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Innov8x™

MINES | McNeil Center for Entrepreneurship and Innovation

bp

MINES Innov8x Challenge, Spring 2023
Process Monitoring

Data Science Team @ bpx

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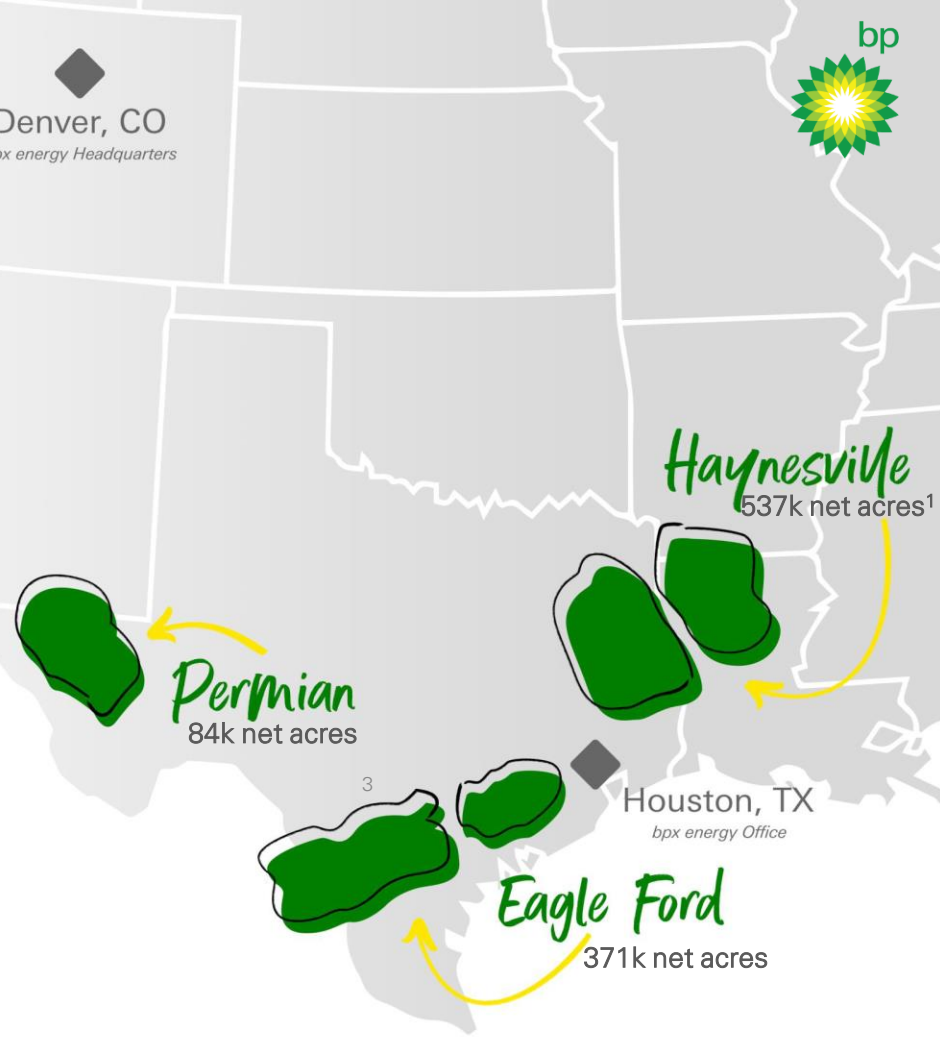
- High quality US onshore position
- Portfolio positioned in the core of the Permian, Eagle Ford and Haynesville shale plays
- Driving operational excellence through our focus on safety and environmental stewardship



Acreage data as of YE21 [1] Excludes mineral leasehold

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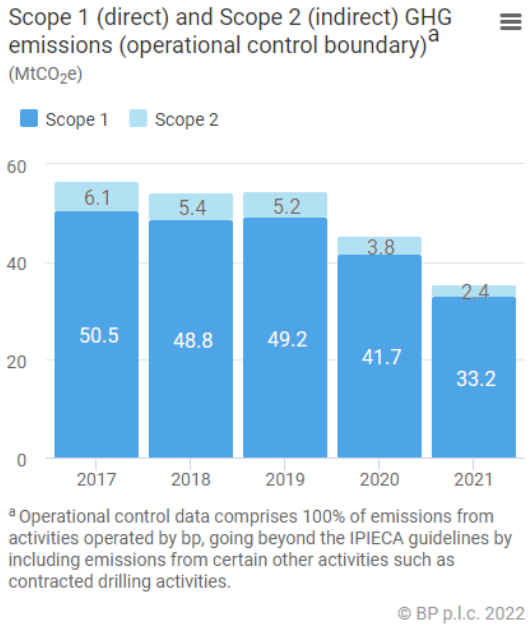
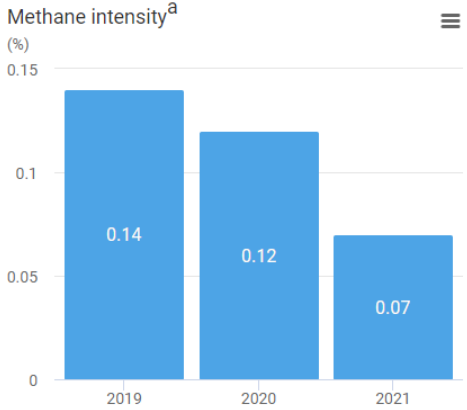


[a] Operational control data comprises 100% of emissions from activities operated by bp, going beyond the IPIECA guidelines by including emissions from certain other activities such as contracted drilling activities.

Aim 1: Be net zero across our entire operations on an absolute basis by 2050 or sooner. This aim relates to our Scope 1 (from running the assets within our operational control boundary) and Scope 2 (associated with producing the electricity, heating and cooling that is bought in to run those operations) GHG emissions.



[a] Methane intensity refers to the amount of methane emissions from bp's operated upstream oil and gas assets as a percentage of the total gas that goes to market from those operations. Our methodology is aligned with the Oil and Gas Climate Initiative's (OGCI).

*We aim to have our new measurement approach in place by the end of 2023.

Aim 4: reducing methane

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What a Thief Hatch Is and How It Works

- *In the oilfield, a thief hatch is a closable aperture in a tank or vessel. They are normally used on low pressure and atmospheric tanks. They are used to take samples of the tank's contents, determining the level of the tank and protect the tank from over pressure and excessive vacuum.*

- *When working with oil tanks, it's important to close the thief hatch after finishing tasks to avoid safety and environmental hazards. If the hatch is left open for extended period, it can increase the risk of fire and harm to workers due to the presence of combustible gases.*

- *Additionally, it may result in environmental damage and fines or penalties from regulatory bodies. Thief hatches may also be opened from process events, such as an event where higher than standard operating pressure is pushed to the tanks.*

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Oil Tank and Thief Hatch

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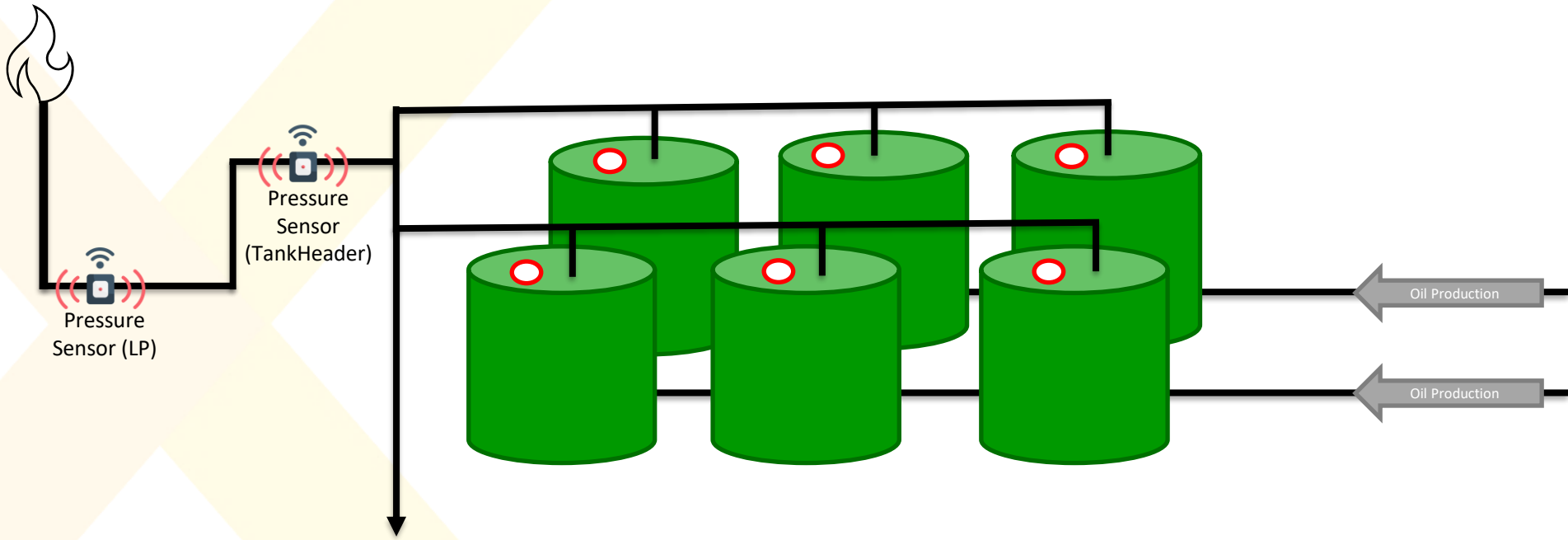
Oil Tank and Thief Hatch



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FlareLPheaderPressureCurr is mounted close to the Flare.
FlareTankHeaderPressureCurr is mounted in the header for all of the tanks above them, could be closer to either the 1st or the last tank.

What does an open thief hatch look like?

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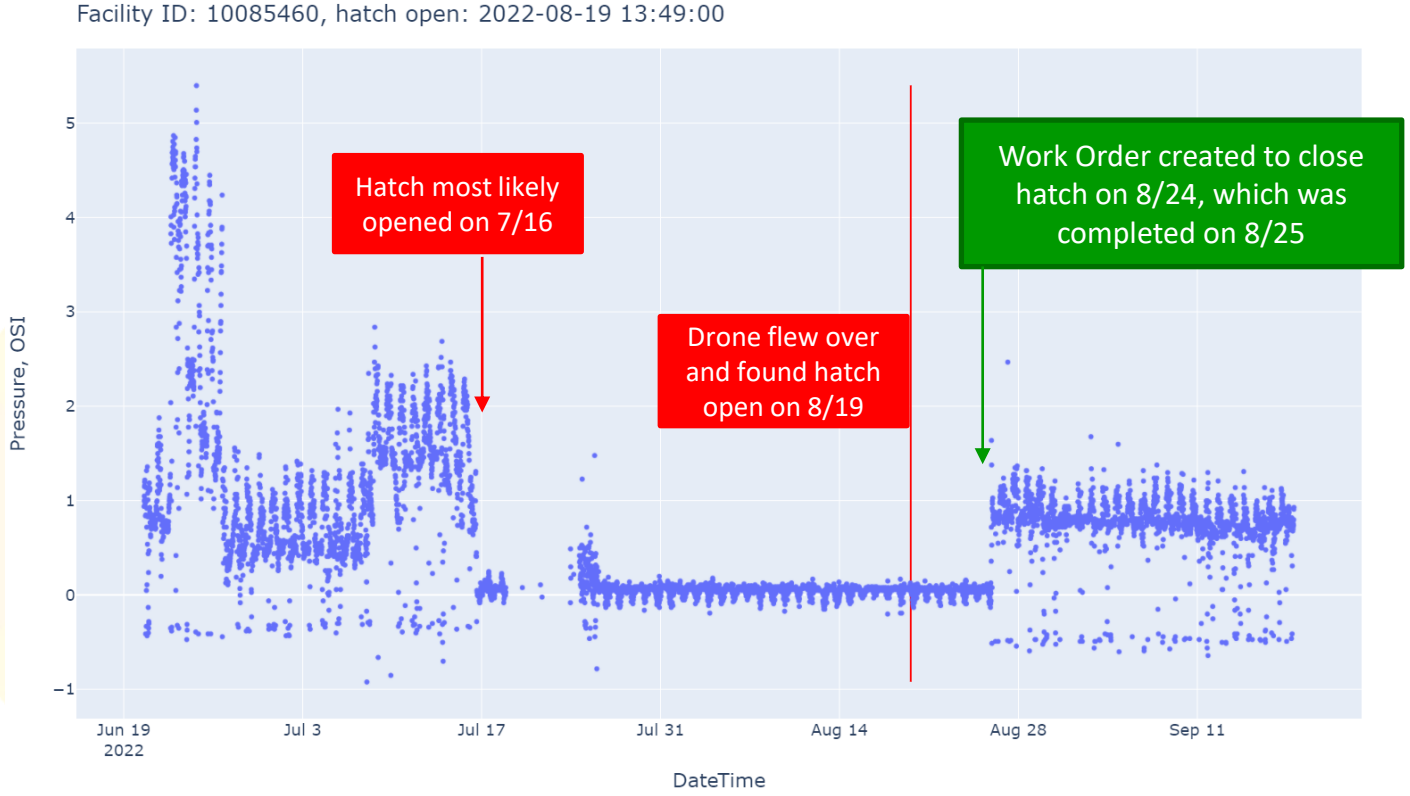
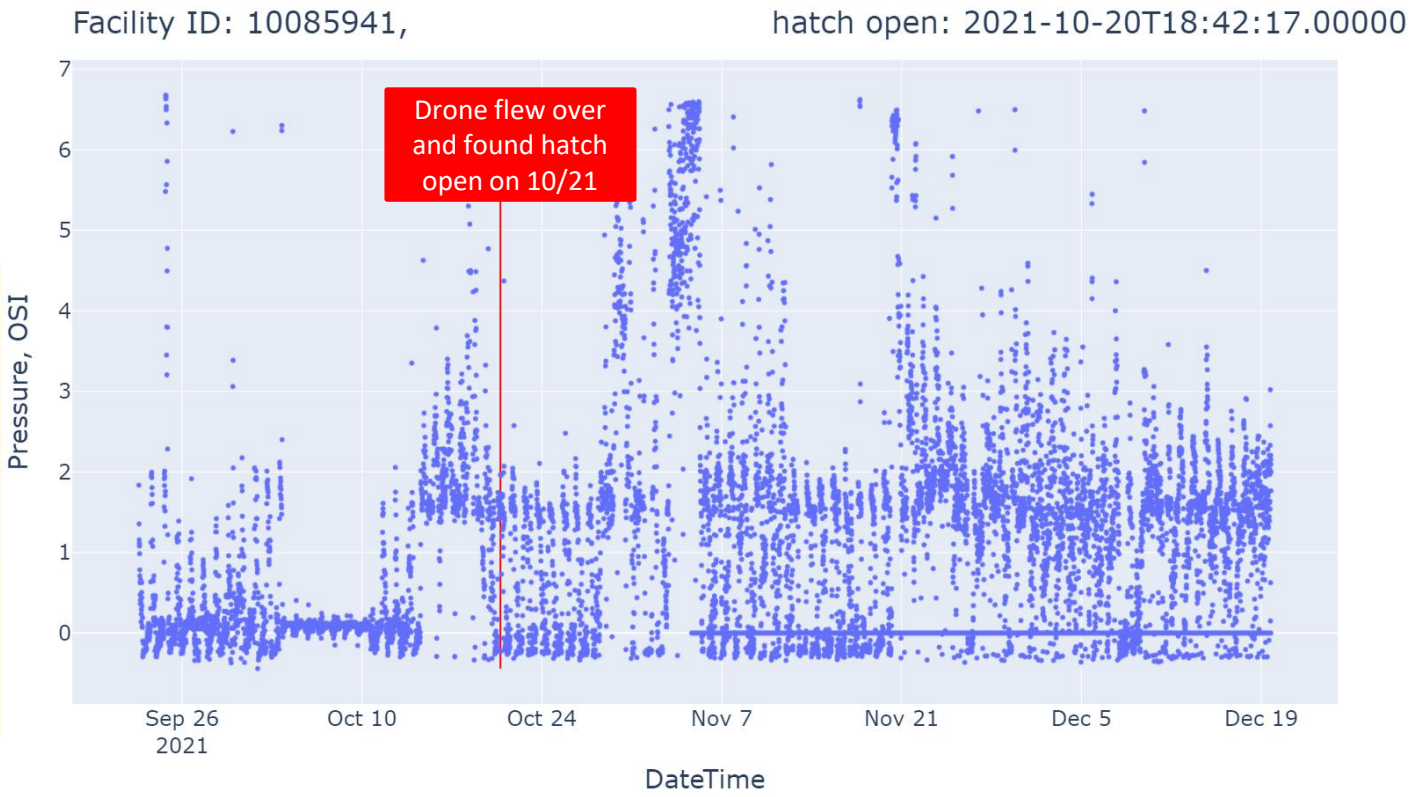
Open Thief Hatch Event Example - 1

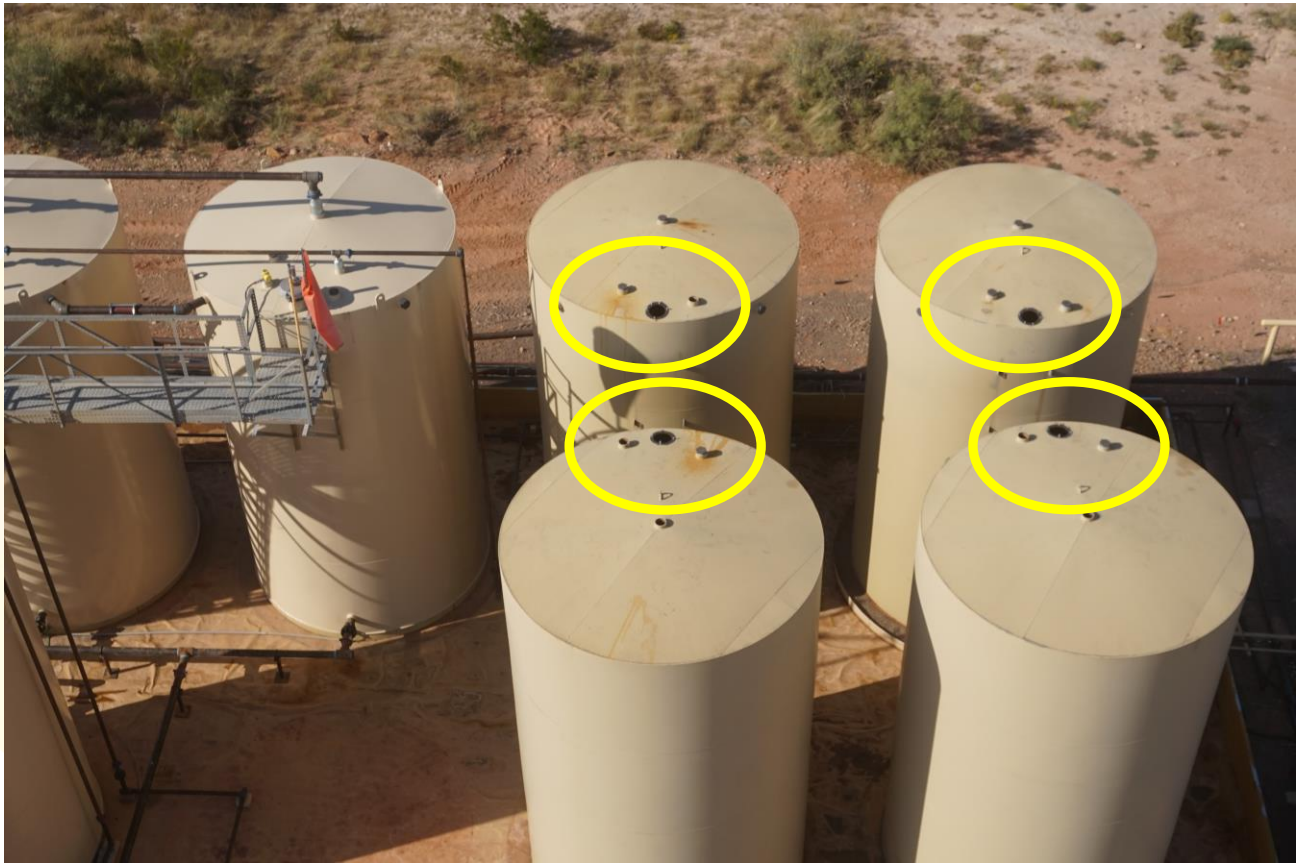


assetType	sourceSystemId	facility_id	corp_id	workOrderDescription	workOrderResolutionDescription	workOrderActualsStartDate	workOrderActualsEndDate
Facility	10085460	10085460	NULL	Got a drone finding indicating there's an open thief hatch, need air crew to close it	Thief hatch has been closed.	NULL	2022-08-25
Facility	10085460	10085460	NULL	Troubleshoot EPA finding	Didn't find any thief hatch venting or flare issues. EPA finding was an open thief hatch that was closed shortly after	NULL	2022-12-09
Facility	10085460	10085460	NULL	Kairos Identified Methane Emissions during flyover. Please utilize FLIR/OGI camera and check for leaks	Eddie performed a test with the FLIR camera "WATER TANK 801 & 802 & OT 701 LEAKING THRU THIEF HATCH", I will move a WM to maintenance	2020-07-19	2020-07-29
Facility	10085460	10085460	NULL	EPA - Tank hatch emissions identified. Examine facility for blowby condition from separators and compressors. Inspect / clean thief hatches and replace gaskets as necessary. Record findings in resolution.	replaced the thief hatch gaskets and cleaned surfaces, they had significant build up of scale/corrosion.	2021-01-04	2021-01-04
Facility	10085460	10085460	NULL	Enardo thief hatch center aluminum piece is corroded will need replaced and new gaskets.	thief hatches have been cleaned, inspected and all gaskets replaced.	2021-12-30	2021-12-30
Facility	10085460	10085460	NULL	Please replace all thief hatch gaskets both vacuum and pressure side and clean mating surfaces while site is down for vent header cleanout	replaced all thief hatch gaskets both pressure and vacuum sides, cleaned mating surfaces.	2022-02-27	2022-02-09
Facility	10085460	10085460	NULL	Inspect tanks and flare	Flare and thief hatches look good.	2023-01-11	2023-01-11
Facility	10085460	10085460	NULL	TCEQ site inspection	Identified packing leak on Axip's V5797 and reported to Axip for repairs. Thief hatches closed, did not identify any other leak/venting after inspecting location	2023-02-09	2023-02-09

Open Thief Hatch Event Example - 2



Open Thief Hatch Event Example - 2



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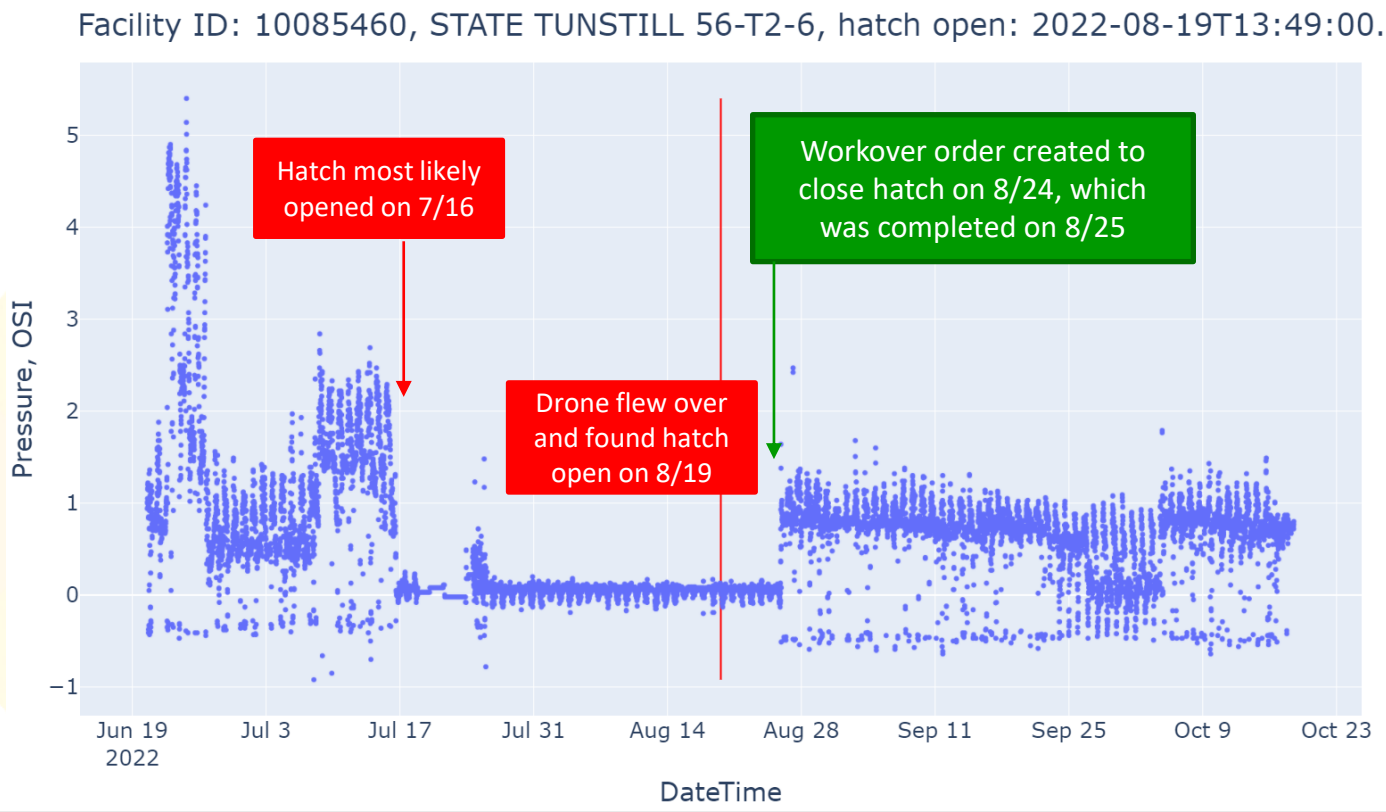
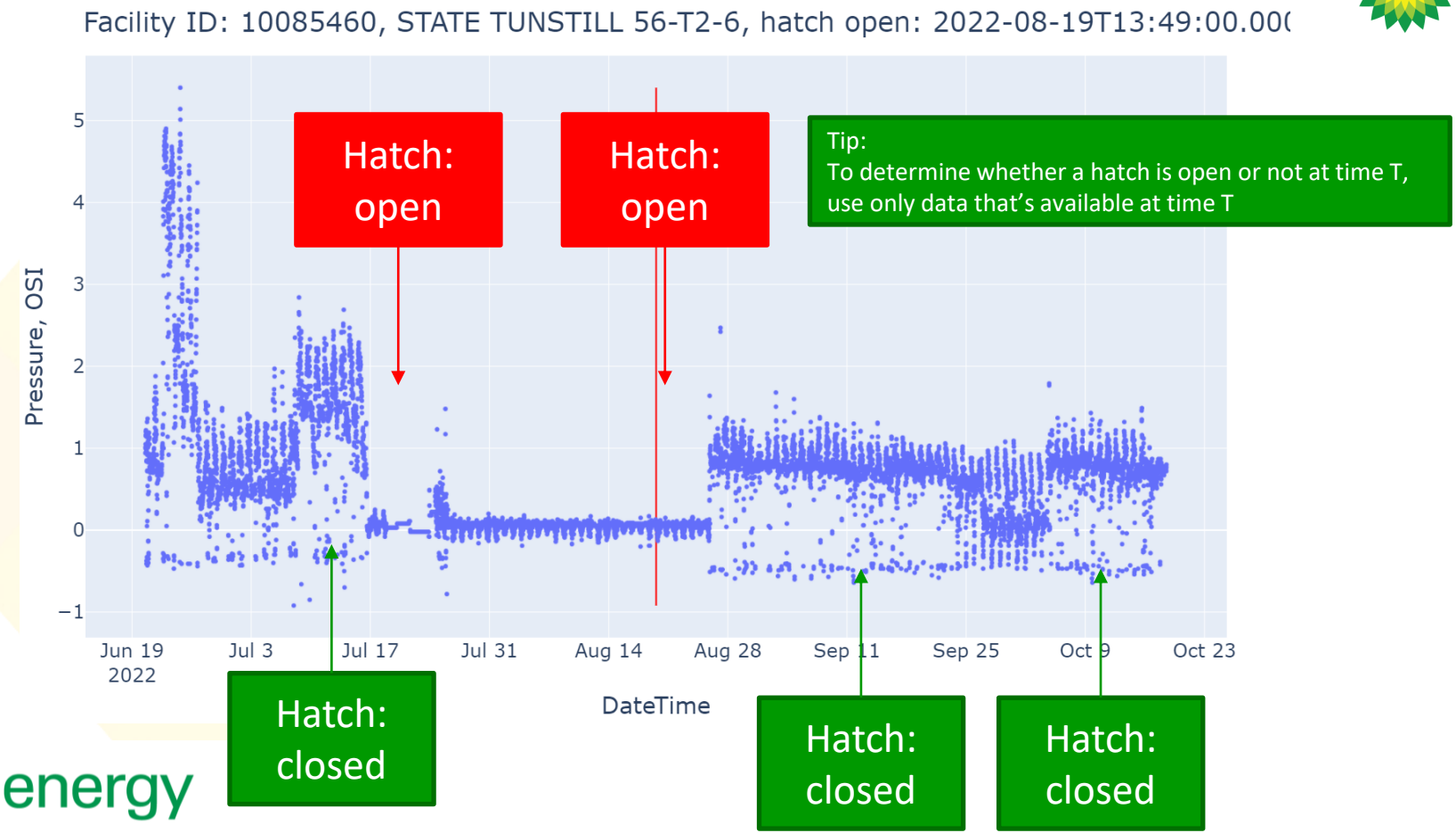
Challenge 1: Manually identify open thief hatch cases: time series data with evidence of drone, work order or forms records to show hatches were open

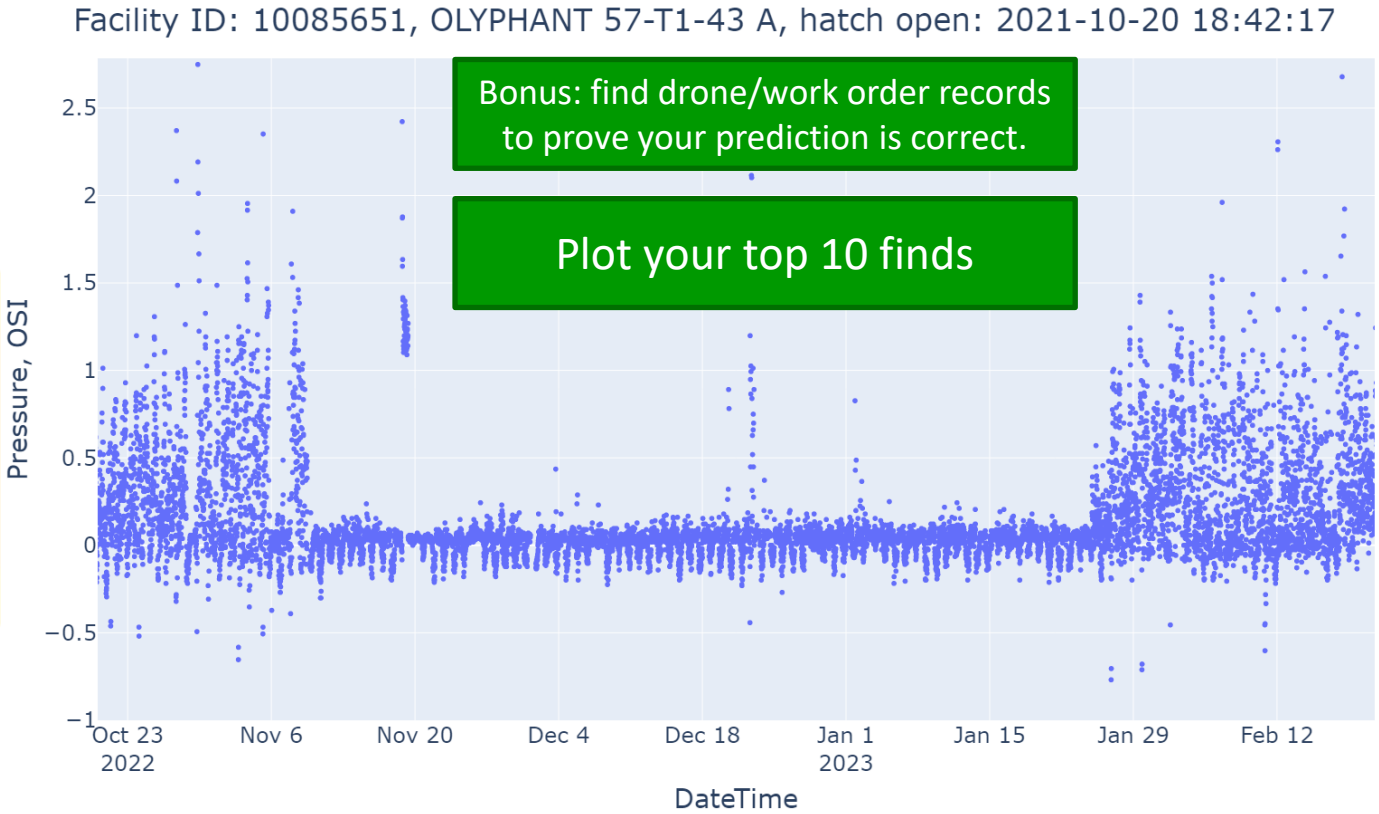


created_date	enbase_asset_id	assetType	sourceSystemId	facility_id	corp_id	workOrderDescription	workOrderResolutionDescription	workOrderActualsStartDate	workOrderActualsEndDate
2022-08-24	Asset-Facility-10085460	Facility	10085460	10085460	NULL	Got a drone finding indicating there's an open thief hatch, need air crew to close it	Thief hatch has been closed.	NULL	2022-08-25
2022-12-09	Asset-Facility-10085460	Facility	10085460	10085460	NULL	Troubleshoot EPA finding	Didn't find any thief hatch venting or flare issues. EPA finding was an open thief hatch that was closed shortly after	NULL	2022-12-09
2020-07-08	Asset-Facility-10085460	Facility	10085460	10085460	NULL	Kairos Identified Methane Emissions during flyover. Please utilize FLIR/OGI camera and check for leaks	Eddie performed a test with the FLIR camera "WATER TANK 801 & 802 & OT 701 LEAKING THRU THIEF HATCH", I will move a WM to maintenance	2020-07-19	2020-07-29
2020-12-28	Asset-Facility-10085460	Facility	10085460	10085460	NULL	EPA - Tank hatch emissions identified. Examine facility for blowby condition from separators and compressors. Inspect / clean thief hatches and replace gaskets as necessary. Record findings in resolution.	replaced the thief hatch gaskets and cleaned surfaces, they had significant build up of scale/corrosion.	2021-01-04	2021-01-04
2021-12-12	Asset-Facility-10085460	Facility	10085460	10085460	NULL	Enardo thief hatch center aluminum piece is corroded will need replaced and new gaskets.	thief hatches have been cleaned, inspected and all gaskets replaced.	2021-12-30	2021-12-30
2022-02-09	Asset-Facility-10085460	Facility	10085460	10085460	NULL	Please replace all thief hatch gaskets both vacuum and pressure side and clean mating surfaces while site is down for vent header cleanout	replaced all thief hatch gaskets both pressure and vacuum sides, cleaned mating surfaces.	2022-02-27	2022-02-09
2023-01-11	Asset-Facility-10085460	Facility	10085460	10085460	NULL	Inspect tanks and flare	Flare and thief hatches look good.	2023-01-11	2023-01-11
2023-02-09	Asset-Facility-10085460	Facility	10085460	10085460	NULL	TCEQ site inspection	Identified packing leak on Axip's V5797 and reported to Axip for repairs. Thief hatches closed, did not identify any other leak/venting after inspecting location	2023-02-09	2023-02-09

Challenge 2: Develop algorithm to classify time series data to determine whether thief hatch is open or not and probability at any given time



Challenge 3: Use the algorithm you developed in Challenge 2 or new algorithm to identify retrospectively open thief hatches in the past that's not detected by drone



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Output Summary

- Challenge 1:
  - “open_hatch_events_manual.csv”
  - Plots of all hatch open/close events you identified manually after exploring drone data, work orders and forms data
- Challenge 2:
  - “model_predict_open_hatch“ in model.py
  - “model_predictions.csv”
  - Plots
- Challenge 3:
  - “search_for_open_hatch” in model.py
  - “search_results.csv”
  - Plots of top 10 most probable hatch open/close events identified with your algorithm

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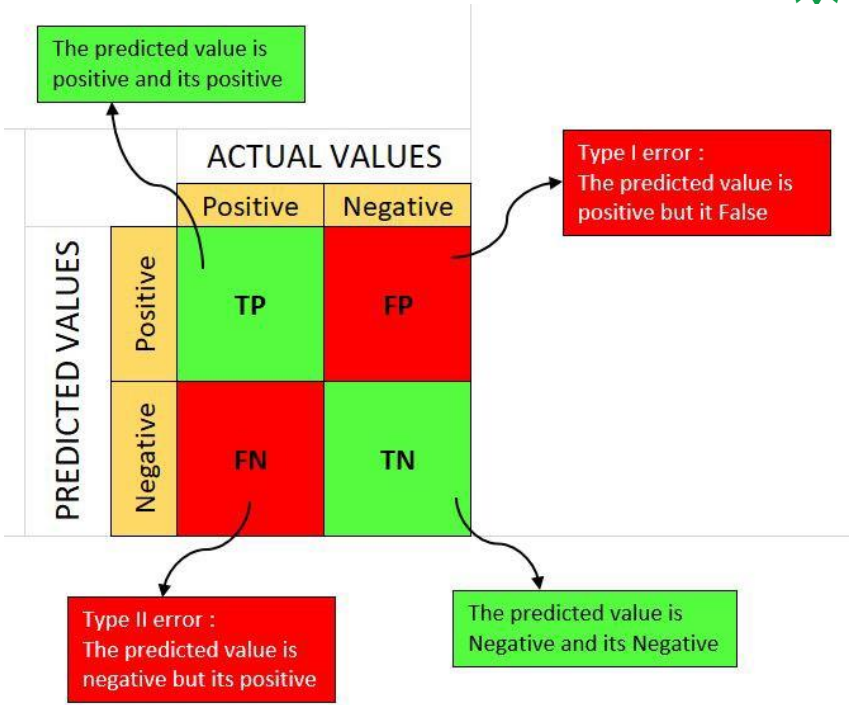
Classification Metrics

$$\text{Accuracy} = \frac{TP + TN}{TP + TN + FP + FN} = \frac{\text{Correct Predictions}}{\text{Total Predictions}}$$

$$\text{Precision} = \frac{TP}{TP + FP} = \frac{\text{Predictions Actually Positive}}{\text{Total Predicted positive}}$$

$$\text{Recall} = \frac{TP}{TP + FN} = \frac{\text{Predictions Actually Positive}}{\text{Total Actual positive}}$$

$$\text{F1-Score} = 2^* \frac{(\text{Recall}^*\text{Precision})}{(\text{Recall} + \text{Precision})}$$



Reference: https://medium.com/analytics-vidhya/what-is-a-confusion-matrix-d1c0f8feda5

Time Series Data (Tank Header Pressure) Example

timestamp	TagType	FACILITY_ID	pressure_osi
2022-06-20 13:59:33.763	FlareTankHeaderPressureCurr	10085460	0.940002
2022-06-20 14:14:33.768	FlareTankHeaderPressureCurr	10085460	1.000000
2022-06-20 14:29:34.027	FlareTankHeaderPressureCurr	10085460	1.050003
2022-06-20 14:44:34.323	FlareTankHeaderPressureCurr	10085460	1.150002
2022-06-20 14:59:34.437	FlareTankHeaderPressureCurr	10085460	1.160004
...	...	...	...
2022-09-18 12:29:34.280	FlareTankHeaderPressureCurr	10085460	0.750000
2022-09-18 12:44:34.341	FlareTankHeaderPressureCurr	10085460	0.739998

Name	Description
Frequency	How often the measurement is polled
Method: Spot	Actual measurement
FlareLPHeaderPressureCurr	Pressure sensor is mounted close to the Flare
FlareTankHeaderPressureCurr	Pressure sensor is mounted in the header for all of the tanks above them, could be closer to either the 1st or the last tank.
TankHeaderPressure**1**Curr	
TankHeaderPressure**2**Curr	

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Work Order Data Example

(when work was done related to thief hatch and other problems)

sourceSystemId	facility_id	corp_id	workOrderDescription	workOrderResolutionDescription	workOrderActualsStartDate	workOrderActualsEndDate
10085460	10085460	NULL	No issues were observed	Normal Operations	2022-05-07	2022-05-07
10085460	10085460	NULL	GLC is currently down	Will return at a later date	2022-05-07	2022-05-07
10085460	10085460	NULL	OOOOa inspection.	OOOOa inspection completed.	NULL	2022-05-13
10085460	10085460	NULL	OOOOa inspection.	OOOOa inspection completed.	NULL	2022-06-24
10085460	10085460	NULL	Shut in for BWTI	Waiting on construction for BWTI	2022-07-08	2022-07-08
10085460	10085460	NULL	OOOOa inspection.	OOOOa inspection completed.	NULL	2022-07-11
10085460	10085460	NULL	Line power brought to location. Please remove generator and all associated equipment	Gen has been removed from location.	NULL	2022-07-23
10085460	10085460	NULL	POL following power upgrade	POL following power upgrade	2022-07-23	2022-07-23
10085460	10085460	NULL	Compressor suction solenoid	Changed SOV 11-30-22 DP	NULL	2022-07-30
10085460	10085460	NULL	Start compressor	Tried to start compressor - suction solenoid needs replaced	2022-07-30	2022-07-30
10085460	10085460	NULL	Start compressor after suction solenoid replacement	Started compressor	2022-07-31	2022-07-31
10085460	10085460	NULL	OOOOa inspection.	OOOOa inspection completed.	NULL	2022-08-22
10085460	10085460	NULL	Got a drone finding indicating there's an open thief hatch, need air crew to close it	Thief hatch has been closed.	NULL	2022-08-25
10085460	10085460	NULL	OOOOa inspection.	OOOOa inspection completed.	NULL	2022-09-04
10085460	10085460	NULL	Secondary containment needs cleaned. Water build up from rain.	Complete	NULL	2022-09-07
10085460	10085460	NULL	Insufficient covering on piping and electrical wires.Dirt has washed out. Please repair	Put new base material in eroded areas	NULL	2022-09-07
10085460	10085460	NULL	Facility oil deferment	Site check completed. Dewatering.	2022-09-07	2022-09-07
10085460	10085460	NULL	oil deferment	increased buyback, gaslift rate holding steady at 550, compressor running but...	2022-09-12	2022-09-12
10085460	10085460	NULL	Troubleshoot deferral	Routed due to deferral caused by a low 24 hour volume. Choke was open, c...	2022-09-15	2022-09-15
10085460	10085460	NULL	Fill methanol tanks, check pumps and pump rates	methanol filled. Complete	2022-09-26	2022-09-16
10085460	10085460	NULL	Site check	Decreased BB setpoint 30psi and increased GL 50mcf.	2022-09-17	2022-09-17
10085460	10085460	NULL	HP Separator water dump line has a 1" vent. This pipe needs to be rotated so the 1" ...	Complete	NULL	2022-09-19
10085460	10085460	NULL	Winterization checklist	Winterization checklist. Louvers did not close, methanol tank 3 needs 400 gal...	NULL	2022-09-21
10085460	10085460	NULL	Need 400 gallons of methanol for tank 3 by compressor	delivered 400 gals of meoh on 9/23	2022-09-23	2022-09-21
10085460	10085460	NULL	shut in for Offset frac	shut in for off-set frac	2022-09-22	2022-09-22
10085460	10085460	NULL	Flare camera not functioning (IP 10.66.17.148) - Send Jameson Keating updated IP a...	Both cameras are fried. The IP of the flare camera is 10.66.17.147. A replac...	NULL	2022-10-03
10085460	10085460	NULL	Site check to confirm flare	Site check to verify flare was lit, got approval to open well back up being flare...	2022-10-04	2022-10-04
10085460	10085460	NULL	Facility deferment-Post RTP check	Frac hit mitigation. Site check completed. Chokes are full open.	2022-10-05	2022-10-05
10085460	10085460	NULL	Check flare	Flare is lit. Not smoking. 0mcf	2022-10-07	2022-10-07

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Drone Data Example

(dates when drone detected open thief hatch)

Row	ASSET	DTM	FACILITY_ID
1	LaHa	2023-01-06 14:57:00.000	20000009
2	LaHa	2022-12-21 10:10:04.000	20000032
3	SOHA	2022-12-09 10:50:30.000	10084684
4	LaHa	2022-11-28 13:02:13.000	20000059
5	Hawkville	2022-11-11 11:47:04.000	10085492
6	LaHa	2022-11-08 10:21:57.000	20000059
7	LaHa	2022-11-07 15:12:35.000	10085667
8	LaHa	2022-11-07 10:48:57.000	10085624
9	LaHa	2022-11-03 13:01:20.000	10085632
10	LaHa	2022-11-02 12:02:58.000	10086027

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Forms Data Example

(Forms submitted by field personnel that recorded their observations)

	SubmitDate	VisibleFlare	ThiefHatchClosed	OpenThiefHatchClosed	IssueDetail	BusinessUnit	FACILITY_ID
144	2023-01-20 16:05:12.680000000	No, one or more flares are not lit.	NaN	NaN	State Hope Springs 113-23X14 is Shut in as wel...	Permian	10090756
209	2023-01-20 16:41:44.383000000	No, one or more flares are not lit.	NaN	NaN	The flare coming off the LP separator is not l...	Permian	10085558
217	2023-01-20 17:08:41.130000000	No, one or more flares are not lit.	NaN	NaN	Well is shut-in, facility under construction	Permian	10085767
139	2023-01-20 17:11:25.993000000	No, one or more flares are not lit.	NaN	NaN	Well is shut-in, facility is under construction	Permian	10085680
205	2023-01-20 17:23:32.003000000	No, one or more flares are not lit.	NaN	NaN	Wells are shut in	Permian	10213848
...	...	...	...	...	...	...	...
170	2023-01-31 15:43:56.783000000	No, one or more flares are not lit.	NaN	NaN	Flare not lit due to well being shut in	Permian	10085554
77	2023-01-31 16:44:07.563000000	No, one or more flares are not lit.	NaN	NaN	Well shut in. Tank hatches are closed.	Permian	10085776
6	2023-01-31 17:08:08.570000000	No, one or more flares are not lit.	NaN	NaN	Well shut in. Tank hatches are closed.	Permian	10085615
1	2023-01-31 17:12:30.443000000	No, one or more flares are not lit.	NaN	NaN	Wells are shut in	Permian	10085679
111	2023-01-31 17:31:19.010000000	No, one or more flares are not lit.	NaN	NaN	Well is shut in	Permian	10085519

220 rows × 7 columns

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Code Repo and Instructions

- Survey (CS, DS, Github)
- Github repo with starter code
  - https://github.com/julianliu-bpx/open-thief-hatch-detection
  - Download data from Canvas
- Follow this instruction for forking a repo.
- Each team creates a branch with its team name and submit code by deadline
  - readme file: your team member name and email

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Key Dates

- Info session and problem framing
  - Tuesday, Feb 28th, 4:00-5:30pm, Metals Hall
  - 6:00pm, meeting ACM

- Office hours (ask questions, gain clarity, etc. with BPX)
  - Thursday, March 2nd, 12:00-12:30pm, Virtual
  - Friday, March 3rd, 12:00-12:30pm, Virtual
  - Monday, March 6th, 12:00-12:30pm, Virtual

- Presentation review
  - Monday, March 6th: Draft presentation submitted to Canvas.
  - Tuesday, March 7th: Feedback on presentation returned to teams.

- Code and presentation submit by (for bpx to review code and evaluate solutions)
  - Wednesday, March 8th, 11:59pm

- Pitch presentations
  - Thursday, Mar 9th, 3:00-5:00pm, Marquez Atrium

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Scoring Rubrics

Criteria	Points (Total 100)
TECHNOLOGY-Challenge 1 (how many events identified)	10
TECHNOLOGY-Challenge 2 (does model classifies events accurately)	30
TECHNOLOGY-Challenge 3 (does model identifies events retrospectively well)	20
DESIGN (is solution easy to adapt)	15
PRESENTATION (is presentation clear)	15
CREATIVITY (is the solution creative)	10

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FAQ

- Programming language: Python preferred
- Recommended IDE: Jupyter notebook (describe what you did and why) with python script
- Presentation time: 5 minutes + 2 minutes for questions
- Non-Disclosure Agreement (NDA):
  - Everyone must sign NDA (‘misc/Form BPX NDA (9.6.22).docx’) in canvas by Feb 28.

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Prizes

- **1st place:**
  - $2500
- **2nd place:**
  - $1500
- **3rd place:**
  - $1000

- Top 3 team members have the opportunities of interviewing for available internship or full-time positions at bpx

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