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# Time and Cost Planning of a Housing Construction Project Using Building Information Modelling

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ABSTRACT

Conventional ways of building construction process lack proper task scheduling and planning of the project work at the site resulting in poor monitoring of the whole process. Building information modelling (BIM) creates a platform where all the information of every single element of the construction process can be virtually integrated. The integration of 3D elements of a building model with its scheduled time and cost parameters results in 5D BIM. This feature enables the visualization, scheduling, planning, and monitoring and clash detection of all pre- construction, construction and post-construction processes of a building. The present study used the information of a live project of a traditionally built residential building which was remodeled using 5D BIM technique. The purpose of this study was to compare and analyses the impact of 5D BIM on time and cost parameters of the live project.

## 1. Introduction

The construction industry is emerging with various new advancements being included in every technique used. Earlier, stakeholders used to employ the 2D technique to get the constructions done. This practice required 2D drawings for dimensional details of all the construction elements, which in turn needed access to many different documents. This process was not of great use as it was prone to human error, mistakes and cumbersome. These reasons paved the way for other accurate and simplified options to overcome the problems experienced by a professional using the 2D technique. The development of efficient techniques which could be engaged throughout the lifecycle of a construction project was high-

ly required. Researchers and engineers worldwide have continuously made their valuable contributions in this field. Recently, building information modelling (BIM) has been developed and gaining popularity in this area. BIM is a primary digital representation of a 3D building and its intrinsic physical and functional characteristics which form a reliable basis for decision making during the life-cycle of a construction project. It is a database and creates a perfect platform to share knowledge and communicate information between project participants. The term BIM does no longer sound strange and has become an integral part of the construction industry. BIM is a wonderful, intelligent, object-oriented and data-rich technology where the appropriate data can be extracted and analyzed according to the need of a user who then makes decisions to improve

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the process of delivering the facility. In the light of the above explanation, BIM is not just software but it is a combination of both process and software which makes substantial changes in the workflow and project delivery processes. From the perspective of a software, BIM is a project simulation which is comprised of the 3D model of the project components containing links to all the required information of the project planning, design, construction or operation, while, BIM could also be seen as a virtual process that merges all aspects, disciplines, and systems of a facility within a single, virtual model, permitting all the team members such as owners, architects, engineers, contractors, subcontractors and suppliers to collaborate more meticulously and efficiently than traditional processes. The team members could constantly refine and adjust their work portions according to project requirements and design changes to ensure the model is as accurate as possible, while the model is being created. This could be achieved way before the physical start of the project. In recent years, the various technologies like 3D (which represents and visualizes an object by height, length and width in a space coordination system) and 4D (4D is a mix of 3D coordinates and the time as 4th dimension)

## 2. Objectives

(1) To introduce the 5D BIM technique for pre-construction modelling, planning, and management of a construction project.

(2) To integrate and simulate the 3D model, time and cost factors using this technique.

(3) To check the effectiveness of this technique in controlling cost and time.

(4) To compare the conventional project execution technique with 5D BIM technique to estimate the accuracy and efficacy of both.

## 3. Literature Review

<sup>[1]</sup> stated that 5D BIM is very helpful in the integration of information that could be visualized on the regularly on computer monitors. Therefore, 5D BIM makes a perfect visualization tool to monitor the project progress. It is a very easy and appropriate tool to be used for construction cost and resource management. Any procedure of construction can be modified and managed at any instance by simply clicking on the model and activity.

Management of schedule, finance & labor. This technology also allows the integration of different sophisticated software which is very instrumental and appropriate in generating the outputs for a particular type of task. This technology enables collaboration and allows the integration of information from all the fields on a single platform, hence

generating the most accurate outputs. Since the 5D BIM is a complex process involving the contribution of people from different fields to work on a single model, therefore, this technology fosters collaboration among different project teams. These techniques are user-friendly and could be easily adopted by quantity surveyors, engineers, project managers etc. 5D BIM utilizes the dynamic linkage between the 3D elements and the corresponding activities in the schedule thus, detecting the problems and logical errors in the schedule sequence prior to the construction, which is not possible in traditional methods. Although, 5D BIM technology employed in this project considered time as 4th and cost as the 5th dimension, further other dimensions are also described as the subsets of BIM such as 6D as operation, 7D as sustainability and even 8D as safety. Furthermore, BIM modelling could be modified using resources, materials, site conditions, global information system (GIS), etc. The report made by Anil Sawhney <sup>[2]</sup> from Amity University on Study of BIM Adoption in India. Goal of his study was to document the current status and outlook of Implementation of BIM in the built sector of India. To achieve this goal it was vital to not only study the current scenario of BIM implementation but also to gauge the mindset of industry leaders with respect to the prospects of BIM in their respective organizations. This was done by first analyzing the current state and then by focusing on:

(1) Drivers for BIM implementation in India.

(2) Barriers to BIM implementation in India.

(3) Perceived benefits of BIM implementation.

### 3.1 Guided by this Overarching Goal the Study had the Following Key Strands

The extent of current BIM usage in India: data was collected pertaining to “who is using BIM” by identifying: (a) type of companies; the (b) size of companies; and (c) location of the companies.

(1) BIM implementation level: Data collection on usage of BIM and BIM implementation by the companies in terms of functional aspects.

(2) Benefits of BIM usage: perceived benefits of BIM were identified from the sub-group of respondents who were either using BIM or were considering using BIM.

(3) Problems & issues in implementation: For identifying barriers to BIM implementation by existing as well as reluctant users of Indian Project sector.

(4) Developing recommendations & future prospects to enable more Indian companies for BIM implementation.

### 3.2 Following Three-pronged Research Methodology was Adopted

(1) Data from software vendors, online sources, and

industry publications was collected on national & international trends through desk research.

(2) An industry-wide survey designed to document the current state of BIM adoption, perceptions surrounding BIM usage and other important indicators;

(3) An online survey tool called SurveyMonkey10 was used for semi-structured interviews of target industry leaders to determine mindset issues. Study team members also did semi-structured interviews across major cities in India including Delhi, Mumbai, Pune, Hyderabad Bangalore, Chennai and Ahmadabad Study team collected the information from:

(4) An online survey in which over 365 respondents provided their input.

40 industry experts interviewed across the country. Data collected via an online survey and interviews were carefully analyzed. Following sections provide a respondent profile and key findings of the study.

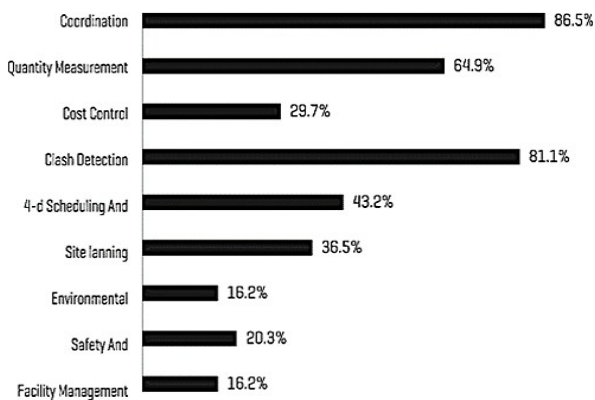


Figure 1. Functions of BIM in Construction

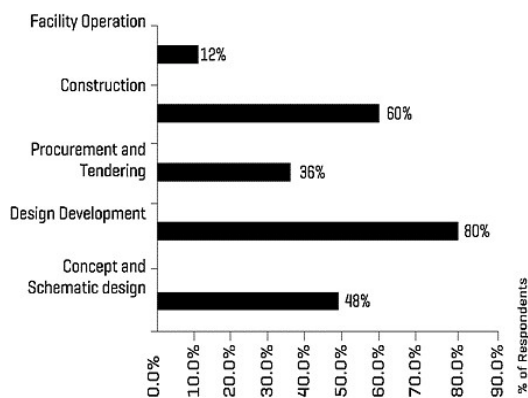


Figure 2. BIM usage by Project Phase

Source: State of BIM Adoption and Outlook in India.

Peter Smith & Procedia<sup>[4]</sup> said that, Minimizing the waste and optimizing the enhancing profitability is possible by reducing the cost of material with proper planning, scheduling, purchasing, procurement, receiving, inspecting, handling, storing. BIM is a modelling philosophy,

which is maturing, automating quantity take-offs, checking compliance with regulations governance, visualizing designs, and organizing construction processes. Construction waste can be resolved through integrated building design and better construction planning and management, which could be facilitated by building information modelling (BIM). BIM provides the base for improved scheduling and planning.

BIM inspects all interferences, clashes and collision by visual technology and thus reduce conflicts. This ability enables BIM to act as an advisor tool for designers and engineers. The models can be rigorously analyzed, simulations can be performed quickly and performance benchmarked. There are better communication and understanding from 3D visualization. Minimum design changes after construction allow project finishes during the logical time and eliminate loss of extra cost. BIM can be used to create an effective schedule of material ordering, fabrication, and delivery of all building component. The design problems are solved early in the design and hence there will be less controversial problems in the plans and fewer damages. Any changes in design entered the building model are automatically updated. Therefore, there will be less rework caused by possible drawing errors. Environment, however, one in five companies “remains in blissful ignorance of BIM’s existence”. In contrast, promising insights indicate a potentially successful adoption rate for BIM implementation in near future.

#### 4. Methodology

The main objective of this thesis is planning the Time & Cost parameters of a construction project using 5D BIM. The time & cost planning of a live G+1 residential apartment is done using 5D BIM platform.

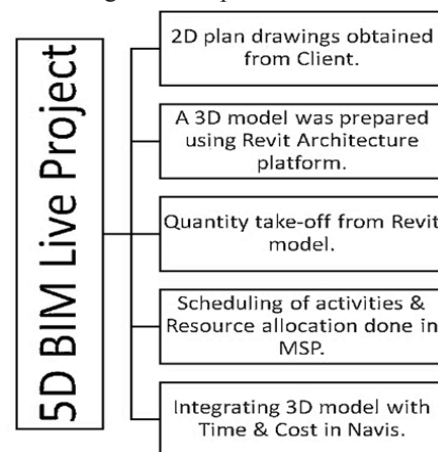


Figure 3. Methodology for Creation of 5D BIM Model

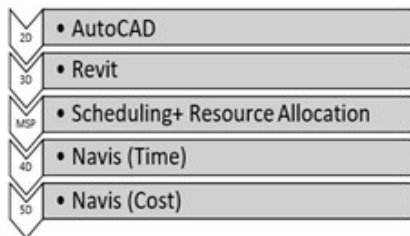
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### 4.1 Implementation of 5D BIM on G+1 Residential Bungalow

**Project Details:**

- (1) **Building type:** G + 1 Residential
- (2) **Location:** Moodbidri, Mangalore, Karnataka.
- (3) **Plot Area:** 8 Acres
- (4) **Plinth area:** 1861.48 sq. Ft (173 m<sup>2</sup>)
- (5) **Project status:** Till 1<sup>st</sup> February 2019, first-floor lintel completed
- (6) **Total project value:** Rs. 26 Lakhs
- (7) **Planned Project Duration:** 344 days
- (8) **Planned Start:** 02-04-2018
- (9) **Planned Finish:** 11-03-2019

Different software’s such as Autodesk REVIT, MS Project (MSP), and Naviswork manage were used to create the 5D model. The steps are mentioned as follows:

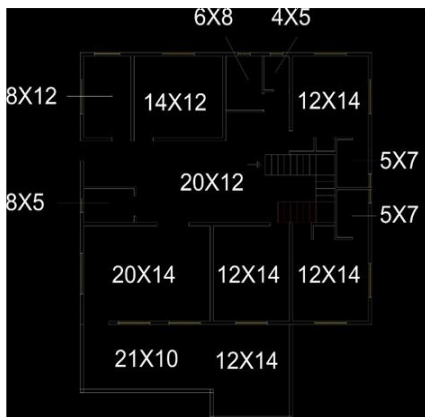


**Figure 4.** Software’s for Methodology

Source: Compiled by author

### 4.2 Stepwise Procedure of Creation of 5D BIM

- (1) Collection of AutoCAD 2D drawings of the project from the client.(Refer Figures 5 & 6)



**Figure 5.** AutoCAD 2D Drawings of G+1 Residential Building

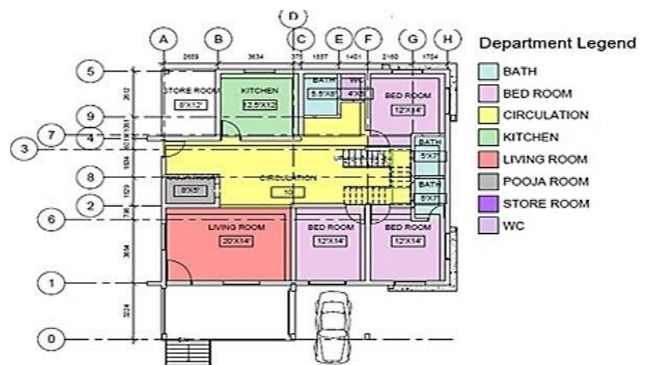
**FLOOR AREA : 1840 SQ.FT**  
**SIT OUT : 210 SQ.FT**  
**CAR PORCH : 168 SQ.FT**  
**TOTAL : 2218 SQ.FT**  
  
**ALL DIMENSION IN SQ.FT**

**Figure 6.** AutoCAD 2D Drawings of G+1 Residential Building

Source: Compiled by author

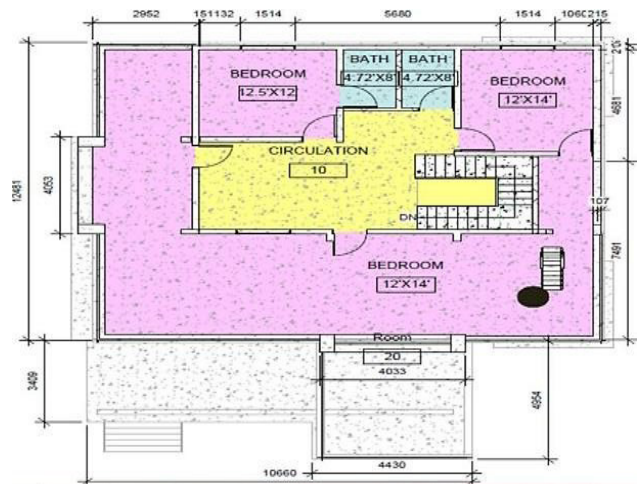
(2) Local item rates were referred locally and the same is been used to generate the cost parameters.

(3) Creation of 3D model and other level plans in REVIT software. Material Quantity take-offs were also generated automatically in REVIT rather than using the conventional method. These material take-offs were used in MSP for resource allocation purpose. (Refer Figures 7, 8 and 9)



**Figure 7.** Revit Ground Floor Plan of G+1 Residential Building

Source: Compiled by author



**Figure 8.** Revit First Floor Plan of G+1 Residential Building

Source: Compiled by author

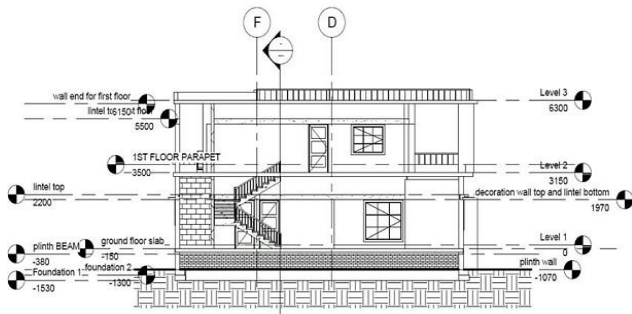


Figure 9. Section of G+1 Residential Building

Source: Compiled by author

(4) A clash was detected in the original plan which was encountered in 3D model rectified. (Refer Figure 10)

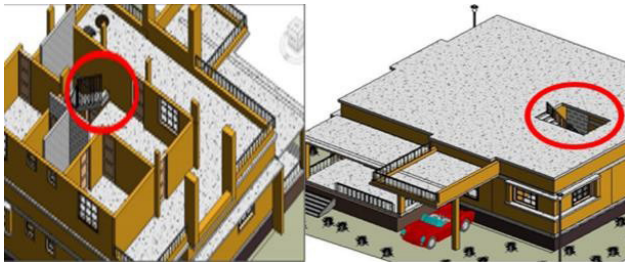


Figure 10. Clash Detection and Rectification of Staircase G+1 Residential Building

Source: Compiled by author

(5) Work Breakdown Structure created for the activities of construction using the data from Revit. This model gave accurate cost and quantity details. (Refer Figures 11, 12 & 13). 5D model created by attaching 3D model from Revit, schedule and cost from MSP in Naviswork which acts as integrating the platform. (Refer tables 1 & 2).

Task	Mode	Task Name	Duration	Start	Finish	Predecessors	Resource Names	Cost
0	MS	msp rajath updated	344 days?	Mon 4/2/18	Mon 5/20/18			\$2,570,860.00
1	MS	SD BIM	344 days?	Mon 4/2/18	Mon 5/20/18			\$2,570,860.00
1.1	MS	Site Layout	1 day	Mon 4/2/18	Mon 4/2/18		Site Layout[1]	\$0,000.00
1.2	MS	Excavation	1 day	Tue 4/3/18	Tue 4/3/18	2	Excavation[1]	\$8,000.00
1.3	MS	Foundation	0 days?	Wed 4/4/18	Tue 4/10/18			\$82,040.00
1.3.1	MS	Foundation layer 1	3 days?	Wed 4/4/18	Fri 4/6/18			\$43,760.00
1.3.1.1	MS	grid A2-H2	1 day	Wed 4/4/18	Wed 4/4/18	3	rubble soling[1]	\$0,720.00
1.3.1.2	MS	grid A3-A4	1 day	Wed 4/4/18	Wed 4/4/18	655	rubble soling[0.5]	\$3,400.00
1.3.1.3	MS	grid H0-H1	1 day	Wed 4/4/18	Wed 4/4/18	755	rubble soling[1.5]	\$6,200.00
1.3.1.4	MS	grid A5-A6	1 day	Thu 4/5/18	Thu 4/5/18	7	rubble soling[0.5]	\$0,720.00

Figure 11. MSP Schedule of G+1 Residential Building

Source: Compiled by author

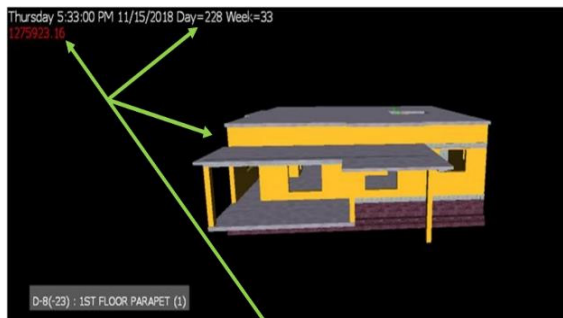


Figure 12. 5D BIM in NAVIS (Date +Time +Simulation) of G+1 Residential Building

Source: Compiled by author



Figure 13. Rendering in Revit of G+1 Residential Building

Source: Compiled by author

Table 1. Resource Sheet of G+1 Residential Building

Resource Name	Type	Initials	Std. Rate	Cost/Use	Accrue At
Brickwork	Material	b	\$5,000.00	\$0.00	Prorated
RCC	Material	R	\$18,000.00	\$0.00	Prorated
Rubble Soling	Material	r	\$4,000.00	\$0.00	Prorated
PCC	Material	P	\$6,000.00	\$0.00	Prorated
Door Windows	Material	D	\$315,000.00	\$0.00	Prorated
Earth Filling	Material	E	\$1,050.00	\$0.00	Prorated
Railing	Material	R	\$2,000.00	\$0.00	Prorated
Site Layout	Material	S	\$5,000.00	\$0.00	Prorated
Excavation	Material	E	\$8,000.00	\$0.00	Prorated
Landscaping	Material	l	\$500.00	\$0.00	Prorated

Table 2. Cost of Rework of G+1 Residential Building

Sr. No	Description	Quantity	Cost of construction	The total cost of construction (Rs)
1	Staircase casting (Riser size=175)	2.5 cum	18000 cum	45000
2	Staircase demolition	2.5 cum	3000 cum	7500
3	Removal of debris (2cum truck)	2 Trips	900 /trip	1800
4	Stair casting (Riser size =150mm)	2	18000 cum	36000
5	The total cost of rework		Rs. 90300/-	

## 5. Time & cost saving using 5d BIM

### 5.1 Changes in Design

Earlier the client requirement was to provide an arch in the bungalow but because of its high cost of construction the change in design was done and the arch was removed. (Refer Figure 14). Because of the availability of 3D mod-

el, it resulted in better visualization of the project and hence change in design at an early stage was implemented and time was saved.



**Figure.14:** Rendering in Revit of G+1 Residential Building

Source: - Compiled by author

## 5.2 Changes in Staircase

While 3D modelling in Revit, a clash was detected in placing of Staircase joining to the first floor. By using the platform, this was encountered at an earlier stage before construction which leads to avoiding the complete Rework of Staircase. The cost of rework saved is approximately Rs. 90000.

## 5.3 Variation in Sill Level

A constant sill level was assumed for all the windows. But in reality, the dimensions of each window varied. This platform helped to come across such variations and completely avoided the extra time & cost assisted with the rework.

## 6. Result & Conclusion

BIM have been employed in many construction projects where significant improvements in these tools to enhance the building process have been observed. Although, 3D and 4D techniques improve the execution of construction in the multidisciplinary and multi-organizational field to a great extent, using these tools on an actual project is a complicated process where a great deal of coordination is required. These problems have paved the way for many new concepts such as 5D BIM, which is the combination of 4D and cost estimation as the 5th dimension.

Time & Cost planning of a proposed residential G+1 building project is done using 5D BIM platform. The time & cost parameters were successfully integrated into Autodesk Navis work platform for simulation. During this process, the clash was detected in stair case placing as well as a constant sill level was assumed for each & every window, but practically it varied in with multiple dimensions. This was conveyed to the client. This helped in saving time

& cost of rework. In addition to the above-mentioned objective, the application of 5D BIM platform to a real ongoing metro infrastructure project was studied thoroughly.

## 6.1 Visualization during Pre-Construction

Designing of a structure by the conventional way may lead to clashes between plans of Architect, Structural designer and another MEP's. This 5D BIM platform lets users interact on a unified interface which leads to streamlining the process of design updating & approval. By utilizing BIM, one can design and picture the whole project amid preconstruction. Space-use re-enactments and 3D perceptions enable customers to encounter what space will look like offering the Engineers, Architects & other stakeholders to make changes before development begins. Having a more noteworthy review from the earliest starting point limits costly and tedious changes later. Come across such variations and completely avoided the extra time & cost assisted with the rework

## 6.2 Improvement in Sequencing

BIM enables plan and documentation to be done in simultaneously, and for documentation to be effectively changed to adjust to new data, for example, site conditions. Timetables can be arranged all the more precisely and conveyed precisely, and the enhanced coordination enables activities to be bound to be finished on time or early

## 6.3 RFI

5D BIM has a better ability to resolve RFI. During the execution phase, missing information may be encountered. A contractor can easily access the information designed by different stakeholders through the 5D BIM platform.

## 6.4 Improves the Quality

5D BIM facilitates the collaboration between different stakeholders (Architects, Engineers, MEP's), thus enhancing productivity & improving the overall quality of construction.

## 6.5 Quantity Take-off

By using 5D BIM, the tedious work of measuring the quantity by analyzing various sections & plans can be avoided. The system gives Quantity take-off of each section

## 7. Future scope of 5d BIM

The construction industry has traditionally been focused on the upfront capital costs of construction. Shifting this

focus to better understand the whole-life cost of assets, where most money is proportionately spent, should make for better decisions upfront in terms of both cost and sustainability. This is where 6D BIM comes in.

Sometimes referred to as integrated BIM or iBIM, 6D BIM involves the inclusion of information to support facilities management and operation to drive better business outcomes. This data might include information on the manufacturer of a component, its installation date, required maintenance and details of how the item should be configured and operated for optimal performance, energy performance, along with lifespan and decommissioning data:

(1) Block chain can be used for the transactions in 5D BIM.

(2) Further enhancements to 5th dimension of BIM is:

(3) 6D BIM (project lifecycle information)

7D-BIM (seventh-dimensional building information modelling) is used by managers in the operation and maintenance of the facility throughout its life cycle. The seventh dimension of BIM allows participants to extract and track relevant asset data such as component status, specifications, maintenance/operation manuals, warranty data etc.

The utilization of 7D-BIM technology can result in easier and quicker parts replacements, optimized compliance and streamlined asset life cycle management over time. 7D BIM provides processes for managing subcontractor/supplier data and facility component through the entire

facility life cycle.

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