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This article focuses first on two types of innovation in software, microcomputer simulations and applications of artificial intelligence, and second, on innovations in hardware that will have implications for political science research. It also adds to previous reviews of computing in political science (e.g., Frantzich & Purkitt, 1987) by discussing some relatively obscure but relevant and potentially valuable information services. *Keywords:* simulation, artificial intelligence, online databases.

**S**imulation software for microcomputers is useful in two ways: it can be used in teaching to give students a feel for the political problems in a specific area, and it may provide unexpected analytical insights for research. A computer simulation is a very effective way of demonstrating the implications of a formal model because it allows users to input key parameters and directly view the consequences. Some packages allow researchers to vary the initial conditions and systematically record the responses of users to the simulation itself, so that the simulation can become the core of a laboratory experiment (see also Hart, 1985; Hart & Simon, 1988).

### Simulations

It makes sense to divide the area of simulations into the following five categories: social choice and game theory, American politics, international politics, comparative politics, and ecological issues. Here we compare the various offerings in these categories and uncover gaps which might be filled in the future.

#### *Social Choice and Game Theory*

*CONAN*. A very general tool for modeling decision problems in strategic environments, *CONAN* is based on Nigel Howard's own theoretical contributions to game theory. It allows the user to set up an array of scena-

rios by specifying actors and options, presents the user with a list of possible outcomes, and assesses their utility to the various actors. The user interface is remarkably friendly, offering a variety of help screens and allowing the user to add his or her own explanations of the scenarios. The user can edit almost any aspect of a scenario to test the effects of modifications on outcomes. *CONAN* comes with a thin but well-written manual, which explains how the program works and how best to use it.

My only criticisms of this very nice package are that the large matrices that summarize the scenarios and the judgments of the outcomes are somewhat difficult to read and interpret. Perhaps in later versions of the program greater use will be made of computer graphics to simplify the presentation of matrices.

*SINGLE TRANSFERRABLE VOTE and VOTING POWER INDICES.* These programs may be used either as instructional tools or as computational tools in practical voting environments. *SINGLE TRANSFERRABLE VOTE* takes ballot data as input and computes the electoral outcome under transferrable voting rules. *VOTING POWER INDICES* computes the Shapley-Shubik and Banzhaf power indices for data on numbers of votes given to voting blocs.

*PRISONER'S DILEMMA and TWO-PERSON PRISONER'S DILEMMA.* I have seen only a demonstration copy of Version 1.0 of the former program, published in 1985, which offers a great deal of flexibility for those who want to use IBM PCs as a base for teaching or conducting research on  $n$ -person mixed-motive games. The latter program is much less flexible, but it does offer an inexpensive and user-friendly alternative to those who need only to explore two-prisoner dilemma games. (A new version of *PRISONER'S DILEMMA*, coauthored by Marc Simon and me, will be available next year. It adds some new strategies to the simple tit-for-tat of the iterative prisoner's dilemma.)

#### *American Politics*

*Election-related packages.* These include *CAMPAIGN!*, *DIRECT MAIL POLITICS SIMULATION*, *ELECTION SIMULATION*, *ELECTORAL COLLEGE SIMULATION*, *ELECTORAL VOTE FORECASTER*, *FAIRMODEL*, *NOMINATION*, *NOMINEE '84*, *PRESIDENT ELECT*, *PRESIDENTIAL ELECTION GAME/SIMULATION*, *PRESIDENTIAL ELECTION QUIZ*, *PRESIDENTIAL POWER SIMULATION*, and *PREXGO*. I am familiar with *NOMINATION* only in its 1984 version. *PRESIDENT ELECT* has been updated for the 1988 elections. According to a recent press clipping, it predicts that George Bush will win the 1988 election on the basis of reasonably accurate data inputs. The microcomputer version of Raymond Fair's econometric model of presidential elections, *FAIRMODEL*, has also predicted a Bush victory. Thus, the interest of some of these programs is highly topical.

*Legislative process packages.* These include *A BILL BECOMES A LAW*, *CONGRESS*, *THE CONGRESSIONAL BILL SIMULATOR*, and *CONGRESSIONAL COMMITTEE CHAIRMAN*.

*Urban politics packages.* These include *CODE RED*, *FINANCING CENTERVILLE*, *POLICE QUEST*, and *URBAN GROWTH SIMULATION*.

I would recommend sophisticated gamelike simulations such as *A MIND FOREVER VOYAGING*, *PROJECT: SPACE STATION*, and *SPACE MAX* as examples of games which integrate some political content. In both of the space games, users have to deal not only with the technical problems of operating space stations but also with the politics of space programs. These simulations may be particularly useful where student motivation is a problem.

#### *International Politics*

It is useful here to distinguish between those programs that deal with nonwarlike interactions among nation-states and the unfortunately much more numerous simulations of war and war-fighting.

*Nonwarlike interaction.* The following programs from the field of international politics do not focus exclusively on war: *BALANCE OF POWER*, *EMPIRE*, *GLOBAL COMMANDER*, *INTER-NATION SIMULATION 2*, *INTERNATIONAL FUTURES*, *MICRO GLOBUS*, *THE OTHER SIDE*, *REACH FOR THE STARS*, *ARMS RACE*, and *RICHARDSON ARMS RACE MODEL*. Of these programs, *BALANCE OF POWER* is the most sophisticated and probably the most interesting for both students and researchers. It allows the user to play one of the two superpowers in a game in which political, economic, and military resources can be used to build up allies or weaken enemies over a reasonably long period of time. The main source of dynamism in *BALANCE OF POWER* is the tendency of the governments of third world nations to fall from coups or revolutions, but action based on challenges to the other superpower's spheres of influence in Europe or Asia and the ensuing diplomatic crisis occurs also.

The main problem with using *BALANCE OF POWER* in the classroom is that it is copy protected. Even at the discounted price, about \$30, it is too expensive to make a required purchase at most colleges and universities. Depositing copy-protected programs in libraries invites disk tampering; and many libraries will not assume the cost of replacing damaged disks. The publisher should reconsider its pricing and copy-protection policies if it seriously wants to penetrate the large educational market for this program.

*EMPIRE* has become, in the very short time since its release, one of the most highly rated commercial simulations on the market. It belongs to the genre of space-based games in which humans and aliens engage in warfare and trade. This program was originally written for the VAX and then ported down for micros. *GLOBAL COMMANDER* is in the same category, except that it does not focus on nation-state-like entities as actors. Instead, the user plays the role of commander of a U.N.-like global federation of states. Thus *GLOBAL COMMANDER* builds in many of the decision-making problems that the secretary general of the U.N. and field commanders of U.N. peacekeeping forces face. *REACH FOR THE STARS* also involves a space environment, and, like *EMPIRE*, it permits the players to combine economic and political strategies to extend their imperial reach.

*THE OTHER SIDE* is a rather simple simulation involving two countries separated completely by a huge chasm. The object of the game is to cooperate in building a bridge to link the two sides. One of the three essential raw materials is common to both sides; two can be found on only one side.

*INTER-NATION SIMULATION 2* is the micro version of the mainframe program that was the basis of Harold Guetzkow's pioneering simulation efforts at Northwestern University. It should be useful as a teaching tool in courses on simulation.

*INTERNATIONAL FUTURES (IFS)* (Hughes, 1988) and *MICRO GLOBUS* are successors to efforts like the Club of Rome's *WORLD MODELS* and the *INTER-NATION SIMULATION*. Each demonstrates interactions among demographic, economic, and political factors in a variety of scenarios in eight different geographical regions. Many of *IFS*'s initial parameters can be modified, and line and pie graphs are available for the presentation of results. The program is entirely menu driven and so simple to use that most students would not require a user's manual. *MICRO GLOBUS* is a microcomputer version of a mainframe model written by the *GLOBUS* project under the supervision of Stuart Bremer, of the Wissenschaftszentrum, Berlin. Apparently this program has not been reviewed yet, but given the background of the research project from which it comes, it should be given a close look. In a sense *IFS* and *GLOBUS* belong to the category of ecological simulations, below, but because they include political factors, they fit somewhat better in the category of international politics. *IFS*'s cost, \$95, is somewhat excessive.

*ARMS RACE* and *RICHARDSON ARMS RACE MODEL* deal with models which take off from game theory and the theories of Richardson, respectively. The latter program may be used in research for data analysis as well as in teaching.

*War and war-fighting.* Of these simulations there are four categories: conventional ground fighting, conventional naval or submarine, nuclear, and guerrilla.

*Conventional ground fighting* packages are *AIRBORNE RANGER*, *BALTIC 1985*, *CALL TO ARMS*, *COMPUTER DIPLOMACY*, *DNIEPER RIVER LINE*, *FALCON*, *FIRE-BRIGADE: THE BATTLE FOR KIEV*, *GEOPOLITIQUE 1990*, *HITLER'S WAR*, *MIDWAY CAMPAIGN*, *PROJECT: STEALTH FIGHTER*, *RDF 1985*, *ROMMEL: BATTLES FOR NORTH AFRICA*, *TIGERS IN THE SNOW*, *TOBRUK: THE CLASH OF ARMOUR*, and *THE TRAGEDY OF WAR: A SIMULATION*. Among these, *CALL TO ARMS*, *COMPUTER DIPLOMACY*, *GEOPOLITIQUE 1990*, and *THE TRAGEDY OF WAR* go beyond simple war-fighting to include geopolitical strategy and the consequences of war. The distinction between conventional war-fighting simulations and historical simulations is a thin one. Most of these programs attempt to create verisimilitude by closely modeling the play of the simulation on historical events. Sometimes uncanny degrees of detail, especially in weapon systems, can be incorporated into these programs.

*Conventional naval or submarine* packages are *BROADSIDES*, *CARRIER FORCE*, *COMPUTER BISMARCK*, *FATHOMS 40*, *GATO*, *THE HUNT FOR RED*

OCTOBER, PT-109, PURSUIT OF THE GRAF SPEE, and SILENT SERVICE. These games offer a more pure strategic environment. Thus, programs like GATO and SILENT SERVICE provide arcadelike entertainment while being more or less faithful to real battlefield factors. In SILENT SERVICE, for example, it is quite easy to run aground or to get knocked out by an underwater mine or depth charge. Torpedoes frequently miss when the opponent takes evasive maneuvers. The ability to wait for the right moment and to plan a safe escape route is the key to doing well in these submarine games. I like to use them to illustrate the fragile existence of combatants—to temper the hot-headedness of the average undergraduate.

Nuclear packages are B-1 NUCLEAR BOMBER, DEFCON 5, and WASTELAND. B-1 NUCLEAR BOMBER is particularly good for bringing undergraduates down to earth. The user manipulates the sophisticated weapons and avionics of a B-1 on a nuclear bombing mission into the heart of the Soviet Union. While any exponent of the nuclear freeze would probably avoid this job, even the Richard Perles of the world would emerge from a session of B-1 with a better appreciation of the difficulties of attacking the huge land mass that is the Soviet Union.

DEFCON 5 and WASTELAND are relatively new programs that deal with nuclear crisis and a post-nuclear-holocaust environment, respectively. WASTELAND takes off from a Mad Max-style scenario in which the survivors fight over the remaining uncontaminated resources, and in which some mutant life forms may be lurking. These games are ultimately very depressing, but that, in a sense, has to be their message.

Guerrilla war is dealt with in only one simulation, VC; this is noteworthy in an era in which guerrilla war is common. VC is a very interesting effort to model the role of the U.S. and the Republic of Vietnam (RVN) in fighting the Vietcong and North Vietnamese. It uses very crude simplification but nevertheless often hits the mark: the U.S. forces can be evacuated by helicopter, the RVN forces cannot; the Vietcong are invisible until hit by artillery or encountered in the bush; artillery attacks intended for enemies may kill friendly civilians instead; and so on. It is very hard to win this game.

#### *Comparative Politics*

The following programs are available in the field of comparative politics: CASTELLON, NATIONALISM: PAST AND PRESENT, REVOLUTIONS: PAST, PRESENT, AND FUTURE, RICE FARMING, and WHO'LL SAVE ABACAXI. All of these games should get careful reviews, and publishers should be encouraged to produce more high-quality work in this area.

#### *Ecological Issues*

The following simulations deal mainly with the ecostructure or with biotechnology issues: CHERNOBYL: THE SOLUTION, ECOLOGY SIMULATIONS I, EPIDEMIC!, MT. ST. HELENS, POLLUTE, PREDATION, SLICK!, THREE MILE ISLAND, TRAGEDY OF THE COMMONS, VALDEZ, THE WHALING GAME, WORLD DYNAMICS, and WORLD FOOD SIMULATION. These programs,

theoretically, are all useful for dealing with the interface between politics and ecology. The most abstract and general of them—*EPIDEMIC!*, *POLLUTE*, *PREDATION*, *WORLD DYNAMICS*, and *WORLD FOOD SIMULATION*—deal with long-term problems that call for sophisticated computational techniques. *SLICK!* and *VALDEZ* deal quite narrowly with the ecological problems posed by supertankers transporting petroleum across the oceans. *THE WHALING GAME* and *TRAGEDY OF THE COMMONS* illustrate the effects of crowding on common resources like the ocean's fish. *CHERNOBYL* and *THREE MILE ISLAND* deal with the management of disasters at peaceful nuclear power plants. In *EPIDEMIC!* and *MT. ST. HELENS*, the user may get some understanding of the problems faced by individuals responsible for protecting the public against natural disasters.

### Artificial Intelligence

Artificial intelligence (AI) techniques have been used with increasing frequency, especially in the study of international politics, to deal with verbal and textual data. In the past such data were analyzed with a variety of content-analytical techniques; the promise of artificial intelligence, on the other hand, is that it permits verbal data to be analyzed in context. Here we focus on recent efforts in international relations, but it is obvious that scholars of domestic and comparative politics will be equally interested in finding other ways of analyzing verbal data in context.

One of the leading research groups in AI is the political science wing of the Artificial Intelligence Laboratory at MIT. Led by Hayward Alker, Jr., this group has concentrated in the past few years on two major areas: computer-based interpretation of verbal data that is useful for research in foreign policy and international politics, and improvement of the transparency of theoretical assumptions in scholarly work. The laboratory's main result in the first area has been a computer program called the *RELATUS NATURAL LANGUAGE SYSTEM*. *RELATUS* is a program which parses natural language texts and represents them semantically. It matches earlier terms in the text to later ones, using a linguistic form of precedent logic, to create a graph-theoretical representation of the text. Instead of the single-word pattern matching common to other AI approaches, *RELATUS* uses a graph-matching system. It is currently available only for MIT's very powerful computers. But *RELATUS* is written in C and can be ported to the superminis and supermicros that will be coming on the market in the next few years (below). *RELATUS* appears to combine many of the good features of earlier work on cognitive maps and operational codes with the information-processing power of AI computing (Mallery, 1988).

In the second category of MIT's research agenda, work undertaken with Frank L. Sherman, of Miami University, has centered on improving data on international conflict and subjecting those data to entirely new forms of analysis (Sherman, 1988). The result, a new dataset called

*SHERFACS*, is a superset of the datasets collected by Butterworth and Scranton (1976).

Somewhat less ambitious but probably equally useful, the efforts of Philip Schrodtt to analyze verbal events data with a variety of algorithms derived from Holland Classifiers and other precedent-based logics have shown that machine coding of such data can be almost as reliable as human coding (Schrodtt, 1987). The great expense and effort of obtaining reliable human coding mean that if those techniques can be improved in the coming years, a new realm of research will open up.

### **Computer Hardware**

The world is headed rapidly in the direction of cheaper and more powerful computers, and political scientists will benefit from them. The transition from 16-bit to 32-bit microprocessors and from 256K RAMs to 1M RAMs is only one part of a larger story. Innovations in microelectronic components have made it possible to produce IBM clones for only about \$500. Chips and Technologies, the leader in duplicating or cloning the core chip sets in each successive generation of IBM machines, recently told me that it expects to make it possible to offer all the new PS/2 machines for about \$50 above the cost of the equivalent DOS models (an IBM PS/2 Model 20 equals an IBM XT and an IBM PS/2 Model 50 equals an IBM AT).

Innovations in displays and storage media may be just as important as innovations in microelectronic components. The compact 3.5-inch hard disk has already made it much easier to think of a desktop computer as an intelligent workstation, rather than as merely a stand-alone computer for simple tasks like word processing. Interactive CD-ROM devices offer the possibility of the medium term of gigabit rather than merely megabit storage capacity. At that point we will all be interested in the capacity of our machines to analyze video and complex graphic images as well as words and mathematical symbols.

The move from CGA to EGA and now to VGA color displays has made it possible for professional users to switch from business monochrome to a richer color graphics environment. The prices of 80386 EGA and VGA systems are still a bit too high for this to become standard across the discipline for some years. CMOS components and super-twist LCD screens are the key innovations behind the current generation of laptop computers, which are showing up with increasing frequency at lectures and conferences in lieu of ruled pads.

In the AI field, the shift to 80386 and 68020 machines makes it more and more easy to create, with a few add-on devices, machines that compare favorably in performance with dedicated LISP computers. A large number of new firms have entered the market for advanced workstations, including Steve Jobs's new firm, Next, Inc., Sun, Apollo, Hewlett Packard, and IBM. There is no question that computer technology will continue to be driven simultaneously toward higher functionality and lower prices.

The move to ISDN in public telecommunications networks will not only lower the cost of modems but also make it possible to purchase a new generation of telecom equipment with the new capabilities of ISDN systems. For example, it will be a lot easier to monitor the source of an incoming call under ISDN than under previous systems. It will be easier and cheaper to transmit data rapidly. The key problem will be scheduling the wiring of universities (as opposed to businesses, factories, and homes) for the new networks. As high-volume users, universities are likely to get special consideration, but the efforts of regional and state authorities to use the Bell Operating Companies as instruments of regional industrial policy may get in the way.

### Updates and Improvements in Databases

The main news on databases is covered in *DDIR-Update*, a newsletter published by the Merriam Laboratory for Analytic Political Research, University of Illinois at Urbana-Champaign, 512 E. Chalmers St., Champaign, IL 61820. Some very interesting databases have been collected in Europe, both at the level of the European Community and at national levels. The largest collection of European databases is now under the French Minitel/Teletel system (see Hart, 1988). Several U.S. firms have been negotiating with France Telecom (the French telecommunications ministry) to provide inexpensive gateways from the U.S. to the Minitel/Teletel network. This would be a boon to political scientists, who now have to get physical copies of the datasets they require or, worse yet, code by hand.

Another potential source of European data will be the German *Bundespost* through its *Bildschirmtext* (BTX) videotex service. The *Bundespost* is now negotiating a gateway between Germany and France so that Germany, whose efforts to date have been largely unsuccessful, can learn from the French how to encourage the growth of information services.

A final source of textual data that I have found helpful in recent years for getting full-text translations of European newspapers and periodicals is the Textline information service of Finsbury Data Services, represented in the United States by the Information Access Company, 11 Davis Dr., Belmont, CA 94002.

### Note

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- THE TRAGEDY OF WAR: A SIMULATION*, Focus Media, Inc., 839 Stewart Ave., Box 865, Garden City, NY 11530. Apple, \$99
- TWO-PERSON PRISONER'S DILEMMA*, National Collegiate Software Clearinghouse, Box 8101, North Carolina State University, Raleigh, NC 27695. Apple, IBM, \$23
- URBAN GROWTH SIMULATION*, Queue, Inc., 562 Boston Ave., Bridgeport, CT 06610. Apple, \$45
- VALDEZ*, Dynacomp, 1064 Gravel Rd., Webster, NY 14850. IBM, \$20
- VC*, Avalon Hill, 4517 Harford Rd., Baltimore, MD 21214. Apple, IBM, \$25
- VOTING POWER INDICES*, National Collegiate Software Clearinghouse, Box 8101, North Carolina State University, Raleigh, NC 27695. IBM, \$23
- WASTELAND*, Electronic Arts, PO Box 7530, San Mateo, CA 94403. Apple, \$50
- THE WHALING GAME*, Queue, Inc., 562 Boston Ave., Bridgeport, CT 06610. Apple, \$60
- WHO'LL SAVE ABACAXI*, Focus Media, Inc., 839 Stewart Ave., Box 865, Garden City, NY 11530. Apple, \$65

*WORLD DYNAMICS*, National Collegiate Software Clearinghouse, Box 8101, North Carolina State University, Raleigh, NC 27695. Apple, \$23  
*WORLD FOOD SIMULATION*, National Collegiate Software Clearinghouse, Box 8101, North Carolina State University, Raleigh, NC 27695. Apple, \$23