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## District Information Modeling and Management for Energy Reduction

# DIMMER

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 Collaborative Project

**WP5**

**Clicks + Links**

**D5.3.2**

### Data visualization: final strategies

Prepared by **Clicks + Links**

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## REVISION HISTORY

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2016.09.11	V02	Vin Sumner	Initial Content and Requests
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2016.09.29	FINAL	Vin Sumner , Clicks and Links	FINAL Input

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## COPYRIGHT

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## ABBREVIATIONS

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Acronym	Full name
DoW	Description of Work
AR	Augmented Reality
VR	Virtual Reality
WP	Work Package
3D	3 dimensional – usually expressed in terms of adding a height element to 2D visualization
2D	2 dimensional – as in X,Y position in a single plane
NO <sub>x</sub>	A generic form for the mono-nitrogen oxides (nitric oxide and nitrogen dioxide)
CO <sub>2</sub> / CO <sub>2</sub>	Carbon dioxide
PV	Photovoltaics – a method of converting solar energy into direct current electricity
BMS	Building Management System
GIS	Geographic Information System
BIM	Building Information Modelling (or sometimes referenced as Management)
EAM	Energy Analysis Model
SIM	(District) System Information Model

## 1. EXECUTIVE SUMMARY

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Visualisation is an important tool in enabling users to understand data and its context. In D5.3.1 we explored the various visualization strategies that can be taken in a project like DIMMER. These strategies have informed the approach taken by the various DIMMER tools, including the Community Portal , GIS , Benchmarking Tool and the District Visualiser; the various simulation and energy efficiency , and finally the presentation of building and BIM data at an individual and district level.

During the time of the project there have been many advances in visualization, in particular the rise of the so called realities (virtual , augmented and mixed ) and these have had an impact on tool development. The creation of multi-user collaborative environments has as a result become easier and has provided the foundation for the creation of the DIMMER district visualizer.

The broad principle of a district or city visualiser is that access is provided to a range of real time and static city data ( in DIMMER case that is energy ) that can be manipulated and presented on a selected visual canvas for example map/model, and viewed in a collaborative mode including the use of virtual and augmented reality. Using the visualiser functionality applications can also be built for specified scenarios/use cases.

## 2. INTRODUCTION AND CONTEXT

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This document concludes the DIMMER work on visualization by presenting the visualization modes and approaches that have been used across the DIMMER data based on the strategies proposed in D5.3.1. In addition, the document considers the significant advances in virtual, augmented and now mixed reality over the life of the project and their relevance to DIMMER and similar projects. Finally, there is a presentation of the approach being taken with the new District Visualiser which seeks to decouple data, canvas and application from the user interface, allowing for greater flexibility in using these technologies.

Task 5.3 of DIMMER forms strategies for the optimal visualization of results from DIMMER that:

- make use of innovative technologies (such as AR and VR)
- present them in an efficient and intuitive way
- are based on common means of communication.

Information on the VR/AR prototypes is provided in D3.3.6

This document following on from D5.3.1 describes how it is intended to ensure the most appropriate use of available technology to provide a useful, usable and engaging view of the information available through DIMMER. The strategies recognize the different needs and perspectives of different types of user whilst seeking efficiency through the use of common processes and components wherever feasible.

The DoW states<sup>2</sup> that Task 5.3 and its deliverables will focus on strategies for data visualization on personal devices such as smart-phones and tablets, however, given the rate of technological change likely to occur during the project's lifetime, we also consider personal virtual reality devices such as the Oculus Rift and Samsung Gear VR. Further, application of the developed strategies may indicate / recommend the use of platforms other than handheld devices and as such, these devices will be referenced in this document as appropriate and in D3.3.6. In particular, we discuss the rise of the so called realities during the life of the project, which we discuss in the next section.

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<sup>2</sup> Workplan table – Page 25 Of 42

### 3. THE RISE OF THE REALITIES

This section discusses the rise over the last few years during the DIMMER project of the so called realities. There is much misuse of the terms as they are linked to commercial products, but virtual , augmented and mixed do have significantly different meanings.

Figure 1 attempts to describe the “realities” in terms of level of immersion and the balance between the real and the virtual. In this context high immersion would exist when a user is totally absorbed in the activity, whilst low immersion implies potential for easy distraction. The horizontal access goes from something with little links to reality through to real being the dominant information. In this context cameras and videos approximate to real.

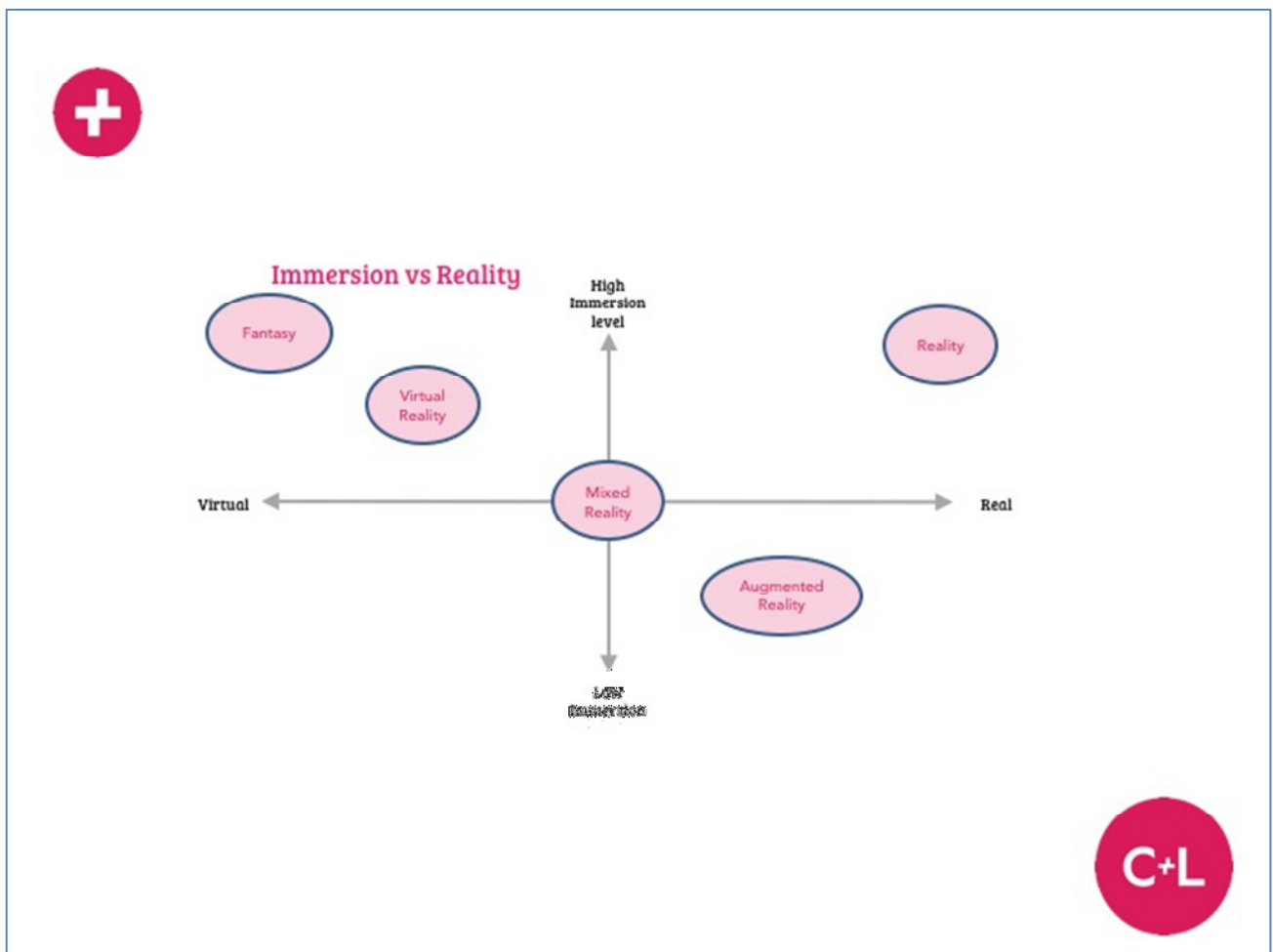


Figure 1 Immersion vs Reality – Today

Virtual Reality has traditionally in all its forms being about trying to immerse the user in a representation of reality, but more likely a reality that does not exist in the real world; because it exists in the past or future, or is simply a product of imagination.



On the other hand, augmented reality has been less about immersion and more about connecting virtual assets with the real world, so as to “augment” the user’s experience of the real world. Implementations of augmented reality are very mixed in their actual recognition of the real world , with virtual assets often simply being placed in response to a marker or a location ( GPS ) as in Pokemon-Go .

Mixed Reality is newer term and has being coined by Microsoft to describe their Hololens product (<https://www.microsoft.com/microsoft-hololens/en-us> ) and may well be the term that is used for Magic Leap (<https://www.magicleap.com/#/home> ). In this case there is greater immersion through use of a headset and greater interaction with the real world through use of projection systems and cameras to locate virtual objects.

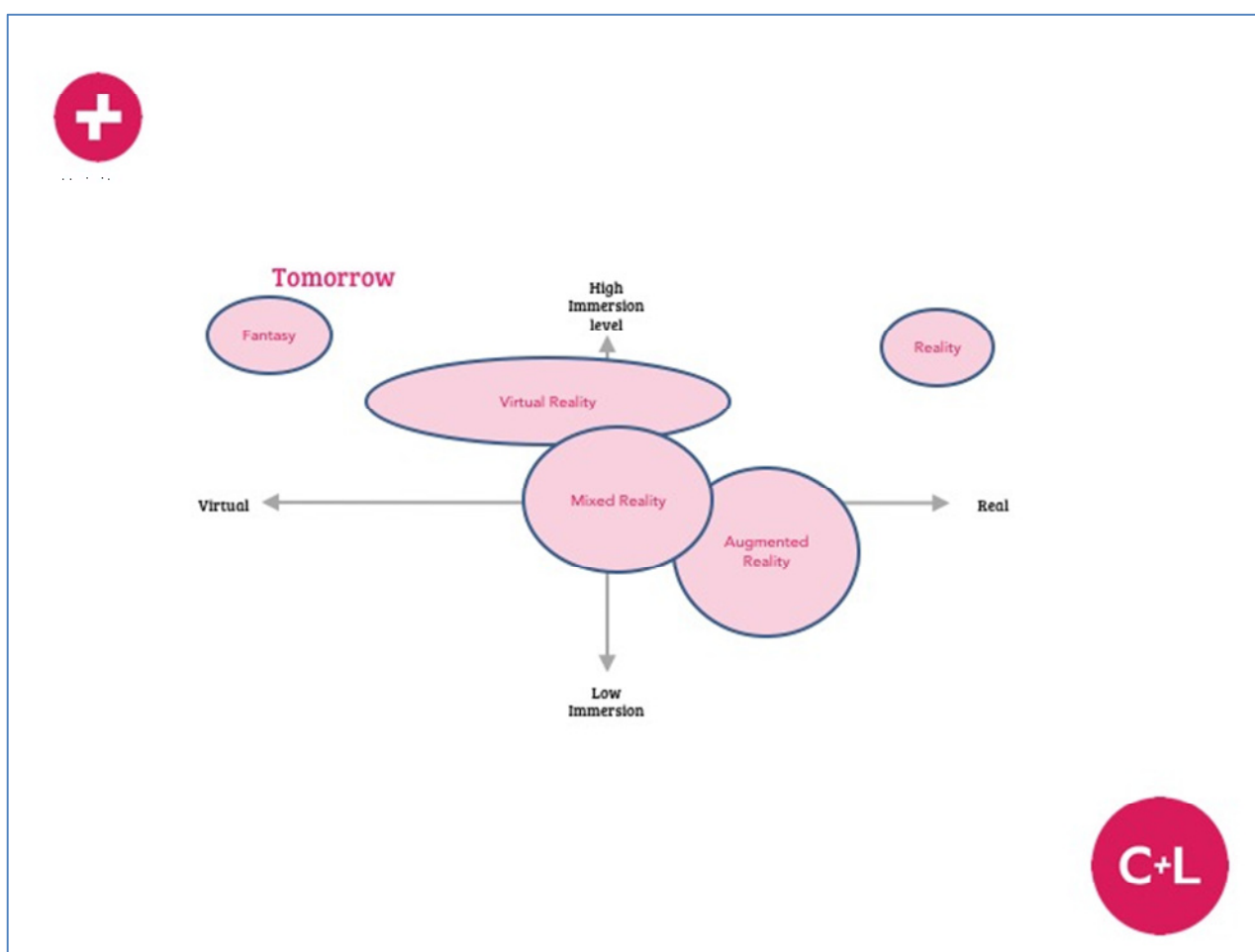


Figure 2 Immersion vs Reality – Tomorrow

Figure 2 shows how all the realities are being stretched as applications for the technology are sought. Virtual Reality is starting to include more real world data , from sensors to photogrammetry to video to live streaming, whilst Augmented Reality is both becoming more immersive and to provide “real” connections to the real world , but analyzing the space and placing virtual objects more accurately ( eg Google Tango ) . Meanwhile mixed reality seeks to become the all encompassing solution. It should also be remembered that most of these technology start with a focus on consumers

often through games and they need to be adapted to the needs of other industries such as energy or built environment. There are also a few examples of headsets being produced for a particular industry such as the Daqri smart helmet (<http://daqri.com>).

In all of the above it is important to distinguish the content from the viewing device, the former being the more important in that it will need to work with a range of devices. Whilst various Architectural, Engineering and Construction (AEC) companies have proprietary software that enables VR/AR/MR viewing, the use of multi-user games platforms like Unity3D and Unreal has produced the most productive in terms of an enabling immersive environment. CL's City-Sense platform that is developing out of the District Visualiser is an example and makes use of Unity3D plus a range of plugins and methods.

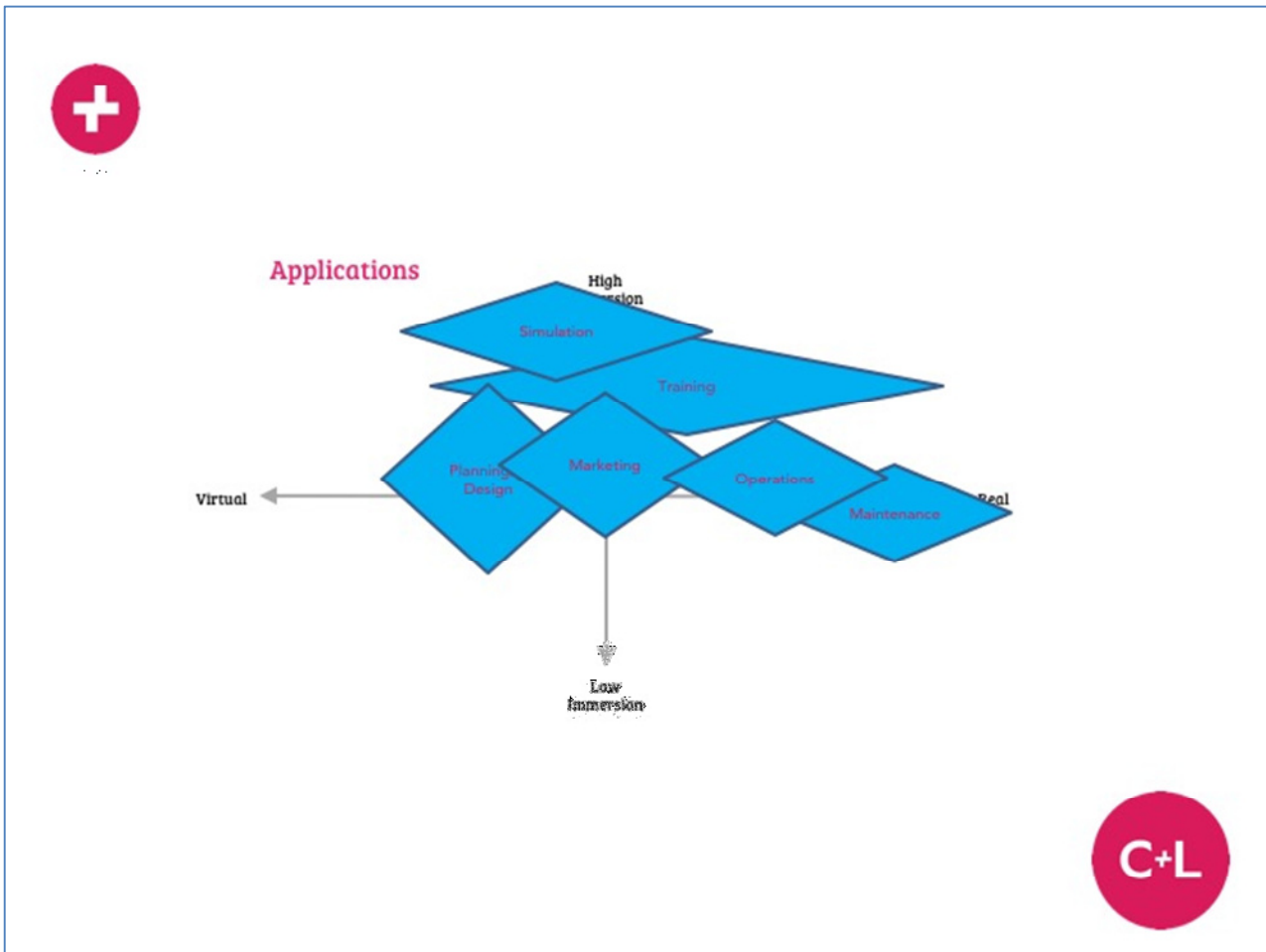


Figure 3 Immersive – Applications

Figure 3 shows how different applications require varying levels of immersion and a different balance between real and virtual data. Technologies that have greater immersion and also include a substantive real component are attractive across applications like simulation, training, planning. The DIMMER district visualizer combines immersion with links to real time data via the middleware and presentation on real world canvases. Figure 4 below repositions the realities against potential applications, showing potential for Virtual , Mixed and Augmented modes.

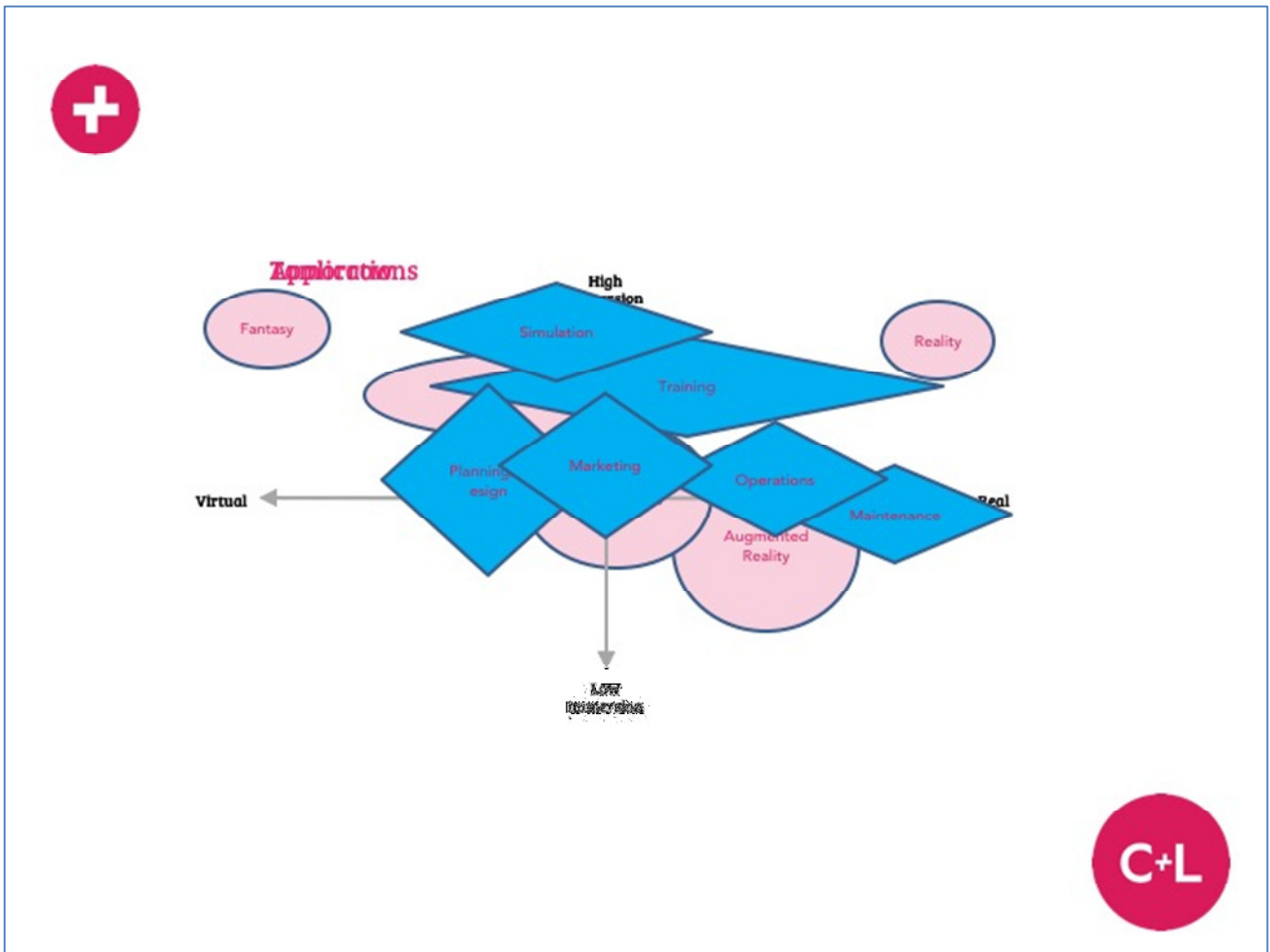


Figure 4 Applications vs Realities

#### 4. VISUALISATION MODES

In D5.3.1 the Visualization Modes below were defined and have subsequently been updated. The actual visualization solution fitted to a Use Case is what is important and modes may be combined to achieve the optimal result.

<b>Informational</b>	Dashboard	
	2D: X,Y plots, tables, etc.	
	2D: scatterplots, infographics	
<b>Geographic</b>	2D: map + data	data (text, numbers), colour representation, etc.
	2D: map + infographics	use of icons, representative graphics, animations (e.g. sweating/shivering people, balloons of CO2, etc.)

	3D: building and topographic models + data	
	3D: building and topographic models + infographics	
<b>Topological</b>	2D: map + data	
	2D: map + infographics	
	3D: topological models + data	
	3D: topological models + infographics	
<b>Augmented Reality</b>	Display of DIMMER information in either data or infographic forms on top of a real world view	Technology: smartphones and tablet – including Google Tango and its vision capability ; AR software such as Vuforia.
<b>Immersive/Virtual Reality</b>	Access to a virtual reality space using using a variety of devices including the latest head mounted displays.	Technology: Oculus Rift and Samsung Gear VR / HTC Vive , Sony Morpheus , Google Cardboard
<b>Mixed Reality</b>	Augmented Reality through holographic projection , provides more immersive experience	Hololens, Magic Leap
<b>Collaborative Immersive Environment</b>	Used as platform for VR, MR and AR solutions	Enables multi users highly immersive interactions using games environments like Unity3D and Unreal.

Table 1 Visualization Modes

Affordances or aspects to be considered when determining visualization modes include:

- types of information to be delivered
- ease of use required – is the user ‘expert’ or what training is it possible / desirable to deliver prior to first use
- depth of engagement – is this a core activity for the user or a means of generating their interest
- implications for data accuracy and latency – what can be displayed well using a particular form of display and in a particular context, including in the context of other information being provided for the Use Case. This will probably also have implications for data source selection
- level of development to be modeled: building, sub-district, district – different data types
- level of detail to be displayed – how much can be absorbed at once – building, sub-district, district – different data types
- data sources – real world data, simulated data, calculated data (e.g. difference between actual and simulated data or the difference between base case and intervention results)
- target devices – format and size, availability of device to user, familiarity with device, policy constraints of use / deployment
- level of collaboration – do multiple people need to access the same visualization with ability to change
- length of experience – how long do people need to use the system for , relevant to some of the head mounted displays.

In terms of virtual reality there are also choices to be made about which head mounted display and figure 5 below shows the options based on level of immersion and mix of real time vs fixed renders,

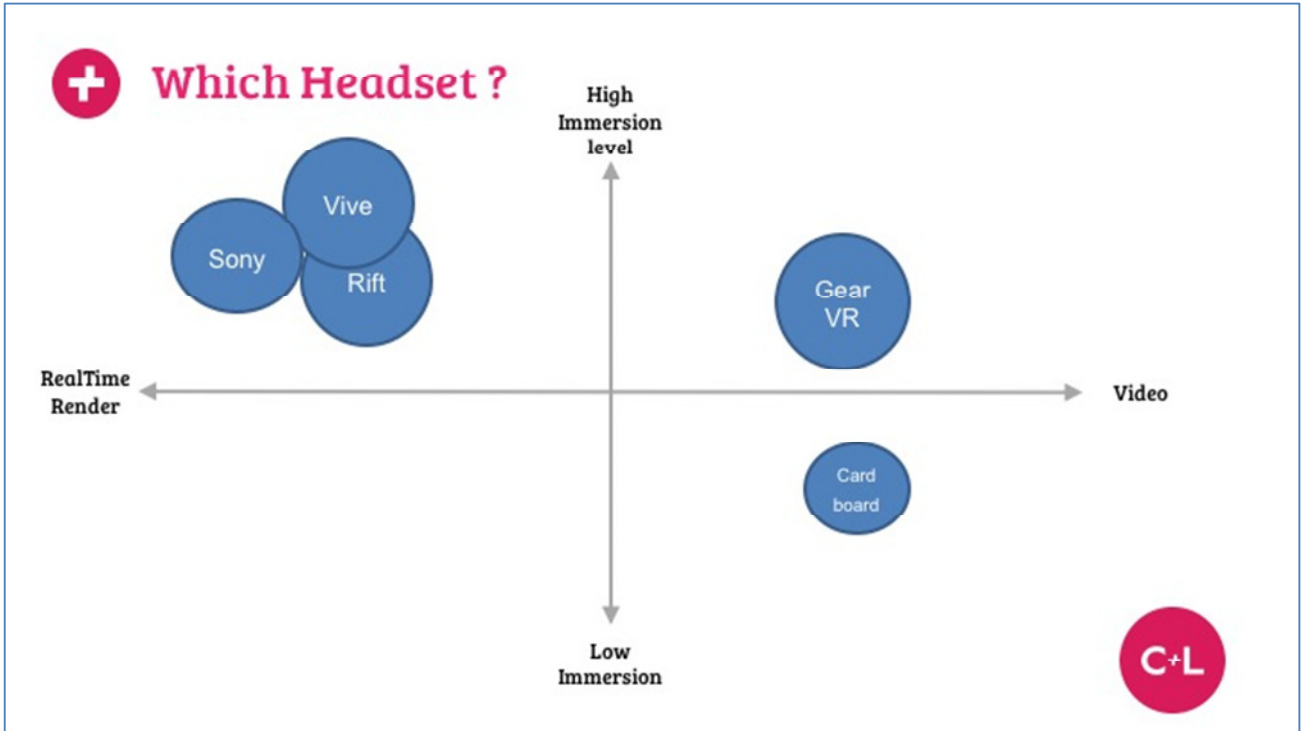


Figure 5 Which VR head set ?

## 5. VISUALISATION CHOICES

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The table below shows the major DIMMER components and the choices that have been made in terms of visualization option.

DIMMER COMPONENT	VISUALISATION MODES
Community Portal	Informational : Dashboard
GIS	Geographic 2D: map + data, 2D: map + infographics 3D: building and topographic models + data 3D: building and topographic models + infographics
Benchmarking Tool	Geographic 2D: map + data, 2D: map + infographics
BIM/DIM	Immersive Virtual Reality Augmented Reality
PV Simulator	2D: map + data, 2D: map + infographics
DH Simulator	2D: map + data, 2D: map + infographics
MultiFlow Engine	2D: map + data, 2D: map + infographics
District Visualiser	Immersive Virtual Reality Collaborative Immersive Environment

*Table 2 Visualisation Choices*

## 6. THE DISTRICT VISUALISER CONCEPT

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CL, as part of their work under Simulation and Visualisation, proposed the development of an application that enables users from all three target User Groups to make changes to a virtual representation of each of the two Demonstrators – in Turin and Manchester. This has been referred to as the Energy Network Visualisation app or District Visualiser. It requires that the total extent of each Demonstrator can be described by what is available in DIMMER.

The diagram below shows the components of the CL District Visualiser (DV) which can operate in collaborative mode for both Manchester and Turin Data. The DV makes use of CL's "Terra Mensa" ( Earth Table ) application that has been developed within the DIMMER project and will become part of the wider City-Sense product.

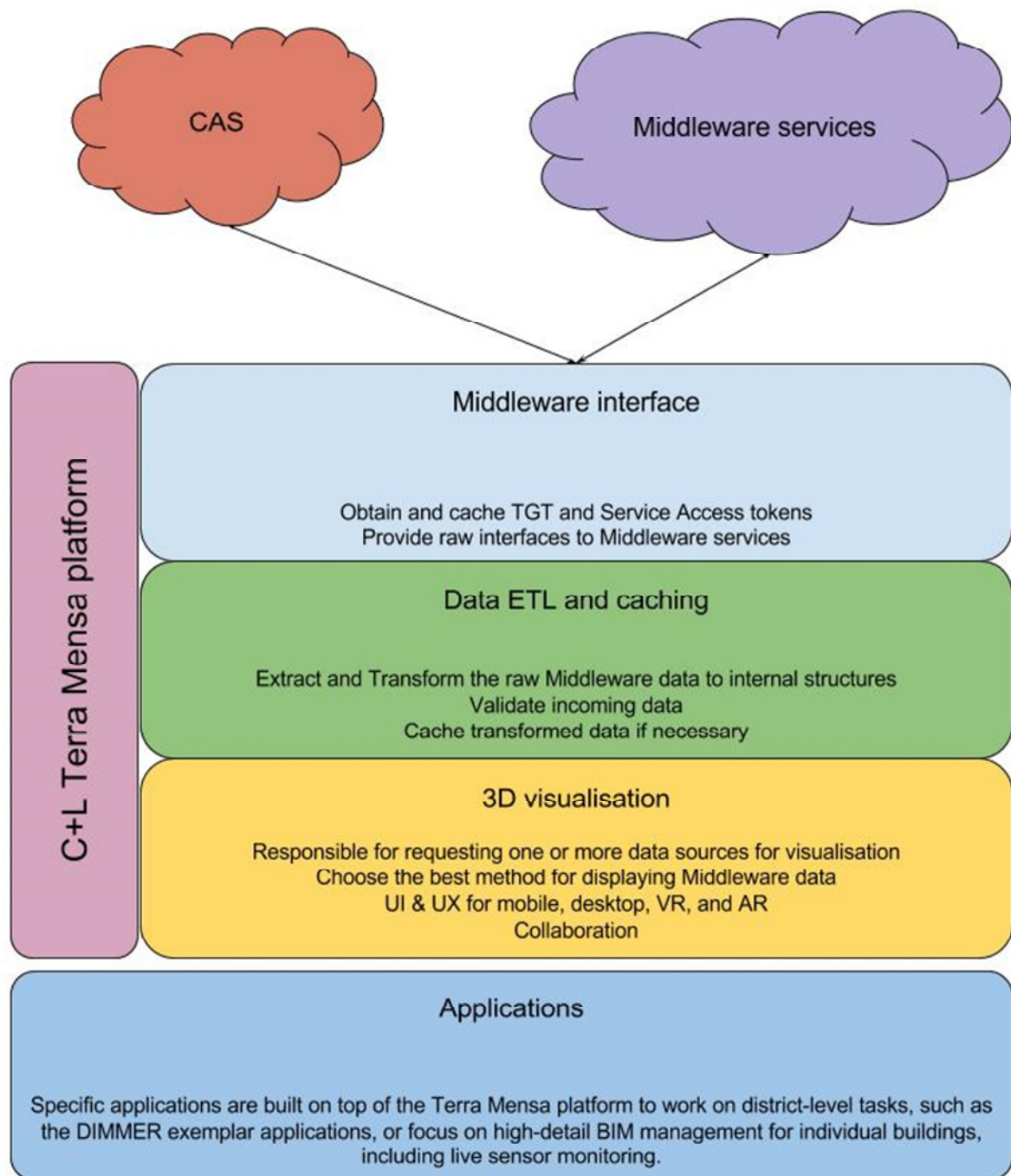


Figure 6 District Visualiser Architecture

The visualiser has a number of layers. The top layer handles all the details of interfacing with the middleware. This includes the authentication, as well as making requests to the middleware itself. As each service tends to be slightly different, this layer abstracts that away from the rest of the application.

The middle ETL (Extract, Transform, Load) layer takes the data and pulls out the stuff we actually need, creates efficient data structures for charting and 3D display. It also caches some data to reduce the amount of work done by the



Middleware servers.

The next layer is the visualiser itself. This puts together multiple requests if necessary, and fires them off to the ETL layer to obtain the necessary data, it doesn't care if it comes from the servers or from the cache, or even a file we provide. It generates the 3D geometry for the buildings, gets the simulation data for instance, and draws the graphs and charts necessary. It also handles the UI, and the collaboration. This layer could be replaced with a simple 2D map version for instance, or something suitable for GearVR and Cardboard. This will mean that regardless of the device it is run on, people will be able to see the same data and collaborate using whatever device is available.

The application layer includes generic sensor and BIM/DIM data presentation on a map or model, plus 3 exemplar apps showing use of the visualiser, for solar panels and district heating applications in Turin and the multi-flow tool in Manchester.

User experience is via screens or virtual reality headsets, and can be collaborative with users in other physical locations. The district visualiser will be built primarily using technology from the games industry, in particular Unity3D. This provides the scalability for future additional canvases and ways to interact with the data.

For the district VR application we have chosen the HTC Vive as the Head Mounted Display (HMD), which provides us with a powerful collaborative tool that users are finding far easier to use than for example the Oculus Rift which we had previously trialled. The main reason being that the application reacts to your total physical movement.

Current demo videos

<https://vimeo.com/184828048>

<https://vimeo.com/184826398>

<https://vimeo.com/184831441>

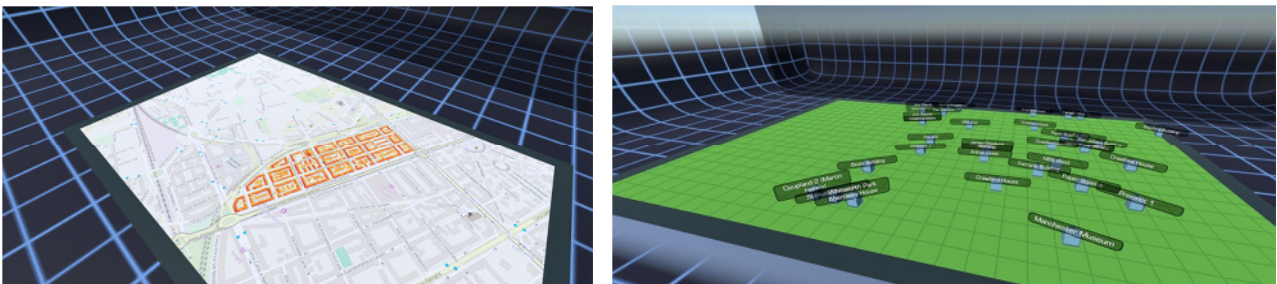


Figure 7: Example DV Interfaces

## 7. CONCLUSIONS

- The technology available for visualization has developed significantly during the the project and witnessed particular advances in the use of immersive devices and the rise of the reality technologies.
- Individual DIMMER components have chosen relevant visualization approaches such as Geographic or Virtual Reality
- The most significant use of visualization on DIMMER has come from the creation of the District Visualizer which enables users to engage and collaborate at a district level, and is making use of the latest VR Head Mounted Display (HMD) in the form of then HTC Vive.





