OPTIMISED MEASUREMENT UNCERTAINTY AND DECISION-MAKING

Incertitude de mesure optimisée et prise de décision

Métrologie 2007 Lille (FR)

***SP Measurement Technology, Box 857, SE-50115 BORÅS*, Sweden**
mailto:leslie.pendrill@sp.se, http://www.sp.se/metrology

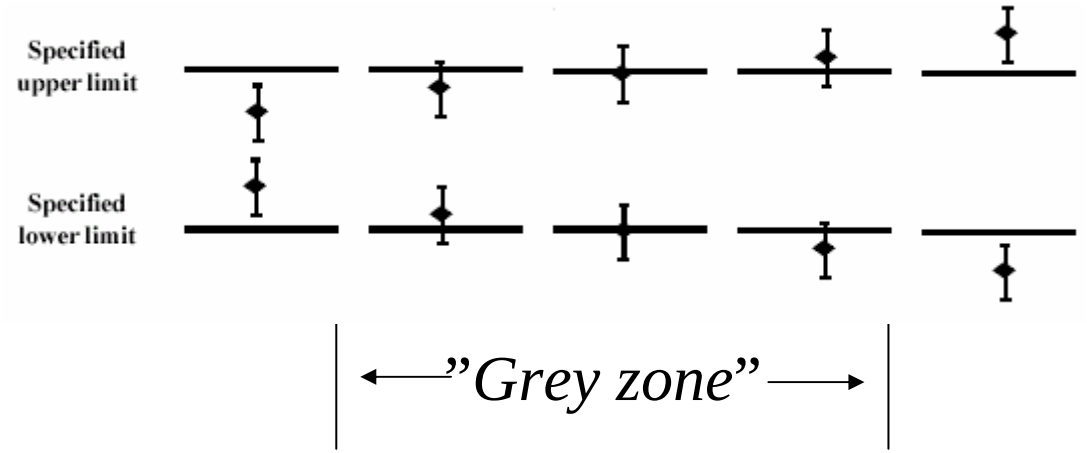
Optimised Measurement Uncertainty – risks and economy in decision-making

1,234 m ☹

1,234 m ± 0,020 m 😐

200 000€ ☺ ?

Conformity assessment and Decision-making – and Measurement



Guidelines on Assessment andReporting of Compliance with Specification
(based on measurements and tests in a laboratory)

Statistical measurement control

$$MPU < \frac{MPE}{5}$$

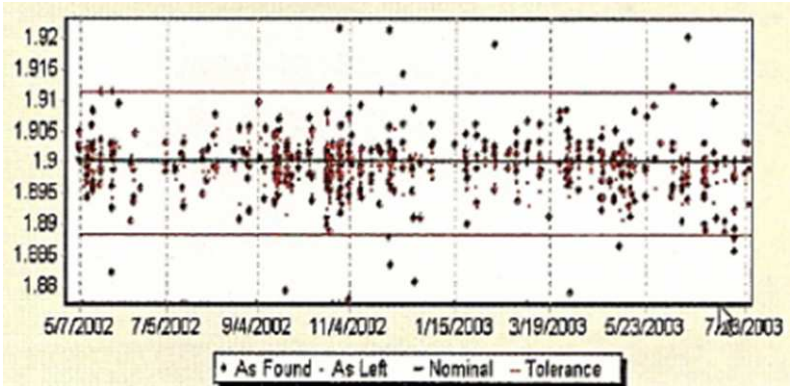
$$C_m < 4$$

”Toolmakers’ rule”

”Guardbands”

”Target uncertainty”

”test uncertainty ratio (TUR)”



”Shared risk”

”Producer risk 7%”

$$MPU < \frac{MPE}{10}$$

”test accuracy ratio”

$$MPU = \frac{MPE}{3}$$

Re-examination of traditional rules in conformity assessment of setting limits on measurement uncertainty and risks:

- maximum permissible uncertainty
- “shared risk” principle
- « operating characteristics » in traditional statistical sampling planning.

in new light provided by **decision-theory approach**.

One of first applications of optimised uncertainty methodology in **testing and sampling by attribute** is reported, assigning costs to both testing and consequences of incorrect decision-making.

Examples taken from measurement of **utilities, environment and pre-packaged goods** covered by legal metrology – where costs are in most cases reasonably well defined for both consumer, producer and authorities – as well as other important conformity assessment areas.

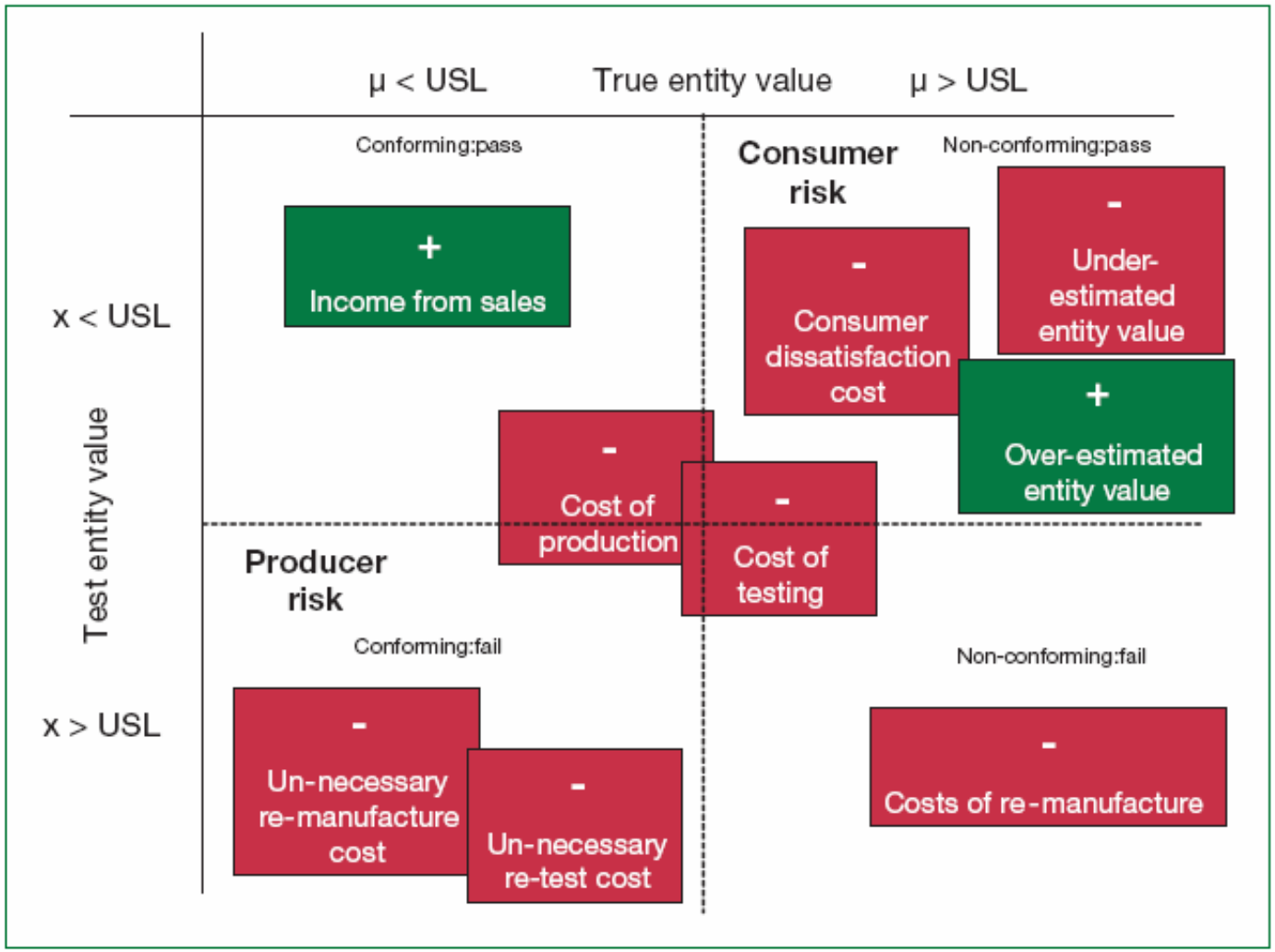
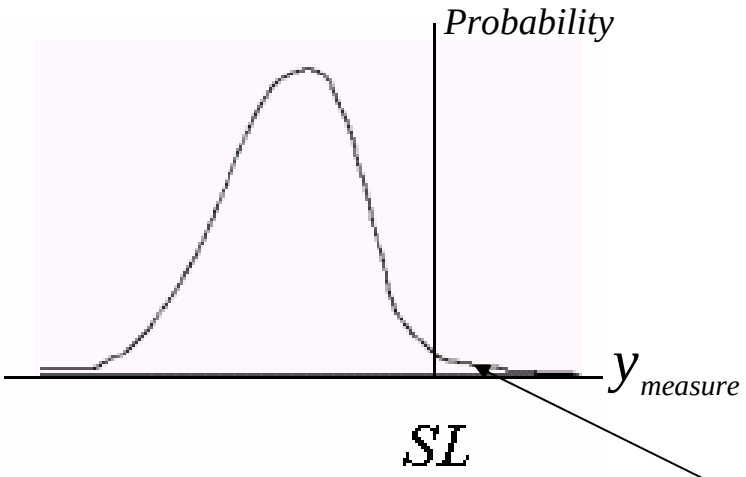


Figure 1. Different costs and income of conformity-assessed entity from the point of view of the supplier. Green represents a profit, while red represents a loss.

L R Pendrill 2007 "Optimised Measurement Uncertainty and Decision-Making in Conformity Assessment", *MEASURE* NCSLi Vol**. 2**, no. 2, pp 76 – 86

Risk analysis – for the Consumer

Optimised Measurement Uncertainty Methodology - by Variable



Passed, non-conforming product

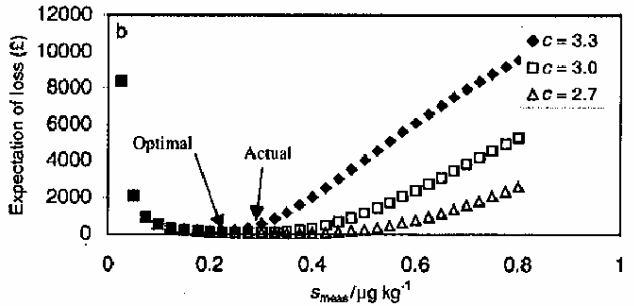
Type II decision error

Consequence cost

Cumulative probability

$$E_{np} = \frac{D_{np}}{u^2_{measure}} + C_{np}\left[1 - \Phi(|SL - y_{measure}|, 0, u_{measure})\right]$$

Measurement cost



M Thompson and T Fearn 1996 *Analyst* **121**, 275 - 8

Exhaust gas CO metering

MID 010

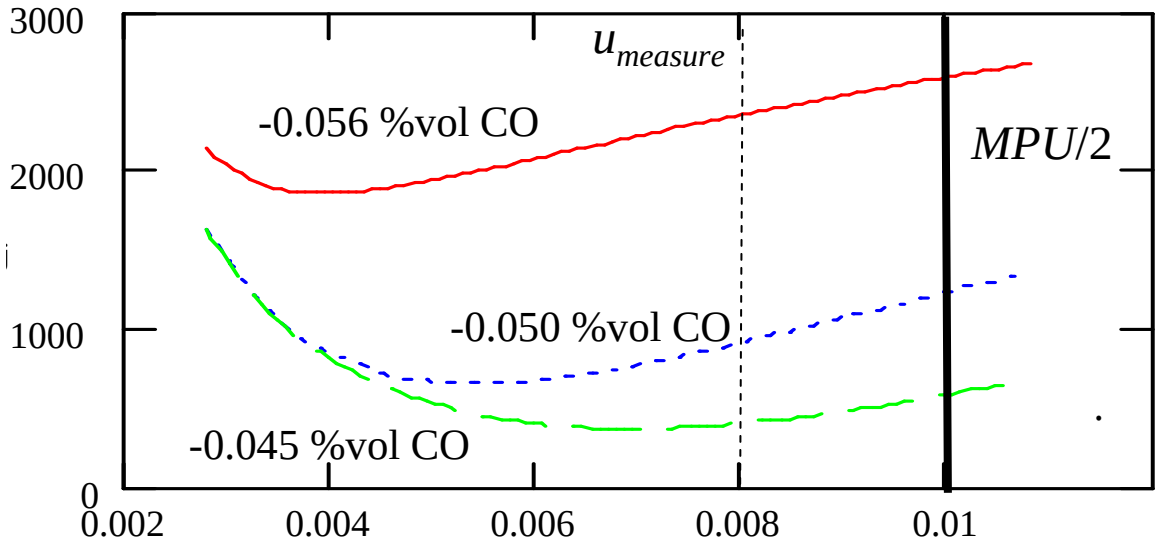
Initial verification cost, D_{np} = 200€/instr.

Consumer costs, C_{np} = 107k€/year

Environmental emission tax: 25%·0.05c per g CO

Parry & Small 2004

Economic loss (€)/instr.



n_{sample} = 180 meters

n_{lot} = 720 meters

L R Pendrill and H Källgren 2006b "*Exhaust gas analysers and optimised sampling, uncertainties and costs*", *Accred. Qual. Assur*. DOI: 10.1007/s00769-006-0163-3 http://dx.doi.org/10.1007/s00769-006-0163-3

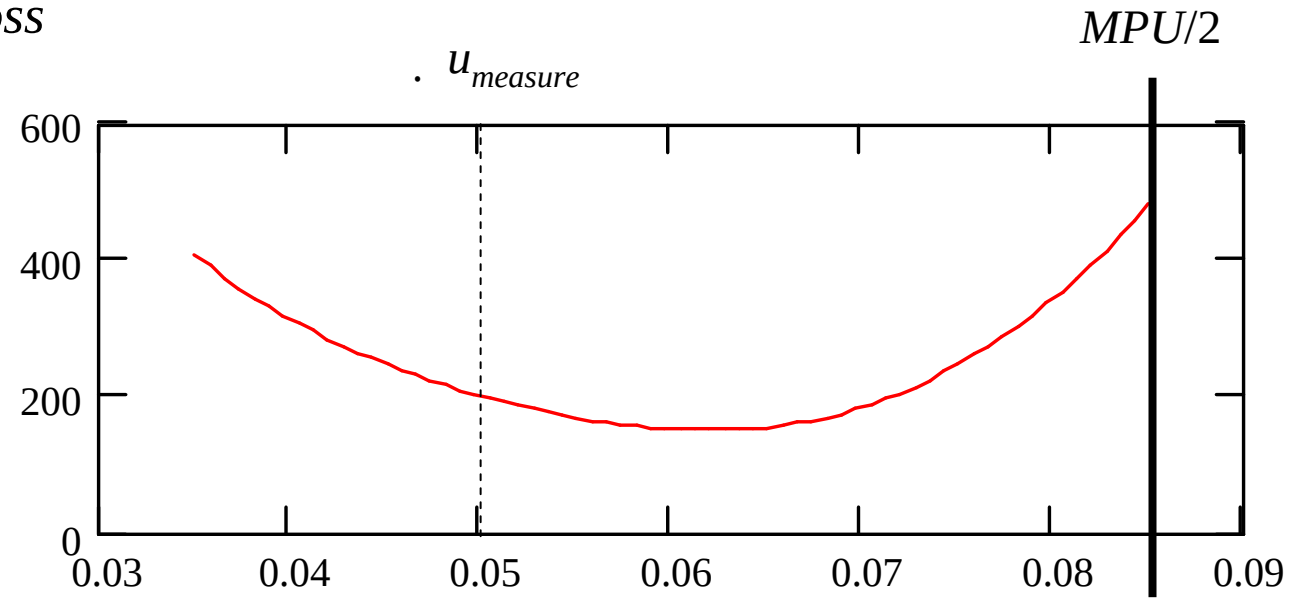
Petroleum Metering

MID 005

Initial verification cost, D_{np} = 100€/instr.

Consumer costs, C_{np} = 166k€/year à petrol price 1,1€/litre

Economic loss (€)/instr.



n_{sample} = 26000 meters

n_{lot} = 28600 meters

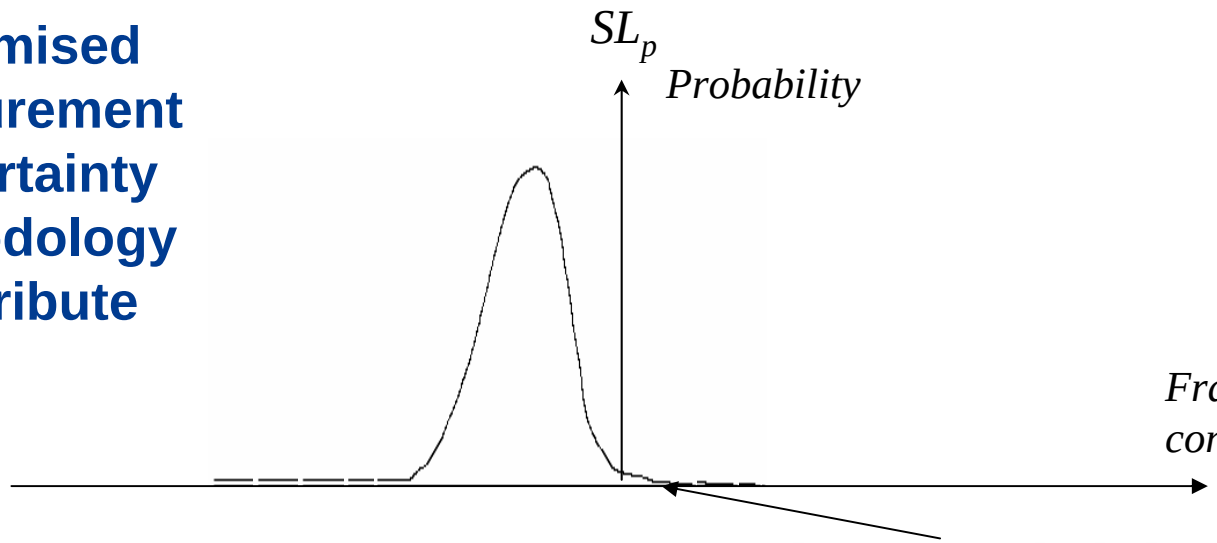
← Too much testing

Too little testing →

L R Pendrill 2006 “Optimised measurement uncertainty and decision-making when sampling by variables or by attribute”, *Measurement* , **39**, 829-840, Advanced Mathematical Tools for Measurement in Metrology and Testing, http://dx.doi.org/10.1016/j.measurement.2006.04.014

Risk analysis – for the Consumer

Optimised Measurement Uncertainty Methodology - Attribute



Passed, non-conforming product

Type II decision error

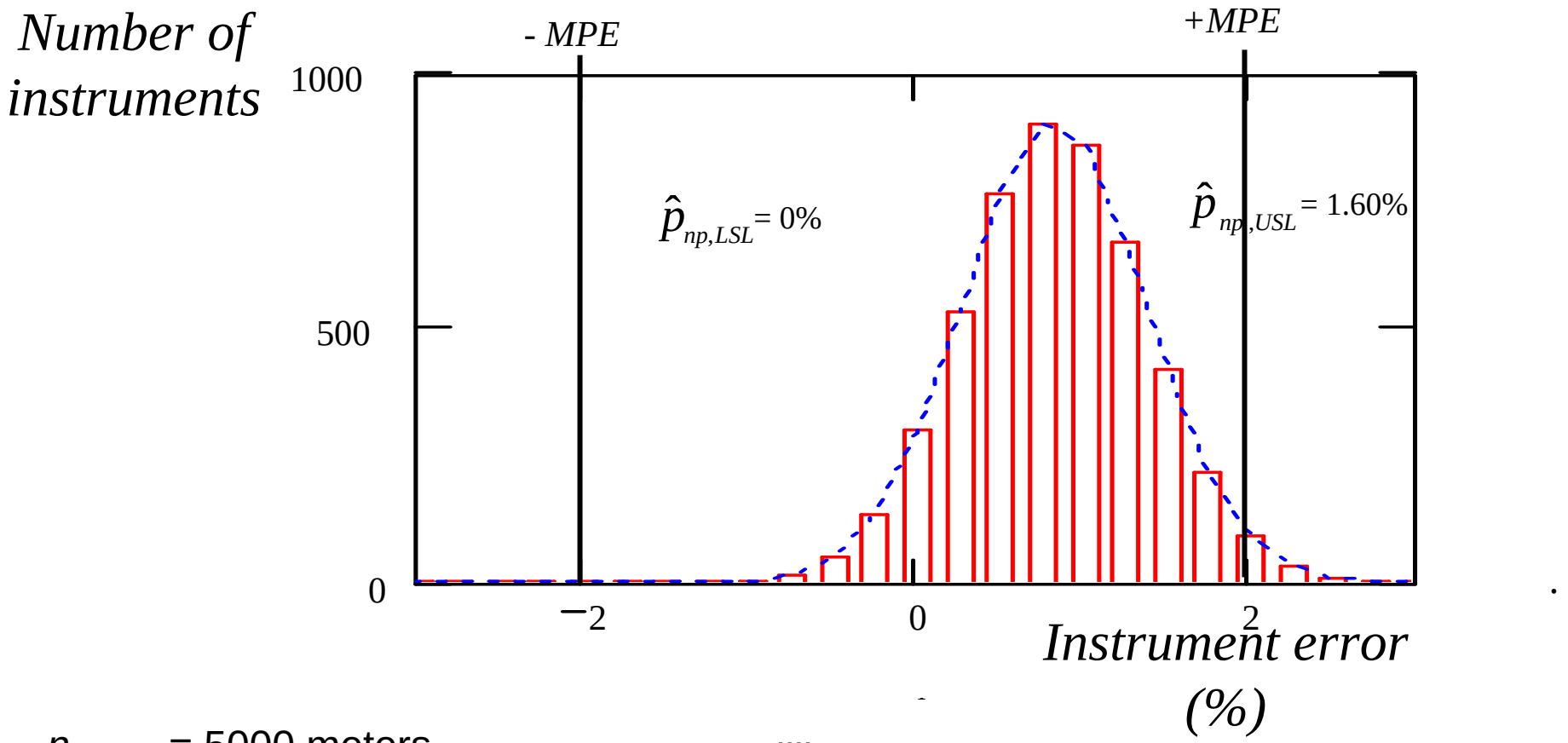
Cumulative probability

Consequence cost

$$E_{np,attr} = C_{survey} \cdot \Phi_{binomial}(d, n, SL_{\hat{p}}) + \frac{D_{np} \cdot n}{u^2_{sample}}$$

Measurement cost

Electrical Power Metering
- Distribution of meter error



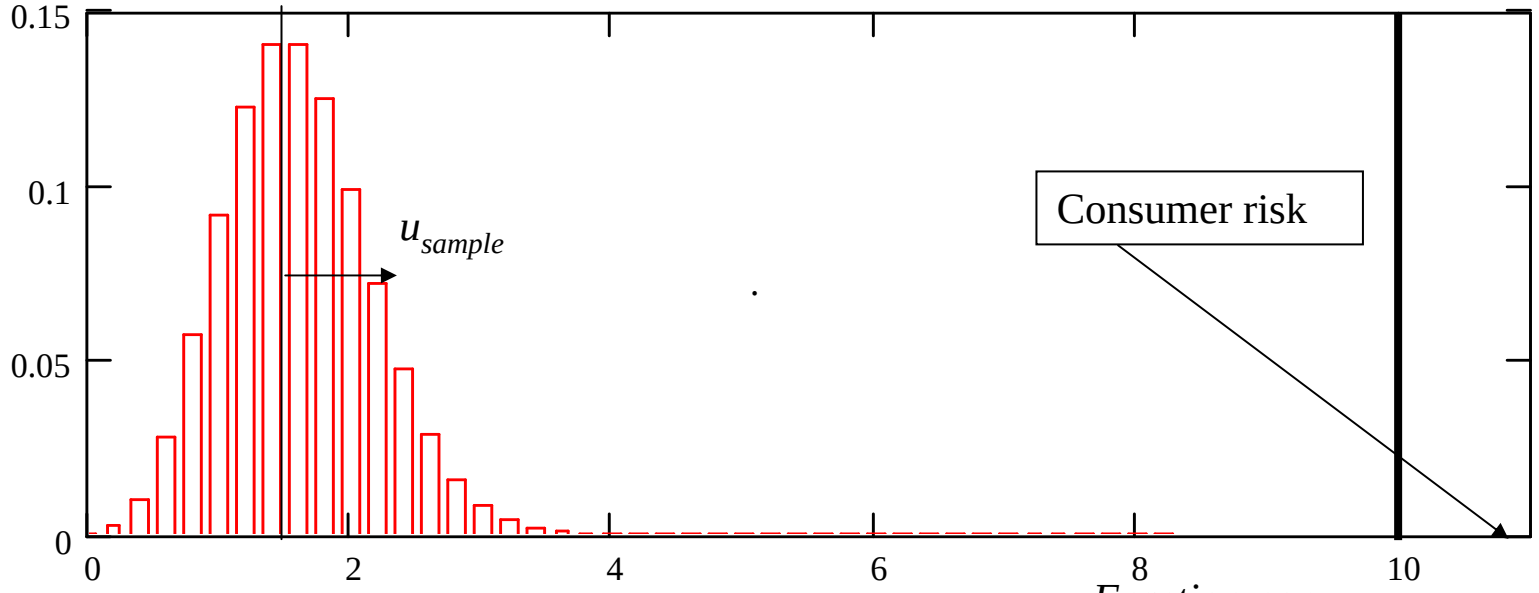
n_{sample} = 5000 meters

n_{lot} = 1,5 million meters

Distribution of fraction non-conforming meters

$$P_{\hat{p}} = \frac{n!}{d!(n-d)!} p^{d} \cdot (1-p)^{(n-d)}$$

$SL_{\hat{p}}$



$$\hat{p} = \frac{d}{n} = 1.60\%$$

n_{sample} = 5000 meters

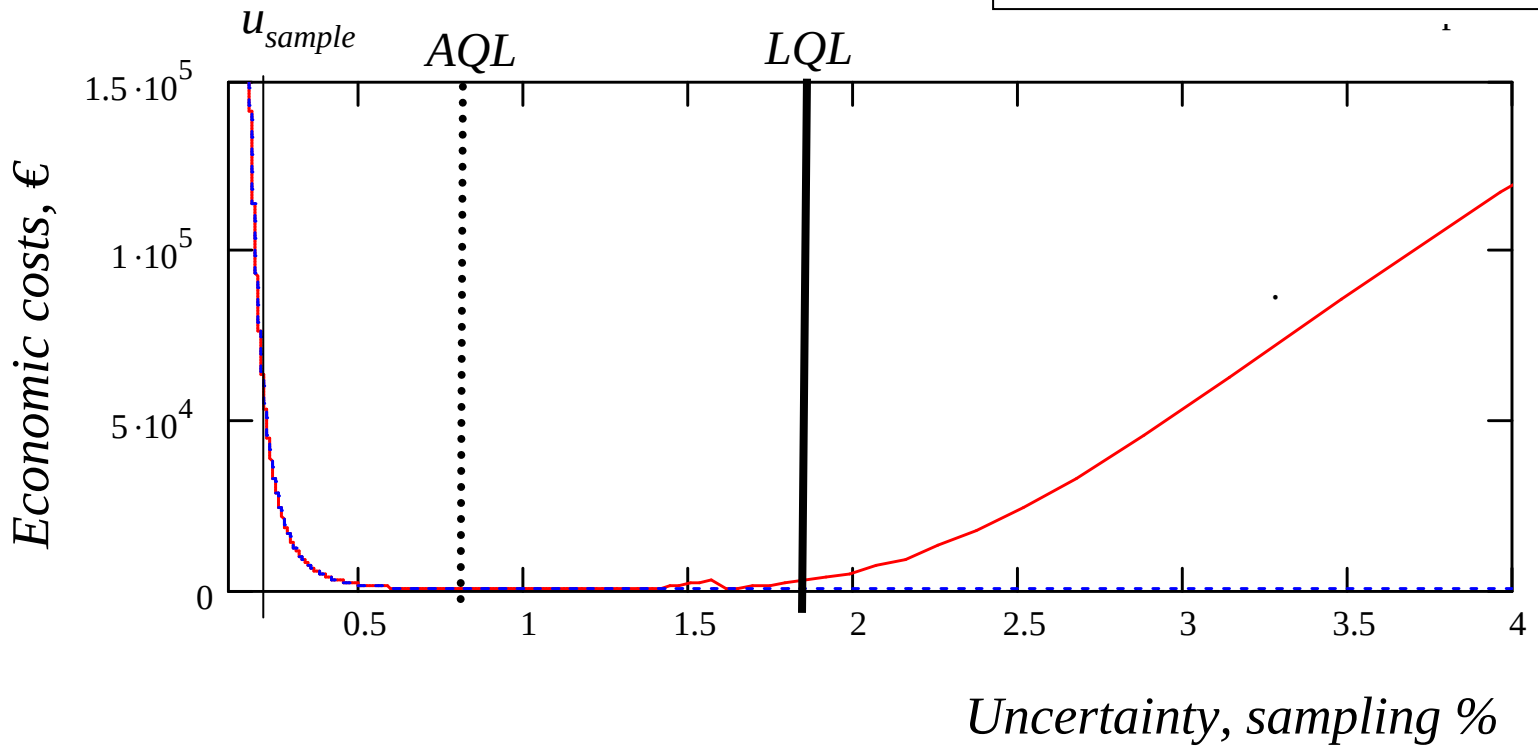
$$u_{sample} = \sqrt{\frac{\hat{p}(1-\hat{p})}{n_{sample}}}$$

MID 003

Optimised sampling uncertainty

Initial verification cost, D_{np} = 10€/instr.

Consumer costs, C_{survey} = 540k€/year à electric power price 0,10€/kWh



n_{lot} = 1,5 million meters

L R Pendrill 2007 “Optimised Measurement Uncertainty and Decision-Making in Conformity Assessment”, *MEASURE* NCSLi Vol. 2, no. 2, pp 76 – 86

Conclusions

Wherever there are uncertainties, there are risks of incorrect decision-making in conformity assessment associated both with sampling and measurement.

The present work reviews how an earlier criterion for ‘fitness for purpose’ in analytical measurement, as recently introduced by Thompson and co-workers, can be extended to more general measurements in conformity assessment.

This approach weighs economic factors, such as the costs of analysis and associated with the consequences of incorrect decision-making, into more traditional percentage analyses of consumer and producer risk.

This is considered to be an important step towards establishing clearer procedures for setting and specifying tolerances and associated uncertainties, and in facilitating acceptance of conformity in general by both customer and supplier.