AI/BDA Underwater Signature Analysis

WESEE

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Agenda

- Objective and Scope
- Data inventory and database design
- Processing pipeline and feature extraction
- Module descriptions (Tonal Analysis, CIS, Silent Regime, Mount Health)
- Trend Analysis
- Intra-Class Analysis
- Reporting and visualization

Objective and Scope

- Automate NUWR's manual acoustic analysis workflows.
- Provide consistent, repeatable detection and attribution of tonals and cavitation onset.
- Decision-support: produce Machine Action Reports with inspection recommendations.

Data Inventory — Inputs

- **BB (Broadband) RNL:** Frequency vs dB (40 pts; 10 Hz – 10 kHz)
- **NB (Narrowband) RNL:** Frequency vs dB (800 pts; 8 Hz – 6400 Hz)
- **MTU Vibration:** Excel, frequency-domain vibration (mm/s^2) at Top, Bottom, Hull sensors
- **Master Data:** PDF tables containing fundamental frequencies for machineries — requires PDF table extraction.
- **MAR:** Generated output from feature modules (not an input).

Database Architecture (High Level)

- **Data-series database :** Store RNL spectra and MTU time-series per SRPM.
- **Relational database :** Structured metadata, trial records, SRPM logs, configuration.
- **Document store :** Parsed Master Data, JSON tables, extracted references for attribution.

Ingestion Preprocessing (Flow)

- File parsers for BB/NB/MTU; robust error handling.
- Master Data extraction: PDF table parsing $\rightarrow$ structured reference table.

Tonal Analysis Module (High Level)

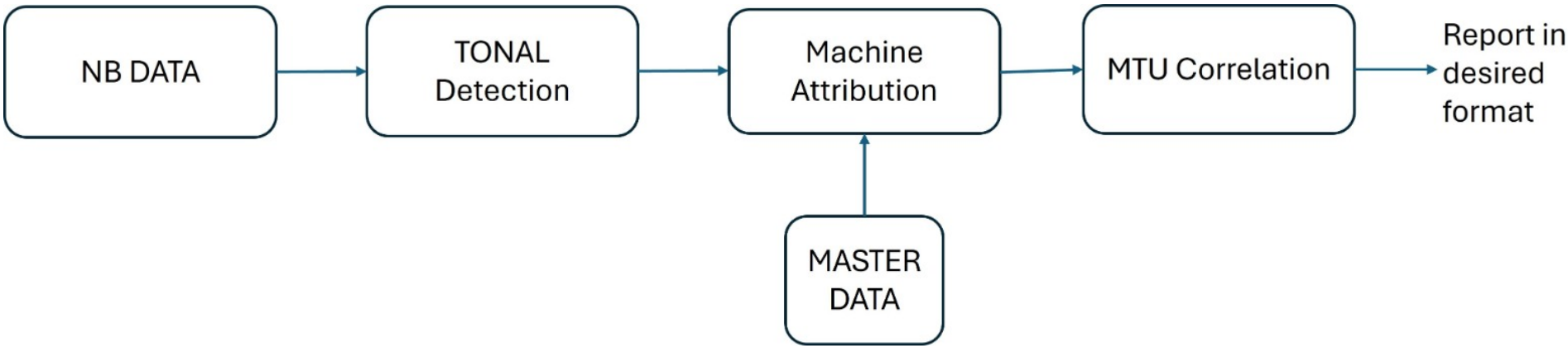

Figure: Tonal Analysis Workflow

Tonal Analysis Module

- Master Data reference mapping: match detected frequencies to machinery fundamental frequencies (tolerance bands).
- MTU correlation: confirm attribution by matching vibration spectral peaks at Top/Bottom/Hull sensors.

CIS Module (ML Overview)

- Inputs: BB + NB RNL at multiple SRPMs; labelled historical CIS points for training.
- Current Status : Existing CIS model has been validated on five ship classes.
- Output: CIS SRPM/regime with confidence metric; visualization on 2D plot.

Silent Regime Detection (Proposed Algorithm)

MDS (Mine Defence Silent Regime)

- Low-speed transit regime; BB/NB RNLs analysed in 0–2 kHz band to ensure minimum platform signature.
- Regime with lowest peak RNL in 0–2 kHz (across all regimes) is recommended as MDS.

ASWS (ASW Silent Regime)

- ASW operating regime at speeds just below CIS (typically 12–14 kts) to avoid cavitation.
- Regime with lowest peak RNL in 2–10 kHz (below CIS) is recommended as ASWS.

Trend Intra-Class Analysis

- **Trend Analysis (Ship-specific) :** Compare current ranging with historical baselines; detect tonal emergence/growth.
- **Intra-Class Analysis :** Compute class baseline and compare per-ship deviation metrics; flag ships outside class norms.
- **Outputs :** Trend reports, anomaly flags.

MTU Mount Health Assessment

- **Principle :** Attenuation verification Top $>$ Bottom $>$ Hull across frequency bands.
- **Steps :** compute attenuation ratios, compare to thresholds, frequency-dependent health score.
- **Output :** Mount health (Good / Warning / Critical) and recommendation for replacement or inspection.

Visualization, Reporting & UX

- Key visualizations: 2D plots, tonal traces, CIS markers, trend timelines, mount attenuation plots.
- Reports: Machine Action Report (PDF), data export (CSV), interactive dashboards for analysts.