MAY 18, 2022

Accelerating the Synergy Value from the Expanded AVEVA Portfolio PETRONAS Illustrative Use Cases:

Ku Muhamad Ashman Ku Aziz

Outline

- PETRONAS *at-a-Glance*
- PETRONAS Journey of Using AVEVA Products
  - *Use Case #1*
    Beyond Data: Insight & Wisdom for PETRONAS Gas Business Division Leadership
  - *Use Case #2*
    PETRONAS Gas Processing Unit Technical Centre
  - *Use Case #3*
    Enabling Smooth Operations by Flowchart Automation Through PI AF
  - *Use Case #4*
    Early Failure Detection Using Predictive Analytics
  - *Use Case #5*
    Enhanced Insights by Leveraging First-Principle Process Simulation
- Q&A

PETRONAS at-a-Glance

FORTUNE Global 500 energy company with a presence in over 50 countries

- Upstream: extends across more than 20 countries globally, with 247 producing fields, 432 offshore platforms and 30 floating facilities
- Downstream: full spectrum of activities include refining (>800kbpd), manufacturing & marketing of petrochemical products
- Gas Business: Comprises LNG (6.69MTPA) & Gas and Power (2,623km pipelines processing 2,060mmscfd gas)
- Clean Energy Solutions: Renewables Energy (i.e. solar, wind, hydrogen, green mobility)

PETRONAS Journey of Using AVEVA Products

AVEVA PI System Journey and Overview

- Started using the PI System in 1991
- Proliferation of use from 2011 thru 2019

Gather operational data across different business

Driven by importance of data to generate insight & wisdom

- Enterprise Agreement signed in 2020 to support a tactical to strategic use
- Summary of the PI System at PETRONAS

100+	3.5M+	200+	4,500+
servers	*number of tags*	*PI AF templates*	*PI Visions screens*

AVEVA Product Portfolio Journey and Overview

- First use of AVEVA PRiSM for predictive analytics of rotating equipment
- UOC is used to provide enterprise view of molecule movement
- List of current AVEVA products used

UOC

PRiSM

ROMEO

AIM

Production Accounting

Spiral

Wonderware

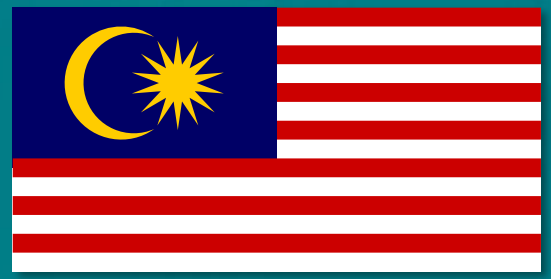
Use Case #1

Beyond Data: Insight and Wisdom for PETRONAS Gas Business Division Leadership

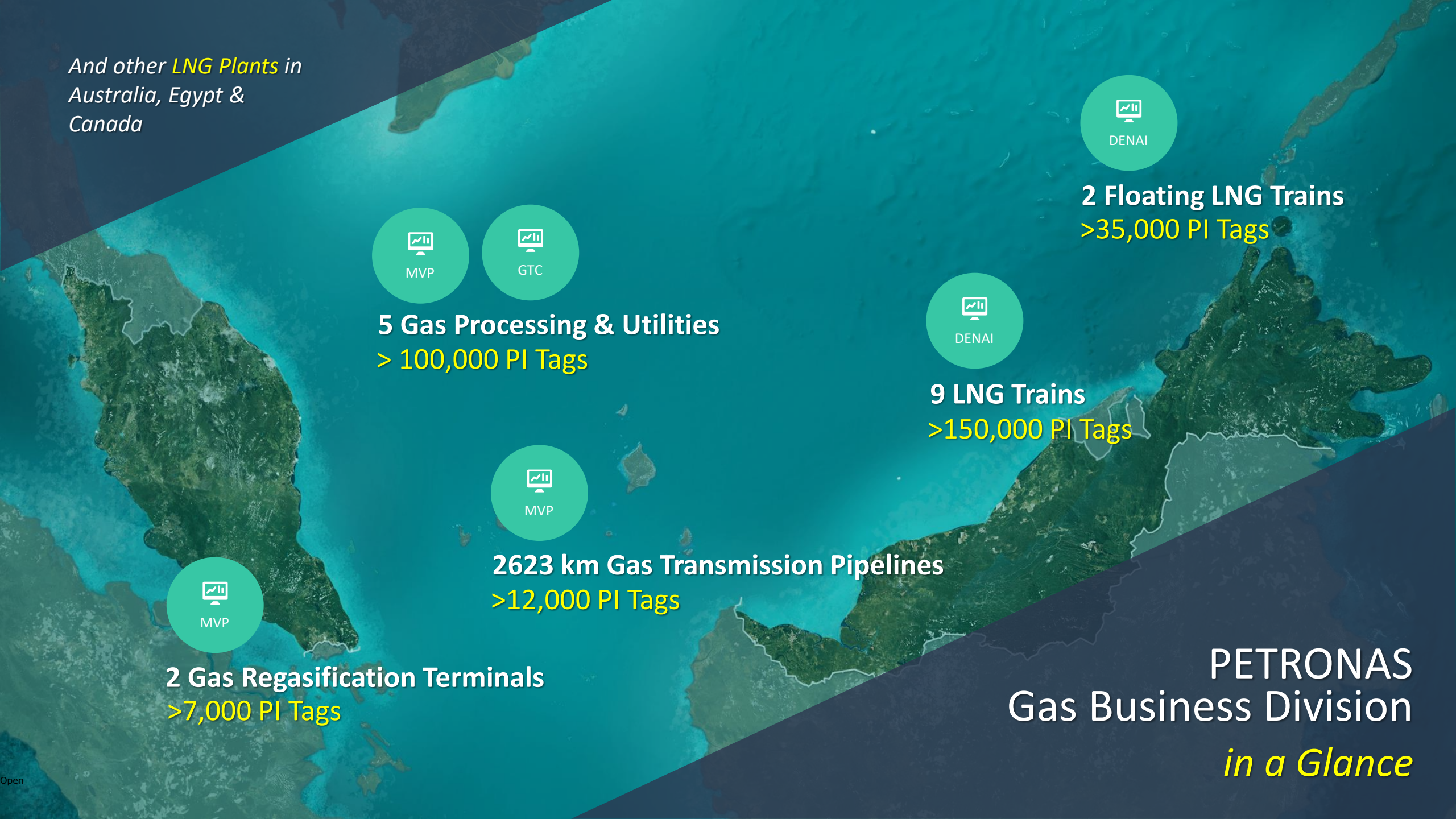
Ts. Muhamad Fauzi Ayub

Ts. Ahmad Ridhwan Hassan

AVEVA



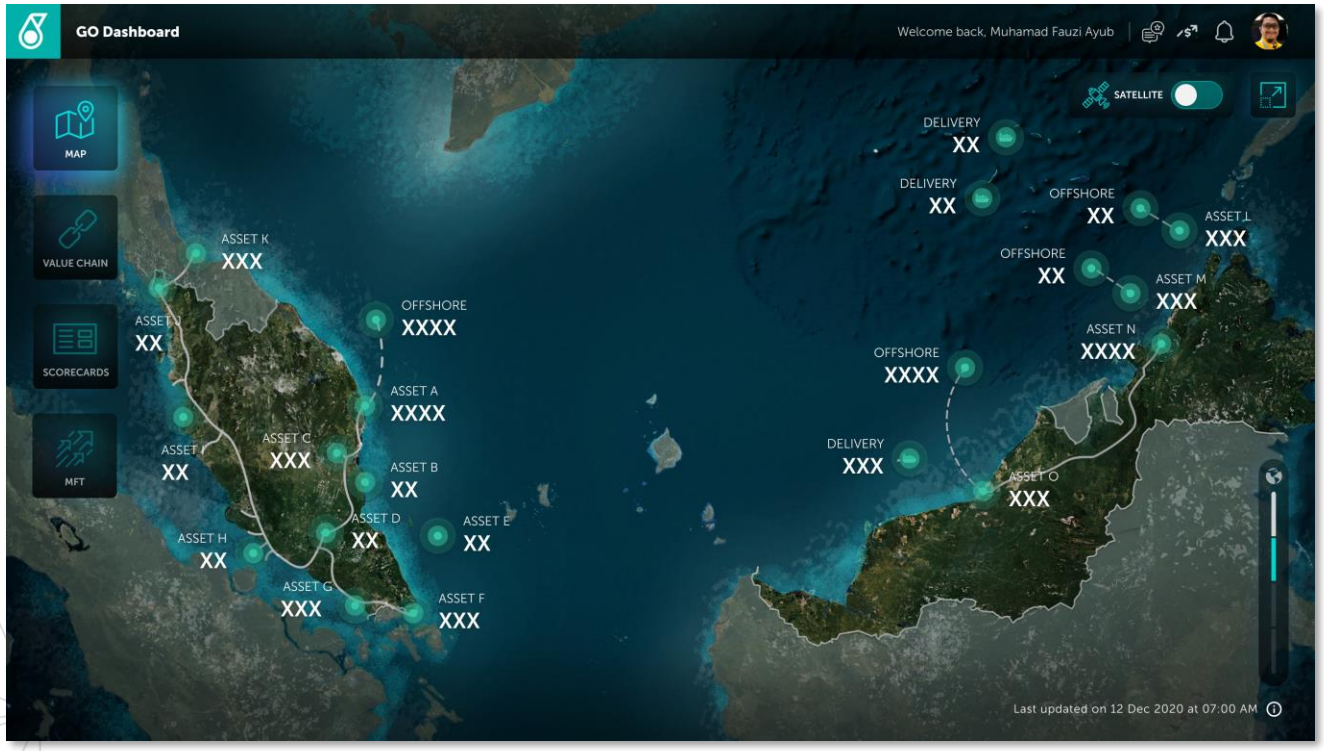
Malaysia


And other LNG Plants in Australia, Egypt & Canada
DENAI
2 Floating LNG Trains
>35,000 PI Tags
MVP
GTC
5 Gas Processing & Utilities
> 100,000 PI Tags
DENAI
9 LNG Trains
>150,000 PI Tags
MVP
2623 km Gas Transmission Pipelines
>12,000 PI Tags
MVP
2 Gas Regasification Terminals
>7,000 PI Tags
PETRONAS
Gas Business Division
in a Glance

#now

Today, GO Dashboard is an integral platform within Gas Business Division

GO (Gas Business Overview) Dashboard a strategic dashboard that provide the oversight of all it's operations



A web responsive platform and accessible via multiple device screen sizes

- Integration with all Gas Business Division's asset, Upstream, Downstream & Customers
- Visualization as per User Persona and focusing to key parameters
- Assurance of information by relying the integrity at the data source

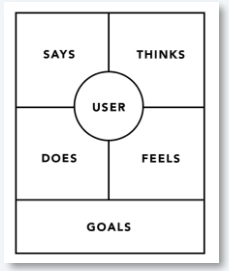
#throwback

Back then, timely data is not readily available & muddles understanding for bigger picture

- Abundant of data is within each respective assets monitoring platforms
- Information overload with too much details & analysis paralysis
- Lacking visibility of scenario at enterprise level integration

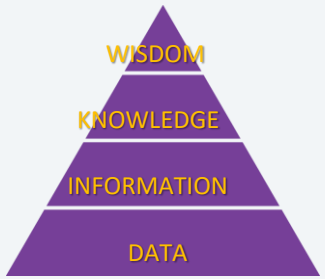
#throwback

We overcome the challenges by building a product that people want to use



Designing a focused product representing end-user characteristic and goals

Construct requirement through Persona of stakeholder, delivering superior User Experience



Converging information from all assets whilst providing insights & visibility of effects across the value chain

Anchor with Wisdom Hierarchy in elevating operational data towards insightful wisdom

Maintaining information logic and integrity at data source

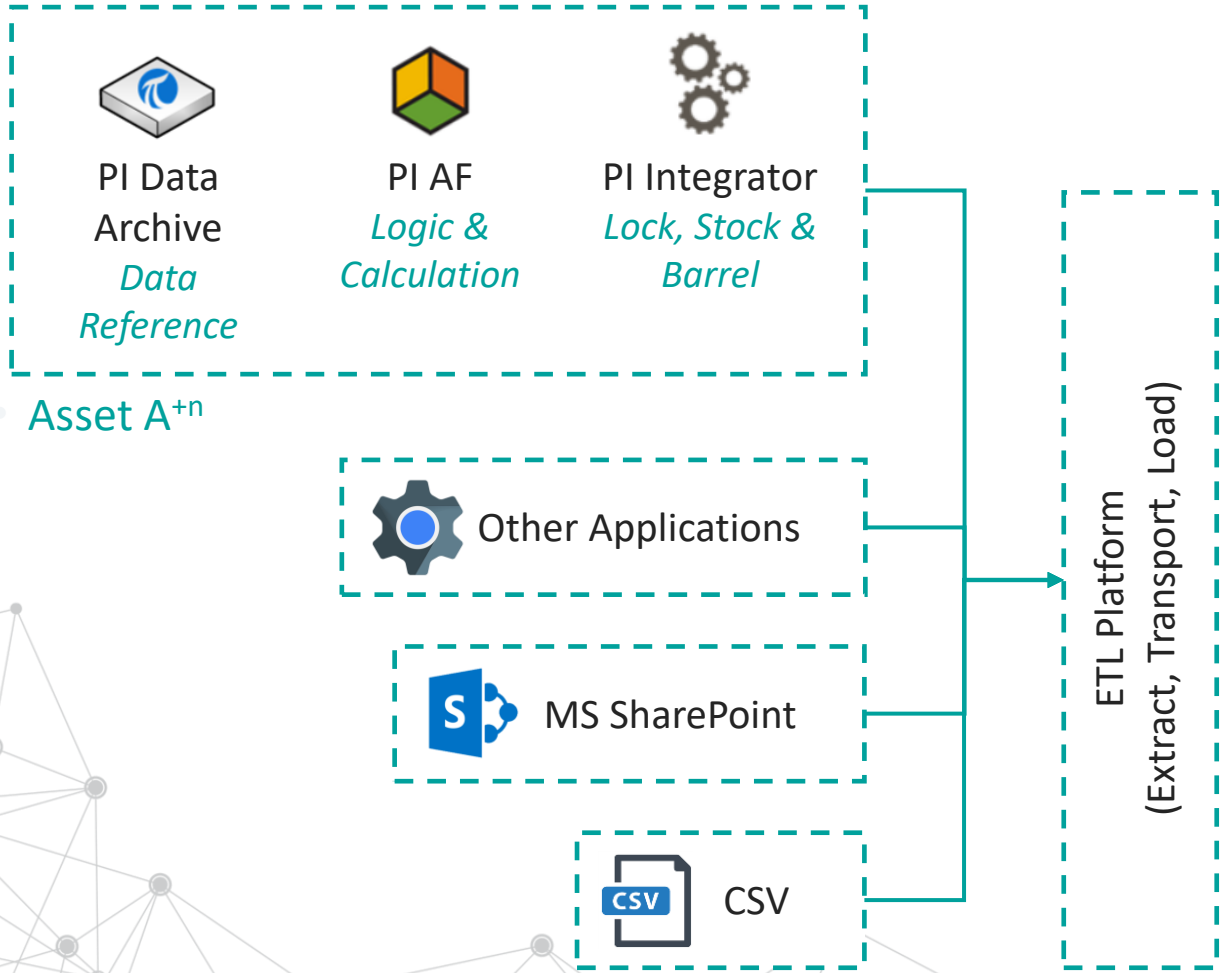
Accelerate integration of data and process with all assets through Agile POD formation

Open

#throwback

Converging existing PI Infrastructure has simplified & accelerated the journey

The PI System Infrastructure remains as the key engine for logic and data source



269 PI Tags

42 Performance Indicators

Initial product successfully delivered & operationalized within 1 month by leveraging existing the PI System infrastructure setup

AVEVA

#throwback

The result speaks, Gas Business Division operations is only within a click

GO Dashboard is adopting Skeuomorphic UI

23%

Process Cycle Efficiency Improvement

- eliminated manual and time-consuming updates
- provide information in a timely manner

6/7

Customer Effort Score

- 100% utilization in Leadership conversation

Open

DEMO


GO Dashboard
Welcome back, Muhamad Fauzi Ayub
MAP
VALUE CHAIN
SCORECARDS
MFT
SATELLITE
DELIVERY
XX
DELIVERY
XX
OFFSHORE
XX
ASSET L
XXX
OFFSHORE
XX
ASSET M
XXX
ASSET N
XXXX
OFFSHORE
XXXX
DELIVERY
XXX
ASSET O
XXX
ASSET K
XXX
ASSET J
XX
OFFSHORE
XXXX
ASSET A
XXXX
ASSET I
XX
ASSET C
XXX
ASSET B
XX
ASSET D
XX
ASSET E
XX
ASSET H
XX
ASSET G
XXX
ASSET F
XXX
Last updated on 12 Dec 2020 at 07:00 AM

GO Dashboard

Welcome back, Muhamad Fauzi Ayub

MAP

VALUE CHAIN

SCORECARDS

MFT

ASSET B
XX

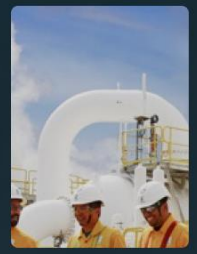
ASSET D
XXX

BERTH
XXX

BERTH
XXX

BERTH
XXX

ASSETS XX



PARAMETER A
XXX unit
Invalid target

PARAMETER B
XXX unit
Higher than 0 unit

PARAMETER C
XXXX unit
Lower than XXXX unit

HIGHLIGHTS

28 Feb 2022 12:40PM

- Activity updates provided by assets
- Activity updates provided by assets
- Activity updates provided by assets
- Activity updates provided by assets
- Activity updates provided by assets
- Activity updates provided by assets
- Activity updates provided by assets
- Activity updates provided by assets
- Activity updates provided by assets
- Activity updates provided by assets

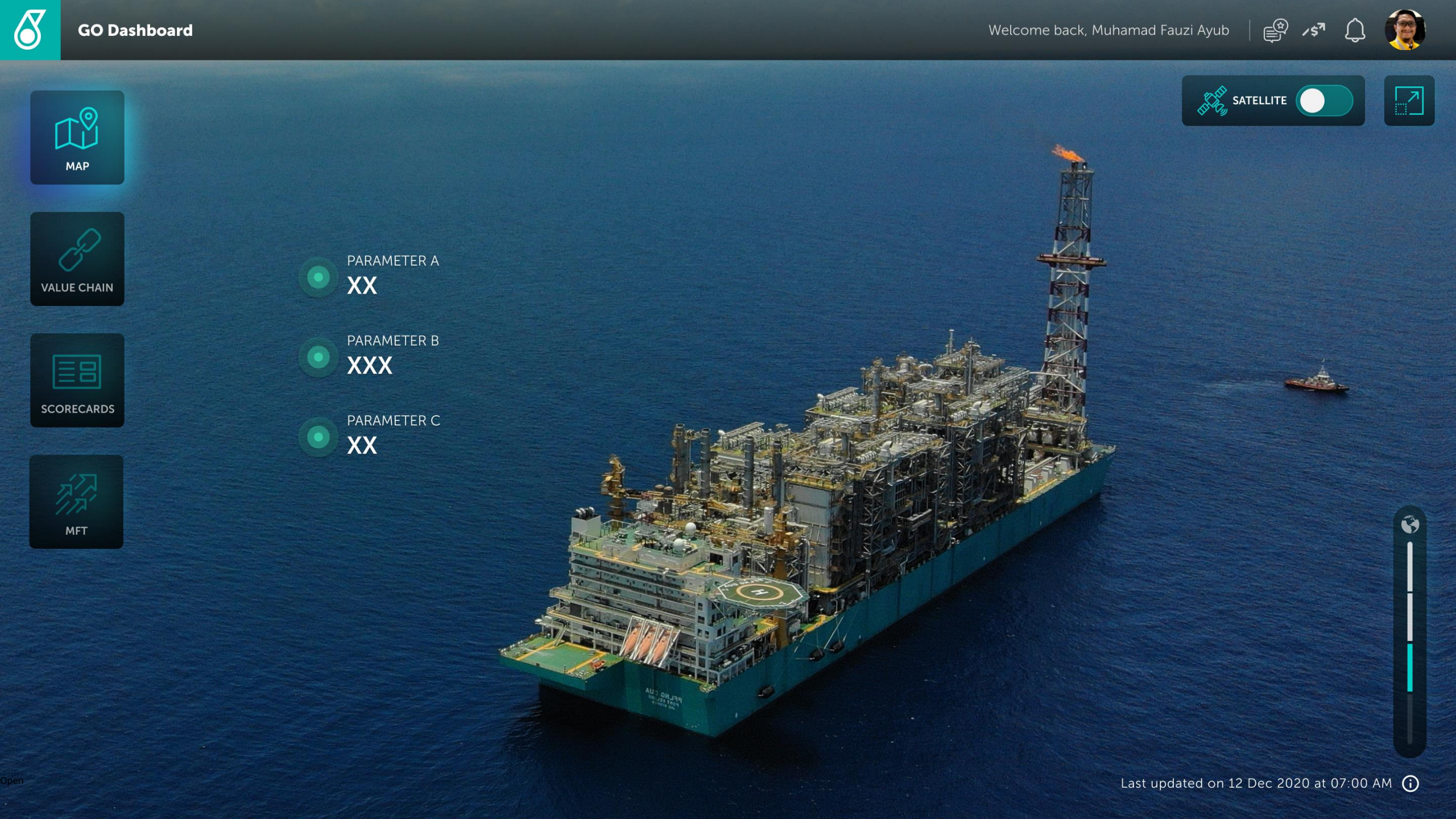
Go to ASSET X

Go to ASSET Y

Link to Other System

Historical Trend

Open


GO Dashboard
Welcome back, Muhamad Fauzi Ayub
SATELLITE
MAP
VALUE CHAIN
SCORECARDS
MFT
PARAMETER A
XX
PARAMETER B
XXX
PARAMETER C
XX
Last updated on 12 Dec 2020 at 07:00 AM
Open

FEEDGAS — PRODUCTION — INVENTORY — DELIVERED

INTEGRATED LNG

FEEDGAS	PRODUCTION	INVENTORY	DELIVERED
XXX unit	XXX unit	XXX unit	XXX unit
ASSET A XXX unit	ASSET A XXX unit	ASSET A XXX unit	ASSET A XXX unit
ASSET B XXX unit	ASSET B XXX unit	ASSET B XXX unit	ASSET B XXX unit
ASSET C XXX unit	ASSET C XXX unit	ASSET C XXX unit	ASSET C XXX unit

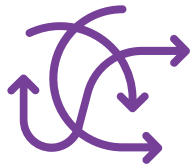
INTEGRATED GAS

XXX

	FEEDGAS	PRODUCTION	INVENTORY	DELIVERED
C1	XXX unit	XX unit	XXX unit	
	ASSET D XXX unit	ASSET D XX unit	BUYER XXX unit	BUYER XXX unit
	ASSET E XXX unit	ASSET F XX unit	BUYER XXX unit	BUYER XX unit
			BUYER XX unit	BUYER XXX unit
C2	XX unit	XX unit	XXX t/h	
	ASSET D XX unit	ASSET Y XX unit	BUYER XX unit	BUYER XX unit
	ASSET E XX unit			

Summary - Beyond Data: Insight and Wisdom

The successful of GO Dashboard delivery was contributed by strong PI Infrastructure and Setup in PETRONAS



Challenges

Timely data is not readily available & muddles understanding for bigger picture

Solution

Building a product that people want to use

Benefits

GO Dashboard provide immediate visibility of health of the integrated value chain operations

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- Azlishah Azizan

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- M Faqrimy Alias

- M Hafidz Rosli

- Syed Mustaza Syed Muhksin

- Aman Zenni Roslan

- Ridzuan Hanafiah

- Khairina Ibrahim

- M Safwan M Diah

- Daren Wong Kien Ting

- Shahrulnizam Hanafi

- James Tan Hua Jin

- Nurul Aida Ngadiso

- Nurul Alia Shaharuddin

- Linda Toh

- Mehmod Mohsin

- S. Faradybah Abdul Manap

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- M Nazril Zulkifli


- M Noor Azmi Mahmood


- Khafidz Ahmad Mohtasar


- Afiq Noor Tuah


- Aiman Syahirah Ahmad Dzulfakhar


- Edrea Chua Ning Wei


- Hazzeir A Muin


- Nur Faradina Mohamed


- Latifah Hanom Mokhtar


- Ernie, Kian Ern Yap


- M Hafiz M Sallehin


- Ezri Fikri M Zubir Ansori


- Rossana Arshad

Use Case #2

PETRONAS Gas Processing Unit Technical Centre

Mohd Johari Bin Mohd Akil

Gas Processing & Utilities (GPU) in PETRONAS is aiming towards world class operations by achieving superior asset reliability performance

Organization Challenges

Scattered information and analysis on plant data and equipment

Manual intervention on communication and integration for plant issues

Gaps in decision making due to lengthy efforts for insights generation

AVEVA

A collaborative efforts was established between multidiscipline teams in realizing the target

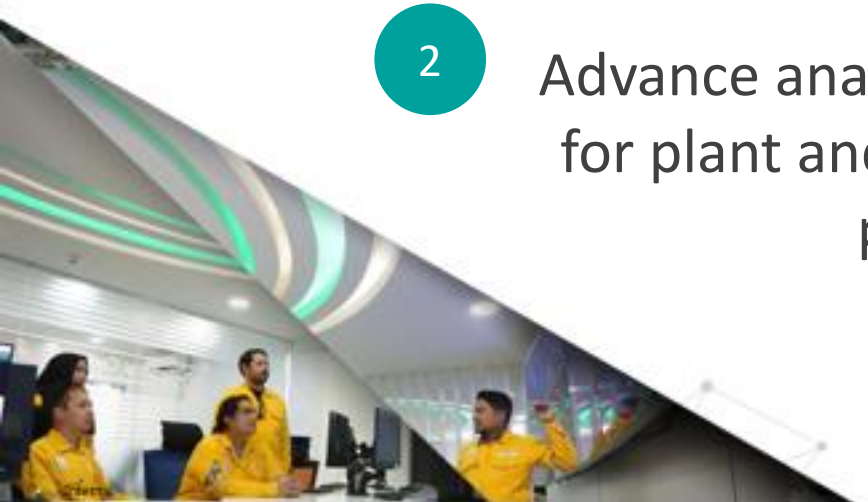
The solutions in addressing our challenges

1 Centralized and integrated information on plant operation and equipment performance

- Technical Collaboration Centre
- Integrated Technical Tools

2 Advance analytic analysis for plant and equipment performance

- Anomalies notification
- Potential plant and equipment issue
- Work process efficiency

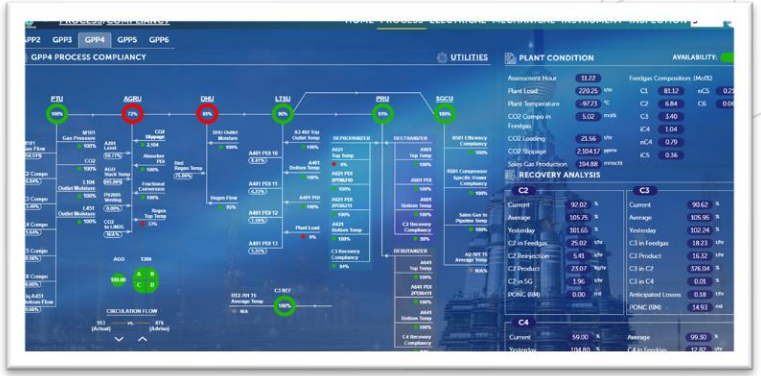


AVEVA

GTC (GPU Technical Center) Dashboard, an integrated and advanced analytic tools covers across multi-disciplines

Management Dashboard

Process Compliancy

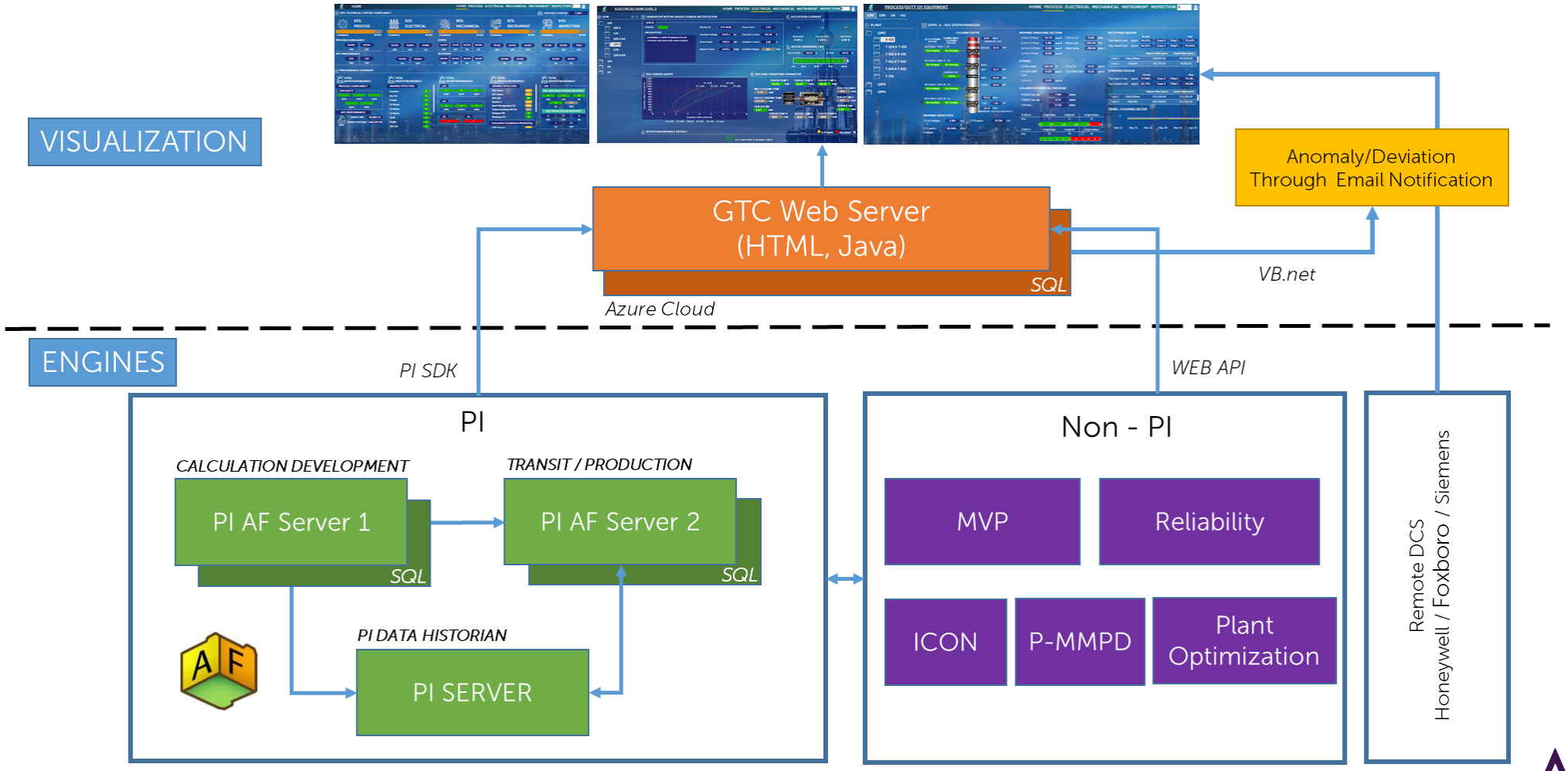


Electrical Dashboard

Equipment Healthiness

and many others…

GTC ecosystem capitalizes on existing PI System setup alongside other supporting systems



7 solutions offered by GTC

Role and function is integrated with work processes and mindset change

Alert is analyzed by technical expert

Speed-up solution and decision - making through online plant data

Early Notification to Operation & Maintenance Crew

Integrated operations planning between upstream and plant operations

Online update on current plant status

Prevention of incident through barrier management tools

AVEVA

Plant reliability has significantly improved since inception of GTC

Benefits of GTC Implementation

Tangible Value Creation

283,090 — Deviations Detected

385 — Genuine Anomalies

150 — Trip Prevention
Cost Of Non-Conformance Avoidance to PETRONAS

Intangible Value Creation

- Facilitate Local Authority approval on regulatory requirements
- Facilitating analysis of reliability program leading to Planned Preventive Maintenance reduction
- Reduction in Root Cause Failure Analysis investigation completion time leading to faster decision-making

AVEVA

New Ways of Working within the Gas Processing Unit Technical Center

Key Take Aways

Collaboration among discipline by using work process

Role and function is integrated with work processes and mindset change

The reliability of the data and genuine anomalies

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Use Case #3

Enabling Smooth Operations by Flowchart Automation Through PI AF

Mohammad Shamsul Akbar Yudin

AVEVA

Open

Sophisticated practices led to ineffective operations in PETRONAS Gas Processing Plant

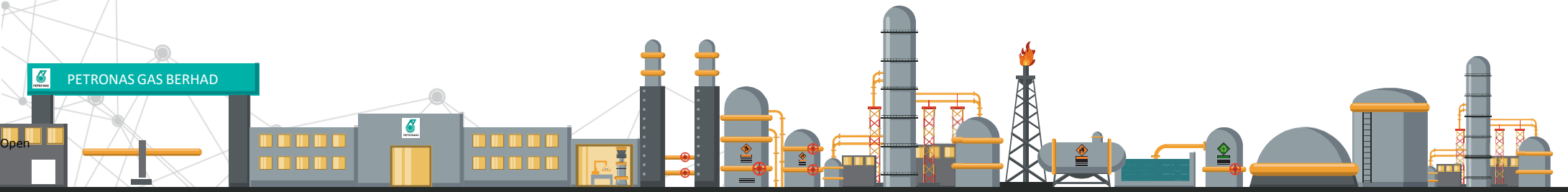
Legacy work culture and dependable to manual processes

Inconsistent judgement due to different experience & knowledge

Data and analysis are scattered, not in one platform

Time consuming due to too many data to digest

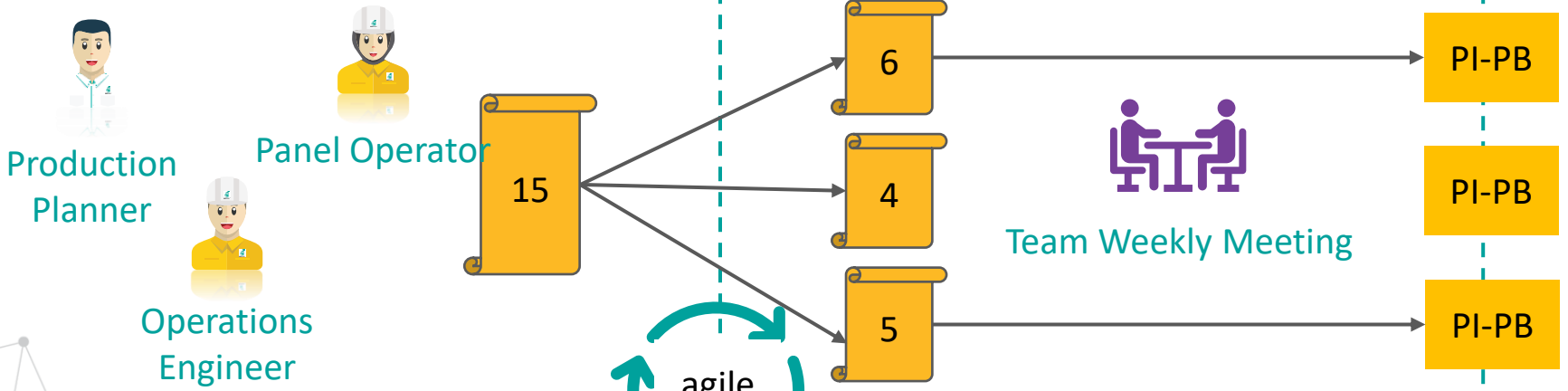
Conventional monitoring method led to ineffective operation



Aligning through process standardization and simplification is key in eliminating the issues

Flowchart automation as enabler

Flowchart & Scenarios Workshop	PI AF Configuration	PI Vision Dashboard



Brainstorm plant scenarios and translate into flowcharts

Discuss, simulate, modify and agree with the PI AF expressions

Develop dashboard by using PI ProcessBook & PI Vision

PI Tags | Data Sets | PI AF Paths

Implementation of Flowchart Automation has enabled smooth operations for PETRONAS Gas Processing Plant

Benefits of solution implementation

Accelerate informed decision

Operations follow the advisory instruction resulted from flowchart automation

Data is presented in one stop center, transparent & referenced by everybody

Eliminated redundant and repetitive efforts

Introduced new way of working

Eliminated engineer's dependency to manual excel calculation

AVEVA

What would I do differently?

Key Take Away & Lesson Learned

The flowchart development is the most crucial process

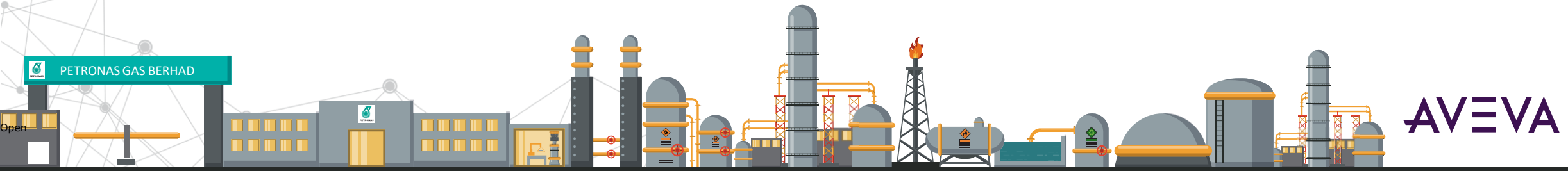
Incomprehensive flowchart causes unnecessary rework on PI AF expressions

Reliability of data representation is key for stakeholder confidence

Ensuring and agreeing with Subject Matter Expert on the right mechanism in handling data unavailability

Competency of PI System Engineer is key for optimum performance

Inability to write expressions properly may affect PI AF server loading



Data Driven Organization – A New Way of Working

Summary

Pain Points

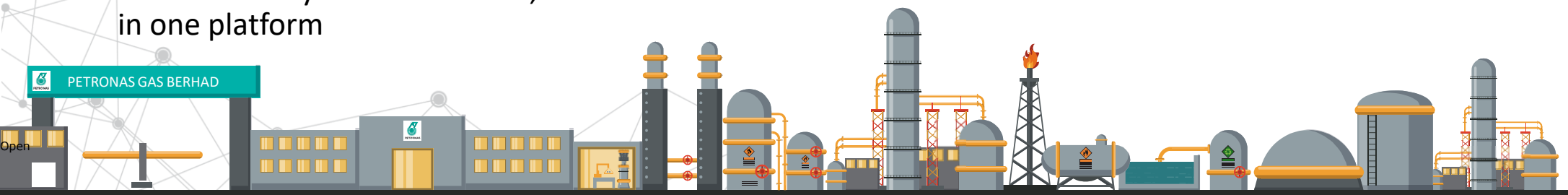
- Conventional monitoring method led to ineffective operation
- Time consuming decision making as too many data to digest.
- Inconsistent judgement due to different experience & knowledge
- Data and analysis are scattered, not in one platform

Solution

- Automating flowcharts periodically via PI AF expressions
- Integration of various data into one-stop-center dashboard using PI ProcessBook & PI Vision

Benefits

- Manual & Repetitive tool are now runs automatic
- Faster decision making can be made as the flowchart is now runs automatic
- Data is presented in one stop center, transparent & referenced by everybody



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Use Case #4

Early Failure Detection Using Predictive Analytics

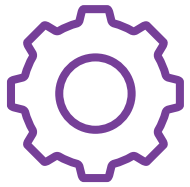
Suhaizal Ismail

Azmi Md Lasin

AVEVA

Early Predictions Solutions that create transparency, visibility and Value of USD33mil in cost avoidance

PETRONAS



Challenges

High Value Leakage across PETRONAS on the Undetected Rotating Equipment Failure

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Visibility issue within SMEs and Operators that scattered across multiple site

Solution

Transparencies, visibilities and early detections

Early detections of anomalies which can be seen by multiple parties allow a proactive diagnostic and issues rectifications and avoid catastrophic failures

Benefits

Improve time to react by early prediction

100% visibility and transparency to SME

Value Creation of Cost Avoidance by 0.1% Increment of Overall Equipment Effectiveness (OEE)

AVEVA

The Key Driver

Risk of equipment failure & unscheduled downtime

Downstream

- Year 2017 till Sept 2018 the unplanned SD due to work management and hardware & design had caused loss of USD 135Mil and USD 60Mil respectively.
- Critical rotating equipment failures had contributed to USD9.1Mil revenue loss.

Upstream

- Malaysia Assets UPD is higher than target of 3.5% ; UPD for oil is at 10% and gas is at 8.4%.
- Rotating equipment had contribute UPD of 1.8% for oil and 0.7% for gas. And in addition, RE bad actors such as GTCs, lift & booster compressors and COTP pumps problems had contributed PoUr of USD13.5Mil.

Upstream & Downstream readily available asset data to be remotely accessed by Centralized Subject Matter Experts to perform advanced analytics & provide solutions.

To provide centralized wisdom & experience to deliver optimum asset performance

New Way of Working (WOW)

The intent of MMPD as a program is to brings new ways of working and not stuck in the old ways of working

TRADITIONAL

MONITOR using DCS & VMS

New WOW

PREDICT using AVEVA Predictive Analytics (PRiSM) + PRESCRIBE By FMEA library which embed in the Solution + MONITOR using MMPD dashboard

PLANT

RE Engineer/Call in External MDS Engineer
Monitors equipment parameters only

When there is problem, need time to diagnose and find solution

Group Technical Services (GTS)

RE experts in GTS
Only called in when there is issue that is beyond resolution by plant team

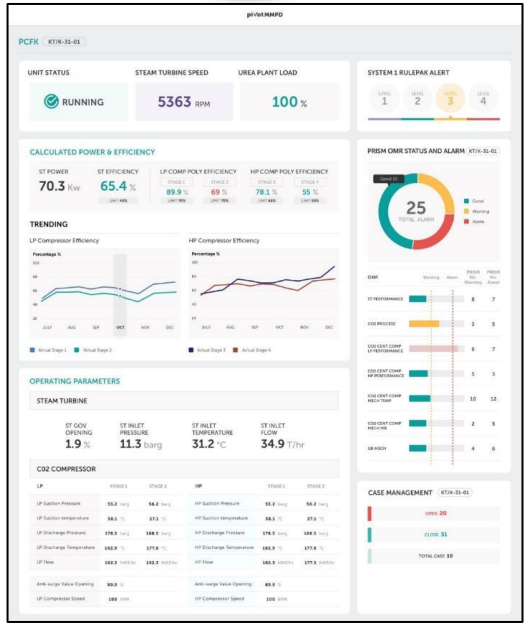
Cannot be proactive in advising

Rotating

pivot MMPD

Operation

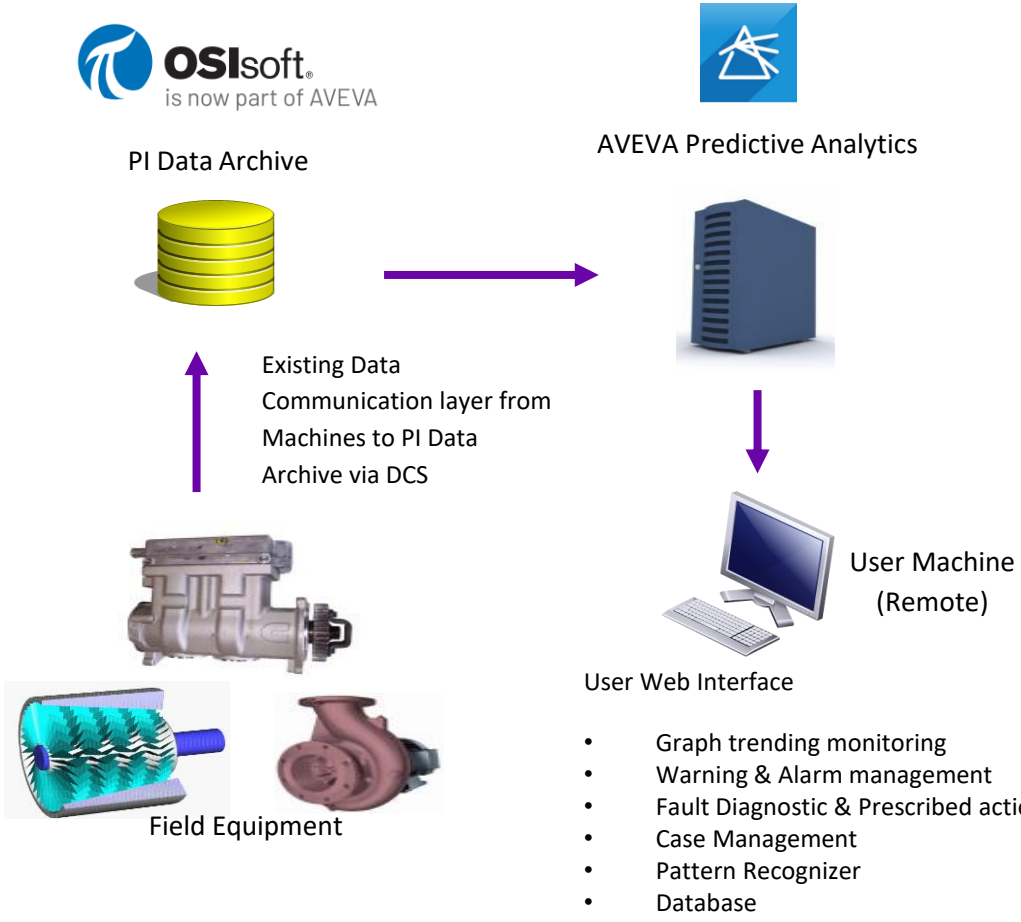
GTS



Implementation Journey - How

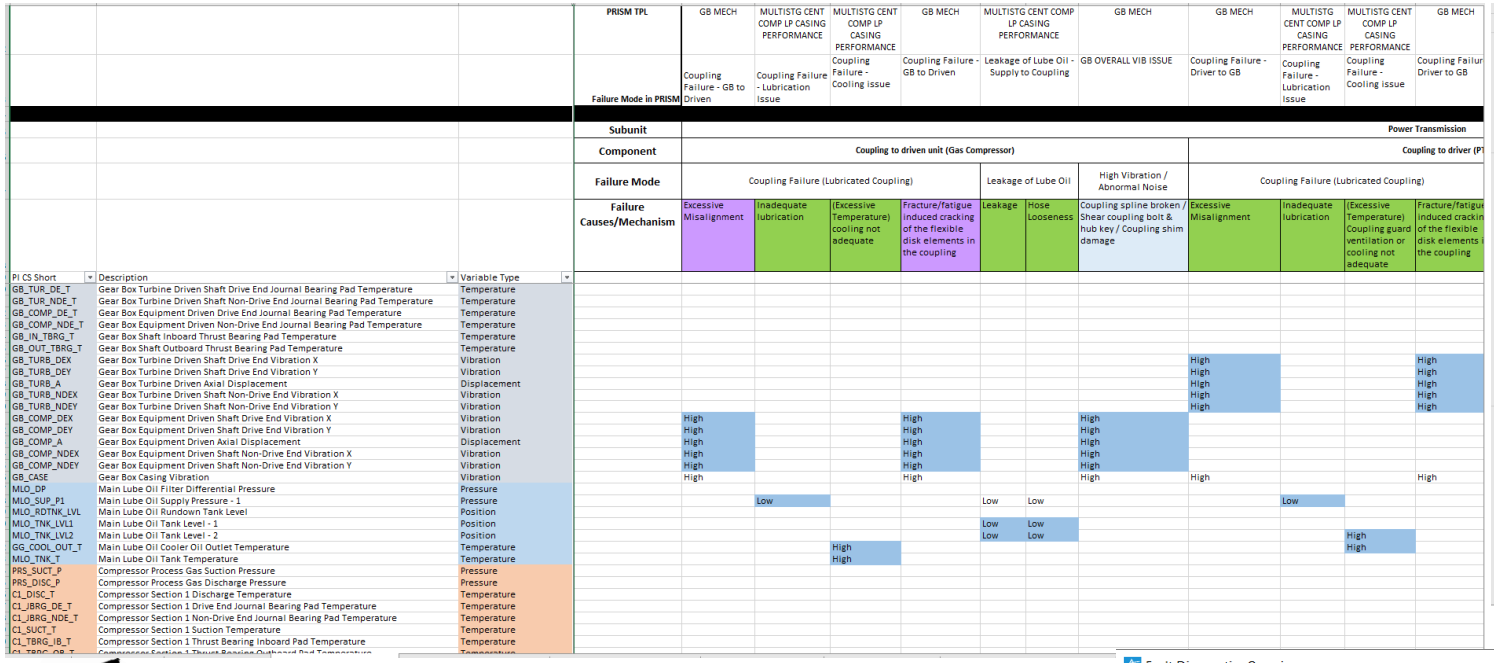
Deployment of solution using agile methodology via sprint planning

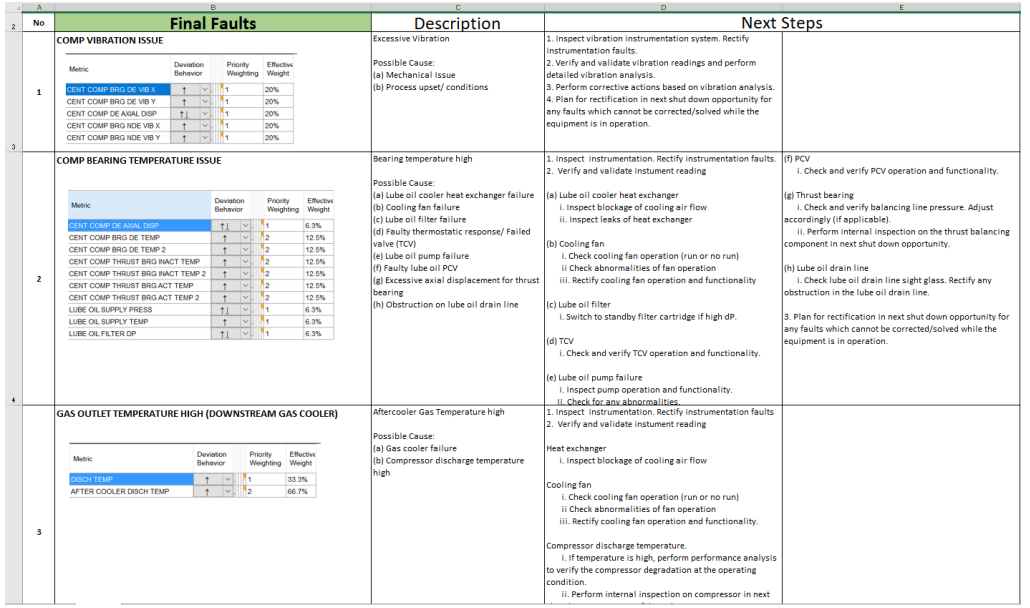
- Each sprint comprise of 7-10 equipment of similar construction & purpose
- 1 sprint activity will take 12-15 working days
- Daily 15 minutes meeting – compact & concise
- Setting the objective to achieve minimum viable product (MVP) at the end of the sprint
- Using templated approach to scale up and increase deployment efficiency



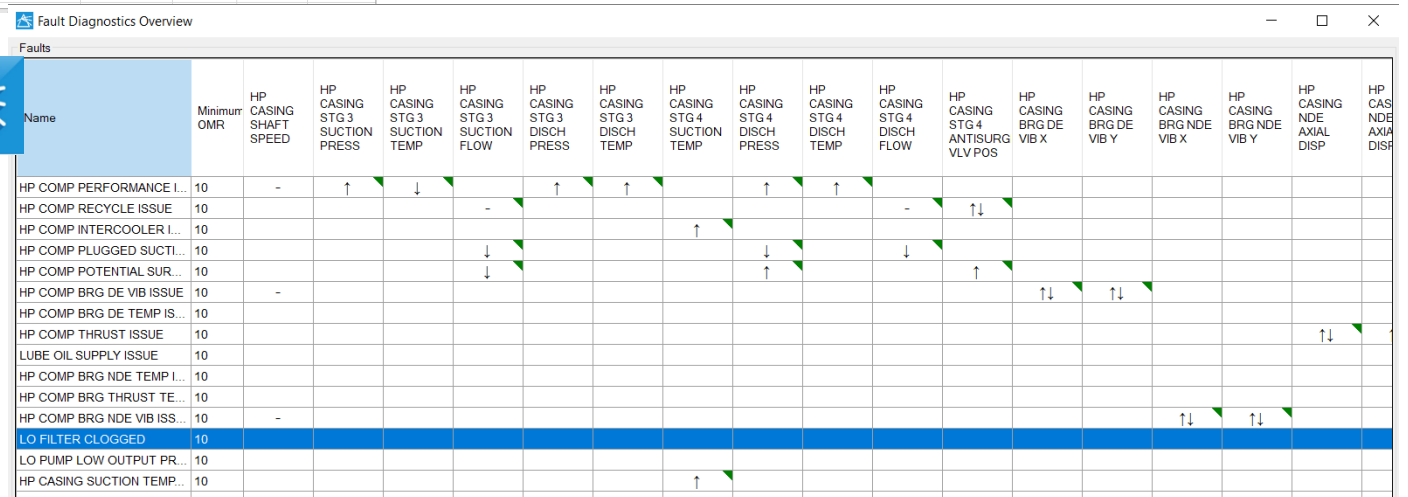
PETRONAS's FMEA – The Valuable Knowledge

Institutionalize years of machine operation experience into digital to provide automated advisory





PETRONAS's FMEA Library can be deposited in the software – and automated the prescriptive action upon any fault detections. The 'knowledge' can be added from time to time by all user for future references

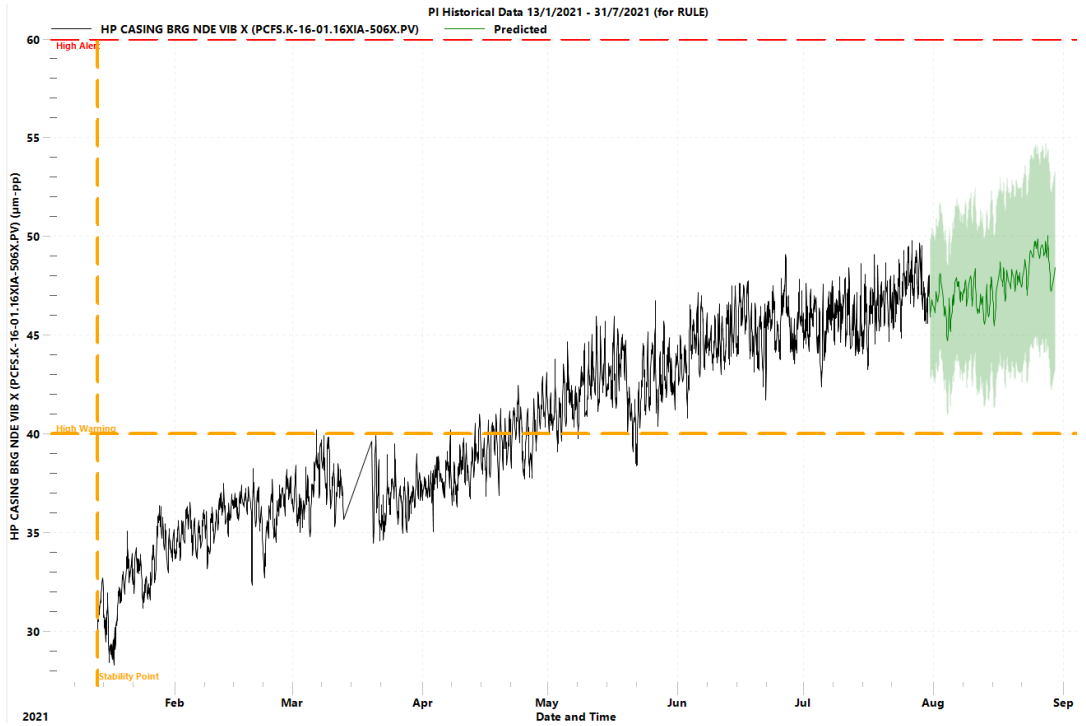


Open

Future Prediction – New Way of Working

Time-to-failure (TTF) prediction as baseline for safe operation decision

- Application of Remaining Useful Life Estimates (RULE) function in AVEVA Predictive Analytics
- Determining equipment overall healthiness & remnant life to support operation extension period
- Single & multi-variable signal characteristic used for this purpose
- Using Statistical & Long-Short Term Memory (LSTM) techniques

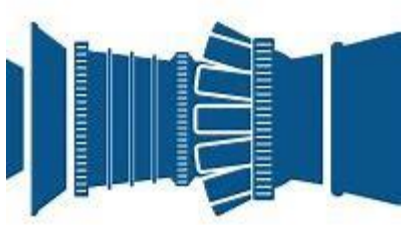


Actual Case Study

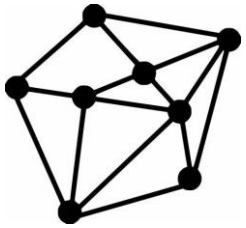
- Critical synthesis gas compressor in one of PETRONAS chemical plants – having vibration issue on both DE & NDE bearing
- Increasing trending over time
- RCA conducted & overhaul was needed - but the equipment was unable to be shut-down due to production demand
- TTF prediction conducted to determine the risk & possible shut-down window

The solutions has been scaled and created value for PETRONAS

Value creation are tangible and intangible



380 Equipment types



More than 500 models

16 onshore plants & 4 offshore platforms

VALUE

- Increased uptime as a result of the 51 avoided lost-time incidents
- Safer working environment, better collaboration between personel (de-silo)
- Significant reduction in maintenance cost
- Increased asset utilization, PU by 0.1% per plant
- Increase in plant reliability (PR) & Overall Equipment Efficiencies (OEE) by 0.1% per plant
- **Realized value of Cost Avoidance of USD33mil which translated to 20x of ROI**

Azmi Md Lasin

Principal Engineer, Rotating

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Use Case #5

Enhanced Insights by Leveraging First-Principle Process Simulation

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Operational excellence could be achieved by having enhanced insights that leveraging first principle process simulation

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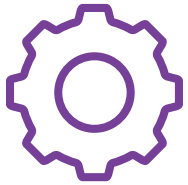

Challenge

- To achieve high accuracy of equipment performance calculation such as efficiency, power, duty, etc.
- Generic calculation normally provides estimation based on rule of thumb, historical experiences
- Tedious and labour-intensive manual key-in to produce equipment performance report

Solution

- Integrating high accuracy first principle process simulation calculation with data analytics in providing better insights of equipment and overall plant performance
- Leverage PI AF analysis to perform calculation of certain parameters not available (e.g. sensor unavailability)
- Automation of the solution to run online to get near real time calculated data via PI DataLink
- Store calculated data into PI tags to be consumed by other applications (e.g. AVEVA Predictive Analytics)
- Near-real time visualization leveraging on Microsoft PowerBI and PI BA Integrator

Benefits

- Accurate calculation of equipment performance
- Calculated data leveraging on first principle Process Simulation are stored back into PI tags
- Remove manual intervention from plant engineer in providing the calculation

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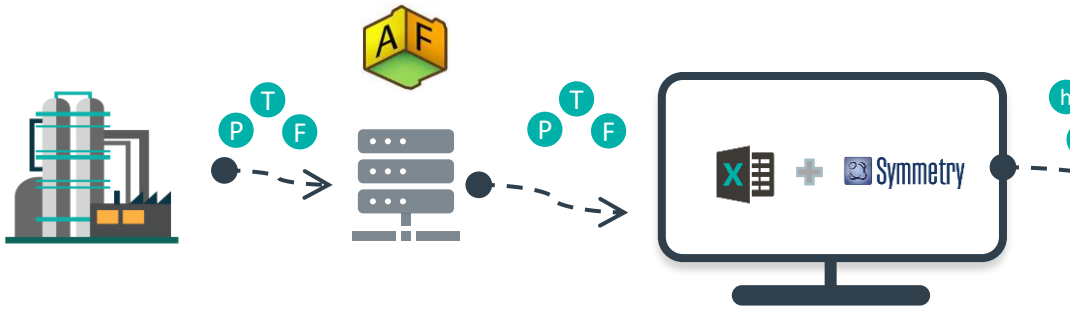
Seamless integration of data source with first-principle process simulation software provides additional insights for predictive analytics

1 Simplification and automation of work process



Field Equipment

- Existing Data Communication layer from Machines to Historian via Process Control Network (DCS)

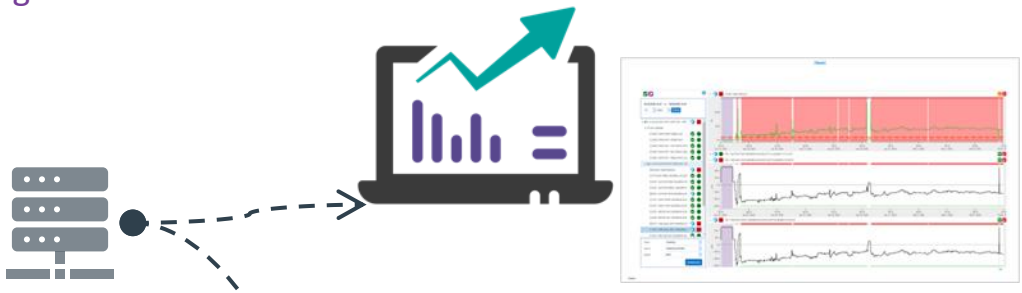
Data Archive & PI AF

- Raw data from the sensor is stored in PI Data Archive
- PI AF is used to perform calculation of data not available at plant

First Principle Model

- Use PI-DataLink to pull data from PI to Excel.
- Customized data filtering programme were developed in Excel and filtered data pushed to Symmetry iCON (first principle model) using Symmetry Excel Add-ins
- Excel is mainly used for data filtering

2 Management of data in centralized database

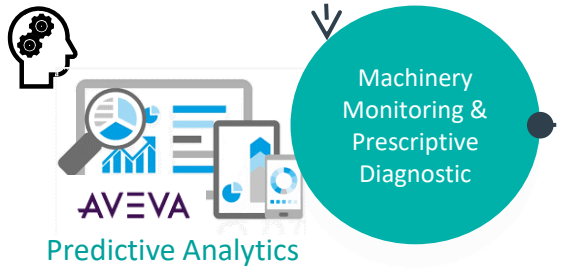


Data Archive & PI AF

- Calculated data from the simulation is stored in PI Data Archive

Dashboarding / Data Visualization

- Equipment performance monitored on centralized dashboard
- Constant alert/alarm limits are typical
- Damage accumulates prior to reaching limit
- Actual minus estimated (residual) signal detects anomaly as-soon-as-possible



Predictive Analytics

- Advisory Support
- Online Optimizer
- Failure Prediction
- Early Warning & Fault Tree

3 Additions of predictive and diagnostic analytics

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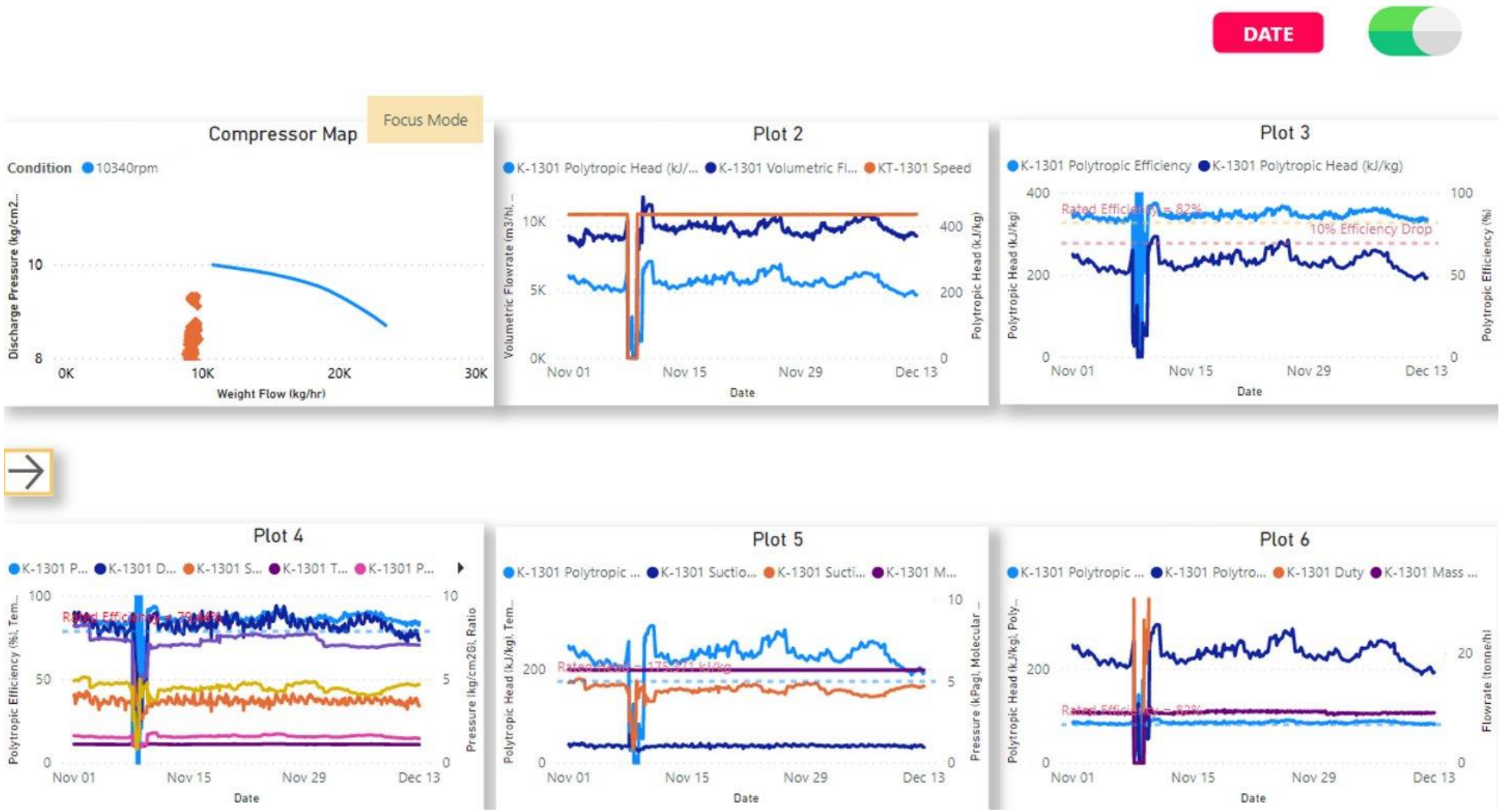
Example of Compressor Performance Plots on PowerBI Dashboard



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Lesson Learnt and Future Plan

Understand user requirement, start small & collaborate closely to reap value early

Lesson Learnt

- Understanding the target audience requirement before embarking any digital twin initiative
- Start small and iteratively improve
- Collaboration between engineering (domain) experts with digital and data science specialists
- Competitive and cost effective

Future Plan

- Replicating the same methodology for all equipment that can be modelled via 1st principle process simulation software such as gas turbine, HRSG, distillation column

Operational excellence could be achieved by having enhanced insights that leveraging first principle process simulation

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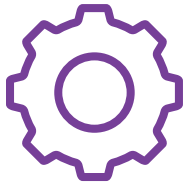

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“PETRONAS leverages technology and digitalisation in our strategy to meet the Sustainability Agenda. Pivoting on “Technology as a Differentiator, Digital as an Accelerator and Data as an Asset”, we capture and optimise value from source to market in fulfilling our role as the custodian of the country’s energy resources, to power the nation and beyond.”


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