

An FPSO Designer Solution for Efficient Mooring Management

June 2025





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Agenda

1. Introduction to Sevan
2. Operational Input and Why it's Not Followed
3. Enabling Proper Mooring Management
4. Improvements for Second Deployment
5. Future Opportunities

Section 1

Introduction to Sevan



Sevan Track Record – Cylindrical Units

6 Floating Production Units



Piranema Spirit
S300
First oil: 2007



Excalibur
(ex. Hummingbird)
S300
First oil: 2008



Petrojarl Kong
(ex. Voyageur)
S300
First oil: 2009/-13/-24



Goliat FPSO
S1000
First oil: 2016



Western Isles FPSO
S400
First oil: 2017



Penguins FPSO
S400
First oil: 2025

4 Drilling Units



Sevan Driller
S650
2010



Sevan Brasil
S650
2012



Sevan Louisiana
S650
2014



Sevan Developer
S650
At Yard

2 Accommodation Units

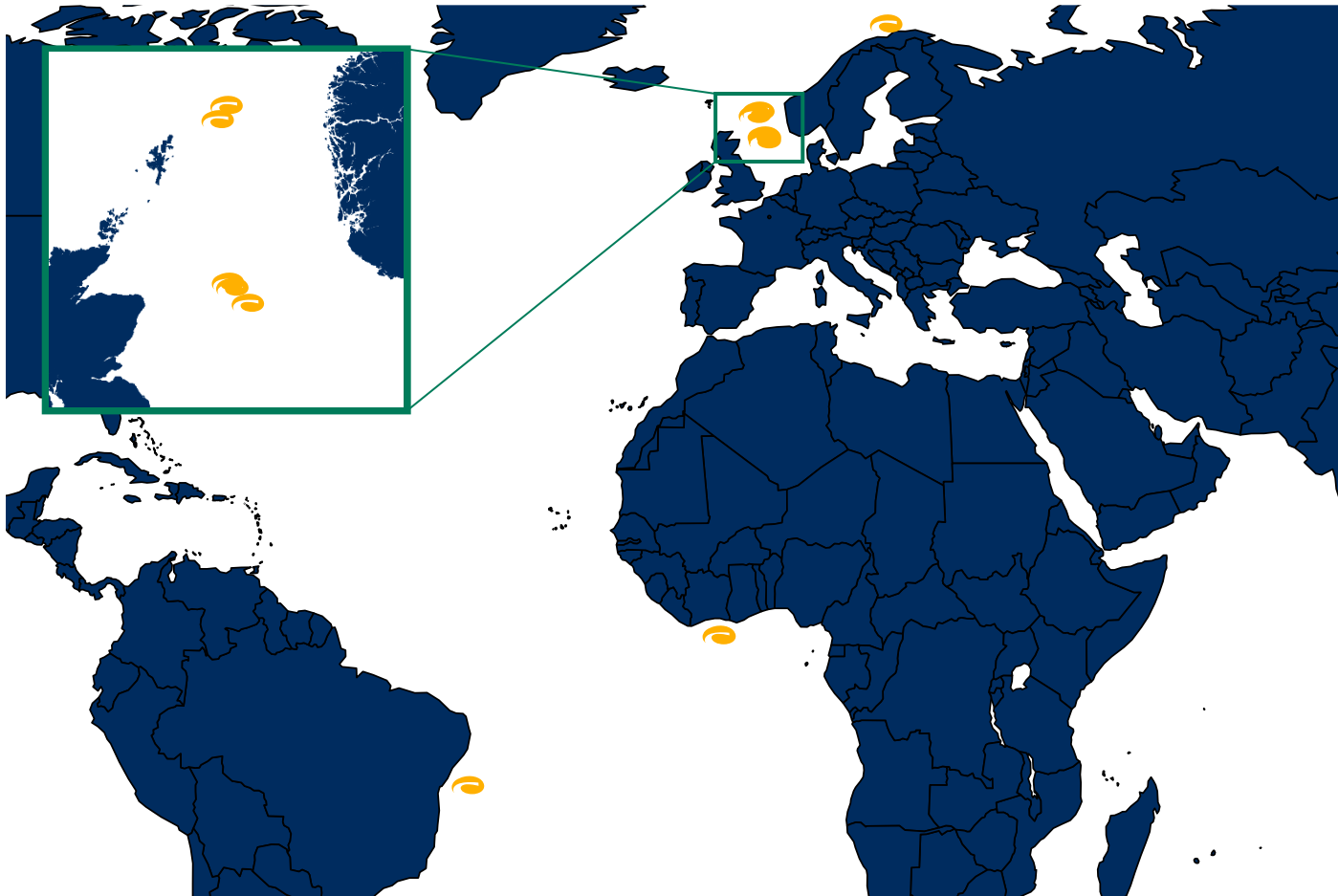


Arendal Spirit
S300
2015



Stavanger Spirit
S300
At Yard

Sevan Track Record – Permanent Mooring (installed)



Year installed – Field

- 2007 – Piranema
- 2007 – Chestnut
- 2008 – Shelley
- 2012 – Huntington
- 2015 – Goliat
- 2017 – Western Isles
- 2024 – Penguins
- 2024 – Baleine (x2)



Section 2

Operational Input





Typical Operational Input



Mooring System Manual

Penguins Redevelopment Project Detailed Design					
C06	27.09.2024	Approved for Construction	HRJ	EBG	HOS
C05	30.01.2023	Approved for Construction	BLA	EBG	HOS
C04	21.12.2020	Approved for Construction	LMR	EBG	HOS
C03	16.10.2020	Approved for Construction	EBG	LMR	HOS
C02	29.03.2019	Approved for Construction	EBG	HGU	HOS
C01	19.12.2018	Approved for Construction	TBT	EBG	HOS
A02	28.11.2017	Approved for Design	EBG	JYO	HOS
A01	30.03.2016	Approved for Design	TSY	EBG	HOS
R01	10.03.2016	Issued for Review	TSY	YSH	HOS
Rev	Date	Reason for Issue	Org	Chk.	App.
			Project Title Penguins Redevelopment Project – Detailed Design		
			Project No. Phase Document No. 592 80 593-SM-V-94-CM-0001		
			Document Title Mooring System Manual		
Contract No:		Client Document Number		No of pages	
		PRD-SEV-MOOR-94-E-CX-0512-00010		50	
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Inspection Program

Penguins Redevelopment Project Detailed Design					
A05	17.12.2024	Approved for Design	HRJ	EBG	HOS
A04	27.09.2024	Approved for Design	HRJ	EBG	HOS
A03	27.01.2023	Approved for Design	BLA	EBG	HOS
A02	11.11.2022	Approved for Design	BLA	EBG	HOS
A01	19.10.2022	Approved for Design	BLA	EBG	HOS
R02	22.12.2020	Re-issued for Review	TBT	EBG	HOS
R01	29.03.2019	Issued for Review	EBG	HGU	HOS
Rev.	Date	Reason for Issue	Org.	Chk.	App.
 SEVAN DEEPWATER TECHNOLOGY A member of the Istitium Group			Project Title Penguins Redevelopment Project – Detailed Design		
			Project No. Phase Document No.		
			593 80 593-SM-V-94-MA-0002		
			Document Title		
			Mooring System Inspection Program		
Contract No.		Client Document Number		No of pages	
		PRD-PT-HULL-94-E-QA-5733-00001		48	
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DFI Résumé



Penguins Redevelopment Project Detailed Design					
A04	22.01.2025	Re-issued for Approval	HRJ	EBG	HOS
A03	19.12.2024	Re-issued for Approval	HRJ	EBG	HOS
A02	05.11.2024	Issued for Approval	HRJ	EBG	HOS
A01	01.02.2023	Approved for Design	BLA	EBG	HOS
R02	29.01.2021	Issued for Review	LMR	EBG	HOS
R01	29.03.2019	Issued for Review	EBG	HGU	HOS
Rev.	Date	Reason for issue	Org.	Chk	App.
 Project Title Penguins Redevelopment Project – Detailed Design					
Project No Phase Document No 693 80 593-SM-V-94-MA-0001					
 Document Title Mooring System DFI Résumé					
Contract No:		Client Document Number			No of pages
		PRD-PT-HULL-94-E-CS-7771-00001			69
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Typical Operational Input

Mooring System Manual



- Operational limits for position, pre-tension, tension distribution between lines, etc.
- Alarm levels for tension and position to be set onboard FPSO (high / high-high)
- Operational procedures at different levels of mooring integrity (traffic light approach)
- Spreadsheets for calculation of virtual target for tension and position

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Contract No. Client Document Number No. of pages						
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Inspection Program

- Designers recommended inspection program first 5 years
- FMECA based
- Detailed instructions for each inspection point (text, figures, pictures)

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 <div>A member of the Seacore Group</div>		Project Title Penguins Redevelopment Project – Detailed Design	
Project No	593	Phase	80
Document No	593-SM-V-94-MA-0001		
Document Title			
Mooring System DFI Résumé			
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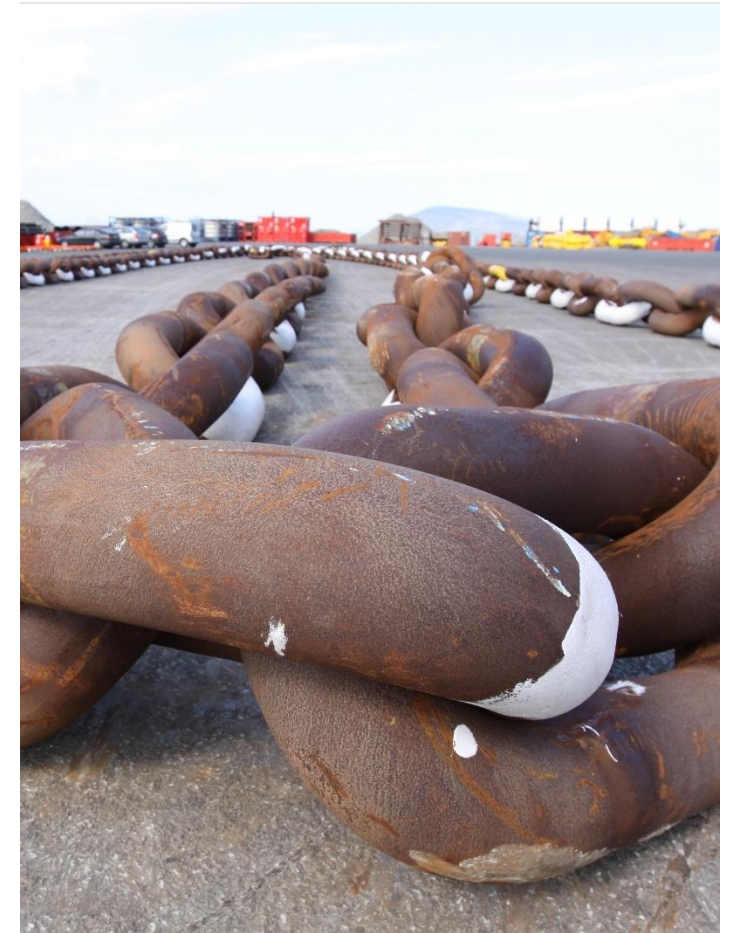
- Design, fabrication and installation resume for mooring system
- Go-to document for further information on the mooring system and components
- Fabrication and installation part focusing on non-conformities

“All right, we’ll take it from here”

–Anonymous Operator(s)

Observations from the Mooring Designer Perspective

- Many operators are capable mooring systems operators
 - Our operational input is taken for information
 - The mooring designer perspective still adds value
- Systems showing mooring system status are lacking
 - Data often not logged or handled correctly to give the required information
- Feedback from operators is limited
 - Ranging from nothing until an incident occurs to checking tensions and position based on values received by email once a year
- Any incident involving our mooring designs will reflect poorly on us
 - Regardless of how the mooring system was maintained



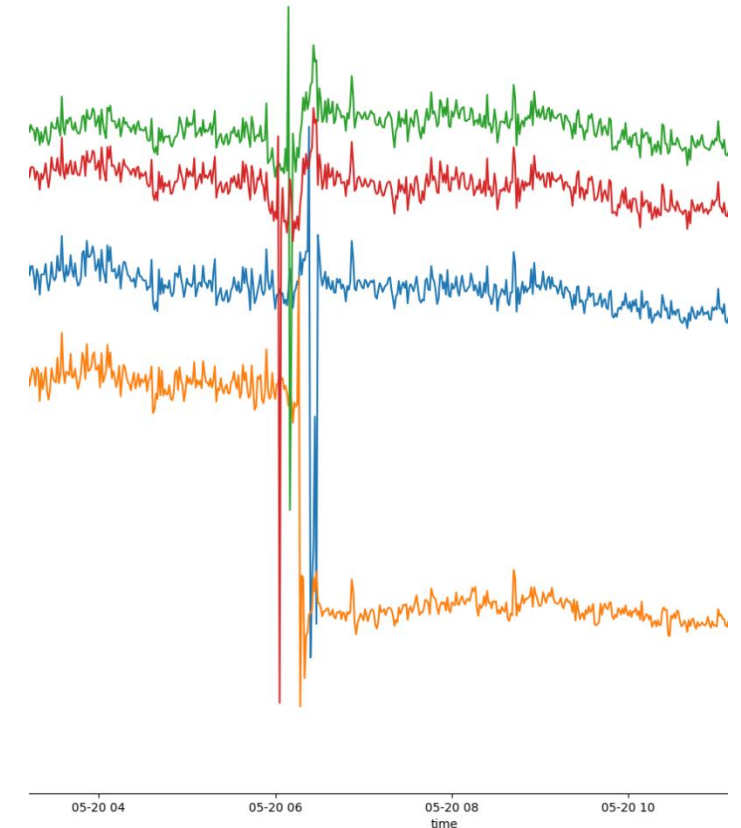
The Long Measurement

- Sevan assignment
 - Evaluate status versus mooring system manual and advise on necessary adjustments
 - Required input forwarded manually by client
- Special considerations
 - Onboard scope included calibration of all load cells, taking about 1 hour each
 - An offshore Support vessel monitors chain interaction with the fairlead using ROV
- Outcome
 - Sevan advises a (surprisingly large) adjustment that should bring us close to virtual target
 - 24 hour later, after a long series of meeting, we reversed all the adjustments



The Unintended Adjustment

- Sevan assignment
 - Investigate the sequence of events leading to a low-tension alarm shortly after a mooring adjustment
 - Raw data of tension was made available
- Special considerations
 - In accordance with operational procedures, winches should be run and fairleads rotated yearly
 - All pre-tension levels were confirmed as acceptable after adjustments
- Outcome
 - The change in tension seen on the right is found about a month before the low-tension alarm
 - The low-level tension alarms were erroneous measurement



“Maybe we should help you with that?”
–Sevan

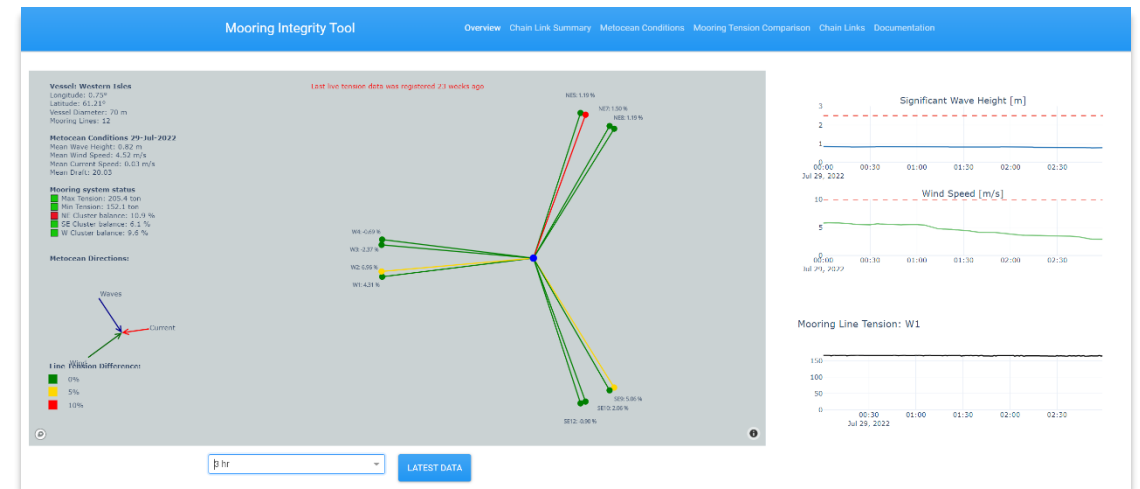
Section 3

Enabling Mooring Management

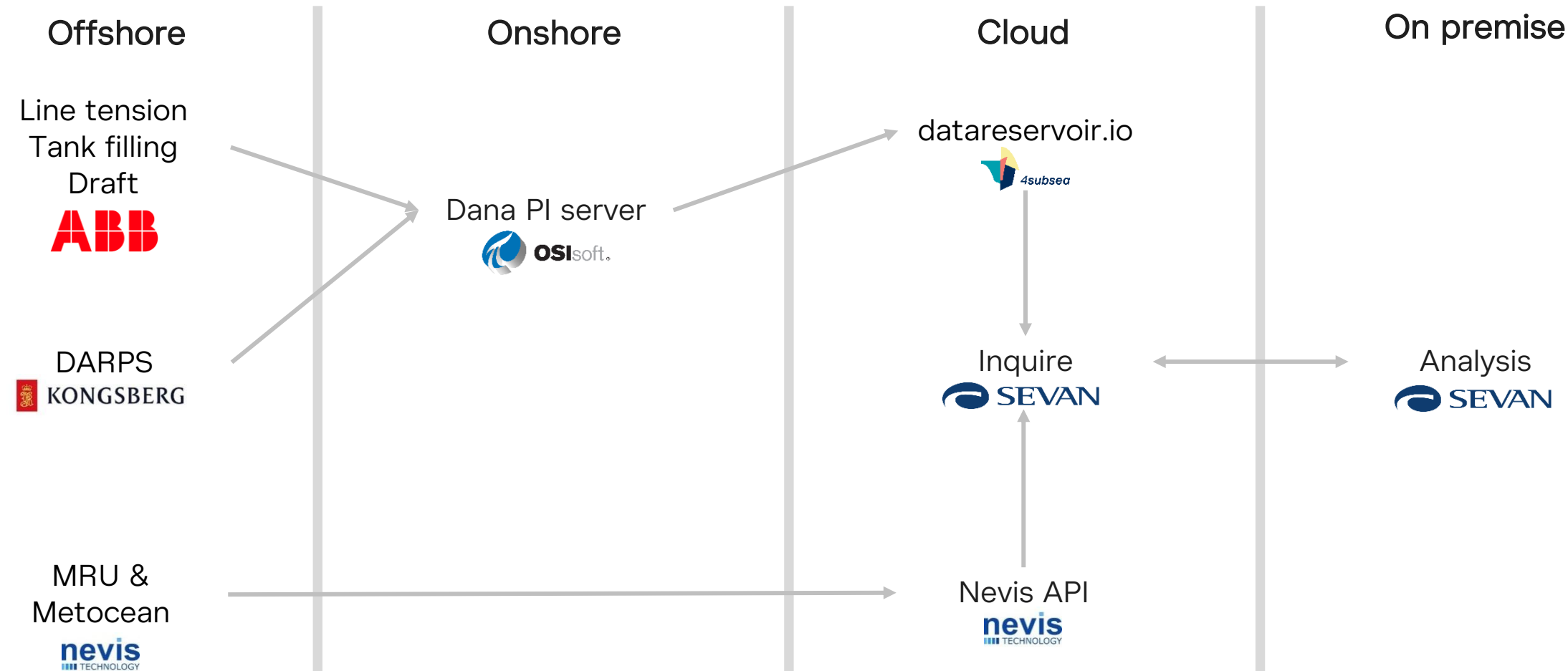


Western Isles – Inquire Mooring Monitoring v0

- Dana Petroleum wanted a system displaying status versus mooring system manual
 - Existing sensors
 - Asset database for timeseries
 - Dashboard for visualization
- Built on inner source model
 - Open-source practises applied to proprietary code
 - Full flexibility regarding development and deployment
 - A wealth of sources of inspiration
 - Non-specific starting point



Western Isles Data Flow



Why was the System not Used?

Digital solution challenges

- Amount of data
- Bandwidth
- Sampling frequency limitation
- Database structure
- Security
- Speed
- Customer involvement
- Adoption by the crew (and other users)

Comments

- Manageable amounts
- Limited, but capable of extracting useful information
- Issues with down-sampling for storage
- Inquire database performance was never limiting
- Fenced-off in Azure, low criticality, but not tested
- Slow front end
- Initially very good, but key persons left
- Only used by Sevan after it was launched

Section 4

Second Deployment



Penguins – inquire Mooring Monitoring v1

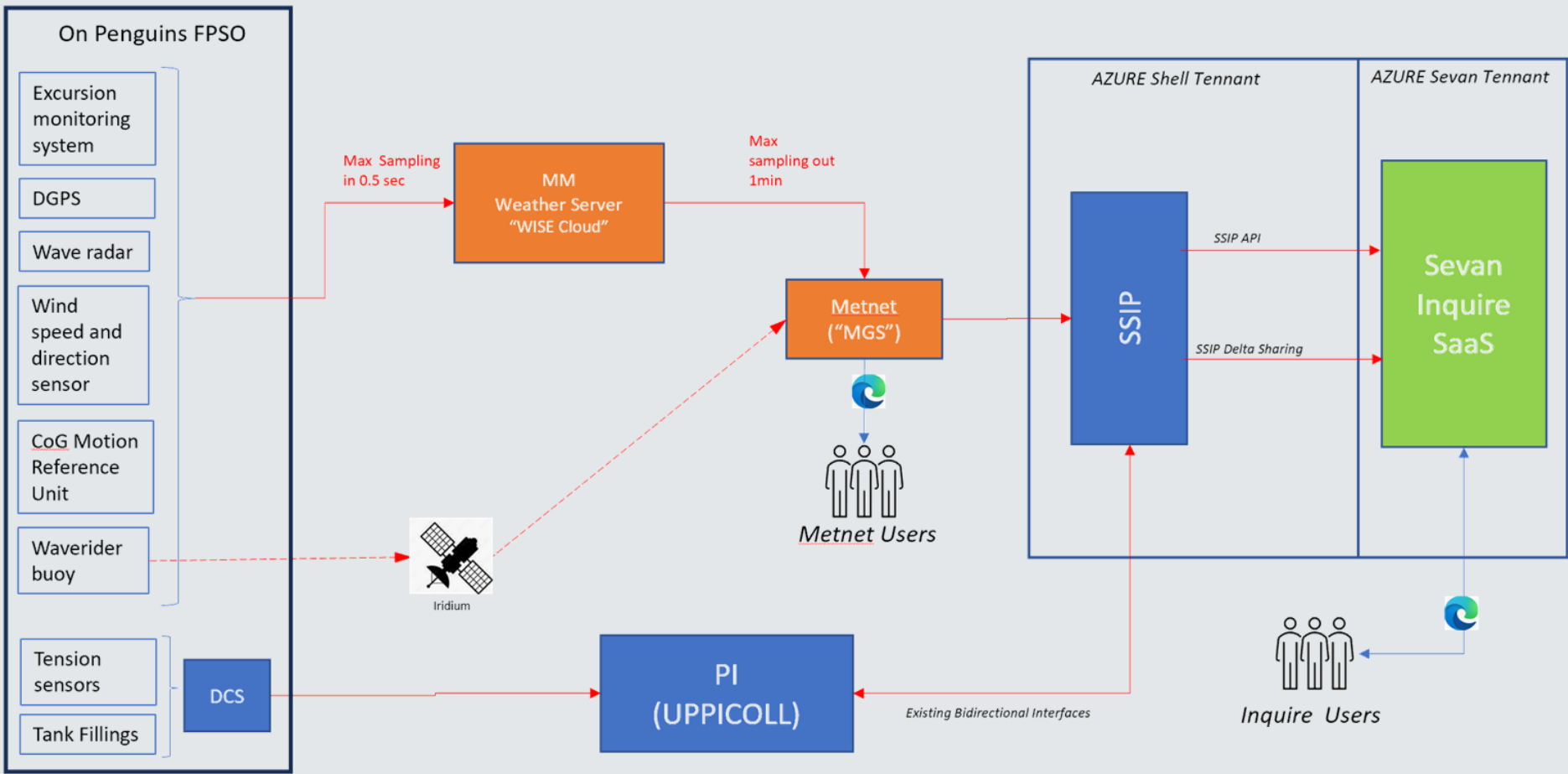
Changes from Western Isles

- Scope
 - Maintain a numerical mooring system model (Orcaflex)
- Early engagement
 - Work started prior to completion of the asset
- Focus points, based on WI experience
 - User engagement
 - User experience
 - Verified data security

Contextual changes

- 7 years of digitalization
 - All relevant data available
 - Data received by querying REST API
 - Faster, more flexible services, more storage
- AI
 - Perfect match with inner source model
 - Empowering domain experts
 - With Claude et al. onboard we built a React front-end in-house

Penguins Data Flow



Current Tech Stack

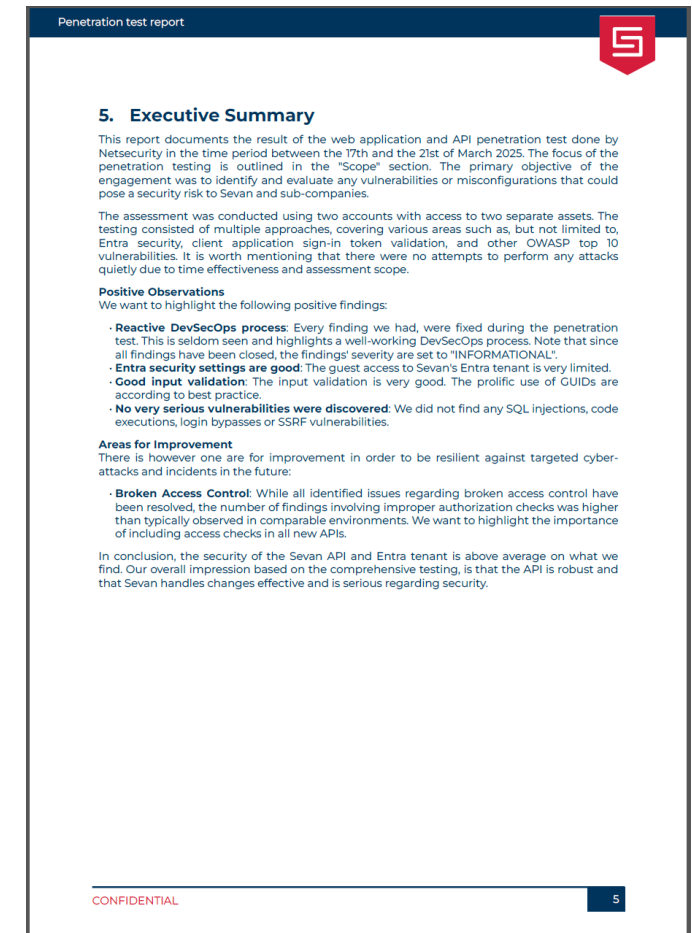
- Storage:
 - PostgreSQL
 - Hosted in Azure
 - Assets / Timeseries / Events / Access Rights
- API Application
 - Python
 - FastAPI
 - Docker
 - Hosted in Azure with Azure AD authentication
- Data Ingestion Pipeline
 - Python
 - Azure Function App
- Dashboard
 - Typescript
 - React
 - Docker
 - Hosted in Azure with Azure AD authentication

The logo for 'Q inquire' features a large, stylized blue 'Q' followed by the word 'inquire' in a dark blue, sans-serif font, with a registered trademark symbol (®) to the upper right.



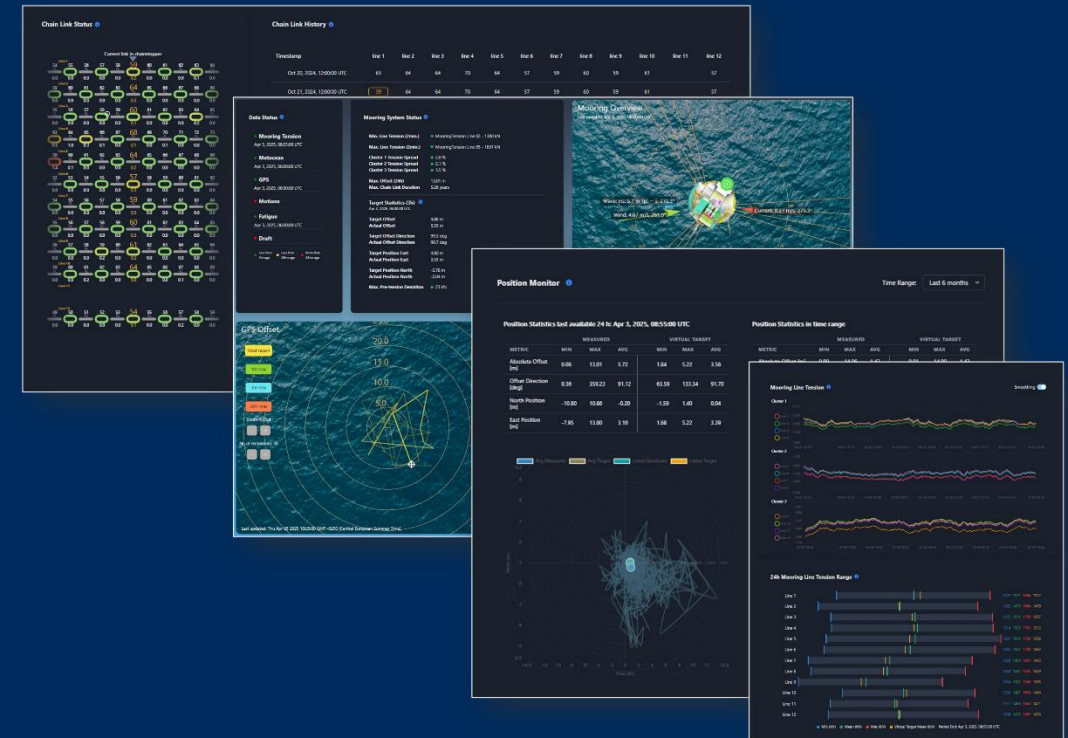
Security

- Azure AD
 - Access security provided by Microsoft Azure cloud solutions
 - Log in with Office 365
- Penetration testing
 - Manual test performed
 - Automatic testing being considered
 - Ensures we have no security flaws or vulnerabilities
- Continuous security scanning
 - Bandit: Scans for vulnerabilities such as hardcoded secrets, weak cryptography, and unsafe function calls
 - Safety: Scans dependencies for known security vulnerabilities
 - Dependabot: Automated dependency updates



Main Features

- Present mooring system status
 - Summary views and specific views for tension, offset, chain link in critical position and fatigue
 - Monthly summary reports automatically distributed
 - Any timeseries can be displayed against each other
- Fatigue monitoring
 - Fatigue directly calculated from sensor data and compared to the expected fatigue
- Virtual target
 - Static mooring analysis based on measured metocean data to find the nominal position given the environment
- Mooring model on demand
 - Self-maintaining model, linearising and iterating to match the condition at the time specified by the user



Section 5

Future Opportunities



Future Opportunities

- More information leads to more opportunities
 - Increased accuracy
 - Improved sampling rate
 - Larger bandwidth
- Examples:
 - Further refinement of OPB predictions
 - More refined verification of long-term fibre behaviour
- Question
 - Should we rely on the sensors found onboard, or should every system have its own set of sensors?





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PS: Demo Access to Inquire Mooring Integrity Management System can be requested at inquire@sevandwt.com