DEVELOPING VISUALIZED SCHEDULES FOR PLANT INFORMATION MODELING

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ABSTRACT

As of November 2012, the Alberta government listed 53 oil and gas, oil sands, and mining construction projects either proposed or currently under construction. These industrial plant construction projects have an estimated value greater than 105 million dollars. A common construction method employed for industrial plant projects is fast-track construction, which is used to reduce construction time. Contractors begin fast-track construction with highly generic scheduling information. This high level schedule turns into a lower level schedule as more detailed information becomes available. From a contractor's perspective, a challenge faced using fast-track construction is the visualization of generic and constantly changing project schedules. This paper discusses the use of a Plant Information Modeling (PIM) system, designed to create a 4D animation to visualize project schedules for fast-track industrial plant construction projects. The proposed PIM system creates a modified project schedule by obtaining specific information from a generic construction schedule. Obtaining the information involves grouping schedule activities in accordance with the level of detail in a 3D model, and the level of detail in a project schedule. The modified project schedule is then used in conjunction with a 3D model to simulate the construction sequence in the form of a 4D animation. This allows for 4D visualization of project activities, installation dates, and crane movements. Furthermore, as engineering reaches completion, the PIM system creates a streamlined channel for schedule information updates to be easily uploaded into the model for a more accurate 4D visualization. Through analyzing a non-modular construction case study, this paper discusses the successes and benefits of the PIM system for 4D visualization, such as increased productivity, shortened construction time, increased constructability, and decreased field costs.

KEYWORDS

Plant Information Modeling, Industrial Plant Construction, Schedule Visualization, Animation, Modular Construction

INTRODUCTION

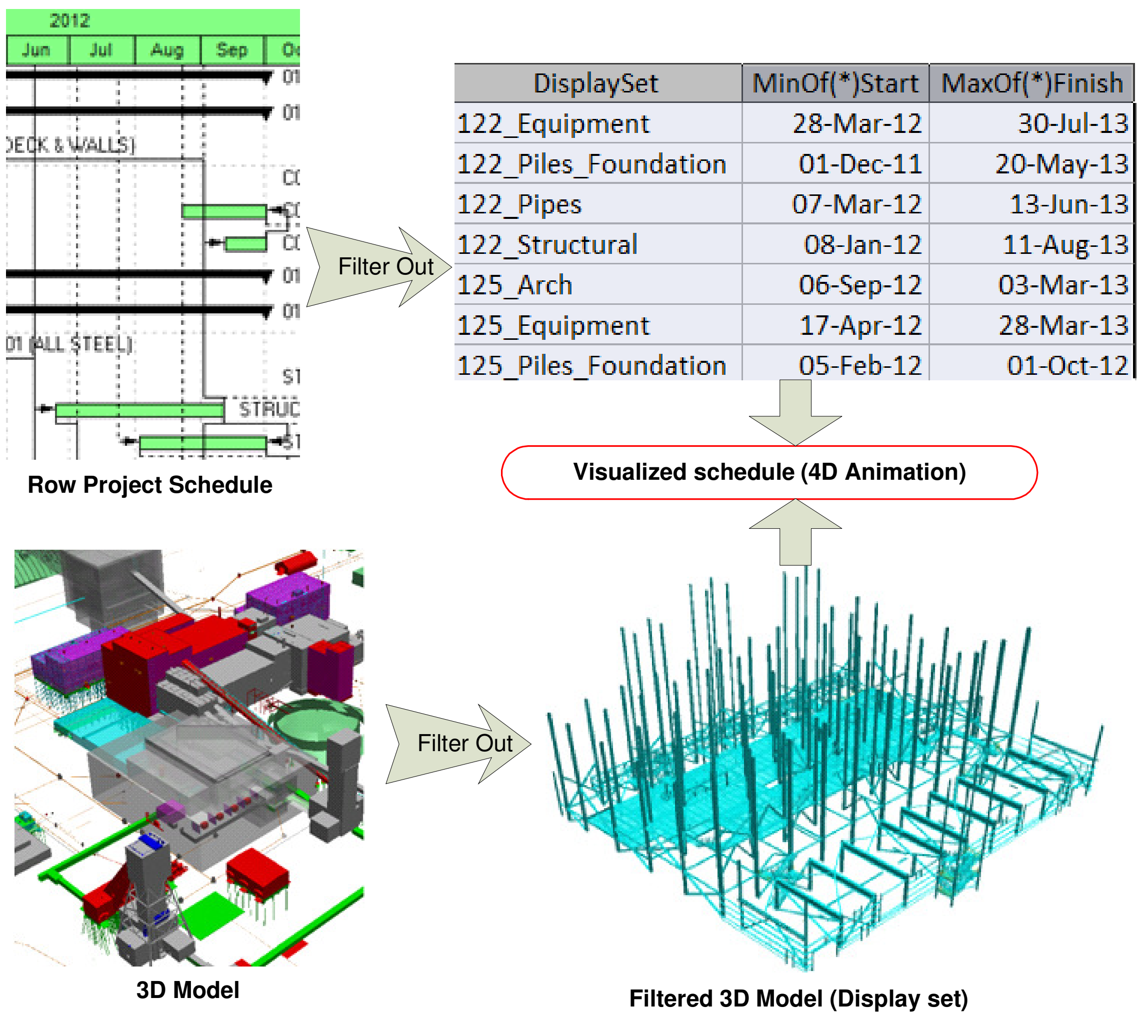
Building Information Modeling (BIM) is increasingly being applied in commercial buildings construction for constructability, planning, coordinating, and scheduling construction tasks and activities (Sheryl Staub-French et al., 2011). BIM allows for multiple parties such as designers, contractors and clients to visualize the entire scope of a project using 4D animations (Lu & Korman, 2010). 4D animations combine 3D project models with project schedules to animate a construction sequence. BIM is widely used in commercial construction; however, it lacks certain qualities that allow it to translate into use for industrial projects. Industrial construction is much smaller than commercial buildings construction in terms of the number of projects built; however, the scale and economic importance of industrial plant projects are often much greater.

As of November 2012, the Alberta government listed 53 oil and gas, oil sands, and mining construction projects either proposed or currently under construction (Alberta Government, 2012). Industrial plant construction clients originate from sectors such as oil and gas, mining, power and electricity, and oil sands. As industrial plant projects are extremely complex in terms of designing, engineering, and construction, a fast-track method of construction is often applied for both modular and non-modular projects. Fast-track construction is a project delivery method in which industrial plant projects commence construction with generic scheduling information provided to contractors by the designers prior to design completion (Colarado University, 2012). The fast-track method ensures the reduction of construction time (Hadyll, 1997), however, provides a challenge to the contractor for scheduling construction activities as initial schedules often contain generic information. As industrial plant construction projects involve extremely specialized activities, such as the scheduling and use of multiple heavy lift cranes to place prefabricated modules (Lin & Haas, 1996), BIM was deemed to be an insufficient modeling system.

PCL Industrial Management, a large Canadian industrial plant contractor, recognized this issue and developed a Plant Information Modeling (PIM) system using 4D technology to visualize industrial construction schedules. By using the PIM system to create 4D animations for project schedule visualization, there are many benefits to all parties involved in construction. Some of these benefits are construction sequence is visually communicated to clients, construction activities are better understood visually than by traditional Gantt chart, scheduling can be modified prior to construction eliminating field errors, and field work can be communicated visually among various disciplines.

DEVELOPMENT OF 4D ANIMATIONS FOR SCHEDULE VISUALIZATION FOR PLANT INFORMATION MODELING

The developed PIM system is unique to industrial fast-track construction as it involves modifying an initial project schedule containing generic information to a more specific schedule that can be animated in a model. The development of the PIM system with 4D technology is an innovation of BIM used to create animations for industrial plant project schedule visualization. The modified schedule is obtained through exporting various construction activities by their activity codes (e.g., discipline, area) from the project schedule and implementing them into a database. In the database, activities are organized by criteria such as discipline, area, and elevation. Tasks that are considered irrelevant or cannot be animated in the model such as permit dates or material delivery dates are filtered out. This is carried out by creating customized queries. With all relevant tasks remaining, the earliest start and latest finish dates for each activity are obtained. From these dates obtained, the start and finish dates for the group of tasks are set (Leonard and Taghaddos, 2013).



DisplaySet	MinOf(*)Start	MaxOf(*)Finish
122_Equipment	28-Mar-12	30-Jul-13
122_Piles_Foundation	01-Dec-11	20-May-13
122_Pipes	07-Mar-12	13-Jun-13
122_Structural	08-Jan-12	11-Aug-13
125_Arch	06-Sep-12	03-Mar-13
125_Equipment	17-Apr-12	28-Mar-13
125_Piles_Foundation	05-Feb-12	01-Oct-12

Figure 1 – Developing visualized schedules (4D animation) for plant information modeling

Prior to animating the schedule, a link between the model objects and the modified schedule is required. Creating custom object filters allows the level of detail in the model to match the level of detail in the modified schedule. Once the modified schedule is implemented into the model, the filter matches the construction schedule activities with the respective model objects creating a link resulting in an overview animation of the project. For areas of higher detail, the schedule can be further modified to contain construction activities by elevation or by other types of details.

At this point, the implemented modified schedule in the model can be visualized in the form of a 4D animation. The 4D animation can be customized to show project areas of higher detail or an overview of the project. Furthermore, implementation of the schedule into the model also creates an information channel that allows simple updates of schedule and model information into the animation resulting in a more accurate animation.

There are many benefits to viewing project schedules in 4D. It can be difficult to look at a Gantt chart and understand the time frame of certain activities in relation to others. Furthermore, it is difficult to foresee conflicts with installation of materials or placement of equipment, for example. These issues are eliminated through visualizing the schedule in 4D. 4D visualization of schedules results in productivity increases through fore planning construction sequence, field errors are eliminated reducing costs, and equipment such as heavy lift cranes can be optimized accordingly. Another use of schedule visualization is during project bidding. Clients are increasingly interested in understanding a finished project and the construction sequence involved prior to financial investment. As many clients are unfamiliar with technical drawings and schedules, 4D animations provide the schedule in a visual manor that represents the construction sequence in an easy to understand format. To visually communicate the construction of a non-modular potash mine project to the client, the engineering department at PCL Industrial Management used the PIM system to create a 4D animation. The potash mine case study will be discussed to evaluate the benefits and successes of the PIM system to create a 4D animation for schedule visualization.

CASE STUDY

In 2012, PCL Industrial Management Inc. began construction on a large potash mine expansion project located in Saskatchewan. As the industrial project was extensive in both cost and scope, the fast-track method of construction was chosen. The engineering department at PCL Industrial management was faced with creating a 4D animation to visually demonstrate the project's construction process to the client. Thus, the PIM system was used to create the 4D animation successfully.

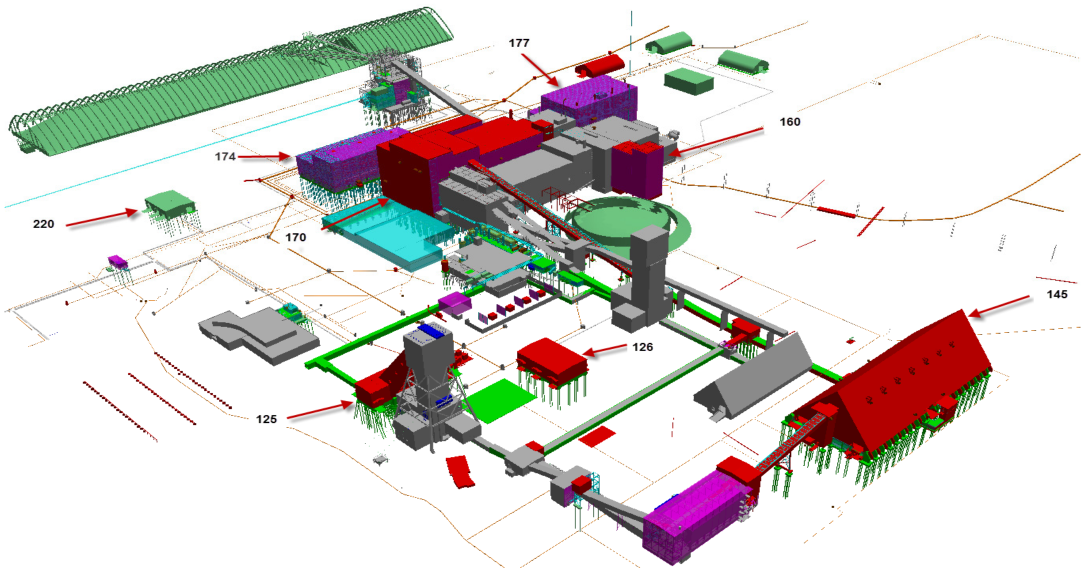


Figure 2 – 3D Model of the case study in SmartPlant Review

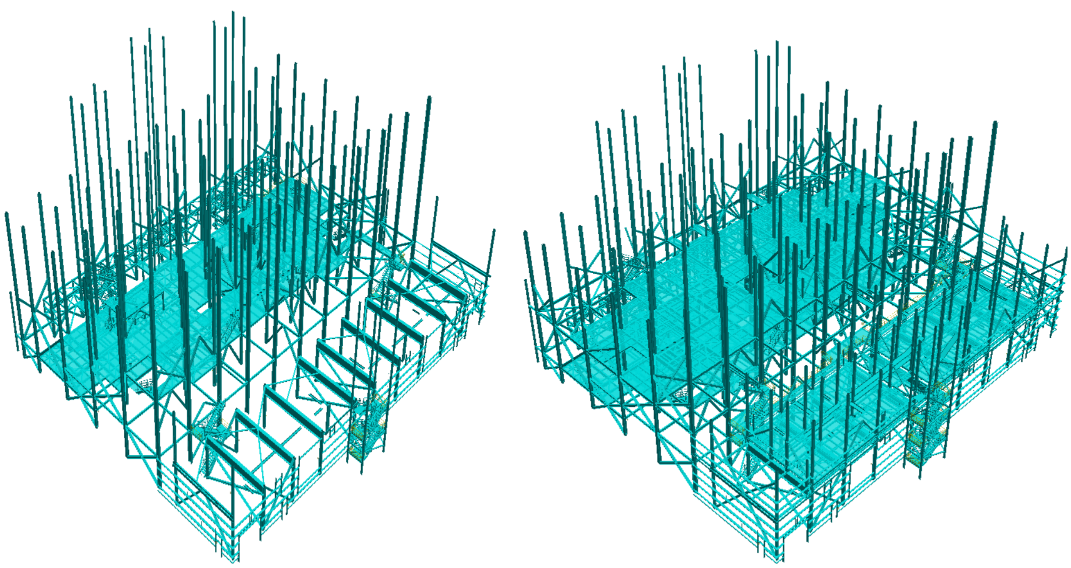
Initially, the raw project schedule was generic and contained irrelevant tasks that could not be animated in the model. To modify the schedule for animation, it was exported from Primavera (P6) into a Microsoft Access database. By implementing the schedule into the database, construction activities were organized and filtered for use in the model. As some tasks could not be modeled, such as material delivery dates, customized queries were created to filter out the irrelevant data. The useful data was then grouped by discipline, area, or construction work packages (CWP), and the earliest start and latest finish dates were used as the start and finish dates for each group. The modified schedule was then transferred into Microsoft Project format for implementation into the model. The modeling software used was SmartPlant Review (SPR), which is model viewing software for large industrial plants, developed by Intergraph. This software was used as the original model was created by the project designer in SmartPlant 3D, a design version of the software. Upon implementing the schedule into the model, SPR required the creation of multiple display sets. As with all 4D animation creation, the viewing software requires a link between model objects (known as Project files in SPR) and the schedule. The link, called a display set, was created in the SPR interface to establish the link between the modified schedule construction activities and their respective project files.

A properly created display set would link a task in the schedule to its project file. Display sets were created in the model based on multiple criteria. Some of the criteria that successfully created a display set in SPR were object colour, volume box (3D box in the model), object names, object location, other display sets, and metadata. As the model required a refreshing process upon initiating, these criteria allowed for optimal refreshing times. When creating display sets, prioritization was important. Prioritization was required to reduce internal SPR conflicts between display sets that may have contained similar data.

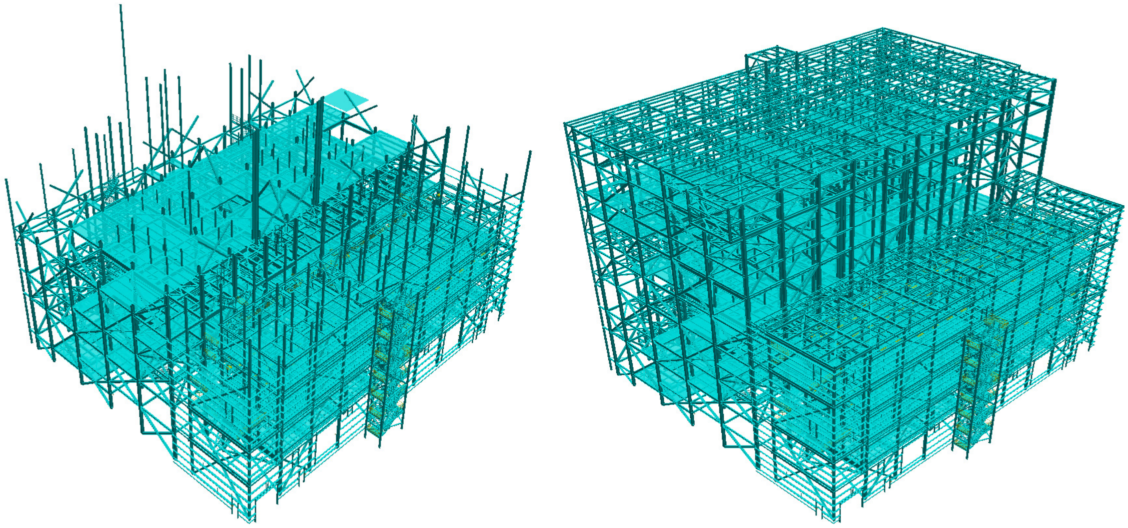
A specific area of the project that required a large amount of detail to be shown was the construction of three large buildings for the project. As the majority of work at site would be occurring at these three buildings, the client wanted to see a high detailed animation of this area. To animate this area in high detail, the erection of steel was organized in the schedule by elevation, and display sets were created in the model by elevation for each building (Figure 3).

Having implemented the schedule, the element of time was added. Naming a project in the model and customizing the animation for colours based on tasks in progress, tasks completed and non-grouped tasks was required to create the animation. Upon modifying the animation for speed, start and finish dates, wireframe or transparency of objects, the animation was able to be viewed. The animation was not exportable in SPR, thus a third party program such as Camtasia was required to record the animation.

The animation was successfully created as an overview of the project as well as the area of high detail. The animations were viewed by the project owner and were well received. The ability to view the project schedule in 4D allowed those unfamiliar with technical schedules to understand the construction process of the project as well as important milestone dates. The animations were then further used at the project site to coordinate between disciplines work that needed to be completed, material installation issues prior to entering the field, and scheduling adjustments. The overall benefits of increased production, increased visual communication, and reduced construction costs were well documented.



a) Volume 1 display set b) Volumes 1 and 2 display sets



c) Volumes 1,2,3 and 4 display sets d) All volumes display sets

Figure 3 – Structural display set divided by volume boxes

This case study discusses the use of the PIM system to create a 4D animation using SPR. To create an animation of a project schedule, a generic schedule is required for modification to create a schedule that can be modeled in 4D. Applying the modification to the schedule and implementing the schedule into a model is a similar process as carried out in SPR.

Similar modeling software platforms with animation capabilities, such as Bentley, Navisworks, and Synchro can create a 4D animation using the PIM system with. The requirements for an animation remain the same regardless of the platform used. The generic schedule is modified using a database to create a more specific schedule that can be modeled in the software. Integrating the schedule into the model is a similar process as the model requires a link between the schedule and the model objects to create the animation. The link custom created in the interface filters 3D objects and links the objects with their respective tasks in the modified schedule. Furthermore, the PIM system also successfully creates an information channel for model and schedule updates similar to SPR.

CONCLUSION

This paper evaluates the Plant Information Modeling (PIM) system successfully creating a 4D animation to visualize scheduled industrial construction activities. The PIM system summarizes the initial schedule in accordance with the level of detail required in the modified schedule, as well as the level of detail in the project model. At this point, schedule tasks are exported to a database and organized by their respective activity codes. Creating customized queries organizes construction activities by start date, finish date, discipline and elevation. Upon completion, the modified tasks are exported back into the same or different scheduling software.

Filtering the 3D model must occur; in the case study, this was carried out by creating display sets in SPR. Integrating the modified schedule into the model and creating a link between the modified schedule and the filtered model objects using display sets animated the schedule for 4D visualization. This PIM system in conjunction with 4D technology has the potential to visually communicate multiple aspects of a project schedule to various parties benefiting the industry as a whole.

Through evaluating a potash mine project, the real life benefits of schedule visualization are evident. Upon viewing the 4D animation, the client was extremely satisfied with the progress of the project and the representation of the final product. The animation successfully represented the construction progress in a manner in which those unfamiliar with technical schedules were able to understand. Furthermore, the animation was successfully used at the project site to plan construction activities and prevent errors prior to reaching the field. The field use of the animation was updated accordingly for accuracy and changes using the information channel created by the PIM system for schedule and model updates. The benefits of using the PIM system to create a 4D animation for schedule visualization are increasingly benefitting construction scheduling at PCL Industrial Management. The adaptability of the PIM system for various modeling reviewer software is also beneficial to users interested in visualizing the project schedule in other software. There are some current limitations to the PIM system such as the lack of automation implementing schedule and model updates. Currently with each schedule update, the scheduled requires re-implementation into the model. Also, with model updates frequenting as often as once weekly, the system requires an individual to download updates from a database into the model, sometimes requiring a significant amount of time. Future work looks to develop an automated process for model and schedule updates as well as further development and use for visualizing project schedules in 4D during project bidding and for field purposes.

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