Spatial Analysis and Map-Based Visualization of New Tram Line Projects

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Abstract

A recent trend in many European inner city redevelopment projects showcases new tram systems that enhance the urban landscape along tram routes. The resulting urban images created in these cities present layered pedestrian spaces within interesting urban scenarios. However, when new tram systems are considered in Japan, issues are focused mainly on root plans and conventional traffic planning systems that miss the potential to develop more liveable and sustainable cities.

To create attractive urbanscapes integrated with tramlines in Japan, systemized overall design information will be helpful. In this paper, the authors perform spatial analysis of new tramline projects based on field surveys to clarify design characteristics. A system to visualize such design information using GIS was constructed so as to share the information among researchers, urban planners/designers and citizens. Our goal is to avail these tools and assist in creating meaningful consensus that will support projects to completion.

1. Introduction

1.1. Background

There has been renewed interest in trams worldwide. New tram systems create environmentally sustainable cities and barrier-free, friendly transport which functions as an effective tool for inner city redevelopment. Numerous cities in Europe have gained favorable reviews as being successful examples of these goals.

In Japan, the idea of new tram systems is gaining popularity, however, when the issue becomes specific, many cities cannot push the projects to completion due to the heavy financial burden on the local community and difficult adjustments between the various stakeholders.

Traditionally, local transportation systems are operated by private companies and funded mainly by ticket receipts. Such a system makes it

difficult to accept additional cost related to extended services and aminities for the good of the commons with the cost borne by public money that may enhance the profit margin of private companies. When new tram systems are introduced into Japan, strict economical issues are emphasized while the inclusion of soft points such as sustainability, unique carriage design and urban landscape design details are limited and fragmented (Aoyama, *et al.,* 2008; Kanamori, *et al.,* 2010; Kawanabe, *et al.,* 2012; Sakai, 2006).

Therefore it is necessary to explain and clarify the social contributions and benefits that effective transportations systems bring related to urban redevelopment and environmental issues in addition to point-to-point transportation services.

However, due to the boundaries that define responsibilities between owners and business operators, these transportation projects traditionally consider only the root plan. Adjacent public spaces and other important influential factors that will impact the urban landscape are not well thought out. This also makes tram projects less visible to the general public during the planning stages. It is important to present concrete images of how the public transportation package will create more attractive urban scenery as well as improved convenience to gain consensus for allocating public funds.

The authors conducted preliminary research in Japan by taking surveys of public opinion that measured interest in the development of new tram systems (Tsukamoto, *et al.,* 2011). From this research the authors realized the need of an overview of recently completed tram systems outside of Japan, including data on urban landscape factors. To understand how a new tram line project will cause changes in the urban landscape, it was felt that visualized information easily accessible to the general population will give valuable assistance.

The numerous projects completed in Europe, both in the planning process and in the construction details, offer an opportunity for Japan to study alternatives to its present system. Some elements needed to create an image of a city as an attractive place to live or visit are convenience for shopping and cultural activities, easy access to various sections of the city and attractive pedestrian spaces that give people alternative routes to make use of a city.

Public transportation is a key to all of the above and tram rolling stock potentially enhances urban spaces as an independent, visually interesting element within a cityscape. Trams also lend support to a sustainable environment. An effect of these new systems is to cause the reallocation of public space with road space decreasing and pedestrian spaces increasing. Also, thought has been given on how to link pedestrian spaces with parks and plazas, in other words, city planners are not just making more sidewalks.

The authors call the spaces that are generally reserved for pedestrians both inside and outside of buildings and open to the public regardless of property ownership, urban interiors. Such spaces include underground passages, colonnades, sunken gardens and plazas (Perry, *et al.,* 2011). These spaces are based on human scale and are generally of high quality, engendering a sense of comfort. Urban interiors that lie along tramways contain elements – design details and spatial composition effects – that are important to support an attractive city. For example, the rail bed can have grass between the tracks that then creates a green belt; tram stops placed at close intervals create a rhythm pacing how people move through the city.

The reason to shift from cars to public transport should not be done just as a means to reduce the environmental load or create greater convenience and/or to increase barrier free access, but to enhance urban spaces that will in turn, enhance urban life and emphasize a sustainable lifestyle at the community level.

1.2. Purpose

In this paper the authors attempt to outline factors that influence urban landscapes, clarify spatial classification and analyze design characteristics so as to gain insight on how to create attractive urban interiors (pedestrian spaces). At the same time, we attempt to establish a way to offer organized results for public review so that experts and the general public can study and comment by using GIS. We consider the visual images of a tram project to be quite valuable for all participants including designers/planners, owners and especially local citizens, and such visuals are the most important missing section of information in the development phase.

GIS is often used to analyze, simulate and visualize certain factors for future predictions or potentials (Thompson, *et al.,* 2011, Yoshikawa, *et al.,* 2009), but these tools are not often used to offer an overview of urban landscape with organized real images. The authors investigate a way to integrate site-specific information into GIS.

A future goal is to analyze the tram projects related to various urban features and create a visual presentation system to be used as a tool to gain input and consensus so that projects can be successfully completed.

2. Paper outline

This study is composed of the following:

- Urban landscape factors are defined and data collected is based on new European tram projects.
- Analysis of the results of the surveys and the classification of the characteristics of new tram projects.
- Authors developed original application named "KML Editor" to visualize the results of analysis and field surveys.

3. Urban landscape factors and field survey

Since trams run on the surface with moderate speed, unlike subway systems, its carriages, stops and related facilities are apart of the cityscape that constitutes the daily view of people, even those who do not actually ride the system. Urban landscape factors include tramways, tram stops, carriages, park & ride facilities, bicycle parking, urban interiors adjacent to the tramway such as parks and plazas, overhead wire poles and other facilities. In this paper, we focus on tramways, tram stops and urban interiors adjacent to the tram lines since these factors are easily identified and located more or less constantly at all of the sites.

Few systems have been built in Japan compared to Europe and those completed generally suffer under the traditional management system described earlier – an innovative system in Toyama City, 2006, a notable exception. Therefore, to create an overall tram projects database, field survey's were conducted between 2009 and 2012 in 30 targeted cities in Europe (see appendix A) where new systems were constructed creating a new type of public traffic network. Contents of the survey include the materials, color and form of tramways and tram stops and carriages. The relationship between tramways and urban interiors was also surveyed. As an additional information source, Google Earth and Google Map were used to check overall geographical input.

4. Spatial classification and analysis

4.1. Tramway

For site survey procedures, often we traveled the total length of the line so as to record data, however, time constraints made it difficult to travel the complete distance of some tram lines. When we could not travel a line from end to end, we did a partial survey by the standard direct physical surveying method and then we supplemented it by viewing Google Earth and Google Street View to survey the remaining sections via computer screen.

Of the initial 30 targeted cities 24 cities were surveyed. Clermont-Ferrand were cut because those trams run on tires not rails, and five cities in Spain and France were cut because the tramways were completed after the most recent photos were taken by Google and time was not available to travel end to end on those lines.

Materials used along the tramways varied from typical street pavement to more finished surfaces typical of pedestrian spaces. Among these varied materials, grass covered tramways exhibited a distinctive character within an urban setting and also functions as a means to reduce noise.

trawway w/grass	standard tramway	tramway w/grass
tramway map of Vitoria		urban landscape along tramway at Nantes

Fig. 1. Tramway with grass

the cities show tramways with grass. The location of the grass strip within the cites differ, for example, in Bilbao, Spain, the grass covered tramway is located in the center of the city, in Nantes, Grenoble and Montpellier, the grass strips are located in outer areas of the cities. At Vitoria and Mulhouse, most of the lines have grass running down the center of the rails for the total length of the lines.

Grassways create greenbelts, an especially important contribution in the center of these cities, and in outer areas the greenway increases harmony with the surrounding atmosphere. Interesting design variations occur as these greenways extend further outside the city centers, including tree lined tramways. However, only a few examples of artificial grass were documented.

It was expected that these types of tramway based greenways would predominate in inner city areas so as to create a touch of green in an otherwise dense urban landscapes. But it was found that extensive greenway development had taken place in the outer rings of these cities as well.

4.2. Tramway and urban interior

Urban interiors connected to tramway development can be divided into three scales and are associated to the spatial scale of the site: large scale plaza, small scale plaza, park like walkway. The location of a tramway in relationship to its associated urban interior is classified, shown in Figure 2.

Space type	tramway location	spatial diagram	city
Large scale parks & plaza	center		Bordeaux Nice Montpellier Le Mans
	side		Clermont-Ferrand
	edge		Bordeaux
	surrounding		Murcia
small scale parks & plaza	along		Nice
	edge		Alicante

Space type	tramway location	spatial diagram	city
pedestrian parkway	center		Montpellier Seville Zuhich Mulhouse
	dboth side		Madrid Zaragoza
	edge		Parla
	edge		Alicante
	next to bicycle road		Nantes

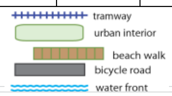


Fig. 2. Spatial Classification of tramway and urban inteior

The tramways run not only next to urban interiors – for example, alongside a plaza or walkway – but also through the center of plazas, along the circumference of plazas and along both sides of walkways and parks. Our subjective view was that the overall design atmosphere of sites were not disturbed when trams ran through the center of large plazas. Small scale spaces had varied success levels in regards to the integration of the tramways and the urban interiors.

The authors tried to find methods to effectively show how rail lines and plaza elements interacted and how these various elements, for example paving material, created borders between different functions such as the space divide between the tramway and its urban interior. We found 9 types of combinations as shown in Table 1. The borders of the tramways in most cases are without steps or bollards, borders denoted by different materials, patterns and finishes that lie on the same plane.

Table 1. Borders for tramways

type		1	2	3	4	5	6	7	8	9
different shape	step	-	○	○	-	-	-	-	-	-
	bollard	-	-	-	○	-	-	-	-	-
different surface treatment	material	-	○	○	-	○	○	-	-	-
	color	-	-	○	○	○	○	○	-	-
	finish	-	-	-	○	-	-	-	-	-
	pattern	-	-	-	○	-	○	○	○	-
	marking	-	-	-	-	-	-	-	-	○
			apploicable : ○			not applicable : ―				


type 9 sample photo

4.3. Tram stops

From the data collected through the surveys, tram stop elements are shown in Table 2. Tram stop designs depend on location and street scale and do not always provide shelter for riders. With or with out shelter, tram stops affect the urban landscape, especially true for large hub stations. Hub stations are divided into three styles: single plane roof, doughnut shape roof

Table 2. Tram stop elements

type	1	2	3	4	5	6	7	8	9	10	11	12
sign board		○	○	○	○	○	○	○	○	○	○	○
plat form	○						○	○	○	○	○	○
shelter			○		○	○			○	○	○	○
bench	○			○	○	○		○			○	○
light at tramway	○											
objects						○				○		○


type 1 sample photo

and multiple roofs. Depending on location, the tramway may run through the center of a hub, alongside the hub but with roof protection, or alongside the hub with no roof protection. A unique example of a standard stop seen at Mulhouse was the inclusion of symbolic arches on either end of the stop (see Figure 3). A connecting stop like hub with one large, single plane

stop type	stop design	tramway location	combined facilities	shelter form diagram: plan	shelter form diagram: section	roof material	city	connecting transportation
hub stop	one big plain roof	inside	no			opaque	Munich	tram subweay bas
			no			clear	Montpellier	tram
			no			opaque	Strasbourg	tram bas train
		outside	kiosk			opaque	Zurich	tram
	donut shape roof	inside	no			clear	Strasbourg Montpellier	tram car
		outside	kiosk			opaque	Augsburg	tram
	multiple roofs	inside	no			clear	Dresden	tram train
			no			clear	Kassel	tram
			no			translucent membrane	Praha	car
			no			opaque	Nantes	tram bas
		outside	no			clear	Parla	tram train
standard stop	symbolic arch	inside	no			N/A	Mulhouse	tram

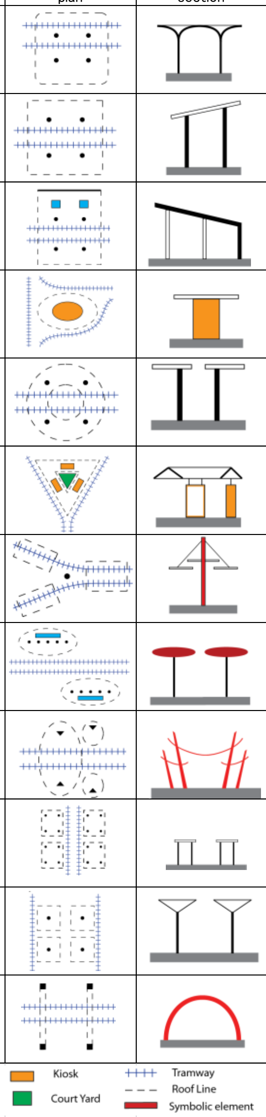


Fig. 3. Spatial classification of tram stops

roof usually was a large scale structure that stood out in the cityscape. Multiple roof design stops and doughnut design stops also stood out when large scale, but some of these stops were small scale and blended into the neighborhoods where they were located.

4.4. Shelter design

Basic elements that compose the stop shelters are classified in Figure 4. Enclosure of shelter design is classified as one of four types: pedestal, parallel, L shape or U shape. Pedestal designs have an outstanding, more unique, feature. Many shelters have U shaped designs with variation of

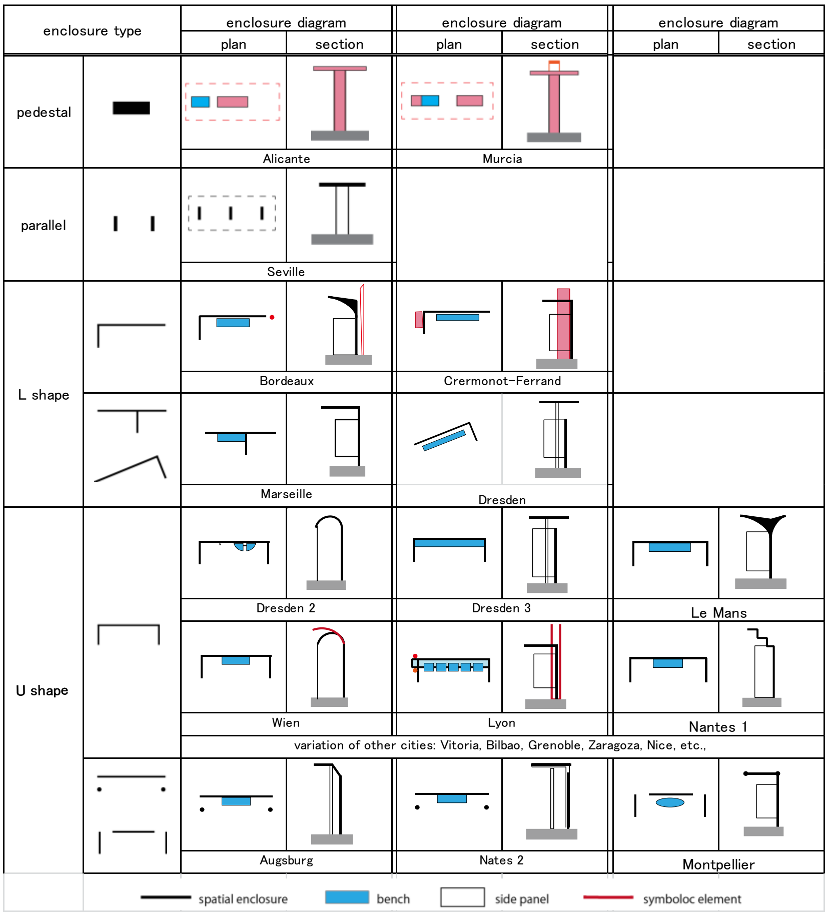


Fig. 4. Spatial classification of Shelter

materials for the enclosure. Also, the roof design gave the widest opportunity for design variations. Clock towers and lighting poles have symbolic functions. Benches in shelter are attached to the shelter back panels or independently attached to the floor. Another design option is the treatment of back and side panels, which are transparent, translucent or opaque. Some cities used unique colors or shapes for shelters, for example, the shelters' roof shape at Grenoble mimics the local mountain shape. There are many combinations of design elements to make shelter design and the shelter design can enhance a city's image.

5. Visualization system of tram projects

5.1. Purpose of system

The goal in creating this visualization system is to assist in the evaluations of future design options by making the analyzed results and databases open to the public.

5.2. Outline of KML Editor's function

Figure 5 shows overall function and data flow of the KML Editor.

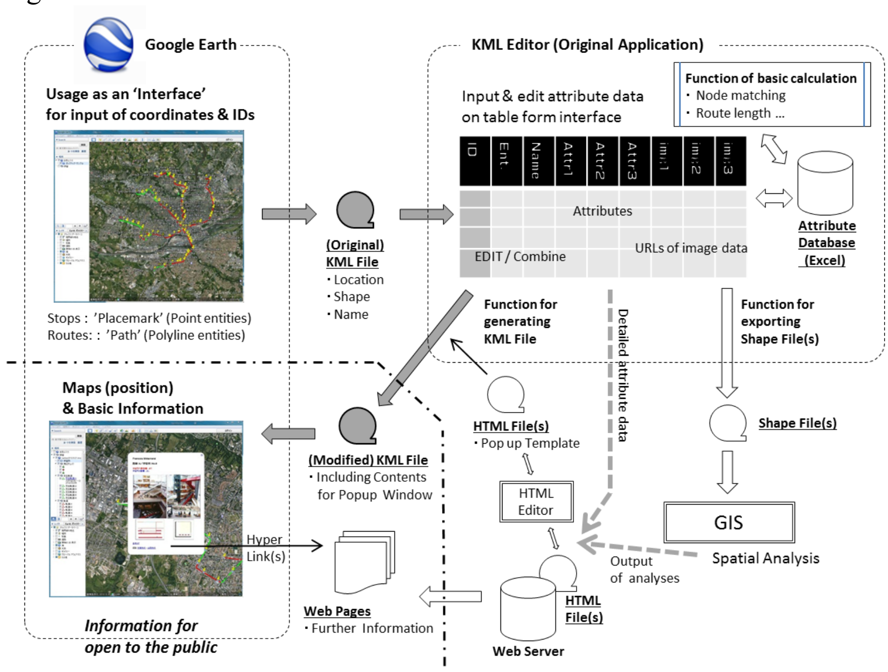


Figure 5. KML editor's function and data flow

This program interprets the contents already written in the KML and HTML files. The information can be edited in an Excel file, which appears as pop-up balloons. For example, a tram line map and the linked attributes of particular tram stops, characteristic design elements and text description.

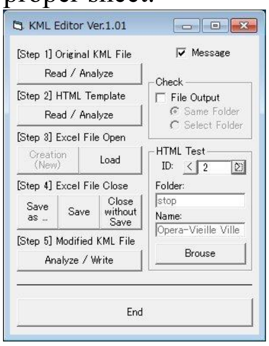
5.3. Features of KML Editor

The feature of this program is the effective use of popular application software, such as Google Earth, Excel and Dreamweaver, in order to create an easy to use interface.
The specific features are listed below:

- By using Google Earth to mark the location of tramways and tram stops, base maps and aerial photos can easily be referred to.
- For easier organization of the data, a table format is used. Columns carry wayside facilities and tramways; rows indicate text descriptions and photos. We can input and edit the table format data on Excel.
- Since KML Editor loads an already made template, it is possible to confirm the pop up image in advance.

5.4. Process of KML Editor

Figure 6 indicates the application form, which contains only buttons so as to simplify as much as possible. A Loaded KML file made on Google Earth (see figure7) and HTML template (see figure 8) generates automatically an Excel book (see figure 9). For different categories, different Excel sheets are formed. The contents of the HTML Templates correspond to the proper sheet.



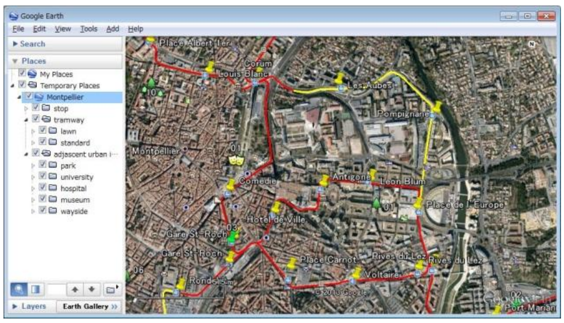


Fig. 6. Application form **Fig. 7**. KML on Google Earth

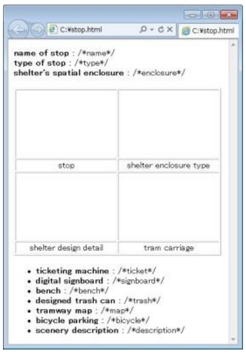


Fig. 8. HTML template

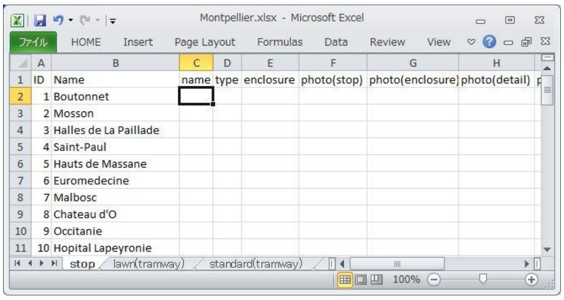


Fig. 9. Excel book

5.5. Visualization results

KML files open Google Earth and Google Earth interprets the KML file contents. While in Google Earth, more information is revealed in pop-up balloons via mouse clicks on hot spots. (refers figure 10, 11, 12, 13)
The visualization display can be seen by researchers, planners/designers and citizens by maintaining a KML file in a central server for download.

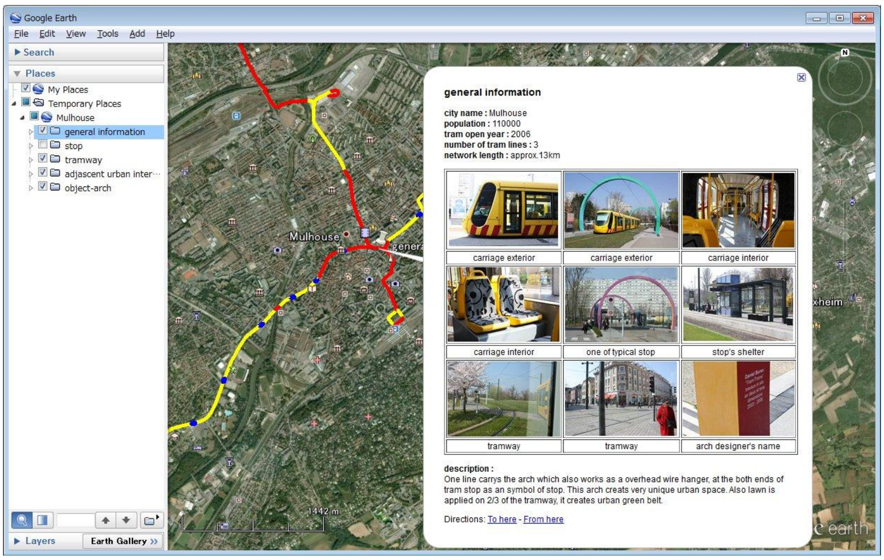


Fig. 10. General information pop-up balloon

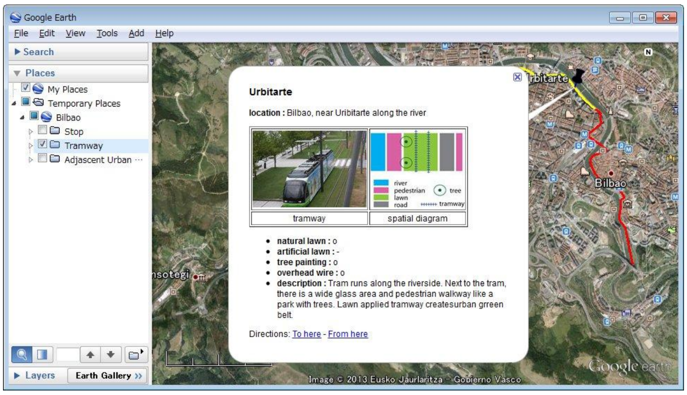


Fig. 11. Tramway pop-up balloon

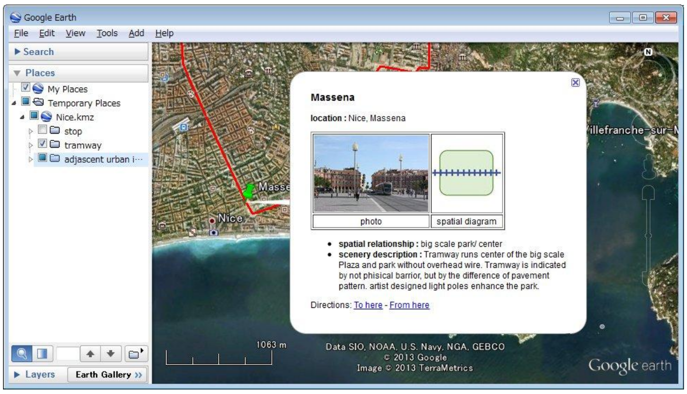


Fig. 12. Tramway and urban interior pop-up balloon

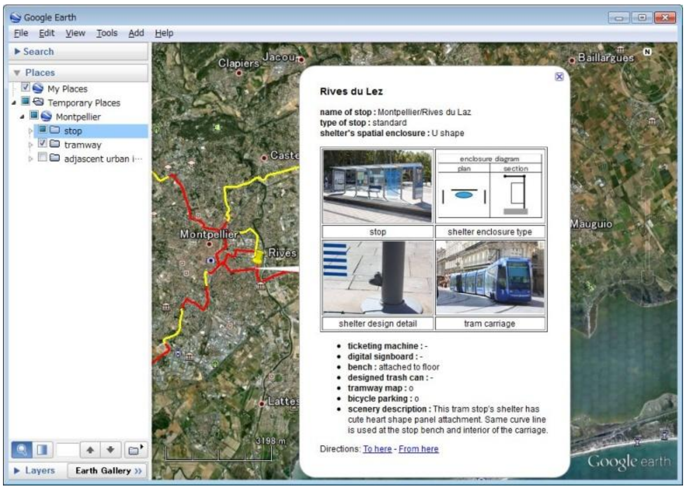


Figure 13. Stop pop-up balloon

6. Conclusion

This study highlights aspects of spatial composition and design of new tramline projects as part of urban landscapes by the construction of a visualization system. Site surveys were conducted to collect information regarding spatial composition and design of new European tram projects, mainly tramways and tram stops. The tramway data was then linked with Google Earth.

The spatial characteristics regarding urban landscapes are clarified:

- Most of the cities surveyed have tramways with greenbelts that contribute effectively to the urban landscape. Extensive development of tramways based greenways is found both in the inner city zones and outer zones, with variation of greenway design according to zone.
- Often there is no physical barrier between a tramway and its urban interior, especially when connected to large-scale urban interiors. With no barrier, an integrated design is created between the urban interior and tramway. Still true even when the tramway runs thorough the center of an urban interiors.
- Tram stops have designs that stand out and blend in with the surrounding cityscape. Ether way, stops can play an important role to create new city identities.
- Shelter design is classified into 4 types, with some design elements containing unique characterization of a city in form and color.

The development of the KLM Editor visualization tool made the following possible:

- The person or group that organization information and/or project owner can manage the comprehensive information, including location and features.
- Visual information such as photos and text descriptions are easily linked to the specific location on the map.
- General populations can acquire information by viewing the database via “google earth” no special software is needed.

Though this tool is only at the first stage of development, it functioned in an appropriate manner, allowing us to organize and analyze the information, making available for consideration design options so as to maximize the design potential of this type of transportation system. This gives us hope that it will be useful to assist in giving meaningful support in the future. When such projects are realized people quickly associate their appearance to the visual/economical changes to the urban landscape since trams run on the surface. These new tram systems have high potential to cause a positive shift in use of public transportation in inner cities and hopefully assist in the creation of a more sustainable lifestyle.

Acknowledgements

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Appendix A

Cities for the field survey are listed below,

France Republic: Angers, Bordeaux, Clermont-Ferrand, Grenoble, Le Mans, Lyon, Marseille, Montpellier, Mulhouse, Nantes, Nice, Reims, Saint－Etienne, Strasbourg

Federal Republic of Germany: Augsburg, Dresden, Freiburg, Kassel, Karlsruhe, Zurich

Republic of Austria: Wien

Spain: Alicante, Bilbao, Murcia, Parla, Sevilla, Valencia, Vitoria, Zaragoza

Czech Republic: Praha