Interactive maps for informing the population about flood risks: experiment in the City of Saint-Etienne, France

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Abstract. The objective of this innovative experimental project is to contribute towards improving the dissemination of preventive information among the population by means of cartography. This is based on the assumption that map interactivity can facilitate the uptake of information on risks among the general public. In 2011, the City of Saint-Etienne, the Institute for Major Risks (IRMa) and the ISTHME research centre developed an online DICRIM (document aimed at the local residents describing the major risks to which they are exposed) comprising several interactive maps. As part of the CEMORAL project (2011-13), three new interactive cartographic applications for Saint-Etienne were tested. The first two applications present information on flood risks, with a level of detail that varies according to the spatial scale of the map. The difference between the two lies in the interactive options, which are developed to different extents. The third application shows past events (floods, landslides) by means of a timeline. All three applications come with explanations that state their purpose and help users become familiarized more quickly.

Keywords: Interactive maps, Web mapping, Preventive information, Risks

1. Introduction

The policy on risk prevention in France comprises several measures for reducing the impact that a particular phenomenon (e.g. flooding) is likely to have on elements at risk (e.g. property, people, the environment). Among these measures is that of preventive information, which entitles citizens to “information about the major risks[1] to which they are exposed in certain areas of the country and the associated safeguard measures” (Legifrance 2004). The aim is to make citizens aware of the risks to which they are exposed so that they may take charge of their own safety and that of the persons around them. Being informed about phenomena, their impact and the associated protective measures makes people less vulnerable and more able to cope when faced with an unusual phenomenon.

There are several ways of disseminating such information at the level of the commune, one of which is the Document d'Information Communal sur les Risques Majeurs (DICRIM) (Legifrance 2007). It is structured into several sections that describe the major risks in the commune, a list of past events, the measures taken by the local authorities to deal with them, including examples of past actions, the safeguard measures to be followed in the event of danger or an alert, as well as the safety communications strategy.

When it comes to improving the readability and comprehensibility of risk data among the population (Ministère de l'Ecologie et du Développement Durable 2006), cartography plays a significant role: first, it allows readers to locate information and situate themselves with respect to this information; second, it makes it easier to analyse the spatial relations between data that would otherwise be difficult to identify; finally, being a visual image, it is very appealing. In addition, we believe that interactivity can reinforce the uptake of information, provided that it is simple to use. The principle of interactivity is to “give users the possibility of carrying out actions within a map. It also has the purpose of providing additional information (displaying hidden nomenclature, zoom function for an area with change in observation level)” (GCART 2004-07).

In 2011, the City of Saint-Etienne, the Institute for Major Risks (IRMa) and the ISTHME research centre of Université Jean Monnet collaborated on the implementation of an online DICRIM comprising several interactive maps[2]. As part of the CEMORAL research project[3] (2011-2013), a few other maps have been proposed (Lieghio 2012).

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[1] A major risk corresponds to a phenomenon whose probability of occurrence is low, but whose consequences for people, property and the environment are damaging.

[2] This project was carried out with the financial support of the City of Saint-Etienne, the Rhône-Alpes region and the Rhône-Alpes Regional Directorate for the Environment, Development and Housing (DREAL).

[3] The CEMORAL project is funded by the Loire Public Establishment (EP Loire) and the European Regional Development Fund (FEDER) as part of the "Plan Loire Grandeur Nature".

In the following sections, we will present the interactive DICRIM of the City of Saint-Etienne. We will then describe the three new map applications that have been developed. Finally, we will conclude with several other avenues worth exploring in future investigations.

2. Interactive DICRIM of the City of Saint-Etienne

2.1. Context

Although a paper version of the City of Saint-Etienne's DICRIM has been available online for some time now, the City has noticed that it is rarely viewed because users are not aware of its availability.

Therefore, in a bid to improve the communication of information via the DICRIM while taking into account the prerogatives of the Flood Directive, which cites the use of innovative methods based on Information and Communications Technology for informing the population about risks (European Union 2007), the City of Saint-Etienne, the IRMa and the ISTHME laboratory proposed making the DICRIM more interactive and easily accessible online.

2.2. Methodological choices

Two interactive map applications have been proposed: one application provides information on flood risks and depicts the flood-prone areas in the commune as well as the associated preventive measures (protective structures, information communications strategy), while the other is a geohistorical application that shows geolocated points for which there are archived documents on past events (floods, landslides) that occurred in the commune. These data are accompanied by additional information that is conveyed through pop-ups and multimedia objects (text, pictures, videos). Furthermore, the maps are supplemented by base maps (city maps, photographs, cadastral maps) that help users to find their bearings in the geographical space.

In both of these applications, users may select the information that they wish to see, move around or change the spatial scale of the map. They may also pinpoint their location by address. In the geohistorical application, it is even possible for users to search for events by type or date. These interactive options are accessible via navigation tools, query tools and a clickable legend, which are arranged around the map.

These two applications may be accessed through webpages containing the explanatory text on the DICRIM. For example, the flood risk application is opened by clicking on a hyperlink located on the webpage about this risk.

2.3. Results

The map applications have been implemented in an architecture comprising a GeoServer map server, an Oracle database server and an Apache TomCat web server. Two JavaScript libraries have been added: OpenLayers for the map display and JQuery for enhancing the JavaScript language possibilities.

The interactive DICRIM has been available on the City's official website since May 2012 (Ville Saint-Etienne 2012). A set of recommendations has also been written in collaboration with the IRMa and serves as a guide for other communes which may wish to develop similar applications (Clément et al. 2012).

Following this work and as part of the CEMORAL project, three other interactive map solutions have been developed. They revolve around several objectives based on proposals that have yet to be implemented – proposals formulated from the experience with the 2011 project and the very first feedback about the City's interactive DICRIM. These objectives will be described in the next section.

3. Aims of future applications

3.1. Improve the graphics density and the visual hierarchy of map reading

In the map applications of the interactive DICRIM of the City of Saint-Etienne, information on flood risks and past events may be displayed on any spatial scale. However, the map can be hard to read, especially on the smallest scales, when there is too much juxtaposed or superimposed data. Additionally, by default, all data is displayed once the applications are opened, which may make it difficult for users to prioritize them and determine the intended meaning of the map. Similarly, the base maps (city maps, photographs, cadastral maps) are available on all scales even though they may not always be relevant, for example the small-scale cadastral map.

We propose that the display of certain data be restricted to certain scales. For example, in the flood risk application, information is presented at different levels of detail and the base maps vary according to spatial scale. In the case of the geohistorical application, the map is accompanied by a timeline so that only events that occurred on the same period are displayed.

3.2. Facilitate the finding of bearings in the map

In the applications of the City's interactive DICRIM, users may locate themselves based on an address by means of a query function. Alternatively, they may zoom in or out and move around within the map itself. However, it seems that users sometimes find it hard to determine their bearings, especially at very small or very large scales.

In order to minimize these inconveniences, four possible solutions have been considered. The first of these is to develop three buttons that will automatically position the map according to three predefined spatial scale ranges (city, district, region around the city). The next solution is to create actions (click, hover) for various objects that will make it easier for users to locate themselves (districts, landmark buildings in the city) thanks to pop-ups that display their names. Another solution is to add an overview map. Finally, it is proposed to reduce or even remove certain navigation options in the map, such as the possibility of moving around or zooming in and out.

3.3. Facilitate the understanding and use of applications

Currently, there are not many explanations provided as to the purpose of the map applications of the City's interactive DICRIM, or how to go about using them. This makes it harder for users to decipher the message behind the map and use the applications. Besides, the tools that allow users to interact with the map (navigation, query, actions on objects, clickable legend) may be missed or poorly understood, notably because of their location on the page or their design. For example, the clickable legend in the drop-down menus at the top of the map is not clearly visible.

In order to help users better understand and use each application, we propose to add several new features. First, the webpage from which users access the application gives a summary of its objectives. Next, once users click on the hyperlink that opens the application, a pop-up window indicates the data that will be shown. It also states that an explanatory note can be accessed at all times simply by clicking on a button in the application. This note shows a map-reading scenario whose aim is to guide users in gathering information as they explore the map.

Once the application is opened, a set of contextual items accompanies each map, comprising a legend, a title, a graphics scale, an orientation, the origin of the displayed data and the creators of the application. In addition, the location and design of the interactive tools on the page are to be modified for greater ease of use. Most notably, there is a need for a legend that comes on display without having to look for it; this legend should also be located beside the map. Finally, a user guide is available at all times within the application to provide information on how each tool works.

Table 1 shows the functionalities developed in the three map applications.

Functionnality	Clickable map	Interactive map	Temporal interactive map
Improve the graphics density and the visual hierarchy of map reading			
1. Data restricted to certain spatial scales	implemented	implemented	not implemented
2. Data restricted to certain temporal scales	not implemented	not implemented	implemented
3. Base maps restricted to certain spatial scales	not implemented	implemented	not implemented
Facilitate the finding of bearings in the map			
4. Predefined buttons	implemented	implemented	not implemented
5. Actions (click, hover) for certain objects	implemented	implemented	not implemented
6. Overview map	not implemented	implemented	not implemented
7. Reduced navigation options in the map	implemented	not implemented	not implemented
Facilitate the understanding and use of applications			
8. Explanations about the purpose of the applications	implemented	implemented	implemented
9. Pop-up window to present data	implemented	implemented	implemented
10. Explanatory note about the map-reading scenario	implemented	implemented	implemented
11. Contextual items	implemented	implemented	implemented
12. Location of interactive tools	implemented	implemented	implemented
13. Design of interactive tools	implemented	implemented	implemented
14. User guide of interactive tools	implemented	implemented	implemented

: implemented
: not implemented

Table 1. Functionalities of the three applications (© Chesneau 2013).

In the next section, we will describe these applications according to the first seven functionalities.

4. Application characteristics

The first two applications display flood risk data at a level of detail that changes according to the map scale. While the interactive options in the first application (clickable map) are relatively limited, those in the second application (interactive map) are more advanced. The third application involves the mapping of past events (temporal interactive map).

4.1. Clickable map

4.1.1. Conceptuel characteristics

To begin with, a city-scale map depicting the districts is shown (Figure 1).

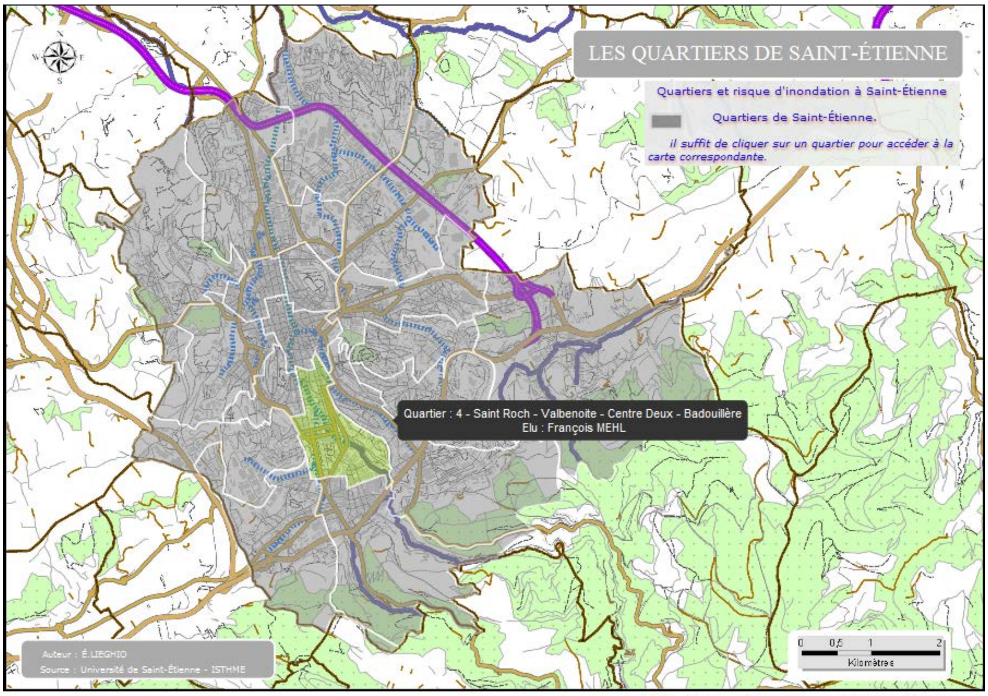
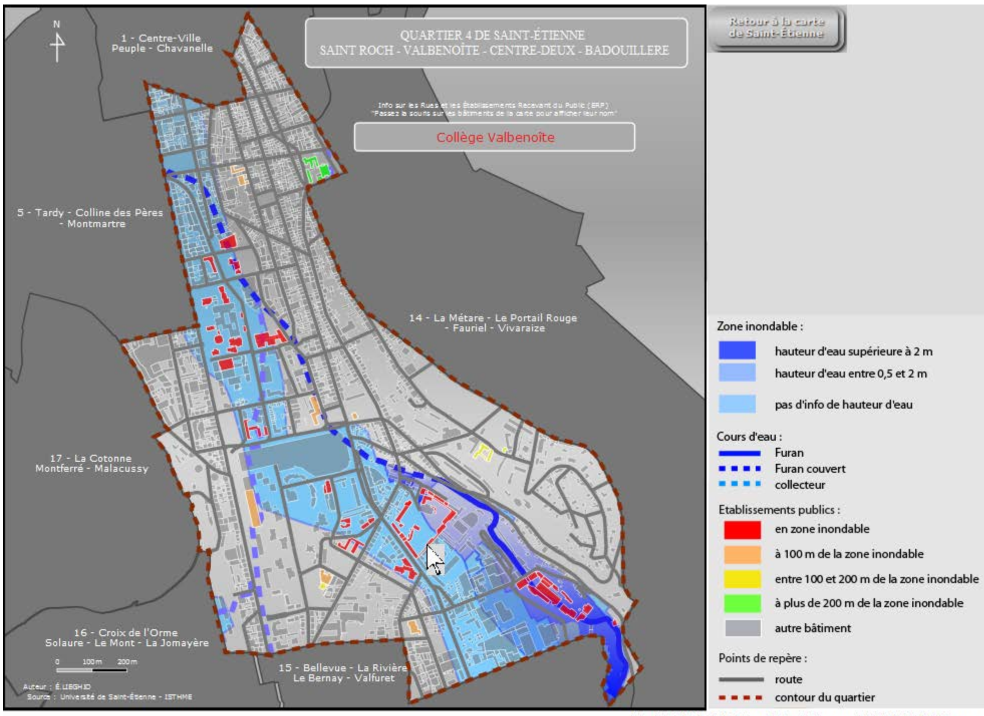


Figure 1. Map at the scale of the city (Lieghio 2012, © City of Saint-Etienne, ISTHME, IGN France).

When users hover over a district, a pop-up appears to indicate that users may, if they wish, view a map on the scale of this district. Additional information is then presented: flood-prone areas and strategic elements for managing an event (establishments open to the public, roads) according to distance from the flood-prone areas. The name of each element is obtained by hovering the mouse pointer over the object. Users may return to the map of the city at all times at the click of a button (Figure 2).



Lieghio 2012, (c) City of Saint-Etienne, ISTHME, IGN France

Figure 2. Map at the scale of the district (Lieghio 2012, © City of Saint-Etienne, ISTHME, IGN France).

District maps are available in both static and animated versions. In the static version, the final map with which users may interact is shown at once. In the animated version, the initial map is only made up of a base map. An animation is started by clicking a button located beside the map. Data on flood-prone areas and elements at risk start to appear on the map. The purpose of this animation is to impose a certain map-reading order.

In this proposal, users may not navigate freely from one map to another at different spatial scales. Only clicking actions (on a district when in a city-scale map, or on a button when in a district-scale map) are possible. Furthermore, the number of interactive options is dependent on the spatial scale. For example, at the district scale, only the names of elements at risk may be displayed by a hover action.

4.1.2. Technical characteristics

The JavaScript Raphaël library has been chosen for building this application. The maps are first generated in SVG language with an SIG software, then developed in JavaScript language implementing the SVG language to incorporate interactive and animation functionalities.

4.2. Interactive map

4.2.1. Conceptuel characteristics

Three reference spatial scale ranges are defined, for which risk information is displayed at different levels of detail.

At first, there is a city-scale map highlighting the flood-prone areas and the number of preventive actions taken in each district (Figure 3).

Figure 3. Map at the scale of the city (Lieghio 2012, © City of Saint-Etienne, ISTHME, IGN France, Cloudmade).

Next, from a drop-down list, users may select a district on which they wish to zoom in. Additional information is then represented on the district map such as the water levels attained in flood-prone areas or the preventive actions according to type (protection, information), each of which is accompanied by an explanatory pop-up and a multimedia object (text, pictures, videos) (Figure 4).

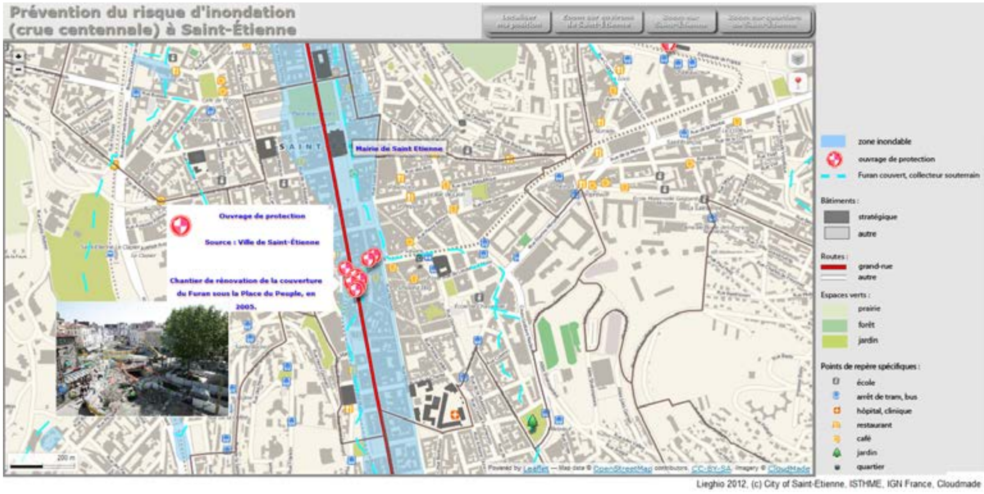


Figure 4. Map at the scale of the district (Lieghio 2012, © City of Saint-Etienne, ISTHME, IGN France, Cloudmade).

At all times, users may return to the city-scale map at the click of a button.

A map depicting the city in its geographical surroundings (hills, waterways, dams, roads, communes) can also be displayed. The purpose of this particular map is to help users find their bearings and better understand the origin of the flood risk (Figure 5).

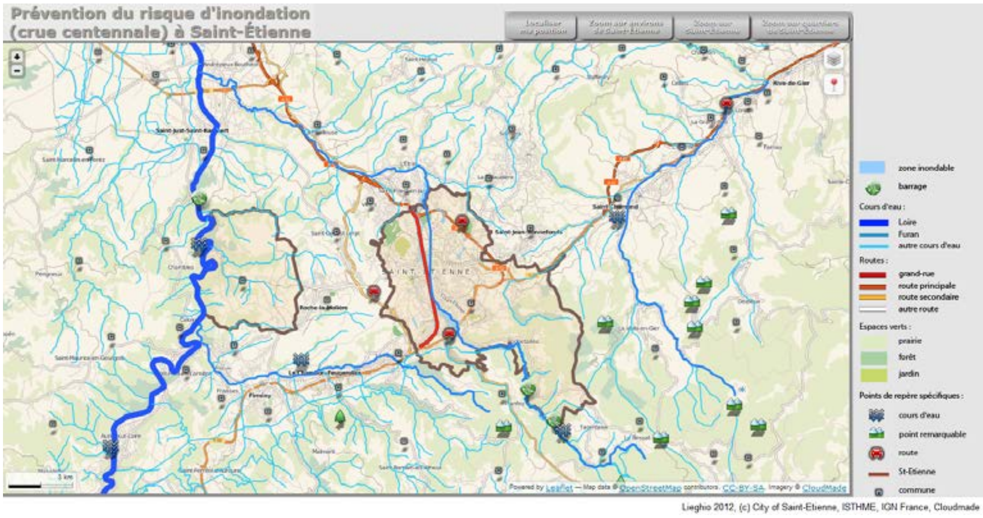


Figure 5. Map at the scale of the surrounding region (Lieghio 2012, © City of Saint-Etienne, ISTHME, IGN France, Cloudmade).

Once again, in order to make it easier for users to find their bearings in the maps, base maps are provided to complement risk data. These maps show varying levels of detail according to the spatial scale at which they are displayed. Furthermore, several base maps are available at a given scale. For example, at the scale of a district, users may choose a standard base map with roads, buildings, waterways and green spaces or an aerial photograph. Additional information such as landmark sites in the district (city hall, universities, squares) may be displayed in these base maps.

Finally, certain objects in the map (flood-prone areas, waterways, green spaces, landmark buildings, districts) are interactive. For instance, when users click on or hover above one of these objects with the mouse, a pop-up appears to indicate what it corresponds to.

4.2.2. Technical characteristics

This application uses three Application Programming Interfaces (API) that correspond to JavaScript libraries providing a wide range of interactive functionalities.

The Polymaps API, developed in HTML5 - CSS3, has been chosen for its simplicity and rapidity of implementation within a website, and also for its compatibility with all browsers. As it implements the SVG format, a high level of interactivity can be generated between the various map items. Besides, the object styles can be directly defined in CSS format, which greatly simplifies the development.

Similarly, the Leaflet API, developed in HTML5 - CSS3, has the advantage of offering quick and simple incorporation within a website. Furthermore, its basic installation is very light and can be added on to as and when required by installing additional plug-ins.

These two APIs have another advantage, namely that of using the GeoJSON format for geographic data, a simple text file composed of data in tabular form. This format simplifies the website structure and enables smoother navigation between websites. These two APIs also make it easier to incorporate personalized base maps, which is what we have done via the Cloudmade website and its online application known as Style Editor.

Finally, we have chosen to use the Géoportail API developed by the National Institute of Geographic and Forest Information (IGN), mainly because it allows us to enrich our own data with reference IGN geographic data (aerial photographs, topographic base maps, administrative boundaries). An extensive body of literature has facilitated its implementation.

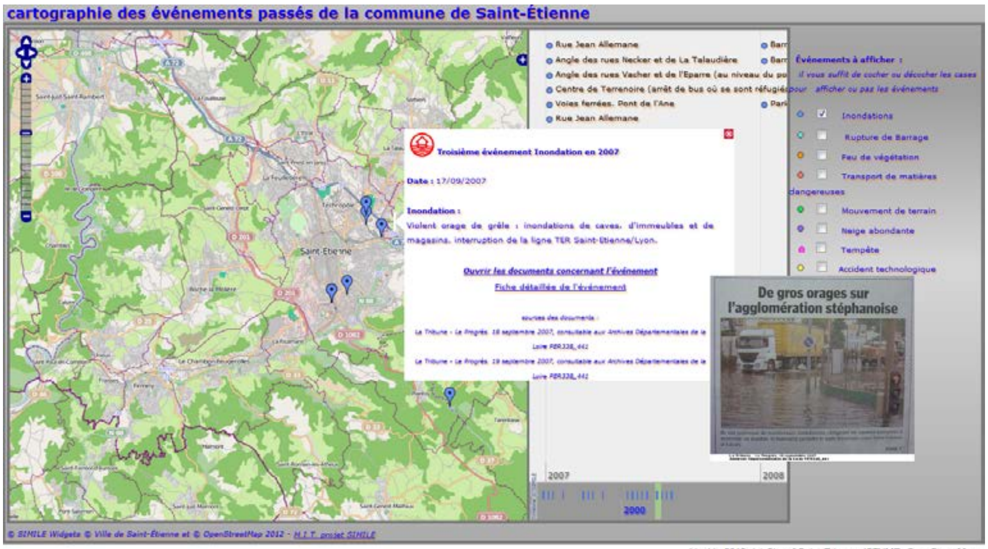
Each of these three APIs has its own advantages and limitations, which will not be detailed in the present paper.

4.3. Geohistorical application: temporal interactive map

4.3.1. Conceptual characteristics

The starting data correspond to geolocated points, each of which is associated with one or more archived documents (pictures, photos) relating to an event that occurred between 1587 and 2011.

When the application is opened, a base map of the OpenStreetMap kind appears at the scale of the city. This is accompanied by a timeline (Figure 6).



Lieghio 2012, (c) City of Saint-Etienne, ISTHME, OpenStreetMap

Figure 6. Map with timeline (Lieghio 2012, © City of Saint-Etienne, ISTHME, OpenStreetMap).

Users may navigate within this map (move around, zoom in or out) and choose to only display events of the same type by means of a clickable legend. The years may be scrolled through manually on the timeline. The map then automatically changes to show only the points relating to events that occurred in the past five years activated in the timeline. All points are present on the timeline, positioned according to date and defined by address. What this means is that there are two ways of gaining access to archived documents related to a particular point: either via the map (by clicking on its sign) or via the timeline (by clicking on its address). In both cases, a pop-up appears, from which the relevant multimedia objects may be accessed.

4.3.2. Technical characteristics

The application is built using the JavaScript Timemap library. It allows us to synchronize the JavaScript Timeline library with online maps such as those from Google, Bing or OpenStreetMap (the last of these being our choice).

5. Conclusion

Today, many interactive map applications are being used by members of the public, based on the Google Maps or OpenStreetMap model. Given this context, one of the challenges faced by researchers in cartography is to think up new solutions for making such maps easier to use, understand and memorize. Most notably, consideration should be given to the data to display depending on the scale involved, their graphic semiology, interactive and multimedia options, contextual menu and explanatory environment, as well as their access within a more global website.

The three map applications described in this paper are a first step in this direction. They should not be viewed as finished, turnkey solutions for local authorities, but rather as experimental models that express our research thoughts on interactive mapping adapted to members of the public.

As in the case of the City's interactive DICRIM, feedback will be gathered for these three maps in order to identify the features that should be retained as well as those that need improvement. Our objective over the longer term is to issue a set of preliminary recommendations for designing interactive maps in DICRIMs.

Another avenue for future research is to develop an interactive-map DICRIM in the form of a mobile application for use in smartphones, possibly coupled with a city-wide experiment and feedback on its use.

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