Managing temporal change of cities with CityGML

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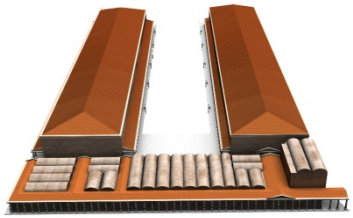
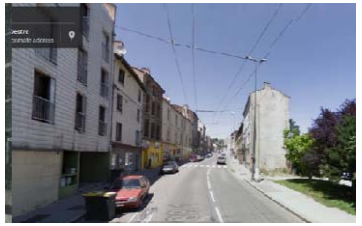
Introduction

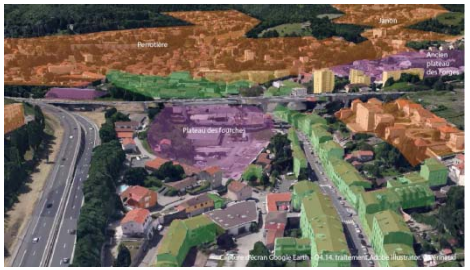
- Need temporal information
  - Archeological/ historical data
    - Each object may have two temporal informations
      - When the object has been founded
      - When the object has been created
    - Important to record these changes during time
    - We may have different scenarios for a given area



SeaPort, Rome (1-3e century) - Archeorient - Liris



Alaric, Terre-noire , France (19e century) - EVS - Liris



Introduction

- Video- games
  - Instances may have to change during the game
    - E.g: Building (destructed, burned, …)
- Urban management
  - Creation, modification, destruction of city Objects
- Physical simulation models
  - Taking into account the temporal aspect
- **Geometry, texture and semantic may evolve during time**

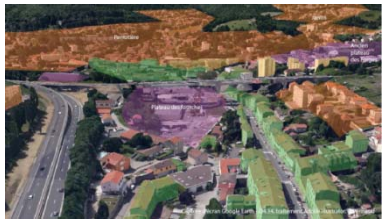
Training in risk management (SimFor)

Urban Management (Virtual City (France))

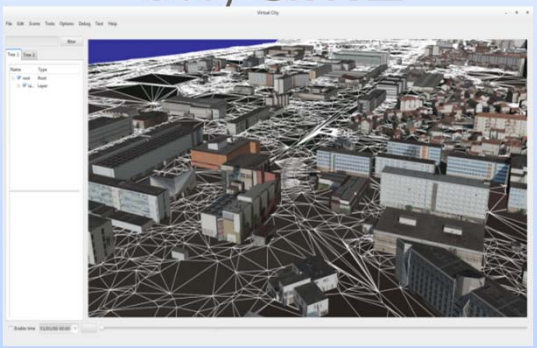
Awareness for forest fire (SDIS13)

Introduction

- Aggregate different sources of data
- Exchange data between different applications



CityGML

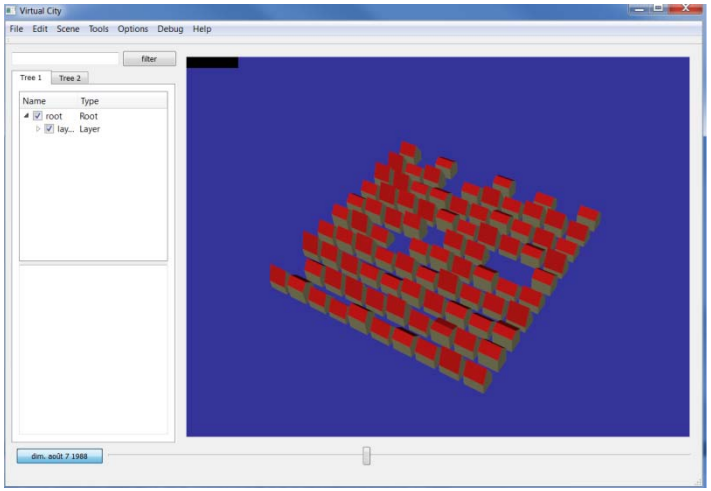


Data stores

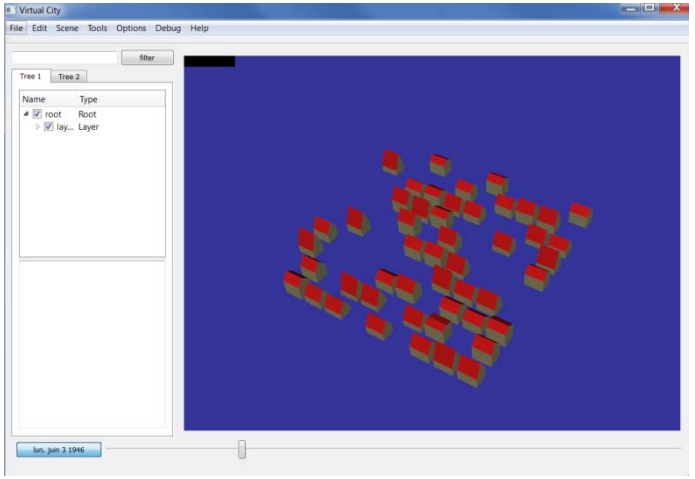
Data (2D/ 3D, topology, semantic)

Introduction- Temporality and CityGML

- Informations are available in cityGML
  - year of construction : The construction is started
  - year of destruction : The building has disappeared
  - Using creationdate/ terminationdate in core::AbstractcityObject



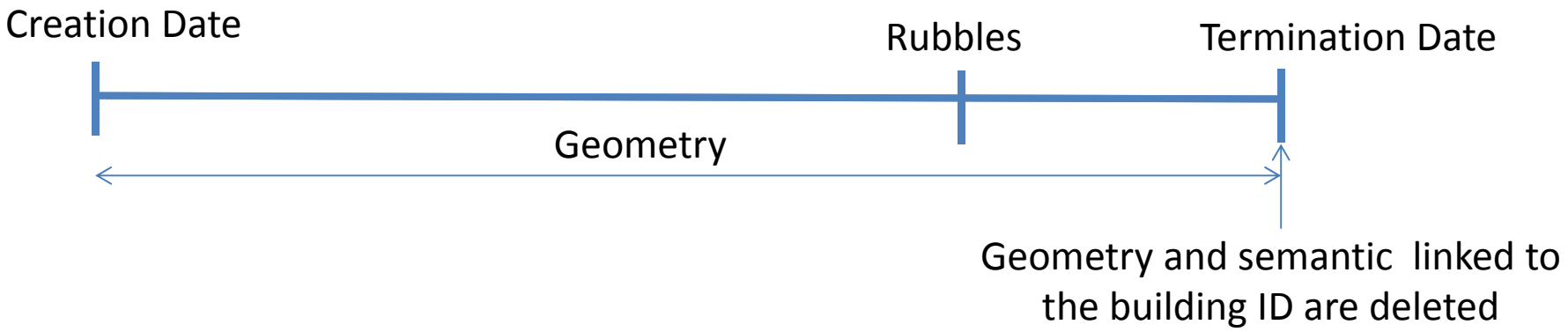
7/08/1988



03/06/1946

Time management (1)

- We propose to add new information in cityGML to take into account temporal part
- We propose to add Tags
  - Temporal step (at a given date)
  - An interval is given by two consecutives Tag
  - A Tag has always a reference to a geometry
    - If there is no reference, the building is considered as deleted



Time management (2)

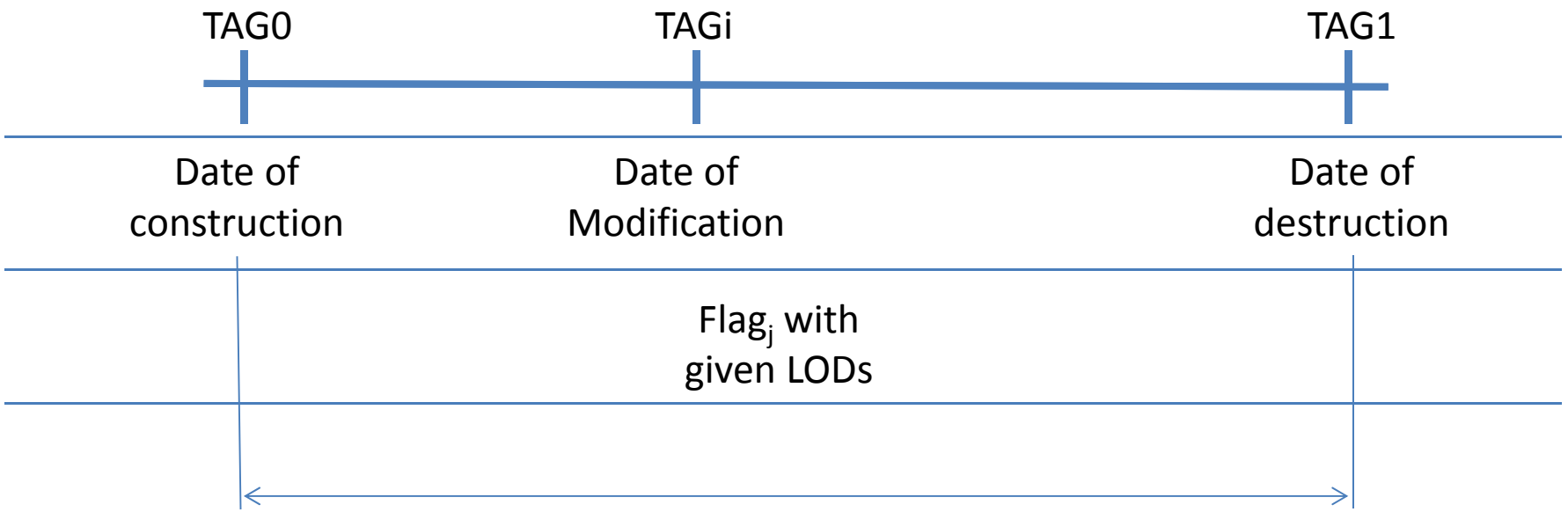
- If there is no Tag
  - Year of construction / destruction or creationDate / terminationDate
  - If there is no date, the building is visible at any time

Time management (3)

- Flags (state)
  - Flag = Description of a behavior
  - Defined for a given tag
  - A Flag is composed of semantic and/or geometry information
  - Examples
    - The building has been
      - Partially constructed
      - Modified
      - Partially destroyed
      - Totally destroyed
      - …

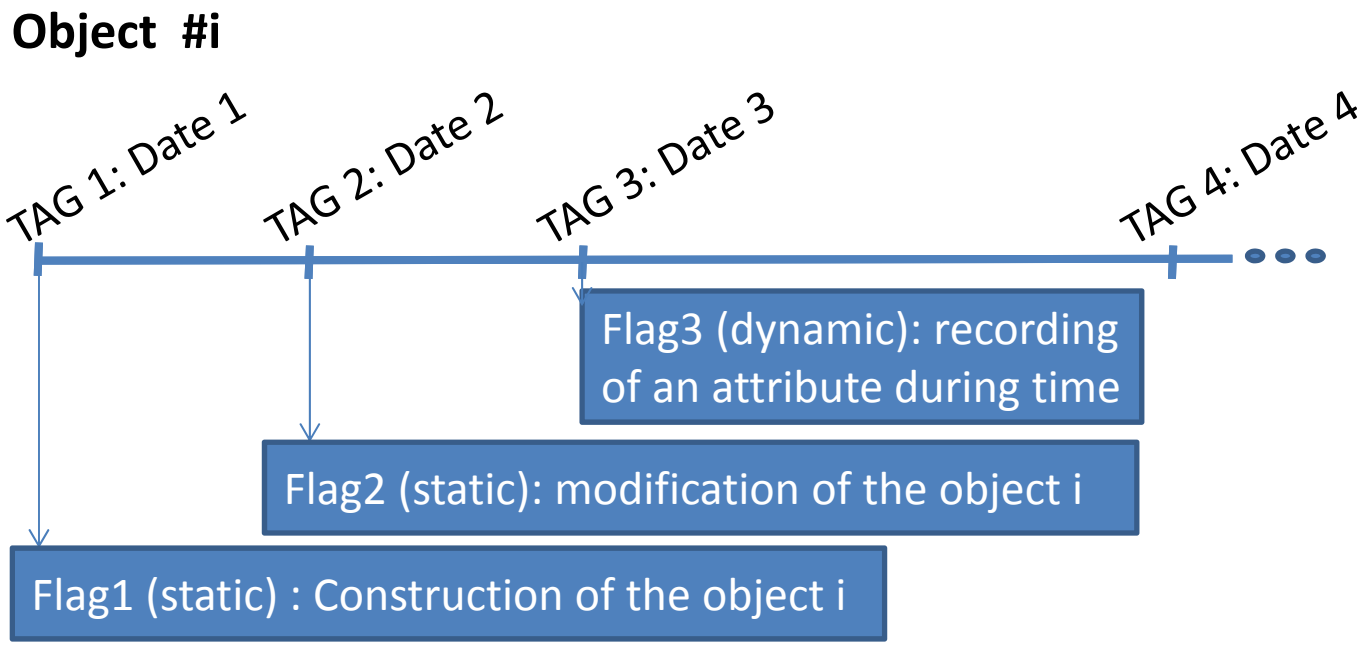
Time management (4)

Example for a given building



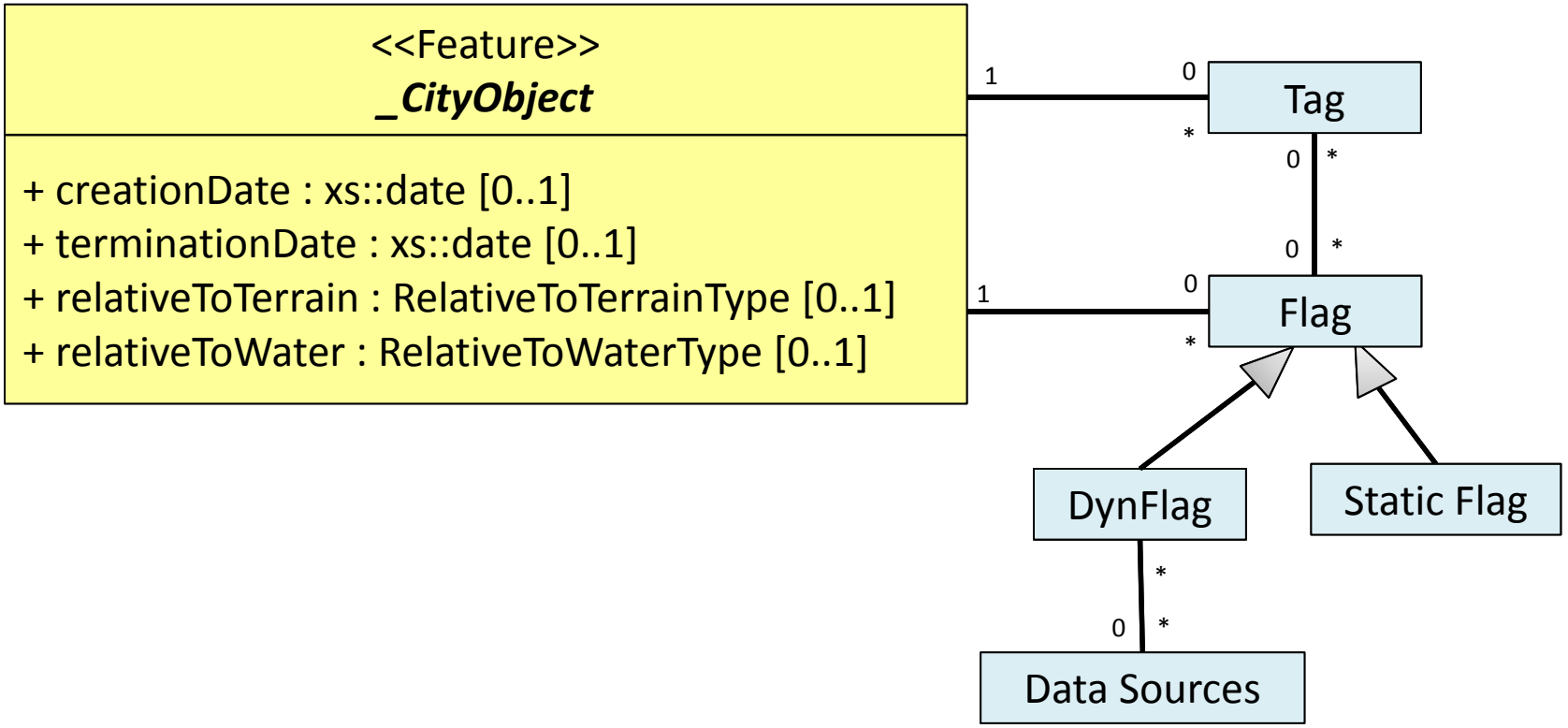
- It is only possible to create Flags on this building between these two dates
- Flags are timeless (we can use them several time between these two dates)

Flag extension : Dynamic Flag



- A Dynamic Flag can be seen as a container
  - Geometry change
  - Attribute modification
- In the dynamic case, a flag is containing a file or a link to a stream of data

TAG/ FLAG: CityGML modification



Example : Time Management

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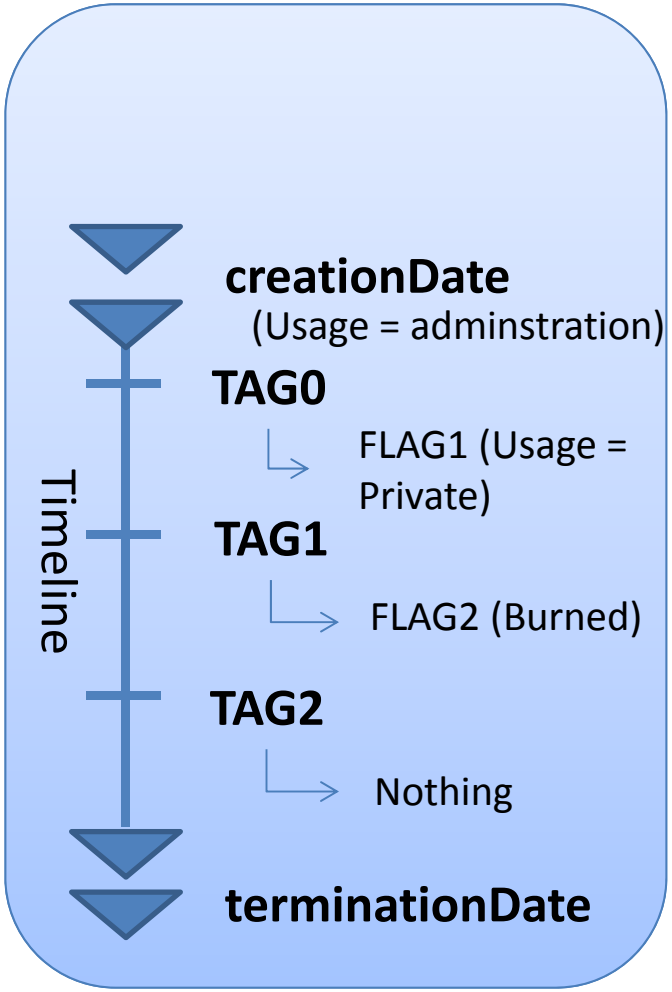

Example : Time Management


```
// Original object : building
<bldg:Building gml:id="building1">
  ... // geometry, texture, attributes
</bldg:Building>

// Adding a flag Flag0
<bldg:Building gml:id="building1_FLAG0">
...
<gen:stringAttribute name="usage">
<gen:value>house</gen:value>
</gen:stringAttribute>
...
</bldg:Building>

// Adding Tag0
<bldg:Building gml:id="building1_TAG0">
...
<gen:stringAttribute name="date">
<gen:value>2012-01-25</gen:value>
</gen:stringAttribute>
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</bldg:Building>
```

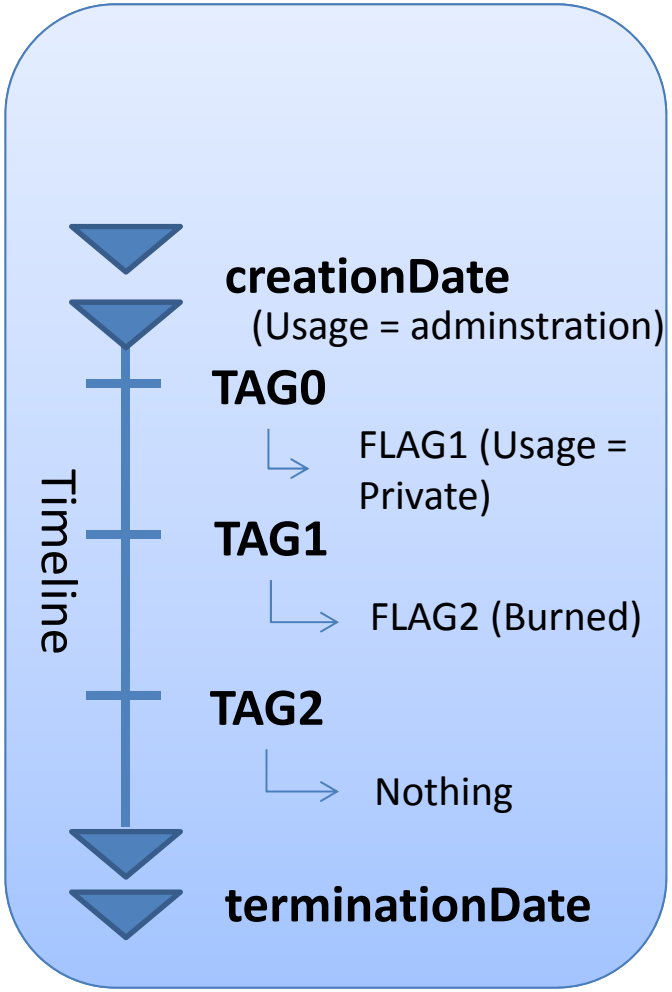

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<gen:value>2012-01-25</gen:value>
</gen:stringAttribute>
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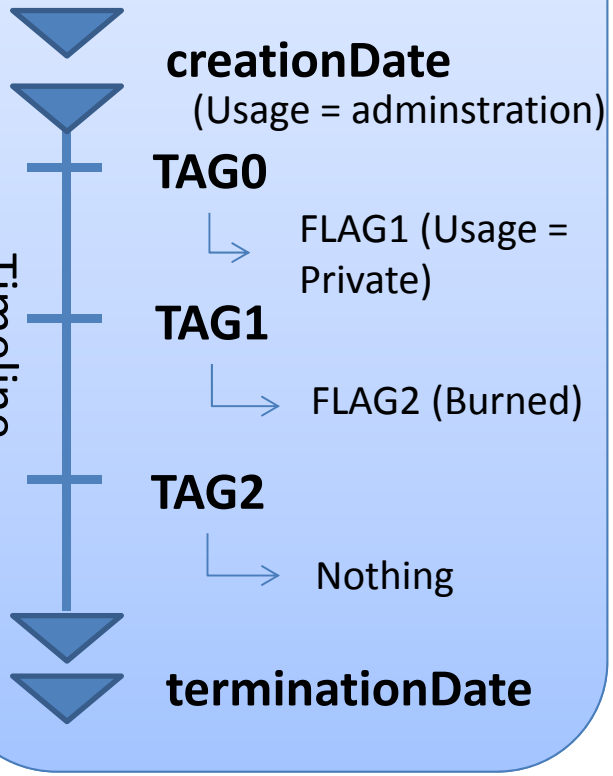
```

Add flag:
- Name
- Value



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<gen:value>2012-01-25</gen:value>
</gen:stringAttribute>
...
</bldg:Building>
```
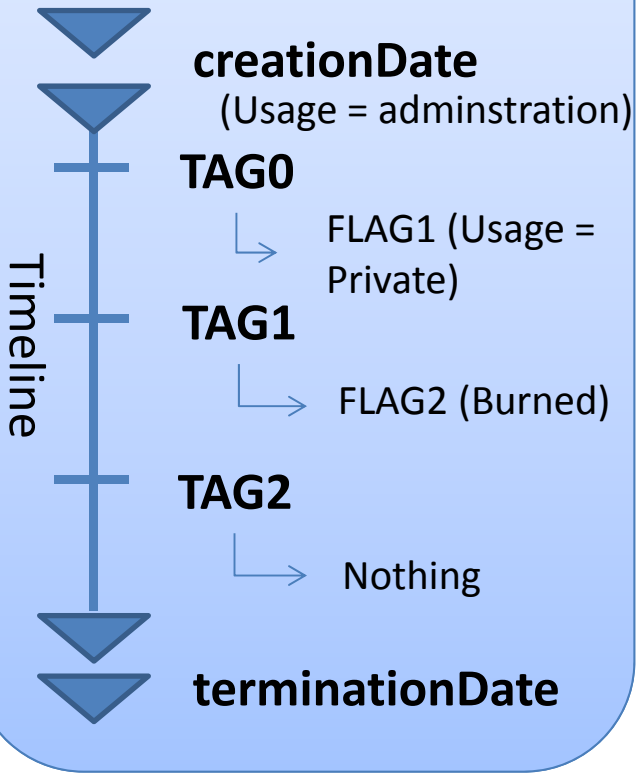

Add flag:
- Name
- Value

with generic attributes



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</gen:stringAttribute>
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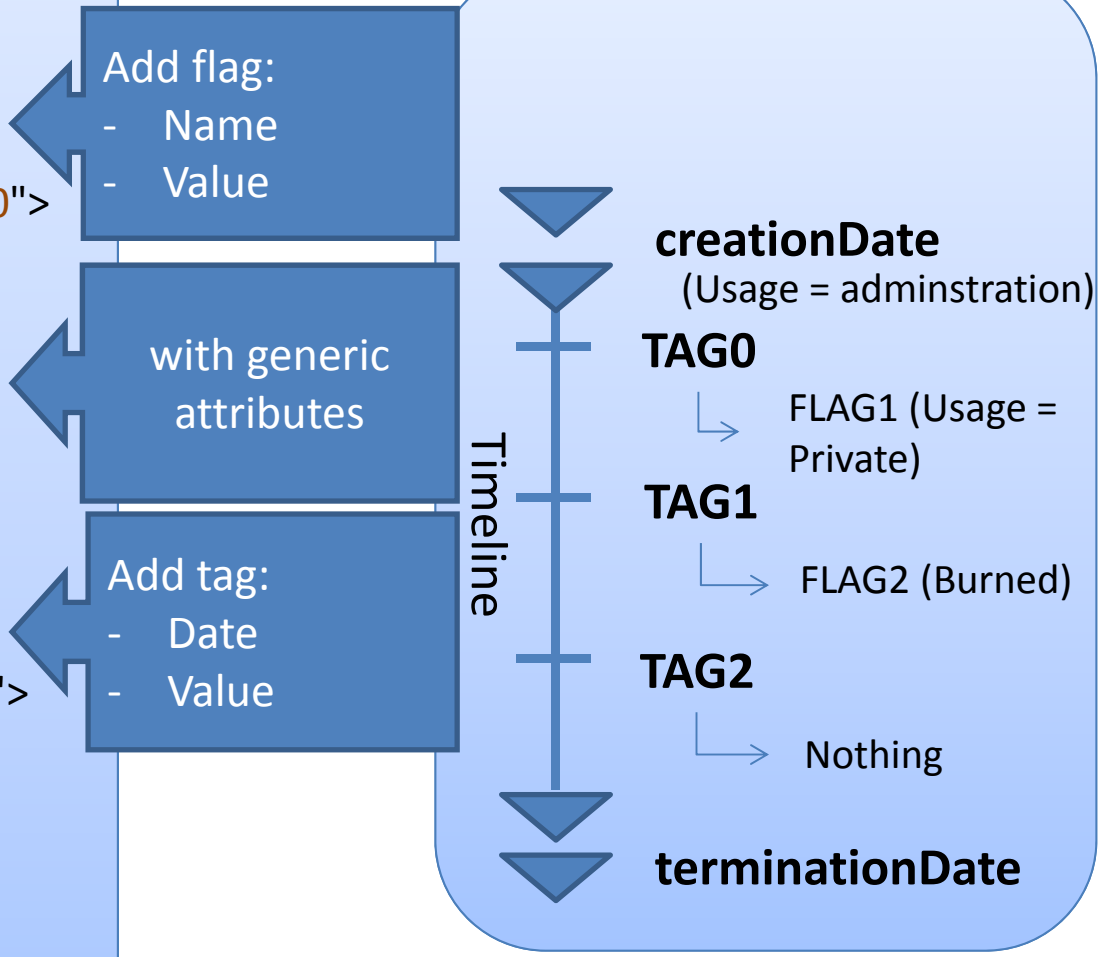

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```

Add flag:
- Name
- Value

with generic attributes

Add tag:
- Date
- Value

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- Date
- Value

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...
</bldg:Building>
```

// Adding Tag0

```
<bldg:Building gml:id="building1_TAG0">
...
<gen:stringAttribute name="date">
<gen:value>2012-01-25</gen:value>
</gen:stringAttribute>
...
</bldg:Building>
```

// Linking the flag FLAG0 with the tag TAG0

```
<bldg:Building
gml:id="building1_TAG0">
...
<gen:stringAttribute name="date">
<gen:value>2012-01-25</gen:value>
</gen:stringAttribute>
<gen:stringAttribute name="flag">
<gen:value>building1_FLAG0</gen:value
>
</gen:stringAttribute>
...
</bldg:Building>
```

// Tag1, ending tag (no flag associated)

```
<bldg:Building
gml:id="building1_TAG1">
...
<gen:stringAttribute name="date">
<gen:value>2014-01-25</gen:value>
</gen:stringAttribute>
```

Example : Time Management

// Original object : building

```
<bldg:Building gml:id="building1">
  ... // geometry,
</bldg:Building>
```

// Adding a flag

```
<bldg:Building g                    0">
...
<gen:stringAttribute name="usage">
<gen:value>house</gen:value>
</gen:stringAttribute>
...
</bldg:Building>
```

// Adding Tag0

```
<bldg:Building gml:id="building1_TAG0">
...
<gen:stringAttribute name="date">
<gen:value>2012-01-25</gen:value>
</gen:stringAttribute>
...
</bldg:Building>
```

Link between FLAG and TAG
- #id tag
- Date
- #id flag

// Linking the flag FLAG0 with the tag TAG0

```
<bldg:Building
gml:id="building1_TAG0">
...
<gen:stringAttribute name="date">
<gen:value>2012-01-25</gen:value>
</gen:stringAttribute>
<gen:stringAttribute name="flag">
<gen:value>building1_FLAG0</gen:value
>
</gen:stringAttribute>
...
</bldg:Building>
```

// Tag1, ending tag (no flag associated)

```
<bldg:Building
gml:id="building1_TAG1">
...
<gen:stringAttribute name="date">
<gen:value>2014-01-25</gen:value>
</gen:stringAttribute>
```

Example : Time Management

// Original object : building

```
<bldg:Building gml:id="building1">
  ... // geometry,
</bldg:Building>
```

// Adding a flag

```
<bldg:Building gml:id="building1_FLAG0">
...
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...
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```

// Adding Tag0

```
<bldg:Building gml:id="building1_TAG0">
...
<gen:stringAttribute name="date">
<gen:value>2012-01-25</gen:value>
</gen:stringAttribute>
...
</bldg:Building>
```

Link between FLAG and TAG
- #id tag
- Date
- #id flag

Tag with no flag

// Linking the flag FLAG0 with the tag TAG0

```
<bldg:Building
gml:id="building1_TAG0">
...
<gen:stringAttribute name="date">
<gen:value>2012-01-25</gen:value>
</gen:stringAttribute>
<gen:stringAttribute name="flag">
<gen:value>building1_FLAG0</gen:value
>
</gen:stringAttribute>
...
</bldg:Building>
```

// Tag1, ending tag (no flag associated)

```
<bldg:Building
gml:id="building1_TAG1">
...
<gen:stringAttribute name="date">
<gen:value>2014-01-25</gen:value>
</gen:stringAttribute>
```

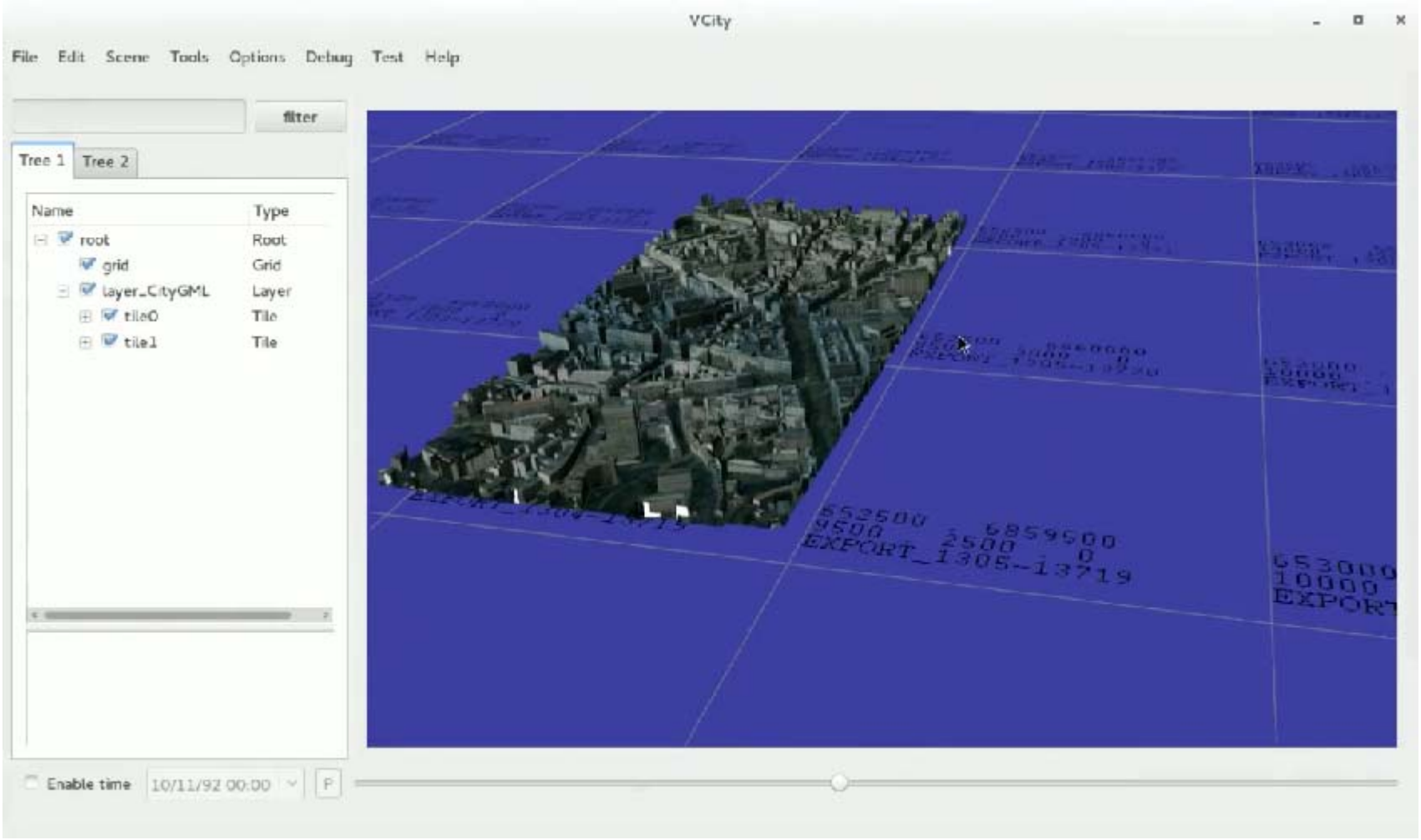
Demonstration

1. Demonstration 1: Static flags + Tags
   a) Open CityGML Files
   b) Add Flags (state)
   c) Add Tags
   d) Use temporal slider
2. Demonstration 2: Dynamic flags + Tags

Four videos can be downloaded

- http://liris.cnrs.fr/gilles.gesquiere/Research/VirtualCity/Media

1.a) Open CityGML Files



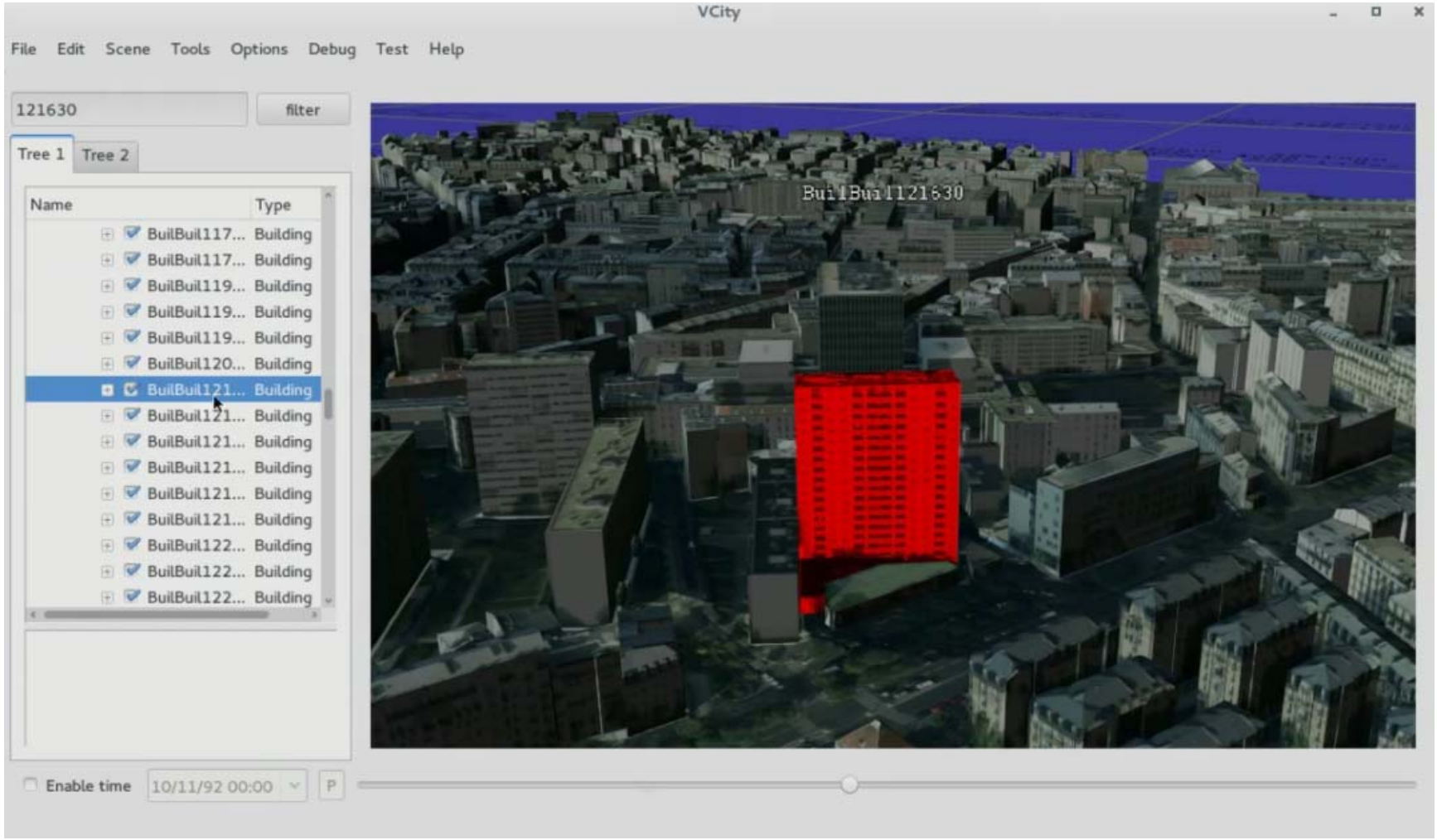
CityGML data are provided by IGN (Bati3D).

1.b) Add several flags

- Flag 0: First step of construction
- Flag 1: Second step of construction
- Flag 2 : Construction is finished
- Flag 3 : Fire event

1.b) Add several flags

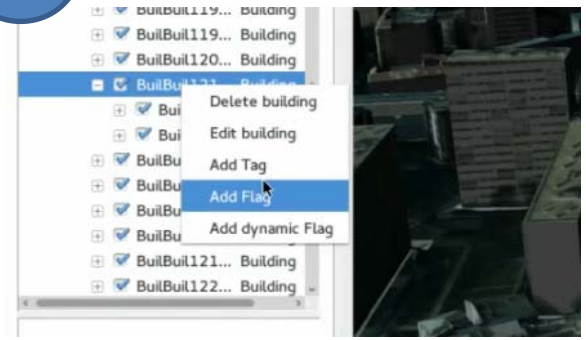
- Select a cityObject



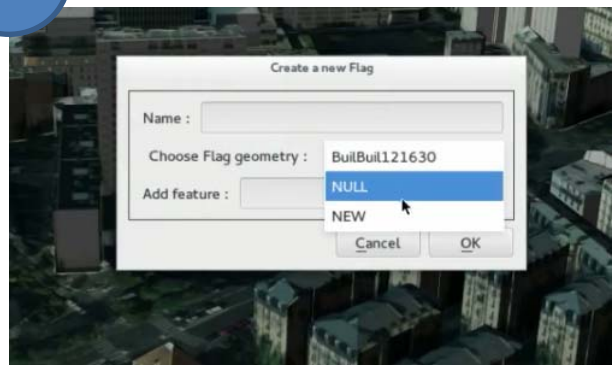
1.b) Add several Flags

- Add one flag (state)

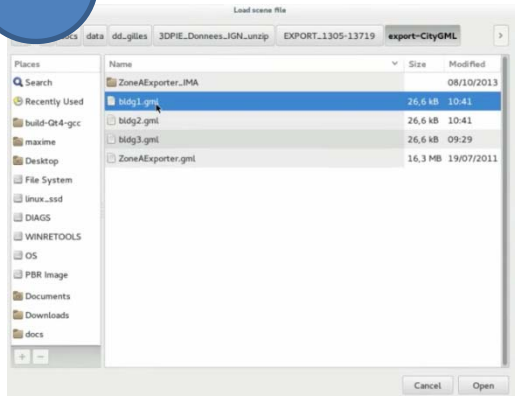
1 Choose one cityObject



2 Choose here the geometry to modify



3 Selected file



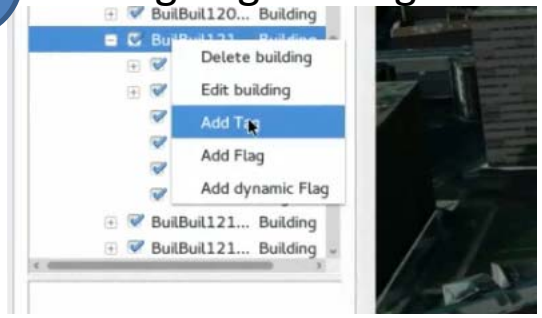
The geometry and semantic can be created / modified in an other software

1.c) Add several tags linked to the flags (1/2)

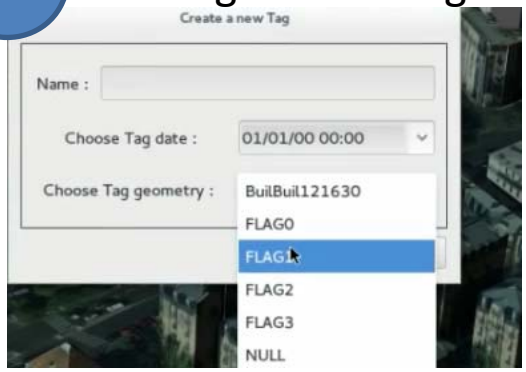
- Tag 0 (2000- 2010): Linked with Flag 0
- Tag 1 (2010-2020): Linked with Flag 1
- Tag 2 (2020-2030): Linked with Flag 2
- Tag 3 (2030-2040): Linked with Flag 3
- Tag 4 (2040- …): No Flag → building has been destructed

1.c) Add several tags linked to the flags (2/2)

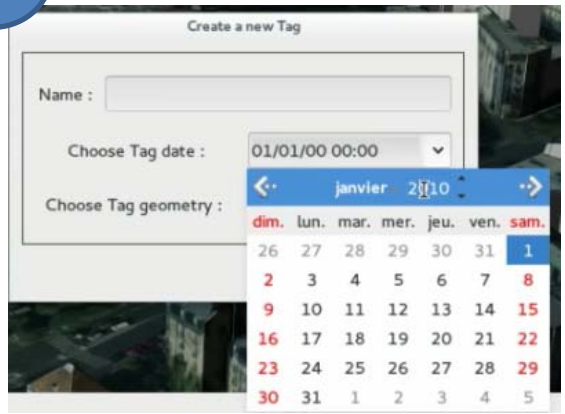
1 Linking flag and tags



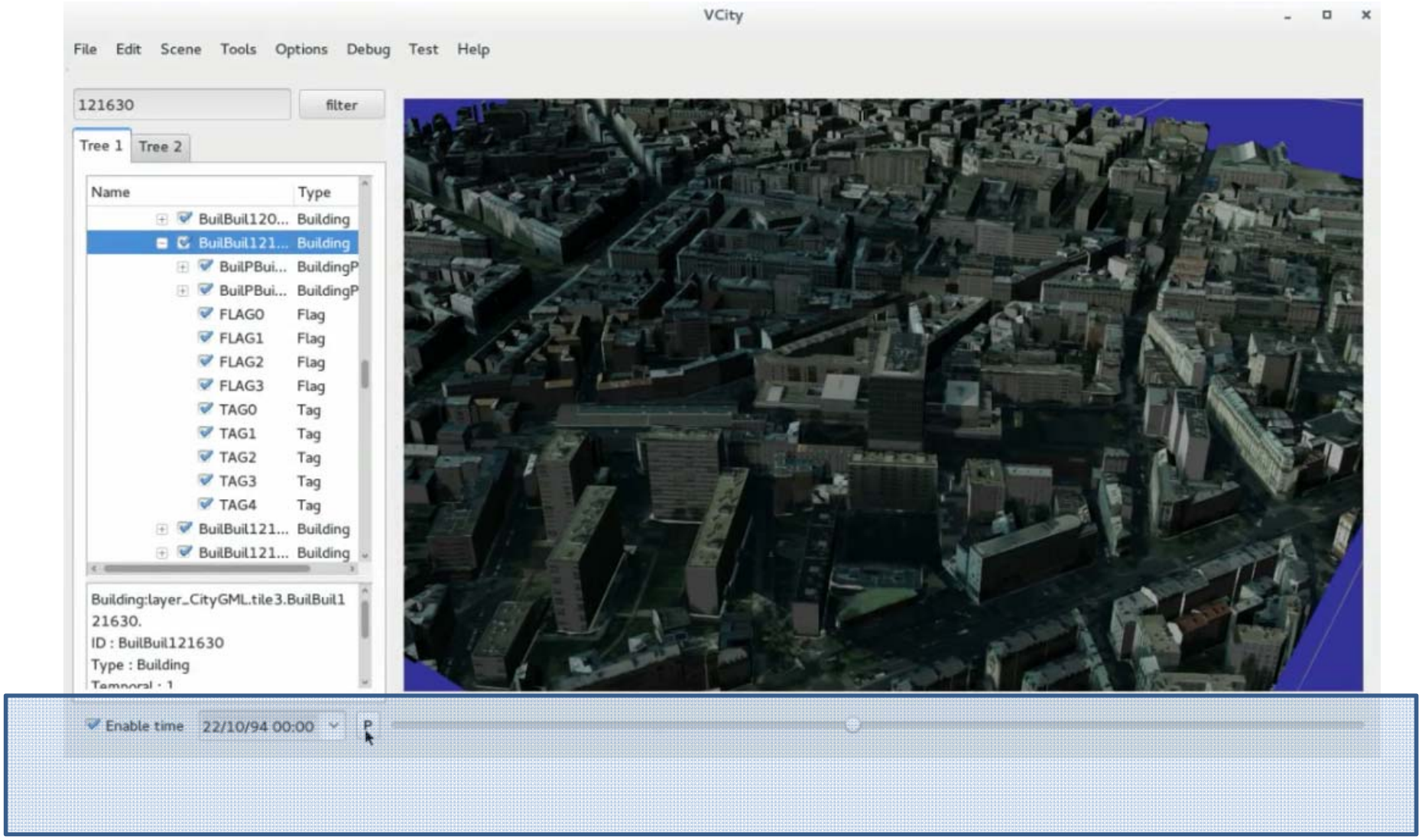
2 Add tags to the flag « flag1 »



3 Add a date to this tag

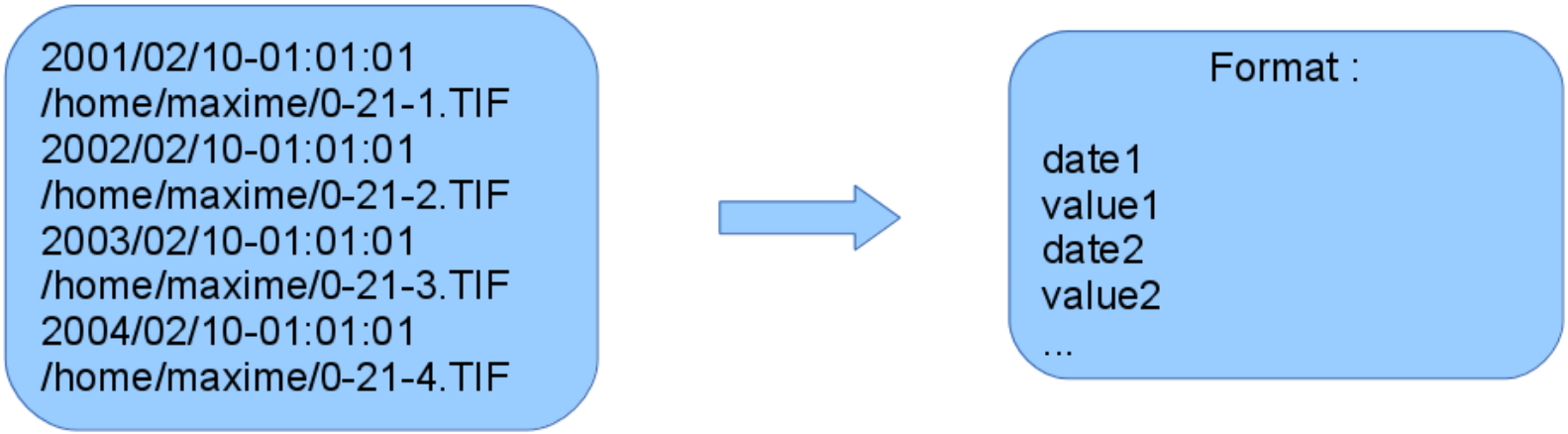


1.d) Use temporal slider



2. Example with DynFlag (1/3)

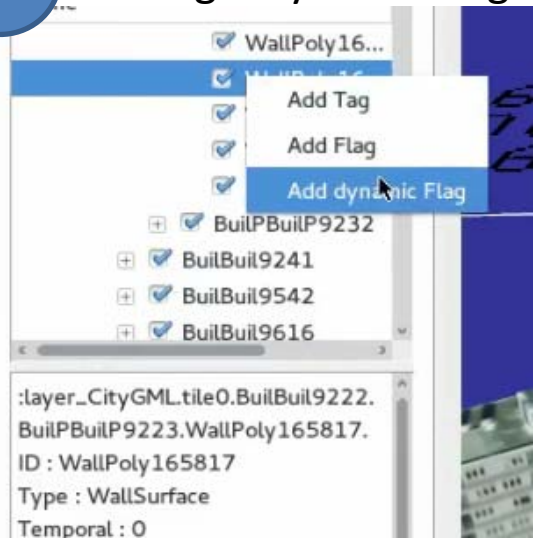
- Show the evolution of temperature
- Texture temporalisation
- All states are stored in one flag : a dynamic flag
- Example of date file for « texture » attribute



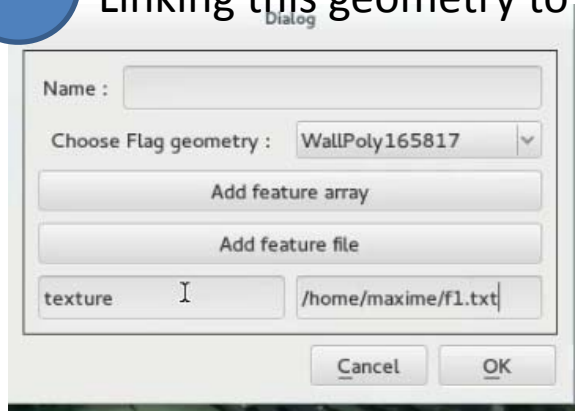
2. Example with DynFlag (2/3)

- Show evolution of temperature

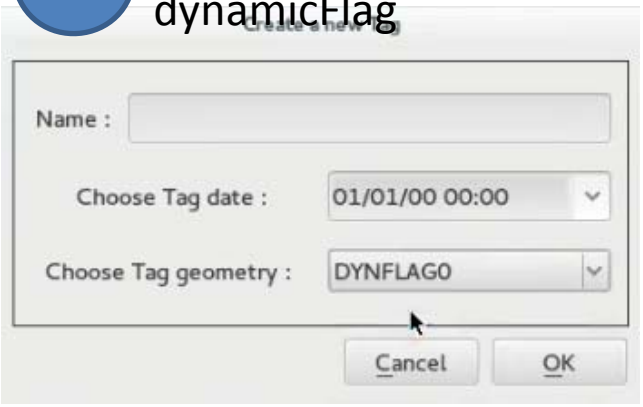
1 Adding a dynamic flag to the wallPoly16…



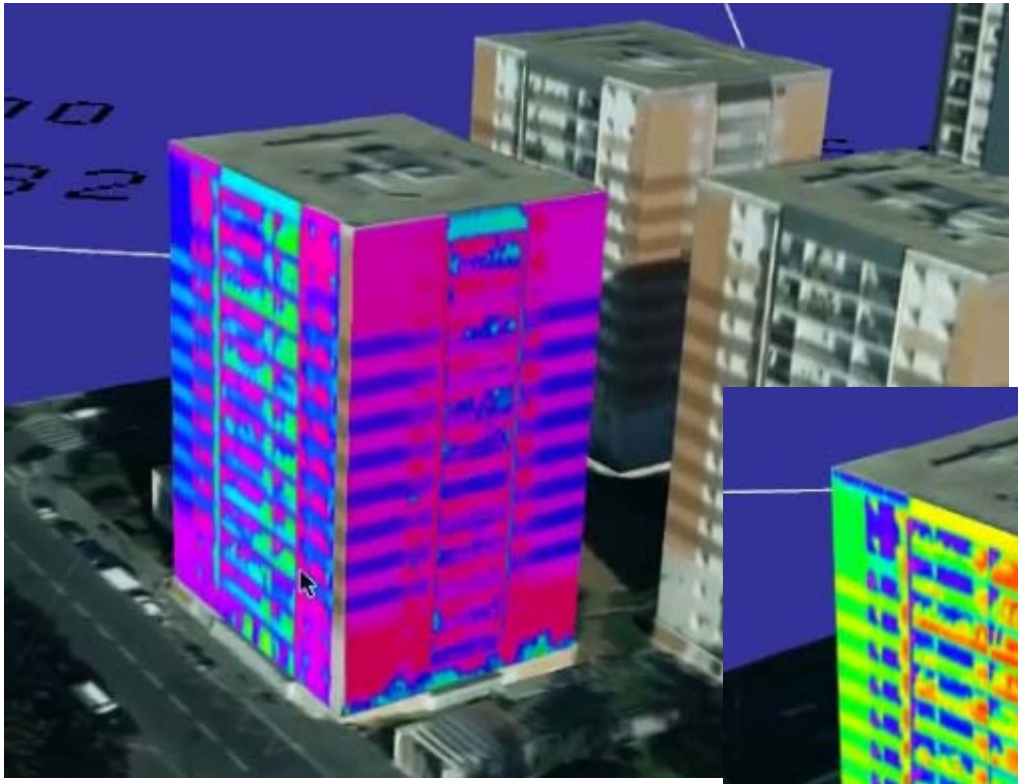
2 Linking this geometry to a stream (here a file f1.txt)



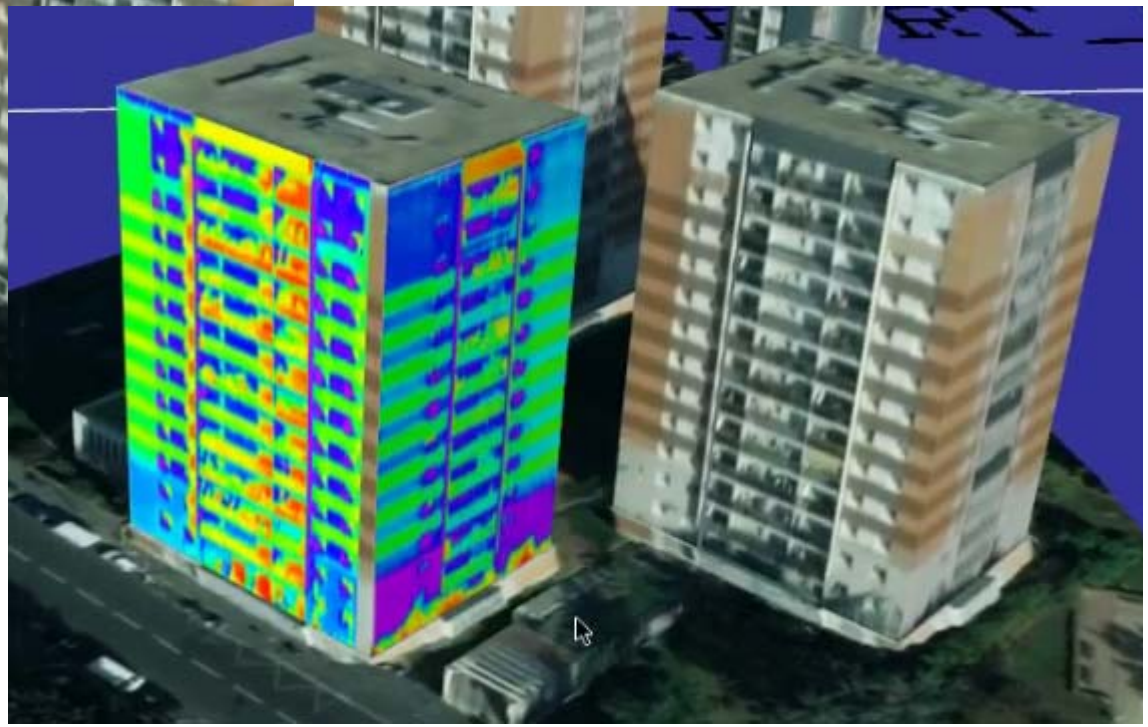
3 Adding a tag to the dynamicFlag



2. Example with DynFlag (3/3)

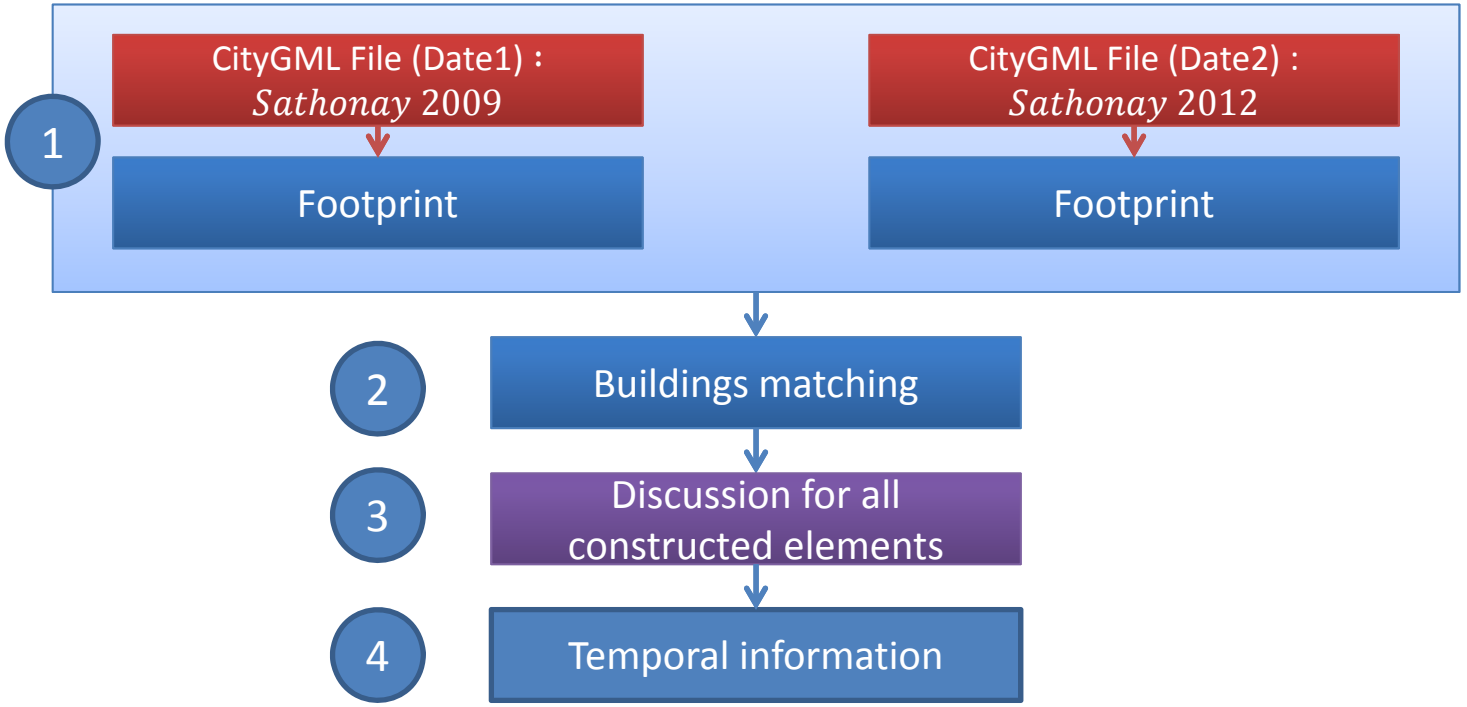


Evolution of the texture during time



3- Discussion on detection change (1/3)

- We have an automatic process in order to propose values for tags and flags.
  - This method permit to detect changes between two versions of a same area provided by two different acquisitions (the #id and the resolution may change)



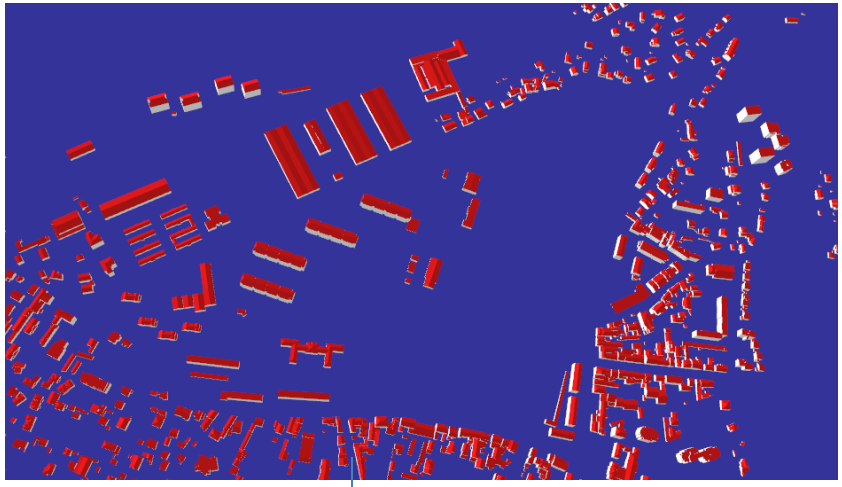
3- Discussion on detection change (2/3)

Discussion for all constructed elements

- Compare the footprint of each building to extract obvious changes
- Compare the 3D data, with the Hausdorff distance, to distinguish the other cases

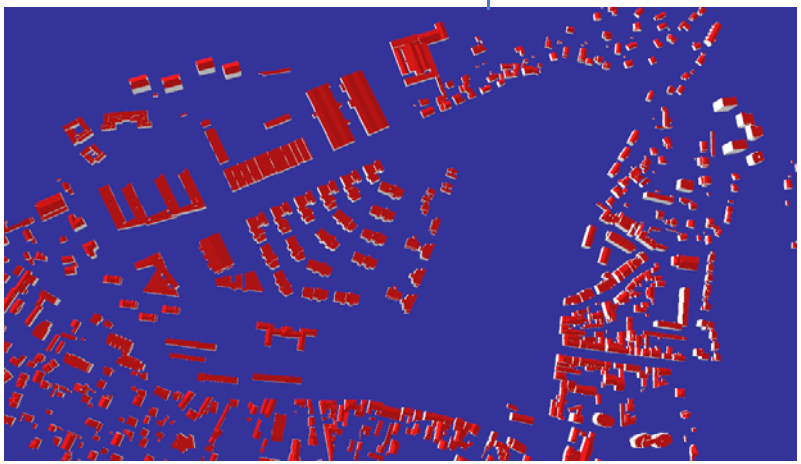
3- Discussion on detection change (3/3)

- 1 City, 2 Dates : Sathonay 2009 – Sathonay 2012

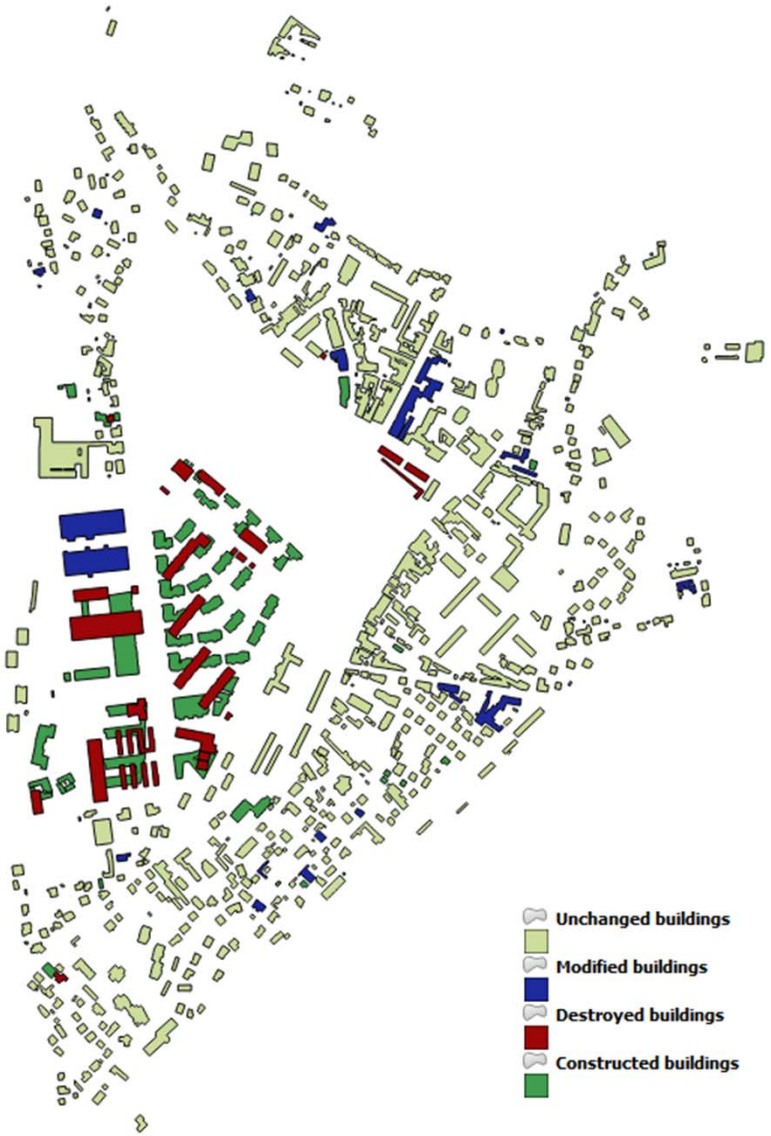


Sathonay 2009

Sathonay 2012



3- Discussion on detection change (4/4)



- Results on Sathonay

Pédrinis F., Morel M., Gesquière G., “CHANGE DETECTION OF CITIES”, submitted to 3DGEOINFO 2014 conference

Conclusion

- We have proposed to add temporal information in cityGML
  - Based on Tag (date), and flag (state)
  - Flag can also contain dynamic information

Morel M, Gesquière G, “Managing Temporal Change of Cities with CityGML”, Eurographics Workshop on Urban Data Modelling and Visualisation, 2014, DOI: 10.2312/udmv.20141076

- We have proposed an implementation in the Virtual City project (3D-Use Software)

Future works

- Study the possibility to add uncertainty in the temporal management
  - Adding uncertainty is important for instance in archeology
  - Visualize these spatial and temporal data aspect in order to provide real assistance in decision-making processes
- Propose to link an interval of date to a cityobject
  - Useful in the detection change process presented below or where the change is not exactly known (historical projects)