

Scheduled Calibration of International Monitoring System Seismic, Hydroacoustic and Infrasound Stations

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INTRODUCTION

Scheduled Calibration of seismic and infrasound measurement systems are performed on an annual basis in compliance with data quality requirements of the IMS Operational Manuals.

METHODS/DATA

Method for seismic: electrical calibration.

Method for infrasound: calibration by comparison using a permanent reference system.

In both cases, a software was developed to support the Scheduled Calibration process.

START

RESULTS

This poster presents:

1. An overview of the Scheduled Calibration process
2. Current and historical calibration results
2. An overview of progress and challenges for the calibration of seismic and infrasound measurement systems

CONCLUSION

Calibration of measurement systems is crucial to monitor and ensure data quality.

Although continuous progress is made, significant efforts remain to be made to fully meet the Operational Manuals requirements over the whole IMS network.

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- “Stations are provided with the **means to carry out a calibration** whose result can be compared against a reference that was established at the time the station was certified or when a revalidation was completed at the station”
- The calibration performed at the time of the station certification or revalidation is referred to as “initial calibration”. “The result of the initial calibration forms the **baseline** for certification and future calibrations”
- The calibration performed on a regular basis to verify that the system response remains “**within tolerances**” of the baseline is referred to as “on-site calibration”.
- “When the results of the calibration are **not within tolerances**, the station operator informs the Technical Secretariat and initiates the **required maintenance**.”
- On-site calibrations are performed **at least on a yearly basis**
- Both initial and on-site calibrations are “**full frequency response calibrations**”



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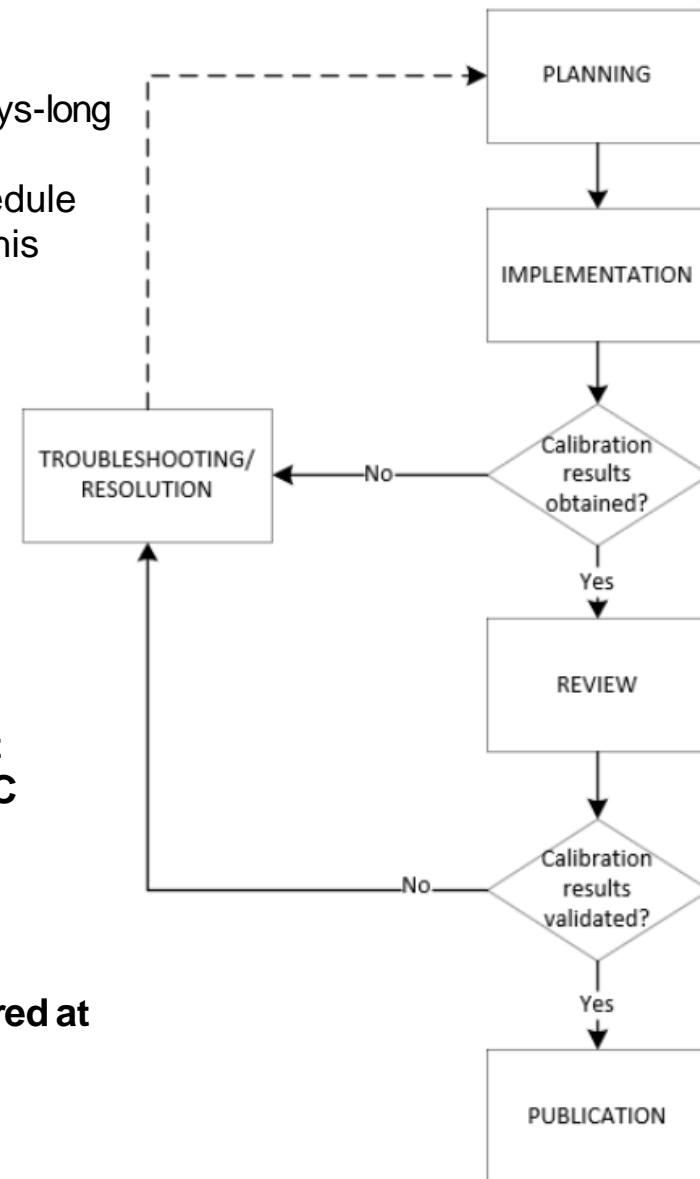
Scheduled Calibration in 4 Phases

Planning: For each station: **PTS generates initial calibration schedule** with two 3-days-long alternative time windows: Main Time Window (**MTW**) and Backup Time Window (**BTW**). **PTS broadcasts** a message to the Station Operator (**SO**) including the calibration schedule and other relevant information on calibration activities. The **SO** is requested to **review** this message **and report** on any potential issue expected to affect calibration activities. The **calibration schedule** for the station is **defined**.

Implementation: For each station the **SO performs calibration tasks to obtain calibration results**. The raw results are typically a list of frequency, amplitude, phase triplets obtained using software or manual computation. The **results** are then **categorized by the SO** as being within or outside the minimum requirements for calibration, as defined in the IMS Operational Manual. The **PTS and SO communicate through** an exchange of **Command and Control (C&C) messages**.

Review: For each station the **PTS verifies that the reported calibration results meet expected data quality criteria and are consistent with information stored in the IDC database**. If any issue is identified, the PTS contacts the SO to **coordinate troubleshooting**; otherwise, calibration results are **validated**.

Publication: For each station **validated calibration results are made available to Authorized Users**. The available values correspond to the **system sensitivity measured at the nominal reference calibration period for each calibrated channel**. Only results compliant with OM requirements are currently made available to Authorized Users.



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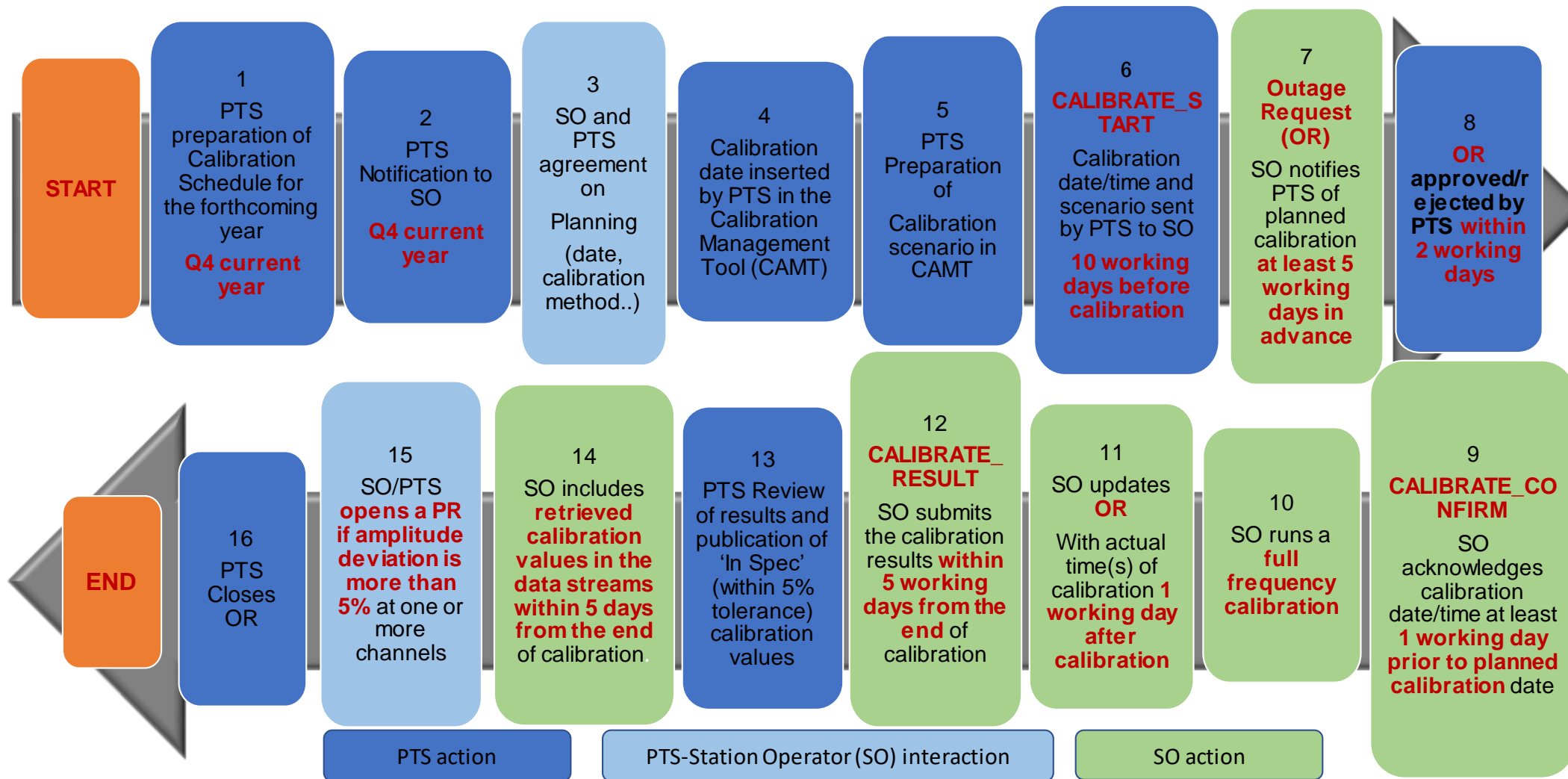
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Seismic and Hydroacoustic T-phase Scheduled Calibration process



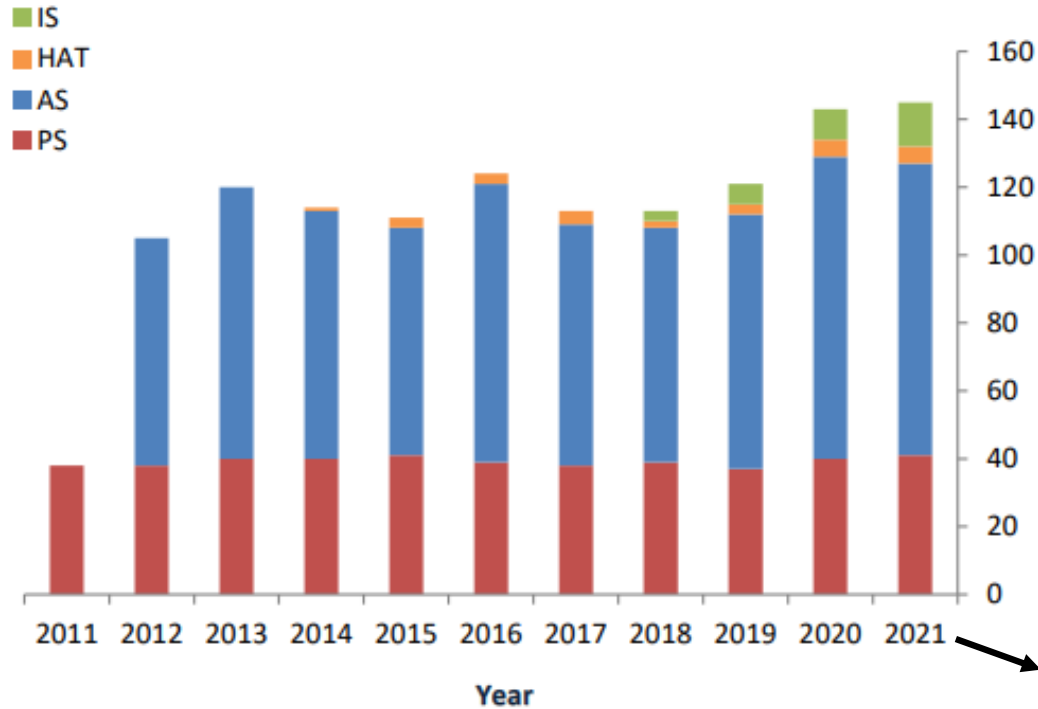
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Scheduled Calibration: 2021 and historical results

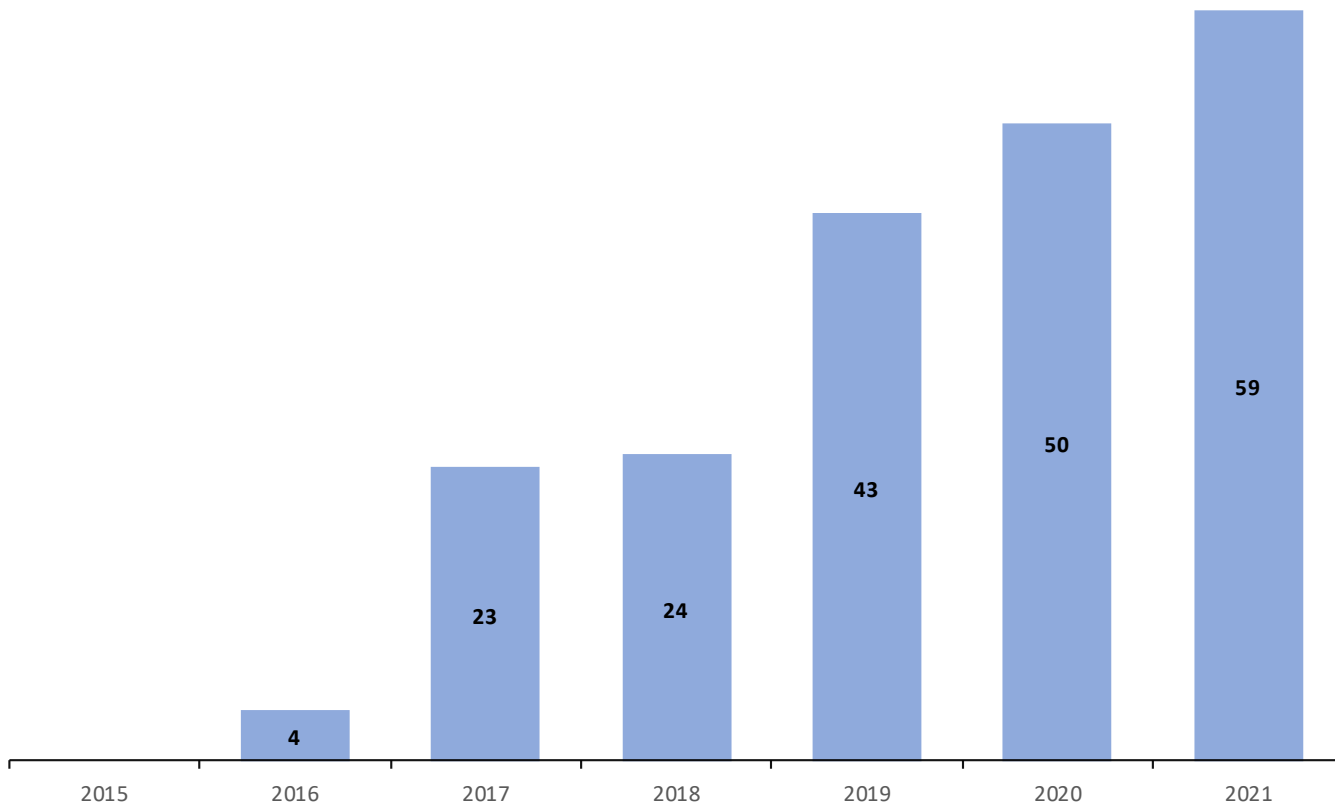


Summary of scheduled and performed station calibrations in 2021.

- High number of calibrations performed at Primary Seismic stations.
- Increased number of calibrations at Auxiliary Seismic stations in the recent years
- Progressive and continuous increase of number of calibrations at Infrasound stations since 2018

Type of Station	Total Number of Certified Stations	Scheduled Calibrations	Scheduled as Percentage of Total Number of Certified	Performed Calibrations	Performed as Percentage of Total Number of Certified	Performed as Percentage of Scheduled
All Types	210	151	72%	145	69%	96%
Primary Seismic	44	41	93%	41	93%	100%
Auxiliary Seismic	108	92	85%	86	80%	93%
Hydroacoustic T-phase	5	5	100%	5	100%	100%
Infrasound	53	13	25%	13	25%	100%

Seismic and Hydroacoustic T-phase Scheduled Calibration Submission of Full Frequency results in IMS2.0 format



PTS support SOs for requested delegated calibration and formatting issues:

Additional 7 Stations in 2020

Additional 9 Stations in 2021

Continuous efforts made by PTS and SOs to increase the submission of Full Frequency results in IMS 2.0 format



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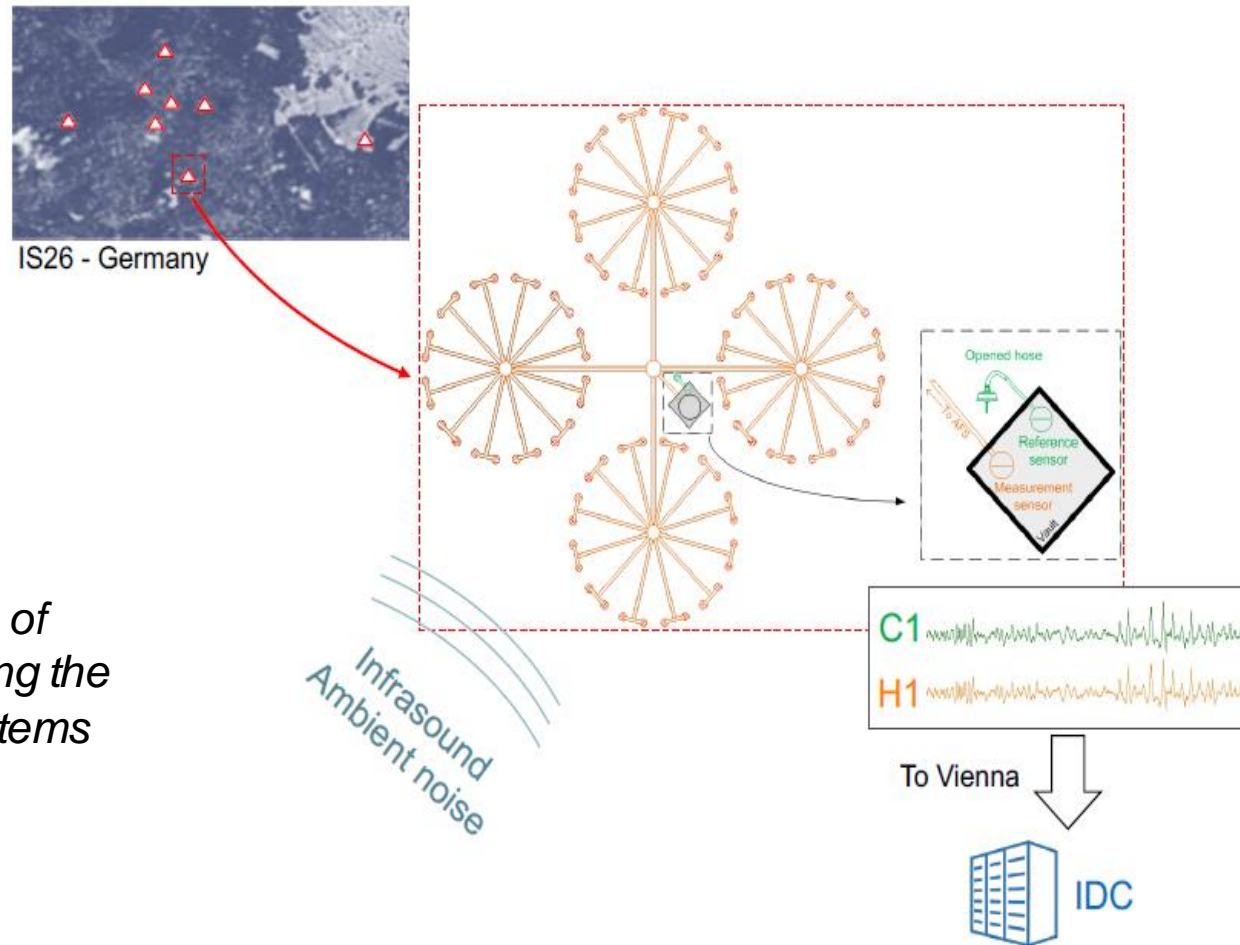
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Infrasound Scheduled Calibration: Calibration by comparison

Scheduled Seismic, Hydroacoustic T-phase and Infrasound Calibration are based on two different principles: in the first case the calibration signal is injected in the sensor once per year for a limited duration of time (minutes, hours). In the second case there is a continuous parallel recording of data spanning across the year.

Station equipped with **calibration capabilities**:

- **reference** sensor, reference pipe/inlet port
- **second** data stream (reference system) forwarded to the IDC
- **Gabrielson's** method: *In situ calibration of atmospheric-infrasound sensors including the effects of wind-noise-reduction pipe systems*
- → **“Passive calibration”**

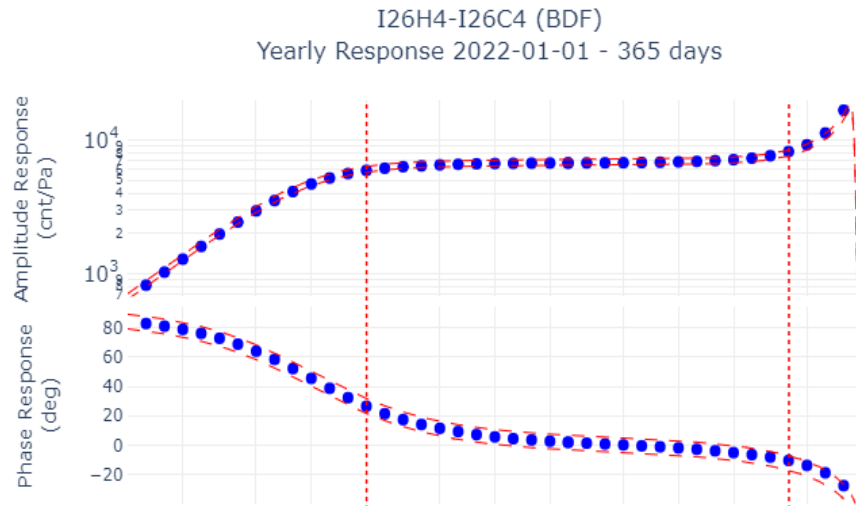


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```

BEGIN IMS2.0
MSG_TYPE COMMAND_RESPONSE
MSG_ID cal_202212061148_I26H4_cr
REF_ID cal_202212061148_I26H4_cs
TIME_STAMP 2022/12/06 11:48:59
STA_LIST I26H4
CHAN_LIST BDF
CALIBRATE_RESULT
IN_SPEC no
CALIB 0.000149
CALPER 4.000000
DATA_TYPE RESPONSE IMS2.0
CAL2 I26H4 BDF MB3a 1.48840070e-04 0.250 20.00000 2022/12/06 11:48:59
FAP2 1 C 0.000 80
0.00126 8.16417844e+02 82
0.00158 1.02321405e+03 81
0.00200 1.27919375e+03 78
0.00251 1.59314969e+03 76
0.00316 1.97320522e+03 72
  
```

- Scheduled Calibration **process already supported by software** (CalxPy) for IS stations equipped with calibration capabilities: The software allows results computation, review and archiving of results.
- Station results **computation centralized** at PTS facilitate calibration planning activities
- **Passive** and **continuous** calibration allows the regular assessment of instrumental response considering also changes in environmental conditions.

[see also presentation PTS-680 on infrasound stations calibration] [see also ePoster on CalxPy]

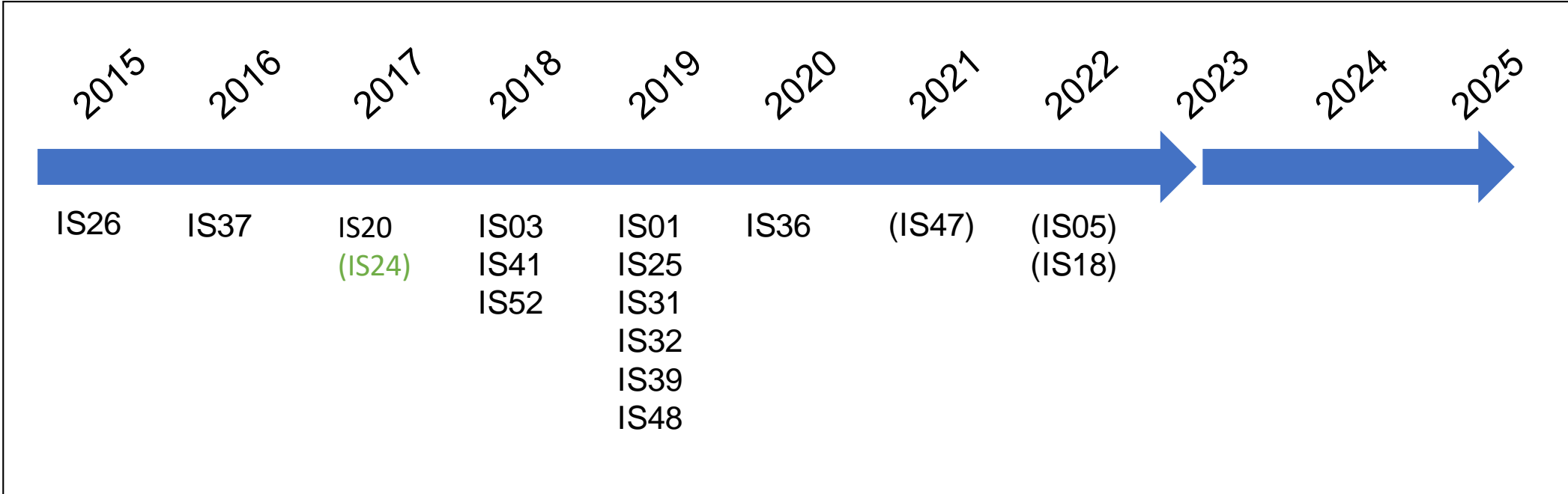
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Infrasound Scheduled Calibration: deployment of calibration capabilities at the IMS Infrasound Network.

- Calibration capabilities and timeline for implementation timeline
- **Results reported** to Member States since 2019
- **13 stations** reported in 2022
- **Delay** between the installation of calibration capabilities and results reporting: upon installation of the array for data comparison, the first year is focused on the definition of the baseline (reference) values.



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Challenges for seismic:

- Progress in the percentage of calibration performed
- Progress in the percentage of full frequency results received
- High level of resources required (especially for planning and review phases)
- Alternative/enhanced solutions (e.g. passive seismic calibration) to be developed?

Challenges for infrasound:

- Continue the roll out the calibration capability at all infrasound stations



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Operational Manuals:

- CTBT/WGB/TL-11,17/15-REV.7
Operational Manual for Seismological Monitoring and the International Exchange of Seismological Data
- CTBT/WGB/TL-11,17/16-REV.7
Operational Manual for Hydroacoustic Monitoring and the International Exchange of Hydroacoustic Data
- CTBT/WGB/TL-11,17/17-REV.7
Operational Manual for Infrasound Monitoring and the International Exchange of Infrasound Data

For further information on the [Scheduled Calibration of IMS Infrasound Stations](#), see [PTS Talk \[PTS-680\]](#).

For further information on the [software tool](#) used for calibration by comparison, see [ePoster \[P3.1-578\]](#).



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