Adaptive Capacity of Buildings
A determination method to
Promote Flexible and Sustainable Construction: Open Building
Rob Geraedts

Outline

• Introduction
• Adaptive Capacity Method
• 7 Indicators for Transformation Dynamics
• 7 Indicators for Use Dynamics
• Assessment Values
• Adaptive Capacity: Demand & Supply Profiles
• Recommendations
Adaptive Building & Sustainability

- Structural vacancy of real estate
- The economic crisis
- Increased awareness of and interest in sustainability
- Growing understanding of importance circular economy
- Sustainable = Adaptable (Wilkinson et al, 2009)
- Assessment method for adaptability is lacking

Adaptive Capacity

- The adaptive capacity of a building includes all characteristics that enable it to keep its functionality during the technical life cycle in a sustainable and economic profitable way withstanding changing requirements and circumstances (Hermans, 2013).
Sustainability

- Building accommodates different types of users during its whole life cycle
- The long-term utility value is a crucial precondition for sustainability

Perspectives of the Demand for Change

- **Users**
  - Accommodation is adaptable to a changing primary process

- **Owners**
  - A building with a highest possible profitability during the ownership cycle

- **Society**
  - Real estate that contributes to an attractive and sustainable living and working environment

The need for change from three different perspectives
Appearances of Adaptive Capacity

The Demand: Use & Transformation Dynamics

Framework of the AC method for the demand and supply on three different levels
The Supply: Rearrange, Extension & Rejection

Framework of the AC method for the demand and supply on three different levels

7 Indicators for Transformation Dynamics

1. Reallocate Redesign
2. Grain Size
3. Facilities
4. Quality
5. Expansion
6. Rejection
7. Transfer

7 Transformation Dynamics Indicators from the perspective of the owner of a building (E1-E7)
7 Indicators for Transformation Dynamics

E1. Reallocate / Redesign
E2. Grain size
E3. Facilities
E4. Quality
E5. Expansion
E6. Rejection
E7. Transfer

E1. Reallocate / Redesign
- Demands / wishes for the possibility of changing of size and partition of user units within building (to combine, to split up, to rearrange);
- Demands / wishes for the possibility of changing layouts on building level;
- Demands / wishes for the possibility of the changing of functions on building level.

E2. Grain size
- Demands / wishes for possibilities to change the number of units in the building.

E3. Facilities
- Demands / wishes for changing the facilities within the building and/or
- Changing the facilities outside the building, on location.
E1. Reallocate / Redesign
E2. Grain size
E3. Facilities
E4. Quality
E5. Expansion
E6. Rejection
E7. Transfer

E5. Expansion
- The usable area of the building has to be expandable in the future (horizontal and/or vertical).

E6. Rejection
- The usable area of the building has to be detachable in the future (horizontal and/or vertical).

E7. Transfer
- The building has to be transferable to another location in the future.

7 Indicators for Use Dynamics

1. Redesign
2. Reallocate Internal
3. Relation Internal
4. Quality
5. Facilities
6. Expansion
7. Rejection

User-Unit Use Dynamics Indicators
Rearrange Flexibility
G1. Redesign
G2. Reallocate Internal
G3. Relation Internal
G4. Quality
G5. Facilities
Extension Flexibility
G6. Expansion
Rejection Flexibility
G7. Rejection

Use Dynamics Indicators from the perspective of the users of a building (G1-G7)
### 7 Indicators for Use Dynamics

<table>
<thead>
<tr>
<th>G1. Redesign</th>
</tr>
</thead>
<tbody>
<tr>
<td>Demands / wishes for rearrange the user unit in the building and / or</td>
</tr>
<tr>
<td>Demands / wishes to change the functions of the user unit in the building.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>G2. Reallocation Internal</th>
</tr>
</thead>
<tbody>
<tr>
<td>Changing of demands / wishes for the location of the user unit in the building.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>G3. Relation Internal</th>
</tr>
</thead>
<tbody>
<tr>
<td>Changing of demands / wishes for the internal relation with other users /</td>
</tr>
<tr>
<td>stakeholders in the building.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>G4. Quality</th>
</tr>
</thead>
<tbody>
<tr>
<td>Changing of demands / wishes for the interior design and finishing of the</td>
</tr>
<tr>
<td>unit (look &amp; feel) in the building.</td>
</tr>
</tbody>
</table>
4 Assessment Values

1 BAD
2 BAU
3 BETTER
4 GOOD

4 assessment values of the spatial/functional flexibility and the constructional/technical flexibility characteristics

Examples assessment of spatial/functional flexibility - owner (A)

<table>
<thead>
<tr>
<th>A1. Division support / infill</th>
<th>Assessment values (%) of infill</th>
<th>Remark</th>
</tr>
</thead>
</table>
| To which degree does the design or building with the division between support (components with long life cycle) and infill (components with short life cycle), easy to dismantle, replace? | 1. < 10%  
2. 10 - 30%  
3. 30 - 50%  
4. > 50% | The more construction components belong to the infill domain, the more easily a building can be rearranged. |

Source: Values: Gouwstra 2013;  
Adapted from:  
Boull: 2008  
Cessell. M. in (Bossle (2008))  
Tihanyi 1999  
Habraken (1996)
**Examples assessment of construction/technical flexibility - owner (B)**

<table>
<thead>
<tr>
<th>B5. Measurement system</th>
<th>Assessment value implementation modular co-ordination in % of implementation</th>
<th>Remark</th>
<th>Source</th>
</tr>
</thead>
<tbody>
<tr>
<td>How positioning and measurement systems for construction components be used, the number co-ordination for the implementation of project independent, accountable and replaceable components?</td>
<td>1. Not implemented. 2. 5-25% implemented. 3. &gt;50% implemented.</td>
<td>The more project independent, accountable and replaceable construction components have been implemented, the more easily a building can be rearranged or transformed to other functions. The implementation of the rules for modular co-ordination is absolutely conditional.</td>
<td>Valaes: Geraets 2013. Geraets, 2004</td>
</tr>
</tbody>
</table>

**Examples assessment of construction/technical flexibility - owner (B)**

<table>
<thead>
<tr>
<th>B5. Replaceable inner walls</th>
<th>Assessment value replaceable inner walls</th>
<th>Remark</th>
<th>Source</th>
</tr>
</thead>
<tbody>
<tr>
<td>To what extent are inner walls easily replaceable?</td>
<td>1. Inner walls are not replaceable without major expensive constructional interventions. 2. Inner walls are not replaceable, but good accountible. 3. Inner walls are replaceable by dismantling them and refitting them at another location. 4. Inner walls are easily replaceable without major expensive constructional interventions (for instance system walls)</td>
<td>The more inner walls are easily to be replaced the more easily a building can be rearranged or transformed to other functions.</td>
<td>Valaes: Geraets, Van Kijfs 2011. Adapted from DfBC 2012. Geraets 2006</td>
</tr>
</tbody>
</table>
**Examples assessment of construction/technical flexibility - owner (B)**

<table>
<thead>
<tr>
<th>BC: Horizontal measurement grid</th>
<th>Assessment values horizontal measurement grid</th>
<th>Remark</th>
<th>Source</th>
</tr>
</thead>
<tbody>
<tr>
<td>What is the size of the horizontal measurement grid?</td>
<td>1: &gt; 3.40 m. 2: Between 2.40 - 3.40 m. 3: Between 1.20 - 2.40 m. 4: &lt; 1.20 m.</td>
<td>The smaller the size of the horizontal measurement grid the more easily a building can be renovated or transformed to other functions. For instance a horizontal grid based on 1.80m. gives great opportunities for a layout for living/room and larger common rooms as well.</td>
<td>Values: Gernade 2013 RN1/97 Ramus 2013</td>
</tr>
</tbody>
</table>

**Examples assessment of spatial/functional flexibility - user (C)**

<table>
<thead>
<tr>
<th>CI: Multifunctional units</th>
<th>Assessment values multifunctional units</th>
<th>Remark</th>
<th>Source</th>
</tr>
</thead>
<tbody>
<tr>
<td>To what extend can user units be used for more functions, like living and/or core functions, different office functions or commercial functions?</td>
<td>1: One function (living, core, office, or commercial). 2: Two - Three functions. 3: Three - four functions. 4: Four functions (living, core, office, and commercial).</td>
<td>The more user units in a building can support more different functions the more easily a unit can be rearranged or transformed to other functions.</td>
<td>Values: Foremde 2013 Adapted from Schröder, Till 2007</td>
</tr>
</tbody>
</table>
Examples assessment of construction/technical flexibility - user (D)

Table: D15. Detailing joints inner-walls - horizontal

<table>
<thead>
<tr>
<th>Assessment value</th>
<th>Horizontal joints</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 BAD</td>
<td>1. Penetration joint.</td>
</tr>
<tr>
<td>2 BAD</td>
<td>2. Arises of soil or weather.</td>
</tr>
<tr>
<td>3 BETTER</td>
<td>3. Unique specific project based joint components.</td>
</tr>
</tbody>
</table>

Remark: The more the horizontal joints of inner walls are easily dismountable, the more easily units in a building can be reorganized or transformed to other functions.


Examples assessment of construction/technical flexibility - user (D)

Table: D15. Exchangability (infill) construction components

<table>
<thead>
<tr>
<th>Assessment value</th>
<th>Exchangability construction components</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 BAD</td>
<td>1. No possibility to exchange infill construction components.</td>
</tr>
<tr>
<td>2 BAD</td>
<td>2. &lt; 30% of components are exchangeable.</td>
</tr>
<tr>
<td>3 BETTER</td>
<td>3. 30 - 60% of components are exchangeable.</td>
</tr>
<tr>
<td>4 GOOD</td>
<td>4. &gt;90% of the infill construction components are easily replaceable and exchangeable.</td>
</tr>
</tbody>
</table>

Remark: The higher the exchangability of the infill construction components, the more easily units in a building can be reorganized or transformed to other functions.

Source: Gerads 2013, adapted from REN (1962).
**Adaptive Capacity: Demand & Supply Profiles**

Flexibility Demand
Of user or owner

Flexibility Supply
Of building

Assessment aspects

Example of a demand and supply profile to see if there could be a match

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**Adaptive Capacity: Recommendations for the next steps**

- Verification, validation in practice
- Developing easy to use instruments
- For small & large projects
- For different sectors or building types

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