

Engineering Integrated Sensing, Power, Telemetry, and Data Processing Systems for Complex Subsurface Environments

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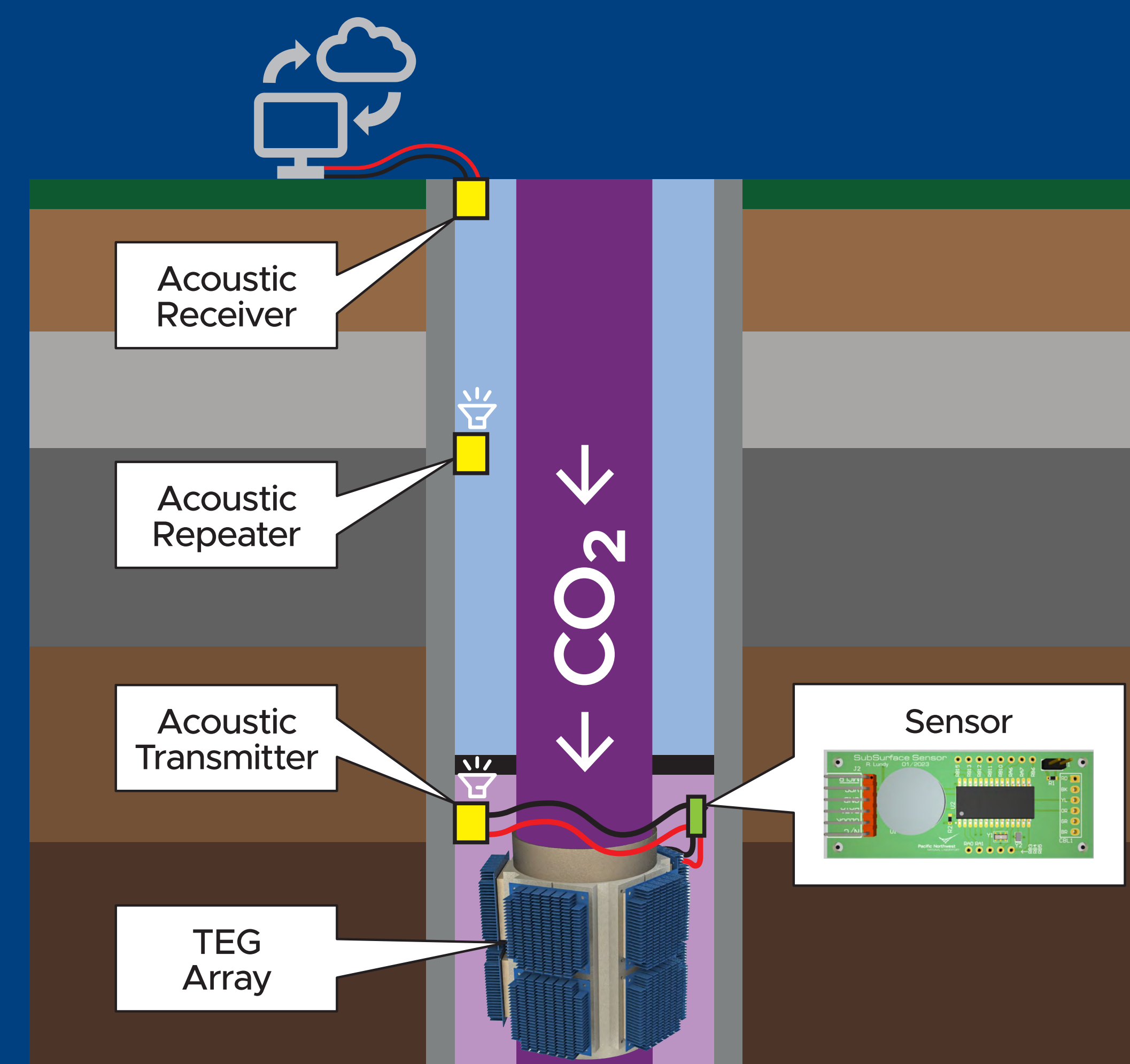
Fundamental
Processes



Reservoir
Simulations



Deployment
& Monitoring

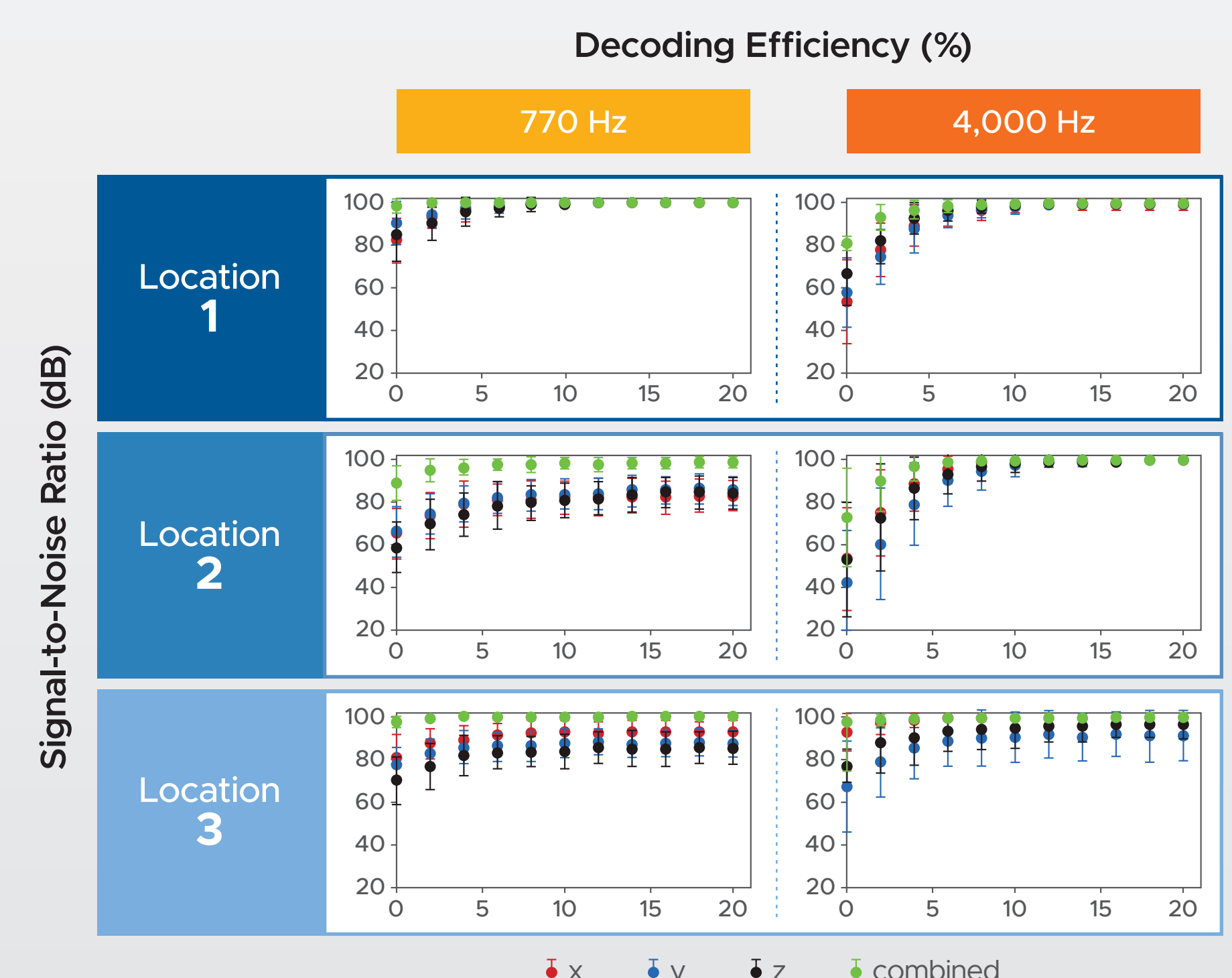
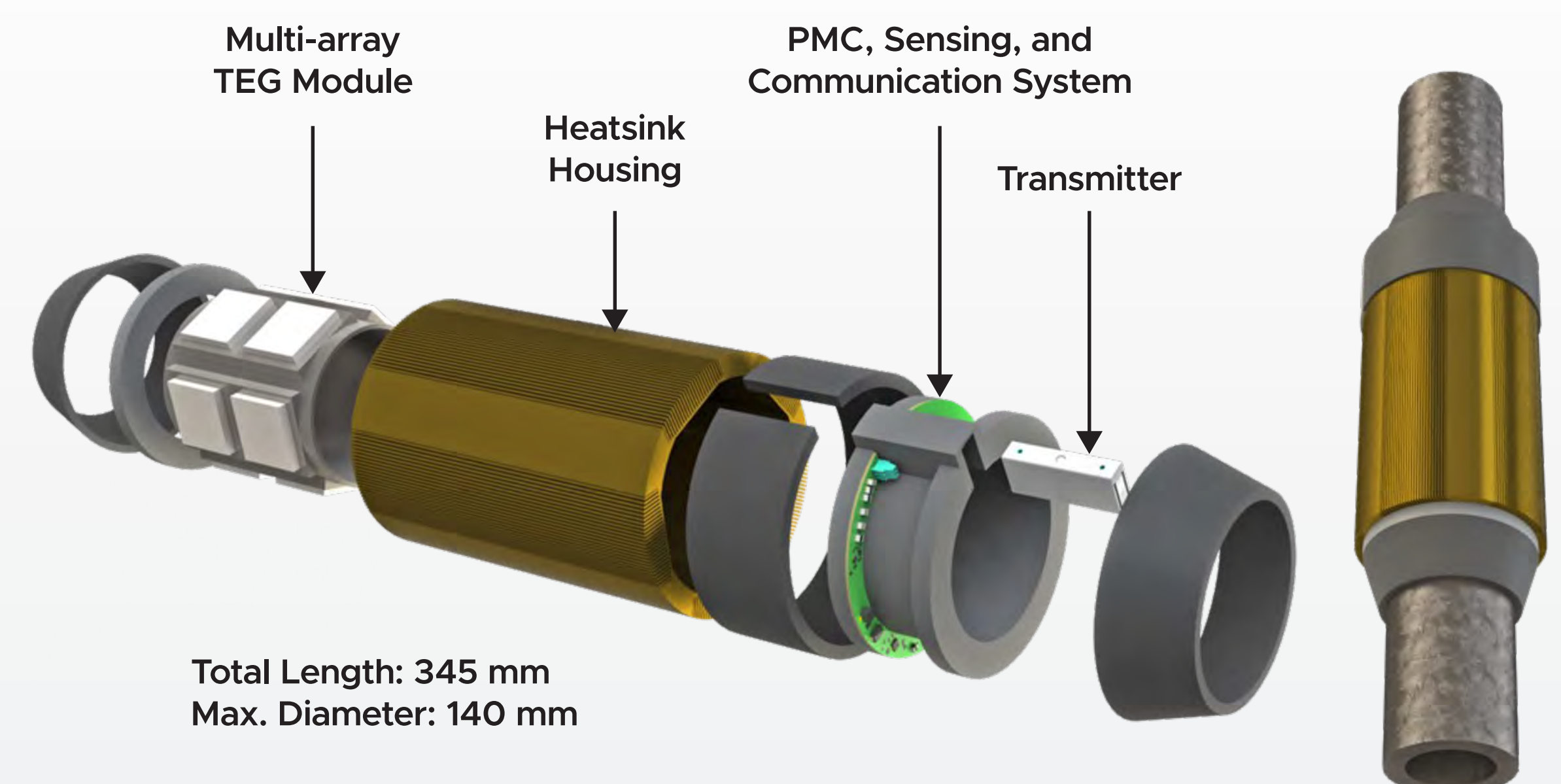
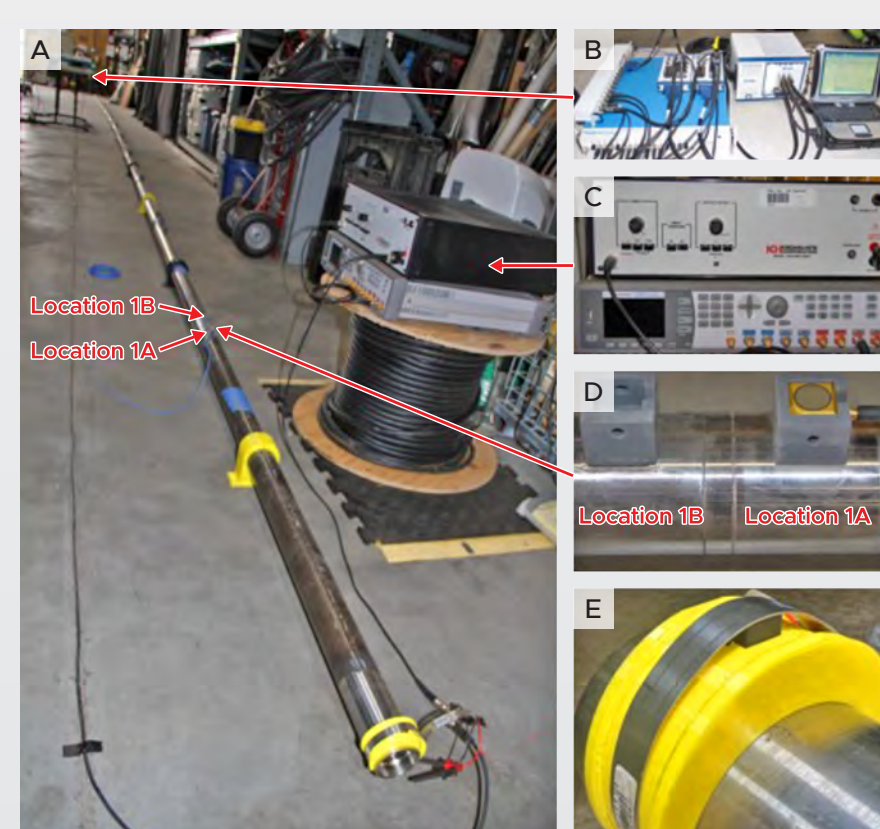
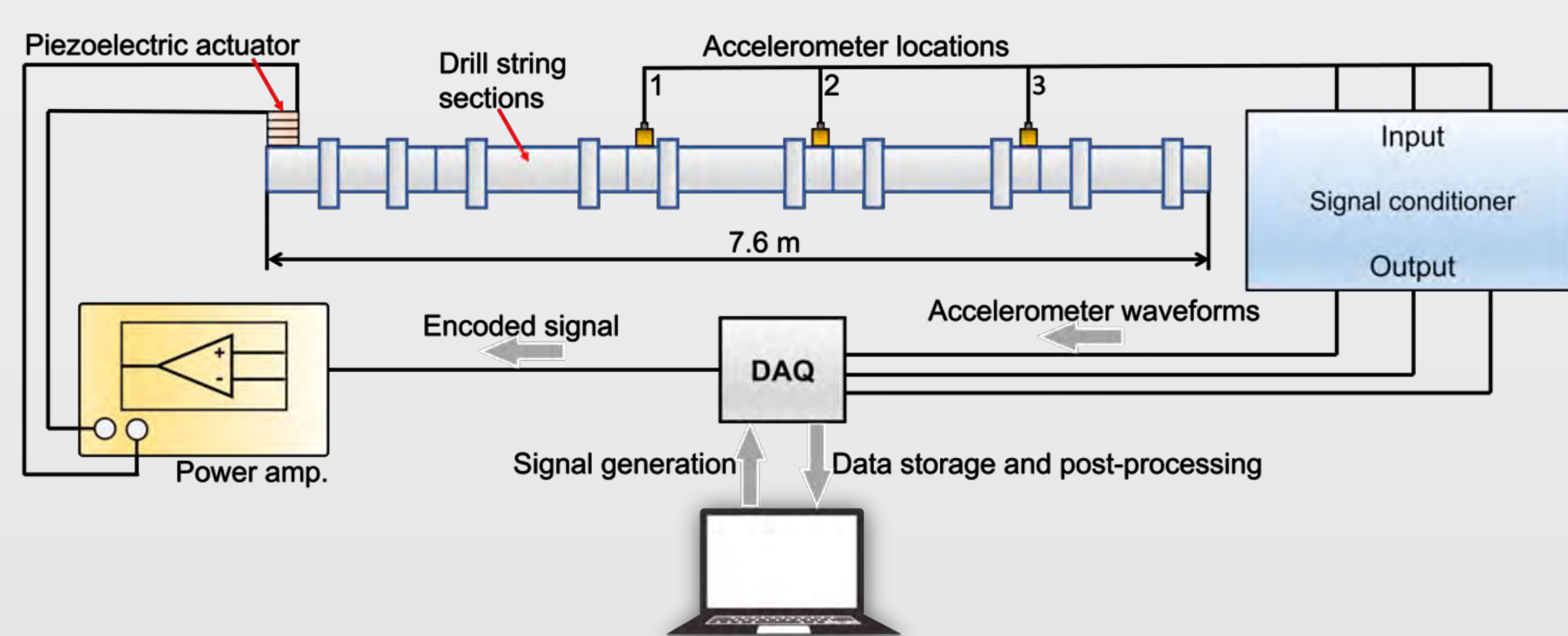


An integrated system for reliable and maintenance-free real-time monitoring

- Advanced monitoring technologies and reliable wireless communication protocols are needed to reduce costs and ensure safe CO₂ injection, and provide data for AI
- An acoustic telemetry system can transmit data from downhole to the surface wirelessly in real time.
- An energy harvesting system uses thermoelectric energy generators (TEGs) to power the integrated system, eliminating the need of external power supply
- A low-power sensing system was developed to monitor downhole temperature and pressure.

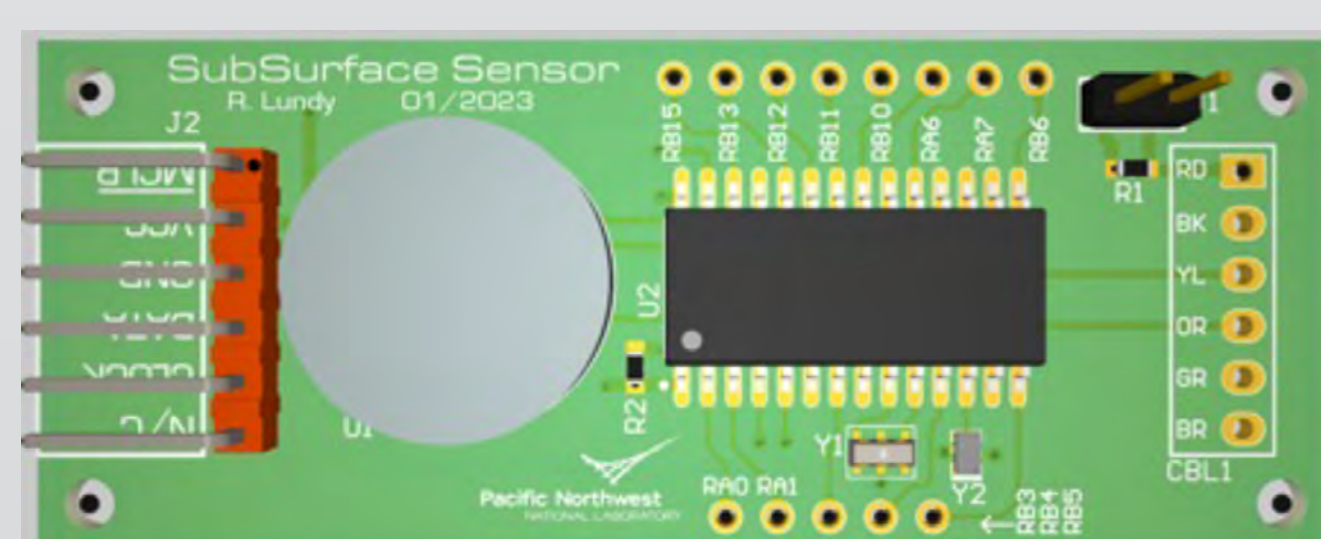
An acoustic telemetry system with high accuracy

- An acoustic telemetry system was integrated in the lab.
- The acoustic properties of the tube-string were investigated to select the carrier frequency.
- Signal processing protocols were designed for the unique tube-string communication channel.
- Both BPSK and DPSK schemes were developed and tested in lab experiments.
- A 100% decoding efficiency was achieved in the lab tests at a signal-to-noise ratio as low as 0 dB.



Energy harvesting & sensing systems for self-powered monitoring

- TEGs will be mounted in annulus to harvest thermal gradient energy between casing and tubing
- An average power of 1.06mW per TEG is generated in high pressure chamber with temperatures mimic the field data from MRCSP (Northern Michigan)
- Multi-array TEG systems with benchtop circuit successfully supply power to acoustic transmitter (approximately 1.036kJ per day, 1448m transmission distance under lab conditions)
- Developed custom sensing system that can operate under high temperature (110°C) and pressure (14500 PSI), with low power consumption



Sensing monitoring system on PCB

