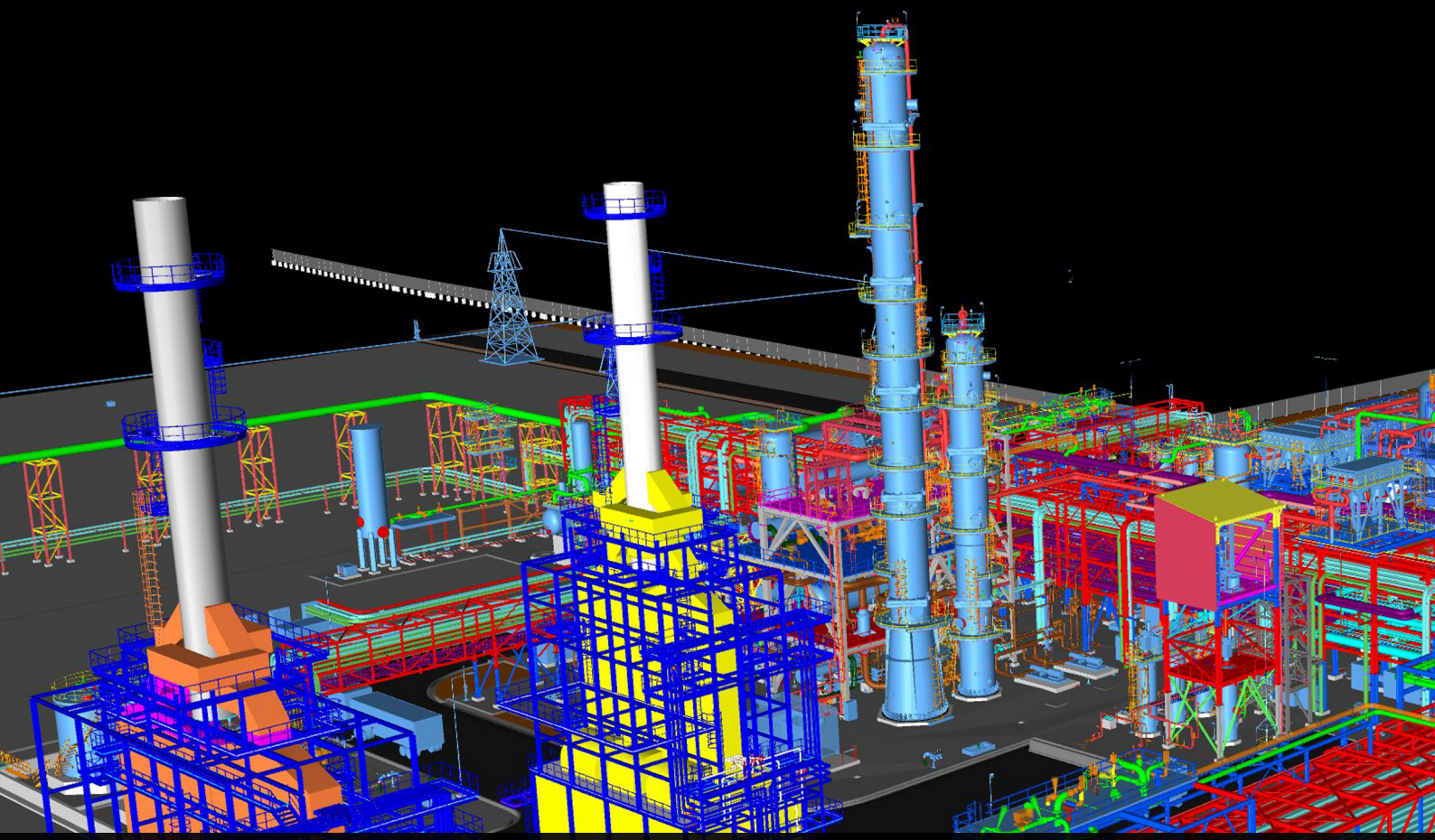
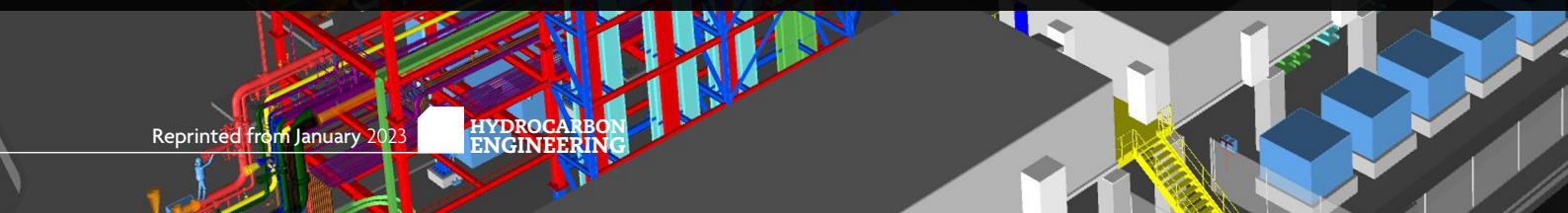
A VIRTUAL WALK-THROUGH



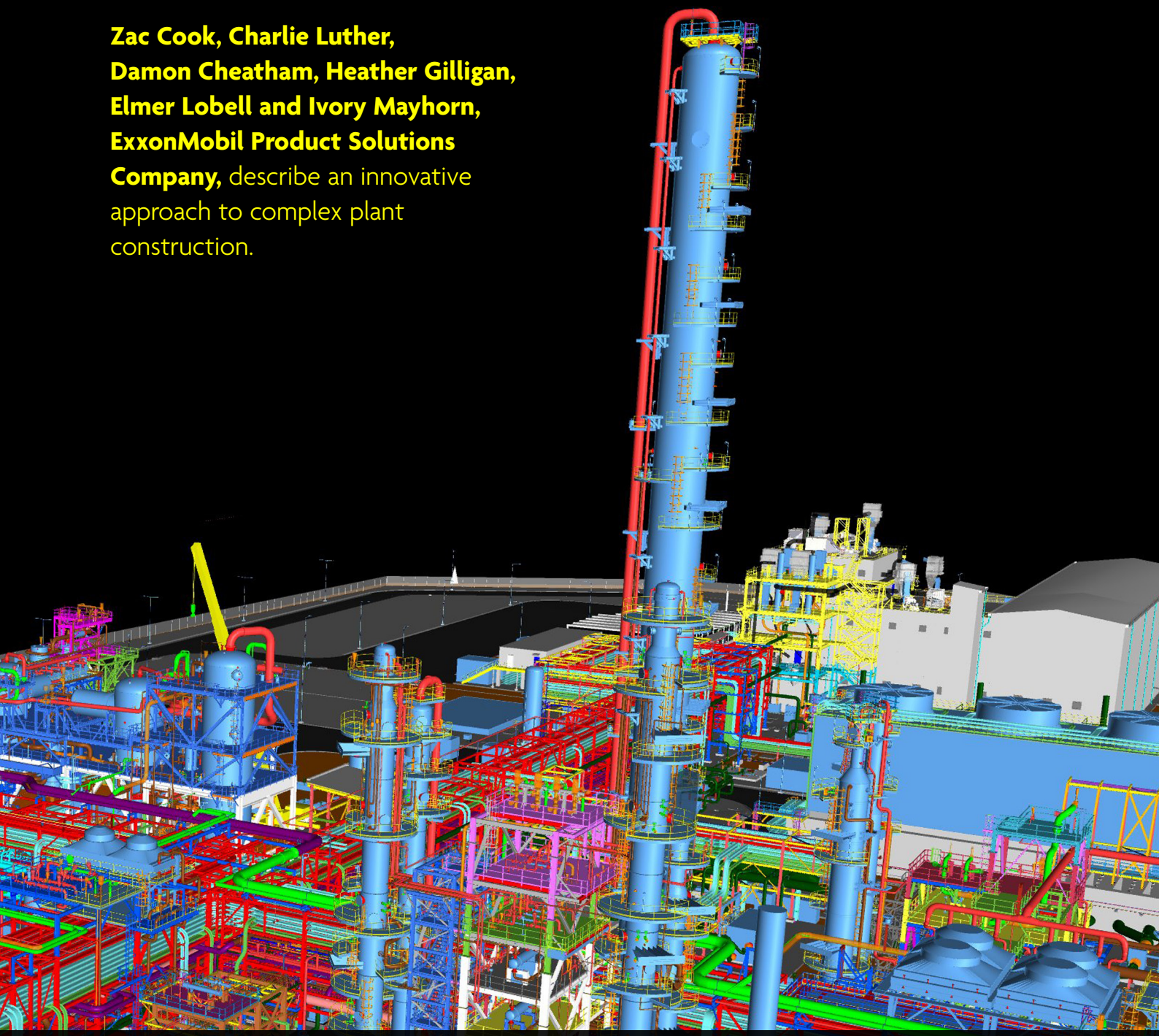
Walking through new processing plants affords facility owners a perspective previously unavailable during the design and construction phases. Until construction contractors complete and turn over projects, owners' access to physical assets may be limited to occasional site visits, if they occur at all. While construction is underway, crucial functions such as model reviews, operator training, and safety planning must be conducted remotely, based on 2D depictions of equipment at shrunken scale. Additionally, some preparatory work must wait until after project completion, further pushing out the start of operations.

The ability to walk through a plant at any time during construction can expedite decision making and operator training. Yet, for obvious physical reasons, it is usually impracticable and possibly unsafe. Walking through a facility before construction begins can greatly facilitate engineering and design, but such a concept seems altogether fanciful. ExxonMobil Product Solutions Company, a division of ExxonMobil Corp. (ExxonMobil), has figured out a way to do so – albeit virtually.

Using an evolving suite of immersive technologies and content-creation tools, technicians can virtually walk through the company's first linear alpha olefins (LAO) plant, taking shape in Baytown, Texas, US, every day – and have been doing so since before construction started. Able to collaborate to a much higher degree than before, they are finding themselves in a culture of innovation, and adhering to an ambitious schedule for a mid-2023 start-up of the 350 000 tpy facility.



Zac Cook, Charlie Luther, Damon Cheatham, Heather Gilligan, Elmer Lobell and Ivory Mayhorn, ExxonMobil Product Solutions Company, describe an innovative approach to complex plant construction.

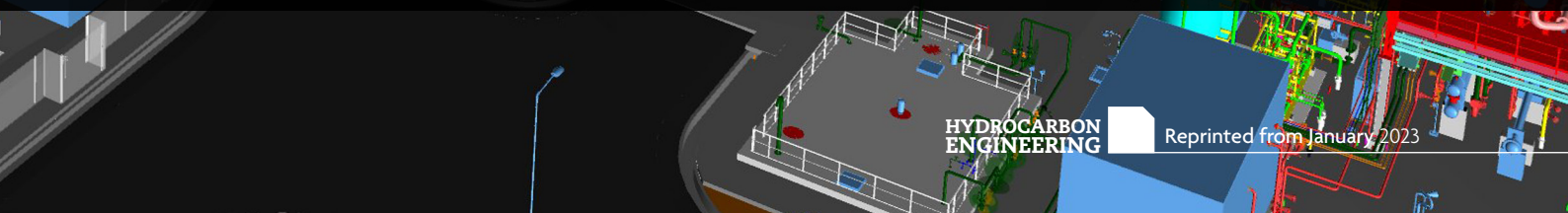


Meanwhile, plant operators are receiving training that otherwise would not have commenced until after facility completion, thanks to these new technologies. At start-up, they will have the skills to work safely and efficiently, and will be able to ensure the quality of 10 high-purity C4-C24-range products to be sold under the brand name ELEVEXX™. These tools are also enabling operators to develop detailed plant procedures much sooner than they could before, given their involvement at the design stage.

Although technicians and trainees do not walk through the physical facility while it remains under construction, they are able to walk through a comprehensive 3D engineering model adapted by an ExxonMobil application to support an immersive experience. When wearing special goggles, for example, a worker can 'enter' an up-to-date unit model at real-life scale, find emergency block valves, and locate switches to operate the valves even though the equipment is not yet in place, at any time.

With these technologies, ExxonMobil team members can update the 3D project model in real time, resulting in everyone involved in the project seeing the same equipment at the same time and in the same place. Additionally, project-specific training scenarios and simulations can essentially be designed at once, allowing plant workers to have the equivalent of hands-on experience with equipment that is still under construction.

The consequent time savings provided by these tools not only keeps the project on schedule, but also improves competency and subsequent reliability in the delivery of consistent, high-quality products. The LAO plant is part of a



US$2 billion expansion of ExxonMobil's Baytown chemical complex that also includes the addition of a plant to produce 400 000 tpy of VISTAMAXX™ performance polymers.

Immersion in the model

The application enabling this comprehensive engagement with the plant ingests large, complex, native 3D models with the click of a button, and outputs them into a real-time game engine, allowing users with wearable devices to physically experience a fully-immersive virtual world. This experience occurs through a group of technologies generically known as extended reality (XR). Within that group, virtual reality (VR) presents a world that is wholly generated by a computer. Augmented reality (AR) overlays a representation of what physically exists now with virtual data or images to portray the future after additions or modifications are complete. Mixed reality (MR) works along the spectrum between AR and VR to essentially merge the virtual and physical worlds.

The ability to virtually walk through the plant before, during and after construction promotes collaboration among professionals working in offices in Baytown and Houston, US; Italy; and India, and fosters teamwork among experts who might once have had only limited opportunities to engage with one another and share ideas. Convenient VR technology provides unprecedented access to the 3D model, increasing the number of design improvements that can be made prior to construction. These immersive technologies are being – or will be – used at the LAO plant to carry out the following functions:

- Engineering and design.
- Model reviews.
- Procedure development.
- Rounds development.
- Maintenance planning and execution.
- Emergency-response planning and drills.
- Personnel onboarding once the facility is in operation.

Additionally, facility operators are receiving training offsite that otherwise would only be available through contact with physical assets. This is enabling them to quickly become highly competent even before new equipment and systems are in place. For instance, in terms of safety training, emergency scenarios that would otherwise be dangerous to attempt in the physical world can be re-enacted virtually.

Figure 1. Wearing virtual reality goggles, technicians at remote locations experience physical assets and 3D engineering models as if they are inside them.

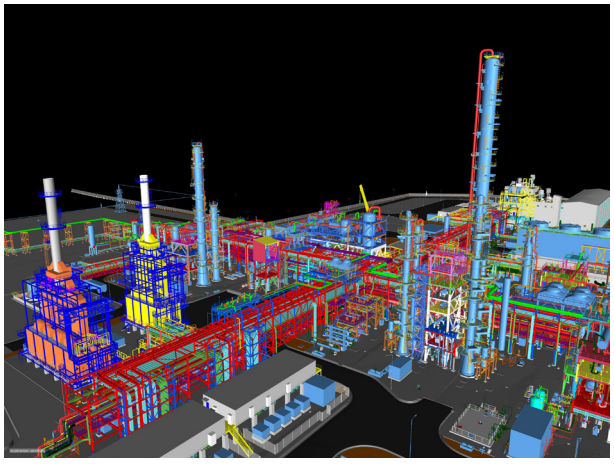


Figure 2. A 3D model of the Baytown Chemical Expansion Project facilities can be accessed and updated in real-world detail at any time, from any location.

The virtually-enhanced project

The LAO plant is part of the Baytown Chemical Expansion Project (BCEP), located in one of the largest and most technically advanced integrated petrochemical complexes in the US. The Baytown Complex occupies 3400 acres along the Houston Ship Channel, about 25 miles east of downtown Houston. Facilities include a 584 000 bpd refinery; a 1.5 million tpy ethane cracker; and a chemical plant capable of producing 700 000 tpy of polypropylene, 600 000 tpy of paraxylene, 125 000 tpy of butyl rubber, 50 000 tpy of synthetics, and other performance products. The BCEP is part of a 10 year, US$20 billion investment by ExxonMobil facilities fed by light crude oil, natural gas, and natural gas liquids produced in the shale plays of West Texas and elsewhere, and delivered at growing rates by pipelines terminating on the gulf coasts of Texas and Louisiana.

While other ExxonMobil projects have made use of XR and related technologies, the Baytown LAO plant – in addition to being the company's entry into a new market – is the first to fully integrate immersive tools into planning and design, construction management, and training – before and after start-up.

Multidisciplinary collaboration made possible by the technologies has revolutionised project management and compressed engineering design, construction, and commissioning timelines. In past projects, viewing a 3D model required a trip to the contractor's office. Now, everyone working on the project has real-time access to 3D models through tablets and computers.

With constant feedback, model review is continuous, and everyone sees updates as they occur. In earlier large projects, 40 – 60 technicians might meet for a week to review the model when the project is 30% complete. At 60% completion, the group would meet again and spend twice the amount of time on the review. They would then repeat the process at the 90% completion marker. This time and number of iterations were necessitated by the difficulty of working

through myriad project details with data in spreadsheets, and models projected onto 2D screens.

Immersive technology speeds up decision making in countless other ways. At the LAO plant, the question arose before construction began as to whether workers would have enough room to move through a unit in order to access a valve. Previously, the team would have spent time researching design documents and trying to measure the passageway. Armed with the new technology, a team member put on a VR headset, walked through the unit virtually, and immediately determined that the real-world valve would be accessible.

Figure 3. On demand, immersive access to the 3D engineering model facilitates unprecedented levels of collaboration and innovation during plant design and construction.

Figure 4. Using immersive technologies, technicians relate physical assets as they exist now with 3D depictions of the facilities as they will be after construction or modification.

Figure 5. With laser scanning, a technician with a tablet can update the 3D model as physical equipment is installed during construction.

Virtual walk-throughs also allow workers to more easily identify details that could potentially turn into hazards after start-up. For instance, by looking at the interior of a virtual asset, operators can quickly spot low-hanging equipment that might result in head bumps, and relocate them before installation.

During a virtual walk-through of the Baytown LAO construction site, technicians noticed a safety valve on a 150 psi steam pipe bolted to a top-level structure close to a potential work area. A design tweak moved the valve higher up and away from where it could have represented a potential hazard. Another virtual walk-through prior to the start of construction revealed an area where exits would be less accessible in the event of an emergency. While the issue would have been identified later in the project under traditional procedures, at that point it would require the expenditure of time and money for rework. With the virtual walk-through, a quick redesign solved the problem. These are just two among innumerable instances in which the ability to experience the LAO plant in 3D and at scale pre-emptively solved problems that would have been difficult to spot on 2D documents and computer screens.

Immersive technologies facilitate collaboration among all involved in the project through every stage of work by making the continuously-updated, virtual 3D model broadly accessible and comprehensible across disciplinary lines. The ability to append metadata to the 3D model ensures that the various project teams all share a common view of what the plant looks like in relation to construction as work progresses from bulk construction to system construction to commissioning and, finally, to start-up.

As the LAO plant approaches commissioning, ExxonMobil workers are using the immersive 3D model to:

- Write commissioning plans in more detail than would have been possible without the technology, in order to produce job packs that include descriptions of pipe spools, temporary equipment, and other utilities needed to execute the plans, for example.
- Write operator procedures.
- Set detailed schedules providing improved visibility of the critical path and optimising the scope of work.
- Interface continuously with the construction organisation to map coexistence plans during turnover.

Streamlining of project workflows has enabled ExxonMobil managers to be aggressive with timelines and confident about on-time start-up. Especially important to time savings is the unique contribution that the technologies make to training.

Learning inside the 3D model

ExxonMobil's immersive technologies package includes a content-creation application with which users generate fit-for-purpose training scenarios with onscreen actions analogous to dragging and dropping in PowerPoint. Trainers can, for example, create scenarios involving lock-out/tag-out, leaks, and emergency responses. The gaming engine also enables

them to embed quizzes into the 3D model so that operators can encounter and respond to questions about the new facility as they walk through the immersive learning environment.

The ability to generate 'as-needed' dynamic simulations cuts creation time from months to hours. As a result, content-creation costs are estimated to be lower by a factor of 10. With the substantial cost reductions, field facilitators generate scenarios and simulations that they otherwise might not be able to do because of the expense. Trainees thus gain exposure to situations that they would have otherwise missed, and experience them virtually inside the 3D model without having to enter plant units during construction.

Because the immersive experience enhances learning, operator competency will be much higher when the LAO plant starts up than it could have been if training had to rely on traditional methods. This, too, has enabled the company to be aggressive with project timelines.

From digital garage to digital ecosystem

With a shared view of an emerging, complex plant inside of which they can virtually walk around at will, professionals involved in the project continuously find and communicate innovations that could not have been planned for previously. A byproduct of the resulting enthusiasm is the consistent confidence that this particular plant, with which the company has had no prior experience, will start up on time and work as designed.

The project-wide application of immersive technologies at the LAO plant is innovative but not experimental. ExxonMobil upstream units use immersive tools to study 3D models of the subsurface, for example. Additionally, broad application of the technologies at the LAO plant builds on more limited use of XR tools at other downstream projects of ExxonMobil affiliates, including an upgrade of ExxonMobil Oil Corp.'s 366 000 bpd refinery in Beaumont, Texas, to increase light crude distillation capacity by 65%. What sets the Baytown LAO project apart from others is that technicians there treat the virtual tools as a 'digital garage' accommodating continuous innovation for all aspects of the project.

Growth in the use of immersive tools for project management and operation occurs within a company-wide initiative to create a 'digital reality ecosystem', within which real-world assets and processes will have virtual counterparts that can be connected, accessed and shared in real time. Pushing the boundaries of technology in this way will improve ExxonMobil's operating assets from design through to construction and into operations, and further unleash workforce creativity. When the ecosystem is in place, a technician in Baytown will be able to not only virtually walk through the LAO unit, which by then will be long in operation, but they will also be able to walk through and do much more in facilities throughout the entire company. This is how a virtual digital technology would result in real-world improvements.

Note

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