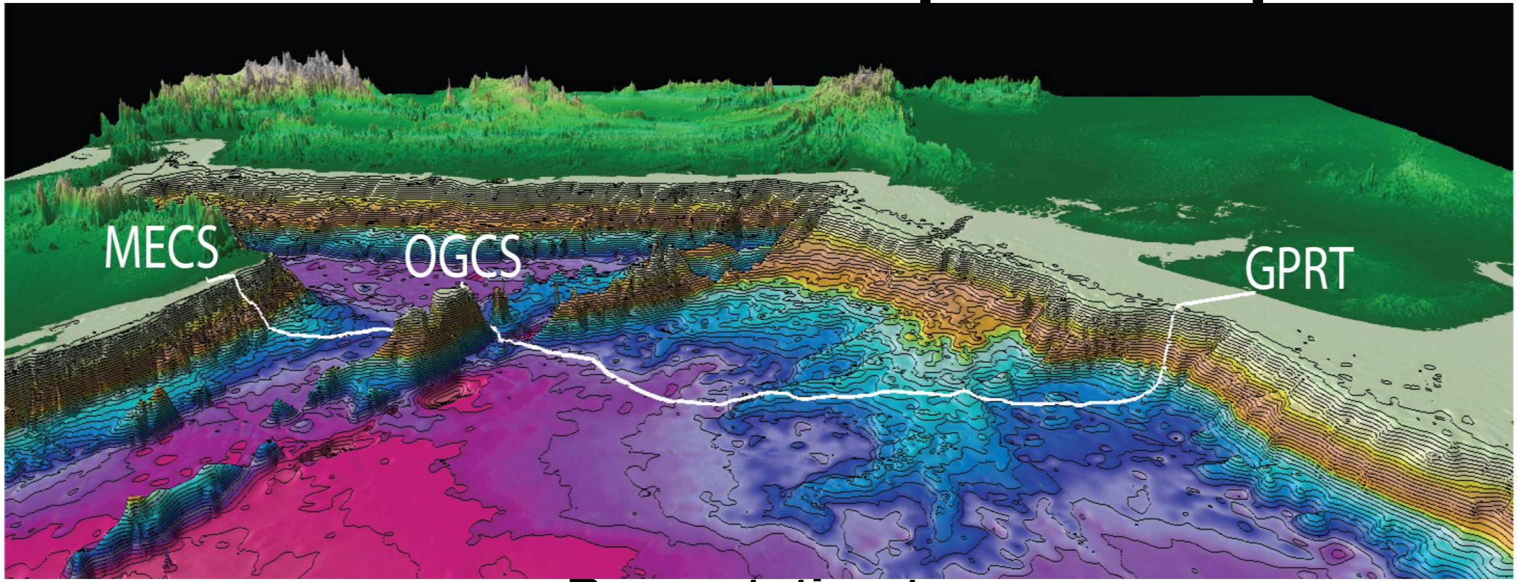
SAGE

Middle East to India Deepwater Pipeline



Presentation to

Planning Commission

(Energy and Power Division)

December 2011

AGENDA

1. Introductions (SAGE)
2. Gas Supply and Transportation Economics
3. MEIDP Project Summary
4. Design Basis
5. Pipeline Routing
6. Flow Assurance and Mechanical Design
7. Metocean Investigations
8. Geohazard Features and Seismic Design
9. Onshore and Offshore Facilities (Incl Risers & By-Pass)
10. Pipeline Installation Intervention and Repair
11. CastorOne Construction Progress
12. AOB

Introduction

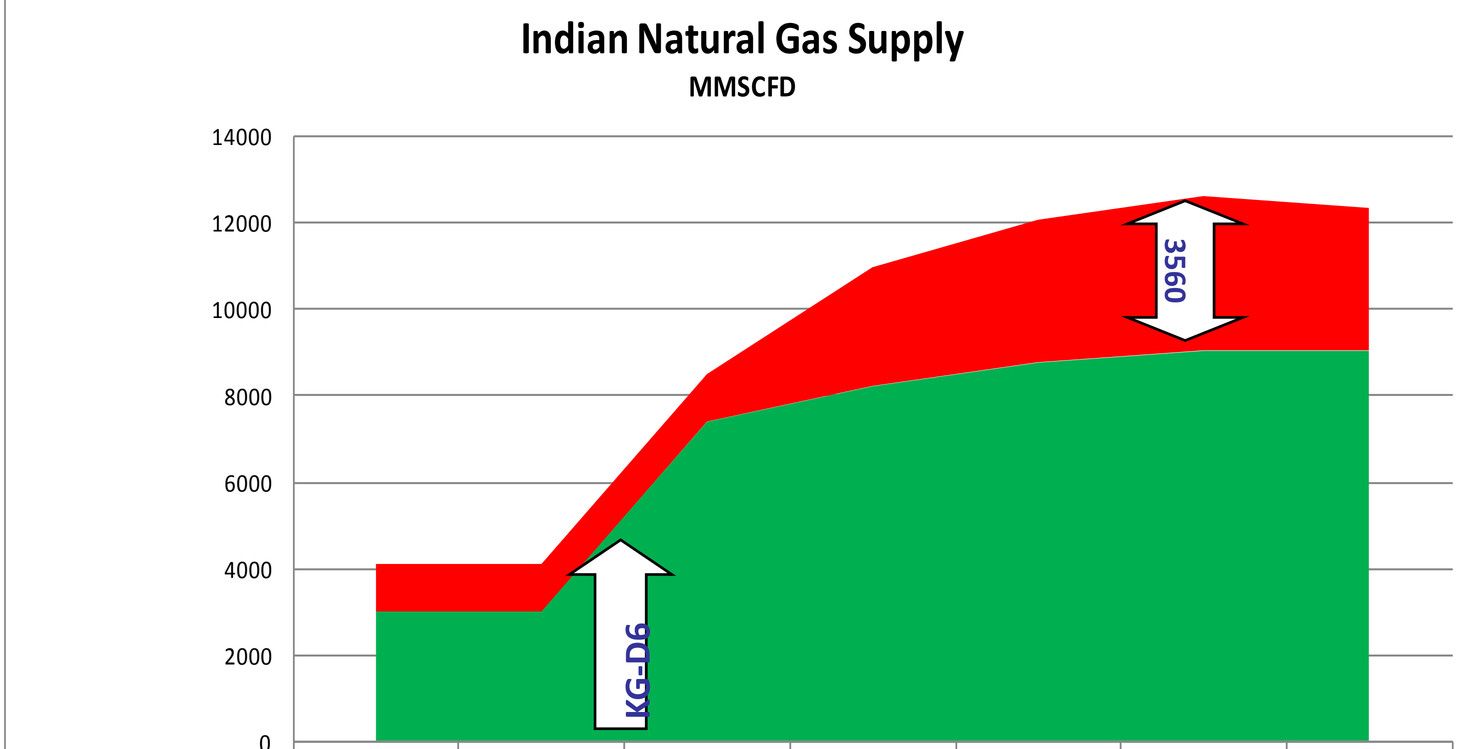
- **Who?** *SAGE*
  - South Asia Gas Enterprise Pvt Ltd (SAGE), a joint venture lead by the Indian Siddhomal group, is actively considering building a deepwater, transnational, natural gas pipeline system from the Middle East to India
- **Why?** *India needs gas*
  - Over 2,000 TCF of natural gas reserves are held by countries with which India has a traditional trading relationship, including Qatar, Iran and Turkmenistan
  - The deepwater route across the Arabian Sea is the shortest secure distance between these huge reserves and the rapidly developing industrial heartland of India in Gujarat, and is too short for LNG to be an economic transportation option
- **How?** *A pipeline across the Arabian Sea*
  - The current work builds on the extensive study of the deepwater route of the Oman to India Pipeline that was carried out in the early 1990's
  - The case for this route has been strengthened by recent development work undertaken by SAGE and by the major body of deepwater design and pipelay experience accumulated over the last decade

The SAGE Project – Key team members

Mr. T.N.R. Rao	▪ Former Petroleum Secretary, Govt. of India and "Architect of the Oman-India Pipeline" ▪ Chairman of the SAGE Advisory Board ▪ Founder Chairman, Hydrocarbons Education & Research Society, Indian School of Petroleum ▪ Founder Chairman – University of Petroleum & Energy Studies
Subodh Jain	▪ Director: INOX-AIR PRODUCTS Ltd. ▪ Director: South Asia Gas Enterprise PVT Ltd ▪ Director: Siddho Mal & Sons, New Delhi ▪ Former Senior Advisor to original Oman-India Pipeline team
Peter M Roberts	▪ Director: South Asia Gas Enterprise PVT Ltd ▪ Director: VerdErg Ltd, London ▪ Former Project Director of original Oman-India Pipeline
Dr Herman Franssen	▪ Senior Consultant to SAGE ▪ Member of the SAGE Advisory Board. ▪ President, International Energy Associates, USA ▪ Former Economic Advisor to the Oman-India Pipeline project ▪ Former Economic Advisor to the Sultanate of Oman, Ministry of Petroleum
Stefano Bianchi Roberto Bruschi Milind Baride	▪ Senior Vice President, Saipem Energy Services, Milan. ▪ Sealine and Subsea Manager, Saipem Energy Services, Milan. ▪ ex-Chairman, Saipem India Projects Ltd., Chennai now in Saipem Milan.
Ian Nash	▪ Business Acquisition and Operations Director, Peritus International (UK) Ltd. ▪ Managing Director INTECSEA (UK) Ltd. ▪ Project Manager for Detailed Design of BP Block 30 Subsea flowlines and Structures ▪ Project Manager & Engineering Manager for MEDGAZ FEED. ▪ Engineering Manager (Saipem Inc) for Canyon Express design EPIC. ▪ Project Manager (SASP UK) for Europipe 2, 42-inch 650 Km Gas Trunkline detailed design.
Dr Alastair Walker FRS	▪ Leading International Expert on Marine Pipeline Engineering ▪ Senior Consultant to SAGE ▪ Member of the SAGE Advisory Board ▪ Professor Emeritus, University of Surrey UK ▪ Visiting Professor, University College London

Gas Supply and Transportation Economics

Indian Natural Gas Supply

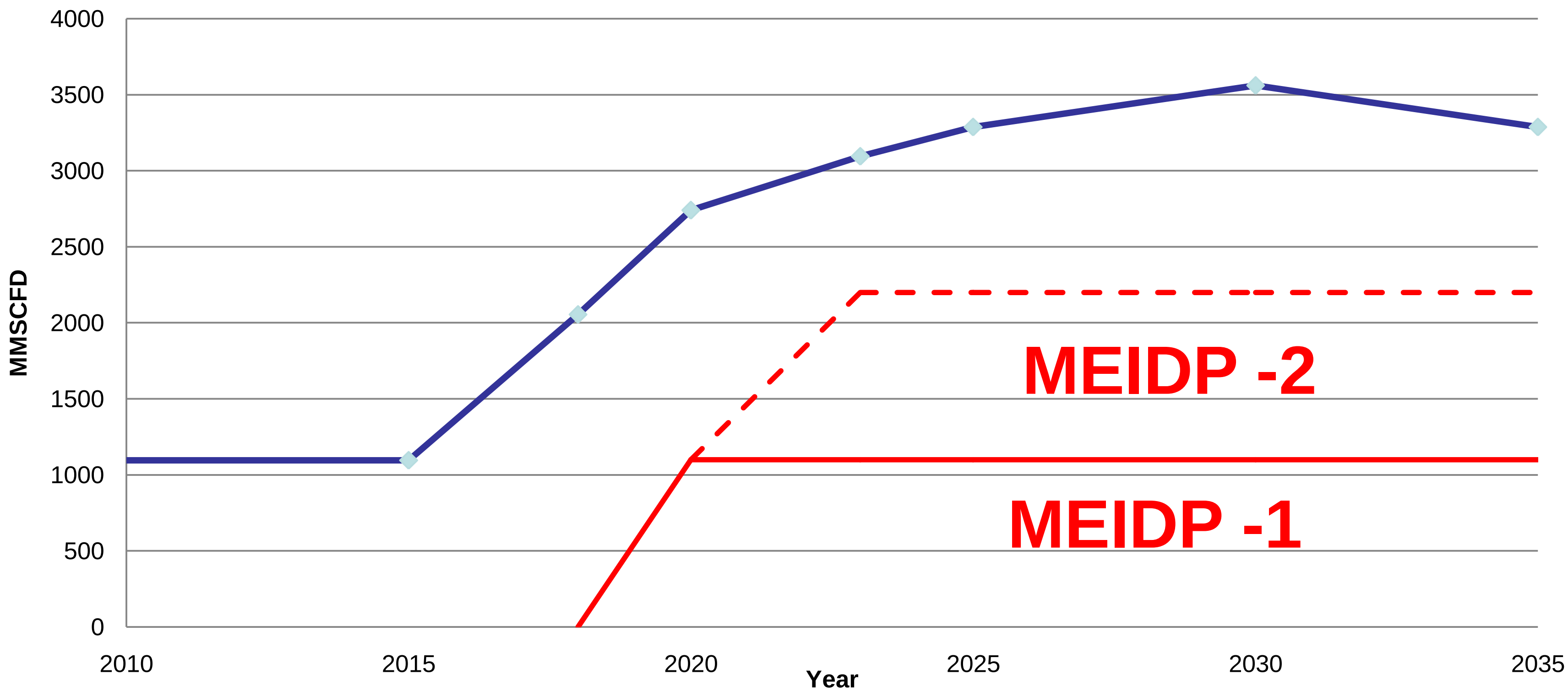


	2007	2008	2015	2020	2025	2030	2035
Import Requirement	1096	1096	1096	2740	3288	3562	3288
Indian domestic Supply	3014	3014	7397	8219	8767	9041	9041

U.S. Department of Energy, DOE/EIA-0484(2010)

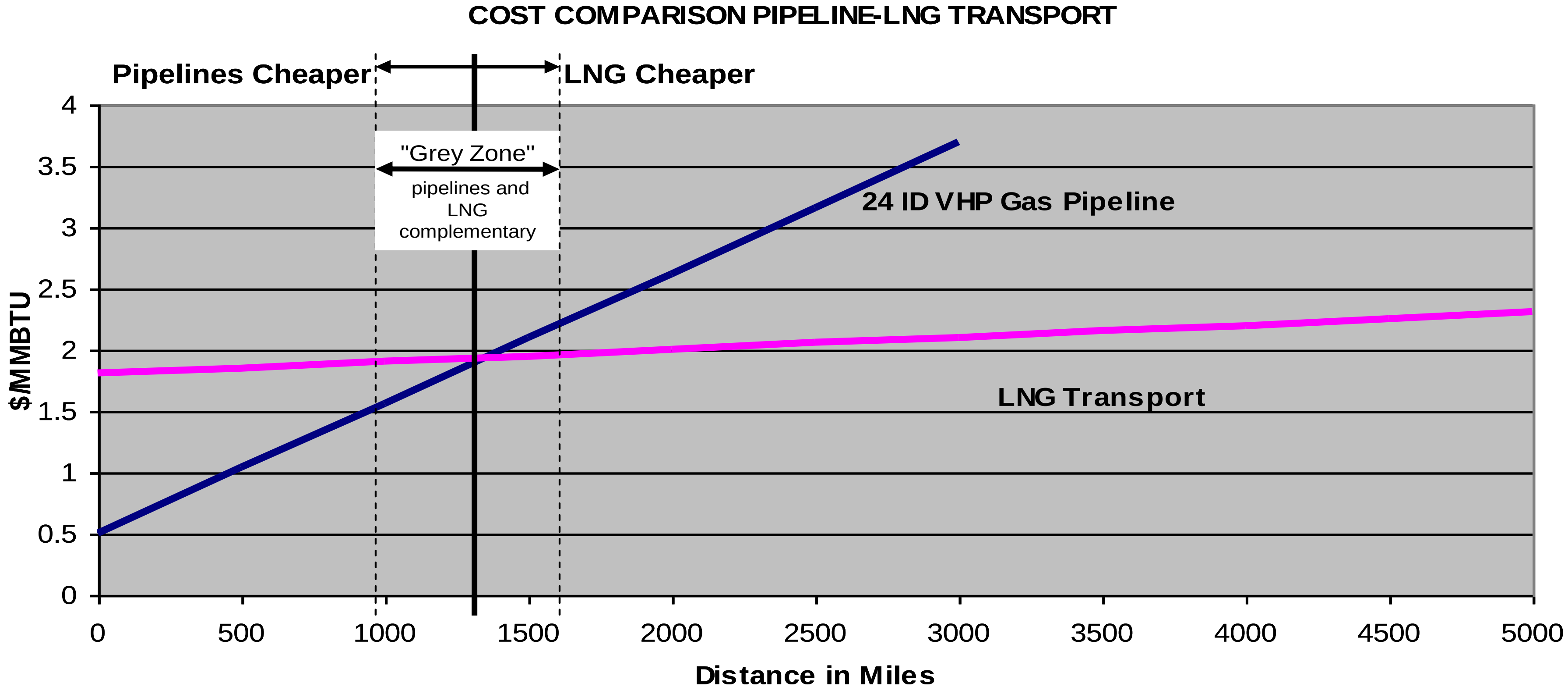
Indian Natural Import Requirements

Projected Gas Import Requirements (MMSCFD thru 2035)



U.S. Department of Energy, DOE/EIA-0484(2010)

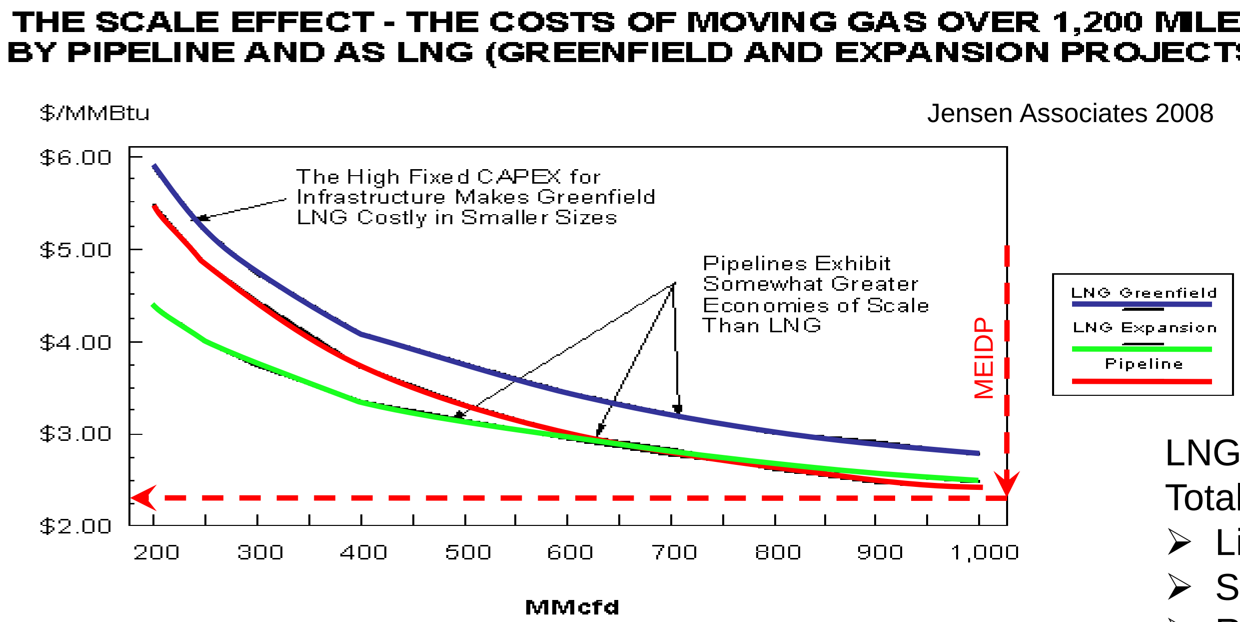
Transportation Economics 2001



Typically pipelines are more economic than LNG for transportation distances below 1200 miles (based on 2001 figures)

Since then the costs of both have risen but the cross-over is still accepted as realistic LNG is competitive at long distance, pipelines at shorter distance like from the Middle East to India.

Transportation Economics 2008



LNG Transport cost for 1.1Bcfd Total $2.35 - $2.50/MMBTU.

- Liquefaction - $1.50 /MMBTU,
- Shipping - $0.35 to $0.50 /MMBTU
- Re-gas $0.50 /MMBTU

For MEIDP Volumes (1.1Bscfd) Pipeline costs in 2008 were slightly lower cost than LNG equivalent cost for liquefaction, shipping and re-gasification

NOTE: this slide was prepared by Jensen Associates around 3 years ago when commodity prices were high, not just the Nickel and Chrome and other high-alloy steels used in LNG but even pipeline steel under Chinese market pressure.

MEIDP Transportation Economics

Since 2008-9 pipeline steel has returned to normal price levels whereas exotic steels used in LNG are still expensive.

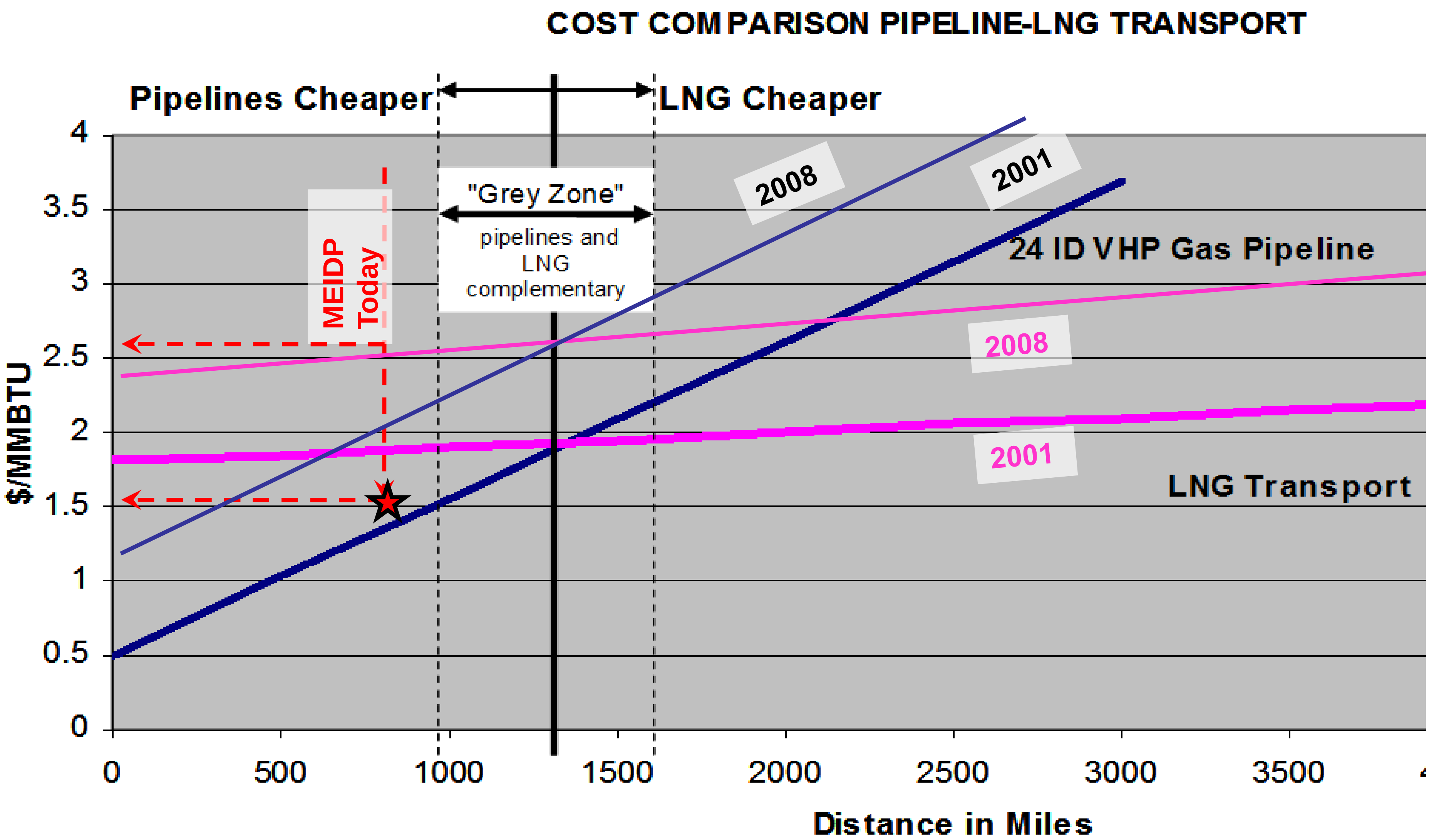
As a result the traditional clear cost advantage of marine pipelines over all LNG at up to around 2000km has been re-established.

A recent updated SAGE cost estimate by Peritus gives a gas transport tariff in 2011 prices between \$1.25/MMBTU - \$1.50/MMBTU depending on the cost of equity in the range 2% to 10%. (With Debt at 5% and a 4:1 Debt to Equity Ratio).

CONCLUSION: SAGE will save at least \$1/MMBTU in transportation costs over LNG and possibly more.

NOTE: If any residual concerns are still held and these can be precisely defined, SAGE will obtain a specialist report from Jensen Associates to address them explicitly.

Transportation Economics Today



Indicative Overall Economics Today

	Costs $/mmBtu	
	Pipeline	LNG
Assumed FOB price of dry gas Arabia	7.0	7.0
Liquefaction Cost	-	1.5
Transportation cost	1.5	0.3- 0.5
Gasification	-	0.5
Total costs gas landed in India West Coast	8.5	9.3-9.5

Discussions with Gas Suppliers

SAGE continues to have discussions with potential Gas suppliers

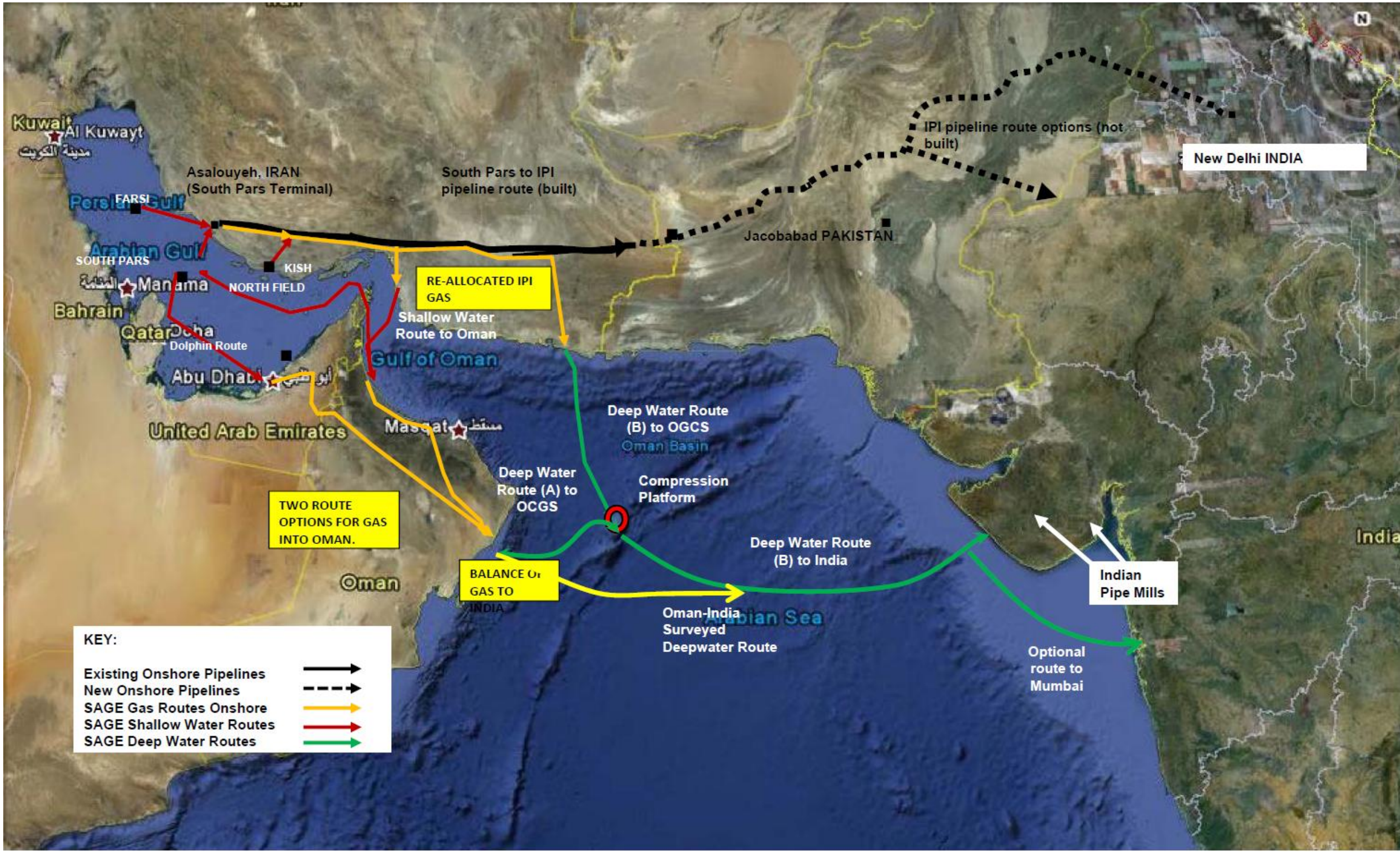
I. Iran – Numerous discussions have been are having Gas supply discussions with National Iranian Gas Export Co. (NIGEC). Latest meeting held in Tehran in Sept 2011.

II. Qatar – MEIDP Project continues to be on their "Waiting List" considering their heavy commitments to LNG Projects.

III. Turkmenistan – Numerous discussions with Turkmen Oil Ministry. Oil Minister has advised that they are ready to Supply Gas Swap for MEIDP Project, when Iran gives NOC for the Gas Swap with Iran.

IV. Oman - Now a net Gas Importer, SAGE has MOU with Oman Ministry of Oil & Gas for a Strategic Alliance for Gas Sourcing from 3rd countries e.g. Qatar / Iran / Turkmenistan / Iraq.

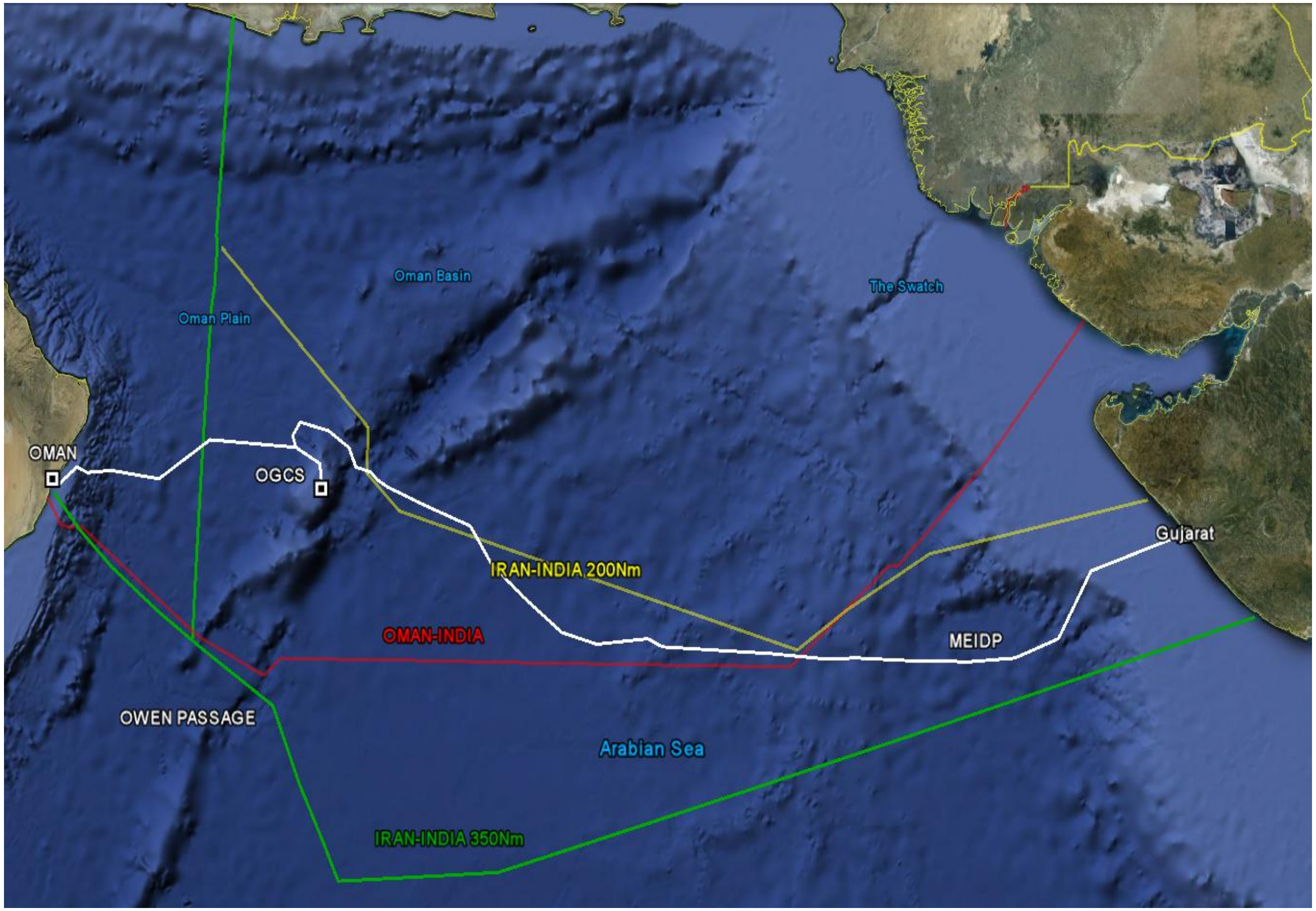
ME Gas Routes to India



Project Summary

Historical Route Options

- Historically many routes have been considered
  - Oman-India 1995
  - Iran-India 1997
  - Iran-India (200NM) 2003
  - Iran-India (350NM) 2003
  - MEIDP 2010
- All were considered to be Installable.



Difficulty of Deep Pipelay Projects

Working in Partnership

MOUs and Agreements to Co-operate in developing SAGE have been signed with:

- Indian Oil Corporation
- GAIL
- EGS Survey Pvt Ltd
- Oman Ministry of Oil and Gas
- NIGEC
- Peritus International Ltd.
- Engineers India Ltd.
- Intecsea (UK) Ltd.
- Saipem SpA
- Heerema Marine Contractors
- Tata (CORUS) steel
- Welspun
- JindalSAW
- FUGRO GeoConsulting Ltd.
- Det Norske Veritas

Completed studies

- Design Basis definition
- Flow Assurance Studies
- Mechanical Design
- Onshore Compression Station Definition
- Onshore Compression Station review
- Offshore Compression Station
- Offshore Layout Optimisation
- Quantified Risk Assessment - OIP Update
- Geohazard and Fault Crossing Assessment Oman Route
- Metocean data Oman Route
- Emergency Repair Equipment
- GIS Data collection Oman Route
- Riser and Subsea By-Pass definition
- Pipeline Intervention Review
- Vessel & Equipment Capabilities review
- Geohazard and Fault Crossing Assessment Iran Leg
- Metocean data Iran Leg
- Alternative Integrity Verification Phase 1 (Establish no hydrotest principle)
- Cost Estimate Update
- Reconnaissance Survey definition and scope of work

Ongoing and planned 2011-2012 work

Ongoing Work

- Master Project Schedule (Ongoing)
- GIS data collection Iran Leg(Ongoing)
- Survey ITT and tender (Ongoing)
- Mill qualification and ring testing program (Ongoing)

Planned Work

- Environmental Statement ITT and Scope Definition
- Onshore Facilities FEED ITT and Scope definition
- Offshore Pipeline FEED ITT and Scope Definition
- Metocean Data Acquisition Scope definition and ITT Documentation
- Environmental Survey Scope Definition and ITT Documentation.
- Update of Design reports to reflect Change in MECS location
- Preliminary design of offtake pipeline to supply UAE from MEIDP system

Comparison With OIP

Technical Risk Issues facing the project in 1995:

- Pipe mill upgrades needed to manufacture linepipe.
- Lack of lay vessel with enough tension capability. Conversion work needed to lay pipe to 3,500m water depth.
- Incomplete understanding of seismic activities and mitigation methods – mudflows, fault lines & slope failures.
- No qualified deepwater pipeline repair system was available.

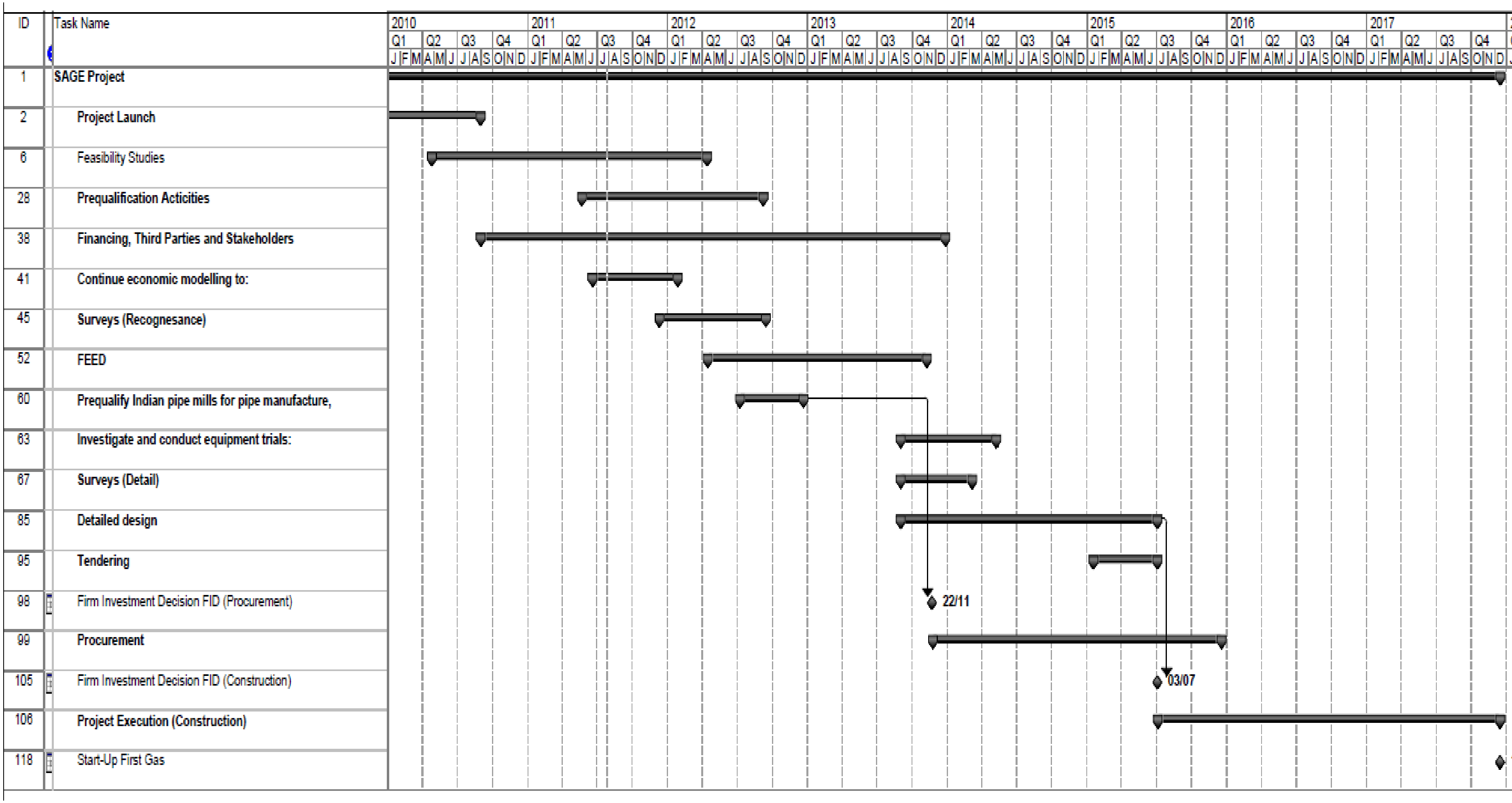
However even in 1995, 15 years ago:

- These were not considered to be fatal impediments by the industry and three competitive bids were received and evaluated before the gas was re-assigned elsewhere.

What makes SAGE's Risk Profile lower now?

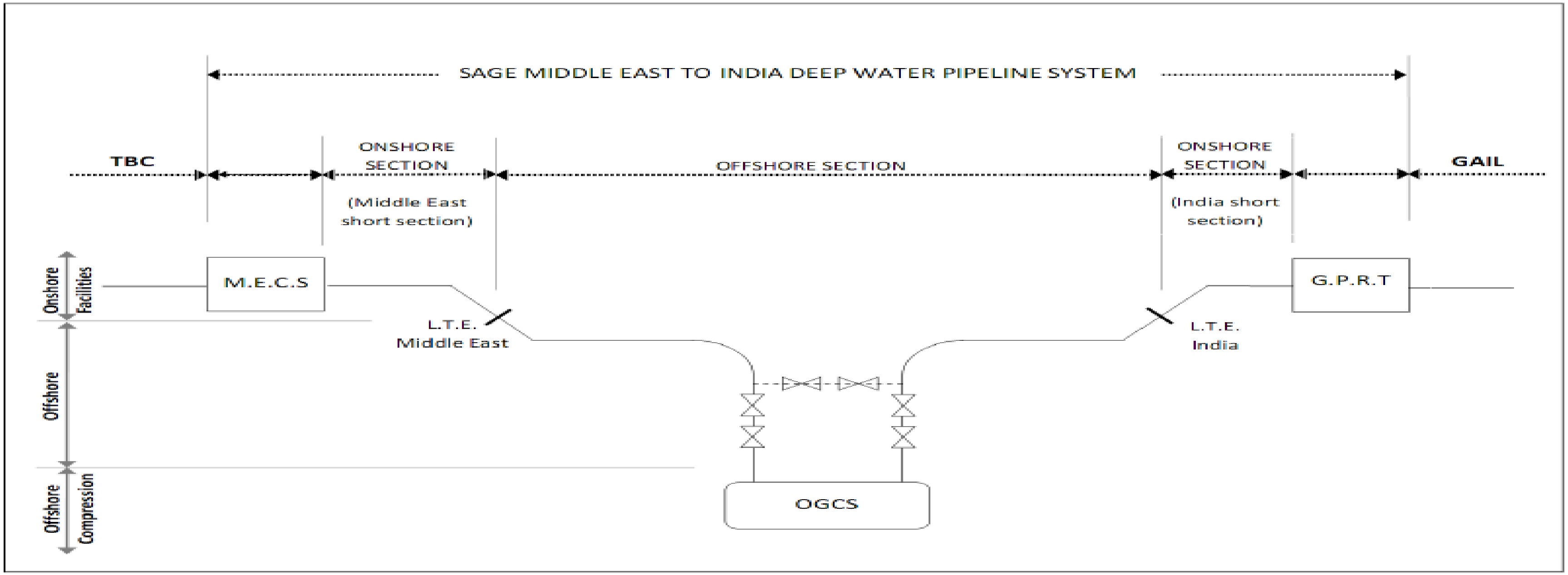
- New generation, large lay vessels ready to build.
- Several mills can manufacture pipe, particularly in India.
- Era of damaging cost escalation appears to be over.
- New and improved design methods for free-spanning and geo-hazards have been developed.
- Better positioning capabilities are now available during pipelay to avoid seabed hazards.
- Deepwater repair systems are now available.
- New testing and commissioning philosophies developed by SAGE with DnV permits use of 28-inch pipe.

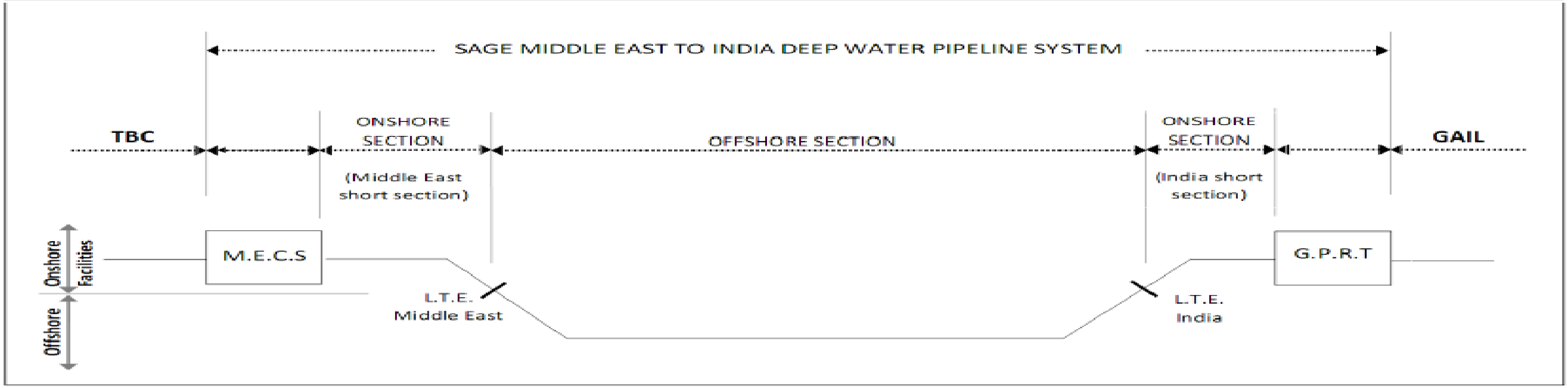
Project Development Schedule



Design Basis

MEIDP Battery Limits

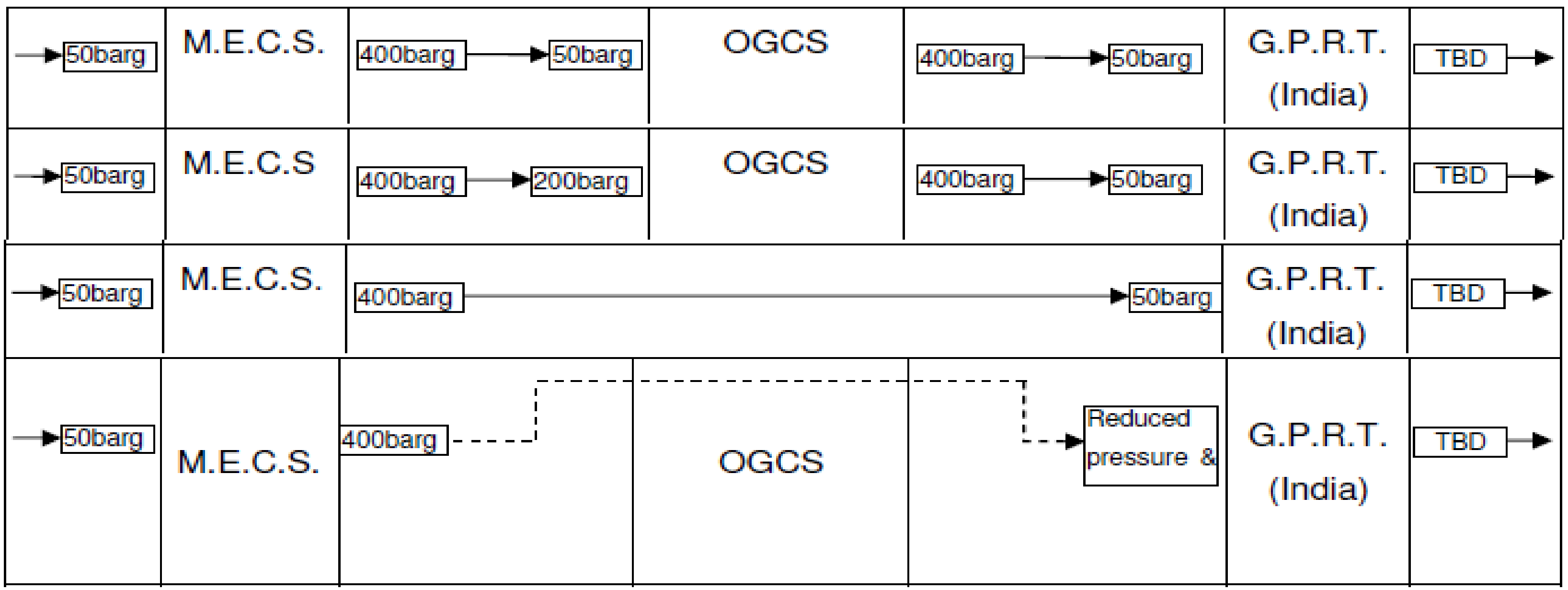




Design Basis

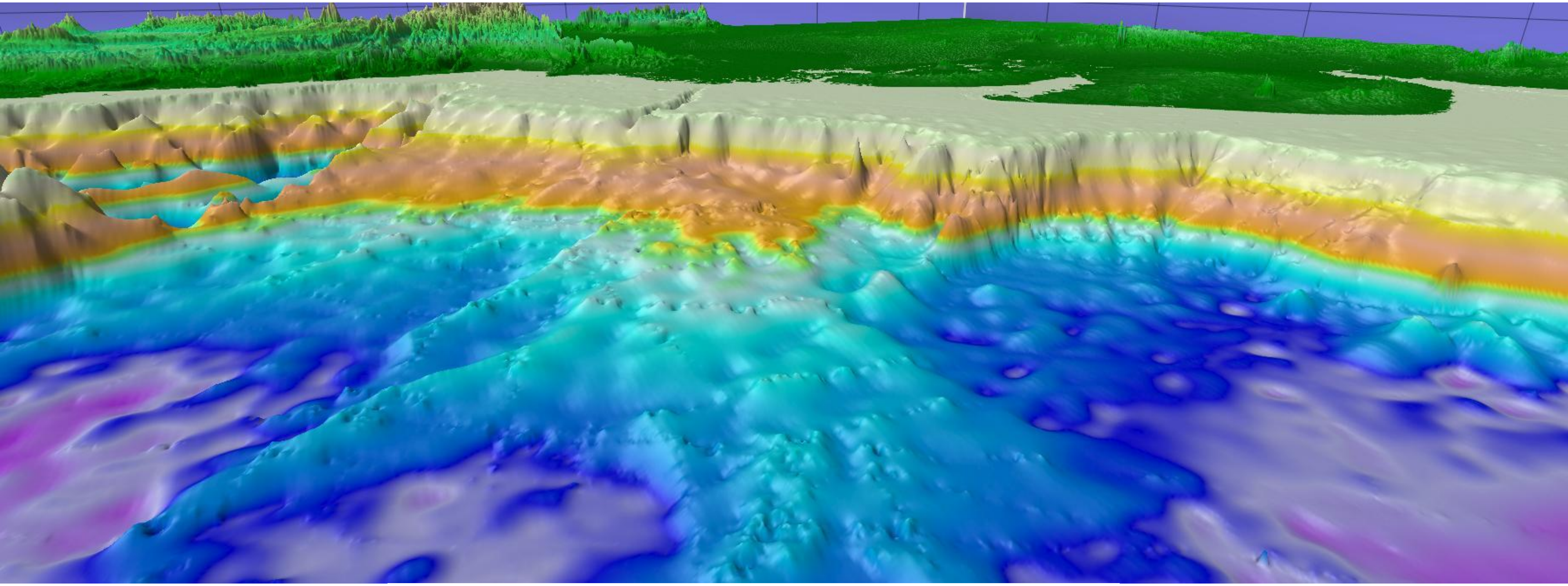
- MECS
  - 1.1BSCFD
  - Sales Quality Natural Gas
  - Dehydrated at MECS
  - Compression to 400Barg
  - Cooling

- OGCS
  - Water Content Monitoring
  - Compression to 400Barg
  - Cooling



Pipeline Routing

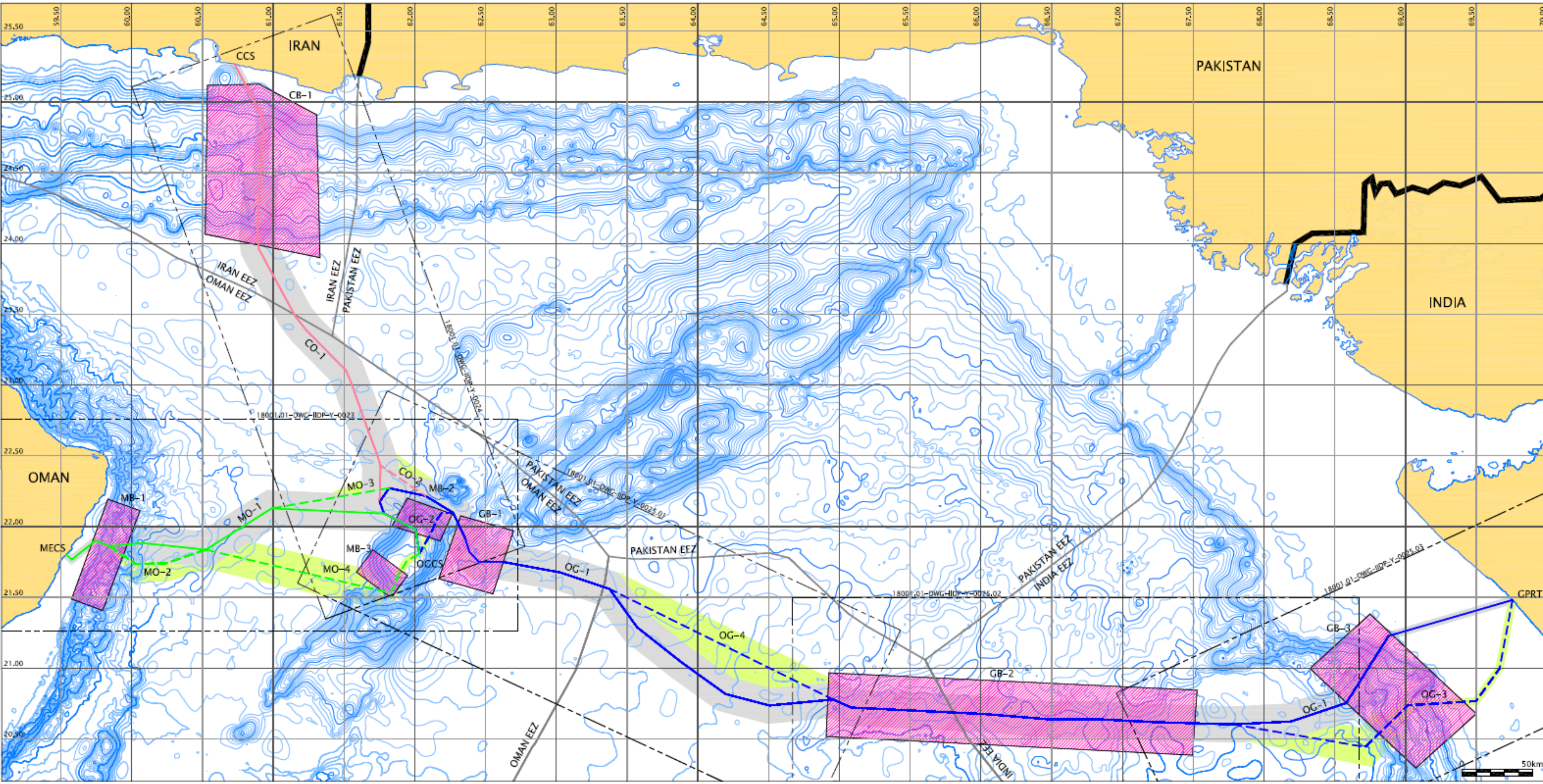
Route across the Arabian Sea



- Indus Fan

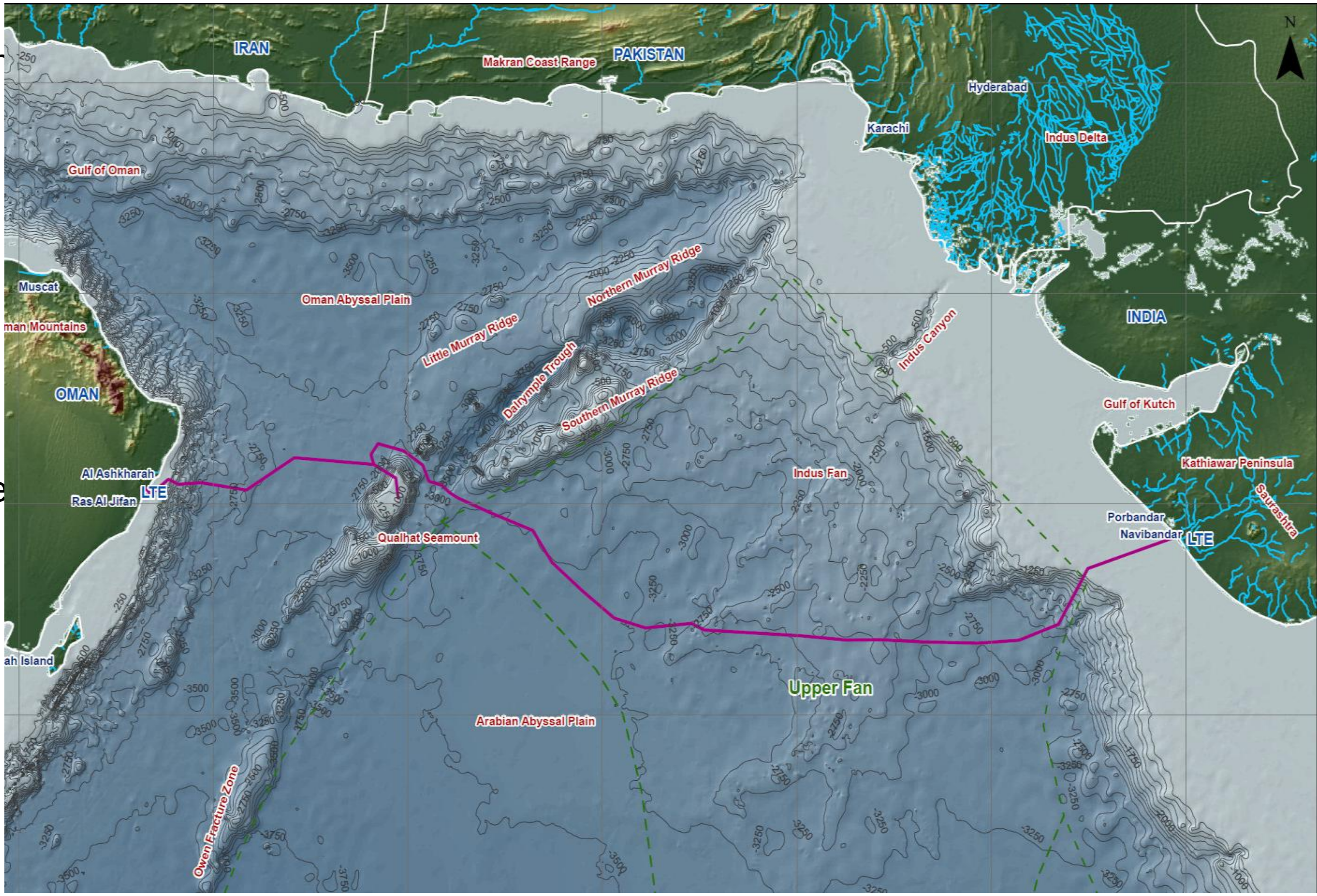
formed in a 2500m thick pile of sediment
covering the greater part of the Arabian sea.

Pipeline Route Options

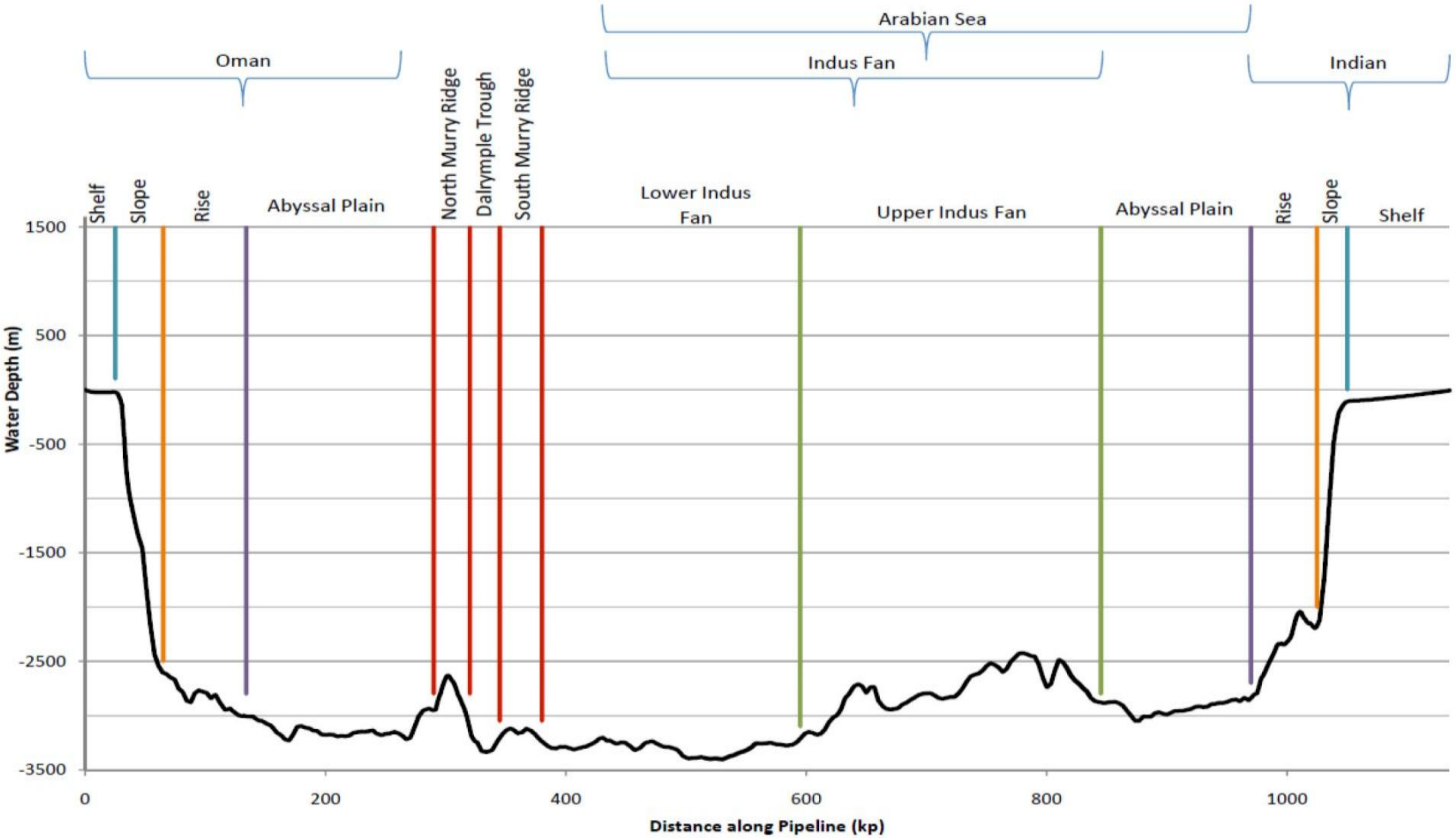


Pipeline Route (Oman Option)

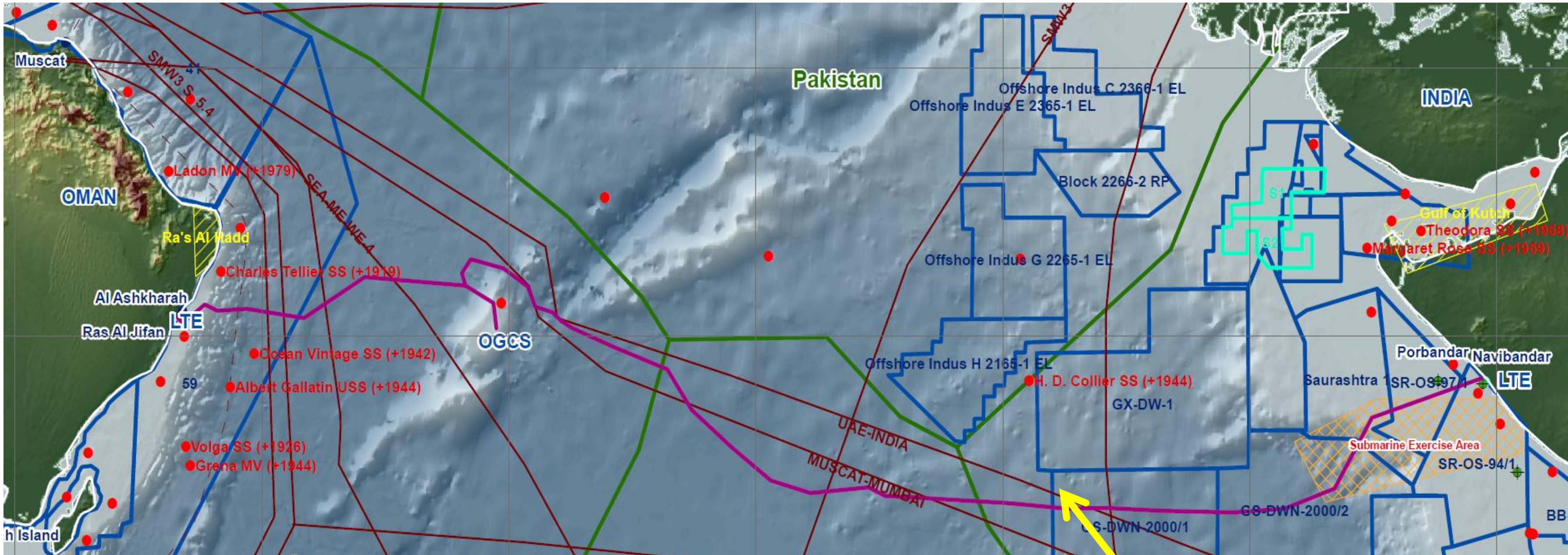
- Routing from Central Oman East coast near Ras Al Jifar and Ghudayran
- Crossing Oman Continental Shelf/Slope/Rise due west
- Crossing Central Oman Abyssal Plain
- Passing North of the Qualhat Seamount
- Crossing the Dalrymple and Arabian Abyssal Plain to the South East
- Crossing lower reaches of the Upper Indus Fan due East
- Crossing Indian Continental Rise & Slope to North East
- Crossing Indian Continental Shelf due East

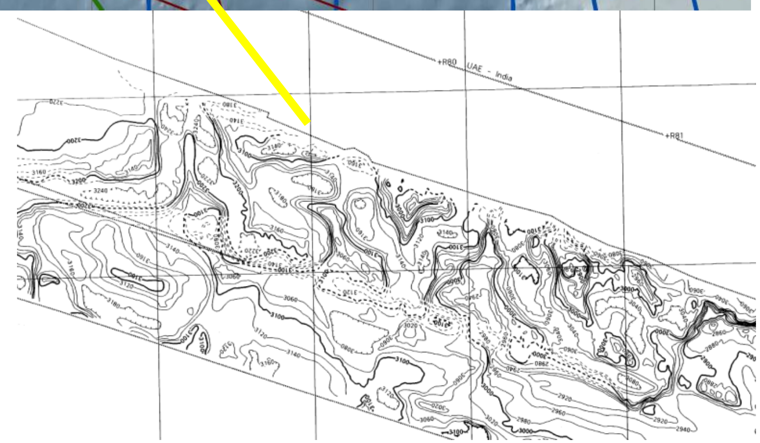


Pipeline Route Profile (Direct)



Cable Crossings Along Route





Name	Status
ADEN-BOMBAY 2	Proposed
ADEN-BOMBAY 3	Proposed
ADEN-BOMBAY 4	Proposed
FLAG Seg H and J	Existing
FLAG Seg G and I	Proposed
SEAMEWE3 Segments 5.2, 5.3 and 5.4	Existing
SEAMEWE4	Existing
ADEN-MUSCAT	Proposed
SALALAH-MUSCAT	Existing
MUSCAT-MUMBAI	Existing
UAE-INDIA	Existing
UAE-PAKISTAN	Existing
KARACHI-MUSCAT	Proposed

Flow Assurance & Mechanical Design

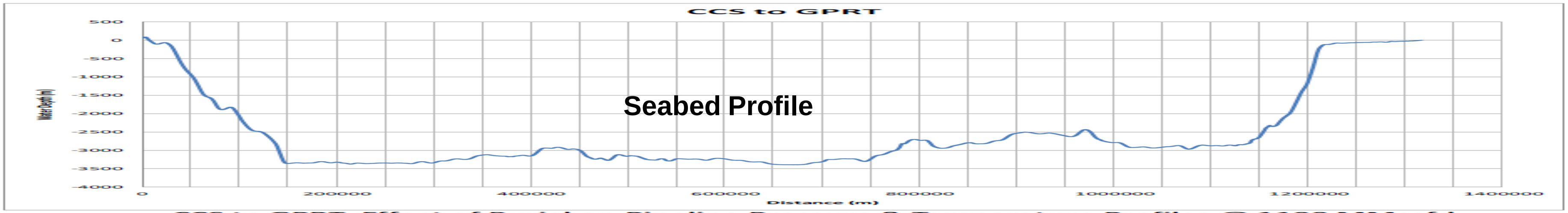
Flow Assurance

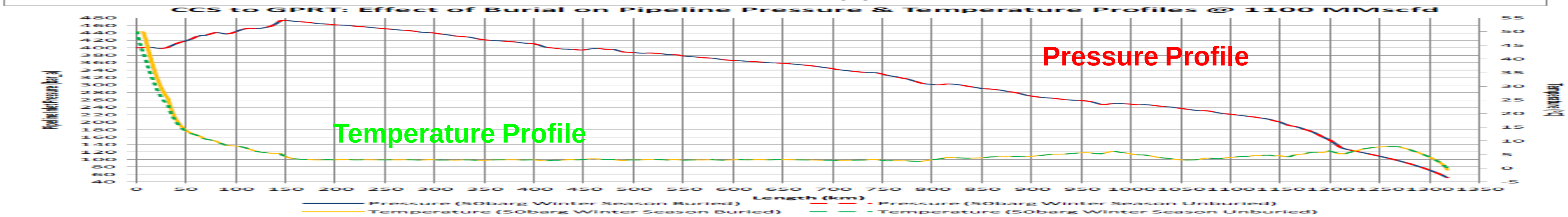
- The following pipeline sizes have been selected for the various options considered for the Middle East to India Deepwater Pipeline from Chabahar to Gujarat for an export (sizing case) flowrate of 1100 MMscfd or 31.1 MMSCMD :
  - MECS to OGCS, 400barg-50barg, ID=487mm (Low pressure arrival)
  - MECS to OGCS, 400barg-200barg, ID=530mm (High pressure arrival)
  - OGCS to GPRT, 400barg-50barg, ID=579mm
  - MECS to GPRT, 400barg-50barg, ID=610mm

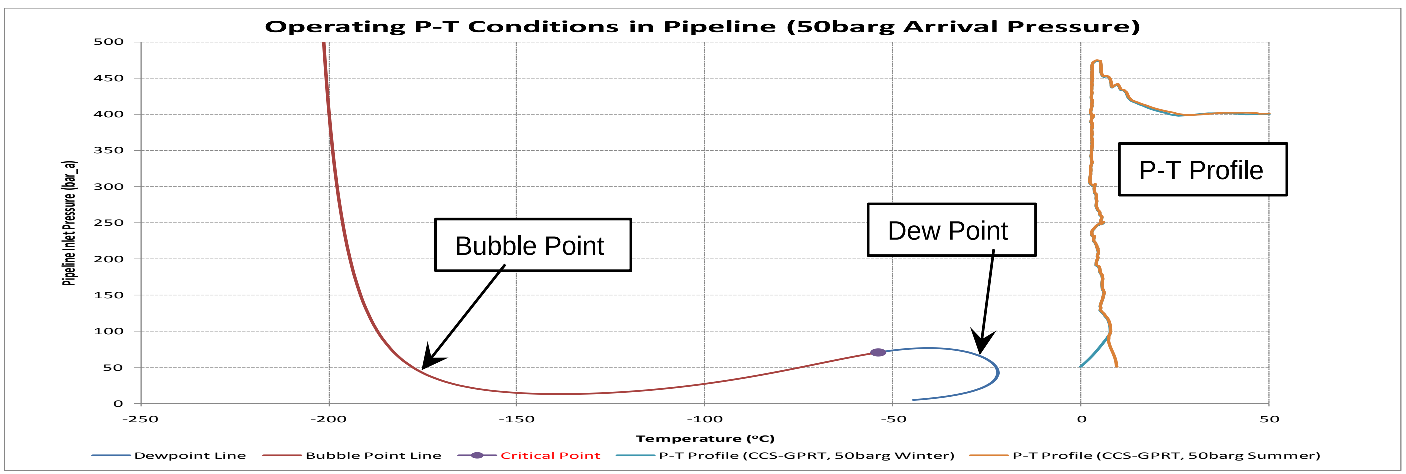
- Of the two OGCS arrival pressures considered in the high arrival pressure case is the preferred option for the following reasons:
  - By operating in dense phase, the velocities are manageable (6 m/s).
  - By operating at lower velocities the gas arrival temperature at the offshore facilities is approximately 7°C which is manageable.

Flow Assurance

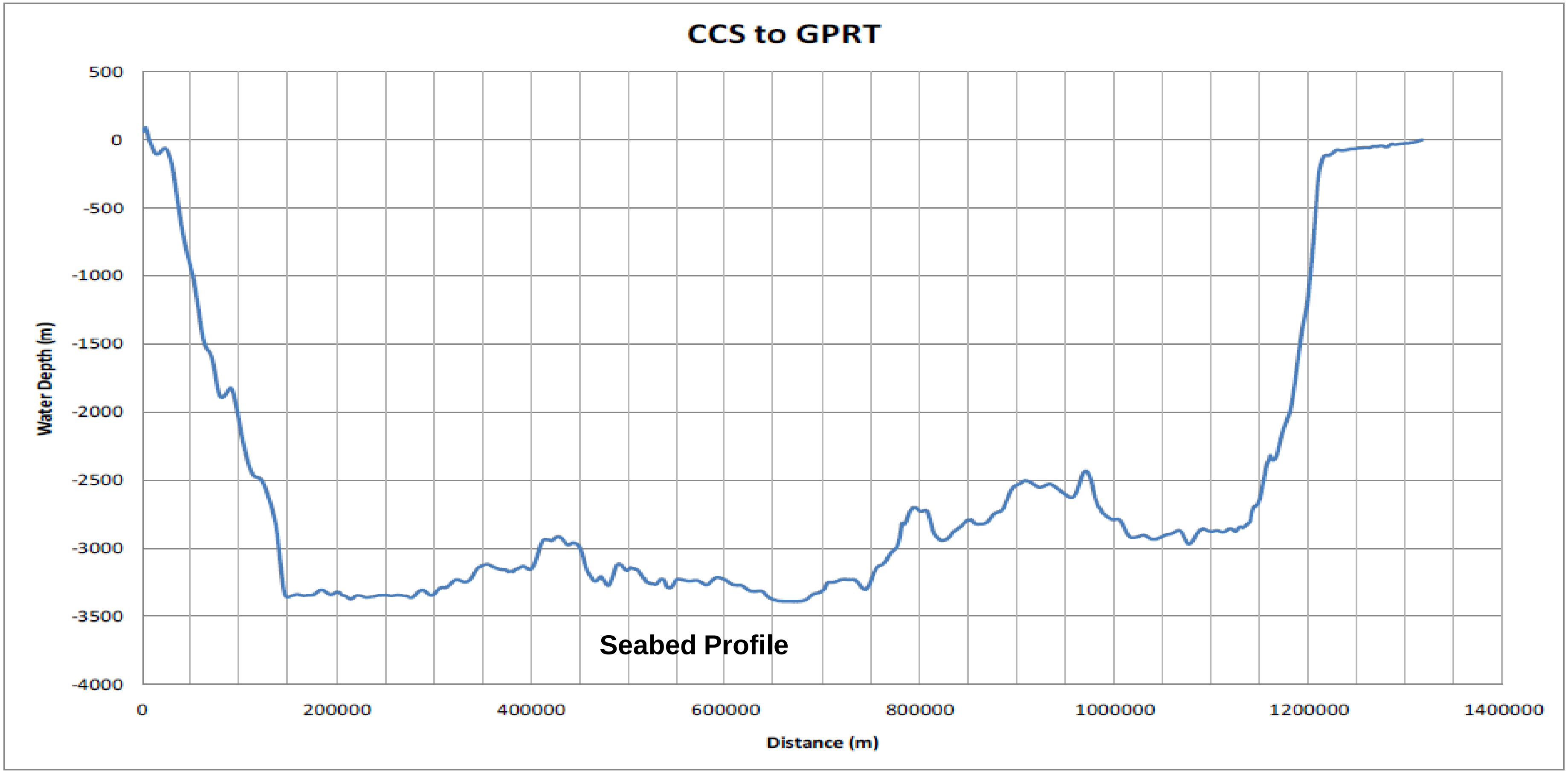
Seabed Profiles, Temperatures and Pressures (MECS to GPRT)







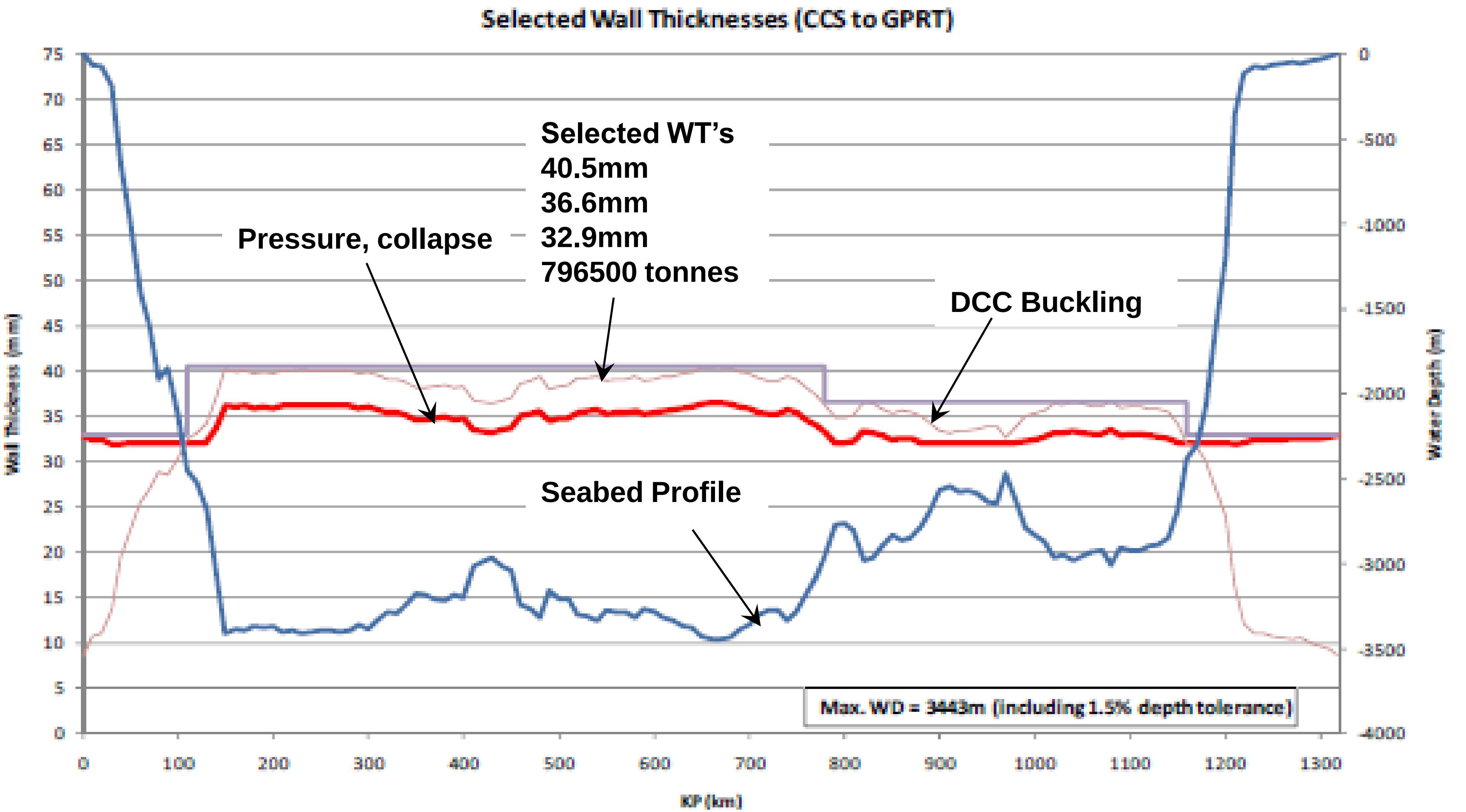
Completed studies – Flow Assurance



Mechanical Design

- The wall thickness design in accordance with DNV-OS-F101 using DNV 485 DSAW linepipe
- Supplementary requirement (U) material strength factor, (D) Dimension Tolerancing, (F) Fracture arrest
- Fabrication factor for UOE pipe (α_{fab}) = 1.0, based on the conclusion made in the DNV technical report that a modest heat treatment during the pipe coating application can increase fabrication factor for UOE from the default value of 0.85 to 1.0.
- Ovality = 0.5% (Readily achievable by experienced deepwater linepipe mills)

Wall Thickness Distribution



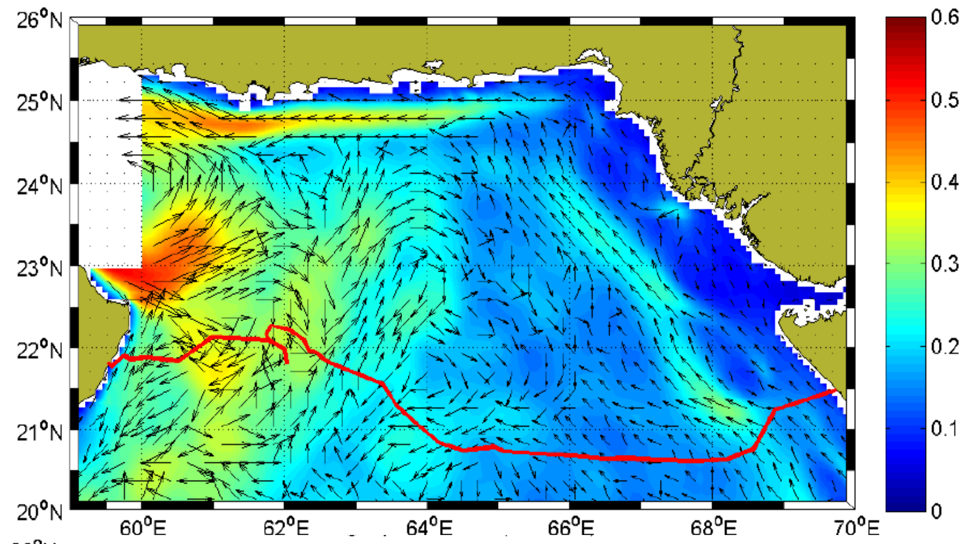
Steel Requirement

KP Range (km)	WD Range (m)	Section Length (km)	Pipe ID (mm)	Selected Wall Thickness (mm)	Buckle Arrestor Required	Tonnage of Steel Required for Line Pipe (Tonne)
0 – 6.8	-82 - 8.8	6.8	610	40.5	No	4,418
6.8 - 40	8.8 - 659	33.2	610	32.9	No	17,318
40 - 110	659 - 2448	70	610	32.9	Yes	36,514
110 - 770	2448 - 3084	660	610	40.5	Yes	428,811
770 - 1150	3084 - 2690	380	610	36.6	Yes	221,779
1150 - 1210	2690 – 361	60	610	32.9	Yes	31,298
1210 - 1317.5	361 – 1.5	107.5	610	32.9	No	56,075
1317.5 - 1318	1.5 - 0	0.5	610	40.5	No	325
					Total	796,537

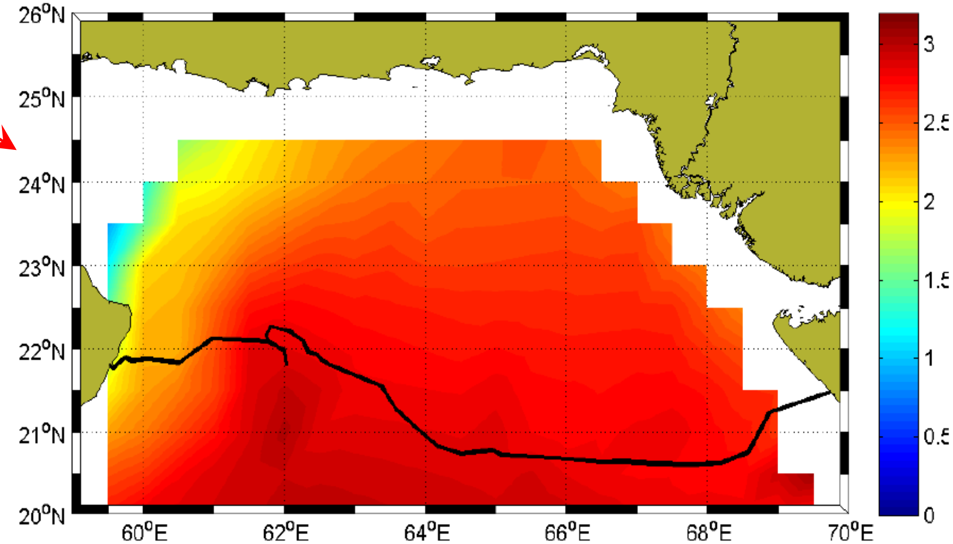
Equivalent to the Annual production of 3 SAW Pipe Mills

Metocean Investigations

North West Monsoon

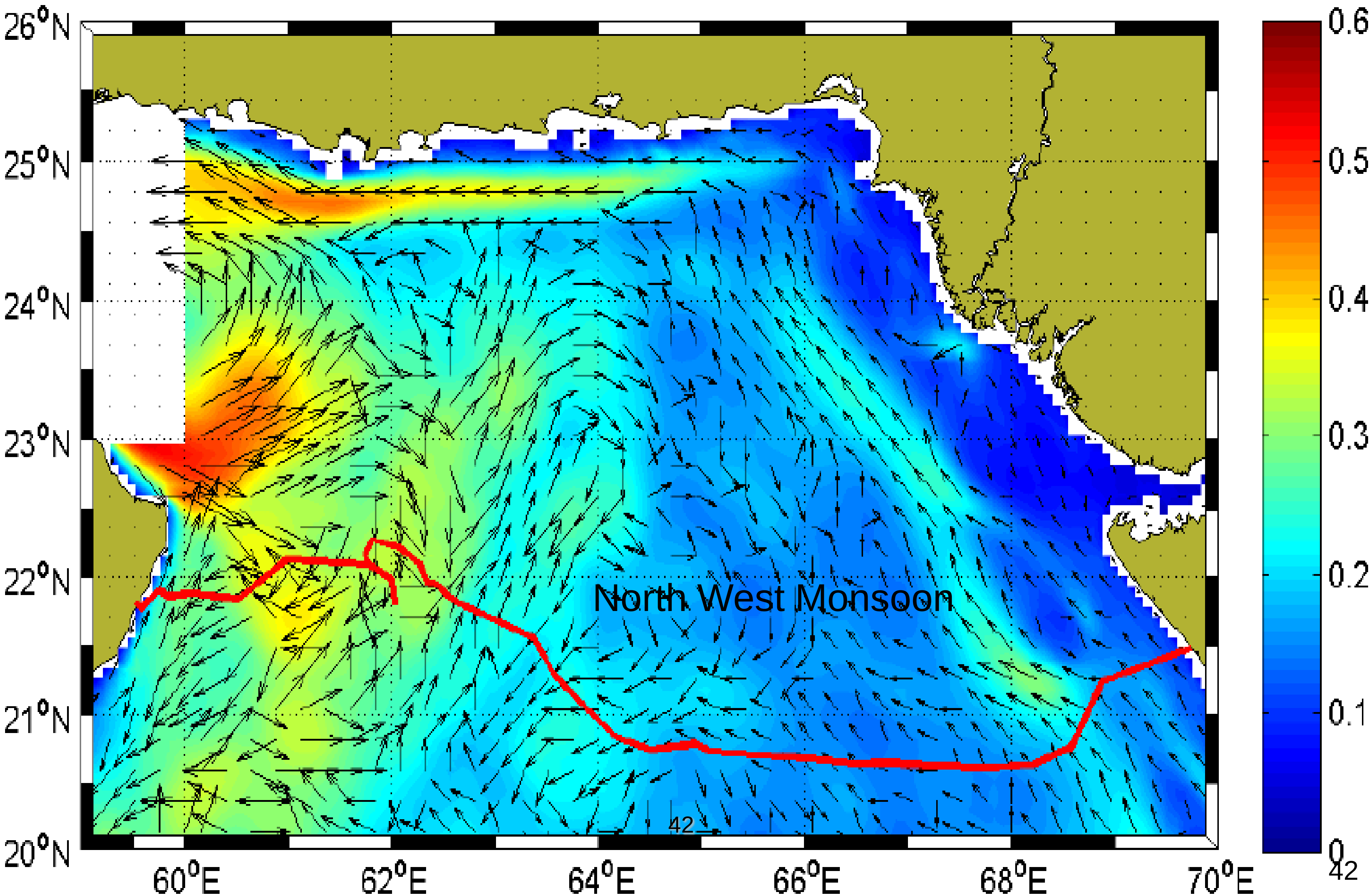


- Environmental Parameters
  - **Mean Surface Currents**
  - **Mean Significant Wave Heights (3hr Storm)**
  - Seabed Currents
  - Temperatures
  - Winds

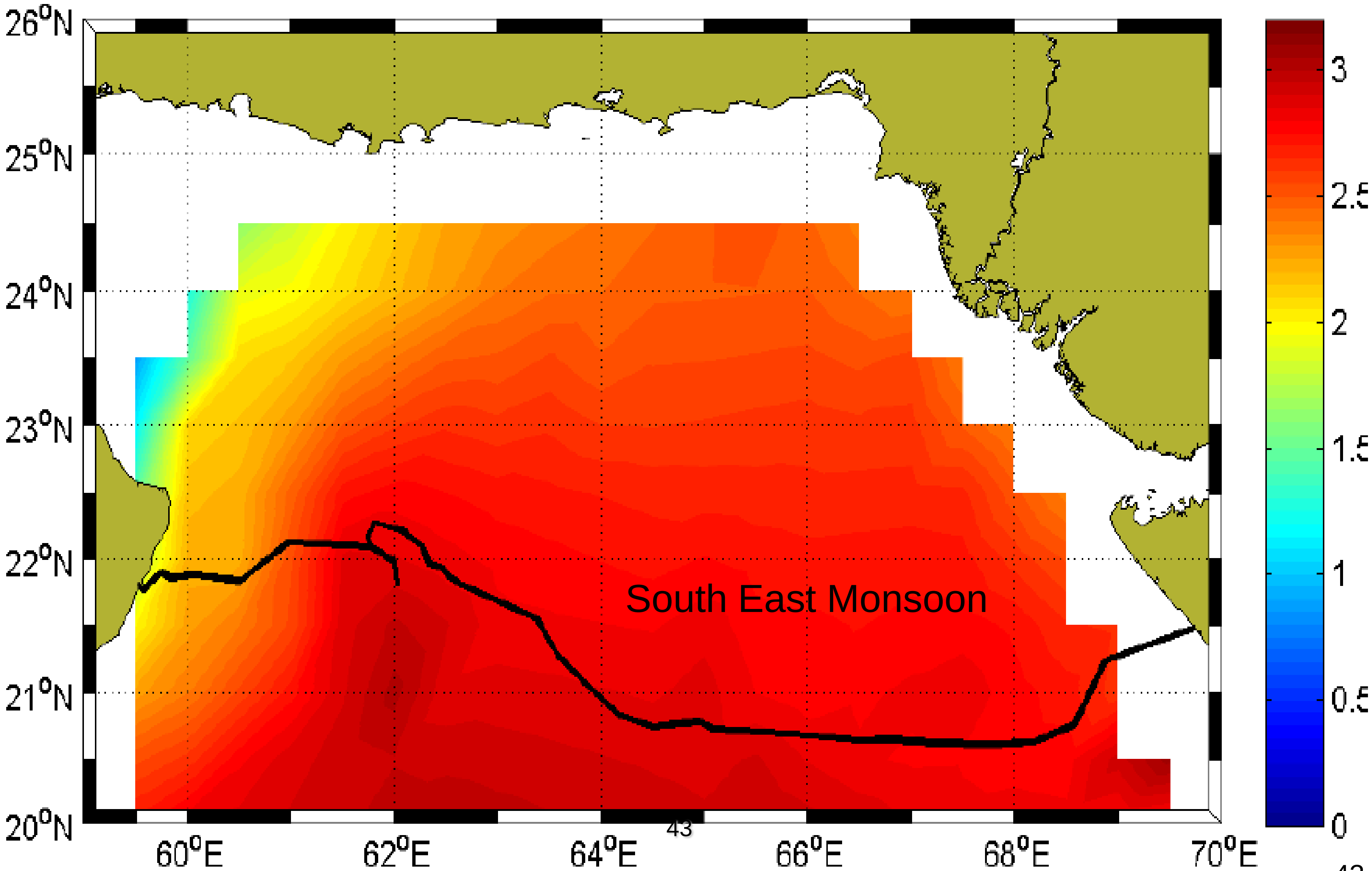


South East Monsoon

Mean Surface Currents

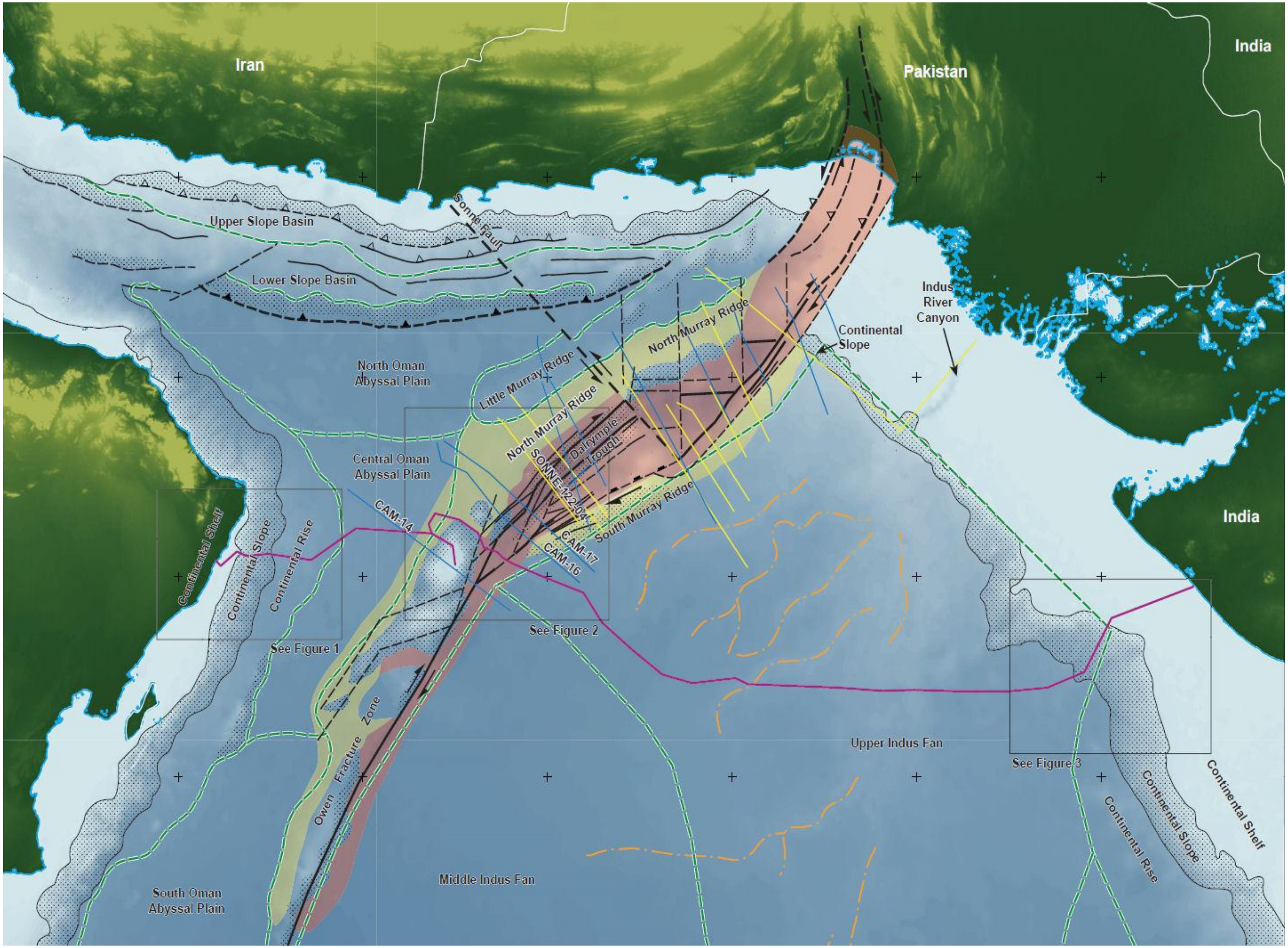


Mean Significant Wave Heights (3hr Storm)



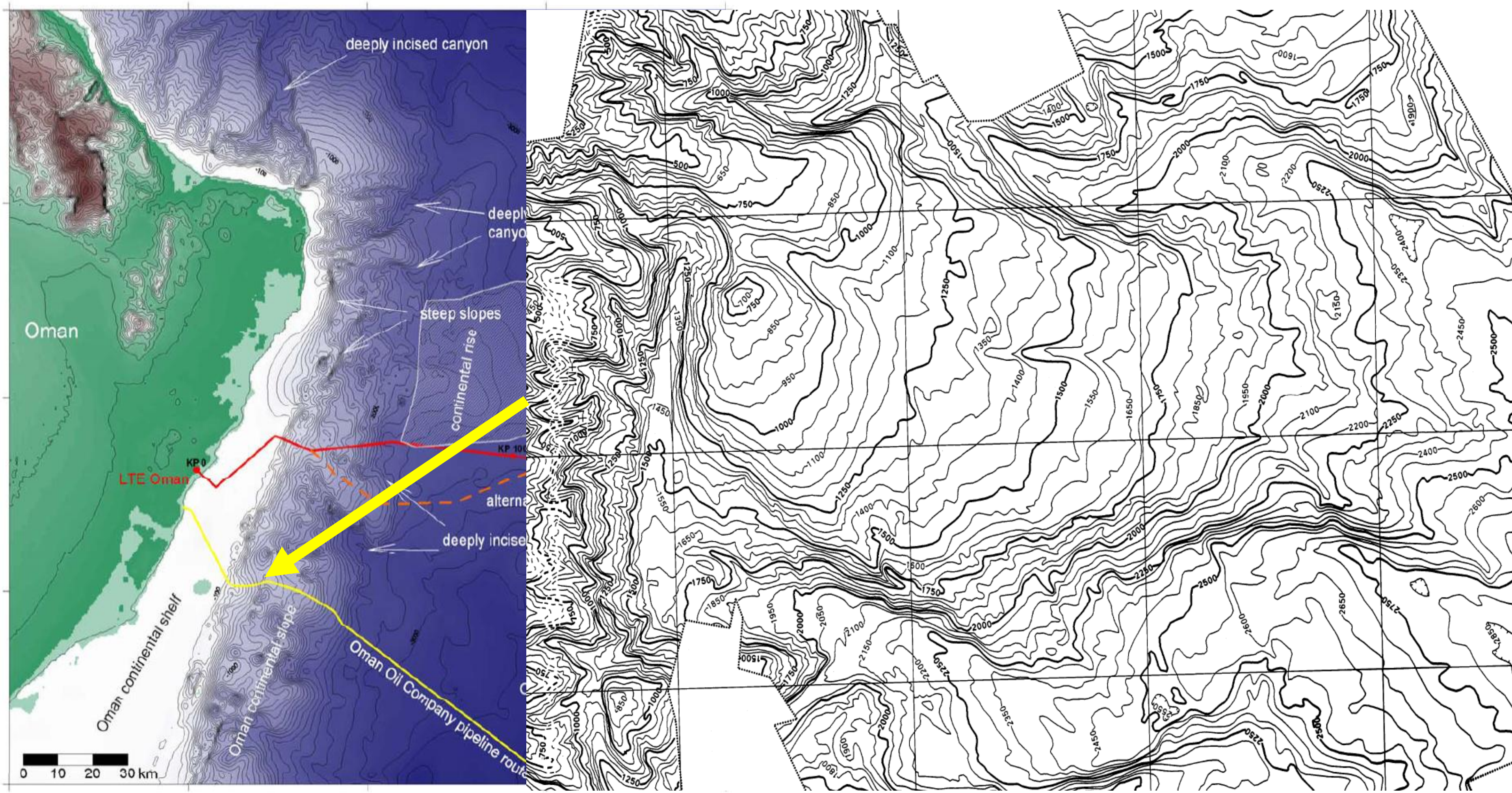
Geohazard Features & Seismic Design

Morpho-Techtonic Features I

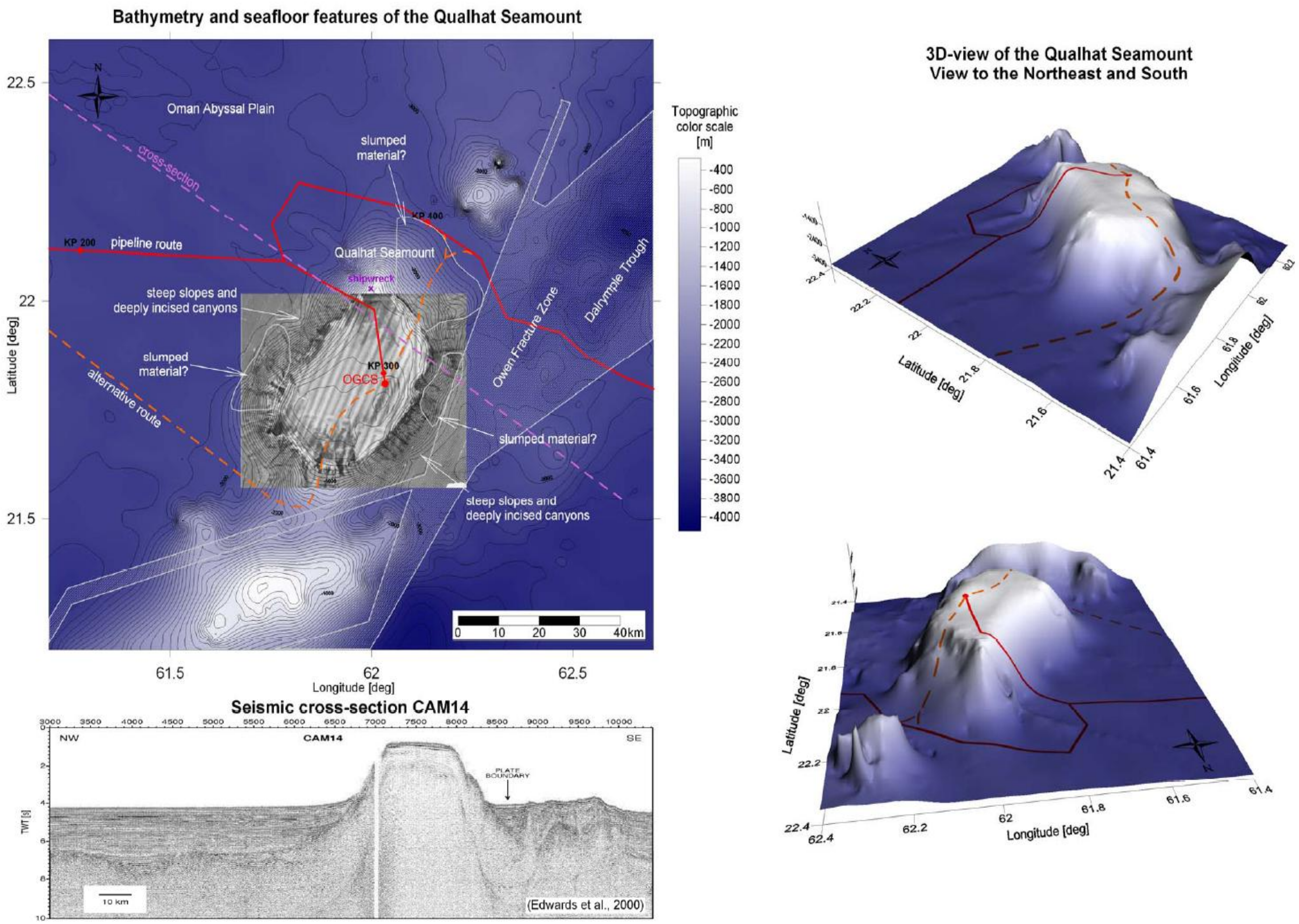


Geohazards and Features Offshore

Bathymetry and seafloor features of the Oman Continental Shelf and Slope



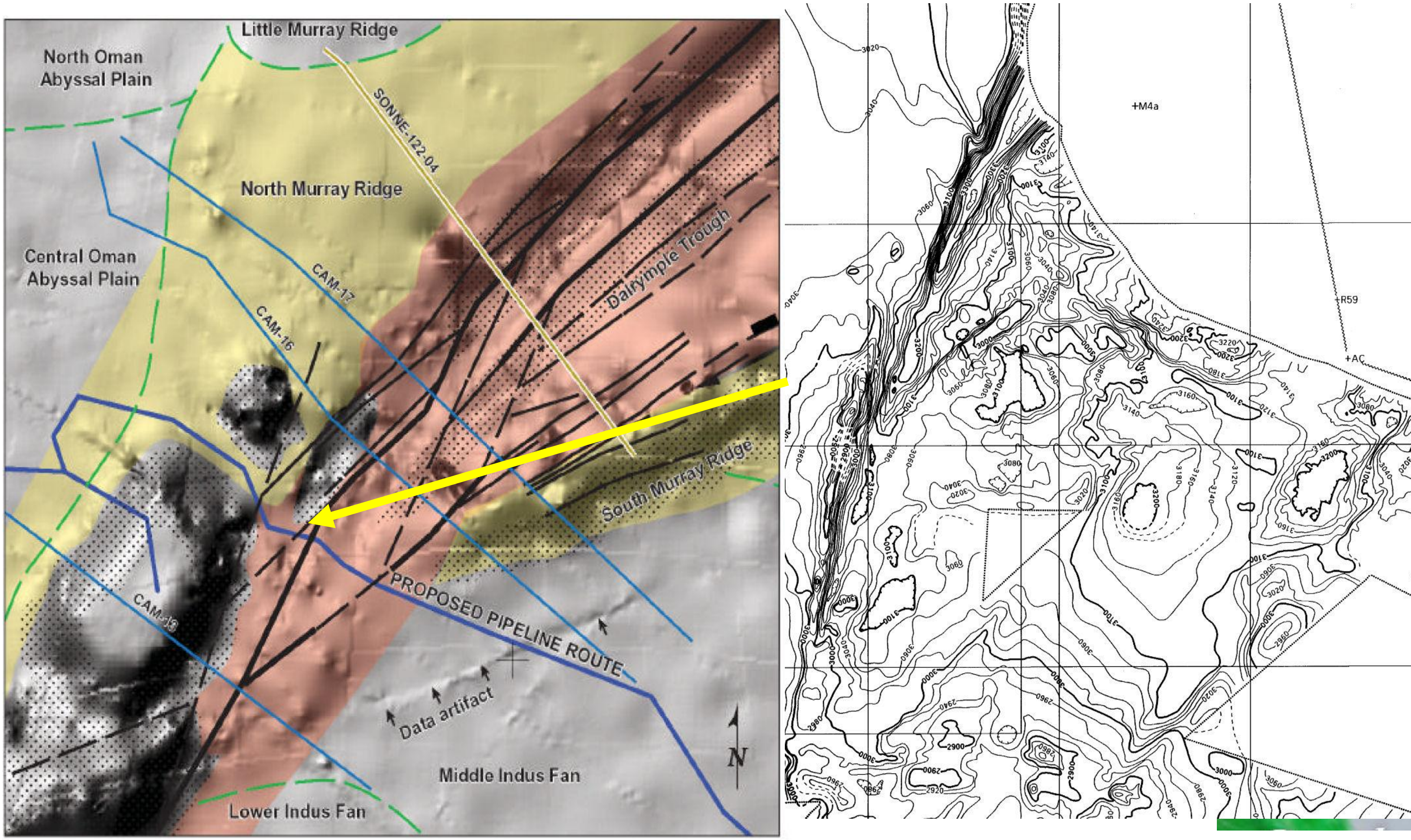
Murray Ridge and Qualhat Seamount



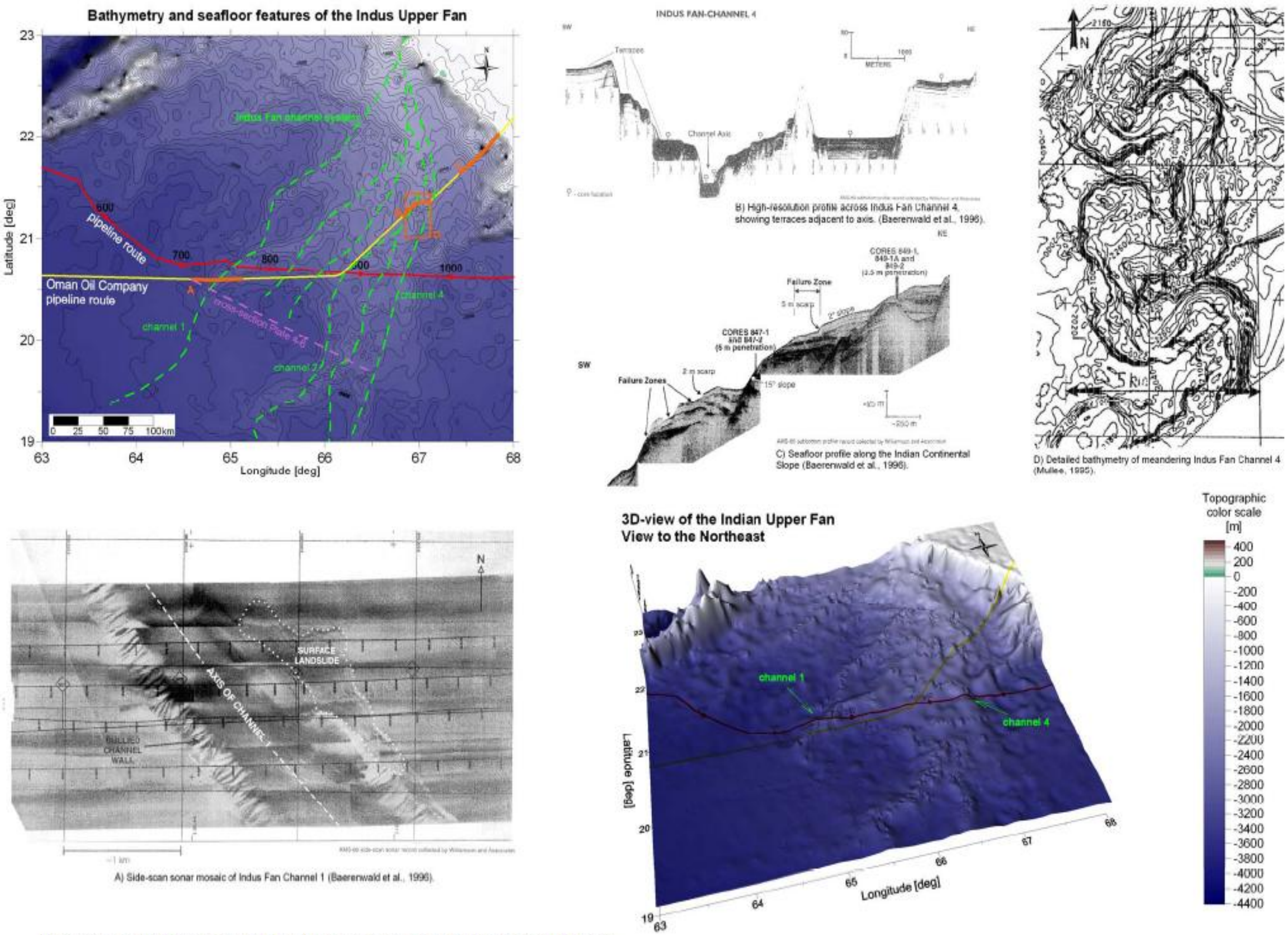
Notes: - Image on map is a multibeam sonar mosaic of the Qualhat Seamount (IFREMER, MARABIE cruises 2000 and 2001)
- Contour interval of bathymetry is 100 metres (derived from GEBCO gridded bathymetry).

- The seamounts at the South-West end of the Murray Ridge present a location for an in-line Compression facility, outside of all Territorial Waters but within helicopter supply range.
- Max Slope 20deg on Northern side similar to Landfalls.

Dalrymple Trough/Owen Fracture



Indus Fan crossing

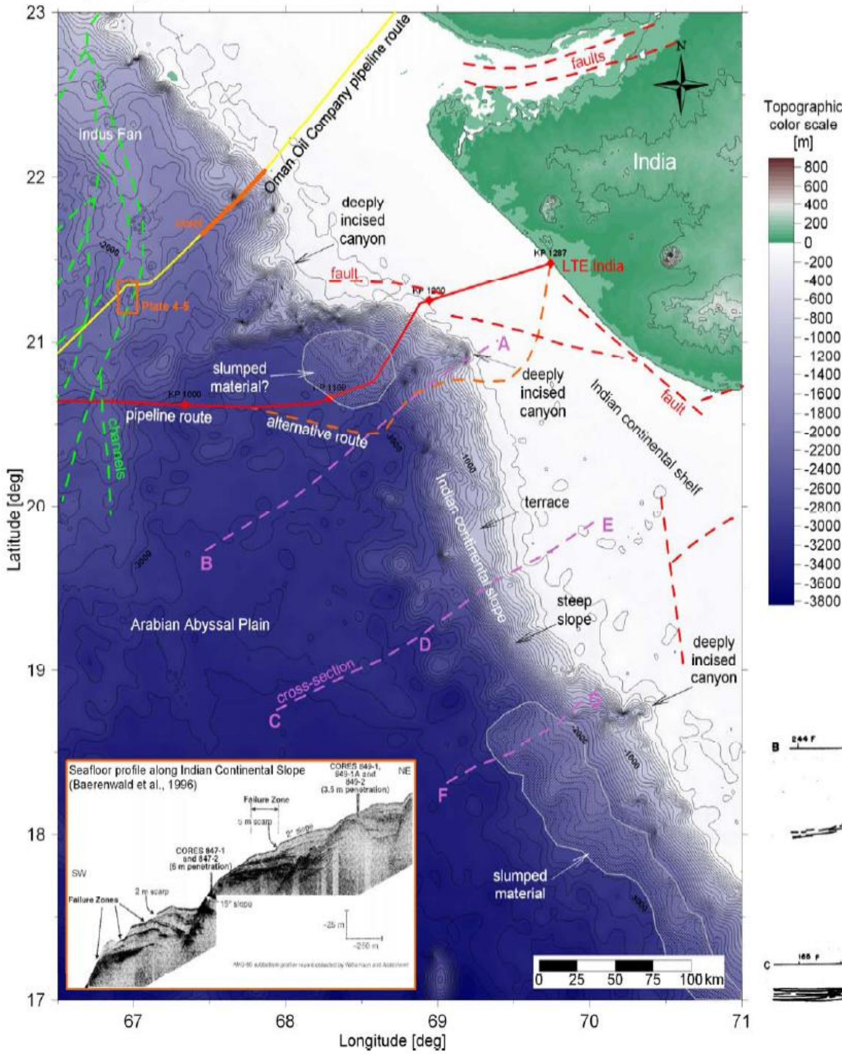


Note: - Contour interval of bathymetry map is 100 metres (derived from GEBCO gridded bathymetry).

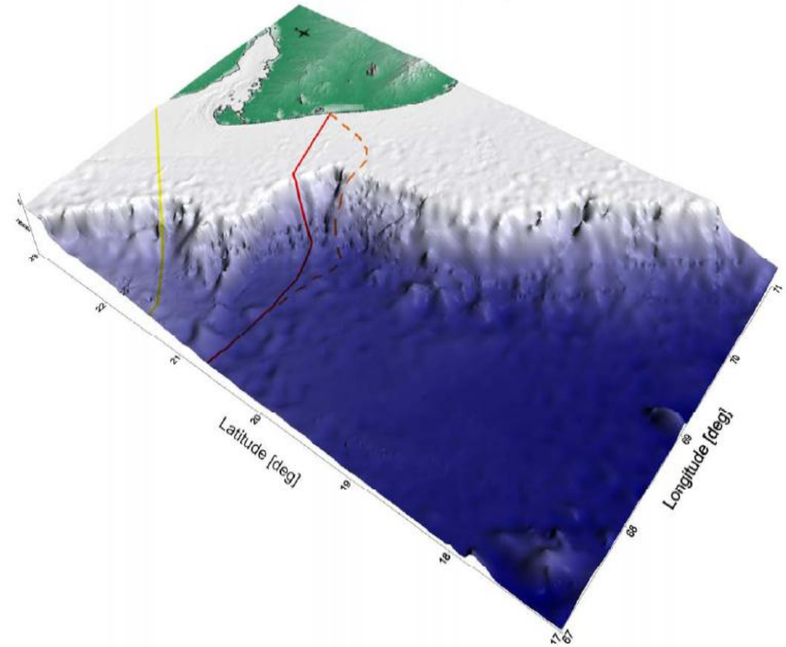
Bathymetry and Seafloor Features of the Arabian Abyssal Plain and Indus Fan
SOUTH ASIA GAS ENTERPRISE (SAGE) PIPELINE – OMAN TO INDIA

Indian Continental Slope

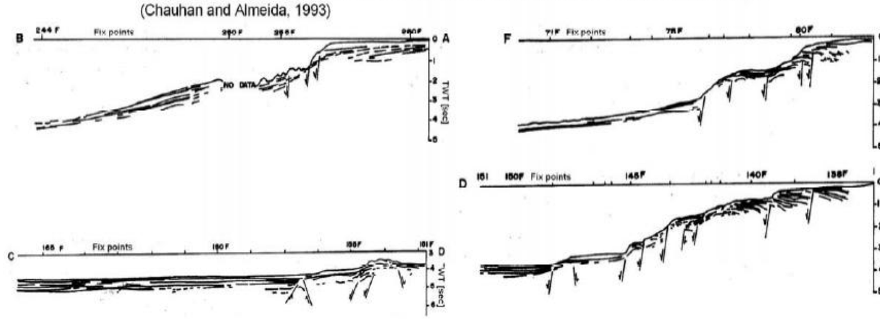
Bathymetry and seafloor features of the Indian Continental Shelf and Slope



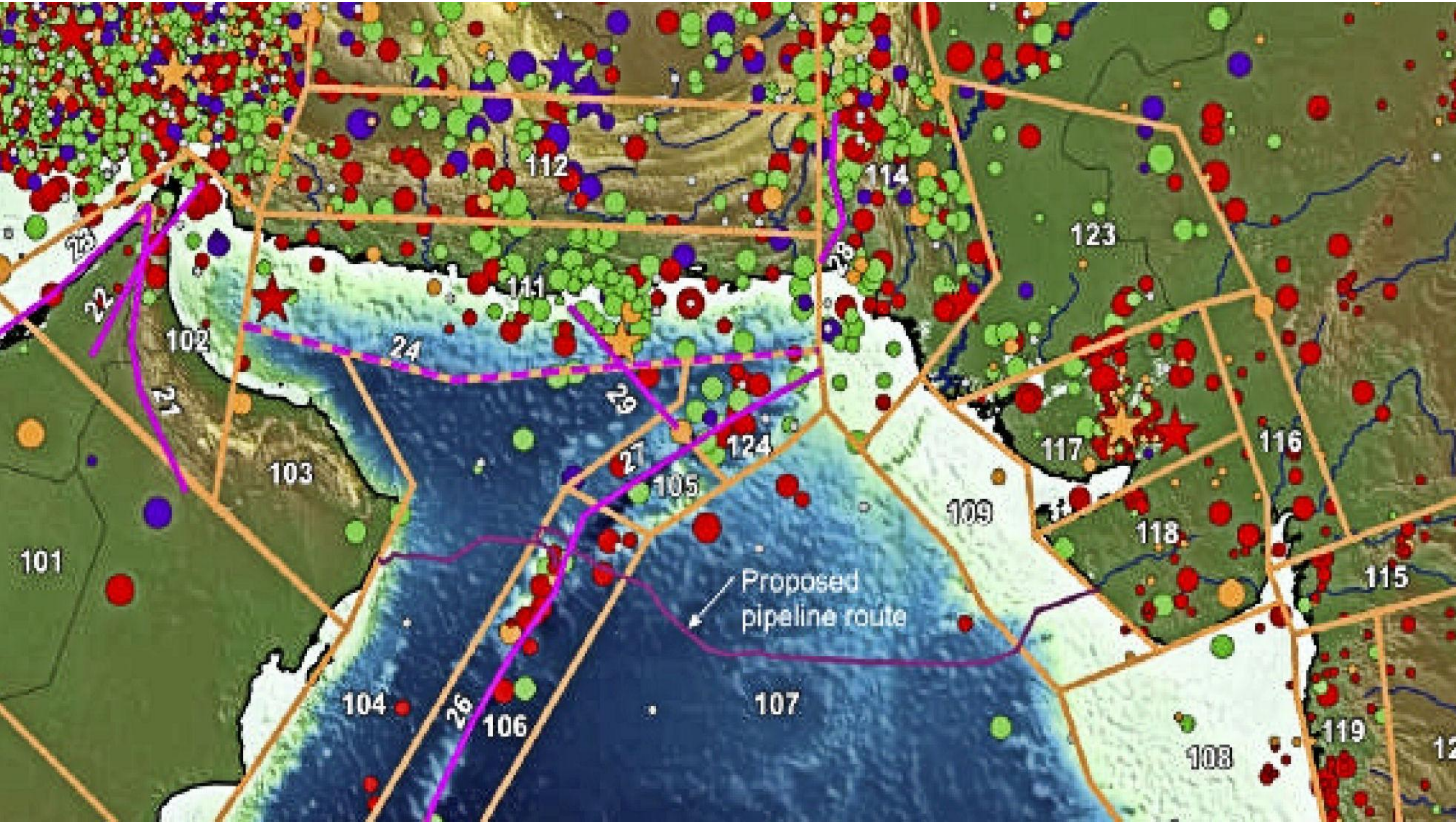
3D-view of the Indian Continental Shelf and Slope
View to the Northeast



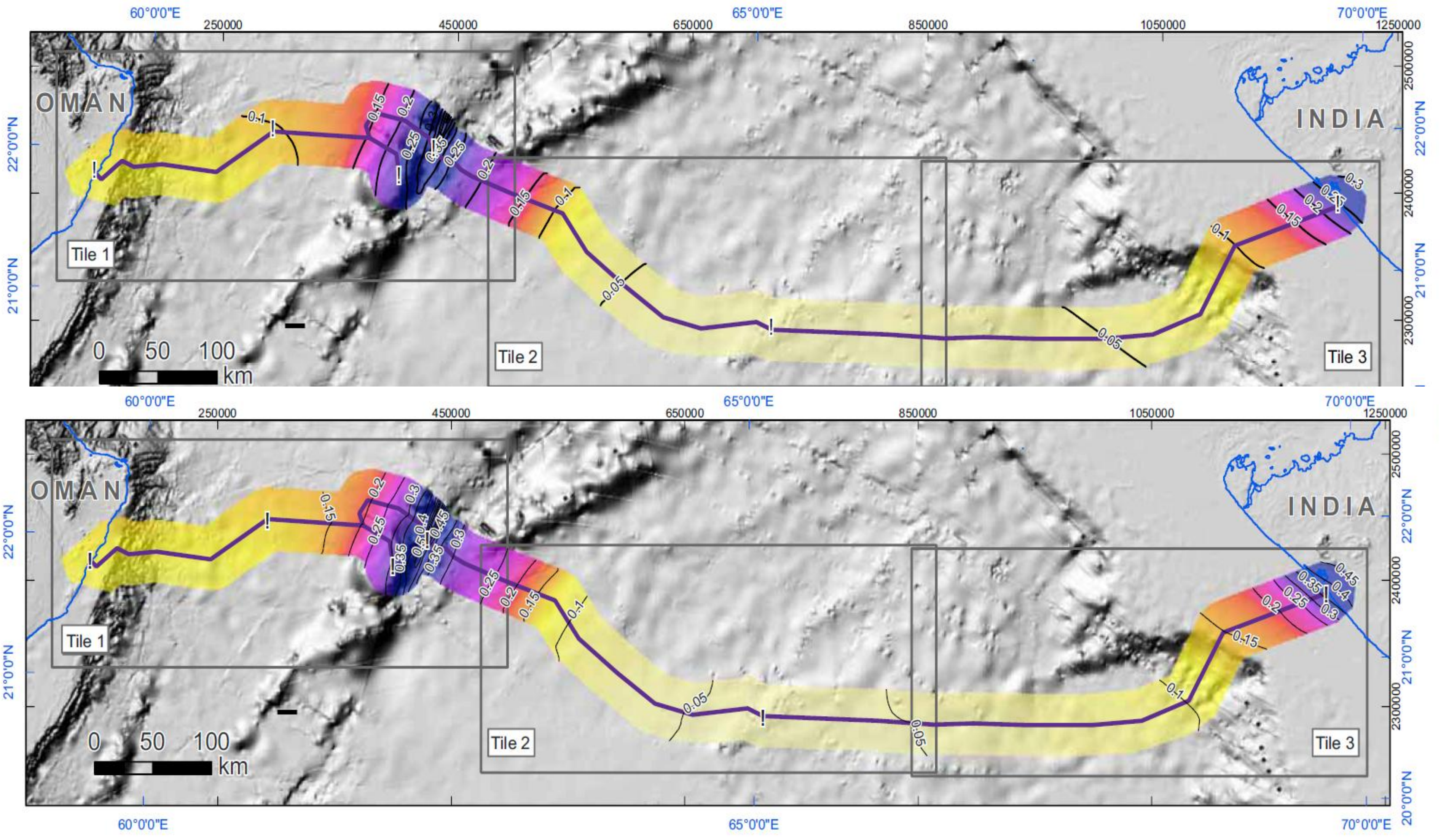
Interpreted seismic cross-sections of the Indian Continental Slope
(Chauhan and Almeida, 1993)



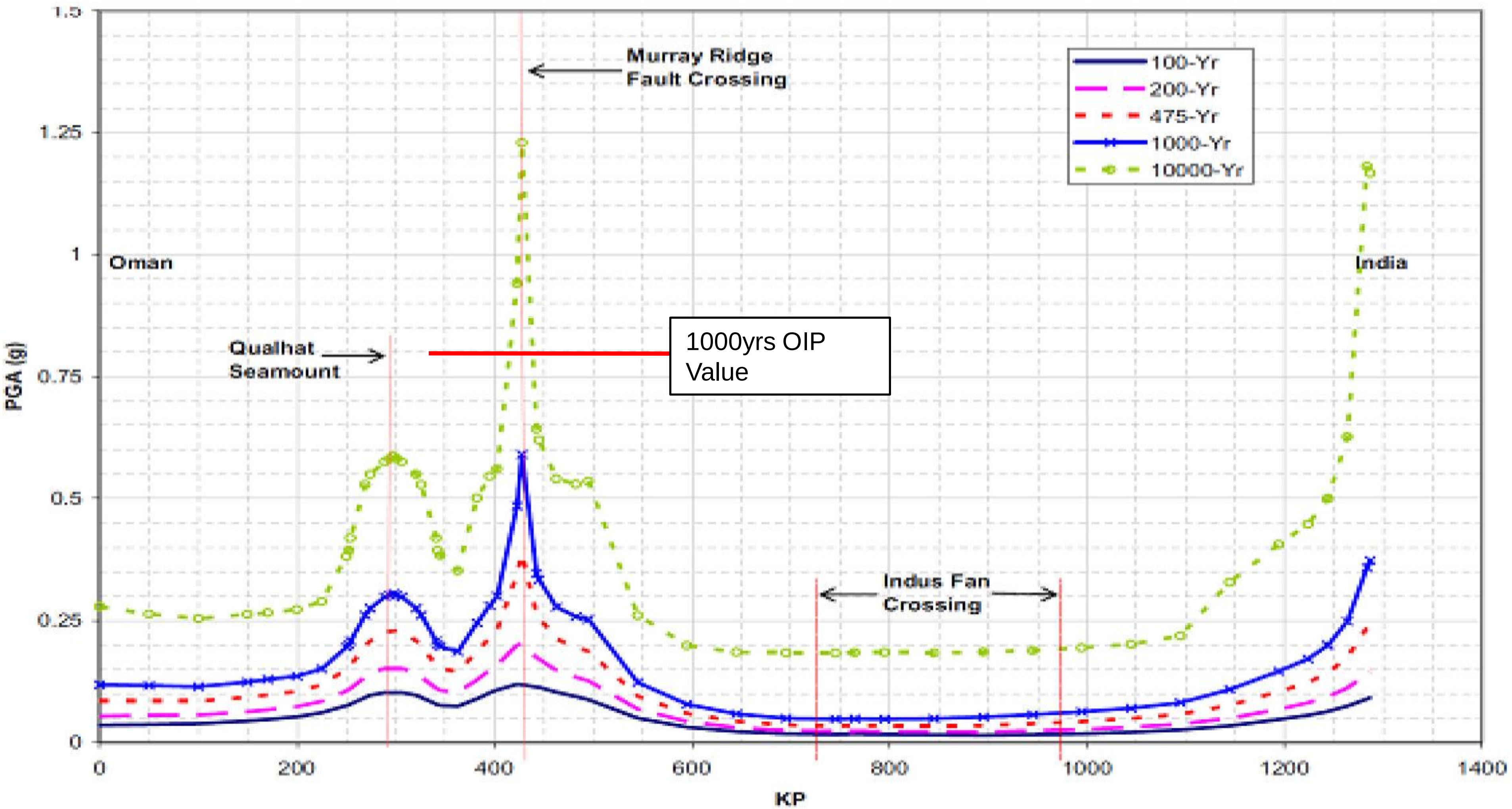
Seismic Events Catelogue



PGA Maps (475yrs & 1000yrs)



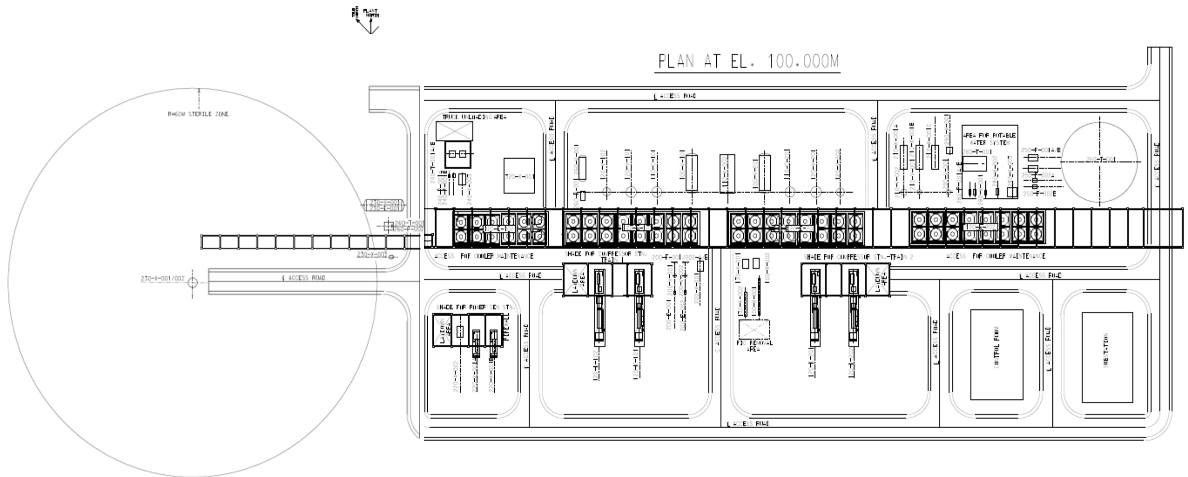
PGA Profiles Along Route



Onshore & Offshore Facilities

Onshore Terminal

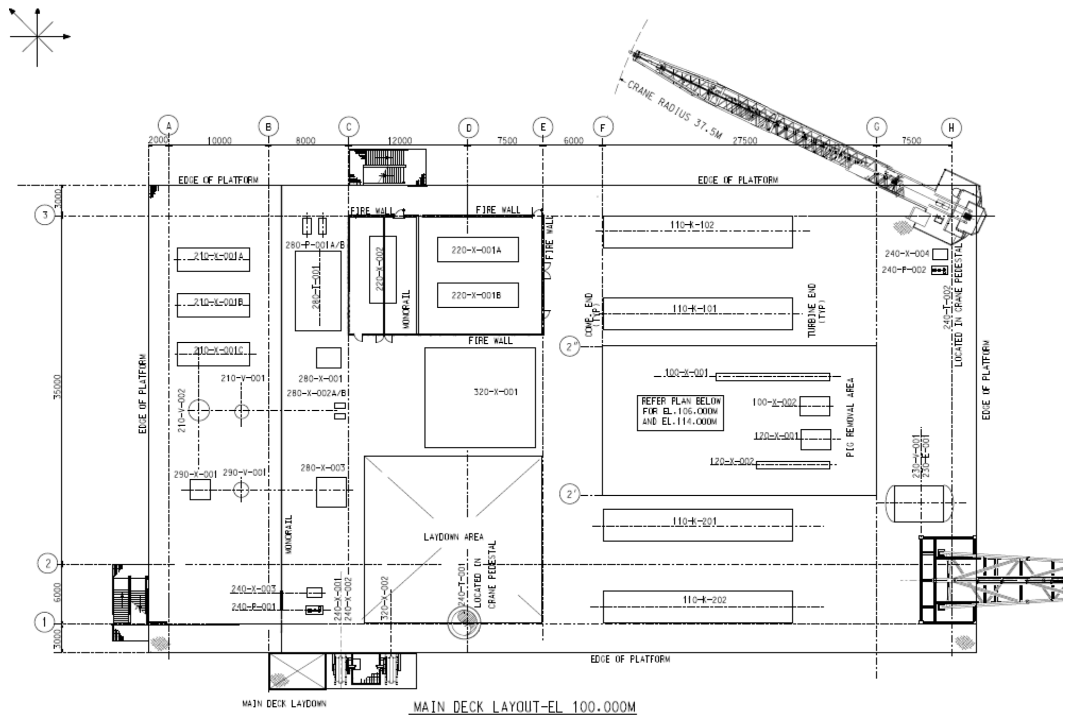
- Concept Definition
  - Equipment Lists
  - PFD's
  - UFD's
  - Weight Take-off
  - Layouts
  - Cost Estimate



- Equipment
  - Compression (2 Stages)
  - Pigging facilities
  - Fuel gas Systems
  - Instrument air systems
  - Gas turbine generation
  - Flare systems
  - Fire water systems
  - Potable water systems
  - Accommodation requirements

Offshore Compression

- Concept Definition
  - Equipment Lists
  - PFD's
  - UFD's
  - Weight Take-off
  - Layouts
  - Cost Estimate



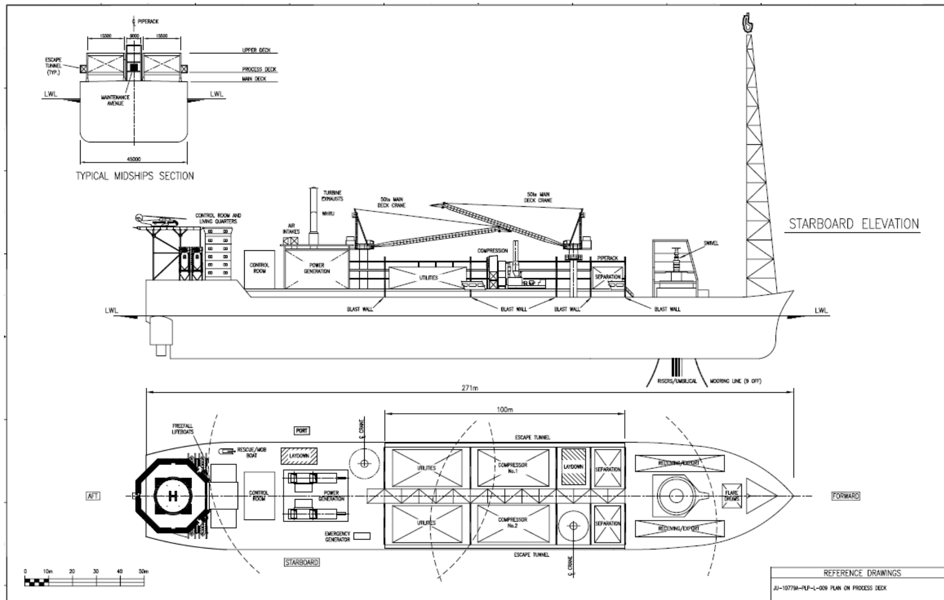
- Equipment
  - Compression (2 Stages)
  - Pigging facilities
  - Fuel gas Systems
  - Instrument air systems
  - Gas turbine generation
  - Cooling systems
  - Flare systems
  - Fire water systems
  - Seawater lift systems
  - Potable water systems
  - Transfer systems
  - Accommodation requirements
  - Sewage disposal systems

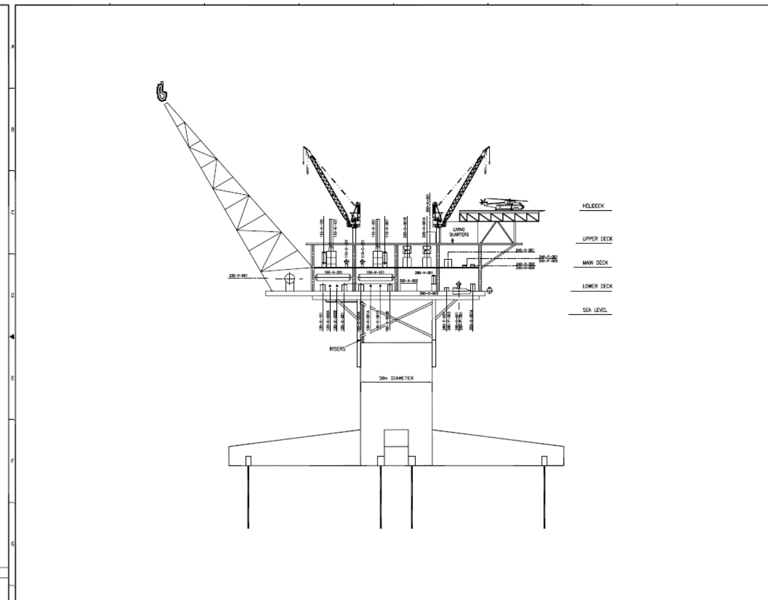
Substructure Options

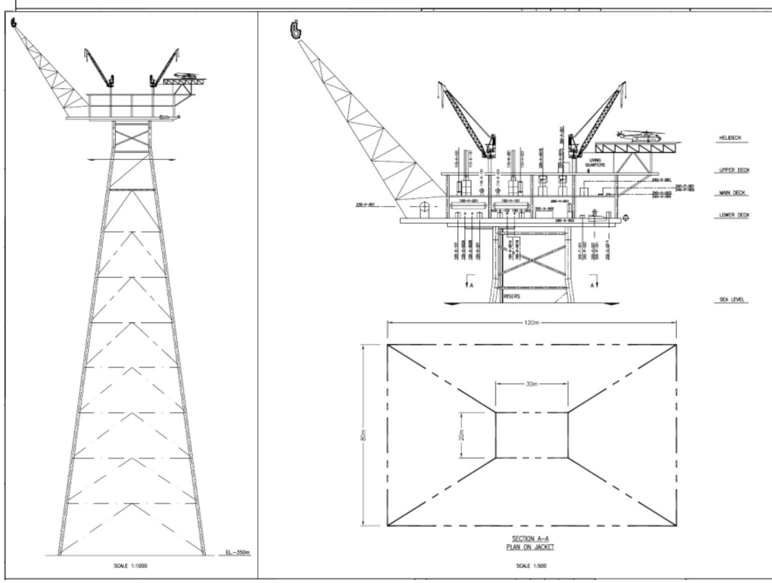
Different types of production platforms (NOAA)

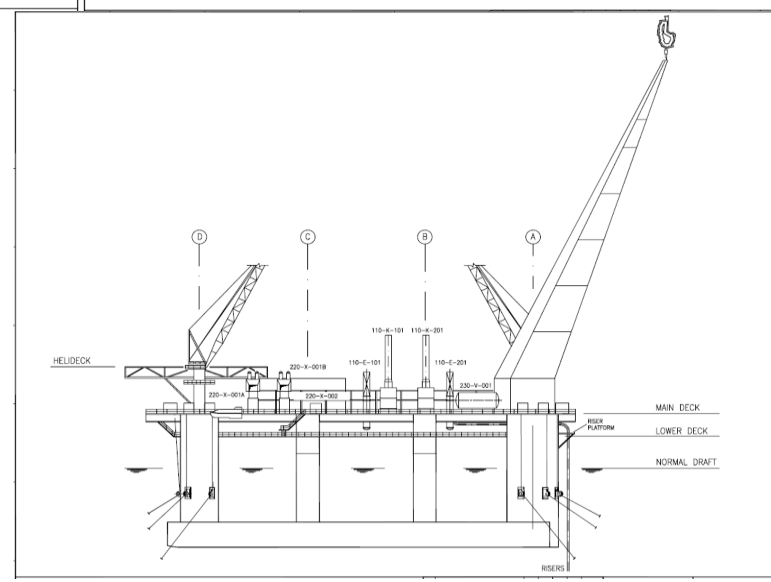
Substructure Type	Technical Drivers								Commercial Drivers					Overall	
	Water Depth Range	Payload	Metocean - Environment	Riser Feasibility	Offshore Integration	Active Seismic Ren	Score	Ranking	Reuse of Existing Maximise	Indian	Future Expansion	Score	Ranking	Score	Ranking
Semi Submersible	3	3	3	2	3	3	17	2	3	2	2	7	**1**	24	1
Tension Leg Platform	3	3	3	3	3	3	18	**1**	1	2	1	4	2	22	2
Fixed Jacket	3	3	3	3	1	2	15	4	1	3	3	7	**1**	22	2
Spar	3	3	3	3	1	3	16	3	1	1	1	3	3	19	3
Compliant Tower	2	3	3	3	1	3	15	4	1	1	1	3	3	19	3

Substructure Options

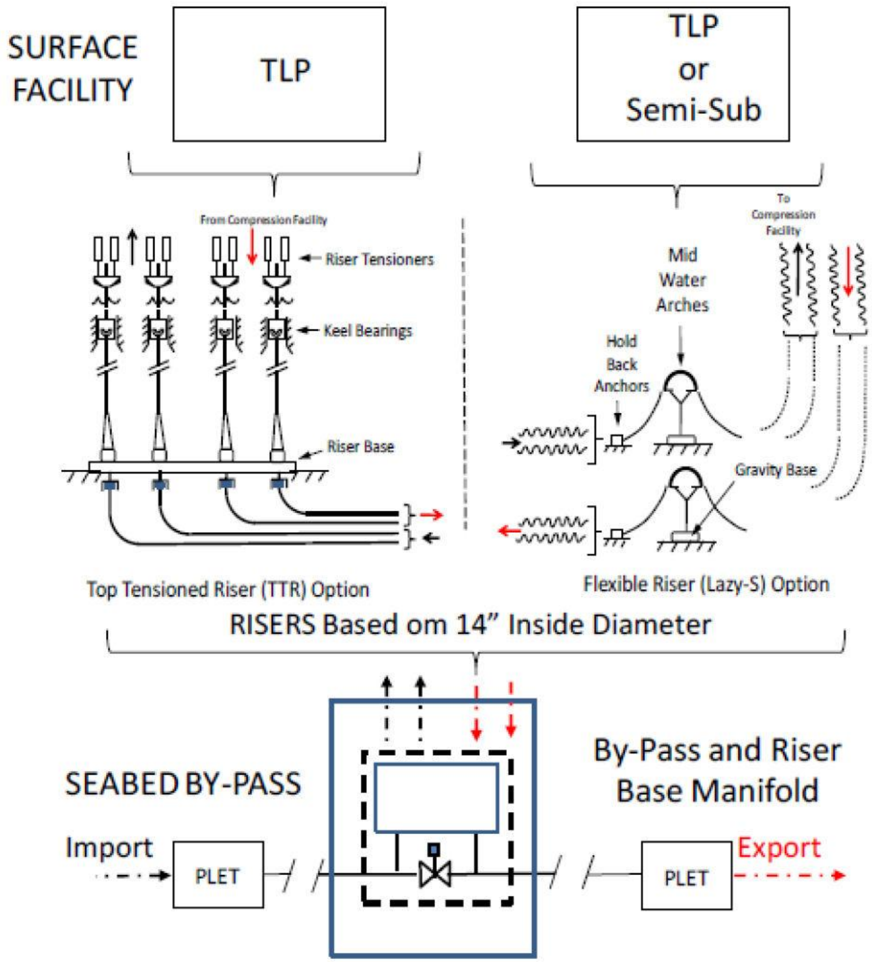


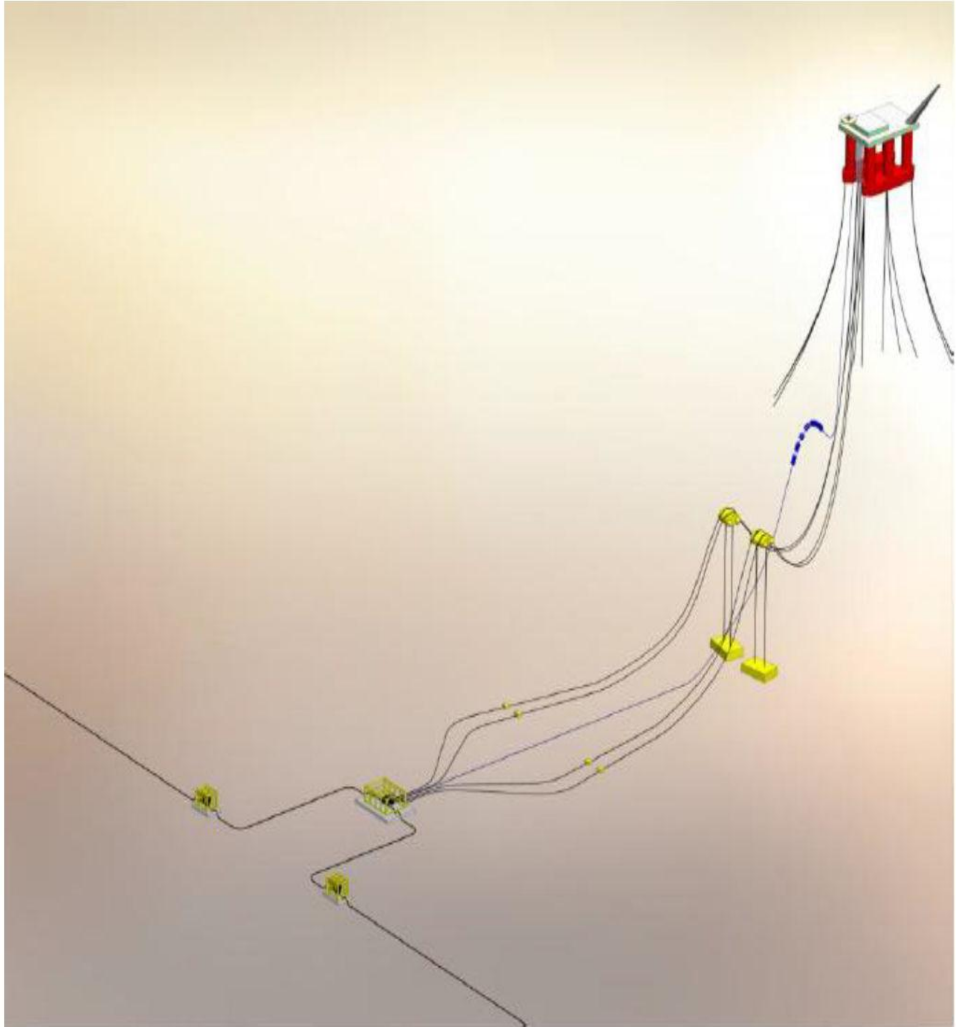






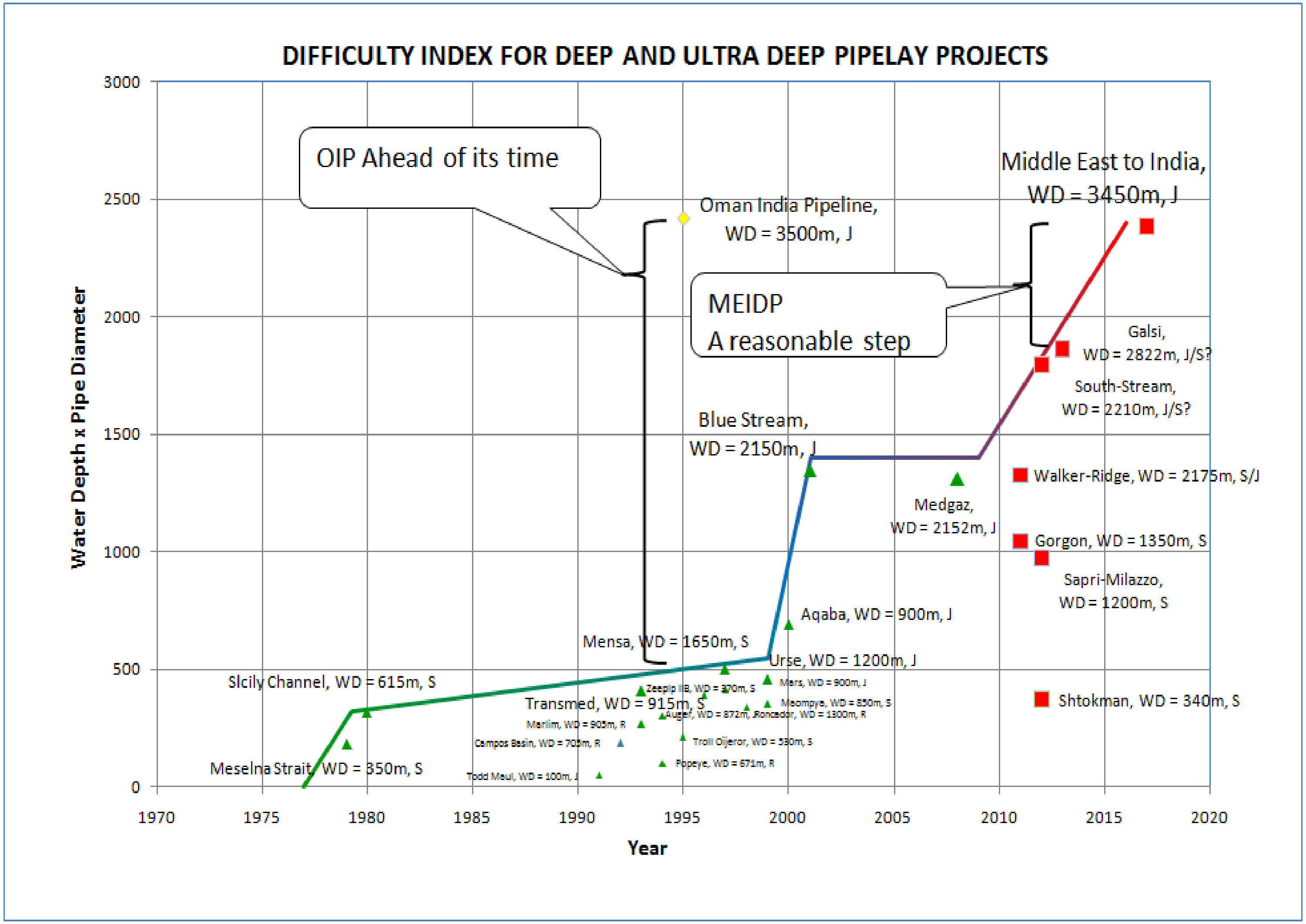
Riser and Subsea By-Pass at Seamount





Pipeline Installation, Intervention & Repair Assessment

Difficulty Index for Deep Pipelay



- J-Lay Vessel Demand
  - 1060tonne normal laying
  - 2000tonne flooded and abandonment

$T_{cr}=T_d.S_f.S_d$

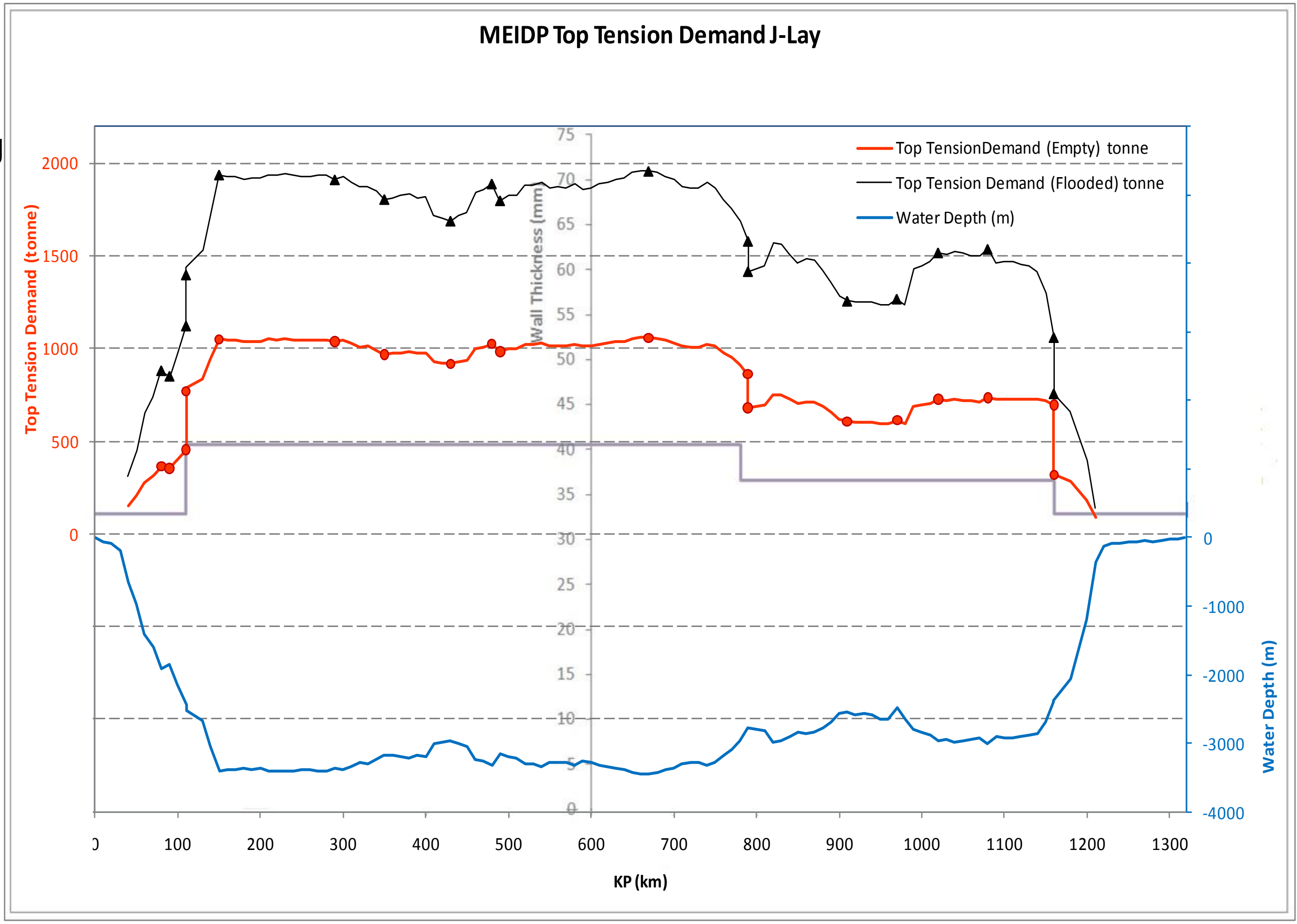
T_d = Tension Demand

T_{cr} = Tension Capacity Required

S_f = Safety Factor (1.15)

S_d = Dynamic Amplication (1.3)

- J-Lay Vessel Capacity Required
  - 1600tonne normal Laying
  - 2500tonne flooded and abandonment



Peritus

New Pipelay Vessels under Construction

SAGE

Saipem SpA new laybarge CastorONE

- Under construction in Singapore
- Ready for offshore operations early in 2012. Saipem has confirmed that the MEIDP is feasible and can be installed in a water depth of 3500m

http://www.saipem.it/site/article.jsp?idArticle=5420&instance=2&node=2012&channel=2&ext=template/37DueColonne&int=article/1DefaultArticolo

HMC new Build vessel Aegir

- Under construction in S. Korea
- proposed to be complete by mid 2013, ready for offshore operations early in 2014

http://hmc.heerema.com/tabid/1838/language/en-US/Default.aspx

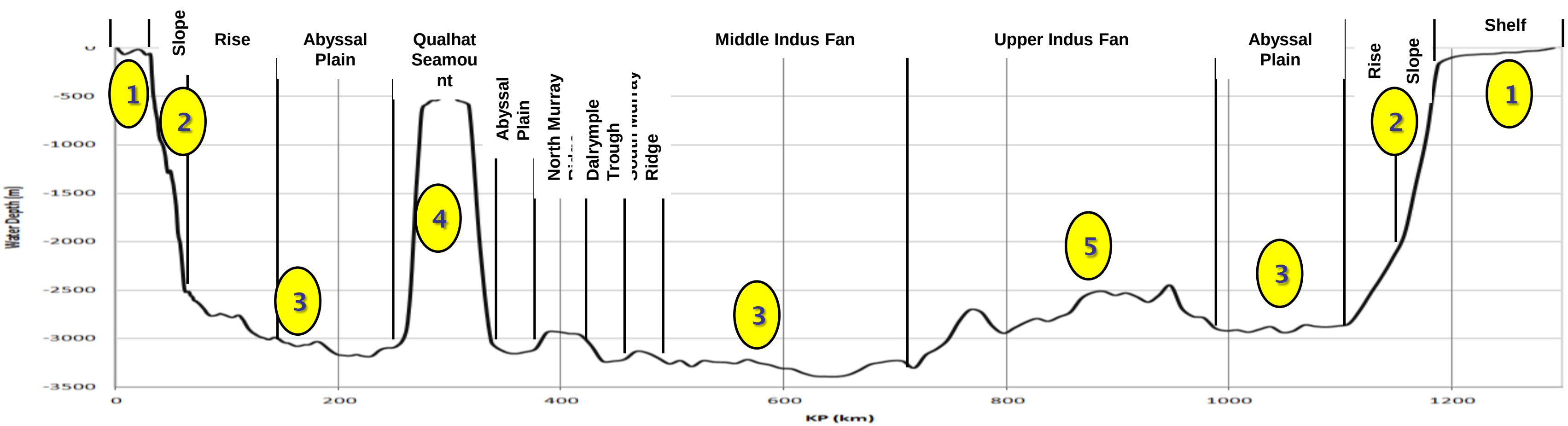
Allseas new build vessel Pieter Schelte

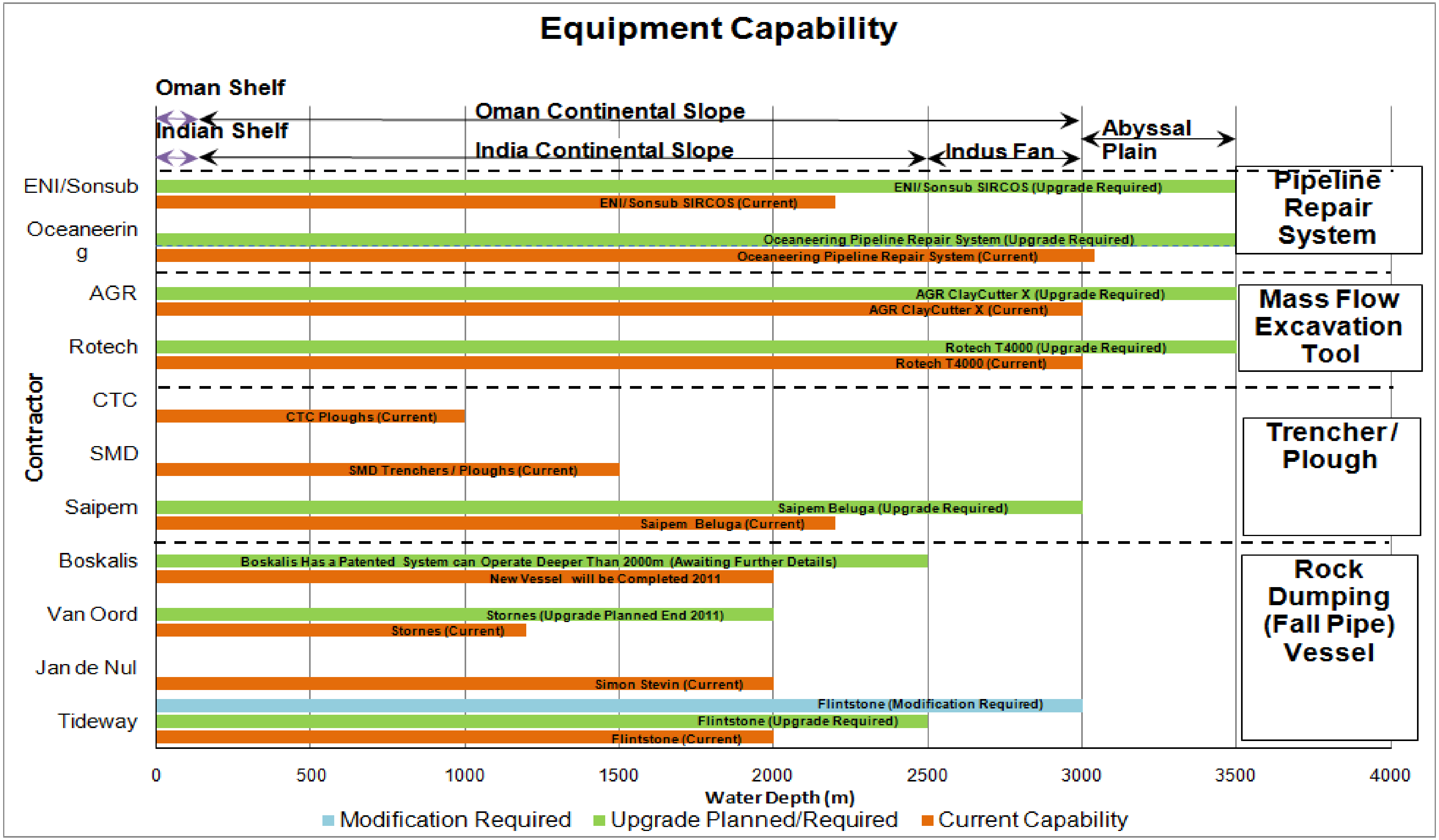
- Under construction in S. Korea
- Proposed to be complete by end 2013, ready for offshore operations in 2014

http://www.allseas.com/uk/19/equipment/pieter-schelte.html

The route has been divided into five different intervention requirement zones.

1) Shallow Water Zone (0 to 150m WD)
2) Continental Slope Zone (150m to 2500m WD)
3) Deep Water Section (2500m to 3500m WD)
4) Remote Seamount Section (300m to 3000m WD)
5) Indus Fan Section (2500m to 3000m WD)



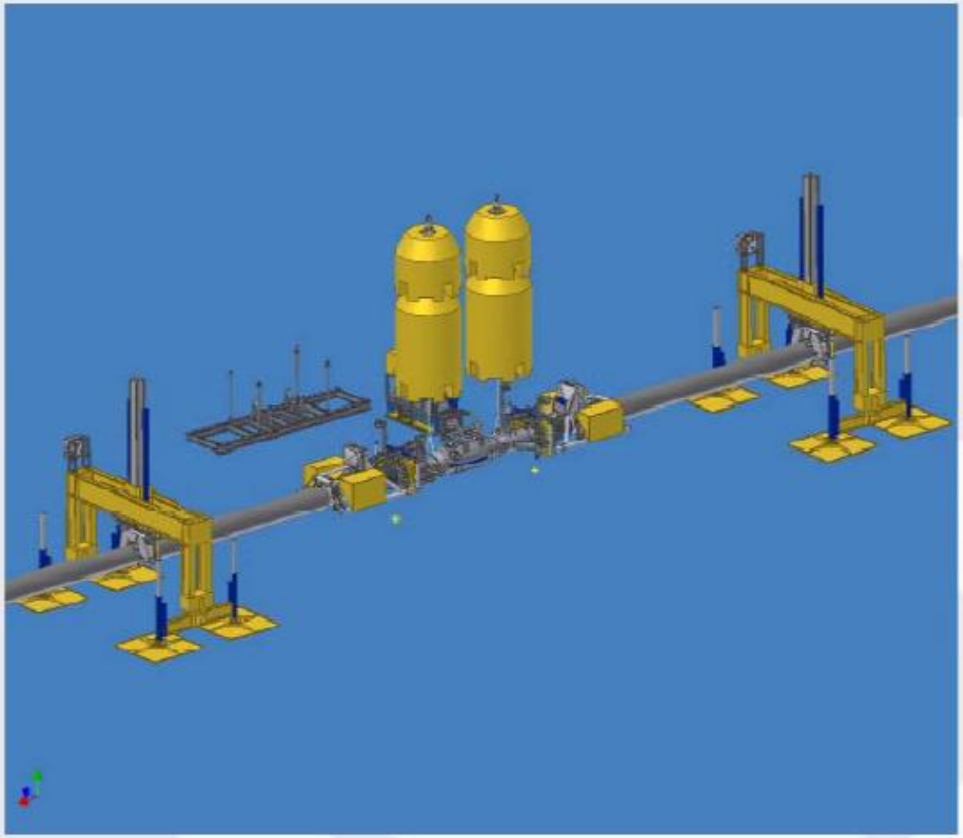

Equipment Capability
Oman Shelf
Oman Continental Slope
Indian Shelf
India Continental Slope
Indus Fan
Abyssal Plain
ENI/Sonsub
Oceaneering
AGR
Rotech
CTC
SMD
Saipem
Boskalis
Van Oord
Jan de Nul
Tideway
Contractor
ENI/Sonsub SIRCOS (Upgrade Required)
ENI/Sonsub SIRCOS (Current)
Oceaneering Pipeline Repair System (Upgrade Required)
Oceaneering Pipeline Repair System (Current)
AGR ClayCutter X (Upgrade Required)
AGR ClayCutter X (Current)
Rotech T4000 (Upgrade Required)
Rotech T4000 (Current)
CTC Ploughs (Current)
SMD Trenchers / Ploughs (Current)
Saipem Beluga (Upgrade Required)
Saipem Beluga (Current)
Boskalis Has a Patented System can Operate Deeper Than 2000m (Awaiting Further Details)
New Vessel will be Completed 2011
Stornes (Upgrade Planned End 2011)
Stornes (Current)
Simon Stevin (Current)
Flintstone (Modification Required)
Flintstone (Upgrade Required)
Flintstone (Current)
Pipeline Repair System
Mass Flow Excavation Tool
Trencher / Plough
Rock Dumping (Fall Pipe) Vessel
0
500
1000
1500
2000
2500
3000
3500
4000
Water Depth (m)
Modification Required
Upgrade Planned/Required
Current Capability

Repair Systems and Clubs

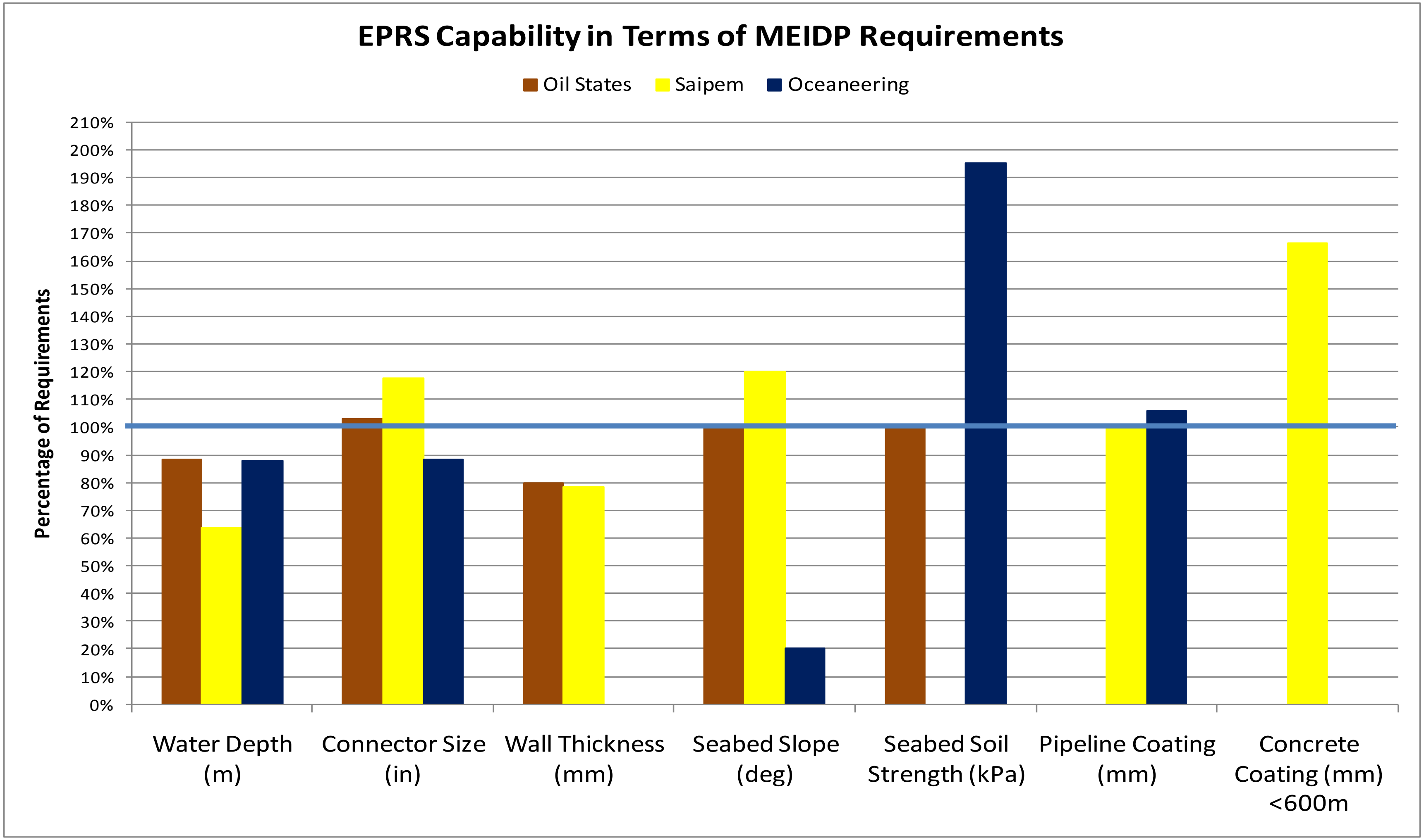
Equipment Name	Main Contractor / Operator
Bespoke Systems	
Chevron Petronius Repair System	**Oil States / Chevron**
BP Mardi Gras Pipeline Repair System	Oil States / BP
SiRCoS	**Saipem**
Pipeline Connection and Repair Systems (PCRS)	**Oceaneering**
Total Girassol Pipeline Repair System	Subsea 7
Repair Clubs	
Shell Deepwater Pipeline Repair System	Shell HOLD (there are two version of the Shell club?)
DW RUPE	DW RUPE
Pipeline Repair System Pool	Technip (Norway), Deep Ocean, Statoil
Newly Founded Repair Clubs	
Emergency Pipeline Repair Equipment Sharing (EPRES)	South East Asia Pipeline Operators Group (SEAPOG)
	Pipeline Repair Operators Forum Australasia (PROFA)

Diverless Sealine Repair System SIRCOS

- SiRCoS is a pipeline repair system developed for deepwater application
- meeting requirements of TransMed (Tunisia – Sicily), Green Stream (Libya – Sicily), Blue Stream (across Black Sea)
- suited to pipeline size ranging from 20" to 32" in water depths up to 2200 m
- SiRCoS is available under a Service Contract Agreement



Emergency Repair Systems
Candidate Systems Capability

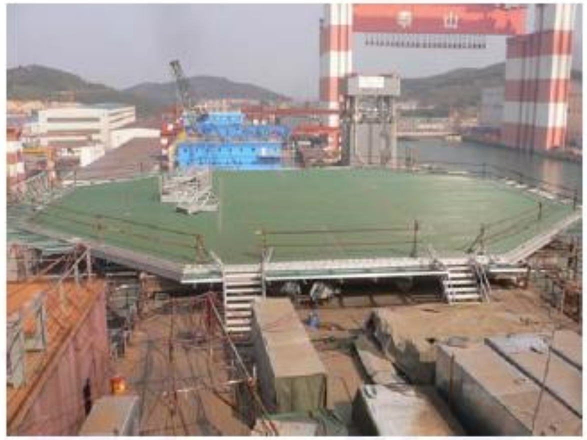


Castorone construction
update/completion schedule ?

CastorOne Progress

CastorOne Progress

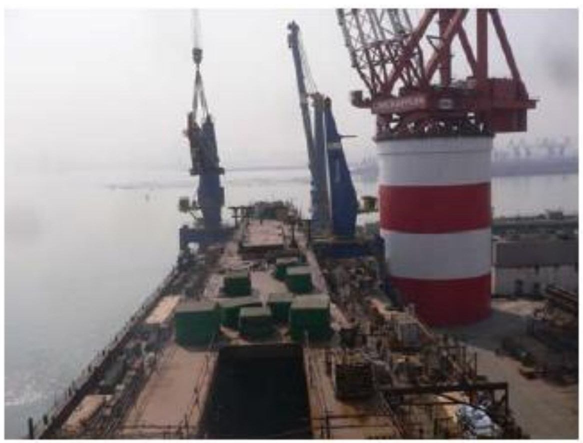
Castorne at quayside



Helideck

DPBridge

Intervention & Repair Assessment



Boom's Gantry Cranes inst

Thrusters Inst. in d-d

CastorOne Progress

- In May 2011 EIL, GAIL and SAGE Visited the CastorOne in Singapore after its recent arrival from China
- In November 2011 a GAIL Team led by Mr. B.C. Tripathi, CMD, GAIL, visited the vessel In Singapore
- In April 2012 SAGE will visit the vessel just before it leaves Singapore for Seatrials

Thank You

Questions ?