IIASA
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OPTIONS

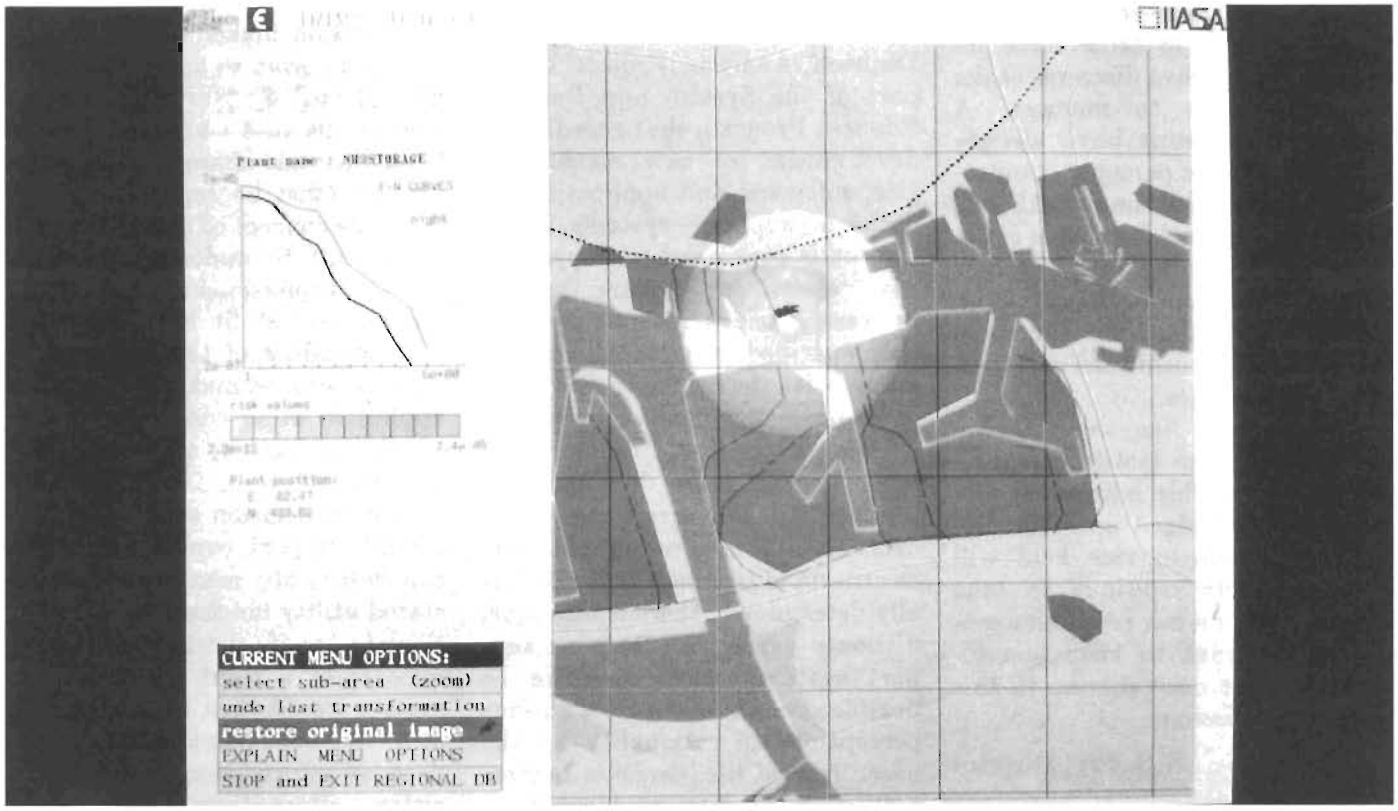

Figure 1. Monochrome reproduction of a risk contour overlay on the Rotterdam area (The Netherlands).

Decision Support Systems

IIASA's research into decision support tools, such as computer software and analytic models, rests on the principle that all our efforts should be applied to solving complicated, important, real-life problems. This is why IIASA almost always ties its theoretical work to practical applications, and collaborates closely with other scientific institutions directly concerned with making decisions about real-world issues.

As this and the next issue of *Options* illustrate, these programs influence and integrate IIASA's substantive work, both here in Laxenburg and in our wide network of collaborating institutions. Indeed, our System and Decision Sciences (SDS) Program has had a major impact on the Institute's core studies on the environment, population, and technology development and on our activities in such areas as food and agriculture, international negotiations, and advanced computer applications.

This clear link with practice implies an emphasis on decision making – or at least on the informed advice that should precede important policy decisions. Moreover, computerized analytical tools can make a direct contribution to the decision making process itself. Although such tools cannot substitute for the judgment and accountability of human beings, they can play an important part by enhancing decision makers' awareness of the criteria involved. In short, such tools promote action on a more informed and rational basis.

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For some years, IIASA has been active in developing decision support software for users who have no special knowledge of computers nor access to expensive equipment. Happily, as the power and sophistication of such systems have increased, they have become easier for non-experts to manage. A number of systems have already been adapted for personal computers. For example, the DIDAS system, which is ideal for a wide range of business applications, is now offered in the form of PC software, putting it within the financial reach of small businesses and individual researchers.

I hope that, like the software developed by the Institute and its collaborators, this edition of *Options* will be judged user-friendly. IIASA's efforts in this field will unquestionably continue to take high priority on our research agenda, so we want to keep you informed about our progress in this important mission.

R.H. Pry, Director

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The **International Institute for Applied Systems Analysis** is a nongovernmental, multidisciplinary research institution supported by scientific organizations in sixteen countries. **IIASA's** objectives are:

* to promote international cooperation in addressing problems arising from social, economic, technological and environmental change;
* to develop and formalize systems analysis and the sciences contributing to it, and to promote the use of the analytical techniques needed to address complex problems;
* to create a network of institutions in the countries with National Member Organizations and elsewhere for joint scientific research;
* to inform policy advisors and decision makers about the application of IIASA's work to current problems.

Methodology of decision analysis

IIASA's Methodology of Decision Analysis Project is the part of the System and Decision Sciences Program that coordinates development of new methodologies, software, and applications of decision support systems. The project is concerned with systems that assist in making choices between various alternatives, either specified in advance or generated with the help of the system.

To develop systems of this sort, it is necessary first to understand how humans make decisions and how to help them arrive at rational decisions. This is no simple task, as criteria of rationality are culturally determined: there is no single, ultimate yardstick. Decision support systems must therefore be flexible enough to allow for various perceptions of rationality by the user. In real life, decision makers will often view a problem from many aspects and with various criteria of success in mind.

The holistic approach

The project's theoretical work draws on a "soft" or holistic approach, treating the decision maker as a learning individual whose way of reaching conclusions depends on the extent of his expertise. Experienced decision makers intuitively absorb and process information. Others may need calculative rationality in the foreground, in order to build up a picture of the problem step by step. Decision support systems should cater to both sorts of user.

Many decision support systems try to approximate the user's utility function (a concept, borrowed from economics, denoting the form of welfare the decision maker seeks to achieve) and then suggest a decision alternative that maximizes this utility function. This subjects the decision maker to much questioning in order to approximate his utility; and if some new information means that the user's view of his utility has changed, the whole process must be repeated. Moreover, the concept of utility is usually difficult to understand for the user, and questions that he should answer do not fit his knowledge, understanding of the problem, or style of decision making. The same applies to other concepts, such as weighting factors, subjective probability, etc.

A good decision support system should support expert users who can holistically maximize their unstated utility function, by allowing them to specify the desirable consequences of a right decision. The system would then take the latter as a "reference point" and use more detailed information about the decision alternatives, constraints, and consequences in order to provide the user with proposals close to, or even better than, the reference point.

Upon analyzing the proposals generated by the system, the preferences of the user might be changed by his learning; but in any event he will know more, and thus be able to specify a new reference point and continue interacting with the system. This technology of decision support, known as aspiration-led decision making, is the original development of the group of scientists collaborating with the MDA Project.

Results to date

Emerging from the principles mentioned above are the DIDAS family of systems and, more recently, the SCDAS package, which supports committees. Both are already being effectively applied in a wide variety of settings. Now, research

is being carried out under contract for the Digital Equipment Corporation, extending the SCDAS methodology for network and electronic mail computer environments.

Several other software packages have been recently developed – the DISCRET package for supporting selection of discrete alternatives, the NEGO package and methodology for supporting negotiations, decision support packages for network optimization, and a version of the DIDAS system for supporting decision processes described by nonlinear and dynamic models.

The current research concentrates on building efficient and robust "solvers" (i.e., optimization systems) for application in decision support systems, improving the user–computer interaction, and network implementation of decision support systems. The experience collected during the last seven years is now being summarized in a forthcoming book.

Selected publications

M. Grauer, A. Lewandowski, and L. Schrattenholzer. *Use of the reference level approach for the generation of efficient energy supply strategies.* IIASA Working Paper WP–82–19.

M. Grauer and E. Zalai. *A reference point approach to nonlinear macro-economic planning.* IIASA Working Paper WP–82–134.

H. Gorecki, J. Kopytowski, T. Rys, and M. Zebrowski. A multiobjective procedure for project formulation – design of a chemical installation. In: *Interactive Decision Analysis.* M. Grauer and A.P. Wierzbicki, eds. Springer–Verlag: Berlin, 1983.

S. Kaden and T. Kreglewski. *Decision support system MINE – problem solver for nonliner multicriteria analysis.* IIASA Collaborative Paper CP–86–5.

M. Kallio, A. Lewandowski, and W. Orchard-Hays. *An implementation of the reference point approach for multi-objective optimization.* IIASA Working Paper WP–80–35.

A. Lewandowski and M. Grauer. *The reference point approach – methods of efficient implementation.* IIASA Working Paper WP–82–26.

A. Lewandowski and A.P. Wierzbicki, eds. *Theory, software and testing examples for decision support systems.* IIASA Working Paper WP–87–26.

J. Majchrzak. *The implementation of the multi-criteria reference point optimization approach to the Hungarian regional investment allocation model.* IIASA Working Paper WP–81–154.

M. Makowski and J. Sosnowski. A decision support system for planning and controlling agricultural production with a decentralized management structure. In: *Plural rationality and interactive decision processes.* M. Grauer, M. Thompson, and A.P. Wierzbicki, eds. Springer–Verlag: Berlin, 1985.

S. Messner. Natural gas trade in Europe and interactive decision analysis. In: *Large-scale modeling and interactive decision analysis.* G. Fandel, M. Grauer, A. Kurzhanski, and A.P. Wierzbicki, eds. Springer–Verlag, Berlin, 1985

M. Strubegger. An approach for integrated energy-economy decision analysis: The case of Austria. In: *Large-scale modeling and interactive decision analysis.* G. Fandel, M. Grauer, A. Kurzhanski, and A.P. Wierzbicki, eds. Springer–Verlag, Berlin, 1986.

A.P. Wierzbicki. A mathematical basis for satisficing decision making. *Mathematical Modeling 3* (1982), pp. 391–405.

A.P. Wierzbicki. On the completeness and constructiveness of parametric characterizations to vector optimization problems. *OR-Spektrum 8* (1986), pp. 73–87.

The DIDAS system

DIDAS stands for Dynamic Interactive Decision Analysis and Support. The prototype of DIDAS was developed by IIASA for a mainframe computer in 1980, and successive versions increased the flexibility and user friendliness of the system. In 1986 a new generation of DIDAS software was introduced for IBM-PC-XT/AT and compatible computers, permitting use on any computer with DOS 2.0 (or higher) operating system.

DIDAS is thus, already well within the financial reach of small businesses. No manager need fear using it to help with his decisions,

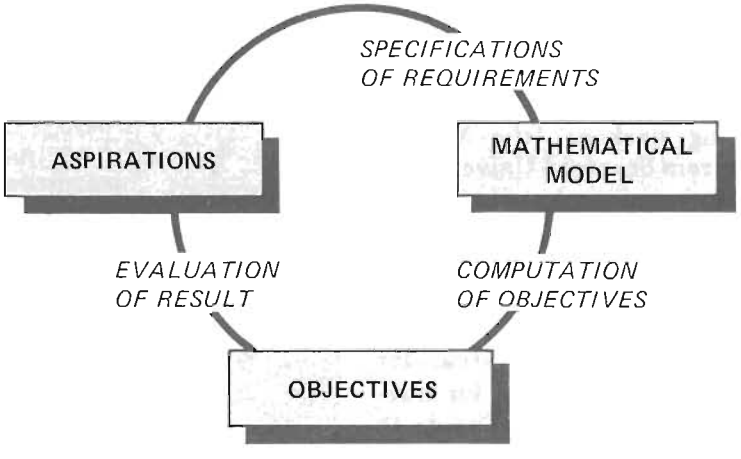


Figure 2. The decision making process using the DIDAS system.

as specialist knowledge is not required. DIDAS assists in finding optimal solutions for complex decision making problems, taking the user through a sophisticated set of optimizing routines and providing answers as close as possible to his/her aspirations.

DIDAS goes beyond the possibilities of spreadsheets, which support "what if?" analyses, but – unlike DIDAS – cannot try all the possible "ifs". DIDAS analyzes the alternatives and presents an optimal decision according to the user's specifications (see *Figure 2*).

DIDAS is a menu-driven software package, requiring no special computer training from the user. In addition to stating and modifying the user's problem, it allows him to input his "aspiration level" for the solution, working back from that ideal to a solution close to the strategic objectives. If the aspiration is not feasible, DIDAS says why, and presents the next-best solution. If the aspiration can be improved upon, the system says so.

What DIDAS does *not* do is control the user. Rather, it lets the user's expertise control the decision making process. It differs from an expert system in that it does not give its answers on the basis of built-in knowledge, but considers the user's opinion and experience. However, expert systems can be a useful tool for building a knowledge data base for DIDAS.

DIDAS is an open system. It has been implemented in standard FORTRAN-77 and can cooperate with any commercial linear programming package (the MINOS system from Stanford University is currently being used at IIASA). It is also possible to use the HYBRID system, especially designed for solving linear programming problems arising in decision problems or MSNP (Modular System for Nonlinear Programming) for solving nonlinear problems. Thanks to the portability of FORTRAN-77, the DIDAS system has been successfully ported to many computer installations and computing environments.

DIDAS has already been distributed to over 40 scientific and commercial institutions in 16 countries. Even the first version was put to practical use in forecasting and planning for the Finnish forestry industry. Since then, DIDAS packages have been applied to such problems areas as:

- Water management in regions with opencast mining.
- Restructuring in the chemical industry.
- Energy planning.

The SCDAS system

SCDAS stands for Selection Committee Decision Analysis and Support. Like DIDAS, SCDAS is an interactive decision support system that evaluates options on the basis of a group of numerically or verbally expressed performance factors ("attributes") and recommends a course of action. However, SCDAS is designed to assist in group as well as individual decision making.

SCDAS is aimed particularly at the task of a committee charged with selecting among a finite set of alternatives. It will incorporate each participant's opinion about these alternatives and use it to form a recommendation. It can thus serve as an impartial referee, testing the conflicting views of group members and finding a path toward consensus (see *Figure 3*).

Other decision support systems that assist more than one decision maker do so by paired comparisons – a method that places severe limitations on the number of attributes that can be dealt with. Unlike these, SCDAS uses aspiration-led relative comparison, meaning that it allows committee members to specify their strategic objectives, then suggests the decision that best matches them.

To reach a decision, SCDAS needs to know who the participants are and what their voting power is. Then the attributes describing voters' decision criteria have to be listed (e.g., in the case of a personnel selection committee, job candidates' experience, qualifications, etc.); these can be in the form of aspirations and/or reservations. Committee members are free to decide whether to influence the result by rating worst achievements or average achievements as most important. In addition, a list of alternative decisions (e.g., to select one of the candidates, Jones, Smith and Brown) must be input.

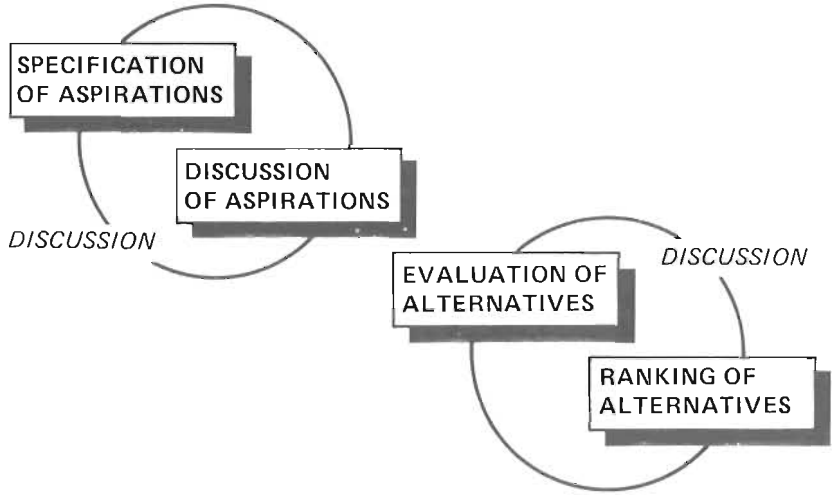


Figure 3. Organization of the SCDAS system.

The next step is for each participant to state his/her personal views of the "ideal" alternative, in terms of the attributes considered most important in making the choice (e.g., highly qualified, very experienced). Finally, the individual attributes each participant assigns to each alternative (Jones well qualified, experienced; Smith underqualified, less experienced) are listed. SCDAS will now evaluate all these inputs and provide score tables for each participant and alternative. Finally, it will produce a clear recommendation in the form of a ranking of the alternatives. SCDAS does not impose decisions, but merely draws the logical conclusions from committee members' own aspirations. It works according to an agenda, at each stage of which the committee must consider the information supplied to the system.

SCDAS can be applied not just to job selection procedures, but to such management activities as comparing staff performance, evaluating investment opportunities, or selecting subcontractors. It has already been put to work in areas such as selection of computer hardware.

The system is designed to work on any IBM XT/AT-compatible computer and is being extended to work in a network, allowing each committee member to have his/her own personal computer connected to the local network.

Contributions from the SDS Program

by Dr. Andrzej Lewandowski, Leader of the Methodology of Decision Analysis Project

Research into decision theory has a long tradition at IIASA. Activities in this area were initiated by Prof. Howard Raiffa, the first IIASA Director and a very well-known specialist in the field. The culmination of the "first wave" of this research was the volume by Keeney and Raiffa, entitled *Decisions in Multiple Objectives. Preferences and Value Tradeoffs* (Wiley, 1976), and the international conference organized at IIASA in 1975.

The "second wave" of research into decision methodology was initiated in 1980 by Andrzej Wierzbicki, in cooperation with Markku Kallio, Andrzej Lewandowski, and William Orchard-Hays. The research is now continuing within the Methodology of Decision Analysis Project of the System and Decision Sciences Program.

The approach applied to this research changed between the two periods. The first efforts concentrated on theoretical research, mostly relating to the classical utility approach. The second period has been more pragmatic, the main goal being to develop theories and methodologies that can lead to practically oriented, computer-implementable tools, capable of supporting decision processes. Such computer systems are known as "decision support systems".

Decision making is one of the most complex forms of managerial activity. The following elements of the decision making process are particularly problematic:

- A degree of (rather high-level) knowledge about the subject being analyzed is required.
- The effects of the decision on system outcome and performance must be predicted by the decision maker – a rather difficult task because the quality of the decision may depend on many performance criteria.
- A degree of uncertainty is encountered during the decision making process, and must be taken into account.
- Complex structural and logical relationships exist between the elements of the system being analyzed, the decision undertaken, system outcome and behavior.
- The decision making process is, in fact, an information processing task, and the decision maker must handle a large and heterogeneous volume of information, usually of poor quality.

Owing to the above, decision making processes would often ideally require considerable time and resources. Even where these are available, the complexity of the process is such that the strategy chosen is often far from optimal, or even satisfactory, because of the difficulty of investigating more than a small subset of the possible options. Lack of *a priori* knowledge, and the presence of uncertainty, can result in the rejection of a potentially good option at a very early stage of the process.

This suggests that the computer, with its ability to process large amounts of information and analyze complex logical relations, could be a useful support tool for such activity.

However, it is necessary to stress that, when applying a decision support system, the decision maker remains an integral part of the process. It is not the role of the computer to render the human agent redundant. Rather, the computer should analyze the human agent's behavior and goals, and actively participate in the decision making process, creating a feedback in which both are equal partners.

Methodology

The most significant problems relating to the development of a decision support system are the

assumptions about the decision process and the behavior of the decision maker. Careful analysis of the state of the art, and of selected decision processes, has led to the conclusion that the principle of *satisficing* is among the most realistic, and corresponds closely to the majority of practical situations.

The satisficing principle assumes that the decision maker evaluates possible decisions on the basis of a set (or vector) of performance factors, which can be expressed in terms of a numerical scale (quantitatively), or a verbal scale (qualitatively, e.g., as "good", "bad" and so on). For each performance factor, the decision maker specifies whether he/she is interested in its maximization or minimization. He/she further specifies aspiration levels, these being the values of the factors in question that would be regarded as acceptable. In some versions of the approach, the decision maker specifies two levels for each performance factor: aspiration level as defined above, and reservation level. The latter describes the lowest acceptable level for a given performance factor.

On the basis of the information specified by the decision maker (i.e., the set of performance factors, aspiration and reservation levels), the satisficing decision principle can be formulated as follows:

Case 1: The decision maker overestimated the system possibilities, and there exists no decision ensuring values for all performance factors exactly equal to the aspiration levels. In this eventuality, the system proposes the decision for which values of performance factors are as close as possible to the aspiration levels.

Case 2: The decision maker underestimated the system possibilities. There exists a decision that ensures values for the performance factors exactly equal to the specified aspiration levels. In this situation, the system proposes a decision that improves on all the components of the performance vector to the maximum degree.

Practical experiments with this approach have shown that the language of aspirations coincides very well with the decision maker's typical style of thinking. The information required of him/her is easy to interpret and articulate, which is not always the case with other approaches based on pairwise comparisons, utility theory, etc.

The decision making process is preeminently interactive in nature. The procedure described above (i.e., specification of aspiration levels – analysis – solution) must thus be repeated several times. This results from the fact that, during the first stages of decision analysis, the decision maker does not sufficiently recognize the limiting possibilities of the system. In other words, some learning and experimentation with the system are necessary. Our trials suggest that after a number of such cycles (usually 10–20), cumulative experience permits the start of the next phase, namely, searching for a satisfactory solution.

Implementation

IIASA's first implementation of a decision support system was undertaken by Kallio, Lewandowski, and Orchard-Hays. This implementation, known as MOCRIT, motivated by applied research on policy design for the Finnish pulp and paper industry, was carried out on an IBM-370 computer, using the SESAME and DATAMAT linear programming (LP) packages. The experiments with this version showed the applicability of aspiration-led decision making, which at the time was no more than a methodological concept and lacked strong experimental verification.

Unfortunately, the MOCRIT package was too complicated for computer nonspecialists, and required specific hard- and software. It was therefore decided to develop a more universal and portable version. This was undertaken by Lewandowski, who developed the first version of the DIDAS system, known as LP-MULTI. Several variants of this package have been distributed to over 40 scientific institutions. LP-MULTI utilized the MINOS linear programming system, which, owing to its high level of portability, was easily adaptable to any commercial LP package and computing environment.

To improve the efficiency of the system, several new variants of the software were developed. MM-DIDAS came about as a multiple-criteria extension of the system, while both MM-DIDAS and MZ-DIDAS were given an improved user interface allowing easy solution of dynamic problems.

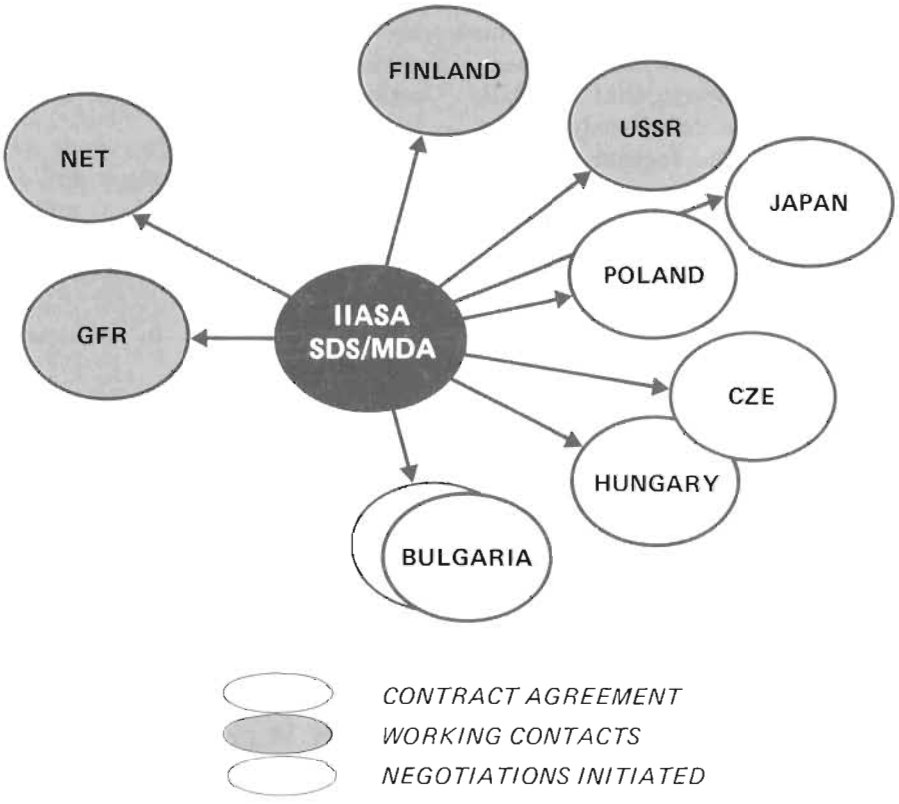
In parallel, the NL-DIDAS system, for solving problems with a model described by a set of nonlinear algebraic equations, was developed and successfully implemented by IIASA.

Beginning in 1984, recognizing the fact that many decisions are made by committees, IIASA developed the SCDAS methodology, and several versions were subsequently implemented. The methodology is currently being used in the framework of computerized teleconferencing systems on distributed computer networks. This research is sponsored by Digital Equipment Corporation.

During the past two years, our research has intensified, thanks to the creation of an international network of cooperating institutions. Contract agreements between SDS and Bulgaria, Japan and Poland already exist, and several others are under negotiation.

In Bulgaria, the collaborating institution's interest focuses on structural and qualitative analysis of decision processes, and on interactive optimization methods. In Japan, work centers on decision support and expert systems in modeling; while in Poland there is concentration on optimization algorithms (nondifferentiable, stochastic, linear nonsimplex), on decision support systems for negotia-

METHODOLOGY OF DECISION ANALYSIS PROJECT
NETWORK OF COOPERATING INSTITUTIONS



tions, and on applications of decision support systems in industry. In addition, cooperation with institutions in the Netherlands, Finland, and the USSR is proceeding.

Experience

A number of experiments have been performed in order to test the principles and implementation of IIASA's decision support systems. Real-life examples and strong feedback from users were crucial to the validity of the experiments with the various implementations, which yielded satisfactory results.

The first implementation of the DIDAS family of systems was applied to the forecasting and planning of the Finnish forestry and forest industry sectors, based on a substantive model of linear dynamic type. Later, another version of the DIDAS system was applied to planning energy supply strategies, which led to other applications in the analysis of future energy-economy relations in Austria and future gas trade in Europe. All these applications have arisen in conjunction with other IIASA projects.

Parallel applications to forecasting and planning agricultural production and chemical industry planning have been initiated in Poland, and to regional investment allocation in Hungary. A special version of linear dynamic DIDAS was adapted to flood control problems. A nonlinear version of DIDAS was first applied to issues of macroeconomic planning; other nonlinear versions were later applied to problems of environmental protection of ground water quality.

Events

Workshop on Multiobjective and Stochastic Optimization, IIASA, Laxenburg, November 1981. Proceedings. M. Grauer, A. Lewandowski, and A.P. Wierzbicki, eds. IIASA Collaborative Paper CP-82-S12.

Workshop on Interactive Decision Analysis, IIASA, Laxenburg, September 1983. Proceedings. M. Grauer, and A.P. Wierzbicki, eds. Lecture Notes in Economics and Mathematical Systems, Vol. 229, 1984, Springer-Verlag, Berlin.

Workshop on Plural Rationality and Interactive Decision Processes, IIASA, Sopron, Hungary, 1984. Proceedings. M. Grauer, M. Thompson, and A.P. Wierzbicki, eds. Lecture Notes in Economics and Mathematical Systems, Vol. 248, 1985, Springer-Verlag, Berlin.

Workshop on Large-Scale Modeling and Interactive Decision Analysis, IIASA, Eisenach, GDR, November 1985. Proceedings. G. Fandel, M. Grauer, A. Kurzhanski, and A.P. Wierzbicki, eds. Lecture Notes in Economics and Mathematical Systems, Vol. 273, 1986, Springer-Verlag, Berlin.

International Conference Toward Interactive and Intelligent Decision Support Systems, organized by the Japan Institute of Systems Research, Kyoto, Japan, August 1986 (cosponsored by IIASA). Proceedings. Y. Sawaragi, K. Inoue, and H. Nakayama, eds. Lecture Notes in Economics and Mathematical Systems, Vol. 286, 1987, Springer-Verlag, Berlin.

Seminar Days on New Advances in Decision Support Systems:

- November 1986, Laxenburg
- February 1987, Laxenburg
- June 1987, Moscow (organized by IIASA and the All-Union Research Institute for Systems Studies)
- August 1987, Laxenburg

Workshop on Methodology and Software for Interactive Decision Support Systems, IIASA, Albena, Bulgaria, October 1987. Proceedings to be published by Springer-Verlag.

Special software techniques

by Prof. Victor Bryabrin, Computing Center of the Academy of Sciences of the USSR

The new wave of computerization launched by personal computers (PCs) has led to new applications in science, management, business, education, medicine and other social and industrial areas. In the past, computers were mainly used in decision making for running mathematical models and accessing data bases on mainframes, and these are still widely accepted applications. Teleconferencing at one time also emerged as an approach to the use of computers in collective decision making. However, it is only recently, with the advent of various application packages for PCs and inexpensive local area networks, that it has become feasible to create computer environments capable of being real engines of decision making processes in practical applications.

DSS for personal computers

What are the required features of a decision support system implemented on PCs? The DSS must include general purpose and special components: a powerful data base management system; text and graphics processing packages; modeling and optimization packages; and other techniques, such as business plan managers, expert systems etc.

Such requirements are being met today, and, indeed, there is a positive flood of attractive, general and special purpose systems for personal computers. Yet many professional managers are reluctant to use PCs in their everyday activities. One reason lies in the necessity of time-consuming training, which is an inevitable overhead of most commercial packages, owing to their relative complexity. Moreover, even if a high-ranking manager does devote some of his valuable time to learning a system, it will often happen that his skills deteriorate or completely disappear if he has no regular practice. In consequence, many organizations opt for development of their own management support systems, more closely attuned to their particular needs and thus requiring less training for potential users.

Applications

At one IIASA national member organization (NMO), the USSR Academy of Sciences Computer Center, a set of packages has been developed for evaluation and application in IIASA projects. One such package – SPECTRUM – consists of several components providing organization of structured data; unified interfaces between application programs; and convenient and flexible man–machine interfacing, including utilities for graphic representation of scientific data. In the internal design of this system, an object-oriented approach was taken, seen as being the most appropriate for achieving these goals. Another package – MASTER – provides all the necessary data processing facilities and the powerful programming language for quick adaptation to special needs. It is well suited for combining with available mathematical models. The third package – DISO – consists of several programs implementing global and local optimization methods, all controlled by the user through a unified man–machine interface; the output is displayed in numerical or graphical form.

All these systems have been designed with a view to maximum simplicity of operation, demanding a minimum of operator training or none at all, yet preserving the required functional flexibility. Other important features – modularity and extensibility – facilitate quick adaptation to special requirements.

The above-mentioned software can be employed in current research by IIASA and the NMOs in the following areas:

- Implementation of methods and models for optimization and decision support.
- Planning for industrial development and assessment of environmental impacts.
- Risk assessment in industrial development.

Once the appropriate model or set of models and methods has been implemented in the form of separate programs, it is important to build a robust and flexible operational environment. Unlike most software packages, the above systems provide such an environment, having been constructed for practical use. The methodology software can easily be plugged into the appropriate operational framework, almost automatically obtaining a friendly man–machine interface and means of data structuring and presentation.

With respect to industrial development, risk and environmental impact assessment, there is always an inherent need to store large amounts of structured data, providing fast and flexible access and special application programs. For instance, it may be necessary to generate computer maps and to overlay them with coordinate grids, data arrays, and special functions operating on distributed data. Such techniques as clustering – e.g., creation of information units corresponding to moving poisoned clouds or other substances under investigation – can be elegantly implemented with the aid of the proposed techniques.

DSS for group decision making

Support for group decision making is another area currently attracting attention. Investment planning, designing new projects, interna-

tional negotiations and staff recruitment are examples of group decision making that can be supported by computerized environments. The idea is to develop systems that can be used at executive board meetings, planning committee sessions and so on. As a rule, this involves a number of participants, situated in one room and discussing a given topic. They will manipulate several sources of information, namely, private data prepared in advance; the contents of corporate, national or international data bases; and data emerging from the meeting itself.

A group decision support system can be based on a tight local network of work stations (WS) located in one room, with a gateway to external networks.

In the course of the meeting, the chairman gives the floor to the main speaker, and the latter starts his presentation by displaying relevant information objects on the large demo screen, which is controlled by his WS. Each participant can view the objects either on this screen or that of his own PC; but he can also temporarily switch his PC away from the main demonstration to browse among the available information objects, make changes and so on, prior to presenting his own viewpoint if the chairman permits.

The protocol of the meeting is automatically recorded under the chairman's control. Besides recording the actual sequence of presentations, some of the information discussed can be put aside with a view to drafting the final documents.

Such a system stimulates participants to take a more active role in discussion and formulate their concepts more accurately. The whole decision making process becomes more productive, and the results become automatically available as a starting point for further examination of the topic.

Software techniques like these can serve as a basis for different types of decision support systems. The basic software can be extended by specialized packages, such as optimization packages, expert systems, or cost–benefit analysis models. Close cooperation between IIASA and the NMOs can help us develop not only the methodology of decision support systems, but also real software packages of practical use.

Regional water policies

Water is vital not only for life itself, but also for socioeconomic development. In many parts of the world, regional water systems bear the brunt of economic growth and carry pollution well beyond the immediate development area. For these reasons, governments and environmentally concerned citizens have a vital interest in understanding the effects of economic development on regional water systems in order to make sound decisions about water policy and related issues.

IIASA's Regional Water Policies Project, begun in 1984–1985, has created decision support systems for framing water policies in two test regions of Europe:

1. The Southern Peel region of the Netherlands, where intensive agriculture has produced alarming contamination of surface water and some drinking water. Fertilizers and animal wastes from factory farms pollute surface water (above all, with phosphates) and groundwater (with nitrates), affecting ecosystems and drinking water supplies; also, irrigation pumping affects the water table there.

Discharges from a Japanese wood pulping plant [United Nations 117,019].

2. The Lusatia region of the German Democratic Republic, where open-cast mining is degrading local water systems. Pumping in the mines lowers the groundwater table, affecting ecosystems over a wide area. Agriculture, which is an important sector in the region, may suffer from reduced soil moisture, and industrial water supply may also be affected. Oxidation of ferrous metals increases the acidity of groundwater, an important consideration in Lusatia, where worked-out mines are used as reservoirs.

Both projects involved close collaboration with scientists in the countries concerned. In the Netherlands, the institution involved was the Institute for Land and Water Management, Wageningen; while in the GDR the Institute for Water Management, Berlin, the Dresden University of Technology, and the Institute for Lignite Mining, Großräschen, collaborated. These institutions helped construct models representing the water, ecological, and other systems under study.

Framing the questions

The aim, in both instances, was to create decision support systems with room for policy makers to participate at each stage of analysis, because the issues contain significant subjective factors and much uncertainty. Planners must satisfy multiple objectives, and no single "best" decision exists. Factors to be considered, and interests to be served, include drinking water quality, water supply to farms and industries, infrastructural costs, and levels of production and income in the local economy.

The two support systems share a structure based on successive stages of decision making. In the first stage, once the user's aspirations are specified, a relatively fast scenario analysis screens out policies that are not sufficiently feasible to deserve further attention. In stage 2, having chosen a preliminary path of regional development, with acceptable trade-offs among competing goals, the user can test feasible policies, in simulation runs using more detailed models, corresponding to operational decisions. In this way, he/she can analyze measures to direct development along the desired path. For instance, in the Dutch example, a basic question to be answered by simulation experiments is whether the irrigation capacities and pumping rates allowed by the screened scenario are compatible with recommended land-use technologies.

For the sake of realism, the data base in each model contains relevant details about the region and its water system. For instance, in the Netherlands case, models were incorporated to simulate the dynamics of water quality, crop yields, and agricultural development under varying conditions. Simplified screening models were constructed for agricultural production and economic development, water flows, soil nitrogen processes, and water quality. The Lusatia system incorporates a special groundwater flow model, reflecting conditions in mining regions.

Similarly, models of the decision making structures operating in the two regions were built into their programs. Distinctions had to be drawn between upper- and lower-level actors, that is, between those making long-term, strategic decisions and those operating within shorter time frames and interacting directly with the environment. These decision support systems are primarily designed for upper-level users, who are collectively termed the Policy Making Authority (PMA).

Using the systems

The decision support system for the Southern Peel test region was implemented on a VAX 11/780 mainframe computer at IIASA and subsequently at Wageningen. The MINE system developed for the GDR was also first implemented on the VAX 11/780, but later adapted for use as a teaching game, for decision makers, on personal and portable computers.

For easy user access and interpretation of results, both systems use interactive display systems with color graphics. With the Southern Peel system, scenario data can be compared using colored subunits on a map, or colored pie or bar charts. The Lusatia model displays maps and flowcharts with water quantity represented by line thickness and quality by color.

Both systems are still being refined in the GDR and the Netherlands, and have been well received. As the systems are flexible, easily extended, and relate to regional decision making situations that exist elsewhere, there is plenty of potential for future applications.

Selected publications

S. Kaden *et al.* *Water policies: Regions with open-pit lignite mining* (introduction to the IIASA study). IIASA Working Paper WP-85-04.

S. Kaden *et al.* Decision support model systems for regional water policies in open-pit lignite mining areas, *International Journal of Mine Water 4*, No. 1, 1985.

S. Kaden and E. Weigkricht. *MINE – a game for the analysis of regional water policies in open-pit lignite mining areas.* IIASA Working Paper WP-85-46.

S.A. Orlovski and P.E.V. van Walsum. *Water policies: Regions with intense agriculture* (introduction to the IIASA study). IIASA Working Paper WP-34-40.

S.Orlovski, S. Kaden, and P. van Walsum. *Decision support systems for the analysis of regional water policies: Final report of the collaborative IIASA "Regional Water Policies" Project (1984-85).* IIASA Working Paper WP-86-33.

News from the Institute

IIASA Council Meeting

At its 29th meeting on 11 and 12 June, the IIASA Council took note of the resignation of *Academician Jermen M. Gvishiani* as representative of the Soviet NMO, the Academy of Sciences of the USSR, and accepted with regret his resignation as Chairman of the IIASA Council. Academician Gvishiani had held this position for 15 years, since the Institute's inception in 1972. In recognition of his immeasurable contributions to the creation of the Institute and the advancement of its ideals, Academician Gvishiani was awarded the title of *IIASA Honorary Scholar and Distinguished Principal Founding Member.* At the meeting, chaired by Vice-Chairman *Professor Wouter Tims* from the Foundation IIASA–Netherlands, the new Council representative of the Academy of Sciences of the USSR, *Academician Vladimir S. Mikhalevich*, was unanimously elected new Chairman of the IIASA Council.

Academician Mikhalevich, Director of the V.M. Glushkov Institute of Cybernetics of the Ukrainian Academy of Sciences in Kiev, is a member of the USSR Supreme Soviet, a full member of the Academy of Sciences of the USSR, and of the Academy of Sciences of the Ukrainian SSR. He has been associated with IIASA for many years. Among other activities, he serves as member of the Institute's System and Decision Sciences Program Advisory Committee.

The Council also unanimously appointed *Dr. Robert H. Pry* (USA) as new Director of IIASA. He assumed his three-year term at IIASA on 15 August, 1987, taking over from *Professor Thomas H. Lee*, who returned to the Massachusetts Institute of Technology (USA).

Dr. Pry has had an extensive career in scientific research and management. Most recently an executive and technical management consultant to business, government, and universities, he has also been Founding President of the Center for Innovative Technology and Adjunct Professor at the Massachusetts Institute of Technology; Vice Chairman (Technology) and Executive Vice President (R&D) at Gould Inc.; and Vice President (R&D) at Combustion Engineering Inc. Dr. Pry is a member of numerous committees and boards, including the Industrial Panel of the US National Science Foundation, and he is a Fellow of the American Association for the Advancement of Science.

At its concluding session, the Council passed a resolution conferring posthumously the title of *IIASA Honorary Scholar and Distinguished Principal Founding Member* upon *Professor Philip Handler*(†) of the US National Academy of Sciences, who was instrumental in the establishment of the Institute and a proponent of IIASA's ideals and objectives.

Developments in Collaborative Research

The Hungarian Ministry of Industry, headed by *Dr. László Kapolyi*, is supporting the establishment of a team under the direction of *Professor Shoji Shiba*, Leader of IIASA's Total Quality Control Project, to create an industrial quality program plan. The aim of the venture is to develop a quality-oriented management style, specifically geared to Hungarian conditions, which will be self-sustaining after the collaborative period has ended. In association with this goal, and to recognize achievements in the field of quality improvement, the IIASA/Professor Shiba Award to promote total quality management in Hungary was founded. This venture, which is intended to have major and far-reaching impacts not only in Hungary, but also in many other Eastern European countries, has already received wide publicity in Hungarian and Japanese media.

The Air Pollution Group of the Nordic Council of Ministers has decided to support an extension of IIASA's RAINS (Regional Acidification INformation and Simulation) model. With this additional support, the current capabilities of this decision support system for European acid rain control policies will be extended, enabling the model to determine optimal control strategies based on critical loadings of pollutants.

The collaborative project network dealing with Decision Support Systems for Managing Large International Rivers (LIR) is gradually expanding. Recently a new contract was signed by IIASA and the Central Meteorological Institute (KMI) of the Hungarian National Meteorological

Academician Vladmir S. Mikhalevich

Dr. Robert H. Pry

Service. KMI will compile a 20-year data series of average monthly precipitation for a pilot area of about 40,000 sq.km. For areal averaging of the point values of precipitation, a one-quarter degree grid system is used. Other activities include surveying the literature, analyzing the reliability of data, preparing the data series on maps and on magnetic computer carriers, and presenting a final report in the form of a working paper. Coordinators of the research are *Professor György Kovács* from IIASA and *Dr. Pal Ambrozy* from KMI.

A one-year study agreement was signed between IIASA's New Logistics Technologies (NLT) Project and the Bulgarian Committee for Applied Systems Analysis and Management. According to the agreement, researchers from the Karl Marx Higher Institute of Economics in Sofia, the Committee for Material Economy, the Institute for Complex Transportation Problems, the Central Statistical Office, and the Economic Union "Territorial Supply" will provide macroeconomic analysis, statistical data, and case studies describing and evaluating the operation and efficiency of existing (acting) logistics systems, as well as development trends, influencing factors, and the socioeconomic consequences of using a predescribed format. The Bulgarian team will also collect data from the NLT Project's collaborating research groups in different countries, and set up and maintain a computer data base that will be used for cross-national analysis of logistic structures and strategies.

The French Ministry for Environment and IIASA's Biosphere Project have signed a second collaborative agreement related to IIASA's study on *Future Environments for the European Continent*. The research will focus on prospective scenarios and the evaluation of early warning indicators.

A two-year executive agreement has been signed by IIASA and the Czechoslovak Research Institute of Technology and Economy in Mechanical Engineering (VUSTE). On the basis of this agreement, VUSTE will contribute to IIASA's Technology–Economy–Society Program, and especially to the Computer Integrated Manufacturing (CIM) Project. VUSTE will collect and analyze data necessary for forecasting key adoption trends of CIM technologies in manufacturing; it will develop long-term alternative forecasts of CIM diffusion among Czechoslovakian industries; and it will apply the models developed in the CIM Project and verify their applicability under the conditions of the Czechoslovak centrally planned economy. VUSTE will also provide special impact studies aiming at a reduction of barriers to innovation and specifying different socioeconomic impacts of the adoption of CIM, as well as managerial and organizational impacts on different organizational levels. In the first year VUSTE will collect data from 10 Czechoslovak flexible manufacturing systems (FMS) for the proposed cross-country comparative analysis aiming at a specification of the main prerequisites, conditions, and consequences of FMS adoption, and it will participate in the other activities of the CIM Project.

Scientific Meetings

The 31st Annual Meeting and Conference of the International Society for General Systems Research took place in the Budapest Convention Center, Hungary, 1–5 June, and was attended by 350 participants from all five continents. One hundred and eighty lectures were scheduled, and a three-volume (1400 pages) proceedings has been published. The opening plenary session was chaired by *Professor James G. Miller*, Doyen and Past President of the Society, and opened by *Academician Pál Tétényi*, President of the Hungarian State Committee for Technical Development. At the same session, *Professor Thomas H. Lee*, Director of IIASA, delivered a lecture entitled "Models and Assumptions in Systems Analysis". Also attending the meeting was *Academician Gurii Marchuk*, President of the Academy of Sciences of the USSR, who lectured on "The Application of Mathematical Systems Theory in Environmental Planning". Relevant to IIASA's research were workshops and symposia on peacemaking, computer-aided networking and conferencing, the role of experts in policy making, decision support systems, and systems education, to mention a few. A series of books is planned, under the title of the meeting: Problems of Constancy and Change. The individual volumes will be grouped and subtitled according to the subject areas covered, e.g., Systems Design. For further details and copies of the proceedings (US $60.00 including postage), please contact *Dr. Istvan Kiss*, Bureau for Systems Analysis, P.O. Box 565, H–1374 Budapest, Hungary.

Stimulated by the launching of the International Geosphere–Biosphere Program by the International Council of Scientific Unions, and to address systematically the socioeconomic and policy aspects of global change, the International Federation of Institutes for Advanced Study convened an exploratory meeting on *Human Response to Global Change*, in Toronto, Ontario, Canada, 10–12 June. IIASA joined a number of international and regional organizations and institutions in cosponsoring the event. The main objectives of the meeting were: (1) to describe and to understand the possible anthropogenic causes, and the consequences for human society, of the changes to the global environment that are now occurring; (2) to predict which changes will become more salient over the next decade; (3) to analyze the risks and benefits of such changes, in social, cultural, economic, health, legal, and policy terms, for different scales and levels of human organization; and (4) to formulate and evaluate practical policy and management alternatives at international and national levels for coping with change and taking advantage of it wherever feasible.

From 16 to 18 June, the *International Energy Workshop*, a joint venture between IIASA and Stanford University, USA, held its annual meeting in Laxenburg. Over 100 energy experts from academia, government, industry, and IIASA met to discuss projections of the future global development of crude oil prices, economic growth, energy supply and demand, and energy trade, based on a poll of over 300 respondents. Discussions focused on the future of natural gas and the prospects of the developing countries. The majority predicted that developing countries' economies would again be expanding more quickly than the world average in the 1990s.

To develop new mathematical tools for new problems generated by applied sciences, including systems analysis, the France–Quebec Cooperation Center, the University of Perpignan, IIASA, and several other organizations and institutions joined in organizing the *International Congress on Applied Nonlinear Analysis*, held in Perpignan, France, 22–26 June. Over 200 participants from 21 countries attended the meeting. The proceedings are forthcoming.

IIASA and the University of Wisconsin, USA, organized a retrospective *Workshop on Energy, the Economy, and the Environment*, held in Laxenburg, 23–25 June. The meeting was based on four comparative studies originally conducted by IIASA in the mid-1970s in four greatly differing regions: the State of Wisconsin in the USA, the German Democratic Republic, the Rhône–Alpes region in France, and Austria. Thirty analysts, managers, and policymakers from the four regions and IIASA presented retrospective analyses of the regions, not only comparing actual development with that forecasted, but also discussing the implemented policy measures and the analysis procedures that influenced their development. The diversity of the four regions and the perspectives developed in the decade since the original studies provided the participants with powerful insights into the basis for failures and successes of both the analyses and policies in the regions. In addition, the workshop provided IIASA an excellent opportunity to evaluate the appropriateness of both the design and methodological tools of one of its early major projects. The discussants also identified methodological and policy issues, common to all four regions, which are central to their current priorities in energy–environmental management.

Thirty scientists from nine countries attended the *International Workshop on Diffusion Approximation and Related Topics*, organized by IIASA's System and Decision Sciences Program, held in Laxenburg, 29 June–8 July. The purpose of the meeting was to gather probabilists working in the areas of stochastic differential equations (involving finite, as well as infinite dimensional processes), functional central limit theorems, and specific approximation problems motivated by applications to such areas as stochastic control, infinite particle systems, population genetics, and neurophysiology.

Task Force Meeting on Integrated Energy Systems: Technical Possibilities and Economic Prospects.

The economic crisis of 1973 and the subsequent extended recession have affected all the economies of the world. High rates of growth, which prevailed in the 1950s and the 1960s, no longer appear attainable. This fact has renewed interest in research into the dynamics of economic growth and its inherent irregularities. A *Workshop on Life Cycles and Long Waves*, sponsored by the French National Center for Scientific Research and organized jointly by the Regional Center for Productivity and Economic Studies and IIASA, was held at the University of Montpellier, France, 8–10 July. Fifty-four participants from 14 countries and IIASA attended the workshop, and over 25 papers were presented. The next conference will be held in Novosibirsk, USSR, 14–19 March, 1988.

Thirty specialists from 11 countries attended the Task Force Meeting on *Integrated Energy Systems (IES): Technical Possibilities and Economic Prospects*, held in Laxenburg, 13–15 July, organized jointly by the International Consortium on IES and IIASA. The main objective of the meeting was to discuss principles and issues related to the concept of integration of current energy systems with high efficiency and minimal emissions. Also discussed were a wide range of new technologies compatible with introduction of IES. Participants agreed to prepare and publish a jointly sponsored book tentatively entitled "Integrated Energy Systems – A Bridge to the Future".

The *Workshop on Computer Integrated Manufacturing (CIM) – State of the Art and Future Development*, held in Ivalo, Finland, 19–22 July, was the first of a planned annual series bringing together collaborating national institutions involved in research on CIM. The aim of the meeting, organized jointly by the Technical Research Center of Finland, the University of Tokyo, and IIASA, was to review the work done by IIASA's CIM Project to date, as well as national technology–economy–society programs and related projects at other collaborating institutions. Forty participants from 12 countries and IIASA discussed technological trends and applications of CIM, as well as methodological issues arising in the socioeconomic impact assessment of CIM technologies.

The study of discrete event systems is a new field. It grew out of the need for dynamic models of systems whose states have logical or symbolic, rather than numerical, values that change with the occurrence of events. Under

the sponsorship of the Hungarian Committee for Applied Systems Analysis, and with the assistance of *Professor Pravin Varaiya* from the University of California at Berkeley, IIASA's System and Decision Sciences Program organized a *Conference on Discrete Event Systems*, held in Sopron, Hungary, 3–7 August, and attended by 30 participants from 11 countries. Twenty-one one-hour talks were delivered. Attendees rated the meeting as extremely successful. In the first place no participant had previously met more than 10 of the 30 people present at the meeting, which implied that different modeling "schools" were well represented (e.g., finite state machines, Petri nets, data flow machines, etc.). Second, everyone soon recognized the significant *common* interests; indeed, some participants made plans for collaborative work. Third, people came away with a better understanding of the differences in the application areas (e.g., communications versus manufacturing), which are not well captured in the mathematical models. Planning is under way to publish the papers presented at the meeting.

IIASA's Biosphere Project, with the support of the Canadian Climate Center of the Atmospheric Environment Service of Environment Canada, held a Task Force Meeting on *The Impacts of Changes in Climate and Atmospheric Chemistry on Northern Forest Ecosystems and Their Boundaries*, 3–7 August. Objectives of the meeting were to: (a) define and elaborate the main open questions and hypotheses related to the theme, thus providing a focus for an international collaborative research program and substantive content for a research prospectus; (b) develop collaborative research agreements on some of the questions identified; and (c) discuss means whereby members within the research community might remain systematically in contact. Twenty-four forest researchers and research managers from six countries and IIASA attended the meeting. Several collaborative research agreements were informally sealed at the meeting. Results of the meeting will be documented in the forms of an Executive Summary and a research prospectus (to appear as an IIASA Working Paper).

Within the framework of the Dendrochronology and Biosphere activities of IIASA's Environment Program, an *International Workshop on Dendrochronological Methods in Forest Science and Ecological Forecasting* was convened in Irkutsk, USSR, 17–23 August, organized jointly with the Siberian Branch of the Academy of Sciences of the USSR, the Department of General Biology and the Scientific Council on the Problems of Forest of the Academy of Sciences of the USSR, and the Soviet Committee of the UNESCO Program on "Man and the Biosphere". The objective of the workshop was to summarize current experience in methodological development of dendrochronology, particularly its applications in forest science and ecological forecasting. The meeting was attended by some 60 senior scientists from 10 eastern and western countries. In addition to presentations of some 50 papers on ecological–biological laws and the impacts of natural and anthropogenic factors in dendrochronological interpretation and forecasting, several special meetings took place during the workshop between top representatives of the International Tree-Ring Data Bank (USA), the Dendrochronological Data Bank of the USSR, and the Commission on Dendroclimatology of the Academy of Sciences of the USSR. At these meetings, international cooperation and data exchange between researchers from East and West were discussed. A statement adopted by the participants calls for the improvement of temporal and spatial coverage in dendrochronological data collection; standardization of data treatment; and a wider application of dendrochronology, not only in climatological studies, but also in environmental monitoring and ecological forecasting.

Stimulated by the discovery of new mathematical techniques and approaches, the area of nonlinear dynamics has significantly changed over the last decade. This fact has created interest in the various emerging results and in understanding how the new methods are providing insights in other disciplines ranging from the physical and biological sciences to the social sciences. An *International Workshop on Nonlinear Dynamics*, jointly sponsored by the Academy of Sciences of the USSR and IIASA's System and Decision Sciences Program, was held in Irkutsk, USSR, 26–31 August. Over 50 participants from 11 countries attended. Topics of the papers presented ranged from theoretical issues of nonlinear dynamics, differential inclusions, Hamiltonian dynamics, stability and methods of Lyapunov functions to applications such as control theory, earth satellite theory, numerical and statistical analysis, and mathematical biology. The proceedings are to be published.

In Memoriam

Dr. József Hatvany, a former IIASA staff member working on computer-aided design, died in Budapest, Hungary, on 11 July. A candidate of technical science, Dr. Hatvany was a foreign associate member of the US National Academy of Engineering, an active member of the International Institution for Production Engineering Research (CIRP), and a member of various other Hungarian and international scientific bodies. Among other awards, he received the Hungarian State Prize for Science and Technology. May his memory long remain with us.

Honors and Awards

Dr. William Clark, Leader of the Biosphere Project, was presented the Distinguished Service Award of the Education Press Association for his role as editor of *Environment* magazine's special issue on "Chernobyl: An Early Report".

Professor Mikhail Antonovski, Chief Scientist of the Environment Program, was recently appointed a member of the Committee on Space and Global Change of the International Academy of Astronautics.

Miscellaneous

Each summer since 1977, IIASA has offered a three-month combined work and study program for a select group of young scientists, mainly from countries with member organizations. In line with IIASA's overall policy to enhance the benefit to those sponsoring IIASA, this summer program offers young scientists a challenging opportunity to take part in an international exchange of experience and ideas on the development and application of systems analysis and related fields. This year, 58 participants joined the program.

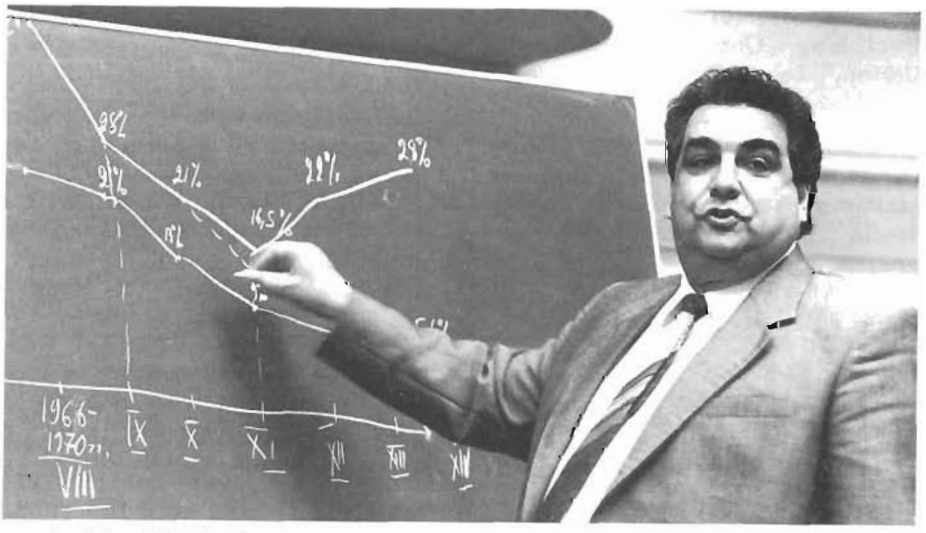
In 1987 Sigma Xi formally joined the consortium of scientific and scholarly organizations that jointly manage the responsibilities of the US NMO. The consortium is led by the American Academy of Arts and Sciences and includes, in addition to Sigma Xi, the American Association for the Advancement of Science, the Operations Research Society of America, and the Social Science Research Council. Sigma Xi is an honorary scientific society, established in 1886, with 500 chapters and clubs currently affiliated with major research institutions, colleges, and government laboratories. The society shares IIASA's goals of advancing scientific research and expanding the understanding and productive application of science. The society is represented on the US Committee for IIASA by its President-Elect, *Thomas F. Malone*, and its Executive Director, *Edward J. Poziomek*.

Professor George R. Bishop, Director General of the Ispra Establishment of the Joint Research Center (JRC) of the Commission of the European Communities (CEC), Italy, also Director of the Natural and Physical Sciences Department of the JRC, visited IIASA for briefings on some IIASA projects that have been identified as candidates for collaboration. On 9 June, Professor Bishop delivered a lecture entitled "The Ispra Establishment of the JRC–CEC". Professor Bishop was accompanied by *Drs. Pierre Bonnaure, Giuseppe Volta,* and *Harry Otway* (an IIASA alumnus). (9–10 June)

Participants of the Young Scientists Summer Program 1987.

Academician Abel G. Aganbegyan, Academician-Secretary of the Department of Economics of the Academy of Sciences of the USSR in Moscow, and an IIASA alumnus, visited the Institute to be briefed on current research activities and to hold discussions with members of various projects. On 13 July, Academician Aganbegyan delivered the third distinguished lecture in IIASA's Dr. Bruno Kreisky Lecture Series on "*Perestroyka*: Recent Developments in the Restructuring of the Soviet Economy". Representatives of the Austrian government, the diplomatic community in Austria, industry, and scientific institutions attended the event, together with a number of journalists. Several other lectures were also given by Academician Aganbegyan at various Austrian and international organizations and institutions. (2–14 July)

Professor Dr. H.G. Danielmeyer, Director General of Siemens AG in Munich, Federal Republic of Germany, *Dr. Walter Wolfsberger*, Director General, *Ing. Gottfried Wolf*, Director, and *Ing. Sandner*, of Siemens AG Austria, Vienna, visited IIASA to get acquainted with current activities and discuss possibilities for collaboration. (3 July)



Academician Abel G. Abanbegyan

Professor F. Kenneth Hare, Commissioner of the Ontario Nuclear Safety Review (ONSR) in Toronto, Canada, visited IIASA to get acquainted with current research activities in general, and the risk project in particular. Professor Hare was accompanied by *Mrs. Margaret Grisdale*, Administrative Manager at ONSR, and *Mr. Ron Thomas*, Scientific Attaché of the Canadian Embassy in Vienna. (12 August)

Twelve top managers from major Japanese companies (Asahi, Denzu, Toyota, NTT, Matsushita, Mitsubishi, etc.) visited IIASA to discuss possibilities of enhancing basic R&D activities with international cooperation. The delegation was headed by *Dr. Hitoshi Hiramatsu*, Chief Researcher at Asahi. (20 August)

Dr. H.J. van der Molen, Director of the Netherlands Organization for the Advancement of Pure Research in the Hague, and Secretary and Treasurer of the Foundation IIASA-Netherlands, visited IIASA for discussions with members of the Directorate and various research projects. (27–28 August)

Recent publications

Books

Optimization Models Using Fuzzy Sets and Possibility Theory. J. Kacprzyk and S.A. Orlovski, editors. D. Reidel Publishing Company, Dordrecht, Boston, Lancaster, Tokyo. ISBN 90-277-2492-X. 462 pp.

Integrated Environmental Modeling: Design and Tools. F.M. Brouwer. Martinus Nijhoff Publishers, Dordrecht. ISBN 90-247-3519-X. 223 pp.

The Long-Wave Debate. T. Vasko, editor. Springer-Verlag, Berlin, Heidelberg, New York, London, Paris, Tokyo. ISBN 3-540-18164-4, ISBN 0-387-18164-4. 430 pp.

Input-Output Modeling. I. Tchijov and L. Tomaszewicz, editors. Proceedings of the Sixth IIASA Task Force Meeting on Input-Output Modeling, held in Warsaw, Poland, 16–18 December, 1985. Springer-Verlag, Berlin, Heidelberg, New York, London, Paris, Tokyo. ISBN 3-540-18194-6, ISBN 0-387-18194-6. 194 pp.

Economic Evolution and Structural Adjustment. D. Batten, J. Casti, and B. Johansson, editors. Proceedings of Invited Sessions on Economic Evolution and Structural Change, held at the 5th International Conference on Mathematical Modeling, Berkeley, California, USA, 29-31 July, 1985. Springer-Verlag, Berlin, Heidelberg, New York, London, Paris, Tokyo. ISBN 3-540-18183-0, ISBN 0-387-18183-0. 382 pp.

The Global Forest Sector: An Analytical Perspective. M. Kallio, D.P. Dykstra, and C.S. Binkley, editors. John Wiley & Sons, Chichester, New York, Brisbane, Toronto, Singapore. ISBN 0-471-91735-4. 703 pp.

Finnish Fertility Since 1722 – Lessons from an Extended Decline. W. Lutz. Publications of the Population Research Institute, Series D, No. 18, 1987, Helsinki. ISBN 951-9048-74-X, ISSN 0357-4725. 136 pp.

These books are available from your regular supplier and the publisher.

Scientific Reports

SR-87-1. *Expert Systems for Integrated Development: A Case Study of Shanxi Province, The People's Republic of China.* K. Fedra, Z. Li, Z. Wang, and C. Zhao. 76 pp. Available for a handling charge of US $8.50.

RR-87-7. *Policy-Oriented Impact Assessment of Climatic Variations.* R.S. Chen and M.L. Parry, editors. ISBN 3-7045-0083-6. 54 pp. US $7.00.

RR-87-11. *Optimal Growth Paths with Exhaustible Resources: An Information-Based Model.* R.U. Ayres. ISBN 3-7045-0084-4. 28 pp. US $5.00.

RR-87-13. *Fuzzy Multiattribute Utility Analysis for Collective Choice.* F. Seo and M. Sakawa. 9 pp. Reprinted from IEEE Transactions on Systems, Man, and Cybernetics, Vol. 15 (1985). Available for a handling charge of US $5.00.

RR-87-14. *An Interactive Fuzzy Satisficing Method Using Augmented Minimax Problems and Its Application to Environmental Systems.* M. Sakawa and H. Yano. 9 pp. Reprinted from IEEE Transactions on Systems, Man, and Cybernetics, Vol. 15(1985). Available for a handling charge of US $5.00.

RR-87-15. *Environmental Prospects for the Next Century: Implications for Long-Term Policy and Research Strategies.* R.E. Munn. ISBN 3-7045-0085-2. 20 pp. US $5.00.

RR-87-16. *Thousands of Data at a Glance: Shaded Contour Maps of Demographic Surfaces.* J.W. Vaupel, B.A. Gambill, and A.I. Yashin. ISBN 3-7045-0079-8. 80 pp. US $8.50.

ER-87-14. *The Global Forest Sector: An Analytical Perspective.* D.P. Dykstra and C.S. Binkley. 16 pp. US $5.00.

WP-87-75. *Forest Decline and Reproduction: Regional and Global Consequences.* L. Kairiukstis, S. Nilsson, and A. Straszak, editors. Proceedings of a workshop held in Kraków, Poland, 23–27 March, 1987. ISBN 3-7045-0087-9. 670 pp. US $30.00.

These publications are available from the IIASA Publications Department.

National Member Organizations

Austria – The Austrian Academy of Sciences; **Bulgaria** – The National Committee for Applied Systems Analysis and Management; **Canada** – The Canadian Committee for IIASA; **Czechoslovakia** – The Committee for IIASA of the Czechoslovak Socialist Republic; **Finland** – The Finnish Committee for IIASA; **France** – The French Association for the Development of Systems Analysis; **German Democratic Republic** – The Academy of Sciences of the German Democratic Republic; **Federal Republic of Germany** – The Association for the Advancement of IIASA; **Hungary** – The Hungarian Committee for Applied Systems Analysis; **Italy** – The National Research Council; **Japan** – the Japan Committee for IIASA; **Netherlands** – The Foundation IIASA-Netherlands; **Poland** – The Polish Academy of Sciences; **Sweden** – The Swedish Council for Planning and Coordination of Research; **Union of Soviet Socialist Republics** – The Academy of Sciences of the Union of Soviet Socialist Republics; **United States of America** – The American Academy of Arts and Sciences.