

TOS: Progress through continuity and community

Francis Pitard, Kim H. Esbensen and Claudia Paoletti



Dominique François-Bongarçon's piece in *TOS forum* issue 3 offered a clear view of the status of the TOS community, summarising where our present knowledge stands, how it is applied today and the challenges ahead. Here we want to continue this effort and share our considerations on how we can go from former knowledge, tradition, to new knowledge and scientific development, without fear of progress and innovation. We also reflect on some more worrisome experiences from the world community of samplers, our scientific duties and on the problem of individualistic pursuits.

World Conference of Sampling and Blending—a resounding success

For the 12 years WCSB has been in existence, there is absolutely no doubt that these events have been beneficial to TOS and its practitioners in many ways:

- Through six WCSB conferences samplers finally had ample opportunities to meet and discuss with each other, creating an intellectually fertile context where new ideas and projects started to develop naturally.
- The WCSB has offered, and continues to offer, the future generation of sampling practitioners, educators and experts a rich training environment to learn, grow and challenge ideas; thus, creating a framework to ensure the future of the TOS community.
- The full spectrum from the academic community to industry and equipment manufacturers are pleased and have gained respect for this forum, its activities and the very relaxed form of communication that allows direct and efficient problem solving.
- Through WCSB the world's top experts in sampling today know each other much better, and rely on a biannual opportunity to share knowledge and experiences according to the fundamental principles of scientific discourse: open and honest dialog, where also disagreement can be constructively addressed.

All is not just good, however

Thus, there is one delicate issue that needs attention: respect for former knowledge. If, today, knowledge from the past may appear less relevant (and perhaps even obsolete), its historical context was never-the-less fully correct for its time, and it provided the necessary foundation to achieve what we have today. This is no different than what we are

doing today; constructing the basis for tomorrow's progress that includes new ways of understanding and using former and historical knowledge. Such knowledge, even if applied in ways that are now no longer front-line, should not be forgotten in the light of today's progress. It is of essential value precisely because it reflects the past intellectual achievements and provides a snap-shot of what was available at a certain point in time, when it represented the best guidelines available to the sampling community. It would be unfair to judge such knowledge only in today's timeframe—just as it would be unfair not to acknowledge that inevitably over the course of time new knowledge arises, opening novel scenarios for the theory and practice of TOS.

Our mission here is to call attention to this mature view of scientific progress in the light of certain occurrences of personal grandstanding observed at several of the recent WCSB conferences as well as behind the lines of our everyday work.

As is the case with history, different approaches can be taken when confronting scientific progress:

1) *The former knowledge and the way it was applied gets completely dismissed*—in the fashion: “Get this old work out of the way, my new approach is far superior (and I am the only one who knows what I am talking about)”. This is a destructive approach, a favourite of egocentrics, never leading to real progress for a scientific community, unless we are talking of a true paradigm shift. Former knowledge was novel at its time and many practitioners in industry could solve their problems in a reasonable way—because there was indeed *some merit* in the ways things were done earlier. As a prominent example of what we are pointing to, take Pierre Gy's rudimentary, graphical variographic analysis of processes for which we will borrow our late friend Pedro Carrasco's words: “*Since we expanded the use of the variogram to study process variability,*

as suggested by TOS, we made significant progress understanding different sources of variability. Now we are in a much better position to effectively control our processes from rock to cathodes.” As a matter of fact, Pedro Carrasco had plenty of extremely successful economic case studies demonstrating his conclusions. So does, for example, Hilde Tellebø (Weber Saint-Gobain) and very many others (see the entire set of WCSB Proceedings), who have presented many practical TOS applications at all levels of complexity for specific process industries with equally important results for efficiency, economic profitability—or for the pure satisfaction of engineering solutions to problems that could not even be identified before the first application of variographic analysis. Whether these applications are simple or complex does not matter. Today's deeper understandings are just as much a consequence of the intellectual path defined both by such applications as well as new, impressive theoretical developments. The point is that our community grows in scientific maturity only because of such *continuity* between former and present knowledge: *continuity* between theory and practice.

2) *The former knowledge and the way it was applied is considered as a vehicle for establishing a new way.* This is precisely what was attempted (perhaps in an imperfect way ... history will judge) when the 2009 doctoral thesis by Francis Pitard made an attempt to reconcile Gy's TOS with Visman and Ingamells' works. At first glance, many were of the opinion that either the one or the other, but not both, could be integrated with TOS. However, this first reaction could not be farther from the truth, because the in-depth analysis presented actually showed not only many similarities, but also several complementary ideas that actually came to fit one another quite well.

We firmly believe, as demonstrated over and again by the history of science, that

all progress is rooted in past experiences. Therefore our emerging scientific community must be able to acknowledge established knowledge and constructively build on it—without blasting away everything that is “former”.

Another challenge we are facing today within TOS is effective communication to the outside world. During the past two decades, TOS has transgressed several scientific boundaries and its applicability is now discussed, albeit not universally implemented, in several disciplines that were not on the agenda when TOS originated, but where sampling plays a definitive role nevertheless: chemistry, agriculture, food and feed safety, a continuing spread of process industries, the geo- and environmental sciences, international trade... We like the phrase “in science, technology and industry”, because it is difficult to consider much valid activity across all of this realm without some basis in proper sampling.

But it is a fact that the dialogue with other communities has not always been easy, effective and smooth—in fact surprisingly often the contrary. Why? Terminology has something to do with this—it must be admitted that some of the terms used in TOS have not always been well understood nor well received in several other important fields (see further below). The lack of universal terminology for sampling leads to the perception (valid, fair or *not*) that TOS was a creation understandable only by experts from the sampling realm. Obviously this situation is beneficial to nobody’s interest. Fruitful developments and enduring progresses, in TOS and beyond, can only be achieved if we continuously improve our communication, if we strive to develop a common language,^a [^aFor example JOAOC Special Guest Editor Section (see page 12 in this issue).] and if we are open for and welcome samplers from all other disciplines and traditions who can in fact challenge and enrich us by broadening TOS’ application fields. Indeed, this objective was one of the main drivers behind the development the world’s first horizontal sampling standard, DS 3077 (2013).¹

The TOS vs MU debacle

Esbensen and Wagner² presented an in-depth analysis of the complex Measurement Uncertainty (MU) concepts, ending in a call for reconciliation between TOS and MU. Here is the essence of their critical analysis: Figure 1 (right panel) shows a standard “fishbone diagram” depicting the

full complement of uncertainty sources of an analytical measurement process. Note that all uncertainty sources connected to sampling, i.e. both sample extraction and those preparation stages involving sampling, are disregarded. It is conveniently assumed that the analytical sample, which ends up as the test portion, has been extracted and mass reduced in a representative fashion. How nice this would be, as long as somebody was responsible! But who? Remarkably, every time the procedures to obtain the test portion in any type of analysis were investigated, it was realised how the responsibility to ensure representativeness was simply missing. Alas, as everybody in the TOS community knows only too well, if the appropriate TOS approaches have not been involved, the resulting uncertainty estimate of the analyte concentration of the test portion is of little value as it unavoidably will be too small to an unknown, but significant, degree. It is structurally flawed and *invalid* as a proper fit-for-purpose MU estimate. This state of affairs was understandably criticised by the authors.^{2,3}

It is necessary to add-in the effects related to all preceding sampling stages. This can in fact be done easily and in a perfectly seamless fashion; furthermore, there is no need to change anything regarding MU_{analysis}, because the MU_{sampling} framework is supplied by TOS. It simply falls to TOS to be responsible for delivering the analytical aliquot for a proper MU_{analysis} estimation. Which is why many from our community are involved in education enterprises with this and related objectives. Who could possibly object to that? Well, many... it turns out.

Sometimes an outreached hand is not respected

Here follow two citations from a review of the work that eventually was published by Esbensen & Wagner.² For readers of this forum there is no need to comment, the citations speak loudly for themselves about the attitude one may experience directed towards TOS specifically and our community’s efforts in general.^b [^bThere is more documentation, but for here these two citations will suffice; a full account of this unilateral unfriendliness can be found in Appendix 7 in Wagner (2013)⁴]

“...there is no need for reconciliation between these two issues, but if this is needed it cannot be done as suggested by the authors by amending a fishbone diagram for the estimation of MU with

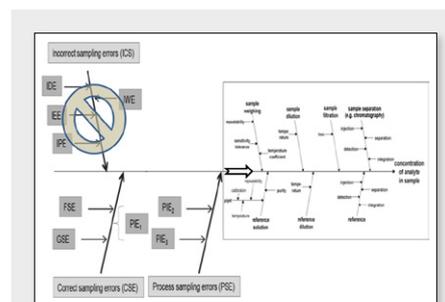
error terms from TOS that largely are not amenable to quantification, but—as the authors contend themselves—have to be eliminated first.”⁵

“Something that must be regarded very strange is the frequent reference to VIM and the VIM-defying language such as “incorrect sampling errors” and “correct sampling errors”: there is no such distinction in metrology, but it presumably dates back to the times when Pierre Gy made up English expressions for his lack of command of this language, a fact he never attempted to deny in personal contact. Nobody has ever come across a “correct error”, but it may be argued that this is a way for TOS freaks to avoid introduction of the notion of random and systematic effects/errors in sampling. Why this is so—except as a reverence for Gy—is completely in the dark.”⁶

“TOS freaks”—indeed.

While these, and similar, transgressions of proper reviewer decorum were duly debunked, and the journal allowing such reviewing left with significantly reduced credibility, the present authors are saddened by such unprofessional, hostile attitude representing a top reviewer from within the MU community. We have at several occasions made a deliberate outreach to this community—alas, mostly with similar results as evidenced above. We shall nevertheless continue to do so on behalf of all of the TOS community. The worrying issues here are both the arrogance (which we must assume is rather a personal, not an institutional character trait) as well as the distinct unwillingness to address sampling issues in a scientific way, first and foremost in the form of how to deal comprehensibly and effectively with *heterogeneity* in all its myriads of manifestations.

Why is this? Most likely because ensuring representative sampling is considered so



The standard analytical fishbone diagram with conventional MU measurement uncertainty sources (right panel) with preceding TOS uncertainty sources (right panel), see Esbensen and Wagner¹ for details.

“difficult” that is preferable to ignore the problem rather than facing it. Our TOS community has a specific responsibility in this context and must devote significant resources to reach out the samplers outside the present community to offer didactic solutions directly oriented towards the specific sampling needs of various disciplines, and to continue to enlarge and enrich the educational literature on TOS—not that there is any lack hereof, witness our plentiful literature.

What can be learned from the above? There is still a vast, largely ungrateful task ahead of us in communicating our science beyond current boundaries. Our energies should converge and complement each other in this mission—and various types of lament sometimes expressed *sotto voce* at conferences, for example, regarding worries for “broadening out beyond mining” is only going to slow down not only the fulfilment of our joint scientific responsibility, but also TOS’ scientific progress in general.

LinkedIn sampling discussion groups and Wikipedia

Recently, we were struck by a saddening and difficult-to-gasp attitude in the business social medium, LinkedIn. Here one finds many discussion groups overwhelmingly most of which of very high value, in which discussions are usually held in a proper tone and format; but there are also many fora here, which mainly seem to exist only to create a sounding board for *opinionating* (no further comments needed).

However, we were blown away by one discussion group with a particularly interestingly title: “Theory of Sampling”—with more than 2500 members. The discussion strand referred to below has 45 entries; if you spend 30 minutes here—and we really recommend this—it gives an incredible insight into the kind of discussions the present opinion is directed at. There is so much animosity lack of respect for the historical TOS, indeed often a lack of even the most fundamental of understanding, that it a.o. provoked an entry of our own:

“I found some time to get a jour with the various discussions on sampling in the LinkedIn forum during the holiday season just concluded. I was taken aback with the willingness to join the Pierre Gy-bashing crowd in this particular discussion strand. Sadly I found very little in the way of a comprehensive understanding of the tenets of the Theory of sampling (TOS), Gy. Instead

all manner of substitute justifications for not being willing to do the work needed in getting a full understanding of all the elements in TOS. Since Geoff Lyman has been one of the pivoting centers in this discussion, I would like to direct attention to a joint work recently addressing much of the kind of ‘critiques’ as is leveled in this discussion, which is published in TOS forum, No. 1 (p. 28–31) <http://www.impublications.com/tos-forum>. Observe here a very different, open attitude regarding what constitute scientifically legitimate ways to criticize TOS.”

We encourage TOS forum readers to find time to peruse this discussion, which you’ll find here: <http://linkd.in/1N70ytB>

Where do we go from here?

Before answering this question, we need to take a decision. Scientific progress happens, it is unavoidable. This is embedded in the nature of *Homo sapiens*. Experienced/senior scientists can either choose to focus inward and draw themselves into an easy comfort zone relying exclusively on secure and already established developments, or to constantly welcome new challenges, being willing to risk one’s comfort zones with the humble attitude that learning and developing is a life-long quest. The latter are typically the same scientists demonstrating knowledge of, and encouraging respect for “former knowledge”, because they are well aware of being a part of a broader path that was there before them and that will also be there after them. A successful and scientific challenging future of TOS can only rely on such attitudes.

After 12 years of ever-increasing positive development for our community, signs are beginning to crop up of a more-or-less frantic search for “alternatives” to TOS, including grave examples of declarations that TOS is wrong because it is not founded on conventional statistics—or, slightly more on the less dangerous side, that “TOS is too difficult to be practical”. A full confrontation of such claims is beyond our limits in this opinion piece, but certainly within the possibilities of further debate in TOS forum. And real scientific progress will never happen on a basis of fear of complexity.

We should always be ready to listen and to accept challenges to TOS, but only on the basis of documentable, scientific argumentations. Conventional statistics is a good example of a complacent comfort zone, difficult to leave perhaps because it

offers the certainty of a very well-developed theory of universal fixture: what is the first course in any natural science, technological or engineering curriculum at university? Statistics 101. We do not criticise this state of affairs—but we do point out that heterogeneity is not well covered with standard statistical distributions. Heterogeneity is, uncomfortably for some, more complex than this—this may be an inconvenient truth, but not one our community should shy away from.

At the microscopic level, from our own little circles, we find the evergreen discussion on the apparently unending intricacies involved in the famous “Pierre Gy’s formula” which seems never to die—and the number of extreme *abuses* of this formula are legion, if for nothing else because people who apply it right away have not invested even a modicum of the effort needed to understand its historicity, and its very clear application limits. Limits which very easily are pointed in poignant examples of contemporary critiques of TOS, but which are to be found self-claimed in the pertinent historical literature. Also here one finds more discord, in-fight and divisiveness than a constructive, joint enquiry.

There are thus a growing number of reasons to worry that as a community we are not completely up to the task of stewarding the development of TOS as a joint undertaking. WCSB7 in Bordeaux is our next opportunity to contribute jointly to TOS’ development and future. Let us focus on a journey made together in full respect of past, present and future work and contributions by our entire community, equally welcoming the full historical view as well with complete openness to all new developments and challenges.

References

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3. K.H. Esbensen and C. Wagner, “Why we need the Theory of Sampling”, *The Analytical Scientist* **21**(October), 30–38 (2014).
4. C. Wagner, *Non-Representative Sampling versus Data Reliability*. PhD Thesis, Aalborg University (2013). ISBN 978-87-93100-49-7