Mapping the intangible value of urban layout (i-VALUL)

Developing a tool kit for the socio-economic valuation of urban area, for designers and decision makers

Alain Chiaradia, Christian Schwander, Jorge Gil, Eva Friedrich,
Space Syntax Limited, UK

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Abstract: In this paper we present the development of a GIS tool kit for the socio-economic valuation of urban areas towards the creation of sustainable communities, describing the project context, development process, the tool kit's structure, its main tools and initial feedback from its use. We then present the plan for training sessions and pilot projects where the tool kit is going to be used, and conclude with the discussion of the development of a single integrated tool to be used beyond the life of the 'i-VALUL' project.

This project was supported by the UCL led UrbanBuzz programme within which UEL is a prime partner.

1. INTRODUCTION

The project 'i-VALUL: mapping the **I**ntangible **Val**ue of **U**rban **L**ayout' coordinated by Space Syntax Limited is part of the 'UrbanBuzz programme: Building Sustainable Communities' knowledge integration and exchange programme.

1.1 UrbanBuzz

'UrbanBuzz: Building Sustainable Communities' is a knowledge integration and exchange programme that aims to develop new ways of delivering genuinely sustainable forms of development and community in London and the Greater South East region of England (40,000km2 and 21 million inhabitants), the coverage of the Mega-City Region of London. The programme is funded by the Higher Education Funding Council for England (HEFCE) and the DTI's Office of Science and Innovation with a total budget of £5 million managed by University College London (UCL) and University of East London (UEL) and is funding a wide range of projects of different sizes addressing different aspects of sustainable development as described in its Pocket Guide (UrbanBuzz, 2008).

1.2 Mapping the Intangible Value of Urban Layout

The importance of urban layout for sustainable communities both for new development and retrofit is beyond question. It has been extensively researched and used as well as incorporated in all relevant strategic policy documents published by UK government bodies and other institutions (ODPM 2005a, DETR 2000, ODPM 2004b). However, according to the Commission for Architecture and the Built Environment (CABE) many new developments in the Greater South East of England fail to meet the standards of high quality urban layout (CABE, 2002). What is the reason for this?

Whilst many aspects of design such as street widths, building heights or construction materials are directly measurable and visible, others seem to be much less tangible. Urban layout, and especially its effects on social, cultural and economic aspects of community, is one such intangible asset, which is difficult to visualise and measure during the planning process.

To help overcome this problem, methods to map and measure the relational properties of urban layout within its wider context have been developed by researchers at UCL and other institutions (Hillier et al, 1989, 1999, 2005), and used successfully within development frameworks and in development projects (Space Syntax 2004, 2006a, 2006b, 2007). With this project we propose to reduce the barriers to the take up of these tools through a collaborative process involving the leading stakeholder organisations from the private, public and voluntary sectors, including several governmental bodies.

1.3 Knowledge Integration Themes (KIT)

The i-VALUL project takes existing knowledge and socio-economic information in the hands of the various knowledge partners and links it to urban layout, focusing on the valuation of five themes: property security (KIT1), personal security (KIT2), value of urban centres (KIT3), residential property value (KIT4) and public realm design (KIT5). Table 1 presents the different levels of partnership within the project as this is an essential element that guarantees the project's success from the sharing of expertise and the testing, validation, dissemination and adoption of its outcomes.

Table 1 Project partner levels, their role and who they are

Partner	**Role**	**Who**
Knowledge Integration Partner	expertise in knowledge integration themes; participate in value definition workshops; contribute to training modules	UCL Savills CBuchanan JMP Space Syntax
Project Integration Partner	end user organisations; contribute to training modules; participate in training; run knowledge integration projects	Public sector (Hants CC LB Croydon, LB Tower Hamlets); Private sector (EDAW, JMP); Voluntary sector (TPF, BAF)
Acceptance Partner	participate in value definition workshops; define standard of acceptance; disseminate outcomes	EEDA; GLA Economics; TfL; Design for London; SEEDA; CLG; Housing Corporation; Highways Agency; CABE; Sustainable London 2012; SKANSKA London 21
Peer Review Partner	review outcome of value definition workshops and integration projects	UEL ; UCL Bartlett; UCL Geomatic Engineering; UCL Civil Engineering; LSE

One of the direct outputs of the project is a valuation software tool kit for quantifying the socio-economic benefit of urban layout. In this paper we describe the tool kit development process, present the collection of tools, discuss the feedback and review stage and describe the next stages of the project and the tool kit in particular.

2. KIT EXPLORATION PHASE

The KIT development process is split in two phases: exploration and integration. The exploration phase consists of workshops with partners to determine the valuation criteria and tool requirements, leading to the production of a software tool kit, training material and a series of layout value maps for use in the second phase, described in chapter 4. We will be focusing on the steps that contribute to the development of the software tool kit.

2.1 Value definition workshops

This project started off with a series of workshops organised by Space Syntax with the knowledge integration partners, one for each KIT, to share expertise on the valuation of socio-economic criteria and link them to urban layout characteristics. The workshops for each KIT were organised by Space Syntax bringing together its own expertise on urban layout analysis with the following expertise:

- **KIT 1 and 2**: UCL study on crime where spatial patterns of robbery and burglary are presented (Hillier et al 2007) and the UK Home Office report on the social costs of crime (Dubourg et al 2005);
- **KIT3**: CABE/Buchanan report on the economic value of local centres (CABE, 2007);
- **KIT 4**: The Prince's foundation/Savills report on residential design and layout (The Prince's Foundation 2007) and current council tax bands;
- **KIT 5**: JMP work on public realm design using the Pedestrian Environment Review System (PERS);

As a result from these workshops we identify a series of urban layout indicators based on the space syntax layout model that correlate with particular socio-economic factors. We then determine the significant collection of indicators that will constitute the valuation index for the focus theme. One output is a series of KIT summary diagrams, exemplified in figure 1 that list the requirements to evaluate an urban area for a particular theme, which are the basis on which the software tool development process starts.

2.2 Methodology Definition

Following the KIT value definition workshops we went through the process of developing an analytical methodology within the MapInfo Professional GIS environment to obtain the urban layout indicators required by the different focus themes.

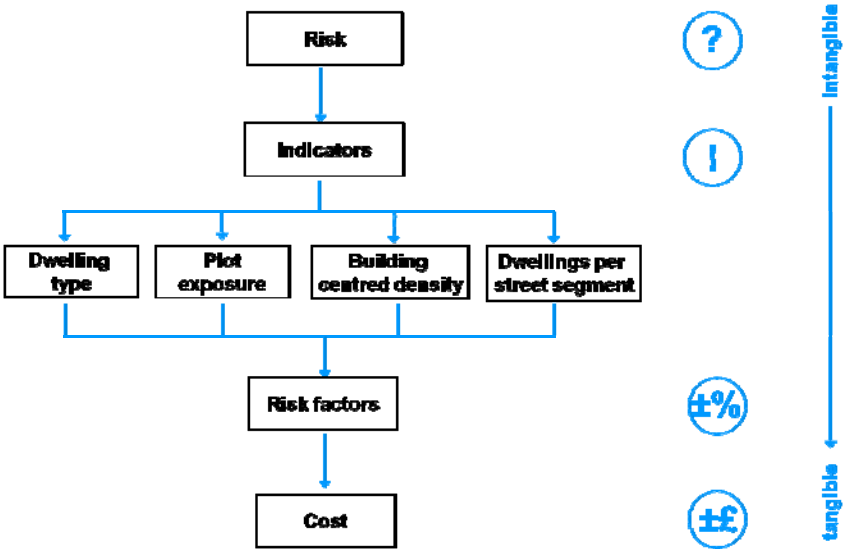


Figure 1. Property security indicators (KIT1) indicator summary diagram

The urban layout valuation process has several stages: data preparation, data analysis and layout indicator calculation. First we created methodology definition documents for each stage in the form of detailed log of the manual procedures to achieve the urban indicators, using a combination of existing GIS features, custom scripts and tools and other existing software like OS2MIF and Depthmap (Turner 2007) which provided complementary functionality. This was by no means a linear process and alternative procedures had to be explored to achieve faster and more consistent results.

Once we had determined the analytical procedures we were able to write a functional specification describing which tools were required for the different stages of the methodology, including the data inputs and outputs available to the user and the calculations being made, always referring back to the methodology document as to provide examples.

2.3 Tool Development

From here we have started the development of a tool kit that automates and standardises the various steps of the layout evaluation process, to some extent based on the previous work done on the Confeego tool set for spatial configuration studies (Gil et al 2007). The tool kit is a collection of MapBasic plug-ins for the MapInfo Professional GIS platform, which also incorporates external modules developed as C++ dynamic linked libraries (dll).

As the tools were being produced they were tested by the same person responsible for the methodology document in order to spot any inconsistency with the initial results or missing functionality.

Furthermore the tools were being applied to other sample scenarios by users external to the development process in order to obtain continuous un-biased feedback and identify different problems not covered by the initial methodology.

3. THE I-VALUL TOOL KIT

The i-VALUL tool kit is a collection of plug-ins for MapInfo Professional that performs the tasks required for the evaluation of the urban layout in relation to the five focus themes of the project. Each methodological stage - data preparation, data analysis and layout indicator calculation – consists of a collection of individual tools that can be mixed and matched to address the specific problems of each focus theme. For example an urban indicator like the number of dwellings per street segment can be relevant to both property security (KIT1) and residential property value (KIT 4). In particular the data preparation tools are common to all five focus themes, as they prepare the input data for the analysis and indicator calculation tools.

The tool kit can be installed in MapInfo using 'Tool Manager' and it creates a new menu called 'i-VALUL' that gives access to the individual tools organised according to the stage they belong to.

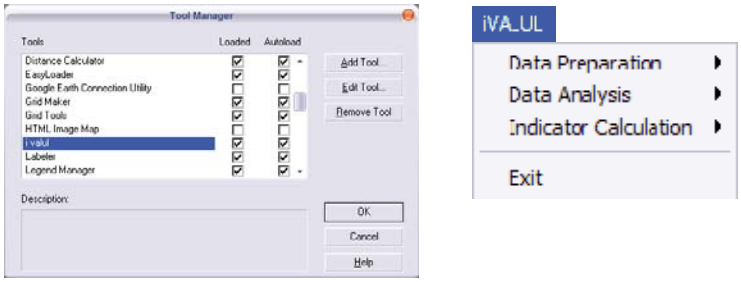


Figure 3. The tool kit set-up in Tool Manager and the new menu structure

3.1 Data Preparation

The data preparation stage revolves around the transformation of the base information in the form of British Ordnance Survey (OS) MasterMap data and UK Census data to use in layout analysis and indicator calculation.

These are the two main input data sets, and although they are UK specific, similar data exists in other countries and these tools can serve as an example of what needs to be generated. As an outcome we get smaller, simpler and filtered site specific data sets adequate for input in the next stages.

3.1.1 Study Area preparation

The study area preparation consists of a group of tools that prepares the various layers from a large OS MasterMap data set for analysis of the study area, performing the following tasks:

- Study area definition
- Topography layer cleaning
- Address layer cleaning
- Buildings and Dwellings extraction

First it creates a smaller subset of the OS MasterMap base layers from a user defined study area by polygon around a selection of routes and extracting data within a buffer zone of 800m from the edge of the selection polygon (figure 4).

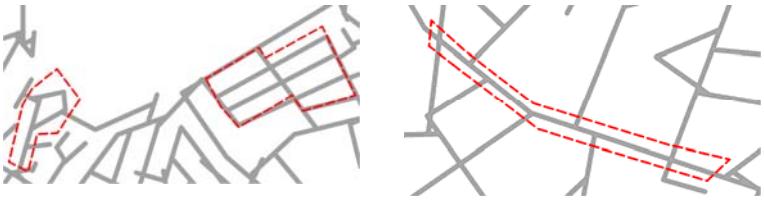


Figure 4. Study area definition by polygon for an area (a) or a single route (b)

Then it cleans the Topographic layer and Address layer 2 data through a series of queries to remove duplicates that have the same TOID column and to extract only the buildings, dwellings and street segments data which are the spatial units of layout indicators calculation (figure 5).

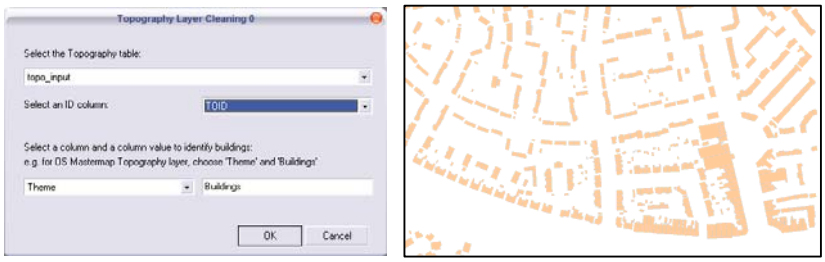


Figure 5. Selection of MasterMap topography layer for cleaning and extraction of buildings

3.1.2 ITN editor and converter

The ITN layer is the road network layer of the OS MasterMap data set and is the main layer representing urban layout which will be used for network analysis (Hillier 2005) and other spatial configuration analysis (Gil 2007). It needs to be prepared in advance to obtain a spatial model closer to the one used by space syntax (Hillier 1984).

The ITN editor is an interactive tool which highlights areas of complex geometries such as roundabouts, complicated junctions of highways, crossings with slip roads, or roads which are represented as double lines (dual carriageways), and assists the user in simplifying these geometries. The tool firstly identifies potential 'problem lines' according to the field 'NatureOfRoad' of the ITN table (figure 6a). Then the user will successively work through the map, in each step grouping a set of 'problem lines' and replacing them with a simplified set of lines which he draws on top of the group (figure 6b).

a) b)

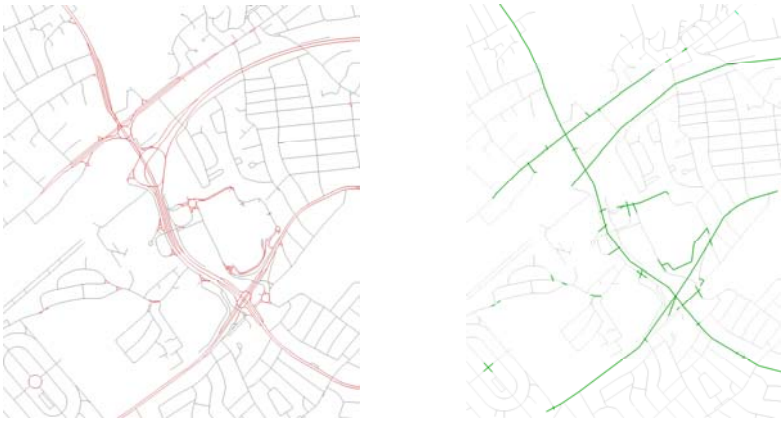


Figure 6. A group of complex lines identified by the tool (a) and edited by the user (b).

The ITN converter takes the edited ITN layer and simplifies it automatically. First it uses the snap/thin feature of MapInfo to reduce the number of segments and straighten the polylines, then these are exploded into individual line segments. If the user chooses to convert to 'axial lines' (Hillier 1984), the tool joins those segments together whose accumulated angle and the angle for each pair doesn't exceed 5 degrees (figure 7).

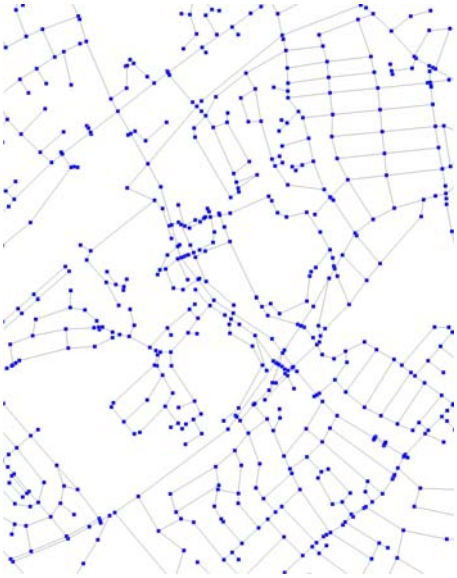


Figure 7. The converted ITN with straight segments and reduced number of nodes.

3.1.3 Socio-economic values filtering

The socio-economic values filtering tool simply facilitates the steps of gathering the data relevant to the study area from the full UK census data set, and extracts the socio-economic band values for analysis.

3.1.4 Building to street link

The building to street link tool automatically generates a new layer of linear objects linking the buildings to the street segments both visually and by their unique IDs. These are unique links pairs between the buildings and the street segments where there is a non-obstructed path between the objects, perpendicular to the building's facade (figure 8). With these links we are able, in the analysis stage, to transfer attributes from one spatial unit to the other enabling statistical correlation of different attributes that are traditionally locked in one level. For example we can evaluate the correlation between street segment accessibility and socio-economic value or dwelling types.

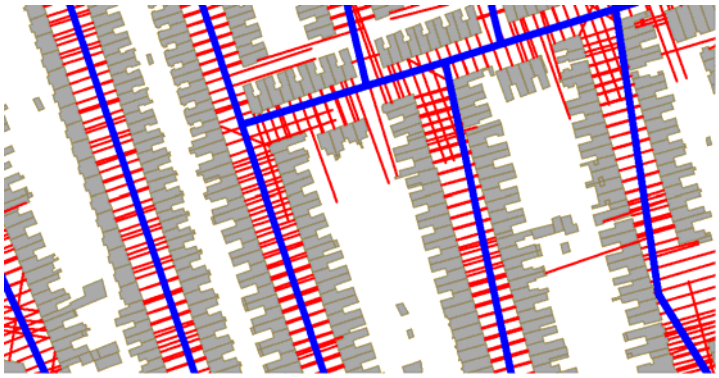


Figure 8. Map showing the link objects between buildings and street segments

3.1.5 Unlinks creator and manager

These tools deal with a problem that rises from the fact that we're working with a 2D geometric representation of the street network. There are lines that cross in 2D space but in reality represent bridges or tunnels where there is no connection between levels. The 'unlink' is an object that indicates intersections that don't actually exist and as such "unlinks" those connections (figure 9).

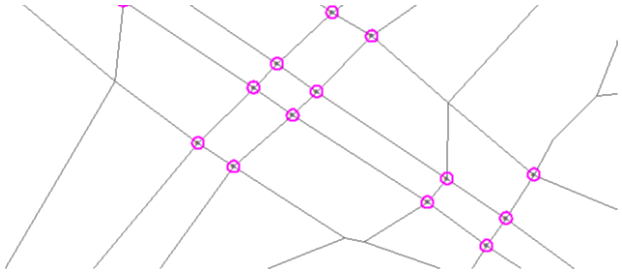


Figure 9. The Map showing an intersection signalled by an unlink object.

The unlinks creator tool automatically identifies areas in the ITN layer where there should be an unlink and supports the user in manually adding further unlinks where required. The unlinks manager tool supports the user in verifying the location and correctness of the unlinks, i.e. if they are disconnecting the right pair of lines from intersecting, by jumping between unlinks that have some problem and giving the option to correct them. Once all the unlinks have been validated an unlinks table is produced that will be used in the network analysis tools.

3.2 Data Analysis

The data analysis tools take the various data sets prepared in the previous stage and perform different types of spatial analysis, producing calculations and thematic maps of different layout properties of the study area. The list of data analysis tools is as follows:

- **Block measures**: calculates block size plus a series of other block shape metrics and generates maps that display the urban grain and block structure of the study area.
- **Line measures**: calculates line direction, length and connectivity and allows the visualisation of different street grid patterns according to a predominant direction.
- **Processing with Depthmap**: this task involves the use of an external module to calculate a series of layout attributes of the street network, like closeness (clustering) and betweenness (path overlap). The data is exported from and re-imported into MapInfo for visualisation of the network map coloured according to the attribute values.
- **Metric Catchment Area**: calculates the metric distance of the spaces in the network to one or more origins, following the real route along the network. The output is a map with distance isochrones at 400, 800, and 1200 metres from the selected origins.
- **Summary Statistics**: calculates descriptive statistics of several attributes for various layers simultaneously, enabling quick comparison of different study areas or different design options. The output is a table with the statistics.
- **Thematic maps and charts**: produces thematic maps and distribution charts for the selected attributes. Although it's only a visualisation tool it provides a first level of qualitative analysis of the results.

The various types of urban layout analysis are typical of Space Syntax work and its application is featured in area action plans and local centre development framework reports (Space Syntax 2004, 2006a, 2006b, 2007).

3.3 Indicator Calculation

The indicator calculation tools take the various data sets and the results of analysis to produce maps of urban layout indicators that have been identified in the KIT value definition workshops. These indicators can positively or negatively contribute to the value of the urban areas, therefore these maps can be used to value the character of these areas.

The list of indicator calculation tools is as follows:

- **Dwellings per Segment**: the total number of dwellings per street segment (figure 10a)

- **Building Centred Density**: the number of dwellings within a 30m radius of every building (figure 10b)
- **Plot Exposure**: the number of sides exposed to public space (figure 10c)
- **Dwelling Type**: every dwelling classified as detached, semi-detached or terraced house or flat (figure 10d)
- **Block Size**: metric area of each urban block (figure 10e)
- **Socio-economic Condition**: average tax band value of each street segment (figure 10f)
- **Street Clustering** (closeness): the accessibility value of each street segment, how easy it is to reach form other segments (figure 10g)
- **Path Overlap** (betweenness): the frequency in which every street segment is part of a shortest route in the study area (figure 10h)

a)

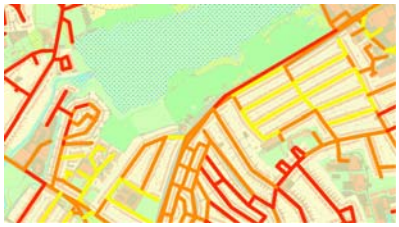
b)

c)

d)

e)

f)



g) h)

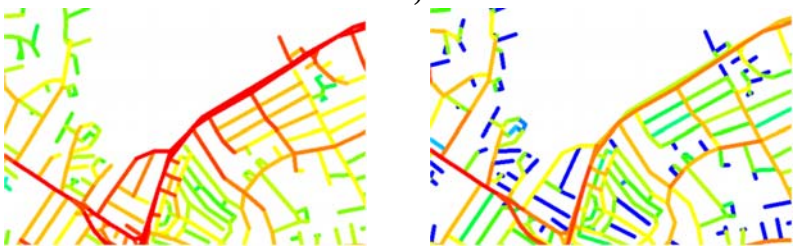


Figure 10. The maps resulting from the various indicator calculations.

4. INTEGRATION PHASE

The integration phase is a 6 month period in which the tool kit and training material produced during the exploration phase is used by project partners in training sessions and applied to pilot projects that are concerned with each of the five focus themes.

4.1 Review and Feedback

In the lead to the integration phase the project outcomes, including the software tool kit, go through a review and feedback process with all project partners. This takes the form of an audit with the Peer Review Partners and the Acceptance Partners (see Table 1).

The feedback received from the tool kit audit midway through the project confirmed the consistency of the results. It shows that the initial approach with workshops, methodology and tool development as interlinked stages led by different people introduced a natural review process that resulted in functionally correct tools, without a separate formal testing stage.

But it also highlighted several issues with the tools and the user manual to do with the clarity and consistency of the menu organisation, terms used and their definitions. What is clear for the project team is not necessarily so for other partners who don't have the expertise in layout valuation and don't share the same jargon. An important next stage will be to clean and organise the tool kit and manual to make it useable outside the i-VALUL project.

There was also a Mid-term workshop with all partners, but in particular the Project Integration Partners, to receive feedback on the overall process and progress of the project. We presented the work completed during the exploration phase, including the findings of the KITs and the resulting tool kit, and discuss the following tasks of the integration phase: training and pilot projects.

4.2 Training

The main objective of the integration phase is to partners from different sectors to consider urban layout in the decision making process. Therefore the integration phase starts with a training session where the project partners are introduced how to use the layout valuation tools in concrete projects.

The training concept has been developed in cooperation between experienced practitioners who use layout valuation techniques in projects on a daily basis and academics with particular experience in adult learning. According to the diverse backgrounds of the project partners there exist tailor-made versions for different audiences:

- **layout for everyone**, explaining the values of urban layout to lay persons particularly local community groups to encourage them to take a more pro-active role in the planning process

- **layout for the urban designer**, establishing the link between design policies (By Design, Safer Places) and urban layout

- **layout for the transport engineer**, establishing the link between transport policy documents (Manual for Streets, WebTAG) and urban layout.

The training session consists of three modules focusing on the values of urban layout, that were established during the exploration phase of the project, the evaluation methods for urban layout based on quantitative layout indicators and the computer tools to assess urban layout quantitatively on a concrete project scheme

4.3 Pilot projects

One of the core activities of the integration phase, towards acceptance and validation of the project outputs, is a series of 6 pilot projects. These are live project with the project integration partners (see Table 2) such as local authorities, both from the urban design and transport sides, together with voluntary and local community sectors.

Table 2 Pilot project partners, theme and study area

Partner	**Sector**	**Theme**	**Area**
Hampshire CC	public	Town Centre Access Plan	Bordon
LB Croydon	public	District Centre Area Action Plan	Croydon
LB Tower Hamlets	public	Housing Regeneration	Tower Hamlets
The Princess Foundation	voluntary	Urban extension	South Oxford
London 21	voluntary	Community champions	London
Better Archway Forum	voluntar	Public Consultation process	London

	y		Archway

The partners will be taking a live project and applying to it the urban valuation tool kit and methodologies, and will be using the layout value maps that have been produced for the whole of the South East of England (2.4 million street segments).

4.4 Towards an integrated tool strategy

The outcome of these two project phases (exploration and integration) will help determine the requirements for an integrated tool, where selected tools from our initial tool kit are combined into simpler wizards for use beyond the 'i-VALUL' project. With this phased approach we allow the experience of the end users in a variety of live projects and the application of the tools in practice to define the specification. From the training sessions we obtain an evaluation of the level of complexity of certain tasks, the expertise or preparation required to complete them, and which tasks are more relevant to particular stakeholder groups.

Other important questions that will need to be considered at this stage relate to the software tool kit distribution platform, the continuing training and dissemination process and the degree to which the valuation can be calibrated to adjust to different locations with different pre-existent socio-economic conditions.

5. CONCLUSION

The 'i-VALUL' project establishes the link between urban form design decisions and their socio-economic cost or value. The design decision process is multi criteria but some criteria that have a tangible valuation take precedence over the ones that have a more qualitative valuation or sometimes the case occurs where the intangible becomes overvalued because it's not quantifiable. A methodology was successfully developed to translate these intangible criteria into quantitative indicators that enable the development of a valuation tool kit. The development process involved a wide range of partners from different backgrounds and with different roles that provided the necessary review and validation levels throughout the process. The resulting software tool kit and training materials demonstrate how a GIS can be used for the specific purpose of valuing urban layout in ways that are relevant to the creation of sustainable communities. These outputs are used by stakeholders of the urban development process on pilot projects, and their feedback on the usability of the tool kit is going to support the development of an integrated tool for use beyond the i-VALUL project.

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