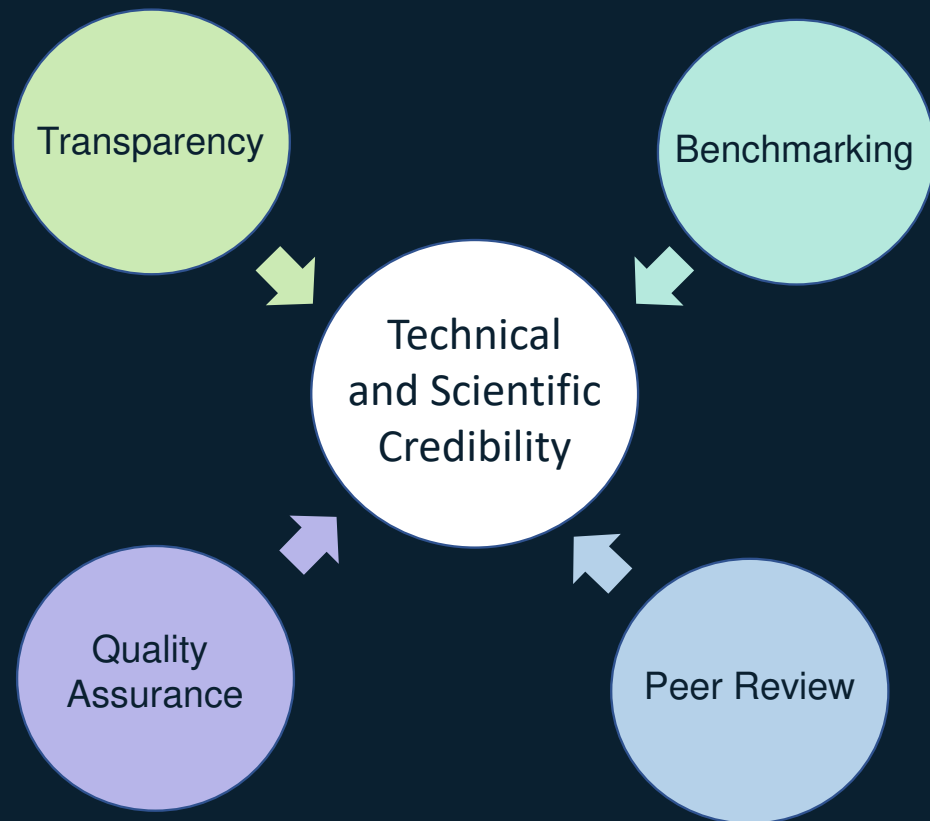


Quality assurance for IMS measurements, Insights from the 2023 Science and Technology Conference

Benoît Doury, Alfred Kramer and Paola Campus

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Why **Quality assurance** for IMS measurement systems?

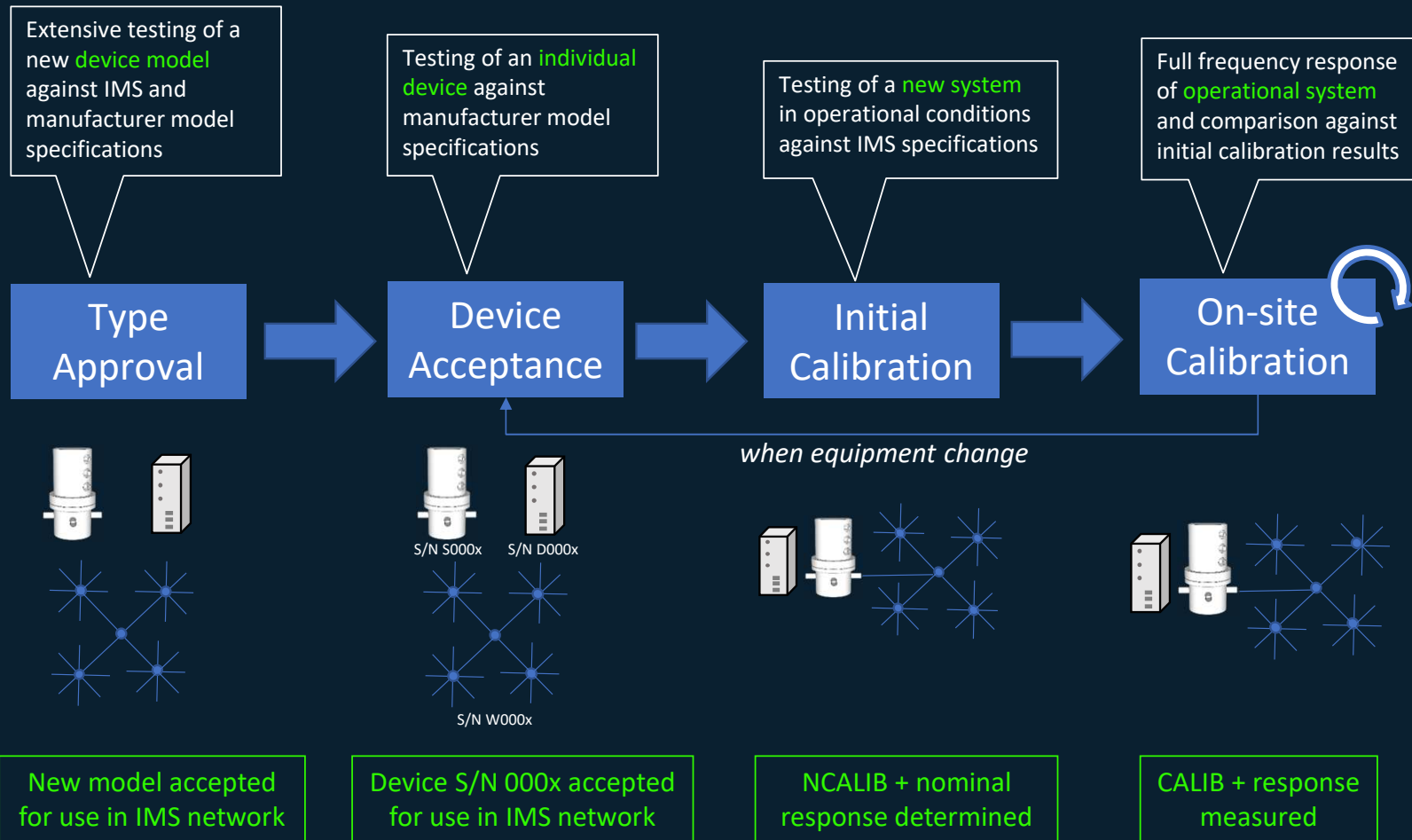


Objectives

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

Requirements for data quality and calibration of IMS measurement systems are laid out in the IMS Operational Manual

Quality Assurance Processes



Over the past 10 years, CTBTO engages with parent network operators, expert laboratories, the metrology community and sensor manufacturers to achieve its quality assurance objectives.

CTBTO – BIPM Collaboration

- CTBTO gives invited presentations to CCAUV biennial strategic meeting since 2017
- CIPM invites CTBTO to the 26th General Conference for Weights and Measures
- CTBTO describes **IMS needs** at the 26th CGPM
- BIPM and CTBTO identified **common goals** that provide the basis for a mutually beneficial relationship
- June 2021: A **practical arrangement** is signed between the BIPM and CTBTO on collaboration on the metrological traceability of measurements of infrasound, seismic activity and radioactivity.
- Metrological community tackles CTBTO's needs for seismic, infrasound and hydroacoustic technologies



CCAUV: Consultative Committee for Acoustics, Ultrasounds and Vibrations

Metrology applied by CTBTO community

CTBTO organizes Pilot studies with IMS service providers

Fruitful cooperation and knowledge exchange

Measurands

Uncertainty budget

Expertise

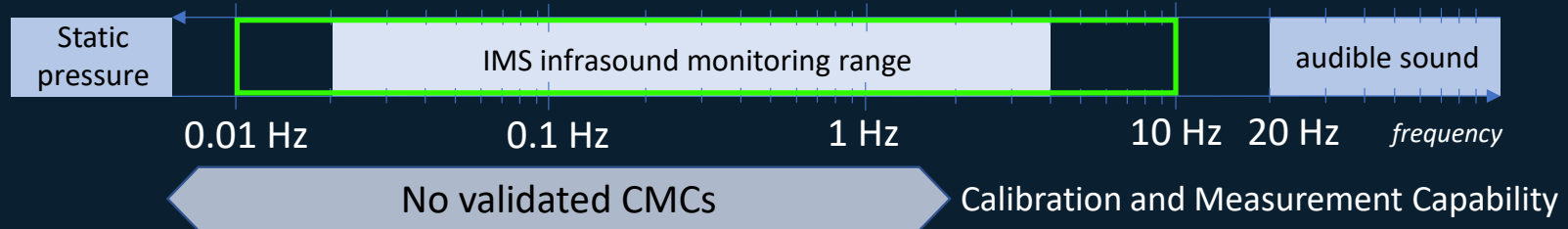
Methodologies






Environment



First CTBTO comparison in IMS infrasound monitoring range

Metrology applied by CTBTO community










CTBTO Comparison


Measurands

Pressure Sensitivity 0.01 to 10Hz


Self-noise



Barometer



Micro-barometer



Microphone

First time that **capability** of IMS service providers was formally **assessed**

Equivalence demonstrated for majority of frequency range

Science and Technology conference 2023

2000+ in-person and online participants

Flagship event showcasing CTBTO's reliance on innovation to strengthen verification capabilities and promote Treaty universalization and entry into force

Five special highlights across all program components:

1. In-depth analysis of the global impact of the Hunga Tonga-Hunga Ha'apai volcano eruption
2. Metrology - Development of **traceable calibration** of acoustic, underwater and vibration sensors
3. Achievements and challenges of noble gas monitoring
4. Sustainment of the International Monitoring System (IMS)
5. Preparations for the 2025 Integrated Field Exercise (Sri Lanka).



Hofburg, Vienna



SnT 2023 - Metrology

- Numerous **oral and poster** presentations in sessions 3.1 and 4.1
- **Side event** on metrology organized by InfraAUV group
- **Valuable exchanges** between metrology and geophysics communities (Station Operators, manufacturers, Parent Networks...)
- **Videos** of the event available on Youtube
- **Report** available online

<https://conferences.ctbto.org/event/23/>



SnT 2023 - Metrology

Invited talk by **Dr Takashi Usuda**, director of NMIJ,
secretary of the CIPM
*International measurement equivalence:
a fundamental backbone for the IMS*



Panel on metrology

Operating the IMS in the framework of the International System of Units (SI)



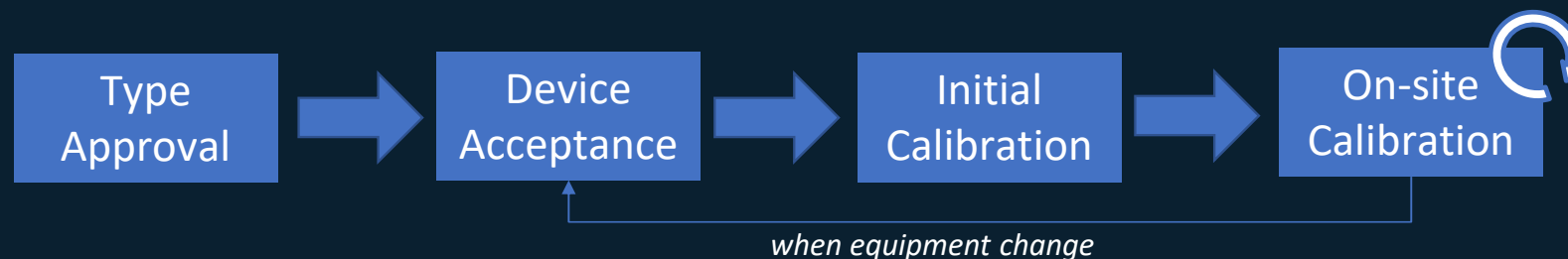
Moderator: Richard Barham, Acoustic Sensor Networks

- Takashi Usuda, director of NMIJ, secretary of the CIPM
- Franck Larsonnier, CEA, France
- Lind Gee, USGS, USA
- Svetlana Nikolova, GA, Australia
- Thomas Bruns, PTB, Germany

SnT 2023 - Conclusions of the **panel** on Metrology

1. « **IMS seismic operations** can leverage established best practices in national networks and draw from recent successes in quality assurance for IMS infrasound measurements.

This involves adopting a **similar approach** tailored to address specific **technical and logistical challenges**, which should not be underestimated. Operational aspects are vitally important and **sustainment** is becoming an increasingly significant key topic. [...]»



SnT 2023 - Conclusions of the panel on Metrology

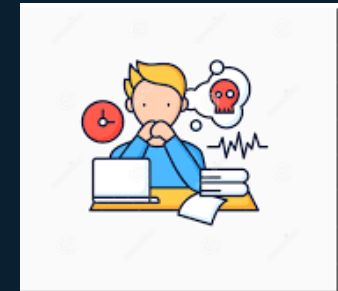
2. Current operational challenges in the calibration of IMS seismic stations:



Equipment compatibility

Complex and infrequent tasks

for station operators and PTS officers,



Timing	Type	RISM	Calibration			Planning		CALIBRATE_START		OUTAGE REQUE	
			Scheduled	Backup	Agreed on	Required	Sent	Required	Sent	Required	Received
In time	3-C	HM	13 Mar - 15 Mar	18 Sep - 20 Sep	13 Mar - 15 Mar	16 Feb	25 Nov	24 Feb	24 Feb	3 Mar	3 Mar
Time out	3-C	YC	27 Feb - 1 Mar	11 Sep - 13 Sep	13 Nov - 15 Nov	6 Feb	25 Nov	30 Oct	28 Aug	6 Nov	3 Mar
In time	AR	YC	3 May - 5 May	24 Aug - 28 Aug	3 May - 5 May	12 Apr	13 Jan	19 Apr	19 Apr	26 Apr	23 Apr
In time	3-C	YC	8 Jun - 12 Jun	19 Oct - 23 Oct	8 Jun - 12 Jun	18 May	13 Dec	25 May	25 May	1 Jun	26 May
In time	3-C	GM	8 Feb - 10 Feb	16 Aug - 18 Aug	8 Feb - 10 Feb	18 Jan	25 Nov	25 Jan	25 Jan	1 Feb	31 Jan
Time out	3-C	HM	3 Apr - 5 Apr	15 Nov - 17 Nov	15 Nov - 17 Nov	13 Mar	1 Dec	31 Oct	31 Oct	8 Nov	31 Jan
In time	AR	RO	21 Mar - 23 Mar	4 Dec - 6 Dec	21 Mar - 23 Mar	28 Feb	30 Nov	7 Mar	7 Mar	14 Mar	10 Mar
In time	3-C	YC	16 Mar - 20 Mar	4 Sep - 6 Sep	16 Mar - 20 Mar	20 Feb	28 Nov	1 Mar	1 Mar	9 Mar	6 Mar
Very late	AR	RA	6 Feb - 8 Feb	3 Aug - 7 Aug	6 Feb - 8 Feb	13 Jan	25 Nov	20 Jan	30 Jan	30 Jan	25 Jan
Time out	3-C	HM	6 Mar - 8 Mar	16 Aug - 18 Aug	8 Nov - 10 Nov	13 Feb	1 Dec	25 Oct	20 Feb	1 Nov	31 Jan
In time	3-C	RO	17 Apr - 19 Apr	11 Oct - 13 Oct	17 Apr - 19 Apr	23 Mar	9 Dec	30 Mar	30 Mar	10 Apr	5 Apr
In time	3-C	HM	20 Mar - 22 Mar	24 Jul - 26 Jul		21 Feb	1 Dec				
Time out	3-C	RA	3 Apr - 5 Apr	13 Nov - 15 Nov	13 Nov - 15 Nov	9 Mar	6 Dec	30 Oct	30 Oct	6 Nov	31 Oct
In time	3-C	GM	22 Mar - 24 Mar	2 Aug - 4 Aug	14 Nov - 16 Nov	1 Mar	30 Nov	31 Oct	31 Oct	7 Nov	31 Oct
In time	3-C	HM	5 Jun - 7 Jun	20 Nov - 22 Nov		11 May	2 Feb				
In time	3-C	sm	13 Mar - 15 Mar	28 Aug - 30 Aug	28 Aug - 30 Aug	15 Feb	9 Dec	14 Aug	14 Aug	21 Aug	21 Aug
Time out	3-C	YC	3 Apr - 5 Apr	1 Nov - 3 Nov	3 Apr - 5 Apr	13 Mar	28 Nov	20 Mar	20 Mar	27 Mar	24 Mar
Time out	3-C	AA	3 May - 5 May	20 Sep - 22 Sep	22 May - 24 May	11 Apr	29 Nov	4 May	9 May	15 May	13 May

Resource intensive planning

Limitations of the underlying electrical calibration principle

Neglects ground coupling, impacts data availability and mission capability, no measurement traceability

SnT 2023 - Conclusions of the panel on Metrology

3. « The **benefits** of further collaboration with the metrology community and linking IMS monitoring within the SI include:

- greater take-up of **measurement traceability**,
- **mutual acceptance** of global calibration capability,
- better **understanding of uncertainty** in measured quantities,
- better characterization of sensors' **susceptibility** to the environment and installation conditions,
- enhanced **interoperability** stemming from performance-based specifications for equipment and common operating procedures.

Such benefits impact all stages from equipment specification and type approval, through to onsite calibration ».

Looking forward

Knowledge **dissemination** to CTBTO community, and beyond!



CTBTO continues to collaborate with IMS service providers to address the needs for traceability **to the station**



Sensors deployed in harsh environments, for their **lifetime**

- Need to better understand the sensors **“in-service”**
- Need to know the impact of the **environment** on sensors characteristics

Conclusion

- **Metrological traceability** for IMS measurements is key to further increase trust and sustain credibility in IMS data in the long term
- The international metrological community is working on extending its **measurement and calibration capabilities** towards lower frequencies
- CTBTO continues to collaborate with **infrasound** community to advance infrasound quality assurance in IMS Operations.
- CTBTO welcomes the efforts of expert laboratories to develop **traceable measurement services**. This will allow IMS to rely on service providers, ensuring consistency and efficiency in QA across its global network.
- CTBTO engages with the seismic community. **IMS seismic operations** can leverage established best practices in national networks and draw from recent successes in quality assurance for IMS infrasound measurements





SnT 2025

CTBT: SCIENCE AND TECHNOLOGY CONFERENCE

8 TO 12 SEPTEMBER

HOFBURG PALACE, VIENNA & ONLINE

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