

# Introducing: BIM Based Process Mining

## *Enabling knowledge assurance and fact based problem discovery within construction companies*

Keywords: Process Mining, BIM, Big Data, Data Science, Planning, 4D, Knowledge assurance.

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### **Abstract:**

The Beyond BIM symposium attends on connecting Building Information Models (BIMs) with several information systems intended for simulation-, sensor-, geographical-, heritage- and facility management- analyses. This paper is about extracting information from those kind of systems in order to gain insight in the entire construction process, from first idea until the maintenance phase of a project. More specific this study explores the possibilities of combining BIM databases and process mining analysing techniques to enable knowledge assurance and fact based problem discovery. With help of a case study this research explores the current possibilities. To enable process mining process data in form of an event log is necessary. The state of the art technology is able to capture process information, store it in event logs and relate it to element information extracted from BIMs. This study states that data can be collected from all kind of different information systems, and also can be stored fragmented. This ensures the a stable quality of the data. When one needs to do specific analysis those data sources can brought together and connected through identifiers. In conclusion this study identifies process mining applications on project-, company- and industry- level.

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## **Beyond BIM Open Symposium**

### ***Short position statement***

**“For my master thesis I am currently studying the topic of process mining in the construction industry. This paper describes my findings until now.”**

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## 1. Introduction and background

The Beyond BIM symposium attends on connecting Building Information Models (BIMs) with several information systems intended for simulation-, sensor-, geographical-, heritage- and facility management- analyses. This paper is about extracting information from those kind of systems in order to gain insight in the entire construction process, from first idea until the maintenance phase of a project. More specific this study explores the possibilities of combining BIM databases and process mining analysing techniques to enable knowledge assurance and fact based problem discovery.

Research among practitioners from the construction industry in the Netherlands has indicated that failures in planning, in specific planning deviation, cause failure costs while executing the project (Bouwkennis, 2013). A realistic planning is suggested as a solution for this problem. The planning is based on how previous projects are executed and how this process lasted, or the company/project planner thinks it was lasted. To gain insight in how this processes actually proceeded and where bottlenecks occur projects are being monitored by the construction company. Interviews with practitioners conducted by Quirijnen & van Schaijk, (2013) revealed that these monitoring systems mainly depend on human written notes or unstructured data sources. It was noticed that despite the importance, the current practices of monitoring systems are still-time-consuming, costly and prone to errors. Because of the inaccuracy of the data, and the unstructured manner of storage the data is hardly reused. Despite this fact companies are constantly trying to improve based on this inaccurate and incomplete data. This results in feeling based improving instead of fact based problem solving.

During the 'data explosion' from last decades the capabilities of information systems expanded rapidly. As a result the digital universe and the physical universe are becoming more and more aligned. The growth of the technological possibilities with RFID (Radio Frequency Identification), GPS (Global Positioning System), Intelligent Imaging Camera systems, and sensor networks will stimulate further alignment of the digital and physical universe. Even in the so called old fashioned construction industry these new technologies are slowly implemented. Specifically the expansion of the use of BIM enables the industry to combine those technologies with the BIM databases. (i.e. (Meadati, Irizarry, & Amin, 2010) (Lu, Huang, & Li, 2011) (Bügler, Ogunmakin, Teizer, Vela, & Borrmann, 2014)) Separate to the evolution of devices and the possibility to easily collect data also new data analyzation approaches are developed. Also the relatively new research field of process mining is gaining momentum. Process mining provides approaches to gain insight and improve processes in a lot application domains. The goal of process mining is to gain event data, extract process-related information and discover a process model. Most organizations detect process problems based on fiction rather than facts. Van der Aalst ( 2011) describes process mining as an "emerging discipline providing comprehensive sets of tools to provide fact-based insights and to support process improvements" (p. 7). Process mining aims to provide a full understanding of as-is to end-to-end processes.

Given (a) the interest in monitoring, observation of construction projects and the interest in construction process models, (b) the limited quality of current monitoring and observation tools, and (c) the possibilities to autonomous create, store, and extract event data with new technologies and BIM, it seems legit to study the possibilities of relating event data to BIM. Therefore this

research will explore the possibilities of shortening construction projects with help of process mining and BIM. First the used method will be elaborated, thereafter executed case study will be described and at last an outline of the results, discussion and conclusion will be given.

## 2. Research

The goal of this study is to explore if it is possible to reuse process data in order to shorten construction projects. Therefore it uses BIM databases and process mining analyzing approaches. It gives answer to questions like: How should the data be structured in order to enable process mining? How should the data be stored? How can the data be linked with BIM? What analysis can you do with it? What applications does the data have?

By use of a case study this paper explores the boundaries of the current state of the art. The target within this case study was to capture 'As-Built process data', compare it to 'As-Planned BIM', measure deviations and store this processes in data formats which could be used as a reference in future projects.

This study focusses on analytics on a project level, but gives an advice in using BIM based process mining on a company- and industry level. In addition this study is encountering the technical limits of the current monitoring tools.

## 3. Case study

A project of a 10 apartment building is used as case study. An As-Planned BIM model (.ifc format) was available which includes besides the planning information also all the parameters which characterize the element (For example the Material name, Product type and Classification code).

In order to enable process mining the As-Planned .ifc model had to be converted into 'event logs'. Event logs consists of events, cases and attributes. All these elements are stored in the As-Planned model. In order to translate the As-Planned .ifc into event logs an 'Event-log' plugin is made in BIMserver<sup>1</sup>. The event log can then be analysed in process mining tools. While analysing the event log of the As-Planned model with the process mining tool Disco<sup>2</sup> different process variants were discovered. Products of the same type were assigned to different process tasks. Also mean durations and bottlenecks are discovered. In addition also planning validation could be done with process mining analytics. Due to the relatively simple project and process, the researcher thinks that process mining will be even more interesting by complex projects. But this case study positions a workflow which is also useful in larger projects.

In order to compare the As-Planned model with the actual information the event log must be enriched with As-Built information. The only requirement is that the GUID in the As-Built information is included. The GUIDs can be used to connect both process data logs. As described by Kopsida, Brilakis, and Vela (2015) a lot of technologies are available to capture As-Built process information. This study uses the RAAMAC<sup>3</sup> BIMserver tool to generate As-Built

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<sup>1</sup> [www.bimserver.org](http://www.bimserver.org)

<sup>2</sup> [www.fluxicon.com/disco/](http://www.fluxicon.com/disco/)

<sup>3</sup> <http://raamac.cee.illinois.edu/>

information of the building elements. This tool uses (drone-) images of the construction site in order to make a 3D point cloud (Golparvar-Fard, Pena-Mora, & Savarese, 2009). As can be seen in figure 1 and figure 2, the point cloud is compared with the 4D model and elements are recognized on existence.



Figure 1 Point cloud comparison with As-Planned .ifc



Figure 2 Point cloud comparison with As-Planned .ifc

At the moment of writing the study is still ongoing. Therefore the event log including As-Built information is not available yet. Currently experiments are done by reusing the As-Planned event logs for giving planning consults for new projects. Therefore a plugin is made in the open source BIMserver which gives an automated planning consult. The consult is a document where advice is given on how elements are planned in previous projects, which tasks were planned, how long the mean duration was, and how often the planning deviated from reality. This gives a project planner insight in the previous processes and will give a fast start to make his own planning. In addition this can be useful for risk detection in planning construction projects.

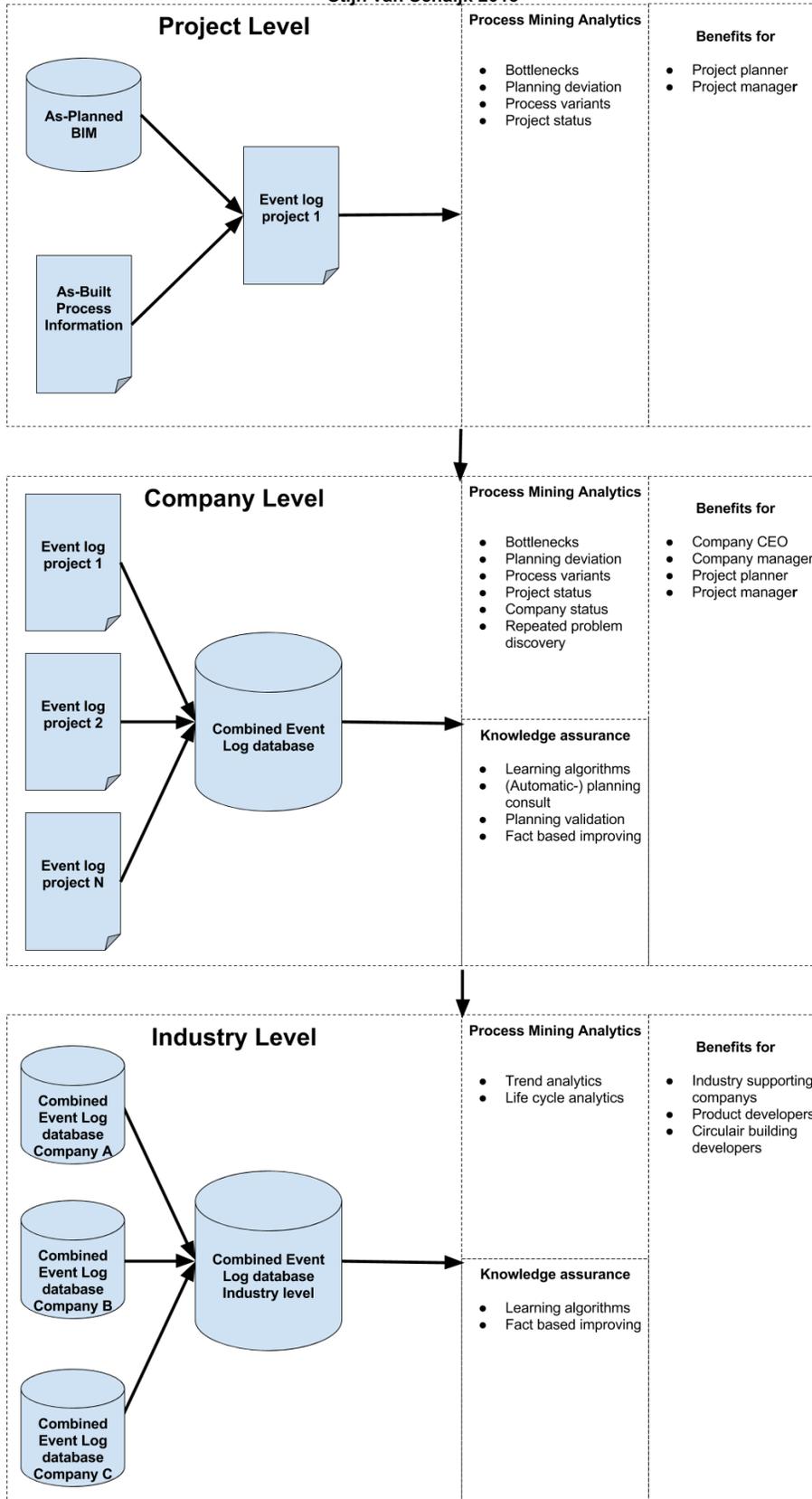
#### 4. Results, discussion and conclusion

The goal of this research is to explore if it is possible to shorten construction projects with BIM and process mining. The research didn't prove that this is possible, but discovered a lot of applications for BIM based Process mining. To enable process mining process data in form of an event log is necessary. The state of the art technology is able to capture process information and store it in event logs. As can be seen in figure 3 the approach stated in his study can be useful on project-, company-, and industry level. On project level BIM based process mining has the potential to evolve in a method which can help project managers and companies to make project planning's more realistic by use of information from previous projects. Therefore the process information must be extracted from information systems in form of an event log. In addition this data does not have to be stored in one system, but can brought together when one needs to do analyzing. To merge the data from different data sources a unique identifier is necessary. When working with BIM the GUID can be used as a glue to combine event logs from different sources. The product information related to the GUID can be connected to the process information from the event logs. With this process mining analyzing techniques will be enabled. One can search for bottlenecks and planning deviation within one project. When event logs of different projects come together at company level larger analysis can be done. Project planning's can be compared and validated to company standards. Processes which often deviate from planning will be

discovered. When this information is collected on a company scale even automated planning services can be built. Where project planners can get advice on how to plan specific building elements based on what was built in previous projects. When all this data is structured in event logs even trend analysis can be done on company level and also on industry level. Life cycle analysis will be empowered, insight can be gained in product processes.

In conclusion processes stored in event logs combined with BIM data has a potential to gain new insights in construction processes. This can have huge value because easy knowledge assurance will be possible. But to enable this agreements have to be made on how to structure the data, how to name specific elements, how to name specific planning tasks, and how to use unique identifiers. This is essential when combining data sources. In addition the experience from this study states that data can be collected from all kind of different information systems, and also can be stored fragmented. This ensures the a stable quality of the data. When one needs to do specific analysis those data sources can brought together and connected through identifiers.

**BIM based Process mining applications on Project -, Company, and Industry level**  
 Stijn van Schaijk 2015



**Figure 3 BIM based process mining applications**

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