WELCOME ADDRESS

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It's a privilege for me to welcome you to the Joint ENBIS-DEINDE 2007 Conference, the centenary of Prof. Diego de Castro, an outstanding statistician of the 20th century. By the way, this is also the 9th edition of DEINDE, a meeting on the subject of industrial experiment, originated towards the end of last century almost as a practical joke with my friends Roberto Corradetti and Giovanni Pistone. Well, it really caught up beyond expectations, mainly thanks to the dedicated efforts of younger colleagues such as Mauro Gasparini, Daniele Romano, and Grazia Vicario. They passed the flag to Ennio Isaia, who spared no effort to make this edition too a memorable and successful one, thanks also to the contribution of you all.

The subject of this Conference, "Computer Experiments versus Physical Experiments", covers quite a broad area, expanding at a fast rate especially concerning the former category, owing to widespread diffusion of inexpensive computing devices with capacity beyond our wildest expectations only a generation ago. Computers and related devices play an ever expanding role in our everyday life, indeed in the first edition of DEINDE most presentation relied upon visual aids such as slides and transparencies, while now I'd have a hard time in finding at all a slide projector.

Introduction of electronic computers in statistical work was very welcome right from the beginning, since it freed people from the thankless, boring chore of tiresome computations, where the slightest oversight would entail the dreaded negative sum of squares, damning the culprit to the Sisyphean task of going it all over again. Canned subroutines soon appeared ready for packing into one's own program, and later on came commercial packages bringing statistical analysis, no matter how complex, within easy reach of everybody; including of course any ignoramus, not an unmitigated success in my opinion.

Then came integration of basic principles of experimental design with numerical simulation strategy, hardly surprising since the latter is ideally suited for application of experimental statistics, aimed at systematic exploration of sample space, and derivation of empirical models. The spectacular development of computer experiments we're currently witnessing bears testimony to the almost explosive potential unleashed by the combination of inexpensive, user friendly fast computing technology, with efficient sampling and parsimonious model building strategies.

Numerical models offer a number of advantages, as they seldom fail or explode in your face owing to wrong combinations of input parameters, and are so much easier and cleaner to handle than messy, painstaking and time consuming laboratory testing. Furthermore, a much broader sample space may be explored in depth on a computer than in the laboratory or in the pilot plant, where such mundane considerations as cost, safety of operation, and equipment preservation must be properly addressed. Long runs may be performed on computers unattended overnight and/or during weekends, while laboratory staff would probably object strongly to such schedules. The ease of obtaining quickly results fit for publication may also appeal to junior faculty members, often overloaded with teaching duties, and caught by the dilemma "Publish or Perish". As a witty colleague remarked, an easy way out is to publish perishables.

Some intrinsic limitations of computer experiments deserve consideration, though. Don Wheeler presented right at the introduction of one of his nowadays classic books a pictorial representation of three major obstacles in experimental research in industry, particularly in R&D work, as coordinate axis of a space. These are *Uncertainty*, or variation in outcomes creating different results for the same set of inputs, *Opacity*, or unknown mechanisms affecting response, and *Complexity*, or large number of factors to be initially considered.

These issues are typically taken care of in laboratory experiments by replication with blocking and randomization, basic research into cause and effect relationship to clarify major underlying mechanisms, and sequential approach to experimentation with screening designs as a first stage. None of these obstacles, which may well turn out to be rather formidable, may be dealt with properly by computer simulation, but for the hardly common case in which exceedingly detailed and comprehensive numerical models are available, accounting accurately for all conceivable source of variation – in which case no investigation at all may be called for.

There's furthermore a fly in the ointment, since results of computer simulation, no matter how carefully performed, strictly speaking apply only to the numerical model described by the software exploited, whose actual relevance with physical phenomena in the real world must be established by hard evidence in order to warrant exploitation in research or industry. Sure enough, many commercial software packages appear to yield reasonable results, often presented with eye-catching colors in impressive, carefully crafted displays; and, who's taking the trouble and expense of checking with time-consuming laboratory tests, since everybody trusts them?

In a case at hand some inconsistencies were noticed, and after several pointed questions to software developers failed to elicit satisfactory answers, properly planned laboratory testing was resorted to, covering a substantial chunk of sample space. Tests results were then systematically compared with the corresponding values obtained from computer simulation. Results showed that, along some definitely reasonable predictions, other computed responses provided little more than hot air in terms of information. Quoting from a recently published keynote paper (Settineri et al. 2005), whose conclusions went undisputed at presentation at an international conference,

> "*Lack of agreement between experimental and computed normal force appears … substantial, relative differences averaging 47%, and ranging between 15 and 72%, experimental values always exceeding computed estimates. Those of cutting ratio* r_c *, on the contrary, are found to exceed experimental values by some 65% on the average, with a maximum over 200%; excluding however the first two treatment combinations, with small uncut chip thickness and negative*

rake angle, average relative difference would fall to a still substantial 48%, and lower limit of 100%. These findings appear to agree with published results obtained at NIST on the same type of steel in a comprehensive series of experimental tests, and numerical simulations."

In that case early misgivings about simulation results were prompted by failure to satisfy some basic checks defined in terms of sound, time proven theory, and properly complied by experimental results. Unfortunately for the software developers concerned, a number of whom might perhaps not even suspect the existence of what does not appear on internet, such theories were published well before the appearance of digital computers, and maybe they aren't much fashionable nowadays. By the way, theoretical values were found to predict experimental results, obtained in a comprehensive testing program, far more accurately than those produced by numerical simulation from a much touted, hardly inexpensive software package.

Nothing new under the sun, an adage three thousand years old, is still valid today. In the past opposite camps were sometimes formed by theorists and experimenters, a sensible blend of theory and testing providing often the best answer for those actually seeking sound results. While the actual predictive value of computer experiments devoid of any factual check may be open to question, sensible combination of a parsimonious yet comprehensive dose of physical experimentation with extended computer simulation seldom fails to provide reliable results suitable for practical exploitation – keeping also in due account theory, of course.

How best to combine deduction derived from theoretical and numerical models, and induction stimulated by actual testing, in order to gather sound information in a time and cost effective way, is a challenge which deserves to be squarely addressed. And, as R. A. Fisher forcefully argued concerning development of experimental statistics and biological research, for best results it ought to be undertaken by researchers with a fairly intensive training in *both* computer simulation techniques, *and* scientific investigation.

(*) D.J.Wheeler (1987), *Understanding Industrial Experimentation*, SPC Press, Knoxville

(**) L.Settineri, A.Zompì, R.Levi (2005), *Numerical & Experimental Metal Cutting Analysis: an Appraisal*), Proceedings of 7th International Conference on Advanced Manufacturing Systems and Technology - AMST'05, Udine, p. 57

(***) R.A.Fisher (1932), *The bearing of genetics on theories of evolution*, Scientific Progress, **27**, p. 273