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PROFILE

Interview with Peter Mertens and Wolfgang König: "From Reasonable Automation to (Sustainable) Autonomous Systems"

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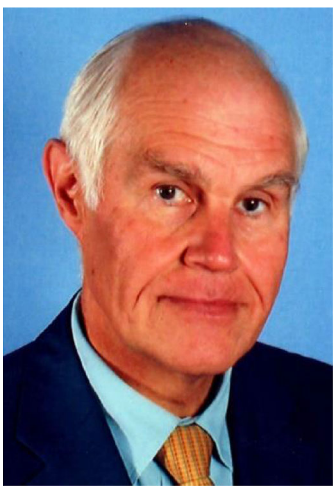

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Erlangen-Nürnberg. After studying industrial engineering, he completed his doctoral studies and his habilitation at the TH Darmstadt (1961) and the TU München (1966), respectively. From 1966 to 1968, he worked for a large software and consulting firm in Switzerland, first as a system designer and later as a managing director. In 1968, Peter Mertens took over the first chaired professorship specialized in business data processing at the University of Linz. He is considered one of the founding fathers of Wirtschaftsinformatik in the German-speaking world. Until September 2005, Peter Mertens held the Chair of Business Administration, especially Wirtschaftsinformatik I at the Faculty of Business and Social Sciences of FAU. In parallel, he was head of the computer science research group "Business Applications" at FAU's Faculty of Engineering. Since fall 2005, he works as an emeritus professor at his former chair. Peter Mertens is the author of numerous books, including 23 monographs. He has also been involved in the editing of 26 collective works. The first volume of his book "Integrated Information Processing" has been published in 18 editions. Some of his books have been translated into English, Chinese, Italian, and Russian. Among other awards, he is a Fellow of the German Informatics Society, an honorary doctor of five universities in Germany, Austria, and Switzerland, and has been awarded the Order of Merit of the Federal Republic of Germany. From 1990 until 2000, Peter Mertens served as Editor-in-Chief for WIRTSCHAFTSINFORMATIK (now: BISE).

Until 2016, Wolfgang König was Professor of Business Administration, especially Information Systems and Information Management at the Faculty of Economics and Business Administration of Goethe University Frankfurt a. M., and until January 2022, he was Chairman of the E-Finance Lab (since 2020: efl – the Data Science Institute) at Goethe University. Since 2008, he holds the position of Executive Director of the House of Finance of Goethe University, and since 2016, he serves as Senior Professor at Goethe University. From 1998 until 2008, König served as Editor-in-Chief for WIRTSCHAFTSI NFORMATIK (now: BISE).

Both Peter Mertens and Wolfgang König are clearly among the research pioneers when it comes to automated systems, which can be seen as a precursor of the central topic of this special issue: autonomous systems (AS). The key difference between automated systems and AS is that, in AS, machines or other technology actors have at least some agency (i.e., they can act autonomously), whereas in automated systems, the agency still lies with humans – who, for example, define the relevant rule system – and machines/technologies merely automate the execution of these predefined rules.

BISE: In the context of the subject of our special issue, you, Professor Mertens, proposed the goal of "reasonable full automation" already back in 1995. (Note: Peter Mertens formulated this goal for the first time during a keynote speech held at the International Conference on Wirtschaftsinformatik in Frankfurt/Main, organized by Wolfgang König.) What were the motivations for this proposal back then?

Mertens: My motivation was to provide a fashion-independent, long-term goal in the back and forth of fads, constant relabeling, and actual advances. I like to use the metaphor of the ship's captain (or his compass) from earlier times, who oriented himself to the polar star. He did not want to reach the polar star, which would have been utopian. As such, the notion of reasonable full automation is a concrete utopia of philosophy (Ernst Bloch).

In my opinion, extensive automation is essential, especially for Germany, given the catastrophic age structure of the German population. However, it must be reasonable. A counterexample: The use of an autonomous vehicle, such as a self-driving car, does not bring any productivity benefits for a manager who would like to study documents while driving, as she or he can be called upon by the car to take over steering and braking in confusing traffic situations. According to psychological studies, after the handover from the car to the human, it will take 12 to 15 seconds for the latter to get an overview of the situation. By then, the car would have traveled a few hundred meters and a serious crash may have already happened. For this reason, the manager is not allowed to study documents while driving her/his autonomous vehicle and thus does not gain any working time. Therefore, automation is *not* reasonable in this example.

It should also be noted that I never intended a short-term realization of the full-automation goal; rather, this concrete utopia was meant to give direction to system architects and others, including legislators. For example, any legislation and related reforms that impair the use of automation technology or even prevent it – that is, are not automation-friendly – are to be scrutinized particularly closely. Here is a concrete example: in Austria, the registration of a newborn child can be done immediately from the delivery nurse's computer screen. Consequently, the formalities at the residents' registration office, which issues the birth certificate, and at the local office responsible for the approval and payment of child benefits can be fully automated; that is, relevant documents are prepared by the Austrian authorities in an automated fashion and then sent to the parents for their files, and child benefits are paid out to the parents automatically. In Germany, however, such automation would not be possible in many communities, as current legislation still requires parents to register their newborn child in an "analog" manner.

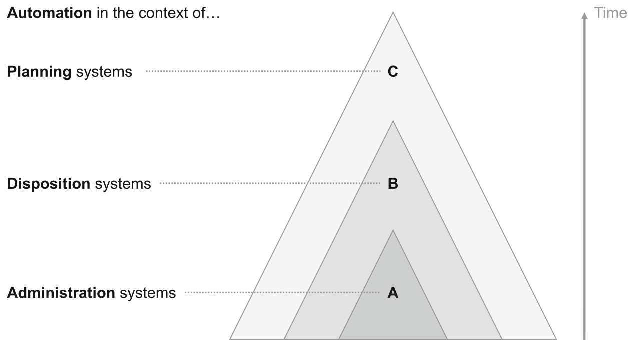

Fig. 1 Development of automated systems over time

König: Generally, the development of automation over time can be illustrated in a pyramid. (Note: see Fig. 1 below.) The smallest pyramid (A) may symbolize the first level of (partial) automation, so to speak. In the area of business applications, this took place in the 1950s. These were very simple administrative tasks (e.g., the documentation of insurance contracts), which took advantage of the then still quite small mass-processing capability of a computer. An important basis of administration systems are legal regulations, such as the posting of an invoice as soon as the amount exceeds the legally binding threshold of a company. These are mandatory regulations and there is in fact no freedom of action. Over time, many of these A-pyramids have developed side by side. Different application experiences were bundled through knowledge transfer; the theory of replacing simple administrative processes with information and communication technologies (ICT) deepened and differentiated (as depicted in the vertical dimension of the pyramid); and first approaches to standardization emerged.

Based on the experiences gained with the automation of administrative tasks (A), attempts were made to automate disposition systems (B), which offer some degree of freedom for relevant actors – be they humans or machines. In logistics, freight scheduling is a good example. Here again, the first task was and is to gain experience with (partial) automation, to bundle different deployment experiences, and to test standardization approaches. Clearly, the automation challenges at this level (B) are more complex than the challenges at the lower level (A). However, the increasingly complex challenges have been mitigated by the fact that the general performance of machines has increased noticeably over the years – and continues to do so.

Lastly, based on the automation experiences at levels A and B, automation experiments were carried out with planning systems that are characterized by a comparatively high degree of freedom for the individual actor.

The dynamics of such a stacked hierarchy can be depicted as a widening of the pyramids' basis (A-C) over time and simultaneously an increase of their heights. Again, the pressure to do so often comes from the administrative level. For instance, think of the ever-growing anti-money laundering regulations in the financial world. All in all, this development can be characterized as an extensive chain of careful palpations – always against the backdrop that the consequences of an "extension error" need to be kept under control.

BISE: What factors have influenced this development?

König: Automation essentially depends on three determinants: First, the performance/price ratio of ICT has been both steadily and massively increasing for the last 50 years. In this regard, not much will change, at least not in the foreseeable future. For example, on the hardware side, the available computing power per US dollar has almost doubled every year. Although ICT themselves absorbed some of the technical improvements, this is an "insane" driving force.

The second determinant is the human controllability of advances in the symbiotic human-machine system, which have been made possible by the above-mentioned technical improvements. In other words, both human designers and users must spend significant time learning to implement these rapidly increasing technical options in relevant application contexts – and then also to control the system outcomes. Those contexts have different characteristics regarding the reproducibility of a specific result and the endurability of any errors that may occur along the way. For example, from a scientific standpoint, controlling the movements of a spaceship can be more easily achieved than "reading" a person's state of mind from a photo; and an error in the former case is often fatal, whereas in the latter case, one can often leave it at an apology.

The third determinant is the intellectual depth of the replacement of human labor by computers. For decades, Peter Mertens, and our discipline in general, has been talking about automation in the context of administration, disposition, and planning systems – in this order. This means that with growing intellectual depth, there is often also greater potential for the beneficial use of ICT (when compared with the purely manual handling of relevant processes or compared with earlier versions of automation).

Against this backdrop, Peter Mertens' notion of reasonable full automation refers to the entire pyramid. (Note: again, see Fig. 1.) Here, it must be ensured that an investment in the degree of automation – and "full" means 100% after all – pays off at every level, including for instance the repair and clean-up costs if the automation technology ever takes a decision that human supervisors consider to be "wrong" in retrospect.

BISE: What key challenges stood or stand in the way of tapping the full potential of automated systems? Why has the implementation of such systems often failed?

Mertens: In the above-referenced case, where a technology actor has made a wrong decision, a task may have been automated based on a wrong prognosis. Such automation was not reasonable then, at least not under the given circumstances. A prominent example in this context is the infamous automation project "Halle 54" by Volkswagen (VW) in the early 1980s. (Note: the name "Halle 54" refers to a VW production facility designed for full automation.) The project was based on a misjudgment regarding the degree of maturity of the computer-integrated manufacturing (CIM) principle back then. Among other things, VW underestimated the efforts of maintaining the automation technology, while overestimating the motivation of the few remaining production employees.

König: Some additional examples: First, as with any new technology, there are always excessive expectations at one point in time. The Gartner Hype Cycle expresses this explicitly. Second, too little attention has been paid to the overall social consequences of automation. For example, job holders (in the "manual" world) have almost always protested and agitated against having their jobs, their work, replaced by robots/technology. And third, if – despite all the cautious probing of new "automation territory" – a corresponding technology has made some serious wrong decision on behalf of humans, there will be a host of critics who have always known better, especially in Germany.

Against this backdrop, the most important failure factor has been and continues to be humans in their role as individual stakeholders; that is, as system providers (e.g., when unrealistic user expectations are propagated), or as developers, or as users, etc. In this regard, I still see the machine as a programmed mechanism of action that is made available to the world intentionally, or erroneously, by *humans*.

BISE: To what extent are the challenges you mentioned above also relevant in relation to the development of (sustainable) AS? How can these challenges be overcome?

Mertens: Broadly speaking, ICT-related advances are naturally moving us forward along the time axis in many areas of the economy and society ("technology push"). On the other hand, as already noted above, a growing "demand pull" results primarily from the current demographic situation in Germany. Both factors (i.e., technology push and demand pull) influence the technical progress. In this context, a fundamental problem – then as now – is that many (new) systems are not sufficiently tested. For instance, online banking systems are often largely automated but also "sloppily" implemented, which implies that especially elderly bank customers tend to lose a great deal of time familiarizing themselves with constantly changing system versions. As such, it may well take bank customers less time to pay a bill using a conventional ("analog") transfer slip on which their IBAN is already pre-printed than to train themselves to use the latest software version.

König: With respect to Fig. 1, it is important to note that different industries and individuals are likely to go through different trajectories on their way from A to C, depending for instance on the requirements of the business world and depending on their own training and experience, as well as their individual level of motivation. Consider the megatrend in economically developed countries that, over time, the main share of their gross national product has moved from "material industries," where for example a machine or a chemical reactor represents the core of a solution (as in the automotive and chemical industry), to the high-tech service sector – think, for example, of the engineering sector of the chemical industry. Both aforementioned technical devices are not readily modifiable during the production process, which restricts the respective scheduling and planning processes. As such, users have fewer degrees of freedom and must adapt to the given machine structures, which cannot be changed on short notice. In fact, parallel to the increase of the share of services in the gross national product, the value-added share of the ICT sector rises considerably. The engineering and ICT sectors are more focused on user benefits – people and their behavior are at the center of a solution. Industrial services, for example, include more flexible ways of producing and distributing goods, which places higher intellectual demands on system developers, service providers, and, of course, end users. Due to their comparatively greater reliance on the human factor, services pose a particularly challenging automation problem – although here, too, the classic administrative processes must be automated first.

How can these challenges be overcome? A first important answer is to improve education and experience. For example, do we need more skilled programmers and system designers? Apparently yes. Do we need more highly skilled staff members to control the quality of the systems we buy in the world? Apparently yes.

BISE: What do you think: where does the journey lead to for AS in the future – also regarding the limits of technological autonomy as well as the tension between this autonomy and human autonomy?

Mertens: This cannot be answered in general terms. Would anyone argue today with the human right of self-determination in order to ban automatic washing machines in the basement? Would one classify the technical aids for flight captains as a restriction of the pilot's responsibility? The question of when exactly an automated system should hand over to the pilot (and vice versa) can only be answered through very meticulous analysis of relevant situations, but not in general.

König: AS are certainly an important step on the development path outlined. Here, if the definition of "autonomous" is taken seriously, the question of how corresponding systems adapt to ever-changing circumstances must be at the center, such as the ability of machines to reprogram themselves. In that case, the pyramid introduced above may get another development level on top; or it might be that the amplitude of the Gartner Hype Cycle increases over time as automation development progresses. In this case, the reprogrammability of machines would be associated with (too?) high development risks.

To me, the dichotomy of human versus technology autonomy seems to reach far into the future. But clearly: in selected work environments, machines already carry out independent planning. So, in principle, why shouldn't they be able to reprogram themselves in the future, especially if certain operational prerequisites are given. This would probably put another "rocket stage" on top of the currently known complexity.

Mertens: In any case, regarding the inherent tension between human and technology autonomy, the development of unethical AS must be avoided at all costs. For example, an AS in which the death of humans is statistically accepted *cannot* be reasonable.

BISE: Finally, what advice would you give young BISE scholars who intend to write their dissertation, or the like, in the field of AS?

Mertens: Think of the higher-level goals that are relevant for the survivability of our economy and society ("demand pull"), and do not philosophize over many pages of your dissertation about the nature of humans as such!

König: In successful symbiotic systems, the common denominator between humans and machines are standards, which are stacked in a multi-level hierarchy. At the lowest level, we see elementary standards (like the letters of an alphabet or the digits of a number system). We study, or have studied, to learn and apply these stacked standards in a subject area, and a dissertation aims to develop and apply new methods to a particular problem, thereby probing and potentially changing the existing stack of standards. For humans, the application of standards limits the degree of volatility and unpredictability of their actions. At the same time, theory and experience teach us that reasonable standards (i.e., those that benefit many users) at lower levels open up immense opportunities to individualize solutions at higher levels of the stack by recombining standard elements. As such, we are challenged to invest into European standards – also in the field of AS. This cannot simply be "outsourced" to the U.S. or China.

BISE: Thank you very much for all the insights, as well as for taking the time to participate in this interview, which is greatly appreciated!

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