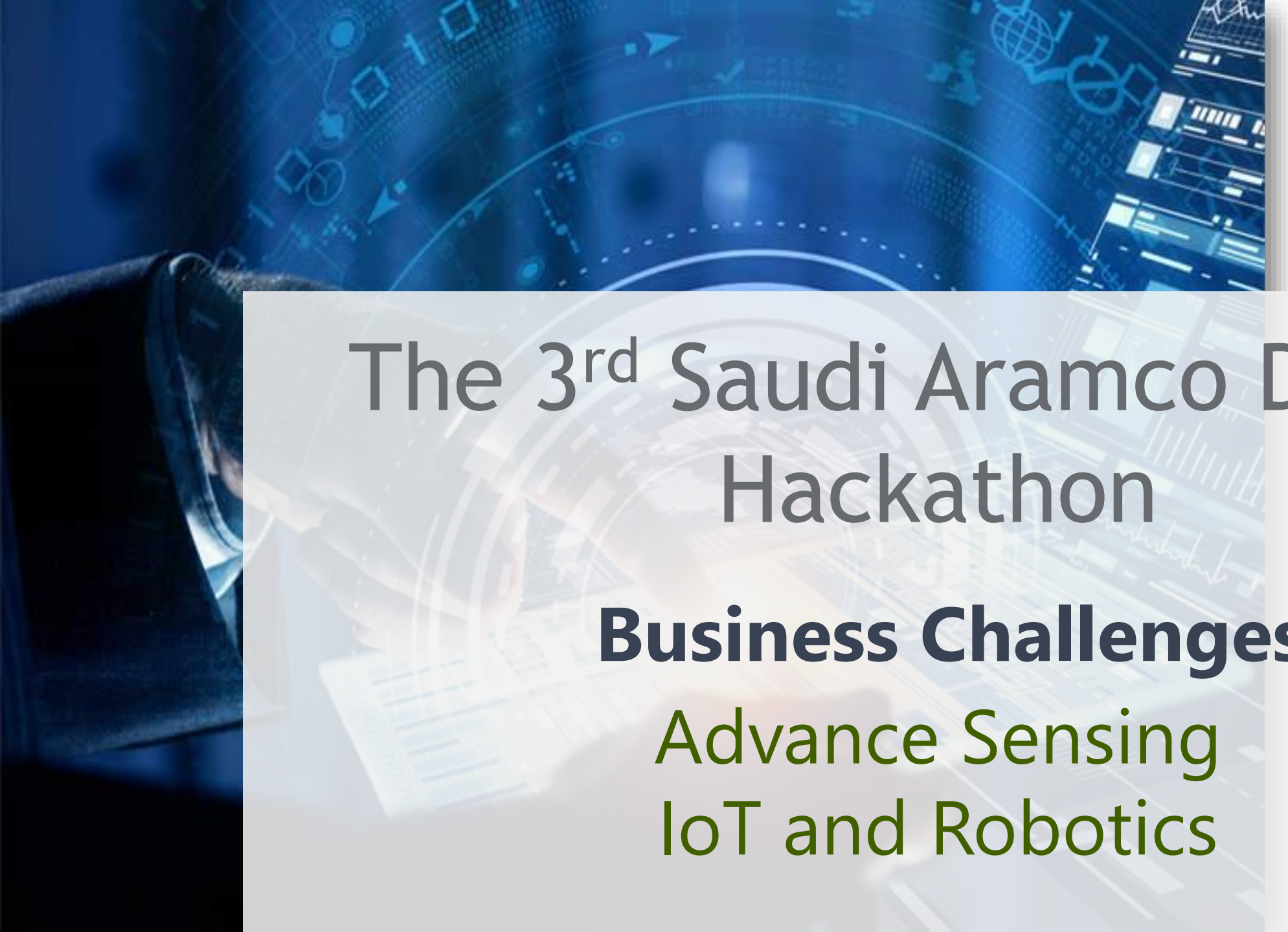


The 3rd Saudi Aramco Digital Hackathon

Business Challenges

Advance Sensing IoT and Robotics

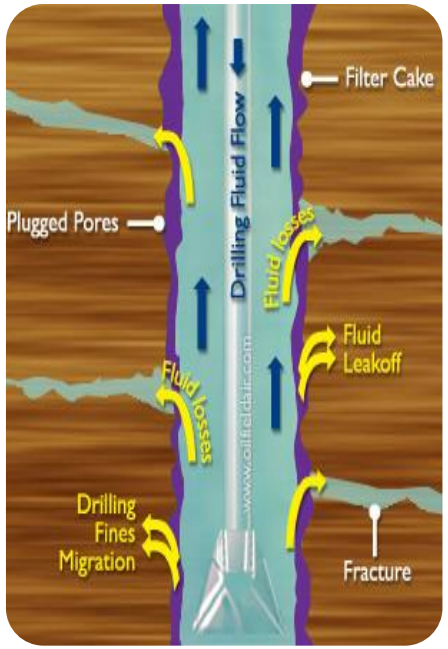
Monitoring Mud Height in Lost Circulation While Drilling

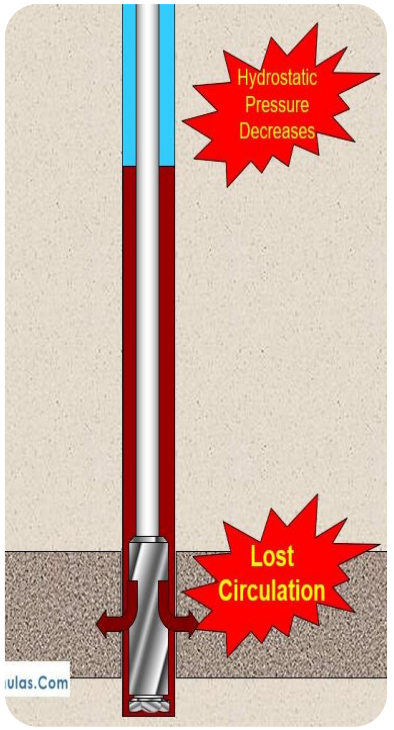
Description

- While drilling, treated mud is pumped into the well
- One of its main purposes is to control the well's pressure and prevent an influx of gas from the surrounding rocks
- When encountering fractures, mud is lost. In severe cases, no mud reaches back to the surface and circulation stops.
- We want to develop a non-intrusive fluid level measurement system to monitor the mud height so the operator can infer the pressure downhole and decide on how to proceed

Business Impact

- Saving on high-cost heavy mud used to ensure higher pressure, minimizing non-productive time, and enhancing the safety of the drilling operation





Deliverables:

- We expect an innovative solution that could achieve long range detection in a noisy environment.
- A working prototype/demo or simulation

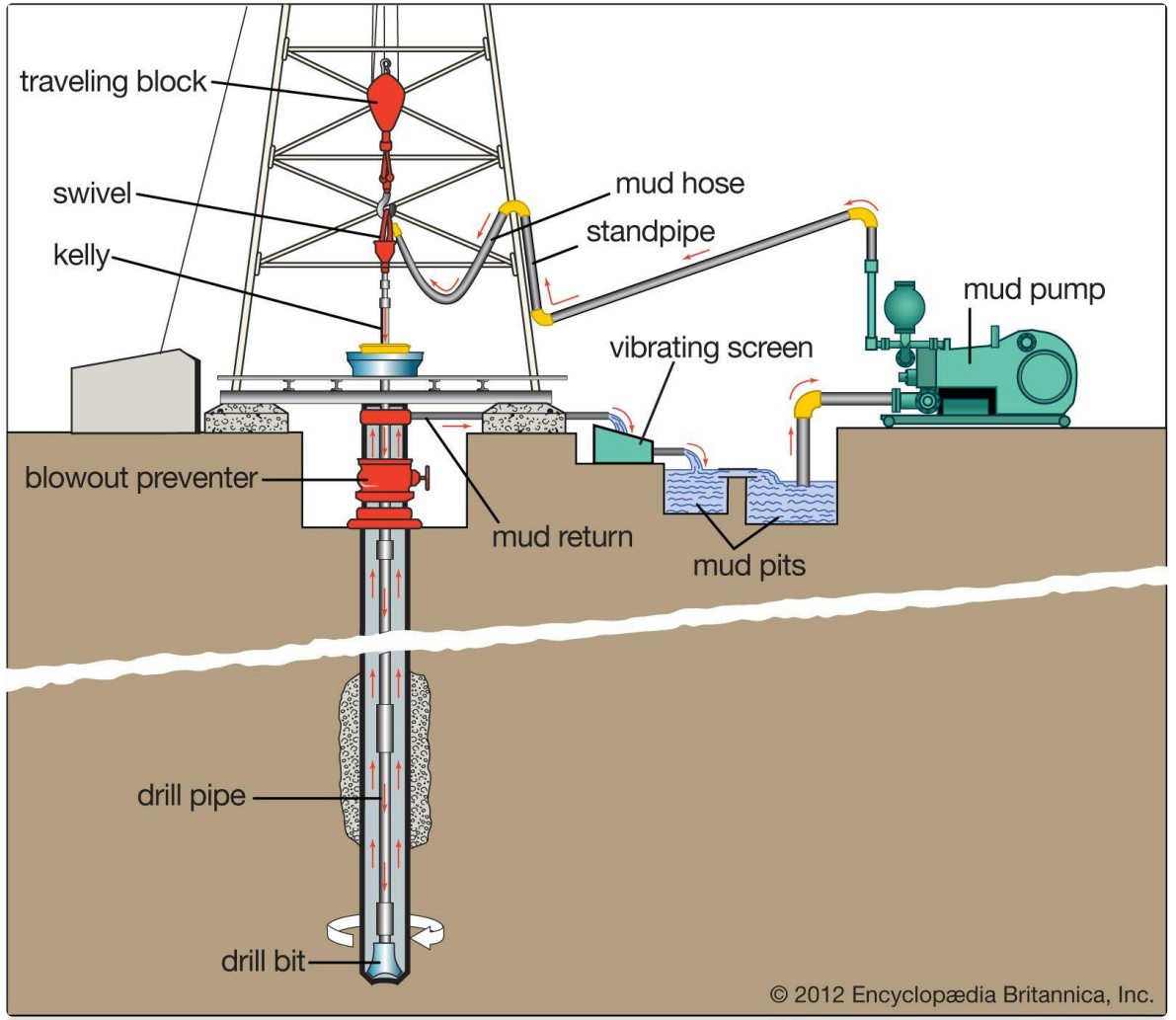
Background

During drilling, drilling mud is circulated through the drill pipe/string → into the annulus → up to the surface → then repurposed and recirculated

One of the main purposes of the drilling mud is to control the borehole pressure to prevent gas kicks

If gas enters the hole from the surrounding rock (formation), the drilling operation halts, and the drilling crew become at risk of a blowout

The mud's weight increases the hydrostatic pressure downhole, keeping the hole pressurized, higher pressure than the formation



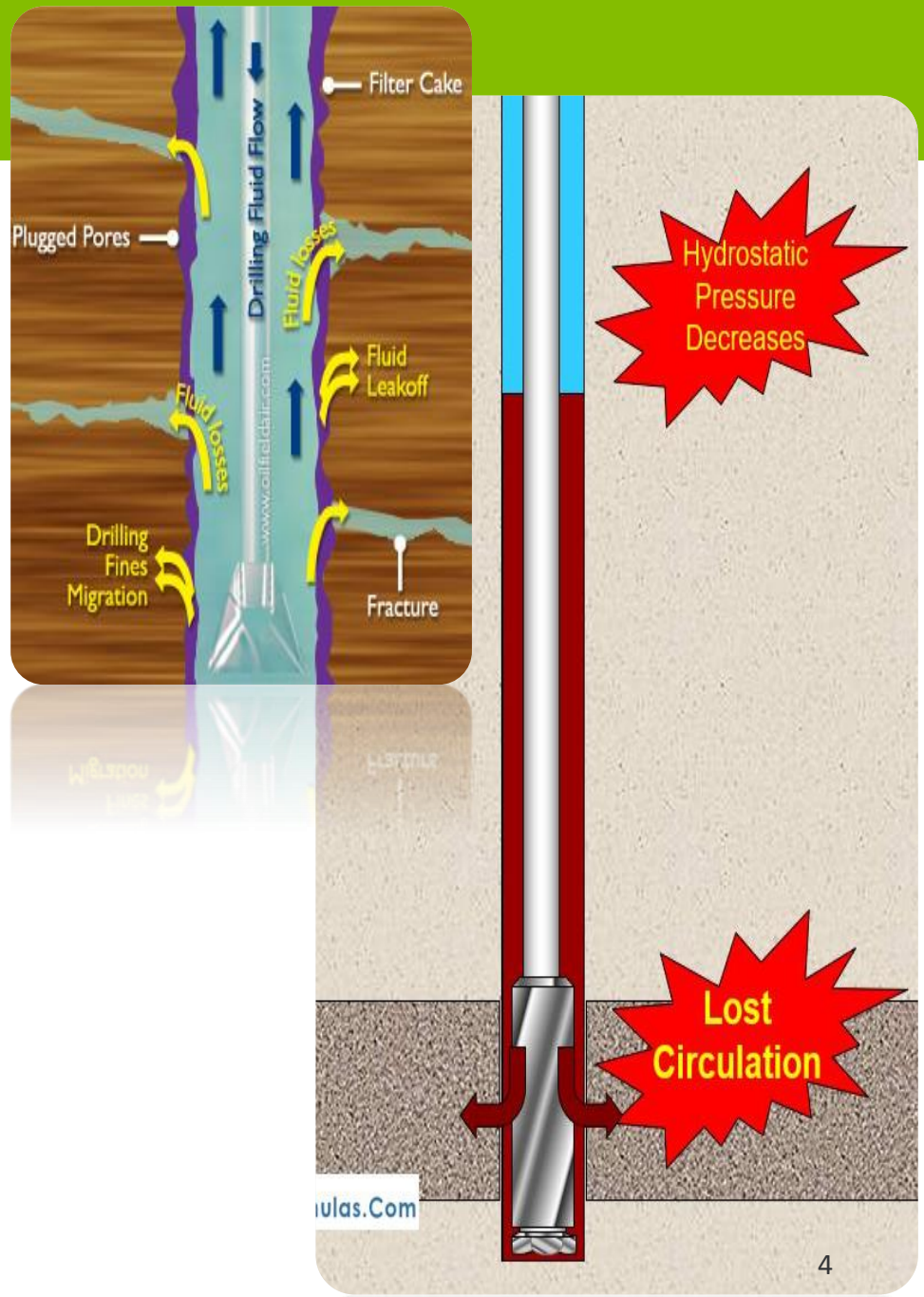
Challenge and Business Impact

When encountering fractures while drilling, mud losses are incurred. In severe cases, total loss of mud circulation happens (no mud reaches the surface)

This decreases the hydrostatic pressure and prevents operators from being able to infer the borehole pressure

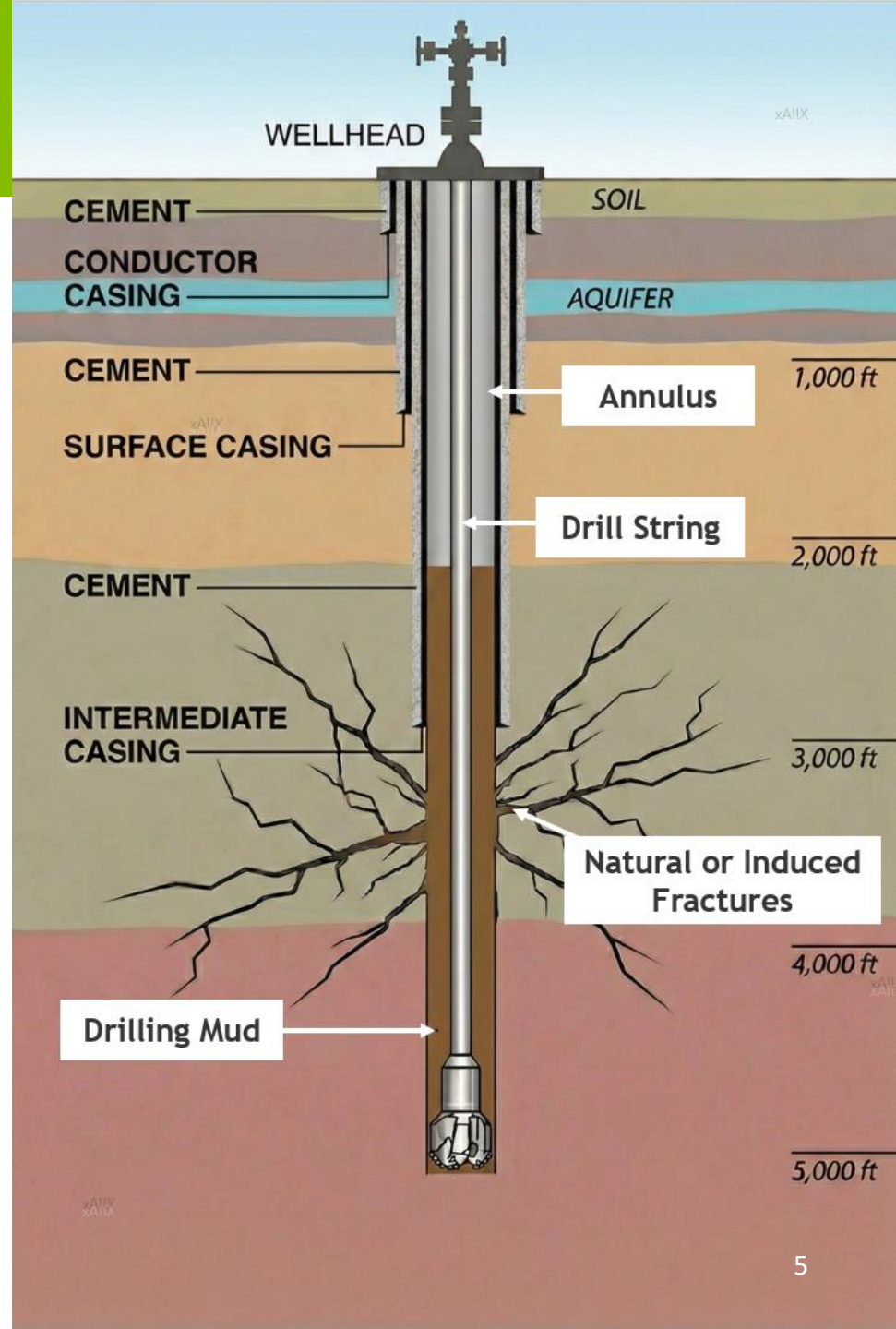
To minimize non-productive time, when total loss is encountered, the operators continue drilling blindly and pump much heavier, more expensive mud to maintain safe pressure margins and avoid a gas kick.

Monitoring the mud height will allow us to infer the hydrostatic pressure, operate safer, and save on unnecessary extra mud pumped.

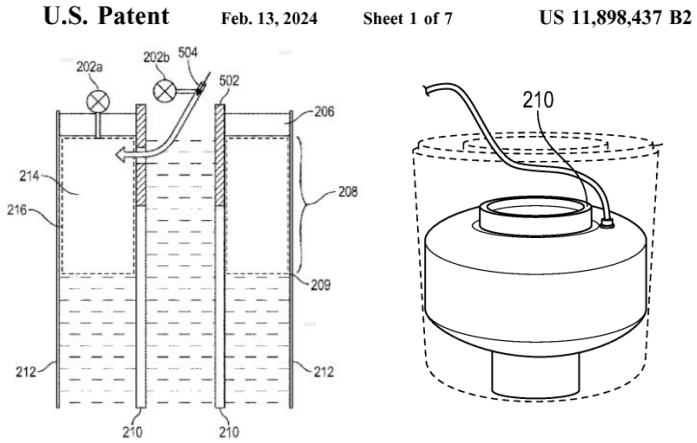


Considerations

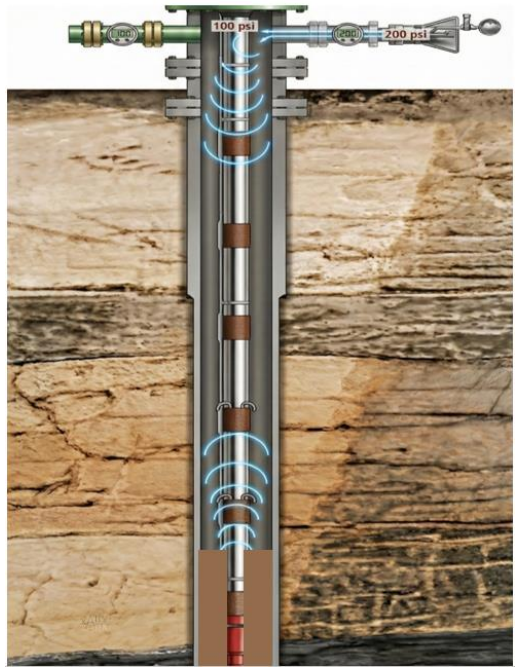
- The drilling environment is harsh. Temperatures downhole can reach ~70°C and pressures of >2000 psi with a hydrostatic head, ~200 psi without any liquid.
- There is no communication with the bottom of the well.
- The annulus size (the area between the drill string and the formation/casing) is small (~4 inches)
- The annulus can have varying cross sections due to joints in the drill string, casings, and unknown well walls geometry



Previous Work



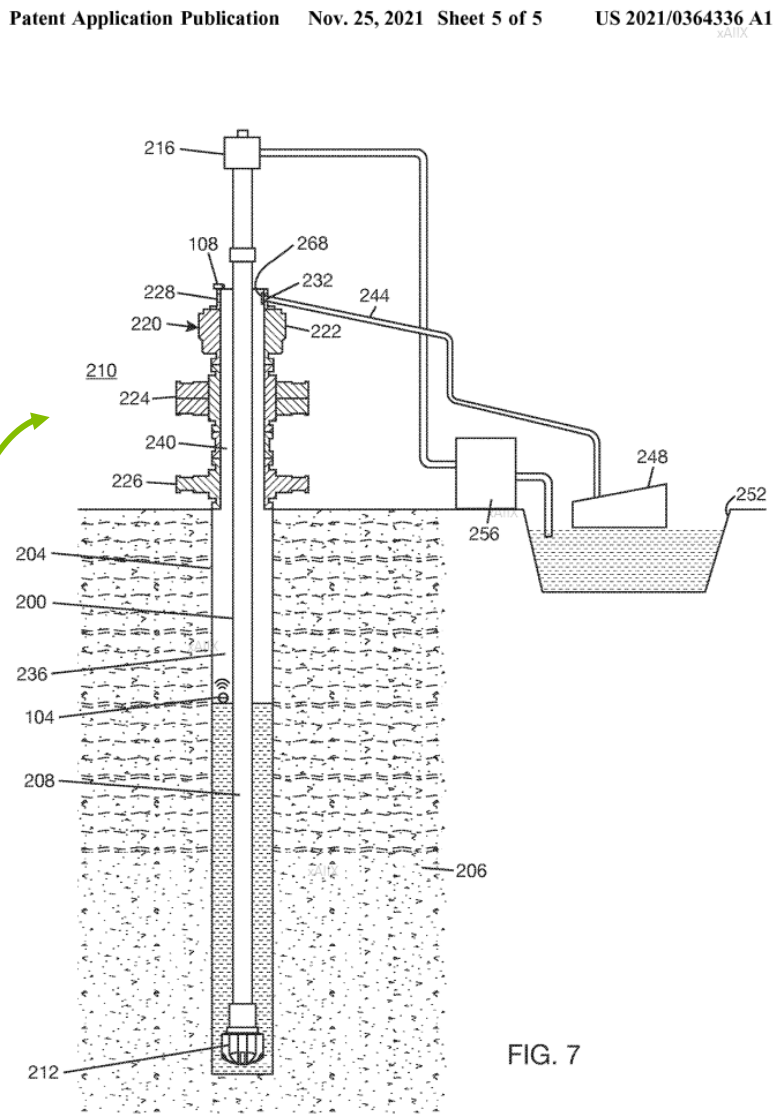
Fluid Level Measurement Echometer



A chamber that measures the volume of air volume flowing into the annulus in response to the displaced mud

A floating device that transmits acoustic or EM signals to a receiver on the surface

An acoustic gun that shoots a pressure wave and measures the travel time through its echo

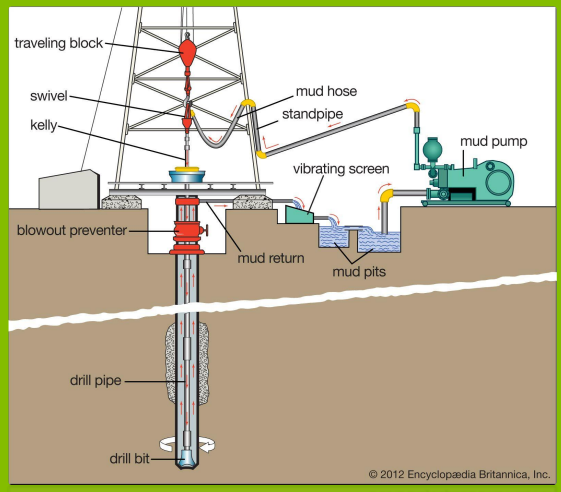


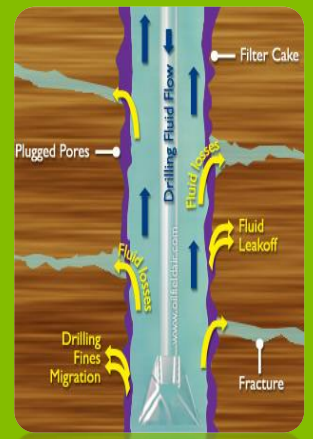
Deliverables

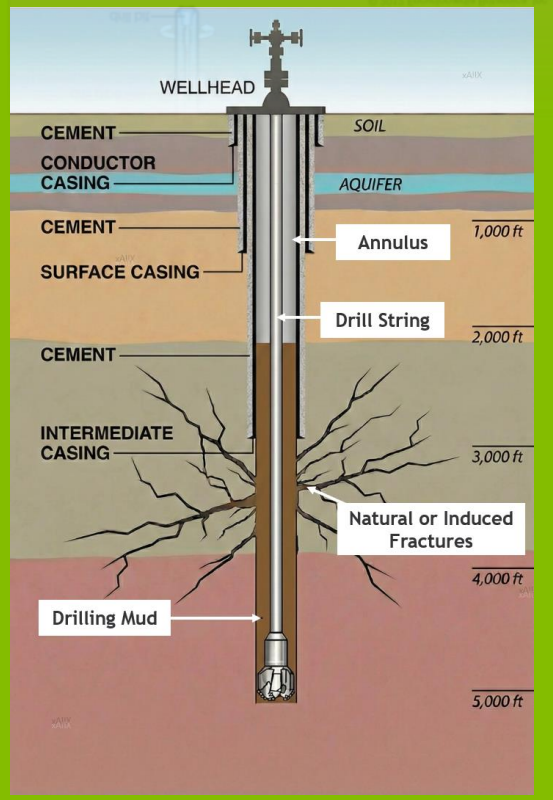
To address the issue, we need a non-intrusive method to detect and monitor the mud level that can possibly reach a range of 1.5 km (~4000ft) in depth.

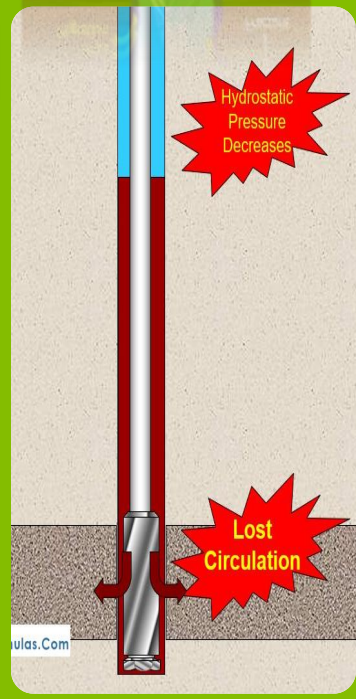
We expect a:

- Prototype
- Experimental Results
- Computational Simulation (if applicable)









Keywords:

total circulation loss, mud cap drilling, drilling fluid, overbalanced drilling, fluid level detection

Drone Perching and Traversing on Nonmetallic Pipe

Description

- Aramco conducts inspection of metallic pipes at high elevation using a drone-crawler system that attaches magnetically to metallic pipes.
- Lately, Aramco has been aiming to use non metallic pipelines.
- We would like to develop another version of the magnetic drone, but for non metallic pipes.
- It should have the ability to perch on the pipe, and travers on it, and the potential to conduct non-destructive inspection

Business Impact

- Eliminating the need to erect scaffolding, significantly reducing the cost of inspection

Deliverables:

- Innovative mechanism / unique design architecture.
- A working prototype/demo
- Simulation or CAD model

Motivation

Reduce Reliance on Inspection Scaffolding

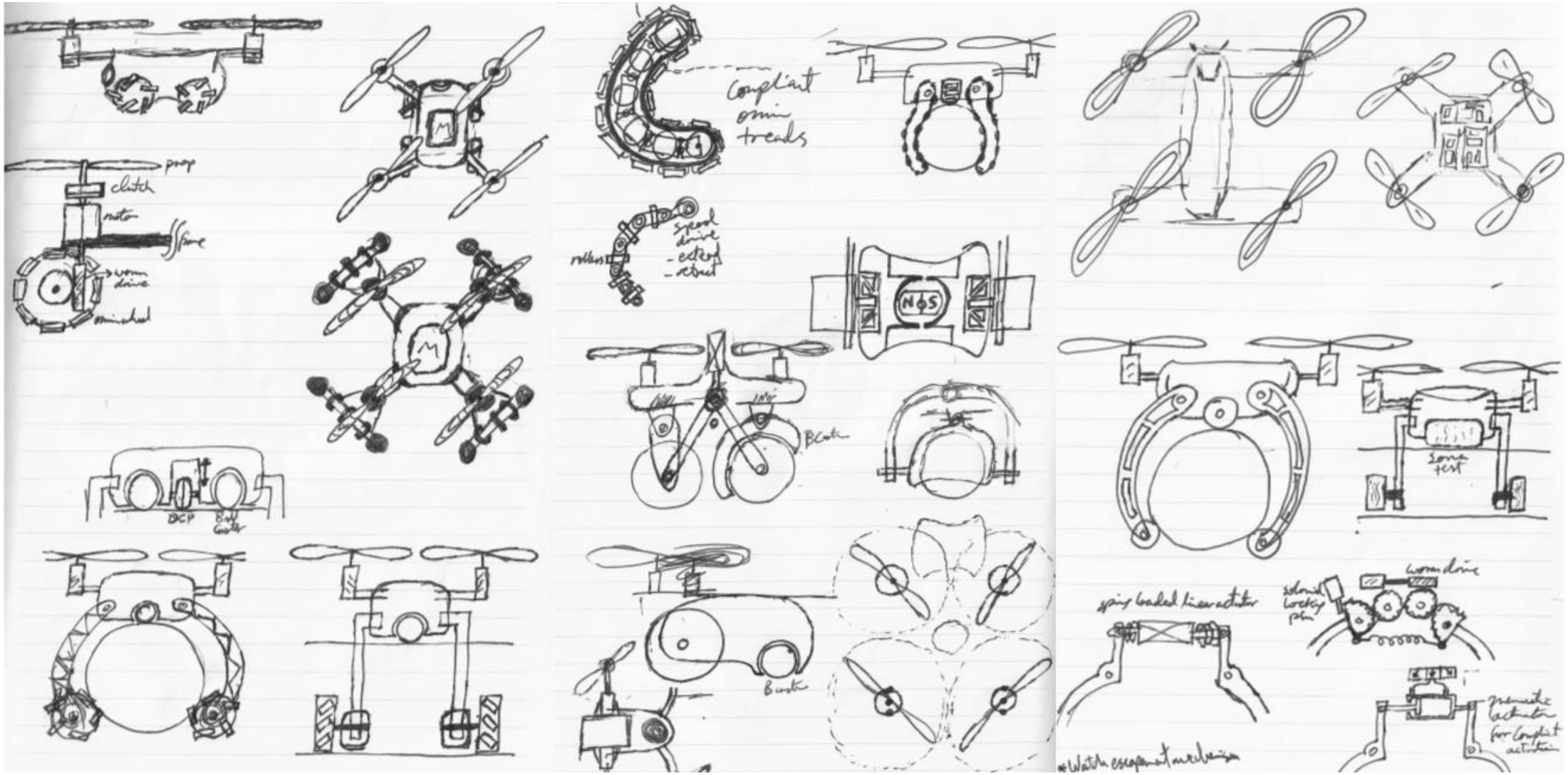
Corrosion Inspection (Metal Thickness)

- Non-Destructive Testing (NDT)
- Ultrasonic Testing (UT)
- Requires contact with surface
- Requires scaffolding for high assets

Objective: Scaffolding Reduction

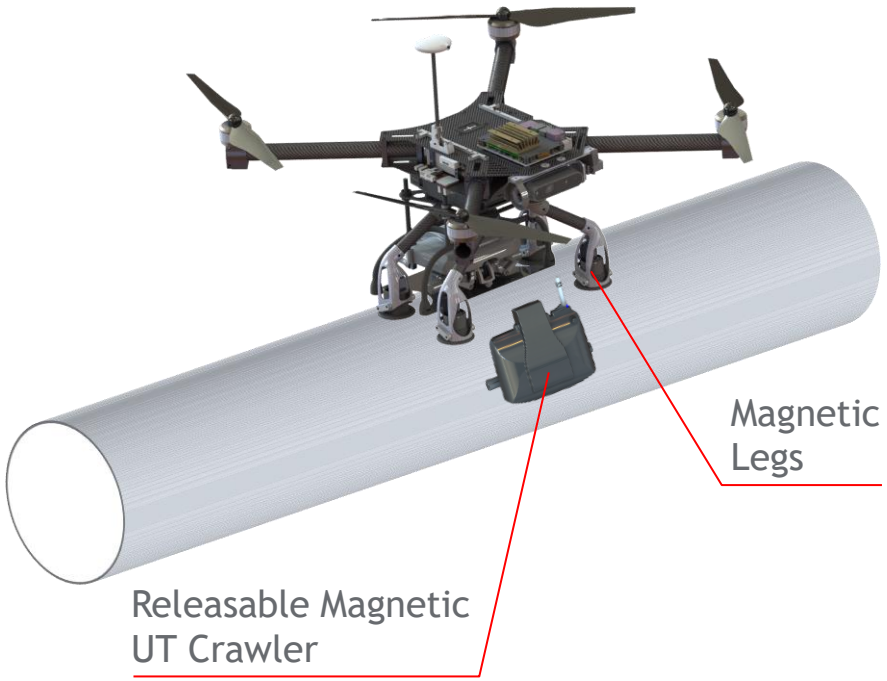
- Minimize inspection safety hazards
- Ease inspection of hard-to-reach assets
- Reduce inspection time
- Reduce inspection cost

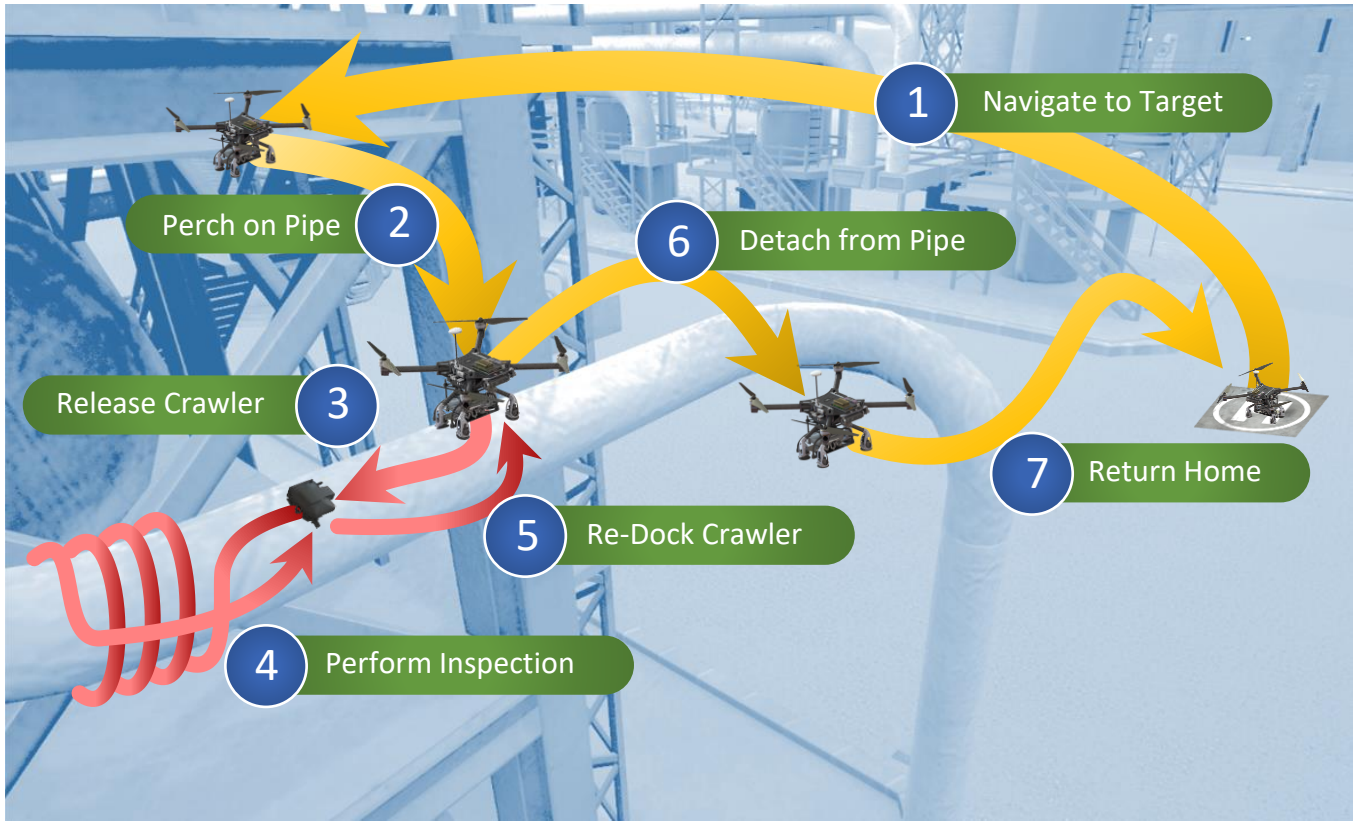
Brainstorming Solution



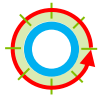
FalconScan

Multi-Robot System (Drone & Crawler)





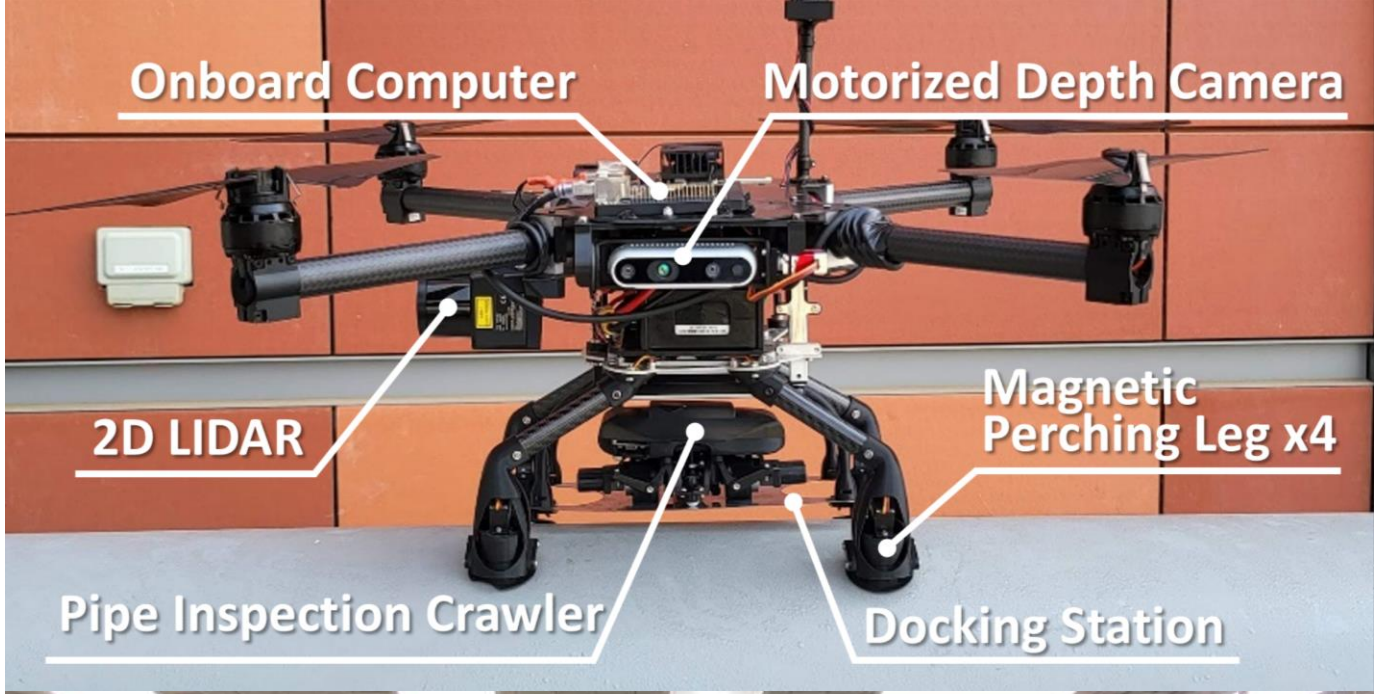
Literature & Market Survey

	Appelix X4	Terra Insp.	Voliro	SkyGauge	AeroX	MHYRO	Hyfliers	FalconScan
Inspection Method	Spot Check	Spot Check	Spot Check	Scan (Hover)	Scan (Hover)	Scan (Perch)	Scan (Perch)	Scan (Perch)
Spot Check Orientation 	0°	-90° to 0°	-90° to +90°	-45° to +45°	-90° to +90°	-90° to +90°	-90° to +90°	-90° to +90°
Cont. Scans — Circumf. 	No	No	No	No	No	No	Yes	Yes
Cont. Scans — Axial 	No	No	No	No	Yes	Yes	Yes	Yes
Access Small Gaps 	No	No	No	No	No	Yes	Yes	Yes
Reach Congested Areas 	No	No	No	No	No	No	No	Yes
								

FalconScan
Fully-Integrated Prototype

- Magnetic perching legs
- Docking station (crawler garage)
- Sensing and control hardware for autonomous perching:
  - Onboard computer
  - 2D LIDAR
  - Motorized depth camera
- Inspection Crawler

- Designed for pipe diameters ≥8in



FalconScan
Field-Proven Drones

- **Field-tested**
- UT inspection A- & B-Scans – Not only spot checks
- Inspect pipe diameters ≥8in
- Magnetically attach on 6 o’clock
- Releasable crawler for inspection from any direction
- Small crawler with low clearance
- Can crawl to areas inaccessible by drone

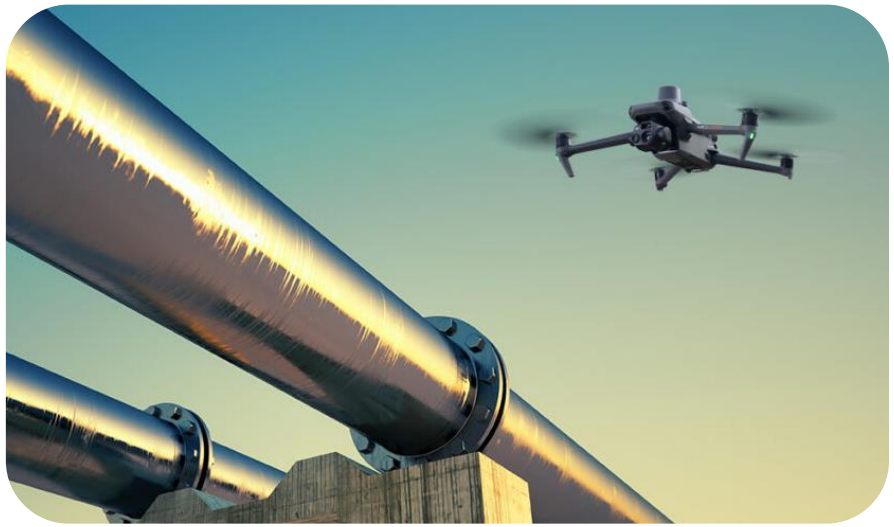
Drone perching and traversing on nonmetallic pipe

Introduction

Aramco is aiming to install non metallic pipelines.

We would like to develop another version of the magnetic drone, **but for non metallic pipes.**

It should have the ability to perch on the pipe, and travers on it and conduct NDT inspection*.



*when the technology is developed

Drone perching and traversing on nonmetallic pipe

Steps

Step 1

Comprehensive Review of current Technologies.

Step 2

Brainstorm and generate ideas and compare between them. Choose 1 system.

Step 3

Design
Build
Test PoC

Drone perching and traversing on nonmetallic pipe

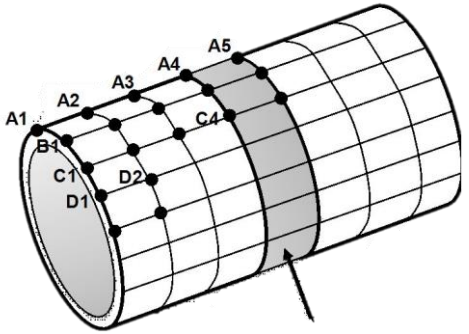
The goal

Objective

A working prototype is preferable, a demo is nice to have and a simulation or a CAD model is encouraged. An innovative mechanism is required for such application or a unique design architecture.

Requirements

- It cannot magnetically attach to the pipe.
- Pipe diameter from 6 to 10 in (preferably whole range).
- It should perch (attach) on the pipe and traverse (drive) around and along its outer surface.
- It should be able to scan the whole outer surface of the pipe (imagine a grid)
- The inspection system can be a drone or released by a drone or a stick, or by hand.
- It should work on straight horizontal pipes and preferably on elbows and vertical pipes.



Inspection area

Register Your Team

Monitoring Mud Height in Lost Circulation While Drilling

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Drone Perching and Traversing on Nonmetallic Pipe

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