

Monitoring Mooring Systems

—
FER Forum
Nov/24

Lucas Castelli

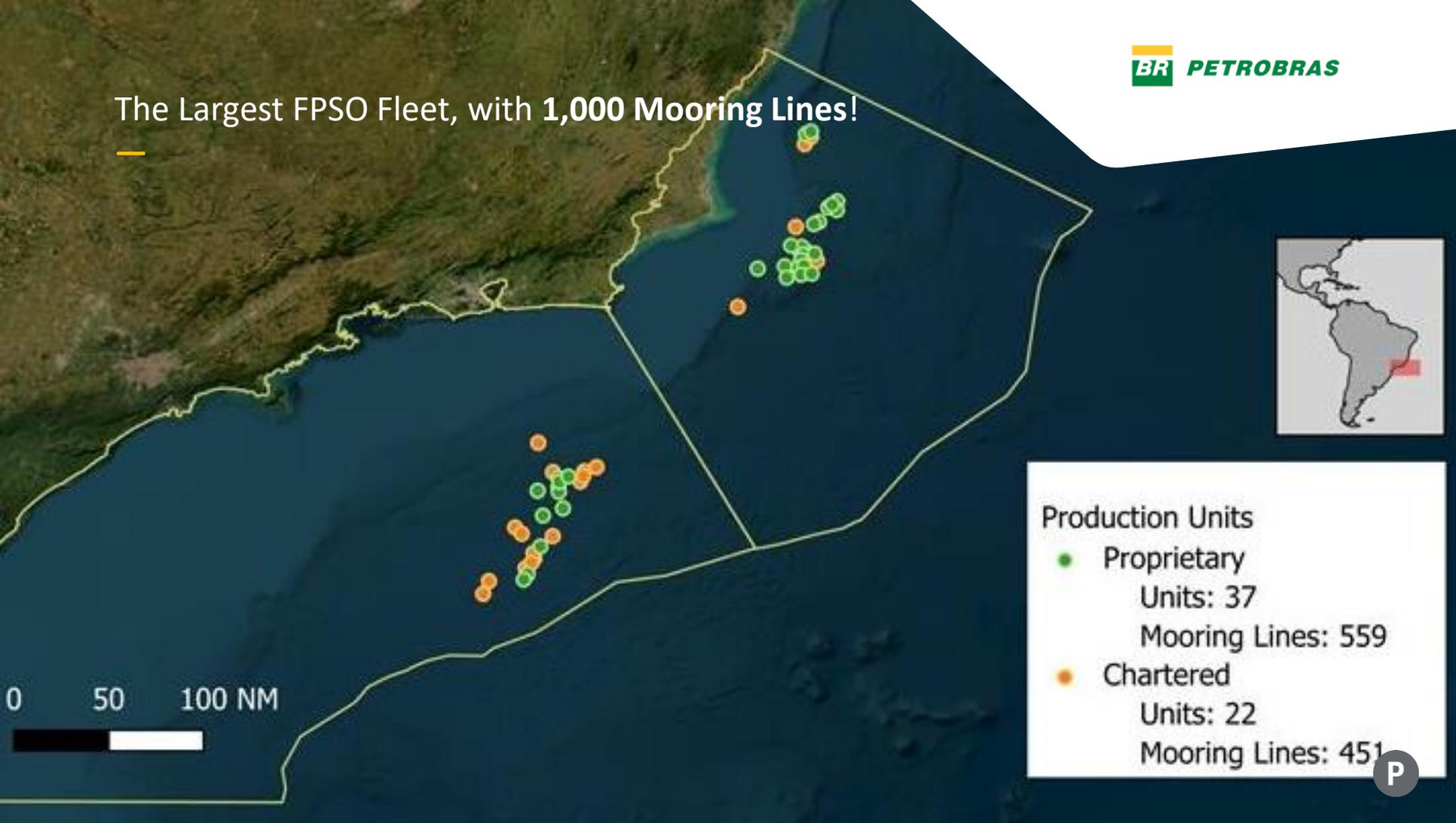
Agenda

- Contextualization
- Monitoring Applications
- Final Remarks
- Partners

Contextualization



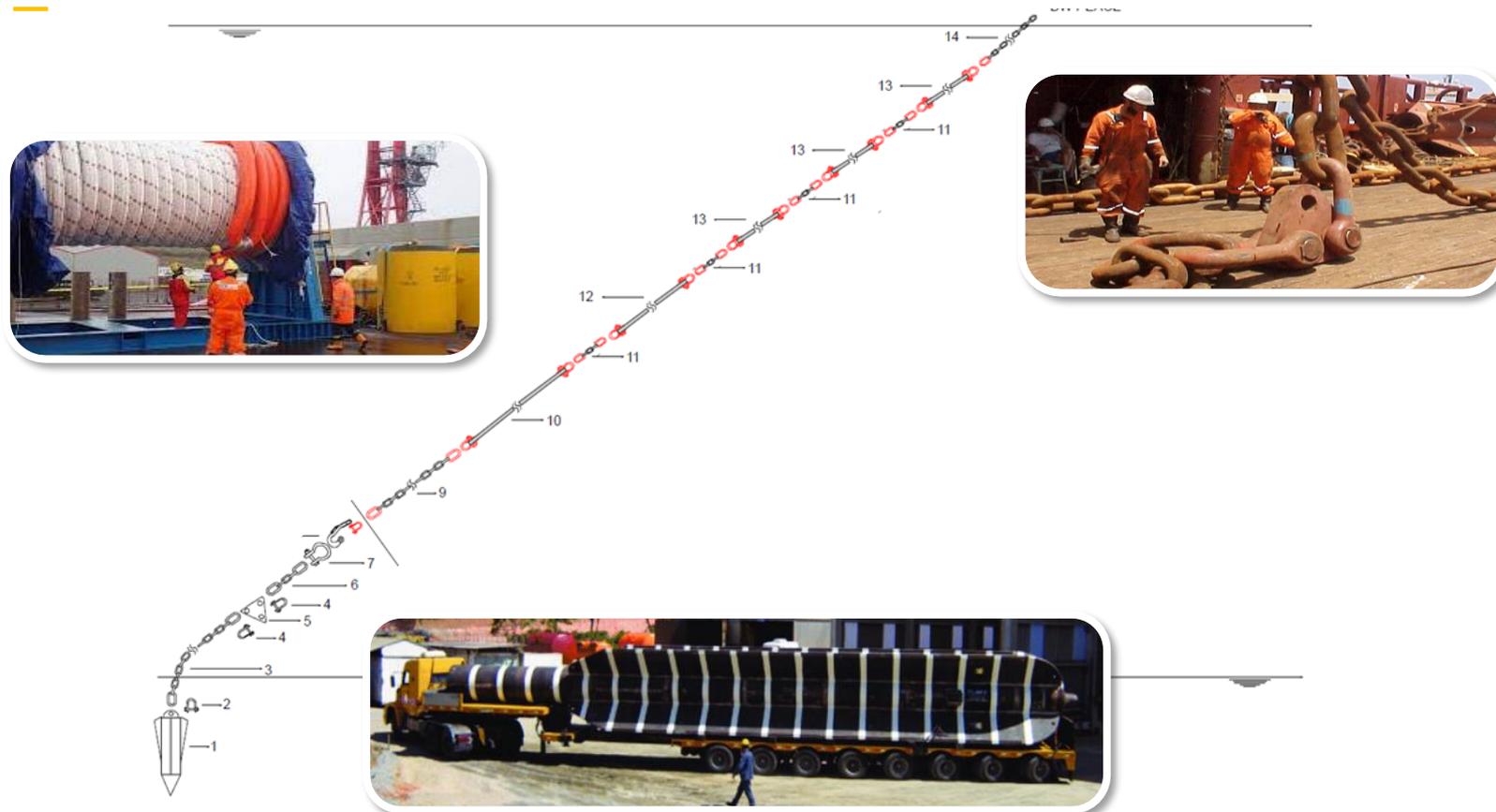
The Largest FPSO Fleet, with 1,000 Mooring Lines!



Production Units

- Proprietary
Units: 37
Mooring Lines: 559
- Chartered
Units: 22
Mooring Lines: 451

Back to Basics



Show must go on!

Our production
2,69 MM BOE/day



**LINE FAILURE STOPS
PRODUCTION!**

N° of Unit x Petrobras fleet age

13(35%)



Up to 10 years

9(24%)



10-20 years

15(40%)



Over 20 years

Failure rate x Operating Time

0.30%



Up to 10 years

0.74%



10-20 years

1.67%

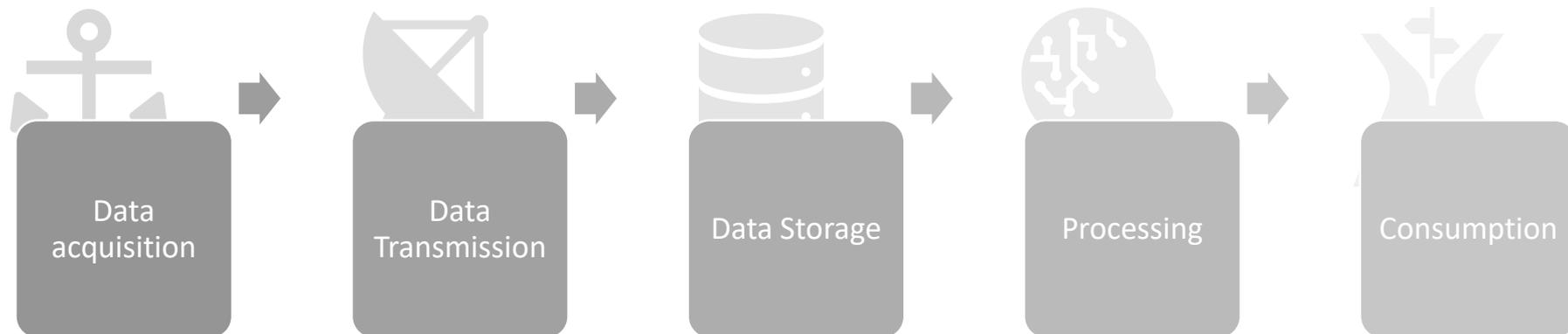


Over 20 years

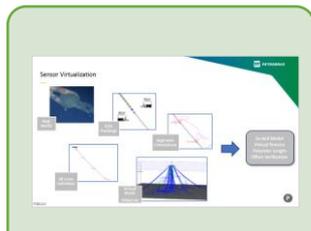
Monitoring Applications



From Offshore to decision making



Several Applications



**SENSOR
VIRTUALIZATION**



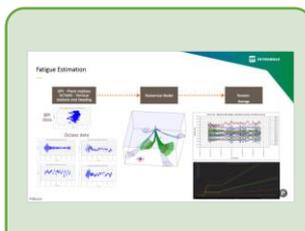
**DATA
VISUALIZATION**



**INTEGRATED
ANALYSIS**



**FAILURE
DETECTION**



**FATIGUE
ESTIMATION**



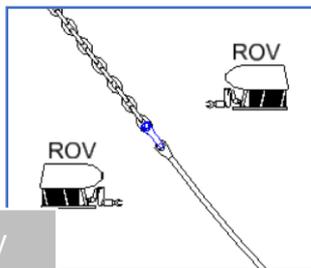
**INTEGRITY
MANAGEMENT**



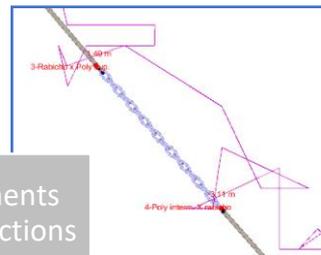
Sensor Virtualization



Real World



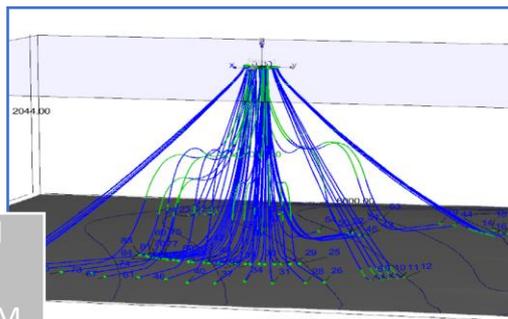
ROV Trackings



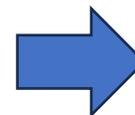
Segments Connections



All Lines Definition



Virtual World
DYNASIM



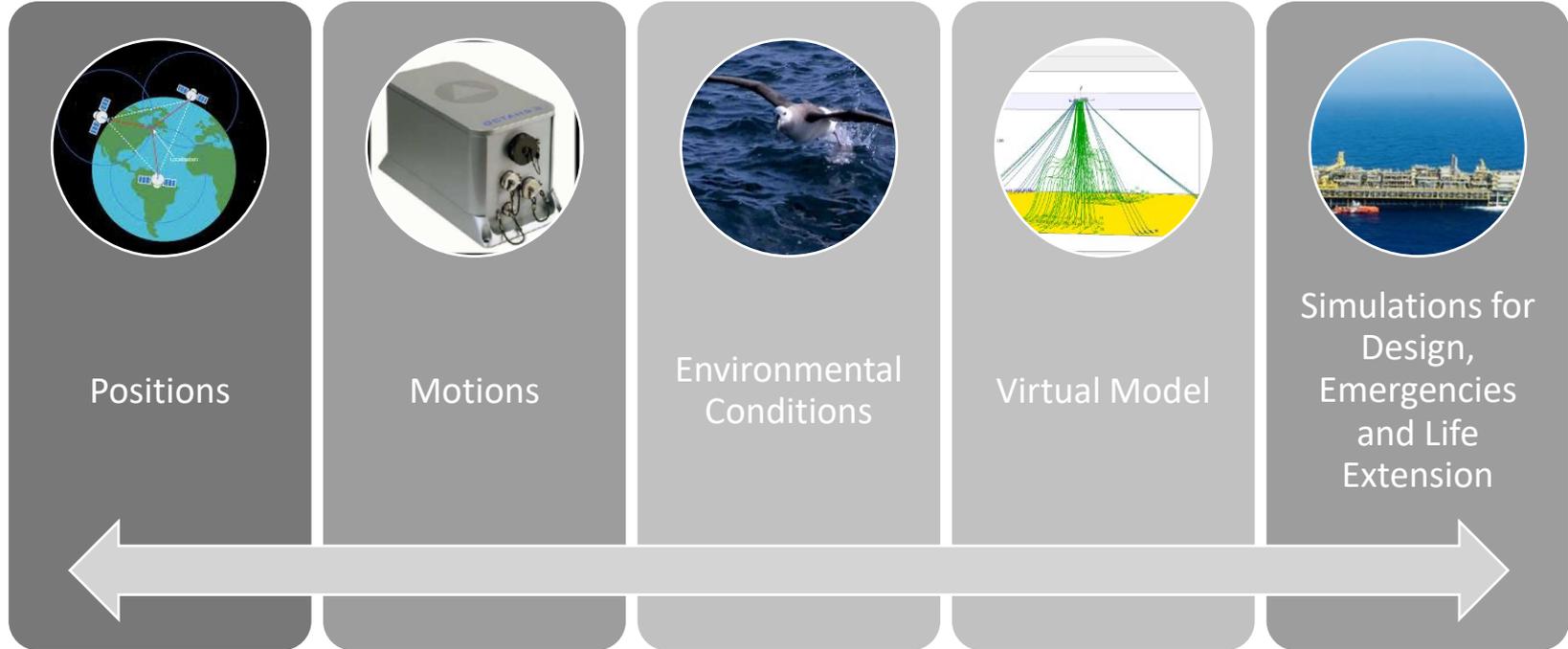
As-laid Model
Virtual Tension
Polyester Length
Offset Verification

Data Visualization

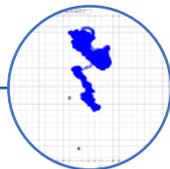
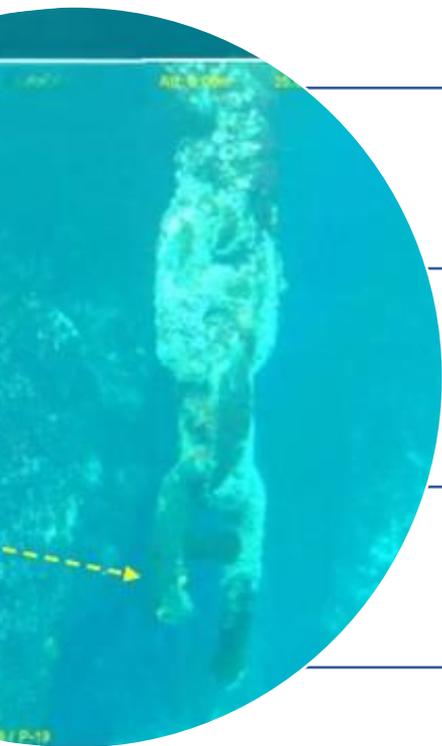
Anytime, Anywhere,
to Anyone
Sensors, Inspections
and Calculations



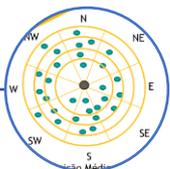
○ Control Room
 ○○ Overview
 ○○○ Onboard
 ○○○ Screen sample



Failure Detection



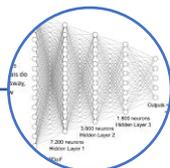
OFFSET
100% IMPLEMENTED



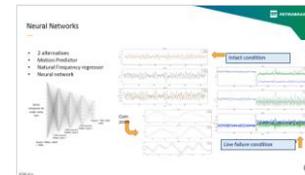
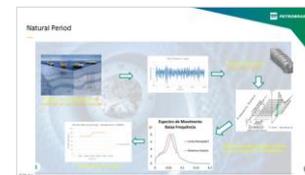
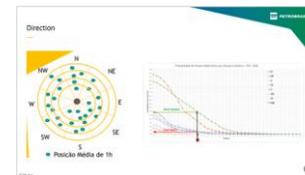
DIRECTION
UNDER DEVELOPMENT



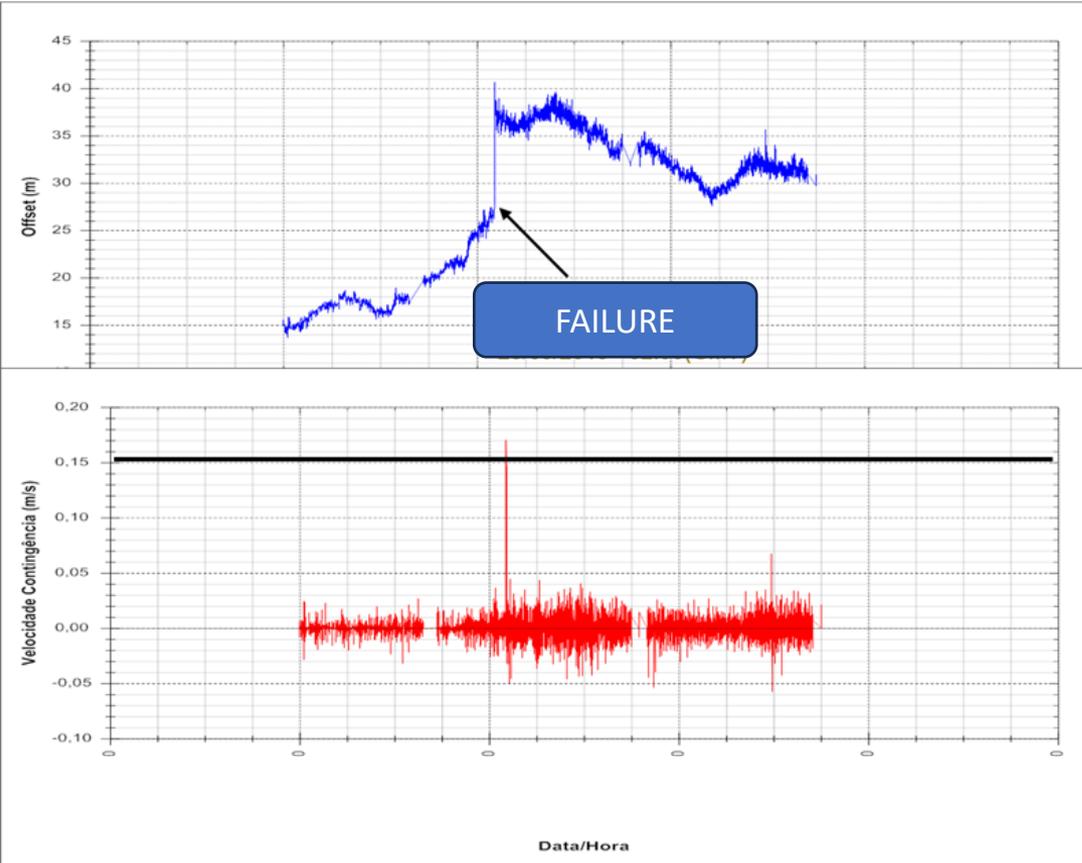
NATURAL PERIOD
UNDER DEVELOPMENT



NEURAL NETWORKS
UNDER DEVELOPMENT



Offset



- Offset monitoring
- Offset velocity
- Pattern differences

PETROLEO BRASILEIRO S.A. PETROBRAS
Av. José de Medeiros Filho
Av. República do Chile 330 Centro
RIO DE JANEIRO-RJ
20031-120

Date: 2023-03-10
Our reference: 17281-3-11

PETROBRAS 74.10 17281 FIC

Reference is made to your e-mail status as shown below:

Document No. Rev
CT FEO 0242021 --

Document No. CT FEO 036203
PRODUCTION STORAGE AND
03.3001-01, with the following:

205013 FIC_1

This approval covers monitoring in capacity of the system to detect Sec.4 (14.2) for permanent moon approval (a. Missing Line Test

DNV Classificação, Certificação e Consultoria Brasil Ltda
Região Americas
Approval and Site Operators
Rua São Bento, 16
5th and 6th floors

BRASIL
SINOSSE & OFFSHORE

INDEPENDENT REVIEW CERTIFICATE
FPSO PETROBRAS P-38
Mozão - (BR-VZL)

Document No. CT FEO 026202
Storage and Offloading FPSO P

Requirement: ISO 19901-2 (5 Mobile Offshore Units)

Client: Petrobras
Description: Software development
Design Reference: Software SC Software Methodology: Integrated Criteria for Operation of a Process

The criteria for break line detect the P-38 offset and velocity after Mooring System:

- Location: Marlin Sul Field / Ca
- Depth: 1312m
- Type: Turret
- Number of Lines: 8 (right) / Ca
- Project Coordinates: (Nadir/P)
- Lines Configuration:

Page 1 of 2

Task: TMS030
PETROBRAS TP, Class No. 0320071
Special Review Services, Class No. 104
Flag Republic of Liberia

Attention: Instituto de Petróleo Brasileiro
PETROLEO BRASILEIRO S.A. (P38) (MOU) (MOU)

The documents shown in the attached list is reviewed in accordance with the applicable requirements of the following:

- ABS Rules for Building and Classing Floating Production Installations (FPI): 2023
- ABS Requirements for Position Mooring Systems: 2023

Please note our review is based on the following scope and conditions:

- 1) The work is to be completed to the satisfaction of the attending ABS Surveyor;
- 2) The details and design conditions are as specified in the documentation listed.

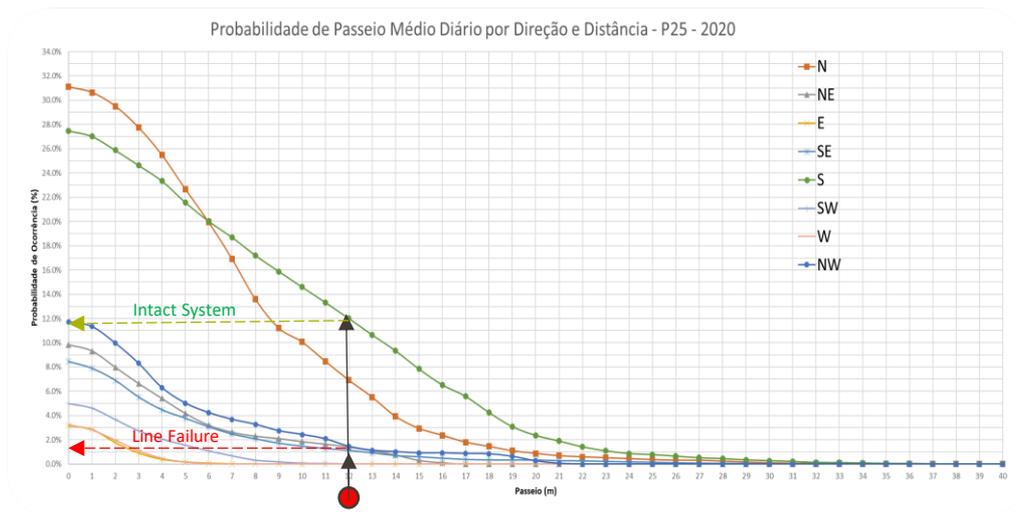
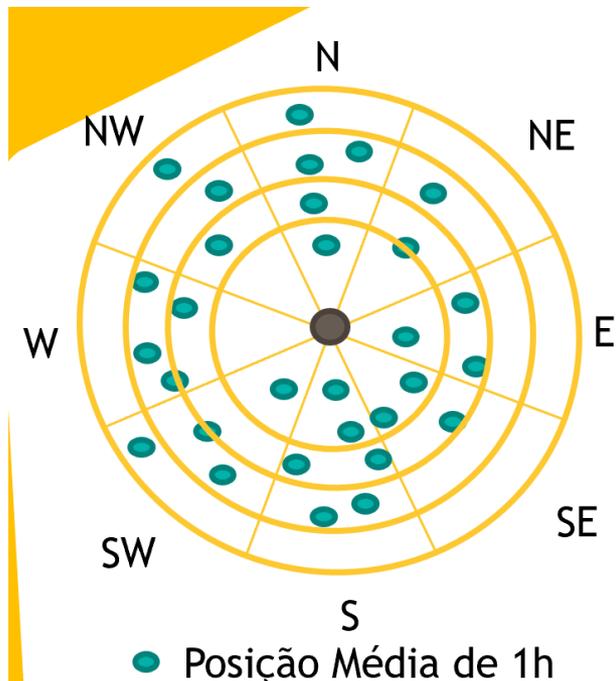
This letter is pertaining to ABS letter dated 09 August 2023 (Ref: T2412670). Based on the certifications and documentation provided, compliance 032071 through 10.104 have been closed.

For any clarifications, contact Mr. Jake Sun at +61 281 677 6022 or jakesun@abs.com.

Very truly yours,
L&B Froude
Vice President of Engineering
Electrically Signed by: Jairo Pires

ABS GLOBAL HEADQUARTERS
Raffles Quay, 17, 100, Raffles Quay, 048570, Singapore, Republic of Singapore
The attention will not be paid if the signatory is not the person responsible for the approval of the design and construction of the project. The liability shall be of course of a general nature and shall not be limited to the project. The approval is given on the condition that the project is approved by the relevant authorities.

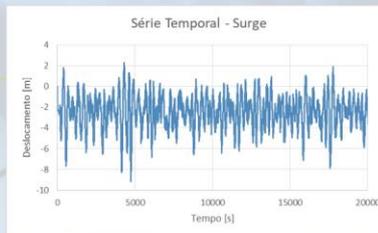
Direction



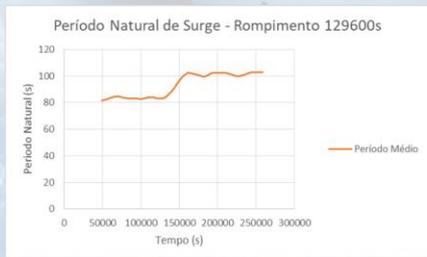
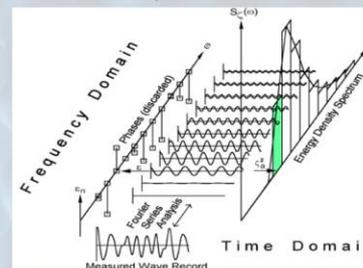
Natural Period



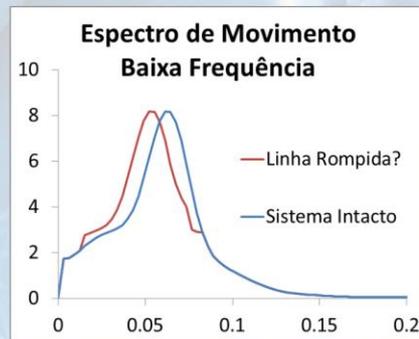
Registro e Armazenamento de históricos de movimentos medidos



Geração de Espectros aplicando Fourier



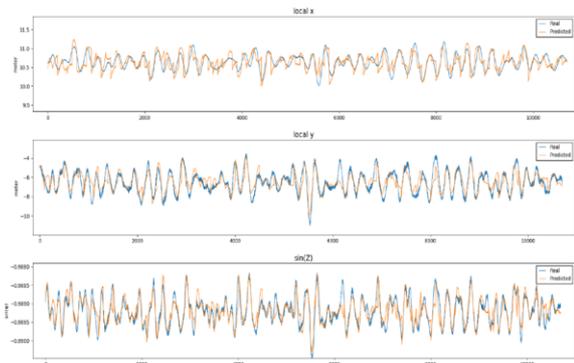
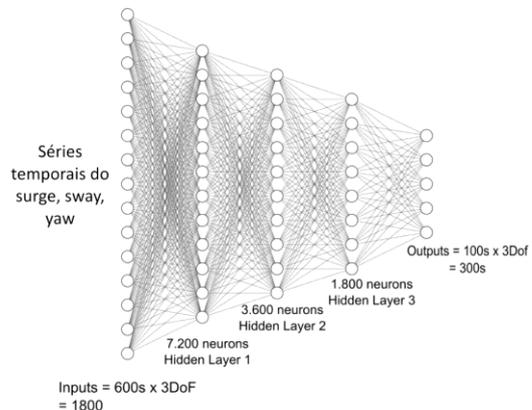
Período Natural x Tempo*



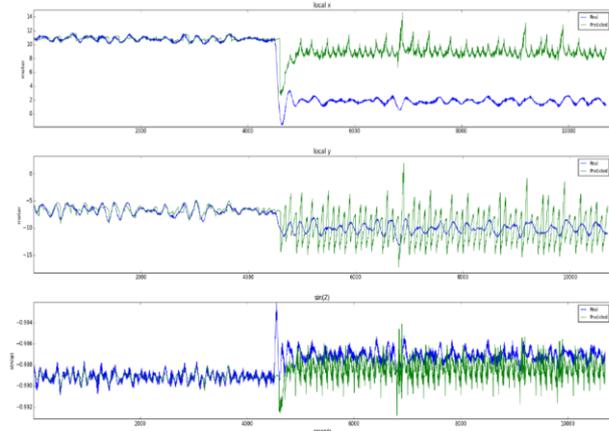
Identificação dos Períodos Naturais através do espectro de Movimento

Neural Networks

- 2 alternatives
- Motion Predictor
- Natural Frequency regressor
- Neural network

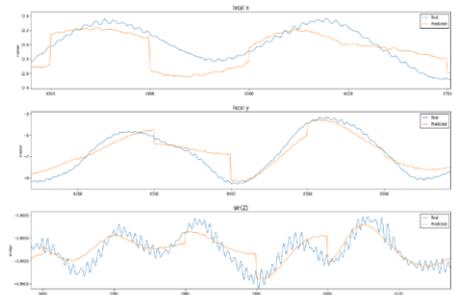


← Intact condition



Line failure condition ↑

Com zoom



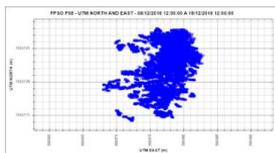
Fatigue Estimation

GPS - Plane motions
OCTANS - Vertical motions and Heading

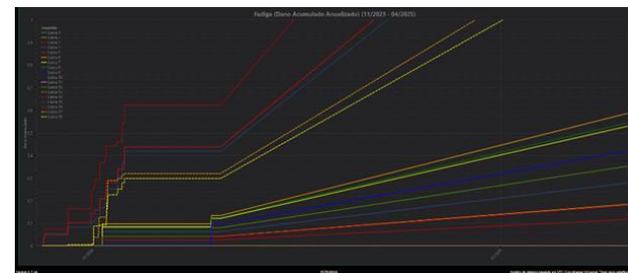
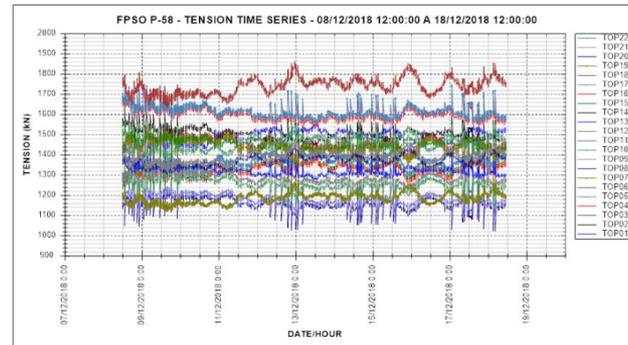
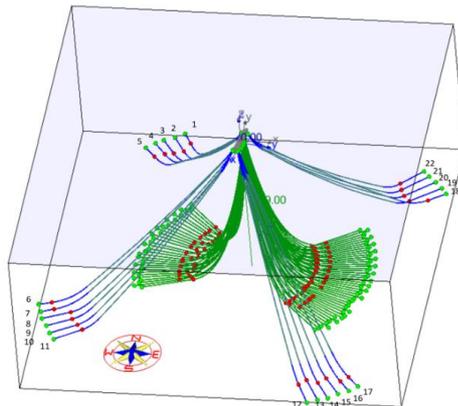
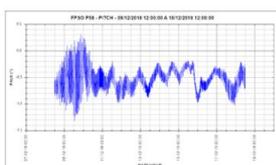
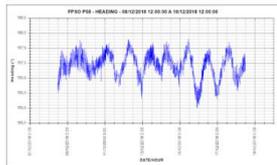
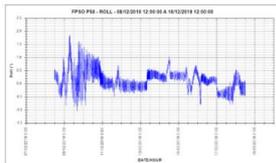
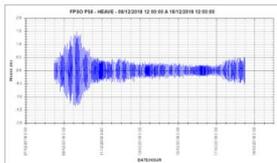
Numerical Model

Tension
Damage

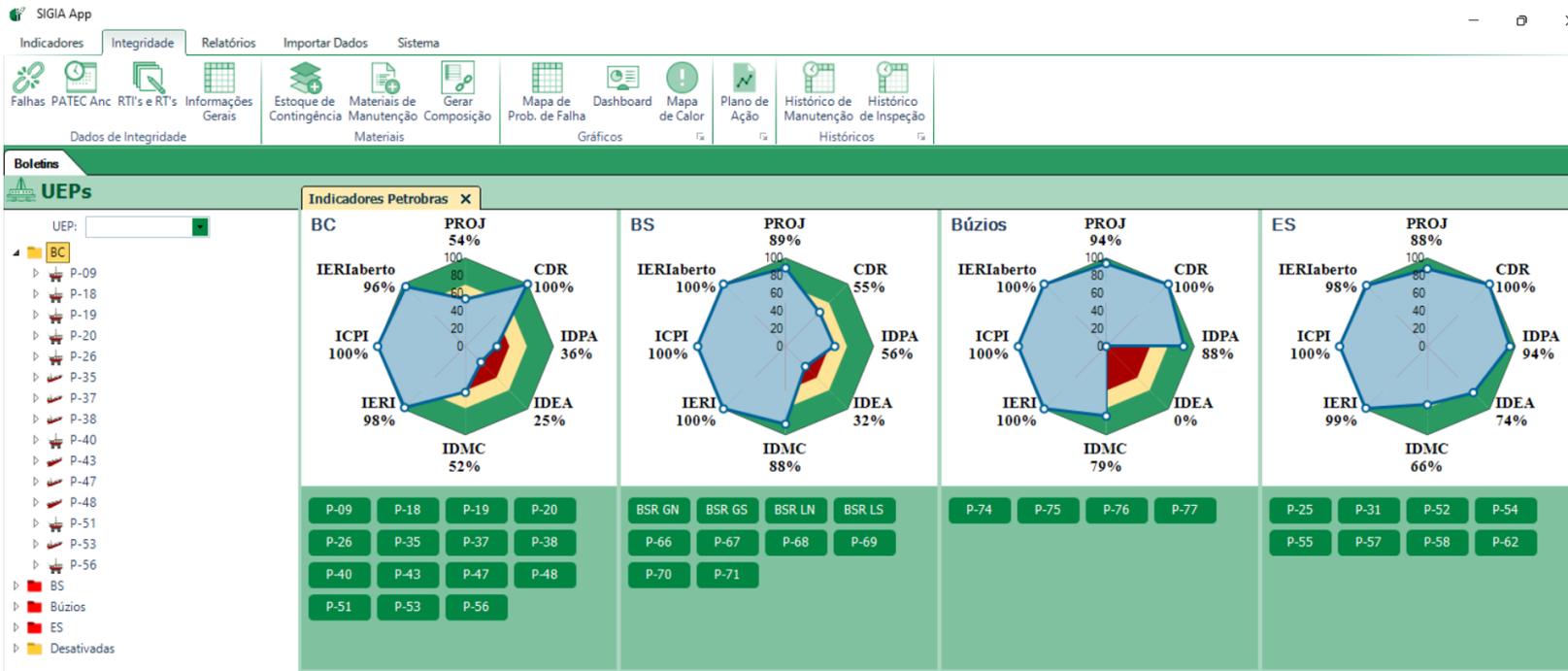
gps data



Octans data



Integrity Management



Final Remarks

Benefits

- Improved Reliability
- Emergency Readiness
- Single Source of Truth
- Cost reductions

Pain points!

- Modularity and **INTEROPERABILITY** is a must
- The results depends on **SENSOR DATA** quality
- AI and Digital Solutions will **ENHANCE** human capabilities
- **STATUS QUO** is the biggest challenge
- Deal with **LEGACY** with reasonability

Partners



Partnership Ecosystem



Contato

Lucas Castelli
Lucas.Castelli@petrobras.com.br

Mauro Costa
Mauro@petrobras.com.br

Rodrigo Barreira
Barreira@petrobras.com.br

