Control for Offshore Oil and Gas Platforms

Recent years have seen the formation and growth of the global deepwater offshore industry, which has been driven by increased demand for oil and gas stemming from years of economic growth, reduction in production of existing hydrocarbon fields, and depleting shallow-water reserves. These factors have encouraged operators to invest billions annually chasing this offshore frontier and the development of floating production and subsea systems as solutions for deepwater hydrocarbon extraction.

Currently, 15% of total offshore oil production is carried out in deep waters, and this proportion is expected to rise to 20% in the next few years. The harsher marine environment and need for subsea production systems in remote deepwater developments opens a set of challenges and opportunities for the control theorist and engineer.

Subsea Production Systems

Subsea systems have to be installed accurately in a specified spatial position and compass heading within tight rotational, vertical, and lateral limits. The tolerances for a typical subsea installation are within 2.5 m of design location and within 2.5 degrees of design heading for large templates and are more stringent for the installation of manifolds into the templates.

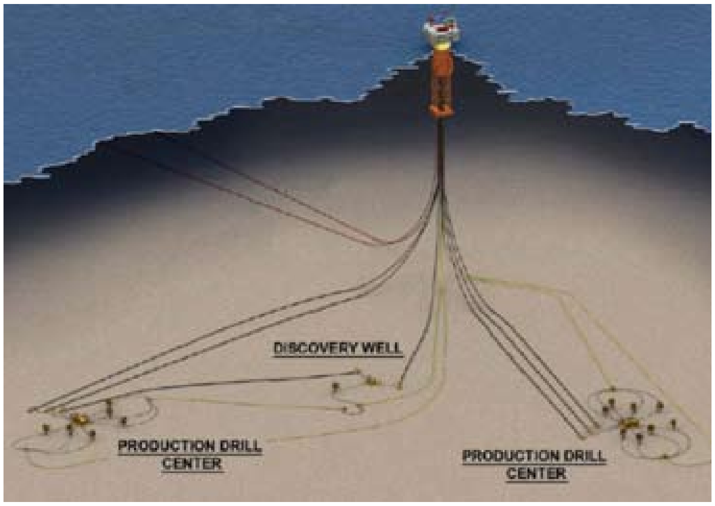
Traditional methods in subsea installation include the use of guidelines or the use of ship dynamic positioning and crane manipulation to obtain the desired position and heading for the payload. Such methods become difficult in deeper waters due to the longer cable between the surface vessel and subsea hardware when near the seabed.

An intuitive solution to alleviate the precision placement problem is the addition of thrusters for localized positioning when the payload is near the target site. The control for the dynamic positioning of the subsea payload is challenging due to unpredictable disturbances such as fluctuating currents and transmission of motions from the surface vessel through the lift cable.

A Critical Need for Technology

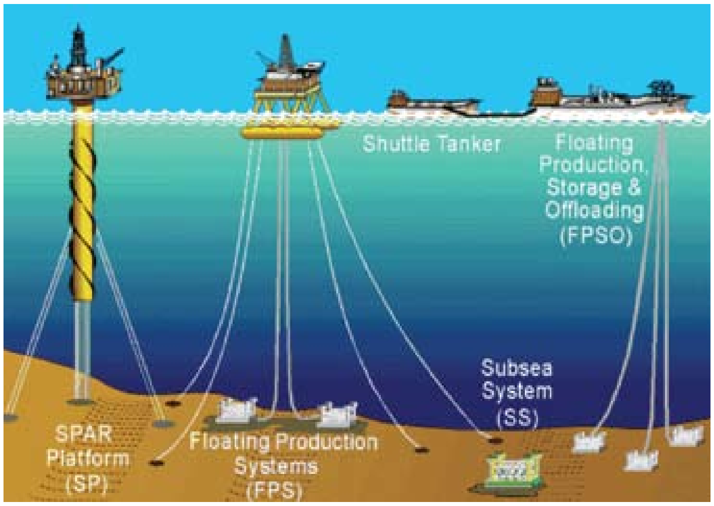
The April 2010 Deepwater Horizon accident in the Gulf of Mexico serves as a reminder of the risks and challenges in offshore operations. In the push toward exploration and production in deeper waters and harsher environments, control theorists and engineers working with colleagues in different disciplines will be challenged to forge a path forward with innovative technological approaches to safely supply the world's energy needs.

A View of the Commercial Subsea System (Wells, Manifold, and Umbilical) on the Seabed



Source: MMS Ocean Science, Nov. 2005

Floating Production and Subsea Systems



Source: Minerals Management Service, U.S. Department of the Interior

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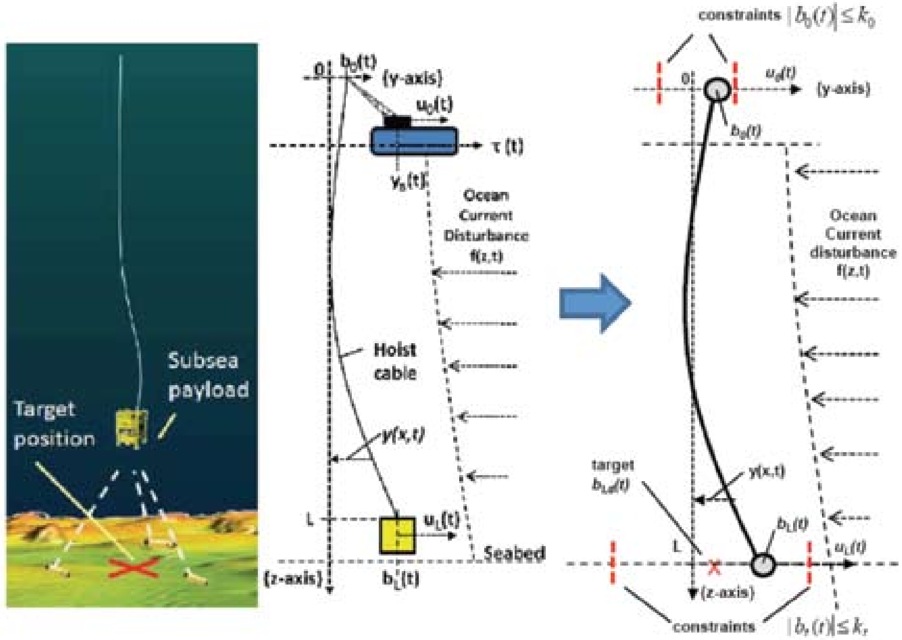
From: *The Impact of Control Technology*, T. Samad and A.M. Annaswamy (eds.), 2011. Available at www.ieeecss.org.

Dynamics of the Lift Cable

With the trend toward installations in deeper waters, the longer cable increases the natural period of the cable and payload system, which in turn may lead to increased pendulum-like oscillations. Time-varying distributed currents may lead to large horizontal offsets between the surface ship and the target installation site. Investigation of the dynamics of the flexible lift cable to aid in control design and operation planning is desirable and challenging.

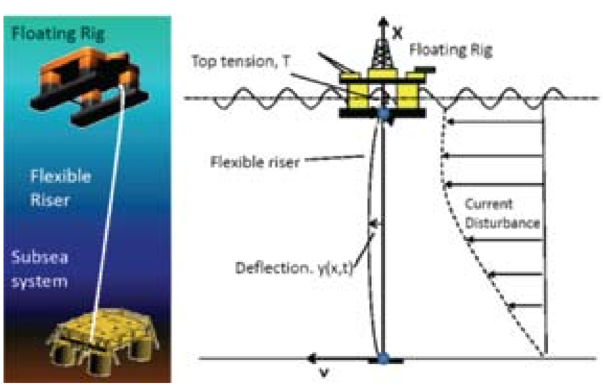


Positioning of subsea hardware using thrusters (left), illustration of subsea positioning (center), and schematic of the installation operation (right)

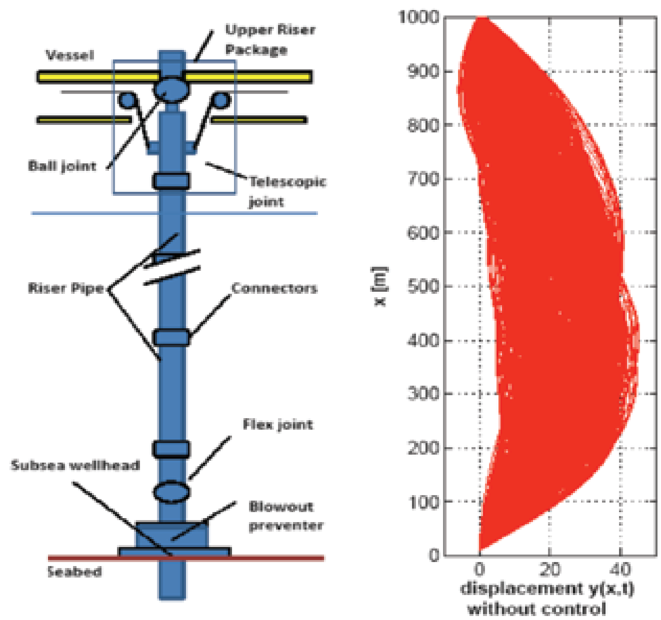
Riser and Drill String Vibration Control

The riser plays a crucial role in offshore oil drilling and production. A marine riser is the connection between a platform on the water surface and the wellhead on the sea floor. A production riser is a pipe used for oil transportation. A drilling riser is used for drilling pipe protection and transportation of the drilling mud. Tension is applied at the top of the riser, which allows it to resist lateral loads, and its effects on natural frequencies, mode shapes, and forced vibration have been studied.

For drilling and workover operations, one objective is to minimize the bending stresses along the riser and the riser angle magnitudes at the platform and wellhead. Hence, vibration reduction to reduce bending stresses and control of the riser angle magnitude are desirable for preventing damage and improving life span.



Schematic of a marine riser



The riser package (left) and an overlay of riser dynamics exposed to current (right)

For further information: Social Robotics Laboratory, National University of Singapore, http://robotics.nus.edu.sg; Centre for Offshore Research and Engineering, NUS, http://www.eng.nus.edu.sg/core