Integrated Project on Interaction and Presence in Urban Environments

FP6-2004-IST-4-27571

ipcity.eu

Final Project Progress Report Phase 4

Project Phase 4

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Abstract

The periodic activity report is submitted after each reporting period as defined by Article 6 of the contract (once per year for IPs). It is based on relevant information from Annex I of the contract.

This periodic activity report covers phase 4 of the IPCity project, i.e. the months 37-51. It consists of a publishable project executive summary, describes the main objectives of the project comparing them to the state of the art and summarizes the specific objectives, achievements and problems of the project within the fourth project phase individually for each work package as well as from a management point of view. It further highlights other important project-related aspects and finishes with an overview of the recent dissemination activities.

Publishable Executive Summary

IPCity

Integrated Project on Interaction and Presence in Urban Environments

IPCity explores new technologies that enable interactive cross-media experiences in urban environments.

Mixed Reality technologies are used to enhance the user's real environment by virtual objects creating a highly dynamic interactive environment featuring more experimental and intuitive forms of interaction with digital information.

Application areas include but are not limited to urban planning, large-scale events, pervasive games, and digital storytelling.

Research Activities

Cross-Reality Presence and Experience

The original contribution of IPCity to research on presence and interaction in mixed reality environments is that it studies the relationship between presence and user experience in real settings, focusing on how users actively construct and co-construct this experience through connecting activities in the digital/virtual space with activities in the real/physical environment. The main attention point is on users' purposeful activities in MR environments – how they collaborate, dynamically enact ('dramatic presence'), and map activities and events. Our research focuses on complex 'Mixed Realities' that emerge from the combination of multiple displays and spaces, including the most interesting element of MR, the real world. We argue that presence research that is meaningful for MR needs a broader conceptual framework, which encompasses traditional perceptual elements of Presence, but has an emphasis on Social Presence, affordances, beliefs and longitudinal effects. We also make a shift of attention away from psycho-physiological studies coming from a laboratory experiment tradition, towards an ecological-cultural approach that is applicable in real world situations and relies on ethnographic rather than fully controlled methods. During the lifetime of the project a concept map was developed and evaluated using empirical approaches, the result of the concept map during the final phase was a set of guidelines for urban mixed reality systems.

Cross-Reality Authoring and Interaction Tools

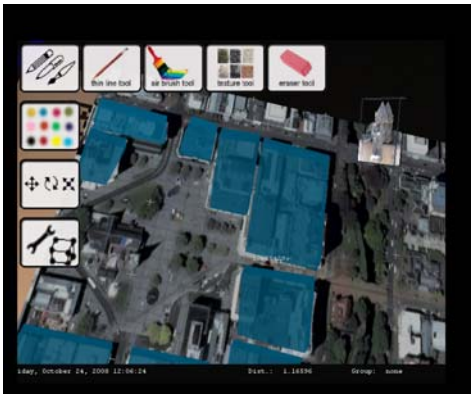
Mixed reality systems require a coherent development approach that encompasses tools to simplify technical development and those to support content creation. From a development perspective this area of work focuses on: cross-platform device access, platform independent user interfaces and interaction prototyping. Tools to support content creation are also being developed. In the last phase of the project we have mostly evaluated (and to some degree fine tuned) the previously developed technologies. Furthermore, the main focus

in the last phase was on making best use of the various technologies in the showcases (and consequently most reported aspects are in the showcases).

The Re-design Interaction Flow of the Colour Table

(AuthOr) now used extensively i.e. within the TimeWarp showcase

MapLens in use with a paper map



UrbanSketcher improvements, i.e. 2D Menu overlay for tool selection

MMC development: now supports stories with multiple types of media files, includes a Radar view for viewing location based stories (Kerro Tarina means Tell-a-Story)

Improved interaction design to assist participants to navigate through time

Next Generation Mixed Reality Infrastructure

Mixed reality (MR) infrastructure is focusing on basic research of mobile devices and their specifics to realize MR applications in urban environments. Mobile settings in this context can vary in scale between light-weight systems such as smart phones or sub-notebooks, and semi-stationary devices such as high-end equipment in the MR tent.

The work on infrastructure explores a range of issues including the suitability of different mobile devices, challenges in enabling AR on these devices, the creation of suitable MR content and the integration and fusion of available mobile tracking technologies. In the last phase of the project, the infrastructure was used in the showcases, and enhancements/adjustments of the infrastructure were made in direct response to short-term needs occluding the showcase work.

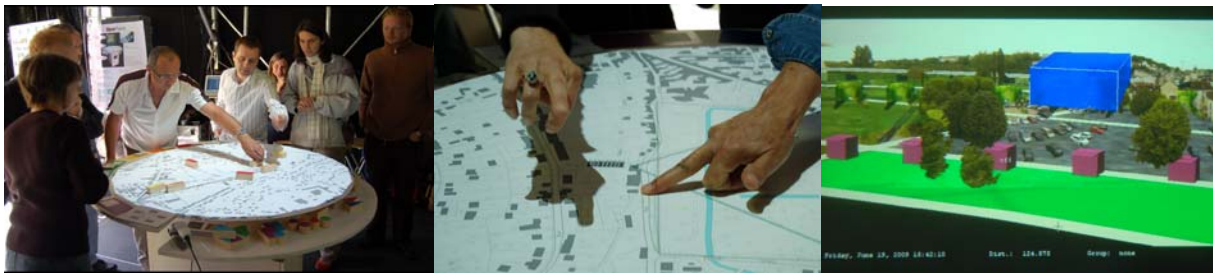
Design of the Mixed Reality Tent with Mobile Device Integration

The mobile scouting system in use outside the Mixed Reality Tent

Application Areas

Showcase 1: Urban Renewal

Mixed reality presents an ideal way for urban planners and architects to envision proposed changes on-site. Research in this work package focuses on developing technology prototypes that allow urban planning teams to create visual scenes and soundscapes, mesh these scenes with representations of the real environment, as well as debate, change, and annotate these configurations. Key challenges deal with interaction issues as well as representation issues to support the collaborative construction of MR scenes within the scope of real life urban renewal projects.



Urban Renewal Showcase: Collaborative creation of MR scenes

Showcase 2: Environmental Awareness

In this the fourth year this showcase's focus continued to address environmental awareness. This year the demonstrators were refined technically, content-wise and through trials and interaction design focus to improve upon the initial re-designs of the CityWall and MapLens demonstrators to address this brief.

Environmental Awareness showcase demonstrators: improved robust MapLens and CityWall in redesign for working interaction design solution

Showcase 3: TimeWarp

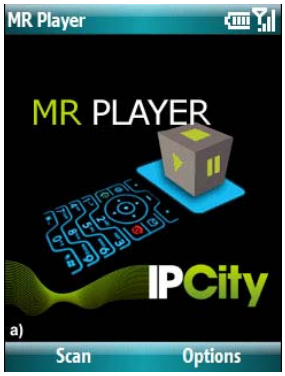
TimeWarp is an outdoor Mixed Reality game that allows the player to travel through time in the city of cologne. The story of the game is about some fictitious historical characters which are trapped in different time periods. Two players have to rescue together these little elves by solving challenges which are situated at different locations in the city. Collaboration is a significant element of the game and both players assume different roles and carry a UMPC device.

Players illustrating the collaborative aspects of TimeWarp

Showcase 4: City Tales

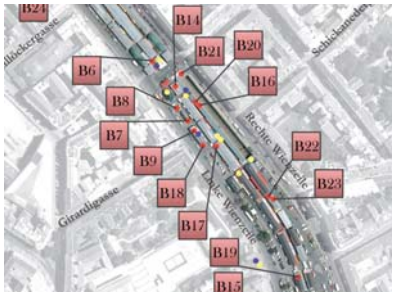
Based on the success of Phase III the work package 9 refocusing yielded to the end of the project a complete new server/client based infrastructure for story-telling in Mixed Reality

environments. A number of prototypes for mobile mixed reality clients, user interfaces and a complete server system to organise location based mixed reality content have been developed and field tested with a mixture of different content and use scenarios.



MR-Player client with localization based content retrieval

In field tests with users



Author created stories with interconnecting content

Further Information

IPCity is partially funded by the European Commission as part of the sixth framework (FP6-2004-IST-4-27571).

For further information regarding the IPCity project please visit the project web site at:
ipcity.eu

If you have any questions, do not hesitate to send an email to:
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1 Project Objectives and Major Achievements during the Reporting Period

1.1 Overview of general project objectives and relation to state-of-the-art

1.1.1 Detailed scientific and technological objectives

Presence is essentially the feeling of being in a real or virtual environment, although research has also explored other media such a film, television and books. At its most broad level sense of presence is the feeling of "being somewhere", where that experience is real enough to give the person a true sense of being at a given location and possibly with others. As a result such a wide definition has encouraged a lively debate and consequently many different approaches being adopted.

The emergence of mixed reality interfaces, since the mid nineties, has opened up new areas of presence research. While virtual reality (VR) refers to the experience of users who are immersed in a virtual computer generated world, mixed reality attempts to mix virtuality (virtual objects or worlds) with the physical world. Researchers have considered a wide range of mixed reality interfaces, from augmented reality to augmented virtuality. Augmented reality (AR) can be implemented using a range of strategies, ranging from where the user´s view is augmented (e.g. with a see-through head-mounted display, HMD) or augmenting a physical object (e.g. embedding devices in physical objects), through to augmenting the physical environment surrounding, users and objects (e.g. by projecting images and record remotely). In general people associated mixed reality with the first approach, this naturally leads to a lack of understanding. However, augmented virtuality (AV) at the other end of the spectrum refers to augmenting a virtual world with information obtained from the real world (e.g. haptic interfaces etc.). Mixed reality interfaces represent a new area for presence research which will no doubt result in the emergence of new theories, measurement methods and applications. One of the central aspects of this new medium is the addition of virtual objects to real world environments.

The IPCity project intends to investigate mixed reality in real settings, i.e., away from laboratories and in real life situations, where the physical, social and cultural environment are constantly changing. This is achieved by focusing on challenging and original showcases that are based around urban life and social gatherings such as: large scale events, urban renewal, urban exploration ("time warp"), and city tales. These address, in distinctive ways various dimensions of presence that have surfaced in research e.g. physical presence (including immersion, engagement and involvement) and social presence (feeling of being present with others).

The approach within IPCity extends current research on presence and interaction in mixed reality with three types of contributions that are explained in this section: 1) new MR technologies and applications, 2) extending the understanding of presence and ways to support it (conceptual and instrumental contribution), 3) developing ways to investigate presence and experience for MR (methodological contribution).

Mixed reality technologies and applications. In order for MR technologies to evolve to a point where they can be used outside laboratories requires a number of objectives to be met:

- **An environment for MR interaction prototyping,** supporting easy creation and evaluation of new interaction mechanisms.
- **Achieving device abstraction and independency** through flexible and adaptable interfaces. A user interface description language allowing for platform and device independent user interface definitions.

- **Developing a platform and toolkit for cross reality content authoring**. Efficient and manageable tools for cross reality content creation accommodating different production models and workflows, (e.g. also tools for end user-content creation).
- **Configurable infrastructures** covering the widest range from wearable equipment to tangible computing environments. Supporting real life situations with a wide choice of MR tools from head worn displays to tangible environments to support group work.
- **Semi-stationary outdoor mixed reality environment**. We envision a semi-stationary (or semi-portable) structure for outdoor use that exploits the features of the surrounding physical environment.

Conceptual and instrumental contributions. The original contribution of IPCity to research on presence and interaction is that it studies the relationship between presence and user experience in real settings, focusing on how users actively construct and co-construct this experience through connecting activities in the digital/virtual space with activities in the real/physical environment. The main attention point is on users' purposeful activities in MR environments – how they collaborate, dynamically enact ('dramatic presence'), and map activities and events.

Our particular conceptual attention points are also shaped by insights from urban studies on salient features of the material environment that contribute to the experience of presence on the one hand, are resources for constructing and co-constructing this experience on the other hand:

- *Spatial aspects* - MR technologies can be used for changing the scale of virtual objects, hence immersiveness, for making invisible objects (borders, archaeology, infrastructure) visible;
- *Temporal aspects* - such as for example making traces of the past visible, envisioning future development or the evolution of an event;
- *Mobility* - urban rhythms play a large role in experiencing a city, such as differences between day and night as well as flow and movement (of people, traffic);
- *Ambience* – includes all forms of sensations and imaginations about the environment surrounding the person resulting in a ‚sense of place and culture';
- *Material aspects* - contribute to the *engaging* the capacity of objects to absorb people's attention, thereby increasing their engagement with each other and the world and they are sources of 'reality' and 'haptic directness'.
- MR technologies and the focus on user activity and experience also require to extend our understanding of how these are supported by interface mechanisms. Our hypothesis is that virtual components modify the experience of the 'here and now' in subtle ways rather than altering it radically. Our main aim is to find out how technologies can be used to support interesting and relevant modifications of the 'here and now'. This necessitates a redefinition of the concept of directness, immersion, and reality on the one hand. It directs attention to:
- *Awareness cues* – cues about social interactions, communication, and activity in an MR environment;
- *Content* – used for building a visual scene or for story-telling can be informative, expressive, based on rules and constraints and is crucial for the experience of presence;

- *Multimodality* – involving all the senses through dynamic representations, the inclusion of sound, and particular representational techniques (fuzziness, abstraction).

Methodological contribution. IPCity develops an approach to investigating presence in real life settings which combines common methods like presence questionnaires with techniques for use in the field such as: participatory workshops, ethnographic observation, interaction analysis, and usability tests. Qualitative and quantitative methods will be integrated to account for cognitive and socio-cultural aspects in particular combining:

- spatial and social presence questionnaires , with the emphasis on understanding aspects which relate to mixed reality and how this can be used to inform the design process
- interaction analysis based on video recordings and interface interaction logs
- mobile experiments which may use methods such as video recording, in-situ interviews etc, in order to understand more about the experience of end users.
- Interviews examining specific areas as defined by prior findings e.g. technical issues or to explore wider aspects of place and presence.

1.1.2 Comparison to the state-of-the-art in MR technologies

Mixed Reality aims at enhancing a user's perception of the real world combining mobile computing using wearable computer set-ups, MR can create a 3D information space that lives around the user. The main technological aim of IPCity is to move high-quality MR a step further from labs to real settings. This requires innovation at several levels and therefore going beyond the state of the art:

- Development environments as reliable and efficient toolkits for prototyping applications are missing and needed to develop and test in short time frames diverse applications,
- Authoring environments as cross reality content production environments have not yet been addressed and need to support advanced features as device independence and different production models
- Infrastructures and platforms need to support a wide range of mixed reality approaches from wearable to semi-stationary environments.

Mobile AR was previously typically implemented using wearable computers coupled with a head mounted display. However this set-up has proven limited in many respects, not least due to the human-factors issues of making people wear bespoke clothing and carrying around hardware. Furthermore such equipment was often complex to set-up and prone to problems with battery-life. This has led to the emphasis moving to small lightweight solutions that will permit quick and easy access to experiences using comparatively low-cost hardware such as mobile phones, ultra mobile or tablet PC's. The primary different being that the latter often adopt a magic lens metaphor where a video stream of reality is augmented, rather than the see-through head-mounted display approach which often superimposes graphics directly into the user's line of sight.

Other problems include high quality tracking which is normally unavailable outdoors, since commercial systems require AC power and are stationary. Moreover, previous research systems for mobile AR have only used rudimentary collaboration features for fully mobile users, since it is significantly more difficult to build collaborative applications if no assumptions can be made about location, size, and other parameters of the user group.

In IPCity we have built several build high quality collaborative mixed reality systems which are wearable, portable and collaborative as portable (not only wearable) environments for

small groups to or even larger communities. The systems will uses diverse approaches to AR (not only head mounted displays), providing also embodied interaction and tangible interfaces. It will also rely relies on projection based AR for unencumbered access to the system for a rapidly changing user groups. To our knowledge, our notion of semi-stationary environments (for example a MR-Tent) is the first attempt to build a portable collaborative MR system. It is a carefully designed compromise between quality and mobility. Also the idea of building a semi-permanent structure to house the technology that can be set up, used and disassembled within a day has not been explored by previous work. All systems documented in the literature either aim at single-user fully wearable solutions, or stationary high quality environments.

There is some existing work (for example, in the MIT tangible media group) on AR or tangible interfaces for architectural design. The recently concluded ATELIER IST project, in which some of the consortium members participated, while experimenting with such interfaces in support of architectural design, did not explore 3D AR or mobile computing directly. The ARTHUR IST project implements 3D AR for architecture and urban planning, but is limited to a round table scenario. The 3DMURALE IST and ARCHEOGUIDE IST projects use augmented reality for reconstruction and presentation of ancient architecture in Europe. While our project is also grounded in the long tradition of architecture and archaeological reconstruction, this tradition - unlike urban renewal - does not require interactive modification of the presented artifacts.

We will also investigated the participation of mobile AR users and the possibilities of connecting their activities to those in the semi-stationary environments. The mobile users we envision will either be specialist are "scouts" with high-end mobile AR equipment, providing mobility in the surroundings (WP6), or ordinary citizens, using low-end devices primarily for informal browsing and interaction (WP9). Both types of interaction are technologically relatively new approaches, and have not been used in the context of architectural design in an urban context. The MARS project carried out by the computer science department at Columbia University investigates collaborative user interfaces for indoor and outdoor AR, but is mainly focused on text-based annotations and does not allow for a sophisticated visualization of construction plans. The *Tinmith-Metro* project at the Wearable Computer Laboratory, University of South Australia, allows viewing and construction of 3D graphical models in an outdoor environment but relies on a single high-end user interface. The types of user interfaces and interactions in IPCity will thus be subject of novel research.

Furthermore, we will develop have developed important enabling technology for MR, in particular displays mobile setups, touch based interfaces and tracking methods. Several prototypes of light weight HMDs will be developed and evaluated during the project. More robust tracking will be developed by fusing several complementary technologies and further developing selected technologies – mainly computer vision based methods.

Handheld devices seem to be a superior alternative for AR - especially for untrained users in unconstrained and non-supervised environments. They are more robust than HMDs and due to the advent of mobile phones and PDAs users are comfortable operating them. Even before the success of the smartphones as mass-marketed items, pioneering projects started using small displays for custom see-through devices. Amselem’s work and Fitzmaurice’s Chameleon used small tethered LCD displays for location based information. Rekimoto’s NaviCam used color-coded stickers to track objects in the environment. Due to the tethered trackers in these early works, the degree of mobility was rather limited. mPARD is a variant using analogue wireless video transmission to replace tethers.

The Transvision project by Sony CSL introduced handheld AR devices for a shared space. Researchers at HITLab later improved this concept with a better user interface and an optical tracking solution re-using the camera needed for video see-through.

From 2000 on, PDAs with wireless networking were considered suitable for thin-client solutions outsourcing computationally intensive tasks such as rendering, tracking and

application to a nearby workstation. The Batportal used non-mixed 3D graphics using VNC, while the AR-PDA project used digital image streaming from and to an application server. Shibata's work aims at load balancing between client and server - the weaker the client, the more tasks are outsourced to a server. ULTRA uses PDA for augmenting "snapshot" still images.

In 2003 Wagner ported ARToolKit to Windows CE and consequently developed the first fully self-contained PDA AR application. This platform was used in a peer to peer game. Meanwhile Möhring et al. targeted a Symbian smartphone for mobile AR. The scarce processing power of the target platform allowed only a very coarse estimation of the object's pose on the screen. Later Henrysson ported ARToolKit to the Symbian platform and created a two-player AR game on current-generation smartphones. Several of these projects involve collaborative applications, but not for larger users group.

Throughout the duration of IPCity, handheld AR has become an extremely popular research topic, and very crude forms of AR on mobile phones ("compass-only AR") have even been commercialized on platforms such as the iPhone. However, consortium members of IPCity have remained technology leaders in that area, and brought this technology into IPCity showcases and developed them further there, resulting in a set of well publicized applications.

We are not aware of any alternative solutions that work in both daylight and night time, and achieve the same performance as our implementation. Technologies from Apple and Microsoft provide similar tools with the difference that the first is not on such a moveable scale (from small to large) and is affected by light, and the second does not integrate already existing technologies, such as yahoo search, twitter, IM, google maps to name a few.

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1.1.3 Comparison to the state-of-the-art in multi-touch display

Technologically the multi-touch display platform we are using is novel in many ways: the computer vision is recognizing not just points of contacts, which allows us for example to display a keyboard for typing when user places two hands on the screen. Switching between normal and infrared camera based recognition, enables using the system in changing lighting conditions, even outside. The tracking is very fast (120 fps) and scales to multiple cameras. Our solution is projector based, which can also integrate multiple outputs (projectors) together: this makes possible creating very large installations. Also, the .NET software platform used for creating applications allows rapid software development using shared components.

In our research, our main goal has been contributing to designing applications on public multi-touch screens with particular focus on engagement and group use. Many studies of collocated collaboration without computer support are relevant to our analysis and have inspired our work (e.g. Robertson 1997). As an example Isenberg et al. (2008) report on an exploratory study of individuals, pairs, and triples engaged in information analysis tasks using paper-based visualisations. They conclude that providing a flexible temporal flow of analysis actions, should possibly allow group members to be engaged in different types of processes at the same time and also allow them to work together adopting the same processes.

Studies have interested the positioning and approach to public displays. Before users can start interacting with a public display, they have to withdraw from other activities they are engaged in. Brignull and Rogers (2003) have suggested positioning public displays along traffic thoroughfares and describe the ways in which the interaction principles are communicated to bystanders.

Morris et al. (2006) reported a series of studies where various multi-touch groupware prototypes were evaluated in order to find out how tabletop user interfaces might respond to, and influence a user group's social dynamics. The results of these studies indicate that aspects of group dynamics, such as conflict, awareness, participation, and communication can be influenced by interactions with a shared multi-touch tabletop display.

More focused studies try to investigate specific aspects of collaboration or understand the impact of a particular set up, for example, studying pair wise work on surfaces. Tse et al. (2007) studied pairs of people who communicated and interacted in a multimodal digital table environment built on top of existing single user applications, mixing and using inter-person speech and gesture actions as commands to the system. Tang et al. (2008) carried out studies with pairs of people using an interactive table top display. Their study shows how

individuals frequently and fluidly engage and disengage with group activity through several distinct, recognisable states with unique characteristics: together, kitty corner, side by side, Straight across, Angle across, End side, and Opposite ends.

Rick et al (2009) carried out studies on how for a child, the position of a tabletop (relative to their own position) affects where s/he touches the table. This study positioned three pupils at three sides of a table top studying equity of participation. A main finding was that children used the entire tabletop surface, but took more responsibility for the parts of the design closer to their relative position.

In their study of a sharing media with a public interactive screen called Dynamo, Brignull et al. (2004) witnessed the users developing ways to attract other people's attention through "upsizing" their pictures and stage video performances in the display. Dynamo also supported the use of private content through reservation of a dedicated space on the screen for personal purposes and in the high-school setting of the study, where the same people used the display for a longer period of time, this possibility for personalisation was found to be an important feature. In their report, Scott et al. (2003) suggest particular design guidelines for digital tabletop display interfaces that aim to support effective co-located collaboration. Guidelines that relate to our work support: fluid transition between activities, interpersonal interaction, transitions between personal and group work, simultaneous user actions. These resonate with the guidelines of Tang et al 2008, that support: a flexible variety of coupling styles (i.e., manners and extent in which collaborators can be involved and occupied with each other's work); lightweight annotations and provide: fluid transitions between coupling styles, and mobile high-resolution personal territories.

Recently Hornecker et al. (2007) presents design principles for shareability. They note the central role of access and entry points for in particular tangible interaction. Entry points invite and entice people into engagement, provide an overview of the system, and draw observers into the activity. Access points are the characteristics that enable users to interact and join a group's activity. All these factors produce the shareability of the system, which refers to how a system engages a group of collocated users in shared interactions around the same content.

While guidelines and principles are useful they still need to be translated in particular solutions. Our contribution is directed to increase examples of design solution and interaction techniques for multi-touch display. To this end we note, that images taken by one person have a limited relevance to another person unless there is a personal connection to the places or activities depicted. We also needed to enable multiple topics, so that many conversations and themes could occur synchronously. However, as this would need to take place on the one-shared screen, this required some spatial visualization thinking on how best to divide up the space to allow for this. As well, we needed to consider that connections between multiple topics would also occur, and individual elements may fit across multiple categories. This also needed to be accommodated into the design planning. We researched the possibility of 3D landscape visualizations but could see we would be restricting users to a one screen visual component if we moved in this direction. We then looked for existing solutions to dealing with data mapping huge amounts of content within the Information Design discipline. Information Design does not replace graphic design and other visual disciplines, but is the structure through which these capabilities are expressed (Wurman 2001). To have informational value, the data must be organized, transformed, and presented in a way that gives it meaning. Transforming data (in this case images, videos and some text) into legible information is accomplished by organizing it into meaningful forms, and presenting it in evocative and appropriate ways. Our solution was to have the content organized into 3D worlds of information, which enabled parallel interaction still in a playful way, allowing browsing through multiple content and timelines.

Through our studies we noted multi-touch 3D widget supported parallel interactions. The observational data demonstrated that the most frequent configurations of users involved

multiple individuals working in groups or pairs, and the instances of individual use that were highest were in tandem with another individual, pair or group. This demonstrates that the system frequently accommodated multiple users, and different coupling styles (Forlines et al., 2008). As well users were influenced by others, both through observation and collaborative exploration, as pairs and groups often influenced each other on the wall. Our users felt that they engaged in shared experience with others, but did not change their actions in response to them, indicating that they could share the space without compromising individual exploration.

The 3D worlds and the metaphor of the worlds proved to be effective solutions to provide mobile territories (Forlines et al., 2008) and access and entry points (Hornecker et al., 2007). In particular *Worlds,* when they are unused, invite passers-by to interact, explicitly, even if someone else is interacting with another world. By adding another layer of complexity with gestures that move beyond the now familiar pinch, expand and rotate movements, we hoped to entice our participants to become more immersed in uncovering interaction techniques by pursuing varied options. By allowing worlds to overlap, participants were required to be aware of each others activity, and we looked to initiate forms of mutual engagement (Everitt et al., 2005), where individuals can spark their curiosity together, and can lose themselves in a joint activity. Walk-up-and-use display can greatly benefit from multi-touch. However we found that not all users fully exploit the multi-finger and multi-hand features. The challenges ahead include providing easy access to relevant content through effective navigation mechanisms. The gradual discovery of more complex functionality should be supported adopting adaptive interface strategies.

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1.1.4 Comparison to the state-of-the-art in presence research

Presence research focuses on the dimension of subjective perception, analyzing the ways in which an individual's experiencing is mediated by technology, distinguishing between “first order mediated experience” (when experience is mediated only by the human senses) and "second order" mediated experience (when experience is also mediated through technologies). Presence as a second order mediated experience has been articulated in a variety of dimensions: spatial presence or presence in a physical space (e.g. perceptual immersion, sense of being there), sensory presence (perceptual realism), engagement (involvement) and social presence (including co-presence). Presence research has considered primarily traditional media as mediating systems. In Presence I, projects have focused on virtual reality, 3D imaging, haptics and robotics. The MEC project: Measurement, Effects, Conditions IST-2001-37661 investigated the role of presence experiences in media-based learning processes with regard to educational hyper text and VR/multimedia systems. In the project POEMS (Perceptually Oriented Ego — Motion Simulation), a VR set-up is explored that allows for convincing simulation of ego-motions without actually moving the observer, by combining auditory, visual, and vibrational cues. Other projects aimed at enhancing virtual environments with novel camera technologies to achieve a system that displays photo-realistic 3D images, one example includes BENOGO, Being There - Without Going IST-2001-39184. TDIS IST-2001-38862 investigated a Three-Dimensional Imaging System based on integral photography for precise simulation of 3d perception and enhancement of the telepresence effect (TDIS). Presence I projects have also addressed haptics and robotics. For example Touch-Hapsys - Towards a Touching Presence, investigated haptic and multimodal illusions to realize presence through perceptual tricks allowing circumvention of current limitations in haptic actuator technology. With an artificial intelligence approach, ADAPT IST 2001-37173 was aimed at realizing an artificial system capable of building internal representations. With another take on robotics the IST-2001-38873 project PELOTE investigated the teleoperations of Mobile Robots. PeLote proposed a system for teleoperation, where the operator is a human supervising many remote entities from a distance and the entities are working in cooperation in the same environment.

Within the presence community there is a growing criticism of mainstream presence research. Mantovani and Riva (1999) suggest that Gibson’s ecological theory of perception would offer a better starting point than the mainstream position presented above. In Gibson’s (e.g. 1971) view valid perception is that which allows affordances that make successful actions possible in the environment, and this perception can vary from one person to another and from one moment to next, depending on what actions one needs to initiate. If we accept Gibsonian view, there is no fundamental difference between ‘real’ and ‘artificial’ environment

– both of them are mediated, we do not perceive either of the 'as such' but always filtered through the purpose of our actions where we are engaged. Based on this perspective, there is a lively debate on cultural and social aspects of presence (e.g. Spagnolli and Gamberini 2005), on users' agency (O'Neill 2005), 'dramatic presence (Dow et al. 2007), and on the role of the physical environment of space and material resources.

Recent advances in mixed reality interfaces call for widening the focus on the mediating systems beyond virtual reality, or the narrow focus of haptics and robotics, towards a multimodal and mixed media approach. As mixed reality environments move nearer to real world settings this provides opportunities to further develop the concept of presence. The 'mixing' of aspects of the immediate surrounding (physical environment) with technological augmentations opens up new forms and experiences of presence. Most of the past "telepresence" research studied the effects of traditional media, teleconferencing systems and virtual environments and application areas such as telemedicine, training, teleconferencing, entertainment (multi player games, MUD etc.). A variety of application areas and emerging technologies remains unexplored. Mixed reality allows users to change and actively shape the configurations of real and virtual layers into an experience – mixing places, (historical) times, staging events, changing social formations and identities. IPCity focuses on novel application areas around urban life and social gathering: large scale events, urban renewal, urban exploration (time warp, city tales). The scenarios developed for these showcases address in distinctive ways the various dimensions of presence indicating novel aspects to be considered, among them:

- the role of users' purposeful activities in achieving presence and the performative and expressive aspects of these activities,
- understanding user experience through creating and interweaving events in the real world with the virtual and imagined,
- augmenting presence by giving access to hidden or invisible aspects of a place,
- supporting the perception of an event that is distributed in an area and that is partly (at times) collocated and partly (at times) moderately remote,
- working with temporality – paths, change, the sequence of events,
- understanding the role of materiality/tangible objects in the construction of presence,
- investigating mobility as a specific research issue for urban interfaces
- using MR as interventions in urban environments.

IPCity moves beyond the state of the art of presence research also in respect to methodology. Most of the research in presence has been carried out in laboratory settings. Field trials in real setting are new to presence research as also mobile and public applications. This requires devising a new triangulation of research methods combining common methods like presence questionnaires with methods for use in the field such as: participatory workshops, ethnographic observation, quasi experiments, and interaction analysis. Qualitative and quantitative methods will be integrated to account for cognitive and socio-cultural aspects.

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1.2 Recommendations from previous reviews and take-up measurements

1. Lack of integration with project results across showcases

Since the last review the project members have worked closer together in this area. For example two workshops have been held specifically to discuss the underlying concepts within the project, research questions and how to evaluate the various showcases. The first workshop focussed on the evaluation methods and what to capture during the studies, for example aspects related to multi-modal interaction. The second workshop presented early data from various studies or pilot tests with a view to understanding more about emerging themes and to discuss areas of commonality. As a result the project took the decision for each showcase to produce a set of guidelines and for commonalities within certain areas to be identified and presented as guidelines applicable across a range of MR experiences.

2. Results which are validated and readily accessible

The project bases its planning and evaluation around the core themes within the concept map developed until the end of year 3. During the final phase the project took the decision to focus on specific research questions identified in D1.12 and the underlying elements related to these within the concept map. As a result the project focussed on a smaller number of areas, the benefit of this approach was that the emphasis was on collecting and validating data. Furthermore by adopting the objective of providing concrete design guidelines to external parties the emphasis was on providing readily accessible, verifiable results.

Relevant project deliverables were placed online during the final phase.

3. Slower pace of development within WP8 and WP9

Workpackage 8 was completely redesigned and developed to reflect the project research questions. One complete new game was developed which covers the City of Cologne, furthermore a small version was designed for use in Christchurch. Within WP9 the problems were resolved during the final period as prior delays predominantly related the delayed acceptance of the amendment in year 3.

4. Technical development should focus on need within the project

Only technical developments which fulfilled the final year project research questions were developed. These included a new interaction scheme for the colour table, 3D interface designs to support the complex interactions which arise in CityWall, video streaming within TimeWarp and new forms of multi-media collection within CityTales.

5. Justification of other costs required

Justification for the other costs incurred during period 3 have been provided to the EC and accepted. Anticipated other costs for period 4 are described within D1.12.

6. Justification of costs with HIT Lab NZ

HIT Lab NZ receive no funding directly or indirectly from the IPCity project. With respect to projects, MIRACLE and MARCUS only provide travel expenses and do not allow for the

payment of staff costs. All partners who were not a member of MIRACLE and MARCUS were given the opportunity to use travel funds to visit New Zealand – in addition FIT received some money for a two week visit to New Zealand. Where partners were members of MIRACLE or MARCUS, IPCity paid the appropriate staffing costs as this work often coincided with specific development or design tasks (e.g. the TimeWarp NZ game user testing and development).

2 Objectives of the reporting period and main achievements

During the final phase of the project the primary objective was to strengthen and enhance the work on presence and iteration within urban mixed reality environments. In contrast with previous years the consortium agreed that the technical developments should focus on areas which were critical to exploring presence or interaction; for example a redesign of gaming scenarios within TimeWarp or improving the interaction scheme within Urban Renewal. In a further change of emphasis the project developed a series of exploratory research questions which were used as a basis to inform the development of the systems and to provide a basis for evaluation. Following on from this and the workshops held during the general meetings the consortium further agreed to emphasise the difference between presence and interaction by seeking not to classify all research undertaken within IPCity as being centred on presence. These shifts in the scientific basis of the project allowed for a more focussed approach to user studies and technical developments. Therefore during the final phase the objectives and timelines are listed below are:

1. To further develop existing technologies only where there are clear scientific merits for doing so
2. To further refine showcases so that they are suitable for public use but also such that they address the underlying scientific issues which have been identified as having an impact on usability on presence
3. To develop clear design and evaluation methodologies and guidelines for assessing and developing presence experiences in mixed realities
4. To conduct studies into specific aspects identified within the concept map and prior work
5. Effective dissemination of IPCity project results through a summer school, final event and studies

In this project phase, the final set prototype services, tools and infrastructure components developed within the research work packages will be provided to the showcases, where they will be tested and evaluated. In general we sub-divide the months 37-51 into the following periods:

- The analysis and (re-)design period (37-40, depending on WP)
- The development period (month 39-44, depending on WP)
- The testing and public demonstration period (months 41-45, depending on WP)
- The evaluation period (months 44-48)
- The dissemination and exploitation period (months 47-51)

Across all showcases the main emphasis was on final developments designed to meet the research objectives followed by a period of user testing. For example TimeWarp (showcase 3) was substantially redesigned to support greater collaboration, narrative and presence aspects than in previous years. The CityTales (showcase 4) was subject of development streamlining, content creation, and testing to reflect the objectives of that workpackage, while

showcase 2 (Environmental Awareness) focussed on improving and finalising investigations around collaboration and embodied interaction using the Map Lens system. Furthermore there was more cross fertilisation of research concepts and methodologies between the showcases through workshops focussing on presence and interaction, most specifically looking at evaluation and design considerations, which were held during the two general meetings.

A breakdown of the tasks is provided in the following page.

Project: IPCity	37	38	39	40	41	42	43	44	45	46	47	48	49	50	51
Workpackage 1: Project Management															
T1.24 Review Organisation															
T1.25 Review Take-up															
T1.26 General Project Meetings															
T1.27 Executive Boards															
T1.28 Scientific Boards															
T1.29 Annual Progress Report															
T1.30 Evaluation Report															
T1.31 Reporting (Financial)															
T1.32 Final Project Review															
T1.33 Project Closing Workshop															
Workpackage 2: Dissemination & Exploitation															
T2.14 Refinement dissemination strategy															
T2.15 Dissemination of project results															
T2.16Preparationand participation in the FET 09															
T2.17 Preparation and organizing of the IPCity															
T2.18Evaluation of dissemination activities															
T2.19 Organise post-project dissemination															
T2.20 Final event organisation and participation															
Workpackage 3: Cross-Reality Presence & Experience															
T3.17 Analysis of Concept Map															
T3.18 Consolidation of goals															
T3.19 Methodology Workshop															
T3.20 Data analysis															
T3.21 Testing Approach															
T3.22Consolidation Sound Work															
T3.23 Formulation of guidelines															
T3.24 Consolidation work															
T3.25 Participation in final event															
Workpackage 4: Cross-Reality Interaction Tools															
T4.12 Final Design															
T4.13 Final Development															
T4.14 Integration in showcases															
T4.15 Evaluation of tools															
T4.16 Dissemination/Exploitation															
Workpackage 5: Mixed Reality Infrastructure															
T5.12 Final Re-design															
T5.13 Developing Prototypes															
T5.14 Dissemination/Exploitation															
Workpackage 6: Showcase Urban Renewal															
T6.19 Redesign of Application															
T6.20Development of Application															
T6.21 Third Cycle Workshops															
T6.22 Analysis and Evaluation															
T6.23 Final Dissemination															
Workpackage 7: Showcase Environmental Awareness															
T7.14 Final Re-design															
T7.15 Final Development															
T7.16 Field Trials															

T7.17 Analysis and publication															
T7.18 Dissemination/Exploitation															
Workpackage 8: Showcase TimeWarp															
T8.13 Re-design of prototype															
T8.14 Development															
T8.15 Testing/Demonstration															
T8.16 Evaluation of prototype															
T8.17 Dissemination/Exploitation															
Workpackage 9: Showcase CityTales II															
T9.14 Evaluation															
T9.15 Re-design															
T9.16 Development															
T9.17 User Testing															
T9.18 Evaluation of prototype															
T9.19 Dissemination															

During the final phase of the project the overall objective was to achieve clearly disseminatable outputs from the underlying and showcase workpackages. As a result of this focus the following aspects were achieved:

- Improved international co-operation by the exchange of researchers through our co-operation with HIT Lab NZ, specifically by utilising connections within MARCUS and the German Funded MIRACLE project. This allowed for development and user testing work to be carried out in New Zealand.
- Training and demonstration events including the FET Conference, Summer School, Oslo Workshop and participation in the MIRACLE workshop in Bonn. IPCity was also represented in the MARCUS workshops in Graz and Dunedin, NZ.
- Work on presence and interaction has been significantly advanced and is now in a form which is readily usable by third parties. This has been achieved through a tightly integrated approach to experimental design, analysis and reporting of results. As a result each showcase provided a set of guidelines and key findings which form the core basis of WP3.
- Major outputs from WP4 included a new 3D interface derived from user study results. Within the Colour Table system significant development on redesigning the interface was undertaken such that it better supported natural and more fluid interaction. The visual prototyping tool was extended to make the workflow and feature set more relevant to the ongoing developments in TimeWarp and for use in the summer school. While the Multi-Media collector system implemented new approaches to supporting the creation of stories and Maplens now contains many usability improvements and is now more tightly integrated with CityTales since the adoption of the same database architecture and platform.
- Based on feedback of the showcases and internal developer meetings, the work on WP5 - Mixed Reality infrastructure components has adapted, redesigned, improved and developed 29 different technologies. New components of the working period are the Physics Abstraction Layer, Slow-Fast Rendering, GPU Painting, In Situ Content Creation, Color Table RFID content assignment, Mobile Navigation and Panorama Annotation and Considerations for Multi -Display Infrastructure. Contributions were made to all the four major building blocks: Tracking, Computation, Storage and Mobile AR. Most of the technologies developed are part of the showcase applications.

- The urban renewal prototypes were successfully further improved. The interactions were simplified by introducing the RFID board along with the info area and command cards. Further work was undertaken to stabilize the system and enable more fluent interactions. An urban workshop prior to the participatory workshop was organized and provided significant information about suitable representations to be used as content. A final participatory workshop was organized in Pontoise including two sessions with several types of stakeholders. The workshop scenario was created around a diverse set of urban issues. In addition to the participatory workshop, the technologies were presented and evaluated in a Masterclass of ECSCW conference, the IPCity Summerschool and in an additional participatory workshop in Oslo. Key findings concerning collaboration, interaction design, as well as representational issues concerning the mixing of realities /(working with different representations of the site and different types of visual content and sound) were substantiated.
- The Final event in Vienna is currently under preparation and will make a significant contribution to dissemination of the project results both to the general public and those working within specific areas. All showcases will be represented and attendees will be able to try them out. Moreover invited guests and panellists will also take part.
- Improved interaction with local bodies, public awareness-raising, and integration of content from local bodies and projects working with environmental awareness has been a primary concern for WP7 over the past 2 years. Relationships were established with early examples of work in the local area displayed. These relationships are on-going for further work to occur in the future.
- MapLens trials facilitated much interaction and discussion between MARCUS and IPCity partners. As well many researchers were involved in the pre-planning, actualisation, analyses and post-write up of the analyses. Standards for comparative testing, as well as methods for rigorous evaluation and analysis of results were improved by this plethora of expert-input from many disciplines. TKK hosted international and Nokia researchers for this interaction to occur.
- WP7 hosted locally as well as at major CHI conferences, co-organised with HitLabNZ, or participated in generally with multiple workshops on MR/ AR, multitouch and evaluation methodologies. Considerable local and international expertise was pulled into these discussions, with an aim to facilitate future collaborations. For WP7, the role of interlocutor was taken up with a mind to join up organizations and individuals working at different aspects/ disciplines but with similar concepts.
- WP8 (TimeWarp) underwent a significant redesign in order to support the exploration of themes such as narrative, city structure and collaboration. A press release was issued for the user trials which resulted in significant media interest on TV, radio and in the press. It also resulted in significant possible commercial interest after the project.
- IMAG was in charge of hosting the IPCity Summer School 2009 workshop in Vienna. We selected 25 international applicants to join us for the summer school where students were given the opportunity to work alongside with IPCity members in the field of urban mixed realities. The summer school did bring together students from a range of backgrounds including: architecture, urban planning, computer games design and information technology with the aim of creating an atmosphere similar to those found in leading research labs.
- The WP9 City Tales approach of using mixed reality technologies for story-telling created a number of different scenarios ranging from non-linear story-telling with the involvement of professional authors to participative social group gaming experiences for a number of users. Proving the previous assumptions that content creation is

attractive and mixed reality creates a new form of digital story telling we experienced great fascination towards user participation.

Most important problems and corrective actions undertaken

During the year UCAM were unable to replace the Gerhard Reitmayr who left to take up a post at TUG. Despite repeated efforts lasting until the latter part of the year no replacement could be found. Some of the work was subsequently undertaken by Gerhard Reitmayr at TUG, this had no impact on the showcases or final results in the project.

3 Workpackage Progress of the Period

This section provides an overview of the actions carried out in the reporting period, based on the workpackages that were active or planned to be active during the period.

For each workpackage, the following information is presented:

- Workpackage objectives and starting point of work at beginning of reporting period
- Progress towards objectives – tasks worked on and achievements made with reference to planned objectives, identify contractors involved
- Deviations from the project work program, and corrective actions taken/suggested: identify the nature and the reason for the problem, identify contractors involved
- List of deliverables, including due date and actual/foreseen submission date; due dates of external deliverables were extended by agreement with the project officer to better reflect the end-date of the project. The due dates listed in the report therefore reflect the initial date and not the revised date.

3.1 WP 2 – Dissemination

3.1.1 Objectives and starting point of work

The overall objective of this work package is to ensure maximum dissemination and impact for the results achieved during the project both internally within the project and externally in relation to the scientific community, other stakeholders and information society in general.

During the fourth project year both the internal and external dissemination activities have continued in a manner developed during earlier years. Because this is the last project year, dissemination activities have been intensive. As a project IPCity has participated the FET09 event in Prague and organised two training and dissemination events in Vienna: A Summer School in September, and the final project event in March.

3.1.2 Progress towards objectives

The dissemination strategy has been updated and accepted as an annex to the project handbook (D2.8). Together with the project handbook the dissemination strategy defines communication channels, practices and responsibilities for dissemination activities.

The communication channels and tools developed during the first project year have been in steady use in the project:

- A central document repository (BSCW, administered by FIT) has been intensively in use during the project, and it is a central resource to the project.
- A number of official e-mail distribution lists (general, one for each board, one for each larger work package). The messages sent to these lists are also archived in the BSCW. Besides the official lists, there is a lot of e-mail traffic between individual members and ad-hoc groups.
- A public website for external and internal distribution (www.ipcity.eu), updated when new information has become available. During the year 2009, 7 095 visits were done to the site, totalling 20 394 page views.
- The electronic newsletter was not published during 2009, instead relying on the News section and rss feeds of the News section in the website. The section had 280 page views during 2009.

Two project-level workshops have been held to discuss about dissemination issues, the first in the general meeting in Oulu in May and the second during the general meeting in Aalborg in November.

Besides the already existing dissemination material the following additional material has been produced or updated to facilitate the publicity work done by partners:

- the IPCity general poster
- IPCity poster for FET09
- the IPCity general brochure
- posters for the Final Event

IPCity has organized the IPCity Summer School in Vienna, September 2009. A Final Dissemination Event is organised jointly with the final review in March 2010 in Vienna.

3.1.3 Deviations from project work program

No major deviations from the original work program have occurred.

3.1.4 List of deliverables

Del. no.	Deliverable name	Date due	Actual / Forecast delivery date	Estimated indicative person-months *)	Used indicative person-months *)	Lead con-tractor
D2.8	Updated dissemination strategy and knowledge management plan for phase 24	M38	M38	0.5	0.5	UOulu
D2.9	Report on dissemination, visibility and training activities during Phase 24	M49	M51	0.5	0.5	UOulu

*) if available

3.1.5 List of milestones

Milestone no.	Milestone name	Date due	Actual/Forecast delivery date	Lead contractor
M 2.11	Revision and adaptation of dissemination strategy finished	M38	M40	UOulu
M2.12	FET 09 exhibition participated	M40	M40	UOulu
M2.13	Summer school organised	M45	M45	UOulu
M2.14	Reporting on dissemination activities finished	M49	M50	UOulu

3.2 WP 3 – Cross-Reality Presence and Experience

3.2.1 Objectives and starting point of work

The overall objectives of this work package are

- to analyze experiences from field trials and presence questionnaires in the four showcases, achieving a deeper understanding of how mixed reality environments

influence the experience of presence and how this enables novel forms of social interaction, of exploration and understanding

- to define a conceptual framework in support of designing 'technologies of presence' that inform the design of interface mechanisms in support of presence within the project and guide the integration of these technologies into real world settings.

The research focus in the fourth year was on

- Analyzing data from field trials in the four showcases, achieving a deeper understanding of how mixed reality environments influence the experience of presence and how this enables novel forms of social interaction, of exploration and understanding;
- Developing the IPCity approach to Presence and Interaction in Mixed Reality and describe this approach in a journal paper.
- Providing a set of guidelines which can be used by people developing or evaluating mixed reality experiences.

3.2.2 Progress towards objectives

Within the framework of WP3 major research activities have been undertaken:

- All showcases carried out field trials (see D6.4, D7.4, D8.4 and D9.4) based on exploring previously identified research questions using a range of agreed methodologies.
- The state-of-the-art of research on presence and interaction in mixed-reality environments has been reviewed and extended;
- All showcases carried out field trials, according to a common evaluation approach. as well as a common analytical framework;
- Two workshops of evaluation and data analysis were held in tandem with the general meetings
- Key findings Several consortium members (from all showcases were identified and a catalogue of design guidelines has been formulated; TUG, TUW, HTT, FIT, UMVL, UOulu) were presented at the RAVE 2009 workshop. A paper in the Journal of Presence, TeleOperators and Virtual Environments based on this work has since been published.
- Research into sound and presence was deepened, with results on how adding sound can enrich the mixed reality experience of users, hence the experience of presence.
- A set of guidelines for the development of mixed reality experiences has been developed based on experimental results from all showcases, additionally the showcases have also developed guidelines applicable in their own domains.

Our consolidated approach to studying presence and interaction in mixed reality can be summarized as follows:

1. Which **design features** of Outdoor Urban Mixed Reality are essential in supporting participants in engaging in novel ways with the city?
2. What is the potential of the concept of **presence** in analyzing participant experience?
3. What do we learn from this analysis for the design of MR applications, interfaces, as well as for how to enable participant experience?

Our research focuses on complex 'Mixed Realities' that emerge from the combination of multiple displays and spaces, including the most interesting element of MR, the real world. We argue that presence research that is meaningful for MR needs a broader conceptual

framework, which encompasses traditional perceptual elements of Presence, but has an emphasis on Social Presence, affordances, beliefs and longitudinal effects.

We argue for and practice a shift of attention away from psycho-physiological studies coming from a laboratory experiment tradition, towards an ecological-cultural approach that is applicable in real world situations and relies on ethnographic rather than fully controlled methods. We are among the first to perform longitudinal social analysis of MR.

Offering citizens new ways of experiencing the city is a key issue of our work. We are among the first to design outdoor MR experiences and to systematically evaluate them designing a diversity of field trial situations and using methods of multimodal analysis for creating a deep understanding of these experiences.

Our work is routed in the urban nature of the showcase systems that span the project these include: *Urban Renewal*, *MapLens*, *CityWall*, *TimeWarp and CityTales*. Each showcase brings to IPCity a set of unique challenges and research questions, which in turn demand novel ways of design and evaluation. However across all showcases the underlying relationship to urban space and themes such as collaboration, co-construction and the mixed reality blends or switches were explored. In the case of *MapLens*, action is in the real environment, while participants orient their task to remote locations and people. In *TimeWarp*, action takes place in an augmented environment, which is carried around by participants in the streets of Cologne and Christchurch. One of the key elements of the experience here is the feeling of connection between the virtual and real gaming elements. In the *MR Tent*, action takes place in the real environment and participants make use of the resources of this environment to construct Mixed Reality scenes. In this complex set-up we can observe the challenges of mapping events and representations within the physical environment to those in the Mixed Reality scenes. CityTales explores the relationship between the physical environment and location-based storytelling and concludes that compelling MR stories must 'stage' into the environment rather than publish. While the process is still complex to our experience users do wish to author and be part of a story telling universe.

During the final phase of the project we further adopted the Gibsonian view in that there is no fundamental difference between reality or virtuality and that all experiences are mediated in some way. Using this basis as an underlying approach we explore how purposes, actions and activities as well as how the social and cultural dimension shape interaction and presence within urban mixed reality environments. This was reflected in the study approaches and findings.

3.2.3 Deviations from project work program

Due to extreme weather conditions there was some delay in certain trials being completed.

3.2.4 List of deliverables

Del. no.	Deliverable name	Date due	Actual / Forecast delivery date	Estimated indicative person-months *)	Used indicative person-months *)	Lead con-tractor
D3.5	Consolidated approach to studying presence and interaction	M48	M51			TUW

*) if available

3.2.5 List of milestones

Milestone no.	Milestone name	Date due	Actual/Forecast delivery date	Lead contractor
M3.10	Joint Analysis findings	M48	M51	TUW

3.3 WP 4 – Cross-Reality Interaction and Authoring

3.3.1 Objectives and starting point of work

The objectives of the Cross-Reality Interaction and Authoring work package for the final period were:

- **MapLens** (augmented maps on mobile devices over paper maps): Further development based on the results received from field trials.
- **Multi-Touch Display:** Further development based on the results received from field trials.
- **Mobile Media Collector (MMC):** The development is advancing after the Fall 2008 trials to phase 2, based on trial feedback. Further field tests and trials with new versions conducted during Spring and Fall of 2009.
- **MMS Entrance**: Further trials integrated to Multi-Touch Display.
- **ColorTable**: Final development including all the results from the former user workshops, ending with some last trials and a user workshop.
- **UrbanSketcher:** Further development based on results from further trials and user workshops.
- **Audio / Video Streaming:** Extending the Device Abstraction Layer (DEVAL) to support audio and video streaming. Designed and developed a audio and video streaming device abstraction
- **Authoring and Orchestration Interface:** Developing a 3D authoring interface based on Interaction Prototyping and improving upon concepts developed in AuthOr. Further, continued development on Interaction Prototyping (Interactive Bits) visual editor.

3.3.2 Progress towards objectives

During the final phase of the project the following objectives have been achieved:

- **Interaction Prototyping / Authoring**: The interaction prototyping language and editor technology development, recently named Interactive Bits, continued based on feedback from the showcases.
- Authoring and Orchestration Interface: **AuthOr** development continued based on feedback from the showcases.
- **Augmented Map Table**: The augmented map table system was successfully integrated with the ColorTable and UrbanSketcher systems in two workshops as part of collaboration between TUW / TUG / UCAM.
- **MapLens** (augmented maps on mobile devices over paper maps) was redesigned and developed further based on the results received from previous field trials in collaboration between HIIT / UOulu / TUG/ Imagination. Two field trials were conducted to test the new features.
- **UrbanSketcher** Interface Streamlining: The UrbanSketcher user interface was redesigned and a new 2D interface for laser pointer interaction was developed comprising the most common functionalities.
- **Mobile Media Collector (MMC):** Development of the MMC continued following the design in Phase II during 2009. The implementation included new features identified in the Fall 2008 user tests, including usability improvements, and a new Radar view to

show nearby location specific stories in the field. Also it is now possible to attach both image and sound files to a single location specific story.

- **Multi-Touch Display:** Last year's field trial data was analysed thoroughly. Based on the analysis and expert evaluations the interaction design of the new 3D UI was improved.
- **ColorTable** The interface and main interactions were redesigned based on the workshop participants feedback of 2008 and the analysis of DataStream from video, sound recording and the photo documentation.

3.3.3 Deviations from project work program

No major deviations to report.

3.3.4 List of deliverables

Del. no.	Deliverable name	Date due	Actual / Forecast delivery date	Estimated indicative person-months *)	Used indicative person-months *)	Lead con-tractor
D4.5	Final Prototypes of Interaction and Authoring Tools	M48	M51	28.5		FIT

*) if available

3.3.5 List of milestones

Milestone no.	Milestone name	Date due	Actual/Forecast delivery date	Lead contractor
M4.7	I4.7 (Internal Report): Final design specification of the interaction and authoring tools.	M40	-	FIT
M4.8	Evaluation report on third set of interaction and authoring tools. (contribution to D1.15)	M48	M51	FIT

3.4 WP 5 – Next Generation Mixed Reality Infrastructure

3.4.1 Objectives and starting point of work

The objectives of the Mixed Reality infrastructure work package for year 4 were met by:

- **Urban Sketcher usability assessment**. The Sketcher has been used in the MR Tent as part of multiple workshops with the main goal of collecting qualitative data on MR presence and related issues, relying mostly on ethnographic observation. However, the usability of the Sketcher interface has been neglected. We therefore performed assessment of the Sketcher's usability through a quantitative evaluation. In particular, various assumptions about the 3D interactions using the Sketcher were scrutinized.
- **GPU Sketching.** The Sketcher was rewritten to use advanced GPU shaders for painting, which speeds up this component significantly.
- **Performance optimization with Slow-Fast Rendering**. The complex setup of the MR Tent featuring the main components ColorTable and Urban Sketcher has proven difficult, because of the variety of computer graphics tools used. In particular, these components can run at very different frame rates. We therefore refactored the MR Tent graphics subsystem into a mini-cluster composed of two PCs acting in parallel, using a slow-fast configuration with sort-last compositing.

- **Content Manager.** The content managing was extended to support more services according to application needs and additional content moderation tools were added.
- **Scouting and multi-perspective MR**. We extended the preliminary system with the ability of streaming both video and information about the spatial position and orientation of the scout. In order to account for extra performance demands by vision tracking, sensor fusion and communication support with the base station e.g. the MR-Tent, hardware re-considerations were inevitable and resulted in utilization of a dual core tablet PC. The integration with the Urban Sketcher interface allows collaborative experience of multi-perspective MR.
- **Outdoor tracking**. Further development of the outdoor tracking with vision-based localization as well as various sensor combinations using vision tracking approaches were developed for outdoor tracking.

3.4.2 Progress towards objectives

Most technologies of WP5, in particular the ones that had underdone revisions in year 4, were tested in collaboration with the showcases, where they were tested by end users. This resulted in many small iterative design changes until an optimal solution was found.

3.4.3 Deviations from project work program

No major deviations to report.

3.4.4 List of deliverables

Del. no.	Deliverable name	Date due	Actual / Forecast delivery date	Estimated indicative person-months *)	Used indicative person-months *)	Lead con-tractor
D5.4	Final Prototypes of MR Infrastructure Components	M48	M48			TUG

*) if available

3.4.5 List of milestones

Milestone no.	Milestone name	Date due	Actual/Forecast delivery date	Lead contractor
M5.11	Re-design of infrastructure prototypes	M40	M40	TUG
M5.12	Final re-design and re-planning	M41	M41	TUG
M5.13	Start of final development, testing and evaluation period	M48	M48	TUG
M5.14	Dissemination and Exploitation activities.	M51	M51	TUG

3.5 WP 6 – Showcase 1: Urban Renewal

3.5.1 Objectives and starting point of work

The objective of this work package is to introduce mixed reality applications in support of presence into urban renewal projects; more specifically:

- To conduct field work in urban planning environments, involving users and researchers as reflective co-designers, from early exploring practice and visions to field trials with gradually more integrated scenarios and prototypes

- To design an application based on the MR-Tent infrastructure from WP5, equipped with a mixed-media workbench interface, in support of collaborative envisioning (in collaboration with WP5)
- To develop mobile technology for public participation supporting situated content creation
- To evaluate the experiences of field trials with the technologies in real urban planning settings, with special attention to participants' experience of presence and co-presence.

The objectives of Phase 4 were:

- To further develop the urban renewal prototypes, based on the redesign issues identified in previous field trials
- To plan and carry out a more elaborate participatory workshop with different stakeholders, including citizens, and an extended experimentation protocol
- To implement sound as expressive content as well as part of interaction design on the basis of research done in WP3.

3.5.2 Progress towards objectives

The final MR-Tent prototype was evaluated in two participatory workshops. The first workshop was carried out in Pontoise (France) in June 2009. It deals with the constitution of a greenway in the city of Pontoise and the future role of the public gardens of Lavandières in such a scheme. The second workshop took place in Oslo in cooperation with the University of Oslo. In both workshops we in invited as participants different types of stakeholders – urban planners and specialists, members of the municipality and representatives of the local community.

We carried out a detailed analysis of the fieldwork material around 8 research questions, for the first time engaging in an in-depth (qualitative and quantitative) multimodal analysis of fieldwork material, a rather new approach to understanding how people use different semiotic resources in accomplishing tasks. This analysis was based on distinguishing four activities: plan intervention, perform intervention, understand MR scenes and evaluate result of intervention. Furthermore, we have identified four sets of activities (observational categories) that describe a) gestures, b) body posture and gaze, c) object manipulations, d) engaging with scene. Results of the analysis are provided as main findings as well as design guidelines. In addition we provide an analysis of the four years work by describing the evolution of the technologies from a design perspective and from an urbanist perspective.

3.5.3 Deviations from project work program

None

3.5.4 List of deliverables

Del. no.	Deliverable name	Date due	Actual / Forecast delivery date	Estimated indicative person-months *)	Used indicative person-months *)	Lead con-tractor
D6.4	Report on urban renewal application re-design Second prototype of Urban Renewal applications	M48	M51			TUW
D6.4	Final prototype of Urban Renewal applications	M51	M51			TUW

*) if available

3.5.5 List of milestones

Milestone no.	Milestone name	Date due	Actual/Forecast delivery date	Lead contractor
M6.8	Re-design of Urban Renewal application finished	M39	M39	TUW
M6.9	Final prototypes of the Urban Renewal applications finished. Goals and measurement criteria specified.	M42	M42	TUW
M6.10	Analysis of participatory workshops and feedback to technology developers as well as WP3 completed, internal evaluation reporting of the final urban renewal application. (contribution to D1.12 – Evaluation Summary Report of Year 3)	M51	M51	TUW
M6.11	Final project review and end of project event.	M51	M51	TUW

3.6 WP 7 – Showcase 2: Environmental Awareness

3.6.1 Objectives and starting point of work

The aim is to introduce environmental awareness in urban activities as a strategic application area and as a creative laboratory for mixed reality application and research on presence, experience and engagement in urban spaces. To be more specific, our objectives are:

- To develop novel applications of mixed reality interfaces in the case of environmental awareness activities including citizens and visitors as active participants.
- Advancing the research on Interaction, Presence and Engagement and looking at environmental awareness to facilitate spatial distribution, multiplicity and simultaneousness in urban activities.

Communication Modalities

We investigate the usefulness of:

A large public display *CityWall* as a means for spectators to interact with general, individual and shared co-authored information/ data visualisation

Annotated MapLens for supporting awareness of the environment, while being mobile in the urban environment.

Enhancing interaction presence and engagement

The research aims at investigating how to enhance and sustain engagement and therefore presence in Environmental Awareness activities for visitors to urban activities. Promotion of green issues and an awareness of the local environment is supported by these two applications. Feedback over long periods of time reinforces research opportunities to better understand rationales for participation, and proffers opportunity to evaluate how presence and engagement can be further supported.

Addressing Environmental Awareness and establishing community

By engaging with the interactive technologies, and sharing information over the modalities and with the emerging community of participants, individuals can then make informed

choices and act in their environment in more responsive and meaningful ways. Collectiveness of activity and co-experience are key components, as is making visible and sustaining engagement with green aspects of the local environment.

3.6.2 Progress towards objectives

As in years 1, 2 and 3 the demonstrator is divided into three components. In each component there have been advancements leading to the continuation of now two separate applications with their own developing and evaluation road map. The mobile component that was implemented in year one by CoMedia is this year again continued with the Augmented Map Lens. The Contact Wall of year one is again continued as a multi-touch public display CityWall. The Pervasive component has been integrated into CityWall and MapLens applications again this second year. The third application Illuminate was not continued as CityWall and MapLens applications continued to make significant developments, and require focused attention. As well using lighting was in conflict with the altered brief of environmental awareness.

The aim of having three complementary components is to be able to address the user experience in a more comprehensive manner and to address most of the state of the art technologies for this showcase supporting the main aspects of visitors: group co-experience, engagement with an event and/ or a theme, and navigation through space.

TKK has lead the showcase bringing forward and coordinating the work especially with design, development and field trials. Field trials of MapLens (8/2009) and CityWall in ECS and for small usability trials continued. Development of both applications continued to address the theme of environmental awareness. Development of MapLens continued as a more integrated solution with other partners, using more robust technology development with improved trials and continuation of use of a game as an innovative solution to testing mobile AR in the field. Development of CityWall continued its focus to support multiple content and multiple time-lines and have an open backend for a more integrated solution. Analysis of ECS data and the interaction design of navigating time were the major focii.

In this fourth year M37-M51 WP7 we continued re-design of the demonstrators to address environmental awareness, improved the new versions and analysed and/or carried out a new round of field trials. Continual re-design has successfully moved forward the demonstrator with more articulated and substantially more developed mixed reality applications in comparison to year 1, and building from year 2 and 3. The current demonstrators follow the plan of having a mobile, and permanent installation, and incorporating the mobile solution into the pervasive component. In all components substantial advancement has been made. The mobile component has moved beyond CoMedia which was already field trialed in year 1 therefore WP7 has moved forward to continually develop and investigate augmented MapLens as a new mobile component. Continued development along with field trial development and implementations has further this project to address green and environmental issues. The installation component has concretized in further development of the interaction design of CityWall as a large multi-touch urban display. Finally we have integrated the pervasive component into the way we manage field trials (as a pervasive location based game) for our mobile MapLens solution as the prototype development of Illuminate had a first prototype version, and addressed lighting. It was difficult to match this to the environmental awareness brief, and focus on 2 rather than 3 projects was decided upon. Both CityWall and MapLens had ambitious targets and goals to meet, so we needed to be more realistic with what we could achieve at a high standard.

The showcase succeeded in carrying out two (more extensive than 2008) MapLens field trials in Helsinki, continued development of CityWall, as well as analyzing the data from the huge passing public at European City of Sciences.

In MapLens field trials data analysis exposed phenomena that arise uniquely when using AR maps in the wild. We noted how augmentation affects the way participants use their body

and hands, manipulate the mobile device in tandem with the physical map, walk while using, and collaborate. We found that the MapLens solution facilitates place-making by its constant need for referencing to the physical, and in that it also allows for ease of bodily configurations for the group, encourages establishment of common ground, and thereby invites discussion, negotiation and public problem-solving. Its main potential lays not so much in use for navigation but in use as a collaborative tool. This year we added several extra testing factors and an additional comparative condition that further drilled down into these findings.

Citywall still operates as a permanent installation in downtown Lassipalatsi, Helsinki. As the 3D version had robustness and sustainability problems, Multitouch.oy now has taken possession of maintaining their 2D solutions at this site. Ironically even the company has technical sustainability problems despite adding new Infra-red system etc.

Citywall continues to attract a lot of attention also in the web. Our site http://citywall.org still receives many contacts, and CityWall is referenced in a variety of important websites, papers and many blogs We still continue to receive requests from all over the world to create similar installations. We pass these on to multitouch.oy. We continue to work along-side the company and a multitouch cell is displayed along with 3 versions of CityWall at the final event.

The start-up company commercialises the software and hardware technology www.multitouch.fi and still has three of the researchers that worked in WP7 in the company. The company successfully obtained local Finland funding (TEKES) and futures investment, and now has outlets globally (with a backlog of orders). The company has expanded and moved premises to keep up with demand.

3.6.3 Deviations from project work program

There are no major deviations from the project work program. The focus for this year was on refining the prototypes and research and analysis, with a view to target major ranked publication outlets. The prototypes of each of the demonstrators have been further developed and publicly demonstrated and/or field trialled.

A working solution to demonstrate at the final event to navigate in time via the interface took more time than anticipated. We allocated 1.5 extra PM to this problem with our developer. We added 0.5 PM from TKK administration management to assist with finalising the project. We added a minor service contract with a graphic designer for finalizing the interaction design on the final version of CityWall. This was the most cost and time-effective method for getting this work done. As the minor service contractor was a former student in Information Visualisation and Multi-Media Design of WP7 leader, there was a shortened lead time for briefing and iteration for this process. None of these changes impact in any major way with the overall budget or project work program.

3.6.4 List of deliverables

Del. no.	Deliverable name	Date due	Actual / Forecast delivery date	Estimated indicative person-months *)	Used indicative person-months *)	Lead con-tractor
D7.3	First Environmental Awareness Demonstrator	M36	M36		-	TKK
D7.4	Second Environmental Awareness Demonstrator –title changed to Final Environmental Awareness Demonstrator	M42	M51			TKK

3.6.5 List of milestones

Milestone no.	Milestone name	Date due	Actual/Forecast delivery date	Lead contractor
M7.7	Environmental Awareness re-design finished. I7.5 (Internal Report): Report on Environmental Awareness application re-design (re-design report made public on website)	M30	M30	TKK
M7.8	Environmental Awareness Events prototypes	M34	M34	TKK
M7.9	Internal evaluation reporting Environmental Awareness events prototypes. (contribution to D1.12 – Evaluation Summary Report of Year 3)	M36	M36	TKK
M7.10	I7.6 (Internal Report): Report on Environmental Awareness events application re-design includes 2 sets of 2 application prototypes developed. (evaluation report made public on website)	M36	M36	TKK
M7.11	17.8 Second Environmental Awareness application Prototypes	M42	M42	TKK

3.7 WP 8 – Showcase 3: TimeWarp

3.7.1 Objectives and starting point of work

The aim of this work package is the development of TimeWarp, a mixed reality game in an urban context that allows users to experience a city in different time periods. It is a collaborative game played by two players equipped with Ultra mobile PCs (UMPCs). Its main research questions are concerned with aspects of Presence, Sense of Place, collaboration and general Mixed Reality game design considerations.

During phase IV we have redesigned *TimeWarp* according to the findings of Phase III. The objectives of the redesign was to advance the infrastructure and gameplay by improving the interface and the gaming experience as well as examining further presence aspects.

The results of the redesign phase IV comprised of improvements and modifications regarding the following parts:

- AR system and devices
- Realization and implementation
- Game Design and Game Play
- Interface Elements
- Level Design and Challenges
- Narrative Structures

3.7.2 Progress towards objectives

During this final phase of TimeWarp we implemented and evaluated the second prototype of the TimeWarp game. The redesign was according to the findings of Phase III. The objectives of the redesign were to advance the infrastructure and gameplay by improving the interface and the gaming experience.

Main improvements to the game include a stronger role for the second player, a more engaging narrative that forced the players to make meaningful decisions during the game and more interesting and exciting challenges for the players.

Intensive test runs of 33 groups and 66 players were performed in Cologne in January 2010, with each test run lasting for about 60 to 90 minutes of actual playing time. For evaluation we recorded all actions of the players with video, but as an extension to our work from the previous year, this time we also recorded all in-game sounds as well as all things said by the players (directly onto the same video). An extensive and automated logfile of all game actions would also later help us to put the actions of the players in context. After the testruns the players had to fill in a questionnaire which was a slightly modified version from the previous year. Additionally, a free form video interview was also conducted.

During late January and early February a smaller study of 11 participants was undertaken in Christchurch, New Zealand, focusing on different aspects like the effect of an underlying structure of a city in relation to the game.

As a result of the evaluation phase, a set of guidelines for Mixed Reality games and applications was created.

3.7.3 Deviations from project work program

The development phase took longer than anticipated, so that the final test runs could not be performed before January 2010 instead of late summer 2009. This of course pushed the evaluation phase further to the back as well.

3.7.4 List of deliverables

Del. no.	Deliverable name	Date due	Actual / Forecast delivery date	Estimated indicative person-months *)	Used indicative person-months *)	Lead con-tractor
D8.4	Final Prototype of Time Warp application.	M48	M51			FIT

*) if available

3.7.5 List of milestones

Milestone no.	Milestone name	Date due	Actual/Forecast delivery date	Lead contractor
M8.11	Time Warp application re-design finished	M41	M29	FIT
M8.12	Third Time Warp prototype	M44	M47	FIT
M8.13	Internal evaluation reporting of the third Time Warp application prototype	M48	M49	FIT

3.8 WP 9 – Showcase 4: City Tales

3.8.1 Objectives and starting point of work

The focus of the City Tales workpackage was set on providing mixed reality with an emphasis on storytelling in an urban mixed-reality environment with user generated content that involves wide range of user groups. The aim was to investigate options to let users participate both actively and passively by enabling them to create mixed reality content via very simple user interfaces and providing technology to browse these. Over the long term our target is to make mixed reality content available to a mass market and by doing so take away the technology based stigmatism in and around mixed reality applications and to provide an alternative forum for urban development.

For Phase IV of the project these objectives were set:

- generalization and combination of used client approaches
- integration of MR content retrieval and MR content creation
- conduct field studies to justify design principles as resulting guidelines
- create scenarios with the consolidated prototypes showing the range of applications to be implemented possibly with the proposed system architecture

3.8.2 Progress towards Objectives

WP9 research started in the actual reporting period with the review of the research prototypes created in the previous reporting period, namely the MR-Player, the Walking Explorer and the Wall Blogging client. These early prototypes have been tested successful in preliminary field tests, yielding in the plan to extract the major positive features of each and combine them together into a unified client application.

The decision was taken to base further development on the MR-Player supporting retrieval and display of diverse multimedia content. The integration of map features of the Walking Explorer was achieved by integrating a Google map service on application level with live layer data feed from the SecondCity database. The MR-Player was extended to be location aware using GPS measurement and thus retrieve near-by content information from the centralized database.

The user interface for web-based content management and creation was extended with the necessary backend functionality to manage users and create a cross-relation between location based and marker technology based indexing. The database was extended to handle a wide range of specialized data types during the course of the research period especially with the involvement of secondary database users. Newly created data-types allow immediate integration with existing (such as the data management of the panorama client at TUG) or to be developed client prototypes (such as the AR-viewer currently under development at Hit Lab NZ).

The content retrieval and advanced content creation integration on the mobile client have been separated in order not to endanger the field trials planned during the period. The ARML description files of powerful in-situ content creation application (see D.5.4) are supported on the database level. Simple commenting actions with the use of the Wall Blogging metaphor have been identified as complex enough for in situ participation during the course of story-perception.

Our investigations show that most accepted are interfaces that do rely on the simplest interaction metaphor, including 'magic lens' metaphor to see virtual elements; map view to find elements nearby and narration to listen to virtual conversations and audio commentary. On the content creation side users do want to comment existing elements on site but creating new stories happens rather in an off-location story telling process in the more traditional sense. This impacts to future content creation pipelines and will give rise to other technologies such as remote presence and the technology described as scouting.

Participative workshops in Vienna during spring 2009 with students of urban planning and digital story-telling, gaming were engaged with the use of the system in the Naschmarkt are to field test the application of MR technology to their problems. Content creation workshops in summer 2009 with invited authors created after a phase of training found that digital story telling can have a significant impact on the story being told. Participants of the summer school in autumn 2009 were invited to experience the stories and participate in the technology of transferring content into the mixed reality system. Instead the engagement reached as far as the autonomous creation of new stories and the extension of the existing story telling universe beyond the originally told stories.

The open architecture of the SecondCity database permits to enter data from different locations using diverse interfaces, such as SecondCity Flash User-Interface, Google Earth, the E-Mail attachment gateway, or the mobile Wall Blogging client. Our findings show however that the created content is in fact published for the specific location, surroundings, local sights & sounds – making it either impossible or not advantageous to transfer to another location. This can be seen also as a big limitation to story-telling using mixed reality technologies, we do however encounter here a new opportunity to see this as a new way of communicating stories on large scale in urban environments. Successful re-application of the SecondCity system to other scenarios under development at TUG, Hit Lab NZ and TKK display a wide range of uses that can be a starting point for disseminating the project results beyond the project end.

3.9 Deviations from project work program

The delays which resulted from the time taken for the amendment to be approved and for new goals to be set during the third phase were removed during the final period. The unification of the technical implementation of the diverse client prototypes dealing work in previous reporting period, could be well streamlined with the field trial planning. The SecondCity server architecture set-up in the previous period created a stable basis for minor extensions (such as user management, multi-marker management, extended types, new export formats) as it's requirements were formulated from the previous theoretical investigations. The current planning period the delay could be taken well into account and focus was given the issue of the evaluation.

IMAG's contribution to the Infrastructure work package exceeded in total however prior planned expectations due to the higher demand for software development to integrate prototype client components into a structured overall system on multiple platforms that act as field test prototypes.

As an addition the simultaneous activities for the proper organisation of the IPCity Summer School 2009 with the WP9 internal preparation of the workshop created a major overrun of the originally planned activities. The successful training activities with the students on the research topic of the WP9 during the summer school created however apart from the other field trials during the IPCity project a valuable result for the further investigation.

3.9.1 List of deliverables

Del. no.	Deliverable name	Date due	Actual / Forecast delivery date	Estimated indicative person-months *)	Used indicative person-months *)	Lead con-tractor
D.9.4	Final Demonstrator of City Tales II application “Second City”	M48	M51			IMAG

3.9.2 List of milestones

Milestone no.	Milestone name	Date due	Actual/Forecast delivery date	Lead contractor
M9.10	Internal evaluation reporting of the initial Second City application	M39	M39	IMAG
M9.11	I9.6 (Internal Report): Second City extended prototype	M44	M44	IMAG
M9.12	Internal evaluation reporting of the final "Second City" application	M49	M49	IMAG

4 Consortium Management

4.1 Consortium Management Tasks

Achievements

The main achievements on the consortium management level were:

- Preparation and completion of the third amendment, this was accepted by the EC during the summer 2009
- Revised and submitted the final stage plan D1.12 which was accepted by the EC during the summer
- Organization and accomplishment of the regular project meetings
- Organization and accomplishment of the monthly Executive Board meetings
- Organization and accomplishment of scientific board and management board meetings
- Introduction of fast track special funds budget which partners can use for smaller items, this now allows approval within 7 days avoiding the need for a management board meeting
- Preparation of the final phase management deliverables
- Ongoing work to complete final cost statements
- Management and budgetary assistance with the summer school and final event.

Problems

The third amendment which contained the addition of HIT Lab NZ and the revised work plan was accepted by the commission during summer 2009. The delay in acceptance from the initial submission resulted in some problems with timing of tasks and events as some partners required confirmation of the project extension period.

TKK became part of Aalto University, at present the project is exploring the exact impact this has no documentation and auditing procedures. As Aalto have been accepted by the European Commission as succeeding TKK, there is no legal problem however it may require the submission of an amendment and additional auditing information relating to the transfer.

The deliverables, in particular those connected to management were written prior to all the information being available; in particular final costings and deviations. Therefore data provided in this respect should not be considered as painting a fully accurate picture. Until the project has closed it is not possible to answer exactly where reallocations between partners or cost categories may take place.

4.2 Contractors

Wolfgang Broll was replaced by his colleague Rod McCall as coordinator of the consortium.

There were a few changes within the individual project boards:

In the Executive Board the following work package leaders were replaced during the final phase of the project:

- Wolfgang Broll was replaced by Rod McCall as WP1 leader at the year 3 review meeting
- Thorsten Fröhlich left Fraunhofer FIT at the end of December 2009, WP4 management taken over by Rod McCall

- Anne-Kathrin Braun was replaced by Richard Wetzel as leader of WP8

In the Scientific Board Dieter Schmalstieg was re-elected as speaker of the board, Jean-Jacques Terrin again was elected as visiting member.

Beyond the new co-ordinator there have been no changes to the management board structure.

4.3 Project Timetable and Status

In general, almost all project activities are in line with the original description of work.

4.3.1 Deviations from cost or person-months budgets

The tables below shows the planned use of person months by each project partner within the previous working period. In contrast with previous years at the time of writing the deliverable it is not possible to provide the actual months used within the project as it ends after the due date for this deliverable. As a result only the planned months are provided at this point in addition partners have provided information as to any expected deviations. However these are subject to change on completion of the final financial statements.

FIT has redeployed some person months from other workpackages to WP8. This was to better reflect the amount of work required to fulfil the re-design and evaluation of TimeWarp. There has also been some transfers between demonstration and training activities. Furthermore due to lower labour costs FIT has invested approximately an extra 4-6 person months within the RTD elements of the project at no extra cost to the EC. This information is based on currently available financial information, the final details will be available after the close of the project.

TUG does not report any major deviations from the workplan, with a minor shift from basic technology workpackages to the showcases, in support of the technical needs of the user trials. Support for WP9 was increased to 1.5 PM. In general PM were slightly higher than estimated in advance.

At TKK there were no major deviations, with two changes. 1) We invested 0.8 PM in WP2 with publications, 2.4 extra PM in citywall development and 0.5 in management for finalizing the project, with small transfers between training to RTD workpackages. 2) As well, we implemented a minor service contract with a graphic designer for finalizing the interaction design on the final version of CityWall. This was the most cost and time-effective method for getting this work done. As the minor service contractor was a former student in Information Visualisation and Multi-Media Design of WP7 leader, there was a shortened lead time for briefing and iteration for this process. Neither of these changes will not impact overall budget. TKK does not expect there to be any other major deviations from the workplan. In general PM were slightly higher than estimated in advance.

At **UMLV** we had two major deviations concerning person-month budget. The first one concerns WP2. The organisation of the summer school and our participation to this event has demanded additional efforts. We have also worked more actively on dissemination issues as can be observed from our publication list. This is why we have used 1PM more than the original PM accorded to WP2. The second major deviation concerns WP3. We thought it important to make a general evaluation of all four showcases before the end of the project from the urban specialists' point of view. Our proposition to do so has been met with general consent and we have spend the time between July and February doing a in-depth work on WP7, WP8 and WP9. This is why we have used 3PM more than the original PM accorded to WP3. This explains why we have exceeded the original personnel budget by 15326€. This does not however influence the total budget accorded to UMLV because the budget allocated to durable equipment, subcontracting and audit costs has been negligible.

UniAK: major deviation in person month budget at UniAK relates to WP2 and WP1. Necessary contributions to the organization of the Final Event, causes unexpected increase of person months at a late and stage of the project. Apart from conceptualizing planning production and set up of the Final Event exhibition, preparation of spaces and facilities for the review, UniAK was also in charge of preparing press-materials and release and coordination of the event related to budgeting, program of activities. As agreed by all partners we also organized a panel discussion with well known architects, planners and theorists from Austria and the US. In this regard deviations in Budget are expected.

Another cost deviation relates to travel costs; for reasons of internal accountings deviations of travel budget from period 3 is now reflected in period 4. In addition to the already travel intense WP6 showcase, the European City of Science caused extra travel expenses. Although additional budget was allocated, we exceeded the previous estimation of travel budget.

TUW Travel costs were high but necessary, due to large field trials, user workshops and further research development. We do not have the final figures for person month deviation -- the report is currently just a first draft. The actual figures for costs and staffing will be delivered with the final reports.

IMAG's contribution to the WP5 Infrastructure work package exceeded prior planned expectations due to the higher demand for software development to integrate prototype components into a structured overall system with multiple platform clients that act as field test prototypes.

IMAG was in charge of the organisation of the IPCity Summer School 2009 event that created a major visibility and appreciation of the research work of the IPCity consortium. The simultaneous activities for the proper organisation of the complete event including announcement, participant application management, participant selection process, invitation, marketing material design and production, agenda management, local hospitality management and organisation, detailed program planning, partially participant and organizers travel organisation, site and facilities preparation, participant and organiser management during workshop, accounting, post-workshop notification, documentation, data and results archiving and presentation with the WP9 internal preparation of the workshop created a major overrun of the originally planned activities. The successful training activities with the students on the research topic of the WP9 during the summer school created apart from the other training activities during the IPCity project a significant impact to the availability of know-how created inside the work package.

UOULU

The work done in Oulu has a deviation from cost and person-month budgets, which has not had any impact on the results delivered, which has happened according to the workplan.

The deviation is that we have again used more PMs to produce the needed results than what is planned in the PM budget (30.5 PM used versus about 25 planned). The reason has been the shortage of experienced persons. Thus we have had two bachelor-level people on the payroll (mainly used as programmers and fieldwork helpers), and this has of course meant less productivity and more supervision, and thus the need for more PMs. But that workforce has also been cheaper, so costwise the work has been done within the budget.

UCAM was not able to replace the staff member who worked on IPCity until part way through 2010, as a result did not claim for the full number of person months. Some of this work was subsequently carried out by the same staff member at Graz.

4.3.2 Communication and Meetings

Communication Issues

All project-internal communication issues and mechanisms (including emails, documents, meetings, minutes, internal review mechanism, publications, etc.) are set down in detail in the project handbook, which has been updated according to recent requirements. All dissemination issues (including the public web page, the Wiki, and the newsletter) are also dealt with in the dissemination plan.

Communication between the individual project partners has been promoted by the use of 14 email lists tailored to the individual needs of the project structure (one for all people involved in the project, one for each board, one for administrative issues, one for each work package). All email lists are archived and can be browsed through the Internet by any project member.

Further, the BSCW shared workspace system hosted by FIT is used as the main platform for the exchange of documents and software, the collaborative preparation of deliverables and reports, polls regarding specific project issues, etc. It is further used for electronic provision of deliverables to the EC and the project's reviewers.

While the IPCity web server is maintained by UOulu, all partners are required to contribute and especially each work package leader is responsible for updates of WP related information. The IPCity newsletter is used to distribute information not only outside but also inside the project related to the project topics.

Meetings

During the fourth phase of the project three major meetings were held. These consisted of the review with accompanying board meetings in March 2009 (Barcelona). Furthermore two further general meetings were held in April (Oulu) and Aalborg (November). While these meetings focussed on management aspects a key new element was introduced to enhance the presence research within the project namely hands-on workshops looking at data analysis and theoretical issues.

There were three meetings of the Scientific Board: one at each general project meeting.

The project's Executive Board met in person at each project meeting. Additionally there were monthly telephone conferences of the Executive Board, checking and coordinating the monthly project progress according to the monthly internal progress report provided by each work package leader based on the input received from the individual work package participants.

Co-operations

The project already cooperates with the PRESENCCIA. These co-operations are mainly driven by shared partners and/or shared activates. TUG, that also is partner of PRESENCCIA and FIT cooperate with PRESENCCIA in the area of solutions for ubiquitous tracking.

Cooperation with HITLAB NZ and to some extend also to the University of Otago has been established by the exchange of researchers and the acquisition of two new projects fostering the exchange of researchers: MIRACLE – a bi-national project between Germany and New Zealand, involving FIT and HITLAB NZ, and MARCUS, an EC funded IRSES project (Marie-Curie) including the European partners FIT (coordinator), TKK, and TUG, and the NZ partners HITLAB NZ (University of Canterbury) and the University of Otago. This co-operation has been further enhanced since the annexation of HIT Lab NZ to the project.

TUG cooperates with the Christian Doppler Laboratory for Handheld Augmented Reality.

Again TKK worked with the Natural History Museum, Finland and with SYKE, Finnish Ministry for the Environment, as well as Urban Mediator project and foresty studies to

implement both MapLens and CityWall environmental awareness applications as part of WP7.

UMLV has worked with the city of Pontoise and the metropolitan authority of Cergy-Pontoise as well as the CAUE'95 for the organization of the urban renewal application as part of WP6.

UOulu has cooperated with the Department of Architecture, University of Oulu, on technology supported land use planning by organizing user trials on technologies related to web based cooperation between stakeholders and planners.

IMAG cooperated in the requirements definition of the City Tales server backend and the mobile clients with business partners and the University of Vienna.

5 Other Issues

None.

6 Annex: Plan for Using and Disseminating Knowledge

6.1 Exploitable knowledge and its use

The CityWall application has been developed further and it is exploited by a spin-off company. The technological framework and components are matured, are widely used within the project and can in principle be exploited further.

WP3:

- an original conceptual (concept map) and methodological contribution to research on presence and experience in mixed media environments; a conceptual and empirical exploration of sound and presence
- A set of guidelines applicable across different mixed reality experiences
- An approach to evaluating mixed reality experiences of varying types
- An underlying theoretical framework which is applicable across mixed reality experiences

WP4:

- A device-independent cross-platform access mechanism, based on DEVAL, OpenTracker and OpenVideo
- Three authoring tools: Interaction Prototyping Tool,AuthOr, and Mobile Media Collector
- Multi-Touch Display

WP5:

- Location aware content management (retrieval, processing, appending) using the Content Manager and the Second City Database and any combination of developed tracking technologies
- Software framework enabling MR on handheld devices, sub-notebook devices or semi-stationary device
- Mobile and stationary Tracking solutions providing more natural approach to tracking maps and real object textures in the environment as well as textured 3D models. This technology is now experiencing increasing demand also from industry
- Streaming solutions for bridging geo indexed video streams across networks enabling live wireless transmissions between remote locations
- Mixed Reality application interface Urban Sketcher for integrating and supporting multiple interfaces and devices
- MR tent for MR experiences outside the lab

WP6:

- several novel application concepts focussing on stakeholder participation and different forms of representations
- several novel mixed reality concepts: see-through augmentation, real time video augmentation and (static or dynamic) ‚panorama'
- several novel interaction concepts based on tangible user interfaces (ColorTable)

WP7:

- Augmented Map Lens has high visibility as one of the new augmented reality mobile systems available. Further work with TUGraz on implementing trials with TKK for other mobile AR technologies is in progress.
- CityWall, (a multi-touch screen installation for groups of visitors and a permanent installation that allows bi-directional input)—now its own expanding start-up company with service outlets located throughout the globe.
- Further implementation of pervasive technology with these two applications is under progress with various projects in TKK/ Aalto.

WP8:

- novel concepts for handheld mixed reality interactions
- novel concepts for level design and game elements for MR games in urban environments
- novel concepts for player collaboration in outdoor MR games
- deployable prototype of engaging MR game with high visibility (press coverage)

WP9:

- Server-client based automated mobile MR content retrieval system using the MR-Player implementation for massive parallel mixed reality story-telling and gaming scenarios.
- Flexible and extendable location aware server-client based content retrieval and authoring.

6.2 Dissemination of knowledge

During the fourth year the technology development focused on finishing touches, and major emphasis was in a number of field trials with real users in ambitious and extensive settings. This has led both a number of technology-related publications targeted to specific audiences, and increasing publications based on the results of field trials. Also the theoretical and methodological work has matured and published to be evaluated by the Presence research community. The volume and quality of publications has been increasing steadily.

Planned/actual Dates	Type, name and location	Type of audience	Countries addressed	Size of audience	Partner responsible /involved
Feb 13 2009	Workshop (discussion panel) with urban professionals and researchers from public and private institutions	Research & professional	French	Na	UMLV
Jan 18-20, 2010	Urban Computing Workshop at University of Queensland with National ICT Australia (NICTA) University of Queensland (UQ) and Queensland University of Technology (QUT), community, plus other IPCity and MARCUS partners in Brisbane, Australia.	Research & professional	Australia, New Zealand, Germany, Finland	20	TKK
April 10-15, 2010	Natural User Interfaces workshop at CHI2010, organisers of workshop Giulio Jacucci, HIIT, Ann Morrison, HIIT, Steve Seow, Microsoft Surface, Dennis Wixon, Microsoft Surface	http://www.stevenseow.com/chi10/	international	Na	TKK

Planned/actual Dates	Type, name and location	Type of audience	Countries addressed	Size of audience	Partner responsible /involved
October 29-30th 2009	MIRACLE Workshop	Research & Industry	International	25-30	FIT
August 16, 23, 2009	Field Trial: Map Lens prototype for environmental awareness	Research & professional	international	50	TKK, TUGraz, Oulu, IMAG, FIT
Mar 30-31 2009	Transilient Boundaries In/Of Architecture Conference, Edinburgh	research	international	Na	UMLV
May 4-5 2009	Urban Issues Workshop	Research, General	international	Na	UMLV, TUW
May 20 2009	Work session with Thales and Terramagna project partners	Research, General	international	Na	UMLV
Jun 17-19 2009	WP6 Pontoise Workshop	Research, General	international	Na	UMLV, TUG, TUW
Oct 12-16 2009	International Symposium on revitalising built environments: requalifying old places for new uses. IAPS-CSBE “Culture &Space in the built environment network” and the IAPS-Housing Network, Istanbul	research	international	Na	UMLV
Oct 22 2009	Workshop organized by the PIRVE / CNRS « Environnement et co-production de projects : échanges franco-italiens » research program in Université de Paris Ouest Nanterre La Défense	research	international	Na	UMLV
Nov 25 2009	Conference on mixed reality technologies, urban projects and IPCity at Ecole Nationale des Ponts et Chaussées	research	French	Na	UMLV
Nov 31 2009	International Conference on Intelligent Systems Design and Applications	research	International	Na	AAU
Dec 12 2009	Workshop (discussion panel) with urban professionals and researchers from public and private institutions	Research & professional	French	Na	UMLV
Jan 21-23 2010	Les premières journées du Pôle Ville de l’Université Paris-Est. Champs-sur-Marne	research	French	Na	UMLV
March 13 2010	Presentation in the symposium “Social media and hybrid social and urban spaces”, City University of Tokyo, Yokohama	Research, professional	Japan	120	UOulu
May 17 2010	International Conference on Computer Vision Theory and Applications	Research	International	Na	AAU
Jan 7-8 2008	Conference, IEEE 2008 Winter Vision Meetings, Workshop on Application of Computer Vision, Colorado,USA	Research	International	Na	AAU
Jan 30-31 2008	Conference & workshop on mixed reality technologies, urban projects and IPCity at Université de	Research	International	Na	UMLV

Planned/actual Dates	Type, name and location	Type of audience	Countries addressed	Size of audience	Partner responsible /involved
	Montreal, School of architecture and institute of environment, Canada				
Feb 18-21, 2008	Conference, ACM Tangible and Embedded Interaction 2008, Bonn, Germany	Research	International	Na	TUW
Feb 27 2008	Conference, Rave¨08, Barcelona, Spain	Research	International	Na	FIT
Mar 8-12 2008	Conference, VR2008, Reno NV USA	Research	International	Na	FIT
Mar 8-9 2008	Conference, IEEE 3DUI 2008, Reno, Nevada USA	Research	International	Na	FIT
Apr 5-10 2008	Conference, CHI 2008, Florence, Italy	Research	International	Na	FIT, TKK, TUG, TUW, UOULU, SONY
Apr 15-21 2008	Visits to UC Berkeley School of Information, Berkeley Institute of Design (BID), Communication between Humans and Interactive Media (CHIMe) Lab of Stanford University, Nokia Research Center (NRC), Palo Alto, California, USA	Research	International	Na	TKK
Apr 29 2008	Field Trial: Map Lens-new prototype for environmental awareness- 5 people	Research	Finland	5	TKK
May 13 2008	Presentation of IPCity Project to the Ateliers urban planning association.	General	France	Na	UMLV
May 28-30, 2008	Conference, AVI 2008, Napoli, Italy	Research	International	Na	TKK
June 3 2008	Presentation of IPCity project at a CNRS research prospective meeting.	Research	France	Na	UMLV
June 19 2008	Workshop on time, distance and reachability Vienna, Austria	Research		8	UniAK, TUW, TUG, FIT
July 1-3, 2008	Conference, International Conference on Image and Signal Processing, ICISP.	Research	International		AAU
July 2-9 2008	Video capture of CityWall activity in new location with same interface as a control and comparative use group. Analysis not completed.	Research, General	Finland	Expected 50-200 participants	TKK
July 17-18 2008	Workshop “Managing e-participatory knowledge” Bari University, Dept Architecture	Research	International	25	UOULU
August 07, 10, 17 2008	Workshop, 3 field trials for Augmented MapLens Helsinki City Centre	Research, General	Finland	Total 37	TKK, UOULU
August 11-15, 2008	Conference, Siggraph’08, Los Angeles, CA, USA, 2008	Research, General	International		FIT
Sept 1-5, 2008	Conference, British HCI conference, Liverpool, UK	Research	International		TKK, UOULU, UCAM, FIT

Planned/actual Dates	Type, name and location	Type of audience	Countries addressed	Size of audience	Partner responsible /involved
Sept 02 - 05, 2008	Conference, MobileHCI08 Amsterdam, The Netherlands	Research	International		FIT
Sept 11-12 2008	Conference, ShareIT –Shareable Interfaces for Learning Workshop, Brighton, UK	Research	International	Na	TKK
September 9, 2008	Workshop on “Mobiles Spielen” at GI Informatik 2008, München	Research	Germany	Na	FIT
September 10 - 12, 2008	Conference, International Conference on Digital interactive Media in Entertainment and Arts (Athens, Greece,). DIMEA ‘08	Research	International	Na	FIT
Sept 10-13 2008	Workshop, Cergy Pontoise Workshop, Paris, France	Research, General	France	21	UMLV, TUW, TUG, FIT, UniAK
Sep. 2008	Conference, ACM International Symposium on Mixed and Augmented Reality, (ISMAR’08), Cambridge, UK.	Research	International	Na	FIT, TUG, UCAM
Sept 30-4 Oct 2008.	Conference, Participatory Design Conference 2008, Bloomington, IN, USA	Research	International	Na	UOULU
Oct 7-9, 2008	Conference, MindTrek 2008, Tampere, Finland	Research, Industry	International	Na	UOULU
October 12, 2008	Launch of new CityWall environmental awareness prototype downtown Helsinki. Local Press and Ministry for the Environment present.	General	Finland	Na	TKK
Oct 14-16 2008	Event, European City Of Sciences Event Le Grand Palais, Paris, France	Research, General	International	Hundreds of users, thousands of visitors	All
Oct 27 – 31, 2008	Conference, ACM Multimedia 2008, Vancouver, BC, Canada	Research	International	Na	TKK
Nov 3-5 2008	Conference, ACM Futureplay Conference, Toronto, Canada	Research	International	Na	FIT
Nov 20 2008	News (EuroNews), City of science: from satellites to scales http://www.euronews.net/en/article/20/11/2008/city-of-science-from-satellites-to-scales/ Features IPCity demonstrations.	General	International	Na	All
Nov 25 2008	Conference on mixed reality technologies, urban projects and IPCity at Ecole Nationale des Ponts et Chaussées (Master Amur), 25.11.2008	Research	France	Na	UMLV
Dec 2008	Conference, International Conference on Pattern Recognition and Computer Vision, Bangkok, Thailand.	Research	International	Na	AAU
Dec 5-12, 2008	Conference, Situated Large Displays Workshop, Australian CHI, OZCHI 2008, Cairns	Research	International	Na	TKK
Dec 1 2008	Presentation of IPCity Project at	Research	Austria	Na	UniAK

Planned/actual Dates	Type, name and location	Type of audience	Countries addressed	Size of audience	Partner responsible /involved
	Academy of fine Arts, Vienna.				
Various dates	Workshop, TimeWarp Test Köln, Germany	Research, General		16	FIT
2008	Newsletter, "IPCity Research Project", in Allez Savoir, University of Cergy-Pontoise internal newsletter.	Research	France	Na	UMLV

6.3 Publishable results

As a result of project dissemination activities during 2009, four magazine articles and three other articles, in addition to numerous radio and television presentations have been published. Project has also actively promoted the scientific and technical results in social media, such as YouTube, blogs and twitter. Project was present at the Future and Emerging Technologies Event (FET09) in Prague, and organized the IPCity Summer School in Vienna. The Final Event in March 2010 concludes the public dissemination of the project. Members of the project have participated and made presentations in 36 conferences and workshops around the world. Altogether 16 workshops, demonstrations and field trials together with showcase stakeholders and end-users have been conducted in the showcases. Four journal publications, two chapters in books and 16 conference papers have been published. Although the main emphasis in publication during the year has still been in forums for human computer interaction (HCI) and Mixed Reality, the scope has continued to broaden both towards more specialized technical audiences (such as pattern recognition) and towards stakeholder communities (such as participatory design).

Acknowledgements and Further Information

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For further information regarding the IPCity project please visit the project web site at:

ipcity.eu