

THE CONNECTED LNG LIFECYCLE: SIMULATION LINKING ENGINEERING, OPERATIONS, AND AI

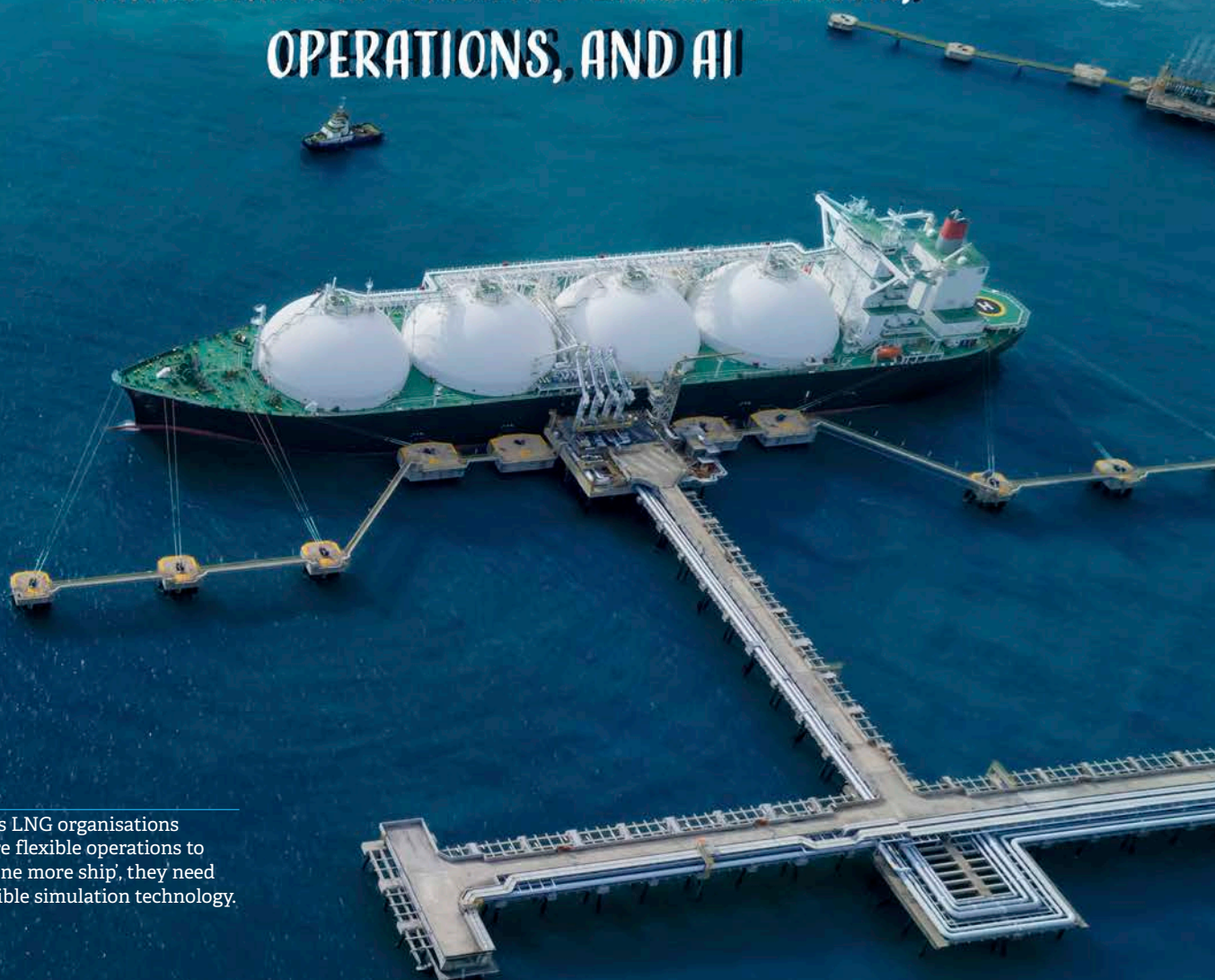


Figure 1. As LNG organisations explore more flexible operations to try secure 'one more ship', they need equally flexible simulation technology.

From design validation and operator training to real-time optimisation, lifecycle-ready simulation tied into a unified automation platform delivers speed, consistency, and reliability, says **Dawn Marruchella, Emerson, Vice President for Emerson's Guardian Software and Solutions Business.**

The demand for LNG is increasing at a pace that nobody could have anticipated just five or 10 years ago. Today, the world has over 400 million tpy of production capacity, and experts anticipate another 150 – 250 million t will come online by the end of 2030.

To meet these intense goals, LNG companies have accelerated expansion, developing new projects at a staggering pace. Consequently, they are shifting focus on how they deliver those projects to help

ensure success by eliminating the challenges that hamper traditional project implementation (Figure 2).

One such shift can be seen in project design. While many organisations are still building traditional 5+ million tpy mega-trains, others are moving towards a more modular model, constructing many smaller trains that can start up much faster and deliver quicker return on investment (ROI). This frees up capital for further investment, empowering companies to deliver the same final output, but with cash flow spread out over a more manageable period of time.

However, modular build styles, small-train replication, and compressed schedules all create engineering and staffing strain. Moreover, LNG plants typically operate with lean crews and no buffer, meaning that from the very first moments of operation, the stakes for successful processes are incredibly high. Therefore, organisations need solutions to help them reduce schedule risk and operational risk simultaneously so they can succeed in this increasingly challenging environment.

Fortunately, a solution exists. Simulation software designed as part of a seamless technology portfolio can tie planning, project engineering, operator training, and lifecycle operations together. Such a strategy provides a lifecycle tool that delivers continuous value from final investment decision through decades of continuous operation.



Figure 2. LNG operations are complex, a factor that is only increasing as project timelines are accelerated.

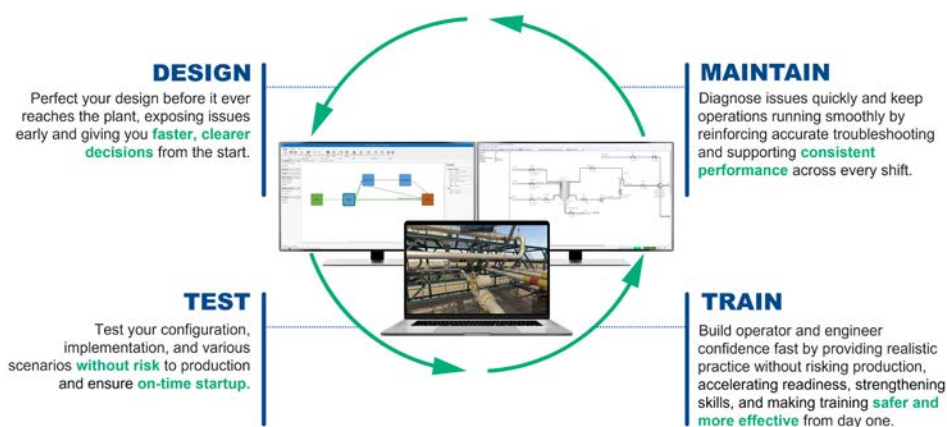


Figure 3. Lifecycle integration is key to driving the most value from a simulation investment.

One model, many purposes

Today's most advanced automation solutions providers are not designing simulation software as a standalone product, but rather as part of a seamlessly integrated enterprise operations platform (EOP). An EOP is a software-defined, operations-ready digital automation platform designed to unify, modernise, and optimise industrial operations across plants and enterprises. When organisations view their simulation investment as part of an EOP-centric, lifecycle-focused architecture, simulation software evolves from a single-use project tool into a technology that supports LNG operations from end-to-end across the lifecycle, delivering far greater ROI.

The key is selecting software designed to make simulation the connective tissue of the entire LNG asset lifecycle. When process and equipment configuration from steady-state models can be seamlessly integrated into dynamic simulation software, teams reduce rework and preserve continuity. Those dynamic models can be used for testing, tuning, and optimisation before the project starts to ensure seamless transition between project phases. In parallel, the dynamic models can be used for operator training to ensure operators are up to speed on day one of operation. After the plant starts up, the models continue to deliver value as a safe and efficient test bed for process optimisation and continuous training, even as equipment and operations change.

In the EOP environment, simulation tools are seamlessly integrated with other automation software. Ultimately, a single evolving model becomes a collaboration sandbox for process engineering, controls, operations, and maintenance. Every change – graphics, advanced process control, state-based control, safety logic updates, and more – can be tested first, eliminating risk and error at every stage, while speeding project execution and increasing uptime during operations.

In short, lifecycle integration avoids siloed simulation that dies on the vine after commissioning (Figure 3).

Designing right the first time

Like many industries, LNG manufacturers are finding deep expertise to be increasingly rare. Project engineers are often less experienced and need more support than their predecessors, many of whom have retired in the last decade. Moreover, even if an organisation can find engineers or bring them up to speed quickly, today's workforce is more transient,

so they are likely to move on well before the passing of a decade.

To address this and related issues, simulation tools provide an intuitive environment in which modern digital workers can upskill quickly to design projects faster and with more confidence. Early-phase design simulation on steady state models supports engineers in their design workflows, helping teams ensure 'right-the-first-time' engineering.

This capability becomes increasingly valuable with more modular projects, where the need for inter-module testing is increased. With simulation software designed as part of a seamlessly integrated automation ecosystem, the ability to import process and equipment configuration from steady-state models helps teams navigate modularity. Simulation also helps ensure package vendors and engineering, procurement, and construction teams have shared expectations.

In addition, teams can use dynamic simulation software to perform virtual factory acceptance testing and commissioning to accelerate timelines. Performing all these tasks in advance also helps avoid late-stage surprises that destabilise budget and timelines.

People are key

While LNG processes rely heavily on automation, human operators are the first pillar of LNG production reliability. Like engineers, however, experienced operators are increasingly hard to find and retain. Organisations are employing an increasing number of inexperienced personnel who must be upskilled quickly for the plant to meet its operational excellence goals.

In most cases, operators can easily be trained via a multitude of methods to manage the steady state operations that make up most of their tasks. Operators rarely see upsets or unusual scenarios – such as start-ups and shutdowns – but when they do, they must respond instantly and flawlessly to preserve safety and productivity.

When organisations employ dynamic operator training simulation that is designed as part of a seamless automation portfolio, the system replicates real control room behaviour using the exact system interface operators will use on a day-to-day basis. That experience helps operators using the training system build instinctual responses and reduces cognitive load during real events. Operators are not translating similar experiences but instead relying on deeply ingrained muscle memory.

The most advanced operator training software leverages design simulation models to provide early access, empowering teams to start training operators well before equipment starts arriving on site. Fit-for-purpose operator training software also provides personalised, tracked training to ensure certification and currency, making the software a valuable tool well before start-up, and across the lifecycle, tracking operator readiness at every stage.

Feature-rich software delivers flexibility

Seamless integration is a critical competency for simulation software operating in the LNG environment. However, as project teams evaluate their options, there are other capabilities they should pursue as well.

LNG operations are a blend of many different technologies and processes. Consequently, an organisation's simulation software needs flexible fidelity to support the many different model types the organisation may need. Today's most advanced simulation software offers this flexibility, providing high fidelity dynamic modelling for critical equipment, along with medium fidelity options to scale simulation across the balance of plant assets (Figure 1).

In addition, that same blend of technologies means that an LNG organisation will likely implement many different solutions across the plant over its lifecycle. Ensuring the simulator can manage vendor-agnostic control system simulation and programmable logic controller (PLC) integration helps teams ensure that they can model any of their critical operations, regardless of the systems controlling them.

Because outdated simulations lose value quickly, LNG's dynamic operating environments also demand simulation solutions that can be easily updated. The most advanced simulation software provides intuitive synchronisation features to quickly and easily bring plant models in line with the actual operating environment, even as changes are made to meet evolving needs.

AI brings lifecycle acceleration

As the rise of industrial artificial intelligence (AI) continues, the value proposition for simulation software in LNG increases dramatically. First and foremost, automation suppliers are already developing AI tools to accelerate model creation. These intuitive AI support tools will ingest historical data, design documents, piping and instrumentation diagrams, and more to help engineers automatically develop configurations. Moreover, the same tools will be able to consume new documentation and historical data as it becomes available to automatically update simulation as the plant evolves.

As these AI use cases emerge, it will become increasingly important to have simulation software built on the same EOP as the organisation's other automation solutions. With the seamless AI-ready connectivity offered by an EOP architecture, AI will become the connective tissue that bridges simulation, real plant data, and engineering and operational intent. Repeatability, faster configuration, and standardisation will become the rule, rather than the exception.

Simulation is foundational to LNG's competitive future

Today, simulation accelerates capital projects, strengthens operator readiness and capability, supports safer operations, and enables faster and more effective digital transformation. When implemented effectively as part of a lifecycle initiative grounded in an integrated platform, simulation software also empowers teams to move from project-centric models to continuous lifecycle optimisation, helping support operational excellence at every stage, while dramatically increasing ROI.

In coming years, AI-enhanced simulation will supercharge operations, further defining the next generation of LNG engineering and operations, and becoming a core element of competitive advantage in an increasingly challenging marketplace. In an industry where speed and reliability define competitiveness, lifecycle-ready simulation is no longer optional, it is foundational. **LNG**