Implementation of Building Information Modeling (BIM) in the Infrastructure Division of Deutsche Bahn AG
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BIM Strategy
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The strategy for implementing Building Information Modeling (BIM) in the Infrastructure Division (I Division) is a continuation of the previous strategy from 2015. It lays out the framework and the new recommendations for action for the continued implementation of BIM at Deutsche Bahn AG (DB) in a time frame extending approximately to 2025 and beyond. It takes into account the insights gained from the current BIM implementation and the application of the BIM methodology in DB infrastructure projects.

The BIM implementation is an indispensable component of the digitalization strategy of DB. It makes an important contribution to overcoming the challenges faced by the I Division. Digitalization will create a perceptible added value for customers in the form of higher quality and greater reliability of DB services. In addition, it will achieve higher profitability and a higher employer appeal for the individual DB AG companies.

The update of the BIM strategy will focus on the following topics:
1. Stabilization of the infrastructure projects with regard to quality, timeline and costs
2. Increase in the productivity and efficiency of the implementation of infrastructure measures with regard to the impending investment ramp-up
3. Increase in the availability of existing assets and enhanced profitability of asset operation by means of significant improvements in data quality

The DB vision regarding the deployment of BIM methodology in infrastructure projects and in existing assets:

Better design, construction and operation of assets – design, construction and operation of better better assets!
The gradual development of BIM, with the support of new digital technologies, aims to improve the quality of design, construction and operation of railway infrastructure assets. The data created using the BIM methodology makes it possible to test scenarios digitally, to use the test results as a basis for better decisions and to obtain current and precise information in all phases of the asset life cycle.

The three-phase structure of the procedure coordinated at the Infrastructure Division level will enable the individual business centres and service units of DB to find optimal technical and economical solutions for implementation of the BIM in the I Division that are appropriate for the individual business models (fig. 1–1).

An integral component of the strategy is the option of achieving the BIM expertise of phases 2 and 3 earlier and to apply these in pilot projects. In this way, the valuable lead in experience achieved by some DB companies becomes accessible to all other business units and service centres as well.

**BIM phase 1 – Convergence**

Since 2015, each business unit has developed its own specific BIM capabilities and adapted them to their respective project portfolio. In terms of the comprehensive deployment of BIM after 2020 according to the "Road Map for Digital Design and Construction" of the Federal Ministry of Transport and Digital Infrastructure (BMVI), the business units have made good progress. The targets stipulated by the federal government will be met.

However, a consolidation and standardization step, referred to as the "convergence phase", remains to be completed by 2020. The former project and company-specific solutions must be converted into DB standards to avoid overtaxing contractors with a large number of different solution approaches.

**BIM phase 2 – Digital expertise**

Phase 2 "Digital expertise" is already beginning now, in parallel to the convergence phase. The aim is to gather the expertise and capacities needed to put the achieved target level into practice in all areas as a new standard by 2025. In this phase, BIM will be expanded to the entire design and construction supply chain. Apart from DB employees themselves, the DB partners and suppliers must also become versed in BIM to ensure both the market and client remain aligned. In parallel, the additional use cases of phase 3 (integration of operation and maintenance) should also be piloted. Moreover, the requirements for the integration of asset operation in phase 3 are also defined in phase 2.

**BIM phase 3 – Digital transformation**

In phase 3, the BIM methodology is to be fully employed for design, construction and operation – collaboratively and digitally. The further development of digital aids will be of central significance. Phase 3 has therefore been designated with the term "digital transformation".
The speed, scope and complexity of the changes brought about by BIM and digitalization require continuous strategic guidance and support by a suitable implementation organization. This will ensure strategic decisions and the coordination of individual strategies at the Group level.

BIM can be successfully implemented if effective forms of collaboration are also adopted. Collaborative project execution is a central factor for success. Openness, transparency and a goal and solution-oriented approach must become the core values of all activities in the infrastructure area – both within DB and the entire supply chain.

BIM presupposes the willingness to implement cultural change. The focus is on the introduction of entirely new concepts and a move from the status quo. This also calls for a change in how we deal with one another – initiated, supported and practiced by the members of the management board and the managers of the companies. BIM can only take full effect if a climate of openness and transparency prevails between all those involved in the projects.
2. Goal and scope of the BIM strategy

2.1 Introduction

Fortunately, DB is experiencing a continuous increase in customer demand (fig. 2–1). However, the railway transportation system is coming up against major challenges: forward-looking and standardized systems must replace aging infrastructure assets and a historically evolved technological diversity. The standardization is intended to reduce the complexity of the railway system – and with it, the system costs.

Examples are the planned replacement of 3,000 signal boxes with modern digital signaling technology including equipping the routes with the ETCS system (a total route length of 2,200 kilometers by 2023) and the bridge renewal program (approx. 850 bridges in the next 5 years).

The existing assets must be consistently modernized and the rail network in Germany expanded. The federal government has incorporated the plans into the Federal Transport Infrastructure Plan 2030 with a 40% investment increase in the rail network over the previous plan. The maintenance funds will likely increase by a similar degree. To be able to tackle the investments and maintenance funds with the existing resources and capacities as far as possible, the efficiency must be increased.

The efficiency can be increased by means of better design, construction and operation of the rail infrastructure, and by design, constructing and operating better infrastructure assets.

1 German Federal Railway Authority (EBA), ETCS National Implementation Plan, version 1.11, December 11, 2017
2 BMVI, Federal Transport Infrastructure Plan, 2016
The digitalization of DB internally and of the entire supply chain will make an important contribution to increasing efficiency. BIM will be implemented to bring about the digitalization of project design and realization, and of asset management over the long term (fig. 2–2).

As a first step, BIM will contribute to stabilizing the design and construction processes of infrastructure projects by deploying digital tools and adapted processes. This will make it possible to adhere to the planned procedures and cost objectives and to start operation with the agreed quality at the scheduled time. An important factor for success is the simulation of the entire construction process in the design phase by means of digital models – with the early involvement of construction expertise and the usage of new partnering models.

Our motto:
Build virtually first and then in real life!

Over the medium to long term, the introduction of BIM is aiming to map the entire asset portfolio as a "digital twin" of the physical assets (fig. 1–2). This will enable optimal design of maintenance and replacement investments. In addition, asset availability will be increased and the impact of building measures on operations will be minimized. It is important to formulate the requirements that must be met by the BIM implementation from the perspective of asset operations as well.

The strategic goals and recommendations for action in this document primarily reflect the perspective of the rail infrastructure companies (RIC). The needs of DB intragroup suppliers (such as DB Engineering & Consulting) are treated on equal grounds with those of external partners. The intensive involvement of intragroup suppliers ensures that the needs and challenges they experience are suitably taken into account and are coordinated with the responsible associations.

2.2 Strategy goal

DB recognized the strategic importance of BIM early on. In 2015, the first version of the BIM strategy laid out the path for achieving the initial set of goals by the end of 2020. BIM Strategy 2019 specifies the scope of the BIM development in the respective business units in greater detail and places greater emphasis on creating a unified solution to overarching matters.
The goals of the current strategy:

1. Delineation of the goals and guidelines for the integrated introduction of BIM in the I Division beyond 2020 – taking into account the specific characteristics of each business unit
2. Definition and communication of the required measures
3. Indication of the potential benefit of the measures.
4. Creation of a straightforward implementation plan containing the most important milestones, making it possible to react appropriately to future development steps.

2.3 Target audiences

The BIM strategy of the I Division is directed toward all DB employees. It provides information on the reasons for introducing BIM at DB as well as the goals and anticipated changes, and involves employees in the change processes early on.

This document is specifically directed toward managers and decision-makers within the I Division to ensure that they can make informed decisions on the deployment of resources and the scope of measures and means needed for the introduction of BIM.

In addition, the strategy is intended for those responsible for BIM at the BMVI, for testing, regulatory and authorizing agencies, for other infrastructure managers as well as for DB partners along the entire project supply chain. These parties obtain clear messages and statements with long-term validity that enable them to take appropriate steps.
2.4 Scope of application

The DB vision for the digitalization of the design, construction and operation of the railway infrastructure assets is subdivided into three segments:
1. Digital design and construction
2. Digital maintenance
3. Digital operation

The BIM strategy of the I Division concerns itself with the "Digital Design and Construction" segment. It involves the creation, renewal and development of large, medium-sized and small infrastructure measures and assets within the DB rail network.

The BIM strategy of the I Division also deals with the interfaces to the "Maintenance" and "Operation" segments. The clear definition and implementation of the requirements of these segments with respect to each other is important for smooth and economical rail operations. Fig. 2–3 shows the arrows for these interfaces.

2.5 Subject context

The full complexity of the "railway infrastructure" is addressed in the strategic considerations. This encompasses the following topics (fig. 2–4):
- Network topology
- Track layout of the individual routes
- Description of individual objects and projects with all associated assets
- in which the elements are detailed down to the smallest exchangeable unit.

2.6 Strategic framework for implementation across the Infrastructure Division

The strategy is oriented on the following guiding concept:
- General implementation synergies are identified as a common denominator among I Division companies. They are formulated and implemented as minimum requirements within the I Division. These synergies create a group-wide added value.
- By specifying the requirements specific to the individual business units, individual action fields can be enabled that extend beyond the minimum requirements of the I Division in general.
- In the pilot phase, new technological developments or implementation plans are introduced as an initial step at the project level. If they prove effective at the project level, the technological developments and implementation plans are standardized at a higher level.

Figure 2–4: Abstraction level of the railroad infrastructure
3. Triggers for action

The decision to advance the implementation of BIM beyond 2020 is based on internal and external triggers and expectations that will now be examined more closely.

3.1 Internal triggers and goals

The introduction of BIM will result in fundamental improvements within DB and will ensure high performance over the long term:

Reduction in cost, scheduling and quality problems during design, construction and operation

When cost limits and deadlines are repeatedly violated in projects, this is an indication that design and construction have structural deficits. Insufficient transparency of the asset situation due to inadequate data quality and the absence of data fusion are impediments to reliable asset provision. By means of the step-by-step development of BIM with the support of new digital technologies, DB is striving to improve the quality of design, implementation and operation of the infrastructure assets. For this purpose, data is created on the basis of which scenarios can be tested, better decisions can be made and a high reliability can be achieved in the design, implementation and operation of infrastructure assets.

Improvement in the availability and performance of assets

To ensure that the right assets with the appropriate performance are delivered, the asset function and the prioritization of new assets can be virtually simulated and planned in the infrastructure network using BIM. The business units and service centres of the I Division can optimally plan and implement projects using digital models that have been made available on a timely basis. The data acquired on the asset portfolio is transferred to the operator in a loss-free, machine-readable format. In combination with real-time information from sensor technology and monitoring systems, service and maintenance times can be optimized ("condition-based maintenance").
Strategic perspective for BIM development beyond 2020
The advantages of BIM can only be realized gradually over a longer time period. For this reason, it is necessary to update the goals and strategies for BIM development beyond 2020.

Enhancement of synergy effects through better coordination and the avoidance of island solutions
The additional technological steps and new modes of cooperation in construction projects require I Division companies to implement a process for general topics that are coordinated among all those involved. These include employees, the federal government as the owner (as well as its application, testing and authorities), the design and construction industry and other industry partners. Shared positions in major strategic topics make it possible to implement the necessary behavioral changes, process adaptations and influences on technological developments (such as standardization) quickly and economically in the interest of the entire railway transport system.

3.2 External triggers

External requirements and opportunities:

BIM specifications from the federal government and policy makers
BIM was incorporated in the political specifications from the federal government in the "Construction of Major Projects Reform Committee" (2013/14). Additional political expectations and specifications are laid out in the "Road Map for Digital Design and Construction" (2015), the "Handbook for the Introduction of Building Information Modelling by the European Public Sector" (2017) and the coalition agreement (2018) between the governing parties. Through the wide-scale introduction of BIM, policy makers hope to achieve a qualitative improvement in the design and construction of infrastructure projects. The faster implementation of projects is a further goal. This is to be achieved by means of shortened approval processes and optimized communication with planners, public bodies and citizens. Positive experience made in other countries support this goal.

Specifications from the federal government and policy makers for infrastructure expansion
The transport infrastructure in Germany must be renewed and expanded. The Federal Transport Infrastructure Plan 2030 (2016 edition) therefore incorporates increased investments in the rail transportation system over a medium to long-term period. To be able to realize these additional investments, productivity must be increased. In the future, a considerably larger project volume must be implemented with same resources that are available today yet in a shorter period of time and with better quality.

Public and customer expectations of DB
Public acceptance and trust – especially when it comes to major projects – have suffered in recent years. Not only adjoining residents and others affected directly, but also the public at large, demand transparent and understandable information and communication regarding planned measures and their costs and impact.

Value chain expectations of DB
In the course of digitalization, large clients will assume a leading role in infrastructure development. To ensure firm grounds for decision making, especially for small and medium-sized enterprises, DB sets out consistent and clear requirements.

DB expectations of the value chain
As a public contracting entity, DB creates incentives for collaborative and goal-oriented partnerships by means of contract awards.

Significant leverage of the DB Group as a whole
The coordinated, external communication on the basis of clear messages creates a coherent and unambiguous perception among partners, suppliers and customers. In addition to a strong stance when cooperating with foreign railways or with respect to different stakeholders, an agreed-upon and coordinated position improves communication and enhances the ability to exert influence on standardization bodies. The first target level of the "Road Map for Digital Design and Construction" of the BMVI is only the very first step and forms the basis for further digitalization. The federal government should create new impetus for beyond 2020. Here DB can assume a pioneering role and position itself alongside international partners such as the SNCF and DACH railways.

The advantages of BIM can only be realized gradually over a longer time period. It is necessary to update the goals and strategies for BIM development beyond 2020.
4. Previous developments and the current situation

The continuation of BIM beyond 2020 is based on the developments in the individual business units that have occurred since the first version of the BIM Strategy 2015 went into effect.

4.1 BIM Strategy 2015 – Goals and priorities

The first BIM strategy dealt primarily with the design phase and the following goals:

- Better project results in the classic target areas (costs, timeline and quality)
- Higher project acceptance due to central data maintenance (satisfaction of customers, employees and special interest groups such as adjoining residents and representatives of the state and municipalities)
- Improvement in project management due to better goal orientation, optimized processes and better leadership

The BIM Strategy 2015 takes into account the status of the project and asset portfolios at the time, which were considerably different than they are today, and the resulting individual priorities and speeds of implementation. The two business units of DB AG as the client have already concerned themselves in detail with the improvement potential of BIM. DB Netz AG and DB Station&Service AG developed their own introduction strategies. DB Engineering&Consulting GmbH, too, has been pursuing a strategic implementation plan since late 2015 and is expanding its digital expertise and capacities.

On account of the optimization potentials in almost all areas of the Project Excellence Model, DB sees in BIM a significant lever for sustainably enhancing project business[1].

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4.2 Current status of the implementation programs

Now that experience has been made with BIM projects in various project portfolios and phases, BIM development must be consolidated and the course set for 2020 and beyond.

Since 2015, introduction of BIM in the individual companies has been initiated in dedicated implementation programs/projects in the following, mutually agreed-upon action fields:

1. BIM applications
2. Processes and guidelines
3. Data and information
4. IT infrastructure
5. People and communication

Good results were achieved within the action fields. A detailed report on the current status of the BIM implementation program, organized by business unit, can be found in Appendix A-3 of this strategy document.

In April 2018, the BIM steering committee resolved to focus the broad spectrum of BIM-relevant topics, use cases, requirements and target definitions on the implementation of the following five core elements of the BIM introduction for the period extending up to the end of 2020:

1. **3D design**
   Increasingly, technical models are to be created in the form of 3D design that takes the value added into account. The LOD concept is used to specify the level of detail.

2. **Employers information requirements (EIR)**
   Introduction, by the responsible project organizations, of coordinated processes and specifications to meet the project-specific data and information requirements of the client, in preparation for the requests for information submitted to future contractors.

3. **BIM execution plan (BEP)**
   Assurance of the development of a BIM execution plan in all projects. This plan documents the joint, project-specific procedure used for the collaboration between the client and contractor, including the goals for all use cases, for the purpose of fulfilling the EIR.

4. **Common data environment (CDE)**
   Assurance of the use, by all project participants, of a joint data environment, consisting of a secure, accessible data environment and the workflow as per DIN EN ISO 19650; see also fig. 6–2.

5. **Virtual data room (VDR)**
   Conducting planning meetings in virtual rooms.

By consistently and continuously applying these five core elements of BIM in infrastructure projects in the I Division, important foundations for more productivity of at least the same quality are created more rapidly and the internal goals and political specifications are met.

Figure 4–1 shows that the application of the five core elements that has been in practice up to now smooths the ground for meeting the requirements laid out in the road map.

All requirements were successfully initiated and largely implemented.

Individual topics are still under development, and in some cases are dependent on external developments. Thus, process standard DIN EN ISO 19650 on which the road map of the Federal Ministry of Transport and Digital Infrastructure (BMVI) is largely based was not yet finally published when this strategy paper was prepared. The activities up to now are based on the available drafts, which in part have changed considerably over the last two years.

DB is also highly dependent on external initiatives and developments when it comes to the requirement for open data standards. DB welcomes the development of open data formats and standards and will support and use these to the best of its ability. To avoid endangering individual projects, proprietary formats must still be used until open standards become available in the required quality. Especially in the area of the rail-specific trades, manufacturer-neutral exchange formats that meet DB security requirements, among other things, are not expected to become available in the near future. Thus, the requirements for the sharing and transmission of data, which in part are too complex, must be simplified accordingly. This approach is pursued by the present strategy.

The BMVI specifications regarding performance level 1 from the "Road Map for Digital Design and construction" of the BMVI will be reached by 2020, provided that the current rate of development remains similar to the previous rate.
4.3 Assessment of the initial situation and identification of requirements

The first important steps are accomplished when the first performance level from the BMVI road map has been achieved as predicted. The administrative and organizational framework conditions for a coordinated and efficient procedure have been established. Joint activities have been identified, prioritized and partially initiated.

Further exertions are now called for to attain a certain penetration level that has a perceptible and measurable positive impact on the creation of infrastructure projects, the availability of assets and smooth rail operations.

The requirements for comprehensive digitalization are presented below, organized by action field.

4.3.1 Strategy

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A quality management that is applied across all business units is indispensable. This is true both for the templates and the delivery results from the BIM implementation programs and for the results from the infrastructure projects.

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The results and products from the implementation programs must be clearly prioritized and managed so that they can become standardized. This avoids duplicates and contradictions, accelerates implementation and ensures a homogeneous outward appearance of the business units.

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The introduction of BIM must be accompanied by the creation of a clearly defined and coordinated risk management strategy.

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The introduction of BIM requires the Management Board and senior managers to take a clear stance, and the implementation must be agreed upon across the Group. This is the only way to implement the necessary changes successfully and sustainably.

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The introduction of BIM requires standards and conventions for data and information management at the international and national levels and at the corporate level.
The introduction of BIM requires adapted project management methods to create a consistent and stable basis for a far-reaching digitalization.

### 4.3.2 BIM applications

- With the help of a uniform method for the evaluation of the quality of BIM activities during projects, it will be possible in the future to make reliable statements on the effectiveness of interventions and investments and to enable effective control measures.
- To ensure the innovative capacity of digital design, construction and operation in the future, further pilot projects are needed, on the basis of which it will be possible to research and test applications and developments.

### 4.3.3 Processes, standards and framework conditions

- Individual documents are created via pilot projects and are used for the standardization and general processes of the BIM use cases. The documents are discussed and standardized in the I Division to achieve the desired learning and synergy effect.
- A standardization of important documents, data and formats at the interface between the client, contractor and agencies e.g. the Federal Railway Authority (EBA) is required. Format inconsistency and friction losses must be reduced on the basis of practical experience.
- A coordinated and long-term strategy for clients in the I Division for dealing with partners and participants in the supply chain creates clarity on both sides. It must be clarified whether the clients expect to participate in possible efficiency gains experienced by their suppliers. In this way, DB could achieve a signaling effect on which the market should orientate itself in the future.
- The absence of agreed-upon qualitative evaluation and award criteria was already identified in the road map of the BMVI and communicated to the market in a clear and transparent manner. DB should assume a pioneering role in the German market in this area.
- Specifications created by individual business units have proven effective in practice and should now be expanded to take additional portfolios into account. For practical reasons, an effort should be made to arrange the specifications in individual modules.
- The standardized working method of BIM will necessitate changes to contracts, business conditions and insurance solutions. Internationally, for example, the trend when introducing BIM is toward project insurance, since individual culpability will be difficult to determine and prove. DB must consider how it will deal with this topic with the involvement of the appropriate parties.
- The I Division BIM steering group has agreed on the common role descriptions and technical expertise needs that are in alignment with the definitions in Germany, Austria and Switzerland. These must be communicated and – with the involvement of HR and employee representatives – adopted in the function description and training courses.

### 4.3.4 Data and information

- For 3D models of DB-internal systems, coordinated quality specifications are mandatory.
- Across the I Division, standardized definitions of objects, object classifications and models are required to ensure the uniformity of information distributed across system limits over the medium to long term. The first pertinent basic documents on track layout and tracks are now available as part of the DACH collaboration with the Austrian Federal Railways (ÖBB) and Swiss Federal Railways (SBB).
- It must be clearly defined how a DB object library with geometry and data attributes is to be built up and maintained for use in design tools. This includes a consensus on the extent to which DB clients submit specifications on object modeling and naming practices to suppliers and demands compliance with these.
- Uniform specifications for data transfer formats must be established that meet the needs of the client and are demanded of the contractor.
- The BIM implementation must be coordinated with various relevant DB-internal areas and activities relating to data and information. These include, for example, the master data management and the resulting data strategies, Portfolio Plan 4.0 and AVANI.
4.3.5 IT infrastructure

The BIM implementation must be coordinated with the relevant DB-internal areas and activities related to the IT infrastructure. These include, for example, the IT architecture principles and further activities yet to be identified. International and national standards for data management, such as process standard DIN EN ISO 19650, should be implemented on the various CDE solutions in the Group. This makes DB as independent as possible from technology partners, and it will be possible to implement the requirements of the federal government.

It must be clearly specified how relevant data will be transferred from the various project CDEs into the DB data architecture. A wide variety of aspects must be considered, including data security in the cloud as well as the legal situation. This requires close coordination with the strategies and specifications for digitalization of the Group, both those already in existence and those still under development.

4.3.6 People and communication

The plans and measures must be continuously communicated in a coordinated manner and with a suitable form and information depth to the relevant stakeholders on the outside and to the employees on the inside.

Coordination is required with specific key partners, for example with regard to the use and advantages of BIM in asset maintenance or rail operations, to ensure that the implementation is needs-oriented.

Coordinated job descriptions, qualification plans and training programs for BIM will make it easier for employees to stand behind and support the change process.

A clear stakeholder management in which the identified target audiences are appropriately informed or integrated eases the change process for all those involved in the value chain.

4.4 General risks

In general, BIM represents a valuable opportunity for the future of DB. Effects that could hinder the introduction of BIM must be identified and controlled with suitable measures. Conversely, all opportunities that may ease or accelerate the introduction of BIM must be identified and utilized.

4.4.1 Opportunities

DB uses digitalization to make its infrastructure available to customers on a faster, more transparent and more reliable basis.

The high demands laid out in the coalition agreement and the investment ramp-up will be managed by means of digitalization.

With its successful implementation as part of the digitalization strategy, the BIM strategy will make a considerable contribution to achieving the Group goals.

The positive and active image of the most important innovation topic to arise in the construction sector in decades is appealing to young talents and motivated skilled employees.

It is now possible to become actively involved in shaping the new international standards. This will not only enable DB to establish its technological leadership in matters regarding the railroad system, but it will also permit DB to influence the suitability of future standards.

4.4.2 Risks

The current development of expertise is not taking place in time and will lead to capacity bottlenecks and delays in the BIM implementation if countermeasures are not taken. The benefits being aimed for will occur late, to a lesser degree or not at all.

An inconsistent and inadequately communicated understanding of digitalization and BIM will lead to a lack of support among managers and employees and ultimately to the wrong prioritization of activities.

Technological developments will not occur on time (cloud-based solutions, needs-oriented development of standard software).

The market will be constricted on account of missing BIM capabilities among DB contractors.

Key elements for the successful implementation of the strategy are not available on a timely basis (such as standards, standardized object models, project and cost structures).

Collaborative contractual models are not available on time and the cultural change that is intended to create an atmosphere of openness and transparency within the project is not achieved. As a result, it will not be possible to attain the anticipated increase in quality and efficiency.

Legal and security matters are not solved in a timely and generally satisfactory manner.

The lack of commitment to creating greater transparency and a collaborative partnership hinders the positive effects associated with the BIM introduction.
As with every innovative program, the question regarding its added value also comes up when introducing BIM. The added value can be seen from a variety of perspectives, which include not only the direct economic advantages in the investment or operating phase but also qualitative aspects. These include, for example, an improved quality of projects and services, a better reputation, improved work safety, sustainability and employer appeal.

The added value is measured in terms of the following target audiences and criteria:

- Beneficiaries (citizens, public sector, project owner, supply chain)
- Time (project implementation, asset operation and maintenance)
- Benefits that can and cannot be evaluated in monetary terms
- Advantages for the administration of assets and other buildings and the performance of organizational tasks
- Scaling effects in the administration of investment assets
5.1 Advantages from the perspective of DB

General advantages:
- Contribution to the acceleration of projects
- Better project quality (higher asset availability)
- Lean production enables better cost control and improves the environmental footprint of construction sites
- Transparency and collaborative project execution
- Increase in the public acceptance of projects
- Enhanced employer appeal

Advantage for DB that can be evaluated in economic terms:
- Simplified data management reduces work expenditures in the design and construction phases
- The collaborative usage of data exceeds the value of the potentially greater effort put into data maintenance in the operating phase (continuous maintenance)
- Reduction in non-conformance costs (CAPEX reduction)
- Reduction in expenditures for maintenance tasks through the use of digital models (OPEX)
- Shorter implementation times lead to reduced production costs
- Reduced production costs in the project portfolio permit the creation of additional infrastructure

The potential benefits can only be augmented overall by implementing the ramp-up in phases, which demands an extended development and change process (figs. 5–1, 5–2).

At this time, there are no international studies that adequately demonstrate the economic benefit of BIM. PwC published a document in 2018 that is one of the few approaches that discuss the topic in a structured manner. DB is striving to create and implement, in cooperation with the neighboring railroads, a joint model for demonstrating the business efficiency of BIM.

Despite the general state of findings, DB can already point to positive experiences gained with the introduction of BIM. At DB S&S, execution of the stopping point projects has become far more efficient due to semi-automatic design.

The early use of visualizations at DB Netz AG has considerably improved consensus formation and decision making.

Employer appeal has also led to positive effects at DB thanks to BIM. A trend has become visible among employees to seek jobs in BIM projects.

1 PwC UK, BIM Level 2 Benefits Measurement Application, London 2018
The business centres and service units profit primarily from the acceleration of project execution and project quality improvements.

The efficiency enhancement brought about by improved processes, the reduction in effort required for data management and when searching for current information (e.g. inventory data), and the benefits arising from the ability to create additional infrastructure have a direct, positive influence on the result of operational business units.

Individual flagship projects are decisive in forming opinions surrounding BIM benefits. Greater employer appeal and a generally improved reputation of the projects only set in if the positive effects of BIM introduction experienced in flagship projects are continuously communicated.

5.2 Advantages from the perspective of the federal government

Both as a client and funder of infrastructure maintenance and expansion, the federal government profits from the advantages of BIM. Strategy 2015 already stated that, after BIM has been fully implemented, a reduction potential of 10% of the overall costs of large-scale projects is expected on account of the effects of project acceleration and the reduction of non-conformance costs. This value is still considered to be plausible since the basic facts (4% from acceleration effects, 6% from efficiency enhancement and reduction in non-conformance costs) have not changed.

This reduction in investment costs across the entire project portfolio will make it possible to more rapidly update the aged railway infrastructure and to drive digitalization of the infrastructure forward, provided that the federal government reinvests the savings in railroad projects. This will bring about highly desirable and necessary effects with a positive impact on rail infrastructure companies, rail transport companies, and customer value.

In addition to the intended reduction in investment costs, the deployment of BIM will also simplify the processes between the federal government and DB. In particular, cooperation with EBA should become far easier through the use of BIM, among other things due to jointly used data sharing platforms and integrated workflows. This involves the following sets of issues:
- Planning authorization and planning approval procedures
- Funding
- Construction control authority
- Railroad control authority
- IT infrastructure

The effort involved in achieving the anticipated economic benefits from BIM will be a marathon rather than a 100-meter sprint.

*Heinz Ehrbar, Head of Competence Center Major Projects 4.0*

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**Figure 5-2: Benefit-complexity diagram of the BIM application**

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**Benefits for the operator**

- **Asset portfolio**
- **Integrated project portfolio**
- **Individual projects**
  - **COE**
  - **Collision check**
  - **3D design and visualization**
  - **Semi-automatic 4D design**
  - **Simulation of building processes (5D)**

**Complexity of the BIM application**

- **Design**
- **Construction**
- **Operation**

**DIGITAL TWIN**

- **Optimization of operation and maintenance**
- **Advanced condition measurement**
- **Execution as a "digital twin"**
- **Automated construction processes**
- **Model-based invitation to tender and remuneration**
- **Automated model-based quality management**

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*Source: DB AG*
5.3 Advantages for the contractors

Due to the highly fragmented supply chain of the construction sector in Germany, there is a wide range of potential improvements.

The contractors profit considerably from standardized processes and data interfaces and from coordinated, clear statements from the client. This gives them the investment security necessary for investing in licenses, training programs and acquisitions.

If the introduction of BIM leads to standard service specifications that are used consistently by all infrastructure operators, the bid costs of the contractor in the quotation phase will be lowered considerably and the quality of the performance definition will go up.

Currently, important developments are being made in building materials and robot technology. It is anticipated that automated fabrication processes will be widely introduced at DB construction sites. These will significantly contribute to a desperately needed increase in productivity in the construction sector. This will open the door to better calculation capabilities for enterprises, as well as lower-risk execution and improved opportunities for profitability.

5.4 Advantages for DB customers

The rail companies benefit from earlier and greater availability and performance of the infrastructure. Rail travelers benefit from the resulting effects regarding punctuality, availability and capacity. Reliable information from construction projects, commissioning and maintenance improve the planning reliability of customer services and enhance the information available for operation.

The greatest benefit can be derived from BIM if daily operations and maintenance and conservation measures can also benefit from the geo-referenced and quality-assured data records of the infrastructure projects. DB anticipates savings of 10% for maintenance and conservation measures, which corresponds to indicators from the international environment. The overall benefit will only be realized once the BIM application has reached the highest level of complexity involving the integration of design, construction and operation (including maintenance).

The benefit drawn from BIM cannot be distinguished from the advantages brought about by other programs such as GPEX (optimization of business processes), lean management and similar. BIM and the digitalization of the construction sector are inseparably intertwined with optimized processes. The successful introduction of BIM is a necessary prerequisite for the effects from the programs named above to take effect.

5.5 Ramp-up of the advantages

The previously described benefits can only be implemented over an extended period. Potential benefits that could be evaluated in monetary terms will be almost impossible to identify over the short-term. Any savings will be counteracted by the effects of initial investments and a learning curve. Over the medium-term, as demonstrated by evaluations in other countries and organizations, an economically verifiable benefit resulting from the overall reduction in construction costs can be expected. For the
6. Targets and time frame

Medium and long-term strategy targets are defined on the basis of the internal and external triggers for action, the determined requirements and the anticipated advantages for DB and its customers and suppliers. The public sector in particular, as the provider of the infrastructure, will also benefit from this considerably.

6.1 Vision and targets

The BIM Strategy 2019 is extending the period under review to ten years.

We anticipate that in ten years time, we will have the capability to plan, build and operate our assets on a standardized data sharing platform with better results.

As is common international practice for implementing BIM, the current implementation strategy of the stipulated vision will be based on a three-phase approach, although the three phases are not understood to be sharply delineated stages or isolated final states. The intermediate goals achieved in each phase are the requirements that must be met for the successful implementation of the next phase. In parallel, however, pilot applications of the next phase should also be run to be able to formulate the necessary "best practice" solutions. The phase model is based on a continuous and long-term implementation process.
6.2 BIM phase 1 – convergence

6.2.1 Short description

The main component of the convergence phase is the piloting of BIM for design and construction and the development of the basis necessary for the consistent introduction into the business units. The relevant basic principles are shared and harmonized throughout the I Division. At the end of the convergence phase, all business units will have reached a stage that is based on a document and file-oriented information sharing in electronic project rooms, and which takes into account the harmonization of the data management processes with national and international standards. The joint minimum standard for project execution encompasses the following five core elements described in section 4.2:

1. 3D design
2. Employers information requirements (EIR)
3. BIM execution plan (BEP)
4. Joint processes for data and document management (CDE)
5. Model-supported planning meetings in virtual data rooms (VDR)

By applying these minimum standards to new projects, the targets of the BMVI road map are met in this first stage.

Training, support and awareness creation are established for DB employees and the stakeholders of the respective supply chain. A basic communication program is required that concentrates on clear messages and focuses on a single topic, such as “Creating the basis for change”.

6.2.2 Desired results

At the end of the first BIM phase, DB is planning complex and standardizable new projects with the first, clearly defined BIM target level from the BMVI road map. Thus, the specifications of the federal government are fulfilled and the basis for a more complex performance level is established.

6.2.3 Field of application and scope

Phase 1 focuses primarily on all design phases, on selected applications from the implementation and on interfaces for information sharing with operations.
All business units and service centres participating in this BIM strategy play an active role in the development and introduction of BIM in the railway infrastructure as a client, contractor, or operator.

The networking between the RICs as clients and the following project participants is especially important:

- Planners, construction companies and specialist companies based on the project-specific circumstances
- EBA for planning authorization, funding and construction inspection
- External data owners (countries, municipalities, private persons) for the purpose of piloting

An coordination with overarching initiatives for implementing the DB digital strategy and of the master data management begins during phase 1. This includes an embedding in the Group data strategy.

The bases are primarily developed by focusing on the methodology components with the highest, directly realizable benefit to the companies, and by concentrating on the expectations of the supply chain and regulatory agency to obtain solutions that have been coordinated across the Group. For this purpose, a support organization is established that is anchored throughout the I Division and coordinates the delivery objects defined in the strategy.

The communication and change program informs employees about what added value they are set to gain from the changed working conditions. The exchange of mutual expectations and requirements between the RIC and the key partners, regulatory agencies and suppliers reduces interface losses.

In phase 1, the contractors are primarily integrated in the BIM methodology on a project-specific basis.

### 6.3 BIM phase 2 – Digital expertise

#### 6.3.1 Short description

BIM phase 2 concentrates on the accumulation of expertise and capacities within the I Division and the enhanced qualification of the supply chain for design and construction using the BIM method. The first important use cases for operating the assets are developed and piloted.

The initial "basic data management" extends phase 1 to include data management, data validation and data usage via the shared data environment. Guidance is provided by the Group-wide strategies for data quality and data governance, which are currently under development. The infrastructure projects begin delivering data in the pre-defined, structured format. Standard libraries for internal and external use, which have been agreed upon at least across the I Division, support this process. The processes for library management and quality control have been defined and established. The data will be successively expanded to include geo-referencing.

In addition to the technological prerequisites, the contractual prerequisites are also described with the aim of promoting a collaborative project execution. The institutional prerequisites for a cooperative project execution are established on the basis of contractual models that have been reformulated and adapted together with our contractors. This generates transparency, accelerated processes, higher quality and lower life cycle costs.

Via the internally and externally communicated goals and core messages in phase 2, DB has established itself as an attractive employer and a client with high digital expertise. A regular exchange takes place with regulators and regulatory agencies, and a basic concept exists.

In the next development stage of our procurement strategy, the data that is accumulated during design and construction is defined as an integral component of the projects. Through continuous data procurement and maintenance, it will not only be possible to create the physical structure itself, but also to simulate its digital twin. In the future, a considerably higher data quality will be required from the supply chain, such as the completeness of metadata, adherence to modeling requirements and geo-referencing. The requirements must be clear and market-oriented.

**Common Data Environment (CDE)**

![Common Data Environment (CDE)](image)

**Fig. 6–2: Workflow on the basis of DIN EN ISO 19650**
6.3.2 Desired results

The most important result of phase 2 is the capability of transitioning from files such as drawings, models and documents to a fundamentally data-centric approach for BIM-based project information. In a subsequent step, this can be integrated in an asset database. The goal is the successive creation of geo-referenced databases taking into account the network topology with project data of a wide variety and from different data sources (visualizations, sensors, documents, drawings, schedules and telemetric data). These are administrated via the CDE.

During phase 2, data and information from far more than 1,000 BIM projects will be made accessible. This data will be integrated in the master data management process to establish the prerequisites for the digital twin of the asset portfolio. Thus, even in their digital form, projects are to be administrated and localized as part of the network and not as isolated components.

As was already the case in phase 1, the communication and change program informs employees about what additional added value they are set to gain for their area of responsibility and from the changed working conditions. The continued sharing of mutual expectations and requirements between the RIC and the key partners, regulatory agencies and suppliers reduces interface losses.

A comprehensive CDE infrastructure will ensure that data can continue to be shared between the actors in a secure and standardized process using open, defined interfaces. Consistent specifications for the structure of these files enables the extraction of value-creating data from the files via CDE. Current, relevant and comprehensive information is available to the infrastructure projects and to operations, and can be used everywhere with mobile terminals. Data from the CDE infrastructure can be made available in a targeted and controlled manner, for example for further project analytics or risk assessment. External data and suppliers (such as a soil database, GIS) are included on a systematized basis.

6.3.3 Field of application and scope

At the end of phase 2, all nine, repeatable and complex projects of the infrastructure project portfolio are planned and implemented using the BIM method. Applications for service and maintenance in the asset portfolio are designed and piloted in a future-oriented, targeted and coordinated manner.

In phase 2, the entire supply chain for the design and construction service phases is fully integrated in the BIM methodology. This demands close cooperation between the federal government, planners, construction sector and their organizations and associations.

The focus of the I Division business units and service centres is on the expansion and maintenance of comprehensive technical expertise in the individual organizations.

6.4 BIM phase 3 – Digital transformation

6.4.1 Short description

In BIM phase 3, the assets are fully planned, built and operated using BIM – digitally and collaboratively. Work on the digital model is embedded in a digital ecosystem that enables the exchange with processes (for example, EBA approval and release processes) and data sources of third parties (for example, federal government GIS data for soil properties) via a wide variety of interfaces.

The limitations arising during file-based work when jointly using complex BIM data are absent in phase 3 thanks to the centrally administrated and jointly used data structures. Apart from the technical reasons and benefits (e.g. during the management of project portfolios and in asset management), substantial economic advantages also speak in favor of this step. The simplified data management leads to savings in hardware and software. Data and information are increasingly decoupled from the documents and are made available as flexibly usable, semantic information.

Via the mutually coordinated processes, technologies and services, BIM users obtain far more flexible and qualitatively enhanced access to technical data. Data access control, security, reliability and quality and the data structures are administrated according to uniform rules. All relevant data is geo-referenced. Methods for the shared use of data for asset design, construction and operation are established. The intelligent information link (linked data) will play a major role in this phase.

Artificial intelligence supports those involved in rapidly and efficiently interpreting the existing data and information.
Significant changes in the relationships between customers, clients and contractors will be brought about to further improve the business performance and results. These changes will be closely coordinated with the key partners and will take into account mutual interests.

6.4.2 Desired results

In phase 3, an integral digital twin of the entire physical network and asset inventory is successively established from data that previously existed in a heterogeneous form in numerous isolated systems. The digital twin forms a unified basis for the design, implementation, operation, conservation and further development of the physical infrastructure. The design costs of infrastructure projects can be reduced due to the availability of reliable data from the asset portfolio, and the design times can be shortened thanks to the high online availability of the full range of relevant data. The specification of the operational requirements for the new projects can be coherently derived from the database of the operator. The activities of DB employees are supported and simplified during design, construction, operation and maintenance throughout the lifespan of an asset. The acquisition of information in all processes should be quick, reliable and of high quality. Working on and with the assets of DB is to become simpler and more efficient.

Real-time data delivers reliable information on the state of the infrastructure network and the rolling stock. In this context, artificial intelligence supports those involved in rapidly and efficiently interpreting the existing data and information in order to attain a new, improved quality level in project processing and asset management.

6.4.3 Field of application and scope

Phase 3 encompasses the entire project portfolio for design and construction, and the controlled transition and further processing of (project) information to the asset portfolio for the purpose of service and maintenance. Interfaces must be established for using the asset data in rail operations and for DB services.

The focus of the I Division in this phase is on creating the capabilities necessary for integral, digital design, construction and operation of the asset portfolio, for which each business unit and service centre makes its own specific contribution in the integrated system.

It is assumed that the market of designers and constructors will be fully BIM-capable in this phase. Partnerships with external data owners and suppliers (for example, soil data, environmental databases, line GIS) will already have been established at many locations and will be supplemented as needed with new, innovative offers.

A shared CDE is the central platform via which all those involved in the project, including the later operator of the asset, can access all relevant data and information on a needs-oriented basis.
7. Action fields and measures

The measures are implemented in the structure of the established action fields and as a continuation of BIM Strategy 2015 (fig. 7–1). The presented phases 1 to 3 govern the time-based prioritization of the measures. The activities are described from phase 1 to phase 3 in order of decreasing detail.

7.1 Strategic and organizational measures

The speed, scope and complexity of the changes brought about by BIM and digitalization demand continuous leadership and support to ensure strategic decisions and coordination of individual strategies at the Group level.

7.1.1 Action field strategy across all phases

This document defines the guidelines for the introduction of BIM in the I Division over the next ten years. The following overarching measures are necessary:

1. Initiating and putting into practice of the cultural change, among other things through the collaborative cooperation in projects, role-modeling by management and build-up of expertise among employees
2. Support of the development of open, internationally standardized systems (no solitary DB solutions)
3. SME-friendly supplier development with regard to BIM capacity and BIM expertise
4. Assurance of the ability to allocate all deployed federal resources to BIM
5. Intensive cooperation with the authorizing and regulatory agencies (EBA) to incorporate the mutual understanding of information requirements into the change process
7.1.2 Operative and coordinated activities across all phases

The specified strategic measures and the subsequently listed recommendations for action in part encompass highly complex and long-term projects. They require the incorporation of central Group divisions such as DB Training and the CIO division. To ensure that the intended synergy effects can be achieved by means of coordinated overall solutions, internal and external resources are needed in addition to project and portfolio management.

Coordination within DB will be required for the following topics:

- Organization of the sharing among business units of the contents of the respective BIM implementation specifications at the project management and sub-project levels
- Conception and implementation of a unified BIM quality and risk assessment for I Division-wide topics and concerns
- Promotion of BIM industry standards and open IT solutions and quality assurance processes (for example, loss-free data sharing)
- Overarching representation of business units in front of the following institutions regarding the topic of technical BIM implementation:
  - Federal Ministry of Transport and Digital Infrastructure (BMVI)
  - Germany Federal Railway Authority (EBA)
  - Further authorizing agencies (for example, ERA and other national hearing agencies)
  - Design associations (for example, VDI and VBI)
  - Business associations of the construction trade (for example, HDB, BVMB and VDB)
  - Universities (for example, Bochum, München, Darmstadt and Gießen)
  - Norming and standardization committees (for example, VDI, DIN, ISO, CEN and bSI)
  - Neighboring railways (for example, SNCF, SBB, ÖBB and Network Rail)
  - Further infrastructure operators (for example DEGES and Airports Association)
- Close cooperation with authorizing and regulatory agencies (for example, implementation of BIM methodology with the EBA with regard to the issues relating to planning authorization procedures)

- Unified standards in the context of the cultural change:
  - Collaborative project execution and cooperation
  - Agreed-upon contents for management communication
  - Expertise build-up among DB managers in the context of existing containers and structures
  - Expertise build-up among DB employees through coordination of training programs of companies and the adoption of "informal" BIM training contents
- Promotion of collaborative contractual models in close cooperation with the relevant DB departments (for example, purchasing and legal affairs) as well as business associations
- Coordination of agreed-upon external appearances at conferences and trade shows
- Responsibility for the creation, update and implementation of the I Division-wide BIM strategy

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7.2 BIM applications

The "BIM applications" action field deals with the testing, piloting and training of new or changed working methods in projects and the insights gained here for the organization. This also encompasses the standards that are derived from this and the support of the build-up of knowledge and expertise in all companies through the sharing of experiences. This action field ensures the innovative capacity of the organization and avoids overtaxing of employees, thinning out of the supply chain and failure to tap into synergy potentials due to poor coordination.
The recommendations for action in the BIM applications area are summarized below and are evaluated at regular intervals:

- Development of an I Division-wide methodology for recording and qualitatively assessing BIM activities, including standardized reporting
- Development of further joint minimum BIM standards (BIM phase 2)
- Establishment of a continuous sharing of insights from BIM applications and conclusions drawn from adaptations and further developments
- Development of guidelines and training material for users
- Focusing on value-creating activities for the contractor: for example, simple procedures for 3D modeling, model-based scheduling, improvement of design quality, for example by means of collision tests and simple procedures for determining quantities from 3D models and model-based invitations to tender, implementation and invoicing.

7.3 Processes and guidelines

7.3.1 Processes and guidelines, phase 1

A comprehensive set of procedures exist for the entire I Division. To achieve a uniform approach throughout the organization and to establish the prerequisites for further process development in phases 2 and 3, targeted and appropriate adaptations must be made. If necessary, appropriate processes and guidelines must be formulated.

The focus is on all processes that relate to data and information (creation, procurement, administration and use) and on collaboration within the project.

Recommendations for action, phase 1 (already partially in progress):

- Checking and, if necessary, adapting the DB guidelines and processes in accordance with DIN EN ISO 19650 for a uniform data and information management

New-build line (NBS) between Offenburg and Riegel PFA 7.2: Taking into account of floodwaters (HQ100) when planning the new-build line. The visualization was implemented in 360° as an interactive model and is VR-capable.
Preparation of standard documents and agreement with design and construction associations

Harmonization of the designation and description of BIM roles and integration in the DB processes

Supplementation of standard scopes of work and tender documents according to the EIR, development of templates and methodological manuals

Development of new formats for insurances, contracts and other framework conditions that are geared toward a collaborative working method

Active participation in the formulation of new national and international norms and standards (for example, data exchange formats, processes and security)

Coordination of qualitative BIM award criteria

Agreement with authorizing agencies (primarily with the Federal Railway Authority) and regulators on the adaptation of information formats and contents as well as future processes

7.3.2 Processes and guidelines, phases 2 and 3

Coordination of a purchasing and supplier strategy in terms of the creation of incentives for BIM application and the support of key partners and suppliers (for example, the provision of software and licenses)

Implementation and continuous improvement of contracts, insurance solutions and other framework conditions that are geared toward a collaborative working method

Continuation of the national and international committee work

7.4 Data and information

The development of recommended measures for data and information is comprehensive and complex. Digital design, construction and operation must be linked within the overarching developments for Group digitalization. This calls for a tight-knit exchange with the responsible parties at the Group level. An intensified intermeshing with other DB strategies may be necessary.

7.4.1 Data and information, phase 1

Establishment of a method for the procurement and provision of information by the client organization to achieve the project objectives. This includes: scope, short description, level of detailing, interfaces and program (timeline), key file allocation including file name, status, owner, classification and more.

Focus on attributable 3D geometries; object reference only in cases in which the prerequisites for this exist (use of object catalogs)

Coordinated development of specifications for object or data models to avoid duplicates and contradictions

Decision regarding a basic I Division administration function of the standard library for the internal and external use of existing BIM objects; development of these if necessary

The I Division must coordinate the following tasks during phase 1 due to their long development period:

Integration of geo-referencing in the data requirements and database

Acquisition and homogenization of object classifications including the definition of component and object library methods, linking with geographical information systems and their object classification (AVANI) and with the "Portfolio Plan 4.0" project

Taking into account of the development of open, broadly coordinated file formats, data structures, classification and validation methods; no DB island solutions

Definition of framework conditions for administrating standard and object libraries

7.4.2 Data and information, phases 2 and 3

In phase 2, the development and application focus shifts from the setup and definition phase (phase 1) to the establishment of prerequisites for an integral interoperability.

This refers to the development of an integrated data architecture:

Continued development of data management and integration methods and of data structures for the purpose of transitioning to a data-centric service

The data exchange between the involved parties becomes increasingly integrated and develops from a file-based information exchange (phases 1 and 2) to a data-centric one (phase 3).
7.5 IT infrastructure

The evolution toward a data-centric information exchange places high demands on the IT infrastructure. It must simultaneously ensure the provision, access and security of data at all times. The generally applicable IT architecture principles in the DB Group apply to the BIM strategy in all phases. The goal is to ensure the efficiency, flexibility and interoperability of the IT infrastructure.

7.5.1 IT infrastructure, phase 1

A central task in phase 1 is the provision of appropriate technologies for the creation, administration and use of data in the CDE. Phase 1 serves as a test phase of various providers, technologies and configurations. The running procurement process and currently deployed systems are checked and evaluated on the basis of specified criteria.

Concrete measures of the overarching coordination in phase 1:

- Coordination with relevant running activities (for example, IT architecture principles, cloud strategy and portfolio strategy)
- Procurement of IT infrastructure as a service from the cloud or for the cloud
- Support of cloud-based solutions (coordination of the evaluation of cloud solutions, coordination of the structural marginal conditions such as IT security and data privacy, increase in potentials through cloud operation)
- Identification and provision of suitable IT infrastructure for the specified applications
- Handover of relevant project information and data after completion of the project to operations, and digital archiving of information according to legal requirements
- Development of a standard set of configuration data to automate repetitive tasks and ensure an appropriate and consistent quality level

7.5.2 IT infrastructure, phases 2 and 3

The demands placed on the IT infrastructure will continue to rise due to the increasing data volume and heterogeneity of the data structures and formats. If the IT architecture principles that apply in the Group are applied without limitations, the IT infrastructure must be able to absorb the rising demands.

Relevant aspects in phases 2 and 3 that affect the IT infrastructure:

- Integration of geo-referencing
- Development of a multi-project CDE solution on the basis of the existing CDE along with the simultaneous assurance of data access rights and security requirements of the client administration
- Administration of multi-data type data records across the entire CDE, including the administration of CAD drawings, specifications and documents
- Creation of possibilities for simulation and analysis, including of real-time data
- Drafting and usage of procedures for standardized interfaces for project control, operator software, for timetable and information services and ERP systems with automated file validation and testing processes
- Continued development of the system architecture for the complete implementation of standardized interfaces between infrastructure projects and data in the operating and administration systems on the basis of an integrative data architecture that is developed in parallel

The strategies and activities that apply for the design of the IT (infrastructure, data and information) must be examined and evaluated with regard to their relevance and effectiveness. In light of the high innovation speeds, the alignment with a concrete technology becomes less important. Rather, it must be ensured that the right requirements are described and coordinated while remaining open to different solutions. If the various technological and procedural solutions (for example, cloud, API-First and Blockchain) are well-coordinated, the IT structure will become efficient, flexible and interoperable.

The Fehmarnsundcrossing is one of our pilot projects. Planning variants for a new bridge over the sound are being developed.
7.6 People

In addition to new tools, working with BIM primarily brings with it new modes of operation, processes and methods. This particularly applies to the intensified cooperation between the involved parties. Processes that already exist must be questioned and new technologies must be added. The working culture must evolve toward an open no-blame culture to create the necessary space for continuous improvement. This can only be achieved by adequately enhancing employee capabilities and with the structured support of the transition by the employee representatives at DB.

Every employee is called upon to understand and support the changes. However, without the management's commitment to and backing of this transition with open communication and active support, the cultural change as a prerequisite for the cooperative project execution on the basis of shared digital platforms will not succeed.

7.6.1 People, phase 1

The central activities in phase 1 serve to "pick up" and "enable" employees with regard to the topics of BIM and digitalization. To this end, the added value created by BIM in a person's own daily work must be recognizable and should be experienced fairly rapidly. At the same time, existing uncertainties and misunderstandings should be eliminated quickly, for example by actively involving employees in the development process.

All (project) participants should be advised that there is no alternative to a transition to a modern and solution-oriented working method if the quality and productivity of infrastructure projects are to undergo lasting improvement.

Especially managers should be enabled during this phase to provide clarity and transparency in the application of BIM and in the impending development process for their respective area of responsibility and for all those involved in the project and process.

Many measures are already being implemented in the business units of the I Division. For the overarching level, the following recommendations for action exist that can be implemented by drawing on relevant offers such as DB Training or corporate communications:

- Information and awareness campaigns on the topic of BIM for all employees through the existing communication channels (for example, DB Planet, newsletters and DB Welt)
- Assistance from DB Training with the coordination of training programs and content, adapted to the changed and newly developed roles and job descriptions; employee capabilities must be enhanced by expanding the currently available training offers. The core messages of the basic training should be standardized across the I Division.

In addition, it must be ensured that the information and training campaigns of the business units are properly coordinated in terms of content, that they are appropriately structured for the respective target audience and that their quality is assured.

7.6.2 People, phases 2 and 3

In phase 2, the focus is on the large-scale build-up and enabling of employees and on supporting the supply chain with the parallel implementation of measures, for example by way of a joint BIM academy. In addition, all activities from phase 1 with adapted content must continue to be offered.

As BIM becomes increasingly integrated in daily operations, the motivation and enthusiasm for working with BIM should be retained as a consequence of continuous innovations and tangible target-group-oriented improvements in the employees’ daily work.

The working culture must evolve toward an open no-blame culture to create the necessary space for continuous improvement.
7.7 Indicative implementation

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<td>Development of standards for an object library with neighboring railroads</td>
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<td>Concept development of a standardized data architecture</td>
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<td><strong>IT infrastructure</strong></td>
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<td>Provision of CDE solutions for infrastructure projects</td>
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<td>Development of a multi-project CDE solution</td>
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<td>Development of standardized interfaces for the CDE solution</td>
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<td>Implementation of standardized interfaces</td>
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<td>Continued development of an integrative system architecture</td>
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<td><strong>People and communication</strong></td>
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<td>Development of a communication plan</td>
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<td>Development of a change strategy</td>
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<td>Setup of an I Division-wide information platform</td>
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<tr>
<td>Setup of the BIM academy</td>
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<tr>
<td>Coordinated development activities</td>
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<tr>
<td>Communication of the core messages</td>
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<td>Training courses</td>
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7.8 Implementation control

This strategy describes the next target status at the I Division level for the individual action fields at the end of 2025. To achieve a coordinated introduction of BIM, measurable intermediate targets are required along with an implementation control. Measurement variables and evaluation standards still need to be developed.

The measurement system for determining the maturity level of the BIM implementation, which has proven effective and has already been introduced consistently across DB (based on the Penn State University Model) will be retained in phase 2 "Digital expertise".
The individual companies define their specific goals, taking the I Division framework into account, and share these with other companies. The action fields are retained without modification. The results of the DB Group companies are consolidated at the I Division level in the usual, effective way.
Digital technologies and 3D models are tools to achieving the intended general improvements in the construction value chain. Without a cultural change practiced by all users, the tools will not be able to deliver its expected potential. For this reason, other countries and organizations primarily concern themselves with the topic of improved collaboration (partnering, alliancing, etc.) and derive the requirements for the digital tools from that.

The final report of the “Construction of Major Projects Reform Commission” addresses this topic and for this reason demands the introduction of a collaborative project partnership in parallel to the digitalization. The goal is more transparency, a solution-oriented no-blame culture and overall more togetherness than opposition.

BIM offers the tools for more transparency and an earlier detection of non-conformance. The cultural change, however, can only be accomplished by involving all project participants and by continuously practicing the new values in the projects as a role model. As the largest infrastructure employer in Germany, DB plays a key role in this. All stakeholders in this realm must be included: federal ministries and EBA, associations and individual companies, as well as the companies’ own employees and managers.
8.1 Core messages

The core messages make clear why DB has decided for BIM, its understanding of BIM, and how it plans to introduce BIM in the market and to implement the life cycle concept. It is important that the core messages are supported from the top down, to take on the role of a role model and convey credibility. The core messages are suitable for internal and external communication.

**DB uses digitalization to make its infrastructure available to customers on a faster, more transparent and more reliable basis.**

- DB improves the adherence to deadlines and costs as well as the project quality. DB makes important information available in an innovative manner using standardized tools and thus increases the acceptance of design and construction projects.
- DB utilizes digitalization to implement the planned investment ramp-up in the infrastructure on a timely basis.

**The BIM methodology has an impact along the entire supply chain.**

- The BIM methodology is introduced collaboratively, in line with market requirements and phase-by-phase.

**DB will apply the BIM methodology to the entire life cycle of the infrastructure assets in the future.**

- During design and construction, DB generates the data for the operation and maintenance of the infrastructure assets.

**BIM is a structured, cooperative working methodology. The guiding concept is a strong, internally and externally intermeshed partnership. This requires a cultural change toward openness, transparency and a constructive no-blame atmosphere.**

- The BIM methodology puts people at the center – the technology is a supportive tool.
- The managers shape the required cultural and technical environment for the application of the BIM methodology.
- The bases for collaborative working are digital models that ensure a shared database and agreed-upon information flows.

**Better design, construction and operation of assets – design, construction and operation of better assets!**

Scherkondevalley Bridge, VDE 8
8.2 Change concept

To be able to implement the intended changes successfully, the following aspects are of central importance:

- **Ability (enabling):** All people involved in the impending transition obtain the knowledge and capabilities they require to use the BIM method in appropriate stages. For this purpose, internal tools such as structures, processes, specifications, hardware and attractive software solutions must be made available.

- **Willingness (conviction, vision and motivation):** Everyone understands why the change is needed. They are in agreement with the transition and consider it to be worthwhile.

- **Commitment (pressure to act):** The overarching relationships and the necessity for the impending transition are recognized.

- **Permission (role models):** Managers, colleagues, business partners and other actors are also in agreement with the transition and act accordingly.

To enable all project partners, a software policy must be instated and training programs set up that have a positive impact on the market. Following a generally applicable, central training block (e.g. in the "BIM academy"), it should subsequently be possible to do training on further subjects. The regional BIM labs are used for this.

Within the DB organization, many instances of interest in BIM can already be found – among personnel that have already been active in the first BIM projects or employees with personal interest. The enthusiasm of these people should be maintained and promoted by specifically deploying them in BIM projects and creating positive experiences. Widespread BIM capabilities of employees should be enhanced by means of training and continued education programs that are coordinated throughout the I Division.

The clear political statements of intent by the federal government to strongly promote BIM via the road map and the coalition agreement create a stable foundation.

It now needs to be ensured that all DB managers unequivocally stand behind and support the implementation goal. The bottom-up approach alone from the BIM applications is insufficient to accomplish the cultural change and thus to establish the prerequisite for a successful introduction of BIM. Managers must be addressed by providing them with pertinent information and communication and must be enabled to create their own communication so that the "permission" aspect of the change strategy is clearly heard by employees. This calls for appropriate communication and training solutions.

8.3 Stakeholder engagement

DB is perceived nationally and internationally as a leader in the introduction of BIM. If DB is a welcome partner, this can further ease the deployment of BIM.

DB imparts its knowledge at conferences, in the press and on websites at the national and international level. The key messages are coordinated internally in the I Division to ensure a unified external presence.

The development of the introduction of BIM at DB is embedded in the national and international development. Institutionalized contacts are already in existence to many relevant organizations, while others still need to be established and equipped with the necessary resources.

DB decided in 2015 to drive the introduction of BIM forward in cooperation with key partners. These include the federal government and the BMVI, the authorization agencies and regulators (for example EBA), planners and planning associations (VDI and VBI), businesses and business associations (HDB, VDMB, VDB), neighboring railways (SNCF, SBB, ÖBB), the academic landscape of various universities, and the norms and standards committees (bSI, ISO, CEN, DIN, VDI).

DB has set itself the goal of backing the impending changes and the digitalization of the construction sector with supportive measures. A thinning of the supply chain due to excessively stringent requirements should be avoided at all times. On the basis of the phased ramp-up, the present strategy dictates a rate of change that is suitably aligned with the expertise and capacities available in the value chain. The dialog with the key partners (construction and planning associations, software manufacturers, neighboring railways) will be specifically intensified with regard to the development and application of market-ready standards. Thanks to the alignment of the strategic considerations with neighboring railroads, market participants have an additional incentive to become involved in this development.
The creation of a central DB BIM academy has the potential of considerably easing communication with the supply chain as well as with policy makers. The establishment of this type of institute in Berlin must be examined in collaboration with the key partners.

Example of modern BIM lab in Karlsruhe

VR cave

Collaborative "ideas space"

Interactive meeting room
# Appendices

## A–1. Glossary

<table>
<thead>
<tr>
<th>Term</th>
<th>Definition</th>
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</thead>
<tbody>
<tr>
<td>3D model</td>
<td>Usually an object-based, three-dimensional and digital representation of the geometric properties of a building or asset</td>
</tr>
<tr>
<td>4D model</td>
<td>Extended 3D model in which the model elements are associated with the events of a timeline. A 4D model can be used to simulate the creation of a building over time.</td>
</tr>
<tr>
<td>5D model</td>
<td>Building model whose linked model elements or structures can be used to determine quantities that can then be linked to cost data</td>
</tr>
<tr>
<td>Assigning attributes</td>
<td>Provision of model elements with further information in the form of a name and an associated value</td>
</tr>
<tr>
<td>Employers Information Requirements (EIR)</td>
<td>Specification of the data and information required by an orderer from its suppliers in the course of a request for quote or award</td>
</tr>
<tr>
<td>Asset Information Model (AIM)</td>
<td>Digital model that contains all data and information for the administration, maintenance and operation of an asset</td>
</tr>
<tr>
<td>API – Application Programming Interface</td>
<td>Programming interface/application interface for the programming of applications</td>
</tr>
<tr>
<td>AVANI</td>
<td>Analysis, administration and provision of DB Netz geo-information</td>
</tr>
<tr>
<td>Component</td>
<td>An object that is delimited by its functional unit. Components have attributes such as material and surface finish. An attribute unambiguously defines this component.</td>
</tr>
<tr>
<td>(BIM) Use</td>
<td>The purpose for which the data and information case from the digital model of a building is created and used</td>
</tr>
<tr>
<td>BIM execution plan (BEP)</td>
<td>A document that strategically describes the BIM-based partnership in the project. It defines goals, organizational structures and responsibilities, establishes the framework for BIM performance and defines the processes and the exchange requirements of the individual participants.</td>
</tr>
<tr>
<td>Blockchain</td>
<td>Continuously expandable list of data records, so-called “blocks”, that are linked to each other by means of cryptographic methods. Each block typically contains a cryptographically secure hash (dispersion value) of the preceding block, a time stamp and a transaction date.</td>
</tr>
<tr>
<td>BMVI</td>
<td>German Federal Ministry of Transport and Digital Infrastructure</td>
</tr>
<tr>
<td>BVMB</td>
<td>Federal Association of Small and Medium Sized Construction Companies</td>
</tr>
<tr>
<td>Building Information Modeling (BIM)</td>
<td>Cooperative working methodology with which, on the basis of the digital models of a building, the information and data relevant to the building's life cycle are consistently recorded, administrated and, by means of transparent communication between the participants, either exchanged or transferred for further processing</td>
</tr>
<tr>
<td>Common Data Environment (CDE)</td>
<td>Shared data environment that primarily describes the process of secure and standardized data management. A special CDE software (or data room or project communication platform) can be used to access centrally managed data.</td>
</tr>
<tr>
<td>DACH</td>
<td>Collaboration platform of Federal railways of Germany, Austria and Switzerland</td>
</tr>
<tr>
<td>Data-based sharing</td>
<td>Information sharing between networked data sources</td>
</tr>
<tr>
<td>DEGES</td>
<td>German Unity Long Distance Road Planning and Construction Company</td>
</tr>
<tr>
<td>Digital twin</td>
<td>Digital representation of actually existing (or planned) assets, other buildings or rooms</td>
</tr>
<tr>
<td>EBA</td>
<td>German Federal Railway Authority</td>
</tr>
<tr>
<td>ERP system – Enterprise Resource Planning System</td>
<td>Application(s) or IT systems that are deployed to support the resource planning of the overall enterprise</td>
</tr>
<tr>
<td>File-based sharing</td>
<td>Information sharing between applications in processes to be defined and on the basis of files</td>
</tr>
<tr>
<td>Industry Foundation Classes (IFC)</td>
<td>Manufacturer-independent and open data model that can be used to document and model-based data and information in all planning, execution and management phases. buildingSMART International is an international non-governmental, non-profit organization. It defines the Industry Foundation Classes exchange format for the exchange of BIM data in the construction sector. IFC is registered under ISO 16739 as an international standard.</td>
</tr>
<tr>
<td>Industry Foundation Classes (IFC)</td>
<td>Master data management, which encompasses all strategic, organizational, methodological and technological activities that relate to the master data of an enterprise</td>
</tr>
<tr>
<td>HDB</td>
<td>Main Association of German Construction Industry</td>
</tr>
<tr>
<td>Industry Foundation Classes (IFC)</td>
<td>Manufacturer-independent and open data model that can be used to document and model-based data and information in all planning, execution and management phases. buildingSMART International is an international non-governmental, non-profit organization. It defines the Industry Foundation Classes exchange format for the exchange of BIM data in the construction sector. IFC is registered under ISO 16739 as an international standard.</td>
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<tr>
<td>Industry Foundation Classes (IFC)</td>
<td>Object library</td>
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<td>SME</td>
<td>Small and Mid-sized Enterprise</td>
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<td>VBI</td>
<td>Association of Consulting Engineers</td>
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<td>VDI</td>
<td>Association of German Engineers</td>
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<tr>
<td>VDB</td>
<td>Association of the Railway Industry</td>
</tr>
<tr>
<td>I Division</td>
<td>Infrastructure Division of Deutsche Bahn AG</td>
</tr>
<tr>
<td>RIC</td>
<td>Rail Infrastructure Companies</td>
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</table>
The introduction of BIM at DB already began at DB Station&Service AG in 2012. DB S&S has been design all new projects using BIM since January 1, 2017. DB Netz AG, DB Energie GmbH and DB Engineering & Consulting GmbH with their separate roles followed suit in 2015.

The variance analysis shows that the BIM introduction achieves the planned values, within the margins of forecast accuracy, both in terms of numbers and with regard to the financial volume.

Ramp-up is updated promptly.

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**A-2. Ramp-up of BIM projects since 2015 in numbers**

The introduction of BIM at DB already began at DB Station&Service AG in 2012. DB S&S has been design all new projects using BIM since January 1, 2017. DB Netz AG, DB Energie GmbH and DB Engineering & Consulting GmbH with their separate roles followed suit in 2015.

The variance analysis shows that the BIM introduction achieves the planned values, within the margins of forecast accuracy, both in terms of numbers and with regard to the financial volume.

Ramp-up is updated promptly.

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**Number of projects**

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**Volume of pilot projects (in million EUR)**

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Figure 9–1: I Division ramp-up design up until 2020

Source: I Division BIM Implementation Strategy

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**DB Netze Fahrweg major projects**

- **DB Netz Stations**
- **DB Netz Energy**
A-3. Ramp-up quality – maturity level measurement of business units

Consolidated maturity level at the I Division level

The computational consolidated maturity level at the I Division level is determined according to the following key: 50% DB Netz AG, 25% DB Station&Service AG and 25% DB Engineering & Consulting GmbH. DB Energie GmbH is currently not included in this measurement system because of its relatively small project volume. A need for action beyond 2020 cannot be derived from the current monitoring system. To be able to answer questions that extend beyond 2020, a more in-depth analysis is needed in addition to the previously described standardized monitoring of the current state. The largest deficits are currently being exhibited by the following action fields: BIM application, processes and standards, and information and data.

DB Netz AG

While the individual pilot plans of the large-scale projects department and the plans and initial projects of the production department already began in 2016, the central implementation project of DB Netz AG was not initiated until the middle of 2017. This led to processing backups in individual action fields. For this reason, there is an increased need for action in all action fields.
DB Station&Service AG

DB Station&Service AG already completed piloting in late 2016 and has been regularly employing BIM methodology for target level 1 as per the road map since January 1, 2017, for projects with low to medium-level complexity. The market responded positively to this development. The activities associated with the capacity expansion of this first target state are taking place alongside deliberations regarding the piloting of applications with a closer focus on asset operations.

- Due to the high diversity of the project portfolio, a clustering procedure is performed early on to examine the use of BIM methodology:
- Complex (large) projects (new building or comprehensive conversion of station buildings or large stations)
- Largely standardized new buildings and conversions at small and medium-sized stations

DB Engineering & Consulting GmbH

In May 2016, DB Engineering & Consulting GmbH started an internal BIM implementation and began the strategic introduction of BIM. In 2016 and 2017, the activities focused on the creation of basic foundations and capacities for the selected digital applications and processes. For this purpose, five concrete activities were identified in the BIM context (EIR review, BEP creation, 3D modeling, use of a CDE and performance of virtual design reviews), and work focused consistently on their wide-scale implementation.

Especially the 3D modeling of the electromechanical equipment is in need of further development effort with respect to the employed IT tools and their integration in the BIM production process without media discontinuity.