Germany's governmental BIM initiative – Assessing the performance of the BIM pilot projects

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Abstract:

The technology of Building information modeling (BIM) promises a significant increase in productivity in the design, construction and operation of buildings and infrastructure facilities. In the entire world, the AEC industry is starting to transform itself by moving from 2D drawings to work with digital building models that do not only represent 3D geometry of the building components, but also all the non-geometric data required throughout the building's lifecycle. As this technological change impacts all stakeholders of the AEC in a fundamental way, a carefully planned transition is necessary to avoid economical damage. In many countries around the world government-driven initiatives are underway to initiate the necessary standards, guidelines and contract templates. The most prominent example is the United Kingdom where in 2010 the Cabinet office has initiated the BIM initiative with April 2016 demarking the official starting point for mandatory use of BIM in all public projects. During the preparation process, a large number of carefully elaborated guidelines and standards defining BIM processes, contents and handover have been developed.

Also Germany is preparing the transition to BIM-based workflows in its AEC industry. In 2014, after analyzing the reasons of failure in a number of large-scale construction projects, a national commission recommended as one measure for reducing projects risks to make extensive use of digital methods such as BIM in order to make the complexity manageable. In consequence, the German Ministry of Transport and Digital Infrastructure has defined a strategic plan for stepwise introduction of BIM methods in public construction projects. In addition, a number of BIM pilot projects, all in infrastructure, have been initiated. The authors have been assigned with the scientific analysis of the performance of these pilot projects. This paper reports on the outcomes of the study and the future steps towards widespread BIM adoption in Germany.

Keywords: Building Information Modeling, Germany, Governmental initiative, Pilot projects, BIM performance assessment.

1. INTRODUCTION

The technology of Building information modeling (BIM) promises a significant increase in productivity in the design, construction and operation of buildings and infrastructure facilities (Eastman et al. 2009). In the entire world, the AEC industry is under transformation - overcoming the conventional inefficient and error-prone practices based on 2D drawings by moving to modern procedures based on digital building models. These digital models that do not only represent 3D geometry of the building components, but also all non-geometric data required throughout the building's lifecycle. As this technological change impacts all stakeholders of the AEC industry in a fundamental way, a carefully planned transition is necessary to avoid economical damage.

In many countries around the world, government-driven initiatives are underway to initiate the necessary standards, guidelines and contract templates. The most prominent example is the United Kingdom where in 2010 the Cabinet office has initiated the BIM initiative with April 2016 demarking the official starting point for mandatory use of BIM in all public projects (Cabinet Office, 2011). During the preparation process, a large number of carefully elaborated guidelines and standards defining BIM processes, contents and handovers have been developed. Other examples of government-driven national BIM initiatives include Finland (Senate Properties, 2007), Sweden (Statsbygg 2013), Denmark (BIPS 2013), the Netherlands (Rgd 2013) and Singapore (BCA 2013).

2. GERMAN STEP-BY-STEP PLAN FOR ESTABLISHING BIM

Also the German government is preparing the transition to BIM-based workflows in its AEC industry. In 2014, after analyzing the reasons of failure in a number of large-scale construction projects, a national commission recommended as one measure for reducing projects risks to make extensive use of digital methods such as BIM in order to make the complexity of large projects manageable (BMVI, 2013).

In consequence, the German Ministry of Transport and Digital Infrastructure has developed a strategic plan for stepwise introduction of BIM methods in public construction projects. The resulting Step-by-Step plan ("BIM-Stufenplan") has been published on December 15th, 2015 (BMVI, 2015).

It defines the following general goals:

- Increase in planning preciseness and reduction in cost overruns
    - in-depth evaluation of planning alternatives
    - improved communication with the public
    - less design errors by collision checks and enforced collaboration between stakeholders
    - precise assessments of cost increases caused by owners' change requests
    - improved reliability of construction processes by simulation of construction sequences
- Optimization of life-cycle costs
    - simulation of life-cycle costs (including operation and maintenance costs)
    - provision of the digital model to the owner as a basis for asset management

The step-by-step plan contains a clear definition of Niveau 1 of BIM-based project delivery encompassing the following key features:

- project delivery based on ISO 19600 (the upcoming international version of PAS 1192-2:2013)
- employer's information requirements (EIR) for defining which data is required by the employer, when and in which detail
- principle of federated domain-specific BIM models merged into a coordination model
- creation of a BIM Execution Plan (BEP) by all stakeholders defining: frequency of model coordination, level of detail delivered in which phase, usage of the model for visualization, quantity take-off, simulations and life-cycle assessment
- usage of a common data environment according to ISO 19600
- derivation of 2D plans from 3D BIM models
- use of open data exchange standards (mainly IFC, but also OKSTRA and GAEB)
- checking of data/models for fulfilment of the EIRs

Apart from these characteristics, the general execution of construction projects is kept stable to the largest extent possible. This includes the legal frameworks as well as the remuneration regulations in effect today (Honorarordnung für Architekten und Ingenieure – HOAI). These decisions were taken to allow an easy and hurdle-free transition to BIM-based project execution. For a future Niveau 2, changes in laws and remuneration regulations may be possible.

The defined Niveau 1 is expected to be implemented for all public infrastructure projects starting in 2020. To reach this goal, three phases (steps) have been defined:

- 2015 – 2017: Preparation Phase
- 2017 – 2020: Extended Pilot Phase
- from 2020: BIM Niveau 1 for all new projects

Within the preparation phase, early-bird pilot projects are conducted, standards and codes are defined and measures for educating the professionals are initiated. Also, BIM guidelines will be developed including templates for contracts, Employer Information Requirements and BIM execution plans. The first four pilot projects have been started in September 2014 in order to gather practical experiences and identify development gaps and required actions.

3. BIM PILOT PROJECTS

To prepare the broad introduction of BIM and allow to gather the necessary practical experiences, four early-bird BIM pilot projects have been initiated by BMVI in September 2014 (BMVI, 2014). Due to the responsibility domain of BMVI, all projects are infrastructure projects. They comprise two roadway bridge projects, one railway bridge project and one railway tunnel project. The selected projects are in different phases of planning and/or execution, and correspondingly BIM technology has been applied with different goals and by different manners.

3.1 Südverbund Chemnitz - Auenbachtalbrücke

As part of a new four-lane roadway passing the city of Chemnitz on the east side, a new infrastructure facility crossing the Auenbachtal is going to be built. The project itself consists of two pre-stressed concrete girder bridges with 142m und 32m length and span lengths between 21m and 35m, separated by a short embankment. The bridges will cross a railway of the Deutsche Bahn (German Railways), the stream named Auenbach and a service road. The project is currently in the early design phase.

Throughout this project, the use of BIM in early design phases is investigated. The main BIM goals are (i) improvement of organization, communication and interface coordination by consistent, interdisciplinary and model-driven planning, (ii) improvement of planning quality through integrated work on basis of a common BIM, (iii) improvement of risk management through greater transparency throughout planning, (iv) improvement of change management leading to a higher adherence of schedule and cost during construction, (v) higher quality of project information through flexible visualization.

The design of the road and railway alignments is realized by means of the software Obermeyer ProVI. The model of the bridge structures and the soil model are designed using Siemens NX. Subsequently, the BIMs are used for quantity take-off (using RIB iTwo) and the simulation of the construction works (using Autodesk Navisworks). For mutual information exchange, BIMs and drawings are exchanged between the stakeholders via the data platform DOXIS following the basic principles of a Common Data Environment.

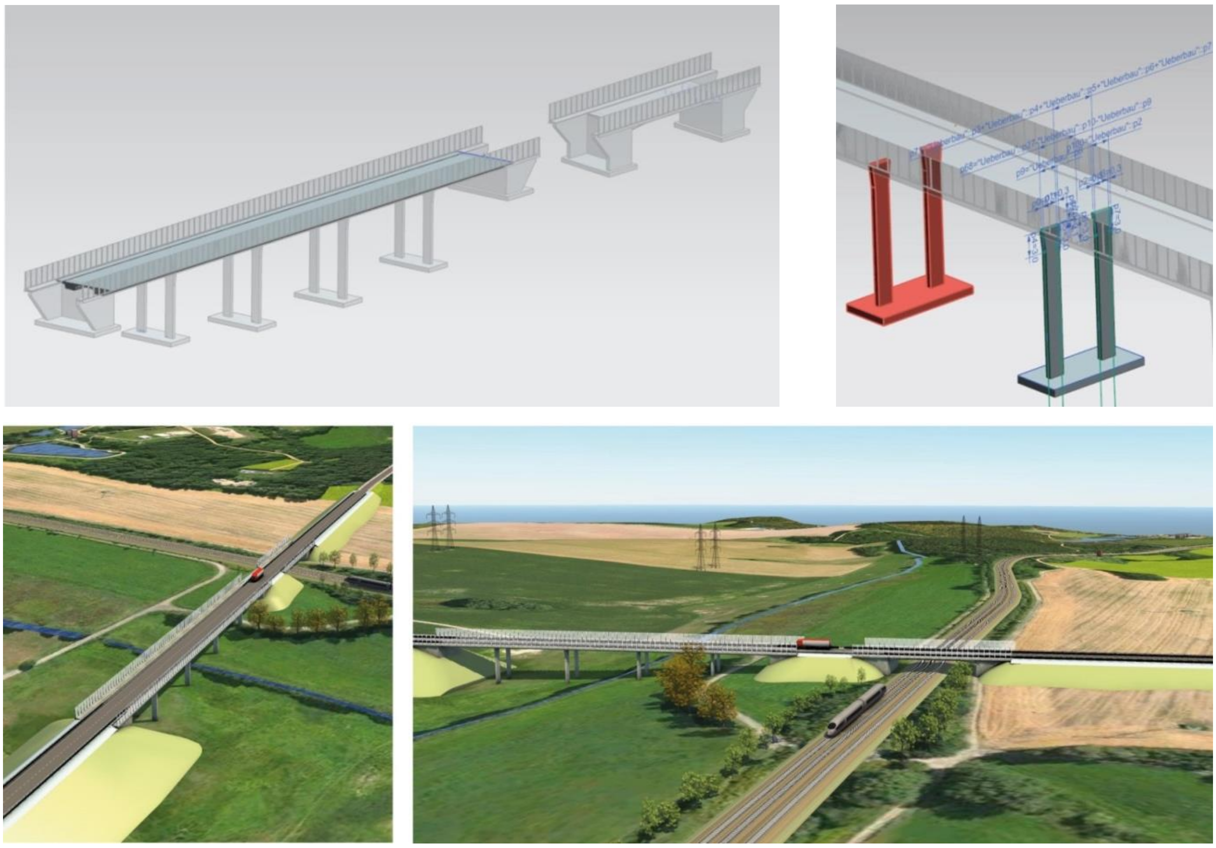

Figure 1. Models and visualizations of the pilot project Auenbachtal (Courtesy of Obermeyer Planen + Beraten)

3.2 Petersdorfer Brücke

The highway A19 is located in Mecklenburg-Vorpommern and is the main north-south highway connecting the Baltic coast to the rest of the motorway network. The Petersdorfer Bridge is part of the A19 and spans over the Petersdorfer Lake with a length of 264 m. Due to the poor condition of the existing bridge, a new bridge is to be constructed. Early works began in June 2015 which included provisional arrangement of site traffic. In the pilot project, the use of BIM methods in road construction was self-sufficient and was carried out parallel to the planning and construction process. The project is currently in the construction phase.

The following key BIM usages are implemented in the course of the project: (i) visualisation of existing conditions based on existing terrestrial surveying, (ii) modelling of the bridge and earthworks for the existing and planned conditions, (iii) validation of the quantity calculations with associated projected costs, (iv) simulation of the construction stages showing the projected timeline, (v) simulation of the traffic flow during the construction period.

It is intended to integrate the survey data from the new bridge to use for operation / maintenance, along with links to the German maintenance database SIB-Bauwerke and the road database. As a common data environment the project management system EPLASS is used, a basic file sharing system with very limited support for model-based collaboration.

The road planning, bridge planning, traffic phases, deadlines and costs – all with associated metadata – is hold in a database. The software system QLX BIMVIEW was used to carry out the import, the management and processing of the data. Using the database, a time-dependent 3D real-time visualization of the geometries, quantity estimation and the representation of the time-dependent cash outflows, construction stages and transport phases has been generated.

Since BIM was employed not before the detailed design phase, many advantages could not be realised. Nevertheless, errors in the conventionally realized tender process have been detected through the subsequent development of the BIM. In consequence, the client become aware of the potential of the BIM technology, even though these could not all be implemented within this project.

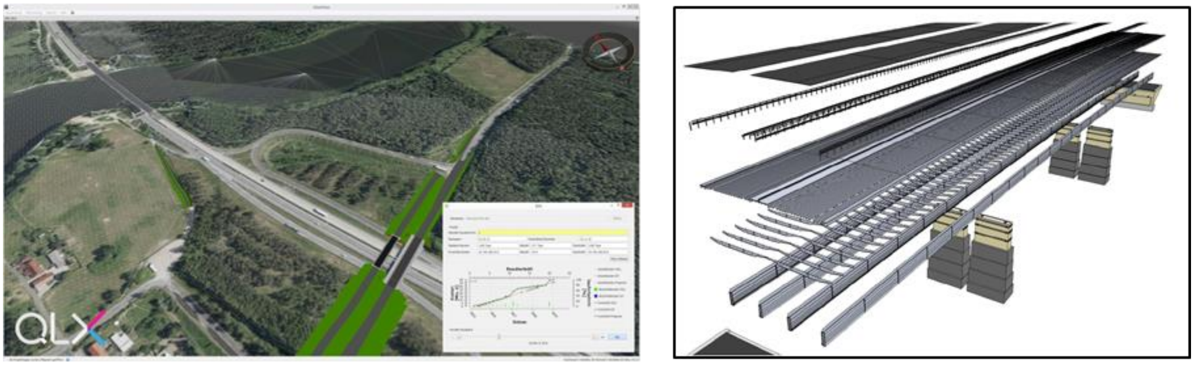

Figure 2: Model and visualization of the pilot project Petersdorfer Brücke (Courtesy of QLX GmbH)

3.3. Filstalbrücke

The railway overpass at Filstal is part of a newly built high-speed line between the metropolises of Stuttgart and Munich. The construction consists of two single-track bridges with lengths of 485 m and 472 m respectively and a maximum height of 85m. The bridges are located directly between the portals of two tunnels that pass through the surrounding mountains. The project is currently in the construction phase. The six-span continuous beam haunched structure is produced using incremental launching formwork carriages and consists of 2 single-track bridge superstructures. The bridges were designed as Y bridges with fewer supports to allow seamless integration into the landscape.

The following BIM targets were defined in the pilot project: (i) risk mitigation, in particular time and cost risks, (ii) improved communication between the stakeholders, (iii) collection of experience for the development of role models, for the use of software and hardware, for the organisation and compilation of the project team and for the variation in cooperation between employer and the contractor, (iv) process analysis and efficiency enhancement.

The following measures were then established and carried out: (i) 4D construction sequence and progress tracking, (ii) billing with the help of BIM, (iii) mobile cloud-based BIM applications with access via iPad and Web Portal, (iv) connection between the Plan Management Platform (EPLASS) and the BIM applications by linking the 3D model and the corresponding drawings at the component level.

The 3D model was created using the CAD software Siemens NX. The incremental launching formwork carriage was modelled using Tekla Structures. The model was accessible to everyone via the cloud software Autodesk BIM 360. Additional information was made available through a web portal dashboard and is retrievable on mobile tablets. The illustration of 4D and 5D model was carried out using RIB iTWO. By assigning the target costs for components and construction phases, along with the generation of weekly project status updates, the comparison between targets and reality were carried out.

Figure 3: Model and visualization of the pilot project Filstalbrücke (Courtesy of Max Bögl and Deutsche Bahn PSU)

3.4. Rastatt Tunnel

The Rastatt Tunnel is one key section of the railway connection between Karlsruhe and Basel. Two single tube tunnels with a length of 4.7 km are driven using two tunnel boring machines of 11 meter in diameter (cf. Figure 1). Due to the low covering with a minimum of 4 meter and thus an increased risk of surface settlements, critical sections within the tunnel alignment will be frozen before the excavation process starts. With a project budged of about 450 Mio Euro the Tunnel Rastatt is a major project for the infrastructural development of the region. Since the project management decided to use BIM and to follow the rule “build digital before real” a BIM Execution Plan was created and use cases for BIM methods during different project phases were defined in advance.

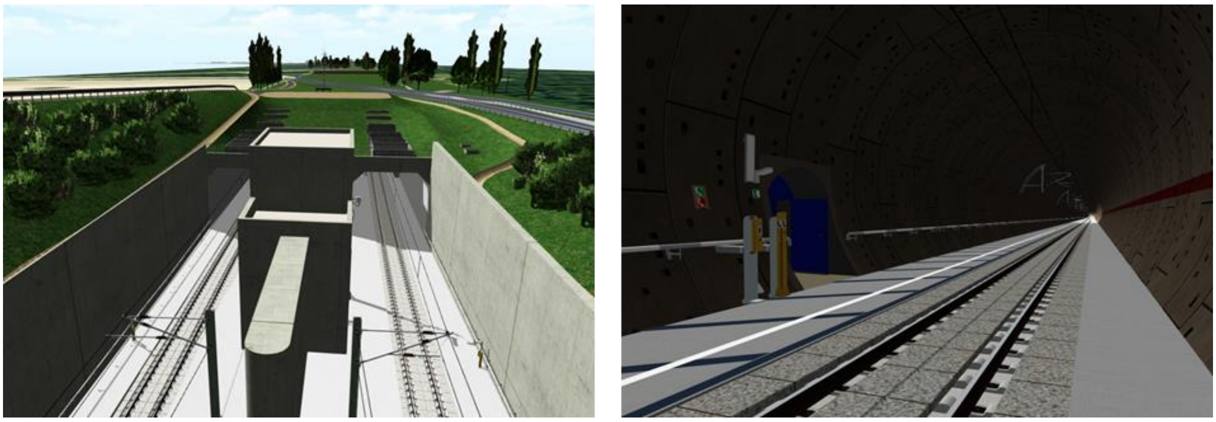

Figure 4: Models of the north portal entrance and the tunnel lining with installations and a crosscut connection (Source: DB Netz AG).

In practice, connecting the frequently update information model with established project management systems (RIB iTWO 5D) allows a (i) key-date earned value analysis. Further, the improved progress report leads to an (ii) increasing quality of planning processes, (iii) fast adaption of processes to changed boundary conditions and (iv) a reduction of supplementary requests. Special focus on an adequate schedule, several simulation of different planning concepts in different construction phases were performed and evaluated. Throughout the whole project a 4D visualization (Autodesk Navisworks/desite MD) is realized. The model design is performed by using the Autodesk products Revit (construction model) and Civil 3D (ground model). Quotation costing as well as quantity takeoff are accomplished on the basis of the model. A detailed definition of required Level of Detail (LOD) were described considering several stages of construction and different sub models.

4. PERFORMANCE ASSESSMENT

The core activity of the scientific analysis of the BIM pilot projects was the development of a performance assessment system. This was done to get a precise insight into current BIM practices, identify shortcomings and give further recommendations regarding the development of guidelines and standards.

There are a number of BIM performance assessment systems available, the most prominent one being the VDC scorecard system which was developed at Standford University (Kam et al. 2013) and is now commercially available as the BIMscore product (Kam 2015). The VDC scorecard performance assessment system is based on the performance areas Planning, Adoption, Technology and Performance. These are further subdivided into 10 divisions which cover in total 56 measures, ranging from Management Objectives over Stakeholder Involvement to Level of Detail, Interoperability and User Emotion. The grade given to the individual measures are subsumed to an overall grade for the entire project by applying predefined percentages. In (Kam et al. 2013) the system has been used to assess the performance of 108 projects from 13 countries. Although VDC scorecard is a very mature assessment system, it turned out to be sub-optimal for assessing the BIM performance of the pilot projects. Main reasons are a too detailed coverage of management practices, while other important areas such as the use of common data environments are only briefly touched. For these reasons, the authors decided to develop an own performance assessment system which was more closely adjusted to the context of Infrastructure projects in Germany.

The system developed by the authors is influenced by the principles of the Arup BIM Maturity Measure (ICE 2015) but adds additional details in order to get a deep understanding and high-resolution picture of the BIM performance of the projects.

The performance assessment system comprises 48 questions covering a broad range of BIM aspects. For each of the questions, the project performance is measured by assigning one of the grades 0 to 5 (ranging from 0 = non-existent to 5 = optimal BIM implementation). In addition, most questions are associated with a checklist to provide a clear understanding of the measures implemented in the project. The questions are grouped according to the following categories:

- Employer's Information Requirements
- BIM Execution Plan
- Technology used for BIM execution
- Contracts
- BIM team
- BIM in preliminary / schematic design phase
- BIM in construction documentation phase
- BIM in the tendering phase
- BIM in the construction phase
- BIM in the operation phase

For each of the questions a precise definition is given, as well as examples that help to assign the correct grade.

As the space available in this paper does not allow for a complete listing of all questions, the questions of the group "BIM execution plan" is provided here as an example (see Figure 5):

1. BIM Execution Plan: Was a BIM execution Plan specified? Is it binding for all involved parties?
2. BIM goals: Did the employer define the goals to be reached by using BIM technology?
3. BIM use cases: Were BIM use cases defined for reaching the aforementioned goals?
4. BIM Technology: Was the technology used in the project specified in the BEP?
5. Organization: Were specifications regarding roles, responsibilities and deadlines included?
6. BIM workflow: Does the BEP include a process map? Are phases, data exchange scenarios and data drops included?

Question	Explanation	0	1	2	3	4	5
BIM Execution Plan							
BIM Execution Plan	Was a BIM Execution Plan defined? How binding is it?	not existing	very short, informal BEP	BEP for individual planning consultant	BEP for the entire planning team	project-wide BEP, not legally binding	BEP as a legally binding document
BIM Goals	Are BIM goals specified in the BEP?	no goals defined	informal, imprecise goals		well-defined qualitative goals		well-defined quantitative goals
BIM Use Cases	Are BIM use cases defined to reach the goals?	no use cases defined	simple, poorly defined use cases ("3D Model")		standard use cases to be implemented are listed		all use cases are explained in detail, including their concrete application
Technical Specifications	Which technical specifications are contained in the BEP?	no specifications	minimal, rough technical specifications		some technical specifications, e.g. exchange formats		detailed spedicifications of all relevant aspects
Organisational Specifications	Which orginazational specifications are contained in the BEP?	no specifications	minimal, rough organizational specifications		some organizational specifications, e.g. responsibilities		detailed organizational specifications incl. roles and responsibilities
BIM Workflow		no definition of the BIM workflow	informal, roughly described workflow		textually described detailed workflow	graphical description using properitary notation	Modeling of the workflow using BPMN and the IDM methodology

Figure 5: Section of the developed performance assessment system

The questions are answered, i.e. the grades are assigned, during interviews of experts with the involved parties of the BIM project. This helps to reduce the subjectivity of the applied grading. A complete objectivity, however, is not realizable using a questionnaire approach. In contrast to other existing approaches, we do not accumulate the grades to a full BIM maturity grade for the entire project. The reasons for this decision lies in the fact that the pilot projects are too diverging, in particular with respect to the project phases where the BIM methodology has been applied. A comparative grading would thus not be suitable. What we do perform is a grade accumulation on category level to give the project stakeholders are clear indication which BIM facets are performing well and which have potential for improvement.

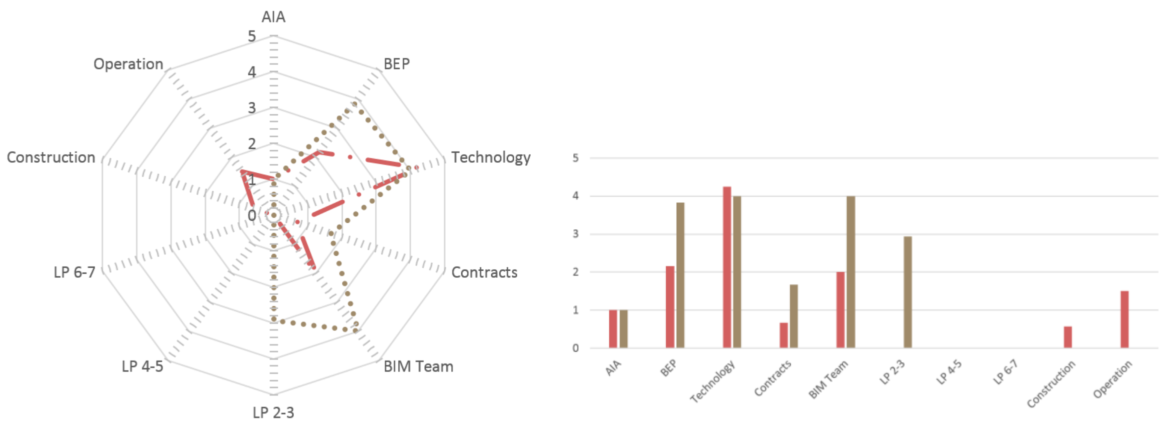

Figure 6: Overview of the preliminary results of assessing two of the pilot projects

Due to the limited space available in this paper, we are not able to present the results of the performance assessment measurement for all projects in detail. Figure 6 shows two diagrams depicting the overview results of two of the four pilot projects (Auentalbrücke and Brücke Petersdorfer See).

We clearly see that there is a significant potential in improving BIM practices in most categories. We emphasize that the BIM methodology has been applied only for limited phases throughout the project. It also has to be noted that in all four pilot projects the BIM methodology was applied in parallel to conventional practices, which obviously should not be the case in future real BIM projects. The results of the scientific evaluation are now taken into account for setting up the next BIM pilot projects.

We will present more detailed results and discussions in follow-up publications.

5. SUMMARY

The paper has presented the step-by-step plan ("Stufenplan") of the German Ministry of Transport and Digitalization (BMVI) as key part of the German national BIM initiative. The step-by-step plan precisely defines Niveau 1 of BIM project execution which is expected to be realized in all construction projects in the infrastructure domain starting 2020. On the way towards this goal, a preparation phase is carried out to test BIM execution and identify demands with respect to the development of standards, guidelines and contract templates. As part of the preparation phase, four early-bird pilot projects have been started in 2014.

The paper has presented a BIM performance assessment system which allows to determine the maturity of BIM project execution. It is tailored to the specific context of German infrastructure projects and comprises a total of 48 questions which are grouped into 10 main categories. The questions allow to assign grades to the individual aspects of a BIM project. The systems helps to identify fields of potential improvement and thus supports the public employers to develop measures for a successful BIM implementation.

The results of applying the assessment system to two of the pilot projects have been shown. Using the development performance assessment system, the deficiencies of the BIM pilot projects could be clearly identified. A major issue is that in all projects, BIM was only used in parallel to conventional drawing-based practices. However, it has to be noted that these were the very first BIM pilot projects in Germany. Our results will be taken into account for setting up the next pilot projects.

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