INL/CON-23-71321-Revision-0

Data Challenges in Multi-Sensor Data Science System for Monitoring a Solvent Extraction Process

March 2023

Luis A Ocampo Giraldo, Edna S Cardenas, Mitchell Greenhalgh, Jay D Hix, James T Johnson, Katherine Neis Wilsdon, Cody McBroom Walker

Changing the World's Energy Future

INL is a U.S. Department of Energy National Laboratory operated by Battelle Energy Alliance, LLC

INL/CON-23-71321-Revision-0

Data Challenges in Multi-Sensor Data Science System for Monitoring a Solvent Extraction Process

Luis A Ocampo Giraldo, Edna S Cardenas, Mitchell Greenhalgh, Jay D Hix, James T Johnson, Katherine Neis Wilsdon, Cody McBroom Walker

March 2023

Idaho National Laboratory
Idaho Falls, Idaho 83415

http://www.inl.gov

Prepared for the
U.S. Department of Energy
Under DOE Idaho Operations Office
Contract DE-AC07-05ID14517

Data Challenges in Multi-Sensor Data Science System for Monitoring a Solvent Extraction Process

L. A. Ocampo Giraldo, E. S. Cárdenas, J. D. Hix, J. T. Johnson, M. R. Greenhalgh, C. M. Walker, & K. N. Wilsdon

Idaho National Laboratory, Idaho Falls, Idaho

Background

Idaho National Laboratory (INL) is maintaining and gaining knowledge into the nuclear fuel cycle by building a test bed to allow researchers the opportunity to study spent nuclear fuel processing operations. This includes studying solvent extraction processes that use centrifugal contactors. As part of INL's mission, the goal of this project is to develop a system that utilizes non-traditional measurement sources such as vibration, acoustics, current, light, flow, and temperature in conjunction with data-based, machine learning techniques that will allow for signal discovery. This multisensory data can support the development of safeguards by design, provide operator process awareness, and discover process anomalies.

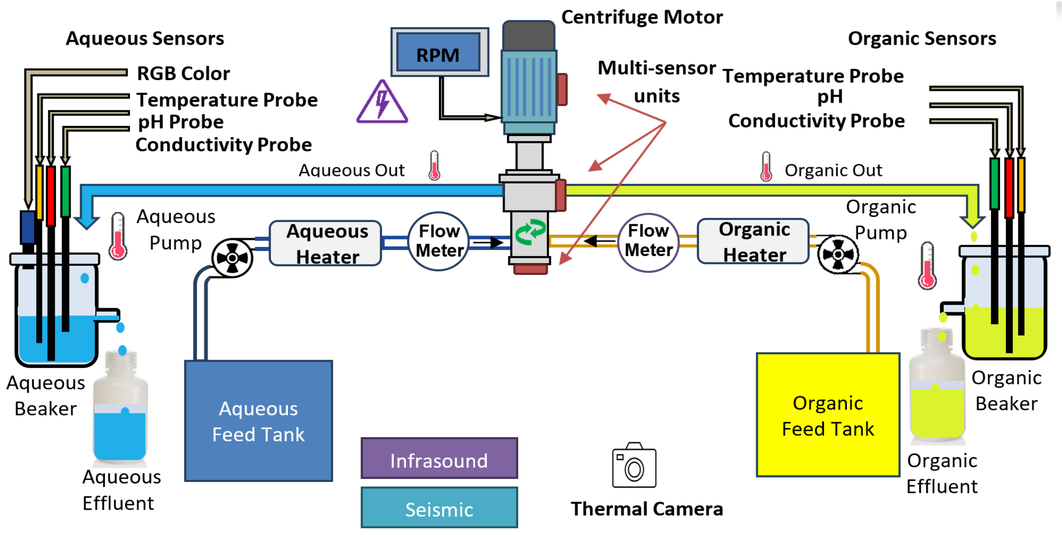
Data Collection Challenges

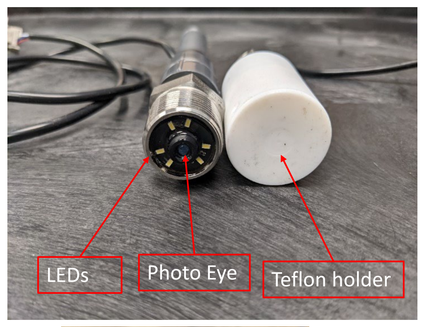
- One of the challenges behind deploying all the sensors, is the need for a fast and reliable data collection process
- The data acquisition system (DAQ) needed to be capable of recording multi-sensors simultaneously at rates up to 12.8kS/s/ch
- The timing of the data varied, and a range of sampling options was necessary
- A single output file from the DAQ was desired

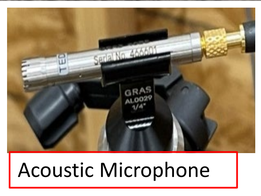
Mitigation Strategies

- The software architecture was developed using LabVIEW
- The Technical Data Management Solutions (TDMS) function inside LabVIEW was utilized to stream the data to disk, without any loss or dropout of information
- TDMS is a binary file structure that consists of three levels of architectural hierarchy (file, group, and channel)
- This architecture allowed the data to be buffered then saved to memory without any signal drops or loss of data

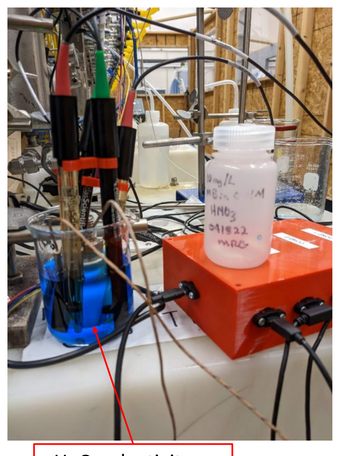
Hardware	Item Number	Sample Rate
Compact DAQ Chassis	CDAQ-9174	0-10Mhz
C-Series Acquisition module	NI-9230	12.8kS/s/ch







Acoustic Microphone

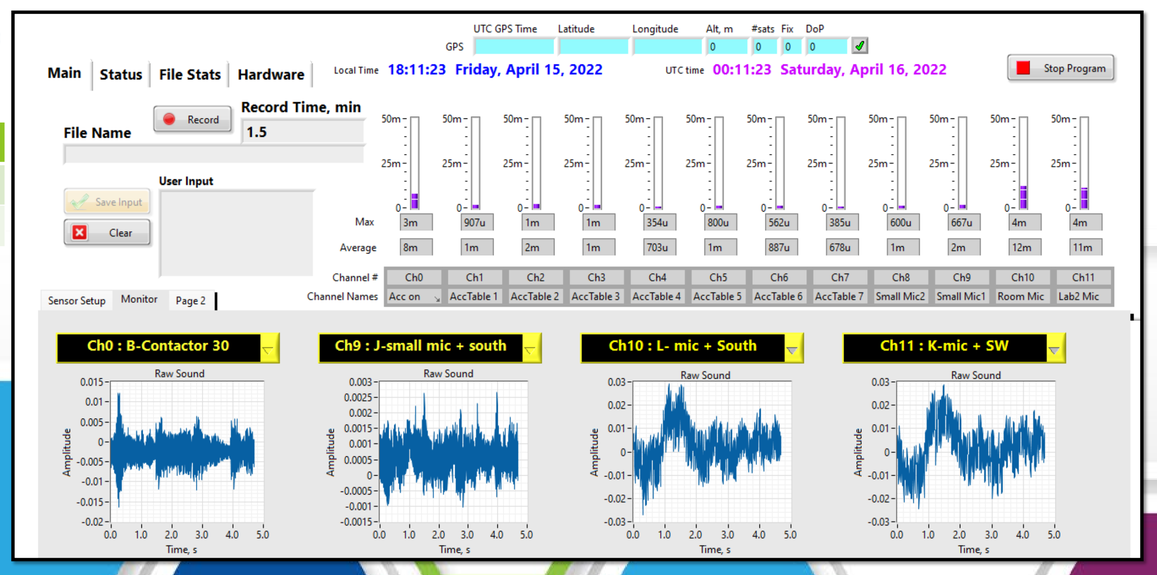


pH, Conductivity, Temperature, RGB

Accelerometer

List of Sensors

Measurement	Sensor	Sensing Range
Vibration	PCB Piezotronics high sensitivity accelerometer	0.5 Hz-10 kHz
Vibration	PCB Piezotronics modal array accelerometer	0.5-3 kHz
Acoustics	GRAS Sound & Vibration ½" Rugged Free-Field microphone	3.15-20 kHz @ 2dB
Acoustics	GRAS Sound & Vibration ¼" Free-Field microphone	4-80 kHz @ 2dB
Acoustics	GEM Infrasound logger	0.05-25 Hz
Seismic-acoustic	Raspberry Shake and Boom	Infrasound 1-44 Hz Seismic 0.7-44 Hz
Color	Atlas Scientific EZO-RGB Embedded Color Sensor	~425- ~750 nm wavelength
pH	Atlas Scientific pH 101P	0-14
Conductivity	Atlas Scientific Conductivity K 10	10 µS/cm-1 S/cm



INL/CON-23-71321

Acknowledgements

This research was funded through a Laboratory Directed Research and Development project under Battelle Energy Alliance, LLC contract number DE-AC07-05ID14517.

Contact: Luis.OcampoGiraldo@inl.gov

Battelle Energy Alliance manages INL for the U.S. Department of Energy's Office of Nuclear Energy

Idaho National Laboratory