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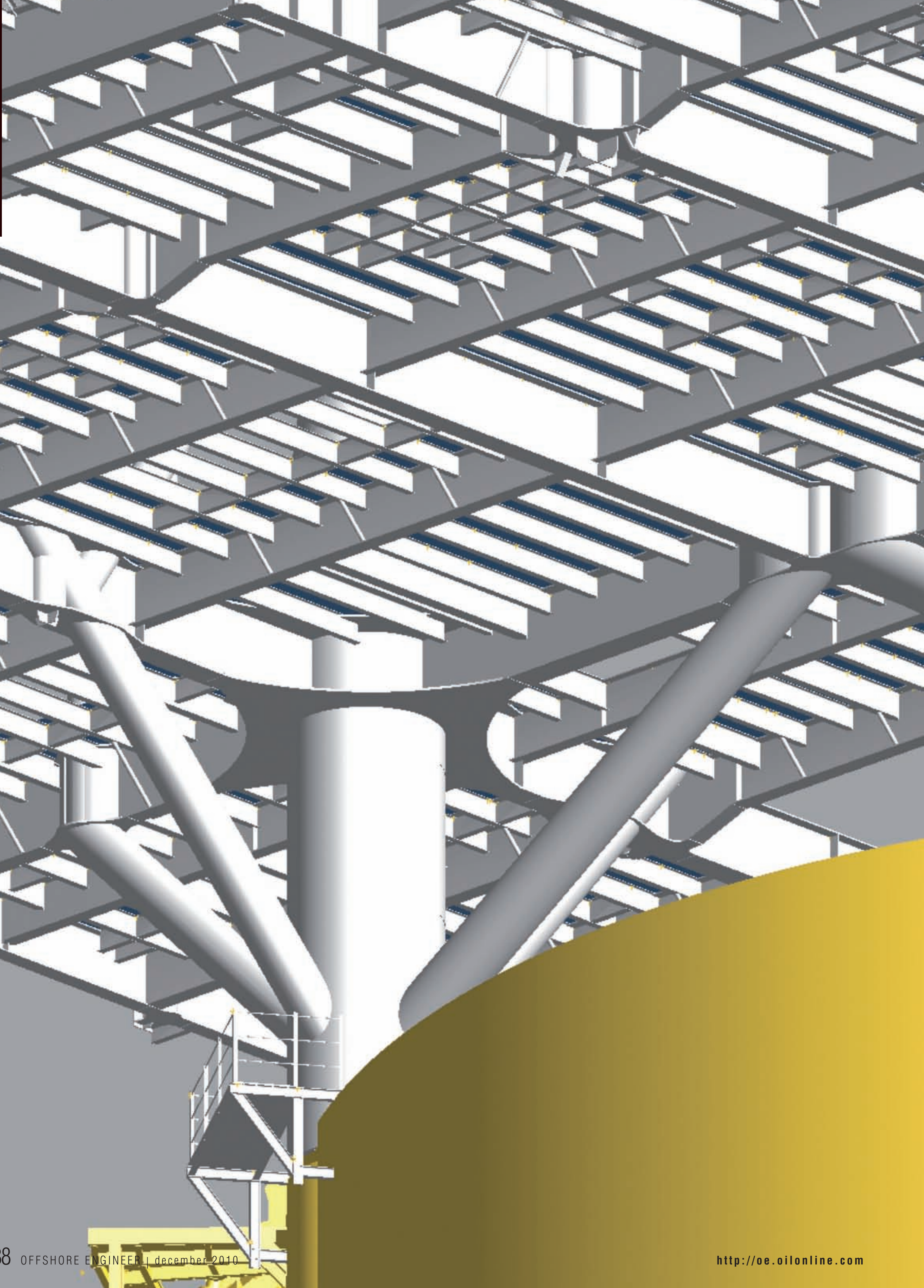
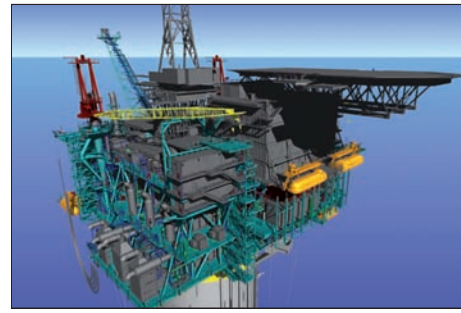
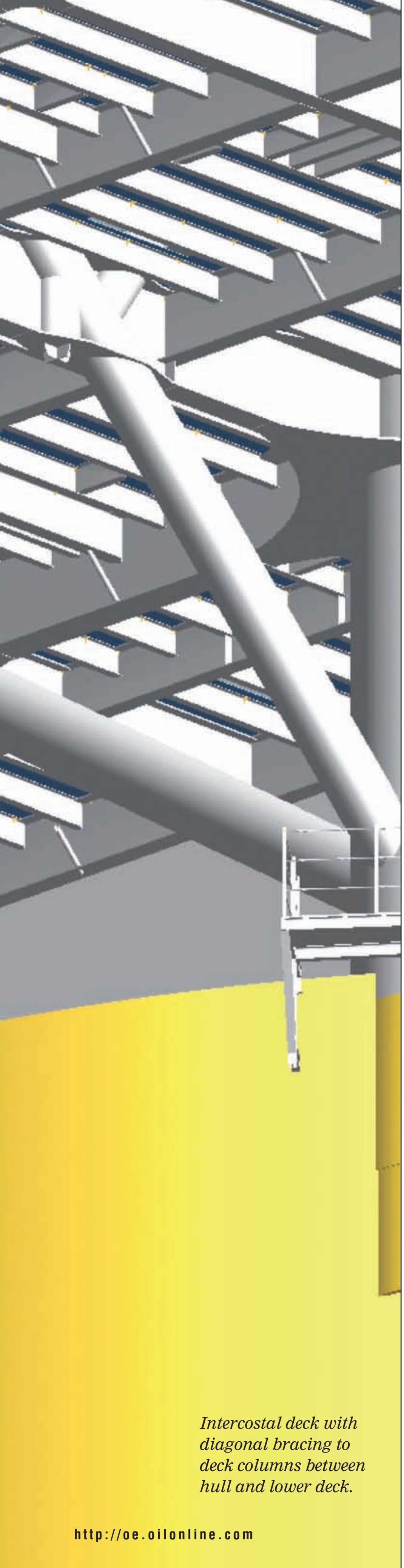




Lightweight topsides designed by Alliance Engineering for Shell's Perdido spar.

Lighter topsides – the what, why and how

Offshore topsides must be light enough to be economical, yet big and robust to contain all the drilling and production equipment needed to develop the field. Alliance Engineering's **Norb Roobaert** argues that there is no need to compromise safety, operability or maintainability when designing lightweight topsides.



Intercostal deck with diagonal bracing to deck columns between hull and lower deck.

A conventional topsides design normally requires several modules to be fabricated onshore, transported to site, lifted onto the hull supported by a module support frame, integrated and pre-commissioned offshore. A single-lift topsides design saves time, reduces safety exposure, and is less expensive to build than the conventional modular approach. The challenge is to find a way to incorporate all of the topsides requirements without compromising safety and operability while maintaining the weight below the lifting capacity of available derrick barges in the area. While working on single-lift lightweight topsides designs for projects over the last 15 years, Alliance Engineering developed a low weight-to-function ratio for the topsides.

The term 'lightweight topsides' has been used for many years. Lightweight topsides are topsides that weigh significantly less than conventional topsides performing the same function. There is less equipment, less pipe, less structural steel, reduced interconnecting for pipe and electrical cable, reduced junction boxes, and reduced offshore hookup manhours compared to conventional 'this-is-the-way-we-always-do-it' topsides. The industry has a history of building 'robust, cookie cutter, brute force' facilities.

Although these facilities may have been overdesigned, higher oil and gas prices covered their additional cost and schedule. However, once the industry began moving to the deepwater arena and began designing production facilities for weight-sensitive floaters – TLPs, spars and semisubmersibles – the value of reducing topsides weight took on a new meaning. There have been misconceptions that lightweight means compromise. There is no need to compromise safety, operability or maintainability when designing lightweight topsides.

There is no reason why designing topsides to weigh less is a bad idea. Lightweight topsides save time and money, lower hull and mooring costs, maintain precious payload for future expansion, and are safer to build and operate. Lightweight topsides require a smaller hull or, if designed with margin for growth, the margin for growth is larger. Topsides weight savings increase return on investment by lowering capital costs and shortening the schedule, which accelerates cash flow. Experience tells us topsides installed costs are in the range of $35,000-$50,000/ton. It's possible to achieve capital cost savings of $100-150 million by reducing a 20,000 ton topsides weight by 15%. Lightweight design is definitely worth taking a look at.

Defining principles

Designing lightweight topsides begins with defining principles that cannot be compromised. These principles, in order of priority, are: safety, operability (up-time), maintainability, schedule and cost. The next important ingredient to achieving a lightweight design is the team. The team requires a lightweight mindset, lightweight design experience on several projects and continual reemphasis on saving weight in every discipline. The road to the outcome begins with the concept. This includes the design basis, a simplified/streamlined process design, equipment selection and layout, compact footprint, communality

A single-lift deck design saves time and reduces safety exposure.

of maintenance area, compact piping, and specifications developed for lightweight design.

Following the concept design is a systematic detailed lightweight design for facilities, structure and piping.

The design for facilities to reduce weight is a case of eliminating unnecessary equipment, using lightweight materials and designs, and modifying the flow, resulting in lighter equipment to produce the same results and the layout of this equipment to reduce piping runs.

Process design improvements to reduce weight include the use of two phase separators instead of the conventional approach of using three phase separators on the high-pressure inlet to the facility. This results in smaller high-pressure vessels, reduces wall thickness and significantly reduces weight. Delete the wet oil tank. A wet oil tank cannot be designed large enough to allow correction of an off specification oil problem without shutting in the facility. If it is a problem that cannot be corrected in a short amount of time, the facility must be shut in. However, if the problem can be fixed in a short amount of time, the off specification oil produced will not be an issue after flowing through miles of pipeline to an onshore facility. Delete the atmospheric vent tank. An atmospheric vent tank offshore is better combined with the low-pressure liquid drain vessel. This approach is safer and saves weight. Use a high-pressure, high-velocity flare system. This reduces pipe size and weight.

Use a single train facility with sparing critical components such as control valves. The onstream time for a single train is in the 98%+ range. A duplicate train is not justified once the full cost of the additional train is accounted for, including equipment cost, transportation, outfitting, structural supports and deck space. When additional heat is required, supplement the heat supply with a fired waste heat recovery system.

When you have high electrical loads, the use of large horsepower electric drives saves weight over engine drive units. Use Division 2 pressure vessels with proprietary internals. This requires additional inspection but saves weight. Where appropriate for lower pressure applications, use compact and light plate and frame or welded plate/printed circuit heat exchangers. Utilize vertical high-pressure pumps where applicable. This saves space and weight. Use non-metallic piping systems for water service. This saves weight and solves corrosion problems. Use compact options for LACT Unit and Prover.

Select equipment to be skid mounted or set directly on the deck. Certain equipment is normally purchased as a skid unit (ie compressors), while most equipment is more weight-efficient if it is designed to be piped on the deck (ie separators). Use lightweight compact options for control valves, actuators, flow meters, flanges, check valves and ball valves.

Weight saving tips for the deck structures include designing for actual dry and operating weights rather than area loads. Design floor beams and girders to specifically support the equipment and locate heavy equipment and buildings directly over girders.

Use diagonal braces to support the deck columns between the hull and lower-most deck level. Use intercostal floor beams instead of stacked beams. Use typical ship hull details except that webs of floor beams are welded to supporting girders.

Avoid large cantilevered beams. Cantilevered beams are sometimes necessary but provide a low functionality per ton. Design trusses using tubular braces instead of plate girders. Use special racking braces only on areas such as crane pedestals and vent booms. Use tubular sleeves for joint details. Combine truss girders, secondary girders and floor beams and spacing to provide lowest weight floor system.

Design pipe supports fit-for-purpose as compared with the conventional one-type-fits-all approach. Use deck plating where appropriate to gain racking stiffness without structural bracing. The industry has strayed from designing fit-for-purpose and has adopted a 'copy-from-the-last-job' approach.

Lightweight designing doesn't work if the hull is designed based on early topsides weight estimates and the estimates later prove to be wrong. Getting the early weight estimates right and maintaining that weight during design and fabrication is a must for success; a good weight database is key. It is critical to have software that translates spreadsheet weights and center of gravity into the structural program and PDMS 3D model. One must continually monitor and correct deck weight and center of gravity to within acceptable limits for the hull design, deck lifting, loadout, transportation, and installation. One must continually challenge weight increases and re-design as appropriate. It can pay to redesign vendor-supplied equipment, modify their layouts and redesign supplied buildings to save weight.

In conclusion, the reward for producing lightweight topsides is well worth the effort. Success requires the right team, concept, mindset, experience, design methods, software and weight control from concept through installation.

The mindset must be to become engineers again and design a fit-for-purpose facility and not fall into the common trap of 'this-is-how-we've-always-done-it'. Don't be afraid to specify, question or re-design vendor-supplied equipment or buildings. **OE**

● *Thanks to Kent McAllister and Bill Mandery at Alliance for their review and to Ron Bohannan for contributing the illustrations for this article.*

Norb Roobaert, PE, is chairman of Alliance Engineering, a Wood Group company. He founded Alliance in May 1993, serving as its president until October 2009, and has over 40 years' engineering and project management experience in the oil & gas industry. Roobaert, who was with Conoco for 15 years before transitioning to the engineering contracting business, holds degrees in chemical engineering and chemistry from the University of Michigan.