TERRESTRIAL LIDAR CAPABILITIES
FOR 3D DATA ACQUISITION
(INDOOR AND OUTDOOR) IN THE
CONTEXT OF CADASTRAL
MODELLING:
A comparative analysis for
apartment units

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Do we need 3D “survey” data to build 3D cadastre model of apartment units?

- No
- We can use 2D data and simply extrude a constant H (height) or the value of an attribute
  - X,Y coordinates or the building footprint
- Ex: Spain, use parallelogram
  - sub parcels having a volumetric attribute floors placed over the ground floor.
- Ex. Portugal, CGA shape grammar

Extracted from Olivares Garcia 2011
Which are the 3D data used to build 3D cadastre model of apartment units?

- Floor height
  - Based on Earth surface or local surface
- Number of floors
- Vertical elevation of the Earth surface
- Vertical elevation (orthometric or ellipsoidal altitude) of all the floors
- Z coordinates of all the points delimitating the units
  - Indoor/outdoor, private and common
- Volume of the legal 3D units
What are the current survey instruments used to collect 3D cadastral data?

<table>
<thead>
<tr>
<th>Survey instruments</th>
<th>Quebec Land Surveyors</th>
</tr>
</thead>
<tbody>
<tr>
<td>Distancemeter (laser rangefinder)</td>
<td>Today: 84% In 10 years: 78%</td>
</tr>
<tr>
<td>Measuring tape</td>
<td>Today: 76% In 10 years: 65%</td>
</tr>
<tr>
<td>Total station</td>
<td>Today: 71% In 10 years: 61%</td>
</tr>
<tr>
<td>GNSS/GPS</td>
<td>Today: 29% In 10 years: 39%</td>
</tr>
<tr>
<td>Terrestrial LiDAR (laser scanner)</td>
<td>Today: 8% In 10 years: 47%</td>
</tr>
<tr>
<td>Stereo-photography</td>
<td>Today: 2% In 10 years: 6%</td>
</tr>
<tr>
<td>Videogrammetry</td>
<td>Today: 0% In 10 years: 12%</td>
</tr>
</tbody>
</table>

Sept 2013, 49 participants on about 250 land surveyors (20%)
Objective

- Identify the capabilities of terrestrial LiDAR instruments to survey apartment units to produce 2D plans and 3D models
  - Under the current specifications of the Quebec land administration authority
Methodology

- Compare with traditional survey instruments
- Survey two apartment units with both instruments
- Establish a list of comparing criteria
- Produce the 2D plans and 3D models based on the same specifications
  - Quebec land administration authority
- and compare...
Survey instruments

- Distancemeter
  - PCE-LDM 50
  - Precision of 5 mm
Survey instruments

- Terrestrial LiDAR (laser scanner)

<table>
<thead>
<tr>
<th></th>
<th>Callidus CP3200</th>
<th>FARO Focus 3D (Trimble TX5)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Year of commercialisation</td>
<td>1997 to 2006</td>
<td>2010 to now</td>
</tr>
<tr>
<td>Spec Field of view (H:V)</td>
<td>360:140</td>
<td>360:305</td>
</tr>
<tr>
<td>Spec Distance range</td>
<td>0.6 to 120 m</td>
<td>0 to 32 m</td>
</tr>
<tr>
<td>Spec Precision (distance of 50 m.)</td>
<td>5 mm</td>
<td>2 mm</td>
</tr>
</tbody>
</table>
## Study sites

<table>
<thead>
<tr>
<th></th>
<th>Site A</th>
<th>Site B</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Number of co-owners</strong></td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td><strong>Number of floors</strong></td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td><strong>Number of walls</strong></td>
<td>16</td>
<td>49</td>
</tr>
<tr>
<td><strong>Instrument</strong></td>
<td>Callidus</td>
<td>Faro</td>
</tr>
<tr>
<td><strong>Survey resolution</strong></td>
<td>2 to 20 cm</td>
<td>2 to 20 cm</td>
</tr>
<tr>
<td><strong>Number of scans</strong></td>
<td>18</td>
<td>10</td>
</tr>
<tr>
<td><strong>Number of surveyed points</strong></td>
<td>562 544</td>
<td>24 350 000</td>
</tr>
</tbody>
</table>
Study sites

Site A (1st floor)
- 10 indoor stations
- 5 outdoor stations

Site B (1st floor)
- 15 indoor stations
- 3 outdoor stations
Site 1 – Example of points cloud

Trimble Realworks
Site 1 – Scan #1 (Facade)
Site 1 – Scan #3 (inside)
Site 1 – Inside scan assembling
Site 1 – Inside scan assembling
Site A

Ground floor

1st floor

Vertical Profile

Autodesk-Autocad

Workshop
Site B

Vertical Profile

Ground floor

1st floor
Comparison

- Acquisition phase
  - Precisions were comparable (5 mm)

|                               | Distancemeter | LiDAR  
<table>
<thead>
<tr>
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</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>(Faro;Callidus)</td>
</tr>
<tr>
<td>Survey duration</td>
<td>4h</td>
<td>4h ; 5.5h</td>
</tr>
<tr>
<td>Number of measures or scans</td>
<td>50</td>
<td>18 ; 10</td>
</tr>
<tr>
<td>Number of operators</td>
<td>1</td>
<td>1 ; 2</td>
</tr>
<tr>
<td>Estimated cost ($CDN)</td>
<td>400$</td>
<td>800$ ; 1500$</td>
</tr>
</tbody>
</table>
## Comparison

- **Modeling phase**

<table>
<thead>
<tr>
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<th>2D plan’s production</th>
</tr>
</thead>
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<tr>
<td></td>
<td>Dist. meter</td>
</tr>
<tr>
<td>Preprocessing time (Scan assembling)</td>
<td>1h</td>
</tr>
<tr>
<td>Geometric modelling of all objects</td>
<td>4h</td>
</tr>
<tr>
<td>Completeness (number of objects collected/required)</td>
<td>100% (49/49, 16/16)</td>
</tr>
</tbody>
</table>

| Estimated cost ($CDN) | 600$ | 1200$ ; 1800$ |
Comparison

- Modeling phase

<table>
<thead>
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<td>Dist. meter</td>
<td>Faro; Callidus</td>
</tr>
<tr>
<td>Preprocessing time (Scan assembling)</td>
<td>1h</td>
<td>1h; 19h</td>
</tr>
<tr>
<td>Geometric modelling of all objects</td>
<td>5h</td>
<td>1.5h; 15h</td>
</tr>
<tr>
<td>Completeness (number of objects collected/required)</td>
<td>125% (20/16)</td>
<td>150% (76/49); 400% (64/16)</td>
</tr>
<tr>
<td>Estimated cost ($CDN)</td>
<td>700$</td>
<td>600$; 5000$</td>
</tr>
<tr>
<td>TOTAL cost ($CDN)</td>
<td>1 700$</td>
<td>2 600$; 8 300$</td>
</tr>
</tbody>
</table>
Discussion – Acquisition phase

- Comparable results
  - Survey duration
    - BUT dependent on the scan speed, the number of scans and the view angle per scan
    - The objects obstruction and occlusion

- Dissimilar results
  - Cost (50% more expensive with LiDAR)
Discussion – Modelling phase

- To produce 2D maps
  - Need more software expertise for LiDAR
  - Cost (50% more expensive with LiDAR)
  - Duration (100% slower with LiDAR)
  - Completeness (10% more objects with LiDAR)

- To produce 3D models
  - Cost (10% less expensive with LiDAR)
  - Duration (100% faster with LiDAR)
  - Completeness (30% more objects for LiDAR)
Discussion

- To be considered:
  - Number of objects to model
  - Geometric complexity of the objects
    - LiDAR point cloud offers the possibility of producing more detailed 3D model (i.e. containing not only cadastral limits)
- Recent LiDAR technology like the Faro instrument obviously shows better results compare to older system like the Callidus
- Are these results comparable for city building (LiDAR acquisition and modeling)?
Discussion

- Two modes of acquisition
  - Object oriented (Distancemeter) vs Space oriented (LiDAR)
- The distinction between the boundary of the physical objects and the administrative limits is determined:
  - During the survey (on the field) = Distancemeter
  - During the modeling phase = LiDAR
- This distinction is important and result from the opinion of an expert
  - Where is the expert in those processes?
  - The LiDAR scans what he see... The Distancemeter measures what the human needs...
Next

- Need more tests
  - Have complex building
  - Focus on 3D modeling and quality control aspects (scan assembling, removing noise, surface reflection, etc)
  - Processing point clouds (have the good software)
- Procedural reports
  - How to collect data (which), How to model data
Acknowledgement

- Groupe VRSB (M.Bédard; G.Langlois)
- Professional Association of Land Surveyors
- Trimble (D.Marcoux; D.Laflamme)
- S. Daniel (professor Ulaval)
Example
Data acquisition procedure

- to walls, ceilings, floors, stairs
Site 1 – Scan #1 (Facade)
Site B

Ground floor

1st floor

Works