
Technical
Conference

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AI-Driven Live Advisory for LNG Plant Start-Up

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PETRONAS

STELLAR was created with the mission to capture the tacit knowledge to enable consistent and smooth start up of LNG trains

Pain point :

Inconsistent start-up performance due to different approaches used by different operators based on their **individual experience and tacit knowledge**.

Solution :

STELLAR (STart-up ExceLlence Live AdvisoRy)

AI-driven live advisory that provides **real-time recommendation of parameters adjustments** in response to **actual plant conditions**.

Machine learning algorithms

Data insights from all start-ups in the past 20 year
(3.4 billion data points from 1862 sensors)

+

Tacit knowledge from experienced operators and engineers

The key personas for STELLAR include panel operators, process engineers and shutdown manager

Panel Operators

I would like **to carry out plant start-up following the validated tacit knowledge and best practices** so that **hiccups and potentially costly mistakes can be avoided**.

Process Engineers

I would like **to capture the tacit knowledge of skilled, experienced operators in starting-up the plant** so that **capabilities can be passed on** to newer team members.

Shutdown Manager

I would like **to achieve consistent and optimized start-ups** so that **the start-up activities durations can be predictable** for scheduling optimization.

Results achieved in pilot train had inspired scaling-up of STELLAR to all 9 trains in PETRONAS LNG Complex

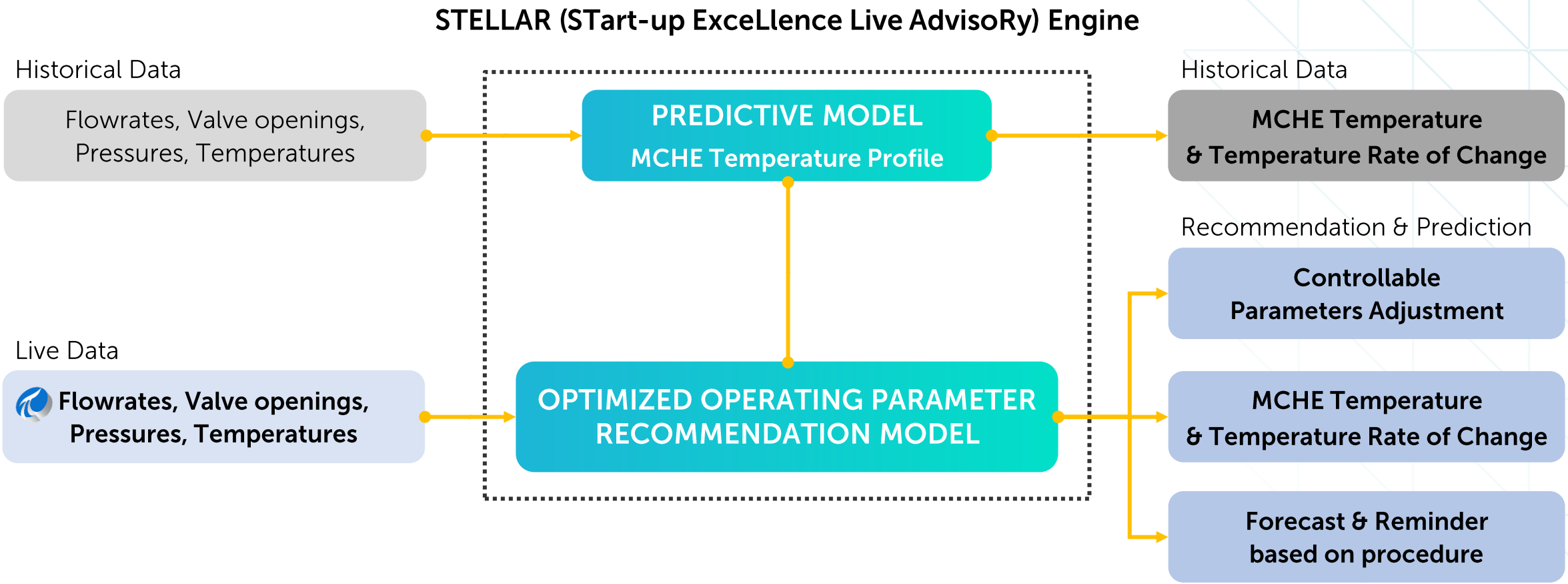
Malaysia LNG Sdn. Bhd. (MLNG SATU)
In operation : 39 years since 1983
- Train 1 (2.8 Mtpa)
- Train 2 (2.8 Mtpa)
- Train 3 (2.8 Mtpa)

Malaysia LNG Dua Sdn. Bhd. (MLNG DUA)
In operation : 27 years since 1995
- Train 4 (3.2 Mtpa)
- Train 5 (3.2 Mtpa)
- Train 6 (3.2 Mtpa)

Malaysia LNG Tiga Sdn. Bhd. (MLNG TIGA)
In operation : 19 years since 2003
- Train 7 (3.8 Mtpa)
- Train 8 (3.8 Mtpa)

Petronas LNG 9 Sdn. Bhd. (PL9SB)
In Operation : 6 years since 2016
- Train 9 (3.6 Mtpa)

Powered by machine learning and optimization algorithms, STELLAR generates real-time control advisory to achieve optimized start-up in response to live plant data



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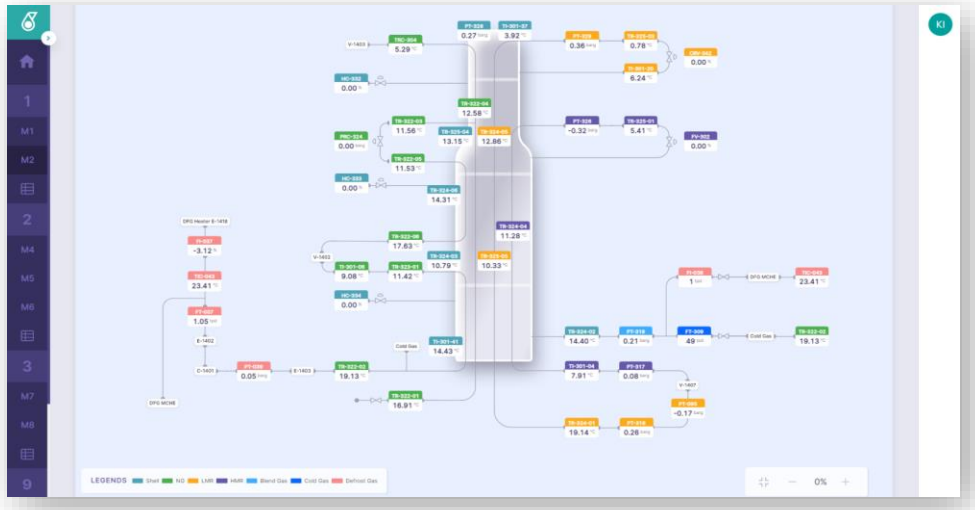
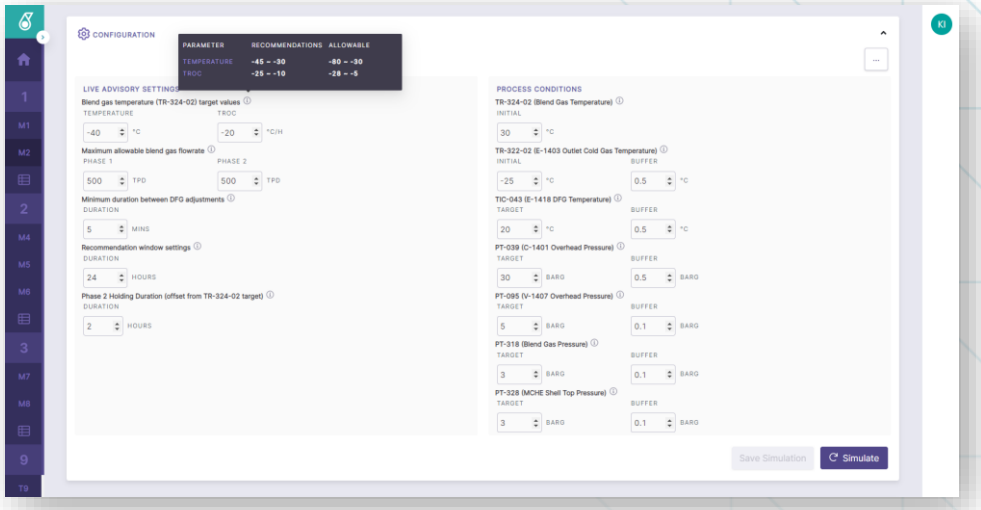
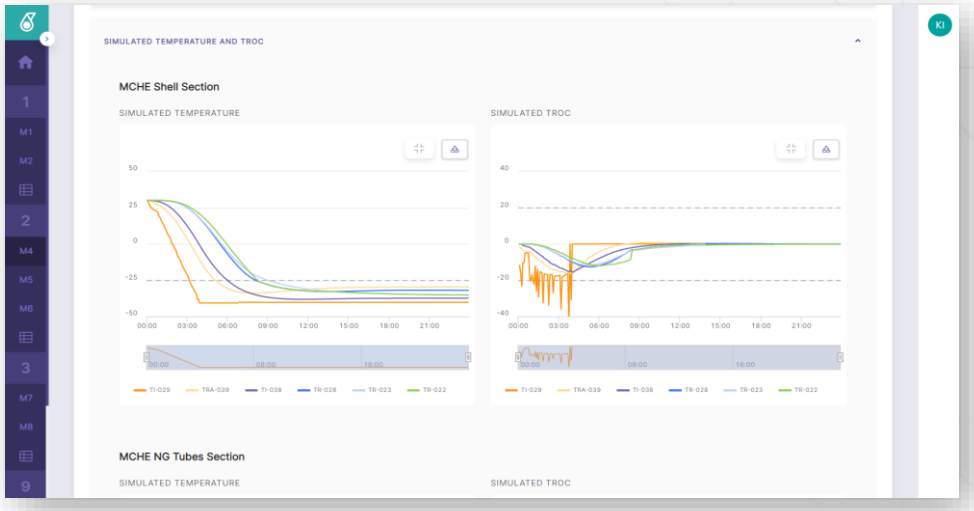
STELLAR User Interface







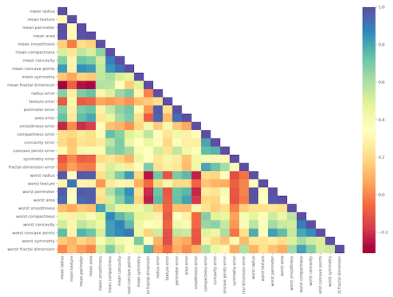
The live advisory is a result of seamless collaboration leveraging on digital skillset and plant domain expertise of PETRONAS staffs

Historical Start-Ups Profile Generation

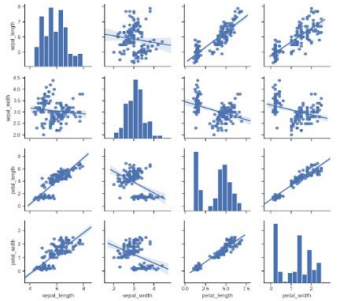
- Generate **overall** duration and performance for all start-ups in the past
- Identify duration and performance of **each step**
- Generate **summary of features** (factors that might impact start-up performance) for each of the start-ups

Statistical and Machine Learning Analysis by PETRONAS Digital

- **Correlation study**



- **Pair plot analysis**



- **Supervised Learning**

  Predictive modelling (e.g. Decision Trees) to identify and quantify key variables contributing towards start-up performance.

- **Unsupervised Learning**
  - Clustering of profiles to identify hidden relationships.
  - Anomaly detection (% of anomaly count) for historical data in generating start-up profiles.

Discussion with Malaysia LNG Subject Matter Experts

- To understand the **process and equipment** limitations
- To formulate **hypothesis** and make sense of the **findings**
- To validate the **feasibility** of parameters control & whether the past adjustment is **replicable**
- To **evaluate the models** and **lead the test runs** of the advisory in actual start-up

To date, 10 start-ups have been executed using STELLAR, proving its capability to enable top-notch start-up performance

Aspects	MLNG TIGA Train 8	MLNG TIGA Train 7	TRAIN 9 Train 9	MLNG TIGA Train 8	MLNG DUA Train 4	MLNG DUA Train 6	MLNG SATU Train 1	MLNG DUA Train 5	MLNG DUA Train 6	MLNG SATU Train 1
Date	22-Jan-2021	29-Mar-2021	16-Jul-2021	18-Aug-2021	25-Aug-2021	21-Sep-2021	21-Oct-2021	20-Jan-2022	28-Apr-2022	18-May-2022
Performance Ranking[1]	1 / 17	1 / 18	1 / 7	1 / 19	7 / 28	1 / 29	1 / 26	5 / 30	5 / 31	3 / 27
Overall Duration	15 hours	12 hours	19 hours	11.5 hours	20.5 hours	9.2 hours	10.0 hours	13 hours	17.1 hours	6.0 hours
Duration Saved as Compared to Past Average	9.6 hours	12.6 hours	4.5 hours	13.1 hours	2.9 hours	14.2 hours	13.8 hours	10.4 hours	6.3 hours	17.8 hours

1. Performance Ranking is benchmarked with all historical start-ups in the past using scorecard criteria established by Malaysia LNG SMEs, i.e. overall duration, temperature rate of change violation, temperature compliance and gas usage.

Apart from the outstanding results, 3 key aspects of STELLAR had been validated through the start-ups

Agility

Unexpected process challenges have validated robustness of the solution to generate optimum control advisory in response to unplanned conditions.

Repeatability

Train 7, 8 as well as Train 4, 5 and 6 are identical trains of the same plants. Consistent and superior performance has been achieved consecutively.

Evolvabilty

The advisory was continuously enhanced with actual results, demonstrating its capability to retain and capitalize on the tacit knowledge.

Complimentary feedback on STELLAR had been received from various stakeholders

I am delighted to see the results achieved by STELLAR. I applaud the team for having the courage to innovate the start-up approach, making our start-ups' performance predictable and consistent.

Laga Jenggi
CEO, Malaysia LNG

It was the best start-up I had carried out so far. The advisory is very useful in guiding us to achieve optimum values for key parameters. It also accurately predicted the temperature profile ahead of time, enabling better planning.

Ahmady Busman
Operator, Malaysia LNG

STELLAR uncovered the best practices and tacit knowledge of our experienced operators and incorporated them to the advisory. This has enabled us to achieve six historical best start-ups to date!

M Hafiz Maamor
Manager (Area Operations)

We had utilized STELLAR three times in MLNG TIGA. I am pleased that the superior results is repeatable and consistent across the three start-ups!

M Saifuddin Zulkaple
Lead Process Engineer

We are glad to see new innovation to assist plant operation with digital technology. Analysis of all our previous start-ups to learn from past experience is very valuable.

Mark Thian
Manager (Shift Management)

STELLAR can make our start-ups consistently optimized. It helps to capture the tacit knowledge and study done by our experienced operators and engineers to improve our performance.

Iskandar B A Khalek
Manager (Shutdown Planning & Execution)

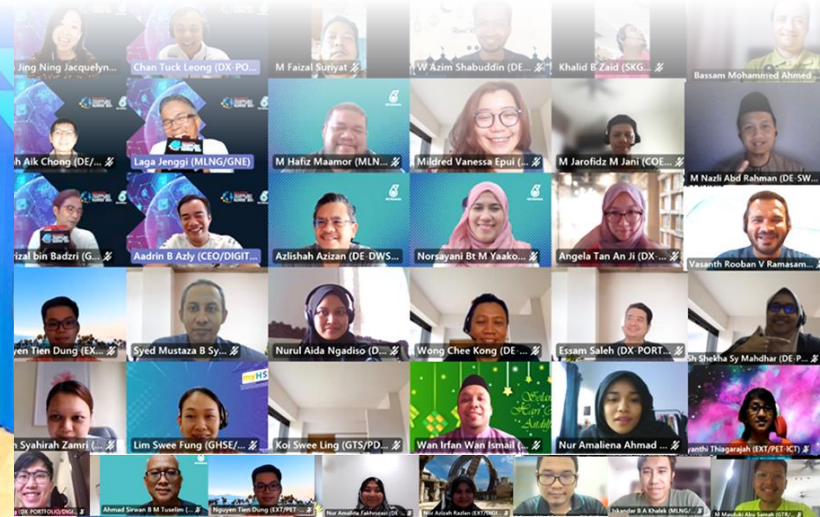
The product has won Gastech Awards 2021, Malaysia Technology Excellence Awards 2021 and IChemE Global Awards 2021

Gastech Awards 2021
Engineering Partnership of the Year

MALAYSIA TECHNOLOGY EXCELLENCE AWARDS 2021
Analytics - Oil & Gas
PETRONAS DIGITAL SDN. BHD.

IChemE Global Awards 2021
Process Automation and Digitalization Winner

IChemE Global Awards 2021
Team Finalist



The STELLAR RESULTS are made possible by the passionate souls who bring together the best of plant expertise and digital skillset

M Hafiz Maamor
MLNG Business Owner

Iskandar Khalek
Shutdown Manager

Mark Thian
Shift Manager

Saifuddin Zulkaple
Process Engineer, TIGA

Chew Pan Hao
Process Engineer, DUA

Hu Chee Kiong
APC Engineer

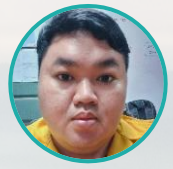
Ting Ting Hiap
Process Technologist

Raj Shanker
Technical Specialist

Anthony Pengiran
Line Trainer

Nurrul Firdaus
Panel Operator

Ahmady Busman
Panel Operator



Fathul Rizan
Panel Operator

Fedelis Martin
Panel Operator

Ambrose Chin
Panel Operator

Lee Kian Seng
Product Manager

Elaine Khoo Synn Yie
Data Scientist

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Frontend Developer

Antonie Trong
Backend Developer

Nur Farhah
Data Engineer

Usha Devarapalli
Data Engineer

Nur Syahira
UI Designer

Linh Tran
QA Tester

Eddy Nguyen
QA Tester

Thank you