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A strategy for the development of metrology to enhance the sustainment of the seismic and infrasound components of the IMS network

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Quality Assurance objectives

Quality Assurance (QA) aspects of waveform technologies have been under development as part of the establishment of the IMS.

The goal is to strengthen technical and scientific credibility through transparency, benchmarking, recognition of best practices and peer review processes.

The initiative has many facets resulting in a diverse range of activities where delivery often requires engagement and the support of several stakeholder groups.

Specialist service providers

Equipment manufacturers

Parent network operators

Metrology community

IMS station operators

Scientific community

Demonstrate quality assurance in IMS seismo-acoustic measurement to ensure credibility and trustworthiness of IMS data

Ensure consistency in IMS seismo-acoustic measurement and equivalence in data produced across the IMS network

Ensure continuity and transparency of best practices independent of changes in instrumentation/service providers, or individual personnel

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CTBT: SCIENCE AND TECHNOLOGY CONFERENCE

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Strategy

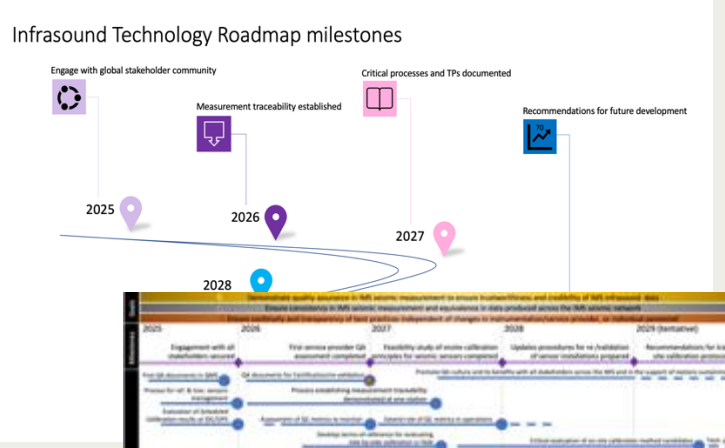
The diversity of activities and stakeholder dependencies means that co-ordination is essential for effective task management, and for visibility and prioritisation.

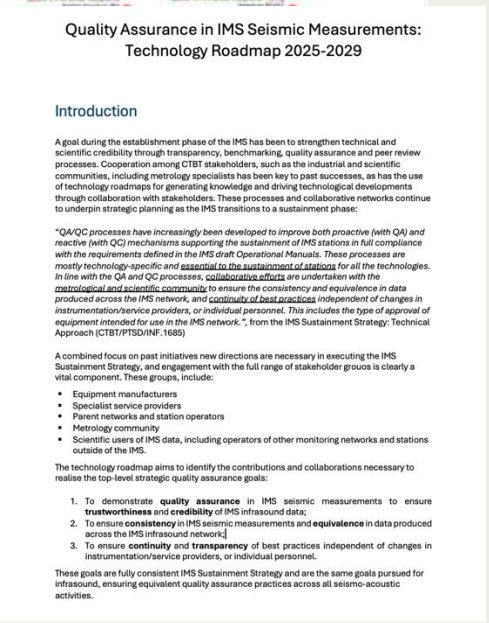
Individual strategies and roadmaps have therefore been developed for seismology and for infrasound reflecting the differing levels of technical maturity and diversity of each technology.

While these aim for further technological advancement, aspects of streamlining across the IMS network and operational efficiency also drive the strategy, in line with the wider Sustainment Strategy for the IMS.

State-of-the-art metrology and specialised measurement capability are central to realising several sustainment goals.

… a selection of topics from the metrology strategy will now be presented.




Quality Assurance in IMS Seismic Measurements: Technology Roadmap 2025-2029

Introduction

A goal during the establishment phase of the IMS has been to strengthen technical and scientific credibility through transparency, benchmarking, quality assurance and peer review processes. Cooperation among CTBT stakeholders, such as the industrial and scientific communities, including metrology specialists has been key to past successes, as has the use of technology roadmaps for generating knowledge and driving technological developments through collaboration with stakeholders. These processes and collaborative networks continue to underpin strategic planning as the IMS transitions to a sustainment phase:

"QA/QC processes have increasingly been developed to improve both proactive (with QA) and reactive (with QC) mechanisms supporting the sustainment of IMS stations in full compliance with the requirements defined in the IMS draft Operational Manuals. These processes are mostly technology-specific and essential to the sustainment of stations for all the technologies. In line with the QA and QC processes, collaborative efforts are undertaken with the metrological and scientific community to ensure the consistency and equivalence in data produced across the IMS network, and continuity of best practices independent of changes in instrumentation/service providers, or individual personnel. This includes the type of approval of equipment intended for use in the IMS network.", from the IMS Sustainment Strategy: Technical Approach (CTBT/PTSD/INF.1685)

A combined focus on past initiatives new directions are necessary in executing the IMS Sustainment Strategy, and engagement with the full range of stakeholder grouos is clearly a vital component. These groups, include:

- Equipment manufacturers
- Specialist service providers
- Parent networks and station operators
- Metrology community
- Scientific users of IMS data, including operators of other monitoring networks and stations outside of the IMS.

The technology roadmap aims to identify the contributions and collaborations necessary to realise the top-level strategic quality assurance goals:

1. To demonstrate **quality assurance** in IMS seismic measurements to ensure **trustworthiness** and **credibility** of IMS infrasound data;
2. To ensure **consistency** in IMS seismic measurements and **equivalence** in data produced across the IMS infrasound network;
3. To ensure **continuity** and **transparency** of best practices independent of changes in instrumentation/service providers, or individual personnel.

These goals are fully consistent IMS Sustainment Strategy and are the same goals pursued for infrasound, ensuring equivalent quality assurance practices across all seismo-acoustic activities.

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Solution for field calibration of seismometer systems

Needs

- Provides measurement traceability and link into the SI.
- Has sufficiently low measurement uncertainty to resolve within-tolerance changes and subtle trends in sensor system response
- Straight-forward implementation.
- Minimal (ideally zero) impact of operations and data availability
- Effective in identifying sensor and system faults and sensitivity to ground vibration.
- Economically viable.

Actions

- Survey of current practices within IMS and parent networks, and in non-IMS networks.
- Steering, monitoring and review of research on potential methods.
- Critique of methods against Needs (benefits, limitations).
- Formulate new R&D goals to evaluate options.

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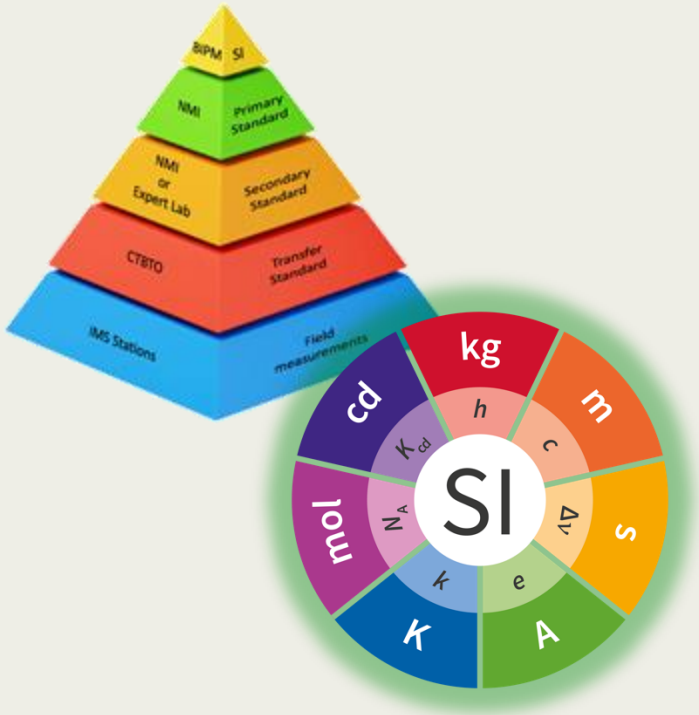
Measurement traceability and the International System of Units (SI)

Needs

- Dialogue with National Measurement Institutes.
- Pilot studies and comparisons amongst service providers.
- Procedures for maintaining and deploying calibrated reference sensors to disseminate measurement traceability in the field.



Actions

- Liaison with the BIPM Consultative Committee on Acoustics, Ultrasound and Vibration (CCAUV) – continue to drive the global metrology research agenda.
- Formulate mutually beneficial pilot studies and comparisons to develop and validate measurement capability for key performance parameters.
- Examine potential for IMS calibration and test protocols to be linked with International Standards (e.g. ISO and IEC).

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Procedures and software for verification of seismometer orientation

Needs

- Need rapid but technically rigorous installation procedures and dedicated software.
- Autonomy - Independent of proprietary software and reliance on assistance from equipment provider during installation.
- Systematic and streamlined with assurances on reliability from appropriate metrology input.

Actions

- Collect experience and current best practices.
- Research to optimise method.
- Address metrology considerations, including assessment of orientation uncertainty.
- Specify and develop software tools.

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Open communication with manufacturers and service providers

Needs

Service Providers:

- Drive research on measurement capability for characterising sensors to estimate long-term performance in a range of environmental conditions.

Equipment Manufacturers:

- Communicate PTS QA rationale and requirements and receive feedback to develop and optimise the requirements.
- Keep abreast of latest developments with sensors and other equipment. Lobby manufacturers to produce devices compliant with IMS needs.

Actions

- Agree on the most appropriate format for supporting discussions and establish a schedule for staying in contact.
- Disseminate the strategy, gain support for the various initiatives and take them forward – achieved most effectively through open discussion.
- Prepare illustrative case studies on the added value of QA initiatives.

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Dialogue with network and station operators

Needs

- Understand current QA and calibration practices and underlying rationale.
- Disseminate PTS/IMS technical requirements for sensor systems and data integrity to widen understanding.
- Work towards convergence of QA best practices (especially in calibration) across different networks and applications.

Actions

- Review and critique of field calibration methods at IMS parent networks and stations.
- Disseminate findings on operational matters such as installation of sensors and field calibration.
- Develop tools to evaluate operational metrics (QC metrics) to assist in trouble-shooting, failure analysis and preventative maintenance.

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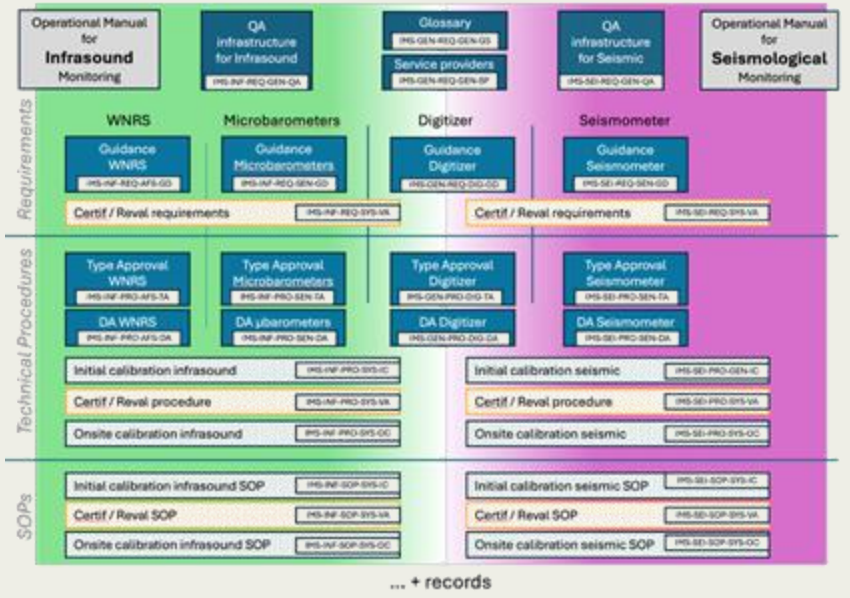
QA infrastructure and documentation

Needs

- Have all processes fully documents for transparency and continuity of established best practices.
- Extend QA requirements to suppliers of equipment and measurement services.
- Clarity on the implementation of the Operational Manual requirements.

Actions

- Prepare technical and operational procedures within a common infrastructure, using a systematic drafting and revision process.
- Extend to procedures covering equipment life-cycle management, station certification and re-validation processes.
- Establish a clear peer review process with key stakeholders.
- Implement QA assessment programme for equipment suppliers and measurement service providers.



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An evolving strategy

The roadmaps will be **reviewed with stakeholders** and revised regularly to:

- Account for progress and changing priorities.
- Integrate emerging external developments.

Technology **horizon scanning** will also contribute to the regular roadmap review providing some technical foresight. Activities include:

- Participation in key conferences.
- Systematic and regular review of scientific literature.
- Market surveys.

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Technology roadmaps have been **invaluable in directing R&D** during the establishment phase of the IMS.

A clear and pre-emptive strategy for seismo-acoustic technology remains vital for delivering the wider IMS ambitions, **especially in the era of sustainment.**

Thank you