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CTBT: SCIENCE AND TECHNOLOGY CONFERENCE

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The Five M's of Seismic Station Quality: Machines, Methods, Metadata, Monitoring, Maintenance

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INTRODUCTION AND MAIN RESULTS

Collection of highly-accurate, precise, and trustworth geophysical data is a sum of many important aspects, reaching far beyond the instrumentation itself. This E-poster provides a closer look at five critical elements, attributing to and safeguarding the overall quality of a turn-key seismic station. The five "M's" mnemonic is employed to emphasize the importance of "Machines", "Methods", "Metadata", "Monitoring", and "Maintenance" to maximize station's operational continuity, integrity, resilience, and agility to face and recover from condition, expected during the station's life cycle in the open environment.

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The Five M's Definitions

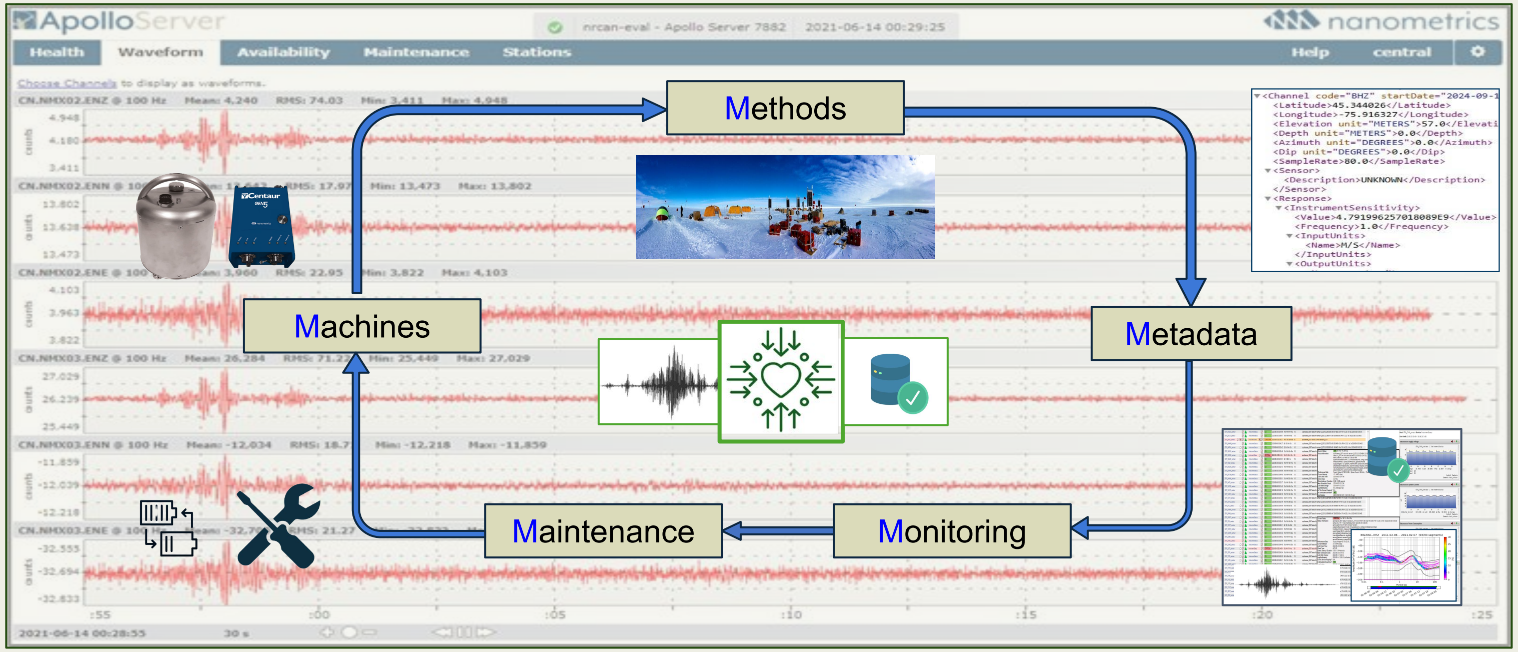
Machines: The instruments (seismometers, digitizers, etc.) and related infrastructure (power, telemetry)
⏩The measuring and support equipment must meet the needs of the use case

Methods: How the instruments and the entire station is installed and deployed
⏩The best equipment poorly installed can produce inaccurate, misleading or incomplete data

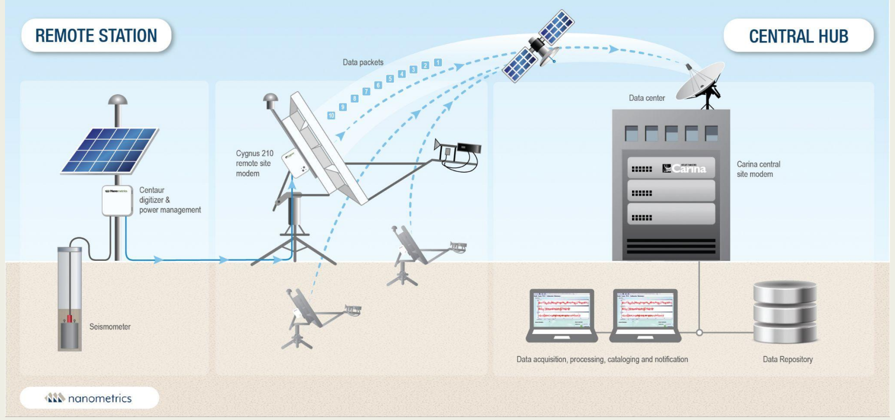
Metadata: Information that gives data meaning (sensitivity, transfer function, sample rates, location, etc.)
⏩The best raw data are just numbers without knowing what they represent

Monitoring: Real-time supervision of station performance (state-of-health, data quality / completeness, etc.)
⏩Measurand of present status, trends, and preconditions leading up to possible problems

Maintenance: Actioning of [scheduled] preventative maintenance, repairs, and on-site updates (i.e. batteries)
⏩Neglected stations face inevitable degradation, even if measuring instruments remain "healthy"



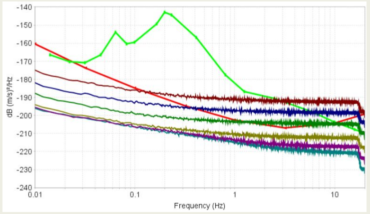
MACHINES: *the instrumentation*



Station quality: the entire end-to-end system is critical, from the site and sensors, to the data archive

Objective: **Ensure Station is Fit-for-Purpose**

- ✓ Equipment meeting the performance criteria and operational objectives (clip level, noise floor, bandwidth, etc.)
- ✓ All station components attribute to, but can also compromise, the overall station performance and/or reliability.
- ✓ Important, but often overlooked elements include: Site-specific power budget, telemetry throughput engineering, serviceability / usability, data surety, location-based environmental conditions (annual temp.deviations / salinity,...), etc.



Seismometer and Digitizer self-noise, relative to NLNM

- ✓ Digitizer and seismometer performance are both important, with the system configuration carefully fine-tuned to the intended monitoring needs (gain, sampling, etc.)

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METHODS: *the installation*

Objective: **Install to maximize station performance**

Installation impairments can degrade performance, and getting it right can be tricky.

Good instrumentation + poor installation = poor performance

Site selection and commissioning:

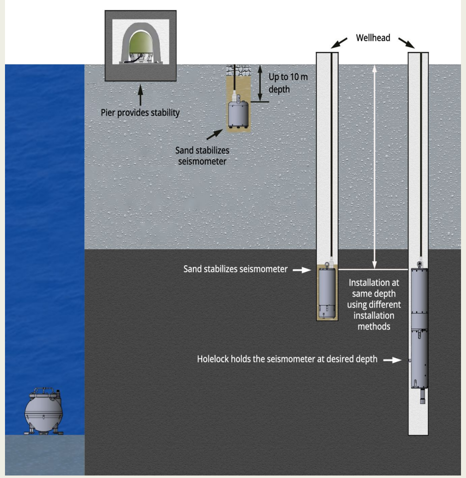
✓ Invest in pre-deployment surveys to assess geology and site conditions (prefer rock / avoid soft sediment, presence of cultural or natural noise, seasonal considerations, theft, ease of access, etc.)

Seismometer installation:

✓ Achieve stable ground-to-seismometer coupling to prevent shifting / slumping / tilting

✓ Mitigate temperature deviations, and exposure to air drafts or air pressure changes (these pollute seismic data quality due to dynamic tilting or long-term tilt, requiring frequent mass centering)

✓ Leverage seismometer form factors for best-fit alignment with observation objectives sensitive to project and/or location constraints (if any). Options include: vault, shallow direct burial, posthole, borehole, OBS

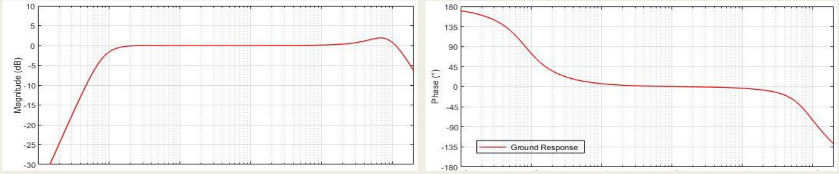


METADATA: *the data about the data*

Objective: **Ensure correct data interpretation**

Accurate and up-to-date metadata is critical for deconvolution of the raw waveforms and defining the signal and instruments characteristics. Inaccuracies cast direct impact on event locations and computation of event source parameters. Metadata is essential for converting raw waveforms (i.e. digital counts) into physical measurements representative of the recorded signal. Examples of critical metadata include:

- Sensitivity and transfer function of the seismometer and the digitizer
- Sampling rate, gain settings, station and channel code(s), location (elevation, LAT, LON), sensor empl. depth, instrument SNs, etc.



Best practices:

✓ Ensure that metadata is accurate and available concurrently with the raw data

✓ Ideally, dataloggers should already contain known instrument responses and automatically produce metadata representative of the deployment location and connected instruments

Metadata standards:

Digital schema have been developed to standardize metadata documentation and interchange by data analysis software. Examples include: dataless SEED, RESP, StationXML

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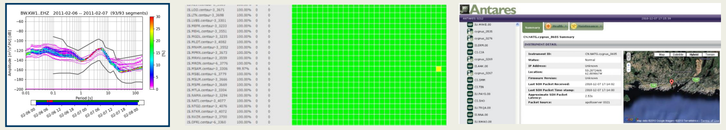
MONITORING & MAINTENANCE

Ounce of Prevention = Pound of Cure



Objective: **Sustain station quality & data availability**

✓ Employ proactive monitoring of critical State-of-Health (SoH) parameters and trends, ideally resulting in automatic triggering of alert notification upon crossing user-defined thresholds (i.e. voltage, timing, mass positions, etc.)

✓ Employ telemetry for SoH monitoring, even for autonomous (non-streaming) stations

✓ Watch for extreme weather, fire, flood events that could degrade station performance

Maintain equipment and site to ensure high station reliability and performance

✓ Conduct periodic calibration tests to verify functionality and monitor for drift in instrument response

✓ Instill scheduled site visits to inspect equipment, infrastructure, initiating repairs as needed

✓ Enforce timely replacement of critical system components (i.e. batteries) and ensure availability of spare inventory (incl. instruments)

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