KHE Consulting

Theory and Practice of Representative Sampling

Why is sampling the critical success factor before analysis?

- for the seller; for the buyer ; for the middleman, for the arbiter ?
- for the company; for the customer; for the scientist; for the technician?
- for science, technology, industry; for compliance; for safety; for society?

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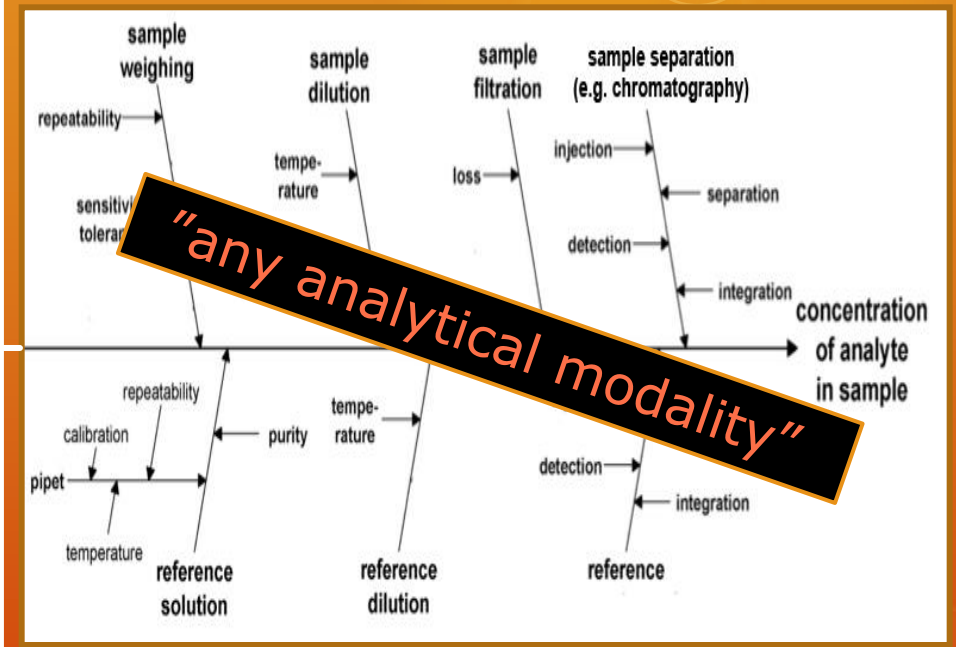
Theory and Practice of TOS Representative Sampling

A minimum understanding of governing principles and sampling unit operations

- all types of materials (all degrees of heterogeneity :low – intermediate – high
- at all scales (for all lot sizes: small – intermediate – big – extreme)
- unifying principles of representative sampling: field/plant/laboratory

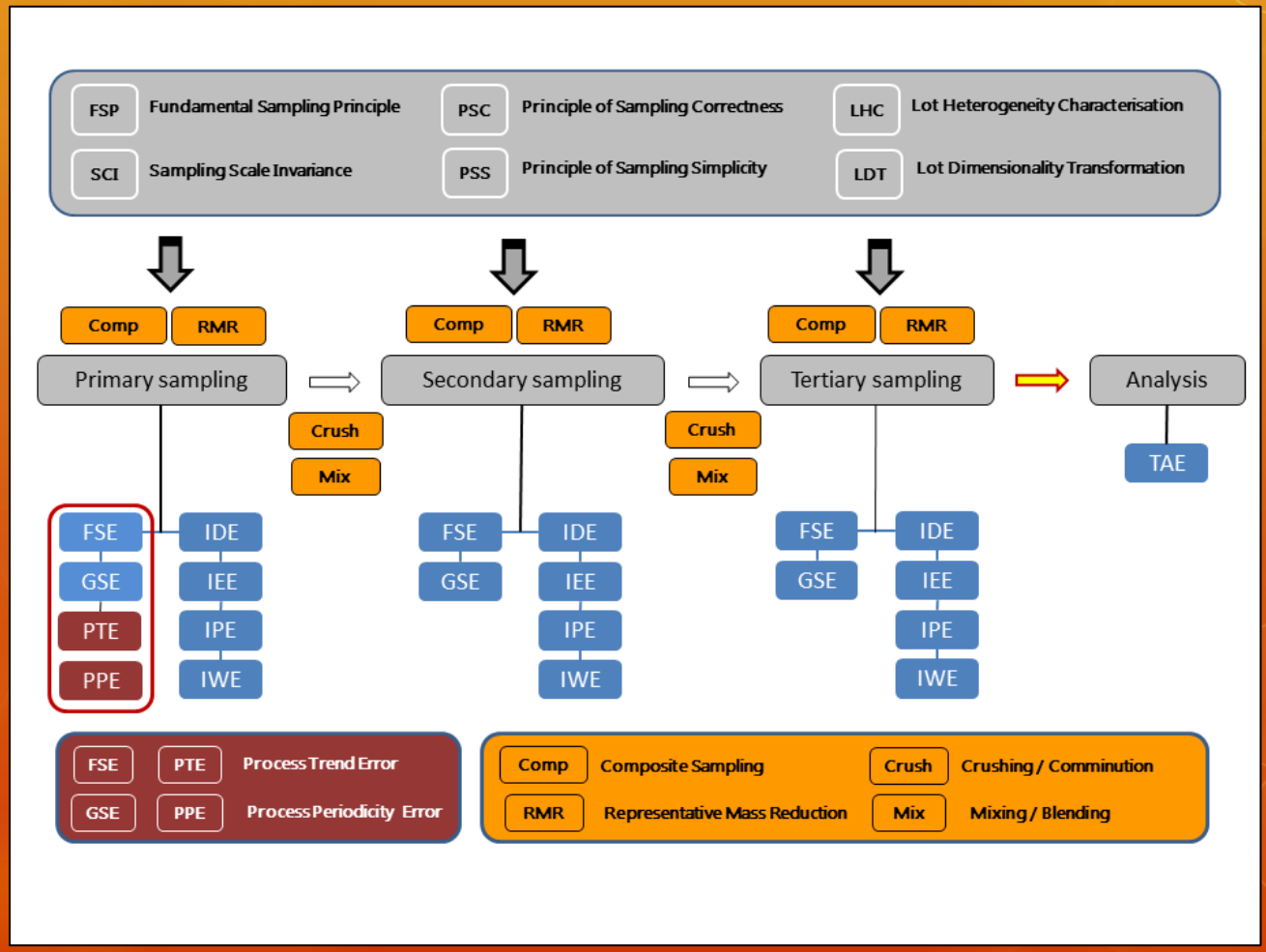
Theory of Sampling (TOS)

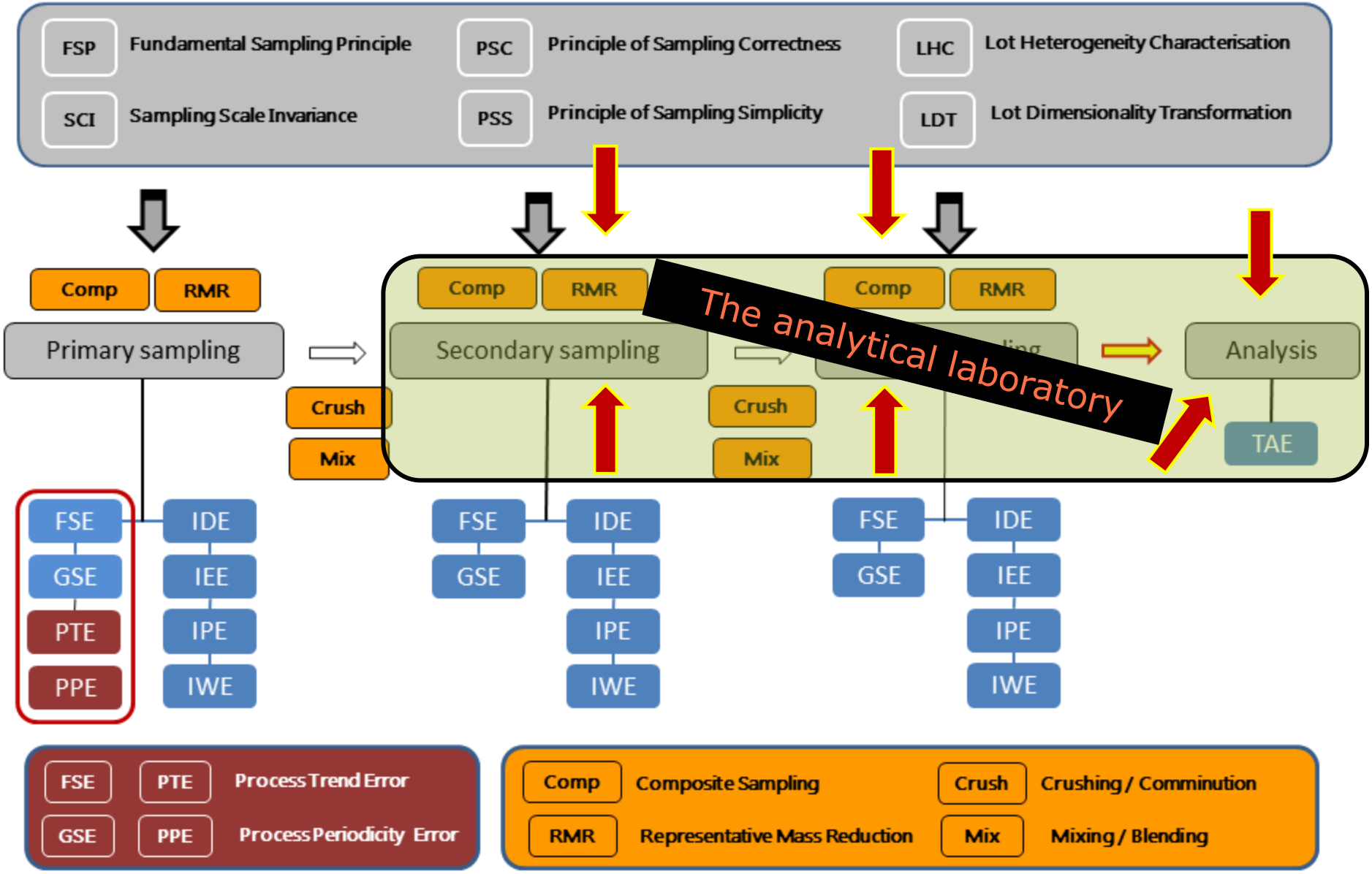
Measurement Uncertainty (MU)



$$MU_{total} = MU_{sampling} + MU_{analysis}$$

Theory of Sampling (TOS) – everything in a glance




FSP
Fundamental Sampling Principle
PSC
Principle of Sampling Correctness
LHC
Lot Heterogeneity Characterisation
SCI
Sampling Scale Invariance
PSS
Principle of Sampling Simplicity
LDT
Lot Dimensionality Transformation
Comp
RMR
Primary sampling
Crush
Mix
Comp
RMR
Secondary sampling
Crush
Mix
Comp
RMR
The analytical laboratory
Analysis
TAE
FSE
GSE
PTE
PPE
IDE
IEE
IPE
IWE
FSE
GSE
IDE
IEE
IPE
IWE
FSE
GSE
IDE
IEE
IPE
IWE
FSE
PTE
Process Trend Error
GSE
PPE
Process Periodicity Error
Comp
Composite Sampling
Crush
Crushing / Comminution
RMR
Representative Mass Reduction
Mix
Mixing / Blending

Representative Sampling: Theory of Sampling (TOS)

TOS - Axiomatic exposé

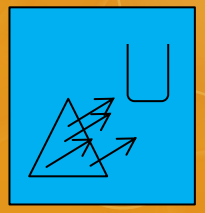
Governing principles (GP) – Sampling unit operations (SUO)

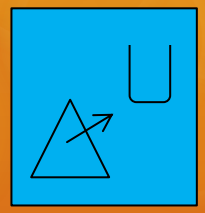
1. FSP: Fundamental Sampling Principle
2. SSI: Sampling Scale Invariance
3. PSC: Sampling Correctness (bias-free sampling)
4. PSS: Sampling Simplicity (primary sampling + mass-reduction)
5. LDT: Lot Dimensionality Transformation
6. LHC: Lot Heterogeneity Characterization (0-D, 1-D)
7. SUO: Composite Sampling
8. SUO: Comminution
9. SUO: Mixing / Blending
10. SUO: Representative Mass Reduction (Sub-sampling)

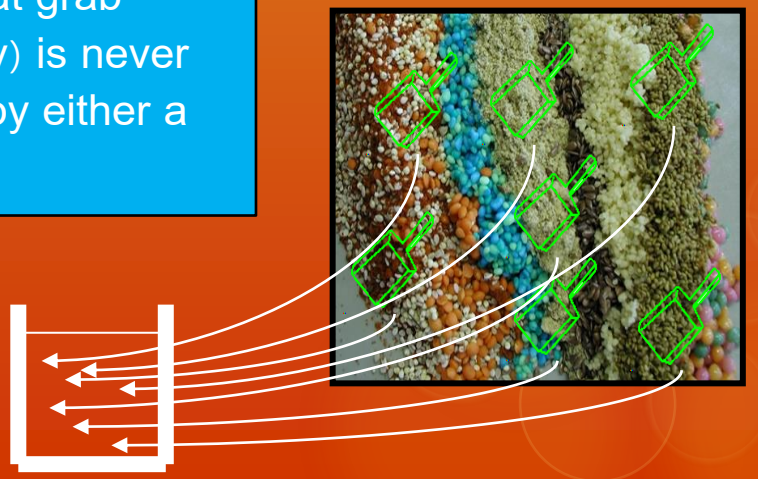
Composite sampling employs Q increment extractions with the aim to 'cover' the lot volume (only Q = 4 increments shown in this principal illustration). Proportional to the heterogeneity encountered, a higher number of increments will be required. Comp samp. must always respect FSP !!!

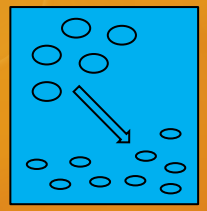
GP (6) Lot Heterogeneity Characterisation (LHC) guarantees that no sampling plan, sampling procedure nor sampling equipment is employed without a mandatory heterogeneity characterisation of the lot material.

Composite sampling is specifically demanding that grab sampling (extraction of one single increment only) is never invoked, unless thoroughly tested and accepted by either a Replication Experiment (RE) or by variographics.





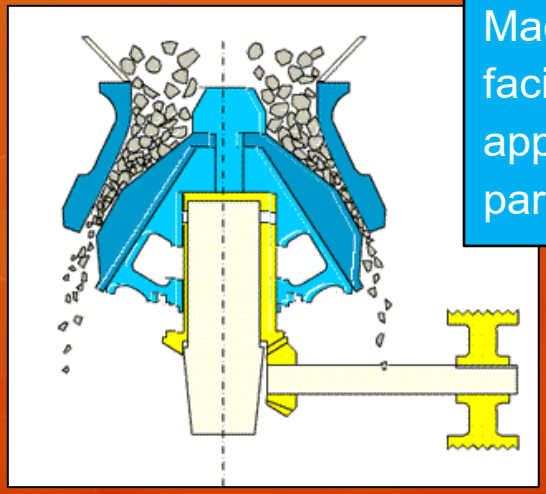


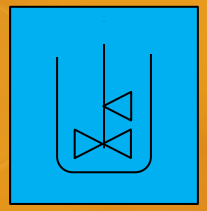


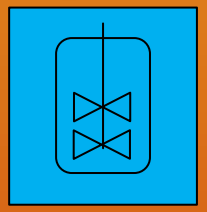
Crushing (**comminution**) is a sampling unit operation which is only brought to bear when necessary, i.e. when the top particle size is contrasting too much with respect to smaller size ranges in order for sampling to be effective and representative. Comminution is the technical process in which the top particle sizes is preferentially crushed first.

A consequence of crushing/comminution is that the majority of particle sizes tend to become more similar, with the further advantage that mixing becomes more effective.

Maceration, crushing or shredding in the presense of a facilitating liquid (often used for selective extraction), as applied to biological materials also lead to reduced general particle sizes.





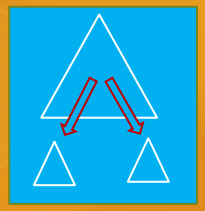


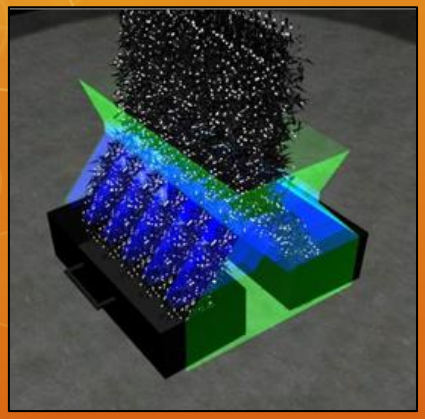
Mixing is a forced mechanical process designed to reduce the distributional heterogeneity (DH) of a material system.

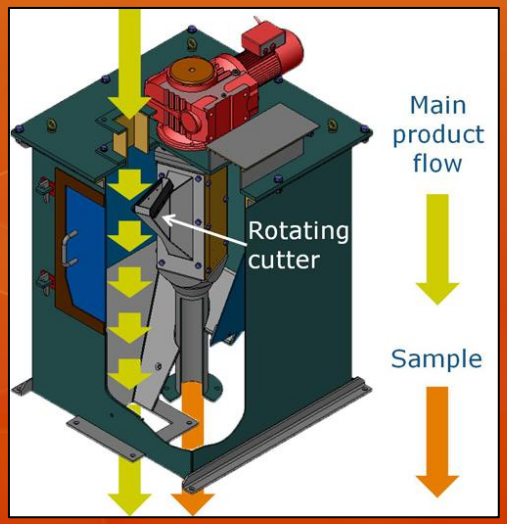
It is always advantageous to mix the results of a sampling or a sub-sampling process *before* further processing (sub-sampling or a next stage mass reduction).

Blending is mixing under stoichiometric constraints, i.e. the final mixing product, a blend, must satisfy compositional constraints e.g. tea, tobacco, cement, pharmaceutical drugs.

Mixing / blending can be applied to both polyphase dry systems (aggregates) and to slurries (solid – liquid systems).







Representative Mass Reduction (**RMR**) is the key sampling unit operation connecting all sampling stages. Often the terms mass reduction and sub-sampling are used inter alia. There are very many sub-sampling procedures and types of equipment offered on the market, but far from all deliver representative solutions.

For stationary lots, the benchmark study by Petersen et al. (2004) showed conslusively that only the *riffle-splitting principle* lead to Representative Mass Reduction (RMR). Riffle splitters have different physical manifestations; both stationary and roraty solutions exist.

For dynamic lots, lots in movement, the *Vezin sampler* is by far the most effective, fully representative RMR equipment in existence. The Vezin sampler is also superior regarding slurries a.o.

Representative Sampling: Theory of Sampling (TOS)

TOS - Axiomatic exposé

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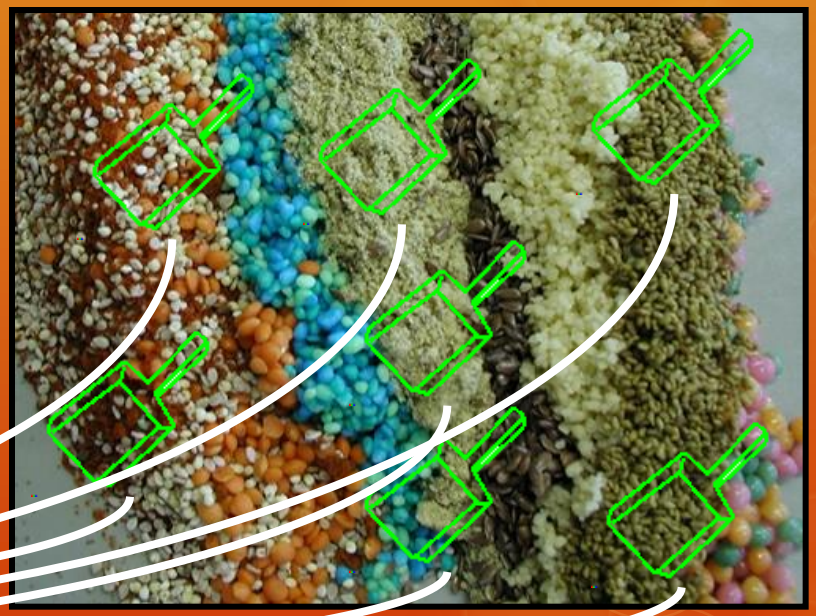
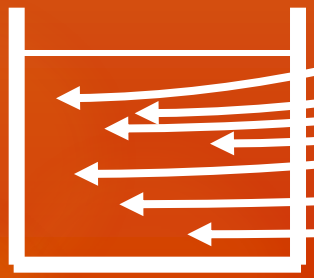
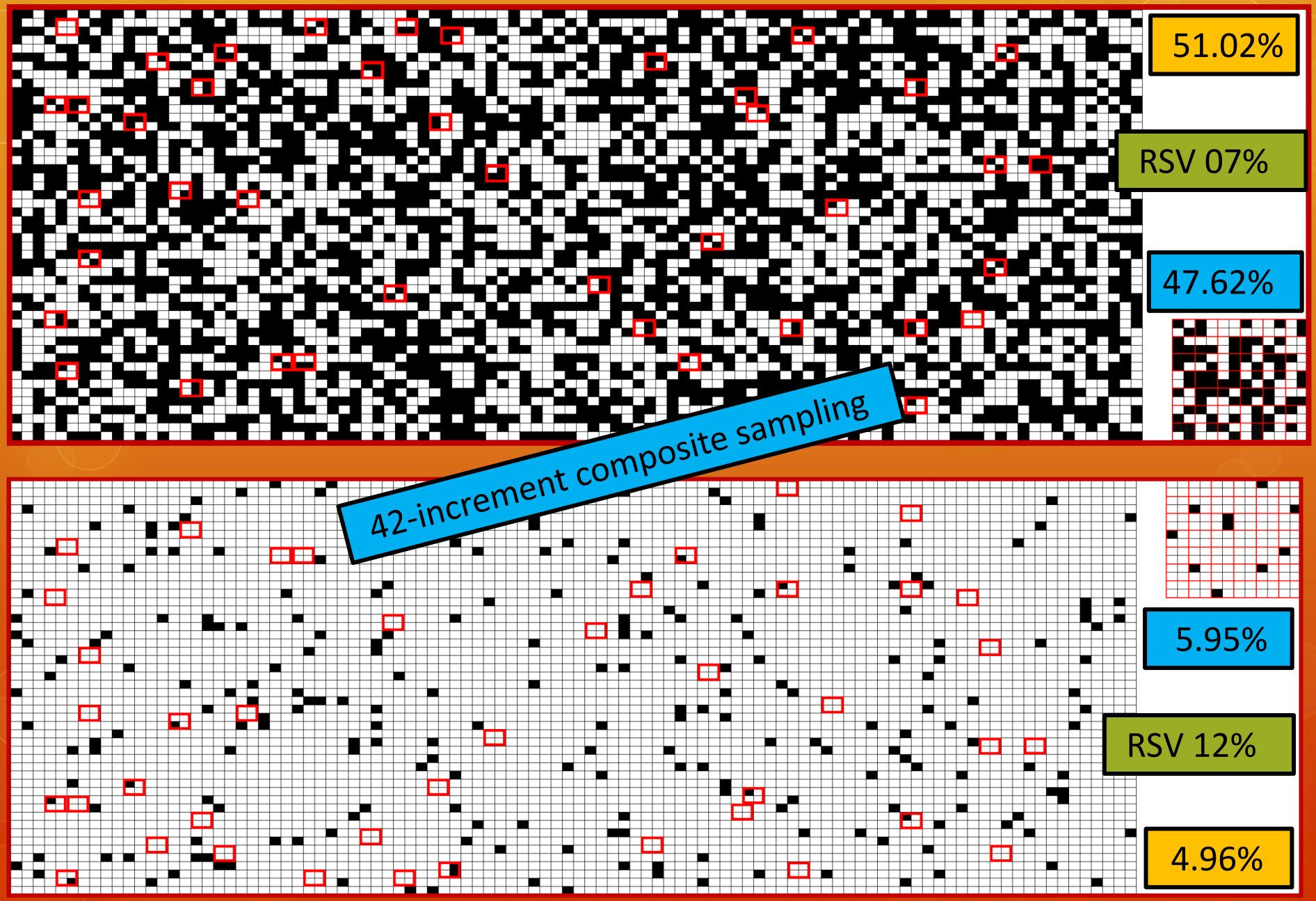
Sampling Unit Operations: Composite Sampling

"Grab Sampling" - "not thinking"





… … *vs.* Composite Sampling … …


51.02%
RSV 07%
47.62%
42-increment composite sampling
5.95%
RSV 12%
4.96%