

IPGSA sampling competence: Crucial added value to international standards

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Current ISO sampling standards and other international standards containing chapters on sampling such as JIS (Japanese Industrial Standards) and ASTM (American Society for Testing and materials) are useful norm-giving documents for industry, regulatory and governmental bodies, research organisations and other stakeholders with which to optimise sampling protocols, monitoring their implementation efficiency, and assessing their performance. Yet, after ten World Conferences on Sampling and Blending (WCSB) over 20 years in which many sampling experts and practitioners brought their valuable experience, knowledge, and innovative proposals to the world sampling community, most of these standards have not been revised and updated to incorporate this body of essential competence, except for DS3077 (2013) Representative Sampling – Horizontal Standard. In this paper we call for the sampling community's support and active participation to ensure that this crucial experience and knowledge is incorporated into current standards and made available to society at large. Unless we succeed in this endeavor, the accumulated contribution of the unique series of WCSB conferences will miss the opportunity to influence the world of standards with this necessary competence. WCSB documentation constitutes a precious scientific foundation for continuing to provide valuable support to minerals exploration, mining, industrial process control, certification of trading commodities, risk assessment, and creating university programmes to teach academe and students an essential and inescapable branch of science and technology: the theory of sampling.

INTRODUCTION

The present authors' extensive experience, gained through focused university teaching, extensive consulting to private, industrial and regulatory clients, supporting governmental bodies and collaborating with research organizations worldwide over many decades, reveals a worrying fact: the knowledge acquired by ten WCSB conferences, and parallel sampling conferences under the auspices of the Australasian Institute of Mining and Metallurgy, Southern African Institute of Mining and Metallurgy and various South American regional conferences, is not sufficiently exploited to improve the world's sampling practices and – worse – often makes no difference regarding ubiquitous sampling malpractices observable throughout society at large. The world is still full of non-probabilistic sampling practices occurring in all sectors of science, technology, industry, trading, testing, inspection, certification and organisations which support regulatory oversight. Moreover, the expectation is that we will continue to see manufacturers installing non-probabilistic, non-representative sampling systems, and reputable engineering firms promoting incorrect, biased, sampling systems in new projects. Today we still detect a plethora of normative documents lacking recognition for the role and impact of proper sampling in critical decision-making processes.

In essence, after 20+ years of hard work, we sadly observe many instances of proper sampling largely being neglected (though with important exceptions to be outlined). The lesson has become clear: unless we coordinate our efforts better with those of relevant standardisation committees, we will likely not be able to change sampling malpractices to a sufficient degree to make a real change.

We see two main difficulties on the road forward:

1. Despite tremendous efforts over 20 years, the theory of sampling (TOS) is not recognised as a key, transversal discipline, essential in all societal sectors in which informed decision-making is dependent upon reliable analytical results and representative samples.
2. International sampling standardisation committees and the International Pierre Gy Sampling Association (IPGSA) and WCSB members/experts do not communicate effectively with each other.

The prime objective of this paper is to open and promote a constructive dialogue between all sampling experts and practitioners within the IPGSA and beyond, to work together to establish the TOS as a scientific discipline that warrants global recognition, understanding and interpretation. In this respect, the sampling community should foster an open and constructive dialogue to elevate sampling to the level of a globally recognised scientific discipline, co-equal with engineering, analytical chemistry, statistics, and data analysis. This paper is the first step on this journey: outlining a roadmap for critically-needed improvements.

Moving forward - together

We see two main issues preventing a constructive dialogue among sampling practitioners: the role of individual sampling experts and that all too well-known universal human condition: resistance to change.

Role of individual sampling experts

Scientific progress relies on constructive open minds, critical attitudes, well-tested problem-solving skills, and extensive collaboration. Asking questions drives science forward, and scientists with different perspectives often ask different questions, which enhance the possibilities for collective innovation. This is true in all scientific disciplines, and the sampling realm is no exception. The IPGSA promotes and fosters sampling communication at all levels [1], with the WCSB series offering the right environment to facilitate this essential scientific dialogue. This activity has hitherto mainly been led by a small number of elite sampling experts, who before 2000 primarily worked individually in relative isolation, save for meeting briefly at the biannual WCSB conferences.

Resistance to change

Inertia and resistance to change are among the most difficult obstacles encountered to implement the benefits offered by TOS. Most individuals, sampling experts being no exception, are comfortable and familiar with existing routine procedures, and do not see obvious advantages in changing a beloved status quo. Occasionally, resistance is expressed through scepticism, negativity, and lack of attention, i.e., by emotions hampering willingness to embrace dialogue and change. Furthermore, organisational culture may play a significant role in influencing how people respond to change. Rigid hierarchical structures, especially within large companies and organisations in the private as well as in the public sector, may object to deviations from established norms, creating barriers to change of any kind. Many industries, research facilities, governmental bodies and public institutions pursue sampling practices that have been in use for many years, sometimes decades. These practices are often far from aligned with the principles of TOS. The perceived lack of practicality, existing organisational traditions and constraints, combined with a lack of awareness and education, often complicate our task to establish a convincing package of useful knowledge and competences that will bring benefits. The series of WCSB conferences is the appropriate environment to facilitate this much-needed dialogue and open exchange of diverging views with the common objective of further enriching each other, and all stakeholders. The documented history of achievements presented at WCSB1 to WCSB10 stands as a testimony of this enabling role; the

full proceedings archive for all conferences can be found on the IPGSA website: <https://intsamp.org/proceedings/>

WCSB – Notable achievements 2003-2023

From day one, the mission of WCSB has been to make TOS known to the world and to ensure its practical implementation and continuous evolution: the TOS, rooted in Dr. Pierre Gy's work, is today a fully-fledged scientific theory enriched by the fundamental works of Gy, Visman, Ingamells, and others.

The range of societal sectors addressed by WCSB has increased steadily since 2003, when mining, minerals processing and the cement industry sectors dominated until 2023. Since then, new sectors in science, technology and industry have appeared and demonstrated the broader usefulness of TOS in new application fields, e.g. environment monitoring, agriculture, food, feed and pharmaceutical processing, and production industries. In the most recent years new fields linked to an emerging circular economy have emerged in which traditional 'waste' is seen as a raw material in its own rights. In this context, proper sampling (and sorting) is a key critical success factor for being able to treat optimally the vast realm of mixed material.

Educational documentation

Notable progress has been made in the form of published high-quality educational documentation at many entry levels, readily available for any- and everyone interested:

- Textbook, third edition: **Pitard** [2]
- Textbook, **Esbensen** [3]
- Textbook, **Lyman** [4]
- Textbook, **Patricia Smith** [5]
- Compendium, **JOAO compendium** [6]
- Compendium, “**Economic Arguments for Representative Sampling**” [7]

It is fair to say that there exists a very large body of professional documentation regarding TOS, theoretical as well as applied, but it is equally fair to say that the global sampling community has not been effective enough in disseminating this vast body of theoretical and practical knowledge. The work in front of us is, to a large extent, not to produce more educational documentation, but rather to ensure a more efficient distribution. Reflections on reasons why and how to contribute to improved, more effective outreach was presented at WCSB10 [7,8] and is also the subject of a 'Action Roadmap' feature article in the inaugural issue of *Sampling Science and Technology* (2024) [9].

DS3077 – First fully TOS-Compliant sampling standard

July 2013 saw the conclusion of a five-year project: i.e., the design, development, and quality assurance of a generic sampling standard: 'DS 3077 Horizontal', published by the Danish Standardisation Authority. A summary of the history of this endeavour, focusing on salient scientific highlights and paying tribute to the taskforce and to a group of external collaborators responsible for initial proof-of-concept and the final practical quality assurance, can be found in [12]. Since the turn of the millennium, the framework of the TOS has been developed into an axiomatic system comprising six governing principles (GP); eight sampling errors (SE) and five sampling unit operations (SUO) [10, 11].

This framework has served the sampling community well when used as a didactic vehicle presenting an introductory overview of TOSs' main concepts and principles, sampling unit operations and rules for equipment design and implementation necessary for guaranteeing sampling representativity. This framework in its most recent, fully updated overview of TOS (2024) [11], is presented in Figure 1.

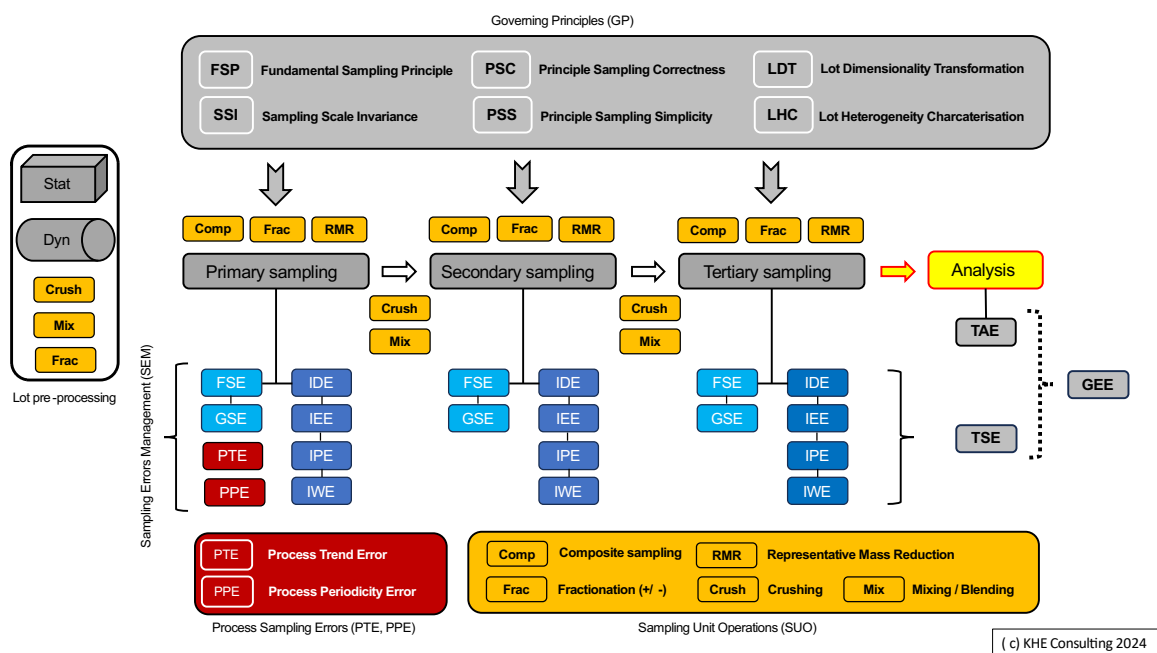


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Figure 1. Graphical overview of the theory of sampling (2024).

DS3077 is the world’s only fully TOS-compliant sampling standard. It is titled ‘Representative Sampling – Horizontal Standard’, emphasising its universal scope regarding all types of heterogenous materials and lots, e.g., rocks, mineralisations, cement, food, feedstuff, industrial waste, environmental samples, and slurries of all kinds – ‘horizontal’ denoting the overlying, universal principles governing sampling (instead of focusing on specific compositional lots only).

DS3077 describes the minimum TOS competence needed for sampling to be guaranteed and documentable as representative, both with respect to accuracy and reproducibility. DS3077 (2013) represents a consensus based on industry, academe, official regulatory bodies, professionals, students, and other interested individuals. In the decade 2013-2023, this standard has functioned as the de facto only international standard for representative sampling. Before this standard, the world was served by extensive but mostly disparate activities of a small group of world-leading authoritative sampling experts: Gy, Pitard, Francois-Bongarçon, Lyman, Minnitt, Minkinen and Holmes. It was precisely the lack of interaction and coordination that prompted the success of the WCSB series; the need for scientific interaction had grown to become overwhelming.

All standards are obliged to be revised at regular intervals, DS3077 being no exception; it has been under comprehensive revision throughout the entire 2023. The updated third revision of DS3077 (2024) was published just before WCSB11 [11].

How to move forward

Since 2003, the WCSB series has revolutionised scientific and technological interaction between individuals, companies, corporations, regulatory and monitoring bodies (national, international and governmental) and other stakeholders where sampling plays a critical role in securing the basis for representative analytical data in support of better decision-making. It is now time to develop a first-ever International Organisation for Standardisation (ISO) sampling standard to provide the authoritative basis for TOS application in all relevant societal sectors.

- DS3077 (3rd ed.) will be submitted as a proposal for a new ISO standard in the first half of 2024, at which time ISO starts its routines for processing new proposals with an international call for interested parties. The purpose of the present contribution to WCSB11 is, amongst others, to make the members of the IPGSA aware of the opportunity to participate in this important work. IPGSA members are encouraged to seek ways to become sponsoring company representatives to the pertinent ISO committee. The global sampling community is also encouraged to interact with pertinent national standardisation authorities, which are the only entities permitted to send representatives to the ISO committee directly. Getting DS3077 successfully elevated to an ISO standard will constitute a quantum leap along the journey outlined in this paper.
- While this ISO process usually takes two to three years (at least), IPGSA shall prepare a survey of guidelines for sampling in existing standards and guiding documents (including relevant company guidelines), to support better harmonisation of the founding principles of representative sampling (TOS) across all sectors involved. IPGSA shall also engage in developing suitable educational documentation at all levels below formal textbooks, of which the world has enough [2, 3, 4, 5, 6]; [7]. This constitutes a unique pitch to all levels of management and business executives, which should be a great work free-for-all (and will be as soon as a suitable sponsor has been identified).
- With 20+ years' experience, matters are now mature enough to raise sampling to the next level: TOS as a comprehensive scientific discipline demanding full recognition. Sampling science and technology has a transcending nature and has the unique feature of affecting all subsequent steps of the pathway 'from lot to aliquot' and subsequent decision-making [8]. TOS is equally important at the industrial and technological sampling frontline as well as in business management and in the boardroom, as has been the recurrent theme in the world's preeminent outreach and teaching environment, sustained throughout the last three to four decades [13].
- Individual action by sampling experts will gradually develop to include the necessary amplification provided by the emerging collective actions of a renewed IPGSA [9]. This augmentation constitutes the critical success factor for the desired end-goal of comprehensive acceptance and implementation of TOS in all relevant sectors in academe, industry, regulation, and society.
- The prospects for the next 20 years of the IPGSA are equally as challenging as the first two decades have been, and are fully within our reach. Let's continue to go further, together!

DISCLAIMER

Claudia Paoletti is employed by the European Food Safety Authority (EFSA). The position and opinions presented in this article are those of the author and do not necessarily represent the views or scientific works of EFSA. The author declares that she has no conflict of interest.

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Colorado School of Mines - Continuing Education and Professional Development “Sampling Theory, Sampling Practices, and Their Economic Impact” (Yearly short course: F. Pitard) <https://learn.mines.edu/sampling/>



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