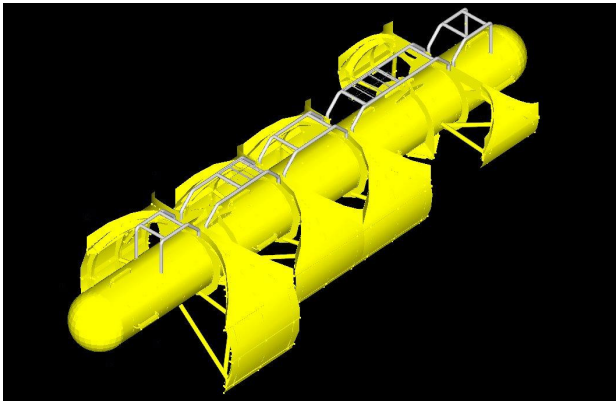


## SEASTREAM JV - PYRENEES FIELD DEVELOPMENT DESIGN OF MID WATER ARCH & GRAVITY BASES

### North West Shelf

ICON Engineering was engaged by Seastream JV to design four (4) mid water arches (MWA) and gravity bases for operator BHP Billiton of the Pyrenees Development, North West Shelf in 200m of water. The design was specifically related to the in-service design, with key consideration given to installation method - a single lift with maximum installation load of 700T.



**Mid Water Arch – CAD Model**

#### Mid Water Arch Design

The mid water arches are 3.9m in diameter and span over 38m with each buoy providing 200t of net buoyancy. The design itself needed to satisfy both the pressure integrity requirements for the buoy shell, heads and internal ring stiffeners as well as the structural design requirements for arches and gutters.



**Pyrenees Mid Water Arch**

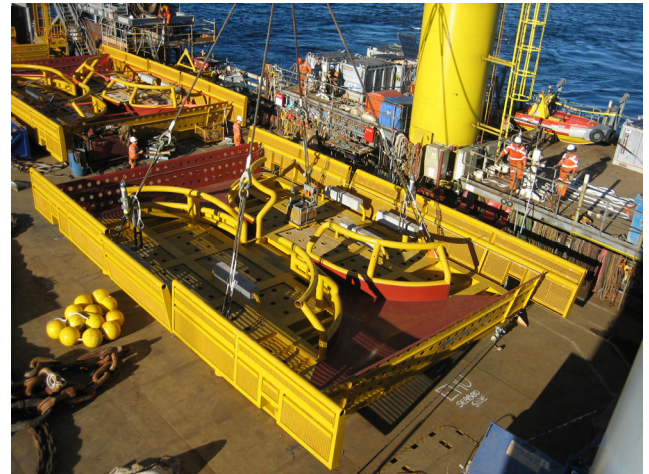
Following the stringent requirements of the BHPB & Wellstream functional specifications, the buoys were also designed for the damaged case scenario in which a single tether had failed without risers in place causing significant loads on the adjacent tether.

Other design requirements included the transportation cradle, cathodic protection & coating, weight control, ROV interface, system recovery and positive restraint clamp securing the risers to the MWA.

#### Gravity Base Design

The design of the gravity bases were based on the worst case installation load, maximum in-service load and the damaged tether failure condition.

Other design considerations included the outboard handling padeyes which aid levelling of the gravity base in the event of CoG offset and could be used for tether pull down to allow change out in the event of single tether failure. The gravity bases also consist of perimeter and internal skirts and a fully plated mudmat as determined by geotechnical design.



**View of the riser restraint prior to deployment.**

#### Riser Restraint Design

In addition to the MWA, ICON also conducted the design of the riser restraints (RR) that provide lateral and axial restraint to the risers by means of a gravity base structure. The restraints transmit all the loading from the riser and clamp to the foundation with the loads based on the worst case installation load and maximum in-service loads generated in the flexible risers.

The riser restraints are designed with shallow skirts to allow seabed penetration and provide lateral stability. However without specific geotechnical information at each location, providing a robust solution presented a challenge. Nonetheless, close interaction with geotechnical designers, Advanced Geomechanics, provided a solution that satisfied the range of soils present in field.

#### Pyrenees Development

The development comprises the tie-back of the Ravensworth, Crosby, and Stickle fields to a newly moored FPSO. BHP Billiton is the field operator and Seastream JV is the main contractor for the subsea installation services. Fabrication of MWA structures was completed in March 2009.