To be completed by the award-holder at the end of the award period.

Please type where possible, or write legibly in black ink. You may paste separately word-processed text onto the form. Alternatively, please contact Joy Whyte (email: j.whyte@ahrb.ac.uk) if you would like an electronic copy of the form.

You should sign both sections A and B of the End of Award Report. Please note that the research report (section A) must additionally be countersigned by someone with the appropriate authority within the institution to confirm that the research supported by the award has been carried out as described, and that the grant has been spent in accordance with the terms and conditions of awards.

<table>
<thead>
<tr>
<th>Name</th>
<th>Address for correspondence</th>
</tr>
</thead>
<tbody>
<tr>
<td>First name</td>
<td></td>
</tr>
<tr>
<td>Surname</td>
<td></td>
</tr>
<tr>
<td>Award Number</td>
<td></td>
</tr>
<tr>
<td>Post code</td>
<td></td>
</tr>
<tr>
<td>Tel No</td>
<td></td>
</tr>
<tr>
<td>Email</td>
<td></td>
</tr>
</tbody>
</table>

**Institution at which award was held:**

SCHOOL OF ARCHITECTURE, UNIVERSITY OF SHEFFIELD

**Amount awarded:**

£84,452

**Title of research project:**

Reconstructing Historical Architecture and Cities in Hypermedia Space for Collaborative Research and Design

**Dates of project:**

Start date 12 1999

End date 31 1 2002
Section A: Research Report

Please attach a copy of the scheme of research from your original application to the AHRB and refer to it when completing the section below. You should include in your report:

- your own assessment of the extent to which the stated aims and objectives of the research proposal have been achieved
- details of any difficulties encountered during the period of the award that you consider are relevant to this report.

The following assessment is made against the objectives stated in the original application (see the attached copy of the original proposal):

(1) To further develop and evaluate the generic computer-based modelling and authoring methodology established in the pilot study

The VRML modelling and HTML authoring methods for urban contextual modelling studied earlier have been used extensively in the research to produce various types of historical urban data. Scanned images of Ordnance Survey maps of different historical periods, HTML pages and VRML models were created on the basis of the Sheffield Urban Study Archive. However, following our review of related research on 3D city modelling and virtual cities, we responded to the limitations observed and developed an alternative approach to 3D urban contextual modelling that enables user-centred dynamic retrieval of online urban data over the World Wide Web. Apart from passive browsing, users of existing virtual city applications cannot do much about the 3D city models retrieved no matter how photo-realistic they may appear. A virtual city representing a large urban region is usually built with a collection of model segments. Yet, how the city models may be retrieved has already been predetermined and fixed at the time when those model segments were built initially. Because users of these pre-built virtual city models cannot select and reassemble them in ways as seen useful to their own purposes, the usefulness of these models for design or research can be drastically reduced. For instance, there will be difficulties if a user’s focal point of interest happens to lie on or somewhere near at the lines of division where the key model segments meet.

To overcome the limitations, we develop a Multi-tier Extensible platform for Dynamic and Interactive Urban Modelling (MEDIUM) to facilitate the implementation of a particular Dynamic Virtual City (DVC) application. Unlike existing virtual cities, a DVC system has the ability to support user-centred dynamic retrieval of compounded urban datasets according to the urban contextual attributes specified by the users. In addition, from the viewpoint of urban data development, the MEDIUM methodology demonstrates that a more effective and sustainable urban data development methodology can be established by interlinking (1) the strength of geo-computation available from Geographical Information Systems (GIS), (2) the power of 3D modelling in Computer-Aided Design (CAD) and (3) the ubiquity of Web computing. The dynamic approach tested throughout the research shows that both the scope of urban data and the range of system functionalities can be extended and maintained in an incremental piecemeal manner, which has not been the case in existing static virtual cities.

In retrospect, the MEDIUM-DVC methodology is an important research finding, which is generic and can be applied to urban studies and city modelling of any historical periods and geographical locations. The resultant Web-enabled DVC facilities can effectively transform existing virtual cities as static websites storing collections of prefabricated urban models into online urban data repositories allowing for user-centred dynamic retrieval and synthesis of urban data. We consider that the DVC’s capability of supporting individual differences in accessing urban contextual information are important and valuable to serve the purpose of design and research—as there lays the origin of creativity and insight that could contribute to the qualities of urban research and design in a fundamental way. Within the 26-month period of the research, our development of the methodology has been evaluated through the implementation and trial uses of the Sheffield Urban Contextual Databank (SUCoD) prototype.
To produce an interactive searchable hypermedia databank in support of on-going research on the historical buildings and places of Sheffield by applying the methodology developed

The end result of the research is the Sheffield Urban Contextual Databank (SUCoD) as a particular Web-based dynamic virtual city application, which is now fully operational at http://sucod.shef.ac.uk, hosting the Sheffield 1900 Urban Study datasets. With an Internet connection at the LAN capacity, users can interactively retrieve a variety of urban contextual data from SUCoD such as scanned historical maps (covering an area of 160 hectares) and the Sheffield 1900 VRML models (covering an area of 44 hectares) by specifying a set of urban contextual attributes in terms of spatial location, boundary, building age and/or building usage. SUCoD is able to respond to the user selections and deliver map images, VRML models and HTML page links in real-time to the user's desktop. Based on MEDIUM's multi-tier system architecture, SUCoD is highly extensible; new data about historical buildings and places can be added to SUCoD's data repository at any time in a piecemeal and bottom-up manner. The "search by key words" facility in SUCoD has not been implemented within the project's lifetime. However, the basic computational principle is known to us, which can be implemented later by building a relational database connected to the Java-enabled mapping environment.

To demonstrate that a hypermedia databank dedicated to reconstructing historical architecture and places of a region can facilitate collaborative design and research regarding the contextual issues of that region

Our work was presented to the "Research Forum on Regional Research" organized by the Research Office at the University of Sheffield on 3 October 2001. A Special Interest Group on "Regional Studies" has since been established, and the SUCoD research team was invited to become a key member of the group. The Regional Studies SIG will meet on a regular basis to discuss opportunities of collaborative research involving disciplines from various departments (Town Planning, Cultural and Languages, Local History etc). At various stages, we have also invited groups of practitioners working in the Sheffield City Centre Regeneration programme to attend our seminars and demonstrations of SUCoD. These include staff from the Sheffield City Centre Urban Regeneration Company Ltd (Sheffield One), the Environmental Planning Office and City Development Unit (Sheffield City Council), Hammerson plc, and Building Design Partnership. Comments and interests were expressed by the visiting practitioners regarding how our current work could be further developed to provide a real-world application that users from different sectors working for city development and urban regeneration will find it useful. In particular, having seen how the Sheffield 1900 historical urban data could be created and utilised as an example, the visitors commented that a DVC-based approach to developing contemporary urban data for supporting immediate urban design intervention and longer-term city development uses are worth of pursuing.

To make the databank accessible nationally and internationally via the Arts and Humanities Data Service and the Internet

We have been in contact with Mr. Phill Purdy at the Visual Arts Data Service regarding the development of the SUCoD resources. We consider that while a full system migration of SUCoD from its current website (maintained by the University of Sheffield) to VADS is possible, the technical resources and expertise required to do so will be substantial. It will involve amending the software components written several languages (Java, Perl, VRML, HTML, JavaScript) and setting up a dedicated Web server (Apache HTTP Server, or Microsoft IIS). More importantly, SUCoD has not been designed as a fixed collection of historical urban data but to allow for piecemeal growth into the future whenever new funding is granted to do so. It is therefore not practical to transfer the entire Web application to a new host. We will soon work with VADS to set up a representative Web page announcing the availability of the SUCoD resources and providing a direct link to SUCoD's front page to enter the system. The current SUCoD website (http://sucod.shef.ac.uk) is a permanent one, which has been set up under the supervision of the Corporate Information Computing Services at the University of Sheffield who operates constant Internet networking security procedures and maintenances.
The major difficulties that we have encountered during the research period include the following:

(1) Mr. David Chang was the sole Research Associate appointed for the project. Not only working on some of SUChD's software development, he has also been mainly responsible for generating all the data files. The original archive covers an area of 160 hectares, and it was not possible to complete the digitization to such an extent within the 26 month-period. Our experience shows that a 12 person-week is a minimal required to generate the 3D VRML and Java map data files for a single urban square of 200m by 200m on a manual basis.

(2) Again, relating to the issue of resources, we were not able to create all the urban documents that reflect the current scope of the Sheffield 1900 archive. However, it is clear to us how this should be implemented and deposited with SUChD. If the human and time resources permitted to prepare the data, users of SUChD would be able to retrieve HTML urban documents according to their preferred spatial and locations and boundaries.

(3) Trial uses of SUChD show that effective access and interaction with the DVC application requires an Internet connection at the LAN capacity. Ordinary phone line dial-up connections to the Internet are too slow to render it a practical application accessible from home. Given that the cost of broadband Internet connection is decreasing, we may be optimistic in the long run. However, further research is needed to reduce the traffic loads required to achieve user access and interaction at a reasonable level of speed and cost.

Output of research
Please indicate any publications or other forms of public output, which have arisen from the research. Outputs that are in preparation should be identified with an asterisk. Where the output differs significantly from that outlined in your application, please provide details. Please also indicate if any other dissemination such as conference papers, seminars or lectures has taken place or is planned for the future.

Refereed Journal Papers


Refereed Conference Papers


**Budgetary Statement**

Please provide a breakdown of how the award was spent, using the table below, listing expenditure forecast in your application and actual expenditure under the appropriate headings. Please identify if there is any underspend arising from the award: any unused funds should be returned to the AHRB – we will raise an invoice for the appropriate amount.

<table>
<thead>
<tr>
<th>Item of expenditure</th>
<th>Amount awarded (including inflation) £</th>
<th>Actual expenditure £</th>
</tr>
</thead>
<tbody>
<tr>
<td>Staff salaries</td>
<td>45,201.93</td>
<td>45,009.18</td>
</tr>
<tr>
<td>Travel and subsistence</td>
<td>2,357.78</td>
<td>2,125.78</td>
</tr>
<tr>
<td>Consumables (over £2,500)</td>
<td>0.00</td>
<td>3,218.44</td>
</tr>
<tr>
<td>Equipment</td>
<td>16,096.28</td>
<td>13,391.38</td>
</tr>
<tr>
<td>Special costs</td>
<td>0.00</td>
<td>0.00</td>
</tr>
<tr>
<td>Indirect costs (46% of staff costs)</td>
<td>20,793.01</td>
<td>20,704.22</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>84,449.00</strong></td>
<td><strong>84,449.00</strong></td>
</tr>
<tr>
<td><strong>Balance</strong></td>
<td><strong>0.00</strong></td>
<td></td>
</tr>
</tbody>
</table>

Please explain any significant variations between actual and forecast expenditure.

The expenditure for Consumables in the original proposal submitted to the AHRB did not exceed £2,500. Consequently, no amount was awarded under this heading. However, throughout the research period, expenditures of office expenses and consumables did occur and amounts to £3,218.44. The discrepancy was later balanced via the savings from Travel and subsistence, Equipment and other actual expenditures.

---

**Award-holder**

Signature

Date 5 March 2002

**Institutional Authorisation**

I confirm that the research supported by the award has been carried out as described, and that the grant has been spent in accordance with the terms and conditions of awards.

Signature

Date 5 March 2002

Name
Professor Jeremy Till

Position
Professor of Architecture and Head of Department
The University of Sheffield

Institutional Stamp
Section B: Impact and Relevance of your Research

How has the research project contributed to the development of your academic knowledge or research activity, and that of your colleagues and staff engaged on the project?

The research funded by the AHRB (B/RG/AN5875/APN9446) is my first major research grant project acting as a principal investigator. Prof. Peter Blundell Jones and Prof Bryan Lawson (all at the School of Architecture, University of Sheffield) are the co-investigators. Mr. David Chang was appointed as the research associate for the project form 1 Dec 1999 to 31 Jan 2002.

My undertaking the research is an important milestone in the development of my academic career. The outcome of the research has generated an innovative dynamic urban modelling and informatics system that has been published in several refereed international journal and conference papers. Several other articles are in preparation for further publications. The research has also been demonstrated to many visitors to the School as well as colleagues from other research institutions. Our development of the MEDIUM platform and the Web-based application SUCoD has delivered a solid basis for further research proposals to be built up in collaboration with other academic researchers and professional bodies involved in urban design, planning and management.

Prof. Blundell Jones is still leading the Sheffield Urban Study programme. He has clearly seen the benefits brought by SUCoD and is encouraging students to access the online resources in carrying out critical reviews on the archive materials gathered previously.

Prof. Lawson has been actively engaging in the review and dissemination of the research. He is particularly interested in taking the current results forward to develop collaborative projects at the European and international level. In March - May 2002, He will present the research to universities in Malaysia and Singapore as a visiting professor.

Mr. David C. Chang is now completing his doctorate at the School of Architecture. The development of his technical expertise is substantial including GIS mapping, 3D CAD modelling and the Web.

How do you think this project has helped, or will help, in the development of your career, and that of any colleagues, staff, research assistants or research students attached to the project?

The project will help in the development of my career in the following ways:

1. There has been a surge of research publications on the basis of the research carried out. These publications do not repeat themselves but present a range of topics that have been studied throughout the research programme. They discuss findings about information retrieval and interaction with virtual city applications, urban contextual visualization for urban design, dynamic urban informatics and a Web-enabled curator application to sustain historical urban and architectural studies. The scope for further research and development opened up by the project is significant, which will enable me to apply for further research funding.

2. The research outcome has contributed partially to the fact that I am now being considered for a promotion to Senior Lecturer at the Faculty level. Although this may not lead to the final recognition at the highest University level in due course, this first step forward is certainly critical in my academic career development.

The project will help the research associate Mr. David Chang in developing his career towards postdoctoral research fellowship and beyond. His name will be put forward in our further research funding applications related to any further development of MEDIUM and SUCoD.
How has your research contributed to advances in creativity, insights, knowledge or understanding in your subject area and how is this of interest and value to the research community and other audiences (which you should specify)?

Computing and information technologies provide useful tools to visualize or simulate the built environments, especially, the many facets of a complex urban context. Recent advances in computing power coupled with the continuous expand of the Internet and World Wide Web permit new ways of modelling urban environments and phenomena to a level of dynamism that could not be achieved previously. By interlinking the latest technologies from Geographic Information System (GIS), 3D Computer-Aided Design (CAD) and Web computing, the research has developed a prototype of Dynamic Virtual City (DVC) system. DVC is envisaged as a new generation of virtual city application capable of supporting low-cost user-centred dynamic retrieval and synthesis of various types of urban data over the Web, including 3-dimensional (3D) urban contextual models.

Through research paper publications and system demonstrations, the research has attracted interests from audiences working in various areas, including regional studies, urban/architectural history, city planning, urban design/simulations, urban regeneration, construction information technology and sustainable urban developments. The technical expertise developed through MEDIUM and SUCoD further provides a solid basis for the School of Architecture to initiate and undertake multidisciplinary research into dynamic urban modelling and urban informatics in directly supporting urban design decision-making and simulation. We are now actively pursuing contacts with the Departments of Computer Science and Information Studies to discuss possible collaborative research into the uses of emerging computational technologies to provide an agile and adaptable environment for research and understanding of city based development issues.

What impact may your project have on wider academic collaboration such as the development of research questions and research agendas and facilitating proactive networking or research activities?

On the basis of MEDIUM and SUCoD, a wider academic and industrial collaboration is currently being sought along the following themes:

1. Modelling Sheffield City Centre Regeneration with a Dynamic Virtual City Platform: applying the DVC framework for developing contemporary urban data to support the aspects of urban regeneration now is taking place in the Sheffield City Centre.

2. Dynamic Virtual Campus System for the University of Sheffield: developing a dynamic virtual city application dedicated to the University of Sheffield for a wide range of uses, including design of new buildings/landscapes, campus development planning, facility management, public relations/marketing, University Virtual Forums, and the forthcoming University Centennial 2005 etc.

3. Modelling Urban Landscape Context Online with a Dynamic Virtual City Platform: developing Web-based environmental resources that will empower local community groups in the process of developing funding applications.

4. Simulation of Urban Green Space for Urban Design and Planning: investigating computer-based simulation methods of delivering ecological survey of Urban Green Space such that a better understanding of the functions and values of urban green spaces can be made more accessible and applicable in the processes of urban design and planning.

Award-holder

<table>
<thead>
<tr>
<th>Signature</th>
<th>Date</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>5 March 2002</td>
</tr>
</tbody>
</table>

Please return 2 copies of the completed form to:

Ms Joy Whyte, Research Awards Team Leader, Research Grants (Monitoring), The AHRB, Whitefriars, Lewins Mead, Bristol, BS1 2AE
A Supplementary Report to the End of Award Report

Project Title: Reconstructing historical architecture and cities in hypermedia space for collaborative research and design

AHRB Reference: B/RG/AN5875/APN9446

Principal Investigator: Dr Chengzhi Peng, School of Architecture, University of Sheffield
Co-investigators: Prof. Peter Blundell Jones and Prof. Bryan Lawson, School of Architecture, University of Sheffield

Date: 21 January 2003

The End of Award (EoA) Report for the above project was submitted to the AHRB on 5th March 2002. We receive the outcome of the Board's initial assessment of the EoA report in a letter from the AHRB dated 14 January 2003. Our EoA report has been assessed as “unsatisfactory,” and we are invited to submit a supplementary report in response to the assessment result. This Supplementary Report is written in three parts:

(A) A response to “the failure to produce a publicly available website.”
(B) A response to the issues raised by the Board as listed in the letter.
(C) An update of the recent progress on the project.

Part (A)
The independent evaluators and the Board's reviewers concluded that “or, in your case, has failed to address its research questions and major objectives. In this case the failure to produce a publicly available website.”

Response: The website resultant from the project, Sheffield Urban Contextual Databank (SUCoD), was fully operational and open to the public as early as January 2002 via the permanent Web address at http://sucod.shef.ac.uk/. We therefore cannot accept the Board's assessment that we have failed to produce a publicly accessible website of the project. This is simply not true. We do not understand why the evaluators and the reviewers have come to this conclusion without being given more detailed information regarding how they have accessed SUCoD. We can only assume the following possible causes:

- The evaluators and reviewers were unable to access the SUCoD website due to that the SUCoD server was temporarily offline at that time for a maintenance purpose. The SUCoD website has been built based on the University's campus network (a Local Area Network, LAN) that connects to the outside world. For the SUCoD website to be seen to the outside world (i.e., beyond the University's campus network), it has to follow the University's firewall exemption procedure operated by the Corporate Information and Computing Services (CiCS) who, for security reason, monitors every externally accessible website created on the campus network. The firewall exemption granting procedure is very thorough and can take up several days to complete the auditing process before the exemption is finally approved. During the CiCS auditing period, the SUCoD website is put back inside the University's firewall and is inaccessible beyond the University of Sheffield domain.

- The evaluators and reviewers could not access the SUCoD website successfully because they did not have high speed (broadband) connections to the Web. The SUCoD website has been created using the Java Applet technology and employing a multi-tier system architecture. Without a LAN or broadband connection, it will take lengthy downloading times for the viewer to get SUCoD up running on his or her own desktop. We have mentioned this point in the EoA report. Perhaps, we should have made this requirement more explicitly on the SUCoD's Home page.

- The evaluators and reviewers did not succeed in retrieving the urban contextual datasets currently made available online through SUCoD because they did not know how to operate the system. To achieve the research objectives, SUCoD has been created not as a conventional static Web repository but a dynamic Web service allowing for user-centred retrieval. In the following, we will provide instructions and illustrations of how to operate SUCoD to retrieve and interact with the various urban content on SUCoD: (1) Scanned Historical Maps, and (2) VRML Models and Urban Documents.
(1) Retrieving Scanned Historical Maps from SUCoD

If the viewer has a high speed Internet link and has installed the required software components properly as explained in the above, the viewer should see the SUCoD's first window opened as below that displays the “SUCoD Index Map” (Fig. 1). Users must first click the **Fit to View** button to ensure that the entire Index Map is displayed fully.

![SUCoD's Index Map](image)

**Fig. 1** SUCoD's Index Map (all the figures shown in this report are captured from Netscape 7.01; similar results can be obtained using other Web browsers such as Microsoft Internet Explorer 6.0)

There are six ways to manipulate the Index Map via the following six buttons:

- **(Fit to View)** to ensure that the entire Index Map is fully displayed.
- **(Zoom-in)** and **(Zoom-out)** to zoom in or out (Factor: 1.25).
- **(Interactive Zoom)** to drag a rectangle area to zoom into that area.
- **(Select Arrow)** to select objects in the map.
- **(Pan)** to pan the content of the map.

The blue grid (shown on the “SUCoD Grid Label” layer) indicates the current scope of the Historical Maps of Sheffield available on SUCoD. The grid corresponds exactly to the urban grid adopted by the Sheffield 1900 Urban Study. Each square on the SUCoD Index Map represents an area of 200m by 200m.

**GET Scanned Historical Map**

Users can select one or more blue squares on the Index Map using the **Select Arrow** tool and press the **GET Scanned Historical Map** button to retrieve a set of multi-layered historical maps. At present, for the entire 40 squares (160 hectares), scanned historical maps of years 1890 and 1999 are provided in two different resolutions. The design of SUCoD's mapping facility allows that scanned historical maps of any other periods can be added easily at a later following the same principle. Each year is displayed on a separate layer that can be turned on or off under user controls. An example of historical maps retrieved from SUCoD is shown in **Fig 2**.
Fig. 2 An example of retrieving a multi-layered scanned historical maps from SUCoD for Square B3. The 1890 layer is displayed on the top and the 1999 layer is shown when the 1890 layer is turned off. An even higher resolution of the historical maps can be retrieved by selecting the 50m by 50m squares (shown in light blue squares) and pressing the GET Hi Reso Scanned Map red button on the right.
(2) Retrieving VRML Models and Associated Urban Documents from SUCoD

Currently, the squares coloured green (see Fig. 1) are areas where the VRML models are available (11 squares, 44 hectares) on SUCoD. The VRML models were created manually using the MicroStation/J CAD system according to the physical models produced by the Sheffield 1900 Urban Study which has produced 40

To retrieve VRML models, users first select one or more squares within the green-coloured region on the SUCoD Index Map and press the **GET Java Enabled Map**. A new page will appear as below (Fig. 3):
After selecting elements on the Java Map (as indicated by the small black dots) and pressing the **GET VRML** button, a VRML model corresponding to the user’s selection will appear on the top right frame of the page. Beneath the VRML model, a list of the URL links associated with the elements selected from the Java map also appears at the same time. By varying selection criteria, the Java map can be used repeatedly to retrieve different VRML models and URL links.

**Fig 5.** Examples of *user-centred dynamic retrieval* of VRML models from SUCoD.
Part (B)
Response to the issues raised by the Board as listed in the letter

- What percentage of the 160 hectares archive has been digitised
- How many 200m x 200m 'squares' were modelled in VRML
- How many associated Java maps were generated

To date, there are the following kinds of digital content produced and deployed with the SUCoD system:

(a) **Historical Maps**: Scanned historical maps of Year 1890 and 1999 for all 160 hectares (100%) of the archive has been produced in two different graphic resolutions (access through the blue squares shown in Fig 1). The original archive does not contain the 1999 Ordnance Survey map sets, which we decided to develop an extra layer of 1999 map to make use of SUCoD’s multi-layering map display facility.

(b) **VRML Models**: 20 squares of physical models were produced at the time when we first submitted the research proposal to the AHRB in December 1998. Another 20 squares of physical models were produced in the subsequent years by the Sheffield Urban Study programme. At present, 11 squares (55% of the 20 squares in the 1998 archive, and 27.5% of the 40 squares in the 2001 archive) have been modelled in VRML (access through the green-shaded blue squares shown in Fig 1).

(c) **Java Maps**: Java maps are created as the front-end for user-centred dynamic retrieval of the VRML models. At present, 11 squares of Java maps are made available (55% and 27.5% respectively as the VRML modelling explained above), which can be accessed through the green-shaded blue squares shown in Fig 1.

We ought to point out that creating the digital content according to the Sheffield Urban Study archive does not constitute the entire workload of the project. From an early stage of the project, we have come to realise that the research objectives could not be achieved by following a conventional approach to digitisation, especially regarding the 3D city models. A new way of creating and storing the digital urban datasets has to be developed so that doors to reaching the objectives, such as “to reveal how urban places have evolved” and “supporting collaborative urban research and design,” could be opened. We have therefore spent nearly the first 12 months of the project on developing and experimenting with new computing methods which later emerged as the Multi-tier Extensible platform for Dynamic and Interactive Urban Modelling (MEDIUM) framework. We then proceeded to develop the Sheffield Urban Contextual Databank (SUCoD) system on the basis of MEDIUM. Details of how we have addressed the research problems and system developments have been described in our journal/conference papers (two journal paper off-prints are enclosed).

To our knowledge, no software packages are commercially available that we could purchase and use directly to achieve the project objectives. In retrospect, we consider that our time and efforts spent on MEDIUM and SUCoD worthwhile as we have discovered and established innovative ways of modelling urban environments to a level of dynamism that could not be achieved previously. In comparison with conventional methods of building large databases at a city-scale, SUCoD can be characterised as a Dynamic Virtual City (DVC). The DVC approach opens up new possibilities of how multi-dimensional multimedia urban datasets may be created and used in urban study and design (see Part C for more details).

During the project’s lifetime, Mr David Chang has been the sole Research Associate employed by the project to create and deploy the datasets with SUCoD. He has also played a part in the design and implementation of the SUCoD system, producing workable system components implemented in several computer programming languages. With the remaining project fund saved from elsewhere, David Chang’s employment was extended two more months and the current scope of data provision of SUCoD was reached on 31 January 2002.

- Which 'urban documents' were created and what was the criteria for choosing them

'Urban documents' is the area that we did not have time to produce a significant amount to be deployed with SUCoD. Only sample documents were created to illustrate how the documents could be accessed. As shown in Fig 4, the listing of the URL links resultant from user selections on the Java map provides the route of how urban documents on SUCoD can be accessed by the users. That is, each urban document created on SUCoD will be geo-registered in a way similar to the VRML models. This will allow users to retrieve urban documents of interest through map-based navigation and selection. Practically, SUCoD has this facility in place already; it is a matter of time and human resources for us to produce more urban documents deployable through SUCoD.

We also experienced that, unlike the physical models and historical maps, documents are less consistent with unequal qualities across the squares. Many document materials collected in the archive are copyright-protected, which cannot be put on SUCoD without a proper copyright-clearing procedure. Ideally, the digitisation need not set new criteria for choosing which documents to be created and deployed on SUCoD because the choices should have been made by the researchers who took part in the Sheffield Urban Study project. In principle, if the issues of quality, consistency and
copyright-clearing have been resolved satisfactorily prior to digitisation, each document found in the original archive should be digitally reproduced faithfully in a simple Web page format without being subject to further filtering. Fig. 6 shows an example of an urban document about the history of the Albert Hall, which has been geo-registered on SUCoD.

**THE ALBERT HALL**

The Albert Hall, designed for musical entertainment and large public meetings, was opened on December 14th, 1873, and was the property of a joint stock company, The Sheffield Music Hall Company (Limited). The Duke of Norfolk laid the foundation stone for the building on September 10th on a plot of freehold ground 1200 yards square. It was centrally situated, on a much too crowded site, at the junction of Pilkington’s pool & Burgesses Street. This is the site presently occupied by the Coop Brothers Department Store. The building was of red brick, relieved by granite pilasters and carved above cornices and beams, but was remarkable rather for ingenuity of appearance than for external beauty. Undoubtedly this building would have been one of the dominant features of Sheffield’s skyline at the time, particularly with its tall tower located in the north east corner of the site.

Internally the large concert room was 60 feet wide and 123 feet long with a two-tier balcony along the sides and across it, stalls behind the balcony at the west end, and gallery above it. An organ and orchestra, arranged to hold 168 chorus singers with band and soloist, occupied the east end. The concert room was designed to seat 1000 auditoria, the balcony and stalls 700, and the gallery 500, in total 2200 people exclusive of the orchestra. It was 50 feet high, the ceiling hexagonal with a view to acoustic excellence. Another of the Hall’s attractions, in a musical sense, was the magnificent organ, erected by the celebrated Messrs. C. and C. F. Willis, at a cost of £5000. The case was from the design by Mr. Semml, a Parthenian architect of eminence in this class of work and was built from oak and Canadian pine. The organ was of immense size, having 14 stops and 4064 pipes, was constructed with all the latest pneumatic and other improvements. The perfection of its mechanism excited the admiration of the English builders who examined it. It was unquestionably one of the best organs in the country at the time.

The greatest success of the Albert Hall was the triennial Music Festival began in 1898. The Festival Chorus reached the pinnacle of its fame with its Empire tour, “round the world on wings of song”, in 1911. However, the Albert Hall, which had been built at a cost of over £250,000 including the organ, had never recovered from its original use by the police in 1937 along with the organ, estimated at £30,000 alone. The invention of the moving image had found a new role for this immense building as a “Picture House”. Reasons for this change of use could be attributed to the abundance of alternative venues within Sheffield and the decline in popularity of music halls and the rise in popularity of the picture house. Furthermore, the building of City 1111 directly opposite may also have had its part to play in the Albert Hall’s demise.

**Click the image above to see the film clip**

What percentage of those originally envisaged were generated

We feel that perhaps the discussions above may have answered partially the question. Still, we wish to point out that there has never been an exact quantity of digitisation specified in the original research proposal, nor did we consider it one of the highest research priorities to achieve a 100% digitisation of the entire archival materials by the end of the project. We were convinced at the beginning of the project that real research contributions should be made in addressing the fundamental functionalities of the hypermedia database system in order that the major research objectives could be met. Had we adopted the conventional route of digitisation and produced a typical static Web-based repository like many other urban modelling groups have done in the past, the outcome could hardly provide satisfactory solutions to the objectives originally envisaged. Our work on the MEDIUM framework has developed a generic computer-based modelling and authoring methodology, and the current version of SUCoD has been a specific implementation of MEDIUM following the results from Sheffield 1900 Urban Study. As a direct benefit from applying MEDIUM, SUCoD is highly extensible in terms of both data provisions and new system functionalities. In so doing, we believe that we have particularly succeeded in achieving the following objectives:

1. To support the on-going Sheffield Urban Study programme which may still grow the archival resources further in the future. SUCoD can easily accommodate future extensions of the archive to provide online urban contextual data of different types, geographical and temporal locations. More importantly, the urban data extension and accumulation will not degrade SUCoD’s usability; the same level of system clarity and user-centred dynamic interactions will be maintained as the databank grows.
2. The 3D VRML models can be retrieved to reveal evolution of city development by structuring and displaying reconstruction across different periods of time rather than a fixed one in the past or at present. In addition to the functionalities of retrieving maps and models introduced above, two new functions have been developed for users to construct multi-stratum VRML worlds as a way to visualise how city development has evolved. Below, we demonstrate a case of how this can be achieved through SUCoD (Fig. 7, 8, 9, 10).

![Fig. 7](image1.png) Java-enabled maps of year 1900 (left) and year 1996 (right) are first generated for the same selected area.

![Fig. 8](image2.png) The LIST VRML function is activated to generate a track record of all the VRML models retrieved during an interactive session on the Java map. Each VRML file listed can then be selected individually and press the Submit button on the HTML form to construct a multi-stratum VRML world containing multiple layers of VRML models.
Fig. 9 A multi-stratum VRML world constructed on SUCoD containing two layers of VRML models: Layer 1 – 1900 VRML Model in brown, and Layer 2 – 1996 VRML model in dark grey. The small blue balls with red digits “1” and “2” appeared at the bottom are the Touch Sensors for turning each model stratum on or off.

Fig. 10 The multi-stratum VRML world generated can then used to perform viewpoint-specific visual comparison by turning each layer on and off (Right: a viewpoint set in the 1996 VRML model with the 1900 layer turned off; Left: staying at the same 1996 viewpoint with the 1900 model turned on and 1996 off).

3. With SUCoD, we are able to demonstrate that a hypermedia databank dedicated to reconstructing historical architecture and places of a region can facilitate collaborative urban design and research regarding the contextual issues of that region. SUCoD’s facilities of urban visualisation on-demand prompt the possibilities of using SUCoD as an online platform for developing urban design proposals. We shall present another demonstration of how contemporary urban and architectural design could take place on SUCoD in Part C.
How do you propose to disseminate the results of the research

We consider the SUCoD website as a primary route of disseminating the results of the research. The SUCoD server is maintained at the School of Architecture at all time, which is and will be publicly accessible via the Internet for a foreseeable future. In the past two years, we have also put up system demonstrations to both international and national audiences on many occasions. An earlier version of SUCoD was demonstrated live during the CAAD Future 2001 international conference held at the Eindhoven University of Technology in the Netherlands. Several presentations of MEDIUM and SUCoD were later given to other countries in Asia including Singapore, Malaysia and Taiwan. The SUCoD project was recently featured in a high-profile interview with Prof Bryan Lawson by the Innovation Magazine published by the National University of Singapore as the cover story (INNOVATION, Vol. 3 No. 2, 2002, pages 34-37, www.innovationamagazine.com).

Closer to home, we have made several presentations of SUCoD to local organisations outside the University including the Sheffield City Centre Regeneration Company (Sheffield One), Sheffield City Council, the winning design consortium selected for the New Retail Quarter, the Centre for Built Environment and School of Cultural Studies at the Sheffield Hallam University, and the Cultural Industry Quarter Agency etc. Some of the dissemination activities have actually paved the road for us to apply for further funding for further development of SUCoD (see Part C).

In addition, adopting a more conventional route of dissemination, we have published the results of the research in three refereed journals and four refereed international conference papers as listed below:

**Referred Journal Papers:**

**Referred International Conference Papers:**

Two new papers have recently been submitted to the following journals:


Part C
Update of the recent progress on the project

The project ended on 1 January 2002. With no further funding, we were unable to create more datasets for more squares. However, experiments and evaluations of SUCoD continue. One of the areas explored was how SUCoD could be used to inform contemporary urban design for the City of Sheffield. Fig. 11 presents an example of uploading a contemporary design to SUCoD and combined with a 1900 VRML acting as a hypothetical building site. The uploading process can be easily performed by users directly over the Web by activating the GET VRML, UPLOAD VRML and LIST VRML functions as explained before. Once generated, the combined VRML world can be navigated to any position for viewing (Fig. 12).

Fig. 11 Using the constructing multi-stratum VRML world facilities in SUCoD to experiment with online syntheses of contextual models and proposed designs (Left: a VRML model was retrieved from SUCoD as the site; Right: a VRML model of a hypothetical building design was uploaded and displayed as the 2nd layer).

Fig. 12 The combined site and proposed design VRML world can be navigated to any position for viewing purpose.
Following our demonstrations of SUCoD’s various facilities as it stood, we were invited by Sheffield One to submit a new proposal with a view of building urban datasets for the contemporary Sheffield City Centre area to support design of urban regeneration. A grant of £20,000 was first awarded by the Board of Sheffield One on 22 Feb 2002. We are now in the process of applying further funding from the Sheffield City Council and Yorkshire Forward that will enable us to create contemporary contextual datasets covering 25 squares of the City Centre area.

In May 2002, we submitted a proposal titled “A Virtual Library for Exploring City Histories: Web Access to the Sheffield Urban Study Archive” to the AHRB’s Resource Enhancement Scheme, to which we have received an “A-” grade. We will revise the proposal according to the comments received and resubmit the proposal in May 2003. If funded, the project will build on SUCoD to complete the digitisation of the entire Sheffield 1900 Urban Study archive achieved up to the 2001 survey that now covers 41 squares.

In September 2002, we submitted a proposal titled “Townscaping: dynamic virtual city augmented 3D sketching for conceptual architectural and urban design” to the AHRB’s Innovation Awards Scheme 2002. The proposed research aims to develop and test a Web-enabled digital design interface called Townscaping that can be applied to architectural and urban design at the conceptualisation stage. The idea of Townscaping is to explore how 3D digital sketching can be augmented with a dynamic virtual city system with which designers can generate conceptual designs by directly placing and manipulating graphical elements within the user-configured virtual worlds of a city context. Through trial uses of Townscaping involving architectural designers, the research will investigate if designers’ engaging in 3D space conceptions can be enhanced through interacting and sketching with virtual townscapes. Clearly, without the work on MEDIUM and SUCoD, the Townscaping proposal is inconceivable.

Finally, we wish to report to the Board that the SUCoD system and the urban datasets created under the AHRB funding have been used extensively by students undertaking the ARC202 Computer Applications in Urban Design course at the School of Architecture in 2001/02 and 2002/03 sessions. Based on SUCoD, course websites were created each year as shared digital workspaces to encourage students’ sharing their urban design concepts, methodologies and modelling techniques developed through the course. These websites can be accessed through the School’s official website under the Year 3 Gallery section (http://www.shf.ac.uk/uni/academic/A-C/archst/main/gallery/y3_01.shtml). A paper written on this particular topic has been accepted by the CAAD Futures 2003 international conference, which is due to be presented in Tainan, Taiwan, on April 29 2003 (see http://www.arch.ncku.edu.tw/cf2003/default.htm).