

Subsea Umbilical Systems

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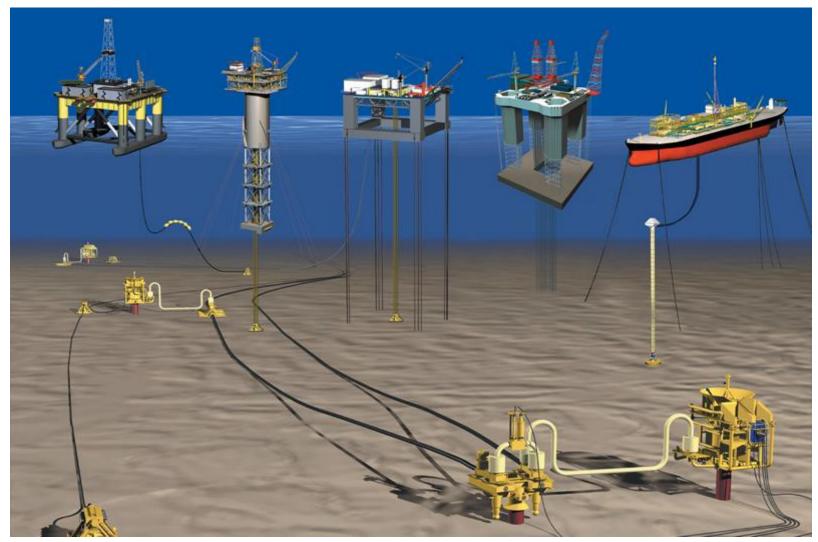


Steve Johnson, my background

- 40+ years subsea oil & gas experience
- North Sea, West Africa, Mediterranean, Eastern Canada, South America, S E Asia, GoM, Australia, Barents Sea
- Design, PM, construction, installation
- Worked for various engineering/ PM companies as well as equipment supply companies
- 15 years with Chevron, retiring today
- SUT member for some 35 years
- Will also be presenting Operator Perspectives later this afternoon



SUBSEA UMBILICAL SYSTEMS



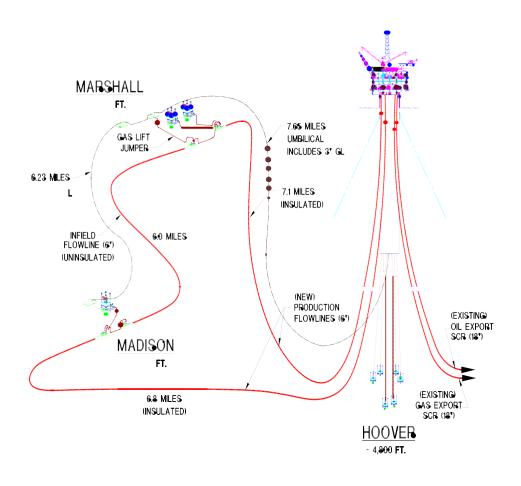


AGENDA

- What Is an Umbilical and What Does It Do
- Subsea Terminations and Flying Leads
- Design Process
- Manufacturing
- Loadout, Transportation, Installation
- Contracting Strategies
- Questions

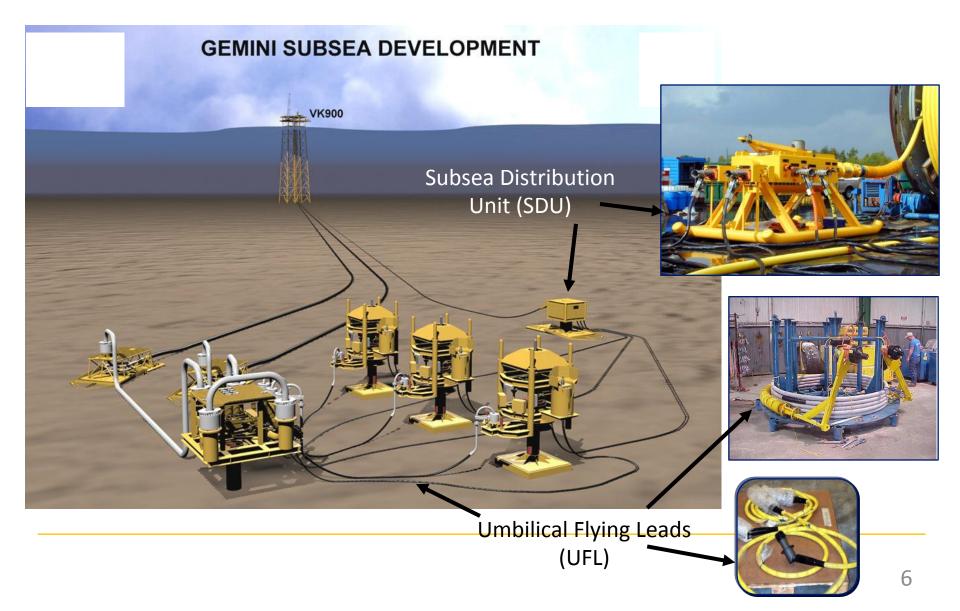


UMBILICALS – BUNDLE OF TUBES AND CABLES



- Provide hydraulic power to subsea control systems
- Provide electrical power and signals to subsea control systems
- Deliver chemicals for subsea injection at manifold, tree or downhole
- Provide bulk Methanol, (ISU)
- Deliver gas for gas lift (ISU)





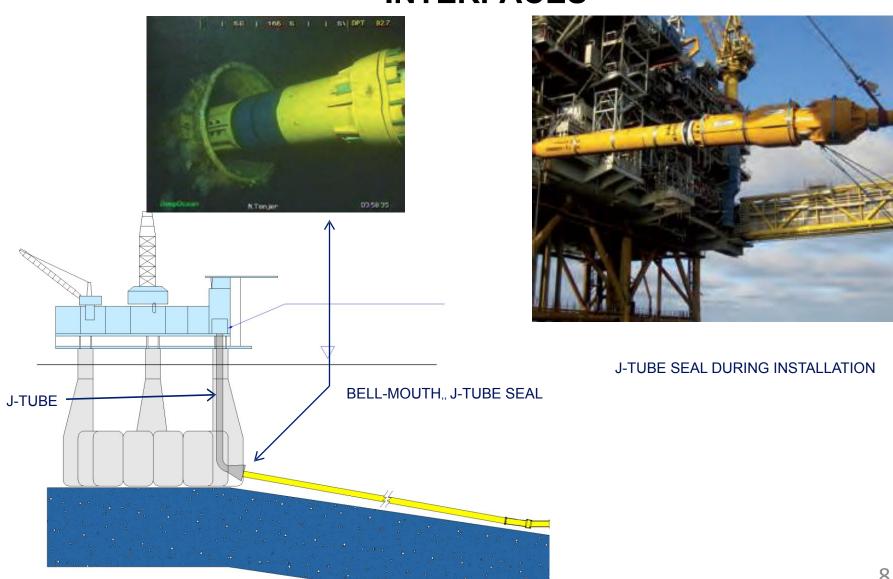


STATIC E/H UMBILICAL FOR SMALL FIELD

APPLICATION: STATIC APPROXIMATE UMBILICAL LENGTH $OD = 61.9 \text{ mm } \pm 3 \text{ mm } [2.4" \pm 0.12"]$ 6,096 m (20,000 ft) => 3.79 miles (2) 12.70mm [0.500"] ID Super Duplex Tubes wt = 1.50mm [0.059] - 10,000 psi WP 0D = 15.70mm [0.618]4.10mm [0.161"] Yellow HDPE (1) 2.80mm [0.110"] HDPE Coating (Black) Outer Sheath OD = 21.30 mm [0.839]Fiber Reinforced Tape 120% Coverage HDPE Filler (Black) -HDPE Filler (Yellow) 6 (6) 9.53mm [0.375"] ID Super Duplex Tubes wt = 1.20mm [0.047"] - 10,000 psi WPOD = 11.93 mm [0.470](2) 4mm² Quads, 0D = 15.80mm [0.622](A = Power)(B = Communication) 6 HDPE Filler (Black)

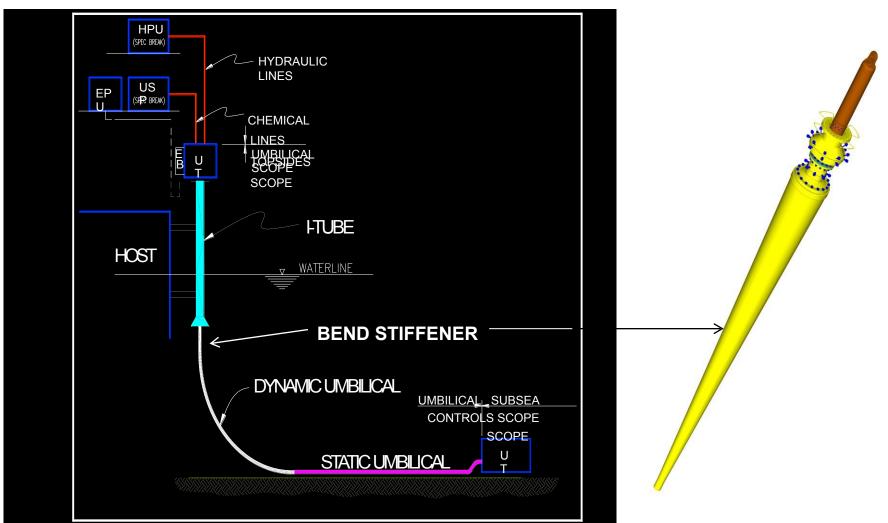


STATIC UMBILICAL, FIXED PLATFORM **INTERFACES**





DYNAMIC UMBILICAL INTERFACE DIAGRAM & BEND STIFFENER





UMBILICAL TUBE MATERIALS

- Thermoplastic Tubes
 - Low tensile strength & better flexibility
 - Shallow water
 - Lower cost
- Steel Tube
 - Higher tensile strength & reduced flexibility
 - Deeper water
 - Higher pressure
 - Materials
 - Super Duplex Stainless Steel
 - Zinc coated Nitronic 19D lean duplex stainless steel
 - 3-layer fusion-bonded-epoxy-coated coiled tubing
 - Stainless Steel 316L



THERMOPLASTIC UMBILICAL

- Kevlar-armored thermoplastic hoses
- High collapse resistance (HCR) hoses
- Can include cables
- Oscillating construction
 no helix assembly
 machine required
- HDPE outer sheath
- Armored for on-bottom stability, tensile and crushing strength

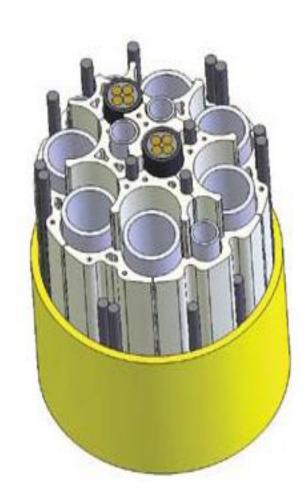




TYPICAL DEEPWATER STEEL TUBE ELECTRO-HYDRAULIC UMBILICAL



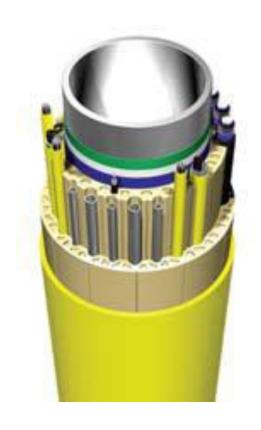
- Chemical Injection tubes
- Hydraulic supply tubes
- Electrical signal cables
- Electrical Power cables
- Fiber optic signal





INTEGRATED SERVICE UMBILICALS (ISU)

 Includes large, central tube as a service line







HIGH VOLTAGE HYBRID UMBILICALS

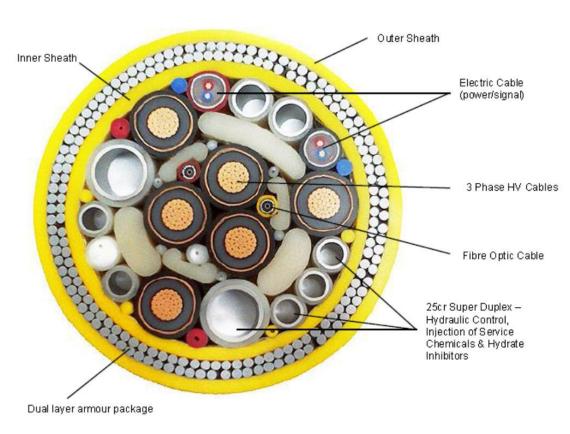
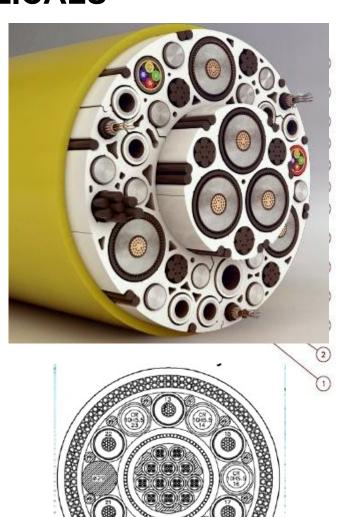
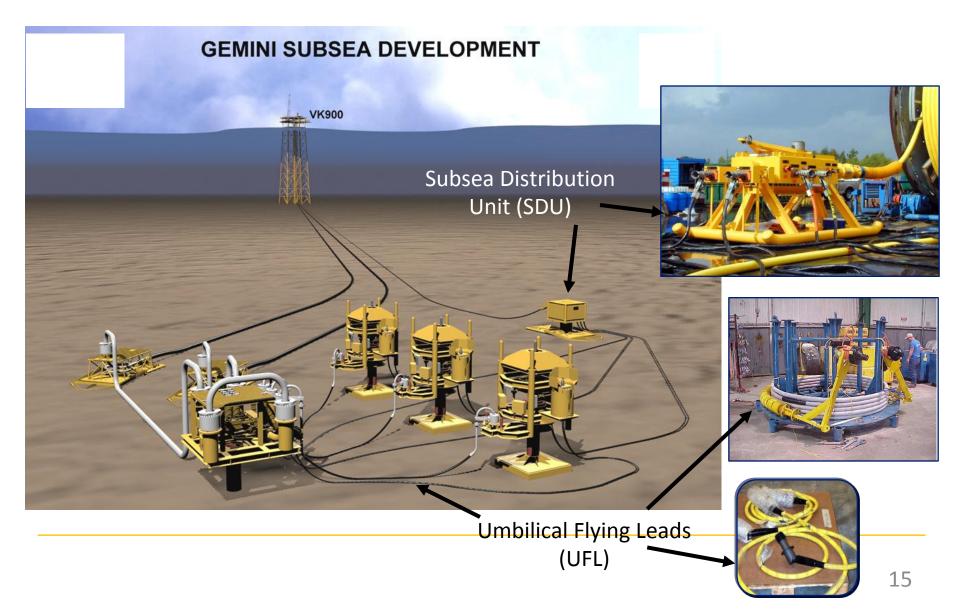


Figure 3 - Umbilical Cross Section Example



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SUBSEA DISTRIBUTION UNIT (SDU)

- Electrical/fiber optic wetmateable connectors
- Hydraulic/chemical junction plates
- Bend restrictor
- Mud mat







FLYING LEADS



 Thermoplastic or steel tubed, with electrical cables

Connects Umbilical
 Termination Assembly to subsea tree/control pod

Installed after umbilical

Connected by ROV

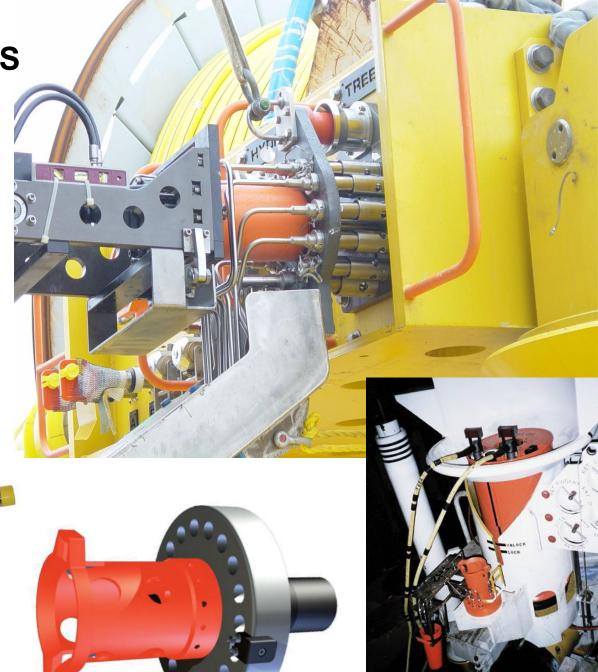




FLYING LEADS

- Flying Lead Orientation Tool (FLOT)
- API 17D ROV bucket standard ROV interface
- Junction plate
- Hydraulic couplers
- Cobra head adaptor
- Electrical, Fiber Optic
 wet-mateable connectors







DYNAMIC UMBILICAL - CONCERNS

- Cross Section
- Fatigue
 - Vessel motions
 - Currents
 - Vortex Induced Vibration
- Clashing with other risers
- Hangoff weight
- Tensile strength



DYNAMIC UMBILICAL DESIGN PROCESS

⊯mbilical Section Engineering Static Configuration Dynamic Analyses Verification Acceptance **Bend Stiffener Design** Interference **Fatigue** Analyses **Analyses** Acceptance Acceptance Bend Stiffener Fatigue Check Acceptance

<u>Input</u>

- •Restrictions on weight diameter ratio (if any)
- •Component fatigue testing to be evaluated
- Umbilical sectional properties
- Water depth
- Static offset
- •Restrictions on hang-off angle
- •Restrictions on touch-down area
- •RAOs (critical)
- •Umbilical hang-off location
- Azimuth angle
- Metocean data (waves / current)
- •Top tension / top angle
- Ambient temperature
- •Length diameter restrictions due to handling,
- •load out, installation or other
- •Bending stiffener design
- •Riser data
- Anchor data
- Positions of other installations
- Long term distribution of environmental loads
- SN-curves

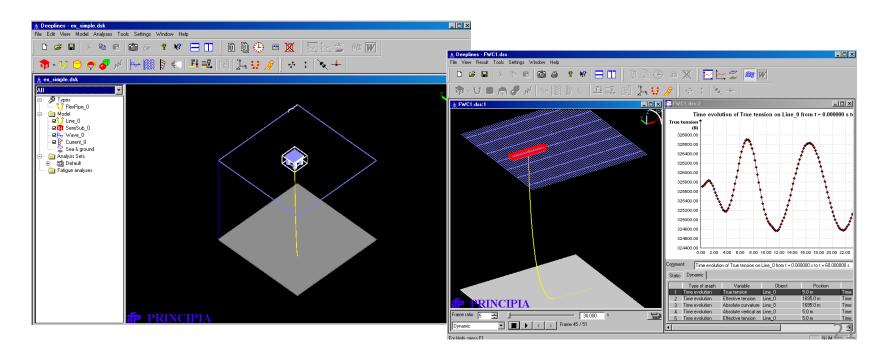
Output and acceptance criteria

- Sectional properties
- •Type of configuration (catenary / lazy wave etc.)
- ·Hang-off angle
- Touch down point
- Required buoyancy
- •Clearance to seabed
- •von Mises equivalent stress
- Longitudinal tension / compression
- •Top tension / top angle
- Maximum umbilical curvature
- •Bending stiffener geometry
- Stiffness
- •Interference with other installations
- •Umbilical fatigue life
- •Top tension / top angle and probability of these for fatigue check of Bending Stiffener



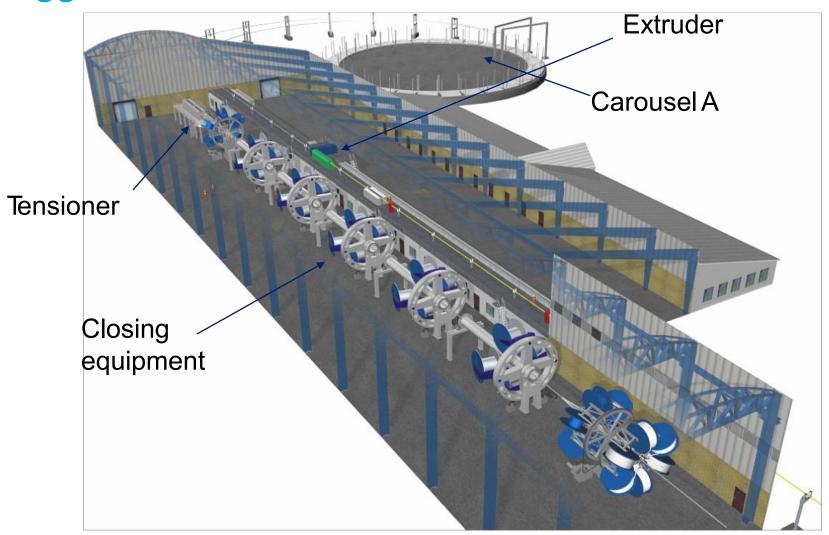
DYNAMIC UMBILICAL DESIGN PROCESS

- Dynamic analysis software (e.g. Orcaflex) analyse the dynamic stability of the umbilical configuration with respect to:
 - Vessels Response Amplitude Operators
 - Environmental Loading Data
 - Umbilical Design Data





MANUFACTURING





STEEL TUBE UMBILICALS

Helically wound

Requires counter-rotating bobbins to remove torsion from tubes





ARMORING MACHINE





FINISHED MANUFACTURED UMBILICAL

- Storage on reels or carousels
- Factory Integration Test (FAT)
- Termination work (applications)
- Site Integration Test (SIT)
- Preparation for loadout

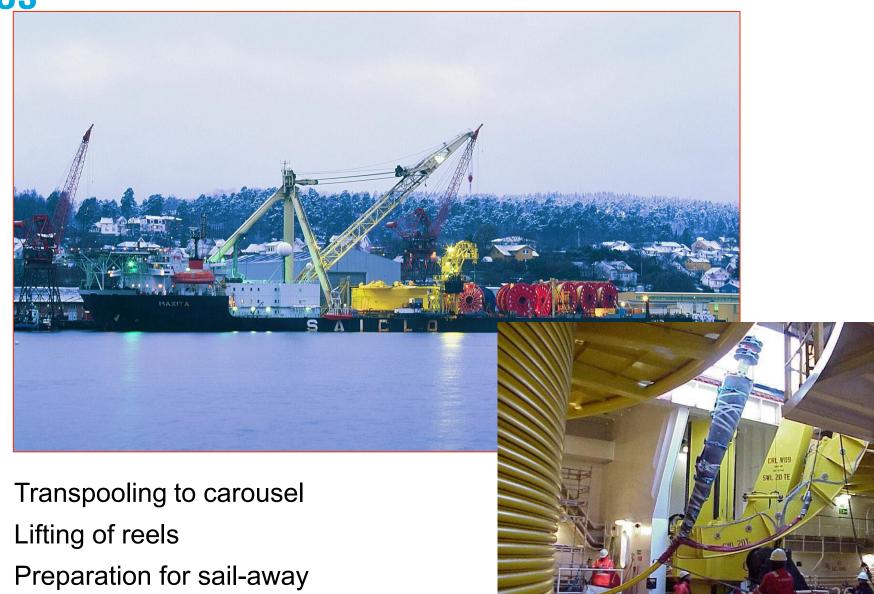






SUTI - US

QUAYSIDE STORAGE AND LOADOUT





INSTALLATION – CAROUSELS AND REELS





INSTALLATION









CONTRACTING STRATEGIES

- Umbilical Purchased by Operator
 - Common where there is much infrastructure GoM, North Sea, Brazil
 - Direct control & inspection by Operator
- Supply and Install by Installation Contractor
 - Reduced installation risk umbilical is purchased delivered, installed, and tested
 - Common in remote areas with little infrastructure
 - Popular in locations such as Nigeria and Angola
- Supply with Subsea Equipment & Installation Package
 - Full subsea EPCI Contract
 - Reduced interface risk entire equipment package delivered as a unit
 - Gaining popularity for projects worldwide



Questions

