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ALTERNATIVE COMMUNICATION MODES IN INTERNATIONAL TEAM RESEARCH

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Preface

Because of IIASA's general interest in computer networking on the one hand and international scientific cooperation on the other, a number of investigations concerning the intersection of these two fields have been conducted recently, with participation by scientists from the Management and Technology Area and the Computer Science Group.*

The present memorandum is one of two which are being issued simultaneously, concerned with the possibility of using computer networks and other modern telecommunications technologies in direct support of team research projects involving geographically scattered groups of scientists. In this volume we present overall conceptual, historical, and cost-analytic background for such efforts, while the other volume** gives concrete details about a significant IIASA experiment in this area.

A slightly expanded version of this memorandum is to be published soon in the journal _Telecommunications Policy_, under the title "Informational Networks for International Team Research".

The authors acknowledge with gratitude the suggestions and comments received during the preparation of this memorandum from R.C. Tomlinson and others at IIASA, and from H.A. Linstone.

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* For an early example see _Study of the Potential Use of Informatics Technology on Problems of Scientific and Technological Cooperation_, prepared for UNESCO (Laxenburg, Austria: IIASA, 1977).

**W. Rauch and R. Randolph, _Computer-Assisted Panel Sessions (CAPS): Review of an Experiment in Accelerated International Teleconferencing_ RM-78-49, (Laxenburg, Austria, IIASA), 1978.

Abstract

Three phenomena playing an increasing role in modern science are team research (TR), international scientific cooperation (ISC), and their intersection--international team research (ITR). Each faces numerous problems, however, and it is observed that the problems of TR and ITR are not identical. This is especially so regarding problems of intra-team communication.

Starting from a general schematic view of the structure of scientific communication, conclusions are drawn about the alternative modes of communication possible in ITR. Four basic modes are identified, two of which rely on the use of telecommuncations. Qualitative costs and benefits are discussed, based on the authors' practical experiences in ITR, and tentative cost calculations are presented for several hypothetical communication configurations.

Electronic solutions to the problem of communication in ITR are shown to be neither inexpensive nor problem-free but, for some applications at least, potentially valuable as an adjunct to more conventional non-electronic solutions.

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Alternative Communication Modes in International Team Research

1. TEAM RESEARCH (TR)

It could be argued that science is and always has been a cumulative "team" activity, in the sense that each achievement inevitably follows from and builds on previous work much more directly than is the case for creative endeavor of other types.[1] True team research, however, is a fairly recent phenomenon, if by this we mean research work performed by a consciously interacting group of scientists.[2] Within living memory, individual research was the rule, or at most research by a closely collaborating pair of scientists; but in the past few decades, full-scale team research has become the dominant scientific style in many fields.[3] This has come about because of at least three key factors: (1) the "information explosion", which has necessitated ever-greater specialization of each scientist's knowledge and has thus required collaboration with others having complementary backgrounds; (2) the emergence and institutionalization of applied science, in which projects are usually motivated by exogenous "societal" needs and so cannot be narrowly limited to subject matter in which the individual researcher is already expert; and (3) the increasing size, complexity, and cost of scientific machinery, data banks, and other support facilities.[4]

Naturally, the main value of team research is that it offers a solution to the difficulties mentioned above, which would be virtually insoluble for any scientist working alone. In addition, however, it has been suggested that TR may have the effect of substituting a unique combination of individual abilities for the sheer power of individual intellect as a basis for scientific breakthroughs.[5] That is, great advances may now be made by groups of people none of whom are individually as brilliant as a Copernicus, a Newton, an Einstein. The result is, in a sense, the "democratization" of science--a trend which many people may find ethically pleasing.

Despite its obvious advantages, team research also presents numerous unique difficulties which have to be overcome if effective team performance is to be achieved. In particular, TR depends heavily on the willingness of the team members to cooperate and on the technical possibilities of communication within the team.[6]

2. INTERNATIONAL SCIENTIFIC COOPERATION (ISC)

Many authors have argued that, "in concept and spirit", science is and always has been international. Such authors assert that all scientists everywhere are adding stones to the same great edifice--man's knowledge of the universe. As Jean-Jacques Salomon has put it (perhaps somewhat extremely): "There can be only one scientific community, which is therefore bound to be international . . ."[6]

The reasons for international scientific cooperation, however, are practical as well as philosophical. As scientific investigations have become more and more complex and costly in recent years, all countries have begun to confront limitations on the resources which they can make available for science. Two complementary responses are possible in such a situation: concentration of resources on a relatively small number of scientific problems, and "extension of resources" through international cooperation.[8] The resource limitation problem is especially severe for the smaller and poorer countries, of course, but it affects the giants as well. It is thus an official article of United States foreign policy to promote international cooperation in science so as to avoid unnecessary duplication of research work and thus conserve scarce resources.[9] This is undoubtedly true for other countries as well.

Perhaps even more important, ISC is a way to improve understanding and reduce tension between nations. This truth has been recognized not only in the statements of individual governments but also in international agreements such as the recent Helsinki declaration and, earlier, the 1958 Declaration of Vienna:

> The ability of scientists all over the world to understand one another and to work together is an excellent instrument for bridging the gap between nations and for uniting them around common aims.[10]

Unfortunately, ISC also faces numerous difficulties. On the most practical level, there are cultural and language barriers to effective cooperation.[11] It is much more serious that ISC has often encountered problems on the level of international politics. At the very least, countries today recognize the impact of science on national prestige, economic growth, industrial and trade patterns, cultural values, and so forth. There is as a result an inescapable tension between cooperation and competition.

And yet, as we have seen, ISC is an integral part of the foreign policy of many countries. In a sense this may be an advantage, because ISC will no longer have to be organized solely by the scientists themselves but will instead have governmental support.[12]

3. INTERNATIONAL TEAM RESEARCH (ITR)

Team research on an international scale is not any more a dream only, it has become a reality--even if we are at present in the very first stage of development. In the framework of the international economic cooperation among the socialist countries, for instance, multilateral scientific and technological links have been established,[13] and similar patterns exist among non-socialist countries as well. The secretariat of the United Nations Economic and Social Council has even noted "that a number of projects have been undertaken in recent years by major international organizations such as the Council for Mutual Economic Assistance (CMEA) and the Organization for Economic Cooperation and Development (OECD) to define guiding principles for the organization of cooperative research".[14]

Nevertheless, ITR is at present not yet regarded as a special topic of investigation and does not at all receive the attention it should have. This situation is unfortunate, because it is not likely that worldwide international team research will be successful if simply performed with methods and organizational schemes originally intended for other circumstances (e.g., national scientific research institutions). Many problems with which ITR is confronted already exist in local or regional research facilities, but they are not so pressing, simply because of the smaller dimensions. Actual worldwide international team research creates by its "quantity" a need for new "qualities" in technical and organizational means for scientific cooperation and communication.

4. A MODEL FOR SCIENTIFIC COMMUNICATION PATTERNS

In order to understand the special communication needs of ITR, it may be useful to begin by examining the basic structures of scientific communication in general.[15]

A simple scheme for the flow of information within an isolated science (S) is shown in Figure 1. (In) and (Ot) are the Input and Output channels of this system which establish a connection between this isolated scientific field and the surrounding socio-economic system, resources, goal orientations, etc. These input and output flows include material factors as well as intellectual ones.

The flow of information between the science (S) and the object of investigation (Ob) can be separated into three different parts: F and F' stand for the information about facts which is known to the science before and after investigating the object. M and M' represent the information on methods, techniques, and means which are used by the science before and after working with the object. C and C' stand for information on concepts, ideas, and theories which have been accepted by science S before and after investigating the object.

It should be mentioned that in descriptive sciences the flow F will be most intensive, in theoretically oriented or strongly formalized sciences the flow C, and in experimental or applied sciences M and F jointly. It could be noted that the intensity of each of the flows of information has its historically changing reasons and roles.

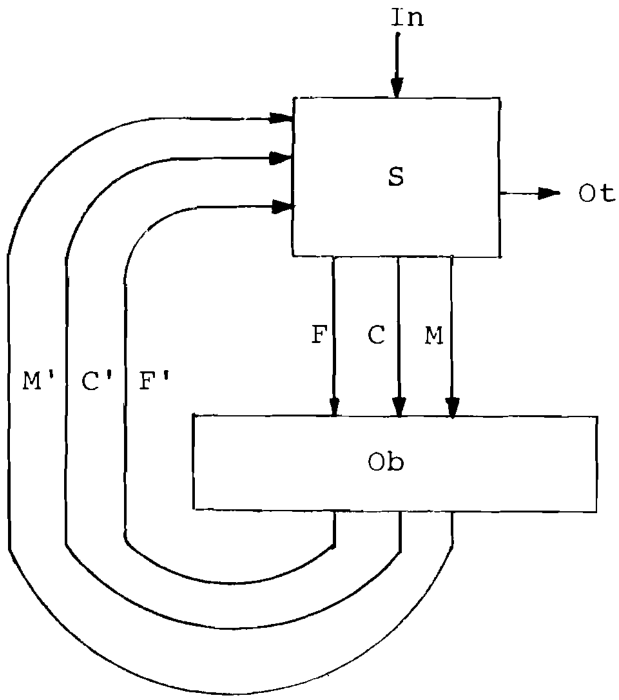

Figure 1

In case two different sciences are studying the same object, they can still remain relatively independent as Figure 2 shows (e.g., if physics and sociology both investigate an advanced railway system).

In case of real team research, the involved partners must have mutually accepted concepts, must use comparable methods, and have to be familiarized not only with final conclusions but with intermediate research findings as well. This means that in every stage of the research activity a strong flow of information of F, M, and C will have to take place among all team members (see Figure 3).

It should be kept in mind that effective informational exchange among all participating scientists is the main advantage and the very aim of international team research. Different stages of the research process require different communication modes.[16] Identifying the major data sources and analytic methods and assembling the participants can probably be performed adequately via conventional communication media like mail or telex. The formulation of requirements and goals, hypothesizing a structure for final results, and testing findings will need the strongest and nearest communication.

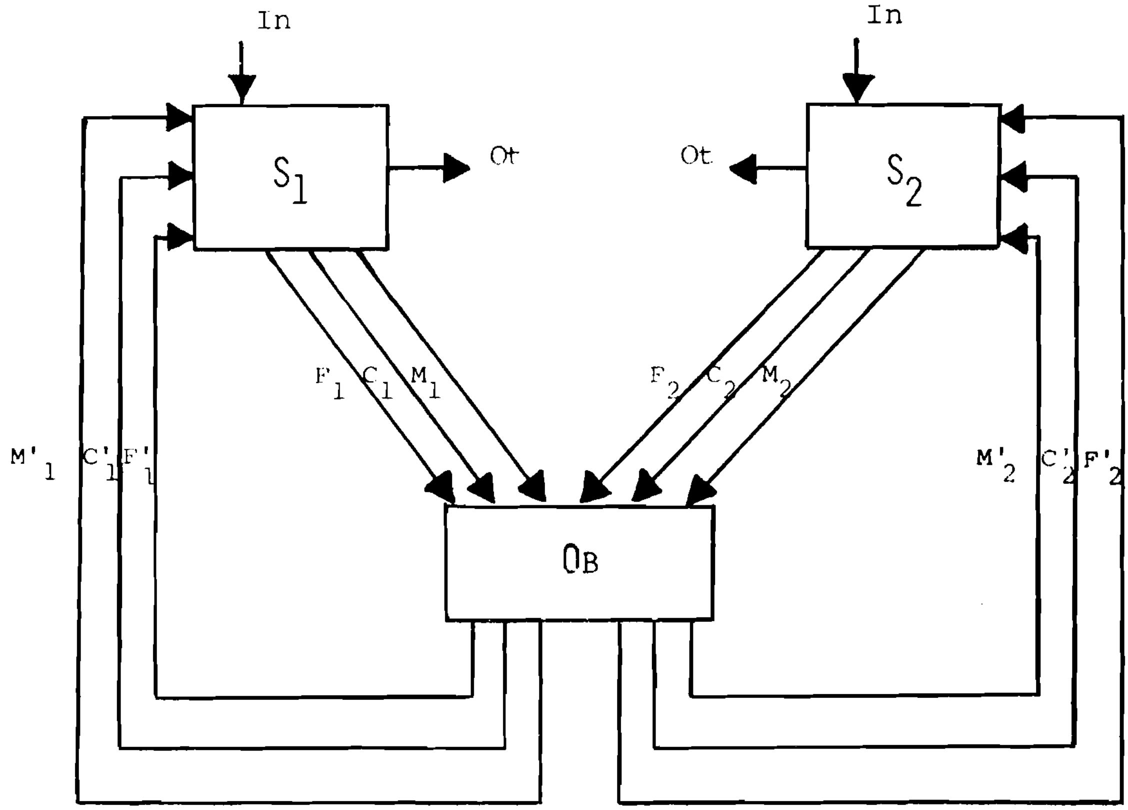

Figure 2

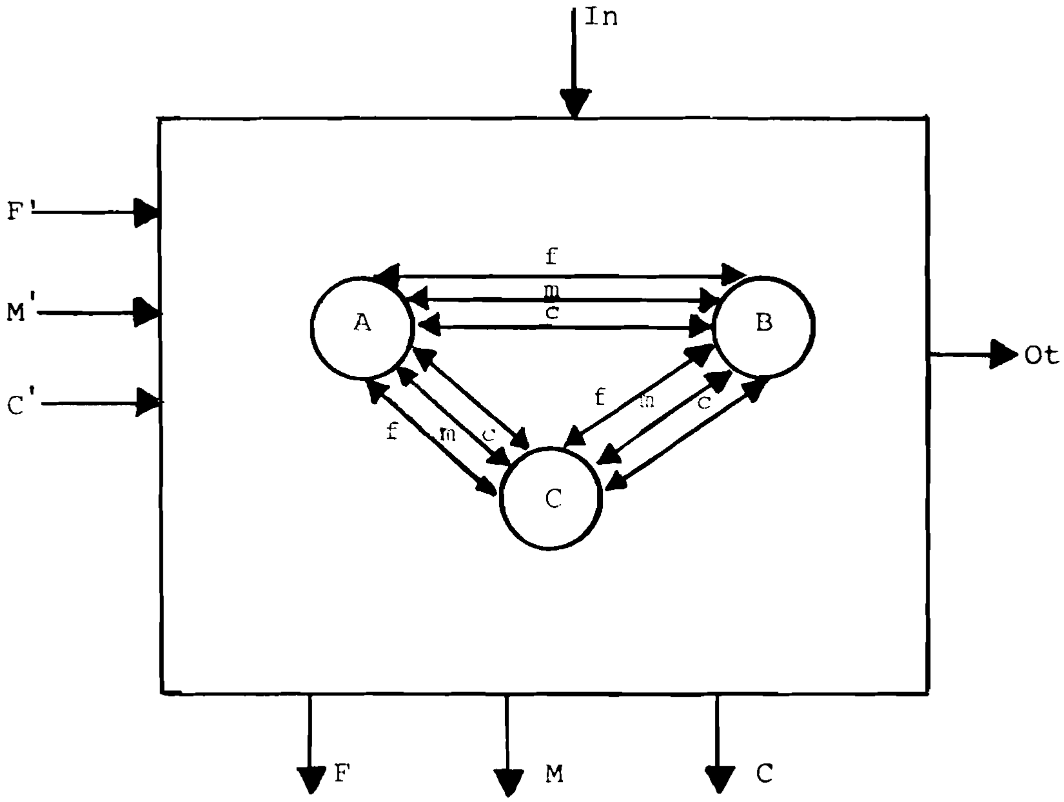

Figure 3

5. CONSEQUENCES FOR THE COMMUNICATION PATTERNS USED IN ITR

This distinction between different types of information flow shows why many existing communication channels are not suitable for ITR. All one-way communications, like publications or lectures in front of a large audience, do not allow for actual exchange of information and should therefore not be regarded as team activity at all. Duplex-type channels (allowing simultaneous two-way communication) or at least semi-duplex ones (two-way but not simultaneous) seem to be a necessary precondition for any team activity. Yet not even every communication channel of the duplex or semi-duplex type is adequate. Very simple semi-duplex channels, such as letters, are able to transmit facts and to a certain degree methods, but it is very difficult if not impossible to communicate about complex concepts via letter-exchange in a reasonable time period. Similarly, the full-duplex telephone connection is a communication channel which could be used to exchange concepts, but it is very difficult to exchange data and/or methods via normal telephone calls.

Taking into account only economically and technologically meaningful alternatives, we end up with four different methods of communication suitable for ITR, as shown in Figure 4.

The distinction between short-term and long-term activities seems very important to us, because completely different questions should be treated in either of these two forms. The exchange of existing conceptualizations, methods, and findings, discussion of questions of terminology, etc., can often be accomplished in periods as short as a few days. But large research projects which involve development of new ideas or methods, field work, data-gathering, etc., can hardly be done in a time less than several months.

The distinction between local and dispersed variants may be less familiar to many readers but is nevertheless vitally important because of its direct impact on the choice of communication channels to be used for ITR. In case of local variants, face-to-face communication is possible, whereas all dispersed forms need sophisticated technological means!

	SHORT-TERM ITR (several days)	LONG-TERM ITR (several months)
LOCAL FORM (all participants at one place)	The international scientific meeting	The international research institute
DISPERSED FORM (participants at different locations)	CAPS (Computer Assisted Panel Sessions)	CAITR (Computer Assisted International Team Research)

Figure 4

6. METHODS FOR INTERNATIONAL TEAM RESEARCH

In accordance with Figure 4 we now want to explain what we think about the different forms of ITR and to report on our practical experience with them.

6.1 International Scientific Meetings

Perhaps because of increasing need for effective international communications, or perhaps just because of improving political conditions, the number of international scientific meetings held each year has increased rapidly over the past two decades. Although few attempts have been made to analyze such trends, it appears that in the first postwar decade the annual count of meetings stayed fairly constant. Then at the time of the International Geophysical Year (1957-58) it jumped about 25%, and in the following decade it almost doubled.[17] Quite probably it has also continued to grow in the 1970s, although no analysis of this period has come to the authors' attention. Ample data for such analysis does exist, in the form of calendars and directories of international meetings,[18] and many interesting questions could be explored through quantitative study of these data.

6.2 International Scientific Laboratories

In the past, relatively few international scientific organizations have had their own research facilities where true team research could take place. The first historical example of this kind was the laboratory of the International Bureau of Weights and Measures, established in the mid-19th century.

More recently, however, the number of laboratories and stations where ITR takes place has grown considerably. One of the most ambitious actual international institutes is the International Institute for Applied Systems Analysis.[19]

6.3 New Technology-Based Options

As we have seen, the first two methods for ITR (international meetings and institutions) have a relatively short history and, especially in the case of ITR on a worldwide scale, do not occur so frequently as one might suppose. Even so, it is a common characteristic of both of them, that they depend on a traditional, very simple, but very expensive form of communication--namely travel. These old fashioned methods of ITR have proven their usefulness. But it is inescapable that limitations on time, travel money, etc., reduce the power of these mechanisms to satisfy all of the scientist's genuine information needs.

Modern telecommunications technology offers a variety of possibilities for electronic interconnection of scientists. Various media (print, voice, and video) have been tried singly and in combination for purposes of this kind, and although much work remains to be done in minimizing cost and maximizing effectiveness, results so far have been promising.

6.4 CAITR

One of the most exciting new means of long-distance human communication to emerge in recent years has been computer-based teleconferencing, whose application in multinational scientific collaboration we refer to as "CAITR": Computer Assistance for International Team Research.

As computer-communication networks have become increasingly widespread in the past decade, numerous attempts at "computer conferencing" have been made--that is, human conferencing with the computer as an intermediary. Most such attempts have naively sought to mimic face-to-face conversational communication patterns, thus ignoring the computer's immense potential for purposeful manipulation not only of information but also of the communication process itself. Nevertheless, "computer conferencing" systems have been put to good use by a considerable variety of academic institutions, corporations, and government agencies in several countries. For instance, when such a system was made available to the U.S. National Aeronautics and Space Administration, NASA used it to facilitate coordination among project heads concerned with the development of a new satellite, and also used it in a technology assessment study regarding future transportation systems. Comparison with an audio conferencing system found the computer-based interaction to be superior in a variety of ways: for instance, it was observed to increase the group interaction, promoting active participation by all team members.[20]

Naturally, computer-based communication systems face a number of unique difficulties. In significant ways they do not and cannot substitute exactly for face-to-face interaction. As with any computer system, it is difficult to make them fully foolproof and thus readily usable by persons lacking prior computer experience. But current system development efforts are aimed precisely at circumventing these and other difficulties, going to such lengths as the designing of entirely new types of computer terminal equipment specially adapted for communication use by computer-naive individuals. It seems likely that such systems will eventually be little more difficult to use than the telephone.

If this expectation proves true, it will greatly increase the feasibility of full-scale CAITR. And this in turn could add a new dimension to the computer's role in modern science, corroborating in a new way the views of those who, like V.G. Afanas'ev, believe that:

> . . . the computer today is not only a powerful calculating instrument and means of processing and storing vast quantities of information, but it is also a means of human intellectual activity. Under the

> influence of computers new structures of human thought are formed, the organization of physical and intellectual labor, cognition and learning, the spiritual world of man, are changed.[21]

6.5 CAPS

In July 1977, a three-week experiment was conducted by IIASA*, involving panels of scientists in four countries: Austria, Poland, the Soviet Union, and the United States.[22]

This experiment was conducted on the occasion of an international conference[23] and its aim was to gain first hand experience in the use of telecommunication media for international team research. In distinction from a real computer conferencing approach, this experiment used the different forms of telecommunication only for bridging the gap between four geographically separated groups of scientists. This experiment was therefore called CAPS (Computer Assisted Panel Sessions) to distinguish it clearly from a real CAITR-type experiment.

As it can be seen from Figure 5, four different types of electronic communication were used: conventional telex, telephone, remote-dial-up terminal, and a highly developed computer network via satellite.

It turned out that all four forms of telecommunication are possible means for international team research, but it was necessary to have in each participating group at least one scientist familiar with the communication system to serve as an interpreter and operator, feeding messages in and getting them out of the channel. Another scientist (or possibly the same one) must bring the group opinion of each involved group into one transmittable form, so that each group can act as one solid node in the information system.

In the experiment, CAPS did demonstrate a capability which is considered to be one of its principal advantages, namely, the ability to suspend time and space. That is, several groups of scientists were able to interact with one another even though they were separated by hundreds or even thousands of kilometers and even though when one group was meeting, the other groups might all be asleep (because of differences in time zones). Full flexibility in time and place of participation was not possible, unfortunately, because none of the groups possessed portable computer terminals which members could take home with them.

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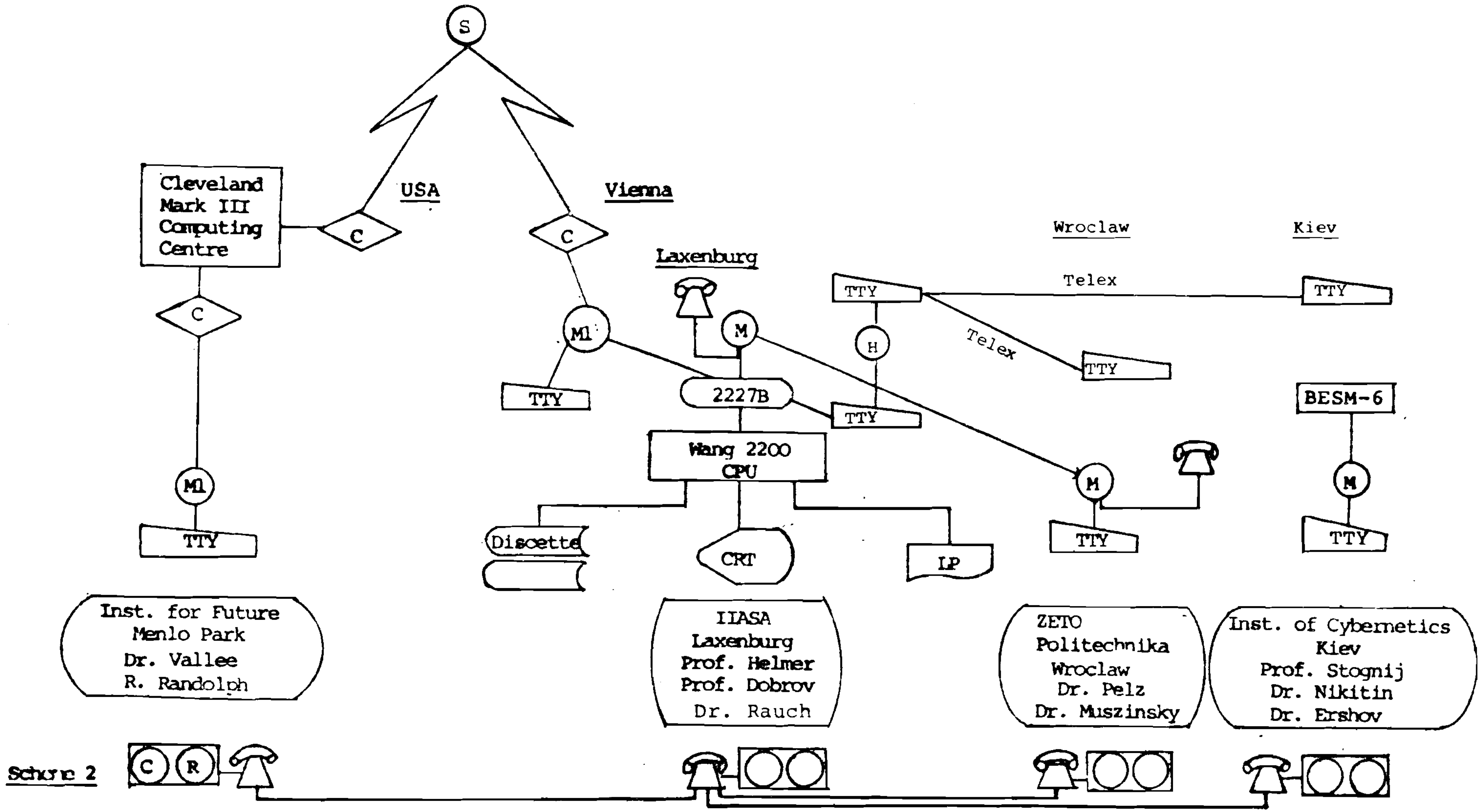
* We are especially grateful to Miss Ulrike Sichra for doing all the programming, and to Valeri Dashko for his valuable collaboration (Figure 5 was mainly prepared by him too), and Prof. Olaf Helmer who was co-organizer and conductor of this IIASA panel session.



Notation:

S	- Satellite for data Communication	M1	- Low speed modem (up to 300 lps)
C	- Concentrators of MARK III Network	M2	- Asynchronous modem 600/1200 lps
TTY	- Remote terminal (teletypewriter) Most displays can be used in TTY modes also	M	- Any of M1 and M2 can be used
CR	- Casette recorder	2227B	- Buffered asynchronous interface for WANG 2200
CRT	- Cathode ray tube (Display)	Wang-2200	- Minicomputer with 32k Bytes core memory
H	- Human interface	CPU	- Central processing unit
			LP - Line Printer

Figure 5

One aspect of the CAPS experiment which reduced the value of its substantive content provides a salutary warning for future activities of a similar nature. The group interaction was of extremely brief duration (no more than a few hours for most participants) and was therefore conducted according to a complex prearranged agenda. It was hoped that this procedure would allow a meaningful group product to be generated within the time available. Unfortunately, because of limited time and staff resources, the organizers of the experiment were unable to conduct a pretest of the planned agenda, even though they were aware that such a test was strongly desirable. During the experiment itself, the agenda proved to be too complicated and time-consuming to be completed in the time available. Also, by trying to cover too much subject matter in too short a time, the agenda forced the group discussions to be much more superficial than anyone had intended. On future occasions, it will be necessary to reduce the amount of work CAPS groups are expected to do in a very brief period of time, or else expand the amount of time available. Also, it is more obvious than ever that agendas for group interaction must always be very carefully designed and pretested.

Another useful lession from the experiment was that, in the absence of high-quality software and "orgware"[24] specifically intended for CAPS use, this use of computer networks is neither particularly convenient nor foolproof. Even with trained programmers actually operating the computer connections (feeding information to and from the groups of scientists), information was sometimes misplaced or even destroyed through human error and had to be retransmitted. On occasion, recourse to alternative media (e.g., telephone) was necessary to clear up confusion resulting from such errors. The implication is that experienced users and alternative media as a "back-up" are necessary at least until better software and orgware become readily available.

7. FIRST STEPS TOWARD A COST/BENEFIT ANALYSIS OF DIFFERENT FORMS OF ITR

Why should scientists interested in international collaboration be willing to use electronic communications media in their joint activities? The main reason, of course, is that telecomunications can at least partly substitute for both meetings and conventional laboratory-style team research. The consequent saving in scarce resources should be very gratifying, especially for the "smaller and poorer" countries whose resources are most overburdened already.

The most serious problem with the use of telecommunications in team research is that, if one of the purposes of team research is to improve general personal contact and relations among scientists, face-to-face meetings will also be necessary from time to time. Other forms of scientific communication (books, journals, etc.,) will remain important, and telecommunications must be seen as an adjunct to them rather than a complete replacement.

If the use of advanced telecommunications technologies is difficult or impossible without some deliberate familiarization, as it will certainly be for the foreseeable future, then it seems likely that only certain individuals will use such facilities very much. This is perfectly acceptable, however, since they will simply perform the "troubador" and "gatekeeper" functions already observed in more conventional situations. Because these roles offer scientists considerable advantages in knowledge and hence influence, others observing this may soon be motivated to follow their example--which is so much the better.

Improved communications will not be able to help with most of the problems of team research per se (rivalries, frustrations, etc.,) except by saving time and money and thus permitting scientists to devote more of their resources to satisfying and creative work. Perhaps technically advanced communications methods could help reduce semantic difficulties by encouraging the formulation of clear and precise statements, but they could also aggravate problems of leadership by depriving the leader of any direct way to enforce his decisions. If the particular communications medium in question is able to facilitate comprehensive record-keeping, it should eliminate the problem of identifying which team members have made what contributions to the team product.

Like other types of international scientific cooperation, team research conducted via electronic media will be subject to cultural, linguistic, and political difficulties. On the other hand, if it can prove its worth in concrete terms of costs and benefits, it could well receive governmental support. This would be especially true if the subject areas in question are not uncomfortably close to sensitive economic, military, or political issues.

We should of course acknowledge that even if the strengths of CAITR (or its CAPS variant) were considered to outweigh their weaknesses, such methods would not in fact be used unless they also compared favorably with other means of scientific communication in terms of cost. Unfortunately, there is no simple way to assess the comparative costs of various communications media, since these costs depend on numerous factors which vary widely from situation to situation (choice of specific technical system, number and location of participants, type and duration of activities, etc.). It is possible, however, to obtain a general idea of the relative costs involved by examining in detail a number of hypothetical but representative team research situations. We have made such calculations (see Appendix), the results of which are summarized in Table 1.

In this table, five hypothetical cases are analyzed, details of whose definitions are presented in the Appendix. In each case we have compared the cost of CAITR with that of an equivalent activity conducted by more conventional means (travel, mail, telex, etc.). The cost figures should not, of course, be taken as definitive, since they are based on many assumptions about future

Table 1 SUMMARY OF COST COMPARISONS

(in 1977 Austrian Schillings)

ACTIVITY	ESTIMATED COST INCLUDING COST OF MANPOWER		ESTIMATED COST EXCLUDING COST OF MANPOWER	
	(1) via CAITR	(2) without CAITR	(3) via CAITR	(4) without CAITR
1. Invisible College, Worldwide (50 participants, 6 months)	2,471,850	3,897,450	1,534,350	3,417,450
2. Invisible College, Europe only (20 participants, 6 months)	866,490	1,250,475	476,490	1,070,475
3. Intensive Encounter At IIASA (20 participants, 3 days)	407,125	397,725	238,525	232,725
4. Intensive Encounter Via Network (20 participants, 3 days)	213,375	397,725	132,875	232,725
5. Administrative Communications (17 participants, 6 months)	857,510	682,750	528,510	524,750

costs of letter writing, travel, secretarial time, lodgings, printing, etc., not to mention an even more debatable set of assumptions as to just what pattern of non-CAITR communications is in fact "equivalent" to a given CAITR activity. Nevertheless, the assumptions used were the best available to their author at the time, and the results are probably within some reasonable range of error from their true future values.

As can be seen from Table 1, CAITR is substantially less costly than its non-CAITR equivalent in three activities (numbers 1, 2, and 4). The reverse is true in the case of activity 3 because both variants of that activity were defined as requiring group members to meet physically at IIASA, and in the case of activity 5 because the communication pattern is relatively simple (a one-to-all and all-to-one "star", for which CAITR is not especially suitable).

One assumption underlying the calculations in columns 1 and 2 of Table 1 was that the value of group members' time must be included if the complete "cost" of an activity is to be identified. Columns 3 and 4 show that the "out-of-pocket" expenses of an organization conducting CAITR activities would be much less than the figures in columns 1 and 2. In these terms, the CAITR versions of activities 1, 2, and 4 are still advantageous, and the cost levels are of course even more attractive than originally calculated.

Judging from our very tentative calculations, it seems fair to conclude that CAITR is not inexpensive, but in an important class of applications it is less expensive than conventional methods of achieving the same group interactions.

8. CONCLUSIONS

Complex global problems can only be solved by comprehensive and global means--such as those which international team research offers. ITR should also be expected to have strong feedbacks into each nation's own scientific effort, because of the very international character of this form; scientists from different nations will learn the ideas and methods of other regions and will personally be confronted with the most advanced means of scientific organization and communication.

Communication and organization in ITR should not simply be taken from existing national or regional institutions; the new quality of research which has been created through ITR should be assisted by new means. We think that the use of informational networks based on modern computer and telecommunication technology is an important step in this direction.

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[21] Afanasev, Viktor G., Sotsial'naia informatsiia i upravlenie obshchestvom (Social Information and the Management of Society) (Moscow: Politizdat, 1975), p. 307.

[22] For complete details on this experiment, see Rauch, Wolf D., and Randolph, Robert H., Computer Assisted Panel Sessions (CAPS): Review of an Experiment in Accelerated International Teleconferencing (Laxenburg, Austria: IIASA, forthcoming).

[23] Dobrov, G.M., Rauch, W.D., and Randolph, R.H., Eds., Systems Assessment of New Technology: International Perspectives (Laxenburg, Austria: IIASA, forthcoming).

[24] Dobrov, G.M., "Why Management Must Catch Up with Technology", International Management, Vol. 32, No. 11 (November 1977), p. 78.

Appendix

COMPARATIVE COST ESTIMATES

Our approach here will be to take five hypothetical IIASA applications of CAITR and to calculate two cost estimates for each, assuming (1) use of the most appropriate available CAITR system configuration, and (2) the most probable non-CAITR means of performing the same task.

The following five paragraphs give quantitative details of the hypothetical CAITR applications and their non-CAITR equivalents.

- Activity 1--Invisible College, Worldwide.

  Fifty scientists in various countries (say, 5 at IIASA, 15 in Europe, 15 in North America, and 15 elsewhere) will interact freely on various self-defined and IIASA-defined tasks. System usage: 15 minutes per day per person for six months plus one four-hour synchronous conference per month. Additional costs: one ten-minute telephone call to help each user establish his initial contact with the system; a two-hour familiarization session for each user, with an IIASA staff member ("facilitator") also on line to assist him; and an extra 100 hours of system usage by the IIASA chairman. Non-CAITR equivalent: five short (120 word) letters dictated and sent per person per working day, plus one three-day conference at IIASA with all group members attending and with proceedings transcribed and distributed subsequently.

- Activity 2--Invisible College, Europe only.

  This activity is identical with number 1 except that only twenty scientists are involved (5 at IIASA and 15 elsewhere in Europe). Non-CAITR alternative: same as in Activity 1.

- Activity 3--Intensive Encounter, at IIASA.

  Twenty scientists present at IIASA (say, 5 from IIASA, 5 from USA, 5 from USSR, and 5 from other European countries) will interact in a highly structured fashion through four terminals located at IIASA (three for teams of participants and one for the chairman). System usage: four hours per terminal per day for three days. Additional costs: two hours of system time for setting up the conference; cost of moving four IIASA terminals into a convenient location. Non-CAITR equivalent: same interaction conducted "by hand", with no computer assistance but with four junior and four senior man-hours per day of extra staff time for handling of materials, processing of intermediate results.

- Activity 4--Intensive Encounter, via Network.

  This activity is identical with number 3 except that the CAITR interaction is conducted entirely over the network (i.e., participants do not travel to IIASA). Twenty terminals would be involved, and each participant would require a preliminary two hour period of system familiarization with an IIASA "facilitator" also on line. Non-CAITR alternative: same as in Activity 2 (i.e., group convened at IIASA).

- Activity 5--Administrative Communication.

  Three staff members at IIASA will interact with liaison officers at fourteen NMO's. Level of usage comparable to Activity 1, additional costs similarly except that each IIASA staff member gets 25 extra hours of system usage. Non-CAITR equivalent: two circular letters (14 copies) and 25 other letters dictated and sent per week by IIASA, 5 letters dictated and sent to IIASA per week by each NMO, 28 telexes sent by IIASA and 2 by each NMO each week, plus one three-day conference at IIASA as in Activity 1.

For Activities 1, 4, and 5, which require worldwide networks, we shall assume that the CAITR system resides on the computers of a worldwide commercial timesharing service such as TYMNET or CYBERNET. CAITR-type software suitable for these particular computers already exists, and group members in most parts of the world should be able to dial into these networks fairly easily. Some of these dial-up connections might have to be long-distance, which would increase costs, but this problem should be mitigated eventually by the expected expansion of the timesharing networks into new geographical areas.

For Activity 2, which requires only a European network, we shall assume that the planned EURONET service has become available and that appropriate CAITR software can be found.

Finally for Activity 3, which does not require network connections at all, we shall assume that a CAITR-type software system is available on IIASA's own in-house PDP-11/45 computer.

In all activities, we assume that each participant has access to a computer terminal (not unreasonable since we are talking about scientists) or will if necessary lease one at his own expense. If the cost of terminals were to be added into our cost calculations, a safe estimate as of 1977 would be ÖS 1700 per participant per month. This figure is strongly expected to decline in the future.

Detailed cost calculations for the five hypothetical applications are presented below.

Activity 1, via CAITR

In this activity, we assume that the cost of arranging the activity (sending letters of invitation etc.) is constant whether or not CAITR is used, and hence we shall disregard this cost.

		COST CALCULATIONS (ÖS) Computer and network charges, ÖS/hr., est. (first term) + Value of participants' time ÖS/hr., avg. (second term)		
● System usage (per participant):				
Familiarization	2 hrs.			
Basic Usage	69 hrs.			
	71 hrs.			
Extra system usage by IIASA staff:				
Chairman	100 hrs.			
Facilitator (2 hrs/ participant)	100 hrs.			
	200 hrs.			
Total system usage:				
From IIASA ((5x71+200) =	555 hrs.	x(400+250) =	360,750	
From elswhere in Europe (15x71) =	1065 hrs.	x(400+250) =	692,250	
From N. America (15x71) =	1065 hrs.	x(300+250) =	585,750	
From elsewhere (15x71) =	1065 hrs.	x(500+250) =	798,750	
			2,437,500	2,437,500
● Disk storage (assuming $1.1x10^6$ characters added per month,* archived on tape weekly to keep only the latest four weeks on disk):				
$1.1x10^6$ @ ÖS2 (est.) per 1000 characters per month, = ÖS2200/mo.,x6mo.				13,200
● Telephone calls, 10 min. each:				
Within Europe (15@ÖS190)**			2,850	
To N. America (15@ÖS395)***			5,925	
To elsewhere (15@ÖS825)****			12,375	
			21,150	21,150
● Total cost:				2,471,850

* Based on an assumed average typing speed of 20 words per minute, average length of word 6 characters, ¼ of connect time spent typing, 11½ hrs. connect time per participant per month, 50 participants, 33 extra connect hrs. per month by IIASA staff members.

** Based on 1977 average for London, Berlin, Moscow.

*** Based on 1977 average for New York, San Francisco, Ottawa.

**** Based on 1977 average for Buenes Aires, Nairobi, Tokyo.

Activity 1, without CAITR

● Letters: (5 Letters/working day) x (20 working days/month) x 6 months x 50 participants = 30,000 @ ÖS80*=		2,400,000
● Conference: Normal IIASA costs (local transportation etc.)		30,000
Value of invitees' time (45 invitees x (3 days at conference + 2 days traveling) x (8 working hours/day) x (ÖS250/hr.))		450,000
Value of IIASA participants' time (5x3x8x250)		30,000
Room and board for invitees (45 invitees x 4 nights @ ÖS250 est.)		45,000
Travel costs (air): from Europe (15 invitees @ ÖS6365**)	95,475	
from North America (15 invitees @ ÖS19965***)	299,475	
from elsewhere (15 invitees @ ÖS30500****)	457,500	
	852,450	852,450
Labour and costs for transcribing, editing, duplicating and distributing proceedings (assumed 300 pp, 600 copies)		90,000
● Total cost:		3,897,450

* Based on statistically observed cost in USA in 1975 (See Dartnell Corporation, "Inflation Soars 1975 Business Letter Cost to $3,79", Analysis and Staff Report, Chicago, Ill. (1975)), inflated at 8% per annum to 1977 and converted to ÖS at 1977 exchange rate, with ÖS5 added to allow for overseas postage on some letters.

** Based on 1977 average for London, Berlin, Moscow.

*** Based on 1977 average for New York, San Francisco, Ottawa, using average of high-season and low-season rates.

**** Based on 1977 average for Buenes Aires, Nairobi, Tokyo.

Activity 2, via CAITR

		COST CALCULATION (ÖS) — x(Computer and network charges, ÖS/hr., est. + Value of participants' time ÖS/hr., avg.)		
● System usage (per participant):				
Familiarization	2 hrs.			
Basic usage	69 hrs.			
	71 hrs.			
Extra system usage by IIASA staff:				
Chairman	100 hrs.			
Facilitator (2 hrs./participant)	40 hrs.			
	140 hrs.			
Total system usage:				
From IIASA ((5x71)+140)	= 495 hrs.	x(300+250) =	272,250	
From elsewhere in Europe (15x71)	= 1065 hrs.	x(300+250) =	585,750	
			858,000	858,000
● Disk storage (same assumptions as in Activity 1, except only 20 participants):				
4.7×10^5 characters added per month, @ ÖS2 per 1000 characters = ÖS940/mo., x 6 mo.				5,640
● Telephone calls, 10 min. each:				
Within Europe (15 @ ÖS190)*				2,850
● Total Cost:				866,490

* Same basis as in Activity 1.

Activity 2, without CAITR

	COST CALCULATIONS (ÖS)
● Letters:	
600 per participant,* x 20 participants = 12,000 @ ÖS75**	900,000
● Conference:	
Normal IIASA costs (local transportation etc.)	30,000
Value of invitees' time*, 15 invitees	150,000
Value of IIASA participants' time*	30,000
Room and board for invitees*, 15 invitees	15,000
Travel costs (air):	
from Europe (15 invitees @ ÖS 6365*)	95,475
Labour and costs for publishing proceedings (100 pp, 600 copies)	30,000
● Total cost:	1,250,475

* As in Activity 1.

** As in Activity 1, minus the ÖS5 for overseas postage.

Activity 3, via CAITR (but at IIASA)

	COST CALCULATION (ÖS)	
● Basic cost of conference: Normal IIASA conference costs (local transportation etc.)		30,000
Value of invitees' time (15 invitees x (3 days at conference + 2 days traveling) x (8 working hours/day) x (ÖS250/hr.)		150,000
Value of IIASA participants' time (5x3x4x250)		15,000
Room and board for invitees (15 invitees x 4 nights @ ÖS 250 est.)		15,000
Travel costs: from Europe (5 invitees @ ÖS6365*)	31,825	
from USA (5 invitees @ ÖS20740**)	103,700	
from USSR (5 invitees @ ÖS9600***)	48,000	
	183,525	183,525
● Extra costs for use of CAITR:		
System charges		none ****
Cost of moving terminals to a convenient location at IIASA (est.)		10,000
Value of IIASA staff members' time needed to operate terminals during activity: 3 people x 12 hrs. x ÖS100 =		3,600
● Total cost:		407,125

* As in Activity 1.

** Based on 1977 average for New York and San Francisco, high and low seasons.

*** Based on 1977 fare for Moscow.

**** Assuming use of IIASA's in-house PDP-11/45.

Activity 3, without CAITR

	COST CALCULATIONS (ÖS)
● Basic cost of conference (same as in Activity 3 via CAITR):	393,525
● Value of extra IIASA staff time needed to process group inputs between sessions:	
Senior ((4 hrs./day) x (ÖS250/hr.) x 3 days) =	3,000
Junior ((4 hrs./day) x (ÖS100/hr.) x 3 days) =	1,200
● Total cost:	397,725

Activity 4, via CAITR

		COST CALCULATIONS (ÖS) Computer and network charges, ÖS/hr., est. (↓) Value of participants' time ÖS/hr., avg. (↓)		
● System usage per participant:				
Familiarization	2 hrs.			
Basic usage ((4 hrs./ day) x 3 days)	12 hrs.			
	14 hrs.			
Extra system usage by IIASA staff:				
Chairman, to set up	2 hrs.			
Facilitator (2 hrs/ participant)	40 hrs.			
	42 hrs.			
Total system usage:				
From IIASA ((5x14)+42)	= 112 hrs.	x(400+250) =	72,800	
From USA (5x14)	= 70 hrs.	x(300+250) =	38,500	
From USSR (5x14)	= 70 hrs.	x(500+250) =	52,500	
From other Europe (5x14)	= 70 hrs.	x(400+250) =	45,500	
			209,300	209,300
● Disk storage (assuming approximately 6×10^5 characters in all*, stored for an average of two weeks:				
6×10^5 @ ÖS2 (est.) per 1000 characters per month, x 0.5 mo.=				600
● Telephone calls, 10 min. each:				
to USA (5@ÖS260**)	=		1,300	
to USSR (5@ÖS300***)	=		1,500	
to other Europe (5@ÖS135****)	=		675	
			3,475	3,475
● Total cost:				213,375

* Based on same assumptions about typing spped etc., as in Activity 1.

** Based on 1977 average for New York and San Francisco.

*** Based on 1977 rate to Moscow.

**** Based on 1977 average for London and Berlin.

<u>Activity 4, without CAITR</u>

(Same as Activity 3 without CAITR)

- Total cost: ÖS 397,725

Activity 5, with CAITR

COST CALCULATIONS (ÖS)

		Computer and network charges, ÖS/hr., est. / Value of participants' time, ÖS/hr., avg.		
● System usage (per participant):				
Familiarization	2 hrs.			
Basic usage	69 hrs.			
	71 hrs.			
Extra usage by IIASA staff:				
3 administrators @ 25 hrs.	75 hrs.			
Facilitator (2 hrs./participant)	34 hrs.			
	109 hrs.			
Total system usage:				
From IIASA ((3x71)+109)	= 322 hrs.	x(400+250) =	209,300	
From W. European NMOs (5x71)	= 355 hrs.	x(400+250) =	230,750	
From E. European NMOs (5x71)	= 355 hrs.	x(400+250) =	230,750	
From USSR	= 71 hrs.	x(500+250) =	53,250	
From N. American NMOs (2x71)	= 142 hrs.	x(300+250) =	78,100	
From Japan	= 71 hrs.	x(400+250) =	46,150	
			848,300	848,300
● Disk storage (based on same assumptions as in Activity 1 except for having only 17 participants, plus 56 extra connect hrs. per month by IIASA staff members): approximately $4.5x10^5$ characters added per month and hence in storage at any given moment, @ ÖS2 per 100 characters per month, x 6 mo.				5,400
● Telephone calls (10 min. each)				
Within Europe (11 @ ÖS190*) =			2,090	
To N. America (2 @ ÖS430**) =			860	
To Japan (1 @ ÖS860***) =			860	
			3,810	3,810
● Total cost:				857,510

* As in Activity 1.

** Based on 1977 average for New York and Ottawa.

*** Based on 1977 rate to Tokyo.

Activity 5, without CAITR

		COST CALCULATIONS (ÖS)
● Circular letters sent by IIASA: two per week x 24 weeks = 48, @ ÖS1500 (est. cost of dictation, transcription, duplication, addressing, mailing of 14 copies)		72,000
● Other letters: 25 from IIASA and 5 from each NMO per week = 95, x 24 weeks = 2280, @ ÖS75*		171,000
● Telex: 28 from IIASA and 2 from each NMO per week = 56, x 24 weeks = 1344, @ ÖS60 (est.)		80,640
● Conference:		
Normal IIASA costs (local transporation etc.)		30,000
Value of NMO representatives' time (14 representatives x (3 days at conference + 2 days traveling) x (8 working hours/ day) x (ÖS250/hr.))		140,000
Value of IIASA participants' time (3x3x8x250)		18,000
Room and board for NMO representatives (14 representatives x 4 nights @ ÖS250 est.)		14,000
Travel costs (air): from Europe (10 @ ÖS6365)	63,650	
from USSR (1 @ ÖS9600)	9,600	
from N. America (2 @ ÖS17760**)	35,520	
from Japan (1 @ 38,340)	38,340	
	147,110	147,110
Labor and costs for transcribing, editing, duplicating, and distributing proceedings (assumed 50 pp, 100 copies)		10,000
● Total cost:		682,750

* As in Activity 2.

** Based on 1977 average for New York and Ottawa, high and low seasons.