

Assessing the sustainability of development options for outer urban areas: Some issues for the SOLUTIONS project

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Abstract

The aim of the SOLUTIONS project is to characterise the sustainability of alternative urban land use and transport plans, designed to accommodate development in areas that experience high growth pressure. Sustainability appraisal is a key element of this characterisation. This paper presents an overview of the appraisal framework proposed for assessing the sustainability of alternative SOLUTIONS plans. The appraisal process is being implemented largely as envisaged, but several significant issues remain to be resolved. These issues relate to: (i) criteria selection; (ii) quantifying criteria; (iii) a series of generic assessment issues; and (iv) summative assessment. Input on these issues from members of the SOLUTIONS consortium and wider stakeholder group is invited.

1. Introduction

A key element of the SOLUTIONS (Sustainability Of Land Use and Transport In Outer NeighbourhoodS) project is the development and application of a coherent process for assessing the sustainability of plans intended to accommodate urban development in peripheral areas experiencing high growth pressures. These plans address a mix of spatial, economic and regulatory instruments, and are being investigated within SOLUTIONS through a mix of land use and transport modelling at the city scale, and local design exercises at the neighbourhood scale, supported by some neighbourhood scale microsimulation modelling of traffic flows. The assessment process also includes modelling of other important factors, such as environmental ones, by post processing the outputs of the city scale land use – transport modelling.

This paper briefly outlines the ‘appraisal framework’ (the broad assessment process) previously proposed for SOLUTIONS (Mitchell, 2004) and its subsequent evolution. The paper then describes some key assessment issues (i.e. problems and uncertainties) associated with the application of the appraisal process. These issues address four areas: (i) the selection of evaluation criteria; (ii) quantifying evaluation criteria; (iii) some generic issues associated with the wider assessment process; and (iv) summative assessment, the process by which assessments for all the individuals criteria are integrated so as to identify the plan(s) that perform best from a sustainability perspective.

The purpose of the paper is not to simply describe the appraisal process proposed for SOLUTIONS. Instead, the paper seeks to highlight a number of assessment issues and problems facing the research team and so provide a mechanism to elicit feedback from the wider consortium and other interested stakeholders that can help improve the assessment process.

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2. Overview and Evolution of the Appraisal Framework

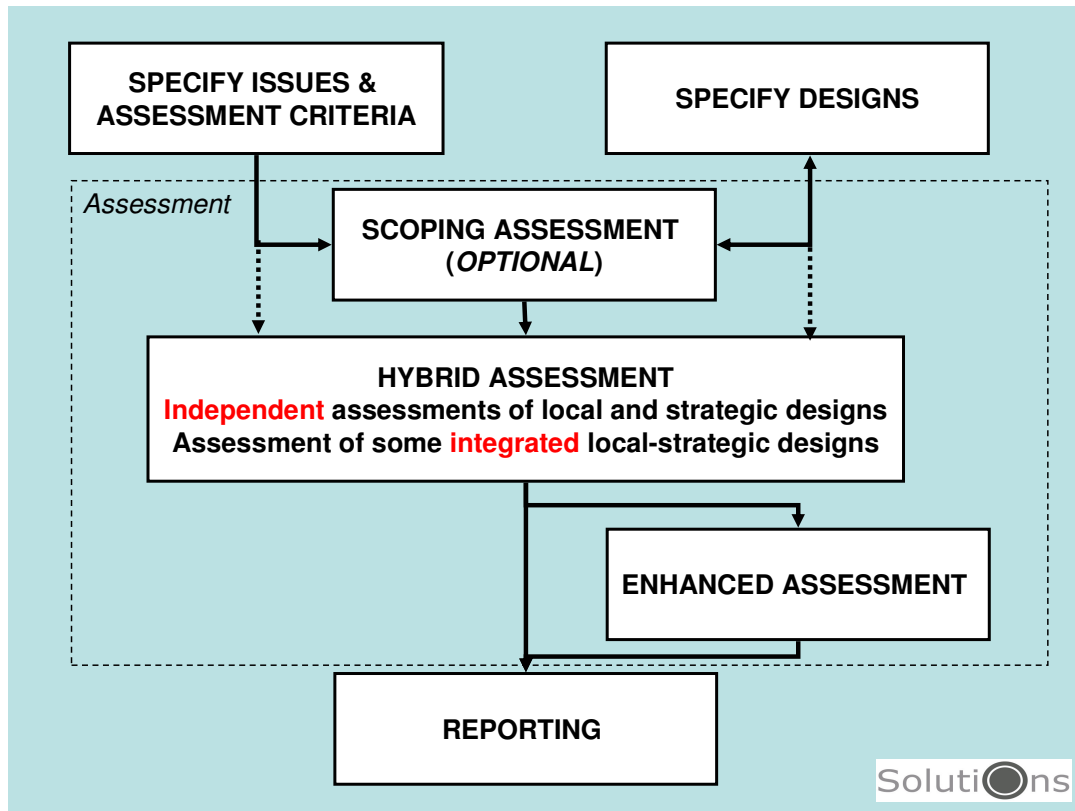
In an earlier paper an appraisal framework for the assessment of SOLUTIONS plans was proposed (Mitchell, 2004). A series of guiding principles for assessment was agreed (Box 1), and current UK and international practice in the sustainability appraisal / strategic environmental appraisal of development plans was reviewed. This best practice review, plus further literature review and discussion with team members and stakeholders provided a basis for the establishment of an appraisal framework tailored to the SOLUTIONS project (Figure 1).

Box 1. Principles of SOLUTIONS assessment

1. Sustainability addresses economic, social and environmental objectives. Consistency is maintained with UK goals of: (a) Social progress which recognizes the needs of all; (b) effective protection of the environment; (c) prudent use of natural resources; and (d) maintenance of high and stable levels of economic growth and employment;
2. Be consistent with current UK practice in sustainability evaluation of land use and transport plans. An evolutionary appraisal framework is thought likely to gain wider acceptance of SOLUTIONS work amongst the stakeholder community;
3. Be objective, minimizing bias and subjectivity, and recording uncertainties. This implies a quantitative approach to assessment wherever possible;
4. Support the production of generic guidance by addressing a comprehensive range of criteria sensitive to urban land use and transport design, in a systematic manner;
5. Be clear in the presentation of information, and transparent in application of the assessment, so that stakeholders can understand how results have been derived;
6. Be practical, operational and achievable with available resources;
7. Be useful to case study city stakeholders but recognize that the primary aim of the research is to support production of generic guidance on peri-urban development.

The appraisal framework comprises six principal steps: (1) Specify the design options - these are the outputs of Work Packages 2-4 that address issues of strategic design, local design and pattern specification; (2) Specify the evaluation criteria via literature review and consultation with consortium members and other stakeholders; (3) Conduct a scoping assessment, an optional step intended to ensure an efficient assessment process by avoiding full assessment of essentially duplicate designs, and also to check that the recommended assessment criteria are sensitive to the designs established under step 1; (4) Assess city and neighbourhood plans using land use-transport models and design exercises. Consideration is given at this point to scale dependencies and interactions between local and strategic designs; (5) Enhance outputs from step 4 through further assessment (including environmental modelling) to address more of the criteria specified in step 2; (6) Report results in a form(s) that allows clear comparison of options, and understanding or relative performance against sustainability objectives.

Figure 1. Summary diagram of the proposed SOLUTIONS appraisal framework



The appraisal framework provides a basic structure that is intended to support the co-ordination of tasks leading to the eventual assessment of the SOLUTIONS design options. The framework is being applied broadly as envisaged. SOLUTIONS ‘designs’ (a mix of spatial plans, regulatory and economic levers) have recently been identified (see Appendix I) at both the city and neighbourhood scales (work packages led by the Martin Centre, UWE and ICS/UCL), and agreed by the research team (step 1). Evaluation criteria have been subject to substantive discussion amongst the team, and a final list was agreed by the team in May 2005 (step 2). This has allowed work to proceed on identifying and developing the technical capability to assess criteria (see more on this in section 3 and 4 below), particularly with respect to the enhancement of outputs of the city scale land use transport interaction models (step 5).

The degree of integration between the local and strategic design work packages has been constrained by technical issues (see section 5), hence there is less representation of the interaction between micro and macro scale processes than is desirable. This means that, as anticipated, a hybrid assessment process (step 4) is being conducted in which scale independent assessments are conducted (i.e. city and neighbourhood designs are tested without explicitly recognising factors operating at the other scale), supported by a more limited set of tests (integrated assessment) in which micro-macro scale interaction is recognised by representing a limited set of local design parameters, such as population density, within a zone of the strategic model, and conversely by constraining local designs parameters with the strategic model. Some transport microsimulation is also being conducted to enhance understanding of scale dependent processes.

The scoping assessment (step 3) has not taken place as envisaged in the proposed evaluation framework. The scoping step recognised that there were numerous land use-transport designs at both city and neighbourhood scales relevant to SOLUTIONS and that when city neighbourhood design combinations were included, the number of designs of interest was potentially very large. The scoping assessment was proposed as one mechanism for increasing the efficiency of the appraisal process by identifying those designs that have broadly comparable sustainability implications and hence which could be excluded from more detailed assessment to avoid duplication. Scoping would be conducted using a simple performance matrix in which designs were qualitatively scored against key indicators using subjective judgement. The scoping assessment also offered potential advantages of: (a) identifying possible conflicts between design features and evaluation criteria that merit closer investigation (e.g. protected greenbelt could increase travel and energy consumption by encouraging development to leap beyond the immediate urban fringe); and (b) identifying evaluation criteria that are particularly sensitive to the SOLUTIONS designs (criteria which therefore merit more thorough assessment).

In practice, the scoping assessment step has not been conducted as SOLUTIONS designs have been identified in work packages 2-4 through research team discussion, rather than the more formal scoping procedure. Due to resource limitations, fewer designs than originally envisaged have been selected for testing (4 at each scale), but each represents a design ‘archetype’, an extreme case of all the possible design options, thus avoiding the danger of duplication.

In the remainder of this paper the appraisal framework is used to structure a more detailed discussion of some of the main issues and difficulties currently facing SOLUTIONS assessment. The discussion addresses the selection and quantification of evaluation criteria, and some wider assessment issues including that of summative assessment, a process intended to aid interpretation of results and so support the production of generic design guidance for peri-urban areas experiencing high growth pressure.

3. Issues in the Selection of Assessment Criteria

3.1 Criteria selection

A draft list of SOLUTIONS criteria were selected through review of sustainability appraisal indicators, particularly those used for assessing spatial development and transport plans. Sources included ‘Local quality of life counts’ (DETR 2000); the Integrated Policy Appraisal Template (DTLR 2002); indicators supporting the New Approach to Transport Appraisal (DfT 2004); guidance on the application of the SEA directive (ODPM 2003, Scottish Executive 2003); national transport indicators (Scottish Executive 2002); local transport plans (LTP) for the case study cities (e.g. DfT, 2003); and relevant research such as PROPOLIS (Lautso *et al.*, 2004) and the SUE DISTILLATE project review of LTP indicators (Marsden, *pers. comm.*).

Following this review, criteria were presented grouped according to six main themes (summarised in Mitchell, 2004), and subject to discussion and review within the research team and wider consortium. The result of this process was to:

- Reduce the number of criteria by dropping those criteria that were felt to have limited sensitivity to land use and transport policy or which were particularly difficult to quantify;
- Adopt a stronger hierarchical structure to reduce the danger of double counting;
- Ensure a greater focus on outcome indicators rather than process or state indicators;

Table 1. SOLUTIONS evaluation criteria

Theme	Sub-theme	Criteria	
		City / Strategic scale	Neighbourhood / Local scale
ECONOMY		Net economic benefit (includes accessibility and externality costs)	-
		Feasibility (Infrastructure economic efficiency)	Feasibility (Practicality, acceptability, marketability)
RESOURCES	Materials	Need for new construction	-
	Energy	Energy use in transport	Mean distance to local amenities ¹
		Energy use in building stock	Energy use in building stock
Land	Undeveloped land developed	Undeveloped land developed	
ENVIRON- MENT	Environmental impact	Surface impermeability	Surface impermeability Properties in flood zone ²
		Green space fragmentation	Designated wildlife sites ²
		Greenhouse gas emission	- (see ¹)
		Acid gas emission (NO _x , SO ₂)	- (see ¹)
	VOC emission	- (see ¹)	
	Environmental quality	Quality of open space	Conservation areas and other valued landscape features ²
		Designated built heritage ²	
SOCIAL	Opportunities	Vitality	Vitality of local retail services
		-	Mean trip distance to local schools and shops
		-	Accessibility to local public transport services
		-	Accessibility to open space
	Equity	Social distribution of economic benefit	-
		Social distribution of environmental quality	-
		Social segregation	-
	Health	Exposure to noise	-
		Exposure to poor air (NO ₂ , PM ₁₀)	-
		Traffic accidents	
-		Trips by walk or cycle (?)	

Notes: 1. Mean trip distance by car to local destinations (supermarket, leisure centre, main road) acts as crude proxy for car transport energy use and emissions. 2. These criteria are used only in screening local designs, to ensure they are realistic in case study applications. They should not be included in the final assessment.

The revised list of criteria agreed by the research team is reproduced above (Table 1), for both city and neighbourhood scales. Note that:

- Some sub-themes / criteria (e.g. health) could be placed under more than one heading, but it is their appearance in the hierarchy that is important, not their position;
- Sub-themes may be relevant to both city and neighbourhood scales, but criteria are not required for all sub-themes at both scales;
- Sub-themes relevant to both scales are usually better addressed by different specific criteria sensitive to the scale context (e.g. consider accessibility);
- Some criteria at the neighbourhood level are intended for use in screening of local plans, rather than in their final assessment. These criteria (built heritage, designated wildlife site, landscape value, properties in flood risk areas) are used to ensure that local design options for case study areas recognise local constraints, so as to ensure they are realistic and have credibility with the local stakeholders. It is recommended that these site specific criteria are not used in the final generic assessment.

3.2 Outstanding issues over criteria selection

Whilst a broad consensus over the evaluation criteria has been reached amongst the research team, the composition of the list became more controversial as the structure became more resolved. The reader is thus invited to comment upon the following outstanding issues.

3.2.1 Number of criteria

A comprehensive list of criteria ensures that no issues are omitted but makes assessment more demanding, and interpretation of the results difficult. Is the criteria list (Table 1) appropriate in terms of length and broad coverage, striking the required balance between comprehensiveness and simplicity?

3.2.2 Double counting

Double counting is a potentially serious issue that gives undue weight to an issue if it is represented by more than one criteria. However, in attempting to avoid double counting, there is a danger of oversimplification, and that key issues that resonate with stakeholders are lost. The criteria revision process sought to avoid any double counting (e.g. specific city scale accessibility measures were dropped as they are addressed within the net economic benefit criteria), but potential double counting problems remain. For example, energy demand and greenhouse gas emissions are both included; the former significant in energy security and economic terms, the latter in environmental terms. Does the criteria list (Table 1) include any double counting problems that need to be eliminated? ²

² If results of criteria assessments are aggregated using a weighted multi-criteria approach, assessors could be advised of any double counting issues in the weight derivation process, so as to reduce the problem whilst maintaining the resonant criteria.

3.2.2 Controversial inclusions

Several criteria that are currently included in the list are controversial. These are:

- Development on previously undeveloped land. The relevance of this criteria was disputed on the grounds that land is an economic resource whose cost is factored into the cost-benefit analysis (net economic benefit). A contrary view was that that land has values that are poorly accounted for in economic costing (aesthetic, biodiversity etc) and that it is a finite resource with a high option value for future generation's.
- Vitality is a social criteria intended to convey the vibrancy of an area. This criteria was used in PROPOLIS (Lautso *et al.*, 2004) and is measured as the ratio of service sector jobs to population. Whilst the inclusion of this criteria was broadly supported, one view was that it should be omitted, as maintaining high levels of service jobs prejudices what is a sustainable urban form.
- Trips by slow mode (walk / cycle) was considered a critical local level indicator by some team members, given its presumed role in physical fitness and health. However, a contrary view was that this criteria should be omitted as no evidence linking trip share by slow mode and health was presented. Furthermore, it is not clear how the criteria would be measured (and modal split at the strategic level is a model input not an output).
- Several criteria are included for which the technical assessment capability is unproven (see Table 2). These criteria will be excluded if they cannot be assessed satisfactorily.

3.2.2 Controversial omissions

One criteria excluded from the list, but which may merit inclusion is water demand. The ODPM Sustainable Communities Plan, which makes provision for 1.1 million new homes in London and the south east by 2016, has been criticised by the Commons Select Committee on the Environment, the Environment Agency, and most recently CIWEM (CIWEM, 2005), for giving inadequate attention to the impacts of development on the water environment. These impacts are those relating to water demand (abstraction and supply), waste water disposal, and land cover impacts (diffuse pollution, flooding). Of these, water demand is seen as a critical issue in the south east, an area already experiencing significant water stress.

In a conventional SEA, water demand would be a significant factor in the environmental appraisal of such a development plan. However, SOLUTIONS is not concerned with development *per se*, but the form of development, and it is assumed that total water demand at the city scale would be broadly the same regardless of whether the new development was accommodated through densification, suburbanisation or some other form. This assumption is not proven, but little analysis of the relationship between urban form and water demand has been undertaken (variation in demand by housing type is a function of the occupants and their behaviour, rather than a built form). If form is to be interpreted more broadly to also address the mix of activities (e.g. domestic, service, industrial), and the prevalence of these activities varies between the SOLUTIONS strategic options, then water demand may deserve assessment, as these activities have very different implications for demand.

Note that a conventional SEA would consider water stress (the surplus of supply over demand). Water stress is very different amongst the SOLUTIONS case study cities (compare 'dry' London with NE England that has abundant supplies), and is a site specific issue unsuited to a generic assessment.

Table 2. Criteria evaluation methods – City (Strategic) scale

	Indicator	Assessment method	Outstanding issues
C1	Net economic benefit	Generalized accessibility costs from LUTI model; Externality costs using standard methods (traffic accidents – DMRB; air quality – COMEAP / IGCB)	- Inconsistency of excluding some externality costs on the grounds that they are not readily monetized.
C2	Infrastructure economic efficiency (Feasibility)	Infrastructure costs associated with land use and transport instruments applied (M. Echenique to advise on detail).	Infrastructure investment costs are likely to vary with urban form – but the nature of this variation is not well known
C3	Need for new construction	Net increase in floorspace per LUTI model zone, summed across the city (Wegener <i>et al.</i> , 2003).	Availability of floorspace data outputs from the LUTI model for all the case study cities
C4	Energy use in transport	Application of TEMMS model (Namdeo <i>et al.</i> , 2002) to road network flow and speed data.	Resolution of network data varies across case study cities (London LASER model only addresses major roads)
C5	Energy use in building stock	Not yet certain. Review (Mitchell, 2005) indicates that commercial sector demand possible using energy-floorspace coefficients from a national database; Potential to model domestic demand based on extant UK models (e.g. BREDEM, ESP-r)	Availability of commercial floorspace data from LUTI model; Aggregation of activity specific energy coefficients to floorspace categories output by LUTI model. Development of energy use coefficients relevant to form attributes represented in LUTI Model outputs.
C6	Undeveloped land developed	To be determined	Establish method – depends on LUTI model outputs
C7	Surface impermeability	Impermeability (a proxy for flood risk and diffuse pollution) is assessed using a land use description (commercial, road, open, and residential development by density) and impermeability values determined by survey of four UK cities.	Availability of land use (frequency distribution not location is adequate) by LUTI model zone.
C8	Green space fragmentation	To be determined	Establish method – depends on LUTI model outputs. Precedents (e.g. PROPOLIS; CUFM model), but resource issue

	Indicator	Assessment method	Outstanding issues
C9	Greenhouse gas emission	<i>Transport:</i> Application of TEMMS model (Namdeo <i>et al.</i> , 2002) to road network flow and speed data. <i>Land use:</i> Energy use in building stock (C5); emission coefficients by fuel type; fuel mix from national values.	Resolution of network data varies across case study cities (London LASER model only addresses major roads)
C10	Acid gas emission	Application of TEMMS model (Namdeo <i>et al.</i> , 2002) to road network flow and speed data.	Resolution of network data varies across case study cities (London LASER model only addresses major roads)
C11	VOC emission	Application of TEMMS model (Namdeo <i>et al.</i> , 2002) to road network flow and speed data.	Resolution of network data varies across case study cities (London LASER model only addresses major roads)
C12	Quality of open space	GIS overlay of green space and environmental impact (air quality, noise) maps.	Availability of future green space distribution (see C8)
C13	Vitality	Change in ratio of service employment to households (See Wegener <i>et al.</i> , 2003)	-
C14	Social distribution of economic benefit	Gini coefficient using zonal data on C1 (above) and socio-economic status of households	-
C15	Social distribution of environmental quality	Gini coefficient using zonal air pollution data (C18 below) and socio-economic status of households	Should a broader environmental quality index be developed incorporating more of the environmental indicators? *
C16	Social segregation	Gini coefficient based on zonal socio-economic data	-
C17	Exposure to noise	Application of TEMMS-SMARTNET model to road network flow and speed data to determine noise	Costly to model noise propagation, so exposure relates to roadside noise only. Data on future population distributions.
C18	Exposure to poor air quality	Air quality modelled using AirViro and a grid approach. Health impacts using COMEAP and DoH IGCB methods	Grid modelling of air quality is fairly crude
C19	Traffic accidents	Application of TEMMS-SMARTNET model to road network flow and speed data (plus DMRB values for cost £)	Resolution of network data varies across case study cities (London LASER model only addresses major roads)

* a weighted index using AHP derived weights (see section 6) might be suitable

Table 3. Criteria evaluation methods – Neighbourhood (local) scale

	Indicator	Assessment method	Outstanding issues
N1	Feasibility	Stakeholder survey - practical, acceptable, marketable?	Design of robust methodology
N2	Mean distance to local amenities	Use GIS to count number or % of people within 'pedshed'	-
N3	Energy use in building stock	Application of LT method to neighbourhood built form (NB. Addresses different form attributes to those at city scale)	Resource intensity of entering 3-D neighbourhood form to LT software; Software availability
N4	Undeveloped land developed	Use GIS to calculate new build footprint (Ignoring brownfield as being site / context specific, not generic)	-
N5	Surface impermeability	Use GIS to allocate land use specific impermeability values	-
N6*	Properties in flood zone	Count properties in Environment Agency mapped flood zone – use only in design screening not generic assessment	-
N7*	Designated wildlife sites	Illustrative map – used only in design screening	-
N8*	Conservation areas and other valued landscape features	Illustrative map – used only in design screening	-
N9*	Designated built heritage	Illustrative map – used only in design screening	-
N10	Vitality of local retail services	Use GIS to count people within 5 and 10 minute walk of retail centre plus passing trade factor based on traffic flow	-
N11	Trip distance to schools and shops	Use GIS to count number or % of people within 'pedshed'	-
N12	Accessibility to local PT services	Use GIS to count number or % of people within 'pedshed'	-
N13	Accessibility to open space	Use GIS to count number or % of people within 'pedshed'	-
N14	Trips by walk or cycle (?)	Not known – local surveys?	Is this a valid proxy for physical activity and health?

- These criteria are used to ensure local designs recognise key constraints in case study areas. They are not used in assessment as they are too site specific

4.0 Issues in Quantifying Criteria

Reaching some consensus on evaluation criteria allows the next stage in assessment to be addressed; that of identifying appropriate tools and techniques to quantify the selected criteria. This process is currently underway – some criteria are familiar to the team and present few real difficulties in quantifying them; others are less familiar, and further investigation is underway to determine if they can be quantified. For the strategic and local scales respectively, Tables 2 and 3 summarise the assessment methods proposed for each criteria. Note that, for the city scale criteria, some are assessed directly using outputs of the land use transport models, but many require substantial post processing. The tables also highlight difficulties in criteria assessment, of which some key ones are discussed further below.

4.1 Treatment of capital investment

At the city scale, the feasibility of the urban plans is a function of the cost of implementing them; these costs are also an input to the net economic benefit assessment. It has been argued within SOLUTIONS that the economic assessment can be simplified by maintaining a constant level of capital investment between the options. The investment for all options tested would be the same as that for the trend option. This is attractive from a practical viewpoint, although it is recognised that the results of the economic assessment would be very sensitive to the discount rate used.

A key problem is that it may be unrealistic to assume that alternative plans have a constant capital investment (roads, public transport infrastructure, utility services etc). For example, it was noted above that it may not be necessary to assess water demand as, city wide, this is assumed to be insensitive to urban form. However, urban development will act to increase demand, and this has clear implications for infrastructure costs (water and waste water transport and treatment) and so the capital costs need to be identified for the trend option. However, it is reasonable to assume that different urban forms will have different infrastructure costs. For example, dispersed low density development may require greater network development than for linear or compact settlements with a comparable number of households. However, such an analysis is not as simple as it appears in practice, as it may prove cheaper to build new water supply networks for dispersed settlements on previously undeveloped sites, than it is to improve and upgrade capacity when densifying existing settlements.

If capital costs are allowed to vary, then we will need to understand the different demands that the designs place on services, and the infrastructure costs of meeting these demands. These costs may be difficult to determine (e.g. to what extent should demand management measures be recognised), and the uncertainty in the assessment is likely to be high.

4.2 Availability of strategic model outputs

Many of the evaluation criteria are dependent upon post-processing of outputs of the land use transport interaction models. Variables for which data are required, and their associated evaluation criteria are shown in Table 4. For these evaluation criteria, all the associated LUTI model output variables (with the obvious exception of the network data) need only be available on a zonal basis. It is enough to know simply how much floorspace or land cover by type there is per model zone, and not its exact location. A review of LUTI models (US EPA, 2000) shows that these outputs are available from MEPLAN, the model used in the London and Cambridge case studies.

However, there is a potential problem in that: (a) we do not yet know what LUTI Models are to be applied in the Tyne and Wear and Bristol case studies – these may not be MEPLAN models and may lack the require capability to support the desired post-processing; and (b) the Cambridge and London case studies are based on established model set ups (the LASER version of MEPLAN for London), and may not have been configured to produce the required outputs.

Table 4. Strategic LUTI model outputs needed for indicator evaluation

Data needed from the LUTI model	Indicators requiring LUTI input data
Floor space by activity	<ul style="list-style-type: none"> • Need for new construction • energy use in built stock;
Land area by activity	<ul style="list-style-type: none"> • Undeveloped land developed • Surface impermeability;
Socio-economic status (population by income group)	<ul style="list-style-type: none"> • Segregation • Equity in social distribution of economic benefit and environmental quality
Employment by sector Population	<ul style="list-style-type: none"> • Vitality • Water demand (if required)
Network flows /speeds	<ul style="list-style-type: none"> • Atmospheric emissions • Noise • Transport energy use • Accidents

4.3 Scale and comparability of case studies

The scale of the London case study presents particular problems for post processing of LUTI model outputs. The size of the study area means that the LASER model uses a coarser description of the road network than is usual only addressing main roads, and not the full network (it is estimated that 30% of the road network is ignored). This means that criteria dependent upon post processing of network flow and speed data (atmospheric emissions, noise, accidents, and associated economic costs) are likely to be underestimated (although it may be possible to address this crudely through model calibration). As long as this issue is recognised, options within the London study can be confidently compared to each other. However, it will not be possible to make absolute comparisons between criteria across the case study cities (e.g. direct comparison of air quality), only relative comparisons (e.g. change in air quality from trend).

The size of the London study also has potential implications re the resources required for post-processing (time, cost of ancillary data such as meteorological data for air quality modelling, etc). These are currently being investigated.

4.4 Undeveloped methods

4.4.1 Criteria requiring fine spatial resolution of land use

Whilst most of the evaluation criteria can be quantified by post processing of zonal level data, some require a more spatially disaggregate level of data. Exposure to air pollution or noise requires a more spatially resolved description of population distribution, whilst green space fragmentation (our proxy for impact on biodiversity, and an input to the environmental quality criteria) requires a more spatially disaggregate description of land use than is available direct from the LUTI model. Whilst these criteria can be readily quantified for a base year using observed data (e.g. census / SURPOP population data; CORINE / ITE land cover maps), deriving a spatially resolved description for future years is problematic.

Urban modellers have made efforts to overcome this ‘tyranny of zonal modelling’. Landis and Zhang (1998) developed the California Urban Futures II Model in which the likelihood of 1 ha grid cells within a zone being developed for residential, commercial or industrial use is calculated. The CUF model uses a GIS technique in which variables (e.g. land price, accessibility, physical constraints) are mapped and overlain to identify cumulative constraints on development, and so provide a basis for a more spatially resolved allocation of land use than is possible with zonal level models. The What If? Planning Support System (Klosterman, 1998) and UrbanSim (Waddell, 1998) adopt a similar approach. Wegener *et al.*, (2001) describe an alternative approach where zonal land use data is allocated to 1 ha grid cells by first converting land use data from vector (polygon) form to raster form, and then using a probabilistic weighting technique to allocate activities to each raster cell.

These techniques are clearly relevant to the problem of assessing criteria that require a finer spatial resolution of land use data than is possible using the zonal level LUTI model outputs. However, these techniques are not trivial to apply, and there is no experience of using them within the SOLUTIONS team, hence there are clear resource issues here. The technique developed by Wegener *et al.* (2001), offers the greatest promise as it appears more readily applicable to the SOLUTIONS work than the other techniques, although further investigation is required to establish if this approach can be applied within SOLUTIONS.

4.4.2 Energy demand from the building stock

An issue of particular interest to SOLUTIONS is energy demand from the building stock, which, since the work of Lionel March in the 1960’s, is assumed to have a relationship with urban form. That is, building stock energy demand is not just a function of the level of development and types of activity, but the morphology of buildings and groups of buildings too. Given the significance of energy demand as a sustainability issue, and the projects focus on form, the SOLUTIONS consortium felt this an issue worth pursuing. As the research team have little experience in this area, a literature review was conducted to determine the importance of building stock energy as a sustainability issue, and to explore assessment options.

The review (Mitchell, 2005), which specifically excludes energy use within transport (assessed elsewhere), found that, whilst there is a significant body of research on the energy use related to the morphology of individual buildings, there is relatively little work investigating the influence of the morphology and geometry of a group of building on energy demand. Theoretical work by Steadman (1979) illustrated the potential role of urban form in building energy use, but only recently has empirical work been conducted. Ratti *et al.*, (2005) provide one of the few empirical analyses on the relationship between urban form and energy use. They compared Mediaeval, Georgian and Modern urban forms, and found that form was responsible

for a variation in energy demand of about 10% between forms. If this variation is applied to the total city energy demand, then urban form is seen to be a significant determinant on total energy use, more so that that for an example transport policy, used as a crude comparator (Table 5).

Table 5. Sensitivity of total urban energy use to urban ‘design’ options

Sector	Share (%) of total urban energy use ^a	Variation (%) in energy use due to factor of...	Variation (%) in total urban energy use due to factor
Buildings	72	Urban form ^b = 10	7.2
Transport	28	Road pricing ^c = 10	2.8

a – Figures for London quoted in Steemers *et al.*, (2005). Transport figure includes air travel.

b – Figure from Ratti *et al.*, (2005)

c – Figure from Mitchell *et al.*, (2005) (an average from four Leeds road pricing schemes each with a £3 charge).

This example illustrates that energy savings achieved through urban design are potentially very significant, and greater than that which could be achieved through transport management. Note also that the energy demand from the building stock is much more fixed than that of transport, due to a slower renewal rate of buildings compared to vehicles. Furthermore, the above example only addresses the energy implications arising from the layout and orientation of a building group, and ignores other form factors operating at different scales (Table 6), and activity type (residential, commercial etc) whose distribution may vary between city scale design options (and within a design option over time). Thus it was concluded that SOLUTIONS should seek to understand the impact of urban design options on the energy use in the built stock, if practicable.

Table 6. Significant structural variables at different scales, affecting energy use.

Structural variable	Region	Individual settlement	Neighbourhood	Building
Settlement pattern (e.g. size and spacing)	✓			
Communication network between settlements	✓			
Size of settlement	✓	✓		
Shape of settlement (circular, linear etc)	✓	✓		
Communication network within settlement	✓	✓		
Density		✓	✓	
Interspersion of land uses		✓	✓	
Degree of facility centralization		✓	✓	
Layout (estates etc)			✓	
Orientation of buildings / building groups			✓	✓
Siting relative to microclimate				✓
Design				✓

Source: Owens, S (1986: p5)

The review next considered how the impact of built form on building stock energy demand could be assessed. No methods exist that are designed specifically to assess the impact of form, and hence the approach is to model energy demand, whilst holding non-form variables constant. Building energy demand models exist at different scales and address different aspects of built form. For a group of buildings (consistent with the SOLUTIONS neighbourhood scale), the

‘LT method’ can be applied, as Ratti *et al.*, (*op. cit.*) did, addressing factors of neighbourhood layout (building spacing) and building morphology (height, depth, orientation). At the city scale, an approach based on linking annualised energy use coefficients (by activity type, and normalised to unit floor space) to zonal floor space data from the land use-transport model appears most suitable. This approach would address form variables of size of development, type of activity, and potentially building type, given appropriate energy coefficients. Non-domestic energy use coefficients are available for the UK, and domestic energy use coefficients are thought to be available via work done for BREDEM, the UK domestic energy model. This appears to have been the approach adopted by Steadman *et al.* (1998), in their study of Swindon, the only study where a land-use transport model (TRANUS) has been used to investigate the impact of urban form on building stock energy demand.

These approaches look promising, although further investigation to determine if they can be practically implemented within SOLUTIONS is underway (and in part depends upon the availability of supporting data – see 4.2). This, and the other difficulties outlined above (4.1-4.4) raises a more general issue associated with application of the appraisal framework. That is, how should the team handle criteria that are deemed to be important, but which for technical (or other) reasons we are unable to quantify? Should attempts be made to conduct more subjective qualitative assessment (e.g. based on judgement and any relevant literature), or should the lack of adequate quantitative data mean the criteria is not considered further when developing the final guidance on outer city development?

5.0 Further observations on SOLUTIONS assessment

Before concluding the paper with a discussion of how individual criteria assessments could be collectively interpreted (summative assessment), some additional, more generic assessment issues are highlighted. These issues represent potential weak points in the SOLUTIONS assessment process, but discussion amongst the team indicates that they have no simple remedy. The points raised, should however, be noted when interpreting the results of the assessment.

5.1 Assessment baseline

The SOLUTIONS baseline for assessment is the ‘trend’ option. This option assumes that a predetermined level of development will take place over the period 2005-2031, although the distribution of that development is unknown. Assessments using a ‘trend’ baseline will therefore be quite different to those using a ‘no growth’ baseline. This issue was highlighted recently by the parliamentary environmental audit committee (EAC), responding to a government commissioned environmental assessment of proposals for an additional 120,000 houses each year (making 260,000 a year in total). The EAC felt that it was not appropriate for government to adopt current build rates as the baseline, as this ignores the totality of environmental impacts; estimated impacts are more than halved by adopting the trend baseline. DEFRA argued that a no growth baseline was neither “realistic or responsible” (ENDS, 2005).

The research team have decided that, within the context of SOLUTIONS, a trend baseline is most appropriate. A trend baseline is considered appropriate as the project seeks to better understand how different urban forms can accommodate existing levels of pressure for growth in the most sustainable manner. Thus a trend baseline is appropriate within the context of the relatively well defined remit of SOLUTIONS. A no growth baseline would be appropriate only if policies (e.g. immigration) were to be tested which led to different levels of growth pressure.

5.2 Sensitivity testing / exogenous scenarios

Sensitivity testing is an important part of any assessment using models, as it provides some indication of the robustness of results. Sensitivity analysis has always been a SOLUTIONS aspiration and discussion here has focussed on the identification of appropriate exogenous scenarios within which the SOLUTIONS options could be tested,. Some sensitivity testing may be appropriate to the post processing of LUTI model outputs (e.g. impact of technological innovation on vehicle emissions), but scenarios of most interest are those relevant to the principal inputs to the strategic LUTI model, particularly assumptions about future rates of economic growth, population change (e.g. due to possible change in immigration policy); and fuel prices.

Currently, it is uncertain to what extent sensitivity analysis will be possible within SOLUTIONS. The logistics and cost of running the LASER model are such that relatively few model runs are possible, hence any sensitivity testing programme is expected to be rather limited. Once LUTI model are established for the other case study cities, it may be possible to conduct a broader range of sensitivity tests (e.g. the Newcastle model is expected to be run 'in house' by the team). If so, which sensitivity tests (and their possible combinations) would be of most interest?

5.2 Environmental feedback

Lautso *et al.*, (2004) note that environmental factors have a significant influence on where firms and households choose to locate, and describe three approaches for incorporating environmental feedback in land use-transport modelling. The simplest form (no spatial disaggregation) has location preference functions (which include an environmental attractiveness component) described for model zones. In this case, the environmental feedback is executed within the LUTI model, but the characterisation of environmental quality and its feedback to location choice is very limited. An improvement is to quantify environmental impacts more explicitly outside the LUTI model (those that affect location choice such as noise and air quality), and spatially disaggregate these impacts (see 4.4.1 above) before feeding them back to the aggregate land use model. A further improvement is to replace the zonal LUTI model with a microsimulation LUTI model so that the spatial resolution in environmental feedback is exploited effectively in the location choice modelling. However, no such model currently exists, and in their PROPOLIS study Lautso *et al.*, (2004) adopted the intermediate option for one of their case study cities (Dortmund), and the simplest form for the remaining cities.

Within SOLUTIONS, there is an intent to spatially disaggregate relevant environmental criteria modelled at the zonal level. However, this is being done to improve the quality of assessments for those output criteria where spatial disaggregation is important (e.g. population exposure to noise and air quality; equity criteria), and not to improve the location choice modelling. The SOLUTIONS project schedule does not permit the feedback of disaggregate environmental data to the LUTI models, hence the treatment of environmental feedback is limited to the first, simplest form of feedback modelling described above. This caveat needs to be recognised in developing the final guidance. Spiekerman and Wegener (2003) helpfully show that some environmental factors (e.g. open space) are acceptable at the zonal level, whilst for others (air quality, traffic noise), significant differences in location decisions occur between zonal and disaggregate data. Such observations may help to understand the extent to which the lack of environmental feedback in SOLUTIONS is a problem.

6.0 Summative assessment

The preceding discussion shows that there are difficulties and uncertainties in assessment of individual SOLUTIONS criteria. However, the aim of the study is to conduct a comparative assessment of design options, and we accept that, as with any SEA-SA, future predictions are simply our best estimate across a range of evaluation criteria. Results of the SOLUTIONS assessment will be presented in a simple matrix where for each option, the performance against all the individual criteria is presented (e.g. as used in the NATA appraisal summary table). This is essential information in terms of developing the final design guidance, where an knowledge of variation within specific criteria is needed. However, a key aspect of the overall evaluation is also how we should judge which design options perform best overall? In this respect SOLUTIONS members have discussed several approaches: a reductive approach where all criteria are expressed in common terms (e.g. CBA); multi-criteria appraisal using scoring and weighting systems, in which stakeholder ascribe relative values to criteria that do not share common units; and directional systems, in which criteria are expressed in terms of whether they are moving towards or away from the desired state.

6.1 Reductive approach

Where criteria are expressed in common units, it is possible to reduce or aggregate the data. This approach is not possible across all the SOLUTIONS criteria but reduction to two or three common metrics may be possible. Several criteria can be expressed in monetary terms; the LUTI model directly monetises some (e.g. accessibility), whilst some others can be monetised using standard methods (e.g. the health costs of air pollution and traffic accidents). However, monetisation of other criteria is difficult as methods are poorly developed or contentious.

Some criteria may be reduced using one or more of the sustainability indexes now available. One environmental index gaining widespread use is the ecological footprint (Rees and Wackernagel, 1994), in which resource use and pollutant emissions are expressed in terms of land area required to indefinitely provide the resource or assimilate the pollutant. The GLA recently commissioned such an assessment, which demonstrated that Londoners require 6.63 ha each to support their lifestyle, compared to a land availability of 2.18 ha per capita globally, and 0.16 ha capita in London (GLA, 2003). This demonstrates the extent to which London is 'importing sustainability' from beyond its boundary, and illustrates the power of the ecological footprint as a tool to compare and communicate impacts with respect to limits imposed by the natural environment. The ecological footprint is easily applied to some of the SOLUTIONS criteria (e.g. land use, energy use) but difficulties are likely for others (e.g. green space fragmentation used as a proxy for biodiversity impact).

No common metric for aggregating the social criteria is available. Sustainability indices that incorporate social criteria, such as the index of social economic welfare (Daly and Cobb, 1989) are essentially economic indices where GDP is adjusted to take account of a wider set of social and environmental criteria (e.g. the value of household labour; the cost of pollution control) normally excluded from conventional economic assessment. Indexes with a more specific social focus are available (e.g. the human welfare indices used by the UN and OECD), but these employ scoring and weighting rather than a common metric.

Such measures offer the potential to reduce SOLUTIONS criteria, at least in the economic and environmental domains, although even here some criteria may defy reduction. Reduction of the social criteria without scoring and weighting appears impractical, although a mixed approach (i.e. common metrics for economic and environmental indices; scoring and weighting for social criteria) would be preferable to reduction of criteria but not others.

6.2 MCA using scoring and weighting approaches

Summative assessment using a multi-criteria analysis is an attractive option as: it can be applied to a diverse range of criteria where reduction to a common metric is impossible; the values that stakeholders attribute to different criteria are obvious; and it delivers a final ‘answer’ as to which option performs best overall. Many multi-criteria approaches are available including multi-attribute utility models, linear additive models, outranking methods and those based on fuzzy sets (see DETR, 2000b for an overview).

Linear additive models are amongst the most well established MCA tools, and have a proven track record in providing robust and effective decision support. This approach converts natural values to scores on a common unit less scale (e.g. 0-100), by means of value function curves. The zero and 100 end points of the curve are set with reference to the extreme range of observed values across all the options being appraised (local scaling), or by reference to natural values that may occur more widely (global scaling). The shape of the curve (linear, curved, stepped) is determined through participants judgement. Having converted natural values to scores for all criteria, the linear additive model is used to judge overall option performance by combining criteria scores and weights, and summing these across the range of criteria.

The weight elicitation process is clearly very important, and there are several methods available to do this. A popular approach is the analytical hierarchy process (AHP) (Sataay, 1980). Criteria are first organised into a hierarchy and at each level, stakeholders conduct pair wise comparisons of criteria so as to derive criteria weights. This process is supported by additional measures to ensure logical consistency in pair wise evaluation. Members of the Leeds team have developed prototype software (SMARTNET) to conduct AHP of road transport networks, and in principle, it would be possible to deliver the AHP part of the tool over the internet. This would facilitate wider engagement with stakeholders, and hence provide a wider range of weight sets that could be used in sensitivity testing, so as to establish the extent to which the ranking of design options varies according to different stakeholder profiles.

MCA can also be applied in conjunction with a reductive approach. An economic assessment of all the costs associated with an option can be made; this could include direct costs and those externality costs amenable to economic evaluation. The remaining criteria are then subject to a MCA. The final scores for each option, which effectively represent the benefits, are then plotted against the corresponding economic costs (DETR, 2000b: p66). This process provides the decision maker with information on the cost effectiveness of each option.

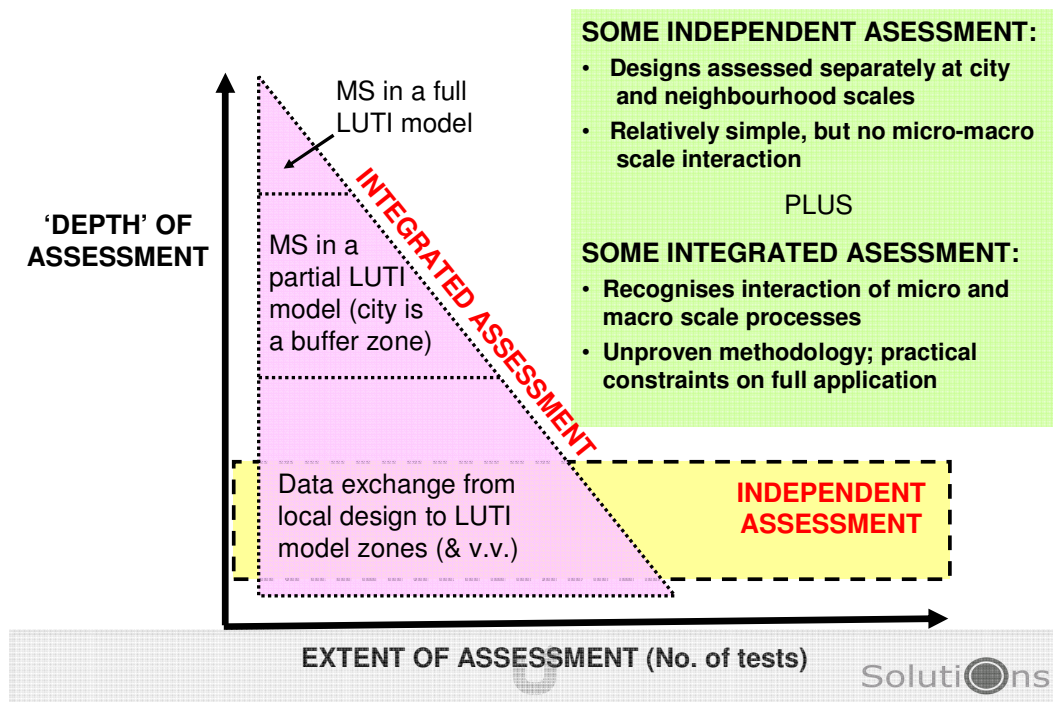
Some members of the SOLUTIONS team are sceptical of the value of such MCA and reductive approaches on the grounds that they suffer from a “fundamental logical fallacy... [in which reducing] all criteria to a common means of exchange (whether money or weights) belies the uniqueness of each criterion. High quality urban design quality, for example, is not in any sense ‘equivalent’ to safety from flood. It is not valid to substitute flood risk for beauty. Both aspects need to be valued in themselves” (Barton, 2004). Barton argues that appraisal in SOLUTIONS must consider thresholds of acceptability – that is, at the extremes, some factors become very important, and may be cause enough alone to dismiss an option (e.g. pollution emission exceeding a local assimilative carrying capacity). This concern has led to the development of the sustainability threshold analysis (STA) technique that has recently been applied by the Environment Agency. Table 7 gives an example of the STA approach from an earlier application.

Table 7. Example Sustainability Threshold Assessment table (Barton, 2004)

<i>Potential</i> <i>Criteria</i>	RED Development IMPOSSIBLE	ORANGE Development PROBLEMATIC	YELLOW Development CONDITIONAL	GREEN Development OK	BLUE Development PRIORITY
1. Physical Development Potential		Contaminated land, buildings awkward to repair, steep slopes	Derelict land and buildings requiring treatment and/or rehabilitation		Previously developed land and vacant buildings capable of easy reuse
2. Market Development Potential	Land-locked site with no access possible	Zero/low value site, lacking appeal or potential; owner unwilling to sell	Marketable site/buildings depending on conditions and costs imposed	Likely to be viable irrespective of conditions or S106 costs	High value sought-after location
3. Infrastructure Capacity		Major threshold breached: shift in investment priorities required	Contribution needed to school/sewage treatment/roads/s tation etc.	No particular thresholds are breached	Spare capacity in local schools, p.t. services, road system, sewage treatment
4. Pedestrian Accessibility to Key Local Facilities	No facilities within 800m	Few facilities available within 800m	Legal agreement could fill key gaps in facilities	Most facilities within 800m	Choice of facilities available, most within 400m
5. Public Transport Accessibility to Jobs/Centres	No regular public transport services accessible or planned	Only poor services accessible or planned	Poor services capable of improvement	Good quality services within 400m	Excellent quality services within 300m
6. Energy Use and Carbon-fixing	Very exposed sites	Shelter belts, woodland, coppices	North-facing slopes, tree-replacement conditions		Gentle South-facing slopes, spare CHP/CH capacity
7. Water	Areas liable to flood every 30 years or more	Marginal flood areas: high ground water vulnerability	Areas of medium ground water vulnerability	Supply, treatment, drainage OK; no flood risk	
8. Land, soils and local food production	Unstable land, areas prone to coastal erosion	Allotments, market gardens, organic farmland	High quality soils; impact on farmland		Contaminated land
9. Biodiversity	SSSIs and other national designations	Locally defined valued habitats and wildlife corridors	Locally valued but common habitats, trees and hedgerows	No threat to assets	Potential to create new habitats in degraded areas
10. Air Quality and Noise	Areas prone to unacceptable level of pollution	Source of pollution capable of correction - but who will pay?	Migratable noise levels		
11. Open Space Value or Impact	Valued and well-used public open-space (POS)	Common-land, valued public access land	Inadequate local open space, contribution needed	Ample supply of accessible open space locally	
12. Aesthetic and Cultural Heritage	Listed buildings; vulnerable landscapes of great value	Specific areas of valued landscape or great archaeological value	Conservation areas, AONBs, National Parks		Ugly or monotonous environment needing improvement

Conversely, MCA advocates would argue that the use of such thresholds is problematic as, first, thresholds for different criteria must be set at levels where just achieving them is equally important across all objectives, else an undue weight has implicitly been given to the objective with the less demanding threshold. Second, thresholds impose a ‘lumpy’ set of priorities for action since it implies that performance just within a threshold is acceptable but that outside it is not (May, *pers. comm.*). Setting thresholds is also likely to be contentious as this is in itself a value laden step with no transparent mechanism for selecting thresholds. Furthermore, trade offs are still possible. For example, Barton (2004) argues that development in a zone of high flood risk exceeds a sustainability threshold, and that this should be an absolute barrier to development, regardless of the merits of such a development on any other criteria. However, mitigation measures are available such that a reduced flood risk is traded off against a higher cost (e.g. proposals have recently been made to build houses on stilts in the high flood risk areas of the Thames Gateway, reducing the risk, but at additional cost). The use of variable weights and sensitivity tests helps to identify which such trade offs are critical, and hence where further consensus building is needed. Finally, note that MCA does have an ability to address thresholds through the appropriate setting of value function curves (e.g. a log curve), although a zero score for any criterion is not sufficient in itself to cause that option to be dismissed.

Figure 2. Possible approaches to local and strategic modelling in SOLUTIONS



In the context of SOLUTIONS, such debate may anyway be moot, because relatively few design options are to be appraised. Originally, it was envisaged that SOLUTIONS would investigate 5 or 6 design options at each of the neighbourhood and city scales, with the modelling work addressing plausible combinations (e.g. city edge expansion achieved via development of ‘open cell’ neighbourhoods). This would give of the order of 20-30 design option combinations for assessment. MCA is very suited to such an assessment, as it can identify a shortlist of options that perform consistently well (e.g. same handful of options appear best following sensitivity testing), and which deserve further detailed examination to

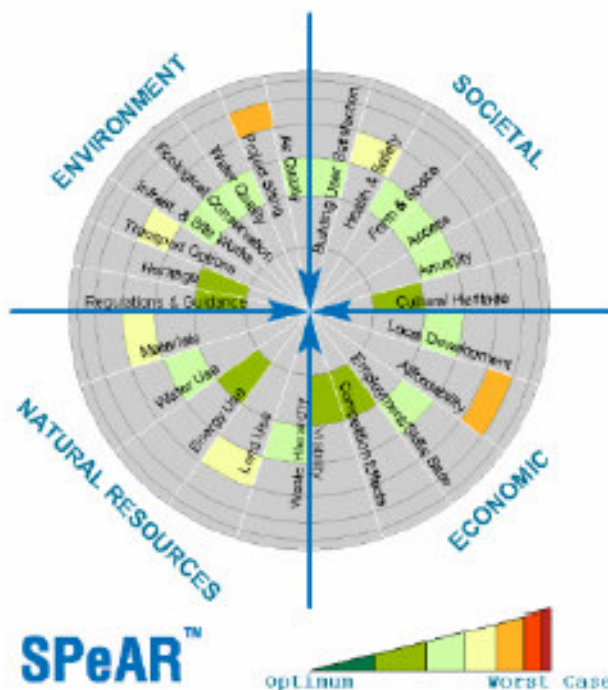
support the production of the design guidance. However, the practical difficulties of the urban modelling has meant that there is relatively little interaction between city and neighbourhood scales within SOLUTIONS, and most of the assessment is of designs that give little recognition to design attributes at the opposing scale, that is scale independent rather than scale integrated assessment (see Figure 2) (there are some notable exceptions, including some microsimulation work). This means that the MCA would be applied to just four options at each of two scales.

MCA is of course also used to identify the single most preferred option form a shortlist. However, the SOLUTIONS designs are not options between which a decision must be made. Rather, they are extreme design archetypes which have been deliberately selected so that their detailed study can provide further insight into the relationship between urban form and sustainability. Thus the utility of MCA in the context of SOLUTIONS must be questioned. Would the application of MCA to just four options at each scale be worth the effort?

6.3 Directional approaches

A directional approach provide a simpler means of conveying the overall sustainability of each design, although it does place a greater burden of interpretation upon the user. Figure 3 is an example of the directional approach. This is the Sustainable Project Assessment Routine (SPeAR™) developed by Arup and first applied to the sustainability assessment of built infrastructure (and latterly master plans). Results of assessment for individual criteria are mapped on to an “assessment wheel”, where each criteria represents a spoke. Performance of each criteria is scored on -3 (red, worst performance) to + 3 (dark green, best performance) scale. In the context of SOLUTIONS, the zero position could be the trend option, and the ‘best and worst’ end points defined via local scaling (i.e. defined by the observed extreme values across all the tests) or global scaling, where values are defined with reference to some wider norms (e.g. best and worst practice nationally or internationally; or expressed targets).

Figure 3. The SPeAR assessment rose.



This type of graphical presentation is useful in showing the strengths and weaknesses of each option, and in option comparison. However, it is less satisfactory in communicating a sense of the overall condition of the system. The decision maker must apply intuition to determine the option that performs best, and this may lead to an inaccurate ranking of options. However, as SOLUTIONS seeks to understand the reasons behind the performance of different options, rather than identifying the best performer overall, this does not appear to be a major problem.

Directional tools of this nature are relatively common. Another example is AMOEBA (ten Brink, 1991) applied in the evaluation of ecological responses to policy instruments in the Netherlands. AMOEBA has a similar ‘wheel and spoke’ design, with spokes representative of individual species, and the position on the spoke indicative of species abundance. End points are set as zero and the ‘reference’ state representing the population abundance in an undisturbed environment. The current abundance is plotted and the distance between current and reference states summed to give an ‘ecological Dow Jones Index’. AMOEBA has been applied with over 60 plant and animal species and is used in public consultation exercises to illustrate expected ecological gains / losses under alternative developments.

The Sustainability Threshold Analysis tool (Barton, 2004) discussed above is a form of directional tool. The distinctive aspect of STA is its thresholds, and the advice that violation of ‘red’ thresholds means that the development is not sustainable, denying any opportunity for trade-offs.

Table 8. A possible approach to summative assessment in SOLUTIONS

Assessment approach	City scale	Neighbourhood scale
Performance matrix	A separate table at each scale showing performance of each criterion in a simple summary table. No overall summation attempted. AND	
A directional chart	A directional chart similar to SPeAR used in an illustrative comparison of criteria. Attention needed on how to define end points and intervals for the scales. STA could be applied at both city and local levels, with SOLUTIONS providing an opportunity to test STA at the strategic level (e.g. compare results to MCA approach below). Thresholds need not be contentious as they will only be used in SOLUTIONS to develop design guidance, and not dismiss an option. AND	
Economic analysis and MCA	Criteria amenable to economic appraisal are costed and presented alongside the directional charts. OR Non costed criteria are subject to AHP MCA, and the cost-benefit performance illustrated by plotting economic cost against MCA benefit score.	No economic costing or weighted MCA

6.4 Conclusion on summative assessment

The preceding discussion indicates that there is no ideal form of summative assessment applicable to SOLUTIONS. A reductive approach using common metrics is applicable to some, but not all SOLUTIONS criteria. MCA techniques are robust, but are not universally favoured within the team, and their usefulness when considering only four options at each scale is questionable when it is more important to understand how options perform differently than understand which performs best overall. Directional methods are useful for comparing options, but are least able to identify overall relative performance between options, and are not without controversial elements of their own (i.e. selection and relevance of inviolable thresholds in STA). A possible framework for summative assessment is illustrated in Table 8, and comprises a mixed approach.

Some questions about this proposed approach include:

- Is the mix of techniques confusing? Will application of multiple summation techniques lead to confusion over what constitutes the most sustainable designs; will it highlight those criteria which are most important in judging a sustainable urban form; or will the focus be on potential flaws in the appraisal methods?
- What is the best way of identifying interval scales for use in the directional charts?
- Is MCA worth the effort with only four design options for each city?
- Is there an alternative approach that could be applied to better integrate strategic and local assessments?

7.0 Conclusion

The SOLUTIONS appraisal framework (Mitchell, 2004) describes a proposed assessment process for the SOLUTIONS project. This process is being followed, with the exception of the scoping step – the urban designs to be assessed within SOLUTIONS have instead been selected via research team discussion, rather than using a more formal design selection process. The selected designs represent extreme archetypes, hence the need for formal scoping to avoid duplication is not great.

The application of the appraisal framework has revealed a number of significant issues that remain to be resolved. These issues relate to four main areas. Firstly, criteria selection – in particular, do the selected criteria represent an adequate balance between comprehensiveness and simplicity, and are there any unacceptable omissions or inclusions? Secondly, there are issues associated with quantifying several criteria, and it seems likely that not all of these issues can be resolved. If so, which of these criteria should receive priority in addressing the difficulties faced in measurement, and which might be excluded with least damage to the final appraisal? Thirdly, a series of difficult generic assessment issues (re the assessment baseline, environmental feedback and sensitivity testing) were identified. There are few opportunities to address these issues at present, but the team do not feel them to be fatal flaws in the assessment process. Finally, issues in summative assessment were discussed, and a proposal made for presenting results to address the conflicting demands of the appraisal process (detail to aid guidance development; summation to compare overall sustainability), and views of team members. Feedback on these issues from members of the SOLUTIONS consortium and wider stakeholder group is warmly invited.

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Appendix I. SOLUTIONS design options for accommodating high growth

(a) Neighbourhood / Local scale

Design Type	Description
Business as Usual	<p>Development in 'pods' of different size and land use of main roads.</p> <ul style="list-style-type: none"> ▪ Mostly segregated land use (e.g. separate commercial parks) ▪ Low density (20-40 dph) ▪ Gated or estate type neighbourhood unit; Off line ▪ Dispersed jobs and services ▪ Tributary style street pattern at micro and meso scale
Neighbourhood unit	<p>Cells of 2-8,000 people, forming inward looking distinct enclaves</p> <ul style="list-style-type: none"> ▪ Partially mixed land use ▪ Medium density (30-50dph) ▪ Closed cell neighbourhood; Off line ▪ Centralised jobs and services ▪ Tributary street pattern at micro scale; grid/web at meso scale
Radical urbanist	<p>Open cell units in pedestrian permeable clusters forming a township</p> <ul style="list-style-type: none"> ▪ Mixed land use ▪ High density (40-70 dph) ▪ Open cell neighbourhood; on line (astride) ▪ Centralised jobs and services ▪ Grid/web street pattern at micro and meso scales
High street	<p>Public transport spine forms a focus for activity along a continuum; density falls away from spine to parallel green space.</p> <ul style="list-style-type: none"> ▪ Mixed land use ▪ Medium, graded density (mean 30-50 dph, but wide range) ▪ Continuous neighbourhood with on line township and edge on localities ▪ Linear focus to jobs and services ▪ Grid/web street pattern at meso scale; grid at micro scale

Source: Hugh Barton, SOLUTIONS paper on Local Design Archetypes, 12/8/04

(b) City / Strategic scale

Design Type	Description
Trend	<ul style="list-style-type: none"> ▪ Maintain greenbelt ▪ Prioritize development to 1. brownfield, 2. sub/urban with good public transport access, 3. other areas with good access, including those with high capacity transport corridors ▪ No pricing ▪ Public transport and highways investment
Compact city	<ul style="list-style-type: none"> ▪ High density development and infilling, very high density around transport nodes and employment centres ▪ Relax green belt, open space and recreation constraints within urban footprint (except for SSSI etc). ▪ Area wide distance based road pricing ▪ Public transport improvements
Remove planning restrictions	<ul style="list-style-type: none"> ▪ Development allowed in all sites but those of highest environmental, scenic or cultural value ▪ No pricing (option to include pricing) ▪ Highway improvements
Planned expansion and new settlements	<ul style="list-style-type: none"> ▪ Relax greenbelt in areas of high employment growth and good transport connections ▪ Minimum density and requirement for local employment ▪ Master planning for a cellular self contained settlement pattern ▪ No pricing but highway improvements

Source: Tony Hargreaves, SOLUTIONS EC meeting, 27/6/05 (Strategic options for London)