Artificial Lift R&D Council

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Conceptual Real-Time Digital-Twin Driven Sucker Rod Pumping Unit For Academic Learning and Commercial Applications

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Well Integrity Laboratory

Engineering | Reliability | Monitoring | Predictive

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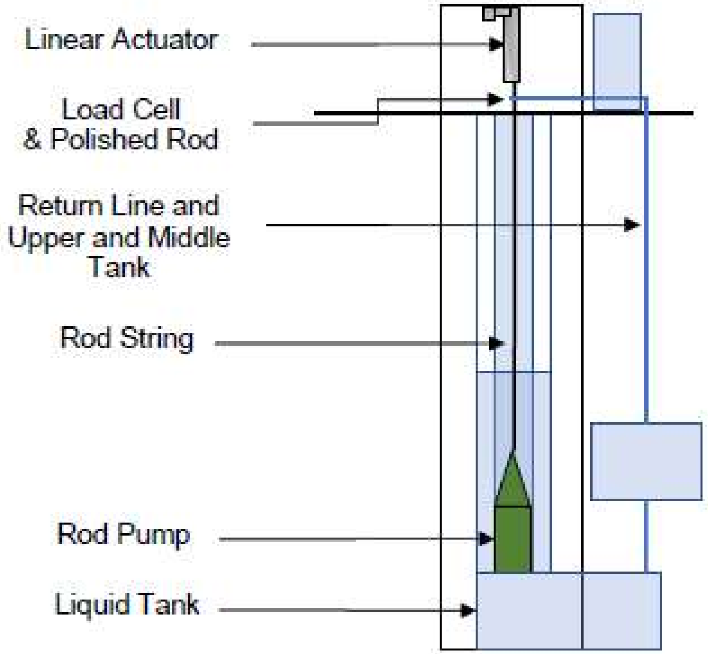
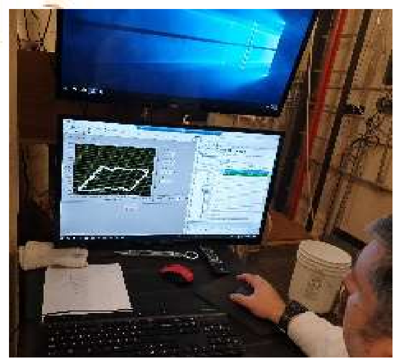
Motivation - 1





ID-SRP solution:
Monitoring |Production optimization |Predictive Analysis |Learning system

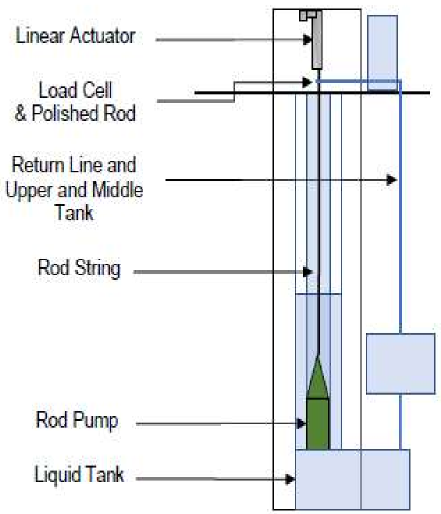
- Sucker rod pump failures are a common occurrence in oil and gas applications
- Regrettably, the industry still lacks a system that can provide SRP health condition monitoring with the added capability of accurately predicting impending SRP failures
- The current AI application require good validation data sets to enhance their application and increase the use of AI.
- The newly experimental setup at OU is designed with AI and big data in mind.

OU interactive digital sucker rod pump

Motivation - 2

OU interactive digital sucker rod pump

Motivation - 3



ID-SRP solution:
Monitoring |Production optimization |Predictive Analysis |Learning system

OU interactive digital sucker rod pump

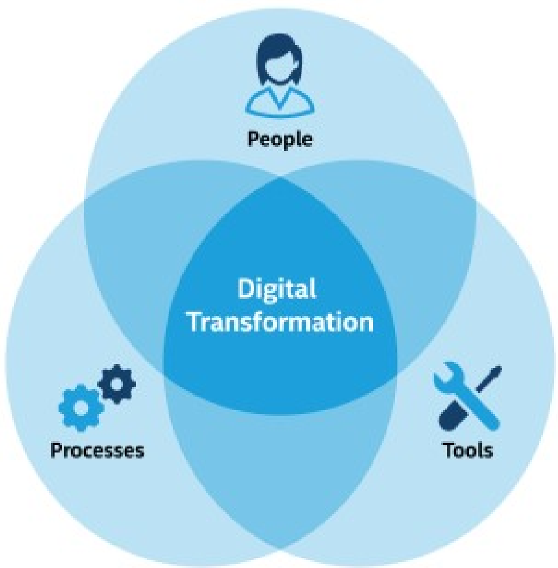
- Presently, several industries are exploring the application of **digital-twins (DT)** to optimize their process, **make data-driven decisions in real-time, improve operational services, develop and enhance products and have more efficient and safer operations**
- The application and development of DTs for artificial lift systems are still in the early stages. This technology is still not available and yet to researched, causing a technological and technical gap for petroleum engineering students
- This study presents a **novel conceptual framework through application of digital-twin** for sucker rod pump systems intended for educational learning and commercial applications

Motivation: Key Technologies Transforming Energy Systems

- *Sensors/Internet of Things (IoT)*
- *Artificial Intelligence / Machine Learning*
- Robotics
- 3D Printing and Visualization
- Mixed Reality
- *Big Data/Open Data*
- *Mobile Internet and Cloud*
- *Digital-Twin Technology*
- Blockchain
- Unmanned Aerial Vehicles and Nano Satellites
- Energy Storage

Sensors/Internet of Things (IoT)

Artificial Intelligence / Machine Learning



Big Data/Open Data

Mobile Internet and Cloud

Digital-Twin Technology

Motivation: Why Digital Twin over predictive software?

- *….A digital twin starts as a simulation, but the difference between a digital simulation and a digital twin is real-time updates*

Comparison Factors	Digital Twin Technology	Predictive Software
• Static vs Active?	**Active**	Static
• Could be vs What is?	**What is**	Could be
• Product-focused vs. business-focused	**Business-focused**	Product-focused
• Real time simulation and Interpretable	**Highly recommended**	Good
• Optimize real-world products and processes	**Can do much more**	Good
• Product quality and enhanced insight in multiple real-time applications and environments	**Can do much more**	Good

Motivation: Why Digital Twin over predictive software?

- ***….A digital twin starts as a simulation, but the difference between a digital simulation and a digital twin is real-time updates***

- ***A mechanical twin will close the gaps of simulation limiting assumptions***

- ***Our mechanical twin will allow for the first time to fully monitor surface and downhole SRP parameters and closed the simulation gaps that may exists***

- ***The mechatronic experimental setup is design to mimic any SRP kinematic concept currently on the market with a touch of a button.***

Research Study Objectives

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The **primary objectives** of this novel research study are as follows:

- Development of a cost effective, user-friendly and highly reliable sucker rod pumping design automation framework under the cloud-based digital-twin to promote SRP digital innovation program for **educational purposes** and **industry-based application**.
- Conversion of the current **Mechanical Twin** into a simulation model
- Development of a digital-twin of SRP system integrating the computational model, field sensor data analytics and predictive maintenance based on the machine learning algorithm
- Creating a course concept to research digital-twin technology in petroleum education and adopting the technology in education learning
- Demonstrating the applicability of the new methodology through case studies

Research Methodology

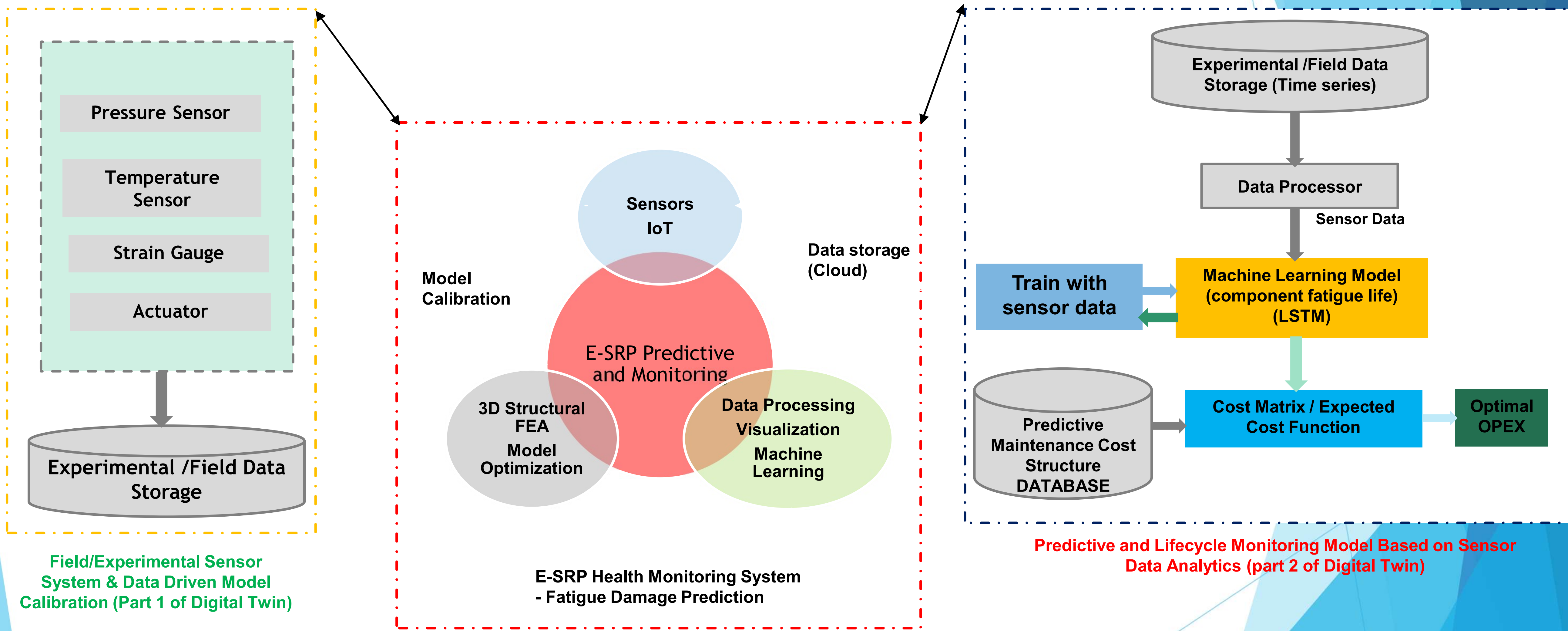
The primary advantage is to build a high-fidelity simulation of a process, known as "digital-twin" using model-based software that is time and operational cost savings. The simulation will be designed to approximate the physical equipment and certain control aspects of the primary sucker rod pumping unit

- Our proposed SRP DT is composed of three main components namely; **physical or experimental reality (physical model – mechanical twin)**, **collected data describing the experimental reality** and the **virtual reality (virtual simulation model – digital twin)**

- The virtual SRP unit in the Digital Twin will consist of an advanced mathematical model including a complex mechanical model, heat transfer model as well as the hydraulic model. The real-time mathematical models utilize real-time data from the experimental SRP setup to compare downhole measurements with the modeled parameters

    - **This enables monitoring sucker rod pump downhole conditions and providing early detection of symptoms of anomalies as diagnostic messages**

Research Methodology - 1



Conceptual e-SRP Digital-Twin Framework and Components

Research Methodology - 2

The key features and capabilities of SRP DT as listed below:

- **Digital replica of SRP** physical unit (asset, process and/or system), in terms of geometry and many other aspects;
- **Data;** the key ingredient of a DT, which includes data about the motor, pump, cable, material, cost, inspection, monitoring, etc;
- It will be **connected** to the physical SRP set**up** in that it can be updated and provide feedback into the SRP system (e.g., monitoring of current state) in near real time as new data is collected;
- We are for the first time creating a synergy between the physical setup **(MECHANICAL TWIN)** and the digital concept **(DIGITAL TWIN)**
- This can expand the research domain, i.e adding SRP vibration investigations or effect of gas in SRP applications

Research Methodology - 3

The key features and capabilities of SRP DT as listed below:

- It will span the **whole life cycle** of the physical SRP unit, with data and information flowing through various stages of the SRP unit, which includes planning, design, construction, operation and maintenance, etc.;
- It will have a **common data environment**, with all data stored in one model and conditionally accessed and modified by various stakeholders of the project;
- **Visualization tool** which can be used to retrieve data or information in context, aid communication and collaboration, etc.;
- A **simulation tool** (e.g., physics-based, data-driven, or both) which can be used to perform 'what-if' scenarios for assessing asset risks, predicting asset performance, etc.;
- Ability to **learn from real measurement data** to improve future projects and practice

Potential Research Deliverables - 1

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The following deliverables will be met after the completion of the novel study:

- Development of an e-SRP, a mechanical/digital-twin integrated system for determining SRP health lifecycle monitoring and optimization
- Development of a SRP digital-twin for educational learning and commercial application intended for failure detection and diagnostics of SRP system
- An interactive SRP digital twin technology and laboratory simulation environments that will afford authentic petroleum engineering students learning experiences
- An integrated, easy-to-use structure leverages design data, control data and historical data to help students and companies make decisions

Potential Research Deliverables - 2

The following deliverables will be met after the completion of the novel study:

- Develop a unique experimental setup capable to train Machine Learning algorithms by providing accurate and repeatable data sets from a fully controllable environment.
- Address AI validation issues through fully available data sets specifically design to help faster AI implementation in the field.
- SRP digital twin that will provide support across the life span of SRP wells from design, installation, operation, production optimization, failure detection, maintenance planning and technology improvement

Research Benefits - 1

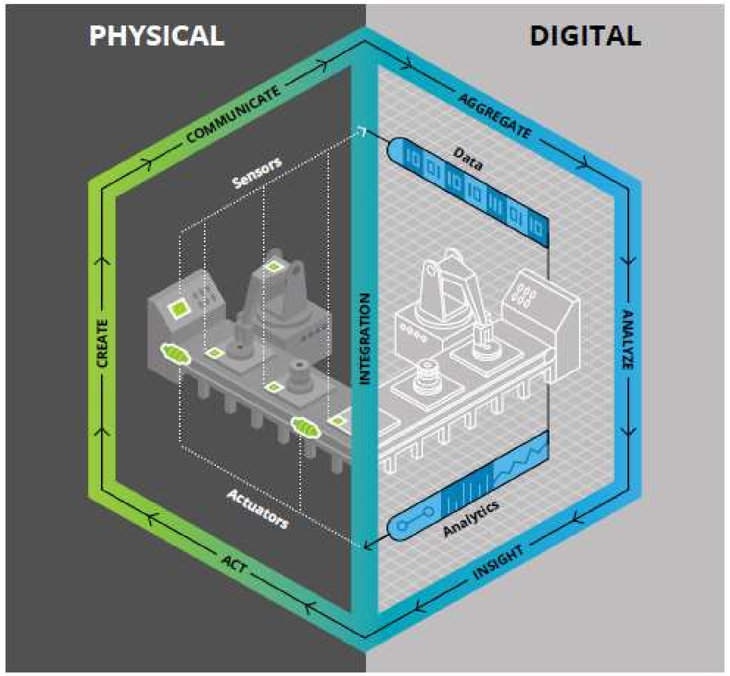
Industrial Benefits

- Building a bridge to oil and gas companies' operations: our proposed SRP digital twin can benefit oil and gas experts to connect their operations, regardless of the location; design, build and test strategies; virtually train operators for abnormal situations; and develop and test process improvements offline
- ***Capability to simulate the response*** of the system under abnormal conditions, i.e., well inflow issues, SRP problems (pump wear), completion problems (scale, hole in tubing), surface problems like closed valves
- ***Maximize*** operational efficiency and avoid downtime
- ***Improve workforce development and operational performance***: our proposed SRP DT model would have the capability to simulate abnormal situations faster, accelerating operator's response
- ***Aid in providing an accurate estimate*** of the true fatigue life of SRP unit, unlocking the potential components fatigue life to extend the life of assets, and optimizing inspection planning

Research Benefits - 2

- **Educational Learning and Knowledge Development**
  - To ***promote*** effective knowledge construction
  - Students can hypothesize, ***make predictions***, and pose ***what-if questions*** targeting the physical system by way of the digital-twin, and ***thereby gain insights related to system development and performance*** through the real-time data provided by the digital-twin
  - Students form many ***logical connections among related concepts and principles***, thereby solidifying conceptual and procedural understanding
  - The ***ability to learn to process and transfer insights*** gained from digital-twin experimentation to the physical twin
  - The ***ability to apply critical thinking and problem solving*** in devising and testing hypotheses and making predictions

Key Takeaways



- The broader impact of this proposed novel research study will enhance the knowledge of petroleum students to quickly and accurately diagnose SRP operating conditions through digital learning

- The results from this conceptual study will help the industry to increase safety, improve efficiency and gain the best economic value-based decision and reduce operational cost

- The framework will address how the use of digital-twin technology in laboratory simulation environments will offer students authentic learning experiences

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Thank you for your kind attention!

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