Microsoft

Optimization of Drilling Operations using Advanced Machine Learning Techniques

Customer Case Study

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Oil & Gas Connected Community
Dec 8th 2021

"Indirect savings are the key motivation for the project. Presently very few operations are classified manually. Model can classify all operations enabling timely decision making and huge cost savings."

Drilling Operations Manager

Kuwait Oil Company

Challenge/ Project Objective

KOC spends more than **$400M** every year on drilling, with around **350k** operations per year over 100s of wells. **18%** of the operations are non-productive.

Solution / IP

Augment the current manual drilling operations **classification process** with **Machine Learning** techniques, using drilling operation details to classify productive and non-productive operations.

Outcome / Business Value

Reduce non-productive drilling operations from 18% to **14%**, resulting in **$1.4M** Direct & **$193M** Indirect cost savings over a period of 5 years.

Microsoft

Project Delivery Value
$ 300K

Project Duration
12 weeks

Industry
Energy

Organization size
Corporate

Business need
Cost savings on drilling operations

Project Team
Gurav Malhotra, Mahmoud Mansour, Nadeem Ishqair, Murari Ramuka, Senani Nori, Suchtria Bhat, Tarun Dugar

Project Status
Completed

MSO
End2End Machine Learning

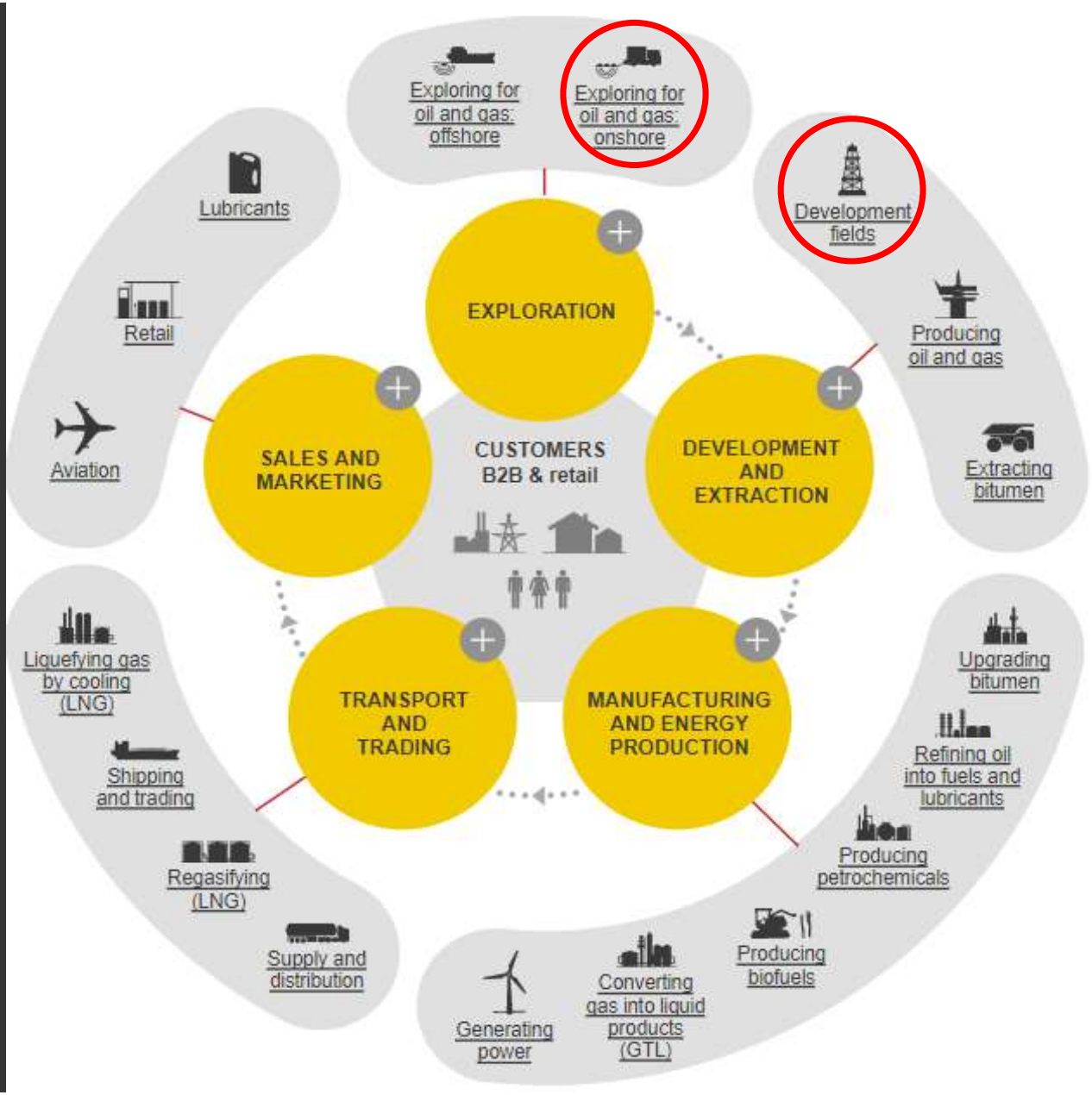
Country
Kuwait

Read more

Non-Productive Time & Productive Time Drilling operations

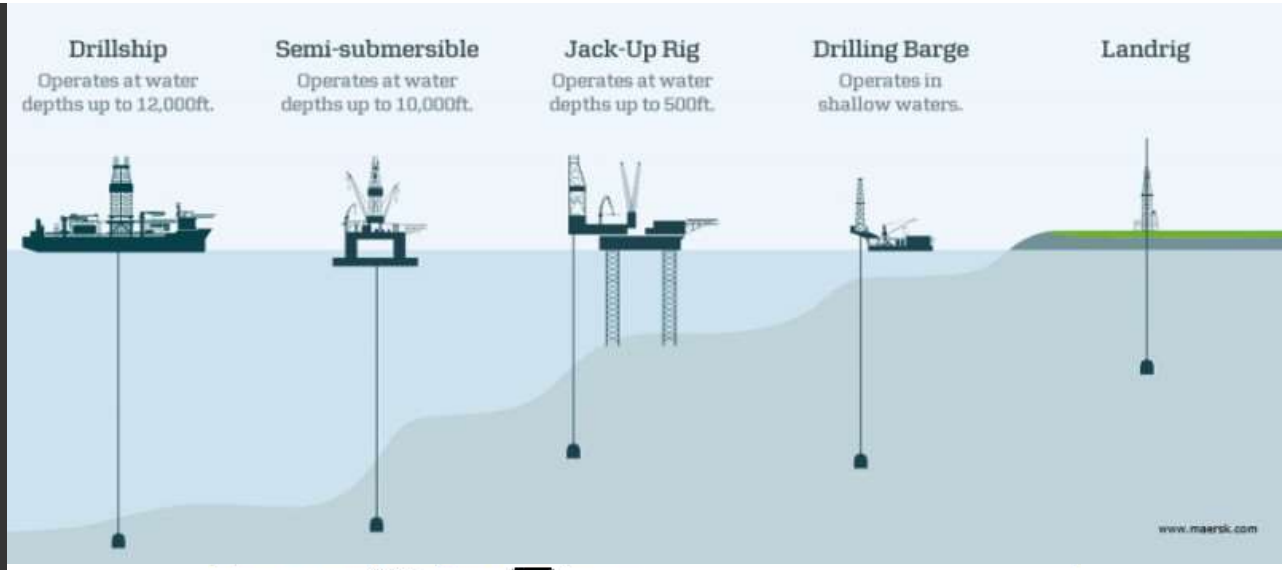
Oil & Gas Value Chain

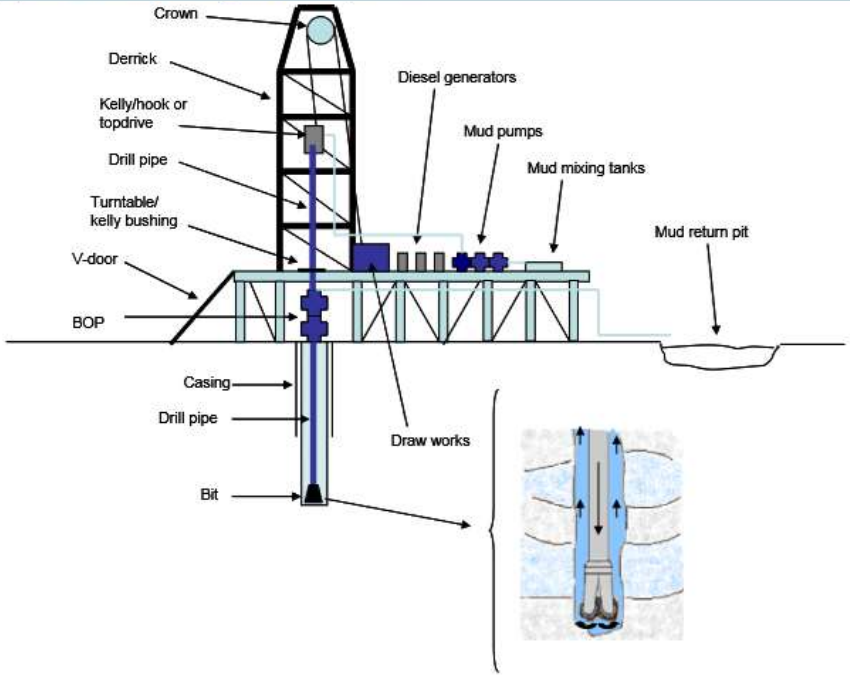
Upstream
Downstream
Midstream
Corporate Functions



Drilling Activities

- KOC spends more than $400M every year in drilling
- Drilling operation is any activity / task done on the oil rig. Ex: “Changed drill bit”
- ~350k “operations” per year over hundreds of wells
- 18% of the operations are non-productive, i.e. the operation does not result in progress of drilling. Example: “Pipe is stuck”, “Waiting, due to bad weather”.





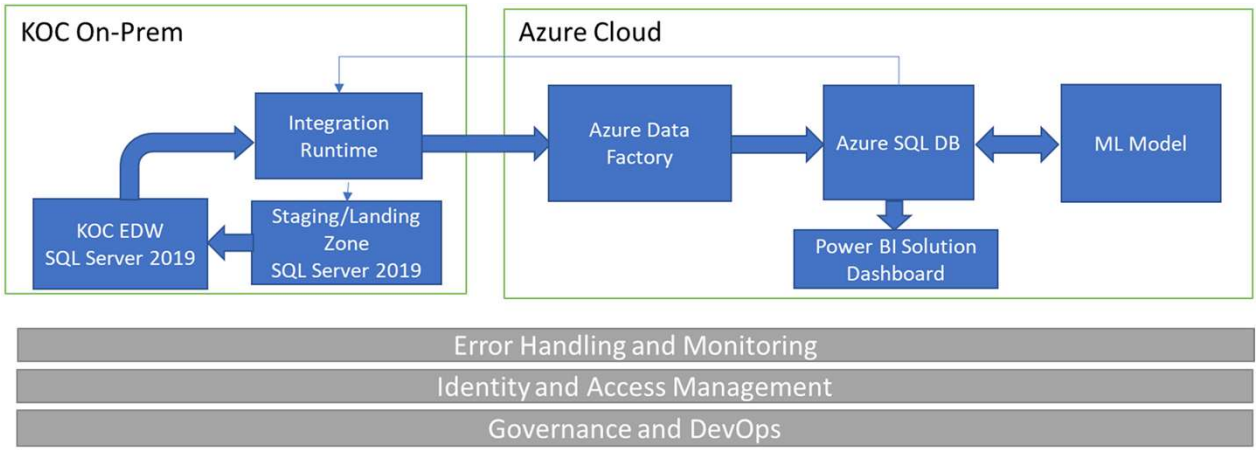
Improve drilling efficiency to save time & costs

- Analyze non-productive operations to draw up action plans
- Find the root causes for non-productive time and tackle them
- Analyze the time taken for productive operations, compare them against the standard time and identify areas for improvement
- First step is to classify each operation
- ML Problem: Read each operation from “Daily Drilling Report” and classify it using a set of pre-fixed codes.
- 303 codes for non-productive operations
- 406 codes for productive operations

Solution Overview

Solution Provided

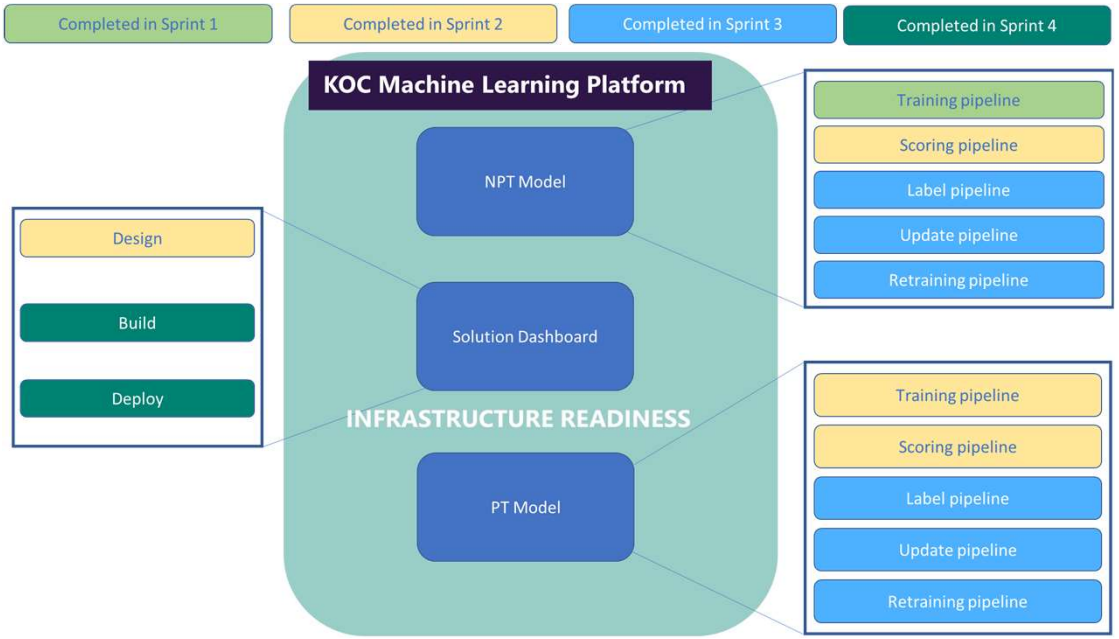
- Provided two ML models
- NPT model to classify non-productive operations into 'Observation', 'Cause' and 'Sub-cause'
- PT model to classify productive operations into 'Phase', 'Code' and 'Sub-code'
- Solution dashboard to monitor performance of models
- Retraining pipeline to automatically retrain models after more labelled data is available



Key Features of Solution

- Exhaustive framework to try out all approaches possible to solve the Hierarchical Multi-level Classification problem
- Using AMLS, a retraining pipeline has been provided so that customer can train more models
- Complex problem. Many other implementations in industry had only one level (Phase) and limited classes (usually around 10, max was 90). Present solution handles 3 levels of classification with 300+ classes for each of PT and NPT
- IP being packaged into a data science accelerator

Note: Accuracy is computed at row level. If a row has three labels, the row is considered accurate only when all the labels are correctly predicted. Hamming loss is the inaccuracy at label level.

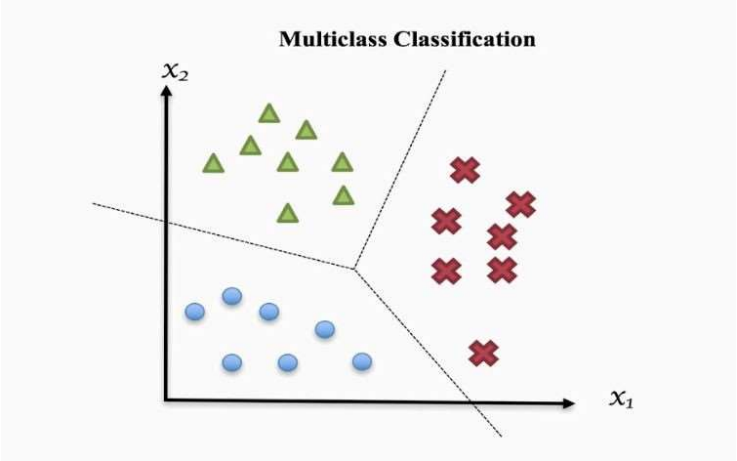


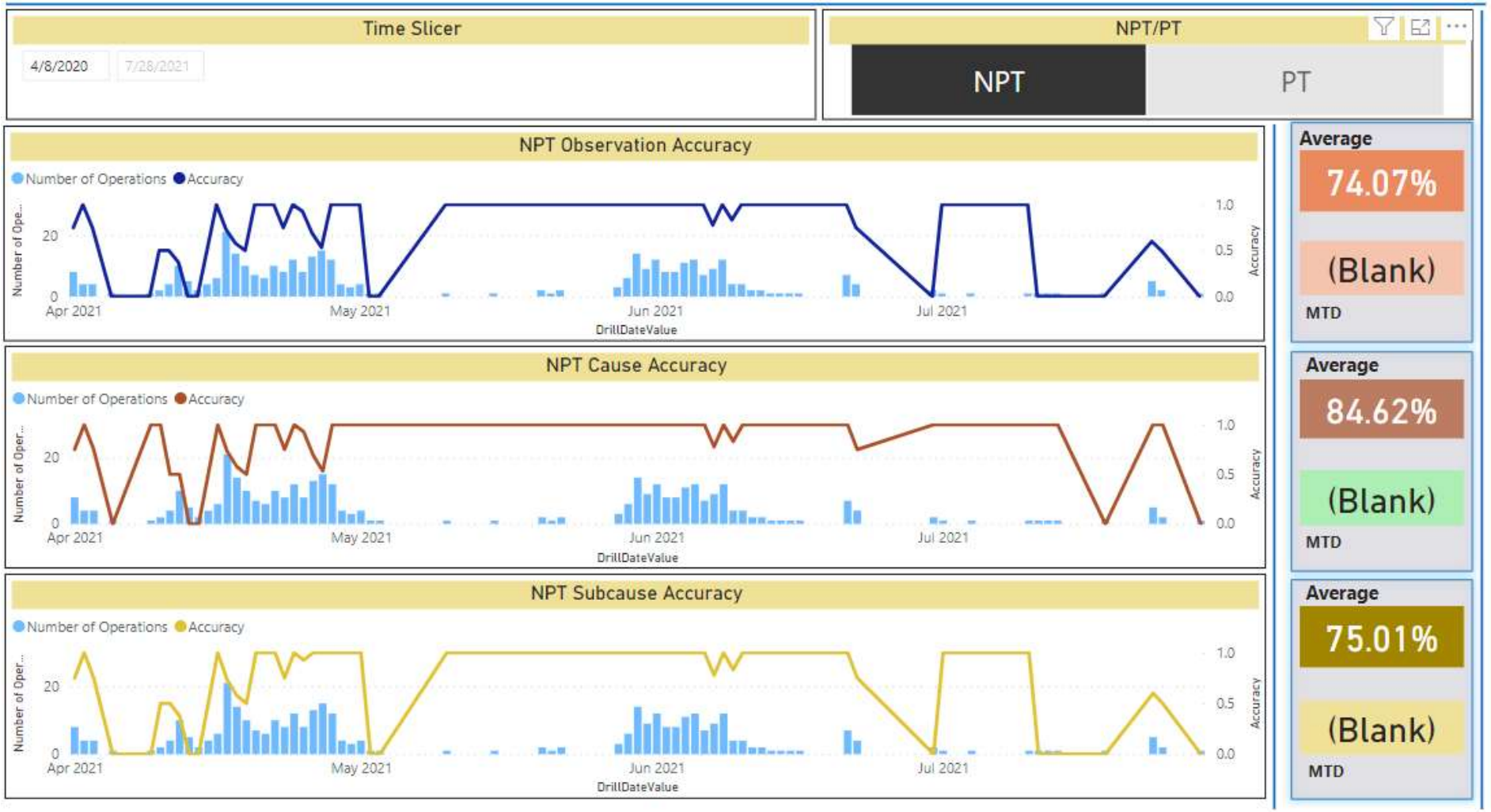
Model	Accuracy	1 - Hamming Loss
NPT Model	81.59%	87.31%
PT Model	69.28%	81.18%

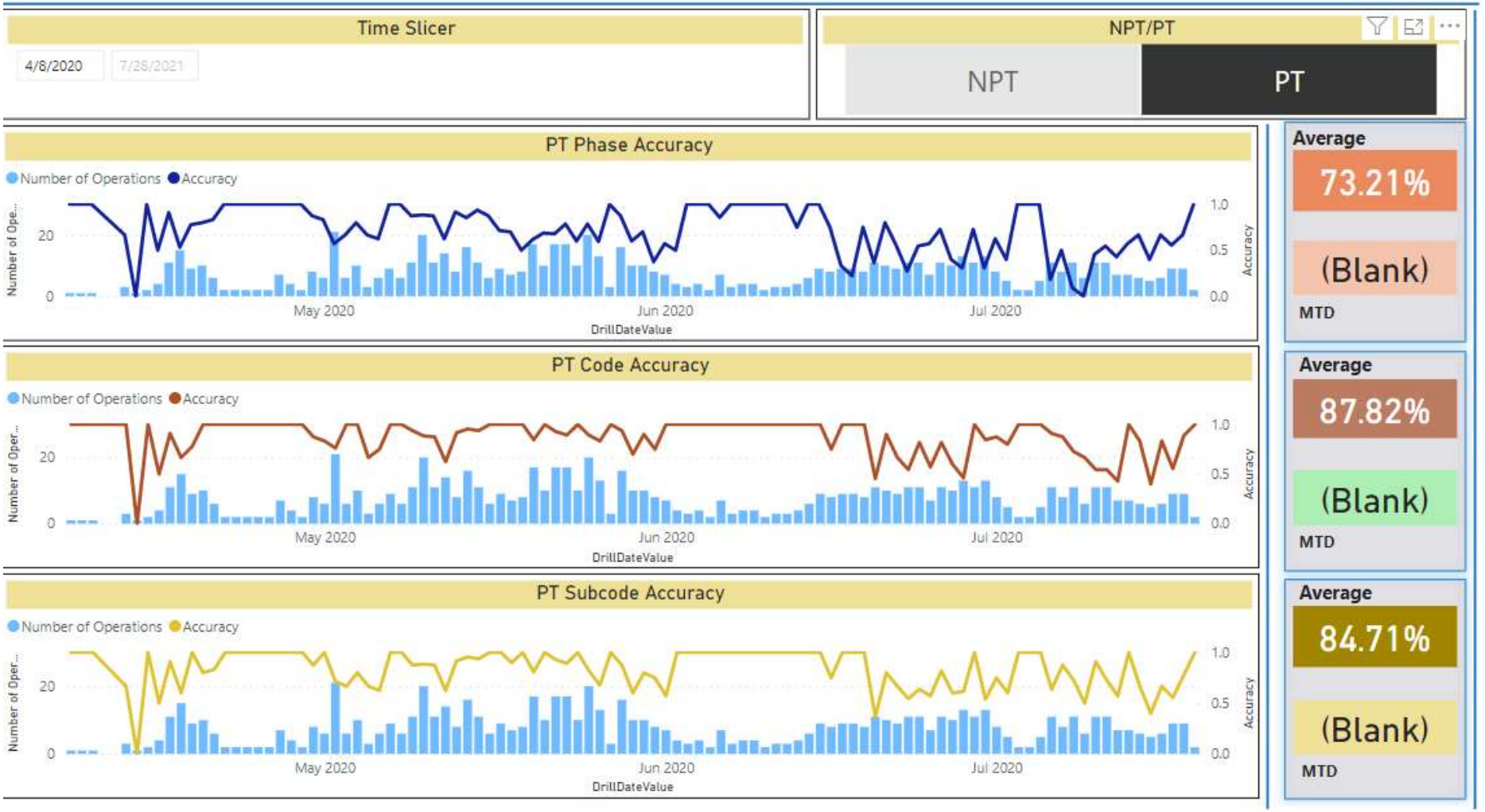
Ready to use IP

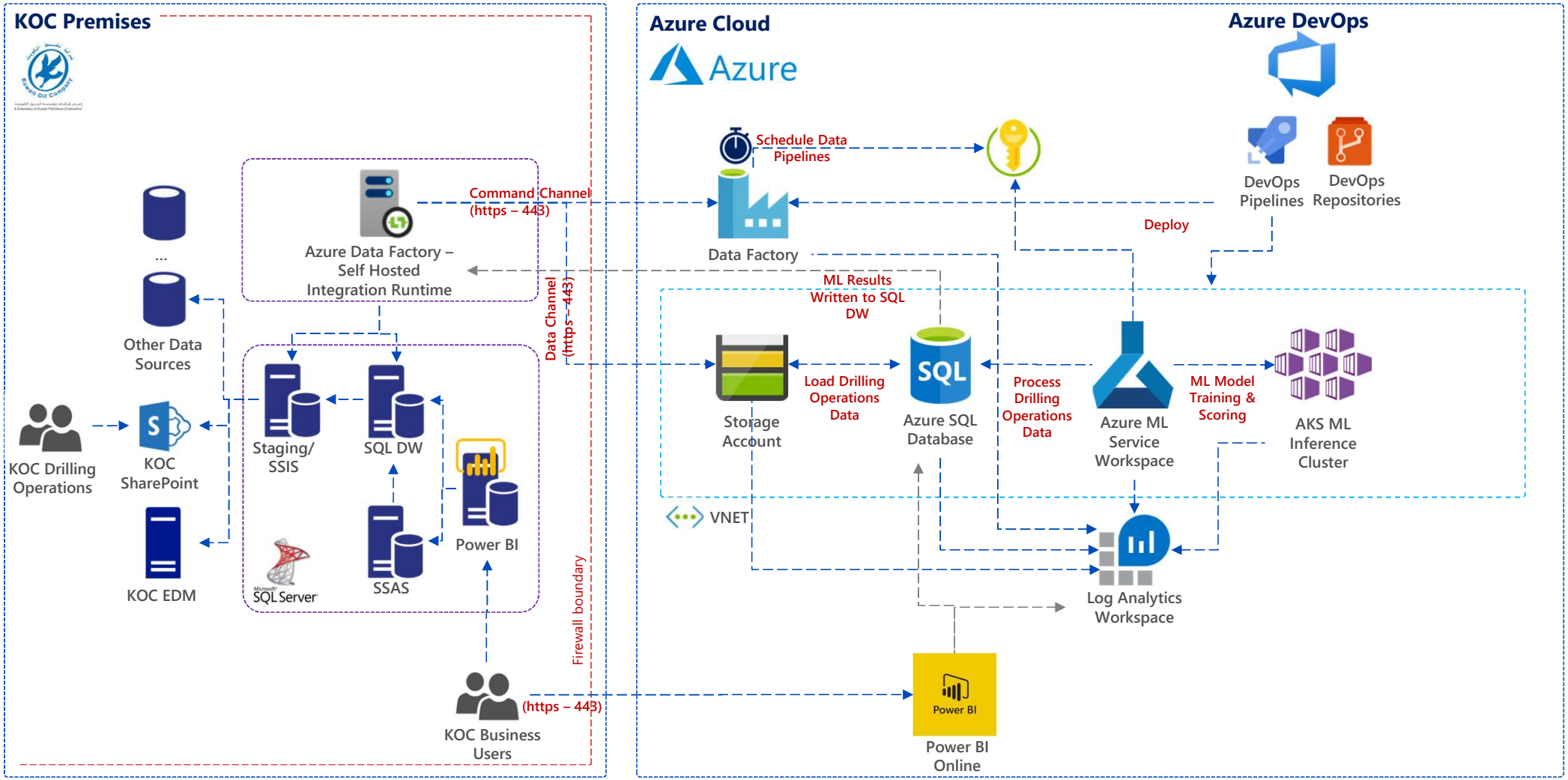
The team has prepared a generalized package of the core ML model developed for npt/pt classifications.

Hierarchical Multi-Label Classification




Time Slicer
4/8/2020
7/28/2021
NPT/PT
NPT
PT
NPT Observation Accuracy
Number of Operations
Accuracy
Number of Ope...
20
0
1.0
0.5
0.0
Accuracy
Apr 2021
May 2021
Jun 2021
Jul 2021
DrillDateValue
Average
74.07%
(Blank)
MTD
NPT Cause Accuracy
Number of Operations
Accuracy
Number of Oper...
20
0
1.0
0.5
0.0
Accuracy
Apr 2021
May 2021
Jun 2021
Jul 2021
DrillDateValue
Average
84.62%
(Blank)
MTD
NPT Subcause Accuracy
Number of Operations
Accuracy
Number of Oper...
20
0
1.0
0.5
0.0
Accuracy
Apr 2021
May 2021
Jun 2021
Jul 2021
DrillDateValue
Average
75.01%
(Blank)
MTD


Time Slicer
4/8/2020
7/28/2021
NPT/PT
NPT
PT
PT Phase Accuracy
Number of Operations
Accuracy
Number of Ope...
20
0
1.0
0.5
0.0
Accuracy
May 2020
Jun 2020
Jul 2020
DrillDateValue
Average
73.21%
(Blank)
MTD
PT Code Accuracy
Number of Operations
Accuracy
Number of Oper...
20
0
1.0
0.5
0.0
Accuracy
May 2020
Jun 2020
Jul 2020
DrillDateValue
Average
87.82%
(Blank)
MTD
PT Subcode Accuracy
Number of Operations
Accuracy
Number of Oper...
20
0
1.0
0.5
0.0
Accuracy
May 2020
Jun 2020
Jul 2020
DrillDateValue
Average
84.71%
(Blank)
MTD


KOC Premises
Azure Cloud
Azure
Azure DevOps
Schedule Data Pipelines
DevOps Pipelines
DevOps Repositories
Command Channel (https – 443)
Azure Data Factory – Self Hosted Integration Runtime
Data Factory
Deploy
ML Results Written to SQL DW
Data Channel (https – 443)
...
Other Data Sources
Storage Account
Load Drilling Operations Data
Azure SQL Database
Process Drilling Operations Data
Azure ML Service Workspace
ML Model Training & Scoring
AKS ML Inference Cluster
KOC Drilling Operations
KOC SharePoint
Staging/ SSIS
SQL DW
VNET
KOC EDM
SQL Server
SSAS
Power BI
Log Analytics Workspace
Firewall boundary
(https – 443)
KOC Business Users
Power BI
Power BI Online

Key take aways

$193 MILLION BUSINESS IMPACT

EXECUTE WITH LED MINDSET FOCUSED ON BUSINESS OUTCOMES

$1.4M Direct & $193M Indirect[1]

of cost savings over a period of 5 years.

All energy companies

have NPT analysis in place. Present solution is exhaustive – multi-level with hundreds of classes.

Applies to other industries

such as Retail and Manufacturing.

Accuracy over 75%

of NPT and PT operations classifications, providing the customer a solid baseline for planning.

Solution IP

Generalized solution IP developed for the community by the project team.

ACAI & CT&I

Best together joining forces providing un-matched experience in enterprise scale innovative solution.

[1] Detail cost savings analysis in Appendix

Appendix

Single-level Problem vs Multi-level

Row Number	Phase_label	Code_label	Subcode_label
Row1	correct	correct	correct
Row2	correct	incorrect	incorrect
Row3	correct	correct	correct
Row4	correct	correct	correct

- Correct means that ML-label matches with SME-label
- Incorrect – does not match
- Accuracy is at row-level, whereas 1 – Hamming Loss is at label-level

$$accuracy = \frac{number\ of\ correctedly\ labelled\ rows}{total\ number\ of\ rows\ labelled} = \frac{3}{4} = 75\%$$

$$hamming\ loss = \frac{number\ of\ incorrectedly\ labelled\ labels}{total\ number\ of\ labels\ applied} = \frac{2}{12} = 16.67\%$$

With single-level, accuracy = 1 – Hamming Loss
In terms of SME effort saved, 1 – Hamming Loss is the more relevant metric

Business Impact: USD 41.5 to 193 millions

- Direct savings: $ 1.5 mn
- Indirect savings: $ 40 mn – 192.5mn
  - NPT model should help reduce non-productive time from current ~18% to ~14%
  - This will save $ 40 mn in cost of contract services over 5 years
  - NPT model will save another $ 45.5 mn in employee costs over 5 years
  - PT model is the core of the Invisible Loss Time project, which when completed can reduce costs by 5% points resulting in a savings of about $ 107 mn over 5 years

A. Direct Savings

Number of FTEs in Task Force Team	6
Reduction in FTEs due to Project	4
Estimate savings @ USD 75k / FTE	300,000
Saving overs 5 years, USD million	1.50

Indirect savings are the key motivation for the project. Presently very few operations are classified manually. Model can classify all Operations in real time enabling timely decision making

B. Indirect Savings

Head	Units	2017-18	2018-19	2019-20
Revenue	KD	3,142,706,000	3,947,451,000	3,290,211,000
Contract Services	KD	701,307,000	676,732,000	625,192,000
Employee cost	KD	673,184,000	836,063,000	718,829,000
Total Operating Cost	KD	1,788,661,000	1,968,088,000	1,928,593,000
Contract Services + Employee cost	KD	1,374,491,000	1,512,795,000	1,344,021,000
Kuwaiti Dinar per USD		3.31	3.30	3.28
Contract Services + Employee cost	USD, million	415.28	458.31	409.21
NPT savings @4% [1]	USD, million	16.61	18.33	16.37
ILT savings @5% [2]	USD, million	20.76	22.92	20.46
Total savings	USD, million	37.38	41.25	36.83
Average savings / year	USD, million	38.48		
Savings over 5 years	USD, million	192.42		

[1] 11% of operations in development wells and 25% of operations in production wells are non-productive, with the average being about 18%. It is estimated that the information generated by the NPT model can reduce the NPT rate from 18% to 14%, reducing 4% of the expenses

[2] For ILT (Invisible Loss Time) project, PT model is only the starting point. 5% savings is a broad order-of-magnitude estimate of the savings possible.