DYNAMICS OF SUSPENDED MID-WATER FLOWLINES

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OMAE 2001

June 05, 2001

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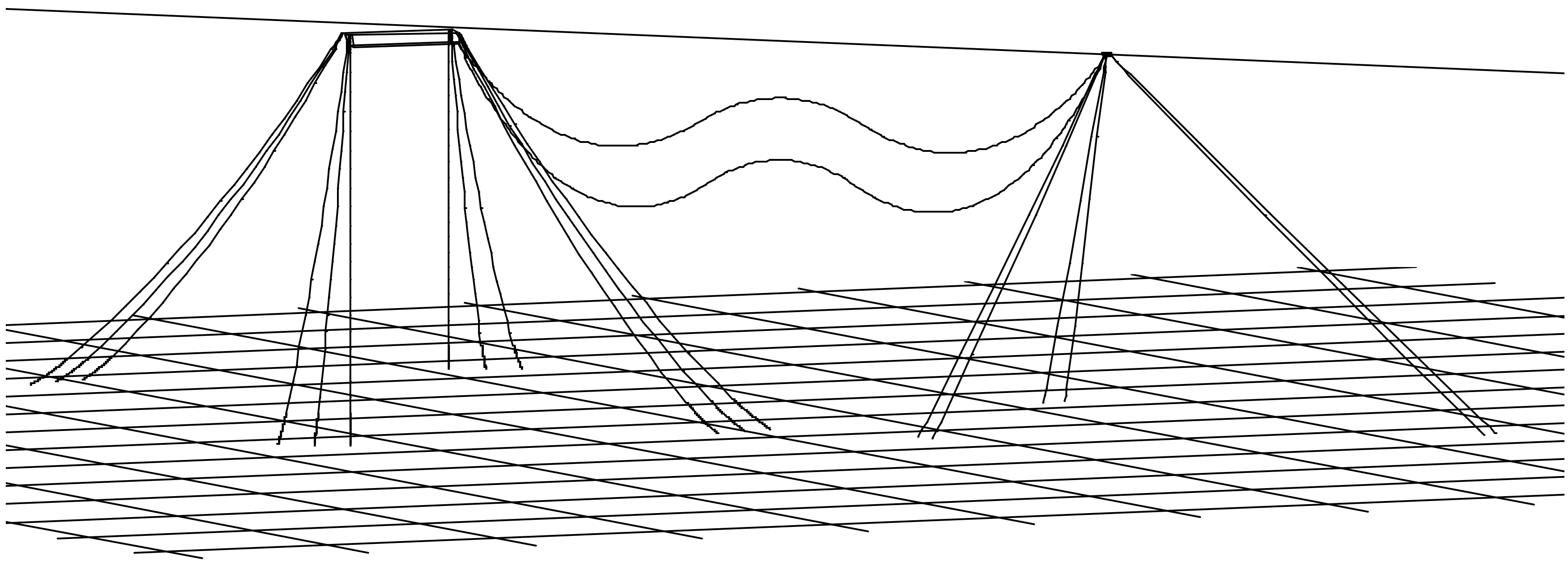
Typical Field Layout



Outline of Presentation

- Introduction
- Study parameters
- Fatigue life estimation
- Sensitivity analysis
- Results
- Conclusion

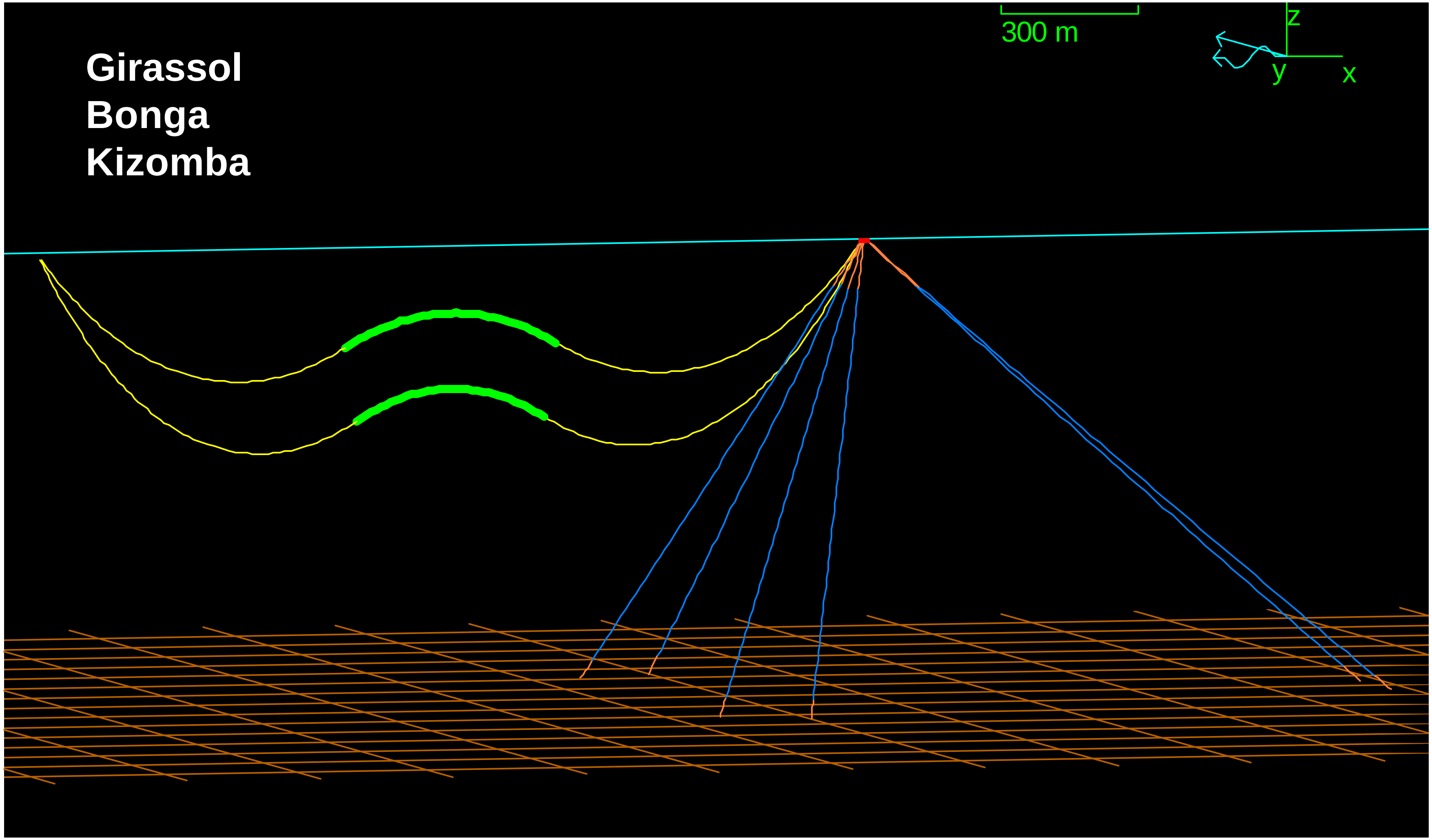
Introduction

- Spread-Moored (non-weathervaning) FPSO’s
- Mild to moderate environment (spread directionality)
- Long Field Life (20 - 30 years)
- High Rates of Production (> 100,000 bopd)
- Frequent Offloading to Vessels of Opportunity
- Perceived Risk of Collision between Tanker and FPSO
- New application for large diameter steel flowlines

Focus of the Study

- Wave induced fatigue damage
- Response to local wave climate
- Sensitivity analysis
- Design guidelines
- Alternative solutions

Suspended mid-water flowlines



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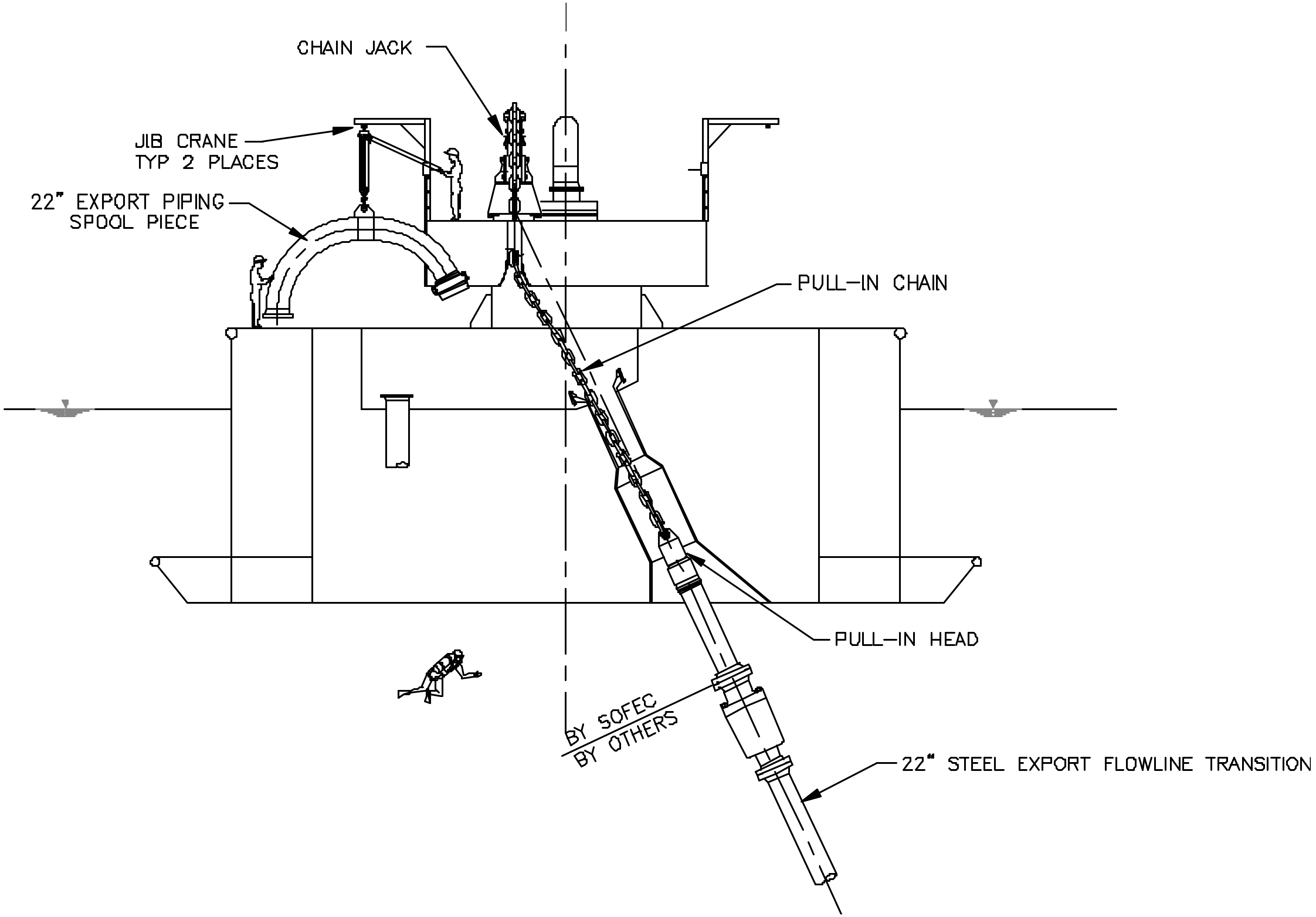
Flowline Physical Properties

	Upper	Lower	
Horizontal Span	1850	1850	m
Flowline Length	2100	2300	m
Outer Diameter	0.559	0.559	m
Wall Thickness	25.4	25.4	mm
Buoyancy Length	500	450	m
Total Buoyancy	2592	2333	kN
Total End Tension	1750	2010	kN
Horizontal End Tension	1031	887	kN
Vertical End Tension	1414	1803	kN
End Angle From Vertical	36	26	deg

Deep Water Offloading Buoy



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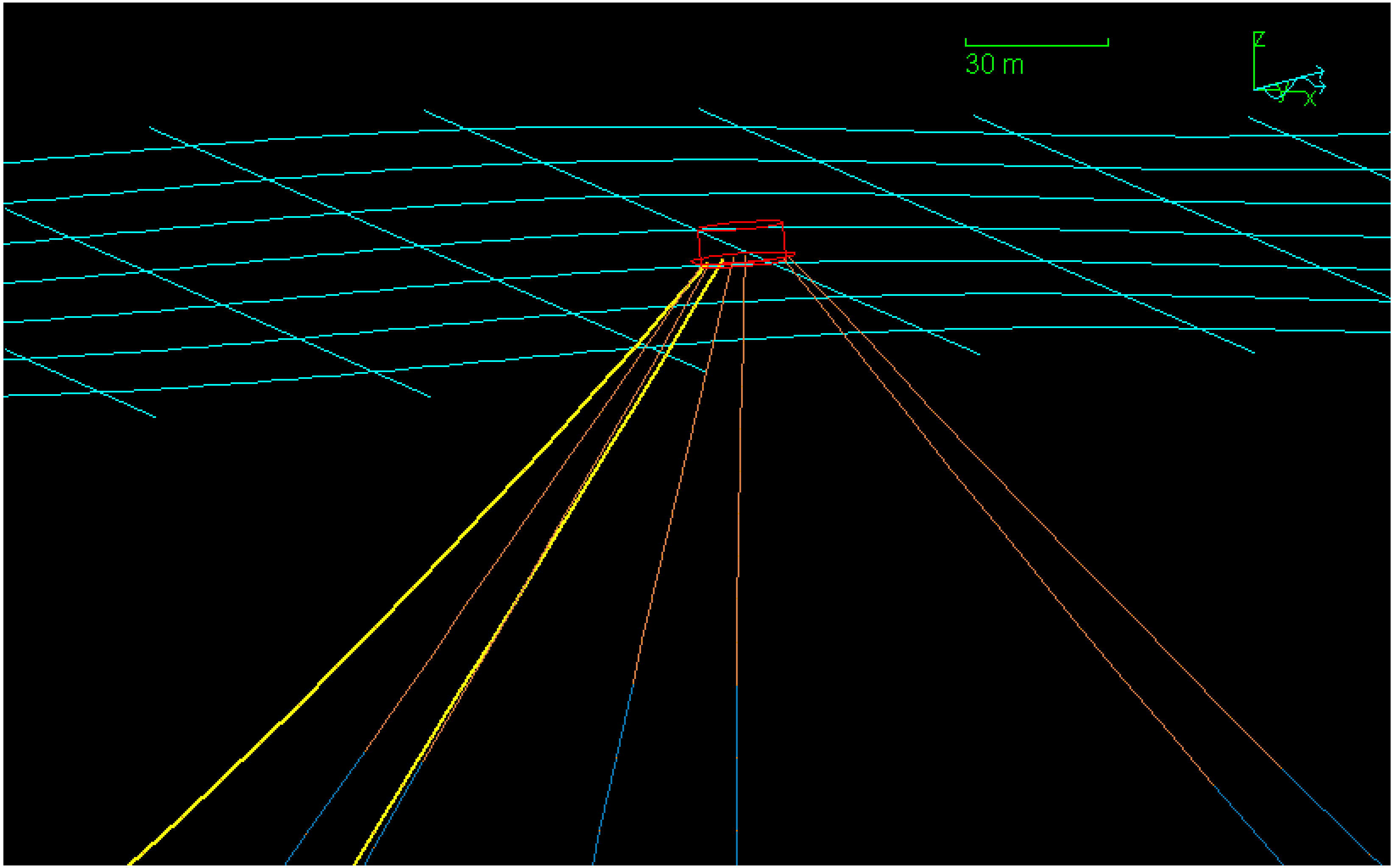
Flowline Fatigue Evaluation

- Sources of flowline fatigue damage
  - **Wave induced fatigue (vessel/buoy motions)**
  - Low Frequency fatigue (LF vessel/buoy motions)
  - VIV induced fatigue (current & vessel/buoy motions)
  - Installation induced fatigue
- Time domain analysis with coupled buoy model
- Rayleigh damage formulation
- Fatigue damage from local waves and swell independent

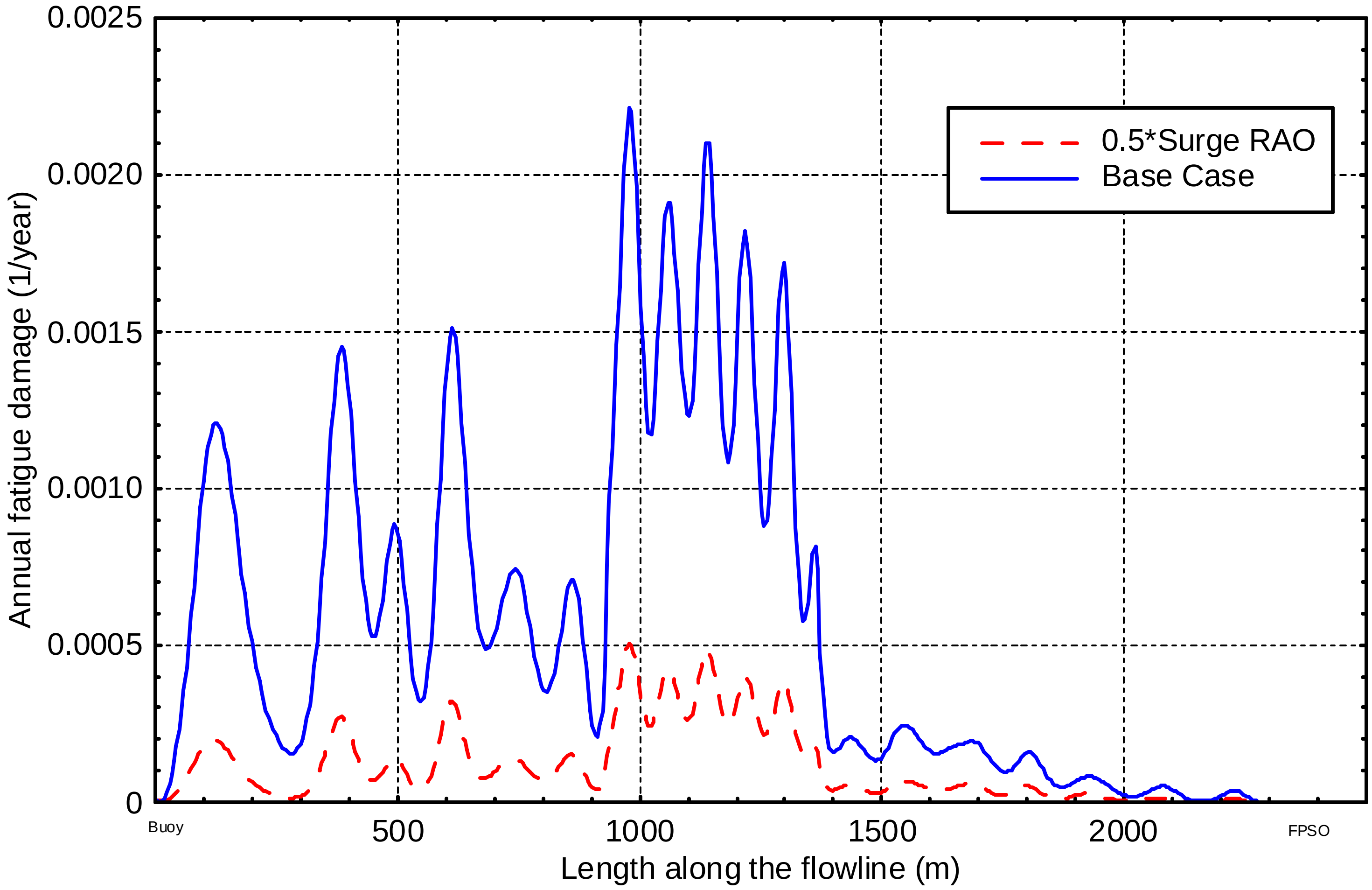
Sensitivity Analysis

- Flowline Response Sensitivity analysis:
  - Buoy Wave Frequency Motions
  - Drag Coefficient (Base case Cd = 0.6)
  - Wave Direction Relative to Flowlines
  - Swell Bin Width
  - Current
  - Flowline Configuration

Simulation of buoy/Flowline Motions



Sensitivity to Surge Motion



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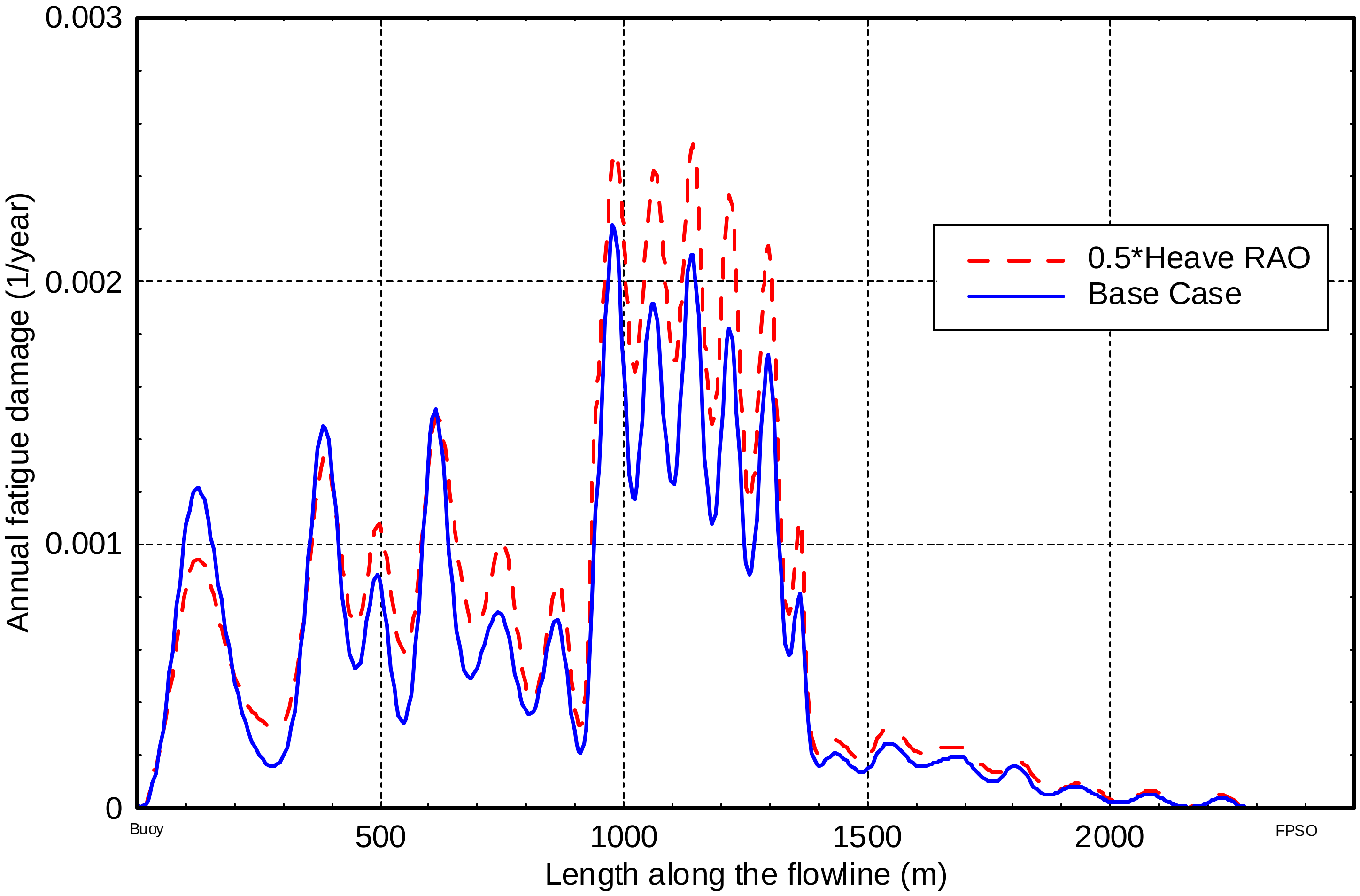
Sensitivity to Heave Motion



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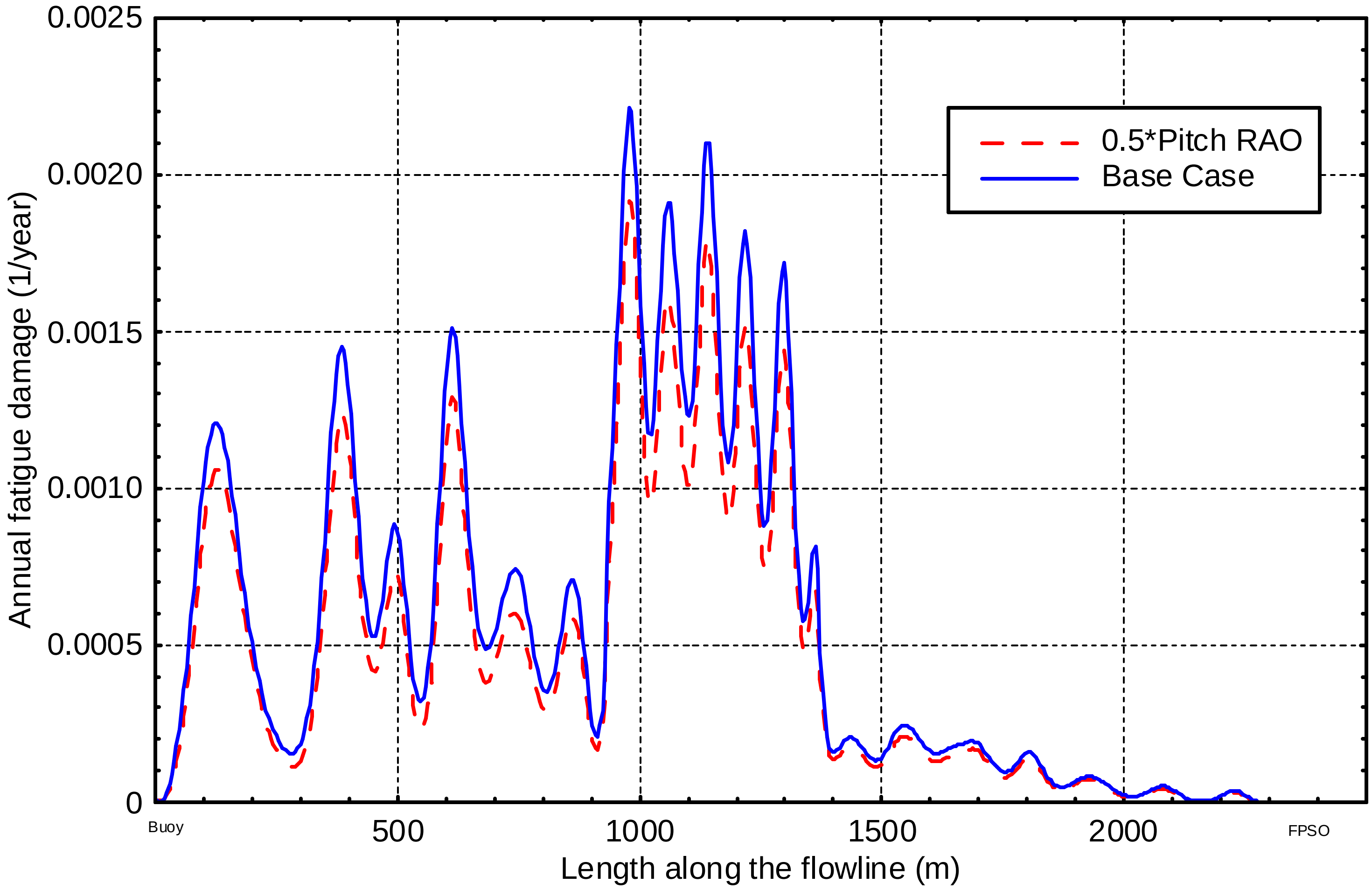
Sensitivity to Pitch Motion



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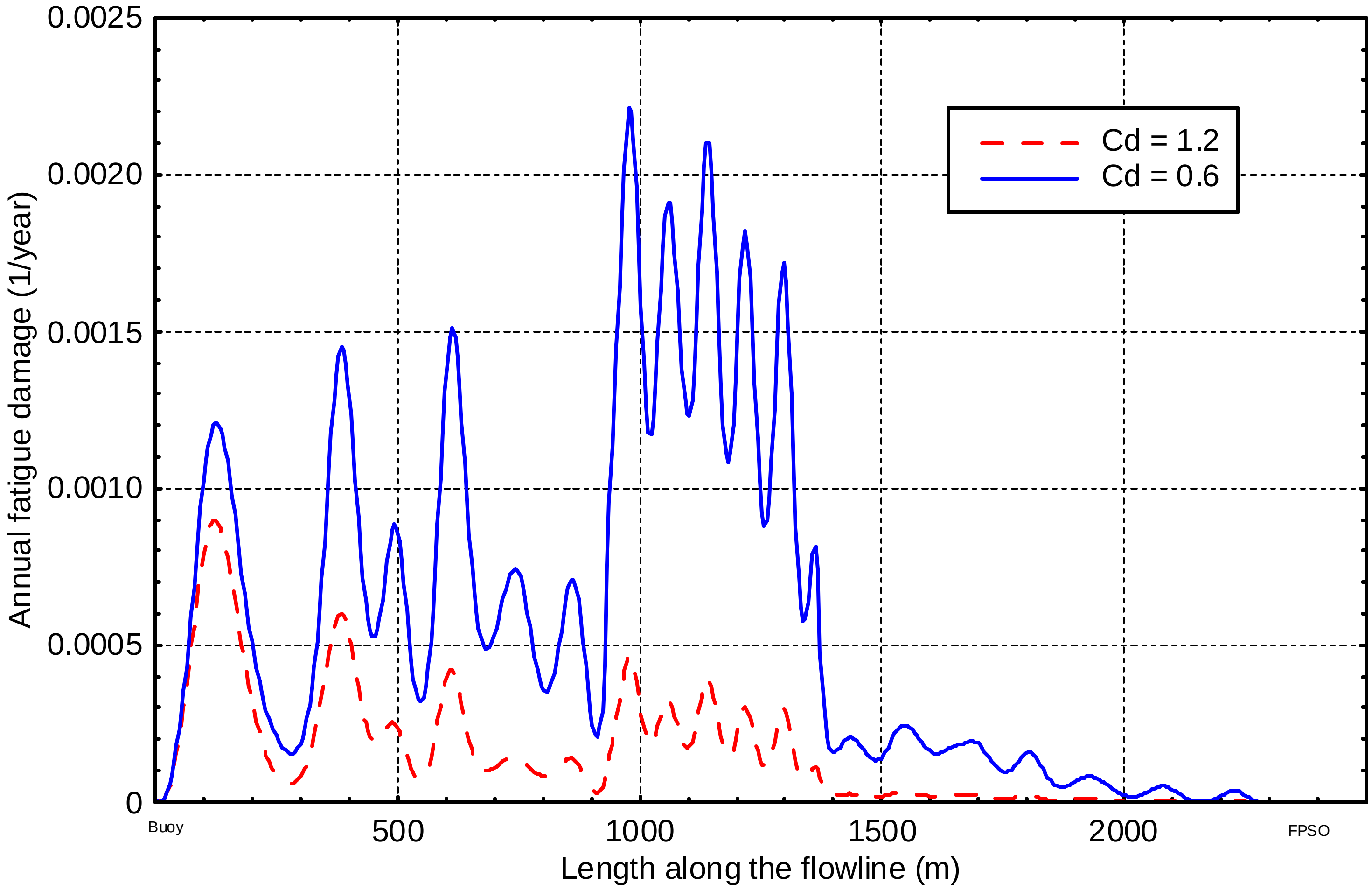
Sensitivity to Drag Coefficient



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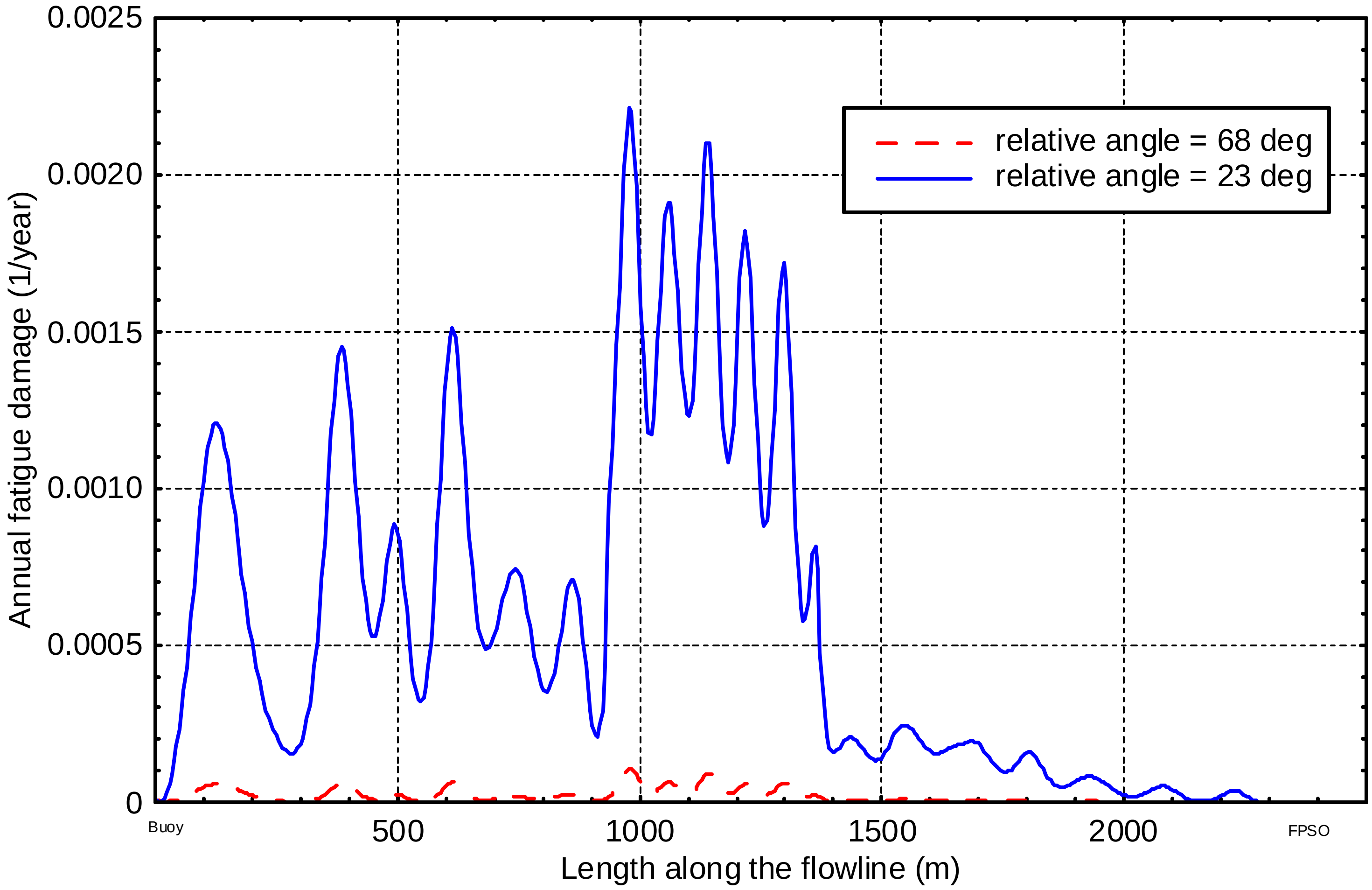
Sensitivity to Wave Direction



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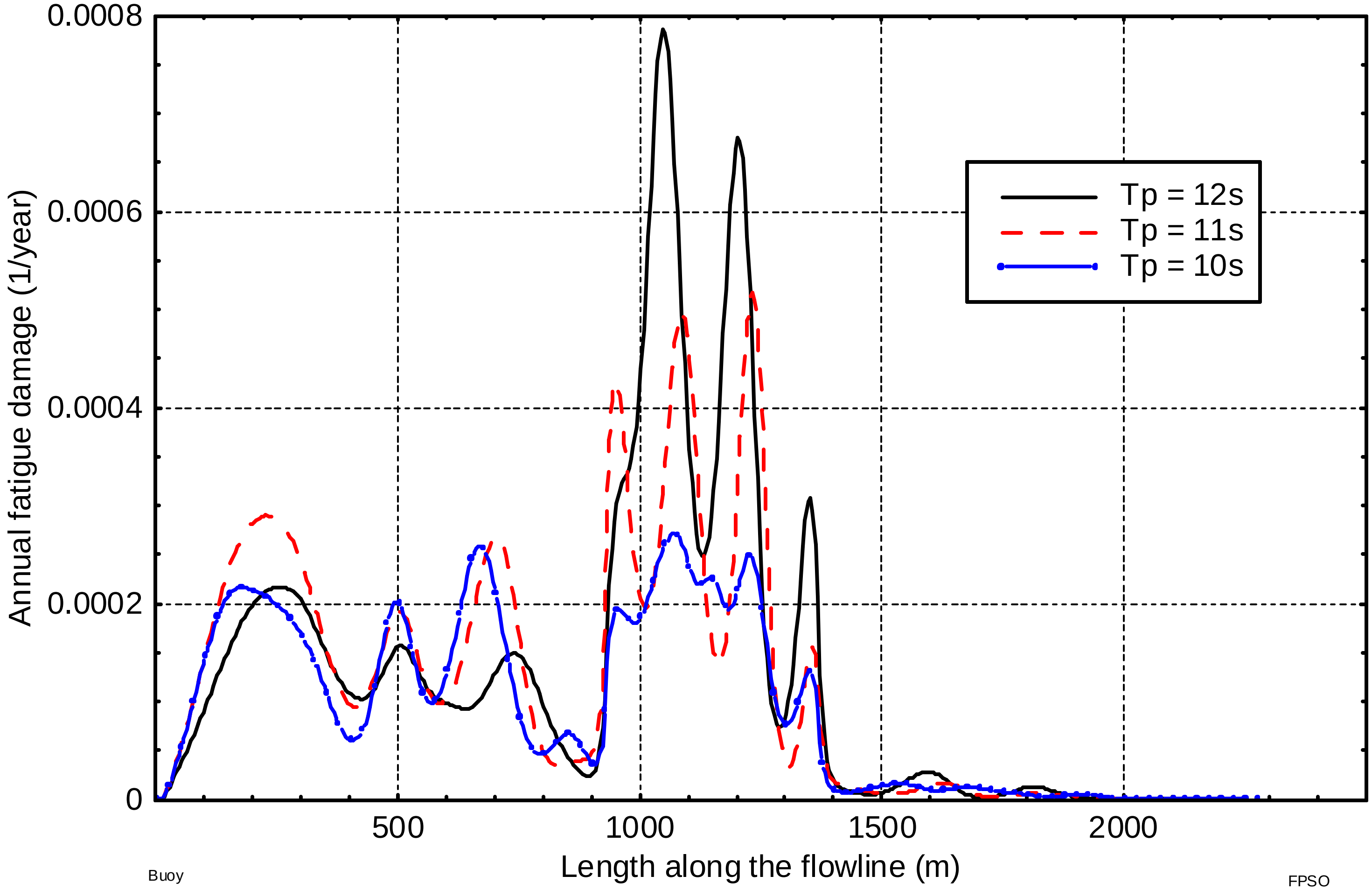
Sensitivity to Swell Bin Period



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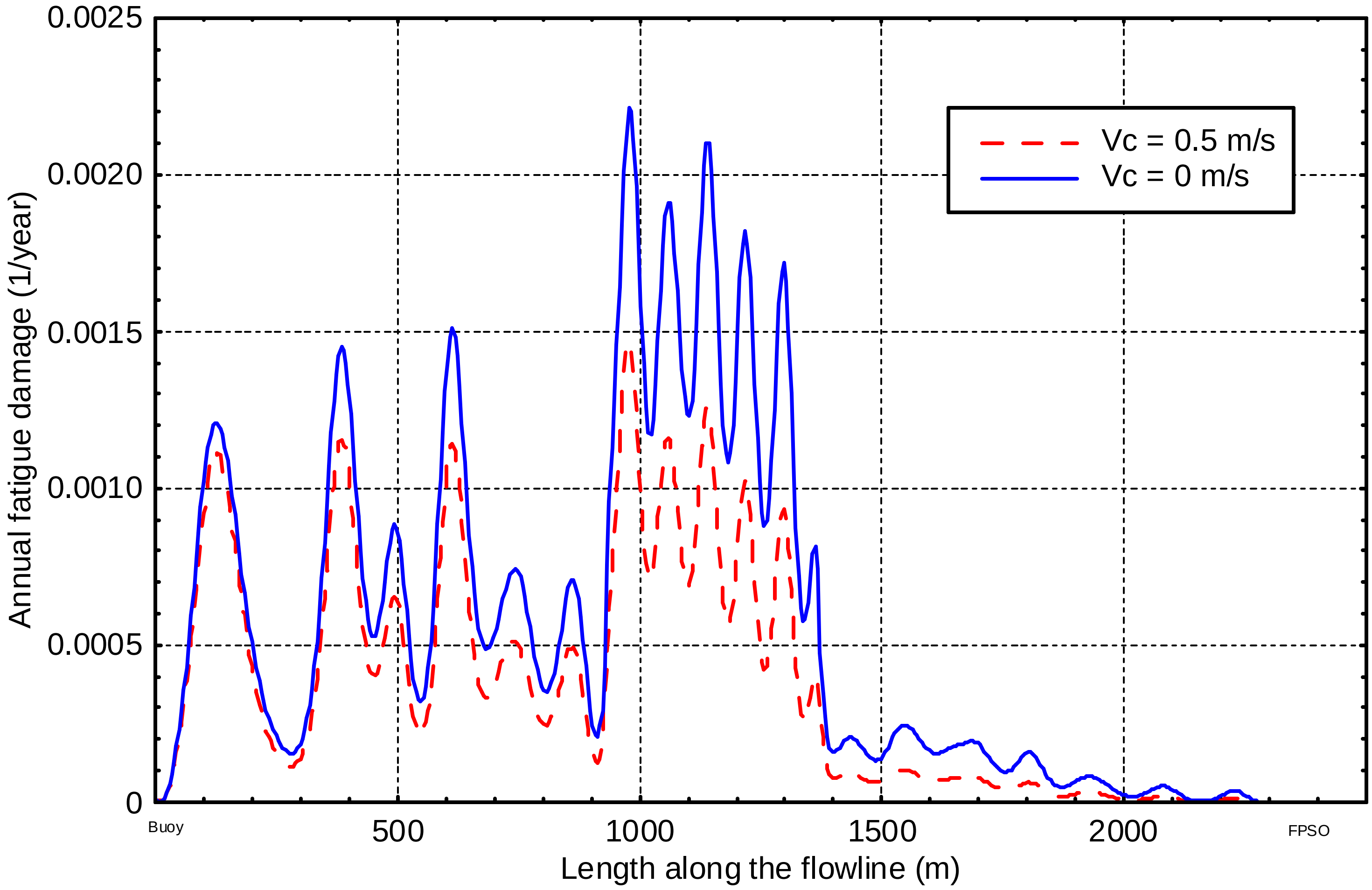
Sensitivity to Current Speed



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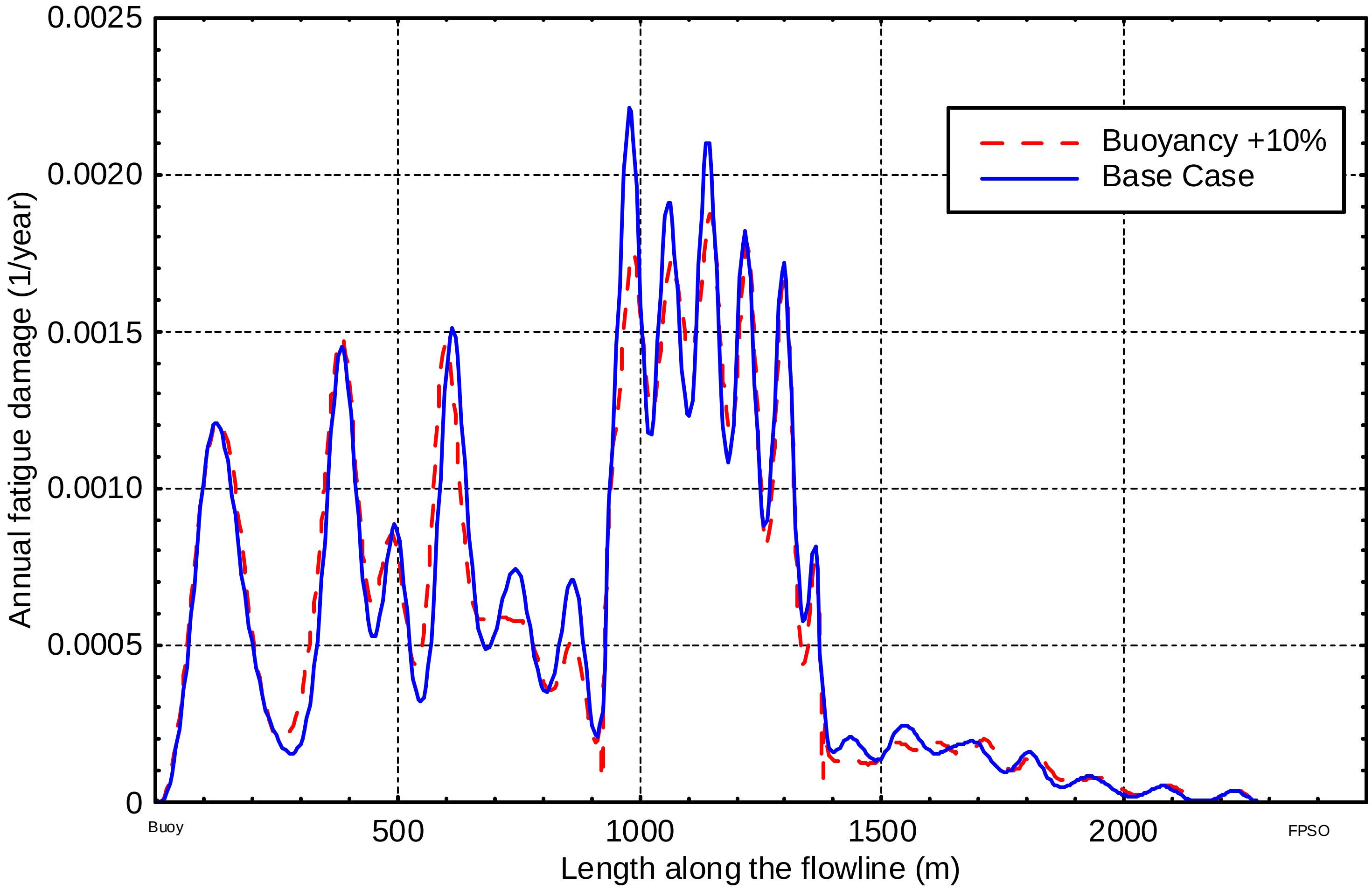
Sensitivity to Configuration



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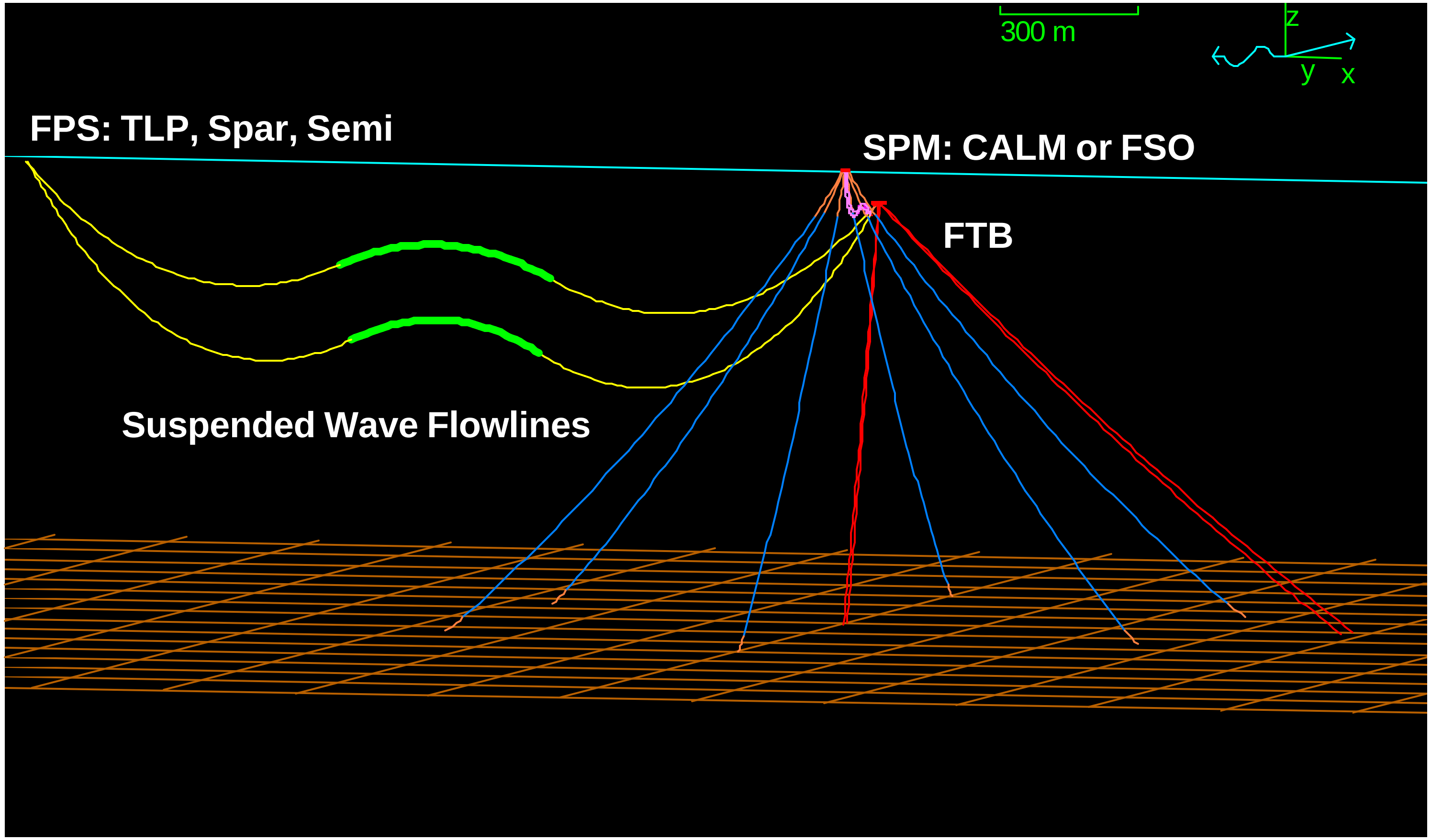
Flowline Termination Buoy System



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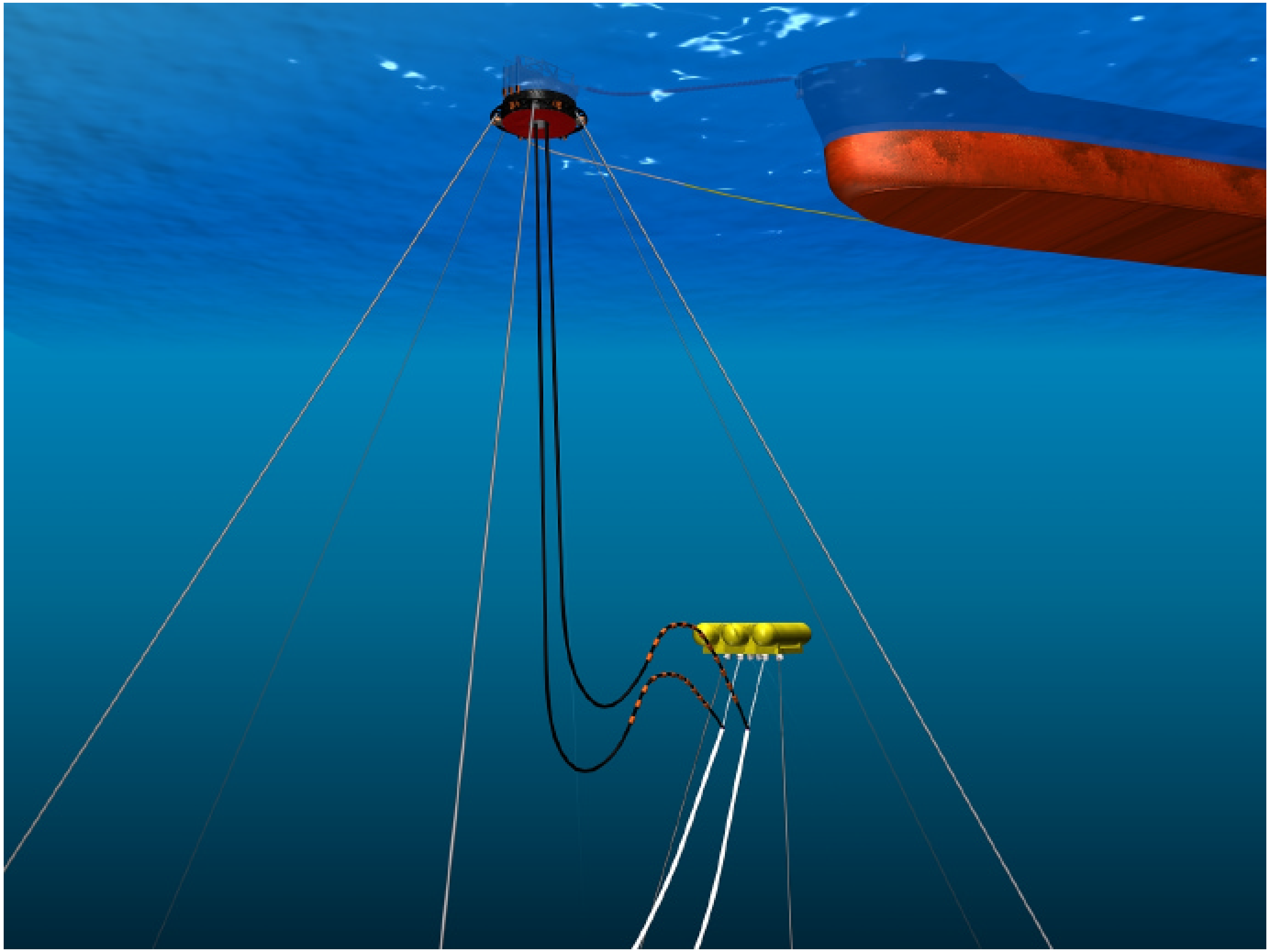
Flowline Termination Buoy System



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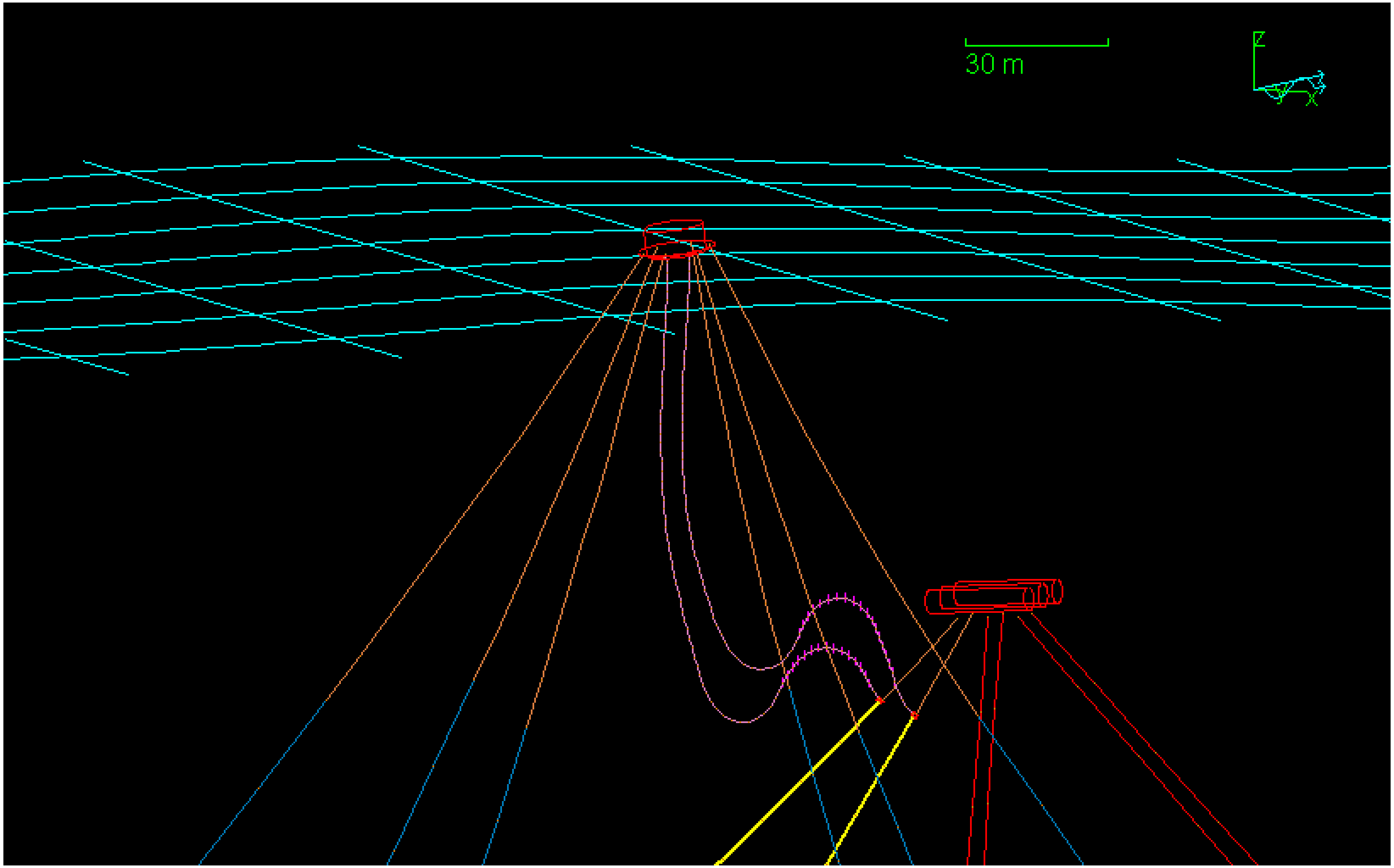
Simulation of FTB/Flowline Motions



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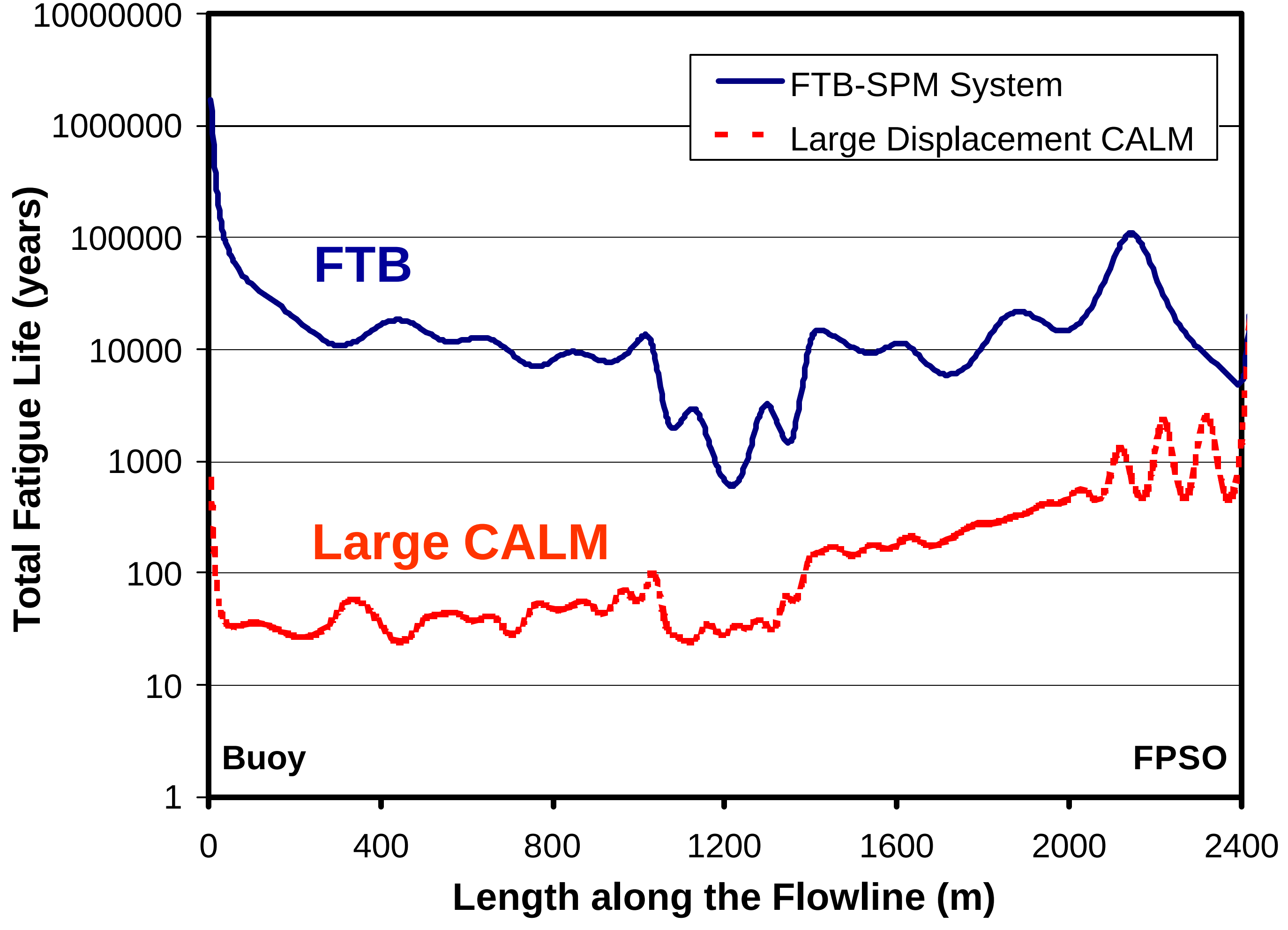
Fatigue Life Comparison



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Conclusions

- Buoy dynamics primary driver of flowline response
- Flowline response very sensitive to:
  - Orientation of flowlines relative to dominant wave directions
  - Drag coefficient
  - Representation of the swell environment
- Accurate and comprehensive fatigue analysis required
- Optimization of fatigue performance possible
- Decoupling of flowlines drastically improves fatigue performance