Engineering resilience

A lifecycle guide to smarter offshore structures with simulation

You're leading the charge in offshore energy. Simulation helps you stay ahead.

The offshore energy sector is transforming fast. As global demand rises and the energy industry expands into offshore wind, you're being asked to deliver more: larger, more complex structures, faster timelines, tighter regulations, and ambitious sustainability goals.

You're navigating high-stakes decisions every day. A single design flaw or installation delay can cost millions—or worse, compromise safety and environmental integrity.

That's where simulation comes in.

Simulation gives you the power to model, test, and optimize offshore structures before they're built. It helps you reduce risk, improve performance, and make smarter decisions across the entire asset lifecycle, from concept to decommissioning.

In this e-book, we'll walk with you through each phase of an offshore project, showing how simulation supports your expertise with real-world examples, measurable outcomes, and strategies for scaling success across your organization.

Whether you're designing floating wind platforms or managing deepwater oil rigs, you're the one driving innovation. Simulation is here to help you do it with confidence.

Contents

The offshore asset lifecycle

You're responsible for resilient offshore assets. Simulation helps you manage them smarter.

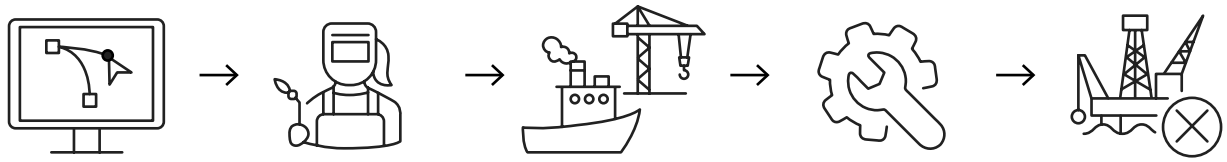
Every offshore structure you design, build, or maintain follows a complex journey, from initial concept to final decommissioning. Whether you're working in oil and gas, offshore wind, or marine infrastructure, this asset lifecycle spans multiple disciplines, harsh environments, and evolving regulations.

You're tasked with delivering offshore systems that are not only safe and cost-effective, but resilient enough to perform reliably over decades.

Managing this lifecycle holistically is key to success. From early design decisions to long-term maintenance strategies, each phase impacts performance, safety, and sustainability.

Simulation is your guide. It helps you understand, predict, and optimize every stage of the offshore asset lifecycle, so you can reduce risk, improve efficiency, and build structures that stand the test of time.

Offshore asset lifecycle



Design and analysis
Develop a safe, efficient, and cost-effective offshore structure

Fabrication
Construct the physical components of the offshore asset

Transportation and installation
Deliver and install the asset at the offshore site

Operations and maintenance
Ensure long-term performance, safety, and compliance

Decommissioning
Safely retire the asset and restore the marine environment

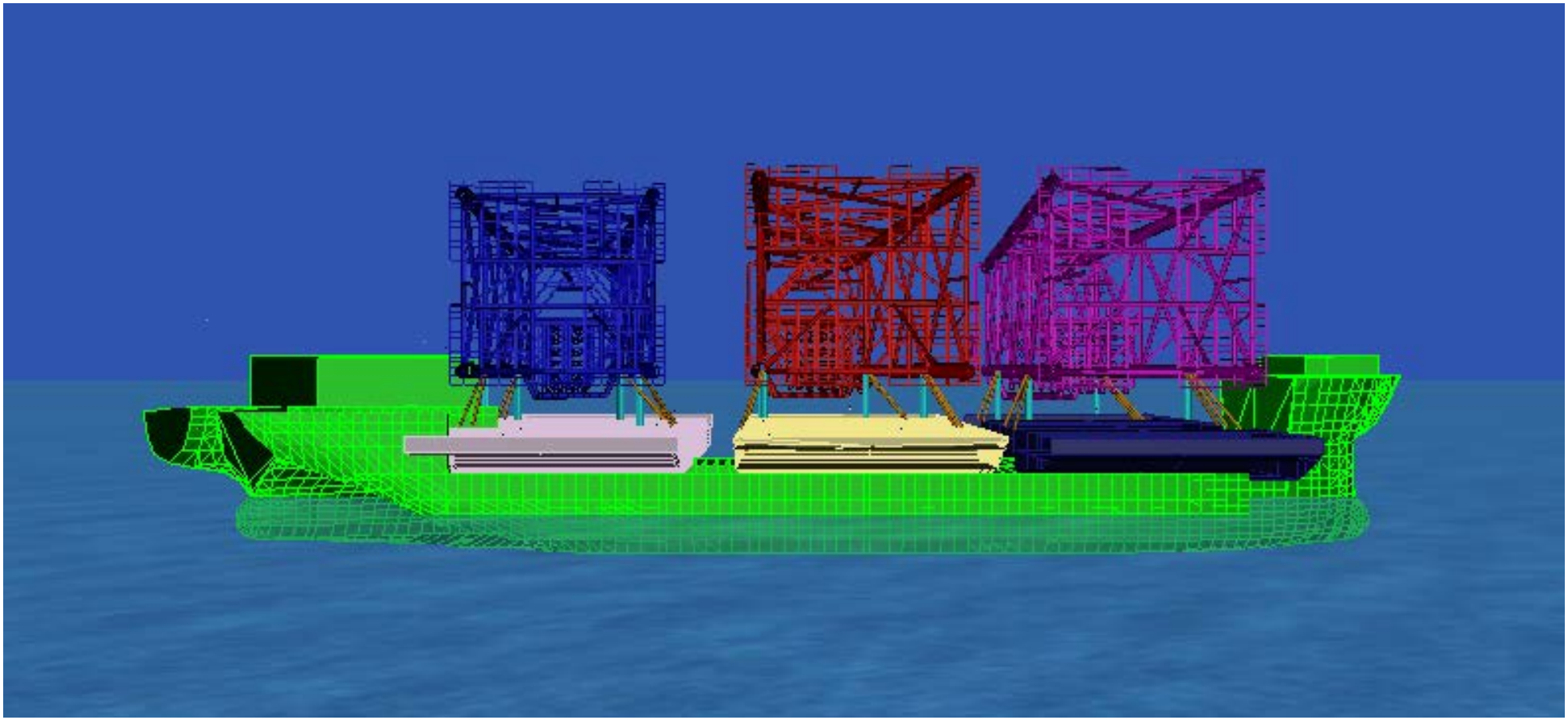


Image courtesy of Sapura Energy Berhad

What is offshore simulation?

You're designing for demanding conditions. Simulation helps you build resilient systems.

Offshore environments are unpredictable. Waves, wind, currents, soil behavior, and structural loads all push your designs to the limit. You need more than intuition to ensure your assets will perform safely and reliably. That's where simulation comes in.

Simulation is the digital replication of real-world offshore conditions, allowing you to predict how your structures will behave before they're built or deployed. You can test designs, validate marine operations, and uncover risks early—long before they become costly problems.

You're not just designing structures. You're safeguarding lives, protecting ecosystems, and proving that engineering can be both resilient and responsible. Simulation gives you the confidence to make decisions that matter.

Simulation empowers you to make data-driven decisions that reduce uncertainty, improve safety, and deliver resilient offshore assets that stand up to the elements and the expectations. It's not guesswork, it's physics-based prediction.

Why a lifecycle approach matters

You're managing complex offshore projects. A lifecycle approach helps you do it smarter and more resiliently.

Offshore projects are too important and too risky to be managed in silos. Yet traditionally, each phase of the asset lifecycle has been handled separately, leading to miscommunication, inefficiencies, and costly surprises. You deserve a better way to work.

By adopting a lifecycle simulation strategy, you gain a connected, end-to-end view of your offshore assets. This approach helps you:

- Improve coordination across design, installation, and operations
- Minimize rework and unexpected costs
- Strengthen safety and compliance
- Advance sustainability through smarter planning and resource use

Simulation acts as your digital thread, weaving together every phase of the lifecycle. It ensures data continuity, supports informed decisions, and enables long-term optimization so you can deliver resilient offshore structures that perform reliably for decades.

Design and analysis: engineering resilience from the start

You're designing for demanding conditions. Simulation helps you build resilient structures from day one.

The design and analysis phase is where your offshore project begins, but its impact lasts for decades. Every decision you make here—every load calculation, every material choice—shapes the safety, performance, and longevity of your asset across fabrication, installation, operations, and even decommissioning.

You're not just designing for today. You're engineering for decades of performance, safety, and resilience.

Simulation gives you the clarity and confidence to get it right from the start. With advanced 3D modeling and physics based analysis, you can model real-world conditions like waves, wind, currents, soil behavior, and structural loads before construction begins.

With simulation you can:

- Validate design concepts
- Uncover hidden risks
- Optimize for durability, safety, and cost-efficiency

Simulation lets you to make smarter, data-driven decisions early in the lifecycle, resulting in fewer surprises and offshore assets that are resilient from the ground up.

Key simulation capabilities:

- Static and dynamic structural analysis (SACS)
- Fatigue and collapse prediction (SACS)
- Hydrodynamic modeling and vessel motion analysis (MOSES)
- Load combinations and environmental condition testing (MOSES)
- Soil-structure interaction and foundation modeling (PLAXIS®)

Simulation-led design reduces manual design time and rework by up to 60% and helps ensure your structures are built to last.

Fabrication: from digital model to offshore reality

You're turning vision into reality. Simulation helps you build it right the first time.

Fabrication is where your offshore design becomes real. But in this high-stakes phase, even small missteps can lead to costly delays, quality issues, or safety risks.

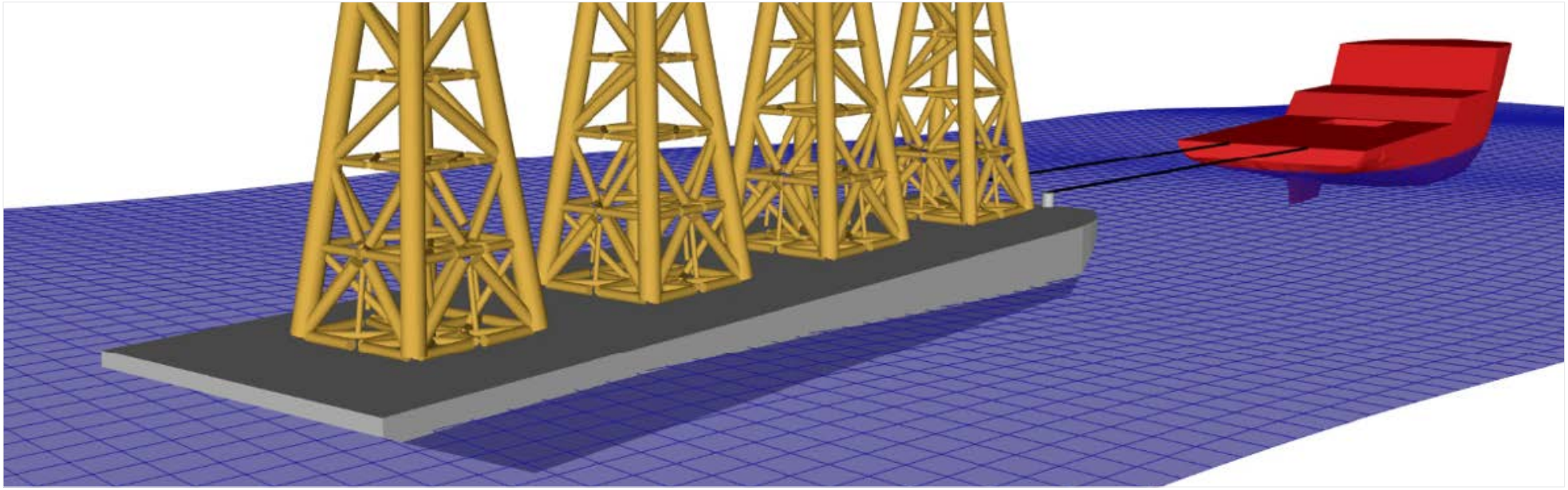
You need more than blueprints, you need confidence. Simulation bridges the gap between engineering intent and physical execution. You can validate construction plans, identify bottlenecks, and optimize workflows before a single weld is made. This proactive approach helps you:

- Ensure structures meet design specifications and safety standards
- Reduce rework and avoid costly surprises
- Streamline fabrication timelines and improve quality control

By simulating how your design will behave in the real world, you can deliver resilient structures that are built to perform, not just to spec.

Simulation supports smarter fabrication with:

- Weld sequencing and structural integrity checks
- Loadout and launch simulations
- Foundation behavior and soil-structure interaction
- Clash detection and constructability validation



Safer, more efficient transportation and installation

You're moving the impossible. Simulation helps you do it safely and seamlessly.

Transportation and installation are among the most complex and risk-prone phases of the offshore lifecycle. You're tasked with moving massive structures across oceans and installing them in unpredictable marine environments where timing, coordination, and precision are everything.

You're not just managing logistics. You're protecting lives, assets, and reputations.

Simulation is your strategic advantage. You can digitally model vessel dynamics, weather conditions, and installation procedures before assets ever leave the yard. This allows you to:

- Anticipate challenges
- Optimize execution
- Minimize risk tied to marine conditions, vessel motion, and narrow weather windows

From towing paths and lifting operations to floatover sequences and seabed interaction, simulation helps ensure structural integrity and safety from day one, so your offshore deployment goes smoothly, not stressfully.

Simulation capabilities for safer transportation and installation:

- Route planning and sea-state analysis
- Load-out and lifting simulation
- Installation procedure modeling
- Vessel dynamics and motion response
- Weather window optimization

Simulation can cut installation costs by 20% and reduce transportation time by over 50%.

Operations and maintenance: extending offshore asset longevity

You're responsible for offshore performance that lasts. Simulation helps you protect it.

Operations and maintenance is the longest and most resource-intensive phase of the offshore lifecycle. You're tasked with keeping structures safe, compliant, and high performing, often for decades in harsh marine environments.

It's not just about fixing problems. It's about preventing them.

Simulation empowers you to shift from reactive to proactive maintenance. You can model how offshore assets behave under real-world conditions, predict fatigue, assess damage, and plan interventions before issues escalate.

This means fewer surprises, lower costs, and longer-lasting, resilient offshore structures.

Simulation capabilities that support long-term asset health:

- Structural health monitoring and predictive maintenance
- Fatigue life assessment under operational loads
- Planning for retrofits and life extension
- Integration with digital twins for real-time insights

Rest assured that simulation can help accurately asses structural integrity and damage of an existing structure and can save millions of dollars in inspection and repair costs.

Decommissioning: the final chapter

You're engineering the end. Simulation helps you do it safely and sustainably.

Decommissioning is the last phase in the offshore lifecycle, but it's far from simple. You're tasked with safely removing, disposing, or repurposing massive offshore structures while minimizing environmental impact, managing operational risks, and meeting strict regulatory requirements.

You're not just wrapping up a project. You're protecting ecosystems, communities, and reputations.

Simulation gives you the foresight to plan with confidence. Model structural behavior, vessel dynamics, and environmental conditions to validate lift plans, towing paths, and removal sequences all before operations begin.

This proactive approach helps you:

- Predict structural response during disconnection and lifting
- Assess vessel stability and motion during removal
- Identify environmental risks and timing constraints
- Support regulatory documentation and stakeholder planning

Simulation ensures your decommissioning strategy is precise, compliant, and resilient, closing the lifecycle with the same care and engineering excellence that started it.

Image courtesy of Sinotech Engineering Consultants Inc.

Case study 1

Accelerating offshore wind design with cloud-powered simulation

Designing support structures for offshore wind turbines is a data-intensive, time-critical process. For the 295 MW Phase 2 of the Changhua Offshore Wind Farm in Taiwan, Sinotech Engineering Consultants needed to run 80,000 simulations to meet design and regulatory requirements. Traditional methods took 3.5 months and generated petabytes of data, threatening the project timeline and efficiency.

> "SACS provides solutions that can handle large, computing-intensive simulations—giving us confidence and control over every design decision."
>
> -Wan-Chien Kung, Structural Engineer, Sinotech Engineering Consultants Inc.

The solution

Sinotech turned to SACS and SACS Cloud Services to transform their design workflow:

- Executed 2,000 concurrent time-history simulations in the cloud
- Reduced post-processing by downloading only critical design results
- Streamlined model complexity by minimizing degrees of freedom (DOFs)
- Enabled efficient collaboration between foundation designers and turbine suppliers

This was the first offshore wind turbine generator (WTG) detailed design project led by a local Taiwanese team using SACS.

The outcome

- Design time reduced by 60%, from 3.5 months to just 1.5
- Saved 5 petabytes of local storage
- Enabled scalable, cloud-based simulation workflows
- Improved model accuracy and reduced complexity

Image courtesy of Fujian Yongfu Power Engineering Co. Ltd.

Case study 2

Designing resilient wind foundations for typhoon-prone waters

Fujian Yongfu Power Engineering Co., Ltd. needed to fabricate and install foundations for 62 offshore wind turbines in one of the world's deepest and most geologically complex wind farm sites located in Changle, Fujian, China. The area faced frequent typhoons, earthquakes, and unstable soil, making traditional foundation designs too conservative, costly, and risky.

> "PLAXIS and SACS allow engineers to optimize wind turbine foundation structures with seamless soil-structure interaction modeling."
>
> -Fan Xia Ling, Engineering, Fujian Yongfu Power Engineering Co., Ltd.

The solution

Using PLAXIS and SACS the team created a unified simulation environment to:

- Analyze soil behavior and foundation interaction
- Design and optimize a three-pile suction conduit frame foundation
- Reduce steel usage and eliminate the need for heavy pile-driving equipment
- Ensure structural resilience against extreme marine conditions

Simulation allowed the engineering team to fabricate foundations that were stronger, lighter, and easier to install, while maintaining safety and environmental integrity.

The outcome

- 30% cost reduction, saving CNY 400 million
- Reduced steel usage per foundation
- Faster, safer construction with fewer staging platforms
- 496 MW of clean energy, eliminating 535,000 tons of coal and 1.46 million tons of CO_2 emissions annually

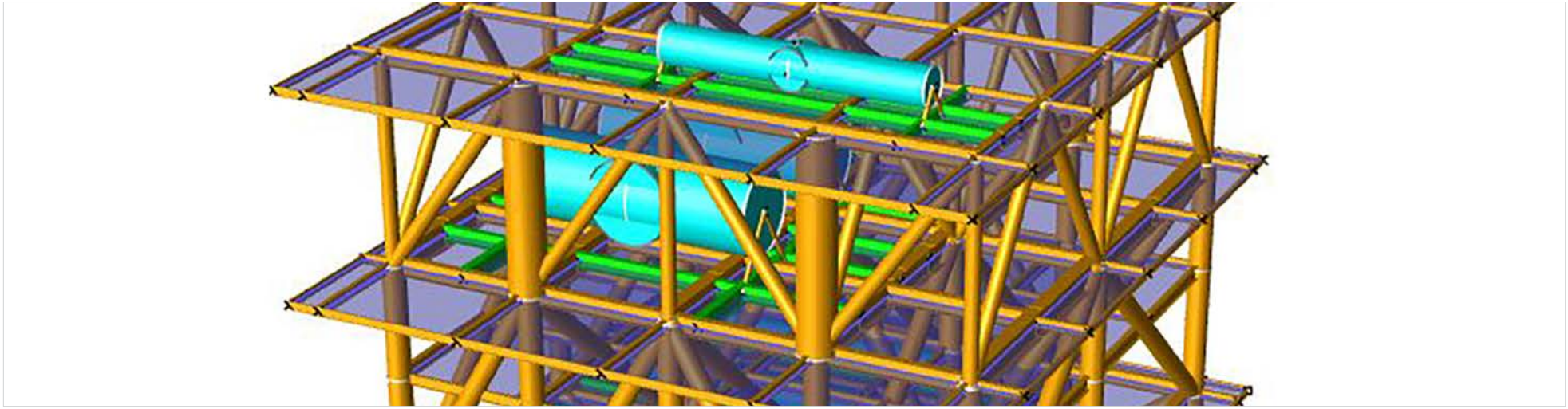


Image courtesy of MCHTM Inc.

Case study 3

Saving time and steel with simulation-led fabrication

Offshore topside fabrication is often delayed by design dependencies and late-stage changes. MCHTM Inc. saw this firsthand in projects involving floating production storage and offloading (FPSO) and floating liquefied natural gas (FLNG) modules. Waiting for finalized inputs and relying on manual design iterations led to missed deadlines, overuse of materials, and costly inefficiencies.

The solution

To overcome these challenges, MCHTM developed a Rapid Structural Design System (RSDS) using SACS:

- Automated structural modeling and weight optimization
- Seamless interoperability with third-party tools
- Fast analysis of multiple design scenarios
- Real-time adaptability to changing project inputs

SACS enabled MCHTM to move from weeks-long design cycles to bid- and FEED-level designs in just days, even under evolving project conditions.

The outcome

- 280 tons of steel eliminated, saving USD 2 million
- Design time reduced from weeks to days
- One engineer now delivers the output of five or six
- Improved accuracy and reduced downstream risk

"SACS is an affordable and essential time-saving tool to produce cost-effective and safe offshore structure designs. We aim to leverage SACS so that one engineer can produce as much work as five or six people would do in a large design firm. The functionality that SACS allows us to compete successfully in the tough engineering design market and be more profitable."

-Michael Harwood, President, MCHTM Inc.

Image courtesy of Sapura Energy Berhad

Case study 4

Cutting transportation time in half with simulation-led planning

Sapura Energy Berhad faced a high-stakes challenge: deliver three massive wellhead platform (WHP) jackets from Malaysia to Qatar's Al Shaheen Field all within just 12 months. Traditional towing methods would take 40 days, leaving little time for design and fabrication. The team needed a faster, safer, and more cost-effective transportation strategy.

> "Bentley's MOSES provides a great platform for analysis, building confidence across all parties and ensuring every aspect of marine resistance, forces, and motions is accounted for."
>
> -Mohd Fariq Billah, CEng, Lead Naval Architect

The solution

With SACS and MOSES simulation, Sapura Energy Berhad developed an innovative plan to transport all three jackets, totaling 8,000 metric tons, on a single semi-submersible vessel. Using simulation as a strategic guide helped them to:

- Predict and assess vessel motion, seastate conditions, and towing paths, ensuring safe transit through 4–5-meter wave heights.
- Model the jackets, piles, and barges, enabling frequency domain analysis to evaluate vessel performance and structural integrity.
- Choose a slimmer vessel with better seakeeping characteristics, reducing dynamic roll and improving safety.
- Validate ballasting strategies and barge overhangs to prevent submersion during transit.

The outcome

- Transportation time reduced by over 50% from 40 days to just 14
- Significant cost savings by avoiding multiple tug hires
- Safe delivery with minimal risk of damage or delay
- Established a new benchmark for offshore transport and installation

Case study 5

Restoring production after disaster: using simulation to turn crisis into opportunity

Zakum Development Company (ZADCO) faced a critical challenge: a 1,600-ton vessel collided with one of its wellhead platforms off the coast of Abu Dhabi, United Arab Emirates, causing a 6.6% loss in structural strength. Oil production was halted, and every hour of downtime meant mounting financial losses. The team needed to act fast, not only to restore operations, but also to document the damage thoroughly enough to support an insurance claim. But rushing repairs without a clear understanding of the damage could lead to safety risks and unnecessary costs. ZADCO needed a solution that was fast, accurate, and cost effective.

> "SACS software and its tailor-made enhancements are very useful tools for structural integrity engineers to use when a quick and workable solution is required in the shortest possible time."
>
> -Wilson John, Structural Integrity Engineer, Zakum Development Company

The solution

ZADCO utilized Bentley's SACS Collapse module to perform a rapid, in-house non-linear boat impact analysis. This allowed engineers to simulate the post-impact behavior and pinpoint the spread of damage with accuracy. Instead of inspecting every inch of the subsea structure, they focused only on the critical nodes, streamlining the scope of inspections and repairs.

The outcome

By using SACS, ZADCO didn't just fix the problem, they optimized the entire recovery process:

- Saved USD 2.6 million in direct inspection and repair costs
- Reduced total project costs by 70%, from USD 3.75 million to USD 1.15 million
- Cut subsea diver inspection time by 75%, from 134 days to just 34
- Generated technical documentation that substantiated the insurance claim
- Gained an additional USD 850,000 in savings from inspection efficiency

ZADCO turned a high-stakes emergency into a strategic win. With the help of Bentley's SACS, they minimized downtime, maximized savings, and got their platform back online faster and safer.

Your next step: build resilience with simulation

Ready to explore how simulation can support your next project? Talk to a simulation expert

Request a demo

You're leading offshore projects that shape the future of energy and infrastructure. From concept to decommissioning, each phase demands accuracy, foresight, and resilience.

Whether you're designing floating wind platforms or managing deepwater oil rigs, simulation helps you deliver offshore assets that last.

Explore Bentley's offshore solutions

Learn more