Dynamic Positioning Committee
Marine Technology Society

Design and Control

Dynamic Positioning System for Deep Ocean Drill Ship “CHIKYU”

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Return to Session Directory

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Dynamic Positioning System for Deep Ocean Drill Ship "CHIKYU"

Mitsui Engineering & Shipbuilding Co., Ltd.
Japan Agency for Marine-Earth Science and Technology

Background

International Scientific Research Program by Ocean Drilling

- **ODP (Ocean Drilling Program) 1985～2003**
  - **Riser-less Drilling Vessel : *JOIDES Resolution* (*USA*)**

- **IODP (Integrated Ocean Drilling Program) October 2003～**
  - **Riser-less Drilling Vessel : *JOIDES Resolution* (*USA*)**
  - **Riser Equipped Drilling Vessel • • *Japan***

OD-21

(Ocean Drilling in the 21st. Century)

Drill to the Mantle !

Japan Agency for Marine-Earth Science and Technology (JAMSTEC)

Appearance and Azimuth Thruster

Azimuth Thruster × 6

Tunnel Thruster × 1

Dimension of “CHIKYU”

- Length (L_{PP}) : 192.0 (m)
- Breadth : 38.0 (m)
- Draft : 9.2(m)
- Gross Tonnage : 57,087 (ton)
- Speed : 10 (kt)
- Accommodation : 150 (personnel)
- Generator (Main) : 5,000 (kw)×6
  (Auxiliary) : 2,500(kw)×2
- Thruster (Azimuth type) : 4,200 (kw) ×6
  (Tunnel type) : 2,550 (kw) ×1
- Derrick(Hook Load) : 1,250 (ton)
  (Height) : 121 (m)
- Drill String Length :10,000 (m)
  (Future Plan) :12,000 (m)

Characteristics of DPS for “CHIKYU”

Position Keeping Ability

Positioning Stability and **Various Conditions**

Redundancy

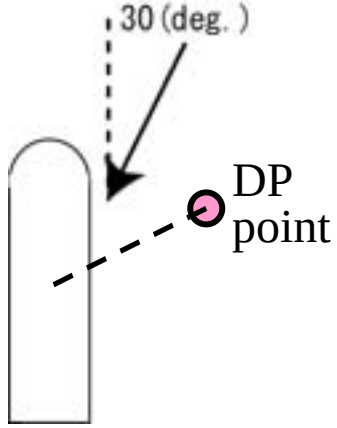
Safety and Long-term Drilling Operations

DP Functions

Ship Handling and Variety of Operations

Specification
Positioning Accuracy in Design Conditions

Conditions		Drilling	Stand-by I	Stand-by II
Current	(knot)	1.5	1.5	**2.5**
Wind	(m/sec.)	23	**30**	23
Wave	(m)	4.5	**5.5**	**5.5**
	(sec.)	8.2	9.0	9.0



Direction ：±30(deg.) against the Heading.

< **Drilling Condition** >

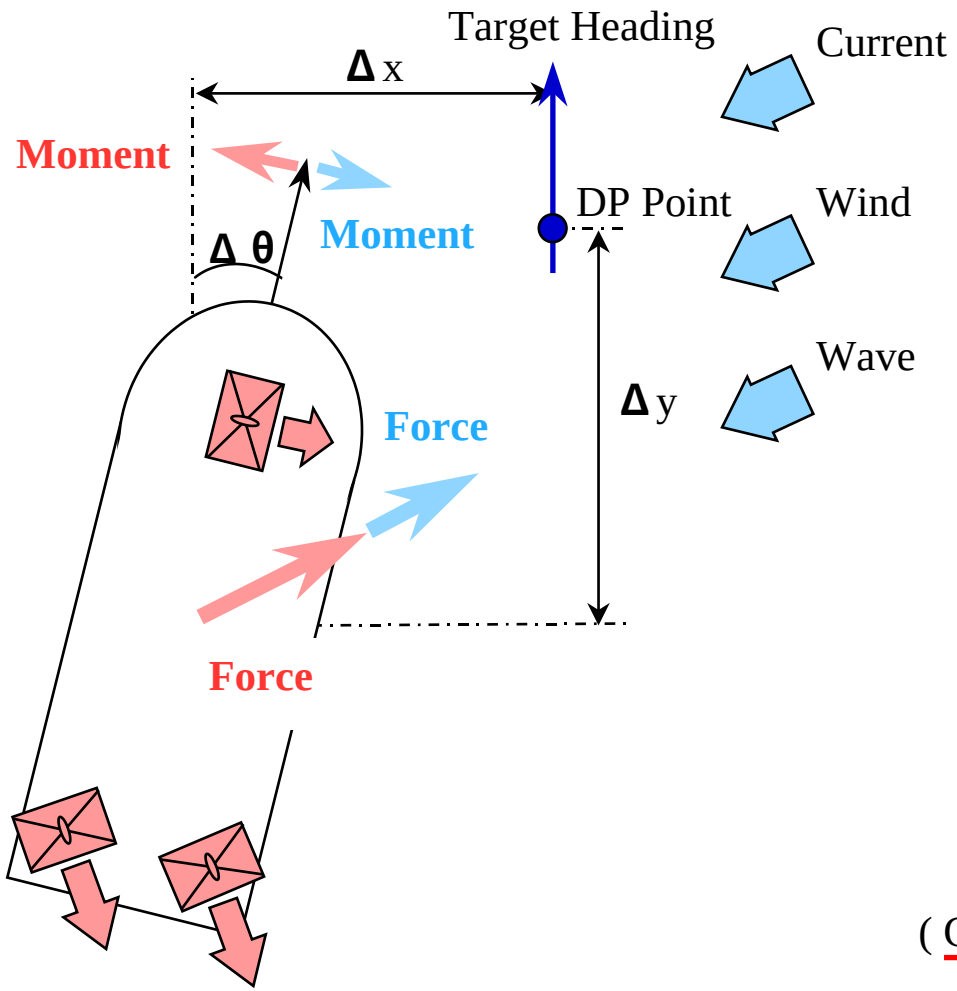
If any single failure occurs in kinetic equipment, DP operation has to be continued.
$2\sigma_P$ has to be less than 1.5% of water depth or 15(m) whichever is larger.

< **Stand-by Condition** >

All equipment for DP is available.
$2\sigma_P$ has to be less than 3.0% of water depth or 30(m) whichever is larger.

Position keeping accuracy is specified using $2\sigma_P$.
(σ_P : Standard deviation of vessel's deviation from the DP point.)

Controlling Theory of DPS



Feed Back Forces and Moment
Forces and Moment to minimize the Deviation from the DP Point and Target Heading.

Feed Forward Forces and Moment
Forces and Moment against the External Disturbances (Wind, Wave, Current etc.).

Control Forces and Moment

Distribute to Available Thrusters
(Considering to Save the Total of Generating Thrust)

Concept of MDPS
(Mitsui Dynamic Positioning System)

The Characteristics of "CHIKYU"

↑

Tank Tests
Wind Tunnel Tests etc.

Static / Dynamic Simulations

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- **Select / Arrange Thrusters**
- **Check the Effect Sensor's Noise**
- **Design the most Suitable Controlling Method etc.**

Suitable Configuration for DPS

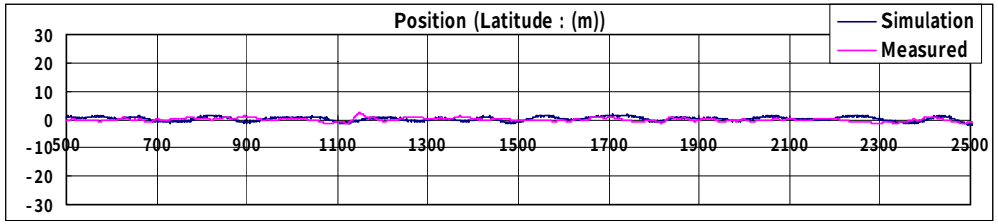
- **Position Keeping Ability**
- **Redundancy etc.**

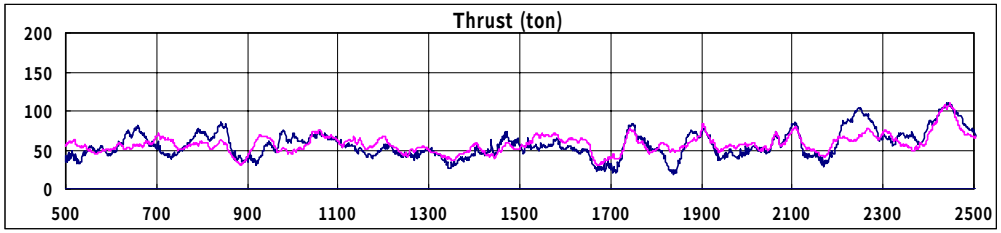
Check the Position Keeping Ability
Simulation and Measured Data

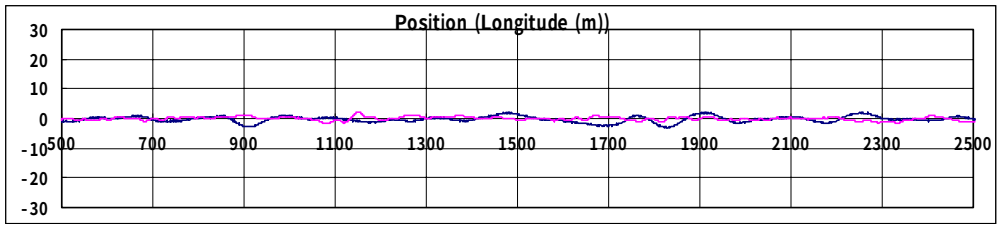
Tank Test
(Position Keeping Test)

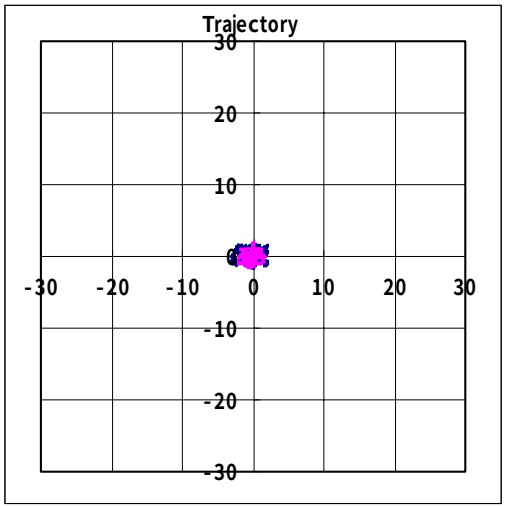
Current：2.5(kt)
Wind　：23(m/s)
Wave　：5.5(m)

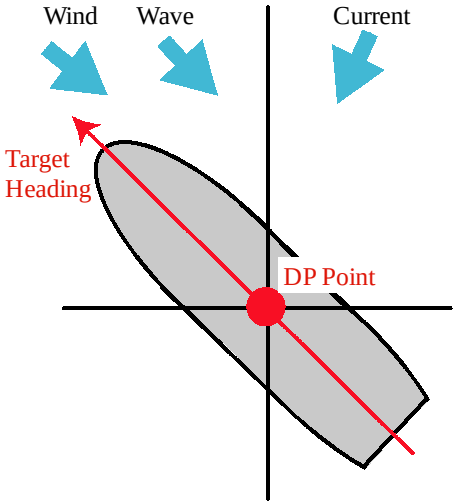
Measured Data and Dynamic Simulation (Time Histories and Trajectory)

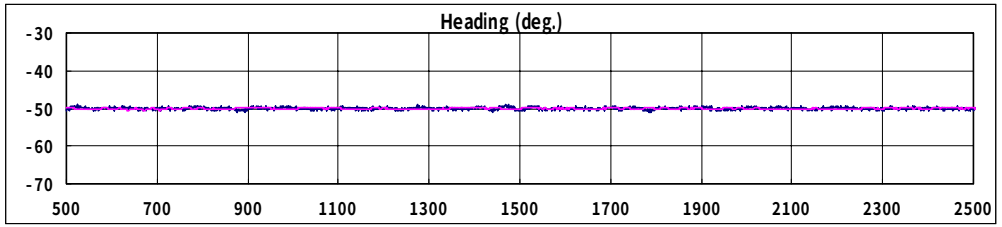


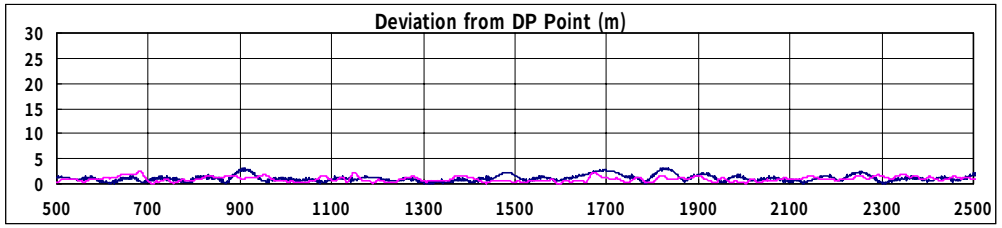








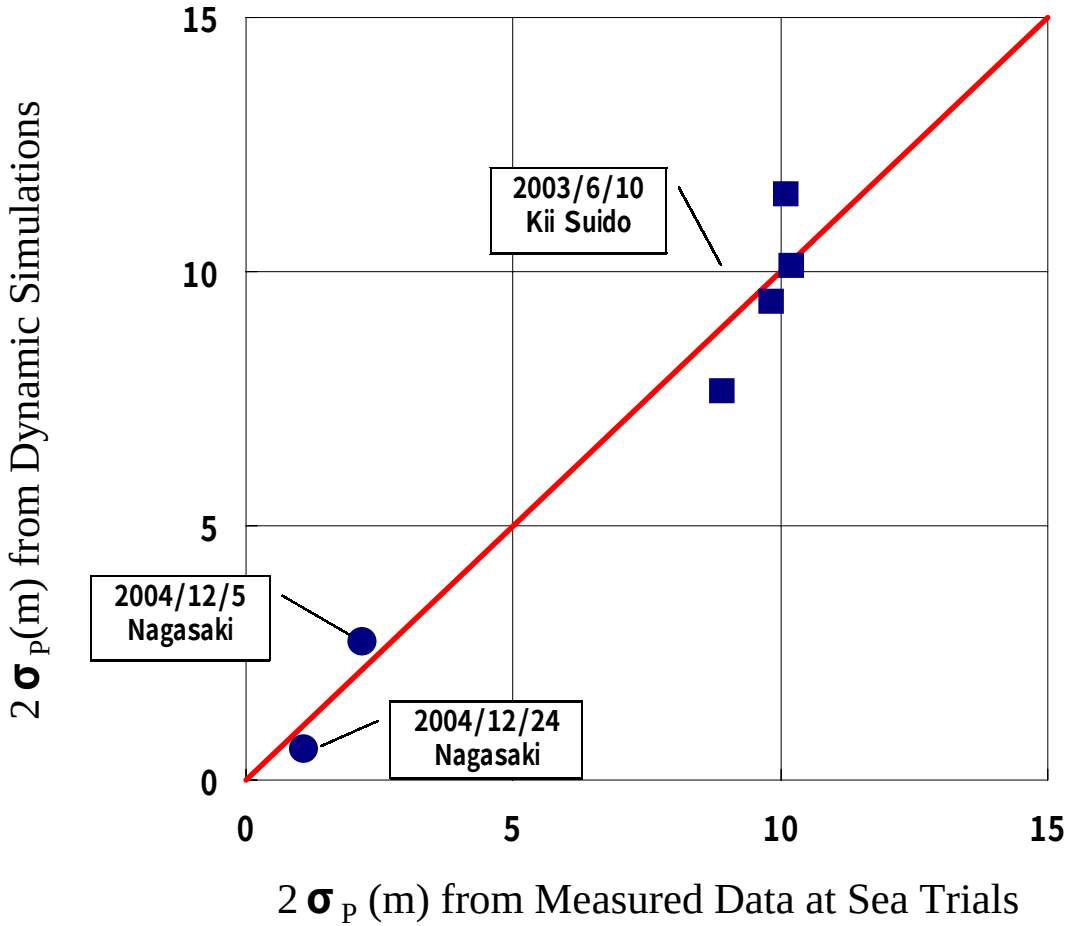




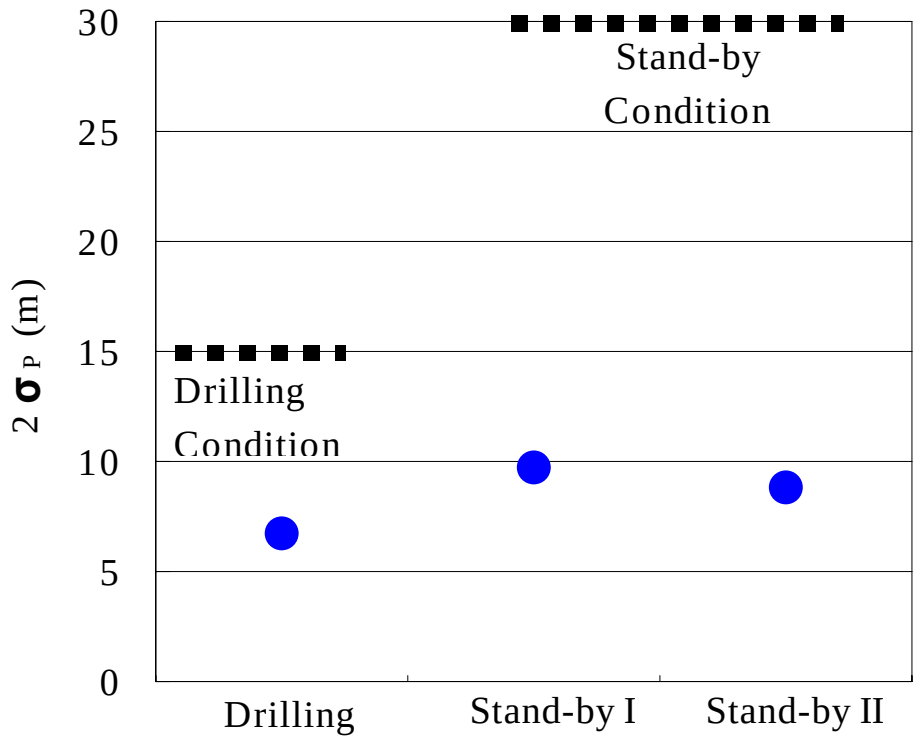
Wind Spd.	19.8 m/s
Wind Dir.	300 deg.
Current Spd.	0.5 kt
Current Dir.	215 deg.
Wave Height	2.3 m
Wave Dir.	310 deg.

	Simulation	Measured
Pos. (2σP)	2.7 m	2.2 m
Heading (Ave.)	310.0 deg.	310.0 deg.
Thrust (Ave.)	60.6 ton	57.7 ton

Measured Data and Dynamic Simulation (Position Keeping Ability)



Position Keeping Ability Check



	Drilling	Stand-by I	Stand-by II
Current	1.5 kt	1.5 kt	2.5 kt
Wind	23 (m/s.)	30 (m/s.)	23 (m/s.)
Wave	4.5 (m)	5.5 (m)	5.5 (m)

■ ■ ■ ■ ■ The maximum allowable 2σp from specification

● The results of numerical simulations under design conditions.

Characteristics of DPS for “CHIKYU”

Position Keeping Ability

Positioning Stability and Various Conditions

Redundancy

Safety and **Long-term Drilling Operations**

DP Functions

Ship Handling and Variety of Operations

Characteristics of DPS for "CHIKYU"
Redundancy

- **DPS System Configuration**

  All signal and electric power source lines are doubled. **Hot Back-up**

  There are **3 Control Consoles and CPU** for DPS. **Triple Voting System**

  Several sensors are equipped to measure the same kind of data.

Sky-Fix DGPS	×2 units	} Position Sensors
GPS-GLONASS Hybrid System	×2 units	
Acoustic Position Reference System	×2 units	
Gyro Compass	×3 units	etc.

- **Engine Room** and **High Voltage Switchboard Room** is partitioned by Watertight and Fireproof Bulkhead.

- The key instruments for DPS (Thrusters, Generators etc.) are installed in **Double Hull** section.

Characteristics of DPS for “CHIKYU”

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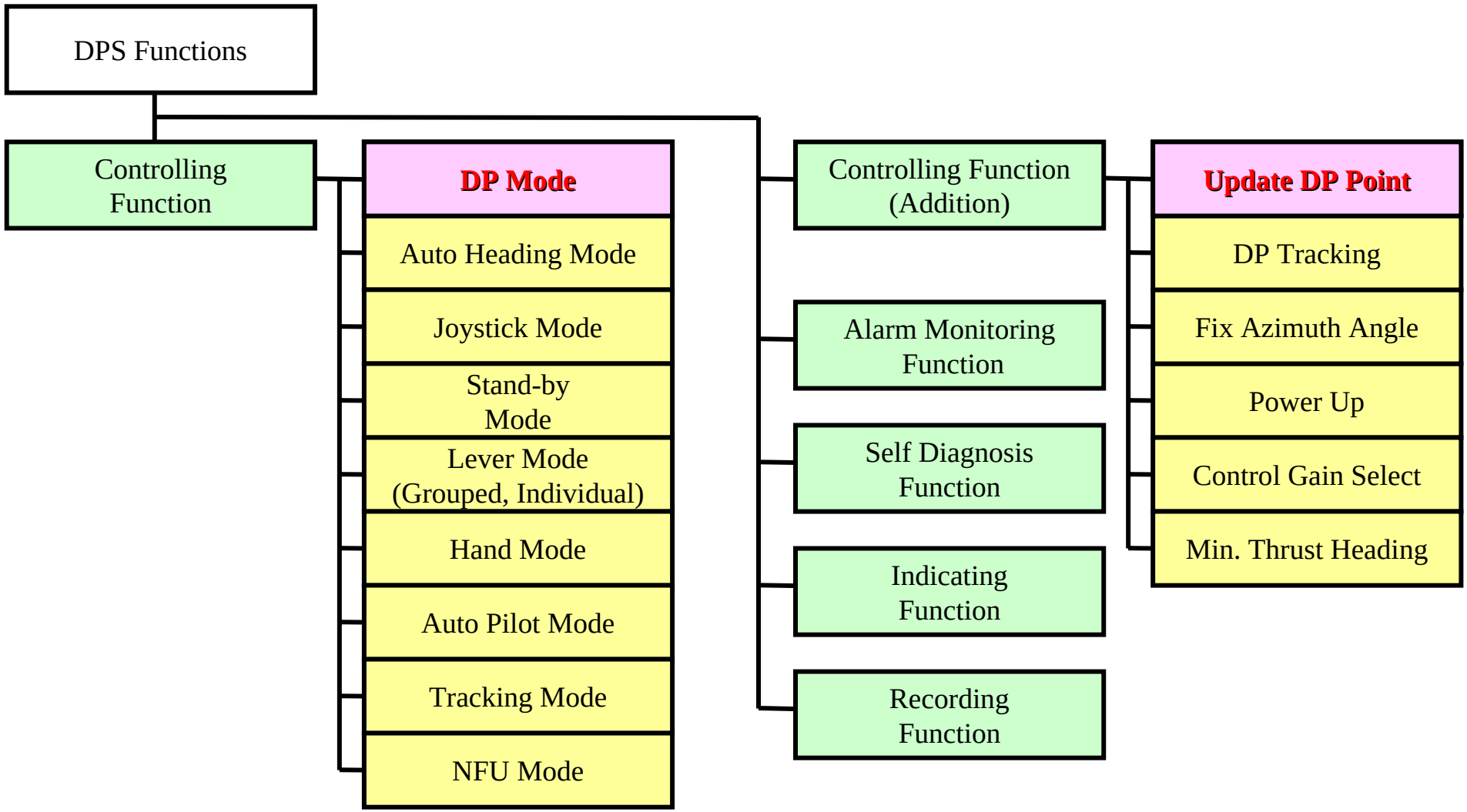
Ship Handling and **Variety of Operations**

DPS Functions

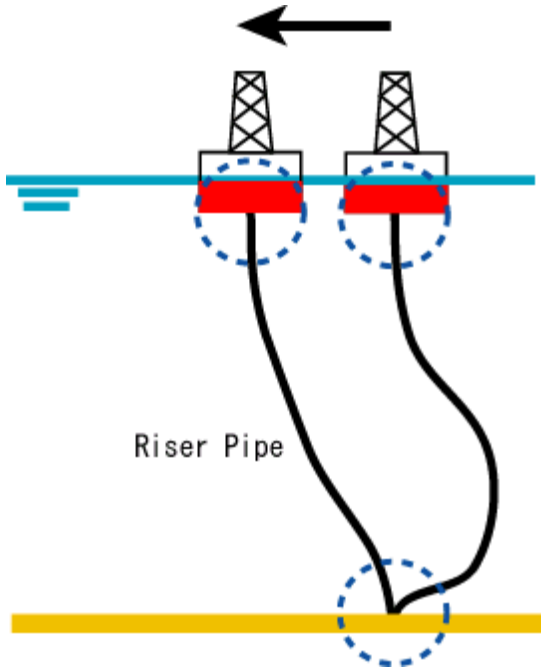


Update DP Point

- Update the DP point to Minimize the Riser Pipe's tilt Angle (top and bottom).

  Riser Angle Control System (RACS)

- Estimate the vessel's position using the Riser's tilt angles (Top and Bottom) without any other position sensor.



Conclusions

This DPS is designed considering the operation of "CHIKYU".

Position Keeping Ability

Sea Trials & Simulation

Develop the Practical Simulator

Confirmed the Complete Position Keeping Ability under Various Conditions.

Redundancy

Enough Redundancy to Assure for Long Term Drilling Operation.

DP Functions

Highly Adaptable Ship Handling Functions for a Variety of Operations.

Scientific Drilling Operation will start in 2007