New Technology Opens the Door for Deepwater Development

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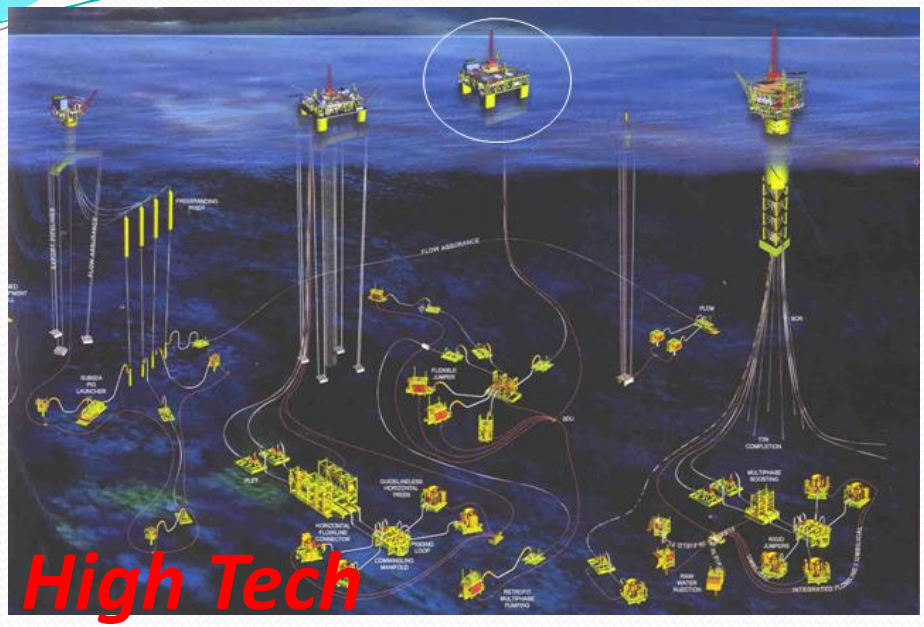
Presentation Outline

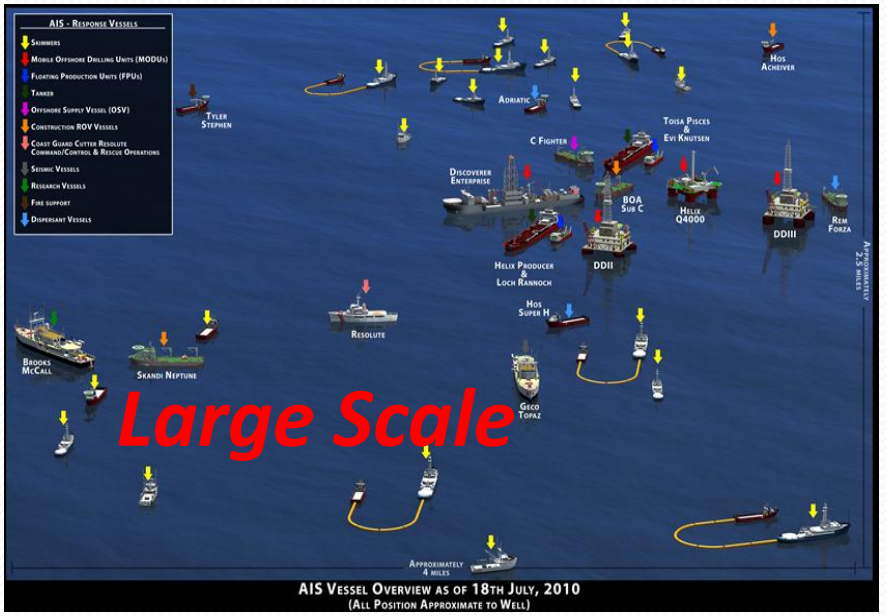
- Current Status of Deepwater Exploration
- China Offshore Development
- Technical Examples of Studies in two areas
- New Technologies for the Continuing Development of Deepwater Exploration
- Summary

Current Status of Deepwater Development

- **Deepwater Development**
  - High Technology Demanding
  - High Investment
  - High Return/Reward
  - High Uncertainty/Risk
  - Fast Track Schedule
- **CHRACTERISTICS of Offshore Engineering**
  - Integrated system
  - Frontier technology
  - Multi-discipline knowledge
  - Need experience



Deepwater Field Development



"Float City" – Offshore Oil Spill Rescue Team

Deepwater Horizon Accident and Its Impact to Environment Due to the Oil Leaking

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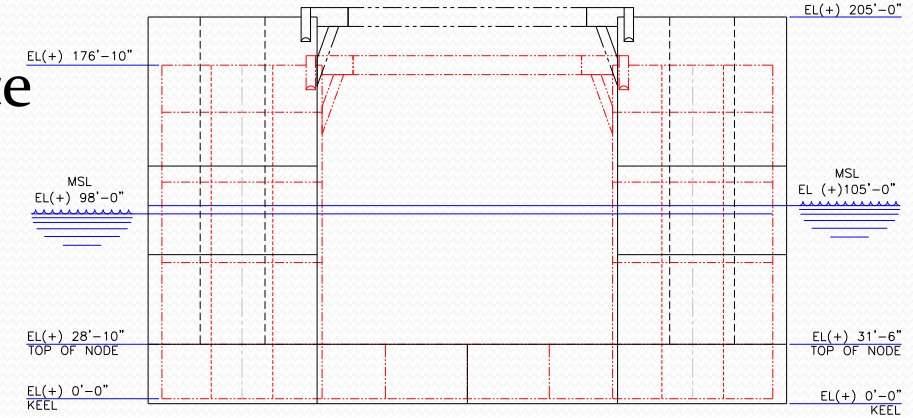
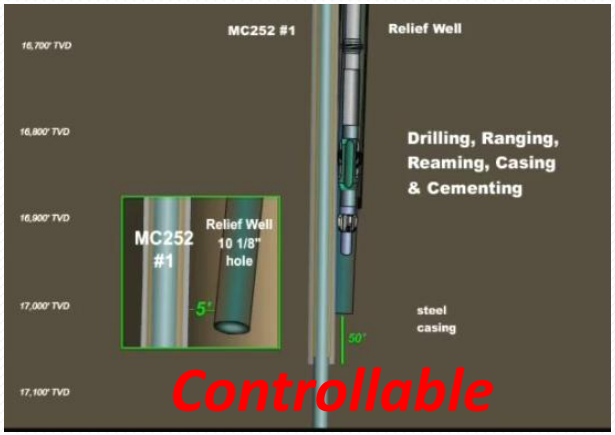
Current Status of Deepwater Development (cont.)

- Deeper
  - Water depth exceeds 3000 meters
  - Drilling depth exceeds 10000 meters
- Larger structure & high cost – larger payload
- Multi system options – field development
- Tender -assisted drilling – reducing payload
- Hurricane impacts on design standards – larger free board, taller column
- Deep draft – better performance
- Optimized hull weight



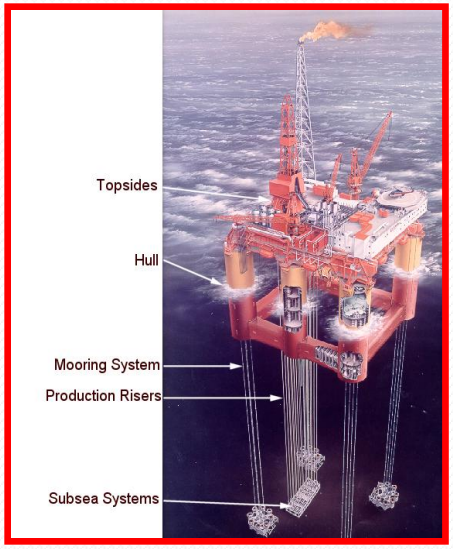
Applications of Key Technologies

- Drilling technology
  - Horizontal drilling
  - Directional drilling
  - Controlled drilling
- **Field development**
  - Multi-systems
  - Tender-Assisted Drilling
- Advanced remote control system
- **Hull forms**
- Riser support methods
- New application material
- Sophisticated advanced analytical tool
- Modern model testing technology



Directional drilling can reach out ten kilometers and can be precised to a couple of feet

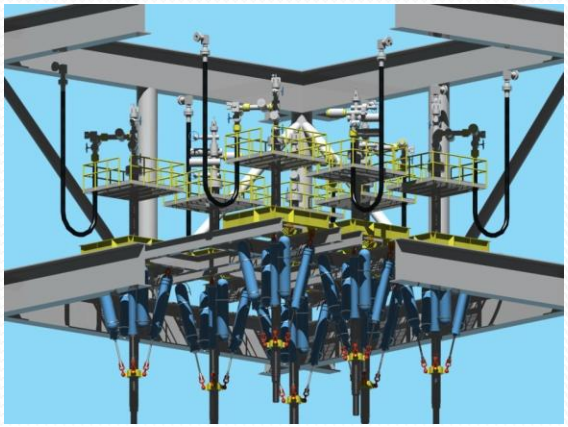
TLP (Tension Leg Platform) Hull Form Examples

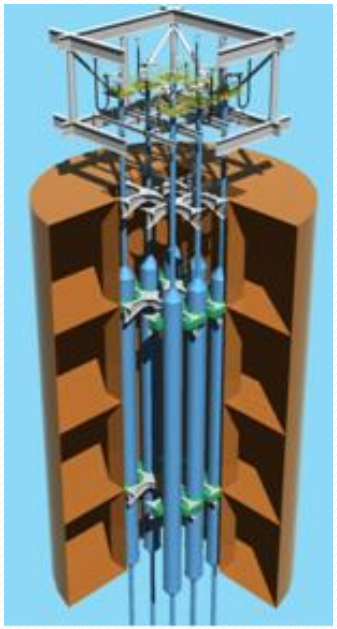


Driver: Performance

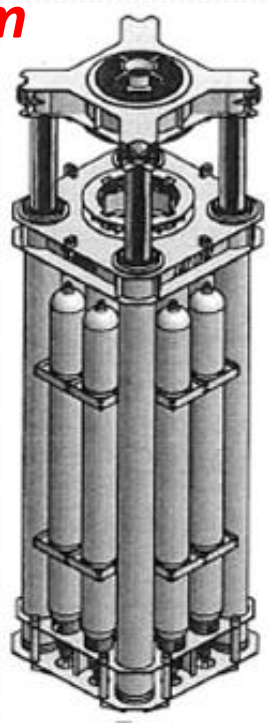
RISER Support Methods

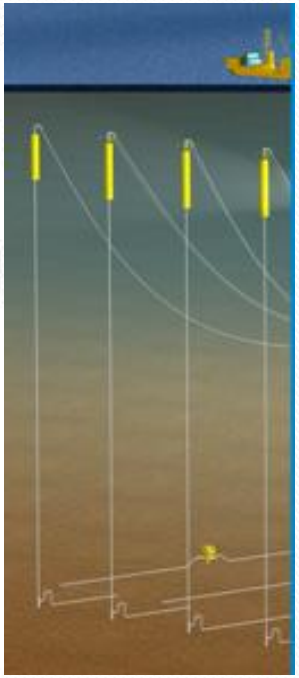
- Direct vertical access wells (Dry Tree)
  - Top-tensioned, rigid risers – single or double cased
- Import flowline risers (Wet Tree)
  - Steel catenary
  - Flexible pipe
- Export pipelines risers
  - Top-tensioned
  - Steel catenary
  - Flexible pipe
- Control umbilical bundles

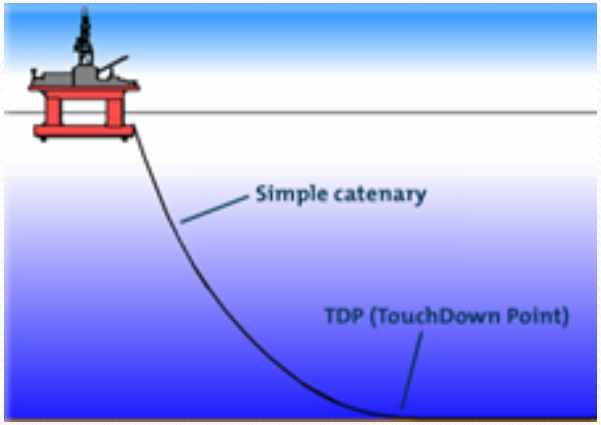




Driver: Function, Platform







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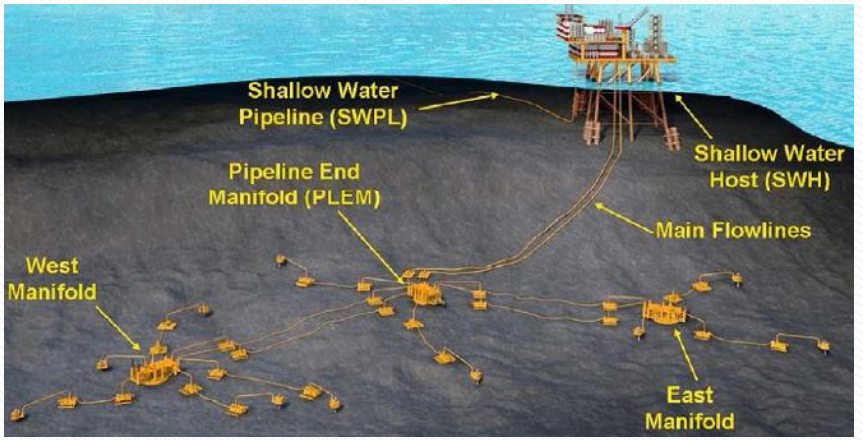
China Offshore Development – What Recently Done?

- Picked up speed in recent years
- State key projects – research
- Real field project simulation – technical preparation
- Heavy investment
- New offshore equipments
- Liwan deepwater development



LIWAN Deepwater - 1500 M Subsea Development

Topside Floatover

Subsea Pipeline Laying
(740 KM in 2009 vs. 100 KM in 2008)

LIUHUA FPSO – Recovery & Upgrade

Hardware Investment – CONCEPT, DESIGN, FABRICATION

HAI YANG SHI YOU 981
3000 M 6th Generation Drilling Semi

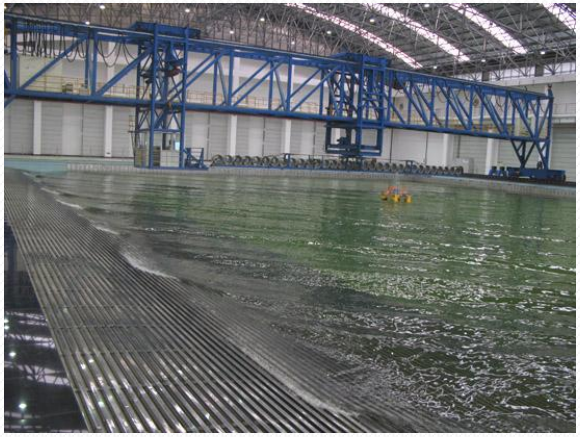
HAI YANG SHI YOU 201
Pipe Lay Barge w/ 4000T Crane

HAIYANG SHIYOU 229
Launch Barge 30000T

50,000 Ton SEMI Transport Barge

7,500T Self-propelled Crane Barge

HYSY 117 - 2million bbl FPSO (Hull)



JTU – Wind, Wave, Current Tank
50m x 40m x 10m w/ 45m pit

QINGDAO YARD – Offshore Platform

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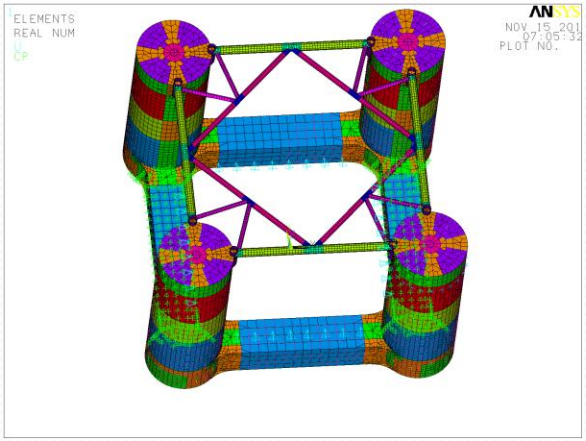
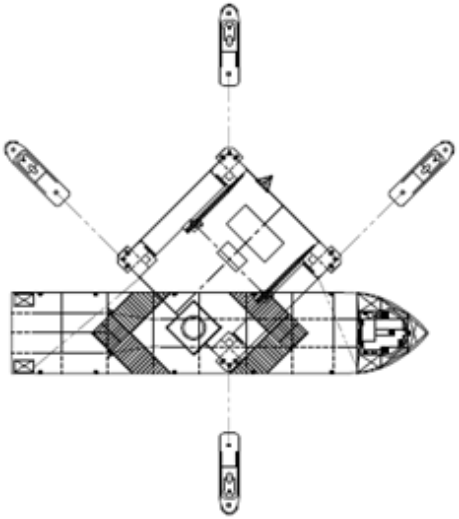
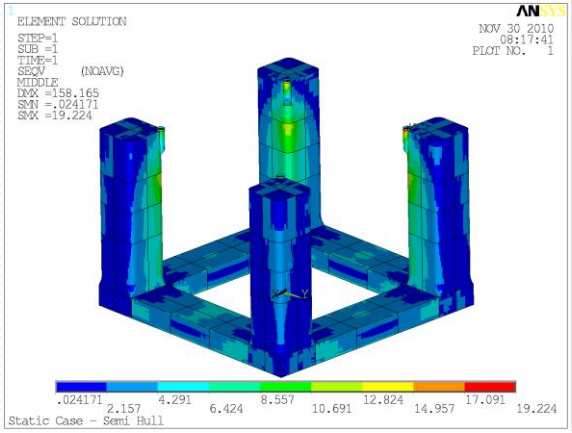
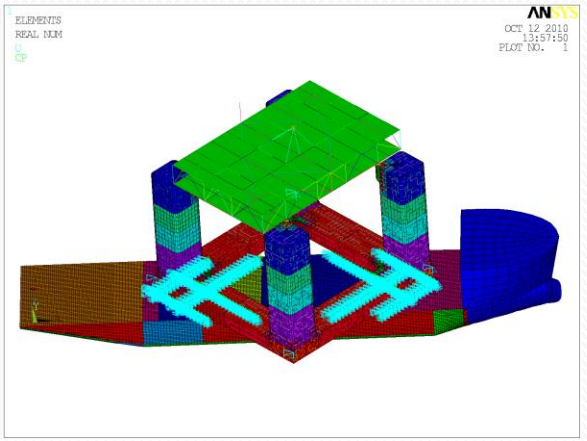
Analysis and Design – Engineering Preparation

- State key project – different floaters
  - Design
  - Analysis
  - Procedures
  - Specifications
  - Risk evaluation
- Liwan project study – floaters & application of new vessels
  - Design
  - Feasibility
  - Applicability
  - Options

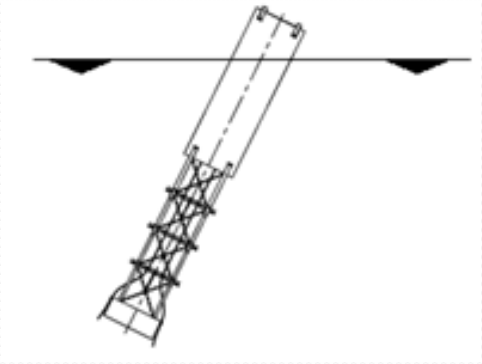


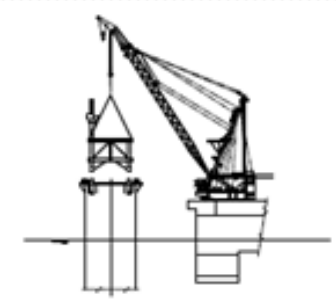


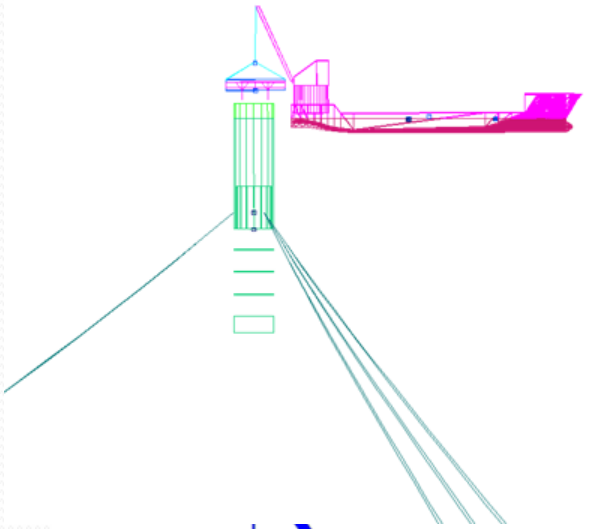


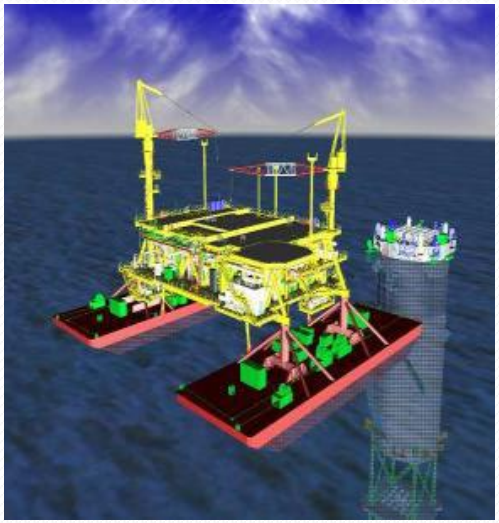


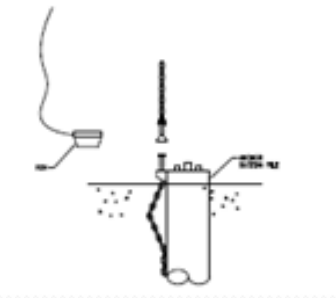
Analysis and Design – Engineering Preparation (cont.)

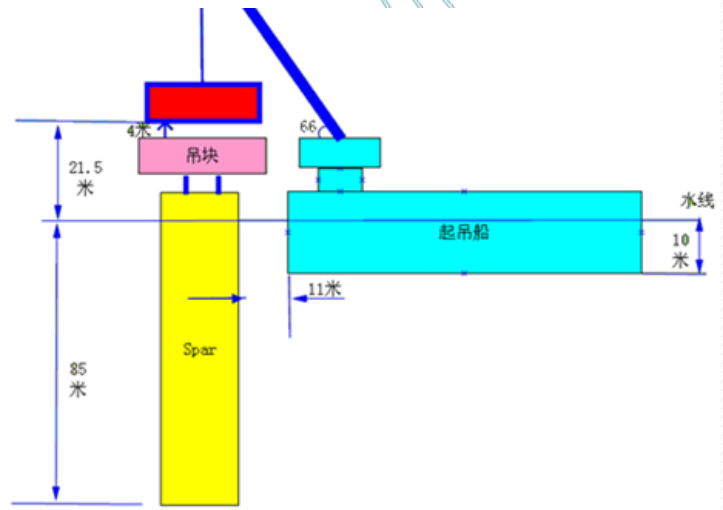












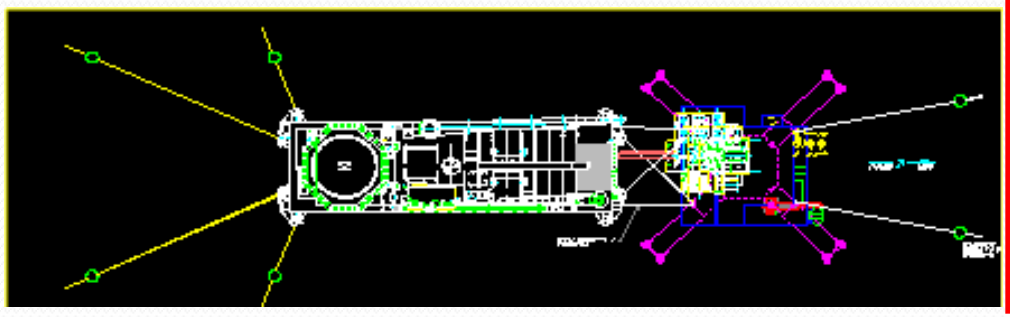
Field Development Study with the Application of TAD

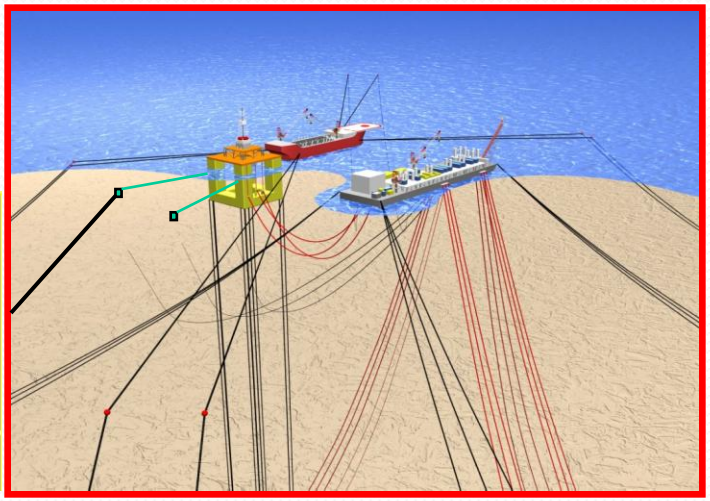
- TAD: Tender Assisted Drilling
- **Application**: China deepwater development
- Why use it: reducing the drilling live load, thus significantly reduce the platform size
- Challenge: fully coupled multi-body dynamic motion
- Advantages:
  - Substantially reduces Floater size
  - Substantially reduces project cost
  - Give field development more flexibility
  - Improve the overall field development economy

TAD Example

Key Technologies and Technical Challenges

- Field architecture of arranging the relative positions
- Fully coupled system time-domain design and analysis between TLP, FPSO and tender vessel (semi or barge)
- Hawser strength and fatigue design and analysis
- Design of drilling equipment set interfaces on TLP
- System field installation
- TAD vessel mooring design and analysis, including mooring buoys and preset system





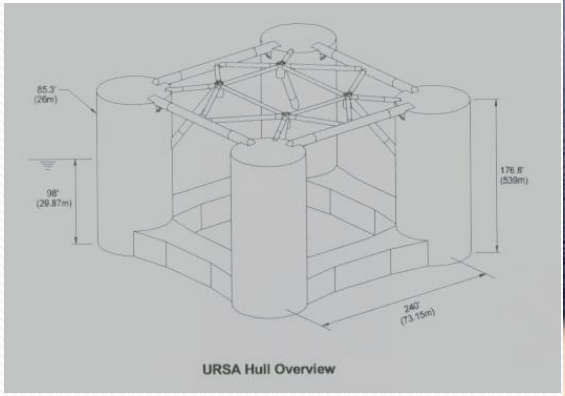
Tender Assist Drilling Arrangement

Application in China Shelf Oil & Gas Development

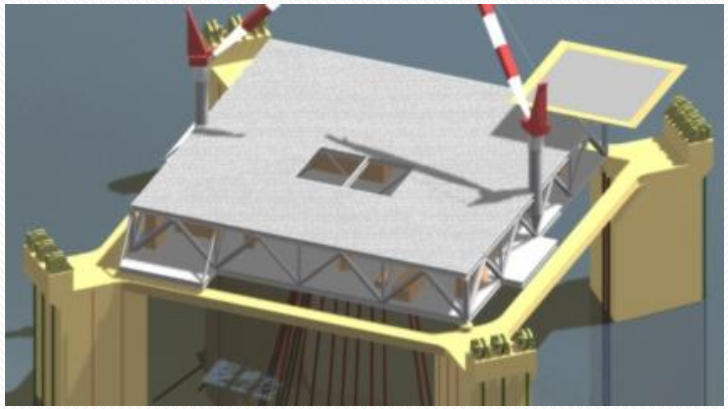
- Most of Oil and Gas fields are lacking of pipeline network infrastructures
- Water depth ranging from shallow to deep
- Take the advantages of the widely used FPSO experience in China, about half of the fields are in combinations with the use of FPSO system
- Take account into the long term in-phase field development
- Take full consideration of China offshore environmental conditions

Study of **Global Bracing Frames** Application in Multi-Column Structures

- What is top of column lateral braces?
- Advantages
- Technical challenges
- Application

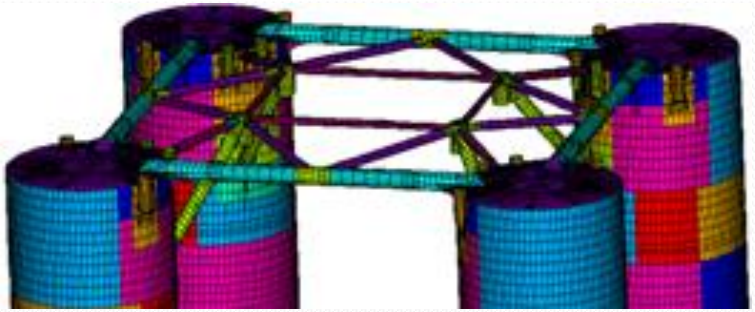


HULL FORMS

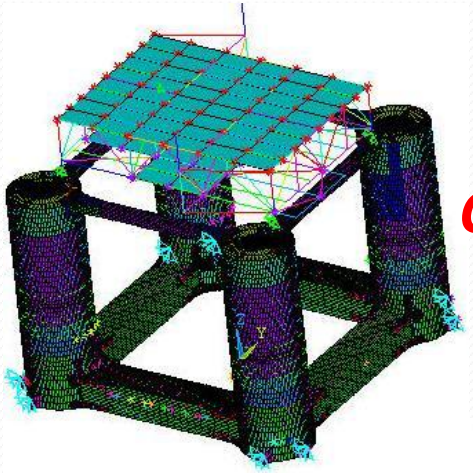


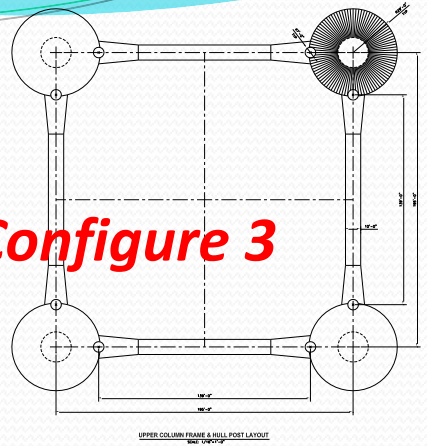
Factors Affecting Lateral Brace Design

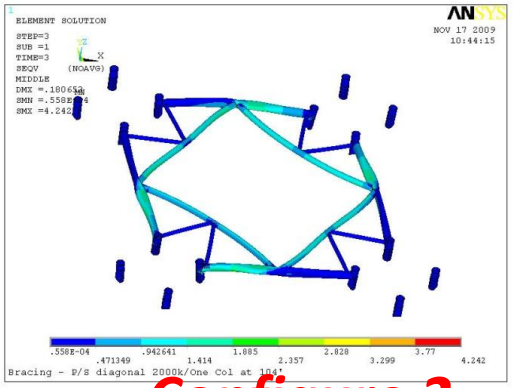
- Global dynamic loads – usually govern the brace design
- Connecting locations – fatigue is always a concern
- Lateral brace is used to facilitate topsides structure design
- Lateral brace can significantly reduce the deck design load
- Column span – large column span may result in large size of braces
- Lateral brace can work well with knee brace to form a strong upper column structure
- Transportation requirement

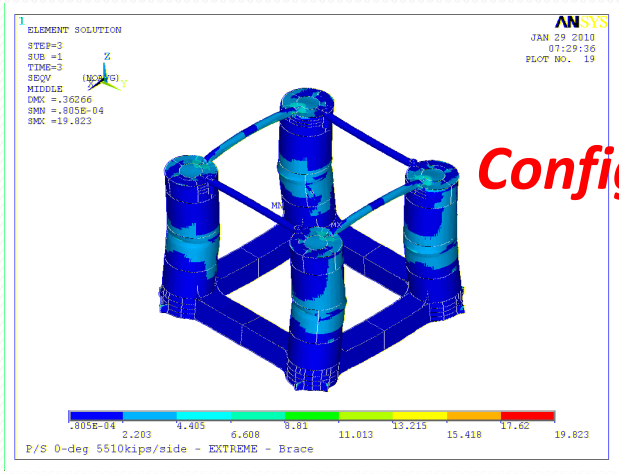


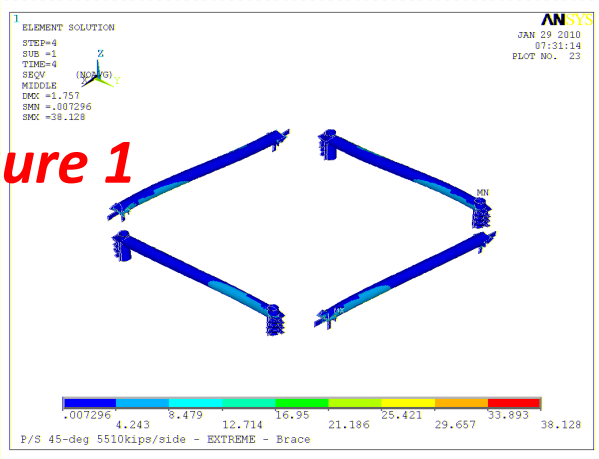
- What have been done?
  - 3 configurations
  - FEA models
  - Strength, Fatigue
  - Connection
- Why do these?
  - Platform has most impact to the project
  - Fatigue is governing structure
  - Steel weight is important

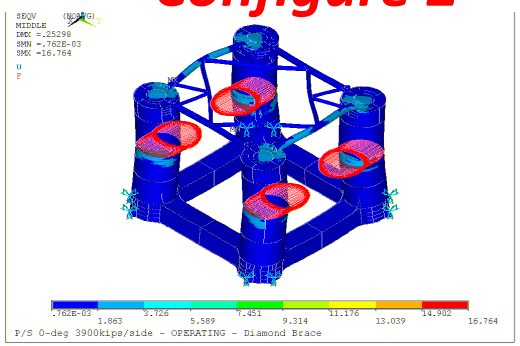










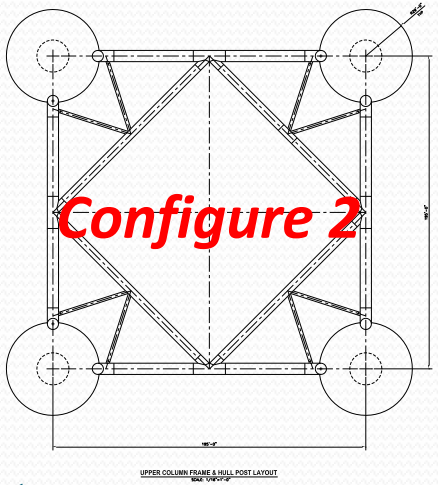


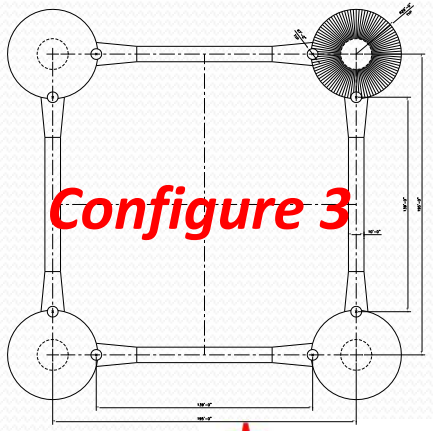
Results Comparison

- Two structures have equivalent weight.
- Along diagonal direction, the maximum stress at stiffened plate braces is about 70% of the stresses at tubular braces.
- Along brace direction, the stresses for stiffened plate braces are much lower.
- Plate brace has more uniform stress distribution.

Braces Stiffness Comparison

TOC Framing Stiffness (kips/in)			
Tubular Brace Type		Plate Box Type	
0 deg	45 deg	0 deg	45 deg
29500	5450	34500	3940





New Technologies for the Continuing Development of Deepwater Exploration

- Continue improving drilling technology
  - Smart drilling
  - Deeper/longer
- New hull forms
  - Dry tree application – less vertical motion
  - Efficiency
  - Fabrication and installation friendly
  - Robust
- Sophisticated integrated subsea system
  - Subsea process
  - Integrated module
  - Subsea pipeline long transport
  - Reliability

New Technologies for the Continuing Development of Deepwater Exploration(cont.)

- New Application of Material
  - High strength, high ductility, high weldability steel
  - Light weight, high strength, high fatigue life synthetic mooring
  - Titanium joints
  - Composite tendon
  - Composite riser – high strength, high resistance to pressure, temperature, corrosive fluid
- Reservoir Detecting Technology, Production Enhancement
- Advanced Remote Control System
- Sophisticated Advanced Analytical Tool
- Advanced Model Testing Technology

Summary

- Deepwater development has the characteristics of high investment, high risk, and high return
- Technology plays key role in deepwater development
- Recent technology advancement has enabled the offshore exploration to reach a new stage
- Offshore development in China has gained speed in recent years: heavy investment, engineering preparation, technology development
- There are innovative ways to economically develop oil & gas fields, such as multi-systems approach combined systems, and TAD system
- Offshore structures are under the action of very complicated environmental conditions. Smart design, such as box global braces, can reduce the dynamic actions, which governs the floating system design.
- **New Technology will help us to continually overcome the current limitation and bring the deepwater development to a new level**

Questions?

Technology is the enabling force for deepwater development!