Research on Application of BIM 5D in Communication of Project Muti-participants—A Case Study of Nagpur Metro Project

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Abstract. At present, our country's infrastructure projects are in a period of rapid development of investment and construction, and they play a vital role in maintaining social production and social harmony. The concept of Building Information Modeling is used to solve the communication problems of various participants in construction projects. It is increasingly being paid attention to and applied by various departments and majors of the construction industry, as well as domestic and foreign research scholars, especially infrastructure projects with complex structures and numerous stakeholders. For the Nagpur Metro Rail Project, an analysis of the relationship between the various stakeholders involved in this infrastructure project and the benefits and challenges of adopting a digital management platform.

1. Background

Infrastructure projects have complex structures, large investments, long lead times, and involve complex and diverse stakeholders, and from the start of the project, infrastructure projects involve a large amount of information about funding and personnel. In the whole life cycle of infrastructure projects, many stakeholders are involved, and they communicate and exchange information around infrastructure projects to meet the coordination and cooperation among themselves. However, infrastructure projects currently suffer from poor communication channels, inadequate communication methods and blocked communication processes.

BIM is a trend in the construction industry where different stakeholders work together to support and reflect their respective responsibilities by inserting, extracting, updating and modifying information in BIM at different stages of a project. A lot of research has been done at home and abroad on the application of BIM technology to construction projects in areas such as communication, collaborative work, and information sharing. However, the research on the application of BIM technology to solve communication problems in infrastructure projects is still relatively less, and therefore, further research on the application of BIM technology in infrastructure is needed.
In this paper, the Nagpur Metro Rail Infrastructure Project is studied based on Mitchell's three-category scoring system to identify the key stakeholders of the project in terms of power, legitimacy and urgency, and to understand the roles of different stakeholders on the 5D BIM platform, the processes involved in 5D BIM, the benefits achieved by analysing each stakeholder in these processes, and the challenges faced by them through the creation of an integrated digital management platform in India and Asia.

2. Method

Figure 1. Technology road-map.

3. Case study and analysis

3.1. Project Overview
The second largest capital of the Indian state of Maharashtra and the third largest city in India, Nagpur
is the rail and road transport hub that connects all the major cities of India, where the zero kilometre of Indian transport begins. In the past, only 10% of Nagpur's citizens used the public transport system and 80% of trips were made by two-wheeled transport. In order to alleviate the travel pressure and other traffic problems in Nagpur, the Central Government of India and the Government of Maharashtra have invested in the Nagpur Metro Rail Corporation Limited (NMRCL), which is responsible for the construction and subsequent operation of the metro. The Nagpur Metro Rail Project is a 38.215 km long project with 36 stations on an elevated basis. The total outlay for the project is estimated at Rs. 8,680 crores, with the Central and State Governments contributing 20% each in the form of equity and subordinated debt, the Municipal Corporation of Nagpur and the Nagpur Trust contributing 5% each and the remaining 50% being financed by loans from the German state-owned development bank KFW and AFD of France. In order to ensure synergy among the various departments involved in the project for smooth operation and maintenance, the Nagpur Metro Rail Project is determined to adopt an innovative solution - digital project management centred on RIB's iTWO.

3.2. Identifying of primary stakeholders
In order to better analyse the benefits brought by the digital management platform, it is necessary to clearly delineate its stakeholders. In this paper, Mitchell's three-category scoring system is used to score stakeholders in terms of power, legitimacy and urgency, using a 5-point Likert scale (1-5 points, respectively, very poor, relatively poor, fair, relatively good and very good), and finally, statistical analysis of the scoring situation is carried out to determine the scope of attribution of a stakeholder according to the results of statistical analysis.

The data collection and analysis of the contractual relationship for this project is an SPV model, which is a 50:50 co-owned company between the Government of India and the Government of Maharashtra. Initially, the stakeholders were selected as government departments, project companies, contractors, consultants, NMRCL employees, lenders, insurance companies, direct users, and public media.

Literature collection, unstructured interviews, and questionnaires were used to obtain scores on the initial screening indicators for power, legitimacy, and urgency, and the results of the statistical analysis are presented in Tables 1, 2, and 3.

| Stakeholders      | N  | Minimum | Maximum | Average |
|-------------------|----|---------|---------|---------|
| Government        | 20 | 2       | 5       | 4.20    |
| Employee          | 20 | 2       | 5       | 4.25    |
| Contractors       | 20 | 2       | 5       | 4.20    |
| Consultants       | 20 | 1       | 4       | 3.40    |
| NMRCL staff       | 20 | 2       | 5       | 4.05    |
| Insurance         | 20 | 1       | 3       | 2.45    |
| User              | 20 | 1       | 3       | 3.25    |
| Public media      | 20 | 1       | 3       | 2.30    |
| Lenders           | 20 | 1       | 5       | 3.80    |

| Stakeholders      | N  | Minimum | Maximum | Average |
|-------------------|----|---------|---------|---------|
| Government        | 20 | 2       | 5       | 4.15    |
| Employee          | 20 | 2       | 5       | 4.30    |
| Contractors       | 20 | 2       | 5       | 4.35    |
| Consultants       | 20 | 1       | 4       | 3.4     |
Table 3. Statistical table of urgency score.

| Stakeholders | N  | Minimum | Maximum | Average |
|--------------|----|---------|---------|---------|
| NMRCL staff  | 20 | 2       | 5       | 4.05    |
| Insurance    | 20 | 1       | 3       | 2.45    |
| User         | 20 | 1       | 3       | 3.20    |
| Public media | 20 | 1       | 5       | 2.60    |
| Lenders      | 20 | 1       | 5       | 3.25    |

The score between 4 and 5 for each of the three attributes are the project's primary stakeholders: government, employee, contractors and NMRCL staff; the scoring between 3 and 4 for the intersection of the three attributes are the project's secondary stakeholders: lenders, consultants, and users. The scoring below 3 on two of these attributes are the marginal stakeholders of the project: insurance companies and public media.

3.3. Application of BIM 5D digital management platform

NMRCL deploys a digital project strategic management platform that combines 5D BIM with ERP and OSO, which provides strategic program management and domain expertise to help build the digital platform. The digital platform is integrated with various standalone systems such as Primavera, SAP and Bentley software, and the results of the integrated systems are reported through the SAP-BI dashboard. See Table 4 for details.

Table 4. Function table of platform software.

|                         | Design | Planning | Cost | Reported | Integration |
|-------------------------|--------|----------|------|----------|-------------|
| Bentley software        | √      |          |      |          |             |
| Primavera P6 EPPM       |        | √        |      |          |             |
| SAP-ERP/EAM             |        |          | √    | √        |             |
| 5D BIM integration on RIB iTWO |        |          |      |          | √           |

3.4. Benefit analysis of digital management platform to primary stakeholder

Table 5. Benefit analysis of primary stakeholders.

| Design Phases | Execution | Handover | O&M |
|---------------|-----------|----------|-----|
|               |           |          |     |
### Design Phases Execution Handover O&M

**Government**
- Input and output of policy documents to reduce document errors and omissions due to manual transmission.
- Avoid design problems caused by inadequate transmission, avoid distortion of information, and improve the quality of work by clearly marking the scope.
- Through the building information model view, grasp the overall situation.
- Deliver results electronically for future review.
- Facilitates overall control of economic returns.

**Employee**
- Automated quality assurance checks, clash detection and solutions that save time through increased productivity and design drawing availability.
- By visualizing the site conditions, work-flow, construction progress, quality inspection and monitoring, they can take measures to avoid delays and cost overruns.
- The entire process results in fewer claims or litigation, fewer delays and less cost overruns at the time of delivery.
- Operate ahead of time to save on inventory costs.

**Contractor**
- Avoiding the difficulty of transmitting information due to large numbers of people and avoiding duplication of information.
- Provide detailed milestone information and comprehensive critical path analysis, and take proactive measures to avoid late delays.
- Enables early electronic transfer of information into the operational phase, reducing paperwork, coordination issues.
- They can quickly identify problem areas for easy resolution.

**NMRCL Staff**
- Offline mode maintenance is performed with the periodic maintenance feature and the platform performs RAMS reporting to reduce failures.

3.5 Results
The Nagpur Metro Rail project has benefited in many ways through the implementation of a digital management platform. However, being the first of its kind in India and Asia, it went through various implementation issues related to the digital management platform.

Firstly, the advantages of early implementation of 5D BIM system can be explored from the concept stage. Ensure that the 3D model is ready before the project begins.

Second, the combination of GIS data and 3D models can be explored to manage above-ground obstructions in subway lines.

Third, staff and project personnel must be trained in the use of BIM and digital management systems for more effective use. The benefits of using digital project management systems must be communicated to people at all levels, and these benefits must be obtained at the lowest possible level.
Fourthly, in order to optimise the use and benefits of cloud-based systems, paperwork must be reduced and redundant processes eliminated in the next phase. Lastly, all stakeholders must be encouraged to recognize the benefits of digital project management and adopt the changes.

4. Conclusion
By analysing the Nagpur Metro Rail Infrastructure Project, this paper draws the following conclusions:

- In the whole life cycle of infrastructure projects, due to the large number of project participants, dispersed personnel and lack of common goals, coordination and communication concepts, resulting in complex communication relationships and poor communication results among infrastructure project stakeholders in China.
- BIM technology plays an important role in the communication between infrastructure project stakeholders, which provides a medium and channel for infrastructure project stakeholders to communicate and indicates the direction for solving the problems of project quality, schedule and cost caused by poor communication among infrastructure project stakeholders.
- Summarizing the above background, this paper combines BIM technology and stakeholder research to analyse the 5DBIM digital management platform built by the project, analyse the benefits of this digital management platform to the main stakeholders, and achieve a breakthrough in the field of stakeholder communication, but of course, it also faces various challenges.
- The stakeholder theory was applied to screen the stakeholders of the infrastructure project, and the Mitchell scoring method was applied to solve the problem of the complex multiplicity of unclear stakeholders of the infrastructure project.

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