Mapping UK Property Values Today

Paper by Tony Vickers MRICS for a MPhil (leading to PhD) at Kingston University School of Surveying

Introduction

This paper is one of three forming the foundation for a research project "Visualising Landvaluescape: Developing the Concept for the UK", leading to a PhD with the School of Surveying, Kingston University. The background to this project and justification for undertaking it was first set out in detail in a paper by the author for the Third Global Environmental Taxation Conference (GETC3) in Woodstock Vermont in April 2002 (Vickers 2002a), soon to be published in a volume on issues in international comparative taxation (Ashiabor *et al*, 2003).

The paper aims to explore the state of UK data and research relating to the mapping of property and land values, examining some technical issues of geospatial analysis and display. It does not deal with the subject of "What is Value?", which a companion paper on valuation theory and practice will cover. It examines the data sets uncritically, assuming they are the product of UK best practice in property valuation, whilst pointing to some differences between the nature, coverage and purpose of those data and their equivalents in other countries. The reasons for those differences will be looked at in more detail in the papers "What Value Maps are Mapping" and "The British Context for Value Mapping", which will cover the valuation and geographic information (GI) policy issues respectively.

The paper takes two case studies, for purposes of illustrating the problems. Both involve funding by the Lincoln Institute of Land Policy, Cambridge MA (Lincoln) and teams of British researchers including this author. One is a study of changes in property values proximate to the construction and opening of the Jubilee Line Extension (JLE) of the London Underground railway system. This deals more with 'macro' issues of aggregation and modelling of property value data. The other study focuses on data relationships at the individual land parcel and property address level, in a small area of inner city Liverpool.

The paper draws conclusions as to the most effective methods for attempting to collate and analyse property data for value mapping in the UK, over the short to medium term (up to five years). It assumes no change in current data production and maintenance programmes, nor in land and property tax policies.

Property Value Mapping Defined and Given Purpose

Howes (1980) defined a value map as *"a cartographical or spatial representation of statistical data which reflects the value of land or buildings*" (p.7). He was writing before the invention of either the personal computer (PC) or the widespread use of the term 'GIS'. In his day, data used in value maps were both difficult to obtain and to manipulate. Of the first problem, data availability, he wrote:

> *"The difficulties in obtaining data of land and property values are perhaps one of the primary causes of the paucity of research into subjects which involve the consideration of land and property value statistics"* (Howes, 1980, p.9).

'Land' in economics is a synonym for Nature (Andelson, 1997, p.1) but in English law land is not distinguished from buildings and other human alterations to the natural creation. For the purposes of this research, land is generally taken to be what most lay persons would accept as the definition:

> *"The solid part of the surface of the earth as distinct from seas, lakes, etc*." (Collins English Dictionary, Second Edition 1989)

'Property' can include movables and intangibles, such as furniture, jewellery and intellectual property. For this research however, it is fixed property or real estate that is being valued. Such property includes land in its natural state as well as land where it is impossible to determine the natural surface of the earth. In modern cities such as Hong Kong the terrain has been so altered by urban development that real estate has become a three-dimensional business. It is becoming necessary to consider 'land' as 'location' in a geodetic sense, where air rights over busy transport networks can be bought, sold or leased and the sea is routinely reclaimed as new land.

Here 'land value' refers to the sum of all rights to property that are inseparable from a particular physical location defined by its projected coordinates in relation to other locations on the surface of the earth. Howes aggregated rating list entries for each site in an area of Norwich city centre (Howes, 1980, p.90) in a similar way to the current Lincoln Liverpool study. These are examples of attempts to produce surrogate 'land value' figures in Britain.

Land and property value data are unlike most other geospatial data in that they do not relate to natural phenomena that can be directly and scientifically measured. They arise either from the operation of the property market itself or from the statutory functions of property taxation which require assessment of taxable value (not necessarily the same as market value) in some formulaic way that is based upon market transactions in some degree. 'Value' is always subjective and - however derived - value data are dependent on the judgement of human beings, either of the parties (prospective or actual) to a property transaction themselves, or more often their professional advisers. The various ways in which value data are produced are not covered here, except to say that it is essential to know what the purpose and method of collection of such data were before attempting to combine them in any statistical analysis, spatial or otherwise.

Analysing property value data is not like analysing records of geodetic height, or incidents of a particular disease or crime records or measurements of average wind speed: these are all physical facts capable of being objectively and consistently measured and verified. Although land and property are physical realities, whose position, use and nature can be measured and/or described like other phenomena, their attribute 'value' can only be measured or verified subjectively through the economic actions of human beings that give it value.

But human beings are all different and therefore the value which each ascribes to a particular piece of land or site is different. Each society and jurisdiction has different norms, property market practices and legal definitions of value effected by a body of professional valuers whose judgement is accepted as being better than that of non-professionals. Yet in a world that sees increased global trading in property, there is a tendency for local valuation practice to conform to developing international standards.

These issues are explored in another paper but a consequence is that the usefulness of value data is judged empirically rather than by rules based on natural laws of science. Data such as rating list entries are 'good' if market players (in this case occupiers of property) accept them, not because they derive from correct application of a theoretical formula. When the Inland Revenue Valuation Office Agency (VOA) Forward Plan 2002/2007 (VOA, 2002) sets targets for improving the quality and efficiency of its work, its key performance indicators include reduction of numbers of appeals against rating assessments and consequent erosion of the forecast property tax revenue. This is an empirical measure of data quality.

The Lincoln Liverpool study has shown that stakeholders in UK property tax overwhelmingly believe value maps can help improve understanding and acceptance of assessments and hence reduce appeal rates (Vickers 2002b). Howes anticipated this, after observing the use of value maps in Denmark, when calling for:

> "*maps ... in England and Wales which specifically display, for example, rateable values that could enable the Inland Revenue to ensure that the assessments for rating purposes were equitable and for this equity to be publicly displayed in map form"* (Howes, 1980, p.128)

Landvaluescape Modelling

Just as landscape is a continuous surface with each point having a height above sea (or some other base) level that can be measured, so the conceptual 'landvaluescape' is a continuous surface formed by connecting the values of each point in a land value data set. Landscape is a physical reality; land**value**scape is a social and economic reality. Both realities can be spatially modelled in a geographic information system (GIS).

The future direction for geographic information policy in the UK was last reviewed comprehensively for the Government in a report by the distinguished geographer Lord Chorley (DOE, 1987), known as The Chorley Report. In it he defines a GIS as:

> *"A system for capturing, storing, checking, integrating, manipulating, analysing and displaying data which are spatially referenced to the earth"*

A spatial model is a representation of the real world to aid our interpretation and understanding and spatial modelling is what makes GIS different from mere computerised or digital mapping..

This paper looks at developments in applying GIS to spatial modelling and mapping of land and property values, since Howes in the pre-GIS era. Although Howes (1980, p.34) says he "*assumed that ... local authorities .... would have their rating assessments stored on computer files*" and used rating lists held on Norwich City Council's computer files for his own research, a third of this data had to be manually extracted from the lists and almost all the manipulation, analysis and display carried out by him and his contemporary practitioners in value mapping had to be done manually. Computers were then only of peripheral use to cartographers, which meant that value map production was extremely tedious, time-consuming and resource intensive. In his conclusions, Howes states that:

> *"The outdatedness of value maps is an inherent weakness if the maps are produced manually; however, the increasing use of computer-based techniques and the geo-coding of land and property data will enable the rapid production of maps, thus reducing the time involved in production."* (Howes, 1980, p.135)

Spatial models of landscape are created and analysed by GIS for many purposes, such as aircraft navigation or water run-off calculations. Borrowing the language of software and process engineering, they can be classified as 'whitebox' models, in that they express relationships that are clear and well understood, involving physical data that are relatively easy to acquire and relate to each other, are stable and verifiable visually. On the other hand, landvaluescape models are 'blackbox', where they exist at all: the data they consist of are neither well understood nor easily verifiable whilst the relationships and processes making up the property market are complex, volatile and unclear.

Nevertheless such models and the value maps derived from them where they exist are clearly of use, especially to the key players in the property market: property tax assessors and advisers to property investors (Ward *et al*, 2002). The main problem with value mapping in the UK is that the necessary property value data sets are not available, for reasons of land policy that this paper will not go into.

In economic theory, every piece of land or location has a value. Many locations far from centres of population and without valuable natural resources have extremely low and stable value (Powelson, 1989). Others reflect competition for rights of access and occupation in cities by exhibiting values that are extremely high and volatile. In between, there are transitional areas of the landvaluescape, such as urban fringes and parts of inner cities, where capital investment (forecast or actual development and re-development) gives rise to rapid and large changes in values over space and time. These areas, using the landscape analogy, exhibit steep value gradients. Howes found that most value maps were part of projects led by planners in such areas, enabling "*the planner, at an early stage, to make relative comparisons for land and property acquisition proposals*"(Howes, 1980, p.134). Because of the complexity and commercial sensitivity of the property market, reliable data upon which to base landvaluescape models for these areas are especially hard to acquire. Nevertheless, even in the absence of computer modelling and GIS, it was – and is - easier to justify the effort of value maps in such areas than in areas of stable or low value.

Landvaluescape implies a surface of values, with only one 'z' value (at a particular time and for a particular market) for each 'x,y' pair of planar coordinates or geographic 'place'. This 'flat' world with a value that can be used to create a semi-solid display is called "2.5D" GIS (Lenk, 2001), as opposed to the true three dimensional (3D) spatial modelling that is mainly used by oil and mineral exploration companies. With true 3D, the conceptual model emulates the geoid and allows for visualisation of planes other than the horizontal, e.g. sloping shafts and tilting sedimentary layers.

Conceptually value maps could also be true 3D, with different 'z' (or 'v') values for different prospective land uses or definitions of 'value', e.g. for site value (value in exchange, say v^1) compared to value in current use (v^2). The relationship between v^1, v^2, $v^{n \ldots}$ could be expressed within the model. An example of this is the model Tax Effect Demonstrator (TED) developed by Vickers and Thurstain-Goodwin from Lucas County Ohio data. Building values were draped over a triangular irregular network (TIN) of land values derived from processed raw assessment values of downtown Toledo (Thurstain-Goodwin & Vickers, 2002), as shown in Figure 1.

Unlike more familiar physical topographic or mineralogical spatial models, the time factor potentially introduces a fourth dimension to landvaluescape models. Howes' study of Norwich included spatial analysis of property values in the city centre over time to derive the shift in 'centre of gravity of values' between 1965 and 1974 (Howes, 1980, pp.108-9).

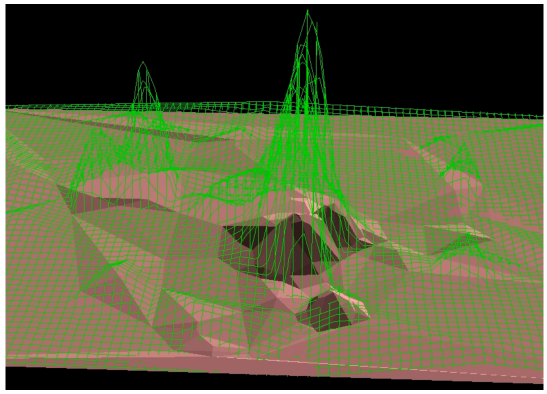


Figure 1: Downtown Toledo 'Landvaluescape'

Property Values in the GIS Processes

One framework for discussing the issues relating to the use of UK property value data is to consider each function of GIS in turn, from the Chorley Report definition above, highlighting the problems and possible solutions in the light of the two previously mentioned case studies and other known current experience. GIS functions may not all be fully developed in every system, for example a system is a GIS even if it does not itself include data capture or display but imports data from another GIS (such as that of a national mapping agency) and exports it to a system that specialises in rapid and complex manipulation of graphics.

But the full list of GIS functions and related issues is:

a. Capture, i.e. data availability, price, content and coverage.

b. Storage: volume, structure, medium of transfer.

c. Checking: quality of data and scope for verification and correction.

d. Integration: ability to accommodate current and future products from relevant national GIS 'N-projects'.

e. Manipulation: application software.

f. Analysis: statistical techniques and human resources skilled in Computer Aided Mass Assessment (CAMA).

g. Display: cartographic options and methods of dissemination.

Capture: Availability of Property Data

In an ideal world of perfectly operating property markets, transactions in real estate would be conducted with all prospective parties knowing about similar recent transactions in the vicinity. In practice, there are numerous reasons why such a rich and transparent data environment is rare, the main ones being:

i. **Confidentiality**. Contracts in real estate are private matters and even where an offer price is published by the vendor or agent it may not reflect the final deal signed by the parties. Where, as is usual, the transaction has to be registered with the authorities for tax or statistical purposes, it is often done under conditions of non-disclosure to third parties, in order to ensure quality of data and to protect the confidentiality of the contract information. As Howes (1980:17) noted, auction results are the best bench-marks of the property market: accessible by being both public and published, as well as timely and 'true'. Although auctions do not cover the rental market, they often reflect actual rents received. Specialist property data agencies such as the Investment Property Databank (IPD) increasingly monitor rental and sales transactions from many private property agents, who recognise that have a common interest with competitors and clients in being able to draw on the widest possible range of market evidence. IPD now pools data on a confidential basis from most major countries and commercial centres, the aggregation achieving anonymity of source and thus overcoming confidentiality problems.

ii. **Timeliness**. It takes much longer to conduct a property deal than to buy equities in the stock market. Even if there was no need for confidentiality in property transactions, it would be impracticable to broadcast details of ongoing or recently completed transactions with sufficient speed to inform all parties to other similar transactions.

iii. **Uniqueness**. To a large degree, every property transaction is unlike any other, since every location is unique and most structures have some unique physical characteristics. Comparisons between properties can be drawn and in some sectors are very reliable but even then the motives of respective parties towards transactions in respect of similar properties can differ and this can influence the price agreed.

Therefore reliance on 'raw' property market data alone for any value mapping or modelling is unwise and very unusual. It was not considered for either the Liverpool or JLE Lincoln studies, nor for any projects in Howes' research.

In any country, the only consistent, continuous, detailed nation-wide public-domain set of property value data is likely to be that produced for taxation purposes. Such data and the processes by which they are acquired are almost always covered by statute law. Expanded by professional guidance, this will set out the scope, frequency and extent of valuations and give powers to authorised valuers to access documentary evidence as well as the properties themselves.

However most countries, including Britain, only update property tax assessments infrequently, typically every three to ten years. Since the 'real' landvaluescape is constantly changing with the underlying general and local economy, models which rely entirely on obsolescent tax assessments are of limited use, as the JLE study of commercial property values, using VOA rating lists, showed (Geofutures, 2002). Even where rating lists are kept up-to-date as new physical developments and changes in property use occur, they usually have to be 'corrected' back to the relevant 'antecedent date' by applying inflation and/or seasonal factors.

An increasing number of countries publish tax lists annually and some do, in effect, maintain a continuously updated 'rolling register' of property assessments which comes close to representing the true landvaluescape. Here the published list is a snapshot of the model in the assessor's office. VOA updates the lists published on its web-site at quarterly intervals but does not itself enable users to compare lists of different currency or era. More sophisticated and cheaper forms of bulk data supply of its lists are available through licensed value added resellers (VARs), such as FOCUS Information Ltd, a part of Property Intelligence plc (see below under Storage and Analysis).

In most countries where value maps have been used widely, the entire property tax jurisdiction employs a single spatially continuous set of assessment (value) data, at least within urban areas. Examples are Denmark, USA (Lucas County, Ohio) and Australia. This was confirmed by a survey of national representatives of members of FIG (Federation Internationale Geographique) by the author early in this research, results of which are quoted by Vickers (2002a) in a forthcoming volume (Ashiabor *et al*, 2003, p.471). These showed that almost all respondents' countries exhibit GIS and CAMA either existing or under development, as part of their national property tax systems. Of the sixteen countries responding, only two said that tax assessments are confidential or even that price paid information is not available to the general public. In this respect, English law is unusually secretive.

In the UK, agricultural land is not subject to property tax and only Northern Ireland maintains a homogeneous urban property tax list since mainland Britain abandoned rating in 1989. The UK also exempts from taxation vacant urban land and some vacant industrial and other occupied but unprofitable non-residential sites, thereby leaving voids in any landvaluescape relying upon tax assessment data for its population. Most important, since 1992 there have been separate, incompatible valuation lists for domestic property (banded Council Tax assessments) and non-domestic property. Combining the two to form a single landvaluescape model is problematic, for a number of reasons:

1. Council Tax bands are extremely crude, spanning as much as £12,000 to £160,000 in a band with a single band for properties above £320,000;

2. Non-domestic rating lists are based on rental value to occupiers, whereas Council Tax is based on capital value;

3. The currency of the lists is different, until 2007 all Council Tax valuations in England are based on a 1992 antecedent date; and NDR lists are based on values ascribed to 1 April 1993, 1998 and (from 2005) 2003.

4. Neither list takes account of the area of land occupied by each rateable property, which makes it difficult to derive a value per unit area of land.

5. Some figures in both lists are negotiated during the appeals process, thus producing internal inconsistencies in the lists. Although some adjustment may take place to rateable values of properties indirectly affected by appeals, this process does not benefit from the use of GIS and is far from transparent or scientific.

For the above reasons, these two statutory lists are unsuitable, by themselves, as the basis of a single definitive landvaluescape model of Great Britain. Unless and until VOA (and the Scottish assessment authorities) revert to a single rating list for all types of property, researchers will have to look also at other sources of data for modelling land and property values. Even then, it will be necessary to consider methods of post-processing the lists and/or combining them with other data sets. For example, there are emerging data sets for land parcel size (see Integration below) and for floor area of most types of commercial building, which could be used to convert property values into value per unit area, as has been noted in the Lincoln/JLE study (Geofutures 2002, p.2).

Details of property transactions have to be reported to the tax authorities irrespective of whether formal lists or spatial data sets are produced, in the UK as elsewhere. These transactions represent income and expenditure to companies and individuals which are liable to taxation quite apart from any *ad valorem* property tax. These 'raw' data are almost always confidential but can be processed internally to produce a variety of statistics. The processing ensures preservation of confidentiality so long as the level of aggregation is high enough: if only a single transaction occurs in a geographic area in a particular period, then publication will potentially reveal details of that transaction. However blanking out all or part of the street address or postcode of the property is usually sufficient to anonymise the transaction.

With VOA, there is an additional statutory restriction upon release of aggregated, anonymised transaction data. Finance and Official Secrets Acts prevent the use of information supplied under statute by taxpayers from being used for any purpose other than that for which it was supplied (Howes, 1980, p.15). This restriction, whilst possibly being imposed originally in order to help ensure compliance by taxpayers and integrity of VOA data, is actually interpreted strictly, irrespective of **any** possible wider public good that might come from its aggregated use. Howes acknowledged that release of VOA data "*would enable more research to be undertaken into the* *allocation and use of the scarce resources of land and property*" (Howes, 1980, p.19) but even researchers sponsored by other Government departments continue to be obstructed by Inland Revenue rules.

There is evidence that VOA believes that GIS could help improve the quality of its rating lists, for the production and maintenance of which the raw data is supplied and held. This would overcome the confidentiality problem because, as Howes predicted even before GIS was in common parlance: "*a data bank of land and property values could use a unique code, thus ensuring confidentiality of supplied data*" (Howes, 1980, p.19). VOA's Forward Plan claims as fact that its local taxation business *"... is being modernised to secure fair, open, uniform and sustainable assessments for non-domestic rates and council tax that are understandable and acceptable to all."* (VOA, 2002, p.10). It goes on to say:

> *"Our information technology systems are critical to our ongoing operational activities, the success of our transformation plans and our interfaces with the other government bodies and the public."* (VOA, 2002, p.16)

While not mentioning GIS or maps, the document cites VOA's collaboration in projects that are clearly map-based as evidence of the above statements. The National Land and Property Gazetteer (NLPG), National Land Information Service (NLIS) and National Land Use Database (NLUD) are specifically mentioned as having VOA participation. These projects are covered under Integration below.

There is another Government department, which Howes had no reason to consider and which now regularly receives details of most property transactions in England & Wales. Since 1990, Her Majesty's Land Registry (HMLR) has held details of price paid for all registered property where a transfer of title is involved. Although short-term rental information is not covered by Land Registration Acts and price paid is absent for pre-1990 entries (still the majority), under the 2001 Act leases as short as three years have to be registered.

HMLR has supplied details of aggregated house prices, based on actual sales and by postcode, for some years. These are used to provide free quarterly regional indexes of house price according to four categories of house type. Price information from the registers is also available for sale, either at a fixed price or by negotiation, to the public and researchers, depending on the level of aggregation required. For the JLE study, information was obtained free from HMLR for selected postcode sectors and quarters. Normally this level of dis-aggregation has to be paid for.

Similar data sets are supplied commercially by two of the leading UK mortgage lenders, based upon valuations for mortgage purposes which are prepared by professional valuers and are a close surrogate for market prices. The methodology for production of these data sets is slightly different from that of HMLR. All three suffer from a common deficiency, from the perspective of this research, in that they miss those parts of the country that do not contain sufficiently large numbers of freehold domestic properties in private owner occupation. This may explain why there seems to have been little or no attempt to create value maps from HMLR or other house price indices.

Many other public and private corporations hold information about their own property transactions and holdings, for their audit and balance sheets and for reasons of good management. Whilst in theory some public bodies might, as Howes (1980, p.13) notes, be permitted to release this information to others under certain circumstances, they do not form a routinely reliable source of data for value mapping by any except their own staff and agents. With the privatisation of most public utilities and the outsourcing or wholesale transfer of property functions of many public bodies to the private sector has come a much decreased prospect for creating any assemblage of property value data that might have wider uses.

Some relevant information is not about price or value but about volume. Thurstain-Goodwin, (Geofutures 2002) in his study of commercial property for the JLE/Lincoln project, outlined the significance of information about amounts of available office floorspace, development land of different categories ‘in the pipeline’ and levels of vacancy in determining the health of property market sectors. Land moves between different uses and although the total supply is fixed it is often the movements between sectors (e.g. agriculture to housing or industrial to commercial) and the stautory limits on intensity of use (e.g. storey height and parking density) that determine the local price levels. Unfortunately this information is not generally available at a fine enough granularity, e.g. office floorspace is only collected for publication by local authority area, not for any smaller area such as postcode sector.

There is a further issue about availability that looms large whenever the subject of GIS in the UK property industry is raised. The price of acquiring data sets is the main concern of prospective users, admitted the civil servant responsible for advising Government on GI at a debate to launch a Special Interest Group for the industry in January 2003 (Vickers, 2003a). If ‘capture’ by users from custodians is thought to be prohibitively expensive, this will be a barrier to the spread of value mapping. We have seen that nation-wide property data sets of most use for mapping and modelling are invariably produced by publicly funded agencies. The data have already been paid for, yet Treasury rules in the UK require those agencies to maximise income from their sale and re-use, regardless of the true direct costs of supply which are trivial. Until now, it has even been policy for other public bodies to pay a ‘market’ rate for data from OS and other ‘trading fund’ data suppliers, which deters their use even for clear public benefit in the public sector.

Although this 'internal market' has ended (for OS data) with the introduction of the Pan-Government Agreement (PGA) in 2002, PGA does not amount to a change of policy from 'high price low volume' to the US model of 'low price high volume'. It merely makes one central government department the agent for all user agencies in the Civil Service Year Book, replacing many 'customers' and potential transactions in data with just one (as far as payment at point of transfer is concerned). This offers all parties administrative savings and user agencies no longer have to cost justify their GIS on data price grounds.

The PGA could, in theory, be abrogated in future and UK agencies that produce data still regard it as 'theirs', as this quote from an OS manager illustrates:

> *"...there is a tendency to focus on the narrow view that the public sector should provide their information at no more than nominal cost."* (Lovell, 2003)

In Howes' day, OS created map data entirely to meet its own internal needs and not with wider potential public benefits in mind; today public policy has created commercial motives that conflict with considerations of public benefit.

In summary, despite the enormous growth in the production of spatial data in general (not excluding Britain, where OS has been at the forefront of the global move from paper-based to digital maps), its availability has in practice not grown nearly as fast as its production. The availability of suitable property value data has in many respects become more, not less, difficult since Howes studied value mapping and concluded:

> "*Value maps will increasingly play a major part in research into the causes and effects of changes in land and property values*." (Howes, 1980, p.4)

implying that such maps have uses far wider than the property market, in urban and regional economic studies. These wider uses are not considered in this paper but will be looked later in this research programme.

The difficulties are not technical but institutional and peculiar to Britain, owing largely to recent changes in property taxes and the effect on rating practice and lists held for rating purposes, in addition to the price and confidentiality issues covered above. They are counter to the trends in value data availability elsewhere and in another paper it will be shown that, without undue effort, it would be possible to remove most of them.

Property Data Storage

The problems of data storage for property value data are much less than those for related 'background' spatial data. The entire rating list for England & Wales fits on a single CD-ROM and is an unstructured tabular file occupying only 8 KB (Focus, 2001). By contrast, OS

MasterMap for the whole UK is currently 600 GB (Baumann, 2003) ten times the data volume of the previous product Land-Line and is supplied in 'chunks' each of only about one km square that exceed several MB each (Holcroft, 2003).

Few potential users of value maps would require the whole of OS MasterMap, which comprises a far greater range of topographic features and scales of data capture, over a far larger geographic area, than is achieved by any other single national mapping agency. Agencies that produce nation-wide value data might need it themselves but those who merely view value maps or wish to analyse landvaluescape models will not need large volumes of map data. MasterMap can be filtered by OS before supply or by the agency acquiring it before passing to users. Volume of data storage is not a problem for value mapping, either in the UK or elsewhere.

The issue regarding storage of property value data is really about co-ordination of the updates with those of related spatial data that might be needed in a GIS. This is covered under Integration below. Focus currently supply updates of VOA rating lists only, on CD-ROM, every four months for £600. There is, as yet, no integrated customised property data product available in the UK equivalent to Lucas County's Assessors Real Estate Information System (AREIS) (Ward *et al*, 2002). AREIS comes with a version of GIS software, complete up-to-date air photo coverage and a range of property related vector data sets, as well as full details of all 180,000-plus land parcels, all on a single CD-ROM priced at only US$10.

The trend in the UK is for data custodians such as VOA, HMLR and OS to make their data available on-line, acting as warehouses for their information. This in theory relieves the users of the complexities of managing updates to large internal databases, because users who participate in on-line access applications will not need to hold their own copies of data sets produced elsewhere. But it does not eliminate the problems caused by having to eventually integrate different kinds of spatial data from different agencies, which are covered below. Nor is it made easier by the UK Government's policy of making users pay to acquire and reuse data (covered under 'Capture') because on-line access involves more complex chargeable transactions in data.

Data Verification

Because of the subjective nature of property valuation, there can never be an objectively 'correct' value for a particular property value record. There are two aspects to checking as applied to value mapping: the use of GIS by valuation agencies as a means of checking the quality of data in their data sets before authorising their use; and the degree to which a prospective user of value maps needs to consider fitness of a particular data set for a particular purpose.

The Assessor of Lucas County, Ohio gave his view of the former in a personal e-mail to the author:

"We were able to clean up much errant data just by having the public view parcel information." (German, 2001)

With colleagues from his department, German describes in Ward *et al* (2002) seven steps in global response surface analysis (GRSA[1]) whereby raw property value data are manipulated using CAMA and GIS prior to publication of assessment lists. These include the standard removal by non-spatial methods of outlier records and several ways of visually highlighting anomalous records by location and the departure from a value surface of their value attributes.

Until rating lists in the UK can be viewed spatially using a GIS, it is difficult to see how the authorities can be sure that many published assessment lists are not flawed, in the sense that they may contain numerous errors which cannot be spotted by statistical means alone.

Fitness for purpose is something that users of value maps and their professional advisers need to consider. The definition of data quality:

"The measure of the fitness for use of data of a particular application" (Chrisman, 1997)

requires that the purpose of using value maps must be known before the quality of the data can be pronounced upon. In the case of assessment authorities, a property value record is 'accurate' if it can be defended successfully at Tribunal and a rating list is adequate if it is sufficiently free from error that the cost of maintaining it greatly outweighs the cost of defending appeals against assessments. If value maps help identify errors and prevent many appeals ever arising, the cost of developing GIS within VOA (for example) that enable value maps to be used in compiling rating lists will be justified, even before any external benefits of value maps are looked at.

Assuming errors in rating lists and other value data sets have been removed, users of value maps still need to consider whether they are suitable. For example, in the JLE study for Lincoln, many non-domestic sites were absent from one or other of the two VOA rating lists being compared, because they had been unoccupied or otherwise exempt rates at the time a list was compiled. This meant that the analysis was bound to be flawed however good the lists themselves were (Geofutures 2002).

Some of the largest increases in property values occur where sites are removed from one class of use, demolished or very substantially refurbished, and returned after some time to another higher value use. In the JLE study, properties could only be compared in rateable value if they were described identically in both lists (snapshots before the JLE was built and after it was opened), which skewed the analysis. Even though there are usually a small number of nearby 'survivor'

[1] GRSA is a technique that applies statistical analysis to the whole of the data contained in spatial model, thereby modifying some of the results that are subsequently used to project an estimated surface of the model in a display.

properties, in aggregate they almost always amount to a stastistically unreliable geographic sample. This may largely explain why the value maps in this study do not demonstrate the expected value uplift around most JLE stations: data which would be expected to show the largest uplift are most likely to be missing.

Integration of Property with other Data

Depending on the use to which value maps are intended to be put, property value data will almost certainly need to be integrated with or overlain onto other information. GIS do not just integrate functions such as acquisition, storage, analysis and display; they integrate disparate data sets, using their common geography (spatial coordinates) to do so.

Although real estate and landvaluescape are potentially 3D, value maps still almost always relate to a merely 2D geography consisting of land polygons aggregated suitably for the scale of analysis and depiction required. The 'building blocks' of property value data sets are, in most countries, the legal land parcels in the state cadastre. Cadastral data are usually structured so that aggregation by administrative unit (e.g. local authority) is easy. The basic unit of property value is usually the land parcel itself, as with AREIS. Hence property values are usually a routine part of the land administration function, focused at a local level where the detailed changes to land parcels take place.

In the UK, it is much more difficult to integrate property value data with other data sets, because there is no overall land administration function in government and no complete national cadastre (at least not in England & Wales). This problem has long been recognised but there is no detailed plan yet for dealing with it (DOE 1987). Several national projects address parts of the problem and a coherent way of resolving it (for mainland Britain) has begun to be devised. This section describes the problems today and what these projects should achieve from the point of view of likely future users of value maps.

At the most detailed level of value mapping, there is no local authority area in the UK which as yet has a complete set of authenticated digital land parcel boundaries, from HMLR or Registers of Scotland (RoS) or Northern Ireland's Valuation & Land Agency (NIVLA). HMLR is expecting to complete the land parcel index maps for the whole of England & Wales by the end of 2004 but is not working to complete any particular area first. RoS plans to extend the Land Register across the whole of Scotland in 2003. NIVLA's target for completion of the Register is 2007. In all cases, parcel/title boundaries are tied where possible to topographical features on the OS base map, which all three agencies use for their internal mapping.

Meanwhile anyone wishing to relate UK property valuations to land parcels has to digitise at least some parcels into a GIS themselves, with no guarantee that the polygons define legal land title boundaries. For the Lincoln Liverpool project, it was necessary to obtain from the city council a marked up map and associated spreadsheet for the trial area, showing the council's best guess at ownership and parcel boundaries (Vickers 2003b).

Rating valuation records do not contain a geocode, nor do they include ownership details because it is the occupier that pays rates (unless the property is vacant). The only way to integrate them with other spatial records at present is through the street address, a text attribute. Even then, automatic address cross-matching between OS AddressPoint (used in the Lincoln Liverpool trial) and VOA/HMLR addresses averages only between 84% (for VOA's NDR records) and 91% (for Council Tax) across the whole of England & Wales (Harrison & Keith, 2002). In the Liverpool trial area, which was deliberately chosen to highlight problems in areas undergoing regeneration, the cross-matching was much worse: less than 40%. This meant that geo-codes for each NDR record had to be created: so few addresses matched AddressPoint that it was not worth attempting to automate the process.

AddressPoint is based on the Postal Addressing File (PAF) of Royal Mail. Properties without a postal delivery point do not have a record. This means that many properties that could have rating records cannot be referenced in a GIS: vacant sites, storage warehouses, workshops and other outbuildings, individual rateable buildings in any large site such as a hospital, school, factory or halls of residence. Even where an AddressPoint record exists, if the textual description in the AddressPoint file is not exactly the same as that in the rating record, it will not automatically match and will need operator intervention to make the records link. And because letter boxes are often at or near the periphery of a building or land parcel polygon, a small error in geocoding for PAF means an AddressPoint record can appear outside the polygon it is supposed to refer to.

Project Acacia points a way forward. It is a collaboration between OS, HMLR, VOA and their sister agencies in Scotland, together with local government and Royal Mail. It was formally launched in September 2002, with the signing of a Memorandum of Understanding (MOU) stating its general objective is:

> *"to promote the development and maintenance in the national interest of definitive national databanks of addresses (including postal and other elements), streets, non-addressable properties and in due course property ownership and occupancy parcels and possibly other elements as well, together with the related definitive mapping, all linked together and held as a land and property layer within the framework of OS MasterMap …."* (IDeA, 2002)

The new definitive address lists will not replace the several existing facilities operated by the project members but rather will "*harmonise the data from these*". Although UK Government and Scottish Executive ministers have welcomed Acacia, they have as yet set no target dates and allocated no special funding. Acacia is therefore more an aspiration to improve on various existing - but faltering - national initiatives than a firm commitment to achieve: the parties to the MOU point out that it carries no legal status.

Acacia currently presents the only serious prospect of achieving full integration of land parcels, addresses, topography and other possible components of a national land management system and the project will be covered in more detail in companion papers to this one. The MOU includes a specific objective:

> *"3. Facilitate the development of a common and consistent national framework of property parcels or polygons, broadly reflecting ownership or occupancy, which can be integrated within OS MasterMap and related to other important national polygons, including administrative areas, land use, environmental and planning polygons as well as physical features."*

and overall intends to....

> *"6. Co-ordinate plans for phasing in the provision of these facilities in a spirit of not letting the best be the enemy of the good."*

An area of "*particular priority*" with regard to "*re-engineering of functions, joint working ad sharing of information*" is:

> *"(d) Development of land parcels (polygons): present initiatives will be combined, rationalised and co-ordinated so far as possible;"*

In England, it is HMLR that has taken the lead in developing land parcels. RoS and NIVLA would be expected to be leaders elsewhere in the UK. These agencies must be aware of the moves at European and international level respectively to develop models for cadastral datasets: Infrastructure for Spatial Information in Europe (INSPIRE) (EC, 2002) and the FIG Core Cadastral Domain Model (Lemmen & van Oosterom, 2003). Acacia will need to be convergent with these, in a world of global property markets. A separate paper will consider this further.

Some 'other important national polygons' were looked at in the JLE project: Royal Mail's postcode boundaries; census enumeration districts. Possibly the most promising are local authority administrative boundaries. The main problem with all these is that they tend to change quite frequently, which makes creation of time series difficult. Also at present there is no requirement in the UK for any of these 'higher' polygons to follow land parcel boundaries, so that it is quite possible (although not common) for a local authority boundary to pass through the middle of a building or field.

Integration with topographic data is less of a problem. Value maps will usually only need to have a visual link to certain features, at most there might be a need to 'clip' a map or model to the line of a river or coast or other physical barrier to movement, which most GIS software can manage. These issues are dealt with under Display later.

Manipulation: Post-Processing and Modelling with Property Data

There are broadly two stages between data capture and analysis where property value data may need to be manipulated. One tends to occur prior to the transfer from data custodian (such as VOA); the other is carried out in conjunction with certain kinds of display techniques. Both involve an understanding of the nature of value data and the concept of landvaluescape. They are analagous to surface modelling techniques used in earth sciences.

Ward et al (2002) describes data manipulation techniques used within Lucas County Assessor's office to smooth the response surfaces created by previous steps in GRSA modelling or to combine the surfaces formed by separate analyses of different types of property market data, such as vacant land sales and improved property sales in the same geographic area. Some of these techniques might appear unsound to British valuers unused to CAMA methods but it is evident that, despite their 'blackbox' nature, they require experienced property assessors with local knowledge to operate them. A combination of skill and intuition is needed to decide, for example, which neighborhoods exhibit 'developing' as opposed to 'mature' land market characteristics, before the different model adjustment variables are assigned to each neighborhood type.

Whereas in landscape modelling the skilled intervention may take the form of choosing break lines and watersheds as boundaries between different water catchment areas, in property value modelling the skilled manipulation lies in identifying neighborhood boundaries and value influence centres (Ward *et al* 2002, p.37). These need to be established before the computer modelling process is run.

Value influence centres often have subtly different effects on different sectors of the property market, which makes a landvaluescape constrained by land use zoning, rather as a landscape is constrained by the combination of geology and climate. In the Lincoln/JLE study, it was very noticeable that stations next to large public housing estates exhibited very little change in property prices, whereas property values around stations in areas used already for commercial purposes reacted markedly to the presence of the new transport node. Establishing 'signatures' for the patterns of influence of different socio-economic features in the landvaluescape – the 'ecomorphology' as Vickers (2001) has called it – will not be easy, although applying knowledge of it to manipulate property value datasets will be an important part of value mapping science.

Where data are aggregated into large areas, there is a danger that analysis will be influenced significantly by the modifiable areal unit problem[2]. This problem arises in all GIS where records are analysed after aggregation: results of analysis can be highly dependent upon the choice of geography for aggregation, often in quite unpredictable ways. British researchers are as aware of the general problem as any (Green & Flowerdew, 1996), although there is little or no UK research in the property valuation field. The problem becomes less important where aggregation of data is into small areas which reflect the nature of (in this case) the property market but only disappears where all individual land or property value records are directly input to the spatial analysis process.

Reflecting the fact that variations in land and property value are largely dependent on local cultural and political factors, not just upon immutable economic or natural physical laws, spatial analysis for value mapping now tends to use geographically weighted algorithms. Interaction between experienced property valuers and statisticians can achieve, through iterative multivariate analysis[3] using CAMA/GIS - what is known as Geographically Weighted Regression (GWR) - models of value which are closer to truth than those that have been in more general use for CAMA prior to the involvement of GIS (Azar & Ferreira 1994, Bond et al 1999, Ward et al 2002). GWR is described fully in Brunsden et al (1996). Deciding where the boundaries or break lines are, between areas that have different variables affecting property values, is a skilled manipulation that depends on GIS. Tax assessors are increasingly attracted to GWR for production of assessment lists.

Techniques such as Moran's *I* (Moran 1950) may enable the selection of boundaries for GWR to be automated, by testing for autocorrelation in group-level data, for example adjacent post-codes and choosing boundaries where local variations in value appear to be systematic rather than random. It is not known whether Moran's *I* has been used with property value data.

The other type of manipulation using GIS is in smoothing the appearance of 3D displays of value models. This is exactly like the manipulation of terrain models to more accurately reflect physical terrain. It involves detailed 'training' of algorithms to produce representations of reality that are more acceptable to the human viewer. Thurstain-Goodwin (Geofutures 2002) describes a typical method and its advantages and disadvantages: Inverse Distance Weighting (IDW) nearest neighbours to each data point and choosing different 'smoothing circles' results in a trade-off

[2] The Modifiable Areal Unit Problem (MAUP) is a potential source of error that can affect spatial studies which utilise aggregate data sources. It has been widely discussed in GIS literature, notably Openshaw (1984).

[3] This involves careful choice of influence centres, break lines and weighting values for a potentially large number of variables. It recognises that the value of a variable may itself vary empirically according to geography.

between simplicity and truth. In this type of manipulation, the underlying data is not altered but merely represented differently.

Figure 2 (from the JLE/Lincoln study) is presented as a set of 2D isochrone plots but could equally have been as 3D displays like Figure 1. The value map at top left in the table is closest to truth but that at bottom right is simplest and easiest to understand.

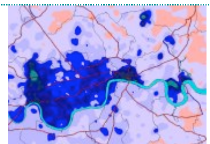
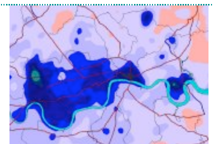
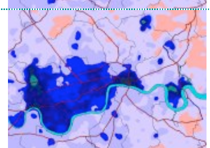
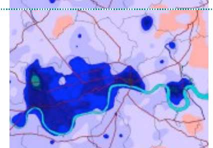
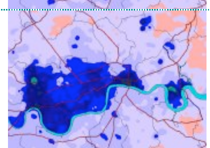
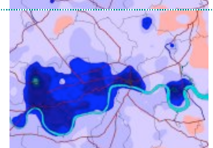
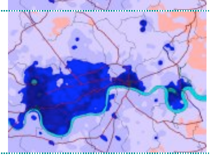
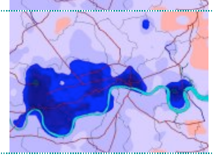
Smoothing □ Interpolation □	250m	500m
250m		
750m		
1250m		
1750m		

Figure 2

Example of Manipulation of Property Value Data-set for Display: Commercial Rating Values in London, with different parameters for smoothing and interpolation.

(Geofutures 2002)

Analysis: the Human-Machine Interface

The analysis function in GIS is bound up with the construction by human analysts of queries addressed to the prepared database, as well as with the machine-applied mathematical correction and interpolation of raw data to produce databases for users to analyse. Analyses can be based on geography or attributes and involve logical Boolean, arithmetical or statistical operations[4], overlay and buffering and various levels of aggregation and/or reclassification for a particular purpose. Analysis is here distinguished from Manipulation which alters the basic property value data, whereas Analysis leaves it unchanged but may create a new layer of secondary data specific to the query, often in preparation for Display.

Ward *et al* (2002) describes how complex mathematical analysis in CAMA has been used for some thirty years, drawing very little on the geography of property values in doing so. Lack of a GIS component in CAMA has not only denied assessors a valuable visualising tool but has

[4] A Boolean operation involves operands that test the relationships between two features. In a GIS it enables such things as containment, intersection, equivalence, overlap, touching to be resolved. Other operations carried out in a GIS are non-spatial but the results can be expressed spatially, e.g. the twenty biggest cities can be designated with a different size of point symbol or the density of population of administrative areas shown with decreasing hue.

prevented geographically variable factors from being fully incorporated in the analysis itself. GIS is increasingly seen by overseas assessors as not a 'bolt-on' to CAMA but as part of a superior 'geo-aided' CAMA.

For the UK, until there is more widespread availability of property value data, there will continue to be a lack of skills among property researchers, tax assessors and other potential analysts and value mappers. The inclusion of a GIS module in the Kingston University undergraduate Immobilia (real estate surveying) course from 2003/04 is thought to be the first attempt to formally introduce valuers to the techniques behind value mapping.

The thrust of Lincoln-funded research in the Liverpool and JLE projects has been to help British researchers learn from CAMA/GIS experiences elsewhere, both at the micro-level where the nature of individual records can be analysed and at the macro-level where statistical analysis of large volumes of data is carried out.

There is as yet a very limited market in the UK property industry for GIS analysts' services. The launch of a Special Interest Group (SIG) on GI in Property at RICS in January 2003 showed how little the GI industry understands this sector – and vice versa (Vickers 2003a). Overseas experience shows that:

> *"given the great expense of sophisticated GIS systems, their use must be for more than making pretty pictures. Truly, spatial analyses and response surface development are the payoff that can justify the cost of these systems."* (Ward *et al* 2002:52)

Other UK public agencies, notably Transport for London (TfL) and the Office of the Deputy Prime Minister (ODPM) are becoming very interested in the relationship between investment in transport and other infrastructure and property values. As Whelan (2003a) notes: *"... the relationship between transport and property impacts is not fully understood."*

A standard methodology for extracting the land value increment resulting from infrastructure investment is needed that can use existing UK property value datasets. TfL and ODPM are currently funding research into this area involving commercial property companies and academia, the first results are due to be published in 2003. Analytical methods are likely to involve GIS and to become more widely used in support of new funding mechanisms for transport projects.

Despite scepticism among many British property professionals, recorded by Whelan (2003b) at a recent gathering to discuss land value taxation (LVT), it is contended that the UK property market cannot operate so differently to property markets elsewhere that CAMA is inherently unsuitable, with or without GIS. Recent work at the University of Ulster for the RICS Educational Trust (Deddis, 2002) seems to support this.

NIVLA is about to invite tenders for a province-wide domestic rating revaluation by CAMA, which means GIS and CAMA are likely to be used in the near future in one part of the UK. This may influence UK property profession and industry perceptions about the virtues of value maps.

Display: Cartographic Options and Disseminating Results Graphically

The primary purpose of GIS is to produce a graphical representation for human view that is more accessible and understandable than non-graphic forms of representation. GIS are the vital means to achieving responsive and cheap value maps.

There are four main kinds of map that can be employed to display property values:

- scatter plots, in which individual records can be identified;
- chloropleth maps, which simply represent aggregate or average values (or ranges of value) by selected areas;
- isochronal ‘contour’ plots;
- 3D images, with ‘v’ (value) replacing ‘z’ (height) in the more familiar terrain image.

All four types of map have their uses. In descending order, they help achieve increasing anonymity for individual property value records, whilst at the same time making the landvaluescape more immediately accessible to the lay person.

Figure 3 is a scatter plot, in this case showing just the location of rating hereditaments in a part of inner Liverpool (Vickers 2003b). The point features (rating records) could have been colour coded to indicate the assessed value of each. Figure 4 is a chloropleth of the same area, showing the relative tax liabilities of land parcels. These two types of value map are more adaptable and informative in scope and also require less sophisticated GIS software or operator skills. Here ArcView was used to construct the queries and to design and produce the resulting displays within MS Powerpoint software. Both maps could have been displayed on screen within ArcView itself ‘live’ or output to printed maps designed within ArcView.

Scatter plots and chloropleth maps have a very wide range of uses to property professionals and within the agencies that produce the data which go into them. Their main uses here are in data quality assurance and property value studies where the individual data items need to be made visible in relation to neighbours.

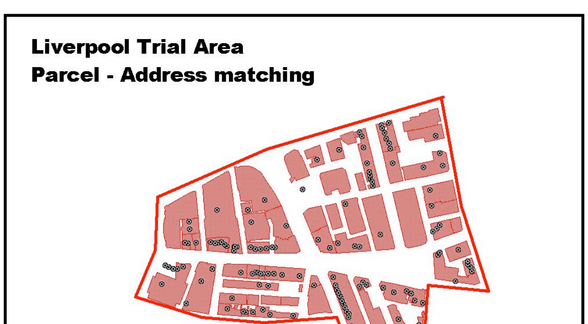


Figure 3 – Scatter plot of rating records (from Vickers 2003b).

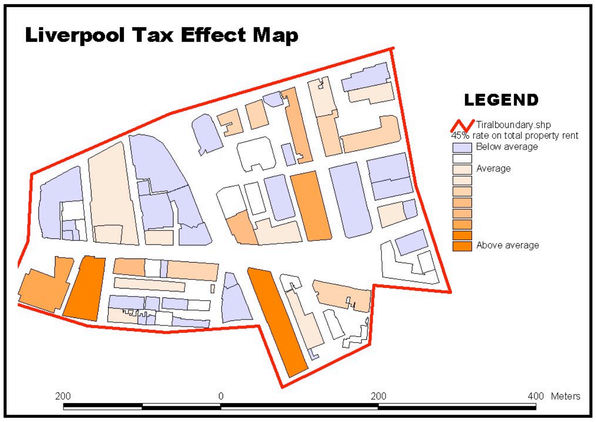


Figure 4 – Chloropleth map of site values, Liverpool (Vickers 2003b)

To elucidate patterns and trends in property values, contour and 3D maps are often more effective than scatter or chloropleth maps. Figures 1 and 2 are examples. They are usually more accessible products to the general lay public and have the great benefit, where confidentiality of data source is a factor, of obscuring the particular in the process of emphasising the generality of value trends spatial and/or temporal.

It is possible to combine selected topographic features with any kind of value map. Even 3D displays can have roads, administrative boundaries or other features draped over the value surface to give the map its geographic association.

A problem with contour and 3D value maps is that the models need to incorporate value data from beyond the edges of the map, if there are not to be excessive errors near those edges. The smoothing algorithms that are used to create a response surface need to work on a larger area than that which is displayed. This was done for the Toledo graphics in Figures 1 and 2 but, owing to lack of value data beyond the trial area, no attempt was made in the Lincoln/Liverpool study to use these types of value map.

An almost infinite range of designs of value map is possible in most modern GIS, with adaptation of design being cheap and easy. The disadvantage of value mapping stressed by Howes (1980) quoted above is overcome by modern desktop GIS. The usual rules of cartographic design apply to either soft-copy or hard-copy map products but are made easier for the non-specialist largely because it is possible to experiment at little cost in terms of time or materials.

Conclusions

The science of value mapping is well advanced in countries such as the US having a rich supply of property value and ownership data in the public domain, generally from the tax assessment function of government. Howes' (1980) prediction of greater use of value maps resulting from CAMA and GIS have been fulfilled elsewhere but not in the UK. Britain has an unusually secretive tradition in property and land information and no statutory requirement for comprehensive and consistent property value records for tax purposes. However recent trends in UK government policy relating to production, integration and supply of land and property information could enable value mapping to be carried out with a comparable level of sophistication to other countries.

It is already possible, for limited areas and with a degree of project-specific data acquisition, to emulate in Britain the kinds of value maps seen overseas. The growing debate over transport funding from land values is especially likely to stimulate further research into spatial analysis of property values, supported by value mapping.

The most immediate problems are related to the cost of obtaining and using these data, in a property industry that lacks staff trained in the GIS skills to use them. Although surveys indicate a public understanding of wider benefits of value maps in government and society generally, shortage of data has held back native research into such uses, creating a vicious circle that hinders attempts to address the skills shortage and high data costs. Legal restrictions on the use of Inland Revenue data held by VOA are also a major barrier to research in this area.

There is no technical reason why such research could not be carried out now in the UK with native data sets. However the costs of research are likely to remain a barrier to progress in this field unless the agencies that produce the data, such as VOA, can be persuaded that it is also in their interests to support this research.

This paper has not attempted to look at the wider reasons for mapping property values. It has shown that significant advances have been made elsewhere in the world in the production and use property value data by CAMA and GIS. It has highlighted deficiencies in UK data production and the reasons why we remain far behind many other developed countries in understanding – let alone exploiting – the potential of GIS in this field. The reasons are political, in the widest sense. Issues of policy will be addressed in another paper.

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