COMPUTER ASSISTANCE FOR INTERNATIONAL TEAM RESEARCH (CAITR): A NEW COMMUNICATIONS MEDIUM FOR IIASA

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PREFACE

A discussion is currently under way at IIASA about the most promising uses for the computer communication network now being developed here. This paper is a contribution to that discussion. As such, it proposes a new form of computer-mediated group interaction intended to assist geographically scattered groups of scientists in performing truly collaborative research. We shall refer to such interaction as CAITR (Computer Assistance for International Team Research). CAITR does not yet exist, but its components do (hardware and software, team research strategies, etc.). In the author's opinion, IIASA has a unique opportunity to assemble these components into a new research tool of value not only for IIASA and its collaborators but for the world scientific community as a whole.

CAITR is an offshoot of "computer conferencing". It differs, however, in being carefully adapted to the needs of international research teams. This difference has many possible concrete manifestations, such as:

- the option of highly structured group interaction instead of mere "conversation";
- the option of nesting within the group interaction a number of advanced man-machine activities, such as group creation of computerized models, group creation and use of data bases, etc.;
- the possibility of such special features as automatic multilingual operation;
- application to specific research tasks such as polling, brainstorming, joint authorship, project coordination, etc.; and
- integration into existing organizational and collegial communication patterns.

Some thought has been given to computer conferencing at IIASA in the past, but it has been conceived narrowly and demonstrated trivially. Its power to aid IIASA through the form of CAITR has not been examined. This paper is intended to initiate such an examination.

For IIASA to become involved in the development and use of CAITR would have several advantages. Most importantly, it would increase the ability of IIASA scientists to work collaboratively with colleagues elsewhere--especially at their home institutions. Because of such improved communications, CAITR would enhance IIASA's role as a hub--a center of rotation--for worldwide co-operative research efforts regarding various world problems. Also, CAITR would help to maximize the usefulness of IIASA's computer network, thus helping to justify the effort expended on its creation. Finally, development of CAITR would provide an opportunity for united efforts by several IIASA research groups (M & T, SDS, CS, etc.)--a desirable end in itself.

As might be expected, CAITR will face serious obstacles. Simply assembling all the necessary components (hardware, software, group interaction procedures, organizational arrangements, etc.) will be a substantial undertaking. No computer-communication network yet exists which reaches all world areas of interest to IIASA. It is unclear how soon IIASA's own network will actually be operating and what its geographical coverage will be. There is even some danger that the use of data networks for the purposes of CAITR will be frowned upon by PTTs as "unfair" competition to other international communication services, especially since CAITR is likely to be much less expensive to use.

Because of these difficulties, CAITR will have to proceed gradually. We must retain and continue to elaborate our vision of CAITR as it ultimately should be, but in the meanwhile go ahead with lesser versions more feasible under present circumstances. Since any effort to develop CAITR will be costly well beyond the limits of IIASA's internal funds, it seems plain that a grant proposal should be prepared for submission to outside agencies interested in the improvement of international scientific communication and cooperation (e.g., UNESCO, UNEP, etc.).

In this paper we shall attempt to make the case that CAITR is needed, then to describe CAITR's expected operating characteristics, effects of use, some possible applications, and estimated costs. We shall conclude by outlining some steps which must be taken in making CAITR a reality.

1. THE NEED FOR CAITR

In General

Modern science, like modern society as a whole, relies heavily on fast and efficient communications. Personnel in a research institution commonly spend more than half of their time in some form of communication activity (face-to-face meetings, telephone conversations, writing and reading articles, etc.).[1] Personal contacts with colleagues, especially those outside one's home institution, are particularly important, because scientists who have relatively frequent contact with colleagues tend to perform at higher levels than those with less frequent contacts.[2] One often hears calls for even greater contact among scientific institutions, especially those which approach the same problem from different directions.[3]

Yet scientific communication is fraught with difficulties. Journal articles are always somewhat stale, scholarly books even more so. Conferences and workshops provide more up-to-date information, but it is seldom possible for the entire international community of interested scholars to attend a given conference. Also, conferences do not normally take place often enough to allow truly joint research by international teams of scientists. Such joint research can of course be conducted by having a few scholars from one country temporarily join a group in another country, but then their access to resources and colleagues at home is substantially reduced. Moreover, the cost of travel is increasing with the cost of energy, and research budgets in many countries are under severe economic pressure.[4]

A partial answer to the problem of scientific communication has recently arisen in the form of computer-assisted group-interaction systems. Early systems of this type have been used mostly for "computer conferencing", and have been both costly to use and relatively primitive. But their fundamental idea is a good one: to apply the power of the computer as an aid to purposeful group interaction. The preconditions for such systems are being satisfied in more and more countries at present: good

computers; networks for interconnection; computer terminals accessible to individual scientists; and a new breed of computer users who are not programmers, who are not interested in computer technology per se, but who see the computer as a potentially powerful scientific tool.[5]

Computer-assisted group interaction, even in its primitive early forms, is being taken very seriously in several countries. In the United States, for instance, it has been used successfully by many universities and research institutes, by such agencies as NASA and the USGS, and even by the campaign staff of presidential candidate Jimmy Carter![6] Similar man-machine-man dialogue systems have reportedly been developed and used in the Soviet Union.[7] Virtually all existing computer networks have found it desirable to implement some mechanism for interpersonal communication, and users of the simplest systems ("electronic mail" or message-sending services) have on occasion spontaneously attempted to use them for fullfledged computer conferencing.[8]

Possibilities for international computer-assisted group interaction have been recognized and some efforts along this line have already been made. It is now possible for individuals anywhere to "attend" United Nations conferences via computer.[9] The author himself has participated in computer-assisted joint research activities involving groups in the United States and the United Kingdom. If computer conferencing could be used for communication between countries which are in some sense international opponents, it has even been suggested that this might help to prevent or at least mitigate international tension.[10] All things considered, it seems clear that the world scientific community could profit from group-via-computer dialogue systems of the type that we shall henceforth refer to as CAITR: Computer Assistance for International Team Research.

At IIASA

The potential value of CAITR is especially great here at IIASA, because of IIASA's unusually strong need for collaborative interaction with scientists and organizations in other countries.

This need has been repeatedly acknowledged by IIASA's leaders, and seems indeed to be an essential feature of IIASA policy. Our Director, Dr. Levien, has put it this way:

> The founders of the Institute saw its true purpose in stimulating and linking collaborative research in the participating countries.[11]

Our Council Chairman, Dr. Gvishiani, has expressed the same fundamental idea:

> A necessary condition for the Institute's effectiveness is cooperation with other organizations in all the various forms such cooperation can take. If the research of the Institute teams is supported by that of national teams, this will have a multiplying effect rather than one of simple summation. The final aim of building up cooperative links is to establish a network in institutions jointly working on problems of systems analysis.[12]

There are of course many methods by which these "cooperative links" can be established. But one feature which all such methods have in common is communication in some form: travel to conferences, telephone calls, TELEX messages, correspondence through the mails, reading one another's articles and books, etc. IIASA has given a great deal of attention to the acquisition of modern, efficient communication facilities, perhaps the most substantial effort being that to create an IIASA computer communication network. This network is intended for precisely the same purposes discussed above--i.e., facilitation of collaborative research. As Dr. Butrimenko, head of the network project, has put it,

> We . . . firmly believe that improved communication facilities will both stimulate international research and also provide a basis for collaborative research of a type which is practically impossible with the small number of people that can be brought together at this institute.[13]

So far, most discussions of the IIASA computer network seem to have assumed that its principal use will be for remote computer usage and for communication of programs and data files. But there are other possibilities that may in the long run prove to be even more important. IIASA has been reminded in the past that computer processing is only part of the job in any problem solving

situation; the most sophisticated hardware and software are useless unless they are adequately integrated "into the complex of problem processing and solving by man".[14] In other words, the creation of tasks and interpretation of results are just as important as the data processing per se. And for this, CAITR is an ideal tool.

To evaluate IIASA's communication needs in detail would require a special study of present communication patterns and perceived difficulties. In the absence of such a study, general observation of IIASA activities suggests that many IIASA scientists simply forego frequent contact with colleagues elsewhere. They rely on postal correspondence much of the time, or TELEX and the telephone for very urgent questions. Most substantive exchanges occur in the form of papers distributed through the mails, plus occasional workshops and conferences at IIASA and elsewhere. The resulting communication is slow and sporadic, or else very expensive when travel is involved. The author himself, for instance, has found it extremely annoying to have airmail communications with his home institute in California require nearly three weeks to get a reply (nine days in transit each way!). This experience has probably been shared by other IIASA scientists, and it seems very likely that their productivity has suffered as a result.

The essence of the problem is that IIASA scientists must, by the very character of the Institute, rely on effective communications with colleagues elsewhere as a source of information. IIASA does not and cannot have the laboratories, field stations, etc., needed for "posing questions to nature".* But such questions can be posed indirectly, through colleagues elsewhere - especially at IIASA scientists' home institutions. True scientific collaboration with such colleagues requires

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* The author is indebted to Professor G.M. Dobrov for this notion.

more than TELEX and the mails or even sporadic and expensive meetings. This is a problem as we shall see in subsequent sections of this report, CAITR may well be the answer.

2. BASIC FEATURES OF CAITR

Fundamentally, CAITR is a concept. It is a combination of three elements: a group-via-computer communcation system, a set of procedures for effective group interaction through such a system, and a complex of organizational arrangements to bring the system and its users together.

With some adjustments, of course, these same three elements can be combined to produce results other than CAITR. As shown in Figure 1, CAITR is a special case of CATR ("Computer Assistance for Team Research"), which in turn is a special case of CAGI ("Computer Assistance for Group Interaction").

It is hoped that the reader will not find this proliferation of acronyms too annoying. The reason for it is that, as already noted, CAITR does not yet exist but its components do. That is, the past experience on which we must base our vision of CAITR comes from the more general realms of CATR and CAGI. Thus whenever we are discussing the present state-of-the-art or the results of past experiments, we shall refer almost always to CAGI, occasionally to CATR. But we shall do so with our mind's eye firmly fixed on our goal at IIASA, which is CAITR.

In the remainder of this section, we shall outline the probable operational characteristics of CAITR in terms of its basic elements (communications system, procedures, and organization), drawing wherever possible on prior experience in the general area of CAGI.

The Communications System

This aspect of CAITR is especially easy to visualize, since numerous group-via-computer communication systems already exist (see Table 1). These systems, with names such as FORUM, PLANET, CONFER, EMISSARI, DIALOG, etc., are by no means identical, but they do have many features in common. Any of them would have some usefulness in CAITR. For the sake of generality, however, we shall refer to all existing systems by the generic designation "CAGI systems".

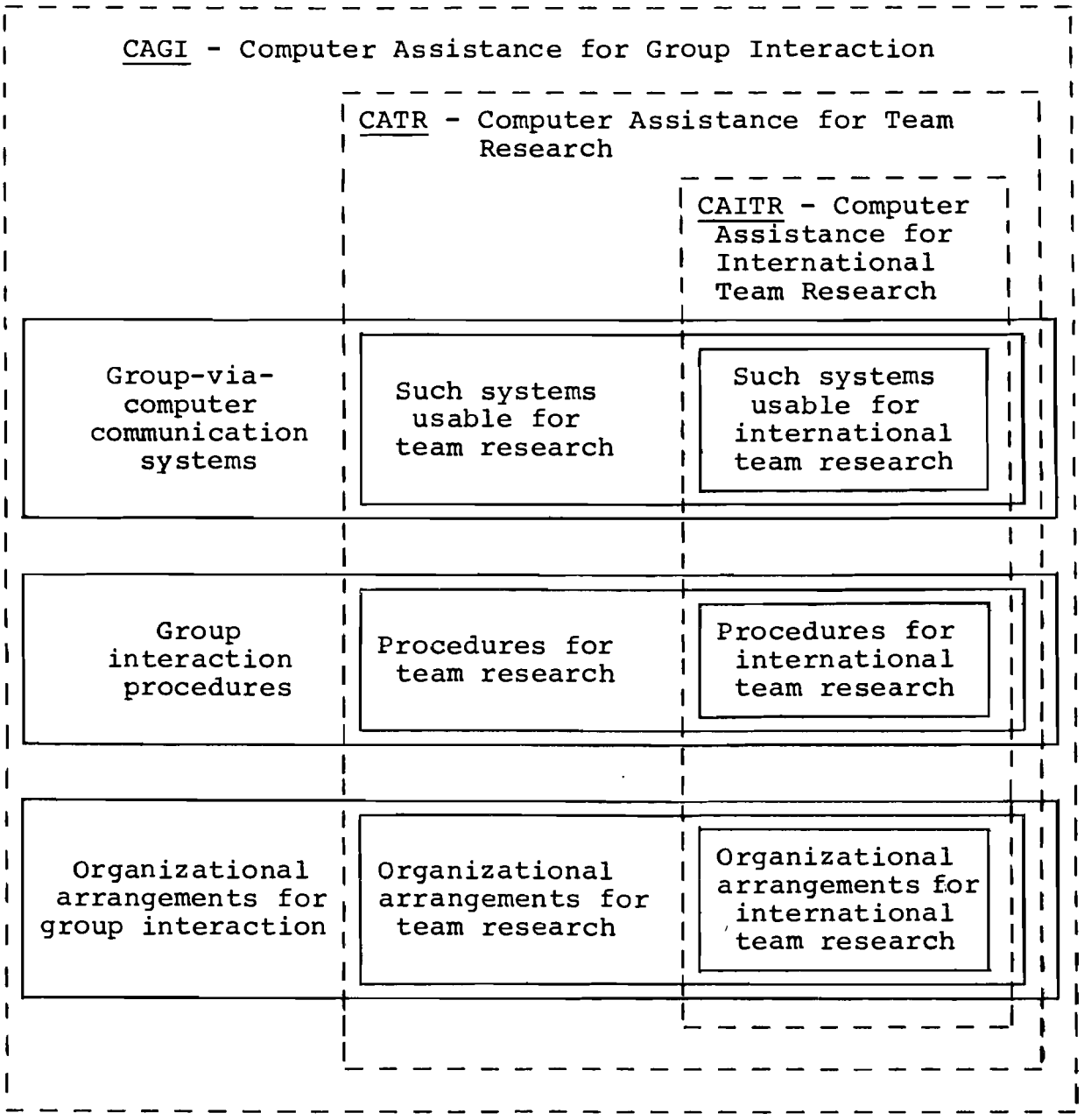

Figure 1 - RELATION OF CONCEPTS CAGI, CATR, and CAITR

Table 1 - REPRESENTATIVE CAGI SYSTEMS

SYSTEM	RESPONSIBLE ORGANIZATION	COMPUTER OR NET-WORK USED	TYPE OF INTERACTION	REF
Technotec Worldtec	CDC	CYBERNET	Data-base querying to locate persons/organizations for subsequent contact through other media for purpose of technology transfer.	15
Interactive Consulting Program	UCLA Health Sciences Computing Facility		Allows "watcher" to supervise "worker's" use of other computer programs.	16
DMS	MIT		Electronic Mail	17
OFFICE-1	SRI-ARC	TYMSHARE, ARPANET	" " Chronological file, other office functions e.g. text edit.	18
MAILBOX	Scientific Time Sharing Corp., Bethesda, Md	TELENET TYMNET STSC network	Electronic Mail	19
ARPANET NEWS	ARPA Network Information Center, Stanford Research Institute	ARPANET	On-line newsletter, with selective reading capability, inputs from anywhere on system.	20
PARTY LINE (No longer in use)	Office of Emergency Preparedness (Murray Turoff)		Simple conversational conferencing, comparable to telephone conference call. Messages limited to 8 typed lines. Not designed for use by novice.	21
EMISARI (No longer in use)	Office of Emergency Preparedness (Murray Turoff)		Similar to PARTY LINE, with additional features.	21
RIMS	Federal Preparedness Agency		Follow-on to EMISARI	19

SYSTEM	RESPONSIBLE ORGANIZATION	COMPUTER OR NET-WORK USED	TYPE OF INTERACTION	REF
ORACLE	Northwestern University			21
DISCUSS	University of Illinois	PLATO	Adapted from computer-aided instruction system. Severely limited by use of special terminal (Plasma panel).	22
D-NET (Replaced by FORUM)	Institute for the Future (Olaf Helmer)	PDP-10, accessed via ARPANET	Complex combination of conversational conferencing with structured Delphi-type enquiry.	23
FORUM (Replaced by PLANET)	Institute for the Future (Jacques Vallee)	"	Similar to EMISARI.	24
PLANET	"	TYMNET	Similar to FORUM, but slightly simpler.	25
TOPICS, NOTEPAD	Infomedia Corp. (Jacques Vallee)	CDC 6600 or CYBER, accessed via CYBERNET	Similar to PLANET.	26
EIES	New Jersey Institute of Technology (Murray Turoff)	Dedicated Interdata 7/32, accessed via TELENET	Similar to EMISARI.	27
CONFER	University of Michigan		Similar to PLANET, except that indexing information and voting requests may be attached to every message. Command-oriented (user must constantly instruct system, rather than vice versa).	28

SYSTEM	RESPONSIBLE ORGANIZATION	COMPUTER OR NET-WORK USED	TYPE OF INTERACTION	REF
HOTLINE INTER-NATIONAL	HOTLINE INTER-NATIONAL	TELEX etc.	Intended for use in conjunction with normal conferences held by United Nations. Remote inputs are called to the attention of conference delegates, and information about conference is fed back.	29
DIALOG.F4	Institut für Betriebs-wirtschafts-lehre der Universität Kiel (FRG)	PDP-10	Intended mainly for Delphi-style interactions.	30
DELPHI.F4	"	"	"	31

Physically, any CAGI system consists of a number of computer terminals, data communication lines, computers, data files, and computer programs (see Figure 2). The precise character of each component can be varied over a wide range, thus adapting the system to the needs of its specific user community.

By its very nature, any CAGI system has certain inherent capabilities. First and foremost, it can link people who are not otherwise in regular contact.[32] These people may never even have met each other beforehand, may belong to entirely different disciplines, may live thousands of miles apart. CAGI can in principle allow these people to communicate with one another according to any logical pattern: one to one, one to some, one to all, all to one, and so forth. It is entirely possible for the "people" at the varous terminals to be groups rather than individuals, if this is desirable for economic or other reasons. The users do not have to be computer experts, since most CAGI systems are specifically designed for use by "laymen". CAGI has a perfect memory and can keep a complete transcript of the group interaction for future reference. And, as we shall discuss later, CAGI can

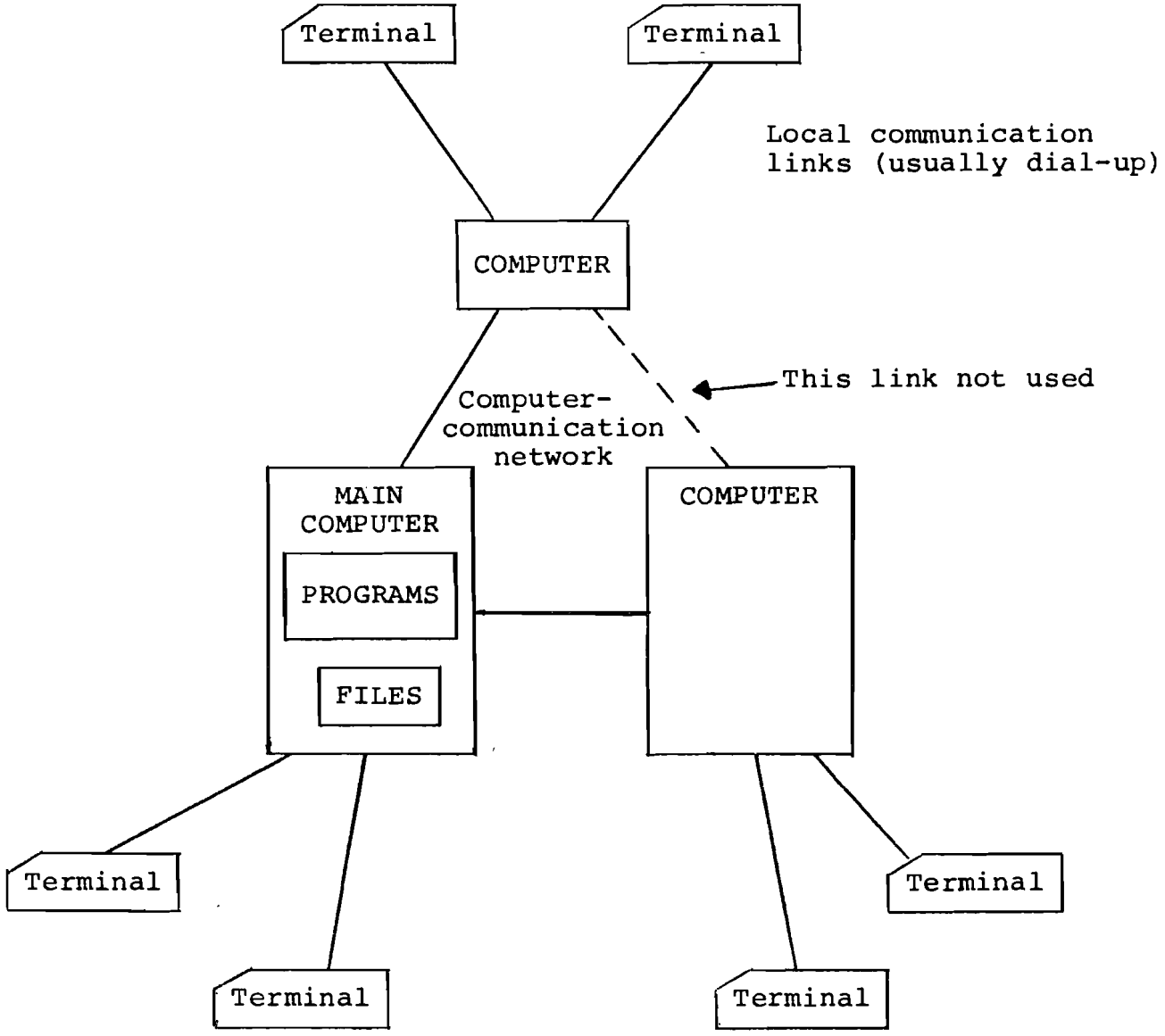

Figure 2 - PHYSICAL STRUCTURE OF A TYPICAL CAGI SYSTEM

automatically provide a variety of services for agenda following, information storage and retrieval, numerical computation, voting, and the like. Such features would be especially important in both CATR and CAITR.

Some special system capabilities desirable for CAITR have not yet been implemented in any CAGI system. These features constitute an especially promising area for system-development innovations.

For instance, CAGI systems could be adapted for use in a multi-language situation. This has already been tried on a small scale in Canada, with users of one CAGI system having the option of receiving system messages in English or French.[33] Conversion into non-Roman alphabets would pose special problems, though some appropriate terminal equipment does already exist. Central simultaneous translation services could be provided, using a human translator at first but perhaps someday incorporating automatic translation systems if and when they are perfected.

To keep users from having to type, it has been suggested that there might someday be voice-actuated CAGI systems.[34] At present, this problem is sometimes dealt with by having a secretary or assistant operate the terminal keyboard.[35]

Because "connect time" is a major source of expense in any CAGI system, there would obviously be value in preparing inputs (lengthy ones at least) on a local mini-computer or intelligent terminal, then transmitting them to the CAGI system in a rapid burst.[36] With some CAGI systems, it is already possible to insert into the proceedings a file prepared on a different computer; but of course this requires a certain amount of computer expertise.

Retrospective searching of the CAGI files would be much accelerated by the use of indexed relational storage rather than simple transcript-type files which must be searched by string matching. Those CAGI systems which use indexed storage, however, require the participant to provide the necessary indexing information (keywords for every message, etc.). And this of course makes participation more difficult. In future systems, it might be

possible to have the indexing function be performed semi-automatically, with the help of a specially assigned human assistant, or even fully automatically by means of word-counting or semantic analysis algorithms.

Interaction Procedures

Virtually any group-interaction procedure can be provided for in CAGI and hence in CAITR. Here we shall discuss some procedures which have been tried in the past and note some possibilities for the future.

Up till now, most CAGI interactions have been essentially conversational in nature. That is, any group member has been free to "say" whatever he liked, whenever he liked. His comments were stored in a computer file along with certain computer-generated identifying information. If the intended recipient of the message happened to be "on line" at the moment, the message would be printed out on his terminal as soon as possible. Otherwise the recipient would see the message the next time he "logged in" to the computer. By implication, a conversation could take place either "synchronously", with all participants on line at once and exchanging messages rapidly, or "asynchronously", with each participant logging in at his leisure to pick up any messages that might have been left for him lately and to make his replies.

Appendix A presents a sample transcript of a typical user session in a conversational CAGI interaction. As shown there, the session begins with the user logging into the computer, selecting the "conference" in which he wishes to participate, and then receiving a series of messages which have accumulated since the last time he logged in. He types in a response to one of the messages. Then, because there happens to be another conference participant on line at the moment, a brief "synchronous" conversation ensues. After leaving new messages for two absent members of the group, the user logs out. The total elapsed time of such a session is perhaps fifteen minutes, and its cost about six dollars (assuming the most expensive system currently used in the United States). In other words, the user has had meaningful interactions

with several colleagues, with less delay and less cost than if he had used the telephone or dictated several letters.*

In a purely conversational interaction, the computer actually does very little most of the time except add identifying information to each message, store and retrieve messages as required, and attend to a few details such as the tidy pagination of output. Most CAGI systems, however, add special features for offering help or instructions to the user when he is confused; transmitting private or anonymous messages; and, more important, performing retrospective searches of the accumulated file of messages according to such descriptors as author, date, keywords, etc. Individual systems sometimes provide very specialized features, such as notification when a requested file search will be very expensive; or automatic maintenance of "skill ratings" which cause the computer to give each user a type and volume of advice suitable to his degree of experience with system use.

Some CAGI systems have moved away from the entirely "conversational" mode of group interaction. In these systems, the conference participant may be required to issue special commands to the computer in order to direct the course of his participation. Or he may be required to give special indexing, cross referencing, or other information along with each message he sends. Naturally, such requirements make the system much less usable by persons who are not specially trained in the use of the system. The ideal type of system would be one in which the user has the choice between easy but relatively inflexible participation and a more difficult but also more powerful mode of operation. No system now in general use is of this type, though many system developers have recognized the need and have given some attention to it.

Special automatic facilities for regulating the structure of the interpersonal interaction have sometimes been proposed.[37] These might include something comparable to Robert's Rules of Order, limits on the length or number of entries made by any one participant, and special voting procedures to allow for vetos, majority rule, etc.

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* See Section 5 for further discussion of the cost question.

More directly relevant to CAITR are the many known group-interaction procedures intended to assist joint scientific problem solving. Some procedures of this kind have already enjoyed some attention at IIASA--e.g., methods for assessing and analyzing preferences concerning multiple objectives.[38]

We have said that the ideal CAGI system would combine simplicity with power. In the author's opinion, the ideal way to achieve this combination is by having the basic group interaction be purely conversational, with other elements being addable at the participants' option. The advantage here is that conversational interaction is the one variety which most resembles users' past experience and is thus most comfortable to use. In many cases, the group's needs may be met entirely by a carefully organized "conversation". But if the group members are sufficiently expert at system usage, they can call upon other system facilities as they see fit.

Appendix B offers a hypothetical transcript of a CAITR session exemplifying the notion above. The user logs in, exchanges conversational messages with one or two other group members in preparation for the next activity, then uses a special system command language to request computer assistance with that activity--group creation of a simple probabilistic model. By requesting this service, he has made himself the chairman of a sub-conference devoted to the model. The computer queries him about the desired nature of the model, then opens it for inputs from other group members. During the time that the sub-conference chairman is setting up the model, he is "absent" from the main conference, to which he returns afterward. A computer-generated invitation to attend the sub-conference (i.e., help in creating the model) is automatically inserted into the transcript of the main conference as soon as the sub-conference has been officially opened. Group members who are on line at the moment will receive the invitation at once and may choose to accept it or not. Group members not currently on line will receive the invitation when they come to it in their asynchronous progress through the main conference. Note that the sub-conference chairman can and does

issue special requests for the prompt attendance of persons especially needed for his new activity. These people, who may not even be members of the "main" conference but are simply known to the CAITR system, will receive these special summonses any time they log into the computer at all. Later on, when the modeling sub-conference has been completed, its results are automatically fed back to the members of the main conference, and as a courtesy, to any "outsiders" who had been specially called in for the sub-conference.

By the expedient of "nesting" non-conversational group activities within a generally conversational CAITR environment, we may hope to achieve the elusive goal of simplicity with power. Any group member knowledgeable enough to set up a special activity may do so. Other members called upon to participate need have no special expertise at all.

Organizational Arrangements

The only absolute organizational requirement for CAITR is that there be some central agency responsible for arranging technical details (network access etc.) and assisting group members in case of difficulty. This is the natural role of any communication utility. Such an agency could, if it were also involved in scientific research itself, take the initiative to institute and coordinate team research activities. This extra role would certainly be appropriate if the agency were IIASA.

The role of technical facilitator requires that the central agency possess appropriate expertise about the CAITR system itself; about the computers, network connections and terminals required for its use; and about the available procedures for maximizing user satisfaction (comfort and productivity). One or more agency staff members should be assigned the task of instructing new system users and offering on-line counsel to all users who request it. The central agency would also be responsible for distributing system documentation. It might or might not be obliged to keep financial accounts and to bill "customers" for their system usage, depending on whether or not a commercial

timesharing service were involved as a provider of computer time or network connections.

The role of scientific coordinator would require little computer expertise, demanding instead the most intimate acquaintance with the subject matter in question and with the world community of interested scholars. At IIASA, this function could easily be performed by IIASA scientists in many subject areas. It could equally well be performed by scientists located elsewhere if this seemed more appropriate.

Let us return for a moment to the question of finances. In the past, CAGI services have been provided almost solely on an experimental basis. They have therefore been paid for out of funds belonging to or obtained by the organization providing the services. This was unavoidable, since no one can be expected to pay for expensive services whose value is unproven. If this has been true for CAGI in general, it will be especially true for CAITR. In the long run, however, there is every reason to believe that CAITR will be seen by the world scientific community as a sensible alternative to travel and other means of group communication. Thus CAITR activities should eventually be paid for in the same way that other forms of scientific communication are: by the organization instigating an activity (say, a professional society, a governmental department, or an international agency), and/or by the participants themselves (presumably from funds earmarked for this purpose by their home organizations or else from specially obtained grant funds). The central agency providing CAITR services should expect to break even or (if it were a profit-making organization) perhaps even come out ahead.

3. EXPECTED RESULTS OF CAITR USAGE

In deciding whether or not the idea of CAITR is worth pursuing, one would naturally like to know what its probable cost-benefit characteristics would be. This is impossible to know for sure. There is a growing body of literature, however, which has sought to evaluate the more general phenomenon of computer-assisted group interaction, and this literature about CAGI offers clues about CAITR. In this section we shall discuss the pros and cons of CAGI, which necessarily apply to CAITR as a special case. Wherever a general statement about CAGI must be modified to fit CAITR, this fact will be noted.

The Problem of Evaluation

For want of any better approach, many observers have tended to evaluate CAGI systems as if they were a direct substitute for travel, face-to-face meetings, and so forth. But this is a misleading approach. True, CAGI can substitute for existing forms of communication, but it is not at its best thus. There are costs involved, and effective system use must be learned. CAGI comes into its own by changing and improving the group interaction. It is at its best when it is used for entirely new kinds of communication which, for one reason or another, do not now take place at all. In evaluating CAGI, and hence CAITR, we must think about new kinds of group interaction with new sets of participants.[39] This is especially true since the effects of CAGI are known to depend heavily on the specific characteristics of the group and task involved.[40]

In addition, we should bear in mind that CAITR is a unique application of CAGI. It is not identical with previous applications, and so we must be cautious about transfering findings from past evaluation studies. These findings are worth reviewing, as we shall do in this section of the report. But ultimately, the only true test of CAITR will be to use it and assess the results.

Advantages

Basic Features. As indicated in Section 2, CAGI has a number of intrinsic capabilities which should be especially attractive in the CAITR application. These include:

- speed of communication, relative to travel or the mails;
- ability to link geographically scattered persons who would not otherwise be in frequent contact;
- automatic production of transcripts in machine-readable form, thus facilitating processing and prinout;
- capability for special services such as agenda following, voting, etc.;
- omni-directional communication;
- usability by non-computerniks, after a brief period of familiarization; and
- suitability for use by a group at each terminal, if desired.

To these points we might add the fact of CAGI's extreme flexibility. Any kind of group, of virtually any size, can use CAGI profitably.[41] CAGI can be adapted to any organizational structure.[42] And the specific features of the CAGI software can, if necessary, be constantly updated to match changing group needs.[43]

Improved Communication. Probably the most important advantage of CAGI is its ability to enhance group communciations, even as compared with the face-to-face situation. This is a relatively intangible advantage,[44] yet its impact on group productivity can be great.

As a rule, information transmitted via CAGI has the desirable qualities of precision and timeliness. This makes CAGI especially suitable for handling emergency situations.[45]

When the interaction is asynchronous, a message always finds its recipient "in" and in a receptive mood (by contrast with a telephone call).[46]

The speed of information flow is enhanced by the fact that it occurs in printed form. "Because reading speed is much faster than listening to the spoken word, it is possible to exchange many more ideas in the same amount of working time".[47]

CAGI is much more democratic than other forms of group communication.[48] In contrast with face-to-face or telephone conferences, each group member is able to "speak his piece" without fear of interruption.[49] And in contrast with all forms of diadic communication (mail, TELEX, normal telephone calls), all group members are able to see all information exchanged within the group (with the exception of messages which are deliberately made private).

Although some CAGI participants are initially disturbed by the absence of non-verbal cues (gestures, facial expressions, etc.), this feature of CAGI can be advantageous under some circumstances. One team of researchers has put it this way: "preconceptions that if fewer cues are available in the interaction, then worse outcomes will ensue, must be dismissed".[50] In particular, use of CAGI reduces the communication of emotion, which could well be a desirable feature for some group tasks.[51]

Perhaps related to the non-communication of emotions, CAGI seems to enhance candor.[52] Much more so than in a face-to-face meeting, group members seem to feel free to express their true beliefs without fear of disapproval. The exact reason for this effect is not known, nor are we sure that it always occurs. But it certainly is an attractive possibility.

The systematic creation of a group data base has several beneficial effects. For one thing, it helps all members of the group to "remember" information previously circulated--a substantial improvement over notes scribbled on bar napkins and the like.[53] With such a data base, a newcomer can quickly and easily catch up on the status of the whole group--which ordinarily he might not be able to do at all.[54] And of course, through such a data base it is unusually easy to include an entire group in a single transmission.[55]

CAGI can have an especially powerful effect on communication patterns within an organization using it. It allows members of a small group or team to inform the larger group or community about their activities. This effect has been found useful even in cases where the small group conducts most of its work via other media (e.g., face-to-face).[56] Seen from the other side, this is equivalent to letting higher people in an organization see what their subordinates are doing sooner than they could otherwise.[57] The supervisors would then have the option of involving themselves in the given activities if they deemed it necessary. This state of affairs could be good or bad depending on one's perspective, but by increasing the extent to which organization members "know what is going on", CAGI probably enhances productivity.

Aside from all these observed effects on communication patterns, several others have been hypothesized on the basis of the wider literature on small-group behavior.[58] It is suggested, for instance, that because of reduced pressure to "conform, defer, or refrain", CAGI will cause a wider variety of ideas to be introduced and discussed than would be the case in face-to-face interaction. For very lengthy problem-solving tasks, CAGI will probably generate more sustained input than would a protracted face-to-face meeting. And "for medium or large sized groups (5 or more) discussing complex problems with no clear solution", CAGI will cause more underlying issues to be exposed than might be otherwise.

New Modes of Thought. As was already suggested in an earlier section, participants in a CAGI activity experience a unique "suspension" of space and time. Unless the activity has been specifically structured to prevent this, the participants are free to transmit information into the CAGI system at whatever times and at whatever pace they like.

At one extreme, there can be an entire group of people typing messages into the system at once. The system will accept all the messages, process them as necessary, and feed them back to the rest of the group without delay. We have already noted that this causes more information to be exchanged in a unit of time than

would be possible in a face-to-face situation. But more than that, it has been observed to induce a remarkable sort of "fast thinking".[59] In a given five-minute period, each participant may receive and respond to ten different messages on ten different subjects! This can be confusing if one is unaccustomed to it. But with practice, it can become very stimulating. At the very least, it causes an extraordinarly efficient use of both people-time and machine-time, in contrast with face-to-face or telephone conferences in which a participant may well find himself impatiently waiting half an hour for an uninteresting discussion to end before he can raise other points more germane to his own concerns.

At the opposite extreme, CAGI can allow unusually slow and reflective consideration of a topic. Instead of trying to dispose of a problem in a two-hour meeting or a three-page questionnaire, CAGI can pose questions to a group and let them answer at their leisure--say, anytime within the next week. Group members are thus able to consult with their office-mates, refer to books or other information sources, discuss the matter with their spouses at the breakfast table--then give their answers. For complex questions, the group members may split up into subgroups, or invite new members to join the discussion (regardless of geographical location). In short, the topic can receive extremely careful and deliberate attention, the product of "slow thinking".

Changed Work Patterns. The basic criterion for evaluating CAGI ought properly to be its effect on the productivity of its users. It is very difficult, however, to measure scientific productivity or even define it precisely. Some researchers attempting to assess the usefulness of CAGI systems have elected to study "working patterns" instead, on the grounds that such patterns--the "when, where, how, with whom, and on what" of scientific work--are "widely believed" to have an effect on productivity.[60] Although this approach leaves much to be desired, it has produced some suggestive results.

Most importantly, CAGI lets group members "choose the times

and intensity of their involvement in the activities of their colleagues".[61] They can integrate their communication activities into the workday in any way they find convenient, entering into the interaction whenever they like, then leaving to take a phonecall, see a visitor, or go to lunch without missing anything.[62]

It has been found statistically that use of a CAGI system tends to cluster in the morning and afternoon work periods as might be expected; but in addition, nearly 40% of total usage occurs outside the normal 8.00 - 5.00 working hours, primarily in the evenings and on weekends.[63] In effect, CAGI extends the workday, allowing group members to engage in collaborative work when their offices are not even open! (It should be noted, of course, that such system usage depends on having convenient access to a terminal at odd hours. Historically, this has been achieved most successfully by letting group members take home a portable, dial-up terminal.)

Another aspect of CAGI's influence on work patterns is its facilitation of new and possibly more effective management styles.[64] We have already noted that a manager can use CAGI to see what his subordinates are doing and intervene if necessary. In addition, he can use the various special features of CAGI to good advantage: perhaps making anonymous contributions to a discussion or using a nom de plume in order to air tentative ideas or elicit his subordinates' real views more easily than he could face-to-face.[65] It could also happen, of course, that a manager would be "left out in the cold" if his subordinates began collaborating via CAGI and he failed to adapt.[66]

On the whole, however, the most important impact of CAGI on scientific work patterns is probably its facilitation of increased contact with distant colleagues. Not only does CAGI provide a communication channel, but also, by allowing asynchronous interaction, it provides a good solution to the eternal problem of getting busy people together physically, even just two at a time.[67]

Effects on Use of Other Media. One of the most tangible consequences of using CAGI is a decline in the need to use other

communication methods (telephone, memoranda, conferences, etc.). As we shall discuss in more detail later, this effect is of great cost significance when long-distance travel to meetings would be a major alternative.[68]

Also, however, CAGI can improve the use of other media. For instance, it can confirm and support information sent via other channels.[69] Even if face-to-face meetings are necessary within a group, prior use of CAGI can greatly enhance the effectiveness of those meetings by revealing the issues and informing everyone beforehand.[70] And if CAGI is used after a face-to-face meeting, it can allow the group to continue deliberation of issues which proved too complex for immediate resolution.

Effects on Decision-Making. Since CAGI is capable of supporting virtually any decision-making procedure, it should have few unalterable effects in this area. It does, however, allow a variety of important effects to be achieved if the users so desire.

For instance, if CAGI is used in a democratic way with all group members entitled to contribute as they see fit, this can forestall domination of the interaction by any one or two vociforous or high-ranking individuals.[71] The risk of such domination can be reduced even further if all group inputs are treated as anonymous, with the computer simply omitting authorship labeling.

By contrast, CAGI can also allow the chairman of a group to communicate more effectively and exercise much greater control over the group's actions than he could through other media. Here is the way one actual chairman reported his experiences with a CAGI system:

> As director, I felt I had a great deal more control . . . than in the face-to-face mode. I felt confident that if I put something on the machine, it would be read by everyone, or if it weren't read, it would be available for them to read when they had time. I felt in closer contact.[72]

Aside from these optional effects of CAGI on the decision-making process, there are a few which appear to be inherent.

It has been hypothesized, for instance, that the "risky shift" (acceptance of risky policy options after group discussion) which is often observed in face-to-face situations is less likely in a CAGI activity.[73]

Elapsed time in decision-making should be less than in face-to-face interaction, at least when medium- or large-sized groups (more than about seven members) are deliberating complex and value-laden issues.[74] (This is in addition to the gain in speed which orderly group interaction procedures give regardless of medium). The rapidity of decision-making via CAGI is especially significant if we account for the time lag involved in summoning geographically scattered group members to a conventional meeting. In a geographically decentralized organization, CAGI has thus been found to provide "reduced lead time for resolving critical issues"--a very tangible pay off of system use.[75]

There is unfortunately no evidence as yet about the effect of alternative communications media (including CAGI) on the nature or quality of the solutions reached in cooperative problem solving.[76] It has been hypothesized, however, that the various changes which CAGI does induce in group communication patterns should tend to produce higher-quality final decisions.[77]

Problems, and Some Solutions

System Access, Reliability, and Suitability. For any group to interact via computer, they must of course have convenient access to the necessary facilities: terminals, a network, one or more computers, and a CAGI software package. All of these components are becoming more readily available year by year, but in most parts of the world they are still in short supply and/or very expensive. This problem places a genuine limitation on the feasibility of including in a CAITR activity even a large fraction of the international scientists that one might like to include. The only answer at present is to do the best one can while waiting for the desired facilities to become more prevalent in years to come. Terminals can be leased for intended group members directly from suppliers in their local area. Network access is possible in

most major cities, though in some cases the particular network most convenient for most group members will not have nodes near other members (necessitating long-distance dial-up connections with the nearest node).* Computer access is no problem once a suitable network has been found, since most networks provide computer services as well. Software access is still a problem, however, since most system developers consider their programs proprietary. Such programs can be bought or leased, or if necessary, new ones can be written.

Even when the facilities needed for CAGI are available, problems of reliability sometimes arise. Computer "crashes" are understandably frustrating to CAGI participants, as are transmission errors caused by noisy local node-access telephone lines.[78] These problems are not correctable by CAGI developers and will have to await improvements in the general state of computer and communication technology. But it is possible for CAGI systems to protect against the worst effects of hardware unreliability--e.g., by frequent and automatic archiving of transcript files. An especially promising approach which some system developers have considered is that of resource duplication to provide reliability through redundancy. The EIES system at the New Jersey Institute of Technology, for instance, employs two mini-computers, one for regular use and the other as a back-up. Since it is not normally feasible to have two computers on one site in this way, an even more exciting idea has been suggested: let the main computer periodically transmit copies of its CAGI files, via the network, to a colleague computer located elsewhere. Then if the main computer fails, the second computer can detect this and take action to resume the CAGI activity under its own auspices.

One very serious problem at present is that users of CAGI have no shared "visual space" and hence find discussion of visual

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* We should note in passing that IIASA use of CAITR need not wait for completion of the IIASA computer network, since other networks adequate for the purpose already exist. The main advantage of the IIASA network will be its inclusion of nodes in Eastern European areas not now served by other networks.

problems slow.[79] A graphics capability is needed for transmitting graphs, flow charts, circuit diagrams, and the like. Special graphics terminals with light pens could be used in CAGI, but no existing CAGI systems are equipped to handle this kind of input. Until future systems can be developed to correct this situation, it will be necessary to augment CAGI with other media for communication of graphics. Facsimile machines would be ideal for this purpose, but groups which have no access to such machines will have to rely on the mails. This solution is plainly unsatisfactory, and until graphics capabilities can be added to CAGI, the usefulness of CAGI for group activities that require a common visual space will be quite limited. Fortunately, by no means all scientific activities are of this kind.

Acceptance. It is not enough for CAGI to be available, or even to have its "effectiveness" verified. It must also be accepted by the real people who will choose whether or not to use it.

A considerable amount of experience has been accumulated on the question of user acceptance. For instance, several environmental factors promoting acceptances of CAGI have been observed:[80]

- increased cost of travel
- decreased cost of computer equipment and time
- need to evaluate more complicated information and
- need to evolve more flexible problem-solving structures.

Other factors, however, seem to inhibit acceptance of CAGI:[81]

- Executives and scientists are not always accustomed to using keyboard terminals.
- Persons who maintain their position by limiting the free flow of information (some administrators, for example) feel threatened by a free flow of information.
- Some people may fear the dehumanizing nature of computers.
- Persons near the top of hierarchical structures may

fear a loss of power as structures become more fluid and adaptive.

- CAGI offers little or no ego reinforcement; ego-motivated individuals may tend not to excel in, or even accept, the relatively anonymous framework of CAGI.
- Some individuals have an innate resitance to innovation.

We should note that most of these inhibiting factors probably apply less to scientists than to most other types of people.

If a person is, on balance, initially inclined to try CAGI, several important factors will then affect his satisfaction with it and hence his willingness to use it again.

Perhaps the most obvious sine-qua-non is convenience, as reflected in the location of new equipment, the way it is introduced, its ease and reliability of use, and the extent to which it satisfies present communication requirements.[82] If the system fails on any of these points, the user is lost for good.

Next the user must have a substantial commitment to participating in the group activity.[83] If the topic under discussion is not urgent or important for him, he will simply stay away.

CAGI is more likely to be chosen for some types of tasks than for others.[84] Like all telecommunications media, CAGI will be most acceptable when the intended task is:

- "idea-oriented" (concerned with information exchange);
- "task-oriented" (intended to be formal, structured, and efficient);
- not "person-oriented" (concerned with "getting acquainted", negotiation, etc.); and/or
- disagreeable.

Similarly, CAGI will be chosen most often when the group

involved is:[85]

- widely scattered geographically (so that travel time and cost are great);
- already acquainted (not strangers); and/or
- heterogeneous, with factions.

Some types of interaction are more congenial than others, too. For instance, the private-message mode is often heavily used,[86] suggesting a user preference for that mode for at least some purposes. Similarly, it has been found that "synchronous conferencing generates an excitement which increases positive attitudes toward [CAGI] and group effectiveness".[87] Whether this would remain true over long-term use is not clear.

On top of all this, it is apparent that individual users vary considerably in their desire to use CAGI. Some group members have been observed to "play with the system" for hours on end, incorporating it quickly into their style of work. Others refuse entirely, and if compelled to participate in a CAGI activity, will rely on a secretary or assistant as an interface.[88]

Perhaps the most hopeful note regarding the problem of acceptance is the fact that even initially skeptical users are usually pleasantly surprised at the convenience and power of CAGI. Detailed studies of attitude change among CAGI users have shown that the medium "was considered more meaningful and important after it had been used by a group than prior to such use".[89]

Familiarization. To use CAGI successfully, each group member must acquire at least a basic level of familiarity with the medium.

Each user of a CAGI system must spend a brief initial period learning how to use the system. Printed instruction sheets or pamphlets are usually given to novice users. If an experienced user cannot be present during the novice's first attempt to use the system, it is often desirable to give the same assistance by telephone. Once the novice has gotten on line, further instructions and advice can be given by the computer or by an experienced

group member through the system itself.

For most systems, it is definitely not necessary to have prior experience with computers (though such experience accelerates the familiarization process). In general, CAGI systems are designed expressly for persons who know nothing about computers and are disinclined to learn about them. One prominent group of system developers described their work in this way:

> We had to accept the challenge of designing the medium for very busy, impatient users who could not afford the time to read a manual and were too far away geographically for a face-to-face tutorial. We had to rely on human facilitation, extreme care in interface design, and a concise user's guide.[90]

Some features of the careful "interface design" in this particular series of CAGI systems (FORUM, PLANET, TOPICS) may be worth noting. Particularly vital is the "menu" approach by which the user is always explicitly told what his options are at each point in the activity, rather than being expected to know and use any kind of special programming language to make the computer do what he wants. Another important feature is that of "adaptive instructions" (previously described), whereby a set of "skill ratings" is maintained for each user and his messages from the computer are expanded or abbreviated accordingly.

Novice users learn rapidly. Skill ratings, for instance, typically rise from "novice" to "competent" in about half an hour of system use, and reach "expert" in about two hours.[91] The learning curve here matches the theoretically expected shape, rising quickly at first and leveling off after about 90-100 messages have been sent.[92] Messages exchanged at the beginning of a group activity are largely of a "learning" or "procedural" character, but the substantive share in the interaction soon dominates.[93]

Perhaps surprisingly, typing skill is not a serious limiting factor even though all system inputs are made through a standard keyboard terminal. Studies have shown that most of a person's time is spent not typing new inputs but rather reading output, taking notes, thinking, or searching for information outside the

system.[94] Also CAGI use involves a unique kind of "typing while thinking" rather than the mindless transcription typing normally used in speed tests.[95] It is true, however, that experienced typists seem to be more comfortable with the medium and thus participate in the interaction more fully than others.[96] This is a problem, though it is probably less serious for scientists (many of whom have some sort of keyboard experience) than for other user groups (e.g., managers).

Effects on Communication and Work Patterns. It is known that information transmission via keyboard is only about one tenth as rapid as by voice (face-to-face or telephone). Much of this disadvantage is counteracted, however, by the observed tendency of the faster oral transmissions to be much more verbose (using five times as many words, eight times as many sentences, etc.).[97] On simple tasks involving diadic communication, a voice channel has been found to produce a 2½-fold gain in speed of solution.[98] But whether this finding is at all applicable to the larger groups and more complex tasks involved in CAITR is highly uncertain, especially because of the beneficial communication effects mentioned earlier. Most notable is the ability for more than one group member to be typing at once, which makes the limiting factor not typing speed but rather reading speed--which is much faster than voice. Thus it seems unlikely that the slowness of typing seriously inhibits CAGI activities.

Some CAGI users have found that misunderstanding can occur if messages are too terse--too telegraphic--or if the recipient lacks the necessary background for understanding the message. Thus it is best if group members have similar backgrounds and/or have already interacted via other media.[99] Fortunately, this situation probably holds for most IIASA uses of CAITR, and where it does not, group members can be warned of this potential difficulty.

It has also sometimes been objected that CAGI produces inordinately lengthy conference transcripts because of the great "intellectual elbow room" which the medium affords.[100] This is in odd contrast with the earlier point about slowness of typing

rates and suggests that users of CAGI actually do communicate more total information than they might under other circumstances. From a scientific standpoint, this should be desirable. If information overload is a problem, this merely indicates that the group interaction requires thoughtful but firm leadership, to keep the group on the subject.[101] When group members feel the need to discuss outside topics, new CAGI activities should be set up to accommodate this.

Another communication-related problem is that the ability of one group member to assess accurately the opinion of another member on controversial issues is better in face-to-face communication than via an artificial medium.[102] This is a serious argument for avoidance of highly controversial or emotive issues in CAGI interaction, or for the simultaneous availability of other media for use in case such issues arise.

More specifically, studies have shown that face-to-face meetings almost always involve some combination of the following basic types of activity:[103]

1. discussion of ideas
2. conflict
3. information seeking
4. disciplinary interview
5. problem solving
6. presentation of report
7. forming impressions of others
8. delegation of work
9. negotiation
10. policy decision-making
11. giving information to keep people in the picture.

If meetings are conducted through some artificial medium, it has been found[104] that this change of medium has little or no effect on two-way tasks in which there is little or no conflict and to which personal relationships are not relevant (activities 1, 3, 5, 10). This is also true whenever there is not much need for two-way communication (activities 6, 8, 11). But a change of medium <u>does</u> affect tasks involving conflict or interpersonal relations (activities 2, 4, 7, 9). In short, there are some types of meetings for which no artificial medium will be a complete substitute for face-to-face interaction.

Turning to the matter of work patterns, it could be objected that involvement in CAGI would interfere inordinately with a scientist's normal activities. Certainly it is true that contact with one's colleagues demands some expenditure of time. But CAGI has been observed to consume only 5-30 minutes per day for the most common "notepad" mode of interaction, and less than an hour per day even the more intensive "seminar", "assembly", or "questionnaire" modes. Only the case of the very intensive "encounter" mode does CAGI require more time (up to 8 hours per day).[105] And even this last is no more demanding of time than the face-to-face conferences or workshops for which it substitutes.

4. POSSIBLE IIASA APPLICATIONS OF CAITR

On the assumption that some kind of CAITR system will eventually be available for use at IIASA, negotiations are already under way for applying such a system to specific areas of IIASA's substantive research. Five such prospective applications, which serve as examples of the uses of CAITR, are described below.

Activities 1 and 2: An Invisible College

Dr. Gennady Golubev, head of IIASA's project on interregional water transfers, has expressed interest in CAITR as a possible way of uniting the large but diffuse world community of scientists concerned with this problem. Such scientists are located in many countries, principally the U.S.S.R., U.S.A., and Canada, but also West Germany, Hungary, Poland, Pakistan, India, Mexico, Peru, and Chile. The scientists represent many academic disciplines, such as hydrology, geology, meteorology, agronomy, and so forth. Precisely because this community of scholars is so scattered, both geographically and academically, effective coordination of their information and activities is extremely difficult. This, then, is an ideal application for CAITR.

Since the IIASA research project on this subject is a relatively new one, it is not yet possible to say in detail what group activities might be appropriate. It seems fair to assume, however, that if all or even some of the relevant scientists were connected by CAITR, specific activities would evolve spontaneously. Quite probably subgroups would form to deal with individual problems, then report their conclusions to the group as a whole. Scratchpad and joint-authorship activities seem likely. System usage would be at a relatively low level--probably only a few minutes per person per day, plus occasional prearranged group sessions of an hour or two. There would be no sharp time limits; on the contrary, the overall activity could continue more or less indefinitely.

A concrete example of the group tasks which might be performed during this overall activity, suggested by Dr. Golubev, is that of developing a recommended method or procedure whereby a national

decision maker could intelligently select among alternative technological solutions to a water-transfer problem. To do this, a CAITR organizer might poll a large group of specialists on technological decision making, asking them for suggested decision-making methods. The resulting suggestions would be examined and commented on by the other members of the group, and possibly by other specially convened groups as well (e.g., a group of real decision makers, a group of scientists specializing in the technology in question, and so forth). This process of critique would help to identify strengths and weaknesses in the various suggested decision-making methods, and would allow a new aggregate method to be assembled by an individual or small working group especially assigned this responsibility. The proposed "aggregate method" would be described to the whole group and subjected to critique as before. On this basis, revisions could be made, and the final recommended method released for use. Note that this entire group task could be performed easily without CAITR, if all the relevant people were physically in the same place for a sufficient length of time. CAITR simply removes this restriction.

The "invisible college" application of CAITR places no special demands on the CAITR system per se. Language problems could arise and would probably be resolved by requiring all inputs to be in one language (probably English or Russian), with individual participants using an interpreter at their end if needed. The main difficulty, however, would be that of access to the necessary terminals and network connections. This would be especially serious for third-world participants.

In light of this last difficulty, then, we shall consider two separate instances of the "invisible college" application. Activity 1 will be essentially as described above, with participants throughout the world. Activity 2, by contrast, will involve a somewhat smaller group of scientists residing in Europe only. As we shall see in Section 5, this distinction has a substantial effect on the cost and therefore the feasibility of CAITR in this application, at least given the present state of international computer networking.

Activities 3 and 4: An Intensive Encounter

Another specific IIASA activity for which CAITR might be useful is a workshop to be conducted in July 1977 on the topic "Systems Assessment of New Technology (SANT): International Perspectives". Rather than devote the workshop entirely to a traditional presentation and discussion of prepared papers, its organizer, Professor G.M. Dobrov, has proposed to spend part of the time in purposeful, structured group interaction. The aim of this interaction will be to elicit the participants' views on a number of significant questions relevant to the workshop topic, then analyze the responses to identify areas of consensus and dissensus. Among the specific issues which are being considered for such examination are the following:

- an ordered listing of internationally important future technologies which might be candidates for international SANT;
- general suggestions for methods and institutional arrangements for international SANTs;
- a systematic evaluation of these suggested methods and arrangements; and
- ideas about IIASA's contribution to international SANT, including an expanded list of possible IIASA "products" in this area and their likely "users".

Details of the group interaction procedure have not yet been finalized. It seems likely, however, that the procedure will involve brief synchronous sessions on each of three or four successive days. During each session, a series of questions will be posed to the group members, their answers will be entered into the computer, and the combined group response will be printed out for distribution to the participants. Because of limited terminal availability, it will probably be necessary to have the group members divide up into approximately three subgroups, each using a single terminal and simulating a research team in a different world region (say, the U.S., Western Europe, and the U.S.S.R.). The participants will communicate with the computer with the help of trained assistants, since there will not be time to familiarize all group members with the use of the CAITR system.

An application such as this places certain special demands on the CAITR system. First, it must be possible for inputs from several persons to be entered on the same terminal in rapid succession, with each input being coded to identify its author. And second, it must be possible to calculate separate "group responses" for each subgroup and to compare these in some simple way (e.g., by printing three graphs on one set of axes).

The most important drawback of this application as a demonstration of CAITR is that, as presently defined, the activity would require all participants to be physically present at IIASA. Much more realistic for the long run would be an activity insofar as possible identical with this but not requiring travel to IIASA. These two variants (with and without travel, respectively) will be considered as Activities 3 and 4.

Activity 5: Administrative Communications

For completeness, it might be well to include a CAITR application of direct interest to IIASA administrators as distinct from IIASA scientists. One such application would be the use of CAITR for some of the routine communications which circulate between IIASA headquarters and the various National Member Organizations. We know, of course, that no artificial medium can substitute for the face-to-face meeting as a means of handling delicate negotiations or resolving deep-seated differences of opinion. Thus CAITR could never hope to take over all communications between IIASA and NMOs. But for many routine tasks of information exchange, polling, inviting, reminding, and so forth, CAITR should be completely satisfactory--and much quicker than alternative media. The only possible stumbling block might be comparative cost, which we shall discuss in the next section.

5. COMPARATIVE COST ESTIMATES

Most cost studies performed so far regarding CAGI systems[123] have little direct relevance to the proposed CAITR application. Costs of CAGI usage depend on a host of factors, most of which vary from system to system and task to task. So too of course do the comparable costs for use of other media to achieve a given purpose. Naturally, then, new cost estimates will have to be made for CAITR.

Our approach here will be to take the five hypothetical IIASA applications of CAITR which were described in the preceding section 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 4-hour synchronous conference per month. Additional costs: one 10-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: 5 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-CAGI 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: 4 hours per terminal per day for three days. Additional costs: 2 hours of system time for setting up the conference; cost of moving 4 IIASA terminals into a convenient location. Non-CAGI equivalent: same interaction conducted "by hand", with no computer assistance but with 4 junior and 4 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 CAGI 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-CAGI 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 dicatated 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. CAGI software suitable for these particular computers already exists, and group members in most parts of the world should be able to dial into these networkds fairly easily. Some of these dial-up connections might have to be long-distance, which would increase costs, but this problem should be mitigated by the expected expansion of the timesharing networks into new areas and by the eventual completion of IIASA's own network.

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

Finally for Activity 3, which does not require network connections at all, we shall assume that a CAGI-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 are presented in Appendix C and the results are summarized in Table 2. As can be seen from the table, CAITR is substantially less costly than its non-CAITR equivalent in three Activities (1, 2, and 4). In the case of Activities 3 and 5, the non-CAITR version is more economical, because both the CAITR and non-CAITR variants of Activity 3 were

Table 2 - SUMMARY OF COST COMPARISONS

ACTIVITY	ESTIMATED COST (ÖS)	
	via CAITR	without CAITR
1. Invisible College, Worldwide (50 participants, 6 months)	2,471,850	3,897,450
2. Invisible College, Europe Only (20 participants, 6 months)	866,490	1,250,475
3. Intensive Encounter, At IIASA (20 participants, 3 days)	407,125	397,725
4. Intensive Encounter, Via Network (20 participants, 3 days)	213,375	397,725
5. Administrative Communications (17 participants, 6 months)	857,510	682,750

defined as requiring the group members to meet physically at IIASA, and because the communication pattern in Activity 5 is relatively simple (a one-to-all and all-to-one "star").

These cost figures emphatically should not be taken as definitive. Even a cursory glance at Appendix C reveals that the figures are based on many assumptions about future costs of letter writing, travel, secretarial time, lodgings, printing, etc., etc., not to mention an even more dubious 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 are the best available to the author at present, and the results are probably within some reasonable range of error from their true future values. If and when serious plans are made to pursue the notion of CAITR, all of these cost calculations should be thoroughly reviewed and revised with the help of the best information then available.

We should note also that the cost figures presented here include a major component representing the value of group members' time. The "out-of-pocket" expenses of an organization conducting CAITR activities would be much less than the figures we have shown. Table 3 shows these "out-of-pocket" expenses in the same format as Table 2. The CAITR versions of Activities 1, 2, and 4 are still advantageous, and the cost levels are of course even more attractive than in Table 2.

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 interaction.

Table 3 - OUT OF POCKET COSTS

ACTIVITY	ESTIMATED COST (ÖS)	
	via CAITR	without CAITR
1. Invisible College, Worldwide (50 participants, 6 months)	1,534,350	3,417,450
2. Invisible College, Europe Only (20 participants, 6 months)	476,490	1,070,475
3. Intensive Encounter, At IIASA (20 participants, 3 days)	238,525	232,725
4. Intensive Encounter, Via Network (20 participants, 3 days)	132,875	232,725
5. Administrative Communications (17 participants, 6 months)	528,510	524,750

6. CONCLUSIONS AND RECOMMENDATIONS

In this report we have attempted to show the need for and potential of CAITR--Computer Assistance for International Team Research. We have seen that this type of group-via-computer interaction has many advantages for a group which uses it and very few insurmountable difficulties. Even on the sensitive question of cost, our estimates have shown that CAITR should compare favorably with the combinations of non-computerized media (travel, the mails, etc.) on which scientists presently rely, provided that CAITR is used to obviate expensive international travel and correspondence.

As we indicated at the outset, IIASA is an especially good place for the development of CAITR, since IIASA has need for the kind of communication which CAITR supports and also has a ramified network of established contacts with scientists who could profitably join in CAITR activities. All that remains to be done is to work out the technical details and start interacting.

Of course, the technical details are not trivial. IIASA does not currently possess adequate network links with all of the world areas with which we would like to interact via CAITR. Nor does IIASA have enough computer terminals for all interested IIASA scientists to have easy access to one. Even the most obvious element--the necessary CAGI software--is not yet available to IIASA except on an expensive lease or purchase basis. The author is continuing his negotiations with software suppliers and at the same time working on plans for a possible new IIASA CAGI system (see Appendix D for some details). But the basic problem with all this is money. IIASA's internal budget almost certainly cannot afford the expense of CAITR, since even a relatively modest experimental CAITR activity would cost something in the hundreds of thousands of Schillings--not to mention the organizational costs of making CAITR available at all.

I therefore urge IIASA to prepare a formal proposal for submission to outside agencies (such as UNESCO, UNEP, UNIDO, OECD, or perhaps CMEA), seeking funds for experimentation with CAITR.

Virtually any substantive area or areas within IIASA's sphere of expertise could be taken as the initial focus of CAITR activity. Such a focus should of course be chosen to match the funding agency's interests insofar as possible, but it should also be one for which a convincing argument can be made that closer constant contact among international scientists in the area would contribute significantly to the solution of some pressing world problem. Of the sample CAITR activities discussed in this report, those which would probably be most suitable for inclusion in a formal proposal are Activity 2 (Invisible College, Europe Only) and Activity 4 (Intensive Encounter, via Network).

If such a proposal were successful, IIASA would have an extraordinary opportunity to join the forces of various departments (Computer Sciences, Management and Technology, and various substantive areas) on a concrete task of direct use to the world scientific community. And scientific work in the field using CAITR would be the beneficiary.

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APPENDIX A

SAMPLE "CONVERSATIONAL" TRANSCRIPT

(Note: All underscored material represents information typed in by the user. All other material is printed out by the computer.)

```
PLEASE LOG IN: user(cr)
PASSWORD:    (cr)
PROJ CODE: 1(cr)

TYMSHARE 1422   10-SEP-77
- RUN (IIASA) CONFERENCE(cr)


Welcome.
Please type your last name (and then strike the CR key).
@ Randolph(cr)
Please type your three-character conferencing password.
@    (cr)
Thank you.
Are you using a terminal which prints on paper? Type Y for yes
or N for no, then strike the CR key.
@ y(cr)
```

(The conference program now skips to a new page.)

10-SEP-77 IIASA CONFERENCE

You may join any of the following conferences at this time:
1. Mineral Resources
2. Global Food and Agriculture Modeling
3. Inter-Regional Water Transfers
4. Comments and Suggestions about CAITR

Please indicate your choice by typing its number and striking the CR key. If you do not wish to join any of these conferences, just strike the CR key.
@ 3(cr)

The title of the activity is:
Inter-Regional Water Transfers

The participants in the activity are:
Golubev (organizer)
Smith
Jones
Ivanov
Nakamura
Chavez
Zanker
Randolph
Lavrentiuk

Chavez, Randolph are present.

You have already seen entries 1-357.

New entries:

[358] Nakamura 9-SEP-77 04.02 GMT
Re 355: Gennady, you should talk to my colleague Dr. Mikami about that. He has already done a survey of the type that you suggest. If you like, I could arrange for him to join our conference next week sometime.

[359] Smith 9-SEP-77 18.47 GMT
I am going to be absent for a few days, attending a conference in Italy. If possible, I shall try to check in from there, and maybe give the group a summary of what happens at the conference.

[360] Chavez 10-SEP-77 14.06 GMT
Gentlemen, I have a question for you. As you know, our Rio de Oro project is using a rockfill dam with 250m. grout curtain--a world record, if it is successful. We would like to know what projects in other countries may be attempting similar work in areas with loose sandy-gravel substrata and unstable seismic conditions.

[361] Chavez 10-SEP-77 14.17 GMT
Re 359: Have a good trip Fred.

10-SEP-77 IIASA CONFERENCE

[362] Chavez 10-SEP-77 14.19 GMT
Hi Bob, I'm glad you happened to log in while I was here. Would you like to respond to my No. 360?

You are up to date.

@ [363] Randolph
-Yes, Jaime, I do know of such a project, the Upper Naglu hydro-
-electric station now under construction in Afghanistan with
-Soviet assistance. Their sub-surface conditions are different
-from yours, but their methods should be instructive. Boris
-should know who is in charge of this, and might be able to have
-them join our conference too. As I understand it, the Upper
-Naglu grout curtain is expected to be about 230m.
-(cr)

@

[364] Chavez 10-SEP-77 14.30 GMT
At Upper Naglu, are they using the same methods as at Lower Naglu? If so, this is just like Pavlovsk on the Ufa, which I visited last year.

@[365] Randolph
-I'm not sure. You'll have to ask Boris.
-(cr)

@

[366] Chavez 10-SEP-77 14.33 GMT
Thanks Bob. Boris, please consider yourself asked.

@(to Jones(cr))
-I'm afraid I didn't understand your question in No.347. Could
-you cite any specific examples perhaps?
-(cr)

Now leaving: Chavez

@(to Lavrentiuk(cr))
-Boris, I hope you don't mind my telling Jaime about your connec-
-tion with Upper Naglu. I thought that was better than telling
-him to contact the Afghanis directly.
-(cr)

@%

Special instructions: Quit(cr)

Your current conference session is ended.
Thank you.

-Logout(cr)

APPENDIX B

SAMPLE "MODELING" TRANSCRIPT

```
PLEASE LOG IN: user(cr)
PASSWORD:      (cr)
PROJ CODE: 1(cr)

TYMSHARE 1706     14-SEP-77
- RUN (IIASA) CONFERENCE(cr)


Welcome.
Please type your last name (and then strike the CR key).
@ Randolph(cr)
Please type your three-character conferencing password.
@    (cr)
Thank you.
Are you using a terminal which prints on paper?  Type Y for yes
or N for no, then strike the CR key.
@ y(cr)
```

(The conference program now skips to a new page.)

14-SEP-77 IIASA CONFERENCE

You may join any of the following conferences at this time:
  1. Mineral Resources
  1. Global Food and Agriculture Modeling
Please indicate your choice by typing its number and striking the CR key. If you do not wish to join any of these conferences, just strike the CR key.
@ 2(cr)

The title of the activity is:
  Global Food and Agriculture Modeling

The participants in the activity are:
  Helmer (organizer)
  Carter
  Keyzer
  Parikh
  Popov
  Rabar
  Rao
  Schmidt
  Randolph

Keyzer, Parikh, Randolph are present.

You have already seen entries 1-16.

New entries:

[17] Parikh 14-SEP-77 16.53 GMT
I think we would be ready to have the modeling sub-activity set up. Are we agreed that Randolph should do that?

[18] Keyzer 14-SEP-77 16.55 GMT
Re 17: yes.

[19] Parikh 14-SEP-77 17.05 GMT
I believe we have also agreed to use the Helmer-type matrix structure with the parameters that Rabar suggested. Whenever Randolph comes on line, he should get on with it.

You are up to date.

@[20] Randolph
-OK, gentlemen, I'll set up the modeling activity now. Five
-variables, right?
-(cr)

@

[21] Parikh 14-SEP-77 17.10 GMT
Re 20: yes.

14-SEP-77 IIASA CONFERENCE

@%

Special instructions: Create model(cr)

What type? (Type "?" to get list of available options.)
-Helmer(cr)
Do you wish group to choose time horizon?
-n(cr)
Time horizon: 2026(cr)
Do you wish group to identify relevant events?
-y(cr)
How many events would you like to retain from their suggested list?
-5(cr)
Do you wish group to identify relevant trends?
-n(cr)
How many trends would you like to provide?
-5(cr)
Name Trend 1:
-World population(cr)
Name Trend 2:
-Average daily calorie intake per capita, worldwide(cr)
Name Trend 3:
-Percent of world calorie intake from non-agricultural sources
-(aquiculture, etc.)(cr)
Name Trend 4:
-Cost of crude oil, $/bbl.(cr)
Name Trend 5:
-Percent of world fertilizer production based on crude oil(cr)
Do you wish group to provide historical data for these trends?
-y(cr)
Do you wish group to provide forecasts for these trends?
-y(cr)
How many forecast intervals do you wish the group to use? (Suggest either 05 or 10.)
-5(cr)
Do you wish group to estimate cross impacts?
-y(cr)
Do you wish to generate monte-carlo scenarios?
-y(cr)
How many (suggest at least 1000)?
-2000(cr)
Do you wish to perform sensitivity analysis?
-y(cr)
Automatically or manually (type A or M)?
-y(cr)
********** Expected either A or M. Please try again. **********
-M(cr)
********** Thank you! **********
Do you wish group to identify decision-making agencies?
-y(cr)
Do you wish group to simulate one decision-making group?
-n(cr)

14-SEP-77 IIASA CONFERENCE

Do you wish group to identify interventive actions?
-y(cr)
Your modeling activity is complete and will be established as a sub-conference. What title would you like to give this sub-conference?
-Food and Fertlizer Cross-Impact Model(cr)
Do you wish to invite anyone who is not now participating in the main conference to join the sub-conference?
-j
********** Expected Y or N. Please try again. **********
-y(cr)
********** Thank you. **********
Please list the last names of these special invitees. Type a double CR at the end of your list.
-Jones(cr)
-Chikiris(cr)
-Trollman(cr)
-(cr)

You are now returning to the main conference.

[22] Parikh 14-SEP-77 17.12 GMT
I am going to lunch, will check back later when the modeling sub-conference is open.

[23] Keyzer 14-SEP-77 17.14 GMT
Good idea. See you later.

Now leaving: Parikh
Now leaving: Keyzer

@%

Special instructions: Quit(cr)

Your current conference session is ended.
Thank you.

-Logout(cr)

APPENDIX C

COST CALCULATIONS

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. ↓	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) 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 1.1×10^6 characters added per month,* archived on tape weekly to keep only the latest four weeks on disk):			
1.1×10^6 @ 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)		
● System usage (per participant):		Computer and network charges, ÖS/hr., est. ↓	Value of participants' time ÖS/hr., avg. ↓	
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 $6x10^5$ characters in all*, stored for an average of two weeks:				
$6x10^5$ @ 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.

Activity 4, without CAITR

(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 4.5×10^5 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 represent-atives 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.

APPENDIX D

SOFTWARE SPECIFICATIONS

If IIASA decides to develop its own CAITR system, several possible software configurations are imaginable. Table D-1 describes four of the most obvious possibilities. Of these four software configurations, the last is probably the most suitable for IIASA's purposes. It offers a healthy combination of easy use by inexperienced group members with powerful options for more proficient participants. Its basically conversational interaction style should be comfortable, yet its provision of agenda structures with explicit questioning and feedback capabilities should allow quite complex group activities to be carried out successfully. Table D-2 catalogues the principal program modules which would be needed to implement such a basic system.

TABLE D-1

SOME POSSIBLE CONFIGURATIONS FOR IIASA CONFERENCING SYSTEM

1. Full Asynchronous

This configuration essentially amounts to an automated questionnaire. The chairman sets up the entire conference in advance, with agenda, elicitation and feedback activities, automatic creation of new agenda items based on inputs received. Conference participants may enter at any time, may jump around in the agenda (if the chairman opts to allow this). Participants answer questions whenever they come to them, get feedback based on inputs up to that point. Implications: earlycomers get little or no feedback, latecomers have little or no opportunity to contribute to feedback which others receive. Note also that programming is very involved, since SETUP routine must guide chairman through the complete logic of the conference (limits on acceptable numerical estimates, number of items to be used from lists, etc., etc.), explicitly, in advance.

1.1 Full Asynchronous, with Agenda Locks

Same as option 1, except that each agenda item must be deliberately opened by the chairman for access by the conferees. Participants may still enter at any time, but will have to stop when they get to the end of the currently open agenda items. The system would tell them to come back later, perhaps even indicating when. A typical procedure might be to open one agenda item per day, so that participants could check in at any time during the day, make their inputs, then wait till the next day to see the results and go on to the next item. Implications: earlycomers are stopped, so that's OK. Latecomers still have little opportunity to affect anyone else's thinking, but so long as a minimal number of people (a quorum perhaps) go through the conference on schedule, this effect might not be too serious. (If the chairman wanted to be absolutely sure that everyone contributed in time to be included in the next day's feedback, he could declare each topic open for one day only, i.e., lock it at the end of the day. Latecomers would be eliminated. This is now asynchronous only within each day, synchronous across days.) Programming is still very involved--indeed, more so.

2. Full Synchronous

This could be based on a simple FORUM-type system in which anyone can say anything at any time. Comments are simply stored in a file, in the order received. But there would be a separate question-posing mode, reached perhaps by striking an escape character at the end of one's comment. This would tell the machine that your comment was in fact a question, and the machine would ask you what kind of response was expected (numerical, list, etc.). Such an item would be stored in the file as usual, and other participants

would see it as usual when they came to it. But instead of just reading the item and passing on, they would be required by the machine to make the necessary response. The response would be stored in a table of some sort attached to the item, and would not appear in the transcript per se. But there would also be a special feedback-giving mode, reached perhaps by striking a different escape character. By this means, the chairman could ask the machine at any time to process the stored responses to question N and insert them into the agenda then and there. This configuration assumes no early- or latecomers. Earlycomers would find an empty file (no questions even) and would just have to wait. Latecomers would find a full file, could vote etc., but their inputs would not be able to affect the feedback seen by anyone (themselves included). They could affect the final results of the inquiry only if a final transcript were produced including a final tallying of responses to all questions. Note that all comments by a latecomer would go into the transcript at the end--i.e., not together with those contributed by other participants regarding a given question. In short, this configuration would work well ONLY if everyone were on line simultaneously. It would, however be very easy to program, involving no agenda at all.

3. Semi-Synchronous

This is the same as the fully synchronous configuration except that the chairman specifies in advance a simple agenda (perhaps linear instead of tree) and must open each item for discussion by explicit command (as in config. 1.1). Comments on each item would be appended to the transcript for that item--a considerable gain over the full sync. config., since latecomers' comments would not now be sent to the end of the whole transcript. When each participant has read all the comments so far on a given topic, he is offered the option of adding his own comments to the discussion or slipping on into the next agenda item (if open). Such a configuration would be very flexible. It could be used for multi-topic chit-chat, with all items open at the start and all users free to jump around in the agenda. Or it could be used for a sequence of questions with feedback. When any user would arrive at a question (inserted in the transcript as in config. 2), he would answer it, thus adding data to a stored table. Feedback could be given either in real time as in the fully synchronous configuration (i.e., chairman orders it, and processed results go straight into the transcript at that point) or in delayed time (chairman inserts a special item into the transcript which, whenever a conferee reaches it, will calculate and present the current group response to the question involved). The disadvantage of this latter procedure is that not everyone will get the same feedback, which could distort Delphi-type effects. The chairman could correct for this by putting feedback items only at the start of a new topic (as in config. 1.1). The new topic would be kept closed until a quorum had answered the question in the previous topic. Implication: because of the agenda locks, this would run slowly (one topic a day perhaps) unless you chose to make everyone stay on line the whole time. Both would be possible. Programming would be more complex than in config. 2, of course, but not so bad as 1 or 1.1, since chairman does not have to set things up entirely in advance.

TABLE D-2

PRELIMINARY SPECIFICATIONS FOR PROGRAM MODULES NEEDED IN IIASA CONFERENCING SYSTEM

IM (Input Monitor). Used by all other routines when seeking input from terminal. Takes as an argument a descriptor of the needed input (single character, word, number, string with conventional terminator such as double carriage return). Watches for editing and escape characters in input stream. Calls editor (ED), "help" routine (HELP), or user command processor (UCP) as appropriate. Returns the buffered input string to the calling routine.

ED (EDitor). Called by IM whenever editing characters (←, \, ↑R, ↑X, etc.) are encountered in the input stream. Modifies buffered input string as requested, and also gives appropriate output to terminal.

UCP (User Command Processor). Called by IM whenever escape character "esc" is encountered. Gives user a prompt character (> perhaps), then accepts string input, matches it against a list of available user commands, executes commands if a match is found, or offers help to user if no match is found.

OM (Output Monitor). Used by all other routines when giving output to terminal. Based on known terminal type (identified by initialization routine IR), performs pagination functions as appropriate. For hard-copy terminals, gives headings, page numbers, etc., and breaks output at desired page length. For CRT's, stops output when screen is full, erases screen and continues output when user strikes any key on terminal (except escape characters "esc" and "?", which retain their basic force).

HELP Invoked by IM whenever a question mark ("?") is received at the beginning of an input line. Outputs a line or two of information about what the user is expected to do at the present point in the conference: input a number, a command, or whatever. If the skill-rating option has been implemented, HELP will give more extensive advice if the user's current skill rating is low, and less if high. Recursive use of "?" causes decrease in skill rating and hence automatically obtains fuller information for the user.

IR (Initialization Routine). The first module encountered by any user when he logs onto the computer and calls the conferencing system. Gives greetings, requests and accepts user name and password. (On user's first entry, instructs him to set a password, then accepts and stores it in encrypted form.) Asks about terminal type and desired level of detail in instructions (this sets initial skill level). -*- Informs user of current conferences available

to him (i.e., those whose chairmen have included him in list of invitees), then asks him to choose. If he picks one, opens the appropriate file for use by other routines, then transfers control to AF. If user chooses no current conference but instead wants to create a new one, transfers control to SETUP. If neither, then EXIT. Note: IR can also be entered at point (*) by jump from UCP, AF, or EXIT. If entered there, it first closes the previously open conference file.

SETUP Creates a file for a new conference. Can be invoked by IR or UCP. Prompts chairman for necessary information: conference topic, list of invitees, tree or list of subtopics. Stores all this in file. Asks chairman if he wishes to set up another conference. If yes, begins again. If no, jumps back to IR to offer other conferences available for participation.

EXIT Can be called by UCP, IR, AF, and possibly other modules. Informs user that his session is terminating. Asks for confirmation. If no, jumps back to IR to offer starting options again. If yes, closes files and logs the user out.

AF (Agenda Follower). Master control module for conference participation. Essentially a program for stepping through the agenda. Invoked by IR. Uses agenda and transcript stored in file for this particular conference. With pointer in transcript, keeps track of user's status. Calls specific participation routines as indicated by agenda. On return from such a routine, updates pointer to next item in agenda and calls again. At end of agenda, notifies user and offers choice of exit or return to IR. Note: user can change his location in agenda by escaping to command level (module UCP) and issuing appropriate commands. See modules BACK, NEXT, JUMP.

AM (Agenda Modifyer). Special control module wherewith chairman conducts the conference. Allows him to use a simple command language to insert new items into the agenda and lock or unlock agenda items for access by other group members. When chairman inserts a new item in agenda, AM prompts him for type of activity, necessary parameters, and other information that may be needed (e.g., background data).

PTTP (PrinT ToPic). One of several modules which can be specified in the agenda and are called by AF. Prints out the short title or topic of the current node in the agenda.

PTBK (PrinT BacKground). Similarly, prints out background information stored at the current node in agenda.

GTCM (GeT CoMments). Prompts for and accepts string input ("comments") on the current topic. Stores the input at this node in agenda.

PTCM (PrinT CoMments). Feeds back to user all comments at this node which he has not yet seen. Uses and updates a set of flag words which indicate who has seen each comment.

GTNUM (GeT NUMber). Poses a numerical question previously stored at this node, then prompts for, accepts, and stores a numerical answer. If chairman has specified a range for logically acceptable answers, or has indicated other limitations on answers (e.g., integer only, positive only, year, dollar amount, etc.), routine watches for this and asks for revised input if faulty answers are given.

GTDIST (GeT DISTribution). Similar to GTNUM but asks for a three-point probability distribution: 10%, 50%, and 90% estimates.

PTDIST (PrinT DISTribution). Takes raw data stored by GTNUM or GTDIST, processes it into a group estimate distribution, then prints this in graph form with correctly labeled axes. Also calculates descriptive statistics (mean, median, standard deviation, inter-quartile range, etc.), and prints them.

PTSTAT (PrinT STATistics). Same as PTDIST but omits printing of graph.

GTLIST (GeT LIST). Poses a previously stored questions which requires a list as its answer (e.g., "suggest ten policy options"). If chairman has specified a number of items desired, routine will continue prompting until it gets this many. Each item must be able to be any length, terminated perhaps by a double carriage return. User should have some way of terminating input in case no "number of items" has been specified or if he can't think of enough items to satisfy the chairman's request; one way would be a carriage return in response to the "next item" prompt.

PTLIST (PrinT LIST). Takes raw data stored by GTLIST, randomizes its order (e.g., by alphabetizing), assigns sequential item numbers, then prints out the combined list of all items. Prepares and stores a table which will allow the reordered list to be subsequently accessed by "item number".

GTLTRK (GeT LisT RanKing). Takes N, the number of ranks desired, as an argument. Uses the list and access table stored by GTLIST and PTLIST. Asks user to indicate which item he would assign "top" rank according to a specified criterion. Accepts an item number in response. Repeats this process until N item numbers have been obtained. Stores the results.

PTLTRK (PrinT LisT RanKing). Takes data stored by GTLTRK, calculates (group) ranking, prints out the resulting list in descending rank order. Prepares and stores another table which will allow the rank-ordered list to be retrieved later.

MAKEQS (MAKE QuestionS). Takes a list of the type produced by GTLIST and a table from PTLIST or PTLTRK and creates new agenda nodes for each item. Takes an optional argument M, signifying that only the first M items in the list are to be used. Requires another argument to specify what sort of question will be attached to each new node (type GTCM, GTNUM, GTDIST, GTLIST, GTLTRK, etc.).

MAKEFB (MAKE FeedBack). Automatically inserts additional new nodes into the agenda for feedback (PTCM, PTDIST, PTSTAT, PTLIST, PTLTRK, etc.) either after each node created by an immediately previous MAKEQS module or at the end of the set of nodes thus created. This choice is made according to a preset argument.

GTLTRT (GeT LisT RaTings). Similar to GTLTRK except that it asks for a numerical rating for each list item instead of a ranking. Criterion for rating, and acceptable range of values, must be specified as arguments.

PTLTRT (PrinT LisT RaTings). Similar to PTLTRK except that it aggregates the group's ratings of the list items.

GTTRND (GeT TReND). Uses GTNUM or GTDIST repeatedly to plot a curve. Takes number of points and abscissa values as arguments.

PTTRND (PrinT TReND). Takes data stored by GTTRND, calculates group distribution of ordinate values for each point, then prints out a set of three curves: median, upper quartile, lower quartile. (Other curves, such as 10% and 90% estimates, could be argument selected.)

BACK Moves AF pointer back to previous node in agenda, allowing user to do that activity over again. In any given conference, chairman must indicate during SETUP whether or not users should be allowed to change previous inputs if they pass through a node more than once. If yes, then on second and subsequent passes through a node, user is shown his own previous inputs to that node and is offered the possibility of revision. If chairman instructs SETUP not to allow this, then a second pass through a node will merely provide a review of the information stored there (modules in the PT series).

NEXT Moves AF pointer ahead to next node in agenda, allowing user to skip current activity. This command can be disabled by the chairman at SETUP time if he wishes to require all participants to perform all activities. If this is done, then a user attempting to use NEXT will receive a message to this effect.

JUMP Moves AF pointer to any node in the agenda, at user option. Like NEXT, can be disabled at SETUP time.