Deepwater Fixed Bottom Wind Turbine Platforms

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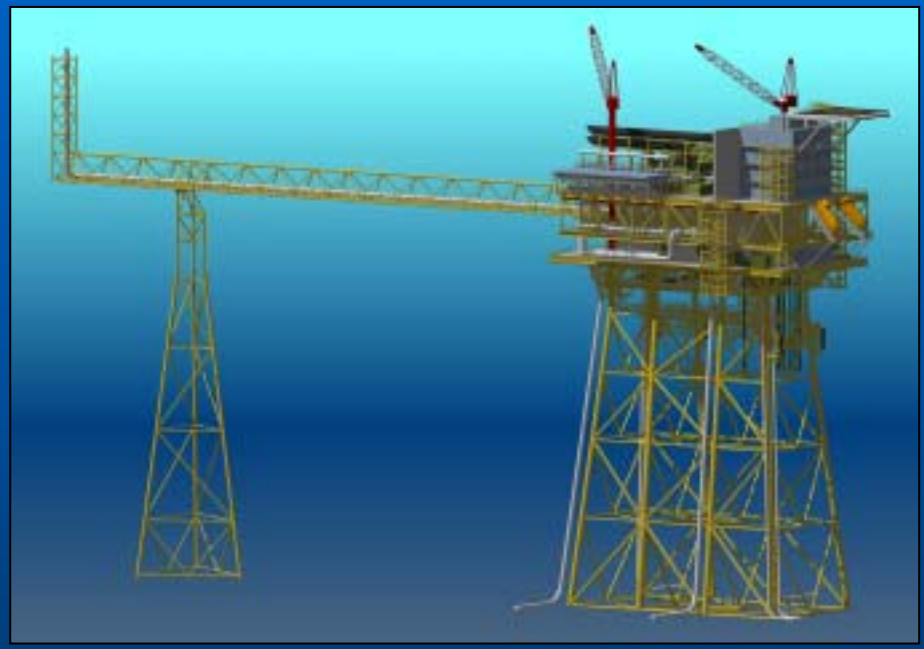
Background and Perspective

- **Design and Analysis of Offshore Structures**
  - **Oil and Gas**
  - **Office of Naval Research**
  - **Offshore Wind Generators**
- **Development of Concepts for Frontier Applications**
  - **Deepwater**
  - **Arctic**
  - **Seismic Regions**
  - **Marginal Field Development**
- **Software Development**
  - **Nonlinear Dynamic Response of Offshore Structures**

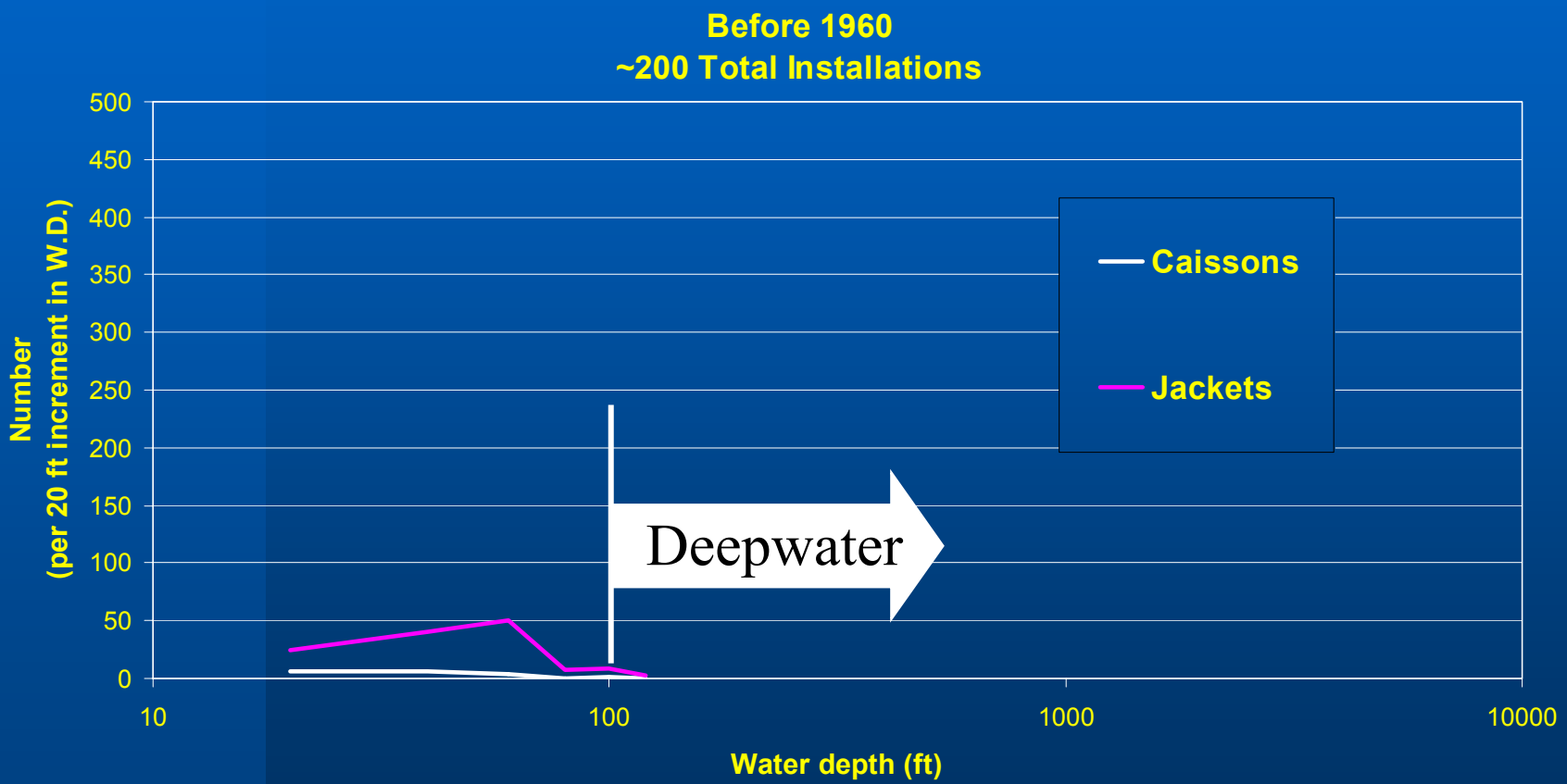
Examples Fixed Based Structures



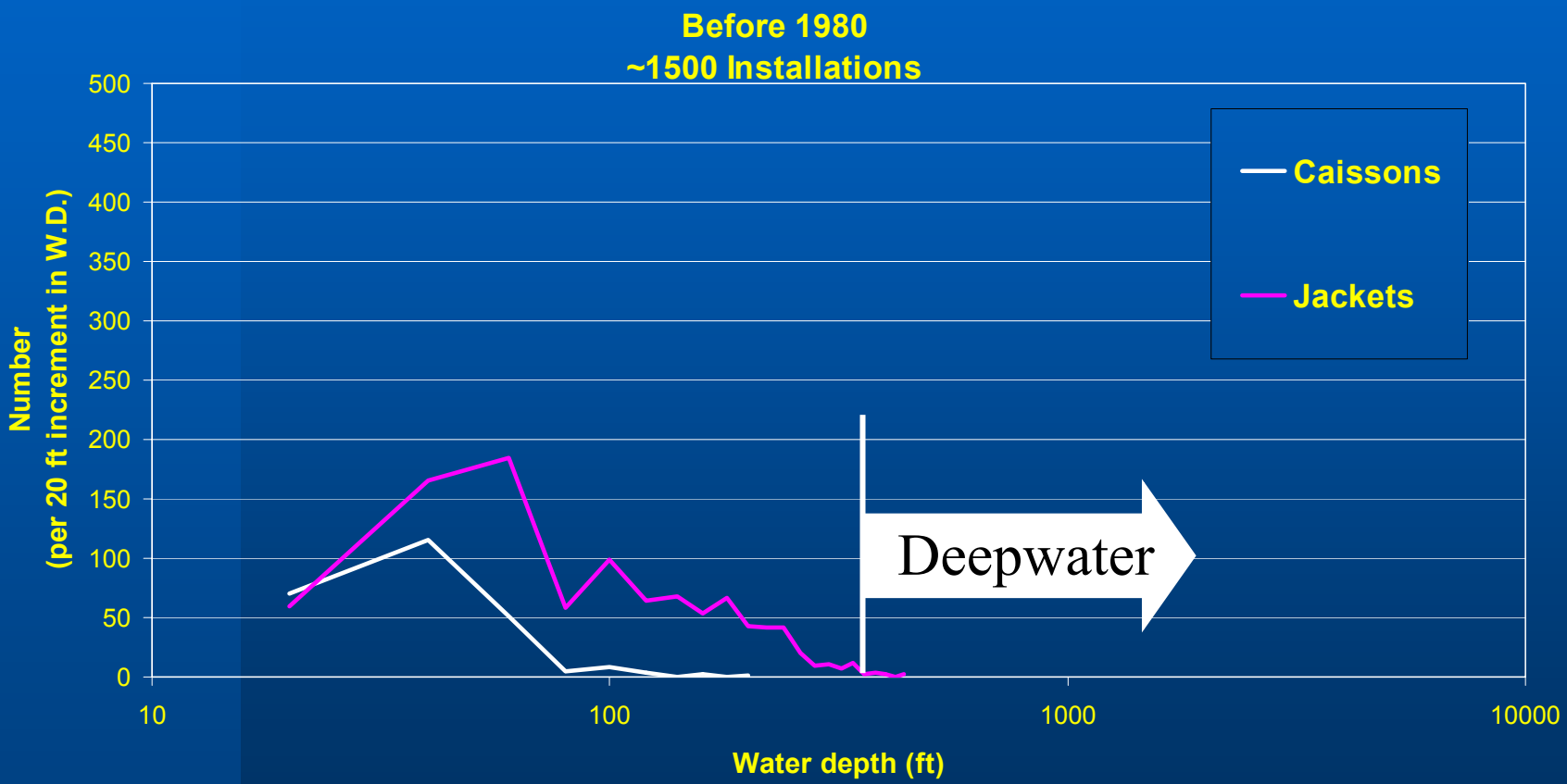
Definitions of Deepwater

Offshore Oil and Gas Perspective

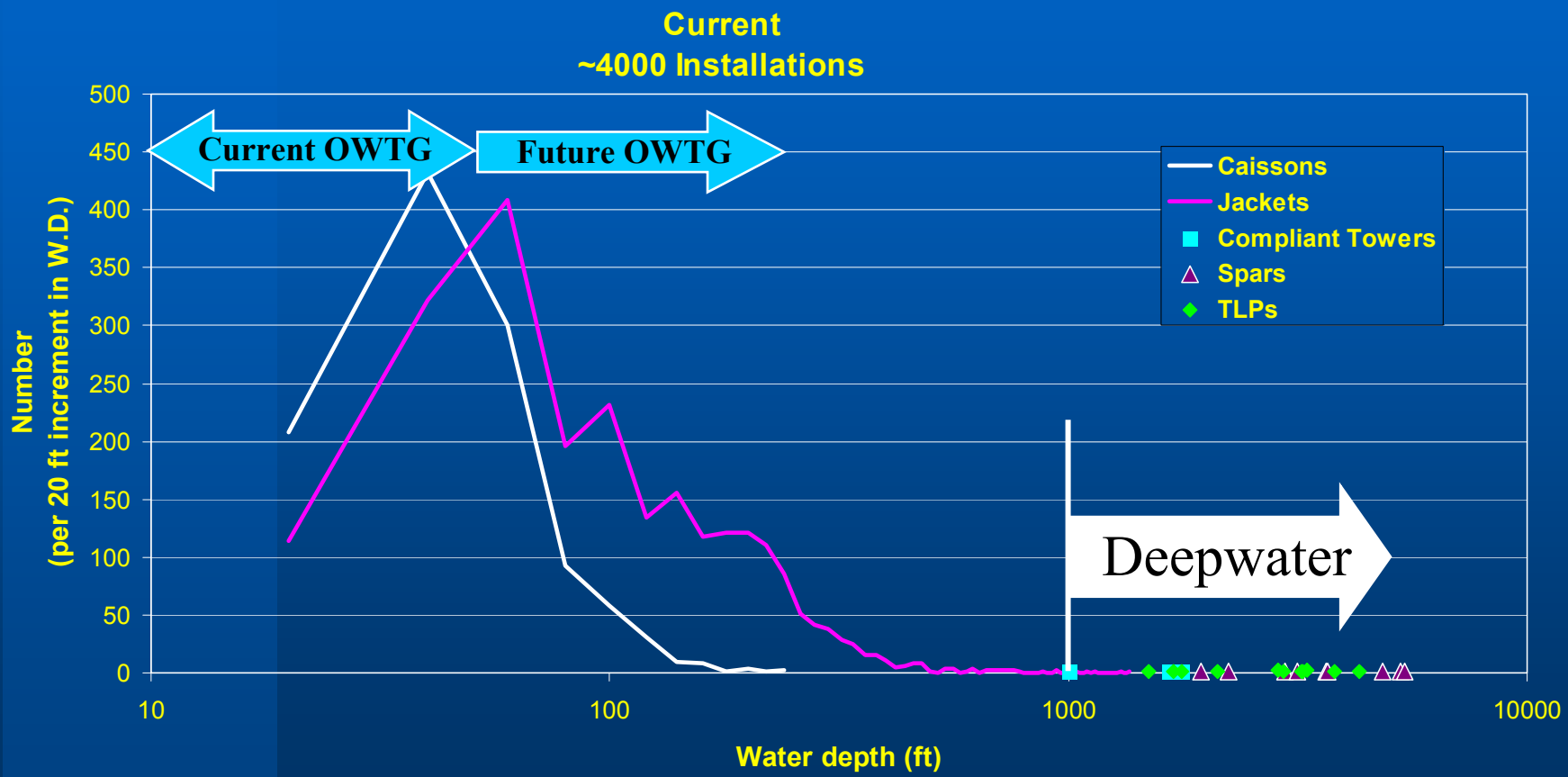
GOM Development (pre 1960)



GOM Development (pre 1980)



GOM Development (current)



Key Question

What are the concepts and technologies that can allow us to expand the range of applicability of OWTG and expand our reach into deeper water?

- **How do wind and oil and gas applications compare?**
- **What are the transitional concepts?**

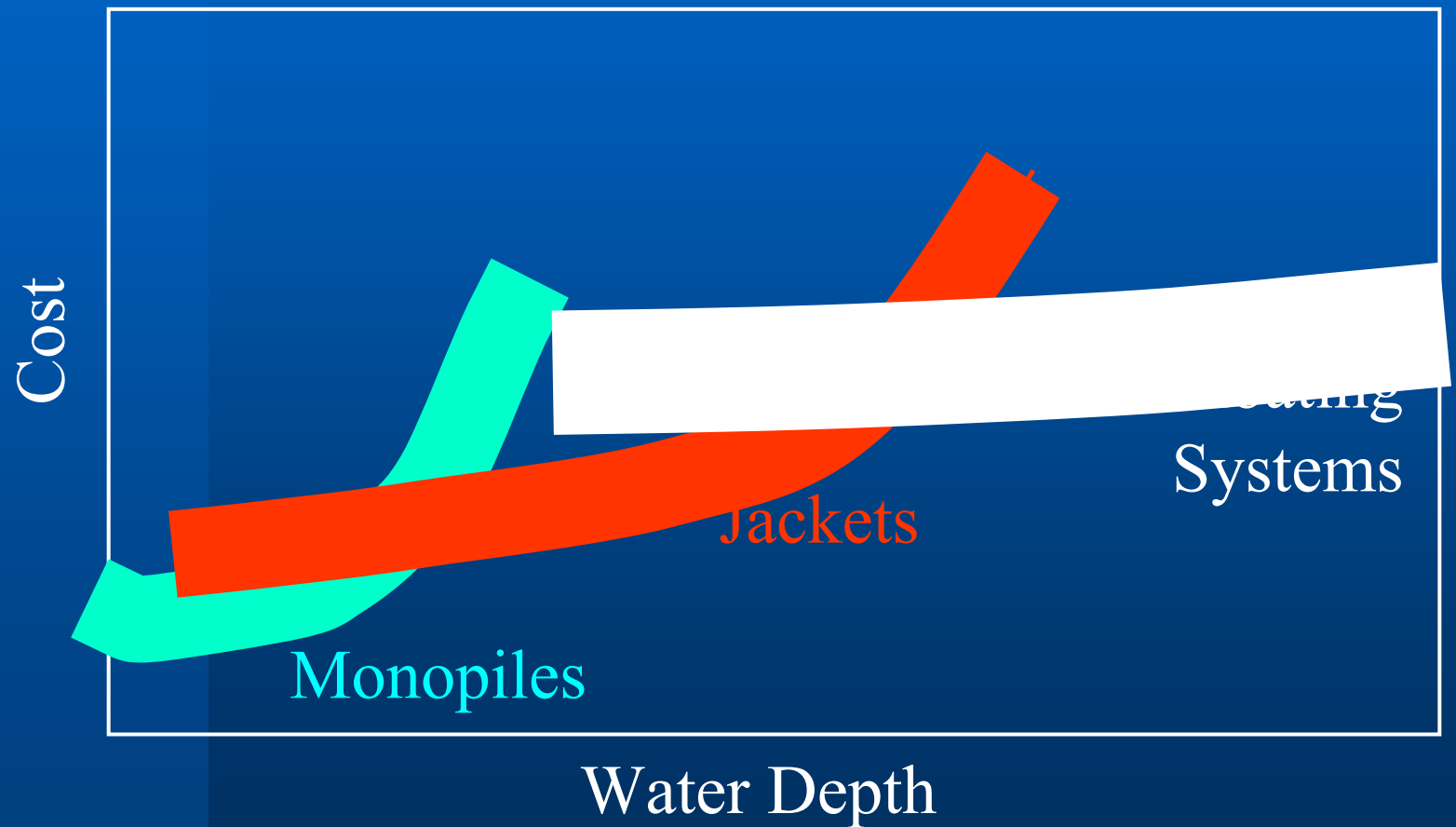
Comparison of Applications

- **Offshore wind power generators**
  - **Low total weight and payload**
  - **No deck area required**
  - **Low Failure Consequence**
  - **High moment arm to wind load**
  - **Cyclic wind and wave load**
  - **Operations very sensitive to platform motions**

Comparison of Applications

- **Offshore platforms**
  - **Significant total weight, payload and deck area**
  - **Higher failure consequence**
    - **Shut down and evacuate ahead of hurricanes in Gulf of Mexico**
  - **Wave load dominated**
  - **Operations less sensitive to lateral motions**

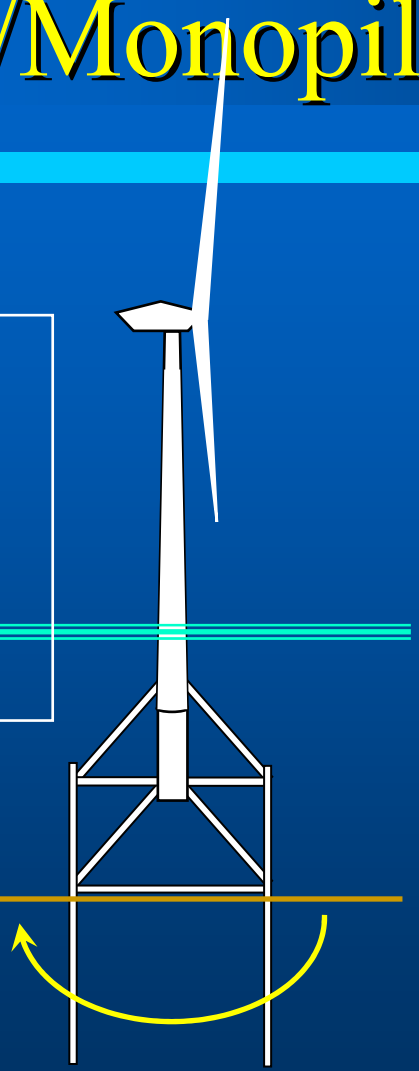
Range of Concept Applicability

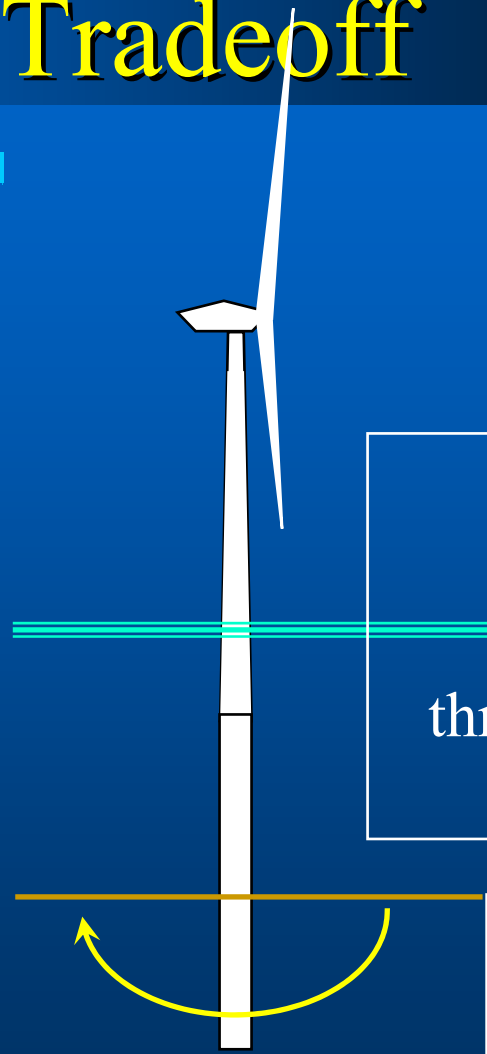


Jackets/Monopile Tradeoff

Strength and Stiffness Developed through redundant frame

Overturning resisted by pile axial couple





Strength and Stiffness Developed through a single D and t.

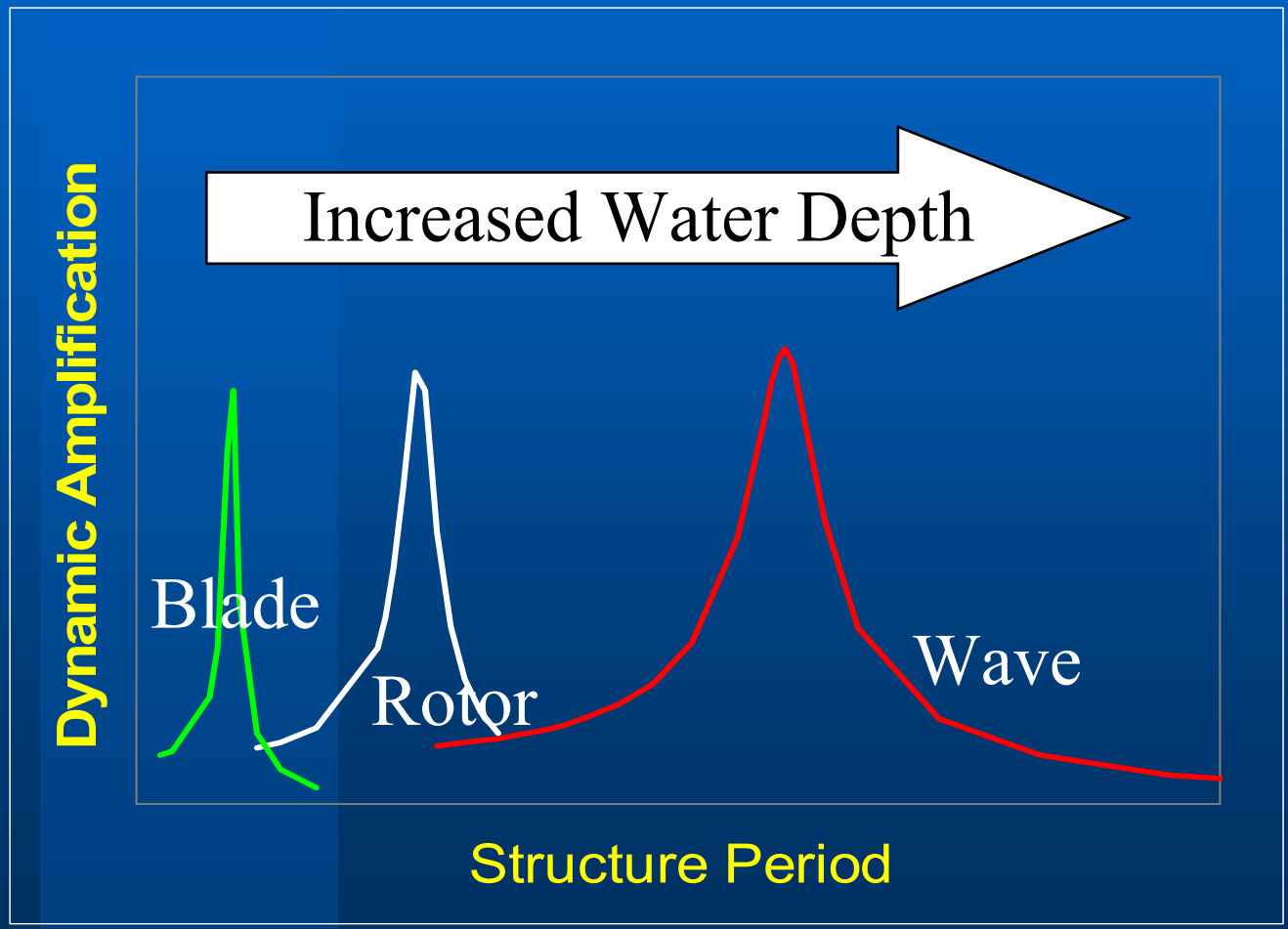
Overturning resisted by pile bending

Design Conditions

- Extreme storm (strength)
  - Non-operating
  - Maximum combined wind, wave and current
- Operating condition (motions)
  - Maximum operating wind with concurrent wave and current
  - Accelerations and frequencies are important
- Fatigue
  - Annual wave and wind conditions
    - (coupled or uncoupled?)
  - Potential resonance conditions must be avoided

- Pile number
- Pile size
- Pile penetration
- Jacket framing arrangements
- Member sizing
- Connection detailing

Dynamics



Key Issues

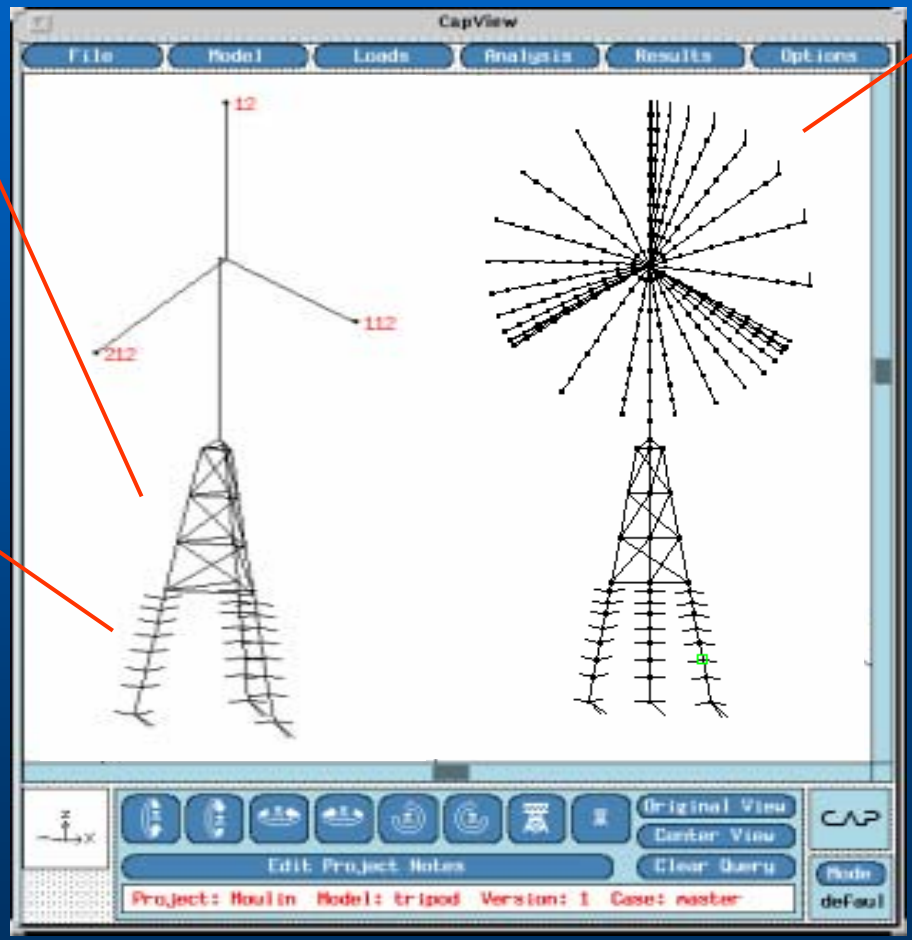
Variability / uncertainty in dynamic characteristics

Rotor / structure interaction

Fully Coupled Analysis

Explicit wave load, nonlinear, large deformation frame elements

Explicit Pile/Soil Model



Time domain analysis with blade and structure motions.

Conclusions and Observations

- **Installation**
  - **The real deepwater step function is driven by offshore construction costs**
- **Keep it simple**
  - **Large jumps in technology involve risk**
  - **Use small steps to optimize costs, gain experience and build the offshore infrastructure**