MEASUREMENT TECHNOLOGY – INFORMATION TECHNOLOGY

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Abstract: Measurement Technology is contemplated from the perspective of information technology.

The concept of dimensions and units has facilitated and accelerated the application of computers in physics and technology. Behind all the details that have been contributed in all those applications hides a philosophical question: what tells us the result of our efforts? An attempt for an answer was the "Epistemology" of Eddington, an attempt that was not continued. On the other hand, the digitalization of our world makes enormous progress. It not only seizes the world of numbers but also the world of language. What importance has the theory of language, semiotics, for measurement technology? In conclusion a science fiction idea is presented, how this importance may increase incredibly in some future.

Keywords: information technology, FIACC, IS unit system, epistemology, semiotics

1   INTRODUCTION

Measurement is striving for information.

Measurement Technology and Information Technology, therefore, not only are related areas, they have an extraordinary overlapping. I shall try to investigate this overlapping by looking on Measurement Technology with the eyes of an information engineer. There is no reason to expect sensational results. But maybe I can make you, Ladies and Gentlemen, as meditative as I became in reflecting the basics of this talk.

The subject has been proposed by the organizers of this congress when I was offered the honor to present a key paper to the Vienna IMEKO Congress 2000. IMEKO is not a foreign territory to me. Permit me to look back in history for a minute. My professional homeland is IFIP, the International Federation for Information Processing. It began as a kind of second part of the first really international computer conference ICIP in Paris 1959 and was founded in 1960 in Rome. I have been attending Paris, but I was not a member of the Rome meeting. However a year later I was a TC chairman in IFIP. I have attended a number IFAC conferences and congresses, I was a keynote speaker at an IFORS congress. Such contacts at this time were rather incidental but at the same time natural because everything was closer together.

Prof. Victor Broida, then IFAC President, developed around 1968 the dream to create a structure similar to ICSU. For in ICSU itself the engineering federations, les associations cybernétiques, as they were called then in French, were foreign bodies. I had experienced that myself, as IFIP Vice-president, at the ICSU meeting in Madrid 1970. In this same year 1970 we started in Paris the "Five International Associations Coordinating Committee" (FIACC) with Prof. V. Broida as Chairman and Prof. Gy. Striker, the well known IMEKO representative, as Honorary Secretary; I was elected Vice-Chairman [1].

The coordinating function was limited to the public activities of the constituent associations, such as congresses, symposia, colloquia seminars and publications, and was to be achieved by oral and written exchange of information. To give an example of the principles we established: all constituents were to be encouraged to share the organization of the events in which they would take interest, but the financial responsibility should under all circumstances be with only one association.

For the following four years we met annually (Dresden 1971, Vienna 1972, Budapest 1974 and Zurich 1975); in 1972 I was elected FIACC Chairman. I continued to struggle with UNESCO to get a kind of ICSU status for FIACC, for instance with the Deputy Director General of UNESCO in Paris with quite some excitement. But it was hopeless.

I think that FIACC as such has reached its intended, wisely restricted goals. The cooperation of the technical committees and working groups was markedly intensified, and I know of no negative aspects of such cooperation. Finally the smaller groups were so much embedded in cooperation that FIACC itself appeared no more necessary, and in 1995 it was dissolved. This end, I must confess, does not seem to me the proper decision; I think that the original idea of aiming at a parallel to ICSU has its

merits. There are things which the engineering associations can reach only in common, with united power. And the reflection of what these associations have in common (this is a developing subject) can only contribute to a clearer picture of each of them – outside as well as inside. To cultivate such thoughts in a small structure would be the best tool.

So much to the past. And now I turn to the "informatical" consideration of your great field.

2   INFORMATION THEORY: THE THEORY THAT DOES NOT EXIST

Measuring is the determination of the kind of information, in German called "Groesse", that consists of a product of a pure number with a measurement unit. The number is the wanted information The measurement unit not only establishes the meaning of the result but also the principle of the measurement method. The number is a syntactic value, the unit delivers the semantics, and everything else around is pragmatics: why one measures, why one selects a particular arrangement and how one applies the result.

I have used here the three levels of semiotics [2] and I shall do so more than once. I will come back to semiotics and to the importance of language for engineering.

Which theory underlies measuring? I would overestimate my insight if I dared to present at an IMEKO Congress the theory of measurement, I permit myself merely to mention a few of my observations from an information engineers point of view. Such a theory should be a branch of the theory of information specialized to reading the pure numbers called measurement values and their proper interpretation. Unfortunately it must be said that there is no theory of information. What is called information theory actually is a theory of information transmission, more precisely a theory of the disturbed channel – a very small selection of information handling. Claude E. Shannon has generalized the time law of information technology that the product between duration of a pulse and the bandwidth to transmit it lies near 1 in the best case – in our time digitalization this is also a basic law of measurement technology – to the disturbed channel. In his first publication Shannon called this mathematical formulation "Theory of Communication" [3]. Only a certain popularization emitted the wrong name information theory. For information the main subject is its content, but Shannon's theory is not concerned with the content; it deals exclusively with the statistics of the information carriers, the symbols. Shannon, however, has put into spotlight a pair of notions which is elementary for any information process, namely the pair information and redundancy. In this pair, information refers to a second notion of information, namely information separated from redundancy or cleaned of redundancy.

Redundancy has different aspects and properties – from irritating, unnecessary and disturbing to useful and necessary redundancy, redundancy for transmission improvement for instance. Information is the new share in a message, redundancy is the share already known. This distinction can not be objective, it depends of the knowledge of the recipient and even of his awareness of his knowledge. It is characteristic that normal language carries 75% redundancy and 25% information (Shannon [2]).

ere is an example how information and redundancy can play in the most primitive measurement case. If I say that I measure between 0,5m and 2,5m I am emitting redundancy, because every man of my age is of the size. If I say I measure 1,59m, this may be information for you provided you want to have it. Would I say however that I measure 1,592367m the recipient would first react by saying: I did not want to know it that precisely. And after some consideration he will doubt the higher decimals and then try to find the reason for the kind of strange precision of the last answer.

3   THE INVENTION OF THE DIMENSION

The invention of the dimension was made in a glorious time of science development: when writing a book on heat theory, one had a chance to invent and introduce notions like the dimension and the Fourier series. It was indeed Joseph Fourier who did this in1822 [4] in his book on the theory of heat. The service he did for physics and technology and for measurement and computer application in particular by inventing the dimension is enormous.

In the early days the computer was merely an electronic version of the desk calculator with no text processing and even no letter symbols. How come that application in physics, technology and measurement went on so easy and so fast? Because the concept of dimension separated so clearly number value and measurement unit, syntax and semantics: it isolated out of physical and technical problems the pure numerical aspects. The rule is that on both sides of an equation in physics there must be the same dimension, the calculation problems are reduced to pure numbers. Consequently all those applications were numerical applications. Use of computers could spread fast.

A few more minutes may be devoted to dimensions and units. It is common use to distinguish basic and derived dimensions and units. Speed for instance is a derived dimension, length by time. But this is an artificial distinction. Speed is a notion of its own as well. I have a British story for this which is

very illustrative. A physicist was called before the judge because a policeman had filed a declaration of speed infringement. Before the court, the physicist accused the policeman of not being able to judge speed precisely enough. He asked the man to estimate the length of the court room and so say stop after 7 minutes. In both cases the policeman was more than 25% wrong. How can he estimate my speed if he is not able to estimate length and time with sufficient accuracy? The judge condemned the physicist not only for speeding but also for lack of respect for the court. Estimating speed does not require the division of length by time.

4   THE IS-SYSTEM

It is a convenience of measurement technology which of the dimensions or units are considered basic; one could select others and an other number of them. The legal system is the IS-system with kilogram, meter and second as basic units. If it would be decided to fix the gravitational constant 1 by dimension and value, mass would become a derived dimension: $P = m\ l/t^2 = m\ m/l^2$ or $m = l^3/t^2$. In this case one could bring all dimensions and units in a two dimensional table like this:

Dimensions:

	2	1	0	-1	-2	-3	-4	-5
5					M	$\hbar_0$	W	N
4							P	
3			V		m_0,q_0	I		
2			A	U	G		p	
1			I	v_0	a			
0			1	f	**b,r**			
-1	R		$\mathbf{k}_0$					
-2	$\mathbf{e}_0$							
-3		$?_0$						

Units:

	2	1	0	-1	-2	-3	-4	-5
5	m^5s^2	m^5s	m^5	m^5s^{-1}	m^5s^{-2}	Js	J	W
4	m^4s^2	m^4s	m^4	m^4s^{-1}	m^4s^{-2}	m^4s^{-3}	N	m^4s^{-5}
3	m^3s^2	m^3s	m^3	m^3s^{-1}	kg	A	m^3s^{-4}	m^3s^{-5}
2	m^2s^2	m^2s	m^2	V	S	m^2s^{-3}	m^2s^{-4}	m^2s^{-5}
1	ms^2	ms	m	ms^{-1}	ms^{-2}	ms^{-3}	ms^{-4}	ms^{-5}
0	s^2	s	1	Hz	s^{-2}	s^{-3}	s^{-4}	s^{-5}
-1	$\mathbf{W}$	$m^{-1}s$	m^{-1}	$m^{-1}s^{-1}$	$m^{-1}s^{-2}$	$m^{-1}s^{-3}$	$m^{-1}s^{-4}$	$m^{-1}s^{-5}$
-2	$m^{-2}s^2$	$m^{-2}s$	m^{-2}	$m^{-2}s^{-1}$	$m^{-2}s^{-2}$	$m^{-2}s^{-3}$	$m^{-2}s^{-4}$	$m^{-2}s^{-5}$
-3	$m^{-3}s^2$	$m^{-3}s$	m^{-3}	$m^{-3}s^{-1}$	$m^{-3}s^{-2}$	$m^{-3}s^{-3}$	$m^{-3}s^{-4}$	$m^{-3}s^{-5}$

The constants of nature, namely curvature of empty space κ_0, speed of light v_0, mass m_0 or load q_0 of the proton, and the Planck constant $\hbar_0$ are on a line that does not go through the origin. I am not the physicist to draw systematic conclusions, but I find the fact fascinating.

With the definition $[\mu] = 1$, evoking the electromagnetic system, one can bring also the electrical dimensions and units into the scheme.

Is all of that only a formal play? Or could it open a new path for computer dealing with the measurement universe? I do not know.

5   EPISTEMOLOGY

The British Astronomer and Physicist Sir Arthur S. Eddington has introduced in his book "The Philosophy of Physical Science" [5] a line of thought which to my knowledge has not been taken up during the following 62 years, namely to investigate not only the physical phenomena but also the message, the epistle, which they give of the existence and nature of the universe and therefore of our existence; hence the name "Epistemology".

He placed his ideas halfway between physics and philosophy and classified his epistology as "Subjective Selectivism". He questioned whether the physicist discovers, for example, elementary

particles or whether he creates them. This is a dissymmetry to macro physics because nobody will accept that the astronomer does not discover his galaxies but creates them. Galaxies however are not concerned with the wave-corpuscle dualism. Whether a neutrino is an existing reality or a wave model was at the time of Eddington a very undetermined question. Since then the neutrino has worked as a thinking model and undergone a development which could require today a reconsideration of Sir Arthur's ideas.

Eddington's basic thought is illustrated by his parable of the ichthyologist exploring the life of the ocean. He casts a net into the water and brings up a fishy assortment. Surveying his catch, he proceeds in the usual manner of a scientist to systematize what it reveals. He arrives at two generalizations:

No sea-creature is less than two inches long.

All sea-creatures have gills.

These are both true of his catch, and he assumes tentatively that they will remain true however often he repeats it. [5]

The ichthyologist stands for the measuring scientist, the net for his method. What is not caught by the net is not a sea-creature, what is not caught by the scientific method is meta-physics – a mild form of non-existence.

The first generalization is a consequence of the method; it could be stated a priori. As long as the method is not altered, the first result is bound to be correct. The second generalization could not be gained before the catch and is valid only until the first sea-creature without gills is caught. (Indeed, fish without gills have been discovered.)

Epistemology stands for the investigation of the scientific and measure-technological methodology and for the continuous check of the results from a higher watch-tower and an interpretation that tries also to recognize the limits, the borderlines of the methodology. One should, in other words, not measure ahead uncritically and add the new results to the previous ones, but one should ask from time to time what one is doing and what message, what epistle emerges from the abundance of results of science and technology. In that we are not really industrious. In our zeal to proceed we rarely ask meta-questions and discredit them although they might yield more, more comprehensive and more efficient answers than the routine occupation with the material itself, without meta-interest.

The first two meta-questions could be: how much does university education to lay out the ground for epistemological consideration? What are the professional societies and federations doing for the culture of epistemology?

Eddington was also of the opinion that God does not create arbitrary constants of nature. It is us, it is measurement science, who creates one part of it by the arbitrary measurement units while other constants are of logical nature. The value of the velocity of light, e.g., is a consequence of fixing meter and second.

As an example for logical derivation he gave the equation [6]

$$10\ m^2 - 136\ m\ m_0 + m_0^2 = 0$$

with the roots

$$m = 0{,}007357\ m_0 \quad \text{and} \quad 13{,}593\ m_0$$

Their ratio is 1847,6, the mass-ratio of the proton and electron. The point is not whether Eddington's conclusions and values are correct – it is the line of thought which should be worthwhile to be pursued. As I said this was not done. But measurement science made some decisions a little in such a direction. So the second was taken away from the astronomers and defined by atomic physics, still an arbitrary fixing, a compromise between a fraction of the daily life hour, the quartz clock and advanced atomic physics. There is no need anymore to wait for the result of astronomic averaging: the second can be produced at any time in the laboratory. The normal meter in Paris was replaced by defining the velocity of light by nine digits – also this is still arbitrary, but is not anymore a property of nature. The gravitational constant could be used in a similar way to replace the normal kilogram in Paris. All such regulations are functions of the state of the art of measurement, and indeed much more is indebted to this art than we realize in the daily and in the scientific life.

6   FORMAL AND INFORMAL, ANALOG AND DIGITAL

Why is technology and also science going digital, so fast and in so many matters?

Let me start with a simple story. A father and two boys go through a wood and suddenly they see a very thick tree. The father invites to two boys to measure the size of this tree. The smaller boy measures by spreading his hands, keeps them like this and comes back saying: so thick!

The bigger boy goes around the tree and measure by spans. He comes back and spells a number. In this sense, measurement was ahead of information technology in digitalization. Reflect this example, Ladies and Gentlemen, for it explains the victory of digital over analog – a victory connected to an abstraction which finally exceeds our power of imagination; step by step abstraction removes our insight and our activity further away from the direct message of our sensory organs. How far will we be able to bridge the increasing gap?

It is a fascinating truth that in spite of the quantization noise which digitalization introduces into the values, digital procedures are more precise than analog procedure. Think once more of my history with the two boys In principle the younger one can gather even an irrational number, but he can not hold his arms are strictly as that would require. Exactly as the analog devices can not keep the operational tensions precisely enough. The older boy has a digital solution which he can easily keep in memory. And spelling the number is noise-free, at least in a certain domain. The little story is sufficient to understand the drive of digitalization and to predict that it will go everywhere.

Analog and digital is a special case of the distinction between informal and formal. What ever is undertaken, it begins informally and stepwise can become more formal. The formality of the computer has developed exactly in this way. But the computer shows also the inverse possibility: one can simulate any informal situation by a formal model. This is a background melody of this paper. But I am at the same time aware of the limitations of formalization and modeling. The danger is to loose the feeling for the limitation and for the difference. The so called Artificial Intelligence steadily reminds this danger. A numerical variable for a feeling is a joke on feelings, but may be useful occasionally.

Time, the dimension that lies particularly on my heart, is the oldest example for digitalization beginning with the day but also with the earliest technical tools: waterdrops, pendulum and balance wheel. Time, the most uncountable phenomenon, was counted since ever, in days and its fractions. It was primarily derevated from human activity, and even the units originally came after from heavens from the human body (like those of length: step, foot, span, digit). One hour has 1080 breathes, one breath has 4 heart beats, and a heart beat has 19 moments (this system is used, e.g., in the Jewish calendar, and influenced by it).

Before we got easy access to watches, time was measured also by means of prayers or songs. The technical world has removed all of that deeper and deeper into indirect conception. Who can really imagine a microsecond?

The last 10 000 years had 3 652 500 days, and each day had 86 400 seconds. (We remain here with the Julian Calendar.) Measured by astronomers and later by atom physicists this statement was not found precise enough. 13 leap days (ruled by the Gregorian reform) and 25 leap seconds were introduced. We can be terribly precise, but we pay for that with a lot of complications. And this is an other reason to accept the help of computer technology. The computer masters complication, but the computer also permits complication (see Airlines Fares) and makes itself indispensable by that.

Most of you might know all of that much better than me. I merely round a picture for you, a picture that shows how measurement technology is proceeding into computer technology so that my view is not merely an exotic excursion but a feature of forthcoming reality.

Like Eddington for Epistemology, I have to quote Konrad Zuse for digitalizing space. Like Eddington's considerations, his book on "Rechnender Raum" (Calculating Space) [7] can not stand criticism. But since equipment goes digital, epistemology and, therefore, space will go digital. Zuse's road sign will have to be altered, but it indicates the right direction. At least physics will generate an auxiliary digital concept of space. The feedback of equipment to philosophy may not be semantically defendable, but it can be presented as semantically useful and successful. And the syntactical tools will then be produced on demand. Some how this is the course of history.

Measurement technology is a servant to science and technology. But seen in this light, its successes feed back to the view we get of the world. How far is science aware and conscious of the power of measurement technology? These all are questions of epistemology, a subject that deserves study.

7   SEMIOTICS: SYNTAX, SEMANTICS, PRAGMATICS

What has the scientific theory of language, Semiotics [2], the constituents of which - Syntax, Semantics, Pragmatics - I have mentioned already several times, to do with measurement technology? The answer is that its three subdivisions, syntax, semantics and pragmatics, apply as well to measurement and may not only illustrate a number of aspects, they may be helpful there.

In language theory, syntax deals with the relationships between the characters without regard to what they designate. Semantics studies the relationships between the characters and the reality which they designate or describe. This reality can also be an invented reality, a virtual reality, a future concept. Semantics clearly includes syntax; syntax is one level lower than semantics. Pragmatics

deals with all other aspects of language and description, up to subjective ones. It may consider the intention the application of characters has in mind and the geography and history of character usage and language.

Syntax is governed by certain formal or semi-formal rules, symbol arrangement rules for instance. Correctness of application of arrangement rules can be checked; in friendly cases it may even be possible to automatically correct mistakes. Syntactical correctness is the first, the basic condition for clean description. Negligent description becomes apparent by unclear, by incorrect symbol arrangement, by bad terms.

Syntactic measurements go little beyond correctness checks: how many deviations from the formulation rules, for instance, can be found in a document. That may tell a lot about author or the status of the document. But unlike numbers text characters lack the sharp relations so that measurements are not really helpful.

Semantics is a matter of verification: does the description properly reproduce the described situation? If you are familiar with the origin of Wittgenstein's philosophy, you may remember that he started with the idea that the protocol of a car accident must be as far as possible identical with the accident. Verification is by far more difficult than checking – it requires bridges between description and described world and their proper use in verification. A lot of knowledge of the reality and of the art of description is prerequisite. In a world of physical views, measurement is an integral part of this art. Measurement science contributes more to the present "Weltbild" than the "Messknecht" realizes when looking on his instrument.

Pragmatics can not be handled with any algorithm, procedural rule or universal systematics. It is as colorful as life itself. Pragmatics is a collection of views, in English one speaks of the philosophy of a problem or a solution. I myself met this aspect the first time with the paper by Oliver, Pierce and Shannon "A Philosophy of Pulse Code Modulation" [8].

It is not a far-fetched or artificial trick to apply semiotics to measurement technology. The three levels obviously exist there too. Syntax is the world of relationships between measurement results without regard to their meaning beyond correct reading and calculation. Syntax is what is done in any case in measurement, maybe with more or less care for the reliability of the results.

Semantics deals with the meaning of the measurement readings: are the results properly interpreted? Very often we trust in what output shows, we are not asking in all necessary cases whether there may be further aspects or dependencies which we may have ignored.

Pragmatics finally like in language theory deals with intentions, with geography and history, with the "Philosophy" of the measurement procedure and measurement interpretation. And it extends all the way to Epistemology: what is the meta-story the set of procedures it telling us?

The application of semiotics to measurement technology could also be inverted to an application of measurement technology to semiotics, to text material. At present this is still Zukunftsmusik (music of the future: so a fear that it could be only noise is justified). I will dare only to indicate the inversion as a closing science fiction story.

I want to conclude this section with a general observation concerning natural language. In our educational system for engineering we consider, and rightly so, formal language as an indispensable tool. We do not consider natural language equally. A student may fail an examination because of formal language failures; he will not fail because of miserable German or English. Technical papers mistreat language and poisons it with unexplained abbreviations until it becomes a slang incomprehensible for the non-initiated. But it is the layman who in the end is to use our products, and also the communication with technical colleagues - from next door to distant technical areas - requires mastering of natural language. Without much attention we loose the power of expression and we glide into an extremely poor language culture. To correct it may require generations. The damage is already here and it is an expensive damage.

8   MEASURING IN COMPUTING

I am sure that measurement engineers make better use of computer technology than computer engineers make use of measurement technology. Because computer engineers are not really keen of measurement. They maximally are interested in certain counting: length of the words, number of storage cells, number of operational steps per second and similar. Information technology could learn a lot from measurement technology and with more measurement ambition – I think – would be a better technology. One reason for measurement laziness of informatics is the fast improvement of hardware. Why to fight for savings if twenty years from now you get one thousand times the values of today? The other reason is the transition of computer application from numeric calculation to word processing. Text is difficult to measure. To this I want to return at the closing of my talk.

Here I want to remain for moment with numerical calculation and have a look on the precision of measurement and computing. Each measurement result has its range of confidence. It would certainly be rather cumbersome to always indicate this range but it would be correct data handling.

Now the computer, although incredibly reliable if one considers the number of steps involved even in relatively simple processes, does not warrant precise calculation under all circumstances. Alone the finite number of decimals produces a limit for calculation precision and the big number of steps so easily organized in the computer reduces the reliability of the computation results more and more. This yields an interesting philosophy for the combination of measurement and computing. There should be a watching mechanism starting with the estimation of the precision (the reliability) of the input values and tracking the range of precision throughout the complete processing in the computer - yielding not only a result but also its margin of confidence.

Indeed mathematicians have designed such a mechanism: interval arithmetic. It has not become popular, as far as I can see. But one never knows when such ideas resurrect and grow in importance.

9   CONCLUDING REMARKS – A SCIENCE FICTION CONSIDERATION

In conclusion: That measurement technology has a giant future, in particular with the support of all computer possibilities, is obvious to anyone. For me there is a phantastic extension conceivable which would deal with texts. The computer is the most powerful computational device and will remain it. But the transition to text processing wins more and more ground. For measurement technology a fascinating question could emerge: how could all the good features of measurement be applied to text processing? Now clearly, this is not a simple question, not an easy problem. The thoughts I am offering you may not be of any direct value for the daily work of the measuring engineer and scientist. But looking a bit further makes sense in any activity.

The science fiction idea I want to offer as the end of my paper has emerged out of the challenge the computer throws on us. If the text has become so much the product of technical processing: would it then not be appropriate and advantageous to make the main virtue of technology applicable, namely the planning and pursuit of the production and application processes governed by measuring activities. This is certainly impossible with the precision and reliability possible in the universe of numbers. But a considerable improvement of production and application might be conceivable if we could create a measurement technology of a second kind.

Measurement applied on prose and lyrics – that is probably really only fiction. But a semantic measurement technology for the giant numbers of texts produced and needed for technology, mainly consisting of routine formulations, that need not be only fiction. It is however fair to mention that such an attempt has already failed. Y. Bar-Hillel and R. Carnap have extended in 1953 information theory to semantics [9], but they had to take back this publication. That was not done formally – the two authors and their colleagues left it at remaining silent. (I have once discussed this with Bar-Hillel.) In all probability the extension of formation theory on the attempted way is not possible.

Since the universe of numbers is not sufficient, we would have to create a universe of words governed by word relationships instead of the number relationships. The computer would permit to store enormous quantities of such relationships and to elaborate them to a base for the evaluation of processed texts. Furthermore, we might have to invent the notion of value and dimension in a new form applicable to text bodies. Of course, it would not be the quality called originality that the computer could master. But routine has also its importance, and in this matter the computer is more than an average "specialized worker".

Maybe I am a century ahead of the development, maybe less. At least, I wanted to present to you this stimulus. And if your reaction is merely an elaboration of good reasons why even my limited goal must remain unattainable, that would also be a gain.

After this escapade I wish to IMEKO and all participants a successful and pleasant congress. It is you, Ladies and Gentlemen, who have to task to perform information processing with all the texts and talks presented (and you can do that as well with less strong papers – really weak ones definitely have been excluded by the programme committee). Congress participation is not a passive notion. And moreover, by the side of the formal programme there is a second part, no less important, no less helpful: the conversations during the breaks and in the corridors, even the talks at meals and excursions. Make the right use of that, and your expenditure doubles its efficiency!

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