MMS

Assessment and Analysis of Deepwater Pipeline Repair in the Gulf of Mexico

Sponsored by:

United States Department of the Interior

Minerals Management Service

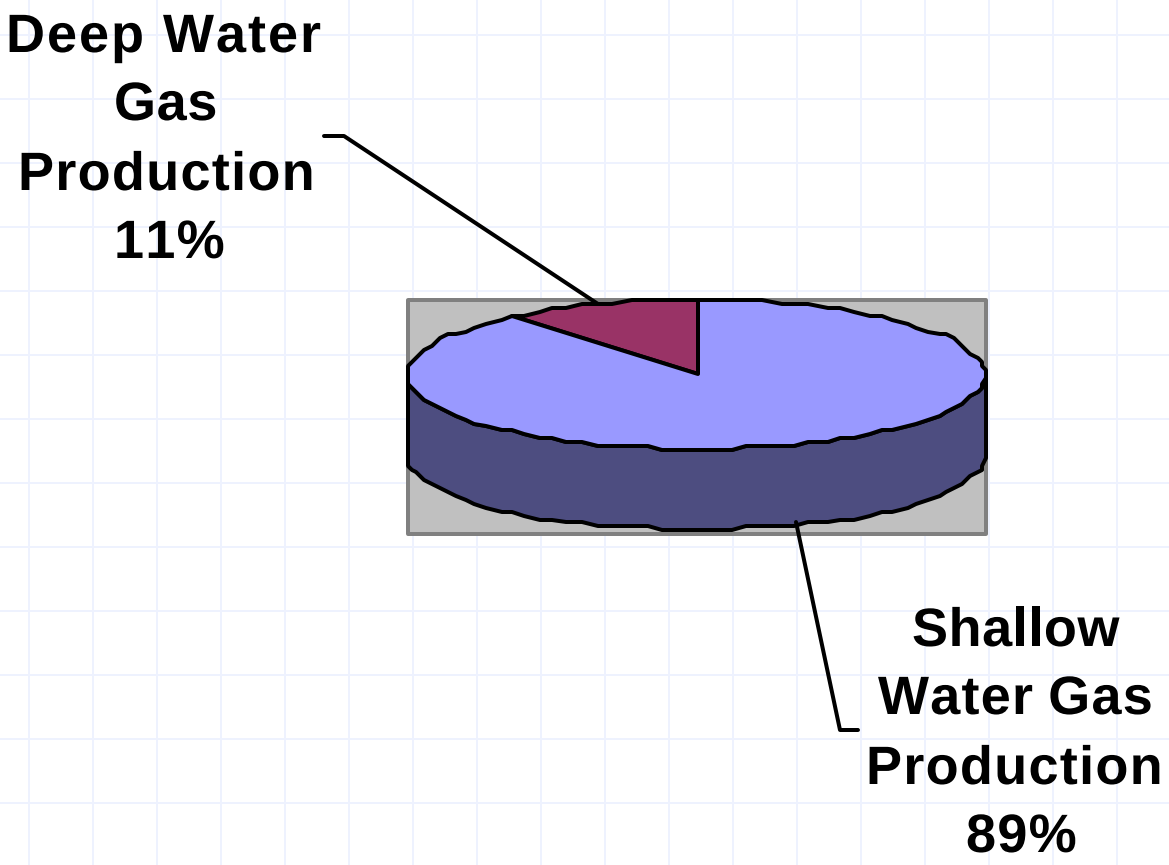
Presented by:

Project Consulting Services, Inc.

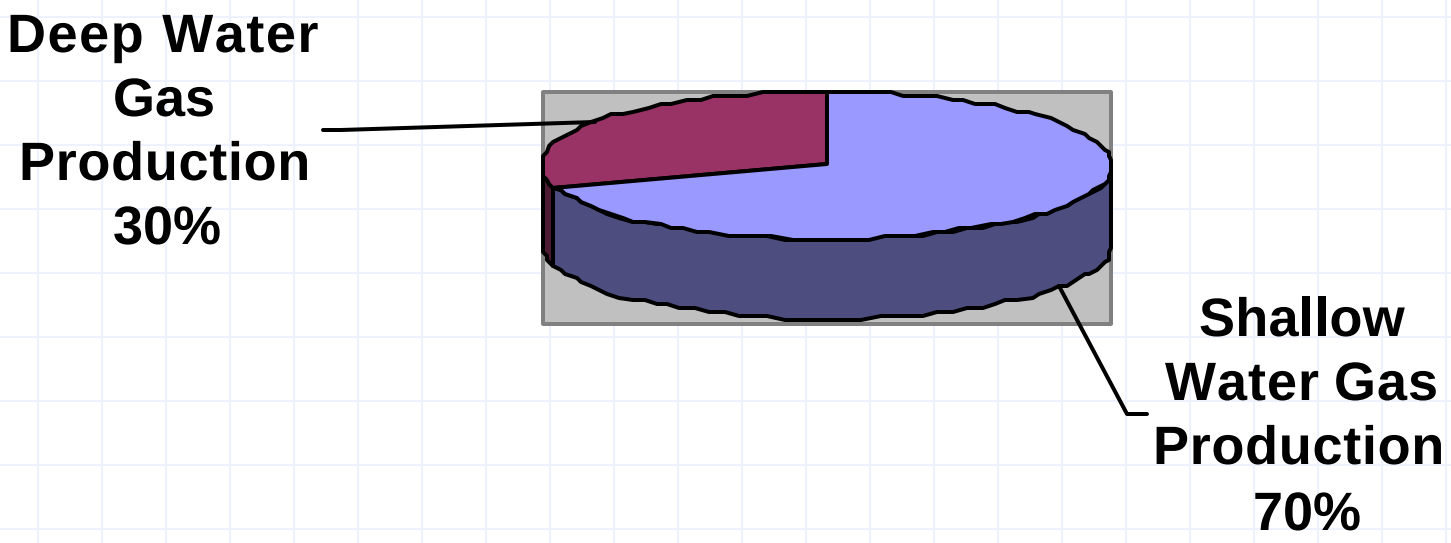
The Need for Deepwater Pipeline Repair in the Gulf of Mexico

- 5 Trillion Cubic Feet of Gas per Year
- 500 Million Barrels of Oil per Year

1998 Gulf of Mexico Gas Production

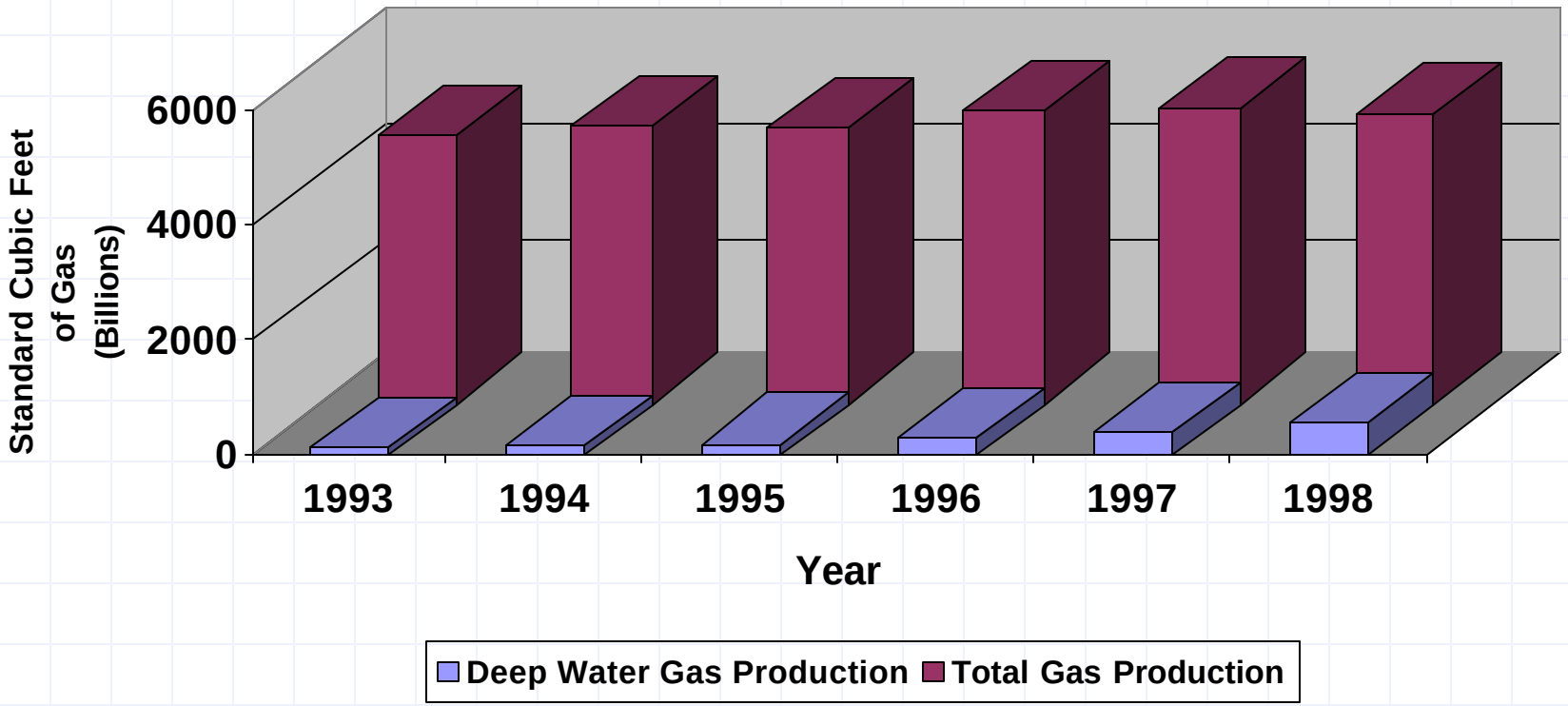


Anticipated 2000 Gulf of Mexico Gas Production

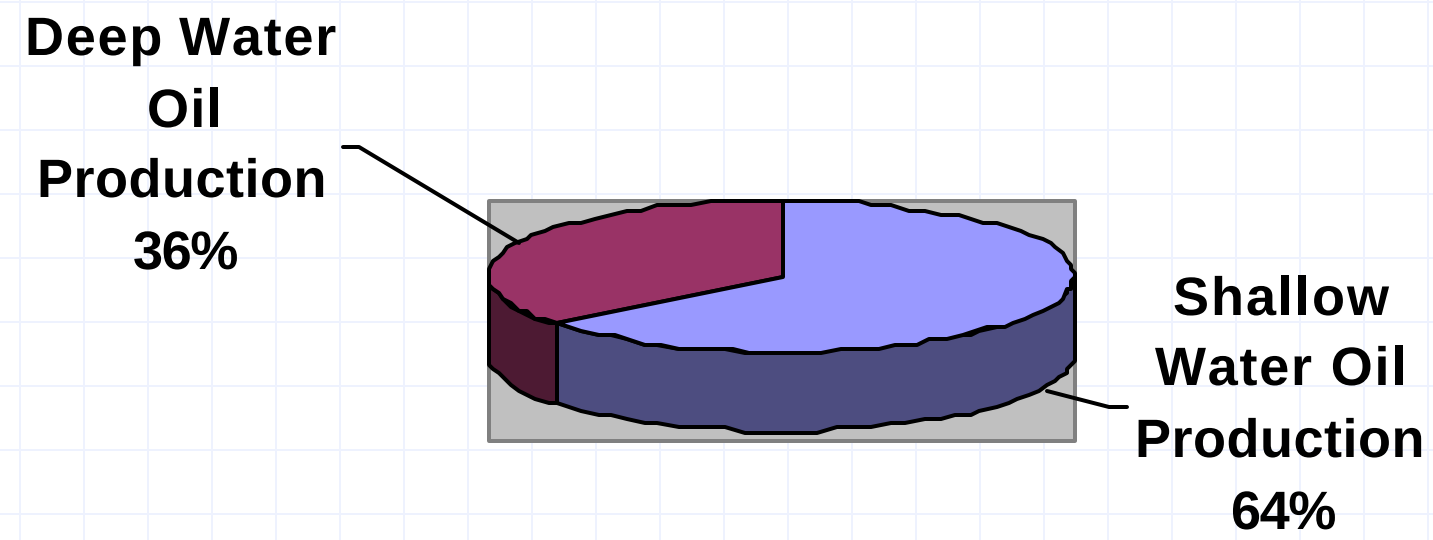


MMS

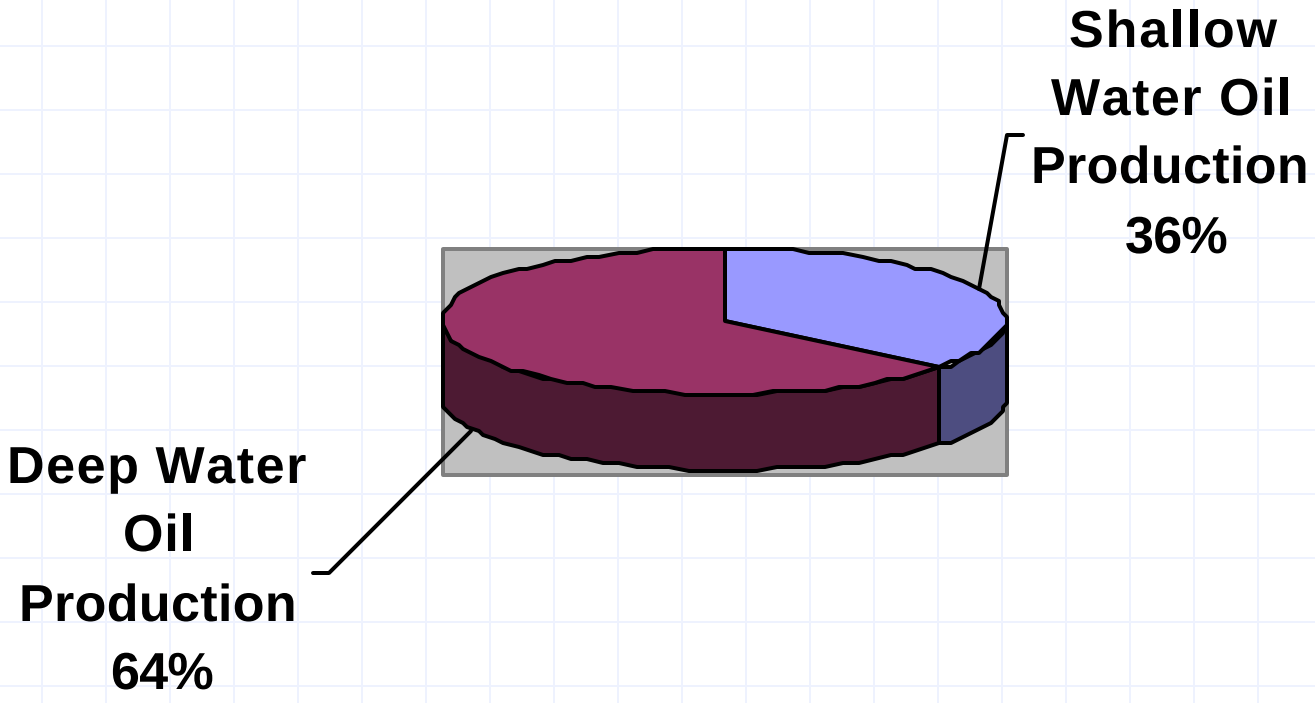
Gulf of Mexico Gas Production Trends



1998 Gulf of Mexico Oil Production

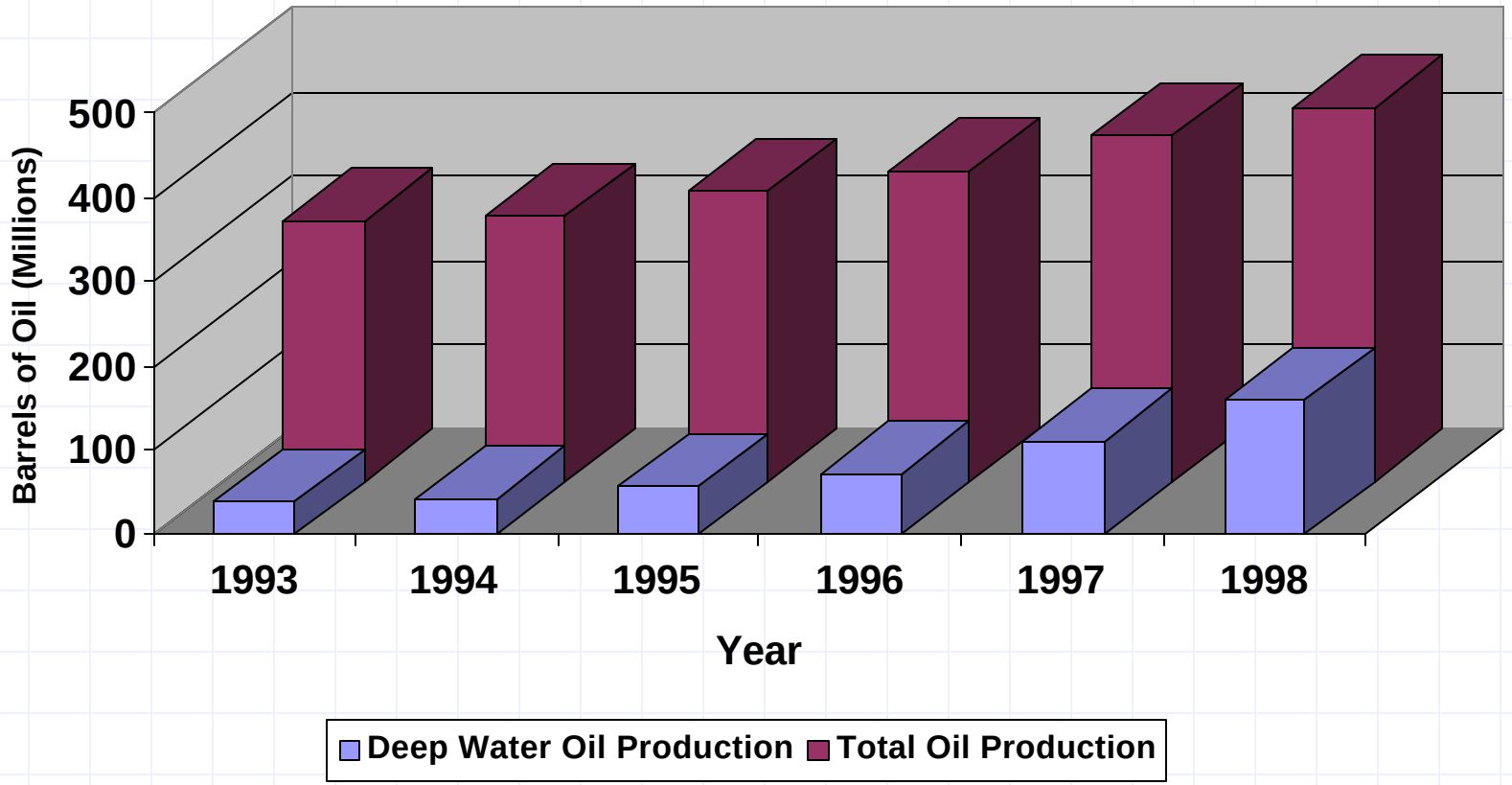


Anticipated 2000 Gulf of Mexico Oil Production



MMS

Gulf of Mexico Oil Production Trends



Deepwater Defined

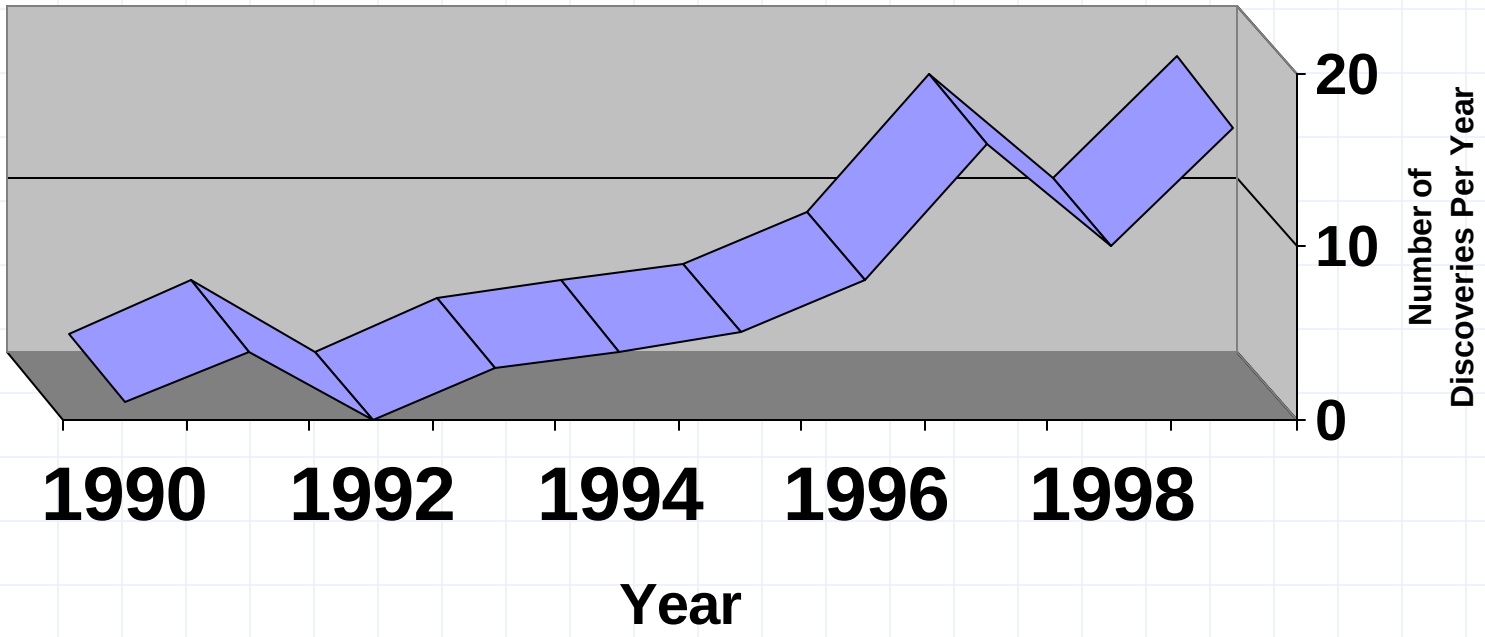
- 1000+ Feet Sea Water
- Gulf of Mexico Bottoms Out at 15,000+ Feet Sea Water

Deep Water Discoveries

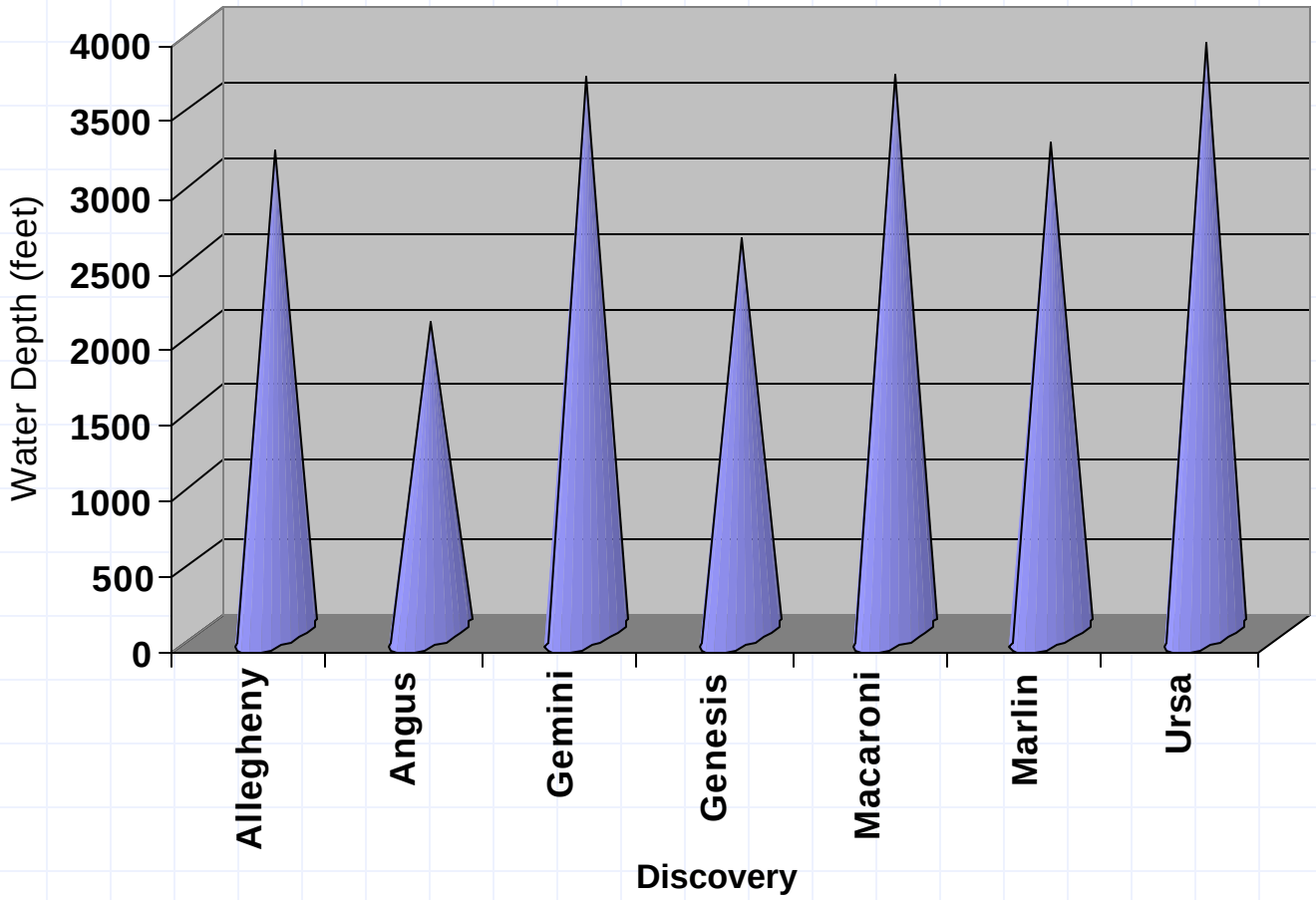
- 112 Deepwater Discoveries as of 1999
- 27 Deepwater Discoveries Producing at end of 1999
- 83 of the Current Deepwater Discoveries have Future Production Plans

MMS

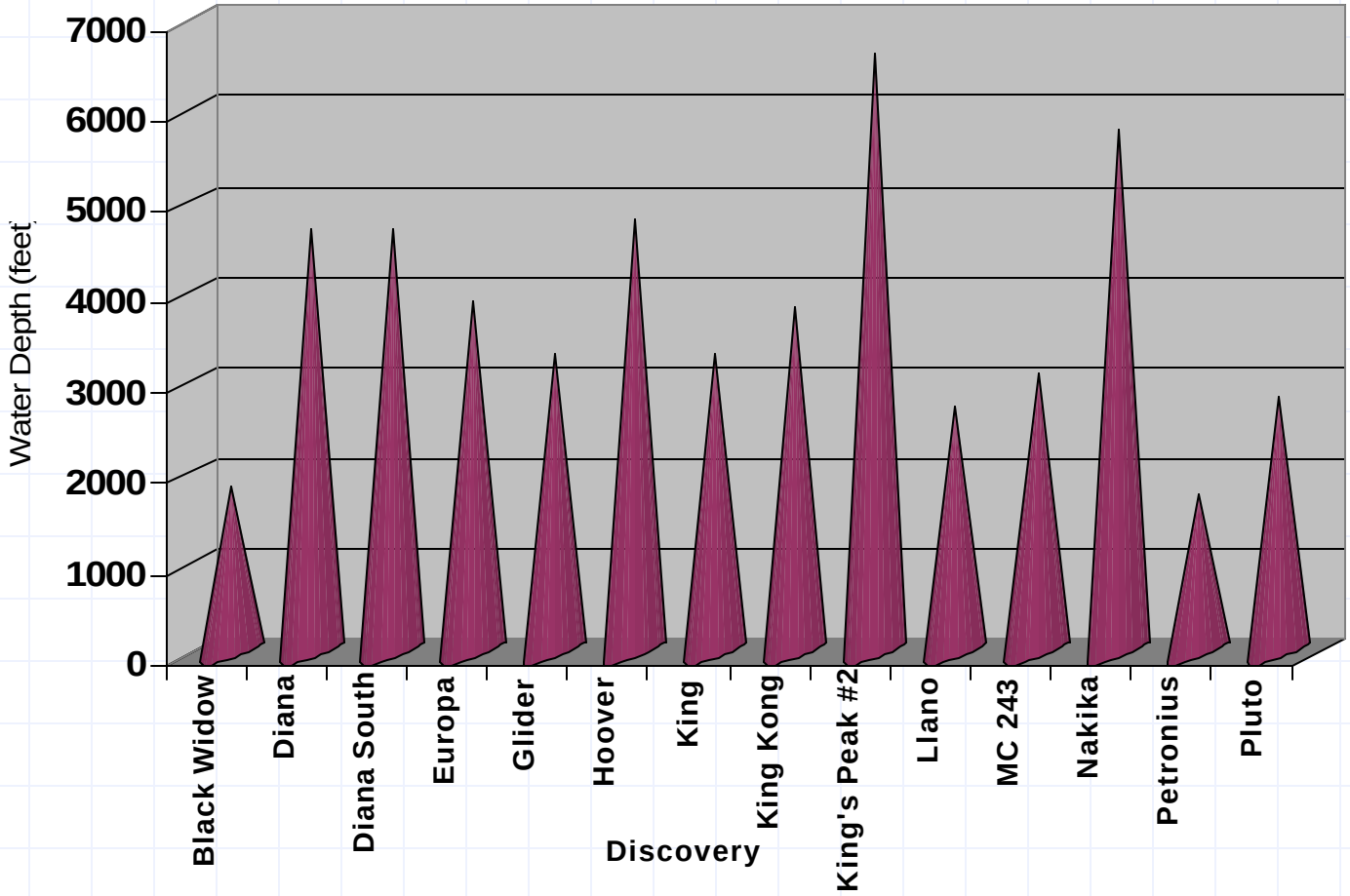
Deep Water Discovery Trend



1999 Deep Water Production Start Ups



Planned 2000 Deep Water Production Start Ups



Gulf of Mexico Transportation Methods to Bring Deepwater Production to Market

Safe

PIPELINES

Reliable

Efficient

Hazards to Subsea Pipelines

- Natural Disasters
- Operational Error
- Physical Impacts from Fishing or Oil and Gas Activities
- Construction of the Pipeline

Purpose and Need For Deepwater Pipeline Repair

- Deepwater Pipeline Repair Capabilities are Essential to Provide Confidence in the Deepwater Oil and Gas Developments and to Ensure a Reliable Supply of Production from Deepwater Producing Fields

Gulf of Mexico Consortiums

- R.U.P.E. Co-Ownership Project
  - Began in 1977 by Tennessee Gas with 11 Participants
  - Today 22 World Wide Participants

Gulf of Mexico Consortiums

- DeepStar
  - Began in 1992 by Texaco
  - Conceptual Study of the Feasibility of Extended Reach Tie-Backs 40-60 miles
  - Has Expanded to Encourage the Production of Hydrocarbons from tracks in up to 10,000+ Feet Sea Water

Challenges of Deepwater

- Saturation Diving Limited to 1,200 Feet Sea Water
- Heavy Lift Vessels Required to Recover Pipelines to Surface
- Remote Operations Essential to Success of Deepwater Pipeline Intervention

History of Deepwater Pipeline Repair

- 1973 Exxon JIP – 16 Participants
  - Repair 36” Concrete Coated Pipe in 3,000 Feet Sea Water
  - Based on Large ROVs that were Non-Existent at the Time
  - Ended 1977 with Report Only

History of Deepwater Pipeline Repair

- 1974 – Shell JIP – 6 Participants
  - Repair of 36” Concrete Coated Pipe to 3,000 Feet Sea Water
  - Proposed Subsea Catamaran Vessel
  - Ended 1977 with Report Only

History of Deepwater Pipeline Repair

- 1977 – Statoil
  - Repair of 36” Concrete Coated Pipe in 1,500 Feet Sea Water
  - Based on HydroTech Manipulating Frame to Install Connectors
  - Operated by Oceaneering WASP
  - Ended Same Year with Report Only

History of Deepwater Pipeline Repair

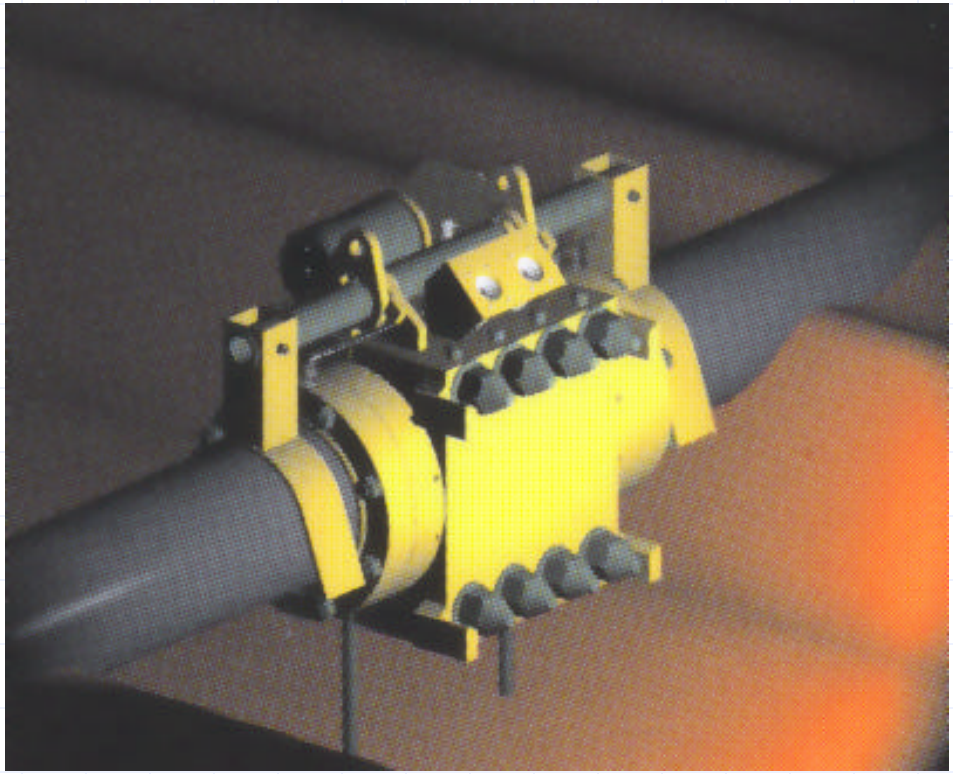
- 1981 – Gulf Oil JIP – 4 Participants
  - Repairs to 8,000 Feet Sea Water
  - System Based on Large (Non-Existent) ROVs and Existing Equipment
  - Ended 1983 with Preliminary Design Only

Deepwater Pipeline Repair Options

- Re-Lay Pipeline Or Portion of Pipeline

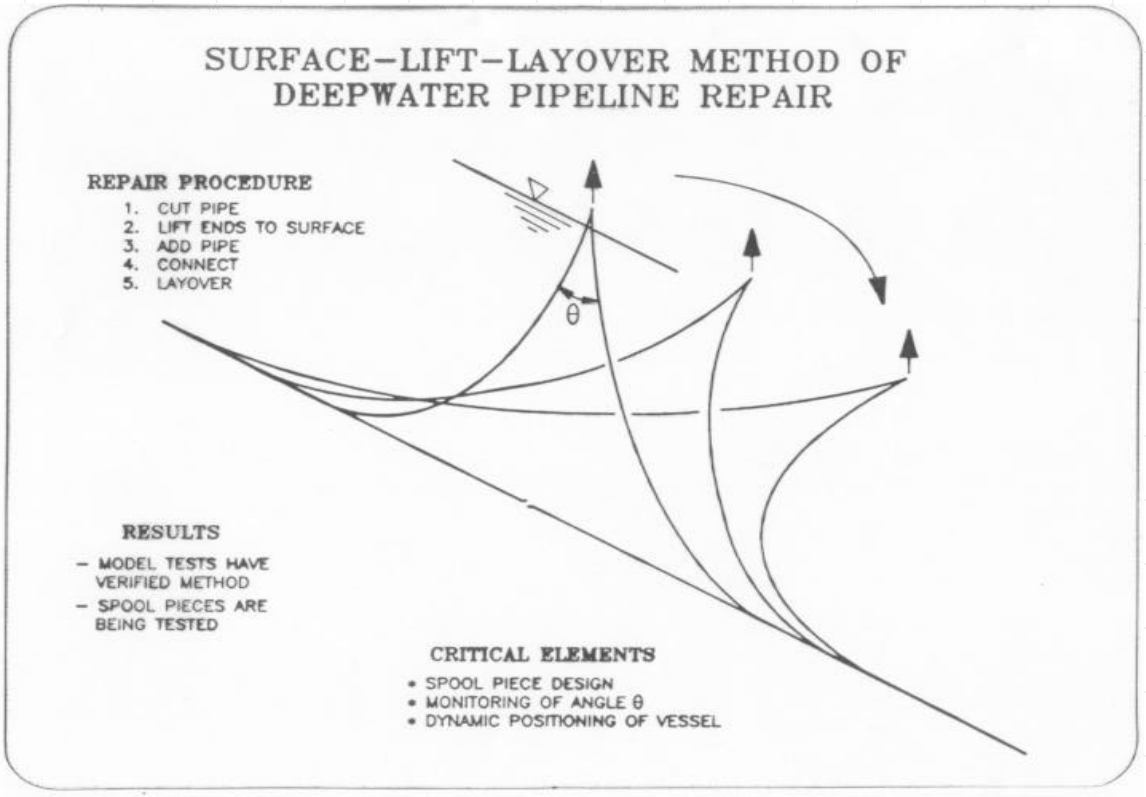
Deepwater Pipeline Repair Options

- Pipeline Repair Clamp



Deepwater Pipeline Repair Options

- Surface-Lift-Layover



The Reality of Deepwater Pipeline Repair

- A Comprehensive Pipeline Repair System Must Exist to Minimize Loss of Production
- More Complete Systems Have Been Available in Europe over the Last Decade than in the Gulf of Mexico
- Estimated Worst Case Repair Scenario for Gulf of Mexico would take 8 months

Pipeline Repair Philosophies

- European Shallow Water Tie-in and Repair Philosophy
  - On-Bottom Hyperbaric Welding
    - -Competitive in European Markets
    - -All Welded System
    - -High Strength / High Reliability
    - -Limited by Water Depth

Pipeline Repair Philosophies

- European Deepwater Pipeline Repair Philosophy
  - On-Bottom Repair As Strong As Pipeline
  - Automated Hyperbaric/Other Welding (Development)
  - Horizontal Mechanical Connections
  - Slip-On/Forged Mechanical Connectors
  - Remote On-bottom Flange Tie-Ins

Pipeline Repair Philosophies

- Gulf of Mexico Shallow Water Tie-In and Repair Philosophy
  - Surface Welding
  - Break-Over Tie-Ins
  - Flanges

Pipeline Repair Philosophies

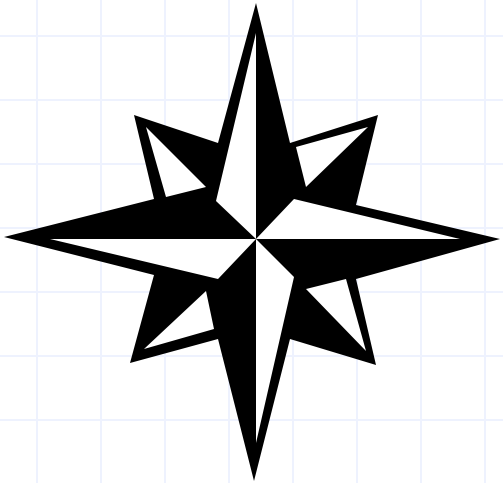
- Gulf of Mexico Deepwater Pipeline Repair Philosophy
  - Surface Welding of Mechanical Connectors
  - Vertical Connectors / U/M-Shaped Jumpers
  - Slip-on Mechanical Connectors (Remote Installation Under Development)

The Major Deepwater Pipeline Repair Systems of the World

Where Have We Been?

Where Are We Now?

Where Are We Going?



The Major Deepwater Pipeline Repair Systems of the World

- Statoil Pipeline Repair System
- Snam/Sonsub Pipeline Repair System
- Stolt MATIS Pipeline Repair System
- Shell Deepwater Pipeline Repair System
- Oceaneering Pipeline Repair System

Statoil Pipeline Repair System

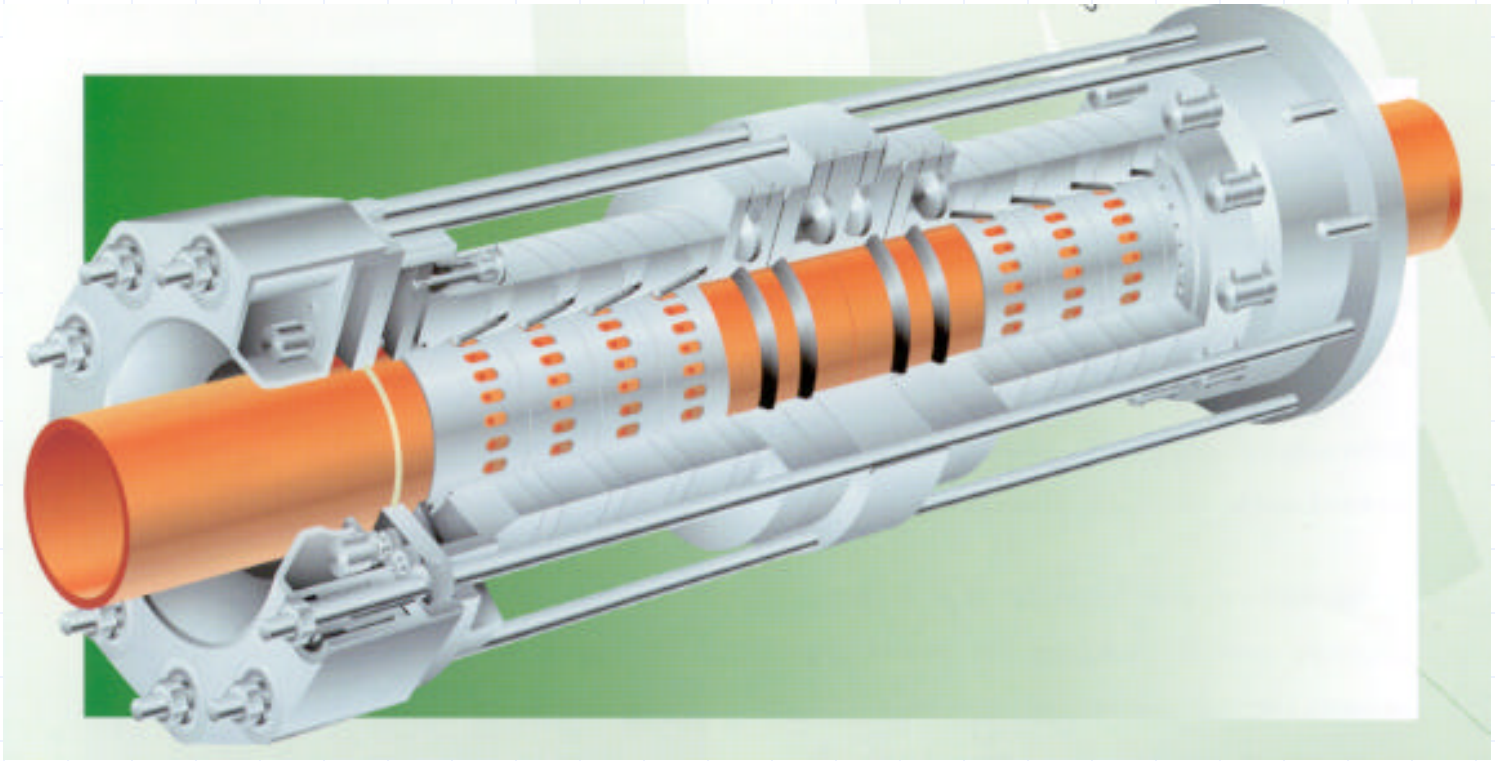
- Origins in 1987
- Covered 1000 km of Pipelines
  - Statoil's Statpipe System
  - Norske Hydro's Oseburg Transportation System
- First System Based on Hyperbaric Welding
- Water depth limitation to 1,200 Feet Sea Water

Statoil Pipeline Repair System

- 1993 Began Development of Deepwater Pipeline Repair System
- Design Criteria
  - Remote Diverless On-Bottom Repair
  - Morgrip Mechanical Connector
  - Strong As Original Pipeline
  - Design Life of 50 Years
  - 20” Pipelines or Less

Statoil Pipeline Repair System

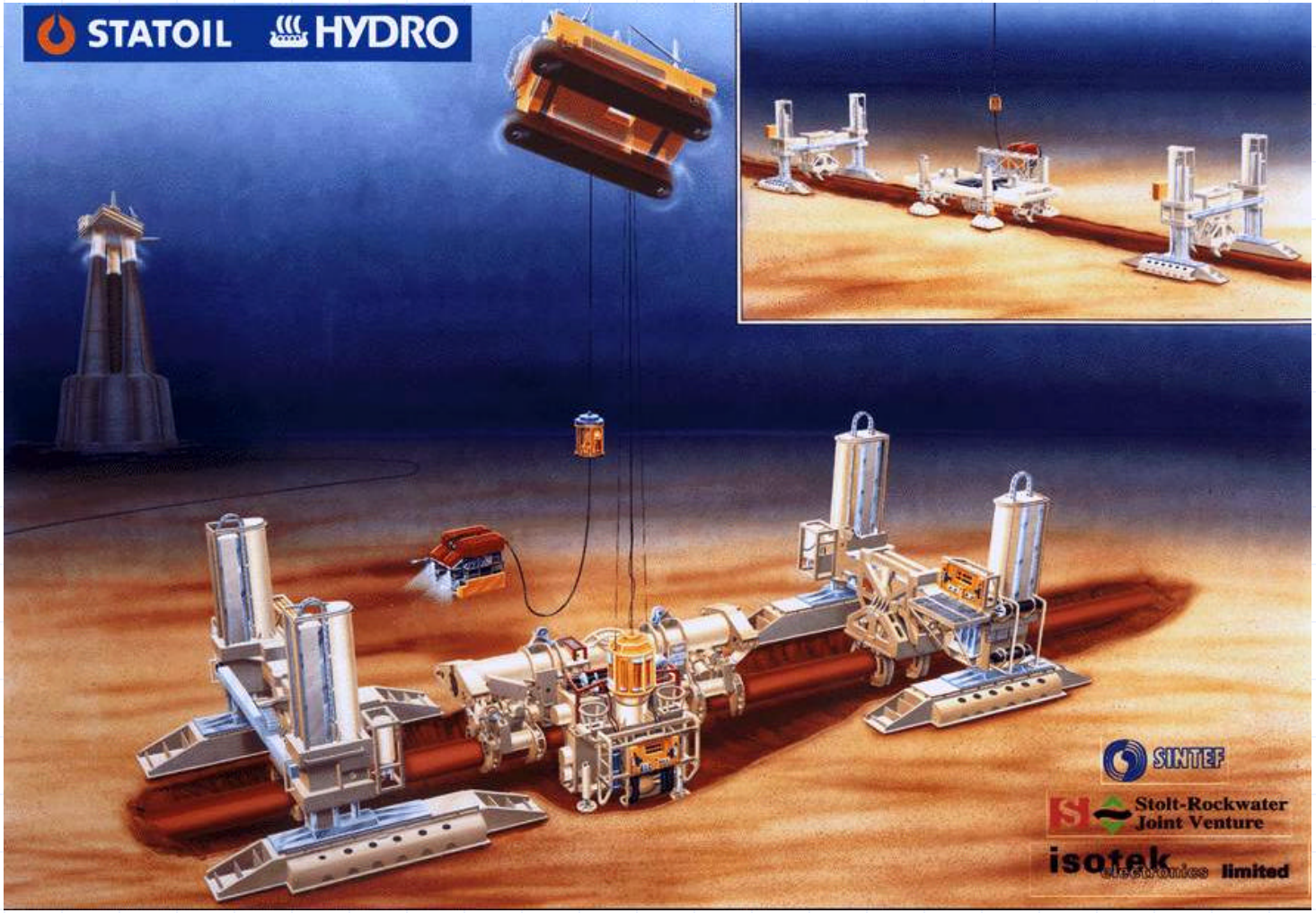
- Morgrip Mechanical Connector



Statoil Pipeline Repair System

- 1996 Haltenpipe Mid-Line Tie-In During Pipeline Construction Using Statoil PRS
- First Remote On-Bottom Tie-In Performed Using Mechanical Connectors
- 16” Pipeline in 460 Feet Sea Water

Statoil Pipeline Repair System



Statoil Pipeline Repair System

- Current Participants Include Statoil, Norske Hydro, and Phillips Petroleum Co.
- Total of 7000 km of pipeline covered
- 42” Diverless Repair System Under Development

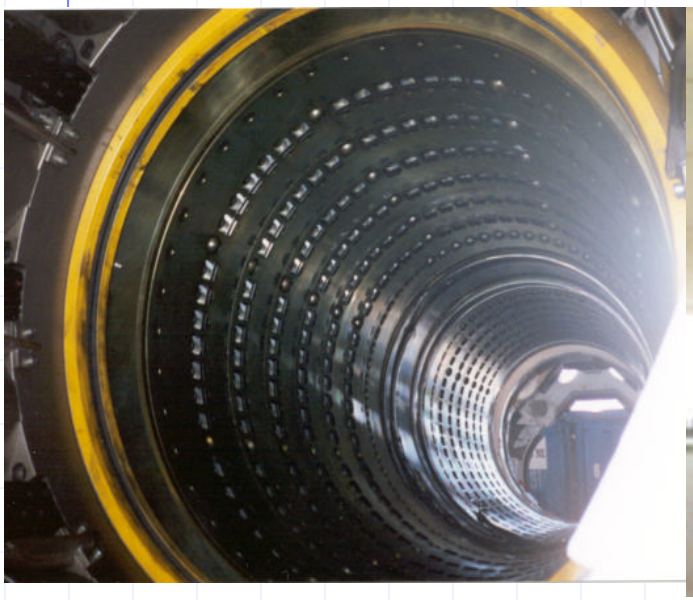
MMS

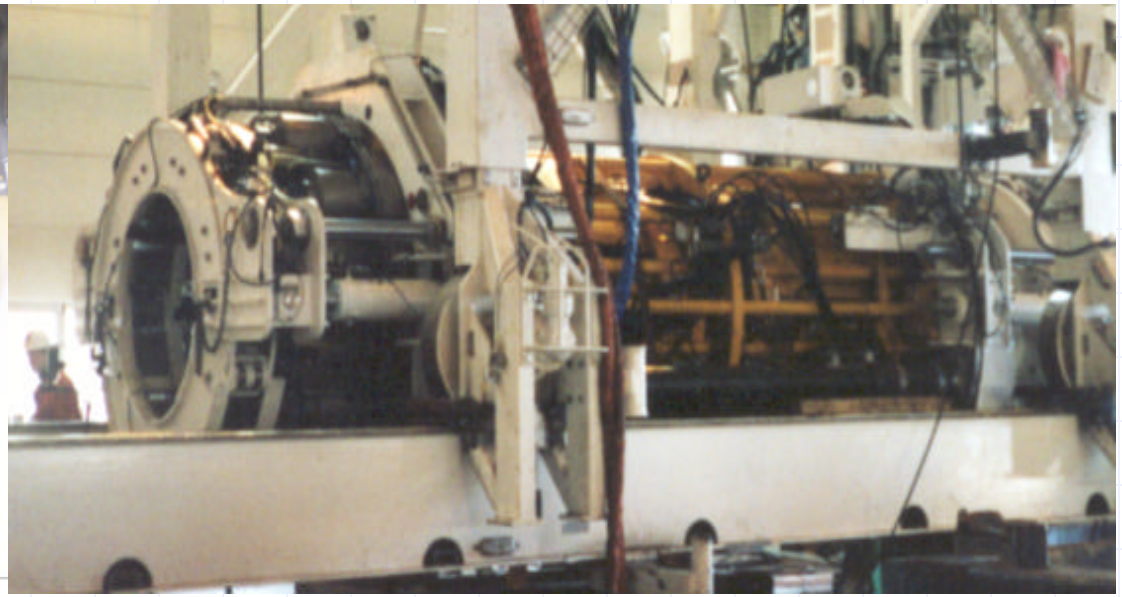
Statoil Pipeline Repair System

- Current Pipeline Systems Covered by PRS

Statoil Pipeline Repair System

- 42” Morgrip Connector





Statoil Pipeline Repair System

- Current PRS Components
  - 2 Hyperbaric Welding Habitats
  - 6 Pairs of H-Frames
  - 2 Morgrip Installation Modules
  - One High Pressure Abrasive water jet system used for pipe cutting, concrete removal, and corrosion coating removal

Statoil Pipeline Repair System

- Limitations for Gulf of Mexico Applications
  - Large and Heavy System Requires Large Heavy Lift Vessel to Deploy
  - All equipment is located in the North Sea Area

Statoil Pipeline Repair System

- Large 70 Ton H-Frame Can Handle Up to 48” Concrete Coated Pipe

Snam / Sonsub Deepwater Pipeline Repair System

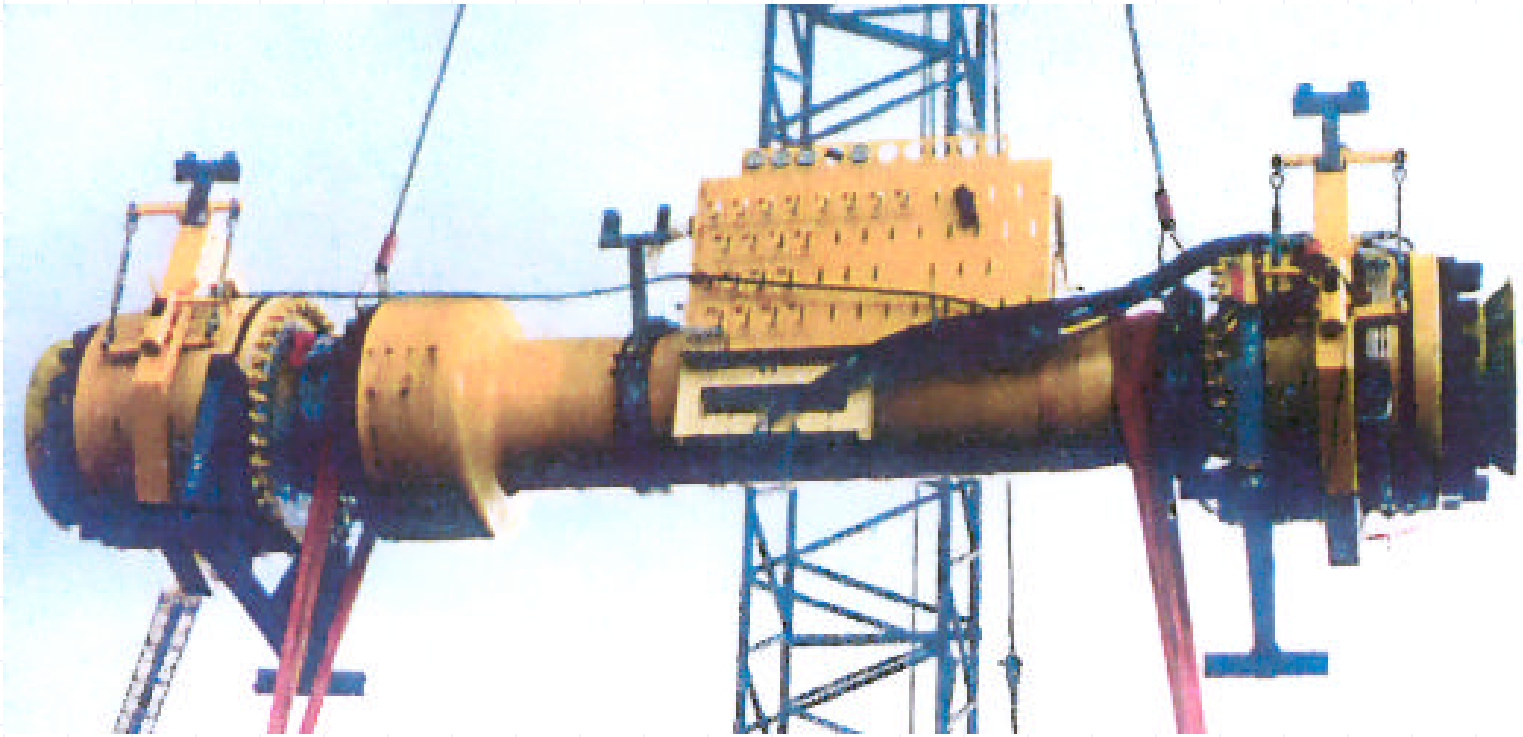
- Origins in late 1970's by Sonsub
- Snam Trans-Mediterranean Pipelines
- 2000 Feet Sea Water Max. Depth
- Pre-Dated "Work Class" ROVs
- Used 14 Autonomous Modules
- Diameter Specific to the 20" Pipelines

Snam / Sonsub Deepwater Pipeline Repair System

- 1993–Sonsub AROWS
- Revolutionary Repair Philosophy
- 20” and 26” Trans-Med Pipelines
- Based on Work Class ROVs
- Simpler ROV Operated Tools
- System Designed around the X-Loc Connector

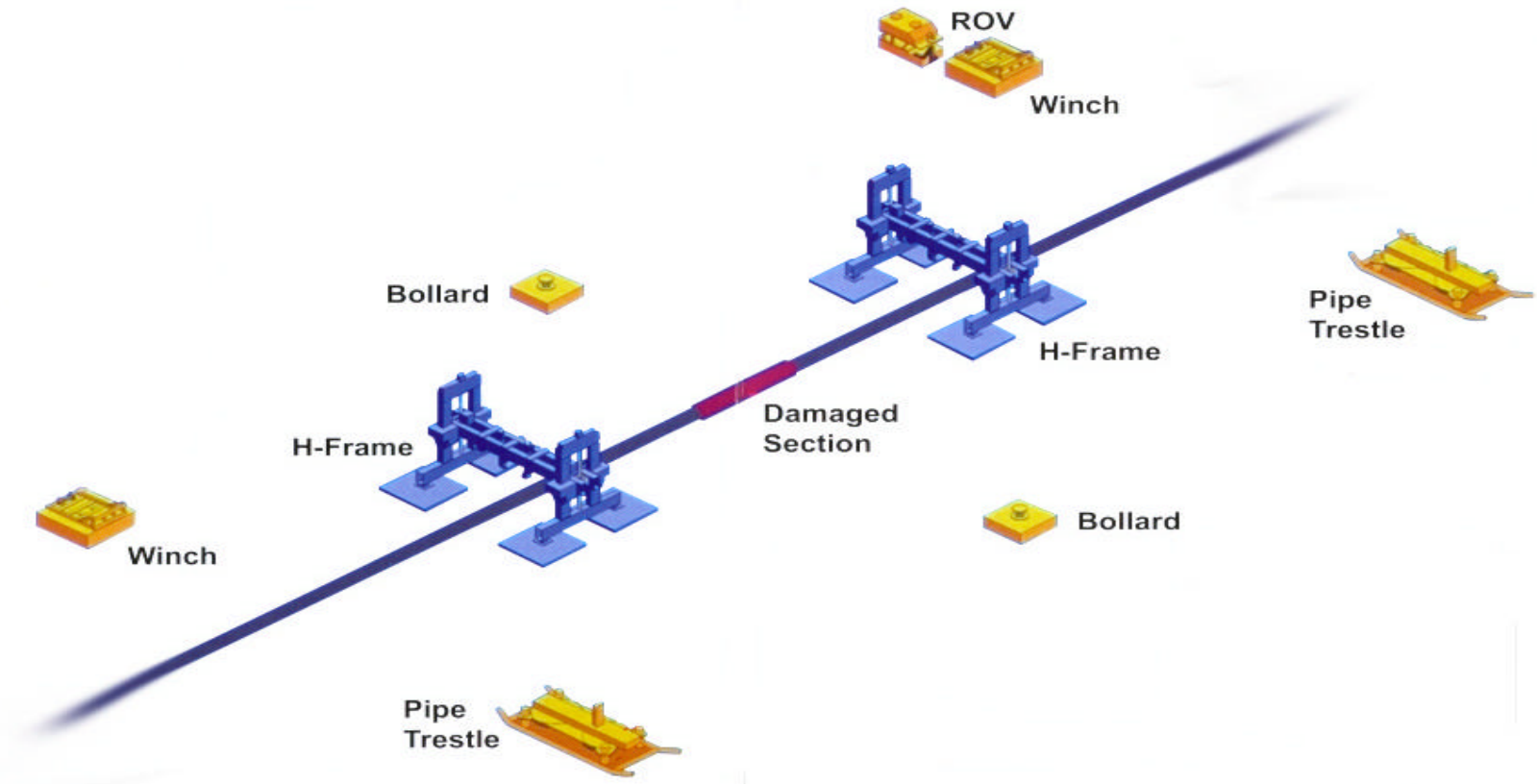
Snam / Sonsub Deepwater Pipeline Repair System

- X-Loc Telescoping Spool Piece



Snam / Sonsub Deepwater Pipeline Repair System

- 1995 Sonsub Diverless Sealine Repair System (D.S.R.S.)



Snam / Sonsub Deepwater Pipeline Repair System

- Pipeline Handling H-Frame

Snam / Sonsub Deepwater Pipeline Repair System

- 1998 – D.S.R.S./A.R.CO.S.
- Combined New Snam Cold Forging / Collet Connection System with Sonsub D.S.R.S.
- The Latest Stand-By System for the 20”/26” Trans-Mediterranean Pipelines

Snam / Sonsub Deepwater Pipeline Repair System

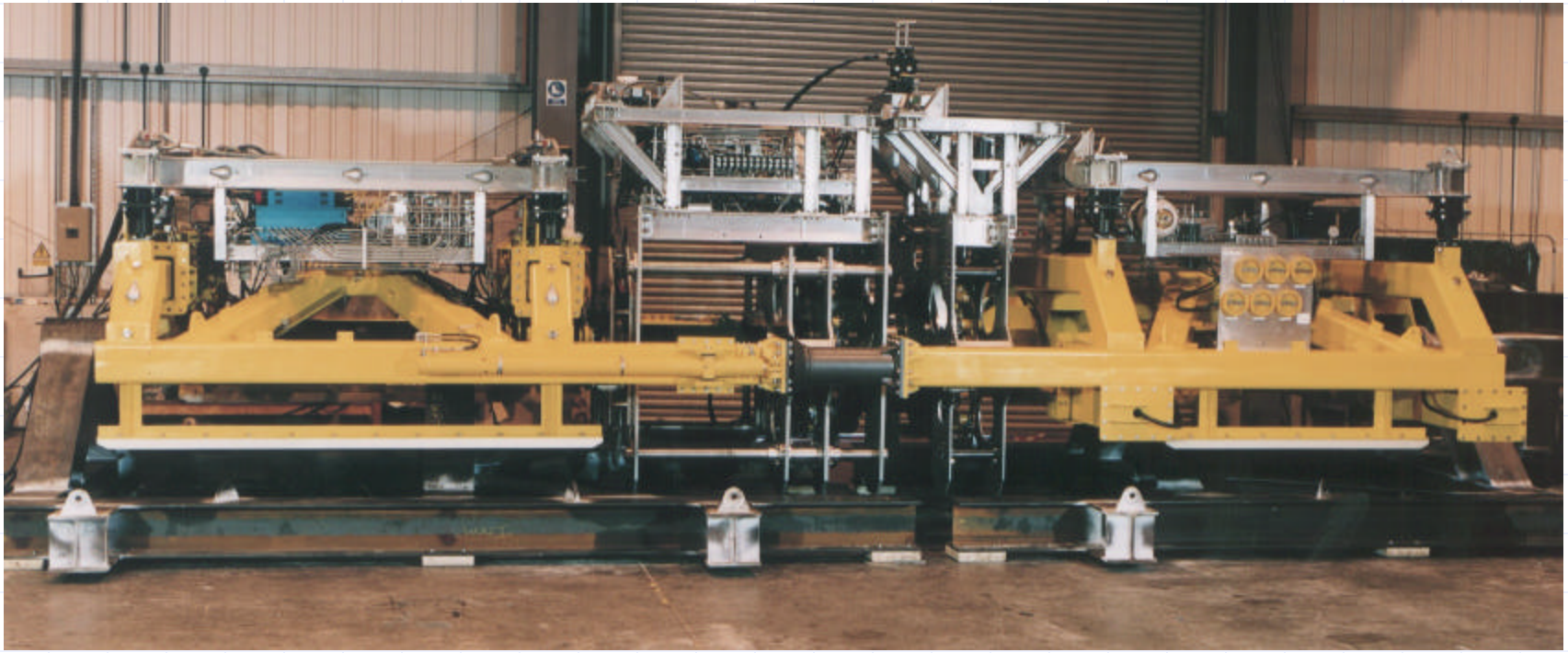
- Telescoping Spool Piece with Snam Connection System

Snam / Sonsub Deepwater Pipeline Repair System

- 1997-BP Foinaven Project-North Atlantic (West of Shetlands)
- Diverless Flange Tie-In System
- 8” and 10” Pipelines
- 1,500 Feet Sea Water

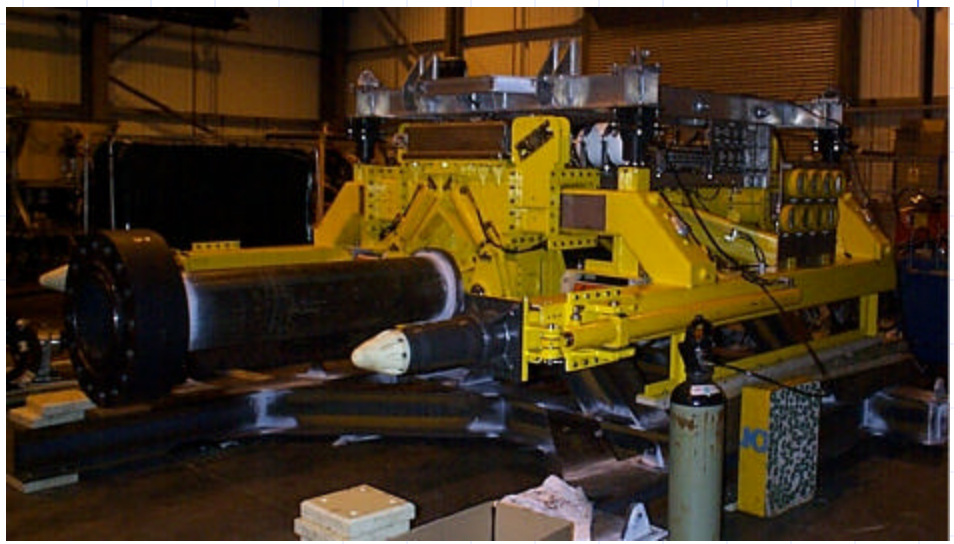
Snam / Sonsub Deepwater Pipeline Repair System

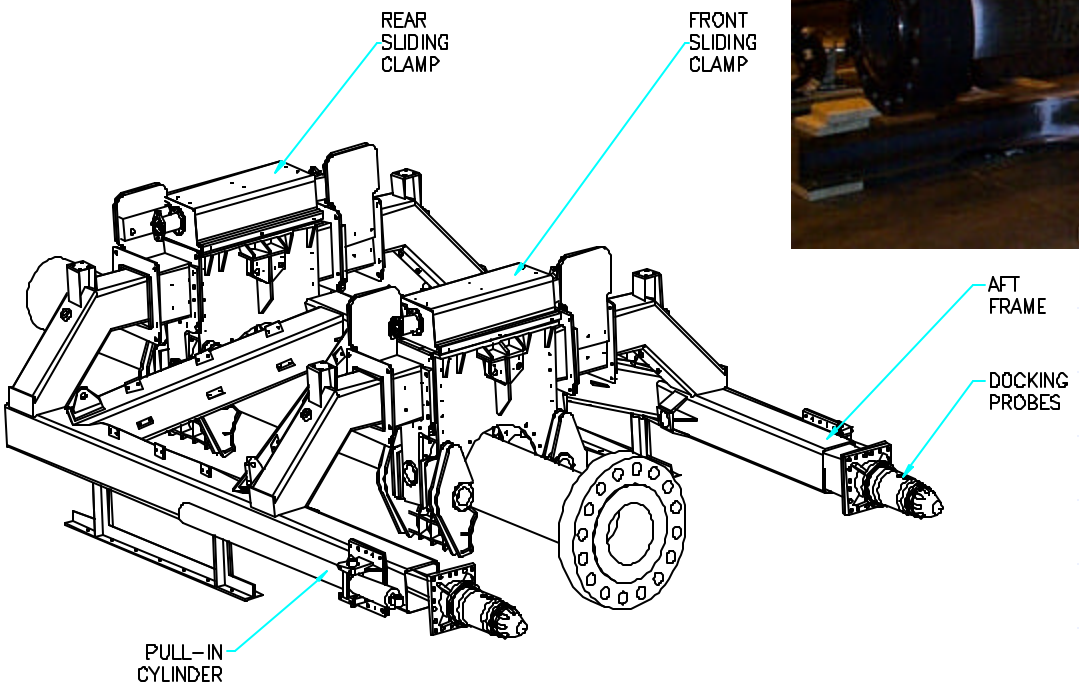
- BRUTUS



Snam / Sonsub Deepwater Pipeline Repair System

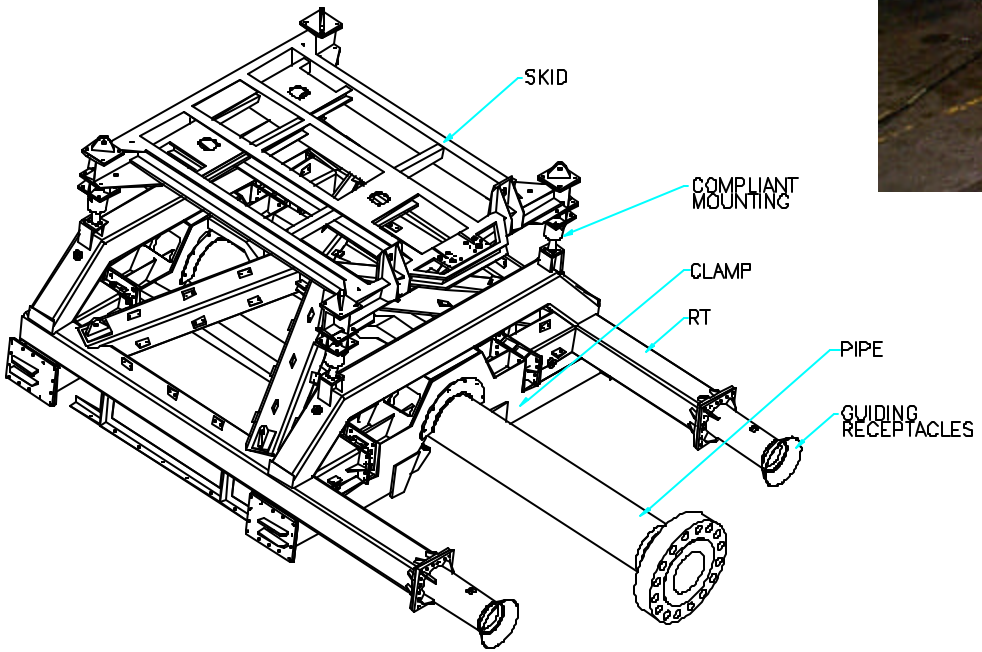
- BRUTUS – Axial Force Tool





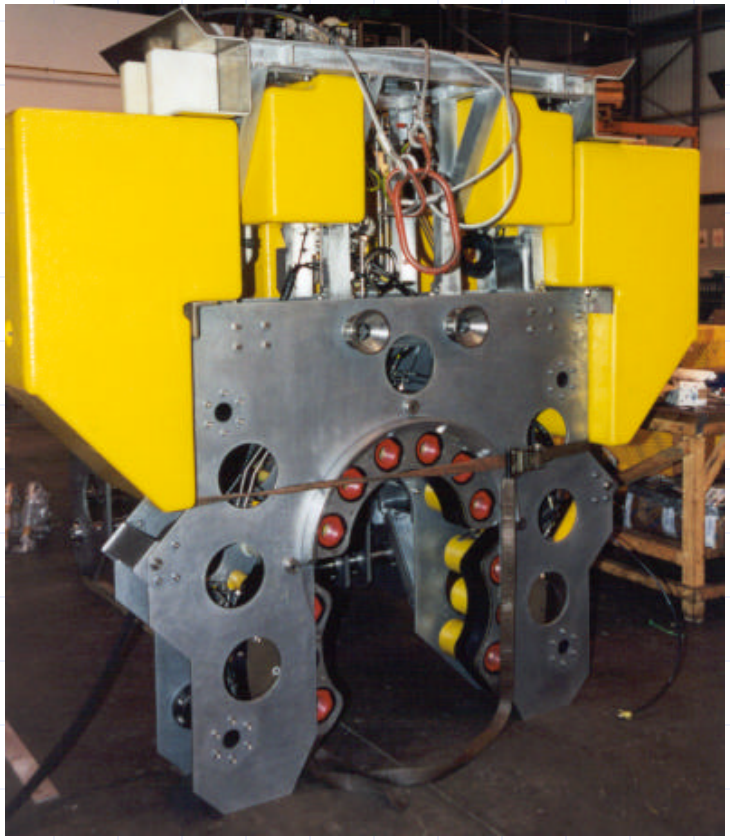
Snam / Sonsub Deepwater Pipeline Repair System

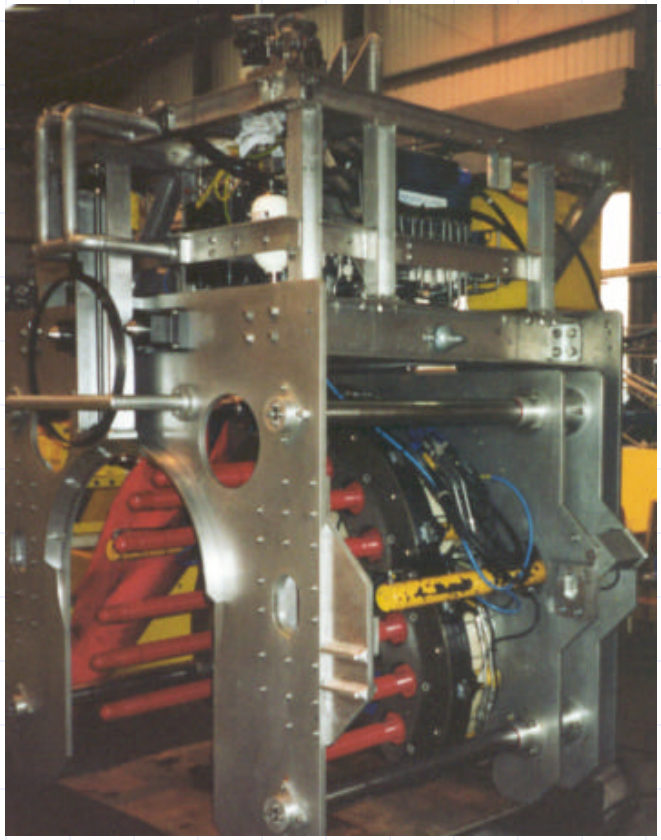
- BRUTUS – Reaction Tool



Snam / Sonsub Deepwater Pipeline Repair System

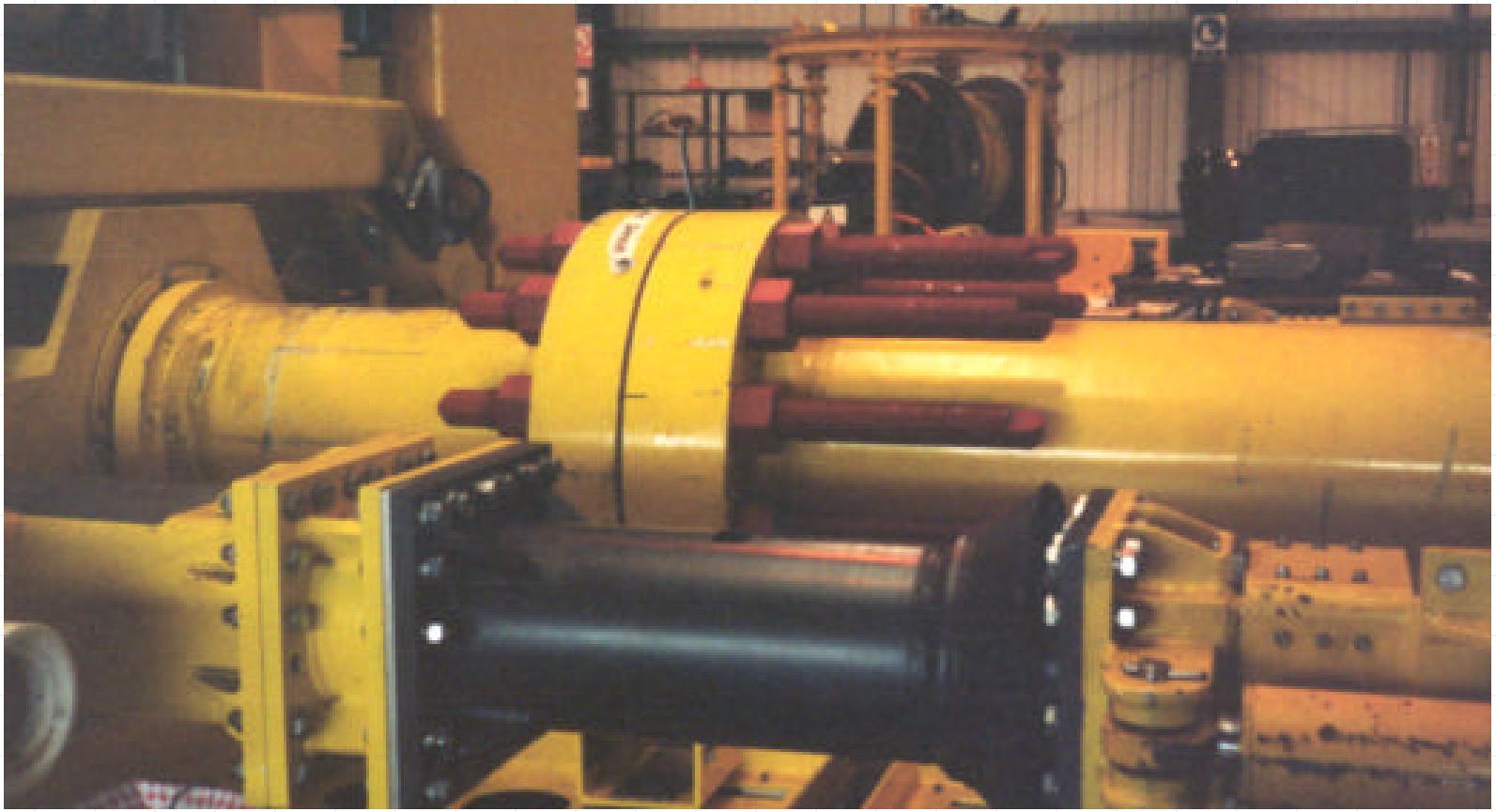
- BRUTUS – Bolt Insertion and Tensioning Tool and Nut Magazine





Snam / Sonsub Deepwater Pipeline Repair System

- BRUTUS Completed Flange Connection



Snam / Sonsub Deepwater Pipeline Repair System

- BRUTUS – First Project
  - June 2000 – North Sea
  - Construction Subsea Tie-In
  - Statoil Norne/Heidrun Pipeline
  - 16” ANSI 1500 Taper-Lok Flange
  - 1000’ Sea Water

Snam / Sonsub Deepwater Pipeline Repair System

- D.S.R.S. / BRUTUS Integrated System

Snam / Sonsub Deepwater Pipeline Repair System

- Gulf of Mexico Applications
  - D.S.R.S. - Large and Heavy System Requires Large Heavy Lift Vessel to Deploy
  - BRUTUS – More Portable But Requires D.S.R.S. Type Support
  - BRUTUS and D.S.R.S. Equipment Are Located In Europe

Stolt MATIS

- June 1999 – Diverless Flange Connection
- Statoil Loke Project North Sea
- Construction Tie-In of 8” ANSI 1500 Taper-Lok Flange
- 260’ Sea Water

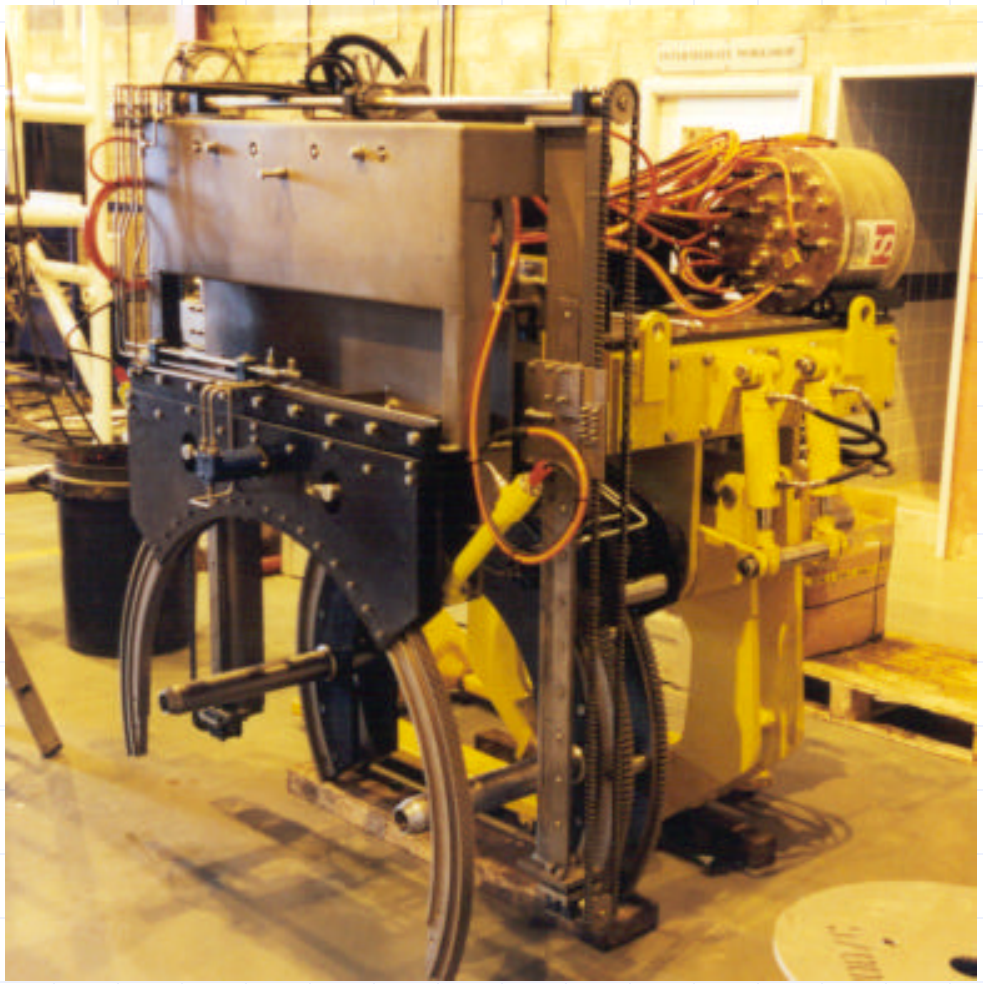
Stolt MATIS

- Components and Procedures
  - Flange Alignment Frame

MMS

Stolt MATIS

- Components and Procedures
  - Flange Alignment Tool

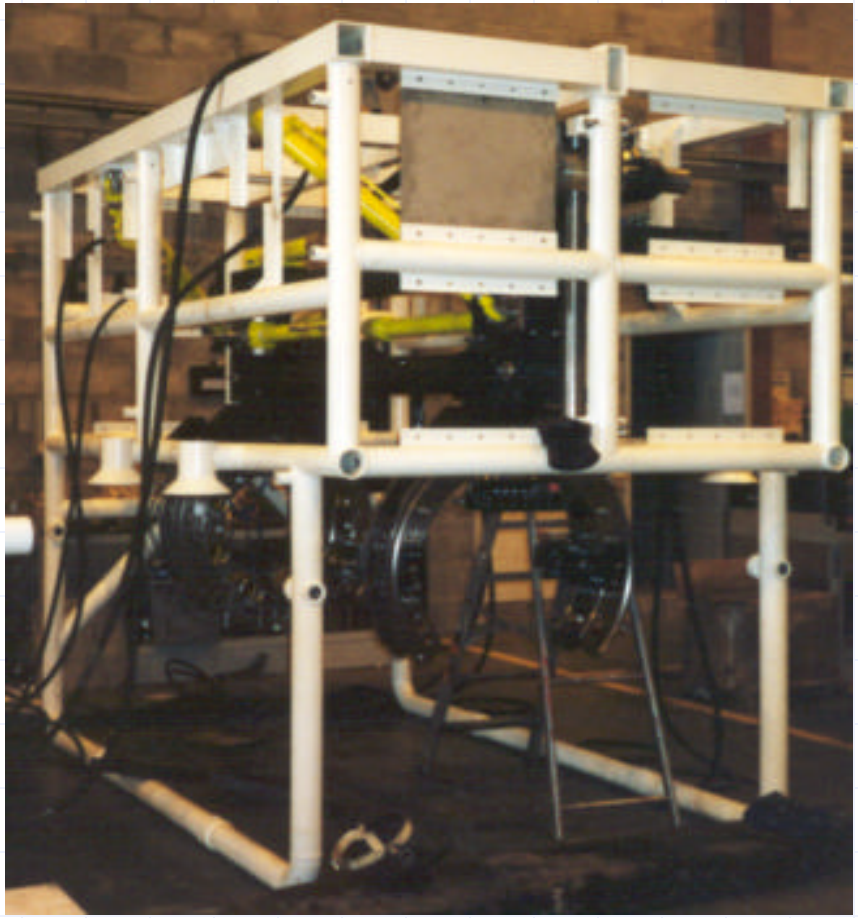


Stolt MATIS

- Deep MATIS System is Currently Under Development
- Elf Angola Girassol Project
  - June 2000 Sea Trials in North Sea
  - November 2000 Girassol Construction
  - 82 Diverless Flange Connections
  - 4,600’ Sea Water

Stolt MATIS

- Components and Procedures
  - Deep MATIS Module Under Construction



Stolt MATIS

- MATIS Support Tools Under Development
  - H-Frames
  - Leak Detection
  - Mechanical Pipe Cutter
  - Concrete Removal
  - FBE Removal
  - Metrology
  - Hydrate Plug Detector
  - Pipe Deburial
  - Pollution Containment

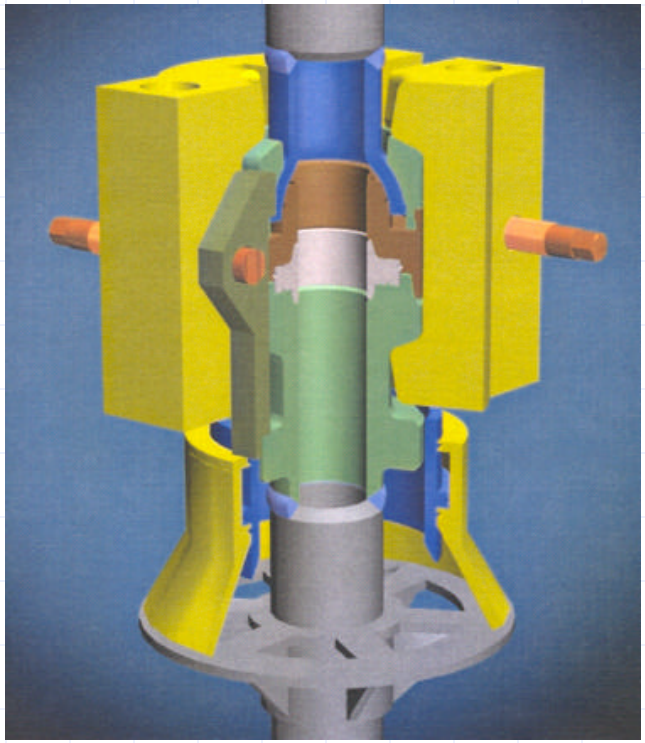
Stolt MATIS

- MATIS as Repair System
  - Easily Adaptable for Existing Diameters
  - Deployable from DSV
  - Requires Surface Lift of Pipeline Ends
  - Multiple MATIS Modules Required for Large Diameter Ranges

Stolt Future Development Goals

- Remote On-Bottom Diverless Repair with Jumper / Mechanical Connectors

BIMS Remote Articulated Connector

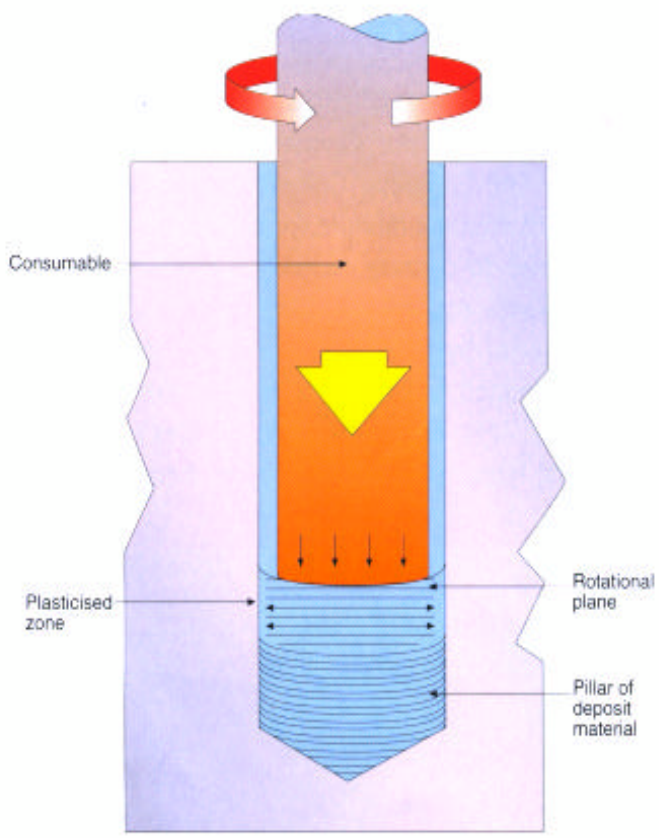


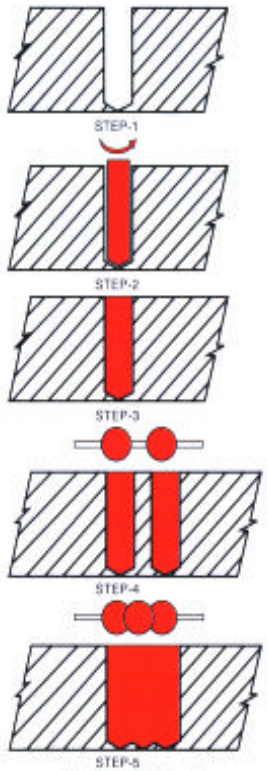
Stolt Future Development Goals

- Wet Friction Welding
  - Better weld metal characteristics than arc welding
  - Not dependent on water depth
  - Automated (diverless) process
  - Not expected to be perfected for several years

Stolt Future Development Goals

- Friction Stitch Welding Process

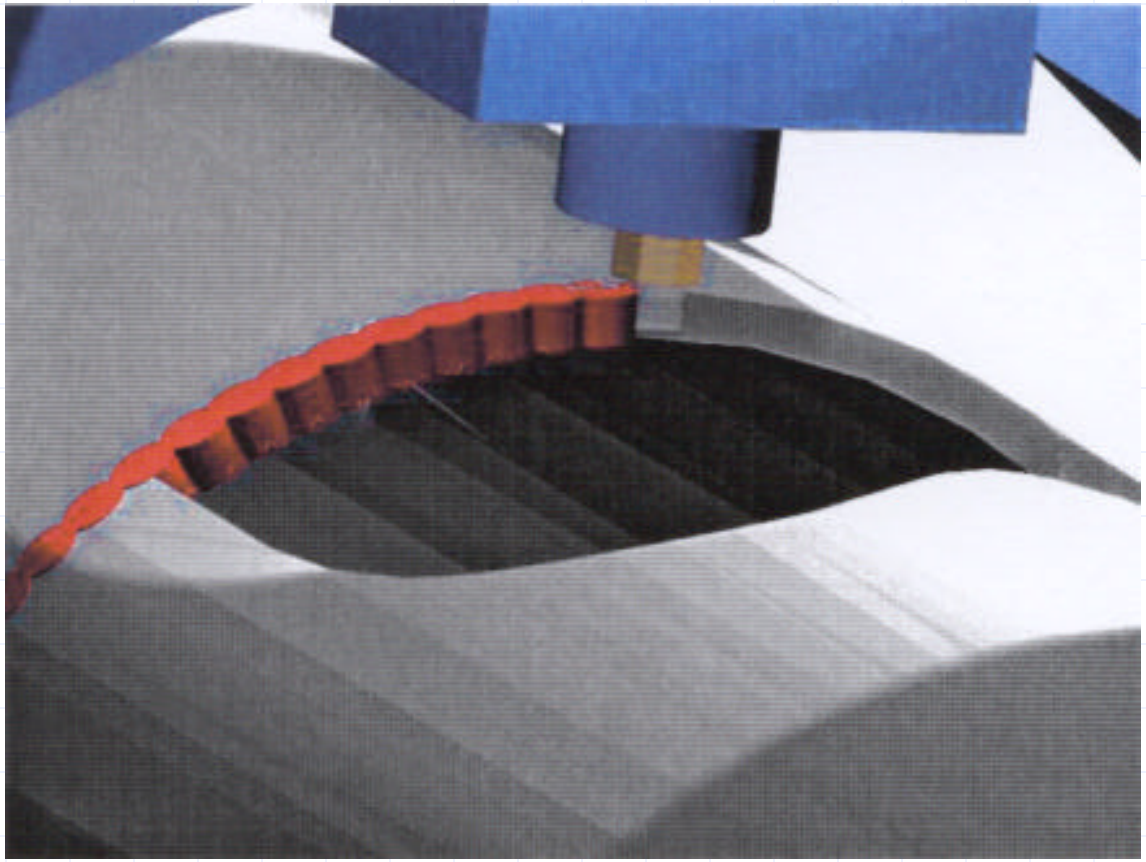




Friction Stitch Welding Process

Stolt Future Development Goals

- Friction Stitch Welding Process



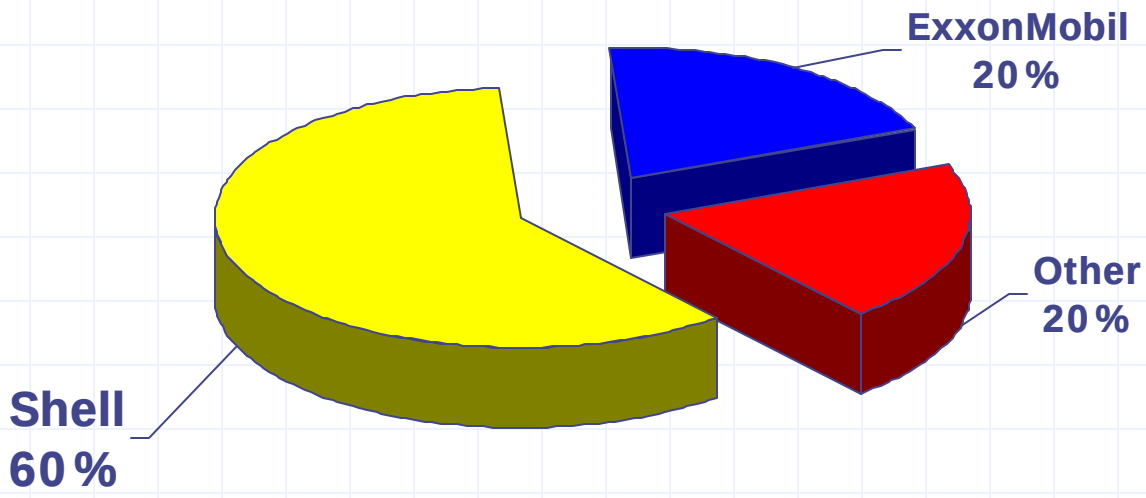
Shell Deepwater Pipeline Repair System

- The First Comprehensive Pipeline Repair System in the Gulf of Mexico

Shell Deepwater Pipeline Repair System

- Shell Stake in Deepwater

Deepwater Pipeline Operation in Gulf of Mexico Based on Mileage

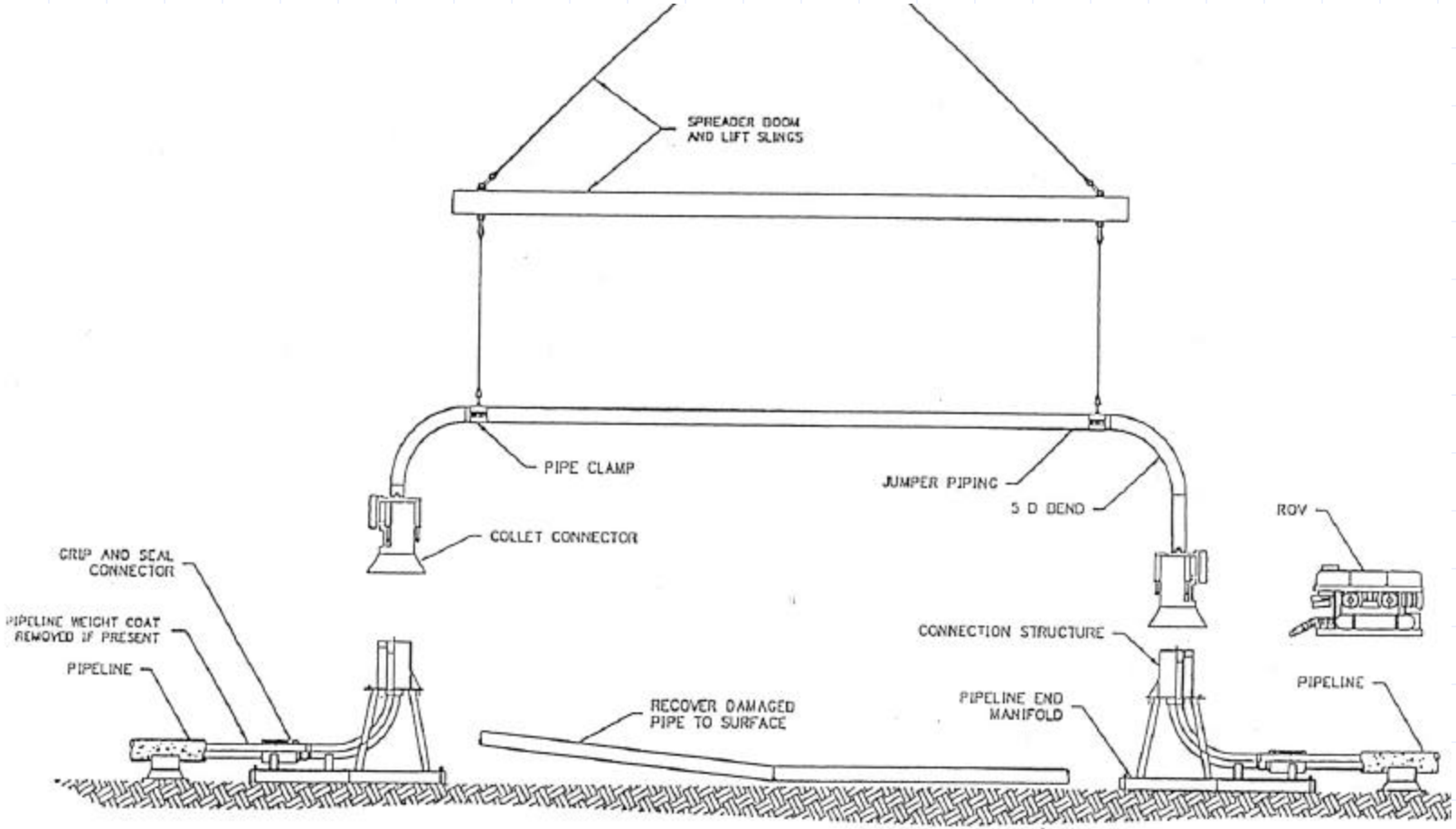


Shell Deepwater Pipeline Repair System

- Shell, Equilon, and Coral Gas (Tejas) Developing Repair System
- Goal is to Minimize Down Time to 1 Month
- Includes
  - Surface Lift OR On-Bottom Repair
  - Commissioning
  - Uninhibited Flow at Start-Up

Shell Deepwater Pipeline Repair System

Surface Lift Repair Procedure



Shell Deepwater Pipeline Repair System

- Advantages to Surface Lift Repair Procedure
  - Allows Welded Male Hubs
  - Allows Accessibility to Pipe Bore for Hydrate Plug Remediation
  - Proven Procedure

MMS

Shell Deepwater Pipeline Repair System

- Disadvantages to Surface Lift Repair Procedure
  - Requires Heavy Lift Vessel
  - Not Applicable in All Damage Scenarios

MMS

Shell Deepwater Pipeline Repair System

- On-Bottom Repair
  - Eliminates Surface Lift
  - Based on grip and seal connectors

MMS

Shell Deepwater Pipeline Repair System

- Advantages of On-Bottom Repair
  - Heavy Lift Vessel Not Required
  - Serves as contingency if Surface Lift is Not Possible

Shell Deepwater Pipeline Repair System

- Disadvantages of On-Bottom Repair
  - Procedure Not Proven
  - No Accessibility to the Pipe Bore
  - Mechanical Seal Reliability

Shell Deepwater Pipeline Repair System

- Philosophy:
  - System Based on Proven Technology
  - All Components Adapted from Existing Products and Equipment
  - Covers Sizes: 12”, 14”, 16”, 18”, 20”

Shell Deepwater Pipeline Repair System

Summary of Major Components:

- Mechanical Connectors (Collet, Grip & Seal) - HydroTech
- H-Frames - HydroTech
- Diamond Wire Pipe Cutter – Sonsub
- Concrete and FBE Removal Tool – Sonsub
- Hydrate Detection Tool – Oceaneering
- Discharge Containment Tent – Oceaneering
- Taut Wire Metrology – Oceaneering
- Acoustic Metrology – Leased from Fugro/Chance

Shell Deepwater Pipeline Repair System

- Additional Requirements
  - Agreements with Contractors and Service Companies for Repair Emergencies
  - Repair Manual

Shell Deepwater Pipeline Repair System

- System Limitations
  - Steel Catenary Risers
  - Pipe-In-Pipe Systems
  - MAOP > 6,000 PSIG

Shell Deepwater Pipeline Repair System

- Status:
  - System Ready by August 2000
  - Soliciting Participation from Other Deepwater Operators
  - Draft Participation Agreement Prepared in a DeepStar Committee Base on R.U.P.E. Model

Oceaneering Deepwater Pipeline Repair System

- Based on WASP Atmospheric Diving System
- On-Bottom Repair Capabilities to 2,300’ Sea Water
- Up to 14” Pipelines

Oceaneering Deepwater Pipeline Repair System

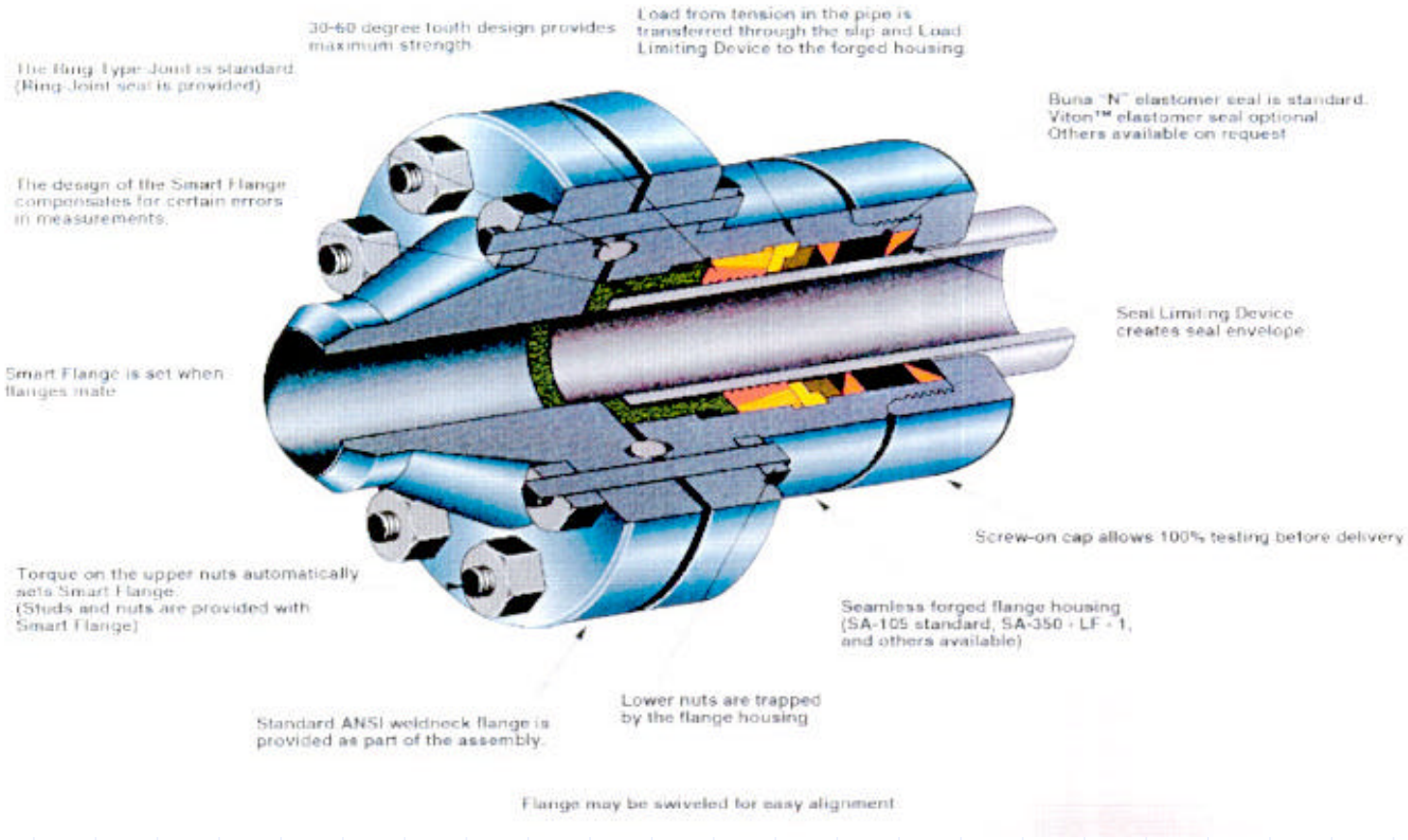
- Oceaneering Pipeline Repair Tools
  - WASP ADS – Rated to 2,300’ Sea Water
  - ROVs
  - Smart Flange Plus Connector
  - Hydraulic Smart Connector
  - WACHS Guillotine Saw
  - PMT – Taut Wire Metrology

Oceaneering Deepwater Pipeline Repair System

- WASP Atmospheric Diving System

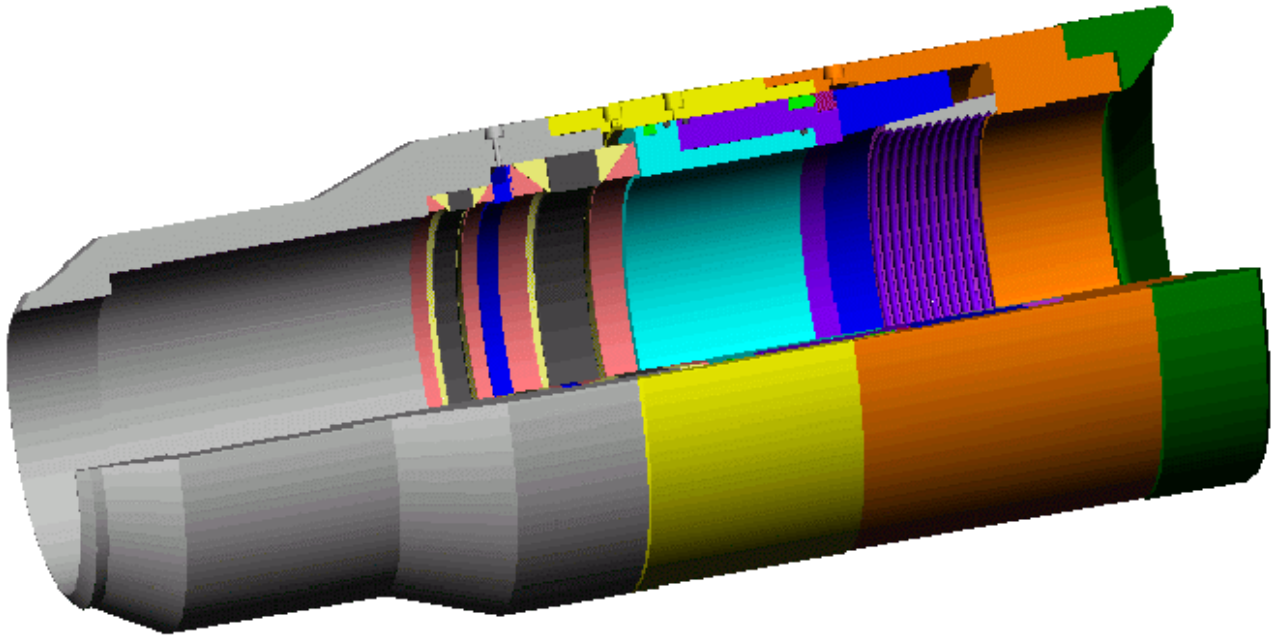
Oceaneering Deepwater Pipeline Repair System

Smart Flange Plus Connector



Oceaneering Deepwater Pipeline Repair System

- Hydraulic Smart Connector



Oceaneering Deepwater Pipeline Repair System

- WACHS Guillotine Saw

Oceaneering Deepwater Pipeline Repair System

- First Deepwater On-Bottom Pipeline Repair in Gulf of Mexico
  - Mariner 4” Dulcimer Flowline Repair

Oceaneering Deepwater Pipeline Repair System

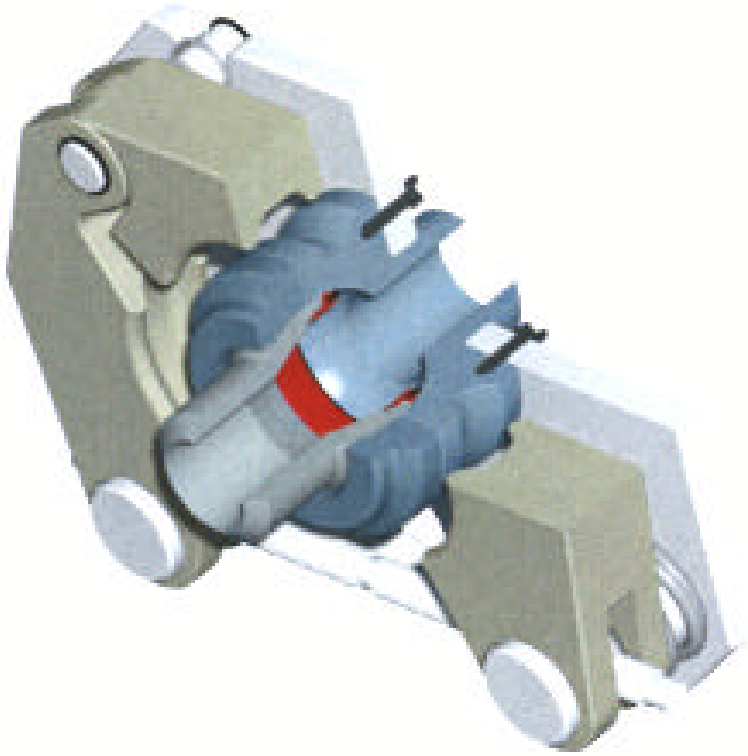
- Mariner 4” Dulcimer Flowline Repair
  - Summer 1999
  - 1,100 Feet Sea Water
  - WASP Installed Smart Flanges
  - Performed off of 243’ MSV

Oceaneering Deepwater Pipeline Repair System

- Mariner 8” Pluto Repair
  - October 1999
  - Leaking Weld Found During Hydrotest
  - Surface Lift by the Pipeline Lay Vessel
  - 2,150 Feet Sea Water
  - ANSI Flange Make Up On-Bottom Using WASP

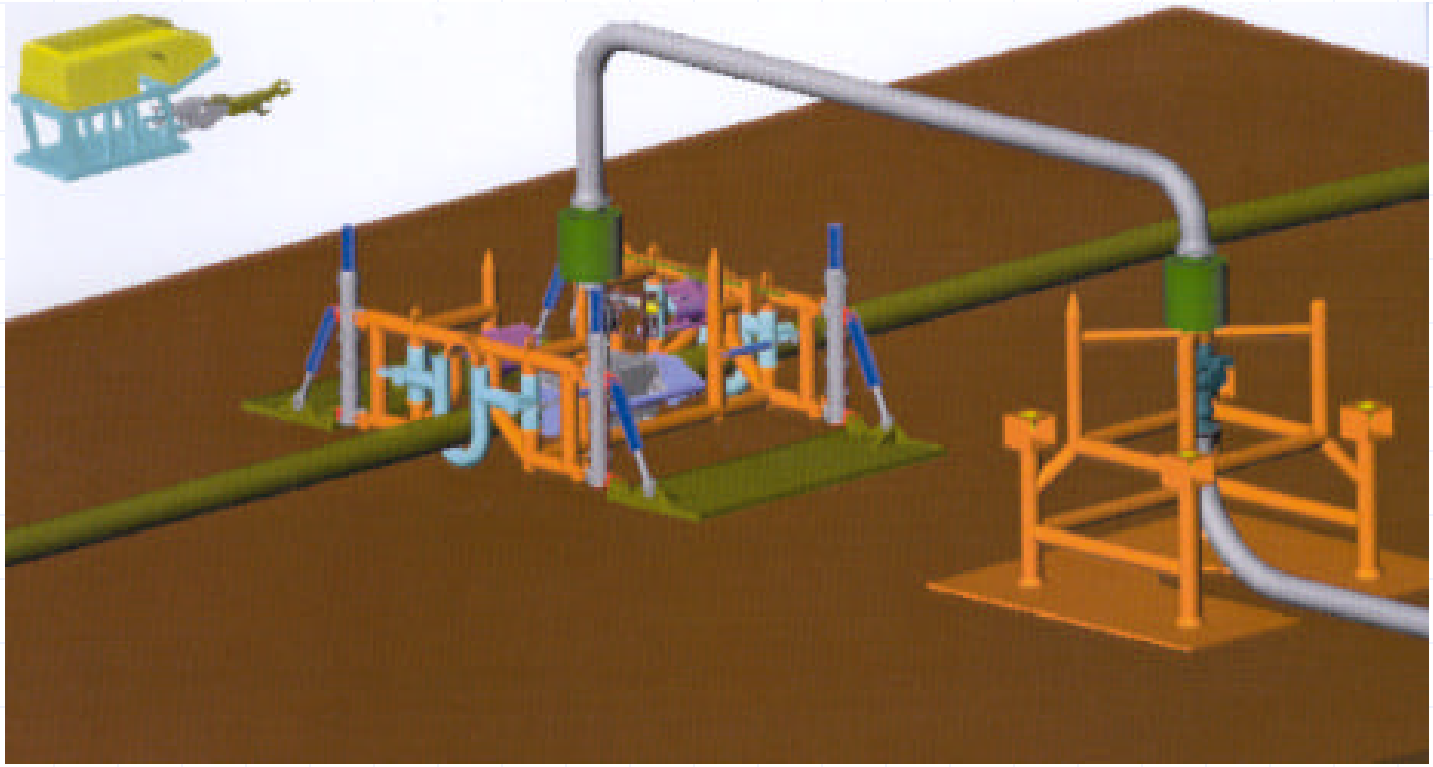
Oceaneering Deepwater Pipeline Repair System

- Reflange A-Con Variable Alignment Connector



Oceaneering Deepwater Pipeline Repair System

- Diverless Hot Tap
  - Williams Field Services JIP
  - Oceaneering, HydroTech, T.D. Williamson



Conclusions

- Deepwater Pipeline Repair Systems Are Available to the Gulf of Mexico
- The First Comprehensive System Will Be Available to the GOM by August 2000
- Pipeline Repair Scenarios have been Reduced from 8 months to 1 month

MMS

Assessment and Analysis of Deepwater Pipeline Repair in the Gulf of Mexico

Sponsored by:

United States Department of the Interior

Minerals Management Service

Presented by:

Project Consulting Services, Inc.