Solution Seeker

AI-BASED SENSOR SURVEILLANCE

Solution Seeker response to Petrobras request for proposal

OP02458: CONFIANÇA EM SENSORES

28.07.2024

Solution Seeker

- **Introduction**
- Proposed solution
- Project execution
- IT infrastructure

Our personal commitment to you and this effort

Dear Petrobras/CENPES team,

We have a long history of working together, dating back to 2011. Petrobras was a partner to the Center for Integrated Operations at the Norwegian University of Science and Technology, of which Solution Seeker is a deep tech spin-off company. The proposed project team have worked and jointly published with Petrobras and CENPES employees since 2011, including Solution Seeker Founder, Dr. Vidar Gunnerud.

We shared a vision for the possibilities that lays in AI and data driven technology already thirteen years ago. Your support through the initial R&D engagement was “company-making” for Solution Seeker. The access to data and your insights has highly influenced the development of our AI technology, and the capabilities Solution Seeker possess today.

Under the current engagement with Libra, we have established our subsidiary in Brazil and we are using a large and advanced neural network model to support operations in real-time. As the O&G business has seen very few successful implementations of AI at scale for production, pioneering the use of this is nothing short of an achievement. The experience we now gain form operating with this neural network model is paramount to taking further steps on the AI journey.

It’s an honor to be asked to respond to your request for proposal. The scope you have requested builds nicely on the current engagement and it fits perfectly with the direction that Solution Seeker want to take its products and technology. We think there is great value to harvest from the functionality you have requested. By better surveillance of sensor data – barrels can be found, losses can be avoided, and time can be freed up to address more opportunities and threats to production.

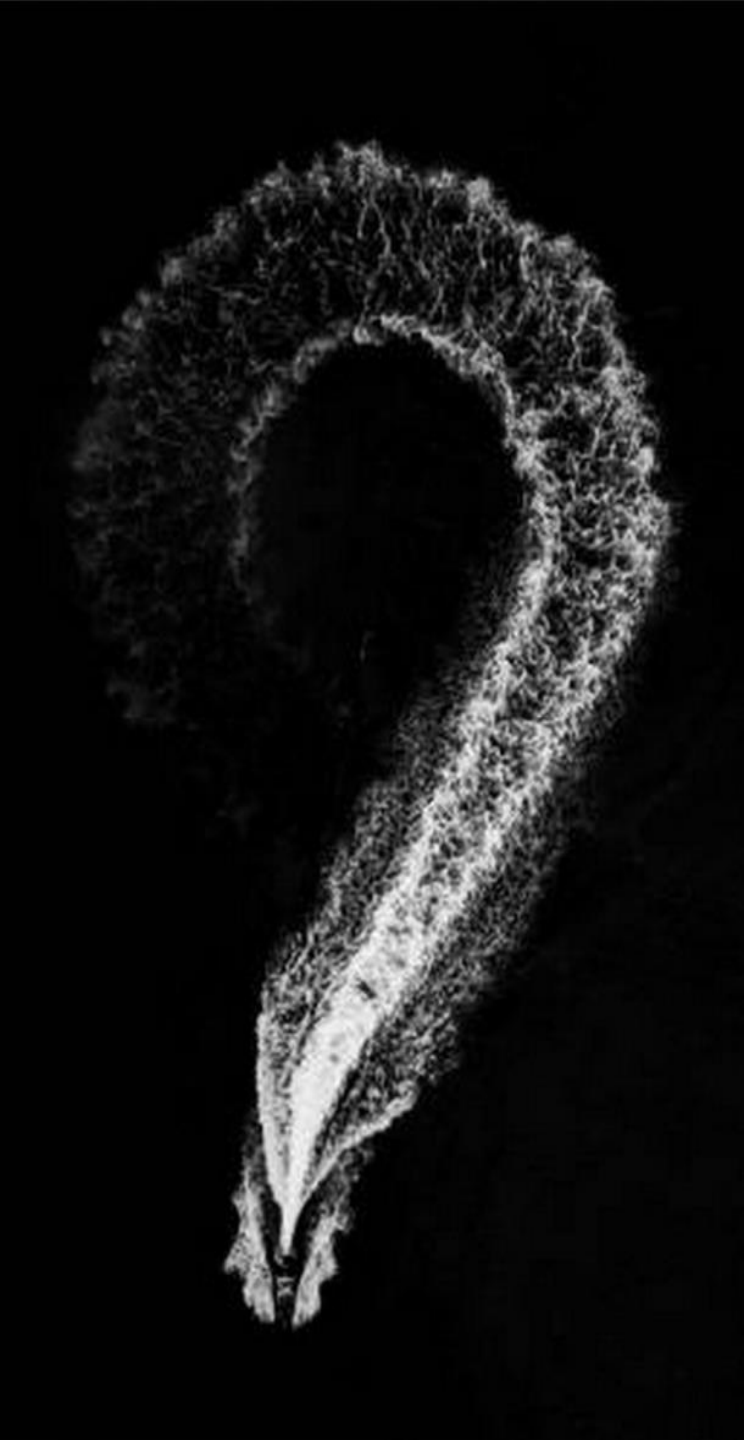
In the event you decide to put your confidence in us, we would greatly appreciate it and by no means take it for granted. We value your business highly, and we are personally committed to deliver real impact to Petrobras. We believe our AI technology and deep expertise on production data make us the right partner.

Vidar Gunnerud
Founder & CEO

Guilherme Kessler
Director Solution Seeker Brazil &
heading relationship with Petrobras

Danielle Monteiro
Project manager

Photos from selected technical workshops with Petrobras/CENPES in 2012, 2019 and 2023



Why Solution Seeker

Problem statement

Using data in real-time to support production decisions in a timely manner and thereby staying optimal over time – is non-trivial. The difficulties of robustly converting data into increased production is underappreciated, and a major reason of why there is an untapped potential in the first place.

Our 3 differentiators to overcome this problem statement

1. **NeuralCompass**, our well AI model transfer learns between data from thousands of wells. Together with **Squashy**, our real-time production data mining framework, this model allows us to overcome the four important data challenges: i) low data volume, ii) low data variability, iii) low data quality, and iv) non-stationary processes. NeuralCompass and Squashy are enablers and integral parts of all value driving use cases.
2. **The ability to cost-effectively tailor and integrate at scale**. Each asset is unique and constantly evolving. Hence, off-the-shelf functionality rarely takes you all the way to increased production. With our **ProductionCompass** system we can i) integrate with third party software and leverage what's already working, and ii) tailor applications and algorithms on top of a highly scalable cloud framework, a powerful transfer learning AI model, and a rich set of algorithms and dashboards – *ensuring that you go end-to-end from raw sensor data to sustained increased production*.
3. **Extensive experience and deep knowledge**. Our team has worked with production data and optimization use cases for more than 15 years. We have encountered close to 100 challenges from more than 30 assets and 10 operators. We have published more than 70 scientific works on the subject and filed 10 patents (link). Six of our team members have written PhD theses on machine learning and Production Optimization. We are truly a niche company dedicated to data-driven production science optimization.

Solution Seeker in Brazil

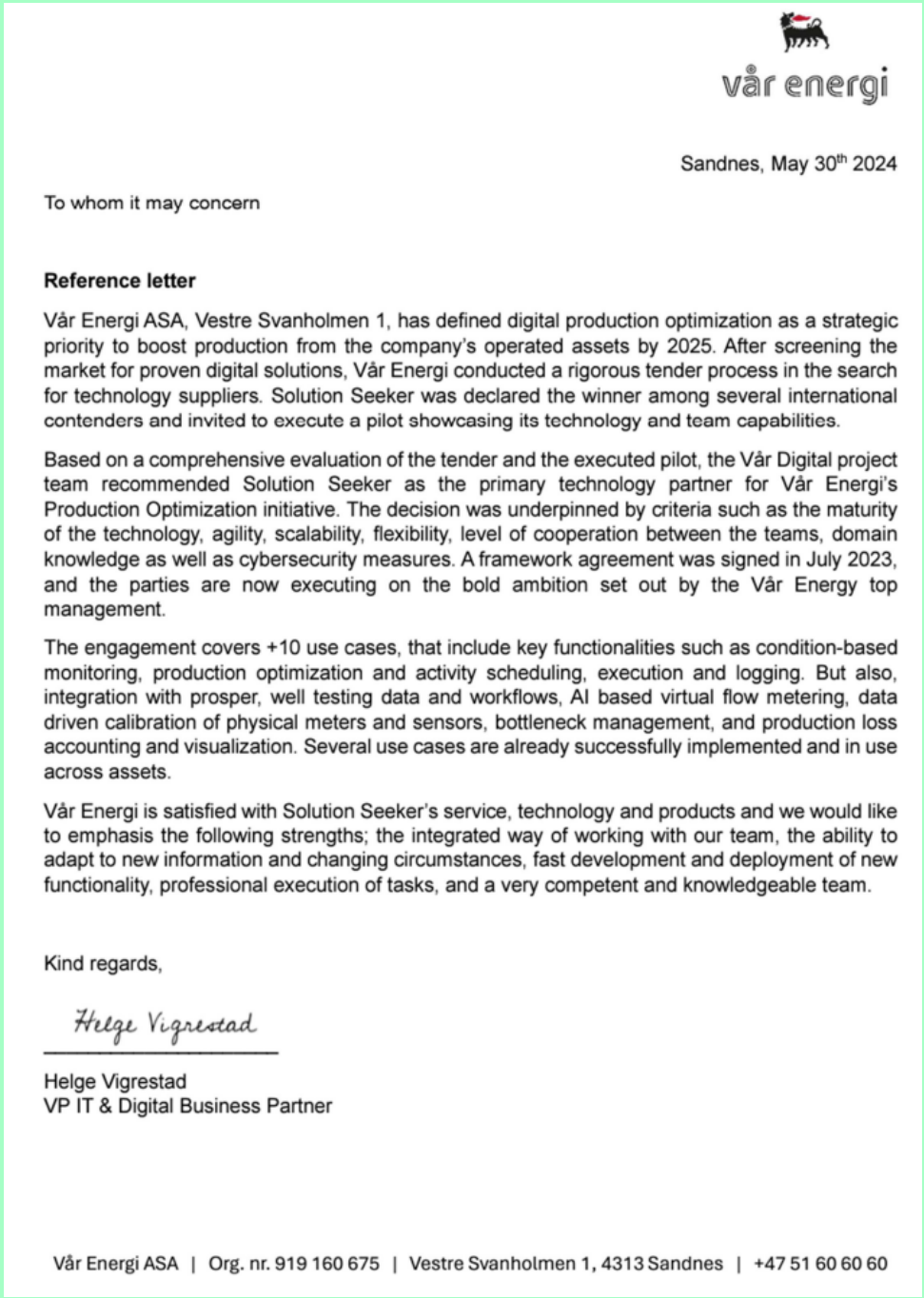
Rio Team at
Solution Seeker Tecnologia Ltda

- Solution Seeker Brazil office in place with 6 people (mix of Brazilians and Norwegians working in a seamless way between the two offices).
- The local team has experience working on “Termos de Cooperação” under ANP rules and managing such R&D engagements.
- Local company established as an “empresa brasileira” and eligible for ANP funding / pre-registered on SIGITEC.
- Mix of Petroleum Engineers, Data Scientists, Software Developers + Local Management.

Strong synergies with ENI Norway and PTTEP of Thailand enables bold ambitions

Solution Seeker is ENI Norway's (Vår Energi's) main partner on digitalization of production, addressing more than 10 different use cases. Among these are sensor surveillance and calibration.

We see strong synergies between this engagement and the functionality requested by Petrobras, enabling Solution Seeker to offer a more comprehensive scope, and on a tighter timeline.



vår energi

Sandnes, May 30th 2024

To whom it may concern

Reference letter

Vår Energi ASA, Vestre Svanholmen 1, has defined digital production optimization as a strategic priority to boost production from the company's operated assets by 2025. After screening the market for proven digital solutions, Vår Energi conducted a rigorous tender process in the search for technology suppliers. Solution Seeker was declared the winner among several international contenders and invited to execute a pilot showcasing its technology and team capabilities.

Based on a comprehensive evaluation of the tender and the executed pilot, the Vår Digital project team recommended Solution Seeker as the primary technology partner for Vår Energi's Production Optimization initiative. The decision was underpinned by criteria such as the maturity of the technology, agility, scalability, flexibility, level of cooperation between the teams, domain knowledge as well as cybersecurity measures. A framework agreement was signed in July 2023, and the parties are now executing on the bold ambition set out by the Vår Energy top management.

The engagement covers +10 use cases, that include key functionalities such as condition-based monitoring, production optimization and activity scheduling, execution and logging. But also, integration with prosper, well testing data and workflows, AI based virtual flow metering, data driven calibration of physical meters and sensors, bottleneck management, and production loss accounting and visualization. Several use cases are already successfully implemented and in use across assets.

Vår Energi is satisfied with Solution Seeker's service, technology and products and we would like to emphasis the following strengths; the integrated way of working with our team, the ability to adapt to new information and changing circumstances, fast development and deployment of new functionality, professional execution of tasks, and a very competent and knowledgeable team.

Kind regards,

Helge Vigrestad

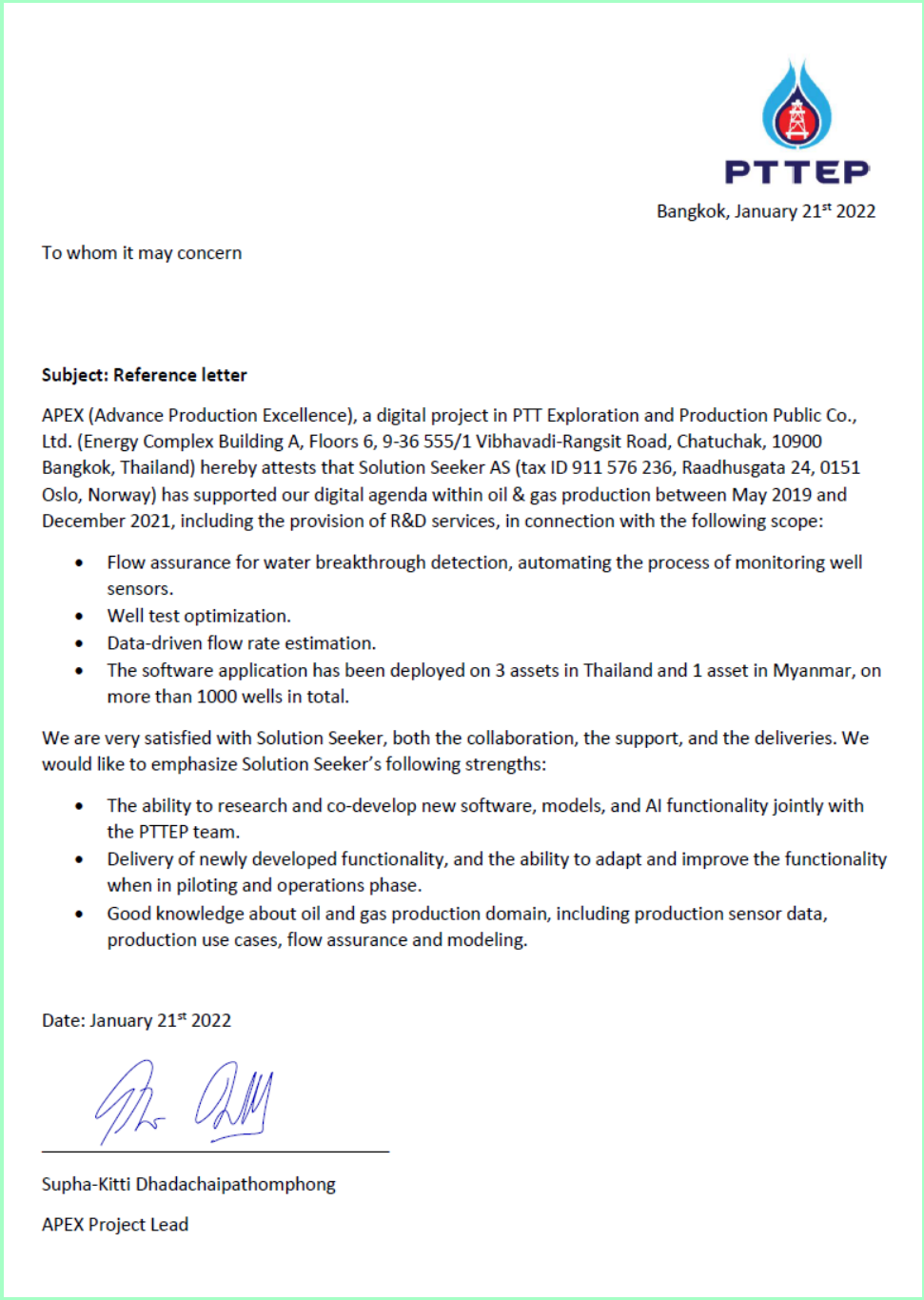
Helge Vigrestad
VP IT & Digital Business Partner

Vår Energi ASA | Org. nr. 919 160 675 | Vestre Svanholmen 1, 4313 Sandnes | +47 51 60 60 60

Strong synergies with ENI Norway and PTTEP of Thailand enables bold ambitions

Solution Seeker has been PTTEP's partner on multiple digital use cases since 2019. Among these are sensor and well surveillance at scale on more than 1000 wells.

Our experience of handling sensor surveillance at such scale should be highly relevant for functionality requested by Petrobras, enabling Solution Seeker to offer a more robust and comprehensive solution, and on a tighter timeline.



PTTEP

Bangkok, January 21st 2022

To whom it may concern

Subject: Reference letter

APEX (Advance Production Excellence), a digital project in PTT Exploration and Production Public Co., Ltd. (Energy Complex Building A, Floors 6, 9-36 555/1 Vibhavadi-Rangsit Road, Chatuchak, 10900 Bangkok, Thailand) hereby attests that Solution Seeker AS (tax ID 911 576 236, Raadhusgata 24, 0151 Oslo, Norway) has supported our digital agenda within oil & gas production between May 2019 and December 2021, including the provision of R&D services, in connection with the following scope:

- Flow assurance for water breakthrough detection, automating the process of monitoring well sensors.
- Well test optimization.
- Data-driven flow rate estimation.
- The software application has been deployed on 3 assets in Thailand and 1 asset in Myanmar, on more than 1000 wells in total.

We are very satisfied with Solution Seeker, both the collaboration, the support, and the deliveries. We would like to emphasize Solution Seeker's following strengths:

- The ability to research and co-develop new software, models, and AI functionality jointly with the PTTEP team.
- Delivery of newly developed functionality, and the ability to adapt and improve the functionality when in piloting and operations phase.
- Good knowledge about oil and gas production domain, including production sensor data, production use cases, flow assurance and modeling.

Date: January 21st 2022

Supha-Kitti Dhadachaipathomphong

APEX Project Lead

Solution Seeker merits

Dedicated to cutting edge

- 70+ scientific publications on production data analytics, modeling and optimization
- 10 patents filed on production data cleaning, modeling and optimization

Data heavy

- A production data base with 500B+ entries, 150k+ well tests with labeled flow rates, 6M+ operating points
- The system streams 7M+ data points from operators per hour

A future proofed AI platform

- Distributed & event-driven cloud native platform for live streaming and computation of time series data
- Low end-to-end latency and very high horizontal scalability

Strategic partnership

- BCG is a partner and minority owner of Solution Seeker. If relevant, we can leverage BCGs skillsets
- Link to video pitch of partnership

We are battle proven by 10+ operators, 25+ assets and on 2000+ wells. These assets have a combined production of more than 1M BOE/d.

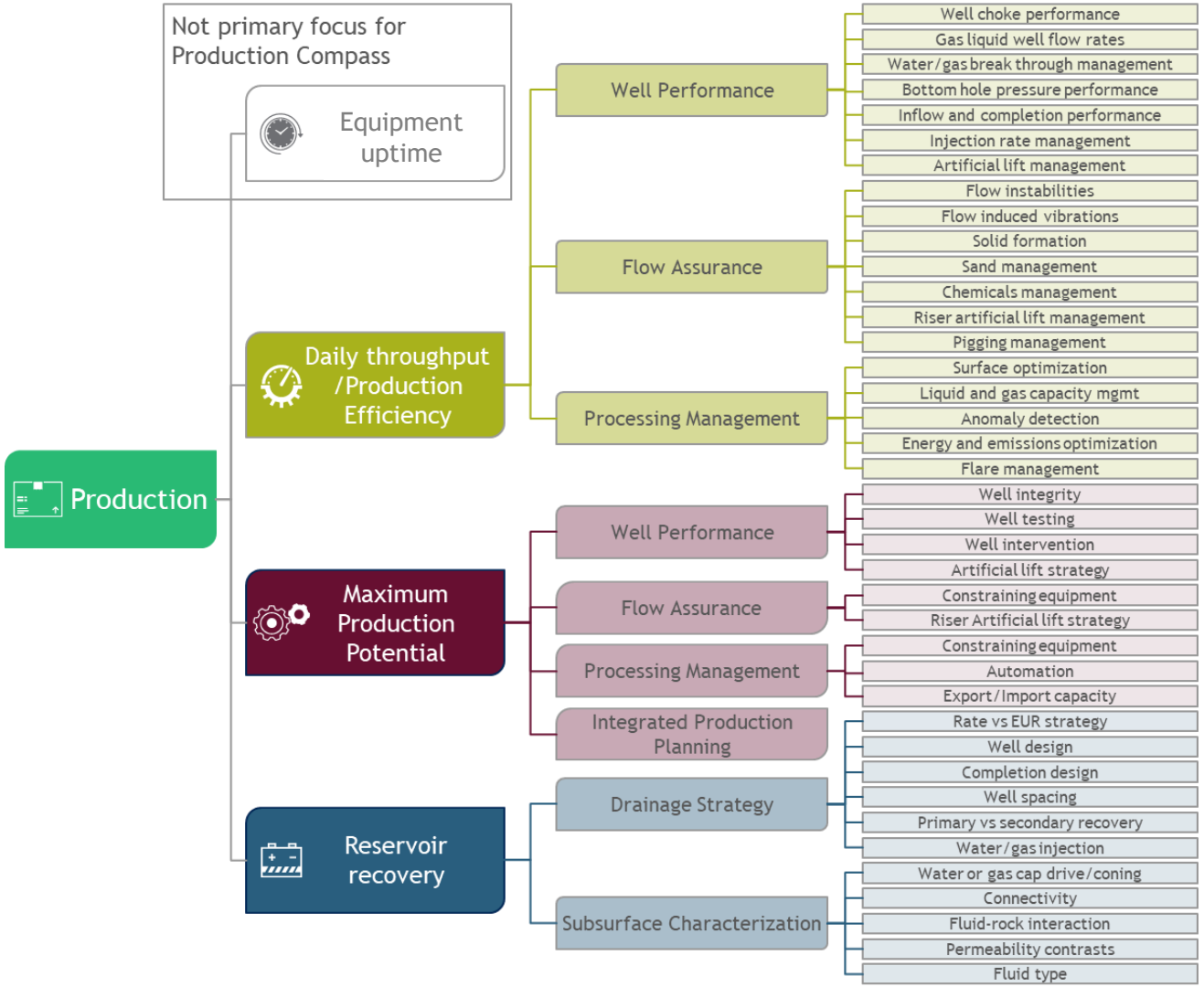
ConocoPhillips · Petrobras · AkerBP · vår energi · PRIO · Neptune Energy · equinor · wintershall dea · OKEA · PTTEP · Shell · Total

An experienced team

Six of Solution Seeker's founding team now have 10+ years experience within PO and working with production data

- *In Solution Seeker, 5 have conducted a PhD and 20 a MSc on ML and PO*
- *The team has been exposed to 100+ PO challenges and use cases over 15y*

Production Compass AI with great value potential across many levers...



… overcoming historical PO challenges

Inherent limitations on quality in decision inputs

- Large amounts of production data with varying degrees of quality
- Complex physical phenomena with infinite modeling solutions
- Huge uncertainties (10-100%) with limited transparency on error range

Often sub-optimal approach to decision making

- Mgmt attention more on high CAPEX activities
- Focus on day-to-day operations / firefighting leaving little room to chase extra barrels
- Uncertainty and number of involved disciplines leading to over conservatism and experience-based decisions

ProductionCompass is a system to build AI-powered production optimization apps tailored for your asset

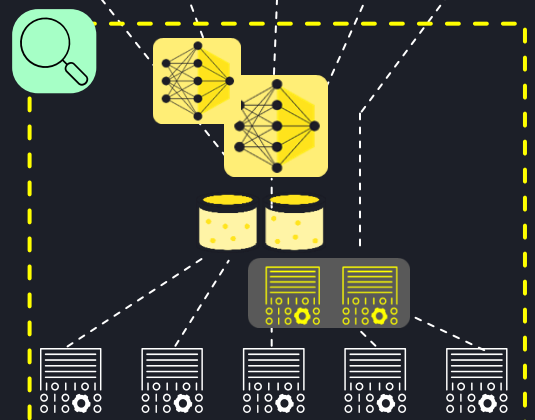
Standard applications

Tailored asset specific applications

Data-driven flow estimation

Action Hub

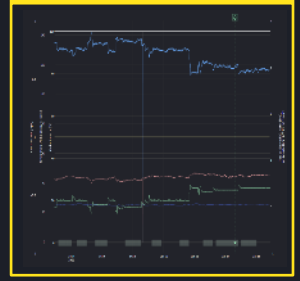
Well test optimizer



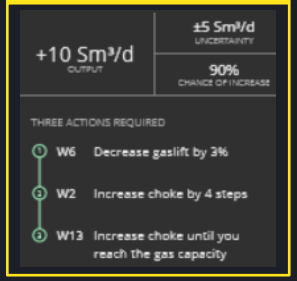
Chemical injection opt.

Maximum production pot.

Sensor surveillance



Production optimization



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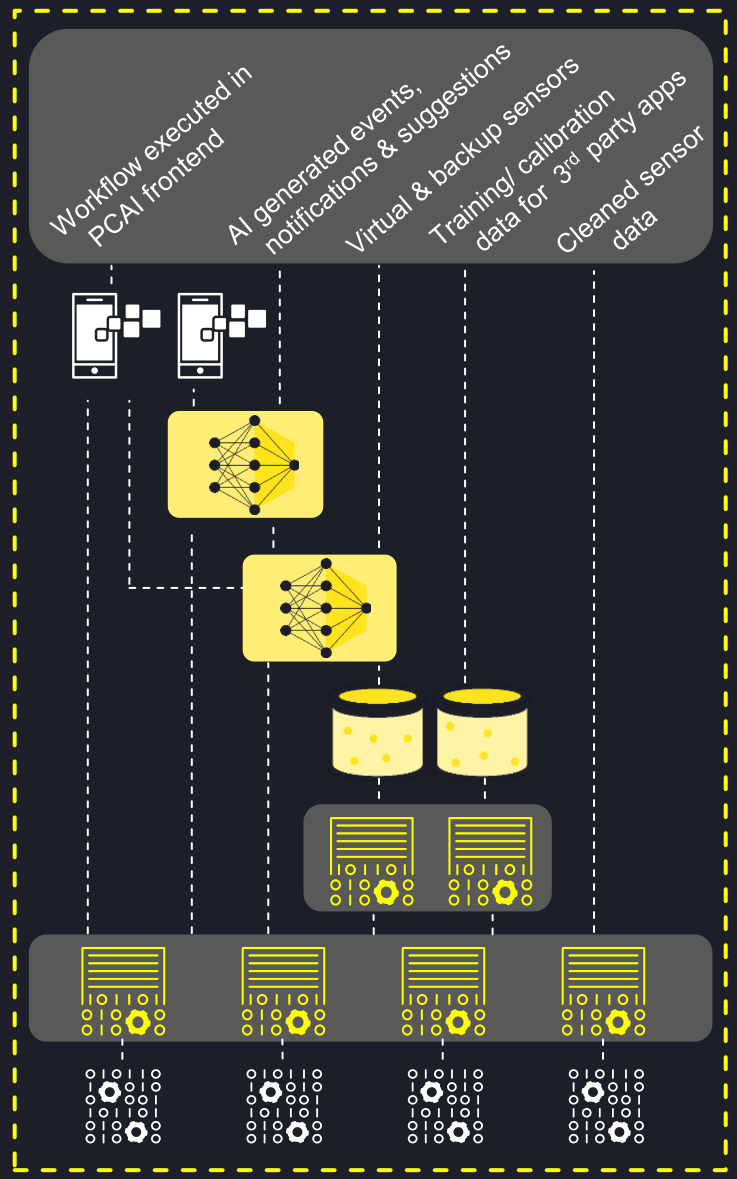
Data feed & AI models

Zoom-in on next page

To overcome the historical challenges and unleash the value potential, tailoring, integration and robust data handling is key

The data feed and AI models provides the basis for insight



Flexibility in applications
- Custom dashboards to fitted your work and data flows, e.g. testing, optimization, allocation, etc.
- AI generated events, notifications and suggestions; e.g. water & gas breakthrough notification, optimized GL reallocation opportunities, possible scaling incident, intervention optimization..
- ML based virtual sensors, e.g. VFM (well oil, gas & water flow estimation), Sensor Surveillance & Backup, slug severity indicator, flow assurance risk, real-time well PI estimator..
- Automatically cleaned sensor data tags, and aggregated labeled production datasets

Production Compass customizable graphical interface
- Build tailored dashboards to fit with data and both condition- and time-based workflows

Event AI system to generate smart notifications and recommendation
- MINLP optimization and ML classification algorithms. Enables automatic notification of risk and opportunities, smart ranking, optimization suggestions, sensor failures.

Generative well flow AI for virtual sensoring
- Hierarchical models with the ability to transfer learn between data from thousands of wells
- Autoregressive modeling of temporal dependencies and multi-modal distributions

High value labeled multi-asset database
- Millions of operating points, thousands of approved well test, labeled water & gas break though events, scaling events, well startup & shut-in statistics, and more..

Automated data mining
- Identification of data intervals of interest and computation of aggregated/ summarized statistics. E.g. Well startup & shut-in duration, well test uncertainty, operating points mean production, transient events amplitude..

Sensor data cleaning & condensation
- Real-time cleansing, filtering, outlier removal, ingestion, mm..
- Combining low information signals into dense info signals

Real-time sensor data steaming
- Use “all” available data; Pressure, temperature, flow meters, GL, ESP, valve positions..

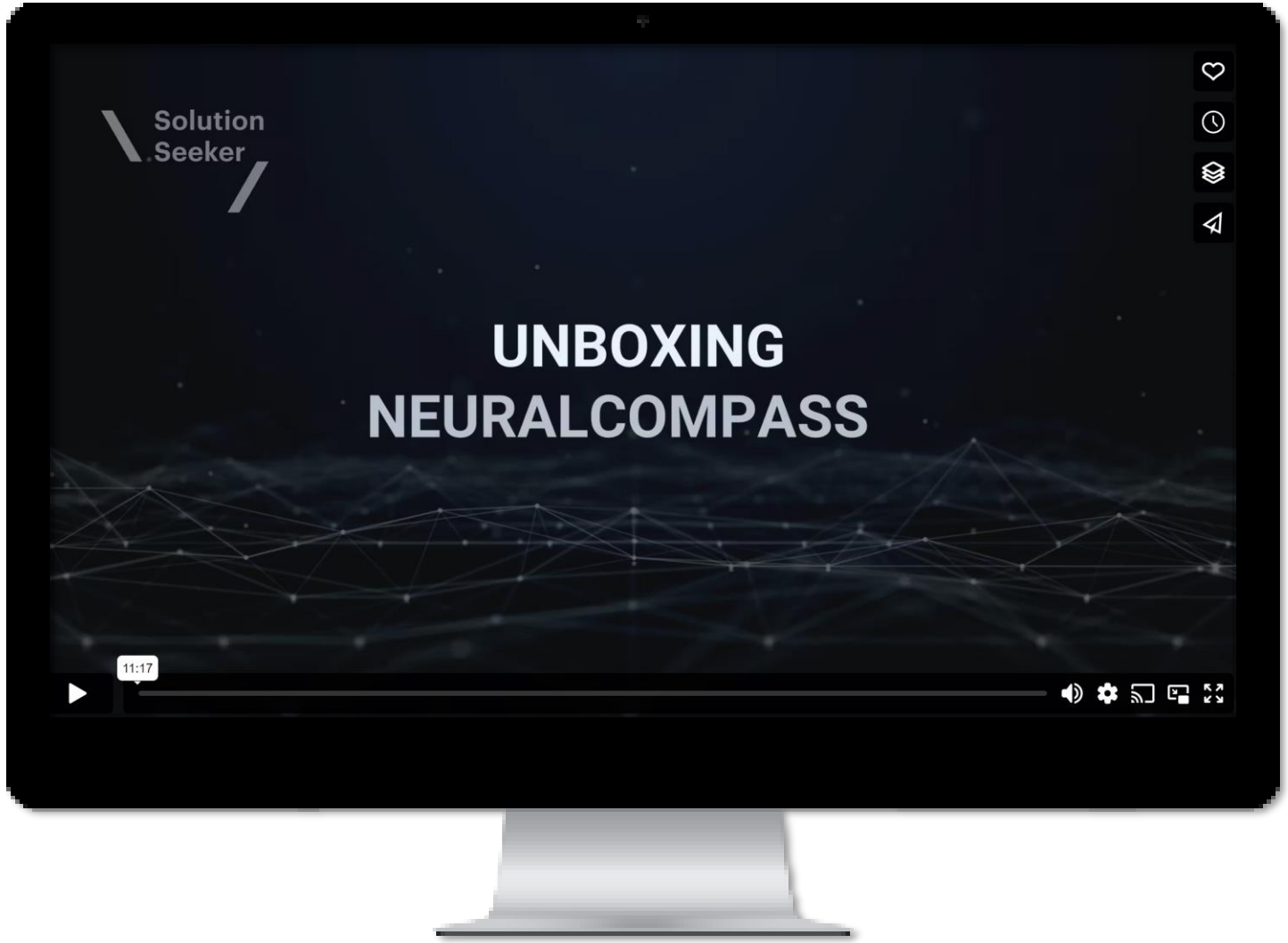
Demo video of AI well flow estimation service

The video (link to Vimeo) elaborates on how a NeuralCompass VFM service is set up, maintained and delivered as an AI service using the Production Compass system.

The video covers data selection and curation steps, model training steps, and model inference and delivery.

The purpose of the video is to explain how an AI service can be set up, and how algorithms and dashboards can be tailored to the asset needs and the preference of the users and the oil company.

PS! The system requested by Petrobras in this tender opportunity will be tailored by Petrobras needs and will not be limited to how the example VFM system explained in this video.



Link to video that explain how one of Solution Seekers AI services is delivered

Selected publications by Solution Seeker on AI-based sensor data modeling

[Link](#) to the full list of Solution Seekers scientific publications

The following short-list is a selection of scientific works published by Solution Seeker relevant to the scope of work for this specific Petrobras opportunity. It highlights Solution Seekers extensive scientific background and its relevance as partner to Petrobras.

1. *A deep latent variable model for semi-supervised multi-unit soft sensing in industrial processes*, link to pre-print on arxiv. This paper elaborates on a modeling strategy that is relevant for quantifying confidence in sensors.
2. *Multi-unit soft sensing permits few-shot learning*, link to pre-print on arxiv. This paper shows that transfer learning from data between wells enables good predictions also for wells with very little data.
3. *Multi-task neural networks by learned contextual inputs*, link to ScienceDirect. This paper deep dives into the potential of multi-task learning (transfer learning) across domain and use cases, a key learning paradigm for the proposed AI model.
4. *Multi-task learning for virtual flow metering*, link to ScienceDirect. This paper addresses the same method as item 3 above (transfer learning between well sensor data), but applies it to virtual flow metering.
5. *Bayesian neural networks for virtual flow metering: An empirical study*, link to ScienceDirect. AI modeling framework that is key to modeling sensor uncertainty and reliability of the data.
6. On gray-box modeling for virtual flow metering, link to ScienceDirect. This paper highlights Solution Seekers capabilities in Hybrid AI modeling of well sensor data, i.e. combining physics based models with Machine Learning.
7. *Production data mining in real-time to improve data quality by removal of noise and selection intervals of interest*, link to Espacenet publication 1, link to Espacenet publication 2. Important technology for cleaning and preparing sensor data for AI model training and inference.
8. *Multi-task (transfer) learning across well sensor data to increase the data foundation an AI model can learn from*, link to Espacenet. Important learning paradigm to increase the data foundation the AI model can learn from.
9. Semi-Supervised learning for learning from both labeled and unlabeled sensor data, link to Espacenet. Key technology for enabling Generative AI modeling and utilize the vast amount of unlabeled sensor data.
10. *Passive learning to address nonstationarity in virtual flow metering applications*, link to ScienceDirect. This work explores the challenges related to nonstationarity which is prevalent in oil and gas sensor signals.
11. Whitepaper on Solution Seekers comprehensive AI flow offering, link to Solution Seeker archive.

Unique starting point to unlock value from data driven production optimization

Petrobras has co-developed parts of the ProductionCompass offering jointly with Solution Seeker, including key functionality related to well test data processing and workflow automation, gas-lift optimization, and more...

Comprehensive ongoing partnership through the Libra engagement - infrastructure in place, great drive and Solution Seeker has intimate knowledge about Petrobras IT and ways of working

Petrobras has a unique starting point and opportunity to reinvent data driven production tech end-2-end and capture high value at scale

Solution Seeker

- Introduction
- **Proposed solution**
- Project execution
- IT infrastructure

Our understanding of the challenge

PETROBRAS

Sobre o Cenpes

Imaginar, criar e fazer
hoje o futuro da Petrobras

Oportunidades

OP2458 - Confiança em Sensores

Submeter

Prazo para envio de proposta	Status	Área de pesquisa
28/07/2024	Aberta para envio de proposta	Área: Exploração e Produção de Petróleo e Gás Natural - Onshore e Offshore

Intenção de enquadramento

Obrigação	Agência	Tema	Subtema
Sim	ANP	Produção - Horizonte Pré-Sal, Águas Profundas, Campos Maduros e Novas Fronteiras Exploratórias	Métodos e Processos de Escoamento

Desafio

Um dos desafios relacionado ao monitoramento da produção é a escassez de sensores. Há sensores de pressão (P) e temperatura (T) nas seguintes posições: fundo do poço (PDG), árvore de Natal (TPT), choke de produção. No choke, há P e T a montante e/ou a jusante dele mesmo. Os sinais são armazenados no servidor PI, aplicando regras de compressão, o que causa diferenças entre os dados reais e medidos. Há também alguns sensores virtuais escritos em tags, disponíveis no PI. Por exemplo, pode-se inferir a vazão de líquido de um determinado poço por modelos físicos. Atualmente não se sabe quão acuradas e, portanto, quão confiáveis são essas medições (sejam físicas ou virtuais). Como consequência, não se sabe quão confiáveis são os alarmes. O desafio principal dessa oportunidade é que determinar o grau de confiança das variáveis e dos alarmes, baseado nos dados. 1) Suponha que exista um alarme de vazamento baseado na medição de P em TPT. Se a pressão superar um certo limiar, o alarme é acionado. No entanto, se a informação do sensor não for confiável, o alarme também não será. Atualmente, não há um indicador de confiabilidade da medição. Neste cenário, a inspeção do alarme é realizada por um especialista humano que analisa os dados dos sensores. Manter especialistas para todos os poços é um grande desafio. Há casos em que não é evidente, com desvios que não podem ser verificados por heurística. 2) Suponha que exista um sensor virtual de medição de vazão de líquido que faz a inferência baseada nas leituras de P e T do PDG, TPT e choke. Como não se conhece a confiabilidade das medidas de P e T, erros podem ser propagados para a estimativa do sensor virtual. Dessa forma, o sensor virtual também não será confiável. 3) Suponha que exista um indicador de P nos canhoneados de um poço injetor baseado na leitura de P do PDG. Se a indicação de P do PDG estiver errada, a estimativa de P nos canhoneados também estará, resultando em uma injeção subótima ou até danosa ao reservatório.

Objetivo

Em resumo, o problema é que não se sabe quão precisa/acurada/confiável são as medições (físicas e virtuais). O objetivo do projeto é o desenvolvimento de um indicador de confiança para os sensores (físicos e virtuais) que permita, automaticamente, descartar ou não a informação que o sensor/alarme fornece.

Petrobras has bold ambitions of harnessing data and digital technologies to improve efficiency, optimize operations, reduce cost, and enhance safety and environmental and sustainable performance.

Production monitoring is essential to achieve improvements to all off the above-mentioned domains, and hence the quality of the sensors used for monitoring and optimization is key.

To our knowledge, quantifying the quality and reliability of sensor data in real-time and at scale, has not been done before. Hence, the anticipated results from this project will be first of its kind worldwide, and the proposed approach will involve cutting edge research on Generative AI.

Based on our understanding from the Sigitec request for proposal, Solution Seekers propose to develop:

1. A software system that will monitor sensor data (physical and virtual) in real-time and at scale across thousands of sensors and multiple/ all Petrobras production assets. The system will communicate with all necessary Petrobras systems.
2. An AI model that in real-time quantifies the confidence of the sensor data for every sensor at the range of 0-100% and classifies the type of failure or problem that causes the lower confidence.
3. The software system with the AI model will: a) allow the user to select target well and tag, and receive its confidence, b) automatically notify relevant user if a sensor degrades of fails.

Generative AI sensor surveillance system

Challenge

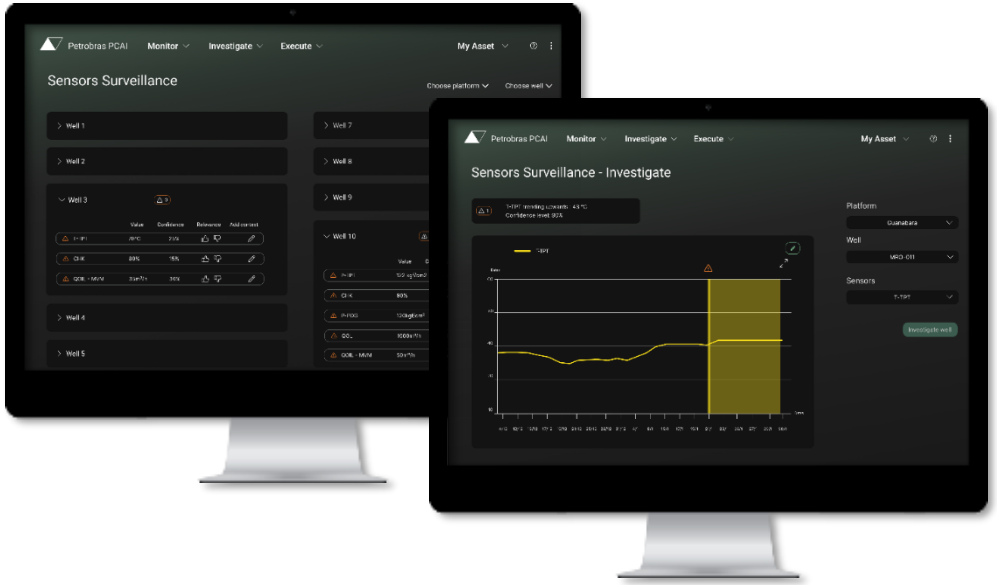
- It's difficult to ensure accurate and trustworthy data for monitoring production.
- The lack of a reliability indicator for sensor measurements makes alarms potentially unreliable, requiring resource-intensive and often ineffective manual inspection by specialists.
- Inaccurate readings can cause errors in virtual sensors, leading to poor decisions.

Goal

- Create an AI indicator for the confidence in the physical and virtual sensor measurements to automatically validate or discard sensor and alarm data.
- The AI system will suggest/ classify type of problem causing the lower confidence in the sensor (e.g. gross error detection, frozen signal/ lost data connection, outlier/ noisy data, etc.)
- Scalable system that integrates with Petrobras' monitoring applications and be applied to any sensor/ tag of PI's system

Benefit

- Automated workflow that frees up engineer time for use on opportunities
- Increased quality and constancy on sensor data
- More reliable data leading to better-informed decisions, minimizing risks of suboptimal actions.
- Scalable integration with Petrobras production systems



As an example, the proposed dashboards provide an overview of wells and guide user attention by displaying warnings, facilitating the quick identification of potential issues. Users can explore detailed functionalities, and check sensor values, confidence levels, and access the relevance of current indicators. Additionally, users can select a specific well/ sensor to monitor trends and confidence levels in real time, enabling precise identification and troubleshooting of anomalies. This comprehensive approach enhances the efficiency and effectiveness of sensor data management and decision-making, facilitating user adoption of the developed system.

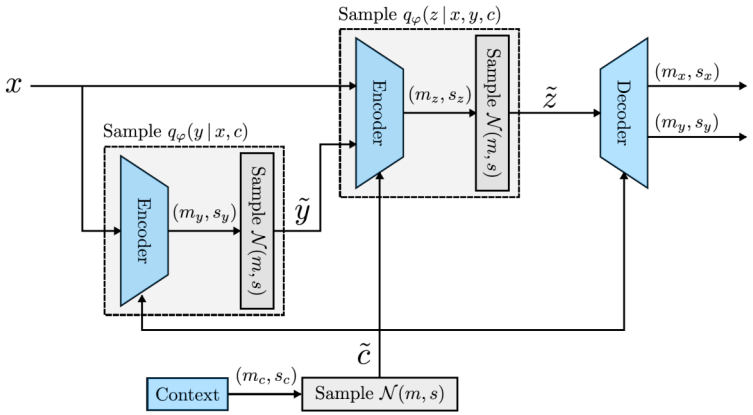


Illustration of an AI model architecture that can handle unlabeled data, i.e. target variable y is unobserved. When y is observed, the encoder qφ(y | x, c) is unused, and y is fed straight into the encoder qφz (z | x, y, c). In either case, the output is an approximation of pθ(x, y). The Context model parameters allow multi-task learning, i.e. transfer learning between data from more than 1000 wells.

Project deliverables

Deployment and tailoring of Sensors Surveillance system, including:

- Adapt automatic (and real-time) sensor data analysis for identifying mal-functioning, frozen measurements, etc.
- Provide a 0-100% reliability score for every sensor, offering an automated overview of sensor data quality
- Seamless integration with Petrobras databases
- User friendly interface to easily check the confidence level of a sensor, facilitating the decision process
- Design tailored dashboards adhering to Petrobras standards and user needs
- Integrate with Petrobras monitoring and alarm systems, such as VIP, as an optional feature

Architecture deep dive on proposed generative AI model for estimation of sensors confidence

We will utilize a deep latent variable model that allows for semi-supervised and multi-unit learning. A pre-print of a forthcoming scientific paper is published on arxiv (link).

This particular paper focuses on the model's applicability to virtual soft sensing. However, as part of the proposed project we will extend the models capability to also handle estimation of sensor confidence (0-100%), and the classification of failure type casing a low confidence, e.g. a gross error in the signal meriting a calibration of the sensor, or a frozen signal indicating a lost connection.

The model architecture enables transfer learning between wells and different types of tasks through its multi-task learning algorithm. It is further able to learn from both labeled and unlabeled data through its semi-supervised learning algorithm. Effectively exploding the amount of what the AI model can learn from.

It is our opinion that it is key for the scope of this project - computing confidence in sensors - that the AI model has the ability to learn semi- or self- supervised, i.e. exploiting unlabeled. And further, that the AI model can do this in combination with the learning from data across wells. This is the only way the data foundation will be sufficient.

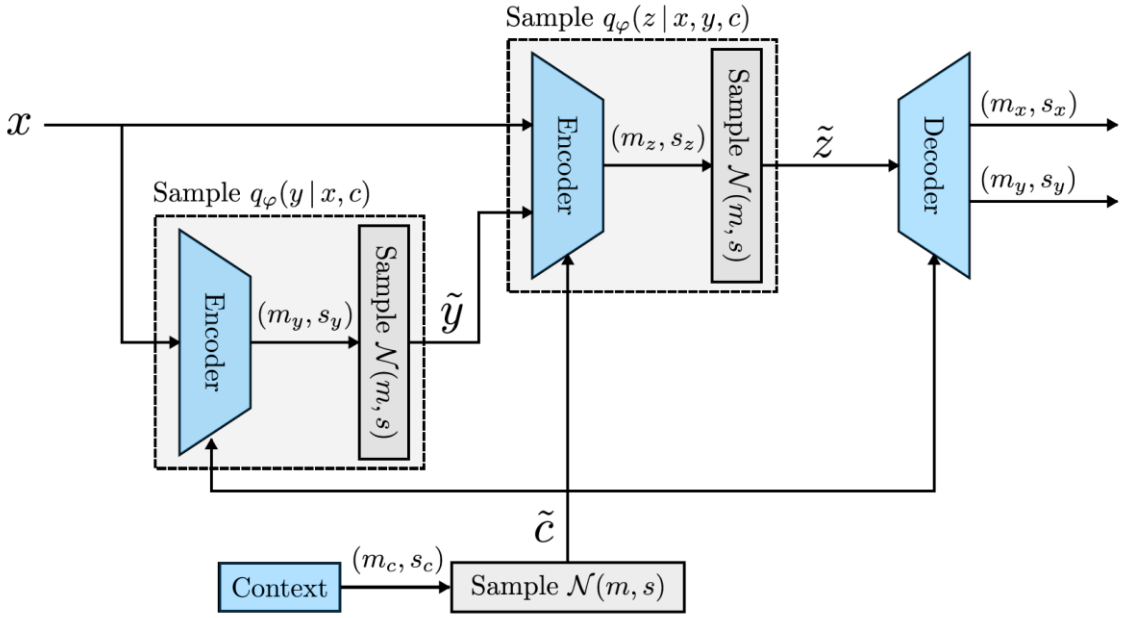
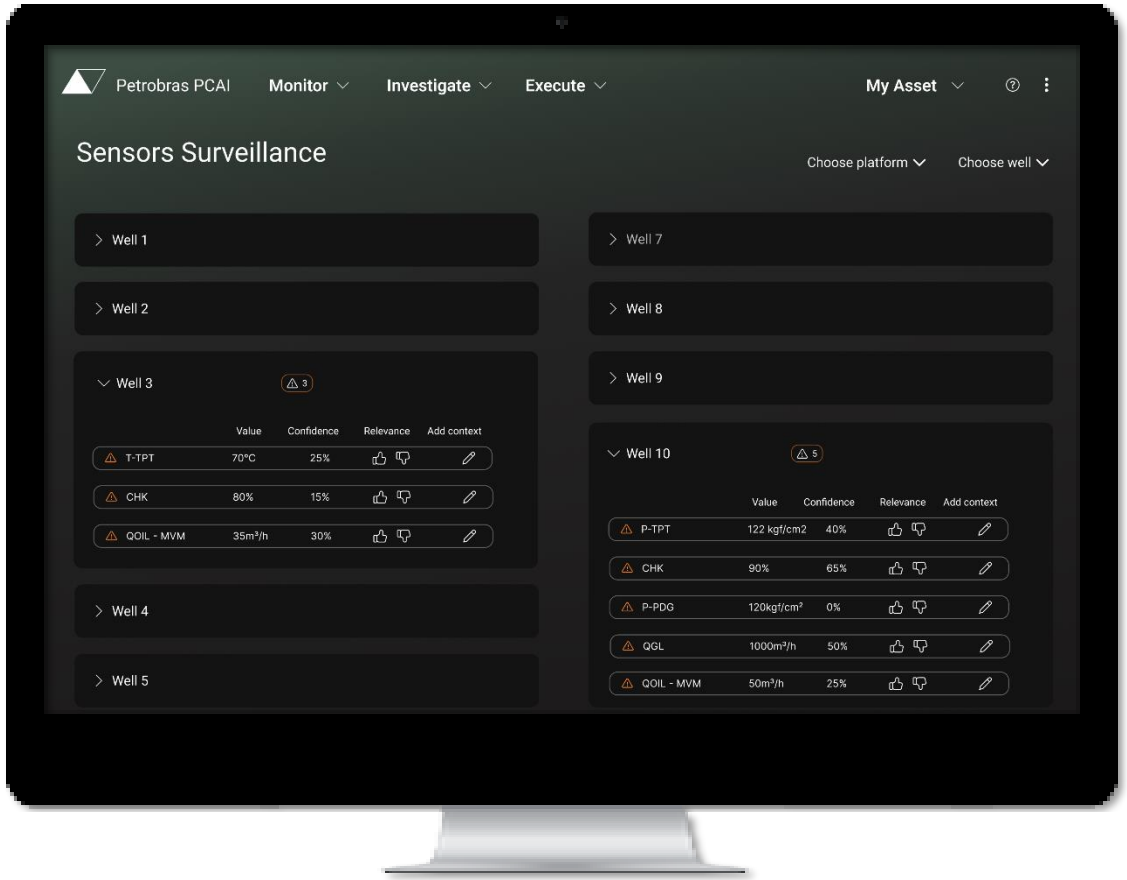
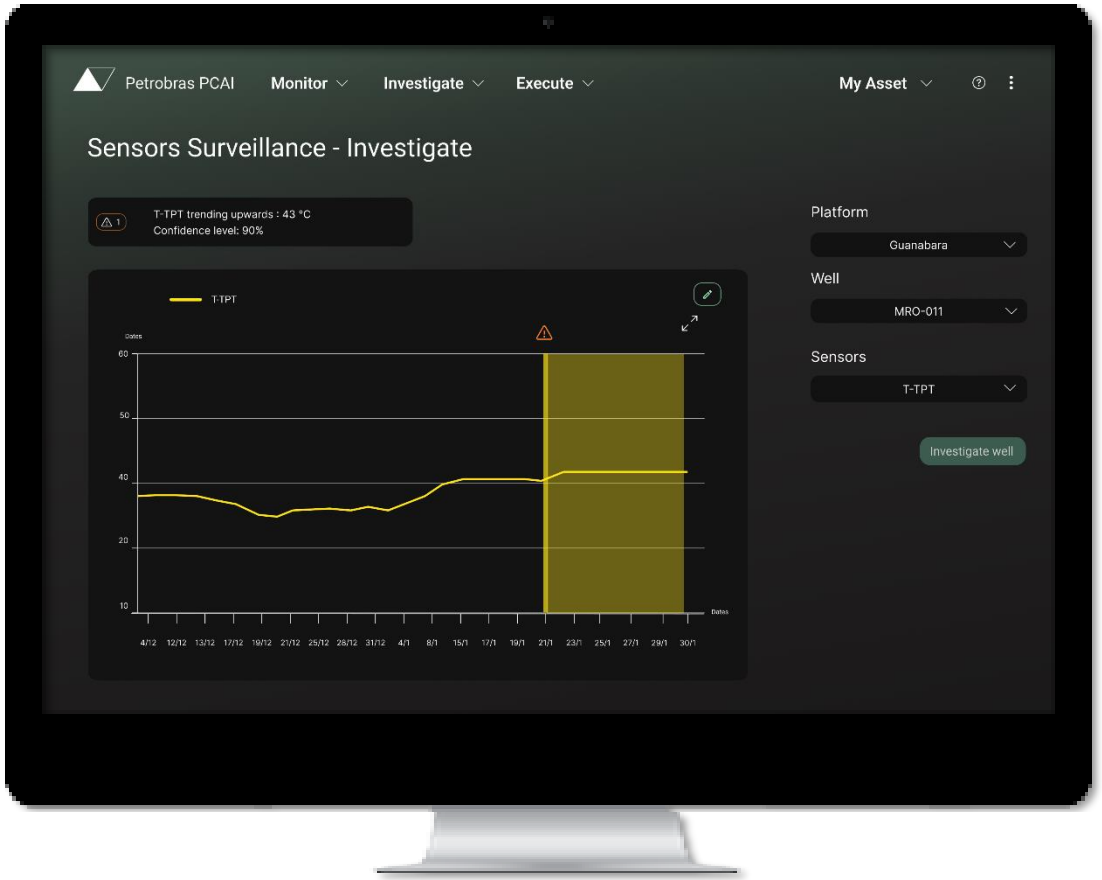


Illustration of model architecture when y is unobserved. When y is observed, the encoder qφ(y | x, c) is unused, and y is fed straight into the encoder qφz (z | x, y, c). In either case, the output is an approximation of pθ(x, y).

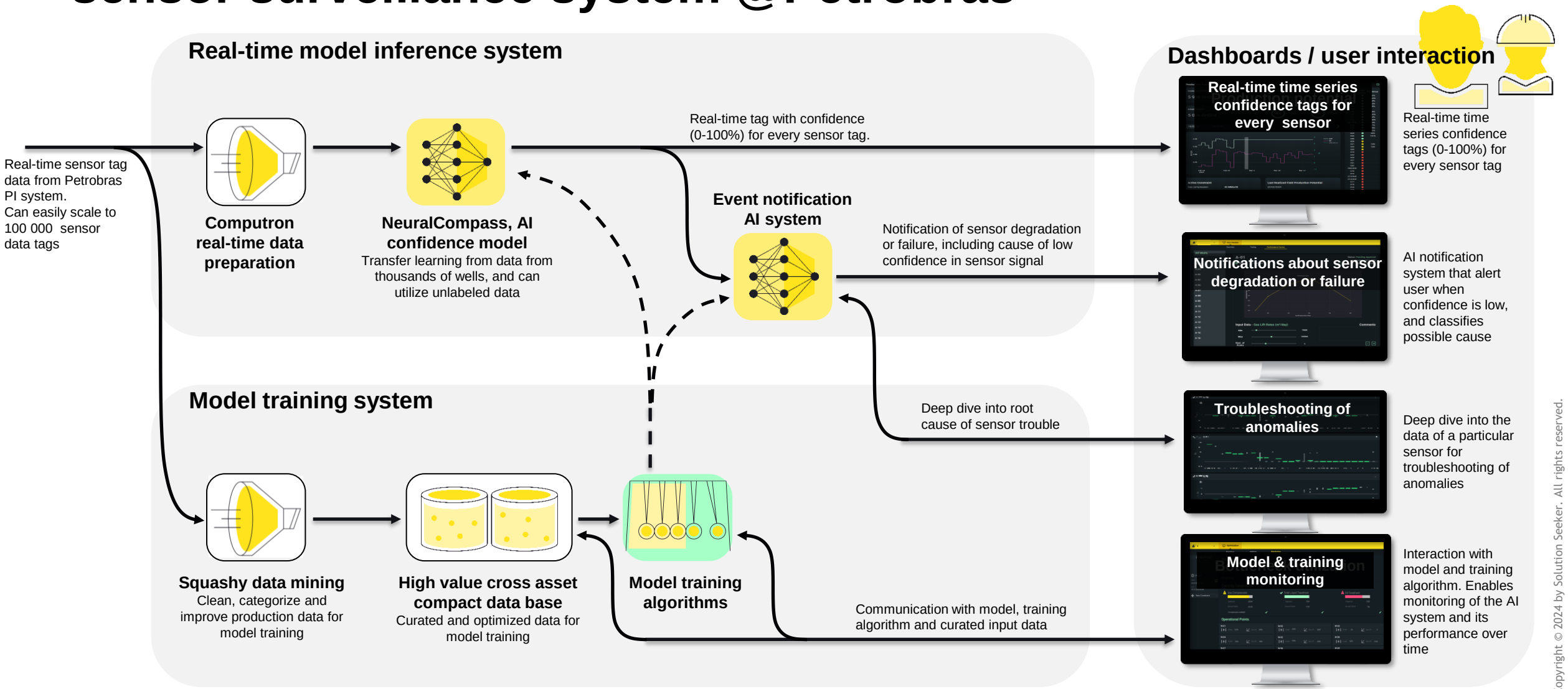
Illustration of potential dashboards with associated workflows to monitor sensor confidence, and handlining the lack thereof





The user will have the ability to select well and sensor, to see the AI models' confidence in this particular sensor signal (left dashboard above). The user will further be able to provide "human feedback", and to add comments/context. If the confidence is low, the AI model will classify the problem/ provide a suggestion to what type problem the sensor has. The user will be allowed to investigate/ deep dive into the data of a particular sensor for troubleshooting of anomalies (right dashboard above). Further, there will be an overview of the wells and sensors, and the AI model will enable a condition-based workflow guiding the user's attention by displaying warnings, facilitating the quick identification of potential issues about degrading sensors and potential problems – enabling the users to prioritize and free their time. Ultimately, the system enhance the efficiency and effectiveness of sensor data management and decision making.

Overview of potential architecture of Generative AI-based sensor surveillance system @Petrobras



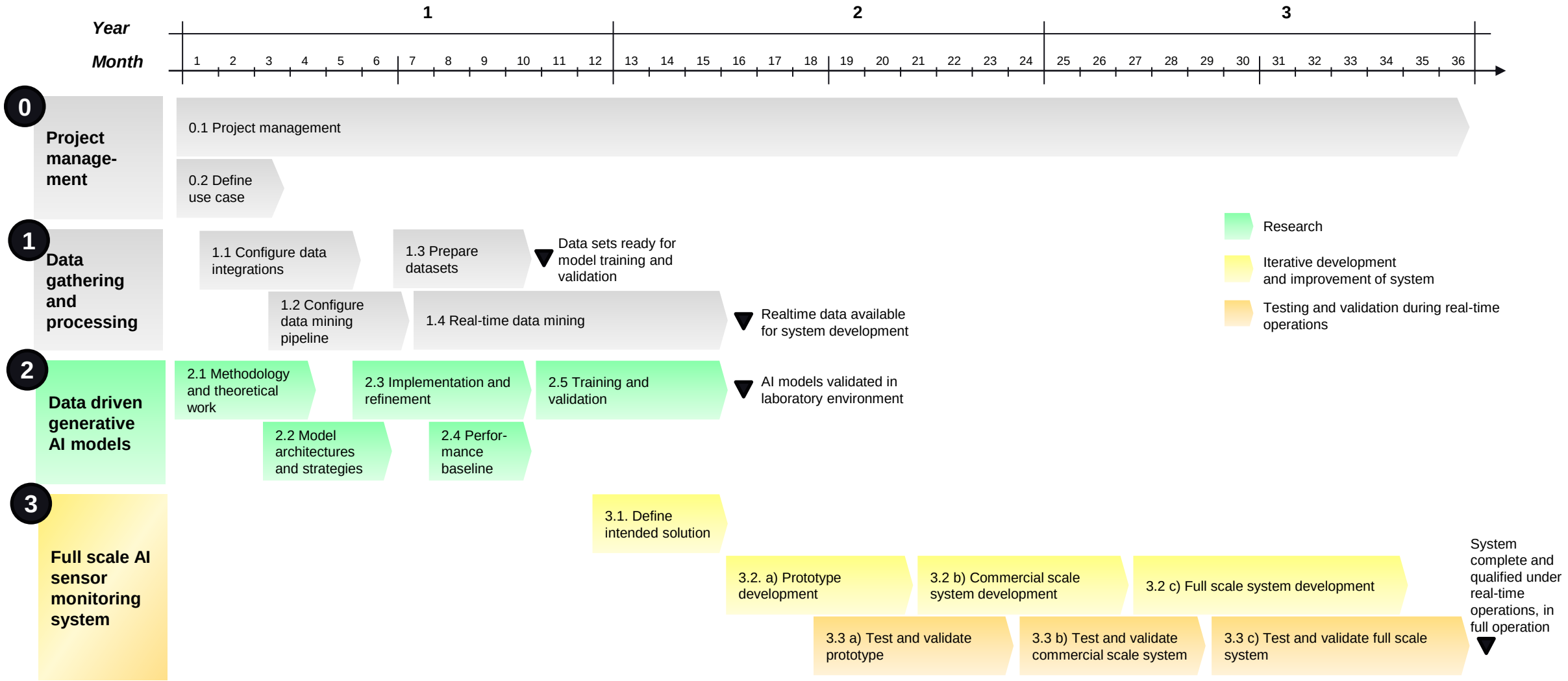
Data may also be sent to Petrobras PI system, VIP system, or other systems.

Solution Seeker

- Introduction
- Proposed solution
- **Project execution**
- IT infrastructure

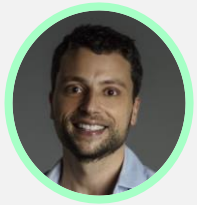
Proposed timeline over 36 months

Timing of activities to be iterated on throughout the course of the project.



A dedicated team with unique experience in data driven PO

Project Management & interface

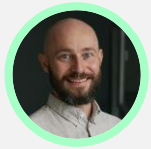


Guilherme Kessler, Director Brazil
Client owner
13 years of experience managing O&G projects. MSc from the Norwegian School of Economics and BSc from USP

Danielle Monteiro, PhD cand.
Project Manager
Significant experience in production management, multiphase flow models and optimization. Extensive experience with well-known industry simulators. Ph.D. candidate at UFRJ in petroleum technology

Subject Matter Experts

Vidar Gunnerud, PhD
CEO & Founder. O&G Production optimization expert. PhD from NTNU Engineering Cybernetics on PO algorithms. Extensive experience with PO challenges across 10+ operators, 30+ assets and 100+ use cases.



Bjarne Grimstad, PhD
Chief Researcher with PhD from NTNU on ML and production optimization. Intricate knowledge on flow simulators, both data-driven and mechanistic. Experience at TechnipFMC as a senior flow assurance engineer.

Mathilde Wekre, PhD
Project role: Field responsible Team lead Data-Driven VFM solution. ML expert with PhD from NTNU on data-driven/ML and hybrid virtual flow metering.

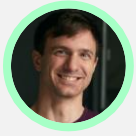
Stine Ursin-Holm
Product owner of our in-house PCAI software framework. 10 years of experience working on software development projects in cooperation with O&G operators.

Anders Sandnes, PhD
Chief engineer, leading design of PCAI algorithmic layer. PhD, on Bayesian machine learning strategy for oil and gas production network models. 10 years' experience with data driven O&G production modelling

Hanne Folde
MSc in Petroleum Engineering, expert knowledge on analysing and understanding production data to explaining various production-related phenomena. Project manager for key client (AkerBP, Vår Energi, PTTEP ++)

Application, Product & Platform/IT resources

Anders Wenhaug
Chief Software Engineer and primary architect of customer integration, time series data storage, processing time series data processing, and the overall architecture of PCAI SW layer.



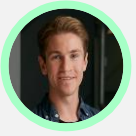
Ole Jørgen Brønner
Full-stack web-developer, responsible for Solution Seeker's entire stack from databases to the front-end graphical user interface.

Christine Sjulstad
Expert on data driven virtual flow modeling (flow reconciliation & allocation, neural network-based flow est., well production testing, flow meter deviation/error detection, etc.)

Knut Viljar Hilstad
Technical lead on key client engagement. Expert on PO applications, significant experience on PO use cases with operators in the North Sea, South America and Asia

Frida Konow
Data scientist with extensive experience developing use cases and analysing value capture with end users to optimize production.

Anine Ahlsand
Well Test Application expert, part of product team responsible for maintenance, improvements, and further development of the application based on user experiences

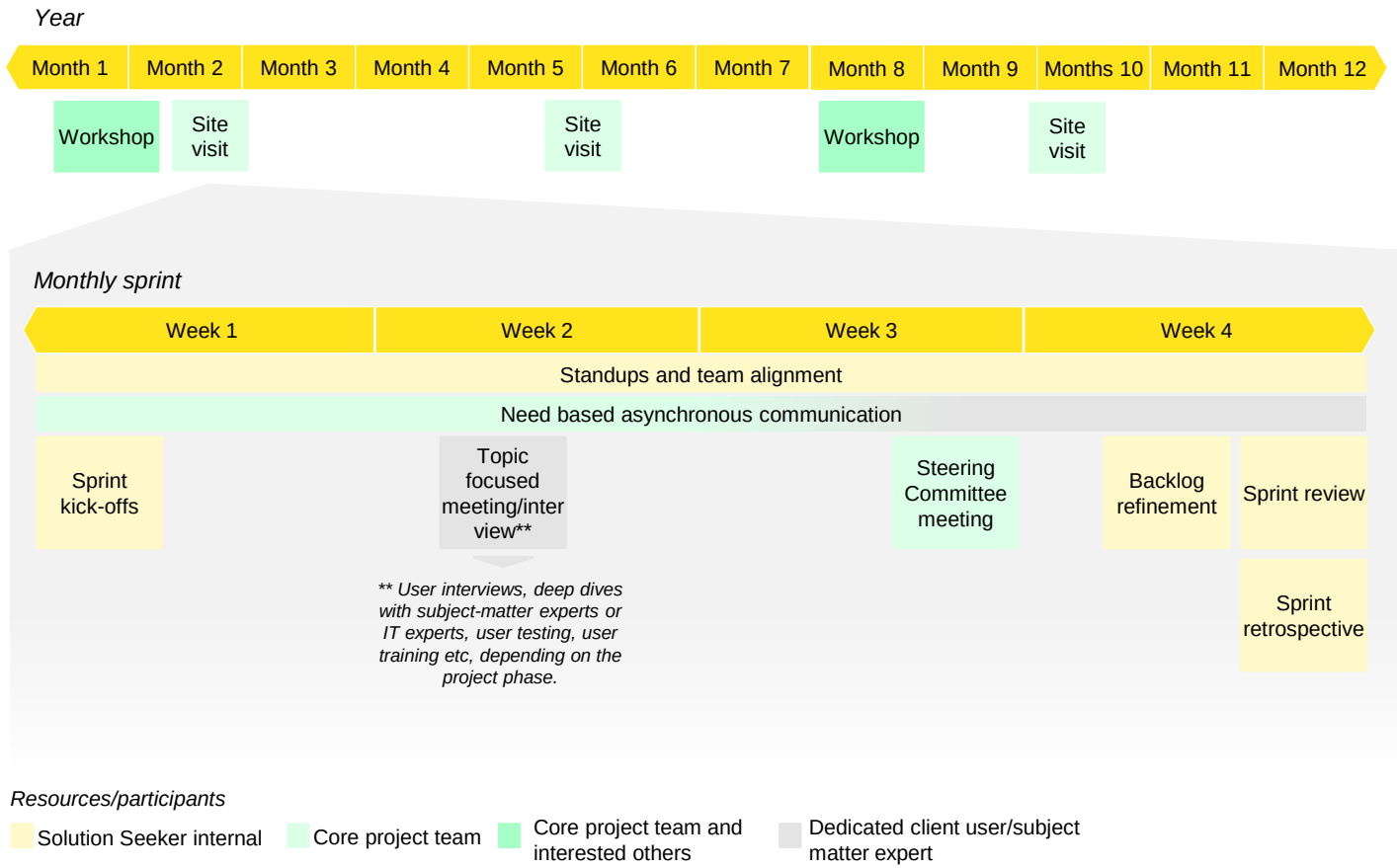


Kristoffer Nesland
Expert on flow estimation, virtual MPFM calibration using Bayesian linear regression, flow reconciliation & allocation
Responsible setup of DD-VFM for multiple clients.

Additional Resources as needed

Proposed project cadence and collaboration with Petrobras*

Business centric approach incorporating subject matter experts and end users to unlock value.



Annual touchpoints to ensure successful deployment and adoption

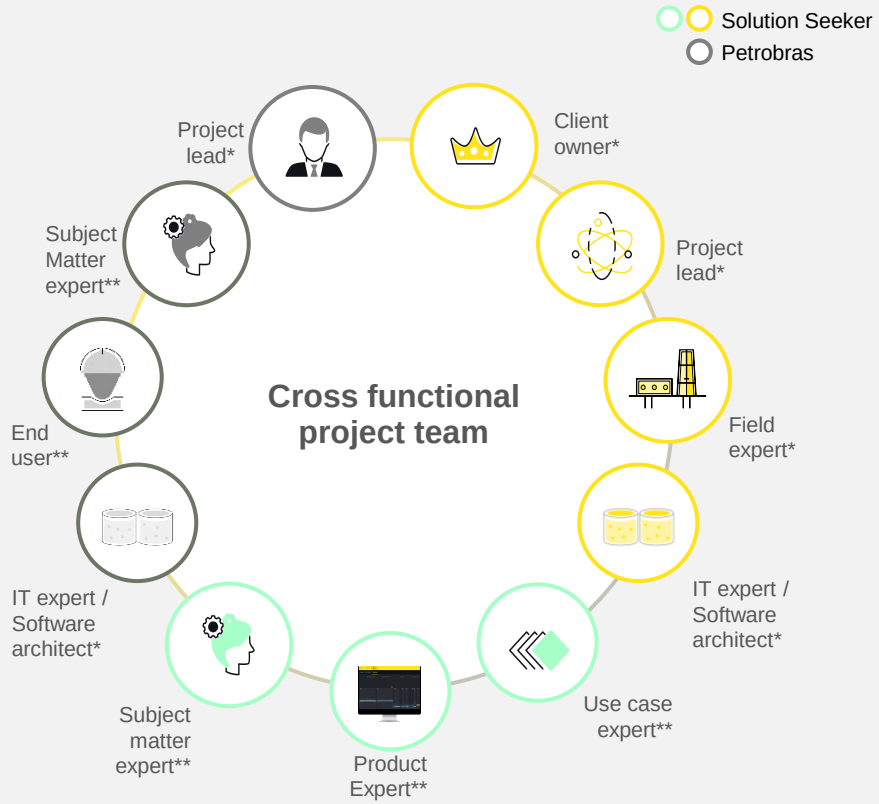
- **Project Workshops**: Bi-yearly sessions for reviewing deliverables, planning, and prioritizing to ensure value creation. These workshops facilitate the acceptance of deliverables and strategize for the upcoming four months. Participation is open to all relevant stakeholders, subject to client's discretion.
- **Site Visits/Contextual Inquiry**: Triannully visits at client location to gain a deeper understanding of the client and overcome communication barriers.

Client engagement in monthly work rhythm to influence and shape the progression of the project and the quality of the solution.

- **Steering Committee Meetings**: Monthly status meetings with the core team for roadmap/use case alignment, roadblock removal, progress maintenance, and value realization monitoring.
- **Topic-focused deep-dive sessions**: As required, focused meetings or interviews are conducted with a select group. These sessions, including user interviews, expert deep-dives, technical discussions, user testing, and training, aim to boost project progress and solution quality. Attendee numbers are kept minimal for efficiency and reduced overhead.
- **Asynchronous communication:** Selected users and experts available for email and chat communication to address questions and inquiries.

**Solution Seeker suggestion. Detailed cadence and collaboration to be agreed upon.*

Cross functional project team to ensure value creation*



* Dedicated resource that follows the project throughout the partnership
** Specific expert resources active dependent on project phase

Project management and client interface with digital and operational expertise in Oil and Gas, to ensure project success and drive value creation

- Follows the project throughout the lifetime.
- Overall satisfaction, project success and value creation, ensuring that the client achieves their desired outcomes. Define and describing target state, priorities and goals, value roadmaps.
- Project management – planning, work and meeting cadence, information sharing, resource involvement etc.
- Deeply engage with client and enabling frictionless incorporation of project with client's daily work and routines.

Expert resources with full understanding of the specific technical needs and business priorities, for fast and excellent delivery of high-quality value adding solutions.

- Subject matter experts: Comprehensive technical capabilities to deliver to the highest standards, covering all required capabilities within Software Engineering/ IT, Data Science and Optimization.
- Dedicated application, product and PCAI platform experts: Responsible for tailoring client specific applications, adapting and customizing current solutions or products and adapting the platform functionality to fit the client needs.

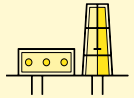
Project success dependent on Petrobras resources

- To be agreed upon.

**Solution Seeker suggestion. Project team and resources from Petrobras to be agreed upon.*

User and data centric iterative approach to identify build & capture production and information value

Use case



Use case ambition, value and feasibility hypothesis for improved performance across activities

Identify ambition and potential for high information and value capture
- Outline asset's information and value metrics given underlying challenge
- Derive use case ambition and value/ information hypothesis/ potential based on key metrics
- Identify value gap to ambition

Frame use case - evaluation and causes of lost value through investigative research, data analysis, and mapping of
- existing client/asset-specific blockers
- process and workflow friction points
- target audience, decision makers and users - and their various perspectives and needs,
- data-driven solution performance and opportunities,
- relevant data-driven solutions/enablers,
- objectives and prioritized needs and challenges for resolution,

Solution

Identify opportunities and implement **data-driven solutions**

Identification of data-driven solutions for high information and value capture
- performance given key metrics
- identify existing blockers for value and information realization,
- identify opportunities for new or improved data-driven solutions based on current performance and value potential,

Implementation and improvement of most value and information driving solutions
- Implement, adjust and refine solutions for data processing and cleaning, virtual soft sensors, sensor quality indicators, AI generated notifications, and optimization suggestions
- evaluate and improve based on key metrics

Application

Ideate and develop **data and user centric application**

Idea generation and planning of application solution to realise full value potential
- establish regular sessions with stakeholders and users to iterate on design and workflow blockers for value realization
- dive deeper into user journeys, processes, and frictions
- create detailed value & information capturing narratives that encompass user stories, scenarios, edge cases, and various user personas,
- use sketches and interactives prototypes to validate and get feedback on assumptions,
- model software solution and architecture based on design and workflow requirements,

Implementation and user testing to ensure data and user centric application
- optimize data storage, retrieval, and processing
- consider scalability and performance requirements
- confirm value hypothesis

Value

$

Deploy, operate and adjust to assure impact and **full value realization @scale**

Deploy, operate and iteratively improve solution and application in close collaboration with client and users
- onboarding session with client and users,
- user testing and feedback sessions,
- solution iterations to ensure high value capture at scale according to ambitions
- Accelerate to value by removing workflow and value blockers
- Monitor performance against value metrics

Continuously improvements based on user feedback, acknowledge that the asset will evolve over time and so does applications

Solution Seeker

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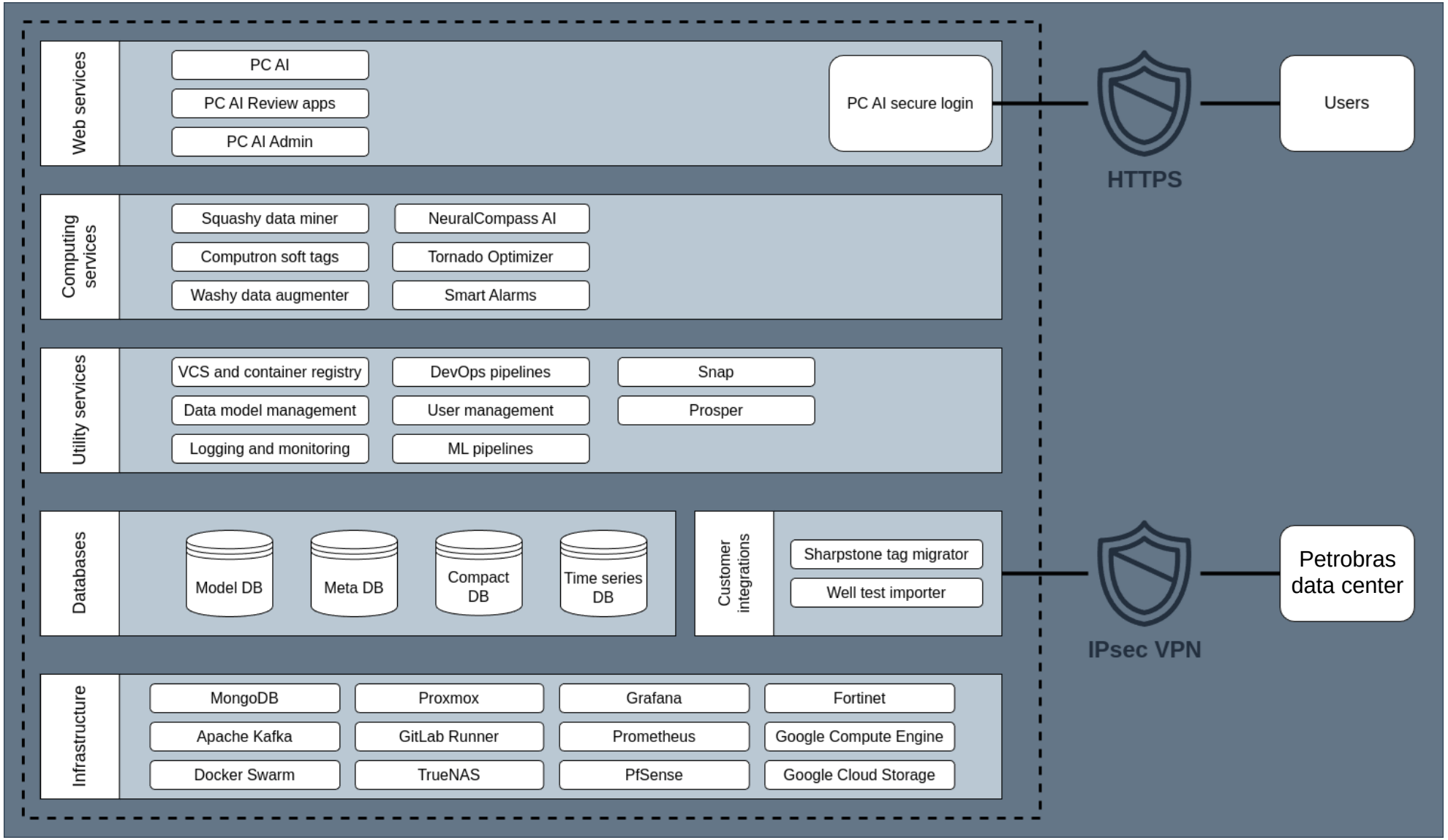
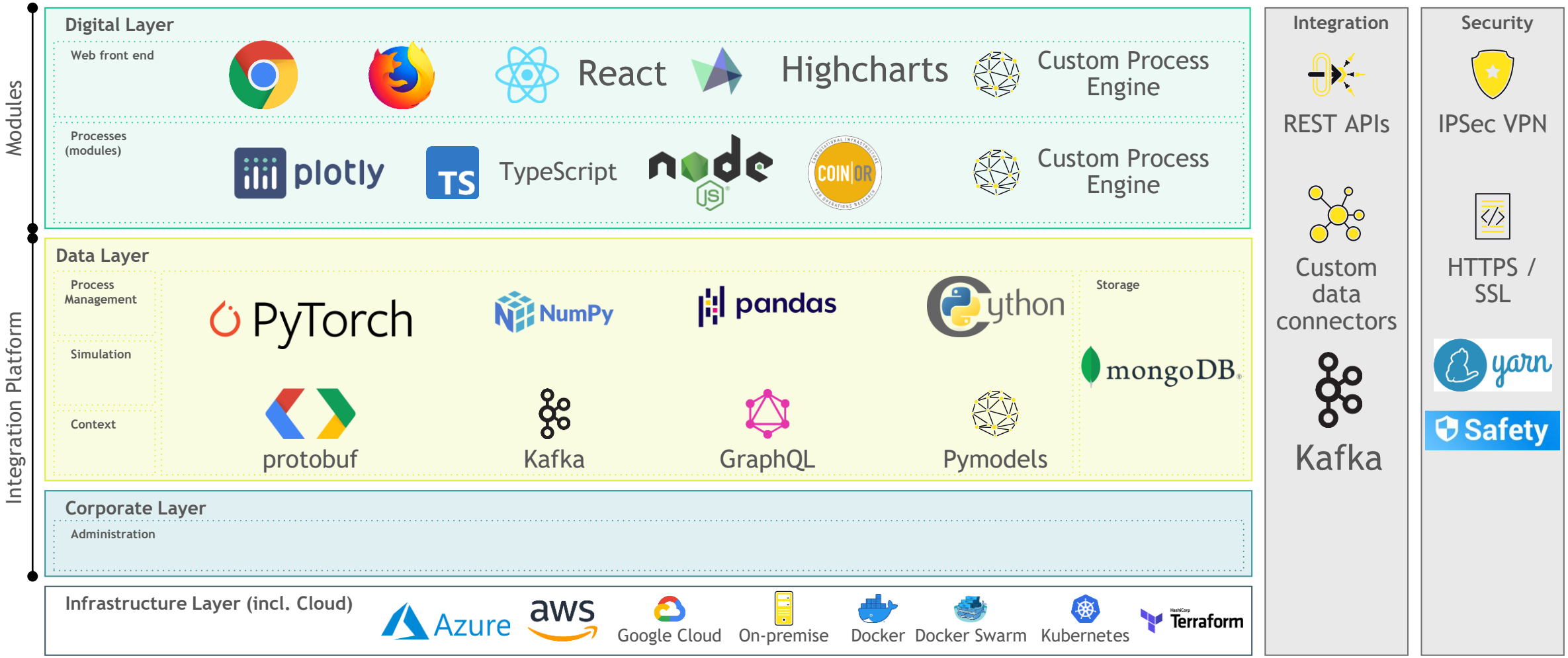
Core technologies used in the deployment and operations of PCAI



Technological foundations for Production Compass AI



Solution Seeker

THANK YOU

brazil@solutionseeker.no

www.solutionseeker.com