INVESTIGATING MODEL EVOLUTION IN A COLLABORATIVE BIM ENVIRONMENT

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Adapted from (Turk, 2000)
background

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Information flow (Tribelsky and Sacks, 2010)
Information waste (Dubler et al., 2010)
Product & Process performance (Du et al., 2014)
Information quality (Berard, 2012)
## Table 1: Measures to evaluate design and product evolution from various domains

<table>
<thead>
<tr>
<th>Author</th>
<th>Domain</th>
<th>Purpose</th>
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</thead>
<tbody>
<tr>
<td>Metrics</td>
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<tr>
<td>• Productivity – speed of development</td>
<td>• Relevance</td>
<td>• Overproduction</td>
<td>• Action rate</td>
<td>• Size (Lines of code, number of classes)</td>
<td>• Complexity</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>• Effectiveness</td>
<td>• Consistency</td>
<td>• Inventory</td>
<td>• package size</td>
<td>• Coupling</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>• Quality</td>
<td>• Correctness</td>
<td>• Extra Processing</td>
<td>• work in progress</td>
<td>• Dynamic coupling</td>
<td></td>
<td></td>
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<td></td>
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<td></td>
</tr>
<tr>
<td>• Accuracy</td>
<td>• Precision</td>
<td>• Motion</td>
<td>• rework</td>
<td></td>
<td></td>
<td></td>
<td></td>
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<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>• Usefulness</td>
<td>• Availability</td>
<td>• Defects</td>
<td>• batch size</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>• Economy</td>
<td>• Distribution</td>
<td>• Waiting</td>
<td>• development velocity</td>
<td></td>
<td></td>
<td></td>
<td></td>
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<td></td>
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<td></td>
</tr>
<tr>
<td></td>
<td>• Flexibility</td>
<td>• Transportation</td>
<td>• bottleneck</td>
<td></td>
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</table>
1. **what measures can be extracted** from a BIM for its **assessment**, from both a product and a process perspective?

2. **how do these measures correlate** between themselves, across time and across disciplines?

3. **what do these measures tell us of how a BIM is evolving** throughout a project?
research objectives

to develop and test measures to evaluate the development of information through a BIM
methodology
<table>
<thead>
<tr>
<th>Native model</th>
<th>IFC file</th>
<th>Timesheets</th>
</tr>
</thead>
<tbody>
<tr>
<td>File size (purged)</td>
<td>File size</td>
<td>Total hours per discipline</td>
</tr>
<tr>
<td>Scheduled Objects</td>
<td>LOC in the schema</td>
<td>BIM hours per discipline</td>
</tr>
<tr>
<td>Quantities – all</td>
<td>Entities</td>
<td></td>
</tr>
<tr>
<td>Clashes</td>
<td>Components</td>
<td></td>
</tr>
<tr>
<td>Sheets created</td>
<td>Model revisions</td>
<td></td>
</tr>
<tr>
<td>Views created</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Annotations (Legends, etc.)</td>
<td></td>
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</tr>
</tbody>
</table>

Table 3: Data collection points for model analysis across all disciplines
methodology

Total time spent on project - all disciplines

BIM-cumulative  Total - cumulative  BIM-by period  Total - by period
methodology
measures developed
Types of analysis of model evolution

• Absolute variation
  \[
  \frac{(x_i - x_{t=0})}{x_{t=0}}
  \]

• Relative to previous iteration
  \[
  \frac{(x_i - x_{i-1})}{x_{i-1}}
  \]

• Relative to final model
  \[
  \frac{(x_{t_{\text{max}}} - x_i)}{x_i}
  \]
### Spearman’s correlation

<table>
<thead>
<tr>
<th>Total hours</th>
<th>BIM hours</th>
<th>File size (native - purged)</th>
<th>File size (IFC)</th>
<th># of objects</th>
<th># of sheets</th>
<th>Lines of Code</th>
<th># of entities</th>
<th># of components</th>
<th># of revisions</th>
<th># of clashes</th>
</tr>
</thead>
</table>
| Spearman’s correlation values are shown in the form of a correlation matrix. Each cell represents the correlation coefficient between two variables. The diagonal values are 1 for each variable, as they are perfectly correlated with themselves. The matrix is symmetrical, with the correlation coefficients reflected across the diagonal.

#### Example:

- **Total hours** vs. **BIM hours**: The correlation coefficient is around 0.28.
- **File size (native - purged)** vs. **File size (IFC)**: The correlation coefficient is around -0.12.

The values indicate the strength and direction of the correlation, with negative values indicating an inverse relationship.
\[
\frac{(x_i - x_{i-1})}{x_{i-1}}
\]
\[
(x_{\text{max}} - x_i) / x_i
\]
Other measures

- Model complexity
- Level of development
- Information quality
- Information flow

Information Value
• Develop measures of information evolution in a BIM-based project delivery setting

• Can be used to:
  • benchmark progress
  • better define fee structures
  • allocate resources
Conclusion

• Clear advantage of BIM in performing this research
• Access to weekly iterations
• Automating the data extraction process
• Spending time in BIM vs. spending time on the model itself
• Exporting IFC files – how much information is lost?
• Differentiating how people work in BIM
Conclusion

- Expand measures to more projects
- Push protocol for replication
- Understanding proportionality in evolution
- Normalizing data across project contexts
- Accounting for BIM uses in the evaluation
References


Bim Forum 2013. Level Of Development Specification For Building Information Models


