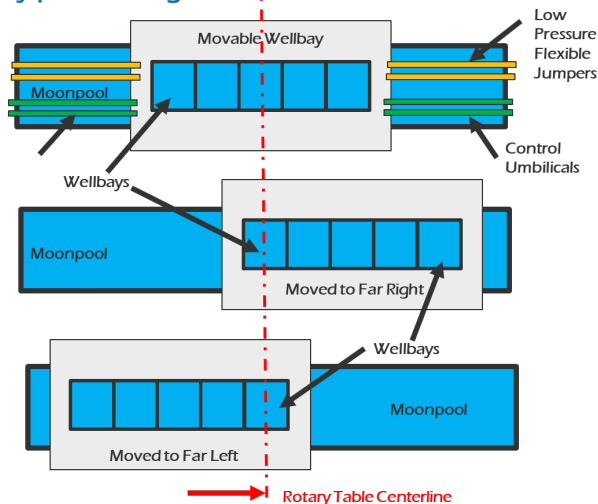


# Making Ultra-deep Water Discoveries Profitable at <\$40/bbl

## Frontier Production System (FrPS)

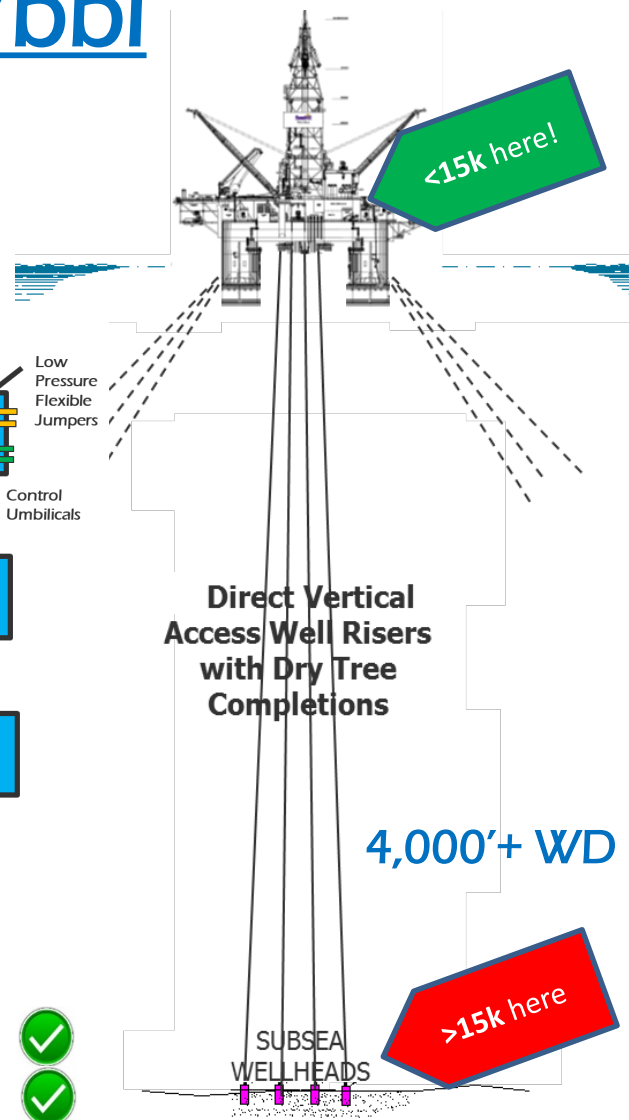


### Wellbay positioning



### Movable Wellbay in FrPS Moonpool

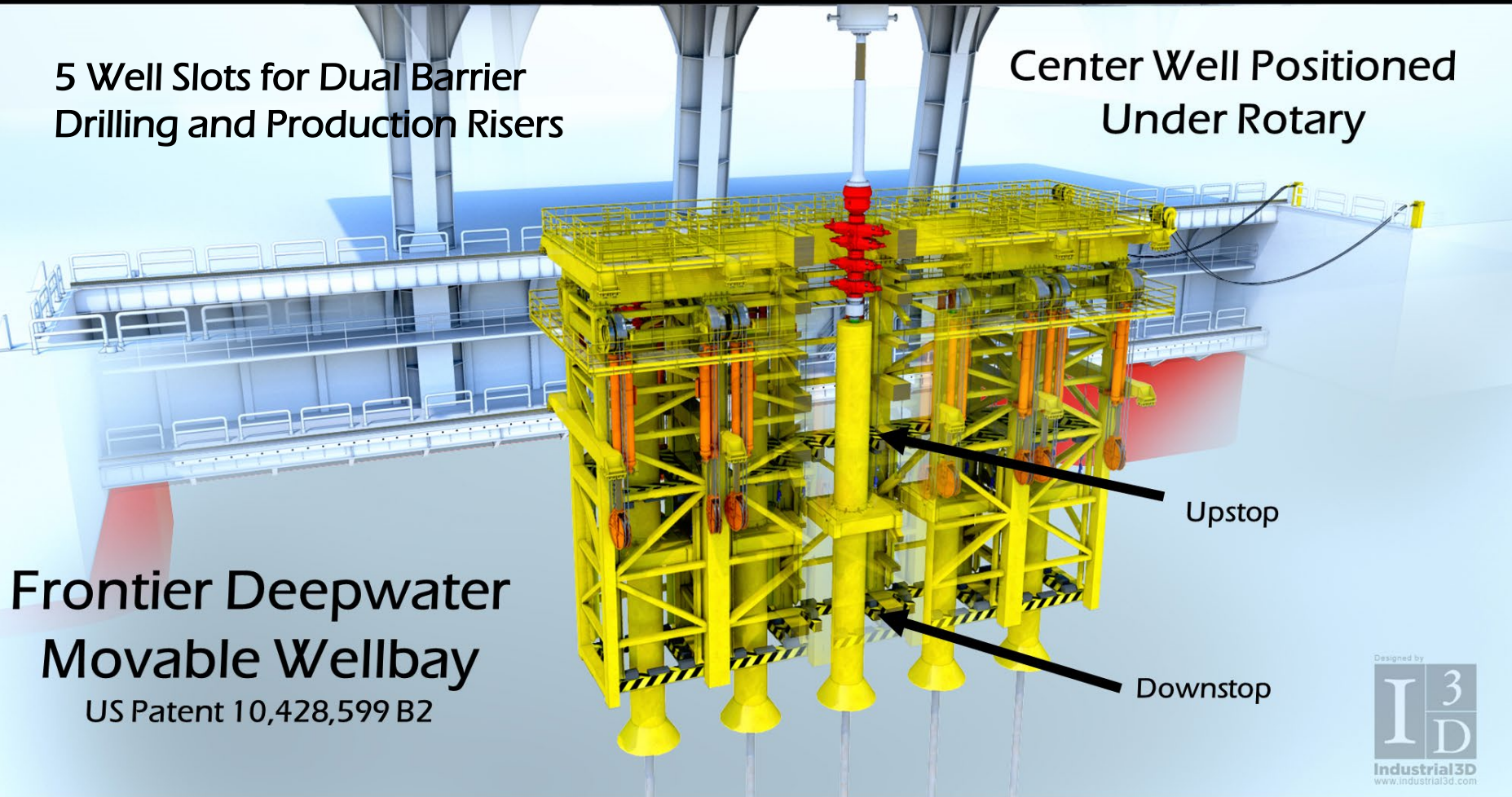
|                           |           |   |
|---------------------------|-----------|---|
| ABS Approval in Principle | 2017      | ✓ |
| BSEE Concept Review       | 2018      | ✓ |
| US & Foreign Patents      | 2018-2019 | ✓ |



# Frontier Movable Wellbay Centered Position in Moonpool

5 Well Slots for Dual Barrier  
Drilling and Production Risers

Center Well Positioned  
Under Rotary

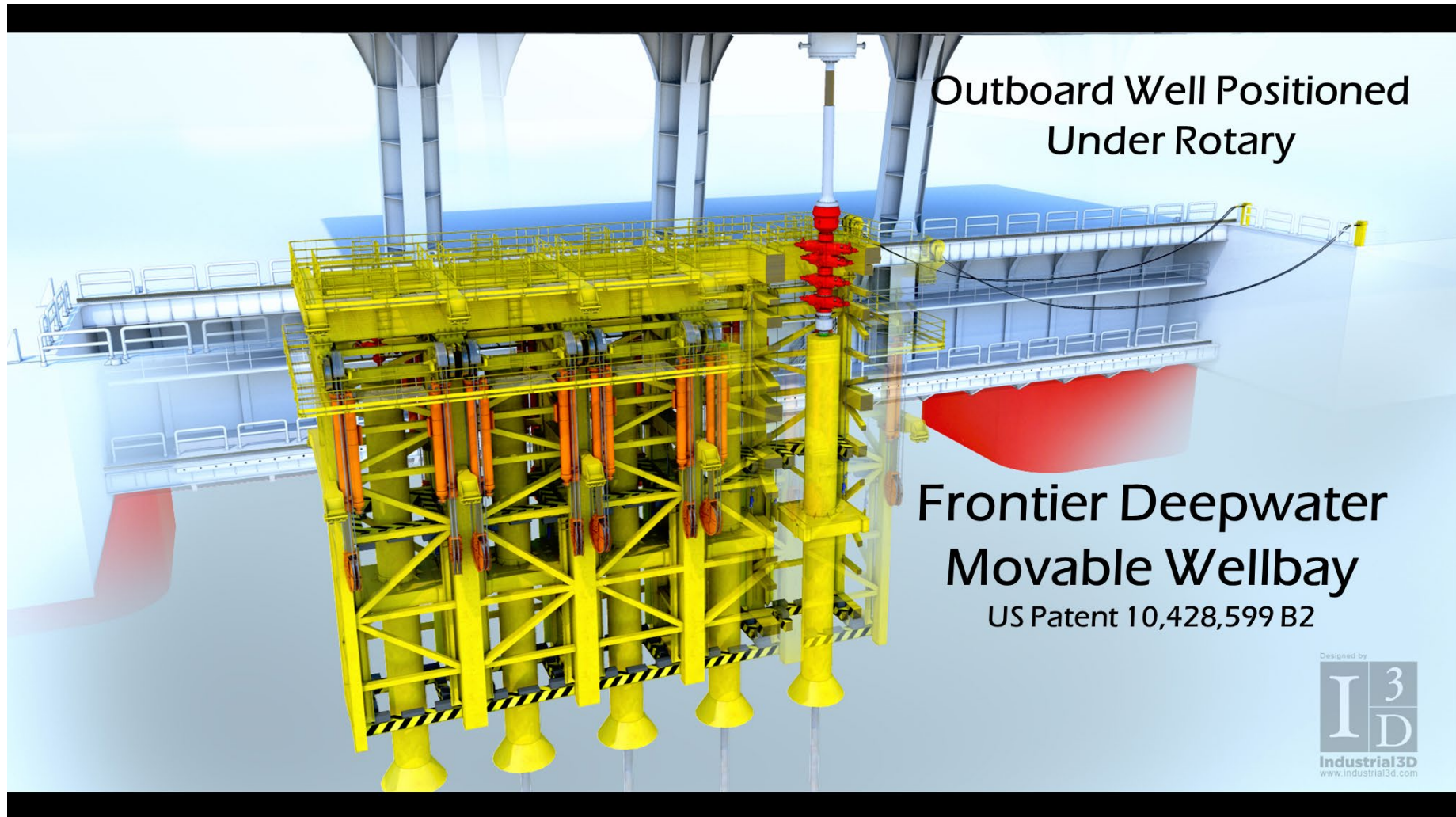


Frontier Deepwater  
Movable Wellbay  
US Patent 10,428,599 B2

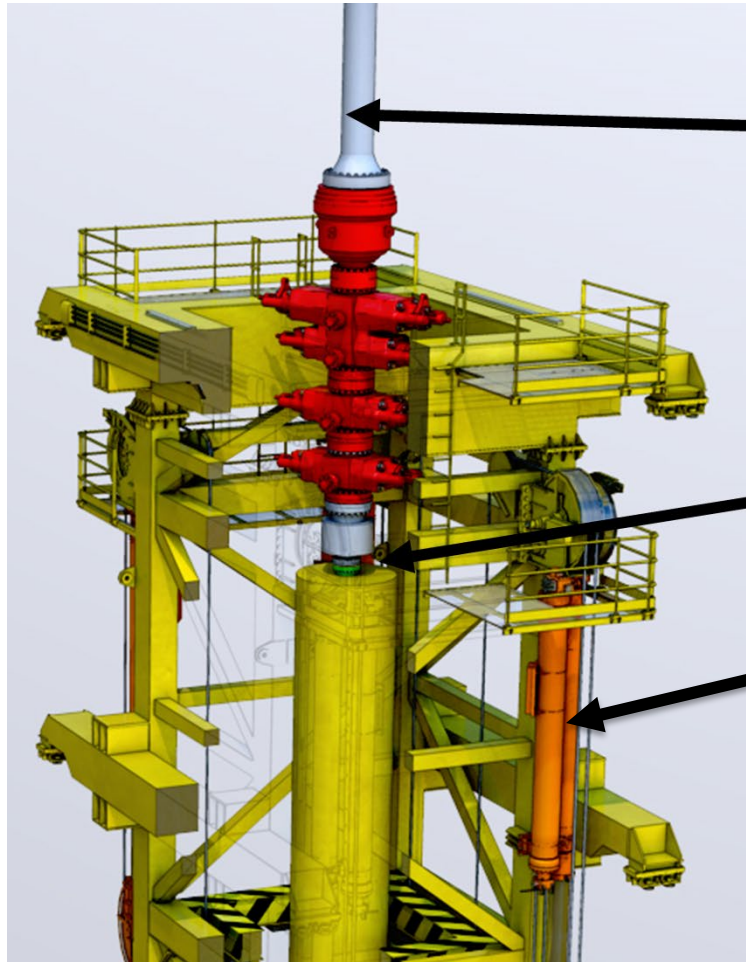
Designed by  
**I 3 D**  
Industrial3D  
www.industrial3d.com



# Frontier Movable Wellbay Outboard Position



# Frontier Movable Wellbay Slot Showing Surface BOP



Telescopic joint connected during 100 year winter storm, then removed when platform is abandoned for Hurricanes.

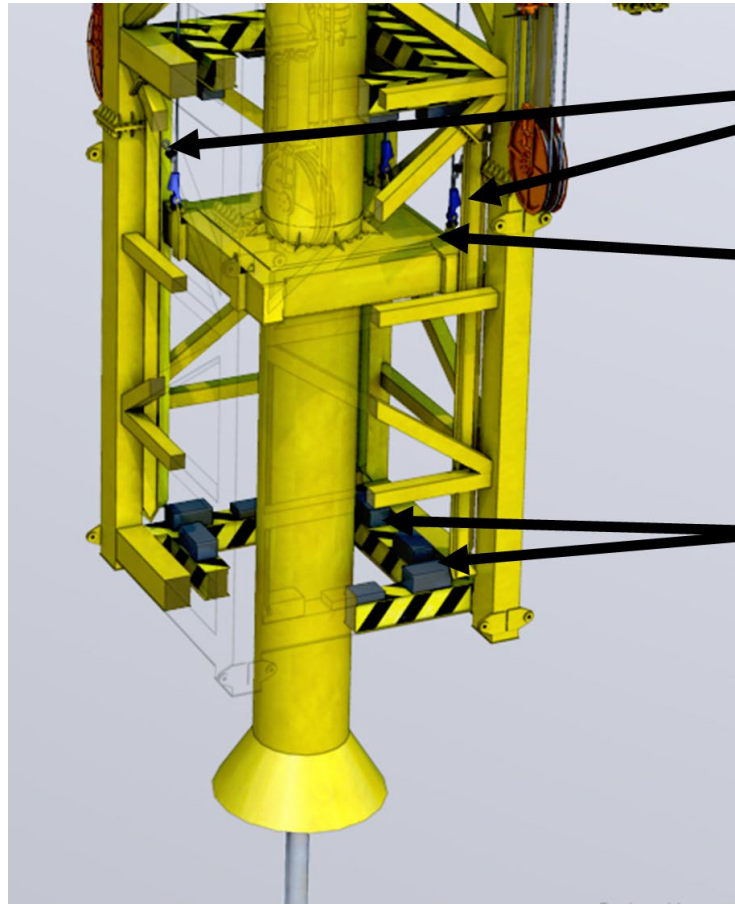
Surface Wellhead landed on Tension Joint. Riser is centralized inside tension joint.

(4x) 250 Kip Standard Wireline Tensioners

**Frontier Deepwater  
Movable Wellbay**  
US Patent 10,428,599 B2



# Frontier Movable Wellbay Slot Guides & Stops



UHMW Wear Strips with very low coefficient of friction allowing the tension ring to slide up and down inside the frame.

"Tension Ring" showing wireline riser tensioner connections

Soft and Hard Rubber Pads to Allow the Tension Ring to land out on the up and down stop with minimum impact loads

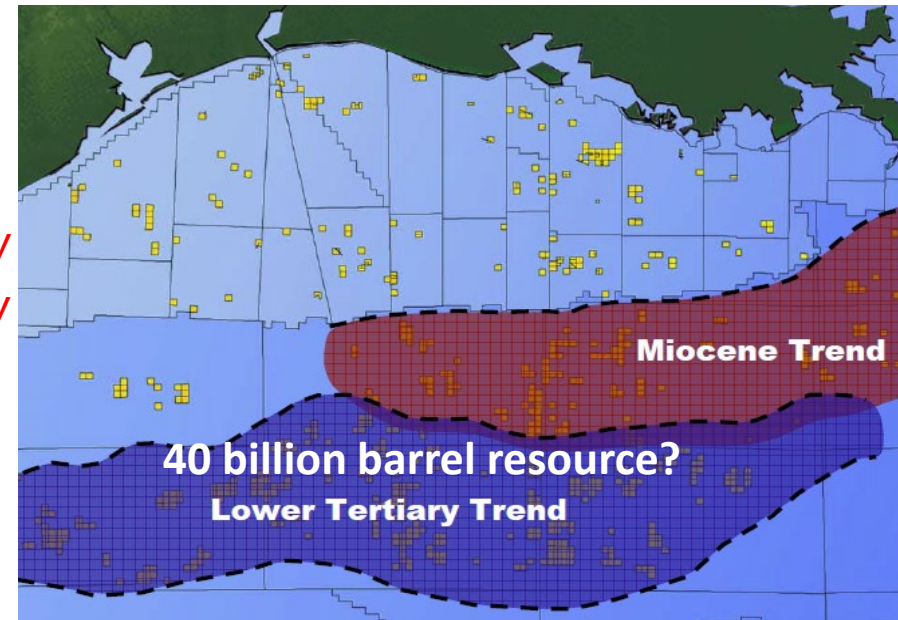
**Frontier Deepwater  
Movable Wellbay**

US Patent 10,428,599 B2



# The Commercial Setting for GoM Lower Tertiary In a Critical State

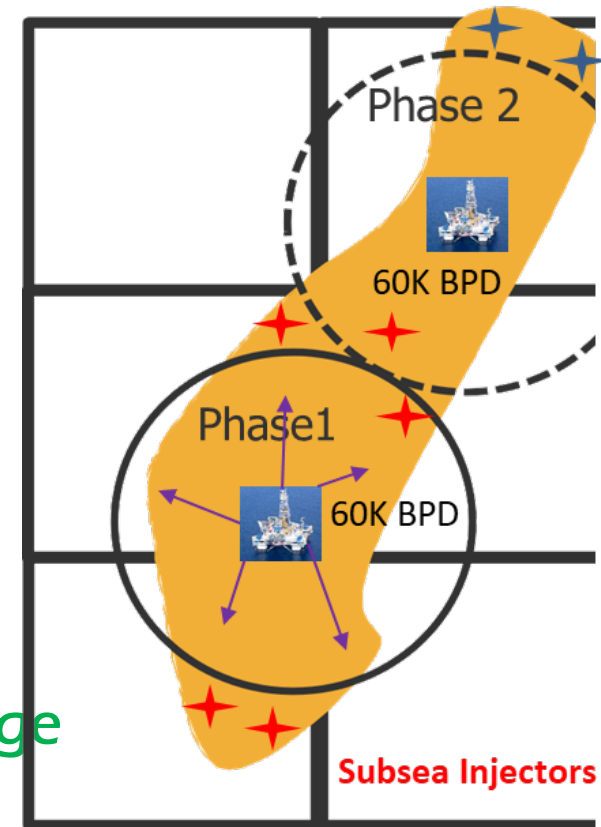
- **Daunting subsalt reservoir uncertainty**
  - Faulting and connectivity?
  - Reservoir drive mechanism??
  - Sand control & completion???
  - Tight rock requiring enhanced recovery
  - Intervention frequency and fluid quality
  - Appraisal requires 5+ wells to sanction full field development (\$2+ billion)
- **Very high drilling and completion costs**
  - 35,000' wells requiring >250 days
  - 20K MODU and intervention system with 20K back up?
  - 20k subsea trees, controls and HIPPS
    - massive CAPEX, OPEX and RISKE



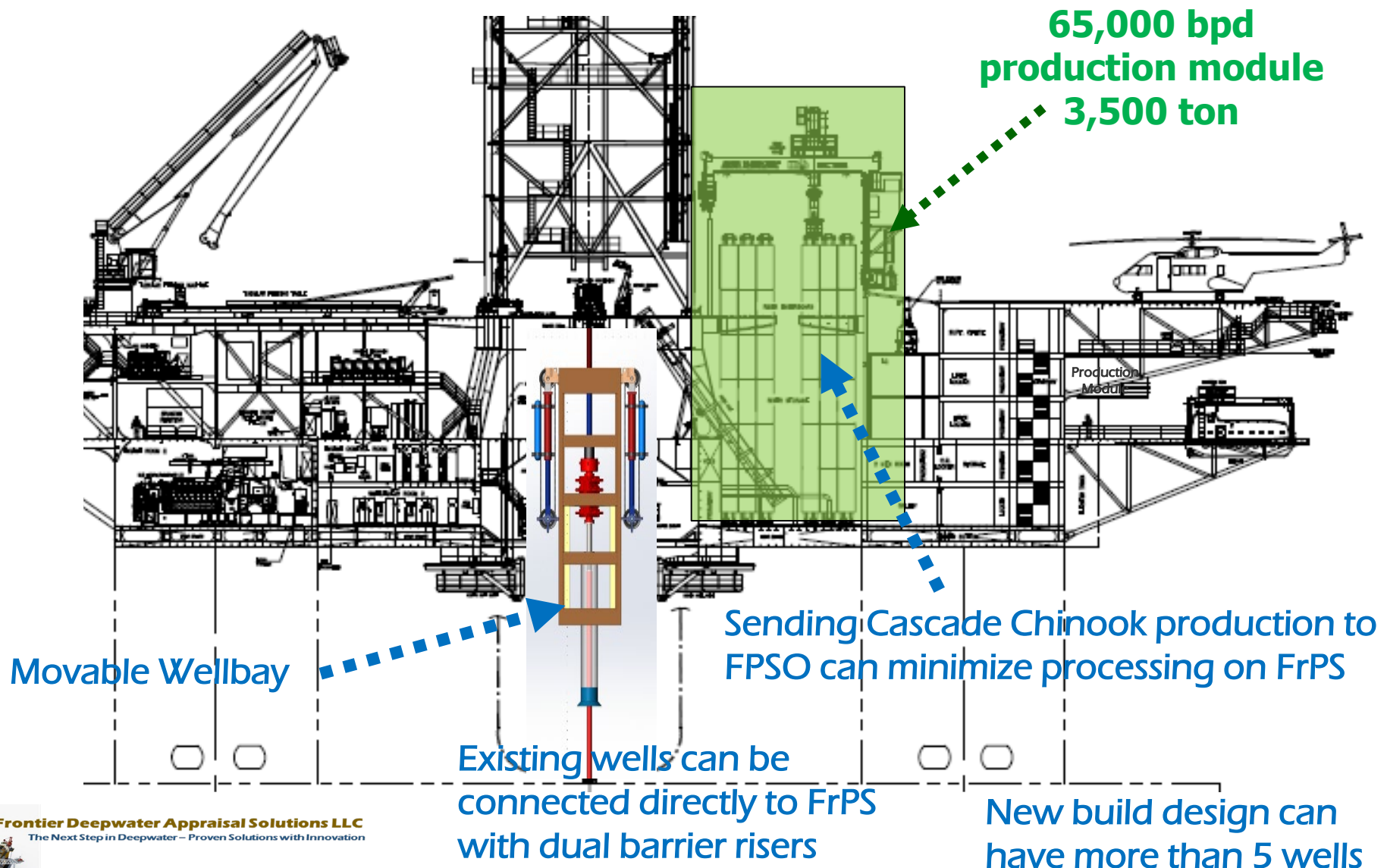
➔ **Lack of reservoir information means huge, riskier bets by Operators**

# Why the FrPS with Movable Wellbay is the Right Solution

- Phased Approach Reduces Cost & Risk
  - 50% of a Hub-style subsea development
  - Delivered in 3 years or less
  - Eliminates the need for drillship contract
  - Earliest dynamic reservoir information
  - Increases completion access and reserve recovery with direct vertical access
  - Safer hydraulic controlled equipment
  - Permanently moored with fully rated dual barrier risers
    - Eliminates the Macondo scenario
  - Standardized development scheme
  - Can be moved and reused over a wide range of water depths

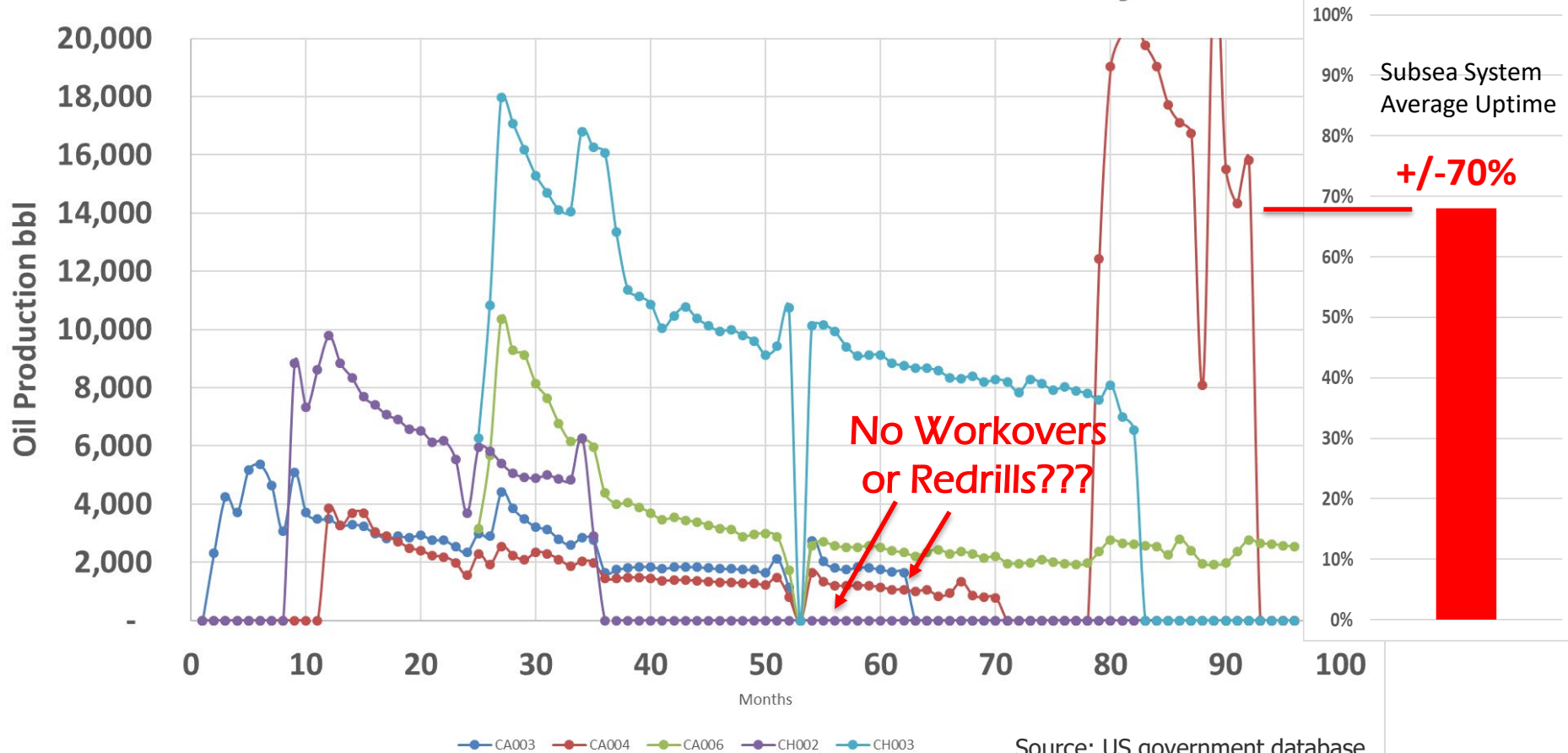


# Conversion to FrPS is straightforward but newbuilding is an option



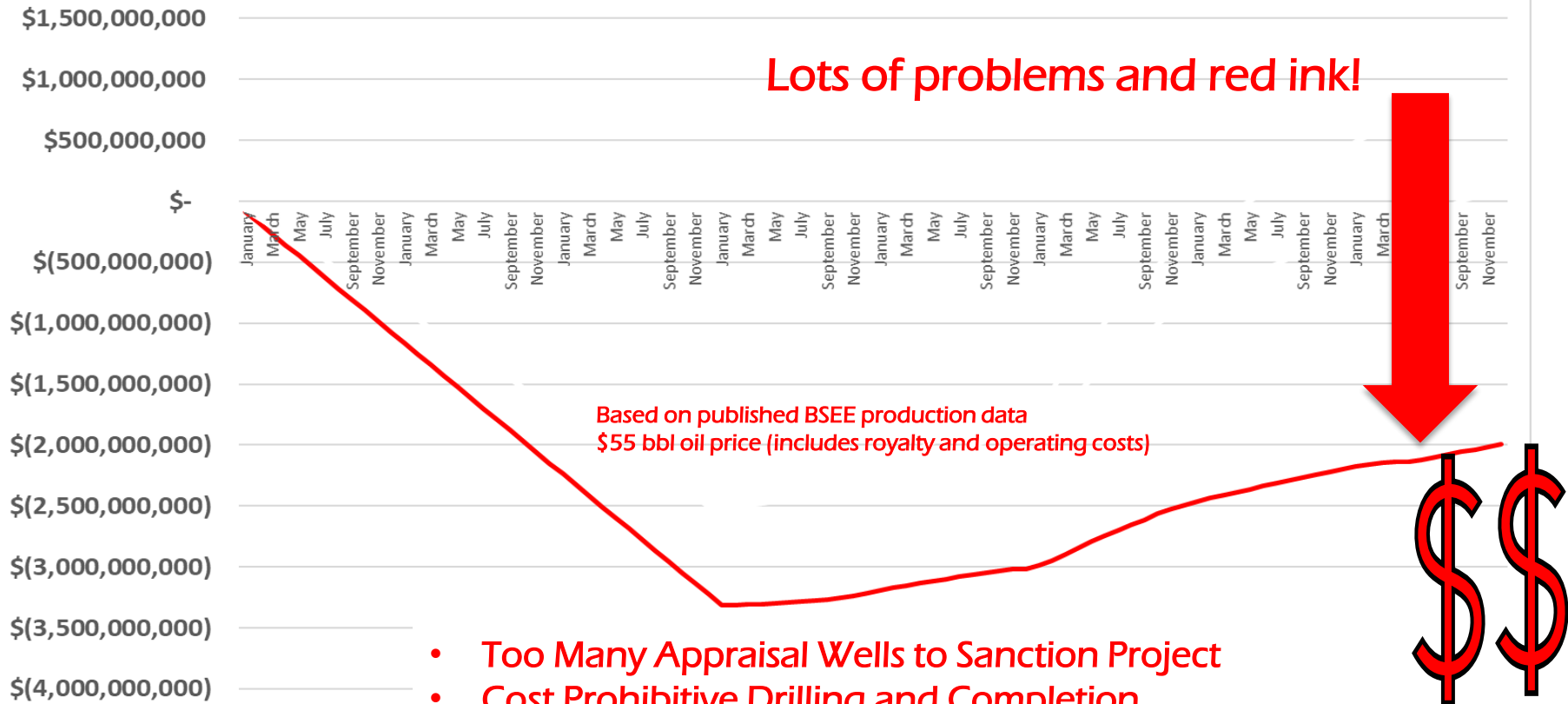
# Is the Cascade Chinook Subsea Development Meeting Expectations?

## Cascade Chinook Production History



# Subsea Lower Tertiary Concept Delivers Negative Economics

## Cascade Chinook Net Revenue Comparison



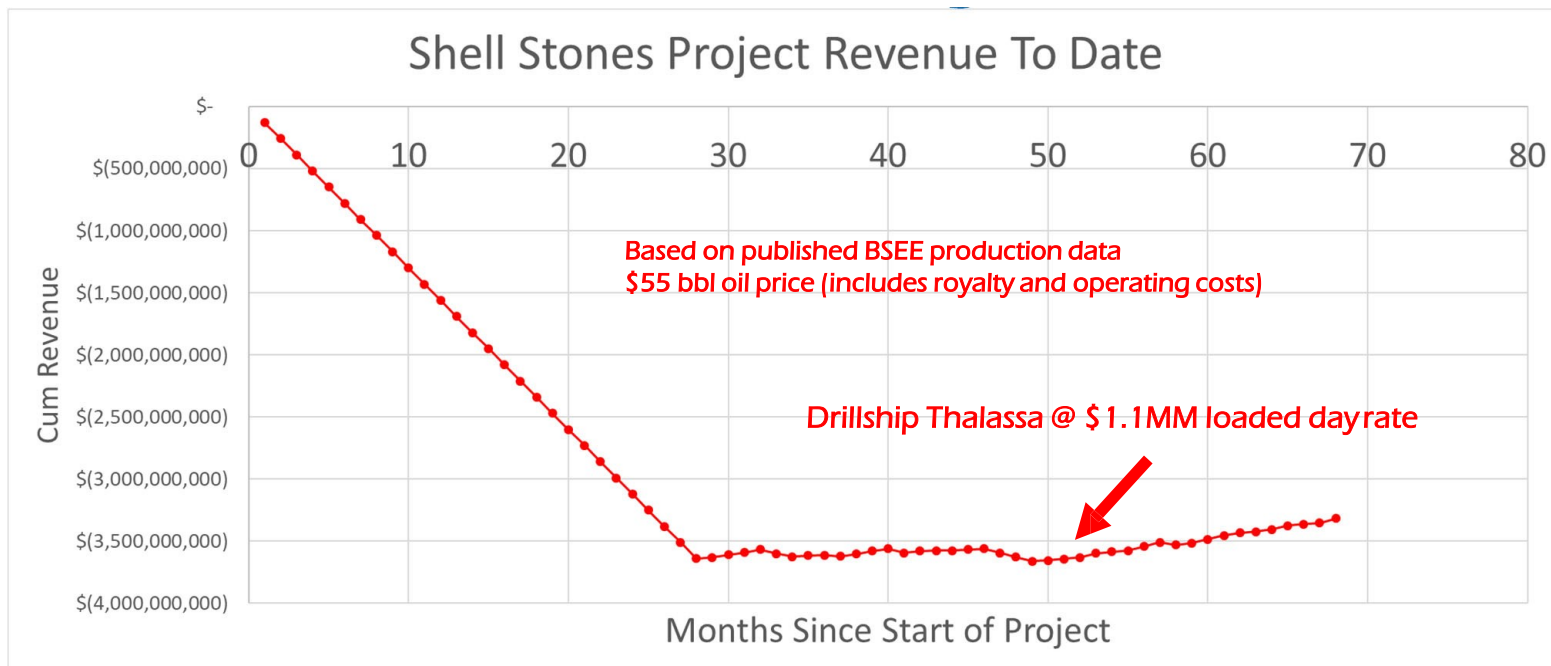
- Too Many Appraisal Wells to Sanction Project
- Cost Prohibitive Drilling and Completion
- Risky Full Field Sanction Rather Than Phases
- Excessive Operating Costs and Expensive Redrills
- Complex and Less Dependable Subsea Equipment – 30 year life???
- Subsea Pumping Not as Effective





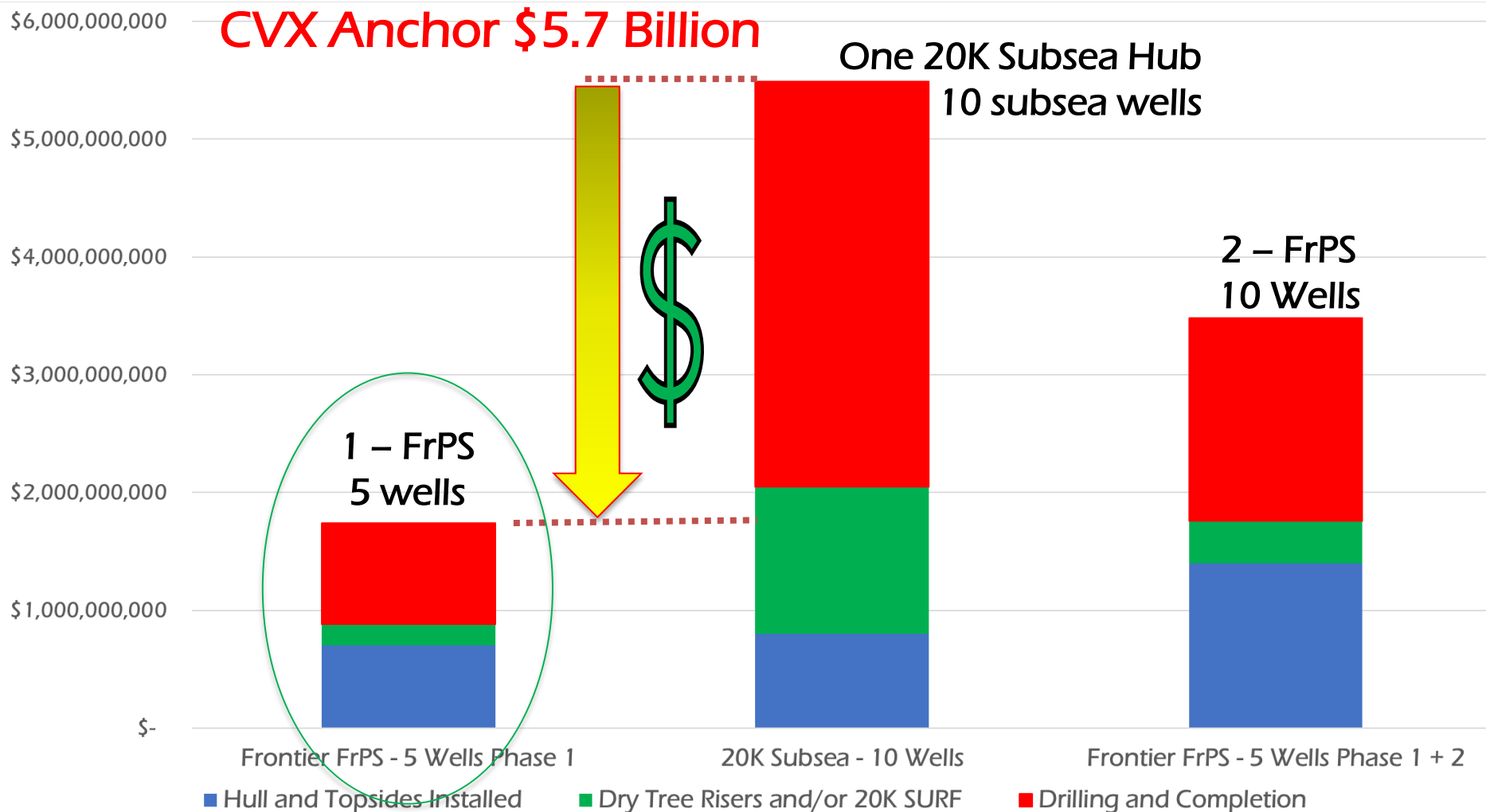
# Lower Tertiary Problems Plague Shell STONES Subsea System

- **Problem:** The STONES field is losing billions of dollars



- STONES field was brought onstream in 2016...11 years after discovery in 2005
  - Phase 1 was sanctioned in 2013 when oil & gas prices were \$100 per bbl
  - SHELL has invested billions into STONES including 15 subsea wellbores plus sidetracks

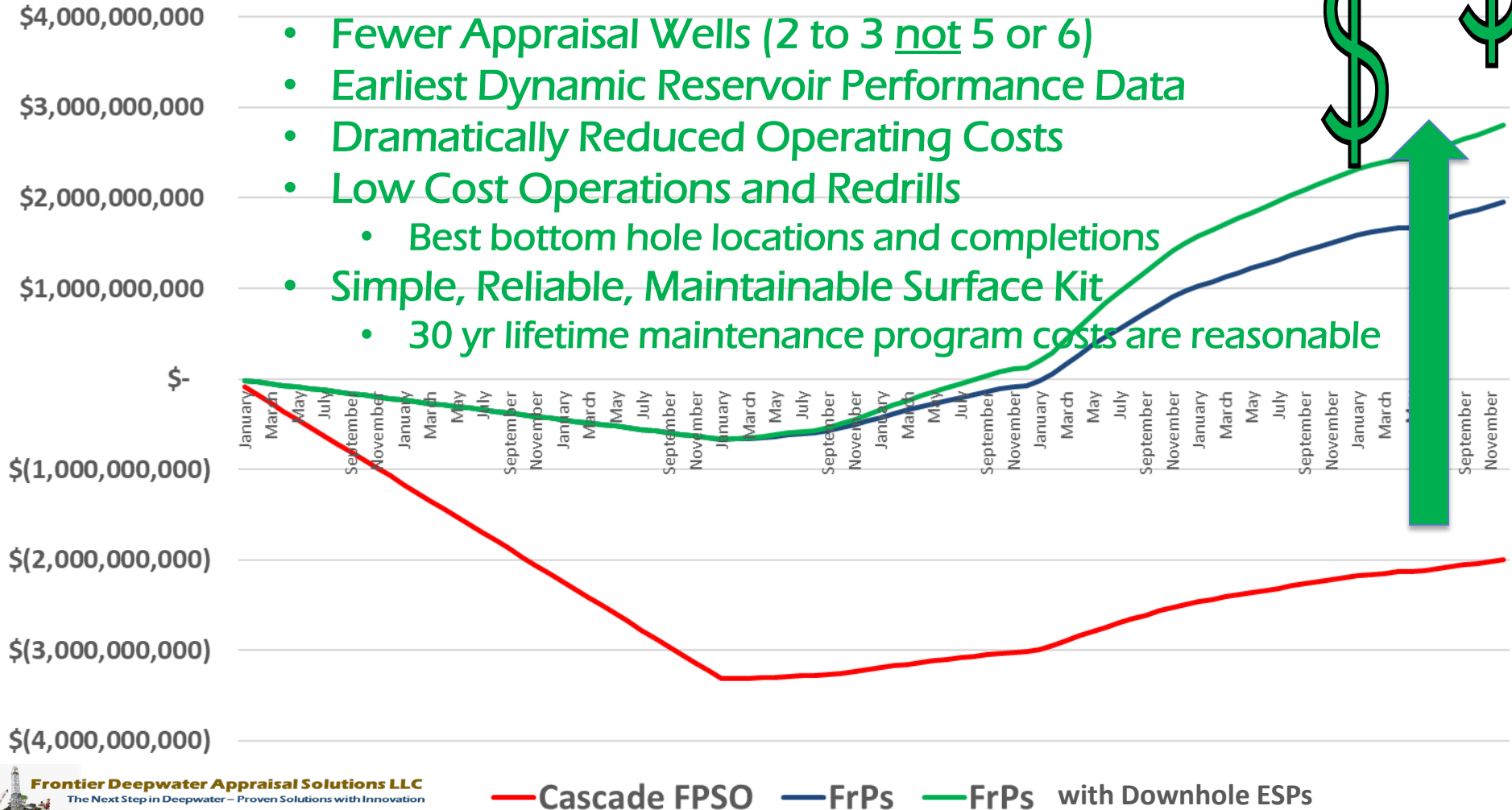
# FrPS provides Game Changing Cost Reduction - Current Cost Comparison



# Dramatically Improve Performance and Reduce Risk with the FrPS

## Cascade Chinook Net Revenue Comparison

- Fewer Appraisal Wells (2 to 3 not 5 or 6)
- Earliest Dynamic Reservoir Performance Data
- Dramatically Reduced Operating Costs
- Low Cost Operations and Redrills
  - Best bottom hole locations and completions
- Simple, Reliable, Maintainable Surface Kit
  - 30 yr lifetime maintenance program costs are reasonable



# FrPS Well System Configuration Options

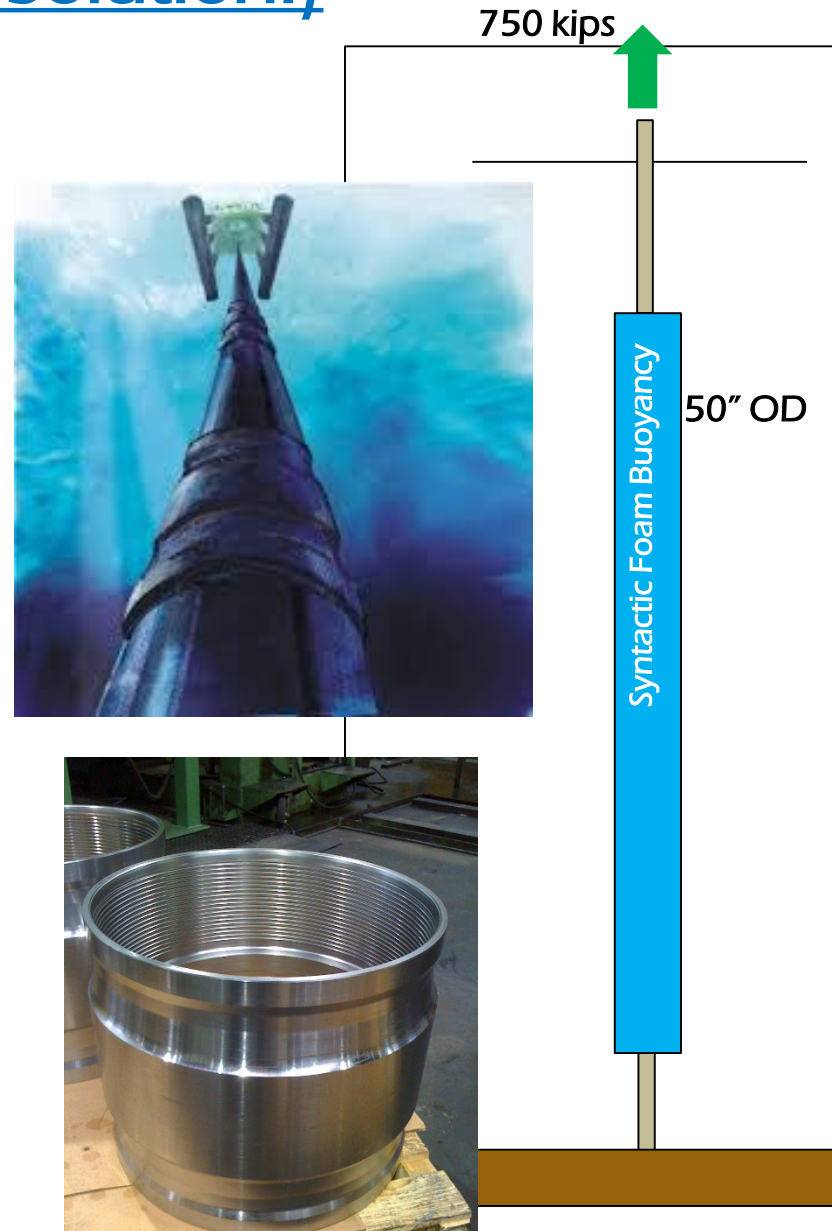
- Option to use 21" OD drilling riser
  - Wells can be pre-drilled with a 15K fleet MODU thru setting 14" casing
- 16" OD outer production riser can be used as a drilling riser with a mudline isolation package
  - \*13-5/8" 15K Surface BOP
- 11-3/4" inner production riser provides fully rated dual barrier system for completions and workovers
- Risers remain connected for hurricanes
  - Movable wellbay centered and locked
  - Risers never exceed 80% of yield



# Movable Wellbay RISER FUNDAMENTALS

## (A Well Systems Solution!)

- Risers have syntactic foam buoyancy to reduce tensioner size to 4 x 250 kips per slot
- Risers stroke freely on tensioners in all winter storm conditions (100 yr)
- Risers allowed to land on the “stops” and stretch for survival conditions
  - Tree and BOP remain inside deck when riser is on downstop
  - Total riser stretch is on the order of 5' in 8,000' of water or 0.06 per cent of length – less than 1/10<sup>th</sup> of a percent!



# Let's Change the Game to Win!

## Lead and Adopt an Industry Enabling Solution!!

### Next Steps (with Murphy's preferred Contractors\*)

- **6<sup>th</sup> Gen MODU Study**
  - Leased/Purchased
  - Movable Wellbay Design
- **Top Tension Riser System Design**
  - 15K system prequalified

\* Frontier has proposals from 2H, Dril-Quip, Schlumberger and Transocean. All are interested but looking for an Operator to take the lead on a project.

### Key references from past work:

- OMAE 2010 – 20904 Design And Qualification Of Fatigue Resistant Heavy Wall Threaded & Coupled Premium Connectors For Drilling And Production Riser Applications In Deepwater Hpht Dry Tree Systems, Roy Shilling, BP America
- OMAE 2011 – 49424 Limit State Design Based On Experimental Methods For High Pressure, High Temperature Riser And Pipeline Design, Roy Shilling, BP America
- RPSEA Swri Projects 18.146 and 18.149 Corrosion-fatigue Performance Of High Strength Riser Materials In Seawater And Sour Brine Environments FINAL REPORT, Roy Shilling, BP America

