaches are outdated in their agile and open presentation of information for decision making. For example in the US, according to Habraken and Kendall (2007), open building thinking has contributed to longer life spans of “base build infrastructure” and is instrumental in achieving sustainability, through the uncoupling of the complexity and intricacy of fit-out demands with high performance envelopes, a principle that they state is now recognised by the United States Green Building Council’s LEED rating system. Many of the tools within the UK that were once the envy of the world such as National HBN standards, ADB, ERIC, SHAPE and AEDET/ASPECT must adapt to address a deeper conceptual understanding of open building.

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REFERENCES

Anderson, P. (1972) "More is Different: Broken Symmetry and the Hierachical Nature of Science." Science 177: 393-396.

Arnstein, S. R. (1969) "A Ladder of Citizen Participation." Journal of the American Planning Association 35: 216-224.

Brand, S. (1995) How Buildings Learn? What happens after they're built?, London, Penguin Books.

Bytheway, C. W. (1965) "Basic Function Determination Technique", Fifth National Meeting of the Society of American Value Engineers,

Ellingham, I. & Fawcett, W. (2006) New Generation Whole-Life Costing: Property and construction decision -making under uncertainty, Abington, Oxon, Taylor and Francis.

Engel, A. & Browning, T. R. (2006) "Designing Systems for Adaptability by Means of Architecture Options", Systems Engineering: Shining Light on the Tough Issues, INCOSE - 16th Annual International Symposium Proceedings, 9-13 July, Orlando, Florida.

Habraken, J. & Kendall, S. (2007) "Base Building: A New (Private) Infrastructure."

Holland, J. (1998) Emergence: From Chaos to Order Reading, Addison-Wesley.

Jensø, M. (2007) Usability and adaptability in hospital buildings, Trondheim, Norway., NTNU.

Kendall, S. (2002) "Performance on Levels", CIB W060 and W096Joint Conference, International Conference on Measurement and Management of Architectural Value in Performance Based Building, May 6-10, Hong Kong.

Kendall, S. (2007) Open Building: A Systematic Approach to Designing Change-Ready Hospitals. Healthcare Design Magazine. Healthcare Design.

Lane, D. (2006) Hierarchy, Complexity, Society In Pumain, D. (Ed.) Hierachy in Natural and Social Sciences. New York, Springer-Verlag.

Miles, L. D. (1972) Techniques of Value Analysis and Engineering (2nd Ed.), New York, McGraw-Hill.

Mills, G., Austin, S. & Thomson, D. (2006) "Values And Value – Two Perspectives On Understanding Stakeholders ", The Joint International Conference on Construction Culture, Innovation and Management (CCIM2006), 26 - 29 November Dubai, UAE.

Mills, G. R., Mahadkar, S. & Price, A. (2010a) Future Directions in Lean Healthcare: Delivering Value in Planning and Design. Loughborough University, Department of Civil and Building Engineering, Fire Station Room, Sir Frank Gibb, Loughborough University, Loughborough University.

Mills, G. R., Mahadkar, S., Price, A. D. F. & Wright, S. (2011) "Lean Strategic Asset Management: Integrating Value, Flow and Capacity Provision in the UK Heath Sector", 19th Annual Conference of the International Group for Lean Construction (IGLC 19), July 13-15, 2011, Lima, Peru.

Mills, G. R., Price, A., Astley, P., Mahadkar, S. & Jun, L. (2010b) "Open Building for a Kaleidoscope of Care: A New Conceptual Approach to Open Scenario Planning", Open and Sustainable Building, 16th International Conference on Open and Sustainable Building, Labein, Technalia.

Mills, G. R., Price, A. D. F., Mahadkar, S., Sengonzi, R. N. & Cavill, S. (2009) "Who Or What Really Counts In Stakeholder Value Management: How Can Stakeholder Weighting Be Used In Strategic Asset Management", HaCIRIC International Conference, Improving Healthcare Infrastructure through Innovation, April 2009, Brighton, UK.

Netherlands Board for Healthcare Institutions (2007) Building Differentiation of Hospitals: Layers Approach, Rotterdam, Netherlands Board for Healthcare Institutions.

Rogers, D. (2011) Minister Favours "Sheds" for Hospitals: Maude emphasises future flexibility. Building Design.

Schmidt, R., Eguchi; T., Austin; S. & Gibb, A. (2009) "Adaptable Futures: A 21st Century Challenge", Changing Roles, New Challenges, 5-9 October, The Netherlands.

Simon, H. A. (1962) "The Architecture of Comcplexity", Proceedings of the American Philosophical Socity, Philadelphia, Pennsylvania; .

Simon, H. A. (1969) The Sciences of The Artificial, Cambridge, MA, MIT Press.

Thomson, D. S., Austin, S. A., Devine-Wright, H. & Mills, G. R. (2003) "Managing Value and Quality in Design." Building Research & Information 31: 334-345.