ZACHRY

TRILLIUM ADVISORY GROUP
a Zachry Group company

Golden Pass LNG Export (GPX) Project

4D Case Study

TABLE OF CONTENTS

4 Introduction

5 4D on the Golden Pass LNG Export (GPX) Project

8 Other Applications of 4D Planning

10 Benefits of 4D Planning on the Golden Pass LNG Export (GPX) Project

12 Conclusion and Summary

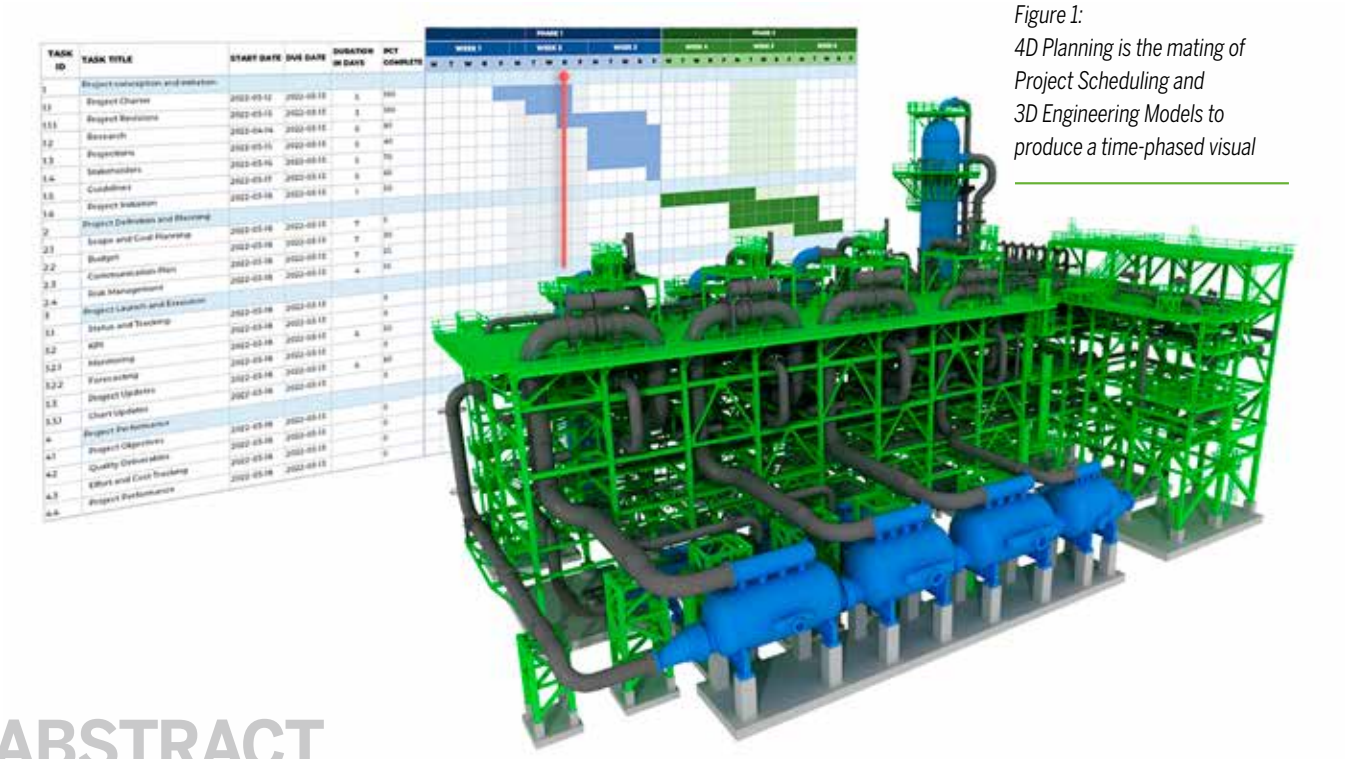


Figure 1:
4D Planning is the mating of Project Scheduling and 3D Engineering Models to produce a time-phased visual

ABSTRACT

As a pioneer and pacesetter in industry digitalization, Zachry Group and its subsidiary, Trillium Advisory Group, as one team, are constantly striving to innovate and improve project outcomes.

To enhance site productivity and produce engaging visuals for stakeholders on the Golden Pass LNG Export (GPX) Project, the team has deployed 4D Planning technology. 4D Planning combines project schedule data and an existing 3D model to produce a time-phased visual of the construction execution sequence. With the generated visuals, the project team can present concise and informative animations to accurately reflect the planned path of construction to the owner and other project stakeholders.

This case study focuses on the technology of 4D planning as well as the specific utilization and measurable benefits to the GPX Project achieved through the deployment of this solution.

INTRODUCTION

4D Planning is an industry practice that combines the 3D model with the project schedule, producing visuals highlighting the scheduled path of construction and component installation sequence in a 3D space.

The generated visuals can provide, at a glance, the construction sequence as well as help identify any apparent issues. Traditional construction scheduling software relies on Gantt charts to visualize the sequence of activities. However, with complex projects, multiple dependencies, and detailed construction scheduling, schedules with hundreds of pages are now the norm and can be extremely difficult to follow. The practice of 4D planning allows the Gantt chart to be visually transformed into a 3D space, allowing a simple understanding of visuals suited for time-constrained managers and stakeholders who may be unfamiliar with Gantt charts.

4D planning requires a 3D model to be established and detailed. Model generation begins during front-end design. As engineering progresses, the 3D model will iteratively gain maturity and include a greater level of detail. Common attributes must be defined at the project kickoff to mate the project schedule successfully and repeatedly to the 3D model. The agreement of common attributes will ensure ease of linking between schedule items and elements in the 3D model.

4D ON THE GOLDEN PASS LNG EXPORT (GPX) PROJECT

Prior to the GPX Project award, Zachry Group established a team to ensure the project could be executed using the latest innovations in the construction industry. The Company's industry-leading Advanced Work Packaging (AWP) process was was identified and tailored for the GPX Project with support from the complete team of project owners and other joint venture (JV) contractors.. With the implementation of the AWP procedure, construction leadership met with the engineering contractor and established a standard work package nomenclature for the project. This standard ensured that the Construction Work Package (CWP) would have the same naming convention as the resulting Engineering Work Package (EWP).

Establishing a standard nomenclature allowed for schedule activities and 3D model attributes to have a common reference, simplifying the process of creating relationships to facilitate the 4D planning process. 4D planning was deployed on the project using standard construction scheduling tools and 3D modeling software. Exports from these systems were combined in specialized 4D modeling software allowing for animated visuals of the schedule to be generated.

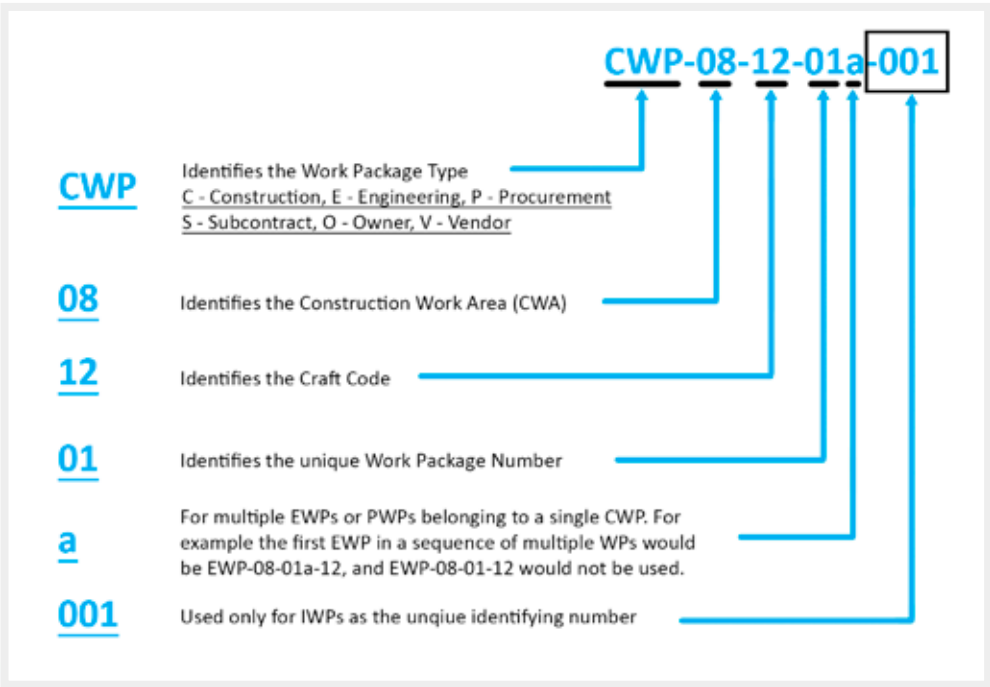


Figure 2:
Zachry AWP procedure naming convention

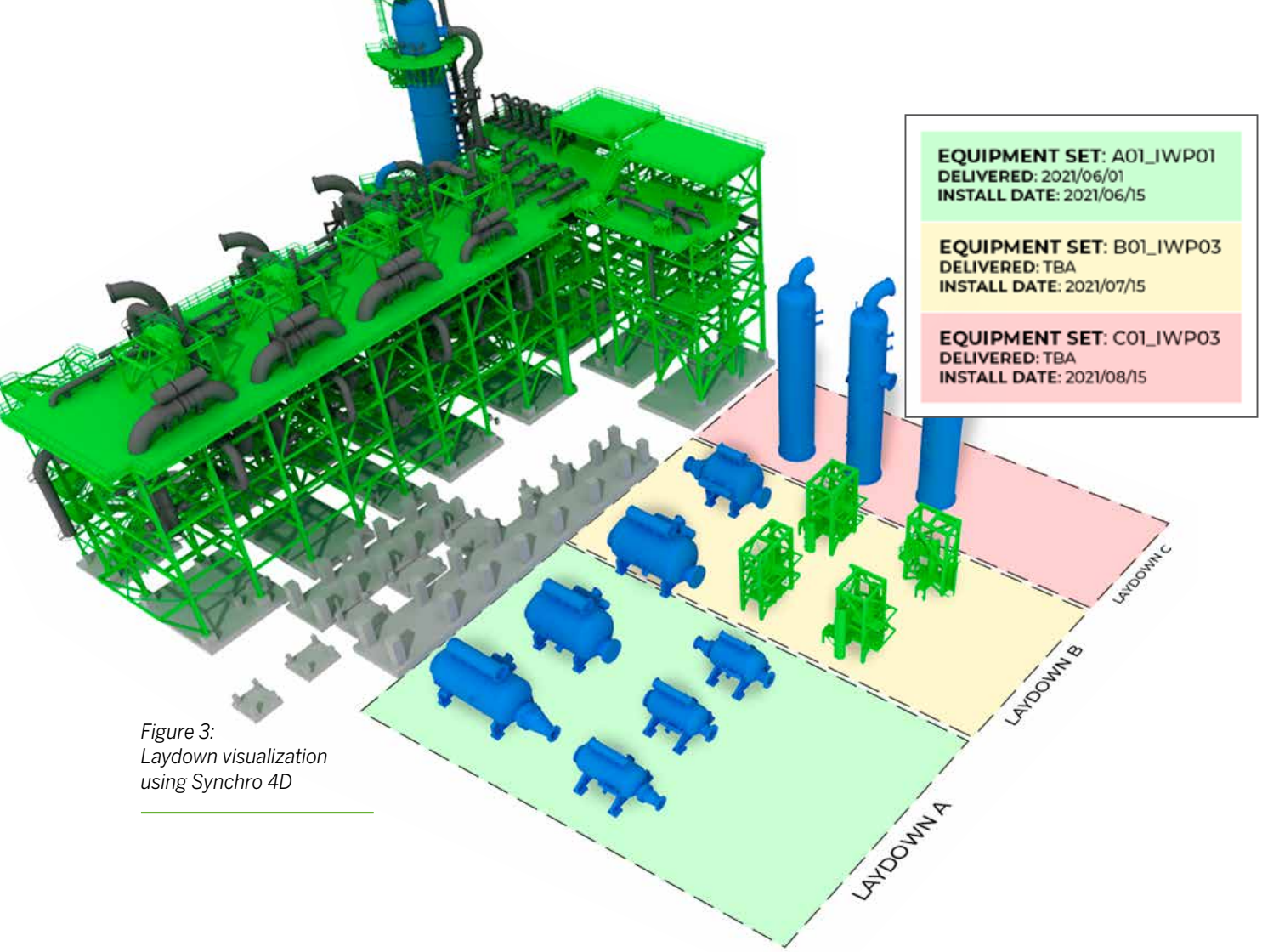


Figure 3:
Laydown visualization using Synchro 4D

One of the earliest applications of 4D Planning on the GPX Project site was creating simulations for laydown planning. Utilizing the construction schedule and a simple 3D model of the laydown yard, a time-phased visualization was produced. Arrival sequences of major equipment, materials, and common infrastructure such as trailers were then visualized in 4D, showing the progression of the laydown area usage. Crews reviewed the visualization with the material management team and their supervisors to ensure an understanding of the schedule and constraints caused by physical congestion. Where possible, elements from the 3D model, such as major tagged equipment, were used in a major off-site laydown yard simulation to help understand how best to use the space available.

Vendor Work Packages were used to determine arrival dates, and visuals were created to ensure sufficient space for all expected arrivals. An estimated footprint was inserted into the visualization for space constraint purposes for items not in the model, such as loose piping and structural steel. Any changes in arrival dates from vendors required adjustments to the 4D visualization to ensure the laydown maintained sufficient space.

As construction proceeded through the COVID-19 pandemic, Zachry and the project JV partners recognized the need to rebaseline the project schedule due to changes to the initial work scope. Due to the contractual nature of the rebaseline, along with the large scale of the project, the rebaseline process was a massive undertaking requiring collaboration from all stakeholders. To ensure changes to the schedule could be easily and quickly understood, the project team produced simulations using 4D planning techniques.

Firstly, the 4D model was reviewed for constructability purposes to ensure the proposed rebaseline was logical and followed the established path of construction.

Any out-of-sequence activities were quickly identified and corrected. To present the rebaseline proposals to project stakeholders, the same visuals were shown to illustrate any changes between the rebaseline compared to the initial baseline schedule. The visualization allowed stakeholders to easily visualize and understand any changes made to the schedule, significantly improving schedule understanding.

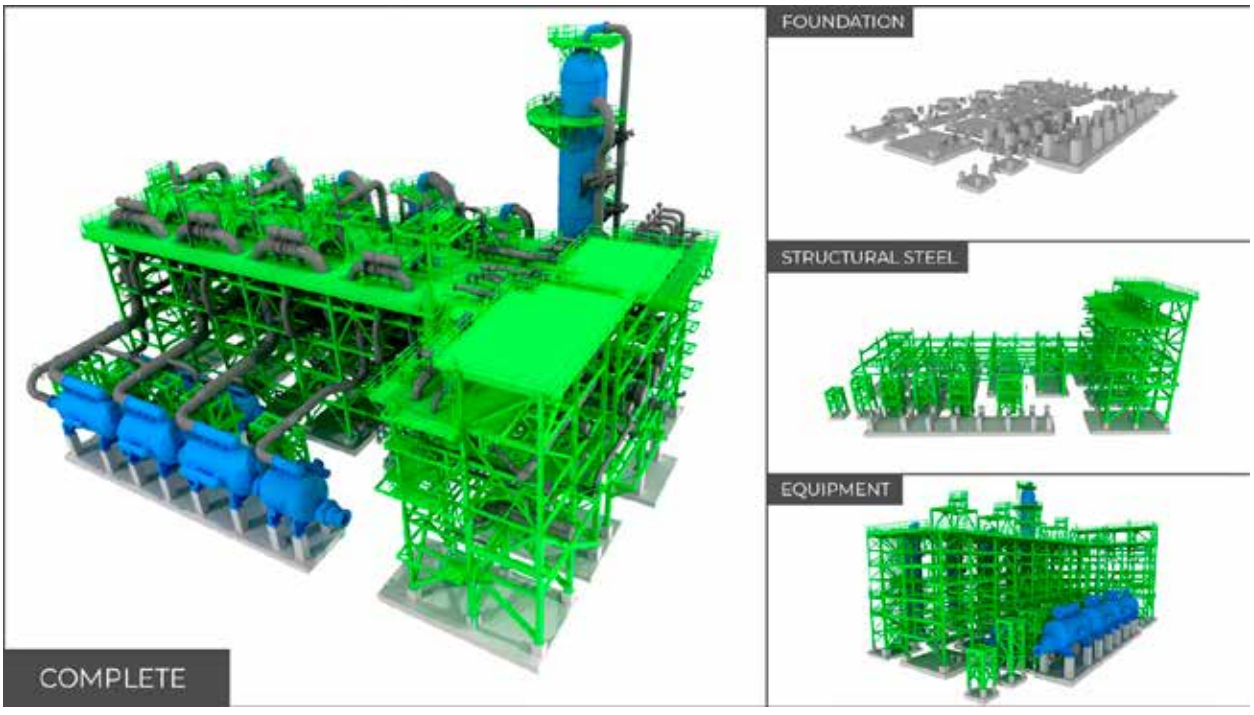
OTHER APPLICATIONS OF 4D PLANNING

A valuable application of 4D planning is the coordination between trade disciplines within a congested area such as a building, or under a pipe rack.

For the visual outlined in Figure 4, various disciplines have overlapping work within a small area. Utilizing 4D planning, the team planned out the sequence of work, including civil, steel, piping, and major equipment. Construction supervision was, and continue to be, engaged throughout the planning process to ensure that all trades understand the planned sequence. 4D planning-generated visuals illustrate the exact sequencing of activities and allow for common sense sequence verification and detailed clash detection. During construction coordination meetings, the 4D visuals are relied upon by construction supervision to visualize the work and any clashes that may be present. 4D Planning allows for quick comprehension of schedule information in a visual format.

Utilizing this ability, the GPX Project team created simple visuals to accurately convey progress updates to major stakeholders. Using the 3D model and the progressed P6 schedule, the project team created color-coded visuals to relay progress status efficiently. In Figure 5 below, each color represents a construction status for the civil work on site. Instead of using the traditional percentage complete, an animation was created to illustrate progress for the main site.

Figure 4:
Visual progression from Synchro 4D

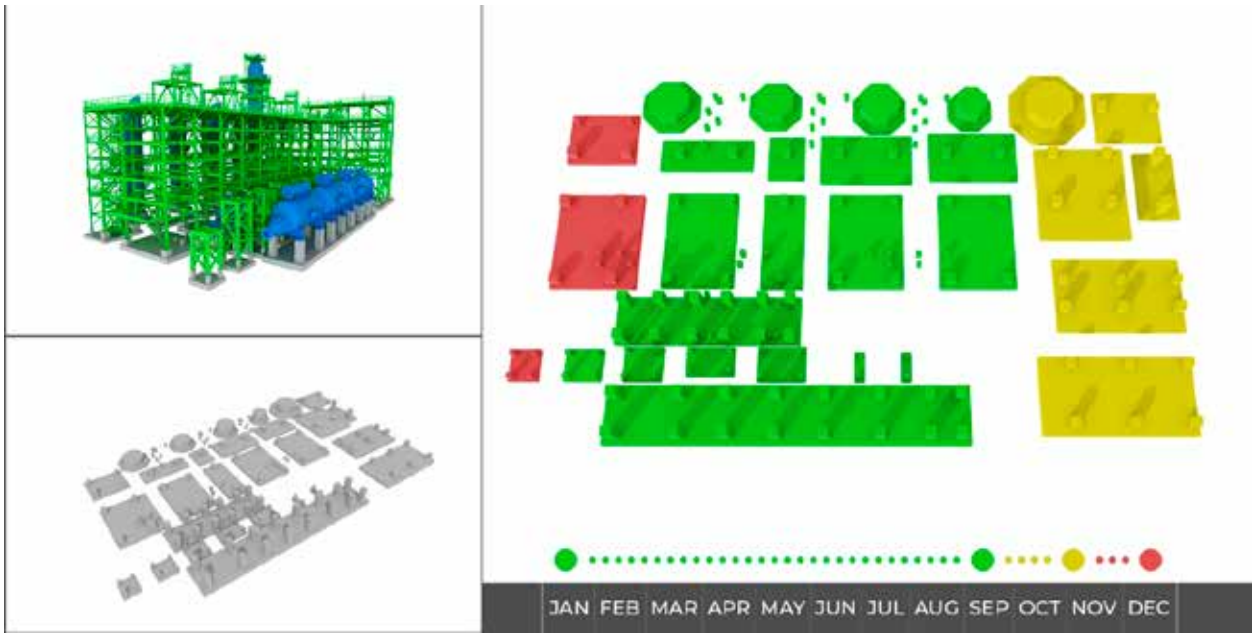


Utilizing the visuals within progress meetings significantly increased understanding and empowered stakeholders to identify risks and opportunities using a visual tool for communication effect. These visuals also enabled the team to clearly identify progress changes between each reporting period.

One challenge that the project team encountered was phase-based model maturity and its impact on the 4D planning process. 4D planning visualizations are limited to the existing level of detail in the 3D model. Throughout the early engineering phases on the project, the 3D model was not detailed (mature) enough to fully animate. Models contained all engineered elements, but details were not available and resulted in generic shapes as opposed to detailed design. The team developed the Model Progression Methodology (MPM) report to track model maturity.

With detailed reporting of MPM, project stakeholders could accurately schedule and track major model review milestones. As the 3D model increased in maturity, so did the visuals and details utilized in the 4D model. Once attributes were available in the 3D engineering model, links could be automatically created between the model and the schedule. This automatic property attribution allowed for quick updates of the schedule and 4D visualizations if model element attributions changed. This automated process is only possible by predefining the AWP naming nomenclature, including the nomenclature in the schedule, and having a detailed and mature model available.

Figure 5:
Progress visualization using Synchro 4D (Green is poured concrete, yellow is rebarred, and red is formed only)



BENEFITS OF 4D PLANNING ON THE GOLDEN PASS LNG EXPORT (GPX) PROJECT

The project has benefited greatly from the deployment of 4D planning.

The initiative is still ongoing, so the final impact is not yet known. However, the average time to produce Installation Work Packages (IWPs) using 4D planning and work package automation tools has been reduced from the expected 8 hours to 2 hours per package. The 75% time savings per package represents a forecasted reduction of 120,000 resource hours in work package development time, or the equivalent of 14 full-time equivalent positions.

The project team implemented 4D planning to enable the team to view the work before they do the work. The 4D model is an integral planning tool within the construction team. The project team has conducted over 30 large group 4D model reviews, and even more small group model reviews. These reviews have contributed to a 35% increase in planned piping installation sustained rates with the confidence of an achievable schedule.

Further, a savings of 29,050 resource hours is forecasted within the scheduling team (three FTEs) because of the investment made in 4D planning. This substantial savings is driven by the reduction in scheduling time for work packages and the optimization of task planning with the ability to visually plan and review work sequences. Out-of-sequence tasks are easily identified and re-planned, which reduces the potential for downtime or productivity loss in the field. 4D planning is being incorporated into organizational planning processes, team members are being trained on solution deployment and use, and the process will become integral to success on future projects.

Using 4D planning tools to support the AWP program, the team clearly defined work package boundaries, optimized the construction work package execution sequencing, and optimized the construction schedule to achieve project schedule targets. Piping execution has particularly benefited from this optimization and the work performance factor for piping packages is currently 1.56 (earned/actual hours), exceeding the target by 0.9%.

BENEFITS OF 4D PLANNING AT A GLANCE
ON THE GPX PROJECT

FORECASTED REDUCTION OF

120,000

RESOURCE HOURS IN WORK PACKAGE DEVELOPMENT TIME

4D PLANNING REVIEWS HAVE CONTRIBUTED TO A

35% INCREASE

IN PLANNED PIPING INSTALLATION SUSTAINED RATES

SAVINGS OF

29,050 RESOURCE HOURS

IS FORECASTED WITHIN THE SCHEDULING TEAM (THREE FTES) BECAUSE OF THE INVESTMENT MADE IN 4D PLANNING

PIPING EXECUTION HAS PARTICULARLY BENEFITED FROM THIS OPTIMIZATION AND THE WORK PERFORMANCE FACTOR FOR PIPING PACKAGES IS CURRENTLY

1.56 EARNED/ACTUAL HOURS,

EXCEEDING THE TARGET BY 0.9%.

CONCLUSION AND SUMMARY

Along with the rollout of Zachry Group's AWP procedures, 4D planning on the Golden Pass LNG Export (GPX) Project allowed the pairing of the project schedule with the detailed 3D engineering model. The utilization of 4D planning enhanced constructability assessments while increasing productivity and safety on site.

Creating a 4D visual that is easy to understand allows for quicker schedule reviews and more accurate communication of complex project schedules to all project stakeholders. The rollout of the AWP procedure was a pre-requisite to the successes achieved via 4D planning on the project. The team wouldn't be able to link schedule activities to the 3D engineering model components without full cooperation and alignment on AWP nomenclature. The successes achieved through the use of these innovative practices on this project can be replicated and applied to future projects, benefiting all project stakeholders.