



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”**

An aerial photograph of the Deep Ocean Drill Ship CHIKYU, a large white vessel with a complex blue and yellow drilling rig structure on its deck. The ship is moving through the dark blue ocean, leaving a white wake. The rig structure is tall and intricate, with various levels and platforms. The ship's hull is white, and there are several yellow cranes and other equipment visible on the deck. The background shows a clear blue sky and a distant horizon.

**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)

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



Appearance and Azimuth Thruster



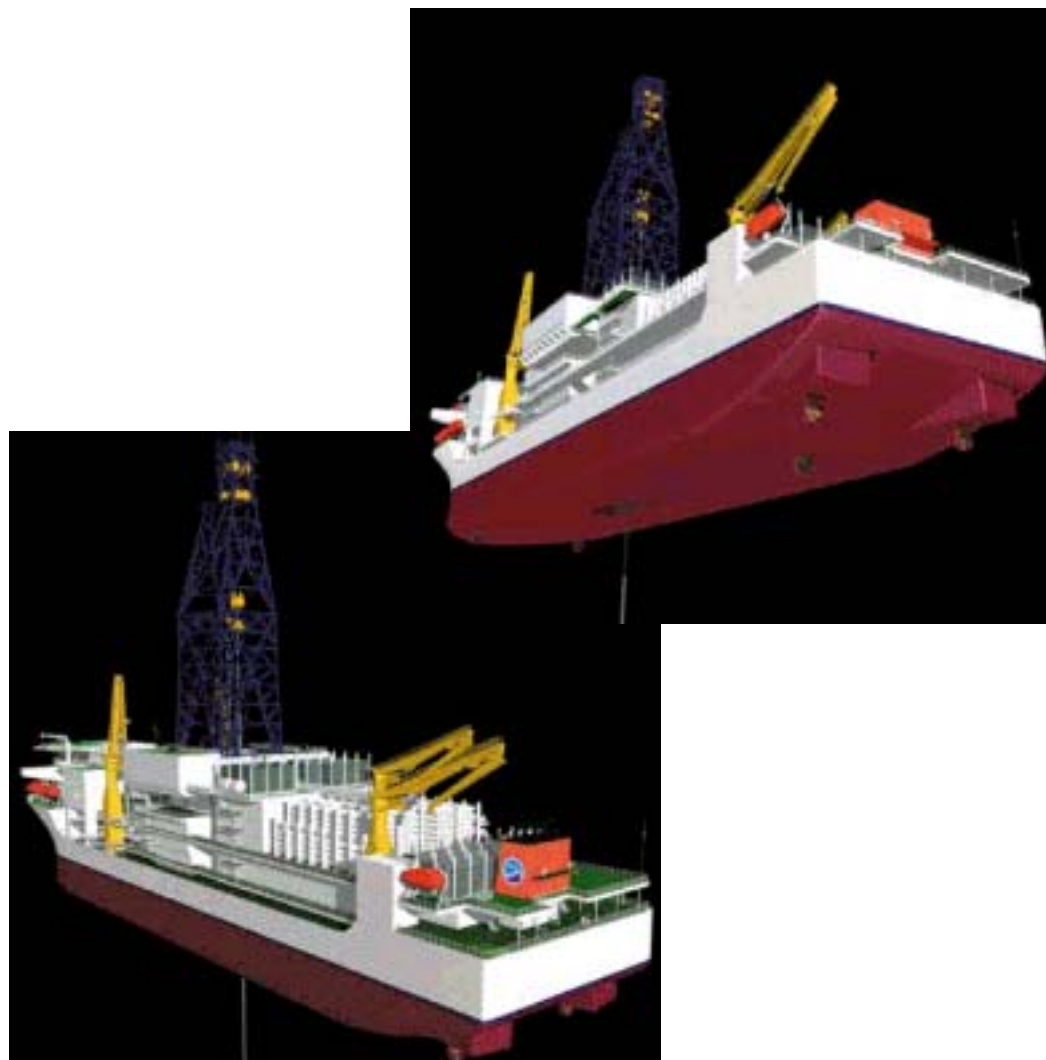
Azimuth Thruster × 6

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

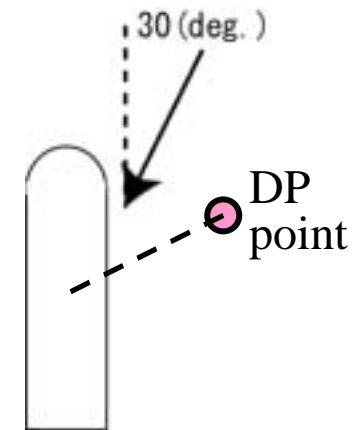
DP Functions

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 : $\pm 30(\text{deg.})$ against the Heading.

< Drilling Condition >

If any single failure occurs in kinetic equipment, DP operation has to be continued.

σ_p has to be less than **1.5% of water depth or 15(m)** whichever is larger.

< Stand-by Condition >

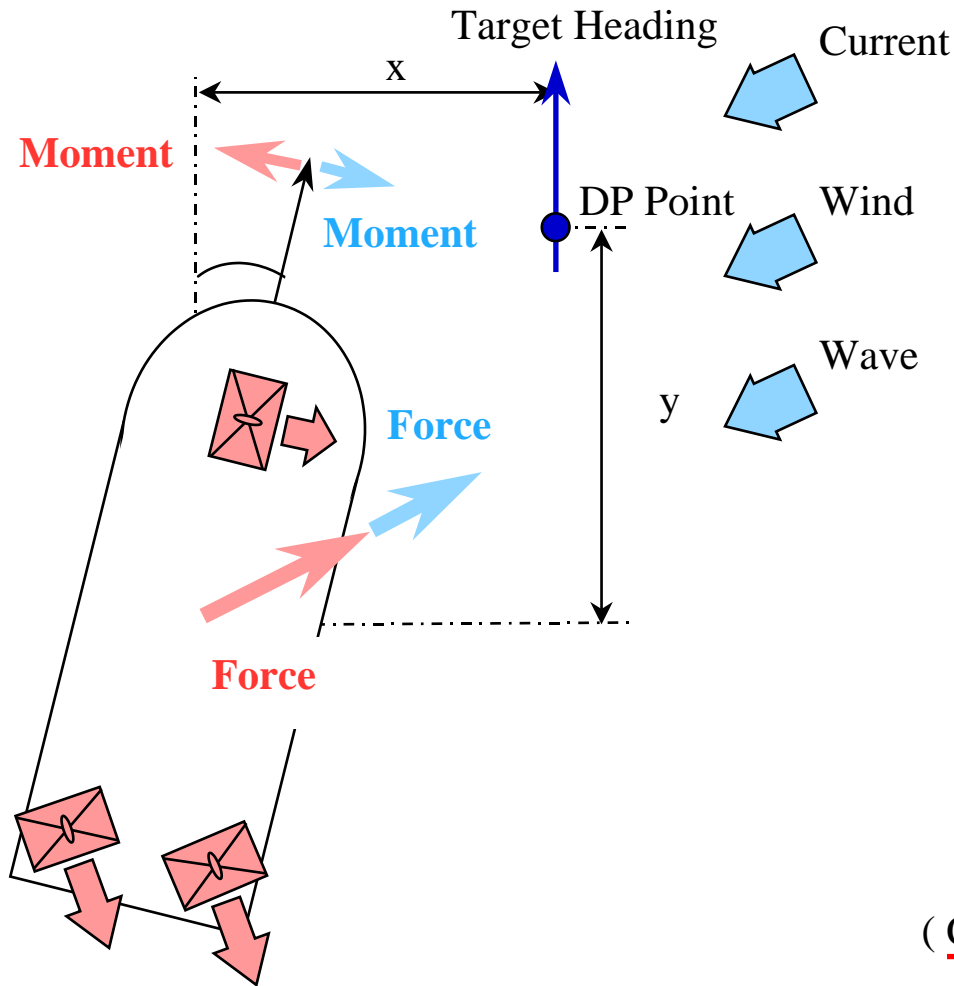
All equipment for DP is available.

σ_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.).



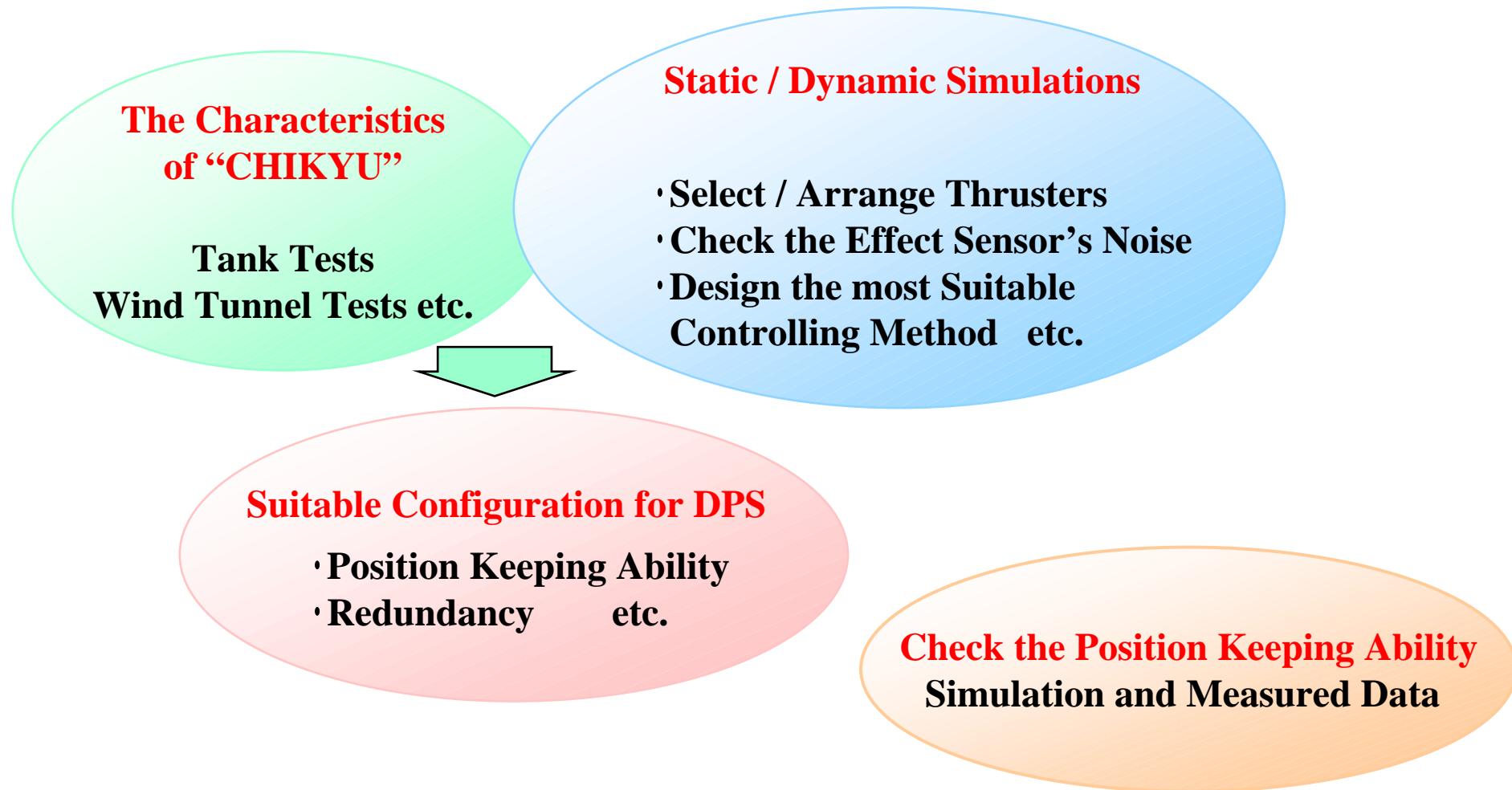
Control Forces and Moment



Distribute to Available Thrusters

(Considering to Save the Total of Generating Thrust)

Concept of MDPS (Mitsui Dynamic Positioning System)

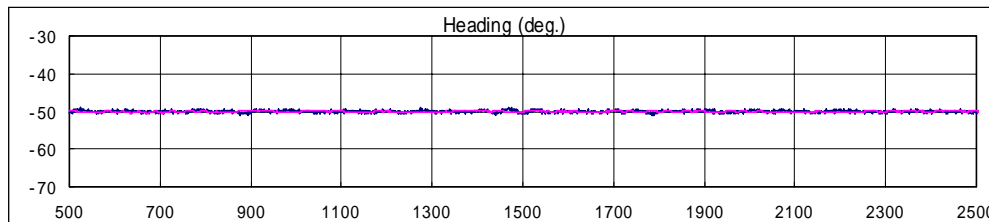
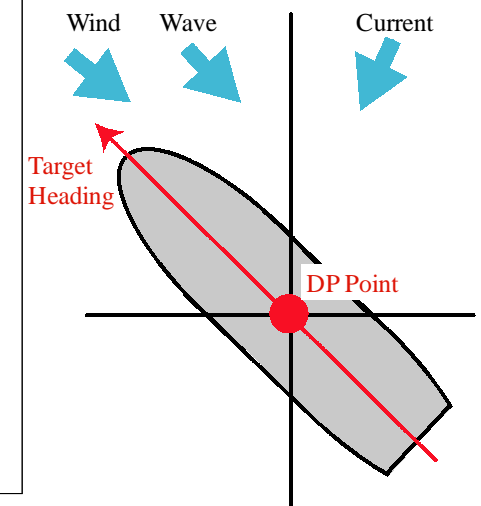
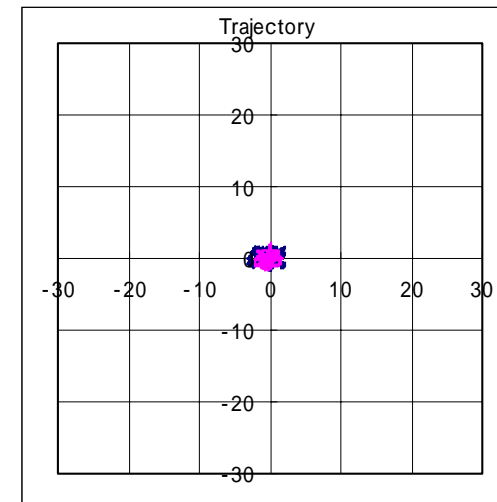
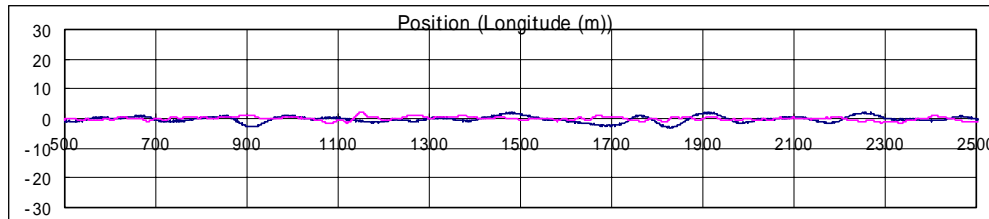
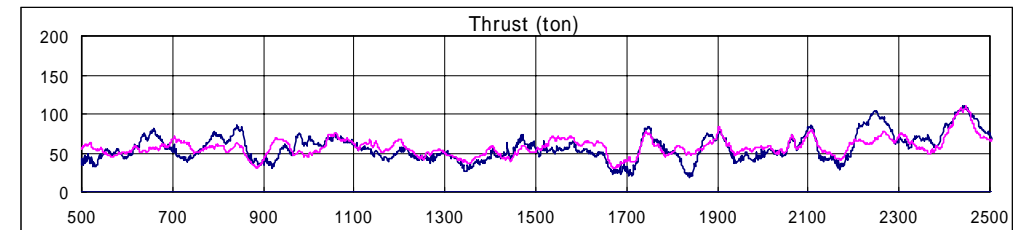
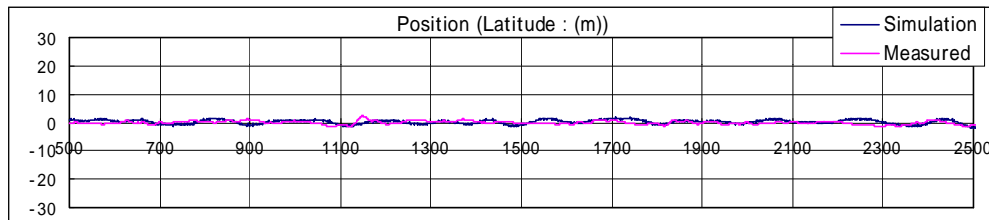


Tank Test (Position Keeping Test)

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

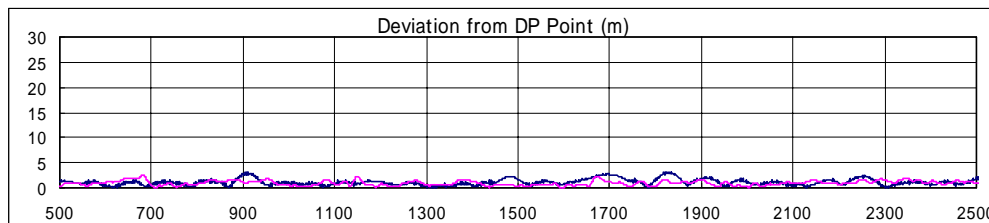


Measured Data and Dynamic Simulation (Time Histories and Trajectory)

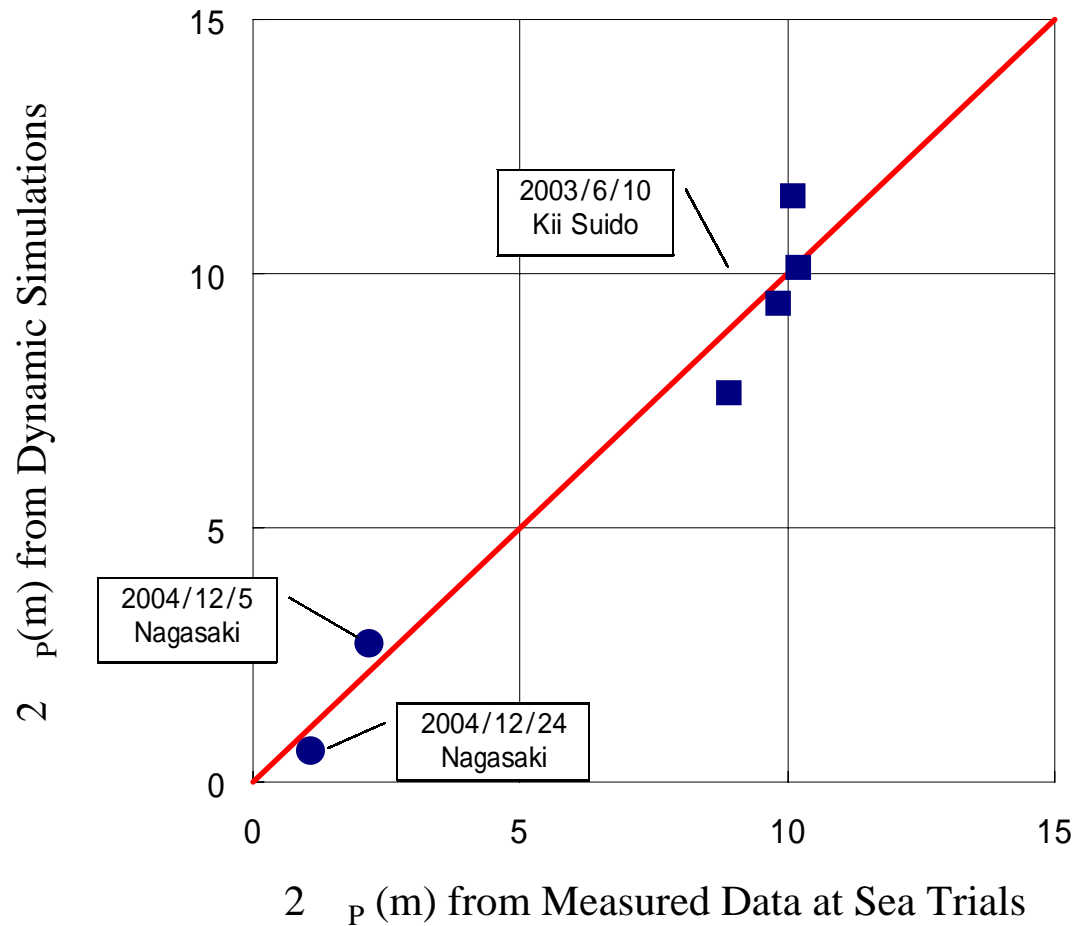


Wind Spd.	19.8 m/s
Wind Dir.	300 deg.
Current Spd.	0.5 kt
Current Dir.	215 deg.
Wave Height	2.3 m
Wave Dir.	310 deg.

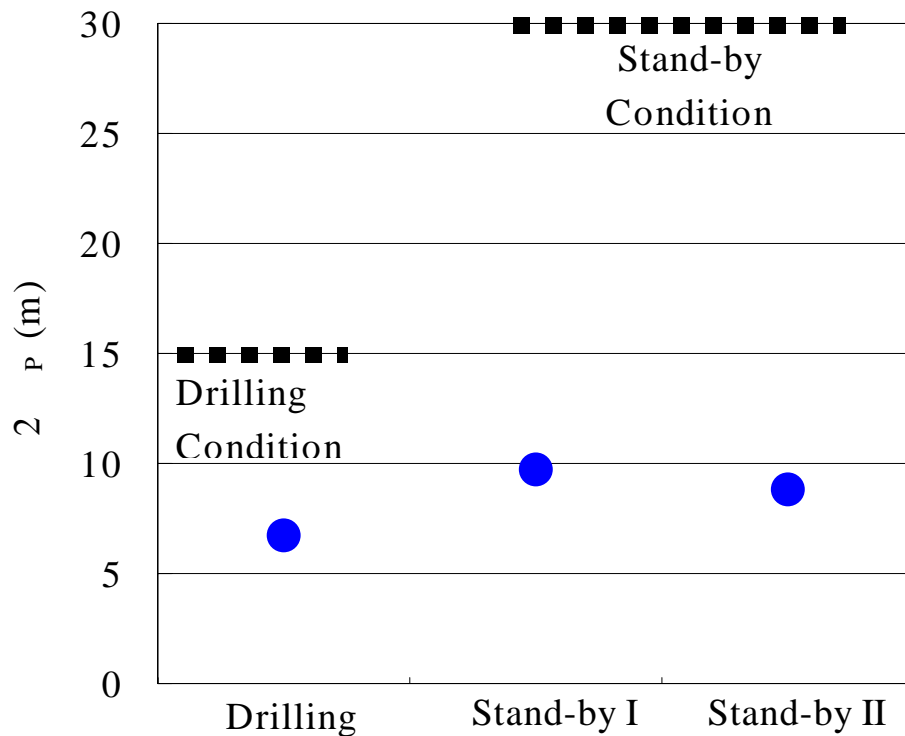
	Simulation	Measured
Pos. (2 P)	2.7 m	2.2 m
Heading (Ave.)	310.0 deg.	310.0 deg.
Thrust (Ave.)	60.6 ton	57.7 ton



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 2_p 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.

There are **3 Control Consoles and CPU** for DPS.

Hot Back-up

Triple Voting System

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

Sky-Fix DGPS

× 2 units

GPS-GLONASS Hybrid System

× 2 units

Acoustic Position Reference System

× 2 units

Gyro Compass

× 3 units

} Position Sensors
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”

Position Keeping Ability

Positioning Stability and Various Conditions

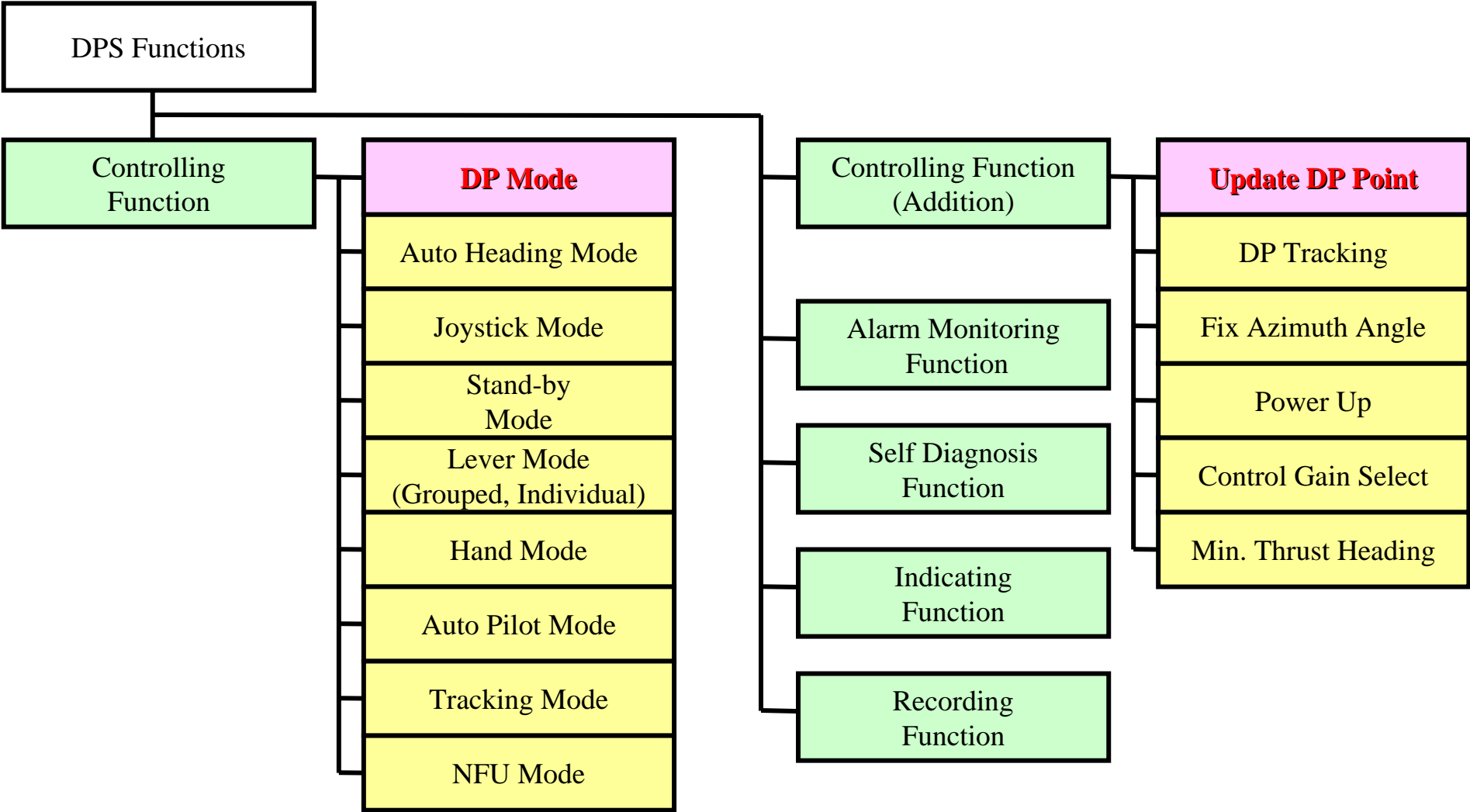
Redundancy

Safety and Long-term Drilling Operations

DP Functions

Ship Handling and Variety of Operations

DPS Functions

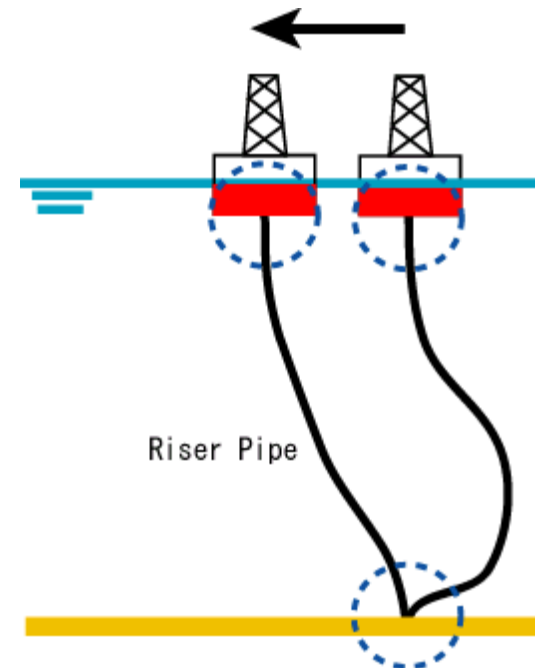


Update DP Point

- 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.

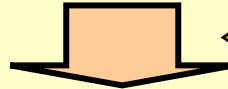


Conclusions

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