VR Simulation for Sustainable Transportation Planning:
Public Participation in Sakai City's LRT Design

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***Abstract*—This paper describes the components of a virtual reality (VR) system and its application to an urban renewal and LRT implementation project in Sakai City, Japan. The system consists of a real-time simulation software program for visualizing transportation environments, and several output methods for presentation and collaboration. Plans to reorganize urban space around the proposed LRT line are still in development, and the creation of a visual model allows the public to be informed and express their ideas. The implementation of this virtual reality simulation serves as a case study for participatory transportation planning where citizens are involved in early design phases and apply their local knowledge to project decisions.**

***Index Terms*—virtual reality, VR, transportation visualization, public involvement, participatory design, transportation simulation, sustainable planning, light rail transit, LRT**

I. Introduction

A. Visualization and Collaborative Planning

The process of public transportation design often requires a re-working of various factors from city arteries to citizens' daily routines. Especially when an overhaul of old travel behavior seems likely, public agreement over new plans is essential. However, local governments' concerns with building public support for new transportation projects differ amongst cultural and legal environments. If public involvement is called for, it is oftentimes during later stages when plans are nearly decided. Ideally, if citizens are engaged in earlier phases, planning time can be reduced if stakeholders are less resistant throughout the approval process.

Invitations for public involvement in planning stem not only from a need to gain approval, but also from the recognition that transportation users can have particular skills that are different from those of designers, or transportation engineers [1]. As found by Corburn, community knowledge can provide "crucial political and technical insights often overlooked by professionals" [2].

In order for the public to effectively join a planning conversation, plan details must be translated for a non-technical audience, and visualization is often employed. 2D renderings can be used during approval meetings to provide a glance at different options. 3D visualizations provide more information and can make it easier to understand spatial relationships. Furthermore, as seen in this case, virtual reality can also be an effective tool for sharing transportation plans. VR simulations enable both environmental constraints and traffic or pedestrian movement to be evaluated together in the same space.

A primary hindrance to the use of VR simulation for planning is that visualization is not often considered necessary at the start of planning projects. As a result, visuals become extra expenses that usually have no set budget [3]. Oftentimes, simulations are not put to use until the end of the design process, and sometimes only once public concerns have already arisen. In order to allow citizens to bring their local knowledge to assist design, visualization technology should be implemented in initial phases, and participation should be structured into the planning process [4].

Here we will take a closer look at Sakai City's VR model and planning process where a reorganization of existing transportation routes has been created virtually and is shared with the public for approval and advice. This paper explores both the process of VR visualization creation, and its use as a platform for participatory design.

II. Sakai City and a Transportation System Proposal

A. Sakai City Background

With a population of over 800,000, Sakai City is the largest suburb of Osaka, and the fourteenth-largest city in Japan. The population density is about 5,570 /km^2 and it is known as an industrious city with a large port. As with most of Japan, it is experiencing population ageing. Chronic urban traffic congestion problems persist. Sakai City also produces 40% of Japan's bicycle parts.

B. LRT and Urban Renewal Plans

Sakai City's current traffic problems coupled with a growing concern for sustainability issues have encouraged the city government to design a transport system that does not rely so heavily on automobiles. The comprehensive city renewal plan includes a reallocation of road space for pedestrian paths, bicycle and bus routes and train lines. A new LRT is planned for construction in 2011-12, and is part of a larger scheme to rebuild Sakai City so that it can stand as a model for urban sustainability. CO2 emissions are expected peak in 2012, and the planning agency has prepared a timeline of goals to receive

a 70% reduction in energy use by 2050. Plans include solar panels and green roofs; official city cars will all be "eco-cars" [5].

The LRT system fits smartly into this model of CO2 reduction: with grass on either side and between its tracks, it literally creates a green belt running through the city. The new line will be 6.92 km long but will also be combined with a converted regular rail line which will add 7.9 km to the total LRT distance [5]. The system will be promoted by "environmental" discounted tickets [5]. As Sakai City is a major site of bike manufacturing, the LRT transportation plans will also be implemented with a focus on bike transit. This not only includes establishing an extensive network of cycle routes throughout the city, but also creating a public bike lending system where users can use free city bikes.

As the plans will have a notable effect on citizens' everyday travel patterns and mobility, proposals have been met with resistance. Particularly as this project goes without similar examples in other Japanese cities, it is difficult for citizens to imagine the changes. As such, the Sakai City government is attaching importance to public participation in the project, and the result is a virtual reality simulation model that is shared with citizens, even in the project's incipient phases.

III. Methods

A. Software Configuration

A virtual reality simulation system is used for visualizing the interaction between urban space, transportation agents, and human traffic. Visualizations are created and presented within a real-time simulation software program called UC-win/Road [6]. This platform combines 3D models of the built environment, simulated vehicle dynamics and traffic flows, terrain information, and even weather effects. The virtual space can be navigated in real-time and users can understand what it will be like to take a drivers' perspective down a road at any chosen speed.

B. Terrain and Road definition

Design of a virtual Sakai City began with orienting the project and inputting road alignments. As seen in Fig. 1, ortho-imagery was projected onto the terrain model to create landscape markers. Road and track section attributes are attached to particular distances along the road alignments, and these elements are photo-textured to look like grass or pavement. Horizontal alignments and IP points for roads are input in 2D (plan view) (Fig.1), but as the model is edited, users alternate back and forth between 2D and 3D interfaces (Fig.2).

C. Model and Texture Input

With the addition of models and textures, the VR space becomes more realistic. For this project, some models are downloaded from the program database, and many are created in .3ds format from images of Sakai city (Fig. 3). As seen in Fig. 2, a large number of building models are imported and many remain un-textured in order to optimize performance and use less texture memory. The most visually detailed areas represent the controversial locations. In crowded places, such as near the station, 2D human images are added to depict crowds of commuters. Textures can be applied to any model or surface. In order to mimic the area's environment, sun position can be set to the minute, and shadows are accurately reproduced.

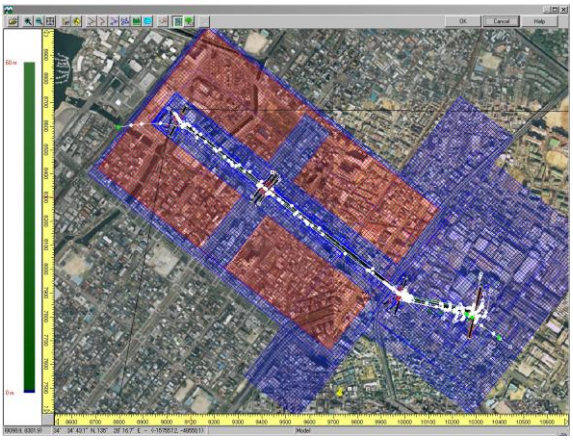

Fig. 1: Plan view interface screenshot - includes road alignments, terrain, satellite imagery and model placement. [7].

Fig. 2: 3D interface screenshot – overview of building models [7].

Fig. 3: Building and satellite textures, human and foliage models [7].

D. Traffic and Movement Simulation

Once the static models and textures are applied, environmental, traffic, and human movement can be added. As seen in Fig. 4, traffic profiles are customized with a proportioned selection of vehicle models, and in this case, the blue LRT train. Traffic settings are established so that cars stop

in accordance with signals, and abide by driving rules specific to Japan. Intersections are individually edited to incorporate road leg lengths, markings, drive paths, stopping points, and signal phases.

Human and animal moving models can be set to "flightpaths" and travel through the VR space. Motion-capture animations can be set to MD3 characters to allow them to move through the city space.

Fig.4: LRT, traffic and intersection drive paths editing window [7].

IV. Model Implementation

A. VR Model Presentation

"Before" and "after" scenes are created to depict the city development in different stages, and scenarios can combine a series of events, scenes and environmental effects. In addition, scenario creation allows users to take a driver's perspective and travel along a certain route where events respond to driving behaviors. When used in combination with a steering controller or drive simulator, users can interact directly with the VR scenarios.

In order to present the VR data in venues where the software is unavailable, video as well as image and sound output are possible. Videos are created within the program's interface, allowing modelers to create a script and record a series of moving scenes or saved camera still shots. These can be easily posted online and frequently updated.

During recent town meetings, the VR model has been run on a laptop computer, and projected onto a screen. Videos were also used together with maps and other relevant diagrams. These images can be saved as textures within the VR space and have been displayed in a slideshow format at town meetings.

B. Public Involvement

Initially, in the case of Sakai City, the VR model was used primarily to convince citizens that construction of an LRT line was a good idea. However, as planning has progressed, the model has served as an editable 3D space upon which the public can project their concerns and ideas during town meetings. Alternatives can be edited and presented in the visual model and several recent changes to the plans have come about as a result of citizen questions. Issues that have been raised and redesigned include truck delivery and ambulance access to homes bordering the LRT line, space between roadways and walkways, and bike parking near the station [8] (Figs. 5 and 6).

C. Planning Applications

An outstanding feature of this VR model is the extent to which it has been edited in order to relay the latest information to citizens. Beyond just a discussion of physical infrastructure changes, "planning" in this case has been research-intensive and includes a focus on process and involvement. University students have conducted surveys on both the public's opinion of the project, and their feelings on the VR model itself. For example, Kawano at Utsunomiya University studied the amount of information (about the LRT) that subjects retained from the visualization. Subjects were first shown an image, followed by a written statement, followed by a simulation, and finally finished with a simulation that included sound [9]. Here we see not only concern for the LRT design as an end in itself, but also for the model to be used as a platform for experimenting with VR applications, and transferring technical knowledge to a public audience.

Fig. 5: Close up of rail stops [7].

Fig. 6: Public gathering space near the station [7].

V. CONCLUSIONS

As new technologies and planning initiatives are implemented, so do innovative visualization platforms become necessary for evaluating the impacts of policy choices on patterns of growth and quality of life. This case study serves as a positive example of using VR simulations to involve non-engineers in early phases of an intricate project. Viewing the plans from a non-engineering perspective, the Sakai City citizens have used their local knowledge to help double-check potential problems.

As the Sakai City LRT project design is still being negotiated, it is early to evaluate an informed and vocal public interacting with a conscientious government will ultimately affect project goals or shape the outcome of the LRT design. Yet, midway through the process, some influences of participatory design are visible in small edits to the plan. In this case, the VR system is not solely a visual pacifier to sway dissent over physical plans; it makes the plans intelligible enough to enable citizens to help improve the design itself.

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