Subsea Well/Pipeline Development

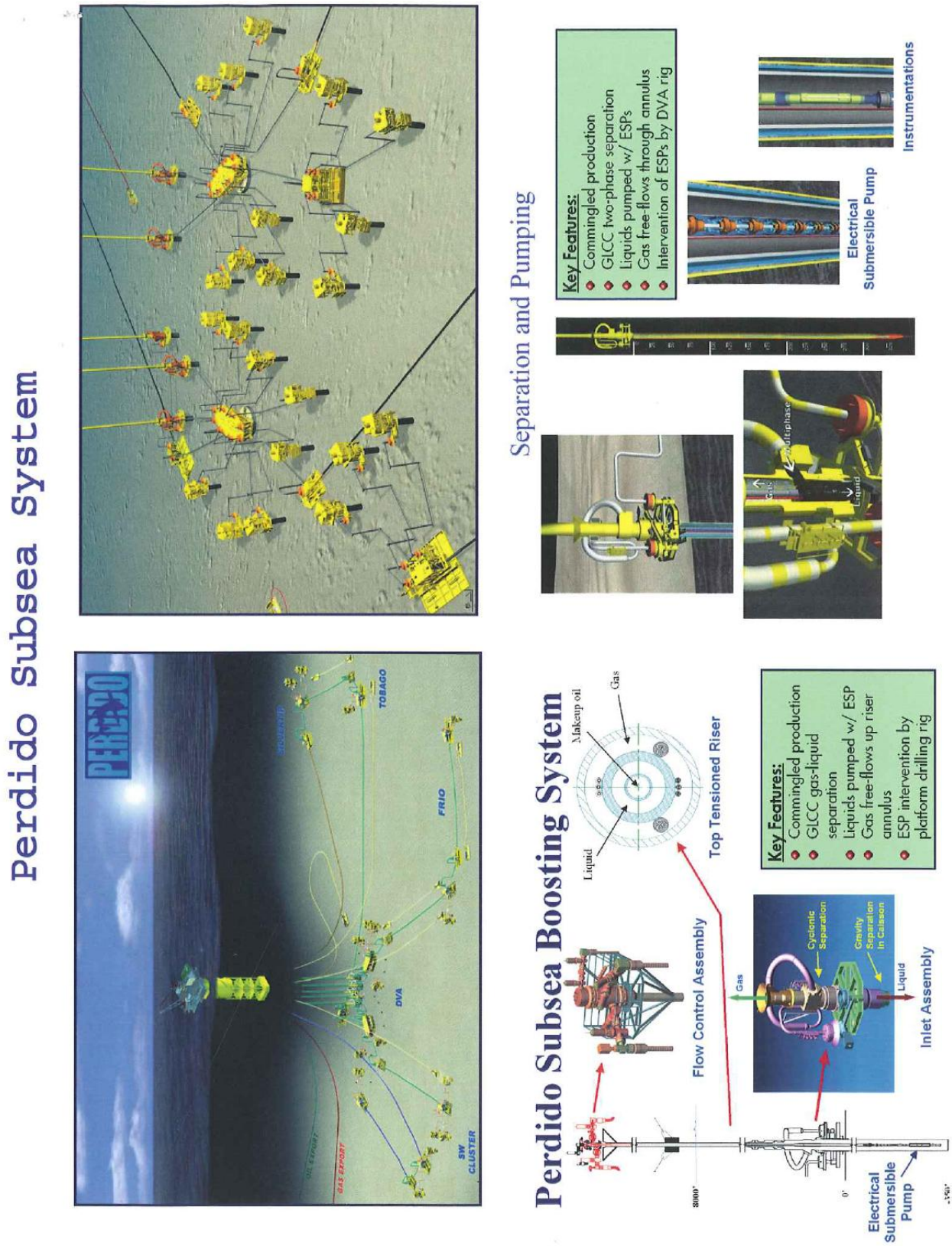
The Perdido Development includes the Great White, Silvertip, and Tobago fields and is located in the Perdido Basin and Foldbelt, in the Alaminos Canyon Protraction Area. This area is located in the western Gulf of Mexico, 200 miles south of Freeport, only eight miles north of the Mexico maritime border. All three fields are developed with subsea wells tied back to the host, which is a Spar with full offshore processing capabilities and pipelines for export.

Significant challenges associated with development of these fields include extreme water depths (up to 9,600 feet), problematic seafloor terrain, low-temperature reservoirs, and active market rig condition. In order to overcome these challenges, the Perdido Development is using cutting-edge technologies that include wet-tree direct vertical access (DVA) wells and a unique subsea boosting system for artificial lift. The development system also incorporates a high-pressure single-bore top-tensioned riser with surface BOP, for drilling/completion of the subsea wells. Unique features of the subsea system are as follows:

- All wells are subsea (wet trees operated by umbilicals) and consist of 22 local DVA wells and 12 offset wells.
- A compact 6-slot Spar equipped with a platform rig will drill and complete the DVA wells and process production from all wells, as compared to the conventional dry tree DVA technology requiring 22 slots, and thus a larger host.
- The DVA wells will be drilled, completed, and intervened through a single high-pressure drilling/completion riser with the host rig through a surface BOP system, using only one of the six well bay slots.
- Production from both the offset and DVA subsea wells is commingled through dual-header manifolds. All production then flows from manifolds into five separation and boosting systems where gas flows naturally to the topside facility and liquids are pumped using powerful electrical submersible pumps.

The first enabling technology that was developed for the Perdido Development is subsea boosting technology. The Subsea Boosting System (SBS) employs a vertical gas-liquid cylindrical cyclonic (GLCC) separator that achieves two-phase separation. The separator consists of an inlet assembly based on the GLCC concept, for passive gas-liquid separation, and a 35-inch, 350-foot long caisson inserted into the seabed for liquid retention. A 1,600 hp ESP is deployed inside the caisson. The inlet assembly is connected to the host through a 14-inch top-tensioned riser that contains three separate flow paths. After the production is separated, the liquid drops down to the bottom of the caisson and the gas flows upward through the outer annulus of the riser naturally. The ESP then pumps the liquid though a 7-5/8 inch tube inside the riser. In order to extend pump life, a 2-7/8 inch tube inside the 7-5/8 inch production tube enables oil to be recycled down from the topside into the caisson to ensure there is sufficient liquid flow to cool the pump motor during low flow rate scenarios, such as well ramp-up. The primary concept behind the GLCC is to separate as much free gas as possible to enhance ESP power efficiency. However, the ESP is still capable of handling a moderate amount of gas with the liquid. Therefore, the separator is not required to perform complete gas-liquid separation. The system is also quite efficient in terms of power consumption since the ESP is primarily used to boost only liquid. Furthermore, this system can accommodate significant variations in fluid characteristics, such as GOR and water cut, over the life of the reservoir. This robustness of design accommodates significant sub-surface uncertainties.

The second key novel technology was using surface BOP to drill and complete a cluster of 22 subsea wells. This concept allows us to minimize the size of the host, while maximizing the number of subsea wells with direct vertical access (DVA) from the Spar. For the DVA subsea wells, drilling, completion, and workovers are performed with a rig located on the Spar. The rig stays in a fixed position over the dedicated drilling/completion slot, and the host is moved by the active mooring system around the well pattern to provide vertical access to all the wells in the working area. Significant cost savings are achieved using this arrangement, compared to using a 5th generation floater to drill and complete the wells in this water depth.


Perdido Subsea System
PERDIDO
TOBAGO
FRIO
DVA
SW CLUSTER
OIL EXPORT
GAS EXPORT
Separation and Pumping
Key Features:
Commingled production
GLCC two-phase separation
Liquids pumped w/ ESPs
Gas free-flows through annulus
Intervention of ESPs by DVA rig
Electrical Submersible Pump
Instrumentations
Gas
Liquid
Perdido Subsea Boosting System
Makeup oil
Gas
Liquid
Top Tensioned Riser
Flow Control Assembly
Key Features:
Commingled production
GLCC gas-liquid separation
Liquids pumped w/ ESP
Gas free-flows up riser annulus
ESP intervention by platform drilling rig
Cyclonic Separation
Gravity Separation in Caisson
Gas
Liquid
Inlet Assembly
Electrical Submersible Pump
8000'
0'
-350'