

# Survey of Virtual Reality Activity in the United Kingdom

Prepared for the Advisory Group on Computer Graphics

by

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## Abstract

This report presents a summary of the findings of a survey of current work on Virtual Reality in the U.K., conducted by the Advanced Interfaces Group between March and September 1994.

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# Introduction

The U.K.'s Advisory Group on Computer Graphics (AGOCG) commissioned the Advanced Interfaces Group at Manchester to conduct a survey into the state of the art in virtual reality in the U.K.. One of our goals was to identify how U.K. activities compare with international developments, and to see how they might be improved upon. At a more detailed level, we wished to find out who is working in which areas, to identify the scale of activities and to see what applications are being developed. We were also interested to discover what kinds of hardware and software are being used.

The survey was conducted by mail, electronic mail, and telephone, with notices placed in newsletters and distributed at conferences, and numerous followups. A total of around 350 groups and individuals were approached and asked to respond by completing a questionnaire (included in Appendix ). This effort achieved a total of 51 responses, which is rather better than the normal return of 10% for a survey of this kind. These responses form the basis of the information presented here. Based on preliminary analysis, visits were made to a small number of sites to interview people and to see first-hand the work in progress.

Whilst every effort was taken to make this survey as representative as possible of VR work currently being undertaken in the U.K., a number of companies, research groups and individuals, known to be working with VR, did not respond to repeated requests for information. The results presented should be viewed as representative of a large cross section of the U.K. community that feels able or willing to discuss its activities.

Subsequent sections of this report define and identify key aspects of virtual reality, present the questionnaire, identify the respondents, analyse the results, and draw conclusions. An edited summary of responses appears in Appendix .

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# The scope of the term 'Virtual Reality'.

Virtual Reality is a term whose usage has become very widespread. In conducting this survey we have chosen not to limit its meaning, so that respondents are free to use it as they wish. As will be clear from the results presented later, it is a term which is used very loosely. However, in analysing the results we have felt it useful to distinguish at least the following two broad categories:

## **Desktop VR and Virtual Environments.**

These usually refer to the use of a conventional computer monitor as the output device onto which the 3D environment is rendered. In some cases, stereoscopic displays are used -- for example, stereo shutter glasses -- but at the low-end of the market this is generally not the case. Interaction is often by means of a 2D mouse, although 3D devices -- such as a dataglove, or 3D mouse -- may be used. Useful work developing underlying software can be carried out in this way.

## **Immersive VR.**

Here, some kind of immersive display and tracking equipment is employed in order to create the psychological illusion of being inside the computer-generated environment, rather than viewing it from the outside through a screen. When appropriate means of input are provided, interaction with the environment can also be directly experienced, greatly enhancing the psychological effect.

There are two main ways in which this effect can be achieved: by using a head-mounted display (HMD); or by using a large-screen system, such as a video projector, which creates the illusion of immersion by filling the field of view of the user. This is similar to the effect achieved in an IMAX or Omnimax cinema.

It is important to realise that a desktop environment is different -- both in terms of the user's psychological responses and the system's HCI requirements -- from an immersive one. There is nothing which fundamentally distinguishes desktop VR from conventional 3D graphics. It is the ability to perceive the environment *from within*, and to interact directly with it (direct manipulation in 3D space), which is the significant new feature that immersive VR brings to human-computer interaction, and which distinguishes it from traditional 3D graphics, and thus from a desktop environment.

In the published literature the term VR is usually synonymous with immersive VR as defined here. For example, if one looks at papers by academic researchers and industrial developers, it is the novel aspects of interaction within a world which are seen as the fundamentally new feature of VR interfaces, as distinct from more traditional graphical user interfaces. The engagement of human perceptual skills, and other aspects of psychology form an important part of this. See, for example, the proceedings of the VR workshops organised by Eurographics and IEEE.

Nonetheless, an informal observation is that the community is divided into two camps: those who view the immersive interface as the significant innovation in VR; and those who regard the use of a 3D environment to be the significant innovation to which an immersive interface can be tacked on fairly easily.

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- Areas of Research
  - World wide activity (US, Europe, Japan)
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## Areas of Research

The following list identifies key areas of VR research and development. It is drawn from our studies of the VR literature and is presented here as a yardstick against which to judge U.K. activities.

### **Psychological aspects.**

Factors which make for successful system use -- perceptual versus cognitive loads, representations, performance issues, acceptance studies (e.g., motion sickness etc.).

### **Interaction paradigms and techniques.**

Addressing the difficulties of interacting in 3D. Issues such as navigation and orientation.

### **Hardware.**

Performance issues -- display speed, tracking devices, problems of latency, input devices.

### **Algorithms.**

Spatial management, culling and level of detail algorithms, collision detection.

### **Software architectures.**

Toolkits, providing consistent interfaces, API, distributed and concurrent processing, cooperative working, systems for managing the virtual environment as a whole, maintaining synchronisation.

### **Applications.**

How to exploit VR. Determining the contexts in which it is appropriate. Constructing specific application demonstrators.

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## World wide activity (US, Europe, Japan)

Worldwide, there is a significant level of activity in the U.S.A., Europe and Japan. Some of the laboratories and companies working on VR are listed here. The list is not meant to be exhaustive, but gives some indication of the scale and scope of activities elsewhere. The important issue of funding levels is hard to estimate reliably with the information available to us, however it can be noted that there appears to be a substantial military involvement in some cases.

In the U.S.A., leading laboratories include Brown University (3D manipulation, [1]), Columbia University (3D visualisation, [2]), Georgia Tech (CSCW and visualisation, [3]), University of Illinois (projection based virtual environments, [4]), MIT (virtual world simulation, [5,6]), NASA AMES (visualisation, [7]), the Naval Postgraduate School (distributed simulation, [8]), University of North Carolina at Chapel Hill (walk-throughs and hardware design, [9]), and the University of Washington (training systems and environments, [10]).

In Europe [11], there are VR centres at the Fraunhofer Institute in Darmstadt (VR toolkits and applications, [12]), the Laboratoire d'Infographie in Laussane (3D interaction, [13]), Delft University of Technology (VR interfaces, [14]), the Swedish Institute of Computer Science (VR operating systems, [15]), the French National Institute for Audiovisual Applications (televirtuality, [16]), and at the European Space Agency in the Netherlands (training and simulation, [17]).

In Japan, several academic and commercial groups are engaged in VR research and development, including the University of Tokyo (input devices, [18]), NEC (CAD systems), Toshiba (architectural visualisation) and Matsushita (design applications) [19,20,21].

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# Survey results: Virtual Reality activity in the U.K.

In this section we present an analysis of information received from respondents.

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- Desktop and immersive VR
  - Type of group (sample size 51 )
  - Number of personnel
  - Backgrounds of group workers
  - Time group has been active
  - Funding
  - Focus and applications of VR work
  - Perceived benefits of VR
  - Hardware and software used
  - Organisations with immersive VR facilities
  - Importance of VR for the United Kingdom
  - Promoting VR activity in the U.K.
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## Desktop and immersive VR

An analysis of the details on the database of the U.K. VR SIG (178 members) showed that of those members (58/178) who provided the appropriate information, 74% were working with desktop VR, and 26% with immersive VR. The remainder of U.K. VR SIG members did not provide any information about what equipment, if any, they were using in their research.

Of the respondents to our questionnaire, 70% worked with desktop VR, 20% with immersive VR, and the remainder did not specify.

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**Type of group (sample size 51 )**

University	30	( 59%)
Company retailer	13	( 25%)
Company research group	6	( 12%)
Government agency	1	( 2%)
Individual researcher	1	( 2%)

## Number of personnel

1--5:	38	(75%)
5--10:	12	(24%)
10+:	2	(1%)

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## Backgrounds of group workers

(These are raw numbers, not percentages)

Computer Science	41
<hr/>	
Engineering	23
Electrical/Electronic Engineering	11
Telecommunications	1
Systems Design	1
Artificial Intelligence	1
<hr/>	
Psychology	11
Art/Design/Fine Art	7
Human factors/Ergonomics	4
Philosophy	2
Theatre	1
History	1
Linguistics	2
Sociology	1
Vision science	1
Acoustic/Audio engineering	2
Colour science	1
Simulation	1
Communication studies	1
Military	1
<hr/>	
Mathematics	6
Physics	6
<hr/>	
Medical physics	1
Medicine	1
<hr/>	
Architecture	2
Computer-based learning	1
Geography/GIS	1
Graphic design	1
<hr/>	
Sales/Marketing	3
Product design	1

## Time group has been active

Less than 1 year	4
1--2 years	18
2--3 years	6
3--4 years	3
4--5 years	2
more than 5 years	4

## Funding

Company	21
University internal	17

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Department of Trade and Industry	6
Unspecified Government agency	4
Defence Research Agency	4
Ministry of Defence	2
Department of the Environment	1
Department of Health	1
Health and Safety Executive	1

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SERC/EPSRC	11
ACME	2
IED	1
ESRC	1
MRC	1

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EC	5
CEC	1
ESPRIT	1

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Charities	3
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## Focus and applications of VR work

Respondents were asked to describe their interest and activity in VR in two categories:

- The focus of their VR work, indicating whether they were concerned with hardware or software development, VR peripherals, applying VR to specific application areas, and so on.
- Which, if any, specific application areas they were interested in.

Reported areas of focus were:

Applications development	18
Human factors/HCI	8
VR peripherals development	4
Software architectures	3
Parallel architectures	2
Medical applications	2
Perception/action/cognitive aspects in virtual environments	2
Product promotion/Marketing	2
Socio-cognitive issues	1
Entertainment	2
Integrated manufacturing	1
Architectural design	1
Social issues of VR	1
Stereoscopic display systems	1
Eye-tracking	1
Art/Design	1
Education	2

There was a wide range of specific application areas reported, including:

Information visualization	6
Medical simulation	5
CAD/CAM	4
Architecture	3
Education and training	3
Construction planning and scheduling	2
Industrial simulation	2
Entertainment	4
Battlefield simulation	2
3D Television	1
CSCW	1
Cognitive aspects of virtual worlds	1
Collision detect	1
Driving simulation	1
Emotional iconography	1
Evacuation and safety	1
Fluid dynamics	1
Human workload when using multiple displays	1
Interactive solid modelling	1
Learning disabilities	1
Minerals industry	1
Modelling	1
Oil-rig abandonment scenarios	1
Remote inspection	1
Retinal scanning	1
Robotics	1
Spatial skills	1
Unspecified defense/military	1

## Perceived benefits of VR

Respondents were asked what they saw as the specific benefits VR brought to their work, and replied as follows:

Increased and improved human-computer interaction	13
Better visualization of information	8
A sense of 'presence' in a virtual environment	7
More rapid prototyping	4
Improved simulation	3
Improved education and training methods	2
Cooperative working in virtual environments	2
Quicker decision making	1
Applying cognitive skills	1

## Hardware and software used

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### Hardware

PC	29
Silicon Graphics	15
Division ProVision	6
Sun	4
Macintosh	4
Apple	1
HP/Apollo	1

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### Interaction Methods

HMD (Commercial)	13
Data/Power Glove	11
Magnetic/ultrasonic tracker	10
3D mouse	10
Stereo glasses	8
Sound	6
Spaceball	6
HMD (home-made)	2
Touchscreen	2
Voice input	1

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### Software

Superscape	13
World Toolkit	6
Renderware	6
rend386	3
3D studio	3
GL/OpenGL/Performer	2
DIVE	2
dVISE	2
MR Toolkit	2
Sense8	1
dVS	1
Swoop VR	1
AudioLab	1

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## Organisations with immersive VR facilities

Those laboratories and organisations equipped with high-performance immersive VR systems and 3D input devices are listed here. As noted elsewhere, the issue of immersive versus non-immersive VR is quite contentious, and yet without an immersive system it is not possible to fully investigate those aspects of VR which arise from being immersed in a virtual environment. Companies reporting this capability were:

BaE Bristol	Human factors
Division	Supplier
DRA	Human factors
Go Virtual	Retail/marketing
ISSL (Salford)	Applications
Virtuality	Entertainment
Virtual Presence	Supplier

whilst university groups were:

Belfast	Robotics
Cardiff	Psychology
Edinburgh	Psychology/human factors
Heriot-Watt	Mechanical Engineering
Hull	Medical applications
Manchester	VR software systems and applications
Nottingham	CSCW
QMW, London	HCI
Southampton	Human factors

## Importance of VR for the United Kingdom

The feeling most commonly voiced was that the U.K. has so far conducted research of excellent quality in the field of VR and its applications, and that it is ideally placed to become the world leader, if sufficient government funding and support is forthcoming.

Some quotes from respondents:

- 'Out of the 4 largest VR companies in the world 3 are U.K. companies, yet 90% of the start-ups are in the United States'.
- 'Currently the U.K. seems to be doing some very good work, perhaps the best in Europe'.
- 'The U.K. leads the world in VR technology'.

Respondents viewed VR -- whether desk-top or immersive -- as poised to become a major 'new technology', pervasive in its applications, as the cost of the technology drops, and the quality of experience improves.

The general opinion was that the importance of VR for the U.K. cannot be overrated.

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## Promoting VR activity in the U.K.

The desire most often expressed was that much more funding is required for VR work. Respondents felt that VR research in the U.K. is on a par with the United States in terms of quality, but without the same government or research funding agency backing.

In particular, many respondents specifically request increased and targeted funding for academic/industrial collaborations, for example as a special EPSRC programme. This funding should be medium/long term, and not be aimed at short-term 'quick' projects.

Other initiatives were suggested:

- Research on the basic concepts of VR.
  - The promotion of 'real' VR applications, to dispel the hype surrounding the subject, and the emphasis on games (important though the games market may be).
  - Joint Research Council initiatives, encouraging workers from different areas to work together on VR.
  - A set of VR demonstrator programs for carefully chosen applications.
  - The formation of a government-sponsored 'VR club', along the lines of the DTI Awareness Clubs. Also national support for existing groups such as the U.K. VR SIG and the Virtual Reality Society.
  - The creation of a publicly accessible database for VR-related information.
  - Use of SuperJANET for centralisation of powerful VR 'server' resources and their remote usage.
  - Research on the social issues of VR technology.
  - A programme of regular nationwide workshops covering aspects of VR technology and its application.
  - More research into rendering algorithms.
  - Have high value areas highlighted, and promote them centrally (government/EC) funded research to target getting the U.K./Europe a world lead in those areas.
  - VR steering committees with good technical representation.
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# Visits to selected laboratories

In order to experience first hand the work in progress at some leading VR institutions the authors visited three sites. The number was constrained principally by the limited time available. The places visited were the University of Edinburgh Department of Psychology, the University of Nottingham Communications Research Group and Queen Mary and Westfield College Computer Science Department. We present brief reports of these visits here by way of background to some of the work currently underway in the U.K..

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- Perception in Action Laboratories, University of Edinburgh
  - University of Nottingham Communications Research Group
  - Queen Mary and Westfield College, University of London
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## Perception in Action Laboratories, University of Edinburgh

The Perception in Action Laboratories at the University of Edinburgh Department of Psychology uses virtual reality primarily as a means of investigating human perception and movement.

The department has a history of psychological research on the perception of visual stimuli associated with motion. In particular, the Edinburgh 'swinging room' experiment [22] is widely known -- the subject stands inside a room in which the walls can be made to swing back and forth, with respect to the observer's fixed viewpoint. Participants quickly lost their ability to balance under such conditions, suggesting that visual information is of primary importance to the perception of body motion.

One way in which VR has been applied is to assess the relative importance of visual stimuli in estimating the rate at which discrete objects approach the observer. In one experiment, the user is instructed to catch a virtual ball as it approaches the head. The system allows specific depth information to be included or omitted, such as the ball's apparent angular size, and/or the effects of binocular disparity. Without a VR-based system, such experimentation would be difficult.

A major research programme is the development of a car driving simulator to assess a user's steering and braking behaviour. VR allows a wide variety of test conditions and speeds to be assessed safely. Experiments are aimed at assessing the user's understanding of visual motion stimuli (both forwards and turning movements) and the ability of the user to act in controlling such motions using braking and steering behaviours.

Another issue under investigation is the (possibly damaging) effects of head-mounted display (HMD) devices on the user's perceptual abilities immediately following the immersion experience. Preliminary results indicate that there is some degradation in (visual) perceptual performance, and that this effect is not simply due to the limited fidelity of current display technologies. These results have caused controversy in some circles, but have recently been supported by subsequent, independent, research carried out by other groups.

The VR laboratory itself is well equipped in comparison with most academic research groups. Both immersive (HMD) and non-immersive VR viewing is supported, the latter being achieved using a large rear-projection screen with Barco projector. Graphics-enhanced PCs are used as image generators, and a selection of 3D interaction devices are also available. One particularly unusual piece of equipment is a (partial) Ford Fiesta car, which is used as a specialised 'input device' for investigating driving skills, as described above.

The laboratory personnel include two full-time research associates, two members of academic staff and, approximately fifteen undergraduate and postgraduate students.

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## University of Nottingham Communications Research Group

The Nottingham Group we visited is based in the Department of Computer Science. (A separate group -- the AIMS Group -- exists in the Department of Mineral Resources Engineering.) The main focus of the group's work is Computer Supported Cooperative Working, and current research has grown out of earlier projects in this field, such as COMIC. They are partners in the VIRTUOSI project which is exploring the use of virtual reality environments for office work -- the `virtual office'. Other partners are the Swedish Institute of Computer Science (SICS -- originators of the DIVE system used in this work), Lancaster University, British Telecom and Division. This work is funded under the EPSRC/DTI CSCW Initiative.

Specific aspects of the group's work demonstrated to us included distributed processing between Sun and SGI workstations, multiple participants in a virtual environment, simple techniques for navigation, and methods for establishing effective control of communication between multiple participants. Their system features dynamic display of 3D environments and transmission of sound (voice) from one user to others. The notion of an aura is used to control the degree to which sounds made by objects in the environment can be heard by the participants. Thus, as a user approaches an object, the sound emitted by that object becomes audible. An interesting idea was that of a podium -- a space which a user could move to if they wished to address the other participants. The demonstration also included facilities for interacting via a simple alphanumeric screen, used to present a plan view of the world, as well as full 3D displays.

The group has a variety of software products (see listing in Appendix [□](#)), but the DIVE system is the basis of the VIRTUOSI work. Although they have a Division 3D mouse and an Eyegen-3 HMD, at the time of the visit little use had been made of these. The HMD was driven from an SG Indigo machine, but to provide the required NTSC signals necessitated losing the use of the main workstation screen whilst the HMD was in use. The output to the HMD in this mode was monoscopic, but the group anticipated buying a suitable stereoscopic output board. This illustrates the kind of difficulty faced by many groups in interfacing different peripherals and machines.

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## Queen Mary and Westfield College, University of London

The QMW group have a variety of Silicon Graphics and Division equipment. The Division stations include two fully immersive setups. Whilst engaged in a variety of VR-related activities, a central theme is that of "body centred interaction" involving an in-depth study of the role of the body in the virtual environment, and its relationship to the psychological experience of presence. This is based on the principle that, if presence is central to the immersive experience, then a key facet of that experience will be the embodiment of the user within the virtual world. Interesting experiments have been devised to test this hypothesis, and to quantify its outcome. The importance of various parameters are being studied - one example being that of auditory versus visual stimulus, with a novel way of quantifying their relative importance for given participants.

A novel emphasis is that of whole body gestures, which stands in contrast to the current preoccupation with hand-gesture techniques. Here, using only the conventional head and hand position sensors, gestures such as walking and scaling the size of the user are achieved with reference to whole body movements. These appear quite natural, and emphasise the role of the whole body within the virtual world. Other projects demonstrated to us at QMW include a study of the use of shadow queues; interactive specification of the VR interface from within the virtual world; a study of 3D air traffic control; the modelling of physical laws, and a design for a display system.

The general impression gained from visiting the laboratory is that of a laudable attempt to break away from paradigms rooted in 2D, iconic, modes of interaction, into a serious study of what appropriate alternatives exist for humans in a 3D virtual world.

The WWW page for the QMW group can be found at  
[http://www.dcs.qmw.ac.uk/steed/ResearchReport/rr/subsection3\\_2\\_1.html](http://www.dcs.qmw.ac.uk/steed/ResearchReport/rr/subsection3_2_1.html)

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# Observations and Recommendations

The information acquired during the survey is included in the appendices of this report so that interested readers are not disadvantaged in distilling their own conclusions. From our experience of conducting the survey we make the following observations.

Looking at the number of groups involved in different application areas reveals that there is a considerable spread of applications. Further analysis shows that this is matched by a diversity of systems and approaches used -- no clear preference of hardware and software or coordination of effort is evident. Nearly everyone is working independently and in different ways. Even where three or four groups report that they are interested in the same areas, such as CAD, architectural walkthrough, or medical imaging, there is little evidence of coordination or common approaches. In Appendix  we show a matrix indicating reported cooperation between different groups. It can be seen that the degree of interaction is relatively small.

Quite a high number of the respondents are working with few resources, and with only modest effort available. VR for demanding applications requires high-performance graphics and few groups have this. PCs are the most numerous hardware platform, but even among groups using Silicon Graphics many of the machines are Indys with only modest graphics speed. Most of the laboratories abroad whose work is reported in the literature are better equipped.

Much of the work in progress is concentrated on applications. The diversity of applications and systems suggests that there must be considerable duplication of effort in solving underlying problems. There seems relatively little activity devoted to these underlying system issues and software architectures. As long as VR is supported in a piecemeal manner in the U.K., this duplication of effort seems destined to continue.

A common plea is for more funding on VR research. VR requires an interdisciplinary approach, combining computer science, psychology, and application skills, and finding sources of funding for this kind of interdisciplinary research is very difficult.

At the present time, three of the world's leading VR companies are based in the U.K., and yet the overall picture across the country is that of enthusiastic but fragmented efforts, usually with minimal resourcing. If we are to remain competitive and build upon our current strengths then the clear recommendation must be that of better coordination and funding for the research that will be needed.



# Acknowledgments

As well as the respondents, to whom we express our thanks for their cooperation, we would like to thank Robin Hollands of the U.K. VR SIG for generously making his membership database available to us.

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# List of respondents

Aerobel Defence Technology Ltd  
Autodesk  
BNR Europe Limited Software and Systems Engineering  
British Aerospace (Ops.) Ltd., Sowerby Research Centre  
CADCentre Ltd  
Cheltenham & Gloucester College of Higher Education  
City University Centre for HCI Design  
Colt Virtual Reality  
Criterion Software Ltd.  
De Montfort University, Imaging and Displays Research Group  
Denne Developments Ltd  
Division Limited  
DRA Centre for Human Sciences  
Go Virtual Ltd  
Heriot-Watt University (Edinburgh) Manufacturing Systems Research Group  
Intelligent Systems Solutions Limited Virtual Environments Group  
Manchester Metropolitan University Department of Computing  
Middlesex University School of Geography and Environmental Management  
Mott MacDonald Computational Fluid Dynamics Group  
Napier University Dept of Computer Studies  
Primary Image Ltd  
Queen Mary and Westfield University of London Virtual Environments Research Group  
Rank Xerox EuroPARC  
Sheffield Hallam University Communication Information Research Group  
Swansea Institute of Higher Education Transformation Software Ltd  
University of Bath Virtual Manufacturing Group  
University of Belfast Control Engineering Research Group  
University of Wales College of Cardiff School of Psychology  
University of East Anglia Computational Geometry Project  
University of Edinburgh Interactive media technology research group  
University of Edinburgh Perception in Action Laboratories  
University of Essex Image Processing Group  
University of Hull Virtual Environment Research Centre (VERC)  
University of Leeds Virtual Working Environment Group  
University of Leicester Virtual Reality Research Group  
University of Loughborough Design Research Centre  
University of Manchester Advanced Interfaces Group  
University of Nottingham AIMS Research Unit  
University of Nottingham Communications Research group  
University of Sheffield  
University of Sheffield Silicon Reality Group (SRG)  
University of Southampton Human Factors Research Unit  
University of Strathclyde  
University of Wolverhampton  
Virtek International Corporation  
Virtual Presence Ltd  
Virtual Reality Applications Research Team (VIRART)  
Virtual `S`  
Virtuality Group Plc  
Westland System Assessment Limited

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# Reported Cooperations

This figure shows the reported cooperations between groups who responded to the survey. It can be read horizontally and vertically, the vertical columns being aligned with the end of the group names. In some cases groups reported cooperation with organisations who did not respond to the survey, but the number of cases in this category is very small. The picture which emerges is one of small-scale collaboration.

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# Resources to support VR workers

This section lists the various resources which the survey respondents reported as their main sources of VR-related information.

- 
- Conferences
  - Journals
  - Organisations
  - Books
  - The Net
-

## Conferences

AIAA  
ATEI  
AVA  
Advanced Visual Interfaces Workshop  
BCS VR Applications events  
BIT VR  
CHI  
Eurographics U.K. Eurographics  
IAAPA  
IEE Colloquium  
IEEE R&A  
IEEE VRAIS  
ITEC  
Imagina  
Live 93  
Meckler VR shows worldwide  
SIGGRAPH  
SPIE  
UIST  
VR Ecpo (Meckler)  
VR User Show  
VRST

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## Journals

ACM Transactions on Graphics  
AI expert  
Aviation  
BIT  
CGW  
Communications of the ACM  
Computer Graphics Forum  
Computers and Graphics  
Cyberedge journal  
Electronics News  
HCI  
Human Factors and Ergonomics Society  
IEEE Computer Graphics & Applications  
IEEE Trans. on Systems, Man and Cybernetics  
International Journal of Man-Machine Studies  
Piz-Elation (VRASP)  
Presence  
SIGCHI  
SIGGRAPH  
Space and Environmental Medicine  
SPIE  
VR News  
VR User  
VRS Journal (forthcoming)  
Virtual Reality Expert  
Virtual Reality World  
Virtual (Italy)  
Visual Computer  
Wired

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## Organisations

Sheffield Virtual Reality Academic Group ([svirg@sheffield.ac.uk](mailto:svirg@sheffield.ac.uk)) Superscape User's Group

VR Society

VR SIG ([ukvrsig@mailbase.ac.uk](mailto:ukvrsig@mailbase.ac.uk))

VRASP (U.S.A.)

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## Books

Tufte, *Envisioning Information*.

*VR Playhouse*, Lavzoff, Waite Group Press, 1992.

*VR Intelligence Report -- VR Centre*,

*Virtual Reality Systems*, R.A. Earnshaw, M.A. Gigante, H. Jones (Eds.), Academic Press, 1993, 0-12-227748-1.

*Virtual Reality*, Howard Rheingold, Mandarin, 0-7493-0889-3.

*Virtual Worlds*, Benjamin Wooley, Penguin.

*VR Applications and Explanations*, Wexelblat, Academic Press, 0-12-745045-9.

*Virtual Worlds and Multimedia*, Thalmann & Thalmann, Wiley, 0-471-93972-2.

*VR Through the New Looking Glass*, Pimentel & Teixeira, McGraw-Hill, 0-8306-4064-9.

*Virtual Reality Madness*, Ron Wodaski, Sams, 0-672-30391-4.

Kalawsky.

*Glimpses of Heaven, Visions of Hell*, Sherman & Judkins, Coronet, 0-340-60155-8.

*The VR primer*, Larijani, McGraw-Hill, 0-07-036416-8.

*Garage VR*, Jacobson, Sams, 0-672-30270-5.

*Pictorial Communication in Virtual and Real Environments*, Ellis (ed),

Taylor & Francis, 0-7484-0082-6.

*Virtual Creations*, Stampe et al.

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## The Net

alt.3d  
alt.uu.virtual-worlds.misc  
comp.graphics  
comp.graphics.visualization  
comp.graphics.research  
comp.robotics  
sci.virtual-worlds  
sci.virtual-worlds.apps  
sgi.\*  
glove-list  
rend386-list  
www-vrml@wired.com  
ukvrsig@mailbase.ac.uk

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## Details of each respondent

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**Name of group:** Aerobel Defence Technology Ltd

**Contact name:** Nicholas Wrobel

**Address:** PO Box 90D, 356 West Barnes Lane, New Malden, Surrey, KT3 6JG

**Email:** --

**Tel:** 081 336 1733

**Fax:** 081 942 8909

**World Wide Web:** --

**Type of organisation:** Company research group..Software vendor/manufacturer.

**Number of personnel in VR group:** 4

**Backgrounds of group members:** Engineering

**Time actively involved in VR work:** Since 1991

**Sources of funding:** Company, MOD, Industry

**Major focus of VR work:** Application development using commercial off-the-shelf equipment.

**Application areas:** Design, MMI, impact on environment, training.

**Collaborations with other groups or organisations:** Coryphaeus Software, Inc. (California), software vendor.

**VR-related hardware and software facilities used:** Silicon Graphics computers (networked), designer's workbench suite of software tools, own software add-ons to above, peripherals/controllers etc.

**Styles of VR interaction techniques employed:** Joystick (3 axis), mouse and touchscreen, sound (3D spatialised sources)

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**Name of group:** Autodesk

**Contact name:** Nick Manning

**Address:** **Email:** nick@adeskgb.autodesk.com

**Tel:** 0483 303322

**Fax:** 0483 304556

**World Wide Web:** --

**Type of organisation:** Software vendor/manufacturer.

**Number of personnel in VR group:** 1 (UK), 20 (USA)

**Backgrounds of group members:** Marketing (UK), Development (USA)

**Time actively involved in VR work:** Since 1988

**Sources of funding:** Company.

**Major focus of VR work:** VR software.

**Application areas:** CAD.

**Collaborations with other groups or organisations:** Division

**VR-related hardware and software facilities used:** VR software toolset to enable software developers to create application based around Autodesk geometry on a PC.

**Styles of VR interaction techniques employed:** From a simple mouse and VGA screens up to a full immersive system.

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**Name of group:** BNR Europe VR Lab

**Contact name:** Tony Plant

**Address:** BNR Europe Limited, London Road, Harlow, Essex, CM17 9NA.

**Email:** T.A.Plant@bnr.co.uk

**Tel:** 0279 402109

**Fax:** 0279 402047

**World Wide Web:** --

**Type of organisation:** Company research group.

**Number of personnel in VR group:** 4

**Backgrounds of group members:** Computer Science, Telecomms Engineering.

**Time actively involved in VR work:** Since 1994

**Sources of funding:** Company.

**Major focus of VR work:** Application development: telecoms equipment installation planning, telecoms network planning, design and presentation, software architecture/design visualisation, CATV service user interfaces.

**Application areas:** Installation layout and configuration planning, Software Visualisation, Network Visualisation.

**Collaborations with other groups or organisations:** Corporate Design Group, BNR: Ergonomics, Psychology, BNR Product Design: Telecomms Engineering, NT European Transmission Systems: Network planning and design, Intelligent Systems, Salford: VR, Simulation, Ergonomics, Psychology, Imperial College.

**VR-related hardware and software facilities used:** 486 PC, Pentium PC, Notebook PC, Spaceball, Superscape VRT 3.5 (access to SGI Onyx, dVS and dVISE).

**Styles of VR interaction techniques employed:** Non-immersive (screen-based).

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**Name of group:** British Aerospace Display Interaction, Human Factors Department

**Contact name:** Karen Carr

**Address:** British Aerospace (Ops.) Ltd., Sowerby Research Centre, FPC 267, PO Box 5, Filton, Bristol, BS12 7QW

**Email:** carr@src.bae.co.uk

**Tel:** 0272 366259

**Fax:** 0272 363733

**World Wide Web:** --

**Type of organisation:** Company research group

**Number of personnel in VR group:** 7

**Backgrounds of group members:** Psychology, Computer Science, Ophthalmology, Human Factors, Vision Science, Audiology

**Time actively involved in VR work:** Since 1987

**Sources of funding:** Company

**Major focus of VR work:** Basic human factors for a broad range of applications, but especially CAD, visualisation, rapid prototyping. We aim to provide specifications for VR hardware and software for specific applications, and also to develop tools for evaluating VR.

**Application areas:** See above.

**Collaborations with other groups or organisations:** University of Cardiff (Psychology and Optometry), UCL (Psychology), University of Durham (Psychology), University of West of England (Computer Science), Interface Technology Research Ltd (Bristol).

**VR-related hardware and software facilities used:** Various experimental rigs for studying specific components of VR, eg. variable configuration head-mounted display; optical rigs for stereo studies and accommodation studies also Division VPX, various HMDs, LCD shuttering goggles for desktop stereo, Ball graphics engine (ex-Megatek 944), Real World graphics cards, data glove, Exos Dextrous Handmaster, Private Eye.

**Styles of VR interaction techniques employed:** Direct manual

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**Name of group:** CADCentre Ltd.

**Contact name:** Paul Elton

**Address:** High Cross, Madingley Road, Cambridge, CB3 0HB

**Email:** --

**Tel:** 0223 314848  
**Fax:** 0223 65737  
**World Wide Web:** --

**Type of organisation:** CADCentre is a software vendor providing engineering products to the process plant industry.

**Number of personnel in VR group:** 1--2 in general

**Backgrounds of group members:** Engineering and Computer Science

**Time actively involved in VR work:** Since 1994

**Sources of funding:** Company / customer

**Major focus of VR work:** Developing a VR application for the walkthrough of process plants (oil rigs, power plants etc.)

**Application areas:** Our application area is producing software for the design of process plant. Our main product is PDMS (Plant Design Management System) which is the world's leading application for plant design. REVIEW is our plant visualization system to which we are adding a VR capability.

**Collaborations with other groups or organisations:** University of Manchester, Silicon Graphics Ltd., Division Ltd.

**VR-related hardware and software facilities used:** We currently have a SGI Onyx Reality Engine graphics computer with stereo goggles. We are in the process of acquiring a HMD, tracker and 6-DOF input device.

**Styles of VR interaction techniques employed:** Presently stereo viewing only.

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**Name of group:** Cheltenham & Gloucester College of Higher Education

**Contact name:** Mike Brooks

**Address:** Virtual Reality Exploration Group, Cheltenham & Gloucester College of Higher Education, Francis Close Hall, Swindon Road, Cheltenham, GL50 4A2

**Email:** --

**Tel:** 0242 532889

**Fax:** --

**World Wide Web:** --

**Type of organisation:** University research group.

**Number of personnel in VR group:** 3

**Backgrounds of group members:** Hardware engineer and graphics design, programmer/mathematician, Computer Science

**Time actively involved in VR work:** Since May 1994

**Sources of funding:** Currently on our faculty budget -- close to zero.

**Major focus of VR work:** Awareness of rapidly increasing significance of VR, and our institution's plan to offer a new degree programme including VR. Consequently at present our group is simply exploring what other people are doing in VR and what its commercial state is.

**Application areas:** Initial exploration of the current state of VR

**Collaborations with other groups or organisations:** --

**VR-related hardware and software facilities used:** --

**Styles of VR interaction techniques employed:** --

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**Name of group:** City University Centre for HCI Design

**Contact name:** Ivor Benjamin

**Address:** Centre for HCI Design, Department of Business Computing, City University, Northampton Square, London EC1V 0PB

**Email:** i.d.benjamin@city.ac.uk

**Tel:** 071 477 8000 x 4033 (not there often!), 071 254 7313 (ansaphone)

**Fax:** 071 477 8586

**World Wide Web:** --**Type of organisation:** University research group.**Number of personnel in VR group:** 3**Backgrounds of group members:** Systems Design, AI, Linguistics, Theatre.**Time actively involved in VR work:** Since 1993.**Sources of funding:** EPSRC, University.**Major focus of VR work:** HCI.**Application areas:** Entertainment.**Collaborations with other groups or organisations:** --**VR-related hardware and software facilities used:** In the process of setting up a PC-based lab, with dataglove and HMD**Styles of VR interaction techniques employed:** Intend to investigate gestural and voice input.

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**Name of group:** Colt Virtual Reality**Contact name:** Tim Martin**Address:** New Lane, Havant, PO9 2LY.**Email:** tim@coltvr.demon.co.uk**Tel:** 0705 451111**Fax:** 0705 454220**World Wide Web:** --**Type of organisation:** Software vendor/manufacturer, end user**Number of personnel in VR group:** 7**Backgrounds of group members:** Manufacturing Engineering, Physics, Computer Science, Mechanical Engineering, Industrial Controls**Time actively involved in VR work:** Since 1992**Sources of funding:** Company and various grants/collaboration.**Major focus of VR work:** Development of software products for the construction industry.**Application areas:** Simulated people management, fluid dynamics and CAD.**Collaborations with other groups or organisations:** --**VR-related hardware and software facilities used:** Superscape VRT3 running on 486 PC's, Explorer on SGI Iris.**Styles of VR interaction techniques employed:** Spaceball.

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**Name of group:** Criterion Software Ltd.**Contact name:** Mike King**Address:** Criterion Software Ltd., 20, Alan Turing Road, Guildford, Surrey, GU2 5YF**Email:** mking@criterion.canon.co.uk**Tel:** 0483 448800**Fax:** 0483 574360**World Wide Web:** --**Type of organisation:** Software vendor/manufacturer, end user**Number of personnel in VR group:** 10**Backgrounds of group members:** Computer Science**Time actively involved in VR work:** Since 1991**Sources of funding:** Company research group.**Major focus of VR work:** Software multimedia tools (3D Rendering).**Application areas:** Interactive 3D rendering.**Collaborations with other groups or organisations:** --

**VR-related hardware and software facilities used:** --

**Styles of VR interaction techniques employed:** --

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**Name of group:** De Montfort University, Imaging and Displays Research Group

**Contact name:** Ian Sexton

**Address:** Dept of Computing Science, De Montfort University, The Gateway, Leicester LE1 9BH.

**Email:** sexton@dmu.ac.uk

**Tel:** 0533 577498

**Fax:** 0533 541891

**World Wide Web:** <http://www.cms.dmu.ac.uk/Research/IDRG/idrg>

**Type of organisation:** University research group.

**Number of personnel in VR group:** 4--8

**Backgrounds of group members:** Computer Science, Computer Engineering, Electronics, Ergonomics.

**Time actively involved in VR work:** Since 1990

**Sources of funding:** DMU and British Industry.

**Major focus of VR work:** Stereoscopic and Autostereoscopic display systems. Monocular and binocular Eye-tracking as means of interaction in 2D/3D. 3-D interaction techniques.

**Application areas:** CAD, Design Visualisation, 3DTV, Remote inspection.

**Collaborations with other groups or organisations:** Dept of Communication, Wayne State University, Detroit USA. Vision & lighting research group, Dept. of Human Sciences, Loughborough University of Technology. We are not at liberty to disclose some of our collaborators

**VR-related hardware and software facilities used:** Prototype lenticular autostereoscopic displays, Prototype parallax barrier autostereoscopic display, Prototype ferroelectric liquid crystal dynamic parallax barrier display, Spaceball, Tektronix Polarising LCD Shutter, Tektronix LC shutter glasses, 2 x SEGA LC shutter glasses, Parallaxscope, 4 Mattel PowerGloves. RenderWare Software Developer's Kit.

**Styles of VR interaction techniques employed:** --

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**Name of group:** Denne Developments Ltd

**Contact name:** Phillip Denne

**Address:** D.D.L., Unit 4, Cedar Trade Park, Ferndown Industrial Estate, Wimborne, Dorset BH21 7SB.

**Email:** --

**Tel:** 0202 861661

**Fax:** 0202 861233

**World Wide Web:** --

**Type of organisation:** Equipment vendor/manufacturer.

**Number of personnel in VR group:** 6

**Backgrounds of group members:** Physics, Electronic Engineering, Mechanical Engineering, electronics, industrial control, Mathematics, Simulation

**Time actively involved in VR work:** Since 1988 (Simulation since 1985)

**Sources of funding:** Customers.

**Major focus of VR work:** Virtual motion systems.

**Application areas:** Active and passive simulator motion bases, human-movement interactive control of experiences.

**Collaborations with other groups or organisations:** 150 clients worldwide.

**VR-related hardware and software facilities used:** Motion hardware.

**Styles of VR interaction techniques employed:** --

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**Name of group:** Division Limited

**Contact name:** Pierre duPont, Marketing Director

**Address:** 19 Apex Court, Woodlands, Almondsbury, Bristol BS12 4JT

**Email:** dupontp@division.demon.co.uk

**Tel:** 0454 615554

**Fax:** 0454 615532

**World Wide Web:** --

**Type of organisation:** Equipment vendor/manufacturer and software vendor/manufacturer

**Number of personnel in VR group:** Approx.\ 60 people world-wide, in all functions of the company. Growing rapidly, so this number will probably change by 50\% before the end of 1994.

**Backgrounds of group members:** Mostly Computer Science

**Time actively involved in VR work:** The company was founded in 1989, and began work on VR software and hardware almost immediately.

**Sources of funding:** Commercial enterprise. However, we are also involved in a number of DTI-sponsored and EC-sponsored projects.

**Major focus of VR work:** Application development; VR hardware and VR software development.

**Application areas:** <

**Collaborations with other groups or organisations:** Many, either as customers, or as joint recipients of a DTI or EC project. Examples include Glaxo Group Research, the University of York, Queen Mary Westfield, Thorn EMI, Reading University, Nottingham University, Salford University, Coventry University, etc

**VR-related hardware and software facilities used:** ProVision 100; SGI Onyx and Indigo; dVS; dVISE.

**Styles of VR interaction techniques employed:** Immersive, and also flat-screen, with both stereo (CrystalEyes) and mono.

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**Name of group:** DRA Centre for Human Sciences

**Contact name:** Mrs E C Regan

**Address:** DRA Centre for Human Sciences, F131, Farnborough, Hants, GU14 6TD

**Email:** anderson%psi%apre.decnet@ccint1.rsre.mod.uk

**Tel:** 0252 394729

**Fax:** 0252 76507

**World Wide Web:** --

**Type of organisation:** Government Research Institution.

**Number of personnel in VR group:** 3

**Backgrounds of group members:** Psychology, computer science.

**Time actively involved in VR work:** Since 1993

**Sources of funding:** Government agency.

**Major focus of VR work:** Establishing human factors standards for displays and tracking systems. Some application development.

**Application areas:** Battlefield simulation.

**Collaborations with other groups or organisations:** --

**VR-related hardware and software facilities used:** Division Provision 200 and Provision 100 systems. Virtual Research flight helmet, and N-vision high resolution CRT-based helmet, both fitted with Polhemus trackers. Division 3D mouse (also Polhemus tracker).

**Styles of VR interaction techniques employed:** Immersive display, with natural or mouse-mediated movement.

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**Name of group:** Go Virtual Ltd

**Contact name:** Mark Anders

**Address:** Go Virtual Ltd, Hamilton House, 111 Marlowes, Hemel Hempstead, Herts HP1 1BB

**Email:** --  
**Tel:** 0442 233030  
**Fax:** 0442 212142  
**World Wide Web:** --

**Type of organisation:** Company.

**Number of personnel in VR group:** 3

**Backgrounds of group members:** Retail marketing and general business, sales, LAN.

**Time actively involved in VR work:** Since 1992.

**Sources of funding:** Ongoing business.

**Major focus of VR work:** To provide Virtual Reality to solve communications problems. Go Virtual provides Virtual Reality services to clients, mostly in the marketing industry, including VR consultancy on the best way to use VR, rental of equipment and commission of program changes (e.g., to include a logo) or bespoke VR experiences.

**Application areas:** Marketing events (e.g., product launches), exhibitions, conferences, training.

**Collaborations with other groups or organisations:** Virtual 'S', software programmers.

**VR-related hardware and software facilities used:** Two Division PV200 systems (one 1-user, one 2-user) using flight helmets, Polhemus tracking, sound samplers.

**Styles of VR interaction techniques employed:** Full immersion.

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**Name of group:** Heriot-Watt University Manufacturing Systems Research Group

**Contact name:** Mr James Ritchie

**Address:** Dept of Mechanical Engineering, Heriot-Watt University, Riccarton, Edinburgh EH14 4AS

**Email:** James\_Ritchie@mech.hw.ac.uk

**Tel:** 031 449 5111

**Fax:** 031 451 3129

**World Wide Web:** --

**Type of organisation:** University research group.

**Number of personnel in VR group:** 6

**Backgrounds of group members:** Engineering, mathematics

**Time actively involved in VR work:** Since 1993

**Sources of funding:** University, Foreign Post Graduates.

**Major focus of VR work:** Research into software applications and VR applications.

**Application areas:** Collision detection for VR. VR mechanical assembly planning and knowledge elicitation (the latter is at the 'RG2' stage with EPSRC).

**Collaborations with other groups or organisations:** Division, AT&T (formerly NCR), Dundee.

**VR-related hardware and software facilities used:** Division Provision 100 VR system with 3D mouse and helmet.

**Styles of VR interaction techniques employed:** Those developed by Division. If EPSRC grant goes ahead we will buy a dataglove.

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**Name of group:** Intelligent Systems Solutions Limited Virtual Environments Group

**Contact name:** Professor Robert J Stone

**Address:** Intelligent Systems Solutions Limited (formerly Advanced Robotics Research Limited, University Road, Salford, M5 4PP.)

**Email:** rjs@arrc.salf.ac.uk

**Tel:** 061 745 7384

**Fax:** 061 745 8264

**World Wide Web:** --



**Type of organisation:** Company research group. (main), University research group. (secondary). I am also visiting Professor with the University of Salford's Surveying Department (VR/Construction group).

**Number of personnel in VR group:** 4

**Backgrounds of group members:** Psychology, Ergonomics, Electronics, Software & Computer Science, Engineering.

**Time actively involved in VR work:** Since 1985 (Stone), since 1989 (ARRL/ISSL).

**Sources of funding:** ISSL: Virtual Reality and Simulation Initiative (14 companies, Department of Health/Wolfson Foundation, DRA, CEC. University: EPSRC, Department of Environment.

**Major focus of VR work:** Applications, systems integration, VR peripherals (especially tactile feedback), human factors.

**Application areas:** Many and varied.

**Collaborations with other groups or organisations:** Many and varied.

**VR-related hardware and software facilities used:** Silicon Graphics Reality Engine, Iris, Suns, PCs, ARRL Laser Rangefinder, Macrospeak, Flock of Birds and Fastrack trackers, DataGlove, CyberGlove, MultiGen, ModelGen, video, LCD stereo projector, Spaceball, Sense8, AutoCAD, Alias, robot vehicle, etc.

**Styles of VR interaction techniques employed:** Desktop (SuperScape VRT), desktop VR and multimedia, Projection VR (2D/3D), fully immersive, glove (cyberglove) or ISSL 'Commander' hand controller.

**Name of group:** Manchester Metropolitan University Department of Computing

**Contact name:** Dr William Mitchell

**Address:** Department of Computing, Manchester Metropolitan University, John Dalton Building, Chester Street, Manchester, M1 5GD

**Email:** billy@sun.com.mmu.ac.uk

**Tel:** 061 247 1493

**Fax:** --

**World Wide Web:** --

**Type of organisation:** University research group.

**Number of personnel in VR group:** 2 lecturers

**Backgrounds of group members:** Computer Science

**Time actively involved in VR work:** Since 1993

**Sources of funding:** Internal funding.

**Major focus of VR work:** VR application development.

**Application areas:** Simple architectural walk-throughs (pilot project now completed), simulation of physiological processes for HE (just starting)

**Collaborations with other groups or organisations:** Department of Biological Sciences, MMU.

**VR-related hardware and software facilities used:** 486 PCs (66 MHz) REND-386, WorldToolkit for Windows.

**Styles of VR interaction techniques employed:** Due to resource limitations using desktop VR with mouse/joystick.

**Name of group:** Middlesex University School of Geography and Environmental Management

**Contact name:** Mr Ifan D H Shepherd

**Address:** Middlesex University, Queensway, Enfield, Middlesex EN3 4SF

**Email:** ifan1@middlesex.ac.uk

**Tel:** 081 362 5388

**Fax:** 081 805 0702

**World Wide Web:** --

**Type of organisation:** University research group.

**Number of personnel in VR group:** 3

**Backgrounds of group members:** Geography, Geographical Information Systems, Remote Sensing, Data Visualization.

**Time actively involved in VR work:** Since 1993

**Sources of funding:** HEFCE.

**Major focus of VR work:** Adaptation for geographical data visualization.

**Application areas:** Data visualization

**Collaborations with other groups or organisations:** --

**VR-related hardware and software facilities used:** SuperScape, Pentium (P90) PC.

**Styles of VR interaction techniques employed:** Mouse (considering DataGlove).

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**Name of group:** Mott MacDonald Computational Fluid Dynamics Group

**Contact name:** Dr Norman Rhodes

**Address:** St Anne House, 20--26 Wellesley Road, Croydon CR9 2UL.

**Email:** nr2@mottmac.co.uk

**Tel:** 081 686 5041

**Fax:** 081 681 5706

**World Wide Web:** --

**Type of organisation:** Engineering consultants.

**Number of personnel in VR group:** 3

**Backgrounds of group members:** Mechanical Engineering, computer animation.

**Time actively involved in VR work:** Since 1993

**Sources of funding:** Internal.

**Major focus of VR work:** Application development.

**Application areas:** Evacuation and safety.

**Collaborations with other groups or organisations:** --

**VR-related hardware and software facilities used:** --

**Styles of VR interaction techniques employed:** --

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**Name of group:** Napier University Dept of Computer Studies

**Contact name:** Peter Johnson

**Address:** Dept. Computer Studies, Napier University, 219 Colinton Road, Edinburgh

**Email:** vrprj@uk.ac.napier.dcs

**Tel:** --

**Fax:** --

**World Wide Web:** --

**Type of organisation:** University research group.

**Number of personnel in VR group:** As yet we don't have a formal VR research group. However, there are 5 people (myself included) doing work in VR. This includes some core VR research, object editing in 3D, and database visualisation. We are also in the process of preparing an introductory course in VR.

**Backgrounds of group members:** Computer Science, Psychology.

**Time actively involved in VR work:** Since 1992

**Sources of funding:** Napier University.

**Major focus of VR work:** Software for VR.

**Application areas:** The preparation of a VR course. In addition, I'm currently looking at object behaviour and networked VR. Work is also being undertaken on database visualisation and object creation.

**Collaborations with other groups or organisations:** --

**VR-related hardware and software facilities used:** RenderWare 1.3.

**Styles of VR interaction techniques employed:** Non-immersive Windows interface with mouse interaction.

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**Name of group:** Primary Image Ltd

**Contact name:** Simon Skinner

**Address:** Lever House, 3 St James Road, Kingston Upon Thames, Surrey KT1 2BA

**Email:** --

**Tel:** 081 546 4908

**Fax:** 081 549 8035

**World Wide Web:** --

**Type of organisation:** Equipment vendor/manufacturer and Software vendor/manufacturer.

**Number of personnel in VR group:** 10 (approx.)

**Backgrounds of group members:** Mainly Computer Science and Electronic Engineering.

**Time actively involved in VR work:** Since 1992.

**Sources of funding:** Company (private venture) and Government Agency (USA and UK).

**Major focus of VR work:** Image generation system, non-immersive for simulation and training.

**Application areas:** None in particular, but simulation and training for military applications is most of our work.

**Collaborations with other groups or organisations:** --

**VR-related hardware and software facilities used:** Own product 'Stride', PC-based image generator plus associated tools.

**Styles of VR interaction techniques employed:** Control platform, laser aiming devices, position trackers (Science Accessories Corp.).

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**Name of group:** QMW University of London Virtual Environments Research Group

**Contact name:** Mel Slater

**Address:** Dept of Computer Science, QMW University of London, Mile End Road, London E1 4NS

**Email:** mel@dcs.qmw.ac.uk

**Tel:** 071 975 5242

**Fax:** 081 980 6533

**World Wide Web:** --

**Type of organisation:** University research group.

**Number of personnel in VR group:** 6

**Backgrounds of group members:** Computer Science

**Time actively involved in VR work:** Since 1992

**Sources of funding:** SERC/DTI/Private.

**Major focus of VR work:** Human-computer interaction -- understanding of people's responses to 'VR' and constructing interfaces based on this understanding. Building applications. Exploitation of parallel architectures.

**Application areas:** Architectural walkthrough, modeling.

**Collaborations with other groups or organisations:** Psychology, and medical sciences. Division PLC.

**VR-related hardware and software facilities used:** ProVision 200, ProVision 100 VX

**Styles of VR interaction techniques employed:** We have developed a paradigm called 'body centred interaction'. The idea of this is that presence is maximised when there is a match between proprioceptive feedback and sensory data.

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**Name of group:** Rank Xerox EuroPARC

**Contact name:** Matthew Chalmers

**Address:** Rank Xerox EuroPARC, 61 Regent Street, Cambridge CB2 1AB

**Email:** chalmers@europarc.xerox.com

**Tel:** 0223 341546

**Fax:** 0223 341525

**World Wide Web:** --

**Type of organisation:** Company research group.

**Number of personnel in VR group:** 1

**Backgrounds of group members:** Computer Science

**Time actively involved in VR work:** Since 1991.

**Sources of funding:** Company.

**Major focus of VR work:** Information visualization.

**Application areas:** Information visualization, document access/electronic libraries.

**Collaborations with other groups or organisations:** Informally, with miscellaneous people here: Bill Gaver (Psychology, soon to be at the Royal College of Art), and at PARC: natural Language Theory and Technology Group, User Interface Research Group.

**VR-related hardware and software facilities used:** Hardware: Sun SS2 with GX board, software: SICS DIVE.

**Styles of VR interaction techniques employed:** Mouse-based.

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**Name of group:** Sheffield Hallam University Communication Information Research Group

**Contact name:** Jonathan Grove

**Address:** Mundella House, Collegiate Crescent, Sheffield Hallam University, Sheffield, S10 2BP.

**Email:** J.M.Grove@SHU.ac.uk

**Tel:** 0742 532236

**Fax:** --

**World Wide Web:** --

**Type of organisation:** University research group.

**Number of personnel in VR group:** 2

**Backgrounds of group members:** Linguistics, Communication studies.

**Time actively involved in VR work:** Since 1992.

**Sources of funding:** University.

**Major focus of VR work:** Application development.

**Application areas:** Educational VR.

**Collaborations with other groups or organisations:** VIRART Virtual Reality Applications Team, Nottingham University.

**VR-related hardware and software facilities used:** We don't possess any VR technology at present, we are using the facilities and technical expertise of VIRART.

**Styles of VR interaction techniques employed:**

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**Name of group:** Swansea Institute of Higher Education Faculty of Electronic Engineering

**Contact name:** Martin Capey

**Address:** Faculty of Electronic Engineering, Swansea Institute of Higher Education, Mount Pleasant, Swansea SA1 6ED.

**Email:** --

**Tel:** 0792 481117

**Fax:** 0792 481117

**World Wide Web:** --

**Type of organisation:** Company Research Group, based within the Faculty of Electronic Engineering.

**Number of personnel in VR group:** 4

**Backgrounds of group members:** Optoelectronics, systems engineer, product design, fine art/management/data management.

**Time actively involved in VR work:** Since We are on the edge of becoming active!

**Sources of funding:** DTI Smart award.

**Major focus of VR work:** VR peripherals, particularly visual displays.

**Application areas:** Head-mounted displays, retinal scanning.

**Collaborations with other groups or organisations: --**

**VR-related hardware and software facilities used:** Apollo 715 workstations, PC platforms, SDRC 'I-DEAS' software, wavefront personal visualizer software.

**Styles of VR interaction techniques employed: --**

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**Name of group:** Transformation Software Ltd

**Contact name:** Ian Lazenby/Roger Morris

**Address:** Thame Park Road, Thame, Oxfordshire OX9 3UQ

**Email:** ilazenby@tswl.co.uk

**Tel:** 0884 261456

**Fax:** 0884 260056

**World Wide Web:** --

**Type of organisation:** Software distributor and hardware value-added retailer.

**Number of personnel in VR group:** 3

**Backgrounds of group members:** Computer Science, Royal Naval Warfare Officer, management.

**Time actively involved in VR work:** Since 1992

**Sources of funding:** Company

**Major focus of VR work:** Selling to VR companies.

**Application areas:** Silicon Graphics based VR, simulators, 3d visualization and modelling.

**Collaborations with other groups or organisations:** Intelligent Systems Solutions Ltd (INSYS), member of Virtual Reality and Simulation Initiative.

**VR-related hardware and software facilities used:** Multigen and Modelgen 3D modelling software, Vega, Audio Works image generation software and 3D sound software.

**Styles of VR interaction techniques employed: --**

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**Name of group:** University of Bath Virtual Manufacturing Group

**Contact name:** Dr Richard Taylor/Professor Phil Willis

**Address:** School of Mathematical Sciences/Mechanical Engineering, University of Bath, Claverton Down, Bath BA2 7AY

**Email:** rit@maths.bath.ac.uk

**Tel:** 0225 826975

**Fax:** 0225 826492

**World Wide Web:** --

**Type of organisation:** University research group.

**Number of personnel in VR group:** 4

**Backgrounds of group members:** Electronic Engineering, Computer Science, Mechanical Engineering, Manufacturing, Mathematics

**Time actively involved in VR work:** Since 1992

**Sources of funding:** SERC (ACME).

**Major focus of VR work:** Software. Design by virtual manufacturing.

**Application areas:** Development of tools for virtual design and manufacturing.

**Collaborations with other groups or organisations:** We have industrial collaborators who do not wish to be named at this stage.

**VR-related hardware and software facilities used:** Silicon Graphics Reality Engine II, Crystaleyes Stereoscopic Glasses, Open Inventor 3D Toolkit, SVLIS Solid Modeller.

**Styles of VR interaction techniques employed:** 2D and 3D mice

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**Name of group:** University of Belfast Control Engineering Research Group

**Contact name:** Dr G Dodds

**Address:** School of Electrical Engineering and Computer Science, The Queen's University of Belfast, Ashby Building, Stranmillis Road, Belfast BT9 5AH.

**Email:** GI.Dodds@vax2.queens-belfast.ac.uk

**Tel:** 0232 2245133 x4086

**Fax:** 0232 667023

**World Wide Web:** --

**Type of organisation:** University research group.

**Number of personnel in VR group:** --

**Backgrounds of group members:** Electronic Engineering

**Time actively involved in VR work:** Since 1992

**Sources of funding:** Achieved funding includes EC, government research funds, company donations.

**Major focus of VR work:** Hardware for sensing and interfacing. Software for multi-arm robotic applications. Entertainment and disabled user aid. Compression for real-time transmission of 3D stereo data (3D MPEG) from server to client.

**Application areas:** See above.

**Collaborations with other groups or organisations:** Mechanical Engineering (QUB) for visualization.

**VR-related hardware and software facilities used:** Silicon Graphics Indy RD4600, dVise software, Liquid Image HMD, CrystalEyes stereoscopic glasses interfaced to PC, in-house force sensing, Polhemus motion detection, 3Ball mouse, rend386, workspace 3.0 and avril.

**Styles of VR interaction techniques employed:** VR interaction -- image, force, head motions, sound (future), position sensing and mouse.

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**Name of group:** University of East Anglia Computational Geometry Project

**Contact name:** Professor A R Forrest

**Address:** University of East Anglia, School of Information Systems, Norwich NR4 7TJ.A

**Email:** forrest@sys.uea.ac.uk

**Tel:** 0603 592605

**Fax:** 0603 507720

**World Wide Web:** --

**Type of organisation:** University research group.

**Number of personnel in VR group:** 8

**Backgrounds of group members:** Mechanical Engineering, Mathematics, Computer Science

**Time actively involved in VR work:** Since 1990.

**Sources of funding:** EPSRC studentships, University, Apple U.K. and U.S.

**Major focus of VR work:** Peripherals, application developments, non-immersive VR, visualization.

**Application areas:** Visualization, design, human interfaces.

**Collaborations with other groups or organisations:** --

**VR-related hardware and software facilities used:** Apple Quadra 950 x2, Silicon Graphics Indy x2, Korg synthesiser.

**Styles of VR interaction techniques employed:** Non-immersive VR exploiting sound and touch.

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**Name of group:** University of Edinburgh Interactive media technology research group

**Contact name:** Derek Nicoll

**Address:** RM.\ B16, Dept. of Psychology, Edinburgh University. 7, George Sq., Edinburgh, EH8 9JZ

**Email:** ejuv19@festival.ed.ac.uk

**Tel:** 031 650 3454

**Fax:** --

**World Wide Web:** --

**Type of organisation:** University research group.

**Number of personnel in VR group:** Variable (1--5).

**Backgrounds of group members:** Psychology.

**Time actively involved in VR work:** Since 1990

**Sources of funding:** ESRC.

**Major focus of VR work:** Hardware or software architectures, VR peripherals, application development, etc.)

**Application areas:** None but interests in emotional iconography.

**Collaborations with other groups or organisations:** --

**VR-related hardware and software facilities used:** --

**Styles of VR interaction techniques employed:** --

**Name of group:** University of Edinburgh Perception in Action Laboratories

**Contact name:** Rycharde Hawkes

**Address:** Virtual Environment Laboratory, Department of Psychology, University of Edinburgh, 7 George Square, Edinburgh EH8 9JZ

**Email:** rych@hagg.psy.ed.ac.uk

**Tel:** 031 650 3426

**Fax:** 031 650 6534

**World Wide Web:** --

**Type of organisation:** University research group.

**Number of personnel in VR group:** Two full-time Research Associates, Two academic staff, One associate optometrist, Numerous part-time under/post-graduate students.

**Backgrounds of group members:** Computer Science, Psychology, Vision Science and Movement Studies.

**Time actively involved in VR work:** Since 1991

**Sources of funding:** JCI (MRC) \* 2, SERC.

**Major focus of VR work:** Perception and action in natural and virtual environments.

**Application areas:** Driving simulation.

**Collaborations with other groups or organisations:** Computer Science Department, University of Edinburgh, Glasgow Caledonian University, Vision Sciences, Virtual Research, Virtuality, Astlee Ainsley Hospital, Edinburgh, Real World Simulation.

**VR-related hardware and software facilities used:** Network of 3-4 486/386 PCs, Super Reality II Image Generator, Reality3 Image Generator, Isotrak, Fastrak, Flock of Bird(s), Mice, joysticks, spaceball, instrumented car, instrumented bike, glove. Projection screens and BARCO projector, monitors, stereo monitor, VPL Eyephone LX (and occasional loans), QNX distributed real-time operating system, compilers etc., 3D Studio, misc. image processing software and home-grown VE support software.

**Styles of VR interaction techniques employed:** Non-immersive through the use of mono & stereo monitors, projection systems and immersive using HMDs. A variety of movement control devices have been tried including spaceball, mice, joysticks, instrumented car, instrumented bike.

**Name of group:** University of Essex Image Processing Group

**Contact name:** Dr Adrian F Clark

**Address:** Dept. Electronic Systems Engineering, University of Essex, Colchester, Essex CO4 3SQ

**Email:** alien@essex.ac.uk

**Tel:** 0206 872432

**Fax:** 0206 872900

**World Wide Web:** --

**Type of organisation:** University research group.

**Number of personnel in VR group:** 2

**Backgrounds of group members:** Physics, Electronic Engineering

**Time actively involved in VR work:** Since 1994

**Sources of funding:** Currently unfunded, though some of it is associated with an IED collaborative project.

**Major focus of VR work:** Developing a system for stereoscopic endoscopy, with VR controlling the gaze. This is currently at the 'proving the principle' stage.

**Application areas:** Endoscopy.

**Collaborations with other groups or organisations:** We are currently in discussion with a 'keyhole' surgeon and an endoscope manufacturer regarding collaboration.

**VR-related hardware and software facilities used:** Silicon Graphics workstations. Looking for suitable hardware for stereo viewing.

**Styles of VR interaction techniques employed:** As yet, only mouse-based -- rather unsatisfactory.

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**Name of group:** University of Hull Virtual Environment Research Centre (VERC)

**Contact name:** Dr R D Macredie

**Address:** Dept of Computer Science, University of Hull, Hull, HU6 7RX.A

**Email:** verc-info@dcs.hull.ac.uk

**Tel:** 0482 465910/5951

**Fax:** 0482 466666

**World Wide Web:** <http://web.dcs.hull.ac.uk/VERC>

**Type of organisation:** University research group.

**Number of personnel in VR group:** 8 (in the CS part of the VERC).

**Backgrounds of group members:** Computer Science

**Time actively involved in VR work:** Since 1992.

**Sources of funding:** We pursue funding through many avenues: EC, EPSRC(SERC), ESRC, DTI, ACME, Medical Charities, companies.

**Major focus of VR work:** Medical applications -- we use this to address what we see as central, fundamental challenges for VR.

**Application areas:** Medical applications, defence/military work, education and training.

**Collaborations with other groups or organisations:** Several organisations -- some are quite sensitive.

**VR-related hardware and software facilities used:** Silicon Graphics 310 VGX, 420 VGXT, Indys (on order), videosplitter, several Suns, PCs, Division HMD, Sense8, WTK, different trackers, VHCs, other modelling software, dVS, spaceball.

**Styles of VR interaction techniques employed:** Desktop (spaceball, mouse) and immersive (HMD, glove).

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**Name of group:** University of Leeds Virtual Working Environment Group

**Contact name:** Terrence Fernando

**Address:** University of Leeds, Leeds LS2 9JT

**Email:** ltpf@uk.ac.leeds.scs

**Tel:** 0532 335767

**Fax:** 0532 335468

**World Wide Web:** --

**Type of organisation:** University research group.

**Number of personnel in VR group:** 12

**Backgrounds of group members:** Computer Science, Engineering.

**Time actively involved in VR work:** Since 1991.

**Sources of funding:** University/Keyworth Institute and DTI.

**Major focus of VR work:** Application Development.



**Application areas:** Interactive Constraint-based Solid Modelling, Virtual Environment for Maintenance Simulation, Distributed Virtual Environment for Concurrent Engineering.

**Collaborations with other groups or organisations:** Keyworth Institute of Manufacturing and Information Systems Engineering, Department of Mechanical Engineering, University of Leeds.

**VR-related hardware and software facilities used:** SGI R4000 machines, Indy machines, Reality Engine, spaceball.

**Styles of VR interaction techniques employed:** We have developed constraint-based 3D interaction techniques for interacting with our solid models.

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**Name of group:** University of Leicester Virtual Reality Research Group

**Contact name:** Drs Nigel Foreman and Paul Wilson

**Address:** Department of Psychology, University of Leicester, University Road, Leicester LE1 7RH.

**Email:** for|pnw|@leicester.ac.uk

**Tel:** 0533 522169/522158

**Fax:** 0533 522067

**World Wide Web:** --

**Type of organisation:** University research group.

**Number of personnel in VR group:** 8

**Backgrounds of group members:** Psychology (sometimes have computing and engineering graduates).

**Time actively involved in VR work:** Since 1992

**Sources of funding:** Charity (Action Research), BT, European funds.

**Major focus of VR work:** Development of applications in Behavioural Sciences.

**Application areas:** Spatial research, spatial skills in man, perception.

**Collaborations with other groups or organisations:** Loose cooperation with various people, mutual interests with BT, and foreign groups in France and Russia.

**VR-related hardware and software facilities used:** 486 PCs mainly, enhanced for speed and graphics quality, SuperScape software, WorldToolKit for Windows, Renderware, dataglove, 3D spectacles; Also have access to head-immersion (liquid image headset, Polhemus).

**Styles of VR interaction techniques employed:** Desk-top keyboard, joystick, spaceball inputs plus devices produced in Russia to interface kids with handicaps, also access to head-immersion system.

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**Name of group:** University of Loughborough Design Research Centre

**Contact name:** Sean Clark

**Address:** Britannia Mill, Mackworth Road, Derby DE22 3BL.

**Email:** S.M.Clark@derby.ac.uk

**Tel:** 0332 622222x4044

**Fax:** 0332 622218

**World Wide Web:** <http://dougal.derby.ac.uk/DRC>

**Type of organisation:** University research group.

**Number of personnel in VR group:** Only 2 out of 15 have a direct interest in VR.

**Backgrounds of group members:** Computer Science, Art and Design, Colour Science.

**Time actively involved in VR work:** Since 1991.

**Sources of funding:** Range of sources inc. internal funds.

**Major focus of VR work:** HCI.

**Application areas:** VR in art and design.

**Collaborations with other groups or organisations:** LUTCHI Research Centre

**VR-related hardware and software facilities used:** Macs with multimedia equipment and 3D modeller. PC with REND386, PowerGlove, Shutter Glasses etc.

**Styles of VR interaction techniques employed:** Our work is in an early stage and we are still investigating this.

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**Name of group:** University of Manchester Advanced Interfaces Group

**Contact name:** Dr Roger Hubbard

**Address:** Department of Computer Science, University of Manchester, Oxford Road, Manchester M13 9PL

**Email:** hubbold@cs.man.ac.uk

**Tel:** 061 275 6158

**Fax:** 061 275 6236

**World Wide Web:** <http://www.cs.man.ac.uk/aig/aig.html>

**Type of organisation:** University research group.

**Number of personnel in VR group:** 4 academic staff, approximately 12 postgraduate and 10 undergraduate students.

**Backgrounds of group members:** Computer Science, Engineering.

**Time actively involved in VR work:** Since 1991

**Sources of funding:** University, EPSRC/ACME

**Major focus of VR work:** research into the use of advanced human-computer interfaces such as Virtual Reality and stereo displays, for the solution of real-world problems.

**Application areas:** Visualisation of volume data, especially 3D medical images (in conjunction with the University Medical School and local teaching hospitals); The development of a VR interface for a large CAD system (in a collaborative project with CADCentre, Cambridge); Generation of high resolution 3D images (in a collaborative project with Sharp Research Laboratories, Oxford); A variety of undergraduate and postgraduate projects ranging from playing virtual musical instruments to VR interfaces for computer animation.

**Collaborations with other groups or organisations:** See above.

**VR-related hardware and software facilities used:** High-performance Silicon Graphics workstations, a pair of Sharp large screen video projectors for stereoscopic projection, a head-mounted display, 3D mice based on Polhemus magnetic trackers, and a stereo sound system using a MIDI interface. The Silicon Graphics screens also support stereo display using LCD shutter glasses.

**Styles of VR interaction techniques employed:** Immersive, using a HMD, 3D interaction using magnetic trackers and 3D mice, stereo glasses and large-screen displays.

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**Name of group:** University of Nottingham AIMS Research Unit

**Contact name:** Dr Damian Schofield

**Address:** Dept. of Mineral Resources Engineering, University of Nottingham, University Park, Nottingham NG7 2RD

**Email:** aims@vmel.ccc.nottingham.ac.uk

**Tel:** 0602 514094

**Fax:** 0602 678494

**World Wide Web:** --

**Type of organisation:** University research group.

**Number of personnel in VR group:** 8 PhD students, 1 Post Doc, 1 Academic. Staff in the AIMS Unit: 1 full-time PhD student on VR, 2 others work part-time on the projects.

**Backgrounds of group members:** Most have engineering backgrounds. Recently taken on a mathematician and a computer scientist.

**Time actively involved in VR work:** Since October 1994

**Sources of funding:** University funded, and proposals into EPSRC and EC for larger amounts of funding.

**Major focus of VR work:** Application development in Minerals industry.

**Application areas:** Minerals industry, risk assessment in underground situations, opencast visualization and planning, oli rig abandonment scenarios.

**Collaborations with other groups or organisations:** JDS Drilling Services (consultancy), British Coal (Group Headquarters), IMCL (Consultants).

**VR-related hardware and software facilities used:** PC equipment: fast, large monitors and graphics cards, Superscape VRT V3.5, purchasing World Toolkit shortly.

**Styles of VR interaction techniques employed:** Large screens, joysticks and mice, SoundBlaster and speakers.

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**Name of group:** University of Nottingham Communications Research group

**Contact name:** Dr Steve Benford

**Address:** Dept or Computer Science, University of Nottingham, Nottingham NG7 2RD

**Email:** sdb@cs.nott.ac.uk

**Tel:** 0602 514203

**Fax:** 0602 514254

**World Wide Web:** <http://web.crg.cs.nott.ac.uk/>

**Type of organisation:** University research group.

**Number of personnel in VR group:** 6 (strictly VR)

**Backgrounds of group members:** Computer Science, engineering.

**Time actively involved in VR work:** Since 1992

**Sources of funding:** COMIC - ESPRIT III, EC project, Virtuosi - SERC/DTI CSCW initiative, Virtual Classroom - Ropa grant, EPSRC, Phobia Investigations - Medical Research Council, GIS project - NERC.

**Major focus of VR work:** software architectures, applications, metaphors of interaction.

**Application areas:** Information visualization, CSCW. Visualising data spaces as populated information terrains, developing VR architecture to support large scale populated worlds of interaction.

**Collaborations with other groups or organisations:** Lancaster University - Computing and Sociology Departments Swedish Institute of Computer Science (SICS), Manchester University, Nottingham Trent University, BICC, British Telecom, Division, GPT (these are with the COMIC and Virtuosi projects mainly)

**VR-related hardware and software facilities used:** Hardware: SGI Indigo 2 Extreme, Division IPU, Eyegen 3 HMD, 2 SGI Indy's, Sun Sparc 10 51/ZX, 2 486 DX2's running Linux/Dos, 2 Sun Sparc 1's, Spaceball. Software: DIVE (from SICS), dVS (from Division), WorldToolKit, Superscape, Multiverse, MR toolkit.

**Styles of VR interaction techniques employed:** Desktop and immersive.

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**Name of group:** University of Sheffield

**Contact name:** Dr Neil Mort

**Address:** Department of Automatic Control & Systems Engineering, University of Sheffield, PO Box 600, Mappin Street, Sheffield, S1 4DU.

**Email:** n.mort@sheffield.ac.uk

**Tel:** 0742 825559

**Fax:** 0742 731729

**World Wide Web:** --

**Type of organisation:** University research group.

**Number of personnel in VR group:** Varies (around 5).

**Backgrounds of group members:** Engineering.

**Time actively involved in VR work:** Since 1992.

**Sources of funding:** --

**Major focus of VR work:** Application development and appraisal.

**Application areas:** Industrial and medical.

**Collaborations with other groups or organisations:** --

**VR-related hardware and software facilities used:** Homebrew hardware \& software, PC with VRT, WTK for DOS, Jack.

**Styles of VR interaction techniques employed:** --

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**Name of group:** University of Sheffield Silicon Reality Group (SRG)

**Contact name:** Rob Yates

**Address:** Department of Electronic and Electrical Engineering, University of Sheffield, Mappin Street, Sheffield, S1 3JD.

**Email:** svirg@sheffield.ac.uk

**Tel:** 0742 825146

**Fax:** 0742 726391

**World Wide Web:** --

**Type of organisation:** University research group.

**Number of personnel in VR group:** 5

**Backgrounds of group members:** Electronic Engineering, Electronic and computer systems engineering, Computer Science, Architecture, Physics. <

**Time actively involved in VR work:** Since 1992

**Sources of funding:** Departmental.

**Major focus of VR work:** VR peripherals, hardware and software architecture.

**Application areas:** --

**Collaborations with other groups or organisations:** Sheffield Virtual Reality Academic Group (SViRG)

**VR-related hardware and software facilities used:** Glove, HMD under design, 486 DX4 PC @100 MHz.

**Styles of VR interaction techniques employed:** Direct hand manipulation and gesture-based UI.

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**Name of group:** University of Southampton Human Factors Research Unit

**Contact name:** Richard So (Research staff), Prof. M.J. Griffin (Head)

**Address:** Human Factors Research Unit, Institute of Sound and Vibration Research, University of Southampton, Southampton SO17 1BJ.

**Email:** rhys@isvr.soton.ac.uk

**Tel:** +44 (0)703 592853

**Fax:** +44 (0)703 593033

**World Wide Web:** --

**Type of organisation:** University research group.

**Number of personnel in VR group:** 17 Research staffs and 2 involved with VR research.

**Backgrounds of group members:** Physics, Electronics Eng., Mechanical Eng., Ergonomics, Psychology, Acoustic Eng.

**Time actively involved in VR work:** Since 1987.

**Sources of funding:** Government agency.

**Major focus of VR work:** Human factors research.

**Application areas:** Head aiming, head tracking, effects of vibration, effects of lag.

**Collaborations with other groups or organisations:** Defence Research Agency, United States Air Force.

**VR-related hardware and software facilities used:** A 17x17 see-thru' monocular CRT HMD, a 50 diameter see-thru' binocular CRT HMD, 2 magnetic head trackers, 1 eye tracker and a Silicon Graphics 4D-50G workstation.

**Styles of VR interaction techniques employed:** Head-coupled immersive.

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**Name of group:** University of Strathclyde

**Contact name:** Dr A Retik

**Address:** Dept. of Civil Engineering, University of Strathclyde, 107 Rottenrow, Glasgow G4 0NG

**Email:** a.retik@strath.ac.uk

**Tel:** 041 552 4400(3429)

**Fax:** 041 553 2066

**World Wide Web:** <http://www.strath.ac.uk/Departments/Civeng/webpers.html>

**Type of organisation:** University research group.

**Number of personnel in VR group:** 3

**Backgrounds of group members:** Civil Engineering, Computer Science, Information Science.

**Time actively involved in VR work:** Since 1993

**Sources of funding:** SERC, University

**Major focus of VR work:** Application development.

**Application areas:** Construction planning and scheduling, design coordination.

**Collaborations with other groups or organisations:** `Virtual Construction Team' from Dept. of Civil Engineering, Carnegie Mellon University, Pittsburgh, PA, USA.

**VR-related hardware and software facilities used:** PC 486/50 MHz, 20 Mb RAM, joystick, SuperScape VRT 3-50, 3D studio.

**Styles of VR interaction techniques employed:** Non-immersive desktop and projection.

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**Name of group:** University of Wales College of Cardiff School of Psychology

**Contact name:** Roy Ruddle

**Address:** School of Psychology, University of Wales College of Cardiff, PO Box 901, Cardiff, CF1 3YG

**Email:** ruddle@cardiff.ac.uk

**Tel:** 0222 874007

**Fax:** 0222 874858

**World Wide Web:** --

**Type of organisation:** University research group.

**Number of personnel in VR group:** 5+

**Backgrounds of group members:** Psychology, Computing and Engineering

**Time actively involved in VR work:** Since 1992

**Sources of funding:** DRA and University of Wales (Cardiff)

**Major focus of VR work:** Research into a wide variety of cognitive aspects of virtual (ie. 3D) environments

**Application areas:** Human workload when using multiple displays Cognitive aspects of virtual worlds

**Collaborations with other groups or organisations:** None (currently -- is probably about to change.)

**VR-related hardware and software facilities used:** SGI Crimson RE, HMD, Audio lab, PC-HMD system.  
Software: in house expertise + SGI OGL + Performer

**Styles of VR interaction techniques employed:** Currently purchasing various (ie. mouse/keyboard + glove, 3d mouse + custom built)

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**Name of group:** University of Wolverhampton

**Contact name:** Dr. J. Crellin

**Address:** School of Computing and Information Technology, University of Wolverhampton, Wulfruna Street, Wolverhampton, WV1 1SB

**Email:** cm1942@ccub.wlv.ac.uk

**Tel:** 0902 322203

**Fax:** 0902 322680

**World Wide Web:** --

**Type of organisation:** PhD Supervision in a related area.

**Number of personnel in VR group:** 4 people interested in this area.

**Backgrounds of group members:** Computer Science, Psychology.

**Time actively involved in VR work:** Since 1994

**Sources of funding:** Company funded research project.

**Major focus of VR work:** Interface metaphors for representation of 3D CAD objects.

**Application areas:** CAD.

**Collaborations with other groups or organisations:** --

**VR-related hardware and software facilities used:** Work primarily on 'desktop' VR.

**Styles of VR interaction techniques employed:** Mouse and command, other IO devices under consideration at the moment.

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**Name of group:** Virtek International Corporation

**Contact name:** Phil Allsopp

**Address:** Barclay House, 35 Whitworth Street, Manchester, M1 5NG.

**Email:** phil@virtek.com

**Tel:** +44 (0)161 237 9929

**Fax:** +44 (0)161 237 5553

**World Wide Web:** --

**Type of organisation:** Software vendor/manufacturer.

**Number of personnel in VR group:** Currently 5.

**Backgrounds of group members:** Qualified Art Director, Engineer qualified to MSc, Mathematician qualified to MSc

**Time actively involved in VR work:** Since 1992.

**Sources of funding:** Private investments.

**Major focus of VR work:** VR Development Software/Consultancy.

**Application areas:** VR development software.

**Collaborations with other groups or organisations:** --

**VR-related hardware and software facilities used:** Software: our own system and many competitors products.

Hardware: the Forte HMD, the CyberMaxx HMD.

**Styles of VR interaction techniques employed:** Immersive and non immersive using standard input devices.

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**Name of group:** Virtuality Group Plc.

**Contact name:** T W Rowley

**Address:** Virtuality House, 3 Oswin Road, Brailsford Industrial Park, Braunstone, Leicester LE3 1HR.

**Email:** --

**Tel:** 0116 2337000

**Fax:** 0116 2471855

**World Wide Web:** --

**Type of organisation:** Equipment/software vendor/manufacturer.

**Number of personnel in VR group:** 110

**Backgrounds of group members:** Computer Science, Electronic Engineering, Graphics Design.

**Time actively involved in VR work:** Since 1984.

**Sources of funding:** Sales of VR products.

**Major focus of VR work:** Hardware and software architectures, special purpose peripherals, man/machine interfaces, VR worlds, applications.

**Application areas:** Entertainment, medical.

**Collaborations with other groups or organisations:** IBM: manufacture and sale of VR products, Sega: development of entertainment environments.

**VR-related hardware and software facilities used:** Several sorts of VR systems are manufactured, giving complete coverage of the range of facilities.

**Styles of VR interaction techniques employed:** Gloves, space joysticks, V-Flexors, head and hand trackers.

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**Name of group:** Virtual Presence Ltd

**Contact name:** Denise Haskew  
**Address:** 25 Corsham Street, London N1 6DR  
**Email:** denise@presence.demon.co.uk  
**Tel:** 071 253 9699  
**Fax:** 071 490 8968  
**World Wide Web:** --

**Type of organisation:** Equipment Vendor/Manufacturer, Software Vendor/Manufacturer.  
**Number of personnel in VR group:** 12  
**Backgrounds of group members:** Computer Science, Engineering, Marketing.  
**Time actively involved in VR work:** Since 1991.  
**Sources of funding:** Private company.  
**Major focus of VR work:** Systems configuration, applications development.  
**Application areas:** Industrial simulation, engineering, space simulation, underwater simulation, ergonomics, training, transport and logistics, CAD, art etc...  
**Collaborations with other groups or organisations:** --  
**VR-related hardware and software facilities used:** Full VR Lab containing: trackers, HMDs, workstations, toolkit software.  
**Styles of VR interaction techniques employed:** Magnetic, ultrasonic gloves and joysticks, 3D mice and spaceballs.

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**Name of group:** Virtual Reality Applications Research Team (VIRART)

**Contact name:** Dr Sue Cobb/Professor John Wilson  
**Address:** ons Management, University of Nottingham, University Park, Nottingham NG7 2RD.  
**Email:** epzjrw@unicorn.nott.ac.uk  
**Tel:** 0602 514070/514004  
**Fax:** 0602 514000  
**World Wide Web:** --

**Type of organisation:** University research group.  
**Number of personnel in VR group:** 6, plus student/research projects.  
**Backgrounds of group members:** Psychology, Ergonomics, Manufacturing Engineering, Computer Science, Theoretical Mechanics, Physics, Electronics.  
**Time actively involved in VR work:** Since 1991.  
**Sources of funding:** A variety of different sources for different projects, including research funding bodies (such as EPSRC), local and national charities and individual companies. Health and Safety Executive.  
**Major focus of VR work:** Applications research, development and testing. Usability/utility evaluations, health and safety research -- effects of VR on users.  
**Application areas:** Training and education (mainstream and special needs), manufacturing -- varied according to user requirements.  
**Collaborations with other groups or organisations:** Department of Learning Disabilities (Queens Medical Centre, University Hospital, Nottingham), and Centre for Augmentative and Alternative Communication (Charing Cross Hospital, London), Loughborough University.  
**VR-related hardware and software facilities used:** 3 486 PCs, Superscape VRT, 1 Apple macintosh Quadra, Virtus, Crystal Eyes, Syberscope.  
**Styles of VR interaction techniques employed:** Glove, spaceball, joystick, mouse.

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**Name of group:** Virtual `S' Ltd

**Contact name:** Ian Capon  
**Address:** `The Limes', 123 Mortlake High Street, Barnes, London SW14 8SN.  
**Email:** --

**Tel:** 081 391 9000  
**Fax:** 081 392 2424  
**World Wide Web:** --

**Type of organisation:** Software vendor/manufacturer.  
**Number of personnel in VR group:** 5  
**Backgrounds of group members:** Sales and marketing, Audio Engineering, Fine Art, Computer Software.  
**Time actively involved in VR work:** Since 1990.  
**Sources of funding:** Company.  
**Major focus of VR work:** Creating applications.  
**Application areas:** Sales and marketing, new products, visualization.  
**Collaborations with other groups or organisations:** Manufacturers.  
**VR-related hardware and software facilities used:** PCs, Apple Macintoshes, Division workstations.  
**Styles of VR interaction techniques employed:** Joystick/3D mouse.

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**Name of group:** Westland System Assessment Limited

**Contact name:** D A Griffith  
**Address:** Telec House, Goldcroft, Yeovil, Somerset BA21 4DQ.  
**Email:** --  
**Tel:** 0935 24545  
**Fax:** 0935 32864  
**World Wide Web:** --

**Type of organisation:** Defense Studies House  
**Number of personnel in VR group:** 6  
**Backgrounds of group members:** Army, Engineering, Physics, Design.  
**Time actively involved in VR work:** Since 1992.  
**Sources of funding:** Other defense companies, Defense Research Agency, non-defence-related companies, Ministry of Defense.  
**Major focus of VR work:** Application development.  
**Application areas:** Sales and marketing, defense study work, loading/packaging studies, site visualization.  
**Collaborations with other groups or organisations:** Superscape Limited.  
**VR-related hardware and software facilities used:** Superscape VRT, spaceball, 3D studio (for textures), IBM-compatible PCs, SPEA monitor and FGA4 graphics card.  
**Styles of VR interaction techniques employed:** Desktop -- PC-based, non-immersive, control by spaceball, joystick, mouse, SpaceMouse, keyboard.

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# References

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## References

- 1 Tom Meyer and Al Globus. Direct manipulation of isosurfaces and cutting planes in virtual environments. Technical Report CS-93-54, Brown University, RI, USA, December 1993.
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# The Survey Questionnaire

## **SURVEY OF VIRTUAL REALITY ACTIVITY IN THE UNITED KINGDOM**

**on behalf of the Advisory Group on Computer Graphics (AGOCG)**

**The Advanced Interfaces Group at the University of Manchester has been commissioned by the Advisory Group on Computer Graphics (AGOCG) to conduct a survey of current activity in the field of Virtual Reality in the United Kingdom.**

**AGOCG is an initiative of the Joint Information Systems Committee of the Higher Education Funding Councils and the Research Councils.**

***(We are trying to contact as many VR workers as possible, so please forgive us if you have received than one copy of this announcement, from different sources.)***

# The Survey

The aim of the survey is to obtain an accurate profile of who is doing what in the field in the UK, including:

- Groups conducting research into VR, its applications, and related fields
- Vendors of commercial VR hardware and software products
- End-users of VR hardware and software

The results of the survey will contribute to AGOCCG's advisory activity in this area, and will be widely disseminated, published as an AGOCCG Technical Report in September 1994 and will be available to all UK academic and industrial VR workers. This is an excellent opportunity for workers in the field to find out exactly who's doing what, where.

Please note: we have tried to make this questionnaire as concise as possible, because we know your time is valuable. Where the questions (and suggested types of answer) are not directly appropriate to your group, please feel free to answer in whatever way you feel is most appropriate. If you do wish to make any detailed responses, these will be appreciated, and carefully attended to.

Please return the completed questionnaire, by post, fax or email, and address any queries you may have, to:

Toby Howard (UK VR Survey)  
Advanced Interfaces Group, Department of Computer Science  
University of Manchester, Oxford Road, Manchester M13 9PL  
Email: [toby@cs.man.ac.uk](mailto:toby@cs.man.ac.uk)  
Tel:+44 61-275-6274, Fax:+44 61-275-6236  
World Wide Web: <http://www.cs.man.ac.uk/aig/aig.html>

We thank you for your cooperation in this survey, and we look forward to being able to share the results with you.

## The Questionnaire

**(This questionnaire is available as a PostScript document, on an anonymous ftp site [m1.cs.man.ac.uk](ftp://m1.cs.man.ac.uk), as `/pub/toby/questionnaire.ps`. Log in as user 'anonymous', giving your full email address as password.)**

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# A. ABOUT YOUR GROUP

1. Name of your group:

Contact name:

Address:

Email:

Tel: Fax:

World Wide Web:

2. Type of organisation:

University research group

Company research group

Equipment vendor/manufacturer

Software vendor/manufacturer

End user

Government research institution

Other (please specify)

3. How many people work in your VR group?

4. Please list the backgrounds of the members of your group (e.g., Computer Science, Psychology, Engineering, etc.)

5. How long have you been actively involved in VR work?

6. How is your work funded? (e.g., EC, EPSRC, Company, Government agency, etc.)

7. What is the major focus of your work on VR? (e.g., hardware or software architectures, VR peripherals, application development, etc.)

8. Please list any other groups or organisations (and their disciplines) with whom you collaborate.

9. What application areas are you actively involved in?

10. What are the main benefits of VR, which you consider important?

11. Please list your publications in the area of VR. It would also be very helpful to us if we could receive copies of these.

*(Please continue on a separate sheet if necessary)*

12. If your project is concerned with constructing a working VR system, please answer the next three questions:

12a. How well developed is your work in terms of demonstrable systems?

12b. What level of functionality are you aiming at for the system?

12c. How long do you think it will be before your work would come to fruition as a marketable product?

## **B. VR TECHNOLOGY**

13. Please describe the VR-related facilities you possess (hardware and software).

14. What styles of VR interaction techniques do you employ?

15. How do you expect VR technology to progress in the future?

16. On what assumptions for future VR technology are you basing your work?



## **C. FURTHERING VR RESEARCH AND DEVELOPMENT IN THE UK**

17. What do you consider the importance and significance of research in VR in the U.K.?

18. How do you think work on VR in the U.K. can best be assisted? For example, what specific initiatives or activities do you think would be helpful?

## D. KEEPING INFORMED

19. How do you keep up to date with developments in VR?

Conferences (please specify)

Journals (please specify)

Books (please specify)

Internet lists (please specify)

USENET newsgroups (please specify)

Local VR Special Interest Groups (please specify)

UK VR Special Interest Group

The VR Society

Other (please specify)

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## **E. THIS SECTION IS FOR SUPPLIERS ONLY**

20. How many people does your company employ in VR-related activity?

21. What is the size of your market for VR-related products?

22. What end-user areas have you sold equipment into (e.g., CAD, medical, games, etc.)?

23. We would be grateful to receive information and product literature on any VR-related products you supply.

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# FURTHER INFORMATION OR COMMENTS

Please use this space to provide any additional information, or make any comments about your work, VR in general, activity in the UK, etc.

Thank you for taking the time to complete this survey, and good luck with your work in VR.

Please return the completed questionnaire, and address any queries you may have, to:

Toby Howard (UK VR Survey)

Advanced Interfaces Group, Department of Computer Science

University of Manchester, Oxford Road, Manchester M13 9PL

Email: [toby@cs.man.ac.uk](mailto:toby@cs.man.ac.uk)

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