# Sustainability of Land Use and Transport in Outer Neighbourhoods (SOLUTIONS): A Proposed Appraisal Framework

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## Abstract

*This paper describes the development of a proposed appraisal framework intended to guide sustainability evaluation within SOLUTIONS, a project that seeks to identify sustainable land use and transport strategies for peri-urban areas that experience high growth pressure. The paper identifies guiding principles for appraisal in SOLUTIONS, before considering relevant aspects of current practice in Sustainability Appraisal and Strategic Environmental Assessment of development planning. A six step appraisal framework process is proposed (option specification, criteria specification, scoping, assessment, enhanced assessment, reporting). To address the difficulty of coherently assessing strategies described at different spatial scales (city vs. neighbourhood) and described using different methodologies (modelling vs. mapping and design), a 'simple hybrid' approach to assessment is proposed. The relative merit of different approaches to indicators (multiple measures vs. aggregation indices) when reporting results is discussed.*

## 1. Introduction

SOLUTIONS (Sustainability Of Land Use and Transport In Outer NeighbourhoodS) is an EPSRC supported research project that has the aim of developing generic guidance to support the planning, design and implementation of sustainable land use and transport strategies in peri-urban areas that experience high pressure for growth. Full details of the programme objectives and structure, the case study cities, and the research consortium are described in Echenique *et al*., (2004).

This paper discusses sustainability appraisal within the context of SOLUTIONS, and proposes an approach to appraisal within the project (the SOLUTIONS appraisal framework, part of Work Package 5). The assessment approach ultimately applied in the project must meet the requirements of stakeholders (within and without the research team), whilst recognising constraints (time, resources, expertise) on the appraisal process. The paper thus aims to encourage discussion over the proposed assessment approach. The paper (a) states the guiding principles for sustainability assessment; (b) considers current best practice in Sustainability Appraisal and Strategic Environmental Assessment of land use and transport strategies, and how this could be applied to SOLUTIONS; (c) Discusses issues arising from the need to assess designs at city and neighbourhood scales; and (d) Proposes a SOLUTIONS appraisal framework and an initial set of evaluation criteria.

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## 2. Guiding Principles for Appraisal

A series of principles were established to guide the development of the SOLUTIONS appraisal framework. These were that the assessment process should:

- Address sustainability aims. These are expressed in a variety of ways depending upon the policy context, but always include economic, social and environmental objectives. Consistency is maintained with the national sustainable development strategy goals of: (a) Social progress which recognises the needs of everyone; (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;

- Be consistent with current UK practice in sustainability evaluation of land use and transport plans. Consistency with current practice is considered desirable, as an evolutionary appraisal framework is thought more likely to gain wide acceptance of the SOLUTIONS work amongst the stakeholder community. Thus the appraisal framework seeks to apply and build on current best practice;

- Be objective, minimising bias and subjectivity, and recording uncertainties in the assessment process;

- 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. This does not exclude the opportunity to additional present results in more aggregated form, to aid identification of more sustainable options;

- Be clear in its presentation of information, and transparent in its application, so that stakeholders can understand how assessment results have been derived;

- Be practical, operational and achievable with available resources;

- Be useful to case study city stakeholders whilst recognising that the aim of the research is to support production of generic guidance on peri-urban development.

The appraisal framework need not be consistent with legal requirements (e.g. of the SEA directive), but these requirements have been considered when developing the appraisal framework.

## 3. Current Practice in Sustainability Appraisal of Development Plans

In 2004, EC Directive 2001/42/EC 'on the assessment of the effects of certain plans and programmes on the environment' came into force in the UK. The so called "SEA directive" applies to a wide range of plans and programmes, including "...transport, regional development …town and country planning or land use…." (Article 4, Para 2), and thus applies to all types of spatial plan, including local plans, UDPs, structure plans, regional planning guidance and regional spatial strategies. Formally, the SEA directive only requires environmental assessment, but note that its aim is to (Article 1) "Provide for a high level of protection of the environment and to contribute to the integration of environmental considerations into the preparation and adoption of plans and programmes with a view to promoting *sustainable development*…"

Before the SEA directive, the UK had established a system for sustainability appraisal (SA) of development plans. This consisted of guidance on sustainability appraisal of regional planning guidance (regional spatial strategies) (DETR 1999a) that set the framework for the local plans, and guidance on local plan appraisal. When first introduced, the latter focussed on environmental appraisal (DoE 1993), but was later revised to incorporate social and economic objectives too (DETR, 1999b). Thus at local and strategic levels, an appraisal system exists in which sustainability objectives and indicators are identified and used as the basis against which to evaluate plans.

SEA and SA have much in common, but also some significant differences. First, SEA requires a more detailed environmental assessment than SA (re baseline data, identification of problem areas, consideration of alternatives, impact prediction and mitigation, monitoring, and provision of information on the decision). Conversely, SA is broader in scope, requiring assessment of social and economic issues, although it has little on health, material assets and cultural heritage, key features of the SEA directive and UNECE SEA protocol. Thus SEA has been characterised as "narrow but deep" and SA as "shallow but broad" (Therivel, 2004).

Subsequently the Office of the Deputy Prime Minister (ODPM) recommended that the SEA and SA processes be merged (ODPM, 2003a). This was felt to create a more efficient, effective and understandable system, as long as the danger of "diluting" the environmental objectives in a broader system were recognised. ODPM (2003a) guidance on implementation of the SEA directive now promotes "deep and wide" assessment, in which SEA requirements are rigorously met, whilst also including a full range of sustainability criteria.

## 4. Application of the SEA-SA process to SOLUTIONS

The key steps in the SEA-SA process are described in Table 1, drawn from current best practice guidance on the evaluation of spatial development plans (ODPM 2003a; Scottish Executive 2004). Planning authorities following this procedure should meet the requirements of the SEA directive whilst also conducting a broader sustainability appraisal of spatial development plans. However, this process need not be followed closely within SOLUTIONS. Firstly, whilst there is merit in following the broad approach outlined in the table, there is no demand to fulfil the stringent requirements of the directive in a research project. Secondly, SOLUTIONS has a particular focus, the sustainability of spatial "design" in peri-urban areas, that limits the range of strategic options that might be addressed, although these options are nevertheless broadly defined, including a mix of spatial policy, economic instruments and regulation.

Table 1 also reviews the purpose of each step in the recommended SEA-SA process, and attempts to identify its relevance to the SOLUTIONS programme. From this review, some steps are identified as inappropriate to SOLUTIONS, others as core aspects of the assessment process, and others as of less importance (optional), or relevant to other SOLUTIONS activities (particularly the derivation of design alternatives to be tested within the research).

From this review the following steps are considered to have most relevance to SOLUTIONS, and merit inclusion in the appraisal framework:

**Table 1. Stages in SEA-SA appraisal of development plans, and their proposed treatment in SOLUTIONS**

| | SEA-SA STAGE | DESCRIPTION | RELEVANCE TO SOLUTIONS |
|---|---|---|---|
| 1 | Screening | Check to see if the plan[1] requires assessment as specified by SEA directive. | Not required - all designs[1] will be assessed. Note that SOLUTIONS plans would automatically require environmental appraisal under the current interpretation of the SEA directive. |
| 2 | Baseline assessment | Collect baseline information relevant to the plan.<br><br>Forecast likely future change in the baseline. The data should be responsive to land use / spatial policy. | Required - inform assessment of the "do-nothing" designs. Baseline criteria should be responsive to SOLUTIONS designs.<br><br>Baseline data is also useful scoping issues for a plan area. However, SOLUTIONS seeks to develop generic, not site specific guidance, hence this is considered a secondary function. |
| 3 | Scoping | Identify significant sustainability issues, and agree with stakeholders through consultation.<br><br>Identify scope and level of detail required. | Required. Key issues to be addressed will be identified from literature and consultation with project stakeholders. Issues must be sensitive to SOLUTIONS designs (spatial land use and transport policy). |
| 4 | Objectives and criteria | Develop and adopt an agreed set of sustainability objectives, criteria and targets. | Indicators but not targets are required. Preliminary draft for discussion is presented below based on literature review. Must have a common indicator set across the four case study cities, and be coherent across strategic and local scales.<br>Discussion will later be required on data presentation issues (e.g. the use of key or aggregation indices to aid interpretation). |
| 5 | Assess plan's vision and aims | A broad level test to assess whether the vision and aims of a plan are internally consistent with sustainability criteria, through application of a simple matrix of strategies vs. SD goals (e.g. Green belt protection aim is potentially in conflict with reduction in energy use in transport). | Not required, as there is no specific plan to be assessed. However, this qualitative assessment exercise could usefully be applied to the SOLUTIONS designs, to aid capture of potential key issues, identify those criteria likely to be sensitive to the designs to be investigated, and thus guide subsequent more detailed assessment (i.e. acts as a scoping tool) |
| 6 | Transboundary effects | Consult other member states over possible transboundary effects upon them. | Not required. Inter-national transboundary effects are assumed to be of low importance in SOLUTIONS appraisal (but note that some indicators are likely to address global issues – e.g. $CO_2$). |
| 7 | Identify alternatives | Identify alternative policies and locational strategies.<br>Directive requires assessment of significant effects, but only for reasonable alternatives. | Required. Basic SOLUTIONS design options (spatial design) for testing have been identified in the research proposal, and are subject to more detailed description (spatial design plus regulation, pricing and investment policies) in WP's 2-4. |

| | SEA-SA STAGE | DESCRIPTION | RELEVANCE TO SOLUTIONS |
|---|---|---|---|
| 8 | Check the policy range of the plan | The plan is checked to ensure it is consistent with wider and higher tier policy objectives. Where plan policies are inconsistent with higher tier policies, this is noted, and consideration is give to modifying the plan accordingly. | Not required. This SA-SEA step aims to identify the extent to which the plan contributes to / is in conflict with higher tier policy objectives. This is not an assessment task per se, but is concerned with plan development, hence has relevance to the derivation of SOLUTIONS design options (WP2-4). |
| 9 | Assess the plan | Assess the plan's policies and proposals. Identify uncertainties and mitigate adverse effects. The focus is on potentially significant effects on agreed criteria (the SEA directive specifies environmental topics to address). Checklists and matrices are used to structure the analysis and present results, using symbols and/or notes. Potential cumulative effects should be identified, and possible mitigation steps described. | Required. The SOLUTIONS tests are not formally of a plan, but of design options that are of interest to those developing spatial and transport plans. A systematic approach using significant modelling will be used (see below). Features include:<br>• Dynamic baseline characterisation<br>• A preference for quantitative assessment<br>• Attention to cumulative effects through strategic modelling<br>• A focus on long term impacts (i.e. SEA not EIA)<br>• Mitigation and compensation opportunities will be ignored in the assessment. These alter the plan and create too many options to test, but merit consideration in the final guidance. |
| 10 | Reporting | Produce an assessment report to accompany the draft plan | A SOLUTIONS appraisal report will be produced to inform development of the generic guidance on peri-urban design. Best practice guidance (ODPM, 2004) recommends the use of action-indicator matrices with quantitative and/or qualitative data (the latter expressed using a variety of symbolic techniques). The use of data summary techniques (indices) will also be explored. |
| 11 | Consultation | Consult over the assessment report and draft plan; modify the plan and revise the report accordingly | Not required in the prescriptive form specified by SEA-SA appraisal, but consultation over results and draft guidance recommended to support final generic guidance report. |
| 12 | Deposit plan | Revised assessment report and plan placed on deposit. | Not required. Relates to planning authority process. |
| 13 | Plan approval | Complete plan adoption procedures | Not required. Relates to planning authority process. |
| 14 | Monitoring and review | Monitor and review results of monitoring; consider need to revise the plan. | Not required, beyond current scope of the research. Monitoring and review of SOLUTIONS guidance could be the subject of further research were recommendations implemented. |

1. In SEA-SA the strategic options under consideration are referred to as plans. In SOLUTIONS, the same options are referred to as designs (encompassing spatial design, investment, pricing and regulation).

(a) Scoping of key issues through literature, consultation and baseline evaluation of case study areas; (b) definition of objectives and indicators related to key issues; (c) identification of design options; (d) assessment of design options; and (e) reporting to support development of generic guidance.

## 5. A Proposed Approach to Assessment in SOLUTIONS

The SEA-SA review and a consideration of local-strategic scale assessment issues suggests an appraisal framework, illustrated in Figure 1 and discussed further below. The framework comprises six principal steps: (1) Specify the design options (these are the outputs of Work Packages 2-4); (2) Specify the evaluation criteria (via literature, consultation, baseline evaluation); (3) Conduct a scoping assessment (this is an optional step that helps ensure design sensitive criteria are used, and to avoid assessment of essentially duplicate designs); (4) Assess design options (apply the 'hybrid' approach – see below); (5) Enhance outputs from step 4 through further assessment (to address more of the criteria specified in step 2); (6) Report results (Present step 4 and 5 outputs in form(s) that allows clear comparison of alternatives.

### 5.1 Specification of design options (Step 1)

Table 2 lists the principal design types considered from the inception of the project. These designs give, in combination, 16 basic options that could be tested for each of the four case study cities. However the number of options is in practice very much greater: (a) basic options can be distinctly sub-divided – type of structured expansion or type of catchment based neighbourhood, for example; (b) there are other design options not described here, such as pricing mechanisms; and (c) some tests will need to be examined under alternative exogenous development scenarios such as oil price shock or demographic change.

There is then a need for a systematic approach to option generation and selection, so that a representative and relevant set of designs can be tested with the available resources. Combinations of strategic and local options should also: (a) be feasible (e.g. Trend plus Use Segregated Dispersal represents a continuation of the current development trend, but are there any mutually exclusive local-strategic design combinations?); and (b) support the distillation of generic guidance (e.g. test one local design at a time in the strategic model; replicate this design test across the case study cities). Selection of designs should also recognise that the research is not intended to support local planning *per se* in the case study areas (although this is a valid secondary goal to that of producing generic guidance). Such issues are being addressed by SOLUTIONS work packages 2-4 (addressing design options generically, locally and strategically).

The UWE team, conducting the local design and appraisals, intend to apply a technique devised by the team known as Sustainability Threshold Analysis (STA) (Barton, *Pers. Comm.*). This tool is understood to operate in a similar manner to a land use capability assessment, in which the development constraints for a site are identified and mapped to reveal land parcels where development can viably proceed. STA adds a sustainability dimension to this process, forbidding development where significant sustainability thresholds would be exceeded (e.g. development in an area of high wildlife significance, or with high flood risk), and directing it to areas where opportunities to promote sustainability are high (e.g. high density development located in areas with good access to public transport and other local services).

**Figure 1. Proposed SOLUTIONS Appraisal Framework**

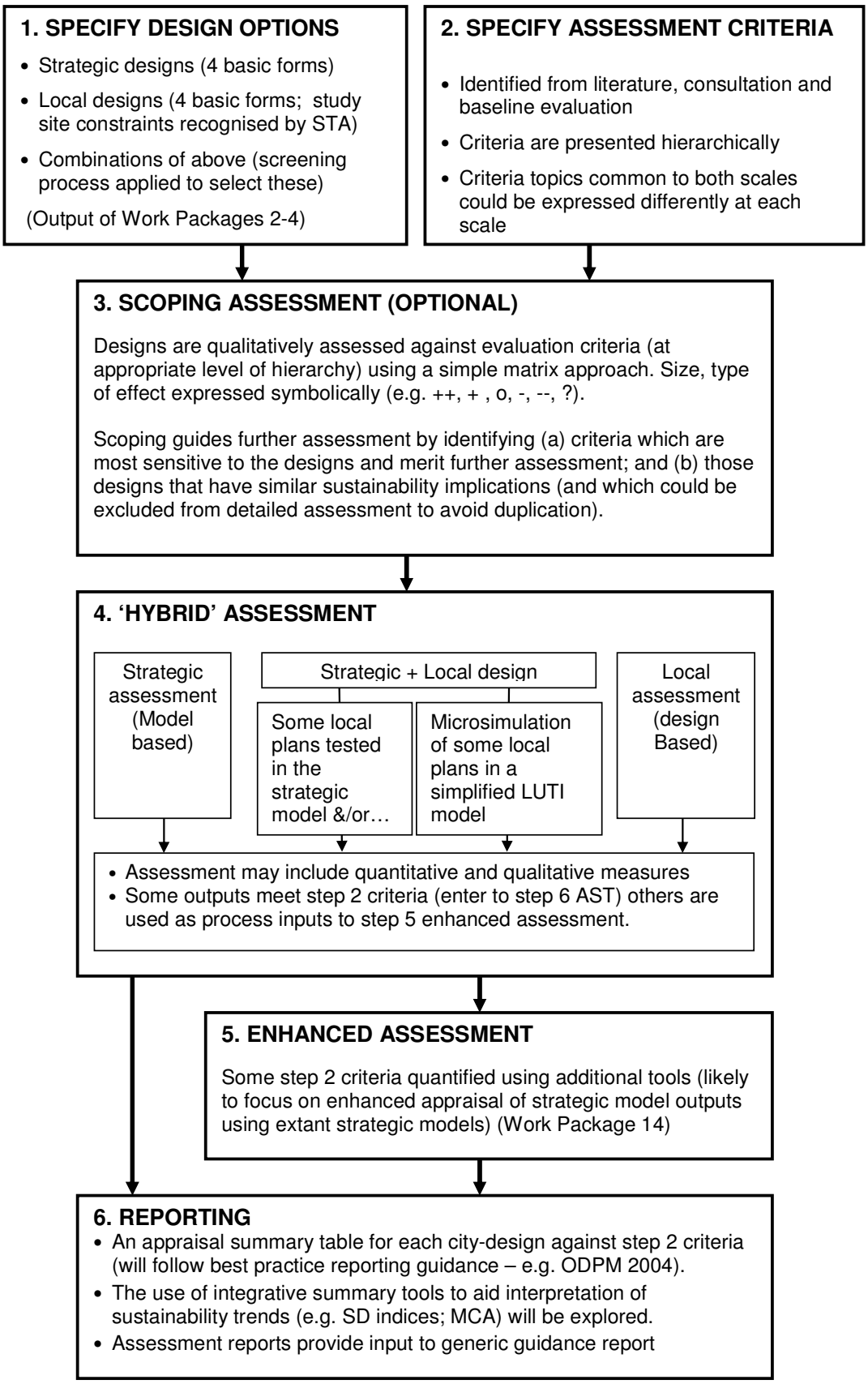


**Table 2. Possible spatial design options to test in SOLUTIONS**

| **STRATEGIC SCALE (CITY OR CITY REGION)** | **DESCRIPTION** |
|---|---|
| Trend | Brownfield infill; Peripheral expansion; Dispersal to outlying settlements |
| Compact City | Densification with little Greenfield release |
| Structured Expansion | Peripheral, corridor and / or new outlying settlements (more Greenfield development) |
| Free Market | Development where there is demand, but with special protection and full cost charges |
| **LOCAL SCALE (NEIGHBOURHOOD)** | |
| Use Segregated Dispersal | Low density "pods" with high vehicle dependency |
| Intensification | Increase current density and maximise brownfield development |
| Linear Township | "High street" served by public transport |
| Catchment Based Neighbourhood | Closed cells (discreet unit) or open cells more permeable to movement and allowing greater interaction within a cell cluster |

Thus STA is applied, not as an assessment tool, but as an aid to local design. It is important that the criteria applied within STA are appropriate - this process can be informed by the evaluation criteria identified through step 2 of the assessment process. The STA thresholds that place a bar on development must also be chosen very carefully, as in practice, there are rarely "black and white" choices, as mitigation and compensation could be implemented to offset negative effect of a development, and thus deliver net benefit from a local design (thus continuous rather than discreet value function curves may be preferable within the STA technique). There is also a need to recognise the aim of producing generic peri-urban design guidance, and that local design constraints (e.g. presence of valued ecological or cultural heritage) should not preclude testing of a particular local design option which is important to the systematic application of the selection and testing of design combinations.

### 5.2 Specification of Evaluation Criteria (Step 2)

Indicator selection can be a prolonged process, often complicated by the ability of indicators to serve different functions (e.g. compare indicators for trend monitoring vs. those for early warning). SOLUTIONS evaluation criteria are required to support the local and strategic scale experimental design, hence a literature review supported by limited consultation is proposed as a valid mechanism for early identification of evaluation criteria. This approach is considered valid, given the goal of generic (not case study specific) guidance and the availability of a body of good practice literature on sustainability appraisal of spatial development and transport plans.

Table 3 presents proposed SOLUTIONS evaluation objectives developed from a review of national guidance on land use and/or transport plans including: "Local quality of life indicators" (DETR 2000); the Integrated Policy Appraisal Template (DTLR 2002); the

New Approach to Transport Appraisal (DETR 1998; DfT 2004); the SEA directive (2001) and guidance on its application within a sustainability framework (ODPM 2003, Scottish Executive 2003); national transport indicators (Scottish Executive 2002) and local transport plans for Cambridge, Bristol and the Thames Gateway (DfT, 2003) (see Mitchell 2004a for further details on the derivation of the table).

**Table 3. Summary of proposed SOLUTIONS evaluation criteria**

| Criteria | Assessment level | | Comments |
|---|---|---|---|
| | Strategic | Local | |
| **ECONOMIC** | | | |
| Net economic benefit | Yes, QN | No? | Local included in strategic? |
| Transport economic efficiency | Yes, QN | No? | |
| Journey reliability | Yes, QN | No? | |
| **ENVIRONMENT (Natural)** | | | |
| Noxious emissions | Yes, QN | Yes?, QN | Addresses networks but not land use |
| Greenhouse gas emission | Yes, QN | Yes?, QN | |
| Noise | Yes, QN | Yes?, QN | |
| Biodiversity | No | Yes, QL | STA address designated sites |
| Green space area and pattern | Yes, QN? | Yes, QL | A surrogate for biodiversity |
| Landscape | No | Yes, QL | Relevant to a generic guide? |
| Diffuse water pollution | Yes, QN | Yes? QN | |
| Properties (value) at flood risk | Yes, QN | Yes, QL | |
| **ENVIRONMENT (Resources)** | | | |
| Productive land lost to development | Yes, QN | Yes, QN | Surrogate for soil conservation |
| Energy use | Yes, QN | No? | Addresses networks but not land use |
| Water use | Yes, QN | Yes? QN | High relevance to spatial plans? |
| Brownfield land use | Yes? QN | Yes, QN | |
| **ENVIRONMENT (Built)** | | | |
| Heritage | No? | Yes, QL | Relevant to a generic guide? |
| Townscape | No? | Yes, QL | |
| **SOCIAL NEEDS & PROGRESS** | | | |
| Physical fitness | Yes, QN | Yes, QN? | As walk / bike modal share |
| Traffic accidents | Yes, QN | Yes? QN? | |
| Security | ? | ? | Pending further investigation |
| Journey ambience | Yes, QN | Yes, QN | |
| Access to public transport | Yes, QN | Yes, QN | |
| Severance | Yes, QN | Yes, QN | |
| Option value | ? | ? | Pending further investigation |
| Equity in access to public transport | Yes, QN | Yes? QN? | |
| Equity in severance | Yes, QN | No? | |
| Equity in emissions exposure | Yes, QN | No? | |
| Equity in noise exposure / annoyance | Yes, QN | No? | |
| **SUPPORTING OBJECTIVES** | | | |
| Transport interchanges | Yes? QL | Yes? QL | Address in generic guidance? |
| Integration of LU and T policy | Yes? QL | Yes? QL | |
| Integration of T and other policy | Yes? QL | Yes? QL | |
| Scheme practicality & acceptability | Yes? QL | Yes? QL | |

Key: QL = Qualitative assessment; QN = Quantitative assessment

A hierarchical structure is implicit in the table. At a high level, Governments' national sustainable development strategy goals are recognised: (a) Social progress which recognises the needs of everyone; (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. Once objectives associated with these goals are agreed within SOLUTIONS, more specific evaluation criteria will be identified (e.g. air quality is an evaluation objective, population exposed to annual mean $NO_2$ in excess of the NAQS standard would be an air quality indicator).

In addition to the hierarchical structure, there are a number of other characteristics of the evaluation criteria to note: (a) the objectives are goal not process oriented (as far as is possible; (b) some objectives (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; (c) some objectives may be relevant at one scale but not the other (e.g. resource use), but in general, objectives are assumed to be common to both scales; (d) an objective common to both scales could be addressed by different indicators (consider accessibility measurement at different scales); and (e) quantifiable criteria are preferred, but qualitative criteria permitted (e.g. Landscape), consistent with the seven point scale applied in NATA appraisal for some criteria (Dft 2004). The issue of 'how many criteria are needed?' will be discussed further in 6.6 below.

Final selection of SOLUTIONS evaluation criteria will be determined by research team review (considering appropriateness and practicalities of implementation), and consultation with external stakeholders. It is anticipated that DISTILLATE (another project in the SUE transport cluster) will provide further input via its audit of transport indicators.

### 5.3 Scoping Assessment (Step 3, Optional)

Very many land use-transport designs could be tested within SOLUTIONS, yet resources are clearly limited. A scoping assessment is thus seen as a useful mechanism for increasing the efficiency of the appraisal process by: (a) identifying those evaluation criteria that are most sensitive to the designs to be tested (and hence which may merit more thorough assessment); (b) identifying those designs that have broadly comparable sustainability implications (and hence which could be excluded from more detailed assessment to avoid duplication), and (c) identifying possible conflicts between design features and evaluation criteria that merit closer investigation (e.g. protected greenbelt could increase travel and energy consumption).

The optional scoping assessment is a qualitative process employing a matrix of designs against evaluation criteria, with subjective judgements made as to the likely effect of design on criteria (magnitude of effect, beneficial/adverse/uncertain etc), supported by brief notes. This scoping assessment is consistent with guidance from DTLR (2002), on the application of screening in integrative appraisal.

### 5.4 Hybrid Assessment (Step 4)

Assessment involves predicting the effects of designs on evaluation criteria (identifying changes in space and time), describing them in a consistent manner, and commenting upon

their significance (duration, magnitude, receptor importance, reversibility etc). So far, this paper has considered assessment in an aspatial manner. However, SOLUTIONS seeks to assess the sustainability of peri-urban development plans through explicit consideration of both local (neighbourhood) and strategic (city or city region) scales. These scales are addressed within SOLUTIONS via distinct work packages applying different research approaches and tools, hence ensuring a coherent assessment across these scales presents a significant challenge. Two distinct approaches to such scale differentiated assessment can be described (Figure 2) as: (a) independent assessment, and (b) integrated assessment.

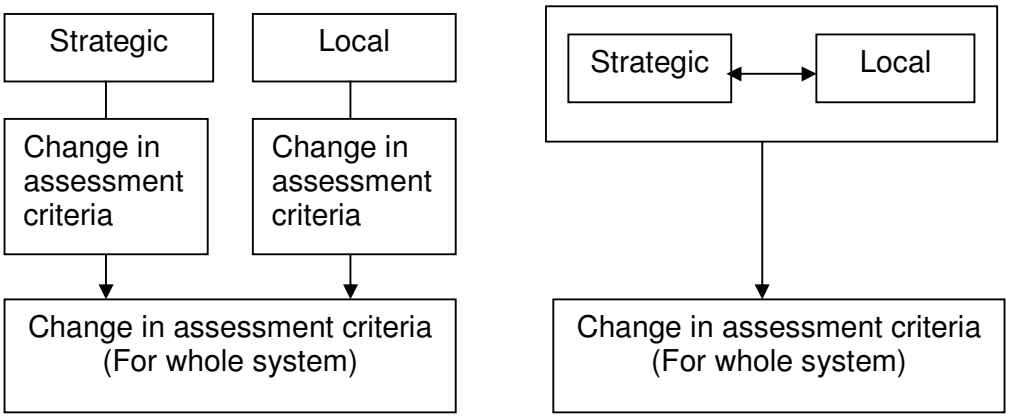
**Figure 2. Approaches to Assessment of Strategic and Local Scale Designs**

**(a) Independent Assessment**

- Wide range of criteria can be assessed
- Robust, well understood
- Little/no integration of scale
- Double counting possibilities

**(b) Integrated Assessment**

- Limited range of criteria can be addressed
- Unproven method (inc. sensitivity issues)
- Resource intensive
- Explicit scale interaction recognised




Under independent assessment development options described for strategic and local scales are assessed without consideration of any scale interaction, with only a collective presentation of results (e.g. a summary matrix in which assessment at both scales are presented against a common set of criteria). This has the advantage of simplicity, but the major disadvantage of no consideration of the interactions between scales (except that considered in the option designs), and a danger of double counting.

With the integrated assessment approach, assessment is made by first addressing scale interactions, and then considering the collective effect of these interactions on the evaluation criteria. For example, the interaction between local design features (e.g. population proximity to public transport) and strategic design features (e.g. public transport charges, or accessibility via public transport) is used to determine travel demand and modal split. This information can then be used in the assessment (e.g. what are the implications for accessibility, energy use, emissions etc?). The integrated approach is preferable, as in reality, macro level patterns emerge from micro level processes and behaviour, and micro level processes and behaviours are controlled by macro level constraints. Key tasks in the integrated approach would be identification of the important scale interactions, and the assessment criteria which are sensitive to them (directly or indirectly).

There are, however, major difficulties associated with implementing the integrated approach. First, strategic LUTI models are relatively insensitive to changes at micro scale; hence interventions represented in the local scale designs may be lost in the 'noise' of the LUTI models. Relying on strong integration of local scale designs in a LUTI model is also a relatively high risk approach, as LUTI models have not yet been secured for all the case study cities.

Secondly, there are insufficient resources to test all the strategic-local design combinations via the independent assessment approach, let alone the more complex and demanding integrated approach. This 'n-dimensionality' problem (see 5.1 above) can be addressed through a clear rationale for design option selection, including a screening procedure to filter out those scale combinations that do not merit further investigation (e.g. due to internal inconsistency, duplication, highly unrealistic in practice). This would allow a focus on those city-neighbourhood design combinations that appear most promising. It is important however, that the scale combinations that are investigated are sufficient in number to represent a sufficient range of viable design options to support the production of generic guidance for peri-urban development. Thus, even if a screening approach was successfully applied, it is likely that there would still be insufficient resources to investigate them all via the integrated assessment approach.

A possible solution to these problems is the application of a 'hybrid' approach to assessment, in which both independent and *simplified* integrated assessments approaches are applied. Through independent assessment, designs are evaluated without consideration of local-strategic scale interaction. The independent assessments can address a wide range of criteria, and will employ methods known to and proven by the respective research groups and thus have the advantage of relative simplicity and practicality.

The simplified integrated approach complements these independent assessments through (a) representing a subset of local designs in the full land use-transport interaction (LUTI) model; and/or (b) using micro simulation modelling to represent local designs within a simplified LUTI model. Under option (a) zonal characteristics in the strategic LUTI model are described using data derived from the local designs (e.g. commercial floor space, housing density). The value of this option requires further discussion, as the strategic model is relatively insensitive to micro-scale changes, and resources may adversely limit the number of local-strategic combinations that can be tested in the strategic model.

Microsimulation offers another means of integrating scales. Here, simplified integration arises not through a reduction in the number of local-strategic combinations tested, as in option (a), but because local designs are represented using a microsimulation model in which the city beyond the microsimulation is represented by a buffer zone, rather than a full LUTI modelled region. The strategic model provides inputs to the microsimulation and its buffer zone (e.g. accessibility to other zones), so that the influence of local designs on travel behaviour can be tested at a wider scale. The local design is represented in the microsimulation by local transport network configurations and land use data (e.g. land use plots with identified dwelling densities, commercial floor space; location of facilities) which can be readily manipulated to represent local development types. Running the microsimulation outputs data (e.g. trips by mode, socio-economic characteristics of residents, employment, household densities, accessibility etc.) for that zone, which can then be used in subsequent sustainability assessment (step 5) as appropriate.

The microsimulation modelling offers a way of systematically testing the generic local options within a wider context, providing a level of consistency and quantification to enable a better understanding of the relationship between design and sustainability. However, reservations have been expressed as to whether the microsimulation work can be initiated early enough in the SOLUTIONS programme to be useful. A hybrid approach to assessment might help resolve this problem, in that early assessment can concentrate on the independent local and strategic scale assessments, with integrated assessment work with the microsimulation model phased for later in the programme.

### 5.5 Enhanced Assessment (Step 5)

In some cases, step 4 outputs will directly match requirements of some step 2 evaluation criteria (e.g. accessibility; transport economic efficiency). Other step 4 outputs are not directly applicable in this way, and require further analysis to quantify evaluation criteria – this is the enhanced assessment process (e.g. vehicle flows and speeds can be used to quantify atmospheric emissions). Identification of required enhancement processes is dependent upon reaching a consensus on evaluation criteria (steps 2 and 3), and the practicalities of assessing particular criteria.

At the local scale, assessment is assumed to be achieved using simple evaluation tools (based on mapping and GIS; spreadsheet analyses etc), although this requires further investigation once evaluation criteria are agreed. Detailed 'EIA type' assessments are not considered appropriate unless effects are clearly sensitive to land use-transport design. Enhanced assessment at the strategic level is more challenging due to the greater scale involved, hence it is anticipated that further modelling work will be required. Initial evaluation suggests that several models developed by the Leeds team may be suited to this strategic level assessment. TEMMS (Namdeo *et al*., 2002) is a VB program used to rapidly exploit outputs of network models (including SATURN) in modelling atmospheric emissions, air quality and transport energy consumption (see Mitchell *et a*l., 2003 for a description of its use in assessing the air quality implications of urban road user charging in Leeds). SMARTNET (system for multi-criteria assessment of road traffic networks) (Mitchell and Namdeo, *forthcoming*) is a development of TEMMS in which additional criteria (e.g. noise, accidents, severance) identified under NATA are quantified. SMARTNET is not scale dependent, and could be applied at the local scale if desirable.

Strategic models relevant to enhanced assessment of land use include those addressing water demand (Mitchell *et al*, 2000; Williamson *et al*., 2002) and diffuse pollution (Mitchell, *in press*), areas neglected by the Sustainable Communities plan (ODPM 2003b) which attracted considerable criticism as a result (ODPM 2003c). The Leeds team also have experience of equity appraisal through a series of recent national environmental assessments (Mitchell and Dorling 2003; Walker and Mitchell 2004).

Feasibility assessment of the integration of these models with the strategic LUTI model is pending, but the possibilities look promising. However, it is recognised that the enhancement process should be driven, not by the assessment capability, but by the required assessment objectives. Once these are agreed, a more formal enhanced assessment process can be planned.

### 5.6 Reporting (Step 6)

Results of the analysis are collated in a SOLUTIONS appraisal summary table (AST) presenting information drawn from the prior assessment steps (and following good practice guidance such as ODPM 2004). The extent to which this data should be aggregated in the AST is an important consideration, on which there are different views amongst the SOLUTIONS team. One view is that all evaluation objectives (indicators) should be reported individually so as to present a "rich" database from which the generic guidance can be distilled. The view is also expressed that the Table 3 objectives are insufficient, and that additional objectives are required to permit a full assessment of alternative designs. The opposing view is that there is a need to aggregate all the assessment data into two or three indices, so as to allow easy comparison of alternatives, and a more ready identification of the "correct" answer (which design is most sustainable). These tensions are well recognised in the appraisal literature. Figure 3, for example, details some pros and cons of alternative approaches to indicator construction and presentation.

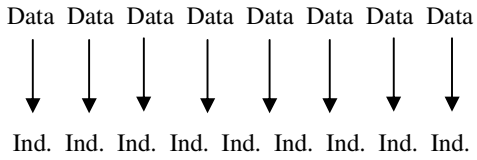
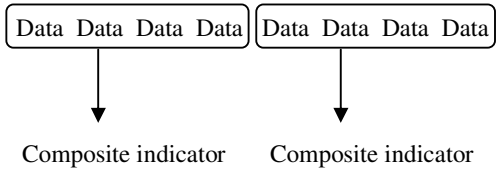
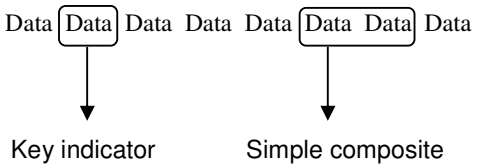
There are, of course, numerous aggregation indices described in the literature for reporting on sustainable development. These indices include those developed from an economic perspective (e.g. Green GDP; the Z index; Approximate Environmentally Adjusted Net National Product); from a socio-economic perspective (e.g. the Index of Sustainable Economic Welfare; The economic aspects of welfare index; and various Quality of Life indices, such as those used by the UN and OECD to predict social need); and from an ecological perspective (e.g. The Ecological Footprint; Net Primary Productivity (NPP) sequestration; and K/NPP which consider NPP use relative to carrying capacity) (see Mitchell 1996 for a review of these indices).

From the perspective of SOLUTIONS, all of these indices are difficult to apply, as the tools used in SOLUTIONS are not able to quantify all the constituent variables in any one index, and many of the variables that are quantified, and which are important to sustainability evaluation of land use and transport options, are not included in the indices. Some indices are flexible in their construction (e.g. the ecological footprint) and could be applied in principle. However, existing sustainability indices are generally not thought suitable for application in SOLUTIONS, and if an aggregation index was required, it is likely that a bespoke index would need to be developed (this is the approach being explored for summation of economic costs within SOLUTIONS).

An alternative approach to summarising SOLUTIONS output data is to apply a multi-criteria approach, in which indicators are scored on a universal scale, using a value function curve, and indicator weights (that express relative importance of indicators) applied to the scores to calculate an overall score (for all indicators or groups of them). This approach was successfully applied in the PROPOLIS land use-transport sustainability project (Lautso *et al*., 2004), and is also used in the SMARTNET software described in 5.5 above, where non-linear value function curves can be constructed by system users, and the Analytic Hierarchy Process is used to derive indicator weights.

A tiered approach to reporting (an AST with multiple indicators presenting "rich" data, supported by application of a MCA to allow unambiguous comparison of alternatives) would appear to be a valid way forward, but remains to be agreed amongst the research team.

**Table 4. Relative Merits of Different Indicator Approaches (Mitchell 1996).**

| Indicator approach | Advantages | Disadvantages | Main indicator uses and users |
|---|---|---|---|
| **A. MANY SPECIFIC INDICATORS**<br>  <br> | • Comprehensive coverage of all the issues<br>• Few data gaps or omissions<br>• Selection difficulties are minimised<br>• Indicators are simple and closely reflect the data<br>• Results are non-controversial | • Burden of interpretation placed on user<br>• Communicates little sense of condition of the whole<br>• Limited potential for resonance. | • Modelling.<br>• Scientists |
| **B. A FEW COMPOSITE INDICATORS**<br>  <br> | • Communicates a sense of condition of the whole (or major parts of the whole) | • Difficult to maintain consistently as old issues disappear, new issues arise<br>• Controversial. An index averages data and much important information can be lost.<br>• Value judgements are required when weighting components.<br>• Limited resonance potential. | • Communicating data to discipline experts.<br>• Communicating data to policy makers.<br>• Modelling |
| **C. KEY AND SIMPLE COMPOSITE INDICATORS**<br>  <br> | • Explicit<br>• Data gaps are clearly seen<br>• Unacceptable omissions corrected by selecting additional key indicator, rather than altering complex composites.<br>• Long term robustness<br>• High potential for resonance | • Subjective decision required in selecting key indicator.<br>• Danger of oversimplification.<br>• Danger of giving false impression of improvement by targeting resources at the key indicator and not the problem. | • Communicating data to non experts and the public. |

## Conclusion

This paper has attempted to develop a method for sustainability evaluation of land use and transport plans within the context of the SOLUTIONS project. The appraisal approach is based upon current UK best practice guidance in sustainability assessment and strategic environmental assessment of development plans, modified to suit the characteristics of the research project. Three principal areas remain to be agreed amongst the research team (in consultation with stakeholders): (a) the evaluation objectives / indicators to be applied; (b) the value of the 'hybrid' approach to assessment (e.g. are resources sufficient to negate the need for any scale independent assessments?); and (c) the application of a two tier (multiple indicators plus MCA aggregation) approach to reporting. SOLUTIONS stakeholders are invited to contribute their thought on these and other assessment issues, to the author.

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