Integrated Design Development of a Low Motion Semisubmersible Hull Form
Contents

• The Semisubmersible as a Deepwater Concept
• Hull Form Development and Optimization
• Hull Motion and Structural Verification
• Platform Features
  – Hull
  – Topsides
  – Mooring and Riser System
• Conclusions
The Semisubmersible as a Deepwater Concept

**Advantages**

- System components adaptable to ultra-deep water
- Concept supports wide range of topside payloads
- Track record of proven design and fabrication and methods
- Proven offshore installation methods with minimal risk
- Quayside Hook-up and Commissioning

**Limitations**

- Currently, the concept is limited to applications with subsea wells
Hull Form Development

Work Flow Path

Functional Requirements
- TOPSIDES
- DRILLING
- PAYLOAD
- RISERS
- HULL

Practical Aspects
- CONSTRUCTION
- TRANSPORTATION
- INSTALLATION
- OPERATION

Hull Form Optimization
- OPTIMIZED
- MOTIONS
- AND
- STEEL
- WEIGHT

Design Verification
- ANALYSIS
- MODEL TESTING
## Functional Requirements

### Basic Requirements

<table>
<thead>
<tr>
<th></th>
<th>Basis</th>
<th>Range of Application</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Location</strong></td>
<td>Gulf of Mexico</td>
<td>Adaptable to other regions</td>
</tr>
<tr>
<td><strong>Water Depth</strong></td>
<td>1830 m</td>
<td>&gt; 3000 m</td>
</tr>
<tr>
<td><strong>Topsides</strong></td>
<td>100 KBOPD</td>
<td>Can be re-configured for larger topsides (&gt;40,000 Tonnes)</td>
</tr>
<tr>
<td></td>
<td>150 MMSCFD Drilling</td>
<td></td>
</tr>
<tr>
<td></td>
<td>26,000 Tonnes</td>
<td></td>
</tr>
<tr>
<td><strong>Riser System</strong></td>
<td>Steel Catenary Risers:</td>
<td>Flexibility to accommodate additional risers and/or larger diameter</td>
</tr>
<tr>
<td></td>
<td>6 Production</td>
<td></td>
</tr>
<tr>
<td></td>
<td>2 Test</td>
<td></td>
</tr>
<tr>
<td></td>
<td>2 Water Injection</td>
<td></td>
</tr>
<tr>
<td></td>
<td>2 Export</td>
<td></td>
</tr>
<tr>
<td></td>
<td>18-inch Maximum Dia.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>4,500 Tonnes vertical load</td>
<td></td>
</tr>
</tbody>
</table>
Practical Considerations

Draft Limitation
Operating Draft (Max.) = 27.5m
- Structural efficiency
- Stability / tow-out draft
- Deck Installation

Transit Draft (Min.) = 12m
- Flexibility for Deck Integration
- Access to yards

Column Configuration
Four-column and Six-Column configurations studied
Six-column solution selected:
- Structural benefit from reduced deck span
- Improved rectangular deck layout (safety, piping, etc.)
- Increased flexibility for deck construction

Ring Pontoon

Omni Directional Motion Response
Hull Form Optimization

**Variables**
- Draft
- Columns (number, size, spacing, shape, inclination)
- Pontoon (length, aspect ratio, bilge radius, shape)
- Cross bracing / ring pontoon configuration

**Constraints**
- Target motion RAOs
- Heave natural period
- Motion/Acceleration at Riser Attachment
- Minimum GM
- Deck area requirement
- Minimum trimming ballast
- Pontoon span / depth ratio
- Maximum Draft
- Transit draft

**SOLVER**

**MOTION RESPONSE MODEL**

**HULL WEIGHT MODEL**

**OPTIMIZED HULL**
Hull Form Optimization

Motion Response Model

- Morison Element formulation for heave pitch and roll motion
- Added mass and inertia (wave) forces calculated assuming hull as an assembly of slender Morison elements
- Closed-form equations for pre-integrated forces along longitudinal, transverse and vertical slender members
- Motions are de-coupled by calculating angular motions about an estimated center of rotation
- Special treatment (added mass corrections) at connections between elements and element ends to obtain reasonable correlation with results from 3-D radiation / diffraction analysis

Example of Hull Idealization
Hull Form Optimization

Steel Weight Calculation:

- Steel Weights defined on a volumetric basis
- Correlated to actual and preliminary designs
- Adjustments for draft / column (tank vent) height
- Adjustments for pontoon height and aspect ratio

![Graph showing Pontoon Weight Coefficients]
Hull Motion And Structural Verification

- Motion Response Prediction
- Comparison to Production Semi’s and MODU’s
- Model Testing
- Structural Verification
Hull Form - Key Features

- Six-columns
- Ring Pontoon
- Pontoon Shaped to Reduce Motion and Provide Omni-directional Response
- Enlarged Center Column and Pontoon Section
- Pontoon Aspect Ratio Maximizes Added Mass Contribution
- Pontoons Consist Entirely of Flat Plate Construction
- Columns Rounded to Reduce Wave Run-up
Motion Characteristics

Heave Rao

Pitch / Roll Rao
Motion Performance Comparison

**Roll Rao**

Roll RAO, Hdg = 90 (Beam Seas)

**Pitch Rao**

Pitch RAO, Hdg = 0 (Head Seas)

- KBR Drilling and Production Semi
- Typical Production Semi
- 5th Generation Drilling Semi
Motion Performance Comparison

Vertical Acceleration At Riser Porch Locations

Heave Acceleration at Riser Porch #1, Hdg=45

Heave Acceleration at Riser Porch #2, Hdg=45
Model Test Verification

Heave Rao Correlation

DIFFRACTION ANALYSIS

- Model Test (soft mooring)
- Model Test (full mooring)
Structural Design Process

Hull Framing and Scantling Calculations
- Global Hull FE Model (Patran):
  - Shell & Bulkhead Plating
  - Pontoon & Column Web Frames
  - Column Deck Flat Plating & Girders
  - Shell and Bulkhead Stiffeners ("Lumped")
  - "Dummy" Members for Risers Porches, Fairleads, etc.

Hydrodynamic Analysis (WADAM)
- Various Wave Headings & Periods
- Map Wave Pressures and Inertial Loads onto Global FE Model

Determine Design Waves
- "Squeeze-Pry" Load between the Pontoons
- Global Torsional Moment
- Longitudinal Shear Force between Pontoons

Global Topsides Model (Patran):
- Primary Transverse Trusses
- Primary Longitudinal Trusses
- Primary Deck Girders and Plating

Global Strength Analysis (SESAM)
- Stillwater + Hydrodynamic Loads
- Yield Checks
- Buckling Checks (SESAM-Platework)

Static and Mooring/Riser Loads (Patran):
- Hull Dead Weight and Operational Loads, including Ballast
- Topsides Dead Weight and Operational Loads
- Mooring Line & Riser Tensions

Fatigue Analysis (SESAM)
- "Screening" Level Stochastic Fatigue Analysis using a Blanket SCF and one or more S-N Curves with G.o.M Scatter Diagram
- Detailed Fatigue Analysis of Critical Areas using Refined FE Models (e.g. "t" x "t")
Hull Structure

- Scantlings in accordance with Class Rules (confirmed by Global Strength and Fatigue Analysis).
- Shell Plate Thickness Limited to 22 mm, except 30 mm in way of cross pontoon connections.
- Plate thickness and stiffener size variations minimized (8 plates sizes and 7 stiffener sizes, excluding local reinforcement at foundations).
- Option for bulb or angle stiffeners.
- Frame Spacing: 2400 - 2950 mm.
- Stiffener Spacing: 640-750 mm.
- 355 MPa (50 ksi) Materials.

Typical Pontoon Framing
Hull Structural Design

- Hull design has adequate strength and meets stress/buckling criteria using reasonable plating and stiffener sizes.
- All areas have fatigue in excess of 200 years (based on Gulf of Mexico Criteria).
- Castings used in “corner” region to provide sufficient fatigue life.

Casting Detail

Global Structural Model
Platform Configuration

**TOPSIDES**
- Process Capacity: 100 KBOPD
- 150 MMSCFD
- Dimensions: 60 x 96 x 14m
- Number of Decks: 2
- Operating Weight: 26,000 tonnes

**HULL**
- Overall Length: 112 m
- Overall Breadth: 95.2 m
- Height (t.o. column): 43.4 m
- Draft: 27.5 m
- Air Gap (to deck): 18.3 m

---

[Diagram of the platform showing various components such as Accommodation & Utilities, Drilling Derrick, Process Facility, Moorings, Risers, and the overall structure.]
Lower Hull Plan

FLUID STORAGE TANKS (TYP)

CROSS PONTOONS (VOID TANKS)

ACCESS TUNNELS

PUMP ROOM (TYP)
Transverse Section At Corner Columns
TRANVERSE SECTION AT CENTER COLUMN

COLUMN STORAGE CAPACITIES
- Barite/Bentonite: 425 m³ (15,000 ft³)
- Cement: 340 m³ (12,000 ft³)
- Liquid Mud: 4,000 bbls
- Drilling Fluid (Brine): 4,000 bbls
- Chemical Storage: 4,500 bbls
Topsides Configuration Alternatives

- **Integrated Deck**
  - Stiffened Plate “Box” Deck
  - Floatover or Lifted Construction

- **Modular Deck**
  - Truss Structure
  - Lifted in 4,000 ton modules or larger
Modular Deck Configuration

PROCESS MODULE

UPPER DECK

MEZZANINE DECK

LOWER DECK

PROCESS MODULE
Topsides - Upper (Weather) Deck
Topsides - Lower (Production) Deck
Hull - Deck Interface

FE Model

BOX BEAM
Modular Deck Construction
Mooring System

- Fairlead
- Platform Chain
- Spiral Strand Wire
- Anchor Chain
- Anchor Radius (1785 m - 2185 m)
- Anchor Pile

[Diagram of mooring system with specific measurements and components.]
SCR Interface - Production Lines

SCR LAYOUT CONCEPT

CLEAR DECK AREA FOR VERTICAL ACCESS

FIXED PIPING

FLEX JOINT/BASKET

SCR

TO MANIFOLD

CHAIN BASKET

TOPSIDES

CHAIN JACK

MESSENGER CHAIN

INSTALLATION SET-UP
Summary

- The semisubmersible hull form provides low motion characteristics within normal draft limits and using a relatively simple hull geometry.

- Motion response verified by analysis and model testing

- Structural design and analysis to verify hull weight and construction.

- Efficient and functional deck layout.

- Flexibility to accommodate alternative deck construction methods.

- Flexibility to accommodate riser system
Integrated Design Development of a Low Motion Semisubmersible Hull Form

Thank You
For further information on our designs and services please contact:

**Singapore Office:**
39, Pandan Road,
Singapore, 609281
Tel.: +65 91093201
+65 68539106

**Malaysia Office:**
11, Jalan 14/2, Taman Tar,
Ampang, Salangor, Kuala Lumpur 68000
Tel.: +60 342665601
Mob.: +60 123210824
+60 178810807

**Dubai Office:**
Jumeirah Lake Towers,
P.O. Box: 643593,
Cluster C, Goldcrest Executive Tower Office 706,
Dubai, UAE.
Tel.: +971 4 447 0897
Fax: +971 4 447 0896
Mob.: +971 567451923
(Main Company Contact)

---

**Irvine Engineering Pte Ltd - Registered Address:**
60 Paya Lebar Road,
#08-43 Paya Lebar Square,
Singapore, 409051
Tel.: +65 68539106

enquiries@irvineeng.com