P4.4-717

Modelling IMS seismic and infrasound networks sustainment needs: data-driven approach for IMS sustainment Planning

B. Doury, I. Ketata, A. Kramer

Preparatory Commission for the Comprehensive Nuclear-Test-Ban Treaty Organization (CTBTO)

CTBTO PREPARATORY COMMISSION

INTRODUCTION AND MAIN RESULTS

This eposter presents the data-driven methodology designed to support and rationalize decision-making for the technical sustainment of the International Monitoring System (IMS) and to anticipate long-term network needs.

This methodology already informs PTS sustainment planning and, when integrated with the financial approach, provides a strong basis for the IMS sustainment strategy. The approach is in continuous development to further improve its accuracy and usefulness for decision-making.

DISCLAIMER: The views expressed on this poster are those of the author and do not necessarily reflect the view of the CTBTO

SnT 2025
8 SEPTEMBER ONLINE DAY
9 TO 12 SEPTEMBER AT HOFBURG PALACE, VIENNA & ONLINE
CTBT: SCIENCE AND TECHNOLOGY CONFERENCE

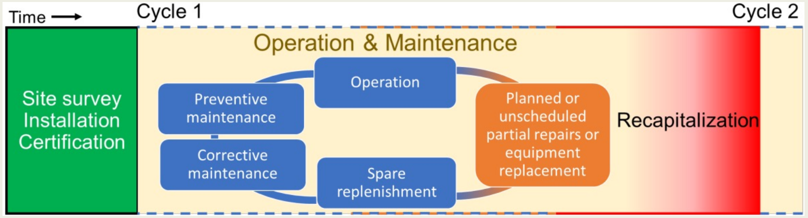
Modelling IMS seismic and infrasound networks sustainment needs: data-driven approach for IMS sustainment Planning

B. Doury, I.Ketata, A. Kramer

P4.4-717

Introduction

30 years after its inception, the IMS network has transitioned from its initial phase of installation and certification to an era of ageing equipment and infrastructure, a transparent and rationalized approach to sustainment planning has become essential.



Life cycle of an IMS station

The data-driven methodology presented here models IMS seismic and infrasound stations as a set of subsystems and applies risk analysis to derive **technical sustainment requirements**, using both data and expert insights. It focuses exclusively on the technical dimension of sustainment; financial aspects are addressed through a complementary method. Ultimately, both approaches must converge to provide a comprehensive picture of future IMS needs. Preliminary results already demonstrate the value of the technical assessment in identifying future requirements and informing discussions on sustainment strategies within the PTS.

Objectives

The process of station recapitalization planning is composed of 3 stages:

The objective of this effort has been to develop and adopt a data-driven approach as a structured basis for identifying risks, prioritizing upgrades, and planning recapitalization activities. By establishing a transparent and systematic process, the methodology underpins the development of software tools (see poster P4.3-854) that will assist technical teams and management in implementing the sustainment strategy.

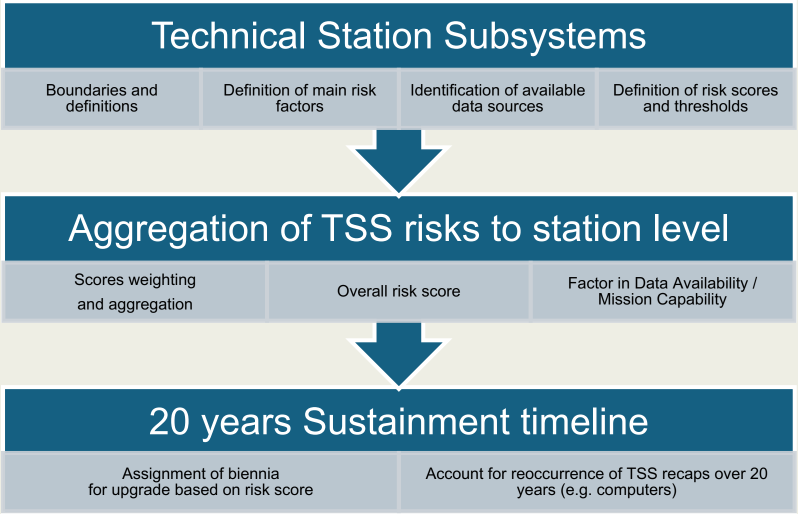
P4.3-854: Ketata et al. - Advancing Decision-Making and Sustainment of Seismic and Infrasound IMS Network: From a Data-Driven Methodology to Network Summary in MuTIP

Method

Each seismic and infrasound station is broken down into Technical SubSystems (TSS). Risks are assessed at the subsystem level, then combined to derive an overall station risk score. This score is used to prioritize upgrades and to build a sustainment timeline that also accounts for recurring recapitalization needs.

Technical Station Subsystems (TSS)		Station Risk Rating (1 = very low, 2 = low, 3 = medium, 4 = high, 5 = very high)		
		Probability of failure of TSS	Impact of failure of TSS	Overall Risk Rating
TSS	Sensor main	4	3	12
	Sensor reference	5	3	15
	Digitizer	4	4	16
	WNRS	4	4	16
	Power	3	3	9
	Communication	3	3	9
	Software and computer	2	5	10
	Security	1	1	1
	Infrastructure	3	5	15
	Grounding and Lighting	2	4	8

Example risk rating of an IMS infrasound station



CTBTO PREPARATORY COMMISSION

DISCLAIMER: The views expressed on this poster are those of the author and do not necessarly reflect the view of the CTBTO

SnT 2025
8 SEPTEMBER ONLINE DAY
9 TO 12 SEPTEMBER AT HOFBURG PALACE, VIENNA & ONLINE
CTBT: SCIENCE AND TECHNOLOGY CONFERENCE

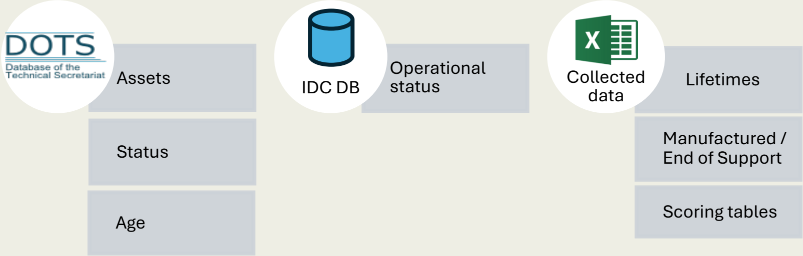
Modelling IMS seismic and infrasound networks sustainment needs: data-driven approach for IMS sustainment Planning

B. Doury, I.Ketata, A. Kramer

P4.4-717

Data

The data assessment resulted in the identification of a few parameters that would be used to determine the probability and impact of failure of a given subsystem.



In the below example, depicting the TSS "sensor" for infrasound sensors (microbarometers),

- the probability score is derived from the age of the equipment as a percentage of its expected lifetime,
- The impact score is computed based on the obsolescence of the equipment (whether it is still manufactured and/or supported), and the robustness of the station (the number of sites).

Station	Max of % Lifetime	Probability score	Count of Site	% MBs Supported by manufacturer	Impact score manufactured ratio	Impact score number of sites	Total impact score as max	Overall risk rate Microbarometer	Timeframe
I01AR (IS01)	29.81	1	8	0%	1	2	2	2	20
I02AR (IS02)	91.92	4	5	100%	5	4	5	20	2
I03AU (IS03)	35.19	1	7	0%	1	3	3	3	20
I04AU (IS04)	77.40	3	8	100%	5	2	5	15	6
I05AU (IS05)	18.16	1	8	0%	1	2	2	2	20
I06AU (IS06)	54.08	2	8	100%	5	2	5	10	10
I07AU (IS07)	122.21	5	8	100%	5	2	5	25	0
I08BO (IS08)	108.89	5	4	100%	5	5	5	25	0
I09BR (IS09)	104.15	5	4	100%	5	5	5	25	0
I10CA (IS10)	112.34	5	4	100%	5	5	5	25	0
I11CV (IS11)	14.78	1	8	0%	1	2	2	2	20
I13CL (IS13)	98.04	4	8	100%	5	2	5	20	2
I14CL (IS14)	100.53	5	8	100%	5	2	5	25	0
I17CI (IS17)	107.37	5	4	100%	5	5	5	25	0
I18DK (IS18)	10.04	1	8	0%	1	2	2	2	20
I19DJ (IS19)	9.89	1	8	0%	1	2	2	2	20
I20EC (IS20)	40.95	2	8	0%	1	2	2	4	18
I21FR (IS21)	96.75	4	4	100%	5	5	5	20	2
I22FR (IS22)	109.00	5	4	100%	5	5	5	25	0
I23FR (IS23)	69.89	3	15	100%	5	1	5	15	6

Results

The data-driven approach provides recommendations, not decisions.

- The methodology was in part developed and applied to support the technical component of the **sustainment strategy** presented to the Preparatory Commission subsidiarybodies.
- These recommendations are **already used** by PTS staff to inform experts and management during their bi-yearly sustainment planning meetings.
- Integration with the **financial component** of the sustainment approach allows better anticipation of the cost of upcoming recapitalization projects.
- The sustainment strategy is an important driver of **Quality Assurance** infrastructure for IMS seismo-acoustic measurements. [P3.1-727]

P3.1-727: Doury et al - Advancements in quality assurance for the International Monitoring System and calibration challenges for seismic and infrasound technologies

Looking forward

Considerations for enhancing the approach's accuracy and utility in Sustainment Planning:

- Development of a streamlined software **solution** [P4.3-854]
- Expanding coverage to all subsystems.and refining and enriching the risk factors.
- Supporting the planning of partial station upgrades.
- Integrating **prioritization factors** into the model, including remoteness, environmental conditions, supply chain constraints, and network-level strategic considerations.
- Refinement to allow a **hybrid maintenance strategy**, combining reactive, preventive, and predictive methods, tailored to the specific technologies and subsystems involved.

SoH monitoring (detectability)	Quality Assurance infrastructure (Type Approval)	Failure Analysis	Equipment tracking and lifecycle management

CTBTO
PREPARATORY COMMISSION

DISCLAIMER: The views expressed on this poster are those of the author and do not necessarly reflect the view of the CTBTO