

# A Simulated Scenario of WikiGIS to Support the Iteration and Traceability Management of the Geodesign Process

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**Abstract**—Geodesign is an emergent term related to a new and complex process. Hence, it needs to rethink tools, technologies and platforms in order to efficiently achieve its goals. A few tools have emerged since 2010 such as CommunityViz, GeoPlanner, etc. In the era of Web 2.0 and collaboration, WikiGIS has been proposed as a new category of tools. In this paper, we present WikiGIS functionalities dealing mainly with the iteration and traceability management to support the collaboration of the Geodesign process. Actually, WikiGIS is built on GeoWeb 2.0 technologies—and primarily on wiki—and aims at managing the tracking of participants' editing. This paper focuses on a simplified simulation to illustrate the strength of WikiGIS in the management of traceability and in the access to history in a Geodesign process. Indeed, a cartographic user interface has been implemented, and then a hypothetical use case has been imagined as proof of concept.

**Keywords**—Geodesign, history, traceability, tracking of participants' editing, WikiGIS.

## I. INTRODUCTION

IN the era of Web 2.0, more and more organizations choose the Web as a vehicle for transmitting their information. We observe that users, specialist or not, become in turn producers of data. This transition introduces the concept of volunteered geographic information (VGI) and changes the concept of traditional mapping production radically. The latter represents the top-down in which professional experts produce and the non-experts consume. The former represents the bottom-up approach and characterizes the content of geolocation that are generated, increased and updated by users [1]. But spatial data, VGI one in particular, are dynamic and change over time and, anyone who works with such kind of data knows that keeping it updated is a challenge. The current collaborative mapping applications are still too limited to track the spatio-temporal evolutions of user-generated geometric objects (geometric: Location and shape, graphics: Iconography and descriptive: Attributes) [2], [3] and lack of relevant metadata to qualify these data [4], [5].

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As an emerging domain, Geodesign needs an innovative theoretical basis, tools, supports and practices in order to fit its complex requirements. The Geodesign summits [6] which have taken place in Redlands since 2010 have regularly confirm those needs. The authors [7] have then proposed a WikiGIS as a response to manage the traceability of an iterative process that characterizes Geodesign. In the context of this research, we chose the term Geodesign with a small "d" of design because it provides smaller scale projects, not taking into account the real complex social, economic, cultural and political constraints, which correspond to the benefit of operational validation of our research.

WikiGIS is built on Web 2.0 technologies and defined as a collaborative platform for decision model. The authors [8] have presented a conceptual framework for WikiGIS using Unified Modeling Language (UML) diagrams. WikiGIS is still in development and progress, and at this level, it is far from other platforms like Geodesign hub [9] developed by Steinitz for instance. This platform deals with the models of representation, process and evaluation that are models of change, impact and decision, measuring the consequences and presenting simulation of the results. Such platform treats GeoDesign with a capital "D" of Design that treats the complexity of the process generated by the disagreements of various stakeholders, the trouble deciding set, feedback loops that change the objectives, constraints and data [10].

This paper is a follow-up to the two papers mentioned above. More precisely, in this paper, we present a hypothetical scenario (use case) that aims at explaining the functionalities of WikiGIS and at demonstrating its utility to support the iteration in a Geodesign process. The next section briefly presents the concept of WikiGIS. The third section is dedicated to the representation of the architecture, database and cartographic interface of WikiGIS. In the fourth section, before concluding, a simulated scenario is showcased to highlight its main functionalities.

## II. WIKIGIS CONCEPT

The authors [7] have defined WikiGIS as a collaborative platform 2.0, supported by a wiki that insures traceability of geographical contributions of participants while insuring the quality of produced data in a dynamic visualization and analysis. It thus offers a simple and quick access to the process of Geodesign via a time browser (a temporal navigator that visualizes the entity's evolution). Some features in editing and design for sketch-mapping and in geoprocessing are as well

1. A web 2.0 application based on wiki track editing. The data may be modified, enhanced, updated or even deleted. All user contributions are archived and can be viewed dynamically with the historical content;
2. A documented traceability of users' contributions ensures the argued documentation of the design process, and an easy access to this process;
3. The WikiGIS ensures the traceability of geometric, graphical and descriptive components of a feature, and the relationships between different features such as topology, intersection, inclusion, etc. over time

4. An ergonomic and simple graphic interface (Geoweb 2.0) for easy viewing and navigation through spatio-temporal versions of contributions;
5. Any contribution is considered as an opinion with arguments;
6. These arguments generated by a media wiki are the main components to qualify external contributions;
7. The perceived quality is a mean to qualify data;
8. All previous versions of an opinion are considered as an integral component of the object (not as a different object).

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graph LR
    WikiGIS((WikiGIS)) --- Design
    WikiGIS --- Wiki
    WikiGIS --- GIS
    WikiGIS --- MultiTheme[Multi-theme]
    WikiGIS --- DataQuality[Data quality]
    WikiGIS --- MultiScalar[Multi-scalar]
    WikiGIS --- Decision[Decision making by consensus]
    WikiGIS --- Interface[Simple, ergonomic interface]

    Design --- Draw[Draw: point, ligne, polyline, polygon, other]
    Design --- Modify[Modify: copy, past, move, resize...]
    Design --- Format[Format: color, thickness, opacity]
    Design --- Symbols[Symbols]
    Design --- Iconography[Iconography]

    Wiki --- Editing[Editing]
    Wiki --- Links[Links]
    Wiki --- History[History]
    Wiki --- Diff[Diff]
    Wiki --- Tracability[Tracability]
    Wiki --- Iteration[Iteration]
    Wiki --- Creativity[Creativity]
    Diff --- GeometricDiff[Geometric diff]
    Diff --- TextualDiff[Textual diff]
    Tracability --- Versioning[Versioning]

    GIS --- Measure[Measure distance, area, angle]
    GIS --- Buffer[Buffer]
    GIS --- Intersect[Intersect]
    GIS --- Merge[Merge]
    GIS --- Union[Union]
    GIS --- Dissolve[Dissolve]

    MultiTheme --- MultiDimension[Multi-dimension]
    MultiTheme --- Zoning[Zoning]
    MultiTheme --- RoadNetwork[Road network]
    MultiTheme --- Hydrography[Hydrography]
    MultiTheme --- Population[Population]

    DataQuality --- Arguments
    DataQuality --- Text[Text]
    DataQuality --- Image[Image]
    DataQuality --- Video[Video]
    DataQuality --- VocalRecords[Vocal records]
    DataQuality --- Figure[Figure]
    DataQuality --- AutoCAD[AutoCAD plan]
    DataQuality --- PerceivedQuality[Perceived quality]

    MultiScalar --- LocalRegional[From local to regional]

    Decision --- GreenCheck[✓]
    Decision --- RedX[✗]

    Interface --- SimpleErgonomic[Simple, ergonomic interface]
    Interface --- ComputerIcon[Computer icon]
  
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Fig. 1 WikiGIS Mind mapping

A multidisciplinary team can edit the same set of data and each contributor can share his own changes with others. The architecture of WikiGIS mock-up, presented in this paper is designed to ensure a fluid coordination between a group of collaborators using and editing the same dataset. This is a classic client/server type architecture. When a user connects to the WikiGIS server, the browser loads the application, and

WikiGIS is built on a spatiotemporal database. Managing time in GIS, has been a hot topic for GI sciences research in the past 20 years. The authors [11] have implemented a fast spatial index on table that refers to real world objects. They proposed the quadtree mechanism to generate the spatial keys.

Later on, Claramunt and Thériault proposed a TGIS architecture that treats the spatio-temporal topology [12]. In the database, the object version is a set of states of an entity. They presented an extended versioning diagram that describes the complex succession, production, and reproduction and

transmission process. In the paper, the authors presented the different methods of indexation mechanism and they proposed a B+Tree for the present version and R-Tree for past and future tables [12].

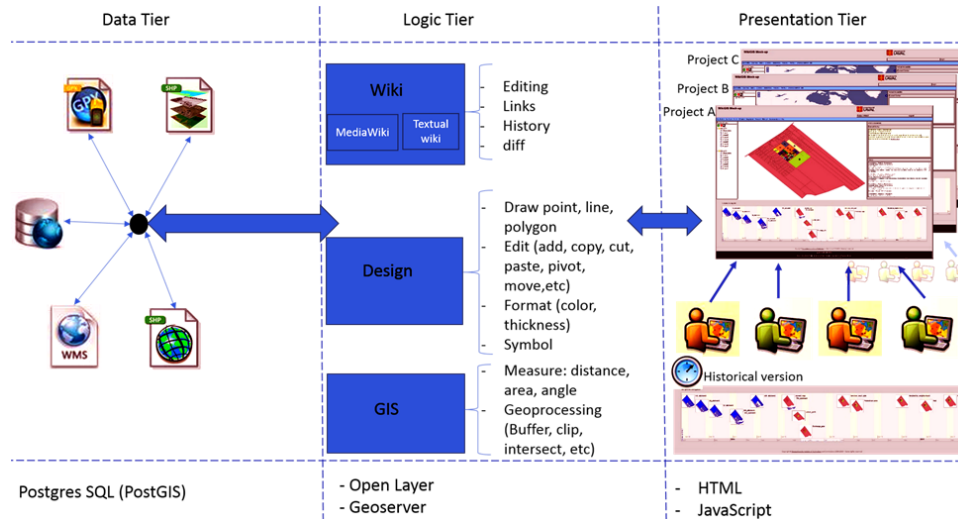


Fig. 2 WikiGIS architecture

Twenty years later, and specifically in a WikiGIS database, versions are up-dated by using the “versioning by occurrence” mode. Each proposition that represents a new version or a new scenario is considered as a different and unique action. The relationship with previous actions can be dealt with proper relations built into the database. The page is reloaded instantly and current versions are displayed in a “thread of versioning” [8]. The fields of ID\_current primitive and ID\_previous primitive help in making the request in both directions: up and down. They indirectly help draw the evolution of the entity. The ID machine of the entity and ID\_previous primitive are re-ordered automatically, but the ID\_current primitive must be indexed.

In the context of wiki as a content management system in WikiGIS, the structure is defined by the relationships among pages and among text sections in a page. The structure begins by the default front page, after other created pages are added. So the structure forms as an inverted tree. By a click, the user can access to the content through different associations. It is necessary to impose a structure in a multi-user wiki in an unstructured environment. The structure content in a wiki could be explicit or implicit. They are many ways to do such as self-maintaining topic list, subheadings and parent-child-sibling page trees [13]. Based on Cunningham’s editing history, the history function in wiki allows a previous version to be edited in order to restore the original content (roll-back). The History/author tab allows to see all the former versions with their editors [14].

### C. WikiGIS Interface

Fig. 3 shows the user graphic interface of WikiGIS. This is

what users see on their screen when they log to the WikiGIS server.

The WikiGIS interface is structured on five areas:

1. *The menu bar* contains the following drop down menus:
  - **User profile:** 1- administrator (the manager of the project), 2- the member project (the participant in the project), and 3- the visitor (anyone). The latter can only view but in some cases he can edit when the public participation is permitted by administrator;
  - **Base map:** Base map provides a user with context for a map (Earth or map view);
  - **Mode:** Two modes are available; a view mode and an edit mode. The former is available by default for all users;
  - **GIS tools:** A set of GIS operators (union, merge, buffer, intersect diff, etc.) allows not only to manage and transform the created feature, but also to make its spatio-temporal analysis;
  - **Design tools:** The main drawing tools for sketch-mapping such as draw point, line, polygon, copy, past, cut, erase, resize, color, symbol, etc.;
  - **Measure:** To measure distance, area, angle;
  - **Filter by:** The user can filter the contributions by actor, date or argument.
  - **Consensus statement:** When the consensus is reached, the participants will be informed and solicited to fill a survey to take decision;
  - **Help:** It is just a Wikipedia page about WikiGIS;
  - **The layer management:** When a user edits (creates, modifies, deletes) a feature, he/she must create a new layer. The layer (s) can be displayed or hidden;

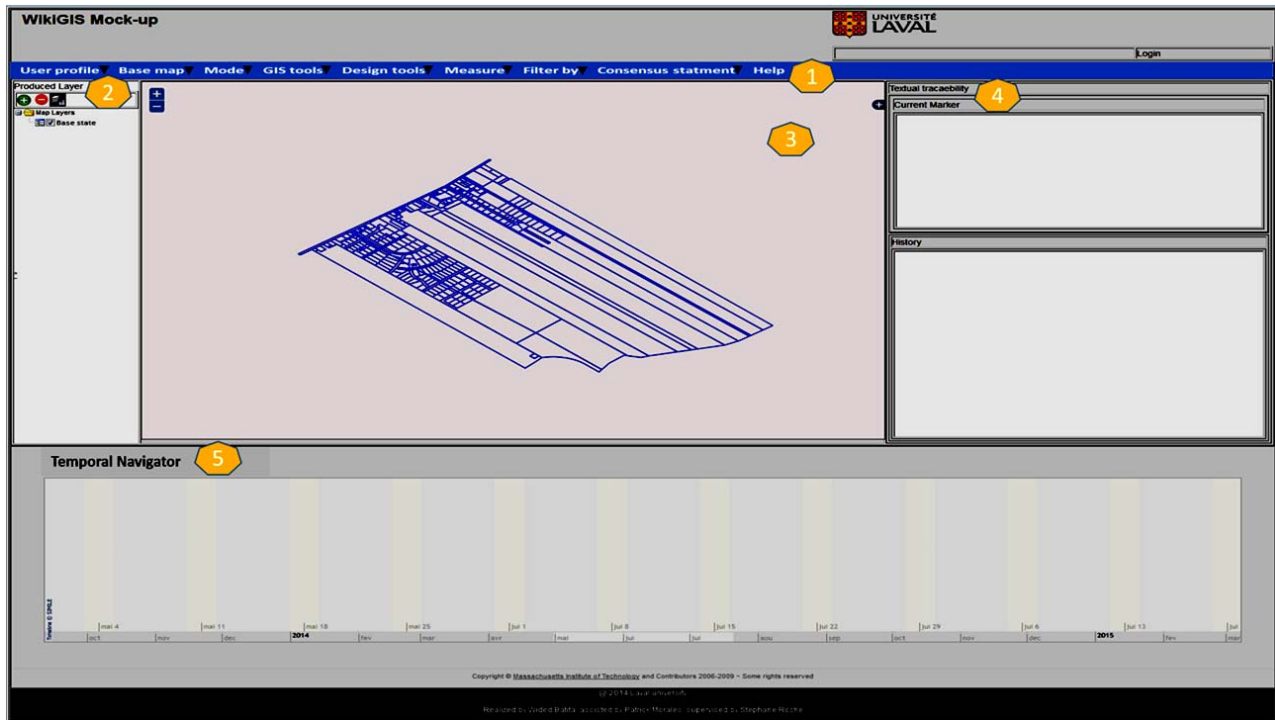


Fig. 3 WikiGIS user cartographic interface

2. *The map* shows the context map. A user can add or remove layer(s) on the map. He can also change the scale and extent. The layers are visualized on the browser through the library OpenLayer2. These layers are saved in PostgreSQL (PostGIS) This database is provided by Geoserver;
3. *The textual traceability window*: All the metadata about a contribution appear in a text box on the right side of the map. Descriptive data are arranged in two sets: The descriptive data associated with the last updated layer, and the descriptive data associated with former versions of the feature. To manage the update, we used the occurrence versioning. For this reason, each version is considered in the database as different temporal instances of the same object. The metadata includes: The author's name and his profession, the creation date of the feature, the title, the description and the argument. The latter is the main component to qualify the contribution. The argument could be a text, image, figure, video, vocal record, plan, etc. This multi-media data was managed in the interface by hyperlinks.
4. *The temporal navigator* provides the evolution of the feature over time. The temporal navigator was implemented by MIT [15] and it was adapted in the WikiGIS mock-up.

#### IV. SCENARIO: HOW WIKIGIS MANAGES THE TRACEABILITY

In this section, a hypothetical scenario is imagined to highlight the built WikiGIS' functionalities.

##### A. Project Description

The municipality of Saint-Pierre in Orleans Island has recently obtained a favorable decision for its request for extension of the urban perimeter. The goals of the project are firstly, to subdivide and define the building perimeter for each new batch while respecting the different regulations that apply to the municipality of St-Pierre; secondly to transform those batches into significant places for the agglomeration while ensuring rapid and continuous services.

##### B. Simulation

A multidisciplinary team (ecologist, geomatician, architect, urban designer, planner and geoinformatician) work together in the project.

The spatial details of the contribution take place on the map panel (in the middle of the interface). The descriptive details are in the textual traceability window at the right of the interface where we find useful metadata on who is contributed, when, what, why, with what intention. To argue his/her contribution, the user uses a multimedia argument. So he/ she can argue his contribution by a text or a figure, or a video or a plan, etc. through a hyperlink. The current version is displayed in the top box while previous versions are shown below. The temporal navigator shows the evolution of the entity in time. So, the last version takes place at the right (Fig. 4).

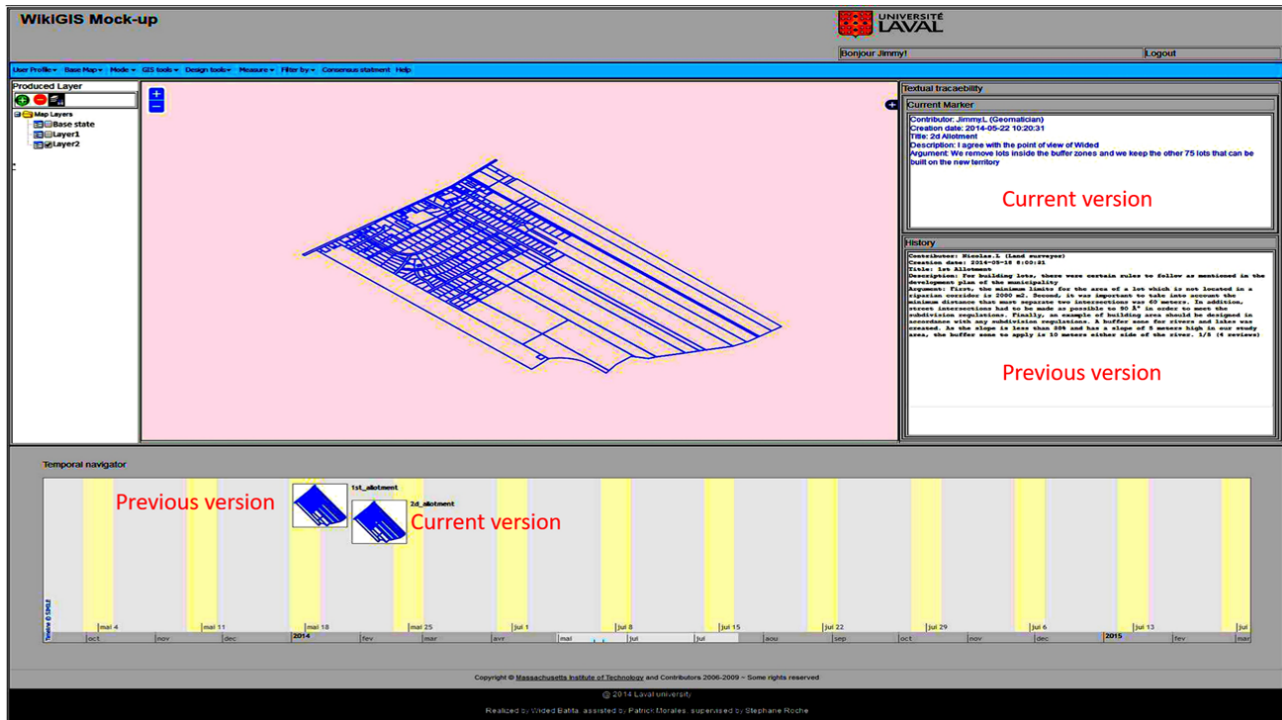


Fig. 4 Iteration and traceability management of Contributions

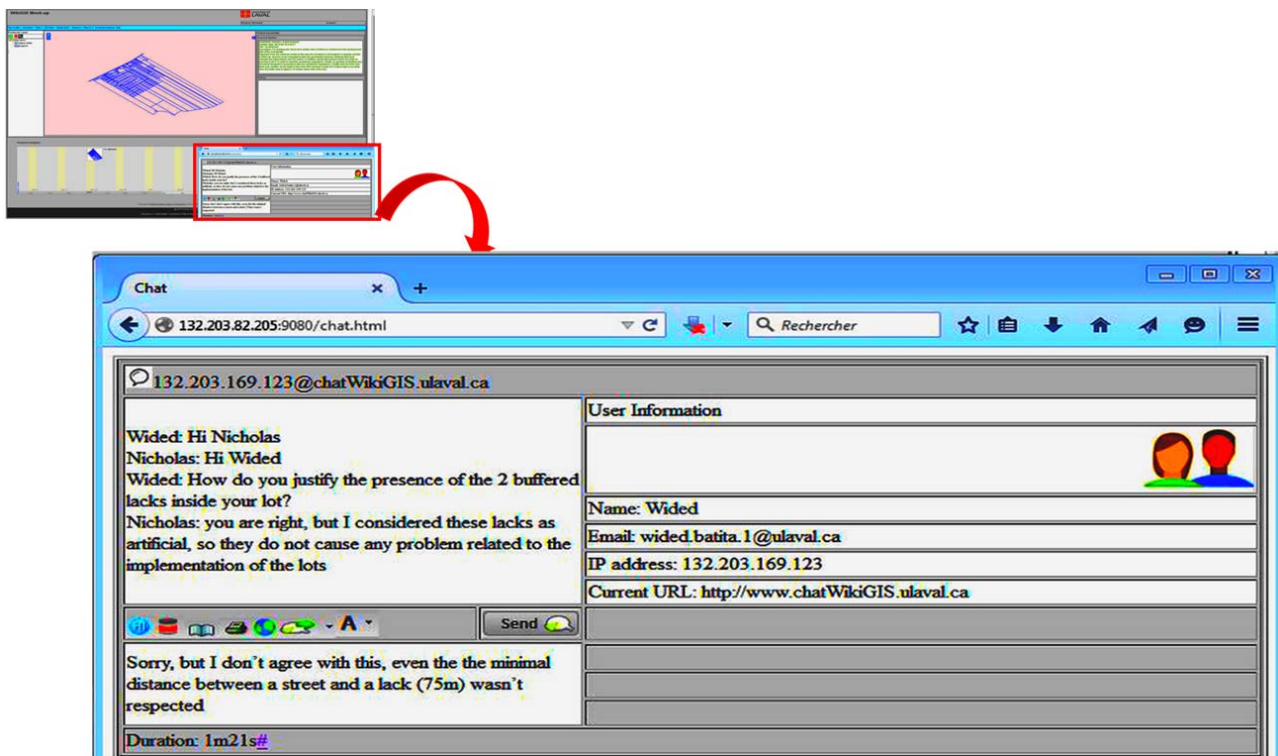


Fig. 5 Collaboration mean

During the project, the participants propose different scenarios and they imperatively justify their contributions. They collaborate via pop up chat window (Fig. 5).

In case of mistake, participants can revise the contribution and correct it for example a participant allots next lakes. So, a participant involves and removes lots inside the two lakes,



then creates the buffer zones 75 m because in the Plan of the municipality Saint-Pierre, it is forbidden to lot next lakes.

## V. DISCUSSION

In this section, a review of several fundamental concepts of Geodesign has been performed in relation to underline concepts of WikiGIS.

### A. Creative, Iterative and Collaborative Approach

As defined by [16], Geodesign is an iterative planning method by which an emerging design is influenced by knowledge derived from the involved stakeholders and geospatial technologies. The authors [17], [18] and [10] proved that iteration is the hallmark of Geodesign.

As mentioned at the beginning of this paper, WikiGIS is a collaborative platform 2.0, supported by a wiki that insures traceability of geographic contributions of participants. Indeed, wiki is a collaborative space and democratic. It allows all users to edit or to create new pages, to make pages' links, and collaborate. Technically speaking, the wiki uses a simple navigational model, and it supports some basic structural markup and it provides fast retrieval [13]. Wiki is designed to support a group of users not necessary on the same territory, not in necessary in synchronous time, create, collaborate and share information [19]. By a wiki, it is possible to keep the track of all the modifications [20].

The participants create and edit the entities on new layers. All the modifications are kept on the WikiGIS database. User can edit any previous version, not necessarily the last. He saves his modifications and the edited version is also saved. This backup then becomes the latest. If another participant publishes the latest version, it comes the last and so on. Versions are fully recorded with a version number of the same object [14].

Kne [21] has presented how web-based Geodesign increases the collaboration process in rural settings. As any collaborative planning, Geodesign is an interactive process of consensus building using stakeholder and public involvement [22].

WikiGIS helps the group to share ideas in an iterative and interactive process. WikiGIS is a synchronous collaborative platform where participants could exchange opinions, enrich ideas, discuss, and correct mistakes via a pop up chat window.

### B. Multi-Actor, Multi-Thematic and Multi-Scalar

Geodesign is a broad field involving many different types of professionals (scientists, planners, architects, landscape architects, engineers, agency representatives, constructors, sponsors, stakeholders, etc.) working in many different domains [23].

Ervin [24] showed that GIS with design is a multi-criteria and multi-dimensional process. In the simulation, many dimensions have been considered such as communication channels, vegetation crops, road network, hydrography, etc.

Geodesign covers a variety of scales, from regional to local contexts [17]. This present project consists on allotment and development of Saint-Pierre municipality, but we can extent it

to neighborhood municipalities and even to the whole island with a functional WikiGIS prototype in future works.

### C. Consensus Building

WikiGIS helps participants to represent, observe and analyze the existing reality to understand the problem and to evaluate scenarios. Then it helps them to assess changes and finally make decisions after many iterations.

To stop the project, the administrator asks the project members to fill a Yes/No survey to the converged proposal. We admit if more than 70% of participants say yes, we can say that the consensus is reached. This threshold was taken randomly, but it seems logic in order to have the best decision-making in a multidisciplinary team. The administrator could decide to stop the project for other reasons like the deadline of project, the divergence of participants, or a specific intervention of the stakeholders, etc.

For further work, an indicator or a coefficient of convergence as in DELPHI study for instance could be implemented in order to automatically calculate the group convergence.

### D. Data Quality

Stored versions need not just elements and relations, but 'metadata' that describes the contribution: who (profile: name, profession, professional qualification, e-mail, etc.), When, How, why? In WikiGIS a textual traceability is documented and easily accessed (Fig. 6).

We propose the perceived quality approach for insuring the data produced in WikiGIS. Jones [25] has defined the perceived quality as "assessment of quality based on previous users' feedback, as it does not rely on formal quality measurements but on personal judgment". It is different from the concept of "internal quality, which measures, often quantitatively, the intrinsic quality of a dataset by comparing the data to a more accurate dataset". It is also different from the concept of "external quality (i.e. fitness for use) as it does not assess how well a dataset fits the user requirements rather; it is assessing how the user perceives the quality of the data". The symbiotic approach allows any user of virtual globes to provide ranking and feedback on a model created and shared by another user.

In our case, any authorized user can assess the quality of the contribution based on the argument from one (1) to five (5) rating system. In fact, when a user edits a new feature and justifies his edition with argument, other users will rate this later. The arguments here are the main components to qualify external contributions. These arguments are generated by multimedia wiki as shown in the simulation above, where user could justify his contribution by a text, or a photo, or a figure, or a video, or a vocal record, or a plan, etc. The media with hypertext is a powerful technique to manage complexity and enable collaboration [24].

According to the rate, we can judge the strength of the contribution.

The rating is calculated by an arithmetic mean:

$$A = \frac{1}{n} \sum_{i=1}^n a_i.$$

The arithmetic mean  $A$  is defined as being equal to the sum of the scores  $a$  given divided by the total number of reviewers  $n$ .

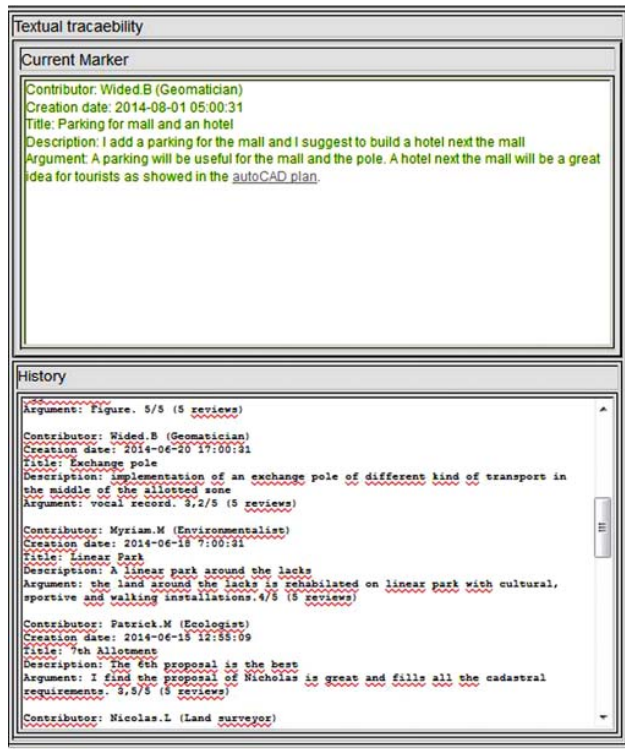


Fig. 6 Textual traceability of contributions and Rating arguments by participants (in red ellipses)

### E. Deltification

The editing potential of hundreds of different versions of the same object justifies the interest of being able to quickly and easily compare two versions and only display their differences. Indeed, Diff function was proposed in WikiGIS. Indeed, the deltification is a concept that we are defining in the framework of this research to give it a geographical sense. It is the ability to compare two versions including the geometric and textual components then to display their differences.

Regarding to the geometric components, we can overlay two layers with different colors (one for each scenario) and with transparency, we can visualize the differences. Fig. 7 shows the differences between the first proposal in brown and the second proposal in blue with 45% of opacity. Sometimes it is more efficient to display two layers for each scenario side by side. For this, it is planned to implement it in further work. Therefore, the user could choose one of the two possibilities depending on the complexity of the differences.

The diff function allows comparison between two texts. The diff algorithm is popular because it compares two files and displays their differences, and it works with the three major operating systems [6]. For this reason, we presented this technique in the WikiGIS mock-up.

### F. Public Participation

The public are welcome in such Geodesign projects. They can involve and help Geodesigners to take the best decisions [26]. The authors in [17] showed that residents are experts in their own way; they know more than anyone about the history, values and culture of where they live, and they have a deep understanding of how the informal systems of the community works and they should contribute in meaningful ways.

In WikiGIS, the public have right to accede as visitor in view mode and they can just comment. Once the group reaches a consensus, the administrator involves the residents of Saint-Pierre municipality in the project by probing their level of satisfaction with the taken decision.

## VI. CONCLUSION

Through the simulation presented in section 4, we explored the potential of WikiGIS mainly for supporting the collaborative dimension of Geodesign process. By combining the principles of iteration and traceability that are specific to wikis with the geospatial data analysis capabilities, WikiGIS becomes a comprehensive tool to support collaboration in an iterative process. Recall that in this research, we treat the Geodesign with a small "d" [10] with a simple design in a small wingspan.

According to [17], Geodesign includes at least four elements: sketching, spatially informed models, fast feedbacks, and iteration. Sketching, fast feedbacks and iteration were demonstrated in WikiGIS through the simulation. In fact, it is able to draw potential scenarios. The iteration and the rapid feedbacks foster creativity, help teams to work together and adjust their decisions, and increases understanding of the complex systems. Spatially informed models with dashboard could be implemented in further work. They are very important in such a tool because users can quickly visualize and understand the environmental, social, economic and political impacts of the scenarios suggested in real time.

In conclusion, through the simulation above, we illustrate the importance of traceability management and how we navigate in the history via a temporal navigator in a Geodesign process. Other functionalities have been suggested to support it like deltification, decision making by consensus, multimedia hyperlinks supporting the arguments and data quality measures. Those functionalities will be validated by a future survey to feed a real functional WikiGIS prototype in perspective.

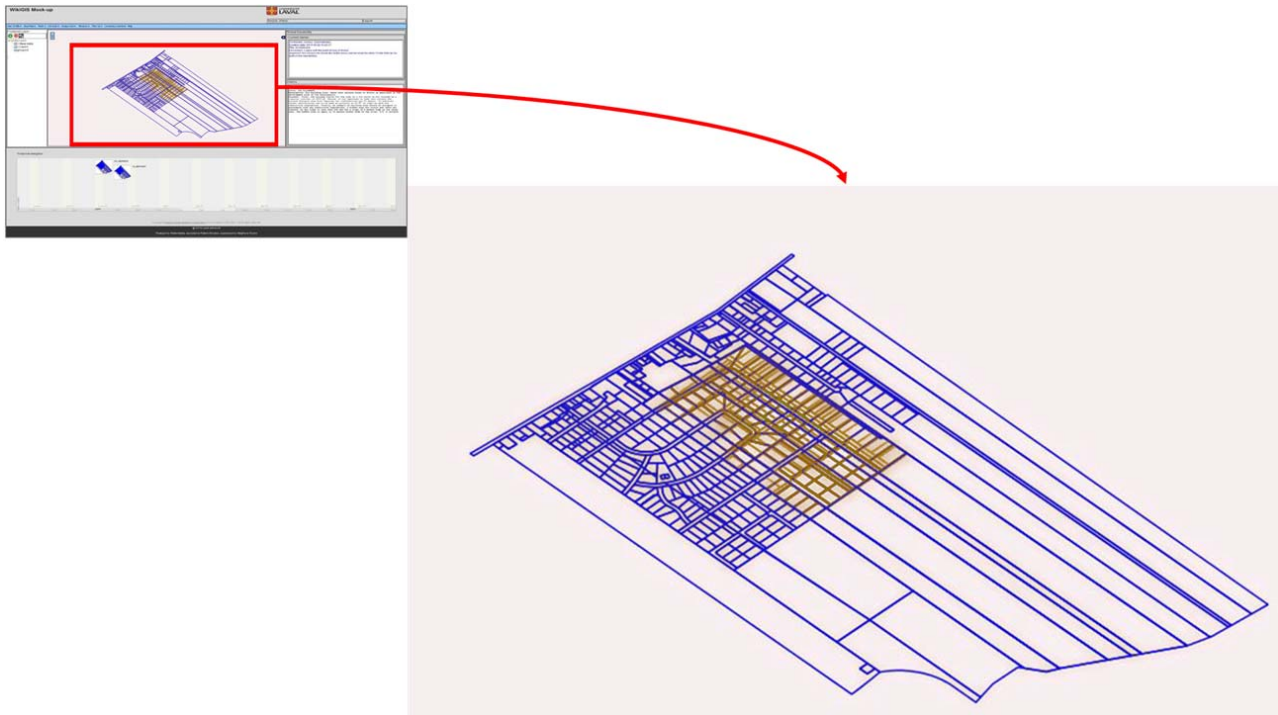


Fig. 7 Geometric Diff

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## AUTHOR CONTRIBUTIONS

This paper is a part of Batita's Ph.D thesis. She is the main authors, first writer. Roche, and Caron and are respectively Batita's supervisor, and co-supervisor. They have been indirectly involved in the writing, have revised the first draft and supervised the correction of the second version.

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