ADVANCES IN THE PHILOSOPHY OF TECHNOLOGY: NEW STRUCTURAL CHARACTERISTICS OF TECHNOLOGIES

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"Advancing" means progressing, taking steps over time or distance toward another, a "better," place, objective, goal or goal state. So the overall topic of these proceedings, on advances in philosophy of technology, would appear to mean one of two things: progress or advances in *technology*, as seen from the perspectives of the philosophy of technology; or as intellectual steps taken toward achieving a new state of the art within the field of *philosophy of technology* itself.

In my conference paper, I addressed both of these issues. First I dealt with the concept of progress (in particular, technological progress), in methodological terms and in terms of sociotechnical systems and related social values. This part of my address has already been published in this journal (1997, 2:3-4, pp. 102-120), in a paper—"Progress, Values, and Responsibility"—that also discusses the responsibilities of various actors within sociotechnical systems.

In what follows here (the second part of my conference paper), I detail some aspects of both general trends and essential characteristics of both the overall development of technological systems and particular developments within them. These trends have begun to appear over several decades, and I predict that they will turn out to be prominent features within technological development in the foreseeable future—especially in terms of the latest technologies and comprehensive technological systems, including their ecological and social contexts.

Surveying classical interpretations of technology—e.g., as extension of human organs (Kapp, 1877), as "realization and reification of ideas" (Dessauer, 1956), and as productive self-realization by working on and encroaching into nature (Marx, various writings)—one gets a bunch of aspects; they belong to what has occasionally been labeled *Realtechnologie* (real technology and/or material technics), but it does not seem to be applicable to just one main fundamental trait but opens up a whole spectrum of diverse elements. All of them together would appear only grossly to characterize or comprise the multilevel phenomena of modern technological or sociotechnological development. It seems fair to say that no one unique trait characterizes techniques or technology or even the essence of technology; only a pluralistic theory of technology could cover all the general fundamental traits. That would mean that philosophy of technology has to be a pluralistic discipline, or to choose a pluralistic approach. Single-factor theories of technology, highlighting just one trait (e.g., the domination of nature) are much too global and offer skewed interpretations that are hardly sufficient to cover all the different levels and aspects either of modern technology or of technological societies.

This is all the more true in our "information-and-systems-technological era" (Lenk, 1972, 1973), with its ever-tighter enmeshment of systems and relationships within systems, as well as the linking and controlling of information in worldwide networks, with scientization and comprehensive organization and management technologies in industry, as well as its abstract procedures, generalizations, and formal and functional approaches.

This seems to be a general and quasi-lawlike trend leading to increasingly comprehensive outlooks. An interdisciplinary theoretical description of technical objects, operations, procedures, systems—including sociotechnical structures and technological action systems, as well as environmental, cultural, economic, and political conditions and influences—has to be taken into consideration in a pragmatic or reality-oriented philosophy of technology. A pragmatic philosophy of technology has to identify and distinguish all of the intriguing practical trends within the different fields of technological or sociotechnological developments; it must supply a kind of total view of the phenomenon of technology, including historical trends as well as cultural traditions, along with new revolutionary outlooks caused by technological breakthroughs such as the "information revolution," or systems engineering, or systems technology management, as well as biotechnologies.

In what follows I would like to give a short characterization of some rather new characteristics of technologies, especially those sometimes called "new technologies." The latter have gained prominence and are still getting emphasized in overall technological development, particularly in leading areas that are shaping our technological future.

I will mention thirty characteristics that transcend what were traditionally called the "essential" features of classical technologies. The classical trends continue and they still have leverage, but they are embedded in new trends—generalizing, funtionalizing, formalizing, and encompassing—which are especially characteristic of the new technologies and of their social, intellectual, material, and ecological contexts.

In 1970 I started to define some trends in the operations-oriented, function-oriented, information-oriented, and systems-oriented aspects of technologies and the technological world. Thus far, developments in what I then called the "information and systems-technological era" have continued, but they have dramatically accelerated, gaining weight and prominence in the last two decades. Now they are progressively having a more and more comprehensive impact and are beginning to reshape if not revolutionize our environment and social world. We seem now to live in something of a sociotechnological, a human-made and artificial world—at least to a considerable and ever-increasing degree.

Here is my list of thirty characteristic traits of the modern technological world:

1. *An orientation toward operations, procedures, and comprehensive processes in technology:* Technology does not only comprise machines, instruments, and other technical products; there is a growing and accelerating importance of and orientation toward technological processes, operations, and procedures. Process control and managerial procedural phenomena are outstanding features of modern technological and industrial production and development (see Lenk, 1972). This simply strengthens an earlier trend, when energy transforming machines and systems and assembly-line production became widespread. In more recent technology, "the *real* is the procedural" (Häusslein, 1995). At least as an interpretation, we can say this is the most characteristic feature of modern technologies.

2. *Systematic methods and methodologies:* Essential are not only methods but also, increasingly, methodologies. This trend is to be found in all science-based technological developments as well as in administration. These general trends characterize more and more fields that have been captured by "operations technologies": process control, systems engineering, operations research, etc.

3. *Informatization, abstraction, formalization, and concentration on operational essentials:* It is by way of computerization and informatization, as well as the use of formal and functional operations technologies (e.g., flow charts, network approaches, etc.), that increasingly comprehensive processes, organizations, and interrelations of different fields and subfields are integrated. Information technologies lead the way.

4. *Comprehensive systems engineering or systems technology:* It is characteristic that different technological developments, including economic and industrial realms, are feeling this joint impact. It provides development with a kind of positive feedback, leading to systematic interaction and generally to a kind of systems acceleration across different fields. (This trend was already predicted in the 1920s by Gottl-Ottlilienfeld, 1923.)

5. *Technological needs and problems generated on the basis of potential solutions produced by systematic searches for options including possible utilization* (Klages, 1967): In research and development, the systems character became obvious already some decades ago: There is a significant tendency to systematically sift and exhaust potentials, possibilities, and options (see Gehlen, 1986, p. 169; also the so-called "morphological matrix" of Zwicky, as noted in Ropohl, 1975, 1978). Frequently, only *after* having detected several products, processes, or procedures in a systematic search will an application be launched or a new "need" discovered, created, or even manipulated—which can only be satisfied by the technological development already completed. In these cases, the technological solution or invention precedes the need or the problem to be solved. (Marx had already predicted this in his philosophy of technology, largely still to be rediscovered.)

6. *Interdisciplinary interaction and stimulation*. Interdisciplinarity is led by spillovers from science to science and from there to technological development

and innovation or implementation—as well as to society at large. It characterizes the embedding of interdisciplinary interactions within the overall developmental purview. System technologies require interdisciplinary approaches in practice.

7. *Artificial environments and a world widely made up of artifacts:* Technogenic relationships, properties, and technological or technology-made objects are shaping our world to such a degree that we can talk of an *artificial world* we are living in. (The "second nature" or "symbolic universe" mentioned in earlier decades by Plessner, 1965; Gehlen, 1957; and Cassirer, 1944, has now become a *technological* second nature, and it includes all the characteristics I have here attributed to technology itself.)

8. *Technicalization of the virtual and fictional:* We now find a kind of virtualization of the artificial and symbolic worlds in information technologies as well as in images and models and the related interpretations that superimpose themselves on real life. (Counterreactions by new cultural critics should also be noted.)

9. *Systematic, and accumulating, combinations of the technomedia ("multimedia"):* All these processes and developments of the technicalization of the symbolic, of virtual representations and their respective interpretations, lead to a kind of *co-action* or co-evolution of different information technologies and media. There is ever-increasing universality and a common impact, as well as systems integration. We seem to be living more and more in a multiply-mediated technogenic world impregnated by multimedia—in short, in a *multimedia technoworld*.

10. *Multiple manipulability and flexibility in software simulations:* Computerization and software models allow a somewhat risk-free and inexpensive simulation or testing of technological constructions and developments in advance. This feature has general, if not universal, scope in adapting the models of science, planning, and administration. Systems organizing and management are rendered more flexible and variable than hitherto.

11. *Model simulations provide flexibility, adaptability, risklessness:* Computer models, software programming, and other successful attempts at improving and optimizing the relevant models by way of computer programming

and computer-graphic constructions provide efficient, inexpensive, and quick solutions to all kinds of design and construction tasks. (This includes scientific modeling, e.g., in molecular design; and the technical construction and development of new machines, procedures, and systems in the narrower sense; and it goes beyond analytic solutions of mathematical equations and systems.) The computer has turned out to be a universal, easily employable, and representative "can-do-anything" instrument, providing extreme variability, easy detours, and energy and cost savings, with no physical resistance or obstacles—since the models are simulated in advance and without real risks.

12. *Modularity, flexibility, and multiple applicability:* Generally speaking in technology there is a comprehensive trend towards modules, functional building-blocks, and functionally integrated microprocessors. These can be inserted, by way of adaptable connections or exchanges of chips, within other modules and systems. This increases technical progress and development, as well as exchangeability of obsolete parts or modules, to an extreme degree. Modularity of parts and elements provides universality of applications of the respective parts and modules within other processes and instrument systems—called, in sum, "flexible production systems" (Ropohl, 1971). Interfaces are relatively open and guarantee a full spectrum of options, possible ramifications, and applications. Connectivity, flexibility, and the dynamics of development—as well as multiple and universalized applicability of partial technical solutions—are enhanced.

13. *Remote control and intelligent sensing:* New electronic and multimedia technologies allow remote control and intelligent sensing at a distance or in unaccessible environments. Examples include robot manipulation in nuclear plants, or in outer space. This multiplies manipulative and technological power in extension and scope; it also allows us to speak of technological instruments and systems as "intelligent."

14. *User-friendliness and self-explaining design:* New technologies have gradually become more user-friendly, more anthropomorphic in their reactions, sometimes displaying a self-explanatory design tending to minimize or even eliminate the need for technical manuals and instructions.

15. *"Intelligent" technology and systems autonomy:* Not only in sensing

and remote control instruments, but in a plethora of instruments, feedback control and "intelligent decisionmaking" techniques and procedures are progressively gaining momentum. This provides a kind of flexible systems autonomy.

16. *Meta-autonomy:* In the designing, building, and monitoring of machines, programs, or technological and organizational systems, there is a tendency to eliminate human interference: "Machines build machines, machines check machines, programs control and check machines, programs supervise programs," according to Mussgnug (1997). In effect, this involves a meta-level technicalization in terms of a higher-order self-applicability of overarching abstract procedures, programs, etc; it amounts to a sort of "reflexive" or "self-referential" self-applicability—a meta-feasibility and metafunctionality (see Häusslein, 1995).

17. *Robotization* will proliferate and be widely disseminated in all fields of technology-guided production.

18. *Computerization and multifunctionality:* Universal machines like the computer provide a certain kind of abstract, software-determined use of programmed processing and control. Generally, universal machines and technological as well as techno-organizational systems are advancing fast and progressively maximizing all the features of flexibility, speed, "intelligent" machine autonomy, exchangeability of parts, and so on.

19. *Mega-information-systems and megamachines:* There is a tendency to conceive of the whole world as technology-dominated, manipulated, organized, shaped by technosystems. Ecosystems and social systems become artificially-encroached-upon ecotechnosystems or socio-technical systems. The trend towards a mega-information-system or mega-world-machine is enhanced by the meta-functionality of technological and operational processing, and by the multiple applicability of processes, machines, and programs.

20. *Telematization and techno-reality:* Telematization of almost everything, world wide ubiquitous presence, is the idea of a global information village come true. Nor does this mean mere passive attention to a ubiquitous media presence. There are locally separated but functionally coordinated teams working on giant virtual projects, designs, or networks (e.g., the Internet). The

"second nature" of technology-enacted reality engendered by information networks is becoming more evident and having a greater impact. The media technicalize a kind of reality. This second-hand informational reality has become a "real reality," so to speak.

21. *Information-technological historicity:* Not only comprehensive information systems, expert systems, and computerized decisionmaking systems designed, developed, operated on, and controlled by many programmers and agencies take on a certain history of their own that mirrors the development of "the system" thus far; a representation of world history in media systems seems to display a peculiar historicity for our "media-ted" virtual reality. *Quod non in actis non in mundo* [what was not written about is not real] used to be a saying of historians; now it is, *Quod non in systemis non in realitate* [what is not in a system is not real].

22. *Globalization of technology:* The overwhelming global success of technology and the technicalization of almost everything leads to a new unity of the world—engenders a new "technogenic world," technological, informational, interactive, integrated. Indeed, to a large extent we seem to live in a *media-electronic global village*. (This was already hinted at in characteristic 20.)

23. *Intermingling, interrelations, and interdependence of all technological products and processes:* By way of the interdisciplinary, formally systematized, functional integration and interrelation of generalized operations in all walks of life, we are getting a weaving together of mutual dependencies among all the realms of life that are susceptible to systematic technological, informational, and operational manipulations (including economic manipulation).

24. *Socio-techno-systems:* Nature and nurture tend to go together, even to coincide almost everywhere. Systems orientation, systems engineering, and the establishment and maintenance of socio-techno-systems lead to an inseparable, indissoluable social systems syndrome provoked by ever-growing, ever-accelerating, ever more encompassing technological measures (see Lenk and Ropohl, 1975, and Ropohl, 1996).

25. *Systems-technocratic tendencies:* As I predicted already twenty-five years ago (Lenk, 1972, 1973), systems technocratic tendencies will gain in

importance. This means that different political, cultural, and human problems of modern societies will tend to be conceived of and discussed, as well as attacked (and maybe even partially solved) by systems-technological means. Systems-technological administrations are gaining momentum everywhere. Systems-technocratic dangers seem to be intimately integrated with systems-technological approaches.

26. *Personal and data protection against information invasions and encroachment:* With respect to information technologies, social and legal problems of data protection and privacy, as well as protection of the integrity and dignity of the human person and aspects of human values, even of what it means to be human—all of these have particular urgency.

27. *Susceptibility to sometimes unnoticeable risks:* The encompassing intertwinement of systems components within all-comprehensive socio-technological systems in general implies a certain susceptibility or proneness to risks. For example, several times there have been electrical blackouts of whole metropolitan areas. Risk susceptibility of highly developed and densely intertwined systems also amounts to a kind of systems-technocratic danger. Some technically-engendered dangers (e.g., radioactivity) may even go unnoticed by those who are affected.

28. *Miniaturization and nanotechnology:* Intriguing trends which favor ever more miniaturized technological subparts, elements, and building blocks (in the figurative and literal sense) produce another kind of danger: the "chipifying" of everything. Combined with ever-increasing miniaturization, micro-systems technology, even nanotechnology, these trends might extend not only the technological availability and manipulability of all sorts of information-management and systems-regulation processes that have universal reach; it might lead to spillovers into these systems of dangers generated at the micro level.

29. *Systems-technological and informational-technological multiplication of impacts, whether of technological success or technological failure:* With the nearly unimaginable explosion of human technological power in the vast extension of energy technologies and systems and information technologies and systems, direct and indirect consequences both of success (domination and manipulation) and of failure (catastrophes, "normal" or otherwise) will pose extraordinary

problems to deal with. Indeed, they seem to grow beyond any potential human grasp (in the literal as well as in the figurative sense).

30. *Who bears responsibilities, their limits, and their distribution:* Ever-extending systems-technological trends and the enlargement of the power of encroachment in multiply distributed technological systems—big technologies, even worldwide technological systesms—pose tough ethical problems, including responsibilities for the still-human-made technological world and events therein. (See Lenk, 1994.) These tough questions arise and seem to present insoluble tasks of how to deal with, divide up, distribute, or share responsibility. Technology appears to take on the characteristic of a fate or destiny. At the same time, the survival of humankind, essentially and cumulatively, appears to depend on increasing technological, social, political, and ecological progress. However, ever-accelerating technological progress, on a worldwide scale—including "globalization" effects in organizations and the economy—seem to take on a vast expansion and momentum. Responsibilities for general systems phenomena, for detailed consequences of technological intertwinements, even for individual decisionmaking at strategic points, can hardly be borne by individual persons, given current legal and moral responsibilities. Large realms of socio-technical development seem to evade responsible decision-making and any willingness at all to accept responsibility. This is a problem that my co-worker, Dr. Maring and I have been struggling with for almost a decade (see Lenk and Maring, 1991, 1998).

With this thirtieth feature, I conclude my list of the structural characteristics of modern technologies. These traits, especially those pertaining to so-called new technologies, seem clearly to force us to extend descriptions of the structural features of technology and technologies beyond any of the traditional accounts mentioned in my introduction. It may be interesting now to analyze combinations and conditional relationships among these characteristic features, and to allocate them to particular technologies and technological fields, as well as to sociotechnical contexts and problems. But that remains a task for future studies.

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