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Edge Computing – Enabling New Application and Insights in the Drilling Sector

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Arturo Magana-Mora

Arturo Magana-Mora obtained his Ph.D. in Computer Science from the King Abdullah University of Science and Technology, Saudi Arabia. During his Ph.D. studies in Computer Science and a postdoctoral fellowship at the National Institute of Technology (AIST) in Japan, he developed novel artificial intelligence models to address problems in biology, genomics, and chemistry that resulted in several peer-reviewed publications in high-impact journals, poster presentations, and invited talks. Currently, he works at the EXPEC Advanced Research Center, Saudi Aramco, where he has opened up many new opportunities in the domain of Drilling Automation and Optimization and catalyzed existing work. During his career he has used his expertise in computer science to bridge artificial intelligence with biology, genomics, chemistry, and the oil and gas industry, and currently serves as Guest Editor and referee for several scientific journals.

Outline

Introduction to Edge Computing and Drilling

Auto Space Out Project

Deployment Results

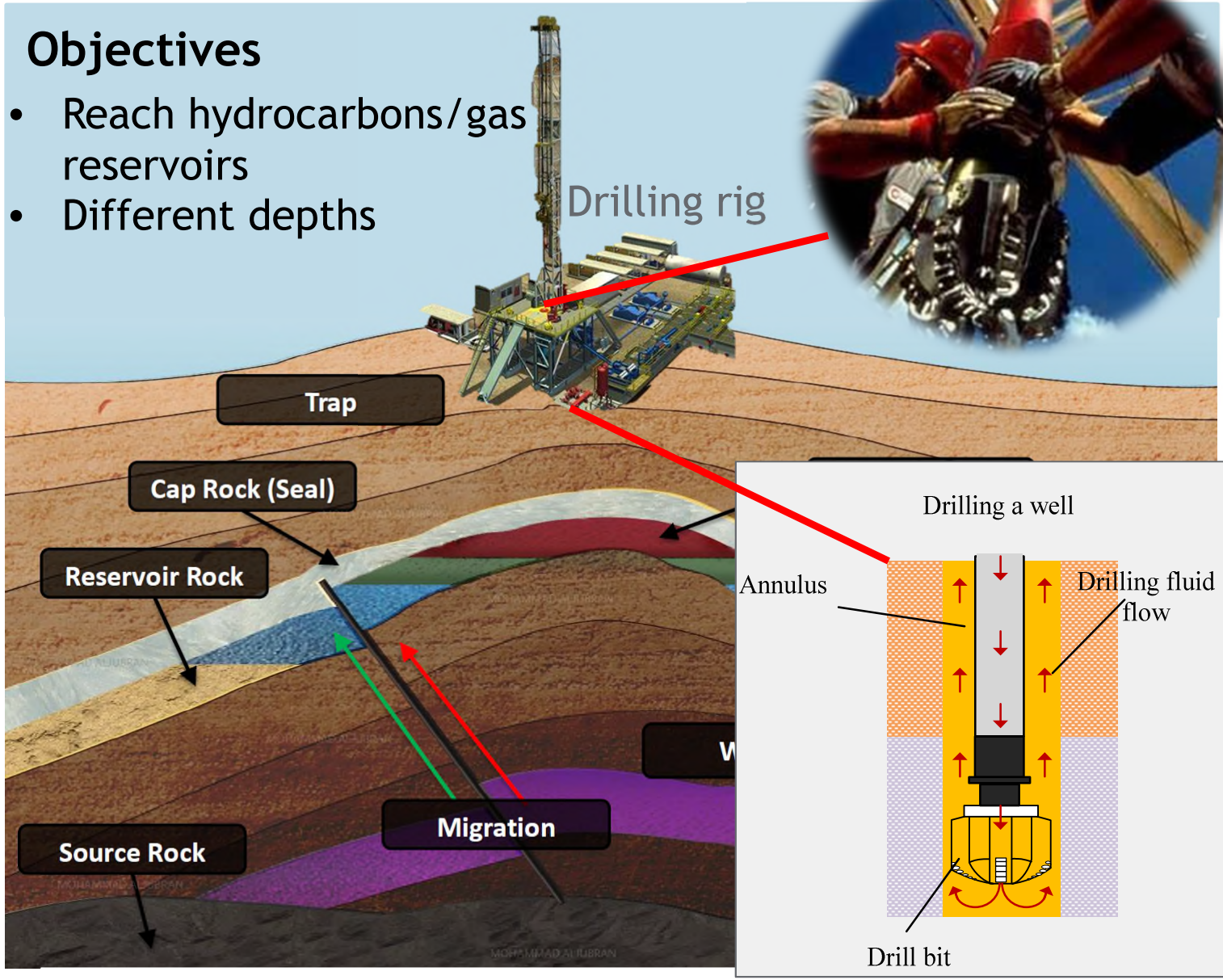
Conclusions & Future Work

Q&A

Introduction

Objectives

- Reach hydrocarbons/gas reservoirs
- Different depths

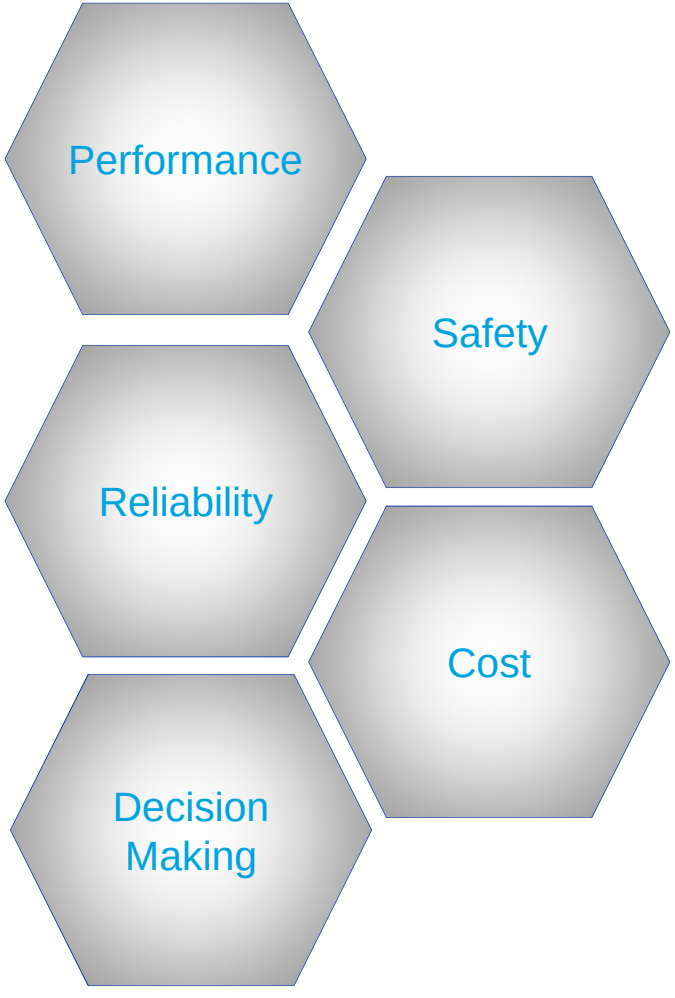


Considerations

- Hydrostatic pressure
- Hole cleaning
- Well control
- Among others

Introduction

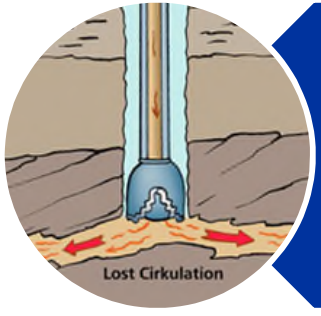
Achieve top performance through integrated solutions – people, process, and technology



Drilling Hazards

Well Control Incident

- Uncontrolled flow of formation fluids from wellbore (kick)
- Failure of well control system causes blow out



Lost Circulation

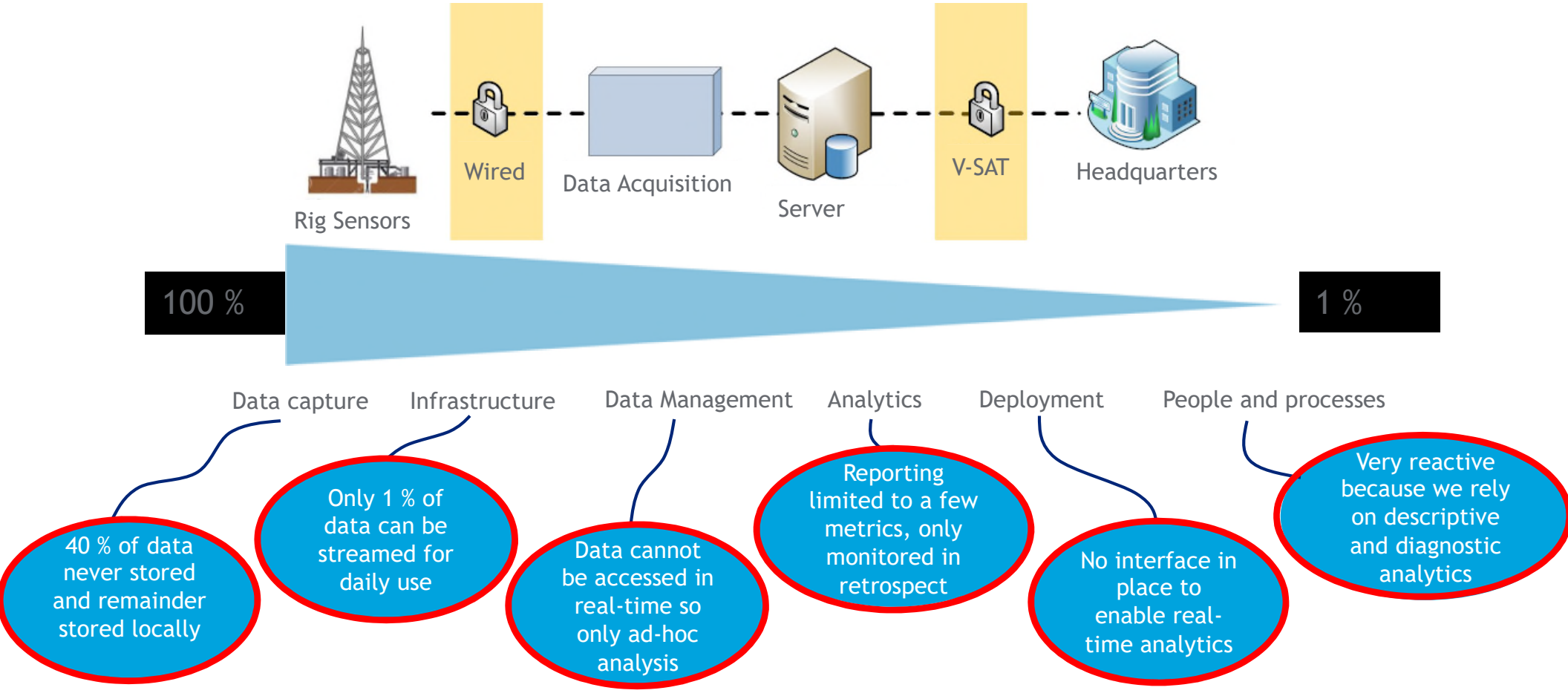
- Uncontrolled flow of mud or cement into a formation
- Vary from gradual lowering of pits to complete loss of returns

Stuck Pipe

- Inability to move the pipe upwards/ downwards or rotate (due to different factors)
- Caving-in and crumbling of rock, accumulation of cuttings

A. Magana-Mora, et al., "AccuPipePred: A Framework for the Accurate and Early Detection of Stuck Pipe for Real-Time Drilling Operations," presented at the SPE Middle East Oil and Gas Show and Conference, 2019

Current Drilling Rig Setup

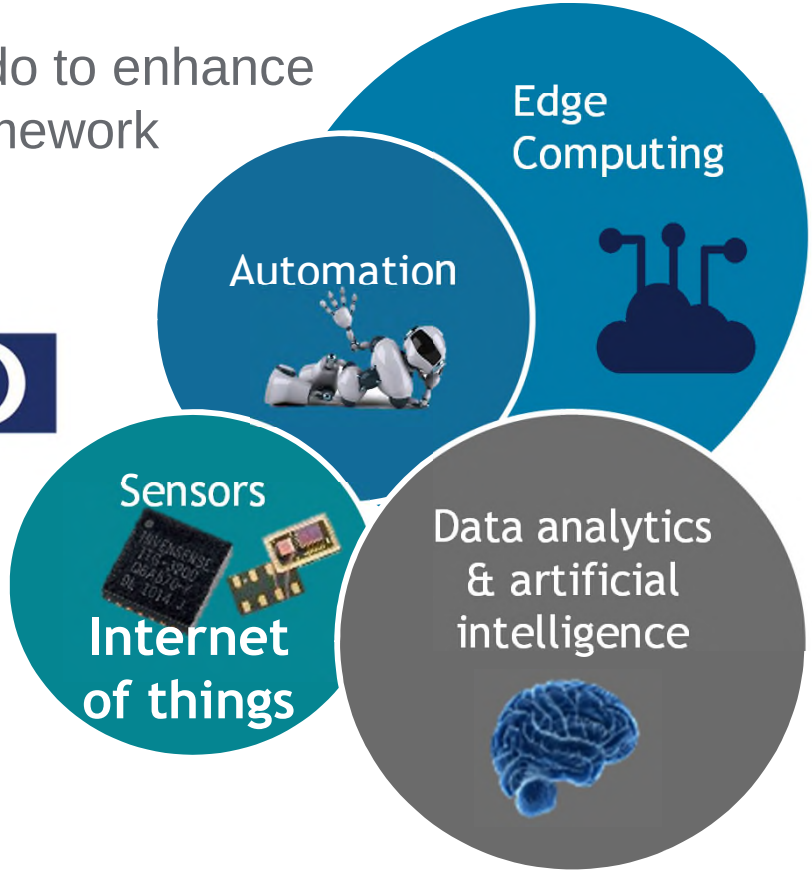


C. P. Gooneratne, A. Magana-Mora, et al., "Drilling in the Fourth Industrial Revolution – Vision and Challenges," *IEEE Engineering Management Review*, 2020.

Introduction

What can we do to enhance this framework

Optimal performance



Introduction

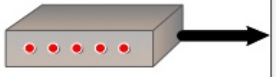
Fog/Edge Computing

Edge computing is the process of bringing computing as close to the data source as possible

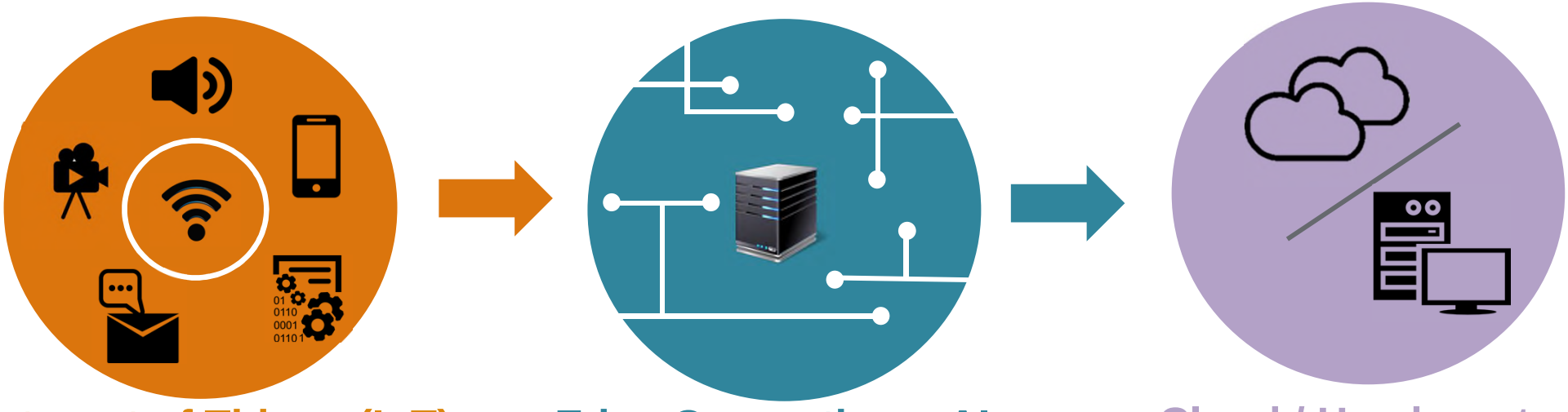
- ✓ Reduce latency
- ✓ Reduce bandwidth
- ✓ Enables processing of high freq. data

Minimizes long-distance communication between client and server

Isolated environment

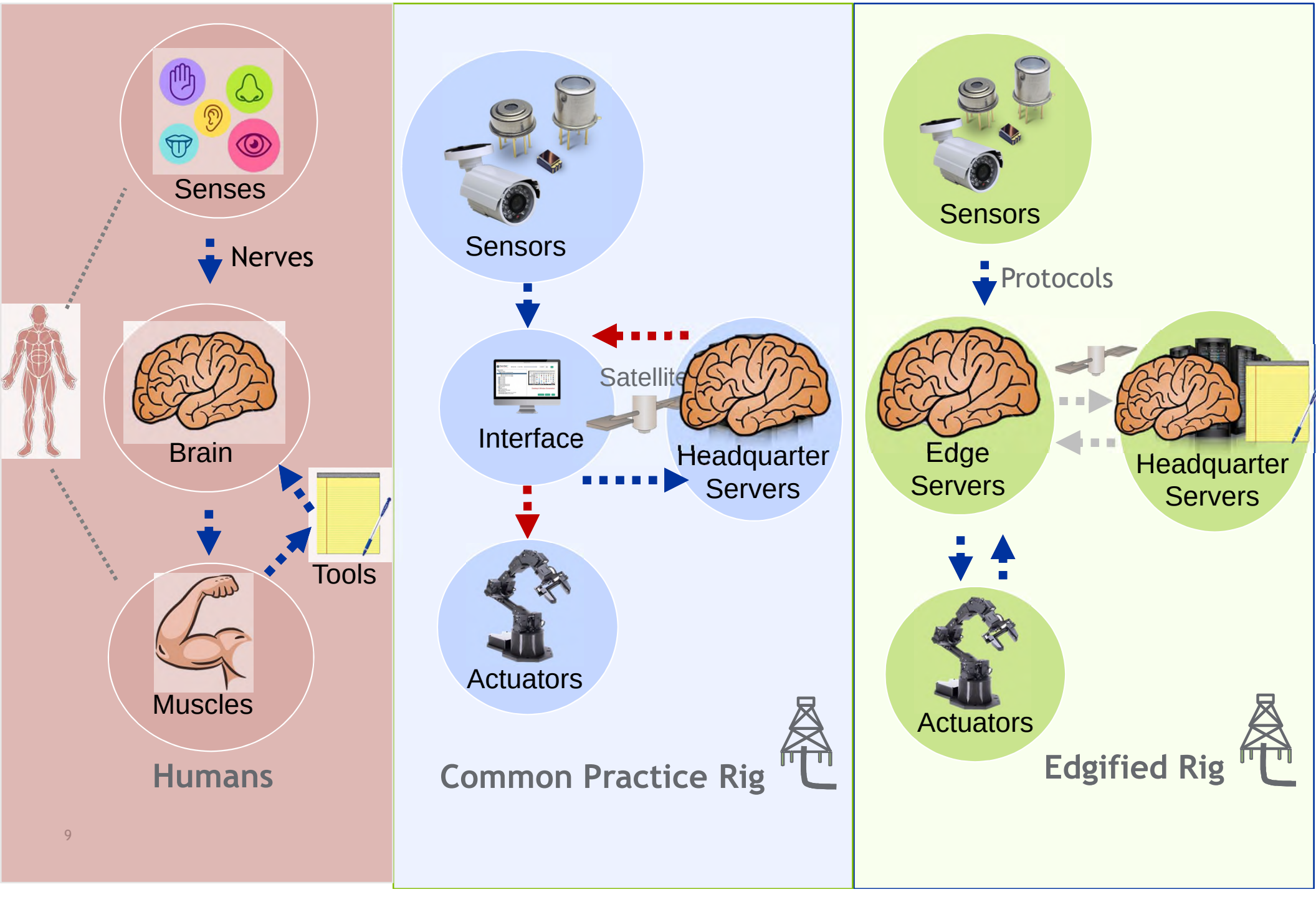


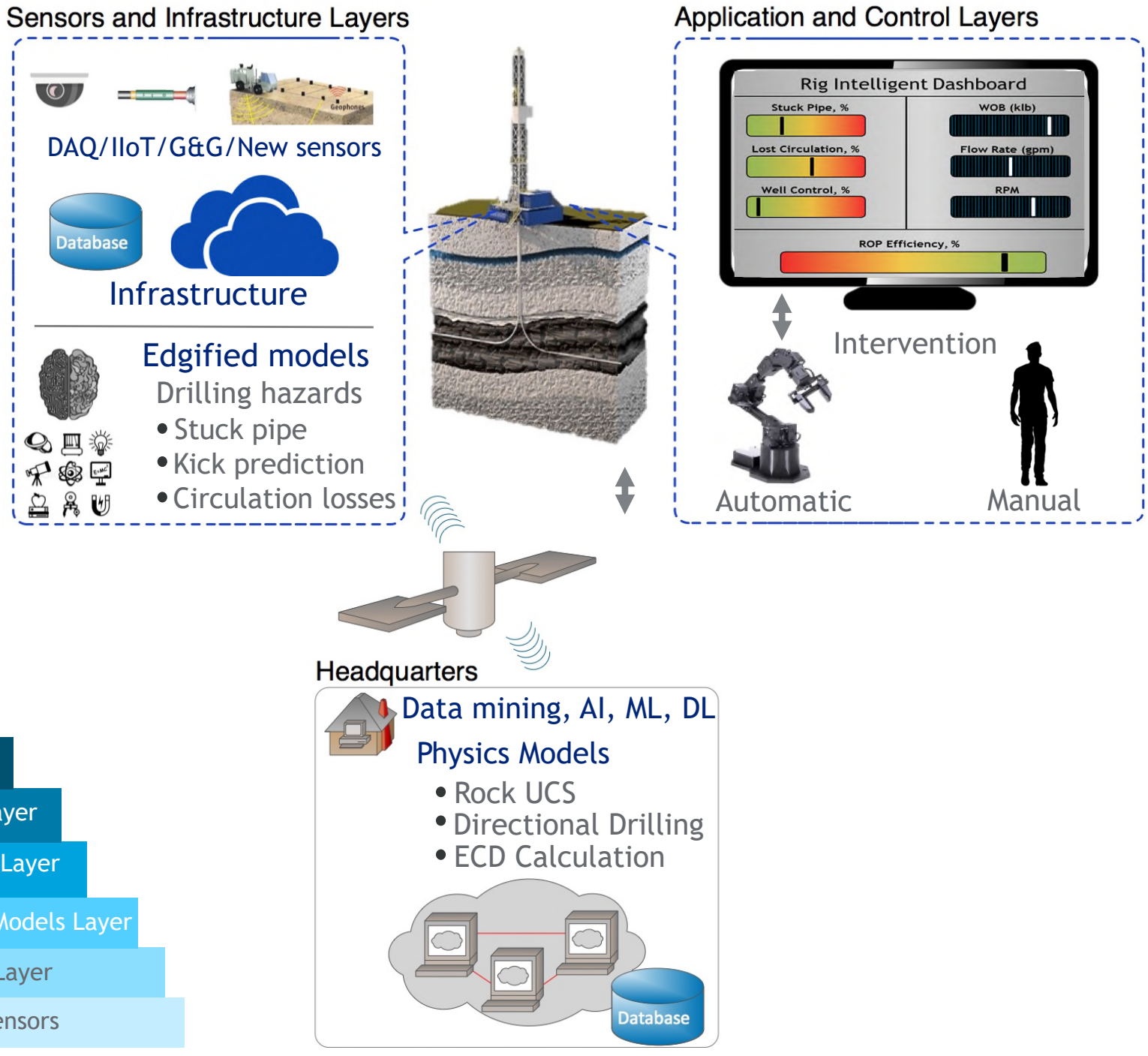
Data acquisition system



Internet of Things (IoT) | **Edge Computing + AI** | **Cloud / Headquarters**

Introduction





Control Layer

Applications Layer

Data Analytics Layer

Physics-based Models Layer

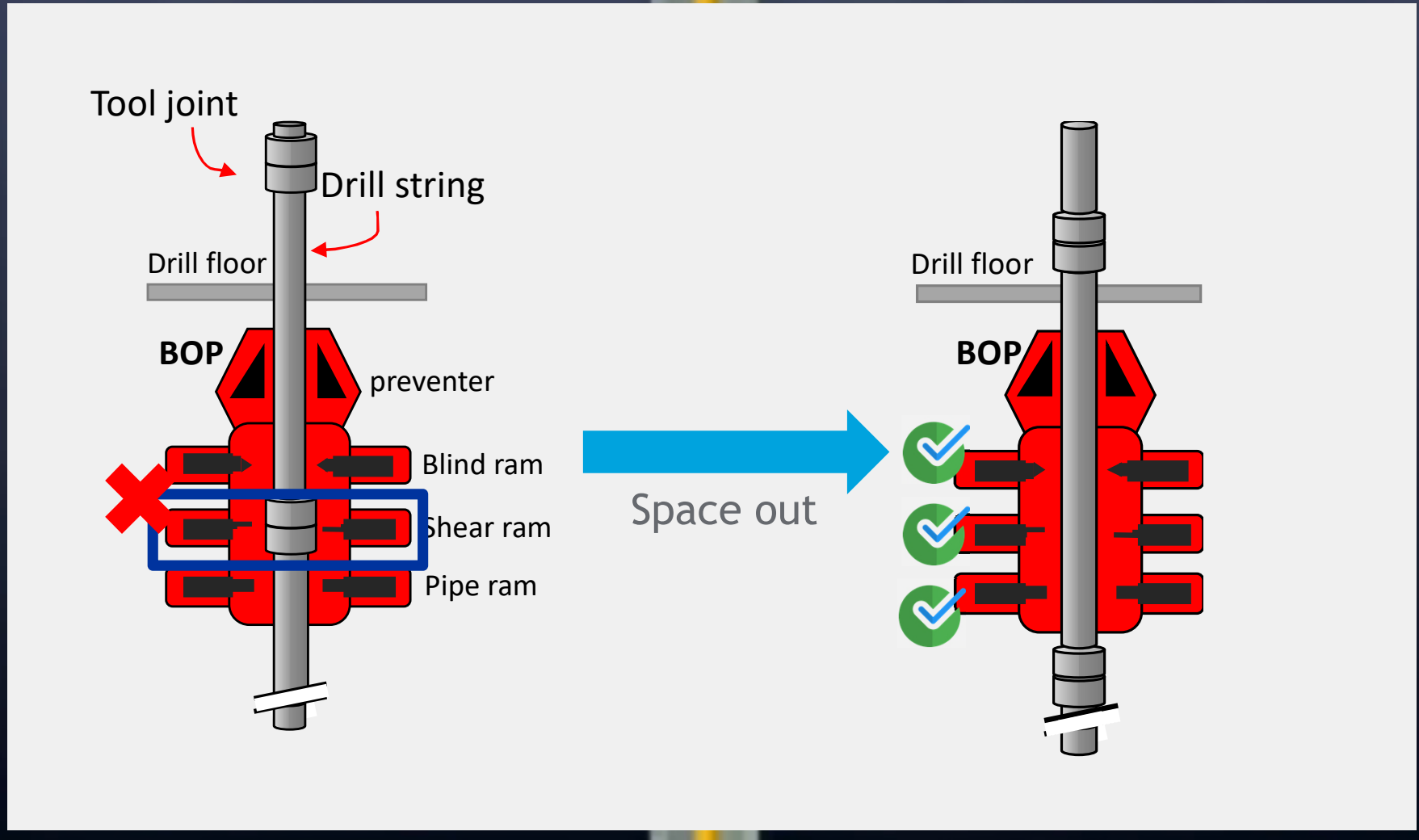
Infrastructure Layer

Data Layer / Sensors

Introduction – Blowout preventer (BOP)

Source: U.S. Chemical Safety and Hazard Investigation Board

Introduction – Blowout preventer (BOP)

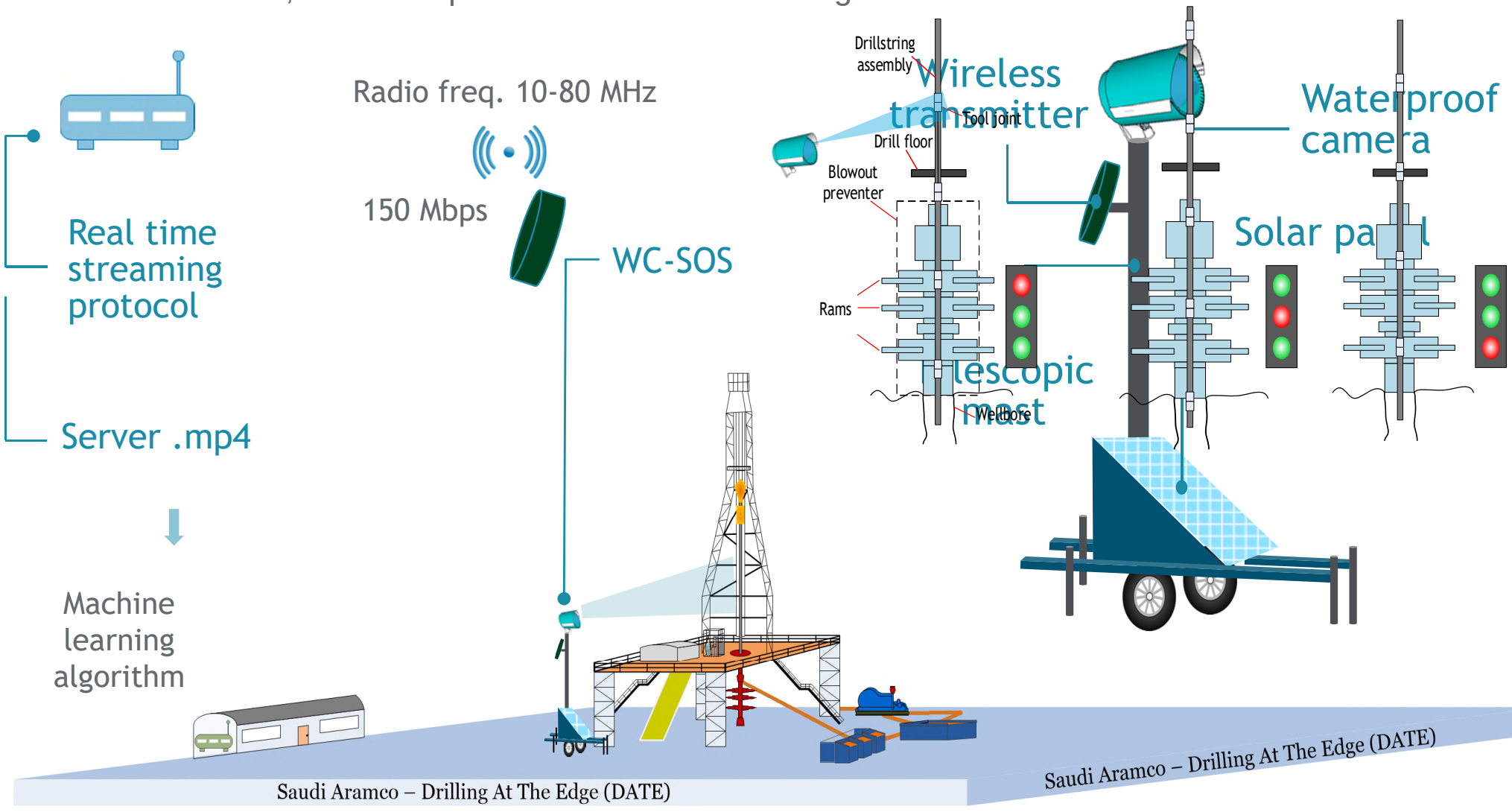


Source: U.S. Chemical Safety and Hazard Investigation Board

Data & Methodology

Well Control Space Out System (WC-SOS)

- Reliable, safe and quick shut-in of a well during an uncontrolled flow



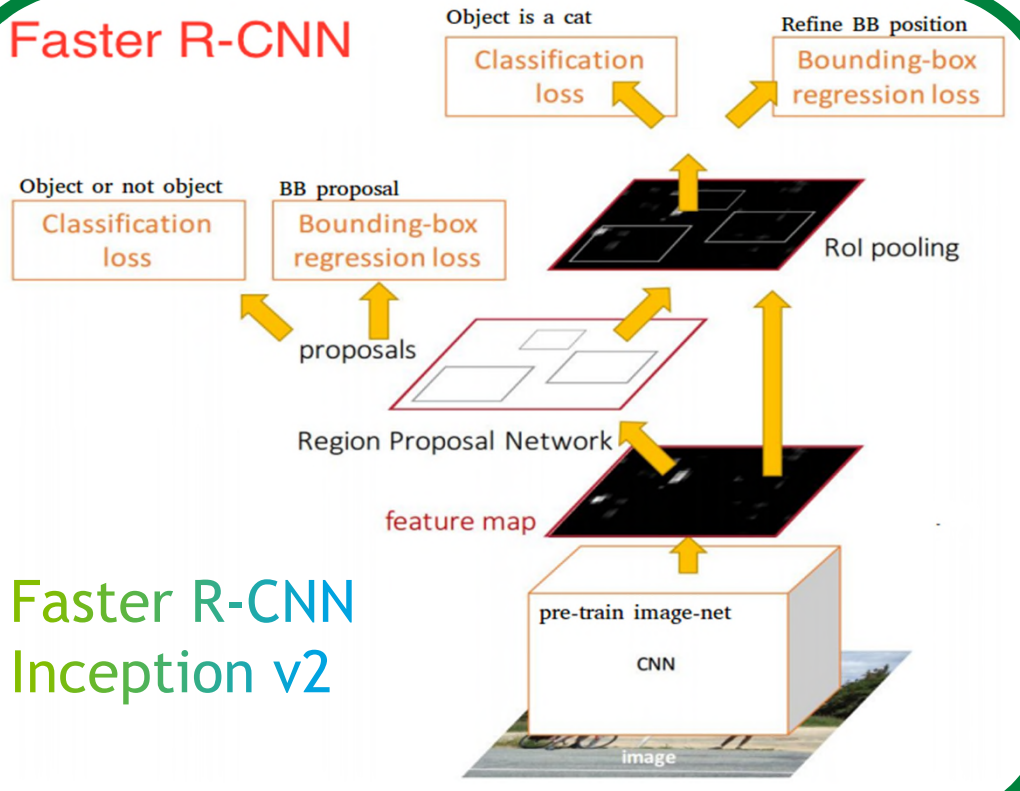
Data & Methodology

7,000 frames manually labeled (tool joint y-max, y-min)

Data

80%

Frames containing drillstring and tool joints



Model	Backbone	Average Precision (mAP)	Average Recall (AR)
Faster R-CNN	ResNet 100	0.79	0.75
Faster R-CNN	ResNet 50	0.75	0.73
SSD	Inception	0.64	0.60
SSD (RetinaNet)	ResNet 50	0.67	0.63
YOLOv3	DarkNet	0.71	0.68
Faster R-CNN	Inception	0.70	0.69
Faster R-CNN -LRP	ResNet50	0.69	0.63

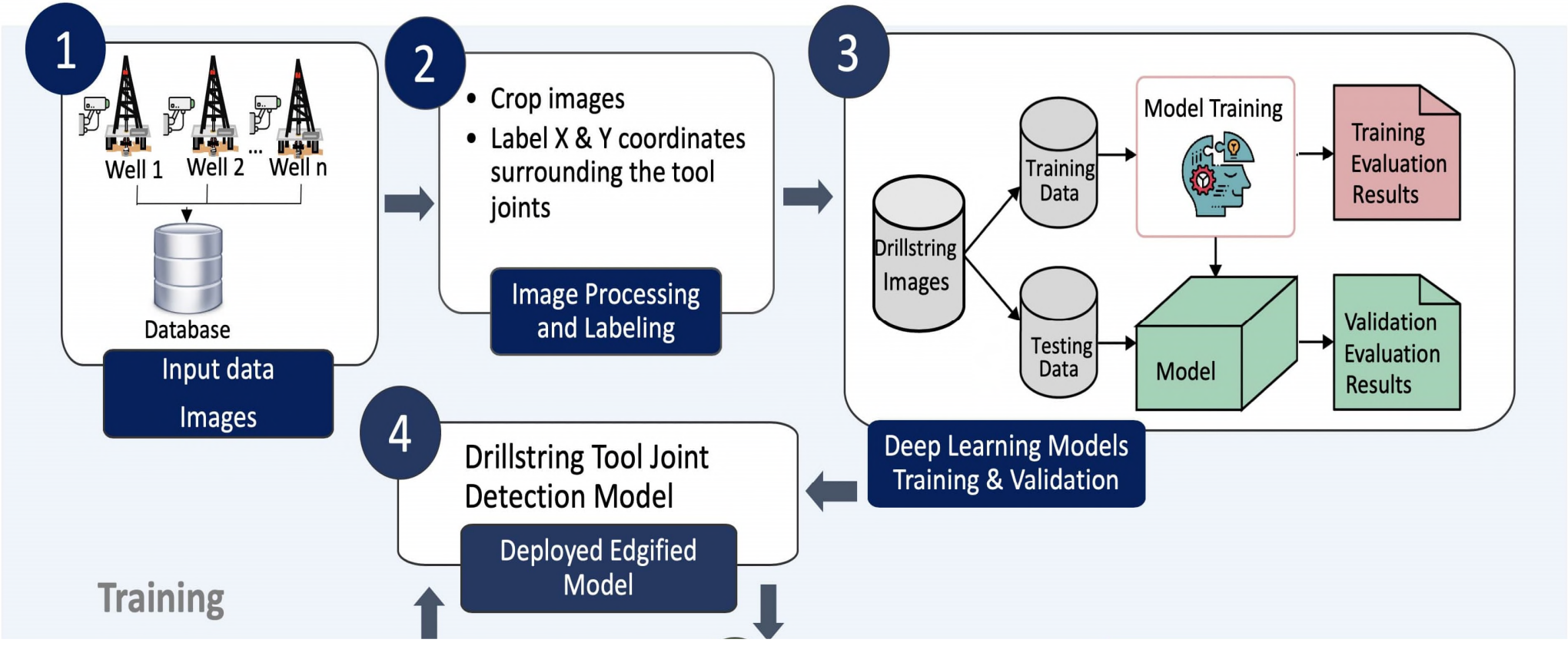
Output

Score for each predicted bounding box of a **tool joint**

Location of bounding box

S. Ren, K. et al., "Faster r-cnn: Towards real-time object detection with region proposal networks," in *Advances in neural information processing systems*, 2015, pp. 91-99.

Data & Methodology

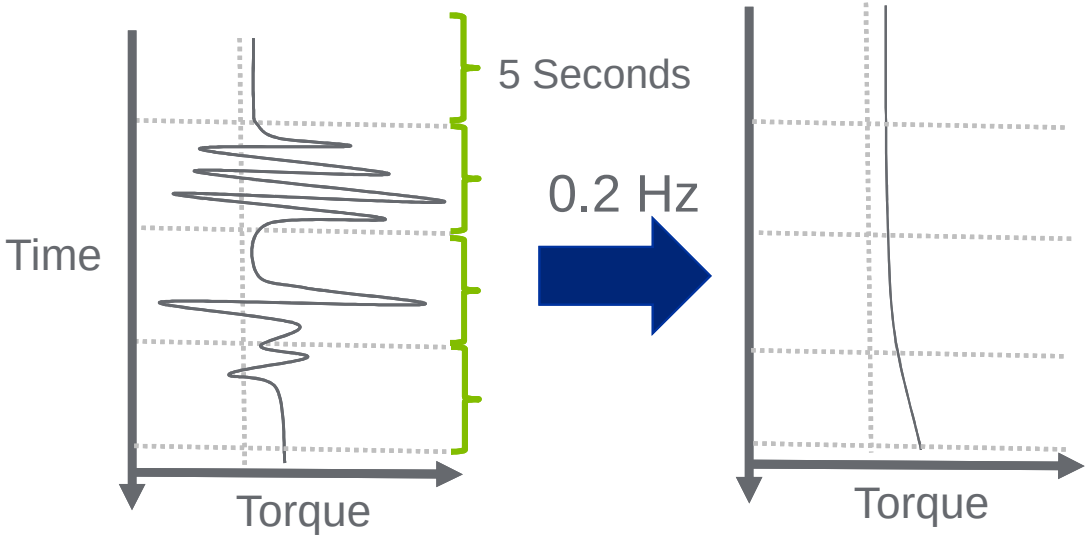


Deployment & Results

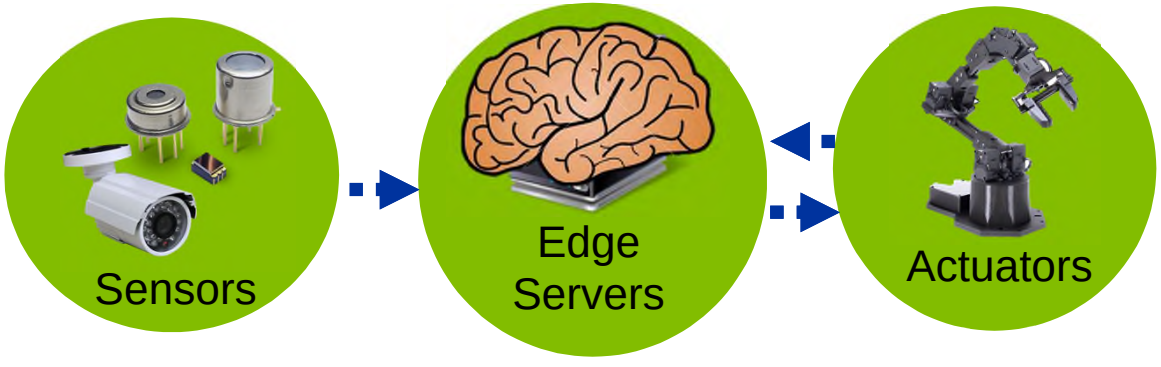
Challenges	Solutions
Cybersecurity at the edge (wireless communication)	IT support to implement cloud, strong firewall, two-factor authentication, other.
Legacy systems, limited sensor capabilities	Update rig sensors and calibration Data supplier (rig contractor/operator co.)
Infrastructure ($$$) Edge devices, sensors, routers	Edge device(s) and new sensors are constantly becoming cheaper
Synchronization of multiple data sources	Data aggregation by edge device (analog, digital, OPC, PLC)
Maintenance scalability More technology at isolated places	Remote assistance available, training Redundant hardware
Scalability of deployed computational models (divergent models)	Federate learning, transfer learning, pre-trained models, among others.

Conclusions & Next Steps

✓ Higher frequency data available for AI/ML/DL models



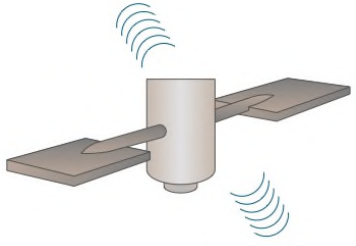
✓ No delays for real-time applications



✓ Reduced privacy risks (local network)

Sensitive data is produced and stored at the edge

✓ Reduced required bandwidth



Only KPIs or down-sampled data may be transferred to headquarters

✓ Step closer toward full automation

- Robust and reliable data-driven models to describe, diagnose, and predict events
- Fast response from edge server able to automatically control actuators

Questions?