Design and Operational Experience with FPSOs Offshore NW Australia

Arun Duggal & Sam Ryu, SOFEC, Inc.

Kei Ikeda, MODEC, Inc.

3 December 2008

Perth, Australia

SOFEC

MODEC

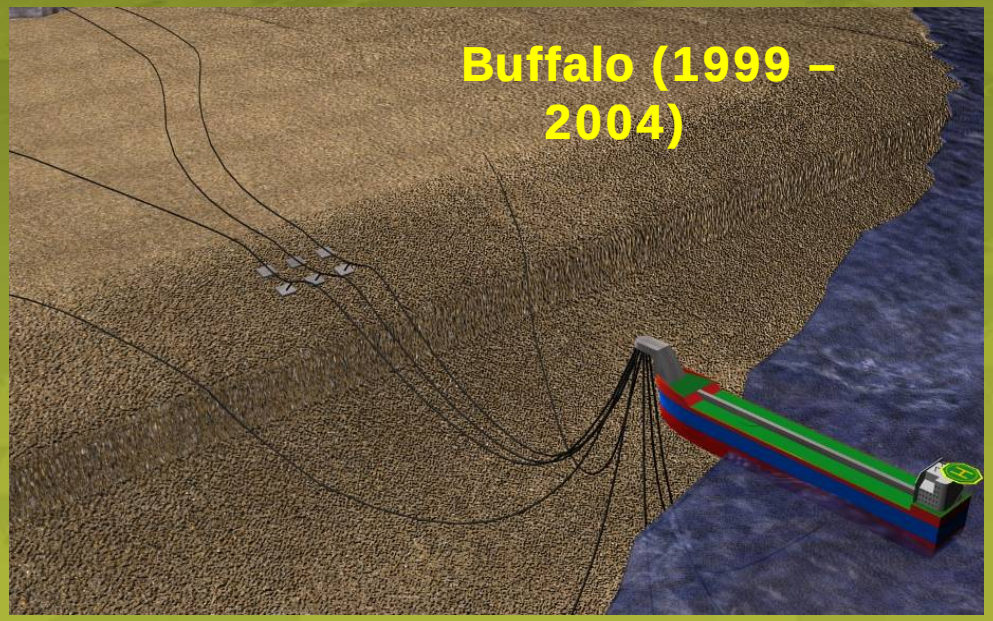
DEEP OFFSHORE TECHNOLOGY INTERNATIONAL ASIA / PACIFIC™

Outline

- Overview of Systems Designed and Installed
- Design Features, Challenges and Lessons Learnt
- Operating Performance in Cyclones (2005 - 2008)
- Summary

DEEP OFFSHORE TECHNOLOGY INTERNATIONAL ASIA / PACIFIC™

Installations Offshore NW Australia

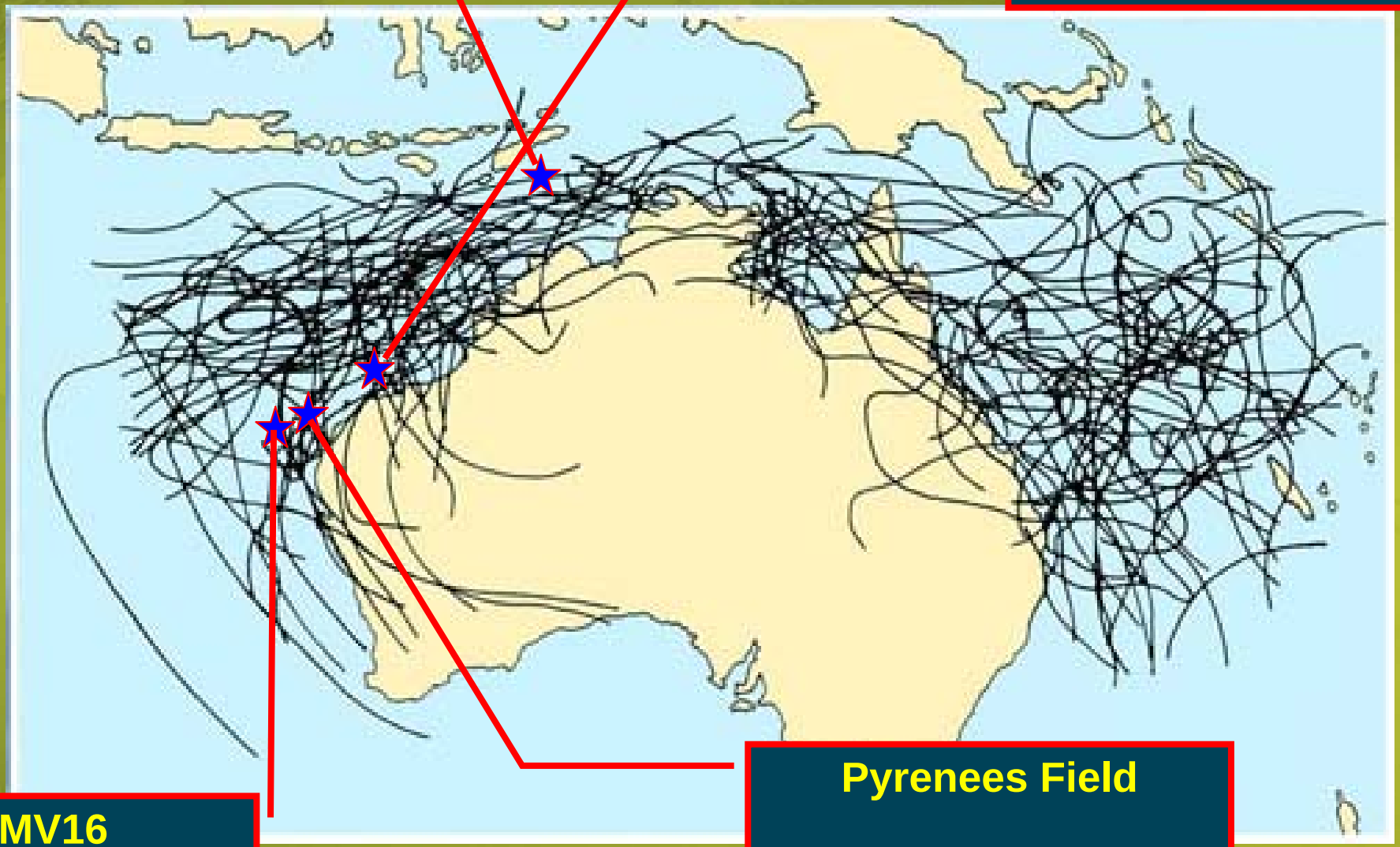


INTERNATIONAL
ASIA / PACIFIC™

Cyclones around Australia

Buffalo Field

MV11 @ Mutineer/Exeter Field



Pyrenees Field

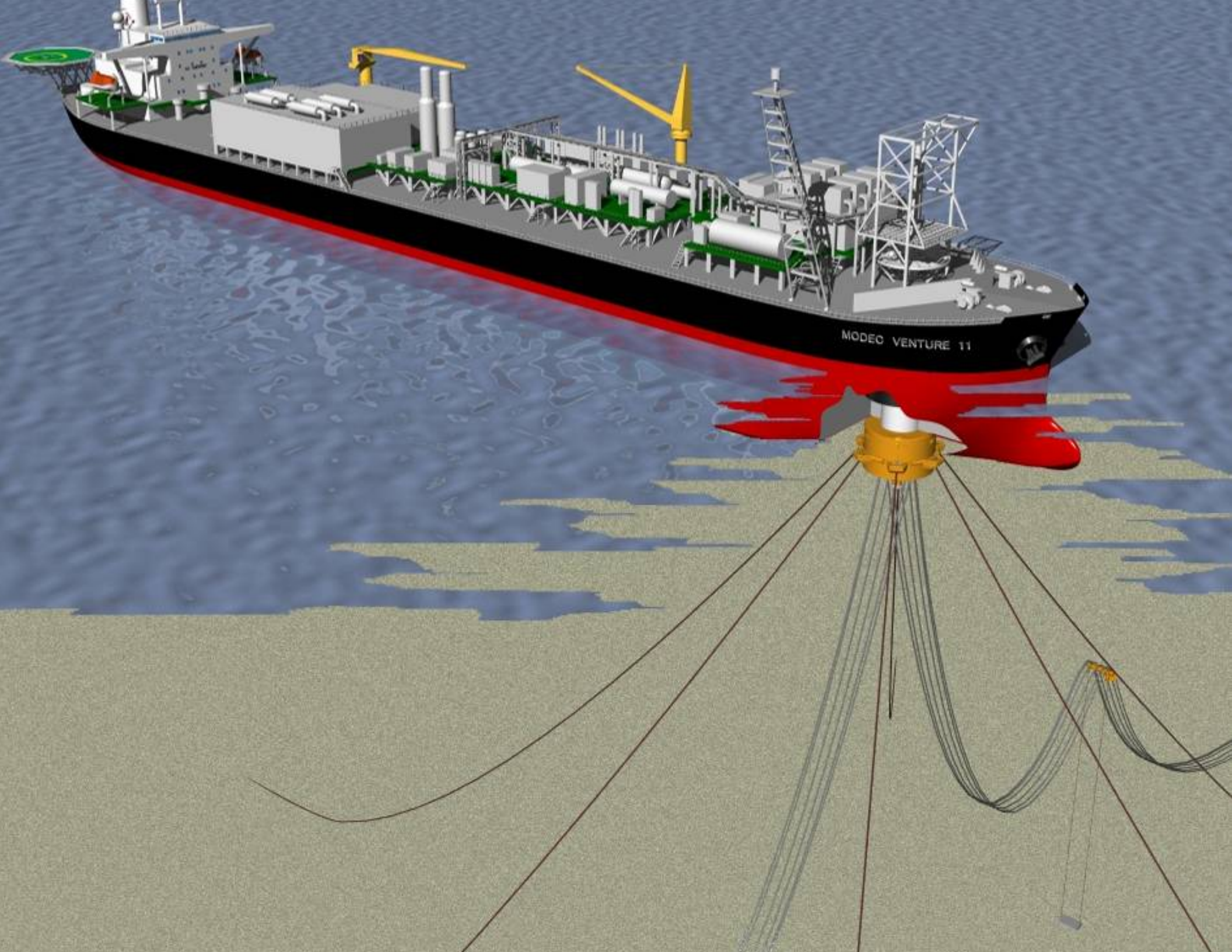
MV16 @ Stybarrow Field

Reference: Australian Government, Bureau of Meteorology
http://www.bom.gov.au/info/cyclone/#severity

DEEP OFFSHORE TECHNOLOGY INTERNATIONAL ASIA / PACIFIC™

Disconnectable FPSOs

- **Mutineer – Exeter FPSO (Installed 2005)**
  - 160 m water depth
  - Suezmax tanker conversion, ~930,000 bbls storage
  - Topsides: 100,000 bbls/day
  - 10 risers and umbilicals
- **Stybarrow FPSO (Installed 2007)**
  - 850 m water depth
  - Newbuild FPSO, ~ 1,000,000 bbls storage
  - Topsides: 100,000 bbls/day
  - 12 risers and umbilicals
- **Pyrenees (To be installed in 2009)**
  - 200 m water depth
  - Similar vessel/topsides as Stybarrow
  - 15 risers and umbilicals


MODEC VENTURE 11

Global Analysis Design Basis

- FPSO to disconnect from mooring and risers to avoid cyclones
- FPSO to stay on station during the 100-year non-cyclonic storm
  - Significant wave height ~ 7.0 meters
- Disconnected spider buoy system designed for 100-year cyclone
  - Significant wave height ~ 12.6 meters
- Reconnect in seas up to Hs = 3 meters
- Mooring system design
  - Maintain adequate offsets for riser system
  - Optimize payload on spider buoy, retrieval loads, and buoy s

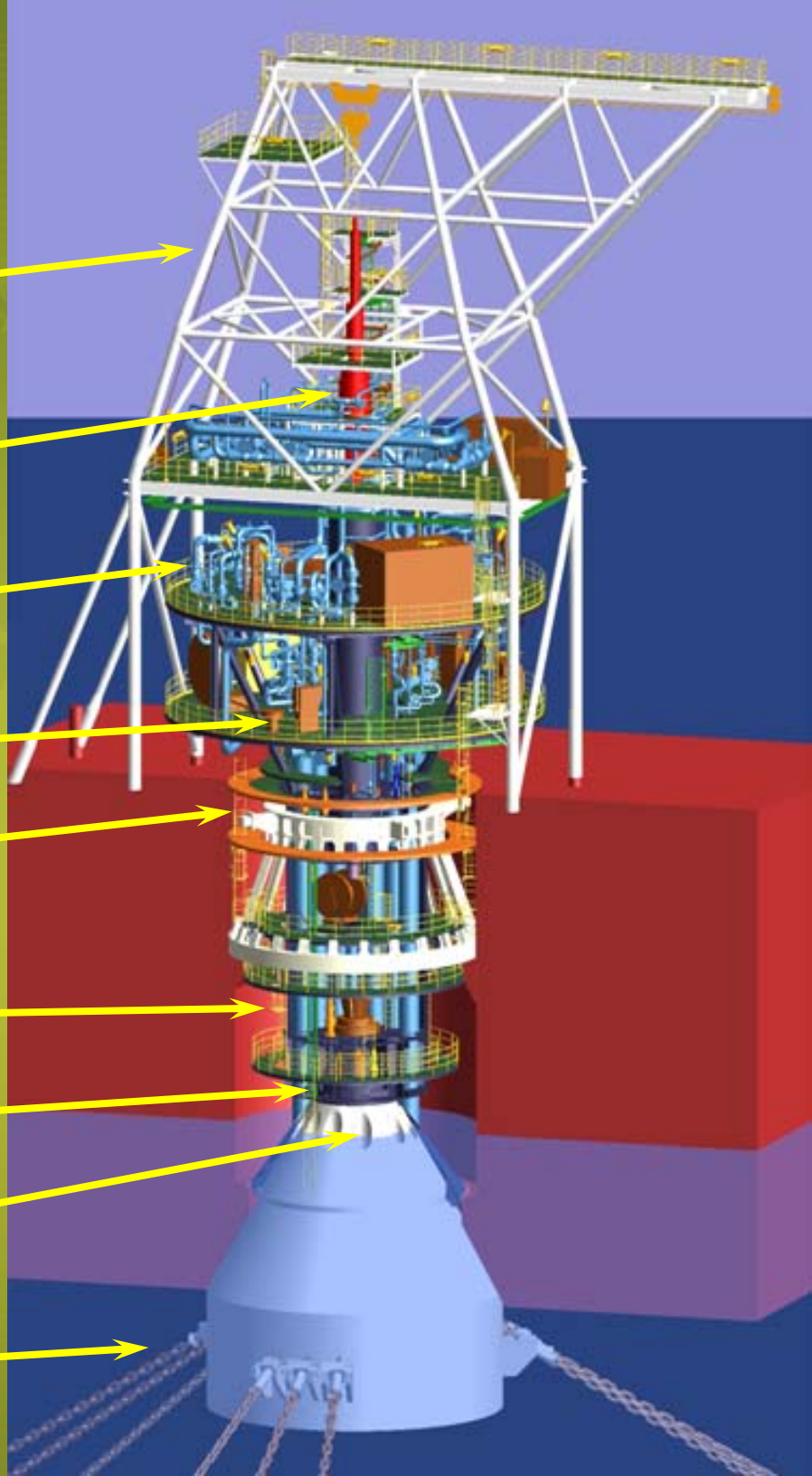
Turret Mooring Design Features

- Robust standardized design
  - Based on 3 previous generations of systems
  - Fluid-transfer and load-transfer components designed to disconnect separately
- Mooring designed to remain connected for 100-year winter storm
- Turret mooring designed to disconnect for cyclones
  - Design disconnect duration ~ 6 hours
  - Reconnect w/o assistance in seas up to Hs of 3 meters
- Disconnectable spider buoy
  - Supports anchor legs, and risers and umbilicals (current design up to 15)

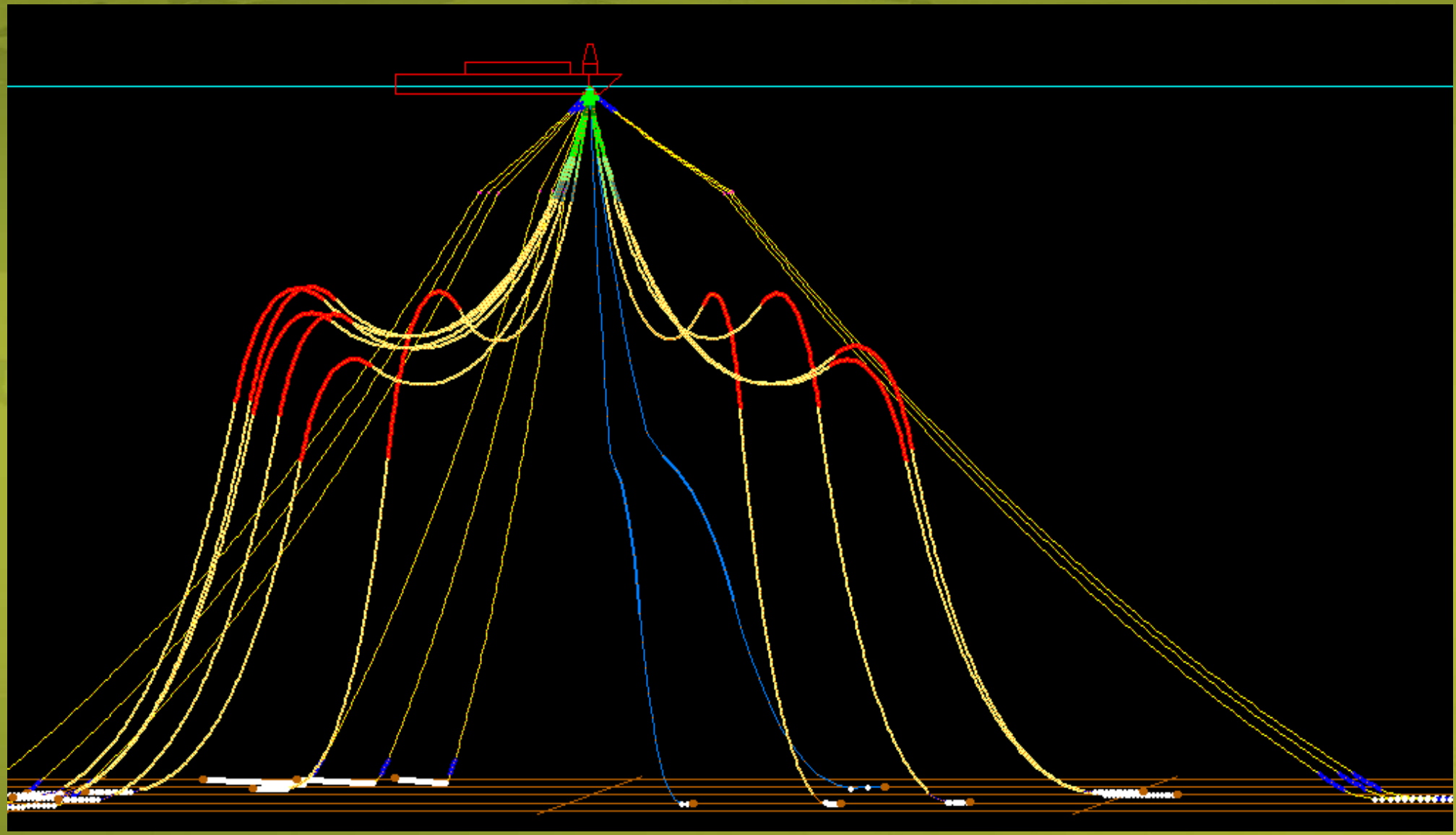
DEEP OFFSHORE TECHNOLOGY INTERNATIONAL ASIA / PACIFIC™

Stybarrow Turret Mooring

- Swivel Access Structure
- Swivel Stack
- Manifold Piping
- Riser Deck
- Main Bearing
- Turret Shaft
- Connector
- Risers & Umbilicals
- Anchor Legs



Stybarrow Disconnectable Turret Mooring



DEEP OFFSHORE TECHNOLOGY INTERNATIONAL ASIA / PACIFIC™

Optimization of Spider Buoy, Riser and Mooring Systems

- Mooring and Riser Payload
  - Riser payload may be variable
- Vertical Stiffness of Mooring / Riser System
  - Deep water systems are typically softer (2MT / m)
- Hydrodynamic Loads on Spider Buoy (connected)
  - Can be greater than mooring and riser horizontal load
- Buoy Motions (disconnected)
- Spider Buoy Retrieval Loads
- System Installation

Riser Design Optimization (825m WD)

- Traditional Lazy Wave Design would result in Payload of 800 – 1000 MT
- Optimized Maximum Design Payload = 510 MT (water filled)
  - All risers gas-filled (except WI) = 400 MT
- Additional Buoyancy on Risers can impact Installation
- Spider Buoy Displacement ~ 1400 MT with weight of 850 MT
  - Diameter: ~14 meters at base
  - Height: ~14.5 meters

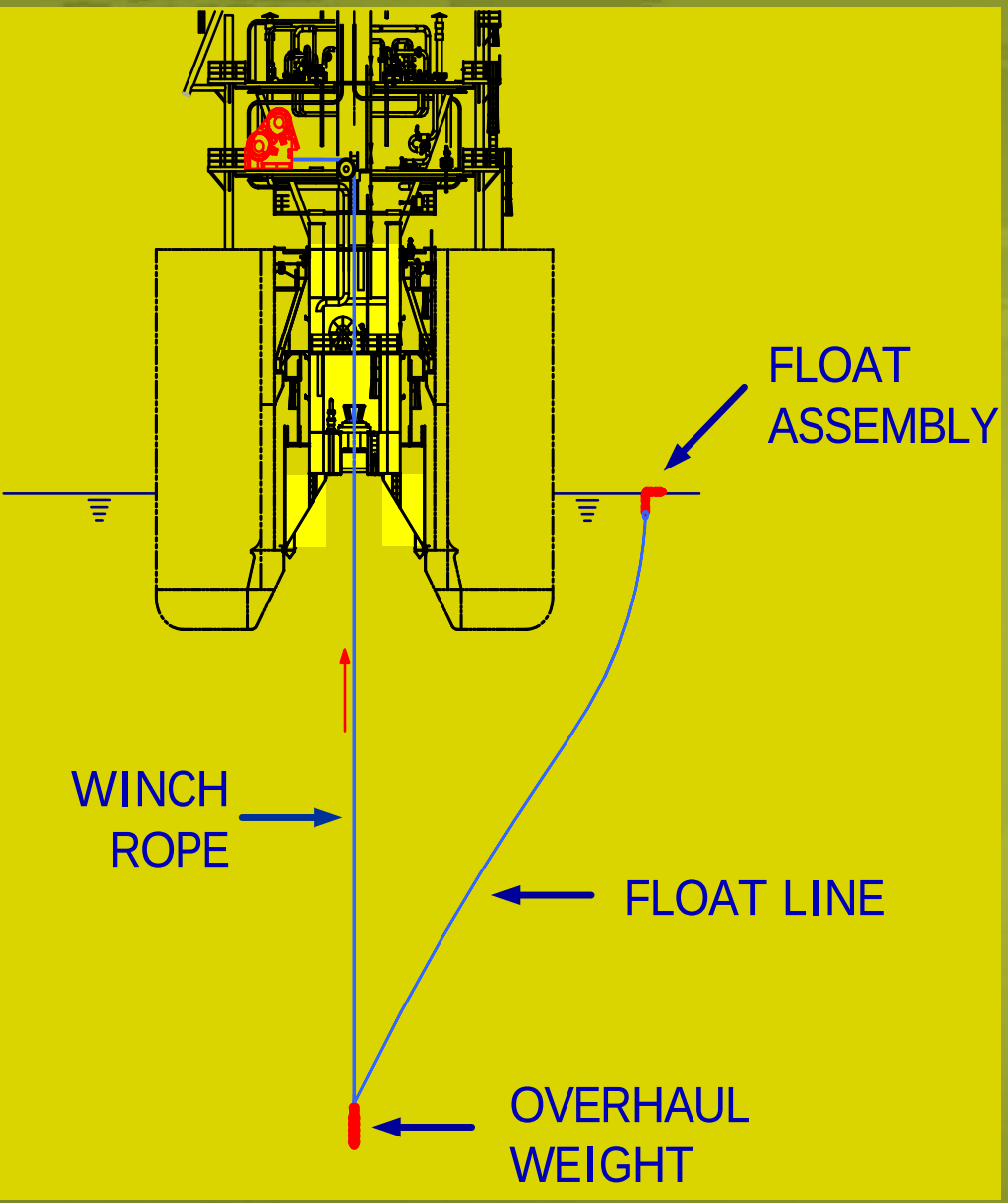
DEEP OFFSHORE TECHNOLOGY INTERNATIONAL ASIA / PACIFIC™

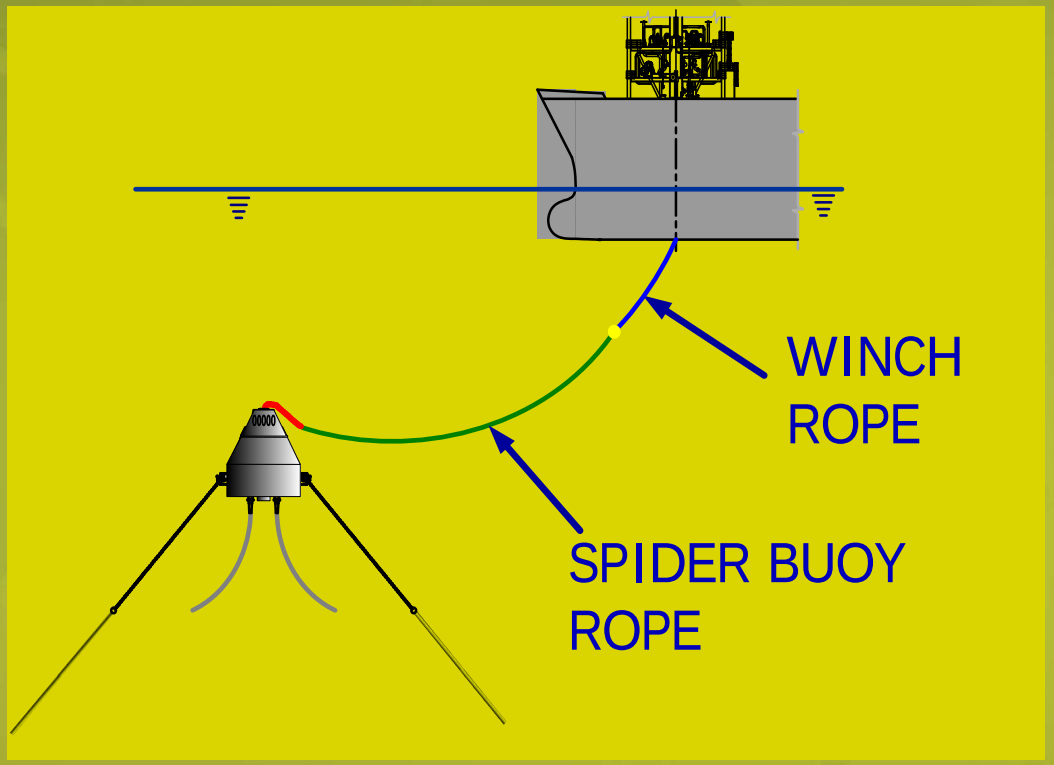
Spider Buoy Ballasting

- Production Risers contain Gas-Crude Mix – average SG of 0.5
  - During disconnection gas separates from crude and affects payload
- Stabilized Crude circulated in Production Riser Pairs during Start-up
  - Storm arrival during start-up requires disconnect with 1-pair oil filled
- Installation
  - Buoy tow stability requires large amount of ballast
  - Risers water filled
- Ballast required Varies from 50 MT to 400 MT

DEEP OFFSHORE TECHNOLOGY INTERNATIONAL ASIA / PACIFIC™

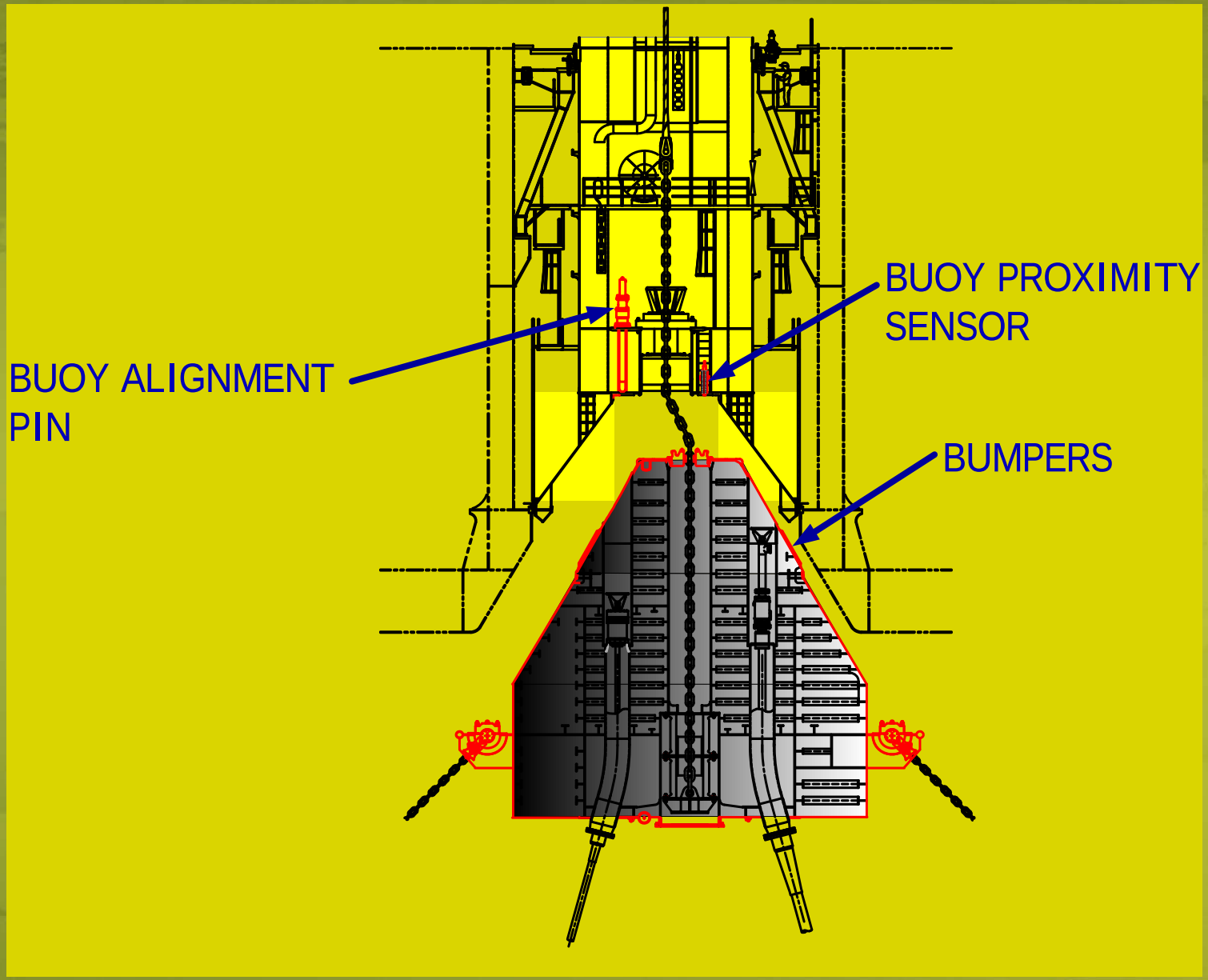
Spider Buoy Reconnection





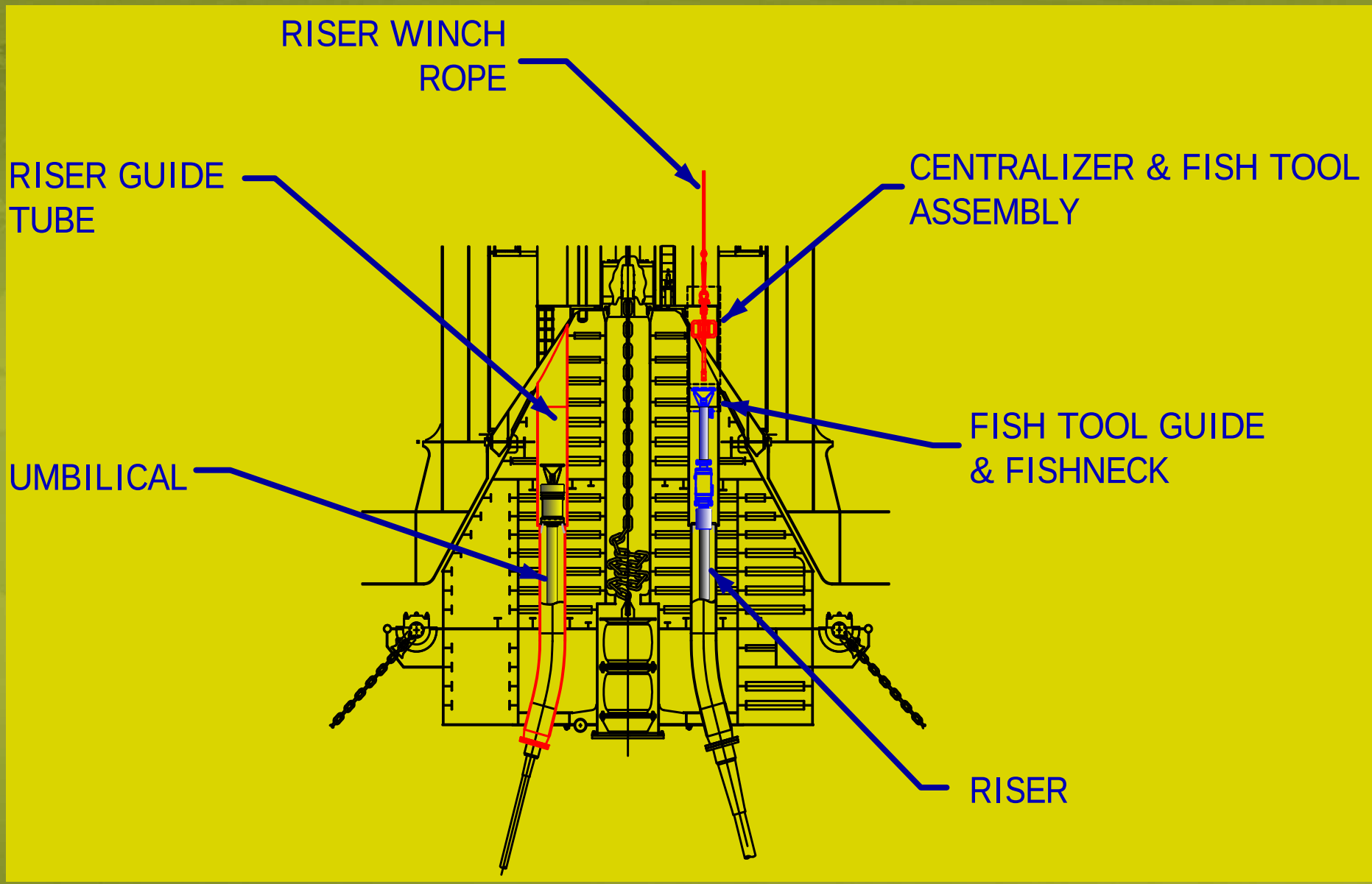
DEEP OFFSHORE
TECHNOLOGY
INTERNATIONAL
ASIA / PACIFIC™

Buoy Entering Turret



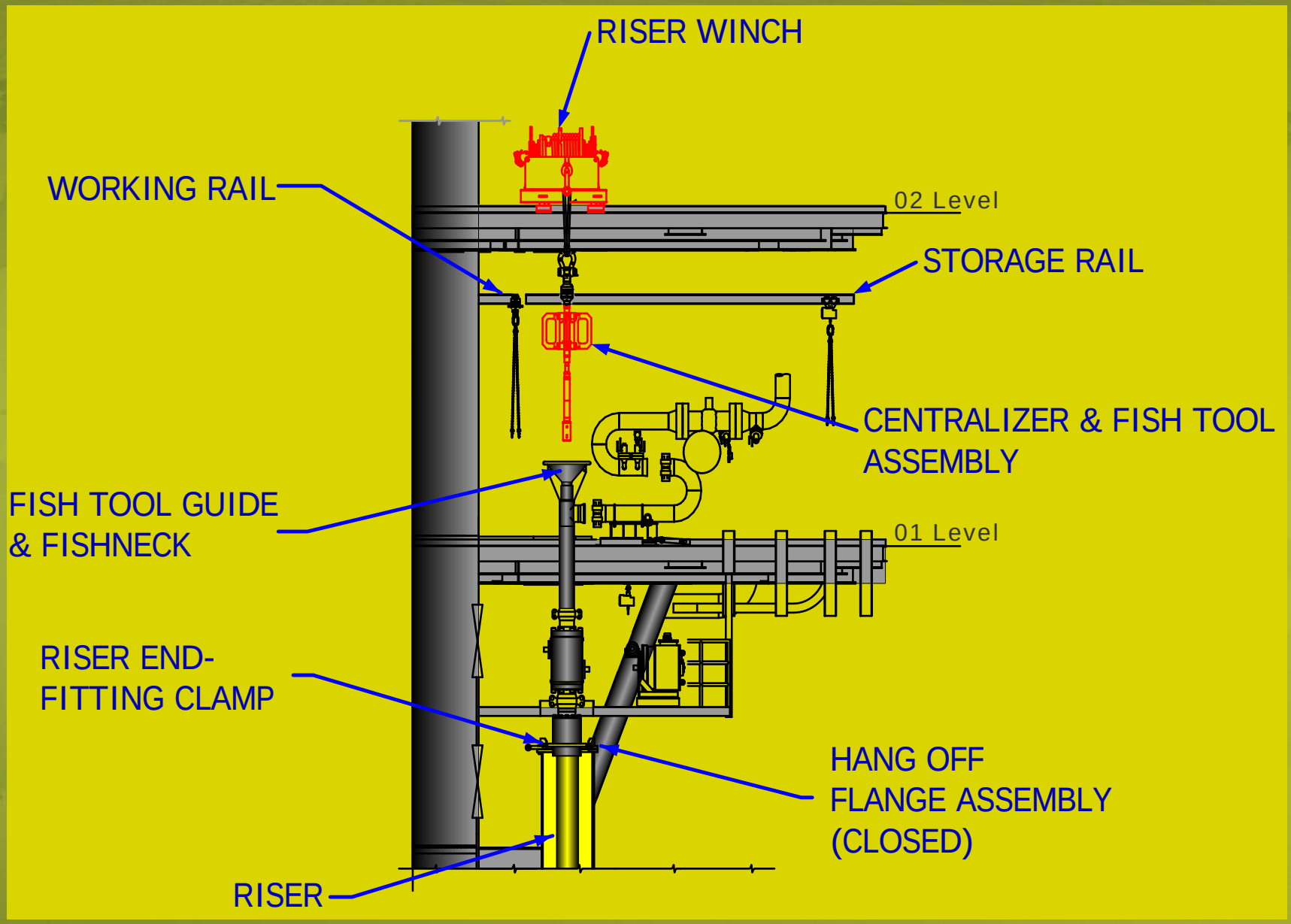
DEEP OFFSHORE TECHNOLOGY INTERNATIONAL ASIA / PACIFIC™

Retrieving the Risers



DEEP OFFSHORE TECHNOLOGY INTERNATIONAL ASIA / PACIFIC™

Hook-up of the Risers



DEEP OFFSHORE TECHNOLOGY INTERNATIONAL ASIA / PACIFIC™

Cyclone Emergency Response Plan

- **Blue**

✓ A plan for preparation for disconnection

✓ A ballast plan

✓ A plan for evacuating non-essential personnel

- **Yellow (12-hour window)**

✓ Shutdown production

✓ Prepare to disconnect from DTM (lower risers)

✓ Proceed with ballast plan

- **Red**

✓ Disconnect from DTM

DEEP OFFSHORE TECHNOLOGY INTERNATIONAL ASIA / PACIFIC™

Cyclones over Mutineer/Exeter Field 2006-08

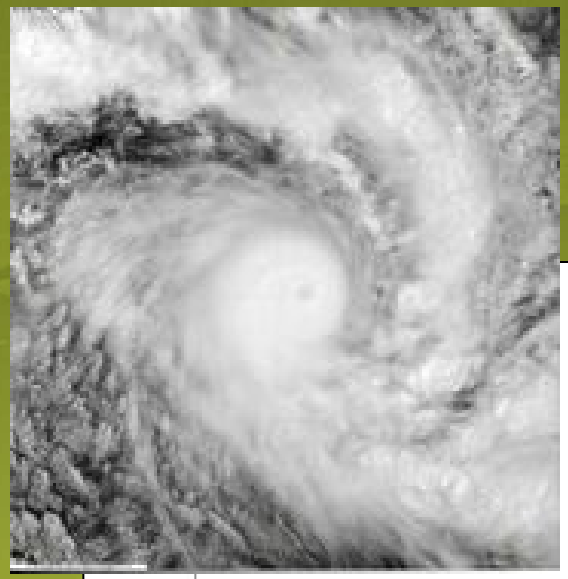
Name	Period	Year	Category
• Clare	Jan 7 – 10,	2006	3
• Daryl	Jan 18 – 23,	2006	2
• Emma	Feb 27 – 28,	2006	1
• Floyd	Mar 21 – 26,	2006	4
• Glenda	Mar 27 – 31,	2006	5
• Hubert	Apr 6 – 7,	2006	2
• Isabel	Jan 2 – 4,	2007	1
• George	Mar 6 – 10,	2007	4
• Jacob	Mar 9 – 11,	2007	3
• Kara	Mar 25 – 28,	2007	3
• Melanie*	Dec 26 – 1/2,	2008	2
• Nicholas*	Feb 10 – 19,	2008	4
• Pancho	Mar 25 – 30,	2008	4

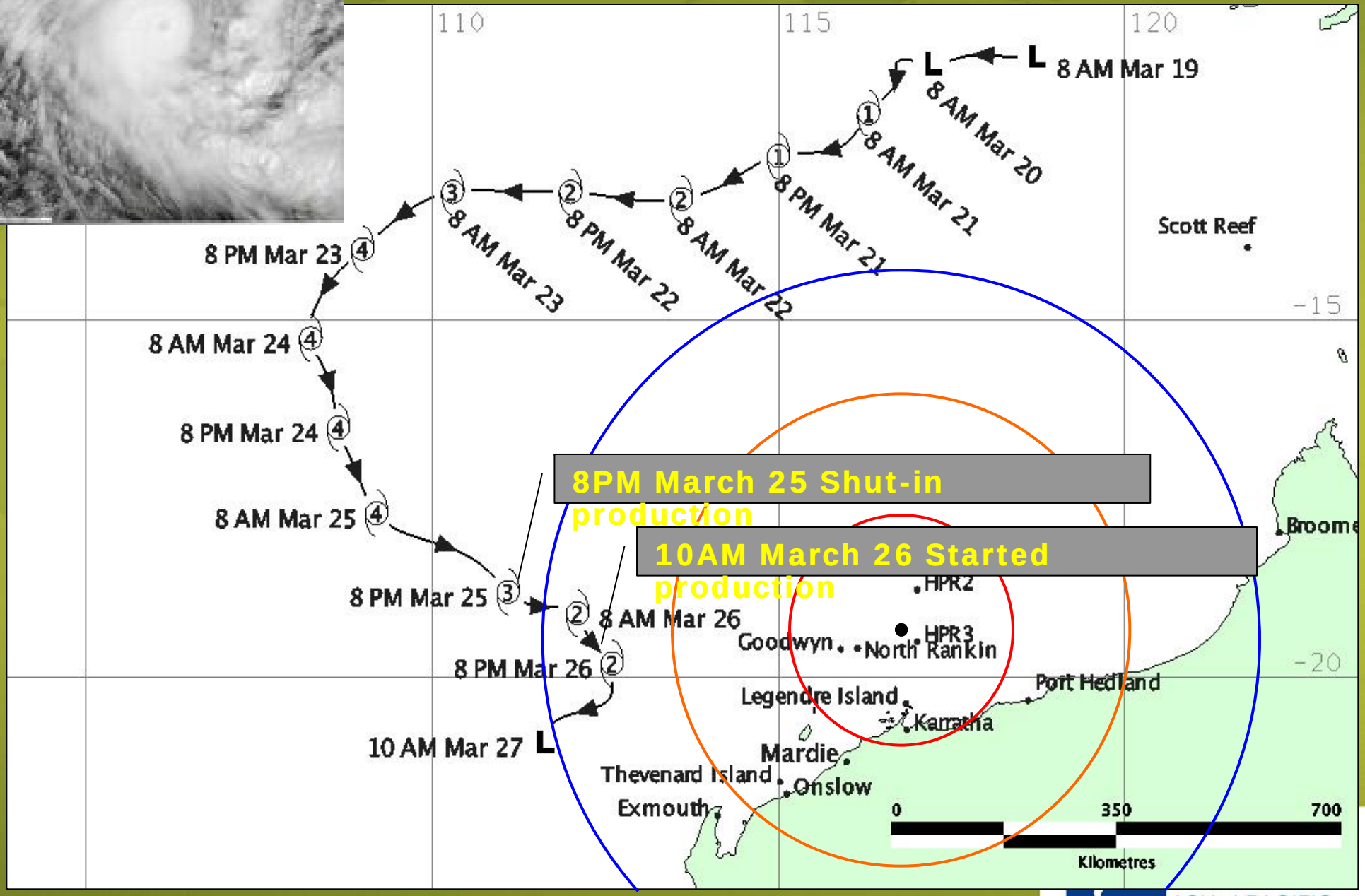
** Also over Stybarrow field*

DEEP OFFSHORE TECHNOLOGY INTERNATIONAL ASIA / PACIFIC™

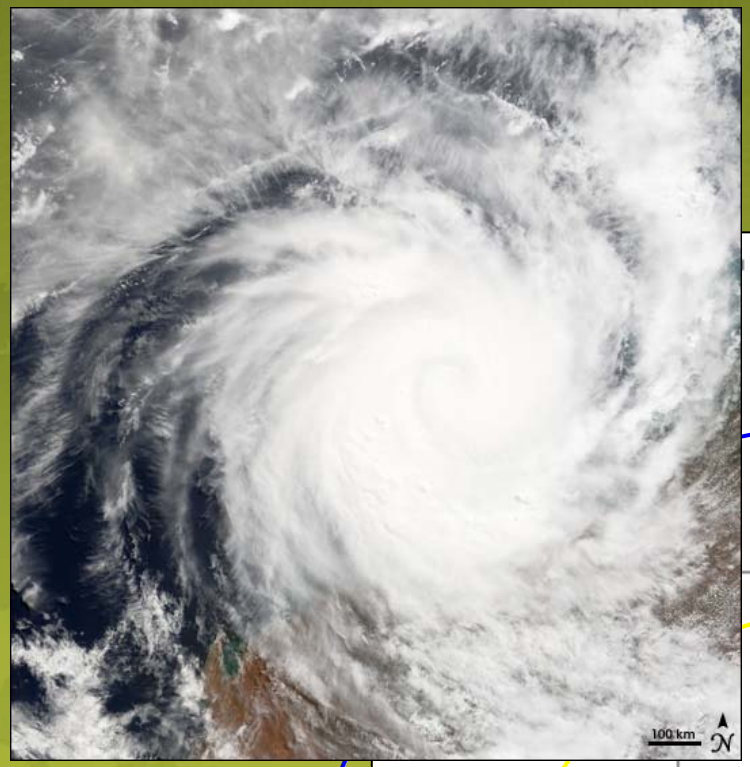
Clare: 7 – 10 January 2006

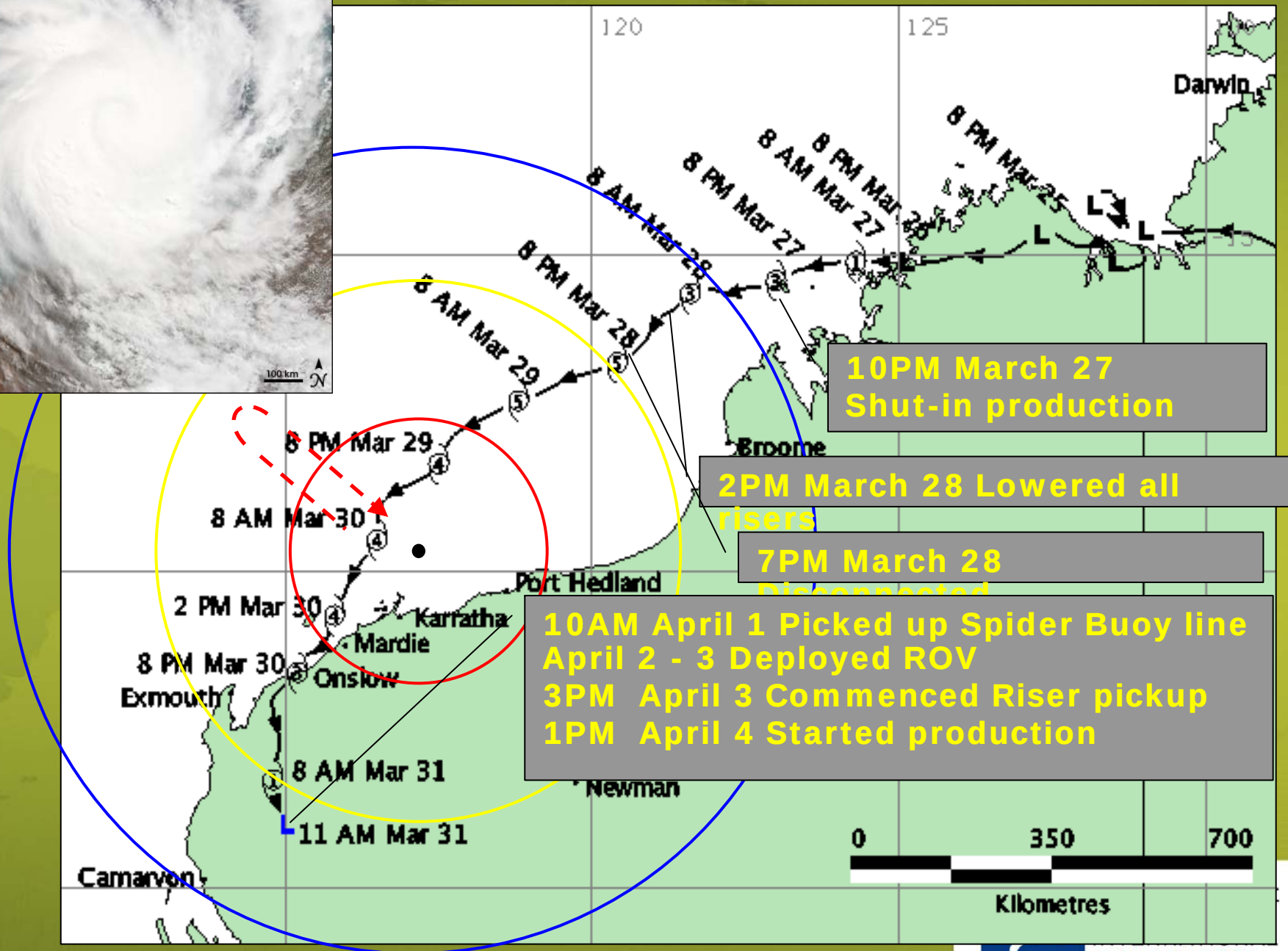
Floyd: 21 – 26 March 2006





Glenda: 27 – 31 March 2006





10PM March 27
Shut-in production

2PM March 28 Lowered all risers

7PM March 28 Disconnected

10AM April 1 Picked up Spider Buoy line
April 2 - 3 Deployed ROV
3PM April 3 Commenced Riser pickup
1PM April 4 Started production

ASIA / PACIFIC

Time Logs for Disconnect / Reconnect

Disconnection	Clare	Glenda	Hubert
Shut-in Production	0200 Jan 8	2215 Mar 27	1100 Apr 5
Started Lowering Risers	0600 Jan 8	0800 Mar 28	1145 Apr 5
Lowered all Risers	2115 Jan 8	1400 Mar 29	1750 Apr 5
Disconnected Spider Buoy	**0210 Jan 9**	**1915 Mar 28**	**2130 Apr 5**
Total Hours	**24 hours**	**21 hours**	**10.5 hours**
Reconnection	**Clare**	**Glenda**	**Hubert**
Picked-up Spider Buoy Line	0730 Jan 11	1000 Apr 1	1200 Apr 8
Pulled-in Spider Buoy	1200 Jan 11	1500 Apr 3	1630 Apr 8
Started Picking up Risers	1500 Jan 11	1530 Apr 3	1900 Apr 8
Connected All Risers	1200 Jan 12	0600 Apr 4	0900 Apr 9
Started Production	**1600 Jan 12**	**1300 Apr 4**	**1300 Apr 9**
Total Hours	**32.5 hours**	**74 hours**	**25 hours**

DEEP OFFSHORE TECHNOLOGY INTERNATIONAL ASIA / PACIFIC™

Summary of Selected Disconnect / Reconnect Durations

Cyclone	Duration		Total
	Disconnect (hours)	Reconnect (hours)	Production D/T (days)
Clare	24	32.5	4.6
Daryl	36	50	6.3
Emma	26*	14*	3.1*
Floyd	*	*	0.6*
Glenda	21	74	7.6
Hubert	11	25	4.2
George / Jacob	29	33	9.9
Kara	32	34	5.5
Melanie	14	39	4.9

** Spider Buoy was not disconnected / reconnected*

DEEP OFFSHORE TECHNOLOGY INTERNATIONAL ASIA / PACIFIC™

Summary and Conclusions

- Disconnectable FPSOs have demonstrated successful performance in a cyclone environment
  - > 98% Uptime
  - 9 successful disconnects and reconnects to avoid cyclones over 3 seasons
  - Typically last off mooring; first on production
- Improvement in design / procedures / experience has improved disconnect – reconnect effort
- Input from Mutineer-Exeter has allowed development of next generation DTMs (Stybarrow & Pyrenees)
  - Less labor intensive, improved disconnect and reconnect operations
  - Technology is adaptable for ultra-deepwater

Thank you!

arun.duggal@sofec.com

www.sofec.com

www.modec.com

SOFEC

MODEC

DEEP OFFSHORE TECHNOLOGY INTERNATIONAL ASIA / PACIFIC™