Title

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Publication Date
1973-02-01

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February 1973

Working Paper No. 206

This research was supported by a grant from the National Science Foundation (IURD: NSF-GS-30984-X1).

THE BERKELEY ENVIRONMENTAL SIMULATION LABORATORY:
ITS USE IN ENVIRONMENTAL IMPACT ASSESSMENT

The Environmental Simulation Project at the University of California, Berkeley, is an interdisciplinary research project to develop an environmental simulation laboratory. The laboratory will be centered on a dynamic environmental simulator which will enable one to "walk" or "drive" through small three-dimensional scale models of urban, suburban, and natural environments. A remotely guided television camera equipped with tiny viewing attachments will move through scale models of the environment and project continuous eye-level views on closed circuit television screens. Trips through miniature environments can be displayed "live" to large television audiences. Color films and video tapes can also be made, by a computer-controlled guidance system, for comparative feedback, permanent records, and later presentation. The laboratory will have model-making and film-making facilities, and wide angle projection equipment for presentations to limited audiences.

In an initial case study, an accurate scale model (30 feet to 1 inch) of a selected San Francisco Bay Area site (size 1 mile by 1-1/2 miles) has been constructed and is being used to test the levels of realism that this form of simulation can achieve. The area is suburban and contains a major shopping center, a freeway, strip commercial, a professional park, residential areas, and pastoral landscape. The open landscape is under intense pressure for development and is already the subject of alternative plans. An analysis of the history, land use, transportation, social structure, and ecological factors of the site has been conducted.

Research participants drawn from a broad range of class and age groups will report their impressions as they travel on a half hour exploration of the actual site, observe filmed or video taped tours of the actual site, or as they watch filmed or video taped trips through the scale model of the site. Other participants will engage in extensive debriefing sessions following their real or simulated trips. The investigators will examine how the travelers describe the environment they pass through, what they notice in it, what they recall of it, how they feel about it, how they evaluate elements in it, and how they mentally organize its subareas and features.

Once the adequacy of this technique for simulating environmental experiences has been established, a number of demonstration projects will test its application to practical problems in environmental planning and design. In conjunction with various public and private planning agencies and citizen groups, alternative development plans for research sites will be selected, dealing with such critical environmental issues as: "new town" versus "unplanned" development, population density, clustered versus scattered site planning, alternative transportation systems, traffic patterns, or the planning of open space. Typical trips and explorations through the scale models, modified in accordance with each alternative development scheme, will be tested for their impact upon the general public's comprehension of and reactions to planning proposals. Both the visible and invisible economic, social, and ecological consequences of each alternative may be prepared for presentation to the public. Systematic tests of the effectiveness of the dynamic simulations in combination with other forms of planning presentations such as site plans, land use and transportation maps, and perspective sketches will be made, and optimal combinations explored.

The simulator will be able to produce simulations of environments at different levels of realism to be tested by the psychologists. Their relative production costs will also have to be assessed. The following possibilities are tentatively ranked according to the ease of production. In the first phase of the project, presentations in modes one through six are planned.

1. Colored slides of sequences and different viewpoints.
2. Black and white "live" video trips through and around static models.
3. Sixteen millimeter conventional colored movies of sequences through and around static models (viewing angle 40°-60°).
4. Sixteen millimeter conventional colored movies of trips through "animated" models, i.e., models with moving cars and so on created by animated movie techniques.
5. Addition of sound effects.
6. Sixteen millimeter "wraparound" cineramic animated movies displayed with three synchronized projectors (viewing angle 120°-140°).
7. Colored video movies of trips through models animated with mixed images of "live" traffic and people scenes.
8. Placement of the viewer in a "realistic" setting. The viewer can be placed in real automobile, as with driving simulators,

and can, by computer programming, operate it as a normal automobile. Alternatively, he might be placed in a full scale mock-up of a rapid transit vehicle, helicopter, or airplane, as with airline simulators. Cycling or walking might also be simulated by the use of exercise cycles or treadmills, although the experience of being out in the open air would seem much more difficult to reconstruct. The viewer, alternatively, can be placed in a full scale mock-up of a room, where the views from different houses could be projected successively onto the windows. Films made in our simulation laboratory can be utilized in other simulation laboratories which have such full scale mock-ups.

Functions of the Environmental Simulator

Present techniques for simulating future environments utilize plans, perspective, photographs, and models. These simulations usually are quite distant from environmental experience. They are difficult for laymen to understand, as with plans and other abstractions, or they provide an illusion of reality that is likely to be inaccurate, as with models, single perspectives, or photos from one or two viewpoints. Drawings and perspectives are necessarily selective, and project planners choose the viewpoints and features that best communicate their ideas of what the project *ought* to be like. At best there is a rich mixture of hope in most project presentations, at worst there is downright deception.

The Berkeley simulator should be a step towards a better understanding of reality in two respects -- first it will provide eye-level views of future environments, second it can provide multiple and sequential views of these environments. Rather than a sample of one or two views, the simulator can range around a model viewing from streets, freeways, sidewalks, hilltops, the water, from houses and other buildings. We will still be faced with the hazards of deception, discussed in the section on "truth in simulation," but the simulator increases the opportunity for more comprehensive views of a future environment, since the view sample will be large.

In our simulation laboratory environmental issues will be primarily communicated through the simulation of the visible environment that people will experience as they travel through it or view it from typical points. Other sensory qualities such as sound and action (that of driving, cycling, or walking while viewing the environment) can be appropriately simulated in addition. Besides experiential presentations, the availability of models and movie equipment provides the opportunity to produce animated evolutionary movies of environments changing over time. The historic development of an area and time projections into the future can help to explain the long-range impact of projects. For a new transportation route the clearing of existing land uses, the construction sequence, the opening and subsequent land use and networks effects could be simulated. A movie showing the history of high-rise buildings in downtown San Francisco has been made, and plans are ready to simulate alternative futures according to different plans.

The environmental simulator will be the most useful when it simulates remote environments -- those that do not presently exist or are not easily available. Simulating future environments will be the obvious function of the simulator, but the simulation of historic or distant environments can be considered for uses in the teaching of urban history or geography.

Five potential uses of the simulator at present stand out as the most interesting and relevant.

Communication and resolution of environmental issues.--By communicating to the public the nature of environmental proposals the simulator can provide a focus for the assessment of environmental impacts and for the resolution of environmental conflicts. Decision-making in public planning and design has been too closely contained within restricted professional circles. This has been encouraged and reinforced by the use of specialized languages, which tends to create barriers to understanding, communication, and involvement by concerned and affected citizens. The abstract nature of the typical design media (i.e., plans, elevations, renderings) upon which decision-making is based does not usually take advantage of the familiarity and real experience of the non-trained public, whose interests and concerns are often different from those of the decision-makers. The simulator should enable plans and designs to be presented to citizen groups in a more experiential mode through the familiar media of film and television. This might enable them to participate more confidently in project evaluation and evolution.

Planning and design tool.--A simulation technique which adequately elicits professional or public responses to proposed plans should enable design alternatives, modifications, and testing to become integral decision-making stages in the planning process. The simulator is seen as a resource for the interactive gaming and assessment techniques already being developed in the design methods and community participation fields. At present, use of the simulator is being considered as a means for involving the community in the design of a low income housing project in the Bay Area, and in another community for the selection of sites to preserve for open space. It can also be used in this way to provide feedback in the education of environmental professionals at the College of Environmental Design, University of California, Berkeley.

Educational films.--The simulator can provide a basis for educational films about environmental problems to be shown to the public and/or professionals. Through the use of animated models and shifts in viewpoint the growth of communities, the history of development, ecological processes, or the chains of environmental impact could be simulated in different situations. The effects on the everyday environment of different kinds of planning or design decision -- the visual meaning of such professional abstractions as "density," "floor area ratio," "traffic volumes," or "flood plains" -- might be made more comprehensible. Movies can be produced for use in school, community, and continuing education programs as well as on TV and CATV programs.

Technological innovation and fantasy futures.--Alvin Toffler in Future Shock (1970) pointed out that most people find it difficult to visualize the future. Yet future environments, many quite different from any that exist, are being conceived in laboratories, on drawing boards, and in imaginative minds around the world. Ocean settlements, floating power stations, megastructures, solar housing, high speed transit systems, automated freeways are just some of the conceptions being proposed. If simulation can bring these projects closer to the real world, the public may have a clearer idea of whether they are utopian or monstrous.

Research in environmental psychology.--The simulator, once it is validated, will allow the psychologist to bring into the laboratory models of existing and future environments so that experiments may be carried out with less investment of money and effort than those undertaken at full scale in the real world. The environment of the real world is so complex that any clear analysis of the effects of different variables becomes a problem, unless these can be controlled at any one time. In the design of a housing layout, for instance, housing types, the distances between houses, widths of streets, vegetative growth, street furniture, and the architectural style of the housing can be varied independently to test responses to appearance by would-be buyers, citizen groups, or public representatives. Reactions by different social classes, age groups, or personality types could also be assessed (Craik, 1970).

Use of the Simulator in Environmental Impact Assessment

The "full disclosure" requirements of the National Environmental Policy Act of 1969 and the California State Environmental Policy Act, as now interpreted, make it mandatory for public and private agencies to inform the public fully of the consequences of projects. This disclosure is usually hidden in reports, obscured in written language.

The simulator can be used in two ways to assess impact: (1) as a display for eliciting public response to the impacts and qualities of proposed alternatives; (2) as a medium through which professional measures of environmental impact can be compared with public response.

The public response method could be implemented by taking viewers on routes passing through and around projects and by presenting views from common viewpoints and neighboring land uses. Responses to these alternative presentations from committees, public representatives, or the public itself would then be assessed.

Means for eliciting articulate and meaningful reactions by the public will have to be developed, for at most presentations of environmental projects the public lacks the means to respond and evaluate in an effective way. Urban simulation games can be produced and modified for use with the simulator.

Professional measurement of environmental impact is at an embryonic stage (see Appleyard and Carp, 1973), but some of the issues that might be simulated are worth listing. Most of these presentations are susceptible to measurement of some sort, but public responses will provide important checks on their reliability.

Safety, stress, pollution.--People (and professionals) interpret levels of safety, noise, overload, air and water pollution from the appearance of environments. Perceived levels of safety may be affected by the presence of walls, enclosures, and street lighting; danger might be perceived in hidden places, nooks and crannies, or in high buildings. Needless to say, they are frequently incorrect or at least inaccurate. Nevertheless their perceptions of projects can be critical in the decision-making process. The presentation of various views of a project can be used to determine apparent levels of stress. These can also be presented in parallel with expert predictions of stress. Sound can be added to the images to simulate the loudness and character of predicted noise.

Privacy intrusion.--Invasion of privacy through the overlooking of houses, offices, and other buildings by new structures is a major environmental problem in high density areas. In order to simulate overlooking the camera can be focused and directed to represent the view of an average person. The following situations could be investigated:

1. Views of residential windows, back yards, front yards, and other outdoor spaces.
2. Visual intrusion of traffic, transit systems, tall buildings, neighboring houses, and so on.
3. Blocked views of landmarks, open spaces, and orienting features.
4. Overlooking during day and nighttime.

Access and disruption.--Changes in accessibility levels due to new projects can be measured by traveling along typical routes and journeys that people would take through the environment of the project. This would help to identify factors within the project area that facilitate or inhibit access to desired destinations: changes in access over time, during the construction period, and on a regular basis, i.e., rush hours, changes in the day/night, week/weekend composition of people and activities. These factors might include simulating:

1. Available roads for access to certain areas, their layout, traffic characteristics such as volume, speed, and direction.

2. Barriers to access or movement such as dead end streets, one-way streets, hidden entrances, and confusing intersections.
3. Access and barriers for rapid transit vehicles, given the locations of transit lines, terminals, parking, and so on.
4. Pedestrian and bicycle access to desired destinations, location of pedestrian and bike routes, areas and points of apparent danger to pedestrians and cyclists.

Territorial access and intrusion.-- Visibility of public and private territory and visual intrusions on that territory can be simulated by viewing different types of domains and boundaries.

1. Visual access to different private/public areas, landscapes, the Bay, the ocean, and so on, assessing the quality of the view, its depth, the degree of blockage, and the significance of each viewing point.
2. Visual barriers, boundaries, and objects blocking views to the above, their permeability, permanance, and so on.

Identity, scale, and diversity.--The relations between the character of the new project and the existing environment, whether it enhances, damages, or disrupts the local character of the area, and whether it adds to the richness of the community's self-image or reduces it are common reasons for opposition to projects. Simulated views of the project could be taken from neighboring sites and on common routes, and could be compared with other parts of the community or with similar facilities elsewhere. The character analysis of environmental images (Appleyard and Carp, 1973) will enable such comparisons to be quantified in approximate terms.

Esthetics.--Images of the views from houses, apartments, and offices, from residential streets, transit lines, or pedestrian networks can be produced for assessment of, for instance:

1. Presence of esthetically powerful elements, e.g., skylines, vegetation, water, historical areas, landmarks, billboards, and so on.
2. The quality of various views, their natural/urban composition, their depth, mystery, interest, and so on; view change and view blockage under different conditions.
3. Existence of vehicular and pedestrian traffic in viewing areas; conflicts or interruption of views generated by vehicles.
4. Day and night views, seasonal change in views, weather effects, and so on.

Symbolism.--Much of the environment is read as a symbol of the social group which has constructed it or owns it. Apartments may be interpreted as the invasion of an alien social group, public buildings may be viewed as an unnecessary expenditure of public funds, certain styles of architecture may be seen as inappropriate to the community's self-image. Such interpretations of social impact may well override purely environmental considerations. It will be important to have these fears articulated prior to construction. The explicit assessment of symbolism may thus become part of environmental assessment.

Simulation Settings

Different types of simulation can be utilized in combination, depending upon the size of the decision-making group. Three significant groups appear to be involved in environmental planning decisions, (1) the committee, (2) the public hearing, and (3) the public television audience.

Committee and design teams.--The committee is usually a group of up to 20 people who can meet in a small room, gather around a model as they simultaneously view a television monitor, and who can discuss and effect changes in a plan during a meeting session. For this kind of group a flexible model and video playback may be the most acceptable means of simulation. This suggests the use of portable simulators with black and white images, using a main simulator as a back-up producing high quality simulation of major alternatives. Small simulators have been developed quite cheaply in several countries for use in planning issues. Such a system would be useful for the larger planning and design offices, city planning agencies, in-house design developments, and planning commissions, city councils, and corporation boards for review of environmental proposals.

Public hearings.--The audience at a public hearing may run into a few hundred people, usually gathering in a council chamber or auditorium. Since plans and models are difficult to view for so large a group, screen projection becomes almost essential. Slides or movies may be the most appropriate means of presentation in these situations. Conventional 16mm movie and sound projection equipment is nowadays owned by most city agencies or can be cheaply rented. Large scale video projection or the provision of a multiple monitor system could allow the kind of feedback available to a small committee; however, "live" group decision-making in an interactive mode may be too complex for this town meeting kind of situation.

Public television and cable TV.--Simulatable environmental issues that affect large numbers of people could be shown on public television. Here there is little chance for audience interaction with presentations, although the phone-in telethons may be a precedent for such interaction. Since most television news programs are presently shot in 16mm color movies, these will be the principal means of simulation in this medium. Colored video tapes are easier to use and may produce more realistic images via the mixed image process, but demand expensive equipment.

Cable television is now becoming more widespread, and two-way cable television represents a potential for involving large numbers of people in the planning process -- who do not normally come to public hearings. Although much of cable TV is in black and white, it is also possible to communicate along the cable lines with relatively cheap color equipment.

Truth in Simulation

One of the principal hazards of any communications medium is the ease with which the truth can be distorted. This is perhaps nowhere so easy as in the projection of future environments, where facts are not available. We can test the level of "realism" when we simulate an existing environment, but projections of the future are much more a matter of opinion. Most environmental proposals, as shown on plans and models, are devoid of such familiar environmental features as traffic congestion, landscape erosion, air pollution, poor maintenance, vandalism, billboards, street furniture or signs, even though after a few years such may be the characteristics of the project area. There are also many political reasons for secrecy in the field of environmental planning, and it is not always on the side of the developers. Planning agencies, highway departments, and other public bodies often do not wish to reveal their plans, for fear of what some public groups might say or some developers might do. A recent book (The Politics of Expertise by Guy Benveniste) argues that the most effective plans have sometimes been those which have had little publicity. Pleas for secrecy on grounds of effectiveness are risky, however. We would prefer to argue for full disclosure -- environmental, social, and economic -- of project consequences. In the long run regulations similar to the "truth in advertizing" legislation may have to be applied to the presentation of environmental projects.

Simulating the true consequences of a project should be the aim of a public environmental simulator. One way to accomplish such a difficult task is to make a distinction between the proposed environment that project planners have designed and the consequent environment that may result. Since such consequences cannot be predicted with certainty, a plural strategy of projection might be necessary. Protagonists and antagonists of a project could be called upon to articulate their predictions of the consequent environment and simulations could then be made of both. Or an independent outside expert may be called upon to make "impartial" predictions. Besides assisting in the public choice of alternative plans, the simulator can therefore aid in predicting the alternative consequences of projects. Trade-offs can then be made between them.

How Real Can We Get?: Limitations of the Simulator

Our simulation laboratory is committed to test different kinds and levels of simulation to see which are the more appropriate in different situations. Cost is the primary limitation on how much and how well plans and projects can be simulated.

Once the initial investment is made, the models may be the most costly item in the production process, and we are presently looking at ways of reducing these costs by testing new techniques and new modeling materials.

Another way to reduce model costs is by restricting the detail to those aspects of models that are perceived in the real environment. Such perceptual models might, for instance, emphasize the aspects of projects visible to the general public, if that were the important issue. Models of this kind are likely to emphasize foreground detail around the road channels, cars, street furniture, signs, front yards, the details of building facades, and floor surfaces rather than the rooftops or rear yards. Buildings viewed along the axis of vision will be more highly detailed than those in peripheral vision. A model of this kind, now under construction, is using photo images of buildings and signs, special castings, and backdrops. It will be considerably cheaper than a conventional model.

Another method of reducing costs might be through film montage. If context models of an area are not available, then movies of project models can be set within movies of the real environment, fading from real context to model world as the camera enters the project area. This technique will depend on the smoothness of transitions from the real to model worlds. The technique of montage can also be utilized to employ different scales of models to explain different aspects of projects. Such techniques are standard in the movie industry, where films like 2001: A Space Odyssey utilized models and time lapse movies in a similar way.

However, for a city or region where continuous planning is under way, it should be worthwhile for the city to invest in a permanent model, even if it takes a few years to finance it. Many cities have such models in their planning offices, but seldom are they on public display.

It is clear, however, that some environmental situations will be easier to simulate than others. It will be easier to simulate automobile experiences, since they are dominantly visual (Appleyard, Lynch, and Myer, 1964). It will be easier to replicate suburban and rural experiences, where fewer people are visible on the streets and where the visual environment is simpler than the inner city. Finally, it should be easier to simulate first encounters with environments rather than the experience of a lived-in environment, since the former are also primarily visual. Lived-in environments take on many social connotations that would be very difficult to replicate in a simulation.

Productions of the simulator will necessarily emphasize the aspects of environmental impacts which are simulatable, and in so doing the medium may subtly distort the truth in the same way that language, plans, and perspectives distort it. We expect to make explicit such limitations and see the simulator as an addition to the array of media which must be used to predict environmental impacts.

Until now, such explicit accounts of the limitations of impact statements have been rare, indeed.

The Berkeley Simulator As a Prototype

The Berkeley simulator is being constructed as an experiment. It may be used primarily as a laboratory instrument, but if it proves to be sufficiently "real," economic, and relevant to public planning and design issues, it could become a prototype, spawning the more general use of environmental simulators. The airlines in the United States utilize over thirty simulators closely resembling the Berkeley simulator, except for the type of probe used; these can be acquired as standard units. Simulators using models are utilized by the U.S. Navy to train ship pilots, by N.A.S.A. to train astronauts and to test new airplanes. Research in automobile driver behavior has been conducted at U.C.L.A. with a similar simulator. None of these simulators, however, have been designed to view the larger visual environment.

Models of cities are also common. The City of Stockholm has a permanent model of its environment on which all new schemes must be inserted for an assessment of their environmental impact. Less of a working tool and more of an exhibit, is Philadelphia's moving model of the downtown area which explains the way the future city will develop. This model has for many years functioned as an educational exhibit, whereby citizens and particularly schoolchildren learn how their city looks and works. Small environmental simulators are already in operation in places as far apart as the Bouw Centrum, Holland's center for building and planning research, Rice University, Glasgow, and Australia. These are primarily used for architectural projects.

In larger cities a model of the city could be permanently placed under a simulator in an exhibition shed at some convenient location in the city. All significant projects could legally be required to produce realistic models constructed according to guidelines and be set in the "context" model. The expense of these project models would probably be no more than is presently expended on project presentations and would be born by the project agency.

All new projects would then be viewed from all commonly used viewing points, and procedures might be developed for objectively assessing degrees of impact through visual image assessment. More significant projects might be displayed on public television -- normal projects would simply be presented to planning commissions, citizen groups, or other bodies. The model would at the same time be on public display. The Bay Simulation Model in Sausalito, which is managed by the U.S. Corps of Engineers to calculate Bay currents, silting, and water pollution, provides some precedent. It is regularly open to the public.

Cheaper and smaller scale simulators may well become more common in private and public planning and design offices, and in educational establishments where environmental professionals are being educated.

In the coming years in the Berkeley Environmental Simulation Laboratory we propose to conduct a series of demonstration experiments to test which media are most appropriate to which planning situations, and the levels of realism which each provides. We hope to utilize and test new media such as computer graphics and three-dimensional image projection as well as old media such as sketches and photographs, for environments are perceived at many levels and in many ways, and no one medium will provide a complete service.

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