Arne COLLEN*

DEVELOPING A SYSTEMIC APPROACH TO HUMAN SCIENCE RESEARCH METHODOLOGY

Six directions to advance research methods for human inquiry are described, illustrated, and discussed in relation to three levels of methodological complexity, which lead to the use of more generic, perspectivistic, and integrative means to construct methodologies for the conduct of collaborative, disciplined, and human oriented inquiry.

1. INTRODUCTION

In previous papers [14, 15, 17] I have described my views on the global problematique and the need to develop better means to address the growing concern. Essentially, our ingenuity of confluence among civilization, culture, science, and technology has brought about a miraculous boon in the proliferation of the human species at a staggering cost to almost all other planetary processes. This fact has also brought an equally impressive potential for amelioration of human existence. But sadly I would contend, a careful examination of human history reveals that the benefits of this confluence seem to come through the exploitation and suffering of many peoples.

It appears clear that we — human beings — got us into the current mess; therefore, I assume it is up to us — human beings — to get us out of it. In other words, if one believes in the value called "progress," then our responsibility for it includes both the positive and negative sides of human activity. It is my position that the subject of methodology is one constructive focus of our energy, resources, and time to address present concerns. However, when I point to methodology, I mean in its broadest sense, not limited to technological advances and magic bullets [13].

As we deal with the planetary trends, it would behove us to scrutinize carefully our current research methods and undertake the task of inventing new ones as deemed necessary. The depth and complexity of the issues now appear to extend beyond our immediate comprehension, thus compeling us to reassess our practices and seek advancements in methodology to levels which match the complexities of the problems we face. It is this increase in complexity that draws us to the systems sciences, the metascience of complexity, in the hope of advancing methodology [6, 24, 26, 30].

*Saybrook Institute, 450 Pacific, 3rd Floor, San Francisco, CA 94133

The purpose of this paper is to sketch several directions toward which methodological advances can occur. The points made above provide the basis of a rationale. Further explication of this rationale must be given with each direction developed, in order to justify that version of human inquiry. In doing so, heavy emphasis is placed on systems theory [37] and systems methodology [11, 12, 17]. Although various conceptual schemes and taxonomies are considered, it is the category of the Human Activity System (HAS), as one kind of system, that occupies repeatedly the center of our stage. Philosophical considerations aside, the general working definition is as follows: a HAS constitutes a set of human beings and the various forms of activity among them. Much interest centers on the communications among the persons comprising the HAS, and often it seems, these communications are of greatest importance than any single person or kind of activity of the system.

At this point, it is important to state my central premise is that methodology can be advanced through a generic and systemic approach to human inquiry, which I term Human Science Research Methodology (HSRM). The core notion of HSRM is its expression in various forms to fit the persons, problem, and context. The power in the notion is its generic potential, that is, its flexibility to become manifest in its various forms. Naturally, methods which are designed to work with a HAS appear to have the greatest relevance to HSRM. Furthermore, HSRM involves a systemic process of methodology development that makes use of systems thinking, which I have defined elsewhere as an integrative, dialectical, oscillative, complex, and rarely achieved form of human thinking involving several subcomponents, noteably induction-deduction, divergence-convergence, analysis-synthesis, objectification-subjectification, structure-process, and space-time [18].

The acronym HSRM represents a generic approach to inquiry. *Human* is an orientation that means inquiry by, for, and about human beings, although it must be emphasized that the intention here is to attend equally to ecological and contextual concerns, because almost all such problems have today become human problems. *Science* is adopted as the chief collective form of human activity for the discovery, production, and evaluation of knowledge, which can be applied to our concerns. But a transdisplinary and multi-methodological view of human science is intended [13]. *Research*, for the purposes of this paper, is synonymous to inquiry; however, by research, I mean disciplined inquiry. Disciplined inquiry is the process of investigation by the scientific community involved with the subject of study that is conducted by means of systematic, formalized, and agreed upon rules and procedures. *Methodology* is both the study of methods and any composite, integrative construction of methods available for application to a specific disciplined inquiry. Thus, HSRM is disciplined inquiry focused on human beings to formulate knowledge which may eventually ameliorate human concerns and problems. Finally, HSRM, as a generic, is a family of research applications that share a set of common characteristics, which may be used to innovate and derive additional applications.

2. SIX ARMS TO MUSCLE FORWARD

The six arms or areas discussed in this section are common ones. There is no attempt to be exhaustive. To reiterate, my intention is to sketch some potentially fruitful directions for developing, then applying HSRM.

2.1. THEORY

The important interrelation between theory and method cannot be overemphasized. There is a rich literature available in that portion of the systems sciences devoted to human activity systems, which contains many contributions for advancing methodology. Some outstanding examples are Checkland [6, 7], Churchman [8], and Miller [30]. Let us note briefly one scheme for illustrative purposes. Checkland [6] classifies systems into five major classes: natural, designed physical, designed abstract, human activity, and transcendental systems. The systems comprising each category are associated with their own features, properties, disciplines of study, bases of knowledge, theories of explanation, and methods of inquiry.

Checkland's scheme can serve as a theoretical foundation for the development of systems methods suited to the study, understanding, and improvement of each type of system. Consequently, if we were to adopt this typology, it is critical that the methods appropriate to each kind of system be well understood. Further, to build a HSRM, we must understand the relation of systems categories to each other and the methods affiliated with each category, in order to integrate appropriately two or more methods in constructing a HSRM productive to the inquiry. In this case, my interest is human inquiry; thus, it is likely that methods relevant to a HAS become primary and those of Checkland's other categories secondary, to the extend that they may fit compatibly into the HSRM application.

In short, we have two levels of consideration. First, we must know the methods of each category. Second, we must know how to fit them together in various combinations to construct a methodology which justifiably transcends categories. In turn, the family of combinations comprise a generic HSRM from which we can draw upon to design a specific HSRM application. In each case, a specific HSRM is required to meet the demands of the problematic aspects of the complexity to be faced. This is no easy task, whether working at the first and/or second levels.

In my opinion, at present, we know little about how to do methodology construction, and — more to an underlying premise of this paper — to do it well, as evidenced by the negative sides of progress, such as human-made overpopulation, chemical pollution, and species extinction. Narrow focus and short-sighted applications of methods have been a contributing factor to generate these global trends. However, the optimistic side is that the growing crises have forced us to engage in more transdisciplinary communication and collaboration, multi-perspective descriptions and considerations of problems, and multi-method approaches to inquiry.

In general, it is possible to base a HSRM on each taxonomy of systems articulated in the systems sciences. In principle, a HSRM can be developed from each direction (each arm to muscle forward). For those who prefer emphatically to integrate theory and method, the challenge becomes: which taxonomy appears to be the more productive and relevant to the task? Does each form of HSRM converge toward the same generic, regardless of its founding taxonomy? Perhaps, each direction is a equipotentiality with a predictable equifinality, as described in General Systems Theory [37].

2.2. EXPERTISE

A second arm is to draw upon those whose wisdom may have something to show us in guiding us through to each HSRM application. These outstanding persons are likely to be those systemists who through a lifetime of work with people and their problems have the insights and adeptness to know what to do in human predicaments. These elders and sages are not necessarily those who have received the most accolades in their field. They may be humble experts, perhaps sparsely published and rarely in the public eye. They may not be formally trained in systems science, systems thinking, and systems methodology; they may have no academic degrees whatsoever. But they may be recognized among their peers for possessing equivalent qualities, which become an invaluable community resource in times of crisis. Maslow's research [29] into the lives of so-called self-actualized persons may help to define this area. When asked for prototypical examples, I reply that Eleanor Roosevelt and Albert Schweitzer represent two such persons.

Each expert can serve as a key member of the HAS developing its HSRM. Various experts may also serve as models for detailing their HSRM; these models in the flesh, so to speak, generate numerous variations, which as a collective comprise the generic. Specifically, there are a number of central contributors to systems methodology who, from their work in bureaucratic organizations, have advanced a systems method or methodology. In effect, each contributor has served as a kind of expert. To note several salient examplars, we have from Ackoff Interactive Planning [1], Argyris Action Research [2], Banathy Three Models Approach [4], Checkland Soft Systems Methodology [6, 7], Linstone Multiple Perspective [28], Miller Living System Process Analysis [10, 30], and Weisbord Future Search Conference [38]. These contributions appear to describe the first level of an emergent HSRM based on the experts. In organization and management research, an initial attempt to move to the second level may be the conceptualization of Total Systems Intervention by Flood and Jackson [25]

2.3. EXPERIENCE

In contrast to the expert, the experience of each member of a HAS is a valuable resource in human inquiry. Each member builds up a fund of experiences which provide the substance to construct a conceptual framework and cognitive map for successfully navigating many social contexts. This personalized expertise makes it possible for the individual to contribute constructively to the process of inquiry as an active collaborator and co-researcher. Thus, as a collective, the HAS can tap into this resource at all stages of the inquiry. Recognition and validation of this rich source of human experience is recognized in forms of collaborative inquiry [1, 4, 6, 7, 38, 39]. Specifically, in earlier versions of his design methodology Banathy [3] defined one of five conceptual spaces as the "Experience Space," in recent versions termed the space of "Evaluate Design Alternatives."

Further, literatures in the social psychology of small groups, communication research, team work, interdisciplinary research, cooperative learning, focus groups, and group facilitation are especially relevant [19, 25, 27].

This direction for the advancement of methodology rests on the human potential inherent in the HAS. It assumes that each person has a needed and worthy contribution to make to the group engaged in a HSRM. The generic HSRM based on

this initial starting point would emerge from a rich diversity of specific HSRM applications generated by the unique talents of individual members combining in synergistic forms to move human inquiry toward its intended end, as defined by its members.

2.4. PRACTICE

This direction for developing methodology is to be distinguished from the others by its emphasis on praxis. Special attention is given to the pragmatic and praxiological aspects of a method or methodology. Some key questions for the practitioners developing their specific HSRM are: What works? What works efficiently and efficaciously with maximally beneficial and minimally aversive consequences. What works cost effectively? But it is through the doing — the practices of inquiry — that the specific HSRM emerges.

An example of methodology development from practice is the Westinghouse studies associated with the notorious Hawthorne effect [33]. In this research program, the investigators developed their inquiry from experimental method to research interviewing to participant observation over the course of nearly two decades. The decision to change their approach to study their subject was based on not only practical considerations, but also the limited results obtained in earlier studies. The delimitations of one method pushed the researchers into using another method.

The published research literature is providing increasing testimony to the fact that researchers find it increasingly necessary to construct through the process of inquiry a more complex methodology. Two further examples, of many I could mention, must suffice here. Trauth and O'Connor [34] studied "the role of societal factors in Ireland's progression from an agrarian to an information economy." Their methodology made use of participant observation, open-ended interviewing, and documentary analysis, a combination frequently found in ethnography. Davies [21] studied the organizational culture of the British army. She constructed the methodology for her inquiry within the framework of Checkland's soft systems methodology. She expanded the methodology beyond its heavy dependence on modeling to include additional recordings from participant observation, unstructured interviewing, documentary reading, and her researcher's diary.

2.5. SIMULATION

Simulation is used in this paper to mean mimicing, modeling, and duplicating in a vicarious and/or representational fashion the phenomenon and method of studying it. Specifically, we develop artifical eyes and arms to collect observations and samples; we develop software subroutines to guide a probe to positions for minute injections into neural tissue or for extraction of single cells; and we augment our personal meetings with media technologies to monitor and influence business transactions, politics, and consumer product distribution.

Though simulation may be the most vivid in the physical presence of technology in our everday life, it may be the most difficult to conceptualize as a basis for methodology development compared to the other arms to muscle forward. People comprise a HAS and from their collaborative process unfolds a HSRM. But much of the essential support for this process depends on the reliable operations of our technologies, that is the hardware. In the conduct of inquiry, for example, computer

communication among the members of the research group is becoming more common at all stages of the inquiry process.

We focus on the substance of our communications, information and meaning, taking for granted that the machinery which makes the communications possible will continue to operate flawlessly. Without the dependability of the technology, we must revert back to an earlier form of the HSRM; in other words, we must be prepared to practice as we did before the technology became an integrated part of our methodology.

This direction is almost entirely supported and dependent on technological devices with human operators. The human-machine interface lies at the core of this direction of methodology development. With the rapid spread and availability of a wide range of technologies, modeling the real world is quickly approaching such realistic proportions that the boundary between natural and virtual reality may appear to be getting fuzzier. Although the publishing and film industries capitalize on the fearful implications in horror and science fiction, there are many profound beneficial applications awaiting our futuristically oriented scientific explorers. The limitations of scale of the human body and the impossibility of entry into environments, which cannot support the existence of human life, have prompted the development of simulation methodologies. Genetics, space and ocean exploration, medical diagnosis and microsurgery, artificial intelligence, and robotics are outstanding examples, where computer supported simulation, imaging and modeling methods provide the methodology of the inquiry by extending the human senses of the collaborating personnel to examine human activity systems to profound microscopic and macroscopic depths. A fine source of abstracts reporting on these developments is the weekly publication, *Science News* [32].

Perhaps the most blatant evidence of the widespread use of simulation in the systems sciences is modeling. Systems methodologies in the service and study of a HAS tend to make use of modeling as a part of the methodology [1, 2, 4, 6, 7, 10, 16, 28, 38]. But most applications tend to be limited to specific problems [5, 22, 36].

More to the purpose of this paper is the following illustration. Routine functioning of large corporations today around the globe rely on the complex interconnection and interdependence of a) people, b) hardware, and c) software [15, 16, 19, 22, 30]. They are so extensively interwoven that any malfunction in a, b, or c produces a blip in the system, so to speak, which chief executive officers and corporate consultants prefer to describe in terms of profit and loss, resource utilization and management, and productivity and employee satisfaction. There is a belief that the efficient interface among a, b, and c can give the corporation a superior competitive edge, and to that end simulation supported HSRM applications have a twofold purpose in the large corporate setting: 1) ongoing organizational analysis and redesign of subsystems of abc interface, and 2) play at designing, planning, and implementing various scenarios of participation and economic survival in the global marketplace.

Once a technology is evident, interests soon follow to apply it in the service of human inquiry and to combine it compatibly with other technologies in use. With careful examination, it soon becomes apparent this complex integration has made possible every major adjunct to human science. I state only a few obvious examples: the telescope, microscope, telephone, automobile, camera, submarine, and computer. One view of the history of science consists of the incremental integration of natural and technological discovery leading to further natural and technological discovery.

To end this section, I stress that simulation not only supports, but also augments a HSRM application. Perhaps this fact becomes clearer when one can see that from

every newly developed technology there develops the method of its application in scientific inquiry. Consequently, one can describe a taxonomy of technologies as the basis for methodology development, in order to formulate a general conceptual scheme of the various methods that human beings have ingeniously applied to the study of human phenomena, problems, predicaments, and issues. From each technology springs a method, and convergence with other methods yield methodologies. Again, we can look for specific HSRM applications and eventually the HSRM generic that umbrellas them. Corroboratively, van Gigch [35] describes a three level hierarchy of modeling that parallels the hierarchy of methodological complexity described in this paper.

2.6. INNOVATION

The last direction may be considered part of the previous five, however, the equal emphasis I wish to give to innovation compared to the other directions comes from the importance of experimentation and serendipity in science. At some level, scientists tinker with the phenomenon under study. Plausible variations in scientific procedures are used to comprehend the scope and depth of the discovery. The conditions in which the phenomenon becomes salient and persists are of great interest. As is often pointed out by scientists, it is the unexpected which leads to the next step in the research, the next breakthrough, and the next serendipitous discovery.

Thus, in this sense, innovation of our current methods becomes the direction to produce the groundbreaking methodological improvements as well as the new methods. Innovation can be a principle used to find those variations of different methods which can be combined compatibly. For example, under some conditions, focus groups may be used with surveys and fed into a soft systems methodology conducted in an organizational setting. Experimental method may be used within a systems methodology [9]. And again, I note the Westinghouse, British army, and Ireland studies [21, 33, 34]. The search for repeated combinations that appear to fit under a variety of circumstances and conditions becomes a pursuit for maximal generalization and articulation of the HSRM applications, which may eventually reveal the HSRM generic.

3. IMPLICATIONS AND CONCLUSIONS

From my perspective, the six directions overlap and to a degree are interdependent. The six directions are used only to organize this presentation, and in other contexts these areas may be largely artificial. The development of any methodology necessarily involves all six directions. It just depends upon which direction, or one might say *perspective*, that the researcher finds more beneficial for constructing and conducting the inquiry.

In searching for directions to improve our methodologies, it is a matter of emphasis; however, the area given greatest emphasis will, of course, influence the HSRM application. Consequently, the implication is that a Theory-based HSRM generic will have primarily theoretical contributions to make, an Expert-based generic will have humanized-prototypic contributions, a Practice-based generic will have pragmatic-praxiological contributions, and so on.

In bringing closure to this paper, it is important that a third level be advanced, whereby the basis of each direction be integrated toward the generic. This more fully

developed and comprehensive approach, HSRM, brings depth, breadth, and complexity to the methodology — an approach which is likely required in order to fit the methodology to the apparent complexity of the phenomena, problems, predicaments, and issues. But this leads us to the matter of the HSRM generic. Of course, as we develop our methods and combine them into various methodologies, the emergent HSRM generic is actually a tertiary level or metamethodology, the subject area of which this paper has from the outset sketched.

Certainly, it is hoped that the explicit and eventual articulation of the overarching HSRM generic, the metamethodological level, breathes renewing life into human collaborative inquiry directed toward the amelioration of humankind, and that it offers an advantageous vantagepoint for the elaboration of the hierarchy of methodological complexity. HSRM involves a systemic process of methodology development benefiting from systems thinking. This paper has described six directions from which this development may proceed. Human science research methods comprise the ground level. They provide the springboards for advancements in methodology from the primary level as well as the foci of delimited application. They can be combined, integrated, and innovated to construct the more complex secondary HSRM level applications. At the apex of the hierarchy, the tertiary level, the commonalities among the HSRM applications amplify to form the generics of metamethodology.

REFERENCES

[1] ACKOFF, R., *Creating the corporate future*, John Wiley & Sons, New York 1981.

[2] ARGYRIS, C., PUTNAM, R., and SMITH, D. Smith, *Action Science*, Jossey-Bass, San Francisco, California 1985.

[3] BANATHY, B. H., *Systems design of education: a journey to create the future*, Educational Technology, Englewood Cliffs, New Jersey 1991.

[4] BANATHY, B. H., *A systems view of education: concepts and principles for effective practice*, Educational Technology, Englewood Cliffs, New Jersey 1992.

[5] BREITENECKER, F., FROTSCHNIG, A., and KOPACEK, P. Kopacek (1990), Simulation methods in peace and conflict research, Proc. Cybernetics and Systems Research '90, World Scientific Publishers, Singapore, Indonesia (1990) pp. 651-658.

[6] CHECKLAND, P., *Systems thinking, systems practice*, John Wiley & Sons, New York 1981.

[7] CHECKLAND, P. and SCHOLES, J., *Soft systems methodology in action*, John Wiley & Sons, New York 1990.

[8] CHURCHMAN, C., *The design of inquirying systems: basic concepts of systems and organizations*, Basic Books, New York 1971.

[9] COLLEN, A. Collen , *Experimental method within systems method-ology: the case for and against*, Proc. Soc. Gen. Systems Research, Intersystems, Seaside, California, Vol. I (1985) pp. 536-539.

[10] COLLEN, A., *Living systems process methodology for the design and redesign of organizations*, Proc. Soc. Gen. Systems Research, St. Louis, Missouri 1988.

[11] COLLEN, A., *Can science be natural, systemic, and human?* Proc. Soc. Systems Sciences, Edinburgh, Scotland 1989.

[12] COLLEN, A., *Human science and systems science: allies or enemies?* Proc. Human Science Research Association, Aarhus, Denmark 1989.

[13] COLLEN, A., *Advancing human science*, Saybrook Review, Vol. 5 (1990) 1-38 .

[14] COLLEN, A. Collen , *Evolutionary guidance systems and systems design*, Proc. Cybernetics and Systems Research '90, World Scientific Publishers, Singapore, Indonesia (1990) pp. 261-265.

[15] COLLEN, A., *Evolutionary guidance systems and societal-to-global learning*, Proc. Fuschl Conversation, Fuschl-am-See, Austria 1990.

[16] COLLEN, A., *The systems approach and its methods for systems development*, Invited address to the Center for Systems Development, Aarhus University, Aarhus, Denmark 1990 .

[17] COLLEN, A., *Methodological perspectives on human systems, design, and learning for a more global ethic*, Cybernetics and Systems Research '92, World Scientific Publishers, Singapore, Indonesia, Vol. I (1992) pp. 561-567.
[18] COLLEN, A., *Forms of scientific thinking: thinking about systems, systems thinking*, Invited address to the Italian Association for Research on Systems, Bologna, Italy 1992.
[19] COLLEN, A., *Thoughts on a system for design learning*, Design and systems. The International Annual of Practical Philosophy and Methodology, Transaction Publishers, New Brunswick, New Jersey, Volume 3 (1994) pp. 299-308.
[20] CLAPPER, D. and McLEAN, E., *Information technology in support of group activity: a theoretical framework and implications for research*, Information Systems Research: Contemporary Approaches and Emergent Traditions, North-Holland, Amsterdam, The Netherlands (1991) pp. 613-629.
[21] DAVIES, L., *Researching the organizational culture contexts of information systems strategy: a case study of the British army*, Information Systems Research: Contemporary Approaches and Emergent Traditions, North-Holland, Amsterdam, The Netherlands (1991) pp. 145-167.
[22] DEUTSCH, T. and LEHMANN, E., *A clinical model for simulating blood glucose profiles*, Proc. Health Systems — The Challenge of Change, Omnipress, Prague, Czechoslovakia (1992) pp. 987-990.
[23] ELLIS, R. and DELGADO-FERNANDEZ, A., *The design of European industrial systems: a systemic investigation*, Proc. Systems Thinking in Europe, Plenum Press, New York (1991) pp. 103-107.
[24] FLOOD, R. and JACKSON, M., *Creative problem solving: total systems intervention*, John Wiley & Sons, New York 1991.
[25] GLASSMAN, U. and KATES, L., *Group work: a humanistic approach*, Sage Publications, Newbury Park, California 1990.
[26] JACKSON, M., *Systems methodology for the management sciences*, New York: Plenum Press, New York 1991.
[27] KRUEGER, R., *Focus groups: a practical guide for applied research*, Sage Publications, Newbury Park, California 1988.
[28] LINDSTONE, H. *et al.*, *The multiple perspective concept*, Design and systems. The International Annual of Practical Philosophy and Methodology, Transaction Publishers, New Brunswick, New Jersey, Volume 3 (1994) pp. 177-242.
[29] MASLOW, A., *Toward a psychology of being*, Van Nostrand, Princeton, New Jersey, 1962.
[30] MILLER, J., *Living Systems*, McGraw-Hill, New York 1978.
[31] PRABHU, S., *Breaking the mould — the effective use of information technology in organizations*, Proc. Systems Thinking in Europe, Plenum Press, New York (1991) pp. 527-533.
[32] *Science news*, Science Service, Washington, D.C.
[33] SCHWARTZMAN, H., *Ethnography in organizations*, Sage Publications, Newbury Park, California 1993.
[34] TRAUTH, E. and O'CONNOR, B., *A study of the interaction between information technology and society: an illustration of combined qualitative research methods*, Proc. Information Systems Research: Contemporary Approaches and Emergent Traditions, North-Holland, Amsterdam, The Netherlands (1991) pp. 131-144.
[35] VAN GIGCH, J., *System design modeling and metamodeling*, Plenum Press, New York 1991.
[36] VERVEEN, A., *Qualitative analysis of physiological control systems*, Proc. Cybernetics and Systems Research '90, World Scientific Publishers, Singapore, Indonesia (1990) pp. 467-474.
[37] VON BERTALANFFY, L., *General systems theory*, Braziller, NNew York 1968,.
[38] WEISBORD, M., *Discovering common ground*, Berrett-Koehler Publishers, San Francisco, California 1992.
[39] WHYTE, W. (Ed.) , *Participatory action research*, Sage Publications, Newbury Park, California 1991.

SYSTEMOWE PODEJŚCIE DO METODOLOGII BADAWCZEJ W NAUKACH DOTYCZĄCYCH CZŁOWIEKA.

Opisano, zilustrowano i omówiono sześć kierunków decydujących o rozwoju metod stosowanych w badaniach dotyczących człowieka w relacji do trzech poziomów złożoności metodologicznej (kierunki te obejmują teorię, ekspertyzę, doświadczenie, praktykę, symulację i innowację). Przedstawione rozważania stanowią podstawę stosowania bardziej ogólnych, perspektywicznych i integrujących środków przeznaczonych do opracowania metodologii prowadzenia wspólnych, dyscyplinowych badań orientowanych na człowieka.

Technical University of Wrocław

Information Systems Architecture and Technology ISAT'94

Proceedings of the 16th ISAT Scientific School

edited by Mieczysław Bazewicz

Wrocław 1994