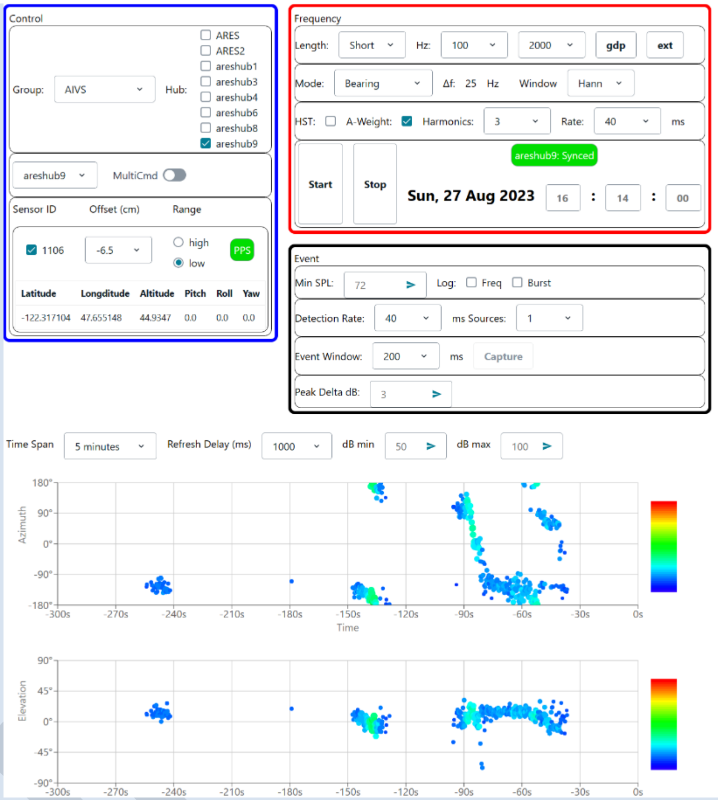
ARES App

Accelerometer-based autonomous 3D acoustic noise monitoring

ARES App is loaded with every ARES Hub as a C++/Python-based Linux software package that computes key measurement parameters, performs event triggering, saves intermediate results for playback in any measurement mode, and broadcasts to AWS cloud storage using MQTT protocol. After login, ARES App runs in a standard web browser, anywhere on the internet.

Focus regions apply to ARES Nodes configured in a Beamformer configuration.



ACOUSTIC INTENSITY

ARES App reads calibrated velocity and pressure spectral data from ARES Nodes, computes triaxial acoustic intensity, and source bearing (azimuth and elevation) angles. In the Fig. 1 below, bearings are computed for a node situated near an in-city flight path observing repeated jet flyovers, and presented to the user as a function of the specified time step.

BEAMFORMER

For improved angular precision in acoustic source detection problems, velocity and pressure spectra from two ARES Nodes are processed together in a delay-and-sum beamformer algorithm. An example elevation vs. time display is shown in Fig. 3 on the next page, for a freight train engine passby.

HARDWARE PLATFORMS

ARES App is delivered as an aarch64 (64-bit ARM architecture) Linux application, intended for the Raspberry Pi 4. The easiest installation path is to order ARES Hub, an industrial Raspberry Pi based IoT platform which comes with ARES App preinstalled. However, the app can be installed on other compatible ARM platforms[1].

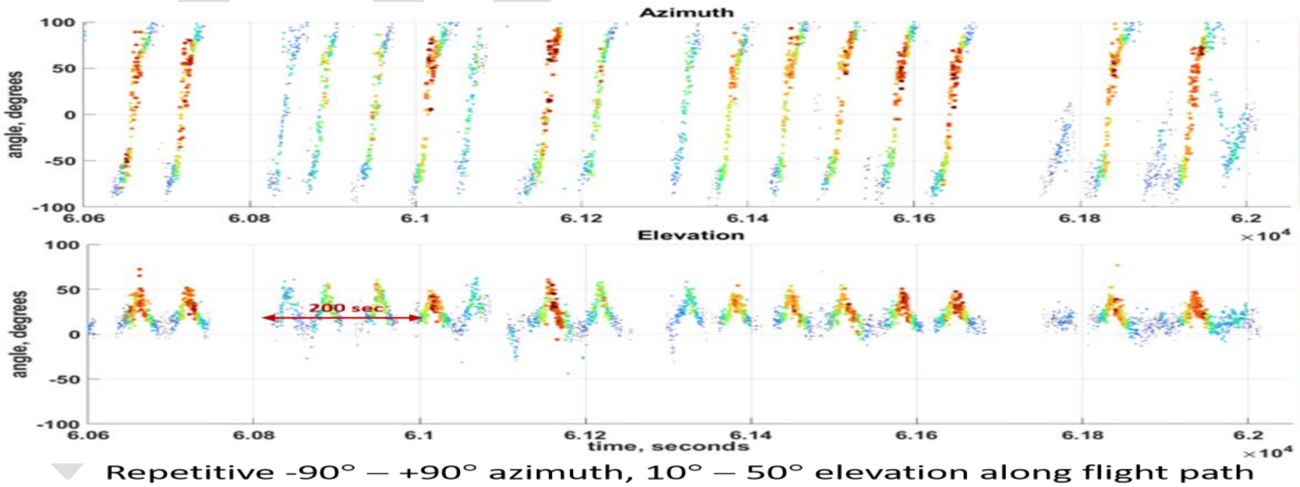


Figure 1. Bearings (azimuth and elevation) as a function of time during repeated jet flyovers from a sensor located near the flight path.

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ARES App Specifications v. 1.0

System Requirement[1]

Processor	Raspberry Pi 4B, Compute Module 4, or equivalent, 4 GB memory, at least 128 GB data storage recommended
Operating System	Ubuntu desktop 22.04, 64-bit (aarch64)
Python	Version 8 or higher
I/O interfaces	CAN-FD for connection to ARES Nodes

Configuration

ARES Nodes	1 or 2 nodes per ARES Hub at minimum time step of 40 ms
Multiple ARES Hubs	ARES App enables multiple coordinated measurements across spatially diverse ARES systems.

Measurements

Intensity	Triaxial active and reactive intensity per each frequency bin Presented in dB re: 1 pW, with the sign indicating direction
Velocity	Triaxial acoustic particle velocity, in dB re: 5e-8 m/s
Pressure	Scalar acoustic SPL coincident with the velocity measurement
Bearing	Based on triaxial intensity, such that azimuth and elevation bearing angles are computed and collected in a histogram per time step. After a selected time window, bearings with the highest power are output. In this way, multiple sources can be simultaneously tracked.
Playback	Saved spectral data can be replayed to any measurement.
A-weighting	Any measurement can be optionally A-weighted

AWS IoT Support

MQTT broadcast	One packet per detected source per time step
Event broadcast	One packet per detected source at maximum SPL per event, or a packet burst over the whole event segmented by time step.
Data store	AWS DynamoDB (optional subscription)
Downstream apps	Training, machine learning using signatures, source characterization, modeling, multi-ARES source tracking and localization
Third party apps	System integration via HTTP REST API

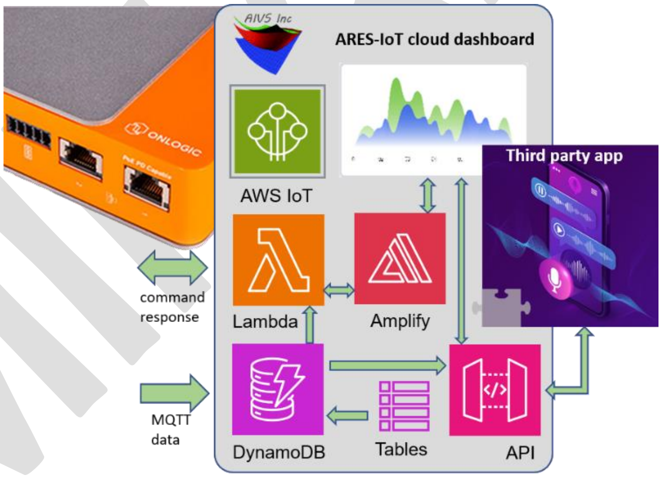

Figure 2. ARES-IoT cloud dashboard components

Event Detection

Minimum SPL	Threshold which defines the onset or end of an event.
Event Window	Defines the time window length of the bearing histogram
Secondary Peak dB	Bearings are output for all peaks in the spectrum higher than this many dB less than the maximum signal.
Crest factor dB	Required difference in dB between successive peaks before detecting a new source.

Bearing Accuracy

Angular accuracy	10 degrees
Resolution	2 degrees
Time step	Min 40 ms (25 measurements per second) Max 240 ms (4.1667 measurements per second)
Real-time performance	Measurements are gap-free

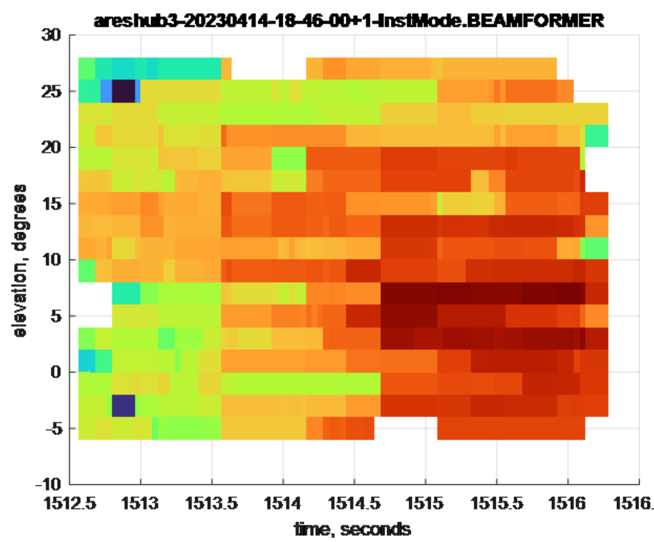

Figure 3. Overall A-weighted beamformer power of the freight train engine pass-by. Frequency detail not shown.

Beamformer Accuracy

Sensor elements	P, Vx, Vy, Vz (4 channels) per ARES Node. Up to two ARES Nodes per beamformer.
Focus region	Steering vector is fixed for a defined measurement, such that the beam is focused in a specific elevation or azimuth direction
Real-time performance	Up to 20 azimuth intervals per time step in the focused elevation direction, or 20 elevation intervals in the focused azimuth direction.
Playback performance	Maximum beamformer power detected over an extended focus region, and multiple focal regions are supported.
Frequency signature	In addition to beamformer power, an option exists to record major frequency components of the detected acoustic source
Sidelobe-free frequency range	100 Hz to 2000 Hz

[1] ARES App is available separately from ARES Hub as an additional cost option.

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