misleading, regulatory agencies of the federal government would have felt themselves justified in withholding substantial amounts of research funding from the university. A further danger in punitive action of this kind is that, being concentrated in the research area, which provides an important source of support for graduate students, it punishes not only male but also female students—women in areas in which women have traditionally been enrolled, such as the social sciences, and also pioneering women in the physical and biological sciences, where federal support has been more concentrated.

17. In fact, data in hand at Berkeley suggest a dramatic decrease in the early dropout rates of women and the disappearance of the differential in dropout rates of men and women. It will be several years before we will be able to judge whether this phenomenon is one of decreased or simply of delayed attrition.
18. If the same naive aggregation is carried out for the 85 departments used in most of the analysis, $N = 12{,}654$, $\chi^2 = 105.6$, d.f. $= 1$, $P = 0$.
19. The investigation was initiated by E.A.H., using data retrievable from a computerized system developed by V. Aldrich. Advice on statistical procedures in the later stages of the investigation was provided by P.J.B., and programming and other computation was done by J.W.O'C.

Crisis Management: Some Opportunities

International emergency cooperation involving governments, technology, and science is now foreseeable.

Robert H. Kupperman, Richard H. Wilcox, Harvey A. Smith

Many alarming trends of our present culture share common roots. Worldwide inflation, worldwide resource shortages, extensive famine, and the inexorable quest for more deadly weapons may very well reach crisis proportions if these trends continue. They serve already as examples of national and international failures of efficient resource allocation and communications. It is important that we understand the possible future implications that these failures hold and, more important, that we develop means for dealing with them.

In discussing the crisis management demanded by such situations it is tempting to start by defining what is meant by a crisis, but this is a difficult matter. Crises are matters of degree, being emotionally linked to such subjective terms as calamity and emergency. In fact it is not necessary to define crises in order to discuss problems generally common to their management, including the paucity of accurate information, the communications difficulties that persist, and the changing character of the players as the negotiations for relief leave one or more parties dissatisfied.

In a sense, crises are unto the beholder. What is a crisis to one individual or group may not be to another. However, crises are generally distinguished from routine situations by a sense of urgency and a concern that problems will become worse in the absence of action. Vulnerability to the effects of crises lies in an inability to manage available resources in a way that will alleviate the perceived problems tolerably. Crisis management, then, requires that timely action be taken both to avoid or mitigate undesirable developments and to bring about a desirable resolution of the problems.

Crises may arise from natural causes or may be induced by human adversaries, and the nature of the management required in response differs accordingly. Thus the actions required to limit physical damage from a severe hurricane and to expedite recovery from it differ substantially from the tactics needed to minimize the economic effects of a major transportation strike and to moderate the conditions which caused it. Yet each also exhibits some characteristics of the other. For example, recovery from the devastation wrought by the hurricane's wind and floodwaters brings competition among different managers whose conceptions of recovery differ: Is the goal to reestablish the status quo, including slums, or to seize upon the opportunity for urban renewal? Similarly, a transportation strike may cause such economic chaos that the Congress—535 crisis managers—might threaten to pass laws that are detrimental to a union leadership's prestige and control over its members.

It is useful to note the characteristics common to most crisis management. Perhaps the most frustrating is the uncertainty concerning what has happened or is likely to happen, coupled with a strong feeling of the necessity to take some action anyway "before it is too late." This leads to an emphasis on garnering information: military commanders press their intelligence staffs, and civil leaders try to get more out of their field personnel and management information systems. Unfortunately, few conventional information systems are equal to the task of covering unconventional situations, so managers in a crisis must frequently fall back upon experience, intuition, and bias to make ad hoc decisions (*1*).

The problems of uncertainty are exacerbated by the dynamic nature of many crises. Storms follow unpredictable courses; famine is affected by vagaries in the weather; terrorists perform apparently irrational acts; and foreign leaders, responding to different value systems or simply interpreting situations differently, select unexpected courses of action. Thus, with limited information and resources the manager may find it difficult just to keep up with rapid developments, let alone improve the overall picture of the situation.

During a crisis, not only does an involved manager suffer from poor information, but he has the problem of identifying the objectives he wishes to accomplish and ordering them by priority in accord with his limited re-

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sources. The order in which his objectives are placed may be quite controversial, and his priorities may change as he learns of the success or failure of his prior actions and the sharply vocalized opinions of his supporters and detractors. There is generally no single acceptable course of events for him to follow; rather, there is a wide selection which can be ordered more or less by their relative economy and political difficulty of accomplishment.

To illustrate this phenomenon, consider the plight of the Federal Disaster Coordinator during a major natural disaster. There is limited manpower, equipment, and time. Few would disagree that the saving of lives and providing of food and initial shelter is the first order of business; and few would disagree that reconstruction of public parks can be postponed. But when one considers the multiple and relatively incommensurate questions of the restoration of utilities, the securing of mobile homes for temporary housing, and the clearance of major debris, the manager has his hands full in setting priorities. The widespread effects of Hurricane Agnes of 1972 provide an example: extensive damage, severe resource shortages, and a lot of political heat.

Under crisis conditions the manager has relatively little time to analyze available alternatives (his own or those of an adversary) or to develop new capabilities. His flexibility depends primarily upon the extent to which he has forecasted for the situation and made the investment to prepare for it. If he has foreseen the potential emergency adequately, he may be able to avoid it entirely. Although this is, in principle, the ideal form of crisis management, in practice it can be a thankless achievement, for few can recognize what has been accomplished. Glamour and a sense of heroism accompany the "crisis resolver," not the "crisis avoider."

If domestic and international tensions are to be mitigated with greater success, the important role of the "crisis avoider" must be recognized. Because some of the problems facing the world today are sufficiently serious, their amelioration may be prerequisite to the avoidance of major world conflict. Included in this category are famine, particularly in Africa and the Indian subcontinent; inadequacy of available world energy supplies and related distribution systems that cannot support even the present rate of growth, let alone the emergence of developing nations; and the spreading trend of terrorism by extremist groups.

The Process of Managing Crises

We will use the term "crisis management" to mean any process which a manager exercises to meet his goals within a potentially deteriorating situation at an acceptable cost to him, persuading those with whom he is interacting that the costs of opposing him are greater than the costs of allowing him to attain his objectives.

This definition of crisis management is broad and admittedly something of a straw man. It implicitly involves resource allocation, urgency, and various forms of communications. It admits the possibilities of programmed conflict as well as of situations offering minimal feedback. The management of economic problems, disasters, famines, and the termination or avoidance of war are includable within the definition.

In international relations, the process of crisis management can be regarded as having the objective of convincing an opponent that the immediate and long-run costs of opting for, continuing, or increasing hostilities exceed the immediate costs of accepting an offer to resolve conflict that minimally promises face-saving opportunities to the leaderships of the more powerful nations.

New initiatives in international crisis management in military policy—and, hence, arms control—are prompted by the present thrusts of U.S. strategic doctrine (*2*). As the United States proceeds to modify its nuclear deterrence policy from mutual assured destruction alone to one involving a wider set of options, we are forced to examine carefully the likely reactions of our opponents. Such a broader policy, in fact, requires the most involved crisis management efforts. Without refined analyses and communications techniques we would be left with little more than the prior binary strategy, albeit prolonged in execution; there would still be missing any planned military activities of less than catastrophic magnitude. Controlled warfighting remains a game-theoretic exercise. Though nuclear war lurks in the shadows, we hardly understand the nature of the game that an adversary may perceive himself to be playing—in fact, we do not even seem to do very well at understanding ourselves.

Negotiations with an adversary in an international crisis rest, at bottom, on conveying to him the costs of opposition in terms of his own value system. (In many cases these may be opportunity costs, that is, costs attributable to lost or deferred opportunities.) Moreover, for our position to be credible to an opponent he must perceive that the costs we propose to meet in gaining our objectives are actually acceptable to us in terms of our value system. There are a number of hazards in this task. One of the hazards implicit in conveying costs is that the tactics themselves are a part of the value system. An opponent may, for instance, have a cultural bias toward noncooperative behavior, such as playing zero-sum games—that is, treating all bargaining as though a gain for one side must represent a loss for the other (*3*).

Another hazard is connected with the conceptual problems of exploring fully an adversary's measures of utility (quantitative indicators of desire or goodness), as well as our own. Nations foster economic and political institutions that are imperfect images of differing implicit value systems. At best we can discern preferences among alternatives, and these preferences need not be internally consistent nor temporally constant. It may be that reluctance to depart from familiar practices has daunted us from responding effectively to the challenges posed by the more difficult communications and control problems between nations, because we have engaged in dialogues that are predicated on our differing value systems.

These difficulties appear to become more tractable, fortunately, as the economic and political interdependencies among nations increase. Such interdependence does not necessarily entail losses in natural or cultural identities. Rather, each party is forced into mutual manipulation of the different socioeconomic structures of the others as each attempts to understand relative preferences among policy options and consequent areas of mutual benefit. This is just as true for competitive trade relations as for cooperative ventures like dealing with international terrorism.

A number of difficulties have been noted here as being common to the

management of crises: uncertainty, poor data-handling methods, too little data, too much data, inadequate communications, differing value systems, changing management objectives, political harassment, little planning, and insufficient time in which to learn. To this long list of conceptual difficulties must be added the psychological and physical problems of confusion and fatigue. Clearly, the successful crisis manager must be a versatile person—a resource allocator, a communicator, and an artful negotiatior with a tough hide.

As we begin to recognize the enormously complex problems that threaten every nation with disaster, can we continue to trust the ad hoc processes of instant reaction to muddle through? If not, "crisis management" must be inseparable from "crisis preparedness" and must consist of concerted international efforts to jointly develop tools of communications, management, and analysis in order to better deal with each other. With natural resource and food shortages as well as the threats of atomic terrorism rapidly coming upon us, little will be solved by reviving the Cold War in any form. In order to institutionalize a more harmonious structure of relationships, a modern international planning process must aid in encouraging further communications leading to economic and political interdependencies.

Of all the planning concerns that must be addressed, the most difficult is the measurement of utility, especially among comparative value systems. Here we face what might appear to be limiting conceptual problems. How can two nations with radically different outlooks and perceptions engage in a meaningful dialogue involving respective value systems not well understood by either? In what follows we present an approach to treating the problems of comparative value systems in a manner that capitalizes on a vital class of analytical and data management activities.

A Metalanguage for Peace

The prior sections of this article emphasize the data management and communications problems that are present during crises. If we can establish our objectives, our inventory of resources, and the time and cost constraints we can allocate scarce materials and services efficiently. This is the essence of any planning function.

In practice, however, planning tends to be ignored. It is most difficult for top executives to give up the immediate services of their more valuable people to do planning. The natural tendency is to call on them every time there is the slightest sense of urgency, and "minicrises" occur in staccato fashion in the top levels of every large institution, including nations.

Let us now consider the potential of computer-assisted conferencing systems as a means for eventually developing planning and operational bases for international crisis management (*4*). The application of computers themselves to such subjects is, of course, not new. Both in research institutions and in government agencies there is a long-standing tradition of politico-military gaming. Scholars from many nations have developed models for economic and military planning (*5*). Military leaders in the United States have often ended up adopting the results of models they have severely criticized initially, and it would not be surprising to discover the same phenomena in other nations. They do so for a very simple reason: there appear to be no better alternatives for justifying their specific weapons and budgetary requests. Thus, we are led to propound an analog of the "Peter Principle" (*6*): computer models are expanded until they become accepted surrogates of an unattainable reality.

But if modeling efforts are to overcome the limitations of narcissistic mirror-imaging or other forms of myth fulfillment, there must be developed a means for nations to share their images of and correct the other's perceptions. The marriage of computer conferencing with computer modeling offers a concept for the international use of models as constructive progenitors for common "metalanguages" to serve as communications bridges.

In a conventional conference the participants follow certain rules in an effort to provide each a chance to air his views and all a chance to hear them. Formal conferences rigidly adhere to highly institutionalized parliamentary procedure, but even small informal groups usually accept tacitly—perhaps even unconsciously—much simplified but still analogous sets of rules. These codes of communication behavior impose a synchronous regimen on the proceedings: only one person speaks at a time, and all participants who wish to address a given topic do so in turn. In general, participants must be present in order to take part in the proceedings effectively. Conferences are of course held over the telephone to overcome geographic separation, but all participants must still take part during the same time interval, and special procedures such as roll calling or unceasing speaker self-identification must usually be invoked to avoid chaos.

In a computer-assisted conference the participants do not need to gather at a common table, or even at a common time by their separate telephones. Their participation is asynchronous. That is, each sits at times of his own choosing at a typewriter-like device which is connected by telephone to a common computer. He receives automatically all written proposals and reactions thereto originated by other participants since his last session at the terminal. He then composes his own comments and new proposals and enters them into the system for distribution to the others. The participant may vote on various proposals placed before the group or request a vote on his own proposals. After doing all this without interruption, he may wait for immediate reactions from others, or he may "sign off" to turn his attention to other pressing matters, returning later without fear of missing anything because all statements generated elsewhere in the interim will be held for his return. In fact, he may never personally sit at the computer terminal, relying instead upon aides to bring him new conference business arriving at his terminal from other participants and giving his aides his own input in the form of comments and proposals. The role of the computer is to store and identify all inputs, forward them to each other participant whenever he or his agent is "on-line," record and tally votes, and provide various editing and sorting services to facilitate the organization of lucid information.

Use of Descriptive Models

In addition to the convenience and economy afforded by simple computer conferencing, as described above, the embedding of a dynamic model in the conference could assist the participants materially in understanding the real

import of each other's statements. (By a model is meant a description, either mathematical or verbal, of the essence of the subject under discussion. Well-known models of the economy, for example, could be easily embedded for analysis.) Because of the power and speed of the computer, a participant could illustrate his proposals for change by demonstrating those changes in the model dynamically and producing results which all could witness identically. Similarly, "what if" questions could be explored with the model by individuals or the group, without problems of their misunderstanding either the options tried or the effects obtained.

A fundamental difficulty during an international crisis is that of conveying accurately to an adversary the essential nature and intent underlying proposals intended to lessen tensions. If these proposals could be made partly in terms of sophisticated socioeconomic models available identically to all discussants, then definitional issues could be more readily resolved, relevant parameters adjusted, and the implications of foreign policy or military decisions mutually tested.

Whether or not the models available to such a conferencing system are initially considered to offer a "true" picture of reality is relatively unimportant; the value lies not in the original basis, but rather in the system's ability to support evolving bases for planning and dialogue among nations (*7*). As the dialogue continues interactively, the phrases and descriptions in the conference—the models—will be modified extensively and grow in number, both from feedback by the principals and as a result of intensive scholarly attention. Eventually a class of models will evolve to the point of being accepted as reality, for the assertion of any other reality must bear the test of mutual interaction and acceptance into the system in order to be believed. The system thus would eventually become the arbiter of reality.

It may be argued by the more operationally oriented, with considerable justice, that present behavioral science models are not sufficient for the level of descriptive and predictive analysis needed to make computer conferencing useful. The often intangible problems of measuring utility are at the root of the conceptual difficulties of socioeconomic modeling. Nevertheless, analytic tools can at least help in establishing relative preferences among alternatives. And in an interactive conferencing context, the invariant properties among differing value systems of the negotiants can be discerned. Although accurate prediction is always important, computer conferencing provides an experimental basis for improving human communication, and the value of such collective judgment in the long run will be considerable. The objective is computer augmentation of human reasoning (*8*), reasoning that is cooperative and involving many nations. By definition, this represents communication, and this is a kind of communication that is much needed.

Computer-supported conferencing is now a reasonably well-established technique in its own right (*9*). Its deliberate use in conjunction with analytical models to achieve an increased level of understanding of differing value systems is, however, decidedly unconventional. Thus it should be expected that the remarkable improvements promised by such an arrangement would be accompanied by several serious problems to resolve. In particular, if adversaries are coupled through a computer conference and are using shared analytical models, the nature of the communication interface between man and machine can become critical.

This problem is perennial in the computer business, and it becomes considerably more difficult when the participants are not "computer people." The results of model calculations must be conveyed effectively to those who make policy and their staffs, and so must the explicit parameters and implicit assumptions behind those calculations. Such people are subject matter specialists, and to be useful to them a computer terminal should be no more difficult to use than an automobile. Just as one need not be a mechanical engineer to use an automobile as an effective mode of transportation support, so one should not have to be a computer engineer to use a remote terminal as an effective mode of cognitive support (*10*).

Current Status, Remaining Problems

Fortunately, there is a growing history of successful experience to draw upon in designing computer conferencing systems for use by "noncomputer people" in poorly defined contexts. Some dramatic results were achieved by the former Office of Emergency Preparedness in 1971 (*11*), from which some very effective extensions grew (*12*). These systems were devised and developed for use in domestic crisis situations characterized by rapidly expanded operational staffing, little advance knowledge of the information which would be needed, and rapidly changing perceptions.

To the casual observer, the distinctive features of these computer conferencing systems for crisis use would appear to be ease of use, breadth of applicability, and extreme flexibility. Rather than requiring knowledge of a computer language, they actively present the user with a "menu" of things which he can do, so that he needs only to select the appropriate items. Through interactive steps, he can refine his selections or correct his mistakes. The nature of the choices presented to users, and the form and content of information obtained or accepted as a result, can be changed relatively rapidly to suit the conditions of a specific crisis and the preferences of the specific decision-makers managing it.

An even more significant feature of these systems, for our purposes, is the underlying concept of perennially evolving design which makes the breadth and flexibility of use possible. It is a fundamental design concept that the specific information requirements placed upon the systems cannot be known ahead of time, so that detailed "final design" has to be transient, taking place during actual operation and based upon feedback from the operators. Thus design is never considered final; the systems continue to evolve throughout each crisis in which they are implemented. The users not only interact with the computer system in addressing the problem of interest, they also interact with the designer in modifying the system to better address the problem (*13*).

Although this approach to computer conferencing has been successful in managing domestic crises, severe problems remain. In particular, the processes of including more sophisticated models, embedding the models overtly into the conferencing system to facilitate computer support, and extending the combination effectively into the sphere of multilanguage international discussions remain to be completed (*14*).

One important concern to be addressed, and to be resolved carefully,

is the fundamental psychological difference between nontechnically inclined professional managers and computer specialists. The managers are concerned that they are losing control of the situation to machines they don't understand. On the other hand, the computer specialists' isolation from the pragmatic world sometimes creates in them the private suspicion that perhaps the machines really could do the job better. It is absolutely essential that the computer output be effectively conveyed to, and controlled by, the humans participating substantively in the discussions. Among the leaders of all advanced nations of the world there is recognition that nuclear war must be avoided; but machines might not be so constrained.

The communications barriers between crisis managers using a model and the computer specialists who would normally design and operate it could be bypassed to a large extent by embedding the model directly into the conference system. The "menu approach" already used to facilitate lay use of computer-based information systems could be used similarly to enable a conferring crisis manager to modify the model himself. That is, a list of model parameters described in conventional language could be presented to the conferee, from which he could select the change he wished to explore and the specific values he wished to try. Other crisis managers in the conference could view the results he obtained, and might try the same or other changes for themselves. Even if the conferees did not fully understand the inner workings of the model, their common observation of its responses resulting from their own stimuli would provide the metalinguistic bases being sought.

It is obvious, of course, that if our own crisis managers could capitalize upon the model-oriented, computer-assisted conferencing system to try out ideas on the side, then an adversary could do the same. In fact, multiple adversaries could use adjunct conferences to form coalitions. But countercoalitions could also be formed, so that in the long run there would be no net loss in plotting capability. Obviously, it will behoove crisis managers to acquire as much skill as possible in the use of conferencing systems, but that is true of any tool or technique used for communications among cooperating adversaries. A computer-assisted conference can facilitate the communications by improving the likelihood that an adversary correctly understands the concepts we intend to convey (and vice versa), but it cannot unilaterally enhance our capability to generate superior concepts, any more than it can improve our physical means to defend ourselves—we must still think intelligently, and we must still have minimally adequate resources available to manage. Computer-assisted conferencing can only assist in communicating and analyzing available information, and in efficiently allocating available resources (*15*).

Possible Future Applications

In keeping with our definition of international crisis management, it seems appropriate to speculate about some of the ultimate uses computer-assisted conferencing can offer. We assume that it will take a decade or so for such systems to develop internationally in such a way that many nations of the world gain sufficient planning experience to engage in computer-assisted crisis management. Nations will then be able to enjoy rich methods of communications that will offer them deep understanding of each other's socioeconomic institutions. A host of cooperative ventures will then become possible.

The conferencing system could simulate foreign exchange between nations, for example. At present, domestic price ratios are used as measures of value in calculating foreign exchange rates. These price ratios, however, do not accurately reflect "value" because most market economies are no longer "free." Price ratios do not even exist in any comparable form in controlled economies. Thus currency exchange rates based on price ratios present accuracy problems. The conferencing system could augment the present system for valuing trade by accommodating a large variety of barter deals.

Also in the economic realm, when changes in internal economies lead individual nations to consider import tariffs, quotas, or other disruptions to existing trade patterns, a model-oriented conference among interested nations could permit relatively unemotional exploration of the international effects of implementing the proposed move. If an economic crisis did occur, perhaps because of unanticipated side effects, the conference would greatly facilitate a cooperative approach to its amelioration and would permit "tuning" the response through successive small actions tailored to the developing situation.

The use of computer conferencing to address economic problems obviously need not be restricted to international forums. For example, a model developed to exhibit the interaction of a corporation and its employees with the community, the industry, and the regional economy could be used in a labor-management conference to explore the implications of demanded or proposed contract provisions and, conversely, of a strike if agreement were not reached. Even if the disputants disagreed concerning the appropriate model parameters to describe some of the effects, representative values chosen by both factions could be used in order to generate alternative predictions which should acceptably bracket the range of expected effects.

A case of particular interest is that of safeguarding nuclear material against terrorists and guerrillas. The proliferation of nuclear weapons and the materials with which to make them may be alarming within the decade. The nations of the world must be able to account for the stockpiles of nuclear materials, safeguard them, and cooperate fully when one or more of them is threatened. For example, in order to coerce the United States, a dissident terrorist group capable of having fabricated a nuclear weapon might threaten Paris with atomic demolition if the French did not place adequate pressures on the United States to meet the radicals' demands. Conferencing could provide an analysis of the repercussions of alternative actions for the United States and France; perhaps even more important, it would enable settlement of an equitable (or at least acceptable) allocation of costs, risks, and losses between the two nations. The crisis is more likely to be mitigated with minimum harm to both nations in such a controlled situation.

An analogous problem comes from the field of strategic warfare. If entire populations were no longer to be used as hostages in order to deter strategic confrontation, then specific economic pressure points, such as key industrial, power, and transportation sites, might become hostages instead. These pressure points would have to be clearly understood by the opponent but kept secret from the public because of their potential vulnerability to terrorists. Optimal investments in redundancy

and physical protection could be determined so that cost thresholds could be set that would be low enough to provide opposing nations unimpeded opportunity for effective retaliatory attack but high enough to deter terrorists from attacking these points.

Finally, consider a case of economic aggression, such as an oil embargo imposed by the Organization of Petroleum Exporting Countries (OPEC). The utility of such behavior is often questionable in both the short and the long run. Do embargoes promote fear and thus support for the aggressor's policies or do they promote outrage and a determination to resist more tenaciously? A greater flow of information among nations, with accompanying appreciation for each other's socioeconomic values and institutions, would lead potential aggressors to better recognize unproductive or self-damaging programs. An interactive conferencing system could let OPEC nations discover the limits beyond which belligerent behavior would become counterproductive; such a system would also help threatened nations coordinate efforts to defend themselves should a crisis occur. Under such controlled circumstances the likelihood of mutually destructive embargoes would be mitigated, as would political and economic chaos should an embargo occur.

A Humanitarian Beginning

Although it was convenient to assume in the last section that use of international computer conferencing systems would be commonplace within a decade or so, such widespread adoption will not come about automatically. Indeed, many factors against rapid adoption have already been identified, including bureaucratic inertia and administrative mistrust of quantitative science and technology—particularly the "fearsome" computers. Thus we turn now to the question of how to introduce the proposed techniques successfully into the international arena.

The surest road to failure would be a lavishly funded crash program to address some delicate and highly controversial issue. With so many aspects of application remaining to be developed, the inevitable failure of such a headlong approach would stifle any further attempts for a long time. What is needed is a situation which is international in scope, noncontroversial in the overall goal sought, nontrivial, inherently interdisciplinary, and sufficiently long-term in nature that there is opportunity for substantial development in both the system and its use while a solution to the problem is being pursued.

Of all the looming world problems, the one which seems best to fit this prescription is famine. The increasingly serious situation in the Sahel region of northern Africa forms a current multination example of growing international concern (*16*). No one seems to favor starvation, although effective relief may perturb other food supplies, compete for transportation, and disturb domestic economies. Despite the long history and widespread nature of the problem, little seems to be known about the quantitative dynamics of famine. Successful attack calls for natural and social science, mathematics and experiment, technology and economics, government and industry. We know, for instance, that at some point seed corn and domestic animals are eaten, and that this complicates the recovery from famine, but useful quantitative models of the process do not appear to exist. Evolving models for the famine process, for world food resources, and for the relevant processing and transportation facilities via a computer-assisted international conference might allow agreement on an objective plan of action and a coherent long-term relief effort, rather than sporadic and ineffective attempts to feed the hungry. Feedback to model designers from field operations would provide checks on the validity of the models. The implementation and management of such a plan would both develop and test the crisis-management potential of the system.

Human lives would, of course, be at risk, and the pressure to make life and death decisions could become increasingly intense. Conceivably, as in the triage system of battlefield medical treatment, the "right" decision may turn out to be counterinstinctual. Although we expect that everyone would favor famine relief in principle, we would expect some divergence based on differing national outlooks when really difficult choices had to be made. When chaos reigns it is easy to fall back on the belief that "nothing can be done" and so avoid responsibility. But when it becomes clear that something can be done, although the choice is among a number of direly unpleasant options each involving numerous fatalities, then the burden of responsibility cannot be avoided.

The challenge to resolve such disputes and allay the resulting passions, growing out of such a worthwhile objective as alleviating famine, would make a first-rate preliminary test of the possible usefulness of model-oriented computer conferencing systems in the larger arena of maintaining world peace. But how can the development of the necessary system be organized and financed? To ask an operational agency with crisis management responsibilities to fund the development would be inappropriate. The international Food and Agriculture Organization (FAO), for instance, would expect to spend its money on distributing food for the hungry and could be severely criticized for investing in a speculative crisis management system instead. Some more broadly chartered organization, such as the United Nations Educational, Scientific, and Cultural Organization, should probably be the custodial sponsor of the activity, in much the same way as such organizations now sponsor more conventional conferences. Initial funding could be sought from foundations, governments, and international agencies and, after the system reached a certain point of development, a user organization such as FAO might join in. As the system began to demonstrate its utility, subsequent beneficiaries could be expected to pick up more of the cost.

To start the ball rolling a working conference of scientists, technologists, and government resource managers addressing the quantitative and management problems of famine relief would be organized, perhaps on an urgent basis. In order to include the necessary experts with their frequent schedule conflicts, the conference would be held on a decentralized basis, use being made of the present forms of computer assistance that would evolve according to needs perceived by the participants and model designers as the conference proceeded. Because of the nature of these systems, the conference participants would be able to take part at their own convenience. Records, training materials, and summaries of proceedings could be maintained automatically and referred to or augmented as needed. If the nature of the problems being discussed require that conference be prolonged, a participant's embarkation on a field trip or other engagement would not have to prevent his continued active partici-

pation in the conference because he could carry a portable terminal that could be linked to the conference by telephone line or even by satellite communications.

At some point the transition between a scientific conference and a crisis management operation would have to begin. This could probably best be effected by having the responsible crisis managers in the role of both sponsors and leading participants in the conference, with the intent of guiding it toward pragmatic rather than (or in addition to) academic ends. The hoped-for end product of such guidance would be a smooth transition from an academic conference to a planning group to a crisis management team as knowledge was sifted and applied. Essentially, the conference would never have to adjourn until the crisis was surmounted. Meanwhile, the custodial sponsor would gain considerable experience with this type of operation and could begin to think about applying it to more controversial areas —another bonus for having a United Nations–affiliated custodian. But the role of the custodian itself would remain one of promoting scientific development, international exchange, and application of technology to world problems by supplying the (computer-based) conferencing facilities.

Although we propose famine relief as an appropriate area for introducing cooperative international crisis management, there are several other areas that are also suitable for the initial application of these techniques, such as control of the illegal international drug traffic and the management of world trade, energy, and monetary problems. Regardless of the area chosen, however, it will be essential to establish during this primary endeavor the effectiveness of computer-based conferencing in bringing scientific, technical, and executive colleagues and adversaries together on one particular problem. If this can be demonstrated then the system will be more readily adopted in other areas and the point will be reached where it will routinely be used as an adjunct to planning before matters reach crisis proportions.

Summary

Modern crises present decision-makers with many agonizing management choices. Very often a crisis manager is confronted with a plethora of conflicting information and given very little time to choose an appropriate course of action. Although contemporary methods of systems analysis have been used in attempts to organize data and clarify options, they have generally been of little use in presenting an accurate picture of an opponent's values and perceptions. Thus it is clear that we must now make use of the improved communications and technological devices at our disposal if crises are to be avoided or resolved with minimum damage.

Our proposal to establish international model-oriented computer-assisted conferences is designed to promote greater cooperation and understanding among scientists and crisis managers of differing nations by enabling them to share images of themselves and one another. With better information and more rational options available, the chances of catastrophic misunderstanding or miscalculation can be meaningfully reduced. We have proposed a possible scenario for the initial implementation of such a system to combat famine, and hope that the same approach might be used in other areas over time. The ultimate goal is a system by which specialists of all persuasions cooperate so that international crises will be resolved on the bases of mutual benefits without resort to armed conflict.

References and Notes

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2. R. H. Kupperman, R. M. Behr, T. P. Jones, *Orbis*, in press.
3. For example, see H. S. Dinerstein, *Fifty Years of Soviet Foreign Policy* (Johns Hopkins Univ. Press, Baltimore, Md., 1968), particularly chap. 3.
4. R. H. Kupperman and R. H. Wilcox, *Proc. 2nd Int. Conf. Computer Communications* (Stockholm, 12 to 14 August, 1974), pp. 469–471.
5. V. Rock, Ed., *Policy-Makers and Model Builders: Cases and Concepts* (Gordon & Breach, New York, 1969). For an even earlier expression of interest by a Soviet academician, see A. J. Ivakhnenko, in *Computer and Information Sciences*, J. Tou and R. Wilcox, Eds. (Spartan Books, New York, 1964), pp. 501–518.
6. L. J. Peter, *The Peter Principle* (Morrow, New York, 1969).
7. The creation of initial models acceptable to both sides can present somewhat of a problem. We are indebted to Professor Oskar Morgenstern for proposing a practical way to start a conference. Each side would design two models, one describing its own national goals and institutions and the other its image of the opponent's goals and institutions. The models would then be exchanged, and an iterative "preconference" would ensue to develop better models. (In addition to analyzing physical, economic, and political models to improve dialogue among nations, one should also note that computer conferencing can deal with a wide variety of psychological and sociological models.)
8. M. A. Sass and W. D. Wilkinson, *Computer Augmentation of Human Reasoning* (Macmillan, New York, 1965), particularly chap. 9.
9. M. Turoff, *Proc. 1st Int. Conf. Computer Communications* (Washington, D.C., 1972), pp. 161–171. For a discussion of the policy implications of the "Era of Forced Choice" see C. R. Price, in *IIAP/PPSST Special Report* (Innovative Information Analysis Project, Program of Policy Studies in Science and Technology, George Washington Univ., Washington, D.C., 1974), particularly pp. 1 and 2. For a recent paper that deals with conferencing for the Project on Global Systems Analysis and Simulation of Energy, Resources and Environmental Systems, see T. Utsumi, Report No. 1 (Mitsubishi Research Institute, Tokyo, February 1973).
10. M. Turoff, *Ekistics* **35**, 337 (June 1973).
11. R. H. Kupperman and R. H. Wilcox, *Proc. 1st Int. Conf. Computer Communications* (Washington, D.C., 24 to 26 Oct. 1972), pp. 117–120.
12. N. Macon and J. D. McKendree, *Proc. 2nd Int. Conf. Computer Communications* (Stockholm, 1974), pp. 89–92.
13. Some recent Russian work appears to permit direct user-computer interaction to improve the "fit" of the problem with the system without requiring the user to participate in the design of the system; see, for example, S. Samoylenko, *Proc. 2nd Int. Conf. Computer Communications* (Stockholm, 1974), pp. 477–483.
14. Computerized language translation is not suggested here. Rather, human interpreters should be included as conference participants, so that a message entered in the originator's language would quickly appear in other participants' languages also. Where participants use different alphabets (for example, Roman, Arabic, Cyrillic), separate printer terminals would be needed.
15. Initially, there would probably be mutual suspicions concerning an opponent's use of deceitful models and data. Each might build—and suspect the others of building—"private" models to aid in his own policy formulation. Although this would impede international acceptance of computer conferencing, the traditional uses for covert intelligence would tend to lessen this difficulty by making the "private" models intelligence targets, thus providing feedback for the conference.
16. C. Sterling, *Atlantic Monthly* **233** (No. 5), 98 (May 1974); condensed in *Reader's Digest* **104** (No. 626), 80 (June 1974). For an extended discussion of inadequate development planning in the Sahel region see N. Wade, *Science* **185**, 234 (1974).

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