Platform Concept in Offshore Development

Faculty of Civil and Environmental Engineering of
Bandung Institute of Technology
April 26, 2010

Tigor Martahan Hutabarat*
Lead Structure Engineer

*) Guest Lecture for Prof. Ricky Tawekal PhD
Reference:
3. N.D.P Bartrop, Floating Structure, a guide for design and analysis

TOPICS
• Platform Concepts
• Field Development
• Fixed Offshore Platform
• Deep Water Design
  ❖ Compliant Tower
  ❖ TLP
  ❖ SPAR
  ❖ Semi submersible
  ❖ FPSO
• Riser and Pipeline
• Subsea Wellhead
Offshore Development Options

Dynamic Response of Offshore Platforms

\[
[M]\{\ddot{x}\} + [C]\{\dot{x}\} + [K]\{x\} = \{F\}
\]

Development Strategy

Field development strategy
- Create sub-surface (reservoir) models
- Select sub-surface development concepts
- Select surface development concepts
- Perform safety evaluation
- Perform economic evaluation
**Project Stages**

- **Appraise**
  - FEL-0 Identify
  - Phase-1 Identify & Assess Opportunity
  - Appraisal Design

- **Select**
  - FEL-1 Appraise
  - Phase-2 Generate & Select Alternative(s)
  - Pre-Project

- **Define**
  - FEL-2 Optimize
  - Phase-3 Develop Preferred Alternative
  - Basic Engineering

- **Execute**
  - FEL-3 Define
  - Phase-4 Execute
  - EPSC

- **Operate**
  - Phase-5 Operate & Evaluate
  - Comm & Start-Up
  - Operations

**Our Topics**

- Leadership and Commitment
- Policy and Strategic Objectives
- Organization and Resources
- Risk Evaluation and Management

**Safety Continual Improvement**

- **PLAN**
  - Monitoring and Implementation
  - Audit and Review

- **PERFORM**
  - Leadership and Commitment
  - Policy and Strategic Objectives
  - Organization and Resources
  - Risk Evaluation and Management
  - Planning

- **MEASURE**
  - Audit and Review

- **IMPROVE**
  - Monitoring and Implementation

Source: Rudianto Rimbono, ITB 2010

Tigor M H
GKU ITB Apr 26, 10
Elements in the oil/gas production process include

- **Wellhead**
  - Surface/ dry wellhead
  - Subsea wellhead
- **Production Manifold**
- **Production Separator**
- **Glycol process to dry gas**,
- **Gas Compressor**
- **Water injection pumps**
- **Oil/gas export metering and**
- **Main online pumps.**
- **Production and Storage**

Oil and Gas Production Overview
Wellhead- Casing Design

**KRI Oil Producer Casing Design**

- **Conductor**
- **Surface Casing**
- **Production casing**
- **Production tubing**

**Block Development Options**

- **18'' x 100 km**
  - ADGF PLEM
  - BELANAK
  - WHP-K
  - WHP-D
  - WHP-C

- **24'' x 93 km**
  - FPSO/FSO
  - KERISI

- **22'' x 10 km**
  - gas phase - 16'' x 37 km
  - liquid phase - 12'' x 37 km

- **16'' x 23 km**
  - gas phase - 16'' x 23 km
  - liquid phase - 12'' x 23 km

- **10'' x 6.5 km**
  - gas phase - 16'' x 27 km
  - liquid phase - 12'' x 27 km

- **CPP**
  - HIU SUBSEA
  - CPP
  - KERISI PLEM
  - KERISI

- **DUYONG**
  - CPP
  - KERISI PLEM
  - KERISI

- **NORTH BELUT**
  - CPP
  - WHP-C
  - WHP-D

**Notes:**
- All CIP XHS producers from CPP do not cross Hydrocarbon bearing strata (strata is pinched-out at this location).
- Risk expected to be water-bearing.
### Hub Option

**Sabah Gas Project – Large Scale Infrastructure Scope**

- **Malikai & Ubah (Block G)**
- **Kebabangan Hub**
- **Kumunusu East & UC**
- **Pipeline**
- **KBB- SOGT 125 km**
- **2x18”**
- **Waxing**

### Discovered volumes (incr. to Sabah Gas)

<table>
<thead>
<tr>
<th>Field</th>
<th>Oil (MMbbl)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Malikai (Block G)</td>
<td>78</td>
</tr>
<tr>
<td>Ubah (Block G)</td>
<td>101</td>
</tr>
<tr>
<td><strong>TOTAL</strong></td>
<td><strong>179</strong></td>
</tr>
</tbody>
</table>

Malikai is marginal as a tie-back to KBB

Ubah is subeconomic (TLVC highlighted upside potential which is being tested by appraisal well in 2008)

Other prospects with Shell interests include Leban (Block G)

Northern Area Development plan has been compiled

### Key Challenges and Needs

- **Reduced CAPEX for (small) tie-back fields**
  - Pipelay, subsea installation
  - Reduced well count (ERD, multi-zone smart wells, open hole smart wells)
- **Subsea boosting**
- ** Longer, more challenging tie-backs (50+ km)**
  - Flow assurance management
- **Thin Bed Reservoirs**
  - Optimised information from appraisal
  - Improved static and dynamic modelling
  - Water injection / Gas injection in thin beds
- **Stranded (or sub-economic) Gas**
- **Reservoir imaging below gas chimneys**
Existing Assets

AGX Platform

Anoa Platform

Anoa Natuna FPSO

West Lobe Platform

Project Management Team

- Client
- Contractor Representative/ Project Manager
- Project HSE Manager
- Project QA/QC Manager
- Project Control Administration Manager
- Engineering Manager
- Procurement Manager
- Construction Manager / Site Fabrication Manager
- Offshore Installation
- Hook-up & Pre-Com./Com. Mgr

- PMT Base location is in Jakarta
- Overall Project Co-ordination
- Quality Assurance/Control
- Certification/Classification

- Interfaces Manager
- Deputy Contractor Representative

- Health
- Safety
- Environment

- Internal Interfaces
- External Interfaces

- Contractor
- Project Administration
- Project Finance
- Planning / Progress Reporting
- Cost Control / Reporting

- Engineering
- Topsides Engineering
- Jacket Engineering
- Process Engineering
- **HSE Engineer
- *Structure Engineer
- *Piping Mechanical Engineer
- *Electrical/Instrument Engineer

- Procurement
- Equipment & Material
- Procurement for Topsides / Jackets
- Fabrication (Topsides / Jackets)
- Load Out & Seafastening

- Construction
- Jackets
- Topsides

- Offshore
- Jackets
- Topsides

- Interfaces
- Internal Interfaces
- External Interfaces

* denotes public information
Global Model
Fixed offshore Platform

Engineering Deliverables

- **SPECIFICATION/ PROCEDURE**
  - Structure Design Criteria
  - Structure Design Brief
  - Weighing Control Procedure

- **CALCULATION NOTE**
  - In Place Analysis
  - Seismic Analysis
  - Fatigue Analysis
  - Load Out Analysis
  - Transportation Analysis
  - Jacket On Bottom Stability and Mudmat Design
  - Pile Drivability Analysis
  - Cathodic Protection
  - Weight Control Report
  - Material take off- MTO
  - Deck Local check / Miscellaneous Calculation

- **DRAWING**
  - Standard Drawing
  - Main and Secondary framing
  - Detail drawing
  - RDMS model

**RESPONSIBILITY**

- LEAD/ SENIOR STRUCTURE ENGINEER
  - SENIOR STRUCTURE ENG.
  - SENIOR DESIGN STRUCTURE ENG.
Deep Water Development

Floating Platform

**Advantage**
- Well testing can be extended and overlap with production to know long term production rate without committing the large risk of field specific platform

**Disadvantage**
- Move too much in larger waves so that drilling or production may suspended during storms

---

Organization Chart, illustration

---

Tigor M H
GKU ITB Apr 26, 10
Compliant Tower Main Feature

- Custom design for site specific application
- Single Drilling centre
- Surface completed well
- Integral drilling / work-over facilities
- No oil storage, pipeline, FSU or direct tanker loading
- Tension rigid riser for production
- Flexible or steel catenary for import/export
- Insensitive to topside load
- Long development schedule

Skid-able Platform Rig

- Hull
  - 4 columns 66.5’ diameter, 166’ high
  - 200’ centers
  - 54,700 ton displacement
  - 13,500 tons steel

- Production Risers/Wells
  - 8 wells maximum
  - 4 - 13 5/8” risers
  - 4 - 10 3/4” risers

- Direct Tendon/Pile Connection
  - 12 piles 82” diameter x 340’ long
  - 245 tons each

TLP- Tension Leg Platform

- Deck & Production Equipment
  - 245’ x 245’ x 40’ high
  - 5 separate modules
  - 100 MBOPD 150 MMCFD
  - 15,000 tons

- Tendons
  - 12 -32” diameter x 1.25”
  - 2900’ long
  - 625 tons each
  - URSA-type connectors
TLP Main Feature

- Custom design for site specific application
- Single Drilling center
- Surface completed well
- Integral drilling/ work-over facilities
- No Oil Storage, Pipeline, FSU or direct tanker loading
- Tension rigid riser for production
- Flexible or steel catenaries for import/ export
- Sensitive to topside load
- Relatively long development schedule

Photo
Tendon Tension Components

- the avoidance of wave impacts on the under side of the deck,
- the wave and low frequency horizontal forces and motions,
- the wave and current induced vortices,
- the avoidance of slack tethers,
- the maximum tether

PRETENSION = Static Top Tension

TLP offset:
MEAN OFFSET TENSION

MAXIMUM TENSION = mean offset tension + dynamic tension + allowances

MINIMUM TENSION = mean offset tension - dynamic tension - allowances

Bottom Tension = top tension - self weight

TLP motions:
DYNAMIC TENSION

Wave Action

- Pryong Action
- Squeezing Action
- Skew Wave

SKEW WAVE (MAXIMUM TUGGER IN PONTIOM)
HULL DESIGN - STRENGTH, GUIDELINES, STANDARDS

\[ P_z = \text{INUNDATION FORCE} \]
\[ = 0.5 \times P_c \]
\[ \text{(SAME PATH & PERIOD AS WAVE)} \]

For TLP in Gulf of Mexico:
- \( H_s = 0' \) for shallow draft case
- \( H_s = 1/4' \) for deep draft case

HULL DESIGN – Finite Element Model

Tigor M H
GKU ITB Apr 26, 10
SPAR Main Feature

- Custom design for site specific application
- Well Option
  - Single Drilling center, surface completed well, integral work-over
  - Remote well completed subsea by specialist vessel
- Export option
  - Integral oil storage, export via offshore loading unit
  - No oil storage, pipeline or direct tanker loading
- Tension riser, flexibles or catenary steel riser
  - Flexible or steel catenaries for import/export
- Medium development schedule
Semi Submersible

- New Built or conversion
- Well Option 1: Remote subsea with work over by specialist vessel
- Well Option 2: Wells below with Integral drilling/ work-over facilities
- No storage, pipeline, FSU, direct tanker loading
- Sensitive to topside load
- Flexible riser, large number flexible
- Short to medium development schedule
**FPSO- Floating Production Storage Offshore**

**MAIN FEATURE**
- New build or tanker conversion
- Remote wells, normally completed subsea
- Drilling/ work-over required special vessel
- Integral Oil Storage and offloading
  - Flexible riser
- Insensitive to topside load
- Short development schedule
STRUCTURE-DESIGN PROCESS
Archimedes Principal
“The upward force on a submerged body in a fluid is equal to the weight of the fluid displaced by the volume of the body”

Buoyancy Force = \( \rho \cdot g \cdot V \)
6 Degrees of Freedom

• Surge (along x)
• Sway (along y)
• Heave (along z)
• Pitch (about x)
• Roll (about y)
• Yaw (about z)

Stability

Metacentric height (GM) is a characteristic that determines vessel stability.

A floating or submerged body is stable if GM>0

B is the center of gravity of the volume of water that the hull has displaced.
G is the center of gravity of the vessel itself.
M is the intersection of the centerline and line of buoyancy
K is the keel point
Heeling and Righting Curves

- Wind Heeling Moment (HM)
- Righting Moment (RM)
- Range of Stability
- Heel angle
- Down flooding Angle

Bonga Model Test at Texas A&M
Functional Requirements for Floaters

Environment – wind, wave and currents
Topsides payload requirements, including drilling
Riser connections
Foundation Integrity
Appurtenances (external & internal)

Design Spiral

Functional Requirements
Contract Strategy
Mooring and Foundation Design
Structural Design
Hydrostatic Compartments
Hydrodynamics (including Model Tests)

Configuration Proportions
Arrangements
Weight estimate
Global Performance Analysis

**ENVIRONMENT**
- Wind, Waves & Current
  - “operating storms”
  - “design storm”
  - “survival event”

**RISERS**
- loads to TLP
- angles, strokes

**TENDON TENSIONS**
- pretension
- maximum (strength)
- minimum (unlatch)

**UNDERDECK WAVE CLEARANCE (“Air Gap”)**

**SUBSIDENCE**

**LATERAL MOORING SYSTEM**
- configuration
- tensions

**RELATED ISSUES**
- tendon components / fatigue life
- riser components / fatigue life
- deck loading and strength
- hull loading and strength

Facilities Design Considerations

- Potential equipment height limitations
- Limitation of gravity systems caused by inadequate deck height
- Maximum use of lightweight equipment
- Shared utilities with drilling and hill systems
- Loads generated by horizontal, vertical, and rotational movements of TLP during fabrication, tow out, mooring, and operations.
- Damping liquid movement and stabilize process levels
- Drain system influence on buoyancy and CG.
- TLP hydrodynamics impact
- Riser connection locations
- Regulatory requirements
- Cool flowing temperatures and possible hydrate formation due to extreme water depth
- Potential souring of reservoir due to water injection.
- Large power consumption associated with gas compression, product pumping and water injection.
Riser System

• Production riser
• Export and import riser

Platform Export Riser and Pipeline
Riser Type

- Rigid: Usually steel, nominally vertical, top tensioned pipes
- Flexible: Usually steel polymer composite pipes hung in a simple or S shape catenary
- Metal catenary riser: Steel or possibly titanium pipe hung in catenary

Deep Water Free Standing hybrid riser

SLOR = Single Line Offset riser
COR = Concentric Offset Riser
Deep Water Free Standing hybrid riser

- Custom design for site specific application
- Multiple drilling centre
- Remote subsea well
- Well work over by specialist vessel
- Integral drilling/ work-over facilities
- No Oil Storage, oil/gas exported from host platform
- Hydraulic performance of long flowlines key design issue
- Topside load capacity/ullage determined by host platform
- Short development schedule

Sub sea tie back to existing facilities
Subsea tie back to existing facilities

- **Pipeline**
  - 24" Dry gas pipeline
  - Concrete weight coated
  - 650 MMscf/day total capacity so ~150 MMscf/d spare (if operating pressure increased to 204 bara)

- **Flowlines**
  - 2 x 16" CRA wet gas flowlines (design rate of 550 MMscf/d per flowline) + 1 spare
  - Scope for additional control umbilical to Malampaya/Camago

- **Wells**
  - 5 Development wells
  - 4 Additional development wells (2009/2010)
  - Horizontal Xmas tree
  - 7" production tubing, max rates 200 MMscf/d (erosional velocity constrained)
  - 30-70 degree deviation
  - Cased and perforated (crestal interval 120-200 ft or m along hole)

- **Subsea Manifold**
  - 10 slot, 2 header manifold (5 slots used)
  - 2 slots planned for Camago, 2 for Malampaya, 1 "spare"
  - Electro-hydraulic subsea control
  - Tie-in porch for 3rd flowline
  - Tie-in porch for 3rd subsea umbilical

- **Onshore Gas Plant**
  - 2x 450 MMscf/d trains
  - Support systems up to 500 MMscf/d
  - 1000 ppm H2S
  - 250 ppm Methanol
  - Candidate location for condensate collection
  - Future location for offshore facilities from OGP platform from Q2 2004

Seabed relief

- Point source
- Slump scars
- Horizon Xmas tree
- Horizontal tubing
- Flue gas injection
- Malaki seamed features

Rendered 3D image of the NW Borneo Slope
Subsea Architecture

Subsea Package
- Subsea wellhead, trees, PFB
- Subsea Control Module
- Electro-Control hydraulic Umbilical

BUTA = Bullnose umbilical termination assembly
SUTU = Subsea umbilical termination unit
TUTU = Topside umbilical termination unit

Subsea Umbilicals

<table>
<thead>
<tr>
<th>Function</th>
<th>WP (Psia)</th>
</tr>
</thead>
<tbody>
<tr>
<td>2 HP</td>
<td>Super Duplex tube 7,500</td>
</tr>
<tr>
<td>2 LP</td>
<td>Super Duplex tube 3,000</td>
</tr>
<tr>
<td>1 MeOH</td>
<td>Super Duplex tube 5,000</td>
</tr>
<tr>
<td>1 spare</td>
<td>Super Duplex tube 7,500</td>
</tr>
<tr>
<td>2 COP</td>
<td>10mm² screen pair</td>
</tr>
</tbody>
</table>

All are pre filled with transaqua
Lateral subsea Tree

Subsea Installation
Thanks

Question ?