

Understanding GIS in visualization and evaluation of construction schedule

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ABSTRACT- Economically successful available scheduling tools such as Primavera and Microsoft Project fail to provide information about the geographical aspects of a construction project. A methodology using geographical information systems (GIS) is developed to represent the geographical aspects of the construction progress graphically by accompanying and linking it with the construction schedule. The spatial or geographical aspects are illustrated by the 3D model developed in AutoCAD and the construction schedule is generated via MS Excel sheets and linking it to ArcVIEW. Spatial and scheduling information are linked together into the GIS environment (ArcGIS) With a GIS, we can identify and analyze the land features, climate, boundaries, population, resources, and many other things about places that interest you. In the past, you needed to use paper maps, globes, and a variety of hard-copy data sources to perform these analyses. The main purpose of the research is to discover a simple and perceptive way of assigning the essential project information from a constructional CAD model to scheduling software and streamlining sequencing and organizing project activities. In achieving this goal, one of the most exhausting and time-consuming steps in producing a construction project schedule will be removed. By the end of this project, we will be able to understand the GIS system, and how to visualize it while scheduling the project and its uses.

Keywords- Geographical Information System, spatial information, scheduling, visualization

I. INTRODUCTION

- What is GIS?

GIS is an abbreviation that stands for geographic information systems. A geographic information system (GIS) allows you to study and explore everything about a place. GIS is a system or tool for displaying, analyzing, capturing, storing, manipulating, managing and presenting all types of geographical data. The keyword to this technology is Geography – this means that some portion of the data is spatial. In other words, data that is in some way specified to locations on the Earth's surface. Geographic information systems are utilized in multiple technologies, processes, techniques, and methods. They are attached to various operations and numerous applications that relate to engineering, planning, management, transport/logistics, insurance, telecommunications, and business.

- Uses-

GIS can be used as a tool in both problem solving and decision-making processes, as well as for the visualization of data in a spatial environment. GIS links map to databases to create a visualization of data and allow interactivity between the map and the data in a database. GIS can also be used as-

- i. GIS technology supports the design, implementation, and management of communication networks for the phones we use, as well as the infrastructure necessary for Internet connectivity.
- ii. GIS is used in managing and designing road networks and transportation infrastructure.
- iii. GIS is used to help plan efficient routes for medical emergency vehicles to travel between emergency sites and medical care facilities like hospitals.
- iv. Businesses use GIS to decide where to build new stores and restaurants.
- v. Marketing companies use GIS to decide to whom to market those stores and restaurants, and where that marketing should be.

- What is the GIS software?

Many GIS software applications are available—both commercial and open source. This softwares are developed by **ESRI** i.e. **Environmental Systems Research Institute**. They are ArcGIS and QGIS and software under ArcGIS are ArcView, ArcMap, ArcCatalog, ArcScene, ArcGlobe etc. The software which is being used while preparing this paper are ArcGIS and ArcView and AutoCAD.

- Some Advantages of using GIS-

- i. It can improve organizational integration. GIS would then integrate software, hardware, and also data to capture, analyze, manage and so display all forms of information being geographically referenced.
- ii. GIS would also allow viewing, questioning, understanding, visualizing, and interpreting the data in many ways that will reveal relationships, trends, and patterns in the form of globes, maps, charts, and reports.

- Some Disadvantages of using GIS-

- i. GIS technology might be considered expensive software. Since the earth is round and so there would be a geographic error that will increase as you get on a larger scale.
- ii. GIS layers might lead to some costly mistakes once the property agents are to interpret the GIS map or the design of the engineer around the utility lines of the GIS.

II. RESEARCH OBJECTIVE

The primary objective of the paper is to understand GIS and its utility for **evaluating, visualizing and productively combining** various types of data used in the construction in the GIS environment. The proposed methodology demonstrates the process of making a schedule and the benefits of using GIS in construction project scheduling. Scheduling of construction projects

contains defining construction techniques and tasks, sequencing of tasks, resource distribution, resource levelling, activity duration estimating, cash flow analysis, and calendar and staff allocations. This study is limited only to activity sequencing because of time and resource limitations.

III. METHODOLOGY

- Construction project scheduling:-

A neat and agreeable plan for a construction project is not a plan which can complete the project in the least amount of time but it is the plan which can safely accomplish the project in a given time and budget without negotiating the quality, quantity and without any lawsuit or complaint. Scheduling is one of the most important steps in the process of planning a construction project and governs the success of the project. Following are the steps for generating a schedule:

- i. Define Construction Methods:- The selection of construction methods to be used should be specified and decided beforehand. It influences the cost estimate as well as the schedule of the project.
- ii. Define schedule tasks:- This includes disintegrating the project into activities and sub-activities. This is the most unmanageable job to do as there can be thousands of activities for a construction project but this is one of the important steps accommodating in the establishment of a formal schedule for the project. Schedule tasks are usually organized in a project schedule using a Work breakdown structure (WBS). It is a decomposition of complicated projects into tasks, subtasks and work packages. It is a planning tool for effective project management but it is not a scheduling method.
- iii. Sequence schedule tasks:- Proper sequencing of the activities plays a very important role in the success or failure of the schedule.
- iv. Estimate resource requirement of each task:- This step equates the resources needed to complete the project. By estimating the resources required for each activity that comprehends the project, the resource requirements of the project are identified. This is done before computing the duration of the activities. By identifying the resources required for the completion of the project ability hindrance related to resource allocation and activity sequencing can be averted. Estimating activity resources involves identifying the number and type of workers, quantity of materials and equipment required.
- v. Estimate duration of each task:- Activity duration is the time required to complete the activity fulfilling the conditions of quality, safety, and budget satisfaction. Duration can be calculated if the amount of work and the productivity of the team are known by simply dividing the quantity by productivity. It can also be computed by referring to historical records of past projects.
- vi. Schedule development/ schedule generation:- Once the project has been divided into activities and sub-activities, a logical order in which they should be organized is identified, resources and the duration required determined, and a schedule is developed such that the project can be executed and finished safely without negotiating quality, within budget and in the minimum possible time. This is done by using methods such as critical path, network logic diagram, schedule compression, and resource levelling.

- vii. **Project Control:-** This is the last step which involves supervising the project implementation at the time of construction and making sure that activities are being performed at their scheduled time and in case there is any deflection from the schedule then taking necessary action to keep the project on schedule.
- **GIS scheduling tools and techniques:-**

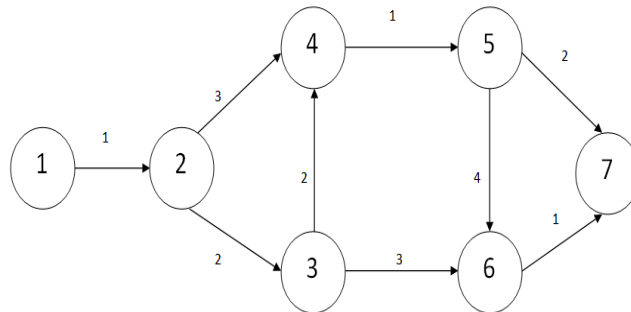
The section gives a summary of some of the methods which are used for scheduling construction projects.

 - i. **Bar Charts:-** Bar charts are one of the conventional scheduling methods. It was the most understandable method of scheduling because of its simplicity. A bar chart consists of several vertically or horizontally placed bars and the length of the bars describes the relative magnitude of the values. It uses rectangular bars with lengths corresponding to the values that they depict. Bar charts give a graphical representation of the process which helps in comprehending the schedule and when which activity should take place. This process is no more considered a suitable option for scheduling because it has many disadvantages. It doesn't show all the interdependencies between activities. There are also limits to the number of activities, usually around 50 that can be trailed on a bar chart before the chart becomes inundated.
 - ii. **Critical Path Method:-** The Critical path method or critical path scheduling is the most extensively used scheduling technique. This method computes the minimum completion time for a project together with the possible start and finish times for the project activities. This method helps in figuring out which activities are critical and are required to be completed in time as per the schedule, apart from that can result in the slow down of the complete project.
 - iii. **Linear or Line-of-Balance Method:-** The line of balance schedule or linear scheduling method shows the project schedule in a unique format that would be very helpful for certain construction projects. It is well suited for a project where the activities are repetitive. The construction projects which usually use this method of scheduling are horizontal in nature instead of vertical e.g. highways, pipelines, and railroads. It can also be used for projects where there are several common activities or one activity with a long duration.
 - iv. **Gantt Chart:-** The Gantt chart (named after its creator, Henry Gantt) is a bar chart that is used particularly for tracking tasks throughout the process of the project. A Gantt chart is a horizontal bar chart used for project management. It is used to represent the timing of numerous tasks that are needed to complete a project. Gantt charts will usually represent the estimated task completion time in one colour and the actual time to completion in a second colour. This colour-coding allows project members to rapidly assess the project progress and identify areas of concern in a timely fashion.
 - v. **PERT Charts:-** PERT (Program Evaluation and Review Technique) charts are similar to Gantt charts in that they are both used to coordinate task completion for a given project. PERT charts focus more on the events of a project than on the start and finish dates as seen with the Gantt charts. This methodology is more often used with very large projects where action to strict time guidelines is more important than economic considerations. PERT charts include the identification of the project's critical path.

IV. PROCEDURE FOR THE EVALUATION AND VISUALIZATION OF SCHEDULE

Various steps involved to evaluate and visualize the construction schedule within GIS are discussed below:

- i. **Creation and relocation of construction schedule:-** A schedule is a representation of how and when the various tasks of a project are going to be achieved. The schedule is a timetable for the implementation of various project activities and acts as a plan for the successful execution of a project. Microsoft Excel is used as a scheduling tool, to establish the starting/finishing times, different floats, project duration, and critical activities. The schedule produced in Microsoft Excel is then transferred into ArcView. The components equivalent to each activity of the project are linked with the CPM schedule based on the earliest or latest start time.



ID	Activity	From_NODE	To_NODE	Duration	EST	EFT	LST	LFT	TF	FF	Int_F	Remarks	Resource1	Resource2
1	10001	1,2	1	2	2	0	2	0	2	0	0	0 Critical	3	0
2	10002	2,3	2	3	2	2	4	2	4	0	0	0 Critical	3	0
3	10003	2,4	2	4	3	2	5	3	6	1	1	0	1	0
4	10004	3,4	3	4	2	4	6	4	6	0	0	0 Critical	2	0
5	10005	4,5	4	5	1	6	7	6	7	0	0	0 Critical	1	0
6	10006	3,6	3	6	3	4	7	8	11	4	4	0	3	0
7	10007	5,6	5	6	4	7	11	7	11	0	0	0 Critical	2	0
8	10008	5,7	5	7	2	7	9	10	12	3	3	0	2	0
9	10009	6,7	6	7	1	11	12	11	12	0	0	0 Critical	3	0

- ii. **Creation and shifting of 3D elements:-** Geographical information of different activities obtained in the schedule is maintained in the data themes, which form the basis of GIS-based visualization. It is not mandatory to have a 3D element corresponding to each activity in the schedule. The ArcGIS permits working with the design plans generated in AutoCAD. After creating the spatial aspects according to an activity in the CPM schedule, spatial information is analysed by viewing the resulting 3D elements. If it compiles the requirements, then it can be proceeded to the next step, otherwise, the elements are modified and improved.

- iii. **Linking activities with corresponding 3D elements:-** Elements transferred into ArcGIS from AutoCAD are linked corresponding to the activities as described above at the schedule generated in Microsoft Excel. Thus, the elements of the drawing/design/plan that pertains to the same activity and are located at different locations in the space are linked together to build the spatial or geographical data for each activity.
- iv. **Connecting the schedule with corresponding 3D elements:-** This step includes adding a field called Activity_ID to the schedule and the attribute table of each element. The field Activity_ID is common between two tables and is used to initiate the relationship between the element and the corresponding activity in the schedule.

The image shows two overlapping database window screenshots. The top window, titled 'schedule.dbf', displays a table with columns: Activity, From_node, To_node, Duration, Est, Eft, Lst, Lft, Tf, Ff, Int_f, Remarks, Resource1, and Resource2. The bottom window, titled 'attributes of scheduling.dbf', displays a table with columns: Id, Activity, From_node, To_node, Duration, Est, Eft, Lst, Lft, Tf, Ff, Int_f, Remarks, Resource1, and Resource2. The data in the bottom table is a 1:1 expansion of the data in the top table, with 'Id' values ranging from 10001 to 10008.

- v. **Schedule analysis:-** This step includes analysing the schedule to verify the construction sequence. A script that generates the lists of all the dates in the table via excel sheets i.e., starting times, finishing times and duration in the construction of the schedule is added to the ArcView in layers with add table icons. By clicking on a date in the table, activities that are prepared to be in operation on or before that date will be graphically visible on the computer screen in 3D. The schedule for different dates can be analyzed by visualizing it in 3D through animations.

The image shows a screenshot of a database window titled 'cpm_schedule.dbf'. The table has columns: Activity, Est, Eft, Lst, and Lft. The data rows show dates for activities 1_2 through 6_7.

Activity	Est	Eft	Lst	Lft
1_2	Tuesday April 12,2022	Wednesday April 13,2022	Tuesday April 12,2022	Wednesday April 13,2022
2_3	Wednesday April 13,2022	Friday April 15,2022	Saturday April 16,2022	Monday April 18,2022
2_4	Wednesday April 13,2022	Saturday April 16,2022	Wednesday April 13,2022	Saturday April 16,2022
3_4	Saturday April 16,2022	Monday April 18,2022	Saturday April 16,2022	Monday April 18,2022
4_5	Monday April 18,2022	Tuesday April 19,2022	Monday April 18,2022	Tuesday April 19,2022
3_6	Saturday April 16,2022	Wednesday April 20,2022	Sunday April 17,2022	Thursday April 21,2022
5_6	Tuesday April 19,2022	Thursday April 21,2022	Tuesday April 19,2022	Thursday April 21,2022
5_7	Tuesday April 19,2022	Wednesday April 20,2022	Saturday April 23,2022	Sunday April 24, 2022
6_7	Thursday April 22,2022	Sunday April 24,2022	Thursday April 21,2022	Sunday April 24, 2022

- vi. **Schedule corrections:** In the resulting model, the GIS-based approach displays at what time elements are to be built and where they will be in the space. It enables understanding

of a 3D model/plan and the topological relationship between different elements in many ways like zooming, pan, flying forward or backward, etc. After analyzing the model, if it does not go along with the desired construction sequence and needs some changes in the logic interrelationship among the activities, the CPM schedule is changed again as per the requirements. All activities that are not in the sequence need to be rearranged in the CPM schedule. All relationships among the activities in the CPM schedule that constitute a physical impossibility or can cause major disruption or delay at the construction site need to be corrected at this step. After implementation of the desired changes, the schedule is again associated with the related elements for evaluation and sequence verification. It is finally accepted if no change in the logic and number of activities is required. If the number of activities in the schedule needs addition/deletion or if some editing is further required in the corresponding components, the entire procedure needs to be repeated.

V. LIMITATIONS AND SUGGESTIONS FOR FUTURE WORK

Regardless of all demonstrated outcomes, some improvements are still required in the proposed methodology. Although the system examines the drafting potential/abilities of GIS, these are incomparable to the existing drafting tools like AutoCAD. However, the drawing/plan generated in AutoCAD can be utilized/modified in the GIS software, thus allocating a practical solution for the drafting part. GIS is being extensively used to fulfil different project objectives and requirements. GIS mainly focuses on geographical or spatial (land-based) information and analyzes that data or information as a basis for the design and assessment of civil infrastructure.

VI. CONCLUSION

GIS permits the user to influence the schedule and 3D elements in a single environment, which in turn makes the rapid generation of alternatives easier. **The proposed methodology combines the construction schedule with corresponding spatial data to make the scheduling and visualization of the project easy to understand.** The schedule in GIS allows easier understanding of the project as well as helps in tracking and resolving possible problems. The proposed methodology supports additional analyses like rate analysis, cost estimates, and allows integrating safety recommendations with critical activity, thus making schedules more realistic.

VII. REFERENCES

Bansal V.K. and Pal M. (2006a), *Geographic Information Systems for Construction Industry: a Review*, NICMAR Journal of Construction Management, 21(2), 1- 12.

Getting to know GIS by *Michael Law and Amy Collins* fourth edition (2015), ESRI Press, Redlands, California.

Bansal V. K. and Pal M. (2006c), *Potential of Geographic Information Systems in building cost estimation and visualization*, *Automation in Construction*, Article in press.

Bansal V.K. and Pal M. *GIS in Construction Project Information System. Proceedings of Map India, 8th Annual International Conference and Exhibition in the field of GIS, GPS, Aerial Photography, and Remote Sensing*. 2005, New Delhi, India.

Chang, Kang-Tsung (2002), *Introduction to Geographic Information Systems*, Tata McGraw-Hill, New Delhi.

Bansal V.K. and Pal M. (2006b), *GIS-Based Projects Information System for Construction Management*, *Asian Journal of Civil Engineering*, 7 (2), 115-124.

Anamika Sharma (2009), *An Interactive Visual Approach to Construction Project Scheduling*, Marquette University

Bansal V.K. and Pal M. (2008), *Generating, Evaluating, and Visualizing Construction Schedule with Geographic Information Systems*, 10.1061/(ASCE)0887-3801(2008)22:4(233)

Dr. Dinesh Singh, P Venkatesh, “*International Conference on Advances in Civil Engineering (ICACE-2019)*” | 21-23 March 2019 | K L Deemed to be University, Vijayawada, A.P. India

Bansal, V. K., and Pal, M. (2007). “*Potential of geographic information systems in building cost estimation and visualization.*” *Autom. Constr.*, 16(3), 311–322

https://en.wikipedia.org/wiki/Geographic_information_system

Vijay Kolagotla Assistant Manager-Planning,” *Geographical information system and its application to project management in the construction industry*“, Gammon India Ltd., Mumbai. 10th ESRI India User Conference 2009

Bansal, V. K., and Pal, M. (2011). “*Construction projects scheduling using gis tools.*“, *The International Journal of Construction Management* (2011) Vol. 11 No. 1, 1 -18

ArcView GIS version 3.2 reference manual for the window. (1996). Environmental Systems and Research Institute, N.Y. Street, Redlands, California.

ArcGIS version 9 introduction parts I & II. (2004). Environmental Systems and Research Institute. N.Y. Street, Redlands, California